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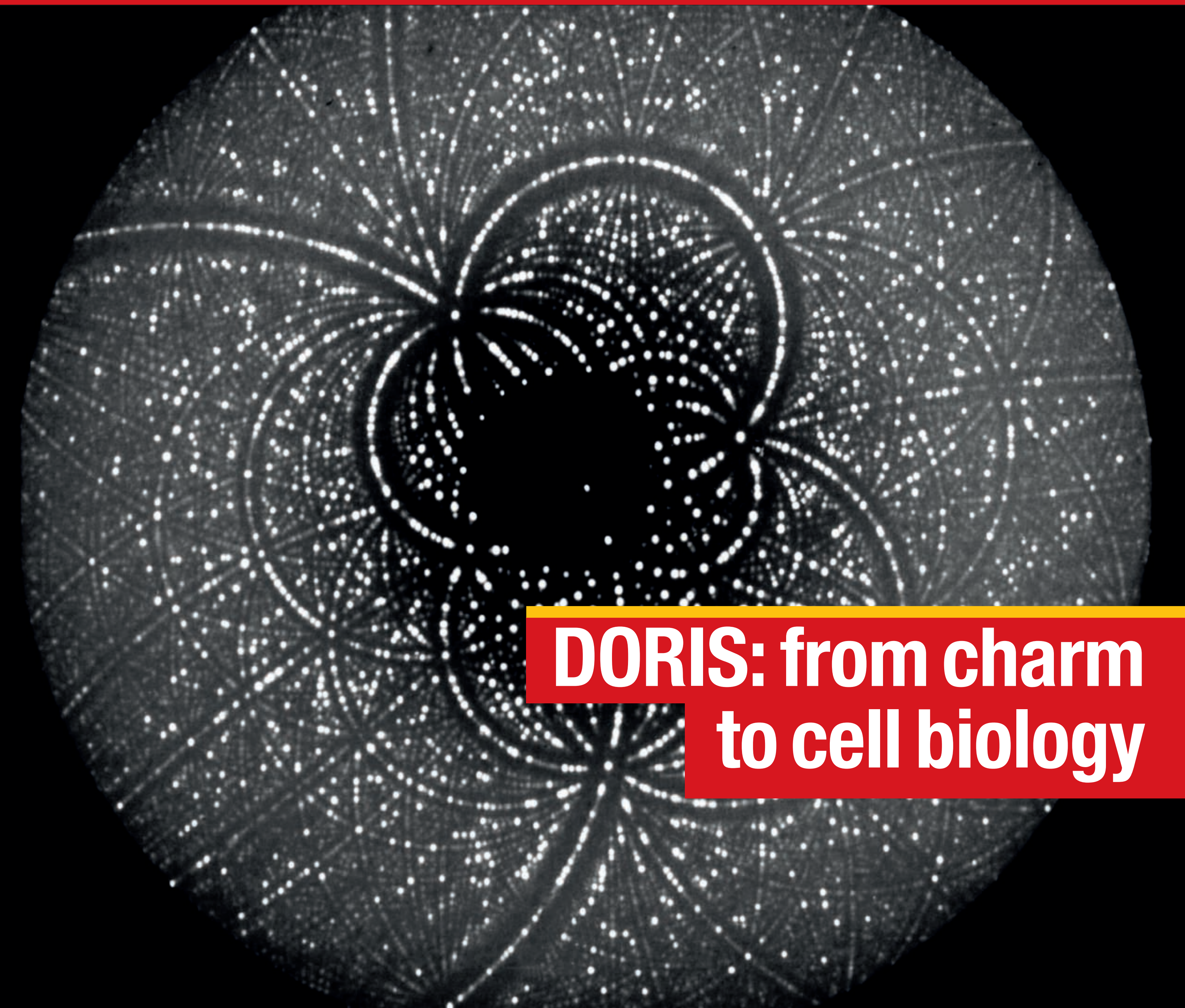

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Covering current developments in high-energy physics and related fields worldwide

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CERN

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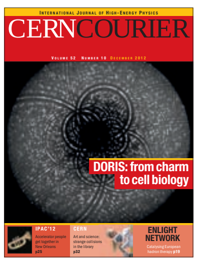


On the cover: The DORIS machine at DESY retires this year after a long career that went from particle physics to becoming a synchrotron light source, supplying experiments at HASYLAB, a dedicated laboratory on the DESY site. The image shows the Laue diffraction pattern of an enzyme called catalase, which splits hydrogen peroxide into water and oxygen. (Image Credit: Max Plank Society.)

News

LHC NEWS

De-squeezed beams for ALFA and TOTEM

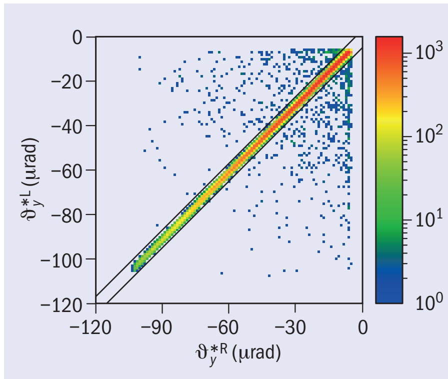
Following tests in September, a short, dedicated run at the end of October provided "de-squeezed" beams to the ALFA and TOTEM experiments, allowing new measurements of the elastic proton–proton cross-section.

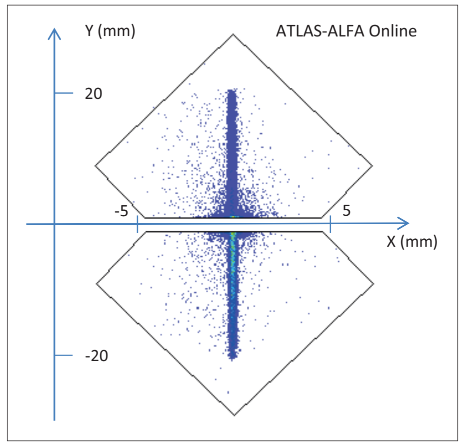
To squeeze the beam and so maximize the number of collisions, LHC beams at full energy typically have a value of β* – the distance to the point where the beam is twice as wide as it is at the interaction point – 0.60 m. However, squeezing to a small beam increases the angular beam divergence such that elastic proton–proton scattering at small angles cannot be observed.

The TOTEM experiment has measured the elastic proton–proton cross-section in previous dedicated runs, resulting in a determination of the total proton–proton cross-section using the optical theorem (*CERN Courier* November 2012 p7). To observe the contribution of electromagnetic interaction (Coulomb scattering) and its interference with the nuclear component to the elastic cross-section, scattering angles of the order of 5 μrad have to be reached. Since the Coulomb scattering cross-section is known theoretically, its measurement also gives access to an independent determination of the absolute luminosity of the LHC.

For this recent special run, a new record value of β* = 1000 m was reached, making the beams at interaction points 1 and 5 almost parallel. The angular divergence of the beams at the interaction points was reduced by a factor of 40 compared with low-beta (high-luminosity) operation. These special settings allowed the ALFA and TOTEM experiments – at points 1 and 5, respectively – to measure proton–proton scattering angles down to the microradian level. The experiments' Roman Pots were moved as close as 0.87 mm to the centre of the beam, which contained three bunches of 10^{11} protons each. At that distance the beam halo is intense and had to be reduced by an optimized collimation procedure that allowed a reduction of the halo background by a factor of 1000. This configuration enabled data-taking in good conditions for about an hour and, for the first time, ALFA and TOTEM could measure the elastic scattering in the Coulomb-nuclear interference region.

For future runs at 13 TeV, optics with β* of around 2 km will have to be developed. This will require the installation of additional quadrupole power cables in the LHC tunnel.





Top: The correlation in TOTEM between the reconstructed scattering angles of the two outgoing protons shows the elastic events. Right: An online hit map of one of the ALFA detectors. The narrow ellipse shape is the typical signal produced by elastically scattered protons.

CERN

The Republic of Cyprus becomes CERN associate member state

On 5 October, CERN's director-general, Rolf Heuer, and the minister of education and culture of the Republic of Cyprus, George Demosthenous, signed an agreement under which the Republic of Cyprus will become an associate member state in the pre-stage to membership. Before it comes into force, the agreement has to be ratified by the Parliament of Cyprus.

In the early 1990s, physicists from the Republic of Cyprus took part in the L3 experiment at CERN's Large Electron Positron collider before joining the CMS collaboration in 1995. A memorandum of understanding was signed between the University of Cyprus and CMS in 1999 under which Cypriot physicists have contributed to the development of the solenoid magnet and of the CMS electromagnetic calorimeter. They are also involved in the physics analyses of the CMS experiment, including certain searches for the Higgs boson and beauty quarks.

The Republic of Cyprus is the third country to accede to the status of associate member state in the pre-stage to membership, following Israel in 2011 and Serbia earlier this year.

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News

LHC PHYSICS

First results from proton–lead colliding beams

On 12 September, during a short, highly successful pilot run, the LHC operated with protons in one beam and lead ions in the other, so providing the LHC experiments with their first proton–nucleus collision data and opening new horizons for the heavy-ion community at CERN (*CERN Courier* November 2012 p6). During these few hours of pilot running, the ALICE experiment collected about 2 million events, sufficient not only to check the readiness of the detector for the long proton-ion run scheduled for the beginning of 2013, but also to perform a first analysis of the data and produce important physics results.

After the start of the heavy-ion physics programme in 2010, the LHC experiments obtained many striking results related to the formation of the hot and dense hadronic state of matter emerging from the collisions of lead nuclei. This state – the quark–gluon plasma (QGP) – is expected to manifest itself through various signatures, such as the suppression of high-energetic jets in the medium (*CERN Courier* January/February 2011 p6), collective particle motion, enhancement of strange-particle production and suppressed quarkonia production. In addition, surprising scaling effects were observed in the particle multiplicity compared with measurements at lower energies. However, given the complexity of the lead–lead (PbPb) colliding system, an important step in the quest for QGP lies in decoupling the effects of cold nuclear matter that arise at the initial stage of the collisions.

The proton–nucleus system represents the perfect benchmark for studying these effects because the colliding components are elementary and give rise to processes where the effects of the medium produced in the collision are either small or even totally absent. The collisions are also interesting because they allow the exploration of nuclear parton distributions in the region of small parton fractional momenta, which are so far unmeasured. Proton–nucleus collisions

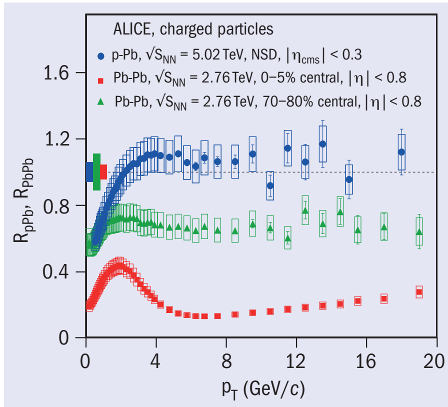


Fig. 1. Pseudorapidity density of charged particles measured in NSD pPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV compared with theoretical predictions.

can therefore provide the data needed to understand better the properties of PbPb collisions at the energy of the LHC. The study of the dense initial state also provides access to a completely new QCD regime where the parton densities are expected to be saturated.

Using the newly acquired data, the ALICE collaboration has been able to measure the charged-particle multiplicity density in proton–lead (pPb) collisions at a centre-of-mass energy of $\sqrt{s_{NN}}$ = 5.02 TeV (ALICE collaboration 2012a). Figure 1 compares this measurement with two main groups of theoretical models. The first group consists of models that incorporate nuclear modification – for example, shadowing – of the initial parton distributions; the second includes various saturation models. While the current experimental and theoretical precision is not sufficient for a detailed comparison, the figure shows that the data are described best by the model where the gluon shadowing parameter (sg) is tuned to previous experimental data at lower energies. Saturation models predict much steeper dependence on the pseudorapidity, which is not confirmed by the measurement.

Another important result from the analysis

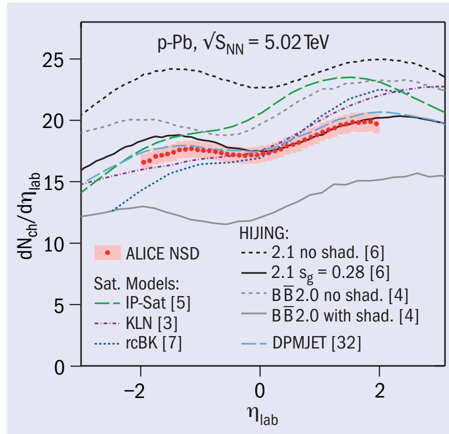


Fig. 2. The nuclear-modification factor of charged particles as a function of transverse momentum in NSD pPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. The data for $|\eta cms| < 0.3$ are compared with measurements in central (0–5% centrality) and peripheral (70–80%) PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV.

of the proton–nucleus data concerns the charged-particle transverse-momentum spectrum and the corresponding nuclear-modification factor (ALICE collaboration 2012b). The latter is calculated using the proton–proton data at collision energies of 2.76 TeV and 7 TeV as reference (figure 2). The result clearly indicates little or no modification of the production of charged particles with transverse momentum greater than 2 GeV/*c*, thus confirming that the suppression of high-energy jets in PbPb collisions is not a result of cold nuclear-matter effects. The comparison with the available theoretical predictions suggests that the models require further development because they have difficulties in describing the multiplicity and the transverse-momentum spectrum simultaneously.

● Further reading

ALICE collaboration, B Abelev *et al.* 2012a CERN-PH-EP-2012–307, arXiv:1210.3615 [nucl-ex].

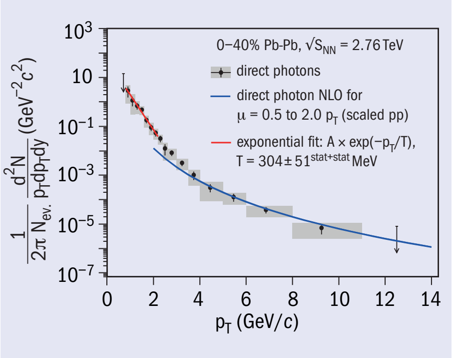
Measurement of photons stimulates quest for QGP temperature

One of the classic signals expected for a quark–gluon plasma (QGP) is the radiation of "thermal photons", with a spectrum reflecting the temperature of the system. With a mean-free path much larger than nuclear scales, these photons leave the reaction zone created in a nucleus–nucleus collision unscathed. So, unlike hadrons, they provide a direct means to examine the early hot phase of the collision.

However, thermal photons are produced throughout the entire evolution of the reaction and also after the transition of the QGP to a hot gas of hadrons. In the PbPb collisions at the LHC, thermal photons are expected to be a significant source of photons at low energies (transverse momenta, p_T, less than around 5 GeV/*c*). The experimental challenge in detecting them comes from the huge background of photons from hadron decays, predominantly from the two-photon decays of neutral pions and η mesons.

The ALICE experiment has measured photons produced in central PbPb collisions at a centre-of-mass energy per colliding nucleon pair, $\sqrt{s_{NN}} = 2.76$ TeV, by reconstructing with the time-projection chamber the tracks of e^+e^- pairs produced by the conversion of photons in the inner detectors. The same sample of photons was also used to measure the p_T spectrum of neutral pions. The analysis found an excess of direct photons of around 15% for $1 < p_T < 5$ GeV/c compared with the calculated decay-photon yields from neutral pions, η mesons and other mesons, with a somewhat larger excess at higher p_T.

Direct photons are defined as photons not coming from decays of hadrons, so photons from initial hard parton-scatterings (prompt photons and photons produced in the fragmentation of jets) – i.e. processes already present in proton–proton collisions – contribute to the signal. Indeed, for p_T greater than around 4 GeV/c, the measured spectrum agrees with that for photons from initial hard scattering obtained in a next-to-leading-order perturbative QCD calculation.



The transverse-momentum (p_T) spectrum of direct photons in central (0–40%) PbPb collisions at the LHC. At high p_T, the spectrum agrees with a next-to-leading-order perturbative QCD calculation. The spectrum is exponential at low p_T, with an inverse slope parameter of $T = 304 \pm 51$ (stat.+syst.).

For lower p_T, however, the spectrum has an exponential shape and lies significantly above the expectation for hard scattering, as the figure shows.

The inverse slope parameter measured by ALICE, $T_{LHC} = 304 \pm 51$ (stat.+syst.) MeV, is larger than the value observed in gold–gold collisions at $\sqrt{s_{NN}} = 0.2$ TeV at Brookhaven's Relativistic Heavy-Ion Collider (RHIC), $T_{RHIC} = 221 \pm 19$ (stat.) ± 19 (syst.) MeV. In typical hydrodynamic models, this parameter corresponds to an effective temperature averaged over the time evolution of the reaction. The measured values suggest initial temperatures well above the critical temperature of 150–160 MeV (approx. 1.8×10^{12} K) at which the transition between ordinary hadronic matter and the QGP occurs. The ALICE measurement also indicates that the LHC has produced the hottest piece of matter ever formed in a laboratory.

Further reading

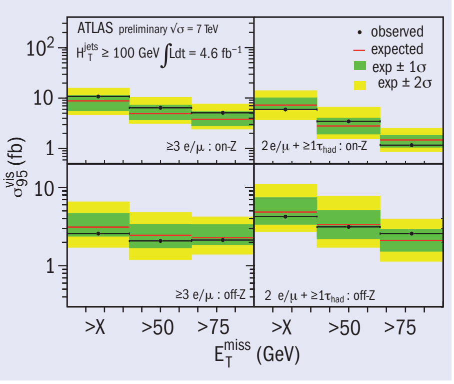
M Wilde *et al.* (ALICE collaboration) 2012 arXiv:1210.5958.

Leptons on the trail of the unexpected

Searches in LHC data that do not depend on specific theoretical models provide a valuable complement to optimized, model-dependent searches because they have the capacity to uncover hints of the completely unexpected. In this spirit, the ATLAS collaboration has recently looked for events with like-sign leptons and three or more leptons, using the full 2011 LHC data set of nearly 5 fb^{-1}, in the pursuit of signs of new physics. Unfortunately, no excess events compared against the Standard Model have been observed. However, the analyses have provided the information needed to set limits on a range of models and to set limits on the production of doubly charged Higgs bosons.

Prompt like-sign lepton pairs are rarely produced in Standard Model processes but they may be produced by fourth-generation quarks, supersymmetry, universal extra dimensions or processes in non-Standard Model Higgs models or new models. A recent study by ATLAS selected isolated electrons and muons and divided the events into dielectron, dimuon, and electron-muon categories. This analysis yielded upper limits on the cross-section of anomalous production of like-sign lepton pairs ranging between 1.7 fb and 64 fb (ATLAS 2012a). An extension to the analysis set limits on the production of doubly charged Higgs bosons decaying to pairs of electrons or muons (ATLAS 2012b).

Events with three or more prompt leptons in the final state are also rare in the Standard Model. A recent search for multilepton events by ATLAS identified isolated electrons, isolated muons and hadronically decaying taus and found only 1827 events with three or more leptons. These events were divided into four categories; depending on whether or not a Z boson was reconstructed from two opposite-charge electrons or muons in the event, and whether or not a tau candidate was present.



The observed 95% upper limits on the visible cross-section as a function of increasing lower bounds on missing transverse momentum, compared with the limits expected with backgrounds from the Standard Model only. The four panels show the four signal channels studied.

The figure shows results for these four categories: the limits on the number of events from non-Standard Model sources have been calculated and converted into limits on the "visible cross-section", i.e. the cross-section that is observable after event selection. The limits on the visible cross-section are given as a function of increasing lower bounds on the missing transverse momentum, a quantity that may be large in models with new physics. The smallest lower bound, "X", is 0 GeV for the off-Z channels (no reconstructed Z) and 20 GeV for the on-Z channels (with reconstructed Z). Limits are shown for events with more than 100 GeV of transverse momenta for the jets in the event (H_T^{jets}); an upcoming publication includes the corresponding limits for lower values of H_T^{jets} and other variables of interest. These visible cross-section limits can be converted into upper limits on the cross-section for many specific models, including the doubly charged Higgs and new theories yet to come.

Further reading

ATLAS collaboration 2012a arXiv:1210.4538 [hep-ex].

