**Welcome**

**CERN Courier – digital edition**

Welcome to the digital edition of the October 2013 issue of *CERN Courier*.

Particle-physics experiments take place in all kinds of places. Out in space, the AMS-02 experiment on the International Space Station has worked flawlessly for more than two years, collecting data on $36.5 \times 10^9$ cosmic rays. Eagerly awaited results were presented at this year’s major cosmic-ray conference. Deep under a mountain, in the Gran Sasso National Laboratory, the XENON100 experiment searches for dark matter and has new stringent limits. Nearer to the Earth’s surface, the current shutdown at CERN is providing the opportunity for improvements to detectors – in this issue the focus is on ATLAS – as well as time to review results from the first long run, as ALICE does here. All this and more were topics for EPS-HEP 2013, the major summer conference that was held in Stockholm.

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Work during the current long shutdown (LS1) of CERN’s accelerator complex is making good progress since starting in February this year (CERN Courier March 2013 p26). Of the LHC’s 1232 dipoles, 15 are being replaced together with three quadrupole-magnet assemblies. By the beginning of September, all of the replacement magnets had been installed in their correct positions and were awaiting reconnection.

Moving the heavy magnets requires specially adapted cranes and trailers. Moreover, there is only one access shaft – made for the purpose during the installation phase – that is wide enough to lower dipoles, each 15 m long and weighing 35 tonnes, to the tunnel. Underground, a specialized trailer carried the replacement magnets to where they were needed. Sensors fitted below the trailer enabled it to “read” and follow a white line along the tunnel floor.

Back in April, the first Superconducting Magnets and Circuits Consolidation (SMACC) teams began work in the tunnel. They are responsible for opening the interconnects between the magnets to lay the groundwork for the series of operations needed for the consolidation effort on the magnet circuits.

The cables of superconductor that form the LHC’s superconducting dipoles and quadrupoles carry a current of up to 11,850 A. The SMACC project was launched in 2009 to avoid the serious consequences of electric arcs that could arise from discontinuities in the splices between the busbars of adjacent magnets (CERN Courier September 2010 p27). The main objective is to install a shunt – a small copper plate that is 50 mm long, 15 mm wide and 3 mm thick – on each splice, straddling the main electrical connection and the busbars of the neighbouring magnets. Should a quench occur in the superconducting cable, the current will pass through the copper part, which must therefore provide an unbroken path. In total, more than 27,000 shunts will have to be put in place – an average of one every three minutes for the teams of technicians, who work on a number of interconnects in parallel.

By the end of summer, three quarters of the interconnect bellows between magnets had been opened. Almost all of the SMACC consolidation activities had been completed in sector 5-6 and the first bellows were being closed again ready for testing. In sector 6-7, the installation of the shunts was being completed and the procedure was starting in sector 7-8. The aim is for completion of the task in July 2014.
Neutrinos

Daya Bay releases new results

The international Daya Bay collaboration has announced new results, including their first data on how neutrino oscillations vary with neutrino energy, which allows them to measure mass splittings between different neutrino types. Mass splitting represents the frequency of neutrino oscillation while mixing angles may determine the oscillation itself and both are crucial for understanding the nature of neutrinos.

The Daya Bay experiment, which is run by a collaboration of more than 200 scientists from six regions and countries, is located close to the Daya Bay and Ling Ao nuclear power plants, 55 km north-east of Hong Kong. It measures neutrino oscillation using electron antineutrinos created by six powerful nuclear reactors. Because the antineutrinos travel up to 2 km to underground detectors, some transform to another type and therefore apparently disappear. The rate at which they transform is the basis for measuring the mixing angle, while the mass splitting is determined by studying how the rate of transformation depends on the antineutrino-energy.

Daya Bay’s first results were announced in March 2012, and established an unexpectedly large value for the mixing angle $\theta_{13}$ — the last of three long-sought neutrino mixing angles (CERN Courier May 2012 p6). The new results, which were announced at the XVII International Workshop on Neutrino Oscillations, Super Beams and Beta Targets (NuFact2013) in Kyoto, give more precise values $\theta_{13} = (0.090 \pm 0.009)$.

The result establishes that the electron neutrino has all three mass states and is consistent with that from muon neutrinos measured by MINOS. Precision measurements of the energy dependence should further the goal of establishing a hierarchy of the three mass states for each neutrino flavour.

Antineutrinos detectors in the far experimental hall of the Daya Bay experiment, located at distances of about 1.5-1.9 km from the two power plants. (Image credit Daya Bay group, University of Wisconsin.)
RF Power?

A stunning image of the nearby Andromeda galaxy (M31) captured by the Subaru Telescope’s Hyper-Suprime-Cam (HSC) has demonstrated the instrument’s capability of fulfilling the goal to use the ground-based telescope to produce a large-scale survey of the universe. The combination of a large mirror, wide field of view and sharp imaging represents a major step into a new era of observational astronomy and will contribute to answering questions about the nature of dark energy and matter. The image marks a successful stage in the HSC’s commissioning process, which involves checking all of its capabilities before it is ready for open use.

The Subaru Telescope, which saw first light in 1999, is an 8.2-m optical-infrared telescope at the summit of Mauna Kea, Hawaii, and is operated by the National Astronomical Observatory of Japan (NAOJ). The HSC – which was installed on top of the telescope in August last year – substantially increases the field of view beyond that which is available with the present instrument, the Subaru Prime Focus Camera, Suprime-Cam. The 3.5-tonne, 3.5 m high HSC mounted at the prime focus contains 116 innovative, highly sensitive CCDs. Its field of view is a diameter of 1.5° – five times as large as the field of the Suprime-Cam and with the 8.2-m primary mirror enables the high-resolution images that will underpin what will be the largest-ever galaxy survey.

First conceived of in 2002, the HSC Project was established in 2008. The major research partners are NAOJ, the Kavli Institute for the Physics and Mathematics of the Universe, the School of Science at the University of Tokyo, KEK, Academia Sinica Institute of Astronomy and Astrophysics and Princeton University, with collaborators from Harunatsuz Photonics KK, Canon Inc. and Mitsubishi Electric Corporation.

News

Soft actuator breakthrough

A long-standing problem is how to build soft actuators – things that could provide the sort of motion that is generated by muscles. Now, Christoph Keplinger of Harvard University and colleagues have developed a class of devices based on ionic conductors that can stretch under an applied electric field. These muscle-mimics are fully transparent across the visible spectrum and can operate at frequencies above 10 kHz. The researchers demonstrated the technology by making a transparent actuator providing large area (up to 67%) strains and a transparent speaker that produces sound across the full audible range of frequencies.

Further reading
C Keplinger et al 2013 Science 341 184.

Near-infrared metatronic nanocircuit

Lumped elements in electrical systems such as resistors, capacitors and inductors are hard to imagine at high frequencies but Homayra Caglayan and colleagues at the University of Pennsylvania have shown that metamaterials using simple nanorod geometry and transparent plasmonic conducting oxides can do the job all of the way up to near-infrared wavelengths. Earlier approaches using silicon nitride could not reach the 1.55 μm wavelength that is used by most telecommunications optical fibers, a problem that is now overcome using indium tin oxide. Changing the shape and spacing of...
Multi-element X-ray detectors for beam-line applications

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Research

Kilonova solves the short GRB puzzle

Follow-up observations of a recent short-duration gamma-ray burst (GRB) provide the strongest evidence yet that these elusive bursts result from the merger of two neutron stars. The evidence is in the detection with the Hubble Space Telescope (HST) of a new kind of stellar blast – a kilonova.

During the 1990s, the detection of thousands of GRBs by the Burst and Transient Source Experiment (BATSE) revealed two bumps in the distribution of their duration. GRBs were therefore classified as being of either short or long duration, with a dividing line at 2 s. The origin of these brief flashes of gamma rays remained mysterious until the “rosetta stone” burst, GRB 030329 (CERN Courier September 2003 p3). A supernova explosion was found to be associated with this bright, relatively nearby burst of 29 March 2003 and therefore proved that long-duration GRBs result from core-collapse in massive stars. The collapse of the core forms a black hole, which powers a pair of relativistic jets that drill their way through the remains of the dying star and produce an energetic flash of gamma rays (CERN Courier June 2013 p2). So what is the origin of the short-duration GRBs? Are they really of a different nature? The favoured hypothesis is that they are produced by the merger of two neutron stars, or a neutron star and a black hole (CERN Courier December 2005 p20). Theorists expect such mergers to produce neutron-rich radioactive isotopes, whose decay within days would lead to a transient infrared source. Such a hypothetical transient is called a kilonova because its brightness is about a thousand times that of a typical supernova, but is still 10 to 100 times less bright than a supernova explosion.

A team of astronomers led by Nial Tanvir of the University of Leicester now claims to have detected the first kilonova associated with the short GRB 130603B. The burst was detected on 3 June by the Burst Alert Telescope on the Swift spacecraft. The subsequent detection of an optical afterglow allowed the team to pinpoint the location of this genuine short GRB, which lasted only about 0.2 s. The burst occurred in a known galaxy at a redshift of z = 0.36, an ideal location for the sharp vision of the Hubble Space Telescope (HST). Two HST observations have been performed: one nine days after the burst and the second after 30 days. While no transient source is detected in visible light, the earlier near-infrared image has a point source at the position of the burst’s afterglow, which is no longer present in the later observation.

Furthermore, the brightness of this source is found to be significantly in excess of the extrapolation of the afterglow decay to nine days after the burst. This discrepancy reveals the presence of an additional component that Tanvir and his team suggest is the expected kilonova. The time delay, infrared brightness and the absence of emission in the visible light are characteristics that are all consistent with recent calculations for the emission of a kilonova.

If the infrared transient observed by the HST is correctly interpreted, this would be a new milestone in the understanding of GRBs. It would confirm that short GRBs are indeed produced by the merger of two compact stellar objects ejecting neutron-rich radioactive isotopes decaying in a kilonova blast. This would also be good news for searches for gravitational-wave signals from the merger of compact objects. Detecting the kilonova associated with a gravitational-wave signal would allow the location and distance of the source to be obtained, even in the absence of a detectable short GRB when the gamma-ray emission is pointing away from the Earth.

