WELCOME

CERN Courier – digital edition

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

News that the BICEP2 telescope has found evidence for an era of cosmic inflation, just after the Big Bang, sent ripples deep into the particle-physics community, where research looks closely into the nature of fundamental forces and particles in the early universe. News on these particles continues to flow from analyses of high-energy data from the LHC's first run, as well as from Fermilab's Tevatron. At the same time, analyses of low-energy data are turning up surprises, with indications of four-quark states, for example at the BESIII experiment in Beijing. Meanwhile, there was much sadness at CERN at the passing of the last of the founding fathers, diplomat François de Rose, whose vision for the organization remains just as compelling 60 years on.

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CERNCOURIER

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BESIII

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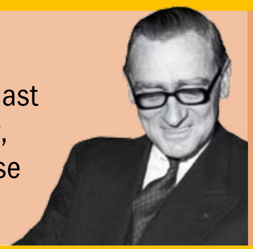

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On the cover: The sun sets behind BICEP2 (in the foreground) and the South Pole Telescope (in the background). In measuring the cosmic background radiation, the BICEP2 experiment has found evidence for cosmic inflation (p13). (Image credit: Steffen Richter, Harvard University.)

News

TOP PHYSICS

LHC and Tevatron teams announce first joint result

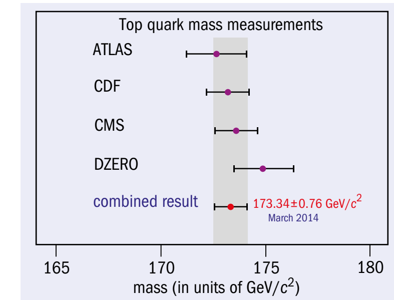
The collaborations working on the world's leading particle-collider experiments have joined forces, combined their data and produced the first joint result from Fermilab's Tevatron collider and CERN's Large Hadron Collider. Scientists from the four experiments involved – ATLAS, CDF, CMS and D0 – announced their joint findings on the mass of the top quark at the 2014 Rencontres de Moriond international physics conference on 19 March. The four collaborations pooled their data-analysis power to arrive at a world's best value for the mass of the top quark of 173.34±0.76 GeV/c^2.

Experiments at the LHC and the Tevatron collider are the only ones that have observed the top quark – the heaviest-known elementary particle. Its large mass makes it one of the most important tools in the quest to understand the nature of the universe.

The CDF and D0 experiments discovered the top quark in 1995, and the Tevatron produced some 300,000 top-quark events during its 25-year lifetime, before it finally shut down in 2011 (*CERN Courier* December 2011 p43). Now the LHC is the world's leading top-quark factory, having produced close to 18-million events with top quarks since it started collider physics operations in 2009.

Each of the four collaborations had previously released their individual measurements of the top-quark mass. Combining them together required close collaboration between the four large groups of researchers, and a detailed understanding of each other's techniques and uncertainties. Each experiment measured the mass of the top quark using several different methods. The analyses involved a variety of top-quark decay channels, employing sophisticated techniques that have been developed and improved over more than 20 years of top-quark research, beginning at the Tevatron and continuing at the LHC.

More than 6000 researchers from more than 50 countries participated in the four experimental collaborations.



The four individual top-quark mass measurements by the ATLAS, CDF, CMS and D0 collaborations, together with the joint and most precise measurement. (Image credit: ATLAS, CDF, CMS and DZero; CERN/Fermilab.)

● **Further reading**
The ATLAS, CDF, CMS and D0 collaborations 2014 arXiv:1403.4427 [hep-ex].

While this article was in preparation, the CMS Collaboration released the world's most precise single measurement of the top-quark mass in the semileptonic decay channel, using the experiment's full sample of data at 8 TeV. Combined with the previous CMS results, this gives a mass of 172.22±0.73 GeV/c². More details will appear in the next edition of CERN Courier.

COLLABORATION

CERN and ESA sign co-operation agreement

On 28 March, CERN and the European Space Agency (ESA) signed a framework agreement for future co-operation on research and technology in areas of mutual interest. Future areas might include the development and characterization of innovative materials for applications in extreme conditions and for cutting-edge scientific performances, the development of new micro-technologies to be applied in miniaturized distributed sensor systems, and the development and testing of high-performance detectors for high-energy physics experiments and space payloads.

This year is CERN's 60th anniversary and ESA's 50th, making the signature an opportunity to celebrate the memory of a scientist who was a founding father of both organizations: the Italian, Edoardo Amaldi. During the ceremony, ESA's director-general Jean-Jacques Dordain presented CERN's director-general, Rolf Heuer, with copies of letters by Amaldi in which he lays out his concern for peace and the role science should play in fostering it. These letters were flown aboard ESA's Automated Transfer Vehicle 3 – a spacecraft named in Amaldi's honour (*CERN Courier* June 2012 p25).

A shared stand at the Hannover Messe – the world's biggest industrial fair held this year on 7–11 April – was the first tangible implementation of this bilateral agreement. Left to right: ESA astronaut Andre Kuipers talks to Enrico Chesta and Giovanni Anelli from CERN's Knowledge Transfer Group. (Image credit: Rheinland Relations.)

Sommaire en français

LHC PHYSICS

CMS sets new constraints on the width of the Higgs boson

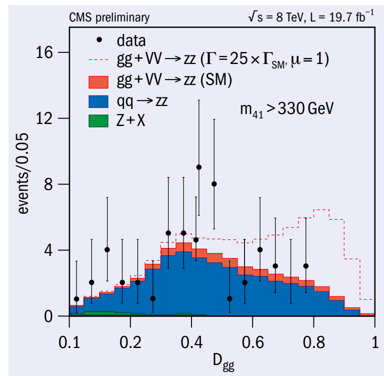
After the discovery of a Higgs boson at the LHC in 2012, all of the measurements of its properties and tests of its spin-parity have proved to be consistent with the predictions of the Standard Model. One important property is its natural width, which is expected to be small in the Standard Model – approximately 4 MeV. A larger width could indicate, for example, additional non-standard Higgs decays into known or unknown particles.

At the 2014 Rencontres de Moriond in March, the CMS collaboration presented new and stronger constraints on the total width of the 125 GeV Higgs boson by applying a novel technique on the data collected at the LHC at a centre-of-mass energy of 8 TeV. Following suggestions from several theorists to measure the ratio of the production rate for Higgs-mediated ZZ events with a mass considerably above the mass of the resonance (larger than approximately 200 GeV) to that on the peak, it is possible to derive precise indications on the maximal size of the Higgs boson's natural width. For this analysis, CMS exploited two ZZ decay channels of the Higgs boson: $H \to ZZ \to 4$ leptons, where the four leptons can be electrons or muons, and $H \to ZZ \to 2$ leptons + 2 neutrinos.

To maximize the sensitivity of this analysis, in the 4-lepton channel, CMS took advantage of the kinematic differences between 4-lepton production occurring through gluon–gluon fusion (as for Higgs production) and through quark–antiquark scattering, which constitutes a large background to this analysis. The collaboration employed a matrix-element likelihood discriminant D_{gg} similar to that used for the standard Higgs analysis to help separate signal from background, and carried out a simultaneous fit of this discriminant versus the 4-lepton mass to measure the cross-section for off-peak production. The figure shows the distribution of the discriminant D_{gg} for events with high mass.

The 2 lepton + 2 neutrino channel has the advantage of a larger branching ratio, but it comes at the price of more background: owing to the presence of neutrinos, the final state is not fully reconstructed. This channel is based on the presence of large missing transverse energy (MET), and therefore is only sensitive to the off-shell part of the cross-section. In the case of on-peak production, the Z decaying into neutrinos does not have large transverse momentum and does not generate a significant MET. The on-peak cross-section measured from $H \to ZZ \to 4$ leptons is used for both channels.

The final result of the analysis is that the two channels have very similar sensitivities. In the Standard Model scenario, each of them is expected to exclude at the 95% confidence level (CL) a Higgs-boson width about 10 times larger than the natural width predicted by the model. The combined result is an exclusion of 17 MeV (35 expected) at 95% CL, which corresponds to 4.2 (8.5 expected) times the width in the Standard Model. Previous direct limits obtained from the measured width of the $H \to ZZ$ and $H \to \gamma\gamma$ peaks, which are dominated by the detector resolution, are much weaker (of the order of a few giga-electron-volts).



Distribution of the gluon-gluon discriminant D_{gg} for events with a 4-lepton mass larger than 330 GeV. The expectations of the Standard Model are given by the solid filled histograms, while data are represented by the black dots. An increased natural width of the Higgs boson would enhance the high region of D_{gg} as indicated by the dashed line for which a total width 25 times the Standard Model value is assumed.

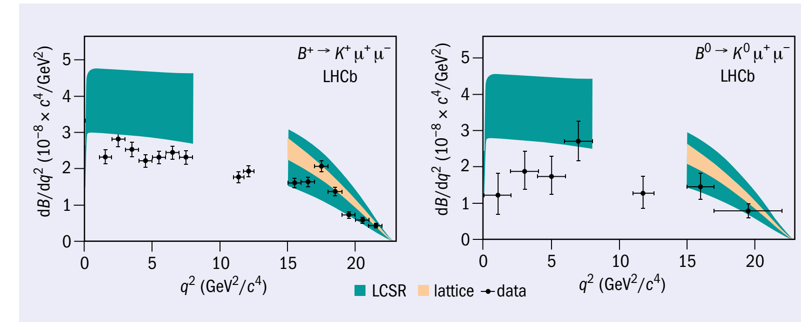
Further reading

CMS Collaboration 2014 CMS-PAS-HIG-14-002.
N Kauer and G Passarino 2012 *JHEP* **08** 116.
F Caola and K Melnikov 2013 *Phys. Rev. D* **88** 054024.
G Passarino 2013 arXiv:1312.2397 [hep-ph].

LHCb's results become more precise

By the time that the first long run of the LHC ended early in 2013, the LHCb experiment had collected data for proton–proton collisions corresponding to an integrated luminosity of 2 fb^{-1} at 8 TeV, to add to the 1 fb^{-1} of data collected at 7 TeV in 2011. The first batch of data allowed the LHCb collaboration to announce a variety of results, many of which have now been updated using the larger data sample and/or by including different decay channels. At the 2014 Rencontres de Moriond conference in March, the collaboration presented more precise results from a number of different analyses.

The flavour-changing neutral-current decay $B \to K^*\mu^+\mu^-$ is an important channel in the search for new physics because it is highly suppressed in the Standard Model. While there are relatively large theoretical uncertainties in the predictions, these can be overcome by measuring asymmetries in which the uncertainties cancel. One of these is the isospin asymmetry, based on the differences in the results of measurements of $B^0 \to K^*\mu^+\mu^-$ and $B^+ \to K^{*+}\mu^+\mu^-$. The Standard Model predicts this isospin asymmetry to be small, which LHCb confirmed in 2011, based on 1 fb^{-1} of data (*CERN Courier* September 2011 p13). On the other hand, a similar analysis for decays in which the excited K^* is replaced by its ground state K, showed evidence for a possible isospin asymmetry (*CERN Courier* July/August 2012 p6).



The differential branching fractions measured by LHCb for $B^+ \to K^+\mu^+\mu^-$ (left) and $B^0 \to K^0\mu^+\mu^-$ show a small tendency to have lower values than the theoretical predictions.

Now, the analysis of the full 3 fb^{-1} of data, which was presented at the Moriond conference, gives results that are consistent with the small asymmetry predicted by the Standard Model in both the K^* and K cases. However, even if this confirms that the difference between B^0 and B^+ decays is small for this channel, there is a tendency for the differential branching fractions to have lower values than the theoretical predictions, as the figures show.

Another interesting result that LHCb has now refined concerned the exotic state X(3872), which was discovered by the Belle experiment at KEK in 2003. The nature of the X(3872) is puzzling because although it appears charmonium-like, it does not fit in to the expected charmonium spectrum. Exotic interpretations include the possibility that it could be a DD^* molecule or a tetraquark state.

With the data from 2011, LHCb unambiguously determined its quantum numbers J^{PC} as 1^{++} (*CERN Courier* March 2013 p8). At Moriond the collaboration went further by presenting a measurement of the ratio of the branching fractions for the decay of the X(3872) into $\psi(2S)\gamma$ and $J/\psi\gamma$. This ratio, $R_{\psi\gamma}$, is predicted to be different depending on the nature of the X(3872). LHCb finds $R_{\psi\gamma} = 2.46 \pm 0.64 \pm 0.29$, which is compatible with other experiments but more precise. This value does not support the interpretation as a pure DD^* molecule.

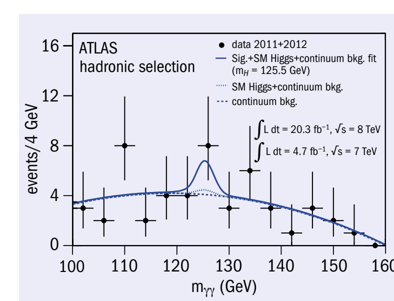
Further reading

M Patel LHCb Collaboration 2014 LHCb-TALK-2014-034.
I Polyakov LHCb Collaboration 2014 LHCb-TALK-2014-047.

ATLAS uses $t \to qH$ decays to pin down the Higgs

Since the observation of a Higgs boson at a mass around 125.5 GeV by ATLAS and CMS in July 2012, both collaborations are making every effort to pin it down and decide if it is indeed the Higgs boson of the Standard Model, or the first member of a somewhat larger family, as predicted by several models that go beyond the Standard Model. Working in this direction, ATLAS used the six million $t\bar{t}$ pairs produced in Run I of the LHC to look for the possible decay of a top quark or antiquark into a light quark (up or charm) and a Higgs boson, $t \to qH$.

In the Standard Model such decays, which proceed via flavour-changing neutral currents, are highly suppressed, but in more complex models they might be present, albeit with a small branching ratio compared ▷



Distribution of the diphoton invariant mass $m_{\gamma\gamma}$ for the selected events with four jets or more. The result of a fit to the data of the sum of a signal component with the mass of the Higgs boson fixed to m_H = 125.5 GeV and a background component (dashed) described by a second-order polynomial is superimposed. The small contribution from SM Higgs boson production, included in the fit, is also shown (the difference between the dotted and dashed lines).

with the dominant $t \to bW$ decay. Doing the search using the dominant decay mode of the Higgs boson ($H \to b\bar{b}$) would lead to final states that are very hard to distinguish from the majority of $t\bar{t}$ decays. Therefore ATLAS made the choice to use the $H \to \gamma\gamma$ decay mode – which has a clean signature of two photons with high transverse-momentm (p_T) clustering as a narrow peak in invariant mass around 125.5 GeV – the power of this decay mode being demonstrated by the Higgs-boson discovery. Unfortunately the use of this decay mode is hampered by a small branching fraction, only 0.23%. Putting numbers together, and taking into account the acceptance of the detector and of the selection, a branching ratio B of 1% for $t \to qH$ would lead to about 11 observed events in a topology with two high p_T photons and four jets, of which one would be identified as a b-jet. In addition, about three events with two high-p_T photons, two jets, a lepton and missing transverse momentum (from the leptonic decay of the W) would also be expected.

After making kinematical cuts to ensure the compatibility of the selected events with the $t\bar{t}$ final state, ATLAS obtained the diphoton mass-spectrum shown in the figure (p7). This rules out B = 1% immediately because it is clear that there is not an 11-event signal at 125.5 GeV. A detailed statistical analysis gives an expected limit on B of 0.53%. The small, non-significant excess in the 124–128 GeV bin worsens the observed limit to 0.79%, at the 95% confidence level.

This is the first experimental result on this channel and its precision is limited, mainly by the available statistics. When data become available at 13/14 TeV – leading to an increase of the $t\bar{t}$ production cross-section of almost a factor of four – and with a larger integrated luminosity, either a much tighter limit will be obtained or, perhaps, a significant signal will show up, giving evidence for physics beyond the Standard Model in the Higgs sector.

Further reading

ATLAS Collaboration 2014 arXiv:1403.6293 [hep-ex].

LHCf investigates proton–lead collisions

The final run of the LHC in January 2013 prior to the start of the current long shutdown provided collisions between a beam of protons and a beam of lead ions, allowing the LHCf experiment to make further studies related to the interactions of cosmic rays in the Earth's atmosphere. In particular, the collaboration was able to measure the distribution in transverse momentum (p_T) for the inclusive production of neutral pions in the very forward region.

Despite several experimental indications at the HERA electron–proton collider at DESY, it is still not well understood how the density of partons (quarks and gluons) in a proton target increases or even saturates when Bjorken-x in the target – essentially the fraction of the proton's momentum – is extremely small. Such phenomena are known to be visible in events at large rapidities – that is, close to the beam direction. Furthermore, in the case of nuclear targets, the parton density in the target is expected to be larger by about $A^{1/3}$, where A is the nuclear mass number. In hadronic interactions, partons in the projectile hadron would lose their energy while travelling in the dense QCD-governed matter of the nuclear target, and particle production mechanisms would change accordingly when compared with

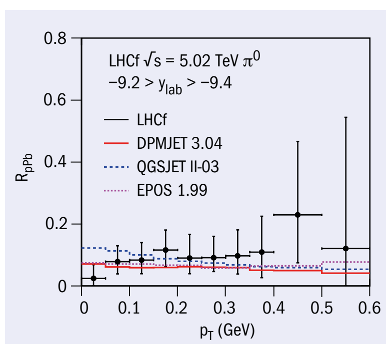


Fig. 1. The nuclear modification factor for π^0's. Filled circles indicate the factors obtained by the LHCf measurements. Other lines are the predictions from hadronic interaction models.

those in nucleon–nucleon interactions.

The LHCf detector is designed to measure the hadronic production cross-sections of neutral particles emitted at angles close to the beam direction – the "very forward" region – in proton–proton (pp) and proton–lead (pPb) collisions at the LHC. The detector covers a pseudorapidity range larger than 8.4 and is capable of precise measurements of the forward high-energy inclusive-particle-production cross-sections of neutral particles. Now, the collaboration has analysed the data taken in January 2013 on pPb collisions at nucleon–nucleon centre-of-mass energies of $\sqrt{s_{NN}} = 5.02$ TeV and a beam-crossing angle of 145 μrad, for an integrated luminosity of 0.63 nb^{-1}.

