WELCOME

CERN Courier – digital edition

Welcome to the digital edition of the January/February 2015 issue of *CERN Courier*.

The coming year at CERN will see the restart of the LHC for Run 2. As the meticulous preparations for running the machine at a new high energy near their end on all fronts, the LHC experiment collaborations continue to glean as much new knowledge as possible from the Run 1 data. Other labs are also working towards a bright future, for example at TRIUMF in Canada, where a new flagship facility for research with rare isotopes is taking shape.

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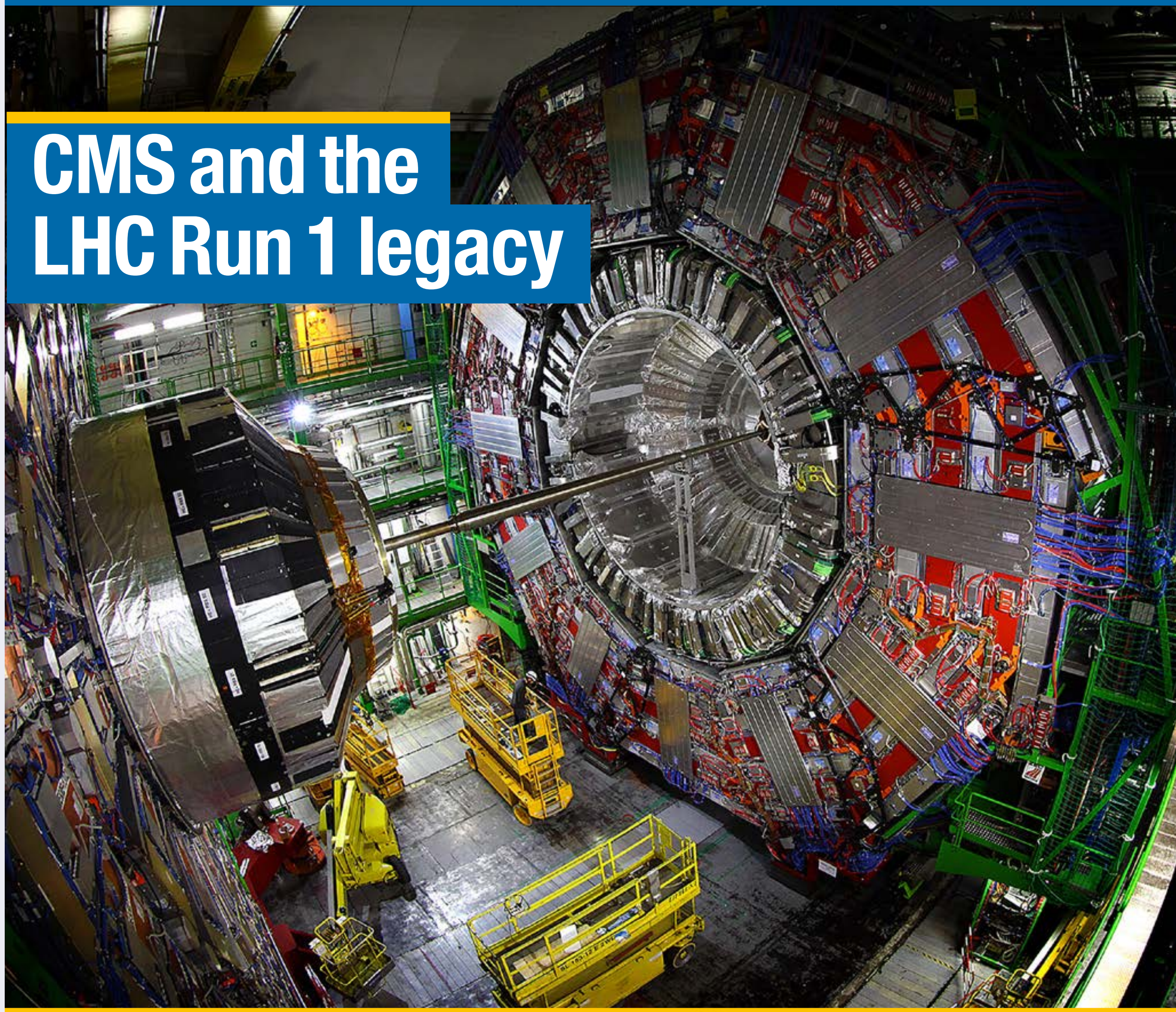
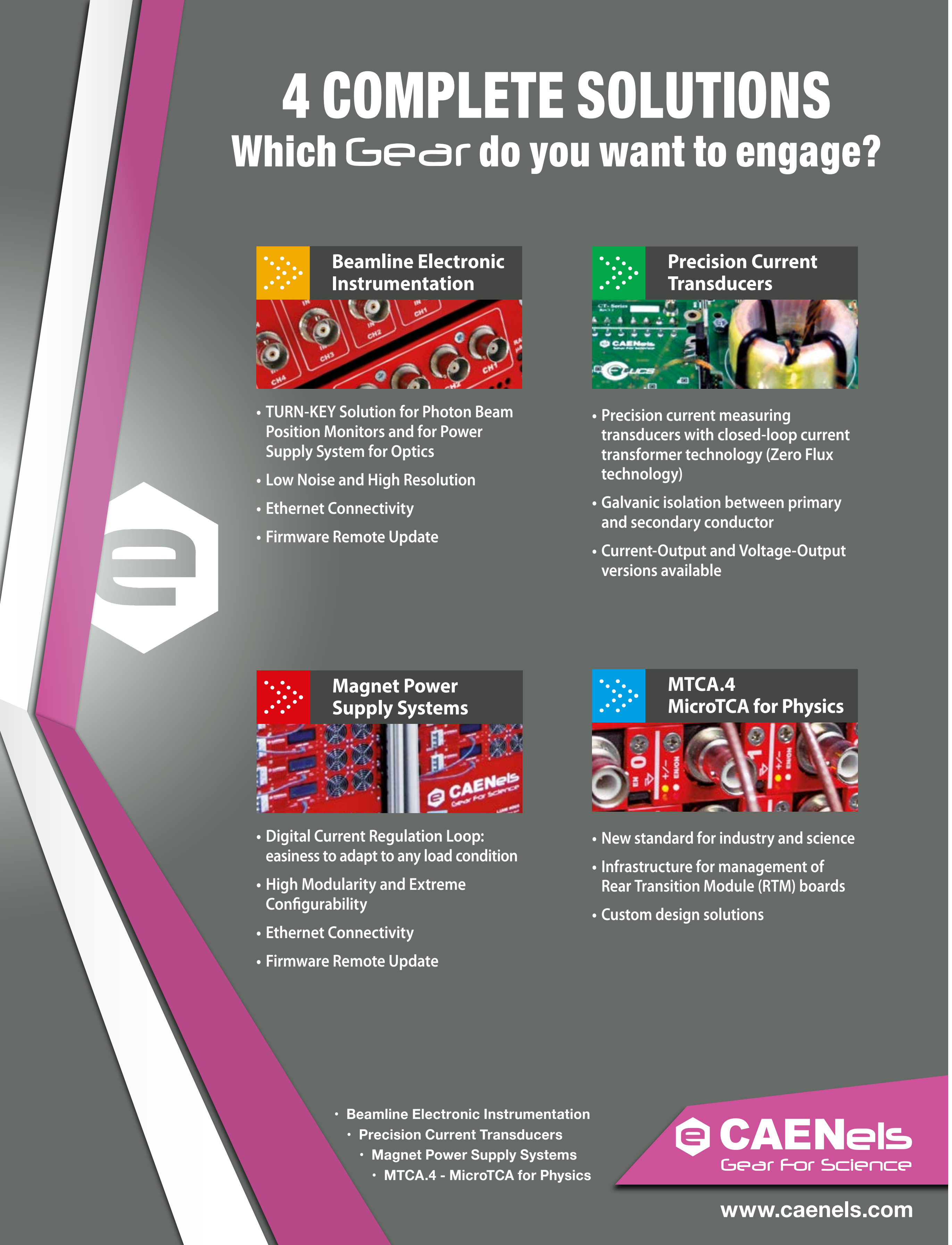
VOLUME 55 NUMBER 1 JANUARY/FEBRUARY 2015



TRIUMF
Canada's new research facility for rare isotopes
p26

TRIBUTE
Emilio Picasso and his enthusiasm for physics
p19

CERN & SOCIETY
The thinking behind a new foundation **p50**



Contents

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

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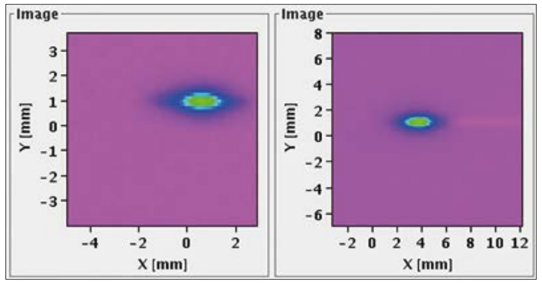
On the cover: The CMS detector, opened up for installation work in preparation for Run 2 of the LHC. During the long shutdown, the collaboration has been hard at work on analysis of the Higgs boson discovered in Run 1 (see p23). (Image credit: CMS Collaboration.)

News

CERN

The LHC gears up for season 2



Beams came knocking on the LHC's door in November. These images show the transverse beam profile in the LHC injection lines (TI2 left, TI8 right).(Image credit: CERN.)

With the end of the long shutdown in sight, teams at CERN have continued preparations for the restart of the Large Hadron Collider (LHC) this spring after reaching several important milestones by the end of 2014. Beams came knocking at the LHC's door for the first time on 22–23 November, when protons from the Super Proton Synchrotron passed into the two LHC injection lines and were stopped by beam dumps just short of entering the accelerator. The LHC operations team used these tests to check the control systems, beam instrumentation and transfer-line alignment. Secondary particles – primarily muons – generated during the dump were in turn used to calibrate the two LHC experiments located close to the transfer lines: ALICE and LHCb.

During the same weekend, the operations team also carried out direct tests of LHC equipment. They looked at the timing synchronization between the beam and the LHC injection and extraction systems by pulsing the injection kicker magnets and triggering the beam-dump system in point 6, despite having no beam.

Tests of each of the eight LHC sectors continued apace. By the end of November, copper-stabilizer continuity measurements were underway in sector 4-5 and were about to start in sector 3-4. Electrical quality assurance tests were being carried out in sectors 2-3 and 7-8, and powering tests were progressing in sectors 8-1, 1-2, 5-6 and 6-7. Cooling and ventilation teams were also busy carrying out maintenance of the systems at points around the LHC ring.

Meanwhile, the operations team were training the magnets in sector 6-7. The first training quench was performed on 31 October (*CERN Courier* December 2014 p6), reaching a current of around 10,000 A, which corresponds to a magnetic field of 6.9 T and a proton beam energy of 5.8 TeV (during Run 1, the LHC ran with proton energies of up to 4 TeV). On 9 December, the team successfully commissioned sector 6-7 to the nominal energy for Run 2 – 6.5 TeV, for proton collisions at 13 TeV. The 154 superconducting dipole magnets that make up this sector were powered to around 11,000 A. This increase in nominal energy was possible thanks to the long shutdown, which began in February 2013 and allowed the consolidation of 1700 magnet interconnections, including more than 10,000 superconducting splices. The magnets in all of the other sectors are undergoing similar training prior to 6.5 TeV operation.

In mid-December, the cryogenics team finished filling the arc sections of the LHC with liquid helium. This marked an important step on the road to cooling the entire accelerator to 1.9 K. During the end-of-year break, the cryogenic system was then set to stand-by, with elements such as stand-alone magnets emptied of liquid helium. These elements were to return to cryogenic conditions in January, to allow the operations team to perform more tests on the road to the LHC's Run 2.

The four large experiments of the LHC – ALICE, ATLAS, CMS and LHCb – are also undergoing major preparatory work for Run 2, after the long shutdown during which important programmes for maintenance and improvements were achieved. They are now entering their final commissioning phase. Here, members of the ATLAS collaboration are cleaning up the inside of the ATLAS detector prior to closing the cavern in preparation for Run 2. (Image credit: CERN-PHOTO-201412-248-3.)

Sommaire en français

COLLABORATION

Pakistan to become associate member state of CERN

On 19 December, CERN's director-general, Rolf Heuer, and the chairman of the Pakistan Atomic Energy Commission, Ansar Parvez, signed in Islamabad the agreement admitting the Islamic Republic of Pakistan to associate membership of CERN, in the presence of prime minister Nawaz Sharif and diplomatic representatives of CERN member states. This followed approval by CERN Council to proceed towards associate membership for Pakistan during its 172nd session held in September 2014. The agreement is still subject to ratification by the government of Pakistan.

The Islamic Republic of Pakistan and CERN signed a co-operation agreement in 1994. The signature of several protocols followed, and Pakistan contributed to building the CMS and ATLAS experiments. Today, Pakistan contributes to the ALICE, ATLAS and CMS experiments, and operates a Tier-2 computing centre in the Worldwide LHC Computing Grid that helps to process and analyse the massive amounts of data that the experiments generate.

Ansar Parvez, right, and Rolf Heuer sign the agreement to admit Pakistan to associate membership of CERN. (Image credit: SIPR, PAEC.)

Pakistan is also involved in accelerator developments, making it an important partner for CERN.

The associate membership of Pakistan will open a new era of co-operation that will strengthen the long-term partnership between CERN and the Pakistani scientific community. Associate membership will allow Pakistan to participate in the governance of CERN, through attending the meetings of the CERN Council. Moreover, it will allow Pakistani scientists to become CERN staff members, and to participate in CERN's training and career-development programmes. Finally, it will allow Pakistani industry to bid for CERN contracts, therefore opening up opportunities for industrial collaboration in areas of advanced technology.

CERN-JINR reciprocal observers

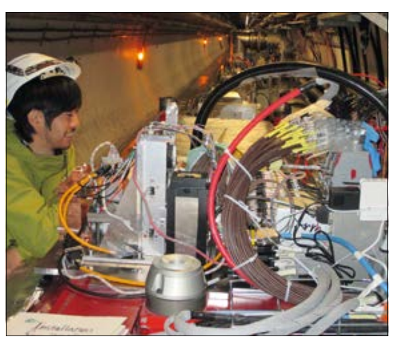
During its December meeting, Council also welcomed the Joint Institute for Nuclear Research, JINR, for the first time as an observer to Council, as part of a reciprocal arrangement that also sees CERN becoming an observer at JINR. Founded as an international organization at Dubna near Moscow in 1956, JINR soon forged a close partnership with CERN that saw exchanges of personnel and equipment throughout the cold war and beyond (*CERN Courier* November 2004 p9).

LHC EXPERIMENTS

LHCf detectors are back in the LHC tunnel

The Large Hadron Collider forward (LHCf) experiment measures neutral particles emitted around zero degrees of the hadron interactions at the LHC. Because these "very forward" particles carry a large fraction of the collision energy, they are important for understanding the development of atmospheric air-shower phenomena produced by high-energy cosmic rays. Two independent detectors, Arm1 and Arm2, are installed in the target neutral absorbers (TANs) at 140 m from interaction point 1 (IP1) in the LHC, where the single beam pipe is split into two narrow pipes.

After a successful physics operation in 2009/2010, the LHCf collaboration immediately removed their detectors from the tunnel in July 2010 to avoid severe radiation damage. The Arm2 detector, in the direction of IP2, came back into the tunnel for data-taking with proton–lead collisions in 2013, while Arm1 was being upgraded to be a radiation-hard detector, using Gd_2SiO_5 scintillators. After completion of the upgrade for both Arm1 and Arm2, the performance of the detectors was tested at the Super Proton Synchrotron fixed beam line in Prévessin in October 2014. Both Arm1 and Arm2 were then reinstalled in the LHC tunnel on 17 and 24 November, respectively. The installation went smoothly, thanks to the well-equipped remote-handling system for the TAN instrumentation. During the following days, cabling, commissioning and the geometrical survey of the detectors took place without any serious trouble.



LHCf's Arm1 detectors installed in the LHC tunnel. (Image credit: T Sako.)

LHCf will restart the activity to relaunch the data-acquisition system in early 2015, to be ready for the dedicated operation time in May 2015 when the LHC will provide low luminosity, low pile-up and high β* (20 m) proton–proton collisions. At $\sqrt{s} = 13$ TeV, these collisions correspond to interactions in the atmosphere of cosmic rays with energy of 0.9×10^{17} eV. This is the energy at which the origins of the cosmic rays are believed to switch from galactic to extragalactic, and a sudden change of the primary mass is expected. Cosmic-ray physicists expect to confirm this standard scenario of cosmic rays based on the highest-energy LHC data.

Another highlight of the 2015 run will be common data-taking with the ATLAS experiment. LHCf will send trigger signals to ATLAS, and ATLAS will record data after pre-scaling. Based on a preliminary Monte Carlo study using PYTHIA8, which selected events with low central activity in ATLAS, LHCf can select very pure (99%) events produced by diffractive dissociation processes. The identification of the origin of the forward particles will help future developments of hadronic-interaction models.

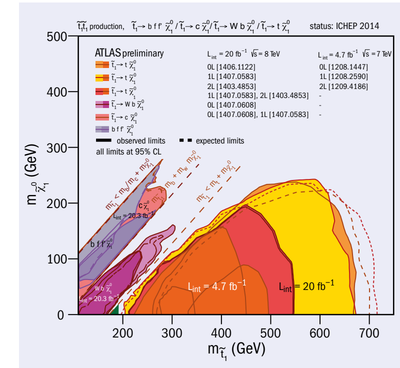
Narrowing down the 'stealth stop' gap with ATLAS

In late 2011, ATLAS launched a dedicated programme targeting searches for the supersymmetric partner of the top quark – the scalar top, or "stop" – which could be pair-produced in high-energy proton–proton collisions. If not much heavier than the top quark, this new particle is expected to play a key role in explaining why the Higgs boson is light.

While earlier supersymmetry (SUSY) searches at the LHC have already set stringent exclusion limits on strongly produced SUSY particles, these generic searches were not very sensitive to the stop. If it exists, the stop could decay in a number of ways, depending on its mass and other SUSY parameters. Most of the searches at the LHC assume that the stop decays to the lightest SUSY particle (LSP) and one or more Standard Model particles. The LSP is typically assumed to be stable and only weakly interacting, making it a viable candidate for dark matter. Events with stop-pair production would therefore feature large missing transverse momentum as the two resulting LSPs escape the detector.

The first set of results from the searches by ATLAS were presented at the International Conference on High-Energy Physics (ICHEP) in 2012. A stop with mass between around 225 and 500 GeV for a nearly massless LSP was excluded for the simplest decay mode. Exclusion limits were also set for more complex stop decays.

These searches revealed a sensitivity gap when the stop is about as heavy as the top quark – a scenario that is particularly interesting and well motivated theoretically. Such a "stealth stop" hides its presence in the data, because it resembles the top quark, which is pair-produced roughly six times more abundantly.



Summary of ATLAS exclusion limits for various modes of scalar-top decay. The green triangle illustrates the limit derived from the top–antitop cross-section and spin-correlation measurements.

Use of the full LHC Run-1 data set, together with the development of novel analysis techniques, has pushed the stop exclusion in all directions. The figure shows the ATLAS limits as of the ICHEP 2014 conference, in the plane of LSP mass versus stop mass for each of the following stop decays: to an on-shell top quark and the LSP (right-most area); to an off-shell top quark and the LSP (middle area); to a bottom quark, off-shell W boson, and the LSP (left-most grey area); or to a charm quark and the LSP (left-most pink area). The exclusion is achieved by the complementarity of four targeted searches (ATLAS Collaboration 2014a–2014d). The results eliminate a stop of mass between approximately 100 and 700 GeV (lower masses were excluded by data from the Large Electron–Positron collider) for a light LSP. Gaps in the excluded region for intermediate stop masses are reduced but persist, including the prominent region corresponding to the stealth stop.

Standard Model top-quark measurements can be exploited to get a different handle on the potential presence of a stealth stop. The latest ATLAS high-precision top–antitop cross-section measurement (*CERN Courier* September 2014 p7), together with a state-of-the-art theoretical prediction, has allowed ATLAS to exclude a stealth stop between the mass of the top quark and 177 GeV, for a stop decaying to a top quark and the LSP.

The measurement of the top–antitop spin correlation adds extra sensitivity because the stop and the top quark differ by half a unit in spin. The latest ATLAS measurement (ATLAS Collaboration 2014e) uses the distribution of the azimuthal angle between the two leptons from the top decays, together with cross-section information, to extend the limit for the stealth stop up to 191 GeV.

The rigorous search programme undertaken by ATLAS has ruled out large parts of interesting regions of the stop model and closed in on a stealth stop. It leaves the door open for discovery of a stop beyond the current mass reach, or in remaining sensitivity gaps, at the higher-energy and higher-luminosity LHC Run 2.

Further reading

ATLAS Collaboration 2014a *JHEP* **09** 015.
ATLAS Collaboration 2014b *JHEP* **11** 118.
ATLAS Collaboration 2014c *JHEP* **06** 124.
ATLAS Collaboration 2014d *Phys. Rev. D* **90** 052008.
ATLAS Collaboration 2014e arXiv:1412.4742, submitted to *Phys. Rev. Lett.*

CMS measures the 'underlying event' in pp collisions

Ever since the earliest experiments with hadron beams, and subsequently during the era of the hadron colliders heralded by CERN's Intersecting Storage Rings, it has been clear that hadron collisions are highly complicated processes. Indeed, initially it was far from obvious whether it would be possible to do any detailed studies of elementary particle physics with hadron collisions at all.

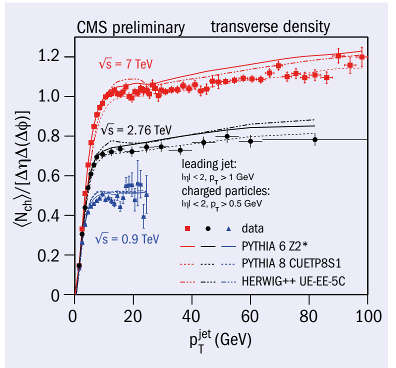
The question was whether the physics of "interesting" particle production could be distinguished from that of the "background" contribution in hadron collisions. While the former is typically a single parton–parton scattering process at very high transverse momentum (p_T), the latter consists of the remnants of the two protons that did not participate in the hard scatter, including the products of any additional soft, multiple-parton interactions. Present in every proton–proton (pp) collision, this soft-physics component is referred to as the "underlying event", and its understanding is a crucial factor in increasing the precision of physics measurements at high p_T. Now, the CMS collaboration has released its latest analysis of the underlying event data at 2.76 TeV at the LHC.