Further reading

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Picture of the month
This unprecedented image of a double jet from a young star combines radio observations acquired by the Atacama Large Millimeter/submillimeter Array (ALMA) with visible-light observations from ESO’s New Technology Telescope (NTT). Young stars are violent objects that can eject material at speeds as high as 10 km/s. When this material crashes into the surrounding gas it glows, creating a Herbig-Haro object (Picture of the Month, CERN Courier/September 2012 p16). Herbig-Haro 46/47 is a spectacular example that is situated about 1400 light-years away. Until now, the visible part of the jet (in pink and purple, upper left) had been seen. Now, the ALMA observations reveal for the first time the counter-jet (orange and green, lower right), which is hidden in the visible by an opaque cloud of gas and dust. (Image credit: ESO/ALMA (ESO/NAOJ/NRAO)/H Arce. Acknowledgements: Bo Reipurth.)
CERN Courier Archive: 1970

It is not always realized that the major part of CERN’s research programme is carried out by Fellows and Visitors. This summer their number was about 700 while staff members who are theoretical or experimental particle physicists numbered about 90. They come from 108 Universities and Research Institutes in CERN Member States and 72 in non-Member States. Most Visitors are “unpaid” (by CERN); financial support comes from their parent University.

In view of the importance of Fellows and Visitors for the research effort of the Laboratory and of Universities and Research Institutes in so many countries, a paper was prepared which reviewed the evolution of the programme since 1960 and made proposals for the years up to 1975; it was approved by Council in June. The proposals imply an increase of 30 to 50% in Fellows and Visitors from Member States. Expenditure on Fellows from Member States will remain at about 1% of the total personnel budget each year. Also, during the summer months, about a hundred University students (not included in the figure) come to CERN. They participate in the day-to-day work of research or technical groups and attend a special course of lectures.

A view inside the XENON100 detector shows the array of PMTs below the TPC. (Image credit: XENON collaboration.)

The present capacity of the IBM 1800 computer controlling the PS would be greatly exceeded when the Booster is brought into operation, so a multiprogramming job-distribution system has been adopted to reduce “dead time” in the central processing unit. CPU.

A computer normally uses two kinds of memories. Internal memories (core or ferrite) are fairly expensive and generally installed in internal memories (core or ferrite) only 25% of the cost of the computer. The higher priority program, (c) calling for more data and (d) returning the first time— where a program (dark blocks) is interrupted by a higher priority one (paler). Block (a) represents the time taken transferring to the disc store, (b) bringing in the higher priority program, (c) calling for more data and (d) returning the first program. In the top lines, multiprogramming illustrates time saving by shuffling between programs.

The most sensitive dark-matter detector to date is Xenon100, which uses radiochemical methods and operates at cryogenic temperatures, as figure 1 illustrates. Particle interactions excite the liquid xenon, leading to prompt scintillation light, and also ionization of the target atoms. A uniform electric field causes the ionization electrons to drift away from the interaction site to the top of the TPC. Here a strong electric field extracts them into the xenon-gas phase above the liquid. Subsequent scattering on the gas atoms leads to signal amplification and a secondary scintillation signal, which is directly proportional to the ionization extracted. Both the prompt and secondary scintillation light are detected by two arrays of PMTs, which are

Numerous astronomical observations indicate that about one-quarter of the energy content of the universe is made up of a mysterious substance known as dark matter. The Planck collaboration recently measured this to be 26.8%, which is slightly greater than the previous value from nine years of observations by the Wilkinson Microwave Anisotropy Probe (WMAP). Dark matter, which is five times more abundant than baryonic matter, provides compelling evidence for new physics and could be made of a new particle not present in the Standard Model. Theories beyond the Standard Model, such as supersymmetric models or theories with extra dimensions, suggest promising candidates and naturally predict so-called weakly interacting massive particles (WIMPs), which are stable or have lifetimes longer than the age of the universe.

There are several complementary strategies to detect dark matter. The ATLAS and CMS experiments at the LHC search for such particles produced in proton–proton collisions. Indirect searches, for example by the AMS-02 or IceCube detectors, aim at detecting the products of dark-matter annihilation in cosmic rays.

Because dark-matter particles are expected to be abundant in the Galaxy, an energy density of about 0.3 GeV/cm$^3$ at the location of the Sun, the most direct strategy is to look for their interactions in laboratory-based detectors. In general, it is possible to study spin-independent WIMP–nucleon interactions – which scale with the square of the target’s mass number, $A$ – or spin-dependent couplings to unpaired nucleons in the target nucleus. Because of their nonrelativistic Maxwellian velocity distribution, with a typical speed of around 200 km/s and because the WIMPs interact significantly only with nuclei (and not with the electrons), the expected signal is a featureless exponential nuclear recoil spectrum. The recoil energies depend on the mass of the WIMP and on the target material and are typically of the order of a few tens of kilo-electron-volts. Because the expected interaction rates are small, a sensitive WIMP detector needs to feature a large target mass, an ultralow background and a low energy threshold. In addition, it should allow to study spin-dependent WIMP–nucleon interactions – which scale with the square of the target’s mass number, $A$ – or spin-dependent couplings to unpaired nucleons in the target nucleus. Because of their nonrelativistic Maxwellian velocity distribution, with a typical speed of around 200 km/s and because the WIMPs interact significantly only with nuclei (and not with the electrons), the expected signal is a featureless exponential nuclear recoil spectrum. The recoil energies depend on the mass of the WIMP and on the target material and are typically of the order of a few tens of kilo-electron-volts.

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installed above and below the cylindrical target of around 30 cm height and 30 cm diameter (figure 2, p.13). The PMTs are immersed in the liquid xenon. Sensors were built to achieve the highest possible light-detection efficiency and therefore the lowest threshold. The 3D position of the interaction vertex is obtained by combining the time difference between the prompt and the secondary scintillation signal with the hit pattern of the localized secondary signal on the array of 98 PMTs above the target. The number of secondary signals defines the event multiplicity.

The detector was built from materials selected for their low intrinsic radioactivity. Thanks to its novel detector design – placing most radioactive components outside of a massive passive shield – and the self-shielding provided by the liquid xenon, XENON100 features the lowest published background of all dark matter experiments. The self-shielding is exploited by selecting only events that interact with the inner part of the detector ("iducialization") and by rejecting all events that exhibit a coincident signal in the active veto, which is made of 99 kg of liquid xenon that surrounds the target. Because of their small cross-section, WIMPs will interact only once in the detector, so background can be reduced further by rejecting all events that exhibit a coincident signal in the active veto, which is made of 99 kg of liquid xenon that surrounds the target. Because of their small cross-section, WIMPs will interact only once in the detector, so background can be reduced further by rejecting all events that exhibit a coincident signal in the active veto, which is made of 99 kg of liquid xenon that surrounds the target.

Fig. 3. XENON100 results on spin-dependent WIMP–nucleus interactions, assuming couplings only to protons (left) or neutrons (right).

In particular, the challenges associated with building a TPC of 100 m drift length, which will be the longest liquid xenon-based TPC ever, are being addressed with dedicated R&D set-ups. Once the main underground facilities are erected, the XENON100 low-background cryostat – to contain the TPC and more than three tonnes of xenon – will be installed inside the water shield. The infrastructure for the storage, purification and liquefaction have been designed to handle more than double the amount of xenon initially used in XENON100. Their commissioning underground is expected to be completed by the summer of 2014. The timeline foresees commissioning of the full XENON100 experiment by the end of 2014 and the first data by early 2015. After two years of data-taking, XENON100 will reach a sensitivity of 2 x 10^{-46} cm^2 for spin-independent WIMP–nucleon cross-sections at a WIMP mass of 100 GeV/c^2. This is a factor 100 better than the current best WIMP result from XENON100.

Further reading

Résumé
Coupe de projecteur sur l’univers noir
L’expérience XENON100 rasque les interactions des particules massives interagissant faiblement (WIMP) dans une cible constituée de 62 kg de xénon liquide. Situé aux Nazionali del Gran Sasso, ce détecteur de matière noire est le plus sensible à ce jour. Les résultats d’une étude réalisée à partir de données enregistrées durant 225 jours n’indiquent aucune présence de matière noire, mais les limites supérieures déduites sont à ce jour les plus restrictives pour une masse de WIMP supérieure à 7 GeV/c². Le détecteur XENON100 qui sera environ 35 fois plus grand, est également en cours de développement. Le but est d’améliorer de deux ordres de grandeur la sensibilité de détection de matière noire.

Marc Schumann, Albert Einstein Center for Fundamental Physics, Bern.
Over many years Microwave Amps Ltd based in Nailsea Bristol UK has established a worldwide reputation as a manufacturer of high power, ultra reliable RF amplifiers for applications as Klystron and IOT drivers in Linear accelerators and synchrotrons.

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A review of results on the hot, dense medium produced in heavy-ion collisions at the LHC.

The dump of the lead beam in the early morning of 10 February this year marked the end of a successful and exciting first LHC running phase with heavy-ion beams. It started in November 2010 with the first lead–lead (PbPb) collisions at √sNN = 2.76 TeV per nucleon pair, when in one month of running the machine delivered an integrated luminosity of about 10 pb-1 for each experiment. In the second period a year later, the LHC’s heavy-ion performance exceeded expectation because the instantaneous luminosity reached more than 10^29 cm^-2 s^-1 and the experiments collected about 10 times more integrated luminosity. A pilot proton–lead (pPb) run at √sNN = 5.02 TeV took place in September 2012, providing enough events for first surprises and publications. A full run followed in February, delivering 30 nb^-1 of pPb collisions — precious reference data for the PbPb studies.