To obtain the soft-QCD component of the forward pion production, which is sensitive to the parton density in target, unavoidable contamination from ultra-peripheral collisions was first calculated using Monte Carlo simulations and then subtracted from the measured p_T spectra. Once the ultra-peripheral collisions have been taken into account, the p_T spectrum measured by LHCf in the rapidity range $-11.0 < y_{lab} < -8.9$ and $0 < p_T < 0.6$ GeV (in the detector reference frame) indicates a strong suppression of the production of neutral pions. This leads to a value of the nuclear modification factor value, R_{pPb}, relative to the interpolated p_T spectra in pp collisions at $\sqrt{s} = 5.02$ TeV, of about 0.1–0.4 – a value that is in overall agreement with the predictions of several Monte Carlo simulations of hadronic interactions.

Further reading

O Adriani 2014 arXiv:1403.7845 [nucl-ex], submitted to *Phys. Rev. C*.

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

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

Gran Sasso

OPERA sees a fourth τ neutrino

The OPERA experiment at the INFN Gran Sasso Laboratory has detected a fourth example of neutrino oscillation, with a muon neutrino (ν_μ) produced at CERN detected as a τ neutrino (ν_τ) after travelling a distance of 730 km.

The international OPERA experiment, which involves 140 physicists from 28 research institutes in 11 countries, was designed to observe this exceptionally rare phenomenon, gathering data in the neutrino beam produced by the CERN Neutrinos to Gran Sasso (CNGS) project (*CERN Courier* November 2006 p24). Generated by decays of pions and kaons made in the interactions of a proton beam from the Super Proton Synchrotron with a graphite target, the beam consisted mainly of ν_μ that would pass unhindered through the Earth's crust towards Gran Sasso. The appearance and subsequent decay of a τ lepton in the OPERA experiment provides the telltale sign of ν_μ to ν_τ oscillation through a charged-current interaction.

After the first neutrinos arrived at the Gran Sasso Laboratory in 2006, the experiment gathered data for five consecutive years, from 2008 to 2012, during which the CNGS beam delivered a total of 17.97×10^{19} protons on target, yielding 19,500 neutrino events in the detector. The first ν_τ was observed in 2010, the second and third ones in 2012 and 2013, respectively (*CERN Courier* July/August 2010 p5, July/August 2012 p7 and May 2013 p8).

The detection of the fourth ν_τ is important confirmation of the events seen previously. It means that the ν_μ to ν_τ transition has been seen for the first time with a statistical significance exceeding the 4σ level, so that OPERA can now claim the observation of this extremely rare phenomenon. The collaboration will continue to search for ν_τ in the data that remain to be analysed.

The OPERA detector, built from two identical super modules, each containing a target section and a large-aperture muon spectrometer. The target consists of alternate walls of lead/emulsion bricks – with 150,000 bricks in total – and modules of scintillator strips for the target tracker. (Image credit: OPERA.)

Sciencewatch

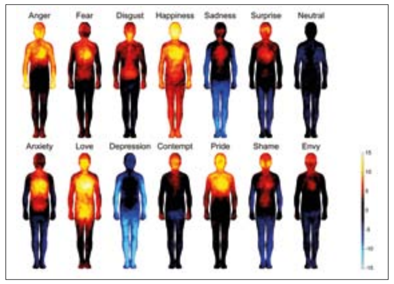
Compiled by John Swain, Northeastern University

Finnish team maps emotions

Common speech has many expressions – e.g, "cold feet" or "a broken heart" – that associate emotions with parts of the body. In a remarkable study, Lauri Nummenmaa of Aalto University in Finland and colleagues asked online participants to report their bodily sensations by colouring human silhouettes in response to emotional words, stories, movies or facial expressions. The responses were digitized on a map of a body represented by 50,634 data points. The survey was conducted as five experiments on 701 participants.

The analysis revealed statistically separable body maps associated with different emotions, from anger and anxiety to sadness and surprise. The results were highly concordant across West European and East Asian samples, suggesting that emotions are felt in the body in universal ways.

To participate in the ongoing online experiment, visit http://becs.aalto.fi/~lnummen/participate.htm.



The patterns found for basic (top) and nonbasic (bottom) emotions associated with words. The body maps show regions where activation increased (warm colours) or decreased (cool colours) when feeling each emotion.

● Further reading
L Nummenmaa *et al.* 2014 *PNAS* **111** 646.

Deep water

Jules Verne imagined an ocean deep underground in his 1864 novel Journey to the Centre of the Earth and it turns out that, in a sense, he might have been right. Graham Pearson of the University of Alberta in Edmonton and colleagues found a sample of ringwoodite – a mineral from the Earth's mantle transition zone, which lies 410–660 km below the surface – in a diamond from Juína in Brazil, which must have been driven upwards rapidly, possibly by a volcanic explosion. If this inclusion (about 1% by weight) is representative of the transition zone, then its high water content indicates that this zone contains 1.4×10^{21} kg, or about the same as all the world's oceans combined.

● Further reading
D G Pearson *et al.* 2014 *Nature* **507** 221.

Smarter in orange

Melanopsin, a light-sensitive protein in the retina, seems to play a role in the cognitive function of the brain. Sarah Chellappa of the University of Liège and colleagues used functional magnetic resonance imaging to look at brain activity in 16 people while they performed cognitive tests after exposure to different colours of light for 10 minutes followed by 70 minutes of darkness. The tests were done under green light.

People exposed to orange light had more activity in the prefrontal cortex, which is involved in higher brain function. This provides the best evidence so far that melanopsin, which plays no role in vision but absorbs orange-red light, affects mental performance and contributes to a unique "photic memory".

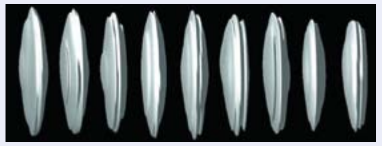
● Further reading
S L Chellappa *et al.* 2014 *PNAS Early Edition*, www.pnas.org/cgi/doi/10.1073/pnas.1320005111.

Seeing the vacuum

The idea of energy in the vacuum of quantum field theory is familiar, at least to physicists. Now it has been imaged in 3D for the first time. Moonjoo Lee of Seoul National University and colleagues used single barium atoms as a spontaneous-emission probe for the vacuum energy density inside high-Q microcavities that were built as a 2D array of 170 nm holes in a 75-nm-thick silicon-nitride membrane.

Excited atoms sent into a cavity emitted a photon with a probability that was proportional to the vacuum field-intensity at the cavity's position. A measurement of transit-time broadening then gave the distribution of the vacuum energy in the transverse directions, while the spectrum of the emitted photons gave it along the atom's flight path. This allowed for the construction of a full 3D image of the vacuum energy density in the cavity. The team could also measure the amplitude of the vacuum field in the cavity, which was as large as 1 V/cm, therefore putting a value on the emptiness of "empty space".

● Further reading
M Lee *et al.* 2014 *Nature Communications* **5** 3441.



The 3D image made of the cavity vacuum-field intensity.

Nanotubes improve photosynthesis

Single-walled carbon nanotubes (SWNTs) can increase photosynthesis in chloroplasts – the parts of plant cells where the process takes place. Michael Strano at Massachusetts Institute of Technology and colleagues have found that SWNTs passively transport to, and irreversibly localize in, the lipid envelopes of extracted choloroplasts. They can absorb light over a wider range than chlorophyll, forming excitons that can feed electrons into the photosynthetic machinery, therefore vastly boosting its efficiency.

Poly(acrylic acid)-nanoceria or SWNT-nanoceria complexes were also incorporated to reduce levels of reactive oxygen species. SWNTs can also be turned into chemical sensors, making chloroplasts not only more efficient but also able to act as photonic chemical sensors. They can even be incorporated into complete living plants.

● Further reading
J P Giraldo *et al.* 2014 *Nature Materials* **13** 400.

Astrowatch

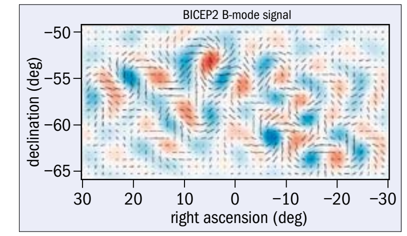
Compiled by Marc Türler, ISDC and Observatory of the University of Geneva, and University of Zurich

BICEP2 finds evidence of cosmic inflation

The news came as a surprise on 17 March, making a "big bang" in the physics community. Within hours of the announcement, physicists around the world had become aware of the existence of the Background Imaging of Cosmic Extragalactic Polarization (BICEP2) telescope at the South Pole, and were hypnotized by the figure showing the swirling B-mode polarization of the cosmic microwave background (CMB), and by the profound implications of the discovery. The observations not only provide the first direct evidence for inflation, but also determine its energy scale and bear witness to a quantum-gravitational process.

The idea of cosmic inflation was originally proposed in 1980 by Alan Guth, then at Cornell University, to solve several cosmological problems identified in the 1970s. In this scenario, the inflationary epoch is an extremely brief period just after the Big Bang lasting a mere 10^{-32} s. During this minuscule fraction of a second, the universe would have expanded at superluminal speed by a factor of at least 10^{25}. Inflation would result from a hypothetical inflaton field acting as a cosmological constant to produce an accelerated expansion of the universe. The inflation ends with the decay of the inflatons into Standard Model particles.

During inflation, quantum fluctuations of the inflaton field would be stretched and amplified to produce the density fluctuations of the CMB observed by the Wilkinson Microwave Anisotropy Probe and Planck satellites (*CERN Courier* May 2006 p12, May 2008 p8, May 2013 p12). Theorists have speculated further that quantum fluctuations of the space–time metric would also be "frozen in" by inflation, producing characteristic gravitational waves. From inflation to the recombination epoch – when electrons combine with protons to form hydrogen atoms – there would have been 380,000 years during which photons would scatter off electrons and become polarized. The net polarization of the CMB therefore reflects inhomogeneities in the hot plasma of the early universe.



Map of the B-mode pattern observed with the BICEP2 telescope, with the line segments showing the polarization amplitude and orientation. The red and blue shading shows the degree of clockwise and anticlockwise twisting of this curl or B-mode pattern. (Image credit: BICEP2 collaboration.)

Whereas both density and metric fluctuations can produce a gradient field in the sky – the so-called E-mode polarization – only metric fluctuations can produce the curl component of the polarization, the so-called B mode. Although there are foreground contaminations that can produce B modes at lower angular scales, finding B-mode polarization on the scale of a few degrees implies the presence of primordial gravitational waves.

It is this type of polarization that BICEP2 has discovered in the CMB. The signal is more than 100 times weaker than the intensity fluctuations of the CMB, which explains why these tiny variations at the 0.1 μK level have not been detected earlier. To achieve this precision, the BICEP2 experiment is equipped with 512 detectors cooled down to 0.27 K and installed at the South Pole. At an altitude of more than 3000 m, the site provides the closest conditions to space with cold, dry, stable air.

The strong B-mode signal found by the BICEP2 experiment corresponds to a tensor-to-scalar ratio $r = 0.20{+0.07}{-0.05}$, with $r = 0$ disfavoured at the 6σ level. This is very good news for theorists who feared a much lower value of r, which would prevent the detection of B modes. The high-value of r implies an energy scale for inflation of around 2×10^{16} GeV. The BICEP2 measurements therefore offer a glimpse at physics at an energy approaching the Planck scale, where all of the fundamental forces are thought to be unified. This explains the burst of nearly 100 new publications citing the BICEP2 paper that had appeared by the end of March. The Planck satellite and other facilities now have the challenge of confirming these exciting results.

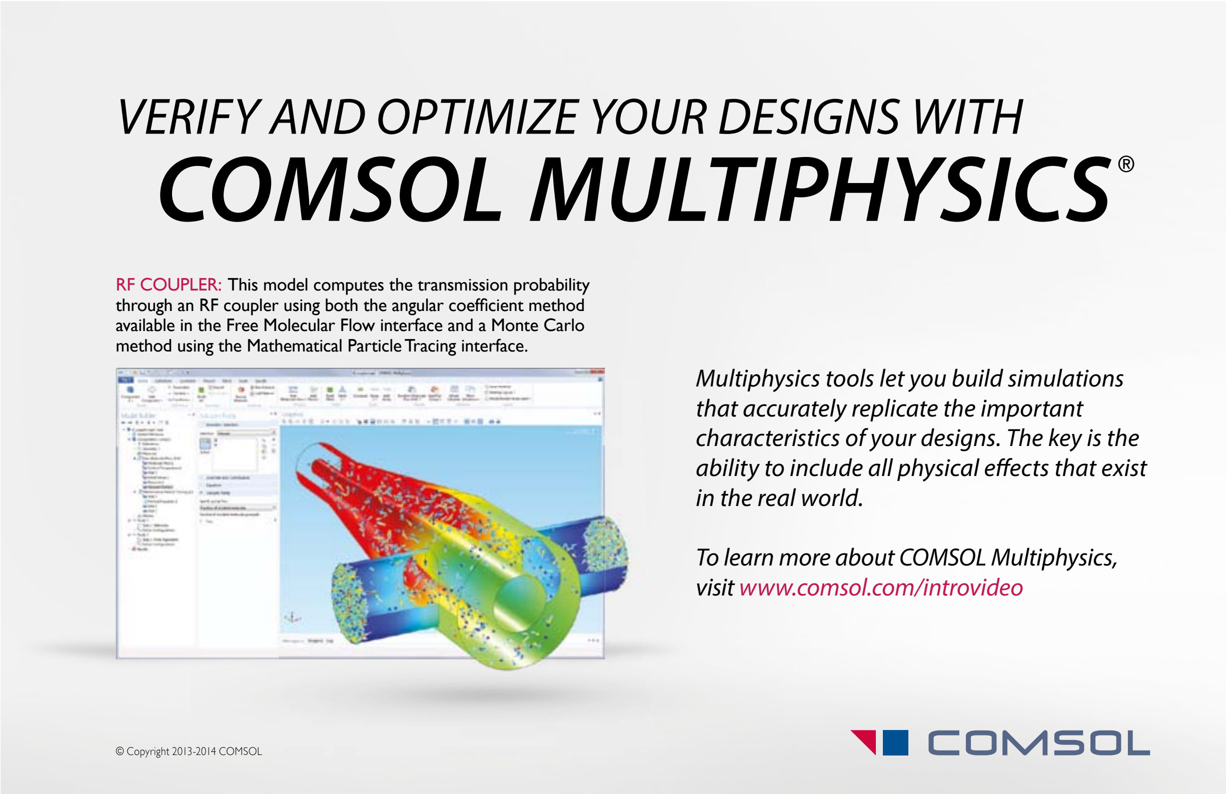
BICEP2 is the second stage of a co-ordinated programme with the BICEP and Keck Array experiments. The four principal investigators are John Kovac (Harvard/CfA), Clem Pryke (University of Minnesota), Jamie Bock (Caltech/JPL), and Chao-Lin Kuo (Stanford/SLAC).

Further reading

BICEP2 Collaboration, Ade *et al.* 2014 arXiv:1403.3985 [astro-ph.CO].

Picture of the month

Each year the Hubble Space Telescope releases a new image to celebrate its birthday. This year, the subject of its 24th celebratory snap is part of the Monkey Head Nebula. Otherwise known as NGC 2174, this cloud of gas and dust lies about 6400 light-years away in the Orion constellation. This region is filled with young stars embedded within bright wisps of cosmic gas and dust. Dark dust clouds billow outwards, framed against a background of bright blue gas. These vivid clouds are actually a violent stellar nursery packed with the ingredients needed for star formation. The image is reminiscent of the "mystic mountains" released for Hubble's 20th anniversary (Picture of the month, *CERN Courier* June 2010 p10). (Image credit: NASA/ESA and the Hubble Heritage Team (STScI/AURA).)



CERN Courier Archive: 1971

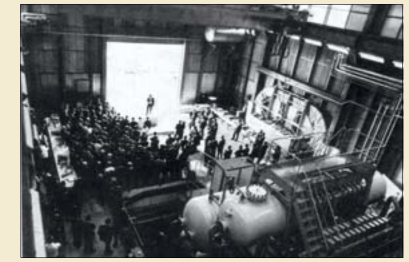
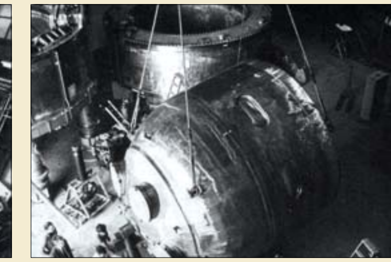
A LOOK BACK TO CERN COURIER VOL. 11, MAY 1971, COMPILED BY PEGGIE RIMMER

DETECTORS

CERN heavyweights

Gargamelle, the largest heavy liquid bubble chamber in the world, was inaugurated on 7 May when it passed formally from the charge of its designers and builders at Saclay to the charge of CERN. There was a large gathering, in the Gargamelle hall, of those who had worked on its construction and those who are now to use it in experiments. Before the inauguration ceremony, Gargamelle had already taken 14,500 photographs of antineutrinos and neutrinos and the quality of its performance makes for an excellent start.

After everyone had had an opportunity to admire the huge chamber and see the photographs of the first tracks, speech-time began. R Levy-Mandel (Director of the Saturne department at Saclay), A Lagarrigue (Director of the Linear Accelerator Laboratory at Orsay) and Ch Peyrou (Director of the Track Chambers Division at CERN) traced the development of the project since A Lagarrigue, A Rousset and R Florent first sketched the outline in 1964. The Director General of CERN, W Jentschke, concluded, wishing Gargamelle well in its coming years of physics research.

Left: The Gargamelle hall during the inauguration ceremony on 7 May. The pressure tanks can be seen in the foreground. (Image credit: CERN 78.5.71.) Right: The body of the Big European Bubble Chamber BEBC shortly after its arrival at CERN on 23 April. (Image credit: CERN 173.4.71.)

To cope with part of the output of the experiments to be done in the 3.7 m European hydrogen bubble chamber [BEBC], CERN is setting up a new data handling system, ERASME, Electron Ray Scanning and Measuring Equipment. An important step has been the signing of a contract with Digital Equipment Corporation for a PDP-10 computer.

ERASME will consist of a number of scanning and measuring S/M units (there is potential for five) linked to the PDP-10 computer. Each unit will have its own precision cathode ray tube scanner to make the measurements, and the film image will be projected optically so that the operator can find the events to be measured and guide the system during the measuring procedure. Immediately after an event is measured the computer can reconstruct it in three dimensions.

The role of the PDP-10 (which will have 96,000 words of core memory, two large disk packs, two magnetic tape units and a line printer) is to provide each S/M unit with the necessary computing capability to control the measuring process, filter the measurements, reconstruct events, output the measured events data, and communicate with the operators.

