WELCOME

CERN Courier – digital edition

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

While collisions at the LHC can directly produce heavy particles – like the one recently identified as a Higgs boson – they can also cast light on the existence of new particles that have masses beyond the energy limit of the machine. Such particles can be observed indirectly through their "virtual" participation in rare decay processes, which are described by penguin-like diagrams. Searches for these processes are important for the LHCb experiment, specialized in studying the transitions of b quarks. It is one area in which LHCb can compete with the huge, general-purpose experiments, ATLAS and CMS, which received the provisional go-ahead exactly 20 years ago. In the same month – June 1993 – the CERN School of High-Energy Physics evolved into the European School of High-Energy Physics. Organized jointly by CERN and JINR in Dubna, the school continues to exemplify how interest in science brings together people from different nations to work in harmony.

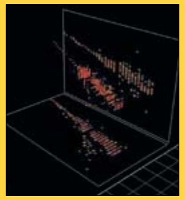
To sign up to the new issue alert, please visit:
http://cerncourier.com/cws/sign-up.

To subscribe to the magazine, the e-mail new-issue alert, please visit:
http://cerncourier.com/cws/how-to-subscribe.

EDITOR: CHRISTINE SUTTON, CERN
DIGITAL EDITION CREATED BY JESSE KARJALAINEN/IOP PUBLISHING, UK

INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS
CERNCOURIER
VOLUME 53 NUMBER 5 JUNE 2013

LHCb: a place to find penguins

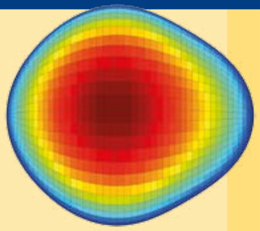


DETECTORS

NOvA records its first cosmic-ray events in 3D
p9

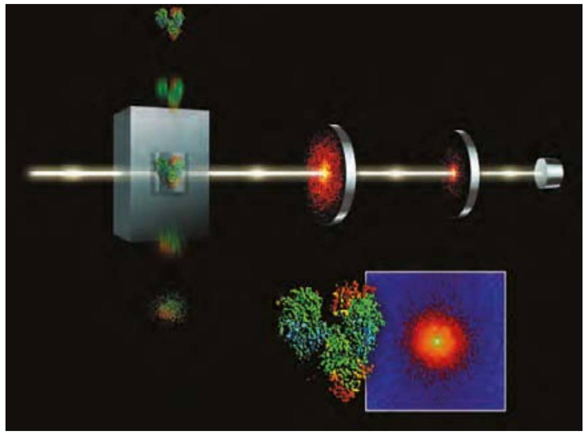
ISOLDE

Are some atomic nuclei shaped like a pear?
p5



ATLAS AND CMS

How it all began **p22**



Contents

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

CERN Courier is distributed to member-state governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly, except for January and August. The views expressed are not necessarily those of the CERN management.

Editor Christine Sutton
News editor Kate Kahle
Editorial assistant Carolyn Lee
CERN, 1211 Geneva 23, Switzerland
E-mail cern.courier@cern.ch
Fax +41 (0) 22 785 0247
Web cerncourier.com

Advisory board Luis Álvarez-Gaumé, James Gillies, Horst Wenninger

Laboratory correspondents:
Argonne National Laboratory (US) Cosmas Zachos
Brookhaven National Laboratory (US) P Yamin
Cornell University (US) D G Cassel
DESY Laboratory (Germany) Till Mundzeck
EMFCSC (Italy) Anna Cavallini
Enrico Fermi Centre (Italy) Guido Piragino
Fermi National Accelerator Laboratory (US) Katie Yurkewicz
Forschungszentrum Jülich (Germany) Markus Buescher
GSI Darmstadt (Germany) I Peter
IHEP, Beijing (China) Tongzhou Xu
IHEP, Serpukhov (Russia) Yu Ryabov
INFN (Italy) Romeo Bassoli
Jefferson Laboratory (US) Steven Corneliussen
JINR Dubna (Russia) B Starchenko
KEK National Laboratory (Japan) Nobukazu Toge
Lawrence Berkeley Laboratory (US) Spencer Klein
Los Alamos National Laboratory (US) Rajan Gupta
NCSL (US) Ken Kingery
Nikhef (Netherlands) Robert Fleischer
Novosibirsk Institute (Russia) S Eidelman
Orsay Laboratory (France) Anne-Marie Lutz
PSI Laboratory (Switzerland) P-R Kettle
Saclay Laboratory (France) Elisabeth Locci
Science and Technology Facilities Council (UK) Julia Maddock
SLAC National Accelerator Laboratory (US) Farnaz Khadem
TRIUMF Laboratory (Canada) Marcello Pavan

