International Journal of High-Energy Physics

CERN COURIER

Volume 50 Number 4 May 2010

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CERN COURIER

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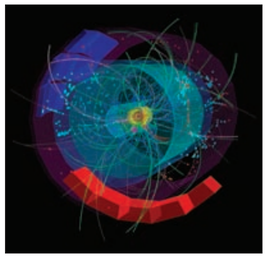
The big switch-on: 1967-style p10



Heralding a new era for physics p27

A multifaceted talent p33

Cover: The crowded CERN Control Centre on 30 March, as the spokespersons from the four big experiments celebrate with the accelerator team after the LHC had produced the first 7 TeV collisions.

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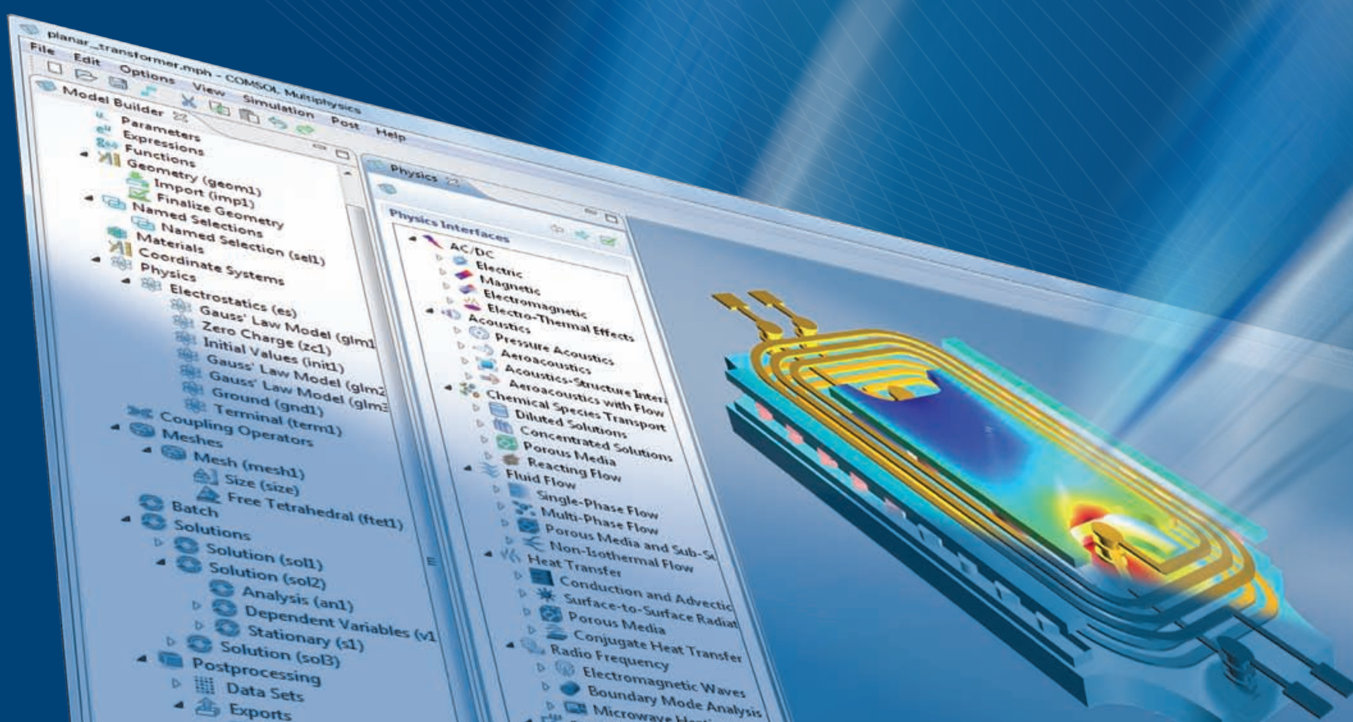

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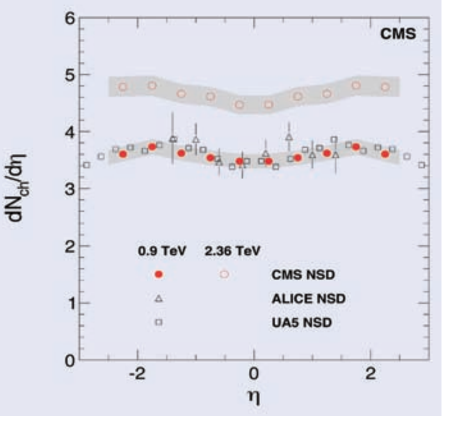
LHC EXPERIMENTS

Let the physics begin at the LHC

The big LHC experiments have been 20 years in the making; the meeting at which the proto-collaborations first presented their ideas publicly took place in Evian-les-Bains in March 1992 (*CERN Courier* October 2008 p12). Over the past few years, as the huge and complex apparatus neared completion, they have gathered data from cosmic rays. While this was important for testing and aligning the multilayered detectors, as well as for exercising data-acquisition systems, it was only in November and December last year that the collaborations had their first sight of the long-awaited collisions at the LHC, first at 900 GeV in the centre of mass and then at 2.36 TeV. Collision data at 7 TeV are now beginning to roll in (p27). In the meantime the collaborations have been eager to make the most of the data obtained last year and the first LHC physics publications have appeared.

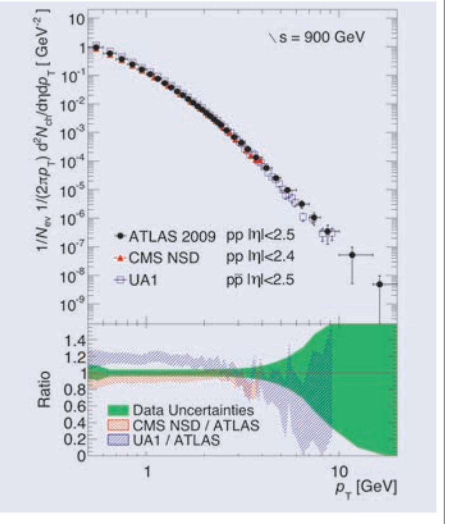
The ALICE collaboration was first off the mark in 2009, with the submission of a paper on the analysis of the 284 events recorded during the first burst of collisions on 23 November (*CERN Courier* January/February 2010 p24). The paper, which presents the measurement of the pseudorapidity density of charged primary particles in the central region at 900 GeV in the centre of mass, was accepted for publication in *European Physical Journal C* on 3 December (ALICE Collaboration 2010). It compares the measurement on proton–proton collisions at the LHC with those from earlier experiments, including UA1 and UA5 at CERN, which collected data for proton–antiproton collisions at 900 GeV in the centre of mass.

On 4 February the CMS collaboration followed suit with a submission to the *Journal of High-Energy Physics*, which was refereed and accepted for publication three days later. This paper presents measurements of inclusive charged-hadron transverse-momentum and pseudorapidity distributions for proton–proton collisions at both 900 GeV and 2.36 TeV, based on data collected in December (CMS collaboration 2010). The results at 900 GeV are in agreement with previous measurements (in UA5 and UA1) and in ALICE, and they confirm the expectation of near-equal hadron production in proton–antiproton and proton–proton collisions. The results at 2.36 TeV are in a new high-energy region, however, and they indicate an increase of charged-hadron multiplicity with energy that is steeper than expected.



Charged-track multiplicity as a function of pseudorapidity at 900 GeV and 2.3 TeV in CMS, compared with ALICE and UA5.

On 16 March, it was the turn of ATLAS, with a paper submitted to *Physics Letters B* entitled "Charged-particle multiplicities in pp interactions at $\sqrt{s} = 900$ GeV measured with the ATLAS detector at the LHC". This details the collaboration's first measurements with some 300 000 inelastic events collected in December using a minimum-bias trigger during collisions at 900 GeV (ATLAS collaboration 2010). It presents results for the charged-particle multiplicity, its dependence on transverse momentum and pseudorapidity, and the relationship between mean transverse momentum and charged-particle multiplicity, measured for events with at least one charged particle in the kinematic range $\eta < 2.5$ and $p_T > 500$ MeV. The results indicate that the charged-particle multiplicity per event and unit of pseudorapidity at $\eta = 0$ is some 5–15% higher than the Monte Carlo models predict.



The ATLAS p_T spectrum of charged-particle multiplicities at 900 GeV, compared with data from UA1 and CMS at the same centre-of-mass energy.

These papers are just the first glimpses of physics at the LHC. To support what is set to be an extensive programme of physics, the LHC Physics Centre at CERN has recently started up. It aims to collect together a variety of initiatives to support the LHC physics programme, from the organization of workshops to the development of physics tools (see http://cern.ch/lpcc).

Further reading

ALICE Collaboration 2010 *Eur. Phys. J.* **C65** 111. arXiv:0911.5430
ATLAS Collaboration. arXiv:1003.3124, accepted by *Phys. Letts. B*
CMS Collaboration. 2010 *JHEP* **2** 041 arXiv:1002.0621v2.

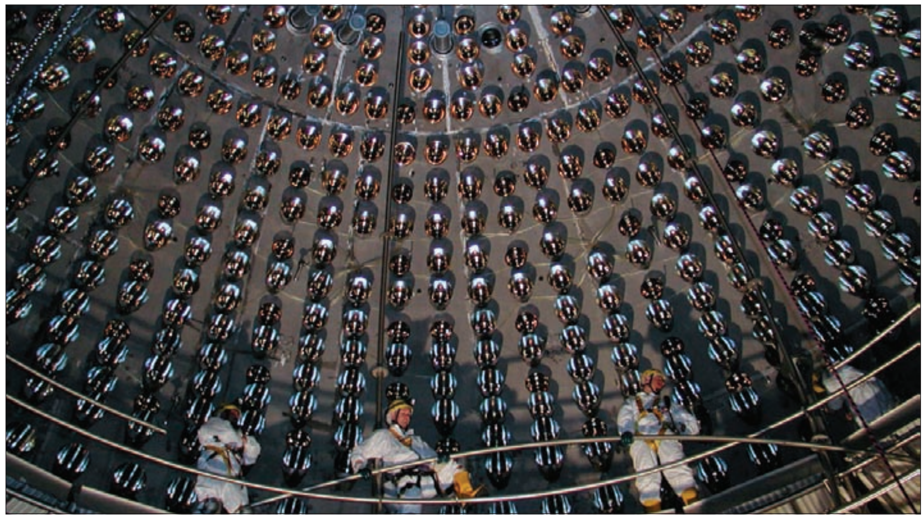
Sommaire

NEUTRINOS

Borexino gets a first look inside the Earth

The Borexino Collaboration has announced the observation of geoneutrinos at the underground Gran Sasso National Laboratory of the Italian Institute for Nuclear Physics (INFN). The data reveal, for the first time, an antineutrino signal well above background with the energy spectrum expected for radioactive decays of uranium and thorium in the Earth.

The Borexino Collaboration, comprising institutes from Italy, the US, Germany, Russia, Poland and France, operates a 300-tonne liquid-scintillator detector designed to observe and study low-energy solar neutrinos. Technologies developed by the collaboration have enabled them to achieve very low background levels in the detector, which were crucial in making the first measurements of solar neutrinos below 1 MeV (*CERN Courier* June 2009 p13). The central core of Borexino now has the lowest background available for such observations and this has been key to the detection of geoneutrinos.



The stainless steel sphere of Borexino during the installation works. (Courtesy INFN – Gran Sasso National Laboratories.)

Geoneutrinos are antineutrinos produced in the radioactive decays of naturally occurring uranium, thorium, potassium and rubidium (*CERN Courier* October 2003 p20). Decays from these radioactive elements are believed to contribute a significant but unknown fraction of the heat generated inside the Earth. This heat produces convective movements in the mantle, which influence volcanic activity and the tectonic-plate movements that induce seismic activity, as well as the geo-dynamo that creates the Earth's magnetic field.

The importance of geoneutrinos was pointed out by Gernot Eder and George Marx in the 1960s and in 1984 a seminal study by Laurence Krauss, Sheldon Glashow and David Schramm laid the foundation for the field. In 2005, the KamLAND Collaboration reported an excess of low-energy antineutrinos above background in their detector in the Kamioka mine in Japan (*CERN Courier* September 2005 p6). Owing to a high background from internal radioactivity and antineutrinos emitted from nearby nuclear power plants, the KamLAND Collaboration reported that the excess events were an "indication" of geoneutrinos.

With 100 times lower background than KamLAND, the Borexino data reveal a clear low-background signal for antineutrinos, which matches the energy spectrum of uranium and thorium geoneutrinos. The lower background is a consequence both of the scintillator purification and the construction methods developed by the Borexino Collaboration to optimize radio-purity, and of the absence of nearby nuclear-reactor plants.

The origin of the known 40 TW of power produced within the Earth is one of the fundamental questions of geology. The definite detection of geoneutrinos by Borexino confirms that radioactivity contributes a significant fraction, possibly most, of this power. Other sources of power are possible, the main one being cooling from the primordial condensation of the hot Earth. A powerful natural geo-nuclear reactor at the centre of the Earth has been suggested, but is ruled out as a significant energy source by the absence of the high rate of antineutrinos associated with such a geo-reactor that should have been observed in the Borexino data.

Although radioactivity can account for a significant part of the Earth's internal heat, measurements with a global array of geoneutrino detectors above continental and oceanic crust will be needed for a detailed understanding. By exploiting the unique features of the geoneutrino probe, future data from Borexino, KamLAND and the upcoming SNO+ detector in Canada should provide a more complete understanding of the Earth's interior and the source of its internal heat.

Further reading

Borexino Collaboration, G Bellini *et al.* 2010 arXiv:1003.0284v2.

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.

MEDICAL PHYSICS

Canada explores cyclotron solution to isotope shortage

The world's most in-demand isotope for medical-imaging purposes is ^{99m}Tc, a daughter of the isotope ^{99}Mo. ^{99}Mo has been produced in plentiful supplies for the entire world chiefly by two research reactors: one in Canada and the other in the Netherlands. Both of these reactors are currently down for difficult repairs related to their age – the younger one is 47 years old.

One mitigating factor in maintaining the supply of ^{99}Mo has been the immense co-operation among medical-isotope suppliers and consumers around the world, primarily brokered through working groups of the International Atomic Energy Agency and several industrial associations. However, in the face of the supply shortages – the pair of reactors produced 65% of the world's ^{99}Mo – Canada has been examining alternatives.

At the end of March the government of Canada released its policy response to an expert advisory panel that analysed the situation in autumn 2009. The report highlights two main alternatives to manufacturing the ^{99}Mo isotope that is currently in so much demand: cyclotrons (with new target materials) and linear accelerators (using photo-neutron processes on ^{100}Mo or photo-fission of ^{238}U).

TRIUMF is one of the organizations that have received initial Canadian government support to begin benchmarking the cyclotron production of ^{99m}Tc. (Courtesy TRIUMF.)

Cyclotrons have been used around the world for four decades to produce isotopes useful for medical-imaging purposes ranging from ^{11}C and ^{18}F to ^{82}Sr. The primary method to be explored for the cyclotron approach to the manufacture of ^{99m}Tc utilizes the ^{100}Mo(p,2n)^{99m}Tc reaction. When bombarding the ^{100}Mo target foil with an energetic proton beam, ^{99m}Tc is produced in direct reactions and can then be extracted. High yields of ^{99m}Tc from this reaction depend on three things: high-energy cyclotrons, high-intensity beams and high-efficiency ^{100}Mo targets – all of which will be developed and tested in the next year or so.

Along with a team of researchers and clinicians from across Canada, TRIUMF, the University of British Columbia and BC Cancer Agency have received initial Canadian government support to begin benchmarking and then optimizing the ^{99m}Tc yield from this process. Other groups are following suit along with several private companies.

If the technology pans out, and the contamination of ground-state ^{99}Tc is controllable in the extracted ^{99}Tc samples, it will be a new "killer app" for medical-isotope cyclotrons. Fine-tuning will be needed to select the optimal beam energy of the protons as well as the target geometries and the extraction and separation procedures. ^{99m}Tc produced directly at cyclotrons would be limited to local use because the six-hour half life prevents it from being shipped round the world as ^{99}Mo currently is (with a 66-hour half life). However, this technology could provide an important supplement in major urban centres where cyclotron capacity exists for burgeoning nuclear-medicine departments. Cyclotron-produced ^{99m}Tc would reduce the need for ^{99}Mo from reactors.

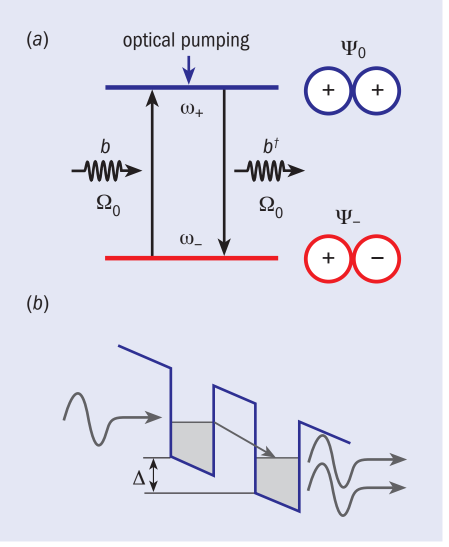
Independent of this innovation, cyclotrons have a bright future in nuclear medicine. The new isotopes and radiopharmaceuticals being developed using the so-called PET isotopes could eventually overtake the market dominance of ^{99}Mo, so that cyclotrons will be everywhere.

Compiled by John Swain, Northeastern University

Phonon lasers produce coherent beams of sound

The acoustic equivalent of a laser – a device that produces a coherent beam of phonons – has recently been realized in two distinct ways. Ivan Grudinin and colleagues at Caltech have used two coupled optical resonators to make a photonic analogue of a molecule with states differing by an energy corresponding to that of a phonon (figure a). The resonators are microtoroids 63 μm in diameter, operating in "whispering-gallery mode". Coupling of the whispering-gallery modes occurs through evanescent waves in the air gap between the cavities. Optical pumping of the system with enough energy leads to coherent production of phonons at around 21 and 41 MHz, with the emission of lower-energy photons produced as "waste".

In independent work, Ryan Beardsley and colleagues at the University of Nottingham have demonstrated coherent sound amplification in the terahertz range. They used a 50-layer n-doped superlattice of GaAs/AlAs to make the phononic analogue of a quantum-cascade laser, in which electrons tunnel down a staircase of quantum wells emitting phonons by stimulated emission as they go (figure b). Interestingly, the same sort of phonon-electron coupling that normally gives rise to electrical resistance with incoherent phonon emission here gives rise to a coherent beam of sound.



(a) Two-level phonon laser energy-level diagram including schematics of the symmetric and antisymmetric orbitals of the photonic molecule formed by coupled microtoroids. (b) Schematic representation of phonon-assisted tunnelling between neighbouring quantum wells in a superlattice by stimulated emission.

Further reading

Ivan S Grudinin *et al.* 2010 *Phys. Rev. Lett.* **104** 083901.
R P Beardsley *et al.* 2010 *Phys. Rev. Lett.* **104** 085501.

Making Majorana fermions in the lab

Majorana fermions, which – like photons – are their own antiparticles, have yet to be observed as fundamental particles. They could, however, be made as quasiparticles in the laboratory. The details are quite sophisticated but the basic idea is that Majorana fermions have half the number of degrees of freedom compared with normal fermions. In the Bardeen-Cooper-Schrieffer theory for superconductivity there is a mixing of electron and hole degrees of freedom with positive and negative energy respectively. Normally only half of the degrees of freedom – the positive energy ones – are considered, but there are situations when a zero-energy state appears. Taking half of the degrees of freedom of that state is then effectively a Majorana fermion.

Jason Alicea of Caltech has now shown that a rather simple set-up of a semiconductor coupled to a conventional superconductor (s-wave) in a strong magnetic field should work. This is interesting for quantum computing because Majorana fermions should display non-Abelian exchange statistics and could be used to manipulate quantum information without decoherence.

Further reading

J Alicea 2010 *Phys. Rev.* **B81** 125318.

Hydrocarbon superconductors

The first of a new class of high-temperature superconductors is a hydrocarbon. Ryoji Mitsuhashi of Okayama University in Japan and colleagues have shown that planar molecules of picene – essentially five benzene rings fused together – will superconduct at 18 K if doped with potassium or rubidium ions.

This is the first molecular superconductor whose organic component is made of only carbon and hydrogen. Interestingly, pentacene, which is isomeric with picene but with the benzene rings laid out a little differently, does not display the same superconducting behaviour. There remains plenty that is still not understood about exactly how this new material works.

Further reading

R Mitsuhashi *et al.* 2010 *Nature* **464** 76.

Qubit memories made of erbium

Photons are good candidates for qubits because they can easily be prepared in a superposition of two (polarization) states, but how might a memory device for such qubits be made without effectively making a measurement on them and destroying the quantum information?

Björn Lauritzen and colleagues of the University of Geneva shone a weak pulse of infrared light on a crystal containing erbium atoms that had previously been excited by a different pulse of light. Via a process called controlled reversible-inhomogeneous broadening, the infrared photons were effectively absorbed over many atoms and could be coaxed back out unchanged by a suitable electric-field gradient. The storage time was several hundred nanoseconds, and while the efficiency was under 1%, this is clearly an important advance in the storage of quantum information.

Further reading

B Lauritzen 2010 *Phys. Rev. Lett.* **104** 080502.

