WELCOME

CERN Courier – digital edition

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

This edition celebrates a number of anniversaries. Starting with the "oldest", 2013 saw the centenary of the birth of Bruno Pontecorvo, whose life and contributions to neutrino physics were celebrated with a symposium in Rome in September. Moving forwards, it is the 50th anniversary of the Institute for High Energy Physics in Protvino, Russia, and also of CESAR – CERN's first storage ring, which saw the first beam in December 1963 and paved the way for the LHC. More recently, a new network for mathematical and theoretical physics started up 10 years ago, re-establishing connections between scientists in the Balkans. At the same time, the longer-standing CERN School of Computing began a phase of reinvigoration. There is also a selection of books for more relaxed reading during the festive season.

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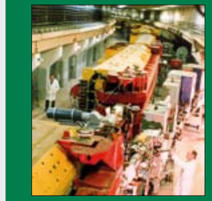
CERNCOURIER

VOLUME 53 NUMBER 10 DECEMBER 2013

Towards the intensity frontier



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SCIENCE IN THE BALKANS

The story behind a physics network **p21**

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

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On the cover: A view of Fermilab with the Booster ring in the foreground, the Linac behind it and the iconic Wilson Hall. Upgrades to the whole accelerator complex are paving the way to a proton beam power of 700 kW (p24). (Image credit: Fermilab.)

News

AWARDS

2013 Nobel Prize in physics goes to Englert and Higgs

Champagne corks popped at CERN on 8 October, to celebrate the award of the 2013 Nobel Prize in Physics to François Englert, professor emeritus at the Université libre de Bruxelles, and Peter Higgs, professor emeritus at the University of Edinburgh. They received the honour "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider". The announcement of the discovery by the ATLAS and CMS collaborations took place at CERN on 4 July last year (*CERN Courier* September 2012 p46).

"I'm thrilled that this year's Nobel Prize has gone to particle physics," said CERN's director-general, Rolf Heuer. "The discovery of the Higgs boson at CERN last year, which validates the Brout–Englert–Higgs mechanism, marked the culmination of decades of intellectual effort by many people around the world."

The Brout–Englert–Higgs (BEH) mechanism was first proposed in 1964 in two papers published independently – the first by Belgian physicists Robert Brout (now deceased) and his colleague Englert, the second by British physicist Higgs. It explains how the force responsible for β decay turns out to be much weaker than electromagnetism, but it is better known as the mechanism that endows fundamental particles with mass. A third paper, published by Americans Gerald Guralnik and Carl Hagen with their British colleague Tom Kibble, further contributed to the development of the new idea, which now forms an essential part of the Standard Model of particle physics. A key prediction of the idea, as was pointed out by Higgs, is the existence of a massive boson of a new type. After searches in earlier experiments, mainly at CERN and Fermilab, the particle was finally discovered by the ATLAS and CMS experiments at the LHC in 2012.

Top: François Englert (left), at the ATLAS experiment, and Peter Higgs, at CMS. Bottom: A jubilant crowd at CERN watches the announcement of the Nobel Prize live on the screen visible to the right.

The Standard Model describes both the fundamental particles from which all the visible matter in the universe is made and the interactions that govern their behaviour. It is a remarkably successful theory that has been thoroughly tested by experiment over many years. Until last year, the BEH mechanism was the last remaining piece of the model to be experimentally verified. Now that it has been found, experiments at CERN are searching assiduously for physics beyond the Standard Model.

Further reading

For more about the work behind the prize, see the official website of the Nobel prize http://www.nobelprize.org/nobel_prizes/physics/laureates/2013/advanced-physicsprize2013.pdf and also Steven Weinberg's article in *CERN Courier* January/February 2008 p17.

Sommaire en français

LHC PHYSICS

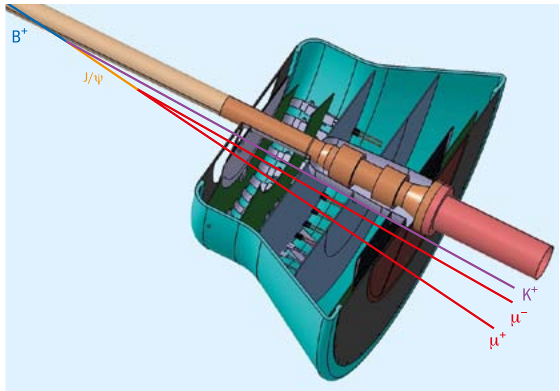
A new focus on forward muons for the ALICE upgrade programme

The ALICE experiment, with its state-of-the-art detection systems, produced a wealth of results during Run 1 of the LHC (2009–2013) — driving a new impetus in the field of heavy-ion collisions. While Run 2 (2015–2017) will see the consolidation and completion of the scientific programme for which the experiment was originally approved, the ALICE collaboration has already taken up the challenge to make a quantitative leap in the precision of its observations by exploiting the high luminosity anticipated for the LHC in Run 3 (2019–2022). The plan is to upgrade the detector during the LHC's second long shutdown, just before Run 3. In September, the LHC Committee (LHCC) approved an addendum to the letter of intent for the ALICE upgrade programme concerning the project for the Muon Forward Tracker (MFT) — an assembly of silicon pixel planes serving as internal tracker, in the forward acceptance of ALICE's muon arm.

The basic idea behind the MFT concept — measuring muons both before and after the hadron absorber, then matching the two pieces of information — is well established in the field of heavy-ion physics, having been exploited both at CERN's Super Proton Synchrotron and more recently at Brookhaven's Relativistic Heavy-Ion Collider. Evaluation of the expected scientific impact of such a major upgrade required the preparation of a detailed letter of intent, the first draft of which was submitted to the ALICE collaboration in December 2011. The final document received internal approval in March 2013 and the first discussions with the LHCC started two months later.

There are three main pillars of the MFT's contribution to the ALICE physics programme: dimuon measurement of prompt charmonia states J/ψ and ψ′, to study in-medium colour-screening and hadronization mechanisms of $c\bar{c}$ pairs; measurement of charm and beauty production via single muons and J/ψ particles from B decay, allowing a tomography of the medium via study of the energy loss of heavy quarks; and low-mass dimuon measurements, to study thermal radiation from quark–gluon plasma and search for in-medium modifications of the spectral functions of light vector mesons. The technical feasibility was also demonstrated as reported in the letter of intent — from the choice of the CMOS pixel technology to aspects related to the detector mechanics and cooling. It is also worth emphasizing that ALICE is the only LHC experiment that is designed to perform precision measurements at forward rapidities in the high-multiplicity environment of heavy-ion collisions.

What will the MFT do for ALICE? Put simply, it will be like wearing a pair of glasses to correct myopia. The MFT will reveal the details of the muon tracks in the vertex region, allowing not only a powerful rejection of background muons but also access to measurements that are not feasible with the existing muon spectrometer. A prime example is the disentanglement of prompt (charm) and displaced (from beauty) J/ψ production (figure 1), which is achievable only by measuring precisely the distance between the primary vertex of the collision and the vertex in which the J/ψ is produced. Because such distances are in the order of a few hundreds of micrometres, a dedicated vertex detector is needed. Figure 2 illustrates how this measurement becomes possible only with the addition of the MFT to the current muon spectrometer set-up.



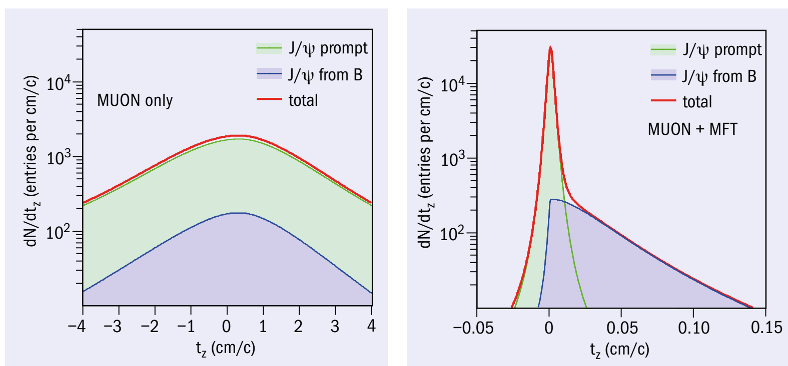


Fig. 1. (Left) Pictorial view of J/ψ production from B decay in the MFT detector. Fig. 2. (Below) Flight-time distributions (corresponding to the distance between the primary vertex and J/ψ origin) for prompt J/ψ and J/ψ from B production, comparing the performances with the current set-up of the muon arm (left), to those expected after the addition of the MFT.

The team involved with the MFT project must now provide details on all of the technological aspects, producing a Technical Design Report in the second half of 2014 – the final effort before assembling the first pieces of the detector. Then four more years of intense work will be needed before the MFT is installed and becomes operational in the ALICE cavern in 2019.

● Further reading

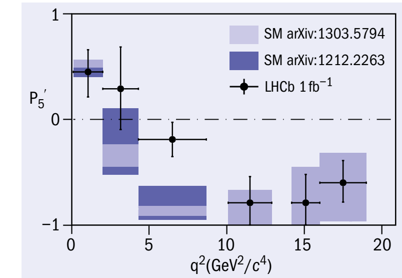
For more details, see the letter of intent at http://cds.cern.ch/record/1592659.

LHCb and theorists chart a course for discovery

Experimenters from LHCb and theorists recently met at CERN to discuss the best ways to obtain the most out of the rich harvest of data from the LHC.

Despite the large size of modern particle-physics collaborations, every experiment faces issues that arise because resources do not match ambitions. For LHCb, the 70 journal papers the collaboration has submitted this year are only the tip of the iceberg of the interesting and often unique measurements that could be achieved. Because this iceberg might be able to fracture the hull of the Standard Model, it is essential to maximize the output of physics. This makes close communication with theorists crucial.

To facilitate such discussions, on 14–16 October LHCb held a workshop at CERN on "Implications of LHCb measurements and future prospects". Following the tradition of two earlier meetings in the series, approximately 50 theorists from around the world joined members of the LHCb collaboration for intense discussions. Sessions covered charm mixing and CP violation, B mixing and CP violation, rare decays and "forward exotica", including topics such as the production of top quarks and Higgs bosons in the LHCb acceptance. There was also a session dedicated to the interplay of LHCb results with, for example, studies of the Higgs boson and searches for supersymmetry at ATLAS and CMS.



Comparison of LHCb data for P_5' with the Standard Model prediction using two different treatments of the theoretical uncertainty.

One of the hottest topics concerned recent measurements by LHCb of the angular distribution of the decay products of $B^0 \to K^{*0}\mu\mu$ transitions that have revealed tension with the prediction of the Standard Model (LHCb collaboration 2013). The observable known as P_5' – shown in the figure as a function of the dimuon invariant-mass squared (q^2) – is particularly interesting. This parameter is sensitive to the modulation of the angular distribution that depends on the interaction between different operators contributing to the decay. It is therefore sensitive to the effects of physics beyond the Standard Model. Additionally, P_5' is insensitive at leading order to theoretical uncertainties related to the K^* hadronic form factor. However, corrections from higher-order terms introduce residual uncertainty. The tension in the data can be reduced if the uncertainty is allowed to be larger than original estimates – an observation that sparked a debate about the best estimate of the size of the so-called "power corrections".

Several key points emerged from the discussion. On the theory side, further studies can help to understand the uncertainties in the form factor. Experimentally, improved analyses with the full LHCb data sample of 3 fb^{-1} are keenly anticipated: with this large data sample and exploiting the power of the LHCb particle identification system, it might be possible for the first time to perform a full angular analysis that also separates the subtle Kπ S-wave component from the K^* signal. Moreover, continuing discussions between theorists and experimenters will be needed to understand which of several different approaches to control the uncertainties is the most sensitive to physics beyond the Standard Model.

● Further reading

For more about the workshop, see http://indico.cern.ch/conferenceDisplay.py?ovw=True&confId=255380.

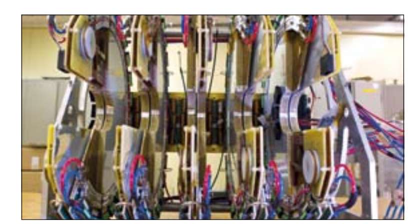
LHCb collaboration 2013 arXiv:1308.1707 to appear in *Phys. Rev. Lett.*

TOTEM continues to pin down physics in the very forward region

The TOTEM collaboration has made the first measurement of the double diffractive cross-section in the very forward region at the LHC, in a range in pseudorapidity where it has never been measured before.

Double diffraction (DD) is the process in which two colliding hadrons dissociate into clusters of particles, the interaction being mediated by an object with the quantum numbers of the vacuum. Because the exchange is colourless, DD events are typically associated experimentally with a large "rapidity gap" – a range in rapidity that is devoid of particles

The TOTEM experiment – designed in particular to study diffraction, total cross-sections and elastic scattering at the LHC – has three subdetectors placed symmetrically on both sides of the interaction point. Detectors in Roman pots identify leading protons, while two telescopes detect charged particles in the forward region. These two telescopes, T1 and T2, are the key to the measurement of double diffraction in the very forward region. T2 consists of gas-electron multipliers that detect charged particles with transverse momentum $p_T > 40$ MeV/c at pseudorapidities of $5.3 < |\eta| < 6.5$. The T1 telescope consists of cathode-strip chambers that measure charged particles with $p_T > 100$ MeV/c at $3.1 < |\eta| < 4.7$. (Pseudorapidity, η, is defined as $-\ln(\tan \theta/2)$, where θ is the angle of the outgoing particle relative to the beam axis, so a higher value corresponds to a more forward direction.)



The T2 telescope, seen during construction at CERN, plays a key role in detecting double-diffractive events.

For this novel measurement, TOTEM selected the DD events by vetoing T1 tracks and requiring tracks in T2. This is equivalent to selecting events that have two diffractive systems with $4.7 < |\eta|_{min} < 6.5$, where η_{min} is the minimum pseudorapidity of all of the primary particles produced in the diffractive system. The measurement used data that were collected in October 2011 at a centre-of-mass energy of 7 TeV during a low pile-up run with special $\beta^* = 90$ m optics and with the T2 minimum-bias trigger. After offline reconstruction, the DD events were selected by requiring tracks in both T2 arms and no tracks in either of the T1 arms. This allowed the extraction of a clean sample of double-diffractive events.

The analysis of these events led to a result for the double diffraction cross-section of $\sigma_{DD} = (116 \pm 25)\ \mu b$, for events where both diffractive systems have $4.7 < |\eta|_{min} < 6.5$. The measured values for the cross-section are between the predictions of the hadron-interaction models, Pythia and Phojet, for the corresponding ranges in η.

Further reading

G Antchev *et al.* 2013 TOTEM collaboration http://arxiv.org/pdf/1308.6722v1.pdf.

Astroparticle physics

First results from LUX on dark matter

The collaboration that built and runs the Large Underground Xenon (LUX) experiment, operating in the Sanford Underground Research Laboratory, has released its first results in the search for weakly interacting massive particles (WIMPs) – a favoured candidate for dark matter.

The LUX detector holds 370 kg of liquid xenon, with 250 kg actively monitored in a dual-phase (liquid–gas) time-projection chamber measuring 47 cm in diameter and 48 cm in height (cathode-to-gate). If a WIMP strikes a xenon atom it recoils from other xenon atoms and emits photons and electrons. The electrons are drawn upwards by an electrical field and interact with a thin layer of xenon gas at the top of the tank, releasing more photons. Light detectors in the top and bottom of the tank can detect single photons and so the two photon signals – one at the interaction point, the other at the top of the tank – can be pinpointed to within a few millimetres. The energy of the interaction can be measured precisely from the brightness of the signals.

The detector was filled with liquid xenon in February and the first results, for data taken during April to August, represent the analysis of 85.3 live days of data with a fiducial volume of 118 kg. The data are consistent with a background-only hypothesis, allowing 90% confidence limits to be set on spin-independent WIMP–nucleon elastic scattering with a minimum upper limit on the cross-section of $7.6 \times 10^{-46}\ \text{cm}^2$ at a WIMP mass of 33 GeV/c^2. The data are in strong disagreement with low-mass WIMP signal interpretations of the results from several recent direct-detection experiments.

The titanium cryostat that encloses the LUX dark-matter detector, seen here suspended in its water tank. (Image credit: Matt Kapust/Sandford Underground Research Facility.)

Further reading

LUX collaboration http://arxiv.org/abs/arXiv:1310.8214.

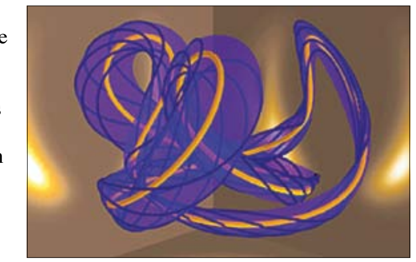
Sciencewatch

Compiled by John Swain, Northeastern University

Maxwell's equations yield knots of light

Everyone knows that light is supposed to travel in straight lines, so it comes as a surprise to find that light can be tied in 3D knots. Hridesh Kedia of the University of Chicago in the US and colleagues have found solutions of Maxwell's equations where the field lines encode all possible torus knots (knots that can be tied around a donut) and links (collections of such knots that link to each other).

The solutions are stable and retain their topology as they evolve in time. They are also stunning examples of topologically non-trivial structures in a linear field theory. The fields are null, with electric and magnetic fields always orthogonal to each other and of equal strength, and could be produced by suitably focussed laser beams. If implemented experimentally, they could be used to manipulate plasmas or quantum fluids in ways that have never before been possible.



The core magnetic-field line (orange) of a trefoil knot of light, wrapped in blue field lines confined to a torus (purple) that encloses the core.

Further reading

H Kedia *et al.* 2013 *Phys. Rev. Lett.* **111** 150404.

Alzheimer's breakthrough

Many neurodegenerative diseases, including Alzheimer's, involve the production of misfolded or otherwise faulty proteins called prions. As part of its defence mechanism against viruses, the brain can detect viral proteins and shut down the production of proteins – including viral ones – to prevent the spread of the virus. This mechanism can also respond to other faulty proteins and the shutdown can lead to the death of brain cells.

Giovanna Mallucci of the University of Leicester and colleagues have shown that an orally administered drug that blocks this response can completely prevent prion-induced neurodegeneration in mice. This is the first time that neurodegeneration has been prevented completely and it is being hailed as a turning point that could lead to an effective treatment for Alzheimer's disease.

Further reading

J A Moreno *et al.* 2013 *Sci. Transl. Med.* **5** 206 206ra138.

Why we sleep

All animals sleep and it has long been established that sleep plays a role in the consolidation of memories. Now it looks as though there is another reason to snooze. Lulu Xie of the University of Rochester Medical Center and colleagues used real-time assessment of tetramethylammonium diffusion and two-photon imaging in mice to show that both natural sleep and anaesthesia increase interstitial space by 60%, boosting convective exchange of cerebrospinal fluid with interstitial fluid. This boosts β-amyloid clearance and suggests that sleep is the brain's way of clearing out potentially toxic metabolic waste products of neural activity. Sleep deprivation not only impairs cognitive function, it kills rodents and flies in days to weeks and causes dementia and eventually death in humans within months to years.

Further reading

L Xie *et al.* 2103 *Science* **342** 273.

Snakes and vision

Many people are afraid of snakes – indeed, humans and primates can detect snakes faster than innocuous objects. Quan Van Le of the University of Toyama and colleagues have found neurons in the primate medial and dorsolateral pulvinar that respond selectively to images of snakes. Compared to three other categories of stimuli – monkey faces, monkey hands and geometrical shapes – snakes gave the fastest and strongest responses, which were not reduced by low spatial filtering.

The response to snakes seems to be hardwired and the parts of the brain involved are unique to primates, among mammals. This gives hard neuroscientific evidence for the "snake detection theory", which suggests that primate vision evolved in part driven by the need to recognize snakes.

Further reading

Q V Le *et al.* 2013 *PNAS Early Edition* www.pnas.org/cgi/doi/10.1073/pnas.1312648110.