Produced for CERN by IOP Publishing Ltd
IOP Publishing Ltd, Temple Circus, Temple Way,
Bristol BS1 6HG, UK
Tel +44 (0)117 929 7481

Publisher Susan Curtis
Production editor Jesse Karjalainen
Technical illustrator Alison Tovey
Group advertising manager Chris Thomas
Advertisement production Katie Graham
Marketing & Circulation Angela Gage

Head of B2B & Marketing Jo Allen
Art director Andrew Giaquinto

Advertising
Tel +44 (0)117 930 1026 (for UK/Europe display advertising)
or +44 (0)117 930 1164 (for recruitment advertising);
E-mail: sales@cerncourier.com; fax +44 (0)117 930 1178

General distribution Courrier Adressage, CERN, 1211 Geneva 23, Switzerland
E-mail: courrier-adressage@cern.ch
In certain countries, to request copies or to make address changes, contact:
China Keqing Ma, Library, Institute of High Energy Physics,
PO Box 918, Beijing 100049, People's Republic of China
E-mail: keqingma@mail.ihep.ac.cn
Germany Veronika Werschner, DESY, Notkestr. 85, 22607 Hamburg, Germany
E-mail: desypr@desy.de
Italy Loredana Rum or Anna Pennacchietti, INFN, Casella Postale 56, 00044 Frascati, Rome, Italy
E-mail: loredana.rum@lnf.infn.it
UK Mark Wells, Science and Technology Facilities Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1SZ
E-mail: mark.wells@stfc.ac.uk
US/Canada Published by Cern Courier, 6N246 Willow Drive,
St Charles, IL 60175, US. Periodical postage paid in St Charles, IL, US
Fax 630 377 1569. E-mail: creative_mailing@att.net
POSTMASTER: send address changes to: Creative Mailing Services, PO Box 1147,
St Charles, IL 60174, US

Published by European Organization for Nuclear Research, CERN,
1211 Geneva 23, Switzerland
Tel +41 (0) 22 767 61 11. Telefax +41 (0) 22 767 65 55

Printed by Warners (Midlands) plc, Bourne, Lincolnshire, UK

ISSN 0304-288X

IOP Publishing

CERNCOURIER

VOLUME 53 NUMBER 5 JUNE 2013

On the cover: This view of the LHCb experiment at CERN gives an idea of the impressive scale of the system used to detect muons – critical in reconstructing the rare transitions of b quarks described on p15. The green "walls" in the middle are the iron filter that ranges out other charged particles, the pipe across the top of the image is the beam pipe and the panels on the right-hand side are some of the muon detectors themselves.

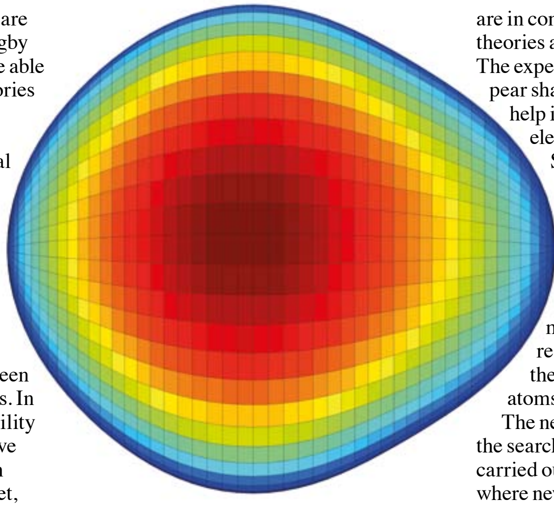
News

CERN

Are some atomic nuclei pear shaped?