The measurement builds on experimental techniques that have been developed at ▷

Fermilab's Tevatron and previously at the LHC to perform measurements that are sensitive to the physics of the underlying event. The main idea is to measure particle production in the region of phase space orthogonal to the high-p_T process – that is, in the transverse plane. In its latest analysis of the underlying event data at 2.76 TeV, CMS has measured both the average charged-particle multiplicity as well as the p_T sum for the charged particles. The scale of the hard parton–parton scattering is defined by the p_T of the most energetic jet of the event.

The measurements are expected to result in more accurate simulations of pp collisions at the LHC. Because the properties of the underlying event cannot be derived from first principles in QCD, Monte Carlo generators employ phenomenological models with several free parameters that need to be "tuned" to reproduce experimental measurements such as the current one from CMS.

An important part of the studies concerns the evolution of the underlying-event properties with collision energy. CMS has therefore presented measurements at centre-of-mass energies of 0.9, 2.76 and 7 TeV. Soon, there will be new data from Run 2 at the LHC. The centre-of-mass energy of 13 TeV will necessitate further measurements, and provide an opportunity to probe the ever-present underlying event in uncharted territory.



Comparison of underlying-event activity in the transverse region at different centre-of-mass energies in CMS, with the average charged-particle multiplicity plotted as a function of p_T of the leading charged-particle jet.

● **Further reading**

CMS Collaboration 2014 CMS-PAS-FSQ-12-025.

LHCb observes two new strange-beauty baryons

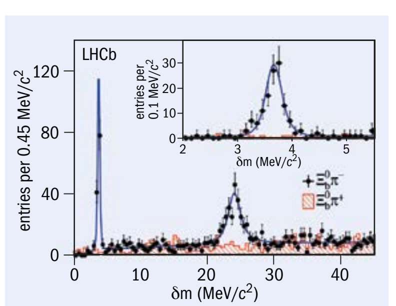
The LHCb collaboration has discovered two new particles, the $\Xi_b'^-$ and Ξ_b^{*-}. Predicted to exist by the quark model, they are both baryons containing three quarks, in this case, b, s and d. The new particles – which thanks to the heavyweight b quarks are more than six times as massive as the proton – join the Ξ_b^-, found several years ago by the D0 and CDF experiments at Fermilab (*CERN Courier* July/August 2007 p6).

The three particles are differentiated by the spin, j, of the sd diquark, and the overall spin-parity, J^P, of the baryon, and in turn the relative spins of the quarks affect the masses of the particles. With $j=0$ and $J^P=½^+$, the Ξ_b^- is the lightest, and so decays relatively slowly through the weak interaction, leading to its discovery at Fermilab's Tevatron. The $\Xi_b'^-$ and Ξ_b^{*-} have $j=1$, and $J^P=½^+$ and $J^P=3/2^+$, respectively, and should decay either strongly or electromagnetically, depending on their masses.

LHCb analysed proton–proton collision data from the LHC corresponding to an integrated luminosity of 3.0 fb^{-1}, to observe the new particles through their decay to $\Xi_b^0\pi^-$. A third of the data were collected at a centre-of-mass energy of 7 TeV, the remainder at 8 TeV. Signal candidates were reconstructed in the final state $\Xi_b^0\pi^-$, where the Ξ_b^0 was identified through its decay $\Xi_b^0\to\Xi_c^+\pi^-$, $\Xi_c^+\to pK^-\pi^+$.

The figure shows the distribution of δm, defined as the invariant mass of the $\Xi_b^0\pi^-$ pair minus the sum of the π^- mass and the measured Ξ_b^0 mass. This definition means that the lightest possible mass for the $\Xi_b^0\pi^-$ pair – the threshold for the decay – is at $\delta m=0$. The two peaks are clear observation of the $\Xi_b'^-$ (left) and Ξ_b^{*-} (right) baryons above the hatched-red histogram representing the expected background. The Ξ_b^{*-} is clearly the more unstable of the two, because its peak is wider. This is consistent with the pattern of masses: the $\Xi_b'^-$ mass is just slightly above the energy threshold, so it can decay to $\Xi_b^0\pi^-$, but only just – its width is consistent with zero, with an upper limit of $\Gamma(\Xi_b'^-)<0.08$ MeV at 95% confidence level.

The results show the extraordinary precision of which LHCb is capable: the mass difference between the $\Xi_b'^-$ and the Ξ_b^0 is measured with an uncertainty of about 0.02 MeV/c^2, less than four-millionths of the Ξ_b^0 mass. By observing these particles and measuring their properties with such accuracy, LHCb is making a stringent test of models of nonperturbative QCD. Theorists will be able to use these measurements as an anchor point for future predictions.



Distribution of the mass difference, δm, for $\Xi_b^0\pi^-$ candidates. The points with error bars show right-sign candidates in the signal region for the Ξ_b^0 mass, and the hatched histogram shows wrong-sign candidates with the same selection. The curve shows the nominal fit to the right-sign candidates. Inset: detail of the region 2.0–5.5 MeV/c^2.

● **Further reading**

LHCb Collaboration 2014 arXiv:1411.4849 [hep-ex].

Profiling jets with ALICE

"Jets are collimated sprays of particles." This ubiquitous characterization used in many articles in the field of jet physics has once again been confirmed by the ALICE collaboration, in a measurement of the production cross-sections, fragmentation and spatial structure of charged jets reconstructed from charged particle tracks.

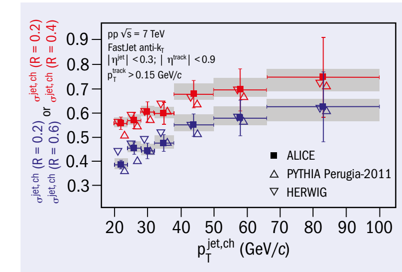
Jets observed in collisions of LHC beams emerge from the violent scattering of quarks and gluons. The highly energetic scattered partons develop a parton shower via sequential gluon splittings, which fragments into the measured hadrons – the constituents of the jet. In heavy-ion collisions, jets are an important diagnostic tool for studying quark–gluon plasma (QGP) at the LHC, where effects arising from the interaction of the scattered partons with the dense produced medium are expected. Indeed, a strong suppression of jet production in lead–lead collisions is observed, along with a modification of the jet-fragment distributions.

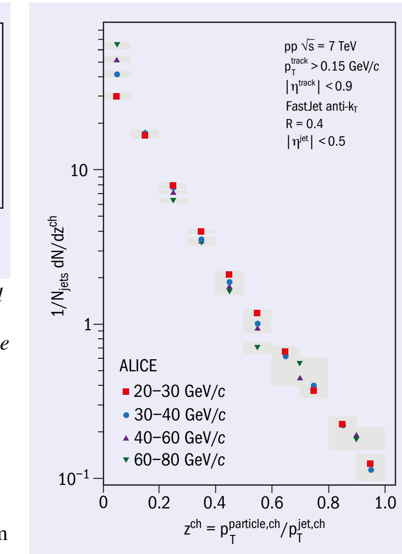
The interpretation of these effects requires detailed reference measurements of the jet structure and fragmentation in proton–proton collisions, where no medium is formed. In ALICE, charged jets are reconstructed in the central barrel from tracks measured with the inner tracking system and the time-projection chamber. Full jets contain neutral as well as charged particles measured with the ALICE electromagnetic calorimeter (*CERN Courier* May 2013 p8), but for this recent study the analysis did not include neutral particles in the jet reconstruction. Jets with transverse momenta (p_T) from 20 to 100 GeV/c can be measured and analysed particle by particle. With the detector's excellent low-momentum tracking capabilities, ALICE is unique in being able to measure constituents down to a p_T of 150 MeV/c. Measurements at low jet and constituent p_T are crucial for heavy-ion collisions, where gluon radiation induced by the medium is expected to enhance the yield of soft jet particles.

The left-hand part of the figure shows the ratios of cross-sections for jets measured with different choices of the resolution parameter, R. Using a distance measure that combines azimuthal angle and pseudo-rapidity differences as $\Delta r^2=\Delta\phi^2+\Delta\eta^2$, the jet p_T for a given R is the summed p_T of the jet constituents accumulated in a cone of size R. The ratio is a measure of the jet structure, i.e. the angular distribution of jet constituents, and the observed increase of R with jet p_T indicates stronger collimation for more energetic jets. The ALICE measurements show that 80% of the energy of the reconstructed jet is typically found within 15° of the jet axis.

The right-hand part of the figure shows the jet-fragmentation distribution of constituent p_T in the reduced transverse-momentum variable $z^{ch}=p_T^{particle,ch}/p_T^{jet,ch}$, which measures the fraction of the total charged-jet p_T carried by a given jet constituent. For $z^{ch}>0.1$, the distributions for different charged-jet p_T are consistent with each other. This scaling is broken for the lowest z^{ch}, owing to the increase of the multiplicity of soft jet constituents with higher jet p_T.

The measurement of jet properties in proton–proton collisions is the first step towards studies of the "quenched" jets in the more complex environment of heavy-ion collisions. They provide a reference for future measurements of the modification of jet fragmentation and structure in heavy-ion collisions, including studies of identified hadrons in jets using the unique particle identification capabilities of ALICE at the LHC.





Top: Ratios of jet cross-sections for charged jets reconstructed with resolution parameters 0.2 and 0.4, and 0.2 and 0.6. The ratios in data are compared with event-generator simulations. Right: Scaled p_T spectra of charged particles in jets for different bins of jet transverse momentum.

● **Further reading**

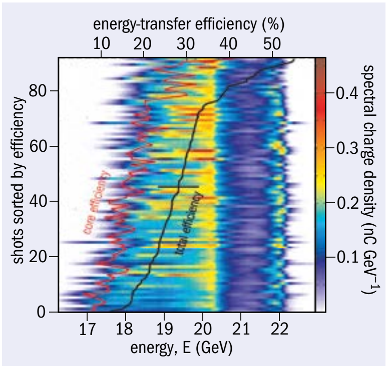
ALICE Collaboration 2014 arXiv:1411.4969 [nucl-ex].

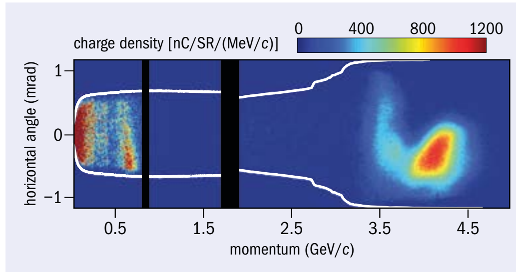
Advanced accelerators

Two teams take big steps forward in plasma acceleration

The high electric-field gradients that can be set up in plasma have offered the promise of compact particle accelerators since the late 1970s. The basic idea is to use the space-charge separation that arises in the wake of either an intense laser pulse or a pulse of ultra-relativistic charged particles (*CERN Courier* June 2007 p28). Towards the end of 2014, groups working on both approaches reached important milestones. One team, working at the Facility for Advanced Accelerator Experimental Tests (FACET) at SLAC, demonstrated plasma-wakefield acceleration with both a high gradient and a high energy-transfer efficiency – a crucial combination not previously achieved. At Lawrence Berkeley National Laboratory, a team working at the Berkeley Lab Laser Accelerator (BELLA) facility boosted electrons to the highest energies ever recorded for the laser-wakefield technique.

Several years ago, a team at SLAC successfully accelerated electrons in the tail of a long electron bunch from 42 GeV to 85 GeV in less than 1 m of plasma (*CERN Courier* April 2007 p5). In that experiment, ▷





Left: Energy-spectrum of a 4.2 GeV electron beam accelerated in the laser-wakefield experiment at BELLA.

Left: Beam spectra from 92 shots, sorted by the total energy-transfer efficiency (black line), in the plasma-wakefield experiment at FACET. The red line shows the core energy-transfer efficiency.

the particles leading the bunch created the wakefield to accelerate those in the tail, and the total charge accelerated was small. Since then, FACET has come on line. Using the first 2 km of the SLAC linac to deliver an electron beam of 20 GeV, the facility is designed to produce pairs of high-current bunches with a small enough separation to allow the trailing bunch to be accelerated in the plasma wakefield of the drive bunch (*CERN Courier* March 2011 p23).

Using the pairs of bunches at FACET, some of the earlier team members together with new colleagues have carried out an experiment in the so-called "blow-out" regime of plasma-wakefield acceleration, where maximum energy gains at maximum efficiencies are to be found. The team succeeded in accelerating some 74 pC of charge in the core of the trailing bunch of electrons to about 1.6 GeV per particle in a gradient of about 4.4 GeV/m (Litos *et al.* 2014). The final energy spread for the core particles was as low as 0.7%, and the maximum efficiency of energy transfer from the wake to the trailing bunch was in excess of 30%.

Meanwhile, a team at Berkeley has been successfully pursuing laser-wakefield acceleration for more than a decade (*CERN Courier* November 2004 p5). This research was boosted when the specially conceived BELLA facility recently came on line with its petawatt laser (*CERN Courier* October 2012 p10). In work published in December, the team at BELLA used laser pulses at 0.3 PW peak power to create a plasma channel in a 9-cm-long capillary discharge waveguide and accelerate electrons to the record energy of 4.2 GeV (Leemans *et al.* 2014). Importantly, the 16 J of laser energy used was significantly lower than in previous experiments – a result of using the preformed plasma waveguide set up by pulsing an electrical discharge through hydrogen in a capillary. The combination of increased electron-beam energy and lower laser energy bodes well for the group's aim to reach the target of 10 GeV.

Further reading

W P Leemans *et al.* 2014 *Phys. Rev. Lett.* **113** 245002.
M Litos *et al.* 2014 *Nature* **515** 93.

HEAVY IONS

Nuclei come under the microscope in California

It has long been known that, when they are put under a sufficiently energetic microscope, nuclei reveal a complicated structure – the more energetic the probe, the more complex the structure. In recent years, continuing studies of deuteron–nucleus (dA) and proton–nucleus (pA) collisions have demonstrated that many features first observed in heavy-ion (AA) collisions are also present in these lighter collisions, and some of these features have even been seen in high-multiplicity pp collisions. Such factors have generated the present intense interest in nuclear structure that was evident when more than 120 physicists gathered in California's Napa Valley on 3–7 December, to discuss the initial state in these collisions during the 2nd International Conference on Initial Stages in High-Energy Nuclear Collisions (IS2014).

In particular, pA collisions at the LHC have demonstrated the existence of anisotropic particle production. The angular distributions look very similar to those observed in AA collisions, where the anisotropy has been attributed to hydrodynamic flow. The material produced in these collisions appears to flow like a low-viscosity fluid, and the final-state anisotropy mimics that present in the initial elliptic-shaped collision region. Recent studies at Brookhaven's Relativisitic Heavy-Ion Collider (RHIC) as well as at the LHC have shown that, in addition to the American-football-shaped collision region, there are also event-to-event anisotropies caused by the different random positions of nucleons within the nucleus. Much of the observed anisotropy might be explained by models based on hydrodynamic flow. One focus of IS2014 was the question of how hydrodynamic flow can arise in smaller nuclear systems, particularly pA collisions. One new approach to this question is being pursued at RHIC, in which ^{3}He collided with gold last year (*CERN Courier* December 2014 p19), to see how the triangular initial state manifests itself in the collision products (figure 2).

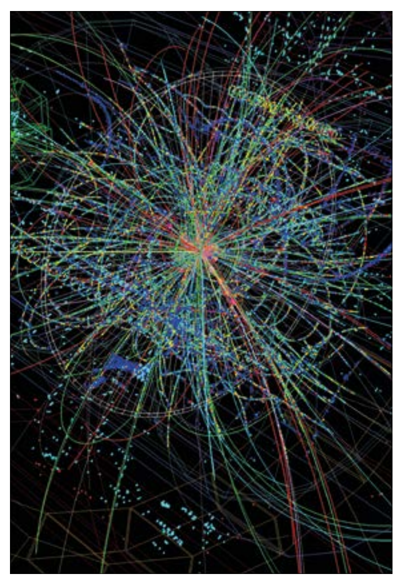


Fig. 1. A pPb collision seen in the ALICE detector. Such collisions look similar to those seen in PbPb reactions.

Some of these phenomena also appear in high-multiplicity pp collisions. One example is "the ridge" observed as two-particle correlations between particles with similar azimuthal angles, but separated by large rapidities (*CERN Courier* June 2014 p10). In contrast, one other expected consequence of the quark–gluon plasma – jet quenching – appears to be present only in AA collisions, for the most part.

The meeting also covered recent theoretical developments. As the centre-of-mass energies increase, collisions probe partons with smaller and smaller momentum fractions (Bjorken-x values). And as the x-values decrease, the parton density increases, and at low enough x values, saturation must set in. This happens when gluons begin to recombine as well as to split. Although saturation is expected on general principles, the details remain the subject of spirited theoretical discussion. One key question addressed in Napa was the search for the colour-glass condensate (CGC), a hypothetical state of matter where the gluons produce coherent fields. These CGCs lead to new nuclear phenomena.

The meeting included presentations on a variety of experimental techniques. The RHIC and LHC collaborations all made presentations highlighting their data and plans for AA, pA and pp collisions. In addition to hadronic collisions, one session was devoted to ultra-peripheral collisions, where two colliding nuclei interact electromagnetically. Here, reactions such as photonuclear production of vector mesons are sensitive to details of the nuclear initial state.

The congenial atmosphere led to many fruitful discussions, and a third conference is planned in Lisbon in 2016.

● For more about IS2014, visit http://is2014.lbl.gov.

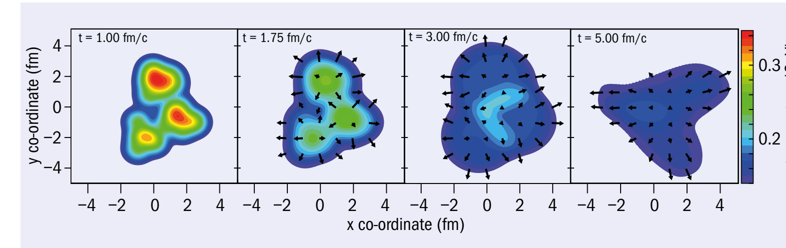


*Fig. 2. An example of a calculation of the time evolution of a ^{3}He + Au event from the initial to final state. The colour scale indicates the local temperature. The arrows are proportional to the velocity of the fluid cell from which the arrow originates. (Image credit: J L Nagle et al. 2014 Phys. Rev. Lett. **113** 112301.*

Sciencewatch

Compiled by John Swain, Northeastern University

How light can make birds blue

Many birds have brilliant blue colouring owing not to pigments, but to the light scattering from tiny structures in their feathers and then interfering. However, this has never been found to produce reds, oranges or yellows. To find out more, Sofia Magkiriadou of Harvard University and colleagues simulated the process in feathers by using randomly packed plastic beads of varying sizes. They found that for small beads, the scattering was dominated by wavelengths corresponding to the inter-bead spacing. For the smaller beads this was blue, but for larger beads the expected red was dominated by an additional peak at shorter wavelengths produced by scattering from the backs of the beads. This meant that, once again, the result was blue, therefore explaining why the longer-wavelength colours are not produced this way in nature. However, it also suggests how red materials could be designed using hollow beads to suppress the back-scattering.

Birds, such as this indigo bunting, appear bright blue as a result of light scattering in the structure of their feathers, but reds cannot be produced the same way in nature. (Image credit: Wikimedia Commons/Dawn Scranton.)

Further reading

S Magkiriadou *et al.* 2014 *Phys. Rev. E* **90** 062302.

The origins of drinking alcohol?

Human ancestors were able to metabolize ethanol 10 million years ago. Matthew Carrigan of Santa Fe College in Gainesville, Florida, and co-workers tracked the gene coding for digestive alcohol dehydrogenase class IV (ADH4) – an enzyme that processes ethanol – in 28 mammals, including 17 primates over more than 70 million years of evolution. They found that ADH4 from the ancestors of humans, chimpanzees and gorillas 10 million years ago was far more efficient than that of more ancient ancestors. The timing corresponds to when our ancestors came down from trees, suggesting that this might have occurred to help hominids adapt to life on the ground, where there would be more fermented fruit than in the trees.

Further reading

M A Carrigan *et al.* 2014 *Proc. Natl. Acad. Sci.* doi: 10.1073/pnas.1404167111.

Chirality from non-chirality

A major puzzle in the origin of life is how chiral biomolecules occur in one-handedness. René Steendam of Radboud University in Nijmegen and colleagues started with achiral reactants and, for the first time, produced a chiral amine that is similar to an amino acid and is enantiopure – i.e. has single-handedness. The mechanism involves chiral-product molecules acting as catalysts for their own production and a process known as Viedma ripening. Together, these amplify any small fluctuation in net chirality so that it takes control of the reaction and leads to a 100% pure chiral product. In addition to shedding light on the possible origin of biomolecular chirality, it also suggests new routes to the totally asymmetric syntheses of important molecules such as drugs.

Further reading

R R E Steendam *et al.* 2014 *Nature Comm.* **5** 5543.

Touching the void

A hologram is a 3D image, but now there is an equivalent that you can also feel. Benjamin Long and colleagues at the University of Bristol used a 2D phased array of ultrasound transducers to produce the sensation of touch on the skin via an acoustic radiation force. Together with a 3D visual display, the net result is a touchable hologram. Obvious applications include allowing doctors to feel imaged diseased tissue or a tumour without cutting or even touching a patient, allowing people to "touch" fragile or distant objects, and enabling touchable controls floating in space.

Further reading

B Long *et al.* 2014 *ACM Transactions on Graphics* **33** 181, doi: 10.1145/2661229.2661257.

For a video about the effect, visit www.youtube.com/watch?v=kaO5cY1aHk.

Above: Ultrasound is focused to create the shape of a virtual sphere. (Image credit: Bristol Interaction and Graphics group, University of Bristol.)

