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CERN COURIER

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

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Cosmic sonification theory p33

Cover: *Supercollider* by Keith Tyson was inspired by goings on at CERN (p24). Mixed media on watercolour paper (388 × 481 cm). (Courtesy Haunch of Venison, copyright Keith Tyson 2009.)

LHC NEWS

CERN prepares for long 7 TeV run

The Chamonix workshop, held on 25–29 January, once again proved its worth as a place where all of the stakeholders in the LHC can come together, take difficult decisions and reach a consensus on important issues. This time the most important decision taken was to run the LHC for 18 to 24 months at a collision energy of 7 TeV (3.5 TeV per beam) before a long shutdown, which will allow time for all of the work necessary for the machine to reach the design collision energy of 14 TeV. As beam returns in the LHC this February it marks the start of the longest phase of accelerator operation in CERN's history, running into summer or autumn 2011.

What is the reasoning behind this decision? First, the LHC a cryogenic facility, so each run is accompanied by lengthy cool-down and warm-up phases. Second, there is still essential work to be done to prepare the LHC for running at energies significantly higher than the collision energy of 7 TeV chosen for the first physics run. These facts led to a simple choice: run for a few months now and programme successive short shutdowns to step up in energy; or run for a long time now and schedule a single long shutdown before allowing a total energy of 14 TeV (7 TeV per beam). A long run gives the machine teams time to prepare carefully for the work that will be needed before running at 14 TeV. For the experiments, 18 to 24 months will bring enough data across all of the potential discovery areas.

Before the 2009 running period began, all of the necessary preparations to run the LHC at the collision energy of 1.18 TeV per beam had been carried out. The goal of the technical stop, scheduled to end in mid-February, was to prepare the machine for running at 3.5 TeV per beam, which requires a

Work on the new quench-protection system comes to an end in the LHC tunnel.

current of 6 kA in the LHC magnets.

The main work during the stop was on the new quench-protection system (nQPS), which is designed to improve the electrical reliability of the connection between the instrumentation feedthrough systems on the magnets and the nQPS equipment. There are around 500 of these connectors for each of the eight sectors in the LHC. An intensive effort ensured that this work was undertaken and completed in the first three weeks of January, so that the hardware-commissioning teams could proceed with testing the magnets up to 6 kA.

Several other teams took advantage of the stop to carry out other technical verifications and efficiency tests, for example, on some vacuum pumping units, the kicker system, the oxygen-deficiency hazard detectors, and on some ventilation components. At the same time as this work on the LHC, repairs took place on the water-cooling system of the CMS experiment.

All work, both in the LHC and in the CMS experiment, was scheduled to be completed by mid-February. The machine operations team will then begin to re-commission the LHC at 450 GeV per beam, building on the experience gained after the restart last year and completing investigations of machine parameters at this energy (*CERN Courier* January/February p24). The team will then prepare for the first ramps to 3.5 TeV per beam. Collisions at 3.5 TeV will follow, but only after the operators have established the appropriate running conditions.

Sommaire

FERMILAB

CDF and DØ joint paper puts a further squeeze on the Higgs

Almost a decade after the experiments at CERN's Large Electron–Positron (LEP) collider set a limit on the mass of the Higgs boson of 114.4 GeV/c^2, the two experiments at Fermilab's Tevatron, CDF and DØ have been able to reduce further the allowed mass range for the missing particle in their first joint Run II publication.

In the proton–antiproton collisions observed at the Tevatron, the Higgs boson could be produced in the fusion of two gluons. If its mass is more than 140 GeV/c^2, it will usually decay into a pair of W bosons. The decay of the W bosons into a charged lepton (electron or muon) and a neutrino leads to three different signatures in the detectors: two electrons, two muons or an electron and a muon, in addition to "missing energy" from the undetected neutrinos. This is the key to reducing the background from the jets, which are copiously produced in hadronic collisions.

The Higgs boson is a scalar particle, i.e. it carries no spin. This fundamental property helps to distinguish the decays of the Higgs to two W bosons from other events that contain pairs of W bosons. The two charged leptons from the W boson decays in Higgs events are more likely to be close together than back-to-back in the detector. As a final step in seeking the Higgs, artificial neural networks are trained to distinguish a Higgs signal from background using a large number of kinematic variables.

Both Tevatron experiments have their best sensitivity at a Higgs mass of about 165 GeV/c^2, i.e. just around the combined mass of the two W bosons. With about 5 fb^{-1} of collision data analysed, each experiment alone does not yet have sensitivity to exclude a Higgs boson if it is produced at the rate predicted by the Standard Model. Putting their data together, CDF and DØ can double the number of collisions used, breaking the "Standard Model barrier" for the first time since LEP.

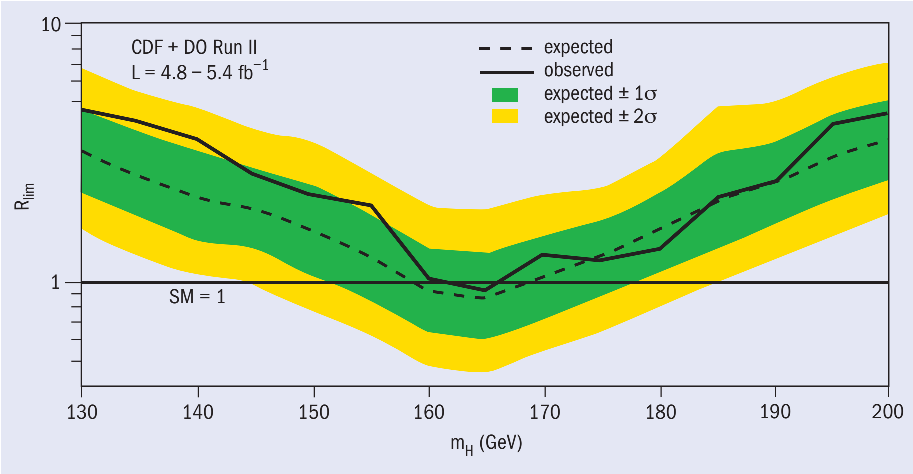


Fig. 1. The ratio (R_{lim}) of the excluded Higgs production cross-section over the theoretical Standard Model cross-section. The mass range where the observed curve falls below one is excluded at the 95% confidence level.

Together, the experiments would expect about 70 Higgs events for a mass of around 165 GeV/c^2 but their combined data are consistent with the assumption that no Higgs events have been produced. This observation is translated into a limit that excludes a Higgs boson in the mass range 162–166 GeV/c^2 at the 95% confidence level.

The paper describing the combination is the first joint publication of the two collaborations using data from Run II of the Tevatron, which started in 2001. The publication, with 1042 authors, will appear in *Physics Review Letters* together with the individual results in separate letters. The data used represent about half the number of collisions that will eventually be recorded by CDF and DØ. This will give them the opportunity to increase significantly the sensitivity of Higgs searches in the future.

Together with the precision electroweak data that favour a low mass Higgs boson, these new results indicate that the most likely mass for the Higgs boson – if it exists – is somewhere between the LEP and Tevatron limits of 114 and 162 GeV/c^2.

Further reading

CDF and DØ Collaboration, arXiv:1001.4162, accepted by *Phys. Rev. Lett.*
CDF Collaboration, arXiv:1001.4468, accepted by *Phys. Rev. Lett.*
DØ Collaboration, arXiv:1001.4481, accepted by Phys. Rev. Lett.

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.**

CERN

Workshop pushes proton-driven plasma wakefield acceleration

PPA09, a workshop held at CERN on proton-driven plasma wakefield acceleration, has launched discussions about a first demonstration experiment using a proton beam. Steve Myers, CERN's director for Accelerators and Technology, opened the event and described its underlying motivation. Reaching higher-energy collisions for future particle-physics experiments beyond the LHC requires a novel accelerator technology, and "shooting a high-energy proton beam into a plasma" could be a promising first step. The workshop, which brought together participants from Germany, Russia, Switzerland, the UK and the US, was supported by the EuCARD AccNet accelerator-science network (*CERN Courier* November 2009 p16).

Some of the participants during a tour of a tunnel that could house a CERN proton-plasma experiment.

Plasmas, which are gases of free ions and electrons, can support large electric fields – a property that can be exploited to accelerate particles to relativistic energies over much shorter distances than is possible with current technologies. Past research has focused on creating large-amplitude plasma waves by injecting a short, intense laser pulse or an electron bunch into the plasma (*CERN Courier* June 2007 p28). Indeed, accelerating gradients up to 100 GV/m have been established over a centimetre with laser excitation and up to 50 GV/m over a metre with a short electron bunch as driver.

A recent proposal is to excite the plasma through a more energetic proton bunch. The maximum energy gain of electrons accelerated in a single plasma wake is limited to roughly twice the energy of the particles in the driving bunch. Given that protons can be accelerated to tera-electron-volt energies in conventional accelerators, it should be possible to accelerate electron bunches in the wake of a proton driving-bunch to energies up to the tera-electron-volt regime in one pass through the plasma.

The plasma wake produced by a 1 TeV proton bunch has been already investigated in computer simulations (Caldwell *et al.* 2009). The simulated electric fields are a factor of 100 higher than those considered for the International Linear Collider, and could lead to the acceleration of a bunch of electrons to several hundred giga-electron-volts within a few hundred metres (starting with a 1 TeV short proton bunch as driver).

So far there have been no beam tests with proton-driven plasmas. The primary goal of the PPA09 workshop was, therefore, to start the discussion on a pioneering experiment – using a proton beam from CERN's Proton Synchrotron or Super Proton Synchrotron to demonstrate the generation of strong wakefields by a proton bunch. The preparation of a letter of intent for such experimentation at CERN was discussed in the workshop. One of the questions left open is the method for generating the required long, dense plasma. The workshop identified two options, which are now being pursued in parallel.

The workshop concluded that a first round of beam measurements, possibly in 2012, would search for modulations of a long proton bunch (rms bunch length around 15 cm). This effect is predicted by particle-in-cell simulations and its observation would provide an excellent benchmarking test. The goals for subsequent rounds of experimentation would include generating stronger electric fields in the plasmas by first longitudinally compressing or otherwise pre-modulating the proton bunch, and eventually, in 2014 or later, demonstrating the acceleration of an electron bunch in the wake of the proton bunch.

Chan Joshi, from University of California, Los Angeles, and one of the prominent researchers participating in PPA09, defined the medium-term goal of a CERN proton-driven plasma wake-field experiment as the demonstration of 1-GeV proton-driven acceleration in less than 5 m; its ultimate goal would be to accomplish 100-GeV acceleration over a distance of 100 m.

● More details of the workshop and all presentations can be found at http://indico.cern.ch/conferenceDisplay.py?confId=74552 and http://accnet.lal.in2p3.fr.

Further reading

A Caldwell *et al.* 2009 *Nat. Phys.* **5** 363.

Compiled by John Swain, Northeastern University

A renewed role for clay

Clay has been used in various kinds of pottery since prehistoric times, but in the 20th century plastic objects became much more ubiquitous. Now clay could see a widespread renaissance thanks to research by Takuzo Aida and colleagues at the University of Tokyo in Japan, which has brought a 21st century touch to this ancient material.

It turns out that water and clay (2–3% by mass) plus small amounts of suitable organic compounds (less than 0.4% by mass) can produce transparent hydrogels that could take the place of plastics. The materials produced in this way are mechanically strong, but what is more remarkable is that, if damaged, they will completely self-heal – after all, they are nearly all water. The key to these remarkable properties is the non-covalent supramolecular bonds between the dendritic organic molecules – ones that have many "fingers" to grab onto things – and the clay.

A bridge constructed by connecting together seven hydrogel blocks can be suspended horizontally and held vertically.

Unlike plastics, these hydrogels are environmentally friendly. Moreover, as the researchers point out, with the world's focus on reducing dependency on fossil-fuel energy, there is a big role for materials that are much less dependent on petroleum than conventional plastics are.

Further reading

Qigang Wang *et al.* 2010 *Nature* **463** 339.

Water splashes are supersonic

Drop a rock on a pond and watch the splash – but look carefully, because some of the air in the splash comes out faster than sound. Stephan Gekle of the University of Twente and colleagues carefully studied what happens when a 2 cm disc is pulled through water at just 1 m/s. The cavity produced in the water rapidly forms into an hourglass shape and air forced through the narrow "waist" can exceed the speed of sound even though it is driven by a pressure difference of just 2% of an atmosphere. At times, the dynamically evolving cavity resembles nozzles used for supersonic jet engines, but the way that it changes in time makes it a completely unique physical system.

Further reading

S Gekle *et al.* 2010 *Phys. Rev. Letts.* **104** 024501-1.

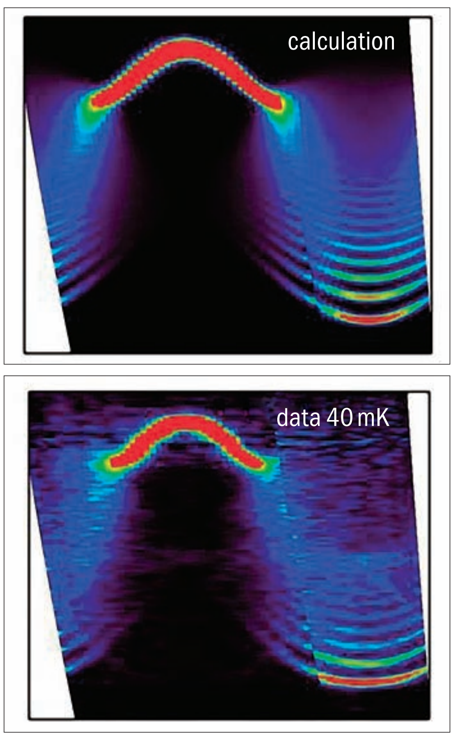
E_8 appears in the real world

Simple Lie groups – in a sense, the basic atoms of symmetry – come in several infinite series. There is also a list of five "exceptional" ones, of which E_8 is the largest and, to many mathematicians and physicists, the most beautiful. For physics, E_8 has mainly attracted the interest of string theorists, but now it has turned up in laboratory studies of quantum magnetism.

Radu Coldea of the University of Oxford and colleagues applied a strong magnetic field to a supercooled crystal of cobalt niobate, which behaves like a quasi one-dimensional Ising ferromagnet. Despite the simplicity of the system, it exhibits a quantum phase transition that is predicted to have excitations corresponding to an emergent E_8 symmetry. The two lowest-lying "meson" states turn out to have a mass ratio of the golden mean (about 1.618), just as predicted from the E_8 theory.

Further reading

R Coldea *et al.* 2010 *Science* **327** 177.



Spectrum of magnetic resonances in cobalt niobate in zero applied field, as calculated and observed by neutron scattering data. Near the critical field the two lowest frequencies approach the golden ratio, one of the key signatures of the predicted E_8 structure.

Liquid materials for invisibility cloaks

Metamaterials with effective negative indices of refraction offer the possibility of making invisibility cloaks by routing light around a concealed object. A new approach on this theme is based on a novel form of ferrofluid. The idea by Y Gao of Fudai University in Shanghai and the Chinese University of Hong Kong and colleagues is to use silver-coated iron-oxide nanoparticles suspended in water.

An external magnetic field would cause the particles to line up into chains so that the desired metamaterial would form by self-organization. Experimental demonstration of the technique still remains to be done, but the idea is quite new in the field, which has so far concentrated on solid devices. Maybe this is what the author J K Rowling had in mind in the Harry Potter novels, where she describes invisibility cloaks as "fluid and silvery".

Further reading

Y Gao *et al.* 2010 *Phys. Rev. Letts.* **104** 034501-1.

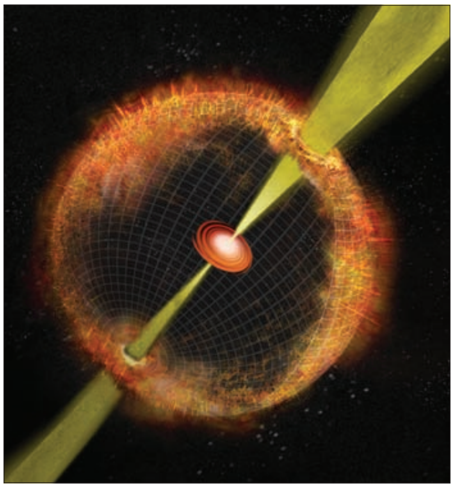
Compiled by Marc Türler, ISDC and Observatory of Geneva University

SN 2009bb: where are the gamma rays?

Long-duration gamma-ray bursts are associated with peculiar supernova explosions and a long-lived radio afterglow emission has been detected for some of them. So the discovery of relativistic radio ejecta from two supernovae not associated with detected gamma-ray bursts is a surprise. Did the gamma rays point away from Earth or were they trapped inside the star?

Gamma-ray bursts lasting more than several seconds are associated with peculiar supernova explosions of massive stars. They are thought to be generated by a central engine that is likely to be a newborn black hole at the heart of the dying star (*CERN Courier* September 2003 p15). These supernovae are all of spectral type Ibc (i.e. either Ib or Ic), which means that they are core-collapse supernovae with no evidence of hydrogen lines in the spectrum, suggesting that the massive star has previously blown away its outer envelope of hydrogen. Only about 1% of type Ibc supernovae display gamma-ray bursts and evidence for relativistic ejecta inferred from radio observations.

Previously, supernovae with relativistic outflows have only been found via their prompt gamma-ray emission. Now, however, A M Soderberg of the Harvard-Smithsonian Center for Astrophysics and collaborators report in *Nature* the discovery of mildly relativistic outflows in a supernova without a detected gamma-ray burst. They deduce the velocity of the blast-wave in this supernova, SN 2009bb, from the luminosity and frequency of the synchrotron spectral turnover that gives a measure of the size of the radio source at a given time after the onset of the supernova. They obtain a velocity of more than about 0.6 times the speed of light, which is interpreted as evidence for a central engine. The latter should have powered a gamma-ray burst coincident in time and position with SN 2009bb, but none was detected by the Interplanetary Network of spacecrafts sensitive to gamma-ray bursts.



Artist's rendering of an "engine-driven" supernova explosion with accretion disc and high-velocity jets. (Courtesy Bill Saxton, NRAO/AUI/NSF.)

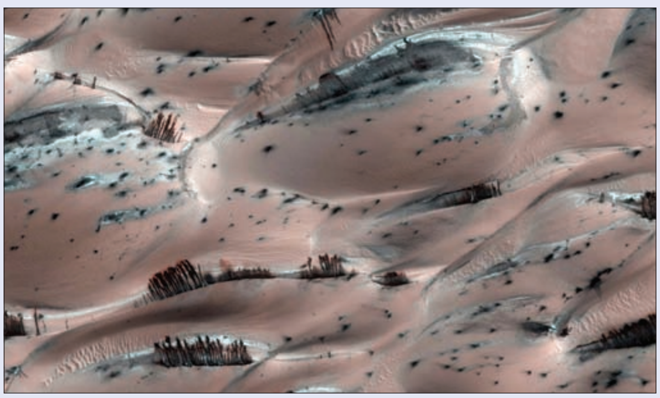
The radio luminosity of SN 2009bb and its decay over several months matches very well that of SN 1998bw, which was the first supernova that could be associated with a gamma-ray burst. The latter, GRB 980425, is still the nearest detected gamma-ray burst at a distance of about 120 million light-years. The new event in the spiral galaxy NGC 3278 is at a similar distance. The absence of an associated gamma-ray burst could indicate that there were no gamma rays or that they were directed away from the line of sight. However, even if the gamma-ray signal was as bright as GRB 980425 it would not have been detectable by the Interplanetary Network. It could thus be that SN 2009bb is just a twin of SN 1998bw. Only two other supernovae have been detected so far to be associated with dim and nearby gamma-ray bursts, namely GRB 031203 (*CERN Courier* September 2004 p13) and the X-ray flash GRB 060218 (*CERN Courier* October 2006 p13).

