WELCOME

CERN Courier – digital edition

Welcome to the digital edition of the October 2014 issue of *CERN Courier*.

CERN is a unique institution, born from the ashes of war as a beacon of science and peace. As its facilities and research arena grew in size following its official foundation in 1954, so too did the extent of international collaboration at CERN. In this issue to celebrate the 60th anniversary, a pictorial timeline illustrates some key moments in this collaborative journey. In addition, a few short articles highlight what CERN has meant to people from various regions of the world, and a physicist and former science minister gives his view on CERN's future direction. The issue also celebrates the 80th birthday of Carlo Rubbia, the only director-general to have received a Nobel prize for his work at CERN.

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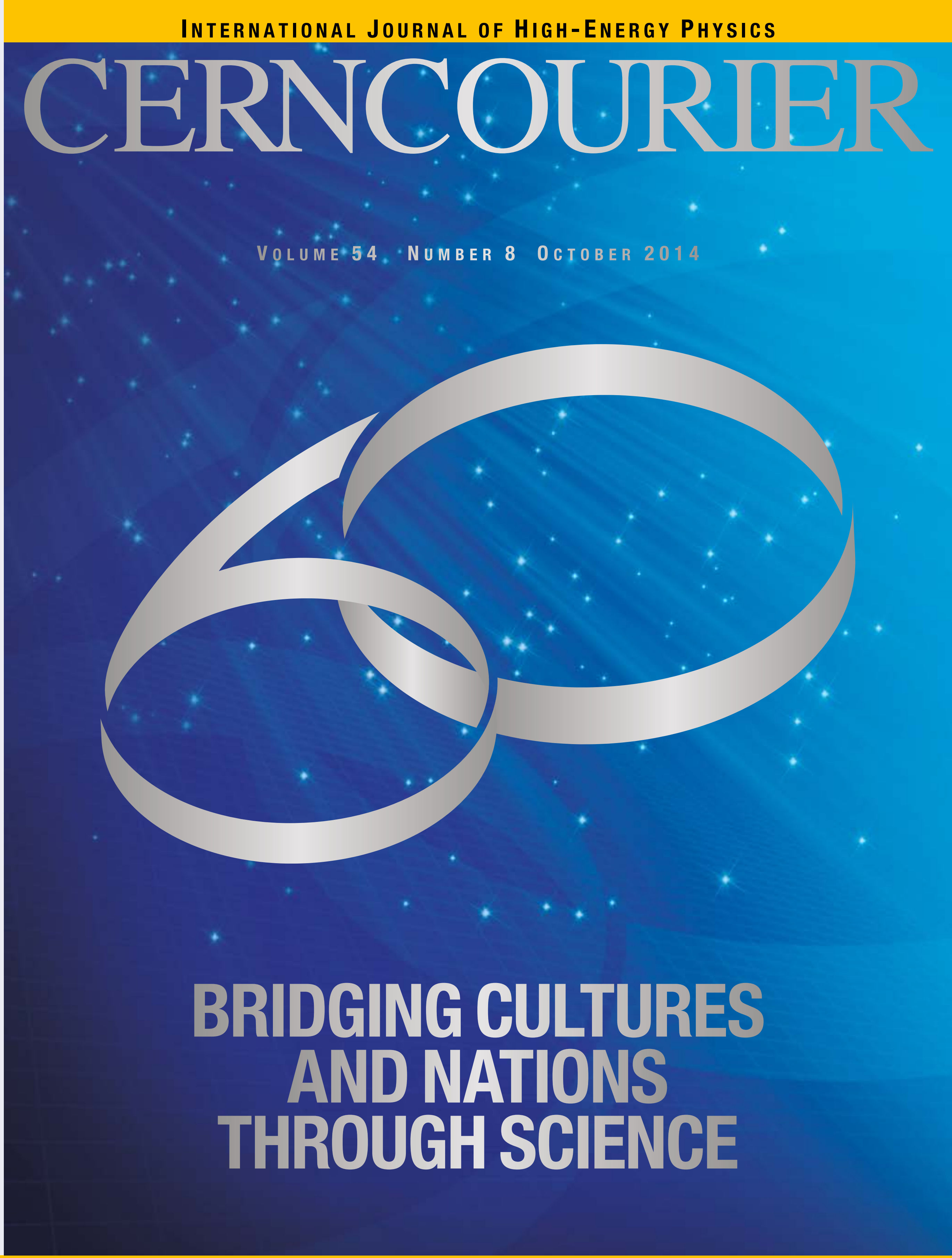

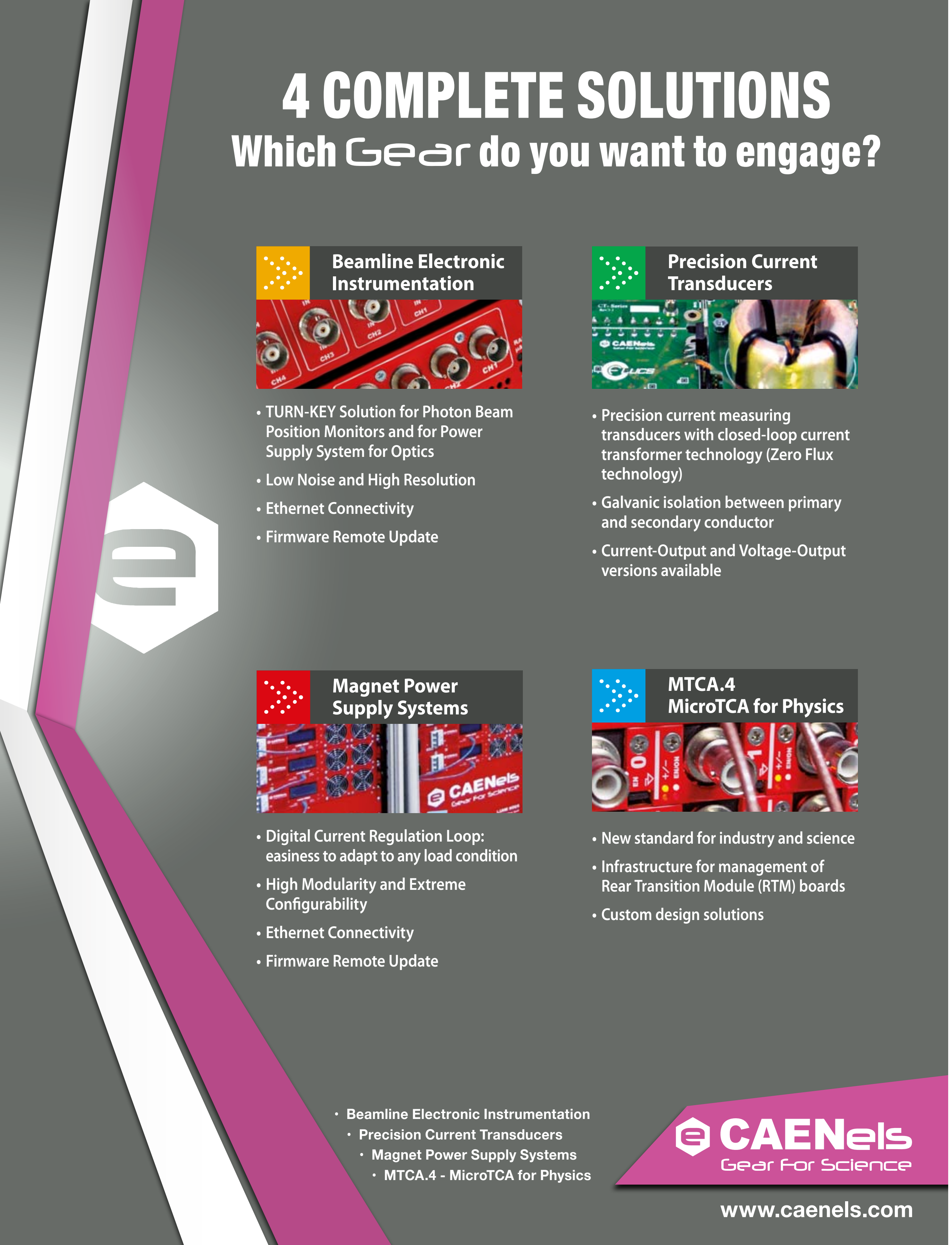

Contents

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

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On the cover: CERN celebrates its 60th anniversary. (Image credit: CERN.)

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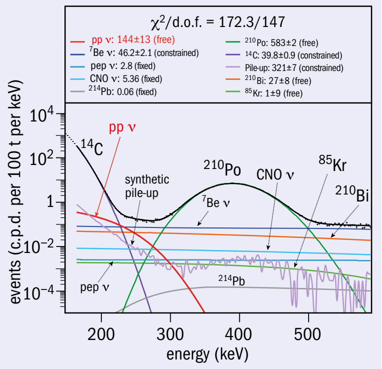
News

SOLAR NEUTRINOS

Borexino measures the Sun's energy in real time

A total of 2212 8-inch photomultipliers mounted on a 13.7-m diameter stainless-steel sphere detect the scintillator light produced in Borexino. (Image credit: Borexino Collaboration.)



Energy spectra for all of the solar neutrino and radioactive background components. All components are obtained from analytical expressions, validated by Monte Carlo simulations, with the exception of the synthetic pile-up, which is constructed from data. (Image credit: Borexino 2014.)

The Borexino experiment at the INFN Gran Sasso National Laboratories has measured the energy of the Sun in real time, showing for the first time that the energy released today at its centre is exactly the same as that produced 100,000 years ago. This has been possible through the experiment's direct detection of the low-energy neutrinos produced in the initial nuclear reactions occurring in the solar core.

Previous measurements of solar energy have always been made on the radiation (photons) that currently illuminate and heat the Earth. The energy of this radiation originates in the Sun's nuclear reactions, but, on average, has taken 100,000 years to travel through the dense solar matter and reach the surface. Neutrinos produced by the same nuclear reactions, on the other hand, take only a few seconds to escape from the Sun before making the eight-minute journey to Earth. The comparison between the neutrino measurement now published by the Borexino collaboration and the previous measurements on the emission of radiant energy from the Sun shows that solar activity has not changed during the past 100,000 years.

Borexino is an ultra-sensitive liquid-scintillator detector designed to detect low-energy neutrino events in real time at a high rate, in contrast to earlier radiochemical experiments such as Homestake, GALLEX and SAGE (*CERN Courier* October 1998 p12). The experiment previously has focussed on measurements of neutrinos from ^{7}Be and ^{8}B – nuclei formed in certain branches of the principal chain of reactions that converts hydrogen to helium at the heart of the Sun. The ^{7}Be neutrinos constitute only 7% of the neutrino flux from the Sun and the ^{8}B neutrinos even less, but they have been key to the discovery and study of the phenomenon of neutrino oscillations, most recently by Borexino (*CERN Courier* June 2009 p13). In contrast in this latest work, Borexino has focused on the neutrinos from the fusion of two hydrogen nuclei (protons) to form deuterium – the seed reaction of the nuclear-fusion cycle that produces about 99% of the solar power, some 3.84×10^{33} ergs/s.

The difficulty of the new measurement lies in the extremely low energy of these so-called pp neutrinos, which is smaller than that of the others emitted by the Sun. The capability to do this successfully makes the Borexino detector unique, and has also allowed the study of neutrinos produced by the Earth (*CERN Courier* May 2013 p8).

The Borexino experiment is the result of a collaboration between European countries (Italy, Germany, France, Poland), the US and Russia, and it will take data for at least another four years, improving the accuracy of measurements already made and addressing others of great importance, for both particle physics as well as astrophysics.

Further reading

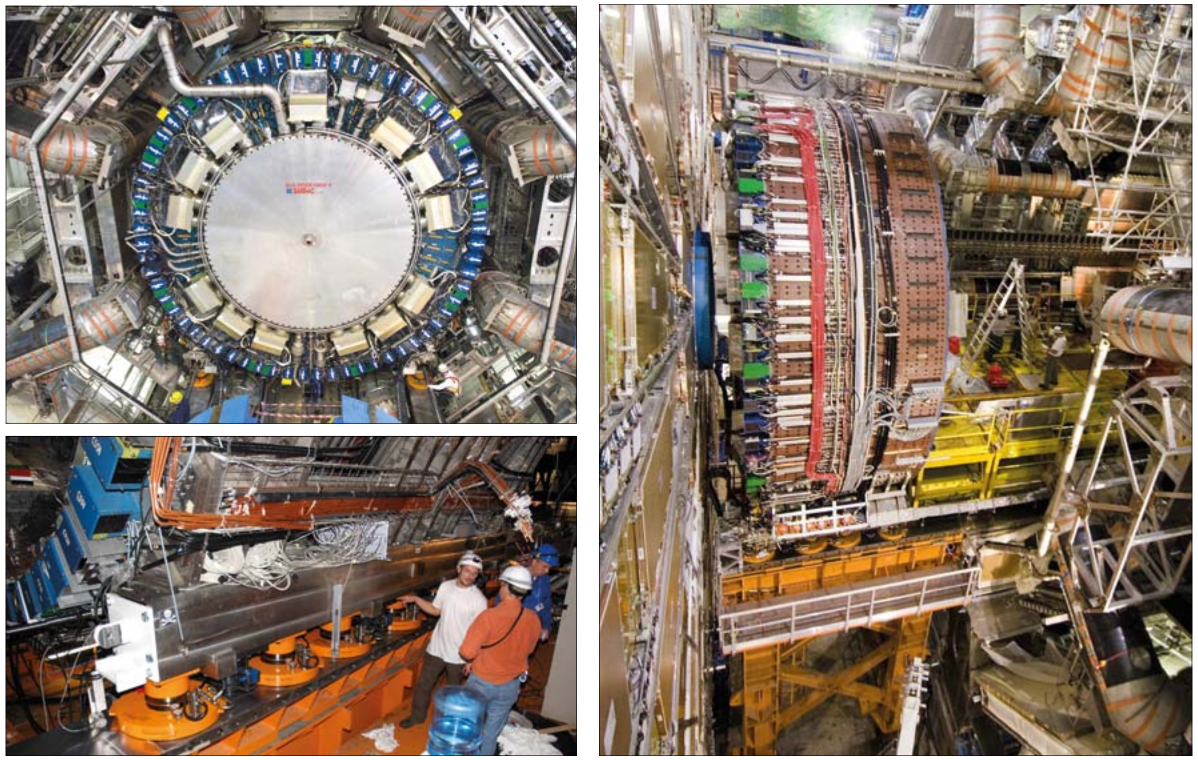
Borexino Collaboration 2014 *Nature* **512** 383.

Sommaire en français

News

LHC EXPERIMENTS

ATLAS closes and prepares for the restart



In closing ATLAS for the next LHC run, with a weight of 1000 tonnes and a diameter of 9 m, the endcap calorimeter, top left, is one of the most difficult objects to move. However, thanks to a system of air pads, the orange discs seen lower left, it can be moved with a force of only 23 tonnes. At the right, the endcap can be seen on the air-pad system at the start of its journey back into the toroid barrel. (Image credits: ATLAS Collaboration.)

On 7 August, the technical teams in charge of closing activities in the ATLAS collaboration started to move the first pieces back into position around the LHC beam pipe. The subdetectors had been moved out in February 2013, at the beginning of the first LHC Long Shutdown (LS1) – a manoeuvre that was needed to allow access and work on the planned upgrades.

LS1 has seen a great deal of work on the ATLAS detector. In addition to the upgrades carried out on all of the subdetectors, when the next LHC run starts in 2015 the experiment will have a new beam pipe and a new inner barrel layer (IBL) for the pixel detector. For the work to be carried out in the cavern, one of the small wheels of the muon system had to be moved to the surface (*CERN Courier* October 2013 p28).

The various pieces are moved using an air-pad system on rails, with the exception of the 25-m-diameter big wheel (in the muon system), which moves on bogies. One of the most difficult objects to move is the endcap calorimeter: it weighs about 1000 tonnes and comes with many "satellites", i.e. electric cables, cryogenic lines and optical fibres for the read-out. Thanks to the air pads, the 1000 tonnes of the calorimeter can be moved by applying a force of only 23 tonnes. During the movement, the calorimeter, with its cryostat filled with liquid argon, remains connected to the flexible lines whose motion is controlled by the motion of the calorimeter.

The inflation of the air pads must be controlled perfectly to avoid any damage to the delicate equipment. This is achieved using two automated control units – one built during LS1 – which perform hydraulic and pneumatic compensation. This year, the ATLAS positioning system has been improved thanks to the installation of a new sensor system on the various subdetectors. This will allow the experts to achieve an accuracy of 300 μm in placing the components in their final position. The position sensors were originally developed by Brandeis University within the ATLAS collaboration, but the positioning system itself was developed with the help of surveyors from CERN, who are now using this precision system in other experiments.

All of the equipment movements in the cavern happen under the strict control of the technical teams and the scientists in charge of the various subdetectors. It takes several hours to move each piece, not only owing to the weight involved, but also because several stops are necessary to perform tests and checks.

The closing activities are scheduled to run until the end of September. By then, the team will have moved a total of 12 pieces, that is, 3300 tonnes of material.

CERN

The SPS gets ready to restart

The SPS tunnel, with a quadrupole magnet in the foreground. (Image credit: CERN-GE-1311288 – 03.)

Work continues apace to ready the Super Proton Synchrotron (SPS) for its planned October restart, while beams are already being delivered to experiments at the Proton Synchrotron (PS) and PS Booster (*CERN Courier* September 2014 p5).

During July and August, SPS teams were kept busy with a range of start-up tests for the various equipment groups, including eight weeks of electrical power-converter tests. Since it began in February 2013, the Long Shutdown 1 (LS1) has seen the replacement and renovation of about 75% of the SPS powering, including major components such as 18 kV transformers, switches, cables and thyristor bridges that sit at the heart of the power converters. There have also been important upgrades to the control and high-precision measurement systems. The summer tests were to confirm that the renovated converters were operating correctly to power the SPS dipole and quadrupole magnets.

Slotted among this busy schedule of powering tests were the final checks of the accelerator's magnets and beam dump. The SPS had one of each of the three main types of magnet fault: an electrical fault (short circuit) in a magnet circuit, a water leak (in the cooling system), and a vacuum-chamber leak. In addition, the main beam dump had to be replaced. Rather than stopping the tests for each move, the teams replaced all four elements in one go.

On 10–12 August, the three magnets and beam dump were removed and replaced with spares in the SPS tunnel. The logistics for this move were complex because of the weight of the magnets and beam dump, and also the 10-tonne chariot and lifting equipment. In addition, these large pieces of equipment fill the entire width of the tunnel, so co-ordinating which vehicles and teams were where and synchronizing their movements was vital.

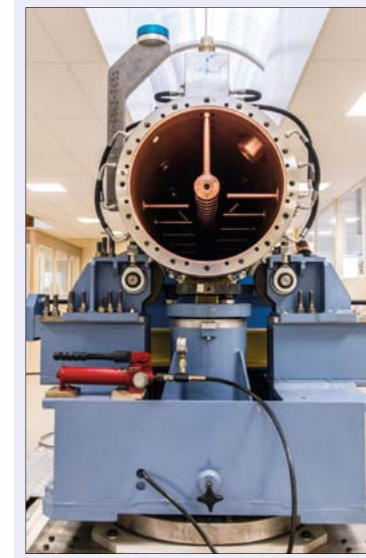
Although the SPS teams are well-versed at replacing magnets – they can replace as many as four magnets during a two-day technical stop – replacing the beam dump proved to be a tougher challenge. Because the dump is radioactive, the length of transport had to be kept as short as possible and moving the dump from the tunnel to the radiation storage area could not take place if it rained. With this in mind, the operations team created detailed plans for the move, providing hourly updates and back-up solutions in case of rain.

Despite these extensive tests and replacements, the SPS remains on schedule to take beam from the PS in early September, with the accelerator operating again in October to provide beams to the North Area.

At the LHC, in late August the cooling of sector 1-2 was in progress, and the cooling of sector 5-6 beginning. Vacuum teams were checking for any final leaks and carrying out sealing tests in various sectors. At the same time, the copper-stabilizer continuity measurement tests were in progress in sector 8-1, before being carried out throughout the machine. The first power tests have begun in sector 6-7, which will be the first sector ready for beam. Elsewhere, electrical validation tests were in progress throughout the machine, together with instrumentation tests, particularly on the beam-loss sensors. All of the collimators, the kicker magnets and the beam instrumentation in the straight sections of the LHC were installed and under vacuum.

First beam in Linac4 DTL

Work progresses on Linac4, the linear accelerator foreseen to take over from the current Linac2 as injector to the PS Booster. On 5 August, the first drift-tube linac (DTL) tank saw beams at 12 MeV. After seven years of design, prototyping and manufacturing, the Linac4 DTL, which comprises three tanks, underwent countless workshop-based measurements of the geometry, vacuum and magnet polarization of the tanks, before the first was installed in the Linac4 tunnel on 5 June. Beam commissioning tests ran until 21 August, and found the DTL operating with nominal transmission.



A DTL tank undergoing workshop tests in May prior to installation in Linac4. (Image credit: CERN-PHOTO-201404-087 – 3.)

***Les physiciens des particules du monde entier sont invités** à apporter leurs contributions aux CERN Courier, en français ou en anglais. Les articles retenus seront publiés dans la langue d'origine. Si vous souhaitez proposer un article, faites part de vos suggestions à la rédaction à l'adresse cern.courier@cern.ch.*

CERN Courier welcomes contributions from the international particle-physics community. These can be written in English or French, and will be published in the same language. If you have a suggestion for an article, please send proposals to the editor at cern.courier@cern.ch.

LIGHT SOURCES

Budker Institute's booster gets going at Brookhaven

The new booster for the NSLS-II in Brookhaven. (Image credit: Pavel Cheblakov.)

The National Synchrotron Light Source II (NSLS-II) is currently being commissioned at Brookhaven National Laboratory. When completed, it will be a state-of-the-art, medium-energy electron storage ring producing X-rays up to 10,000 times brighter than the original NSLS, which started operating at BNL in 1982 and will be shut down at the end of September.

The injector system includes a 200 MeV linac and booster with energy up to 3 GeV. The booster is a joint venture between the NSLS-II injector group and the Budker Institute of Nuclear Physics (BINP) in Novosibirsk, one of the NSLS-II partners. BINP has a solid relationship with the Brookhaven lab and has played a significant role in NSLS-II development, coming up with the final design of the booster. The institute has its own well-developed workshops and a variety of specialists, who are not only involved in many major international projects but also operate the VEPP-2000 and VEPP-4M colliders.

In May 2010, according to tender results, a contract was signed between Brookhaven and BINP on the manufacturing, installation and commissioning of the turnkey booster (except an RF system). One year later, Brookhaven staff visited BINP and accepted all first articles. Most of the components – including the magnets, power supplies, diagnostic systems, injection-extraction system – were made at BINP. However, BINP also engaged subcontractors, including European firms. For example, power supplies for the booster dipole magnets were produced by Danfysik A/S.