ASTROWATCH

Compiled by Marc Türler, ISDC and Observatory of Geneva University

Astronomers miss 90% of distant galaxies

The rate of star formation in the early universe is mainly deduced based on a specific hydrogen-emission line observed in remote galaxies. It was already suspected that this Lyman-α line is strongly absorbed by dust but not to the extent now found by a careful study of the effect using the Very Large Telescope (VLT) of the European Southern Observatory (ESO). It turns out that on average only about 5% of the emitted radiation escapes the galaxies, which in turn means that almost 90% of remote star-forming galaxies cannot be detected by current methods.

The formation of the first galaxies and stars started in the first 100 million years after the Big Bang. Star-forming galaxies are characterized by the presence of short-lived, massive stars that emit predominantly ultraviolet light, which ionizes the gas in their neighbourhood. The recombination of ionized hydrogen results in a series of emission lines corresponding to the transition between different excitation levels of the atoms. The strongest lines are the Lyman-α emission at an ultraviolet wavelength of 121.6 nm and the Balmer H-α line visible in red at 656.3 nm. For a distant galaxy, these lines are observed at longer wavelengths because of the expansion of the universe. A galaxy at a redshift of $z = 2$ will have the lines shifted towards longer wavelengths by a factor of $z + 1 = 3$, making the Lyman-α line almost visible and moving the H-α line to the near infrared.

The Lyman-α line has an ideal wavelength to identify ionized hydrogen gas in high-redshift galaxies with telescopes operating in visible light. It is furthermore typically 8.7 times brighter than the Balmer H-α line, which makes it the prime tracer of star formation at high redshift. Lyman-α is however also a resonant line and this means that its photons scatter on neutral hydrogen. This is a problem because it keeps the Lyman-α photons inside the galaxy for a long time, so giving them a big chance to be absorbed by dust before eventually escaping the galaxy.

Portion of the GOODS-South field of remote galaxies imaged by the FORS and HAWK-I instruments on two of the four 8.2-m telescopes of the VLT. (Courtesy ESO/M Hayes.)

The determination of the escape fraction of Lyman-α photons from the galaxy is difficult to assess. Model-dependent estimations based on galaxies observed at high-redshift ($z = 2–3$) previously suggested an escape fraction between 30% and 60% on average. This is far above the measurement obtained now by an international group of astronomers lead by Matthew Hayes from the Observatory of the University of Geneva. They have obtained an escape fraction of $5.3 \pm 3.8\%$ with a firm model-independent upper limit of $10.7 \pm 2.8\%$ at a redshift of $z = 2.2$, which corresponds to galaxies whose light took 10 thousand million years to reach Earth (Hayes *et al.* 2010).

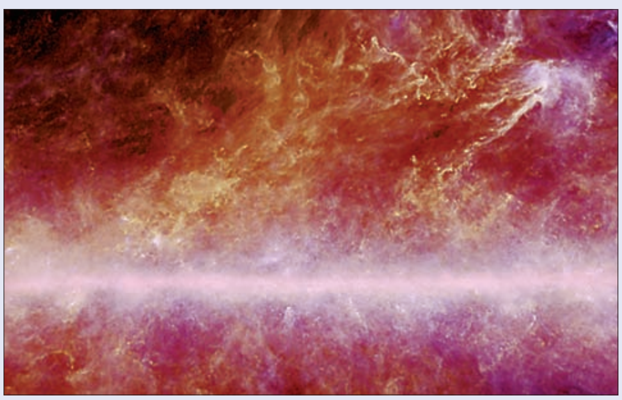
The result was obtained by looking at a field of galaxies with dedicated narrow-band filters to get the Lyman-α and H-α line emission at this particular redshift. The GOODS-South (Great Observatories Origins Deep Survey) field of view was chosen because it was observed previously by different instruments, which had already characterized the properties of its galaxies. A custom-built filter for Lyman-α was mounted on the FOcal Reducer and low-dispersion Spectrograph (FORS) camera on one of the four 8.2-m telescopes of the VLT, while the H-α line emission was recorded by the new High Acuity Wide field K-band Imaging (HAWK-I) camera attached to another VLT telescope.

The analysis of these unique observations shows that the Lyman-α line is undetectable in most star-forming galaxies. Indeed, 90% of the galaxies remain unnoticed, such that for every 10 galaxies detected, there should be 100. The determination of this huge proportion of missed galaxies will allow astronomers to obtain a far more accurate description of the history of star formation in the universe.

Further reading:

M Hayes *et al.* 2010 *Nature* **464** 562.

Picture of the month



This beautiful image of dust structures in the Milky Way is one of the first images by the Planck mission to be released by the European Space Agency (ESA). The image spans about 50° of the sky, showing giant filaments of cold dust in our galactic neighbourhood, within about 500 light-years from the Sun. It is a three-colour combination of data taken with Planck's High-Frequency Instrument (HFI), at wavelengths of 540 and 350 μm (shown in red and yellow), and a 100-μm image (shown in white) taken in 1983 with the Infrared Astronomical Satellite (IRAS). White-pink tones show dust with a temperature of a few tens of kelvin, while the coolest dust at only about 12 K appears in red. The mapping of dust in our galaxy is bonus science for Planck which was launched in May 2009 primarily to study the cosmic microwave background, the relic light of the Big Bang. (Courtesy ESA and the HFI Consortium/IRAS.)

CERN COURIER ARCHIVE: 1967

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

CERN

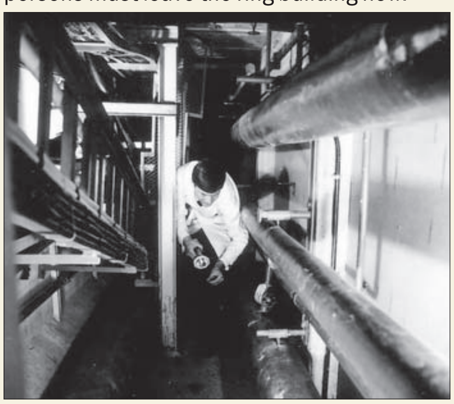
Switching on the PS

After a month's shutdown for maintenance, the proton synchrotron was started up on 18 May. Here we follow the main steps in switching on the PS.

4.00 p.m. A safety patrol sets out to ensure that all is in order inside the magnet ring tunnel and outside in the areas surrounding the PS. A second patrol inspects the basement of the ring tunnel; after this, entrances to the basement are locked.

4.30 p.m. In the main control room the operators are at their stations and the first of several warnings, in four different languages, is broadcast over loudspeakers in the ring building: "Operation will begin in half an hour. The ring building will be cleared of all personnel in 20 minutes."

4.50 p.m. The second warning is broadcast: "Operation will begin in 10 minutes. All persons must leave the ring building now."



6.00 p.m. All doors leading to the inside of the ring are locked electrically. An operator in the main control room can observe the access doors on television screens and authorize entry in an emergency.

In the meantime, two magnet operators have entered the ring tunnel to make sure, visually, that the magnets are in order and that nothing has been forgotten or moved to a dangerous position.

Three other operators and two watchmen also go on a tour of inspection round the ring to make quite sure that everything is normal; for example, that no one is still inside. A few moments later, the magnet operators ask for the magnets to be fed with power and carry out a second inspection, this time listening for any abnormal noises, caused, for example, by metal objects moving in the main magnetic field.

After these inspections the operators leave the ring, watched by closed-circuit television cameras, and the machine is ready to start up.

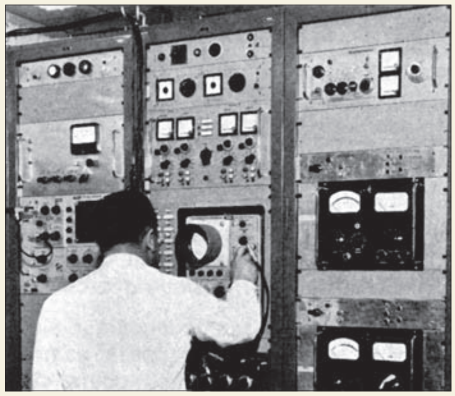
7.30 p.m. Inside the main control room, an operator takes over control of the linear accelerator, the PS injector, which has been running for four or five hours already.

All safety systems having been checked, the operator switches on a recording which will be broadcast in the ring tunnel all of the time that the PS is running: "Attention. You are in danger. Push an emergency stop."

After a further two minutes, the operator presses the beam stopper button, which lets the beam from the linear accelerator enter the synchrotron ring. The PS is in operation: the first pulse of protons has started its journey of nearly 300 000 kilometres inside the vacuum chamber.

In the main control room, various steps to develop a good proton beam begin. One technician adjusts the controls; another follows traces on a "scope". Then comes the moment that they have been waiting for: all eyes turn to a series of illuminated numbers indicating the number of particles accelerated, causing various reactions as to whether it corresponds to the expected value or not.

There is still a lot to do. For example, the accelerated beam has to be directed onto internal targets or ejected from the machine, according to a programme often drawn up long before.



8.00 p.m. From this point onwards, the machine is given over for 12 hours to the engineers, technicians and operators responsible for its running. This time will be used to optimize its performance before making the various beams available to the experimental physicists.

From now on, and during the whole PS running time, the operators on duty, led by an engineer, will watch the machine performance and make any corrections required. They will also answer requests of the experimenters, for example, to move a target or change the beam intensity.

● From the article on pp90–91.

COMPILER'S NOTE

When the PS started up on 24 November 1959 with a beam energy of 25 GeV it was, for a brief period, the world's highest-energy accelerator. Since the 1970s, its principal role has been to supply particles to succeeding accelerators. After some anti-ageing treatment, this venerable machine is part of the injector chain for CERN's most recent arrival, the LHC, which started up in September 2008. After some post-natal treatment, the LHC accelerated twin proton beams to 1.18 TeV on 30 November 2009, taking its turn as the world's highest-energy particle accelerator, 50 years and 6 days after the PS (*CERN Courier* January/February 2010 p24).

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Alan Jackson, former Technical Director of the Project (ASP)

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Black holes and qubits

While string theory and M-theory have yet to make readily testable predictions in high-energy physics, they could find practical applications in quantum-information theory.

Quantum entanglement lies at the heart of quantum information theory (QIT), with applications to quantum computing, teleportation, cryptography and communication. In the apparently separate world of quantum gravity, the Hawking effect of radiating black holes has also occupied centre stage. Despite their apparent differences it turns out that there is a correspondence between the two (Duff 2007; Kallosh and Linde 2006).

Whenever two disparate areas of theoretical physics are found to share the same mathematics, it frequently leads to new insights on both sides. Indeed, this correspondence turned out to be the tip of an iceberg: knowledge of string theory and M-theory leads to new discoveries about QIT, and vice versa.

Bekenstein-Hawking entropy

Every object, such as a star, has a critical size that is determined by its mass, which is called the Schwarzschild radius. A black hole is any object smaller than this. Once something falls inside the Schwarzschild radius, it can never escape. This boundary in space–time is called the event horizon. So the classical picture of a black hole is that of a compact object whose gravitational field is so strong that nothing – not even light – can escape.

Yet in 1974 Stephen Hawking showed that quantum black holes are not entirely black but may radiate energy. In that case, they must possess the thermodynamic quantity called entropy. Entropy is a measure of how disorganized a system is and, according to the second law of thermodynamics, it can never decrease. Noting that the area of a black hole's event horizon can never decrease, Jacob Bekenstein had earlier suggested such a thermodynamic interpretation implying that black holes must have entropy. This Bekenstein–Hawking black-hole entropy is given by one quarter of the area of the event horizon.

Entropy also has a statistical interpretation as a measure of the number of quantum states available. However, it was not until 20 years later that string theory provided a microscopic explanation of this kind for black holes.

Bits and pieces

A bit in the classical sense is the basic unit of computer information and takes the value of either 0 or 1. A light switch provides a good analogy; it can either be off, denoted 0, or on, denoted 1. A quantum bit or "qubit" can also have two states but whereas a classical bit is either 0 or 1, a qubit can be both 0 and 1 until we make a measurement. In quantum mechanics, this is called a superposition of states. When we actually perform a measurement, we will find either 0 or 1 but we cannot predict with certainty what the outcome will be; the best we can do is to assign a probability to each outcome.

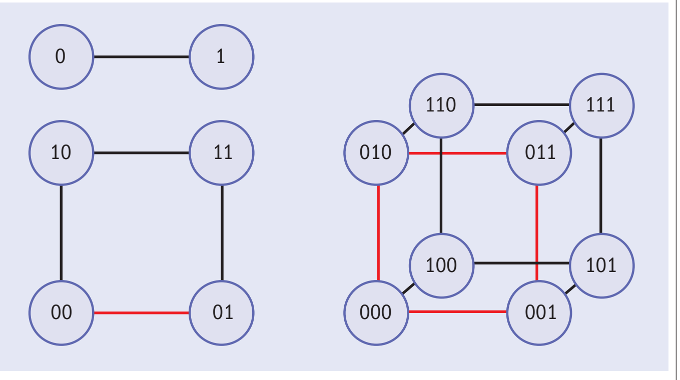

Fig. 1. A single qubit is represented by a line, two qubits by a square and three qubits by a cube.

There are many different ways to realize a qubit physically. Elementary particles can carry an intrinsic spin. So one example of a qubit would be a superposition of an electron with spin up, denoted 0, and an electron with spin down, denoted 1. Another example of a qubit would be the superposition of the left and right polarizations of a photon. So a single qubit state, usually called Alice, is a superposition of Alice-spin-up 0 and Alice-spin-down 1, represented by the line in figure 1. The most general two-qubit state, Alice and Bob, is a superposition of Alice-spin-up–Bob-spin-up 00, Alice-spin-up–Bob-spin-down 01, Alice-spin-down–Bob-spin-up 10 and Alice-spin-down–Bob-spin-down 11, represented by the square in figure 1.

Consider a special two-qubit state that is just 00 + 01. Alice can only measure spin up but Bob can measure either spin up or spin down. This is called a separable state; Bob's measurement is uncorrelated with that of Alice. By contrast, consider 00 + 11. If Alice measures spin up, so too must Bob, and if she measures spin down so must he. This is called an entangled state; Bob cannot help making the same measurement. Mathematically, the square in figure 1 forms a 2×2 matrix and a state is entangled if the matrix has a nonzero determinant.

This is the origin of the famous Einstein–Podolsky–Rosen (EPR) paradox put forward in 1935. Even if Alice is in Geneva and Bob is millions of miles away in Alpha Centauri, Bob's measurement will still be determined by that of Alice. No wonder Albert Einstein called it "spooky action at a distance". EPR concluded rightly that if quantum mechanics is correct then nature is nonlocal, and if we insist on local "realism" then quantum mechanics must be incomplete. Einstein himself favoured the latter hypothesis. However, it was not until 1964 that CERN theorist John Bell proposed an experiment ▷

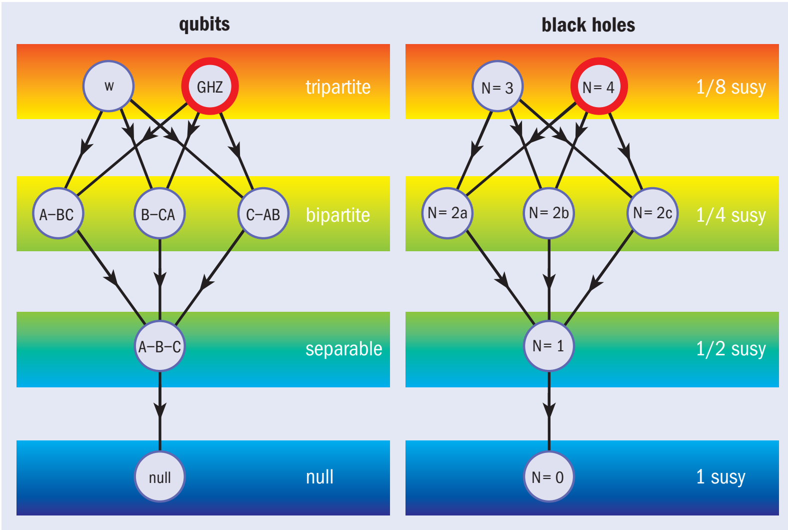

Fig. 2. The classification of three qubits (left) exactly matches the classification of black holes from N wrapped branes (right). Only the GHZ state has a nonzero 3-tangle and only the N = 4 black hole has nonzero entropy.

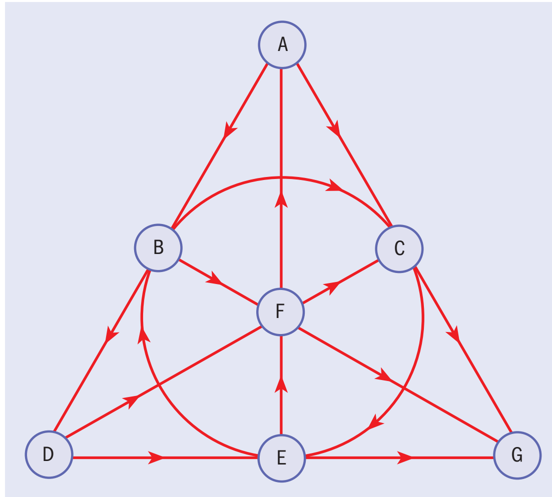

Fig. 3. The Fano plane. The vertices A, B, C, D, E, F, G represents the seven qubits, and the seven lines ABD, BCE, CDF, DEG, EFA, FGB, GAC represent the tripartite entanglement.

that could decide which version was correct – and it was not until 1982 that Alain Aspect actually performed the experiment. Quantum mechanics was right, Einstein was wrong and local realism went out the window. As QIT developed, the impact of entanglement went far beyond the testing of the conceptual foundations of quantum mechanics. Entanglement is now essential to numerous quantum-information tasks such as quantum cryptography, teleportation and quantum computation.

Cayley's hyperdeterminant

As a high-energy theorist involved in research on quantum gravity, string theory and M-theory, I paid little attention to any of this, even though, as a member of staff at CERN in the 1980s, my office was just down the hall from Bell's.

My interest was not aroused until 2006, when I attended a lecture by Hungarian physicist Peter Levay at a conference in Tasmania. He was talking about three qubits Alice, Bob and Charlie where we have eight possibilities 000, 001, 010, 011, 100, 101, 110, 111, represented by the cube in figure 1. Wolfgang Dür and colleagues at the University of Innsbruck have shown that three qubits can be entangled in several physically distinct ways: tripartite GHZ (Greenberger–Horne–Zeilinger), tripartite W, biseparable A-BC, separable A-B-C and null, as shown in the left hand diagram of figure 2 (Dür *et al.* 2000).

The GHZ state is distinguished by a nonzero quantity known as the 3-tangle, which measures genuine tripartite entanglement. Mathematically, the cube in figure 1 forms what in 1845 the mathematician Arthur Cayley called a "$2 \times 2 \times 2$ hypermatrix" and the 3-tangle is given by the generalization of a determinant called Cayley's hyperdeterminant.

The reason this sparked my interest was that Levay's equations reminded me of some work I had been doing on a completely different topic in the mid-1990s with my collaborators Joachim Rahmfeld and Jim Liu (Duff *et al.* 1996). We found a particular black-hole solution that carries eight charges (four electric and four magnetic) and involves three fields called S, T and U. When I got back to London from Tasmania I checked my old notes and asked what would happen if I identified S, T and U with Alice, Bob and Charlie so that the eight black-hole charges were identified with the eight numbers that fix the three-qubit state. I was pleasantly surprised to find that the Bekenstein–Hawking entropy of the black holes was given by the 3-tangle: both were described by Cayley's hyperdeterminant.

Octonions and super qubits

According to supersymmetry, for each known boson (integer spin 0, 1, 2 and so on) there is a fermion (half-integer spin 1/2, 3 /2, 5/2 and so on), and vice versa. CERN's Large Hadron Collider will be looking for these superparticles. The number of supersymmetries is denoted by $\mathcal{N}$ and ranges from 1 to 8 in four space–time dimensions.

CERN's Sergio Ferrara and I have extended the STU model example, which has $\mathcal{N}=2$, to the most general case of black holes in $\mathcal{N}=8$ supergravity. We have shown that the corresponding system in quantum-information theory is that of seven qubits (Alice, Bob, Charlie, Daisy, Emma, Fred and George), undergoing at most a tripartite entanglement of a specific kind as depicted by the Fano plane of figure 3.

The Fano plane has a strange mathematical property: it describes the multiplication table of a particular kind of number: the octonion. Mathematicians classify numbers into four types: real numbers, complex numbers (with one imaginary part A), quaternions (with three imaginary parts A, B, D) and octonions (with seven imaginary parts A, B, C, D, E, F, G). Quaternions are noncommutative because AB does not equal BA. Octonions are both noncommutative and nonassociative because (AB)C does not equal A(BC).

Real, complex and quaternion numbers show up in many physical contexts. Quantum mechanics, for example, is based on complex numbers and Pauli's electron-spin operators are quaternionic. Octonions have fascinated mathematicians and physicists for decades but have yet to find any physical application. In recent books, both Roger Penrose and Ray Streater have characterized octonions as one of the great "lost causes" in physics. So we hope that the tripartite entanglement of seven qubits (which is just at the limit of what can be reached experimentally) will prove them wrong and provide

Table 1

x^0	x^1	x^2	x^3	x^4	x^5	x^6	x^7	x^8	x^9	brane	ABC
X	O	O	O	X	O	X	O	X	O	D3	000
X	O	O	O	X	O	O	X	O	X	D3	011
X	O	O	O	O	X	X	O	O	X	D3	101
X	O	O	O	O	X	O	X	X	O	D3	110

Table 1. A GHZ state corresponds to a four-charge black hole in 4-dimensional space–time x^0, x^1, x^2, x^3 coming from four D3-branes each wrapping three of the six extra dimensions (x^4, x^6, x^8), (x^4, x^7, x^9), (x^5, x^6, x^9) and (x^5, x^7, x^8).

a way of seeing the effects of octonions in the laboratory (Duff and Ferrara 2007; Borsten *et al.* 2009a).

