WELCOME

CERN Courier – digital edition

Welcome to the digital edition of the July/August 2015 issue of *CERN Courier*.

Appropriately in the International Year of Light, SESAME, the first light source for the Middle East, is coming together in preparation for commissioning in 2016. The project is a working example of Arab–Israeli–Iranian–Turkish–Cypriot–Pakistani collaboration, and is already on its way to becoming the region's first truly international centre of excellence. Meanwhile, in Russia, Lake Baikal is on its way to becoming one of the world's largest neutrino telescopes, thanks to the detection of Cherenkov light in its deep, clear water. And out in space, the Planck mission detects the oldest light in the universe, and complements experiments at the LHC by studying fundamental phenomena at the opposite end of the distance scale.

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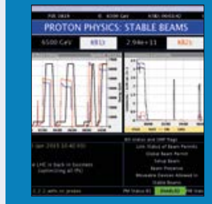
CERNCOURIER

VOLUME 55 NUMBER 6 JULY/AUGUST 2015

A bright light in the Middle East



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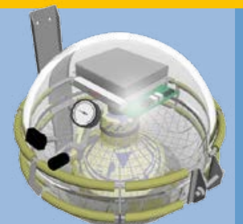

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Covering current developments in high-energy physics and related fields worldwide

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On the cover: The entrance to the SESAME building, the site of an exciting new international research centre for the Middle East (p19), 35 km north-west of Amman. (Image credit: CERN-PHOTO-201504-069-29.)

News

LHC Run 2

LHCf makes the most of a special run

Run 2 of the LHC may only just have officially begun, but the Large Hadron Collider forward (LHCf) experiment has already completed its data taking with proton–proton collisions at the new high energy of 13 TeV in the centre of mass. The experiment collected data in a special physics run carried out on 8–12 June, just after the start of Run 2.

The motivation of LHCf is to understand the hadronic interactions taking place when high-energy cosmic rays collide with the Earth's atmosphere, producing bunches of particles known as air showers. These air showers allow the observation of primary cosmic rays with energies from 10^{15} eV to beyond 10^{20} eV. Because a collision energy of 13 TeV corresponds to the interaction of a proton with an energy of 9×10^{16} eV hitting the atmosphere, the LHC enables an excellent test of what happens at the energy of the observed air showers.

The interaction relevant to air-shower development has a large cross-section, with most of the energy going into producing particles that are emitted in the very forward direction – that is, at very small angles to the direction of the incident particle. LHCf therefore uses two detectors, Arm 1 and Arm 2, installed at 140 m on either side of the interaction point in the ATLAS experiment (*CERN Courier* January/February 2015 p6).

For LHCf to be able to determine the production angle of individual particles, the experiment requires beams that are more parallel than in the usual LHC collisions. In addition, the probability for more than one collision in a single bunch crossing (pile-up) must be far smaller than unity, to avoid contamination from multiple interaction events. To meet these constraints, for the special run the beams were "unsqueezed" instead of being "squeezed", making them larger at the collision points. This involved adjusting magnets on either side of the interaction point to increase β^* – the parameter that characterizes the machine optics for the squeeze – to a value of 19 m. In addition, the collisions took place either with low beam intensities or with beams offset to each other to reduce pile-up.

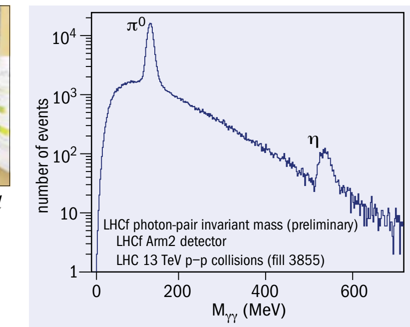
In the LHCf control room during the special physics run. (Image credit: LHCf Collaboration.)

The first collisions for physics ("stable beams") were provided at midnight on 10 June with very low pile-up, followed until noon on 13 June by a total of six machine fills providing various pile-up values ranging from 0.003 to 0.05. This allowed LHCf to take more than 32 hours of physics data, as scheduled.

Even with a luminosity of 10^{29} cm^{-2} s^{-1} – five orders of magnitude below the nominal LHC luminosity – the LHCf detectors achieved a useful data rate of > 500 Hz, recording about 15% of inelastic interactions with neutral particles of energies > 100 GeV. A preliminary analysis during the run showed the clear detection not only of π^0 mesons but also of η mesons, which had not been the case with the data at the collision energy of 7 TeV in Run 1.

A highlight of the operation was collaboration with the ATLAS experiment. During the special run, trigger signals in LHCf were sent to ATLAS, which recorded data accordingly. The analyses of such common events will enable the classification of events based on the nature of processes such as diffractive dissociation and non-diffractive interactions.

The LHCf detectors were removed from the LHC tunnel on 15 June during the first technical stop of the LHC, to avoid the radiation damage that would occur with the increasingly high luminosity for Run 2.



Invariant-mass distribution of photon-pair events (preliminary). The two clear peaks at 135 MeV and 548 MeV correspond to the π^0 and η, respectively.

Stable beams at 13 TeV

At 10.40 a.m. on 3 June, the LHC operators declared "stable beams", signalling the official start of Run 2, see pp25–28. The LHC experiments are now ready to take data at the unprecedented collision energy of 13 TeV and, as this page shows, LHCf has already collected all of the data it requires.

Sommaire en français

NEUTRINOS

Fifth event signals discovery of ν_τ appearance

OPERA – the Oscillation Project with Emulsion-tRacking Apparatus experiment at the INFN Gran Sasso Laboratory – has detected the fifth occurrence of a tau neutrino (ν_τ). Setting out from CERN as a muon neutrino (ν_μ), the particle was detected at Gran Sasso as a ν_τ after travelling 730 km through the Earth. This detection of a fifth ν_τ firmly establishes the direct observation of the transition from ν_μ to ν_τ, with a statistical precision of 5σ, the now standard threshold for a discovery in particle physics.

The international OPERA experiment, which involves about 140 physicists from 26 research institutes in 11 countries, was designed to observe this exceptionally rare phenomenon, gathering data in the neutrino beam produced by the CERN Neutrinos to Gran Sasso (CNGS) project (*CERN Courier* November 2006 p24). A small fraction of the incoming neutrinos interacted with the giant detector, consisting of more than 4000 tonnes of material, with a volume of some 2000 m^3 and some nine million photographic plates, to produce the particles observed. After detecting the first few ν_μ produced at CERN in 2006, the experiment has collected data for five years, from 2008 to the end of 2012. The first ν_τ was observed in 2010. The second and third events were reported in 2012 and 2013, respectively, while the fourth one was announced in 2014 (*CERN Courier* May 2014 p9).

The OPERA collaboration will continue to analyse the data collected, searching for other ν_μ to ν_τ transitions, and possibly also measure the oscillation parameters, for the first time using oscillated ν_τ.

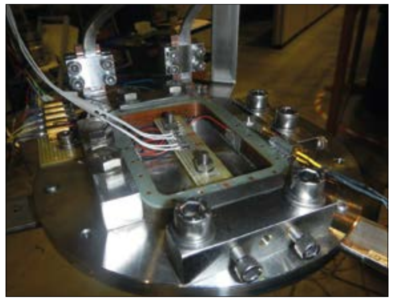
ACCELERATORS

HL-LHC begins the move from paper to hardware

The design study for the High-Luminosity LHC (HL-LHC) project is now approaching completion. The conceptual design is completed for most of the magnets, engineering is in progress, and the first hardware that will be used in the prototypes is being manufactured and tested. Recent months have seen successful tests of some of the magnets that will be essential for this high-luminosity upgrade (*CERN Courier* March 2015 p28).

The interaction regions of the HL-LHC will contain nine different types of new magnet, relying on three different technologies – Nb_3Sn and Nb-Ti superconductors in the form of Rutherford cable, and superferric magnets with Nb-Ti coils. These magnets are in the design and prototype phase, being developed internationally by the US LHC Accelerator Research Program (US-LARP), the CIEMAT research centre in Spain, CEA Saclay in France, the INFN-Milano LASA laboratories and INFN-Genova in Italy, and KEK in Japan.

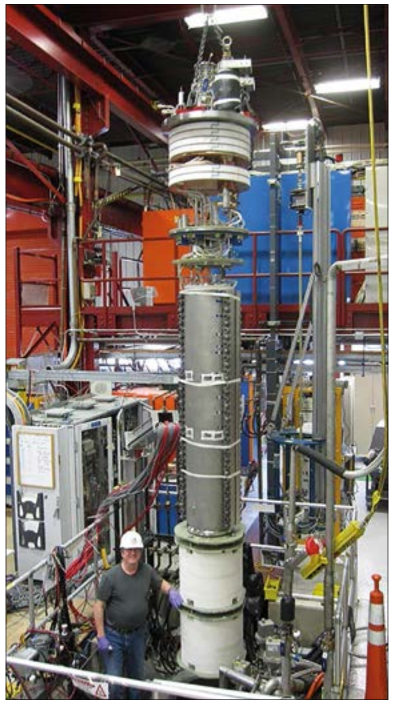
In April, the winding and impregnation of the first coil of the superferric sextupole corrector was completed and successfully tested as a stand-alone coil in the INFN-LASA laboratories. The coil had a first quench at 80% of the short-sample limit – the maximum field achievable in the magnet – and reached 91% after three quenches at 2.5 K. In these correctors, the operational current is set at 60% of short-sample limit. This was the first test of a component of the HL-LHC interaction-region magnets, with an operational peak field in the coil of 2.3 T.



The coil of the sextupole corrector. (Image credit: G Volpini/LASA.)

In May, the first short coil for the Nb_3Sn quadrupoles, manufactured by the US-LARP collaboration, was tested in a mirror configuration at Fermilab. The coil had a first quench at 70% of the short-sample limit, a second one at 76%, and reached 90% after 20 quenches. The triplet will operate at 75%, with a peak field of 11.5 T – a value that has been recently reduced from the original 80% to add some margin, following the advice of a review committee held at CERN in December.

Since the beginning of the year, coil-winding tests have been under way, both at KEK, for the 5.6-T Nb-Ti separation dipole (D1), and at Saclay, for the 115-T/m-gradient Nb-Ti quadrupole. An iteration of the design of the iron yoke was performed at KEK to guarantee a better alignment of the dipole field during assembly. At Saclay, the first tests have confirmed the correct geometry of the end spacers and of the coil components.



The mirror quadrupole entering the test station at Fermilab. (Image credit: G Chachidze/US-LARP.)

The next step is testing of the Nb_3Sn quadrupole short model this coming autumn. This is made up of two CERN coils, which have recently been shipped to the US, and two LARP coils. A test of the first corrector sextupole is foreseen in LASA at the end of the year, and a test of the first short model of the separation dipole will be carried out at KEK.

● Based on an article in acceleratingnews.web.cern.ch.

COMPUTING

Korean Tier-1 link upgrades to 10 Gbps

On 21 May, the Korea Institute of Science & Technology Information–Global Science experimental Data hub Center (KISTI-GSDC) – the Korean Tier-1 site of the Worldwide LHC Computing Grid (WLCG) – completed the upgrade to 10 Gbps of the bandwidth of its optical-fibre link to CERN. The link is part of the LHC Optical Private Network (OPN) that is used for fast data replication from the Tier-0 at CERN to Tier-1 sites in the WLCG.

KISTI-GSDC was approved as a full Tier-1 site at the 24th WLCG Overview Board in November 2013, backed by the ALICE community's appreciation of the effort to sustain the site's reliability and the contribution to computing resources for the experiment. At the time, the bandwidth of the dedicated connection to CERN provided by KISTI-GSDC was below that required, but the road map for upgrading the bandwidth was accepted.

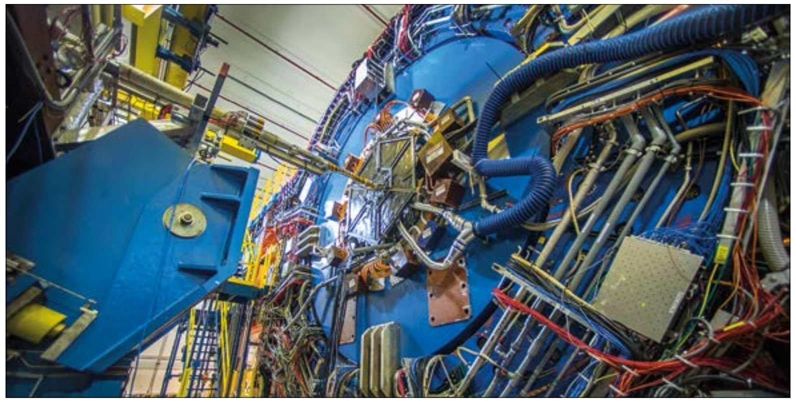
The LHC OPN link from KISTI-GSDC. (Image credit: Map data: © Google 2015, INEGI.)

The original proposal was to provide the upgrade of the OPN link by October 2014. However, following an in-depth revision of the executive plan with the Ministry of Science, ICT and Future Planning – the funding agency – to find the most cost-effective way, the upgrade process did not start until the end of February this year. It was finally completed just before the scheduled start of the LHC's Run 2 in May.

The OPN link between KISTI and CERN is composed of two sections: Daejeon–Chicago (operated by KISTI) and Chicago–Geneva (operated by SURFnet). An additional line to be switched on in case of any necessary intervention complements the link. The yearly budget is about CHF1.1 million.

HEAVY IONS

STAR helps to pin down a key phenomenon in gold collisions



The STAR detector at RHIC. (Image credit BNL.)

The STAR collaboration at the Brookhaven National Laboratory (BNL) has published new evidence indicative of a "chiral magnetic wave" rippling through the quark–gluon plasma created in high-energy gold–gold collisions at the Relativistic Heavy Ion Collider (RHIC).

Heavy-ion collisions at RHIC and the LHC involve many spectators – nucleons that are not involved in any direct collision. The charged spectators – protons – have an important influence because they can produce a magnetic field of some 10^{14} T. In principle, this can lead to a collective excitation in the hot dense matter produced, the chiral magnetic wave. It results from the separation both of electric charge and of chiral charge, that is, right or left "handedness", but only in a chirally symmetric phase. The phenomenon is predicted to manifest itself as an electric quadrupole moment of the collision system, where the "poles" and "equator" of the system acquire, respectively, additional positive and negative particles. This in turn influences differently the elliptic flow of positive and negative particles, decreasing the former and increasing the latter.

To look for this effect, STAR measured the elliptic flow, v_2, of π^+ and π^- produced in gold–gold collisions at mid-rapidity, as a function of the event-by-event charge asymmetry, A_{CH}, over a range of energies. The team found that v_2 increased linearly with A_{CH} for π^-, but decreased for π^+. At the highest energy, $\sqrt{s_{NN}} = 200$ GeV, the slope of the difference in v_2 between the π^+ and π^- as a function of A_{CH} depends on the centrality of the collision in a manner consistent with calculations that incorporate the chiral magnetic wave. The team also found a similar result for energies down to $\sqrt{s_{NN}} = 27$ GeV, with no obvious dependence on beam energy. The researchers note that none of the conventional models they have considered appear to explain the observations.

● Further reading

L Adamczyk *et al.* (STAR Collaboration) 2015 *Phys. Rev. Lett.* **114** 252302.

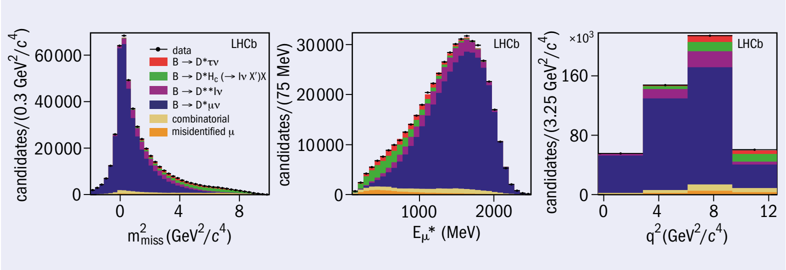
LHC EXPERIMENTS

$\overline{B}^0$ decay reveals an intriguing anomaly

At the Flavor Physics and CP violation (FPCP) conference in Nagoya, the LHCb collaboration presented a measurement of the rate of $\overline{B}^0 \to D^{*+}\tau^-\overline{\nu}_\tau$ relative to the related decay $\overline{B}^0 \to D^{*+}\mu^-\overline{\nu}_\mu$. The first measurement of any $B \to \tau X$ decay at a hadron collider, it also indicates a tantalizing anomaly.

In the Standard Model, the ratio of these two branching fractions differs from unity only as a result of effects related to the mass of the much heavier τ lepton. The ratio $R(D^*) = BR(\overline{B}^0 \to D^{*+}\tau^-\overline{\nu}_\tau)/BR(\overline{B}^0 \to D^{*+}\mu^-\overline{\nu}_\mu)$ is therefore precisely calculable in the Standard Model as equal to 0.252 ± 0.003.

Lepton universality dictates that the electroweak coupling strength of the electron, muon and tau are identical, with the three flavours distinguished only by their respective masses. So the observation of decays with differing rates to each lepton flavour, after accounting for mass effects, would be a clear sign of physics beyond the Standard Model. Owing to the large τ mass, the semitauonic $\overline{B}^0 \to D^{*+}\tau^-\overline{\nu}_\tau$ decay rate is particularly sensitive to the charged Higgs bosons predicted by many extensions of the Standard Model. Previous measurements have consistently been above predictions, making new results hotly anticipated.



One-dimensional projections of the 3D fit for $R(D^*)$ in each of the three fit variables: the invariant-mass squared of the neutrino system m^2_{miss}, the energy of the muon in the B^0 rest frame E^*_μ, and the invariant square of the momentum transfer q^2.

LHCb has analysed 3 fb^{-1} of data from Run 1 of the LHC to measure $R(D^*)$ using the $\tau \to \mu\nu_\mu\nu_\tau$ decay, which allows both the semitauonic and semimuonic mode to be reconstructed in the same final state. The two decays are distinguished via a fit to the decay kinematics, reconstructed using the visible decay products and an approximation for the rest frame of the B (see figure). In addition to the $\overline{B}^0 \to D^{*+}\tau^-\overline{\nu}_\tau$ and $\overline{B}^0 \to D^{*+}\mu^-\overline{\nu}_\mu$ decays, the $D^{*+}\mu^-X$ final state also receives large contributions from several background processes. The modelling of these backgrounds in LHCb is constrained using control samples in data, strongly controlling uncertainties due to theoretical models. The result presented of $0.336 \pm 0.027 \pm 0.033$ is in close agreement with a result from BaBar in 2012, and is 2.1σ away from the Standard Model prediction.

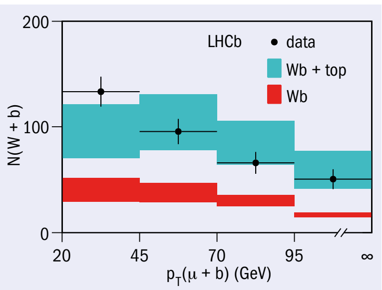
Between the results from LHCb, BaBar and the Belle collaboration – which also presented updated results at the conference – a tantalizing picture is emerging in this channel. LHCb already has plans for complementary measurements in the decays $B^- \to D^0\tau^-\overline{\nu}_\tau$ and $\Lambda^0_b \to \Lambda^+_c\tau^-\overline{\nu}_\tau$ with the LHC Run 1 data set, and data from Run 2 is expected to allow for exciting improvements.

LHCb observes top production in the forward region

Studies of the production of top quarks in the forward region at the LHC are potentially of great interest in terms of new physics. Not only does the process have an enhanced sensitivity to physics beyond the Standard Model (owing to sizable contributions from quark–antiquark and gluon–quark scattering), but measurements of the forward production of top-quark pairs ($t\overline{t}$) can be used to constrain the gluon parton distribution function (PDF) at large momentum fraction. Reducing the uncertainty on this PDF will increase the precision of many Standard Model predictions, especially those that serve as backgrounds to searches for new high-mass particles.