Most atomic nuclei that exist naturally are not spherical but have the shape of a rugby ball. While state-of-the-art theories are able to predict this behaviour, the same theories have predicted that for some particular combinations of protons and neutrons, nuclei can also assume an asymmetrical shape like a pear, with more mass at one end of the nucleus than the other. Now an international team studying radium isotopes at CERN's ISOLDE facility has found that some atomic nuclei can indeed take on this unusual shape.

Most nuclear isotopes predicted to have pear shapes have for a long time been out of reach of experimental techniques. In recent years, however, the ISOLDE facility has demonstrated that heavy, radioactive nuclei, produced in high-energy proton collisions with a uranium-carbide target, can be selectively extracted before being accelerated to 8% of the speed of light. The beam of nuclei is directed onto a foil of isotopically pure nickel, cadmium or tin where the relative motion of the heavy accelerated nucleus and the target nucleus creates an electromagnetic impulse that excites the nuclei.



The shaoe of ^{224}Ra as deduced from the experiments at ISOLDE.

By studying the details of this excitation process it is possible to infer the nuclear shape. This method has now been used successfully to study the shape of the short-lived isotopes ^{220}Rn and ^{224}Ra. The data show that while ^{224}Ra is pear shaped, ^{220}Rn does not assume the fixed shape of a pear but rather vibrates about this shape.

The findings from the teams at ISOLDE are in contradiction with some nuclear theories and will help others to be refined. The experimental observation of nuclear pear shapes is also important because it can help in experimental searches for atomic electric dipole moments (EDMs). The Standard Model of particle physics predicts that the value of the atomic EDM is so small that it will lie well below the current observational limit. However, many theories that try to refine the model predict values of EDMs that should be measurable. Testing these theories requires improved measurements, the most sensitive being to use exotic atoms whose nuclei are pear shaped.

The new measurements will help to direct the searches for EDMs currently being carried out in North America and in Europe, where new techniques are being developed to exploit the special properties of radon and radium isotopes. The expectation is that the data from the nuclear-physics experiment at ISOLDE can be combined with results from atomic-trapping experiments that measure EDMs to make the most stringent tests of the Standard Model.

Further reading
L P Gaffney *et al.* 2013 *Nature* **497** 199.

ALPHA presents novel investigation of the effect of gravity on antimatter

The ALPHA collaboration at CERN has made the first direct analysis of how antimatter is affected by gravity. The ALPHA experiment was the first to trap atoms of antihydrogen, held in place with a strong magnetic field for up to 1000 s (*CERN Courier* July/August 2011 p6). Although the main goal is not to study gravity, the team realized that the data that they have collected might be sensitive to gravitational effects. Specifically, they searched for the free fall (or rise) of antihydrogen atoms released from the trap, which allowed them to measure limits directly on the ratio of the gravitational to inertial mass of antimatter, $F=M_g/M$.

Measuring a total of 434 atoms, they found that in the absence of systematic errors, F must be <75 at a statistical significance level of 5%; the worst-case systematic errors increase this limit to <110. A similar search places somewhat tighter bounds on a negative F, that is, on antigravity. Refinements of the technique, coupled with larger numbers of cold-trapped antiatoms, should allow future measurements to place tighter bounds on F and approach the interesting region around 1.

Meanwhile, the antimatter programme at CERN is expanding. AEgIS and GBAR, two experiments currently under construction, will focus on measuring how gravity affects antihydrogen.

Further reading
Nature Communications **4** doi:10.1038/ncomms2787.