In another development, QIT has been extended to super-QIT with the introduction of the superqubit, which can take on three values: 0 or 1 or \$. Here 0 and 1 are "bosonic" and \$ is "fermionic" (Borsten *et al.* 2009b). Such values can be realized in condensed-matter physics, such as the excitations of the t-J model of strongly correlated electrons, known as spinons and holons. The superqubits promise totally new effects. For example, despite appearances, the two-superqubit state \$\$ is entangled. Superquantum computing is already being investigated (Castellani *et al.* 2010).

Strings, branes and M-theory

If current ideas are correct, a unified theory of all physical phenomena will require some radical ingredients in addition to supersymmetry. For example, there should be extra dimensions: supersymmetry places an upper limit of 11 on the dimension of space–time. The kind of real, four-dimensional world that supergravity ultimately predicts depends on how the extra seven dimensions are rolled up, in a way suggested by Oskar Kaluza and Theodor Klein in the 1920s. In 1984, however, 11-dimensional supergravity was knocked off its pedestal by superstring theory in 10 dimensions. There were five competing theories: the E8 × E8 heterotic, the SO(32) heterotic, the SO(32) Type I, and the Type IIA and Type IIB strings. The E8 × E8 seemed – at least in principle – capable of explaining the elementary particles and forces, including their handedness. Moreover, strings seemed to provide a theory of gravity that is consistent with quantum effects.

However, the space–time of 11 dimensions allows for a membrane, which may take the form of a bubble or a two-dimensional sheet. In 1987 Paul Howe, Takeo Inami, Kelly Stelle and I showed that if one of the 11 dimensions were a circle, we could wrap the sheet round it once, pasting the edges together to form a tube. If the radius becomes sufficiently small, the rolled-up membrane ends up looking like a string in 10 dimensions; it yields precisely the Type IIA superstring. In a landmark talk at the University of Southern California in 1995, Ed Witten drew together all of this work on strings, branes and 11 dimensions under the umbrella of M-theory in 11 dimensions. Branes now occupy centre stage as the microscopic constituents of M-theory, as the higher-dimensional progenitors of black holes and as entire universes in their own right.

Such breakthroughs have led to a new interpretation of black holes as intersecting black-branes wrapped round the seven curled dimensions of M-theory or six of string theory. Moreover, the microscopic origin of the Bekenstein-Hawking entropy is now demystified. Using Polchinski's D-branes, Andrew Strominger and Cumrun Vafa were able to count the number of quantum states of these wrapped branes (Strominger and Vafa 1996). A p-dimensional D-brane (or Dp-brane) wrapped round some number p of the compact directions (x^4, x^5, x^6, x^7, x^8, x^9) looks like a black hole (or D0-brane) from the four-dimensional (x^0, x^1, x^2, x^3) perspective. Strominger and Vafa found an entropy that agrees with Hawking's prediction, placing another feather in the cap of M-theory. Yet despite all of these successes, physicists are glimpsing only small corners of M-theory; the big picture is still lacking. Over the next few years we hope to discover what M-theory really is. Understanding black holes will be an essential prerequisite.

Falsifiable predictions?

The partial nature of our understanding of string/M-theory has so far prevented any kind of smoking-gun experimental test. This has led some critics of string theory to suggest that it is not true science. This is easily refuted by studying the history of scientific discovery; the 30-year time lag between the EPR idea and Bell's falsifiable prediction provides a nice example (see Further reading p16). Nevertheless it cannot be denied that such a prediction in string theory would be welcome.

In string literature one may find D-brane intersection rules that tell us how N branes can intersect over one another and the fraction of supersymmetry (susy) that they preserve (Bergshoeff *et al.* 1997). In our black hole/qubit correspondence, my students Leron Borsten, Duminda Dahanayake, Hajar Ebrahim, William Rubens and I showed that the microscopic description of the GHZ state 000+011+101+110 is that of the N = 4;1/8 susy case of D3-branes of Type IIB string theory (Borsten *et al.* 2008). We denoted the wrapped circles by crosses and the unwrapped circles by noughts; 0 corresponds to XO and 1 to OX, as in table 1. So the number of qubits here is three because the number of extra dimensions is six. This also explains where the two-valuedness enters on the black-hole side. To wrap or not to wrap; that is the qubit.

Repeating the exercise for the N < 4 cases and using our dictionary, we see that string theory predicts the three-qubit entanglement classification of figure 2, which is in complete agreement with the standard results of QIT. Allowing for different p-branes wrapping different dimensions, we can also describe "qutrits" (three-state systems) and more generally "qudits" (d-state systems). Furthermore, for the well documented cases of 2 × 2, 2 × 3, 3 × 3, 2 × 2 × 3 and 2 × 2 × 4, our

D-brane intersection rules are also in complete agreement. However, for higher entanglements, such as 2 × 2 × 2 × 2, the QIT results are partial or not known, or else contradictory. This is currently an active area of research in QIT because the experimentalists can now control entanglement with a greater number of qubits. One of our goals is to use the allowed wrapping configurations and D-brane intersection rules to predict new qubit-entanglement classifications.

So the esoteric mathematics of string and M-theory might yet find practical applications.

Further reading

Read or listen to Michael Duff's debate with Lee Smolin in 2007 at the Royal Society for the Arts about "The trouble with physics – the rise of string theory, the fall of a science and what comes next" at www.thersa.org/events/speakers-archive/d/michael-duff.
E Bergshoeff *et al.* 1997 *Nucl. Phys.* **B494** 119, arXiv:hep-th/9612095.
L Borsten *et al.* 2008 *Phys. Rev. Lett.* **100** 251602, arXiv:0802.0840 [hep-th].
L Borsten *et al.* 2009a *Phys. Rep.* **471** 113, arXiv:0809.4685 [hep-th].
L Borsten *et al.* 2009b arXiv:0908.0706 [quant-ph].
L Castellani *et al.* 2010 arXiv:1001.3753 [hep-th].
M J Duff *et al.* 1996 *Nucl. Phys.* **B459** 125, arXiv:hep-th/9508094.
M J Duff 2007 *Phys. Rev.* **D76** 025017, arXiv:hep-th/0601134.
M J Duff and S Ferrara 2007 *Phys. Rev.* **D76** 025018, arXiv:quant-ph/0609227.
W Dür *et al.* 2000 *Phys. Rev.* **A62** 062314, arXiv:quant-ph/0005115.
R Kallosh and A Linde 2006 *Phys. Rev.* **D73** 104033, arXiv:hep-th/0602061.
A Strominger and C Vafa 1996 *Phys. Lett.* **B379** 99, arXiv:hep-th/9601029.

Résumé

Trous noirs et qubits

Quand deux domaines très différents de la physique théorique ont en commun les mêmes mathématiques, cela aboutit souvent à de nouvelles découvertes des deux côtés. Le concept d'intrication quantique, au cœur de la théorie de l'information quantique, a des applications dans les domaines de l'informatique quantique, de la téléportation, de la cryptographie et de la communication. Dans le monde de la gravité quantique, les trous noirs peuvent émettre de l'énergie du fait de l'effet Hawking. Malgré les disparités apparentes, il y a un rapport entre ces deux sujets. Cette correspondance s'avère même être la partie émergée d'un iceberg : l'exploration de la théorie des cordes et de la théorie M amène à de nouvelles découvertes sur la théorie de l'information quantique et inversement.

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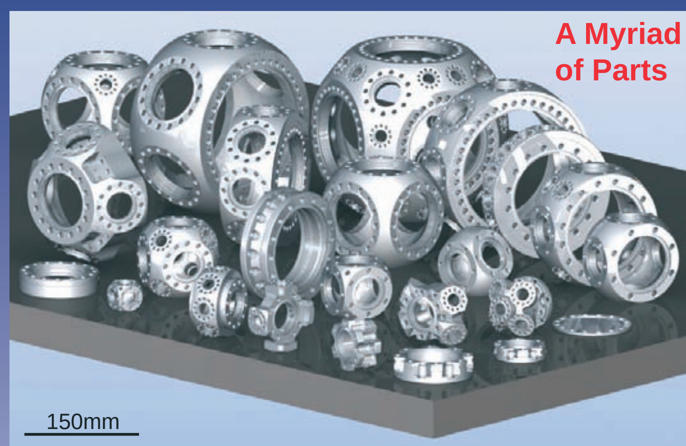

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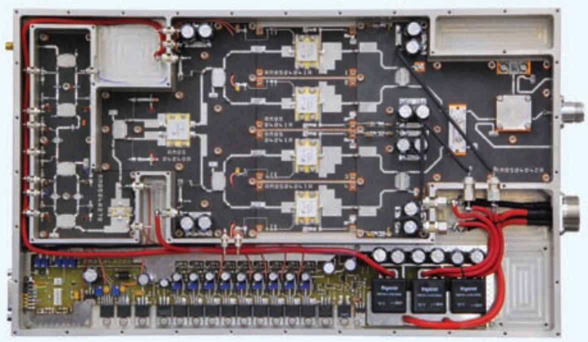

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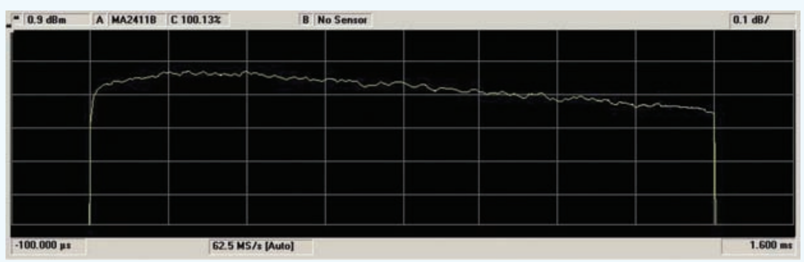

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MoEDAL becomes the LHC's magnificent seventh

A new experiment is set to join the LHC fold. As **James Pinfold** explains, MoEDAL will conduct the search for magnetic monopoles.

On 2 December 2009 the CERN Research Board approved the LHC's seventh experiment: the Monopole and Exotics Detector At the LHC (MoEDAL). The prime motivation of this experiment is to search for the direct production of the magnetic monopole at the LHC. Another physics aim is the search for exotic, highly ionizing, stable (or pseudo-stable) massive particles (SMPs) with conventional electric charge. Although MoEDAL is a small experiment by LHC standards it has a huge physics potential that complements the already wide vista of the existing LHC experiments.

The scientific quest for the magnetic monopole – a single magnetic charge, or pole – began during the siege of Lucera in 1269 with the Picard Magister, Petrus Peregrinus. He was a Franciscan monk, a soldier, a scientist and a former tutor to Roger Bacon, who considered him the foremost experimentalist of his day. It was during this siege that Peregrinus put the finishing touches to a long letter entitled *the Epistole de Magnete*, which is his only surviving work. In this document, Peregrinus scientifically established that magnets have two poles, which he called the north and south poles.

In 1864 the Scottish physicist James Clerk Maxwell published the 19th-century equivalent of a grand unified theory, which encompassed the separate electric and magnetic forces into a single electromagnetic force (Maxwell 1864). Maxwell banished isolated magnetic charges from his four equations because no isolated magnetic pole had ever been observed. This brilliant simplification, however, led to asymmetric equations, which called for the aesthetically more attractive symmetric theory that would result if a magnetic charge did exist. Thirty years later, Pierre Curie looked into the possibility of free magnetic charges and found no grounds why they should not exist, although he added that it would be bold to deduce that such objects therefore existed (Curie 1894).

Paul Dirac, in a paper published 1931, proved that the existence of the magnetic monopole was consistent with quantum theory (Dirac 1931 and 1948). In this paper, he showed that the existence of the magnetic monopole not only symmetrized Maxwell's equations, but also explained the quantization of electric charge. To Dirac the beauty of mathematical reasoning and physical argument were instruments for discovery that, if used fearlessly, would lead to unexpected but valid conclusions. Perhaps the single contribution that best illustrates Dirac's courage is his work on the magnetic monopole. Today, magnetic-monopole solutions are found in many modern theories such as grand unified theories, string theory and M-theory. The big mystery is, where are they?

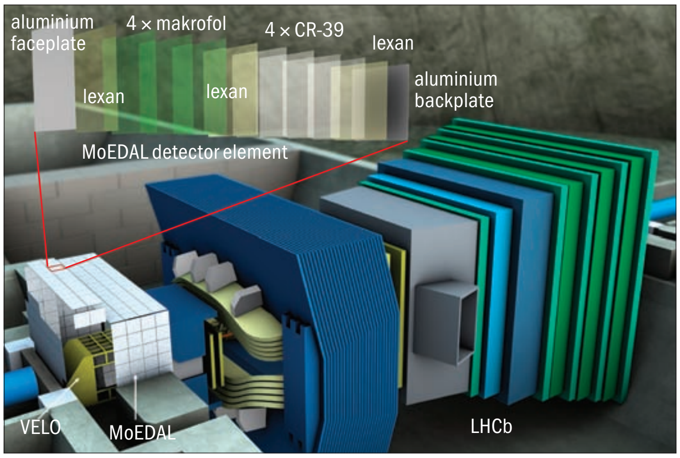


Fig. 1. The MoEDAL detectors will be deployed close to the interaction point for the LHCb experiment. (Courtesy MoEDAL collaboration.)

In the 1980s, two experiments found signals induced in single superconducting loops that could have indicated the passage of monopoles, but firmer evidence with coincidences in two loops was never found. Cosmic-ray experiments have also searched for monopoles but so far to no avail. For example, the Monopole, Astrophysics and Cosmic Ray Observatory (MACRO) detector in the Gran Sasso National Laboratory has set stringent upper limits (*CERN Courier* May 2003 p21). High-energy collisions at particle accelerators offer another obvious hunting ground for monopoles. Searches for their direct production have usually figured at any machine entering a new high-energy regime – and the LHC will be no exception.

New limits

At CERN, the search for magnetic monopoles – using dedicated detectors – began in 1961 with a counter experiment to sift through the secondary particles produced in proton–nucleus collisions at the PS (Fidecaro 1961). Over the following years, searches took place at the Interacting Storage Rings and at the SPS. At the Large Electron–Positron (LEP) collider, the hunt for monopoles in e^+e^- collisions was carried out in two experiments: MODAL (the Monopole Detector at LEP), deployed at intersection point I6 on the LEP ring (Kinoshita *et al.* 1992); and the OPAL monopole detector, positioned around the beam pipe at the OPAL intersection point (Pinfold *et al.* 1993). These established new limits on the direct production of monopoles.

The international MoEDAL collaboration, made up of physicists ▷

from Canada, CERN, the Czech Republic, Germany, Italy, Romania and the US, is preparing to deploy the MoEDAL detector during the next long shutdown of the LHC, which will start late in 2011. The full detector comprises an array of approximately 400 nuclear track detectors (NTDs). Each NTD consists of a 10-layer stack of plastic (CR-39 and MAKROFOL) and altogether they have a total surface area of 250 m^2. The detectors are deployed at the intersection region at Point-8 on the LHC ring around the VErtex LOcato (VELO) of the LHCb detector, as figure 1 indicates. The MoEDAL collaboration positioned 1 m^2 of test detectors before the LHC was closed for operation in November 2009. Figure 2 shows the detectors being installed. If feasible, they will be removed for analysis during the planned short shutdown at the end of 2010 and a substantial subset of the full detector system will be deployed for the run in 2011.

The MoEDAL detector is like a giant camera for photographing new physics in the form of highly ionizing particles, and the plastic NTDs are its "photographic film". When a relativistic magnetic monopole – which has approximately 4700 times more ionizing power than a conventional charged minimum-ionizing particle – crosses the NTD stack it damages polymeric bonds in the plastic in a small cylindrical region around its trajectory. The subsequent etching of the NTDs leads to the formation of etch-pit cones around these trails of microscopic damage. These conical pits are typically of micrometre dimensions and can be observed with an optical microscope. Their size, shape and alignment yield accurate information about the effective Z/β ratio, where Z is the charge and β the speed, as well as the directional motion of the highly ionizing particle.

The main LHC experiments are designed to detect conventionally charged particles produced with a velocity high enough for them to travel through the detector within the LHC's trigger window of 25 ns – the time between bunch crossings. Any exotic, highly ionizing SMPs produced at the LHC might not travel through the detector within this trigger window and so will have a low efficiency for detection. Also, the sampling time and reconstruction software of each sub-detector is optimized assuming that particles are travelling at close to the velocity of light. Hence, the quality of the read-out signal, reconstructed track or cluster may be degraded for an SMP, especially for subsystems at some distance from the interaction point.

Another challenge is that very highly ionizing particles can be absorbed before they penetrate the detector fully. Additionally, the read-out electronics of conventional LHC detector systems are usually not designed to have a wide enough dynamic range to measure the very large dE/dx of highly ionizing particles properly. In the case of the magnetic monopole there is also the problem of understanding the response of conventional LHC detector systems to particles with magnetic charge.

The MoEDAL experiment bypasses these experimental challenges by using a passive plastic NTD technique that does not require a trigger. Also, track-etch detectors provide a tried-and-tested method to detect and measure accurately the track of a very highly ionizing particle and its effective Z/β. Importantly, heavy-ion beams provide a demonstrated calibration technique because they leave energy depositions very similar to those of the hypothetical particles sought. If it exists, a magnetic monopole will leave a characteristic set of 20 collinear etch-pits. There is no other conventional particle that could produce such a distinctive signature – thus, even one event would herald a discovery.

Fig. 2. Installing test detectors at LHCb. (Courtesy MoEDAL.)

One of the world's leading string theorists, Joseph Polchinski, has reversed Dirac's connection between magnetic monopoles and charge quantization. He has posited that in any theoretical framework that requires charge to be quantized, there will exist magnetic monopoles. He also maintains that in any fully unified theory, for every gauge field there will exist electric and magnetic sources. Speaking at the Dirac Centennial Symposium at Tallahassee in 2002, he commented that "the existence of magnetic monopoles seems like one of the safest bets that one can make about physics not yet seen" (Polchinski 2003). The MoEDAL collaboration is working to prove him right.

Further reading

For further information, including the *Technical Design Report*, see http://web.me.com/jamespinfold/MoEDAL_site/Welcome.html.

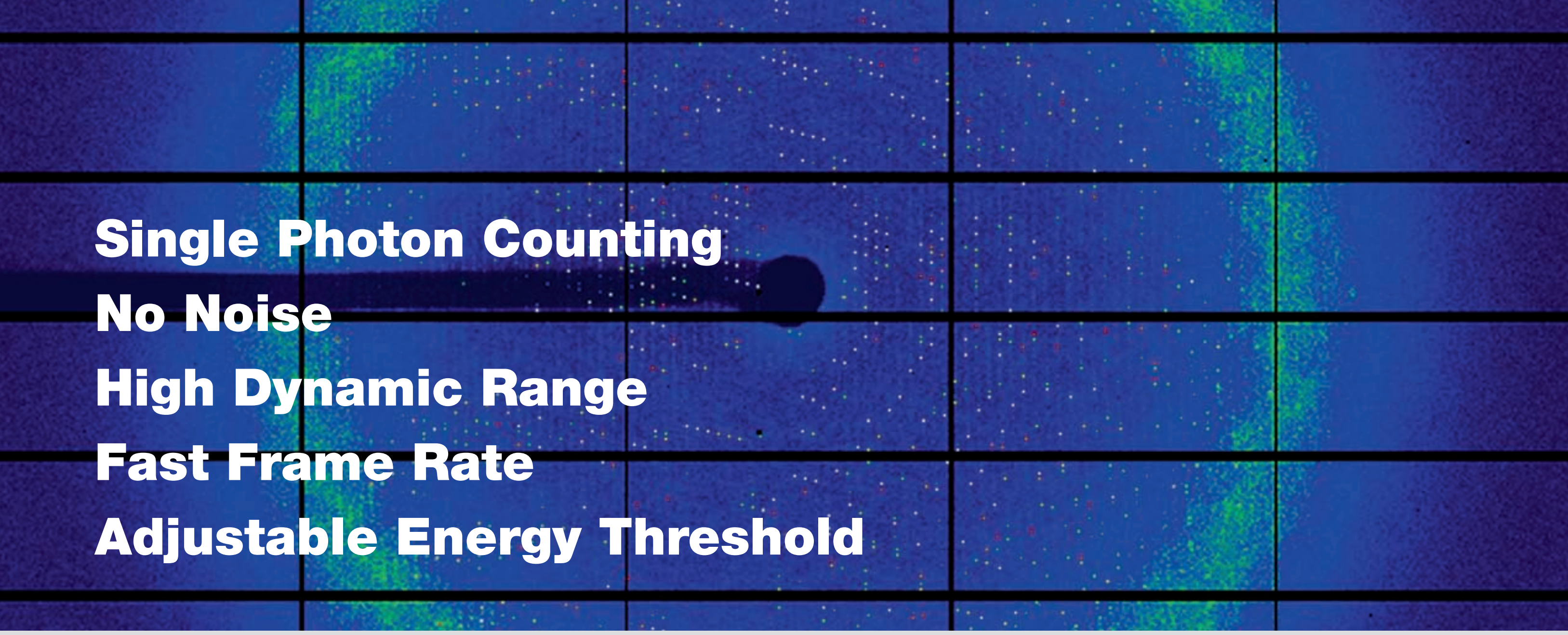
P Curie 1894 *Séances de la Société Française de Physique* (Paris) 76.
P A M Dirac 1931 *Proc. Roy. Soc. Lond.* **A** 133 60.
P A M Dirac 1948 *Phys. Rev.* **74** 817.
K Kinoshita.*et al.* 1992 *Phys. Rev.* **D46** R881.
J C Maxwell 1864 *Philosophical Transactions of the Royal Society of London* **155** 459.
J L Pinfold *et al.* 1993 *Phys. Lett. B* **316** 407.
J Polchinski 2004 *Int. J. Mod. Phys.* **A19** S1 145.