Top quarks decay almost exclusively to a W boson and a b-quark jet. The LHCb collaboration has already made high-precision measurements of W-boson production, and recently demonstrated the ability to identify, or tag, jets originating from b and c quarks (LHCb 2015a). Now, the collaboration had combined these two abilities in a study of W-boson production in association with b and c jets (LHCb 2015b), using a subset of these data samples to observe top-quark production for the first time in the forward region (LHCb 2015c). The data show a large excess of events compared with the Standard Model's W+b-jet prediction in the absence of top-quark production (see figure).

LHCb measured the top-quark production



Production of top observed by LHCb in association with Wb.

cross-sections in a reduced fiducial region chosen to enhance the relative top-quark content of the W+b-jet final state. Within this region, the inclusive top-quark production cross-sections, which include contributions from both $t\overline{t}$ and single-top production, are $\sigma(top)$ [7 TeV] = 239±53(stat.)±38(syst.) fb and $\sigma(top)$ [8 TeV] = 289±43(stat.)±46(syst.) fb. These values are in agreement with the Standard Model predictions of 180^{+51}_{-41} (312^{+83}_{-68}) fb at 7(8) TeV obtained at next-to-leading order using MCFM, the Monte Carlo programme for femtobarn processes.

In the LHC's Run 2, the higher beam energy should lead to a greatly increased cross-section and acceptance for top-quark production. This will allow LHCb to measure precisely both $t\overline{t}$ and single-top production, and so provide important constraints on the gluon PDF as well as potential signs for physics beyond the Standard Model.

● **Further reading**
LHCb Collaboration 2015a arXiv:1504.07670 [hep-ex].
LHCb Collaboration 2015b arXiv:1505.04051 [hep-ex].
LHCb Collaboration 2015c arxiv:1506.00903 [hep-ex].

On the trail of long-lived particles

When searching for new particles in ATLAS, it is often assumed that they will either decay to observable Standard Model particles at the centre of the detector, or escape undetected, in which case their presence can be inferred by measuring an imbalance of the total transverse momentum. This assumption was a guiding principle in designing the layout of the ATLAS detector.

However, another possibility exists: what if new particles are long lived? Many models of new physics include heavy particles with lifetimes large enough to allow them to travel measurable distances before decaying. Heavy particles typically decay quickly into lighter particles, unless the decay is suppressed by some mechanism. Suppression could occur if couplings are small, if the decaying particle is only slightly heavier than the only possible decay products, or if the decay is mediated by very heavy virtual exchange particles. Looking for signatures of these models in the LHC data implies exploiting the ATLAS detector in ways it was not necessarily designed for.

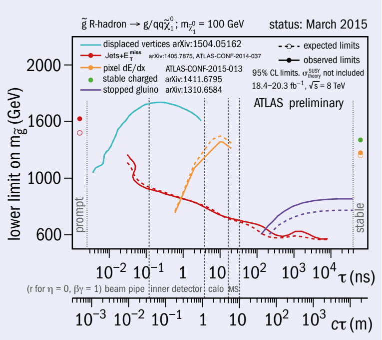
These models can give rise to a broad range of possible signatures, depending on the lifetime, charge, velocity and decay channels of the long-lived particle. Decays to charged particles within the ATLAS detector volume can be detected as "displaced vertices". Heavy charged particles that traverse the detector will move more slowly than their Standard Model counterparts, and will leave a trail of large ionization-energy deposits. Particles with very long lifetimes could even stop in the dense material of the calorimeter and decay at a later time. The ATLAS collaboration has performed dedicated searches to explore all of these spectacular – and challenging – signatures.

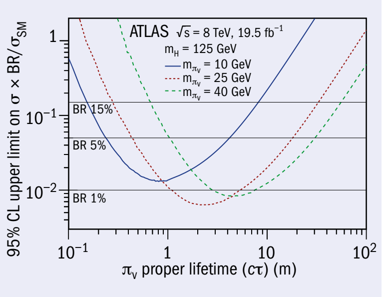
Standard reconstruction algorithms are not optimal for such unconventional signatures, so the ATLAS collaboration has used detailed knowledge of the experiment's sub-detectors to develop dedicated algorithms; for example, to reconstruct charged-particle tracks from displaced decays or to measure the ionization-charge deposited by long-lived charged particles. A class of specialized triggers for picking up these signatures has also been designed and deployed.

These searches generally have very low background, but it is nevertheless essential to estimate the level because some of the signatures could be faked by instrumental effects that are not well-modelled in the simulation. Sophisticated data-driven background estimation techniques have therefore been developed.

One postulated type of long-lived particle is the "R hadron" – a supersymmetric particle with colour-charge combined with Standard Model quarks and gluons. Several ATLAS searches are sensitive to R hadrons, and between them they cover a wide range of lifetimes, as the figure (top right) shows (ATLAS Collaboration 2013 and 2015a). Other analyses have searched for a long-lived hidden-sector pion ("v pion") by looking for displaced vertices in different ATLAS sub-detectors (ATLAS Collaboration 2015b and 2015c). Exotic Higgs-boson decays to long-lived neutral particles that decay to jets were constrained to a branching ratio smaller than 1% at the 95% confidence level, for a range of lifetime values, as in the figure (right).

With 13-TeV collisions under way at the LHC, the probability of producing heavy new particles has increased enormously, revitalizing the searches for new physics. ATLAS experimentalists are rising to the challenge of exploring as many new physics signatures as possible, including those related to long-lived particles.





Top: Observed and expected 95% CL lower limits on R-hadron mass, presented as a function of lifetime for various ATLAS searches. Above: Observed 95% CL limits on the branching ratio of the Higgs boson to long-lived v pions decaying to jets within the ATLAS volume.

● **Further reading**
ATLAS Collaboration 2013 *Phys. Rev. D* **88** 112003.
ATLAS Collaboration 2015a arXiv:1504.05162, submitted to *Phys. Rev. D*.
ATLAS Collaboration 2015b arXiv:1504.03634, submitted to *Phys. Rev. D*.
ATLAS Collaboration 2015c *Phys. Lett. B* **743** 15.

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CMS and the continuing quest to unveil dark matter

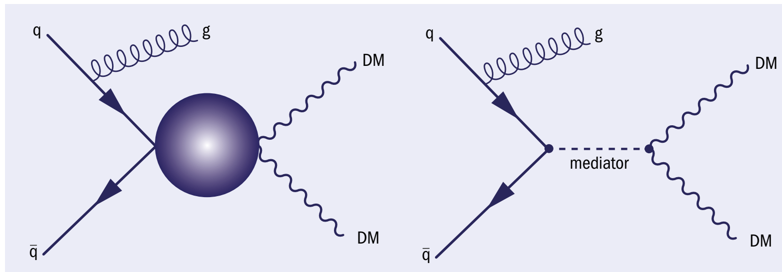
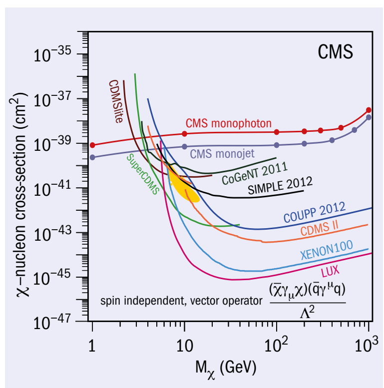
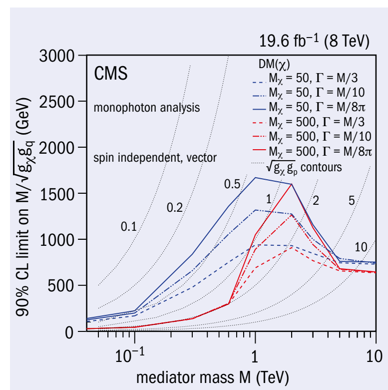


Fig. 1. Production of a pair of dark-matter particles within an effective field theory (left), and within a simplified model with an s-channel mediator.





Left: Fig. 2. Sensitivity of spin-independent dark-matter–Standard Model interactions from CMS and from direct-detection experiments. Right: Fig. 3. CMS constraints on the mediator mass and couplings of a vector interaction for the dark-matter masses of 50 and 500 GeV.

The search for particles that could constitute dark matter in the universe relies on detecting their interplay with the Standard Model particles through a three-pronged approach: via direct-detection experiments, via indirect-detection experiments, and with hermetic detectors at colliders, covering the full 4π-phase space. Because dark matter behaves as a weakly interacting neutral particle, it escapes the detectors without interacting, so in collider experiments its production is inferred by measuring the imbalance in transverse momentum left in the detector. At the LHC, a search for the pair production of dark-matter particles can be performed by looking for events with a large momentum imbalance in association with initial-state radiation of either a jet or a photon – the "monojet" or "monophoton" searches.

The CMS collaboration now has results based on proton–proton collision data collected at a centre-of-mass energy of 8 TeV, amounting to 20 fb^{-1} of integrated luminosity. In the analysis, both monojet and monophoton searches employ a "cut-and-count" approach. A set of cuts is applied to select potential dark-matter events and, at the same time, to reduce the contamination from Standard Model processes.

One of the dominant and irreducible backgrounds for both searches is the decay of the Z boson into neutrinos, which accounts for roughly 60–70% of the total monojet/monophoton events. The searches look for an excess of events above those expected from the Standard Model processes. In the absence of an excess, limits can be placed on the pair production of dark-matter particles. The results are presented within the framework of an effective field theory where a contact interaction is assumed between the dark-matter and Standard Model particles. Because the effective field theory is not valid for the full parameter space probed at the LHC, the searches are also interpreted in the context of a simplified model with an s-channel mediator. Both assumptions are depicted in the Feynman diagrams in figure 1.

The results (see figure 2) show that CMS extends the sensitivity to spin-independent dark-matter–Standard Model interactions including a vector operator to dark-matter masses that are lower (below 5 GeV) than is currently accessible to the direct-detection experiments. For spin-dependent interactions that include an axial-vector operator, the sensitivity of CMS (not shown here) extends down to dark-matter–nucleon cross-sections of 10^{-41} cm^2. If the particle mediating the dark-matter–Standard Model interaction is accessible at LHC energies, CMS has the opportunity to search for the mediator itself. Figure 3 shows the constraints placed on the mass and coupling strengths of vector-mediator interactions in the monophoton analysis.

The LHC plays a significant role in the search for dark matter and complements well the searches by the direct-detection experiments. The CMS collaboration is now looking forward to intensifying the search with data at 13 TeV and opening up a completely new energy regime to spot hints of dark-matter particles.

Further reading

CMS Collaboration 2014 CMS-EXO-12-047, CERN-PH-EP-2014-253, arXiv:1410.8812 [hep-ex], submitted to *Phys. Lett. B*.

CMS Collaboration 2015 *Eur. Phys. J.* **C** 75235.

FUTURE FACILITIES

EuroCirCol: a key to new physics

EuroCirCol, the EC-funded part of the Future Circular Collider (FCC) study that will develop the conceptual design of an energy-frontier hadron collider, officially started on 1 June. The "kick-off" event at CERN on 2–4 June brought together 62 participants to constitute governance bodies, commit to the project plan and align the organization, structures and processes of 16 institutions from 10 countries. The goal of the project is to conceive a post-LHC research infrastructure around a 100-km circular hadron collider capable of reaching 100-TeV collisions. The project will run for four years, with a total estimated budget of €11.2 million, which includes a €2.99 million contribution from the European Commission's Horizon 2020 programme on developing new world-class research infrastructures.

Participants at EuroCirCol's first meeting in June. (Image credit: OPEN-PHO-ACCEL -2015-008-1)

EuroCirCol will deliver a design for a hadron collider as part of the broader FCC study (*CERN Courier* April 2014 p16). It will provide input to an accelerator-infrastructure road map, taking into account European and global interests by the time of the next update of the European Strategy for Particle Physics in 2018. It was the only one of 39 submissions to receive the maximum points from reviewers, a clear sign that high-energy physics remains a top priority for the European Commission.

EuroCirCol is organized around four technical work packages. The first two are to develop the collider's lattice and beam optics, including the experimental regions. A third develops prototypes and tests a novel cryogenics beam-vacuum system that can respond to the challenges of the high levels of synchrotron radiation expected at such a collider. This work also pioneers collaboration between the particle-physics and light-source communities, with opportunities to improve existing synchrotron-radiation facilities and to reduce cost and performance of fourth- or fifth-generation light sources. The fourth work package will study a viable design for a 16-T accelerator magnet, as part of a worldwide study of conductor R&D for the High-Luminosity LHC project and the FCC.

The EuroCirCol project is set to create opportunities for doctoral and postdoctoral assignments in the areas of beam optics and accelerator technologies, in the participating institutes. It will also provide excellent training opportunities for the next generation of accelerator physicists, under the guidance of world-renowned experts in the field.

As a building block in the globally co-ordinated strategy of the FCC study to produce a global design for a global machine, EuroCirCol's main outcome will be to lay the foundations for subsequent research-infrastructure development that will strengthen Europe as a leader in global research co-operation over the coming decades.

● For more information about EuroCirCol, visit cern.ch/eurocircol.

Sciencewatch

Compiled by John Swain, Northeastern University

Drunken-monkey hypothesis confirmed

The "drunken-monkey hypothesis", which says that natural selection favoured primates with an attraction to ethanol, has had largely anecdotal support, and often in relatively distant species, such as the slow loris. Now, Kimberley Hockings of Oxford Brooks University and the Centre for Research in Anthropology in Lisbon and colleagues have found evidence of "long-term and recurrent ingestion of ethanol from the raffia palm" at Bossou in Guinea, by wild chimpanzees.

Villagers on the region tap the raffia palms and collect the sap in plastic containers, where it can rapidly ferment, averaging 3.1% alcohol by volume, but going as high as 6.9%. The research, headed by Tetsuro Matsuzawa of the Primate Research Institute at Kyoto University, covers a long period, from 1995 to 2015. The chimps use leaf sponges as tools to get at the fermented sap, so some "brain power" is involved. The ability to metabolize alcohol as well as chimps and humans do is recent, with the relevant mutation occurring in a common ancestor around 10 million years ago, increasing our rate of ethanol metabolism by a factor of 40 (*CERN Courier* January/February 2015 p13). This latest research certainly supports the idea that this last common ancestor was not averse to ingesting foods containing ethanol.

The chimps use leafy sponges to drink the alcohol. (Image credit: G Ohashi/Chubu University/Wildlife Research Center, Kyoto University.)

Further reading
K J Hockings *et al.* 2015 *R. Soc. Open Sci.* **2** 150150.

Werewolf plant

Ephedra foemicia *cones, with pollination drops. (Image credit: Kristina Bolinder.)*

The first plant ever discovered to synchronize its activity to the lunar cycle is a relative of conifers and cycads. Catarina Rydin and Kristina Bolinder of Stockholm University found that *Ephedra foeminea*, a shrub that grows in the Eastern Mediterranean, excretes a sugary liquid to attract nocturnal pollinators, but only during the full Moon in July. Rather ordinary by daylight, the plant is apparently spectacular when covered in glittering droplets in the light of the full Moon.

Further reading
C Rydin and K Bolinder 2015 *Biology Letts.* **11** 20140993; DOI: 10.1098/rsbl.2014.0993.

Near-perfect mirrors made easy

Common household mirrors reflect about 90% of the light that hits them. Such mirrors are easy to fabricate, but while the reflectivity is good enough for everyday use, it falls far short of what is needed for high-performance applications. Now, Jason Valentine of Vanderbilt University in Nashville and colleagues have found a way to get plastic nanoparticles to assemble themselves into masks that can subsequently allow the formation of a silicon structure with an amazing 99.7% reflectivity for infrared light.

The technique is to drop polystyrene beads of 820-nm diameter into a film of water where, driven by electrostatic forces, the beads self-assemble to form a monolayer with a repeated hexagonal pattern on the water's surface. Lowering the layer of beads onto a submerged silicon wafer, and using a plasma-etching process to shrink the beads to 560 nm, allows the bead layer to serve as a lithographic mask. Subsequent etching creates a similar array on the underlying wafer, this time composed of silicon cylinders, each 335 nm tall and 480 nm across the top. These tiny resonators then act as an almost perfect mirror for a wavelength of 1530 nm.

Further reading
P Moitra *et al.* 2015 *ACS Photonics* **2** 692.

Positron clouds in storms

Six years after making the observation during an accidental flight into a thundercloud, Joseph Dwyer of the University of New Hampshire and colleagues have reported detecting two isolated clouds of positrons inside an active thunderstorm. The Airborne Detector for Energetic Lightning Emissions (ADELE) consists of six gamma-ray detectors, which flew on a Gulfstream V jet aircraft through the top of an active thunderstorm in August 2009. The detector recorded two enhancements in the 511-keV gamma-ray count rate, 35 s apart, each about a factor of 12 over background and lasting approximately 0.2 s. These appear to suggest that the aircraft was briefly immersed in clouds of positrons more than a kilometre across. The origins of the clouds are still unknown, but they may have been caused by the presence of the aircraft itself in the highly electrified environment.

Further reading
J R Dwyer *et al.* 2015 *J. Plasma Physics* **81** 475810405.

Closer to Jurassic Park?

What appears to be dinosaur blood has been found serendipitously in Cretaceous dinosaur bones that were not particularly well-preserved and showed no external signs of soft tissue. Sergio Bertazzo of Imperial College London and colleagues were cutting into the fossils to study bone fossilization, when they found blood-like cells and collagen from 75 million years ago – or 10 million years before *Tyrannosaurus rex* (hence the heightened although slim hopes for a real "Jurrasic Park"). While it is unlikely that DNA can be extracted from these samples, it might be possible with better-preserved fossils.

Further reading
S Bertazzo *et al.* 2015 *Nature Communications* **6** 7352.

Astrowatch

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

VLT sees evidence for first-generation stars

Astronomers using ESO's Very Large Telescope (VLT) have discovered a very bright galaxy in the early universe, and found strong evidence that it contains first-generation stars. These massive luminous stars – previously purely theoretical – are made of primordial material from the Big Bang, and produced the first heavy elements. The newly found galaxy is three times brighter than the brightest distant galaxy known up to now.

Astronomers have long theorized the existence of a first generation of stars – known as Population III stars – born out of hydrogen, helium and trace amounts of lithium, the only elements produced by Big Bang nucleosynthesis. All of the heavier chemical elements, such as oxygen, nitrogen, carbon and iron, were forged by nuclear fusion in the cores of stars. The Population III stars would have been enormous – several hundred or even a thousand times more massive than the Sun. They would have exploded as supernovae after only about 2 million years, which is less than a thousandth of the Sun's lifetime.

A team led by David Sobral, of the University of Lisbon and Leiden Observatory, has used the VLT to peer back into the ancient universe, to a period known as re-ionization, approximately 800 million years after the Big Bang. Instead of conducting a narrow and deep study of a small area of the sky, they broadened their scope to produce the widest survey of very distant galaxies ever attempted. Their expansive study was made using the VLT, with help from the W M Keck Observatory and the Subaru Telescope, as well as the NASA/ESA Hubble Space Telescope. The team discovered and confirmed a number of surprisingly bright, very young galaxies at a redshift, z, of around seven. One of these, labelled CR7 – for COSMOS Redshift 7, but also as an allusion to the footballer Cristiano Ronaldo, who is known as CR7 – is by far the brightest galaxy ever observed so early in the history of the universe.

Artist's impression of CR7, a very distant galaxy displaying three main stellar clusters at different stages of evolution. One of them is likely to consist of first-generation stars. (Image credit: ESO/M Kornmesser.)

The X-shooter and SINFONI instruments on the VLT found strong ionized-helium emission in CR7 but, crucially and surprisingly, no sign of any heavier elements in a bright area of the galaxy. This suggests that the team has discovered the first evidence for clusters of Population III stars that had ionized gas within a galaxy in the early universe. Bluer and somewhat redder clusters of stars were found within CR7, indicating that the formation of Population III stars had occurred in waves, as had been predicted. What the team directly observed was the last wave of Population III stars, suggesting that such stars should be easier to find than previously thought: they reside among regular stars, in brighter galaxies, not just in the earliest, smallest and dimmest galaxies, which are so faint as to be extremely difficult to study.