Are men stupid?

The Darwin Awards are given to people who have done idiotic things that have led to their demise and elimination from the gene pool. Now, a study of the data from 1995–2014 by Ben Lendrem, a student at the King Edward VI School in Morpeth in the UK, has revealed a disturbing trend. Of the 413 award nominations, 332 were independently verified and confirmed. Of these, 282 went to men and 36 to women. Men are, therefore, significantly more likely than women to receive the dubious award ($P < 0.0001$). Any final conclusions are left to the reader.

Further reading

B A D Lendrem *et al.* 2014 *BMJ* 2014;349:g7094.

Ultrafast imaging

A new ultrafast camera can take 100 thousand million frames a second. Liang Gao and colleagues at Washington University in St Louis used the image geometry and optics of a streak camera together with compressed sensing to reach this new record. With no need for specialized illumination – it is "receive-only" – it can imagine fluorescent or bioluminescent objects. The technique, called compressed ultrafast photography, has been demonstrated for laser-pulse reflection and refraction, photon racing in two media, and apparently (with no transfer of information) faster-than-light phenomena.

Further reading

L Gao *et al.* 2014 *Nature* **516** 74.

Astrowatch

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

Gamma-ray bursts are a real threat to life

A new study confirms the potential hazard of nearby gamma-ray bursts (GRBs), and quantifies the probability of an event on Earth and more generally in the Milky Way and other galaxies. The authors find a 50% chance that a nearby GRB powerful enough to cause a major life extinction on the planet took place during the past 500 million years (Myr). They further estimate that GRBs prevent complex life like that on Earth in 90% of the galaxies.

GRBs occur about once a day from random directions in the sky. Their origin remained a mystery until about a decade ago, when it became clear that at least some long GRBs are associated with supernova explosions (*CERN Courier* September 2003 p15). When nuclear fuel is exhausted at the centre of a massive star, thermal pressure can no longer sustain gravity and the core collapses on itself. If this process leads to the formation of a rapidly spinning black hole, accreted matter can be funnelled into a pair of powerful relativistic jets that drill their way through the outer layers of the dying star. If such a jet is pointing towards Earth, its high-energy emission appears as a GRB.

The luminosity of long GRBs – the most powerful ones – is so intense that they are observed throughout the universe (*CERN Courier* April 2009 p12). If one were to happen nearby, the intense flash of gamma rays illuminating the Earth for tens of seconds could severely damage the thin ozone layer that absorbs ultraviolet radiation from the

Artist's rendering of a GRB, where life-damaging gamma rays are produced by two relativistic jets powered by a new-born black hole at the heart of an exploding massive star. (Image credit: ESO/A Roquette.)

Sun. Calculations suggest that a fluence of 100 kJ/m^2 would create a depletion of 91% of this life-protecting layer on a timescale of a month, via a chain of chemical reactions in the atmosphere. This would be enough to cause a massive life-extinction event. Some scientists have proposed that a GRB could have been at the origin of the Ordovician extinction some 450 Myr ago, which wiped out 80% of the species on Earth.

With increasing statistics on GRBs, a new study now confirms a 50% likelihood of a devastating GRB event on Earth in the past 500 Myr. The authors, Tsvi Piran from the Hebrew University of Jerusalem and Raul Jimenez from the University of Barcelona in Spain, further show that the risk of life extinction on extra-solar planets increases towards the denser central regions of the Milky Way. Their estimate is based on the rate of GRBs of different luminosity and the properties of their host galaxies. Indeed, the authors found previously that GRBs are more frequent in low-mass galaxies such as the Small Magellanic Cloud with a small fraction of elements heavier than hydrogen and helium. This reduces the GRB hazard in the Milky Way by a factor of 10 compared with the overall rate.

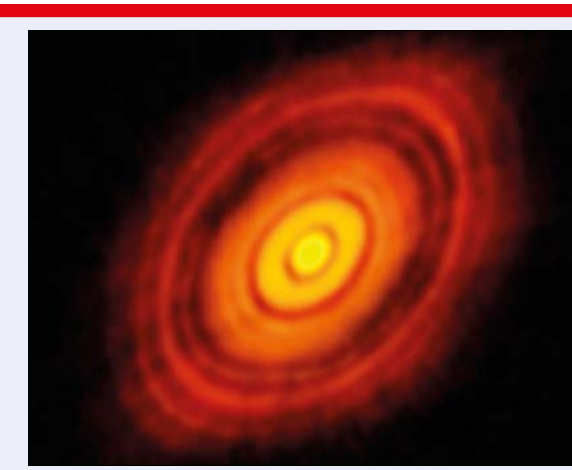
The Milky Way would therefore be among only 10% of all galaxies in the universe – the larger ones – that can sustain complex life in the long-term. The two theoretical astrophysicists also claim that GRBs prevent evolved life as it exists on Earth in almost every galaxy that formed earlier than about five-thousand-million years after the Big Bang (at a redshift $z > 0.5$). Despite obvious, necessary approximations in the analysis, these results show the severe limitations set by GRBs on the location and cosmic epoch when complex life like that on Earth could arise and evolve across thousands of millions of years. This could help explain Enrico Fermi's paradox on the absence of evidence for an extraterrestrial civilization.

Further reading

T Piran and R Jimenez 2014 *Phys. Rev. Lett.* **113** 231102.

Picture of the month

This image from the Atacama Large Millimeter/submillimeter Array (ALMA), located high in the Chilean Andes, reveals an unprecedented view of a planet-forming disc around a young star. The major systems of ALMA, which consists of 54 antennas with 12-m dishes and 12 smaller 7-m dishes, were completed in early 2013 (*CERN Courier* May 2013 p43). This first-released image from ALMA with the antennas in the near-final configuration is the sharpest picture ever made at submillimetre wavelengths, and even exceeds the resolution achieved with the Hubble Space Telescope (Picture of the month, *CERN Courier* November 2011 p13). By showing concentric bright rings separated by gaps around the star HL Tauri, the image suggests that ALMA is witnessing the formation of planet-like bodies in this stellar disc, about 450 light-years away. Seeing such features in a star that is only one-million years old has astounded ALMA's scientists, and could revolutionize theories of planetary formation. (Image credit: ALMA (ESO/NAOJ/NRAO).)



CERN Courier Archive: 1972

A look back to CERN Courier vol. 12, January 1972, compiled by Peggie Rimmer

CERN

New home for apprentices

On 9 December, a ceremony was held to inaugurate the CERN "Centre d'Apprentissage", with people from CERN's Training and Education Section, the apprentices and their supervisors, and representatives of the Geneva authorities concerned with apprentice training.

Following an initiative of the Geneva "Département du Commerce et de l'Industrie", in 1966 a small number of young people began apprentice training at CERN. A revision of the training programmes was carried out last year, which led to the creation of the centre, a specially converted barrack fitted with equipment providing a range of practical facilities.

Apprentices can now spend their first 18 months at CERN following common programmes at the centre to supplement the theoretical work: in workshop practice, technical design and electrical and electronics systems. Laboratory assistants then do another year and a half covering topics such as surface treatment, glass blowing, vacuum techniques, etc, as well as gaining experience of working in a physics group. Those training in mechanics and electronics do another two and a half years of practical work.

Inside the new "Centre d'Apprentissage". (Image credit: CERN.)

At the end of the training, the apprentices take examinations for certificates that enable them to move into industry or laboratories in member states, or to apply for a position at CERN after several years experience elsewhere. Though on a modest scale, the apprentice scheme is one way of using the wide range of expertise at CERN in training young people of the region.

● Compiled from text on p8.

Around the labs

On the move

CERN: Left, one of the Big European Bubble Chamber (BEBC) protection resistors installed in the power-supply circuit of the magnet to dissipate the energy stored in the superconducting magnet of the bubble chamber (up to 750 MJ), should any fault send the superconductor "normal".

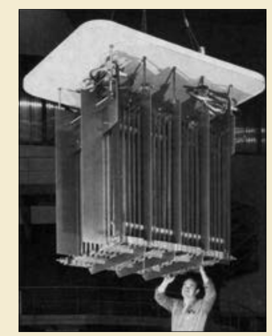
● From p11.

TRIUMF: Middle, the huge lid of the vacuum tank of the TRIUMF cyclotron (being built on the campus of British Columbia University, Vancouver, Canada) being turned for its final cleaning. The triangular projections are supports on which the lid rests on the floor. The pips, liberally sprinkled over the surface, take the tie rods coming from the support structure to prevent the vacuum tank collapsing under atmospheric pressure (a load of about 2700 tonnes) when it is pumped out.

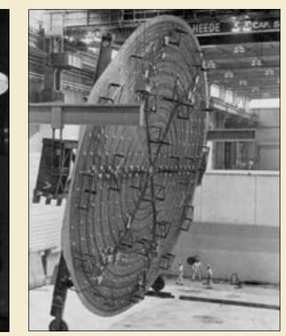
● From p14.

Batavia: Right, one of the last panels of the geodesic dome topping the bubble-chamber control building at NAL swinging into place. As reported previously, these panels are constructed from discarded beverage cans bonded between layers of strong plastic, following an idea by a NAL materials specialist. About 120,000 cans are built into the completed roof.

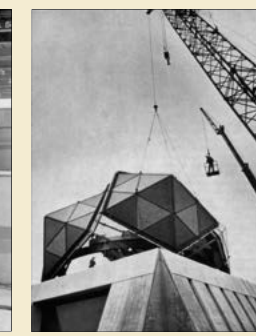
● From p41.



(Image credit: CERN.)

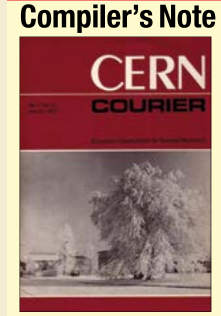


(Image credit: TRIUMF.)



(Image credit: USAEC.)

Compiler's Note



Still on a modest scale, CERN trains six technical and two administrative apprentices each year, following codes of practice applicable in Geneva. However, young people far and wide benefit directly or indirectly from the rich variety of educational programmes offered by the laboratory.

At any one time, there can be hundreds of member-state and non-member-state students on site: doctoral students stay for 6–36 months, technical and administrative students for 4–12 months, while summer students and CERN openlab students are around for a few weeks during the long vacation.

As for physics teachers, there are three-day and three-week programmes in English, plus week-long programmes in the mother tongue of the participants, currently in more than 25 languages – first languages for about a quarter of the world's population. CERN provides all scientific, administrative and technical support, national language facilitators, lecturers and guides. The lecture materials and archived video recordings constitute a unique resource for teaching physics in schools around the globe.

Tribute

Emilio Picasso's contagious enthusiasm for physics

During a scientific career that spanned six decades, Emilio Picasso, who passed away last October, played some key roles, especially at CERN, where he was widely appreciated.

This photo from CERN Courier *August 1966 shows the first muon storage ring built at CERN and the team carrying out the g-2 experiment on the anomalous magnetic moment of the muon. Left to right: S van der Meer, F J M Farley, M Giesch, R Brown, J Bailey, E Picasso and H Jöstlein. (Image credit: CERN/PI 284.6.66.)*

Never has such an illustrious career at CERN hung from so slender a thread of improbability. He was in Genoa, I was in Geneva. Were we destined to meet? In Bristol? As a result of some tiny chance?

His final day of a one-year sabbatical. My first day of a visit. All alone on his last evening, Emilio wanted to say goodbye to Bristol and went to a bar. Out of hundreds of options, I ended up in the same bar...and got a warm welcome. I described the new g-2 experiment, which was just starting to roll: the first ever muon storage ring at 1.2 GeV to dilate the muon lifetime to 27 μs and see more precession cycles. Simon van der Meer was on board but no one else. Emilio loved fundamental physics, and there and then he offered to join the project, visiting CERN from Genoa and later becoming a full-time member of staff. Little did I know that I would be making speeches and writing articles in his honour: Chevalier of Legion of Honour of France and Knight Grand Cross of the Order of Merit of the Republic of Italy.

Francis J M Farley

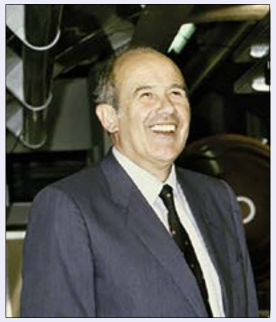
Emilio read physics at the University of Genoa, where he stayed after receiving his doctorate in July 1956. Within a small team, he worked mainly on technical aspects of visual particle detectors, first with gas bubble chambers – based on using a supersaturated solution of gas in a liquid at room temperature – and diffusion chambers. By the early 1960s, he had moved on with some of his collaborators to study proton and meson interactions in nuclear emulsions, and participated in the International Co-operative Emulsion Flights, which took two large stacks of emulsion plates high into the atmosphere to detect the interactions of energetic cosmic rays. This international collaborative effort included the Bristol group of Cecil Powell, recipient of the 1950 Nobel Prize in Physics for his work on emulsions and their use in the discovery of the particle now known as the pion in cosmic rays.

So it was not surprising that Emilio arrived in Bristol as a NATO postdoctoral fellow in 1962/1963. There, his chance meeting with Farley in Bristol in 1963 set him on course to CERN. When he offered to join the g-2 experiment, Farley accepted with pleasure, and soon Emilio started travelling to Geneva from Genoa, becoming a research associate at CERN in 1964. From the beginning he insisted on understanding everything in depth. He wrote Fortran programs, checked the calculations and found some mistakes, which luckily for the future of the experiment were not lethal.

Emilio's enthusiasm was contagious, and he and Farley gradually assembled a small team. Farley recalls: "There were many difficulties, but eventually it worked and we measured the anomalous moment of the muon to 270 ppm. The result disagreed with theory by 1.7σ but we were sure of our number (confirmed by the next experiment) and we published anyway. (The fashionable shibboleth is that you need 5σ for an effect; true if you are looking for a bump in a wiggly graph, which might be anywhere. But for one number 2–3σ is important and anything over 3σ is huge – see p37 this issue). The discrepancy was enough to worry the theorists, who set to work and discovered a new correction. Then they agreed with us. This was a triumph for the experiment."

In 1967 Farley moved to a job in England and Emilio became ▷

Emilio Picasso 1927–2014



Emilio Picasso in 1983. (Image credit: CERN-PHOTO-8309793-1.)

After a long illness, Emilio Picasso passed away on 12 October. One of the earliest and most outstanding staff members of CERN, he made remarkable contributions to the prodigious success of the organization for more than 50 years.

Born in Genoa on 9 July 1927, Emilio first studied mathematics, followed by two years of physics. After his doctorate he became assistant professor for experimental physics at the University of Genoa, and began research in atomic physics before changing to particle physics.

Short stays with the betatron at Torino and with the electron synchrotron at Frascati provided him with his first experiences with particle accelerators. He then went to Bristol in the years 1962/1963, where he joined the group of Cecil Powell, who had received the Nobel prize in 1950 for investigating cosmic radiation using photographic emulsions and discovering the π meson. There Emilio met Francis Farley who told him that he intended to measure at CERN the anomalous magnetic moment of muons circulating in a storage ring. After some drinks they became friends, and Emilio decided to join Farley on the CERN experiment.

The measurement of the anomalous magnetic moment – or more precisely the deviation of its value from the Bohr magneton, expressed as "g-2" – yields an extremely important quantity for testing quantum electrodynamics (QED). Emilio was attracted by this experiment because it matched two different aspects of his thinking. He was fascinated by fundamental questions, and at the same time the experiment required new technologies for magnets.

From 1963, Emilio commuted between Genoa and CERN, becoming a research associate in 1964 to work on the g-2 experiment and a CERN staff member in 1966. In addition to Farley, John Bailey and Simon van der Meer joined the group, which Emilio was later to lead. The measurements went on for 15 years at two successive storage rings (the second with Guido Petrucci and Frank Krienen), and achieved an incredible accuracy of 7 ppm, so becoming one of the most famous precision tests of QED.

In 1978, Luigi Radicati convinced Emilio to participate in an experiment to look for gravitational waves produced by particles circulating in a storage ring. Superconducting RF cavities were to be used as detectors. The attempt was unsuccessful, but it gave Emilio the opportunity to get to know the technology of superconducting cavities – knowledge that was to serve him extremely well later at the Large Electron–Positron collider (LEP).

In 1981, the LEP project was approved by CERN Council, alas under very difficult conditions, i.e. with a reduced and constant budget. In addition, the requisite personnel had to be found among the staff of the newly unified CERN I and CERN II laboratories. Under such conditions it was not easy to find the right person to lead the LEP project. Several outstanding accelerator experts were available at CERN, and it would have been an obvious step to appoint one of them as project leader. However, because it became necessary to reassign about a third of the CERN staff to new tasks – implying that personal relations established across many years had to be broken – I considered the human problems as dominant. Hence I appointed Emilio as project leader for LEP, a decision that was greeted by many with amazement. I considered his human qualities for this task to be more important than some explicit technical know-how. Emilio was respected by the scientists as well as by the engineers. He was prepared to listen to people, and his moderating temper, his honesty and reliability, and last but not least his Mediterranean warmth, were indispensable for the successful construction and operation of what was by far the largest accelerator of its time. His name will always remain linked with this unique project, LEP – a true testament to Emilio's skills as a scientist and as a project leader.

After his retirement I visited Emilio often in a small office in the theory division, where he had settled to study fundamental physics questions again. But he also took up other charges. One of the most important tasks was the directorship of the Scuola Normale Superiore at Pisa from 1991 to 1995, where he had been nominated professor in 1981 – a commitment that he could not fulfil at the time because of his CERN engagements.

Emilio received many distinctions, among them the title of Cavaliere di Gran Croce dell'Ordine al Merito della Repubblica, one of the highest orders of the Italian state.

Despite the heavy demands of his job he always cared about his family, and in return his wife Mariella gave him loving support in difficult times.

We all regret that sadly Emilio was not well enough to enjoy the enormous recent success of CERN. Science has lost a great physicist and many of us a dear friend.

● *Herwig Schopper, CERN director-general, 1981–1988.*

group leader, having joined the CERN staff in November 1966. Together with John Bailey they discovered the magic energy, 3.1 GeV, at which electric fields do not affect the spin precession. This led to a new muon storage ring with a uniform magnetic field and vertical focusing using an electric quadrupole field. Emilio masterminded this much larger project, creating a warm happy atmosphere and encouraging new ideas. The muon precession could now be followed out to 500 µs and g-2 was measured to 7 ppm. The team had the right number again (confirmed by the later measurement at Brookhaven National Laboratory) and this time it agreed with the theory.

While the g-2 saga was coming to an end, Emilio and Luigi Radicati, who was then a visiting scientist at CERN, became interested in the possibility of detecting gravitational waves by exploiting suitably coupled superconducting RF cavities. The idea was to detect the change of the cavity Q-value induced by gravitational waves. They were joined by Francesco Pegoraro and CERN's Philippe Bernard, and published papers analysing the principle in 1978/1979. It was an unconventional idea, which Emilio continued to consider and improve on and off with various collaborators for the next quarter of a century. However, at the end of the 1970s a much larger project lay on CERN's horizon.

In November 1978, John Adams – then CERN's executive director-general – decided to push R&D on superconducting RF with a view to increasing the energy reach of the proposed Large Electron–Positron (LEP) collider. He asked Philippe Bernard and Herbert Lengeler to put together a research programme, and they in turn proposed that Emilio should co-ordinate collaboration with outside laboratories because of his "vivid interest in RF superconductivity" and his "excellent contacts" in the field. The result was that in spring 1979, Emilio became team leader of the development programme at CERN, and responsible for co-ordination with other laboratories – in Genoa, Karlsruhe, Orsay and Wuppertal.

The development work at CERN led to superconducting cavities that could achieve the necessary high electric-field gradients, and the team went on to design and build, in collaboration with European industries, the system of superconducting RF that was eventually deployed in LEP during the 1990s. In 1986, Emilio and others proposed the installation of a maximum of 384 superconducting cavities to reach an energy of at least 220 GeV in the centre-of-mass. In the end 288 such cavities were installed, and LEP eventually reached a total energy of 208 GeV. Emilio would later express sadness that the collider's energy was never brought to its fullest potential with the maximum number of cavities.

Leader of LEP

However, he was to take on a still more significant role in 1980, when at the suggestion of the new director-general, Herwig Schopper, CERN Council designated him LEP project leader. With Schopper's agreement, Emilio began by setting up the LEP Management Board, consisting of the best experts at CERN, in all of the various aspects, from magnets, RF and vacuum to civil engineering and experimental halls. The board met one day a week throughout the period of LEP's construction, discussing all of the decisions that needed to be taken, including the technical specifications for contracts with industry. Schopper would regularly join in, mainly to observe and participate in the decision-making process, which took place in a warm and enthusiastic atmosphere.

The main aspect of the project in which Emilio had no experience was civil engineering, but one of the early major issues concerned the exact siting of the tunnel, which in the initial plans was to pass for 12 km beneath some 1000 m of water-bearing limestone in the Jura mountains. While this would avoid the larger communities in France and Switzerland, it presented formidable tunnelling challenges. Rather than downsize, Emilio decided to look into locating the ring further from the mountains. This needed crucial support from the local people, and he was instrumental in setting up regular meetings with the communes around CERN. The result was that in the final design, the LEP tunnel passed for only 3.3 km under the Jura, beneath 200 m of limestone at most.

This final design was approved in December 1981 and construction of the tunnel started in 1983. It was not without incident: when water burst into the part of the tunnel underneath the Jura, it formed a river that took six months to eliminate, and the smooth planning for construction and installation became a complex juggling act. Nevertheless by July 1988, the first sector was installed completely. A test with beam proved that the machine was indeed well designed, and just over a year later, the first collisions were observed on 13 August 1989.

Following the completion of the construction phase of LEP, and the end of his successful mandate as leader of the LEP project, Emilio began to focus again on the detection of gravitational waves, an interest that had continued even while he was a director at CERN, when he supported the installation of the EXPLORER gravitational-wave detector at the laboratory in 1984. He was nominated director of the Scuola Normale Superiore in Pisa in 1991, where he had been named professor a decade earlier, and served as such for the following four years, retiring from CERN in 1992. At Pisa, he played a key role in supporting approval of Virgo – the laser-based gravitational-wave detector adopted by INFN and CNRS, which is currently running near Cascina, Pisa.