The ALICE experiment is optimized to cope with the large particle–densities produced in PbPb collisions and nothing was left unprepared for the first heavy-ion run in 2010. Nevertheless, immediately before the first collisions the tension was palpable until the first event displays appeared (figure 1). The image of the star-like burst with thousands of particles recorded by the time-projection chamber became an emblem for the accomplishment of a collaboration that had worked for 20 years on developing, building and operating the ALICE detector. With the arrival of a wealth of data, a new era for comprehension of the nature of matter was opened. A full run followed in February, delivering 30 nb^-1 of PbPb collisions – precious reference data for the PbPb studies. A year later, the LHC’s heavy-ion performance exceeded expectation when in one month of running the machine delivered an integrated luminosity of about 1000 nb^-1, which is about 2.5 times more per nucleon pair participating in the collision than at RHIC. Since the particles are also, on average, more energetic at the LHC, the transverse-energy density is about 2.5 times higher. This allows a rough estimate of the energy density of the medium that is produced. Assuming the same equilibration time of the plasma at RHIC and the LHC, the energy density has increased at the LHC by at least a factor of three, corresponding to an increase in temperature of more than 30% (CERN Courier June 2011 p17).
A more accurate thermometer is provided by the spectrum of the thermal photons emitted by the plasma that reach the detector unscathed. Whereas counting inclusive charged particles is a relatively easy task, the thermal photons have to be arduously separated from a large background of photons from meson decays and photons produced by QCD processes in collisions with large momentum transfer, p_T. The thermal photons appear in the low-energy region of the direct photon spectrum (\(p_T^2 < 57\) GeV/c) as an excess above the yield expected from next-to-leading order QCD and have an exponential shape (fig. 2). The inverse slope of this spectrum measured by ALICE gives a value for the temperature, \(T = 304 \pm 51\) MeV, about 40\% higher than at RHIC. In hydrodynamic models, this parameter corresponds to an effective temperature averaged over the time evolution of the reaction. The measured values suggest initial temperatures that are well above the critical temperature of 150–160 MeV.

In the same way that astronomers determine the space–time structure of extended sources using Hubble–Brown–Twiss optical intensity interferometry, heavy-ion physicists use 3D momentum correlation functions of identical bosons to determine the size of the medium produced (the freeze-out volume) and its lifetime. In intensity interferometry, heavy-ion physicists use 3D momentum correlations to determine the size of the medium produced as well as the lifetime. The measured values suggest initial temperatures that are well above the critical temperature of 150–160 MeV.

The second Fourier coefficient, \(v_2\), with respect to the reaction plane. The second Fourier coefficient, \(v_2\), is shown only for the 0–20% centrality class, compared with those for charged hadrons and non-prompt J/ψ from B decays in the same centrality class. The charged hadron \(p_T\) is shown only for \(2<p_T<16\) GeV/c.

Fig. 3. Average nuclear-modification factor, \(R_{AA}\), of D mesons in the 0–20% centrality class, compared with those for charged hadrons and non-prompt J/ψ from B decays in the same centrality class. The charged hadron \(p_T\) is shown only for \(2<p_T<16\) GeV/c.

As discussed above, using hydrodynamical models the basic parameters of the medium can be extrapolated in a continuous manner between the energies of RHIC and the LHC and they turn out to show a moderate increase. Although this might not seem to be a spectacular discovery, its importance for the field should not be underestimated: it marks a transition from data-driven discoveries to precision measurements that constrain model parameters.

Hard probes
What is new at the LHC is the large cross-section (several orders of magnitude higher with respect to RHIC) for so-called hard processes, e.g. the production of jets and heavy flavour. In these cases, the production is decoupled from the formation of the medium and, therefore, as quasi–external probes traversing the medium they can be used for tomography measurements – in effect, to see inside the medium. Furthermore, they are well calibrated probes because their production rates in the absence of the medium can be calculated using perturbative QCD. Hard probes open a new window for the study of the QGP through high-\(p_T\) parton and heavy-quark transport coefficients, as well as the possible thermalization and recombination of heavy quarks.

High-\(p_T\) partons are produced in hard interactions at the early stage of heavy-ion collisions. They are ideal probes because they traverse the medium and their yield and kinematics are influenced by its presence. The ability of a parton to transfer momentum to the medium is particularly interesting. Described by a transport parameter, it is related to the density of colour charges and the coupling of the medium: the stronger the coupling, the larger the transport coefficient and, therefore, the modification of the probe. Energy loss of partons in the medium is caused by multiple elastic scatterings and gluon radiation (jet quenching). This was first observed at RHIC in the suppression of high-\(p_T\) particles with respect to the appropriately scaled proton–proton (pp) and proton–nucleus (pA) references (the nuclear-modification factor \(R_{AA}\)) and from the disappearance of back-to-back particle correlations. At the LHC, rates are high at transverse energies where jets can be reconstructed above the fluctuations of the background-energy contribution from the underlying event. In particular, for jet transverse energies \(E_T > 200\) GeV, the influence of the underlying event is relatively small, allowing robust jet measurements.

ALICE has measured the nuclear modification factor for charm mesons \(D^+, D^+\) and \(D^*+\) for \(2<p_T<16\) GeV/c (fig. 3). For central \(\text{Pb-Pb}^+\text{Pb}^+\) collisions at \(\sqrt{s}\text{NN} = 2.76\) TeV, the suppression is almost as large as that observed for charged particles that are dominated by pions from gluon fragmentation. This observation favours models that explain heavy-\(p_T\) quark energy loss by additional mechanisms, such as in-medium hadron formation and dissociation or partial thermalization of heavy quarks through re-scatterings and in-medium resonant interactions. Such a scenario is further corroborated by measurement of the D-meson elliptic-flow coefficient, \(v_2\). For semi-central \(\text{PbPb}\) collisions, a positive flow is observed in the range \(2<p_T<4\) GeV/c, indicating that the interactions with the medium transfer information on the azimuthal anisotropy of the system to charm quarks. The suppression of the \(\text{J}/\psi\) and other charmonia states, as a result of QGP screening of the strong interaction, was one of the first signals predicted for QGP formation and has been observed both at CERN’s Super Proton Synchrotron and at RHIC. At the LHC, heavy quarks are abundantly produced – about 100\% more per event in central \(\text{PbPb}^+\text{Pb}^+\) collisions. If these charm quarks roam freely in the medium and the charm density is high enough, they can recombine to form quarkonia states, competing with the suppression mechanism.

Indeed, in the most central collisions a lower \(\text{J}/\psi\) suppression than at RHIC is observed. Also, a smaller suppression is observed at high-\(p_T\) compared with low \(p_T\) and it is lower at mid-rapidity than in the forward direction (CERN Courier March 2012 p14). In
LHC physics

Line with regeneration models, suppression is reduced in regions where the charm-quark density is highest. In semi-central PbPb collisions, ALICE sees a hint of nonzero elliptic flow of the J/ψ. This also favours a scenario in which a significant fraction of J/ψ particles are produced by regeneration. The significance of these results will be improved with future heavy-ion data-taking.

Surprises from pPb reference data

The analysis of pPb collisions allows the ALICE collaboration to study initial and final state effects in cold nuclear matter, to establish a baseline for the interpretation of the heavy-ion results. However, the results from the data taken in the pilot run have already shown that pPb collisions are also good for surprises. First, the CMS collaboration observed from the analysis of two-particle angular correlations in high-multiplicity pPb-collisions the presence of a ridge structure that is elongated in the pseudo-rapidity direction (CERN Courier January/February 2013 p8). Using low-multiplicity events as a reference, the ALICE and ATLAS collaborations found that this ridge structure actually has a perfectly symmetrical counterpart, back-to-back in azimuth (CERN Courier March 2013 p7). The amplitude and shape of the observed double-ridge structure are similar to the modulations that are caused by the elliptic flow that is observed in PbPb collisions, therefore indicating collective behaviour in pPb. Other models attribute the effect to gluon saturation in the lead nucleus or to parton-induced final-state effects. These effects and their similarity to PbPb phenomena are intriguing. Their further investigation and theoretical interpretation will shed new light on the properties of matter at high temperatures and densities.

If pPb-collisions do produce a QGP-like medium, its extension is expected to be much smaller than the one produced in PbPb collisions. However, the relevant quantity is not size but the ratio of the system size to the mean-free path of partons. If it is high enough, hydrodynamic models can explain the observed phenomena. If the observations can be explained by coherent effects between strings formed in different proton–nucleon scatterings, we must understand to what extent these effects contribute also to PbPb collisions. While the LHC takes a pause, the ALICE collaboration is looking forward to more exciting results from the existing data.

Résumé

ALICE : sur les traces d’un nouvel état de la matière

Après deux périodes de collisions plomb-plomb au LHC, complétées par des campagnes de collisions proton-plomb, de nouvelles perspectives s’ouvrent pour la compréhension de la matière à haute température et densité, conditions dans lesquelles la chromodynamique quantique prédit l’existence d’un plasma de quarks et de gluons. Conçue pour supporter les fortes densités de particules générées par les collisions d’ions lourds, l’expérience ALICE a fourni de nombreuses mesures du milieu produit au LHC, qui sont ici résumées. Élément nouveau, la large section efficace pour les processus dits durs tels que la production de jets et de saveurs lourdes peut être utilisée pour « voir » à l’intérieur du milieu.

Andreas Morsch, CERN, on behalf of the ALICE collaboration.

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More than 100 years have passed since the discovery of cosmic rays by Victor Hess in 1912 and there are still no signs of decreasing interest in the study of the properties of charged leptons, nuclei and photons from outer space. On the contrary, the search for a better understanding and clarification of the long-standing questions – the origin of ultrahigh energy cosmic rays, the composition as a function of energy, the existence of a maximum energy, the acceleration mechanisms, the propagation and confinement in the Galaxy, the extra-galactic origin, etc. – are more pertinent than ever. In addition, new ambitious experimental initiatives are starting to produce results that could cast light on more recent challenging questions, such as the nature of dark matter, the apparent absence of antimatter in the explored universe and the search for new forms of matter.

The 33rd International Conference on Cosmic Rays (ICRC 2013) – The Astroparticle Physics conference – took place in Rio de Janeiro on 2–9 July and provided a high-profile platform for the presentation of a wealth of results from solar and heliospheric physics, through cosmic-ray physics and gamma-ray astronomy to neutrino astronomy and dark-matter physics. A full session was devoted to the presentation of new results from the Alpha Magnetic Spectrometer, AMS-02. Sponsored by the US Department of Energy and supported financially by the relevant funding and space agencies in Europe and Asia, this experiment was deployed on the International Space Station (ISS) on 19 May 2011 (figure 1). The results, which were presented for the first time at a large international conference, are based on the data collected by AMS-02 during its first two years of operation on the ISS.

AMS-02 is a large particle detector by space standards and built using the concepts and technologies developed for experiments at particle accelerators but adapted to the extremely hostile environment of space. Measuring 5 × 4 × 3 m$^3$, it weighs 7.5 tonnes. Reliability, performance and redundancy are the key features for the safe and successful operation of this instrument in space (CERN Courier July/August 2011 p18 and p23).