Résumé

MoEDAL devient la septième expérience du LHC

Le 2 décembre 2009, la Commission de la recherche du CERN a approuvé la septième expérience du LHC : le détecteur MoEDAL (Monopole and Exotics Detector At the LHC). Le premier objectif de cette expérience est de rechercher la production directe du monopôle magnétique auprès du LHC. Elle s'efforcera également de découvrir des particules massives stables (ou pseudo-stables) fortement ionisantes à charge électrique conventionnelle. De dimensions modestes, par rapport aux autres détecteurs du LHC, le détecteur MoEDAL est constitué d'un ensemble d'environ 400 détecteurs de traces nucléaires (NTD). Ceux-ci sont déployés à la région d'intersection au point 8 de l'anneau du LHC, à proximité du détecteur VELO de l'expérience LHCb.

James Pinfold, *University of Alberta, spokesperson for the MoEDAL collaboration.*



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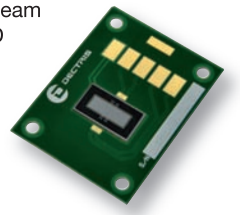

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CERN@school brings real research to life

Becky Parker, the inspirational teacher behind a project in which school students are using chips developed at CERN to design a cosmic-ray detector that will fly into space, talks to **Antonella Del Rosso** about how her school is making it 'cool' to study physics.

School is where students study what is in textbooks and university is where they start doing research. Or so most people think. It therefore comes as a surprise to discover that teenagers still at school can participate in a research programme that allies space science and earth science. While sceptical educators would argue that in a normal situation teachers have no time, energy, motivation or money for such projects, Becky Parker at Simon Langton Grammar School in the UK has proved that the opposite can be true.

Inspired during a visit to CERN in 2007, she decided to bring leading-edge research to her school. Instead of going back with a simple presentation about how CERN works, Becky took back a real detector and started sowing ideas about how to set up a real research programme, which she called CERN@school. Her ideas fell on fertile ground as her school in Canterbury, in the county of Kent, is one of the most active in implementing innovative ways of teaching science in the UK. One of the school's declared goals is to "provide learning experiences which are enjoyable, stimulating and challenging and which encourage critical and innovative thinking". Students at Simon Langton Grammar School do not just study science, they do it.

"During one of my visits to CERN, I had the opportunity to meet Michael Campbell of the Medipix collaboration, and his young enthusiastic team," recalls Becky. "They showed me the Timepix chip that they were developing for particle and medical physics. I thought that something like this could be used in schools for conducting experiments with cosmic rays and radioactivity."

High-school students in Kent monitor the read-out from a Timepix detector (left). (Courtesy Simon Langton Grammar School.)

Cross-collaboration

The Timepix chip is derived from Medipix2, a device developed at CERN that can accurately measure the position and energy of single photons hitting an associated detector. The most recent success of the Medipix collaboration is the Medipix3 chip, which is being used in a project to deliver the first X-ray images with colour (energy) information. Initially designed for use in medical physics and particle physics, the Timepix chip now has applications that include beta- and gamma-radiography of biological samples, materials analysis, monitoring of nuclear power-plant decommissioning and electron microscopy, as well as the adaptive optics that are used in large, ground-based telescopes.

The students at Simon Langton Grammar School use the Timepix chip by connecting it directly to their computer via a USB interface box. "The box was developed by the Institute of Experimental and Applied Physics in Prague," explains Becky. "They also developed the Pixelman software that we use to read out the data." The chip and the box have a certain material cost but the software is made available for free by the Medipix collaboration.

Given the simple set-up and its relatively low cost, Becky's idea can potentially be transferred to many other schools across the UK and elsewhere in Europe. "Collaboration is a key factor in modern research," confirms Becky. "And, like in a real scientific collaboration, we are going to involve as many schools as possible in our project. We have received funding from Kent to put 10 Timepix chips into the county's schools to create a network. This will allow us to show students how you do things at CERN and in other big laboratories."

By setting-up a network, schools will collect large amounts of data on cosmic rays. "In the future we hope to have Timepix detectors in schools across the world. Participating schools will be able to send data back to us because we have powerful IT facilities and we can store large quantities of data," says Becky. "We know that in other countries, such as Canada, Italy and the Netherlands, there are similar school programmes that collect data on cosmic rays. It would be ideal if we could all join our efforts and integrate all of the collected data together."

Timepix in space

Nothing is out of reach for Becky's ambitious teaching methods, not even deep space. In 2008 the school's students decided to enter a national competition run by the British National Space Centre to design experiments that will fly in space. Next year, Surrey Satellite Technology Ltd will fly the Langton Ultimate Cosmic ray Intensity Detector (LUCID), a cosmic-ray detector array designed by Langton's sixth-form students, on one of its satellites. "The students are learning so much from working on LUCID with David Cooke at Surrey Satellite Technology Limited and Professor Larry Pinsky from the University of Houston," says Becky.

In LUCID, four Timepix chips are mounted on the sides of a cube (figure 1). Students have demonstrated that the four chips allow for the largest active area without breaking power and data transmission limits. A fifth chip, mounted horizontally on the base of the cube, will be modified to detect neutrons. LUCID's electronics, including a field-programmable gate array for read-out, will be on printed circuit boards attached to the chips.

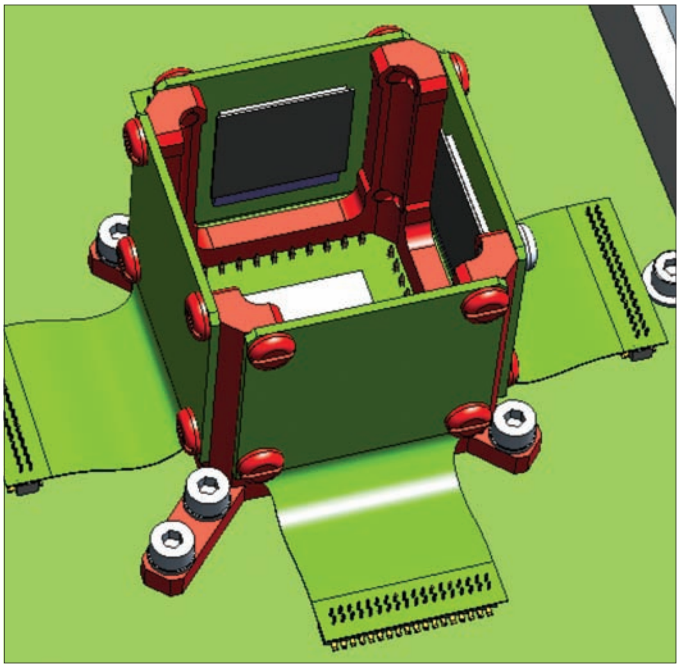

Fig. 1. The LUCID with four Timepix chips mounted on the sides of a cube. A fifth chip is mounted on the base. (Courtesy SSTL PDR.)

Students with their research projects including the CERN@school detector at the Royal Society Summer Science Exhibition 2009. (Courtesy Simon Langton Grammar School).

The Timepix detectors produced at CERN do not qualify for use in space. "At one of the last stages of the competition, we were told that our project would go through if we could raise the additional £60 000 needed to qualify the Timepix detectors for space," Becky recalls. Thanks to the support of the South East England Development Agency and Kent County Council the money was found and LUCID could go into space. LUCID will be mounted outside the spacecraft's fuselage, housed in a 3 mm (0.81 g cm^{-2}) or 4 mm (1.08 g cm^{-2}) enclosure. Components will mostly be on an inside face of the board offering a further 0.25 g cm^{-2} of shielding. The detector will also have to be qualified to withstand a vibration level of 20 g_{rms}.

Under Becky's plans, data from LUCID will be compared with data collected by detectors installed on Earth, thus providing information about cosmic rays. "We expect terabytes of data each year from space. We will receive support from the UK Particle Physics Grid (GridPP) to use the Grid. It is a whole research package!," she says.

The CERN@school project is not the only scientific project that Simon Langton Grammar School students are carrying out. "We collaborate with Imperial College on a research project in plasma physics. One of our students won the 'Young Scientist of the Year' prize and published a paper in a proper scientific journal. Others participate in a scientific project for the observation of exoplanets using the Faulkes Telescopes in Hawaii and Australia," says Becky.

In addition the school hosts special projects in biology and in other branches of science, and also has its own research centre, the Langton Star Centre. This facility, still under construction, will have laboratories and training and seminar rooms. "We will be able to train teachers and students from other schools who want to take part in CERN@school and our other projects," explains Becky. The centre's website will include pages where data and analysis results from the network of participating schools will be shared.

These innovative teaching approaches benefit both students and teachers. The school's philosophy is that 30% of the activities carried out must be beyond the official syllabus. The outcome is that the school provides about 1% of the total number of students studying for physics and engineering degrees at British universities. At the same time, motivating the teachers becomes much easier when they have the prospect of participating in real research ▷

programmes in collaboration with CERN, for example.

Many young people at school do not know what it would be like to study physics or engineering at university and do forefront research. However, when they get to work with the real scientists, they discover how amazing this is and readily jump aboard ambitious programmes. "If teachers let students take control in these kinds of projects, they will not mess around – they are going to do all of this properly because they know that this is serious stuff," assures Becky. "With my students, I am quite rigorous. I tell them that they are going to do it like real scientists. And because this is really an amazing thing to be involved with, they do it properly and with a lot of enthusiasm."

Becky's attitude to "her" students, whom she calls "sweethearts", is a far cry from that of teachers who say how difficult it is to control behaviour in schools and motivate students every day. So why is Becky's experience so different? "I am in a lovely school," she explains. "The cool thing to do at my school is physics. A 12 year old came to me last year and said: 'Miss, we would like you to teach us quantum physics' and so I did it."

Becky's initiative to foster the knowledge of "cool" physics in the region includes the "Langton Guide to the Universe", in which parents are invited to attend physics lectures on modern and exciting physics. "Families come and receive a first input on things like quantum mechanics. Some kids who attended those lectures when they were very young later joined the school and set up the 'quantum working group', which produced a guide to how to teach quantum mechanics to the youngest. They have entered a national competition and reached the final." These are the sort of expectations that you can have when you go to Simon Langton Grammar School. As Becky explains: "Our philosophy is that if students are interested in doing a scientific project, however ambitious, they can come and talk to us. This is your world, take the initiative and make it successful!"

● For more information about the LUCID project, see www.thelangtonstarcentre.org/.

Résumé

Chercheurs en herbe

On s'imagine généralement que les élèves du secondaire ont à apprendre ce qui se trouve dans les manuels : la recherche, c'est pour plus tard, à l'université. Or des lycéens peuvent participer à un programme de recherche alliant science de l'espace et science de la terre. Becky Parker nous présente un projet dans lequel des lycéens utilisent des cellules réalisées au CERN pour construire un détecteur de rayons cosmiques qui sera envoyé dans l'espace. Grâce à cette approche innovante de l'enseignement scientifique, l'établissement où elle enseigne produit à lui tout seul 1% de l'effectif total des formations en physique et ingénierie des universités du Royaume-Uni.

Antonella Del Rosso, *CERN.*

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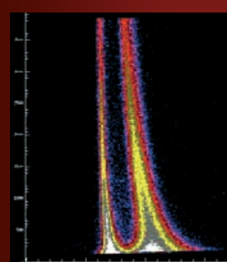

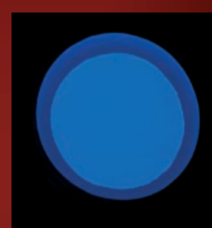

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The LHC's new frontier

The first 7 TeV collisions herald the start of physics at the high-energy frontier.

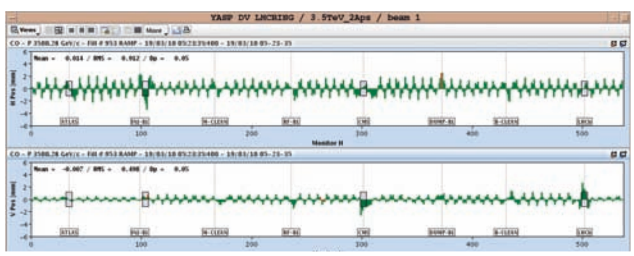
On 30 March, just one month after CERN's Large Hadron Collider (LHC) had restarted for 2010, control rooms around the 27 km ring echoed with cheers as the machine produced the first collisions at a record energy of 7 TeV in the centre of mass. Over the following days, the LHC experiments started to amass millions of events during long periods of running with stable beams, thus beginning an extended journey of exploration at a new energy frontier.

The first taste of beam for 2010, on 28 February, was at 450 GeV, the injection energy from the SPS (*CERN Courier* April 2010 p6). Operating the LHC at this energy soon became routine, allowing the teams to perform the tests necessary to optimize the beam orbit and the collimation, as well as the injection and extraction procedures. This work resulted in the definition of the parameters for collimation and machine protection devices for a "golden" reference orbit, with excellent reproducibility. It showed that the collimation system works as designed, with beam "cleaning" and other losses exactly where expected at the primary collimators. The tests also involved systematic and thorough testing of the beam dumping system, which proved to work well. One mystery about the beam still remains: the "hump", a broad frequency-driven beam excitation that leads to an increase in the vertical beam size. Nevertheless, the teams measured good beam lifetimes, and in just under two weeks, on 12 March, the operators were able to ramp the beams up to 1.18 TeV, the highest energy achieved in 2009 (*CERN Courier* January/February p24).

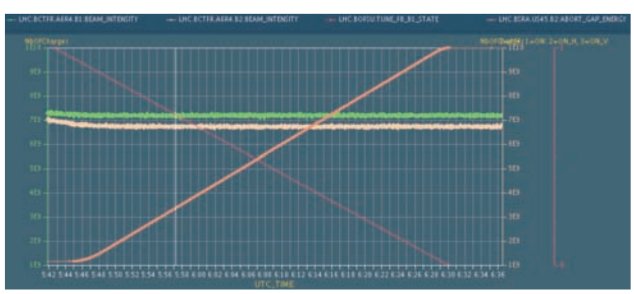
A short technical stop followed, during which the magnet and magnet protection experts continued their campaign to commission the machine to 6 kA – the current needed in the main magnets to operate at 3.5 TeV per beam. A key feature is the quench protection system (QPS): on detecting the first indication that part of a superconducting magnet coil is turning normally conducting – quenching – it forces the whole coil to become normally conducting, thereby distributing the energy of the magnet current over its whole length. In the induced quench, the huge amount of energy stored in the coil is safely extracted and "dumped" into specially designed resistors. At the same time the QPS triggers a mechanism to dump beam within three turns.

In 2009, the system was fully commissioned to 2 kA, the current necessary to reach an energy of 1.18 TeV. However, during the final stages of hardware commissioning in February, multiple induced quenches sometimes occurred during powering off. It turns out that the system can be "over-protective", because transient signals unrelated to real quenches can trigger controlled quenches. Once the problem was understood, the machine protection experts decided that they could solve it by changing thresholds in the magnet circuits equipped with the new QPS. For those parts with the old QPS, however, the solution required a modification to cards in the tunnel (to delay one of the transients). While awaiting full tests before ▷

It's there – 3.5 TeV for the first time in the early morning of 18 March. Mike Lamont points to the record energy on the screen.



The difference between the orbit for beam 1 immediately after the first ramp to 3.5 TeV and the reference orbit for 450 GeV.



By 26 March, ramps to 3.5 TeV at 2 A/s in just less than 47 minutes are routine, here with 7×10^9 protons in both beams (green/cream traces).

implementing these changes (later in April), the experts took the decision to go ahead and run the main bending magnets up to 6 kA, but to limit the ramp rate to 2 A/s to reduce the transients.

By midday on 18 March the operators had the green light to try ramping to 6 kA at the agreed slow rate, first testing this ramp rate to 2 kA (1.18 TeV). By 10.00 p.m., after one or two interruptions, they had succeeded with a "dry ramp", without beams. Work on beam injection and orbit corrections followed before a ramp started at around 4.00 a.m. with a low-intensity probe beam – about 5×10^9 protons in a single bunch per beam. Gradually, the current in the main bending magnets rose from 460 to 5850 A and at about 5.23 a.m. the beams reached 3.5 TeV – a new world record at the first attempt. Already, measurements suggested a lifetime for both beams of as long as 100 hours.

Over the following days, machine studies at 3.5 TeV continued, with ramping becoming routine and the orbit stable and reproducible. Just as at 450 GeV, machine protection and collimation studies were important before the step to collisions at 3.5 TeV could take place. Only then would the operators be able to declare "stable beam" conditions so that the experiments could turn on the most sensitive parts of their detectors to observe events at the new high-energy frontier.

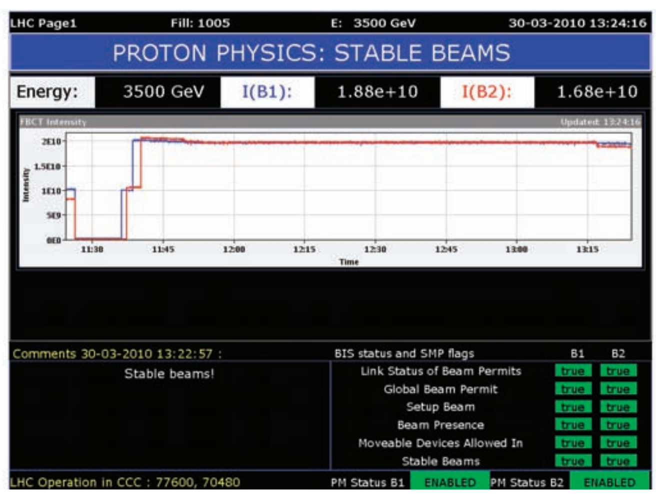
With some critical work still remaining, on 23 March the management took the decision to announce that the first attempt at collisions would take place a week later, on 30 March, with invited media in full attendance. The following days were not without difficulties, as a variety of hardware problems occurred, and each morning saw a change of plans in the run-up to the first collisions at 3.5 TeV per beam. Further planned running at 450 GeV and studies at higher intensities at 450 GeV were among the casualties. By 29 March, however, the operators had performed all of the essential tests for declaring "stable beams" at 3.5 TeV and were able to run the machine for several hours at a time, with a non-colliding bunch pattern to avoid premature collisions in any of the experiments.

Finally at 4.00 a.m. on 30 March the LHC team was ready to inject beam in a colliding bunch pattern with two bunches per beam, in preparation for collisions. After the necessary checks, they began the ramp to 3.5 TeV at 6.00 a.m. just as the first media were arriving on CERN's Meyrin site. Twice, part of the machine tripped during the ramp and twice the operators had to ramp back down and re-establish beam at 450 GeV. The third attempt, however, from 11.52 a.m. to 12.38 p.m., was successful. Then, after some final measurements on the beam, it was time to remove the "separation bumps" – the fields in corrector magnets that are used to keep the beams separated at the interaction points during the ramp.

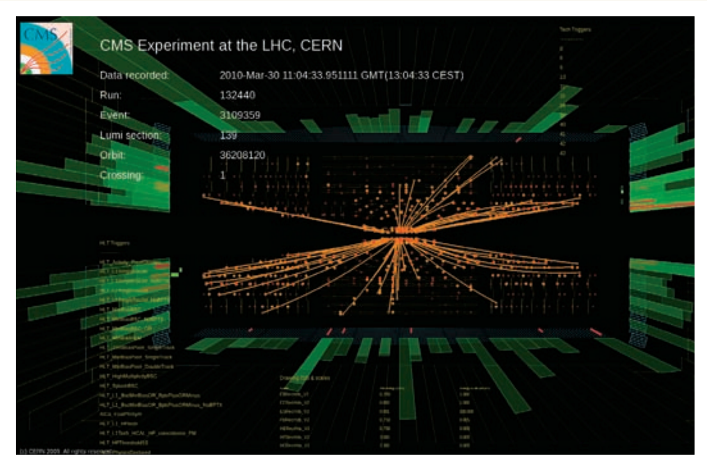
At 12.52 p.m. the operators announced that they were happy with the beam orbit and were about to remove the separation bumps. At 12.57 p.m. online beam and radiation monitors indicated that the CMS experiment had collisions, confirmed almost immediately by the online event displays. At 12.58 p.m. the ATLAS collaboration saw the experiment's first events at a total energy of 7 TeV burst onto the screens of the crowded control room. At 12.59 p.m. the LHCb experiment saw its first collisions and by 1.01 p.m. the ALICE website was announcing its first 7 TeV events. At the same time, the two smaller LHC experiments also reported collisions. The TOTEM experiment saw tracks in one of its particle telescopes, while the LHCf calorimeters recorded particle showers with more than 1 TeV of energy. ▷

Waiting for the big moment – some of the key players, seated left to right Ralph Assmann (collimators), Andrej Seimko (machine protection), Frédérick Bordry (head of technology), Lyn Evans (former LHC project leader), with Roberto Saban (head of engineering) and Gianluigi Arduini (LHC machine co-ordinator) behind.

Applause for the first collisions in the control room of the LHCb experiment.