An 11-hour time difference between Novosibirsk and New York did not prevent good interaction between the laboratories. In the morning and evening, Brookhaven and BINP experts usually made contact to discuss the latest achievements and pose new questions. So the Sun never set over the booster project.

Booster parts arrived at Brookhaven from January through to August 2012. Most of the components came as girder assemblies with magnets aligned to tens of microns, and vacuum chambers installed. The journey of more than 10,000 km was made first by road from Novosibirsk to St Petersburg and then to New York by ship. Upon arrival at Brookhaven, all assemblies were thoroughly tested, but the long journey did not affect the alignment of magnets on the girders.

The testing and installation activities have spanned both organizations. The booster commissioning also involved staff from both NSLS-II and BINP. Following authorization, the commissioning of the booster started in December 2013 and was successfully completed in February 2014, ahead of schedule. The beam passing through booster was up to 95%, with all systems working according to design.

The commissioning of the main storage ring started in March and on 11 July, NSLS-II reached a current of 50 mA at 3 GeV, using a new superconducting radio-frequency cavity. The second cavity and other hardware are still to be installed before the accelerator reaches the full design current of 500 mA. The next step is commissioning insertion devices and front-ends.

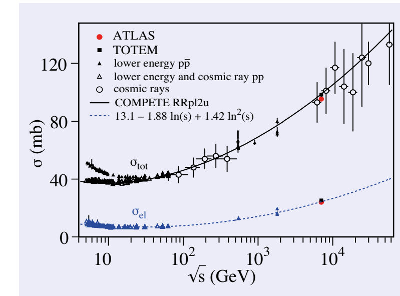
LHC PHYSICS

ALFA in ATLAS measures pp cross-section with high precision

ATLAS EXPERIMENT

Data from a special run of the LHC using dedicated beam optics at 7 TeV have been analysed to measure the total cross-section of proton–proton collisions in ATLAS. Using the Absolute Luminosity For ATLAS (ALFA) Roman Pot sub-detector system located 240 m from the interaction point, ATLAS has determined the cross-section with unprecedented precision to be σ_{tot} (pp→X) = 95.4±1.4 mb.

The total cross-section is a fundamental parameter of the strong interactions, setting the scale of the size of the interaction region at a given energy. To measure the total cross-section, the optical theorem is used, which states that the total cross-section is proportional to the imaginary part of the forward elastic-scattering amplitude, extrapolated to momentum transfer, t = 0. From a measurement of the elastic-scattering cross-section differential in t, the value of the total cross-section is inferred, and is found to increase logarithmically with the centre-of-mass energy (see figure).



Energy evolution of the total and elastic cross-sections.

Measuring elastic scattering is a challenge because elastically scattered protons escape the interaction at very small angles of tens of micro-radians or less. To detect these protons, dedicated detectors are installed, such as ALFA. To achieve the required focusing properties, the LHC was operated with special beam optics of $\beta^* = 90$ m. The detectors can then be moved as close as a few millimetres from the LHC beam, to access the smallest scattering angles.

Further reading

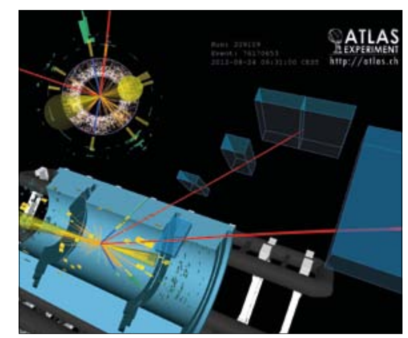
ATLAS Collaboration 2014 submitted to *Nucl. Phys. B* arXiv:1408.5778 [hep-ex].

ATLAS provides further insights into the Higgs boson

The discovery of a Higgs boson by the ATLAS and CMS collaborations in 2012 marked a new era in particle physics. Since then, the experimental determination of the properties of the new boson, such as its mass and production rate, as well as the study of its decays into as many final states as possible, have became crucial tasks for the LHC experiments.

The ATLAS collaboration has recently published a new set of measurements of the Higgs boson's properties from the two high-resolution decay channels, to two photons (ATLAS Collaboration 2014a) and to four charged leptons (ATLAS Collaboration 2014b). The new measurements have been performed using the proton–proton collisions delivered by the LHC in 2011 and 2012. They exploit the most accurate knowledge of the detector performance achieved so far, which has also led to an updated measurement of the Higgs mass, m_H = 125.36±0.41 GeV (ATLAS Collaboration 2014c).

The Standard Model predicts precisely the couplings of the Higgs boson to all other known elementary particles, once its mass is measured. The simplest way to probe the new boson couplings is to measure the ratio μ (or signal strength) between the number of Higgs bosons measured in the collected data and the number predicted by the theory: a measured μ = 1 would mean that the observation is consistent with the Standard Model Higgs boson. In these latest analyses, the signal strength in the two-photon channel is found to be μ = 1.17±0.27, while it is $\mu = 1.44^{+0.40}_{-0.33}$ in the four-lepton channel. So, within their uncertainties, both results agree with the Standard Model.



Display of a candidate event for the decay of a Higgs boson into two electrons and two muons, accompanied by two energetic jets in the forward directions.

The Standard Model also predicts that a Higgs boson can be produced through different mechanisms in proton–proton collisions. The most frequent mechanism (87%) is the scattering (or "fusion") of strongly interacting gluons to form a Higgs boson. Production through the fusion of W or Z bosons is predicted to occur in 7% of the cases, and has a characteristic event signature of two jets in the forward direction (along the proton beams) that accompany the Higgs boson. The figure shows a candidate event for this production mode. In the recent papers, ATLAS physicists have identified and measured Higgs bosons from various production mechanisms (ATLAS Collaboration 2014a and 2014b).

So far, no surprises have emerged when looking into the details, but the statistical uncertainties are still large. The new data-taking campaign starting in 2015 will be important to improve the precision of the measurements, and will lead to an improved understanding of the nature of the Higgs boson.

Further reading

ATLAS Collaboration 2014a arXiv: 1408.7084 [hep-ex].
ATLAS Collaboration 2014b arXiv: 1408.5191 [hep-ex].
ATLAS Collaboration 2014c arXiv:1406.3827 [hep-ex].

ASTROPARTICLE PHYSICS

A bright future for dark-matter searches

The US Department of Energy Office of High Energy Physics and the National Science Foundation Physics Division have announced their joint programme for second-generation dark-matter experiments, aiming at direct detection of the elusive dark-matter particles in Earth-based detectors. It will include ADMX-Gen2 – a microwave cavity searching for axions – and the LUX-Zeplin (LZ) and SuperCDMS-SNOLAB experiments targeted at weakly interacting massive particles (WIMPs). These selections were partially in response to recommendations of the P5 subpanel of the US High-Energy Physics Advisory Panel for a broad second-generation dark-matter direct-detection programme at a funding level significantly above that originally planned.

While ADMX-Gen2 consists mainly of an upgrade of the existing apparatus to reach a lower operation temperature of around 100 mK, and is rather inexpensive, the two WIMP projects are significantly larger. SuperCDMS will initially operate around 50 kg of ultra-pure germanium and silicon crystals at the SNOLAB laboratory in Ontario, for a search focused on WIMPs with low masses, below 10 GeV/c^2. The detectors will be optimized for low-energy thresholds and for very good particle discrimination. The experiment will be designed such that up to 400 kg of crystals can be installed at a later stage. The massive LZ experiment will employ about 7 tonnes of liquid xenon as a dark-matter target in a dual-phase time-projection chamber (TPC), installed at the Sanford Underground Research Facility in South Dakota. It is targeted mainly towards WIMPs with masses above 10 GeV/c^2. The timescale for these experiments foresees that the detector construction will start in 2016, with commissioning in 2018. All three experiments need to run for several years to reach their design sensitivities.

Meanwhile, other projects are operational and taking data, and several new second-generation experiments, with target masses beyond the tonne scale, are fully funded and currently being installed. The Canadian–UK project DEAP-3600, installed at SNOLAB, should take its first data with a 3.6-tonne single-phase liquid-argon detector by the end of this year. Its sensitivity goal is a factor 10–25 beyond the current best limit, depending on the WIMP mass. XENON1T, a joint effort by US, European, Swiss and Israeli groups, aims to surpass this goal using 3 tonnes of liquid xenon, of which 2 tonnes will be inside a dual-phase TPC. Construction is progressing fast at the Gran Sasso National Laboratory, and first data are expected by 2015. These experiments and their upgrades, the newly funded US projects, and other efforts around the globe, should open up a bright future for direct-dark-matter searches in the years to come.

The cryostat for the XENON1T experiment. (Image credit: The XENON1T Collaboration.)

Sciencewatch

Compiled by John Swain, Northeastern University

Plants that drink from rocks

Some plants are able to live in dry environments by extracting water from the crystalline structure of gypsum, in the absence of any free liquid water. Sara Palacio of the Instituto Pirenaico de Ecología in Jaca, Spain, and colleagues have shown that the gypsum specialist plant *Helianthemum squamatum* – a small evergreen shrub that can be found in northeastern Spain, and other places – can draw water from gypsum. The mineral, which is a hydrated form of calcium sulphate ($CaSO_4 \cdot 2H_2O$), can also exist as bassanite with a quarter of the water content, or as anhydrite, with no water at all. The isotopic composition of the crystallization water in gypsum differs from free water, and can be used to show that for shallow-rooted plants, 70–90% of the water taken up comes from gypsum. Details of how the plants extract the crystallization water have yet to be worked out, but it is interesting to note that gypsum is widespread not just on Earth, but also on Mars.

Helianthemum squamatum. *(Image credit: Ghislain118 http://www.fleurs-des-montagnes.net.)*

Further reading
S Palacio *et al.* 2014 *Nature Commun.* **5** 4660.

Imaging with undetected photons

In a remarkable extension of earlier interaction-free measurement techniques, Gabriela Barreto Lemos of the Austrian Academy of Sciences in Vienna and colleagues have managed to make images using only photons that have not interacted with the object to be visualized. Two separate down-conversion nonlinear crystals are driven with the same pump laser, but creating only one pair of photons. The ambiguity in which crystal produced the photons, together with a rather subtle interferometric set-up, allows an image to be formed entirely using information from photons that are not themselves detected – that is, the photons that illuminate the object are not detected, while those that are detected never illuminated the object. The technique is demonstrated by making images of objects that are opaque or invisible to the photons that are detected.

Further reading
G B Lemos *et al.* 2014 *Nature* 512 409.

Reliable teleportation

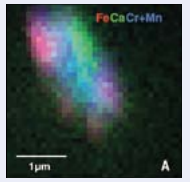
Implicit in the now iconic phrase "Beam me up, Scotty!" is the assumption that teleportation should be reliable – something that has only just been achieved. W Pfaff of Delft University in the Netherlands and colleagues used two diamond crystals, each with a cryogenically cooled nitrogen-vacancy (NV) as the sender and receiver sites (traditionally called "Alice" and "Bob"). An input qubit is entangled with Alice's NV, 3 m from Bob's, with which it was previously entangled by optical means. Before decoherence spoils things – here a few milliseconds – Alice couples her input qubit to her NV, and makes a measurement whose result can then inform Bob (via a classical channel) what to do to his NV to get the original qubit at his end.

This is a first for quantum teleportation between distant solid-state (as opposed to photonics) qubits. Owing to small imperfections, the actual fidelity was 86%, but in principle could be perfect. Now it is just a matter of getting from one qubit up to Avogadro's number, to make Star Trek fans happy, but in the meantime the technique holds great promise for quantum computing.

Further reading
W Pfaff *et al.* 2014 *Science* **345** 532.

Space dust

NASA's Stardust spacecraft might have brought the first specks of dust from outside the Solar System back to Earth. Andrew Westphal of the University of California, Berkeley, and colleagues, together with 30,714 volunteers worldwide working with Stardust@ home, scanned more than 1 million tracks left in the .1 m² Stardust Interstellar Dust Collector. The collector, made of ultralow-density aerogel and aluminium, was exposed to the interstellar dust stream coming from the direction of the constellation Ophiuchus for 195 days during two periods in 2000 and 2002.



Tri-colour iron, calcium, (chromium+ manganese) elemental map of one dust-particle candidate derived from X-ray fluorescence data.

Interstellar dust-particle candidates were distinguished on the basis of composition and/or impact trajectory, rather as in a particle-physics experiment. Seven candidate dust specks were found – one dominated by carbon, another a silicate, and the others more complex. The observations diverge from any one representative model of interstellar dust, leaving the understanding of its nature an ongoing open problem that will take more data to solve.

Further reading
A J Westphal *et al.* 2014 *Science* **345** 786.

Searching for (not-so?) intelligent alien life

Attempts to detect signatures of alien life have involved looking for atmospheres with molecular oxygen and a reducing gas, but what about intelligent life? Henry Lin of Harvard College in Cambridge, Massachusetts, and colleagues have made the amusing – or perhaps depressing – suggestion that exoplanetary atmospheres could be searched for industrial pollutants, such as the chlorinated fluorocarbons (CFCs) that are damaging our own ozone layer and are unlikely to arise naturally. They estimate that the James Webb Space Telescope could, within a couple of days of observation and at no significant extra cost, check out other worlds, not just for signs of life, but for signs that their residents are dumping around 10 times as much CFCs into their atmospheres as we have done.

Further reading
H W Lin *et al.* 2014 *The Astrophysical Journal Letters* **792** L7.

Astrowatch

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

INTEGRAL catches radioactivity of a supernova

ESA's INTEGRAL satellite has detected gamma-ray lines from the radioactive decay of nickel and cobalt in a nearby supernova of type Ia. This unprecedented result confirms that the intense light of the supernova comes from the radioactive decay of these elements, which were formed by the thermonuclear explosion of a white-dwarf star.

There are basically two main classes of supernova explosions. Type II supernovae result from the collapse of the core of a massive star, whereas those of type Ia are thought to be the thermonuclear disruption of a white-dwarf star. According to the theory of such explosions, the carbon and oxygen found in a white dwarf should be fused into radioactive nickel (^{56}Ni) during the explosion. The ^{56}Ni should decay quickly into radioactive cobalt (^{56}Co), which itself subsequently decays, on a somewhat longer timescale, into stable iron (^{56}Fe). The ignition should arise when the white dwarf's mass exceeds a critical mass of about 1.4 times the mass of the Sun. This can result from mass transfer from a companion star or by the merger of two white dwarfs.

It is this uniform process among all type-Ia supernovae that makes them "standard candles" for cosmology, which were used to measure the acceleration of the expansion of the universe (*CERN Courier* November 2011 p5). Type Ia supernovae are also less frequent than type IIs, and it is only by coincidence that two relatively nearby events appeared recently: SN 2011fe in the Pinwheel Galaxy (*CERN Courier* January/February 2012 p13) and now SN 2014J in Messier 82 (Picture of the month *CERN Courier* March 2014 p12).

Hubble image of the supernova SN 2014J, taken in visible light on 31 January 2014 (inset) superimposed on an earlier wide-field view of the host galaxy Messier 82. (Image credit: NASA/ ESA/A Goobar (Stockholm University)/ Hubble Heritage Team (STScI/AURA).)

At a distance of 11.5-million light-years from Earth, SN 2014J is the closest of its type since 1972. Its appearance offered a unique opportunity to use the SPI gamma-ray spectrometer aboard INTEGRAL to try to detect the emission lines from the decays of ^{56}Ni and ^{56}Co. All other scheduled observations of INTEGRAL were delayed, but it paid off.

Eugene Churazov, from the Space Research Institute in Moscow and the Max Planck Institute for Astrophysics in Germany, and collaborators, report the detection of two emission lines at 847 and 1238 keV from the radioactive decay of ^{56}Co between 50 and 100 days after the ignition. They also find a weak signal at 511 keV from the electron–positron annihilation following the decay $^{56}Co \rightarrow {}^{56}Fe + e^+$ and associated emission in the 200–400 keV band. By fitting a three-parameter model to the observations, they calculate that about 0.6 solar masses of ^{56}Ni have been produced by the thermonuclear explosion. The observed broadening of the lines suggests a typical expansion velocity of about 10,000 km/s.

Another team, led by Roland Diehl from the Max Planck Institute for Extraterrestrial Physics, reports the detection of ^{56}Ni already 15 to 20 days after the explosion. This came as a surprise, and suggests that about 10% of the nickel is not produced at the centre of the star – from where the radiation could not escape – but must have been produced outside it. The researchers propose that a belt of helium accreted from the companion star could have detonated first, forming the observed nickel and then triggering the internal explosion that became the supernova.

Regardless of the fine details, these results represent a new breakthrough for the 12-year-old INTEGRAL spacecraft, which has previously detected the radioactive signal of ^{44}Ti from the bright type-II SN 1987A in the Large Magellanic Cloud (*CERN Courier* December 2012 p11). The new results provide direct evidence that type-Ia supernovae are indeed thermonuclear explosions of white-dwarf stars.

● **Further reading**

E Churazov *et al.* 2014 *Nature* **512** 406.

R Diehl *et al.* 2014 *Science Express* DOI:10.1126/science.1254738.

Picture of the month

This unprecedented high-resolution view of the nucleus of a comet was taken by the OSIRIS narrow-angle camera of ESA's Rosetta spacecraft on 3 August 2014. "After 10 years, five months and four days travelling towards our destination, looping around the Sun five times and clocking up 6.4-billion kilometres, we are delighted to announce finally 'we are here'," declared Jean-Jacques Dordain, ESA's director-general. Indeed, launched on 2 March 2004, Rosetta finally reached its target comet 67P/Churyumov-Gerasimenko on 6 August, and remains in orbit around this icy body at a distance of less than 100 km. The comet nucleus is only about 4 km in size, and was found to have an unexpected double-lobed structure with many surface features. The next major mission objective – scheduled for 11 November – is to drop the Philae module to land on the surface and drill into the comet. (Image credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA.)

CERN Courier Archive: 1971

A look back to CERN Courier vol. 11, October 1971, compiled by Peggie Rimmer

CERN

Accelerator Conference

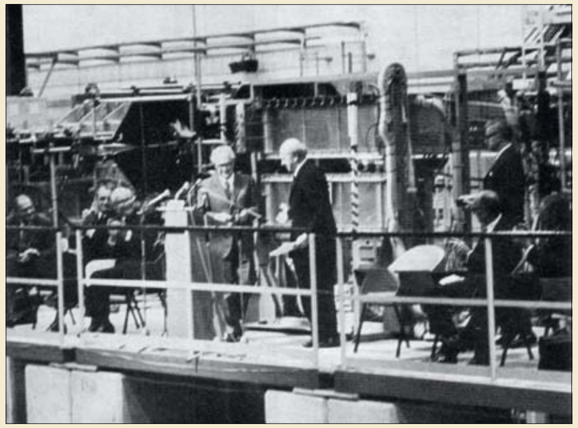
The Eighth International Conference on High-Energy Accelerators was held at CERN from 20 to 24 September. It attracted about 200 specialists from many research centres, mainly in Europe, the US and USSR, in addition to people from CERN itself.

Four years ago, at the Cambridge conference, people were obsessed by space-charge effects and boosters. At Yerevan two years later, interest had swung to electron-ring accelerators and superconductivity. At CERN, electron-ring accelerators had moved down a peg but superconductivity was still there, although narrowed to superconducting accelerator rings. But above everything else, storage rings held the stage.

In the wake of the success of the ISR, and with electron–positron machines at Frascati, Orsay and Novosibirsk supporting fruitful experimental programmes, there are some major new proposals from Brookhaven and Stanford for storage-ring construction, in addition to the projects already underway at Cambridge, DESY, Novosibirsk, Orsay and Stanford. Also, when talking of options beyond the several hundred GeV stage at the new US and European proton synchrotrons, the possibility of superconducting storage rings is much more prominent.

● Compiled from texts on pp295–296.

ISR inauguration

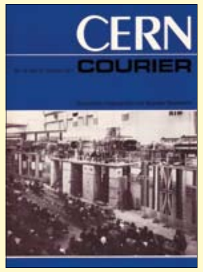


Left: At the inauguration of the ISR, 16 October 1971, Professor Werner Heisenberg hands the key to Professor Edoardo Amaldi, president of CERN Council and representing the European high-energy-physics community. (Image credit: CERN 342.10.71.) Right: The key to the beam stopper that is located between the 28 GeV proton synchrotron and the ISR. Gold-plated for the occasion, it is kept in a small box that has a picture by the 19th-century painter Gustave Doré engraved on the lid. Designed to illustrate La Fontaine's fable "The Two Goats", the picture shows the goats in head-on collision. (Image credit: CERN 396.10.71.) Above right: At the ISR closure ceremony on 26 June 1984, the key was symbolically returned from Giorgio Bellettini, the last chairman of the ISR Experiments Committee, standing right, to Viki Weisskopf, doyen of theorists, who as director-general of CERN in the early 1960s did much to promote the construction of the ISR. (From CERN Courier *September 1984 p287.)*

In his speech at the CERN Intersecting Storage Rings inauguration, 16 October 1971, Werner Heisenberg [a theorist] said: "Here we have a golden key, which controls the transfer of protons from the Proton Synchrotron to the Intersecting Storage Rings. I have it not only for our own protection but also to hand it to the president of the CERN Council, Professor Amaldi [an experimentalist]. As is the rule in physics, such a symbolic key should first be in the hands of the experimental physicists and only when they have done their work should it be handed back to the theoreticians. I give it to Professor Amaldi in the hope that it will not be too long before your colleagues can symbolically hand it back to my colleagues with many good new results."

● Compiled from texts on pp295–296.

Compiler's Note



During the 1960s and 1970s, more than 20 particle accelerators of various designs came on line for research.

There were three high-intensity hadron accelerators: LAMPF (now LANSCE) at Los Alamos, at SIN (now PSI) in Villigen, and at TRIUMF in Vancouver – the largest cyclotron ever built. These are still going strong, supporting a diverse range of applications from materials science to nuclear medicine.

And there were 10 colliders: nine for leptons and just one for hadrons, CERN's Intersecting Storage Rings (ISR). On 27 January 1971, the ISR produced the world's first proton–proton collisions. A decade later, on 4 April 1981, it produced the world's first proton–antiproton collisions, heralding the conversion of CERN's Super Proton Synchrotron to a proton–antiproton collider in July of that year.