● Compiled from texts on p127 and p132.

Omega progress

One of the major items of the CERN improvement programme is the construction of Omega, a large "universal" detector using electronic techniques, to be used in much the same way as a bubble chamber. It will be permanently positioned in the West Hall and will accommodate a variety of experiments.

The main component is a large superconducting magnet providing a field of 18 kG over a useful volume of 14 m^3. For initial operation, optical spark chambers would fill the magnet aperture and events would be photographed. The advantage over bubble chambers is that the system will be triggered to photograph only interesting events.

To eliminate the time consuming business of scanning and measuring photographs, TV cameras of the Plumbicon type, which have recently become commercially available, could be used to convert the spark chamber information into electronic form for direct processing by a computer. With a dead time between 5 and 10 ms, their data taking potential is over fifty events per PS cycle, implying that figures approaching a million events per day become possible.

An additional factor has been the possible use of multiwire proportional chambers. MPCs can operate in high magnetic fields and have a very short resolution time (less than 100 ns). Initially, MPCs will be used for triggering, where they can be more selective than scintillators.

● Compiled from texts on pp127–128.

Compiler's Note

Before the advent of electronic detectors, more than 100 bubble chambers were built throughout the world and more than 100 million stereo pictures were taken. Invented in 1952, for the next 30 years these chambers played a key role in the reconstruction of physics in post-war Europe and the growth of wider international collaboration. Globally, their use propagated an impressive evolution in particle physics and associated technologies.

The exploitation of digital computers for data handling started with bubble chambers. Bubble-chamber film was easily transportable from recording sites to collaborating institutes and universities for analysis, and joint efforts with industry produced commercially available measuring machines.

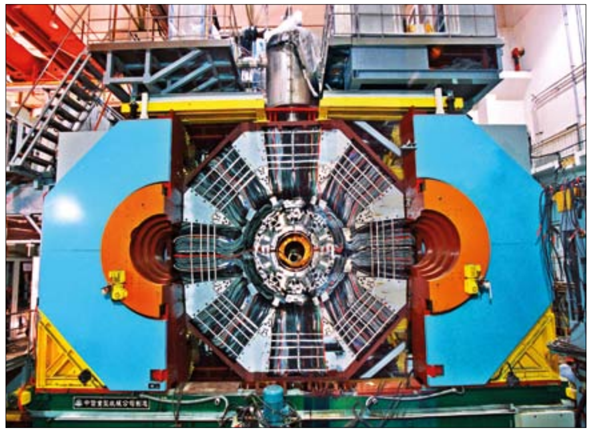
Gargamelle was noted for the 1973 discovery of weak neutral currents and operated until 1979, while BEBC produced physics until 1984. They were two of the last chambers constructed. The fossils of these venerable dinosaurs can be seen in the CERN garden alongside the Microcosm exhibition.

● See also *CERN Courier* July/August 2004 p26.

New particles

BESIII and the XYZ mystery

In continuing its precision studies of the energy region of the τ and charm particles, the BES collaboration has begun to investigate the puzzling XYZ states.



The BESIII spectrometer. (Image credit: BESIII/IHEP.)

BESIII is the latest incarnation of an experimental programme that began in 1989 when the Beijing Electron–Positron Collider (BEPC) and the Beijing Spectrometer (BES) detector started operation at the Institute of High Energy Physics (IHEP). The focus is on the physics of charm and the τ lepton, which are accessible at the centre-of-mass energies of BEPC. The BES programme is the only one in the world to focus entirely on this area of particle physics through the collection of record numbers of J/ψ, ψ', D and τ particles. During the past two decades, thanks to the luminosity available first at BEPC and then at BEPCII, the BES collaboration has made many important, high-precision measurements. More recently, this has led to investigations of new particles – the XYZ particles – that appear not to fit in with the standard picture of charmonium states.

One of the first major contributions of the BES programme came in 1992, when the collaboration made a much more precise measurement of the mass of the τ lepton and cleared up a big disagreement between the particle's mass, its lifetime and its branching ratio to electrons – quantities that are related by the Standard Model. Then from 1993 to 1997, BEPC and BES were upgraded. BES became BESII and received a new main drift chamber (MDC) and time-of-flight (TOF) system. The collaboration soon embarked on a scan of the ratio of hadron to muon-pair production, which measured the hadronic cross-section at 93 energy points in the range 2–5 GeV and improved the precision in this region from 15–20% to less than 6%.

These cross-section results, together with many different measurements from Fermilab, CERN's Large Electron–Positron collider and the LHC, are used in stringent tests of the Standard Model. The cross-section measurements are required to determine the value of the fine structure constant, α_{QED} – which is not constant – at the mass of the Z boson, $\alpha_{QED}(M_Z)$. The new cross-section measurements shifted the value of $\alpha_{QED}(M_Z)$ and also moved the mass of the Higgs boson predicted by the Standard Model to be more in line with the measured lower limits on the mass at that time. BES and BESII also produced many other results on J/ψ and ψ' hadronic decays, ψ' transitions, and D and D_s decays.

The upgrade of BEPC to BEPCII began in 2004 and finished in 2008 (*CERN Courier* September 2008 p7). The facility became a two-ring collider with 93 beam bunches in each ring, superconducting micro-β focusing quadrupole magnets, superconducting RF, and a design luminosity of $1\times10^{33}\,cm^{-2}\,s^{-1}$. At the same time, a brand new detector – BESIII – was constructed with a small-celled, helium-based MDC, a new TOF system, a CsI(Tl) electromagnetic calorimeter, a resistive-plate-chamber muon identifier and a 1 T superconducting solenoidal magnet.

In the first year of operation, 2009, BESIII accumulated 106 million ψ' events and 226 million J/ψ events (*CERN Courier* June 2009 p7). With the ψ' data, BESIII was able to observe clearly the process $\psi'\rightarrow\pi^0 h_c$ followed by $h_c\rightarrow\gamma\eta_c$ and measure for the first time the individual branching ratios, which allowed comparison with theoretical predictions.

Later, BESIII measured the mass and width of the η_c, taking into consideration for the first time interference between the resonance and the non-resonant background. Previously, the CLEO collaboration had pointed out that the masses and widths of the η_c were different when measured in ψ' radiative decay and measured in proton–antiproton or two-photon production. Including the interference effect produced results that were consistent with the latter, and the most precise measurements to date. Moreover, BESIII was able to observe for the first time the M1 transition $\psi'\rightarrow\gamma\eta_c(2S)$ and measure the mass and width of the $\eta_c(2S)$ and the branching fraction for this process. With the J/ψ data, BESIII confirmed the X(1835) seen by BESII and observed two new resonances, the X(2120) and the X(2370), in the process $J/\psi\rightarrow\gamma\pi^+\pi^-\eta'$.

In the following years, BESIII accumulated another 1000 million J/ψ events, 400 million ψ' events, and approximately 3 fb^{-1} of data at the $\psi(3770)$ resonance. The $\psi(3770)$ decays more than 90% of the time to quantum-correlated $D\bar{D}$ pairs, which allow measurement of absolute branching ratios, as well as of $D\bar{D}$ mixing. The collaboration recently made the most precise determination of ▷

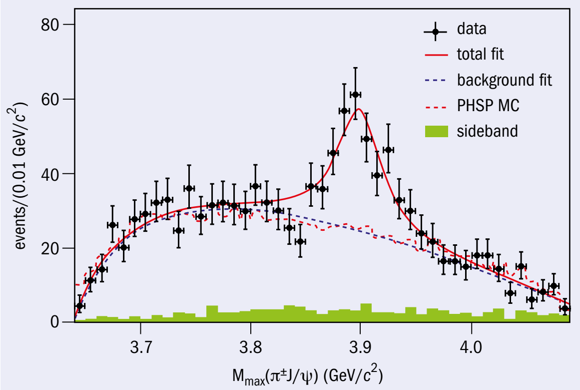


Fig. 1. Distribution of $\pi^{\pm}J/\psi$ mass for $e^+e^- \to \pi^+\pi^- J/\psi$ events at a centre-of-mass energy of 4.26 GeV, with a peak visible at 3.9 GeV/c². Dots with error bars are data, the dash-dot curve is the smooth non-resonant background and the smooth curve is the fit.

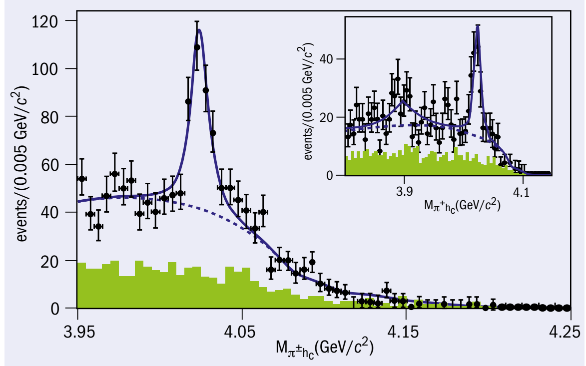


Fig. 2. Distribution of $\pi^{\pm}h_c$ mass for $e^+e^- \to \pi^+\pi^- h_c$ events for the combined data at centre-of-mass energies of 4.23, 4.26, and 4.36 GeV, with a peak visible at 4.02 GeV/c². Dots with error bars are data, the dotted curve is the smooth, non-resonant background and the smooth curve is the fit.

the branching ratio of $D \to \mu\nu$, which allows determination of the pseudo-scalar decay constant, f_{D+}, using the world-average value of the Cabibbo-Kobayashi-Maskawa matrix element $|V_{cd}|$, or determination of V_{cd} using the lattice QCD value of f_{D+}. The energy region of τ and charm is extremely rich in the variety of physics topics available and BESIII is accumulating world-class data sets to study them.

XYZ physics

The X(3872) was discovered in the decay of B mesons at KEK by the Belle experiment in 2003 (*CERN Courier* January/February p8). This was the first member of a family of exotic particles that do not agree with the predicted masses of charmonium particles in this mass region and decay in a peculiar way. Rather than decaying as expected into a pair of particles with open charm, such as a D meson and its antiparticle $\bar{D}$, they decay into $\pi^+\pi^- J/\psi$. In 2005, the BaBar experiment at SLAC discovered the Y(4260) in initial-state radiation (ISR) production, where much of the electron or positron energy is radiated away leaving the energy remaining at 4260 MeV (*CERN Courier* September 2005 p8). Like the X(3872), the Y(4260) has a mass that does not agree with those expected for charmonium and also decays to $\pi^+\pi^- J/\psi$.

The X(3872) and Y(4260) are members of the XYZ family of particles, which now contains numerous members, although many of them are not yet confirmed. The discovery of the particles, which do not fit into the standard picture, has sparked a great deal of theoretical interest and many theoretical papers.

In December 2012, BESIII jumped into the world of XYZ physics by beginning to take data at 4.26 GeV – the energy of the Y(4260). Running at this energy has the advantage that Y(4260) events might be produced directly rather than indirectly by B decay or ISR production, both of which have a much smaller cross-section.

Analysing the accumulated sample after one month of data taking, the collaboration found 1477 $e^+e^- \to \pi^+\pi^- J/\psi$, $J/\psi \to l^+l^-$ events – where l is an electron or a muon – and obtained a cross-section consistent with Y(4260) production (Ablikim *et al*. 2013a). The $\pi^{\pm}J/\psi$ mass distribution, shown in figure 1, revealed an unexpected structure that was named the $Z_c(3900)$. The mass and width of the $Z_c(3900)$ are $3899.0\pm3.6\pm4.9$ MeV/c² and $46\pm10\pm20$ MeV, respectively. The decay contains both charmonium – the J/ψ – and a charged pion, suggesting that the $Z_c(3900)$ contains four quarks (*CERN Courier* May 2013 p7). The discovery was quickly confirmed by the Belle collaboration and by an analysis of CLEO data. Other charged charmonium-like particles had been found earlier by Belle but never confirmed, so this is the first confirmed Z state.

Data taking continued through to June 2013 at 13 energies between 3.9 and 4.4 GeV, bringing the total luminosity to approximately 2.5 fb^{-1}, and the analysis of four other processes has now been completed. The first is $e^+e^- \to \pi^+\pi^- h_c$, where $h_c \to \gamma\eta_c$ and η_c decays to 16 exclusive hadronic states (Ablikim *et al*. 2013b). This is similar to the previous analysis with the J/ψ replaced by the h_c – another charmonium particle. Here again the $\pi^{\pm}h_c$ mass distribution reveals a narrow structure, named the $Z_c(4020)$, as shown in figure 2. The mass and width of the $Z_c(4020)$ are $4022.9\pm0.8\pm2.7$ MeV/c² and $7.9\pm2.7\pm2.6$ MeV, respectively. No significant $Z_c(3900)$ is seen in this process.

The second process analysed is $e^+e^- \to \pi^{\pm}(D^*\bar{D}^*)^{\mp}$, where a partial reconstruction technique is used that requires the identification of the $\pi^{\pm}$, a charged D from the decay of a charged D^*, and one π^0 from either the D^* or the $\bar{D}^*$ decay (Ablikim *et al*. 2014a). The analysis is based on 827 pb^{-1} of data at 4.26 GeV. When the mass recoiling from the $\pi^{\pm}$ is plotted, an enhancement is seen, as shown in figure 3, so the process is interpreted as $e^+e^- \to \pi^{\pm}Z_c(4025)^{\mp}$, $Z_c(4025)^{\mp} \to (D^*\bar{D}^*)^{\mp}$, where the mass and width of the $Z_c(4025)$ are $4026.3\pm2.6\pm3.7$ MeV/c² and $24.8\pm5.6\pm7.7$ MeV, respectively.

The third process is $e^+e^- \to \pi^{\pm}(D\bar{D}^*)^{\mp}$, where again a partial reconstruction technique is used, requiring that the $\pi^{\pm}$ and a D be identified (Ablikim *et al*. 2014b). The analysis is based on 525 pb^{-1} of data at 4.26 GeV. When the mass of the $(D\bar{D}^*)^{\mp}$ is plotted an enhancement is seen, as shown in figure 4, so the process is interpreted as $e^+e^- \to \pi^{\pm}Z_c(3885)^{\mp}$, $Z_c(3885)^{\mp} \to (D\bar{D}^*)^{\mp}$, where the mass and width of the $Z_c(3885)$ are $3883.9\pm1.5\pm4.2$ MeV/c² and $24.8\pm3.3\pm11.0$ MeV,

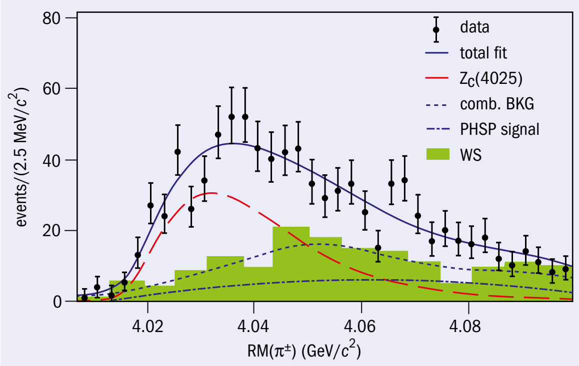


Fig. 3. Distribution of mass recoiling from the $\pi^{\pm}$ for $e^+e^- \to \pi^{\pm}(\bar{D}^*D^*)^{\mp}$ events at a centre-of-mass energy of 4.26 GeV, with a peak visible at 4.025 GeV/c² on top of the expected broad phase-space distribution and combinatorial background. Dots with error bars are data and the solid curve is the fit.

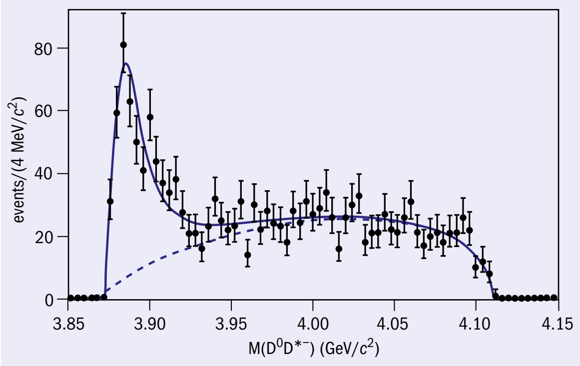


Fig. 4. D^0D^{*-} mass distribution for $e^+e^- \to \pi^+D^0D^{*-}$ events at a centre-of-mass-energy of 4.26 GeV, with a peak visible at 3.885 GeV/c². Dots with error bars are data, the dotted curve is the non-resonant background and the smooth curve is the fit. The corresponding mass distribution of $D^+\bar{D}^{*0}$ looks very similar.

respectively. The data prefer that the $Z_c(3885)$ has spin-parity $J^P = 1^+$.

Some of the Z_c states described above might be the same state. Interference has been neglected in the fitting of the peaks, and it could shift the masses and widths obtained. However, there are probably at least two separate Z_c states.

So far the X(3872) has been seen in B decays and hadron collisions only, but its quantum numbers are such that it should be able to be produced in radiative decays of the Y(4260). Figure 5 shows the $\pi^+\pi^- J/\psi$ mass distribution for $e^+e^- \to \gamma\pi^+\pi^- J/\psi$ events from the combined data at 4.009, 4.229, 4.26 and 4.36 GeV (Ablikim *et al*. 2014c). The clear peak has a mass of $3872.1\pm0.8\pm0.3$ MeV, to be compared with the mass $m(X(3872)) = 3871.68\pm0.17$ MeV listed in the Particle Data Group tables. Although the events could be produced directly, it is highly plausible that the X(3872) is from radiative decay of the Y(4260).

There are many possible theoretical explanations for the XYZ particles, including the Y(4260) and the recently discovered Z_c structures observed by BESIII. They include four-quark models with molecular states comprising charm and anti-charm particles, tetraquark states, and hadro-charmonium, as well as hybrid states (charmonium states with an extra gluon) and a model of initial single-pion emission. More experimental results are necessary to check the predictions of the various models and to decide which ones, if any, describe the physics correctly.

BESIII entered the era of XYZ physics by acquiring about 2.5 fb^{-1} of data at around 4.26 and 4.36 GeV. Currently, more data are being acquired and many other analyses of the data collected so far are in progress. Future results will help decide among the various models, or rule them all out.