SN 2007gr is another supernova that can now be added to the list. It also has a mildly relativistic outflow detected without gamma-ray emission. This independent discovery was reported in the same issue of *Nature* by a group of astronomers led by Z Paragi from the Joint Institute for Very Long Baseline Interferometry in Europe, the Netherlands, and from the MTA Research Group of Budapest. This time, the expansion of the supernova was directly measured from two high-resolution radio interferometric observations separated by 60 days.

Further reading

A M Soderberg *et al.* 2010 *Nature* **463** 513.
Z Paragi *et al.* 2010 *Nature* **463** 516.

Picture of the month



Are there trees on Mars? Obviously not, but you could have doubts looking at this stunning landscape captured by the High Resolution Imaging Science Experiment (HiRISE) camera on NASA's Mars Reconnaissance Orbiter. The picture was taken in a vast region of sand dunes at high northern latitude on Mars. The dunes are covered with a layer of carbon-dioxide ice during the winter, which melts in the spring. The evaporation of the ice dislodges sand from the crests of the dunes. When the sand cascades down the dune, it produces dark streaks, which resemble aligned trees. Indeed, a small cloud of dust just kicked up by falling material is visible in the lower left part of the image. This new HiRISE image confirms that landscape diversity on Mars is beyond imagination (*CERN Courier* December 2009 p11). (Courtesy NASA/JPL/University of Arizona.)

CERN COURIER ARCHIVE: 1967

A look back to *CERN Courier* vol. 7, March 1967, compiled by Peggie Rimmer

OBITUARY

Tribute to Professor Oppenheimer

Prof. J R Oppenheimer died on 18 February. He was a physicist who had achieved worldwide renown for his part in the production of the atomic bomb. He was also a theoretical physicist who made several important contributions to physics and had considerable influence on the progress of physics in his own country and abroad.

Robert Oppenheimer was born in New York on 22 April 1904 into a wealthy and highly cultured family. His early years were spent in an environment where his lively mind was given every encouragement and opportunity to develop. At the age of 5 he started a collection of rocks and was admitted to the New York Mineralogical Club when he was only 11 years old.

In 1922 he went to Harvard, initially intending to make his career in chemistry. He studied chemistry and physics and also learnt Latin, Greek and Dutch, finally graduating *summa cum laude* in 1925. Then began several important years in Europe, the hotbed of atomic and nuclear physics at that time. He first went to work under Rutherford at Cambridge University in the UK and from there, at the invitation of Born, to Göttingen in Germany where he received his doctorate in 1927. He returned briefly to the USA to Harvard and Caltech, later returning to Europe

to the University of Leyden, Netherlands, and ETH Zurich, Switzerland. In 1929, he joined Caltech at Pasadena and the University of California at Berkeley, becoming professor in 1936, and was associated with both centres until 1947. He then became director and professor of physics at the Institute for Advanced Study, Princeton. He retired as director in 1966.

A crucial time in his life, which led to fame far beyond the field of physics itself, was the period 1943–1945 when he was chosen to be director of the Los Alamos Scientific Laboratory, to lead the work on production of the atomic bomb. Because of his broad and deep scientific understanding of all aspects of the project he was able to weld together the abilities of a brilliant group of scientists to produce the atomic bomb in a remarkably short time.

From 1946 to 1952 he was chair of the General Advisory Committee of the US Atomic Energy Commission but his high position in forming US scientific policy came to an abrupt end following an investigation by the Atomic Energy Commission, which culminated in the removal of his security clearance. This sad affair has been discussed extensively elsewhere and will not be covered here. In 1963, he was effectively reinstated in public esteem when he was awarded the Fermi prize, the highest honour at the disposal of the Atomic Energy Commission.

After the Second World War, Oppenheimer felt deeply the need to re-open the worldwide exchange of scientific information, which had been so badly curtailed during the war. He holds a place in the history of CERN for the important part that he played in the years 1947–1949, in the discussions which led to the idea of European collaboration in high-energy physics. This was recognized at the inauguration of the proton synchrotron when Oppenheimer was one of the two non-Europeans (the other being Prof. E McMillan, director of Berkeley) in the select group of people invited to give an inaugural address (see photograph). More recently, he was a member of the Scientific Council of the International Centre for Theoretical Physics in Trieste.

● From the article on p43.

NEWS

New buildings change the face of CERN

These two photographs show the great changes at the CERN site from 1955 to 1967. One of the factors that has contributed most is the large number of new buildings put up during that time.

The 1966 construction budget covered commitments worth 10.9 million Swiss francs, 70% for civil engineering and 30% for technical installations. The main construction work finished during the year was the neutrino area, i.e. the tunnel and adjoining buildings (the first experiment began this month). A number of projects begun in 1966 have just been completed or will be completed in the course of 1967; for example, the six-storey

CERN in June 1965 (left) and February 1967.

building known as Laboratory 14 is being handed over to the Track Chambers and Nuclear Physics Divisions. Underground experimental halls for the ISOLDE project have also been finished this month.

● From the article on p44.

COMPILER'S NOTE

CERN owes its existence in part to several men of science who came out of the Manhattan Project with a feeling of blood on their hands, determined that things would be different for future generations of researchers. While Oppenheimer was being investigated by the Atomic Energy Commission, his close friend Isidor I Rabi and others were working through UNESCO to create a European laboratory where physicists could conduct nuclear research of a pure scientific and fundamental character, with no concern for military requirements. The rest is history – still in the making.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Participants at the International Symposium on Exotic Nuclei, EXON 2009, held at the Black Sea resort of Sochi. (Courtesy JINR.)

Collaboration: the key to unlocking exotic nuclei

An international symposium organized in Russia underlined how worldwide collaboration is pushing forward investigations of exotic nuclei. **Yuri Penionzhkevich** reports.

The most sophisticated physics experiments today take place at large facilities – accelerators – which in turn need large financial investments that cannot be provided by a single country, even if it is highly developed. Such investigations can be carried out only by collaborations between scientific centres in several countries, each bringing financial and intellectual contributions to the development of the cutting-edge facilities that make it possible to penetrate deeper into the secrets of matter. The LHC at CERN, for example, is the result of contributions from 20 member states and many other countries worldwide. Similarly, the Joint Institute for Nuclear Research (JINR) in Dubna, with 18 member states, is home to several accelerators. This internationally based research leads to new information not only about physics but also other fields, such as astronomy, condensed-matter physics and modern technology. The methods used are also of great importance for interdisciplinary fields, such as nanotechnology, medicine and microelectronics.

The physics of nuclei in exotic states is one of the most important and rapidly developing areas in nuclear physics. Researchers can now produce nuclei in extreme states – such as nuclei with high angular momentum (rapidly rotating nuclei), high excitation energy ("hot" nuclei), highly deformed nuclei (nuclei with unusual, super- and hyper-deformed shapes), nuclei with extremely large numbers of neutrons or protons (neutron-rich and proton-rich nuclei) and superheavy nuclei with a proton number, Z, above 110. The investigations of nuclear matter in such extreme states provide important information about the properties of the microcosm and make possible the modelling of a variety of processes taking place in the universe.

These studies, which rely on collaborative effort between countries, were the subject of the international symposium EXON 2009 held in the Black Sea resort of Sochi, Russia, on 28 September – 2 October. The symposium was organized by the four largest centres involved in the investigation of exotic nuclear states: JINR in Russia; the Grand Accélérateur National d'Ions Lourds (GANIL) in France; the GSI Helmholtzzentrum für Schwerionenforschung in Germany; and the research centre RIKEN in Japan. Some 140 scientists from institutes in 24 countries as well as from JINR attended the conference, with the largest number of participants from outside Russia coming from Germany (20 participants), France (16), Japan (12) and the US (8), with about 40 participants from JINR and 16 from institutes across Russia. ▷

EXON 2009 was the fifth in this series of symposia on exotic nuclei, all of which have been held in Russia, the first one in 1991. All have been of interest not only for the organizers, but also for participants from other research centres. In addition to the discussions of scientific problems and the collaboration necessary to address them, participants have the opportunity to become acquainted with some of the most remarkable places in Russia, while the local research authorities and universities find out about the latest results in nuclear physics and the possibilities of applications in interdisciplinary fields of science and technology.

The scientific programme included invited talks about pressing problems in the physics of exotic nuclei as well as about new projects for large accelerator complexes and experimental facilities. The main discussions about the properties of nuclei at the limits of nucleon stability took place on the first day, with reports on the newly observed unusual states at high values of the ratios of the proton to neutron numbers. The topics included: the change of the "accepted" magic numbers when approaching the limit of neutron stability; the coexistence in the same nucleus of two or more types of deformation; and the increase of nuclear stability resulting from deformation, which is important for understanding the stability of pure neutron matter. As UNESCO had declared 2009 the International Year of Astronomy, one talk was dedicated to investigations in this field. Shigeru Kubono from the University of Tokyo discussed the possibilities of studying important astrophysical problems with the use of radioactive secondary beams.

Superheavy elements

In addition to the talks on light exotic nuclei, other reports covered the results of the latest experiments on the synthesis and properties of superheavy elements. Joint experiments by JINR's Flerov Laboratory of Nuclear Reactions (FLNR), GSI and the Paul Scherrer Institute have found interesting results on the chemical identification of elements 112 and 114 at the FLNR U400 cyclotron, as Heinz Gäggeler of PSI described. Speakers from different countries reported on a range of investigations of the properties of the superheavy elements using different methods. These reports underlined the importance of the investigations of superheavy elements that are carried out in Dubna by existing collaborations. One striking example is the experiment aimed at the synthesis of element 117 that is currently being performed at the U400 cyclotron by a large group of physicists and chemists under the guidance of Yuri Oganessian and Sergei Dmitriev, in collaboration with scientists from different laboratories in the US, who provided the target material of ^{249}Bk. In addition, theoretical presentations included predictions of possible reactions for synthesizing superheavy elements and of their chemical properties.

A second day was dedicated to reports on the current and future heavy-ion and radioactive beam accelerator complexes in different scientific centres. The four laboratories that co-organized the symposium are currently creating a new generation of accelerators that will make it possible to improve considerably the work on the synthesis and studies of the properties of new exotic nuclei. There were detailed talks on the SPIRAL project at GANIL, the RI Beam Factory at RIKEN, the Facility for Antiproton and Ion Research (FAIR) at GSI and the DRIBs project at JINR. In his talk, Mikhail Itkis, JINR's vice-director, presented plans for the development of the institute's accelerator facilities, including the new complex, NICA (*CERN Courier* January/February 2010 p13). Georg Bollen of Michigan State University reported on the project for the Facility for Rare Isotope Beams (FRIB), now funded and to be built at the university (*CERN Courier* March 2009 p7). In this way, more centres are joining the group of institutes that are developing a new generation of accelerator complexes.

There were also presentations about other facilities for the production of radioactive beams, including ALTO in Orsay, EXCYT in Catania, RIBRAS at the University of Sao Paulo and the radioactive beams project at the Cyclotron Institute of Texas A&M University. The discussions around these talks showed that beams of radioactive nuclei are fundamental to investigations of the properties of nuclear matter in extreme states.

Round-table discussions also took place during the symposium to consider the results obtained in joint work and possible future collaborations. Bollen, a leader of the FRIB project, suggested including Michigan State University as a co-organizer of the next symposium, EXON 2012, which could take place in the city of Vladivostok in the Russian Federation.

● For full details about the scientific programme and speakers, see http://exon2009.jinr.ru/. There were about 80 talks in total and some 40 posters shown, all of which will be published in conference proceedings by the American Institute of Physics.

Résumé

Collaboration : dévoiler des noyaux exotiques

Le colloque international EXON 2009 a eu lieu à Sotchi, une station balnéaire de la mer noire, en Russie, du 28 septembre au 2 octobre. Organisé par les quatre principaux centres participant à la recherche des état nucléaires exotiques – IURN pour la Russie, GANIL pour la France, GSI pour l'Allemagne et RIKEN pour le Japon, il a été l'occasion de montrer combien la collaboration internationale fait avancer la recherche sur les noyaux exotiques. Quelque 140 savants provenant d'instituts de 24 pays ont participé à la conférence. Au programme, des interventions sur des problèmes pressants de la physique des noyaux exotiques, ainsi que de nouveaux projets pour de grands complexes d'accélérateurs et des installations expérimentales.

Yuri Penionzhkevich, *JINR, Dubna.*

Cosmic rays, climate and the origin of life

Does ionization of the atmosphere produced by cosmic rays influence cloud cover? Analysis as a function of geomagnetic latitude suggests not. However, it is possible that cosmic rays may have a role in lightning, and perhaps even in the origin of life on Earth.

In his pioneering work on supersaturated vapours, which began in the 1890s, C T R Wilson found that droplets condensed on the ionization trails left by charged particles. This led to many positive advances, among the most significant of which was the use of "cloud chambers" in ushering in the field of elementary particle physics. Just over 50 years ago, Edward Ney at the University of Minnesota suggested that cosmic rays might have an influence on the climate (Ney 1959). He proposed that ions from cosmic rays act as condensation centres for cloud droplets. It is immediately obvious that this is not the phenomenon that Wilson discovered. To make ionization trails visible, cloud chambers need very clean conditions and supersaturation at a level about four times greater than saturation. By contrast, it is rare to find such clean conditions in the atmosphere and supersaturation levels are almost never more than 1% above saturation.

More recently, in 1997 Henrik Svensmark and Eigil Friis-Christensen reported a link between clouds and elementary particles (specifically cosmic rays) that has been used to claim that changes in cosmic-ray intensity cause changes in cloud cover and could affect global warming (Svensmark 2007). In this article we describe work that examines this claim critically. We also touch on the fascinating topic of lightning initiated by cosmic-ray showers and its possible role in the origin and evolution of life.

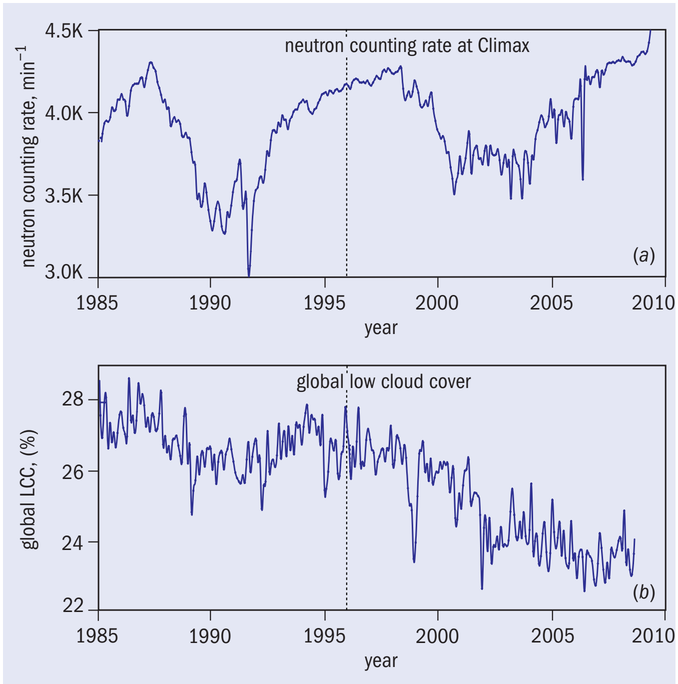

Fig. 1. Upper plot: variation with time of the cosmic-ray intensity, presented as the counting rate of the neutron monitor at Climax, Colorado. Lower plot: the low-cloud data from the International Satellite Cloud Climatology Project (ISCCP, D2-IR data). Both plots cover the period of two solar cycles separated by the vertical dotted line at 1996.

Cosmic rays and cloud cover

Figure 1 shows the basic evidence used to claim a causal correlation between cosmic-ray intensity (measured by the neutron monitor operated by the University of Chicago at Climax, Colorado) and low cloud cover (at altitudes below 3.2 km as measured by satellites). The data in the figure are for the period 1985 to 2008, which covers two solar cycles. In the 22nd cycle (1985–1996) the correlation between cosmic-ray intensity and low cloud cover was strong and this was the origin of the claim. However, the next (23rd) solar cycle has now passed (1996–2007) and the correlation is much more difficult to see. This suggests that the 1985–1996 observation might have been "accidental" and the effect of something completely different (such as temperature). Nevertheless, we will put this to one side and consider whether the apparent correlation is causal.

A test of the causal hypothesis is to examine the correlation as a function of geomagnetic latitude. The 11-year cosmic-ray variation becomes bigger at higher magnetic latitudes because of the effect of the Earth's magnetic field. Fewer low-energy cosmic rays enter the Earth's atmosphere near the magnetic equator than near the poles. This effect is measured by the vertical rigidity cut-off (VRCO) – ▷

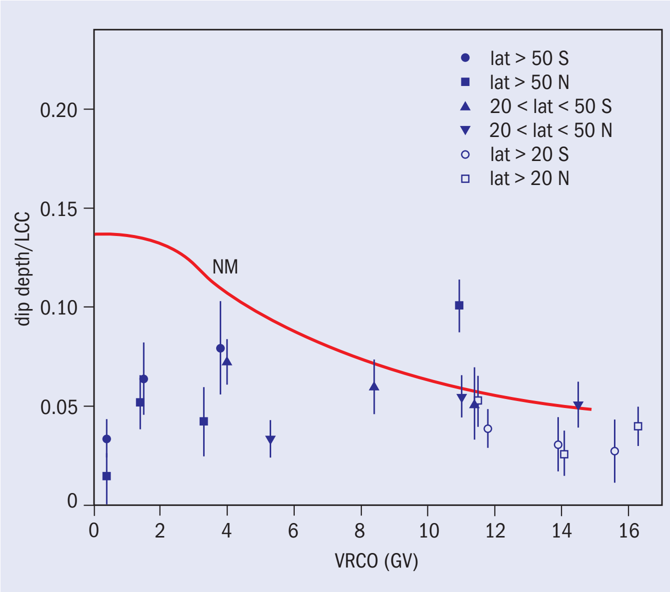

Fig. 2. The depth of the dip in low cloud cover (LCC) in 1990 compared with the LCC values in 1985 and 1995 for data at different geomagnetic latitudes, represented by the vertical rigidity cut-off (VRCO). The curve labelled NM shows the variation in cosmic rays over the 11-year solar cycle, also plotted against VRCO. The values are grouped into the geographical latitude ranges indicated.

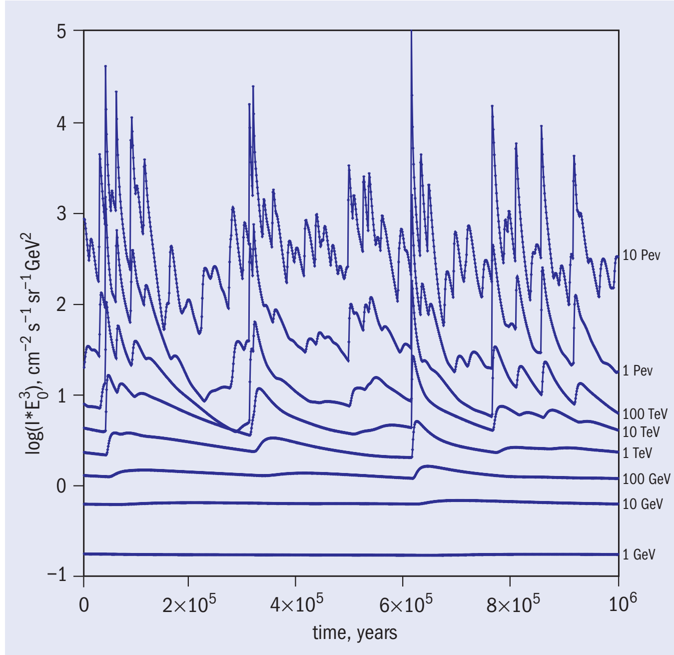

Fig. 3. Variation in the intensity of cosmic rays of various energies, indicated at the right side of the plot, over 1 My from the supernova remnant model of Erlykin and Wolfendale, 2001. To improve visibility, intensities at 1 and 10 PeV are increased by 2 and 10, respectively.

the minimum rigidity for a primary cosmic ray to reach the Earth's atmosphere – which is computed from the local value of the planet's magnetic field. Our analysis looked at the differences between the low cloud cover at solar minima in 1985 and 1996 and that at solar maximum in 1990 at different VRCO (Sloan and Wolfendale 2008). These were then compared with the changes in the cosmic-ray rate as measured from neutron monitors located around the world (figure 2). If the dip in the low cloud cover observed in 1990 was caused by the decrease in ionization from cosmic rays then all of the points in figure 2 would follow the line of the cosmic-ray variation, marked NM. They do not.