At the LEP ground-breaking ceremony on 13 September 1983. Left to right: Emilio Picasso, the French president François Mitterand, the Swiss president Pierre Aubert, and Herwig Schopper. (Image credit: CERN-PHOTO-8309631-1.)

Emilio's love for physics problems lasted throughout his life in science – a life during which warmth and welcome radiated. He knew how to switch people on. Now, sadly, this bright light is dimmed, but the afterglow remains and will be with us for many years.

● Further reading

For Emilio Picasso's memories from the days at LEP, see chapter 3 in *From the PS to the LHC: 50 Years of Nobel Memories in High-Energy Physics*, L Alvarez-Gaumé *et al.* (Springer 2012).

For more on the g-2 experience, see "G minus TWO plus EMILIO" by F J M Farley, CERN-OPEN-2002-006.

Résumé

Emilio Picasso : la passion de la physique

Emilio Picasso, décédé en octobre 2014, était renommé pour ses qualités de chef, ainsi que pour son caractère chaleureux et son enthousiasme pour la physique fondamentale. Dans cet hommage, on retrouvera certains aspects des activités de physique d'Emilio Picasso, en particulier au CERN, où il a dirigé les expériences sur le g-2 du muon après avoir rejoint l'Organisation en 1966. Par la suite, il devait coordonner la conception et la construction des cavités supraconductrices pour le Grand collisionneur électron-positon (LEP). Nommé chef de projet pour le LEP en 1981, il a dirigé la construction du plus grand accélérateur de particules du monde, dans le tunnel de 27 km qui abrite actuellement le LHC.

Christine Sutton, CERN, based on contributions kindly supplied by Francis Farley, Günther Plass and Italo Manelli.

CMS: final Run I results on the Higgs boson

Measurements submitted recently for publication by CMS show that the Higgs boson at 125 GeV is, at least so far, consistent with the minimal scalar sector expected in the Standard Model.

Since the inception of the LHC, a central part of its physics programme has been aimed at establishing or ruling out the existence of the Higgs boson, the stubbornly missing building block of the Standard Model of elementary particles. After the discovery of a Higgs boson by the ATLAS and CMS experiments was announced in July 2012, the study of its properties became of paramount importance in understanding the nature of this boson and the structure of the scalar sector. Given the measured mass of the Higgs boson, all of its properties are predicted by the theory, so deviations from the predictions of the Standard Model could open a portal to new physics.

The CMS collaboration recently completed the full LHC Run 1 data analysis in each of the most important channels for the decay and production of the Higgs. Bosonic decays such as $H \to ZZ \to 4$ leptons (4l), $H \to \gamma\gamma$, and $H \to WW \to l\nu l\nu$, and fermionic decays such as $H \to bb$, $H \to \tau\tau$ and $H \to \mu\mu$, were studied, and the results have been published. All of the analyses are based on the proton–proton collision data collected in 2011 and 2012 at the LHC, corresponding to 5 fb^{-1} at 7 TeV and 20 fb^{-1} at 8 TeV centre-of-mass energy. The di-boson channels are observed with significance close to or above 5σ. The Standard Model's hypothesis of 0^+ for the spin-parity of the observed Higgs boson is found to be favoured strongly against other spin hypotheses (0^-, $1^\pm$, $2^\pm$). The comparison of off-shell and on-shell production of the Higgs boson in the ZZ channel also sets a constraint on the natural width of the Higgs boson that is comparable to the width expected in the Standard Model. Furthermore, evidence is established for the direct coupling to fermions, with significance above 3σ for the decay to ττ.

The combination of all of the production and decay channels provides the opportunity to obtain a global view of the most important Higgs-boson parameters, and to disentangle the contributions to the measured rates from the various processes. The first preliminary results on the full Run 1 data were presented by CMS last July at the International Conference on High Energy Physics in Valencia. Now, the collaboration has submitted the final "Run 1 legacy" results on the Higgs boson for publication. The results combining individual channels are remarkably coherent.

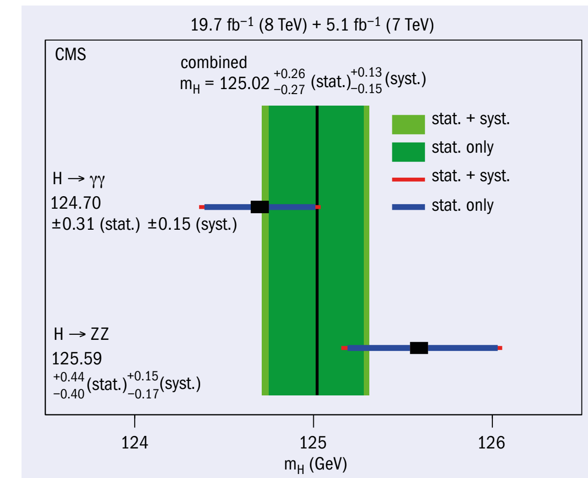
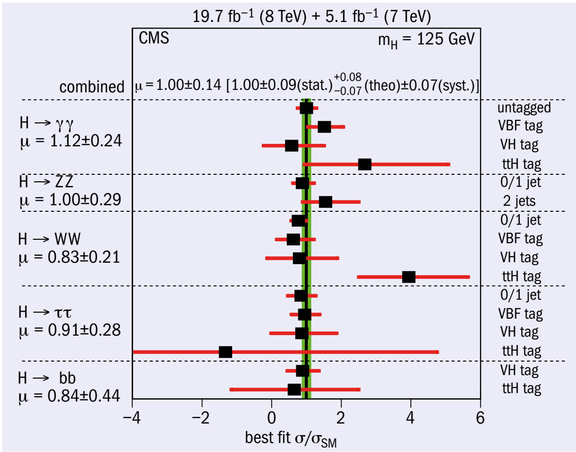
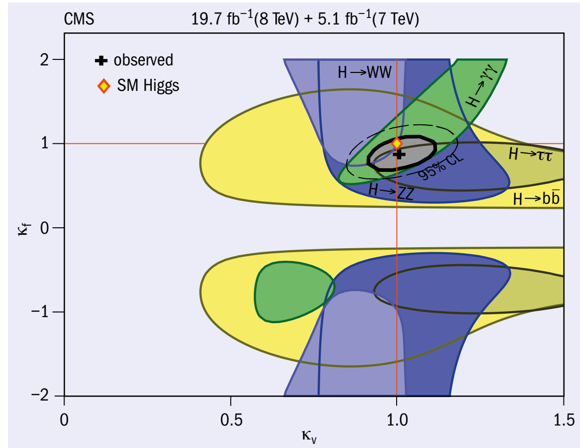


Fig. 1. Results of the mass measurement in the two high-resolution channels, $H \to \gamma\gamma$ and $H \to ZZ \to 4$ leptons, and their combination.

A first major outcome of the combination is a precise measurement of the mass of the Higgs boson. This is achieved by exploiting the two channels with the highest resolution: $H \to \gamma\gamma$ and $H \to ZZ \to 4l$. Thanks to the high precision and accurate calibration of the CMS electromagnetic calorimeter, the $H \to \gamma\gamma$ channel gives a most precise single-channel measurement of $M_H = 124.70 \pm 0.34$ GeV. Using the combination with the $H \to ZZ \to 4l$ channel, the final measurement of $M_H = 125.03^{+0.29}_{-0.31}$ GeV is obtained with an excellent precision of two per mille. The measurements in the two channels (figure 1) are compatible at the level of 1.6σ, indicating full consistency with the hypothesis of a single particle. The measured value of the mass is used for further studies of the Higgs-boson's couplings. It is worth noting that the uncertainty is still dominated by the statistical uncertainty and will therefore improve in Run 2.

The various measurements performed at the two centre-of-mass energies are carried out in a large number (around 200) of mutually exclusive event categories. Each category addresses one or more of the different production and decay channels. Four production mechanisms are considered. Gluon–gluon fusion (ggH) is a purely quantum process, where a single Higgs boson is produced via a virtual top-quark loop. In vector-boson fusion (VBF), the ▷





Left: Fig. 2. Measurements of signal strength for the overall combination (solid vertical line with green band representing the uncertainty) and different combinations, grouped by predominant decay mode, and additional tags targeting a specific production mechanism. Right: Fig. 3. The 68% CL contours for individual channels (coloured swaths), and for the overall combination (thick curve) for the (κ_V, κ_f) parameters. The cross indicates the global best-fit values. The dashed contour bounds the 95% CL confidence region for the combination. The diamond represents the Standard Model expectation at (κ_V, κ_f) = (1, 1).

Higgs boson is produced in association with two quarks. Lastly, in VH- and ttH-associated production, the Higgs boson is produced either in association with a W/Z boson or with a top–antitop quark pair. The main decay channels are indicated on the left of figure 2, which shows the measurement of the signal strength μ, defined as the ratio of the measured yield relative to the Standard Model prediction. All of the measurements are found to be consistent with $\mu = 1$, which by definition indicates consistency with the prediction. The combination of all of the measurements gives an overall signal strength of 1.00±0.13. The figure also shows the signal strengths measured for the different decay tags. All of the combinations are obtained using simultaneous likelihood fits of all channels, with all of the systematic and theory uncertainties profiled in the fits.

Signal strengths compatible with Standard Model expectations are also found for each of the production mechanisms, with an observation of ggH production at more than 5σ and evidence for VBF, VH and ttH production at close to or above 3σ.

Another set of tests of consistency with the Standard Model consist of introducing coupling modifiers, κ, that scale the Standard Model couplings. The simplest case is to allow one scaling factor for the coupling of the Higgs boson to the vector bosons (κ_V) and one for the coupling to fermions (κ_f), and to resolve the loops – namely gluon–gluon fusion and γγ decay – using Standard Model contributions only.

Figure 3 shows the 1σ contours obtained from the different decay channels in the plane κ_f versus κ_V, and from their combination. The only channel that can distinguish between the different relative signs of the two couplings is H→γγ, because of the negative interference between the top-quark and W-boson contributions in the loop. The combination (thick curve) shows that the measurement is consistent within 1σ with $\kappa_V = \kappa_f = 1$, while the opposite sign hypothesis, $\kappa_V = -\kappa_f = 1$, is excluded with a confidence limit (CL) larger than 95%.

Many other tests of modified couplings with respect to the Standard Model have been carried out, and all of the results indicate consistency with the predictions. For instance, the so-called "custodial" symmetry that fixes the relative couplings κ_W/κ_Z of the Higgs boson to W and Z bosons is verified at the 15% precision level and the couplings to fermions of the third family are verified at the 20–30% precision level.

The Higgs boson is tightly connected with the mechanism for generating mass in the Standard Model: the Yukawa couplings for the fermions are predicted to be proportional to the mass of the fermions themselves, while the gauge couplings to the vector bosons are proportional to the masses squared of the vector bosons. Figure 4 illustrates this by showing the couplings to the Standard Model particles as a function of the mass of their masses. All of the measurements are in excellent agreement with the expected behaviour of the couplings, indicated by the black line. In this plot the H→μμ channel is also included and, even though it currently has a large uncertainty, it is consistent with the fitted line. This demonstrates beautifully that the Higgs boson is linked to the fundamental field at the origin of the masses of particles.

Summary and conclusions

CMS has just submitted for publication the final Run 1 measurements of the properties of the Higgs boson – mass, couplings and spin-parity parameters – with the highest precision allowed by the current statistics. So far, all of the results are found to be consistent, within uncertainties, with the newly established scalar sector, just as predicted for the spontaneous electroweak symmetry breaking in the Standard Model. The measurements provide overwhelming evidence that the observed Higgs-boson couples to other particles in a way that is consistent with the Standard Model predictions. After achieving the major milestone of completing all of the most important Run 1 Higgs-boson measurements, the CMS experiment will now direct its efforts towards the exploitation of the upcoming LHC run (Run 2) at a centre-of-mass energy of 13 TeV. The new energy frontier promises increased reach into the Higgs sector, but also a unique look at a totally new, unchartered territory.

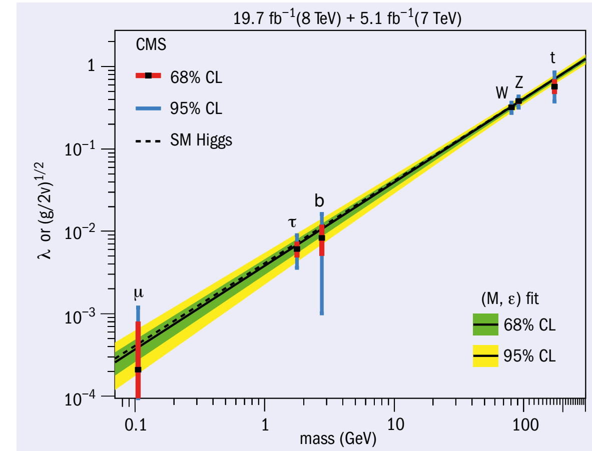


Fig. 4. Graphical representation of the results obtained from likelihood scans for a model where the gluon and photon loop-interactions with the Higgs boson are resolved in terms of other Standard Model particles. The dashed line corresponds to the Standard Model expectation. The inner bars represent the 68% CL intervals, while the outer bars represent the 95% CL intervals. The ordinate differs between fermions and vector bosons to take account of the expected Standard Model scaling of the coupling with mass, depending on the type of particle. The continuous line shows the result of the coupling–mass fit, while the inner and outer bands represent the 68% and 95% CL regions.

Further reading

CMS Collaboration arXiv:1412.8662 [hep-ex], submitted to *Eur. Phys. J. C.*

CMS Collaboration arXiv:1411.3441, submitted to *Phys. Rev. D.*

CMS Collaboration 2014 *Phys. Lett. B* **736** 64.

Résumé

CMS: résultats définitifs de la première période d'exploitation concernant le boson de Higgs

La collaboration CMS vient d'achever l'analyse complète des données de la première période d'exploitation du LHC pour chacune des voies de désintégration et de production du boson de Higgs, découvert au LHC en 2012. À présent, la collaboration présente pour publication les résultats définitifs de cette exploitation pour ce qui concerne le boson de Higgs. Les résultats combinant différentes voies de désintégration sont remarquablement cohérents. Ils montrent de façon très concluante que le couplage du boson de Higgs avec d'autres particules correspond, dans la limite des incertitudes, aux prédictions liées à la description de la brisure de symétrie électrofaible spontanée dans le Modèle standard.

Guillelmo Gomez-Ceballos, **Marco Pieri** and **Yves Sirois** for the CMS collaboration.

ARIEL begins a new future in rare isotopes

The superconducting electron linac for ARIEL, TRIUMF's new flagship facility, has achieved its first accelerated beam.

TRIUMF is Canada's national laboratory for particle and nuclear physics, located in Vancouver. Founded in 1968, the laboratory's particle-accelerator-driven research has grown from nuclear and particle physics to include vibrant programmes in materials science, nuclear medicine and accelerator science, while maintaining strong particle-physics activities elsewhere, for example at CERN and the Japan Proton Accelerator Research Complex. Currently, the laboratory's flagship on-site programme uses rare-isotope beams (RIBs) for both discovery and application in the physical and health sciences.

Rare isotopes are not found in nature, yet they have properties that have shaped the evolution of the universe in fundamental ways, from powering the burning of stars to generating the chemical elements that make up life on Earth. These isotopes are foundational for modern medical-imaging techniques, such as positron-emission tomography and single-photon emission computed tomography, and are useful for therapeutic purposes, including the treatment of cancer tumours. They are also powerful tools for scientific discovery, for example in determining the structure and dynamics of atomic nuclei, understanding the processes by which heavy elements in the universe were created, enabling precision tests of fundamental symmetries that could challenge the Standard Model of particle physics, and serving as probes of the interfaces between materials.

TRIUMF's Isotope Separator and Accelerator – ISAC – is one of the world's premier RIB facilities. ISAC's high proton-beam power (up to 50 kW) that produces the rare isotopes, its chain of accelerators that propels them up to energies of 6–18 MeV per nucleon for heavy and light-mass beams, respectively, and its experimental equipment that measures their properties are unmatched in the world.

The Advanced Rare IsotopE Laboratory (ARIEL) was conceived to expand these capabilities in important new directions, and to establish TRIUMF as a world-leading laboratory in accelerator technology and in rare-isotope research for science, medicine and business. To expand the number and scope of RIBs feeding TRIUMF's experimental facilities, ARIEL will add two high-power driver beams – one electron and one proton – and two new isotope production-target and transport systems.

Together with the existing ISAC station, the two additional target stations will triple the current isotope-production capacity, enable full utilization of the existing experimental facilities, and satisfy researcher demand for isotopes used in nuclear astrophysics, fundamental nuclear studies and searches for new particle physics, as well as in characterizing materials and in medical-isotope

Fig. 1. TRIUMF's new ARIEL building houses the target hall, remote-handling facilities, mass-separation and radioactive beam front end, and electrical and mechanical services. Funding for the civil construction was provided by the Province of British Columbia.

research. In addition, ARIEL will deliver important social and economic impacts, in the production of medical isotopes for targeted cancer therapy, in the characterization of novel materials, and in the continued advancement of accelerator technology in Canada, both at the laboratory and in partnership with industry.

The e-linac

ARIEL-I, the first stage of ARIEL, was funded in 2010 by the Canada Foundation for Innovation (CFI), the British Columbia Knowledge Development Fund, and the Canadian government. It comprises the ARIEL building (figure 1), completed in 2013, and a 25 MeV, 100 kW superconducting radio-frequency (SRF) electron linear accelerator (e-linac), which is the first stage of a new electron driver designed ultimately to achieve 50 MeV and 500 kW for the production of radioactive beams via photo-fission.

ARIEL was conceived as a world-leading facility in rare-isotope research for science, medicine and business.

The ARIEL-I e-linac, which accelerated its first beam to 23 MeV in September 2014, is a state-of-the-art accelerator featuring a number of technological breakthroughs (figure 2). The 10 mA continuous wave (cw) electron beam is generated in a 300 kV DC thermionic gridded-cathode assembly modulated at 650 MHz, bunched by a room-temperature 1.3 GHz RF

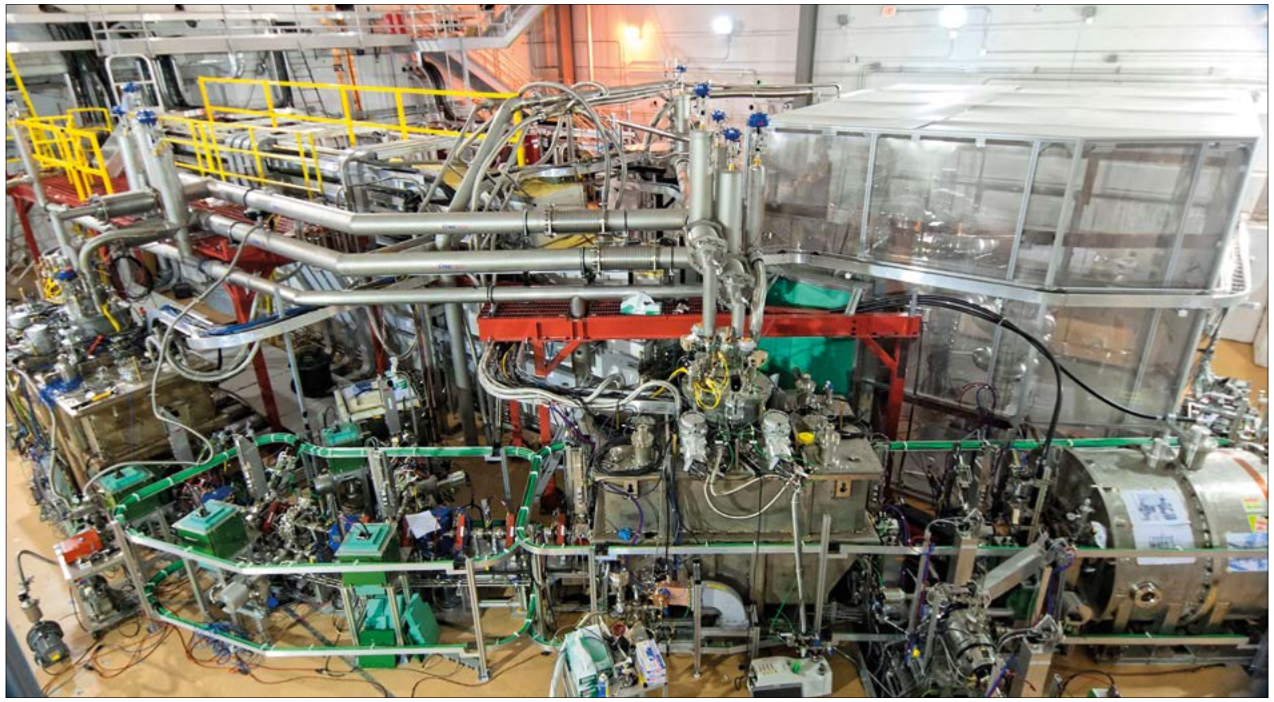


Fig. 2. The newly commissioned first stage of the SRF electron linac for ARIEL, showing the electron gun (cylinder far right), injector cryomodule (bottom centre) and accelerator cryomodule (ACM far left). A second ACM will ultimately bring the accelerator to the 50 MeV and 500 kW design specifications. Funding was provided by the Canadian government and the CFI. (All image credits: TRIUMF.)

structure, and accelerated using up to five 1.3 GHz superconducting cavities, housed in one 10 MeV injector cryomodule (ICM) and two accelerator cryomodules, each providing 20 MeV energy gain.

The design and layout of the e-linac are compatible with a future recirculation arc that can be tuned either for energy-recovery or energy-doubling operation. The electron source, designed and constructed at TRIUMF, exhibits reduced field-emission and a novel modulation scheme: the RF power is transmitted via a ceramic waveguide between the grounded vessel and the gun, so the amplifier is at ground potential. The source has been successfully tested to the full current specification of 10 mA cw. Specially designed short quadrupoles (figure 3) present minimum electron-beam aberrations by shaping the poles to be locally spherical, with radius 4π times the aperture radius (Baartman 2012).