The RNA of noble rot

Plant pathogens often cause disease through protein effectors, a case in point being the fungus *Botrytis cinerea*. Arne Weinberg of the University of California at Riverside and colleagues have now elucidated the exact mechanism. The fungus infects tomatoes and strawberries, causing grey mold, and is also the "noble rot" that is essential in the production of desert wines like Sauternes. The researchers have found that it uses small RNAs (sRNAs), typically 20 to 24 nucleotides long, to disrupt plant cell functions. More than 800 sRNAs are produced by *Botrytis* – a remarkable fact to contemplate over some Chateau d'Yquem.

Vineyards of Château d'Yquem, famous for its desert wine. (Image credit: Hel080808/Dreamstime.com.)

Further reading

A Weinberg *et al.* 2013 *Science* **342** 118.

Astrowatch

COMPILED BY MARC TÜRLER, ISDC AND OBSERVATORY OF THE UNIVERSITY OF GENEVA

Light echoes reveal black hole's violent past

Researchers using NASA's Chandra X-ray Observatory have found evidence that the normally dim region close to the supermassive black hole at the centre of the Milky Way flared up with at least two luminous outbursts during the past few hundred years. This was deduced from the light echoes of these outbursts on nearby gas clouds.

The motion of the stars at the centre of the Galaxy – which is seen from Earth as the Milky Way – has indicated the existence of a black hole with a mass of about four million times that of the Sun at the position of the radio source Sagittarius A*, or Sgr A* (*CERN Courier* November 2012 p15). This supermassive black hole is remarkably quiescent with an X-ray luminosity only about 10 orders of magnitude below the emission of active galactic nuclei. To explain such a weak emission, theorists developed a new class of models for which gas accretion onto a black hole would be radiatively inefficient. Nevertheless, despite its low emission, Sgr A* displays some activity in the form of flares. These occur almost daily and last less than about an hour. During a flare, the flux increases by a factor that ranges from a few to about a hundred at most, well below the emission potential of such a massive black hole.

X-ray astronomy began only 50 or so years ago, but there are ways to probe the earlier activity of this apparently dormant giant. One of them is to observe the X-ray emission of gas clouds surrounding the supermassive black hole. An outburst from Sgr A* could be reflected by the clouds towards Earth. The reflected light would then replay the original event with a delay, just as sound echoes reverberate long after the original noise was created. A beautiful example of such a light echo was witnessed around the flaring star V838 Monocerotis (Picture of the Month, *CERN Courier* June 2003 p13 and May 2005 p13).

A group of French astrophysicists with colleagues from the US and Germany used the high-resolution images from the Chandra satellite to investigate the past activity of Sgr A*. In data collected from 1999 to 2011, the team – led by Maïca Clavel from the AstroParticle and Cosmology (APC) laboratory in Paris – observed strong variations of the X-ray emission of clouds located near the Galactic centre. The X-ray echoes suggest that Sgr A* would have been

Composite false-colour image of the centre of the Milky Way hosting the supermassive black hole Sgr A. The infrared view by Hubble shows stars (yellow) and gas (pink), whereas Chandra's X rays reveal hot gas (blue). (Image credit: X-ray – NASA/UMass/D Wang* et al.*, IR – NASA/STScI.)*

at least a million times brighter had it been observed during X-ray outbursts of the past few hundred years.

This is the first time that astronomers have seen both increasing and decreasing X-ray emission in the same structures. Because the change in X rays lasts for only two years in one region and more than 10 years in others, this new study indicates that at least two separate outbursts were responsible for the light echoes observed from Sgr A*. These were likely to have been produced when large clumps of material – possibly from a disrupted star or planet – fell into the black hole. Some of the X rays produced by these episodes would then have produced X-ray fluorescence emission in gas clouds a hundred light years away from the black hole.

This study suggests that the recent quiescence of Sgr A* is only temporary and that the Milky Way's black hole can flare up whenever enough matter approaches its event horizon. During the past summer, a cloud of gas was observed to have been ripped apart by the tidal forces near Sgr A*. It remains to be seen how much X-ray radiation the accretion of some of this gas might produce in the coming months. A much stronger past activity of the nucleus of the Galaxy is also suggested by the detection by the Fermi Space Telescope of the two huge gamma-ray bubbles blown out on both sides of the Milky Way (*CERN Courier* January/February 2011 p11).

Further reading

M Clavel *et al.* 2013 *A&A* **558** A32.

Picture of the month

Look at the sky on Christmas Eve and you might see this comet called ISON. "Might", because astronomers are still speculating whether the comet's nucleus is big enough to survive its closest passage to the Sun on 28 November or whether it will disintegrate. In this respect, this Hubble Space Telescope image taken on 9 October when ISON was inside Mars's orbit is reassuring. There is no sign of fragmentation and the coma or head surrounding the comet's nucleus is symmetric and smooth. The comet's coma appears cyan, due to ionized gas, while the tail is reddish from dust streaming off the icy nucleus under the pressure of sunlight. The closest approach to Earth will be on 26 December at a distance of 64 million km. (Image credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA).)

CERN Courier Archive: 1970

A LOOK BACK TO CERN COURIER VOL. 10, DECEMBER 1970, COMPILED BY PEGGIE RIMMER

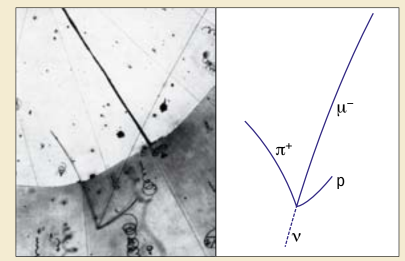
NEWS ROUND-UP

Five years at CERN

During a dinner with Council delegates on the night of 22 December, Bernard Gregory (left) receives an album of photographs from Professor Amaldi, recording some of the major events of his five years as director-general of CERN. On the right is his successor, Professor Jentschke.

● Taken from p378.

Firsts at Argonne and Batavia...



The first photograph of a neutrino interaction in pure hydrogen, recorded in the 12 foot hydrogen bubble chamber at Argonne. The sketch illustrates the analysis of the event. A neutrino enters from the bottom of the picture and interacts with a proton at the hydrogen nucleus to yield a positive pion, a proton and a muon.

● Taken from pp388–389.

A cluster of people around the controls of the Batavia 200 MeV linac when it produced its first full energy beam in the early hours of 1 December. In the foreground are R Rihet, R Goodwin, E Hubbard and M Shea. (Photo NAL.)

● Taken from p391.

...and a last?

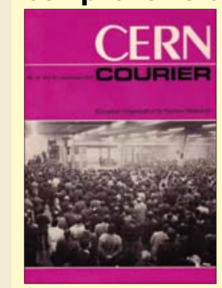
A small, just about portable, radiation detector, known as the Albatros I Neutron Monitor, has been designed by the Radiation Physics section at Batavia to monitor fast neutrons, which are usually the most serious radiation hazard in personnel-occupied areas when a high-energy accelerator is operating (in certain areas high-energy muons may also be a problem, but for most areas neutrons are the most troublesome).

The meter can be read in dose rate or in occupation time per day. The total integrated neutron dose is also recorded. An audible signal sounds when the dose rate exceeds 50 mRem/hr. The unit operates either on a battery pack or on AC power. It weighs approximately 10 kg (22 l lbs).

Other attractive features in the photograph are exclusive to Batavia. (Photo NAL.)

● Taken from p392.

Compiler's Note



Another year, *et plus ça change*...

In 1970, just as in 1969, Hildred Blewitt was the only female pictured in *CERN Courier* who could unequivocally be identified as a scientist/engineer (see *CERN Courier* November 2013). Buried among hundreds of photos of men of all kinds were about a dozen that featured women: a couple of data aides, a few secretaries, possibly a technician, a wife or two, a pair of ladies helping out in the ground-breaking dig for the Batavia main ring, and Margaret Thatcher visiting CERN as UK secretary of state for education and science. This count excludes females embellishing commercial adverts and the young lady shown here alongside a laboratory-developed instrument. We wouldn't get away with that kind of presentation these days! Even in the scene on the December 1970 cover (see thumbnail), there are only two people who are definitely identifiable as women in the CERN crowd that gathered to bid farewell to departing director-general Bernard Gregory.

So, how far have we come? Well, certainly more women feature in *CERN Courier* photos these days but what about actual CERN numbers? In 1970, 11% of the 2970 staff members were female. In 1990 the proportion had fallen to 10% out of 3140, but climbed to 21% out of 2430 by 2010.

At the last census in 2012, 20% of CERN's 2510 staff members were female. They were at roughly half-strength pro rata in the scientific and technical sectors: 10% among research physicists, 13% of applied physicists, 11% in computing and 14% in engineering. However, in administration women were punching very successfully above their statistical weight, comprising 52% of professional administrators, 94% of administrative assistants and 54% of the clerical staff.

Accelerators

CESAR: CERN's first storage ring

Fifty years ago, on 18 December 1963, the first beam circulated in the small machine that set CERN on course to the Intersecting Storage Rings and, ultimately, the LHC.

Mention CESAR today in accelerator circles and the likely reaction will be "Caesar who?" However, the CESAR we are writing about was not a person. It was the CERN Electron Storage and Accumulation Ring – a small machine, just 24 m in circumference, but of decisive importance for the direction in which CERN's accelerators evolved. To understand why, we have to go far back in CERN's history, to well before the first beam in the 26 GeV Proton Synchrotron (PS).

In 1956, when components for the PS were starting to be assembled, thoughts were already turning to what should come after. So in 1957, a group was constituted within the PS Division for research on new ideas for high-energy accelerators. An intensive exchange on such ideas ensued between CERN, the US and Novosibirsk (in what was then the USSR). Theoretical studies were supplemented by building prototypes for experimental studies and plans were made for entire model accelerators.

Apart from accelerators with energies well beyond that of the future PS, the concept of colliding beams – where the centre-of-mass energy would be orders of magnitude higher than achievable with beams on stationary targets – was gaining interest. The problem, however, was in obtaining sufficient beam intensity. The novel idea of "beam stacking", i.e. accumulation of many beam pulses of low intensity into a beam of high intensity, pioneered by a group at the Midwestern University Research Association (MURA) in the US, showed the way to go.

The PS started up brilliantly in November 1959, soon far exceeding its design intensity of 10^{10} protons per pulse and promising to go much further (*CERN Courier* December 1999 p15). That opened the possibility for the PS to be the injector for a proton–proton collider consisting of two synchrotron rings, in which successive PS pulses would be accumulated through beam stacking at 26 GeV, without the need for further acceleration. However, experience with beam stacking needed to be gained and important aspects of the collider rings had to be verified experimentally. To this end, the design of a small strong-focusing synchrotron-type model started

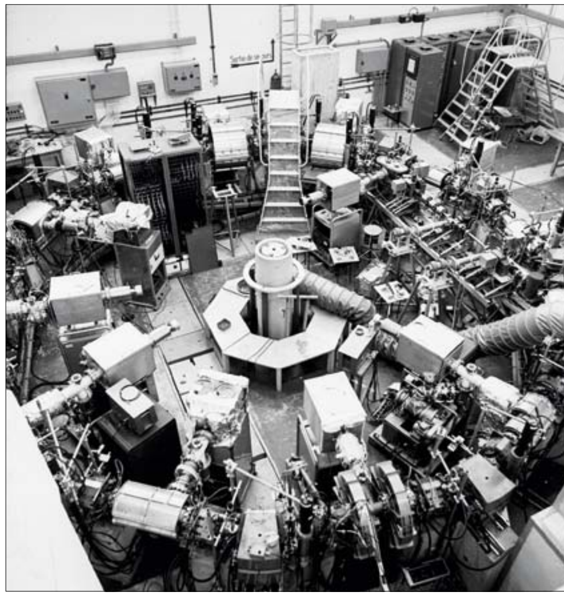


Fig. 1. The CESAR machine in its final state.

in 1960 – and so CESAR was conceived.

As a model, CESAR had to be small – 24 m in circumference – and yet the particles had to be highly relativistic, which meant the use of electrons. On the other hand, effects from synchrotron radiation had to be negligible, which meant low magnetic fields – 130 G (13 mT) in the bending magnets – and a corresponding kinetic energy of 1.75 MeV. The 2 MV van de Graaff generator already ordered for the fixed-field alternating-gradient (FFAG) model that CERN had previously intended to build therefore fitted the bill as injector.

Experience with beam stacking needed to be gained and important aspects of collider rings verified.

In 1961, the group that had been formed in 1957 was extended to become the Accelerator Research Division. It had groups to design the Intersecting Storage Rings (ISR) and the 300 GeV machine, which was to become the Super Proton Synchrotron. The CESAR group ▷

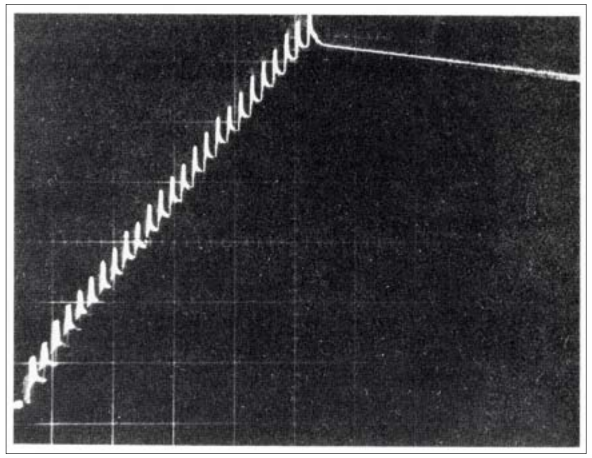


Fig. 2. The beam-transformer signal in CESAR showing stacking of 25 pulses injected at a rate of 50 Hz.

completed both the design of the storage-ring model and the ordering and building of components that had begun in 1960, and prepared for construction in a new experimental hall. Construction, installation of the magnet system and, in particular, the preparation of the vacuum system took place in 1962–1963. During this time, the long-awaited van de Graaff generator arrived. Its conditioning took months, through which loud bangs from spark-overs rang around the hall.

Finally, in summer 1963, the first beam was injected into the completed CESAR (figure 1). However, it would not circulate. To make it do so turned out to be a tedious job. The cause was that the magnetic fields were extremely low – 130 G in the bending magnets and a mere 15 G (1.5 mT) at the poles of the quadrupole magnets – compounded by the fact that the magnets were not laminated but made of massive soft iron. After powering a bending magnet, it took more than a day for its magnetic field to settle down to within 10^{-4} of its final value. The overhead crane had always to be parked at the end of the hall, as its position influenced the path of the electrons. Jokingly, we even evoked the phase of the Moon! Every power failure was a catastrophe, from which it took days to recover. Nevertheless, we finally made it. Early in the morning of 18 December 1963, the beam circulated.

A challenging experimental and technical programme lay ahead. Foremost, we had to demonstrate RF-capture of the injected beam and beam stacking and measure the stacking efficiencies for various modes of stacking. Of equal importance, we had to prove that a vacuum of 10^{-9} Torr, as required for the ISR, could be achieved in an extended accelerator system. We also had to measure beam lifetime in terms of number of turns, as an input to the considerations about long-term stability of the ISR beams. Later, there were also studies of the influence of higher-order resonances on emittance and beam lifetime.

Through 1964 and 1965, beam stacking was the dominant topic. Measurements showed that the stacking efficiency depended on various parameters more or less as theory and simulations predicted. Several variants of the stacking process were successfully developed, all with high efficiency and some approaching 100%. The vacuum system reached pressures of 2×10^{-9} Torr and clearly showed that lower pressures could be achieved. The beam lifetime of about 1 s was consistent with the calculated scattering on the residual gas.

By early 1965, we therefore had enough positive results to bolster the conviction that the ISR could achieve sufficiently intense beams with sufficiently long lifetimes. In June 1965, CERN Council approved the ISR Project. CESAR had done its job.

Experiments with CESAR, however, continued until the end of 1967, delivering a host of results that were useful later for the ISR, its vacuum system and its stacking operation. And there was another benefit from CESAR. It was an excellent accelerator school, from which several accelerator physicists emerged to play important roles in CERN's subsequent projects.

One can muse about the course that CERN's accelerator history might have taken without CESAR and its results. The ISR would not have been built. Would we then have dared to convert the SPS to a proton–antiproton collider? And without the competence and experience gained with these two colliders, would we have dared to propose the LHC? We opine that CESAR was decisive in setting CERN on the collider course – a course of great success – and that tiny CESAR is actually the great-grandfather of the giant LHC.

Résumé

CESAR : le premier anneau de stockage du CERN

Le 18 décembre 1963, le premier faisceau circulait dans CESAR, une petite machine qui a été pour le CERN une première étape sur la voie des anneaux de stockage à intersection et, à terme, du Grand collisionneur de hadrons. Le succès du démarrage du Synchrotron à protons en 1959 a incité les chercheurs à utiliser cette machine comme injecteur d'un collisionneur protons-protons à deux anneaux, permettant d'accumuler des impulsions successives de faisceaux injectés . Il a été décidé d'expérimenter ce procédé au moyen d'un petit anneau de stockage : CESAR, dont la conception a commencé en 1960. L'expérience a été suffisamment probante pour amener l'approbation du projet des anneaux de stockage à intersection (ISR).

Kurt Hübner, CERN, and **Heribert Koziol**, formerly CERN, retired.

(Left to right) Students at the 2013 CSC in Nicosia in August. (Image credit: G Lo Presti.) With the CSC Diploma in their sights, students take the final exam. (Image credit: F Fluckiger.) The social dimension – discovering sea kayaking. (Image credit: J Hammer.)

CERN School of Computing: 10 years of renewal

François Fluckiger looks at how the CSC has been reinvigorated during the past decade.

On 29 August 2013, on the ground floor of Building FST01 of the Faculty of Pure and Applied Sciences at the University of Cyprus in Nicosia, 31 students filed silently into the two classrooms of the CERN School of Computing and took a seat in front of a computer. An hour later they were followed by a second wave of 31 students. They were all there to participate in the 12th occasion of a unique CERN initiative – the final examination of its computing school.

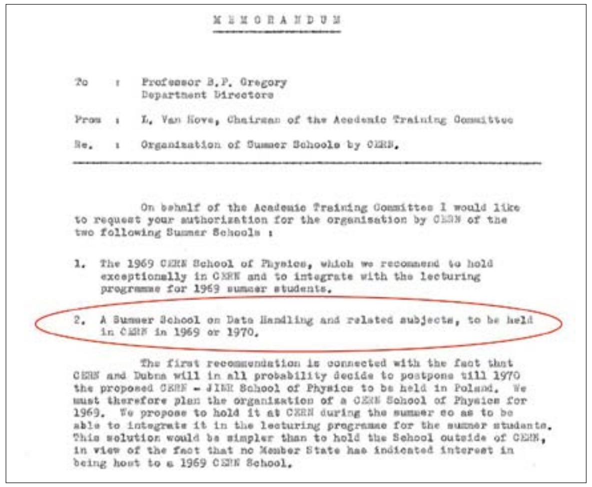
The CERN School of Computing (CSC) is one of the three schools that CERN has set up to deliver knowledge in the organization's main scientific and technical pillars – physics, accelerators and computing. Like its counterparts, the CERN Accelerator School and what is now the European School of High-Energy Physics, each year it attracts several-dozen participants from across the world for a fortnight of activities relating to its main topic.

How and why was the CSC set up? On 23 September 1968, future director-general Léon van Hove put forward a proposal to the then director-general, Bernard Gregory, for the creation of a summer school on data handling. This followed a recommendation made on 21 May 1968 to the Academic Training Committee by Ross MacLeod, head of the Data and Documents Division, the forerunner of today's Information Technology Department. The proposal recommended that a school be organized in summer 1969 or 1970. The memorandum from van Hove to Gregory gave a visionary description of the potential audience for this new school: "It would address a mixed audience of young high-energy physicists and computer scientists." Forty-five years later, not a word needs to be changed.