Cosmic rays are not the only source of ionization in the atmosphere. We have looked for changes in cloud cover associated with a variety of other sources. The ionization released from nuclear weapon tests in the atmosphere was one example that we examined. At large distances from the test centre, radiation levels are high but other effects of the blast are negligible. For example, measurements showed that the Bravo test (the largest of the US tests), which exploded a 15-megatonne device at Bikini Atoll on 1 March 1954, produced radiation levels of 100 R/h at a distance of 480 km from the explosion. This corresponds to 5×10^7 ion pairs/cm^3, i.e. seven orders of magnitude more ionization than that produced by cosmic rays. However, no effects on cloud cover were observed. This shows that the efficiency for conversion of ions to cloud droplets must be low. Similarly, we examined radon concentrations in various parts of the world to see if high-radon regions had more cloud cover than their neighbours with low-radon concentrations. We also examined the ionization released in the Chernobyl disaster in 1986. Again, we did not find any significant effects of ionization on cloud cover.

Recently, Svensmark's group examined the so-called Forbush decreases in cosmic-ray intensity, which are caused by solar coronal mass ejections. The group found that the six strongest (over the past 20 years) are followed by significant drops in low cloud cover and in other indicators of atmospheric water content. We have examined the evidence in detail and concluded that it is not only statistically weak but that it also needs unphysically long periods (6–9 days) for the change in cosmic-ray flux to manifest itself as changes in cloud cover or the cloud water content.

The correlation between low cloud cover and cosmic rays in figure 1 is presumably therefore *not* causal because we have found that ionization is not efficient at yielding cloud cover. A more likely cause relates to solar irradiance, not least because the change in energy content of solar irradiance is about 10^8 times that of cosmic rays. In this context, Mirela Voiculescu of Dunarea de Jos University in Romania and colleagues showed correlations between low cloud cover and either the cosmic-ray rate or the solar irradiance in limited geographical areas (Voiculescu *et al.* 2006). Such areas cover less than 20% of the area of the globe. A close examination of these geographical areas reveals that only the correlation between the solar irradiance and the cloud cover is seen in both solar cycles. By contrast, any correlation that there is with cosmic rays does not appear in both cycles.

Variation in solar irradiance over the 11-year solar cycle is a much more plausible cause of any correlation with cloud cover than cosmic rays; indeed, Joanna Haigh of Imperial College London has modelled such an effect (Haigh 1996). A comparison of the long-term variation of the global average surface temperature with the long-term solar activity shows that less than 14% of the observed global warming in the past 50 years comes from variations in the solar activity.

This is not to say that ionization has no effect on climate at all. There may well be an interesting effect involving the terrestrial electrical circuit, which seems to be affected by cosmic rays. No doubt the CLOUD experiment underway at CERN will throw further light on this problem and tell us just how much such an effect will be.

Lightning and the origin of life

One fall-out of the work described above has been interest in the role of cosmic rays in a particularly dramatic cloud effect: lightning. Alexander Gurevich and Kirill Zybin of the P N Lebedev Physical Institute in Moscow suggested in 2002 that extensive air showers (EAS) created by cosmic rays play a key role in initiating the leader strokes in lightning. This has been confirmed in more recent observations at the Lebedev Institute's Tien-Shan Mountain Cosmic Ray Station by Gurevich and colleagues.

This phenomenon has a possible relevance to the origin of life on Earth. The current favourite models for this origin are either on comets in outer space, as Fred Hoyle and Chandra Wickramasinghe suggested, or in the black smokers or alkaline vents that result from volcanic activity in the deep oceans. However, another possibility follows from the famous early experiments of Stanley Miller and Harold Urey, in which they passed a spark through a mixture of liquids (water, methane, ammonia, etc) – the "prebiotic soup". This resulted in the appearance of the basic building blocks of life, such as amino acids, RNA and monomers. One problem, however, was that the available spark energy, from lightning, was thought to be inadequate.

This is where the long-term variability of EAS rates may have relevance. We have shown that there should have been periods during which the EAS rate was higher by orders of magnitude than at present (Erlykin and Wolfendale 2001). Our theory is based on the statistical nature of supernova explosions, which are thought to be the originators of high-energy cosmic rays. Figure 3 shows how, from time to time, periods of high cosmic-ray intensity of tens of thousands of years will occur, as a nearby supernova explodes. This will lead to high lightning rates. One of these, occurring at around 4 Gy before the present (a not unlikely occurrence), could have led to the formation of the building blocks of life via the Miller-Urey mechanism. Life could then have evolved from such a start.

Perhaps less speculatively is the role of NO_x ($NO + N_2O$) generated by lightning strokes. It seems that nearly 20% of the contemporary concentration of NO_x is produced by lightning. Its rate of production would certainly vary considerably. NO_x is poisonous to mammals but promotes growth in plants; thus, an effect on evolution of species, both positive and negative, is likely.

In conclusion, the interaction of cosmic rays with the Earth's atmosphere is a topic of considerable interest. Although it is unlikely that cosmic rays are a significant contributor to global warming, their contribution to the pool of aerosol-cloud condensation nuclei could be non-negligible; the CLOUD experiment has a big role to play in elucidating the interesting science involved. On a wider canvas it would not be surprising if electrical effects in the atmosphere, initiated by cosmic rays, played a role in the evolution of the Earth's inhabitants.

Cosmic influences: cosmic rays could have a role in initiating lightning strikes. (Copyright Kristian Sekulic/Dreamstime.com).

● The authors are grateful to the John Taylor Foundation for supporting this work.

Further reading

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Résumé

Rayons cosmiques, climat et origines de la vie

L'ionisation de l'atmosphère produite par les rayons cosmiques a-t-elle une influence sur la couverture nuageuse ? On le pensait depuis plus d'une décennie, en s'appuyant sur des données issues du cycle solaire 1985–1996. Dans cet article, les auteurs décrivent leurs travaux, qui sont un examen critique de cette thèse. L'analyse de la couverture nuageuse en fonction de la latitude géomagnétique laisse penser qu'il n'y a pas de corrélation causale avec l'intensité des rayons cosmiques atteignant l'atmosphère. L'article évoque également la troublante question du déclenchement de la foudre par les gerbes de rayons cosmiques, et du rôle éventuel de ce phénomène dans l'apparition et l'évolution de la vie sur la Terre.

Anatoly Erlykin, *P N Lebedev Physical Institute in Moscow,* **Terry Sloan**, *University of Lancaster, and* **Arnold Wolfendale**, *Durham University.*

Lepton Photon goes back to its roots in Hamburg

The 2009 meeting of the biennial Lepton Photon conference provided a clear and comprehensive review of particle physics as the field tests the Standard Model to its limits.

The first time that the International Symposium of Lepton and Photon Interactions at High Energies took place in Hamburg, in 1965, it was in its earlier incarnation that referred to electrons, rather than all leptons. The DESY electron synchrotron had started up the previous year, so the young laboratory was an obvious host for a conference that was relatively specialized. Since then, high-energy electrons have revealed the reality of quarks and the complex nature of the proton; muons have provided signatures of new states of matter, from charmonium to quark–gluon plasma; neutrinos from beyond the Earth have given glimpses of physics beyond the Standard Model; and photons have begun to offer a new view of the high-energy universe. "Lepton Photon" has thus grown to encompass all of particle physics and the 24th symposium, held in Hamburg during DESY's 50th anniversary year, was no exception.

Within its standard format of invited plenary sessions only, Lepton Photon 2009 presented a clear and concise overview of particle physics today. Expectations for the future formed a recurrent theme, not only in view of the imminent start-up of the LHC but also looking to upgrades, new experiments and facilities to push frontiers in energy and luminosity. This report will focus mainly on recent results presented at the conference in topics varying from QCD and heavy ions to neutrinos and dark matter.

When originally planned, it was likely that this conference would be dominated by the first collisions at the LHC. This news should now fall to the summer conferences in 2010, but the LHC still loomed large in the presentations at Lepton Photon 2009. The first scientific session heard the latest news about the steady progress towards the restart, following the incident of September 2008. The four major experiments, ALICE, ATLAS, CMS and LHCb, took advantage of the prolonged shutdown to complete installation work, implement improvements and make thorough tests with cosmic rays – efforts that led to a highly successful restart in November and December last year (*CERN Courier* January/February 2010 p24).

Ken Peach, convener of the first session on searches, enjoys a lighter moment with Andreas Ringwald. (All photos courtesy DESY.)

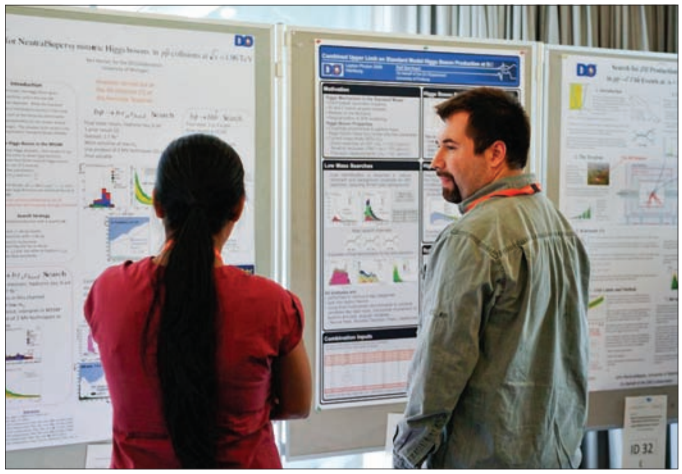
A steamer takes participants around the habour before the conference dinner at the old warehouse, Schuppen 52.

HERA's harvest

The harvest of data from HERA – the world's only electron–proton collider, which ran from 1992 until 2007 – continues to paint a remarkably clear picture of the internal workings of the proton within the context of QCD, the theory of the strong force. The precision that comes from combining HERA-I data (1996–2000) from the H1 and ZEUS experiments yields impressively accurate distribution functions for the gluons and the quark–antiquark sea in the latest QCD analysis at next-to-leading order (NLO), especially at low values of the momentum fraction x (*CERN Courier* January/February 2010 p21). Both H1 and ZEUS have made the first measurements of the structure function, F_L, at low x and there are also new results from ZEUS with improved precision at high values of momentum-transfer-squared (high Q^2).

The HERMES collaboration at HERA took a different approach by observing the collisions of the electron beam with a gas target. ▷

CERN's director-general, Rolf Heuer, shows off the LHC during his talk to the public on particle physics and the dark universe.



As usual at conferences, the poster session provided food for thought ...

The analysis of kaon production from deuterons indicates that the density of strange quarks – present in the quark–antiquark sea in protons and neutrons – varies differently with x than does that of the sea of lighter quarks. H1, meanwhile, has new measurements for charm and bottom quarks, which agree with QCD analyses.

The main aim of HERMES was to learn more about contributions to the nucleon's spin, the goal also of COMPASS at CERN (using muons), fixed-target experiments with electrons at Jefferson Lab and polarized proton–proton collisions at RHIC at Brookhaven. Results from these studies have fed the first global NLO QCD analyses of both polarized deep-inelastic lepton–nucleon and proton–proton scattering. The results reinforce the puzzling discovery that the quarks and antiquarks contribute only 25–35% of the nucleon's spin. They also indicate a large negative contribution from the strange quark at low x, with small contributions so far from the gluon, derived for the first time from the polarized proton–proton data, but subject to large uncertainties.

A fuller view

While parton distribution functions (PDFs) give a picture of the momentum fraction carried by the constituents in a nucleon, generalized PDFs (GPDFs) give a fuller view that includes information on longitudinal and transverse momentum, which should allow the contribution of orbital angular momentum to the nucleon's spin to be derived. GPDFs can be extracted from measurements of deeply virtual Compton scattering. The e1-dvcs experiment with the CLAS detector at Jefferson Lab has made an extensive set of high-quality measurements of the beam-spin asymmetry, which will constrain the GPDFs. Also at Jefferson Lab and elsewhere, experiments have studied transversity, which gives a measure of helicity-flip. Last summer the HERMES collaboration reported clear evidence for a non-zero "Sivers effect" in semi-inclusive deep-inelastic scattering from a transversely polarized target, which suggests a non-zero orbital angular momentum for the quarks in a nucleon. A recent fit to data from both HERMES and COMPASS to determine the Sivers function indicates that the orbital angular momentum is mainly from the valence quarks.

Fermilab's Tevatron continues its Run II, which began in 2001, with proton–antiproton collisions at a total energy of 1.96 TeV. Here the study of jets of particles reveals the hard scattering of the quarks. The DØ collaboration has now measured the angular distribution of pairs of jets (dijets) at 1.96 TeV collision energy, for dijet masses ranging from 0.25 TeV to more than 1.1 TeV – in effect, the first "Rutherford" experiment to go above 1 TeV, a century after Hans Geiger and Ernest Marsden published their results on alpha-particle scattering, which gave the first evidence for Rutherford scattering. This sets the most stringent limits to date on the scale for quark structure, $\Lambda > 2.9$ GeV, and also on the scale of extra dimensions.

The large amounts of data accumulated in Run II provide a major test-bed for QCD and an important hunting ground for new particles and new physics. By the time of the conference, the collider had delivered 7 fb^{-1} and the collaborations had analysed 2.7 fb^{-1}. The CDF and DØ experiments have high-precision results that agree well with NLO perturbative QCD for inclusive jets and dijets, setting limits on new particles with masses up to more than 1.2 TeV. By contrast, there are discrepancies that are still to be understood in the production of isolated photons.

While results such as these from HERA and the Tevatron continue to consolidate QCD, there has also been impressive theoretical progress in making more precise predictions, in particular in higher-order calculations in readiness for the LHC. Leading-order calculations are already automated and are beginning to include more final-state particles, as in $2 \rightarrow 6$ body. There are important breakthroughs at NLO, with the first calculation of a $2 \rightarrow 4$ body cross-section, $q\bar{q} \rightarrow t\bar{t}b\bar{b}$, in 2008 and developments in automation, for example in calculating W+3 jets, in 2009. These are important for estimating backgrounds to searches at the LHC. At next-to-NLO, there is progress in calculations on processes that will provide "standard candles" at the LHC.

At the same time, lattice QCD is moving from simulation to the calculation of real physical quantities, a quarter of a century after its invention. Improved algorithms with light quarks have led to new results on the hadron spectrum, with masses agreeing well with experiment. Contributions to flavour physics are also progressing with improved inputs for the Cabibbo–Kobayashi–Maskawa (CKM) matrix. A steady increase in computing power, to the petaflop scale, should lead to further improvements through simulations with smaller spacings (from 0.1 to 0.05 fm) on larger volumes (3–6 fm scale), which will be better suited for studies of QCD in hot, dense matter.

The ultimate test for QCD lies arguably in the hot and dense matter that forms in relativistic heavy-ion collisions and in determining

... while coffee breaks provided plenty of time for continued discussions.

Warm smiles at the registration desk were a feature of the conference.

its equation of state and bulk thermodynamic properties. Lattice QCD provides access to this extreme state through simulation, while RHIC at Brookhaven has been the main scene for such studies since 2000. The elliptical flow observed at RHIC is consistent with a phase transition – and this is what recent lattice QCD simulations also clearly indicate. It is also consistent with the formation of an almost perfect fluid, with a ratio of viscosity-to-entropy-density almost 10 times lower than in superfluid helium. Intriguing puzzles remain, however. The BRAHMS and PHOBOS experiments at RHIC shut down in 2006, but STAR and PHENIX are being upgraded. The LHC will also target hot QCD matter and perhaps observe the kinds of shockwave described in hydrodynamical calculations of a fluid-like medium.

Making inroads

In the electroweak sector, the Tevatron continues to make inroads into the areas that were out of reach to experiments at the Large Electron Positron (LEP) collider and SLAC Linear Collider, in particular measuring the W boson and top quark as never before. Nine years after the discovery of top, through $t\bar{t}$ pair-production, both CDF and DØ finally observed the electroweak production of single top quarks in 2009. The combined results presented at the conference yield $\sigma_t = 2.76 + 0.58 - 0.47$ pb; they also allow a measurement of the CKM matrix element, $|Vtb| = 0.91 \pm 0.08$. The experiments together now know the top quark mass to 0.7%, with a combined measurement of 173.1 ± 0.6 (stat.) ± 1.1 (syst.) GeV. Other results include a new world average for the mass of the W boson of 80399 ± 23 MeV, incorporating Tevatron data that gives an average of 80420 ± 31 MeV.

The Tevatron experiments also continue to chip away at channels that are difficult to pull out of the data, but which will be important in searches for the Higgs boson at the LHC. For example, both DØ and CDF have now observed the production and decay of a pair of Z bosons to four leptons – the smallest cross-section of diboson states in the Standard Model – at significances of 5.3σ and 5.7σ, respectively.

For real progress, the Standard Model is still screaming out for hard evidence for (or against) the Higgs boson. Direct searches at the Tevatron now exclude a Standard Model Higgs with a mass in the range 160–170 GeV (at 95% CL), while precision measurements, including the Tevatron's masses for the W boson and top quark, push the mass below 163 GeV. By 2011, or soon after, the Tevatron should provide sufficient luminosity to exclude the Standard Model Higgs directly – or provide evidence for it.

In addition to squeezing the Higgs, CDF and DØ continue to search for new phenomena, but so far without success. At the same time, a variety of experiments are putting pressure on the Standard Model, searching for cracks that might lead to new physics. The Standard Model, meanwhile, remains so impervious that effects not much bigger than 2σ seem hopeful: at HERA, combined data from H1 and ZEUS show a slight excess (2.6σ) at high-momentum-transfer events in e^+p interactions with multilepton final states.

Low-energy experiments also offer a route to new physics, for example, through measurements of finite electric dipole moments (EDMs) and rare muon decays. Here, the experiment at the University of Washington in Seattle delivered an important result in 2009, with a new limit on the EDM of ^{199}Hg of $<3.1 \times 10^{-29}$ e cm (at 95% CL) – a factor of seven reduction in the previous upper limit. The collaboration has further improvements in the pipeline, which should increase the experimental sensitivity by a factor of 3 to 5. In the search for rare muon decays, the MEG experiment at PSI found a preliminary result for the branching ration of $\mu^+ \rightarrow e^+\gamma$ of $<3.0 \times 10^{-11}$ from data collected in 2008.

Flavour physics offers a different line of attack, in particular through the CKM matrix, which links the different quark flavours. Testing the unitarity of the matrix ultimately tests the integrity of the Standard Model. New measurements on nuclear β-decays and from the KLOE, CLEO-c, Belle and BaBar experiments, as well as from CDF and DØ, continue to probe the matrix with increasing precision, with the result that the magnitudes of the matrix elements agree well with unitarity, although there are some small (up to 2σ) inconsistencies in results from different analyses. The global fit to the unitarity triangle is also good with the angles summing to (185 ± 13)°, although again there is some tension concerning $\sin 2\beta$ at the 2σ level. High luminosity at the B factories at KEK and SLAC are making possible an impressive series of measurements on rare B decays with potential to expose new physics. The decay $B \rightarrow \tau\upsilon$, for example, which puts constraints on a charged Higgs particle, disagrees with the CKM fit at the 2.4σ level.