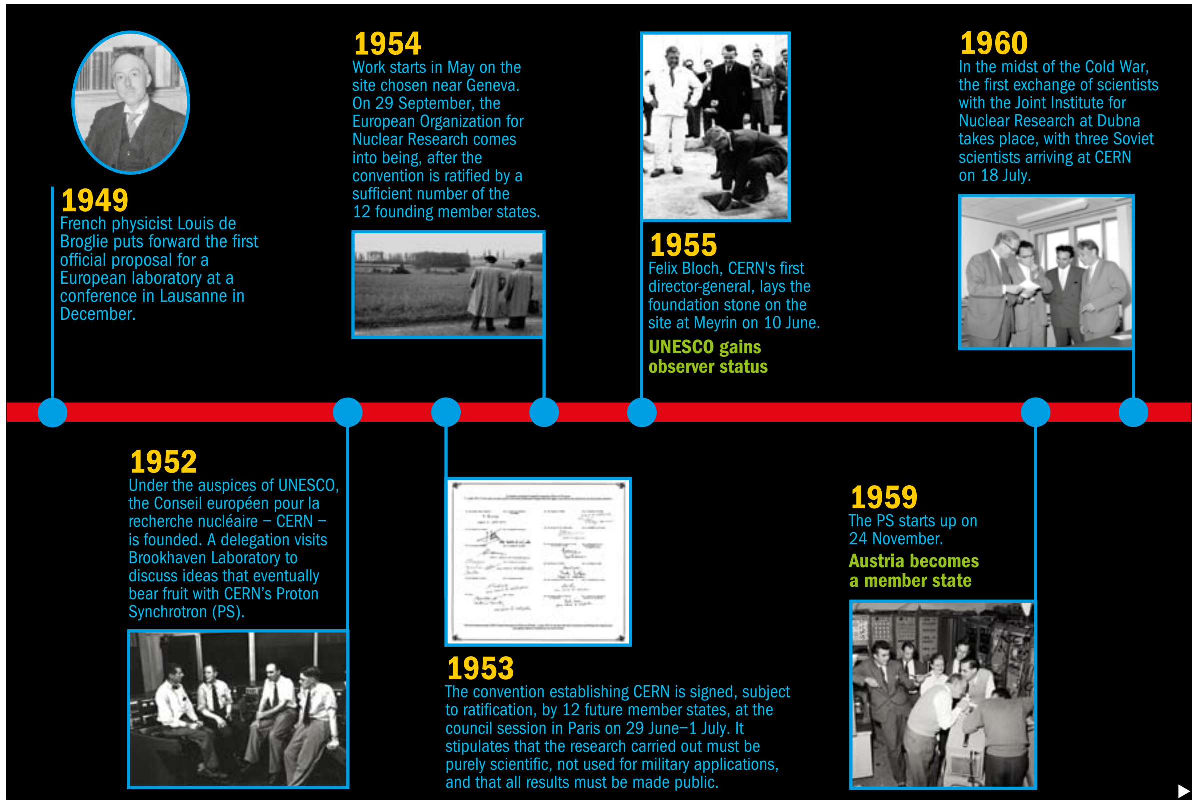
As for the golden key to the ISR, does anyone know of its whereabouts?

SIX DECADES OF SCIENCE FOR PEACE

CERN's origins can be traced back to the late 1940s, when a divided Europe was emerging from the ashes of war. A small group of visionary scientists and public administrators, on both sides of the Atlantic, identified fundamental research as a potential vehicle to rebuild the continent and foster peace in a troubled region. It was from these ideas that CERN was born on 29 September 1954, with a dual mandate to provide excellent science, and to bring nations together. Twelve founding member states – Belgium, Denmark, France, the Federal Republic of Germany, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, the UK and Yugoslavia – signed the convention that officially entered into force 60 years ago.

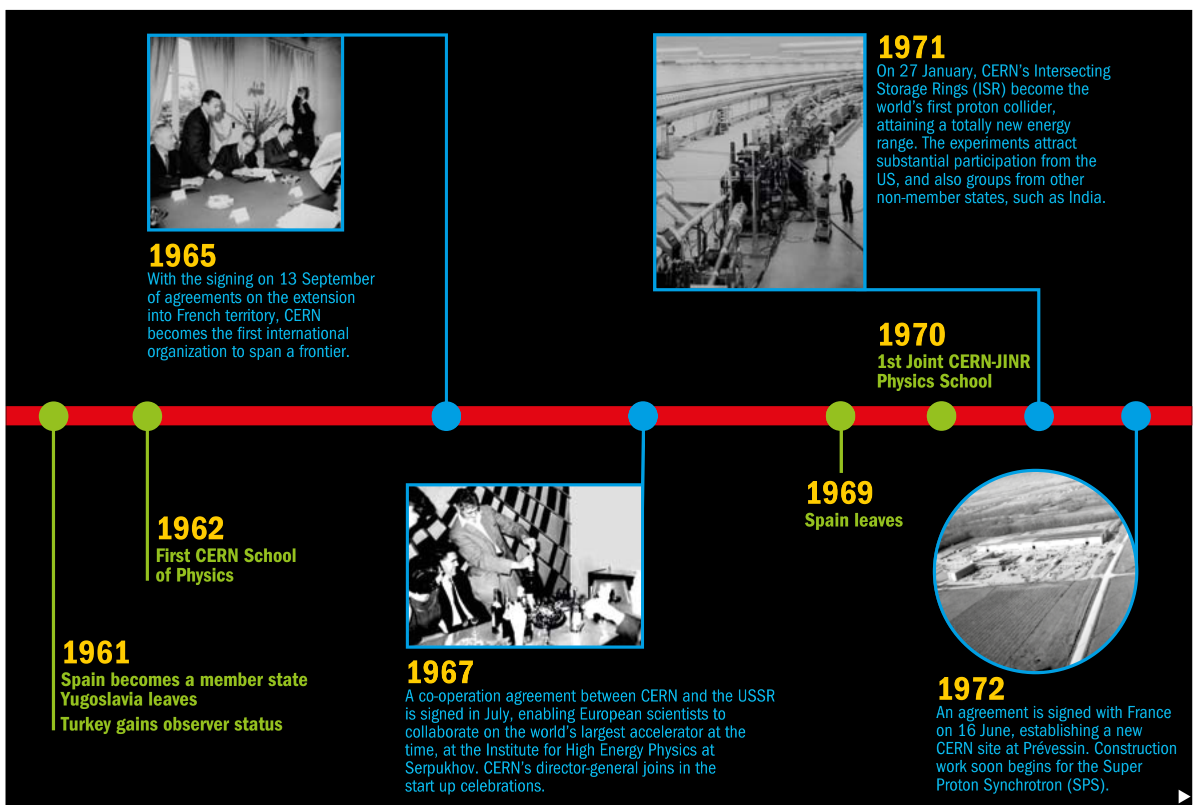
As CERN's facilities and research arena grew in size, so too did the extent of collaboration, with more countries becoming involved – in particular with the programme for the Large Electron–Positron (LEP) collider, and more recently with the construction of the Large Hadron Collider (LHC) itself, as well as its experiments. Today, CERN has 21 member states, with one candidate for accession, one associate member in the pre-stage to membership and seven observer states and organizations. In addition, it has co-operation agreements with many non-member states.

This timeline illustrates a few key moments in this collaborative journey, from those early days to 2014, the 60th anniversary year.



60 years of CERN

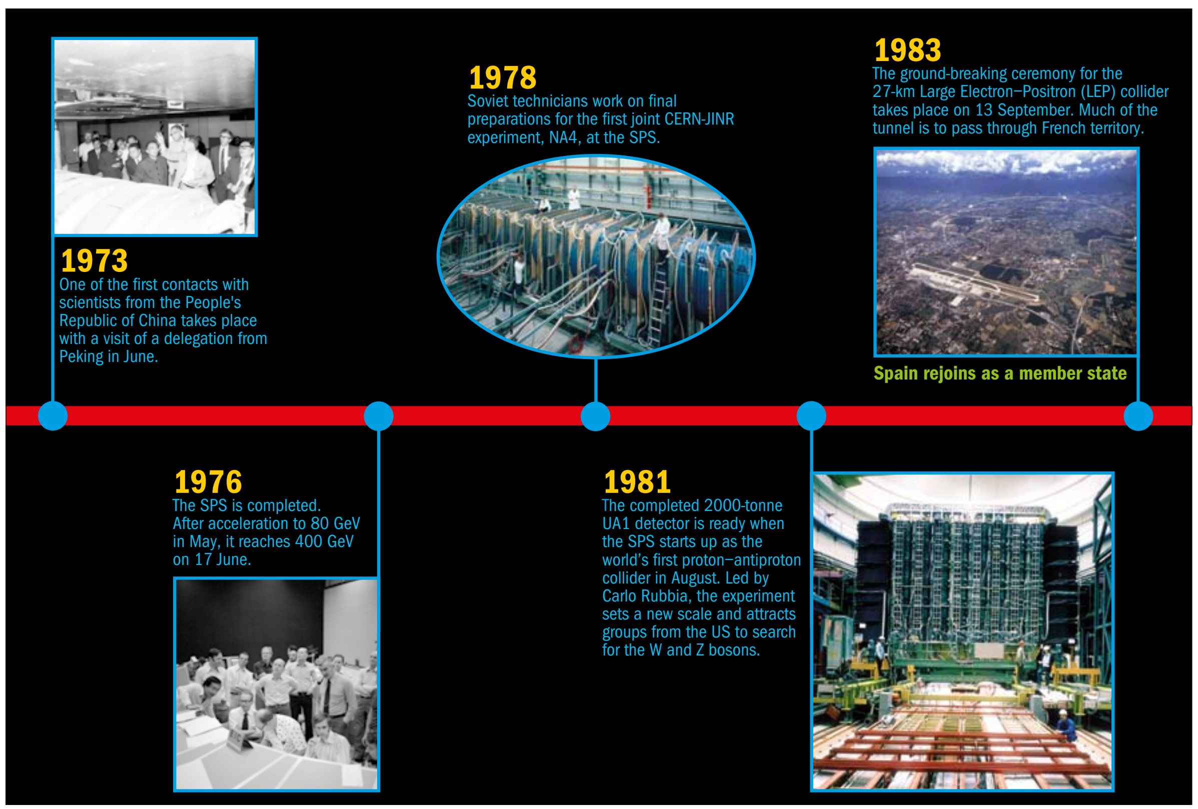
On 27 January 1971, Kjell Johnsen announces that the world's first interactions at a proton collider have been recorded in the ISR.

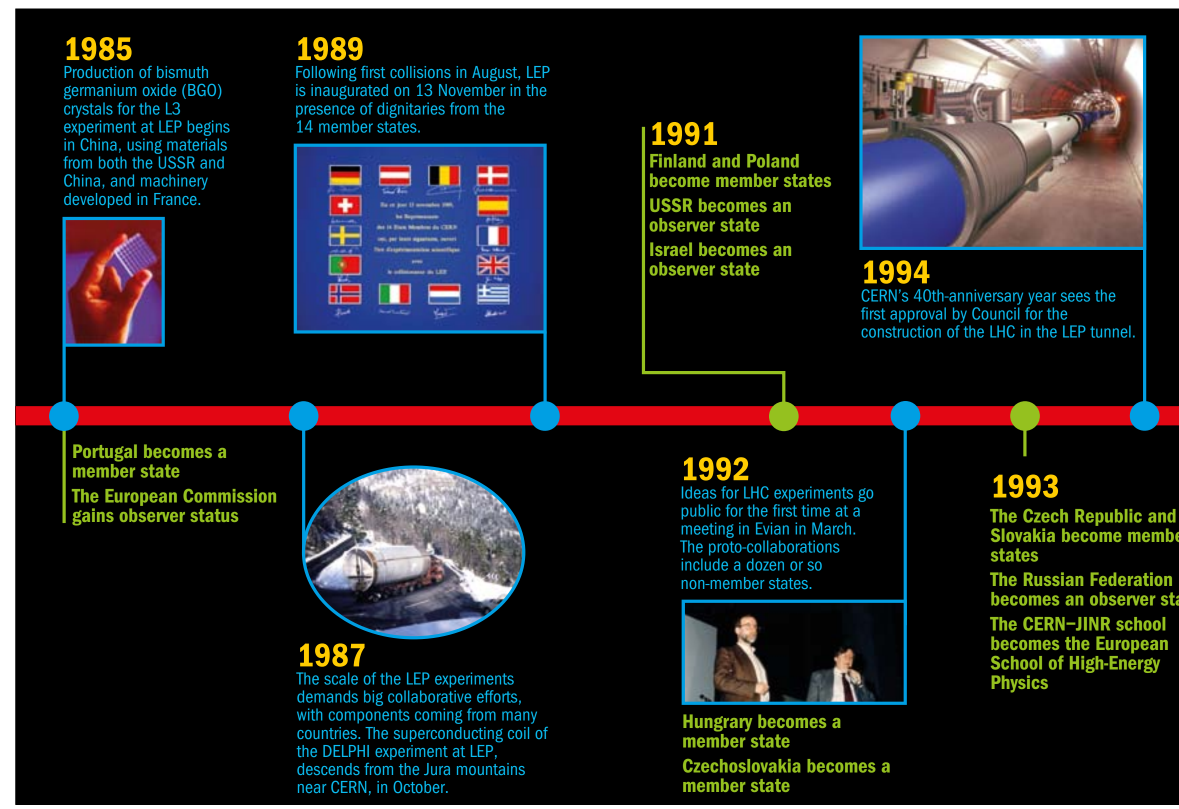


CERN Courier October 2014
60 years of CERN

The Super Proton Synchrotron's 7-km tunnel straddles the Franco-Swiss border, making it the first cross-border accelerator.

The LEP ground-breaking ceremony on 13 September 1983, with François Mitterand, centre left, and Pierre Aubert, centre right, presidents of the host states, France and Switzerland, respectively.





CERNCOURIER
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New heights in magnetic field measurement

Today's "gold standard" for magnetometers, based on Nuclear Magnetic Resonance (NMR), was conceived at the CERN in the late 1970's. Now an all-new NMR magnetometer promises a breakthrough in high precision magnetic field measurement.

A 35-year old design goes into retirement

CERN's 1970's-era design for an NMR magnetometer turned out to be a huge hit in the (admittedly minuscule) world of high precision magnetic field measurement. Originally conceived for one of the muon g-2 experiments, and perfected by the Geneva-based company Metrolab, it has established itself as the unrivaled magnetic-field reference for standards and research laboratories. It has also become an essential production tool for, for example, MRI system manufacturers. A derivative of the original design is still being sold today, as the Metrolab Precision Teslameter PT2025.

But now its designated successor, the PT2026, is in the starting blocks. This flexible and modern laboratory instrument promises to improve all key performance specifications of NMR magnetometers, by roughly an order of magnitude.

Pushing back the limitations of NMR magnetometers

The foremost improvement concerns the measurement range. NMR magnetometers actually measure the NMR resonant frequency of a sample, directly proportional to the surrounding magnetic flux density. The PT2026 measures up to 1 GHz; for hydrogen nuclei, this corresponds to over 23 T, whereas the PT2025's limit was 2.1 T. The primary beneficiaries are manufacturers of ultra high-field superconducting magnets.

The PT2026 also improves the measurement resolution. Today's systems use the Continuous-Wave (CW) technique to detect the NMR resonance: sweep the RF frequency (or equivalently, modulate the field) and detect the absorption peak. The PT2026 also supports the Pulsed-Wave (PW) technique: excite the sample with a broadband pulse and detect the re-emitted frequency. The PW technique is more direct, and, combined with low noise and advanced signal processing, results in < 1 Hz resolution in stable, homogeneous fields – nearly one part per billion for strong fields! This allows, for example, magnet manufacturers to measure the field decay rate of new superconducting magnets more quickly, providing a clear productivity gain.

If appropriate, this resolution can be traded off against speed, by reducing the measurement integration time. Measurement rates of up to 20 Hz, instead of 1 Hz, now allow capturing short-lived transients.

Another key limitation of NMR magnetometers is sensitivity to inhomogeneous fields, which cause a spread of resonant frequencies and make the resonance harder to measure. Side-by-side comparisons show that the PT2026 is 2.5x more tolerant than the PT2025, thus making NMR magnetometers suitable for many new real-world applications.

The NMR sample size – on the order of millimeters – limits their use in very small gaps. CW probes also contain modulation coils and electronics close to the sample, which aggravates the situation. PW probes feature a much simpler, smaller probe head that can be several meters removed from the electronics. This is also useful in hostile environments, such as high radiation or low temperatures, which would cause the electronics to fail.

Ease of use through systems improvements

In addition to pushing back physical limits, a modernized and improved system design improves the ease of use. A frustrating aspect of using an NMR magnetometer is that before starting to measure, the instrument has to painstakingly sweep through its entire frequency range to seek out the NMR resonant frequency. This process typically takes ten seconds – and may never terminate if something is wrong. The PT2026 dramatically reduces the time required, using a built-in 3-axis Hall sensor that reduces the search range by two orders of magnitude.

A feature of the original CERN design is the close coupling of the RF generator with the probes. Feedback loops keep the RF generator tuned to the NMR resonance detected by the probe, and each step of a frequency divider corresponds to a probe with a different range. In the PT2026, the RF generator is freely programmable and decoupled from the probes, thus allowing customized probe ranges.

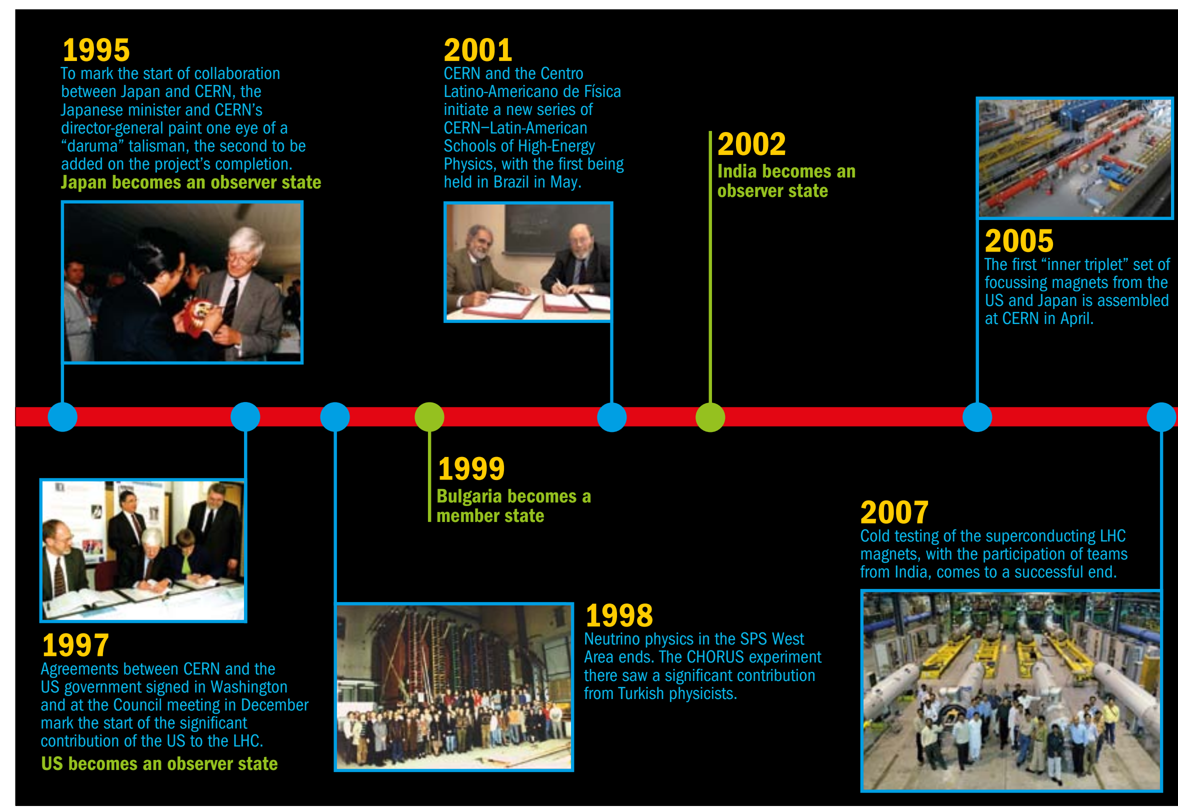
Other examples of the many systems-level improvements include modern interface standards, full software support, input and output triggers, and the possibility of eliminating the need for calibration by using an external reference clock.

Wanted: challenging applications

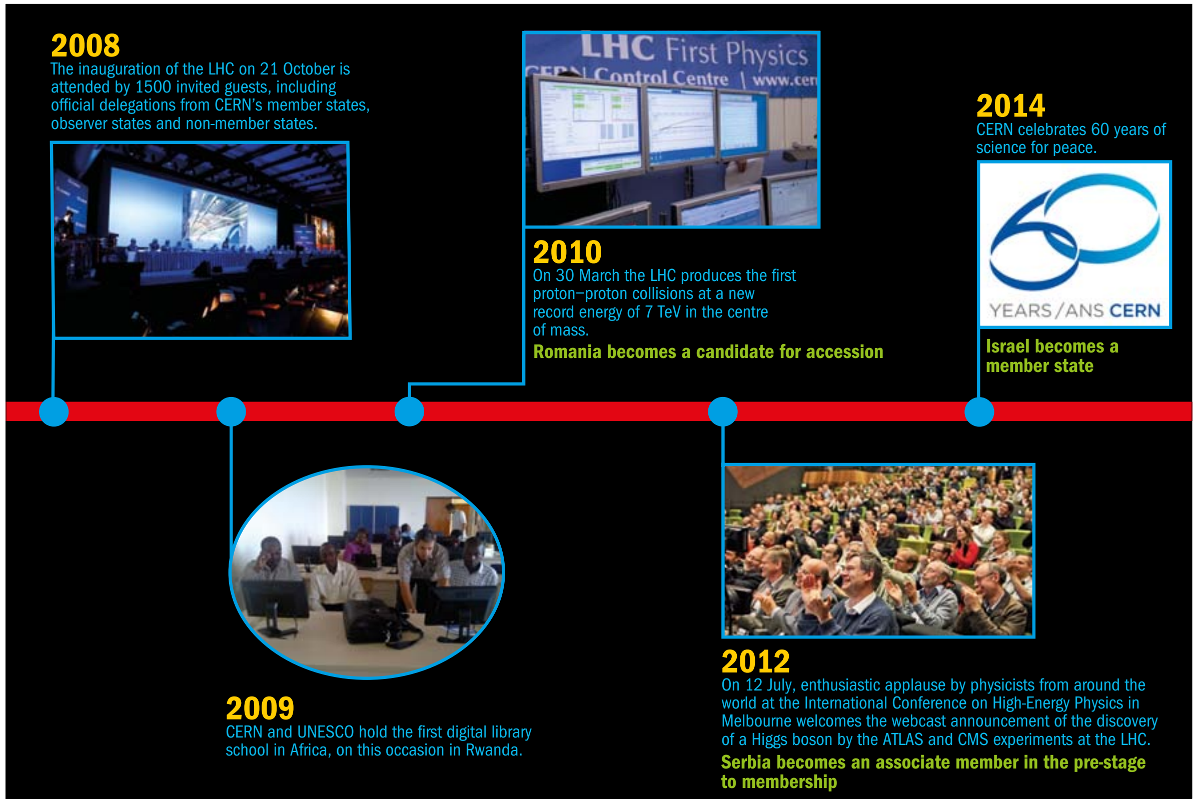
The PT2026 is a breakthrough in precision magnetic field measurement. Metrolab is especially excited to present this instrument to the high energy physics community, where it has its roots and where it will certainly find some of its most challenging and innovative uses.

Contact
Claude Thabuis
Sales and Production Manager
www.metrolab.com

The first magnets installed in the LHC tunnel, in April 2005. The last of the 1232 dipoles was put in place two years later.