The justification for the school was also prophetic: "One of the interests of the Data Handling Summer School lies in the fact that it would be useful not only for high-energy physicists but also for those working in applied mathematics and computing. It would be an excellent opportunity for CERN to strengthen its contacts with a field which may well play a growing role in the long-range future." With the agreement of Mervyn Hine, director of research, Gregory approved the proposal on 15 November 1968 and on 20 December MacLeod proposed a list of names to van Hove to form the first organizing committee. Alongside people from outside CERN – Bernard Levrat, John Burren and Peter Kirstein – were Tor Bloch, Rudi Böck, Bernard French, Robert Hagedorn, Lew Kowarski, Carlo Rubbia and Paolo Zanella from CERN.

The first CSC was not held at CERN as initially proposed but in Varenna, Italy, in 1970. It was realized quickly that the computing school – with the physics and accelerator schools – could be effective for collaboration between national physics communities and CERN. Until 1986 the CSC was organized every other year, then yearly starting with the school in Troia, Portugal, in 1987. To date there have been 36 schools, attended by 2300 students from five continents.

Ten years ago, I took over the reins of the school and proposed a redefinition of its objectives as it entered its fourth decade: "The school's main aim is to create and share a common culture in the field of scientific computing, which is a strategic necessity to promote mobility within CERN and between institutes, and to carry out large transnational computing projects. The second aim is the creation of strong social links between participants, students and teachers alike, to reinforce the cohesion of the community ▷



MEMORANDUM

To : Professor B.P. Gregory
Department Directors

From : L. Van Hove, Chairman of the Academic Training Committee

Re. : Organisation of Summer Schools by CERN.

On behalf of the Academic Training Committee I would like to request your authorization for the organisation by CERN of the two following Summer Schools :

1. The 1969 CERN School of Physics, which we recommend to hold exceptionally in CERN and to integrate with the lecturing programme for 1969 summer students.

2. A Summer School on Data Handling and related subjects, to be held in CERN in 1969 or 1970.

The first recommendation is connected with the fact that CERN and Dubna will in all probability decide to postpone till 1970 the proposed CERN – JINR School of Physics to be held in Poland. We must therefore plan the organisation of a CERN School of Physics for 1969. We propose to hold it at CERN during the summer so as to be able to integrate it in the lecturing programme for the summer students. This solution would be simpler than to hold the School outside of CERN, in view of the fact that no Member State has indicated interest in being host to a 1969 CERN School.

How it all began – the 1968 memorandum from Léon van Hove to Bernard Gregory, then director-general of CERN.

and improve the effectiveness of its shared initiatives. The school should be open to computer scientists and physicists and ensure that both groups get to know each other and acquire a solid grounding in whichever of these domains is not their own."

Moreover, the new management proposed three major changes of direction. First, they vowed to reinvigorate the resolutely academic dimension of the CSC, which during the years had gradually and imperceptibly become more like a conference. Conferences are necessary for scientific progress – they are forums where people can present their work, have their ideas challenged, have fruitful discussions about controversial issues and talk about themselves and what they do. The interventions at conferences are short, sometimes redundant or contradictory. The transmission of facts and opinions becomes more prominent than the transfer of knowledge. I took the view that this should not be the primary role of the CSC, since conferences such as the Computing in High-Energy Physics series serve this purpose perfectly. The academic dimension was therefore progressively re-established through the implementation of three principles.

Three principles

The first academic principle concerns the organization of the teaching. A deliberately limited number of teachers – each giving a series of lessons of several hours – ensures coherence between the different classes, avoids redundancy and delivers consistent content, more than a series of short interventions. Moreover, for several years now all of the non-CERN teachers have been university professors. This is not the result of a strict policy but it is worthy of note that the choice of teachers has been consistent with this academic ambition.

The second principle for restoring the academic dimension concerns the school's curriculum. The main accent is on the transmission of knowledge and not of know-how. In this way, the CSC differs from training programmes organized by the laboratories and institutes, which are focused on know-how. The difference between knowledge and know-how is an important principle in the field of learning sciences. To get a better understanding of this distinction, the management of the school established relations with experts in the field at an early stage, particularly at the University of Geneva.

What are the differences? Knowledge is made up of fundamental concepts and facts on which additional knowledge is built and developed to persist over time. Moreover, the student acquires knowledge, incorporates it into his or her personal knowledge corpus and transforms it. Two physicists never have the same understanding of quantum mechanics. On the other hand, know-how – which includes methods and the use of tools – can generally be acquired autonomously with few prerequisites. With the exception of physical skills – such as knowing how to ride a bike or swim – which we tend not to lose, know-how requires regular practise so that it is not forgotten. Knowledge is more enduring by nature. Finally – and this is one of the main differences – knowledge can be transposed more readily to other environments and adapted to new problems. That at least is the theory. In practice, the differences are sometimes less clear. This is the challenge with which the CSC tries to get to grips each year when defining its programme – are we really operating mainly in the field of knowledge? The school is made up in equal parts of lectures and hands-on sessions, so do the latter not relate more to know-how? Yes, but the acquisition of this know-how is not an end in itself – it provides knowledge with a better anchorage.

The third principle of the academic dimension is evaluation of the knowledge acquired and recognition of the required level of excellence with a certificate. Following requests from students who wanted the high level of knowledge gained during the school to be formally certified, the CSC Diploma was introduced in 2002 to recognize success in the final exam and vouch for the student's diligence throughout the programme. To date, 671 students have been awarded the CSC Diploma, which often figures prominently in their CVs. But that's not all. Since 2008, the academic quality of the school, its teachers and exam has been formally audited each year by a different independent university. Each autumn, the school management prepares a file that is aimed at integrating the next school into the academic curriculum of the host university. The universities of Brunel, Copenhagen, Gjøvik, Göttingen, Nicosia and Uppsala have analysed and accepted CERN's request. As a result, they have each awarded a formal European Credit Transfer System (ECTS) certificate to complement the CERN diploma.

This academic reorientation of the school is one of the three main renewal projects undertaken during the past 10 years. The second relates to the school's social dimension. The creation of social links and networks between the participants and with their teachers has become the school's second aim. This is considered to be a strategic objective because not only does it reinforce the cohesion of the community, it also improves the efficiency of large projects or services, such as the Worldwide LHC Computing Grid, through improved mutual understanding between the individuals contributing to them.

The main vehicle chosen for socialization is sport. Every afternoon, a large part of the timetable is freed up for a dozen indoor and outdoor sports. Tennis, climbing or swimming lessons are given, often by the school's teachers. Each year, participants discover an activity that is new to them, such as horse riding, sailing, canoeing, kayaking, scuba diving, rock climbing, cricket and mountain biking. The sport programme is supported by the CERN Medical Service and is associated with the "Move! Eat better" initiative.

A second vehicle for socialization – music – is being considered and could be introduced for future schools. The intention is to give those who are interested the opportunity each afternoon to take part in instrumental music or choral singing or to discover them for the first time, with the same aim as for sport of "doing things together to get to know each other better".

The third renewal project is plurality. In contrast to CERN's high-energy physics and accelerator schools, which have organized several annual events for a number of years, the CSC has long remained the organization's only school in the field of computing. However, since 2005 the CSC management has organized the inverted CSC (iCSC, "Where students turn into teachers") and starting in 2013 the thematic CSC (tCSC). The idea behind the inverted school is simple – to capitalize on the considerable amount of knowledge accumulated by the participants in a school by inviting them to teach one or more lessons at a short school of three to five half-days, organized at CERN at the mid-point between two summer schools. To date, 40 former students have taught at one of these inverted schools.

It should be noted that the academic principle is still predominant. The goal is not to talk about oneself or one's project but to present a topic, an innovative one if possible. This is not always easy, so each young teacher who is selected is assigned a mentor who follows the design and production of the lesson across three months. The inverted school has another aim – it is also a school for learning to teach. It represents the second link in a chain of training stages for new teachers for the main school. The first link, for those who are interested, is to give a short academic presentation while attending the main school. After the iCSC, i.e. the second link, some are invited to give an hour's lesson at the main school before the last stage – their full integration into the teaching staff. This process generally takes several years.

During the latest CSC in Nicosia, five out of the 11 teachers were younger than 35. Three of them had passed through the CSC training chain. Along with their forthcoming colleagues, they are the future of the school. Leaving the CSC after 11 years as its director, I am confident that the next generation is ready to take up the baton.

● Further reading

For more about the CSC, visit http://csc.cern.ch.

Résumé

L'École d'informatique du CERN : 10 années de rénovation

Quand François Fluckiger a pris les rênes de L'École d'informatique du CERN, en 2003, il a proposé trois chantiers de rénovation. L'affirmation de la dimension académique tout d'abord : un contenu fondé sur les connaissances et non sur les savoir-faire ; un examen final sanctionné par un diplôme et un certificat officiel de crédit ECTS. En second lieu, la promotion du rôle social de l'école, avec le sport comme véhicule principal. En troisième lieu, la pluralité : non pas un seul événement annuel mais également une école thématique et une école inversée (« Quand les étudiants deviennent professeurs »), l'un des maillons d'une chaîne de formation par laquelle sont passés trois des enseignants actuels.

François Fluckiger, director, CERN School of Computing.

The multifaceted life of Pontecorvo

A symposium in Rome celebrated the centenary of Bruno Pontecorvo. **Luciano Maiani** was one of the speakers.

Bruno Pontecorvo (1913–1993) was born in Pisa but his scientific life began in Rome, when he was accepted into the group of physicists working at Sapienza University of Roma with Enrico Fermi. It was a small but exceptional group of young people attracted by the strong personality of Fermi, who were later known as "the boys of Via Panisperna" from the name of the street where the physics institute was located at that time. Pontecorvo arrived in Rome in time to participate in the discovery of radioactivity induced by slow neutrons, for which Fermi was to receive the Nobel Prize in Physics in 1938. A famous picture shows the group at the time of the discovery, with the notable absence of Bruno (figure 1). This was for good reason – he was behind the camera, taking the picture.

On 11–12 September 2013, Sapienza University of Rome celebrated Pontecorvo's centenary with an international scientific symposium – The Legacy of Bruno Pontecorvo: the Man and the Scientist. (Another was held later in Pisa.) Inaugurated in the presence of the president of the republic, Giorgio Napolitano (figure 2), it was attended by distinguished physicists from Italy and other European countries, as well as Japan, Russia, the US and CERN. The talks revisited different sides of Pontecorvo's long and multifaceted scientific life, which was marked by his lucid and deep passion for science and his important contributions to several branches of nuclear and particle physics.

It was a life sharply divided in two parts by his sudden move to the Soviet Union in the summer of 1950, when he went from England via Italy and Sweden, to reappear five years later in Dubna as part of the Soviet scientific establishment. Presenting an historical perspective of Pontecorvo's life, Frank Close spoke of "a life of two halves". One could add a third life – the one lived during the decline and dissolution of the Soviet system, with periodic visits to Italy and disenchantment in the 1980s, which are well described in a book by Miriam Mafai, *Il lungo freddo* (*The Long Cold*), published in 1990.

Jack Steinberger opened the meeting by speaking about when he was a student of Fermi and Pontecorvo came to Chicago from Canada to visit his old mentor. Pontecorvo had discovered that the capture of the muon by nuclei, measured by Marcello Conversi, Ettore Pancini and Oreste Piccioni in Rome, was consistent with having the same strength as electron capture – that is, that the muon and the electron, besides having the same electric charge, share the same coupling in the weak interaction. It was the start of the lepton family and the universality of the weak interaction, which would eventually evolve into the long story of electroweak unification. Steinberger was doing his thesis with Fermi on muon decay, which led him to discover the continuum character of the electron's spectrum, entirely analogous to nuclear beta decay.

Pontecorvo's research during his Canadian period was presented by Giuseppe Fidecaro, who delved into the development of the radiochemical method to detect neutrinos – later applied by Raymond Davis to detect solar neutrinos. Luigi Di Lella described the studies by Pontecorvo and Ted Hincks on muon decay, including the search for the decay $\mu \rightarrow e\gamma$ – a long saga, which also saw Steinberger as a protagonist and which continues today with the MEG experiment at PSI. Di Lella ended with the ideas that Pontecorvo developed in Dubna on high-energy neutrino interactions, somehow anticipating the independent line of research carried out at Brookhaven by Leon Lederman, Melvin Schwarz and Steinberger, which eventually led to the discovery of the two kinds of neutrino in 1962 and the award of the Nobel prize in 1988.

An important part of the conference was dedicated to neutrino oscillations – Pontecorvo's other great intuition – with an update on solar and atmospheric neutrino oscillations by Till Kirsten and Yoichiro Suzuki, respectively. An overall view was given by Samoil Bilenky from Dubna, who was a collaborator and friend of Pontecorvo for a long time.

In Dubna, Pontecorvo became the reference figure for many Russian physicists and also for the physicists from Western Europe

(Top) Fig. 1. The boys of Via Panisperna. Right to left: Enrico Fermi, Franco Rasetti, Edoardo Amaldi, Emilio Segrè, Oscar D'Agostino... so where is Bruno Pontecorvo? (Image credit: Wikipedia commons.) (Above) Fig. 2. Giorgio Napolitano, left, president of the Italian Republic, greets some of the speakers at the symposium celebrating Bruno Pontecorvo's centenary. From right to left: Carlo Bernardini, Fernando Ferroni, Jack Steinberger, Carlo Dionisi. (Image credit: Antonio Di Gennaro, Ufficio Stampa del Quirinale.)

Fig. 3. (Left) Bruno Pontecorvo with N N Bogolioubov, Dubna's director and (right) talking to Vicky Weisskopf, CERN's director-general.

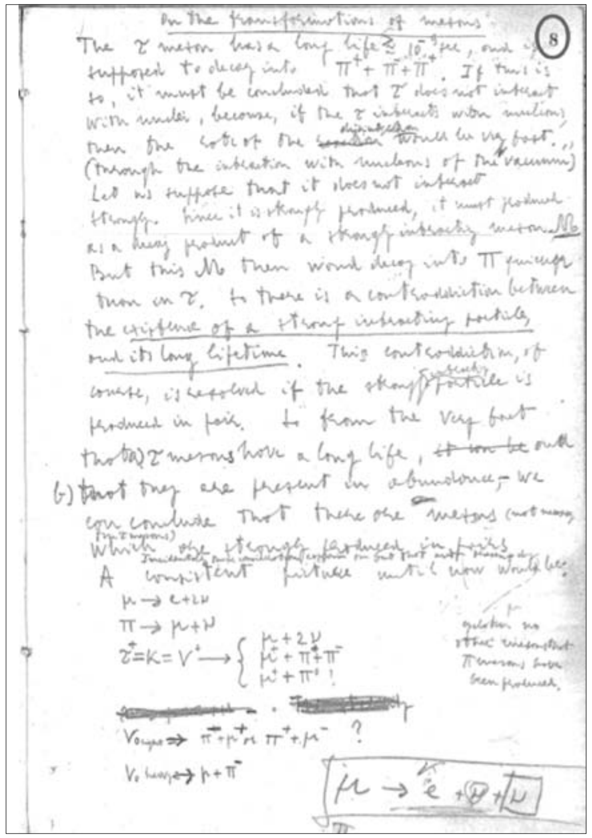


Fig. 4. A page from Pontecorvo's log book started in Dubna on 1 November 1950: "On the transformations of mesons". Note the formula at the end of the page with a different characterization for the two neutrinos from muon decay. (Image credit: G Pontecorvo.)

and CERN who visited countries in the East (figure 3). Ettore Fiorini brought his recollections of Pontecorvo at the Balaton School, in Hungary, at the time of the discovery of neutral currents, while Ugo Amaldi spoke of his relations with Pontecorvo at Dubna, when the Russian participation in the DELPHI experiment at the Large-Electron Positron collider was taking shape.

Two historical talks gave an idea of the depth of Bruno Pontecorvo's personality.

Nadia Robotti documented the path of Pontecorvo in the Panisperna group. From his initial position as the youngest and most inexperienced member of the group – he was called "the cub" – he went on to become in few years a respected researcher, signing one publication with Fermi and Rasetti alone, and owner of part of the slow-neutron technologies. Later, when the group in Rome started to split up, Pontecorvo moved independently from Fermi to find a position in Paris, in the laboratory of Frédéric Joliot and Irène Curie, where he arrived in spring 1936 as a fully formed and independent investigator in the most advanced fields of nuclear physics.

Precious testimony

In a second historical talk, Rino Castaldi brought a precious testimony from when Pontecorvo arrived in Dubna. It was a handwritten log book begun on 1 November 1950, which Gloria Spandre and Elena Volterrani obtained from Pontecorvo's eldest son, Gil. Page after page, written in minute but precise writing with remarkably few cancellations, reconstruct a picture of Pontecorvo building up his future activity in particle physics in the new laboratory where he had chosen to spend his life. From issues in the life of an experimental physicist and ideas about new experiments, through glimpses about his thoughts on the mysterious strongly produced but long-lived particles (the strange particles), to a tantalizing formula for muon beta decay, with one neutrino encircled and the other in a box (figure 4) – could this be a hint that the two neutrinos might be different? We can leave the answer to Pontecorvo himself. Much later, he described his earlier activity on the weak interaction in a contribution to the International Colloquium on Particle Physics in Paris in July 1982:

"I have to come back a long way (1947–1950). Several groups, among which J Steinberger, E Hincks and I, and others were investigating the (cosmic) muon decay. The result of the investigations was that the decaying muon emits 3 particles: one electron…and two neutral particles, which were called by various people in different ways: two neutrinos, neutrino and neutretto, ν and ν´, etc. I am saying this to make clear that for people working on muons in the old times, the question about different types of neutrinos has always been present…for people like Bernardini, Steinberger, Hincks and me…the two neutrino question was never forgotten."

The centenary symposium took place in the Aula Magna of Sapienza University in Rome, where Fermi worked from 1935 to 1938, the year of his departure to Stockholm (for the Nobel prize) and then to the US. Organized with efficiency by the indefatigable Carlo Dionisi, professor of physics at Sapienza, it was an occasion for the larger Pontecorvo family – the Italian and Russian branches – to gather, cheer and greet friends and colleagues.

● For all of the presentations at the symposium, see https://agenda.infn.it/conferenceOtherViews.py?view=standard&confId=6051.

Résumé

Bruno Pontecorvo, physicien aux multiples facettes

Un colloque s'est tenu à Rome en septembre pour célébrer le centenaire de la naissance de Bruno Pontecorvo, qui faisait partie de la petite équipe de jeunes chercheurs d'exception ayant travaillé sous la supervision d'Enrico Fermi à Rome. Les conférences ont traité des nombreux aspects de la vie scientifique de Pontecorvo, marquée par la passion profonde et lucide du chercheur pour la science, ainsi que par sa contribution importante à de nombreux domaines de la physique nucléaire et de la physique des particules. Luciano Maiani, l'un des conférenciers, rappelle les points forts du colloque, notamment la découverte d'un journal de bord que Pontecorvo a rédigé peu après son arrivée à Doubna en 1950.

Luciano Maiani, Sapienza University in Rome.

Ten years of SEE-NET-MTP. Left: SEENET-MTP developed from the vision of Julius Wess (left) to re-establish scientific co-operation in Balkan countries post-1990. Centre: The network's first meeting was the 2003 Balkan Workshop in Serbia. Right: at the 2013 Balkan Workshop (left to right), Luis Álvarez-Gaumé, Goran Djordjević, Guido Martinelli, Paolo Creminelli and Raul Jimenez. (Image credits: (Left) Jelena Djordjević and (centre and right) Milan Milosevic.)

A network for the Balkans

Ten years ago, a project to establish a Balkan network in mathematical and theoretical physics took shape. **Goran Djordjević** looks at the origins of SEENET-MTP and how it developed.