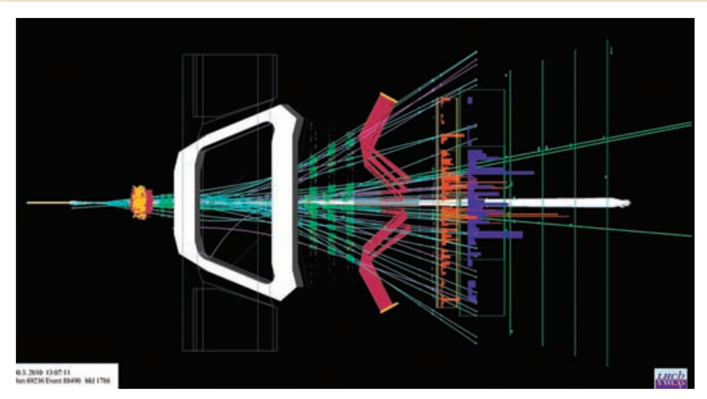


Stable beams at 1.24 p.m. with some 1.8×10^9 protons in two bunches per beam.

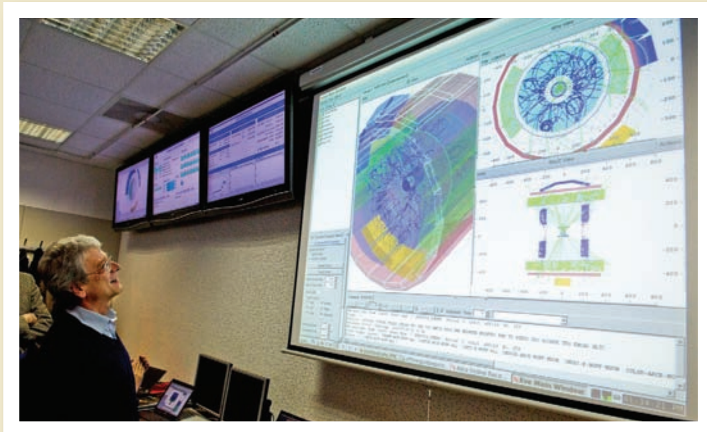


One of the first approved 7 TeV event displays from CMS.

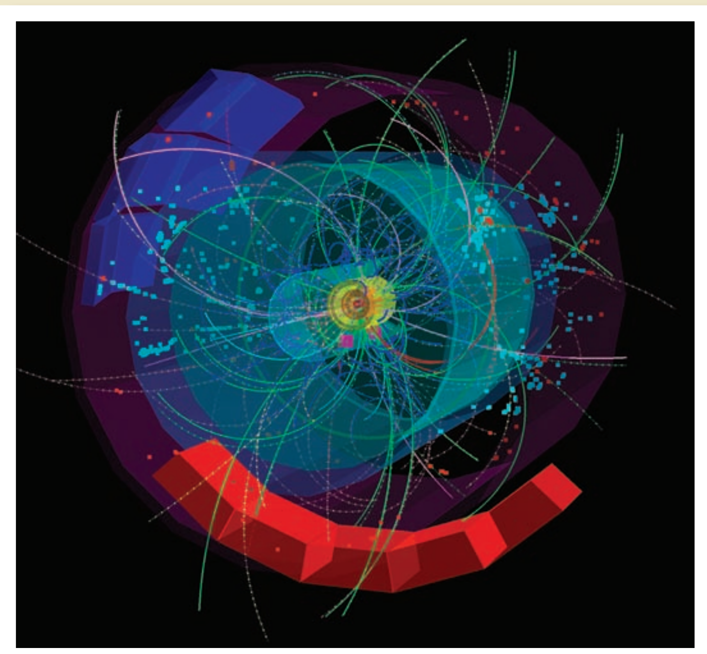
We have collisions – spokesperson Guido Tonelli relays the news from CMS.



The first 7 TeV collision recorded in the LHCb experiment.



Spokesperson Jurgen Schukraft admires one of the first 7 TeV collisions in the ALICE detector on the big screen in the control room.



One of the first 7 TeV events with all of the detectors switched on in ALICE.

Spokesperson Fabiola Gianotti, looks at displays of some of the first 7 TeV collisions in the ATLAS detector, together with Lyn Evans.

CERN's press office swiftly told the assembled media and reported the successful observation of collisions at 7 TeV total energy to the world: the LHC research programme had finally begun.

At 1.22 p.m. the operators declared "stable beams" and the LHC provided three and a half hours of collisions before an error caused the beams to dump safely. During this time, CMS, for example, collected around 600 000 collision events and LHCf detected as many as 30 000 high-energy showers.

The following week saw several prolonged periods of "quiet" running during which the experiments continued to accumulate events. These were interspersed with further tests and machine development work. There were also scheduled periods for access to the tunnel, for example to begin work on the QPS to allow a faster ramp rate of 10 A/s. There was also the almost inevitable "down time" that arises with any complex machine.

The challenge ahead for the LHC team is to increase the luminosity, which is a measure of the collision rate in the experiments. The design luminosity is $10^{34}\,cm^{-2}\,s^{-1}$, but in these early days the experiments are seeing around $10^{27}\,cm^{-2}\,s^{-1}$. It is a case of learning to walk in small steps before running flat out, especially considering the total energy of the beams at higher luminosities. This is why the first investigations are always performed with the low-intensity "probe" beam.

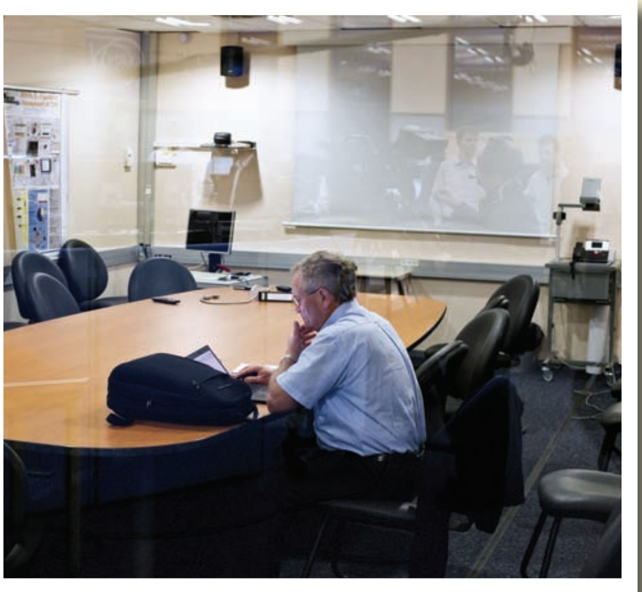
The luminosity depends not only on how many particles are in the beams, but also on making sure that the beams collide head-on exactly at the interaction points. Ensuring that this happens is the goal of dedicated "luminosity scans" in horizontal and vertical beam position for the experiments at each of the four interaction points. In addition, the LHC operators can reduce the beam size at the collision points by "squeezing" the betatron function that describes the amplitude of the betatron oscillations about the nominal orbit. On 1 April the first squeeze from 11 m down to 2 m was successfully performed in several steps at Points 1 and 5, where ATLAS and CMS are located (together with LHCf and TOTEM, respectively).

By the end of the first week of April, each of the four large experiments had accumulated some 300 μb^{-1} of data, corresponding to several million inelastic events. When optimized and with about 1.1×10^{10} protons per bunch, they were recording data at a rate of up to around 120 Hz and finding a luminosity lifetime of well in excess of 20 hours. The first stage of the journey to attain 1 fb^{-1} before a long shutdown towards the end of 2011 had begun.

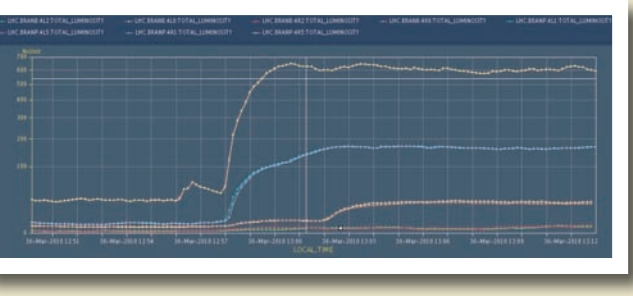
Résumé

Les nouveaux horizons du LHC

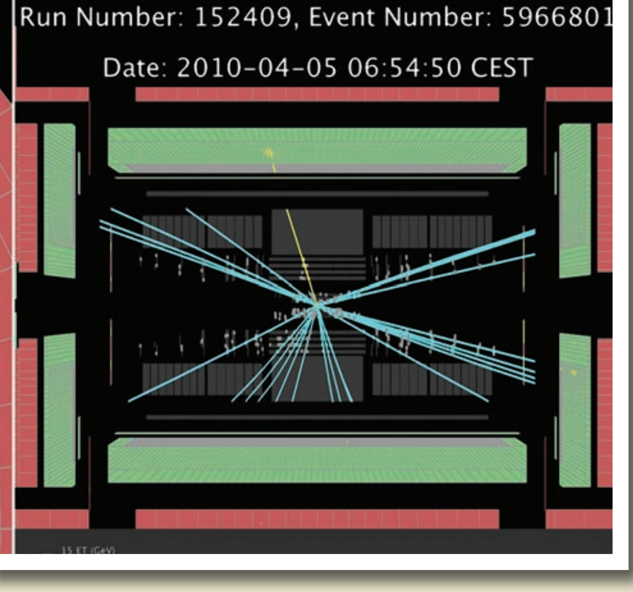
Le 30 mars, un mois à peine après le redémarrage du Grand collisionneur de hadrons du CERN, les salles de contrôle situées en différents points de l'anneau de 27 km ont retenti de cris de joie: le machine venait de produire les premières collisions à une énergie record de 7 TeV dans le centre de masse. Des collisions à haute énergie ont été obtenues aux quatre points d'interaction, après plusieurs tentatives d'injection et d'accélération des faisceaux. Ce succès vient couronner un mois de préparation et d'essais à plus basse énergie. Au cours des jours suivants, les expériences du LHC ont commencé à recueillir des millions d'événements pendant de longues périodes de fonctionnement avec faisceaux stables, donnant ainsi le signal d'un départ vers de nouveaux horizons.



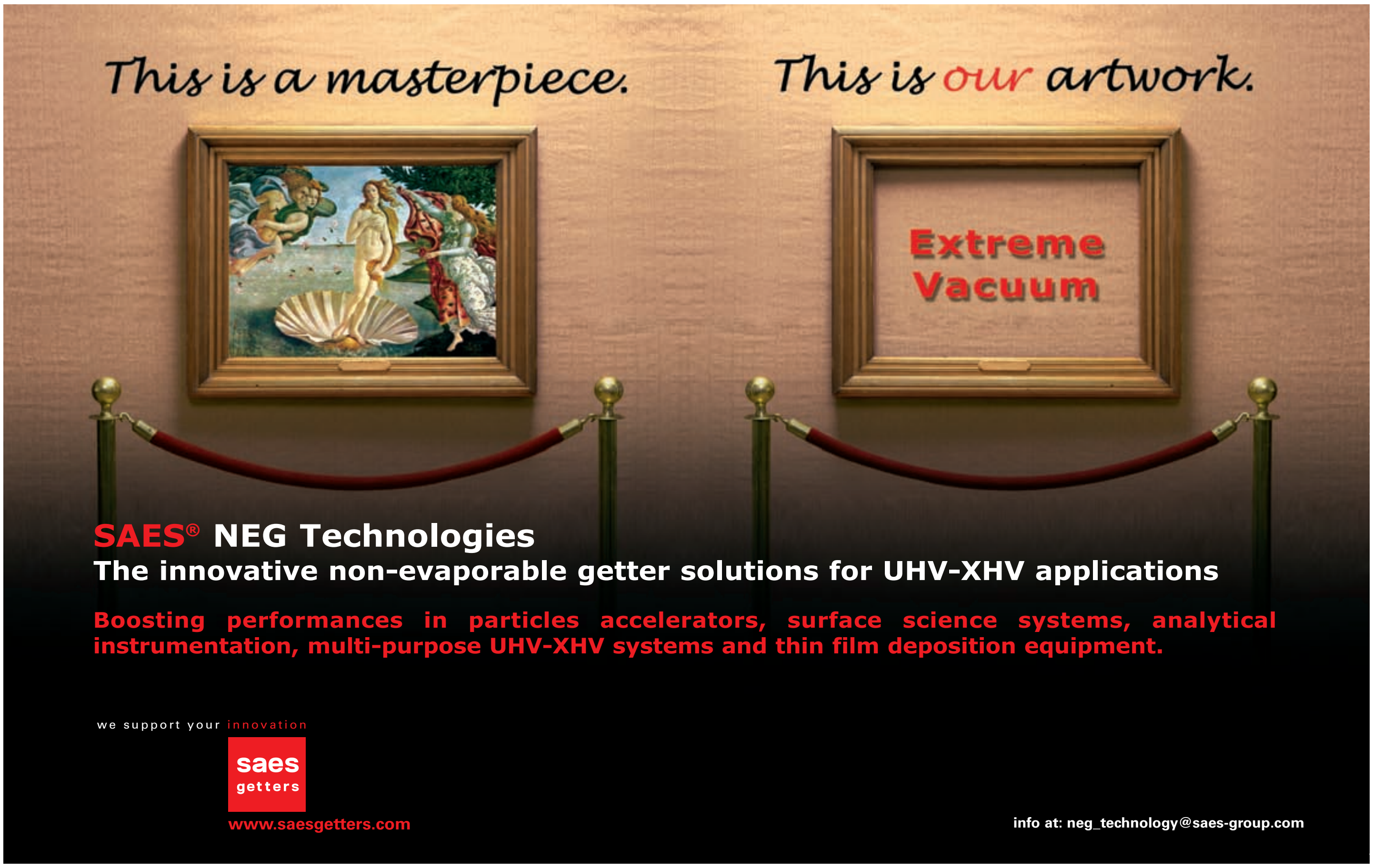
A moment of reflection – Steve Myers, director of accelerators and technology, finds a quiet space.



Increases in luminosity monitors reveal collisions at around 12.58 p.m.



On 5 April after several periods of running with 7 TeV collisions, ATLAS spots the decay of a W boson to an electron (yellow) and neutrino (unseen).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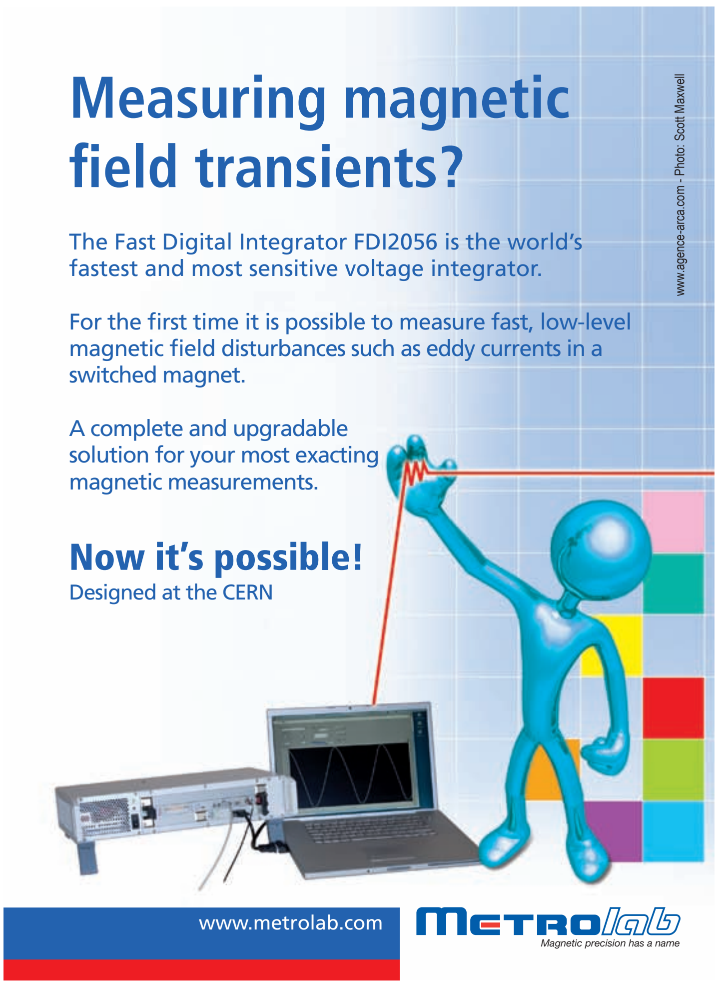
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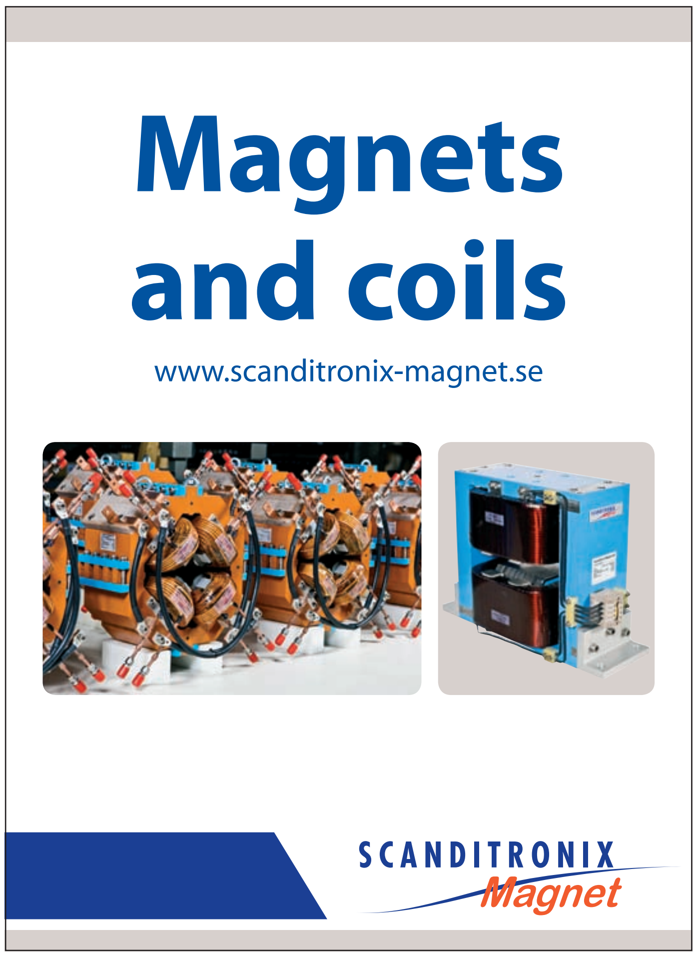
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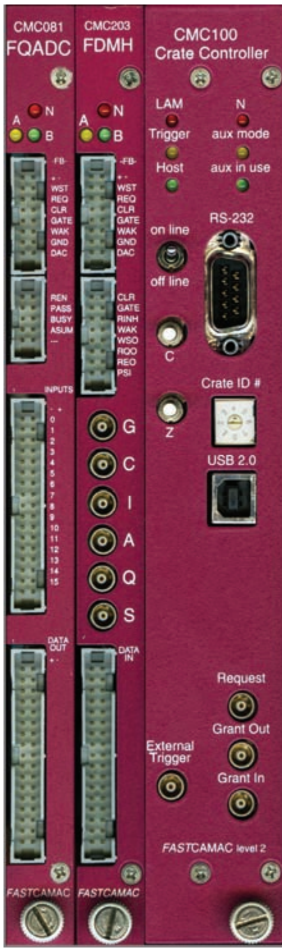

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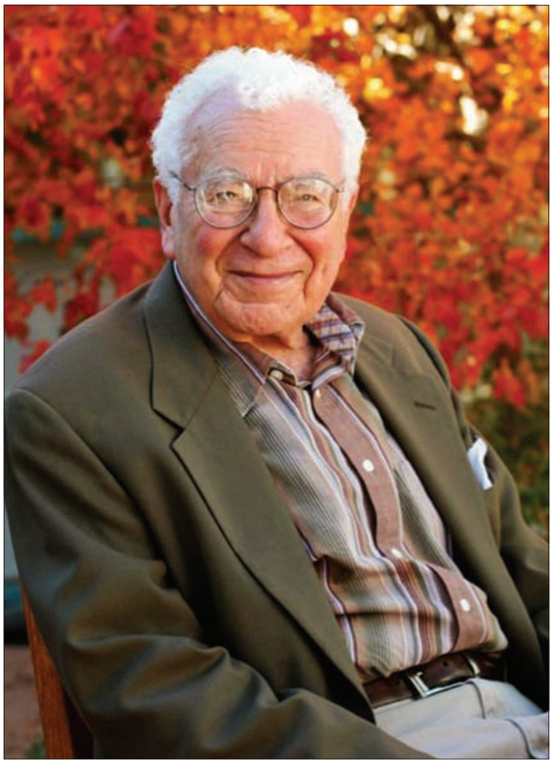
Gell-Mann: quantum mechanics to complexity

A conference in Singapore held at the Institute of Advanced Studies, Nanyang Technological University, gathered former students and collaborators of Murray Gell-Mann to celebrate his 80th birthday with a retrospective of his achievements in various fields.

To celebrate Murray Gell-Mann's many contributions in physics in his 80th year, the Institute of Advanced Studies at Nanyang Technological University and the Santa Fe Institute jointly organized the Conference in Honour of Murray Gell-Mann, which took place in Singapore on 24–26 February. Aptly entitled "Quantum Mechanics, Elementary Particles, Quantum Cosmology and Complexity" to focus on Gell-Mann's achievements in these fields, the three-day conference was a festival of lectures and discussions that attracted more than 150 participants from 22 countries. Those in attendance included many of Gell-Mann's former students and collaborators. For a select few this was their second visit to Singapore, having attended the 25th Rochester Conference held there 20 years ago.



Murray Gell-Mann. (Courtesy Santa Fe Institute.)