Delight in the CERN Control Centre on 30 March as the LHC produces the first collisions at 7 TeV in the centre of mass, and embarks on a journey that unites physicists from all corners of the globe.



CERN: a bridge between cultures and nations

Reflections on CERN's influence through the decades on people and events.

CERN is a unique institution, born from the ashes of war as a beacon of science and peace. Ben Lockspeiser, the first president of CERN Council, encapsulated the spirit of CERN succinctly when he said: "Scientific research lives and flourishes in an atmosphere of freedom – freedom to doubt, freedom to enquire and freedom to discover. These are the conditions under which this new laboratory has been established."

Today, CERN has 21 member states and collaboration agreements with around 40 other countries. More than 10,000 people from around the world, representing nearly 100 nationalities, come to the laboratory on the Franco-Swiss border to carry out their research. At CERN, you find collaborations between people from countries more often associated with conflict than with reconciliation, which is the way it has always been at CERN.

The following short articles, written mainly from personal experience, highlight what CERN has meant to people in various regions of the world, from the Europe of the 1960s through to later decades, and the laboratory's wider engagement with countries in other regions, such as Asia, Australasia and South America.

Résumé

Le CERN, passerelle entre cultures et entre nations

Le CERN, créé il y a 60 ans, représentait dès l'origine un symbole de la science et de la paix. Ces courts articles, s'appuyant essentiellement sur l'expérience personnelle, soulignent ce que le CERN a pu représenter dans différentes régions du monde : en Europe dans les années 1960, ou encore en Asie, en Océanie et en Amérique du Sud.

Rebuilding East–West relations

Adolf Mukhin, far right, and Vladimir Nikitin, far left, during their visit to CERN in 1961. (Image credit: CERN.)

In July 1946, at the invitation of the Physical Society of London, physicists met at the Cavendish Laboratory in Cambridge for the International Conference on Fundamental Particles and Low Temperatures. This was the first such meeting in Europe since the conference on New Theories in Physics, which had been organized in part under the auspices of the International Institute for Intellectual Cooperation, a branch of the League of Nations, in Warsaw eight years earlier. As nobody from the so-called Eastern block was present in Cambridge, it seems that new clouds were already forming over the world – and over science.

Ten years later, in July 1956, CERN organized the Symposium on High-Energy Accelerators and Pion Physics, less than two years after its official foundation. Held at the Institut de Physique in Geneva, it attracted more than 300 participants from 22 countries, including some 50 scientists from the US and about the same number from the USSR, all of whom had been invited by CERN and were able, for the first time, to exchange information freely and compare ideas. Highly interesting papers dealing, in particular, with new principles for the acceleration of particles and with pion physics, were presented and discussed. According to CERN's Annual Report for 1956, the conference was a landmark in the history of the organization.

It followed an opening in the West–East relationship around 1955. In August that year, the International Conference on the Peaceful Uses of Atomic Energy – "Atoms for Peace" – took place in Geneva, attended by a delegation from the USSR that included a number of scientists, among them Vladimir Veksler. A year later, the Joint Institute of Nuclear Research (JINR) was established with a charter very similar to the CERN convention, and with Dmitri Blokhintsev as the first director ▷

(*CERN Courier* March 2006 p15). It was based on scientific institutions that had grown up after the Second World War in a town on the Volga that eventually was named Dubna – city of sciences. At the same time, Soviet scientific work previously recorded in internal reports was declassified and published in scientific journals. English translations were published, mainly in the US, and learning Russian became popular among physicists.

The symposium organized by CERN in July 1956 offered the opportunity for many people to make personal contacts, and especially during an excellent reception held by the Soviet delegation at the Hotel Metropole, where they were all lodged for security reasons. Vodka ran abundantly. Many of the Soviet physicists subsequently became directors of the different laboratories of JINR and/or were to have important roles in Soviet physics. It was the first time that a large delegation of Soviet scientists working in particle physics took part in a scientific conference in the West.

The scientific sessions included reports from the Soviet delegation on the work done at the synchrocyclotron, at was then the Institute of Nuclear Problems, during the years 1950–1955, together with work done in other sectors and in other laboratories. This was when the whole world learnt that the USSR had what was then the largest synchrocyclotron ever built – with a diameter of 6 m. At the same time, the world learnt that Bruno Pontecorvo had an active part in the scientific work with that machine (*CERN Courier* September 2013 p78). Although he was not present in Geneva, he had contributed to a paper on the synchrocyclotron's beams and their use.

Adolf Mukhin presented results on π^+p scattering at energies in the 176–310 MeV range. These results, together with those on pion production from other experiments, created some embarrassment in the physics community interested in performing similar experiments at the CERN Synchrocyclotron (SC). In 1956 the SC was still being constructed, and pion beams for users were foreseen only for early in 1958. Fortunately nature was kind, because weak interactions were soon to come to the fore, and experiments at the SC were able to make an important impact. Later, in 1961, Mukhin was one of the first two experimental physicists from the USSR to visit CERN for a long period – the other was Vladimir Nikitin – during which he joined an experiment on muon nuclear capture at the SC.

● *With the kind help of Maria Fidecaro, CERN.*

CERN is knowledge, understanding and peace

Marilena Streit-Bianchi, centre, with Karen Panman, left, and Roger Paris, with an experiment by the Radiobiology Group to study the effect of radiation on living cells. (Image credit: CERN-PHOTO-8010439-1.)

After 40 years at CERN, what have I learnt? From a Russian: the meaning of 8 March, how communication can be achieved with few words, and friendship, even if interrupted abruptly, can remain for life. From a Chinese: is the insurmountable really insurmountable? From an Iranian: what is important is not appearance but that you are respected. This is a short list – in reality, I was always learning something from the people I met at CERN. If nothing else, new recipes, what to see in their countries, or new cultural insights.

When I arrived at CERN in 1969, I thought I was a rare being – not only an academic woman but also a biologist. However, time showed that the biggest rarity was the place where I had come to work. During the first month, I was invited for dinner to the home of my boss, Johan Baarli, a Norwegian physicist who was head of the Health Physics Group. Travelling there on the bus, I met a Polish radiation-dosimetry physicist, Mieczyslaw Zielczyński, who was also invited. At that time it was a great rarity to encounter someone from behind the "Iron Curtain", and although we could not talk much because of our different languages, we became lifelong friends. A still bigger surprise came in April 1971, when the International Congress on Protection against Accelerator and Space Radiation was held at CERN, and Russian, American and European physicists and engineers could speak freely with each other.

As a collaborator on studies towards the possible applications of high-energy particle beams for cancer therapy, a Russian biologist, Valentina Kurnaeva, was working with me, whose husband was with the Serpukhov collaboration at the Proton Synchrotron. I still have many memories of good work and warm hospitality – invited for lunch, I arrived at noon, but the meal did not start until 2:00 p.m., and at 10:00 p.m. we were still there, singing, talking, eating and drinking. Sadly, it ended abruptly when one of the Russians disappeared mysteriously. My friends had to leave within a week, and we cried knowing that there was not much hope that we would see each other again.

By the end of the 1970s, Chinese physicists were appearing at CERN, with three in the Radiation Protection Group. They were friendly and eager to know everything. The Chinese philosophy on life helped me a great deal, not only because they were hard workers, no matter what time of day or night, but also because of their kindness and politeness. When I organized the farewell party after the decision was taken to end radiobiological activity at CERN in 1981, one of them did me a drawing. Even now, when I feel down, I look at it and it cheers me up. It is true that there is always light somewhere, one just has to pass over the mountain.

Later, when I was doing the safety courses for the physicists who had to work underground at the Large Electron–Positron (LEP) collider, I needed translations of a safety note and a sticker to call the fire brigade, in as many languages as possible. It was simple to find help with Chinese, Russian and ▷

many other languages, but the adventure was to find someone to help with Arabic and Turkish. Finally, I found assistance with the Turkish version by asking a worker who drove a truck in the Transport Group to help me. He was so proud that he introduced me to all of his family on a CERN open day, and I regularly met him thereafter and discussed safety issues.

During the LEP era in the 1990s, I would meet and lunch with an Iranian engineer. At that time Iran was closed to the West and pictures showed completely veiled women. She wore blue jeans and had studied in the US and UK, so I decided to ask her, how was it when she went home? Was it hard to switch from a typical western mode to the other? I was astonished by her answer. At home she felt free, respected for her knowledge and capabilities and not at all devalued as a woman – just the opposite of what I thought from reading the press.

During my last period of time at CERN, a rose left on my table on 8 March by Dmitry Rogulin, a Russian computer scientist working on a technology-transfer project, brought back sweet memories. It took me back to when I was first told by Valentina of what the date means, some time before International Women's Day became recognized in the West.

What a big family CERN is and, I hope, will remain. It has opened my eyes and my mind to the world. For anyone working there, CERN truly is knowledge, understanding and peace.

● *Marilena Streit-Bianchi worked at CERN for 41 years, first in radiobiological research, then later in safety training and finally technology transfer. She is also responsible for CERN's Oral History Project.*

From physics in Poland to medicine in America – via CERN

Stan Majewski, at the back with glasses, with Georges Charpak, centre at the table, and colleagues, at a typical banquet in Georges's lab. (Image credit: I Giomataris.)

My formative years as a young Polish experimental high-energy physicist were spent at CERN, starting in 1974 and lasting, with breaks, until 1984, when I emigrated from Europe to the US. Today, I am a research faculty member in the radiology department in a medical centre – quite a transformation for a person with PhD training in experimental high-energy physics, who specialized initially in the development of gaseous particle detectors.

CERN had a special ambiance and offered tremendous opportunities to any young particle physicist, not only those from Poland. However, the Polish contingent at CERN was always disproportionally large compared with the size of the country in the Soviet block. We always had much more freedom to travel than others from the block, and I benefited 200% from that opportunity. I owe much gratitude to all who were supportive. Luckily for my family and me, we left Poland before martial law was imposed in December 1981.

At CERN I worked in several groups, but I owe the most to Georges Charpak and Fabio Sauli, and to the "Nucleus Heidelberg" group. Whatever I learned later after emigrating to the US was a natural continuation and expansion of that initial training – not just in a technical sense, but mostly in a cultural sense, with the mindset that everything is possible. This was the message from Georges, at least to young people like us. It was Georges who got me interested in imaging in nuclear medicine, and throughout my life I have repeated to all who would listen that I would not have been able to invent the breast-specific gamma imaging (BSGI) camera followed by other medical imagers, were it not for Georges. I was lucky to be able to tell him this in person – he did not believe me – in Paris, about six months before his death (*CERN Courier* December 2010 p33). On that trip I also stopped by the Hôtel Dieu hospital in Paris where I could see one of the BSGI cameras that I invented in operation. What satisfaction! And it all started at CERN.

I am still a proud member of the international particle-physics community, all these years after I left CERN and then Fermilab. What is exciting is that I still communicate with many of my colleagues and friends from the CERN-related community who are now working in medical imaging, including David Townsend, Paul Lecoq, Stefaan Tavernier, José Maria Benlloch, Franco Garibaldi, Alberto Del Guerra and João Varela. I cannot imagine my career without CERN.

● *Stan Majewski is a faculty member at Radiology Research, Department of Radiology, University of Virginia.*

Two generations of Chinese collaboration with CERN

The first official approach from CERN to China was in January 1966, when Bernard Gregory, then director-general, sent a letter to the director of the Institute of Atomic Energy (IAE) at the Chinese Academy of Sciences (CAS), expressing the wish to establish a scientific exchange programme between CERN and China. The IAE director at that time happened to be my father, Sanqiang Qian (*CERN Courier* April 2014 p39). Unfortunately, the letter arrived on the eve of the disastrous so-called "Cultural Revolution" in China (1966–1976), and my father never saw this letter because he was among the first people to be wrongly criticized, even before the "Cultural Revolution" started. Together with my mother, Zehui He – one of the deputy directors of the IAE (*CERN Courier* December 2011 p29) – my father was banished in 1969 to the remote countryside to work in agriculture, until he was allowed to return to Beijing for medical treatment in 1972 and then returned gradually to work at the IAE and CAS.

▷

In China in 1975. At the front are Wu Lein-Fu, centre, vice-chairman of the National Peoples Congress, between Vicki Weisskopf, left, and Willibald Jentschke, with Sanqiang Qian far left. At the back are Léon Van Hove, centre left, and Georges Charpak, centre right, with Zehui He second from right. (Image credit: CERN-PHOTO-7510436-1.)

Meanwhile, part of the IAE was separated out to establish a new independent institute of CAS – the Institute of High Energy Physics (IHEP) – at the start of 1973, and my mother was appointed one of the IHEP deputy directors until 1984. The first director of IHEP was Wenyu Chang, who had some private contact with high-energy physicists in the US prior to 1972, and then exchanged official letters with CERN during 1972 and into 1973. He led the first delegation from China to visit CERN in June and July 1973. This was followed by the milestone visit to China in September 1975 by Victor Weisskopf, Willibald Jentschke and Léon Van Hove – respectively, CERN's former, then current, and elect director-generals – together with Georges Charpak. During the visit, the CERN delegation had extensive discussions with their Chinese counterparts led by Sanqiang Qian who, as vice-president of CAS, visited CERN in June 1978.

Since then, CERN–Chinese collaboration has grown steadily from the visits of a few theorists and accelerator experts from a couple of Chinese institutes in the 1970s and 1980s, through larger groups on the L3 and ALEPH experiments at the Large Electron–Positron collider, to groups on all of the four major LHC experiments, with contributions from more than 10 Chinese universities and research institutes and more than 100 physicists and students.

My own work at CERN started in 1988, following my PhD from Illinois Institute of Technology in 1985 and work as a postdoc at Fermilab. The first five years of my work were with the INFN/Frascati group (based at CERN) on the ZEUS experiment at DESY. I was fortunate to work with top experts so that I could learn new techniques and skills more efficiently and make contributions, in particular in developing track-reconstruction algorithms by the Kalman filtering method. I'm pleased to see that this algorithm is used today by almost all experiments in high-energy physics, including the major LHC experiments.

Since 1994 I have worked on the CMS experiment, helping Peking University (PKU) to join the CMS collaboration in 1996, and proposing that PKU participate in the resistive-plate-chamber (RPC) system for forward muon detection. With strong support from the Chinese funding agencies, and with many colleagues from PKU and other countries, I was able to contribute to the entire RPC process, from prototyping and co-ordinating the chamber construction, through testing and installation, to commissioning and monitoring during Run I of the LHC. Muon triggering and reconstruction were to be crucial to the Higgs-boson discovery.

I felt extremely fortunate and excited when ATLAS and CMS announced the discovery of a Higgs boson in 2012, and when the award of the Nobel Prize in Physics to François Englert and Peter Higgs was announced in 2013. These achievements were the consequence of the tremendous hard work and close collaboration among thousands of physicists from more than 30 countries for about 20 years, which is nearly two-thirds of my physics career!

● *Sijin Qian is a professor at Peking University (PKU) and deputy team leader of the PKU group in CMS. He represented China and 18 other non-member states of CERN on the CMS Management Board from 2008 to 2010. Chinese involvement in CMS is supported by NSFC, MoST and CAS.*

Forging links between CERN and Argentina

Mario Benedetti, left, shakes hands with Cristina Fernández de Kirchner, the president of Argentina, when she visited CERN in 2009, together with the science minister, Lino Barañao, far right, and CERN's director-general, Rolf Heuer. (Image credit: CERN-HI-0906085-19.)

In Argentina, the situation in 1975 was already becoming desperate. Then on 24 March 1976, a military junta was installed. Some of my friends in the faculty had disappeared, and I with my beard – something that made me look suspicious at the time – was saved by chance.

Knowing about CERN, and wishing as a young engineer to specialize, I applied for a job. Being from a non-member state, it was not easy to be selected, but chance, tenacity and probably the type of expertise helped. In September, I obtained authorization for leave from the National University of La Plata, where I was working as a researcher, and moved to the extraordinary international scientific research centre that CERN had already become. When I arrived, I was immediately taken by the spirit of universality that reigned there. This was surely the experience that changed my life and

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my way of thinking and looking at things forever. Few places in the world were so open in spirit. Science was above any political, social, religious or racial difference. It was the common objective that was important. Ask, and there was always someone ready to help or teach you, and it has remained so throughout the 38 years I have been collaborating with CERN.

When I went back to Argentina in 1978 at the end of the first military government, I tried without success to get an agreement signed between the government and CERN. After much toing and froing, and following my second stay at CERN in 1988 and 1989, a first agreement was set up finally. This was not a particularly fruitful agreement, but it led to the act of intent signed in 2006 by Lino Barañao – currently the minister of science in Argentina – who at the time was president of the National Agency for Science and Technology (ANPCyT). In turn, this was followed in 2007 by a framework agreement concerning both physics and technological collaboration between Argentina and CERN. Then, in 2009, the first protocol for collaboration between CERN and the Laboratory of Instrumentation and Control (LIC) of the National University of Mar del Plata, was signed.

About 30 students and researchers from the laboratory that I have been working for and leading have collaborated, either from Argentina or by being at CERN, and this has been beneficial to both partners. The developments carried out for CERN accelerators for many years – including most recently work for Linac4 – have undoubtedly contributed to improving the technology and the academic level of our research. Moreover, not only scientific achievements but also human relationships have been part of these wonderful 38 years of fruitful collaboration, for which I am grateful and proud.

● *Mario Benedetti, director of LIC at the University of Mar del Plata (1983–2012), has worked at CERN's Proton Synchrotron and most recently for the LHC upgrade.*

From 'down under' to CERN

The announcement at CERN in July 2012 of the discovery of a Higgs boson was timed to coincide with the International Conference on High-Energy Physics, in Melbourne. (Image credit: ATLAS-PHO-COLLAB-2012-014-2.)

In 1943, Mark Oliphant, an Australian physicist who had been working at Birmingham in the UK, took up a post as Ernest Lawrence's deputy at Oak Ridge. In his spare time, Oliphant proposed a new method of accelerating particles – the synchrotron. Upon his return to England, he completed in 1953 the construction of the Birmingham 1 GeV proton synchrotron, one of the world's first high-energy particle accelerators. Another Australian, Colin Ramm, joined Oliphant at Birmingham to work on the synchrotron. Ramm's exceptional talents in instrumentation led to an invitation to join CERN soon after the organization's foundation – initially to work on the design and construction of the magnet system of CERN's Proton Synchrotron and later as leader of the Nuclear Physics Apparatus Division. This division built the famous heavy-liquid bubble chamber that made the first observations of high-energy neutrino interactions. In 1972, Ramm joined Melbourne University, where he continued analysing neutrino data from CERN.

In the mid-1960s, David Caro and Geoff Opat founded the Melbourne High Energy Physics Group, Australia's first experimental particle-physics group. Its initial research programme, carried out at Brookhaven, searched for excited sub-nuclear species by observing interactions of antiprotons with deuterons in a bubble chamber. The 250,000 frames of 70-mm film were analysed at Melbourne.

A key appointment at Melbourne was that of Stuart Tovey, recruited in 1975 from CERN as an experienced experimentalist. Tovey was to become a pioneer of Australian involvement at CERN (*CERN Courier* March 2011 p46). He was prominent in the 1960s and 1970s in the study of hyperons and kaons, and later participated in the discovery of the W and Z bosons in the UA2 experiment.

The foundations for strengthening the involvement of Australia at CERN were laid towards the end of the 1980s, with the return to Australia of Geoffrey Taylor to work alongside Tovey at Melbourne. In 1991, Australia and CERN signed an International Co-operation Agreement. The group led by Lawrence Peak at Sydney University, which had a strong programme in cosmic rays, neutrino physics and fixed-target accelerator experiments at Fermilab, evolved towards accelerator-based experiments at CERN. The groups at ANSTO, Melbourne and Sydney participated in NOMAD in the mid-1990s – an important milestone because the Australian groups participated for the first time as equals in all stages of a major CERN experiment. Melbourne and Sydney have also participated in the Belle experiment at KEK since 1997.

A major highlight is Australia's involvement in ATLAS. The international engagement and solid personal and professional ties with CERN of both Taylor and Tovey ensured strong participation of the Melbourne and Sydney groups from the early 1990s. They contributed to the construction of silicon modules for the end-cap wheels of the semiconductor tracker, through Australian industry delivered large precision-machined alloy plugs serving as ATLAS radiation shields, and set up a Tier-2 centre of the Worldwide LHC Computing Grid. Australian physicists have subsequently made significant contributions to the ATLAS Higgs analysis. An experimental particle-physics group led by Paul Jackson at Adelaide University also joined ATLAS in 2012.

The successful Centre of Excellence for Particle Physics at the Terascale, which incorporates Adelaide, Melbourne, Monash and Sydney Universities under the exceptional leadership of Taylor, will no doubt continue to build on these achievements in the years to come. The future looks bright and the only way for "down under" is up.

It was a great privilege and honour to have been part of the stimulating intellectual environment at Melbourne in the 1980s, and to be mentored and introduced by the likes of Opat, Peak, Ramm, Taylor and Tovey to the magical world of particles and fields.

● *Emmanuel Tsesmelis is CERN's deputy head of international relations. He has worked on UA2, NOMAD and CMS, and has led the LHC experimental areas group.*

CERN Courier October 2014

Interview

Carlo Rubbia: a passion for physics and a craving for new ideas

CERN's 60th anniversary is also the year of **Carlo Rubbia**'s 80th birthday. Here he talks about some of the highlights of his long career and his thoughts for the future.

With CERN as his scientific home since 1961, Carlo Rubbia is unique in the organization. One of the three Nobel laureates who received their prizes for research done at the laboratory, he was also director-general from 1989 to 1993 – during the crucial years when the ground for the future LHC was prepared. Rubbia's fame, both at CERN and worldwide, is related closely to his work in the early 1980s, when the conversion of the Super Proton Synchrotron (SPS) to a proton–antiproton collider led to the discovery of the W and Z bosons. The Nobel Prize in Physics was awarded in 1984 jointly to Rubbia and Simon van der Meer "for their decisive contributions to the large project, which led to the discovery of the W and Z field particles, communicators of weak interaction".

However, Rubbia is much more than an exceptional CERN physicist awarded a Nobel prize, who also became director-general. As a child he was forced to flee his home in Gorizia in north-eastern Italy during the Second World War. He went on to become a brilliant physics student at Scuola Normale in Pisa, after almost taking up engineering; a scientist who continues to push the frontiers of knowledge; a volcano of ideas whose inextinguishable fuel is his relentless curiosity and vision; and a courageous citizen of the world, convinced of the duty of science to find solutions to today's global emergencies. In August 2013, the president of the Italian Republic, Giorgio Napolitano, recognized Rubbia's contribution to the history and prestige of CERN, and to a field "vital to our country", as he put it, when he appointed Rubbia "senator for life" (*CERN Courier* November 2013 p37).

The path that would take Carlo Rubbia to Stockholm for the Nobel prize started in the Scuola Normale in Pisa, just one year before CERN was founded, in September 1953. There he chose physics against the will of his parents.