From 1945 to 1990, the development of scientific educational and research capacities in physics in the Balkans followed the political and economic courses of the relevant countries. Yugoslavia and the six republics in its federation developed ties – to a greater or lesser extent – with both the East and the West, while Romania and Bulgaria became well integrated into the scientific system of the Soviet Union and the Eastern Bloc. In these countries and in the entire Balkans, the period was marked by a significant increase in the number of scientists – primarily in the field of physics – and scientific publications. There was also a substantial rise in the level of university education and scientific infrastructure, which had been lower before the Second World War or limited to a small number of exceptional yet isolated individuals or smaller institutions. Greece and Turkey were connected mainly to the US or Western Europe, while Albania was in self-imposed isolation for much of this period.

The years following 1990 brought significant changes, which were particularly dramatic and negative for the countries that were created after the break-up of Yugoslavia. The wars waged on the territory of the former Socialist Federal Republic of Yugoslavia and enormous economic problems resulted in the devastation of scientific capacities, the leaving of mainly young physicists and the stopping of many programmes and once-traditional scientific meetings – in particular the world-renowned "Adriatic meetings". Less dramatic but more significant changes took place in Bulgaria, Romania and even Moldavia and the Ukraine – countries on the periphery of the Balkans but in the same neighbourhood. The number and quality of students graduating in physics, as well as financial investment in all forms of scientific educational work, plummeted. The number of researchers and PhD students, in particular, dropped so significantly in the majority of university centres that the critical mass necessary for teaching at graduate level as well as for teamwork and competitiveness was lost. The remaining young research groups and students – some only 100 km apart – had no form of communication, exchange or co-operation. European integration – if it began at all – proceeded slowly, while many previously established ties were severed.

Wess and WIGV

The origins of the Southeastern European Network in Mathematical and Theoretical Physics (SEENET-MTP) are linked to Julius Wess and his initiative "Wissenschaftler in globaler Verantwortung" (WIGV) – "Scientists in global responsibility" – launched in 1999 (Möller 2012). Wess was professor at the Ludwig Maximilian University (LMU) of Munich and director of the Max Planck Institute (MPI) for Physics in Munich. Like most people in Europe, he deplored the Yugoslav Wars of the 1990s and this eventually turned into a resolve to engage hands-on in re-establishing scientific co-operation with the scientists of former Yugoslavia during the "Triangle meeting" in Zagreb in 1999. Wess collected information about the remaining links between scientists in the new countries of the former Yugoslavia and the rest of the world, and especially between the former Yugoslav countries. He also found out about the institutional and economic situation of the universities and institutes.

The first network meeting of WIGV was organized in Maribor, Slovenia, in May 2000. It was followed by activities such as the Eighth Adriatic Meeting in Dubrovnik, Croatia, and the First German-Serbian School in Modern Mathematical Physics in Soko Banja, Serbia, in 2001. Three postdoc positions and many short-term fellowships were established in Munich, supported by the German ▷

Participants at the 2013 Balkan Workshop, which was held in Vrnjačka Banja, Serbia, as was the first one. (Image credit: M Milosevic.)

Academic Exchange Service (DAAD), the German Research Foundation (DFG) and the Federal Ministry of Education and Research (BMBF). The biggest and, in a sense, the most important action was the Scientific Information Network for South East Europe (SINSEE/SINYU) project to establish new high-speed fibre capacity across large distances, especially for the scientific community, with SINYU covering the region of the former Yugoslavia.

Unfortunately, between the summers of 2002 and 2003 the WIGV initiative lost its momentum. Many of the financial ad-hoc instruments created for the region ended during this time. Wess also needed to pause because of serious health problems in 2003. However, between October 2000 and December 2002 the idea of a "southeastern European" rather than "Yugoslav" network in mathematical and theoretical physics emerged and evolved in discussions between Wess, myself and other colleagues who visited Munich or took part in numerous meetings supported by WIGV.

Our impression was that a critical mass of students and researchers in the region of the former Yugoslavia could not be achieved and that a larger context should be attempted – the Balkans. In addition to the former Yugoslavia, this would include Bulgaria, Greece, Romania, Turkey, etc. We hoped that this kind of approach would have a political as well as scientific dimension, alongside other benefits. Agreement was quickly reached and the name Southeastern European Network in Mathematical and Theoretical Physics (SEENET-MTP) was created. With the personal recommendations of Wess, I visited CERN, the International Centre for Theoretical Physics (ICTP), the UNESCO headquarters in Paris and the UNESCO Venice office to promote the idea. In the course of discussions, the foundations were laid for support for the future network.

The SEENET-MTP Network

The founding meeting of the network was set up as a workshop – the Balkan Workshop (BW2003) on Mathematical, Theoretical and Phenomenological Challenges Beyond the Standard Model, with Perspectives of Balkans collaboration – that was held as a satellite meeting of the Fifth General Conference of the Balkan Physical Union, in Vrnjačka Banja, Serbia, in August 2003. This made it possible to have a regional meeting, with representatives from nearly all of the relevant countries present. Unlike the First German–Serbian School and some other actions, Germany's contribution to the budget of BW2003 was no more than a third. The organization of the workshop was not without some controversy. It was a difficult but important lesson in the writing of applications for funding, proposals for projects and their implementation. The meeting, which had excellent lecturers, ended with the ratification of a letter of intent, followed by the election of myself as co-ordinator of the Network and Wess as co-ordinator of the Scientific-Advisory Committee (SAC) for the network (Djordjević 2012).

While singling out the role of individuals might seem disproportionate, it is a pleasure to underline the role of Boyka Aneva in motivating colleagues from Sofia, Mihai Visinescu for those from Romania, Goran Senjanović of ICTP for his service as co-ordinator of the Network SAC (2008–2013) and the first and the current presidents of the Representative Committee of the SEENET-MTP Network, Radu Constantinescu of Craiova (2009–2013) and Dumitru Vulcanov of Timisoara, respectively. Starting in 2003 with 40 members and three nodes in Niš, Sofia and Bucharest, the network has grown steadily to its current size, now covering almost all of the countries in the Southeastern European region plus Ukraine. The Balkan Workshops series is an important part of the SEENET-MTP programme (see box). The most complex meeting of the network was the Balkan Summer Institute (BSI2011) with 180 participants and four associated events (*CERN Courier* November 2011 p46).

The main goals of the network and its activities and results can be summarized as follows.

- *To organize scientific and research activities in the region and the improvement of interregional collaboration through networking, the organization of scientific events and mobility programmes.* The network has organized 15 scientific meetings (schools and workshops) and supported an additional 10 events. Around 1000 researchers and students have taken part in these meetings. Through UNESCO projects, followed by the ICTP project "Cosmology and Strings" PRJ-09, there have been more than 200 researcher and student exchanges in the region, about 150 seminars and 100 joint scientific papers. In co-operation with leading publishers both in the region and the rest of the world, the network has published numerous proceedings, topical journal issues and two monographs. It has also implemented 15 projects, mainly supported by UNESCO, ICTP and German foundations.
- *To promote the exchange of students and encourage communication between gifted pupils motivated towards natural sciences and their high schools.* Three meetings and contests in the "Science and society" framework have been organized in Romania with 100 high-school pupils and undergraduate students. The network was a permanent supporter and driving force in establishing and supporting the first class for gifted high-school pupils in Niš, Serbia, and its networking with similar programmes.
- *To create a database as the foundation for an up-to-date overview of results obtained by different research organizations and, through this, the institutional capacity-building in physics and mathematics.* The SEENET-MTP office in Niš, established in 2009, in co-operation with the University of Craiova and UNESCO Venice office, set up the project "Map of Excellence in Physics and Mathematics in SEE – the SEE MP e-Survey Project". It has collected a full set of data on 40 leading institutions in physics and mathematics in seven Balkan countries.

BW2013: 10 years of the network

This year's Balkan workshop – BW2013 Beyond the Standard Models – was held on 25–29 April in Vrnjačka Banja, Serbia, just like the first one. The meeting also provided an opportunity to mark 10 years of the network, which now consists of 20 institutions from 11 countries in the region and has 14 partner institutions and more than 350 individual members from around the world. It was organized by the Faculty of Science and Mathematics and SEENET-MTP office, Niš, in co-operation with the CERN Theory Group, the International School for Advanced Studies (SISSA) and ICTP, with the Physical Society Niš as local co-organizer.

The workshop offered a platform for discussions on three topics: beyond the Standard Model, everyday practice in particle physics and cosmology, and regional and interregional co-operation in science and education. The first two days were devoted to purely scientific problems, including new trends in particle and astroparticle physics: theory and phenomenology, cosmology (classical and quantum, inflation, dark matter and dark energy), quantum gravity and extra dimensions, strings, and non-commutative and non-archimedean quantum models. It was an opportunity to gather together leading experts in physics and students from the EU and Eastern Europe to discuss these topics. The third day was organized as a series of round tables on building sustainable knowledge-based societies, with a few invited lecturers and moderators from the Central European Initiative (CEI), UNESCO, the European Physical Society (EPS) etc.

In total, 78 participants from 25 countries came to the events. Around 30 invited scientific talks, 15 panel presentations and several posters were presented. The EPS president John Dudley, EPS-CEI chair Goran Djordjević and former EPS presidents Macie Kolwas and Norbert Kroó were among the panellists. Mario Scalet (UNESCO Venice), Fernando Quevedo (ICTP), Luis Álvarez-Gaume, Ignatios Antoniadis and John Ellis (CERN), Alexei Morozov (ITEP, Moscow), Guido Martinelli (SISSA), Radomir Žikić (Ministry of Education and Science, Serbia) and others contributed greatly to the overall discussion and decisions made towards new projects. Dejan Stojković (SUNY at Buffalo) was unable to attend but has contributed a great deal as lecturer, adviser and guest editor in many network activities. Under the aegis and with the support of the EPS, the first meeting of the EPS Committee of European Integration (EPS-CEI) took place during the workshop and the first ad-hoc consortium based on the SEENET-MTP experience for future EU projects established.

Despite the unexpected success of the SEENET-MTP initiative, its future faces challenges: to provide a mid-term and long-term financial base through EU funds, to prove its ability to contribute to current main lines of research, to extend the meeting's activities from Bulgaria, Romania and Serbia and to other countries in the network, to organize a more self-connected and permanent training programme through topical one-week seminars for masters and PhD students in its nodes and, possibly in the future, joint masters or PhD programmes.

SEENET-MTP and physicists in the SEE region still need a partnership with leading institutions, organizations and individuals, primarily from Europe. In addition to LMU/MPI, the role of which was crucial in the period 2000–2009, and the long-term partners UNESCO and ICTP, the most promising supporters should be EPS, SISSA and CEI, as well as the most supportive one in the past few years – CERN and its Theory Group.

SEENET-MTP: main network meetings

- BW2003 Workshop, Vrnjačka Banja, Serbia
- BW2005 Workshop, Vrnjačka Banja, Serbia
- MMP2006 School, Sofia, Bulgaria
- BW2007 Workshop, Kladovo, Serbia
- MMP2008 School, Varna, Bulgaria
- SSSCP2009 School, Belgrade-Niš, Serbia
- EBES2010 Conference, Niš, Serbia
- QFTHS2010 School and Workshop, Calimanesti, Romania
- BSI2011 Summer Institute, Donji Milanovac, Serbia
- QFTHS2012 School and Workshop, Craiova, Romania
- BW2013 Workshop, Vrnjačka Banja, Serbia

Further reading

For more about SEENET-MTP, visit www.seenet-mtp.info.

R Constantinescu and G S Djordjević 2009 *Education and Research in the SEENET-MTP Regional Framework for Higher Education in Physics* 7th Conference of BPU CP1203 AIP 1261.
G S Djordjević 2012 *Scientific and Human Legacy of Julius Wess – JW2011, Int. J. Mod. Phys. Conf. Ser.* **13** 66.
L Moeller 2012 *Scientific and Human Legacy of Julius Wess – JW2011, Int. J. Mod. Phys. Conf. Ser.* **13** 141.

Résumé

SEENET-MTP : créer un réseau de la physique dans les Balkans

De 1945 à 1990, le développement des capacités de recherche et d'enseignement en physique dans les Balkans a suivi de près les évolutions économiques et politiques des différents pays de la région. Après 1990, la région a connu de grands bouleversements, et la physique a particulièrement souffert dans les pays formés à la suite de l'éclatement de la Yougoslavie. En 1999, Julius Wess a lancé une action visant à ranimer la collaboration scientifique avec les chercheurs de l'ex-Yougoslavie. C'est ainsi qu'est né un projet de réseau de physique mathématique et théorique pour l'Europe du Sud-Est, SEENET-MTP, qui a vu le jour il y a dix ans à l'occasion du premier atelier Balkans en août 2003.

Goran S Djordjević, SEENET-MTP Executive Director, University of Niš.

CERN Courier December 2013
Facilities

Fermilab gears up for an intense future

After a 16-month shutdown, the Fermilab accelerator complex is again providing particle beams for many different physics experiments.

When a beam of protons passed through Fermilab's Main Injector at the end of July, it marked the first operation of the accelerator complex since April 2012. The intervening long shutdown had seen significant changes to all of the accelerators to increase the proton-beam intensity that they can deliver and so maximize the scientific reach of Fermilab's experiments. In August, acceleration of protons to 120 GeV succeeded at the first attempt – a real accomplishment after all of the upgrades that were made – and in September the Main Injector was already delivering 250 kW of proton-beam power. The goal is to reach 700 kW in the next couple of years.

With the end of the Tevatron collider programme in 2011, Fermilab increased its focus on studying neutrinos and rare subatomic processes while continuing its active role in the CMS experiment at CERN (*CERN Courier* October 2011 p20). Accelerator-based neutrino experiments, in particular, require intense proton beams. In the spring of 2012, Fermilab's accelerator complex produced the most intense high-energy beam of neutrinos in the world, delivering a peak power of 350 kW by routinely sending 3.8×10^{13} protons/pulse at 120 GeV every 2.067 s to the MINOS and MINERvA neutrino experiments. It also delivered 15 kW of beam power at 8 GeV, sending 4.4×10^{12} protons/pulse every 0.4 s to the MiniBooNE neutrino experiment.

Higher intensities

This level of beam intensity was pushing the capabilities of the Linac, the Booster and the Main Injector. During the shutdown, Fermilab reconfigured its accelerator complex (see figure 1) and upgraded its machines to prepare them for the new NOvA, MicroBooNE and LBNE experiments, which will demand more muon neutrinos. In addition, the planned Muon g-2 and Mu2e experiments will require proton beams for muon production. With the higher beam intensities it is important to reduce beam losses, so the recent accelerator upgrades have also greatly improved beam quality and mitigated beam losses.

Before the shutdown, four machines were involved in delivering protons for neutrino production: the Cockcroft–Walton pre-accelerator, the linear accelerator, the Booster accelerator and the Main Injector. During the past 15 years, the proton requests for the Linac and Booster have gone up by more than an order of magnitude – first in support of MiniBooNE, which received beam from the Booster, and then in support of MINOS, which received beam from the Main Injector. Past upgrades to the accelerator complex

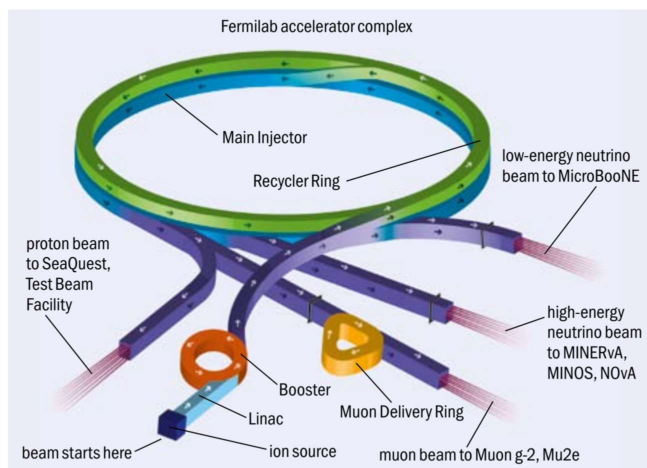
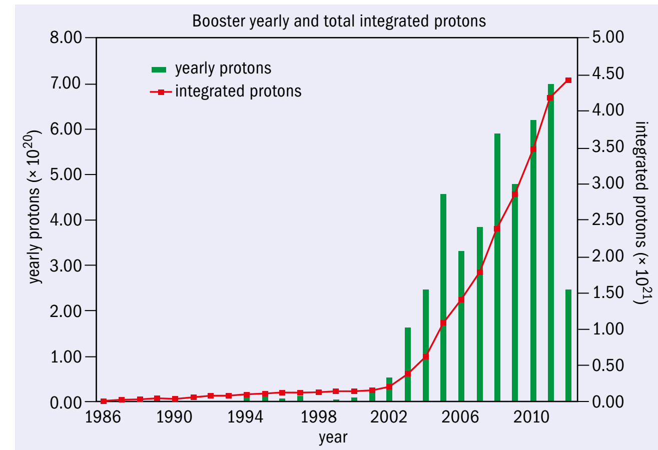


Fig. 1. (Top) Satellite view of Fermilab with the Main Injector ring to the right of the ring of the former Tevatron. (Above) Fermilab's reconfigured accelerator complex. The proton beamlines point to the lower left in both images. (Image credit: Fermilab.)

ensured that those requests were met. However, during the next 10 years another factor of three is required to meet the goals of the new neutrino experiments. The latest upgrades are a major step towards meeting these goals.

For the first 40 years of the laboratory's existence, the initial stage of the Fermilab accelerator chain was a caesium-ion source and a Cockcroft–Walton accelerator, which produced a 750 keV H^- beam. In August 2012, these were replaced with a new ion source, a radiofrequency quadrupole (RFQ) and an Einzel lens.



(Top) Fig. 2. Proton throughput in the Booster since 1986. Throughput in 2003 was more than the integrated number of protons delivered in the previous 10 years. Delivery in 2012 was low compared to 2011 because the accelerator complex shut down at the end of April for upgrades. (Above) Fig. 3. Protons from the Booster can now be injected into either the Main Injector (lower beam line) or directly into the Recycler (upper beam line). (Image credits: Fermilab.)

The RFQ accomplishes transverse focusing, bunching and acceleration in a single compact device, significantly smaller than the room-sized Cockcroft–Walton accelerator. Now the 750 keV beam is already bunched, which improves capture in the following Linac (a drift-tube linear accelerator). The Einzel lens is used as a beam chopper: the transmission of the ions can be turned on and off by varying the voltage on the lens. Since the ion source and RFQ are a continuous-wave system, beam chopping is important to develop notches in the beam to allow for the rise times of the Booster extraction kicker. Chopping at the lowest possible energy minimizes the power loss in other areas of the complex.

The Booster, which receives 400 MeV H^- ions from the Linac, uses charge-exchange injection to strip the electrons from the ions and maximize beam current. It then accelerates the protons to 8 GeV. For the first 30 years of Booster operation, the demand for proton pulses was often less than 1 Hz and never higher than about 2 Hz. With the advent of MiniBooNE in 2002 and MINOS in 2005, demand for protons rose dramatically. As figure 2 shows, in 2003 – the first year of full MiniBooNE operation – 1.6×10^{20} protons travelled through the Booster. This number was greater than the total for the previous 10 years.

Booster upgrades

A series of upgrades during the past 10 years enabled this factor of 10 increase in proton throughput. The upgrades improved both the physical infrastructure (e.g. cooling water and transformer power) and accelerator physics (aperture and orbit control).

While the Booster magnet systems resonate at 15 Hz – the maximum number of cycles the machine can deliver – many of the other systems have not had sufficient power or cooling to operate at this frequency. Previous upgrades have pushed the Booster's performance to about 7.5 Hz but the goal of the current upgrades is to bring the 40-year-old Linac and Booster up to full 15 Hz operation.

Understanding the aperture, orbit, beam tune and beam losses is increasingly important as the beam frequency rises. Beam losses directly result in component activation, which makes maintenance and repair more difficult because of radiation exposure to workers. Upgrades to instrumentation (beam-position monitors and dampers), orbit control (new ramped multipole correctors) and loss control (collimation systems) have led to a decrease in total power loss of a factor of two, even with the factor of 10 increase in total beam throughput.