The main scientific goal is to perform a high-precision, large-statistics and long-duration study of cosmic nuclei (from hydrogen to iron and beyond), elementary charged particles (protons, antiprotons, electrons and positrons) and $\gamma$-rays. In particular, AMS-02 is designed to measure the energy- and time-dependent fluxes of cosmic nuclei to an unprecedented degree of precision, to understand better the propagation models, the confinement mechanisms of cosmic rays in the Galaxy and the strength of the interactions with interstellar media. A second high-priority research topic is an indirect search for dark-matter signals based on looking at the fluxes of particles such as electrons, positrons, protons, antiprotons and photons.

Another important item on the list of priorities – which will be addressed in future – is the search for cosmic antimatter nuclei. This variety of matter is apparently absent in the region of the universe currently explored but – according to the Big Bang theory – it should have been highly abundant in the early phases of the universe. Last but not least, AMS-02 will explore the possible existence of new phenomena or new forms of matter, such as strangelets, which this state-of-the-art instrument will be in a unique position to unravel.

The AMS-02 detector was designed, built and is now operated on the ISS. AMS-02 provides a precise measure of cosmic rays.
by a large international collaboration led by Nobel laureate Samuel Ting, involving researchers from institutions in America, Europe and Asia. The detector components were constructed and tested in research centres around the world, with large facilities being built or refurbished for this purpose in China, France, Germany, Italy, Spain, Switzerland and Taiwan. The final assembly took place at CERN, benefiting from the laboratory’s significant expertise and experience in the technologies of detector construction. The instrument was then tested extensively with cosmic rays and particle beams at CERN, in the Maxwell electromagnetic compatibility chamber and the large-space thermal simulator at ESA-ESTEC in Noordwijk, as well as in the large facilities at NASA’s Kennedy Space Centre in the US.

The construction of AMS-02 has also stimulated the development of important and novel technologies in advanced instrumentation. These include the first operation in space of a large two-phase CO2 cooling system for the silicon tracker (CERN Courier June 2012 p29) and the two-gas (Xe–CO2) system for the operation of the cooling system for the silicon tracker (of important and novel technologies in advanced instrumentation). Kennedy Space center in the US.

First results

At ICRC 2013, the AMS collaboration presented data on two important areas of cosmic-ray physics. One addresses the fluxes, ratios and anisotropies of leptons, while the other concerns charged cosmic-ray nuclei (protons, helium, boron, carbon). The following presents a brief summary of the results and of some of the most critical experimental challenges.

In the case of electrons and positrons, efficient instrumental handles for the suppression of the dominant backgrounds are: the minimal amount of material in the transition radiation and time-of-flight detectors; the magnet layout, separating the transition radiation detector and the electromagnetic calorimeter; and the capability to match the value of the particle momentum reconstructed in the nine tracker layers of the silicon spectrometer with the value of the energy of the particle showering in the electromagnetic calorimeter. The performance of the transition-radiation detector results in a high proton-rejection efficiency (larger than 10^6) at 90% positron efficiency in the rigidity range of interest. The performance of the calorimeter with its 17 radiation lengths provides a rejection factor better than 10^4 for protons with momenta up to 10^5 GeV/c. The combination of the two efficiencies leads to an overall proton-rejection factor of 10^8 for most of the energy range under study.

Precision measurement of the positron fraction in primary cosmic rays, based on the sample of 6.8 million positron and electron events in the energy range of 0.5–350 GeV — collected during the initial 18 months of operation on the ISS — was recently published and presented at the conference (Aguilar et al. 2013 and Koenneke ICRC 2013). The positron–fraction spectrum (figure 2, p.25) does not exhibit fine structure and the highly precise determination shows that the positron fraction steadily increases from 10–250 GeV, while from 20–250 GeV, the slope decreases by an order of magnitude. The AMS-02 measurements have extended the energy ranges covered by recent experiments to higher values and reveal a different behaviour in the high-energy region of the spectrum.

AMS-02 has also extended the measurements of the positron spectrum to 350 GeV — that is, above the energy range of determinations by other experiments. The individual electron and positron spectra, with the E^3 multiplication factor and the combined spectrum, were presented at the conference (Schael, Bertucci ICRC 2013). Figure 3 shows the electron spectrum, which appears to follow a smooth, slowly falling curve up to 500 GeV. The positron spectrum, by contrast, rises to 30 GeV, flattens from 10–30 GeV, before rising again above 30 GeV (figure 4). For the time being, it is not obvious that the models or simple parametric estimations that are currently used to describe the rate spectrum can also describe the behaviour of the individual electron and positron spectra. Using a larger data sample, comprising of the order of 9 million of electrons and positrons, the collaboration has performed a preliminary measurement of the combined fluxes of electrons and positrons in the energy range 0.5–300 GeV (Bertucci ICRC 2013). The data do not show significant structures, although a change in the spectral index with increasing lepton energies is clearly observed. However, the positron flux increases with energy and a promising approach to identifying the physics origin of this behaviour lies in the determination of the size of a possible anisotropy, arising in primary sources, in the arrival directions of positrons and electrons measured in galactic co-ordinates. AMS-02 has obtained a limit on the dipole anisotropy parameter δ < 0.030 at the 95% confidence level for energies above 16 GeV (Casas ICRC 2013).

For the future

After nearly 28 months of successful operation, the results presented at ICRC 2013 already give a taste of the scientific potential of the AMS-02 experiment. In the near future, the measurements sketched in this article will extend the energy or rigidity coverage and the study of systematic uncertainties will be finalized. The experiment will measure the fluxes of more cosmic nuclei with unprecedented precision to constrain further the size and energy dependence of the underlying background processes. High on the priority list for AMS-02 is the measurement of the antiproton flux and the antiproton/proton rate – a relevant...
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and most sensitive quantity for disentangling, among the possible sources, those that induce the observed increase of the positron flux with energy. With the growing data sample and a deeper assessment of the systematic uncertainties, the searches for cosmic antinuclei will become extremely important, as will the search for unexpected new signatures.

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**Further reading**

For more about AMS-02, see www.ams02.org.

J Bertucci AMS collaboration ICRC 2013 (ID 1267).
J Casaux AMS collaboration ICRC 2013 (ID 1264).
V Chatzis AMS collaboration ICRC 2013 (ID 1262).
S Haino AMS collaboration ICRC 2013 (ID 1265).
A Kounine AMS collaboration ICRC 2013 (ID 1264).
A Oliva AMS collaboration ICRC 2013 (ID 1266).
S Schael AMS collaboration ICRC 2013 (ID 1257).

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**Résumé**

AMS-02 mesure les rayons cosmiques avec précision

Déployée le 19 mai 2011 sur la Station spatiale internationale (ISS), l’expérience AMS-02 a pour objet une étude de longue durée et de haute précision des noyaux cosmiques, des particules chargées et des rayons gamma. Le détecteur, qui jusqu’à présent a fonctionné parfaitement, a fourni des données sur 36,5 milliards de rayons cosmiques en 28 mois de service. Lors de la 33e Conférence internationale sur les rayons cosmiques (ICRC 2013), la collaboration AMS a présenté les premiers résultats relatifs à deux sujets importants : le premier concerne les flus, les taux et les anisotropies des leptons ; le second les noyaux cosmiques chargés (protons, hélium, bore, carbone).

Manuel Aguilar, CERN and CIEMAT, on behalf of the AMS collaboration.
The LHC's Long Shutdown 1 (LS1) is an opportunity that the ATLAS collaboration could not miss to improve the performance of its huge and complex detector. Planning began almost three years ago to be ready for the break and to produce a precise schedule for the multitude of activities that are needed at Point 1 – where ATLAS is located on the LHC. Now, a year after the famous announcement of the discovery of a “Higgs-like boson” on 4 July 2012 and only six months after the start of the shutdown, more than 800 different tasks have already been accomplished in more than 250 work packages. But what is ATLAS doing and why this hectic schedule? The list of activities is long, so only a few examples will be highlighted here.

The inner detector

One of the biggest interventions concerns the insertion of a fourth and innermost layer of the pixel detector – the IBL. The ATLAS pixel detector is the largest pixel-based system at the LHC. With about 80 million pixels, until now it has covered a radius from 12 cm down to 5 cm from the interaction point. At its conception, the collaboration already thought that it could be updated after a few years of operation. An additional layer at a radius of about 3 cm would allow for performance consolidation, in view of the effects of radiation damage to the original innermost layer at 5 cm (the b-layer). The decision to turn this idea into reality was taken in 2008, with the aim of installation around 2016. However, fast progress in preparing the detector and moving the long shutdown to the end of 2012 boosted the idea and the installation goal was moved forward by two years.

To make life more challenging, the collaboration decided to build the IBL using not only well established planar sensor technology but also novel 3D sensors. The resulting highly innovative detector is a tiny cylinder that is about 3 cm in radius and about 70 cm long but it will provide the ATLAS experiment with another 12 million detection channels. Despite its small dimensions, the entire assembly – including the necessary services – will need an installation tool that is nearly 10 m long. This has led to the so-called “big opening” of the ATLAS detector and the need to lift one of the small muon wheels to the surface. The “big opening” of ATLAS is a special configuration where at one end of the detector one of the big muon wheels is moved as far as possible towards the wall of the cavern, the 400-tonne endcap one end of the detector one of the big muon wheels is moved as far as possible towards the wall of the cavern, the 400-tonne endcap calorimeter is opened as far as the already opened big calorimeter is moved out by about 3 m. But that is not the end of the story. To make more space, the small muon wheel must be lifted to the surface to allow the endcap calorimeter to be moved further out against the big wheels.

This opening up – already foreseen for the installation of the IBL – became more worthwhile when the collaboration decided to use LS1 to repair the pixel detector. During the past three years of operation, the number of pixel modules that have stopped being operational has risen continuously from the original 10–15 up to 88 modules, at a worryingly increasing rate. Back in 2010, the first concerns triggered a closer look at the module failures and it was clear that in most of the cases the modules were in a good state but that something in the services had failed. This first glance was then augmented by substantial statistics after up to 88 modules had failed by mid-2012.

In 2011, the ATLAS pixel community decided to prepare new services for the detector – code-named nSQP for “new service quarter panels”. In January 2013, the collaboration decided to deploy the nSQP not only to fix the failures of the pixel modules and to enhance the future read-out capacities for two of the three layers but also to ease the task of inserting the IBL into the pixel detector. This decision implied having to extract the pixel detector and take it to the clean-room building on the surface at Point 1 to execute the necessary work. The “big opening” therefore became mandatory.