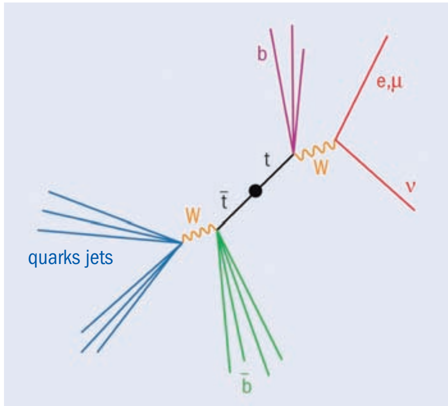
News

CMS homes in on the heaviest quark

The top quark is the heaviest point-like particle known. It weighs about as much as an atom of tungsten yet is an elementary building block of the Standard Model of particle physics. Its mass is one of the model's important parameters and is directly related via radiative corrections to the masses of the W and Higgs bosons. Precise knowledge of the top quark's mass is therefore extremely valuable to constrain theoretical models.

The CMS collaboration has measured the top-quark mass by exploiting all possible final states originating from different decays of W bosons produced in the decays of top quarks. Final states where the W boson decays into leptons are particularly "clean" (see figure). Such events are selected by requiring energetic jets in the central region of the CMS detector, of which at least one must be compatible with originating from a bottom quark ("b-tagged jet"), together with one or two isolated and high-energy leptons. The selected samples are extremely pure in top-quark-pair events, with estimated purities greater than 95% for events containing at least one electron or a muon.

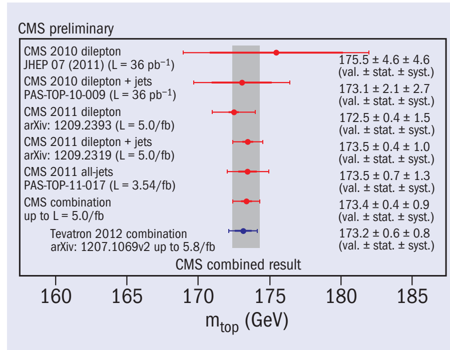
For hadronically decaying W bosons, the reconstruction techniques make use of kinematic fits to improve the energy resolution and the likelihood methods that can handle the combinatorial ambiguities in finding the triplet of jets corresponding to the top-quark decay. The use of b-tagging helps considerably in constraining these ambiguities further. For dilepton events, the presence of two neutrinos accompanying the charged leptons from the W-boson decays requires alternative techniques.



Example of a top-quark-pair decay chain leading to a final state with a charged lepton (e/μ) and four jets, two of which originate from the b quarks.

All of the methods and channels used give consistent measurements of the top-quark mass. The results are now fully dominated by uncertainties other than statistical, with major contributions coming from the uncertainty associated with the jet-energy scale and how well the Monte Carlo simulations model the details of the top decay. The best single measurement of the mass of the top quark, from the e/μ+jets channel, results in a statistical uncertainty of 0.4 GeV and a systematic uncertainty of around 1 GeV.

The combined CMS measurement, accounting for correlations between uncertainties obtained in the individual channels, yields a total uncertainty of about 1 GeV. This result is already competitive (and in agreement) with the combined measurement from the CDF and DØ experiments at Fermilab's Tevatron, as the figure shows. For a further reduction of the uncertainty, it will become important to employ novel measurement techniques.



The CMS measurement of the top-quark mass, using combined data from 2010 and 2011 at the centre-of-mass energy of 7 TeV, as presented at the TOP2012 conference.

The CMS collaboration has also measured the difference in mass between the top quark and its antiquark – an important test of the symmetry between matter and antimatter. This is done by splitting the sample of events with e/μ+jets into two subsamples with opposite lepton charges. The difference in quark–antiquark masses is compatible with zero with an uncertainty of about 0.5 GeV. This is the best precision on this mass difference to date.

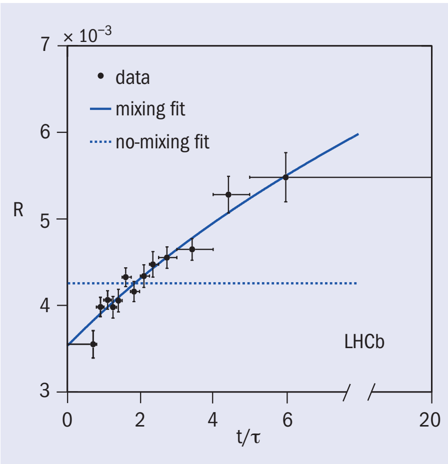
After more than 15 years of precision top physics at the Tevatron, the baton in the race to understand nature's heaviest quark has now passed to the LHC. With an uncertainty on the top-quark mass of 1 GeV, CMS is now at the forefront of precision physics in the top sector.

LHCb reports first 5σ observation of charm mixing

The large cross-section for charm production at the LHC, and the geometry and instrumentation of the LHCb detector, provide samples of charmed hadrons far larger than those accumulated by previous experiments. These allow the Standard Model to be tested by studying various interesting phenomena such as CP violation and mixing in D^0 mesons.

The electroweak force can cause D^0 mesons (consisting of a charm quark and an anti-down quark) to transform into their antiparticle, $\bar{D}^0$ (anti-charm and down), and back. Such "flavour oscillations" or "mixing" have been observed and studied in detail in K^0, B^0 and B_s^0 mesons. In the charm system, however, the period of the oscillations is so long – over one hundred times the average lifetime of a D^0 meson – that although the BaBar, Belle and CDF collaborations have reported strong evidence of the effect, none of them has been able to claim an unambiguous observation.

One of the best channels to search for charm mixing is the decay $D^0 \rightarrow K\pi$. The initial flavour can be identified by the charge of the accompanying pion in the decay $D^{*+} \rightarrow D^0\pi^+$ or $D^{*-} \rightarrow \bar{D}^0\pi^-$. The mixing effect appears as a decay-time dependence of the ratio R between the number of reconstructed "wrong-sign" (WS) and "right-sign" (RS) processes: $D^0 \rightarrow K^+\pi^-$ and $D^0 \rightarrow K^-\pi^+$, respectively, and their charge conjugates. The WS process can proceed either by a Cabibbo-suppressed decay or through flavour oscillation followed by a favoured decay. In the absence of mixing, R will be constant as a function of the D^0 decay time, t, while, in the case of mixing, it is predicted to be an approximately



Decay-time evolution of the ratio WS/RS (points) with the projection of the mixing allowed (solid line) and no-mixing (dashed line) fits overlaid.

parabolic function of t. Determining R in bins of t therefore allows a measurement of the mixing parameters, while also cancelling many potential sources of systematic uncertainty.

The figure shows the ratio WS/RS, measured by the LHCb experiment, as a function of decay time, from a total of 36,000 WS and 8.4 million RS decays selected from the 1.0 fb^{-1} of data recorded in 2011. The horizontal dashed line shows the no-mixing hypothesis; the solid line is the best fit to data when mixing is allowed. The clear time-dependence observed excludes the no-mixing hypothesis by 9.1σ. The oscillation parameters are determined with uncertainties about a factor two smaller than in previous measurements.

Since the Standard Model predictions for the mixing parameters have large uncertainties, the next step will be to focus on cleaner observables to search for possible contributions from new physics. In particular, LHCb is now well placed to investigate whether there is a CP-violating contribution to the oscillations, in contrast to the Standard Model expectation. This will be achieved by studying charm mixing in this and other decay channels and exploiting the large increase in data following the successful 2012 LHC run.

● Further reading

LHCb collaboration, LHCb-PAPER-2012-038, to be submitted to *Phys. Rev. Lett.*

ASTROPARTICLE PHYSICS

XMM-Newton discovers new source of cosmic rays

Researchers using the European X-ray astronomy satellite XMM-Newton have discovered a new source of low-energy cosmic rays in the vicinity of the Arches cluster, near the centre of the Milky Way. Their origin differs from that of higher-energy cosmic rays that originate in the explosions of supernovae.

Low-energy cosmic rays with kinetic energy less than half a billion electronvolts are not detected at Earth, since the solar wind prevents them from entering the heliosphere. Therefore little is known about their chemical composition and flux outside the solar system.

V Tatischeff, A Decourchelle and G Maurin, from the institutes of CNRS and CEA in France began by studying the X-ray emission that should theoretically be generated by low-energy cosmic rays in the interstellar medium. They then looked for signs of this in X-ray data collected by XMM-Newton since its launch in 1999. By analysing the properties of the X-ray emission of interstellar iron recorded by the satellite, they found the signature of a large population of fast-moving ions in the vicinity of the Arches cluster, about 100 light-years from the centre of the Milky Way. The stars in this cluster are travelling together at approximately 700,000 km/h. The cosmic rays are in all likelihood produced in the high-speed collision of the star cluster with a gas cloud in its path.

This is the first time that a major source of low-energy cosmic rays has been discovered outside the solar system. It shows that the shock waves of supernovae are not the only objects that can cause mass acceleration of atomic nuclei in the galaxy. These findings should make it possible to identify new sources of ions in the interstellar medium, and may lead to a better understanding of the effects of these energetic particles on star formation.

● Further reading

V Tatischeff *et al.* 2012 *A&A* **546** A88.

SUPERHEAVY ELEMENTS

RIKEN gets clear view of element 113

Researchers at the RIKEN Nishina Center for Accelerator-based Science have obtained the most unambiguous data to date on element 113. A chain of six consecutive α decays, produced in experiments at the RIKEN Radioisotope Beam Factory, conclusively identifies the element through connections to well known daughter nuclides.

In the experiment at the RIKEN Linear Accelerator Facility in Wako, near Tokyo, Kosuke Morita and his team fired zinc ions travelling at 10% the speed of light at a thin target of bismuth and used a custom-built gas-filled recoil ion separator coupled to a position-sensitive semiconductor detector to identify the reaction products. On 12 August they detected the production of a very heavy ion followed by a chain of six consecutive α decays, which they identified as the products of an isotope of element 113. The chain began with the decay to roentgenium-274 (element 111) and ended in mendelevium-254 (element 101).

The team previously detected element 113 in experiments conducted in 2004 and 2005, but were then able to identify only four α decays followed by spontaneous fission of dubnium-262 (element 105), which is not a well known process. The decay chain detected in the latest experiments takes an alternative route via α-decay, the data indicating that the dubnium decayed into lawrencium-258 (element 103) and finally into mendelevium-254. The decay of dubnium-262 to lawrencium-258 is well known and provides unambiguous proof that element 113 is the origin of the chain.

● Further reading

K Morita *et al.* 2012 *J. Phys. Soc. Jpn* **81** 103201.

***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 proposals to the editor at cern.courier@cern.ch.

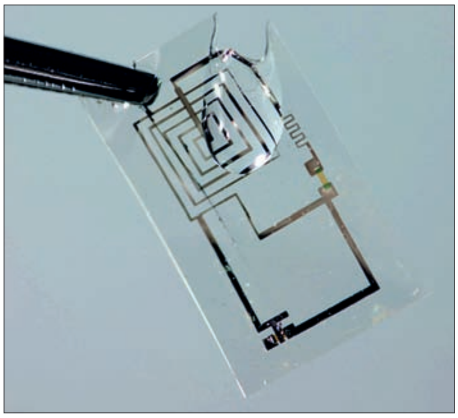
Sciencewatch

Compiled by John Swain, Northeastern University

Silicon electronics that can disappear

Researchers in the US have found a way to produce silicon devices that degrade, opening the door to biodegradable electronics and medical implants that can be absorbed safely in the body. John Rogers and colleagues at the University of Illinois at Urbana-Champaign, Tufts University and Northwestern University, have developed a new type of technology that they call "transient electronics". Based on earlier work with ultrathin sheets, the new devices dissolve in a few days – for example, in biological fluids.

Silicon hydrolyses in the body at a rate of about 1 nm a day. So, working from this understanding, Rogers and his co-workers have built devices out of 100-nm-thick silicon, using magnesium for conductors, magnesium or silicon oxide for insulators and silk as a substrate. Three weeks after implanting these in mice, the team's devices leave only residues of silk – with the silk taking a little longer to break down.



A biodegradable integrated circuit during dissolution in water. (Image credit: Beckman Institute, University of Illinois and Tufts University/Courtesy J Rogers.)

Further reading

S-W Hwang *et al.* 2012 *Science* **337** 1640.

Evolution caught in the act

Opponents of evolution often complain that it is not seen in real time – but now that objection is gone. Zachary Blount of Michigan State University and colleagues grew *E. coli* bacteria for almost 25 years and followed them for more than 56,000 generations starting in 1988. The idea was to see if some of them would evolve to consume citrate as a nutrient. While *E. coli* may have been able to do this long ago, the ability to consume citrate in the presence of oxygen was lost at least 13 million years ago.

Around 33,000 generations into the experiment, one strain learnt the trick. It took three steps, taking place over more than 13,000 generations, to develop this ability. This experiment demonstrates that evolution really does take place and it even reveals how pre-existing genetic information is reshuffled to give rise to new characteristics. Darwin would have been thrilled.

Further reading

Z D Blount *et al.* 2012 *Nature* **489** 513.

The smallest ice crystal

How many water molecules does it take to make a crystal? About 275 ± 25, according to Christoph Pradzynski of the University of Göttingen and colleagues. The researchers developed a technique that allowed them to measure for the first time the infrared spectra of precisely selected molecular clusters in a size range that was previously inaccessible. Studying size-selected clusters with the number of water molecules ranging from 85 to 475, they found that the absorption band at around 3200 cm^{-1}, which is indicative of crystalline ice, first appears in clusters of about 275 molecules.

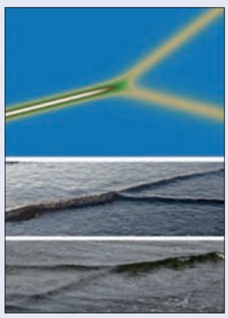
The results should help to refine the interaction potentials of water that are used in predicting water's macroscopic properties and the techniques could also be applied to other substances.

Further reading

C C Pradzynski *et al.* 2012 *Science* **337** 1529.

Nonlinear-waves at the beach

Most people think of low-amplitude ocean waves as being linear to a good approximation but it turns out that this is far from the case. Mark Ablowitz and Douglas Baldwin of the University of Colorado in Boulder report on nonlinear interactions that occur every day at low tide on two flat beaches at Nuevo Vallarta, Mexico, and Venice beach, California. Waves that intersect in X and Y shapes are closely related to interacting "line soliton" solutions of the nonlinear Kadomtsev–Petviashvili equation.



Plot of a Y-like interaction, top, and photos at the beaches in Mexico, centre, and California.

Their observations follow a tradition of soliton-spotting that began in 1834, when a naval architect, J S Russel, first recorded a solitary wave on the Union Canal in Edinburgh. They show that these nonlinear interactions are not rare events, as had been previously thought. Apart from being something to look out for while on holiday, such interactions play an important role in the formation of tsunamis – though, of course, with much larger waves.

Further reading

M J Ablowitz and D E Baldwin 2012 *Phys. Rev.* **E86** 036305.

Reaching the Planck scale at accelerators

The Planck scale – around 10^{-35} m – is far below scales that can be reached with current accelerators; even the LHC gets down to only about 10^{-19} m. However, there may yet be hope. Vahagn Gharibyan of DESY, Hamburg, has looked at laser Compton-scattering from leptons at current and future accelerators for effects of a modified dispersion relation that is expected in many quantum-gravity models. Despite the deviations from the usual relation being suppressed by the Planck scale, it turns out that the effective change in refractive index of space could be detectable. For 6 GeV electrons at PETRA-III, a scale of 10^{-31} m could be reached, while at a future 250 GeV lepton collider, the real Planck scale could come into view.

Further reading

V Gharibyan 2012 *Phys. Rev. Lett.* **109** 141103.

Astrowatch

Compiled by Marc Türler, ISDC and Observatory of the University of Geneva

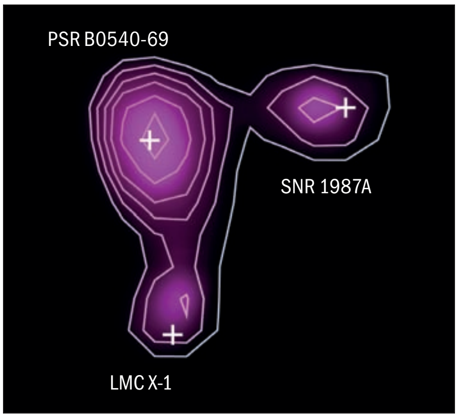
Titanium illuminates the 1987 supernova

The INTEGRAL gamma-ray satellite has detected the radioactive decay of an isotope of titanium, ^{44}Ti, in the remnant of the nearby supernova SN 1987A. This observation confirms that ^{44}Ti powers the infrared, optical and ultraviolet emission that is still being observed 25 years after the stellar explosion.

On 24 February 1987, two astronomers at the Las Campanas Observatory in Chile and an amateur astronomer in New Zealand were the first to notice an unexpected bright star in the Large Magellanic Cloud, a small satellite galaxy of the Milky Way. They actually witnessed the first supernova to be visible to the naked eye since SN 1604, which was studied by Johannes Kepler (*CERN Courier* December 2004 p15, January/February 2006 p10). SN 1987A reached peak brightness in May that same year and slowly declined over the following months.

The shape of the light curve of a supernova – the evolution of the luminosity – is determined by the radioactive decay of elements produced during the explosion of the progenitor star. Nickel-56, with a half-life of six days, is responsible for the peak of the emission, while the radioactive decay of cobalt-56 to iron-56 slows down the subsequent decrease in brightness for several months (77 days of half-life). Over longer timescales, ^{44}Ti is expected to dominate in sustaining the remnant emission of the explosion for decades (85 years of half-life).

The actual contribution of ^{44}Ti to the late time emission of a supernova is poorly known. Indeed, the violent interaction of the stellar ejecta with the surrounding medium will lead to shock waves and additional emission blending with the contribution from this radioactive decay in the infrared to ultraviolet band. Theoretical simulations of SN 1987A suggest that the amount of ^{44}Ti synthesized during the explosion is in the range $0.02–2.5 \times 10^{-4}$ solar masses. This uncertainty by two orders of magnitude is because there are many unknowns in the physical properties of the stellar interior and of the explosive shock wave. Direct detection of ^{44}Ti is thus important for improving the constraints on the physical conditions in this supernova explosion.



INTEGRAL image of SN 1987A and two other sources in the Large Magellanic Cloud taken in the 65–82 keV energy range. A spectral analysis reveals that the emission of the supernova remnant SNR 1987A comes from the radioactive decay of ^{44}Ti, unlike the emission of the two other sources. (Image credit: ESA/INTEGRAL/IBIS-ISGRI/ S Grebenev et al.*)*

This breakthrough has now been achieved by a small group of astronomers led by Sergey Grebenev of the Space Research Institute in Moscow. His request for a long observation (around 40 days) of SN 1987A by ESA's INTEGRAL gamma-ray satellite turned out to be highly fruitful. The decay of ^{44}Ti can be directly detected by INTEGRAL through emission lines produced in both hard X-rays at energies of 67.9 keV and 78.4 keV and in gamma-rays at 511 keV and 1157 keV. While the observation of the latter lines yielded only upper limits, the former ones allowed a 4.7σ detection.

SN 1987A is visible in the energy band 65–82 keV, while it remains invisible in two adjacent bands. The emission corresponds to a mass of ^{44}Ti of $3.1 \pm 0.8 \times 10^{-4}$ solar masses. This is slightly above the upper bound of the theoretical predictions but corroborates the results obtained for Cassiopeia A ($1.6{+0.6}{-0.3} \times 10^{-4}$), the only other supernova remnant where ^{44}Ti has been clearly detected. Both measurements favour theoretical models with important production of ^{44}Ti during the stellar explosion.

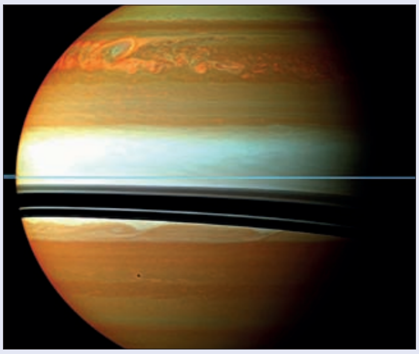
This discovery arrives at the end of the INTEGRAL satellite's 10th year in orbit. The anniversary of the launch was celebrated on 17 October during a conference in Paris. Among the highlights of the spacecraft's mission so far are the mapping of electron–positron annihilations in the bulge of the Galaxy, as well as the detection of polarization in the Crab Nebula and in the black hole binary Cygnus X-1 (*CERN Courier* March 2008 p12, November 2008 p11, May 2011 p12). Over the years, INTEGRAL has detected and characterized hundreds of new, heavily obscured X-ray sources among which some – called super-fast X-ray transients – were observed to undergo extremely rapid and high-amplitude luminosity variations.