Two ongoing upgrades to the RF systems continued during the recent shutdown. One concerns the replacement of the 20 RF power systems, exchanging the vacuum-tube-based modulators and power amplifiers from the 1970s with a solid-state system. This upgrade was geared towards improving reliability and reducing maintenance. The solid-state designs have been in use in the Main Injector for 15 years and have proved to be reliable. The tube-based power amplifiers were mounted on the RF cavities in the Booster tunnel, a location that exposed maintenance technicians to radiation. The new systems reduce the number of components in the tunnel, therefore reducing radiation exposure and downtime because they can be serviced without entering the accelerator tunnel. The second upgrade is a refurbishment of the cavities, with a focus on the cooling and the ferrite tuners. As operations continue, the refurbishment is done serially so that the Booster always has a minimum number of operational ▷

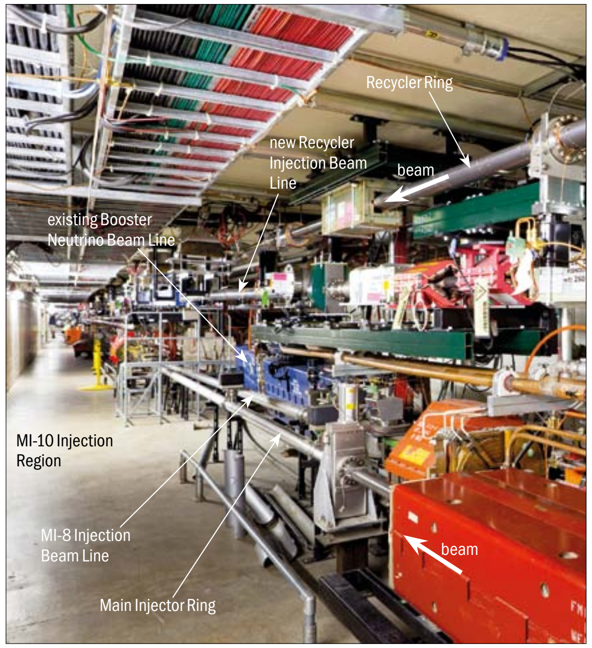
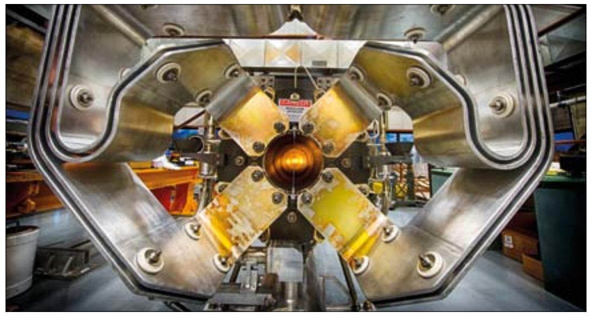


Fig. 4. The injection area showing the Main Injector (MI), the Recycler, the Booster Neutrino Beam, the MI-8 line and the Recycler Injection line. (Image credit: Marty Murphy, Fermilab.)



(Top) Fig. 5. The refurbished RF cavities of the Booster are driven by a solid-state system. (Above) Fig. 6. The new neutrino horn before installation in the NuMI beam line. (Image credits: Reidar Hahn, Fermilab.)

RF cavities. Working on these 40-plus-year-old cavities that have been activated by radiation is a labour-intensive process.

The Main Injector and Recycler

The upgrades to the Main Injector and the reconfiguration of the Recycler storage ring have been driven by the NOvA experiment, which will explore the neutrino-mass hierarchy and investigate the possibility of CP violation in the neutrino sector (*CERN Courier* June 2013 p9). With the goal of 3.6×10^{21} protons on target and 14 kt of detector mass, a significant region of the phase space for these parameters can be explored. For the six-year duration of the experiment, this requires the Main Injector to deliver 6×10^{21} protons/year. The best previous operation was 3.25×10^{21} protons/year. A doubling of the integrated number of protons is required to meet the goals of the NOvA experiment.

In 2012, just before the shutdown, the Main Injector was delivering 3.8×10^{13} protons every 2.067 s to the target for the Neutrinos at the Main Injector (NuMI) facility. This intensity was accomplished by injecting nine batches at 8 GeV from the Booster into the Main Injector, ramping up the Main Injector magnets while accelerating the protons to 120 GeV, sending them to the NuMI target, and ramping the magnets back down to 8 GeV levels – then repeating the process. The injection process took 8/15 of a second (0.533 s) and the ramping up and down of the magnets took 1.533 s.

A key goal of the shutdown was to reduce the time of the injection process. To achieve this, Fermilab reconfigured the Recycler, which is an 8 GeV, permanent-magnet storage ring located in the same tunnel as the Main Injector. The machine has the same 3.3 km circumference as the Main Injector. During the Tevatron collider era, it was used for the storage and cooling of antiprotons, achieving a record accumulation of 5×10^{12} antiprotons with a lifetime in excess of 1000 hours.

In future, the Recycler will be used to slip-stack protons from the Booster and transfer them into the Main Injector. By filling the Recycler with 12 batches (4.9×10^{13} protons) from the Booster while the Main Injector is ramping, the injection time can be cut from 0.533 s to 11 μs. Once completed, the upgrades to the magnet power and RF systems will speed up the Main Injector cycle to 1.33 s – a vast improvement compared with the 2.067 s achieved before the shutdown. When the Booster is ready to operate at 15 Hz, the total beam power on target will be 700 kW.

To use the Recycler for slip-stacking required a reconfiguration of the accelerator complex. A new injection beamline from the Booster to the Recycler had to be built (figure 3, p25), since previously the only way to get protons into the Recycler was via the Main Injector. In addition, a new extraction beamline from the Recycler to the Main Injector was needed, as the aperture of the previous line was designed for the transfer of low-emittance, low-intensity antiproton beams. New 53 MHz RF cavities for the Recycler were installed to capture the protons from the Booster, slip-stack them and then transfer them to the Main Injector. New instrumentation had to be installed and all of the devices for cooling antiproton beams – both stochastic and electron cooling systems – and for beam transfer had to be removed.

When the Booster is ready to operate at 15 Hz, the total beam power on target will be 700 kW.

Figure 4 shows the new injection line from the Booster (figure 5) to the Recycler, together with the upgraded injection line to the Main Injector, the transfer line for the Booster Neutrino Beam programme, and the Main Injector and Recycler rings. During the shutdown, personnel removed more than 100 magnets, all of the stochastic cooling equipment, vacuum components from four transfer lines and antiproton-specific diagnostic equipment. More than 150 magnets, 4 RF cavities and about 500 m of beam pipe for the new transfer lines were installed. Approximately 300 km of cable was pulled to support upgraded beam-position monitoring systems, new vacuum installations, new kicker systems, other new instrumentation and new powered elements. Approximately 450 tonnes of material was moved in or out of the complex at the same time.

The NuMI target

To prepare for a 700 kW beam, the target station for the NuMI facility needed upgrades to handle the increased power. A new target design was developed and fabricated in collaboration with the Institute for High Energy Physics, Protvino, and the Rutherford Appleton Laboratory, UK. A new focusing horn was installed to steer higher-energy neutrinos to the NOvA experiment (figure 6). The horn features a thinner conductor to minimize ohmic heating at the increased pulsing rate. The water-cooling capacity for the target, the focusing horns and the beam absorber were also increased.

With the completion of the shutdown, commissioning of the accelerator complex is underway. Operations have begun using the Main Injector, achieving 250 kW on target for the NuMI beamline and delivering beam to the Fermilab Test Beam Facility. The reconfigured Recycler has circulated protons for the first time and work is underway towards full integration of the machine into Main Injector operations. The neutrino experiments are taking data and the SeaQuest experiment will receive proton beam soon. Intensity and beam power are inceasing in all of the machines and the full 700 kW beam power in the Main Injector should be accomplished in 2015.

Résumé

Fermilab : des préparatifs intensifs

Fin juillet, le premier faisceau de protons depuis avril 2012 a circulé dans l'injecteur principal de Fermilab, marquant la fin de la période d'interruption du complexe. Le long arrêt a permis d'apporter à tous les accélérateurs des modifications importantes visant à accroître l'intensité des faisceaux de protons pour augmenter le potentiel scientifique des expériences du laboratoire. Ainsi, l'accélérateur Cockcroft-Walton a été remplacé par un quadripôle radiofréquence, de nouvelles améliorations ont été apportées au système RF du Booster, et une reconfiguration de l'anneau de recyclage a été mise en œuvre, ce qui a nécessité de nouvelles lignes de faisceau d'injection et d'extraction.

Paul Derwent, Fermilab.

(Top left) Signatures of those involved or present at the start-up of the U-70 in October 1967. (Bottom left) The 30 MeV RFQ linac – injector. (Centre) The main ring of the 70 GeV synchrotron. (Top right) An aerial view of IHEP. (Bottom right) The main experimental area at the U-70. (Image credits: IHEP.)

Golden jubilee in Protvino

On 15 November, IHEP in Protvino celebrated its 50th anniversary. Today, the institute continues research in high-energy physics at home and with its international collaborators.

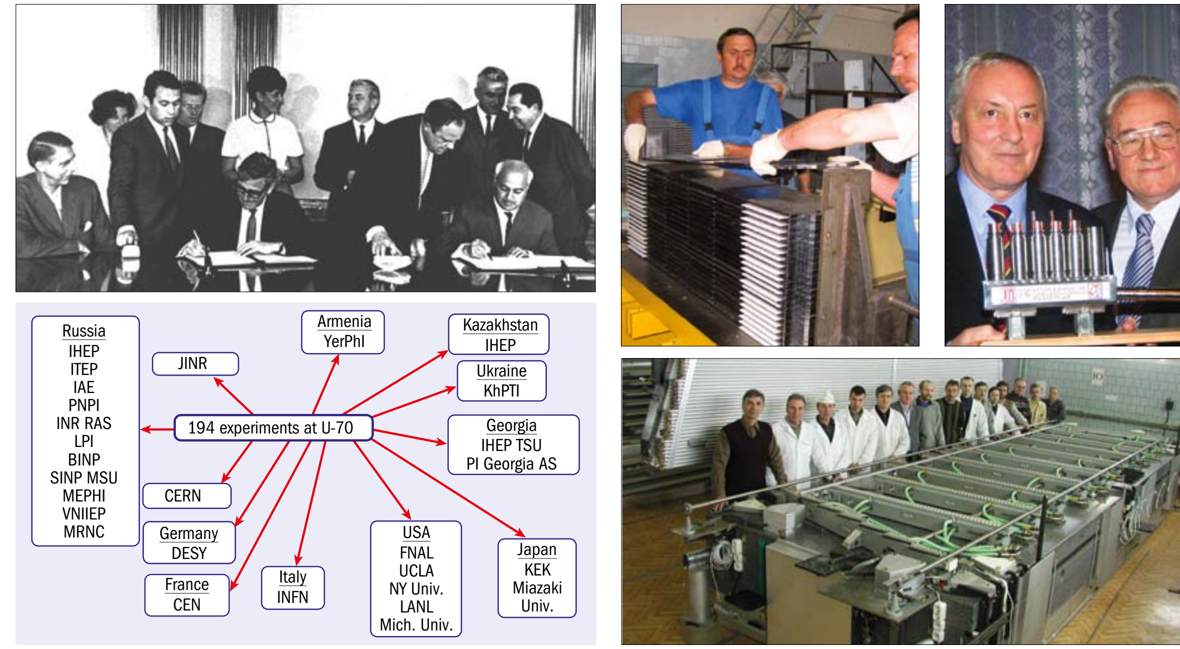
The Institute for High Energy Physics (IHEP), Protvino, was established as a new Soviet particle-physics laboratory 50 years ago in November 1963. Four years later, the 70-GeV proton synchrotron U-70 – which became known as the "Serpukhov accelerator" – was commissioned, reaching a world-record proton energy of 76 GeV on the night of 14 October 1967 (*CERN Courier* November 2003 p31). Physics research started at the beginning of 1968, conducted by several groups with unprecedented international participation for that time, in teams from CERN and the French Atomic Energy Commission (the CEA).

Only four years had passed since the theoretical proposal of quarks as elementary constituents of matter, so searching for them in the new energy range became one of the top priorities for the experiments at the U-70. Free quarks were not found but this negative result appears to have been the first of a long list from similar attempts that resulted finally in the well-known hypothesis of quark confinement.

Meanwhile, among many interesting new results that were obtained at the IHEP accelerator during its first years of operation, two in particular stand out: discovery of the growth of hadronic cross-sections with energy and the scaling behaviour of hadronic inclusive distributions. It is worth noting that both phenomena are poorly understood still, even in the framework of modern theory.

Today, IHEP is continuing to carry out a programme of fundamental research at the U-70 in the areas where the accelerator's parameters offer the opportunity for significant outcomes. In particular, the upgrade of the accelerator complex for higher intensity will create a unique beamline of separated K mesons and a new experimental facility OKA for an extensive programme of research with kaons (*CERN Courier* July/August 2009 p5).

The current physics research programme covers a variety of topics. The spectroscopy of mesons and baryons is served by several experimental facilities: VES, SVD, HYPERON and MIS-ITEP. The search for rare decays of K mesons and for CP violation is the focus for ISTRA+ as well as for OKA. The study of the structure of nucleons takes place with polarized beams in the Spin Asymmetry in Charm production (SPASCHARM) experiment and the FODS double-arm spectrometer, while FODS also investigates hard processes. Last, the SPIN experiment is looking at the properties of baryonic matter. In theoretical particle physics, the main achievements and current activities of the IHEP physicists are related to the physics of heavy quarks, strong interactions at high energies, quantum field theory, gravitation and cosmology.



(Top left) On 4 July 1967, CERN's director-general, Bernard Gregory, and Andrey Petrosiants sign the agreement between CERN and IHEP. (Bottom left) International co-operation at the U-70. (Top centre) Construction at IHEP of the first test module for the LHCb hadron calorimeter. (Image credit: R Kristic.) (Top right) Lyn Evans, left, LHC project leader, receives a model of an electric feedbox from IHEP's general director, Nikolaj Tyurin. (Bottom right) The Protvino group with the rig for assembling large monitored drift-tube chambers for the ATLAS muon endcap, with 6.3 m example behind.

Alongside the fundamental physics research, IHEP also undertakes extensive studies in accelerator physics and technology. Here, the principle and techniques of radio-frequency quadrupole (RFQ) acceleration proposed and developed at IHEP have been one of the notable achievements in accelerator science. IHEP also put forward the use of bent-crystal deflectors for the extraction of particle beams and for collimation (*CERN Courier* January/February 2006 p37 and May 2008 p15). This technique is now widely used at the U-70 accelerator as well as at Fermilab and at CERN.

An important recent achievement at the U-70 was the commissioning in 2010 of stochastic slow beam extraction, which has significantly improved the performance of the machine and increased the efficiency of the experiments (*CERN Courier* March 2007 p7). Since 2011, the U-70 has been upgraded to accelerate carbon nuclei to 24.1–34.1 GeV per nucleon. This has allowed IHEP to proceed with experiments in the field of fixed-target relativistic nuclear physics.

In the area of applications, in 2004–2010 IHEP developed and constructed a unique proton radiography facility, which has been successfully used in co-operation with physicists from the All-Russian Research Institute of Experimental Physics (VNIIEF) in Sarov. In 2011, the U-70 received a new slow-extraction system at flat bottom, which delivers a beam of carbon nuclei at 450–455 MeV per nucleon for applied research.

Last but not least, IHEP contributes significantly in broad international collaborations with CERN, Fermilab and Brookhaven National Laboratory. Examples include the production of an endcap muon wall for the DØ expriment at Fermilab's Tevatron, an electromagnetic calorimeter for the PHENIX experiment at Brookhaven's Relativistic Heavy-Ion Collider, electrical feedboxes, dump resistors, septum magnets and beam-loss monitors for CERN's LHC (*CERN Courier* October 2007 p6), monitored drift-tube chambers and tiles for hadron calorimetry in the ATLAS detector at the LHC, crystals for electromagnetic calorimetry in the CMS experiment, and modules for LHCb's hadron calorimeter. IHEP is also a Tier-2 site in the Wordwide LHC Computing Grid.

Résumé

Cinquante ans de physique des hautes énergies à Protvino

Cette année, l'Institut de physique des hautes énergies (IHEP), situé à Protvino, célèbre ses 50 ans d'existence : ce laboratoire de physique des particules a en effet été créé en novembre 1963. Quatre ans plus tard, le synchrotron à protons U-70, l'« accélérateur Serpoukhov », était mis en service, atteignant un record mondial d'énergie pour les protons : 76 GeV le 14 octobre 1967. Aujourd'hui, l'IHEP poursuit la recherche fondamentale et appliquée à l'U-70. En 2011, la machine a été améliorée pour accélérer des noyaux de carbone, permettant de premières expériences en physique nucléaire relativiste dans cet institut.

Faces & Places

CERN

Englert, Higgs and CERN receive the Prince of Asturias Award

CERN, François Englert and Peter Higgs received the Prince of Asturias Award for "the theoretical prediction and experimental detection of the Higgs boson", in a ceremony held on 25 October at the Campoamor Theatre in Oviedo, in the presence of Her Majesty the Queen of Spain and the Prince and Princess of Asturias. CERN's director-general, Rolf Heuer, was there to accept the prestigious prize on behalf of the laboratory.

The ceremony was preceded by a cultural programme of exhibitions and events organized by the Prince of Asturias Foundation. Within this programme, Luis Álvarez-Gaumé, a theoretical physicist at CERN, gave a talk on the day of the awards ceremony at the Faculty of Science of Oviedo University, while the day before, CERN's director for research and computing, Sergio Bertolucci, joined Englert and Higgs in meeting with hundreds of students at the university. Their public lecture was broadcast live on screens throughout the campus and online. The day closed with a concert by the Symphony Orchestra of the Principality of Asturias and the Choir of the Prince of Asturias Foundation.

Each Prince of Asturias Award is divided equally among the laureates and comprises a Joan Miró sculpture representing and symbolizing the award, a cash prize of €50 000, a diploma and an insignia. CERN's management has decided that the prize to the laboratory will be used to offer 10 grants for PhD students from around the world to attend next year's major particle-physics conference, the International Conference on High-Energy Physics, ICHEP2014, in Valencia.

The prize to CERN will also be used to launch a competition for school students in Spain. Pupils aged 6–18 will be challenged to submit a drawing, photo, video or news article. Entries will be evaluated through a public vote and by an expert committee involving scientists from CERN and the Spanish Centre for Particle Physics (CPAN), which will contribute to the competition with related outreach activities and awards. Six winners will be rewarded with a two-day visit to CERN. Full details will be available from 1 December at www.cernland.net.

Felipe, Prince of Asturias (left), presents the insignia, a part of the award, to Rolf Heuer, CERN's director-general, who received the award on behalf of the laboratory. (Image credit: Iván Martínez/FPA.)

François Englert (left), Peter Higgs (centre), and Rolf Heuer celebrate in Oviedo. (Image credit: Iván Martínez/FPA.)

Collaboration

Ukraine to become an associate member of CERN

On 3 October, CERN's director-general Rolf Heuer and the vice prime minister of Ukraine Kostyantyn Ivanovych Gryschenko signed a document admitting Ukraine to associate membership of CERN, subject to ratification by Ukraine's parliament – the Verkhovna Rada.

Ukraine and CERN signed a co-operation agreement in 1993 and a joint declaration in 2011, setting priorities in scientific–technical co-operation. But the relationship dates back much further, principally through CERN's co-operation with JINR, of which Ukraine is a member.

Beyond its participation through JINR, Ukraine has been a long-time contributor to the ALICE, CMS and LHCb experiments at the LHC and to research and development on new accelerator technologies. Ukraine also operates a Tier-2 computing centre of the Worldwide LHC Computing Grid.