• Further reading

M Ablikim *et al.* (BESIII) 2013a *Phys. Rev. Lett.* **110** 252001.
M Ablikim *et al.* (BESIII) 2013b *Phys. Rev. Lett.* **111** 242001.
M Ablikim *et al.* (BESIII) 2014a *Phys. Rev. Lett.* **112** 132001.
M Ablikim *et al.* (BESIII) 2014b *Phys. Rev. Lett.* **112** 022001.
M Ablikim *et al.* (BESIII) 2014c *Phys. Rev. Lett.* **112** 092001.

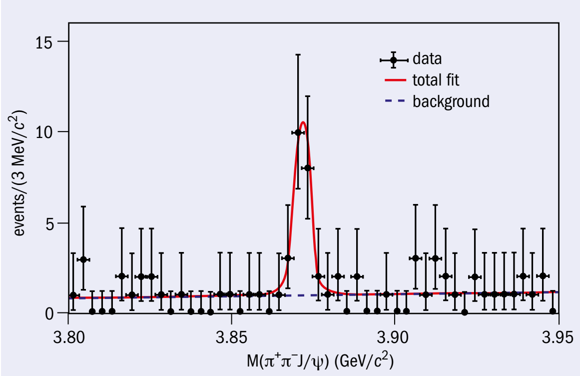


Fig. 5. $\pi^+\pi^- J/\psi$ mass distribution for $e^+e^- \to \gamma\pi^+\pi^- J/\psi$ events, with a peak at 3872 GeV/c². Dots with error bars are data and the smooth curve is the fit.

Résumé

Le BESIII et le mystère XYZ

Le BESIII est la dernière réalisation d'un programme d'expérimentation qui a commencé en 1989 avec le début de l'exploitation du collisionneur électron-positon de Beijing (BEPC) et du spectromètre de Beijing (BES) à l'Institut de physique des hautes énergies. Le programme se concentre sur la physique du charme et le lepton τ, qui sont observables aux énergies dans le centre de masse que peut produire le BEPC. Au cours des vingt dernières années, la collaboration BES a enregistré un grand nombre de mesures importantes et de haute précision, qui ont récemment ouvert la voie à des recherches sur les mystérieuses particules XYZ, lesquelles semblent ne pas s'intégrer dans la représentation standard des états charmonium.

Frederick A Harris, University of Hawaii.

PARTNER

A network for life

PARTNER – an innovative project to train young scientists in aspects of hadron therapy – has proved to be a great success.

PARTNER researchers at the network's final meeting at CNAO, the Italian centre for hadron therapy. (Image credit: PARTNER.)

The Particle Training Network for European Radiotherapy (PARTNER) was established in 2008 to train young biologists, engineers, radio-oncologists and physicists in the various aspects of hadron therapy. This deceptively simple statement hides a vision that was truly innovative when the project started: to offer a multidisciplinary education in this cutting-edge discipline to train a future generation of experts who would be aware of the different scientific and technological challenges and move the field forward. PARTNER went on to provide research and training opportunities for 29 young scientists from a variety of backgrounds and countries, between 2008 and 2012. The publication of selected papers from PARTNER in the *Journal of Radiation Research* offers the opportunity to assess the research outcomes of the project.

As a Marie Curie Initial Training Network (ITN) within the European Union's 7th Framework Programme (FP7), PARTNER was naturally focused on education, with a training programme encompassing science, technology and transferable skills (*CERN Courier* March 2010 p27). At the same time, the young scientists became engaged in research on a variety of topics from radiobiology to motion monitoring techniques, dosimetry, accelerators, computing and software tools. All of the research projects shared a focus on the impacts of clinical application, and many brought significant advances to the field.

Ingenious technologies

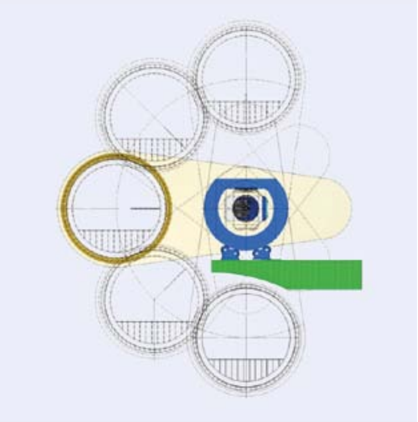
A key technology area is the development of affordable hadron-therapy installations. The next generation of accelerators should be smaller and less expensive. At the same time, they should allow fast, active energy modulation and have a high repetition rate, so that moving organs can be treated appropriately in reasonable time. PARTNER contributed to the design for the CArbon BOoster for Therapy in Oncology (CABOTO) – a compact, efficient high-frequency linac to accelerate C^{6+} ions and H_2^+ molecules from 150 to 410 MeV/u in about 24 m.

Gantries – the magnetic structures that bring particle beams onto the patient at the desired angle – are a major issue in the construction of carbon-ion facilities. The only existing carbon-ion gantry is installed at the Heidelberg Ion-Beam Therapy Center (HIT). It is a fixed, isocentric gantry 6.5 m tall and 25 m long, with a total weight of 600 tonnes. A design study supported by PARTNER and the FP7 project ULICE (*CERN Courier* December 2011 p37) proposed an innovative solution based on both the gantry and the treatment room being mobile. The isocentric gantry consists of a 90° bending dipole that rotates around the axis of the beam entrance, while the treatment room can move ±90°, thanks to an arrangement that keeps the floor of the room horizontal – like the cabin in a panoramic wheel (see figure p22). This design reduces the weight and dimensions of the gantry greatly and hence the overall cost.

Clever solutions are also needed to ensure the correct positioning of the patient for treatment. This is particularly important in the case of tumours that change position as organs move – for example, when the patient breathes. A standard technique to reposition the patient accurately at each treatment session involves the implantation of radiographically visible fiducial markers. These markers must not introduce imaging artefacts or perturb the dose delivery process. In particle therapy, however, the interaction of the therapeutic beam with the markers can have a significant impact on the treatment. In this context, PARTNER conducted a study at the treatment set-up at HIT to compare a range of commercially available markers of different materials, shapes and sizes. Some of the markers offered promising results and will soon be used in clinical routine, but the study highlighted that markers should be chosen carefully, taking into account both the tumour localization and the irradiation strategy.

The combination of image guidance with a mask-immobilization system was also investigated at HIT on patients with head-and-neck, brain and skull-base tumours. The study demonstrated that, for the same immobilization device, different imaging verification protocols translate into important differences in accuracy.

At the National Centre for Oncological Treatment (CNAO) in Pavia, PARTNER researchers carried out a comparative analysis of in-room imaging versus an optical tracking system (OTS) for patient positioning. The results showed that while the OTS cannot replace the in-room imaging devices fully, the preliminary OTS correction can greatly support the refinement of the patient ▷



Left: Gantry concept with a movable treatment cabin, developed within the ULICE project with a contribution from PARTNER. (Image credit: ULICE.) Right: A PARTNER researcher working on treatment planning. (Image credit: PARTNER.)

set-up based on images, and provide a secondary, independent verification system for patient positioning.

State-of-the-art techniques are also needed for treatment planning – the tool that allows medical physicists to translate the dose prescribed by the oncologists into the set-up parameters for the beam. A PARTNER research project developed a novel Monte Carlo treatment-planning tool for hadron therapy, suitable for treatments delivered with the pencil-beam scanning technique. The tool allows the set-up of single and multiple fields to be optimized for realistic conditions for patient treatment, and also allows dosimetric quality assurance to be performed. Another study led to an accurate parameterization of the lateral dose spread for scanned proton and carbon-ion beams, which is currently in clinical use at HIT and CNAO.

Set-up errors and organ motion can influence the dose distribution during a treatment session. To deal with these potential variations, additional margins are applied to the tumour target, forming the so-called planning target volume (PTV). This procedure ensures that the tumour is irradiated entirely, but inevitably increases the dose delivered to the surrounding healthy tissues. PARTNER researchers studied the generation of a patient-specific PTV from multiple images and were able to achieve satisfactory control of possible target variations, with no significant increase in the dose delivered to organs at risk.

The great attraction of hadron therapy is the possibility of a precisely tailored dose distribution, which allows tumour cells to be hit while sparing the healthy tissues. Sophisticated measurements are needed to verify the actual dose delivered in a specific beam set-up, and air-filled ionization chambers are extensively used in this context. The conversion of data from the ionization chambers into standard dosimetric quantities employs a quality factor that accounts for the specificity of the beam. The ratio of water-to-air stopping power is one of the main components of this quality factor and – in the case of carbon-ion beams – its biggest source of uncertainty. PARTNER researchers developed a fast computational method to determine this stopping-power ratio, with results that were in good agreement with full Monte Carlo calculations.

Faster calculation methods are essential to re-compute the treatment plan quickly when needed, but they should not reduce the accuracy of the treatment planning. The PARTNER studies also demonstrated that a chamber-specific correction could be implemented in the treatment planning, bringing a small improvement to the overall accuracy of the verification of the plan.

Combining treatment modalities has become a standard approach in oncology, and it is important to understand how hadron therapy can fit into these combined treatment schemes. Within the PARTNER framework, three emerging treatment modalities were compared: volumetric-modulated arc therapy (VMAT), intensity-modulated proton beam therapy (IMPT) and intensity-modulated carbon-ion beam therapy (IMIT). Their combinations were also evaluated. The results clearly showed a better dose distribution in the case of combined treatments, but their actual clinical benefit remains to be demonstrated.

Biological factors

In the biological field, studies were performed to understand better the impact of hypoxia – oxygen deprivation – on cell survival, for various types of radiation therapy. Hypoxia is well known as one of the major reasons for the resistance of tumour cells to radiation. It also enhances the risk of metastatic formations. Understanding radioresistance is a key factor for more effective cancer therapy that will minimize local recurrences. Different levels of oxygen deprivation were studied, from intermediate hypoxia to total oxygen deprivation or anoxia. Cells irradiated under chronic anoxia turned out to be more sensitive to radiation than those under acute anoxia. Measurements also suggested that ions heavier than carbon could bring additional advantages in therapeutic irradiation, in particular for radioresistant hypoxic tumour regions.

The initial clinical experience at the CNAO facility provided the opportunity to study toxicity and quality of life for patients under the protocols approved by the Italian Health Ministry, namely for chordoma and chondrosarcoma. The preliminary results showed that all patients completed their treatment with no major toxicities and without interruptions, and that proton therapy did not affect

Left to right: PARTNER researchers during a radiobiology course, attending the annual project meeting, and working on detector prototypes. (Image credits: PARTNER.)

their quality of life adversely. The assessment of quality of life in patients with these tumours is so far unique, as no other study of this kind has been published.

Side effects such as toxicity are an integral part of the information that determines the appropriate choice of treatment. Realistic, long-term data on such effects are difficult to obtain, mainly because of the limited duration of medical studies, so decision-making processes in medicine rely increasingly on modelling and simulation techniques. One of the PARTNER research projects focused on the implementation of a general Markov model for the analysis of side effects in radiotherapy, and developed a specific language to encode the medical understanding of a disease in computable definitions. The proposed method has the potential to automate the generation of Markov models from existing data and to be applicable to many similar decision problems.

Making optimal use of the available resources is a major challenge for the hadron-therapy community, with secure data sharing at the heart of the problem. The Hadron therapy Information Sharing Prototype (HISP) was developed within PARTNER to provide a gateway to patient information that is distributed in many hospital databases, and to support patient follow-up in multicentre clinical studies. HISP demonstrates a range of different and important features, and uses open-source software components that are important for the platform's sustainable extension and potential for adoption.

The PARTNER network made important contributions to key research areas connected to hadron therapy, geared towards the optimization of this option for cancer treatment. A unique multidisciplinary training portfolio allowed more than 90% of the PARTNER scientists to find positions soon after the end of the project, thanks also to the expertise acquired at the most advanced European hadron-therapy centres and to the networking opportunities provided by the ITN. The medical doctors from India and Singapore went back to their countries and hospitals, while most of the other researchers are now working in hadron-therapy facilities in Europe, the US and Japan. The specific goal of training experts for upcoming and operational facilities was therefore successfully met, and the researchers ensure that the network lives on, wherever they are in the world.

Research results

PARTNER was a Marie Curie Initial Training Network (ITN) Programme co-ordinated by CERN, which ended in September 2012. The project is under the umbrella of the European Network for Light Ion Hadron Therapy (ENLIGHT). In 2013, results from several PARTNER research projects were published in a special issue of the *Journal of Radiation Research*. In line with the collaborative and open-access spirit of ENLIGHT and CERN, this peer-reviewed publication is freely available. The papers collected in the issue demonstrate the variety of subjects and disciplines dealt with by the PARTNER researchers.

● For the PARTNER results, see *JRR* **54** suppl. 1, also available online at http://jrr.oxfordjournals.org/content/54/suppl_1.toc.

● The PARTNER project was funded by the European Commission within the FP7 People (Marie Curie) Programme, under Grant Agreement No 215840.

Résumé

Un réseau pour la vie

Le réseau PARTNER, réseau de formation pour la radiothérapie européenne, a été créé en 2008 pour former de jeunes biologistes, ingénieurs, radio-oncologues et physiciens aux différents aspects de la thérapie hadronique. L'objectif était de proposer un enseignement multidisciplinaire afin de former une génération de spécialistes capables de faire progresser ce domaine. Le réseau PARTNER a offert entre 2008 et 2012 des possibilités de recherche et de formation à 29 jeunes scientifiques issus de pays et d'horizons divers. La publication récente de certains résultats dans le Journal of Radiation Research *fournit une bonne occasion d'évaluer la réussite du projet en matière de recherche.*

Manuela Cirilli and **Manjit Dosanjh**, CERN.

CERN Courier May 2014
Tribute

François de Rose: strategist and visionary

When François de Rose died in March, CERN lost the last of its founding fathers, a loyal supporter and a dear friend.

Visionaries have the freedom of mind to shape the future when other people's horizons are obstructed by the present. François de Rose was a visionary. In the aftermath of the Second World War, when Europe was in ruins and everything had to be rebuilt, the diplomat understood the importance of reviving fundamental research and, above all, of co-operation on a continental scale as the driving force of this ambition. In a Europe that was just starting to get back on its feet, it would be no mean feat. Nonetheless, François, alongside the prominent physicists of the time, put his energy into making this vision a reality. They lobbied governments for the creation of a centre that would work towards this goal and winning support, CERN was established in 1954 – an achievement of which François was extremely proud. "The result is even better than its founders hoped for," he was often heard saying. His pride was even greater knowing that a visionary's ideas, however strongly he or she believes in them, often take years to become reality and are sometimes never realized at all.

A strategist and a visionary to the end, François de Rose passed away on 23 March 2014 in Paris at the age of 103, having recently published his memoirs, *Un diplomate dans le siècle*. With his passing CERN has lost the last of its founding fathers, a loyal supporter and a dear friend.

Born in 1910 in Carcassonne in the south of France, he lost his right eye in a childhood accident, which prevented him from following the family tradition of a military career. His father, Charles de Tricornot de Rose, had been the founding father of combat aviation in France, the holder of the first military aviation licence, and had died in action in 1916.

After obtaining his *baccalauréat*, François embarked on a career as a diplomat and joined the French Embassy in London in 1937. He enjoyed recounting the splendid receptions that he attended at Buckingham Palace in the days when King George VI still ruled the British Empire and the future Queen Elizabeth II was just a child. Many years later, in the early years of the 21st century, it was fascinating to hear him tell anecdotes from his career of days long-passed, rather like reading an animated history book.

During the Second World War, his fluency in English led him to serve as a liaison officer for the British military. However, it was after the conflict that his career took him down the route of European science – an unexpected detour for someone who had been discouraged by his maths teacher from pursuing a career in science. François was sent to the US to serve on the United Nations Atomic Energy Commission. There he met several renowned physicists, including the American Robert Oppenheimer, with whom he forged a friendship, and the Frenchmen Pierre Auger, Francis Perrin, Lew Kowarski and Bertrand Goldschmidt. François took up their cause. European physicists and some of their American counterparts were convinced that fundamental research in Europe needed to be brought back to life, and that this could only be achieved if the countries that had just been at war co-operated. The instruments that were needed to further the study of the infinitesimally small were particle accelerators, which were too expensive for any individual European country to build.

At the inauguration of the PS in 1960: François de Rose (left) and John Adams. (Image credit: CERN-HI-6002058.)

François de Rose in the CERN Control Centre, during the celebration at CERN of his 100th birthday. (Image credit: CERN-HI-1011311 – 41.)

François and a handful of physicists embarked on a tour of Europe to appeal for the creation of the first European organization for fundamental research. Their objective was to pool resources for research to provide researchers with the tools that they needed and so curtail the brain drain. Pierre Auger, director of UNESCO's Natural Sciences Department, organized an intergovernmental conference in Paris in 1951, presided by François, during which the first resolution for the creation of a European Council for Nuclear Research was adopted. The rest is history: CERN was established by 12 European states in 1954.

A humanist, he always used CERN to counter the arguments of the Eurosceptics.

François became France's delegate to the CERN Council and later served as president of Council from 1958 to 1960. In this capacity, he gave a speech at the inauguration of the Proton Synchrotron (PS), which for a few months was the most powerful accelerator in the world. His visionary nature was evident in this speech, which he gave in front of an audience of well-known faces and legendary physicists including Niels Bohr and Werner Heisenberg. "The people who will meet here," he said of CERN, "who will come from the member states and beyond to work together on a wholly peaceful and impartial mission, are united by the same passion for knowledge and subject to the same rules of utmost intellectual integrity." Today, CERN welcomes researchers from all over the world and its membership has recently been opened to non-European states, but a few years after its founding, such an international future was still a long way off.

During his mandate, François negotiated CERN's extension into French territory, which was agreed in a treaty signed in 1965. To commemorate his role in this milestone, CERN gave François a piece of rock drilled from the site, engraved with the words: *"À François de Rose – La science ne connaît pas de frontières"* ("To François de Rose – Science knows no borders").

François continued to pursue his diplomatic career for many years. Notably, he served as the French ambassador to Portugal from 1964 to 1969 and as the permanent representative of France to the NATO Council from 1970 to 1974. He was well known as a specialist in defence and nuclear matters. For a long time, he was an eminent member of the London-based International Institute for Strategic Studies, whose expertise in international strategy and military matters is world renowned.

The diplomat would remain attached to CERN, which he described as "the most beautiful feather in my ambassador's cap". He continued to take an interest in and show his enthusiasm for scientific discoveries, even in his final years. In 2010, when he came to CERN to celebrate his 100th birthday, he promised to return when the Higgs boson was discovered – a promise that he fulfilled last year with a further visit to the laboratory. During this last visit, he expressed with modest sincerity his great admiration for the physicists that he met – a mutual admiration that led to some often comical exchanges of compliments.