My family would have preferred that I took engineering, but I wanted to study physics. So we agreed that if I passed the entrance exams for the Scuola Normale in Pisa, I could study physics there, otherwise I would have to do engineering. There were only 10 places for Pisa, and I was ranked 11th, so I lost – and I started engineering at Milan. Luckily an unknown student among the first 10 in Pisa (whom I'd be curious to meet one day) gave up and left a place open to the next applicant on the waiting list. So, three months later, I was in Pisa, studying physics, and I stayed there and had a lot of fun.

Left: Carlo Rubbia at the 2012 Lindau Nobel Laureate Meeting. (Image credit: Markus Pössel.) Right: As CERN's director-general, presenting the LHC to a special session of CERN Council on 19 December 1991. (Image credit: CERN HI 47.12.91/5.)

It's not unusual to hear research physicists speak about their job in terms of "fun". In Rubbia's case, physics is still a huge part of his life and is a real passion. Why is this?

"New" is the keyword. Discovering something new creates alternatives, generates interest and fuels the world. The future is not repeating what you've done in the past. Innovation, driven by curiosity, the desire to find out something new, is one of the fundamental attributes of mankind. We did not go to the Moon because of wisdom, but because of curiosity. This is part of human instinct, it is true for all civilizations, and is unavoidable.

After obtaining his degree from Pisa in 1957 in record time – three years, including the doctoral thesis – Rubbia spent a year on research at Columbia University in the US, followed by a year at La Sapienza university in Rome as assistant professor to Marcello Conversi – whom he remembers as "a great friend in addition to being a great mentor, someone with whom the transition from student to colleague happened very smoothly" – before landing at CERN in 1961.

I thought Europe was the real future for someone who wanted to do research. Europe needed to resurrect in science in general, and physics in particular. [After the US] my interest was not in going back to Italy, but rather to go back to Europe. So I left Rome after a year of teaching and went to CERN.

When Rubbia arrived, CERN's active laboratory life was just beginning.

When I arrived, none of the buildings you see today were there. There was no cafeteria. We took coffee and our meals at a restaurant near the airport [Le Café de l'Aviation] and the University of Geneva offered us space to carry out our work while CERN was under construction. In this group of CERN pioneers there were also two others who received the Nobel prize: Simon van der Meer and Georges Charpak. All three of us were among the few who have experienced CERN since its early days.

CERN was the stage for Rubbia's greatest scientific adventure, which led to the discovery of the W and Z bosons. He convinced the director-general at the time – John Adams – to modify the programme of the SPS and transform it into a proton–antiproton collider, with technology that all had to be developed.

My first proposal was written for the US, because I was teaching at Harvard and therefore part of the US system – the most advanced research system in the world at the time. But this did not work for a number of reasons, among them the bureaucracy that was starting to grow there. CERN was a new place, there were people like Léon van Hove and John Adams who had a vision for the future, and they supported my idea that soon became a possible solution. Clearly this kind of idea involves a lot of pressure, hard work, and competition with alternative ideas. There were many competing projects, all aiming to become the new big project for CERN, for which there were funds. Bjorn Wiik wanted to make an electron–proton machine, Pierre Darriulat was pushing for a super-ISR, a superconducting one. All of these ideas were part of a purely scientific debate, without any political influence, and this was very healthy.

Making collisions between two beams, especially between protons and antiprotons, required enormous development, but not that many people. The number of people who developed the proton–antiproton collider – I mean those who made a real intellectual contribution, those who did 99% of the work – were no more than a dozen. We were looking for an answer to a very specific question and we had a very clear idea of what we were looking for.

Rubbia's next big challenge after the discovery of the W and Z bosons was his mandate as CERN's director-general, from January 1989 to December 1993, at a crucial time for setting up CERN's next big project – the LHC.

The name LHC was invented by us – by myself and a small group of people around me. I remember Giorgio Brianti saying that the acronym LHC could not be used, because it already meant ▷

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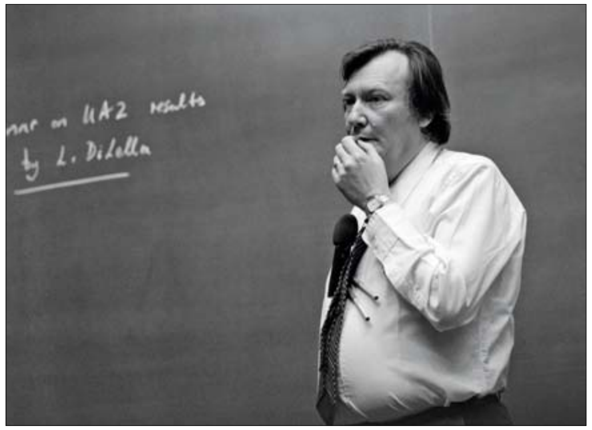

Left: Announcing the discovery of the W boson at CERN in January 1983. (Image credit: CERN-PHOTO-8301284.) Right: With Simon van der Meer, toasting the award to them both of the Nobel prize in October 1984. (Image credit: CERN-HI-8410523.)

Lausanne Hockey Club, which was, at the time, much more popular for the lay public than a machine colliding high-energy protons. Nowadays things are quite different! We started with a programme that was much less ambitious than the US programme. The Americans were still somehow "cut to the quick" by our proton–antiproton programme, so they had started the SSC project – the Superconducting Super Collider – which would be a huge machine, a much more expensive one, but which was later abandoned. So, when my mandate as director-general finished, I left an LHC minus the SSC to the CERN community.

On 4 July 2012, when CERN announced to the world the discovery of "a new boson", 30 years after his discovery of the W and Z bosons, Rubbia' s reaction – from the press conference held at the annual Nobel gathering in Lindau that he was attending – was as enthusiastic as ever.

"This result is remarkable, no question. To get the line at 125 GeV – or 150 protons in terms of mass – which is extremely narrow, has a width of less than 1%, and comes out exactly with a large latitude of precision, with two independent experiments that have done the measurements separately and found the same mass and the same very, very narrow width…well, it's a fantastic experimental result! It doesn't happen every day. The last time, as far as I know, was when we discovered the W and Z at CERN and the top at Fermilab. We are in front of a major milestone in the understanding of the basic forces of nature."

The basic forces of nature are not the only fodder to feed Rubbia's inextinguishable curiosity and craving for innovation. After his mandate as CERN's director-general finished at the end of 1993, he fought to bring accelerator technology to a variety of fields, from the production of "sustainable" nuclear energy to the production of new radioisotopes for medicine, from a new engine to shorten interplanetary journeys to innovative solar-energy sources.

"Homo" is essentially "faber" – born to build, to make. Today there are many things that need development and innovation. One of the most urgent problems we have is that the population on our planet is growing too fast. Since I was born, the number of people on Earth has multiplied by a factor of three, but the energy used has grown as the square of the number of people, because each of us consumes more energy. We know today that the primary energy produced is 10 times the quantity produced when I was born – and the planet is paying a price. So I find it normal to wonder, where are we going in the future? Will the children born today have 10 times the energy produced today? Will we have three times the population of today? This is the famous reasoning started by Aurelio Peccei, founder of the Club of Rome – the well-known "limits to growth", discussed in Italy at least a quarter of a century ago. This is still an important issue and it's all about energy. And this opens up the question of nuclear energy – the old one versus the new one.

Clearly, nuclear energy has gone through a lot of development, but still the nuclear energy that we have today is fundamentally the same as yesterday's, based on the ideas brought about by Enrico Fermi in the 1940s. It's part of the era of the Cold War, of development projects for nuclear energy as a weapon rather than basic research. Today the stakes have changed. So if we want to use nuclei to make energy, which we should, we have to do it on a different basis, with elements and conditions that are fundamentally different from yesterday's. Three aspects of yesterday's/today's nuclear energy are worrying: Hiroshima, Chernobyl, and, more recently, Fukushima is also now part of the family of disasters. And of course there's the problem of radioactive waste. These aspects are no longer manageable in the same way that they were during the Cold War's golden era. We obviously have to change. And it's the scientist's task to improve things. Planes in the 1940s and 1950s scared everybody. My father never boarded a plane. Today everyone does. Why? Because we accepted and modified the technology to make planes super safe. We have to make nuclear energy super safe.

How does someone who has witnessed the entire history of CERN – often first-hand – see its future, and the future of physics?

The LHC brought an enormous change to CERN, whereby today the collaboration with the rest of the world, with non-European countries like the US and Japan, is rather a co-operation than a competition. The LHC transformed CERN from a European laboratory into the main laboratory for an entire research field across the whole world. But this is not without disadvantages, because competition has its benefits. Having a single world-laboratory doing a specific thing is a big risk. If there is only one way of doing things, there is no alternative, unless alternatives come from the inside. But alternatives coming from the inside have a difficult life because the feeling of continuity prevails over innovation. Fortunately, we have an experimental programme and all the elements are now there to conduct high-precision research, and we are on the verge of turning a new page.

I do not know what the next page will be and I would prefer to let nature decide what we physicists will find next. But one thing is clear: with 96% of the universe still to be fathomed, we are faced with an absolutely extraordinary situation, and I wonder whether a young person who wants to study physics today, and is told that 96% of the mass and energy of the universe is yet to be understood, feels excited. Obviously they should feel as excited as I did when I was told about elementary particles. Innovative knowledge, the surprise effect, exists today, still continues to exist and is very strong, provided there are people capable of perceiving it.

CERN will have to choose a new director-general soon. If you had a chance to take that position again, what would your policy for the laboratory be?

I always said that physics at CERN has to be "broad band". It cannot be "narrow band". Transforming the SPS into a p–$\bar{p}$ collider and cooling antiprotons were not part of the programme, and we had the flexibility and freedom to do it. We built the LHC while LEP was still functioning – that was a broad-band scientific policy. The problem is, you never know where the next discovery will come from! Our field is made of surprises, and only a broad-band physics programme can guarantee the future of CERN.

Résumé

Carlo Rubbia : la passion de la physique et la quête d'idées nouvelles

Le soixantième anniversaire du CERN est également le quatre-vingtième anniversaire de Carlo Rubbia, une grande figure de l'histoire de l'Organisation. L'un des trois lauréats du Nobel ayant reçu leur prix pour des recherches faites au Laboratoire, Carlo Rubbia a été directeur général du CERN de 1989 à 1993, une période cruciale où l'on a réalisé les fondations du futur LHC. Depuis lors, il n'a eu de cesse de faire reculer les limites de la connaissance, poussé par une curiosité insatiable et un grand sens de l'anticipation. Citoyen du monde aux engagements courageux, il est également convaincu que la science a le devoir de trouver des solutions aux problèmes urgents de la planète.

Paola Catapano, CERN. Part of this interview is an edited version of a video interview released for Italian TV in July 2012. For the full video in Italian, see https://cds.cern.ch/record/1670684.

CERN and ITER co-operate

CERN's LHC and the ITER fusion project share many technologies, in particular a huge superconducting magnet system. This provides a natural basis for collaboration.

In November 2006, the last LHC dipole and quadrupole cold masses arrived at CERN, signalling the end of the industrial construction of the major components of the new 27-km particle collider (*CERN Courier* October 2006 p28 and January/February 2007 p25). The LHC then entered the installation and the commissioning phases. In the same month, at the Elysée Palace in Paris, the ITER Agreement was signed by seven parties: China, the EU, India, Japan, Korea, Russia and the US. The agreement's ratification on October the following year marked the start of a new mega-science project – ITER, standing originally for the International Tokamak Experimental Reactor – that in many respects is the heir of the LHC. Both machines are based on, for example, a huge superconducting magnet system, large cryogenic plants of unmatched power, a large volume of ultra-high vacuum, a complex electrical powering system, sophisticated interlock and protection systems, high-technology devices and work in highly radioactive environments.

The two projects share many technologies and operating conditions and are both based on large international collaborations. These elements constitute the basis for a natural collaboration between the two projects, despite there being distinct differences between their managerial and sociological models.

In the years 2007–2012, CERN could not engage in new large projects, not only because effort was focussed on installation and commissioning of the LHC – and repair and consolidation (*CERN Courier* April 2009 p6) – but also because of budgetary constraints set by the repayment of loans for its construction. Many groups and departments at CERN faced a related reduction of personnel. In contrast, the new ITER organization had to be staffed and become immediately operational to organize the procurement arrangements between ITER and the domestic agencies acting for the seven members. Indeed, some new staff members were recruited from laboratories that had just finished their engagement with the LHC, such as the CEA in France and CERN itself. However, the number of staff, compounded by the need to train some of them, was not sufficient to satisfy ITER's needs. For example, the ITER magnet system – perhaps the largest technical challenge of the whole project – required many further detailed studies before the design could be brought to sufficient maturity to allow hand-over to the domestic agencies for construction. The ITER magnet management was also interested in benefitting from the technical skills and project-management

Top: The director-generals of CERN, Robert Aymar, left, and ITER, Kaname Ikeda, after signature of the CERN-ITER co-operation agreement on 6 March 2008. (Image credit: CERN-HI-0803002-01.) Bottom: At a meeting at CERN in 2010 in the B163 facility in front of a sample holder for the superconductor reference laboratory, with left to right, Luca Bottura, Lucio Rossi, Frédéric Bordry, Arnaud Devred and Neil Mitchell. (Image credit: CERN-ITER.)

experience for large-scale procurement from industry that CERN had accumulated during construction of the LHC.

In addition to the primary reasons for collaboration between CERN and ITER, there were additional reasons that made it interesting to both parties. For CERN there was the possibility of conducting R&D and studies in key domains, despite the lack of new projects and internal funding. Examples include:

- the superconductor reference laboratory, set up for the ITER organization, which has proved to be useful for CERN's internal programme, formally launched in 2011, for the new High Luminosity LHC;
- qualification of new commercial nuclear-radiation-hard optical fibres, with measurements also at cryogenic temperatures;
- design of high-temperature superconductor (HTS) 70-kA-class current leads, with sophisticated 3D simulations and experimental mock-ups;

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Collaboration

IA#	Topics and tasks	Duration
IA1	Superconductors and magnet technologies and procurement	2008
IA2	Superconductor and magnet technologies (conductor, feeders, CL, HV instrumentation, etc)	2009
IA3	Superconductor reference laboratory	2009–2010
IA4	Superconductor reference laboratory operation	2010–2014
IA5	Magnet technologies (metallurgy, HTS CL, etc)	2010
IA6	Magnet technologies (HV, rad-hard fibres, etc)	2010
IA7	Magnet and machine protection	2010–2012
IA8	ITER cryoplant process simulation and control	2010–2014
IA9	Magnet technologies (metallurgy, Instrum. plug, cryo-thermometry, rad-hard fibres, etc)	2011
IA10-I	Test of HV cryogenic devices	2011–2013
IA10-II	HTS current leads	2011–2013
IA11	Management plan and QA of the interlock control system	2011–2014
IA12	Laboratory tests of thermomechanical instrumentation	2011
IA13	Materials and metallurgy, instrumentation (plugs, rad-hard fibres, thermometry) and TF coils	2012
IA14	Metallurgical and material testing support for the construction of the ITER magnet system	2013–2017
IA16	HTS current leads of the ITER magnet system	2014–2016
IA17	Magnet instrumentation (protection, rad-hard fibres) and magnetic measurement PF coils	2013
IA18	ITER cryolines	2014–2016
IA19	Magnets, instrumentation and plant engineering	2014

Table. 1. CERN-ITER implementing agreements.

- setting up a unique high-voltage laboratory for cryo-testing insulation and instrumentation equipment;
- new concepts and controllers for the HTS current leads and magnet protection units; and
- activities in metallurgy, welding and material testing, which have helped to increase CERN's already world-renowned competence in this domain.

The list could be longer. Only a minor part of the activity was supplying a "service" or the transfer of knowledge. In many cases the activity was new design, new R&D or validation of beyond-state-of-the-art concepts.

For ITER, the benefit lay not only in receiving the services and studies, for which it paid. It was also in having access to a large spectrum of competence in a single organization. CERN could react promptly to the demands and needs stemming from contracts and unexpected difficulties in the multiparty complex system set up for ITER construction.

Discussions between CERN and ITER management started in 2007 and were formalized with a framework co-operation agreement signed at CERN by the director-generals of the two organizations on 6 March 2008. This agreement foresaw a co-ordination committee that was in fact not set up until 2012, and has met only twice so far, because the collaboration is working so smoothly that no issues have been raised. The collaboration was then implemented through contracts, called implementing agreements (IAs) to the co-operation agreement. Each IA contract details the specific content, goals, deliverables, time duration and resources.

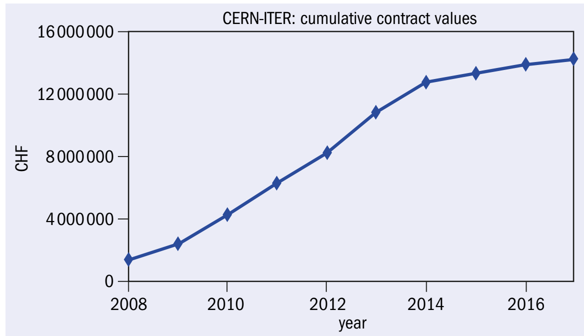


Fig. 1. The values of the contracts signed in the CERN-ITER collaboration so far.

Table 1 lists the 18 IAs signed so far between CERN and ITER. Each year from 2008, an IA was signed according to the needs of ITER and the possibilities and interest at CERN. Standard annual IAs span one calendar year and contain a variety of different tasks – these are annual IAs. However, IAs with extended durations of up to five years soon became necessary to secure long-term service by giving CERN the possibility of hiring new personnel in excess of those allowed by the internal budget. In total, CERN has had eight annual contracts so far, one short-term contract (IA12) and nine multiyear contracts, two of them lasting five years – one for operation of the superconductor reference laboratory (IA4) and one for metallurgy and material testing for the magnet system (IA14).

As already mentioned, the Co-ordination Committee was not set up until 2012, so the various agreements were overseen by a Steering Committee – later renamed the Technical Committee to distinguish it better from the Co-ordination Committee – which is composed of two members per party. The membership of these committees has been relatively constant and this continuity in management, with smooth changes, is probably one of the reasons for the success of the collaboration. Also, some IAs started outside the usual entry points and were later adjusted to report inside the framework. The CERN-ITER collaboration is a textbook case of how managing relations between complex organizations that are at the centre of a network of institutes is an endless job.

The steering and technical committees meet twice a year and each session is prepared carefully. The committee members review the technical work and resolve resource problems by reshuffling various tasks or setting up amendments to the IAs – which has happened only five times and never for extra costs, only to adjust the execution of work to needs. Long-term planning of work and of future agreements is done in the meetings for the best use of resources, and problems are tackled at their outset. So far, no disputes, even minor ones, have occurred.

As in any sustainable collaboration, there are deep discussions on the allocation of resources, most being personnel related, with only a minor part being about consumables. Figure 1 shows the budget that was allocated for the execution of the agreement. The total of more ▷

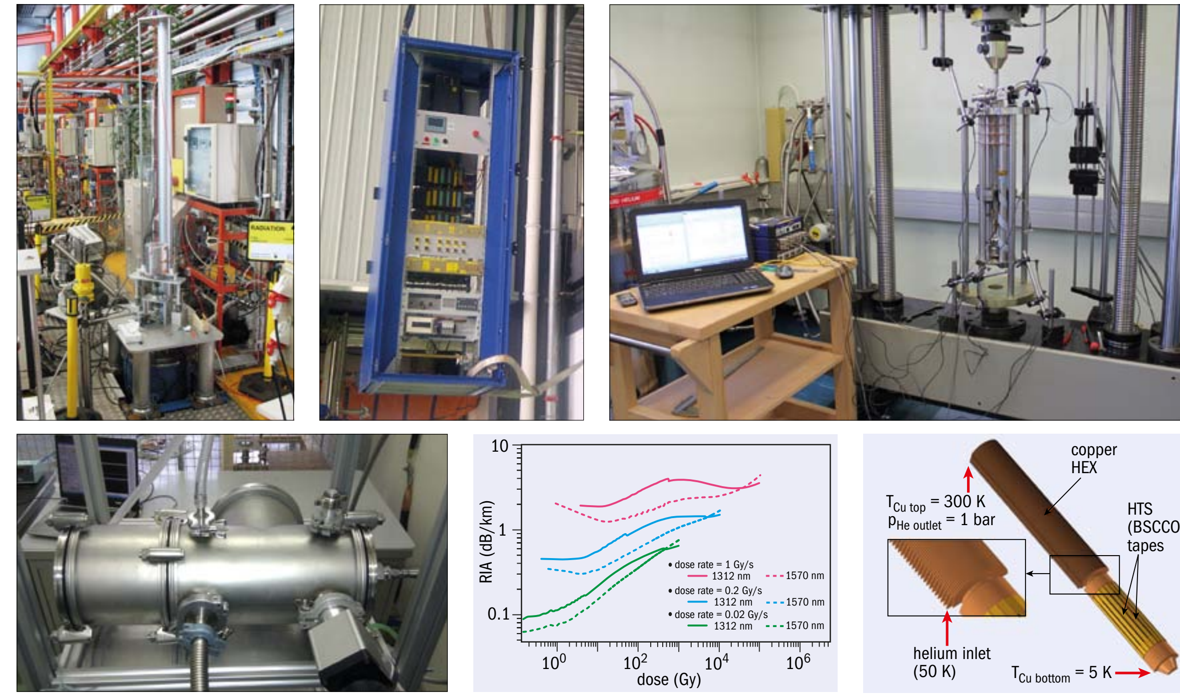


Fig. 2. Clockwise from top left: A test station used for ITER with the 10.5-T magnets used for magnetization measurements at 4.2 or 1.9 K. (Image credit: B Bordini and E Seiler.) Prototype of the magnet-powering interlock system delivered to ITER, based on redundant industrial automation equipment combined with 2003 voting logic at the I/O level. (Image credit: A Vergara/ITER.) Trial of a four-column cryostat for low-temperature mechanical tests on an electromechanical universal testing machine. (Image credit: S Sgobba and S Langeslag.) Overview of a 70-kA HTS current lead for ITER based on LHC technology. (Image credit: A Ballarino and B Bordini.) Measured radiation-induced attenuation as a function of the dose for different irradiation rates for an optical fibre. (Image credit: D Ricci and E Guillermain.) Vacuum chamber for the cryogenic HV (56 kV) tests of instrumentation cables, feed-throughs and insulators. (Image credit: R Lopez, D Tommasini and J Kosek.)

than CHF14 million engaged corresponds approximately to 80–90 full-time equivalent years used by CERN to fulfil the agreement. Most personnel are CERN staff, in some cases recruited ad hoc, but fellows and associated personnel are also involved.

The examples in figure 2 show a few of the most important technical achievements. One of the key ingredients of the success of the CERN-ITER collaboration is that checks are done on deliverables, rather than on detailed accounting or time-sheet reporting. This has been possible because of the technical competence of both the management and the technical leaders of the various tasks, as well as of the personnel involved, on both sides. Goals and deliverables, even the most difficult ones, were evaluated correctly and reasonable resources allocated at the outset, with a fair balance and good appreciation of margins. This leads to the conclusion that – despite modern management guidelines – technical competence is not a nuisance: it can make the difference.