Neutrinos have been the only particles that have so far provided a playground outside the Standard Model, with the discovery of neutrino oscillations – and hence neutrino mass – in atmospheric ▷

and solar neutrinos some 10 years ago. Since then various experiments have pinned down oscillation parameters to the level of a few per cent, with different types of experiment being suited to different parameters. For example, experiments with solar electron-neutrinos and reactor electron-antineutrinos give access to the mass m_{21} and mixing angle θ_{12}. The reactor experiment KamLAND finds $\Delta m_{21}{}^2 = 7.58 \times 10^{-5}\,eV^2$ (to a level of 2.7%) and $\tan^2\theta_{12} = 0.56$ (to~25%) compared with the global solar result from the solar neutrino experiments of $\Delta m_{21}{}^2 = 4.90 \times 10^{-5}\,eV^2$ (~34%) and $\tan^2\theta_{12} = 0.437$ (~10%). The Borexino experiment is now producing interesting results for solar neutrinos, over an energy range that includes electron-neutrinos from ^7Be and the carbon-nitrogen-oxygen cycle as well as from ^8B (*CERN Courier* June 2009 p13).

Using the muon-neutrino beams at the Neutrinos at the Main Injector facility at Fermilab, the MINOS experiment has measured the disappearance of muon-neutrinos, observing 848 events against an expectation of 1060 ± 60 for no oscillations and disfavouring other theoretical possibilities at a level of 6σ. MiniBooNE is, by contrast, investigating oscillations at lower energies with neutrinos from the Fermilab Booster neutrino beam. Set up to investigate the excess electron-antineutrino events seen in a muon–antineutrino beam by the LSND experiment at Los Alamos, MiniBooNE finds no significant excess across an energy range of 200–1250 GeV, but the results are as yet inconclusive regarding oscillations with Δm^2 at the 1 eV^2 scale suggested by the LSND result. Intriguingly, however, MiniBooNE does continue to observe an excess of electron-like events in the muon-neutrino beam, in the energy region between 200 and 475 GeV, as first reported in 2007.

Neutrinos from outer space have the potential to provide a new view of the cosmos, but their sources continue to elude discovery. There is more success with charged cosmic rays, where the Pierre Auger Observatory is making headway in the study of ultra-high-energy cosmic rays, with as many as 58 events above 55 EeV (55×10^{18} eV). The latest results confirm the extragalactic origin of these ultra-high-energy particles and their anisotropic distribution and underpin the collaboration's enthusiasm for an Auger North array in the Northern Hemisphere to complement the existing Auger South array in Argentina.

The greatest success in pinning down sources comes from the cosmic gamma-ray experiments, with the Cherenkov arrays such as HESS and MAGIC complemented by the new spacecraft Fermi and AGILE. At very high energies the number of identified sources has risen from 12 in 2003 to an impressive 96 in 2009, which includes new categories such as starburst galaxies (2) and Wolf-Rayert objects (3) as well as the more familiar active galactic nuclei (24) and pulsar wind nebulae (23). The FermiLAT collaboration has also significantly increased the number of identified sources of high-energy gamma rays, finding 205 with a significance level of more than 10σ.

Cosmic radiation is also offering a tantalizing window on dark matter to complement the direct laboratory-based searches for dark-matter particles. The direct searches have seen much progress in looking for the hypothesized axions and weakly interacting massive particles, but confirmed detection remains elusive. Similarly, cosmic rays provide conflicting and unconfirmed evidence. The FermiLAT collaboration and the PAMELA experiment find increases in electrons and positrons, respectively, which could indicate dark matter but are probably effects from nearby pulsars (*CERN Courier* April 2009 p7).

Outside the plenaries

Lepton Photon 2009 was organized jointly by DESY and the University of Hamburg and took place on 17–22 August in the Congress Center in the city centre. The gothic-style Hamburg City Hall provided the location for a reception for the conference and the conference dinner took place in the Schuppen 52, a historic warehouse in the middle of the Port of Hamburg.

To complement the plenary talks, a poster session gave students the opportunity to present their work, with prizes for the best posters in the three categories sponsored by the Association of the Friends and Sponsors of DESY. Sasa Prelovsek of the University of Ljubljana won the award for the best poster in theoretical physics, on the topic "Searching for Tetraquarks on the Lattice". The award for experimental results went to Chris Neu of the University of Virginia for his poster on "Probing the Physics of Ws and Bs from the Tevatron to the LHC". The winner in the third category, Experimental Methods and Projects, was Sebastian Aderhold of the University of Hamburg/DESY, whose poster was on "High-Gradient SRF Research at DESY".

From QCD to dark matter, Lepton Photon 2009 took a sweeping view across the whole range of particle physics today. While the Standard Model stands firm there remain many unanswered questions. In the closing talk, Guido Altarelli raised the spectre of the anthropic solution: perhaps we live in a universe that is very unlikely but that allows our existence, but he swiftly said he thought that this was not appropriate. In his view, supersymmetry remains the best solution to difficulties such as the hierarchy problem and, if this is the case, the LHC should find the light supersymmetric particles. The LHC is thus heavily charged with the expectations of the worldwide particle-physics community. If all goes well, results from the new collider should indeed dominate the next meeting in the Lepton Photon series, which is to be held in Mumbai in 2011.

Further reading

For all of the material presented, including the posters and videos of all talks, see the conference website at http://lp09.desy.de/.

Résumé

Lepton-photon : retour à Hambourg

La première édition du colloque international sur le thème des interactions leptons–photons à haute énergie avait eu lieu à Hambourg en 1965. Depuis lors, « lepton photon » s'est diversifié à l'ensemble de la physique des particules. La 24e édition, tenue à Hambourg en août 2009, n'a pas fait exception. Cette manifestation, organisée sous la forme de séances plénières uniquement, donne un aperçu concis et clair de la physique des particules aujourd'hui. Les attentes pour l'avenir étaient un thème récurrent, non seulement en raison du démarrage imminent du LHC, mais aussi eu égard aux améliorations, nouvelles expériences et installations visant à repousser les limites en matière d'énergie et de luminosité.

Christine Sutton, *CERN.*

Keith Tyson: the art of

Ariane Koek finds out about the inspiration behind some of the work by the British, T

Take an idea, and you open up the world. When the now world-famous British artist Keith Tyson was a lonely child, growing up in Cumbria in the North of England, he found his only salvation and companionship in the television programmes of the American popularizer of science, Carl Sagan. Television was what Keith calls "the transitional space", where he learnt about the world around him and which took him beyond his own confines and loneliness. It is where he found escape in Sagan's journey into the science of stars and the universe. From that moment on, Keith became a seeker of new ideas and new forms of knowledge. To this day, this search is what drives his art.

The studio wall drawing Supercollider (2001) is inspired by the goings on at CERN; mixed media on watercolour paper (388 × 481 cm). (Courtesy Haunch of Venison, copyright Keith Tyson 2009.)

The 5-m wi
knowledge
Venison, c

Observer and observed

It should come as no surprise then, that the work at the Large Hadron Collider at CERN has been the jumping-off point for some of Keith's most critically acclaimed work. His 2002 exhibition "Supercollider", shown at the South London Gallery in the UK, took its title from the goings on at CERN. The title piece of the exhibition (right) was a giant studio drawing with the subtitle "From the Action of Four Forces on 103 elements within four dimensions, we get…" and needs no explanation to any scientist. Random quotes drawn from everything from planetary charts to entries in anonymous diaries, combined with splashes of colour and pictures of a red-haired model wearing an itsy-bitsy, green bikini, are some of the myriad miscellaneous items that collide on this giant painting and which reflect the wonderful diversity of the world created "from the action of four forces…". Another mixed-media piece, *Bubble Chambers: 2 Discrete Molecules of Simultaneity*, bursts with random quotes with random dates from 1325 to 2002 dotted across a surface that is crammed with molecules represented as bubbles in reds, blacks, blues, pinks and whites.

Both of these pieces are like a mirror held up to the viewer. Look at them both and, inevitably, the temptation kicks in to start drawing conclusions or to make narratives out of the random juxtapositions: the mind's processes writ large. Like much of Keith's work, he is interested in the way that we make sense of the world: as the observer and the observed; the viewer and the artist; and the ways in which we use logic, counter-intuition and intuition to make these discoveries. In essence, we are all in this artistic experiment together, discovering who and what we are in the act of looking – the artist included.

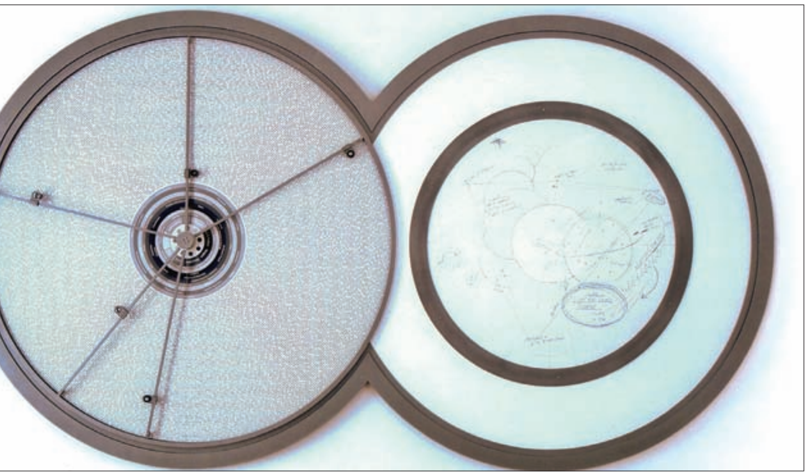
But if looking is important to Keith, it wasn't until 2009 that he finally came to take his own look at CERN. Talk to him about his visit and he says that what impressed him above everything was "not so much the LHC or the machines themselves, as the way in which the scientists at CERN meet ideas head on and change the way we think about ourselves".

Keith Tyson's recent visit to CERN was in many ways an inspirational homecoming.

He came as part of a private party of artists, including fellow British artist Cerith Wynn-Jones and the German experimentalist Ali Janka, who were shown round the CERN complex by the communication team in September 2009. In many ways, visting CERN was a

science and discovery

, Turner Prize winning artist Keith Tyson, whose art is driven by science and discovery.



m wide sculptural piece Teleological Accelerator *(2003) encompasses several edge systems; aluminium and steel, pencil on graph paper. (Courtesy Haunch of n, copyright Keith Tyson 2009.)*

Mathematical Nature Painting Nested *(2009) is a portrait of original transformations; mixed media on aluminium (149 × 149 cm). (Courtesy Haunch of Venison, copyright Keith Tyson 2009.)*

homecoming for Keith and one that he found profoundly moving. He encountered an international community dedicated to breaking the boundaries of knowledge and challenging the world of appearances – ideals that are so close to his heart and mind too.

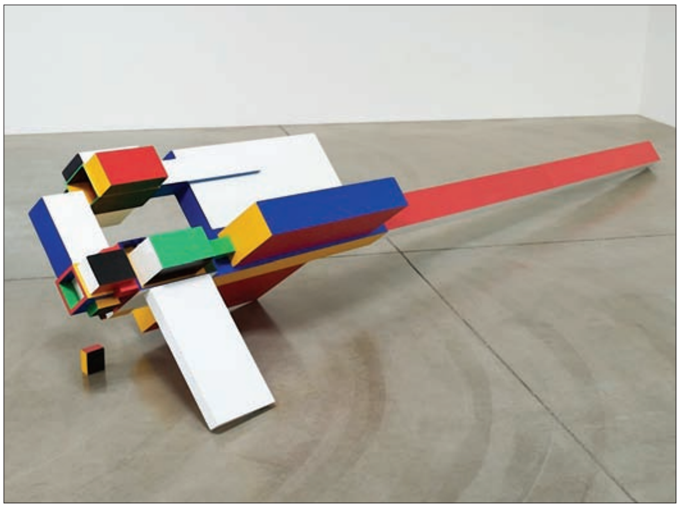
For someone who is so omnivorous in his wish to gain knowledge, physics isn't the only science that fascinates him. Chemistry and mathematics engage him too. Some of his most famous pieces include the fractal dice, part of the *Geno Pheno* series (2005), which explores the worlds of cause and effect and takes its title from genetics. The work explores the idea of what is a starting point – an artwork's DNA, so to speak; its physical manifestation or where it leads. The fractal dice pieces (p26) are three-dimensional aluminium and plastic sculptures, in vibrant primary colours – reds, blacks, greens and yellows. They are assembled in galleries around the world where they are shown according to a mathematical system, known as random iterative-functions systems, which is supplied to the curators by the artist. The form of each piece – sometimes as many as 14 are shown at any one time, sometimes fewer – is determined by the rolls of a dice and by the rules set out by the artist. For example, rule number one determines which colour a particular side of the sculpture should be. Complexity and unpredictability are both shown to be crucial components of the creative process, which involves both decisions and chance.

This love of engaging with different sciences and their processes shows how critical Keith is of being enslaved by any one knowledge system. His sculptural piece, *Teleological Accelerator* (2003), clearly shows this (top right). It is a massive wall installation measuring 5 m across, with two interlocking metal discs made of aluminium and steel that comprise a diagram of words and concepts written in pencil, ranging over all kinds of human achievements as well as an accumulation of scientific definitions. The flexible indicators can be twisted by the viewer so that the artist playfully conveys his idea that teleology is whatever you can make of it. Meaning is not a fixed point: it is always changing.

Pushing boundaries

If much of Keith's work shows a great indebtedness to science and a love of it as a knowledge system, and form of enquiry about the world, some of his latest work also shows an awe-inspiring sense of nature. After all, as Keith so eloquently says, "Science and art are the ways in which we describe the world. Nature *is* the world." The 2009 work *Mathematical Nature Painting Nested* (bottom right), currently being shown at the Royal Academy of Art, London, is a portrait of original transformations. Paints and chemicals have been poured onto a primed aluminium sheet and a painting takes shape thanks to the hydrophic reaction that forms the basis of the painting. This is the first phase. In the second phase, Keith determines the appearance of the painting, as far as he can, to make it resemble cells structures or geographical strata, according to the way that he dries the paint over the following month.

Like particle physics itself, Keith is pushing boundaries, working ▷



Geno Pheno *sculpture* "Fractal Dice No.1" *(2005) explores the worlds of cause and effects; aluminium and plastic (91.4 × 538.5 × 114.3 cm). (Courtesy Haunch of Venison, copyright Keith Tyson 2009.)*

within limits and constraints and outside them too: "I am not interested in the role of the artist as creator. Art is a vehicle of enquiry and the role of the artist is much more like that of Christopher Columbus – we are navigators and discoverers of what is already out there in the world but has yet to be discovered."

He could just as easily be talking about the role of the scientist, but he is clear about how different artists and scientists are, as well as the ways in which the arts and science could and should interact: "Artists, unlike scientists, are not attempting to model the world. They are trying to engage the viewer with the wonder of it. If you attempt to marry and equate art with science, then you fail. If you allow what is not similar about art and science, and their different methods and processes to co-exist and thrive, then a real art/science collaboration and aesthetic will emerge. But at the end of the day, both art and science are united by one logic and one impulse – both are attempts to understand what it is to be human and the world around us."

● For more information about Keith Tyson's latest creations, see his official website at www.keithtyson.com.

Résumé

Keith Tyson: l'art de la science et de la découverte

Encore enfant, Keith Tyson, artiste britannique lauréat du prix Turner, a été inspiré par les émissions de télévision produites par le savant américain Carl Sagan. Depuis lors, il a toujours été en quête d'idées nouvelles et de nouvelles formes de savoir. C'est cette quête qui l'inspire encore à l'âge adulte, par exemple, dans son exposition 2002 Supercollider*, dont le titre évoque les travaux menés au CERN. Comme la physique des particules, il repousse les limites, en sachant à la fois respecter des contraintes particulières et s'en affranchir. En 2009, il est venu visiter le CERN. Cet entretien mené par Ariane Koek est l'occasion de découvrir les thèmes qui ont inspiré son œuvre.*

Ariane Koek, *Clore Fellow seconded to CERN. See her blog at http://wwwbeautyquark-beautyquark.blogspot.com.*

Hadron-therapy training takes off with PARTNER

In its first year, a training network co-ordinated by CERN has pointed the way to how the exchange of knowledge between European institutes and disciplines can benefit young researchers in the emerging field of hadron therapy.

In June 2008 the European Commission awarded €5.6 million to the Particle Training Network for European Radiotherapy (PARTNER), with the objective of training young researchers in aspects of hadron therapy that involve particle physics and applications in medicine. Co-ordinated by CERN, the four-year project involves 10 institutes and research centres in Europe. It represents a unique multidisciplinary network in which 25 students, 4 of whom are based at CERN under the fellowship programme, receive training in fields that range from elementary particle physics through the design of gantries for hadron therapy to epidemiology. Such specially trained students are vital now that hadron therapy is becoming established as an important procedure for the treatment of cancer (*CERN Courier* December 2006 p24).

PARTNER's activities got underway in October 2008 with the network's initial meeting at CERN (*CERN Courier* December 2008 p6). Since then the network has designed a strategy for efficient project management and the timely distribution of the agreed deliverables, as well as having developed a training programme and recruited its key element – the researchers. The project is funded under the EC's Marie Curie Initial Training Network (MC-ITN) scheme, which seeks to improve the career prospects of young researchers. One of the first activities for PARTNER was thus an MC-ITN Administrators Course for Marie Curie Projects, which was organized at CERN in January 2009 together with external consultants to help all of the collaborating institutes to understand what is required in the management of such projects.

PARTNER's training programme got off to a good start with the course on Detectors and Accelerators Applied in Medicine, which was held at IFIC, Valencia, in June 2009. (Photos courtesy E Dimovasili/M Dosanjh.)

A successful collaboration

The student training programme started the following June with a course on Detectors and Accelerators Applied in Medicine, held at the Instituto de Física Corpuscular (IFIC) in Valencia. The workshop provided an overview of several topics involved in the biomedical applications of detectors and accelerators, from Monte Carlo simulation and Grid computing to image science. CERN's input into the PARTNER training programme is closely linked to its strengths not only in accelerator research but also in Grid technologies.

By adopting Grid technologies, the PARTNER project hopes to solve some of the multilayered problems of sharing data for referring patients, optimizing treatment planning and making use of the experience gained from managing databases. This involves the exchange of large diagnostic images, sharing cancer databases and merging referral systems across European borders. In this first course, the students were able to reinforce their knowledge as well as learn about new subjects. They also had the opportunity to meet each other for the first time and find out what others in the project are working on.

The second course was a workshop designed to familiarize young researchers with relevant aspects of leadership and team-building in the research environment. This took place in September at the University of Surrey and was led by David Faraday from Evolve Leadteam Ltd. The topics covered included communication, assertiveness, negotiation and time-management skills. Practical exercises and discussion groups complemented the theoretical presentations. Group activities included projects on technical problem solving, financial planning and analysis, risk assessment, product availability, implementation and construction. Those attending the workshop suggested that such a course would be valuable for all of the researchers in PARTNER, including those with more experi- ▷

A valuable PARTNER

Lara Barazzuol (Italian), Surrey Materials Institute, University of Surrey.

"The 'Radiobiology hands-on' training was an intensive and active time in which we all learnt a lot, actually practicing what was taught during the first session. Personally, I think it was very useful for my studies, being involved in radiobiological experiments. In particular, I have learnt new techniques that I am currently applying in my own research. Overall, I can say that the PARTNER project has immense potential to grow in the next two years, providing training that helps us to improve and develop our skills.