François had a strategic vision for science, a vision that drove him to contribute to CERN's creation in the hope that scientific collaboration between countries that had been at war would play a part in maintaining sustainable peace. A humanist, he always used CERN to counter the arguments of the Eurosceptics. When he met some members of the French parliament during his visit to CERN last year, at the height of the European crisis, he said to them: "When Europeans unite, they can do great things."

Optimistic and full of energy, he performed some substantial feats even in his later years. To mark his 90th birthday, he played 90 holes of golf in one day, and when he was 96, he travelled around Cape Horn to Patagonia with his two daughters. He regularly had opinion pieces published in major daily newspapers. To those who asked if he had a secret for reaching 100 years of age, he responded that it had simply required "patience, because it took quite some time". He never failed to display elegance with a touch of humour, which charmed those who spoke to him. During his last visit, he promised to come back for the next big discovery. "But you'll have to be quick," he joked, "I won't be around forever." Sadly, he was right again.

• Further reading

For the speech that François de Rose made during the inauguration of the PS in 1960, see https://cds.cern.ch/record/840127?ln=fr.

Résumé

François de Rose : stratège et visionnaire

L'année de célébration de ses 60 ans, le CERN a perdu le dernier de ses fondateurs : l'ambassadeur de France François de Rose s'est éteint le 23 mars dernier à l'âge de 103 ans. Humaniste, fervent partisan de la construction européenne pour maintenir la paix, le diplomate avait embrassé la cause des physiciens européens au lendemain de la seconde Guerre mondiale. Par la suite délégué au Conseil du CERN, président du Conseil de 1958 à 1960, il avait négocié l'extension du Laboratoire sur le territoire français. Il considérait la création du CERN comme l'une de ses plus grandes fiertés et ne manquait jamais une occasion de soutenir le Laboratoire.

Corinne Pralaorio, CERN. For a viewpoint written for *CERN Courier* by François de Rose on the occasion of CERN's 50th anniversary, see page 46.

The World Wide Web's 25th anniversary

Twenty-five years ago, a proposal first laid out the principles of what was to become the World Wide Web.

In March 1989 at CERN, Tim Berners-Lee submitted his proposal to develop a radical new way of linking and sharing information over the internet. The document was entitled "Information Management: A Proposal" (*CERN Courier* May 2009 p24). And so the web was born. Now, Berners-Lee, the World Wide Web Consortium (W3C) and the World Wide Web Foundation are launching a series of initiatives to mark the 25th anniversary of the original proposal, and to raise awareness of themes linked to the web, such as freedom, accessibility and privacy.

Twenty-five years to the day after he submitted his proposal, on 12 March Berners-Lee, together with the Web Foundation, launched the "Web We Want" campaign. The aim is to promote a global dialogue and changes in public policy to ensure that the web remains an open, free and accessible medium, so that everyone around the world can participate in the free flow of knowledge, ideas and creativity online.

Berners-Lee announced the campaign at the Palais des Nations in Geneva on 10 December – Human Rights Day 2013 – during a series of conversations on a variety of issues in human rights, which were held in celebration of the 20th anniversary of the Office of the High Commissioner for Human Rights. There he set out the principles that inspire the movement for a free flow of information, such as affordable access, protection of privacy, freedom of expression, and neutral networks that do not discriminate against content or user.

Fittingly, the campaign is using the web to pass on the message, and it has already seen significant mobilization on social media with half a billion people worldwide hearing Berners-Lee's call for a digital bill of rights in every country. CERN promoted the launch of the campaign on its website with a series of opinion pieces from early contributors and enthusiasts of the World Wide Web, which are republished here.

For more about Web@25 and the "Web We Want" campaign, visit www.webat25.org and webwewant.org.

Résumé
25ème anniversaire du World Wide Web

Vingt-cinq ans après avoir proposé le projet qui est devenu le World Wide Web, *Tim Berners-Lee veut attirer l'attention sur certaines questions qui se posent dans ce domaine, telles que la liberté, l'accessibilité et la protection de la vie privée. Le CERN a soutenu le lancement de sa campagne sur son site web, en publiant les articles d'opinion reproduits ici.*

Marina Giampietro, CERN.

On the open internet and the free web

The internet created the platform and opportunity for people to communicate, to collaborate and to share at unprecedented scale and speed. The creation of the World Wide Web opened up these possibilities to the world, enabling individuals to participate and play their own creative role in the sharing of all human achievements.

This has enabled interactions between all sorts of people – from all sorts of domains, including business, government and scientific communities – for all manner of activities like never before in human history. The web has evolved from simple information sharing to transacting business through socializing and more recently collaborative problem solving in citizen cyber science. In these ways it harnesses the capabilities of humanity to do what we do best – share, learn, collaborate and innovate.

However, with this capability comes considerable responsibility. Basic human rights – including the right to freedom of expression and the protection of privacy – all need to be balanced and preserved in order that this incredible resource can be a safe and exciting place for creativity, for people of all ages and interests. The accessibility and openness of the internet are crucial to enabling new ideas to flourish and compete with long-standing traditions, and to ensure that the evolution of the web continues to proceed at a pace limited only by our ideas.

This responsibility rests with all of us – whether politicians, lawmakers, scientists or citizens – to ensure that the incredible progress we have made in the last 25 years, starting with the work of a few, and now capturing the innovations of many, can continue in an open, trusted, safe, free and fair way.
● *David Foster, Deputy Head of CERN's IT department. (Image credit: David Foster.)*

▷

Minimizing the muddle

Reams of material have been written about where, why and when the World Wide Web was born, but what about its conception? Gestation was rather like that of an elephant – difficult to know it had started and taking almost two years to complete. In fact, I think the title of Tim Berners-Lee's book *Weaving the Web*, published in 1999 with Tim dubbed the inventor, is a better metaphor. When do a spider's first few threads become a web? And when, if ever, is the job finished?

In 1984, Tim was recruited by CERN's Data and Documents (DD) division and he elected to join the Read-Out Architecture (RA) section in the On-Line Computing (OC) group. I was the RA section leader and Tim worked with (and without!) me for the next six years. Mike Sendall, the OC group leader, agreed our work plans and held our purse strings.

At the time, CERN hosted lots of small and medium-sized experiments using a variety of mini-computers, personal computers, operating systems, programming languages and network links. Back at the ranch, the OC group was endeavouring to provide data-acquisition systems, the software used by equipment closely connected to the detectors, for as many experiments as possible. The conundrum, as in other areas, was how to embrace heterogeneity without having squads of workers generating exclusive solutions to intrinsically identical problems for bewildered users. Just the kind of anarchic jumble that Tim found challenging.

Several of us believed that standardization, where apt, reduced waste and frustration. But the s-word was anathema in some corners of CERN, on the grounds that it stifled creativity, and we evangelists incurred the wrath of a few mandarins. Yet conformity seemed to rankle less when it came to electronics. Commercial companies were already competitively producing computer interfacing hardware that conformed to ANSI/IEEE international standards.

Hurrah! If you know the hardware you're going to get, you can prescribe how to handle it. I had worked with the NIM (US)/ESONE (Europe) group that defined standard software routines for CAMAC interfacing and was on the committee developing hardware and software standards for the speedier FASTBUS system. Tim arrived as we were dotting the Is and crossing the Ts of the FASTBUS routines.

He was obviously a smart young man (smart-clever rather than smart-sartorial!), full of fizz and, as a bonus, entirely likeable. When he presented his ideas in our section meetings, few of us if any could understand what he was talking about. His brain would overtake his voice, and holding up signs saying "Tim, slow down" rarely had the desired effect. We sometimes asked him to put things in writing, which didn't necessarily help either. One of his erstwhile colleagues recalls "we knew it was probably exciting, maybe even important, but that it could take hours to figure out". Listening to one of Tim's presentations today, one can still detect the run-away style, even after his training in public speaking. However, I remember an occasion when his delivery was impeccable, in a play performed by the Geneva English Drama Society!

Tim's main activity in the RA section was his Remote Procedure Call RPC, whereby a program on one computer could transparently access procedures, routines, on other computers, even if they used different operating systems and programming languages, and whatever the network connecting them. He wasn't too pleased when I asked him to specify the FORTRAN binding for FASTBUS routines, that is to define precisely the properties of the routines' parameters as seen from within a FORTRAN program. Only later did he appreciate the value of that unwelcome task, when preparing the standards that would underpin the first two Ws of WWW. He knew that the job, however tedious, had to be done and done well, with the devil lurking in the nit-picking details.

Come 1990, another CERN reshuffle and Tim stayed behind in the new Computing and Networks (CN) division, while the rest of us went off to Electronics and Computing for Physics (ECP). Shortly afterwards I drifted away from ECP, but I will always retain happy memories of the 1980s and the pleasure of having Tim in our section. He was not the only singular character in that multifaceted team, but with his congenial personality he could work with anyone. At least I don't recall having to field any complaints, apart from "what on earth is Tim proposing?" Well, now we know.

● *Peggie Rimmer, Tim Berners-Lee's supervisor from 1984 to 1990. (Image credit: Peggie Rimmer.)*

Good old Bitnet, and the rise of the World Wide Web

Although I presented my PhD thesis a mere 17 years ago, the last back-up of my thesis, programs and data was saved on a 7-inch magnetic tape reel. This of course meant that I did my graduate studies at the time when the word "network" was most often used in the plural. Each and every network was endowed with its own set of applications and accessibility for e-mail, document exchange, remote interactivity and even chatting.

Yes, computer-mediated social interaction came long before the World Wide Web. In the late 1980s, connectivity exploded at universities and research laboratories around the world. One noticeable side product was that young academics started dating each other from across the globe!

All of this was a heterogeneous mess, of course. But at the same time, it was pleasurably low level, and it was awesome. You knew what was happening behind the scenes when retrieving data and documents, you knew the hops that your "Relay" instant messaging made on the Bitnet, because you simply had to know. Data, documents, social interaction – it was all there. It was cool and in some ways efficient, but not practical, and it scaled very poorly.

And so the World Wide Web arrived on the internet. With the web came an immediate sense of need: you needed a fancy personal homepage, complete with graphical interface and colour. The personal homepage was quickly perceived as a way of asserting one's very existence. I was on a text-based, black-on-orange remote terminal, and I still remember putting together my first homepage late at night in early 1993, while one of the graphical stations was free in the research group.

The web was practical and universal, and the other networks quickly withered away in a form of Darwinian selection. The web quickly drove the quest for desktop computer stations with screens with graphics capability. I still opted for size and sharpness, staying with black and white for several years, while all of my colleagues seemed to be rubbing their sandy eyes after only a few hours of 15-inch colour experience.

The web brought a singular revolution that quickly changed every aspect of our screen work: a global, all-topic search possibility. Computer code, a formula, a result, a cooking recipe, a person, a phone number – everything was at hand in little more than an instant, with no physical displacement. We immediately started setting up analysis team pages to share progress more efficiently. I was in the DELPHI experiment Team 5, the "Higgs hunters" team. It was mostly pages with some expert documentation and links to plots, programs and data, but we also all invented countless ways to make information on the web dynamic. It took time and pain before it deserved the word interactive.

Today I sometimes have the impression that no development is ever made without constantly interrogating the web for advice, before even thinking through the problem: "Someone will surely have solved the problem in a better way, no?" is an all-too-common approach.

In those early days I rarely discussed my networked profession and life with friends and family – the web was just a new tool of my trade. After another long stay at CERN in 1993–1994, I went back to Stockholm in February 1994. Sitting quietly reading on the subway, it was with an indescribable surprise and awe for what was to come that I discovered an http address on a regular advertisement! Within months, commercial web addresses were all over our billboards in Sweden.

Back then, the good old Bitnet chat had a rule. The Dutch Master Operators insisted that "Relay is a 'privilege', NOT a right, and Relay abuse will NOT be tolerated!" I often wish the web had it too, including commercial boundaries under the same heading.

● *Richard Jacobsson, senior physicist on the LHCb experiment. (Image credit: Alban Kakulya/STRATES.)*

Not at all vague and much more than exciting

In 1989, when Tim Berners-Lee invented the World Wide Web at CERN, I was responsible for the laboratory's multi-protocol e-mail gateway. I remember discussing with Tim naming conventions for applications, and configuration rules for the first mailing lists that he requested to allow pioneer websites to discuss World Wide Web code.

We attended technical meetings sponsored by the European Commission – myself for e-mail standardization, and Tim for the Information Services Working Group (WG) – where he presented his code, and some Scandinavian universities even showed an interest in installing it.

Tim conceived, wrote and presented the web as an open, distributed, networked medium. He believed that the web should be accessible by everyone, everywhere – embracing from the first web conference at CERN in 1994 development for people with disabilities or a sub-optimal network infrastructure. He presented the web – in his proposal to CERN in March 1989 – as a platform for scientific collaboration, and 20 years later reinforced this commitment, announcing http://webscience.org as a home for scientists online.

And Tim Berners-Lee continues to strive for a free, open web today. Setting up the World Wide Web Foundation was just one of the many steps he took to maintain this ideal. On 12 May last year, at the United Nations in Geneva, Tim announced the Web We Want campaign, which will form the centre of the debate around today's information-surveillance methods.

As a CERN scientist, I share Tim's ideas for an open, collaborative web. I believe that CERN's software development based on web standards should be linked to the relevant working groups in the World Wide Web Consortium (W3C) – the main international standards organization for the World Wide Web.

Up until 1998, in the Web Office at CERN, we were still able to count all the world's web servers. We still thought we could keep track of the web's expansion. Apache put an end to this, as starting one's own web server became so easy. But we were still writing search algorithms of our own, with integrated dictionaries for natural language searches, with help from technical students. We enjoyed, at the time, a certain pluralism, because we had multiple commercial or public-domain products to compare and evaluate, search engines, web calendars and editing tools. We didn't use "Google" as a synonym for "search".

The explosion of websites around the turn of the century highlighted the importance of identifying trustworthy information online. At CERN, we understand that presence on the web doesn't necessarily make information valid – it must be recent and from a trusted source. Sophisticated algorithms are developed to promote web content by devious means, such as clever use of metadata to "arrange" the importance of search results, spread false rumours, manipulate public opinion. Browsing today requires a discerning eye and a knack for research.

Today, CERN software developers write grid middleware, data-management software, collaborative tools, repositories for data-preservation projects and web-based applications. They use, among other standards, the http protocol. A collaboration with relevant W3C working groups would lead to technical benefits in these times when resources are limited and the web has become much more than a document repository.

The web has changed human society more radically than Gutenberg's printing press. It is a valuable platform for education and free exchange of ideas. But it can also be a tool for propaganda and surveillance.

Now more than ever, we at CERN should keep in touch with the evolution of the web: after all, it changed the world as we know it at the end of the 1980s – it could do so again.

● *Maria Dimou, CERN computer scientist and early web contributor. (Image credit: CERN-GE-0712019 – 01.)*

Faces & Places

APPOINTMENTS

TRIUMF announces new director

After a seven-month international search, on 18 March TRIUMF's management board announced that Jonathan Bagger would be the laboratory's next director. Bagger is Krieger-Eisenhower professor, vice-provost, and former interim provost at Johns Hopkins University and will lead TRIUMF for a six-year term starting from 1 July.

Bagger's research focuses on high-energy physics at the interface of theory and experiment, and together with Julius Wess he is the author of the monograph *Supersymmetry and Supergravity*. He has served on multiple committees, including chairing the International Linear Collider Steering Committee and being a member of the US National Research Council's Board on Physics and Astronomy.

He received his PhD from Princeton University in 1983, before taking a postdoctoral research position at the Stanford Linear Accelerator Center. From 1986 to 1989 he was associate professor at Harvard University, before joining Johns Hopkins University as a faculty member.

TRIUMF is Canada's national laboratory for particle and nuclear physics, focusing on probing the structure and origins of matter and advancing isotopes for science and medicine. The appointment comes at an exciting time, when TRIUMF's new strategic plan has recently secured five years of core funding from the Canadian government.

Jonathan Bagger will lead TRIUMF from 1 July (Image credit: JHU.)

AWARDS

EPS Accelerator Group announces 2014 prize winners

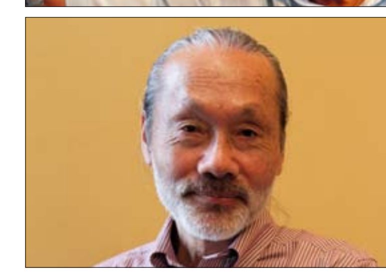
The European Physical Society Accelerator Group (EPS-AG) has announced the winners of the 2014 Accelerator Prizes, to be presented on 19 June at the International Particle Accelerator Conference, IPAC'14, in Dresden.

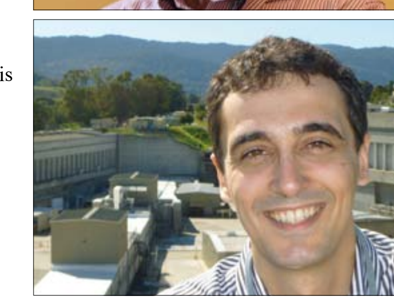
Mikael Eriksson, machine director of the Max-IV Laboratory in Lund, receives the Rolf Wideröe Prize for outstanding work in the accelerator field, with no age limit. He is rewarded for "outstanding leadership in the design, construction and commissioning of the MAX-lab synchrotron radiation facilities". For more than four decades, Eriksson has been the driving force behind all of the MAX-lab synchrotron radiation sources, at all stages, from design to performance. The design and implementation of the MAX IV storage ring is today paving the way for a new generation of extreme, low-emittance "ultimate storage rings" to achieve diffraction-limited radiation sources.

The Gersch Budker Prize, awarded for a recent, significant and original contribution to the accelerator field, with no age limit, recognizes Tsumoru Shintake, of the Okinawa Institute of Science and Technology Graduate University, for "leading the design, construction, commissioning and operation of the SACLA X-ray free-electron laser (FEL)". Shintake contributed to all aspects of the project, including the electron source, the C-band linac and the undulator alignment. The first lasing of the FEL in June 2011 (*CERN Courier* July/August 2011 p9) was a crowning achievement, made possible by numerous technological developments.

The Frank Sacherer Prize, for an individual in the early part of his or her career who has made a recent, significant and original contribution to the accelerator field, goes to Agostino Marinelli of SLAC, for "recent important, original contributions to accelerator physics, especially to the development of techniques that significantly improve parameters of free-electron lasers such as their spectrum and longitudinal coherence". Marinelli's achievements include the theoretical analysis and experimental demonstration of the gain-modulated FEL – a novel concept to generate two or more colours from one electron bunch, so enabling a new class of FEL experiments.