The extraction of the pixel detector was an extremely delicate operation but it was performed perfectly and a week in advance of the schedule. Work on both the original pixels and the IBL is now in full swing and preparations are under way to insert the enriched four-layer pixel detector back into ATLAS. The pixel detector will then contain 92 million channels – some 90% of the total number of channels in ATLAS.

But that is not the end of the story for the ATLAS inner detector. Gas leaks appeared last year during operation of the transition radiation tracker (TRT) detector. Profiting from the opening of the inner detector plates to access the pixel detector, a dedicated intervention was performed to cure as many leaks as possible using techniques that are usually deployed in surgery.

Further improvements

Another important improvement for the silicon detectors concerns the cooling. The evaporative cooling system that was based on a complex compressor plant has been satisfactory, even if it has created a variety of problems and interventions. The system allowed operating temperatures to be set to -20 °C with the possibility of going down to -30 °C, although the lower value has not been used so far as radiation damage to the detector is still in its infancy. However, the compressor plant needed continual attention and maintenance. The decision was therefore taken to build a second plant that was based on the thermosyphon concept, where the pressure that is required is obtained without a compressor, using instead the gravity advantage offered by the 90-m-deep ATLAS cavern. The new plant has been built and is now being commissioned, while the original plant has been refurbished and will serve as a redundant (back-up) system. In addition, the IBL cooling is based on CO₂ cooling technology and a new redundant plant is being built to be ready for the IBL operations.

Both the semiconductor tracker and the pixel detector are also being consolidated. Improvements are being made to the back-end read-out electronics to cope with the higher luminosities that will go beyond twice the LHC design luminosity.

Lifting the small muon wheel to the surface – an operation that had never been done before – was a success. The operation was not without difficulties because of the limited amount of space for manoeuvring the 140-tonne object to avoid collisions with other detectors, crates and the walls of the cavern and access shaft. Nevertheless, it was executed perfectly thanks to highly efficient preparation and the skill of the crane drivers and ATLAS engineers, with several dry runs done on the surface. Not to mis the opportunity, the few problematic cathode-strip chambers on the small wheel that was lifted to the surface will be repaired. A specialized tool is being designed and fabricated to perform this operation in the small space that is available between the lifting frame and the detector.

Many other tasks are foreseen for the muon spectrometer. The installation of a final layer of chambers – the endcap extensions – which was staged in 2003 for financial reasons has already been completed. These chambers were installed on one side of the detector during previous mid-winter shutdowns. The installation on the other side has now been completed during the first three months of LS1. In parallel, a big campaign to check for and repair leaks has started on the monitored drift tubes and resistive-plate chambers, with good results so far. As soon as access allows, a few problematic thin-gap chambers on the big wheels will be exchanged. Construction of some 30 new chambers has been under way for a few months and their installation will take place during the coming winter.

At the same time, the ATLAS collaboration is improving the calorimeters. New low-voltage power supplies are being installed for both the liquid-argon and tile calorimeters to give a better performance at higher luminosities and to correct issues that have in full swing and preparations are under way.
constructed. Designing, prototyping, constructing and testing new devices like these has kept the ATLAS calorimeter community busy during the past four years. The results that have been achieved are impressive and life for the calorimeter teams during operation will become much better with these new devices.

Improvements are also under way for the ATLAS forward detectors. The LLUCID luminosity monitor is being rebuilt in a simplified way to make it more robust for operations at higher luminosity. All of the four Roman-pot stations for the absolute luminosity monitor, ALFA, located at 240 m from the centre of ATLAS in the LHC tunnel, will soon be in laboratories on the surface. There they will undergo modifications to implement wake-field suppression measures that will fight against the beam-induced increase in temperature that was suffered during operations in 2012. There are other plans for the beam-conditions monitor, the diamond-beam monitor and the zero-degree calorimeters. The activities are non-stop everywhere.

The infrastructure
All of the above might seem to be an enormous programme but it does not touch on the majority of the effort. The consolidation work spans the improvements to the evaporative cooling plants that have already been mentioned to all aspects of the electrical infrastructure and more. Here are a few examples from a long list.

Installation of a new uninterruptible power supply is ongoing at Point 1, together with replacement of the existing one. This is to avoid power glitches, which have affected the operation of the ATLAS detector on some occasions. Indeed, the whole electrical infrastructure for the counting rooms is also undergoing complete improvement with redundancy measures inserted everywhere. All of these tasks are the result of a robust collaboration between ATLAS and all CERN departments.

LS1 is not, then, a period of rest for the ATLAS collaboration. Many resources are being deployed to consolidate and improve all possible aspects of the detector, with the aim of minimizing downtime and its impact on data-taking efficiency. Additional detectors are being installed to improve ATLAS’s capabilities. Only a few of these have been mentioned here. Others include, for example, even more muon chambers, which are being installed to fill any possible instrumental cracks in the detector.

All of this effort requires the co-ordination and careful planning of a complicated gymnastics of heavy elements in the cavern. ATLAS will be a better detector at the restart of LHC operations, ready to work at higher energies and luminosities for the long period until LS2 – and then the gymnastics will begin again.

Résumé
ATLAS se refait une santé
L’arrêt de longue durée du LHC a donné l’occasion de mettre en œuvre un important programme de consolidation et d’amélioration pour le détecteur ATLAS. L’une des interventions majeures est l’installation d’une quatrième couche au détecteur à pixels, au plus près du centre. Cette opération a nécessité un démontage de grande envergure d’ATLAS, au cours duquel une petite roue à muons a été remontée à la surface. De même, le détecteur à pixels a été remonté pour subir des réparations. D’autres opérations visent à améliorer les chambres à muons et les calorimètres et à consolider l’infrastructure du détecteur.

Beniamino Di Girolamo and Marzio Nessi, CERN.
The regular “DiS” workshops on Deep-Inelastic Scattering and related subjects usually bring together a unique mix of international communities and cover a spectrum of topics ranging across proton structure, strong interactions and physics at the energy frontier. DiS2013 – the 21st workshop – which took place in the Palais des Congrès in Marseilles earlier this year was no exception. Appropriately, this large scientific event formed part of a rich cultural programme in the city that was associated with its status as European Capital of Culture Marseilles-Provence 2013.

A significant part of the programme was devoted to recent and exciting experimental results, which together with theoretical advances and the outlook for the future created a vibrant scientific atmosphere. The workshop began with a full day of plenary reports on hot topics, followed by two and a half days of parallel sessions that were organized around seven themes: structure functions and parton densities; small-\(x\), diffraction and vector mesons; electroweak physics and beyond the Standard Model; QCD and hadronic final states; heavy flavours; spin physics; future experiments.

Higgs and more

The meeting provided the opportunity to discuss in depth the various connections between strong interactions, proton structure and recent experimental results at the LHC. In particular, the discovery of a Higgs boson and the subsequent studies of its properties attracted a great deal of interest, including from the perspective of the connections with proton structure. A tremendous effort was made in the past year to provide an improved theory, study the constraints from the wealth of new experimental data and adopt a more robust methodology in analyses that determine the proton’s parton distribution functions (PDFs). The PDFs are an essential ingredient for most LHC analyses, from characterization of the Higgs boson to self-consistency tests of the Standard Model. The first “safari” into the new territory at the LHC and the impressive final results with the full data set from Fermilab’s Tevatron have revealed no new phenomena so far. However, it might well be that the search for new physics – which will be re-launched at higher energies during the next LHC run – will be affected by the precision with which the structure of the proton is known.

Results from the LHC were a key element of the latest DiS workshop.

The proton’s PDFs are an essential ingredient for most LHC analyses. From HERA – the electron–proton collider that ran at DESY during 1992–2007 – were presented, in particular, both the H1 and ZEUS collaborations have now published measurements at high photon virtualities (\(Q^2\)). While the refined data from HERA form its immensely valuable legacy, the transfer of the baton to the LHC has already begun. A large number of recent results – in particular from the LHC – provide further constraints on the PDFs, such as in the case of final states with weak bosons or top quarks, which are already in the regime of precision measurements with about 1% accuracy. Stimulated by an active Standard Model community that has many groups that are working on the determination of PDFs (such as ABM, MSTW and cTeQ) and by the release of common analysis tools such as HERAFitter, the new measurements from the LHC are rapidly interpreted in terms of valuable PDF constraints, as figure 1 shows (p34). More exclusive final states have the

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potential to complement inclusive measurements: for instance, measurements on the W in association with the charm quark could shed new light on the strangeness content of a proton. A huge step in the precision of PDF determination – which might be essential to study new physics – complemented by a standalone programme at the energy frontier would be possible at the proposed Large Hadron Electron Collider (LHeC), which could provide a new opportunity to study Higgs–boson couplings.

The understanding of proton structure would not be complete without understanding its spin. Polarized experiments – including fixed-target DIS experiments at Jefferson Lab and CERN, as well as the polarized proton–proton programme at Brookhaven’s Relativistic Heavy-Ion Collider (RHIC) – continue to provide new data and to open new fields. The goal is to understand the parton contributions to the proton’s spin, long considered a “puzzle” because of the unexpected way that it is shared between the quarks – with only a quarter – the gluons and the relative angular momentum. Recent, more precise measurements of W-boson production in polarized proton–proton collisions at RHIC have the potential to constrain further the valence quark contributions, while semi-inclusive DIS scattering at fixed-target experiments (for instance, using final states with charm mesons) continue to reduce the uncertainty on the gluon contribution. The goal of the spin community – manifest in the project for a polarized Electron–Ion Collider (EIC) – is to produce a 3D picture of the proton with high precision using a large number of observables across an extended phase space.

Impressive precision

The current scientific landscape includes many experiments that are based on hadronic interactions, with the LHC taking these studies to the highest energies. These are reaching impressive, increasing precision across a large phase space, not only in final states with jets but also in more exclusive configurations including photons, weak bosons or tagged heavy flavours. The measurements performed in diffraction – by now a classical laboratory for QCD tests – are also available from the LHC in inclusive and semi-inclusive final states and enforce the global understanding of the strong interactions. An interesting case concerns double-parton interactions where the final state originates from not one but two parton–parton collisions – a contribution that in some cases can pollute final-state configurations (including bosons or Higgs production). Although the measurements are not yet precise enough to identify kinematical dependencies or parton–parton correlations, they are beginning to unveil this contribution, which may prove in future to be related to profound aspects of the proton structure, such as the generalized parton distributions and the proton spin.