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

Vice prime minister of Ukraine, Kostyantyn Ivanovych Gryschenko (left), shakes hands with CERN's director-general after signing the documentation for associate membership.

Awards

APS announces winners for 2014

The American Physical Society (APS) has announced its awards for 2014, including major prizes in particle physics and related fields.

One of the highlights early this year was the announcement that the Daya Bay reactor neutrino experiment had observed the disappearance of electron-antineutrinos and established a significantly nonzero value for the "third" mixing angle in neutrino oscillations, θ_{13} (*CERN Courier* October 2013 p7). So it is appropriate that the 2014 W K H Panofsky Prize in Experimental Particle Physics, which recognizes and encourages outstanding achievements in the field, goes to Kam-Biu Luk of the University of California, Berkeley, and Lawrence Berkeley National Laboratory (LBNL), and Yifang Wang of the Institute of High Energy Physics, Beijing, for "their leadership of the Daya Bay experiment, which produced the first definitive measurement of the θ_{13} angle of the neutrino mixing matrix". Luk and Wang are the co-spokespersons for the experiment.

The contribution of young physicists to the Daya Bay experiment is also recognized in awarding the Henry Primakoff Award for Early-Career Particle Physics to Daniel A Dwyer of the Lawrence Berkeley National Laboratory, for his "innovative contributions to neutrino physics, particularly the broad and substantial role he played in commissioning, calibration and analysis in the Daya Bay measurement of the mixing angle θ_{13}".

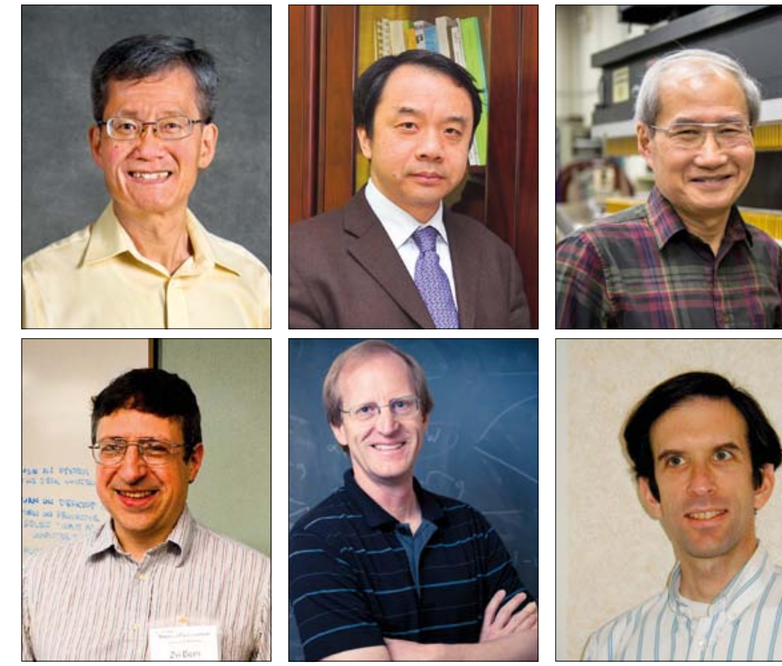
The Robert R Wilson Prize for Achievement in the Physics of Particle Accelerators is another important award to recognize and encourage outstanding work. Kwang-Je Kim of Argonne National Laboratory (ANL) receives the 2014 prize for "his pioneering theoretical work in synchrotron radiation and free-electron lasers that laid the foundation for both third and fourth generation X-ray sources". Also related to the developments in accelerators, the 2013 James Clerk Maxwell Prize for Plasma Physics was recently awarded to Phillip Sprangle of the Naval Research Laboratory and the University of Maryland for his "pioneering contributions to the physics of high-intensity laser interactions with plasmas, and to the development of plasma accelerators, free-electron lasers, gyrotrons and high-current electron accelerators".

The 2014 award that recognizes and encourages outstanding achievement in particle theory – the J J Sakurai Prize for Theoretical Particle Physics – goes to Zvi Bern of the University of California, Los Angeles, Lance Dixon of SLAC and David Kosower of CEA-SACLAY. The three theoreticians receive the award for "path-breaking contributions to the calculation of perturbative scattering amplitudes, which led to a deeper understanding of quantum field theory and to powerful new tools for computing QCD processes".

The Dannie Heineman Prize for Mathematical Physics recognizes outstanding publications in the field of mathematical physics. The 2014 award goes to Gregory Moore of Rutgers University, for "eminent contributions to mathematical physics with a wide influence in many fields, ranging from string theory to supersymmetric gauge theory, conformal field theory, condensed-matter physics and four-manifold theory".

Theoretical work is also recognized with the Herman Feshbach Prize in Theoretical Nuclear Physics, which for 2014 goes to John Negele of Massachusetts Institute of Technology, for "lifetime contributions to nuclear many-body theory including identifying mechanisms for saturation and relating the Skyrme interaction to fundamental nuclear forces, and for initiating and leading efforts to understand the nucleon using lattice QCD".

Also in nuclear physics, the Tom W Bonner Prize recognizes and encourages outstanding experimental research in nuclear physics, including the development of a method, technique or device that significantly contributes in a general way to nuclear-physics research. William Zajc of Columbia University received the 2014 prize for "his contributions to relativistic heavy-ion physics, in particular for his leading role in the PHENIX experiment, as well as for his seminal work on identical two-particle density interferometry as an experimental tool".



Top: Kam-Biu-Luk (left), and Yifang Wang (centre), winners of the Panofsky Prize; (right) Kwang-Je Kim, winner of the Robert R Wilson Prize. (Image credits: LBNL, IHEP/CAS, ANL.) Bottom: Zvi Bern (left), Lance Dixon (centre), and David Kosower, who receive the J J Sakurai Prize. (Image credits: M Shifman, Brad Plummer, CEA.)

IOP medals: from particles to the cosmos

Studies at the smallest and largest scales in the universe are among the areas of research recognized in the 2013 awards by the UK's Institute of Physics (IOP).

Among the annually awarded gold medals, the Glazebrook Medal – named after the first president of IOP, Richard Glazebrook – rewards leadership in a physics context. This year it goes to Lyn Evans of CERN and Imperial College London, who receives the award for "his outstanding leadership of the Large Hadron Collider Project", the success of which " is in large measure the result of Lyn Evans's expertise in accelerator physics and his superb qualities as a project leader".

In the subject awards, the Chadwick Medal and Prize is awarded for distinguished research in particle physics. Jonathan Butterworth of University College London is the 2013 recipient, for "his pioneering experimental and phenomenological work in high-energy particle physics, especially in the understanding of hadronic jets". The Payne-Gaposchkin Medal and Prize recognizes distinguished research in plasma, solar or space physics and this year goes to Peter Norreys of the University of Oxford and STFC Rutherford Appleton Laboratory. He is rewarded for "his pioneering contributions to the physics of fast particle generation and energy transport in relativistic laser–plasma interactions".

Left: Lyn Evans, winner of the IOP's 2013 Glazebrook Medal. Centre: Jonathan Butterworth, recipient of the Chadwick Medal and Prize. Right: Peter Norreys, who was awarded the Payne-Gaposchkin Medal and Prize. (Image credits: J Butterworth (centre), STFC (right).)

The Maxwell Medal and Prize is an early career award made to physicists within the first 12 years of their career (allowing for career breaks), for outstanding contributions to theoretical physics, mathematical or computational physics. Joanna Dunkley of the University of Oxford receives the 2103 medal for "her contributions to determining the structure and history of our universe". She has worked as part of the science team on NASA's Wilkinson Microwave Anistropy Probe (WMAP) and led analysis for the Atacama Cosmology Telescope in Chile.

Finally, the Kelvin Medal and Prize, for outstanding contribution to public engagement within physics, this year goes to a theoretical particle physicist, Jeff Forshaw of the University of Manchester, for "his wide-reaching work aimed at helping the general public to understand complex ideas in physics".

Mikhail Shifman and Andrei Slavnov receive the Pomeranchuck Prize

Mikhail Shifman of the Theoretical Physics Institute, University of Minnesota and Andrei Slavnov of the Steklov Institute, Moscow, received the Pomeranchuk Prize 2013 in a ceremony that was held at the Institute for Theoretical and Experimental Physics (ITEP) on 19 September. The prize – established by ITEP in 1998 in memory of Isaak Pomeranchuk – is annually awarded to one foreign and one Russian theoretician for outstanding achievements in the field.

Shifman has been honoured for outstanding results in nonperturbative quantum field theory, including sum rules in quantum chromodynamics (QCD) and exact results in supersymmetric gauge theories. The Shifman–Vainshtein–Zakharov (SVZ) sum rules provide a powerful tool for the calculation of QCD and the Novikov–Shifman–Vainshtein–Zakharov β-function plays an extremely important role in supersymmetric gauge theory. The exact calculation of the gluino condensate was one of the first applications of the idea that there are topological sectors in non-topological theory.

Mikhail Shifman (left) and Andrei Slavnov. (Image credit: ITEP.)

Slavnov received the award for his contribution to the investigation of non-Abelian gauge theories, including the formulation and proof of renormalizability. Widely employed since the early 1970s, it inspired further important developments, such as the Slavnov–Taylor identities that are now described in textbooks on quantum field theory.

Polish institute makes Guido Altarelli honorary professor

Guido Altarelli (left) with Marek Jeżabek, the general director of IFJ PAN, and Adam Maj, the institute's scientific director. (Image credit: IFJ PAN.)

In a ceremony on 16 September, the Henryk Niewodniczański Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN) conferred the title of Honorary Professor of the Institute of Nuclear Physics on Guido Altarelli, of the University of Roma Tre.

Altarelli joined CERN's Theory Division in 1987, where he held the position of head in the years 2000–2004, and is still at CERN as an honorary member. He has had a role on advisory boards for many leading laboratories and has been a member of the Scientific Advisory Board at IFJ PAN since 2004.

Altarelli received the honour "in recognition of his outstanding contribution to theoretical particle physics, in particular in verifying the Standard Model of fundamental interactions and ideas in physics beyond the Standard Model, and for his enduring support of the collaboration between CERN and IFJ PAN". The author and co-author of more than 200 scientific papers, Altarelli's research achievements cover a range of problems in the phenomenology of particle interactions within and beyond the Standard Model, in close connection with experiment.

Appointments

Fabiola Gianotti selected for UN's Scientific Advisory Board

CERN physicist Fabiola Gianotti is among the 26 scientists who have been appointed to the Scientific Advisory Board of the UN secretary-general, Ban Ki-moon.

The Scientific Advisory Board consists of experts in a variety of fields, from technology and engineering to medicine and agricultural science. They will provide advice on science, technology and innovation for sustainable development to the UN's executive heads and secretary-general. UNESCO will host the board's secretariat. The first meeting of the board will take place at the start of 2014.

Besides Gianotti, four other physicists have been appointed to the board: Susan Avery, president and director of the Woods Hole Oceanographic Institution, Vladimir Fortov, president of the Russian Academy of Sciences, and nuclear physicist Dong-Pil Min of Seoul National University. The appointments are for two years with the possibility of renewal. The positions are unpaid and the members are expected to "act in their personal capacity and will provide advice on a strictly independent basis".

Last December, the United Nations General Assembly granted CERN observer status (*CERN Courier* January/February 2013 p5), which allows CERN the right to participate in the work of the General Assembly and to attend its sessions as an observer.

Fabiola Gianotti, ATLAS spokesperson from March 2009 to February 2013, in front of the ATLAS detector.

Se-Jung Oh (right), the president of the Institute for Basic Science (IBS) in Korea, and Yannis Semertzidis, after signing the first contract between IBS and a foreign-born IBS institute director. On 15 October, Semertzidis became the director of the Center for Axion and Precision Physics Research, which will be located at the Korea Advanced Institute of Science and Technology in Daejeon. The plan is to launch a competitive Axion Dark Matter Experiment in Korea, participate in state-of-the-art axion experiments around the world, play a leading role in the proposed proton electric-dipole-moment (EDM) experiment and take a significant role in storage-ring precision physics involving EDM and muon g-2 experiments. (Image credit: Ahram Kim IBS.)

ISMD 2013

An umbrella symposium for the physics of multiparticle dynamics

Participants of ISMD 2013 at IIT in Chicago. (Image credit: B Robinson.)

A colourful contributor to a successful symposium. (Image credit: Z Sullivan.)

Record rainfall in Chicago failed to dampen the enthusiasm for multiparticle physics of those attending the XLIII International Symposium on Multiparticle Dynamics, when it took place on 15–20 September at the Illinois Institute of Technology (IIT). While some jokingly credited the umbrellas that were provided to participants for the meeting's success, everyone was excited to attend the first in the series to be held in the US for seven years. With more than 100 participants from nearly 20 countries, ISMD 2013 was organized jointly by the High Energy Physics Division of Argonne National Laboratory and IIT to review progress and discuss upcoming issues in the fields of high-energy physics, nuclear physics and astrophysics.

The ISMD series started more than 40 years ago in Paris, with the goal of establishing a dedicated international conference to discuss multihadron production in quantum chromodynamics (QCD). Early on, the symposium alternated its location between countries in Eastern and Western Europe, which were divided at that time by the Iron Curtain. From the beginning, the goal was to bring experimentalists and theorists together to discuss all aspects of multiparticle dynamics, from new analysis techniques to the latest discoveries.

The tradition continued in September, with plenary discussions of new results from the LHC experiments at CERN as well as from Fermilab's Tevatron, the HERA collider at DESY, Jefferson Lab, the Relativistic Heavy-Ion Collider at Brookhaven and the BaBar experiment at SLAC. In addition, several talks covered recent progress in theoretical QCD calculations, attempts to model and control the underlying event, searches for exotic processes using boosted jet techniques, multiparticle correlations, diffractive physics and searches beyond the Standard Model using multi-object final states.

A primary theme this year was the striking similarity between proton–proton collisions and heavy-ion collisions. This similarity, which exhibits itself in the high detector occupancy of proton–proton collision events, presents significant challenges for future high-precision physics. A critical question for the next decade will be how to maintain energy resolution and reconstruction with a large contribution from multiple proton–proton interactions (pile-up). Many participants expressed their concern that continued access to low-pT jet physics is essential for the future of the field.

The symposium concluded with two views of the future of multiparticle dynamics. Chip Brock of Michigan State University discussed the conclusions of the Snowmass series of planning meetings that took place in the US throughout 2012–2013. James Bjorken of SLAC concluded with a historic perspective on QCD. He considered the connections between outstanding issues that span nuclear physics, high-energy physics and cosmology, and encouraged a broad examination across the subdisciplines for answers.

ISMD 2013 was supported by the US Department of Energy, the National Science Foundation, CERN and DESY, a Research Centre of the Helmholtz Association. The XLIV International Symposium on Multiparticle Dynamics will be held in Bologna in 2014.

● For more information about the presentations and proceedings of ISMD 2013, see http://atlaswww.hep.anl.gov/ismd13/.

The installation of the electron injector for the European XFEL has begun at the project's Bahrenfeld site. Scientists and engineers are currently putting together the different systems of the injector, many of which are tailored to produce 27,000 X-ray flashes per second, a far higher rate than other free-electron laser facilities. The injector will fire electron bunches – needed to produce the X-ray beam – into the accelerating section of the free-electron laser. Here workers guide the injector klystron into place using a crane in the injector hall. DESY is building the injector as part of the German contribution to the European XFEL. (Image credit: European XFEL.)

ANNIVERSARY

China's IHEP celebrates its first 40 years

(Left) Aerial view of IHEP. (Right) The BESIII experiment at BEPCII. (Image credits: IHEP.)

The Institute of High Energy Physics (IHEP) of the Chinese Academy of Sciences (CAS) in Beijing celebrated its 40th anniversary this year. Founded in 1973, it has grown to become one of the foremost research institutions in China, focusing on particle and astroparticle physics, accelerator physics and technologies, radiation technologies (mainly X rays, neutrons and positrons) and their applications.

In September 1972, China's premier, Zhou Enlai, wrote to high-energy physicists Zhang Wenyu and Zhu Guangya, saying "This issue should not be delayed any further. The study of high-energy physics and the R&D of a high-energy accelerator should be one of the main projects of CAS." Less than six months later, IHEP was established in February 1973, with Zhang Wenyu, a noted physicist and Purdue professor (1949–1956), appointed as its first director.

The proposal for a high-energy accelerator came to fruition a decade later. In April 1983, the State Council officially approved the project to construct the Beijing Electron Positron Collider (BEPC). Deng Xiaoping and other leaders laid the foundation stone in a ground-breaking ceremony in October the following year. Four years later, on 16 October 1988, the first electron–positron collisions took place. Only a few months earlier, IHEP had established the first computer link with CERN via satellite – a VAX785 at IHEP became the first computer to be connected to the internet from China with the node BEPC2.IHEP.CERN.CH.

The beam energy of BEPC was in the range 1–2.8 GeV and the Beijing Spectrometer (BES) installed there focused on τ-charm physics. During its lifetime it collected large samples of J/ψ, ψ′, D mesons and τ particles, with notable results (*CERN Courier* December 2001 p6 and December 2002 p6). However, to meet the challenges in precision measurements in this energy region, a thorough upgrade was necessary. In December 2003, a double-ring design was officially approved and on 30 April 2004, BEPC shut down and the installation of BEPCII began (*CERN Courier* June 2004 p6). The new BESIII detector observed its first collisions in July 2008 and by May 2012 it was accumulating as many as 40 million J/ψ particles a day. Earlier this year, the BESIII collaboration announced the discovery of a new mystery particle (*CERN Courier* May 2013 p7).

IHEP is also involved in non-accelerator particle physics and astroparticle physics. Extended in 1994, the Yangbajing Cosmic Ray Observatory in the Tibetan Highlands is one of the four largest international extensive air-shower arrays for studying γ rays and cosmic rays at ultra-high energies. More recently, construction of the Daya Bay Reactor Neutrino Experiment started in October 2007. IHEP's current director, Yifang Wang (p31), is co-spokesperson of the experiment, which attracted the world's attention with its discovery of a nonzero value for the neutrino mixing angle θ_{13} (*CERN Courier* October 2013 p7).

The Beijing Synchrotron Radiation Facility (BSRF), constructed almost in parallel with BEPC, has been open to users since 1991. Following the upgrade to BEPCII, the machine runs with 2.5 GeV full-energy injection and 250 mA beam current when in dedicated synchrotron radiation mode. Three experimental halls house 14 beamlines for research in topics ranging from condensed-matter physics to environmental science. Similar multidisciplinary research will also be served by the China Spallation Neutron Source (CSNS) project, which was approved in September 2008. The ground-breaking ceremony for the project took place in Dongguan in October 2001.

Over the years, IHEP has also developed broad and strong co-operative ties with the international high-energy physics community. Important collaborations with Europe and the US currently include the ATLAS and CMS experiments at the LHC and the Alpha Magnetic Spectrometer on the International Space Station. In addition, IHEP is a Worldwide LHC Computing Tier-2 Grid site.

The "Israel at CERN" Industrial Exhibition was inaugurated on 2 October with (left to right) Emmanuel Tsesmelis, CERN deputy head of International Relations, Eviatar Manor, ambassador of Israel to the office of the United Nations and the other International Organizations in Geneva, ATLAS physicist George Mikenberg, Shai Moses, Economic Attaché of Israel in Geneva, and CERN's director-general, Rolf Heuer.

School

New series of summer schools starts in Oxford

The First International Summer School on Intelligent Front-End Signal Processing for Frontier Research and Industry took place in Oxford on 10–16 July – the first of a new series of annual summer schools covering the complete signal-processing chain found in modern instrumentation. The aim is to focus on the most advanced technologies in the fields of semiconductors, deep sub-micron and 3D technologies, nanotechnology, advanced packaging and interconnects, telecommunications, real-time signal processing and filtering, and massive parallel computing. The participants studied many of the crucial challenges and issues of front-end detection and processing for building 21st-century frontier instruments.