David Watts (British/Canadian), CERN and TERA.

"One very positive aspect of PARTNER is that the researchers, mostly young people like myself, are encouraged to network and share ideas and tackle problems together. We are given these opportunities during training sessions and courses, and during the leadership training we began to make bonds that should help us stay in contact during our careers in the field, thus keeping open the channels of communication between biologists, physicists, computer scientists and doctors. In short, we are kept very busy with our research, we are given all the opportunities to get training within and beyond our field, and I should not forget that though we have much to do, we are having fun doing it!"

Silvia Verdu Andres (Spanish), TERA Foundation (Therapy with Hadronic Radiations).

"PARTNER has succeeded in bringing together researchers from the different fields involved in hadron therapy and encouraging the exchange of knowledge between them. From a young researcher's point of view, training is one of the most important things. The training courses have been carefully selected to introduce us to the complex world of hadron therapy and to help us become future professionals in our field, giving special importance to the way that we communicate and work in groups. Last but not least, I like PARTNER because it is composed of very enthusiastic people from all over the world who love the work they are performing for society."

Faustin Roman (Romanian), CERN.

"I feel very privileged to be part of the PARTNER network because of the challenges of the project and the people involved. The programme is amazing: multidisciplinary courses, soft-skills training, practise and access to state-of-the-art technology. All of this is well organized, which says a lot about the quality of supervisors and the co-ordination of the project. Within the PARTNER project I have had the opportunity to build a software platform to share medical data. I know that by sharing medical information we can improve greatly the patient's treatments and quality of life."

ence, because they come from differing disciplines and tend to have different skill levels.

A hands-on radiobiology course came next, held on 25–27 November 2009 at GSI, Darmstadt. This offered an introduction to radiobiology and lectures on experiment results, including topics such as DNA experiments, chromosome analysis, cell survival curves, DNA damage repair and DNA fragmentation after irradiation. In the context of the specific training offered by PARTNER, researchers also participated in the Particle Therapy Co-Operative Group Congress held in Heidelberg on 28 September – 3 October 2009 and the ESTRO course on "Radiation Therapy with Protons and Ions" held at Pfäffikon on 10–14 May 2009.

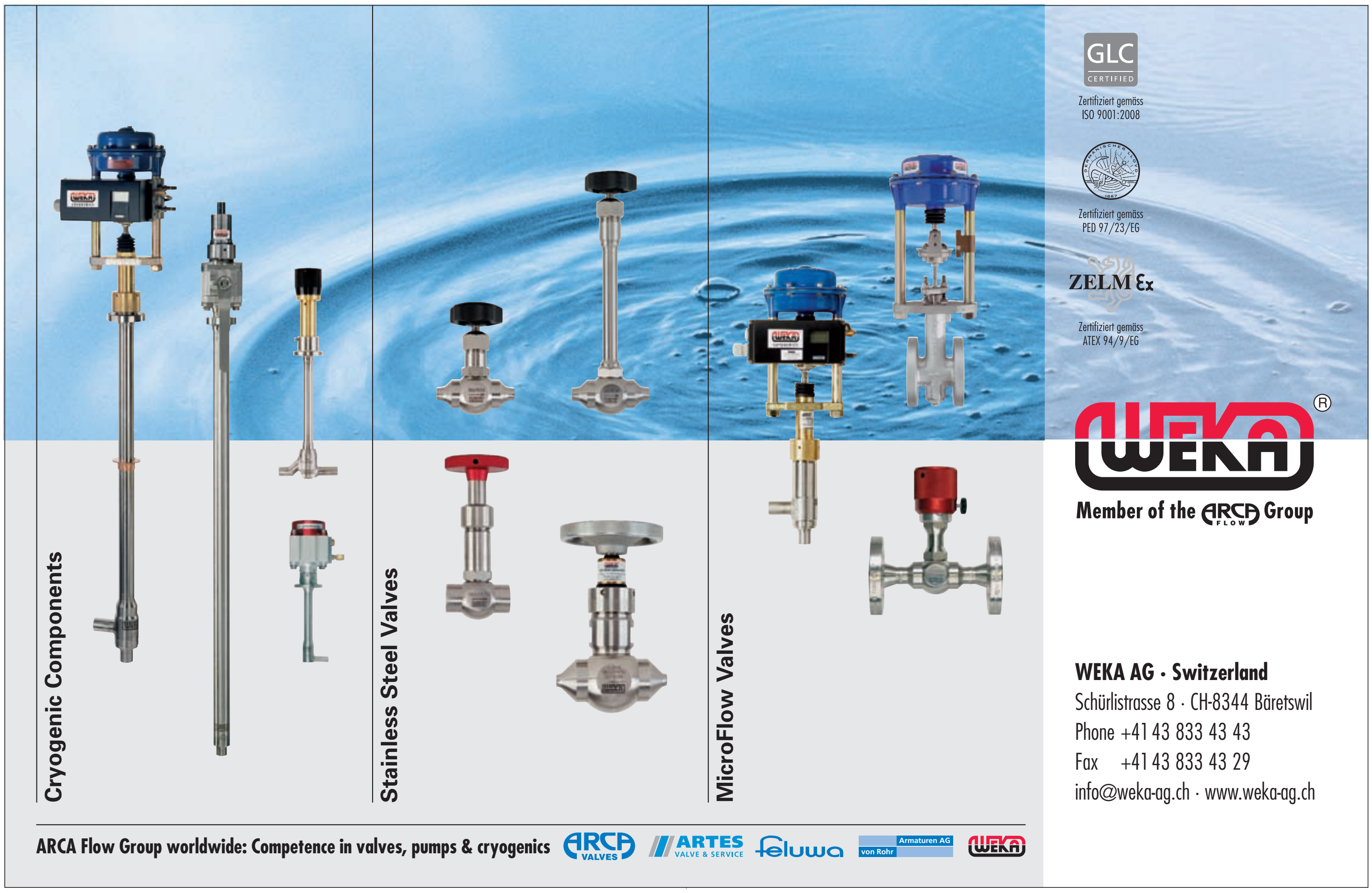
In all, PARTNER has had a successful first year. Students have given positive and constructive feedback on all of the activities and they particularly seemed to appreciate the possibility to network with students and experts in the field from all over Europe. The training programme continues in 2010, with the first course of the year, "Hadron therapy: past, present and future". Held at CERN on 21–26 February, the course was co-organized by two medical experts from the MedAustron project and from Oxford University. Their aim is to teach what has been learnt in the past, to define clearly the relevant disciplines from physics and technology and to examine the potentials for proton- and ion-beam therapy

Résumé

PARTNER : une formation pour l'hadronthérapie

En juin 2008, la Commission européenne a accordé 5,6 millions d'euros au projet PARTNER (Particle Training Network for European Radiotherapy), l'objectif étant de former de jeunes chercheurs sur certains aspects de l'hadronthérapie, touchant à la fois à la physique des particules et aux applications thérapeutiques. Coordonné par le CERN, ce projet, d'une durée de quatre ans, réunit 10 instituts et centres de recherche d'Europe. Il s'agit d'un réseau pluridisciplinaire exceptionnel dans lequel 25 étudiants reçoivent une formation sur des sujets allant de la physique des particules à l'épidémiologie. Au cours de la première année, le réseau a déjà organisé des formations sur les détecteurs et les accélérateurs, le travail en équipe et la radiobiologie pratique.

Evangelia Dimovasili, *technical co-ordinator,* **Manjit Dosanjh**, *project co-ordinator, and* **Marina Giampietro**, *CERN.*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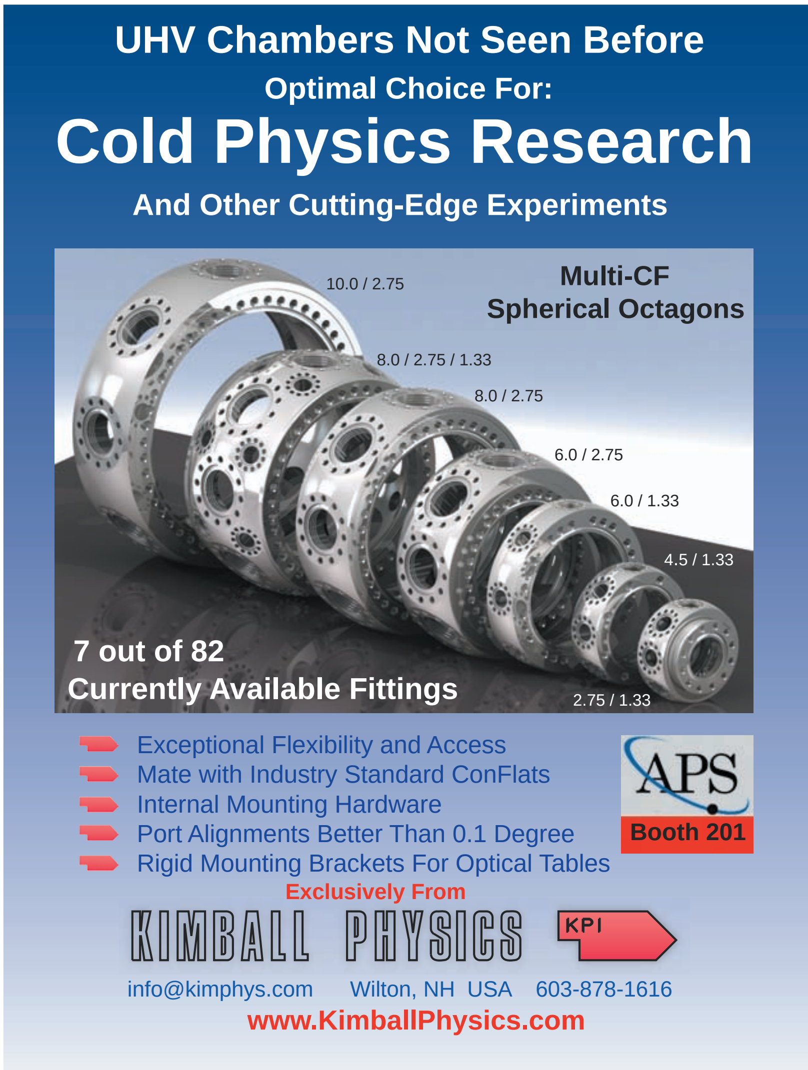
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AWARDS

ACFA and IPAC announce accelerator prizes

The Asian Committee for Future Accelerators (ACFA) has joined forces with the first International Particle Accelerator Conference, IPAC '10, to award prizes for outstanding work in the field of accelerators. This follows the introduction of a three-year cycle among the former Asian, European and North American particle-accelerator conferences (*CERN Courier* November 2009 p42). The ACFA/IPAC '10 Prizes Selection Committee, chaired by Won Namkung of Pohang Accelerator Laboratory, decided on the prizes and the names of the winners in a meeting on 20 January. The awards will be awarded during IPAC '10, which is being held in Kyoto on 23–28 May.

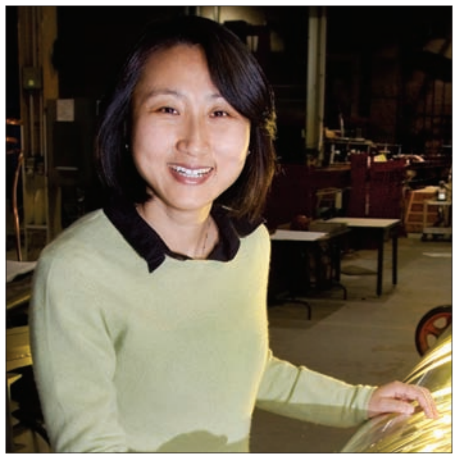
Steve Myers, the director for accelerators and technology at CERN, receives the Achievement Prize for outstanding work in the accelerator field, with no age limit. He is rewarded "for his numerous, outstanding contributions to the design, construction, commissioning, performance optimization and upgrade of energy-frontier colliders – in particular the ISR, LEP and the LHC – and to the wider development of accelerator science".

Efforts on the LHC are also recognized in the award of a prize for an individual, having made significant, original contributions to the accelerator field, with no age limit. This goes to Jie Wei of Tsinghua University in Beijing "for his exceptionally creative contributions to the design, construction and commissioning of circular accelerators, in particular RHIC, SNS, LHC, as well as the design of CSNS and for numerous significant developments in the field of beam dynamics".

The Achievement Prize goes to Steve Myers.

Jie Wei. (Courtesy Tsinghua University.)

A third prize, for an individual, in the early part of his or her career, having made a recent and significant, original contribution to the accelerator field, goes to Mei Bai of Brookhaven National Laboratory. She receives the reward "for her significant contributions to spin dynamics and polarized-proton acceleration in circular accelerators – in particular the AGS and RHIC, and to successful polarized proton beam collisions at 500 GeV centre-of-mass".



Mei Bai of BNL. (Courtesy BNL.)

Victor Hess prize awarded for work on CMS experiment

The Committee for Nuclear and Particle Physics of the Austrian Physical Society has awarded the 2009 Victor Hess prize to Edmund Widl for research on the CMS experiment at CERN. He receives the prize for his doctoral thesis, *Global Alignment of the CMS Tracker*. The Victor Hess prize is awarded annually by the "Nuclear and Particle Physics" section of the Austrian Physics Society, for the best thesis in the field of nuclear and particle physics.

Widl did the research for his thesis at the Institute of High Energy Physics (HEPHY) of the Austrian Academy of Sciences. The CMS Inner Tracker is the largest silicon tracking detector ever been built and consists of more than 13 000 silicon modules. The large number of modules and the complicated geometry of the detector make the task of alignment anything but trivial. In his thesis work, Widl developed a novel algorithm to estimate the nearly 100 000 positions and angles that comprise the alignment information.

Edmund Widl receives the Viktor Hess prize. (Courtesy Maximillian Atems, FAKT der ÖPG.)

WORKSHOP

Vertex 2009 looks to the LHC and beyond

The 18th Vertex Workshop, Vertex 2009, took place on 13–18 September in the Veluwe, a scenic rural area of the Netherlands. The aim of this annual workshop is to foster the open exchange of ideas and expertise in state-of-the-art vertex-detector technology.

The 2009 meeting, with 50 invited participants, began with a broad overview of the excellent state of the silicon detectors at the LHC prior to the restart in November. Cosmic-ray data have shown that the sensors work with high efficiency and low noise, and that there is already a deep understanding of calibration and alignment issues.

Even though the LHC is just getting going with collision data, a significant number of silicon-detector experts are already moving towards the development of the next generation of LHC detectors. The expected high particle fluence at the Super LHC – the luminosity upgrade – requires new developments in both sensors and front-end electronics (*CERN Courier* July/August 2008 p17). Materials budgets are also crucial in this respect, so the workshop included presentations on powering and cooling technologies.

New sensor and processing technologies from high-energy physics continue to strengthen their link with applications in space and medical imaging. Integration of functionality and the assembly of large systems with high granularity are common aims for these applications, as well as for use in a future linear collider.

Extended lunch breaks allowed for lively discussions around the centrally located espresso bar and fireplace. Participants were invited for a very "Dutch'" excursion on the Wednesday: a regatta of four groups sailing in 100-year-old wooden fishing vessels. The rain stopped for the day and most participants enjoyed the fried fish and tried the raw (not red!) herring.

The next Vertex Workshop will continue the tradition of waterfront venues. It will be held at Loch Lomond in Scotland on 6–11 June.

● Presentations from Vertex 2009 are available online at www.nikhef.nl/pub/conferences/Vertex2009/index_talks.html. The workshop proceedings will be published in the open-access journal *Proceedings of Science* in April.

CELEBRATION

Victor Yarba celebrates his 75th birthday

Victor Yarba, an internationally renowned leader of frontier accelerator projects in Russia and the US, as well as a fosterer of international collaborations and education programmes, celebrated his 75th birthday on 1 February.

Yarba began his scientific career in 1958 at JINR in Dubna as a researcher in particle physics. In 1969 he moved to the Institute for High Energy Physics (IHEP), Protvino, where he remained until 1992. His international reputation developed mainly during this period with research that included the discoveries of $_2He^8$ and double charge-exchange of pions on nuclei; kaon and neutrino interaction measurements with the Big European Bubble Chamber at CERN, the MIRABEL bubble chamber at IHEP and the 15-ft bubble chamber at Fermilab, as well as accelerator technology. In 1974 he became the first-deputy director for research at IHEP, a position he held for 18 years.

In the years 1983–1992 Yarba was project manager of UNK, the 3 TeV accelerating and storage complex at IHEP. There he built a strong team of physicists, engineers, designers and technicians to develop the project, from a conceptual stage through essential R&D to the final engineering design. He had a particular interest in superconducting-magnet technologies and his team developed and started fabrication and testing of superconducting magnets for UNK, in particular 6-m long 5.5 T NbTi dipoles. Although most of the high-quality equipment for the injection chain was built, as well as 18 km out of the total 21 km of the UNK tunnel, the project was unfortunately terminated gradually as a result of economic problems in Russia.

Victor Yarba is 75. (Courtesy Tom Nicol.)

During his IHEP years, Yarba was head of the high-energy physics department of Moscow Institute of Physics and Technology. He was also involved with many national and international committees, being for example co-chair of the CERN–Minatom Joint Scientific Committee (1974–1980).

In 1992 he moved to the Superconducting Super Collider laboratory in Texas. After the collapse of the project, he joined Fermilab in 1994 and is currently an associate head of its Technical Division. He has had key roles in the magnet programmes of many projects at Fermilab including the Main Injector and the Recycler, as well as design and fabrication of muon chambers for the CMS experiment at CERN and RF R&D for linear colliders.

Yarba has initiated several key educational activities, such as the PhD programme at Fermilab, involving a consortium of eight US universities and Fermilab to attract and support the best PhD accelerator students, and an educational unit at Fermilab for Accelerator Physics and Technology.

COLLABORATION

Italy and JINR sign memorandum

An Italy–JINR round-table discussion has led to a memorandum that aims to boost scientific and technical collaboration between Italy and Russia. Held at JINR in Dubna on 18–19 December 2009, the meeting brought together about 50 participants including Italian and Russian scientists, as well as scientists from JINR and official representatives from other institutions. The event, "Efforts in fundamental research and perspectives for applied science and technology and business development", was co-organized by the Italian embassy in the Russian Federation and JINR. It was co-chaired by Pietro Frè, the scientific counsellor at the Italian Embassy in Moscow, and Alexei Sissakian, the director of JINR and member of the Presidium of the Russian Academy of Sciences.

Left to right: Guido Martinelli, president of the IV Commission (Theoretical) of INFN; Richard Burger, science counsellor of the delegation of the European Union to Russia; Giovanni Iannuzzi, counsellor in the Italian Ministry of Foreign Affairs; Pietro Frè, scientific counsellor of the Italian Embassy in Moscow; Alexei Sissakian, director of JINR; and Victor Matveev, director of the Institute of Nuclear Research of the Russian Academy of Sciences. (Courtesy JINR.)

The aim of the round-table discussion was to obtain a multifaceted review of the historical development of Italian–Russian and Italian–JINR collaborations, as well as perspectives for future developments and, last but not least, news from ongoing research projects. A distinctive feature of the event was the presence of researchers from more abstract areas of contemporary science, notably string theory, gravity and pure mathematics, together with others from the fields of experimental physics, biophysics, applied science and technology. This was done to strengthen the bridge that should connect these two areas, so as to promote the fast propagation of ideas that could be helpful for innovation – from academic institutions to technological laboratories.