The injector and accelerator cryomodules house the SRF cavities (figure 4, p28), which are cooled to 2K and each driven by a 300 kW klystron. To take advantage of prior developments – and to contribute to future projects – TRIUMF chose the 1.3 GHz technology, the same as other global accelerator projects including the XFEL in Hamburg, the LCLS-II at SLAC, and the ▷

Fig.3. Close-up of the "short" quadrupoles used in the electron-beam transport line. These TRIUMF-designed magnets employ a novel pole design that presents minimal aberrations to the electron beam.

TRIUMF

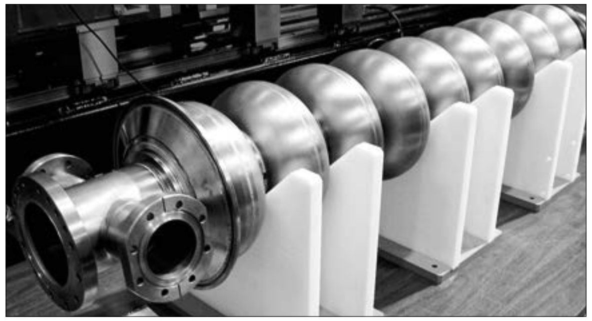


Fig. 4. Close-up of the 1.3 GHz SRF cavity employed in the ARIEL e-linac. The technology chosen is the same as other current and proposed global accelerator projects. TRIUMF transferred the technical expertise to the Canadian company PAVAC Industries Inc. in a successful research–industry partnership.

proposed International Linear Collider.

Through technology transfer from TRIUMF, the Canadian company PAVAC Industries Inc. fabricated the niobium cavities and TRIUMF constructed the cryomodules, based on the ISAC top-loading design (figure 2 bottom centre, p27). The TRIUMF/PAVAC collaboration, which goes back to 2005, was born from the vision of "made in Canada" superconducting accelerators. Now, 10 years later, the relationship is a glowing example of a positive partnership between industry and a research institute.

International partnerships have been essential in facilitating technical developments for the e-linac. In 2008, TRIUMF went into partnership with the Variable Energy Cyclotron Centre (VECC) in Kolkata, for joint development of the ICM and the construction of two of them: one for ARIEL and one for ANURIB, India's next-generation RIB facility, which is being constructed in Kolkata. In 2013, the collaboration was extended to include the development of components for ARIEL's next phase, ARIEL-II. In addition, collaborations with Fermilab, the Helmholtz Zentrum Berlin and DESY were indispensable for the project.

ARIEL's development is continuing with ARIEL-II, which will complete the e-linac and add the new proton driver, production targets and transport systems in preparation for first science in 2017. Funding for ARIEL-II has been requested from the CFI on behalf of 19 universities, led by the University of Victoria, and matching funds are being sought from five Canadian provinces.

ARIEL will bring unprecedented capabilities:

- The multi-user RIB capability will not only triple the RIB hours delivered to users, but also increase the richness of the science by enabling long-running experiments for fundamental symmetries that are not practical currently.
- Photo-fission will allow the production of very neutron-rich isotopes at unprecedented intensities for precision studies of r-process nuclei.
- The multi-user capability will establish depth-resolved β-detected NMR as a user facility, unique in the world.
- High production rates of novel alpha-emitting heavy nuclei will accelerate development of targeted alpha tumour therapy.

The new facility will also provide important societal benefits. In addition to the economic benefits from the commercialization of accelerator technologies (e.g. PAVAC), ARIEL will expand TRIUMF's outstanding record in student development through participation in international collaborations and training in advanced instrumentation and accelerator technologies. The e-linac has provided the impetus to form Canada's first graduate programme in accelerator physics. One of only a few worldwide, the programme is in high demand globally and has already produced award-winning graduates.

ARIEL is not only the future of TRIUMF, it also embodies the mission of TRIUMF at large: scientific excellence, societal impact, and economic benefit. And it is off to a great start.

Further reading

For more information, see the articles on ISAC and ARIEL in *Hyperfine Interactions* 225, issue 1–3 (2014), or visit www.triumf.ca/ariel.

R Baartman 2012 *Phys. Rev. ST Accel. Beams* **15** 074002.

Résumé

Isotopes rares : premiers pas d'ARIEL

TRIUMF, le laboratoire national canadien pour la physique des particules et la physique nucléaire, abrite l'une des installations les plus en vue pour la production d'isotopes rares. L'installation à isotopes rares ARIEL (Advanced Rare IsotopE Laboratory) *a été conçue pour renforcer les capacités existantes afin d'explorer de nouvelles directions prometteuses, et ainsi établir TRIUMF en tant que laboratoire de premier plan au niveau mondial pour les technologies des accélérateurs et la recherche sur les isotopes rares pour la science, la médecine et l'industrie. La première phase, ARIEL-I, inclut un accélérateur linéaire d'électrons supraconducteur, qui a accéléré son premier faisceau à 23 MeV en septembre 2014.*

Lia Merminga, Accelerator Division head, **Shane Koscielniak**, e-linac project leader, and **Reiner Krücken**, Science Division head, TRIUMF.

Faces & Places

INNOVATION

CERN inaugurates the IdeaSquare building

On 9 December, members of CERN Council had the opportunity to take part in the inauguration of a refurbished building named IdeaSquare, after a new project designed to nurture innovation at CERN. The aim is to bring together researchers, engineers, people from industry and young students, and encourage them to come up with new ideas that are useful for society, inspired by CERN's ongoing detector R&D and upgrade projects.

Originally created in response to requests from experimentalists working in the collaborations, IdeaSquare has evolved into a place where innovative ideas meet established expertise. Although the project is still in its pilot phase, two EU-funded projects have found their home in the IdeaSquare building at Point 1 on the LHC, and 46 students have already participated in the Challenge-Based Innovation courses that are based there. The building – once an old storage space – has been refurbished creatively, using reinforced shipping containers and an old bus for office space and a meeting room, and has a ready-to-use technical infrastructure.

President of CERN Council, Agnieszka Zalewska, centre, Tula Teeri, rector of Aalto University, right, and CERN's director-general, Rolf Heuer, decorate the celebratory cake at the inauguration of the IdeaSquare building. (Image credit: CERN-PHOTO-201412-263-137.)

IdeaSquare, which has already gathered over a hundred new ideas – some of which might be prototyped at CERN eventually – was set up by Marzio Nessi and Markus Nordberg within CERN's Development and Innovation Unit. The unit works with and engages external partners to foster the development and innovation potential of detector technology outside the domain of particle physics. The only requirement needed to take part in the IdeaSquare programme is to have an idea worth nurturing – that is, an idea that combines innovation with usefulness in particle physics and for society.

COLLABORATION

New international offices to aid CERN-KEK partnership

CERN and KEK, the Japanese high-energy accelerator research organization, have a long history of collaboration. An agreement signed at KEK on 21 November puts this on even firmer ground: both organizations will establish CERN-KEK offices to increase the collaborative effort on accelerator R&D and construction projects of mutual interest.

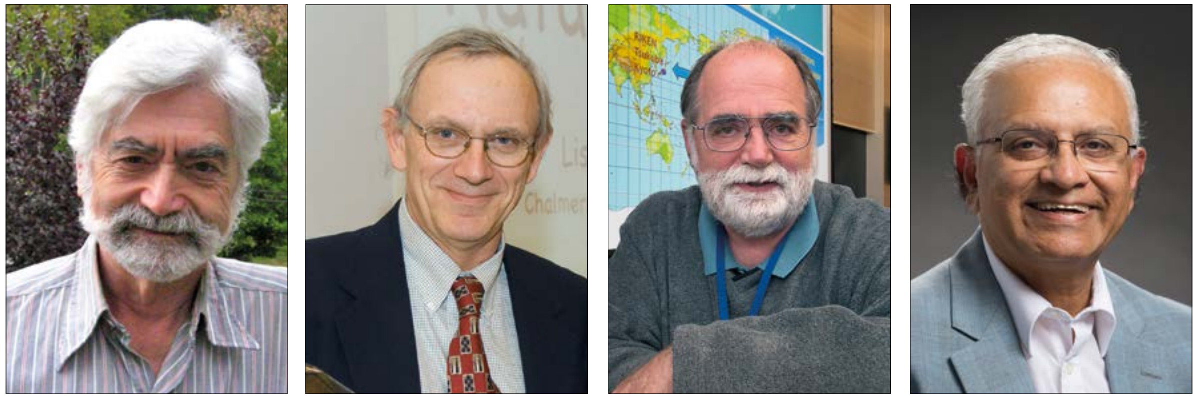
A number of key projects fall into this category. The LHC and its luminosity upgrade, the LHC injectors, linear-collider studies and the associated accelerator test facilities ATF and ATF2 all feature on the strategy roadmaps for the future of particle physics, both in Europe and in Japan. While the programmes at the Japan Proton Accelerator Complex – including upgrades and KEK's future SuperKEKB electron–positron collider – involve a broad community of European researchers, generic R&D on high-field magnets and high-gradient structures for the Future Circular Collider and Compact Linear Collider studies are of great importance for both organizations. Scientists from Europe, including CERN, form part of the preparation team for the International Linear Collider project that is being pursued in Japan.

Rüdiger Voss, head of international relations at CERN, front left, and Atsuto Suzuki, director-general of KEK, signed the agreement during the 9th CERN-KEK meeting. (Image credit: KEK.)

The new offices provide not only physical space but also administrative help for researchers travelling to and settling in at the partner laboratory. Registration procedures at a new laboratory and in a new country are often tricky, and the office staff will make sure that accelerator specialists can focus on R&D rather than on paperwork. The offices will also handle official visits from the partner organization and from other regions – planning and arranging travel, meetings, workshops and training, and the exchange and transport of hardware components.

AWARDS

APS announces prizewinners for 2015



Some of the APS prizewinners, left to right: George Zweig, Pierre Ramond, Larry McLerran and Hasan Padamsee. (Image credits: Left to right: G Zweig, Chalmers University of Technology, BNL, Fermilab.)

The American Physical Society (APS) has announced many of its awards for 2015, including major prizes in nuclear and particle physics, astroparticle physics and cosmology.

Last year saw many anniversaries, including the 50th anniversary of two papers predicting the existence of quarks, by Murray Gell-Mann and George Zweig (*CERN Courier* March 2014 p37). For 2015, the APS honours Zweig of Massachusetts Institute of Technology with the J J Sakurai Prize for Theoretical Particle Physics. This prize, which recognizes and encourages outstanding achievement in particle theory, is awarded to Zweig for "his independent proposal that hadrons are composed of fractionally charged fundamental constituents, called quarks or aces, and for developing its revolutionary implications for hadron masses and properties".

The 2015 Dannie Heineman Prize for Mathematical Physics, which recognizes outstanding publications in the field, also goes to a well-known figure in theoretical particle physics. Pierre Ramond of the University of Florida receives the prize for "his pioneering foundational discoveries in supersymmetry and superstring theory, in particular the dual model of fermions and the theory of the Kalb–Ramond field". Still in the theoretical domain, the Herman Feshbach Prize recognizes and encourages outstanding research in theoretical nuclear physics. The 2015 prize goes to Larry McLerran of Brookhaven National Laboratory (BNL) for "his pioneering contributions to our understanding of QCD at high energy-density and laying the theoretical foundations of experimental ultra-relativistic heavy-ion collisions. His work has been a crucial guide to experiments at RHIC and the LHC, and he has mentored a generation of young theorists".

Experimental work at Brookhaven's RHIC is also recognized this year with the Tom W Bonner Prize, which recognizes and encourages outstanding experimental research in nuclear physics, including the development of a method, technique or device that significantly contributes in a general way to nuclear-physics research. The recipients of the 2015 prize are Howard Wieman of Lawrence Berkeley National Laboratory and Miklos Gyulassy of Columbia University. They are rewarded for "developing foundational experimental and theoretical tools to enable and guide generations of experiments in relativistic heavy-ion physics. The combination of experiment and theory led to the initial discoveries at RHIC, ongoing precision studies of the properties of hot nuclear matter, and to exploration of the nuclear-matter phase diagram".

Elsewhere in experimental particle physics, the 2015 W K H Panofsky Prize, which recognizes and encourages outstanding achievements in the field, goes to Stanley Wojcicki of Stanford University. He receives the award "for his leadership and innovative contributions to experiments probing the flavour structure of quarks and leptons, in particular for his seminal role in the success of the MINOS neutrino oscillation experiment".

The Robert R Wilson Prize for Achievement in the Physics of Particle Accelerators is another important award that recognizes and encourages outstanding work. Hasan Padamsee of Fermilab receives the 2015 prize "for his leadership and pioneering world-renowned research in superconducting radiofrequency physics, materials science, and technology, which contributed to remarkable advances in the capability of particle accelerators".

In astroparticle physics and cosmology, the Hans A Bethe Prize recognizes outstanding work in theory, experiment or observation in the areas of astrophysics, nuclear physics, nuclear astrophysics, or closely related fields. James Lattimer of State University of New York, Stony Brook, receives the 2015 prize for his "outstanding theoretical work connecting observations of supernovae and neutron stars with neutrino emission and the equation of state of matter beyond nuclear density". The 2015 Einstein Prize recognizing outstanding accomplishments in the field of gravitational physics goes to Jacob Bekenstein of Hebrew University for "his ground-breaking work on black-hole entropy, which launched the field of black-hole thermodynamics and transformed the long effort to unify quantum mechanics and gravitation".

The APS awards also go beyond the recognition of pure research. The Edward A Bouchet Award "promotes the participation of under-represented minorities in physics by identifying and recognizing a distinguished minority physicist who has made significant contributions to physics research". The 2015 award goes to Jorge Lopez of University of Texas, El Paso, not only for "his extensive research accomplishments in theoretical nuclear physics, pioneering work in heavy-ion collision dynamics and development of systematic ways to study problems of nuclear fragmentation", but also for "his relentless work in building bridges to Latin America and his outreach to the Hispanic community to increase diversity in physics".

Particle physics also features in the awarding of the 2015 Prize for a Faculty Member for Research in an Undergraduate Institution. Donald Isenhower of Abilene Christian University receives the award for "his essential contributions in hardware construction, installation, calibration and operation for experiments at LAMPF, FNAL, RHIC and at CERN, and for enthusiastic mentoring of a large number of undergraduate students while being recognized for outstanding teaching at the undergraduate level". Last but by no means least, there are a number of awards for young people. Of these, the 2015 Henry Primakoff Award for Early-Career Particle Physics goes to Rouven Essig of State University of New York, Stony Brook, for his "seminal contributions to theoretical models of dark matter with new gauge interactions, and for leadership of the APEX experiment at the Jefferson Laboratory".

Breakthrough prizes for the dark universe

Left to right: Brian Schmidt, Saul Perlmutter and Adam Riess at the award ceremony. (Image credit: Breakthrough Prize.)

The 2015 Breakthrough Prize in Fundamental Physics, which recognizes major insights into the deepest questions of the universe, has been awarded to Saul Perlmutter of the University of California Berkeley and Lawrence Berkeley National Laboratory, the Supernova Cosmology Project, and to Brian Schmidt of the Australian National University, and Adam Riess, of Johns Hopkins University and the Space Telescope Science Institute, and members of the High-Z Supernova Team.

The two teams, totalling 51 people, will share the $3 million prize, awarded for "the most unexpected discovery that the expansion of the universe is accelerating, rather than slowing as had been long assumed". Their discovery, which is interpreted in terms of "dark energy" – a mysterious anti-gravitational force that drives the accelerating expansion – was also honoured with the Nobel Prize in Physics in 2011 (*CERN Courier* November 2011 p5).

The awarding of the 2015 Breakthrough prizes, which honour top scientists and mathematicians, took place in a gala ceremony held on 9 November at NASA's Hangar 1 in Mountain View, California. The following day, the Breakthrough Prize Symposium took place at Stanford University, with talks from the prize winners. In addition, awards were handed out in a category for junior researchers in physics – the New Horizons in Physics Prize. These, again, recognized work on the "dark side of the universe", with an award given to Philip Schuster and Natalia Toro of the Perimeter Institute "for pioneering the 'simplified models' framework for new physics searches at the LHC, as well as spearheading new experimental searches for dark sectors using high-intensity electron beams".

Symposium

Michigan honours Homer Neal

Homer Neal, right, with the sculpture by Jens Zorn showing collisions of protons at D0 and ATLAS, presented to him at the symposium. (Image credit: M Okunawo and S Lemons.)

In April, colleagues and friends from around the world gathered at the University of Michigan in Ann Arbor for a symposium to honour Homer Neal.

After receiving his BS degree at Indiana University in 1961, Homer gained his PhD at Michigan in 1966, mentored by Mike Longo. While he was there he shared an office with fellow graduate student Sam Ting and they became close friends. At the symposium, despite an important meeting at CERN the previous day with senior Chinese government officials, Sam used all available high-tech devices to deliver an excellent talk about their days together in Ann Arbor.

Homer's next step was a year at CERN as a National Science Foundation postdoctoral fellow, after which he returned to Indiana in 1967 as an assistant professor, where he started the university's high-energy physics group. He became a tenured associate professor in 1970 and then a full professor in 1972. In 1974 he spent a sabbatical year at the Bohr Institute. Then, in the years 1976–1981, he served as Indiana's dean of research and graduate development, and was simultaneously head of Indiana's spin-physics group, doing experiments first at the new polarized beam at Argonne's Zero Gradient Synchrotron, and then using a polarized target at Fermilab's unpolarized 200 GeV proton beam.

The first three sessions of the symposium focused on Homer's experiments at Brookhaven, Argonne, SLAC, Fermilab's Main Ring and Tevatron and, most recently, at CERN's LHC. Paul Grannis of Stony Brook discussed his and Homer's intertwined careers, starting with Paul's PhD thesis at Berkeley and Homer's at Michigan, both measuring spin parameters in proton–proton elastic scattering. They next crossed paths in 1981 when Homer became Stony Brook's provost, providing support when Paul's D0 experiment at Fermilab was being planned in 1983. Homer meanwhile maintained his own research programme by commuting to SLAC monthly to take shifts on the High Resolution Spectrometer experiment. Their paths intertwined again in 1986 when Homer joined D0, agreeing to instrument the inter-cryostat region of the calorimeter. This detector was crucial in several major D0 results, such as the discovery of the top quark and the measurement of the W boson's mass.

Jianming Qian, who has worked with Homer since joining Michigan in 1993, described him as a physicist, a colleague and a mentor, first in D0 at the Tevatron and then in ATLAS at the LHC. Jianming stressed how Homer's strong and persistent interest in spin physics influenced the direction of the group's research. Examples are the discoveries of the Ξ_b and Ω_b baryons at D0, as a result of the spin analyses that Homer initiated to study Λ and Λ_b baryons. During the height of Michigan's D0 programme, Homer also had the vision to see that the group's future would be at the LHC, therefore leading Michigan to join ATLAS.

Eduard De La Cruz Burelo, now at Cinvestav-IPN in Mexico, recalled working as a postdoc under Homer, first on D0, where he noted in particular the Λ_b analysis, which led to what was then the world's best lifetime measurement for this particle, as well as the discoveries of the Ξ_b and Ω_b. He also recalled the many hours spent with Homer on the hyperon polarization puzzle in proton–proton scattering, figuring out how to measure polarization parameters and how to test various theories in D0 and ATLAS.

Howard Gordon of Brookhaven, who leads the US ATLAS programme, praised Homer's leadership and accomplishments in ATLAS. In leading the strong Michigan ATLAS group he has used his physics vision and exceptional negotiating skill, for example securing resources at Michigan to make significant contributions to ATLAS. On Homer's initiative, Michigan hired Bing Zhou in 1997 to lead the construction and development of the ATLAS muon detector and, under Zhou, Michigan built the largest monitored drift chambers of the ATLAS endcap muon system and also operates one of the three worldwide muon-detector calibration centres. Homer's wisdom allowed the Michigan ATLAS group to make a major contribution to the discovery of the Higgs boson.

Shawn McKee of Michigan noted Homer's impact on developing cyber-infrastructure and collaborative tools for both Michigan and the high-energy physics community, benefiting from his leadership roles in both academia and industry. Homer was a pioneer in developing collaborative tools to ensure that all LHC physicists can contribute effectively to the physics programme. He chaired the ATLAS computing review committee in 1999 and secured funding for a Tier-2 site at Michigan and Michigan State. He has also been instrumental in many cyber-infrastructure projects, such as Campus Automated Rich Media Archiving (CARMA), which recorded all the symposium presentations.

The fourth session of the symposium focused on Homer's leadership contributions, for example to the US government as a member of the National Science Board, and as a regent of the Smithsonian Institute. He also serves on the board of Ford Motor Company – the only car company in the US not to go bankrupt during the 2008 recession – and his valuable high-tech advice was praised strongly by William Coughlin, president and CEO of Ford Global Technology LLC. In academia, Homer was chosen to serve as provost of Stony Brook in the years 1981–1986. He returned to Michigan in 1987 as chair of the physics department, and in 1993 was chosen to be Michigan's research vice president, before becoming its interim president in the years 1996/1997. More recently, he was elected to be president of the American Physical Society in 2015.

● For all of the presentations, visit http://nealsymposium.physics.lsa.umich.edu/.

Industry

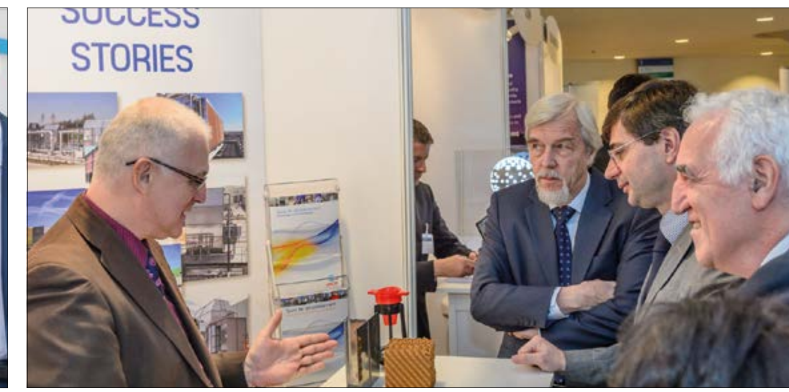
Spain and France show their wares at CERN

Companies from two of CERN's member states recently took the opportunity to display their products and services at CERN.