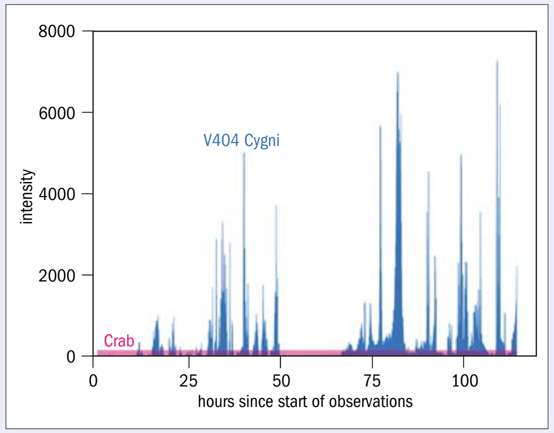
The team considered two alternative theories: that the source of the light was either an active galactic nuclei, or Wolf–Rayet stars. The lack of heavy elements, together with other evidence, strongly refutes both these theories. The team also considered that the source may be a direct-collapse black hole, which would itself be an exotic, so far purely theoretical, object. The lack of a broad emission line, and the fact that the hydrogen and helium luminosities are much greater than what has been predicted for such a black hole, indicates that this scenario is also rather unlikely.

Further reading

D Sobral *et al.* 2015 arXiv:1504.01734 [astro-ph.GA], to be published in *ApJ*.

Picture of the month

This graph shows variation in the X-ray luminosity of the black-hole binary system V404 Cygni, as observed with the IBIS instrument on ESA's INTEGRAL gamma-ray observatory. This system, comprising a black hole and a star orbiting one another, is located in the Milky Way Galaxy, almost 8000 light-years away in the constellation Cygnus. On 15 June, V404 Cygni started showing signs of extraordinary activity, something that had not happened since 1989. The renewed activity is likely to be caused by material slowly piling up in the disc, until eventually reaching a tipping point that dramatically changes the black hole's feeding routine for a short period. The data show repeated outbursts of X-rays on time scales shorter than an hour, something rarely seen in other black-hole systems. On these occasions, V404 Cygni becomes the brightest object in the X-ray sky, up to 50 times brighter than the level shown with the pink line, which refers to the Crab Nebula, the brightest steady source in the high-energy sky. (Image credit: ESA/INTEGRAL/IBIS/ISDC.)



CERNCOURIER
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IOP Publishing

CERN Courier Archive: 1972

A look back to CERN Courier vol. 12, July/August 1972, compiled by Peggie Rimmer

CERN

CDC 7600 passes acceptance tests

On 8 July, CERN's new, large, central computer, a CDC 7600, passed its acceptance tests. This required 30 consecutive days of operation on CERN's normal computing workload. Over those 30 days the computer was "down" due to faults for less than 10% of the time and, with a few minor reservations, it was then accepted by CERN. Since then, the performance has continued to improve.

Part of the large hall of the new computer centre. It houses the CDC 7600 (seen in the upper left-hand corner) and a CDC 6400, which serves as a front-end machine channelling computing to and from the 7600. (Image credit: CERN 135.8.72.)

● Compiled from texts on p232.

Black holes at CERN

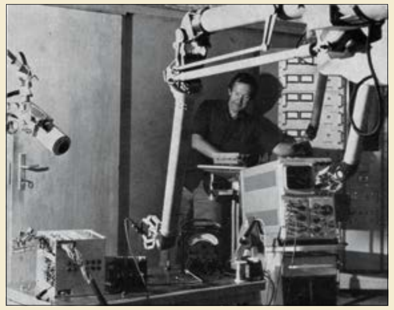
The world of astrophysics has recently rocked to the news of the possible identification of a "black hole", a collapsed star where the gravitational pull is so strong that no signals can escape. Not to be outdone, we have identified seven black holes at CERN. Though of less immediate physics interest, CERN's black holes are still impressive. They are the shafts being dug on the site of the new accelerator, the Super Proton Synchrotron. Some of the shafts are now so deep that the work under way at the bottom is lost in the gloom.

● Compiled from texts on p238.

Above: 45-m underground, work begins on cutting a tunnel between two shafts on the SPS site. In this tunnel the "Mole" will be assembled to burrow around the 7-km circumference of the machine. Seeing the light, construction workers watch the camera pointed to the top of a shaft. (Image credit: CERN 60.8.72.)

Some like it hot

Experience in remote handling techniques is being gathered in the Proton Synchrotron PS Division, with a new advanced type of "teleoperator" known as Mascot. The interest in remote handling techniques at CERN and other high-energy physics laboratories is to develop expertise, should it prove necessary to use remotely controlled robots to work in "hot" regions around the accelerators, where radiation levels can prevent human intervention or make it extremely difficult.



The teleoperator Mascot in action, checking one of its own pulses. Movements of the operator are followed by the slave unit. (Image credit: CERN 99.8.72.)

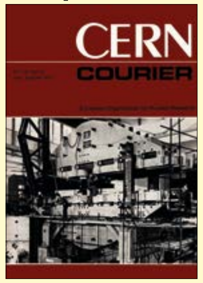
Already at the PS there have been occasions when work in and around the vacuum chamber had to be done in relay, so that no single person absorbed more than the maximum permitted dose. This problem will become much worse as the beam intensity goes up a factor of five using the Booster.

Robots have been fertile material for science-fiction writers for a very long time, but it is only in the past 25 years that their development has really got off the ground (leaving aside the pre-programmed type such as the famous Jaquet-Droz automata). Much of the stimulus came from the nuclear industry, and the Argonne Laboratory was the scene of a great deal of the pioneering work. Space programmes are another obvious user, with the possibilities of doing things like sending teleoperators to dig up bits of Mars. Another user is the oil industry, where interest centres on sending teleoperators to the bottom of the sea to exploit oil fields at great depths.

In these examples, the teleoperator is mainly used to extend man's normal handling abilities into hostile environments. However, there is also the potential of greater power, greater finesse, and of transmitting exceptional manipulative skills over great distances. Advocates of teleoperators speak of the possibility, by the end of the century, of a heart surgeon in South Africa (where the more voluble seem to reside) carrying out refined surgery on a patient in Canada by operating a miniature slave manipulator via a satellite telemetry link. Just as the computer has extended man's brainpower, the teleoperator could extend man's physical power.

● Compiled from texts on pp239–240.

Compiler's Note



The computer-centre equipment shown is well known to have had the computing power of a smartphone or two, at a multi-million-dollar cost that needed the approval of CERN's Finance Committee. Less recalled are the real estate, life-support systems and running-in time required by those behemoths.

As for running-around times, the Super Proton Synchrotron Mole spent two years digging the 7-km tunnel. In 1985, three Moles started excavating the 27-km ring for the Large Electron–Positron collider – Europe's largest civil-engineering project prior to the Channel Tunnel – and completed the work in three years. Started in 1988, the triple-bore 51-km Channel Tunnel was constructed by 11 Moles in six years.

SESAME: a bright hope for the Middle East

SESAME – Synchrotron-light for Experimental Science and Applications in the Middle East – will be the region's first light source.


The SESAME building, 35-km north-west of Amman, seen with its new roof in May 2015. (Image credit: CERN-PHOTO-201504-069-15.)

INTERNATIONAL YEAR OF LIGHT 2015

Synchrotron-light sources have become an essential tool in many branches of medicine, biology, physics, chemistry, materials science, environmental studies and even archaeology. There are some 50 storage-ring-based synchrotron-light sources in the world, including a few in developing countries, but none in the Middle East. SESAME is a 2.5-GeV, third-generation light source under construction near Amman. When it is commissioned in 2016, it will not only be the first light source in the Middle East, but arguably also the region's first true international centre of excellence.

The members of SESAME are currently Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey (others are being sought). Brazil, China, the European Union, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Spain, Sweden, Switzerland, the UK and the US are observers.

SESAME will

- foster scientific and technological capacities and excellence in the Middle East and neighbouring regions, and help prevent or reverse the brain drain; and
- build scientific links and foster better understanding and a culture of peace through collaboration between peoples with different creeds and political systems.

The origins of SESAME

The need for an international synchrotron light-source in the Middle East was recognized by the Pakistani Nobel laureate Abdus Salam, one of the fathers of the Standard Model of particle physics, more than 30 years ago. This need was also felt by the CERN-and-Middle-East-based Middle East Scientific Co-operation group (MESC), headed by Sergio Fubini. MESC's efforts to promote regional co-operation in science, and also solidarity and peace, started in 1995 with the organization in Dahab, Egypt, of a meeting at which the Egyptian minister of higher education, Venice Gouda, and Eliezer Rabinovici of MESC and the Hebrew University in Israel – and now a delegate to the CERN and SESAME councils – took an official stand in support of Arab–Israeli co-operation.

In 1997, Herman Winick of SLAC and the late Gustav-Adolf Voss of DESY suggested building a light source in the Middle East using components of the soon-to-be decommissioned BESSY I facility in Berlin. This brilliant proposal fell on fertile ground when it was presented and pursued during workshops organized in Italy (1997) and Sweden (1998) by MESC and Tord Ekelof, of MESC and Uppsala University. At the request of Fubini and Herwig Schopper, a former director-general of CERN, the German government agreed to donate the components of BESSY I to SESAME, provided that the dismantling and transport – eventually funded by UNESCO – were taken care of by SESAME.

The plan was brought to the attention of Federico Mayor, then director-general of UNESCO, who called a meeting of delegates from the Middle East and neighbouring regions at the organization's headquarters in Paris in June 1999. The meeting launched the project by setting up an International Interim Council with Schopper as chair (*CERN Courier* March 2000 p17). Jordan was selected to host SESAME, in a competition with five other countries ▷

SESAME will be arguably the Middle East's first true international centre of excellence.

Parameter	Value
energy (GeV)	2.5
current (mA)	400
circumference (m)	133.2
natural emmittance (nmrad)	26
straight sections	16 of length 1.7/3.7 m, of which 12 can accommodate insertion devices

Table 1. SESAME storage-ring parameters.

from the region. It has provided the land and funded the construction of the building.

In May 2002, the Executive Board of UNESCO unanimously approved the establishment of the new centre under UNESCO's auspices (*CERN Courier* November 2002 p6). SESAME formally came into existence in April 2004, when the permanent council was established, and ratified the appointments of Schopper as president and of the first vice-presidents, Dincer Ülkü of Turkey and Khaled Toukan of Jordan. A year later, Toukan stepped down as vice-president and became director of SESAME.

Meanwhile, the ground-breaking ceremony was held in January 2003, and construction work began the following August. Since February 2008, SESAME has been working from its own premises, which were formally opened in November 2008 in a ceremony held under the auspices of King Abdullah II of Jordan, and with the participation of Prince Ghazi Ben Mohammed of Jordan and Koïchiro Matsuura, then director-general of UNESCO. In November 2008, Schopper stepped down as president of the Council and was replaced by Chris Llewellyn Smith, who is also a former director-general of CERN. In 2014, Rabinovici and Kamal Araj of Jordan became vice-presidents, replacing Tarek Hussein of Egypt and Seyed Aghamiri of Iran.

SESAME users

As at CERN, the users of SESAME will be based in universities and research institutes in the region. They will visit the laboratory periodically to carry out experiments, generally in collaboration. The potential user-community, which is growing rapidly, already numbers some 300, and is expected eventually to grow to between

Eliezer Rabinovici

"As a string theorist, I work on parallel universes. I was always curious about what a parallel universe was like, and now I know. I'm living in one when I go to SESAME meetings, working hand in hand with our neighbours on a common goal, bringing advanced knowledge to our region."

● *Eliezer Rabinovici, Hebrew University, and Israeli representative on the SESAME Council. (Image credit: O Arbeli.)*

The SESAME booster synchrotron, built using components from BESSY I, pictured here without the shielding roof. It is now the highest-energy accelerator in the Middle East. (Image credit: SESAME.)

1000 and 1500. It is being fostered by a series of Users' Meetings – the 12th, in late 2014, attracted more than 240 applications, of which only 100 could be accepted. The training programme, which is supported by the International Atomic Energy Agency, various governments and many of the world's synchrotron laboratories, and which includes working visits to operational light sources, is already bringing significant benefits to the region.

Technical developments

In 2002, the decision was taken to build a completely new main storage ring, with an energy of 2.5 GeV – compared with the 1 GeV that would have been provided by upgrading the main BESSY 1 ring – while retaining refurbished elements of the BESSY I microtron to provide the first stage of acceleration and the booster synchrotron. As a result, SESAME will not only be able to probe shorter distances, but will also be a third-generation light source, i.e. one that can accommodate insertion devices – wigglers and undulators – to produce enhanced synchrotron radiation. There are light sources with higher energy and greater brightness, but SESAME's performance (see table) will be good enough to allow users – with the right ideas – to win Nobel prizes.

Progress has not been as rapid as had been hoped, owing mainly to lack of funding, as discussed below. The collapse of the roof under an unprecedented snowfall in December 2013, when it even snowed in Cairo, has not helped. Nevertheless, despite working under the open sky throughout 2014, the SESAME team successfully commissioned the booster synchrotron in September 2014. The beam was brought to the full energy of 800 MeV, essentially without loss, and the booster is now the highest-energy accelerator in the Middle East (*CERN Courier* November 2014 p5).

The final design of the magnets for the main ring and for the powering scheme was carried out by CERN in collaboration with SESAME. Construction of the magnets is being managed by CERN using funds provided by the European Commission. The first of 16 cells was assembled and successfully tested at CERN at the end of March, and installation will begin later this year (*CERN Courier* May 2015 p6). If all goes well, commissioning of the whole facility

The third SESAME Users' Meeting, Antalya, Turkey, in 2004. (Image credit: SESAME.)

Engin Ozdas

"SESAME has created trust and personal friendships between researchers in the members and developed countries, which may help solve regional and global political problems."

● *Engin Ozdas, Hacettepe University, Ankara. (Image credit: E Ozdas.)*

– initially with only two of the four accelerating cavities – should begin in June next year.

The scientific programme

SESAME will nominally have four "day-one" beamlines in Phase 1a, although to speed things up and save money, it will actually start with just two. Three more beamlines will be added in Phase 1b.

One of the beamlines that will be available next year will produce photons with energies of 0.01–1 eV for infrared spectromicroscopy, which is a powerful tool for non-invasive studies of chemical components in cells, tissues and inorganic materials. A Fourier transform infrared microscope, which will be adapted to this beamline, has already been purchased. Meanwhile, 11 proposals from the region to use it with a conventional thermal infrared source have been approved. The microscope has been in use since last year, and the first results include a study of breast cancer by Fatemeh Elmi of the University of Mazandaran, Iran, with Randa Mansour and Nisreen Dahshan, who are PhD students in the Faculty of Pharmacy, University of Jordan. When SESAME is in operation, the infrared beamline will be used in biological applications, environmental studies, materials and archaeological sciences.

An X-ray absorption fine-structure and X-ray fluorescence

The first of 16 cells of the SESAME storage ring, assembled for testing at CERN in late March, with components constructed in SESAME members and observers: quadrupoles (green) – Spain and Turkey; dipoles (red) – UK; sextupoles (yellow) – Cyprus and Pakistan; sextupole coils – France; vacuum chambers – Germany; girders – Spain. In addition, there are: dipole power supply – Italy; controllers and corrector power supplies – Switzerland; quadrupole and sextupole power supplies – Israel. (Image credit: CERN-PHOTO-201503-059-31.)

beamline, with photon energies of 3–30 keV, will also be in operation next year. It will have potential applications in materials and environmental sciences, providing information on chemical states and local atomic structure that can be used for designing new materials and improving catalysts (e.g. for the petrochemical industries). Other applications include the non-invasive identification of the chemical composition of fossils and of valuable paintings.

It is hoped that macro-molecular crystallography and material-science beamlines, with photon energies of 4–14 keV and 3–25 keV, respectively, will be added in the next two years, once the necessary funding is available. The former will be used for structural molecular biology, aimed at elucidating the structures of proteins and other types of biological macromolecules at the atomic level, to gain insight into mechanisms of diseases to guide drug design (as used by pharmaceutical and biotech companies). The latter will use powder diffraction for studies of disordered/amorphous material on the atomic scale. The use of powder diffraction to study the evolution of nanoscale structures and materials in extreme conditions of pressure and temperature has become a core technique for developing and characterizing new smart materials.

In Phase 1b, soft X-ray (0.05–2 keV), small and wide-angle X-ray scattering (8–12 keV) and extreme-ultraviolet (10–200 eV) beamlines will be added. They will be used, respectively, for atomic, molecular and condensed-matter physics; structural molecular biology and materials sciences; and atomic and molecular physics, in a spectral range that provides a window on the behaviour of atmospheric gases, and enables characterization of the electrical and mechanical properties of materials, surfaces and interfaces. ▷

SESAME has faced seemingly impossible odds. Luckily, the will prevailed.

Azadeh Shahsavar

"SESAME will provide me a great opportunity to access a synchrotron-light source near home. I expect SESAME to support a broad range of science and technology in the Middle East, and bring together bright scientific minds."

● Azadeh Shahsavar, pictured at the 8th SESAME Users' Meeting at Petra (Jordan) in 2009, Iranian postdoc, Aarhus University. (Image credit: A Shahsavar.)

The main challenges

The main challenge has been – and continues to be – obtaining funding. Most of the SESAME members have tiny science budgets, many are in financial difficulties, and some have faced additional problems, such as floods in Pakistan and the huge influx of refugees in Jordan. Not surprisingly, they do not find it easy to pay their contributions to the operational costs, which are rising rapidly as more staff are recruited, and will increase even faster when SESAME comes into operation and is faced with paying large electricity bills at $0.36/kWh and rising. Nevertheless, increasing budgets have been approved by the SESAME Council. As soon as the funding can be found, a solar-power plant, which would soon pay for itself and ease the burden of paying the electricity bill, will be constructed. And SESAME has always been open to new members, who are being sought primarily to share the benefits but also to share the costs.

So far, $65 million has been invested, including the value to SESAME of in-kind contributions of equipment (from Jordan, Germany, the UK, France, Italy, the US and Switzerland), cash contributions to the capital budget (from the EU, Jordan, Israel, Turkey and Italy), and manpower and other operational costs that are paid by the members (but not including important in-kind contributions of manpower, especially from CERN and the French light source, SOLEIL).

Thanks to the contributions already made and additional funding to come from Iran, Israel, Jordan and Turkey, which have each pledged voluntary contributions totalling $5 million, most of the funds that are required simply to bring SESAME into operation next year are now available. At the SESAME Council meeting in May, Egypt announced that it will also make a voluntary contribution, which will narrow the immediate funding gap. More will, however, be needed, to provide additional beamlines and a properly equipped laboratory, and additional funds are being sought from a variety of governments and philanthropic organizations.

The ongoing turbulence in the Middle East has only had two direct effects on SESAME. First, sanctions are making it impossible for Iran to pay its capital and operational contributions, which are much needed. Second, discussions of Egypt joining other members in making voluntary contributions were interrupted several times by changes in the government.

Outlook

SESAME is a working example of Arab–Israeli–Iranian–Turkish–Cypriot–Pakistani collaboration. Senior scientists and administrators from the region are working together to govern SESAME through the Council, with input from scientists from around the world through its advisory committees. Young and senior scientists from the region are collaborating in preparing the scientific programme at Users' Meetings and workshops. And the extensive training programme of fellowships, visits and schools is already building scientific and technical capacity in the region.

According to the Italian political theorist Antonio Gramsci, there is a perpetual battle between the optimism of the will and the pessimism of the brain. Several times during its history, SESAME has faced seemingly impossible odds, and pessimists might have given up. Luckily, however, the will prevailed, and SESAME is now close to coming into operation. There are still huge challenges, but we are confident that thanks to the enthusiasm of all those involved they will be met and SESAME will fulfil its founders' ambitious aims.