Sixty young physicists and engineers from around the world – master's and PhD students and young postdocs – participated in a programme of lectures and laboratory work. Technical examples were drawn from cross-disciplinary applications and ranged from exploration of the distant universe through medical imaging to the physics of elementary particles. This variety brought together a new generation of engineers and scientists from across the research communities, allowing them to get to know each other through training sessions that combined advanced technologies with frontier research. Worldwide experts from academia and industry gave lectures on technical developments and science overviews, alongside hands-on laboratory sessions with technology demonstrators, as well as masterclasses on related science and as a forum for discussions.

A laboratory session at the school. (Image credit: Garret Cotter.)

The school began with an introductory examination of why is it essential to introduce "intelligence" at the early processing stage, followed by an explanation of advances in related cutting-edge technologies. The first day covered the main components of a state-of-the-art full processing chain and the technologies for designing and producing the front-end ASIC circuits. The next two days looked at silicon photomultipliers and then semiconductor microstrip- and pixel-based instruments. Silicon photomultipliers, microstrips and pixels are the technologies that are most used today in research and many applied fields.

The fifth day of the school moved on to the tools for real-time filtering, triggering and data selection at the front end and in testing conditions. The challenges of data transmission at the front end and related advanced high-tech solutions were then discussed and finally the seventh day looked at the tools for testing, characterizing and ensuring the performance of the demonstrators produced.

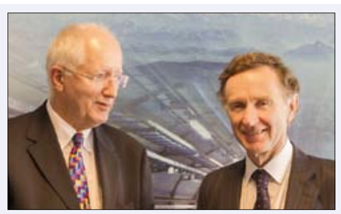
Participants also took part in social activities in and around the city of Oxford. These included a banquet in the ancient dining hall of Exeter College, evenings in traditional English pubs and an entertaining race around Port Meadow on the River Thames.

Building on the success of this inaugural school, the next will be held in Paris on 14–25 July 2014.

● For more information on the 2013 school, visit www.physics.ox.ac.uk/INFIERI2013/.

Visits

On 27 September, Lithuanian minister of culture **Šarūnas Birutis** visited CERN. As well as finding out about CERN's collaborations with the arts, he also visited the LHC tunnel and the CMS underground experimental area.



The UK's minister of state for trade and investment, **Lord Green**, of Hurstpierpoint (right) was welcomed to CERN on 1 October by **Rüdiger Voss**, head of international relations, who gave a general introduction to CERN's activities. The minister then had the opportunity to visit the ATLAS underground experimental area.

On 7 October, **Piotr Styczeń** (left), Polish deputy-minister of transport, construction and maritime economy, **Daniel Braun** (centre), first deputy-minister for regional development of the Czech Republic, and **František Palko** (right), state secretary of the Ministry of Transport, Construction and Regional Development of the Slovak Republic, came to CERN. They visited the LHC tunnel and ATLAS underground experiment areas before signing the CERN guestbook.

Fidel Castro Diaz, scientific advisor of Cuban State Council, visited CERN on 14 October, accompanied by a delegation from the Permanent Representative of Cuba to the United Nations in Geneva. His visit included a tour of the underground experimental area of ATLAS and the LHC tunnel.

Obituary

Alfredo Susini 1926–2013

Alfredo Susini, an expert in RF cavities, died at home in Switzerland on 17 August after a long struggle with illness.

Alfredo was born in Imperia, Italy. An electrical engineer, he was working for the Italian Military Aviation as an expert in microwaves in the 1950s when he was selected by Edoardo Amaldi to work at CERN as an RF engineer in the Synchrocyclotron (SC) Division for the 600 MeV accelerator. He was a brilliant engineer and even though he did all of his computing on a pocket calculator he was never proved wrong. He was among the first to use ferrites and water to damp the higher modes of resonance of the RF cavities.

He soon became a world leader in RF for cyclotrons and synchrotrons and, when the SC was stopped, he moved to the Proton Synchrotron Division and took leave from CERN during 1973–1977 to work for Scanditronix AB in Sweden to construct the RF systems for a 120 MeV/nucleon research cyclotron at the Hahn-Meitner Institute in what was then West Berlin. The spin-off from this project became a production chain of medium-sized cyclotrons in the energy range 40–60 MeV, which were built for research, isotope production and neutron therapy.

Albert Susini with RF cavities for CERN's Large Electron-Positron collider.

Alfredo contributed to the construction of the 40 MeV cyclotrons for Euratom in Ispra, Italy, and for the Clatterbridge Hospital in the UK, as well as 60 MeV machines for Seattle in the US and Seoul in Korea. He also collaborated with the Gustav-Werner Institute of Uppsala, the INFN synchrocyclotron of Catania, the Antoine Lacassagne Hospital in Nice and the TERA Foundation in Pavia, and was "Libero docente" at the University of Pisa.

Alfredo was used to building his RF cavities on a small budget, sometimes even re-using equipment that had been discarded by other groups. He impressed his colleagues when at the Low Energy Antiproton Ring at CERN he constructed the RF cavity using a wooden box that he covered internally with aluminium paper. The cavity worked perfectly for six months. Because of this attitude he often came into conflict with some of his younger colleagues, who were not used to recycling.

In private, Alfredo was gentle and full of curiosity. He often enjoyed sailing with a small boat on Lake Geneva or on the sea at Isola del Giglio, where he spent his vacations in a summer residence. He leaves behind his wife Clara and two sons, Stephane and Alberto, who had made him a grandfather.

He is greatly missed and will be remembered by us all.

● *His friends and colleagues.*

Meetings

INSTR14, the **International Conference on Instrumentation for Colliding Beam Physics**, will be held in the Budker Institute of Nuclear Physics, Novosibirsk, on 24 February–1 March. The conference covers novel methods of particle detection used in various experiments at particle colliders and other accelerators as well as in astrophysics. It is organized in close relationship with the Vienna Conference on Instrumentation (last held in 2013) and the Pisa Meeting on Advanced Detectors (to be held in 2015). The deadline for registration and abstract submission is 15 January. For more details, visit the conference website http://instr14.inp.nsk.su/.

The **5th International Particle Accelerator Conference**, IPAC'14, will take place at the International Congress Center Dresden, on 15–20 June 2014. The programme includes plenary sessions and parallel sessions with invited and contributed presentations. There will also be poster sessions – including a special poster session for students – held during conference registration on 15 June. An industrial exhibition will take place on 16–18 June and there will be a special session for industry on 18 June. For a detailed conference programme, as well as information on registration (before 14 April for lower fees) and reservation of accommodation, see www.ipac2014.org.

New products

Elsys Instruments has developed a new software driver that makes Elsys' entire range of highly accurate data-acquisition products fully compatible with LabVIEW. Comprised of a set of virtual instruments (VIs), the LabVIEW driver supports all of the advanced data-acquisition modes offered by Elsys. These include the Event Controlled Recording (ECR) mode, standard scope mode, multiblock mode and continuous acquisition modes. The installer that comes with the instrument driver supports 32-bit and 64-bit Windows (XP or newer) and LabVIEW (2010 or newer). For the free plug-and-play driver, complete with installer, manual and examples, contact Thomas Berger: e-mail thomas.berger@elsys.ch, or visit www.elsys-instruments.com/labview.

FLIR Systems has expanded its range of entry-level R&D-grade thermal-imaging kits for academic teaching and industrial research labs. New additions are the portable (< 1 kg) and easy-to-operate E40 and T420 packages. They eliminate guesswork with instant non-contact readings that deliver up to 76,800 repeatable, accurate temperature measurements in each thermographic image. Visualizing temperatures from –20 °C to +650 °C, the kits deliver high accuracy (±2%) and sensitivity (up to < 0.045 °C) to reveal fine thermal variations. For a full information pack, contact FLIR: e-mail research@flir.com, or visit www.flir.com/thermography/americas/us/view/?id=49960.

Recruitment

For advertising enquiries, contact *CERN Courier* recruitment/classified, IOP Publishing, Temple Circus, Temple Way, Bristol BS1 6HG, UK.
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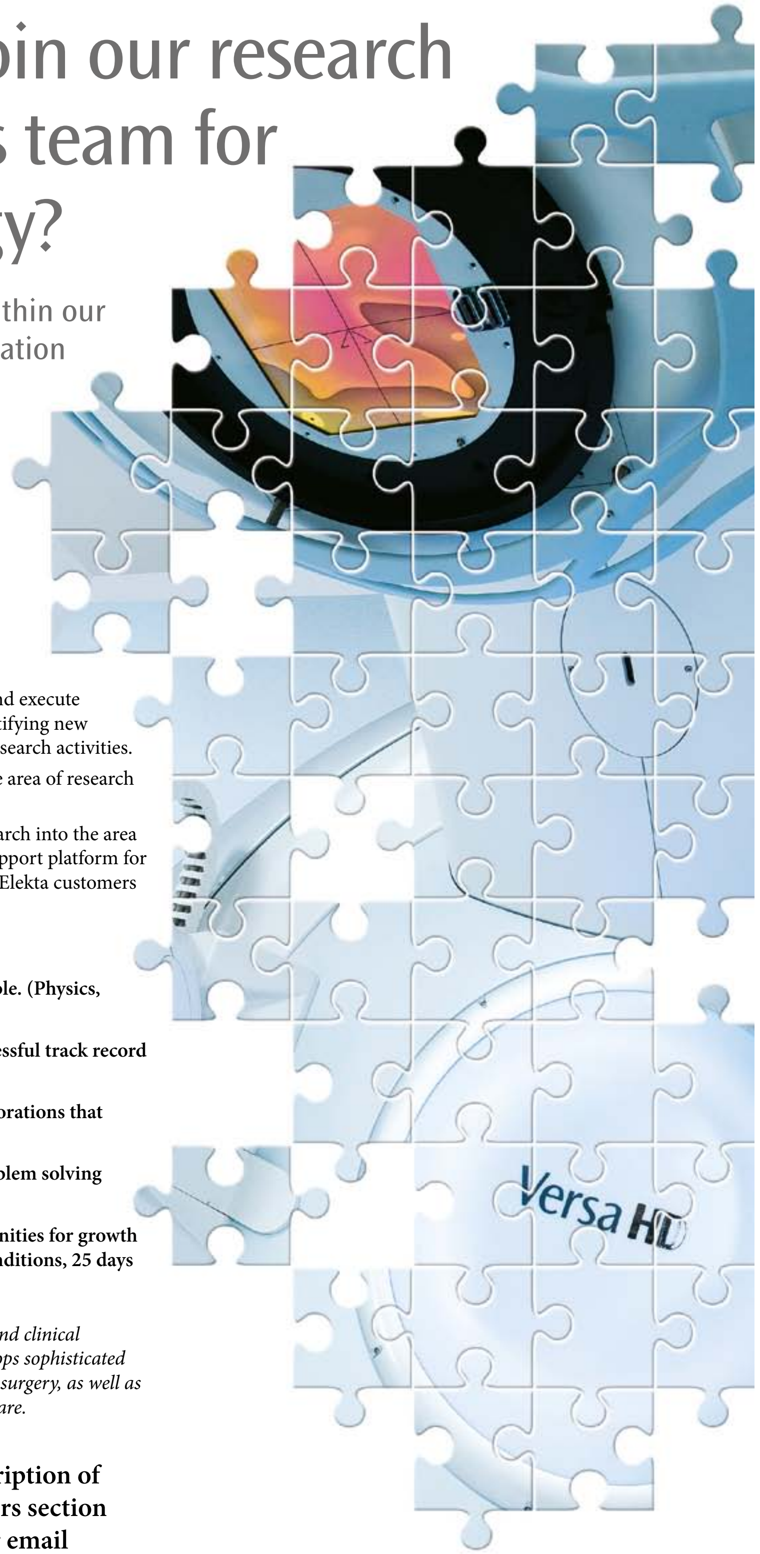
- **A Degree in a technical and clinical speciality would be preferable. (Physics, Maths, Engineering).**
- **A strong knowledge of Elekta's portfolio of products and a successful track record of research is essential.**
- **You will be required drive forward the already successful collaborations that Elekta have developed.**
- **Experience of planning, team leadership, negotiating skills, problem solving and senior project management needs to be demonstrated.**
- **Elekta encourages professional development and offers opportunities for growth within the company. Other benefits include flexible working conditions, 25 days holiday, private medical insurance and pension.**

Elekta is a human care company pioneering significant innovations and clinical solutions for treating cancer and brain disorders. The company develops sophisticated tools and treatment planning systems for radiation therapy and radiosurgery, as well as workflow enhancing software systems across the spectrum of cancer care.



For further details and full job description of both positions, please visit the careers section of our website at www.elekta.com or email Lucy.Parsons@elekta.com

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INDIANA UNIVERSITY

FACULTY POSITIONS THEORETICAL NUCLEAR PHYSICS

The Department of Physics at Indiana University invites applications for a position in theoretical nuclear physics, subject to funding and approval for appointment beginning Fall 2014. Applicants must hold a Ph.D. in Theoretical Physics or a related field at the time of appointment (August 1, 2014). Candidates will be evaluated for appointment at the tenure-track assistant professor level at a salary commensurate with qualifications and experience. Members of IU's world-class efforts in nuclear theory are also active within the newly created Center for Exploration of Energy and Matter (CEEM) that provides enhanced support for research and promotes cross-disciplinary research.

The initial position will be a bridge appointment with Thomas Jefferson National Accelerator Facility (Jefferson Lab) for a period of up to six years. During this period, the appointee will spend about half of his/her time at Indiana University and the other half at the Jefferson Lab.

The successful candidate will be expected to develop a world-class research program in any of the forefront areas of theoretical nuclear physics, with particular emphasis on those that support, strengthen and promote collaboration on the Jefferson Lab 12 GeV physics program over the next decade. The areas of specialization include the fields of perturbative and non-perturbative QCD, hadron structure and spectroscopy, hadron reaction theory, electromagnetic and weak interactions and symmetries, effective field theory, and the application of lattice QCD to all aspects of strong interactions.

A commitment to excellence in teaching at the undergradute and graduate level is essential. Candidates should submit a letter of application, research statement, curriculum vitae including a list of publications, description of teaching interest and a minimum of three letters of reference. Applications should be submitted through the application portal located at https://indiana.peopleadmin.com/hr/postings/475. For questions, please contact the Physics Department at 812-855-1247. In addition, a copy of the application package should be mailed to: Dr. Michael Pennington, Associate Director for Theoretical & Computational Physics, Jefferson Laboratory, 12000 Jefferson Avenue, Newport News, VA, USA.

Applications received by January 15, 2014 will be given full consideration. Further information about the IU Physics Department can be found at http://physics.indiana.edu.

Indiana University is an Affirmative Action; Equal Opportunity Employer strongly committed to excellence through diversity and is responsive to the needs of dual career couples. The University actively encourages applications of women, minorities, and persons with disabilities.

TRIUMF

TRIUMF LABORATORY DIRECTOR

TRIUMF is seeking an individual with an extraordinary combination of scientific vision, accomplishment, and leadership to assume responsibility for directing the laboratory.

TRIUMF is Canada's national laboratory for particle and nuclear physics. Owned and operated as a joint venture by a consortium of 18 Canadian universities, the laboratory enables research that benefits every sector of the Canadian science, technology, and innovation enterprise and leads to major advances in particle and nuclear physics, materials science, nuclear medicine, and accelerator physics. Core financial support for operations is provided through a contribution agreement via the National Research Council of Canada. TRIUMF has a dedicated staff of 350 continuing employees, a user community of 1,000, and provides unique educational experiences and training for undergraduate students, graduate students, and postdoctoral scholars.

The successful candidate will demonstrate his or her ability to advance an organization that is recognized nationally and internationally for excellence:

Effectively lead overall strategic planning, decision making, and the development of policies and budgets

- Provide leadership in determining the scientific direction of the laboratory;
- Interact closely with relevant funding agencies and with members of the federal and provincial governments to secure financial support;
- Define objectives and approve policies for achieving employee and public safety at TRIUMF;
- Be responsible to the appropriate government agencies for regulatory compliance; and
- Report to the Board of Management on policy and carry out policy decisions.

Position the laboratory to drive societal and economic benefits for Canada

- Encourage interaction between TRIUMF researchers and industry to foster innovation and maximize the economic benefits to Canadians; and
- Promote TRIUMF to the general public.

Interact with Canadian universities and the physics community in formulating plans and in supporting community priorities

- Facilitate the use of TRIUMF's infrastructure to support Canadian-led offshore projects; and
- Develop and maintain contact with other laboratories throughout the world that have common interests.

The position requires broad insight into the research capabilities of TRIUMF and a thorough understanding of how these capabilities can be exploited and further developed. The successful candidate will have leadership experience and a research career of international distinction.

Please note the position is open to all qualified applicants, and in the case of equal qualifications, preference may be given to a Canadian Citizen or Permanent Resident. TRIUMF is an equal opportunity employer. The term of the appointment would be for five years.

Applications should include a full curriculum vitae and a statement on vision for the laboratory. The review of applications will begin on November 4 and continue until an appointment is made. Applications and inquiries should be directed to:

Professor Robert Kowalewski, University of Victoria
Chair, Search Committee
E-mail: next-director@triumf.ca

http://www.triumf.ca/next-director

Bookshelf

Festive Bookshelf

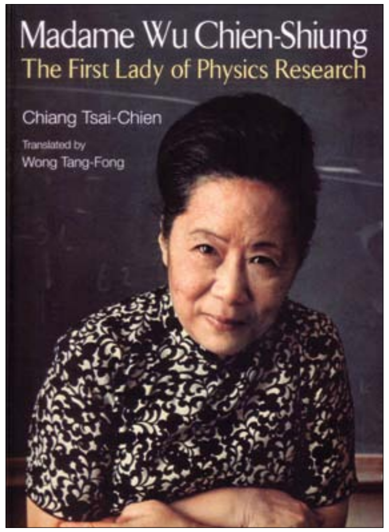
Once again, it will soon be time for many of us to take a well-earned break with friends and family, probably after a few hectic hours searching for presents in this festive season. To help with the shopping – whether for others or for yourself – this end-of-year Bookshelf presents some suggestions for more relaxed reading.

Madam Wu Chien-Shiung: The First Lady of Physics Research

By Chiang Tsai-Chien (translated by Wong Tang-Fong)
World Scientific
Hardback: £65
Paperback: £32
E-book: £24

The discovery of parity non-conservation was honoured with a Nobel Prize in Physics awarded to Chen-Ning Yang and Tsung-Dao Lee who raised the "question of parity conservation in weak interactions" in 1956 (*Phys. Rev.* **104** 254). Originally the preprint contained a question mark – "Is parity conserved in weak interactions?" – but the editors of *Physical Review* at that time discouraged question marks in the titles of regular articles. The crucial question mark was eliminated forever the same year by the valiant effort of Chien-Shiung Wu and her collaborators – Ernest Ambler, Raymond Hayward, Dale Hoppes and Ralph Hudson. They conducted a memorable experiment at the National Bureau of Standards and the results were published in the first few months of 1957 (*Phys. Rev.* **105** 1413). The concept of their experiment was remarkably simple: take a β-decay source (cobalt-60) and magnetize it with a circular current flowing first in one direction and then in the opposite sense, so that the initial states are the mirror images of each other. The β decays of the mirror-symmetric initial states turned out to be non-mirror-symmetric. Immediately afterwards, two other groups published similar evidence for parity non-conservation – Richard Garwin, Leon Lederman and Marcel Weinrich in Columbia University and Jerome Friedman and Valentine Telegdi in Chicago.

Weak interactions are at the heart of this interesting biography. Of course, Wu was not the first lady working in physics – other remarkable women preceded her in the path to great discoveries. However, as the author argues, she was a person of many



"firsts", such as the first recipient of the Wolf prize and the first female president of the American Physical Society.