A global picture and complete understanding of the strong force can only emerge by using all of the available configurations and energies. In particular, the measurements of the hadronic final states performed in electron–proton collisions at HERA and the refined measurements at the Tevatron provide an essential testing ground for the increasingly precise calculations. Figure 2 illustrates this statement, presenting measurements of the strong coupling from collider experiments – including the most recent measurements from the LHC.

The high-energy heavy-ion collisions at both RHIC and the LHC have been a constant source of new results and paradigms during the past few years and this proved equally true for the DIS2013 conference. Probes such as mesons or jets “disappear” when high densities of the collision fireball are reached. The set of such probes has been consolidated at the LHC, where the experimental capabilities and large phase space allow further measurements involving strangeness, charm or inclusive particle production. In addition, the recently achieved proton–lead collisions provide new testing grounds for the collective behaviour of the quarks and gluons at high densities.

A total of 300 talks were given covering the seven themes of the workshop, distributed across two and a half days of parallel sessions, a few of which combined different themes. As tradition requires at DIS workshops, the presentations were followed by intense debates on classic and new issues, including a satellite workshop on the HERA Fitter project. On the last day, the working group convenors summarized the highlights of the rich scientific programme of the parallel sessions.

The conference ended with a session on future experiments, where together with upgrades of the LHC experiments and other interesting projects related to new capabilities for QCD-related studies (AFTER, CHIC, COMPASS, NA62, muSTORM, etc.), the two projects for new colliders EIC and LHeC were discussed. Rolf Heuer, CERN’s director-general, presented the recently updated European Strategy for Particle Physics. The programme at the energy frontier with the LHC will be followed for at least 20 years, and studies for further projects are ongoing. The conference ended with a truly inspiring outlook talk by Chris Quigg of Fermilab, with hints of a possible QCD-like walk on the new physics frontier. In the evening, Heuer gave a talk for the general public to an audience of more than 200 people on recent discoveries at the LHC.

In addition to the workshop sessions, participants enjoyed a dinner in the Pharo castle – with a splendid view of the old and new harbours of Marseilles – where they found out why the French national anthem is called La Marseillaise. There was also half a day of free time for most of the participants – except maybe for convenors who had to prepare their summary reports – with two excursions organized at Cassis and in the historic centre of Marseilles. In summary, the DIS2013 workshop once again allowed an insightful journey around the fundamental links between QCD, proton structure and physics at the energy frontier – an interface that will continue to grow and create new research ideas and projects in the near future. The next – 22nd – DIS workshop will be held in Warsaw in April 2014.

Further reading


Résumé

Des quarks et des gluons s’invitent à Marseille

Les ateliers DIS (diffusion profondément inclinante et sujets connexes) rassemblent des chercheurs de divers horizons et couvrent de nombreux sujets, allant de la structure du proton aux interactions fortes en passant par la physique aux frontières des hautes énergies. DIS2013, la 2e édition, qui s’est tenue à Marseille cette année, a aussi démêlé le vrai du faux. Cette rencontre a permis aux participants de discuter en détail des rapports entre les interactions fortes, la structure du proton et les derniers résultats des expériences au LHC. Cet événement scientifique majeur s’est parfaitement inséré dans le riche programme culturel de Marseille-Provence 2013, Capitale européenne de la culture.

Cristinel Diaconu, Centre de Physique des Particules de Marseille, CNRS/IN2P3 and Aix-Marseille Université.
The Higgs boson, dark matter and rare processes were among the highlights of the 2013 International Europhysics Conference on High-Energy Physics.

When the Swedish warship Vasa capsized in Stockholm harbour on her maiden voyage in 1628, many hearts must have also sunk metaphorically, as they did at CERN in September 2008 when the LHC’s start-up came to an abrupt end. Now, the raised and preserved Vasa is the pride of Stockholm and the LHC – following a successful restart in 2009 – is leading research in particle physics at the high-energy frontier. This year the two icons crossed paths metaphorically, as they did at CERN in September 2008 when the ATLAS and CMS experiments at the LHC, with their top, t – and its antiquark, the new boson can in principle be produced together with a t̅ pair, so yielding a sixth coupling. While this is a challenging channel, new results from CMS and ATLAS are starting to approach the level of sensitivity for the Standard Model Higgs boson, which bodes well for its future use.

The mass of the top quark is in fact so large – 173 GeV/c² – that it decays before forming particles, making it possible to study the “bare” quark. At the conference, the CMS collaboration announced the first observation, at 6.0 × 10⁻³, of the associated production of a top quark and a W boson, in line with the Standard Model’s prediction. Both ATLAS and CMS had previously found evidence for this process but not to this significance. The results for the five major decay channels – top, t̅ – and its antiquark, the new boson can in principle be produced together with a t̅ pair, so yielding a sixth coupling. While this is a challenging channel, new results from CMS and ATLAS are starting to approach the level of sensitivity for the Standard Model Higgs boson, which bodes well for its future use.

The new boson’s couplings provide a crucial test of whether it is the particle responsible for electroweak-symmetry breaking in the Standard Model. A useful parameterization for this test is the ratio of the observed signal strength to the Standard Model prediction, μ = (σ × Br)/σSM, where σ is the cross-section and Br the branching fraction. The results for the five major decay channels measured so far (γγ, WW*, ZZ*, bb and ττ) are consistent with the expectations for a Standard Model Higgs boson, i.e. μ = 1, to 15% accuracy. Although it is too light to decay to the heaviest quark – top, t – and its antiquark, the new boson can in principle be produced together with a t̅ pair, so yielding a sixth coupling. While this is a challenging channel, new results from CMS and ATLAS are starting to approach the level of sensitivity for the Standard Model Higgs boson, which bodes well for its future use.

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The city of Stockholm provided a beautiful setting for the 2013 edition of EPS-HEP, one of the major international summer conferences in particle physics. (Image credit: Marina Lukeshova/Dreamstime.com.)
EPS-HEP 2013

lepton asymmetry in production, which had previously indicated some deviation from theory. The new measurement, based on the full data set of 9.7 fb \(^{-1}\) of proton–antiproton collisions at the Tevatron, gives an asymmetric (4.7±2.3 stat.\(^{+1.4}_{-1.3}\) syst.)%, which is consistent with predictions from the Standard Model to next-to-leading order.

The study of B hadrons, which contain the next heaviest quark, b, is one of the aspects of flavour physics that could yield hints of new physics. One of the highlights of the conference was the announcement of the observation of the rare decay mode B\(^-\)\to J/\psi K\_S at both the LHCb and CMS collaborations, at 4.0 and 4.3 standard deviations (\(\text{STDVs}\)) respectively (CERN Courier September 2013 p9). While there had been hopes that this decay channel might open a window on new physics, the long-awaited results align with the predictions of the Standard Model. The BallBar and Belle collaborations also reported on these precise measurements of the decay B\(\to D^0\)\(\to\)\(V\)\(\ell\nu\) at SLAC and KEK, respectively, which together disagree with the Standard Model at the 4.3 SD level. The results rule out one model that adds a second Higgs doublet to the Standard Model (2HDM type II) but are consistent with a different variant, 2HDM type III—a reminder that the highest energies are not the only place where new physics could emerge.

Precision, precision

Precise measurements require precise predictions for comparison and here theoretical physics has seen a revolution in calculating next-to-leading order by solving a single loop in the Feynman diagrams. Rapid progress during the past few years has meant that the experimentalists’ wish-list for QCD calculations at NLO relevant to the LHC is now fulfilled, including such high-multiplicity final states as W+4 jets and even W+5 jets. Techniques for calculating loops automatically should in future provide a “do-it-yourself” approach for experimentalists. The new frontier for these studies, meanwhile, is at next-to-NLO (NNLO), where some measurements—such as pp \(\to t\bar{t}\)—are already at an accuracy of a few per cent and some processes—such as pp \(\to\gamma\gamma\)– could have large corrections, up to \(\pm 40\%\). So a new wish-list is forming, which will keep theorists busy while the automatic code takes over at NLO.

With a measurement of the mass for the Higgs boson, small corrections to the theoretical predictions for many measurable quantities—such as the ratio between the masses of the W and the top quark—can now be calculated more precisely. The goal is to see if the Standard Model gives a consistent and coherent picture when everything is put together. The GFitter collaboration of theorists and experimentalists presented their extensive searches for supersymmetric partners of the Standard Model particles in the local galaxy as they pass through highly sensitive detectors. Their experiments are showing an increase in the rate of interaction with the cosmic background radiation, which is expected if dark matter is composed of supersymmetric particles. The results reveal a large excess of events that are consistent with the production of supersymmetric particles with masses of the order of 100 GeV. However, these results do not provide conclusive evidence for the existence of supersymmetry, as they could also be explained by new physics beyond the Standard Model.

The results on the Higgs boson, and those from other measurements of the Higgs boson, present a consistent picture of the Standard Model and its extensions. The precision of these measurements allows for a detailed understanding of the properties of the Higgs boson, including its coupling to the SM particles and its decay modes. This has important implications for the search for new physics beyond the Standard Model, as they provide a benchmark for comparing to theoretical predictions.

The number of papers with dark matter in the title is growing faster than those on the Higgs boson.

Supersymmetry and dark matter

The energy frontier of the LHC has long promised the prospect of physics beyond the Standard Model, in particular through evidence for a new symmetry—supersymmetry. The ATLAS and CMS collaborations presented their extensive searches for supersymmetric particles, which could explain dark matter and resolve the hierarchy problem of the SM. However, assumptions involved in the work so far mean that there are regions of parameter space that remain unexplored. So while supersymmetry may be “under siege”, its survival is certainly still possible. At the same time, creative searches for evidence of extra dimensions and many kinds of “exotics”—such as excited quarks and leptons—have likewise produced no signs of anything new.

However, evidence that there must almost certainly be some kind of new particle comes from the existence of dark, non-hadronic matter in the universe. Recent results from the Planck mission show that this dark matter must make up some 26.8% of the universe—about 4% more than previously thought. This drives the search for weakly interacting particles (WIMPs) that could constitute dark matter, which is becoming a worldwide effort. Indeed, although the Higgs boson may have been the top of the hill for hadron collider physics, more generally, the number of papers with dark matter in the title is growing faster than those on the Higgs boson.