The meeting began with a brief scientific biography of Gell-Mann presented by his close collaborator Harald Fritzsch of Ludwig-Maximilians University, who highlighted his main achievements. During the 1950s Gell-Mann worked with Francis Low on the renormalization group and with Richard Feynman on the V-A theory of weak interaction. The application of the SU(3) symmetry group to classify hadrons led Gell-Mann to predict the existence of the Ω^- particle in 1961; its subsequent discovery in 1964 paved the way to his receiving the Nobel Prize in Physics in 1969. Gell-Mann and George Zweig independently proposed quarks as the constituents of hadrons in 1964.

Gell-Mann studied the current algebra of hadrons together with various co-workers. In 1971 he introduced light-cone algebra together with Fritzsch, as well as the colour quantum number for quarks. A year later they proposed the theory of QCD for the strong interaction. In 1978 Gell-Mann, Pierre Ramond and Richard Slansky proposed the seesaw mechanism to explain the tiny neutrino masses. Then, in around 1980, Gell-Mann switched his interest towards the foundations of quantum mechanics, quantum cosmology and string theory.

Multifaceted

Gell-Mann's interests extend beyond physics – he loves words, history and nature. He has moved between disciplines that include historical linguistics, archaeology, natural history and the psychology of creative thinking, as well as other subjects connected with biological and cultural evolution and with learning. He currently spearheads the Evolution of Human Languages Program at the Santa Fe Institute, which he co-founded.

The subsequent talks by Nicholas Samios of Brookhaven National Laboratory and George Zweig of Massachusetts Institute of Technology (MIT) were very entertaining. They touched on the historical background that led to the discovery of the Ω^- – predicted by Gell-Mann's Eightfold Way – and to the quark model of hadrons, and were accompanied by interesting anecdotes and photographs. Zweig related the origin of the terminology "quark" and how the battle between "aces" and quarks unfolded.

There were several talks on recent advances in various theoretical and experimental aspects of QCD as well as on the Higgs boson. CERN's John Ellis discussed the Higgs particle and prospects for new physics at the LHC. Nobel laureate C N Yang of Tsinghua University gave a talk on his recent work on the ground-state energy of a large one-dimensional spin-1/2 fermion system in a harmonic trap with a repulsive delta-function interaction, based on the Thomas-Fermi method. Gerard 't Hooft of Utrecht University – another ▷

Nobel laureate – presented a possible mathematical relationship between cellular automata and quantum-field theories. This may provide a new way to interpret the origin of quantum mechanics, and hence a new approach to the gravitational force.

Gell-Mann himself ended the first day's sessions with interesting personal recollections and reflections on "Some Lessons from 60 Years of Theorizing". His main observations can be summarized as follows. First, every once in a while, it is necessary to challenge some widely conceived idea, typically a prohibition of thinking in a particular way – a prohibition that turns out to have no real justification but holds up progress in understanding. It is important to identify such roadblocks and get round them. Second, it is sometimes necessary to distinguish ideas that are relevant for today's problems from ones that pertain to deeper problems of the future. Trying to bring the latter into today's work can cause difficulties. Finally, doubts, hesitation and messiness seem to be inevitable in the course of theoretical work (and experiments too, sometimes). Perhaps it is best to embrace this tendency rather than organizing over and around it, for example, by publishing alternative contradictory ideas together with their consequences, and leaving the choice between them until a later time.

The following day and a half covered a variety of topics. Rabindra Mohapatra of the University of Maryland discussed neutrino masses and the grand unification of flavour. Further talks focused on the origins of neutrino mixing and oscillations, as well as on what the LHC might reveal about the origin of neutrino mass.

John Schwarz of Caltech gave an interesting review of the recent progress in the correspondence between anti-de Sitter space and conformal field theory, which is one of the most active areas of modern research in string theory. He focused mainly on the testing and understanding of the duality and the construction and exploration of the string theory duals of QCD. Other talks reported on string phenomenology and string corrections in QCD at LHC. Itzhak Bars of the University of Southern California described a gauge symmetry in phase space and the consequences for physics and space–time.

The sessions on quantum cosmology covered topics on black holes, dark matter, dark energy and the cosmological constant. These included a talk by Georgi Dvali of New York University, who discussed the physics of micro black holes.

The main sessions of the conference ended with a talk by Nobel laureate Kenneth Wilson of Ohio State University, a former student of Gell-Mann. He touched on a fundamental problem: could the testing of physics ever be complete? According to Wilson, in the real world no law about continuum quantities such as time, distance and energy can be established to be exact through experimental tests. Such tests cannot be carried out today, and cannot be done in the foreseeable future – although estimates of uncertainties can be improved in future. Wilson also took part in a discussion session with school teachers and students in a Physics Education Meeting held in conjunction with the conference.

The parallel sessions on particle physics, cosmology and general relativity attracted presentations by more than 30 speakers, many of whom were young physicists from Asia (China, China (Taiwan), India, Indonesia, Iran, Japan, Malaysia and Singapore). There was also a special session on quantum mechanics and complexity featuring invited speaker Kerson Huang of MIT who gave a talk on stages of protein folding and universal exponents.

Participants gathered in the foyer of Nanyang Executive Centre in Nanyang Technological University (NTU) with Gell-Mann (front row, seventh from the left). (Courtesy Institute of Advanced Studies, NTU.)

Murray Gell-Mann (left), Feng Da Hsuan (centre) and Gerard 't Hooft engaged in some light discussions during a tea break. (Courtesy Institute of Advanced Studies, NTU.)

● To mark the occasion of Gell-Mann's 80th birthday, the publication of *Murray Gell-Mann: Selected Papers*, edited by Harald Fritzsch (World Scientific 2010), was launched during the conference.

For the full list of speakers and more information about the conference, see www.ntu.edu.sg/ias/upcomingevents/GM80Conference/. The proceedings will be published by World Scientific Publishing Company, Singapore.

Résumé

Gell-Mann : mécanique quantique et complexité

Pour célébrer, à l'occasion de son 80e anniversaire, les nombreuses contributions de Murray Gell-Mann à la physique, l'Institut de recherche avancée de l'Université technologique de Nanyang et l'Institut Santa Fe ont organisé conjointement une conférence en son honneur, qui a eu lieu à Singapour du 24 au 26 février. Sur le thème « Mécanique quantique, particules élémentaires, cosmologie quantique et complexité », pour souligner les apports de Gell-Mann dans ces domaines, cette conférence de trois jours a été l'occasion de communications et d'échanges variés. Elle a rassemblé plus de 150 participants issus de 22 pays, dont d'anciens étudiants et collaborateurs de Gell-Mann et plusieurs prix Nobel.

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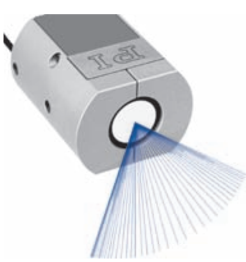

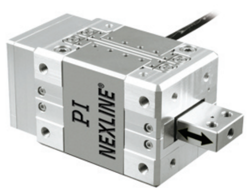

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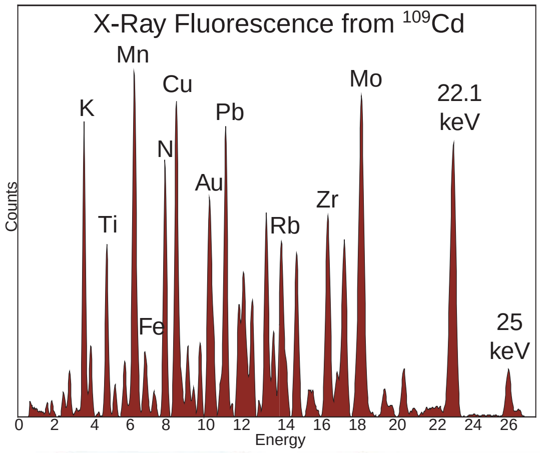

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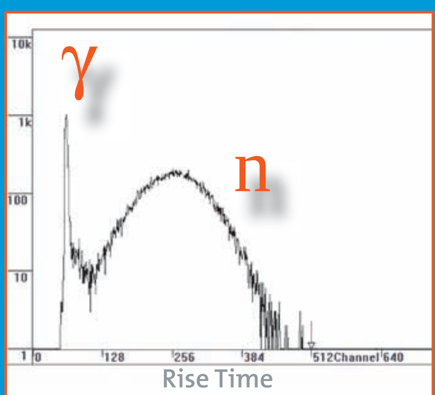

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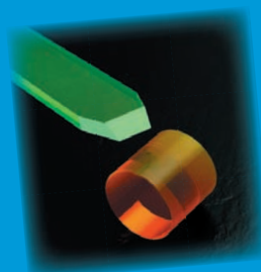

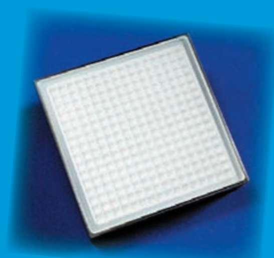

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APPOINTMENTS

Martino takes over as director of IN2P3

Jacques Martino has been appointed director of the National Institute of Nuclear and Particle Physics (IN2P3) by the president of the Centre National de la Recherche Scientifique, Alain Fuchs. He succeeds Michel Spiro, who was elected president of the CERN council last December, and took over the role on 1 April.

Martino has been director of the Subatech laboratory (CNRS/Ecole des Mines de Nantes/Université de Nantes) since 2001, and director of the Arronax cyclotron public interest group in Nantes. At CNRS he was also leader of the SBADE (Signal Bruit Alerte Détection Environnement – Signal, Noise, Warning, Detection, Environment) interdisciplinary project from 2007.

An experimental nuclear physicist, his research has focused mainly on nucleon structure, first with the Saclay Linear Accelerator, then at CERN where he coordinated the building of the muon polarimeter for the experiment of the Spin Muon Collaboration. He is currently participating in the Double Chooz experiment to measure the θ_{13} neutrino mixing angle and the Nucifer project for monitoring nuclear reactors through antineutrino detection for thermal power measurement and non-proliferation.

Jacques Martino. (Courtesy Nicole Tiget, CNRS.)

Martino graduated as an engineer from the Ecole Centrale de Paris in 1975 and gained his doctorate in nuclear and particle physics in 1982. From 1980 to 1993 he was a physicist at the Service de Physique des Hautes Energies of the French Atomic Energy Commission, before becoming head of the Service d'Instrumentation Générale from 1993 to 1996, and then head of the Service de Physique Nucléaire from 1996 to 2001.

McKeown becomes deputy director at JLab

The US Department of Energy's Thomas Jefferson National Accelerator Facility has announced the appointment of Robert McKeown from the California Institute of Technology to the position of deputy director for science. In addition to serving as deputy director, McKeown will become a Governor's Distinguished CEBAF Professor at the College of William and Mary in Williamsburg. He will begin his duties at the laboratory on 1 May.

McKeown's research interests have included studies of weak interactions in nuclei, neutrino oscillations, parity-violating electron scattering, and the electromagnetic structure of nuclei and nucleons. He first became interested in experimental nuclear physics as an undergraduate student at Stony Brook University, New York. He continued his studies at Princeton University, where he received a PhD in 1979. After a year at Argonne National Laboratory, he took a position as assistant professor of physics at the California Institute of Technology, becoming an associate professor in 1986 and a professor in 1992.

Robert McKeown. (Courtesy R McKeown.)

McKeown has served on the Nuclear Science Advisory Committee, the editorial board for *Physical Review C* and on advisory committees for Brookhaven National Laboratory, Fermilab and Jefferson Lab, where he served as chair of the JLab Users Group Board of Directors in 1990–1991. He recently received the 2009 Tom W Bonner Prize in Nuclear Physics from the American Physical Society for his work using parity-violating electron scattering to study nucleon structure.

LABORATORIES

CERN and Fermilab celebrate International Women's Day

The control rooms at CERN may have resounded to cheers for the first collisions of 3.5 TeV beams on 30 March, but earlier in the month they had witnessed a different kind of celebration. On 8 March both CERN and Fermilab chose to mark International Women's Day for the first time by honouring the past and current contributions of women at the two laboratories.

CERN encouraged its staff and users to enable as many women as possible to be on shift on the day in the control rooms of the experiments and accelerators, and to staff the IT helpdesk and guide official visits. Poster exhibitions also highlighted the presence of women scientists at the laboratory both now and in earlier decades. At Fermilab, women took the lead in certain control rooms and led special guided tours focusing on how women have contributed to the experimental facilities at the laboratory's intensity frontier.

At 15.30 CET a video conference linked the CMS Centre at CERN with the LHC Remote Operations Center at Fermilab for a live discussion about the contributions of women in physics. In this way, CERN's director-general, Rolf Heuer, and the co-ordinator for external relations, Felicitas Pauss, joined Fermilab's director, Pier Oddone, and deputy-director, Young-Kee Kim, for the celebrations, together with Fabiola Gianotti and Guido Tonelli, the spokespersons of the ATLAS and CMS experiments, respectively.

The idea for these celebrations began at CERN, with Pauline Gagnon from Indiana University, a scientist on the ATLAS experiment. Gagnon hopes that spotlighting women physicists at CERN will send an encouraging message to young women interested in science. In the experiments, in all of the departments and in the management, women are increasingly represented at CERN. In the CERN Control Centre, for example, half of the engineers in charge, who take responsibility for operating the LHC, are women.

Scenes on International Women's Day. Lower right, colleagues at Fermilab, with deputy-director Young-Kee Kim, talk via video conference to the CMS Centre at CERN. (Courtesy Fermilab Visual Media Services.) Women at work in the control rooms at CERN, clockwise from lower left: CMS at Point 5; the CERN Control Centre; ALICE at Point 2; ATLAS at Point 1; LHCb at Point 8.

At Fermilab, Women's Day formed part of a month-long Women's History Month celebration, during which weekly lunchtime discussions focused on the experiences of women during various decades at the laboratory.

● For more details about the event as well as video interviews with women at CERN discussing why celebrating International Women's Day is important to them, see http://cern.ch/womensday.

LABORATORIES

The JINR committee appoints Alexei Sissakian for a second five-year term

The Committee of Plenipotentiaries of the governments of the member states of the Joint Institute for Nuclear research (JINR) held a regular session in Dubna on 25–26 March. Discussions centred on the main outcomes of the institute's activities over the past seven-year period, together with plans of the JINR community for 2010–2016.

The main topics included the considerable progress in upgrading the Nuclotron-M/NICA accelerator complex, the DRIBs cyclotron complex, the IBR-2M reactor, the development of the IREN pulsed neutron source and the success of the JINR community in the synthesis of element 117. The successful development of partnership programmes with member states and with international and national scientific organizations was also discussed, in particular, the agreements concluded with CERN, Brookhaven National Laboratory and Fermilab, the Budker Institute of Nuclear Physics, and the National Research Nuclear University (Moscow Engineering Physics Institute). The session also considered further support of JINR's educational programmes, the implementation of a broad programme of innovation activities that take advantage of the special "Dubna" economic zone, and information about the establishment of the International Innovation Centre for Nanotechnology of the Commonwealth of Independent States.

Alexei Sissakian, is re-elected for a second term as director of JINR. (Courtesy JINR.)

The election of the JINR director was also held at the session, which unanimously approved the appointment of Alexei Sissakian for a second five-year term. Well known in the fields of elementary particle physics, theoretical physics and mathematical physics, Sissakian is the author of fundamental papers on multiparticle production, approximation methods in quantum field theory, and the physics of strong interactions at high temperature and density. He is also the initiator of the NICA project based on the JINR accelerator complex for the studies of phase transitions and critical phenomena in nuclear matter (*CERN Courier* January/February 2010 p13).

VISIT

Kasit Piromya, Minister of Foreign Affairs of the Kingdom of Thailand, left, visited CERN on 3 March. During his visit he toured the LHC superconducting magnet test hall with Felicitas Pauss, CERN co-ordinator for external relations, right, and Frédérick Bordry, head of CERN's technology department. The minister also visited the ATLAS visitor centre.

LETTER

Galilean science

The letter of Peter Schmid (*CERN Courier* January/February 2010 p34) is a mixture of semantics and a lack of knowledge of the three levels of Galilean science. I refer him to the paper where the problems mentioned in my short note are discussed in full, for which the reference was given in my Viewpoint article (*CERN Courier* October 2009 p42).

Colleagues and friends who understood the purpose of my intervention, namely not to ignore questions of interest to the general public and tax payers, who fund our labs, have reacted to my article by encouraging me to organize – before the end of this year – an interdisciplinary seminar on the topic at the Ettore Majorana Centre for Scientific Culture. Following the credo of the greatest Galilean scientist of the 20th century, Enrico Fermi, participation will be on the basis of results achieved in terms of scientific discoveries and/or technological inventions. According to Fermi, physicists who have never been able to get something out of their work in terms of technological inventions and/or scientific discoveries should first solve this problem before trying to become involved in problems that are apparently more easily understood.
Antonino Zichichi.

MEETINGS

The **12th International Workshop on Radiation Imaging Detectors (IWORID12)** will be held at Robinson College, Cambridge, on 11–15 July. The workshop covers all aspects of detectors, including detector materials and device processing, front-end electronics and readout, imaging theory, and applications in physics and biology. The deadline for abstracts is 11 May. For further information see http://iworid2010.mrc-lmb.cam.ac.uk/.

The **4th International Workshop on Charm Physics (Charm 2010)** will take place at the Institute of High Energy Physics, Beijing, on 21–24 October. The workshop will cover recent results in the field of charm physics, including its impact on and from theory, as well as projections for results to be expected from upcoming facilities. The registration deadline is 1 July. For further programme and registration details, see http://bes3.ihep.ac.cn/conference/charm2010/.

PHYSICS SCHOOL

ITEP hosts winter school at Otradnoe

The 38th ITEP Winter School of Physics (the 13th International Moscow School of Physics) took place at the Otradnoe resort on the outskirts of Moscow on 13–20 February. The lectures covered many subjects in elementary particle physics and closely related areas.

The school was a success, attracting more than 70 students representing 14 nationalities from all over the world. The students reported their scientific results at special sessions, and the best experimental and theoretical presentations received special diplomas.

More than 70% of the participants took part in the traditional cross-country ski competition where many prizes were awarded: from the absolute winner to the fastest professors. JoAnne Hewett of SLAC and Valerii Rubakov of the Institute for Nuclear Research of the Russian Academy of Sciences, Moscow, succeeded in beating the competition to claim these accolades.

Fastest professors: JoAnne Hewett (left) and Valerii Rubakov. (Courtesy ITEP.)

● For further information about the school and the slides of the lectures, see www.itep.ru/ws/2010/?info.

NEW PRODUCTS

Eurotech has launched the Aurora Au-5600, a next-generation supercomputer for green petascale computing. Based on the latest Intel 32 nm processors (the Xenon 5600) and relying on the liquid-cooled Aurora design, the new Aurora Au-5600 brings the efficiency and power of the 32 nm architecture to the high-perfomance computing domain. The liquid cooling brings important savings in power requirements. For more information tel +39 0433 485411; e-mail welcome@eurotech.com; or see www.eurotech.com.

Future Technology Devices International has announced its new Vinculum VNC2 user-programmable dual USB 2.0 host/slave intelligent controller. The VNC2 introduces the capability for designers to develop their own application firmware and to program the host controller themselves. It comes with the royalty-free software-development environment that includes a compiler, linker and debugger. The software toolkit is based on the C language and provides a comprehensive suite of object files to provide support for USB host functionality. For further details, contact Daniel McCaffrey, tel +44 141 429 2777; e-mail sales1@ftdichip.com; or see www.ftdichip.com.

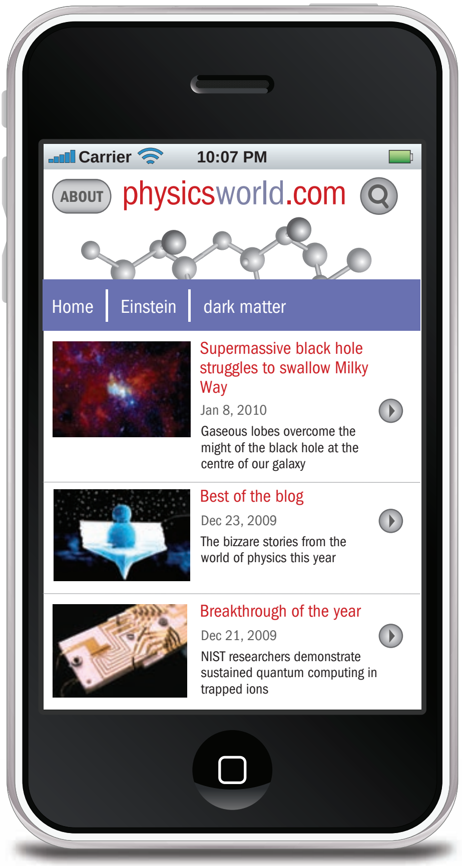
Highland Technology has launched two new products, the T750 and T760 high-voltage pulse drivers. Both feature fast, low-jitter, transformer-isolated pulse outputs, which are user adjustable from +5 V to +100 V into a 50 Ω load, with rise and fall times typically 2 ns. The T750 has four channels, each with a logic-level input and an isolated HV pulse output, while the T760 has two channels with fibre-optic inputs and isolated HV electrical outputs. For more information, tel +1 415 551 1700; e-mail info@highlandtechnology.com; or see www.highlandtechnology.com.

Kepco has introduced the BOP 6-125MG as part of its 1 kW bipolar operational amplifier (BOP) series. The new model enables the user to source or sink up to 125 A using a single 3U module with accuracy and read-back in current mode of 200 ppm. Up to five units can operate in parallel providing a source-sink capability of up to 625 A at 0–6 V. Kepco has also announced its new RMW series of 300 W switch-mode, DC power supplies. Overvoltage, overcurrent and short-circuit protection, an auxiliary 12 V fan output and remote error sensing are among the standard features. For further details, contact Oscar Rozo or Veena Rao, tel +1 718 461 7000; or e-mail orozo@kepcopower.com.