Further reading

S A Grebenev *et al.* 2012 *Nature* **490** 373.

Picture of the month

A giant storm was at the origin of the beautiful spirals imprinted in Saturn's atmosphere. This false-colour infrared image of the ringed planet was taken by NASA's Cassini spacecraft, which has been in orbit about Saturn since July 2004 (*CERN Courier* September 2004 p13). Colours correspond to different heights in the atmosphere, from red, deep inside, to blue at the top. The view is taken from the plane of the rings (blue horizontal line), which cast their shadow on the planet's southern hemisphere. The vortices in the northern hemisphere are atmospheric perturbations following the passage of a massive storm that moved from right to left and is hidden on the other side in this view taken in January 2011. Such giant storms on Saturn typically occur every 30 Earth years, or once every Saturn year. It was, however, a surprise to see one so early, well before Saturn's summer solstice in 2017. (Image credits: NASA/JPL-Caltech/Space Science Institute.)



CERN Courier Archive: 1969

A LOOK BACK TO CERN COURIER VOL. 8, DECEMBER 1969, COMPILED BY PEGGIE RIMMER

CORNELL

2 GeV synchrotron closes down

On 3 November, the Cornell 2 GeV electron synchrotron was closed down. This machine was the third in a line of synchrotrons built at the same site, each successive accelerator taking over many of the components of its predecessor. The first, a 300 MeV machine, came into operation in 1949 and was responsible for much of the pioneering work on pion photoproduction, leading to the discovery of the first pion–nucleon resonance. In 1955 its successor, the world's first alternating gradient synchrotron, came into operation at 1 GeV. Finally, in 1964 the magnet ring was replaced again to raise the energy to 2 GeV. Since then the accelerator has been active in meson-photoproduction and electron-scattering experiments.

The 2 GeV machine still has a future but not at Cornell. It has been dismantled and shipped to Argonne National Laboratory to be reincarnated as a fast-cycling booster for the Zero Gradient Synchrotron proton accelerator.

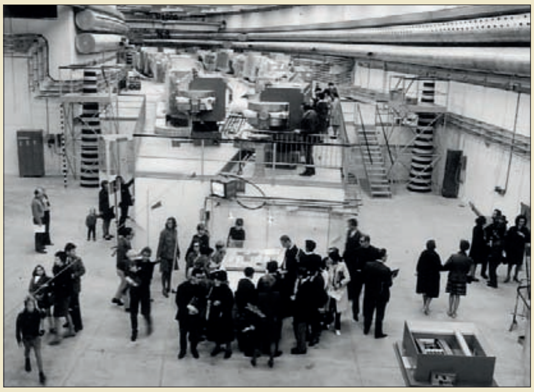
● Compiled from texts on p392.

Faculty, students and technicians toast the end of 20 years of service by the Cornell 2 GeV synchrotron and its predecessors. Wearing helmets, laboratory director B D McDaniel (left) helps R L Martin of Argonne National Laboratory to start dismantling the accelerator. Argonne will receive the accelerator for use in a fast-cycling Booster. (Image credit: Cornell.)

CERN

The Finance Committee – in session on the 12 November, its 100th meeting since the beginning of CERN – is an advisory committee to the CERN Council. It has the exacting job of supervising CERN's finances, being concerned with such things as examining budget proposals, salary structures and cost variation formulae and with approving the award of major contracts to industry.

Saturday 25 October was "Open Day" at CERN, when CERN staff, their families and friends could tour the site to see the big machines and specially prepared exhibits illustrating the work of the different sections. By the end of the day, 2472 visitors had been clocked through the gates. For the first time on an Open Day, there was much to see at the Intersecting Storage Rings and the photograph shows visitors flowing through the huge tunnel, where many magnet units are now installed.



Compiler's Note

There was and still is an acute lack of role models for women in science. In *CERN Courier* during the whole of 1969, only one indisputably "scientific" woman was photographed – the late Hildred Blewett, a machine engineer (see cover thumbnail); one other candidate was the long-haired blond in the foreground at the Cornell celebration. The corresponding count for men was in the hundreds. Excluding women at the Open Day and in advertisements, only six other women featured in *CERN Courier* photos throughout 1969: two government representatives, three assistants to CERN Council and one scanner.

The number of women in scientific, engineering and technical (SET) photos in *CERN Courier* today is better but not as good as it could be for the simple reason that there are just not that many women entering or staying in the field. At the end of 2011, CERN Users numbered 10,388; of the 10,302 engaged in SET activities, 16% were women and this is well matched on CERN Council, which is 17% female. On the other hand, while 21% of the 2424 CERN staff members were female, only 10% of the 896 employed in the SET sectors were female.

On the administrative side, the situation is greatly improved. In the 1960s, the CERN Finance Committee was an all-male assembly; today 33% of the delegates are female. Better still, half of CERN's professional administrators are women – or 50.42%, to be precise. Best of all, from 1 January 2013 CERN Council will have its first woman president, Polish physicist Agnieszka Zalewska.

A visit to CERN might be an epiphany for some school or college students, so it is encouraging to note that the Visits Service records an impressive increase for half-day guided tours from around 24,000 in 2008 to 84,000 in 2012. And the really good news is that some of the underground areas will once again be accessible on the next Open Day, planned for September 2013, offering a unique experience that no visitor ever forgets.

One CP-violating phase, three beautiful results

Three experiments converge in their quest to measure the least-known angle of the unitarity triangle.

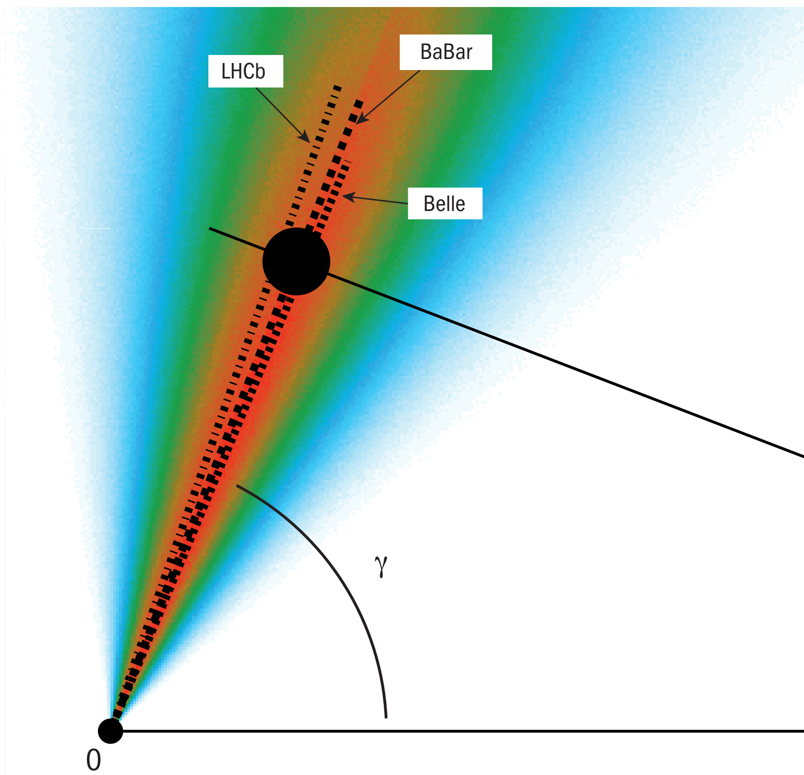


Fig. 1. An illustration of the three independent measurements of γ, as presented at CKM2012. The colouring gives an impression of the total uncertainty based on a combination of the three results. The large black dot indicates the expectation based on measurements of other Standard Model parameters.

The last day of September saw an exciting coincidence of three competing experiments simultaneously releasing three new and directly similar results. The occasion was the CKM2012 workshop in Cincinnati and the subject of interest: excellent new measurements of the CKM phase, γ.

Two of the contenders were well known to each other, having battled for supremacy in B physics for more than a decade. The "B factory" experiments, Belle and BaBar, were designed on the same principle: e^+e^- collisions at the $\Upsilon(4S)$ resonance produce large numbers of $B\bar{B}$ pairs, which can be cleanly reconstructed in isolation. Except for a few selective technology choices, their most obvious dissimilarity is their location: Belle is at KEK in Japan while BaBar resides at SLAC in the US.

The meeting in Cincinnati saw these old foes joined by a new competitor, LHCb, which unlike the B factories collects its huge samples of bottom hadrons from high-energy proton–proton collisions at the LHC. Although there is little doubt that the CERN-based experiment will ultimately triumph with precision measurements of γ, on the morning of 30 September no one yet knew if that time had come.

Among the fundamental forces of nature, the weak force is special. Not only does it have a unique structure that gives rise to fascinating and often counter-intuitive physical effects, it is also highly predictive, making it excellent territory for searches for new physics. Perhaps the most celebrated phenomenon is CP violation – a common short-hand for saying that weak interactions of matter differ subtly from those of antimatter. Discovered in 1964 as a small effect (10^{-3}) in K^0_L decays, CP violation has more recently been observed as a large effect (10^{-2}–10^{-1}) in several B-meson decay modes (*CERN Courier* April 2001 p13.)

The CKM matrix

The size and variety of CP violation in b-quark transitions is widely acknowledged as a triumphant validation of the Cabibbo-Kobayashi-Maskawa (CKM) description of quarks coupling to $W^\pm$ bosons. This mechanism explains three-generation quark-mixing – up-type quarks (u, c, t) transmuting to and from down-type quarks (d, s, b) via the charged weak current – in terms of a 3 × 3 matrix rotation of the quarks' mass eigenstates into their weak-interaction eigenstates. CP violation arises naturally through the mathematically mandatory presence of one complex phase in this generically complex matrix. Furthermore, if nature indeed has only three quark generations and probability is conserved, then the CKM transformation must be unitary. ▷

CP violation arises naturally through the presence of one complex phase in this generically complex matrix.

LHC physics

Unitary matrices have a property that the scalar product of any two rows or columns must equate to zero. In the case of the 3 × 3 CKM matrix, six equations can be written down that must hold true if there are three – and only three – generations of quarks. Of these six relations, which are all triangles on the Argand plane, the most celebrated is

$$V^*_{ub}V_{ud} + V^*_{cb}V_{cd} + V^*_{tb}V_{td} = 0$$

where each V_{XY} is one of nine CKM matrix elements that encode the strength with which quark X couples to quark Y. This triangle, whose internal angles are usually labelled α, β and γ, is widely publicized because it summarizes concisely the largest CP-violating processes in B mesons. Studying the geometry of this unitarity triangle (UT) tests the internal consistency of the three-generation CKM picture of quark mixing. The lengths of the sides of the UT are measured in CP-conserving processes, whereas the size of the angles (or phases) can be measured only via CP-violating decays.

In Cincinnati, the BaBar collaboration announced that it had achieved a measurement of $\gamma = 69^{+17}_{-16}$° from a combination of many analyses of $B^\pm \to D^{(*)}K^\pm$ decays. The precision of around 25% can be compared with the precision with which the other two UT angles are known. The smallest of the three angles, β, is known to less than 4%, $\beta = 21.4 \pm 0.8°$, principally from measuring the time-dependent CP asymmetry in the mixing and decay of $B^0 \to J/\psi K^0$ decays. The angle subtended by the apex of the triangle, α, is known to around 5%, $\alpha = 88.7^{+4.6}_{-4.2}$°, from similar, time-dependent analyses of $B^0 \to \pi\pi$ and $B^0 \to \rho\rho$ decays. Remembering that the three angles of a triangle always add up to 180°, it is clear that BaBar's central value is remarkably close to the CKM expectation.

The Belle collaboration's presentation quickly followed and explained a similar measurement of $\gamma = 68^{+15}_{-14}$°, the modest improvement perhaps being a result of the almost twice-as-large data set. As with BaBar, this number results from the careful combination of various measurements of CP-violating properties of $B^\pm \to DK^\pm$ and $B^\pm \to D^*K^\pm$ decays.

Interfering amplitudes

The B factories' common choice of $B^\pm \to DK^\pm$ decays is not a coincidence. Among the current UT angle analyses, only γ measurements use direct CP violation in charged B decays. This promises a simple asymmetry of matter versus antimatter but requires two interfering amplitudes resulting in the same, indistinguishable final state. They must have different CP-conserving phases (generally true for any two quantum processes) and be of similar magnitude, or the influence of the less-likely process is too hard to detect.

In the UT definition, γ is identified as the weak phase difference between $b \to c$ and $b \to u$ quark transitions. Figure 2 shows Feynman diagrams for two paths of $B^\pm \to DK^\pm$. The one involving a $b \to c$ quark transition is labelled "favoured" because a b quark is most likely to decay to a c quark. The second diagram involves a $b \to u$ quark transition and is labelled "suppressed" because the chance of its occurrence is around 1% of that of the favoured process (i.e. the ratio of amplitudes, r_B is around 0.1).

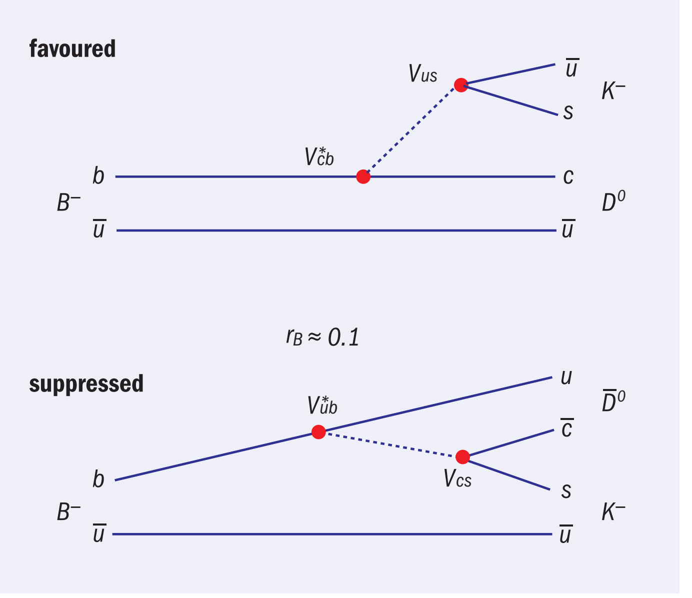


Fig. 2. The basic principle of accessing γ in $B^\pm \to DK^\pm$ decays. Two processes of similar magnitude are needed, one based on a $b \to c$ transition and the other $b \to u$. These two paths must arrive at an indistinguishable final state such that phase information may be accessed via quantum interference.

This all looks good except for the detail in figure 2 that the favoured diagram results in a D^0 while the suppressed diagram yields a $\bar{D}^0$. For the two B decays to interfere, the two neutral particles must be reconstructed in a final state that is common to both, i.e. the D^0 and $\bar{D}^0$ should be indistinguishable. This might occur in the following ways, all of which are studied by Belle, BaBar and to some extent, LHCb.

- CP-eigenstate decays of neutral D mesons are by definition equally accessible to D^0 and $\bar{D}^0$. In this case, the interference – and hence the size of the direct CP violation – is around 10% (from r_B in figure 2). Examples of this type are $B^\pm \to [K^+K^-]_D K^\pm$ and $B^\pm \to [K_S{}^0\pi^0]_D K^\pm$ decays, where the D indicates that the particles in parentheses originated from a D meson.
- The unequal rate of the favoured and suppressed B decays can be redressed by selecting D final states that have an opposite suppression. Such combinations are referred to as ADS decays, after their original proponents. The most obvious example is $B^\pm \to [\pi^\pm K^\mp]_D K^\pm$ decays where, importantly, the kaon from the D decay is of an opposite charge to that emanating from the B decay. In this particular case, the favoured B decay from figure 2 is followed by the doubly Cabibbo-suppressed $D^0 \to \pi^- K^+$ decay, whereas the suppressed B decay precedes a favoured $\bar{D}^0 \to K^+\pi^-$ decay. With this opposite suppression, the total ratio of amplitudes (r_B/r_D) is much closer to unity than

The combination of these three results leads to the conclusion that γ is known to better than 14% accuracy.

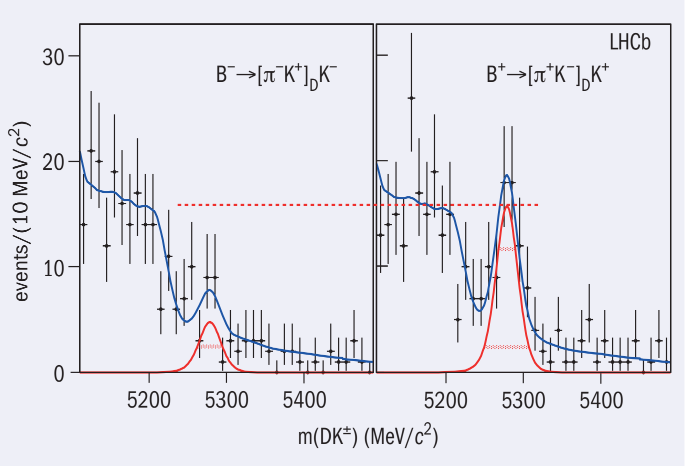


Fig. 3. Invariant mass distributions of ADS candidates from LHCb. The left plots are B^- events, B^+ events are on the right. The data, which were collected during 2011, are shown as black markers. The total fitted function is shown in blue and the signal, which exhibits a large asymmetry, is highlighted in red.

the first case, so larger CP violation, and hence greater sensitivity to γ, is achieved.

- A third possibility considers multi-body D decays such as $B^\pm \to [K_S{}^0\pi^+\pi^-]_D K^\pm$. In this case, the kinematics of the three-body D decay is studied across a 2D histogram, the Dalitz plot. When the $D \to K_S{}^0\pi^+\pi^-$ Dalitz plot for $B^- \to DK^-$ decays is compared with that of $B^+ \to DK^+$ decays, they look identical except for a few places where γ has induced CP violation. Some places on the Dalitz plot have large sensitivity to γ, others less, but a big advantage comes from understanding the CP-conserving phases that vary smoothly across the Dalitz plot. Such an analysis is complicated, but worth it as the patterns of CP asymmetry across the Dalitz plane can be solved by only one value of γ (modulo 180°). This compares well to the first two cases whose interpretations suffer from trigonometric ambiguities because of their non-trivial sinusoidal dependence on γ.

Both the Belle and BaBar results combine all of these methods using $B^\pm \to DK^\pm$ and $B^\pm \to D^*K^\pm$ decays. This diversity is vital since the branching fraction of γ-sensitive decays is so small (proportional to $|V_{ub}|^2$) and only a few hundred events have been collected in these experiments, even after a decade of operation.

LHCb has different advantages and challenges. On one hand the huge cross-section for B production at the LHC means that LHCb has a considerable advantage in the number of charged-track-only decays that it can gather. On the other hand, because of the hadronic environment LHCb fairs less well with modes containing neutral particles. The $D \to K_S{}^0\pi^+\pi^-$ mode is still useful, but cannot be relied on as heavily as at the B factories. Modes with a π^0 or a photon, notably the otherwise important $B^\pm \to D^*K^\pm$, $D^* \to D^0\pi^0/D^0\gamma$ suite of modes, have not yet been attempted at LHCb.

Nevertheless for the charged-track final states, such as the easiest ADS modes, LHCb has triumphed with first observations of the $B^\pm \to [\pi^\pm K^\mp]_D K^\pm$ mode (see figure 3), as well as the similarly interesting $B^\pm \to [\pi^\pm K^\mp \pi^- \pi^+]_D K^\pm$ mode. By measuring the large CP asymmetries in these modes, and with the help of an ambiguity-busting $B^\pm \to [K_S{}^0\pi^+\pi^-]_D K^\pm$ analysis, the LHCb collaboration concluded the CKM2012 session by announcing a measurement of $\gamma = (71.1^{+16.6}_{-15.7})°$ from $B^\pm \to DK^\pm$ decays.