The main result of the discussion was a memorandum approved by all the participants. This document, which was officially translated from English into Italian and Russian at the Italian Embassy, comprises a list of 16 recommendations to Russian and Italian authorities responsible for the organization and financing of science, concerning what the round-table discussion regarded as the best practices for maintaining and boosting scientific–technical co-operation between the two countries. Highlights from the memorandum concern, in particular, the official restoration of Italy as an associate member state of JINR and the support from the participants for the development of the NICA/MPD collider project at JINR (*CERN Courier* January/February 2010 p13). Italian participation was considered to be very important in this venture and mutually beneficial for the scientific communities of both countries. Other key topics mentioned in the memorandum relate to the opening of Italian–Russian–JINR collaborations in the fields of radiation and RNA-biology, nanotechnologies and Grid-technology developments. In addition it enumerated various on-going and newly planned educational and scientific programmes, to be jointly run by Italian–Russian–JINR institutions.

The trilingual version of the memorandum has been sent by the Italian Embassy to the Ministry of Foreign Affairs of the Russian Federation for distribution among top governmental agencies and scientific institutions, in particular, the Ministry of Education and Science, the Federal Agency of Science and Innovation, the committees on Science, Technology and Education of both branches of the Russian Federation parliament, the Russian Academy of Sciences, Rosatom, Moscow State University and the Kurchatov Institute. It has also been sent to the Italian Ministry of Foreign Affairs for distribution among the main Italian scientific agencies, including the Italian National Institute of Nuclear Physics, the National Research Council and the Italian Space Agency

● For more about the meeting, and for the full text of the memorandum, see http://theor.jinr.ru/meetings/2009/rt/.

CORRECTION

The article "US-industry-built ILC cavity reaches 41 MV/m" in the November 2009 issue contained an unfortunate error. It should have begun: "For the first time, a US-industry-made superconducting radiofrequency (SRF) cavity has reached and exceeded the accelerating gradient required for the envisioned International Linear Collider (ILC)." In the editing process the words "US-industry-made" were moved, making the sentence factually wrong. Many apologies to all concerned.

LETTERS

Acronym oddities

When editing *LEPnews* in the 1980s, chronicling the construction of the Large Electron Positron collider (LEP), I found that this acronym could also mean Laboratorio Emilio Picasso, named after the project leader. As for the Large Hadron Collider (LHC), these letters are also the first-name initials of Lyndon Evans, Herwig Schopper and Carlo Rubbia – three who envisaged, inspired and realized this giant undertaking.

Simon Newman, Slough, UK.

MUSICAL INTERLUDES

The cosmos is gratefully dead

Mickey Hart, of the Grateful Dead, at the drums. (Courtesy John Werner.)

The universe may be 14 billion years old, but it has still got rhythm. Mickey Hart, percussionist for the band Grateful Dead and a Grammy Award winner, is capturing the beat in *Rhythms of the universe*, a composition based on a variety of astrophysical data. The composition represents a collaboration between scientist and artist, using their own sophisticated tools. Nobel laureate George Smoot, from the University of California, Berkeley, and Lawrence Berkeley National Laboratory (LBNL), and Keith Jackson, a computer scientist and musician also from LBNL, are providing some of the data for the project. The final result will be a musical "history of the universe", from the Big Bang onwards through galaxy and star formation, up until modern times.

The data come from diverse astrophysical sources and detectors, from supernova to cosmic microwaves to the Crab Nebula. Optical spectra of two well studied supernovae, SN2005gj and SN2006d, came from the Nearby Supernova Factory, while the Wilkinson Microwave Anisotropy Probe (WMAP) provided cosmic-microwave background data. Jackson used the MATLAB computing language to convert the supernova optical spectra into sound snippets 3 s long, with the frequency mapped into time. The chosen supernovae had interesting spectra with a number of spectral lines. These produced a deep background rumble punctuated by louder sounds from the lines. For example, the carbon excitation line at 630 Å produces a louder section about 1.5 s into the clip. For the WMAP data, the temperature–temperature autocorrelation data at different multipole moments played the role of time, while for the pulsars, Jackson stretched the data to form a snippet about 1 s long, and stacked five of these snippets in a row.

From there, Hart took over and used a MIDI interface to alter the sounds in a variety of ways – adjusting their pitch, adding reverb and/or echo, and adjusting their envelope. The sounds were divided into short segments and also mapped to a synthesizer, with the keyboard controlling the pitch. Sometimes, the sounds were layered on top of acoustic instruments, again merging science and art. The end result will be recorded in 5.1 surround sound using equipment from Meyer Sound.

This is a work in progress: Hart and Jackson are looking for new types of data to sample, and Jackson is considering alternative approaches to sonification. Although the project is yet to be completed, Hart presented a preview, accompanied by images from NASA, at the Cosmology on the Beach winter school, sponsored by the Berkeley Center for Cosmological Physics, which was held in Playa del Carmen in Mexico on 11–15 January.

● Anyone with data to suggest for the project can contact Jackson at KRJackson@lbl.gov. For more cosmic music, go to www.dead.net/universe-of-sound.

The Particle Physicists' Song

The following song was submitted to *CERN Courier* by Danuta Orlowska, a clinical psychologist with Guy's and St Thomas' NHS Foundation Trust in London. It is written to be sung to the tune of *The Hippopotamus Song*, by Michael Flanders and Donald Swann, which will be well known to many British readers. On 3 February, members of the CERN choir gathered to give a rendition in the CERN Control Centre – the nerve centre of the LHC, which lies at the heart of the lyrics. As inspiration, Danuta cites the songs of Flanders and Swann (www.nyanko.pwp.blueyonder.co.uk/fas/) as well as the *Particle Physics UK* website (www.particlephysics.ac.uk).

The Particle Physicists' Song

Some particle physicists were standing one day
At the Hadron Collider in CERN
They gazed at the buttons and the output display
Thought of projects they'd had to adjourn...
They dreamt of new papers, new grants and new chairs
A thirteenth dimension and more –
Those physics professors were no idle guessers
And answers there'd be they were sure...

Higgs, Higgs, glorious Higgs
The theory told them these thingumajigs
Were so fundamental
And not accidental
They got sentimental
When thinking of Higgs.

The key to the origin of mass they supposed
Was the boson they hoped would be found
By hard-working scientists who rarely reposed
And constantly rushed round and round...
Inventing, designing experiments new

To answer deep questions that seek
Where most anti-matter'd gone off to and
scattered
And why gravity is so weak.

Higgs, Higgs, glorious Higgs
The theory told them these thingumajigs
Were so fundamental
And not accidental
They got sentimental
When thinking of Higgs.

They all thought of SUSY with love in their eyes
And hoped things would work out this time
Exploring the Big Bang – the ultimate prize
And a mountain of knowledge to climb.
They switched on the LHC, hoped it would start
And the data would help them decide
What actually goes on when hunting a boson
And protons with protons collide.

Higgs, Higgs, glorious Higgs
The theory told them these thingumajigs
Were so fundamental
And not accidental
They got sentimental
When thinking of Higgs.

The CERN Choir in full voice in the CERN Control Centre, with writer Danuta Orlowska at the right.

● With thanks to Philip Harris of the University of Sussex for his enthusiastic response to the song and for his fine-tuning suggestions; also thanks to Martin Gatehouse and Mary Stuttford of the CERN Choir for their hospitalty.

OBITUARIES

Jacques Prentki 1920–2009

The theoretician Jacques Prentki, a major figure of CERN, passed away on 29 November 2009 in his 90th year.

Jacques Prentki arrived at CERN in 1955 and remained until the end, continuing to visit the laboratory three times a week after his retirement. He had a very eventful life, with many tragic episodes that he overcame.

Born in Lyon of a Polish mother, Jacques did not often see his father, who was working in the Congo. When his father died in 1939, his mother, who had no resources, decided to return to Poland. As a result, Jacques was in Warsaw when the Germans occupied the city. Risking his life, he followed the courses at the clandestine university. Once, he was picked up in the street in a round-up by the German police who wanted to "test" a new camp. On the way to the camp, on a curve where the train slowed down, he jumped out, saving his life.

After the war, Jacques took up physics in Lublin and then in Warsaw. In 1947 he moved to Paris where he entered the Centre National de la Recherche Scientifique, first working at the Institut Henri Poincaré and later at Ecole Polytechnique. It was there that he made friends for life, such as Philippe Meyer, Pierrette Benoist, Claude and Nadine Marty, Anatole Abragam, Jean Yoccoz, and Bernard D'Espagnat. All attended the Séminaire Proca, one of the rare places where modern physics was studied at the time. It was during this period that Jacques returned to Poland to visit his mother and was arrested as a spy from the West. A famous biologist, who had been his protector during the war, succeeded in convincing the police to send him back to Paris. It is there that he met his wife Marysia and together they had two sons, Marc and Pierre – who, unfortunately, is no longer with us.

Jacques Prentki, second from left, with left to right, Steve Adler, Dmitrij Volkov and Henri Ruegg.

In 1955, a year after the foundation of CERN, Jacques moved to Geneva and became the second member of the theory division, the first being D'Espagnat. Jacques acted as a link between successive division leaders, Bruno Ferretti, Markus Fierz and Léon Van Hove, before himself becoming a revered division leader during two periods, from 1967 to 1970 and from 1975 to 1982. He became a French citizen but kept his attachment to Poland as well as to France, where he was born. In parallel to his functions at CERN, he was professor at Collège de France from 1964 to 1983, where he gave a series of lectures beautifully calligraphed by Louis Jauneau.

Jacques made very important contributions, first in the field of nucleon and meson interactions and nuclear physics, then in the search for symmetries in elementary particles and in weak interactions. At CERN, D'Espagnat was his main collaborator in the beginning, but he also had other very illustrious collaborators, including Abdus Salam and Martinus Veltman. Jacques also had strong contacts with experimentalists, some of them being close friends, such as Charles Peyrou, Georges Charpak and Pierre Lehmann. At the time of CERN's major discovery of neutral currents, Paul Musset visited him almost every day, seeking advice.

Jacques had a very critical mind and often debated with friends such as Wladimir Glaser for the fun of it, even changing sides once he thought he had won an argument. This probably saved his life when, on a train in Poland, someone asked him: "Don't you think that the communist regime is disgusting?" He replied: "No! Not at all!". Of course the person was a provocateur. Many theoreticians appreciated this critical sense and, before publishing their work, submitted it to Jacques. In this way they saved themselves the trouble of publishing a wrong or dubious result.

Jacques was a person with an immense interest in everything cultural: artistic, literary, historical, musical and, naturally, scientific. He was also a man with an extremely warm personality, welcoming and helpful with everyone, irrespective of their social level; he was also very modest. At CERN and elsewhere in the world, including in particular France and Poland, we will all deeply miss Jacques.

His friends at CERN

Juan Antonio Rubio 1944–2010

Juan Antonio Rubio, director-general of CIEMAT (the Spanish research centre for energy, the environment and technology) passed away on 17 January. He vigorously dedicated his professional life to the development of basic research and technology, but experimental high-energy physics was his original and permanent passion – and CIEMAT and CERN were two of his three homes.

Born and raised in Madrid, Juan Antonio studied physics at the university there from the age of 16. In 1968 he was lucky to be selected as a CERN fellow – just in time, because Spain would quit CERN in 1969. From 1968 to 1971 he worked on bubble-chamber experiments with Lucien Montanet, the French "grandfather" of Spanish high-energy-physics. Back in Spain at CIEMAT, then called "la Junta", and armed only with his fresh PhD, Juan Antonio and his few colleagues had to face years of "lean cows", with no institutional support and with international connections only on the personal level.

Not easily discouraged, Juan Antonio, with his irresistible enthusiasm, attracted many young and brilliant physicists to the then seemingly desperate endeavour of high-energy physics in Spain. Even more difficult, he secured sufficient support to maintain a small team that initially continued their bubble-chamber work and eventually joined and contributed significantly to the European Hybrid Spectrometer and, with the inestimable collaboration of Sam Ting, to the MARK-J experiment at DESY and L3 at LEP. In 1986 Juan Antonio negotiated with Carlo Rubbia for the participation of CIEMAT in the UA1 experiment. The period of Juan Antonio's leadership in particle physics at CIEMAT continued until 1987; it will never be forgotten by those who collaborated with him at the time.

It is jokingly but correctly said that, just to avoid Juan Antonio's unbearable insistence, the Spanish authorities would grant him anything they could. In this way, a Mobilizing High-Energy Physics Plan was born – a pioneering concept in which a new system for Spanish R&D was developed. Simultaneously, he spearheaded an effort so bold that many people would have given up on it: the re-entry of Spain as a CERN member state in 1983. One of us, amazed to this day, witnessed how Juan Antonio finally extorted the entrance fee from a minister, in the form of a substantial cheque to be brought to CERN by hand! The entire high-energy physics community could never sufficiently thank him for all that was made possible by that cheque – and subsequent ones.

In 1987, after a few years as scientific director of CIEMAT, Juan Antonio returned to CERN, where he served as CERN's group leader for L3, as scientific adviser to the director-general (1990–2000), and leader of the Education and Technology Transfer division (2001–2004). During the last years of this period he devoted more time to education, communication, outreach and technology transfer, as by-products of the fundamental research in high-energy physics. He also tirelessly fostered relations between Europe and Latin America, energetically supporting collaboration projects such as the network, HELEN. He was an acknowledged leader in creating high quality high-energy physics schools in Latin America. In addition he embarked on other extremely challenging endeavours. One of them – a tau/charm factory in Spain – never saw the light of day; another was the validation of Carlo Rubbia's project of an Energy Amplifier.

Juan Antonio Rubio at CERN in 1999.

In 2004, Juan Antonio was appointed director-general of CIEMAT, stirring up the place with his characteristic impetus. He promoted successful collaborations with several Spanish regional governments and wide-scattered institutes on all known promising alternative-energy resources, as well as specific projects in accelerator science and in the medical applications of high-energy physics technologies. He also supported CIEMAT's by-now traditional activities in fusion research, high-energy physics and its sister disciplines, including the LHC experiments CMS and ALICE, and the cosmic-ray satellite AMS. How he could do all this not only simultaneously, but so intensively remains a mystery even to those who know that he was, seven days a week, the first to reach his work place and the very last to leave.

It has to be admitted that, like every great achiever, Juan Antonio left behind a trail of small-minded detractors. However he had many more admirers and there are many who thankfully admit that they owe to him a good fraction of their professional careers. He also has many close and sincere friends.

During the last six months of his life Juan Antonio had to fight an invincible adversary. He battled against his illness with his customary and unbelievable determination. He never exteriorized fear, to the point that those who would visit him to offer comfort would come out comforted. As he himself would put it: "La medida de la grandeza de un hombre no la da la abundancia de sus recursos, sino lo extenso de sus sueños" (the measure of a man's greatness is not the wealth of his resources, but the breadth of his dreams).

His friends and colleagues.

Thomas Binoth 1965–2010

On 3 January, Thomas Binoth, a theoretical physicist at the University of Edinburgh, died in an avalanche while skiing in the Diemtigtal, south of Bern.

Thomas was born on 16 August 1965 and grew up in Maulburg, Germany. He entered the University of Freiburg in 1987 to study physics, writing a diploma thesis in 1993 on supersymmetric extensions of the Standard Model. He proceeded to a PhD under the supervision of Jochum van der Bij, also at Freiburg, on the subject of non-perturbative effects in the Higgs sector of the Standard Model and beyond. Thomas then went on to a series of postdoctoral appointments at LAPTH Annecy, the University of Edinburgh and the University of Würzburg. His work during this time had evolved into the development of advanced techniques for next-to-leading order (NLO) calculations in the Standard Model and the application of them to LHC processes. He was appointed to a lectureship at the University of Edinburgh in 2005 and promoted to a readership in 2009.

With his collaborator and partner Gudrun Heinrich, Thomas developed a new systematic algorithm called "sector decomposition" to isolate divergences in Feynman-diagram calculations. This method has had a high impact in the particle-theory community and is now used by various groups in the context of next-to-NLO predictions for the LHC. He was the author of various computer codes for the production of gauge-boson pairs (a key background for the discovery of a light Higgs boson) and had been leading the international GOLEM project, which aims to provide NLO predictions for a wide variety of LHC processes involving as many as six external particles.

Thomas was exceptional in his warm-hearted approach towards his physics colleagues. He was always interested in the physics as well as the person, never in self-promotion. He was extremely good fun and stimulating to be around, both for physics discussions and late-evening beer sessions. He will be greatly missed at upcoming LHC workshops and conferences.

He was also a dedicated and enthusiastic teacher, who saw it as his mission to enthuse and motivate physics students in the same way in which he had been encouraged as a student. His courses in mathematical physics were presented logically and consistently, exposing the beauty and simplicity of the mathematical structure in the physical laws of nature. They were highly appreciated.

Thomas in the Ecrins National Park in the French Alps. (Courtesy Gudrun Heinrich.)

When not engaged in physics, Thomas loved to go to the mountains – climbing in summer and skiing in winter. His enthusiasm and respect for nature in all of its splendour and grandeur was immense.

He leaves behind his partner and collaborator, Gudrun Heinrich, a legacy of physics results and data analysis tools that may yet play a key part in discoveries at the LHC, and many friends and collaborators worldwide who are honoured to have known and worked with him.

Richard Ball, Edinburgh, Herbi Dreiner, Bonn, and Michael Krämer, Aachen.

MEETINGS

The **17th IEEE NPSS Real Time Conference RT-2010** will be held at the Congress Centre of the Instituto Superior Técnico, Lisbon, on 24–28 May. As before, this will be a multidisciplinary conference devoted to the latest developments in real-time techniques in the fields of plasma and nuclear fusion, particle physics, nuclear physics and astrophysics, space science, accelerators, medical physics and radiation instrumentation. The conference will only feature plenary sessions, with mini-orals arranged for posters. The aim is to provide a stimulating environment and ample opportunity for discussions and fruitful exchanges, particularly for young scientists and engineers. For more details, see http://rt2010.ipfn.ist.utl.pt.

Physics in Collision 2010 will take place at Karlsruhe Institute of Technology, Karlsruhe, on 1–4 September. At the meeting, invited speakers will review and update key topics in elementary particle physics with the aim of encouraging informal discussions about new experimental results and their implications. Topics will cover a range of subjects from experimental and theoretical collider physics to astroparticle physics, in particular: electroweak phenomena, QCD, neutrino physics, heavy flavour physics, Higgs physics and beyond the Standard Model. The poster session is open to contributions from all participants and short talks in plenary session will be allocated to selected posters. For more details, see www.pic2010.kit.edu.

NEW PRODUCTS

Cynerg3 Components Ltd has introduced a new series of high-voltage reed relays, available through AMS Technologies. The series 2 sub-miniature reed relays are suitable for high-voltage isolation in RF applications in the 1–30 MHz range. They use rhodium contacts in a vacuum and offer an isolation voltage of 1.5 kV across contacts, with a contact resistance of 200 mΩ and a lifetime of 10^9 dry switching cycles. For more details, tel +49 89 89 5770; or e-mail salesinfo@ams.de.

Goodfellow, through the **Technical Glass Company**, now have available SHAPAL-M soft (aluminium nitride), which is a high-purity, high-strength machinable ceramic with thermal conductivity five times higher than alumina. It has a range of applications including heat sinks and electronically insulating components. Unlike ordinary ceramics it can be machined into complex shapes with high precision and is available as machinable rods and plates in a range of sizes. For more details, e-mail info@goodfellow.com; or see www.goodfellow.com.

Kurt J Lesker are offering a new rugged MEMS Pirani gauge to measure vacuum down to 1 × 10–4 torr. The gauge uses advanced MEMS technology and lock-in AC signal processing in its integrated electronics. It allows for digital field calibration and mounting in any orientation and has an optional rear sensor. For more details, contact tel +1 412 387 9200; e-mail sales@lesker.com; or see www.lesker.com.