● For further information, visit www.eps.org/members/group_content_view.asp?group=85227&id=143442.





Top to bottom: Mikael Eriksson, Tsumoru Shintake, Agostino Marinelli. (Image credits: Johan Persson, Mayumi Nishioka/OIST, Gabriel Marcus.)

CONFERENCE

'La Thuile' celebrates Bellettini's 80th


Giorgio Bellettini, left, with Pier Oddone, then director of Fermilab, in 2008. (Image credit: Fermilab Today.*)*

The week beginning 24 February saw 100 physicists gather for the 28th Rencontres de Physique de la Vallée d'Aoste – the annual "La Thuile" meeting – and to celebrate the 80th birthday of Giorgio Bellettini who, together with Mario Greco, started the series in 1987. At that time, first data were appearing from the Tevatron and there was exciting news from other fields, such as the supernova SN 1987A and high-temperature superconductors. Today, the La Thuile series is organized jointly with Giorgio Chialrelli and Gino Isidori – and measurements of the recently discovered Higgs boson are among the hot topics.

From the start, the meetings were organized around in-depth reports on current work in particle physics and a few special topics from related fields. During the years they have featured either a session on physics and society or a round-table discussion about future directions in particle physics. This year it was "Which facilities to understand neutrinos?", featuring a theoretical picture of the field by Francesco Vissani and reports from CERN, the Institute of High Energy Physics (IHEP) in Beijing, INFN, Fermilab, SNOLAB and the Institute for Cosmic-Ray Research, Tokyo.

The La Thuile meetings are also a base for outreach to the Province of Aosta, which takes pride in the fact that the region is now well known to physicists worldwide. On the Wednesday, the president of INFN, Fernando Ferroni, gave a public lecture to high-school students and teachers in Aosta on "Higgs e dopo Higgs" ("Higgs and after the Higgs?"). The La Thuile series is also unique in providing, through the Young Scientists Forum, an opportunity for physicists who are just starting out to present their current work.

On the Thursday afternoon, there was a special session to commemorate Bellettini's contributions to the field in his early career (e.g. at CERN's Intersecting Storage Rings) and the significant impact he had on the physics climate of Fermilab during the Tevatron era – "the Italian Invasion". Among the scheduled and impromptu speakers were Sergio Bertolucci, now director of research at CERN, who started his career as Bellettini's student; and Chiarelli, now co-organizer of the La Thuile series, who was one of the first beneficiaries of the programme that Bellettini started to bring summer students from Italy to experience physics in US laboratories. This programme, which began with only four students in 1984, is currently recruiting about 20 students a year.

During this session, people also remarked on the usefulness of the traditional La Thuile format. As Nicola Khuri pointed out, concentrated exposure to a broad survey of the latest developments in the field is very stimulating to theorists, with its overview of current progress. In recent years the long-running Moriond meeting series has moved to the same La Thuile venue, with help from Greco and Bellettini.

The Saturday morning session, rather than being a traditional wrap-up, included in-depth reports on the ongoing LHC refurbishments by Gianluigi Arduini, and on the prospects for high-energy physics beyond the LHC by Michelangelo Mangano. This led to plenty of discussions, which will probably continue until next year's meeting.

● For more information, visit https://agenda.infn.it/conferenceDisplay.py?confId=7102.
Sebastian White, Rockefeller University.

MEETING

ISC'14, the **2014 International Supercomputing Conference**, will take place at the Leipzig Conference Center on 22–26 June. The comprehensive five-day programme consists of half-day and full-day tutorials on 22 June, followed by a four-day conference that includes four keynote talks, the ISC Research Paper and Poster sessions, and various topics and interest-specific sessions. The prestigious PRACE-ISC and Gauss Awards will be presented for the best research papers. The ISC exhibition, which is a three-day event, will again feature exhibits from leading high-performance computing companies and research organizations. Early registration fees are available until 15 May. For further information, visit www.isc-events.com/isc14/.

WORKSHOP

Testing quantum mechanics 50 years after Bell's theorem


Left to right: Reinhold Bertlmann, Catalina Curceanu, Beatrix Hiesmayr and GianCarlo Ghirardi. (Image credit: Johann Marton.)

Experts and young researchers from around the world converged on the European Centre for Theoretical Studies in Nuclear Physics and Related Areas – ECT* – in Trento on 24–28 February for an international workshop on Quantum Mechanics Tests in Particle, Atomic, Nuclear and Complex Systems: 50 Years After Bell's Renowned Theorem. This workshop was also funded by the EU COST Action "Fundamental Problems in Quantum Physics" MP1006, which is building up an international network to explore the foundations of quantum theory (*CERN Courier* June 2011 p32).

In 1964, John Stewart Bell, a theoretician at CERN of world renown, published a paper on a field he considered to be a hobby: the foundations of quantum mechanics. He came up with an experimentally testable theorem that must be fulfilled for any local realistic theory, but is in contradiction to the predictions of quantum theory. In simple terms, Bell's theorem gives a device-independent toolbox to prove when quantum systems outperform systems that can be described with classical theories. This seminal work initiated a new line of research, far beyond his expectations, which has led to novel applications such as quantum cryptography, or might lead to a possible quantum computer.

The recent workshop was devoted to Bell's heritage and brought together theoreticians and experimentalists from many different fields. Happily, these researchers succeed in finding a common language to address fundamental problems, working out the respective advantages and disadvantages of distinct physical systems and developing approaches that might lead to a unified picture.

Superposition and entanglement seem to be the basic ingredients for an explanation of various quantum phenomena for physical systems at different energy scales and of different complexity. There were talks dealing with neutral K-mesons, which are entangled in their strangeness property. This system, which oscillates between the particle and antiparticle state, has been shown to be a unique laboratory for fundamental studies. In particular, Bell's theorem is violated because of a tiny violation of the matter–antimatter symmetry – CP violation, which was found experimentally in 1964, the same year that Bell published his seminal paper. Theoreticians have since shown that the generator of time (the Hamiltonian) is not symmetric with respect to time-reversal symmetry, for a certain toy model of the universe, and that this tiny difference measured in meson systems has a huge impact on a cosmological scale.

There were also talks dealing with biological systems. These included topics such as light-harvesting complexes in photosynthesis, radical-pair creation in navigation in birds, and charge separation in organic solar cells, discussing whether genuine quantum effects could be responsible for high efficiency.

Given that all experiments are so far in agreement with the predictions of (standard) quantum theory, it is tempting to think that this is the fundamental theory. However, this leads immediately to the problem of how to explain the absence of superpositions in the macroscopic world. Collapse models provide a mathematical framework that explains the transition from a quantum to a classical world, and provide new predictions for the regime in between. Some talks dealt with these predictions for different physical systems. It was noted that it is not only massive interfering systems that might provide new experimental results in the near future. On the theoretical side, discussions focused on whether dark matter/energy could provide an explanation for the collapse.

Several talks referred to condensed-matter systems, showing that genuine multipartite entanglement plays an important role in understanding the physical properties of these systems. The orbital angular momentum of entangled photons provides a highly controllable system, which can reveal the power of entanglement in multipartite and multidimensional space.

On 25 February there was a panel discussion on the role of superposition or entanglement in the universe. The panel and the active participants had different views, the only agreement being that there is still not enough known about quantum theory to capture the underlying picture.

Last but not least, Reinhold Bertlmann and GianCarlo Ghirardi gave talks on their personal encounters with Bell. Bertlmann, a particle physicist, told the story of how "Bertlmann's socks" became a subject of physics, and how this brought him to the foundations of quantum mechanics. GianCarlo Ghirardi, one of the three founders of the collapse models, emphasized how Bell realized from the beginning the importance of his contribution to the foundations of the subject, which are currently under extensive investigation. The workshop certainly benefited from the presence of these two researchers, who had experienced the exciting half-century since Bell's seminal paper.

● The workshop was organized by Beatrix Hiesmayr (University of Vienna), Catalina Curceanu (LNF-INFN) and Andreas Buchleitner (University of Freiburg).

School

ITEP hosts winter school of physics

The 17th International Moscow School of Physics (the 42nd ITEP Winter School) took place on 11–19 February near Moscow. The ITEP Winter School of Physics, which dates back to 1973, became international in 1994 and attracts participants from leading research centres and universities. This year the programme included lectures on Higgs-boson physics, flavour physics and new results from the LHC, as well as cosmology, dark matter, quarkonia and neutrino physics. In addition, there were talks on higher-spin gauge theories and the status of the International Linear Collider.

Students from eight countries – Belgium, Belorussia, France, Germany, Kazakhstan, Russia, Ukraine and Vietnam – enjoyed the Russian winter and presented their results at the Young Scientists Forum, where Alexander Novikov and Max Zoller received diplomas for the best experimental and theoretical presentations.

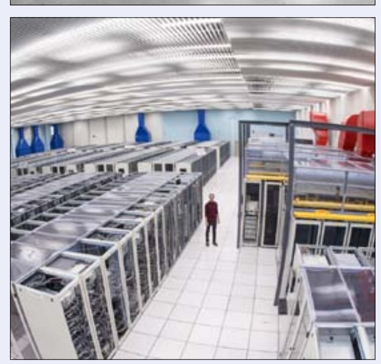
Zhi-zhong Xing, who lectures on neutrino physics, in the school's traditional ski competition. (Image credit: ITEP.)

● For a list of lecturers and their presentations, see http://ws.itep.ru/?page_id=169.

There is a sense of calm and spaciousness in these images of CERN's central computing facilities in 1958 (top) and 2013 – but there is little else in common. The first "central" computer was a large, vacuum-tube-based Ferranti Mercury, installed in Building 2 on 30 June 1958. Its clock speed was a modest 1 MHz and it had a RAM capacity of 2000 20-bit words. "Mass" storage was provided by four magnetic drums, each holding 32,000 × 20 bits – insufficient to hold the data from a single proton–proton collision in the LHC. It was replaced in 1960 by an IBM 709, which was installed in the first computer building (B510), and so the inexorable growth of computing at CERN began.

The modern computing centre in Building 513 now has responsibility for vast amounts of data from the LHC experiments. By 14 February 2013, the day the LHC's first three-year run ended, the centre's mass-storage systems had surpassed 100 million gigabytes of physics data.

While the bulk of the data is archived on more than 50,000 tapes, the rest is stored on a disk-pool system that is optimized for fast access by many concurrent users.



(Image credits: CERN-CO-1269 and CERN-CO-1302162 – 06.)

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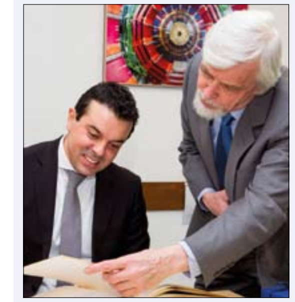
Visits

When the Swedish minister for enterprise, **Annie Lööf**, centre, visited CERN on 3 March, she toured the LHC tunnel with **Malika Meddahi**, left, deputy head of the Accelerator Beam Transfer Group in the Technology Department, accompanied by **Richard Jacobsson**, a senior physicist on the LHCb experiment. (Image credit: CERN-PHOTO-201403-042 – 10.)



On 4 March, the Macedonian minister of foreign affairs, **Nikola Poposki**, visited CERN. After signing the guestbook, accompanied by the director-general, **Rolf Heuer**, he was taken on a tour of the CMS underground experimental area. (Image credit: CERN-PHOTO-201403-043 – 01.)

The Lithuanian minister of education and science, **Dainius Pavalkis**, right, visited CMS on 13 March, accompanied by **Rytis Paulauskas**, permanent representative of the Republic of Lithuania to the United Nations Office and other international organizations in Geneva. During his visit, the minister also met Lithuanian teachers taking part in CERN's teachers' programme. (Image credit: CERN-PHOTO-201403-048 – 17.)

Olman Segura Bonilla, left, the Costa Rican minister of labour and social security, visited CERN on 21 March. He was shown the ATLAS underground experimental area by the deputy spokesperson of the ATLAS collaboration, **Thorsten Wengler**. (Image credit: CERN-PHOTO-201403-057 – 06.)

Letters

Who invented quarks?

The official story (*CERN Courier* March 2014 p37) is that they were invented by Murray Gell-Mann and George Zweig, in that chronological order: Gell-Mann's published paper was received by *Physics Letters* on 4 January 1964, while Zweig's unpublished work is a CERN Yellow Report dated 17 January of the same year. But, as Napoleon is said to have said: "History is the version of past events that people have decided to agree upon."

This official story might be wrong in its dates, since Gell-Mann's paper, at least according to the same hardly trustable source of the previous quote (i.e. the internet) was, shamefully, rejected by *Physical Review Letters*. That would not change the chronological order, which is irrelevant anyway, because the dates were so close. Concerning dates, it must also be recalled that Gell-Mann wrote: "These ideas were developed…in March 1963; the author would like to thank Professor Robert Serber for stimulating them."

The official story is demonstrably wrong on one point: André Petermann published a paper (in French!) in *Nuclear Physics* that was received on 30 December 1963, shortly before the dates quoted in the first lines of this letter, although not published for some time (A Petermann 1965 *Nuclear Physics* **B63** 349). In that paper, perhaps delayed by yet another sceptical referee, Petermann discussed mesons as made of a "spinor/anti-spinor pair" and baryons as "composed of at least three spinors". Concerning the delicate issue of their charges, Petermann delightfully writes: "If one wants to preserve charge conservation, which is highly desirable, the spinors must have fractional charges. This fact is unpleasant, but cannot, after all, be excluded on physical grounds."

There are other unofficial issues concerning this gorgeous chapter in the history of science. Who rejected Gell-Mann's paper? Was Zweig forbidden to give a talk at CERN at the time? If so, by whom? I am only allowed to write up to 300 words, that's it. Thou shalt not know the answers.

● *Álvaro de Rújula, CERN, and IFT/CSIC/UAM, Madrid.*

UA2's inner silicon detector

I read with interest the article "Microelectronics at CERN: from infancy to maturity" in the March 2014 issue (pp 26–29). Reading the caption to the first figure ("Two decades of microelectronics at CERN – enabled by the LAA project."), it might be believed that the LAA project contributed to the successful operation of the detector made of 3072 small silicon pads, which fit just around the beam pipe in the UA2 experiment at the CERN proton–antiproton collider.

In fact, the proposal to build the UA2 inner silicon detector was submitted to the SPS Committee at CERN by the UA2 Collaboration in March 1987, and was approved at the Research Board on 3 June 1987. As the article indeed mentions, the contributions of Erik Heijne and Pierre Jarron were crucial to the detector's success. Jarron designed and supervised the construction of the AMPLEX chip — using CMOS technology, which allowed the detector to fit in the 9 mm space around the beam pipe. The detector was financed by the institutes collaborating on the UA2 experiment and was already operational in 1988 for the first run of the collider with the upgraded antiproton accumulator.

Also, this detector's main purpose was not "to solve the difficulty of identifying the single electron that comes from a decay of a W boson close to the primary interaction vertex" (W decays to electrons had already been seen by UA1 and UA2 at the end of 1982). Its purpose was to identify single electrons of energies as low as 15 GeV, which were expected from the decay $W \to t\bar{b}$, $t \to be\nu$ (at the time, nothing was known about the t-quark mass, and the decay chain would have been observed if the t-quark had been lighter than the W boson).

● *Luigi di Lella, University of Pisa.*

Obituaries

Alick Ashmore 1920–2014

Alick Ashmore, a highly regarded former director of Daresbury Laboratory and a major figure in the development of research facilities in the UK in the 1960s and 1970s, passed away on 28 February.

Alick was born in Cheshire, England, and graduated in physics from Kings College, London, in 1941. After working at the Radar Research Establishment, Malvern, in 1947 he joined the physics department at Liverpool University, where he led a research group working on the 156 inch synchrocyclotron – a machine that was also used by CERN staff before the first CERN accelerator came into operation.

In 1960 he was appointed by Queen Mary College, London, to lead a user group on Nimrod, the 7 GeV proton synchrotron that was under construction at the Rutherford High Energy Laboratory (RHEL). He continued research begun at Liverpool on the spin-dependant parameters in proton–proton scattering using the 50 MeV proton linear accelerator at RHEL, and also spent time at CERN, measuring proton–proton total cross-sections at the new Proton Synchrotron. Together with Eric Taylor of AERE Harwell, he proposed the first approved experiment on Nimrod: small-angle proton–proton elastic scattering.

Alick was promoted to professor in 1964, and during 1965–1966 spent a sabbatical year at Brookhaven, where he participated in experiments on pion–proton, kaon–proton and proton–proton scattering with a Brookhaven-Cornell group. In 1968 he became head of department at Queen Mary College.

In 1970 he was appointed director of Daresbury Nuclear Physics Laboratory, where the 5 GeV electron accelerator, NINA, supported a mature particle-physics programme. Additionally, synchrotron radiation was also being used on two embryonic beamlines for molecular and

Alick Ashmore. (Image credit: Daresbury Laboratory.)

atomic research on a range of materials. Alick enthusiastically pursued funding for the expanded use of NINA by installing a new experimental area for using synchrotron radiation in material and life sciences. When the Science Research Council closed NINA in 1977 to concentrate UK resources at CERN, Alick was instrumental in organizing the particle-physics users from Daresbury and several northern UK universities in two collaborative projects: the Omega spectrometer and the European Muon Collaboration, both of which had highly successful programmes at CERN.

Alick also led the development of the Nuclear Structure Facility at Daresbury – a tall, tandem Van de Graaff accelerator. This delivered outstanding nuclear physics, including the discovery of nuclear super-deformation, providing a new insight into the dynamics of atomic nuclei. Following this success, Alick initiated construction in 1975 of the Synchrotron Radiation Source (SRS), which became the world's first dedicated facility for X-ray synchrotron radiation research. During its 28 years of operation, the SRS supported cutting-edge research in physics, chemistry, materials science, medicine, geological and environmental studies, structural genomics and archaeology. It played a critical role in supporting Sir John Walker's research on solving the structure of an enzyme that opened the way for new insights into metabolic and regenerative disease, and resulted in a share of the Nobel Prize in Chemistry in 1997.

In this way, Alick led the transformation of Daresbury Laboratory from a high-energy physics laboratory into an international centre for nuclear physics and synchrotron radiation. He also saw significant growth in scientific computing there, through the inclusion of work related to applications of computing to structural chemistry, X-ray crystallography and atomic physics.