The simple combination of these three independent results (neglecting their common systematics) leads to the conclusion that γ is known to better than 14% accuracy: $\gamma = 69.3^{+9.4}_{-8.8}°$. This is illustrated in figure 1, which also shows the remarkable similarity of the three measurements and their mutual agreement with the expectation based on the world-average values of β and α.

The concluding theme in Cincinnati was that despite LHCb's coming of age since CKM2010 (*CERN Courier* January/February 2011 p17) the CKM description of the quarks' weak interactions continues to prove impressively complete. It was noted however, that many flagship B-physics measurements, including the UT angles α and β, involve processes that contain quantum loops and/or boxes. Such exotic processes are the reason for well established phenomena such as B-mixing and flavour-changing neutral-current decays. Standard Model loop-processes contain the virtual existence of high-mass particles such as $W^\pm$, top quarks and by extension, possibly non-Standard Model particles too. If they exist, and if they couple to quarks, such new-physics particles could be altering the physical behaviour of B mesons from the CKM-based expectation (*CERN Courier* October 2008 p60).

Detection of non-CKM effects is possible only if loop-sensitive observations can be compared with a gold-standard CKM process. $B^\pm \to DK^\pm$ decays provide exactly this. They are "tree-level" measurements (meaning, no loops) that are almost unique in heavy-flavour physics for their theoretical cleanliness. The measurement of γ in these modes is a measurement of γ_{CKM}, something the other two angles of the UT cannot boast with such certainty.

Though γ is currently the least well known UT property, by the end of this decade LHCb will have reduced its uncertainty to less than 5° (less than about 8%). By the end of the epoch of the Belle and LHCb upgrades, sub-degree precision looks likely (*CERN Courier* January/February 2012 p21 and December 2011 p7.). Such stunning precision will mean that this phase will become the CKM standard candle against which loop processes will be compared increasingly carefully.

Further reading

For the all the presentations at the CKM2012, see the workshop website: http://ckm2012.uc.edu.

Résumé

Trois résultats de toute beauté

Le 30 septembre, trois collaborations concurrentes ont livré trois nouveaux résultats directement comparables, à l'occasion de l'atelier CKM2012, à Cincinnati. Elles ont fait état d'excellentes nouvelles mesures de la phase de violation de CP, γ. Si l'on combine ces derniers résultats de BaBar (au SLAC), de Belle (au KEK) et de LHCb (au CERN), il apparaît que γ est connu avec une exactitude de plus de 14%.

Malcolm John, Royal Society Research Fellow, University of Oxford, and LHCb collaboration.

ENLIGHT: catalysing hadron therapy in Europe

As a pioneering multidisciplinary network celebrates its 10th anniversary, some of the founders recall how it all started.

Ten years ago, in February 2002, the European Network for Light Ion Hadron Therapy (ENLIGHT) had its inaugural meeting at CERN (*CERN Courier* May 2002 p29). About 70 specialists attended this first gathering from different disciplines, including radiation biology, oncology, physics and engineering. This was a considerable achievement, coming at a time when "multidisciplinarity" was not yet a buzz-word. The EU-funded project, co-ordinated by the European Society for Therapeutic Radiology and Oncology (ESTRO), came to an end in the summer of 2005 with the final meeting in Oropa, in the Italian Alps. Here, it was widely acknowledged that ENLIGHT had been a key catalyst in building a European platform to propel hadron therapy forwards. The encouraging results motivated the community to discuss how to maintain and broaden the network (*CERN Courier* October 2005 p31).

Less than a year later, in March 2006, more than 100 scientists from 20 European countries arrived at CERN for the preparatory meeting of ENLIGHT++; the two plus signs indicate more countries and more hadrons with respect to the previous project (*CERN Courier* June 2006 p27). The enlarged group of participants agreed that the goals of the network could be met best through two complementary approaches: research in areas needed for highly effective hadron therapy; and networking to establish and implement common standards and protocols for treating patients. The primary mandate of ENLIGHT++ is therefore to develop strategies for securing the funding necessary to continue the initiative in these two fundamental aspects, mostly through dedicated EU projects, while the network itself carries on without specific funding.

A growing success

Since starting in 2002, ENLIGHT has been growing steadily and it now counts some 400 participants from more than 20 countries across Europe. It entered its second decade with four EC-funded projects under its umbrella: PARTNER (which came to an end in September), ULICE, ENVISION and ENTERVISION, with total funding of €24 million. All of these projects are directed towards the different aspects of developing, establishing and optimizing hadron therapy.

The inaugural ENLIGHT meeting at CERN in February 2002.

The success of ENLIGHT and ENLIGHT++ is the result of years of work aimed towards a unified approach towards hadron therapy in Europe. Here, some of the key players from the birth of ENLIGHT share their personal recollections of those early years.

J-P Gérard, Centre Antoine-Lacassagne, Nice and ESTRO

Jean-Pierre Gérard.

"ENLIGHT was launched in 2002 as a result of several years of European activity in the field of hadron therapy. Indeed, as early as the 1970s, particle-beam therapy was already considered an attractive field of research (J P Gérard et al. 1978). In the 1980s, the EULIMA project – established in collaboration with CERN – was the first European attempt to design a cyclotron to produce carbon-12 ions. The award of an honorary degree to Ugo Amaldi by Lyon University 1 in 1997 marked the origin of the ETOILE project for a carbon-ion facility in Lyon, which is now part of the 'France HADRON' project.

"At that time, radiation oncologists in Germany, Italy, Switzerland and Austria were actively engaged in the design of accelerators to produce protons and carbon-ion beams through the Proton Ion Medical Machine Study (PIMMS). I was president of ESTRO in the period 1999–2001, and the European Framework Programme offered a good opportunity to initiate a co-operative European action that would bring together all of the teams interested in the field. ▷

Medical physics

Participants at the 10th anniversary meeting of ENLIGHT at CNAO, Pavia, in September 2012. (Image credit: ENLIGHT/L Iorino.)

"Thanks to the energy and vision of Germaine Heeren, the general secretary of ESTRO, it was possible to create the ENLIGHT group. A memorandum of understanding was signed in collaboration with CERN in 2002 and this became the basis of a call for a grant from the EU 5th Framework Programme (FP5).

"The grant was of a modest amount but represented a strong incentive to create, with the support of CERN, a dynamic collaboration between all of the radiation oncologists and physicists involved in this great hadron adventure. It is a real pleasure to see – 10 years later – that the dreams of these pioneers are becoming reality in Heidelberg, Pavia and other European centres, for the benefit of paediatric and adult patients."

Richard Pötter, Medical University of Vienna

Richard Pötter. (Image credit: ENLIGHT/ Manuela Cirilli.)

"ENLIGHT was founded on the basis of various developments in the field of particle therapy during the 1990s. Specific projects in different European countries had been conceived of but there was the common vision that these initiatives had to come together to strengthen efforts globally and establish light-ion radiotherapy successfully. Within ESTRO, a working group had already been initiated by prominent members of various European projects. This group prepared a comprehensive programme that included a range of topics, such as patient-selection modalities, preparation of clinical trials, technology, biology, imaging and health economics.

"An essential step forward was the decision to apply for an EC grant under the 5th Framework Programme, to fund the development of ENLIGHT with regards to these topics. The application was successful, so this European network gained a unique opportunity to enhance its activity through the different working groups and regular meetings, over a period of three years."

Ugo Amaldi, TERA Foundation

Ugo Amaldi.

"For me, the ENLIGHT project started with an e-mail received on Saturday 6 October 2001 from Germaine Heeren, secretary general of ESTRO. The subject line was "ESTRO Hadrons project – VERY URGENT" and it was addressed to many European radiation oncologists and physicists. The purpose – defined in a meeting chaired by Richard Pötter in December 2000 and better focused in a second meeting called by Jean-Pierre Gérard, who at the time was ESTRO president – was to submit a proposal by 18 October to the European FP5. In the e-mail, I was asked to co-ordinate the "theoretical physics and engineering part" of the proposal. Hans Svensson and Jean-Pierre Gérard had already been given the responsibilities of the 'physics part' and 'the clinical tasks', respectively.

"Since there were less than two weeks to the deadline, I exchanged the first e-mails with Germaine Heeren on Sunday and as of Monday morning I contacted all of the European groups that I knew. Most of them were informed of the fact that something was on the move and everybody said that, in principle, they agreed – but few people were ready to contribute to the write-up. Thus, I had to do a lot of the work myself, helped by Hans Svensson, but I still remember those hectic days with pleasure, because for me a European project initiated by ESTRO was the completion of 10 years of activity.

"In fact, the TERA Foundation had been conceived of in 1991: PIMMS, which was initiated at CERN by Meinhard Regler and myself in 1995 and led by Phil Bryant, had completed the design of an optimized proton–carbon synchrotron; and, last but not least, the Italian health minister, Umberto Veronesi, was drafting the law financing CNAO (the National Centre for Oncological Hadron Therapy), which was based on a modified version of PIMMS. A European project would have been the best framework for the next steps. Towards the end of the writing, there were some difficult moments – and here the intervention of Jürgen Debus was instrumental.

"I sent the text – for which Walter Henning had written a preface and Gerard Kraft had contributed the radiobiology part – to Germaine Heeren around noon of 18 October. The approval of ENLIGHT came on 6 February 2002, just one week before the opening of the inaugural meeting. This was held at CERN, following our request, supported by Hans Hoffmann who was then CERN's director for technology transfer and scientific computing, and Luciano Maiani, CERN's director-general at the time."

Vision for 2022

ENLIGHT held its 10th anniversary meeting on 15 September 2012 at CNAO, in Pavia, with a look back at its founding, current progress and future challenges. Summarizing the historical perspective, Richard Pötter proposed building a European multicentre hadron therapy collaboration in close co-operation with ESTRO, EORTC and other key players in radiation oncology. This would gather under one umbrella the best clinical practices, research and development, together with education and training.

Progress in this young and vigorously developing scientific and medical discipline will be possible through joint basic and translational biology, clinical research and physics research. What it now requires is younger leadership, to be recruited from the many young and talented participants at the 10th anniversary meeting.

● PARTNER, ULICE, ENVISION and ENTERVISION are funded or co-funded by the European Commission under Grant Agreements 215840, 228436, 241851 and 264552. This article is based on one published in the first issue of *ENLIGHT Highlights*, see http://enlight.web.cern.ch/sites/enlight.web.cern.ch/files/highlights_attachments/highlights.summer2012.pdf.

● Further reading

For more on the ENLIGHT network, see www.cern.ch/enlight.

JP Gérard *et al.* 1978 *J Radiol.* **60** 691.

Résumé

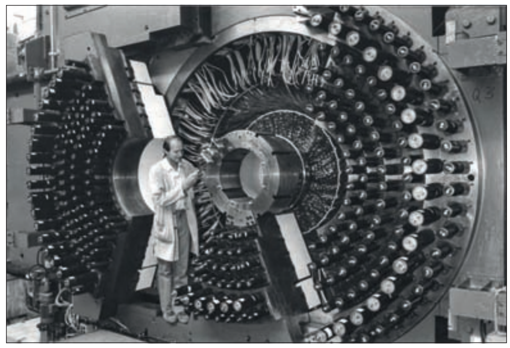
ENLIGHT : catalyseur de la thérapie hadronique en Europe

Il y a dix ans, en février 2002, ENLIGHT, le Réseau européen de recherche sur la thérapie hadronique par les ions légers, tenait sa réunion inaugurale au CERN. Le but était de réunir des spécialistes de diverses disciplines, dont la radiobiologie, l'oncologie, la physique et l'ingénierie. Le réseau a été un catalyseur de l'établissement d'une plateforme européenne pour promouvoir l'hadronthérapie. Aujourd'hui, ENLIGHT++ compte quelque 400 participants de plus de 20 pays européens. Quelques-unes des figures de proue de la création d'ENLIGHT évoquent ici des souvenirs des premières années.

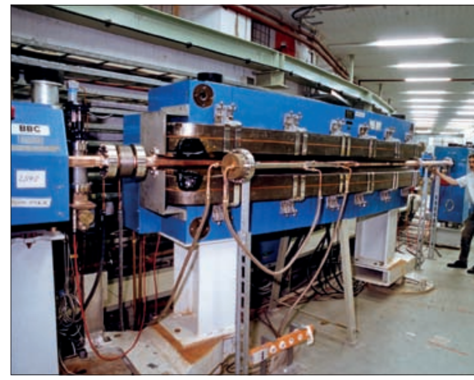
ENLIGHT Co-ordination Office, CERN.

Accelerators

Excavation of the DORIS site in the early 1970s. (All images: DESY unless stated.)



The ARGUS detector, where oscillations of neutral B mesons were discovered in the 1980s.



Inside the DORIS III ring in 1991.

The three lives of DORIS: from

DESY's pioneering and highly productive storage ring retires at the end of this year. **Till Mundzeck** looks back at almost 40 years of many contributions to a variety of fields in science and technology.

It is a seemingly simple question: when an electron scatters off a proton, how many photons are exchanged? The obvious answer would be: just one. Whether nature really acts as simply as this is, however, far from clear. The venerable storage ring DORIS at DESY is dedicating the last few weeks of its nearly 40 years of operation to this simple yet fundamental question. After three consecutive lives at the forefront of physics and with a wealth of scientific achievements, DORIS will be shut down for good at the end of 2012.

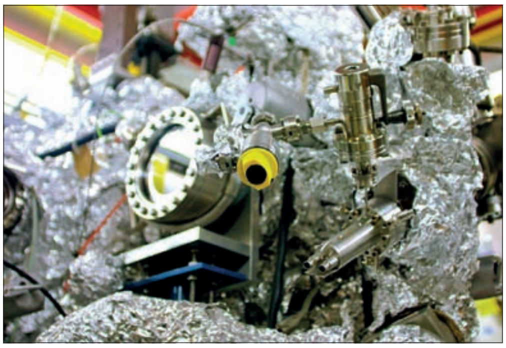
When DORIS ceases operation, it will leave behind some degree of nostalgia but most of all an invaluable scientific legacy in many fields. DORIS has been a pioneer in several ways: in accelerator science; in particle physics; and, notably, in the application of synchrotron radiation, where the machine helped spark a whole new field of photon science. "Synchrotron radiation measurements played an important role right from the start and the people working at DORIS fostered a creative spirit that let this young scientific field thrive," says DESY's photon-science director, Edgar Weckert. "This led to DESY becoming a global magnet for research with extremely intense X-ray light." Indeed, various methods that today are standard techniques in photon science were developed at DORIS.

When DORIS went into operation in 1974, it was one of the world's first storage rings. The concept of keeping the accelerated particles for repeated head-on collisions within the ring was only just beginning to compete with the practice of shooting them at a target all at once. Experience with DORIS certainly helped to develop this technology further. With a circumference of 289 m, DORIS started out in fact as two storage rings (hence the German name DOppel RIng Speicher, double storage ring) for electrons and positrons, with a maximum beam energy of 3.5 GeV each. However, because of technical difficulties, the machine was converted after three years into a single storage ring with two circulating beams.

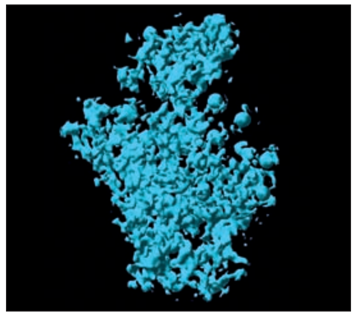
With its early particle-physics experiments, DORIS made important contributions to establishing the concept of quarks, which was still in question at the time. After the "November revolution" of 1974, when the unexpected J/ψ resonance was discovered at the Brookhaven National Laboratory and SLAC, DORIS helped to establish that the new particle was, indeed, a bound state of a new quark and its antiparticle, i.e. charm and anti-charm.

B-meson oscillations

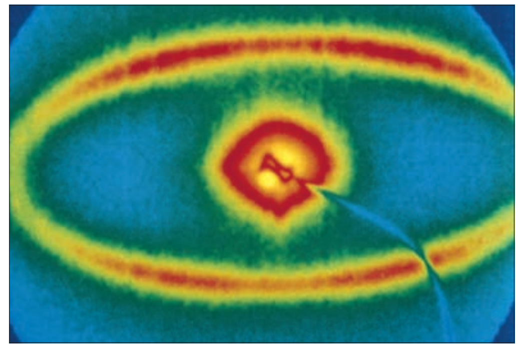
In its second life, starting in 1982, an enhanced machine with a nearly doubled collision energy (compared with 1974) discovered and probed a host of new particles – and finally discovered spontaneous B-meson oscillations, probably the machine's best known contribution to particle physics (*CERN Courier* January/February 2008 p58). The prolific ARGUS experiment at DORIS II observed that neutral B mesons spontaneously change into their antiparticles and vice versa. "The large mixing rate measured indicated that CP violation should also be observable in B-meson decays, which would be the second example of CP violation after the neutral K mesons," explains DESY's particle-physics director Joachim Mnich. CP violation is one of the pre-conditions to explain the observed dominance of matter over antimatter after the big bang. "The discovery at DORIS formed the foundation for further experiments, for instance with BaBar at SLAC and BELLE at KEK. But now we also know that the CP violation in the Standard Model is not sufficient to explain all of the matter in the universe. There have to be additional sources of CP violation beyond the Standard Model." Today, B mesons and their oscillations are examined for



A vacuum chamber at a HASYLAB measuring station.



Electron-density map of a ribosome created from X-ray images. (Image credit: MPG.)



An X-ray diffraction image of a plastic (triblock polymer) under strain.

charm quarks to cell biology

instance by the LHCb experiment at CERN and soon also at the upgraded BELLE II experiment, in which DESY is participating.

In 1991, DORIS was reborn in its third incarnation – as one of Europe's brightest hard X-ray sources, bringing synchrotron-radiation applications and photon science to full bloom at DESY and beyond. There had been synchrotron-radiation measurements at DORIS right from the start in 1974, and only one year later the European Molecular Biology Laboratory (EMBL) established an outstation on the DESY campus to use the intense light for the investigation of biomolecules.

In 1980 the Hamburg synchrotron-radiation laboratory (HASYLAB) was founded, and while synchrotron-radiation techniques were constantly improving and their applications gaining weight, they were still riding piggyback on a particle-physics machine. This changed with the proposal of a DORIS "bypass" in 1986, specially designed to improve its synchrotron radiation. The northern straight section of the racetrack-shaped storage ring was to be replaced – or bypassed – by a 74-m-long, gently curved arc that offered space for additional wiggler magnets to enhance the quality and intensity of the X-ray beams. After approval of the plans, work began in 1990 and DORIS III went into operation only about a year later.

Unfortunately, the alteration had unforeseen consequences for the luminosity at ARGUS. Although the machine operators tried hard to improve this, the highly successful experiment had to stop taking data early because it was no longer competitive. In 1993 DESY decided to dedicate DORIS III exclusively to photon science, leaving particle physics to DORIS' bigger sisters PETRA and HERA. Today, ARGUS graces DESY's main entrance as a scientific landmark.

X-ray beams for all

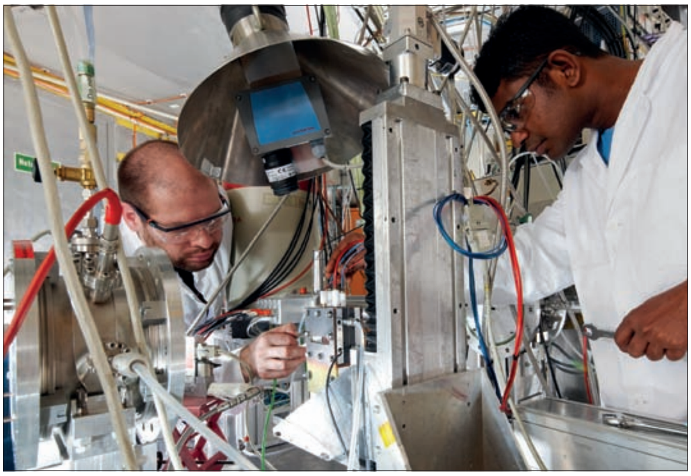
During its lifetime, DORIS has peered into nearly everything imaginable with its X-rays, from innovative alloys and magnetic nanostructures to biomolecules, viruses and corals. Even bronze-age axes, mediaeval palimpsests and hidden paintings by Dutch master Vincent van Gogh have been screened at DORIS. Thousands of guest scientists have used the facility every year. Eventually, there were more than 30 beamlines at DORIS, offering all sorts of X-ray techniques, with many results having a benefit for everyday life. Researchers there have investigated new kinds of electronics and routes towards better catalytic converters, evaluated new welding techniques and more effective luminescent materials for energy-saving lamps, developed medical and technical X-ray applications and studied the properties of clusters of atoms and even of the Earth's interior.