Résumé

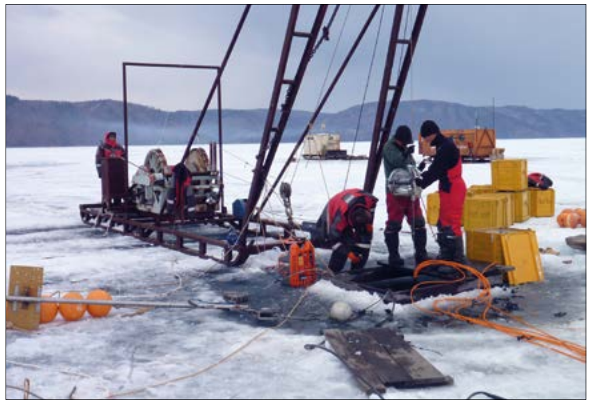
SESAME : un espoir lumineux pour le Moyen-Orient

SESAME (le Centre international de rayonnement synchrotron pour les sciences expérimentales et appliquées au Moyen-Orient) est une source de lumière de 2,5 GeV de troisième génération actuellement en construction près d'Amman (Jordanie). Quand elle sera mise en service, en 2016, elle sera non seulement la première source de lumière synchrotron au Moyen-Orient, mais sans doute aussi le premier véritable centre international d'excellence scientifique de la région. La première des 16 cellules destinées à l'anneau de stockage a été assemblée et testée avec succès au CERN à la fin du mois de mars et sera installée cette année. Si tout se passe bien, la mise en service de l'installation complète – d'abord avec deux lignes de faisceaux – devrait commencer en juin de l'année prochaine.

Chris Llewellyn Smith, SESAME Council president, director of energy research, Oxford University, and **Zehra Sayers**, SESAME Scientific Advisory Committee chair, Sabanci University, Istanbul.

A new neutrino telescope for Lake Baikal

Baikal-GVD takes the first step to becoming a next-generation deep-underwater neutrino telescope.



Assembling strings of optical modules. (Image credit: INR RAS.)

In early April, members of the Baikal collaboration deployed and started operation of the first cluster of the Gigaton Volume Detector (Baikal-GVD). Named "Dubna", the cluster comprises 192 optical modules arranged at depths down to 1300 m. The modules are glass spheres that house photomultiplier tubes to detect Cherenkov light from the charged particles emerging from neutrino interactions in the water of the lake. By 2020, GVD is set to consist of 10–12 clusters covering a total volume of about 0.4 km^3 (GVD phase-1). This is about half the size of the present world leader – the IceCube Neutrino Observatory at the South Pole (*CERN Courier* December 2014 p30). A planned further extension should then lead towards a second stage containing 27 clusters in a telescope with a total volume of about 1.5 km^3.

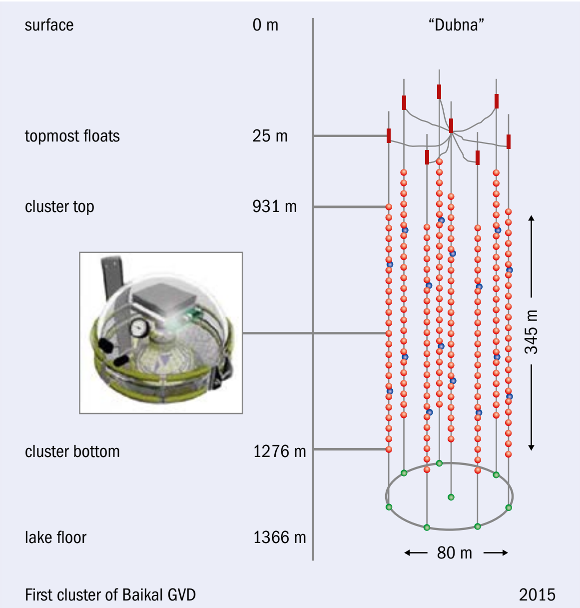
Neutrino detection in Lake Baikal will be an important part of the effort to understand better the high-energy processes that occur in far-distant astrophysical sources, to determine the origin of cosmic particles of the highest energies ever registered, to search for dark matter, to study properties of elementary particles, and to learn a great deal of new information about the structure and evolution of the universe as a whole. Together with KM3NeT in the Mediterranean Sea, the other future Northern-hemisphere neutrino telescope (*CERN Courier* July/August 2012 p31), GVD will allow an optimal view to the central parts of the Galaxy.

The start of the Baikal neutrino experiment dates back to 1 October 1980, when a laboratory of high-energy neutrino astrophysics was established at the Institute for Nuclear Research of the former Academy of Sciences of the USSR in Moscow – now the Institute for Nuclear Research of the Russian Academy of Sciences (INR RAS). This laboratory later became the core of the Baikal collaboration, including at various times the Joint Institute for Nuclear Research (JINR) in Dubna, Irkutsk State University, Moscow State University, DESY-Zeuthen, the Nizhni Novgorod State Technical University, the Saint Petersburg State Marine Technical University, and other scientific research organizations in Russia, Hungary and Germany. At present, the participation of institutes from the Czech Republic, Slovakia and Poland is under discussion.

The idea to register neutrinos in large-scale Cherenkov detectors in natural water was expressed for the first time by Moisey Markov, then at Dubna, at the 10th International Conference on High-Energy Physics, in 1960. Two decades later, Alexander Chudakov, of INR, proposed using Lake Baikal as a site both for tests and for future large-scale neutrino telescopes. The choice of this lake – the largest and deepest freshwater reservoir in the world – was determined by the high transparency of its water, its depth, and the ice cover that allows the installation of deep-water equipment during two months in winter.

The predecessor of GVD was constructed during 1993–1998. Named NT200, it comprised 192 photodetectors placed on eight vertical strings at a depth of 1100–1200 m. NT200 covered some 100,000 m^3 of fresh water (an order of magnitude less than the present Dubna cluster). Already in 1994, data taken with only 36 of the final 192 photodetectors showed two neutrino events. These two events were the first of several-hundred-thousand atmospheric neutrinos since recorded by deep-underwater and under-ice experiments. Scientific research with NT200 covered a wide programme, most notably the search for a cosmic diffuse neutrino flux leading to tight limits on that flux (*CERN Courier* July/August 2005 p24). Moreover, limits were derived on the flux of magnetic monopoles and on muons from dark-matter annihilation in the centre of the Earth and the Sun. Last but not least, the NT200 infrastructure was used for innovative environmental studies.

A notable breakthrough in the field came in 2012, when IceCube detected the first high-energy "astrophysical" neutrinos, i.e. high-energy neutrinos generated beyond the solar system ▷



Schematic of the "Dubna" cluster, the first for the Baikal-GVD neutrino telescope.

(*CERN Courier* July/August 2013 p35). That marked the birth of high-energy neutrino astronomy, and underlined the need to develop neutrino telescopes of similar capacity in the Northern hemisphere, to be able to study high-energy neutrino sources across the whole celestial sphere. JINR, with many years of experience as a participant in the Baikal neutrino project, recognized this opportunity and decided to treat activities related to Baikal-GVD as a scientific priority.

Baikal-GVD will have a modular structure formed from functionally independent clusters of vertical strings of optical modules. This modular structure will allow data acquisition at early stages in the construction of the facility. The choice of the telescope structure will also allow adjustment of its configuration in response to changes in scientific priorities at different times.

Prototypes of all of the basic elements of the GVD telescope system were designed, manufactured and tested during 2006–2010. The final stage of complex *in-situ* testing started in 2011 and finished in 2015 with the development of the Dubna cluster. Its 192 optical modules are arranged down to depths of 1300 m on eight vertical strings, each 345-m long. Different from NT200, the optical modules are not grouped in pairs, resulting

The project team. (Image credit: INR RAS.)

in 192 space points per cluster (instead of only 96 for NT200). Moreover, the former custom-made, hybrid QUASAR phototube has been replaced by a conventional 10-inch photomultiplier with a high-sensitivity photocathode. The mechanical structure has been simplified compared with NT200, and a totally new system for front-end and trigger electronics and for data acquisition has been designed and implemented.

Deployment of the Dubna cluster is an exciting step towards a next-generation neutrino telescope in Lake Baikal. Such a telescope will be a cornerstone of a future worldwide neutrino observatory, with detectors at the South Pole, in the Mediterranean Sea and in Lake Baikal. The Baikal collaboration pioneered this technology in the 1980s and 1990s, and measured neutrinos generated in the Earth's atmosphere. Two decades later, the long-awaited discovery by IceCube of the first high-energy neutrinos from far beyond the Earth and the solar system has given increased motivation to projects for similar large detectors in the Northern hemisphere. IceCube has lifted the curtain that hides the high-energy neutrino universe, but just by a little. In the future, Baikal-GVD will help to chart this new cosmic territory fully.

Résumé

Un nouveau télescope à neutrinos pour le lac Baïkal

Les membres de la collaboration du Baïkal ont procédé au déploiement et commencé l'exploitation du premier groupe de modules optiques pour le Gigaton Volume Detector *(GVD-Baïkal), détecteur d'un volume d'une gigatonne. Les modules détectent la lumière Tchérenkov qu'émettent les particules chargées engendrées par les interactions des neutrinos dans l'eau du lac. Il est prévu que, d'ici à 2020, le GVD compte 10 à 12 groupes de modules, couvrant un volume total d'environ 0,4 km^3 (GVD phase 1). Une autre extension est prévue ; elle permettrait de passer à une deuxième étape, avec 27 groupes et un télescope à neutrinos, dispositif qui couvrirait un volume total d'environ 1,5 km^3.*

Grigory Domogatsky, spokesperson of the Baikal neutrino project.

Stable beams at 13 TeV

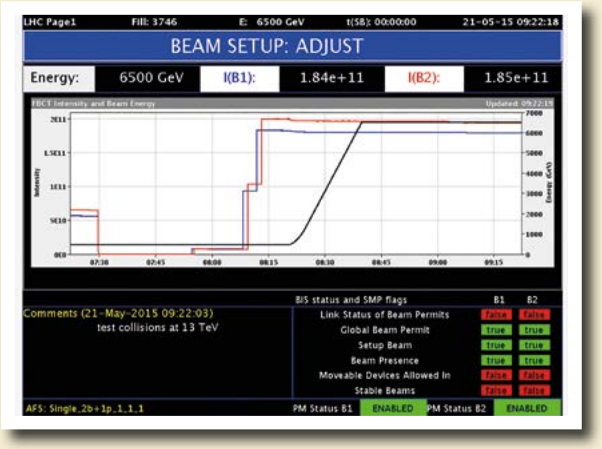
The LHC is back in business, with the start of Run 2 at a new record collision energy.

At 10.40 a.m. on 3 June, the LHC operators declared "stable beams" for the first time at a beam energy of 6.5 TeV. It was the signal for the LHC experiments to start taking physics data for Run 2, this time at a collision energy of 13 TeV – nearly double the 7 TeV with which Run 1 began in March 2010 (*CERN Courier* May 2010 p27). After a shutdown of almost two years and several months re-commissioning without and with beam, the world's largest particle accelerator was back in business. Under the gaze of the world via a live webcast and blog, the LHC's two counter-circulating beams, each with three bunches of nominal intensity (about 10^{11} protons per bunch), were taken through the full cycle from injection to collisions. This was followed by the declaration of stable beams and the start of Run 2 data taking.

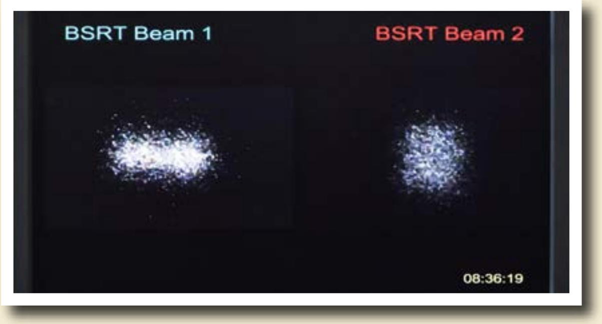
The occasion marked the nominal end of an intense eight weeks of beam commissioning (*CERN Courier* May 2015 p5 and June 2015 p5) and came just two weeks after the first test collisions at the new record-breaking energy. On 20 May at around 10.30 p.m., protons collided in the LHC at 13 TeV for the first time. These test collisions were to set up various systems, in particular the collimators, and were established with beams that were "de-squeezed" to make them larger at the interaction points than during standard operation. This set-up was in preparation for a special run for the LHCf experiment (p5), and for luminosity calibration measurements by the experiments where the beams are scanned across each other – the so-called "van der Meer scans".

Progress was also made on the beam-intensity front, with up to 50 nominal bunches per beam brought into stable beams by mid-June. There were some concerns that an unidentified obstacle in the beam pipe of a dipole in sector 8-1 could be affected by the higher beam currents. This proved not to be the case – at least so far. No unusual beam losses were observed at the location of the obstacle, and the steps towards the first sustained physics run continued.

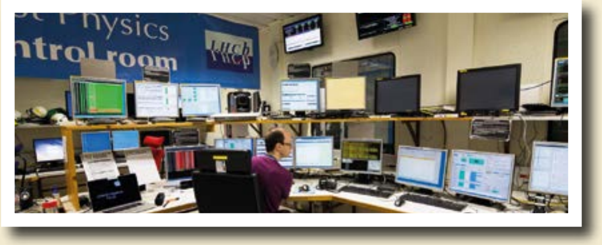
The final stages of preparation for collisions involved setting up the tertiary collimators (*CERN Courier* September 2013 p37). These are situated on the incoming beam about 120–140 m from the interaction points, where the beams are still in separate beam pipes. The local orbit changes in this region both during the "squeeze" to decrease the beam size at the interaction points and after the removal of the "separation bumps" (produced by corrector magnets to keep the beams separated at the interaction points during the ramp and squeeze). This means that the tertiary collimators must be set up with respect to the beam, both at the end of the squeeze and with colliding beams. In contrast, the orbit ▷



The LHC "Page 1" screen during test collisions at the record total energy of 13 TeV on 21 May. (Image credit: CERN.)



Early in the proceedings on 3 June, cameras record the screens of the beam synchrotron-radiation telescopes at point 4: beam 1 on the left, beam 2 on the right. (Image credit: CERN-PHOTO-201506-125-59.)



Early morning on 3 June in the LHCb Control Room. (Image credit: CERN-PHOTO-201506-131-9.)

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LHC Run 2

and optics at the main collimator groupings in the beam-cleaning sections at points 7 and 3 are kept constant during the squeeze and during collisions, so their set-up remains valid throughout all of the high-energy phases.

By the morning of 3 June, all was ready for the planned attempt for the first "stable beams" of Run 2, with three bunches of protons at nominal intensity per beam. At 8.25 a.m, the injection of beams of protons from the Super Proton Synchrotron to the LHC was complete, and the ramp to increase the energy of each beam to 6.5 TeV began. However, the beams were soon dumped in the ramp by the software interlock system. The interlock was related to a technical issue with the interlocked beam-position monitor system, but this was rapidly resolved. About an hour later, at 9.46 a.m, three nominal bunches were once more circulating in each beam and the ramp to 6.5 TeV had begun again.

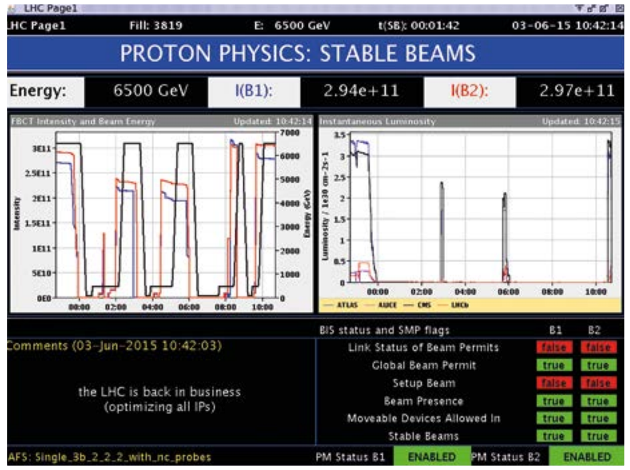
At 10.06 a.m., the beams had reached their top energy of 6.5 TeV and the "flat top" at the end of the ramp. The next step was the "squeeze", using quadrupole magnets on both sides of each experiment to decrease the size of the beams at the interaction point. With this successfully completed by 10.29 a.m., it was time to adjust the beam orbits to ensure an optimal interaction at the collision points. Then at 10.34 a.m., monitors showed that the two beams were colliding at a total energy of 13 TeV inside the ATLAS and CMS detectors; collisions in LHCb and ALICE followed a few minutes later.

At 10.42 a.m., the moment everyone had been waiting for arrived – the declaration of stable beams – accompanied by applause and smiles all round in the CERN Control Centre. "Congratulations to everybody, here and outside," CERN's director-general, Rolf Heuer, said as he spoke with evident emotion following the announcement. "We should remember this was two years of teamwork. A fantastic achievement. I am touched. I hope you are also touched. Thanks to everybody. And now time for new physics. Great work!"

The eight weeks of beam commissioning had seen a sustained effort by many teams working nights, weekends and holidays to push the programme through. Their work involved optics measurements and corrections, injection and beam-dump set-up, collimation set-up, wrestling with various types of beam instrumentation, optimization of the magnetic model, magnet aperture measurements, etc. The operations team had also tackled the intricacies of manipulating the beams through the various steps, from injection through ramp and squeeze to collision. All of this was backed up by the full validation of the various components of the machine-protection system by the groups concerned. The execution of the programme was also made possible by good machine availability and the support of other teams working on the injector complex, cryogenics, survey, technical infrastructure, access, and radiation protection.

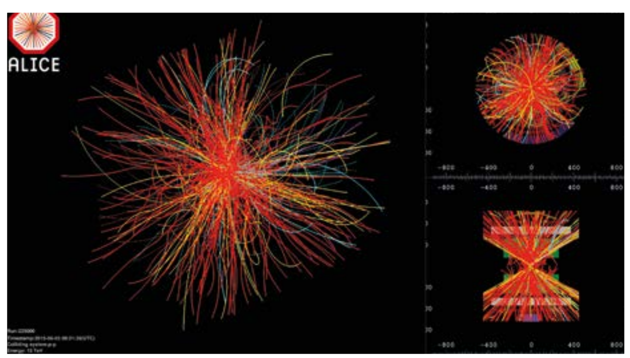
Over the two-year shutdown, the four large experiments ALICE, ATLAS, CMS and LHCb also went through an important programme of maintenance and improvements in preparation for the new energy frontier.

Among the consolidation and improvements to 19 subdetectors, the ALICE collaboration installed a new dijet calorimeter to extend the range covered by the electromagnetic calorimeter, ▷



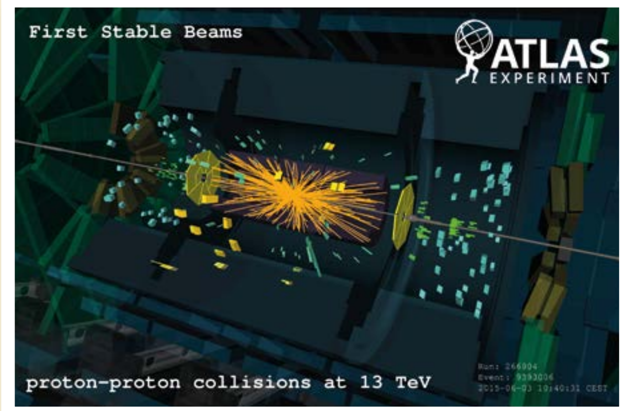
10.42 a.m. 3 June. The LHC is back in business! (Image credit: CERN.)

Applause breaks out in the ATLAS Control Room. (Image credit: CERN-PHOTO-201506-128-1.)



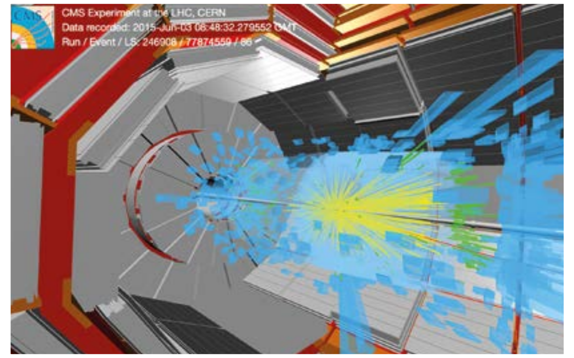
A 13 TeV collision in the ALICE experiment with the first stable beams. (Image credit: ALICE/CERN OPEN-PHO-ACCEL-2015-007-15.)

Happiness in the CERN Control Centre as "stable beams" is declared. (Image credit: CERN-PHOTO-201506-125-36.)