While experiments at the LHC look for the production of new kinds of particles with the correct properties to make dark matter, “direct” searches seek evidence of interactions of dark-matter particles in the local galaxy as they pass through highly sensitive detectors. These experiments are showing an increase in the rate of interaction with the cosmic background radiation, which is expected if dark matter is composed of supersymmetric particles. The results reveal a large excess of events that are consistent with the production of supersymmetric particles with masses of the order of 100 GeV. However, these results do not provide conclusive evidence for the existence of supersymmetry, as they could also be explained by new physics beyond the Standard Model.
to create a large circular electron–positron collider, 80–100 km in circumference, to produce Higgs bosons for precision studies (CERN Courier July/August 2013 p26).

The main physics highlights of the conference were reflected in the 2013 EPS-HEP prizes, awarded in the traditional manner at the start of the plenary sessions. The EPS-HEP prize honoured both ATLAS and CMS – for the discovery of the new boson – and three of their pioneering leaders (Michel Della Negra, Peter Jenni and Tejinder Virdee). François Englert and Peter Higgs were there to present this major prize and took part later in a press conference together with the prize winners. Following the ceremony, Higgs gave a talk, “Ancestry of a New Boson”, in which he recounted what led to his paper of 1963 and also cast light on why his name became attached to the now-famous particle. Other prizes acknowledged the measurement of the all-flavour neutrino flux from the Sun, as well as the observation of the rare decay \( B^0 \rightarrow \mu^+ \mu^- \), work in 4D field theories (CERN Courier July/August 2013 p39) and outstanding contributions to outreach. In a later session, a prize sponsored by Elsevier was awarded for the best four posters out of the 130 that were presented by young researchers in the dedicated poster sessions.

To close the conference, Nobel Laureate Gerard ’t Hooft presented his outlook for the field. This followed the conference summary by Sergio Bertolucci, CERN’s director for research and computing, in which he also thanked the organizers for the “beautiful venue, the fantastic weather and the perfect organization” and acknowledged the excellent presentations from the younger members of the community. The baton now passes to the organizing committees of the next EPS-HEP conference, which will take place in Vienna on 22–29 July 2015.

Résumé

Conférence-anniversaire à Stockholm


Christine Sutton, CERN, with thanks to the communication team of Sten Hellman, Stockholm University, Pauline Gagnon, Indiana University, and Abha Phadke and Ashley WintersHerron, CERN.
The Italian Physical Society has honoured five Italian physicists with the Enrico Fermi Prize for their work on LHC experiments, in their roles as current or former spokespersons.

Former ATLAS and CMS spokespersons, Fabiola Gianotti and Guido Tonelli, respectively, were awarded the prize for the discovery with their experiments “of a new fundamental particle with mass around 125 GeV and properties consistent with a Higgs boson, theoretically predicted almost 50 years ago, the existence of which ensures a huge insight in the understanding of the Standard Model of particle physics.”

Spokesperson for LHCb, Pierluigi Campana, received the prize for “the first observation, with the LHCb experiment, of CP violation in B, meson decays and for a large number of high-precision measurements in heavy flavour physics”.

TOTEM’s spokesperson, Simone Giani, was honoured for “the first direct confirmation that the total proton–proton cross-section increases with energy and for further in-depth studies on the proton structure”.

Paolo Giubellino, spokesperson for ALICE, received the award for “the unveiling, with the ALICE experiment, of the new features of the hottest and densest state of matter ever produced in high-energy nucleus–nucleus collisions”.

The award was established 12 years ago in honour of Enrico Fermi’s 100th birthday to recognize outstanding work done by members of the Italian Physical Society. The recipients received their awards at the society’s annual meeting in September.

CERN receives three National Instruments awards

At the NIWeek conference in Texas on 5–8 August an engineering company National Instruments presented three awards to CERN: the National Instruments Graphical System Design Achievement Award, the National Instruments Humanitarian Award and the Intel Intelligent Systems Award.

The Graphical System Design Achievement Awards recognize companies and universities that use graphical-system design to develop applications that meet complex challenges in science and engineering. CERN was selected for the particle accelerator and control systems for the MedAustron ion-therapy facility, which was designed and constructed under the guidance of CERN in Austria (CERN Courier October 2011 p.30).

Johannes Gutbrod, centre, receives the National Instruments humanitarian award on behalf of CERN (from NI cofounders – president James Truchard, left, and Jeff Kodolsky, right. Image credit: National Instruments.)

Three young ISOLDE scientists win awards

Three young Portuguese researchers participating in an experiment on emission-channeling lattice location with short-lived isotopes (EC-SL) at CERN’s ISOLDE facility have won awards at major conferences in materials science.

Lino Pereira, a postdoc at the instituut voor Kern- en Stralingsfysica (iKS) of the university of Aveiro, the university of Porto and iKS/KU Leuven, won the prestigious J.W. Corbett prize at the 27th International Conference on Defects in Semiconductors, which was held in Bologna on 21–26 July.

All three awards resulted from studies by the ISOLDE experiment IB453, which includes researchers from IST/ITN Lisbon, the Centre for Nuclear Physics of the University of Lisbon (CFNUL), the University of Aveiro, the University of Porto and KU Leuven. The work made use of the Portuguese and Belgian experimental infrastructure that was commissioned and is maintained at ISOLDE by researchers from IST/ITN, CFNUL, and KU Leuven. It was partially funded by the Portuguese Science Foundation Fundação para a Ciência e a Tecnologia within its CERN Projects funding scheme and by the Flemish Science Foundation FWO.
CERN's Fabiola Gianotti – former spokesperson of the ATLAS collaboration – has been appointed an honorary professor at the University of Glasgow and inSS2014 will be held in China.

Students, lecturers and organizers of INSS2013. (Image credit: Li Chen/INSS2013)

INSS2013: nurturing young neutrino physicists in Beijing

Students, lecturers and organizers of INSS2013. (Image credit: Li Chen/INSS2013)

The second Hadron Collider Physics Summer School (HASCO 2013) took place on 7–19 July in Göttingen, Germany, drawing 65 undergraduate students from 20 institutes in eight countries and 20 lecturers spent two weeks learning about hadron-collider physics. The students learnt about the foundations of quantum field theory and physics.

Numerous research topics that are relevant for hadron-collider physics were discussed, including QCD, 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. This year’s focus, however, was the physics of the Higgs boson – a suitable emphasis after the discovery of a Higgs-like boson by the ATLAS and CMS experiments, which was announced just a week before HASCO 2012 took place last year.

This type of fundamental research can be carried out only in large international collaborations, so the school aims for the students not only to learn about the relevant physics, but also to experience the creative and productive atmosphere of working in an international team at an early stage in their career. Forming pairs from different institutes and countries, they summarized recent developments and their own on-going analyses and detailed studies of the new boson that was discovered last year at CERN. Among those attending were, left to right, Ludovic Fadduri, Karl Jakobs, Guido Altarelli and Monica Pepe-Altarelli. (Image credit: L Fayard.)

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How to build an accelerator

Having read The Particle at the End of the Universe (reviewed in CERN Courier July/August 2013 p52), and especially the section on accelerators (pp56–73), I feel that more is needed to do justice to the work of accelerator physicists and engineers (while agreeing with the reviewer’s praise for the accelerator physicists and engineers (while more is needed to do justice to the work of section on accelerators (pp55–73), I feel that July/August 2013 p52), and especially the

To build an accelerator, one needs to understand the basic principles of particle physics, and how these principles can be used to design and build accelerators. This requires a deep understanding of the properties of particles and how they interact with each other, as well as knowledge of the technical aspects of building and operating accelerators.

The process of building an accelerator involves several key steps:

1. **Conceptual Design**: This involves the initial planning and design of the accelerator, including the selection of the type of accelerator (e.g. linear accelerator, cyclotron, synchrotron) and the energy level of the particles to be accelerated.
2. **Detailed Design**: Once the conceptual design is completed, the next step is to develop a detailed design, which involves more technical aspects such as the choice of materials, the design of the cooling system, and the layout of the accelerator components.
3. **Construction**: The construction phase involves the actual building of the accelerator, which can be a complex and time-consuming process.
4. **Commissioning and Testing**: Once the accelerator is built, it needs to be commissioned and tested to ensure that it is functioning correctly.
5. **Operation and Maintenance**: After commissioning, the accelerator is put into operation, and regular maintenance is required to keep it functioning properly.

In the public domain and relinquished all intellectual property rights in it. This is quite different from "royalty free". The declaration on p2 of the document – which is available on http://cds.cern.ch/record/1164399 – leaves no ambiguity in reference to either "public domain" or the "intellectual property rights".

However, the declaration concerns only the software of that moment. There never was a statement about the technology, whatever indeed that might mean.

Robert Callau, PhD/PhD

3D trench electrode detectors

I read with interest the article published in CERN Courier (April 2013 p35) that accurately copied parts of an erroneous press release from Brookhaven National Laboratory on Zheng Li. Li won an award from the IEEE Long Island section for his “groundbreaking work in the development of novel silicon detectors,” including the development of the “3D trench electrode detector” – one in which at least one type of electrode is made by depositing dop polycrystalline silicon in etched trenches.

However, I would like to make it clear that Zheng Li was not the first to discuss the “3D trench electrode detector,” which was in fact already proposed in our group by Chris Kenney. Sensors were fabricated in 1998 at the Stanford Nanofabrication Facility with internal and peripheral trenches as part of our first 3D sensor batch. Our group also made and tested all trench electrode sensors and showed photographs of them at the 2003 IEEE Nuclear Science Symposium.

Li also wrote an article, “New BNL 3D-Trench Electrode Si detectors for radiation hard detectors for lHC and for X-ray applications” (Li 2011), where on p91 references to our 2001 paper on wall trench electrodes (Kenney et al 2001) are made: “There was a trench-wall-electrode proposed by Kenney et al. (11), where the detector boundary was etched and doped as trench-wall for the fabrication of edgeless or active-edge detectors, while the electrodes in the bulk are column ones.” On the third page of our 2001 paper, taking almost a quarter of the page, a photomicrograph of “part of a sensor with alternating n-type wall and p-type cylinder electrodes” clearly fitting Li’s definition of a 3D trench electrode detector. It is difficult to see how Li could make the sweeping comment “while the electrodes in the bulk are column ones” without looking at our first wall or trench electrode paper (his reference 11). It is equally difficult to see how he could look at the paper and miss the obvious figure 5.