Among the countless scientific highlights, one in particular stands out. In 1999 the team of Ada Yonath, who was leading a Max Planck research group founded on the DESY campus in 1986, decoded the structure of the ribosome with the help of DORIS and different machines at other centres. The ribosome is the protein factory of the cell and is of central importance to life. It is an ▷

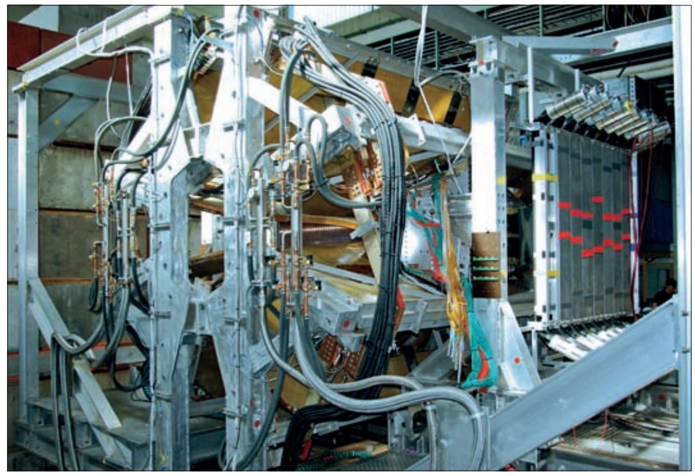
Profile of DORIS III

Type: storage ring
Particles: positrons
Circumference: 289.2 m
Beamlines: 33
Positron energy: 4.45 GeV
Initial positron beam current (5 bunches): 140 mA
Number of buckets: 482
Number of bunches: 1 (for tests), 2 and 5
Bunch separation (minimum): 964 ns (for tests), 480 ns and 192 ns
Horizontal positron beam emittance: 410 π nm rad
Vertical positron beam emittance: 12 π nm rad
Positron beam energy spread (rms): 0.11%
Curvature radius of bending magnets: 12.181 m
Magnetic field of bending magnets: 1.2182 T
Critical photon energy from bending magnets: 16.04 keV

Accelerators



Investigation of a fuel cell with synchrotron light at DORIS III.



The OLYMPUS experiment – the last to take place at DORIS.

incredibly complex structure that seemed almost impossible to decode. "DESY provided us very generously with beam-time even back in the 1980s, when our project met worldwide scepticism as it was widely assumed that the structure of the ribosome might never be determined," recalls Ada Yonath, who in 2009 received the Nobel Prize in Chemistry for her groundbreaking research.

DORIS's achievements are not only scientific. Over the years, the accelerator team maintained an innovative atmosphere and a remarkable collaborative spirit. Not only have several techniques that were pioneered at DORIS now become standards of photon science, the continued improvements also led to PETRA III, the world's most brilliant X-ray source (*CERN Courier* January/February 2010 p31). Dedicated exclusively to photon science, PETRA III offers much more intense and much finer X-ray beams than DORIS, opening up new opportunities. "Some experiments, however, do not always require PETRA's extraordinary brilliance," says Wolfgang Drube of the DESY photon-science department. "Until now, these experiments have been located at DORIS."

To meet the continuing demand, DESY and its international partners are building two additional experimental halls at PETRA. The most successful of the DORIS III experiments will move into these extensions. "At several experimental stations, the beam will be up to 100 times more intense compared with DORIS," explains Drube, who is leading the PETRA III extension project. This way, the best of DORIS will live on at PETRA III, which today is also complemented by DESY's free-electron laser, FLASH. "The unique properties of our light sources are attractive for a multitude of research disciplines. Co-operation and exchange in these various disciplines stimulate research in the next generation," stresses Weckert.

At the end of its lifetime, there is one more "half-life" in store for DORIS. Synchrotron-radiation operation ceased on 22 October but the rest of the year has been dedicated to a small but clever particle-physics experiment called OLYMPUS. The collaboration led by Richard Milner of Massachusetts Institute of Technology (MIT) will use it to compare in detail the scattering of electrons and positrons by protons to find out if more than one photon can be exchanged in this process. "Recent data suggest strongly that higher-order photon exchange is happening in certain situations," says Milner. "The experiment is to measure the angular distribution of the scattering for electrons and positrons and compare it. If two-photon effects indeed are there, we should see a significant difference of the order of 5% at larger angles – that is around 60° – in this comparison."

That this became possible is owed to a coincidence that Milner refers to as a miracle. His team had realized that the experiment that they wanted to do would be possible with a disused particle detector from MIT, and they were looking for a storage ring where intense electron and positron beams were readily available. "So, we came to DESY to discuss this and together we decided that we could attempt the experiment at the location of ARGUS. The miracle was that an experiment designed at MIT in the 1990s to do electron–proton scattering would fit exactly in the footprint of an experiment designed at DESY in the 1980s to look at things like B mixing. Essentially, you took one out and dropped the other one in. Everything fit on the rails of ARGUS!"

OLYMPUS may be DORIS' last experiment but the legacy of this machine will live on for a long time.

● Further reading

This article is based on information in *Von schnellen Teilchen und hellem Licht – 50 Jahre Deutsches Elektronen-Synchroton DESY* (Wiley-VCH 2009) by Erich Lohrmann and Paul Söding.

Résumé

Les trois vies de DORIS : des quarks charmés à la biologie cellulaire

L'anneau de stockage de DESY, DORIS, cessera toute activité à la fin de l'année. Il laisse derrière lui un inestimable héritage scientifique. Mis en service en 1974, DORIS, l'un des premiers anneaux de stockage du monde, a connu trois phases distinctes. Les premières expériences ont contribué à établir l'existence du quark charmé ; l'expérience ARGUS, menée à DORIS II, a découvert les oscillations spontanées de mésons B. Enfin, la machine a fait figure de pionnier pour l'application du rayonnement synchrotron dans diverses sciences, l'axe majeur de DORIS III.

Till Mundzeck, DESY.

Accelerators, light sources and all that jazz

The International Particle Accelerator Conference series completed its first three-year cycle in style with IPAC'12, which was held in New Orleans.

Three years ago, the annual International Particle Accelerator Conference (IPAC) series was launched to reflect the increasingly global effort in the field, with Asia, Europe and North America hosting the meeting on a three-yearly basis. Following meetings in Kyoto (2010) and San Sebastián (2011), it was North America's turn in 2012. IPAC'12 took place on 20–25 May at the Ernest N Morial Convention Center in New Orleans. True to its international mission, the conference attracted more than 1200 delegates from a diverse cross-section of nationalities, laboratories and areas of expertise. The scientific programme included plenary talks as well as invited and contributed oral presentations, with a healthy balance of speakers representing scientific research efforts from all three global IPAC regions.

The local organizers of IPAC'12 approached the LSU College of Art and Design about creating the printed material for the conference. The winning artwork was this blaring trumpet design by Sarah Lisotta, a young artist from New Orleans.

Key themes

The conference opening reflected well this international balance and several of the key themes. It began with synchrotron light sources and free-electron lasers (FELs), as Joachim Stohr of the Stanford Radiation Light Source at SLAC highlighted the scientific revolution that is being enabled by X-Ray FELs. CERN's Steve Myers described the first two years of operation at the LHC – a leading example of high-energy circular colliders, as well as of international collaboration. Accelerator-driven systems for the transmutation of nuclear waste provided one of the latest examples of developing accelerator applications, presented by Dirk Vandeplasche of SCK-CEN. Kenji Saito of KEK put the spotlight on accelerator technology, with a look at future prospects for RF superconductivity. To finish, the opening session moved back to North America and the theme of beam dynamics and electromagnetic fields as Sergei Nagaitsev described the novel concept of the Integrable Optics Test Accelerator that is under development at Fermilab using strong nonlinear magnetic focusing fields.

Proceeding from this synoptic overview, the programme divided into parallel invited oral sessions before the lunch break and contributed oral presentations after lunch. In each case the topical sessions and the topics of the individual speakers had been carefully arranged to avoid overlap of scientific content and/or other interests of the conference delegates. The layout at the New Orleans Convention Center afforded generous space for people to intermingle and easy access between the main hall and parallel sessions.

From Monday to Thursday, each afternoon also featured poster sessions arranged by topic in groups named after famous streets of central New Orleans. About 1250 posters were presented in all. A novel electronic poster session was appropriately held on "Bourbon Street" each afternoon. This session consisted of selected posters featuring colourful animated presentations showing complex machine designs, dynamical beam measurements and the results of 3D simulations, with 54 electronic posters in all. The posters were displayed on large flat screens with local PC connection.

A highly successful exhibit featuring 85 separate vendors was also arranged in the centre of the poster sessions, with ample seating arrangements for conversations between participants. The exhibitors generously sponsored a reception on Tuesday for all of the conference delegates and companions, including complimentary drinks and a buffet of Louisiana-style finger foods.

The programme on Wednesday afternoon contained a special session for industry, covering a range of forward-looking topics. These included projections for future accelerator projects in Asia ▷

IPAC'12

Poster sessions are a major feature of the IPAC meetings, allowing participants to meet and discuss topics in detail. At IPAC'12, there were both conventional poster sessions (left) as well as new electronic poster sessions (right), which allowed for animated presentations on the various flat-screen displays that were available. (Image credit: Ramirez/CAMD.)

presented by Zhentang Zhao of the Shanghai Institute of Applied Physics, a look at future medical accelerators by Kiyoshi Yasuoka from the University of Tsukuba and a review of present and future prospects for laser plasma acceleration by Wim Leemans of Lawrence Berkeley National Laboratory. These talks were followed by a review of accelerator-enabled materials development by Wendy Flavell of the University of Manchester, an overview of secondary-beam production by Jens Stadlmann of GSI and the benefits of accelerator R&D to society by Norbert Holtkamp of SLAC.

The IEEE-sponsored event for "Women in Engineering and Science" also took place on Wednesday after the poster sessions. This featured talks covering the demographics of women pursuing careers in engineering and science, personal experiences, objective evaluations and historical perspectives. The talks were delivered by Lia Merminga of TRIUMF, Mei Bei of Brookhaven National Laboratory (BNL), Tracy Morris of Louisiana State University (LSU) and Lorraine Day representing the Center for Advanced Microstructures and Devices (CAMD) at LSU. A buffet reception was held for approximately 50 participants among a display of posters depicting the lives and achievements of outstanding female engineers and scientists.

Thursday afternoon featured the annual awards session and an invited presentation on the LIGO Laser Interferometer Gravity-wave Interferometer by Rainer Weiss of Massachusetts Institute of Technology. Hasan Padamsee from Cornell and Vasili Yakimenko from BNL received the prestigious Particle Accelerator Science Award of the Institute of Electrical and Electronics Engineers/Nuclear and Plasma Science Society (IEEE-NPSS) (*CERN Courier* September 2012 p64). Erdong Wang from BNL received the IEEE/NPSS student thesis award for studies of secondary emission and the thesis award of the American Physical Society Division of Physics of Beams (APS/DPB) went to Daniel Ratner from SLAC for work on beam dynamics in FELs.

There were also prizes for student posters, exhibited at the Student Poster Session during the conference reception on Sunday. A total of 86 students from around the world received financial support to attend the conference, from the Asian Committee for Future Accelerators, the European Physical Society Accelerator Group and the APS/IEEE. The exhibition attracted an impressive 129 entries, the prizes going to Chen Xu at the Thomas Jefferson National Accelerator Facility (TJNAF) for work on the surface characterization of superconducting radio-frequency cavities and to Theodoros Argyropoulos at CERN for studies of longitudinal single-bunch instability thresholds in the Super Proton Synchrotron.

Parallel satellite meetings were held during the conference for the team behind the Joint Accelerator Conference Website (JACoW), the Joint Universities Accelerator School Advisory Board and the Fixed-Field Alternating Gradient collaboration. The online open-access journal *Physical Review Special Topics – Accelerators and Beams* (*PRST-AB*) hosted a "Meet the editors" evening during the conference and held its annual Editorial Board meeting. During the meeting, CERN's Christine Petit-Jean-Genaz received the first *PRST-AB* Robert H Siemann Prize, a prize introduced to honour and recognize contributions to the scientific publishing process. A teacher's day sponsored by the APS took place on the Tuesday. Local high-school science teachers heard from conference speakers during the event, which also included physics demonstrations on topics of current interest in particle accelerators.

The chair's cocktail reception hosted by conference chair Vic Suller was held in the Mardi Gras World exhibition centre adjacent to the Morial Convention Center. Approximately 250 attended, comprising members of the international Organizing Committee, the Scientific Program Committee and the Local Organizing Committee, as well as support staff, session chairs and invited speakers. The conference banquet took place at the convention centre in the spacious La Nouvelle Orléans ballroom, the evening concluding with enthusiastic dancing to live music by a traditional-style jazz band.

After an invigorating week of accelerator science and engineering, the conference closing session featured plenary talks on the future of X-Ray FELs by Hans Braun from PSI, a review of proton accelerators at the intensity frontier by Paul Derwent from Fermilab and a much anticipated presentation on physics at the LHC – including implications for future high-energy physics programmes – by CERN's director-general, Rolf Heuer, which foreshadowed the announcement later in the summer of the discovery of a Higgs-like boson at the LHC.

IPAC'12 was closed by the traditional hand-over of the IPAC gavel to the IPAC'13 conference chair, Zhentang Zhao, and the IPAC bell to the chair of the IPAC'13 Science Program Committee, Chuang Zhang. IPAC'13 will take place in Shanghai, with IPAC'14 to follow in Dresden and IPAC'15 in Newport News, Virginia, completing the second three-year cycle through Asia, Europe and North America.

On the Saturday after the closing day, participants had the opportunity to tour the laboratory of the Laser Interferometer Gravitational-wave Observatory (LIGO) in Livingston, north of New Orleans – one of the project's two sites (the other being in Hanford, Washington). Building on Thursday's guest seminar by Weiss, one of the project's co-founders, the LIGO staff provided excellent guided tours of the control room, interaction region and a rare opportunity to enter experimental areas that would normally be closed off because of concerns about vibration.

No conference review would be complete without acknowledgment of those who worked for years in advance on the preparations. IPAC'12 was sponsored by the IEEE-NPSS and by the APS-DPB. It was hosted by LSU through its synchrotron-light facility, CAMD, located in Baton Rouge, Louisiana. Particular recognition goes to the small team of CAMD staff who worked diligently behind the scenes to provide local arrangements that spanned the full spectrum of conference needs.

Christine Petit-Jean-Genaz of CERN ran the Scientific Secretariat throughout the organization of the scientific programme, sharing the load with Cathy Eyberger from Argonne National Laboratory and Todd Satogata from TJNAF during the conference. Under their guidance the complete IPAC'12 editorial team, comprising 27 individuals from accelerator laboratories around the world, contributed more than 200 days of work to produce the IPAC'12 conference proceedings, which went online at the JACoW site on 23 July. The IPAC'12 organizers are indebted to the support of the international JACoW team, including its chair Volker Schaa from GSI and deputy Ivan Andrian from Elettra-Sincrotrone Trieste.

● Further reading

For all of the papers and presentations, see the IPAC'12 proceedings published on the JACoW site, www.jacow.org.

Résumé

Accélérateurs et sources de lumière à la Nouvelle-Orléans

La série de conférences internationales sur les accélérateurs de particules a terminé son premier cycle de trois ans en beauté avec IPAC'12, tenue à la Nouvelle-Orléans. Fidèle à sa mission internationale, la conférence a attiré plus de 1200 délégués, représentant une riche palette de nationalités, de laboratoires et de compétences. Au programme scientifique figuraient des conférences plénières, de même que des exposés d'orateurs invités et de collaborateurs, avec un bon équilibre entre les trois régions de l'IPAC parmi les intervenants : Asie, Europe et Amérique du Nord.

Jeff Corbett, SLAC, IPAC'12 Scientific Program Committee chair, and **Vic Suller**, CAMD/LSU, IPAC'12 conference chair.

Faces & Places

Appointments

Chi-Chang Kao takes the reins at SLAC

On 1 November, Chi-Chang Kao became the fifth director of the SLAC National Accelerator Laboratory. He succeeds Persis Drell, who held the position from December 2007 and had announced her intention to step down in November last year.

Kao came to SLAC in 2010 as associate lab director for the Stanford Synchrotron Radiation Lightsource. As a respected X-ray scientist, his research focuses on X-ray physics, superconductivity, magnetic materials and the properties of materials under high pressure. His scientific career began with a bachelor's degree in chemical engineering from National Taiwan University in 1980. After gaining a doctorate in chemical engineering from Cornell University in 1988, he joined Brookhaven National Laboratory to work on the National Synchrotron Light Source and worked his way from postdoctoral research assistant to chair, before moving to SLAC.

SLAC celebrated its 50th anniversary this year (*CERN Courier* November 2012 p26). Among its facilities, it operates the world's most powerful X-ray laser, the Linac Coherent Light Source (*CERN Courier* December 2009 p6).

"With his experience and expertise in X-ray science, Chi-Chang is the right person to set a vision for how this extraordinary machine, as well as SLAC's other excellent facilities and its world-class scientists, can revolutionize science in the years to come," states the US Department of Energy Secretary of Energy, Steven Chu.

New SLAC director, Chi-Chang Kao. (Image credit: Brad Plummer, SLAC National Accelerator Laboratory.)

Stöcker begins second term at GSI

Horst Stöcker is to extend his period of service as the scientific director of GSI by an additional five years at the request of the Supervisory Board.

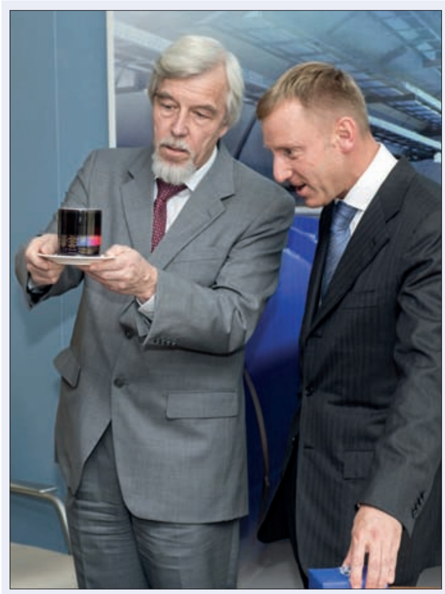
Since Stöcker became scientific director in August 2007, GSI has co-operated with partners in Germany and other countries to fulfil the preconditions for the start of construction of the Facility for Antiproton and Ion Research (FAIR), which will be linked with the existing GSI accelerator facility. The construction of FAIR, which is now under way, is one of the world's largest projects in basic physics research. To bring together the know-how for the R&D that will be carried out at FAIR, as well as to ensure a supply of new talent in the areas of science and technology, Stöcker has actively built networks with universities and research laboratories.

Approximately 3000 scientists from more than 40 countries are already working on the planning of FAIR. The facility will provide antiproton and ion beams of an intensity and quality never attained before. In its final phase, FAIR will consist of eight circular accelerators with a circumference of up to 1100 m, two linear accelerators and approximately 4 km of beamline.

Horst Stöcker begins another term of office at GSI. (Image credit: G Otto.)

"The greatest challenge during my next term of office will be to work with GSI to do everything that's necessary to complete the construction of FAIR," says Stöcker. "To celebrate the commissioning of FAIR during my next term of office would be fantastic."

Visit



Dmitry Livanov, the minister of education and science of the Russian Federation, right, and CERN's director-general, **Rolf Heuer**, admire the history of the universe on a mug during the minister's visit to CERN on 22 October. The minister also toured the LHC superconducting magnet test hall, the ATLAS visitor centre and the Antiproton Decelerator facility.