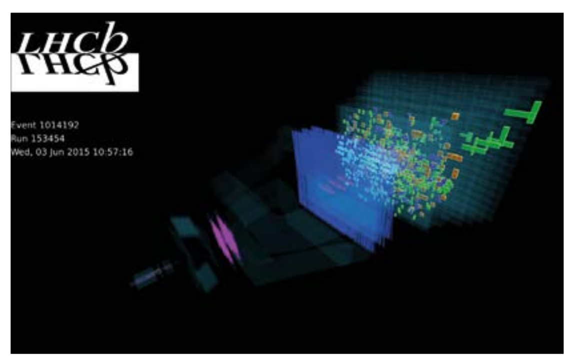
One of the first collisions with stable beams at 13 TeV, recorded in the ATLAS experiment at 10.49 a.m. (Image credit: ATLAS/CERN OPEN-PHO-ACCEL-2015-007-18.)

Smiles in the ALICE Run Control Centre. (Image credit: ALICE-PHO-GEN-2015-003-10.)



A 13 TeV collision recorded in CMS at 10.48 a.m. (Image credit: CMS-PHO-EVENTS-2015-004-3.)

Excitement spills over in the CMS Control Room. (Image credit: CERN-PHOTO-201506-130-32.)



Collisions at 13 TeV as seen by LHCb. (Image credit: LHCb/ CERN OPEN-PHO-ACCEL-2015-007-11.)

allowing measurement of the energy of the photons and electrons over a larger angle (*CERN Courier* May 2015 p35). The transition-radiation detector that detects particle tracks and identifies electrons has also been completed with the addition of five more modules.

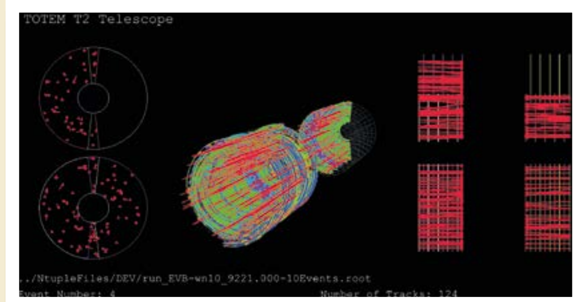
A major step during the long shutdown for the ATLAS collaboration was the insertion of a fourth and innermost layer in the pixel detector, to provide the experiment with better precision in vertex identification (*CERN Courier* June 2015 p21). The collaboration also used the shutdown to improve the general ATLAS infrastructure, including electrical power, cryogenic and cooling systems. The gas system of the transition-radiation tracker, which contributes to the identification of electrons as well as to track reconstruction, was modified significantly to minimize losses. In addition, new chambers were added to the muon spectrometer, the calorimeter read-out was consolidated, the forward detectors were upgraded to provide a better measurement of the LHC luminosity, and a new aluminium beam pipe was installed to reduce the background.

To deal with the increased collision rate that will occur in Run 2 – which presents a challenge for all of the experiments – ATLAS improved the whole read-out system to be able to run at 100 kHz and re-engineered all of the data acquisition software and monitoring applications. The trigger system was redesigned, going from three levels to two, while implementing smarter and faster selection-algorithms. It was also necessary to reduce the time needed to reconstruct ATLAS events, despite the additional activity in the detector. In addition, an ambitious upgrade of simulation, reconstruction and analysis software was completed, and a new generation of data-management tools on the Grid was implemented.

The biggest priority for CMS was to mitigate the effects of radiation on the performance of the tracker, by equipping it to operate at low temperatures (down to –20 °C). This required changes to the cooling plant and extensive work on the environment control of the detector and cooling distribution to prevent condensation or icing (*CERN Courier* May 2015 p28). The central beam pipe was replaced by a narrower one, in preparation for the installation in 2016–2017 of a new pixel tracker that will allow better measurements of the momenta and points of origin of charged particles. Also during the shutdown, CMS added a fourth measuring station to each muon endcap, to maintain discrimination between low-momentum muons and background as the LHC beam intensity increases. Complementary to this was the installation at each end of the detector of a 125 tonne composite shielding wall to reduce neutron backgrounds. A luminosity-measuring device, the pixel luminosity telescope, was installed on either side of the collision point around the beam pipe.

Other major activities for CMS included replacing photodetectors in the hadron calorimeter with better-performing designs, moving the muon read-out to more accessible locations for maintenance, installation of the first stage of a new hardware triggering system, and consolidation of the solenoid magnet's cryogenic system and of the power distribution. The software and computing systems underwent a significant overhaul during the shutdown to reduce the time needed to produce analysis data sets.

To make the most of the 13 TeV collisions, the LHCb



One of the smaller experiments at the LHC, TOTEM, records a first collision with stable beams at 13 TeV. (Image credit: TOTEM/CERN OPEN-PHO-ACCEL-2015-007-17.)

collaboration installed the new HeRSCheL detector – High Rapidity Shower Counters for LHCb. This consists of a system of scintillators installed along the beamline up to 114 m from the interaction point, to define forward rapidity gaps. In addition, one section of the beryllium beam pipe was replaced and the new beam pipe support-structure is now much lighter.

The CERN Data Centre has also been preparing for the torrent of data expected from collisions at 13 TeV. The Information Technology department purchased and installed almost 60,000 new cores and more than 100 PB of additional disk storage to cope with the increased amount of data that is expected from the experiments during Run 2. Significant upgrades have also been made to the networking infrastructure, including the installation of new uninterruptible power supplies.

First stable beams was an important step for LHC Run 2, but there is still a long way to go before this year's target of around 2500 bunches per beam is reached and the LHC starts delivering some serious integrated luminosity to the experiments. The LHC and the experiments will now run around the clock for the next three years, opening up a new frontier in high-energy particle physics.

● Complied from articles in CERN's *Bulletin* and other material on CERN's website. To keep up to date with progress with the LHC and the experiments, follow the news at bulletin.cern.ch or visit www.cern.ch.

Résumé

Des faisceaux stables à 13 TeV

Le LHC est de retour, avec le début de la deuxième période d'exploitation, à une énergie de collision record. Le matin du mercredi 3 juin, les faisceaux ont été déclarés « stables », ce qui a permis de recommencer à fournir des données de physique aux expériences du LHC, pour la première fois depuis 27 mois. Au bout de près de deux ans de maintenance et de réparation, et de plusieurs mois de remise en service, le plus grand accélérateur de particules du monde est maintenant prêt à explorer la frontière des hautes énergies, à une énergie totale sans précédent, 13 TeV, soit près de deux fois l'énergie de collision de la première période d'exploitation du LHC, qui a duré trois ans.

LHC and Planck: where two ends meet

Researchers at opposite ends of the distance scale are looking at each other's findings, to unveil the universe's most hidden secrets.

Over the past decade and more, cosmology on one side and particle physics on the other have approached what looks like a critical turning point. The theoretical models that for many years have been the backbone of research carried out in both fields – the Standard Model for particle physics and the Lambda cold dark matter (ΛCDM) model for cosmology – are proving insufficient to describe more recent observations, including those of dark matter and dark energy. Moreover, the most important "experiment" that ever happened, the Big Bang, remains unexplained. Physicists working at both extremes of the scale – the infinitesimally small and the infinitely large – face the same problem: they know that there is much to search for, but their arms seem too short to reach still further distances. So, while researchers in the two fields maintain their specific interests and continue to build on their respective areas of expertise, they are also looking increasingly at each other's findings to reconstitute the common mosaic.

Studies on the nature of dark matter are the most natural common ground between cosmology and particle physics. Run 2 of the LHC, which has just begun, is expected to shed some light on this area. Indeed, while the main outcome of Run 1 was undoubtedly the widely anticipated discovery of a Higgs boson, Run 2 is opening the door to uncharted territory. In practical and experimental terms, exploring the properties and the behaviour of nature at high energy consists in understanding possible signals that include "missing energy". In the Standard Model, this energy discrepancy is associated with neutrinos, but in physics beyond the Standard Model, the missing energy could also be the signature of many undiscovered particles, including the weakly interacting massive particles (WIMPs) that are among the leading candidates for dark matter. If WIMPs exist, the LHC's collisions at 13 TeV may reveal them, and this will be another huge breakthrough. Because supersymmetry has not yet been ruled out, the high-energy collisions might also eventually unveil the supersymmetric partners of the known particles, at least the lighter ones. Missing energy could also account for the escape of a graviton into extra dimensions, or a variety of other possibilities. Thanks to the LHC's Run 1 and other recent studies, the Standard Model is so well known that

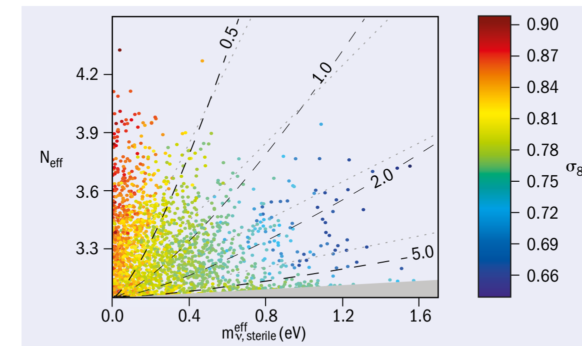


Fig. 1. Samples from Planck data colour-coded by σ_8, the fluctuation amplitude at a radius of 8 h^{-1} Mpc, in models with one massive sterile neutrino family, with effective mass, $m^{eff}_{\nu,sterile}$, and three active neutrinos. The physical mass of the sterile neutrino, in electron-volts, is constant along the dashed or dotted lines, depending on the model. (Image credit: Planck Collaboration 2015a.)

future observation of an unknown source of missing energy could be confidently linked to new physics.

Besides the search for dark matter, another area where cosmology and particle physics meet is in neutrino physics. The most recent result that collider experiments have published for the number of standard (light) neutrino types is $N_\nu = 2.984 \pm 0.008$ (ALEPH *et al.* 2006). While the search for a fourth right-handed neutrino is continuing with ground-based experiments, satellite experiments have shown that they can also have their say. Indeed, recent results from ESA's Planck mission yield $N_{eff} = 3.04 \pm 0.18$ for the effective number of relativistic degrees of freedom, and the sum of neutrino masses is constrained to $\Sigma m_\nu < 0.17$ eV. These values, derived from Planck's data of temperature and polarization CMB anisotropies in combination with data from baryonic acoustic oscillation experiments, are consistent with standard cosmological and particle-physics predictions in the neutrino sector (Planck Collaboration 2015a). Although these values do not completely rule out a sterile neutrino, especially if thermalized at a different background temperature, its existence is disfavoured by the Planck data (figure 1).

Working out absolute neutrino masses is no easy task. Ground-based experiments have observed the direct oscillation of neutrinos, which proves that these elusive particles have a nonzero mass. However, no measurement of absolute masses has been ▷

performed yet, and the strongest upper limit (about one order of magnitude more accurate than direct-detection measurements) on their sum comes from cosmology. Because neutrinos are the most abundant particles with mass in the universe, the influence of their absolute mass on the formation of structure is as big as their role in many physics processes observed at small scales. The picture in the present Standard Model might suggest (perhaps naively) that the mass distribution among the neutrinos could be similar to the mass distribution among the other particles and their families, but only experiments such as KATRIN – the Karslruhe Tritium Neutrino experiment – are expected to shed some light on this topic.

In recent years, cosmologists and particle physicists have shown a common interest in testing Lorentz and CPT invariances (*CERN Courier* November 2013 p31). The topic seems to be particularly relevant for theorists working on string theories, which sometimes involve mechanisms that lead to a spontaneous breaking of these symmetries. To find possible clues, satellite experiments are probing the cosmic microwave background (CMB) to investigate the universe's birefringence, which would be a clear signature of Lorentz invariance and, therefore, CPT violation. So far, the CMB experiments WMAP, QUAD and BICEP1 have found a value of α – the rotation angle of the photon-polarization plane – consistent with zero. Results from Planck on the full set of observations are expected later this year.

Since its discovery in 2012, the Higgs boson found at the LHC has been in the spotlight for physicists studying both extremes of the scale. Indeed, in addition to its confirmed role in the mass mechanism, recent papers have discussed its possible role in the inflation of the universe. Could a single particle be the Holy Grail for cosmologists and particle physicists alike? It is a fascinating question, and many studies have been published about the particle's possible role in shaping the early history of the universe, but the theoretical situation is far from clear. On one side, the Higgs boson and the inflaton share some basic features, but on the other side, the Standard Model interactions do not seem sufficient to generate inflation unless there is an anomalously strong coupling between the Higgs boson and gravity. Such strong coupling is a highly debated point among theoreticians. Also in this case, the CMB data could help to rule out or disentangle models. Recent full mission data from Planck clearly disfavour natural inflation compared with models that predict a smaller tensor-to-scalar ratio, such as the Higgs inflationary model (Planck Collaboration 2015b). However, the question remains open, and subject to new information coming from the LHC's future runs and from new cosmological missions.

In the meantime, astroparticle physics is positioning itself as the area where both cosmology and particle physics could find answers to the open questions. An event at CERN in April provided a showcase for experiments on cosmic rays and dark matter, in particular the latest results from the Alpha Magnetic Spectrometer (AMS) collaboration on the antiproton-to-proton ratio in cosmic rays and on the proton and helium fluxes. Following earlier measurements by PAMELA – the Payload for Antimatter Matter Exploration and Light nuclei Astrophysics – which took data in 2006–2011 (*CERN Courier* September 2011 p34), AMS now has results based on more than 6×10^{10} cosmic-ray events (electrons, positrons, protons and antiprotons, as well as nuclei of helium, lithium, boron, carbon, oxygen...) collected during the first

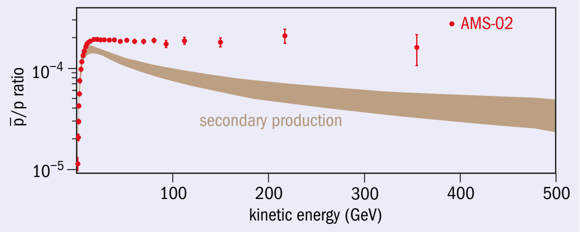


Fig. 2. The antiproton-to-proton ratio in cosmic rays measured by AMS cannot be explained by existing models of secondary production. (Image credit: AMS.)

four years of AMS-02 on board the International Space Station (*CERN Courier* July/August 2011 p18). With events at energies up to many tera-electron-volts, and with unprecedented accuracy, the AMS data provide systematic information on the deepest nature of cosmic rays. The antiproton-to-proton ratio measured by AMS in the energy range 0–500 GeV shows a clear discrepancy with existing models (figure 2). Anomalies are also visible in the behaviour of the fluxes of electrons, positrons, protons, helium and other nuclei. However, although a large part of the scientific community tends to interpret these observations as a new signature of dark matter, the origin of such unexpected behaviour cannot be easily identified, and discussions are still ongoing within the community.

It may seem that the universe is playing hide-and-seek with cosmologists and particle physicists alike as they probe both ends of the distance scale. However, the two research communities have a new smart move up their sleeves to unveil its secrets – collaboration. Bringing together the two ends of the scales probed by the LHC and by Planck will soon bear its fruits. Watch this space!

Further reading

ALEPH, DELPHI, L3, OPAL and SLD Collaborations, LEP Electroweak Working Group, SLD Electroweak Group and SLD Heavy Flavour Group 2006 *Phys. Reports* **427** 257.

Planck Collaboration 2015a arXiv:1502.01589v2 [astro-ph.CO], submitted to *Astronomy & Astrophysics*.

Planck Collaboration 2015b arXiv:1502.02114 [astro-ph.CO], submitted to *Astronomy & Astrophysics*.

Résumé

LHC et Planck : rencontre entre deux extrêmes

Les physiciens des particules et les cosmologistes travaillent à des échelles de distance opposées – l'infiniment petit et l'infiniment grand – mais sont confrontés au même problème : il leur reste énormément de choses à découvrir, encore hors de leur portée. Aussi les scientifiques de ces deux domaines s'intéressent-ils de plus en plus à leurs découvertes respectives, afin de reconstituer le puzzle sur lequel les deux groupes travaillent. Alors que les études menées auprès du LHC et avec la mission Planck dans l'espace se penchent sur ces deux extrêmes, des expériences en astrophysique des particules pourraient également faire la lumière sur certaines questions non résolues.

Antonella Del Rosso, CERN.

Frontier detectors for the future

The latest in the series of "Pisa meetings" showed that progress in detector technology is alive and well, and attractive to young scientists.

Participants at the round table. (All image credits: Nanni Darbo.)

The last week of May saw a gathering of 390 physicists from 27 countries and four continents on the island of Elba. The 13th edition of the Pisa Meeting on Advanced Detectors for Frontier Physics took place in the secluded Biodola area. The conference, which takes place every three years, is based on a consolidated format, aiming at an interdisciplinary exchange of ideas: all sessions are plenary, with a round table on a topic of interest (*CERN Courier* July/August 2006 p31). The programme for this year was built on a record number of contributions (more than 400), out of which 327 were selected for either oral (66) or poster presentations. Eight industries were present throughout the meeting, with stands to display their products and to discuss ongoing and future R&D projects.

The opening session saw an introductory talk by Toni Pich of Valencia that described the situation in frontier physics today. The discovery of a particle associated with the Brout–Englert–Higgs mechanism has opened a whole new field of investigation to explore, in addition to the "known unknowns". Among these, revealing the nature of dark matter and of neutrino masses is the main priority. In the following talk, CERN's Michelangelo Mangano discussed the search for supersymmetry, as well as different possibilities for signals of new physics that will be explored with high priority from the start of Run 2 at the LHC.

A key event was the round table organized on the second day of the meeting, with 13 people representing nine laboratories (CERN, the Institute of High Energy Physics (IHEP) in Beijing, Fermilab, PSI, TRIUMF, the European Spallation Source, KEK and the Japan Proton Accelerator Research Complex) and four funding agencies (the US Department of Energy, the Institut national de physique nucléaire et de physique des particules (IN2P3), the Istituto Nazionale di Fisica Nucleare (INFN) and the UK's Science and Technology Facilities Council). The topic for discussion was "Synergies and complementarity among laboratories", in view of the challenges of the coming decades and of the growing role of CERN as the place where the energy frontier will be explored. The presentation about the future of high-energy physics in China by Gang Chen of IHEP was particularly enlightening, giving a perspective and an impressive plan spanning the middle of this century. Representatives of the funding agencies discussed the nearer future, where – besides the High Luminosity LHC project – a strong neutrino programme is foreseen. The lively exchange among the scientists at the table and participants on the floor left everyone with a vivid perception that what Sergio Bertolucci, CERN's director for research and computing, defined as "co-opetition" among different institutions in high-energy physics, must move forward and become part of the texture of daily work. Several participants stressed that although CERN is central, regional laboratories have an important role because they relate directly to the host nations. Demonstrating the societal impact of research in high-energy physics to politicians and to the public at large is a key point in obtaining support for the whole field.

Each Pisa meeting has a number of standard sessions on gas and solid-state detectors, particle and photon identification, calorimetry and advanced electronics, astroparticle physics, and the application of high-energy-physics techniques in other fields. The presentations, both oral and with posters, demonstrated that significant improvements in existing detectors and current techniques are still possible. The topics presented covered dedicated R&D as well as novel ideas, some developed in a beneficial crossover with other areas, ranging from material science to nanotechnology and chemistry. In a dedicated session, speakers from the LHC experiments noted that the detectors are now performing well and are ready to help harvest the physics at 13 TeV that will come from the LHC's Run 2.

As the field keeps changing, so does the conference. This year, a new session was introduced to offer adequate space to applied superconductivity. The technique is now fundamental, not just to provide stronger magnetic fields for accelerators and spectrometers, but also in specialized detectors. The review talk by Akira Yamamoto of ▷

Conference

Left: David Nygren, second left, and Fabio Sauli, second right, were awarded the first Aldo Menzione Prize, presented by Angelo Scribano, the president of the FDFP, left, and Donata Foà, Aldo's widow. Above: The awarding of the FDFP Pisa meeting prizes with, left to right, Angelo Scribano, the winners Lars Graber, Raffaella Donghia and Roberto Acciarri, and chairperson Marco Grassi.