Alick was awarded Commander of the Order of the British Empire for services to science in 1979, and retired in 1981. His leadership was shaped by his benign, sympathetic and gentle character, and was strongly driven by an awareness of social fairness. He was highly regarded and widely admired by the staff at Daresbury and by his colleagues and students at Queen Mary, where the group he started more than 50 years ago has now evolved into the QMUL Particle Physics Research Centre.

Alick enjoyed a long and healthy retirement with his wife Eileen in Cumbria, where he was deeply involved in local events and organizations. He enjoyed walking in the Lake District and travelled extensively to visit family, for relaxation and education. He is survived by Eileen, who he married in 1947, his five children, 13 grandchildren, and seven great grandchildren.

● *Peter Kalmus, Queen Mary University of London (QMUL).*

Erich W Vogt 1929–2014

TRIUMF lost a dear member of its family when Erich Vogt, co-founder, visionary leader and father to all, passed away on 19 February. He was 84.

Erich Wolfgang Vogt and TRIUMF have been inseparable since 1966, when the Canadian federal government entrusted a three-university consortium of academics to build a meson factory at the University of British Columbia (UBC). Erich believed that co-operation would pave the way for Canadian scientists to play a leadership role in nuclear and particle physics worldwide. This defined his management style and the laboratory work ethic.

Erich was born in the centre of Canada and received his undergraduate education at the University of Manitoba, earning his PhD at Princeton in 1955 in nuclear-reaction theory under Eugene Wigner. He worked for 10 years at the Chalk River Laboratory, then one of the world's premier nuclear-physics laboratories. He joined the physics department at UBC in 1965, and quickly established himself as the champion of a bold project to replace UBC's 3 MeV Van de Graaff accelerator with a 500 MeV cyclotron. The brainchild of Reg Richardson of University College Los Angeles, it was a challenging, high-intensity machine incorporating many innovative technologies, such as H^- injection, multiple extraction, energy variability and separated turn extraction. By the late 1970s, the TRIUMF cyclotron reached its design intensity with a broad science programme in full swing, competing with the other meson facilities at Los Alamos and what is now PSI. Strong collaborations were built with Japan and the University of Tokyo, with Japanese physicists providing a muon beamline. Israeli collaborations enhanced the proton and pion-nuclear programme, and collaboration with UK groups provided the best study on the nucleon–nucleon phase shifts in the 200–500 MeV region.

Erich became director of TRIUMF in 1981, serving until 1994, and foresaw the importance of broadening the science programme beyond nuclear and particle physics. He supported a material-science and chemistry effort using polarized muons, and pushed a radiochemistry programme to support medical imaging diagnostics. He nurtured a collaboration with AECL (now NORDION) to produce and deliver radioisotopes worldwide, yielding more than 50,000 patient doses of short-lived radioisotopes delivered each week to hospitals worldwide for the past 35 years. Erich envisaged the importance of developing small cyclotrons capable of producing radiotracers in hospital environments and initiated

Erich Vogt. (Image credit: Alex Waterhouse-Hayward.)

a transfer of cyclotron technology from TRIUMF to a local manufacturer. The TR series of mini-cyclotrons were developed, and soon acquired a reputation for reliability and performance.

TRIUMF was then well established and well regarded for its scientific output. However, Erich had a much more ambitious plan to move the laboratory to another level in international science. The KAON proposal would raise the proton beam energy to 30 GeV at a healthy 100 µA intensity. Erich convinced Europe, the US and Japan (which had developed similar projects) to join KAON. The Canadian government invested in a study to better define the technical aspects, cost estimates and partners for the facility. Erich became a travelling salesman and advocate, rallying the world to his cause. He expanded on the so-called "HERA model" of co-operation, whereby Canada joined DESY's HERA project with accelerator and detector contributions to gain access to the nationally operated facility.

Erich always encouraged TRIUMF's scientific staff to take a more visible role in international experiments, at labs such as SLAC, DESY, CERN, Brookhaven and KEK, bringing TRIUMF into the big league of particle-physics research and establishing the reputation and competencies of the laboratory staff. By the time of his retirement from the TRIUMF directorship, and after the decision by the Canadian government not to proceed with KAON, Canada was able to join the LHC programme, push a rare kaon-decay programme at Brookhaven, establish a neutrino group, and generally support its particle-physics community to access foreign facilities. KAON was not to happen on Canadian soil, so Erich passed the baton to the Japanese JHF team and followed with proud interest the construction and first operation of the Japan Proton Accelerator Research Complex – J-PARC.

Erich was a fantastic educator and motivator. More than 5000 students enjoyed the three 8.30 a.m. honours physics lectures he gave each week for 45 years until he turned 80. He would always adjust his travel schedule to minimize missed lectures, and the TRIUMF student programme always managed to survive budget trimming.

The TRIUMF family will continue to build on his legacy of excellence, strength, collaborative spirit, and above all, friendship. Perhaps the recent announcement of a federal-funding commitment for TRIUMF from 2015 to 2020 (p31), a full year ahead of expectation, was recognition of his sweeping vision for the lab that he let go knowing TRIUMF would continue to prosper.

Thank you Erich for the many lessons and for your trust.

● *Jean-Michel Poutissou and Ewart Blackmore, senior scientists emeriti at TRIUMF.*

New products

Hiden Analytical has announced the compact Hiden HPR-30 differentially pumped mass spectrometer, which enables real-time measurement and control of gas composition in vacuum processes in the pressure range 1 mbar to 10^{-4} mbar. The system is fully PC controlled and programmable for automatic operation and data reporting. Multiple input channels enable process data such as process pressure, temperature, etc to be fully integrated with the acquired mass spectra. For further information, e-mail info@hiden.co.uk or visit www.HidenAnalytical.com.

Pfeiffer Vacuum has introduced the world's first ATEX-certified Roots pumps with a magnetic coupling. The tried and tested Roots pumps principle has been developed further for this certification and named OktaLine ATEX. These pumps are ideal for evacuating explosive gases according to the ATEX directive (94/9/EC).The hermetically sealed pumps have very low leakage rates of less than 1×10^{-6} Pa m^3/s. The complete series of pumps covers pumping speeds from 280 m^3/h to 5190 m^3/h. For more details, visit www.pfeiffer-vacuum.com.

Siemens has announced two new product lines for industrial wireless LAN. With the compact Scalance W761-1 RJ45 access point and the Scalance W721-1 RJ45 client module, users can implement wireless machine-networking out of the cabinet, with cost and space savings, for example, in conjunction with the Simatic ET 200SP distributed I/Os. The components support transmission rates of up to 150 Mbit/s. The second product line comprises the Scalance W774-1 RJ45 access point and the Scalance W734-1 RJ45 client module and is designed for transmission rates up to 300 Mbit/s. These devices are enclosed in a compact and robust aluminum housing. For further information, contact Peter Jefimiec, tel +49 911 895 7945, e-mail peter.jefimiec@siemens.com or visit www.siemens.com/iwlan.

Recruitment

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Director General

With 2,300 staff members, 1,600 other paid personnel and some 10,500 scientific users from almost 100 countries, the European Organization for Nuclear Research, CERN, an Intergovernmental Organization with its seat at Geneva, Switzerland, is the leading international Laboratory for fundamental research in particle physics. The annual Budget of presently about 1 billion Swiss francs is funded by 21 Member States. CERN is presently operating the Large Hadron Collider, LHC, the world's most powerful particle accelerator that provides new insights into the origin and the structure of matter and into the forces governing the Universe.

The Director-General is the Chief Executive Officer and legal representative of the Organization. He/she is directly responsible to, and shall execute the decisions of, the CERN Council, the Organization's governing and decision-making body composed of the representatives of the Member States.

The term of office of the present Director-General, Professor Rolf-Dieter Heuer ends on 31st December 2015. The Council is therefore inviting applications for the appointment of a Director-General for a five-year term of office starting on 1st January 2016.

THE POSITION

The successful candidate will:

- provide scientific and managerial leadership to the Organization;
- lead the implementation of the approved scientific programme, with emphasis on the full exploitation of the scientific potential of the LHC;
- develop strategic options for the long-term scientific programme of the Organization as an integral part of the European Strategy for Particle Physics;
- be responsible for implementation of the European Strategy for Particle Physics in collaboration with the European national laboratories and institutes in the field;
- maintain and develop close relations with Member States and non-Member States, and with the world-wide scientific user community of CERN.

REQUIREMENTS

- Capacity for providing scientific and managerial leadership for CERN, for representing the Organization in dealings with governments and other bodies in and outside the Member States and for effective building of consensus within the Organization, the Member States and internationally;
- Outstanding expertise and a high reputation in particle physics and/or closely related fields;
- Excellent communication and negotiation skills. Applicants are requested to address a letter of interest, with a detailed curriculum vitae, to the Chairperson of the Search Committee and to send it to the CERN Council Secretariat [1], before 31st May 2014.

The Council is scheduled to make the appointment in December 2014. To allow the Director-General Designate sufficient time for consultation and familiarisation with CERN, a position within the Organization can be arranged for the year 2015.

For general information about CERN: **http://cern.ch**

Additional information may be obtained from the Chairperson of the Search Committee; please contact the Council Secretariat[1].
An appropriate remuneration and benefits package will be offered.
In line with CERN's equal opportunities policy, both men and women are encouraged to apply.

1] **CERN, Council Secretariat – L00500, CH-1211 Geneva 23**
Tel. +41 22 767 28 34 – Fax. +41 22 766 62 22
council.secretariat@cern.ch

RWTH AACHEN UNIVERSITY Zukunft denken. | JARA Jülich Aachen Research Alliance | JÜLICH FORSCHUNGSZENTRUM

Forschungszentrum Jülich, member of the Helmholtz Association, and RWTH Aachen University have set up the strategic research alliance JARA (Jülich-Aachen Research Alliance). This created a new platform of interdisciplinary cooperation opportunities between a university of excellence and one of the largest research centres in Europe.

The Institute of Nuclear Physics (IKP) at Forschungszentrum Jülich and the Faculty of Mathematics, Computer Science and Natural Sciences are jointly seeking a qualified applicant for teaching and research in the area

Experimental Physics – Symmetry Breaking

In accordance with the "Jülich Model", the successful applicant will be appointed **professor (grade W2) of experimental physics** at RWTH Aachen University. We are seeking an internationally recognized scientist to work on experiments on the breaking of symmetries in the micro cosmos, especially on the leptonic CP-violation possibly through neutrino oscillations.

The position will be embedded in the JARA section FAME (Forces and Matter Experiments). FAME is trying to understand the fate of antimatter in the evolution of the universe. Its main experimental activities lie in the development of a dedicated storage ring for the measurement of the electric dipole moment of the proton and light nuclei and in the search for antimatter with the AMS-experiment on the international space station ISS. The section is extending its scope into the field of leptonic CP-violation. The research group will be part of the Institute of Nuclear Physics (IKP-2) at Forschungszentrum Jülich.

Contributions to the teaching duties of the Experimental Physics at RWTH Aachen University are expected to the amount of two hours per week (2 SWS), for example with courses in the bachelor and master programs in physics.

Successful applicants will have completed a university degree followed by a PhD and should be able to demonstrate additional scientific achievements in the form of a postdoctoral qualification, activities within the framework of a junior professorship or research work at a university, research institution or in another social sphere.

This position is also available as part-time employment per request. RWTH Aachen University and Forschungszentrum Jülich are certified as family friendly employers and offer a dual career program for partner hiring. We particularly welcome and encourage applications from women, disabled people and ethnic minority groups. The principles of fair and open competition apply and appointments will be made on merit.

Applications comprising curriculum vitae, list of publications and short summary of past and planned scientific activities and existing experience in teaching should be sent by **June 13 2014** to

Dean of Faculty of Mathematics, Computer Science and Natural Sciences
Prof. Kowalewski
RWTH Aachen University
52056 Aachen

Further information:
www.fz-juelich.de and **www.rwth-aachen.de**

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN FACULTY OF PHYSICS

As one of Europe's leading research universities, Ludwig-Maximilians-Universität (LMU) in Munich is committed to the highest international standards of excellence in research and teaching. Building on its more than 500-year-long tradition, it offers a broad spectrum that covers all areas of knowledge within its 18 Faculties, ranging from the humanities, law, economics and social sciences, to medicine and the natural sciences.

The **Faculty of Physics** invites applications for a

Professorship (W 2)
(6 years/tenure track)
of Theoretical Physics – Particle Physics

commencing as soon as possible.

Special emphasis will be given to candidates who work on the intersection of fundamental particle physics/gravity and their observational aspects. This includes the identification of the low energy consequences and possible experimental signatures of microscopic theories of nature in the framework of particle physics and cosmology, such as the study of fundamental physics beyond the standard model and of its phenomenological and cosmological implications for current and future experiments.

LMU Munich seeks to appoint a highly qualified junior academic to this professorship and, therefore, especially encourages early-career scholars to apply. Prerequisites for this position are a university and a doctoral degree. With an excellent record in research and teaching to date, prospective candidates will have demonstrated the potential for an outstanding academic career.

The initial appointment will be for six years. After a minimum of three years, it can be converted into a permanent position pending a positive evaluation of the candidate's performance in research and teaching as well as his or her personal aptitude and if all legal conditions are met.

Under the terms of the "LMU Academic Career Program", in exceptional cases and subject to outstanding performance in research and teaching, the position may be converted from a W2 into a W3 Full Professorship at a later date.

LMU Munich makes a point of providing newly appointed professors with various types of support, such as welcoming services and assistance for dual career couples.

LMU Munich is an equal opportunity employer. The University continues to be very successful in increasing the number of female faculty members and strongly encourages applications from female candidates. LMU Munich intends to enhance the diversity of its faculty members. Furthermore, disabled candidates with essentially equal qualifications will be given preference.

Please submit your application, comprising a curriculum vitae, documentation of academic degrees and certificates, list of publications and research statement, in both printed and electronic form, to the **Dean of the Faculty of Physics, Schellingstr. 4, D-80799, Munich, Germany, dekanat@physik.uni-muenchen.de, no later than May 31, 2014.**

University of HUDDERSFIELD Inspiring tomorrow's professionals

THE AWARDS AWARD WINNER UNIVERSITY OF THE YEAR

The International Institute for Accelerator Applications at the University of Huddersfield is offering a new and unique 12 month taught Master's course in Accelerator Science, providing a comprehensive training in the subject. Its graduates will be well matched to jobs working with accelerators, or to proceeding to a PhD.

Students learn using the computer packages (MAD, COMSOL, LabView, GEANT4, R and LaTeX) that accelerator scientists actually use. Through short projects with these they learn skills useful in their later career, and appreciated by those already in the field.

This is complemented by short laboratory experiments, meeting the subject hands-on: magnets, RF power, beam deflection and focusing, signal measurement, and more.

Students also write a dissertation on a research project, chosen to suit individual talents and plans.

The course is suitable for students with a Bachelor's degree in physics, or similar, wanting to specialise in Accelerator Science.

Students will be coming from very different backgrounds, so the course is designed to be flexible and allow for divergence. The University of Huddersfield has a strong system of student support: services, libraries, sports facilities and pastoral care. With students from over 120 countries on the campus, students from outside the UK soon settle in.

For details see **https://www.hud.ac.uk/research/researchcentres/iiaa/researchdegrees/mscdegrees/**

European XFEL SEIZE THE CHANCE

European XFEL is a is a multi-national non-profit company that is currently building an X-ray free-electron laser facility that will open up new areas of scientific research. When this facility is completed in 2015, its ultrashort X-ray flashes and unique research opportunities will attract scientists from all over the world to conduct ground-breaking experiments. We are a rapidly growing team made of people from more than 20 countries. Join us now!

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English is the working language. We offer salary and benefits similar to those of public service organisations in Germany, a free-of-charge company pension scheme, generous relocation package and support, international allowance for non-German candidates hired from abroad, training opportunities etc.

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eli Nuclear Physics

Senior and Junior Researchers, Postdoctoral Research Assistants, Engineers and Technicians at Extreme Light Infrastructure – Nuclear Physics (ELI-NP)

Extreme Light Infrastructure – Nuclear Physics (ELI-NP) will be a new Center for Scientific Research to be built by the National Institute of Physics and Nuclear Engineering (IFIN-HH) in Bucharest-Magurele, Romania.

ELI-NP is a complex facility which will host two state-of-the-art machines of high performances:

- A very high intensity laser, where beams from two 10 PW lasers are coherently added to get intensities of the order of 10^{23} - 10^{24} W/cm^2;
- A very intense (~10^{13} γ/s), brilliant γ beam, ~ 0.1 % bandwidth, with E γ > 19 MeV, which is obtained by incoherent Compton back scattering of a laser light off an intense electron beam (Ee > 700 MeV) produced by a warm linac.

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

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

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

FOM NIKHEF

FOM announces the search for a new

DIRECTOR OF NIKHEF

URL: http://cerncourier.com/cws/job/J000008202

The end of the fixed term appointment of the current director Frank Linde will be reached by 1 December 2014. FOM, the formal employer of the Nikhef director, has started a search for his successor.

The deadline for applications is 15 May 2014.

The international search committee will interview the top candidates in June 2014 in Amsterdam.

More information can be found on **www.fom.nl** and on **www.nikhef.nl**.

Should you have any questions regarding this search, or want to bring suitable candidates, especially women, to the attention of the committee, you can contact Dr. Wim van Saarloos, director of FOM, at **wim.van.saarloos@fom.nl.**

Fermilab

Fermilab offers Intensity Frontier Fellowships to outstanding researchers in the areas of neutrino physics, muon physics, and other topics in the Intensity Frontier. Fellows will receive funding to allow enhanced participation in Fermilab experimental and data analysis efforts, in relevant areas of particle physics theory, or in future projects. The fellowships provide the ability for researchers to spend significant time at Fermilab working within the Intensity Frontier Department, with the goal of expanding and sustaining an intellectual center of excellence within the laboratory and the department.

Successful candidates will ordinarily be resident at Fermilab for 50% or more of the duration of the Fellowship.

- Term: 6 months to 1 year.
- During the requested award period, candidates must be employed by a U.S. or non-U.S. institution. Fermilab employees are not eligible.
- Renewable to maximum of 2 years, with new proposal.
- Financial support: up to 50% of researcher's overall compensation, with remainder from researcher's home institution.
- Awards may include a travel budget.