AWARDS

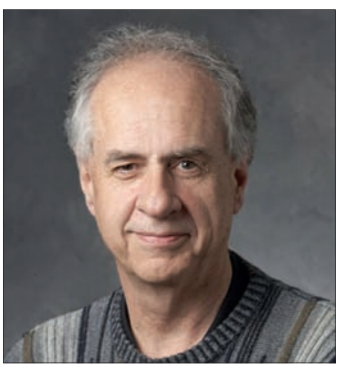
Italy honours CERN and INFN researchers

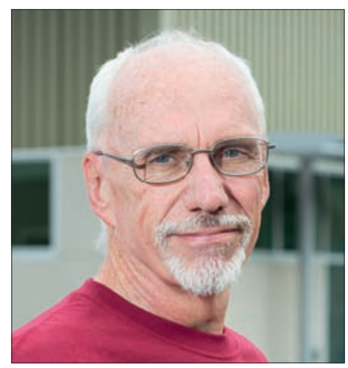
On 24 September at the Quirinale Palace in Rome, the Italian president, Giorgio Napolitano, greeted Italian researchers from the National Institute of Nuclear Physics (INFN) and CERN, who, at various levels, have contributed to the recent discovery of a Higgs-like boson.

Napolitano took the occasion to give the honour of Grande Ufficiale dell'Ordine al Merito della Repubblica Italiana to Sergio Bertolucci, director of research and computing at CERN, and to Fabiola Gianotti, spokesperson for the ATLAS experiment.

At the same time, he also gave the honours of Commendatore della Repubblica Italiana to: Fernando Ferroni, President of INFN; Oscar Adriani, co-spokesperson of LHCf; Pierluigi Campana, spokesperson for LHCb; Simone Giani, spokesperson for TOTEM; Paolo Giubellino, spokesperson for ALICE and Guido Tonelli, who was CMS spokesperson until December 2011.

Giorgio Napolitano, right, shakes hands with Sergio Bertolucci, while Fabiola Gianotti, centre right, and other researchers from INFN and CERN look on. (Image credit: Presidenza della Repubblica Italiana.)



Left to right: Blas Cabrera, Stanford University; Bernard Sadoulet, University of California, Berkeley; and Helen Quinn and John Galayda of SLAC are among the APS prizewinners for 2013. (Image credits: B Cabrera (left) and SLAC.)

APS rewards searches for dark matter and more

The American Physical Society (APS) has announced many of its awards for 2013, with a number for work in particle physics – in particular related to searches for new particles and new effects in experiments away from accelerators. Physicists from SLAC and the University of California figure prominently.

The nature of dark matter is one of the puzzles driving current research in particle physics. It is highlighted this year in the awarding of the 2013 W K H Panofsky Prize in Experimental Particle Physics to Blas Cabrera of Stanford University and Bernard Sadoulet of the University of California, Berkeley. They receive the prize, which recognizes and encourages outstanding achievements in experimental particle physics, for "their pioneering work and leading roles in the development and use of phonon detection techniques enabling direct searches for weakly interacting massive particles". Their decades-long effort with the Cryogenic Dark Matter Search has taken them to several underground sites in the hunt for direct evidence of hypothetical weakly interacting massive particles, which – if discovered – could help to define and explain dark matter.

On the theoretical side, the 2013 J J Sakurai Prize for Theoretical Particle Physics, which recognizes and encourages outstanding achievement in particle theory, goes to Roberto Peccei of the University of California, Los Angeles, and to Helen Quinn of SLAC. They are rewarded for "their proposal of the elegant mechanism to resolve the famous problem of strong CP violation, which in turn led to the invention of axions, a subject of intense experimental and theoretical investigation for more than three decades". The axion is one of the candidates for dark matter being searched for in a variety of experiments.

Rare processes related to new physics is the subject of the 2013 Tom W Bonner Prize in Nuclear Physics. Michael Moe of the University of California, Irvine, receives this award for "his leadership in the first observation of the rare process of two-neutrino double-beta decay, where his creative contributions were instrumental to its successful detection and transformed the field". His team's detection of the process in 1987, in the decay of ^{82}Se, came 40 years after the first efforts to observe it began.

Faces & Places

Since then, searches employing similar techniques have been directed at neutrinoless double-beta decay, which can occur only if the neutrino is a Majorana particle.

Neutrinos feature in the work of the winner of the 2013 Hans A Bethe Prize, which is to "recognize outstanding work in theory, experiment or observation in the areas of astrophysics, nuclear physics, nuclear astrophysics, or closely related fields". This year the prize goes to George Fuller of the University of California, San Diego, for his "outstanding contributions to nuclear astrophysics, especially his seminal work on weak interaction rates for stellar evolution and collapse and his pioneering research on neutrino flavour-mixing in supernovae". The 2013 Henry Primakoff Award for Early Career Particle Physics also recognizes research in neutrino physics, this time at accelerators. The recipient is Fermilab's Teppei Katori, for "outstanding contributions to a range of accelerator-based neutrino physics, including cross-section measurements and searches for violations of Lorentz and CPT symmetry".

The Robert R Wilson Prize for Achievement in the Physics of Particle Accelerators looks once again to what has become a major field throughout the world, with the development of accelerator-driven free-electron lasers (FELs) for light sources. SLAC's John Galayda receives the 2013 prize for "his leadership and outstanding and pioneering contributions to the development, construction and commissioning of the Linear Coherent Light Source, the first X-ray FEL to lase at 0.15 nm, and his contribution to the Advanced Photon Source and the National Synchrotron Light Source".

Back with more general theoretical physics, the 2013 Dannie Heineman Prize, for outstanding publications in the field of mathematical physics, goes to Michio Jimbo of Rikkyo University and Tetsuji Miwa of Kyoto University. They are recognized for "their profound developments in integrable systems and their correlation functions in statistical mechanics and quantum field theory, making use of quantum groups, algebraic analysis and deformation theory".

Correction

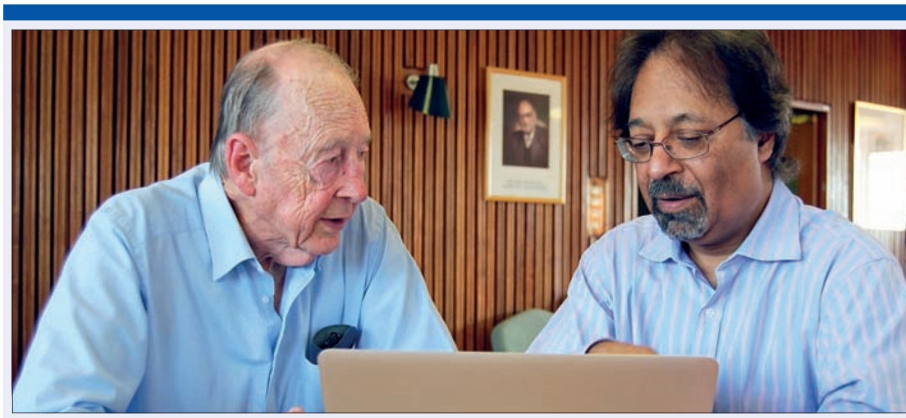
The article on the 50th anniversary of SLAC (*CERN Courier* November 2012 p26) incorrectly implied that Samuel Ting was affiliated to Brookhaven National Laboratory at the time of the J/ψ discovery. While the discovery was made in an experiment at Brookhaven, Ting was, and still is, with Massachusetts Institute of Technology. Apologies to all concerned.

Myers receives UK engineering fellowship

Steve Myers, director of accelerators and technology at CERN, has been elected as a fellow of the Royal Academy of Engineering. Each year the academy honours the UK's most eminent engineers by electing up to 60 fellows from nominations made by existing fellows. This year's new fellows were announced in July and had the opportunity to meet at a dinner for newcomers on 5 November.

Myers is internationally recognized for his engineering contributions and leadership in the development of CERN's particle colliders over the past 40 years, including the Intersecting Storage Rings, the Large Electron–Positron collider and the LHC. These complex machines depend on many branches of engineering, including civil, mechanical, electrical and informatics. In his current role at CERN, Myers is responsible for the exploitation of the LHC.

Steve Myers, now a fellow of the Royal Academy of Engineering.



The end of the year will see the 80th birthday of Tom Kibble, left, a senior research fellow and emeritus professor of theoretical physics at Imperial College London. Kibble is best known as one of the theoretical physicists whose work in the early 1960s became a key piece of the Standard Model, through giving mass to the W and Z bosons via a symmetry-breaking mechanism that would require a new particle, dubbed the Higgs boson. Kibble was not at CERN when the ATLAS and CMS collaborations announced the discovery of a particle consistent with being the Higgs boson. However, the following day he met the former spokesperson of CMS, Tejinder Virdee of Imperial College, who gave him a personal presentation of the results. (Image credit: M Sancho/Imperial College.)

School

ISOTDAQ 2013, the fourth International School of Trigger and Data Acquisition, will take place on 1–8 February 2013 at Aristotle University of Thessaloniki. The aim is to introduce MSc and PhD students to the "art and craft" of triggering and acquiring data for high-energy physics experiments. About half of the time will be spent on laboratory exercises based on techniques described in the lectures. A maximum of 48 students will be chosen by CV and a recommendation letter, with limited financial support available for selected students. The application deadline is 1 December 2012. For more information and more about how to apply, see www.isotdaq2013.physics.auth.gr.

ASTROPARTICLE PHYSICS

HESS II is officially inaugurated

The world's largest Cherenkov telescope, HESS II, located in the Khomas Highlands of Namibia, was officially inaugurated on 28 September, two months after it saw first light (*CERN Courier* October 2012 p39). Werner Hofmann of the Max Planck Institute for Nuclear Physics, Heidelberg, and spokesperson of the HESS collaboration, opened the ceremony with a brief presentation on HESS II, which was followed by messages from representatives of key collaborating institutes and agencies.

Abraham Iyambo, minister for education of the Republic of Namibia, gave the keynote speech on behalf of the president of Namibia, Hifikepunye Pohamba. He emphasized the previous pioneering discoveries of the HESS Cherenkov telescope array and its international recognition among the world's 10 top observatories. HESS put Namibia on the world map of science and is a success story that will continue with HESS II. Iyambo recalled how as a boy he had been fascinated by the stars in the sky and had dreamt of one day becoming an astronaut. Addressing future junior scientists, he encouraged school students to visit the HESS site.

Namibia's minister of education, Abraham Iyambo, is just about to press the symbolic red button to activate the HESS II telescope, visible in the background, with HESS spokesperson, Werner Hofmann, right, and Lazarus Hangula, vice-chancellor of the University of Namibia, far left. (Image credit: C Föhr/HESS collaboration.)

At the end of the ceremony, Iyambo pressed the symbolic "red button" to activate the new telescope. Guests were impressed by the synchronized motion of the five telescopes of the HESS array and by how rapidly the 580-tonne HESS II telescope can point to any position in the sky. During the tour round the HESS site, the automatic assembly of the 2.8-tonne camera was demonstrated and the operation of the control room explained. Despite several failures of the Namibian power grid during the ceremony, the telescope drive and control systems worked flawlessly, backed by HESS's emergency power generators.

The inauguration events had started the day before with an international symposium at Heja Lodge near Windhoek and concluded with an open day for the general public at the HESS site on 30 September. Several hundred Namibians and tourists took the opportunity to see the telescopes and learn about gamma-ray astronomy from guided tours and an exhibition presenting posters and telescope components.

OUTREACH

Particle physics at the Frankfurt Book Fair

From 10–13 October, CERN showcased its research at the Frankfurt Book Fair, the largest of its kind in the world. In addition to presenting a range of books on the science of CERN and the LHC, the CERN stand unveiled a new interactive LHC "time tunnel".

The time-tunnel display was built especially for the book fair with a view to integrating it into future exhibitions. Using state-of-the-art motion sensors and projectors, it allows visitors to visualize the effect of the Brout-Englert-Higgs field and to kick virtual particles to see how they collide in the LHC.

The CERN stand allowed visitors to the Frankfurt Book Fair to kick virtual particles in the LHC "time tunnel".

The stand, in the Hall for Expert Information, Science, Technology and Education, was based around a partial reconstruction of the CERN Control Centre (CCC), with live LHC status-updates on the screens. It also included the first computer used by Tim Berners-Lee to develop the original World Wide Web software and the antimatter trap from the film *Angels & Demons*. Each day, physicists from CERN presented insights into the LHC, featuring live connections with the control rooms of the ATLAS and CMS experiments, as well as with the CCC.

The fair also provided the occasion for CERN to announce a collaboration with the Finnish games-developer Rovio to create new educational resources for children linked to their award-winning *Angry Birds* video game series.

Faces & Places

Arts and science

Changing places: Collide@CERN's artists in residence

An ethereal figure dressed in white is floating on an upper shelf in the CERN library, handing out books such as *Don't Make Me Think*. The restaurant has its chairs and tables swept away to become transformed into a live contemporary dance studio. Even the computer centre is not out of bounds, with dancers in orange, blue, white and gold threading and dancing their way through its maze.

Adventurous interventions such as these have been a hallmark of the residency of CERN's first choreographer in residence, the Swiss dancer, Gilles Jobin. They have been designed specifically to create new ways for the laboratory's scientists to look at the spaces that they are working in as they go about their daily working lives. Such interventions are a key feature of CERN's Collide@CERN programme, which began earlier this year, with the first artist in residence in its digital-arts strand, Julius von Bismarck (*CERN Courier* January/February 2012 p39 and March p28).

For three months this summer, Jobin has been encountering the ideas, people and places behind the physics at CERN, seeking choreographic inspiration. The results will be seen in the autumn of 2013, when he intends to premiere a new piece inspired by his residency, which he says, has profoundly affected the way he relates to his own body, as well as the way he choreographs and even perceives his career in the future. Another "collision" is also promised, as von Bismarck's installation *Versuch unter Kreisen*, showcased at this year's Ars Electronica Festival in Linz, may well become the stage set for Jobin's new dance work.

In the meantime, von Bismarck's successor to the digital arts strand of Collide@CERN has just been announced. One of the world's leading artists and a pioneer in his field, the American sound artist, Bill Fontana, will be taking up his residency in June 2013 for two months, following introductory visits over winter to familiarise himself with the laboratory. This is the second year of the Prix Ars Electronica Collide@CERN, which marks CERN's three-year cultural partnership with one of the world's leading digital arts organizations, Ars Electronica, Linz.

Fontana, who came out on top of entries from 49 countries around the world to win the award, has exhibited at the Tate Modern and The Whitney Museum of American Art. It is extremely rare for artists of his international standing to enter an open international competition but he said that the lure of CERN was simply irresistible: "As an artist, even with 40 years behind me, I am always looking for situations to expand my horizons and I want to be in a situation where I am completely challenged. Coming to CERN will certainly do that." His entry for the competition talked about his wish to explore the physics of sound at the laboratory, creating a new soundscape that could also link with the city of Geneva in an artistic experiment he calls "acoustic time travel".

Above: Sound-artist Bill Fontana. (Image credit: Stuart Davidson.)

Right: Strangels *in the CERN library, a new take on working space by Gilles Jobin.*

Further reading

For more about the work of Julius von Bismarck and Gilles Jobin at CERN, see: http://arts.web.cern.ch.

On 27 September, Uppsala University organized a Higgs Fest Symposium that was held in the State Hall of Uppsala Castle. The programme included presentations by Fabiola Gianotti, right, spokesperson of the ATLAS experiment at CERN, and by Nobel laureate Frank Wilczek, left, and Janet Conrad, both from Massachusetts Institute of Technology. With the discovery by ATLAS and CMS of a Higgs-like boson earlier this year, Wilczek won a bet that he had made with Conrad in 2005. He bet that the Higgs boson would be found at the LHC, while she bet against the discovery. The event drew 700 people, including four school groups. For videos of the main presentations, see: http://cdsweb.cern.ch/record/1489653, http://cdsweb.cern.ch/record/1489652 and http://cdsweb.cern.ch/record/1489651. (Image credit: T Thörnlund, Uppsala University.)

Recruitment

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Scientific staff

KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

Kavli IPMU: Postdoctoral Fellows, Kavli Institute Fellowship, Faculty Positions

The "Kavli Institute for the Physics and Mathematics of the Universe" (Kavli IPMU) is an international research institute with English as its official language established in October 2007. The goal of the institute is to discover the fundamental laws of nature and to understand the universe from the synergistic perspectives of mathematics, statistics, theoretical and experimental physics, and astronomy. We are particularly interested in candidates with broad interests and a willingness to interact with people across disciplines.

We intend to make appointments in all three categories of the positions listed above. We seek to build a diverse, highly interactive membership, and female and international applicants are strongly encouraged. We have generous travel support for our postdocs and faculty, and encourage full-time members to be away from the Institute for between 1 and 3 months every year.

The focus of Kavli IPMU includes but is not limited to: mathematics; string theory and mathematical physics; particle theory, collider phenomenology; cosmology and astrophysics theory; astronomy and observational cosmology; and particle and underground experiments. We are leading efforts on the XMASS dark matter experiment, the KamLAND- Zen neutrino experiment, the HyperSuprimeCam project for weak lensing surveys, Prime Focus Spectrograph for the dark energy at the Subaru telescope, GADZOOKS! at Super- Kamiokande, the Belle II experiment, and R&D for future large neutrino detectors. Kavli IPMU is a full institutional member in SDSS-III.

TRIUMF & Kavli IPMU: Joint Faculty Position in Neutrino Physics

TRIUMF

The neutrino physics is now in an important turning point. The precise determination of the neutrino parameters by T2K and also by Super-Kamiokande will be of significant importance and there is a plan to build a mega-ton class detector for the future high intensity neutrino beam from J-PARC.

We initiate to form a new group at Kavli IPMU which would primarily study in the long baseline neutrino oscillation experiment, T2K and we anticipate some involvement of the water Cherenkov activities and its future projects like Hyper-Kamiokande.

TRIUMF, Canada's national laboratory for particle and nuclear physics, and Kavli IPMU will jointly appoint this assistant professor with an initial term through March 2017 working primarily at Kavli IPMU, and with a possible extension for five more years at the choice of incumbent, contingent on review and funding*. Either Kavli IPMU or TRIUMF, at the discretion of the incumbent, will give the tenure, contingent on review and funding.
(*) The term is subject to change due to University Policy and applicable laws.

The search is open until filled, but for full considerations please submit the applications and letters by Dec 1, 2012.
Further information can be found here: `http://www.ipmu.jp/job-opportunities`
For inquiries please contact: `application-inquiry@ipmu.jp`

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THEORETICAL CONDENSED MATTER AND STATISTICAL PHYSICS (CM&SP) POST-DOCTORAL POSITIONS AT THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS (ICTP) TRIESTE, ITALY (ACADEMIC YEAR 2013-2014)

The current research areas of the ICTP CMSP Section include disordered quantum many-body systems, quantum Monte Carlo simulations of ultra-cold gases: BEC-BCS crossover in strongly interacting Fermi gases, low-dimensional and/or disordered Bose gases; physics of nano-devices; statistical physics of complex systems and interdisciplinary applications; random matrix theory and its applications; density functional theory based investigations of structural, electronic and optical properties of materials, in particular in the field of renewable energy storage and conversion; development of efficient algorithms for the computation of electronic excitations in nanoscale systems.

A limited number of post-doctoral positions for young CM&SP theoreticians will be available starting Fall 2013.

Appointments will be made for two years, with the possibility of renewal for one more year.

Applicants should be no more than 35 years of age at the time of application and should have obtained their Ph.D. after 2008. The application form can be accessed at the website: **https://onlineapps.ictp.it/ENTER/APPLICANT/CP12.mhtml**

Additional detailed curriculum vitae, list of publications and at least three recommendation letters (sent separately after submission of application) must all be appended on-line.

Deadline for receipt of applications: 13th January 2013.

PAUL SCHERRER INSTITUT

PSI

The Paul Scherrer Institute, PSI, is with 1500 employees the largest research centre for natural and engineering sciences within Switzerland. We perform world-class research in three main subject areas: Matter and Material; Energy and the Environment; and Human Health. By conducting fundamental and applied research, we work on long-term solutions for major challenges facing society, industry and science.

The Paul Scherrer Institute is currently operating the world's highest intensity DC muon beams for particle physics and material research. For the next generation of experiments a further significant improvement is necessary. The Laboratory for Particle Physics plays an essential role in the development of the facility and in precision muon physics experiments.