Yokogawa Electric Corporation has launched its new Yokogawa GS200, a programmable DC voltage/current source with high accuracy, high stability and high resolution. The GS200 generates low-noise DC voltage and current signals for a range of device-driving and test-and-measurement applications. It acts as a voltage source up to ±32 V and a current source up to ±200 mA. Typical accuracy is ±0.016% (on the 10 V range) and high resolution is provided by a 5½ digit display with a display count of ±12 000. For more information, contact Terry Marrinan, tel +31 88 464 1811; e-mail terry.marrinan@nl.yokogawa.com; or see www.yokogawa.com/ea.

CORRECTION

An error crept into a name in the article about recording *The Particle Physicists' Song* (*CERN Courier March* 2010 p33). This should have thanked Martin Gatehouse and Mary Stuttard of the CERN Choir for their hospitality. Apologies in particular to Mary.



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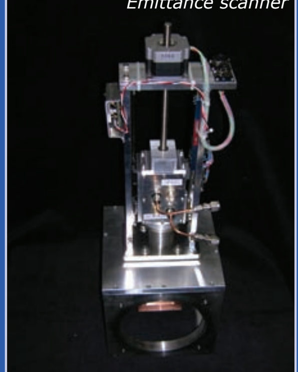
H^- ION SOURCE

D-Pace, Inc. has licensed H^- volume-cusp ion sources from TRIUMF. The 15 mA, 30 keV H^- ion source, featured here, has 4 rms normalized emittance <0.8 mm•mrad. This TRIUMF type DC volume-cusp H^- ion source, model IS•15mA•30keV•H^- produces stable and reproducible H^- ion beams with low emittance and high brightness.



Emittance scanner

EMITTANCE SCANNER

Shown here is an Emittance/ Phase Space Scanner, which D-Pace, Inc. has licensed from TRIUMF. The emittance scanner provides the phase space characteristics of a low energy charged particle beam, such as the phase space distribution, (x,x', intensity) or (y,y', intensity) and a detailed characterization of low energy charged particle beams.

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CONFERENCE

Vienna meeting looks at detector progress

The 12th Vienna Conference on Instrumentation was held at the Vienna University of Technology on 15–20 February. About 300 participants from 30 countries gathered to listen to the 60 talks and discuss the 110 presented posters. While the number of participants remains constant in this conference series, the number of submitted abstracts continues to increase. The task of the international advisory committee to select talks and posters was therefore very difficult and the decisions certainly disappointed some potential contributors.

A significant proportion of the contributions were from the large LHC experiments. Participants were relieved to see the first results of real LHC collisions, which have been used to study the performance of the detectors. The experiments made efficient use of the unforeseen delay of the LHC start-up by commissioning and calibrating their detectors with cosmic rays. The results obtained only a few days or weeks after the first LHC collisions in autumn 2009 are remarkable. Detector parameters, such as resolution, efficiency and alignment precision, are already close to specifications. The preliminary π^0 mass reconstruction obtained with the CMS electromagnetic calorimeter after only a few days of data taking is within a few per cent of the Particle Data Group's mass value, to mention just one example.

Gaseous detectors are traditionally an important field at the conference, and this time many new ideas, prototype tests and operational experiences with large systems were presented. Classical wire chambers are being replaced by micropattern gas detectors in many applications. In particular, structures such as the gas electron multiplier (GEM) and Micromegas are already being used in experiments for large-area detectors. Many other structures have been prototyped, some of them in combination with silicon readout chips. After the elimination of wires in wire chambers, will the next coup be the elimination of the gas? Harry van der Graaf of Nikhef discussed new structures of detectors working in vacuum and using electron emission foils.

The conference also reviewed the full variety of silicon detectors. While standard planar strip detectors are the workhorses of vertex and tracking detectors, there are many new and sophisticated structures of monolithic devices, combining detection and readout in one structure. Examples are the depleted p-channel field effect transistor (DEPFET), silicon on insulator (SOI), monolithic active pixel sensor (MAPS), column parallel CCD (CPCCD) and spot-coated CCD (SCCCD). Amos Breskin of the Weizmann Institute of Science, who gave the summary talk, asked for a dictionary of acronyms for these devices.

Talks and posters describing calorimeters, detectors for particle identification and astroparticle physics experiments on satellites and deep underground completed the programme. Finally, the last day was devoted to applications of detectors in medicine and biology.

Elsevier, the company that will publish the proceedings of the conference in *Nuclear Instruments and Methods A*, sponsored two prizes for young scientists: one for the best poster and one for the best talk. The criteria for the awards were the scientific value and originality of the work, the quality of the presentation and the knowledge that the presenter showed in the discussion. The awards were given to Jelena Ninkovic of Munich for the best talk and Gabriella Gaudio of Pavia for the best poster.

Participants at the 12th Vienna Conference on Instrumentation. (Photos courtesy M Hoch.)

Jelena Ninkovic (centre) and Gabriella Gaudio (second left) receive the NIM young scientist award from Luca Franco (second right), representative of Elsevier, Robert Klanner (right), editor of NIM A*, and Manfred Krammer, chair of the conference.*

OBITUARIES

Alexis C Pappas 1915–2010

Alexis Pappas, an early pioneer and acknowledged giant of nuclear chemistry for over half a century, died peacefully in his Oslo home on 12 February. He was the Norwegian delegate to CERN Council from 1968 to 1983, and vice president in 1976–1978.

Alexis Constantin Georg Pappas was born in London of exiled Greek parents before the family moved to Norway shortly after the end of the First World War. He studied natural science at the University of Oslo, where he did his graduation work on uranium radiochemistry under Ellen Gleditsch. She was a pioneer in the field, having worked with the Curies in Paris for five years around 1910, and remained a personal friend of Marie Curie. These contacts allowed Pappas as a young graduate to visit the Institut de Radium and the Collège de France to study with leaders such as M Haïssinsky, Frédérick Joliot and Irène Joliot-Curie. He then went on to the US to join the group headed by C D Coryell at the Laboratory of Nuclear Science at the Massachusetts Institute of Technology. His doctoral work on radiochemical studies of fission yields placed Pappas at the forefront of a fast growing field.

After returning to Norway and establishing a nuclear chemistry group at the University of Oslo, Pappas was appointed to a chair in radioisotope chemistry, which in 1962 was transformed into a permanent chair in nuclear chemistry, the first in a Scandinavian country. He remained in office until retirement in 1985.

Because of his unique expertise Pappas was frequently called upon to be a consultant for or member of governmental advisory boards in matters of ionizing radiation and

Alexis Pappas as vice-president of Council in 1977.

nuclear safety. He supervised a 15-year long project in the 1950s and 1960s, studying the uptake of radioactive strontium in people and grain from fallout after the testing of Soviet nuclear devices in the Arctic.

Pappas' involvement with the "embryonic CERN" started very early. Experiments on spallation and fission were performed with the new 170 MeV Uppsala synchrocyclotron, in a fruitful collaboration with the Gustaf Werner Institute involving the Swedish chemist G Rudstam and A Kjelberg, Pappas' first graduate student. In 1953 Niels Bohr, on the behalf of the CERN Theoretical Study Group then located in Copenhagen, wrote to Pappas inviting him to join the group as consultant. This arrangement continued until 1957. It was therefore logical that the director of the CERN Synchrocyclotron (SC), Wolfgang Gentner, asked Pappas to help build up CERN's nuclear-chemistry laboratory and to extend the research that had started in Uppsala to higher energies. The laboratory was ready in 1958 with Rudstam as its first leader.

An important extension to the experimental facility came 10 years later with ISOLDE, the online isotope separator at the 600 MeV SC. Again Pappas was active in the planning stage, notably together with Rudstam, G Andersson from Gothenburg, R Bernas from Orsay and K O Nielsen from Aarhus. When the future of the aging SC was hotly debated in the early 1970s, and the question was raised in the Scientific Policy Committee whether CERN should concentrate on high-energy physics and exclude medium- and low-energy physics from its activities, Pappas was among those in the Council and the Finance Committee who most strongly advocated that CERN must maintain a broad scientific programme to serve the needs of a large body of users in the Member States. In later life he enjoyed following the extraordinary success of ISOLDE, which is now by far the longest-lasting experiment at CERN.

Alexis Pappas – Aleco among friends and colleagues – was a kind person, always positive and in good spirits despite an often-fragile health. He was an excellent lecturer and good communicator of popular science. He leaves behind a legacy of more than a hundred graduates in nuclear chemistry, of whom quite a few have gone on to spend part of their later careers at CERN.

He will be missed very much by of all those who learnt to know him, and he will be remembered for all his engagements in the science he loved.

His students, colleagues and friends.

Marcel Vivargent 1923–2010

Marcel Vivargent, a leading figure of French high-energy physics, passed away on 31 January 2010 in his 87th year.

Marcel Vivargent started his scientific career at the French Centre National de la Recherche Scientifique (CNRS) in 1951, joining the group of Fréderic Joliot-Curie in the Laboratoire de Physique et Chimie du Collège de France in Paris. After his thesis, in 1958, he contributed to the start of the cyclotron of the Institut du Radium in Orsay.

He came to CERN in the early 1960s to pursue his research at the new Proton Synchrotron. First by himself, and then with a small team from the Institut du Radium, he started collaborating with European colleagues to perform "electronic experiments", which provided important results in the production of identified hadrons and in kaon physics. His experimental skill was soon recognized, in particular in the field of Cherenkov counters.

In 1968 Marcel took over as head of the High-Energy Physics Division of CNRS, which included particle physicists at the Institut de Physique Nucléaire Orsay and the Faculté de Paris Jussieu. Meanwhile he contributed to the CERN–Hamburg–Orsay–Vienna experiment at CERN's Intersecting Storage Rings, studying elastic and diffractive processes in proton–proton interactions at the highest energies then available. It was also at this time that, together with physicists and engineers in Orsay and Saclay, he worked on the design of a 45 GeV accelerator project in France, which never saw life.

In parallel, together with some colleagues from Orsay working at CERN, he proposed and convinced the director of the newly created Institut National de Physique Nucléaire et de Physique des Particules (IN2P3) to set up a new laboratory near CERN. In 1976, with the support of local authorities, the Laboratoire d'Annecy-le-Vieux de Physique des Particules (LAPP) was opened, with Marcel as its first director; he remained in charge until 1982.

During the same period, he contributed to the start of the European Muon Collaboration, which was later to bring important results on proton-structure functions. As president of the European Committee for Future Accelerators from 1978 to 1980, he also played a key role in the preparation of the Large Electron-Positron (LEP) collider at CERN.

Marcel initiated the participation of the LAPP and the Institut de Physique Nucléaire Lyon groups in L3, one of the four LEP

Marcel Vivargent, then president of ECFA, right, with Jean Teillac, then president of CERN Council, during the Council meeting in June 1978.

experiments, and he was their representative from 1981 to 1991. He was responsible for the conception, building and testing of a new type of electromagnetic calorimeter in L3, which used about 10 000 crystals of bismuth germanate oxide (BGO) and was developed through a worldwide collaboration. This detector performed exceptionally well and was used successfully during the whole period of LEP running (1989–2001).

At the end of his career Marcel contributed effectively to the setting-up of the Crystal Clear Collaboration that performed key R&D work on new types of scintillating crystals. One of these (lead tungstate) is now used in the CMS experiment at the LHC and elsewhere. After his retirement, he still followed the developments in physics as an emeritus research director, with a special interest in the ALICE experiment at the LHC.

Besides his qualities as a physicist and a leader, Marcel Vivargent was a most courageous, open and critical man, never hesitating to engage himself and serve the community. In 1944 he interrupted his studies to join the French Resistance. After his retirement he was active in a project to transport freight in a dedicated railway tunnel under Mont Blanc. He was also involved in solar energy and he managed to set up in Dakar an International Center for Study and Training in Solar Energy, CIFRES, which was inaugurated in 2003 by the president of Senegal. In 2009 he was made Chevalier de la Légion d'Honneur by the president of France.

Marcel was held in high esteem by his colleagues of all ages. He will be remembered for his strong personality, his talents and his outstanding ability to tackle difficult challenges and to lead them successfully.

We offer our condolences to his wife, daughter and granddaughter.

His friends and colleagues.

Albert Nikiforovich Tavkhelidze 1930–2010

On 27 February, academician Albert Nikiforovich Tavkhelidze passed away in his 80th year.

Albert Nikiforovich Tavkhelidze was an outstanding physicist and scientific organizer and a laureate of the Lenin prize and State prize. One of the most active founders of the colour-quark theory, he was the initiator of a number of scientific trends at the Joint Institute for Nuclear Research (JINR) in Dubna. He was the Georgian Plenipotentiary to JINR, a member of the JINR Scientific Council, and one of the establishers and a scientific supervisor of the Russian Academy of Sciences' Institute for Nuclear Research, Troitsk. He was also president of the Georgian Academy of Sciences (1986–2006) and a member of the presidium of the Academy of Sciences of the USSR for many years.

The predictions made by Tavkhelidze and his colleagues in the dynamic theory of colour quarks lie at the basis of modern

Albert Tavkhelidze, with a photograph of Nikolai Bogoliubov behind. (Courtesy JINR.)

understanding of the origins of nuclear matter origin and they are verified nowadays at the accelerators of large research centres including CERN, Brookhaven, Fermilab and JINR. The new Nuclotron-based Ion Collider fAcility (NICA) under construction at JINR will continue research in this field. The facility is being developed in Dubna where Tavkhelidze began his scientific career as a brilliant member of the scientific school founded by the great physicist–theorist and mathematician Nikolai Bogoliubov.

Tavkhelidze had an utter devotion to science. He was notable for his rare sense of purpose and working capacity, as well as for his ability to unite people to implement ambitious goals. He was demanding both of himself and of his colleagues, but at the same time he was a kind and sympathetic person. His passing is an irretrievable loss to science, and brings great sorrow to his numerous pupils and followers.

We express our deep and sincere condolences to the family members and others close to Albert Nikiforovich Tavkhelidze. The bright image of a remarkable scientist and person will stay forever in the memories of those who knew him.

JINR directorate.

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Dr. P. Fritz, Vice President Research and Innovation, Karlsruhe Institute of Technology (KIT) Campus North, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

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The Abdus Salam
International Centre for Theoretical Physics

DEPUTY DIRECTOR POSITION (D-2 level)

The Abdus Salam International Centre for Theoretical Physics (ICTP) is a world-class institution focused on research in basic sciences with the responsibility for the promotion, dissemination and support of science, especially in developing countries. It operates under the aegis of UNESCO and IAEA.

The successful candidate is expected, upon delegation from the ICTP Director, to act on his behalf on all matters concerning the Centre, both Scientific and Administrative. In particular:

- To determine and oversee the coordination, preparation and finalization of the Calendar of Scientific Activities of the Centre;
- To provide leadership to and to supervise the activities and staff of Scientific Services of the Centre;
- To serve as a direct link between the Director and the Centre's Senior Administrative Officer and the scientific Groups.
- To collaborate in the preparation of the annual budget of the Centre;
- To ensure the coherency and efficiency of administrative services;
- To guide the development and modification of new and existing policies for the Centre;
- To actively mobilize resources and to assist in fundraising actvities.

All candidates must possess:

- PhD or equivalent doctoral degree and strong research record in one of the major areas of research of the Centre.
- At least 15 years of experience in an international organization and in a leading scientific and administrative position with experience in organization, personnel policies and budgetary control.
- Experience gained in environments supporting science on developing countries and knowledge of their needs in the areas of basic sciences required.
- Familiarity with standard scientific computing systems.
- Excellent knowledge of written and spoken English and good knowledge of French. Knowledge of Italian will be an asset.

For further information: www.unesco.org/employment
Applications should reach UNESCO before 26 May 2010. Please quote post number "EU/TP/ITA/SC/0801".

iter
china eu india japan korea russia usa

Heating and Current Drive Division Head

ITER will be the world's largest experimental fusion facility and is designed to demonstrate the scientific and technological feasibility of fusion power. As an international organization, ITER offers challenging assignments in a stimulating multi-cultural workplace sited at Cadarache in Southern France.

ITER's Heating and Current Drive systems provide the means to operate the plasma. They are a central part of the tokamak core and consist of various radio frequency systems as well as neutral beams and diagnostic neutral beam accelerators.

ITER is currently seeking an experienced manager with strong scientific and technical background in relevant fields to lead its Heating and Current Drive Division. This position is responsible for the design, research and development, procurement, installation and commissioning of the Heating and Current Drive systems within the planned schedule and budget.

For details of application procedure please go to:
http://www.iter.org/Pages/Jobs.aspx

Direct link to this job: **http://iter.profils.org/Pages/Utils/RouterMenu.aspx?MenuID=5&OfferID=71&LCID=1033&OriginID=1436**

CERN

As CERN's Large Hadron Collider opens up a new high energy frontier, the Organization is pursuing advanced research and development for an electron-positron linear collider to exploit the anticipated discoveries and further the understanding of the underlying physics.

In order to lead, coordinate, and liaise the studies of both accelerator and detectors, the linear collider community at CERN is looking for a
Linear Collider Studies Leader

Your main responsibility will be to lead the linear collider work at CERN in a new project phase. You will also have a strategic international role to participate in shaping the linear collider and detector landscape beyond the host Organization. Reporting directly to the CERN Directorate and the CLIC/CTF3 collaboration board, you will engage with other laboratories to strengthen the current collaboration. Within this framework you will drive the R&D and prototyping work with a view to the production of a Technical Design Report.

Already having extensive leadership and project management experience with international renown in the field of particle physics, you will have successfully led large collaborations requiring interactions with both research and industry.

Details of the vacancy, application process and employment conditions can be found at:
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OAK RIDGE NATIONAL LABORATORY
NEUTRON SCIENCES

The Neutron Sciences Directorate at Oak Ridge National Laboratory (ORNL) invites applications for an Accelerator Operations Manager.

With the United States' highest flux reactor-based neutron source for condensed matter research (the High Flux Isotope Reactor) and the world's most intense pulsed, accelerator-based neutron source (the Spallation Neutron Source), ORNL is becoming the world's foremost center for neutron science. Research at these facilities encompasses the physical, chemical, materials, biological, and medical sciences and will provide opportunities for up to 2000 researchers each year from industry, research facilities, and universities all over the world. To learn more about Neutron Sciences at ORNL go to: http://neutrons.ornl.gov.

PURPOSE: This position will provide oversight of accelerator operations and the accelerator operations team during shutdowns, upgrades and production running of SNS accelerator systems. Provide technical and administrative expertise during accelerator operations and coordinate development activities.

MAJOR DUTIES/RESPONSIBILITIES:

- Responsible for the overall safe, efficient, effective operation of SNS Particle Accelerator Systems
- Maintain operation of the SNS Particle Accelerator Systems within the established Accelerator Operations Envelope (OE) and Accelerator Safety Envelope (ASE).
- Develop and execute operations, maintenance and commissioning plans for accelerator systems.
- Provide technical oversight during operations, maintenance and commissioning of all SNS accelerator systems.
- Provide administrative oversight of Accelerator Operations Coordinators, Accelerator Control Room Shift Supervisors and Control Room Accelerator Specialists as required.
- Update and add to the SNS Accelerator Systems Operations Procedures Manual as required.
- Participate in documenting and implementing the development plans within budgetary and schedule constraints.
- Analyze data and prepare reports on the performance metrics for SNS accelerator systems.
- Assist in developing and execute plans for improving the performance of SNS accelerator systems.
- Manage the hiring of the Accelerator Operations Group staff.
- Comply with environmental, safety, health and quality program requirements, including ISMS and SBMS.
- Maintain a strong commitment to the implementation and perpetuation of values and ethics.

QUALIFICATIONS REQUIRED:
At least 10 years experience in design, construction or operation of a particle accelerator and related control systems or an equivalent combination of education and experience. Prior experience in managing or directing physicists, engineers, technicians and accelerator operators desired. A BS degree in physics, engineering or a related field is required and MS degree preferred. Must have excellent written and verbal communications skills. Must be detail oriented.

To learn more and apply for this position, go to: http://jobs.ornl.gov

BROOKHAVEN
NATIONAL LABORATORY

Postdoctoral Research Associate - Experimental Particle or Nuclear Physics (5320)

The Physics Department at Brookhaven National Laboratory seeks to fill a Postdoctoral Research Associate position in Physics. Requires a Ph.D. in physics with emphasis on experimental particle or nuclear physics.

The candidate will participate in the activities of the group including the design of the Long Baseline Neutrino Experiment, especially the large water Cherenkov detector planned for DUSEL in South Dakota. There will be opportunity to participate in the Daya Bay reactor neutrino experiment in China that will have superb sensitivity to $\sin^2 2\theta_{13}$ and will begin data-taking soon. Participation in the MINOS experiment (Fermilab-Soudan) may also be possible. Travel to DUSEL, Fermilab, Minnesota and/or China should be expected. The candidate will work within the electronic detector group and will have broad associations with other groups in the laboratory and throughout the world to carry out his/her function.

The Electronic Detector Group in the Physics Department currently has ten physicists at various career levels with major current responsibilities in neutrino physics and a long history of research in fundamental particle physics. Under the direction of S. Kettell, 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 # 14944.

BNL policy states that Research Associate appointments may be made to those who have received their doctoral degrees within the past five years.

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

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Leading Scientist (m/f) Accelerator Division
Salary group W3

DESY

DESY is one of the world leading accelerator centers for research on the structure of matter. DESY develops, builds and operates accelerators and detectors for the research with photons and for particle physics.