ZTEC Instruments has released a major update to its 8, 12, 13 and 14-bit Experimental Physics and Industrial Control System (EPICS) digital oscilloscopes and digitizers, with improved implementation of the embedded input/output controller of its EPICS instruments. The oscilloscopes are available in four series, with different maximum real-time sampling rates and ADC resolution, including the ZT4610 series with 4 GS/s maximum sampling rate and 8-bit ADC resolution. For more details, see www.ztecinstruments.com.

RECRUITMENT

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- Commitment to active engagement with experimental groups

Applications should include CV, research statement and a list of publications.

For further information please contact Dr. Georg Weiglein, +49 40 8998-2523, georg.weiglein@desy.de.

Salary and benefits are commensurate with those of public service organizations in Germany. DESY operates flexible work schemes. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. There is an English-speaking Kindergarten on the DESY site.

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Human Resources Department | Code: 14/2010C
Notkestraße 85 | 22607 Hamburg | Germany | Phone: +49 40 8998-3392
e-mail: personal.abteilung@desy.de
Deadline for applications: 15. March 2010
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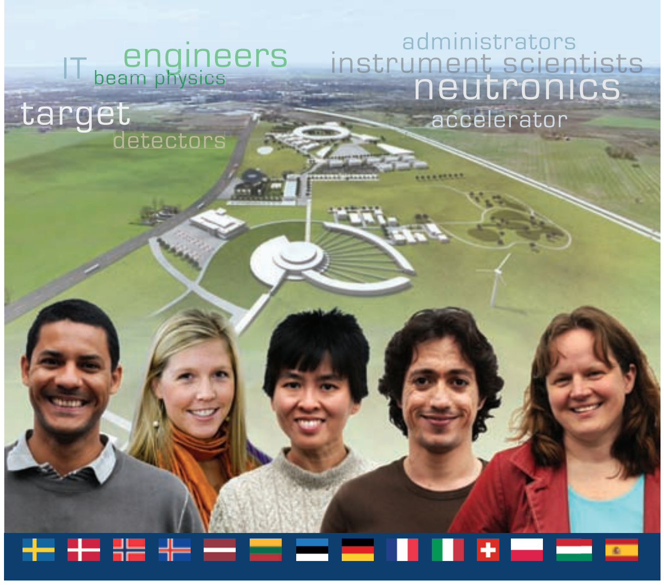

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[Job No. 991007]

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Applicants should submit a CV including a list of publications, statements of research and teaching interests, and arrange to have at least three letters of recommendations sent to:

Prof. John Portman, Chair, Theory Faculty Search Committee,
Department of Physics, Kent State University, Kent, Ohio, 44242.
Email: **phystheorysearch@kent.edu.**

Screening of applications will begin February 15, 2010 and continue until the position is filled. Applicants must also fill out an online application at
http://jobs.kent.edu/applicants/Central?quickFind=184625.

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Karlsruhe Institute of Technology

The Karlsruhe Institute of Technology (KIT) is the result of the merger of the Universität Karlsruhe (TH) and the Forschungszentrum Karlsruhe. It is a unique institution in Germany, which combines the mission of a university with that of a national research center of the Helmholtz Association. With 8000 employees KIT is one of the largest research and education institutions worldwide.

The Physics Department at Karlsruhe Institute of Technology invites applications for the position of a

Professorship (W3) of Experimental Elementary-Particle Physics

at the Institut für Experimentelle Kernphysik (IEKP). The position has been established in the framework of the Ausbauprogramm 2012 of the state of Baden-Württemberg which will take effect as of winter 2010/2011.

The research focus of the successful candidate should lie in the field of physics at particle accelerators with emphasis on the search for dark matter or for other new phenomena, and should include the development of new detector technologies.

The position is embedded in an excellent research environment in theoretical and experimental elementary particle physics and astroparticle physics carried out in several institutes at KIT. The successful candidate is expected to support the KIT-Center Elementary Particle and Astroparticle Physics (KCETA) and to participate at current and future graduate schools of KCETA.

Teaching duties include appropriate participation in the lecture courses for our basic and advanced programmes in physics, both for physics majors and students of other disciplins. Proficiency in German is expected.

Applicants must have the degree of Habilitation or demonstrate equivalent scientific qualification as well as experience in teaching.

KIT aims to increase the number of female professors and especially welcomes applications from women. Handicapped persons with equal qualifications will be preferred.

Applications with standard documentation, including a summary of past teaching, a research plan as well as a list of the five most important publications, should be sent by **April 9th, 2010** to:
Dekan der Fakultät für Physik, Karlsruher Institut für Technologie (KIT), Campus Süd, D-76128 Karlsruhe

KIT - University of the State of Baden-Württemberg and National Laboratory of the Helmholtz Association.

BROOKHAVEN NATIONAL LABORATORY

The Physics Department at **Brookhaven National Laboratory** seeks to fill an **Associate Physicist** position. This position requires a Ph.D. in high-energy nuclear physics or high-energy physics. Candidates should have a proven track record on design, fabrication, assembly and operations of detectors, as well as having demonstrated the capacity for doing independent research in high-energy nuclear physics or high-energy physics for a minimum five years after receipt of Ph.D. Experience with data-acquisition systems is highly desirable.

The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory is the world's only machine capable of colliding high-energy beams of polarized protons, and is a unique tool for exploring the puzzle of the proton's 'missing' spin. Members of the RHIC spin group are playing key roles in detector development and analysis of the polarized proton-proton data in both the PHENIX and STAR collaborations at RHIC. The other major involvement of the RHIC spin group is in the RHIC polarimeters, which provide the measurement of the polarization of the proton beams at RHIC.

The successful candidate will be asked to take a leadership role in the RHIC polarimetry effort by coordinating the upgrade of the RHIC carbon polarimeters as well as the online and offline data analysis. As a member of the group, the successful candidate will be able to choose one of the collaborations and work on analysis of the polarized proton-proton data. In the future, the eRHIC program will give the opportunity to advance and to develop new technologies for hadron and electron polarimetry.

For further details on this position, please contact E.C. Aschenauer (elke@bnl.gov). Under the direction of E. Aschenauer, Physics Department.
Please go to http://www.bnl.gov/hr/careers/ and click on Search Job List to apply for this position. Please apply to Job ID # 15114.

Brookhaven National Laboratory is an equal opportunity employer committed to building and maintaining a diverse workforce.

Accelerator | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

DESY

PARTICLE PHYSICS.

DESY has openings for:
DESY-Fellowships (m/f)

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

The position
Fellows in experimental particle physics are invited to participate in DESY's particle physics research.
- Analysis of HERA data
- Participation in the LHC experiments ATLAS and CMS
- Preparations of the International Linear Collider ILC (accelerator and experiments)
- Phenomenology and Monte Carlo development within the Analysis Centre of the Helmholtz Alliance

Requirements
- PhD completed within the last 4 years
- Application including a resume and the usual documents (curriculum vitae, list of publications and copies of university degree)
- Three letters of reference shall be arranged to be sent to the DESY Human Resources Department

DESY-Fellowships are awarded for a duration of 2 years with the possibility of prolongation by one additional year.

Salary and benefits are commensurate with those of public service organisations in Germany. DESY operates flexible work schemes. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. There is an English-speaking Kindergarten on the DESY site.

Please send your application quoting the reference code, also by e-mail to:
Deutsches Elektronen-Synchrotron DESY
Human Resources Department | Code: 1/2010
Notkestraße 85 | 22607 Hamburg | Germany
Phone: +49 40 8998-3392 | E-mail: personal.abteilung@desy.de
Deadline for applications: 31 March 2010
www.desy.de

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

HELMHOLTZ | GEMEINSCHAFT

Karlsruher Institut für Technologie

Das Karlsruher Institut für Technologie (KIT) ist aus der Fusion von Universität Karlsruhe (TH) und Forschungszentrum Karlsruhe hervorgegangen. Damit entstand eine deutschlandweit einmalige Institution, in der die Missionen einer Universität und eines Forschungszentrums in der Helmholtz-Gemeinschaft vereint sind. Mit 8000 Mitarbeitern und einem Jahresbudget von 650 Mio. Euro zählt das KIT zu den weltweit größten Forschungs- und Lehreinrichtungen.

In der Fakultät für Chemieingenieurwesen und Verfahrenstechnik ist am Institut für Technische Thermodynamik und Kältetechnik, Campus Süd, zum 1. Oktober 2011 eine

W3-Professur für Kälte- und Kryotechnik

zu besetzen, die mit der Leitung einer Arbeitsgruppe in der Abteilung Kryotechnik am **Institut für Technische Physik,** Campus Nord, verbunden ist.

Gesucht wird eine ausgewiesene Persönlichkeit, die das Fach Kälte- und Kryotechnik in Lehre und Forschung vertritt. Die zukünftigen Forschungsschwerpunkte sollen sowohl grundlegender als auch angewandter Natur im Bereich der Kälte- und Kryotechnik sein. Drittmitteleinwerbung und Mitarbeit in themenbezogenen nationalen und internationalen Fachgremien werden erwartet.

Zu den Lehraufgaben gehört unter anderem die Übernahme von Vorlesungen in den Bachelor- und Masterstudiengängen der Fakultät zu Grundlagen der Kältetechnik bis zur angewandten Kryotechnik. Die Mitwirkung im Institutsbetrieb und in der akademischen Selbstverwaltung wird erwartet.

Das KIT legt Wert auf die berufliche Gleichstellung von Frauen und Männern. Wir würden uns daher insbesondere über die Bewerbungen von Frauen freuen. Schwerbehinderte Bewerber/innen werden bei entsprechender Eignung bevorzugt berücksichtigt.

Bewerbungen mit den üblichen Unterlagen werden erbeten bis zum **16.04.2010** an das **Karlsruher Institut für Technologie (KIT), Campus Süd, Fakultät für Chemieingenieurwesen und Verfahrenstechnik, D-76128 Karlsruhe.**
Fachliche Auskünfte erteilt Ihnen gerne der Dekan, Herr Prof. Dr.-Ing. H. Nirschl, Tel. ++49 (0)721/608-3786.

KIT - Universität des Landes Baden-Württemberg und nationales Forschungszentrum in der Helmholtz-Gemeinschaft

Westfälische Wilhelms-Universität Münster

Zertifikat seit 2008 audit familiengerechte hochschule

The Institute for Theoretical Physics at the Department of Physics of the Westfälische Wilhelms-University Münster invites applications for a tenured

Professorship in Theoretical Physics - Particle Theory - (salary scale W3)

starting in the winter term of 2010.

The successful candidate should hold a PhD in theoretical physics and should have a strong research and teaching record in the field of quantum field theory or particle theory. The candidate is expected to seek close collaboration with the other theoretical and experimental research groups at the department in the area of particle physics. Teaching obligations include all areas of theoretical physics at the B.Sc. and M.Sc. level. In addition, the successful candidate is expected to participate in the academic administration of the department as well as in the further development of curricula of the B.Sc. and M.Sc. programs as well as graduate programs.

The Westfälische Wilhelms-University Münster is an equal opportunity employer and is committed to raising the proportion of women scientists in academic positions. Consequently, we actively encourage applications from suitably qualified women. Women with the qualifications and disciplinary expertise required will be preferentially considered. We also welcome applications from candidates with severe disabilities who, with suitable qualifications, will be preferentially considered.

Applications with a C.V., including teaching experience and publication list, copies of degree certificates, and a statement of past and future research interests, should be made by **April 30th, 2010** to the Dean of the Faculty of Physics:

Dekan des Fachbereichs 11 (Physik)
Herrn Prof. Dr. Johannes P. Wessels
Wilhelm-Klemm-Str. 9, 48149 Münster, Germany

www.uni-muenster.de

BROOKHAVEN NATIONAL LABORATORY

The Physics Department at Brookhaven National Laboratory seeks a Linux/Solaris System Administrator. This position requires a masters degree with a minimum of 3 years of experience or a bachelors degree with a minimum of 5 years of relevant experience, preferably in computer science or related discipline. Demonstrated experience in administering Linux-based clusters, Solaris, ZFS, Java and distributed systems is required. Working knowledge of shell scripting, Perl/Python, cfengine or similar tools for cluster administration, virtualization (vmware or xen) software, web-based languages and MySQL is essential. Familiarity with monitoring tools such as Nagios, Ganglia and Cacti is desirable. The ability to work in a team-like environment (often under pressure and project deadlines) is essential.

The Linux/Solaris System Administrator will provide system level administration and support to a large scale storage cluster and contribute to the efforts by the General Computing Environment (GCE) team to support the RACF operations. In this role they will be responsible for hardware/software deployment, configuration management, user support and troubleshooting.

Yearly compensation is in the range of $66k - $80k U.S. dollars (plus health, retirement and other benefits), depending on qualifications and experience.

Please go to http://www.bnl.gov/hr/careers and click on Search Job List to apply for this position. Please apply to Job ID # 15122.

Brookhaven National Laboratory is an equal opportunity employer committed to building and maintaining a diverse workforce.

Technische Universität München

The Physics Faculty of the Technische Universität München invites applications for a

Full Professorship (W3) in Theoretical Elementary Particle Physics

opening October 1, 2010.

The professorship includes teaching obligations in the broader field of Theoretical Physics. Candidates should have a strong research record in Theoretical Elementary Particle Physics, in particular in phenomenology and modelling beyond the Standard Model, with reference to the scientific programme of the Cluster of Excellence “Origin and Structure of the Universe” (www.universe-cluster.de). The successful candidate is expected to communicate and co-operate with theoretical and experimental groups in the Munich research area.

Prerequisite is a university degree, pedagogical aptitude, PhD and “Habilitation” or equivalent scientific profile. Applicants may not yet have completed 52 years of age. Deviations from this age limit can be granted in exceptional situations. Disabled persons will be favoured in case of otherwise comparable suitability.

Within the German Federal and State supported Excellence Initiative, the Technische Universität München aims at a significant increase in the number of women in science and teaching. Female scientists are therefore advised with special emphasis to apply for this position.

Applications including a curriculum vitae, documentation concerning earned degrees, a publication list and copies of the most important publications, should be sent by **March 15, 2010** to:
Dekan der Fakultät für Physik, TU München, James-Franck-Straße, D-85748 Garching, Germany, or via www.universe-cluster.de (-> Jobs).

Research Associates

The Accelerator Physics Center (APC) is seeking strong candidates for Research Associate positions. Fermilab's APC is responsible for coordinating and/or providing support for all accelerator R&D at Fermilab including activities aimed at improvements to the existing complex, next-generation accelerator facilities, and advanced accelerator R&D for the long-term future. Main areas of the APC research are Muon Collider and Neutrino Factory R&D; High Intensity Neutrino Source; Beam Physics in Project-X, ILC and at the LHC; Theory and Simulations; Advanced Accelerator R&D. Appointments are typically for three years with one year renewals possible thereafter.

Postdoctoral research associates may participate in the full range activities of the Fermilab Accelerator Physics Center including mathematical modeling of new and existing accelerator facilities, design, commissioning and operation of beam facilities, performance and analysis of beam physics experiments, design of new accelerator components, and research on new concepts and methods of beam acceleration.

Principal Responsibilities

- Participate on scientific teams to carry out research on the relations between space, time, matter, and energy in the areas of detectors and electronics, accelerator technology, computing techniques, ES&H documentation, and/or other technical procedures and functions related to the mission of the Laboratory
- Apply established scientific methods and technology to well-defined, moderately difficult projects to achieve Laboratory goals
- Select and make minor adaptations to procedures and accepted practices
- Participate in Laboratory and University collaborations
- Develop, present, defend, and complete paper on research projects

Demonstrated ability to carry out independent research and Ph.D. in Physics or relevant subject are required. Preference will be given to applicants seeking their first long-term postdoctoral appointment, but applicants with previous postdoctoral experience will also be considered.

Applications and requests for information should be addressed to Dr. Vladimir Shiltsev shiltsev@fnal.gov. Applications should include a curriculum vitae, publication list, research statement, and three letters of reference.

Fermilab

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

The Excellence Cluster for Fundamental Physics
'Origin and Structure of the Universe'

RESEARCH FELLOWS in
Astrophysics, Cosmology, Nuclear and Particle Physics

The Cluster of Excellence 'Origin and Structure of the Universe' is a joint research institution at the Technical University Munich funded by the Excellence Initiative of the Federal Government of Germany. It is a co-operation by the physics departments of the Technical University Munich and the Ludwig-Maximilians University, four Max-Planck Institutes (MPA, MPE, MPP, IPP) and ESO. The main goal of the Cluster is to solve fundamental questions of astrophysics and cosmology by interdisciplinary research.

For our **FELLOWSHIP PROGRAM** we are looking for excellent young scientists on the postdoc level who will pursue their individual research activities and are interested in a strong collaboration with existing Cluster research groups. Fellows benefit from an ideal scientific infrastructure at the Campus Garching and the attractions of the Munich area. The duration for **contract is 2 years**. Fellows receive their **own budget** for running costs.

The advancement of women in the science is an integral part of the cluster and the university's policy. Women are therefore especially encouraged to apply. Persons with disabilities will be given preference to other applicants with equal qualifications.

Application
Applicants should prepare a covering letter and the following documents as PDF files: a CV, a publication list, certificates (diploma, PhD), past research activities and a research plan. These files can be uploaded in the job section on the Cluster website **www.universe-cluster.de**. Further, applicants are asked to arrange for three letters of recommendation to be sent by e-mail to andreas.mueller@universe-cluster.de. The closing date for receipt of applications is **30 April 2010**.

Contact
Technische Universität München · Excellence Cluster Universe
Dr. Andreas Müller · Boltzmannstrasse 2
85748 Garching · Germany

We are looking for a

Project Coordinator Grid

About Us
SWITCH is operating the Swiss education network with innovative IT services for Universities in Switzerland. In addition, SWITCH is operating the domain name registration for domains ending in ".ch" and „.li". Our offices are located in downtown Zurich, and the company has 90 employees.

The Job
SWITCH is participating together with Swiss Universities in a EU-funded project that coordinates a Grid infrastructure across Europe („European Grid Initiative" – EGI). SWITCH is acting as the leading institution for Switzerland within this project, for which we have an open position for a project coordinator. The job description comprises besides the coordination of the Swiss participants, the reporting towards the overall project as well as participation in technical work. The latter consist of software development as well as operating grid services.

Your Profile
You hold a higher degree in computer science or a related field and have in-depth knowledge of internet technologies, web services, object-oriented programming, PKI and software engineering.
Experience in grid computing is highly desirable; participation in EU funded projects is a definite plus. You have gained experiences in project management and you enjoy working in an international environment in the area between research, implementation and operation. As an open personality with good communicative skills you value the collaboration with your customers. You are fluent in English and have the ability to express yourself in German.

We Offer
Competitive employment conditions, very good social benefits, flexible working hours as well as your continuing education are important to us.

Contact
SWITCH, Human Resources, Gudrun Reheis, P.O. Box, 8021 Zürich,
Tel. 044 253 98 22, personal@switch.ch

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JEDI KNIGHT OF NEW TECHNOLOGY

HexWax Ltd is a well-financed technology start-up based in Central London. Its core business is the development of pre-programmed microcontroller products serving the electronics industry.

We have an exciting opportunity for an exceptional candidate to work as Jedi Knight of New Technology, responsible for the development of a portfolio of new microcontroller products. Each project requires microcontroller software development and electronics skills, and the ability to switch from one field of study to another on a regular basis. Typically you will develop a handful of products in parallel, taking them from initial concept to marketable product, and support them as needed. Documenting products will require good written English. (Chinese would be a bonus.)

The ideal candidate will not only be a graduate or postgraduate in physics or electrical engineering but will also have strong entrepreneurial instincts. This job is not just about developing a product to specification; you need a gut feel what makes products a success.

The salary is competitive and contains a significant component directly related to the success of the products the candidate is responsible for, with no cap on the up-side. Reporting directly to the CEO from the outset, the candidate will be well placed to rise in seniority as the company grows.