The biography tells the exciting story of a young woman who left the rural China vividly described in the novels of Pearl S Buck and became one of the recognized authorities in the physics of β decay. Wu joined the Manhattan Project and later worked on several other topics, ranging from the Mossbauer effect to exotic atoms. However, her main contributions remain connected to weak interactions. In collaboration with her group in Columbia she also tested the conserved vector-current hypothesis and the universality of Fermi interaction proposed by Richard Feynman and Murray Gell-Mann – a discovery that was essential for the subsequent development of the Standard Model of electroweak interactions.

Wu was above all a scientist who did not like much exposure and dramatic headlines. She also had a wonderful family and various interests, including the rights of women in science. After leaving Shanghai in 1936, she was not allowed back into mainland China for 37 years and so never again saw family members who had died in the meantime. The Cultural Revolution threatened Chinese science but did not succeed. A number of remarkable Chinese scientists, including Wu, contributed enormously to the current success of the standard electroweak theory.

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

Time Reborn: From the Crisis of Physics to the Future of the Universe

By Lee Smolin
Allen Lane
Hardback: £20
E-book: £11.99

This is a fascinating and thought-provoking book about the nature of time and its role in explaining the universe. Smolin is an original thinker who is unafraid to challenge established orthodoxy. He argues that modern attempts to understand the universe have reached an impasse as a result of the extraction of time from our concept of reality.

The book is presented in two parts. The first offers an historical and philosophical account of how we have arrived at a timeless view of the world. The second develops ideas for a new approach to physics, which incorporates time as a central and fundamental theme. While both parts are interesting and relevant, physicists might find it more satisfying to read the second part first. There is also an epilogue where Smolin discusses some of the implications of redefining our concept of time and reality and how we might meet the challenges of the future, such as climate change and market economics. Finally, he considers the nature of consciousness.

Smolin begins by illustrating, with the simple example of projectile motion, how time can be excluded from our understanding of a physical system by using mathematical constructs. The role of mathematics is to make a physical system abstract, rendering it eternal and timeless. Here Smolin gives an excellent account of the history of the Copernican Revolution, Johannes Kepler and Galileo Galilei. His unique perspective gives new insight into how each world view might have developed and persisted. At each stage the concept of time becomes increasingly obsolete, culminating in the determinism of the Newtonian paradigm. Relativity is no less deterministic, leading us to a timeless "block universe" picture where reality is the whole history of the universe at once.

In what he calls "doing physics in a box", Smolin examines the applicability of the Newtonian paradigm to cosmology. A physical system can never be isolated from external influences, so the solutions are an approximation to reality. The approximation can be removed by taking the universe as a whole into consideration but such a step cannot be justified because the Newtonian paradigm necessarily applies to a system that is part of a whole. Smolin calls the inappropriate application of physical laws to the universe a "cosmological fallacy". His reasoning draws attention to the distinction between physics-in-a-box and cosmology. "The universe is an entity different in kind from any of its parts."

Smolin is a strong proponent of Leibnitz and the principle of sufficient reason, which states that if there is more than one possibility for things to be as they are, then there must be a sufficient reason for the actual outcome being the case. He uses this to great effect in defining his principles for a new cosmology. In particular, "there should be nothing in the universe that acts on other things without itself being acted upon." This expresses the philosophy of relationism, where every entity in the universe evolves dynamically, including the physical laws governing the universe. These laws then "become explicable only when they participate in the dance of change and mutual influence that makes the world a whole". A consequence of relationism, Smolin argues, is that symmetries and conservation laws can only be approximations to reality.

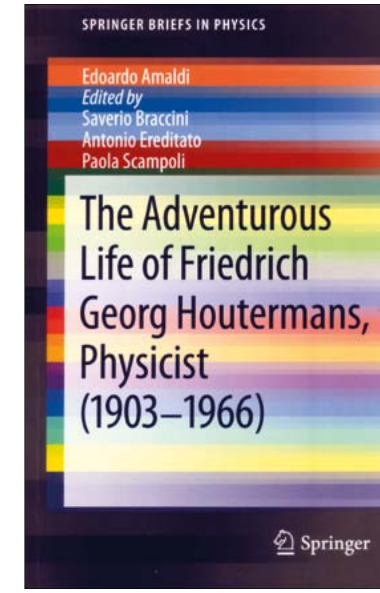
Smolin is keen to emphasize a new approach to a theory of the universe that is not constrained by the Newtonian paradigm. He attempts to provide a framework for a new theory, insisting that it must be able to provide falsifiable predictions. In this sense he is less speculative than those who opt for a multiverse of universes that are not causally connected to our own. He proposes the existence of many universes but with causal connections, which in principle allow their existence to be detected. A possible candidate for the new theory is cosmological natural selection – the subject of his earlier book *The Life of the Cosmos* – in which universes reproduce through the creation of new universes within black holes. The presence of a large number of black holes in a universe is a measure of its fitness in evolutionary terms. The analogy with Darwinian evolution raises the fascinating possibility of novel outcomes, similar to the emergence of new species through natural selection.

This book is great for providing numerous thought-provoking ideas. The reader does not have to agree with all of them to be stimulated into pondering the nature of time. Unsettling and controversial in places, it offers a much needed re-examination of some of our most cherished views.

● *Theresa Harrison, Warwick University.*

The Adventurous Life of Friedrich Georg Houtermans, Physicist (1903–1966)

By Edoardo Amaldi (Saverio Braccini, Antonio Ereditato and Paola Scampoli eds.)
Springer
Paperback: £44.99 €52.70 $49.95
E-book: £35.99 €41.64 $39.95



Before visiting a university or physics laboratory, most people imagine today's physicists as peaceful men or women wearing white lab coats and dealing with test tubes, clouds of coloured smoke and mathematical equations. Although the description would be more appropriate for ancient alchemists rather than modern physicists, one word should still stand out – peaceful. However, there was a time when physicists were investigating dangerous radiation, fissile nuclei and particles to trigger a nuclear-reaction chain. These were also the times when Europe was a battlefield and scientific results were regarded as potential material for spies and the tellers of spy stories. In those days, almost every scientist could have made a good subject for writers and Hollywood.

Friedrich "Fritz" Houtermans is no exception. Indeed, his private and professional lives make a good subject for a book. However, in my opinion, the most intriguing aspect of this book is the author – Edoardo Amaldi – and the reason why he decided to write about Fritz, a man who was married four times, spent a few years in Lubianka and other prisons and published several important physics results along the way. Amaldi had seen *L'Aveu* – the film by Costa Gravas about Artur London, the Czechoslovakian communist minister falsely arrested and tried for treason and espionage – and was struck by similarities with the story of Houtermans. Amaldi began to write about Houtermans but died in 1989. Twenty years later, Edoardo Amaldi's son Ugo gave his father's unpublished manuscript to the Laboratory for High Energy Physics at the University of Bern, where Fritz had done much to initiate research on particle physics. I share the fascination of the editors when they describe how grateful they were to have the opportunity to "meet two outstanding physicists" – Fritz and Edoardo.

The result is a detailed description of both the life of Houtermans and the lives of other friends of Amaldi. It is a beautiful description of Europe and science during the years before, during and after the Second World War. The words Amaldi uses – which are well edited – are not those of a storyteller. Instead, he provides a detailed – almost scientific – report of this almost unknown physicist.

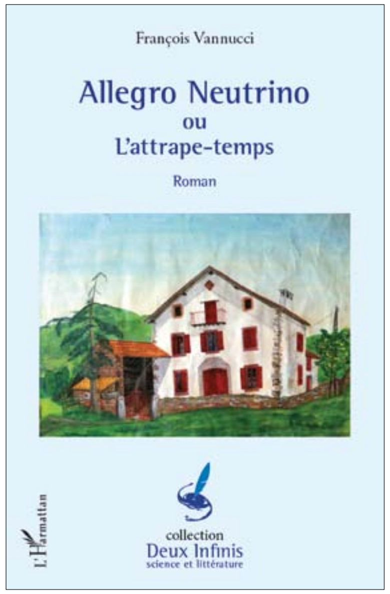
Although Houtermans is an interesting subject, more interesting to me are the chapters where Amaldi explains the "making of" the book and his research into accurate information sources about its subject. I think that soon I will be looking for an equivalent book about Amaldi's life.

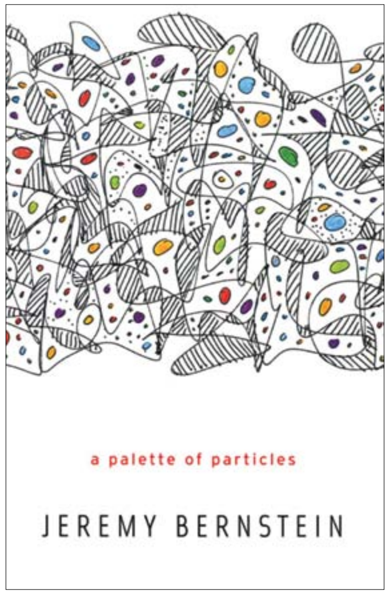
● *Antonella Del Rosso, CERN.*

Allegro Neutrino ou L'attrape-temps

De François Vannucci
L'Harmattan
Broché: €27

Paris, dans les années 1950. Michel a 11 ans et voit des bulles, ce dont il est très fier. Terme résolument non scientifique, le mot « bulle » désigne pour le narrateur – Michel





– « une myriade de points lumineux dansant dans tous les sens », points lumineux qui se révèleront être, au fil des pages, des « neutrinos ». Nous y voilà.

Vous l'aurez compris, bien qu'écrit par un physicien des particules spécialisé en physique des neutrinos, ce livre est un roman. L'objectif n'étant pas de vous en apprendre des kilomètres sur ces fameux neutrinos, mais de vous embarquer dans une histoire dont ils sont les protagonistes. Et si l'histoire est contée par un jeune narrateur passionné de physique, il n'en reste pas moins qu'il s'agit d'un enfant, et non pas (encore) d'un physicien des particules.

L'intrigue, si je puis donner à l'histoire cette connotation très romanesque, est somme toute assez simple. Michel, écolier plutôt mauvais en maths mais bon en imagination, vit dans un minuscule appartement parisien avec ses parents. Il va à l'école à pied, troue ses chaussettes, accompagne sa mère au marché le jeudi et à la messe le dimanche, passe ses vacances d'été à la campagne, collectionne les timbres, adore les truffes au chocolat, et se délecte des histoires de science de son oncle Albert, fonctionnaire tire-au-flanc et lecteur assidu de magazines de vulgarisation scientifique. Mais ce qui anime surtout Michel, moins son histoire, c'est cette étrange capacité à voir des neutrinos.

Mais ne vous méprenez pas, les neutrinos de Michel sont loin de coller à l'idée que l'on s'en fait au CERN. Pour Michel, ce ne sont en effet ni plus ni moins que les constituants de l'âme des êtres vivants, ou, comme les décrit encore le narrateur, « notre carburant spirituel ». Ce qui explique d'ailleurs que les jeunes en émettent plus que les vieux, et que ceux qui n'en émettent plus sont morts. CQFD.

Au final, ce livre est un long voyage dans la tête d'un gamin de 11 ans, à la rencontre de ses idées farfelues, de ses expérimentations et déductions scientifiques, de ses découvertes triomphantes et de ses confrontations au monde des adultes. Certains passages sont franchement réjouissants, et l'on finit par se prendre d'affection pour le jeune Michel, qui garde précieusement au fond de sa poche, un marron, une bille et une boîte pleine de neutrinos.

● *Anaïs Schaeffer, CERN.*

A Palette of Particles
By Jeremy Bernstein
Harvard University Press
Hardback: £14.95 €17.10 $18.95

This book presents a somewhat personal tour through the zoo of more-or-less elementary particles discovered in the past hundred years or so. In general, the content should be well known to most people who are interested in this topic, except for a few original "anecdotes" that Bernstein – a physicist – experienced first hand. Surprisingly, such personal accounts and opinions are limited both in number and impact. Occasionally the author seems tempted to say something but then avoids developing the arguments further, so that the reader ends up not quite knowing what the message is. For instance, after reporting that a Higgs boson was discovered at CERN (using the clumsy wording "CMS and ATLAS each reported a sigma close to five"), Bernstein criticizes the experimenters at CERN for "claiming victory". "There was so much pressure to discover this particle that it makes me a bit queasy," he says. He then implies that his uneasiness will not disappear "until there are more data from the LHC" but he forgets to explain what he thinks the "more data" should show to clarify his doubts. Another example is the much-too-brief mentioning of dark energy, quickly dismissed with the words "its origin is unclear". The reader is left disappointed that these thoughts are not developed further.

It seems that Bernstein had a hard time trying to find a suitable balance between explaining things accurately and staying within the reach of the "lay reader". He certainly knows, for instance, that the expression "the electron temperature" is meaningless – single particles have energies not temperatures. And why does he systematically quote the masses of the particles with respect to "the mass of the proton" instead of introducing the mass unit GeV? I wonder if such decisions are imposed by the publishers of "popular science books", together with the rule of strictly avoiding any equations (except $E = mc^2$). To me, it sounds more confusing. It also seems that the author became confused, judging from the statement that Λ^0 is "a neutral particle about half as massive as the proton". Hopefully the reader will understand that this is a "misprint" when seeing, in the next sentence, that Λ^0 decays into π^- and a proton. Unless the reader stopped believing in energy conservation after reading about the decays of a Higgs boson "into a W^+ and a W^- or two Z^0s". The "lay reader" would appreciate some discussion on how these "most interesting decays" can occur, despite a mass for the Higgs boson less than twice the masses of the W or Z, something that is nicely addressed by Lisa Randall in her short book *Higgs Discovery: The Power of Empty Space* (*CERN Courier* December 2012 p37).

If I were to recommend a book giving a popular account of particle physics, a few other books would come to mind first, but this one has the advantage of (probably) being the smallest and fastest to read – and it fits in most pockets.

● *Carlos Lourenço, CERN.*

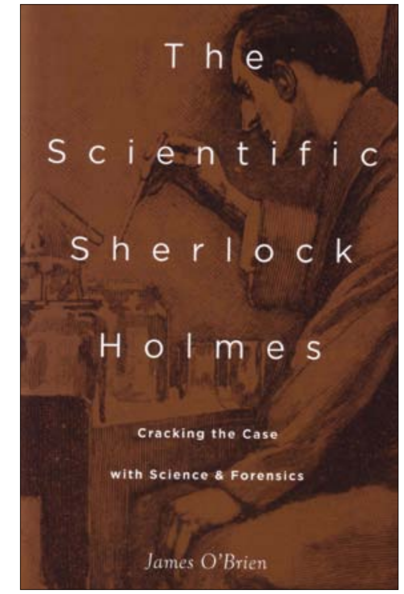
The Scientific Sherlock Holmes: Cracking the Case with Science & Forensics
By James O'Brien
Oxford University Press
Hardback: £18.99 $29.95

Devotees of the criminal-investigation TV drama *NCIS* will know that Special Agent Gibbs does not believe in coincidences – it's enshrined in his rule number 39: "There is no such thing as a coincidence." More than a century earlier, the same belief seems to have inspired Arthur Conan Doyle in his creation of probably the best known pioneer of crime-scene investigation – Sherlock Holmes. Conan Doyle was later to explain that detective stories he had read were "nonsense...because for getting the solution to the mystery the authors always depended on some coincidence". Instead, the key to solving the cases in the Sherlock Holmes stories was the central character's knowledge of science and his powers of deduction.

The stories became hugely popular. Fans would eagerly await the next edition of *The Strand Magazine* to read the latest mystery and refused to let Holmes die – famously, Conan Doyle had to bring the detective back from near death at the Reichenbach Falls. Indeed, Holmes continues to live on in peoples' imaginations, long after his creator died. The attraction continues today, as Holmes appears on TV and cinema screens in many different incarnations and has been brought into the 21st century, for example by the popular actor Benedict Cumberbatch.

In *The Scientific Sherlock Holmes*, James O'Brien, an emeritus professor of chemistry, puts forward the case that the scientific element played an important part in the success of the stories. His book is essentially a pocket guide to the science in Holmes's adventures – short enough to read quickly but packed full of facts and quotations from Conan Doyle's 60 stories about the maverick detective. Just like the stories themselves, the book becomes compulsive reading as O'Brien looks in detail at how Holmes used science in his investigations. Most fascinating is the chapter on forensic science, from fingerprints and footprints to the use of dogs. What makes this especially intriguing is the way that the author matches the work of Holmes with real forensic science and some famous cases. The development of the Automated Fingerprint Identification System (AFIS – well known to modern fans of crime fiction), as well as the use of handwriting in apprehending the New York Zodiac Killer and typewritten letters in convicting the Unabomber, are some examples.

O'Brien also looks closely at Holmes's deep interest in chemistry, before covering other sciences. Here he defends Holmes against the criticisms of Isaac Asimov – the well-known chemist, author and "Sherlockian scholar". In Asimov's view, Holmes was a "blundering chemist", while the chronicler Dr Watson describes Holmes's knowledge of chemistry as "profound". After analysing several stories,



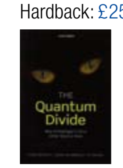
O'Brien comes down between the two, ranking Holmes the chemist as "eccentric".

Of course, Holmes was a character in a book – although it is sometimes easy to fall into thinking about Holmes as a real person, as O'Brien and his many sources often seem to do. Instead, the stories reflect the knowledge of Conan Doyle, who had trained as a doctor. The fascination is that Conan Doyle was so up-to-date on the application of forensic science – and that fictionalizations centred on forensic science continue to draw large audiences in many countries, where they can see modern variants on Holmes on TV on almost any night of the week.

● *Christine Sutton, CERN.*

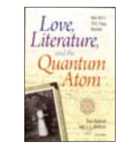
Books received

The Quantum Divide: Why Schrödinger's Cat is Either Dead or Alive
By Christopher C Gerry and Kimberley M Bruno
Oxford University Press
Hardback: £25



Aimed at undergraduate physics students and anyone else who wants to grasp the essential issues of quantum physics, the authors use a selection of key experiments performed during the past 30 years to discuss the counter-intuitive phenomena of the quantum world that defy explanation in terms of "common sense" and provide the corresponding quantum mechanical explanations with only an elementary use of associated formalism. Most, but not all, of the experiments described are optical, involving a small number of photons (particles of light). Starting with experiments on the wave–particle duality of electrons, the authors proceed to experiments on the particle nature of light and single-photon interference, delayed-choice experiments and interaction-free detection. The book then moves on to experiments involving the interference of two photons, quantum entanglement and Bell's Theorem, quantum teleportation, large-scale quantum effects and the divide between the classical and quantum worlds, addressing the question as to whether or not there is such a divide.

Love, Literature and the Quantum Atom: Niels Bohr's 1913 Trilogy Revisited
By Finn Aaserud and John L Heilbron
Oxford University Press
Hardback: £35



Niels Bohr ranks with Albert Einstein among the physicists of the 20th century. He rose to this status through his invention of the quantum theory of the atom and his leadership in its defence and development. He also ranks with Einstein in his humanism and sense of responsibility to his science and the society that enabled him to create it. This book presents unpublished excerpts from extensive correspondence between Bohr and his immediate family, using it to describe and analyse the psychological and cultural background to his invention. The book also contains a reprinting of the three papers of 1913 – the Trilogy – in which Bohr worked out the provisional basis of a quantum theory of the atom.

Under the Spell of Landau: When Theoretical Physics was Shaping Destinies
By Mikhail Shifman (ed.)
World Scientific
Hardback: £82
Paperback: £45
E-book: £34

This invaluable collection of memoirs and reviews on scientific activities of the most prominent theoretical physicists belonging to the Landau School — Landau, Migdal, Zeldovich, Smorodinsky, Ter-Martirosyan, Kirzhnits, Gribov, Larkin and Anselm — is published in English for the first time. The main goal is to acquaint readers with the life and work of outstanding Soviet physicists who, to a large extent, shaped theoretical physics in the period 1950–1970. Many intriguing details brought together here were unknown beyond the Iron Curtain of those years.

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