KEK and CERN outlined the new frontier of superconducting magnets, both in terms of achievable field and of stored energy/mass ratio. Emanuela Barzi and Alexander Zoblin presented the R&D programme for high-field superconducting magnets at Fermilab. The laboratory that pioneered the use of superconducting magnets in accelerators now aims to be able to build magnets suitable for the Future Circular Collider design study (*CERN Courier* April 2014 p16). The use of superconducting materials to detect photons was discussed in two talks, by Martino Calvo of CNRS Grenoble and Roberto Leoni of IFN-CNR, Rome. The use of cryogenic detectors – bolometers, kinetic-inductance detectors, transition-edge sensors, to name but a few – was discussed by Flavio Gatti of INFN Genova, in a review of the large number of posters on the subject presented at the conference.

The meeting saw the awarding of the first Aldo Menzione Prize. Among his many activities, Aldo was one of the founders of the Pisa meeting and recipient of the W K H Panokfsky Prize in 2009. He passed away in December 2012 (*CERN Courier* April 2013 p37), and to honour his memory, the Frontier Detectors for Frontier Physics (FDFP) association that organizes the conference series, established an award to be assigned at each meeting to "a distinguished scientist who has contributed to the development of detector techniques". The recipients of the prize on this first occasion were David Nygren, now of the University of Texas at Arlington, for the invention of the time-projection chamber, and Fabio Sauli, now of the TERA Foundation, for the invention of the gas electron-multiplier, or GEM. The prizes were presented by Donata Foà, Aldo's widow, and Angelo Scribano, the president of the FDFP.

Winners of the Glenn Knoll Award, Joana Wirth, left, and Filippo Resnati, right, together with Fabio Sauli.

At the end of the conference dinner, several awards were also assigned by an international jury. Elsevier established two Elsevier Young Scientist Awards to honour the late Glenn Knoll, who was an editor of *Nuclear Instruments and Methods* (*NIM*). These were presented by Fabio Sauli, on behalf of *NIM*, to Filippo Resnati of CERN and Joana Wirth of the Technische Universität München, respectively, for his talk on the "Charge transfer properties through graphene for applications in gaseous detectors", and for her poster on "CERBEROS: a tracking system for secondary pion beams at the HADES spectrometer". Three FDFP awards to "talented young scientists active in the development of detection techniques and contributing, by talk or poster, to the scientific programme" were conferred by Angelo Scribano to Lars Graber of the University of Göttingen for his talk on "A 3D diamond detector for particle tracking", Roberto Acciarri of Fermilab for a poster on "Experimental study of breakdown electric fields in liquid argon" and Raffaella Donghia of INFN-LNF for her poster on "Time performances and irradiation tests of CsI crystals read-out by MPPC".

Concluding the conference, the chair, Marco Grassi of INFN-Pisa, provided a few statistics. He remarked that 36% of the participants were below 35 years old and nearly all of them – 96% – contributed to the conference programme with oral presentations or posters. This demonstrates that the field of detector development is attractive and has a strong basis on which it can grow, as long as, at a national level, institutes can continue to recruit these young scientists. This, as Catherine Clerc from IN2P3 reminded everybody during the round table, is the most pressing challenge in many European countries.

● For further information, visit the conference website https://agenda.infn.it/conferenceDisplay.py?confId=8397, where all of the presentations (oral and posters) are available.

Résumé

Repousser les limites des détecteurs pour le futur

La dernière de la série des rencontres de Pise a montré que les avancées dans les technologies des détecteurs vont bon train et que le domaine attire les jeunes scientifiques. La conférence, qui a lieu tous les trois ans, vise à susciter un échange d'idées interdisciplinaire. Cette année, un nombre record de contributions – dont beaucoup proposées par de jeunes chercheurs – ont été présentées lors des sessions plénières, sur des sujets allant de l'identification des particules et des photons à l'électronique de pointe et aux applications dans d'autres domaines. La traditionnelle table ronde portait sur les synergies et la complémentarité entre les laboratoires, et a réuni des représentants de grands laboratoires et agences de financement.

Giorgio Chiarelli, INFN-Pisa.

Advertising feature

Kurt J. Lesker company enables propulsion research

The Bogazici University Space Technologies Laboratory (BUST-Lab) presents its research findings into sourcing reliable technologies for testing space simulation.

Satellites and spacecraft moving in an orbit or in interplanetary space use propulsion systems that utilize the principle of conservation of momentum to provide thrust. Typical in-space propulsion systems convert the chemical energy stored in the on-board propellant into kinetic energy. Propulsion systems that use other sources of energy (batteries, solar panels, radioactive sources of energy, nuclear reactors, etc) are being developed as an alternative to the standard space propulsion systems. Because in these alternative propulsion systems the energy carried by the vehicle is not limited to the energy stored in the propellants' chemical bonds, these types of propulsion systems can provide higher levels of impulse for the same amount of propellant, or can accomplish certain missions with a lesser amount of propellant.

There are numerous ways to use external energy sources for propulsion. In some of these systems the propellant is ionized and plasma is obtained. This plasma is then accelerated with the help of electromagnetic forces, and expelled from the spacecraft at high velocities to produce the desired thrust. These thrusters, also called plasma rockets, are being considered for use in Earth-orbiting satellites of various types (communication, meteorology, military, intelligence, etc) because they provide possibilities for extending the life of the satellites, as well as for reducing the amount of fuel that they require.

Additionally, the development and use of these thrusters will be significant for the realization of certain manned and/or unmanned interplanetary missions.

To develop and test thrusters to be deployed on spacecraft or satellites, vacuum facilities that provide a vacuum environment similar to that in low Earth orbit are needed. At this point, high-quality vacuum systems emerge to satisfy this requirement. Pressure levels below 10^{-6} Torr are required for the simulation of space conditions. Moreover, for examination of the impact of thermal effects in the space environment on spacecraft components, establishing a thermal test section in vacuum systems is also another requirement for researchers.

Chamber placement at the laboratory.

The vacuum chamber

The establishment of a vacuum facility on-site at Bogazici University Space Technologies Laboratory (BUST-Lab) would allow dedicated testing and development of electrical thrusters as deployed on spacecraft or satellites.

The process was then to source a preferred supplier of vacuum equipment to aide with the design and construction of a vacuum chamber, for which Kurt J. Lesker was chosen.

The vacuum facility provides a vacuum environment that is similar to the environment in low Earth orbit, even when a plasma thruster is in operation inside the chamber (when releasing gas into the chamber). The vacuum facility will primarily be used to develop electric spacecraft thrusters that run on xenon or argon propellants. The facility is able to obtain a base pressure of 2×10^{-8} Torr and to maintain a vacuum level of 3×10^{-5}, with 10 sccm (~1 mg/min of xenon) of gas being released by the thruster.

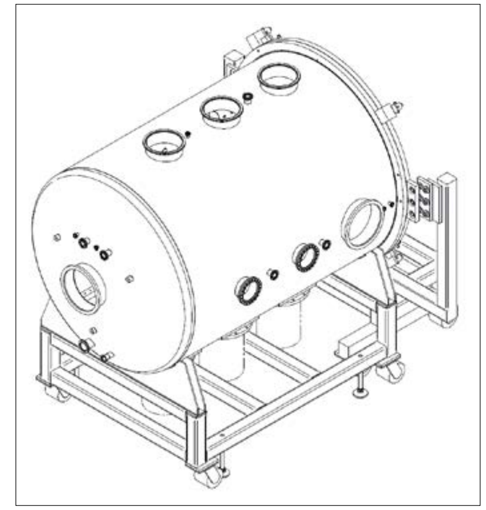
The constructed vacuum chamber is 1.5 m in diameter and 2.7 m in length. A 3D technical drawing of the chamber is shown above. The chamber took approximately 13 months from design to delivery, and was expertly manufactured at the Kurt J. Lesker facilities in Pittsburgh, PA, USA.

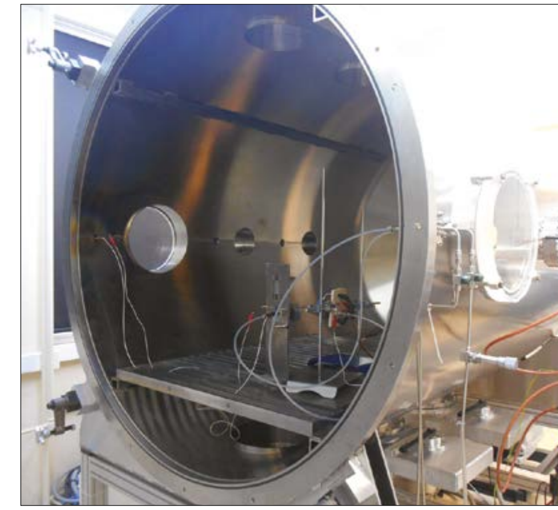
Upon installation of the mechanical pump and cryogenic pumps, and all of the necessary ports for electrical and gas connections, the chamber was then ready for experiments from the time it was first brought into the laboratory.

The BUST-Lab vacuum chamber became fully operational on 17 December 2014.

Chamber design and operation

Currently, the vacuum chamber is integrated with one mechanical and two cryogenic pumps that are used to decrease the pressure to the desired levels. The chamber is rough-pumped with a rotary-vane pump with roots blower, with a pumping capacity of 253 m^3/h. The rough pump-down of the chamber takes about 35 minutes (from 760 Torr to 2×10^{-3} Torr). The chamber is then pumped with two 12-inch cryopumps, each with 3100 litres-per-second argon pumping capacity. The cryopumps are attached to two water-cooled helium compressors. These two compressors are placed on the side of the chamber inside the laboratory. The chilled water to both of the compressors is provided by an air-cooled chiller. The chiller is located outside of the laboratory. The chiller has a rated cooling capacity of 16.8 kW (14,448 kcal/h) for a water exit temperature of 15 °C at an ambient temperature of 25 °C.





(Left) Technical drawing of BUSTLab Vacuum Chamber. (Right) Cusped field Hall thruster and the RF cathode.

The reduction of the base pressure inside of the vacuum chamber consists of two stages. In the first stage, only the mechanical pump is operational. When the chamber pressure is reduced to the order of 4×10^{-3} Torr, the mechanical-pump port valve is shut off and the mechanical pump is shut down. At this point, the second stage of the pumping process is started by opening the gates of the two cryogenic pumps.

Reduction of the base pressure from 4×10^{-3} Torr to 10^{-6} Torr level by the cryogenic pumps takes only a few minutes. With the cryogenic pumps, the base pressure of the chamber could be brought down to 2×10^{-8} Torr levels. The time taken to reach the base pressure depends on the size of the experimental set-up and the cleanliness level of the equipment inside the chamber.

To clarify, the vacuum facility should provide a vacuum environment that is similar to the environment in low Earth orbit, even when a plasma thruster is in operation inside the chamber (when releasing gas into the chamber). Therefore, to determine the balance pressure inside the vacuum chamber for various propellant flow rates, argon gas is released into the chamber at flow rates regulated by two MKS mass-flow controllers. The balance-pressure levels of the vacuum chamber for various argon gas-flow rates are fed into the chamber. It is observed that from 1 sccm up to 22 sccm argon mass-flow rate, the balance pressure inside of the chamber shows a linearly increasing tendency with increasing mass-flow rate. The balance pressure is around 3×10^{-5} Torr for a gas-flow rate of 10 sccm. The results are that the pumping rate of the chamber is suitable for the plasma-thruster testing.

Preliminary thruster testing

Proceeding with the building of an SPT-type Hall thruster and a cusped-field Hall thruster, testing began in the BUST-Lab vacuum chamber. The prototype cusped-field Hall thruster (CFHT-40), along with the radio-frequency (RF) cathode built at BUST-Lab, were placed inside the vacuum chamber, and the CFHT-40 was operated with high-purity argon propellant gas at 400 V discharge voltage and 1.2 A discharge current. The thruster and the cathode placed inside the BUST-Lab vacuum chamber are shown above. The cathode was operated at argon gas-flow rates of 2 to 5 sccm, at 50 watts of RF power provided by a 13.56 MHz RF power source.

Preliminary testing of the developed SPT-type Hall-effect thruster was also conducted inside the BUST-Lab vacuum chamber. The thruster was operated at a discharge voltage of 260 V and discharge current of 1.2 A, with high-purity argon propellant for the initial tests. During the Hall-effect-thruster testing, a cathode made of tantalum wire placed just in front of the thruster was used as the electron source.

To conclude, the acquisition, manufacturing processes and capabilities of a newly built vacuum facility at the Bogazici University Space Technologies Laboratory (BUST-Lab) provided preliminary testing of two different prototype Hall thrusters – the first experimental plasma thrusters to be designed, built and successfully tested in Turkey.

The use of an established vacuum chamber has enabled simulation of the space environment to conduct experiments on electric propulsion systems as well as other spacecraft components.

The project would not have been possible without financial support from Bogazici University Scientific Projects Office (BAP) and The Turkish Scientific and Technological Research Council (TUBITAK).

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Faces & Places

Appointments

Pavel Logachev is new director of the Budker Institute

Pavel Logachev has been appointed director of the Budker Institute of Nuclear Physics (BINP), of the Siberian Branch of the Russian Academy of Sciences, in Novosibirsk, with effect from 1 June. He succeeds Alexander (Sasha) Skrinsky.

After studying accelerator physics at Novosibirsk State University, Logachev gained his PhD in experimental physics in 1996, for research at BINP on ultracold beams and short intense electron bunches. He has since become a well-known specialist on charged-particle beams and accelerator technologies. He has developed and successfully implemented high-frequency linear accelerators operating in the S-band, and built a unique linear induction accelerator to serve as an injector for a new-generation pulsed X-ray source for imaging.

Pavel Logachev, now at the helm at BINP. (Image credit: Valentin Baev.)

A corresponding member of the Russian Academy of Sciences, Logachev has experience of scientific management and has been deputy director of BINP since 2013. He is also associate professor at Novosibirsk State University, giving lectures on sources of charged-particle beams and supervising numerous Masters and PhD students. Since 2013, he has been a member of the working group on "Infrastructure of scientific research", part of the Russian president's Council on Science and Education.

Marcel Demarteau takes over at Argonne

Marcel Demarteau has been appointed as the new director of the High Energy Physics Division at Argonne National Laboratory (ANL). He succeeds Harry Weerts, who was appointed interim associate laboratory director of Argonne's Physical Sciences and Engineering Directorate in May 2014 (*CERN Courier* July/August 2014 p35), and takes over from Rik Yoshida, who has been interim director of the High Energy Physics Division for the past year.

Demarteau has served as a senior scientist and the group leader for the instrumentation programme in the High Energy Physics Division since 2010. From 1992 to 2010, he worked at Fermilab, where he was a member of the D0 collaboration and deeply involved in the analysis of precision electroweak-physics processes. He also managed the collider-detector instrumentation programme and the development of several generations of detector technology.

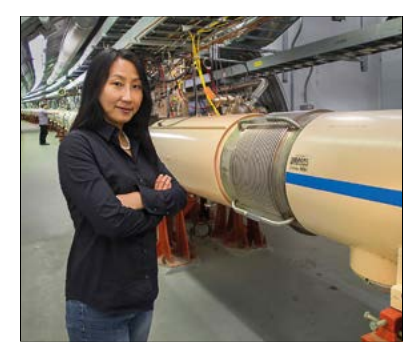
Building on Argonne's multidisciplinary nature, Demarteau will lead the division in its efforts to develop new detector technology for the next generation of accelerators and particle-physics experiments, and build on the laboratory's strengths, such as in high-performance computing and theoretical physics, to advance its science programme.

Marcel Demarteau, in charge of high-energy physics at Argonne. (Image credit: ANL.)

Awards

Bai and Schlegel receive 2014 Lawrence Awards

Mei Bai of Brookhaven National Laboratory and David Schlegel of Lawrence Berkeley National Laboratory are among the nine winners of the 2014 Ernest Orlando Lawrence Awards, which were established in 1959 to honour the memory of the inventor of the cyclotron. The awards recognize mid-career scientists and engineers in the US who have advanced new research and scientific discovery in the chemical, biological, environmental and computer sciences; condensed matter and materials; fusion and plasma sciences; high-energy and nuclear physics; and national security and non-proliferation.



Mei Bai in the RHIC tunnel. (Image credit: BNL.)

Bai is honored with the nuclear-physics award for her "outstanding contributions to advancing our understanding of the dynamics of spin-polarized beams and for the acceleration of polarized protons at the Relativistic Heavy Ion Collider (RHIC), making it the world's first and only high-energy polarized-proton collider". This work has allowed the first direct measurement of the gluon and ▷

sea-quark contribution to the spin of the proton. Schlegel, who is a long-time contributor to the Sloan Digital Sky Surveys (SDSS), receives the high-energy physics award for his "exceptional leadership of major projects making the largest two-dimensional and three-dimensional maps of the universe, which have been used to map the expansion rate of the universe to 10 billion light years and beyond". His work has helped to ascertain the nature of dark energy, test general relativity and make precision cosmology an important tool in high-energy physics.

David Schlegel, with a SDSS plug plate used in mapping a small patch of the night sky. (Image credit: LBL.)

Brookhaven team honoured for building LHC magnets

Energy secretary Ernest Moniz (fourth from right) presenting the award to several members of the 17-person team, primarily based at Brookhaven Lab, including (from left): DOE Office of High Energy Physics federal project manager Bruce Strauss, Ramesh Gupta, Brookhaven site office federal project director Robert Caradonna, Mike Anerella, Piyush Joshi, Ron Prwivo, and project manager Peter Wanderer. (Image credit: DOE.)

Following the restart of the LHC in April, a 17-member team, primarily based at the Brookhaven National Laboratory, was recognized with one of the most prestigious awards of the US Department of Energy (DOE), for successfully completing two superconducting magnets for the collider.

Energy secretary Ernest Moniz presented the Secretarial Honor Award for Achievement to the team during a ceremony on 7 May at the DOE headquarters in Washington, "for successfully constructing, testing and delivering the magnets to enhance the reliability of operations at the LHC". The team completed this four-year, $11.4-million project on time and under budget, with increased scope. Initially, CERN requested one magnet, and as the team made considerable progress, the project was expanded to include a second. The magnets were delivered to CERN separately, with the second of the two arriving in March 2014. Both magnets are now serving as backups for the collider system.

CERN Courier July/August 2015

Faces & Places

Matveev receives 2015 Markov Prize

Victor Matveev, the director of JINR Dubna, has been awarded the 2015 Markov Prize of the Institute for Nuclear Research of the Russian Academy of Sciences (INR RAS). He received the award at the 2015 Markov Readings, held at the INR on 15 May, for his "contribution to strong interaction theory and the quark model of hadrons".

Matveev has made a number of important contributions in theoretical physics, including the development of methods of quantum field theory for studying high-energy scattering, the description of relativistic composite systems, the formulation of the quark theory of nuclear forces and studies of the effects of quark degrees of freedom in nuclei. He also introduced the notions of hidden colour and quark counting rules. He now works on the search for supersymmetry at the LHC.

The Markov Prize was established by INR RAS in commemoration of Moisey Markov, who made pioneering contributions to neutrino physics, as well as to physics at the boundary between particle physics and cosmology.

Left to right: Valery Rubakov, a co-chairman of the Markov Readings, Victor Matveev, winner of the 2015 Markov Prize and director of JINR, Leonid Kravchuk, director of INR RAS, and Rozaliya Matveeva. (Image credit: INR.)

Steve Myers, second from left, formerly CERN's director of accelerators and technology and now head of the CERN Medical Applications Office, was officially admitted as an honorary member of the Royal Irish Academy (RIA) on 29 May. He is seen here with Mary Daly, president of the RIA, and Tom Millar, left, and Matthew Zepf, right, of Queens University Belfast. This year, the academy is celebrating its 230th anniversary, and now has 493 members and 76 honorary members, in disciplines from the sciences, humanities and social sciences. Honorary members are usually academics who have made a major international contribution to their discipline, but who are not normally resident in Ireland. (Image credit: John Bambury.)

School

Accelerators for medical applications

Participants at the school, organized by CAS and MedAustron. (Image credit: Michael Holi.)

The CERN Accelerator School (CAS) and MedAustron jointly organized a course on accelerators for medical applications, in Vösendorf on 26 May–5 June. Held in the Eventhotel Pyramide on the outskirts of Vienna, the school attracted 76 participants of 29 nationalities, from countries as far away as Canada, China, Lithuania, Thailand, Ukraine and Russia.