The position is open until filled, so the sooner you apply, the better. Send your cv and 250 words on why the position interests you to **rgh@hexwax.com**, to whom any inquiries may also be addressed.

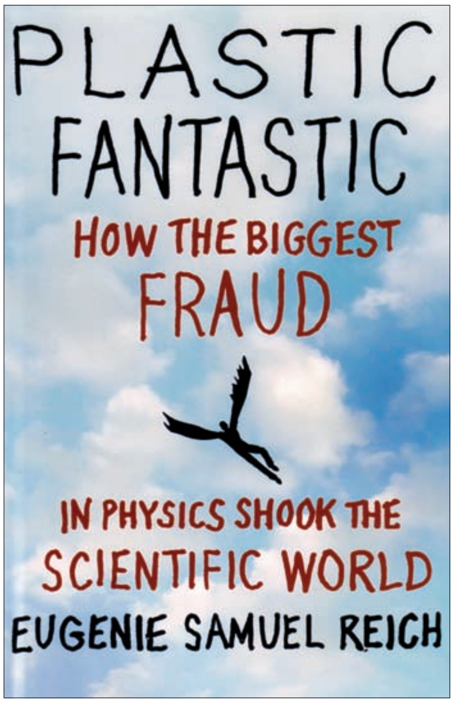
BOOKSHELF

Plastic Fantastic: How the Biggest Fraud in Physics Shook the Scientific World by Eugenie Samuel Reich, Palgrave Macmillan. Hardback ISBN 9780230224674, £15.99 ($26.95). Paperback ISBN 9780230623842, £12.99 ($17).

This book devotes 266 dense pages – 20 of them listing hundreds of notes – to a case of scientific misconduct staged at Bell Labs between 2000 and 2002, with Jan Hendrik Schön as the central figure. The plot follows the path leading up to the discovery that Schön's breakthroughs on "molecular electronics" (which included lasers and superconductors made of organic plastics) were fraudulent.

Reich makes a good case in defending the argument that the economic situation at Bell Labs and the need to justify keeping a strong basic-research department in the company made the ground fertile for an ambitious young person to flourish and enchant (fool) the senior people. It is actually quite amazing to see that the co-authors of Schön's papers knew so little about important points of the reported work, and that the fabrication of data was not uncovered earlier than it was, given the frequent questions being asked by many Bell people, including close collaborators, managers and other staff. It helped that many of his papers presented "measurements" that matched predictions. He seemed to write his papers backwards: first the conclusions, then the "data" that supported them, often generated from equations rather than from the apparatus.

In hindsight, it looks preposterous to think that Schön could possibly write more than 20 groundbreaking publications in such a short time period, including seven papers in a single month, November 2001. This, alone, should have alerted people to the possibility that the reported results may have been fabricated. The journals *Nature* and *Science* emerge from this book as not being very careful about reviewing the articles that they publish, placing the emphasis on selecting papers that will make the headlines (the "breakthrough of the year") rather than in ensuring that they provide enough technical details to allow for a good scrutiny of their plausibility and for an efficient verification by other labs. Many people wasted time and money trying to replicate the fabricated results. Schön's publication "success" surely benefited from having signed the papers with a senior co-author, a well known expert



who gave further credibility to the fraudulent results by giving a multitude of seminars on the subject, to the point of being awarded, and accepting, prizes for the "discoveries".

This is an interesting book and Reich clearly convinces the reader that, despite our natural tendency to think that scientists can be trusted (honest people, who might make mistakes), some of them deliberately fudge the measurements to fit with preconceived ideas, old or new. The scientific method needs to be learned, sometimes through years of careful training, modulated by sceptical professors (who can notice patterns that look "too good to be true"). However, I would gladly have exchanged many of the specific details about this single case for more information about other cases, together with a global discussion of the factors that lead to such frauds. Are they caused by young people with inadequate training and supervision? Or by ambitious senior people desperately looking for an important prize and pushing their young partners to search for anomalies and "new physics", neglecting the importance of time-consuming validation checks? Are there branches of science where they are more frequent?

Reich was very meticulous and gives all sorts of details that interrupt the fluidity of the reading. She could have redesigned the narrative, avoiding some repetition, placed the introductory text of chapter 9 (!) at the start of the book, and removed a few of the lines and paragraphs containing little information. Without an introductory chapter preceding the main plot and giving a broad overview of this field, most readers will lack the minimum background knowledge needed to appreciate the reported saga. As a side remark, it is curious to learn that Nobel laureate Bob Laughlin repeatedly claimed that Schön's results had to be fraudulent but his opinion "didn't count because he was known to be too sceptical".
Carlos Lourenço, CERN.

Perspectives on LHC Physics by G Kane and A Pierce (eds), World Scientific. Hardback ISBN 9789812779755, $99/£55. Paperback ISBN 9789812833891, $54/£30. E-book ISBN 9789812779762, $129.

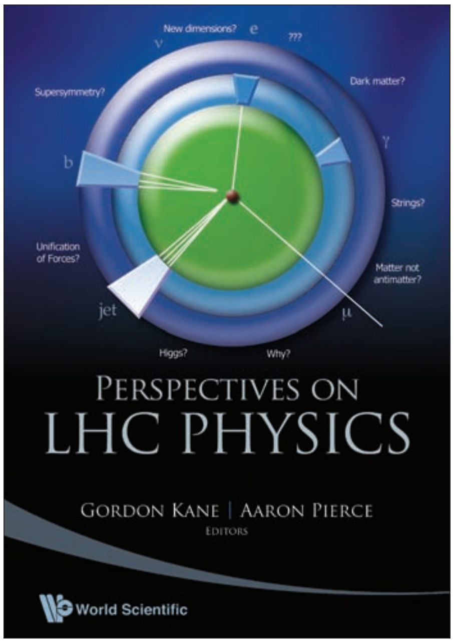
This book could hardly seem more timely, with the Large Hadron Collider (LHC) having started operations and new discoveries being eagerly awaited (but quite possibly a few years off yet). It consists of 17 chapters, each on a different topic, ranging from a description of the detectors to discussions of naturalness in quantum-field theories of particle physics.

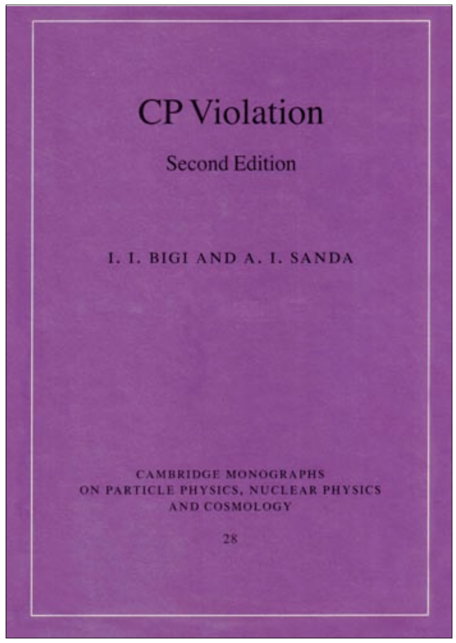
The contributors are particle physicists, several of whom are prominent in the field. However, each chapter has different authors, so the result is inevitably a little patchy. The chapters differ widely in scope, in character and in the level of expertise assumed for the reader. For instance, the chapter on dark matter at the LHC is very basic and could be read by undergraduates, whereas the informative chapter on top physics is of a graduate level. There are also some much more general expansive essays, such as one that explores similarities between the BCS theory of superconductivity and particle physics, and the introductory chapter. The introduction assumes a fair amount of prior knowledge and is much too optimistic for my taste about the chance of discovering supersymmetry at the LHC. The author asserts that supersymmetry must be correct because of several pieces of circumstantial evidence, but I really think that other such a posteriori scraps could be used to prop up the evidence for competing theories.

There are a couple of obvious omissions, for example quark-gluon plasma physics and the ALICE detector. After all, the LHC will spend some of its time providing collisions between heavy ions, rather than protons, and ALICE will be trying to divine the properties of the resulting soup of quarks and gluons. The other missing topic is that of diffractive physics. It is likely that both the ATLAS and CMS experiments will eventually have forward detectors to measure protons that have just grazed another one in a collision. Under certain theoretical circumstances, it is even possible to produce Higgs bosons in the central detector during these collisions. Such rare events could provide useful experimental constraints on the properties of Higgs bosons. The chapter about the ATLAS and CMS detectors is welcome, but it could benefit from some basics about how particles interact as they travel through matter. This important link in the logical chain is missing from the discussion.

Perspectives on LHC Physics is a timely, heterogeneous offering, with some interesting gems and informative parts, as well as some fairly off-the-wall speculation. I think that there should be sections of it to interest most readers in the physical sciences, but that they may well wish to choose particular chapters to read. Luckily, the format of the book makes this easy to achieve.

Ben Allanach, DAMTP, University of Cambridge.





CP Violation (2nd edition) by I I Bigi and A I Sanda, Cambridge University Press. Hardback ISBN 9780521847940, £80 ($160). E-book ISBN 9780511577284, $128.

At the time of the first edition of this book, 10 years ago, the authors had, in their words, "ample reasons to expect imminent dramatic changes" in the land of discrete symmetries. With this second edition, they return to cover what has indeed happened since then. There was certainly drama in the sense of "action" on the experimental side and many of the players became better defined. Experiments at CERN and Fermilab have measured direct $\Delta S=1$ CP violation in K_L decays, with consistent results and a precision of a few percent, and the B factories have revealed the large CP asymmetries expected in the B sector. Also, precision measurements with the SNO, K2K and KamLAND experiments have opened the way to CP violation studies with neutrinos.

In this second edition, the authors include the new results and update the theoretical models. They indicate new directions in model building, in particular in the context of supersymmetry and extra dimensions, and are always attentive to questions that remain unanswered. Are there additional sources of CP violation? What happens in the lepton sector? What is the origin of the baryon asymmetry?

The structure of the book remains unchanged, consisting of three parts, slightly rearranged with respect to the first edition. Each chapter includes an introduction, a short summary and a number of problems (but no hints for solutions).

Part 1, on "Basics of CP violation", follows a pedagogical style, leading from symmetry concepts in classical mechanics and electrodynamics to their translation to the domain of non-relativistic quantum mechanics, and subsequently to relativistic quantum theories. It is completed by two sections on the historical role of strange particles, in particular neutral kaons, in the discovery of CP violation and on the simple "master equations" of time evolution.

In Part 2, "Theory and experiments", the authors deal with decays, i.e. the directly observable phenomena. This starts with details of the phenomenology related to kaons and the latest experimental results. It leads, via a history of the Standard Model, to the Kobayashi-Maskawa ansatz and the need for at least three families. It is here, in chapter 10, that the forecasts of the first edition are shown to materialize, with the experimental opportunities offered by B physics. The late 1990s saw the construction of the asymmetric B factories and finally in 2001 the demonstration of CP violation, with a multi-standard-deviation effect, for the first time outside the kaon domain, in four decay channels.

A glimpse beyond the Standard Model forms the content of Part 3, starting with a quest for CP violation in the neutrino sector and possible corrections to the current paradigms. It then leads on to top quarks and charged leptons, supersymmetry, minimal flavour-violation and extra dimensions, and baryogenesis in the universe.

Part 4 consists of only one chapter. Here, in their dashing style at its best, the authors recall that CP violation represents "a profound intellectual insight" that also has "many and far-reaching concrete consequences". Although the three-family Standard Model can implement CP violation through the KM mechanism, we have not yet reached an understanding of it, for we are left with the mysteries related to the quark mass matrices. After looking back to the successes of the past, the authors advance an "Agenda for the future". Happily (from the point of view of an experimentalist) this agenda covers many different experimental fields, so there will be no shortage of work.

The cut of the book is theoretical but is suitable and stimulating for an

experimentalist, showing rigour and insight. The authors concede that it does not make easy reading and more than one reading may be necessary. Sometimes other sources (quoted as references) may also be needed. Some lack of precision in the historical details could have been avoided, and the bibliography would gain from a less casual presentation. The tone is friendly, however, even if the jocular comments are occasionally puzzling. The reader is shown how to see the CP "wood" among the "trees" of phenomenological details, without missing anything of importance.
Maria Fidecaro, CERN.

Books received

Principles of Radiation Interaction in Matter and Detection (2nd edition) by Claude Leroy and Pier-Giorgio Rancoita, World Scientific. Hardback ISBN 9789812818270, £112 ($191). Paperback ISBN 9789812818287, £61 ($104).

This book addresses the fundamental principles of interactions between radiation and matter and the principle of particle detectors in a range of fields, from low to high energy, including space physics and the medical environment. It provides abundant information about the processes of electromagnetic and hadronic energy deposition in matter, detecting systems, and the performance and optimization of detectors. In this second edition, new sections dedicated to the following topics are included: space and the high-energy physics radiation environment, non-ionizing energy loss, displacement damage in silicon devices and detectors, single-event effects, detection of slow and fast neutrons with silicon detectors, solar cells and pixel detectors. This book will be of use to students as a reference for courses in particle, astroparticle and space physics and instrumentation, as well as researchers dealing with instrumentation in particle physics. Part of it is directed toward courses in medical physics.

Of Matter and Spirit: Selected Essays by Charles P Enz, World Scientific. Hardback ISBN 9789812819000, £48 ($83).

The essays selected for this book comprise ideas presented in oral or written form between the years 1972 and 2000, some of which were originally given in French or German. They are preceded by a biographical and topical introduction. As the title suggests, one major theme of the essays collected here is the material world, which is viewed in its extreme spatial extensions of the universe and of the elementary particles. In particular, the fascinating notion of the void and its fluctuating energy is the subject of various discussions, as is the subdivision of material bodies and its limits. The latter, as well as the limit of gravitational stability, are depicted in a diagram leading to the ultimate point of the Planck mass and length. The other topic of the title is the spiritual realm and here the book's content is based on reflections and quotations from various religious texts.

VIEWPOINT

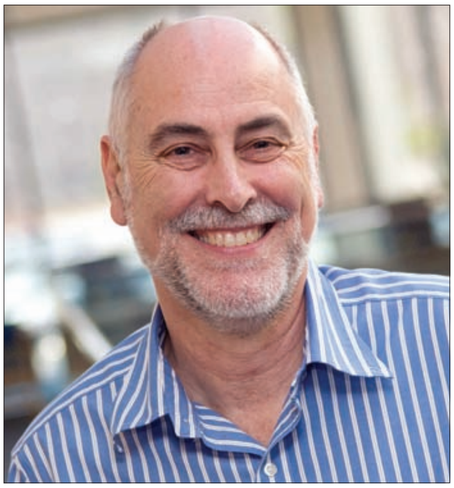
Profiting from the long view

Andrew Hutton looks at lessons from "cryomodule centuries" of SRF performance.

We can measure and analyse accumulated superconducting RF (SRF) operating experience in broad, high-level terms using the "cryomodule century", or CC. Ten cryomodules operating for a decade, or 50 of them operating for two years, yield 1 CC. In the past, Tristan at KEK and HERA at DESY each accumulated more than 1 CC, and LEP-II accumulated nearly 4 CC. KEK-B, Cornell, and the Tesla Test Facility/FLASH have each accumulated a large fraction of 1 CC. In addition, well over half of the world's SRF operating experience has taken place at two US Department of Energy nuclear-physics facilities: ATLAS at Argonne National Laboratory and the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab.

Although a mere 25 years old – including more than 15 years of running SRF in CEBAF – Jefferson Lab has, in this sense, accumulated many centuries' worth of operating experience, about 6 CC . This experience has made it possible for CEBAF to operate at energies exceeding 6 GeV, 50% above its design energy. These energies resulted from a refurbishment programme that sought to improve the 10 lowest-performing cryomodules of the 42¼ installed at CEBAF. Refurbishment involved fixing problems in the SRF accelerating cavities inside the cryomodules, applying the latest advances in SRF science and technology. Each of the 10 refurbished cryomodules has performed at least 50% better than the best of the original complement – at two and a half times the original specification.

In Hamburg, the European XFEL project will in its first decade yield more than 10 CC, roughly comparable to today's combined world total. The main linacs of the International Linear Collider (ILC), however, will require cryomodules for some 16 000 SRF cavities. ILC's first decade will yield some 186 CC – more than an order of magnitude greater than the world's present total or XFEL's projected total. What challenges will confront those who seek to operate the ILC and other future machines over long periods?



Andrew Hutton. (Courtesy G Adams/Jefferson Lab.)

At Jefferson Lab, ILC's order-of-magnitude scale-up calls to mind the SRF pioneering of CEBAF, itself an order-of-magnitude scale-up from seminal SRF R&D that was conducted mainly at Cornell, KEK, DESY, and earlier at Stanford University. In the effort to head off or pre-compensate for operational difficulties, CEBAF's scale-up challenges included higher-order modes, overall reliability in a many-cryomodule system and the fact that the beams to be accelerated had distinct properties not previously engaged. Yet, even though these and countless other pre-operational questions were attacked, actual practice, year in and year out, has turned up much that was simply unforeseen, and was probably unforeseeable. As a result, in CEBAF's decade and a half of operating, about 1.5 refurbishments have been necessary per CC. Extrapolated, that would imply about 30 per year for the ILC.

Of course, extrapolations about the ILC and other future SRF machines are inevitably subject to errors. For one thing, experience to date involves operating gradients significantly lower than those planned for the ILC (and for the XFEL, as well). And at CEBAF and other operating SRF machines, most of the post-construction problems have already been corrected. For example, in SRF cavity processing, future accelerator builders won't have to re-learn the value of high-pressure rinsing, which removes the performance limitation of field emission – and which is helping the ILC high-gradient R&D programme to achieve significantly higher accelerating gradients than past machines have reached.

But both the XFEL and the ILC will push the (current) state of the art just as CEBAF pushed the (then) state of the art. So it is certain that the problems that these future SRF machines are sure to encounter will be new and different. Nevertheless, past experience is all that we have, and we should try to learn from it. Despite the uncertainties, strategies for spares will need to be developed. To maintain the operating gradient, failure rates will need to be estimated. CEBAF had one cryomodule failure per CC, but the failures appeared only after the first 7 years, or the first 3 CC. The failures exposed flaws but new problems are surely coming. CEBAF has also had gradient degradation of 1% per year from new field-emission sites caused by particulates inside the vacuum system. In sum, from our experience, any SRF machine needs to plan for refurbishments at a rate of 1–2 per CC.

In current SRF accelerators, cryomodules are independent, standalone entities that can (with some difficulty) be pulled out for refurbishment. In future SRF accelerators, the need to minimize static heat losses pushes the design toward more integrated accelerator systems, even at the cost of making replacement harder. Yet if extrapolation from current operating experience is valid, it will be important to have the ability to refurbish, which means that it will be necessary to avoid having cryomodules that are difficult to extract. It's the continuation of a longstanding design conflict: tight integration of systems improves performance, but makes repair harder.

SRF operating experience now has a long standing – many cryomodule centuries of it, in fact. This experience base constitutes an imperfect yet vital tool. And for all of us, there's profit in looking back in order to see forward.

Andrew Hutton is Jefferson Lab's associate-director for accelerators.

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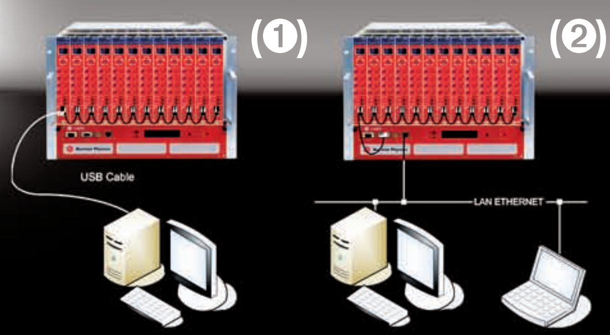

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