Further reading

For more about the achievements of the CERN-ITER collaboration, see the paper by F Bordry, A Devred, N Mitchell and L Rossi at the Applied Superconductivity Conference 2014, submitted to *IEEE Trans. on Appl. Supercond.*

For more about the ITER superconducting magnet system, see N Mitchell *et al.* 2012 *IEEE Trans. Appl. Supercond.* **22** 4200809.

Résumé

Coopération CERN-ITER

Le LHC du CERN et le projet de fusion d'ITER ont beaucoup de technologies en commun. Les deux s'appuient sur un ensemble impressionnant d'aimants supraconducteurs, des centrales cryogéniques d'une puissance exceptionnelle, d'énormes volumes d'ultravide et un réseau d'alimentation électrique complexe. Les deux projets ont également des conditions de fonctionnement comparables, et tous deux reposent sur de vastes collaborations internationales. Ces éléments communs conduisent tout naturellement à une coopération entre les deux projets, malgré des modèles managériaux et sociologiques très différents. La collaboration, entamée en 2008, s'est avérée très fructueuse, grâce en particulier aux compétences techniques des personnes prenant en charge les différentes tâches.

Lucio Rossi, CERN.

Faces & Places

APPOINTMENTS

Stan Bentvelsen to be next director of Nikhef

Stan Bentvelsen has been appointed as director of Nikhef – the National Institute for Subatomic Physics, the Netherlands – with effect from 1 December. He will succeed Frank Linde, whose second term as director finishes at the end of the year.

Bentvelsen is currently professor at the University of Amsterdam, where he is director of the Institute for High Energy Physics. He is also a member of the governing board of the Foundation for Fundamental Research on Matter (FOM), a partnership between Radboud University Nijmegen, the University of Amsterdam, Utrecht University and VU University Amsterdam. In the run-up to and during the discovery of a Higgs boson at CERN, he was responsible for the Dutch contribution to the ATLAS experiment, in his capacity as programme leader.

After studying theoretical physics at the University of Amsterdam, Bentvelsen gained his PhD in experimental physics for research at the HERA collider at DESY. He subsequently worked for six years at CERN on the OPAL experiment, and then joined Nikhef in 2000 as a senior researcher, starting with the preparations for ATLAS. Since 2005, he has been professor of "Collider Physics at the LHC" at the University of Amsterdam.

Stan Bentvelsen is to take the helm at Nikhef. (Image credit: Jan Willem Steenmeijer.)

Bentvelsen will be employed by FOM, but will retain his professorship at the University of Amsterdam. His appointment is for a period of five years, with the possibility of a single reappointment for the same period.

Hafeez Hoorani to head NCP in Pakistan

Hafeez Hoorani has been appointed as director-general of the National Centre for Physics (NCP) in Pakistan. NCP is the focal point of the CERN–Pakistan collaboration, and is currently the only collaborating institute from Pakistan within the CMS collaboration.

Hoorani studied physics at Karachi University before gaining a Masters at Simon Fraser University, Canada, in experimental physics related to the quark–gluon plasma, and later a PhD at the University of Geneva. He first went to CERN in 1989 to work at the Large Electron–Positron collider, later becoming research director at NCP and professor at Quaid-i-Azam University, Islamabad. He currently works on the forward muon system of CMS, as well as on top-quark physics at CERN. He also served as the scientific director of SESAME for seven years – the light source under construction in Jordan (*CERN Courier* September 2014 p46).

Hafeez Hoorani, new director-general of the NCP. (Image credit: Muhammad Imran/NCP.)

Since 1994, Hoorani has played a key role in establishing CERN–Pakistan collaboration, which has now led to an important step in the form of Pakistan's application for associate membership of CERN, which was approved by CERN Council in June.

The National Centre for Physics was set up in 1999, with the distinguished theorist Riazuddin as the first director (*CERN Courier* March 1999 p5). Its range of studies encompasses not only particle physics but also other fields, from condensed matter to cosmology. NCP collaborates with CERN in the CMS experiment and in the LHC Computing Grid, being the only node for grid in Pakistan.

AWARDS

Theorists honoured in Edinburgh and London

On 28 June, Peter Higgs, of the University of Edinburgh, and François Englert, of Université Libre de Bruxelles, received doctorates in science from one another's institutions, at a graduation ceremony in the University of Edinburgh's McEwan Hall. They were honoured for their work on the Brout–Englert–Higgs mechanism, which enables elementary particles to acquire mass. In addition, Higgs was awarded the Freedom of the City of Edinburgh. The particle predicted by the mechanism, known as the Higgs boson, was discovered in 2012 by the ATLAS and CMS experiments at CERN. In recognition of CERN's role, the organization's director-general, Rolf Heuer, also received an honorary degree from the university.

At the same event, Tom Kibble of Imperial College London received a Royal Medal from the Royal Society of Edinburgh – the society's most prestigious award, granted only with permission of the Queen. Kibble received the award for "his outstanding contribution to the field of theoretical ▷

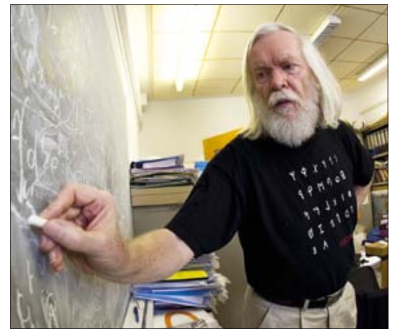
Left to right: Tom Kibble, Peter Higgs and François Englert, at the ceremony in Edinburgh. (Image credit: Gareth Easton Photography.)

Faces & Places

physics through his research and discovery, with others, of the mechanism that gives mass to elementary particles and which, in so doing, paved the way for unification of the weak and electromagnetic forces". Born in India, he moved to Edinburgh in 1944, where he attended school. He gained his first degrees and then his PhD at the University of Edinburgh. As part of the day's celebrations, the Royal Society of Edinburgh organized a discussion event on "The Future of Particle Physics and CERN", at which Englert, Heuer, Higgs and Kibble all spoke.

In London, the Royal Society has awarded the 2015 Bakerian Lecture to John Ellis, Clerk Maxwell professor of theoretical physics at King's College London, and a leading theorist at CERN until his retirement in 2011. He receives the award "for his ground-breaking contributions in the physics of the Higgs boson and his attempts at unifying the fundamental forces of nature through his work at the LHC".

The Bakerian Lecture is one of the society's premier awards, and is delivered annually at the Royal Society in London. The lecture series began in 1775, after the lectureship was established through a bequest by Henry Baker – a typical 18th-century polymath, who made "valuable contributions to the dissemination of scientific knowledge, in particular in the field of microscopy".


John Ellis in his office at CERN. (Image credit: CERN-GE-1107174-06.)

Celebration

Golutvin and Onuchin reach their 80th birthdays

Igor Golutvin, one of the leading scientists at JINR, was 80 on 8 August – an event that was celebrated on the day in a special session in Dubna of the 17th Annual RDMS CMS Collaboration Conference. He is well known for several generations of large-scale experiments at JINR, the Institute for High Energy Physics in Protvino and at CERN.

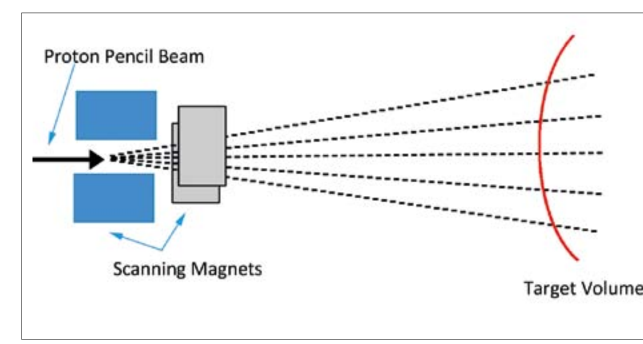
Golutvin began to develop wire spark chambers for neutrino experiments during a first visit to CERN in 1964, when the use of online computers was just beginning. He then used this experience in experiments at the synchrophasotron in Dubna and at the U-70 accelerator at Protvino. Under his leadership, the USSR then had its first – and one of the world's first – online installations to study elastic πp scattering and $K^0 - \bar{K}^0$ regeneration.

In 1974, he was one of a group of physicists sent to CERN to establish a joint JINR–CERN experimental programme. The successful work by Golutvin and the Dubna team strengthened the participation of the JINR physicists at CERN, and promoted the development of co-operation. NA4, the first joint experiment by the Bologna–CERN–Dubna–Munich–Saclay collaboration, was approved in 1975, and


Igor Golutvin, now 80. (Image credit: Anatoli Zarubin.)

Golutvin led the R&D and construction of the large proportional chambers. The excellent performance and outstanding reliability of these chambers were a key factor in the success of the experiment, which measured structure functions with a precision that has still not been exceeded in the corresponding kinematic region.

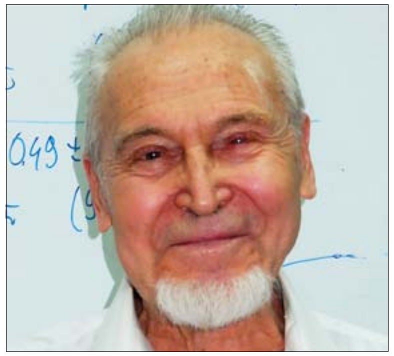
At Dubna, Golutvin organized a powerful base for R&D and the mass production of wire detectors of different types and ▷



their electronics. Drift and proportional chambers constructed under his leadership were used in experiments at Dubna, and large-area chambers manufactured at Dubna were used by the Spin Muon Collaboration at CERN and in the HERA-B experiment at DESY. In 1988, Golutvin initiated a silicon programme at Dubna to develop applications of radiation-hard silicon detectors in experiments at colliders.

For the past 22 years, he has been an organizer of international co-operation in the CMS experiment at the LHC, and has been spokesperson of the Russia and Dubna Member States (RDMS) collaboration in CMS since 1994. The RDMS CMS collaboration, which involves 24 research institutes, was responsible for the design, construction, commissioning and operation of the endcap detectors, including hadron calorimeters and the first forward-muon stations, together with active participation in the design and production of several other sub-detectors. Golutvin continues to pay meticulous attention to development of the RDMS physics programme and computing based on grid technology. He is looking forward to the High Luminosity LHC and actively co-ordinates efforts for further upgrades to CMS calorimetry.

On 3 October, Alexei Onuchin, one of the pioneers of colliding beams, will be 80. His whole scientific career has been spent at the Budker Institute of Nuclear Physics (BINP) in Novosibirsk, where he has worked since 1959, starting with a PhD thesis devoted to luminosity measurement by small-angle scattering – one of the world's first experiments with colliding beams – and became one of the organizers and active participants of experiments at the VEP-1, VEPP-2 and VEPP-4 colliders.



Alexei Onuchin, now 80. (Image credit: Valentin Baev.)

In 1970, experiments at the e^+e^- collider VEPP-2 in the centre-of-mass energy range 1.18–1.34 GeV discovered multihadronic annihilation simultaneously with the Frascati group. This phenomenon was later to become some of the first evidence for the existence of light quarks. From 1980 to 1985, Onuchi was a leader of the MD-1 experiment at the VEPP-4 collider, which studied the energy range from 7 GeV to the mass region of the Υ mesons. The high-precision measurement of particle masses using resonance depolarization brought him and his colleagues a USSR State Award in 1989. Later he participated in experiments with the KEDR detector at the VEPP-4M collider, and led a Russian group in the BaBar experiment at the SLAC B-meson factory.

Onuchin has contributed a great deal to various experimental techniques of particle detection at BINP – multiwire proportional chambers, the liquid-krypton calorimeter and particularly Cherenkov counters, with which he started working as a student in the laboratory of the Nobel Prize winner Pavel Cherenkov. Onuchin has developed various types of such counters for experiments throughout the world. His work on using aerogel in Cherenkov detectors is well known, and in 2008 he received a Pavel Cherenkov Prize of the Russian Academy of Science for this.

He has always taught and supervised young physicists. His former students include professors, BINP deputy-directors, and a corresponding member of the Russian Academy. Most of the colliding-beam experiments at BINP are led by his students.

A secret of Onuchin's active longevity lies with sport. For many years, fans of cross-country skiing have met him on the skiing track of the Novosibirsk Academy town – and hope to meet him there again next winter.

CONFERENCE

QCD creates strong interactions in Montpellier

The 17th International Conference in Quantum Chromodynamics took place on 30 June–4 July at the Delegation Regionale du Centre Nationale de la Recherche Scientifique (CNRS) in Montpellier. It combined, on one hand, theorists and experimentalists from laboratories around the world and, on the other, young PhD students and postdocs who presented their work for the first time in front of world experts, all working actively within QCD. Its medium size of about 80–100 participants ensures strong interactions at the conference and a family atmosphere where new collaborations often emerge.

This biannual conference, which alternates with the HEPMAD conference series in Madagascar, featured LHC physics (on the Higgs boson, top-quark, and W and Z boson production) together with new heavy flavour spectroscopy, light flavours and glueballs, τ-, K- and B-decays, CP-violation, the QCD plasma and some non-perturbative aspects of QCD. Participants discussed several questions, including the new exotic-hadron spectrum. Some talks also tackled the use of perturbation theory at high energy, the inclusion of higher-order corrections and the optimization of QCD perturbative series to evaluate with a better accuracy production rates at the LHC and other QCD processes, such as the heavy hadron-molecule masses.

Participants at QCD14 in Montpellier. (Image credit: Alizé Photo.)

The review on the Shifman–Vainshtein–Zakharov sum rules on recent improved results presented by Stephan Narison, the conference organizer, could serve as a useful reference, both for experiments and for theories, in much the same way as lattice computations. Measuring the g-factor of the muon could give a clue to new physics, where the current discrepancy of 3.6σ, between the theoretical estimated value within the Standard Model and the measured one, needs first to be confirmed and then will require improvements of present estimates of the hadronic contributions.

The programme concluded with talks on searches for some new physics beyond the standard model of electroweak interactions.

● For more information about QCD14, visit www.lupm.univ-montp2.fr/users/qcd/qcd14/. Exceptionally, a QCD conference will be held in Montpellier next year (in addition to the regular edition in 2016) on 29 June–3 July, to celebrate its 30th anniversary.

SCHOOLS

Royal Holloway hosts oPAC school

A week-long advanced school on accelerator optimization took place at the Royal Holloway University (RHUL) of London on 7–11 July, attracting around 80 participants from across Europe. Organized as part of the activities of the oPAC network – which focuses on the "optimization of the performance of any particle accelerator" – the school covered accelerator optimization through beam-physics studies, instrumentation R&D and charged-particle beam simulations at an advanced level.

Paul Hogg, the RHUL vice-principal for research and enterprise, and dean of science, opened the school with a welcome address. Lecturers from universities, research centres and industry then presented all aspects of accelerator optimization throughout the week, leading to many interesting discussions. Highlights included the tutorials held during the week, the lively poster session on Thursday afternoon, the seminar about the discovery of the Higgs boson by Phil Burrows of the University of Oxford, and a lecture about different roads into antimatter by CERN's Michael Doser.

In addition, the school provided excellent opportunities for networking with colleagues from other institutions, and included a visit to the city of London. Meetings of the oPAC Steering Committee and Supervisory Board also took place during the busy week. Plans were made for future events and all of the R&D projects within the network were discussed.

● oPAC is a network within the Marie Curie Initial Training Network scheme of the European Union's Seventh Framework Programme for research, technological development and demonstration, and has received funding under grant agreement no. 289485. For more about oPAC, visit www.opac-project.eu/. For all of the lectures for this school, see https://indico.cern.ch/event/297045/.

Participants of the oPAC school outside the impressive Founder's Building at RHUL. (Image credit: oPAC.)

HASCO 2014 credits its students

The third Hadron Collider Physics Summer School (HASCO 2014) took place on 20 July–1 August in Göttingen, where 83 undergraduate students from 23 institutes in nine countries and 23 lecturers spent the two weeks learning about hadron-collider physics at Femilab's Tevatron and at the LHC at CERN. The aim of the school is to give the students their first experience of the creative and productive atmosphere associated with working in an international team.

At the HASCO school, the students learn about numerous research topics relevant for hadron-collider physics, including quantum chromodynamics, jet physics, statistical methods in data analysis, accelerator physics, detector physics, physics of the top quark, and searches for supersymmetry or exotic models and particles. In addition, this year's focus was Higgs boson physics and the transition from the 7/8 TeV run at the LHC to the upcoming 13/14 TeV run. In groups of two from different institutes and countries, the students summarized recent papers from the LHC, the Tevatron or from theory.

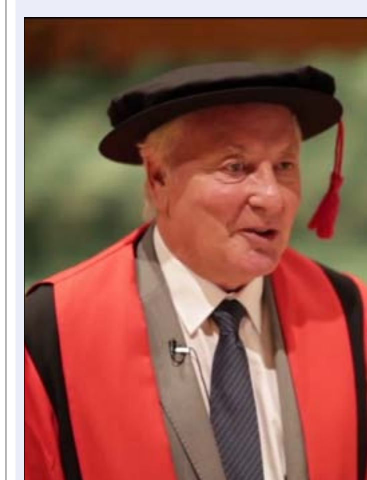
All participating students passed the written examination at the end and each of them received six European Credit Transfer System points, which they can invest in their study programmes back at their home institutions. Many of the students became more interested in studying particle physics, so the hope is to see them in collider-physics research soon.

Happy HASCO students. (Image credit: Arnulf Quadt.)

The 23 partner institutes are Clermont-Ferrand, Grenoble, Orsay, Saclay, Göttingen, Bologna, Milano, Pisa, Roma Sapienza, Amsterdam, Krakow, Bratislava, Barcelona, Madrid, Stockholm, Uppsala, CERN, Bern, Geneva, Glasgow, Manchester, Oxford and Ghent. Ghent, Göttingen and Uppsala are also members of the closely collaborating U4 network. Some of the participating students were summer students from Tokyo, Cambridge, Guincho, Portland and Kathmandu.

● The HASCO school is funded as an ERASMUS intensive programme by the German Academic Exchange Service and the EU under the contract DE-2013-ERA/MOBIP-3-29749-1-16. For further information, visit http://hasco.uni-goettingen.de.

Lyn Evans returned to Wales on 17 July to receive an honorary degree from Cardiff University. Born in Aberdare, Evans has spent his whole career in the field of high-energy physics and particle accelerators, and from 1993 led the team at CERN that designed, built and commissioned the LHC. He is currently director of the Linear Collider collaboration, which brings together the Compact Linear Collider Study and the International Linear Collider in a collaboration of more than 2000 scientists. (Image credit: Cardiff University.)



ASTROPARTICLE PHYSICS

CERN hosts Patras Workshop on Axions, WIMPs and WISPs

The Patras Workshop returned to CERN in July for its 10th anniversary, having begun there in 2005. The initial aim was to provide academic training to the new generations of scientists working within the EU's Integrated Large Infrastructure for Astroparticle Science network, which covered the already mature field of astroparticle physics (*CERN Courier* July/August 2006 p19). Following increasing worldwide interest in the workshop, the organizers widened its agenda, inspired by the possibilities that are opening up in ongoing searches for exotica such as axions, WIMPs, etc. Results from direct and indirect searches for axion-like particles (ALPs), also dubbed weakly interacting slim (light) particles (WISPs), and new, more sensitive searches for electric-dipole moments, were also covered in the latest workshop. Participants from more than 40 institutions around the world had the opportunity to present their latest results and discuss detector-upgrade plans and exciting new ideas for future research. As a result of the high number of participants, the programme also included a poster session for the first time.

Speakers covered diverse new approaches in dark-matter, dark-energy and neutrino physics, including astrophysical observations, as well as novel ideas for detection using state-of-the-art instrumentation. In his opening address, CERN's director-general, Rolf Heuer, emphasized that following the discovery of a Higgs boson, there remain big questions related to the hidden side of the universe. The talks that followed demonstrated the breadth in experimental searches for constituents of dark matter and dark energy, from direct searches for WIMPs in underground experiments with the lowest noise, axion or WISP searches with cavity and "light-shining-through-a-wall" experiments, and not-so-indirect searches in specific solar or cosmic observations with orbiting equipment, to searches at the LHC. Hidden photons and gauge bosons of various kinds are also being searched for with accelerators and solar observations. Theories span an even greater breadth, as manifest in the mass range of the expected exotica.

The Patras programme traditionally features results, theoretical ideas and exciting projects beyond the main focus of the meeting. This time, participants heard about the latest results from space X-ray missions, the Indian SOXs and the Chinese Chang 'E1. Data from both missions are being re-analysed to search for overlooked signatures of dark-matter or dark-energy constituents in their solar X-ray observations.

Upgrade plans were also presented at the workshop. The performance of experimental techniques – either in use or suggested – to unravel the nature of the enigmatic dark sector is advancing impressively, with a remarkable overlap between LHC physics and astroparticle physics. The state-of-the-art equipment used faces two extreme situations: the LHC experiments have to deal with unprecedented high background rates, while the dark-matter/dark-energy searches with the lowest signal levels require ever increasing background screening. Here, equipment developed for high-energy physics and other disciplines finds an increasing number of applications in astroparticle physics. Micromegas detectors, powerful magnets and high-sensitivity antennae in the sub-electron-volt range, for example, are typical of the interdisciplinary character of many experiments that are being upgraded or are in the conceptual-design phase.

In the spirit of the workshop series, discussions were lively and the atmosphere friendly, although occasionally not without scientific controversy. A number of new ideas were presented, mostly highly interdisciplinary in character, profiting from the strong synergies developed between theory and experiment. By bringing together experts working on so many diverse topics, the workshop continues to contribute to the ongoing scientific revolution in astroparticle physics to uncover the unknown universe.

● For more information, visit http://axion-wimp2014.desy.de/.

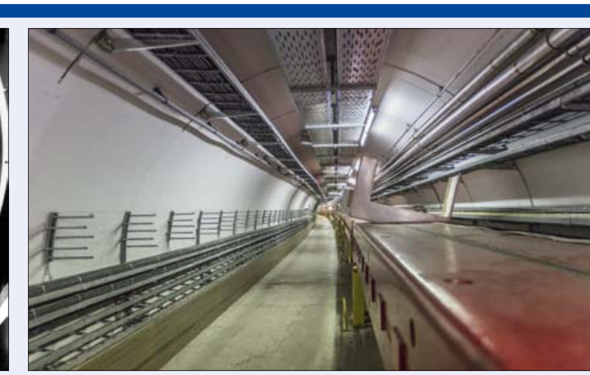
Faces & Places

Visits

On 16 July, the European Commission Joint Research Centre director-general, **Vladimir Šucha**, left, visited the LHC tunnel accompanied by CERN's director of accelerators and technology, **Frédérick Bordry**, right, and the head of the EU Projects Office at CERN, **Svetlomir Stavrev**. (Image credit: CERN-PHOTO-201407-148 – 10.)