The emphasis of the intensive programme of 37 lectures was on using charged-particle beams for cancer therapy. It began by covering the way in which particles interact with biological material, how this translates into the dose needed for treatment, and how this dose is best delivered. The different options for accelerators to provide the required particles were then presented in some detail. The course also covered the production of radioisotopes and how these are used for diagnostics and therapy, and provided a look at novel acceleration techniques that may play a future role in the field. A case-study exercise of 10 hours completed the programme. For this, the students were divided into small groups in which they pursued a given task to design a facility for hadron therapy, presenting their results on the final day.

A day-long visit to the MedAustron facility (*CERN Courier* October 2011 p33), with talks in the morning and visits to the facilities in the afternoon, also formed part of the programme. In addition to the academic activities, the students could also join an excursion to the Benedictine monastery at Melk, combined with a boat trip on the Danube and a typical Austrian evening at a "Heurigen".

Next year, CAS will be organizing a specialized course on free-electron lasers and energy-recovery linacs, on 31 May–10 June, to be held in Hamburg in collaboration with DESY. An introduction to accelerator physics will be held in Turkey in the autumn, and a second specialized course on injection and extraction will be held at CERN in early autumn.

● For further information on future CAS courses, visit www.cern.ch/schools/CAS.

BINP

Alexander Bondar celebrates his 60th

Alexander Bondar, deputy director at the Budker Institute of Nuclear Physics (BINP) in Novosibirsk, was 60 on 27 May.

Bondar started work at BINP in 1973, while still a student of Novosibirsk State University. He went on to become an expert in developing new methods of particle detection and in detailed effects in beam polarization, and participated in various experiments at the e^+e^- colliders in Novosibirsk.

Since the beginning of the 1990s, he has been active in the Belle collaboration at KEKB – the world's highest-luminosity e^+e^- collider at KEK in Japan. The caesium-iodide electromagnetic calorimeter was constructed and maintained by the Novosibirsk team under his guidance, and has worked reliably during the whole operation of Belle. In addition, he has contributed to the varied physics studied at Belle, suggesting a novel method for determining the angle γ of the unitarity triangle related to the Cabibbo–Kobayashi–Maskawa matrix – a fundamental parameter of the Standard Model. He has also played a leading role in discovering new exotic states of heavy bottomonium. Knowledge gained in these experiments allowed the Novosibirsk team to join experiments with the LHCb detector at the LHC.

Bondar actively represents BINP in Russia and abroad, and regularly presents new results in heavy-quark physics and organizes scientific meetings. He has been a member of CERN's Scientific Policy Committee (2006–2012), and a member of the International Committee for Future Accelerators since 2012. He continues to teach and supervise students of Novosibirsk State University, becoming dean of the Department of Physics in 2010.

Alexander Bondar, now 60. (Image credit: Valentin Baev.)

Corrections

An unfortunate error crept in at the end of a recent article on the first full jet measurement in Pb–Pb collisions by ALICE (*CERN Courier* June 2015 p7). The new measurement uses jet constituents down to a few-hundred MeV/*c*, rather than GeV/*c*.

In the same issue, a mistake also occurred in the book review on p41. The famous pioneer of applications of particle accelerators for society is of course Ugo Amaldi.

Apologies to all concerned.

Outreach

CERN scientist on FameLab podium

Lillian Smestad, a member of the AEgIS collaboration at CERN, took an excellent second place in the FameLab International final in Cheltenham on 4 June. She was one of nine finalists selected from hundreds in 20 countries worldwide, in the 2015 edition of the well-known science-communication competition, in which scientists have to engage the audience in a three-minute presentation on a scientific topic.

Smestad, from the Norwegian Research Council, gave a captivating talk on what would happen to you if you fell into a black hole. As Gill Samuels, one of the judges, noted, she was impressive "not only for the clarity of her presentation and the clarity of her answers, but for being brave to be the first person on the stage". It was the first time that a CERN competitor had reached the final – and also the first time that CERN had entered the contest as a separate entity, being the first organization, rather than nation, to compete.

Famelab, which was started in 2005 in the UK by the Cheltenham Science Festival, is sponsored by the British Council, and has seen more than 5000 young scientists and engineers participate in more than 23 different countries. CERN has been a partner of FameLab in Switzerland since 2012, and in France since 2014. This year, the winner of the international final Oskari Vinko and joint second François-Xavier Joly trained for the competition in masterclasses at CERN, which helped to provide them with the content, clarity and charisma on which they scored so highly.

- For a video of the final, and more on the competition, see www.britishcouncil.org/education/science/famelab-international-final-2015.

Lillian Smestad in action in the Famelab International final. (Image credit: Famelab.)

Workshop

Hadron physics in Tuscany

Participants at the workshop in Cortona. (Image credit: NPQCD 2015.)

The first Italian Workshop on Hadron Physics and Non-Perturbative QCD (NPQCD 2015) took place in Cortona, Tuscany, on 20–22 April. Intended as an occasion for the Italian community involved in hadron physics and non-perturbative QCD to meet, discuss, exchange information and plan its future, the workshop was based on review talks and descriptions of current activities, with ample time left for discussions, and a concluding round table. With an attendance of around 60 scientists, it was highly successful in bringing together theorists and experimentalists in the field of hadron physics.

The idea of the workshop was born from discussions and events related to the "What Next?" process, promoted from early 2014 by INFN, and during the writing of a white book by the Commissione Scientifica Nazionale 1, the INFN committee that manages experiments at high-energy particle accelerators. "What Next?" aims to understand the current scientific scenario for all INFN activities and to propose a strategy for the next 10 years in the context of a 20-year global vision.

The workshop's themes were identified starting from the consideration that in most interactions involving hadrons, the dynamical properties and degrees of freedom of quarks and gluons combine with some non-perturbative QCD aspects to give measured physical quantities. The description of and attempts to understand such properties are the subject of various branches of hadron physics: three-dimensional nucleon structure; hadron spectroscopy; proton–proton cross-sections, elastic scattering and diffraction physics; multi-parton interactions and underlying events; and cosmic rays and accelerator physics.

The different working groups at the workshop covered a broad programme, from experiment to theory, through phenomenology, in an effort to identify crucial aspects, open issues and future prospects. Several aspects emerged:

- The three-dimensional structure of protons and neutrons, both in momentum and co-ordinate space, represents a new phase in imaging the nucleon that goes beyond the traditional and simple one-dimensional picture of a fast-moving nucleon as a bunch of collinearly moving partons.
- The plethora of new data from B and charm factories, besides completing the conventional spectra of mesons and baryons, have indeed opened up promising pathways to a new spectroscopy: multi-quark degrees of freedom, predicted in QCD since its birth, have finally been observed with unambiguous signatures. At the same time, the wealth of discoveries has raised even more intriguing questions, and high-statistics data from current and future facilities are eagerly awaited, to gain further insights into strong interactions.
- Total, elastic and diffractive cross -sections are of fundamental importance to understand the mechanisms of hadronic interactions and their evolution with respect to centre-of-mass energy and momentum transfer.
- The dynamical QCD properties of partons become crucial when processes involving hadrons at large energies take place, and the role of multi-parton interactions, rather than a single elementary interaction, has to be explored and understood.

The concluding round table focused on links between the various topics, common problems, and possible strategies to ▷

tackle them, exploiting all of the tools and knowledge of the hadron-physics community. A couple of highlights are worth mentioning. Recent progress in the modelling of multi-parton interactions can be helpful in the description of parton distribution functions, both in collinear and three-dimensional representation, and in the study of spin and quark angular-momentum correlations. Also, precise knowledge of the cross-sections and of the properties of particle production in hadronic collisions is crucial to reduce systematic errors in several measurements of great astrophysical interest. Notably, data on antiproton production in proton–helium collisions are highly desired to help understand recent data from the Alpha Magnetic Spectrometer experiment and, more generally, searches for antimatter in the universe.

The workshop was supported by the University of Torino, the Sezione INFN of Torino, and by the University of Piemonte Orientale. Special thanks go to the conveners for their work and enthusiasm. The success of the workshop led to the unanimous decision to hold it on a yearly basis.

● For details about the working groups and the workshop programme, visit http://npqcd15.to.infn.it.

TECHNOLOGY TRANSFER

HEPTech brings an entrepreneurial perspective to research

Participants in Prague. (Image credit: Petr Pulc, CTU, Prague.)

The CERN-fostered High Energy Physics Technology Transfer Network (HEPTech) brought together young researchers with entrepreneurial and technology-transfer potential at its second annual symposium, which was hosted by Inovacentrum at the Czech Technical University in Prague, on 31 May–6 June. The event was attended by 17 early stage researchers from Bulgaria, the Czech Republic, Hungary, Italy, Lithuania, Romania, Sweden, Switzerland and the UK. They had been carefully selected, in terms of both eligibility and entrepreneurial potential, from 27 applicants, by a panel of HEPTech experts.

The five-day programme addressed the needs of the young researchers as potential entrepreneurs, by introducing them to topics including issues relating to patent law and intellectual property protection, how and where to find help when starting a new business, what ideas work best for incubation, how to promote and market their research results, and how to attract an investor. Best practice on successful start-ups and products was presented, such as the story of the creation and growth of the Raspberry Pi (an affordable, credit-card-sized computer for educational purposes), and the lessons young entrepreneurs could learn from it. The participants were also introduced to the infrastructure and market potential of the Extreme Light Infrastructure facility hosted by the Institute of Physics at the Czech Academy of Sciences.

The topics were presented by commercially experienced professionals and technology-transfer experts, such as Markus Nordberg of CERN, who spoke about the use of cross-disciplinary teams in creating ideas for new products, and Stephen Blake, a European patent attorney who ran a practical workshop discussing the best intellectual-property protection for a particular case. Jean-Marie Le Goff of CERN, and HEPTech chair, addressed the multi-faceted relationships between research, innovation and industry. He discussed the context of these relationships and explored possible routes for setting up R&D collaborations with industry.

An expert team on innovative product design inspired the young researchers, and made them realize that they were creative and could come up with practical applications for their technology. In one day, the participants went through the main phases of the process of converting research results into a marketable product. All of the experts acknowledged the mutual benefits of networking with young researchers and declared their intention to continue communications with them.

On the last day of the symposium, the participants learnt the lesson that finding the right investor was like finding a life partner and were introduced to the top 10 steps for attracting investors. They gave three-minute pitches on their technologies, and received recommendations for marketing and commercialization from two business investors.

Two special awards provided by the Raspberry Pi Foundation were given for the project that attracted the investors' attention and for the participant who had progressed the most over the week. The first went to Florina Tuluca of the Institute of Geodynamics of the Romanian Academy, Bucharest, for her prototype of a soil-pollution testing device, thus giving her confidence in the market potential of her research. The second award went to Lyubomir Stoyanov of the Faculty of Physics, Sofia University, who, in one week, managed to move physics out of the lab and onto the market.

The overall opinion of the participants was that they had attended a meeting with a unique format, which introduced them to knowledge they had never accessed before, provoked their creativity and gave them a different perspective on research. They described their experience as "life changing" and a "brilliant combination between theory and practice".

● HEPTech organizes many events (*CERN Courier* April 2015 p17). Coming soon are: September 2015, Bulgaria: Workshop on Marketing of Science and Technology (Follow-Up); October 2015, Romania: AIME on ELI-NP and High Energy Laser Applications; November 2015, Italy: Best Practice in Technology Transfer.

INDUSTRY

Romanian firms visit CERN

Maria Ciobanu, left, at the inauguration ceremony in the CERN Council Chamber, right, for the first visit of Romanian firms to the laboratory. (Image credits: CERN-PHOTO-201505-082-19 and CERN-PHOTO-201505-082-24.)

The Bucharest Chamber of Commerce and Industry, in partnership with the Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, and with the collaboration of the Association of Exporters and Importers of Romania, organized the first economic mission of Romanian firms to CERN on 19–21 May. The event, attended by participants from 13 Romanian companies, was inaugurated in a ceremony in the Council Chamber by Maria Ciobanu, ambassador extraordinary and plenipotentiary permanent representative of Romania to the United Nations Office and other international organizations in Geneva. On the following two days, the participants were able to learn about procurement at CERN, meet with technical experts and visit points of interest at the laboratory.

NEW PRODUCTS

Finisar's new WaveShaper 1000/SP 1μm Programmable Single Polarization Filter shapes femtosecond and short-picosecond optical pulses in fibre laser systems, in applications such as precision micromachining, spectroscopy and quantum control systems. The new 1μm WaveShaper module enables stable operation of short-pulse laser systems in harsh environments, by providing precise control of the spectral characteristics of the optical signal. For further information, contact Jan Brubacher, AMS Technologies, e-mail jbrubacher@amstechnologies.com.

Highland Technology has introduced a new VME model, the V280 Isolated Digital Input Module. The V280 features 48 individually isolated digital inputs, with programmable debounce times and extended overload protection. It will accept DC or AC inputs, and includes glitch-catch capability. Versions are available for 24-V and 3.3/5-V logic-level inputs. For more details, e-mail info@highlandtechnology.com or visit www.highlandtechnology.com/DSS/V280DS.shtml.

Murata has introduced the NMUSB202MC, a competitively priced surface-mount powered data-isolator module that conveniently provides dual port USB data and power isolation from a single upstream port with full power (500 mA) available from each port. Used with a host controller, a single module counts as two USB hubs for cascaded applications, with the level of safety isolation additionally providing effective breaking of ground loops and immunity to EMI in harsh environments. For further information, contact Donia Kamil, e-mail dkamil@murata.com or visit www.murata.com.

Spectrum Systementwicklung GmbH has extended its digitizerNETBOX series of LXI-based instruments, and released eight new models for applications where fast electronic signals in the GHz range need to be remotely acquired and analysed. Available with two, four or eight fully synchronous channels, the new units feature sampling rates up to 5 GS/s, bandwidth in excess of 1.5 GHz, and on-board acquisition memory up to 8 GS. Spectrum has also announced the release of three new M4i series Arbitrary Waveform Generators. The new models of the M4i.66xx series offer one, two and four channels, with each channel capable of outputting electronic signals at rates of up to 625 MS/s with 16 bit vertical resolution. For more details, e-mail info@spec.com or visit www.spectrum-instrumentation.com.

VISITS

The Lithuanian minister of health, **Rimantė Šalaševičiūtė**, here with the director-general **Rolf Heuer**, came to CERN on 20 May. Her visit included meetings with scientists involved in medical applications at CERN and the CERN MEDICIS facility (*CERN Courier* November 2013 p37). (CERN-PHOTO-201505-084 – 5.)

On 2 June, **Petr Drulák**, left, the Czech Republic's deputy minister of foreign affairs, was welcomed to CERN by **Rüdiger Voss**, head of international relations. The minister went on to see the Synchrocyclotron exhibition and the ATLAS visitor centre. (CERN-PHOTO-201506-121 – 3.)

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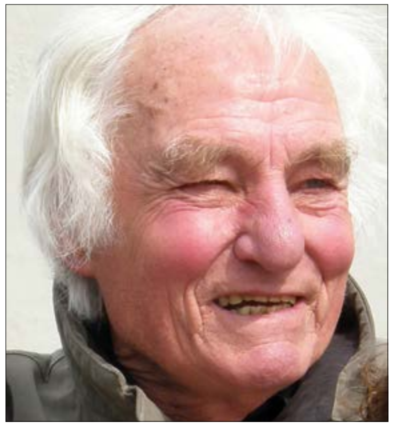
OBITUARIES

Rudolf Böck 1935–2015

The particle-physics community has been saddened to learn of the sudden and unexpected death of Rudolf (Rudy) Böck, on 15 April at the age of 80.

Rudy obtained his PhD in Munich, and started work at CERN in October 1959 as a mathematician in the Data Handling Division. These were pioneering days for the application of computers to the analysis of data from experiments, and he worked on problems ranging from finding camera positions on a new bubble chamber to the more generic fitting of kinematic variables to measured tracks. He was a member of the small team of "ace programmers" who produced a standard suite of programs (REAP, THRESH, GRIND) for data analysis in bubble-chamber experiments. While these were initially written in FORTRAN II, it became clear that greater portability was required, and therefore the CERN Track Chamber Program Library was written in "CERN FORTRAN", which was designed to simplify porting to the various dialects of FORTRAN that were then emerging. This library of programs was used by many bubble-chamber groups throughout Europe and further afield, and Rudy was involved in producing code and documentation, as well as in the installation at some of these sites.

The 1970s saw the further evolution of this software into the HYDRA framework, which added advanced mechanisms to handle large data and program structures, and the development of automatic film-measuring machines, where Rudy was involved in defining the software for the CERN ERASME system. Following this came the move away from bubble chambers to electronic experiments in which greater data selectivity allowed increasingly rare events to be studied. Rudy went on to



Rudy Böck. (Image credit: Gabi Böck.)

work on several such experiments: WA7, UA1 (where he helped to introduce the third-level software trigger) and JETSET at LEAR. However, his great passion was for more generic work, and in the 1980s he was one of the initiators and promoters of the Physics Analysis Workstation (PAW). The PAW package, which was used across the majority of experiments in CERN, combined earlier ideas of data analysis with the user-friendliness of the new personal workstations to provide powerful interactive analysis systems.

Rudy subsequently turned to the study of how developments in computing could be applied to triggering at future colliders. These studies were initially within the LAA project (*CERN Courier* March 2014 p26), but then on a larger scale within the RD11 (EAST) collaboration. RD11, which he led, focussed on second-level triggering for the LHC, bringing together many people with different backgrounds and ideas. Over several years, RD11 made a comprehensive study of the suitability of a range of possible solutions and technologies for the challenges to be faced. These studies fed into each of the LHC experiments, but particularly into ATLAS, which Rudy joined together with many members of RD11. Within ATLAS, Rudy was deeply engaged in second-level trigger activities – from physics requirements and architectural design to studies with early prototypes.

In parallel to the work on experiments, Rudy worked with other experts to produce two important reference texts – *Data Analysis Techniques for High Energy Physics Experiments* (1990 and 2000) and *The Particle Detector Brief Book* (1998).

He retired from CERN in 2000, but pursuing his passion for astrophysics, joined the MAGIC experiment in La Palma as a member of the MPI Munich group, splitting his time between Munich and Geneva. He started teaching and implementing methods of multivariate analysis within the collaboration, and took a leading role in the major effort to produce data-analysis software for the MAGIC telescopes.

Rudy will be remembered as a charming, kind and generous man, always interested and ready to help and share his wisdom, both in professional and other matters. His colleagues greatly appreciated his vision and professionalism, as well as his broad knowledge and almost limitless energy. His many interests outside of work included sailing, music, mountain activities and enjoying good food and wine with friends.

Our thoughts go to his family, and to the many who have shared an important part of their professional lives with Rudy.

● *His friends and colleagues.*

Gerhard Höhler 1921–2014

Gerhard Höhler, professor of theoretical nuclear physics in Karlsruhe, died on 4 June, at the age of 93.

Born in 1921, Höhler completed his abitur (A-levels, college preparatory high-school diploma) in 1939 in Berlin, and began his study of physics the same year. After military service and time as a prisoner of war in the US, he continued his studies at the Technical University in Munich and later at the Humboldt University in Berlin. His doctoral thesis in experimental physics dealt with the optical characteristics of cadmium sulphate. Thereafter he switched to theory, in which he received his PhD in 1950 with his dissertation on the generalization of Maxwellian electrodynamics. Höhler's time in Berlin came to a close in 1952, when he obtained a position with Richard Becker in Göttingen to qualify as a professor (habilitation). Becker died before the habilitation was completed, so Höhler accepted an offer from Friedrich Bopp and attained his habilitation in Munich in 1956, with a study of electron–phonon interactions in ion crystals.

In Munich, Höhler began a reorientation

in his scientific interests. He studied problems of theoretical nuclear and particle physics, received several offers of professorships, and became chair of theoretical physics at the University of Karlsruhe. His area of research at his new university remained that of elementary-particle physics. Together with his many co-workers, doctoral and undergraduate students, Höhler produced a large number of important scientific results in the following 30 years until his retirement. Examples include the photoproduction of mesons, nucleon and pion form factors, the validity of dispersion relations, the sigma term and especially pion–nucleon interactions. These studies brought Höhler much international acclaim.