First, on 28 October, the state secretary of science, development and innovation for Spain, Carmen Vela Olmo, visited the laboratory to inaugurate the "Spain at CERN" exhibition, which provided a showcase for Spanish industry. It was the first time that Spanish companies have exhibited at CERN, and 47 of them showed their wares and discussed business opportunities. Representatives from a number of the most relevant research institutes and a few technology universities also attended, with the aim of building a strong and durable connection between the Spanish science industry network and activities at CERN.

The two-day programme of events included the opportunity to visit different departments at CERN and discuss supplies and services linked to the many technologies that underpin CERN's activities, from civil engineering to vacuum and cryogenic systems. There were also presentations on knowledge and technology transfer at CERN, as well as the opportunity to visit the LHC underground.

On 1–3 December it was the turn of representatives from 37 French companies in sectors related to particle physics to meet scientists, engineers and other potential purchasers at the 13th "France at CERN" exhibition. The main subjects covered electrical engineering, electronics, informatics, mechanical engineering, vacuum and low-temperature technologies, instrumentation and safety. The first day included presentations on technology transfer and purchasing at CERN.



Left: On inaugurating the "Spain at CERN" exhibition, state secretary of science, development and innovation for Spain, Carmen Vela Olmo, left, shakes hands with CERN's director-general, Rolf Heuer. (Image credit: CERN-PHOTO-201410-219-5.) Right: Nicolas Niemtchinow, second from right, ambassador and permanent representative of France to the United Nations Office and other international organizations in Geneva, tours the "France at CERN" exhibition, with CERN's director for accelerators and technology, Frédérick Bordry, far right, and director-general Rolf Heuer, centre. (Image credit: CERN-PHOTO-201412-252-55.)

New products

AUREA Technology has announced its newly designed fast, near-infrared single-photon counting module, SPD_NIR_OEM_120MHz, which provides gated-mode operation up to 120 MHz trigger rate with very fast timing resolution, < 150 ps. It performs with a very-low-noise dark count rate of < 5.000 cps and high photon-detection efficiency up to 30%. Parameter set-ups and data transmission are managed via a USB and Bluetooth interface and easy-to-use graphical interface. For more details, contact Jerome Prieur, e-mail jerome.prieur@aureatechnology.com or visit www.aureatechnology.com.

E4 Computer Engineering and **Applied Micro Circuits Corporation** have launched the low-power platform ARKA RK003, now enhanced with new essential features to address high-performance computing (HPC) projects. The two major developments consist of a smaller, 1U 17" short depth, which is ideal for high-density environments, and the implementation of Mellanox FDR Connect-X3 InfiniBand. For more information, contact Ludovica Delpiano, e-mail Ludovica.delpiano@e4company.com or visit www.e4company.com.

Eurotech has announced the launch of the Hiv́e (High Velocity) system, a new addition to the Aurora line of supercomputers. A new family of HPC systems, built on the innovative "Brick" supercomputing architecture, the Hiv́e HPC systems are optimized for accelerated workloads, offering high performance and energy efficiency obtained by a high degree of modularity in conjunction with water cooling of all components. For further details, contact Giovanbattista Mattiussi, tel +39 345 7153193, e-mail Giovanbattista.mattiussi@eurotech.com, or visit www.eurotech.com.

Zurich Instruments AG has recently launched the UHF-DIG Digitizer as a fully featured digitizer option for its high-end signal-processing platform UHFLI Lock-in Amplifier (the UHFLIf). This latest extension represents the first time that a lock-in amplifier has been equipped with the capability of storing a raw digitized signal along with demodulated samples. For further information, contact Stephan Koch, tel +41 44 5150415, e-mail stephan.koch@zhinst.com, or visit www.zhinst.com/products/uhfli/uhf-dig.

Nuclear physics

EXON 2014 highlights research with exotic nuclei

EXON 2014, the International Symposium on Exotic Nuclei, took place on 8–13 September in Kaliningrad – the seventh time that the event has been held in Russia. It was organized by the five largest scientific centres where this important and actively developing field of nuclear physics is successfully studied: JINR in Dubna, GANIL in France, RIKEN in Japan, GSI in Germany and the National Superconducting Cyclotron Laboratory in the US. Around 160 scientists from 24 countries took part, the largest delegations being from France (12 persons), Germany (10), Japan (10) and the US (8). Scientific centres in these countries are interested in co-operation with JINR and Russian scientific centres, which were represented by 28 participants.

Research at these laboratories studies nuclei in extreme conditions – nuclei with high angular momentum ("violently" spinning nuclei) or high excitation energy ("hot" nuclei), large deformation (super- and hyper-deformation, nuclei with unusual shapes), abnormally large numbers of neutrons or protons (neutron-rich and proton-rich nuclei), and superheavy nuclei with proton number Z > 110. Studies of nuclear-matter properties in such extreme conditions give important information about the properties of the microworld, and allow simulation of processes that occur in the universe.

The symposium was hosted by the Immanuel Kant Baltic Federal University, which is well known for training staff of

The symposium attracted around 160 participants. (Image credit: JINR.)

the highest calibre and for the organization of joint scientific research. The scientific programme included invited reports on the latest trends in the physics of exotic nuclei and new projects at the largest accelerator complexes and experimental facilities. In addition, round-table discussions were organized where leading scientists from various scientific centres around the world exchanged their views on co-operation in fundamental physics and applied research.

The results of the latest experiments on the synthesis and study of nuclei properties of new superheavy elements were a highlight of the symposium. Here, the discovery of new superheavy elements shows the effectiveness of international collaborations. Interesting results have been obtained in joint research by JINR's Flerov Laboratory of Nuclear Reactions (FLNR), GSI, and the Paul Scherrer Institute in Switzerland, in experiments on the chemical identification of elements 112 and 114 in beams at the FLNR's U-400 cyclotron. Another shining example of successful co-operation is the experiment on the synthesis of element 117, in collaboration with scientists from American laboratories who provided the target of ^{249}Bk, which was undertaken at the FLNR cyclotron by a large group of physicists and chemists under the guidance of Yuri Oganessian.

A day in the symposium agenda was devoted to present and future accelerator complexes for heavy ions and radioactive nuclei in leading scientific centres. A new generation of accelerators developed at the laboratories represented by the co-organizers of the symposium will allow advancement in the synthesis and studies of the properties of new exotic nuclei. These projects are SPIRAL2 at GANIL, the RI Beam Factory at RIKEN, the Facility for Antiproton and Ion Research in Darmstadt, the DRIBs and NICA projects at JINR, and the Facility for Rare Isotope Beams in Michigan.

● The around 80 oral presentations and 40 poster reports will be published in a standard issue of *Proceedings of the International Symposium "EXON"*.

Workshop

Low-energy QCD with strangeness in Trento

Participants at ECT in Trento. (Image credit: C Curceanu.)*

Experts and young researchers from across the world met at the European Centre for Theoretical Studies in Nuclear Physics and Related Areas – ECT* – in Trento on 27–31 October, for the international workshop Achievements and Perspectives in Low-Energy QCD with Strangeness. The participants discussed the most recent achievements and future perspectives in strangeness nuclear physics, debating the possible role of strangeness in astrophysics and the universe.

With a mass between that of light and heavy quarks, the strange quark represents the ideal testing ground for low-energy QCD theories, such as chiral symmetry breaking, which together with the Higgs mechanism is supposed to give mass to the visible universe. At the intersection of nuclear and particle physics, strangeness nuclear physics plays an important role in contemporary physics, being a rapidly evolving field with new data coming from experiments worldwide.

Among recent experimental results, an intriguing situation is represented by the so-called "deeply bound kaonic nuclei" (DBKN), where the presence of a strange (anti)quark in the nuclei might bind it by tens of millions of electron volts per nucleon, according to some theories. New results in this sector obtained by the AMADEUS, FINUDA, FOPI, HADES and E15 collaborations were discussed at the workshop, together with future perspectives.

Currently, there is no clear, universally accepted experimental signature of the existence of DBKN. The search for them proceeds in parallel with developing a deeper understanding of the underlying processes in the interaction of strange particles with ordinary nuclear matter. In addition, a plethora of new results in strangeness physics obtained by the BESIII and CLAS collaborations were reported on and discussed during the workshop.

The study of kaonic atoms provides another tool for obtaining valuable information for low-energy QCD. Following the first exploratory measurement of kaonic deuterium by the SIDDHARTA collaboration at the DAΦNE facility at the Frascati National Laboratory, a precision measurement is planned by the SIDDHARTA-2 collaboration. Combined with SIDDHARTA's measurement of kaonic hydrogen, it will enable the first extraction of the isospin-dependent antikaon–nucleon scattering lengths – fundamental quantities for understanding low-energy QCD in the strangeness sector.

On the theoretical side, refined calculations and methods are yielding results with continuously improving precision, which together with the experimental results allows a better and more accurate understanding of the processes occurring in the low-energy QCD sector. The techniques include effective field theories, lattice calculations – where new results were shown by Ulf-G Meißner – and few- and many-body approaches.

Another rapidly evolving field – especially following the discovery of neutron stars of two solar masses – is the study of the possible role of strangeness in astrophysics. The equation of state for neutron stars including strangeness (hyperons or kaons), or even (strange) quark stars or strangelets, is a flourishing field of research. Discussions on the possible role of strangeness in neutron stars followed presentations by Alessandro Drago, Ignazio Bombaci and Andreas Schmitt. The study of the neutron-rich hypernuclei might help in understanding the processes involved, as Avraham Gal, Emiko Hiyama and Francesco Pederiva showed.

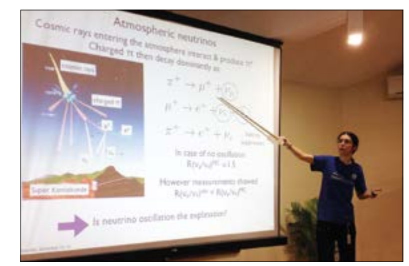
Wolfram Weise, director of ECT*, presented a fascinating report on pending issues in low-energy strong interactions with strangeness. In addition, 10 years of the EU-supported HadronPhysics Integrating Activities in Europe was celebrated in a talk by Carlo Guaraldo, the project's co-ordinator.

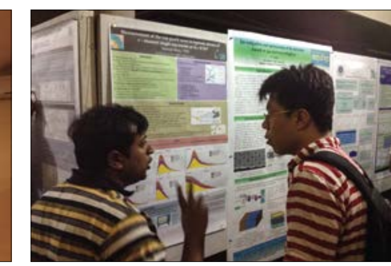
The workshop was organized by Catalina Curceanu (LNF-INFN, Italy), Laura Fabbietti (Excellence Cluster, TUM, Germany), Carlo Guaraldo (LNF-INFN, Italy), Jiri Mares (Nuclear Physics Institute, Rez Prague, Czech Republic), Johann Marton (SMI-Vienna, Austria) and Ulf-G Meißner (Bonn and FZ Jülich, Germany).

● For all of the presentations, see www.oeaw.ac.at/smi/research/topics/strong-interaction/leannis-hp3/leannis-meetings/meeting-october-2014/.

Schools

Asia-Europe-Pacific school goes to India





Left: A student presents the results of a project on behalf of her group. Right: Students from India and China discuss physics research during a poster session in Puri. (Image credits: N Ellis.)

Following its successful launch in Japan in 2012, the second Asia-Europe-Pacific School of High-Energy Physics (AEPSHEP), took place in Puri, Orissa, in India, on 4–17 November. In addition to teaching the participants about particle physics and related disciplines, an important objective for the school is to foster cultural exchange and networking between young researchers from different countries.

A total of 64 students, of 22 different nationalities, took part in an intense programme of lectures and discussion sessions. The students also presented and discussed their own research work in an informal evening poster session, and participated in group project work. An effort was made to mix students from different countries in the discussion and project groups, as well as in the shared sleeping quarters. The school's teachers, from 11 different countries, also reflected the global nature of high-energy physics.

In addition to courses on numerous aspects of particle-physics theory, there were classes addressing instrumentation and detectors, and statistical techniques. The importance of training the next generation of young researchers was reflected in the fact that the directors-general of both CERN (by live video link) and KEK (in person) lectured at the school, on particle physics in Europe and in Asia, respectively.

The Indian physics community was well represented. The participants were welcomed via live video link by K Vijayaraghavan, secretary of the Department of Science and Technology, and Naba Mondal, leader of the India-based Neutrino Observatory, spoke about the country's work in high-energy physics. The regular teaching programme also included lecturers and a discussion leader from India.

An essential ingredient in experimental particle physics is the ability of researchers to work together in international teams, collaborating with colleagues from other countries to achieve a common goal. This was a motivation for the group projects. A general subject area was assigned to each group of about 12 students, who had to decide on a specific paper to study, and then share the work of in-depth study of different aspects (including theory and experimental set-up and techniques, as well as the data analysis) between the group members, and finally select a member of their group to represent them in an evening session. The students carried out their project work with great enthusiasm during free periods in the programme, culminating in a lively after-dinner session on the school's penultimate day.

In addition to the academic side of the school, thanks to the local organizers, the participants were able to experience many aspects of Indian culture, including visits to the Sun Temple at Konark, to numerous sites and temples in and around the city of Bhubaneswar, and to see Lake Chilka and its associated wildlife. They also had ample opportunity to appreciate excellent Indian food, including delicious dinners served in the open air, with live performances of Indian dance.

● The AEPSHEP schools are held every two years in countries of the Asia-Pacific region. The next will take place in China in 2016.

Accelerator schools join up in California

Participants at the joint school. (Image credit: A Pham, Michigan State University.)

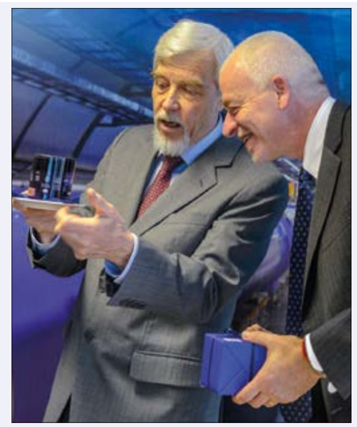
The CERN and US Particle Accelerator Schools recently organized a Joint International Accelerator School on Beam Loss and Accelerator Protection. Held in Newport Beach, California, on 5–14 November, this was the 13th in a series of such joint schools, which started in 1985 and also involve the accelerator communities in Japan and Russia.

The school in California attracted 58 participants representing 22 different nationalities, with around half from Europe and the other half from Asia and the Americas. The programme comprised 26 lectures, each of 90 minutes duration, together with 13 hours of case studies. The students were given homework each day, and had the opportunity to sit a final exam, which counted towards university credit. Feedback from the participants praised the expertise and enthusiasm of the lecturers, as well as the high standard and quality of their lectures.

Initial discussions in California between the heads of the schools resulted in a proposal that the next joint school, tentatively scheduled for spring 2017, will concentrate on RF acceleration systems.

Visits

While visiting Geneva to deliver a lecture at the UN, the president of Ecuador, **Rafael Correa Delgado**, left, took the opportunity to make a lightning visit to CERN on 24 October. This included a tour of the ATLAS experimental cavern, accompanied by the collaboration spokesperson, **Dave Charlton**, as well as the opportunity to meet the co-organizer of the CERN Latin America School of High-Energy Physics, which will be held in Ecuador in March. (Image credit: CERN-PHOTO-201410-214 – 12.)



On 27 October, **Lapo Pistelli**, right, the Italian vice-minister at Foreign Affairs and International Cooperation, visited CERN. After being welcomed by the director-general, **Rolf Heuer**, he was presented with a temperature-sensitive mug that depicts the history of the universe. A visit to the ATLAS experiment followed. (Image credit: CERN-PHOTO-201410-218 – 12.)

Sanja Vlahović, left, the minister of science of Montenegro, visited CERN on 1 December. Following a welcome by **Rolf Heuer**, her visit included the CMS experimental cavern, the Antiproton Decelerator facility and the computer centre, where she heard about the LHC Computing Grid project. (Image credit: CERN-PHOTO-201412-251-3.)

During a visit to CERN, also on 1 December, **Anne-Marie Descôtes**, centre-right, of the Directorate General of Globalization, Development and Partnerships in the French Ministry of Foreign Affairs and International Development, visited the LHCb experimental cavern, accompanied by LHCb collaboration members. (Image credit: CERN-PHOTO-201412-254-12.)

Computing

ALICE Grid family has a new member

On 3 November, CERN's director of research and computing, Sergio Bertolucci, and the secretary general of the Universidad Nacional Autonoma de Mexico (UNAM), Eduardo Barzana, signed a memorandum of understanding between UNAM and CERN for the operation of a Tier-2 centre for the ALICE Grid within the Worldwide LHC Computing Grid.

The inaugurated cluster has 1024 nodes and 570 TB of storage, and represents the second largest such structure in Latin America for ALICE. It is envisaged as a first step towards incorporating a full Tier-1 site on the premises, as planned in the initiative launched in 2011 jointly by Federico Carminati of CERN and Guy Paic, of the Instituto de Ciencias Nucleares of UNAM and a member of ALICE.

During the signature ceremony attended by Paolo Giubellino, ALICE spokesperson, and Latchezar Betev from CERN, and the directors of the IT division of UNAM, Felipe Bracho and Miguel Alcubierre, and the Instituto de Ciencias Nucleares, Fabian Romo, Lukas Nellen and Guy Paic, the importance of the project for the Mexican physics community's collaboration with ALICE was stressed. The next steps towards the implementation of the Tier1 centre were discussed during a two-day symposium organized for the occasion, with a focus on ways to involve more computing scientists in the operation.

Letters

The changing PS control room

The Faces & Places item in the November issue about CERN control rooms (p45) suggests that between 1963 and 1974 not much changed, but the picture at the top right of the sequence actually shows Jean-Pierre Potier using the first graphical display workstation, an IMLAC PDS-1. This was installed in 1971, with software that displayed the closed orbit and allowed computer control of the main dipole magnets of the Proton Synchrotron. That was an important step on the way to fully computerized control of the Super Proton Synchrotron a few years later.

I wrote the software, and was standing just out of sight when the photograph was taken. The picture also appears in a paper on "Injection and trapping of the beam at 800 MeV in the CPS" (D Boussard *et al.* 1974 *Proc. IXth International Conf. on High Energy Accelerators* (Stanford 1974) pp 475–479).

● *Brian Carpenter, University of Auckland.*

Brian Carpenter with the IMLAC PDS-1 in 1971. (Image credit: CERN-CO-7110231.)

A crazy idea

I was interested to read the article on CP violation in the November issue of *CERN Courier*, and would like to comment about the sentence that begins at the bottom of the left-hand column on p33: "Pier Oddone, together with Ikaros Bigi and Tony Sanda, proposed…[producing] boosted neutral B mesons using asymmetric pairs of e^+ and e^- beams tuned to the $\Upsilon(4S)$ resonance."

I am a fan of novel ideas, in particular "crazy" ones, and indeed Tony Sanda and I discussed the possibility of using asymmetric e^+e^- collisions with Pier at a dinner during a workshop in Los Angeles. However, it was Pier who not only suggested the idea but also produced the way to do it in reality. I was very excited straight away, but of course I am a theorist. Afterwards, I talked to other experts about using asymmetric collisions. They told me that it was indeed a crazy idea, but I loved it and continued to ask other people. Tony Sanda followed it further, telling Japanese experts to learn about it and do it. They did!

● *Ikaros Bigi, University of Notre Dame du Lac.*

Is 5σ necessary?

The feature in the November issue on the g-2 ring repeats the belief that a 5σ discrepancy is needed for a discovery. In my opinion, this is rubbish. If generally adopted, physics would be frozen. Many famous signals have been less than this: the deflection of light by the Sun, solar neutrinos, the missing solar neutrinos, Kamiokande's 11 neutrinos from the 1987 supernova, weak neutral currents, and the W boson. More recently, the brightness of distant supernovae was only 2–3σ less than predicted. Fixing it up with dark energy won the Nobel prize (for an alternative explanation, see Farley 2010 *Proc. Roy. Soc.* **A466** 3089).

In a graph with many points, a bump of 2σ will show up once in every 200. So yes, if you do not know where to look, then a 5σ bump is required. The clinching evidence for the Higgs boson was that both ATLAS and CMS saw a bump in the same place. But if you are testing one predicted number, 2σ is interesting, 3σ is huge.

For 10 years theorists have tried to explain the 3–4σ discrepancy for the muon g-2. The result is sound. Three quasi-independent measurements, all agreeing with each other, are well above theory. The conclusion is inescapable: the Standard Model cannot explain this result; it is only a pointer to new physics. But g-2 is only one number. It cannot say which of the many hypotheses is correct. For that we need a new discovery – and 3σ will be fine.

● *Francis J M Farley, University of Southampton. From 1957 at CERN he measured the muon g-2 in three successive experiments, including two with muon storage rings in close collaboration with Emilio Picasso (see p19 this issue).*

OBITUARIES

Agnès Orkin-Lecourtois 1925–2014

En juin 2014, la physicienne Agnès Orkin-Lecourtois disparaissait à l'âge de 88 ans. Au cours de sa carrière, elle participa à des expériences phare de la physique des particules, notamment sur l'interaction faible.

Agnès Orkin-Lecourtois naquit à Paris le 3 octobre 1925. Ses parents, juifs russes émigrés en France, se séparèrent et sa mère, tragédienne, se remaria avec un acteur de théâtre et de cinéma, Daniel Lecourtois. Il adoptera plus tard Agnès, d'où son double nom. Après la guerre, durant laquelle la famille se réfugia dans le sud de la France, Agnès poursuivit des études de sciences physiques à Paris. En 1950, elle intégra le Laboratoire de l'École Polytechnique de Louis Leprince-Ringuet. Avec Daniel Morellet, Louis Jauneau, Jean Crussard, Georges Kayas et Tchang-Fong Hoang, elle faisait partie de l'équipe qui étudiait les rayons cosmiques au moyen d'émulsions photographiques lancées par des ballons-sondes dans la stratosphère. Ce groupe étudiait notamment les mésons K. Elle travailla ensuite sur la technique des chambres à bulles à liquide lourd introduite à la fin des années 1950. Elle participa au développement des chambres à bulles à liquide lourd BP2 et BP3, précurseurs de

Agnès Orkin-Lecourtois en 1963, entourée de Viki Weisskopf, à gauche, alors directeur général du CERN, et Charles Peyrou, chef de la Division des Chambres à traces du CERN. (Crédit image : CERN-GE-6306155.)