Giesela Kopper, the minister of science, technology and telecommunications of the Republic of Costa Rica, visited CERN on 29 August. After learning about the High School Teachers' programme, she visited the Synchrocyclotron, ATLAS, the superconducting magnet test hall and the CERN Computer Centre, before signing the guestbook, with the director-general, **Rolf Heuer**. (Image credit: CERN-PHOTO-201408-169-9.)

To mark the opening of the 7th Bulgarian High School Physics Teachers Programme at CERN, the Bulgarian deputy minister of education and science, **Mukkades Nalbant**, left, visited the laboratory on 28 July. Here she is being presented with a temperature-sensitive mug that depicts the history of the universe by CERN's head of international relations, **Rüdiger Voss**. (Image credit: CERN-PHOTO-201407-163 – 11.)



Construction work on the Super Proton Synchrotron (SPS) at CERN began in 1972, soon after an agreement had been signed with France to establish a new site at Prévessin. With its 7 km tunnel, it became the world's first cross-border accelerator. In the black and white image from early 1974, the year of CERN's 20th anniversary, the metal structure of the shuttering used when pouring the concrete walls of the tunnel gives a remarkable optical effect. The accelerator started up two years later on 17 June 1976. The colour image, from last November, shows the red bending magnets of the SPS, almost 40 years later, during the first long shutdown of the accelerator complex. Today, the SPS serves as the final stage of the injection chain to the LHC, and also continues to deliver beam to experiments in the North Area at Prévessin. Like the rest of the complex, it has seen its fair share of refurbishment during the shutdown (p9). (Image credits: CERN-CE-7402048 and CERN-GE-1311288-02.)

Obituaries

Andrew Sessler 1928–2014

Andrew Marienhoff Sessler passed away on 17 April, following a long illness. A former director of Lawrence Berkeley National Laboratory (LBNL), he was a visionary in accelerator and energy sciences, and was instrumental in the worldwide effort to liberate scientists suffering from political oppression.

Born on 11 December 1928, Andy showed an early talent for science, and was one of the first Westinghouse Talent Search finalists. He received a BA in mathematics from Harvard and a PhD in physics from Columbia University. He was in the first group of National Science Foundation postdocs, working at Cornell University with Hans Bethe. From 1954 to 1959 he was on the faculty at Ohio State, after which he joined what is now LBNL. He spent the rest of his career there and served as the third director from 1973 to 1980.

Andy made several key contributions to physics and accelerator science. His paper with J Emery in 1960, together with a contemporaneous competing paper from Anderson *et al.*, is generally acknowledged as the first to predict the superfluid transition of helium-3. His contributions to accelerator science, which began with his association with the Midwestern Universities Research Association, were pivotal for developing modern high-performance accelerators. They included a Hamiltonian-based radio-frequency acceleration theory, developing a method to produce intense circulating proton beams by stacking, which made very-high-luminosity proton colliders feasible, such as CERN's LHC, and a systematic study of beam instabilities at high intensity, which became the standard for all modern accelerator design. His 1981 proposal for a high-gain free-electron-laser (FEL) amplifier for high-power, millimetre-wave generation, helped lay the foundations for the emergence of the era of X-ray FELs that began in 2009 with the successful start of operation of the Linac Coherent Light Source at SLAC. His basic concept for a two-beam accelerator that mixed high and low energies and currents was modified to become the Compact Linear Collider project at CERN, a candidate technology for a future multi-tera-electron-volt electron–positron linear collider.

As director of LBNL, Andy ushered in a new era of research on energy efficiency and sustainable-energy technology by

Andy Sessler. (Image credit: The Regents of the University of California, through the Lawrence Berkeley National Laboratory.)

establishing what would become the Energy and Environment Division, the first such group at any of the US national laboratories. This was instrumental in transforming the mission of the national laboratories from science labs to science, engineering and energy labs. Under Andy's leadership, LBNL grew to its largest size ever, with more than 5000 employees, and expanded beyond its leading roles in physics, chemistry and biology to its current multi-programme efforts.

In addition to his ground-breaking work in particle-accelerator and beam physics, and his leadership in directing the scientific research landscape towards new horizons in sustainable energy and the environment, Andy was also an acclaimed humanitarian and public advocate for scientific freedom. His activities at the American Physical Society (APS) across many years helped transform its focus on "physics" to include "physics and society", with attention to national funding, patterns of employment, science education at all levels, societal issues involving physics, informing the public, international affairs, arms control and, in particular, the human rights of his physics colleagues.

Intensely concerned about human rights, Andy focused on scientists caught in political situations beyond their control. He wrote letters in support of dissidents in the Soviet Union and other countries. He was active on boards and committees that pursued human-rights activities within many organizations, including the APS, the National Academy of Sciences, the New York Academy of Sciences, the Committee of Concerned Scientists, the Union of Concerned Scientists, and Amnesty International. He donated large sums of money to charities including Doctors without Borders, Berkeley Food and Housing, and FINCA (a global charitable microfinance organization).

He was instrumental in initiating the APS Committee on International Freedom of Scientists and raising funds to endow the APS Sakharov Prize for Human Rights. Along with his colleague Moishe Pripstein, he was a co-founder of Scientists for Sakharov, Orlov, and Sharansky (SOS). Protests by SOS and others led to the release of these Soviet dissidents and to an overall increase in pressure by the scientific community in solidarity with their politically oppressed colleagues. He also was one of the principal organizers of the "good-faith witness" exchange, which earned the release of Elena Bonner, the wife of Andrei Sakharov, from the Soviet Union to the US to receive medical care.

Andy's many honours included the 1970 Ernest Orlando Lawrence Award – the US Department of Energy's highest scientific recognition; the 1995 Dwight Nicholson Medal and the 1997 Robert R Wilson Prize of the APS; and the US government's Enrico Fermi Award in early 2014. He was APS president in 1998.

Andy was an avid outdoor person and loved sharing physical activities, such as swimming, rowing, skiing and cycling, with family and friends. He was a mentor to many younger colleagues and to many his own age, who learned much from him. Later in life, he could be found jogging with others during lunchtime, sharing jokes and solving physics challenges. Just as he loved sharing the outdoors, he loved sharing knowledge, and seldom wrote scientific papers alone. A long-time friend and colleague expressed a sentiment shared by many who knew Sessler: "If there was ever a scientist for whom the physics community was at the centre of his life and work, it was Andy Sessler."

He is survived by three children and six grandchildren.

● *Andy Sessler's longtime friends and colleagues Robert Budnitz, Kwang-Je Kim and Herman Winick. Based with permission on the obituary published on the Berkeley Lab News Center website http://newscenter.lbl.gov/2014/04/18/in-memoriam-andrew-sessler/.*

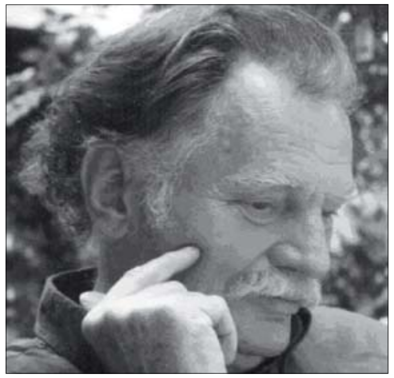
Faces & Places

Klaus Dietz 1934–2014

Klaus Dietz passed away on 17 January at the age of 79, after a long struggle with complications following a heart operation. The Physikalisches Institut at the University of Bonn has lost a highly renowned colleague who made his mark beyond theoretical particle physics.

Born in 1934 in Würzburg, Klaus studied physics at the universities of Erlangen, Munich and Karlsruhe, where in 1962 he earned his PhD under Gerhard Höhler, on the role of pion–pion interactions in pion–nucleon scattering. After three years at CERN and the University of Illinois, he took up research positions at the Nuclear Research Centre Jülich and the University of Bonn, where he began teaching in 1967. Two years later he accepted a professorship in Bonn, a position he held for 40 years until his retirement as emeritus in 2009. Besides research and teaching, during this period Klaus co-organized the Johns Hopkins Workshops in the years 1980–1985, and provided advice to the Alexander von Humboldt Foundation for a number of years.

His research until 1968 featured important contributions to the interaction of pions with pions, nucleons and photons, followed by papers on dual-resonance models. However, his central research topic after 1975 became the application of semiclassical field-theoretical methods to relativistic many-body systems, in particular to atoms and the inhomogeneous electron gas. Hardly anyone has more effectively combined the



Klaus Dietz. (Image credit: Hannelore Dietz.)

formal elegance of functional methods with concrete physical problems. After the late 1980s, strong laser fields and periodically driven quantum systems moved into his focus. The breadth of his work is remarkable, ranging from fundamental mathematical physics to the physical chemistry of certain molecules. In his final decade, Klaus became fascinated with open quantum systems, in particular with Lindblad dynamics and multi-qubit states.

Still more remarkable than this broad range of work is his success as a teacher: Hartmann Römer, Werner Nahm, Wilfried Buchmüller, Thomas Filk, Heinz-Peter Breuer, Martin Holthaus and Joachim Henkel, like myself, took their first steps in science under his supervision. Klaus applied a high standard to his students, as he did to himself. His criticism could be harsh but it was always to the point and never disrespectful. His keen sense of the essential and a disdain for trivialities set an example to follow. His imposing appearance underscored the persuasive power of well-chosen words.

Research was a passion for Klaus. Driven by his quest for beauty and true to his motto "off to pastures new", he had an avid interest in new scientific ideas. He also had a keen interest in music, fine arts and literature, as well as in foreign cultures and languages. His wanderlust led him to extended research stays in India, Brazil, Japan, Korea and the US, and to repeated visits to CERN, the International Centre for Theoretical Physics in Trieste, the universities of Oxford, Palermo, Vienna and Virginia, and Imperial College London. Numerous international collaborations and friendships derived from these. Klaus was a cosmopolitan. In his final years he was often to be found at the Max Planck Institute for the Physics of Complex Systems in Dresden or at the Gran Sasso National Laboratory. Until near the end, he was working methodically on new ideas and making plans for the future.

Klaus was a highly respected personality, whose acumen and elegance did not conflict with his open-heartedness, curiosity, humility and ability to wonder. We bid farewell and will not forget him.

● *Olaf Lechtenfeld, Leibniz Universität Hannover.*

New products

Altera Corporation has released early access design software for Stratix 10 FPGAs and SoCs, targeting 14-nm FPGAs. With this design software, Altera introduces the Hyper-Aware design flow, which includes the Fast Forward Compilation capability that allows customers to perform rapid design performance exploration and attain high levels of performance. For high-performance systems that have strict power budgets, Stratix 10 devices allow up to a 70% reduction in power consumption, compared with Stratix V FPGAs. Altera has also released Quartus II software Arria 10 edition v14.0 for 20 nm FPGA and SoC design. For more information, visit www.alter.com.

Cobham Technical Services has released new parallel-processing software that accelerates one of the major electromagnetic simulation solver options for the Opera-3d suite of electromagnetic and multi-physics design tools, which use finite element analysis to compute the physical interaction of charged particles with electrostatic or magnetostatic fields. The effects of space charge, self-magnetic fields and relativistic particle flow are included in the analysis. The 3D Space Charge module will be of particular interest to engineers and scientists developing devices such as electron or ion guns. For more details, visit http://charged-particle-devices.com.

Hiden has announced the HMT residual gas analyser, offering a single partial-pressure gauge to operate through the full vacuum spectrum from ultra-high vacuum (UHV) through to millitorr, to provide process-gas trend analysis, vacuum background diagnostics and leak detection. The integral dual-detector enables monitoring at high pressure by a Faraday detector and at lower pressures to UHV by an electron-multiplier detector, giving partial-pressure detection down to 2×10^{-13} mbar, and a total dynamic range in excess of 10 decades. For further information, visit www.HidenAnalytical.com.

RUBIS-PRECIS / MICROPIERRE / HIGH TECH CERAM have developed new mounted assemblies of high-tech materials for specialized sectors such as space, aerospace, medical and instrumentation. The materials include titanium, biocompatible ceramic, tantalum, tungsten, molybdenum, medical stainless steel, gold and platinum. The assemblies incorporate advanced materials to solve problems such as wear, corrosive environments, use in ultra-high vacuums, high temperature (over 1000 °C) and high pressure (over 1000 bar). For more information, visit www.rubis-precis.com.

Recruitment

For advertising enquiries, contact *CERN Courier* recruitment/classified, IOP Publishing, Temple Circus, Temple Way, Bristol BS1 6HG, UK.
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Please contact us for information about rates, colour options, publication dates and deadlines.

Northern Illinois University | Fermilab

NIU-Fermilab ACCELERATOR RESEARCH CLUSTER

A new joint initiative between Northern Illinois University (NIU) and Fermi National Accelerator Laboratory (Fermilab) envisages developing a collaborative program with targeted and matched mutual investments to create a cluster of research excellence in advanced accelerator science and technology. The research cluster will enable "discovery-class" science driven by charged particle beams and associated advanced techniques and technologies of superconducting cavity electrodynamics, high-field magnets, lasers and nonlinear dynamical control of particle, atomic and molecular beams. The R&D will be directed towards developments in particle physics and related disciplines of cosmology, material and life sciences and their applications to societal grand challenges of energy, environment, health and security.

Opportunities exist to contribute to large scale national and international accelerator activities such as the development of the long-baseline neutrino facility at Fermilab and TeV-scale collider developments world-wide as well as cutting edge innovative research in laboratory –scale experiments to investigate the "dark" sector of the vacuum and other precision experiments e.g. "g-2" and "mu-to-e".

Working seamlessly with the outstanding accelerator research staff at Fermilab, NIU physics and engineering departments and its Northern Illinois Centre for Accelerator and Detector Development (NICADD) and the consortium of mid-western universities and laboratories, with access to advanced accelerator test facilities at Fermilab, ANL and other international laboratories such as CERN (Switzerland), DESY (Germany), ESS (Sweden), John Adams Institute and Cockcroft Institute (UK), the cluster will offer unique collaborative research opportunities. Details of specific opportunities and recruitment will be announced in near future.

Prospective Masters- and PhD-level students, postdoctoral fellows, research scientists and aspiring academic faculty members should contact **Professor Swapan Chattopadhyay** (**schaterji@niu.edu** or **chaterji@fnal.gov**) for further details and send early expressions of interest and professional background information in advance.

unesp
UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO"

Parallelization of HEP Applications

The Center for Scientific Computing of the São Paulo State University (UNESP) in São Paulo, Brazil is opening **two positions** for outstanding **senior C++ developers or research fellows** to work in the R&D efforts to adapt High Energy Physics (HEP) software tools to the modern computing architectures. The work will be mostly concentrated on Geant, a toolkit for the simulation of particle-matter interactions.

Grant funds are provided by Intel, through the Intel Parallel Computing Center (IPCC) program. The successful candidates will participate in R&D studies, development and prototyping of different strategies and algorithms to run HEP simulation applications efficiently with multiple computational threads in new and upcoming Intel hardware. They will also be involved in the implementation and evaluation of existing and new algorithms required by Geant type of applications using many computational threads.

The key selection criteria include:

- Advanced development skills in C++, including STL and templates;
- Strong background in design, program and optimize parallel applications;
- Knowledge of massively parallel, heterogeneous or many-core architectures;
- Expertise in using key HEP software packages such as Geant4.

The appointments could be extended up to **two years**, with yearly income of about USD 35,000.00 (tax exempt).

For more details, see **https://www.sprace.org.br/twiki/bin/view/Main/OpenPositions**

Applications must be submitted to **Sergio.Novaes@cern.ch**. The deadline is **30 September 2014**.

Postdoctoral Research Positions
LIGO Laboratory

California Institute of Technology (Caltech)
Massachusetts Institute of Technology (MIT)

The Laser Interferometer Gravitational-Wave Observatory (LIGO) has as its goal the development of gravitational wave physics and astronomy. The LIGO Laboratory is managed by Caltech and MIT, and is funded by the National Science Foundation. It operates observatory sites equipped with laser interferometric detectors at Hanford, Washington and Livingston, Louisiana. The initial LIGO detectors performed better than their design sensitivity and data sets spanning over three years of coincident operation have been collected. Analysis is ongoing, with extensive participation by the LIGO Scientific Collaboration (LSC). A major upgrade (Advanced LIGO) is almost complete which will increase the sensitivity of the detectors by tenfold once commissioned. In addition, an R&D program supports the development of enhancements to the detectors as well as future capabilities.

The LIGO Laboratory anticipates having one or possibly more postdoctoral research positions at one or more of the LIGO sites – Caltech, MIT and at the two LIGO observatories – beginning in Fall 2015. Hires will be made based on the availability of funding. Successful applicants will be involved in the operation of LIGO itself, analysis of data, both for diagnostic purposes and astrophysics searches, as well as the R&D program for detector improvements. We seek candidates across a broad range of disciplines. Expertise related to astrophysics, modeling, data analysis, electronics, laser and quantum optics, vibration isolation and control systems is desirable. Most importantly, candidates should be broadly trained physicists, willing to learn new experimental and analytical techniques, and ready to share in the excitement of building, operating and observing with a gravitational-wave observatory. Appointments at the post-doctoral level will initially be for one-year with the possibility of renewal for up to two subsequent years.

Applications for post-doctoral research positions with LIGO Laboratory should indicate which LIGO site (Caltech, MIT, Hanford, or Livingston) is preferred by the applicant. Applications should be sent to **HR@ligo.caltech.edu** (Electronic Portable Document Format (PDF) submittals are preferred). Caltech and MIT are Affirmative Action/Equal Opportunity employers. Women, minorities, veterans, and disabled persons are encouraged to apply.

Applications should include curriculum vitae, list of publications (with refereed articles noted), and the names, addresses, email addresses and telephone numbers of three or more references. Applicants should request that three or more letters of recommendations be sent directly to HR@ligo.caltech.edu (Electronic Portable Document Format (PDF) submittals are preferred). Consideration of applications will begin December 1, 2014 and will continue until all positions have been filled.

Caltech and MIT are Affirmative Action/Equal Opportunity Employers
Women, Minorities, Veterans and Disabled Persons are encouraged to apply
More information about LIGO available at www.ligo.caltech.edu

Universidad de los Andes
Colombia

Faculty Position in Experimental High Energy Physics

UNIVERSIDAD DE LOS ANDES – BOGOTA, COLOMBIA

The Physics Department at Universidad de los Andes, Colombia, is seeking to fill a position in Experimental High Energy Physics for a faculty member at the level of assistant or associate professor.

Applicants are expected to have a PhD degree with postdoctoral experience in experimental High Energy Physics, in hardware and software, with emphasis in Collider experiments. Commitment to excellence in research and teaching are required.

The new faculty will join the High Energy Physics group of our department, who is collaborating in the CMS experiment at the LHC, with responsibilities in the RPC detector and in data analysis for SUSY searches and Higgs studies. In the near future we will also contribute to the CMS GEM project.

More information about the physics department can be found at:
http://fisica.uniandes.edu.co/index.php/en/

Applicants should send a curriculum vitae, a description of research and teaching interests, and arrange to have three recommendation letters sent to:

Carlos Avila,
Chairman, Physics Department, Universidad de los Andes
e-mail: director-fisica@uniandes.edu.co
A.A. 4976, Bogotá, Colombia.
Phone (57-1)-332-4500, Fax (57-1)-332-4516.

Review date: October 31st 2014
Desired starting date: January 2015, however the position will remain open until a suitable candidate is found.

Faculty Position in Particle Theory Phenomenology
University of Pittsburgh
Department of Physics and Astronomy

The Department of Physics and Astronomy at the University of Pittsburgh is recruiting an Assistant Professor in particle theory phenomenology. This tenure stream appointment, which is subject to budgetary approval, will begin in the Fall Term 2015, or thereafter.

All candidates should have the potential to teach effectively at both the graduate and undergraduate levels, to attract external funding for a creative, independent and broad-based research program, to provide cohesion with existing efforts and potentially to initiate new research directions.

Preference will be given to candidates with expertise in physics beyond the Standard Model and/or LHC physics. We expect the new faculty member to be active in our PITTsburgh Particle physics, Astrophysics and Cosmology Center (PITT PACC).

To ensure full consideration, complete applications should be received by November 30, 2014. However, applications will be accepted until the position is filled. Applicants should email PDF documents (preferably a single document) containing curriculum vitae, a statement of research interests, and a brief teaching statement to pasearch+particletheory@pitt.edu. In addition, applicants should arrange to have at least three letters of reference sent to pasearch+particletheory@pitt.edu.

The University of Pittsburgh is an Affirmative Action, Equal Opportunity Employer. Women and members of minority groups under-represented in academia are especially encouraged to apply.

IFAE
EXCELENCIA SEVERO OCHOA

INSTITUT DE FÍSICA D'ALTES ENERGIES
Consorci de la Generalitat de Catalunya
i de la Universitat Autònoma de Barcelona

CALL FOR APPLICATIONS: DIRECTOR OF IFAE

The Institute of High Energy Physics (IFAE), **www.ifae.es/eng** is a consortium of the Universitat Autònoma de Barcelona and the Generalitat of Catalonia. IFAE is part of the Catalan public network of research Institutes, CERCA (**www.cerca.cat**).

IFAE conducts experimental and theoretical research at the frontier of fundamental physics, namely in Particle Physics, Astrophysics and Cosmology. IFAE also works at the cutting edge of detector technology, applying its know-how to Medical Imaging and other applied research fields. It maintains a fruitful collaboration with its spinoff company, X-Ray Imatek.

In 2012, IFAE was granted the Severo Ochoa award, given by the Spanish government to a few leading national research centres.

Candidate profile and contact information

IFAE is seeking applicants with a distinguished record of scientific excellence and the innovative thinking necessary to lead a dynamic organisation. A PhD or comparable degree, high international visibility in IFAE's field(s) of activity and significant research management experience are required. Salary will be commensurate with qualifications and consistent with IFAE management's salary scale.

More information, including a description of the Director's post and responsibilities, is at **www.ifae.es/eng/work/open-positions.html**.

The successful candidate may be offered an indefinite position as Full Research Professor. The appointment as Director will be for a period of 4 years, which could be extended. Applicants should send a CV and a cover letter by e-mail to the Director of CERCA, at **applications@cerca.cat**, citing as the subject "IFAE Director call".

The deadline for applications is October 10, 2014.