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- You are expected to make major contributions to the feasibility study for the next high intensity muon beam line (HiMB) and to join one of the fundamental muon experiments
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- Beam line and Monte Carlo simulations
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Your profile

- PhD in experimental particle physics
- In-depth practical experience in one or several particle physics experiments
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- Excellent communication skills in English and working knowledge in German

For further information please contact Prof. Dr Klaus Kirch, phone +41 56 310 32 78, or Dr Stefan Ritt, phone +41 56 310 37 28.

Please submit your application online under http://www.psi.ch/pa/offenestellen/0433-1 (including list of publications and addresses of referees) for the position as an Experimental Physicist (index no. 3203-01).

Paul Scherrer Institut, Human Resources, Thomas Erb, 5232 Villigen PSI, Switzerland
www.psi.ch

ÖAW Austrian Academy of Sciences

HEPHY Institute of High Energy Physics

Postdoctoral position for the CMS experiment

The Institute of High Energy Physics of the Austrian Academy of Sciences in Vienna, Austria, is opening a PostDoc position in experimental particle physics for work on the CMS experiment at CERN's Large Hadron Collider.

Scientific environment The institute is involved in two major experimental programmes: CMS at CERN and BELLE / BELLE II at KEK. Within the CMS collaboration the institute has major responsibilities in the tracker and trigger projects. The research priorities with CMS data are the search for supersymmetry and QCD studies with quarkonium states. More information may be found at http://www.hephy.at .

Description of position The new collaborator is expected to strengthen the analysis activities in the search for new physics with the CMS experiment and to supervise PhD students. Good communication skills and the quality to work in a team are required. Interested candidates should hold a PhD in elementary particle physics and have an excellent research record. Experience of working in a large international collaboration is essential.

The remuneration follows the scheme of the Austrian Science Fund (FWF). The location will be Vienna. The position will be opened for an initial period of two years, with a possibility of extension. Under exceptional circumstances the position could eventually lead to a permanent appointment.

Application Applications should include a CV, a publication list and a statement of research interests. Applicants should arrange to have two recommendation letters sent to W. Adam (wolfgang.adam@oeaw.ac.at). The deadline is Dec. 31st, 2012, but applications will be considered beyond this date until the position is filled. For further information please contact W. Adam (see above) or Prof. C. Fabjan (christian.fabjan@oeaw.ac.at).

ALICE

A JOURNEY OF DISCOVERY

Korea ALICE (A Large Ion Collider Experiment) Team

Pusan National University, Gangnung-Wonju National University,
Sejong University and Yonsei University

One Post-doctoral Researcher in Heavy Ion Physics Experiment (ALICE)

Applicants are invited to a research fellow (post-doctoral) position for Korea ALICE team, which consists of 4 institutions (Pusan National University, Gangnung-Wonju National University, Sejong University and Yonsei University).

The successful candidates will be expected to take a leading role in ALICE and to publish research from the current ALICE data with coordinating/assisting the Korean MA/PhD students at CERN. They are, therefore, strongly expected to have well experienced in heavy ion data analysis as well as detector operations with staying at CERN more than 60%. Details can be discussed.

Depending on experience, the salary will be in the post-doctoral level : CHF 4,300 per month for CERN residents and KRW 3,000,000 per month for staying in Korea. The contract will be for two years and can be renewed.

APPLICATION

Please, send your application (a letter introducing yourself) with your CV and at least two letters for references to
Prof. Dr. In-Kwon Yoo, Department of Physics,
Pusan National University, Busan, South Korea, 609-735 or
e-mail to yoo@pusan.ac.kr

Further information can be obtained by sending mail to **yoo@pusan.ac.kr.**

Deadline for applications : 15 December 2012

US

University of Sussex

School of Mathematical and Physical Sciences
Department of Physics & Astronomy
Lecturer in Experimental Particle Physics
(Full Time, Permanent)

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Expected start date: 1 April 2013, or as soon as possible thereafter.

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This post is to expand the activities of the ATLAS team within the Sussex EPP Group. Sussex has leading involvement in the search for new physics at ATLAS, and the group's main technical responsibilities are in the ATLAS High-Level Trigger (HLT) system and its upgrade, as well as the proposed Level-1 track-trigger (L1Track) upgrade project. We seek a creative researcher with a demonstrated ability to lead an original research programme that is well aligned with the existing ATLAS and EPP activities. The successful candidate will strengthen and extend Sussex's leadership within the ATLAS trigger system, especially in view of its future upgrades, and contribute to an expansion and possible diversification of our physics programme on ATLAS.

The EPP group is one of four research groups within the Department of Physics & Astronomy. The University of Sussex is part of the South East Physics Network (SEPnet).

Informal enquiries may be addressed to Dr Antonella De Santo (a.de-santo@sussex.ac.uk).

Closing date: Monday 14 January 2013.

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Closing date: 25 November 2012

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Indiana University
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FACULTY POSITION

The Department of Physics at Indiana University invites applications for a tenure-track assistant professor position in theoretical astrophysics, cosmology, or nuclear astrophysics starting in the fall of 2013. We are interested in excellent candidates in several areas including neutrino astrophysics, gravitational wave astrophysics, supernova and neutron star merger simulations, gamma ray astronomy, dark matter, baryogenesis, nucleosynthesis, and properties of dense matter and neutron stars. The successful candidate will join astrophysics colleagues in both the Physics and Astronomy Departments at Indiana University and interact with very strong research groups in several related areas including neutrino physics, fundamental symmetries, high-energy physics, and nuclear physics. The candidate must have a Ph.D in physics or astrophysics and some postdoctoral experience.

A commitment to excellence in teaching at the undergraduate and graduate level is essential. Candidates should submit a letter of application, curriculum vitae including a list of publications, statement of research, and a statement of teaching, and arrange for a minimum of three letters of reference. Applications should be submitted through the application portal located at http:/ /indiana.peopleadmin.com. For questions please contact the Physics Department at 812-855-1247. Applications received by January 15, 2013 will be given full consideration. The position will remain open until filled. Further information about the IU Physics Department can be found at http://physics.indiana.edu.

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These positions are available on September 1, 2013. Interested applicant should email his/her application with curriculum vitae, research statement, publication list and three letters of recommendation before December 1, 2012 to

Ms. Yen-Ling Lee ntulecospa@ntu.edu.tw

For more information about LeCosPA, please visit its website at **http://lecospa.ntu.edu.tw/**

Three letters of recommendation should be addressed to

Prof. Pisin Chen, Director
Leung Center for Cosmology and Particle Astrophysics
National Taiwan University

Bookshelf

Festive Bookshelf

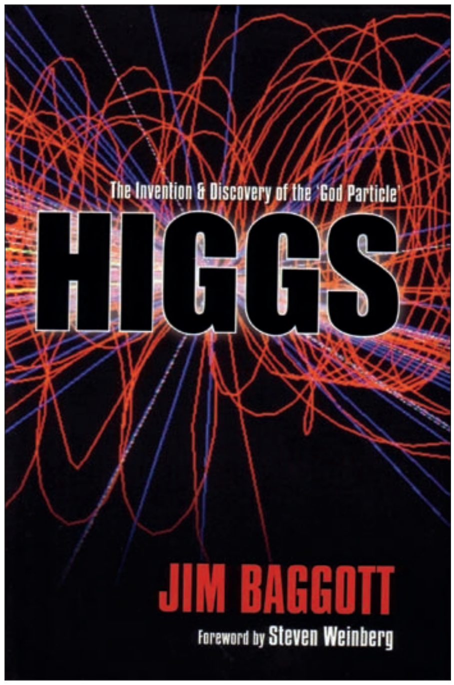
It will soon be time for many of us to spend some time with friends and family, after an exciting year that saw the discovery at CERN of a new particle consistent with being the long-sought Higgs boson. This end-of-year selection includes two books published hot on the heels of that announcement, together with others for more relaxed reading.

Higgs: The Invention and Discovery of the 'God Particle'

By Jim Baggott
Oxford University Press
Hardback: £14.99 $24.95

Jim Baggott is the author of *The Quantum Story*, an exceptionally interesting and detailed "biography" of quantum physics, very nicely exposed over almost 500 pages. Having had the pleasure of reviewing this wonderful book for the *CERN Courier* (July/August 2011 p55), I was quite happy to learn, through a text by Steven Weinberg that appeared on 9 July this year on *The New York Review of Books* (NYRB) website (www.nybooks.com/blogs/nyrblog/2012/jul/09/big-higgs-question/), that Baggott had written a new book, succinctly titled *Higgs*. However, I was perplexed to realize that the new book had been finished just two days after the seminar at CERN on 4 July, when the ATLAS and CMS collaborations announced "the discovery of a new particle that seems to be the long-sought Higgs particle" (to quote Weinberg). Indeed, most of the book had been written well before, in anticipation of the day when the discovery would be announced.

Unfortunately, I became rather disappointed soon after getting my hands on the new book. Apart from Weinberg's "foreword" (most of it available through the NYRB blog) and from the final chapters, most of the book left me with a feeling of "*déjà vu*", constantly reminding me of pages from *The Quantum Story*. As the author writes in the preface, "the present book is based, in part, on that earlier work". Some sentences were refurbished and some (not all) minor mistakes were corrected, but if you have read the original you will feel that much of the new book is a "remake". At least Baggott has added a few Feynman diagrams, which were clearly lacking in *The Quantum Story*, such as the one relating the GIM mechanism to the dimuon decay of the neutral kaons, but a lot more illustrations (and a few equations) could have been included to facilitate the understanding of



certain narratives.

The final three chapters of *Higgs*, written specifically for the new book, should have gone through an extra round of editing to eliminate several imperfections. For instance, the general reader will be puzzled when reading that the CMS collaboration is led by Guido Tonelli (page 188), that the CMS spokesperson is Tejinder Virdee (page 189) and that Joe Incandela is "acting as spokesperson for CMS" (page 215); the three sentences were no doubt correct when they were written but producing a good book implies more than copy/pasting sentences written over a period of several years. In general, the original chapters provide enjoyable reading but some details reveal that the author followed the action from far away and, in a few instances, became sidetracked by blog-driven animation. This constitutes an eye-opening experience for some readers (such as myself). Having followed the reality of the discovery as an insider and now seeing how things are written up in a popular-science book will allow me to assess the kind of "acceptance correction" that I should apply to analogous descriptions of the many things of which I have no direct knowledge. As an aside, I was amused to see that Baggott decided to illustrate the LHC's achievements using a dimuon mass distribution that I helped to prepare but astonished to see that an error was introduced in the CMS Higgs plot when restyled for inclusion in the book. Things were really done too much in a hurry.

If you are looking for a good book to read over the end-of year break, I highly recommend *The Quantum Story*, a dense plot with heroic characters, covering the fantastic odyssey of quantum physics. But how many of us have crossed paths with Einstein, Bohr, Pauli or Dirac? It is refreshing to read books about present-day physics and physicists, where one can enjoy the plot and recognize the main characters. In that respect, *Higgs* is an interesting alternative and has the advantage of being much faster to read. Another option for people specifically interested in reading about the "hunt for the God particle", is *Massive*, by Ian Sample, an easy-to-read, lively book that gives a fast-paced and well humoured overview of the history behind and surrounding the Higgs boson, until mid-2010 (*CERN Courier* December 2010 p51), although the reader needs to be patient and ignore the annoying detail of seeing CERN written as Cern and RHIC as Rick … oh, well.

I am looking forward to reading more books about the LHC experiments and their discoveries, concerning Higgs physics and other topics, written by people who made those experiments and those discoveries. These are important issues and they deserve being treated by professionals with direct knowledge of the inside action, who can provide much more information – and much more accurately – than (award-winning) popular-science authors.

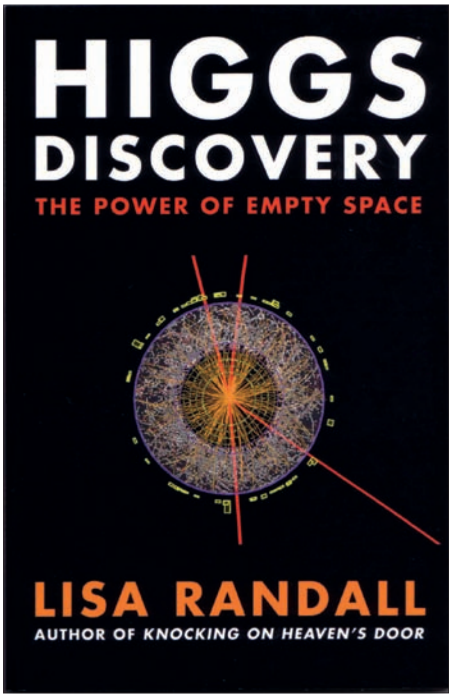
● *Carlos Lourenço, CERN.*

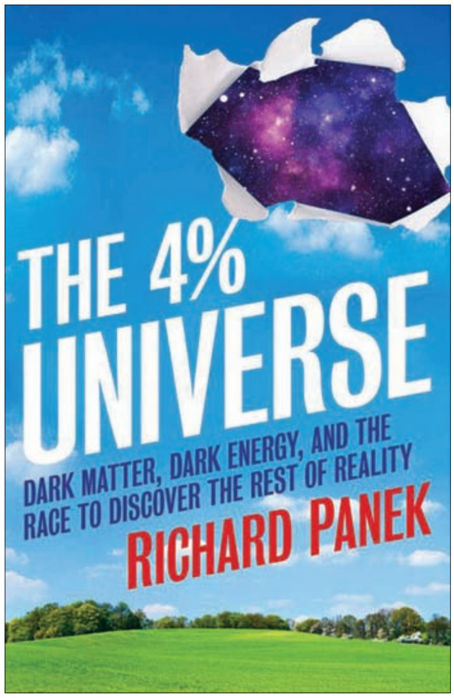
Higgs Discovery: The Power of Empty Space!

By Lisa Randall
Bodley Head
Paperback: £4.99

Readers of *CERN Courier* need no introduction to Lisa Randall, the well known theoretical physicist. Her previous books, *Warped Passages* and *Knocking on Heaven's Door*, are exceptionally interesting and surprisingly easy to read, especially when considering the complexity of the topics that she addresses. I cannot judge if the fluidity of her writing is a natural talent or the result of much hard work through several editorial iterations – but the result is outstanding. Her new book, *Higgs Discovery: The Power of Empty Space*, reports her reactions to the announcement by the CMS and ATLAS experiments that "a particle related to the Higgs mechanism had been found" – "I was flabbergasted" – and compiles her answers to the many

Bookshelf





questions that she has been asked since.

This is a small book of fewer than 50 pages, which can be read in a couple of hours. The writing style is refreshing and informal, with a warped sense of humour that helps to grab the target audience: the people who were fascinated with the discovery without knowing why. Sometimes it is a little repetitive and almost feels like "Higgs for dummies" but this is more a compliment than a criticism. Nowadays, most people forget to explain "the basics", a challenge that Randall excels at. And she does not forget to wrap her teachings with passages that extend well beyond high-energy physics: "The Higgs boson discovery is more likely to be the beginning of the story than an end." I wonder if she purposely paraphrased Winston Churchill.

I certainly agree that "the discovery is truly inspirational" and I am also glad that we can avoid the need to explain why not finding the Higgs boson would be even more interesting than actually finding it.

● *Carlos Lourenço, CERN.*

The 4% Universe. Dark Matter, Dark Energy, and the Race to Discover the Rest of Reality.

By Richard Panek
Oneworld
Paperback: £9.99

The 4% Universe is, as you might gather from the title, an account of how the scientific community has come to the idea that only (a little over) 4% of the universe seems to be made of the same stuff as you and me. In other words, normal matter is only a tiny percentage of all that there is, with the remainder being about 23% dark matter holding galaxies together and 73% being dark energy, which drives the acceleration of cosmic expansion.

This account is unusual, written more like a thriller than in the style of many popularizations. There is a great emphasis on not only describing the sequences of events leading to the discoveries of dark matter and dark energy but also of the people involved. Personalities, co-operations, disagreements, collaboration and individualism all take a large part of the stage, making the book lively and readable. I had originally planned to read it in chunks over a few days but found myself taking it all in during a single sitting, somewhat later into the night than I had planned!

This book would be a nice gift for anyone with a genuine interest in science but, oddly enough, it may be a hard read for someone without at least some background knowledge. At the same time, it is short on details (no equations, graphs, plots or photographs) for a practising physicist who is not so interested in the personal dramas involved. If you're looking for a book about dark matter and dark energy *per se*, then this may not be the best choice. While the science is probably more than 4% of the book, the bulk is about sociology, history and politics.

Nevertheless, technical terms are well explained, down to footnotes for those who need to know what the Kelvin scale or a megaparsec is. The physics is pretty good, too, but not perfect in all places. For example, the discussion on the Casimir effect seems not quite to get that the energy density between the plates is negative with respect to the region outside.

The emphasis is very much on astronomy and astronomical observation and how data are collected and presented. Particle physicists should not expect much about the direct search for particles that could make up dark matter. The LHC merits a brief mention but without further discussion. Axions and neutralinos are introduced as dark-matter candidates but without any explanation of the ideas that gave rise to them.

Apart from the insights into the sociology of how "big astronomy" is done, I think that the book's greatest merit is to drive home how much our view of the universe has changed in the past 100 or so years – from a rather simple, static universe to an expanding, even accelerating one, with far more stars and galaxies than had ever been imagined and, now, the realization that all of that visible matter may be only a few per cent of all that is. That, as well as to show how cosmology has made the giant step from being little different from theology to being a real scientific discipline.

● *John Swain, Northeastern University.*

About Time: From Sun Dials to Quantum Clocks, How the Cosmos Shapes Our Lives – And How We Shape the Cosmos

By Adam Frank
Oneworld
Paperback: £12.99

In 1963, Bob Dylan penned the song *The Times They Are a-Changin'*, which quickly became the anthem for a new generation. But according to Adam Frank's provocative book, the times have always been changing: first, hunter-gatherers driven by the immediacy of hunger; then pioneer farmers dictated by the seasons. After that came a series of industrial revolutions: workers having to move to towns and adapt to factory drudgery; mechanical transport extending the span of distance of daily life; and today's digital devices compressing time and distance even further (with the constant pressure to download the latest app or have the newest browser update).

About Time compares the accelerating pace of this race towards no clear destination with the evolution of cosmology, from ancient mythology to the modern picture of multiple universes. The changing world picture is continually benchmarked against the seemingly unpredictable emergence of new lifestyles as technology advances.

In doing so, the story line can lurch startlingly at times. It leaps from the introduction of labour-saving electrical household appliances in the early 20th century to the commissioning of the Mt. Wilson Hooker telescope; from the measurement of galactic red shifts and an apparently expanding universe to the cultural revolution brought about by domestic radio. The ideas of quantum mechanics are then wedged into two pages.

Frank's illustrations cover a wide range. I appreciated being reminded of the tragic figure of British music producer Joe Meek, whose 1962 instrumental piece marking the technological miracle of *Telstar* resonated in contemporary lifestyle as the first British recording to appear in the US charts – one year before the Beatles, who the mercurial Meek had meanwhile chosen to ignore.

The book traces the key historical giants, from the Ancient Greek philosophers and before through to Albert Einstein, Edwin Hubble and beyond. Some figures are less familiar, for example Ambrose Crowley, a British industrial magnate who was a contemporary of Isaac Newton. Despite his obscurity, Crowley's impact on technology is compared with that of Newton's on science.

Some conventional ideas are sold short, for example the role of time in quantum physics and its deep connection with antimatter. Paul Dirac, the pioneer of antimatter, appears in a cameo role to introduce a whole section on the iconoclast Julian Barbour and his provocative book *The End of Time*. Barbour suggests that the continual quest to understand time fails because time itself is an illusion.

Although Frank's *About Time* does not venture that far, it is an unconventional book, which could motivate an inquisitive young mind.