Gargamelle. Elle vint au CERN préparer l'installation de BP3, dans le premier faisceau de neutrinos. Elle participa également aux travaux du groupe liquide lourd du CERN, dirigé par Colin Ramm (*CERN Courier* novembre 2014 p41).

Agnès Orkin-Lecourtois suivit André Lagarrigue lorsqu'il rejoignit en 1964 le Laboratoire de l'accélérateur linéaire LAL avec une grande partie de son équipe. Dans les années 1970, elle participa à la grande aventure Gargamelle qui mena à la découverte des courants neutres faibles en 1973, validant la théorie électrofaible. Agnès Orkin-Lecourtois contribua ensuite aux recherches avec les ISR, puis avec UA1 qui, dix ans après la découverte des courants neutres, mit en évidence les porteurs de l'interaction électrofaible.

Agnès Orkin-Lecourtois avait une personnalité d'une grande originalité. Très cultivée, elle vivait au milieu de milliers de livres qu'elle collectionnait. Elle aimait restaurer les vieilles pierres et conduire de belles voitures. Son esprit indépendant se traduisait dans le domaine de la physique par une grande intuition, beaucoup de persévérance et des méthodes très personnelles qui la préservaient des dérives liées aux gigantismes et à l'informatisation de notre discipline.

● *Ses amis et anciens collègues.*

Martin Lewis Perl 1927–2014

Martin Perl, professor emeritus at the SLAC National Accelerator Laboratory, died unexpectedly on 30 September. His career encompassed elementary-particle physics from the bubble chamber to the colliding-beam era. Most notably, it included the discovery of the τ lepton, for which he won the Nobel prize in 1995.

Perl grew up in a middle-class Jewish family in Brooklyn, in an environment that encouraged his skills as a student and his interest in mechanics. After a term in the Merchant Marine and a stint as a chemical engineer at General Electric, his interests led him to enroll in physics at graduate school. He entered Columbia and did his PhD in the lab of Isidor I Rabi, using an atomic resonance method to measure the quadrupole moment of the sodium nucleus. There Perl absorbed elements of the Rabi tradition that he was not shy about passing on to his younger colleagues – the importance

Martin Perl in his office. (Image credit: SLAC.)

of meticulous care in reporting experimental results, of working on fundamental questions, and of choosing original problems outside of the mainstream.

Perl spent eight years as a professor at the University of Michigan, working on bubble chambers and hadronic reactions. In 1962, he was offered the opportunity to join the new accelerator laboratory, SLAC. He accepted, as he often related, against the advice and warnings of his Michigan colleagues. He had become fascinated by the problem of the relation between the electron and the muon. In the early days of SLAC, he mounted a number of experiments to look for differences between electron and muon interactions, and to search for new particles that could be produced in final-state radiation.

As the e^+e^- collider SPEAR began to be constructed at SLAC, Perl joined the group being organized by Burton Richter to construct a novel particle detector for this accelerator. The vision of this detector – later called the Mark I – was that it would provide a complete view of elementary-particle events, with imaging of charged and neutral particles and muons over a large solid angle. At the same time, Perl encouraged Yung-Su Paul Tsai, a SLAC theorist, to work out a complete description of the decay of a heavy lepton through weak interactions. He put forward the heavy-lepton search as one of the goals of the experiment in a short, and mainly ignored, final section of the Mark I proposal.

In 1974 – along with the discoveries of the ψ system of resonances and the jet structure of final states – events suggesting heavy-lepton production appeared in the Mark I data. These were events with one electron and one muon as the only visible particles in the final state. It seemed easy to dismiss them at the time. The Mark I detector's angular coverage was considerably less than 4π, and its muon and electron identification systems were weak by modern standards. The muon system contained only 1.7 absorption lengths of material. Electrons were identified as particles with four times minimum ionization in the shower counters. It was possible that both signals were dominated by fakes. But Perl and his colleagues evaluated the misidentification probabilities and argued that the events were real. If so, these events had no explanation in terms of particles known at the time.

It did not take long for theorists to realize that the increasing cross-section for hadron production in e^+e^- annihilation, newly measured by Mark I, could be fit using a charmed quark and a heavy lepton, with masses, by mysterious coincidence, within 100 MeV of one another. It took much longer for the experimental community to accept the observation of anomalous e–μ events. Perl was steadfastly confident in his analysis. Finally, in 1977, the Pluto and DASP experiments at DESY reported confirmation of the production of the new heavy lepton, τ.

In the 1980s, Perl worked on the successor experiment Mark II at the PEP collider at SLAC. In this period, he was involved in two more milestones in e^+e^--collider physics. First, he was the godfather of the first special-purpose precision vertex detector deployed in a colliding-beam environment. This detector, designed to measure the lifetime of the τ (0.3 ps), also enabled discovery of the unexpectedly long b quark lifetime (1.5 ps). Second, he contested the precision of measurements of τ branching-ratios by formulating a "1-prong problem" – that the sum of branching ratios for 1-prong channels did not add up to the total 1-prong rate. The Mark II group introduced new analysis methods that looked at the τ sample more holistically, and brought the uncertainties in the pattern of τ branching fractions below the percent level.

In the last phase of his life, Perl expressed concern over the dominance of large-scale particle-physics experiments, and the concomitant loss of opportunities for young people to think independently. He searched for and devoted himself to small-scale experiments of potentially high impact, in particular a search for fractional charge that used an elegant ink dropper and a video camera to test unprecedented amounts of material. He lobbied for new funding mechanisms that could allow young people to pursue their own creative ideas in the laboratory. He also continued to dispense advice and encouragement to members of succeeding generations.

Perl's discovery of the τ provides a striking example of a truly surprising discovery achieved in the context of big science. He showed us the level of vision, technical care and personal toughness that it takes to bring such a discovery from hints in the data to accepted scientific fact. As we work towards the next great breakthrough, he continues to inspire us.

● *His colleagues and friends.*

Tullio Regge 1931–2014

If mathematical insight into the fundamental properties of a physical system is the most important tool for a theoretical physicist, Tullio Regge was one of the most brilliant and creative minds of the second half of the 20th century. His contributions to both quantum theory and general relativity still have a profound impact worldwide.

Tullio graduated in Turin and gained his PhD from Rochester in the US. In 1961 he became a professor of relativity at Turin University, and then also a member of the Institute for Advanced Studies in Princeton until the early 1980s.

One of his first radically new ideas was the introduction of complex angular momenta for studying the behaviour of scattering amplitudes in strong interactions, therefore discovering the intimate relation between the famous "Regge poles", the bound states of the system and the power-law growth of the amplitudes. This opened the way to the Veneziano amplitudes and dual models, later reinterpreted as string theories.

Tullio also created the basis for the early theory of black-hole perturbations with John Wheeler, and discovered unsuspected symmetry properties of the 3-j and Racah

Tullio Regge, with Gabriele Veneziano, left, and Schu Martin, right. (Image credit: André Martin.)

coefficients. Most important, he created a completely new approach to general relativity based on a discretization of space–time, universally known as the Regge calculus. In this new approach he introduced a "triangulation" with four-dimensional polyhedra of the space–time. Regge calculus is widely applied to solve Einstein equations when lack of any symmetry prevents the use of analytical methods.

Leaving Princeton in 1979, Tullio went back to Turin where he founded a more group-theoretical approach to supergravity, usually known as the group-manifold or geometric approach, and worked extensively on (2+1)-dimensional quantum gravity. During this time he was a visiting scientist at CERN on several occasions. After 1995 he moved to the Politecnico in Turin, where he became deeply interested in an original approach to the three-dimensional Ising model, considered as a two-dimensional one whose graph has a very high genus.

As well as his pioneering work, mostly aiming at a formulation of a four-dimensional theory of quantum gravity, Tullio made other important contributions regarding the so-called Ponzano–Regge model, the physics of many-body systems and quantum vortices. He also wrote an elegant paper on the two-dimensional Ising model having a dodecahedral symmetry group that was later recognized as the symmetry of the fullerene molecule.

His outstanding contributions were recognized with the Heineman Prize for Mathematical Physics in 1964, the Cecil Powell Medal in 1987, the Einstein Award in

1979 and the Dirac Medal of the International Centre for Theoretical Physics in 1996.

Tullio was, in my opinion, the best mathematically minded Italian theoretical physicist after Enrico Fermi. Everyone who had the opportunity to collaborate with him – and I am one of those lucky people – was impressed by his power of reasoning and his non-conservative way of handling problems. He devoted time, talent and passion to spreading scientific knowledge, and produced a number of books – including one reporting his dialogues with Primo Levi – and many popular articles, which attracted many young people, including myself, to the world of physics.

An eclectic character of great humanity, endowed with enormous curiosity and charisma, Tullio had many other interests apart from physics. He was a pioneer in computer art and design, an active politician serving in the European Parliament and a fierce advocate for the rights of the disabled.

● *Riccardo D'Auria, Department of Applied Science and Technology, Politecnico of Turin.*

● For a short autobiographical text by Tullio Regge, see https://inspirehep.net/record/1330473/, and for recollections of Regge by Vittorio de Alfaro, see https://inspirehep.net/record/1330474/.

Eckart Lorenz 1938–2014

Eckart Lorenz, from the Max Planck Institute for Physics (MPI), Munich, passed away unexpectedly in Berlin on 21 June. A familiar face at CERN and other particle-physics laboratories, he also became a leading figure in gamma-ray astrophysics, applying his expertise in light and particle detection, in particular to imaging atmospheric Cherenkov telescopes (IACTs).

Eckart Lorenz was born on 7 June in 1938. His early memories were linked to the final phase of the Second World War and the loss of his father, to hunger, and the family's escape from regions of active military actions. The by-then catastrophic situation only made him stronger, and in later life he seemed never to lose his high spirits.

When I first met Eckart in June 1990, he had already had a successful career in particle physics at CERN and other laboratories, working in a number of well-known collaborations involving the Munich group. We started discussing the details of the newly planned array of five IACTs within the High-Energy Gamma Ray (HEGRA) cosmic-ray detector on La Palma, the Canary Islands. From the beginning I was deeply impressed by his wit and erudition. With his unquenchable energy Eckart became the motor and heart of HEGRA, and I had the good fortune to work with him for 24 years.

It was never any trouble for Eckart to try to solve a problem, if possible in the most cost-efficient way. The AIROBICC detector – AIRshower Observation By angle Integrating Cherenkov Counter – integrated in HEGRA was his idea and "baby". This 100-detector array was essentially planned and built by two people – Eckart and his PhD student, with the help of workshops of course. Only two months after installation of the electronics and the imaging camera on the first HEGRA IACT in the summer of 1992, we obtained the first signal of about 6σ from the Crab Nebula, which was the first confirmation of the gamma-ray emission from Crab Nebula – Eckart's credo was efficiency.

Eckart Lorenz. (Image credit: P Lorenz.)

While developing avalanche photodiodes (APDs) for the needs of IACTs, Eckart soon had the idea to use them for much improved positron-emission tomography (PET). A full-scale APD-based small-animal PET was built and successfully operated for a few years, offering a spatial resolution of around 2.2 mm, to be compared with the 6–8 mm resolution provided typically by commercial instruments. Today, there are commercial APD-based medical diagnostic instruments. Eckart's work initiated several commercial sensors. For example, Hamamatsu sells matrixes of APDs, as well as hybrid photodiodes, resulting from development work by Eckart, and he initiated at least three types of photomultiplier tube (PMT) produced by Electron Tubes Enterprises. He also pioneered using PIN diodes for reading out scintillator – now a widespread technique used in experiments at accelerators.

To me, Eckart was like Thomas Edison, who once confessed that whenever he had something in his hands, his first thought was about improving it. Eckart's technological know-how was for me unique, and not only for a physicist.

Though he retired 11 years ago, little changed as Eckart focused more on physics projects, teaching and educating young physicists. He was enthusiastic about the 17-m-diameter MAGIC gamma-ray telescope, which he shaped from the earliest days (*CERN Courier* June 2009 p20). He pioneered several new technologies: the reinforced carbon-fibre frame of the reflector, diamond-machined aluminium mirrors, a system for active mirror control, fast positioning of the telescope, PMTs with a hemispherical window, analogue signal conversion and transfer over optical fibres. MAGIC opened a new window in the electromagnetic spectrum – into the sub-100-GeV range – and some of the novel technologies played a key role in this. When the Cherenkov Telescope Array (CTA) collaboration started, Eckart became one of its most enthusiastic members, giving shape to the Large Size Telescope of 23 m diameter.

He chaired and was a member of many international committees, such as CERN's SPS and PS experiments Committee, the DESY Physics Advisory Committee, the Particle and Nuclear Astrophysics and Gravitation International Committee, the Joint Astrophysics Division of the European Physical and Astronomical Societies, the Scientific Committee of the Gran Sasso National Laboratory, and the Science Advisory Committee of the IceCube experiment. He supervised 35 PhD and 13 undergraduate (diploma) theses.

On 22 May, Eckart was invited to the Polish embassy in Berlin and accepted into the Academy of Sciences of Poland. Shortly before the end of the ceremony, while in high spirits, he collapsed and never recovered. He passed away a month later.

Most scientists who knew him will remember Eckart as a brilliant colleague who made important contributions to current high-energy physics, astroparticle physics and the physics of cosmic rays.

Our great respect and admiration go out to him.

● *Razmik Mirzoyan, MPI, Munich.*

Samuel Krinsky 1945–2014

Samuel Krinsky, senior physicist at Brookhaven National Laboratory, passed away on 26 April. He died at age 69, soon after receiving a diagnosis of an aggressive form of brain cancer.

With a BS in physics from MIT in 1966 and a PhD in physics from Yale University in 1971, Krinsky took a research associate position at Stony Brook University, where he met Martin Blume. Recognizing his abilities, Blume took Krinsky to Brookhaven Lab, where he was to spend his entire career.

Krinsky started as an assistant physicist in the physics department in 1973 and received tenure in 1980, after transferring to the AGS department in 1977, where he began learning accelerator physics under Kenneth Green and Renata Chasman. Together with John Blewett, Krinsky, Chasman and Green formed the nucleus of the group that became the National Synchrotron Light Source (NSLS) department in 1982, the year the NSLS began operations as a user facility.

When Green and Chasman died in 1977, Krinsky was the only accelerator theorist on the team. One indication of his capability was his early design of a 12 super-period X-ray ring similar to what would later be called a third-generation light source. Deemed too risky, it was abandoned in favour of the eight super-period ring that was eventually built at NSLS. Krinsky had shown tremendous foresight, designing a ring of lower emittance and with 12 straight sections for insertion devices. Even at this stage, he was extremely interested in developing wigglers and undulators for use with electron accelerators as light sources – a passion that drove most of his career.

Samuel Krinsky. (Image credit: BNL.)

Unlike others in the group, who had worked only with proton machines, Krinsky appreciated the importance of good vacuum, stable magnets and good component alignment for precision light sources, and pushed hard for these basics for NSLS. He was also a major driver for development of the global orbit-feedback system, for which the group won an R&D 100 award from *R&D Magazine* in 1989.

Krinsky also made outstanding contributions to both theory and experiments for an X-ray free-electron laser (FEL), receiving the International FEL Prize in 2008. His work with Li-Hua Yu and the late Robert Gluckstern had a significant impact on the advent of X-ray FELs. He is credited for conceiving of and building Brookhaven's Source Development Laboratory (SDL), where the demonstration of the outstanding qualities of a high-gain, harmonic-generation FEL operating in deep-ultraviolet mode has played an important role in seeding FEL projects worldwide.

At NSLS, Krinsky was promoted to senior physicist in 1985 and served in various leadership roles. In January 2008, he became group leader of accelerator physics in the project to construct NSLS-II. At the time of his death, he was managing the accelerator-physics group within the Photon Sciences Directorate.

It was Krinsky who proposed the actual concept of the NSLS-II accelerator – the combination of a double-bend achromat lattice complemented with damping wigglers. This made possible the natural succession of the NSLS ring to NSLS-II – a brighter, more controllable and more complex accelerator system, which will be superior in many ways and by many orders of magnitude.

On a personal level, Krinsky is remembered for guiding his group, educating his scientists and bringing the NSLS-II storage-ring design to completion. His door was always open and his staff discussed their projects with him all day. There was no problem that he would not help with his advice, wisdom and experience.

Krinsky is survived by his wife, Faith, and daughter, Sylvia. Son Benjamin died of the same form of brain cancer in 1999, while a student at MIT.

● *Richard Heese, Timur Shaftan, Ferdinand Willeke and Li-Hua Yu, Brookhaven National Laboratory.*

Theodore Todorov 1966–2014

Teddy Todorov, who did important work on DELPHI, CMS and ATLAS, died in an accident on Mont Blanc on 19 October.

Teddy prepared his PhD, which he defended in 1993, at IReS-Strasbourg on the DELPHI experiment at CERN's Large Electron–Positron (LEP) collider. He was then recruited by CNRS, and moved on to the CMS experiment, being built at the LHC. In 2007, he moved to the Laboratoire d'Annecy-le-Vieux de physique des particules (LAPP-Annecy) and joined the ATLAS experiment.

Teddy Todorov. (Image credit: Sarka Todorova.)

During his PhD, as a member of the DELPHI experiment, he measured the hadronic decays of the Z^0 boson and extracted Standard Model parameters, having developed fits to the data. He presented the DELPHI results in a CERN seminar in 1994.

When he joined the CMS experiment in the 1990s, he very quickly became the maestro of the CMS core software. He was

Faces & Places

among the architects of the initial CMS offline software, and trained many of the people who are managing and developing the CMS software today. Much of the CMS core software still bears Teddy's hallmark.

On joining ATLAS and LAPP-Annecy in 2007, Teddy initiated and co-ordinated the development of a new concept for the future ATLAS tracking detector, which he baptized the "Alpine layout". He was active on all fronts of the experiment – the mechanics, electronics, detector description, tracking software, and the setting up to prove the validity of his concept. In parallel, he led the LAPP team's participation in the construction and installation of the newly inserted fourth pixel layer (IBL) in ATLAS.

We miss our colleague Teddy but even more our friend: his smile, his voice, his way of pointing out the absurdity of some situations, his humour and his tact. We remember his great culture.

He loved the mountains and had a unique way of talking about them and about his treks. He loved the days out with his family.

Our thoughts go to Sarka, Helena and Katya.

● *His colleagues and friends.*

Meetings

The **17th Lomonosov Conference on Elementary Particle Physics** will be held at Moscow State University on 20–26 August. The programme includes electroweak theory, Brout–Englert–Higgs physics, tests of the Standard Model and beyond, neutrino physics, astroparticle physics, gravitation and cosmology, developments in QCD, heavy-quark physics, and physics at present and future accelerators. The International Year of Light (2015) will be celebrated with a special round-table discussion on "Particle physics in the Year of Light: from Maxwell's equations to physics beyond the Standard Model". For further details and registration (deadline 1 March), see www.icas.ru/english/LomCon/17lomcon/16lomcon_main.htm.

PHOTON 2015, the International Conference on the Structure and the Interactions of the Photon, will take place at the Budker Institute of Nuclear Physics, Novosibirsk, on 15–19 June. The conference includes the 21st International Workshop on Photon–Photon Collisions and the International Workshop on High Energy Photon Linear Colliders. Recent progress in understanding photon–photon and photon–proton processes will be presented, as well as recent results on astrophysics and prospects for photon colliders, new acceleration techniques and future accelerators. For further details on registration (deadline 10 May), abstract submission, etc, visit photon15.inp.nsk.su.

Corrections

Unfortunate errors occurred in two obituaries in the November issue of *CERN Courier*. The caption for the photo of Colin Ramm (p41) is of him as dean at the University of Melbourne, not as dean at the University of Western Australia, which was his alma mater. Bruno Zumino (p43) died on 21 June, not 22 June as stated. Because he died around midnight, there was initial confusion about the date of his death. Apologies to all concerned.

Recruitment

For advertising enquiries, contact *CERN Courier* recruitment/classified, IOP Publishing, Temple Circus, Temple Way, Bristol BS1 6HG, UK.
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eli Nuclear Physics

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IFIN-HH – ELI-NP is organizing competitions for filling the following positions: Senior and Junior Researchers, Postdoctoral research assistants, Engineers and Technicians. The job description, the Candidates' profiles and the Rules and Procedures of Selection can be found at www.eli-np.ro.

The applications shall be accompanied by the documents requested in the Rules and Procedures of Selection for these positions.

The applications shall be sent to the Human Resources Department at human.resources@eli-np.ro.