Still, I would like to express my happiness to see Zheng Li working on 3D technology. He must just avoid incorrect claims of originality and should feel free to ask members of our 3D group for help on that subject.

Sherwood Parker, member, ATLAS collaboration.

Further reading


Correction

The article on IceCube’s detection of neutrinos with energies >1 PeV (CERN Courier July/August 2013 p5) should have stated that “the probability that the two observed events are background is 2.9×10−4.” Unfortunately, the word “not” entered this sentence by mistake.

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Features & Places

CERN Courier October 2013

V I S I T S

Robert Madelin, right, director-general of the European Commission Directorate General for Communications Networks, Content and Technology (DG Connect), visited CERN on 4 July. After signing the guestbook he visited the CMS experimental area with collaboration deputy spokesperson Joao Varela, left.

Giuseppe Ruocco, director-general for prevention, left, and Daniela Roderigo, director-general for European and international relations, right, visited CERN on 23 July to see the ATLAS experiment cavern and presentations of CERN’s medical and health collaborations.

On 16 July, the visit of Dafni Stauder, left, director-general of the Swiss Ministry of Education, included a descent to the LHC tunnel with Laurent Tavella, right, from CERN’s technology department and Girosa Mikolajcz, centre, from the Wismann Institute of Science and ATLAS collaboration.

Italian health ministers Giuseppe Ruocco, director-general for prevention, left, and Daniela Roderigo, director-general for European and international relations, right, visited CERN on 21 August. As well as a tour of the CMS cavern, she saw the LHC tunnel accompanied by Zohera Zahanera, right, of the beams department.

Aneilya Klaricheva, left, Bulgarian minister of education and sciences, visited CERN on 16 August. As well as a tour of the CMS cavern, she saw the LHC tunnel accompanied by Zohera Zahanera, right, of the beams department.
Lorenzo Resegotti, renowned accelerator physicist and engineer at CERN from 1954 to 1988, passed away on 23 May 2013.

A native of Piemonte, Italy, Renzo earned his laurea in industrial and electrical engineering at the prestigious Politecnico di Torino, later gaining a diploma in radio engineering from the National Electro-Technical Institute. He became interested in accelerators during a further year spent as a fellow at the Institute of Physics, Rome University. This training provided the perfect background for working at CERN and he was recruited to work in the newly formed organization in April 1954. Renzo quickly acquired a reputation for being technically competent, rigorous and hard-working – attributes that led to him being given ever-increasing responsibilities in the young organization. His first assignments included the design, purchase and commissioning of the power supply for the proton synchrotron, as well as the design and construction of the 120-cm high energy synchrocyclotron. Applicants should request the "Would you be well paid with your own money?" rule. When the magnet equipment was installed and working, the group continued to work on the machine and evolved into the Beam Optics and Magnets group (BOM) – an ideal creation for improving the accelerator by optimal use of the magnet system. Therefore coupling-control systems using sets of skew quadrupoles were designed, plus low-beta insertions to enhance luminosity.

Aware of the recent advances in superconductivity and of the importance that this could have for CERN, Renzo established a strategic project to build a set of eight reliable superconducting quadrupoles at the lowest price. The success of the ISR bore witness to this dedication. In addition, he regarded it as his duty to imbue the engineers and scientists in his group with training of the sort that he had received (e.g. to get best value for taxpayers’ money by having the "right tool for the right job"). He would ask questions about "how much do you need price with your own money?" rule). When the magnet equipment was installed and working, the group continued to work on the machine and evolved into the Beam Optics and Magnets group (BOM) – an ideal creation for improving the accelerator by optimal use of the magnet system. Therefore coupling-control systems using sets of skew quadrupoles were designed, plus low-beta insertions to enhance luminosity.

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In a joint procedure with the University of Bonn, Forschungszentrum Jülich is seeking an internationally experienced scientist for the position of a

DIRECTOR (f/m) (W3)

at the Nuclear Physics Institute – Large-Scale Nuclear Physics Equipment (IKP-4)

In accordance with the Jülich Model, the successful applicant will also be appointed professor of experimental physics at the University of Bonn.

The Nuclear Physics Institute (IKP), which consists of four divisions, conducts basic research in the fields of hadron physics, particle physics, and nuclear physics. The institute focuses on hadron physics with polarized hadron probes. IKP-4 currently operates the cooler synchotron COSY, with a priority on further developments in beam cooling, polarization, and spin manipulation. With the construction of the high-energy storage ring HEIR, IKP-4 has taken an important role in the FAIR project. Strategic cooperation is maintained with RWTH Aachen University within the framework of JARA-FAME.

Applications are welcome from internationally respected scientists in the field of accelerator physics who will both further develop the accelerator, storage, cooling, and spin manipulation to the highest level, and can also realize the construction of HEIR within the approved time schedule and budget. The successful candidate will be expected to play a leading role in the scientific development and implementation of pioneering accelerator-based projects. The ability to head an institute as a member of the board and a willingness to cooperate are essential. The successful candidate will be expected to contribute adequately to the teaching of experimental physics at the University of Bonn, for example by holding lectures for the master’s course in physics, and is also encouraged to carry out joint research projects with the University of Bonn.

Prerequisites for the position are a PhD, a Habilitation, or equivalent scientific achievements, and a record of excellent publication activity. Experience in leading a scientific working group and in teaching, the position may also be converted from a W2 into a W3 Full Professorship at a later date.

The Nuclear Physics Institute – Large-Scale Nuclear Physics Equipment (IKP-4) invites applications for a Distinguished Junior Fellowship.

The successful candidate will be expected to play a leading role in the scientific development and implementation of pioneering accelerator-based projects. The ability to head an institute as a member of the board and a willingness to cooperate are essential. The successful candidate will be expected to contribute adequately to the teaching of experimental physics at the University of Bonn, for example by holding lectures for the master’s course in physics, and is also encouraged to carry out joint research projects with the University of Bonn.

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Please send your application in English with the usual documents preferably by email to  berufungen@fz-juelich.de  or by post to Forschungszentrum Jülich, c/o Recruitment, D-52425 Jülich, Germany.

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For more information about LeCosPA, please visit its website at  http://lecospa.ntu.edu.tw/  or contact Professor K.T. Chan, Director, Leung Center for Cosmology and Particle Astrophysics, National Taiwan University, Taipei 10617, Taiwan, Republic of China.

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Le boson et le chapeau mexicain – Un nouveau grand récit de l’Univers
Par Gilles Cohen-Tannoudji et Michel Spiro. Postface de Michel Serres.
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Gilles Cohen-Tannoudji et Michel Spiro revisitent plusieurs siècles de physique, en s’attardant bien sûr sur le XXe, qui a vu les révolutions de la théorie de la relativité et de la mécanique quantique. Si la partie consacrée au passage de la mécanique quantique à la théorie quantique des champs n’est pas de lecture vraiment aisée pour le non-scientifique, celui-ci peut vite retrouver le rythme grâce à l’introduction des diagrammes et amplitudes de Feynman, qui sont une mise en musique de la théorie dynamique des interactions fondamentales. Le Modèle standard est évoqué rapidement, ainsi que les théories de jauge. La nécessité de mécanisme de BEH (pour Brout, Englert et Higgs) est alors introduite avec l’émergence des masses. Il faut noter que jamais les auteurs ne se laissent aller au racourci facile de l’expression « boson de Higgs » ni ne parlent de « particule de Dieu » : tout au long de l’ouvrage, le boson est nommé, à juste titre, « BEH ». Le non-physicien devra s’armer de courage pour parcourir le chapitre sur la chromodynamique quantique mais en sera récompensé en découvrant l’explication de l’énigmatique titre du livre, qui associe le boson et le chapeau mexicain. L’histoire du CERN, de sa compétition avec les laboratoires à accélérateurs d’outre-Atlantique et de ses succès, tient une grande place dans ce livre. Les auteurs n’hésitent pas à développer les aspects techniques de l’aventure. Le plaisir que j’ai eu à lire ce livre a été d’autant plus grand que j’ai eu le privilège d’interagir avec Michel Spiro durant son mandat de président du Conseil du CERN. Il m’appelait souvent tôt le matin afin de discuter des nouvelles de la santé du LHC et voulait savoir pourquoi on ne pouvait pas plus rapidement les performances de cette fantastique machine à découvertes. C’est dire l’importance qu’il attache à la découverte du boson BEH, annoncée le 4 juillet 2012 au CERN : consécration d’une longue traque mondiale qui n’a pu être obtenue que grâce à la conception, à la construction et à la mise en service de l’accélérateur LHC. Les aspects politiques du CERN ne sont pas oubliés : ils sont décrits comme des ingrédients essentiels du succès de l’organisation, et cette description est magistralement développée dans la postface de Michel Serres, où au CERN et à son mode de gouvernance, où le philosophe défend l’idée que le modèle fonctionne si bien qu’il devrait être reproduit dans d’autres domaines des sciences. Cette postface remarquablement claire et de richesse aurait pu être mieux valorisée – si le texte avait servi de préface, il aurait permis au lecteur de mesurer encore mieux le rôle du CERN dans la découverte du boson. Ce livre, que les auteurs ont voulu à moins de 10 €, est écrit dans la langue de Louis de Broglie et François de Rose, pères fondateurs du CERN. Il décrit avec précision et passion la quête du boson BEH qui ouvre les portes de la physique au-delà du Modèle standard. Ne boudons pas cette chance de pouvoir lire un tel ouvrage en français ! Il précise que l’aventure est bien terminée. Le boson BEH n’est qu’une étape et de nombreuses questions demeurent : le Modèle standard ne décrète que 4% de la matière de l’Univers. Comme le mentionnent les auteurs, il faut des maintenant serrer les grignes des prochaines technologies des accélérateurs et des détecteurs afin d’être en mesure de construire des machines post-LHC. En fonction des résultats du LHC quand il fonctionnera à une énergie de 13–14 TeV après le long arrêt technique de 2013–2014, il faudra financer et construire un accélérateur capable d’atteindre des énergies proches de 100 TeV.

Gilles Cohen-Tannoudji et Michel Spiro, Le boson et le chapeau mexicain.

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