The so-called Karlsruhe–Helsinki phase-shift analysis, KH80, is still used as a standard for pion–nucleon interactions and non-strange baryon resonances. His famous book *Elastic and Charge Exchange*

Gerhard Höhler. (Image credit: Herwig Schopper.)

Scattering of Elementary Particles (Landolt-Börnstein 1983) is usually called the "Höhler Bible". Höhler also contributed for several years to the *Review of Particle Physics*, and was a co-creator and co-editor of the *πN Newsletter*.

Recognition of Höhler's expertise is reflected in his appointment to the scientific council of DESY (Hamburg), as well as in his long-term membership of the Advisory Committee of the federal research ministry of Germany. In addition, he earned merit as the editor of publications and monographs, among others the *Springer Tracts in Modern Physics*. He was also a dedicated university professor who continually incorporated new areas in his lectures and, when possible, in the curriculum. The development of new courses, such as "Computer Theoretikum", is an example of his commitment.

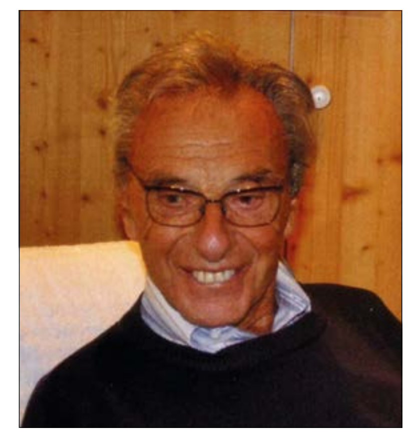
● *William Briscoe, Wolfgang Kluge, Johann Kühn, Peter Kroll, Mark Manley, Jugoslav Stahov, Hans-Martin Staudenmaier, Igor Strakovsky, Alfred Svarc, Lothar Tiator.*

François Wittgenstein 1931–2015

François Wittgenstein, well known for his work on generations of magnets at CERN, passed away on 1 May.

François received his diploma as electro-engineer at the Ecole Polytechnique Fédérale de Zurich in 1955 at the age of 24. He started his career in industry by taking up a job with the Maschinen Fabrik Oerlikon Zurich, to work first on electrical locomotives and then on magnets. In 1961 he joined CERN, and was first involved in calculations for the magnet for the 2-m bubble chamber, before being put in charge of various projects relating to beams feeding the bubble chambers: magnets, collimators and even an electrostatic separator.

In 1966, François joined the nascent Big European Bubble Chamber (BEBC) project – a special French–German–CERN programme – that was implemented at CERN during the early 1960s. With his experience as an electrical engineer in industry, François was put in charge to set up a technical group within the BEBC project that would be responsible for the design and construction of a very large superconducting magnet. This would provide a magnetic field of 3.5 T, uniform over the sensitive bubble chamber volume of 35 m^3. The stored energy of 800 MJ for a single magnet was a record at the time and would remain so until the end of the 20th century. During all of the years up to the end of BEBC, François and his team



François Wittgenstein. (Image credit: Mrs Wittgenstein.)

supervised the correct operation of their large magnet.

With the closure of BEBC in 1984 and the start of construction of the Large Electron–Positron collider at CERN, François and his team took up the task of constructing an even larger magnet again. This time, the magnet was normally conducting but nevertheless equally challenging – the assembly of the huge aluminum coils for the magnetic volume of the L3 experiment. This huge magnet is still an integral part of the ALICE experiment at point 2 on the LHC.

At the beginning of the 1990s, François pushed the early development of large conductors that were needed for the proposed large LHC experiments. Besides numerous tests in relation to the extrusion parameters, he played an essential role, in collaboration with ETH Zürich, in the development of the system for online quality-control of the conductor, in particular, of its geometry and the quality of the joint between the copper cable and the aluminum stabilizer. He continued to take an active interest in this topic after reaching retirement age and, following the approval of the LHC experiment collaborations, he was appointed member of the technical Magnet Advisory Group to review magnet construction until the early 2000s.

After retiring in 1996, François was also active in the CERN-ESO Pensioners' Association (GAC-EPA). After many years as observer to the Pension Fund Governing Board, he was formally appointed as the first representative of GAC-EPA to the governing board, when the new governance for the pension fund was introduced in 2006. During this period he faced many, often turbulent and sensitive issues, but his competent contributions and his strong commitment to this task were broadly acknowledged from all sides.

François was a real "CERNois" – we will miss him greatly.

● *His colleagues and friends.*

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Group Leaders at the Center for Axion and Precision Physics Research

The Center for Axion and Precision Physics Research (CAPP) of the Institute for Basic Science (IBS) in Korea invites applications and nominations for senior Group Leaders in the areas of experimental physics of axion dark matter, low noise RF electronics, and storage ring electric dipole moments.

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Applications will be accepted until the positions are filled. Nominations for this position are also encouraged. For more information about the CAPP and its goals, as well as how to apply, see **capp.ibs.re.kr**.
Nominations and questions should be addressed to the director of the center, **Professor Yannis K. Semertzidis**, at **yannis@ibs.re.kr**.

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The candidate is required to have at least five years of experience after his doctoral degree.

Each candidate should also indicate the names and e-mail addresses of not less than 3 renowned physicists. These physicists will receive an e-mail message from us with instructions on how to submit a recommendation letter on the candidate's behalf.

The decisions will be announced in October 2015 and the selected candidates are expected to start their activities at IIP between January 1st and February 1st, although a different arrangement can also be agreed upon.

For submission and further enquiries, please contact **tenure-track@iip.ufrn.br** or access our web page **www.iip.ufrn.br**.

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Highly qualified and motivated national and international students are invited to apply. Applicants should preferably hold a Masters or equivalent degree in physics. Excellent candidates holding a four year bachelor degree and proof of research experience may also be considered. At equal level of qualification, preference will be given to disabled candidates. Female students are particularly encouraged to apply.

Applicants are expected to submit their application documents including two letters of reference via the website of the Heidelberg Graduate School of Fundamental Physics:

www.fundamental-physics.uni-hd.de/fellowships

The application deadline is August 15, 2015. Further information can be obtained via highRR@physik.uni-heidelberg.de.

Prof. Dr. H.-C. Schultz-Coulon & Prof. Dr. A. Schöning
Kirchhoff-Institut für Physik, Universität Heidelberg
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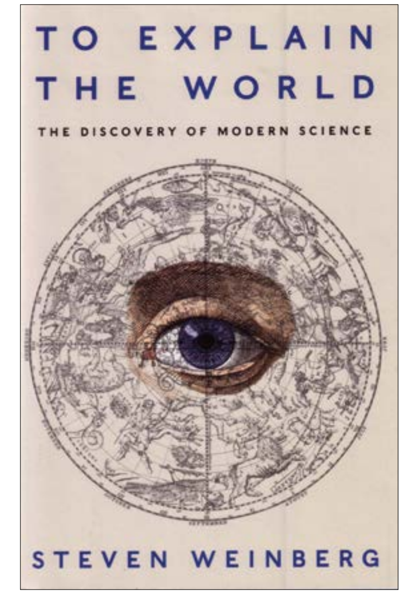

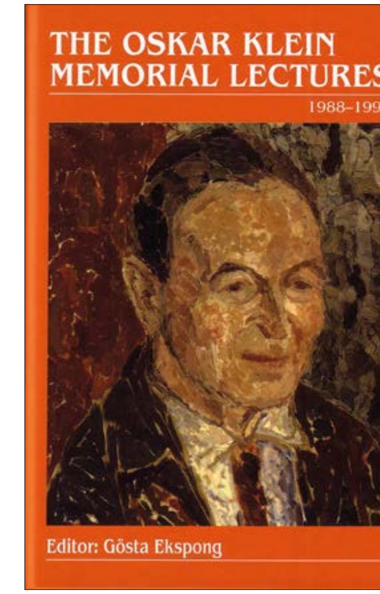

To Explain the World: The Discovery of Modern Science
By Steven Weinberg
Harper Collins/Allen Lane
Hardback: £20 $28.99
Also available at the CERN bookshop

Steven Weinberg's most recent effort is neither a treatise on the history of science nor a philosophical essay. The author presents instead his own panoramic view of the meandering roads leading to the Newtonian synthesis between terrestrial and celestial physics, rightfully considered as the beginning of a qualitatively new era in the development of basic science.

The first and second parts of the book deal, respectively, with Greek physics and astronomy. The remaining two parts are dedicated to the Middle Ages and to the scientific revolution of Copernicus, Galileo and Newton. The aim is to distil those elements that are germane to the development of modern science. The style is more persuasive than assertive: excerpts of philosophers, poets and historians are abundantly quoted and reproduced, with the aim of corroborating the specific viewpoints conveyed in the text. A similar strategy is employed when dealing with the scientific concepts involved in the discussion. More than a third of the 416 pages of the book contain a series of 35 "technical notes" – a quick reminder of a variety of geometric, physical and astronomical themes (the Thales theorem, the careful explanation of epicycles for inner and outer planets, the theory of rainbows and various other topics relevant to the main discussion of the text).

Passing before you through the pages, you will see not only Plato and Aristotle, but also Omar Khayyam, Albertus Magnus, Robert Grosseteste and many other progenitors of modern scientists. Nearly 2000 years separate the natural philosophy of the "Timaeus" from the birth of the scientific method. Many elements contributed serendipitously to the evolution leading from Plato to Galileo and Newton: the development of algebra and geometry, the divorce between science and religion, and an improved attitude of abstract thinkers towards technology. All of these aspects have certainly been important for the tortuous emergence of modern science. But are they sufficient to explain it? Scientists, historians and laymen will be able to draw their own lessons from the past as presented here, and this is just one of the intriguing aspects of this interdisciplinary book.

After reading this book quietly, you might be led to conclude that good scientific ideas and daring conjectures take a long time to mature. It has been an essential feature of scientific progress to understand which problems are ripe to study and which are not. No one could have made progress in understanding the nature of the electron, before the advent of quantum mechanics. The plans for tomorrow require not only boldness and fantasy, but also a certain realism that can be trained by looking at the lessons of the past. Today's most interesting questions may not be scientifically answerable tomorrow, and lasting progress does not come by looking along a single line of sight, but all around, where there are mature phenomena to be scrutinized. This seems to be true for science as a whole, and in particular for physics.

● *Massimo Giovannini, CERN and INFN Milan-Bicocca.*

The Oskar Klein Memorial Lectures 1988–1999
By Gösta Ekspong (ed.)
World Scientific
Hardback: £45
E-book: £34

Perhaps every reader of *CERN Courier* has heard about the Klein–Gordon equation, the Klein–Nishina (Compton effect) cross-section, the Klein paradox and the Kaluza–Klein compactified five-dimensional unified theory of gravity, electricity and magnetism. However, few will know about the scientist, Oskar Klein (1894–1977), the pre-eminent and visionary Swedish theoretical physicist from Stockholm whose work continues to influence us to this day.

This book is needed. The reason is described eloquently in the contribution by Alan Guth, whose words I paraphrase: how many recognize Oskar as the first name of "this" Klein? Compare here (by birth year, within 10 years): Niels B (1885), Hermann W (1885), Erwin S (1887), Satyendra N B (1894), Wolfgang P (1900), Enrico F (1901), Werner H (1901), Paul A M D (1902), Eugene W (1902), Robert O (1904). Thanks to this book, Oskar K (1894) will take his place on this short list.

Part of the book collects together all of the Oskar Klein Memorial Lectures given since the series began at Stockholm University in 1988, through to 1999, by many well-known theoreticians, from Chen Ning Yang to Gerard 't Hooft. Some of these lectures relate to Klein because he often happened to "be there" at the beginning of a new field in physics. For example, in early 1948, Klein recognized immediately, following the disambiguation of the pion and muon, that muon decay and common beta decay can be described by the same four-fermion interaction (see the contribution by T D Lee).

The other part of the book – a third of the 450 pages – is a biographical collection

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about Klein and his pivotal scientific articles (about a fifth of the volume), all presented in English, although Klein published in Danish, French, English, German and Swedish, as a check of the titles in his publication list reveals. Having Klein's important work all in one place can lead to interesting insights: for me, finding that 24 December 1928 was a special birthday.

On this day, just eight weeks after the Klein–Nishina paper on the interaction of radiation with electrons, the paper on the Klein paradox reached the editors of *Zeitschrift für Physics*. Klein concludes: "...(the) difficulty of the relativistic quantum mechanics emphasized by Dirac can appear already in purely mechanical problems where no radiation processes are involved." The yet-to-be-recognized and discovered antiparticle – the positron – was the "difficulty", allowing for both radiative and field-instigated pair production (the "paradox"), when vacuum instability is inherent in a prescribed external field configuration.

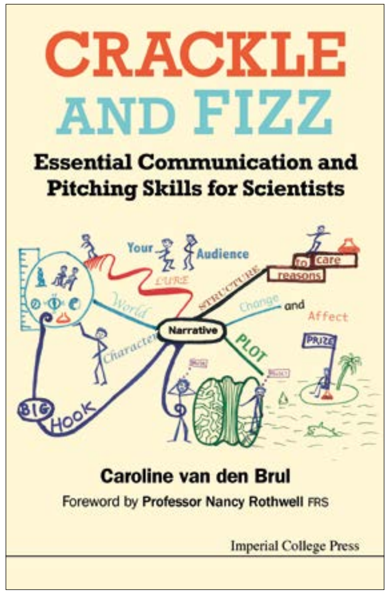
The Klein-paradox result resurfaced soon in the work by Werner Heisenberg and Hans Euler, and Julian Schwinger on the vacuum properties of QED. Today, as we head towards the centenary of the Klein paradox, pair production in strong fields is being addressed as a priority within the large community interested in ultra-intense laser pulses.

Oskar Klein was always a colleague I wished I could meet, and finally, I have. Thank you, Gösta Ekspong, for this introduction to my new-found hero. While at first my profound personal interest in this book arose from curiosity originating from many years of working out the consequences of the Klein paradox in heavy-ion collisions, I now see how Klein can serve as a role model. This is the book to own for anyone interested in seeing further by "standing on the shoulders of giants".

● *Johann Rafelski, The University of Arizona.*

Crackle and Fizz: Essential Communication and Pitching Skills for Scientists

By Caroline van den Brul
Imperial College Press
Hardback: £35
Paperback: £15
E-book: £11



The introduction of *Crackle and Fizz* sets out a trope that may sound familiar: a decade-old social *faux pas* between scientists and journalists at a dinner party, where the speed-dating format for presenting science was met with ire, derision and altogether not having a nice time. The claim is made that this could have been a chance to start over, to reframe science communication and realign the expectations of those involved. To do so misses out on the past few decades of development in the science-communication field, which is now reaching a reflective maturity and presence between academia, industry and media. Unfortunately, the same erasure is a leitmotif in many of the chapters that follow.

Caroline van den Brul's credentials are impressive, with years at the helm of BBC productions and engagement workshops. This history forms the backbone of the book, setting an anecdote-per-chapter rate that reads more like an autobiography than an attempt to impart any lessons or experience to the reader. The remaining space is given over to consideration of narrative devices useful in contextualizing topics and engagement from a practitioner's perspective. However, these are only superficially explored and offer little in variation. After many pages promoting the importance of clarity, the titular "Crackle" is eventually revealed in the final chapter to be a (somewhat forced) acronym that summarizes and distils all preceding guidance. Had this been the starting point from which each aspect was explored in depth, the tone and flow of the book may have made for a more compelling read. When used as the conclusion, it feels condescendingly simplified. It's a shame that, considering van den Brul's history, the final chapter is the main one worth reading.

Overall, the book feels less like the anticipated dive into years of experience, and more like a pre-lunch conference workshop. If you are in the first stages of incorporating engagement and communication into your current practice, working through each chapter's closing questions could be of some use. Or, should you feel like refreshing your current framework, they might give you a moment's pause and adjustment, but no more than any other evaluation.

● *Will Davies, Live Science Team, @Bristol.*

Books received

A Chorus of Bells and Other Scientific Inquiries

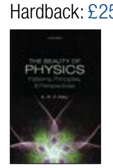
By Jeremy Bernstein
World Scientific
Hardback: £25

E-book: £19

In this volume of essays, written across a decade, Bernstein covers a breadth of subject matter. The first part, on the foundations of quantum theory, reflects the author's conversations with the late John Bell, who persuaded him that there is still no satisfactory interpretation of the theory. The second part deals with nuclear weapons, and includes an essay on the creation of the modern gas centrifuge by German prisoners of war in the Soviet Union. Two shorter sections follow: the first on financial engineering, with a profile of Louis Bachelier, the French mathematician who created the subject at the beginning of the 20th century; the second and final part is on the Higgs boson, and how it is used for generating mass.

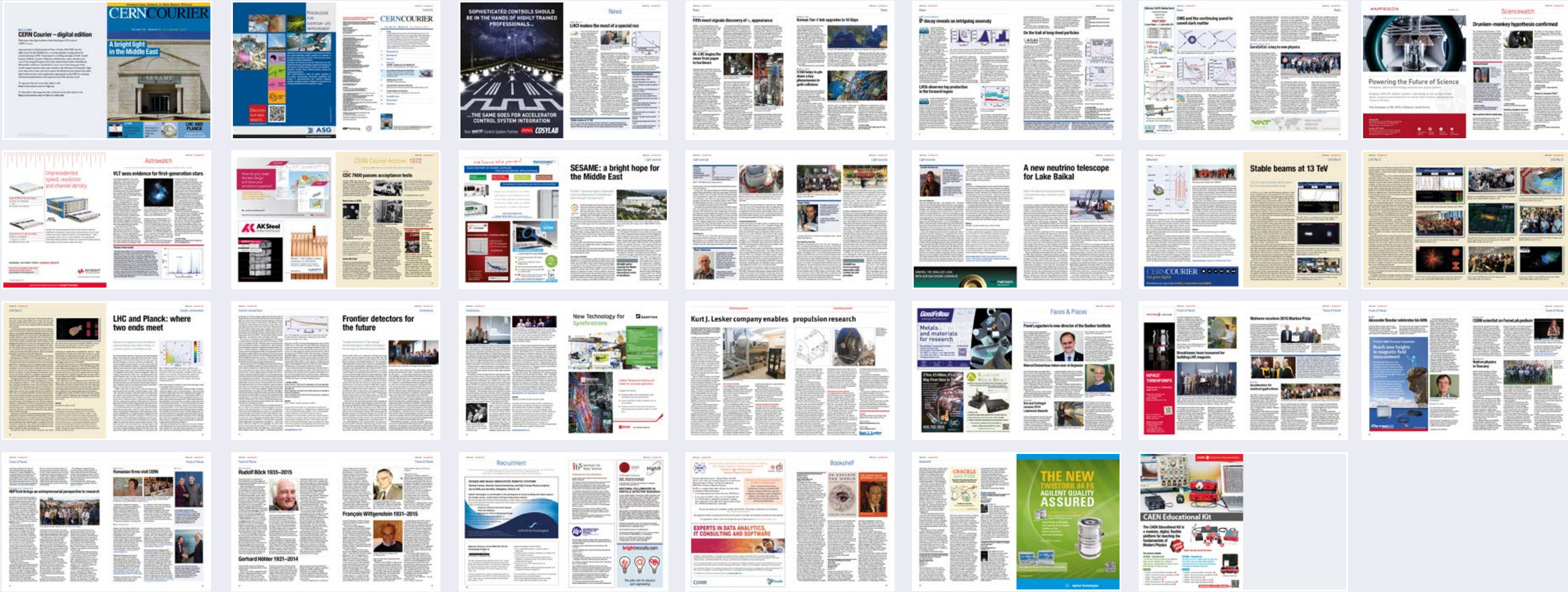
The Beauty of Physics: Patterns, Principles, and Perspectives

By A R P Rau
Oxford University Press
Hardback: £25



Also available as an e-book

The selection of topics in this book reflects the author's four-decade career in research physics and his resultant perspective on the subject. While aimed primarily at physicists, including junior students, it also addresses other readers who are willing to think with symbols and simple algebra in understanding the physical world. Each chapter, on themes such as dimensions, transformations, symmetries, or maps, begins with simple examples accessible to all, while connecting them later to more sophisticated realizations in more advanced topics of physics.



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