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Email: janis.davidson@stfc.ac.uk
Closing date for applications: 27th February, 2015

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CERN Courier January/February 2015

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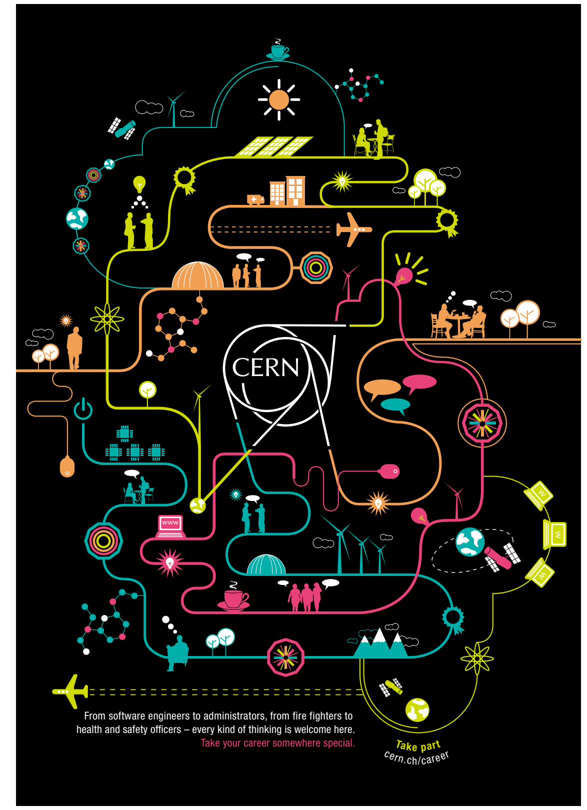

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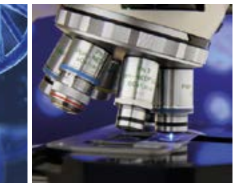

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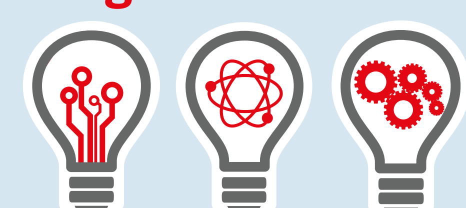
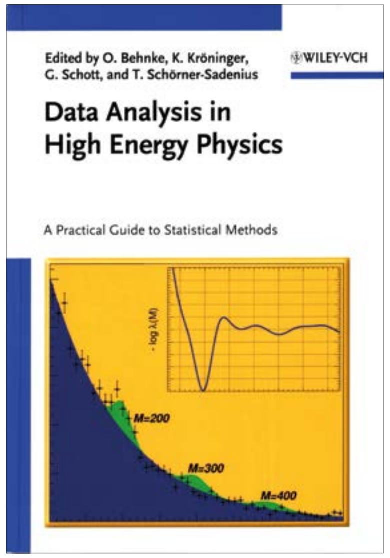


The jobs site for physics and engineering

Bookshelf



Data Analysis in High Energy Physics: A Practical Guide to Statistical Methods
By Olaf Behnke, Kevin Kröninger, Grégory Schott and Thomas Schörner-Sadenius (eds)
Wiley
Paperback: £60 €72
E-book: £48.99 €61.99
Also available at the CERN bookshop

This book is actually 11 books in one, with 16 authors, four of whom are also editors. All are high-energy physicists, including one theorist, and all are experts in their assigned areas of data analysis, so the general level of the book is excellent. In addition, the editors have done a good job putting the 11 chapters together so that they work as a single book, and they have even given it a global index. Still, each chapter has its own author(s) and its own style, and I will comment on the individual contributions that I found most interesting.

Roger Barlow ("Fundamental Concepts") gives a good introduction to the foundations, but surprisingly he has some trouble with frequentist probability, which is the one that physicists understand best because it is the probability of quantum mechanics. Instead of taking an example from physics, where experiments are repeatable and frequentist probability is applicable, he uses life insurance and finds problems. But his example for Bayes's theorem works fine with frequentist probabilities, even if they are not from physics.

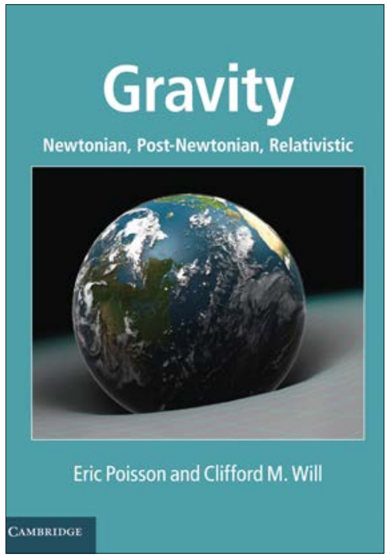
Olaf Behnke and Lorenzo Moneta ("Parameter Estimation") have produced a useful practical guide for their chapter. The treatment is remarkably complete and concise. I especially liked figure 2.9, which illustrates the fit of a typical histogram to a single peak, showing the value of chi-square as a function of peak position across the whole range of the abscissa, with a local minimum at every fluctuation in the data.

Luc Demortier ("Interval Estimation") displays an impressive knowledge of both frequentist and Bayesian methodologies, and is careful to list the good and bad features of both in a level of detail that I have seen nowhere else, and did not expect to find in a "practical guide". He succeeds in presenting a balanced view overall, even though his personal prior shows through in the first sentence, where the point estimate is intuitively defined as "in some sense the most likely value", instead of the more tangible "in some sense the value closest to the true value".

The most remarkable aspect of this book is found in the chapters devoted to topics that are not usually covered in books on statistics. Therefore "Classification" (by Helge Voss) is treated separately from "Hypothesis Testing" (by Grégory Schott), describing techniques that are common in data analysis but not used in traditional statistics. In "Unfolding", Volker Blobel reminds us that statistics is really an inverse problem, although it is not usually treated as such. There are two separate chapters on "Theory Uncertainties" and other "Systematic Uncertainties", a chapter on "Constrained Fits" and two chapters on "Applications", some of which duplicate subjects treated elsewhere, but of course from a different point of view. In the concluding chapter, Harrison Prosper, in his inimitable style, takes the reader on "a journey to the field of astronomy".

In summary, this ambitious project has produced a useful book where experimental physicists will find expert knowledge about a range of topics that are indispensable to their work of data analysis.

● *Fred James, CERN.*



Gravity: Newtonian, Post-Newtonian, Relativistic
By Eric Poisson and Clifford M Will
Cambridge University Press
Hardback: £50 $85
E-book: $68
Also available at the CERN bookshop

I heard good things about this book before I got my hands on it, and turning the pages I recognized a classic. Several random reads of its 788 large, dense pages offered a deeper insight into a novel domain, far away from my daily life where I work with the microscopic and cosmological worlds. On deeper inspection, it was nearly all that I hoped for, with only a couple of areas where I was disappointed.

The forward points out clearly that the reader should not expect any mention of cosmology. Yet the topic of the book has a clear interface with the expanding universe via its connection to our solar system, the so-called vacuole Einstein–Straus solution. Another topic that comes in too short for my taste is that of Eddington's isotropic (Cartesian) co-ordinates. They appear on pages 268–269, and resurface in a minor mention on page 704 before the authors' parametrized post-Newtonian approach is discussed. While this is in line with the treatment in the earlier book by one of the authors (*Theory and Experiment in Gravitational Physics* by C M Will, CUP 1993), it seems to me that this area has grown in significance in recent years.

The book is not about special relativity, but it is a topic that must of course appear. However, it is odd that Box 4.1 on pages 191–192 on "Tests of Special Relativity" relies on publications from 1977, 1966, 1941 and 1938. I can feel the pain of colleagues – including friends in particle and nuclear physics – who have worked hard during recent decades to improve

Bookshelf

limits by many orders of magnitude. And on page 190, I see a dead point in the history of special relativity – authors, please note. Lorentz failed to write down the transformation named after him by Poincaré, who guessed the solution to the invariance of Maxwell's equations, a guess that escaped Lorentz. However, Einstein was first to publish his own brilliant derivation.

We know that no book is perfect and complete, entirely without errors and omissions. So the question to be asked is, how useful is this book to you? To find the answer, I'd recommend reading the highly articulate preface available, for example, under "Front Matter" on the publisher's website. I quote a few words because I could not say it better: "This book is about *approximations* to Einstein's theory of general relativity, and their applications to planetary motion around the Sun, to the timing of binary pulsars, to gravitational waves emitted by binary black holes and to many real-life, astrophysical systems... this book is therefore the physics of weak gravitational fields."

Personally, I found in the book what I was looking for: the technical detail of the physics of large objects such as planets and stars, which can be as many times larger than the proton as they are smaller than the universe. I could not put the book down, despite its weight (1.88 kg). Some might prefer the Kindle edition, but I would hope for a shrunk-silk volume. Whichever you choose or is available, in dollars per page this book is a bargain. It is a great read that will enrich any personal library.

● *Johann Rafelski, University of Arizona.*

Books received

Next Generation Experiments to Measure the Neutron Lifetime: Proceedings of the 2012 Workshop
By Susan J Seestrom (ed.)
World Scientific
Hardback: £63
E-book: £47

The neutron lifetime is an important fundamental quantity, as well as a parameter influencing important processes such as nucleosynthesis and the rate of energy production in the Sun, so there is great interest in improving the limits of its value to a precision level of 0.1 s. This workshop, held in November 2012, aimed to create a road map of R&D for a next-generation neutron-lifetime experiment that can be endorsed by the North American neutron community. The focus was on experiments using traps with ultracold neutrons and confinement by a combination of magnetic and/or gravitational interaction to avoid systematic uncertainties introduced by neutron interactions with material walls.

Astroparticle, Particle, Space Physics and Detectors for Physics Applications: Proceedings of the 14th ICATPP Conference
By By S Giani, C Leroy, L Price, P-G Rancoita and R Ruchti (eds)
World Scientific
Hardback: £117
E-book: £88

Exploration of the subnuclear world is done through increasingly complex experiments covering a range of energy in diverse environments, from particle accelerators and underground detectors to satellites in space. These research programmes call for new techniques, materials and instrumentation to be used in detectors, often of large scale. The reports from this conference review topics that range from cosmic-ray observations through high-energy physics experiments to advanced detector techniques.

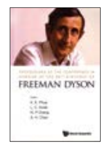
What We Would Like LHC to Give Us
By Antonino Zichichi (ed.)
World Scientific
Hardback: £104
E-book: £78

This book is the proceedings of the International School of Subnuclear Physics, ISSP 2012, 50th Course, held in Erice on 23 June–2 July 2012. The course was devoted to celebrations of the 50th anniversary of the subnuclear-physics school, started in 1961 by Antonino Zichichi with John Bell at CERN, and formally established in 1962 by Bell, Blackett, Weisskopf, Rabi and Zichichi in Geneva (at CERN). The lectures cover the latest, most significant achievements in theoretical and experimental subnuclear physics.

The Bethe Wavefunction
By Michel Gaudin (translated by Jean-Sébastien Caux)
Cambridge University Press
Hardback: £70 $110
E-book: $88

Available in English for the first time, this translation of Michel Gaudin's book *La fonction d'onde de Bethe* brings this classic work on exactly solvable models of quantum mechanics and statistical physics to a new generation of graduate students and researchers in physics. The book begins with the Heisenberg spin chain, starting from the co-ordinate Bethe ansatz and culminating in a discussion of its thermodynamic properties. Delta-interacting bosons (the Lieb–Liniger model) are then explored, and extended to exactly solvable models associated to a reflection group. After discussing the continuum limit of spin chains, the book covers six- and eight-vertex models in extensive detail, while later chapters examine advanced topics such as multi-component delta-interacting systems and Gaudin magnets.

Proceedings of the Conference in Honour of the 90th Birthday of Freeman Dyson
By K K Phua, L C Kwek, N P Chang and A H Chan (eds)
World Scientific
Hardback: £56
Paperback: £29
E-book: £22



As a tribute to Freeman Dyson on the occasion of his 90th birthday, and to celebrate his lifelong contributions in physics, mathematics, astronomy, nuclear engineering and global warming, a conference covering a range of topics was held in Singapore in August 2013. This memorial volume brings together an interesting lecture by Professor Dyson, "Is a Graviton Detectable?", contributions by speakers at the conference, as well as guest contributions by colleagues who celebrated Dyson's birthday at Rutgers University and the Institute for Advanced Study in Princeton.

Symmetries in Nature: The Scientific Heritage of Louis Michel
By Thibault Damour, Ivan Todorov and Boris Zhilinskii (eds)
World Scientific
Hardback: £83

Reflecting the oeuvre of "a man of two cultures: the culture of pure mathematics and the culture of theoretical physics", this volume is centred around the notion of symmetry and its breaking. Starting with particle physics, the content proceeds to symmetries of matter, defects and crystals. The mathematics of group extensions, non-linear group action, critical orbits and phase transitions is developed along the way. The symmetry principles and general mathematical tools provide unity in the treatment of different topics. The papers and lecture notes are preceded by a lively biography of Louis Michel, and a commentary that relates his selected works both to the physics of his time and to contemporary trends.

Viewpoint

Helping CERN to benefit society

Anne Richards describes the thinking behind a new foundation that is spreading CERN's spirit of scientific curiosity to benefit the widest possible public.

Anne Richards. (Image credit: CERN-PHOTO-201412-271-1.)

I first came to CERN as a student in the mid 1980s, and spent an entrancing summer learning the extent of my lack of knowledge in the field of physics (considerable!) and meeting fellow students from across Europe and further afield. It was a life-changing experience and the beginning of my love affair with CERN. On graduation I returned as a research fellow working on the Large Electron–Positron collider, but at the end of three wonderful years I reluctantly came to the realization that the world of research was not for me. I moved into a more commercial world, and have been working in the field of investments for more than 20 years.

However, as the saying goes, you can take the girl out of CERN but you can't take CERN out of the girl. I stayed in touch, and when, a few years ago, I met Rolf Heuer, the current director-general, and heard his vision of creating a foundation that would expand CERN's ability to reach a wider audience, I was keen to be involved.

Science is, in some respects, a field of study that is open largely to the most privileged only. To do it well requires resources – trained educators, good facilities, textbooks, access to research and, of course, opportunity. These are not available universally. I was fortunate to become a summer student at CERN, but that is possible for a lucky few only, and there are many places in the world where even basic access to textbooks or research libraries is limited or non-existent.

And to those outside of the field of science, there is not always a good understanding of why these things matter. The return on a country's investment in science will come years into the future, beyond short-term electoral cycles. There can appear to be more immediate and pressing concerns competing for limited spending, so advocacy of the wider benefits to society of investment in science is important.

The case for pure scientific research is sometimes difficult to explain. This is not just down to the concepts themselves, which are beyond most of us to understand at anything but a superficial level. It is also because the most fundamental research does not necessarily know in advance what its ultimate usefulness or practicality might be. "Trust me, there will be some" does not sound convincing, even if experience shows that this generally turns out to be the case.

Communication of the tangible benefits of scientific discovery, which can occur a long time after the initial research, is an important part of securing the ongoing support of society for research endeavours, particularly in times of strained financial resources.

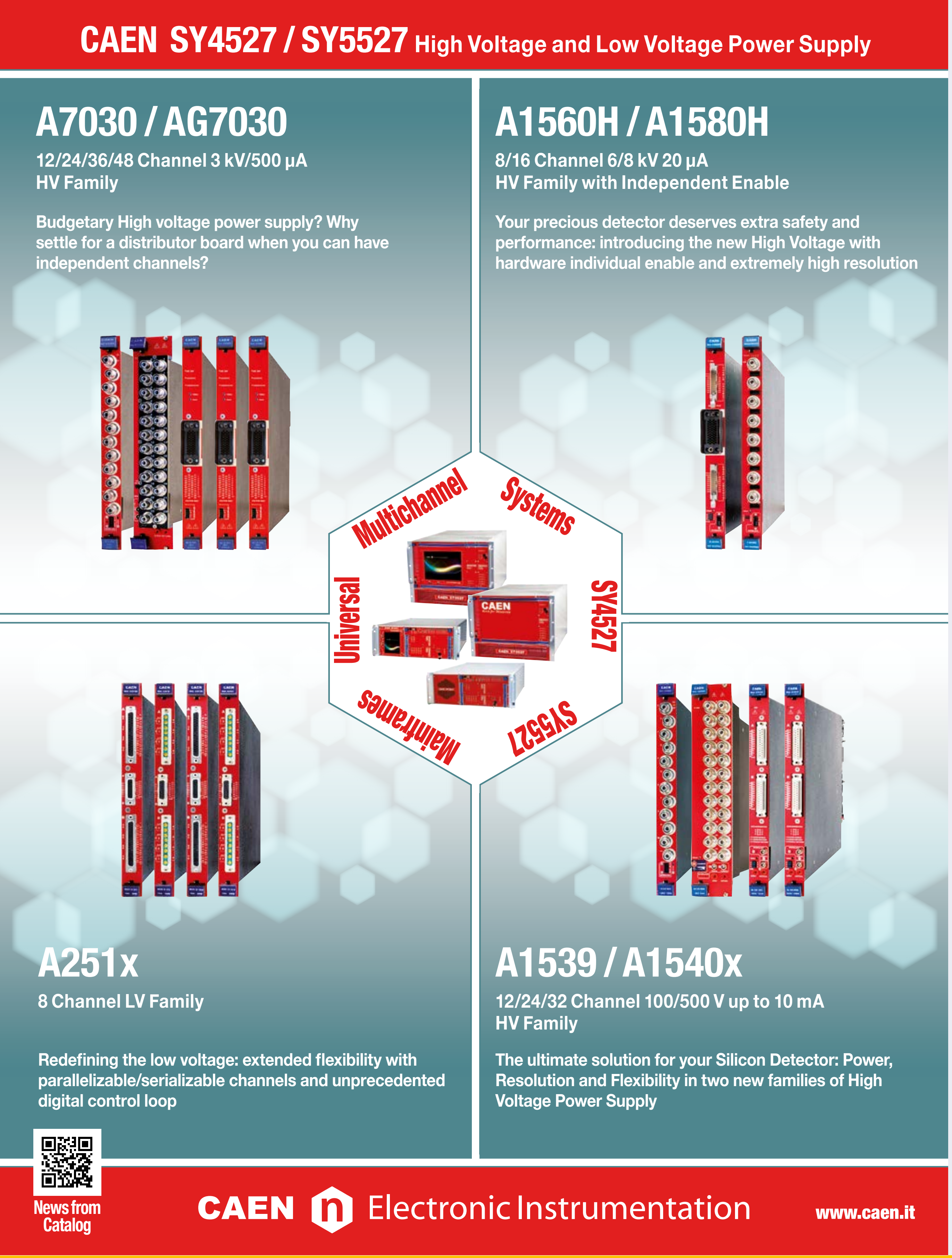
After many months of hard work, the CERN & Society Foundation was established in June 2014. Its purpose is "to spread the CERN spirit of scientific curiosity for the inspiration and benefit of society". It aims to excite young people in the understanding and pursuit of science; to provide researchers in less privileged parts of the world with the tools and access they need to enable them to engage with the wider scientific community; to advocate the benefit of pure scientific research to key influencers; to inspire cultural activities and the arts; and to further the development of science in practical applications for the wider benefit of society as a whole, whether in medicine, technology or the environment. The excitement generated by the LHC gives us a unique opportunity to contribute to society in ways that cannot be done within the constraints of dedicated member-state funding.

To translate this vision into reality will, of course, take time. The foundation currently has a three-person board, made up of myself, Peter Jenni and the director-general. It has benefited from some initial generous donations to get it off the ground and allow us to fund our first projects.

The foundation benefits from the advice of the Fundraising Advisory Board (FAB), which ensures compliance with CERN's Ethical Policy for Fundraising. It filters through ideas for projects looking for support, and recommends those that are likely to have the highest impact. The FAB, chaired by Markus Nordberg, consists of CERN staff who help us to prioritize the areas on which to focus. In our early years, we have three main themes where we are looking for support: education and outreach; innovation and knowledge exchange; and culture and the arts. With the help of CERN's Development Office, we are seeking support from foundations, corporate donors and individuals. No donation is too large or small.

Matteo Castoldi, heading the Development Office, has been instrumental in the practical side of the foundation, and is a good person to contact if you have ideas for a project, want help in formalizing a proposal for FAB or would like to discuss any aspect of the CERN & Society Foundation. Our website is up and running – please take a look to find out more, and if you would like to make a donation just click on the link. Thank you in advance for your support.

● *Anne Richards, chair of the CERN & Society Foundation board, is chief investment officer, Aberdeen Asset Management Ltd. For more about the foundation, visit http://giving.web.cern.ch.*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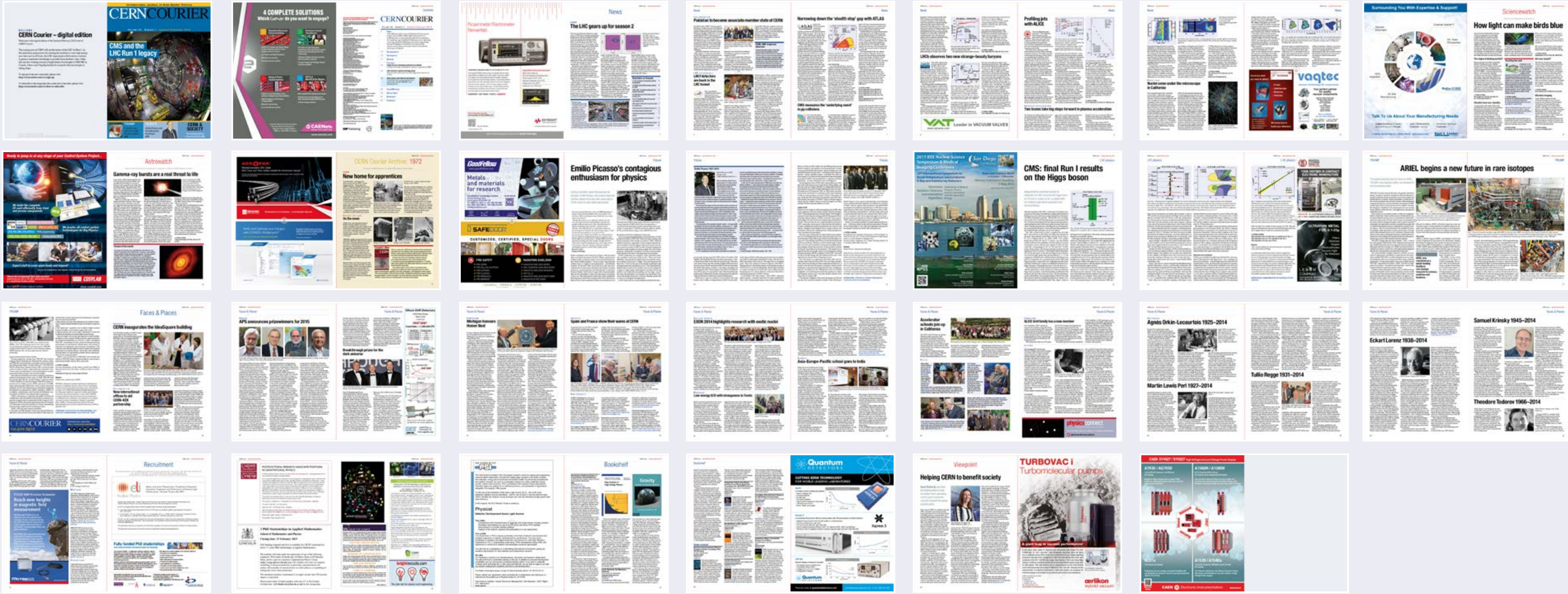

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Contents