NATIONAL TAIWAN UNIVERSITY
Leung Center for Cosmology and Particle Astrophysics
Distinguished Junior Fellowship

The Leung Center for Cosmology and Particle Astrophysics (LeCosPA) of National Taiwan University is pleased to announce the availability of several Post-Doctoral Fellow or Assistant Fellow positions in theoretical and experimental cosmology and particle astrophysics, depending on the seniority and qualification of the candidate. Candidates with exceeding qualification will be further offered as LeCosPA Distinguished Junior Fellows with competitive salary. LeCosPA was founded in 2007 with the aspiration of contributing to cosmology and particle astrophysics in Asia and the world. Its theoretical studies include inflation, dark energy, dark matter, large-scale structure, cosmic neutrinos, and classical and quantum gravity. The experimental investigations include the balloon-borne ANITA project in Antarctica, the ground-based ARA Observatory at South Pole, and the TAROGE Observatory in the east coast of Taiwan in search of GZK neutrinos, and a satellite GRB telescope UFFO that can slew to the burst event within 1sec. These positions are available on August 1, 2015. Interested applicant should email his/her application with curriculum vitae, research statement, publication list and three letters of recommendation before December 1, 2014 to **Ms. Yen-Ling Lee** ntulecospa@ntu.edu.tw
For more information about LeCosPA, please visit its website at http://lecospa.ntu.edu.tw/

Three letters of recommendation should be addressed to
Prof. Pisin Chen, Director
Leung Center for Cosmology and Particle Astrophysics
National Taiwan University

UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

The **Heidelberg Graduate School of Fundamental Physics (HGSFP)** at the Department of Physics and Astronomy at Heidelberg University, a School funded by the German Excellence Initiative, invites applications for

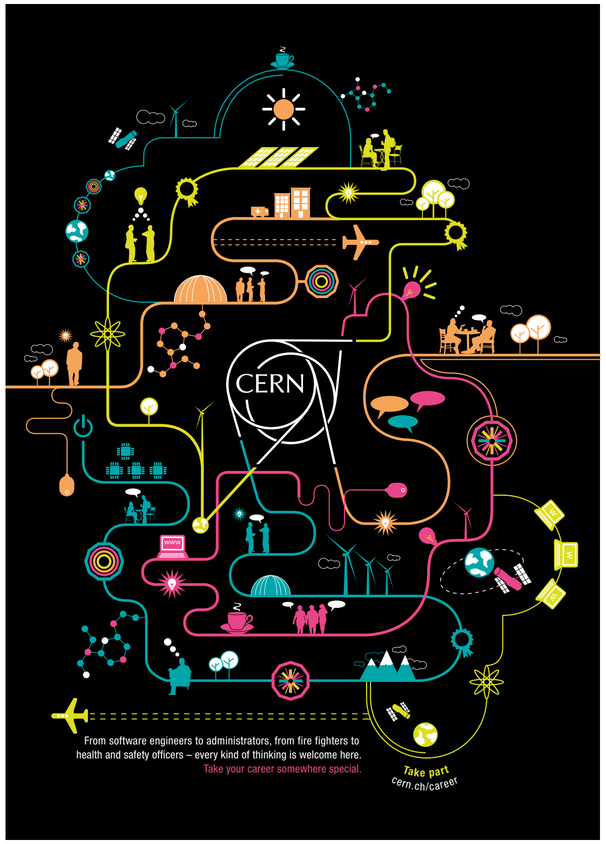
DOCTORAL FELLOWSHIPS

in the following areas of modern fundamental physics: (a) Astronomy and Cosmic Physics, (b) Quantum Dynamics and Complex Quantum Systems, (c) Fundamental Interactions and Cosmology, (d) Complex Classical Systems, (e) Mathematical Physics, and (f) Environmental Physics. Thesis research topics cover areas such as experimental and theoretical astrophysics, cosmology, accelerator based particle physics, precision measurements in physics, study of quantum systems – many body as well as small systems, low as well as high temperature physics, atomic, molecular and optical physics, mathematical physics and string theory. In addition, fundamental problems in biophysics, e.g. in materials science aspects of cell biology, and in environmental physics are studied. The HGSFP combines doctoral projects at the forefront of international research in the areas mentioned above with a rich and thorough teaching programme. Further information can be found on the School's web site: **http://www.fundamental-physics.uni-hd.de.**

The branch Astronomy & Cosmic Physics is the International Max Planck Research School (IMPRS) for Astronomy and Cosmic Physics at the University of Heidelberg (**http://www.mpia.de/imprs-hd**). Students accepted into the Graduate School will automatically be members of the IMPRS-HD and conversely. Admission to the IMPRS for Precision Tests of Fundamental Symmetries (**www.mpi-hd.mpg.de/imprs-ptfs**), to the IMPRS for Quantum Dynamics in Physics, Chemistry and Biology (**http://www.mpi-hd.mpg.de/imprs-qd**), or to the RTG Particle Physics Beyond the Standard Model (**http://www.thphys.uni-heidelberg.de/~gk_ppbsm**) is also possible. The IMPRS and RTG offer doctoral positions and fellowships as well, and are combined efforts of Heidelberg University with the Max Planck Institutes for Astronomy and Nuclear Physics, which form an integral part of the exciting and broad research environment in Heidelberg.

Highly qualified and motivated national and international students are invited to apply. Applicants should preferably hold a Master of Science 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 have to initiate their application registering via a web form available at **http://www.fundamental-physics.uni-hd.de/fellowships**. Applications should be completed by November 17, 2014.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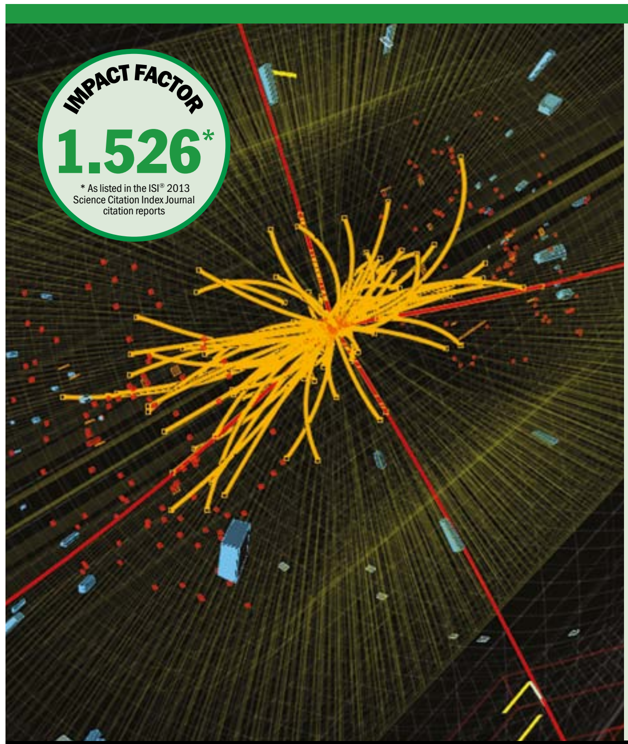
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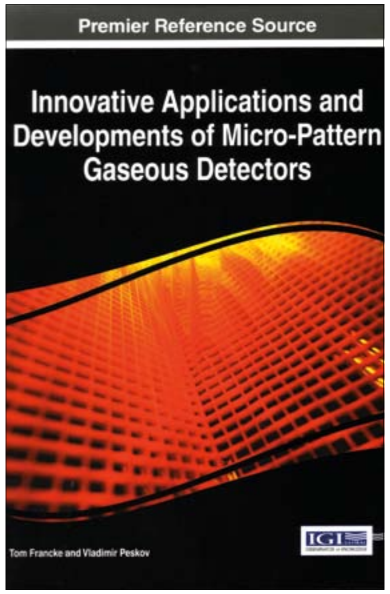
Bookshelf

Innovative Applications and Developments of Micro-Pattern Gaseous Detectors
By Tom Francke and Vladimir Peskov
IGI Global
Hardback: $215
E-book: $215



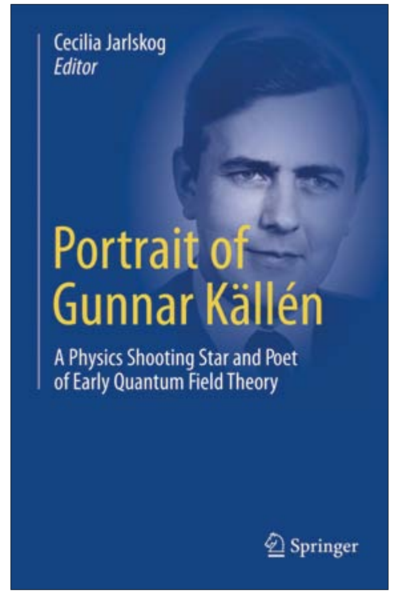
Research in nuclear physics is inconceivable without the Geiger counter. This gas-filled instrument allows both the presence and the energy of ionizing particles and radiation to be measured. It is now 100 years since Hans Geiger designed the arrangement of its electrodes, but this construction is still used in most current gaseous detectors. In this arrangement, the electrons produced by collision and ionization of the gas atoms are multiplied in the electric field around a thin wire, and the resulting avalanche of electrons delivers an easily detectable signal.

It is only recently that other electrode arrangements for gas counters have been proposed and tested. Besides offering improved properties such as higher counting rates, a certain number of prior conceptions of the electron amplification process had to be revised. These new counters are called "micro-pattern gaseous detectors" because the same lithographic technique is used for their production as is employed in the semiconductor industry.

In their book, Francke and Peskov describe the complete historical development of these counters and discuss the properties and special features of each type. Smaller detectors with a sensitive window of up to 30 × 30 cm² can be built using the lithographic technique exclusively. These are mainly detectors in a hermetically sealed housing filled with high-pressure gas. Detectors of this type are very stable for many years. For example, the detector of the two-axis diffractometer D20 at the Institut Laue–Langevin has been operating for 14 years. Detectors with larger sized windows work at normal gas pressure and with constant gas current. Their electrodes still have to be assembled precisely by hand.

This handbook should allow every research scientist to choose and produce the best detector possible for a specific application. Numerous pictures with descriptions and many diagrams assist in making a good choice, while the detailed bibliography is particularly helpful.

● *Anton Oed, who introduced the concept of the micro-strip gas chamber in 1988 – at the Institut Laue–Langevin.*



Portrait of Gunnar Källén: A Physics Shooting Star and Poet of Early Quantum Field Theory
By Cecilia Jarlskog (ed.)
Springer
Hardback: £62.99 €74.89
E-book: £49.99 €59.49

This book is extremely interesting. Mainly a collection of testimonies, it helps in understanding the special personality of Gunnar Källén – his kindness and aggressiveness. Cecilia Jarlskog is named as "editor", but she is more than an editor in having written an informative biography.

Källén worked in the "Group of Theoretical Studies" – one of three groups that were set up as part of the "provisional CERN" in 1952 – which was based in Copenhagen until it was officially closed in 1957. He later became professor at Lund University, and tragically died in 1968 when his plane crashed while he was flying it from Malmö to CERN.

I was impressed by Steve Weinberg's admiration for Källén – he considers himself a student of Källén, although he was Sam Treiman's student – as well as by that of James Bjorken and Wolfgang Pauli, who wanted Källén as professor at ETH Zurich. I cannot comment on the fact that it was finally Res Jost who was appointed, because I have the highest esteem for him also.

It is interesting that Pauli disapproved of Källén's work on the n-point function. It was only long after Pauli's death that Källén quit this subject, and took a 90° turn with the writing of his book on elementary particles. It is true that Källén failed, while being critical of Jacques Bros, Henri Epstein and Vladimir Glaser because they were not using invariants. However, Bros–Epstein–Glaser succeeded and proved crossing symmetry, allowing proof of the Froissart bound without dispersion relations, and providing a starting point for the Pomeranchuk theorem.

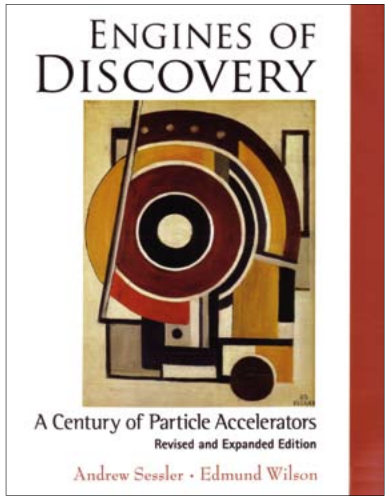
Because the book is based on testimonies, there is a certain redundancy, in particular about the accident, but this is unavoidable. Overall, Cecilia Jarlskog has done an excellent job. The plane crash was a tragedy, and if he had lived, Källén would certainly have made further important contributions. (His two passengers – his wife Gonella and Matti von Dardel – survived the crash. Matti has told me that her husband Guy von Dardel and Källén were planning a collaboration between a theoretician and an experimentalist. The accident put an end to that.)

● *André Martin, CERN.*

Engines of Discovery: A Century of Particle Accelerators. Revised and Expanded Edition
By Andrew Sessler and Edmund Wilson
World Scientific
Hardback: £58
Paperback: £32
E-book: £24
Also available at the CERN bookshop

▷

Bookshelf



The first edition of *Engines of Discovery* was published seven years ago to wide acclaim (*CERN Courier* September 2007 p63). Since then, particle physics has seen the dramatic start up of the LHC and the subsequent discovery of a Higgs boson – a long-awaited missing piece in the Standard Model of particles and their interactions. At the same time, the field of accelerators has seen further developments to push back frontiers in energy, intensity and brightness, together with growth in the use of accelerators in other areas of science, medicine and industry.

In the revised and expanded edition of their book, Sessler and Wilson have aimed to match this growth, in particular through a number of essentially new chapters. These naturally cover the work that is going into developing new machines for fundamental physics, from high-intensity super-beams and factories for neutrino physics, to future high-energy linear colliders, and back to the low energies of rare-isotope facilities and, lowest of all, the production of antihydrogen. However, most of the new chapters focus on applications beyond the confines of particle and nuclear physics, with dedicated chapters on the use of accelerators in isotope production and cancer therapy, industry, national security, energy and the environment. Here, for example, spallation neutron sources have been promoted to merit a chapter of their own.

Last, the authors have brought the future and the young more into focus by directing all of the final chapter, rather than only the last paragraph, "mainly to the young". Sadly, Andrew Sessler – a visionary leader in the field of accelerator science – died earlier this year (see p63 of this issue), but this book will stand as part of his legacy to future generations. It would have appealed greatly to me when I was young, and the hope is that it will inspire budding young scientists and engineers today, for they are the future of the field.

● *Christine Sutton, CERN.*

Books received

Dark Matter and Cosmic Web Story

By Jaan Einasto
World Scientific
Hardback: £82
E-book: £61

This book describes the contributions that led to a paradigm shift from the point of view of a scientist from behind the "Iron Curtain". It describes the problems with the classical view, the attempts to solve them, the difficulties encountered by those solutions, and the conferences where the merits of the new concepts were debated. Amid the science, the story of scientific work in a small country – Estonia – occupied by the Soviet Union, and the tumultuous events that led to its break up, are detailed as well.

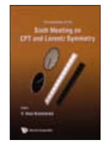
Strong Coupling Gauge Theories in the LHC Perspective (SCGT12)

By Yasumichi Aoki, Toshihide Maskawa and Koichi Yamawaki (eds)
World Scientific
Hardback: £109
E-book: £82

The proceedings of the KMI-GCOE Workshop held in Nagoya in December 2012 contain contributions that are focused mainly on strong coupling gauge theories and the search for theories beyond the Standard Model, as well as new aspects in hot and dense QCD. These include many of the latest, important reports on walking technicolour and related subjects in the general context of conformality, discussions of phenomenological implications with the LHC, as well as theoretical implications of lattice studies.

Proceedings of the Sixth Meeting on CPT and Lorentz Symmetry

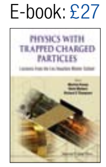
By V Alan Kostelecký (ed.)
World Scientific
Hardback: £76
E-book: £57



The Sixth Meeting on CPT and Lorentz Symmetry held in 2013 focused on tests of these fundamental symmetries and on related theoretical issues, including scenarios for possible violations. Topics covered at the meeting include searches for CPT and Lorentz violations in a range of experiments from atomic, nuclear, and particle decays to high-energy astrophysical observations. Theoretical discussions included physical effects at the level of the Standard Model, general relativity, and beyond, as well as the possible origins and mechanisms for Lorentz and CPT violations.

Physics With Trapped Charged Particles

By Martina Knoop, Niels Madsen and Richard C Thompson (eds)
World Scientific
Hardback: £78
Paperback: £36
E-book: £27



This is a collection of articles on physics with trapped charged particles, by speakers at the Les Houches Winter School in January 2012. They cover all types of physics with charged particles, and are aimed at introducing the basic issues as well as the latest developments in the field. Topics range from detection and cooling techniques for trapped ions to antihydrogen formation and quantum information processing with trapped ions. The level is appropriate for PhD students and early career researchers, or interested parties new to the subject.

Viewpoint

Thoughts on CERN's future

A science-policy contribution to the debate, by physicist and former science minister, **José Mariano Gago**.

On its 60th birthday, CERN should, first of all, be justly praised for its scientific results – results that stem from the organization's unique model, which has allowed the modernization of fragmented, hierarchical and largely closed scientific and academic systems in Europe. In my view, CERN's indirect influence on the evolution of research institutions and universities has not been sufficiently recognized yet.

As a European intergovernmental scientific organization, CERN has proved a robust and sustainable model. Its institutional framework has inspired other successful international collaboration endeavours in science and technology in Europe. CERN owes part of this success to its special way of being European, therefore becoming a model for a certain humanist idea of Europe. The organization has evolved legally to allow for wider participation, and has "implicitly" created new entities that operate as "world organizations", such as ATLAS and CMS. In the long run, this fruitful evolution could require visionary choices at a global level: CERN must remain firmly European to be globally attractive.

CERN's intergovernmental nature has also provided a progressive balance of collective ambition and self-interest. It allows small and large nations, including non-member states, to contribute according to their specificities and size, and to extend their contributions by investing in experiments and in technological R&D.

Building on the recognition of all of these factors is key for the future institutional evolution of CERN itself.

In this respect, CERN needs to address the challenge to intergovernmental organizations that is triggered by the incomplete EU institutional framework. Moreover, current EU financial rules are largely unspecialized, and therefore less appropriate for the specificity of research, even if much has been done to minimize these difficulties. However, intergovernmental research organizations have accumulated a vast experience in responsibly managing public funding and stimulating industrial innovation under rules appropriate to frontier science and technology. As EU budgets for research are likely to be strengthened in the future, the EU's role in new international research ventures might be expected to increase. Contributing to the right institutional environment is, therefore, an issue that we must address.

José Mariano Gago. An experimental physicist for many years at CERN, he was minister for science and technology in Portugal twice, in the years 1995–2002 and 2005–2011. (Image credit: Luisa Ferreira.)

CERN is also recognized for attracting to Europe talent, ideas and resources from the world at large. However, keeping this unique role requires aiming relentlessly at locating the heart of the world's best research infrastructure in Europe. The issue of the location of the next generation of accelerators will, therefore, be decisive – both for CERN and for Europe.

Becoming a world leader comes with a price. Could CERN act as an incubator for a new world organization for non-accelerator particle physics, namely astroparticle physics research? The infrastructure in this field must be widely distributed, but the evaluation of priorities – as a result of joint scientific, political and technical expertise – could sit together at CERN, or at a new organization outside Europe that CERN might help to frame.

CERN is also justly recognized as a driver for networking with other fields of science and technology, as well as for new applications. We might expect Europe's pressing social and economic needs to increasingly require research organizations to improve their direct contribution to the creation of new start-up companies, products and services, and new jobs in Europe. This should be seen as a challenge to be met.

A major opportunity seems now to be at hand. CERN's initiative for a new R&D international open facility for the biomedical, biophysical and bioengineering communities (e.g. medical imaging and new accelerators for hadron therapy) should, in my view, be considered as an important priority for the laboratory and for its member states.

On the other hand, the societal responsibility of research is bound to increase sharply if science development in Europe progresses faster. Under economic constraints, strengthening and widening the social constituencies for science becomes more important. CERN contributes generously to formal and informal science education. I would, however, suggest that fundamental physics has not yet contributed to its full potential to the needs of general experimental science education in schools, or to the demands of modern science centres.

Finally, CERN is justly proud of having continuously pursued one of the original purposes for its creation in the aftermath of the Second World War: science for peace. Its commitment to peace has been greatly influential in the discreet and stable support for scientists and students from regions of conflict and in painful periods, as well as in more visible support to the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) project in Jordan (*CERN Courier* September 2014 p46).

However, much more is now needed from us all. The social responsibility of scientists for peace is now desperately needed against war, oppression and misery, increased fanaticism, and against national stereotyping as an insidious prelude to blind acceptance of the inevitability of war. Let us hope that science continues to make bridges for peace.

● *José Mariano Gago, president of the Portuguese Laboratory for Instrumentation and Experimental Particle Physics.*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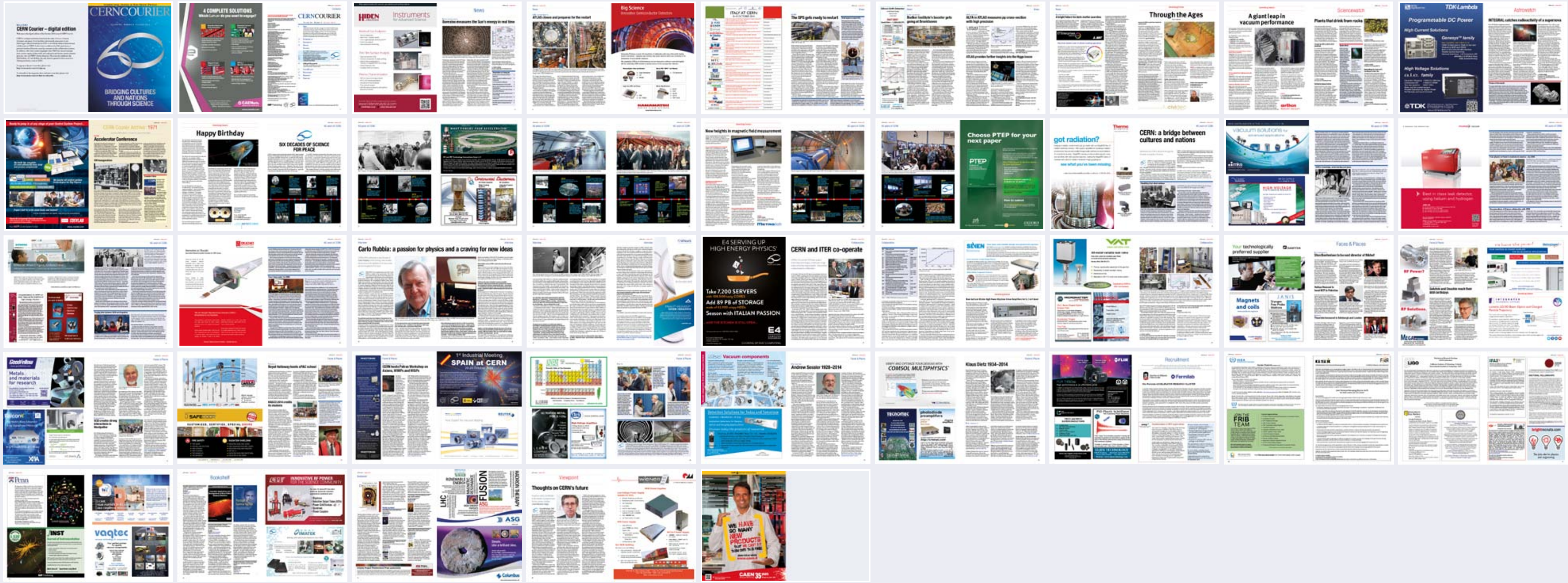

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