Superconducting RF technology is one of the key competences of DESY's accelerator division. In addition to operating and further developing the FLASH facility, DESY is a partner in the European XFEL project, contributing major parts of the accelerator components and leading the international consortium in charge of constructing the accelerator complex.

DESY is seeking a leading senior scientist in the accelerator division with the following responsibilities:

- Project leader of DESY's contributions to the construction and commissioning of the XFEL accelerator complex
- Coordination of international contributions within the XFEL accelerator consortium
- Coordination of further developments at DESY in physics and technology for superconducting accelerators
- Liaison with worldwide ongoing R&D programmes in the field of superconducting RF technology, e. g. in the TESLA technology collaboration and the ILC global design effort

Requirements

- PhD in physics or engineering
- Several years experience in construction and operation of accelerators based on superconducting RF technology
- Several years experience in planning and organizing complex, large scale projects
- Excellent communication and leadership skills

For further information, please contact Prof. Dr. Helmut Dosch (desy-director@desy.de, phone +49 40 8998-3000) or Dr. Reinhard Brinkmann (Reinhard.brinkmann@desy.de, phone +49 40 8998-3197).

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 Kinder-garten on the DESY site.

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Deutsches Elektronen-Synchrotron DESY
Human Resources Department | Code: 30/2010
Notkestraße 85 | 22607 Hamburg | Germany
Phone: +49 40 8998-3392 | E-mail: personal.abteilung@desy.de
Deadline for applications: 16 May 2010
www.desy.de

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

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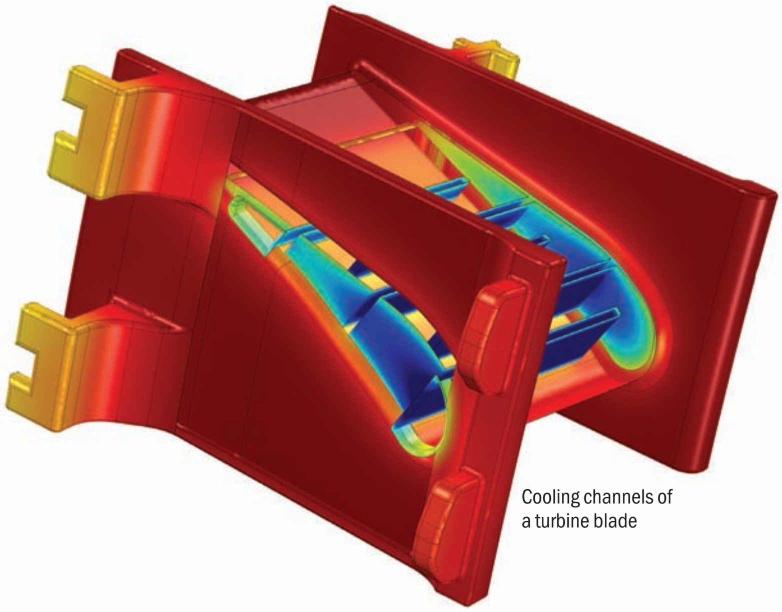
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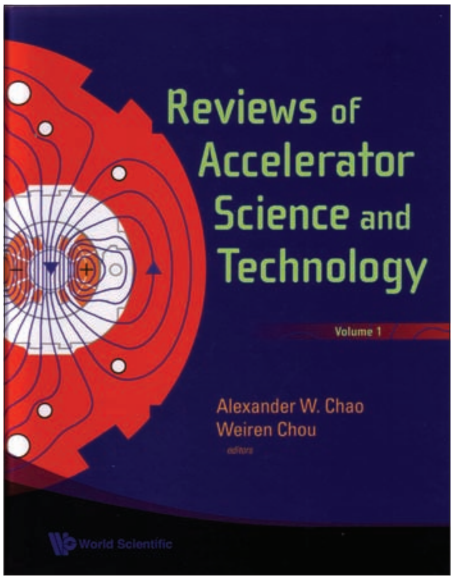
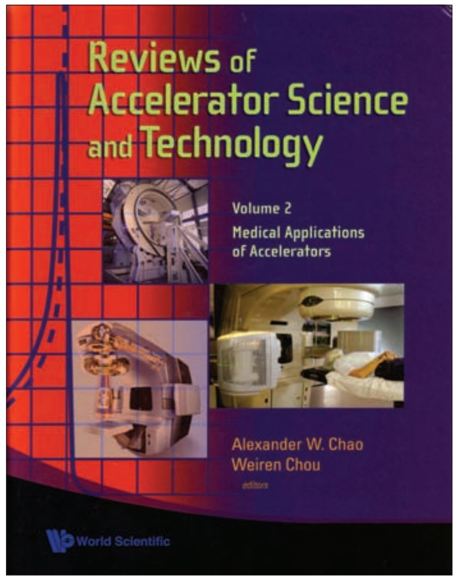
BOOKSHELF

Reviews of Accelerator Science and Technology Volumes 1 and 2 by Alexander W Chao and Weiren Chou (eds), World Scientific. **Volume 1** Hardback ISBN 9789812835208, £55 ($99). E-book ISBN 9789812835215, $129. **Volume 2** Hardback ISBN 9789814299343, £81 ($108).

The development of accelerators represents one of the great scientific achievements of the past century. The objective of this new journal – *Reviews of Accelerator Science and Technology* – is to give readers a comprehensive review of this dynamic and interesting field and of its various applications. The journal documents the tremendous progress made in the field of accelerator science and technology and describes its applications to other domains. It also assesses the prospects for the future development and use of accelerators.





The history and function of accelerators is told from its beginnings and extends to future projects in an extremely competent and complete approach, as the authors have themselves contributed in many ways to the success of the fields presented. The journal shows clearly how progress in science is strongly coupled to advances in the associated instruments, allowing us to see beyond the macroscopic world – into the finer structure of matter – and to apply these instruments to fields such as elementary particle physics, medicine and industry. From the structure of cells, genes and molecules to the Standard Model of elementary particles, the scientific developments are recounted back to the early development of these versatile instruments.

Volume 1 presents the history of accelerators, from the first table-top machines to the colliders of today and those being planned for the future. It is written in a fashion that serves as a historical account while also providing the scientific and technical basis for a deeper understanding. The volume transmits the spirit of this truly multidisciplinary and international field. With an excellent bibliography for each chapter, together with the historical development of the science of accelerators and the contributions by key figures in the field, it succinctly describes the overall history and future prospects of accelerators.

The articles in this volume include a review of the milestones in the evolution of accelerators, a description of the various types of accelerators (such as electron linear accelerators, high-power hadron accelerators, cyclotrons, colliders and synchrotron-light sources) as well as accelerators for medical and industrial applications. In addition, various advanced accelerator topics are discussed – including superconducting magnets, superconducting RF systems and beam cooling. There is also a historical account of the Superconducting Super Collider, and an article on the evolution, growth and future of accelerators and of the accelerator community.

Volume 2 focuses on the first of many specific subfields, its theme being medical applications of accelerators. Out of about 15 000 accelerators of all energies in existence today, more than 5000 are routinely used in hospitals for nuclear medicine and medical therapy. The articles in this volume feature overviews of the medical requirements written by physicians; a review of the status of radiation therapy, radioisotopes in nuclear medicine and hospital-based facilities; a detailed description of various types of accelerators used in medicine; and a discussion on future medical accelerators. In addition, one article is dedicated to a prominent figure of the accelerator community – Robert Wilson – in recognition of his seminal paper of 1946, "Radiological Use of Fast Protons".

These first two volumes of *Reviews of Accelerator Science and Technology* are timely, instructive and comprehensive. The journal is well laid out and, thanks to the many informative photos and diagrams, it is easy also to read. It is written in an impartial and balanced way and covers the achievements made at several laboratories around the world. To ensure the highest quality, the articles are written by invitation only and the submitted papers have all been peer-reviewed. An editorial board consisting of distinguished scientists has also been formed to advise the editors.

The journal represents an excellent balance between a historical account of the developments in the field and the technical challenges and scientific progress made with such machines. *Volume 2* in particular comes at an auspicious moment because the synergies between the science behind accelerators and the related spin-offs, such as the applications of accelerators to fight disease, are of great importance to human health – with a profound impact on our society.

In conclusion, the journal is a tribute to accelerators and the people who developed them. It appeals to the expert as well as to all scientists working and applying the use of accelerators. Active scientists and historians of science will appreciate this chronicle of the development of accelerators and their key role in the progress of various domains during the past century. It should be on the shelf of every scientist working with accelerators and of those with an interest in the history and future directions of accelerators and their applications. I hope that it also inspires students to look deeper into accelerator

science and technology and to choose this field as a career.
Emmanuel Tsesmelis, CERN.

Particle Beam Diagnostics for Accelerators: Instruments and Methods
by Victor Smaluk, VDM Verlag Dr. Muller. Paperback ISBN 9783639213812, €79 (£72, $119).

This is an excellent introductory book based on a series of lectures given by the author for undergraduate students of the Novosibirsk State University and Budker Institute of Nuclear Physics (BINP) – a school with long-standing traditions and vast experience in particle accelerators for high-energy physics. Smaluk presents a pedagogical view of instrumentation for charged-particle beams and illustrates it with numerous practical examples from operational electron–positron colliders and synchrotron light sources at BINP and Synchrotron Trieste. The book's strength is in its deep insight into the underlying physics and detailed explanations of how the beam-diagnostics instruments work.

The introductory first chapter is short and can be omitted by the experienced reader with a prior knowledge of the basics of beam optics. The next three chapters address the subjects of contact beam probes, synchrotron-radiation monitors and electromagnetic pickups. The author discusses the ideas, methods and practicalities of Faraday cups, optical transition-radiation monitors, secondary-emission multistrip detectors, electron beam and magnesium jet probes, "laser wire" scanners, streak cameras and synchrotron-radiation interferometers. He also presents the principles of operation and parameters of modern detectors used in beam-diagnostic devices, such as microchannel plates, photomultipliers and charge-coupled devices. The detailed drawings and photos of the beam-diagnostic devices used in various accelerators are very helpful. When necessary, electromagnetic field calculations are outlined, such as beam-induced fields in cavity monitors, wall current monitors, strip-line pickup electrodes and inductive monitors.

Chapter 5 examines the methods of spectral analysis of the beam oscillations, mathematical peculiarities of the discrete Fourier transformation, beam tune and chromaticity measurements, as well as measurements of beam-induced wake-fields and coupling impedance. High-resolution beam energy and energy-spread measurement methods, such as resonant spin-depolarization and backscattered Compton photon spectrum edge, are presented with detailed explanations as to how they can push the accuracy to the 10^{-5}–10^{-6} level.

The sixth and last chapters address the important subject of beam-orbit stabilization. The reader is brought up to date with stabilization requirements, correction algorithms and practical aspects of the beam-based orbit-feedback systems.

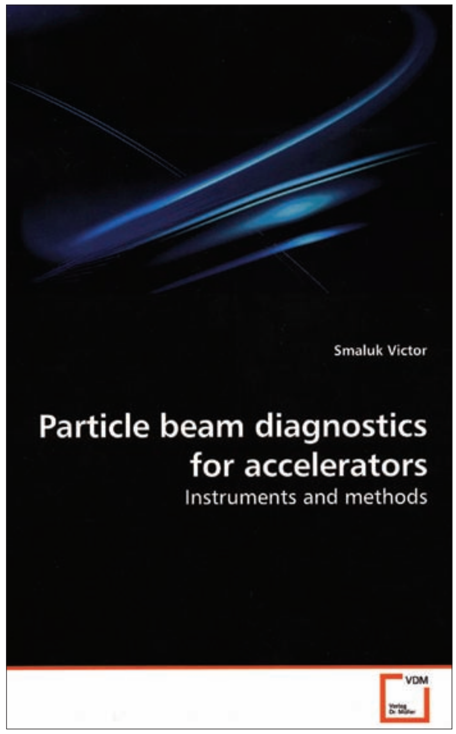
Though references are given in abundance, some of them are in Russian and cannot be retrieved from easily accessible sources. This deficiency is compensated for by the depth of the presentation of related subjects, so the essential results can be learnt from the book itself. In summary, this book is a most welcome and valuable addition to literature on accelerator beams. It can be readily recommended to students, designers and users of modern low- and medium-energy machines.
Vladimir Shiltsev, Fermilab.

Books received

Nuclear Reactions for Astrophysics: Principles, Calculation and Applications of Low-Energy Reactions by Ian J Thompson and Filomena M Nunes, Cambridge University Press. Hardback ISBN 9780521856355, £45 ($85).

Describing the processes in stars that produce the chemical elements for planets and life, this book shows how similar processes may be reproduced in laboratories using exotic beams – and how these results can be analysed. Beginning with one-channel scattering theory, the book builds up to its examination of multichannel reactions. Emphasis is placed on using transfer and breakup reactions to probe structure and predict capture processes, as well as R-matrix methods for modelling compound nucleus dynamics described by Hauser–Feshbach methods. Practical applications are prominent, confronting theoretical predictions with data throughout.

The book also features supplementary materials (available at www.cambridge.org/9780521856355) that include the



Fresco program, input and output files for examples given in the book and hints and graphs related to the exercises.

Electrical Properties of Materials, 8th edition, by L Solymar and D Walsh, Oxford University Press. Hardback ISBN 9780199565924, £55 ($100). Paperback ISBN 9780199565917, £27.50 ($55).

An informal and accessible writing style, a simple treatment of mathematics and a clear guide to applications have made this book a classic text in electrical and electronic engineering. Students will find it both readable and comprehensive. The fundamental ideas relevant to the understanding of the electrical properties of materials are emphasized; in addition, topics are selected in order to explain the operation of devices having applications (or possible future applications) in engineering. The mathematics, kept deliberately to a minimum, is well within the grasp of second-year students. The whole text is designed as an undergraduate course, however most individual sections are self contained and can be used as background reading in graduate courses and by anyone who wishes to explore advances in microelectronics, lasers, nanotechnology and other topics that impinge on modern life.

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VIEWPOINT

CERN: the knowledge hub

Claudio Parrinello highlights CERN's role as a catalyst for the exchange of knowledge.

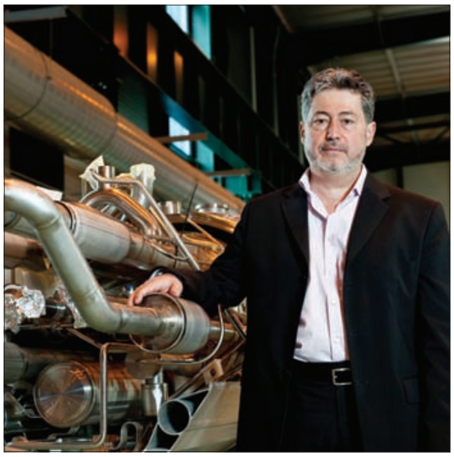
If you ask 10 people working at CERN how they would describe what CERN is in a single sentence, the chances are that you will get 10 different answers.

Most people think of CERN, first and foremost, as an accelerator "factory" and a provider of facilities for the experiments. Some would state that it is a high-profile research organization, as well as a formidable training centre. Others will emphasize that it is an attractive and responsible employer. Finally, some may point out that CERN is, among other things, a strong, internationally recognized "brand".

They are all correct in some way because CERN is a complex system with manifold activities and worldwide impact, to an extent that is sometimes hard to appreciate from an in-house perspective. Personally, I like to think of CERN as a "knowledge hub". In fact, despite people's different views on what CERN is, they are all part of its knowledge-exchange network.

Knowledge from universities, research institutes and companies flows into CERN through the people who come to participate in its activities. New knowledge is generated at CERN and knowledge then flows out, for example through R&D partnerships and technology transfer and through those who leave.

CERN is actually more than a hub because it plays the role of an active "catalyser" in the exchange of knowledge. As a concrete example, in February 2010 the "Physics for Health in Europe" workshop took place at CERN. It brought together more than 400 participants – both medical doctors and technology experts from the physics community. Medical experts attending expressed their appreciation that CERN had organized the workshop, acknowledging the need for such cross-cultural and interdisciplinary events, which cannot easily be organized at a national level. The value of CERN both as a provider of technologies and as a catalyst for the community was widely recognized. There are, of course, many other activities where CERN makes similar



contributions towards global endeavours, for example, the Open Access initiative and the deployment of a computing Grid infrastructure in Europe.

Some of the knowledge exchanges taking place across CERN's network are structured, explicit and therefore easy to track. This is the case, for example, with technology-transfer activities, which are typically formalized through contracts that give third parties access to CERN's intellectual property portfolio. Other knowledge-exchange processes are tacit or informal. For example, knowledge transfer through people's mobility from CERN towards European companies is hard to track in a systematic way.

The CERN Global Network aims to facilitate knowledge exchange across the various groups described above and to improve the visibility of partnership opportunities related to CERN's activities. It will also enable CERN to gather data on knowledge transfer through mobility.

This Global Network will welcome former and current members of the CERN personnel (including users), companies from CERN's member states, universities and research institutes. It will deliver a database of members and a dedicated website, providing information about partnership and knowledge-sharing opportunities (training, new R&D projects, transferable technologies, jobs etc) across the community. It will also foster the creation of special interest groups and organize events at CERN.

The scope of the Global Network is broader than a typical "alumni" association because it aims to build and reinforce links between all of the key players in the knowledge-exchange process – be they individuals or institutions. Interactions between individuals will generate a CERN-specific social and professional network, while interactions between individuals and institutions will create value in areas such as recruitment by linking job seekers with potential employers. Finally, interactions between institutions will enable the exchange of best practice in specific thematic areas.

As a last point, I would like to stress that the importance of knowledge transfer through day-to-day exchanges with the general public cannot be overemphasized. No doubt most readers of this article are routinely asked by ordinary citizens to explain what CERN is. In these circumstances we are all acting as ambassadors for CERN, endowed with the responsibility to remove misconceptions about our field and to explain the role of fundamental research as a driver for innovation.

Contributing to communication with the general public is everyone's responsibility – the CERN Global Network will provide its members with information about the CERN-related projects that make an impact on society and that can be used to illustrate how CERN concretely delivers value to the community, in addition to its contribution to the advancement of basic science.

Facilitating and catalysing knowledge exchanges are among the most valuable benefits that we at CERN can deliver to society. A few words from George Bernard Shaw suffice to illustrate why: "If you have an apple and I have an apple, and we exchange these apples, then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas."

● For more about the CERN Global Network, see www.globalnetwork.cern.ch.

Claudio Parrinello, head of knowledge and technology transfer, CERN.

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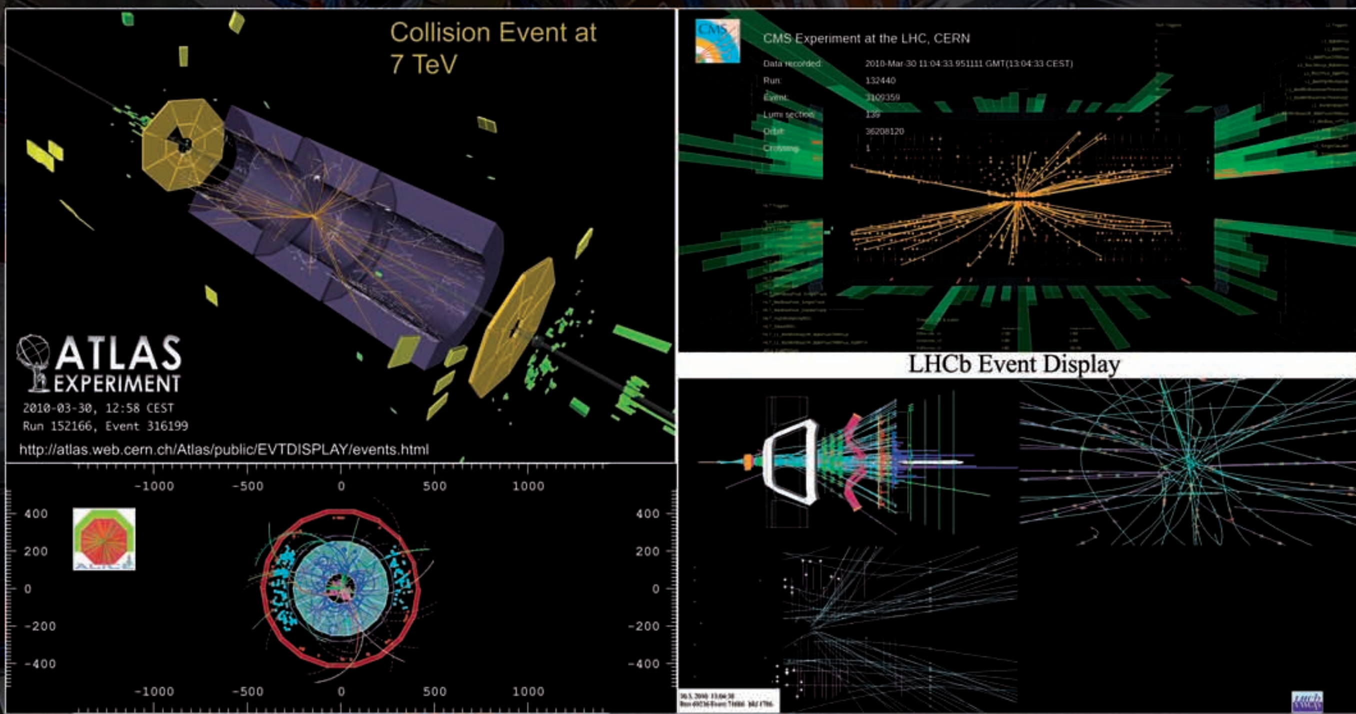

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