Application Information
Applications for the current round of awards will be accepted until 11 May, 2014. It is anticipated that awards will be given out twice yearly. Applicants should be notified by 25 May, 2014.

Applications should be made electronically via:
https://academicjobsonline.org/ajo/jobs/3940

Further queries should be sent to:
intensity_frontier_fellowships@fnal.gov

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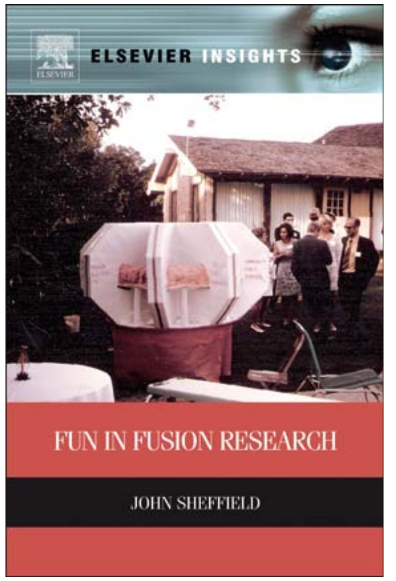
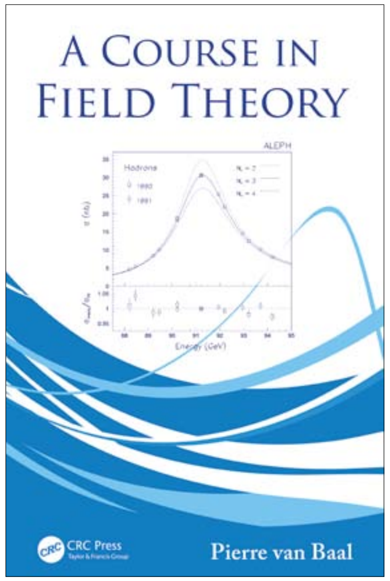




Fun in Fusion Research

By John Sheffield
Elsevier
Hardback: €50.95
E-book: €50.95

One thing the reader learns from this book is that the path towards achieving controlled nuclear fusion is not smooth or free from the vagaries of funding agencies. You also realize how incredibly difficult the problem is.

The fusion process is well understood and a number of experiments around the world have verified the principles. However, it still has to be demonstrated that a gain in energy can be achieved. There are two main approaches to accomplishing this. One is the magnetic confinement of deuterium–tritium plasma and the other is laser compression of a cryogenic layer of deuterium and tritium in a pellet. Sheffield takes the reader on a personal journey in the quest for a fusion device capable of producing net energy gain, recounting some amusing moments from his career as he oscillated between Europe and the US. Interspersed between the many stories, there is an historical account of modern fusion activity, covering both science and politics.

His research career in fusion started when he joined the United Kingdom Atomic Energy Authority laboratory at Harwell, close to Oxford, in 1958. There he began working on shock-wave experiments to reach the temperatures necessary for fusion. In these early shock experiments, as in all fusion experiments, high-voltage systems were the norm – and where large amounts of electrical energy are stored, sparks and explosions can occur. Sheffield recounts several stories of such explosions, sparks and fires. He was always amazed that no one was seriously injured – this was not a result of stringent safety precautions, but sheer luck. Today, safety officers reading these stories of capacitors accidentally discharging megajoules of energy would swiftly close down the site. Sheffield's early experiments on shock waves were indeed shut down, but because they were a dead end in terms of fusion. Nevertheless, by the end they had amassed a wealth of data on collisionless shock waves. This science of collisionless shocks is now an active research area in space physics and astrophysics.

The imagination of fusion scientists shows no bounds when it comes to thinking of new magnetic-field topologies to contain plasma with a temperature of 100 million degrees. However, the closing down of machines is a major problem in fusion research, which has resulted in there being today only a few major facilities, such as the Joint European Torus in the UK, the ITER international tokamak device being built in France, and the National Ignition Facility in the US, where a laser-fusion machine is operating and producing interesting results. Sheffield describes the "dinosaur chart" he created when accused by a congressional staffer that fusion scientists never wanted to close any line of research or a machine. The chart shows how projects are closed or cancelled. A parallel in accelerator physics is the Superconducting Super Collider (SSC) in the US, but most of the machines described in the dinosaur chart were being used for science, unlike the SSC, which was never completed.

The book is, in a sense, a short history of the quest for fusion, mainly through magnetic confinement, and the various stories paint an interesting picture of some of the characters in the field. A number of them are well known in fusion circles, but little known outside, so this will interest readers who are already working in fusion or plasma physics, where the stories and characters will be familiar. A few exceptions include Edward Teller, Andrei Sakharov, Lev Artsimovich and Marshall Rosenbluth.

There is some useful information about the various fusion processes and while the book is not comprehensive, it gives the main ideas – even if briefly – behind magnetic and inertial fusion. It conveys a strong message that fusion is well worth the effort, even though it is likely to be decades before energy is delivered to the Grid. It will appeal to those who have an interest in fusion and in the psychology behind scientific activity.

● *Robert Bingham, Central Laser Facility, Rutherford Appleton Laboratory and University of Strathclyde.*

A Course in Field Theory

By Pierre Van Baal
CRC Press
Hardback: £44.99 $69.95
Also available as an e-book

Quantum field theory is a mature discipline. One of the key questions today is how to teach and organize this large body of information, which spans several decades and encompasses diverse physical applications that range from condensed-matter to nuclear and high-energy physics. Since the turn of the millennium, interested readers have witnessed progressive growth in publications on the subject. More often than not, the authors choose to edit their own notes extensively, with the purpose of presenting a whole series of lectures as a treatise.

Indeed, it is common to see books on quantum field theory of around 500 pages. Most of these publications give slightly different perspectives on the same subjects, but their treatments are often synoptic because they all refer to some of the classic presentations on field theory of the

Bookshelf

20th century. The proliferation of books is at odds with the current practice where students are obliged to summarize a large number of different subjects through shorter texts, or even by systematic searches through various databases.

In this respect, *A Course in Field Theory* is a pleasant novelty that manages the impossible: a full course in field theory from a derivation of the Dirac equation to the standard electroweak theory in less than 200 pages. Moreover, the final chapter consists of a careful selection of assorted problems, which are original and either anticipate or detail some of the topics discussed in the bulk of the chapters.

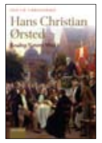
Instead of building a treatise out of a collection of lecture notes, the author took the complementary approach and constructed a course out of a number of well-known and classic treatises. The result is fresh and useful. The essential parts of the 22 short chapters — each covering approximately one or two blackboard lectures — are cleverly set out: the more thorough calculations are simply quoted by spelling out, in great detail, the chapters and sections of the various classic books on field theory, where students can appreciate the real source of the various treatments that have propagated through the current scientific literature. Despite the book's conciseness the mathematical approach is rigorous, and readers are never spoon-fed but encouraged to focus on the few essential themes of each lecture. The purpose is to induce specific reflections on many important applications that are often mentioned but not pedantically scrutinized. The ability to prioritize the various topics is wisely married with constant stimulus for the reader's curiosity.

This book will be useful not only for masters-level students but will, I hope, be well received by teachers and practitioners in the field. At a time when PowerPoint dictates the rules of scientific communication between students and teachers (and vice versa), this course – including some minor typos – smells pleasantly of chalk and blackboard.

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

Books received

Hans Christian Ørsted: Reading Nature's Mind
By Dan Ch Christensen
Oxford University Press
Hardback: £39.99 $69.95
Also available as an e-book, and at the CERN bookshop



Hans Christian Ørsted (1777–1851) is of great importance as a scientist and philosopher, far beyond the borders of Denmark and his own time. His discovery of electromagnetism revolutionized the course of physical research, and in time prompted technological inventions that changed the life of modern societies. He was also remarkable in unifying two cultures – the sciences and the arts. This first comprehensive and contextual biography of Ørsted offers cultural and sociological insights into the European network of scientists in the 19th century, when divergent national paradigms prevailed. It also illuminates Danish cultural and intellectual circles in the so-called Golden Age.

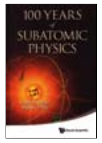
Space–Time Symmetry and Quantum Yang–Mills Gravity: How Space–Time Translational Gauge Symmetry Enables the Unification of Gravity with Other Forces
By Jong-Ping Hsu and Leonardo Hsu
World Scientific
Hardback: £65
E-book: £49

Yang–Mills gravity is a new theory, consistent with experiments, that brings gravity back to the arena of gauge field theory and quantum mechanics in flat space–time. It provides solutions to long-standing difficulties in physics, such as the incompatibility between Einstein's principle of general co-ordinate invariance and modern schemes for a quantum mechanical description of nature. The book aims to provide a treatment of quantum Yang–Mills gravity with an emphasis on the ideas and evidence that the gravitational field is the manifestation of space–time translational symmetry in flat space-time, and that there exists a fundamental space–time symmetry framework that can encompass all of physics, including gravity, for all inertial and non-inertial frames of reference.

Selected Papers II: With Commentaries
By Chen Ning Yang
World Scientific
Hardback: £65
Paperback: £32
E-book: £24

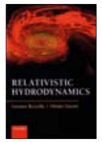
Since receiving his PhD from the University of Chicago in 1948, Chen Ning Yang has had great impact in both abstract theory and phenomenological analysis in modern physics. In 1983 he published *Selected Papers (1945–1980), With Commentary*. Freeman Dyson considered it to be one of his favourite books. This sequel to that previous volume is a collection of Yang's personally selected papers (1971–2012), supplemented by his insightful commentaries. Its contents reflect his changing interests after he reached the age of 30. It also includes commentaries that he wrote in 2011 when he was 89. The papers and commentaries in this collection comprise a remarkable personal and professional chronicle, shedding light on both the intellectual development of a great physicist and on the nature of scientific inquiry.

100 Years of Subatomic Physics
By Ernest M Henley and Stephen D Ellis (eds.)
World Scientific
Hardback: £58
Paperback: £32
E-book: £24
Also available at the CERN bookshop



By 1911, radioactivity had been discovered for more than a decade but its origin remained a mystery. Ernest Rutherford's discovery of the nucleus and the subsequent discovery of the neutron by James Chadwick started the field of subatomic physics – a quest to understand the fundamental constituents of matter. This book reviews the important achievements in subatomic physics in the past century. The chapters are divided into two parts – nuclear physics and particle physics – with contributions by many eminent researchers, from Steven Weinberg's overview of the subject to John Schwarz on string theory and M-theory.

Relativistic Hydrodynamics
By Luciano Rezzolla and Olindo Zanotti
Oxford University Press
Hardback: £55
Also available as an e-book



This book provides an up-to-date, lively and approachable introduction to the mathematical formalism, numerical techniques, and applications of relativistic hydrodynamics. It presents a well-organized description of the subject, from the basic principles of statistical kinetic theory, through the technical aspects of numerical methods devised for the solution of the equations, to applications in modern physics and astrophysics. There are numerous figures and diagrams, and a variety of exercises, which support the material in the book.

Viewpoint

Origins: the early days of CERN

François de Rose recalls the first discussions that ultimately led to the birth of CERN.

In 1946 a commission of the United Nations Security Council was entrusted with the task of making proposals to bring atomic energy under international control. It was one year after the devastation of Hiroshima, and the idea of such control had been approved by all the governments. The commission was made up of influential scientists who had the knowledge that was needed to understand the problem fully and of politicians and diplomats representing the governments' interests. It was in this capacity as a diplomat that I represented France on the commission and was able to establish trusting and friendly relations with many of my countrymen who were scientists, as well as with foreign scientists, first and foremost among whom was Robert Oppenheimer, who was to play a very important role in the creation of CERN.

In the course of the many conversations I had with Oppenheimer in the US, in which we were often joined by other Frenchmen, who were my scientific and technical advisers, he confided his worries about the future development of fundamental physics in Europe. "Almost all we know, we have learnt in Europe" is the substance of what he said. He himself had been a pupil of Niels Bohr in Copenhagen. "But in the future," he continued, "research is going to require industrial, technical and financial resources that will be beyond the means of individual European countries. You will therefore need to join forces to pool all your resources. It would be fundamentally unhealthy if European scientists were obliged to go to the US or the Soviet Union to conduct their research."

Early in 1950, convinced by this argument, Francis Perrin, then high commissioner for atomic energy in Paris, and I began to visit the main European research centres that would need to be persuaded. We met with a favourable response from Edoardo Amaldi in Italy, Niels Bohr in Copenhagen, Paul Scherrer in Switzerland and possibly Werner Heisenberg in Germany, if I remember correctly, but we were given a cooler reception in other capitals. Nevertheless, the idea was now on the table and was no doubt starting to take root in people's minds. Moreover, it came on top of an appeal on similar lines from the European Centre for Culture in Geneva, led by Denis de Rougemont from Switzerland and Raoul Dautry from France. It was then that Isidor Rabi, a Nobel prize winner, made his crucial speech at the UNESCO General Conference in Florence in June 1950. Speaking on behalf of the US, he more or less said the same thing that Oppenheimer had said to us in private.

A loyal supporter of CERN, François de Rose last visited the laboratory in July 2013. (Image credit: CERN-GE-1307171 – 01.)

This speech marked a definite turning point, persuading the majority of European scientists and their governments to adopt a resolution authorizing UNESCO to "assist and encourage the formation and organization of regional centres and laboratories in order to increase and make more fruitful the international collaboration of scientists". Pierre Auger, UNESCO's director of natural sciences, took matters in hand and, at the end of 1951, managed to organize a conference of all European scientists and government representatives, which I had the honour to chair and at which it was decided to establish the European Council for Nuclear Research.

The fundamental ideas, namely the goals that all the pioneers of what was to become CERN set themselves, consisted first of all in promoting European co-operation in this vital area. CERN was thus the first venture on a European scale and I can say that Robert Schuman, who was then French minister of foreign affairs and one of Europe's founding fathers, was immediately in favour of it. A second goal was to reintroduce complete freedom of communication and the sharing of knowledge into this branch of science.

It should be realized that, in the wake of Hiroshima, people were afraid of science and of nuclear science in particular. "The physicists have known sin" said Oppenheimer, and the consequence of using scientists' work for military purposes was the imposition of secrecy and the lack of communication between research centres. By immediately taking the opposite approach to fundamental research in its statutes, CERN was following the great tradition of science knowing no boundaries. The ambitions of these pioneers were more than fulfilled, since CERN is today home to scientists from all over the world, including the US, China, Japan and Russia, all working together and in teams on the same research, the results of which are published in full.

Another of my memories concerns the extension of the CERN site into France. After the construction of the 28 GeV Proton Synchrotron, it soon became apparent that, in the time-honoured fashion, this was only a scale model of more powerful machines to come. The area that Switzerland had been able to set aside for CERN could not be extended on the Swiss side. Luckily, the site ran alongside the border with France, and the land in that area was essentially being used for farming. The continuation and development of CERN's activities were therefore dependent on extending the site into France, thus requiring a parcel of around 500 hectares of French land to be made available to an international organization with its headquarters in Switzerland. I prepared a dossier, which was submitted to the then French president, General de Gaulle, by the minister of foreign affairs, Maurice Couve de Murville. That is how CERN became – and I think remains to this day – the only research centre to straddle the border of two countries.

● *François de Rose, a French diplomat, was involved in the creation of CERN from the very beginning. He wrote this Viewpoint at the time of CERN's 50th anniversary (CERN Courier October 2004 p74). Sadly, he died in March, in the 60th anniversary year of the organization he helped to found (see tribute p24).*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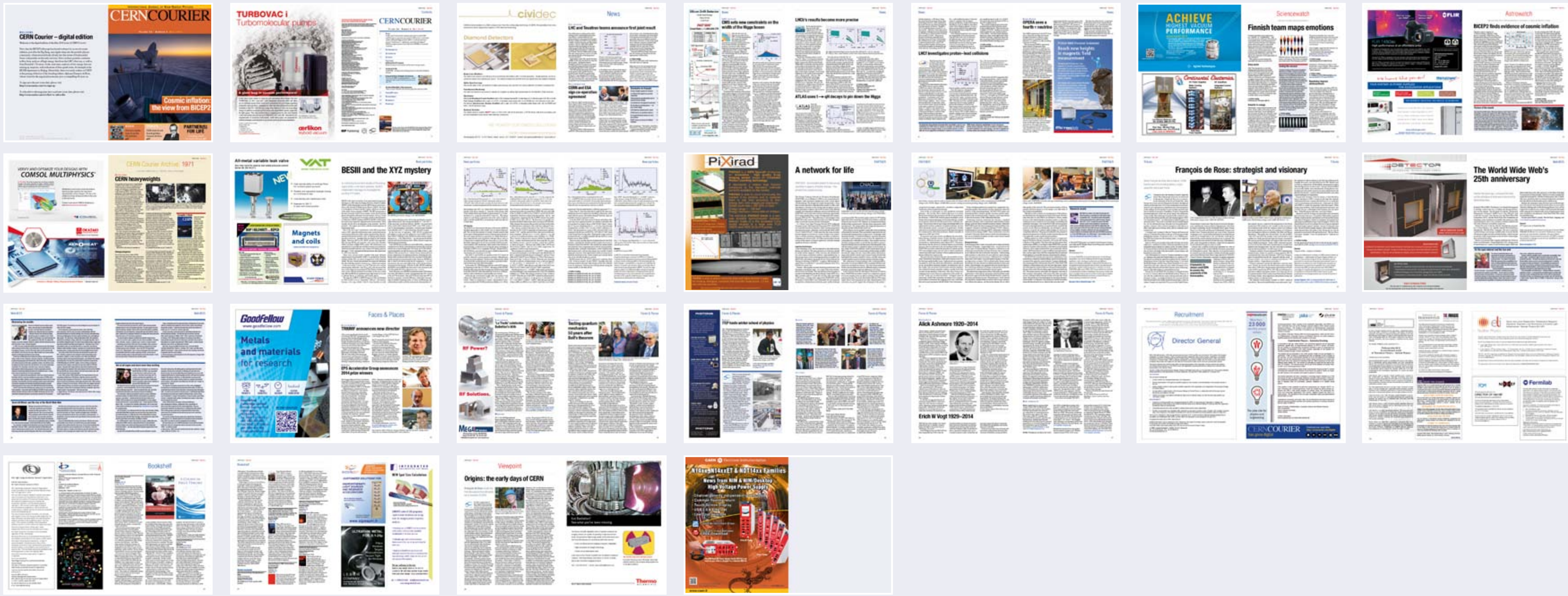

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Volume 54 Number 4 May 2014

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