● *Gordon Fraser is author of* Quantum Exodus: Fugitive Jews, the Atomic Bomb, and the Holocaust *(OUP 2012).*

Reinventing Discovery: The New Era of Networked Science

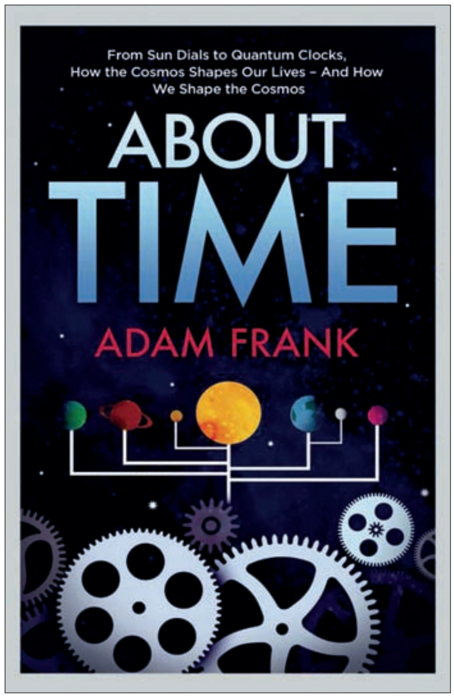
By Michael Nielsen

Princeton University Press

Hardback: £16.95 $24.95

The term "disruptive innovation" is used in the business world to refer to how new technologies sometimes upend whole industries, just as the telephone did to the telegraph and the mobile phone is doing to the telephone. The internet has disrupted a whole slew of industries: think of the impact of online bookstores on their bricks-and-mortar analogues, or how professional journalism has been challenged by free and often high-quality amateur blogs and other forms of online social media.

The profound question raised in this

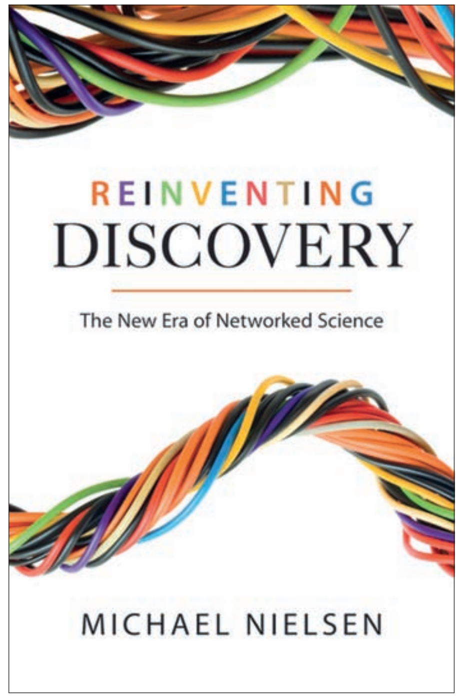


book, written by Michael Nielsen, a young pioneer in the field of quantum computing, is whether the scientific establishment may be facing a similar disruption. As the web enables new ways of sharing ideas online and participating in science over the internet, could it favour amateur involvement and threaten the status quo of professional science?

The author illustrates many ways in which web-based technologies are challenging traditional models of sharing and collaboration in science. These range from popular open-access forms of scientific publishing such as arXiv's online preprints to a blog where Cambridge mathematician Tim Gowers successfully enlisted help from colleagues and strangers to crack a tough mathematical nut, to the computer game *FoldIt*, where thousands of players help to solve protein-folding problems that stymied professionals.

The backbone of this book is a thoughtful review of what "open science" means. This emerging buzzword is inspired by the open-source movement in software but, as Nielsen correctly points out, science has been aspiring to greater openness for centuries. Indeed, scientific articles evolved to accelerate the dissemination of scientific knowledge and patents were meant to do the same for new technologies. Yet these tools have been gradually co-opted for other uses – measuring researcher productivity and valuing companies – that often seem at odds with their original goal of promoting greater openness.

The strength of Nielsen's thesis is that



he does not propose glib solutions, nor is he naive about the entrenched social order that fuels much of the "publish or perish" mentality of the academic world. He is wisely wary of trivializing the "crowd sourcing" of scientific problem solving, something that is hard to do well. Rather, he details a number of best practices for moving the open-science agenda forward, using online technologies. This thoughtful approach should be immediately useful to professional and amateur scientists, alike.

If, indeed, the internet is ushering in a new era of networked science, as this book's subtitle suggests, it will surely have some downsides, such as decreased job security for white-collar academics in industrialized countries. But the potential upsides of such disruptive innovation, as this book so eloquently reveals, could be huge.

● *François Grey, Citizen Cyberscience Centre, CERN.*

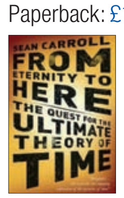
Books received

From Eternity to Here: The Quest For the Ultimate Theory of Time

By Sean Carroll

Oneworld

Paperback: £10.99 $12.24



Twenty years after Stephen Hawking's *A Brief History of Time*, Sean Carroll takes investigations into the fundamental nature of time to the next plane – to what happened before the Big Bang. Here Carroll, a leading theoretical cosmologist,

Bookshelf

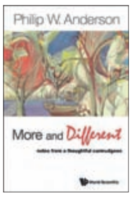
delivers a paradigm-shifting approach to understanding the mysterious "arrow of time" in which other universes experience time running in the opposite direction to our own. Exploring subjects from entropy and quantum mechanics to time travel and the meaning of life, Carroll presents a dazzling view of how things came to be.

More and Different: Notes From a Thoughtful Curmudgeon

By Philip W Anderson

World Scientific

Hardback: £51
Paperback: £25
E-book: £67



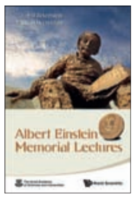
Now nearly 90, Philip Anderson spent many years at two important universities – Princeton in the US and Cambridge in the UK – as well as Bell Laboratories, from 1949–1984, and shared the 1977 Nobel Prize in Physics, for "fundamental theoretical investigations of the electronic structure of magnetic and disordered systems". In 1972, he wrote a well known article, "More is Different", in which he eloquently countered the purely reductionist view of science, with a broader perspective based on emerging complexity and "broken symmetry" in macroscopic systems. This sparked a writing career in parallel to his scientific work, with many articles in *Physics Today*, for example. Forty years later, the title of this collection of essays echoes that of the earlier article and it serves well to summarize succinctly the many and varied topics that Anderson has thought and written about.

Albert Einstein Memorial Lectures

By Jacob D Bekenstein and Raphael Mechoulam (eds.)

World Scientific

Hardback: £51
Paperback: £22
E-book: £67



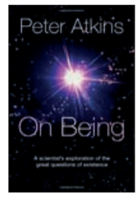
This volume consists of a selection of the Albert Einstein Memorial Lectures presented annually at the Israel Academy of Sciences and Humanities, since it was inaugurated by the academy following an international symposium held in Jerusalem in March 1979 to commemorate the centenary of Albert Einstein's birth. Delivered by eminent scientists and scholars, including several Nobel laureates, they cover a broad spectrum of subjects in physics, chemistry, life science, mathematics, historiography and social issues. In particular, Carlo Rubbia, who delivered the lecture in 1998, describes "Harmless Energy from Nuclei', Steven Weinberg writes on "Beautiful Theories" (1984) and Haim Harari elucidates "The Structure of Quarks and Leptons" (1983).

On Being: A Scientist's Exploration of the Great Questions of Existence

By Peter Atkins

Oxford University Press

Hardback: £10.99 $19.95
Paperback: £8.99 $13.95



In this slim volume, Peter Atkins considers the universal questions of origins, endings, birth and death to which religions have claimed answers. With his usual economy, wit and elegance, unswerving before awkward realities, Atkins presents what science has to say and science's capacity to reveal the deepest truths.

Inside Story

Maurice Lévy and his impact on science

Maurice Lévy, who was 90 in September, has had a long and influential career in science, in particular in France.

On 21 October 2002, the Institut d'Études Scientifiques de Cargèse in Corsica inaugurated a new amphitheatre named in honour of its founder, Maurice Lévy (left), seen here with André Martin. (Image credit: Schu Martin.)

Like many prominent French intellectuals, including three Nobel laureates, Maurice Lévy came from North Africa, where he was born in Algeria. He had an incredibly rich and diverse career. During the Second World War, he studied at the University of Algiers, gained his PhD in molecular optics in Paris, moved to Manchester, where he switched to theoretical physics, and then to the Institute of Advanced Studies in Princeton, where he considerably impressed Robert Oppenheimer. On his return to France in 1952, Lévy launched the first French group of theoretical physics at the École normale supérieure and became a professor at the University of Paris. The group moved to Orsay in 1959 but Lévy returned to Paris in 1971 as a professor at the University of Paris VI. This professorship was interrupted by several important responsibilities: scientific advisor at the French embassy in Washington DC; president of the Centre National d'Études Spatiales, where he launched the programme for the construction of Ariane launchers; president of the European Satellite Research Organization and the European Space Agency; founder and first president of the "Cité des Sciences de La Villette". After his retirement from the university he continued to have advisory and business activities.

Lévy played a considerable role in the resurrection of French theoretical physics after the war. Several people – in Saclay, the École Polytechnique and the Radium Institute – were aware of the dismal situation and tried to do something about it. Cécile Morette-DeWitt started the Les Houches theoretical summer school in 1951 and invited Lévy to lecture there in 1952. At this session, Lévy told Loup Verlet and myself that Yves Rocard had proposed the creation of a theoretical physics group at the École normale. He asked us if we were interested in joining him and we accepted immediately, becoming the first two members of the group. A number of talented "normaliens" joined the group – Bernard Jancovici, Michel Gourdin, Madeleine Collin, Claude-Annette Rive – as well as other distinguished scientists, such as Philippe Meyer, Jacques Mandelbrojt, Georges Bonnevay, Khrosrow Chadan and Jean Tran Thanh Van. Lévy also provided hospitality for Louis Michel and his group, Claude Bouchiat, Henri Epstein and Gérard Flamand, from the École Polytechnique. We had many prestigious visitors, the most illustrious being Murray Gell-Mann, Robert Oppenheimer and Chen-Ning Yang.

Lévy's plan was to conquer the university, a thing that nobody before him had dared to try. The problem was that there was already a chair of "physical theories" in the hands of Louis de Broglie and his friends. By playing with words, a chair of "theoretical physics" was created with the help of Gaston Berger, director of "enseignement supérieur". Lévy started immediately to teach quantum mechanics, field theory and particle physics. He asked us, his students, to help him and I remember that I gave some lectures at the École normale and the Institut Henri Poincaré. The result was that Lévy could recruit excellent people outside the "grandes écoles". The best example is John Iliopoulos, who came from Greece, sent by Themis Kannelopoulos, and became a star of theoretical physics as one of the three physicists who predicted the existence of the charmed quark (in the Glashow-Iliopoulos-Maiani mechanism).

During the period where I was at the École normale (before leaving for CERN in 1959) two important events took place. I had a friend, Louis Pons, who knew a certain Mr Partiot who wanted to sell a piece of land in Cargèse, Corsica, for an educational purpose. In 1958, a meeting was organized between the four of us and Lévy's secretary, Colette Movchet. During the meeting, Mr Partiot offered to let us try the Cargèse site for a summer school, without any commitment on our part. We accepted. The courses were held in a barn, the participants were accommodated at Hotel Thalassa or in the camp Rocca Marina, or simply camped. It was a complete success. After that, Lévy tried various other possibilities in Corsica, with the help of Rocard. In the end, the Cargèse site was chosen and with his cleverness and management skills Lévy found the necessary financial support. The first official summer school took place in 1960 in what is called now the "Institut d'Études Scientifiques de Cargèse".

The second important event was the creation of a group of experimental nuclear and particle physics at the initiative of Rocard and Lévy. They convinced Hans von Halban to come back with his group from Oxford to the École normale. The group moved to Orsay, where the linear accelerator was built. The Linear Accelerator Laboratory (LAL) became one of the most important experimental laboratories in the world of particle physics (*CERN Courier* July/August 2006 p33). The linear injector for CERN's Large Electron–Positron collider was built there, for example, and the laboratory was one of the main contributors to the discovery of neutral currents. Lévy also helped choose André Blanc-Lapierre and André Lagarrigue as successive directors of LAL.

Maurice Lévy's lasting impact on French science is a result of his vision of how scientific organizations should be and his relentless efforts to build them for our community.

● *André Martin, CERN.*

Inside Story

C S Wu: First Lady of physics research

Chien-Shiung Wu is the subject of a new biography that marks her centenary. The author talks about how the book came about.

Chien-Shiung Wu, right, with Wolfgang Pauli in the early 1940s. (Image credit: Pauli Archive/CERN.)

Chien-Shiung Wu was born on 31 May 1912 in Liuhe, near Shanghai. In 1957, Wu and her colleagues published their historic paper, "Experimental test of parity conservation in beta decay", which established for the first time the non-conservation of parity. The study of nuclear beta decay was a central focus of Wu's research. In 1949 and 1950, through a series of beautiful experiments, Wu measured the allowed and forbidden beta spectra, corrected many previous mistakes and firmly established Fermi's theory. Almost single-handedly she cleared up the confusion in beta decay that had existed for one and a half decades. (*CERN Courier* April 1997 p21.)

It has been many years since the first idea of writing this biography occurred to me. During this period, I have talked to many people about Chien-Shiung Wu: some knew her a little, most had only vague understandings; some asked me why I should write a biography of Wu, and some even asked who Wu was!

In 1956, Wu was the first to perform a rather difficult and precise experiment, and confirmed the hypothesis [of parity violation] proposed by C N Yang and T D Lee. Yang and Lee became the first two Chinese Nobel laureates. Although Wu did not share the prize – to the surprise of many – she was acknowledged as one of the most distinguished experimental physicists in the world.

Wu went to the US in 1936. By the time she earned a PhD in 1940, her achievements and insights in research had already received the highest admiration from many professors at the University of California, Berkeley, such as the great American scientists Robert Oppenheimer and Ernest Lawrence. As a result, she was invited as a non-citizen of the US to participate in the top-secret "Manhattan Project", working on atomic bombs, and made critical contributions to the project.

Because of her significant achievements and her profound influences in physics, Wu was often called "the Chinese Madame Curie", "the First Lady of Physics Research" and the "Queen of Nuclear Research". In 1975, she broke the white-male-president tradition and became the first female president of American Physics Society.

Wu visited Taiwan on the invitation of Academia Sinica in 1983, after an absence of 18 years. I met her for the first time as a science reporter for the *Reading Times*, which served as the beginning of the adventure of writing her biography. She had retired from Columbia University in 1980 after 36 years. As professor emeritus, her major research activities slowed down gradually. She was in her 70s – a good time for reflection.

I received much encouragement when planning this biography, particularly from C N Yang, who mentioned that a distinguished scientist such as Wu deserves to have a good biography. I discussed this proposal with Wu two years later. Always matter-of-fact, modest and never seeking fame, she declined. Only after many verbal and written persuasions, and the argument put forward by Luke Yuan [her husband] that her biography would help in inspiring Chinese youth in addition to publicizing her achievements, was she finally convinced.

With the inspiration of Yang, I realized the importance of using an objective narrative in writing this book. As a result, I did not rely only on her own account but would interview her colleagues, students, friends, relatives and even competitors, and make reference to many documents and literature. This turned out to be a time-consuming undertaking.

I started the official interviews with Wu in New York in September of 1989. They were unexpectedly rough. I had imagined a rather romantic setting, with Wu vividly recounting her life and events. With the tape recorder turning and my pen moving, the Sun would be setting slowly. But this almost never happened in the tens of interviews in more than a year!

Wu never wrote a diary. While wholeheartedly immersed in her scientific experiments in the past years, she never considered recording this process for the world, and therefore had no memory of many events. In addition, she was down-to-earth and of few words. The medicine that was lowering her blood pressure also affected her memory. The many hours of interviews and reminiscences were not enough to reconstruct her past.

I flew more than 30,000 miles, all over the world, to interview more than 50 individuals in China, Hong Kong, Europe, the US and Canada. The tape recording of tens of hours was followed by telephones calls to confirm details.

I used objective narrative as much as possible, avoiding subjective opinion or novel-style descriptions. Basically, this book conforms to the current trend in biographic writing: using a style closer to news reporting. In a way, its writing could be regarded as an attempt to test the idea that "news serves as a footnote of history".

● *Tsai-Chien Chiang, author of* Madame Chien-Shiung Wu: The First Lady of Physics Research *(translated by Tang-Fong Wong, World Scientific 2012). This article is extracted with permission from the September 2012 issue of* Asia Pacific Physics Newsletter, *which also includes an article on Chien-Shiung Wu's scientific achievements. See www.worldscientific.com/toc/appn/01/02.*

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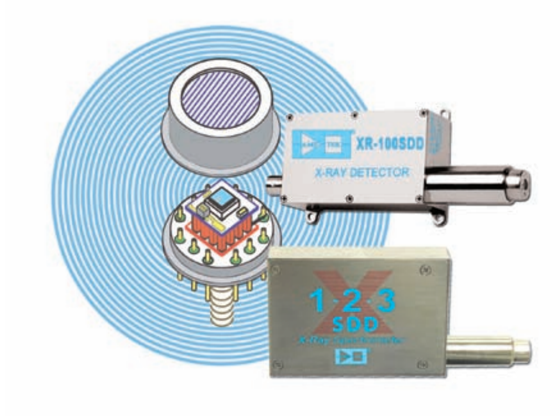

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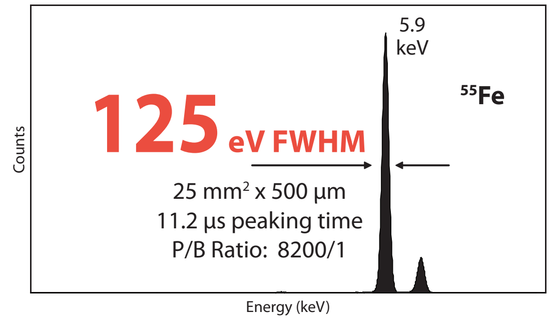

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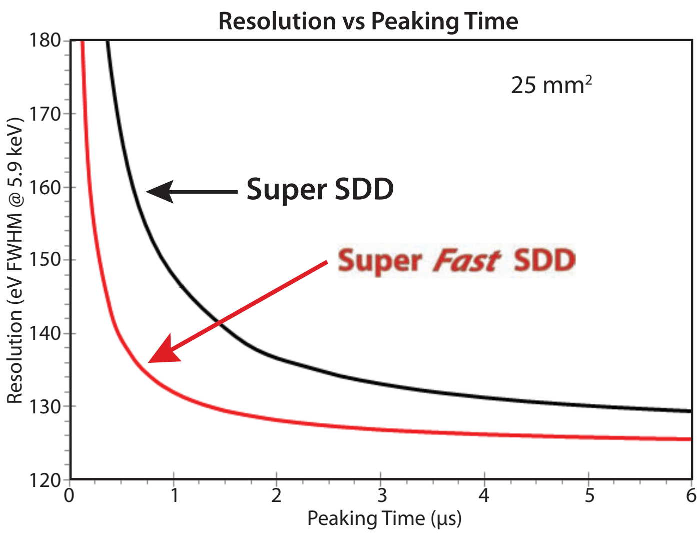

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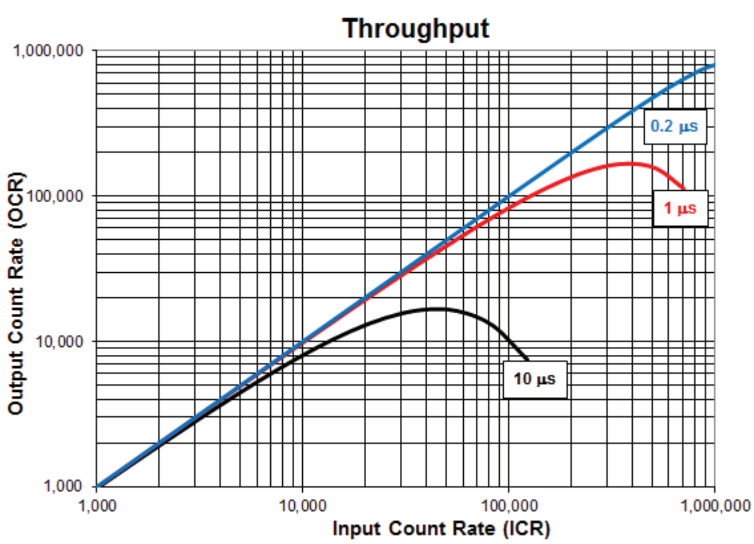

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