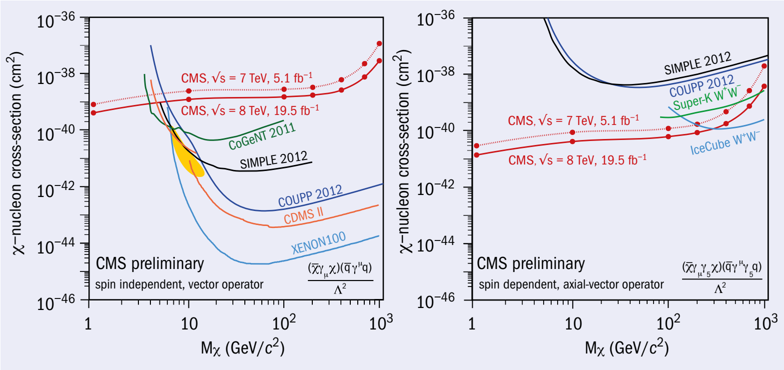
Sommaire en français

LHC PHYSICS

CMS hunts for low-mass dark matter

Astronomical observations – such as the rotation velocities of galaxies and gravitational lensing – show that more than 80% of the matter in the universe remains invisible. Deciphering the nature of this "dark matter" remains one of the most interesting questions in particle physics and astronomy. The CMS collaboration recently conducted a search for the direct production of dark-matter particles (χ), with especially good sensitivity in the low-mass region that has generated much interest among scientists studying dark matter.

Possible hints of a particle that may be a candidate for dark matter have already begun to appear in the direct-detection experiments; most recently the CDMS-II collaboration reported the observation of three candidate events in its silicon detectors with an estimated background of 0.7 events. This result points to low masses, below 10 GeV/c^2, as a region that should be particularly interesting to search. This mass region is where the direct-detection experiments start to lose sensitivity because they rely on measuring the recoil energy imparted to a nucleus by collisions with the dark-matter particles. For a low-mass χ, the kinetic energy transferred to the nucleus in the collision is small, and the detection sensitivity drops as a result.



CMS 90% CL upper limits on the χ–nucleon cross-section as a function of χ mass for spin-independent (left) and spin-dependent scattering (right). Also shown are limits from other experiments, and the 68% and 90% contours for the candidate events from CDMS (arXiv:1304.4279 [hep-ex]).

The CMS collaboration has searched for hints of these elusive particles in "monojet" events, where the dark-matter particles escape undetected, yielding only "missing momentum" in the event. A jet of initial-state radiation can accompany the production of the dark-matter particles, so a search is conducted for an excess of these visible companions compared with the expectation from Standard Model processes. The results are then interpreted within the framework of a simple "effective" theory for their production, where the particle mediating the interaction is assumed to have high mass. An important aspect of the search by CMS is that there is no fall in sensitivity for low masses.

The monojet search requires at least one jet with more than 110 GeV of energy and has the best sensitivity if there is more than 400 GeV of missing momentum. Events with additional leptons or multiple jets are vetoed. After event selection, 3677 events were found in the recent analysis, with an expectation from Standard Model processes of 3663 ± 196 events. The contribution from electroweak processes dominate this expectation, either from pp → Z+jets with the Z decaying to two neutrinos or from pp → W+jets, where the W decays into a lepton and neutrino, while the lepton escapes detection.

With no significant deviation from the expectation from the Standard Model, CMS has set limits on the production of dark matter, as shown in the figures of the χ–nucleon cross-section versus χ mass. The limits show that CMS has good sensitivity in the low-mass regions of interest, for both spin-dependent and spin-independent interactions.

- **Further reading**

CMS collaboration CMS-PAS-EXO-12-048.

CP violation observed in the decays of B^0_s mesons

In March 2012, the LHCb collaboration reported an observation of CP violation in charged B-meson decays, $B^\pm \to DK^\pm$. Now, just over a year later, the collaboration has announced a similar observation in the decays in another B meson, in this case the B^0_s meson composed of a beauty antiquark b bound with a strange quark s. This first observation of CP violation in the decays $B^0_s \to K^-\pi^+$ with a significance of more than 5σ marks the first time that CP violation has been found in the decays of B^0_s mesons – only the fourth type of meson where this effect has been seen. It is an important milestone for LHCb because the precise study of B^0_s decays is sensitive to possible physics beyond the Standard Model.

The study of CP violation in charmless charged two-body B decays provides stringent tests of the Cabibbo-Kobayashi-Maskawa picture of CP violation in the Standard Model. However, the presence of hadronic contributions means that several measurements from such decays are needed to exploit flavour symmetries and disentangle the different contributions. In 2004, the BaBar and Belle collaborations at SLAC and KEK, respectively, discovered direct CP violation in the decay $B^0 \to K^+\pi^-$ and a model-independent test was proposed to check the consistency of the observed size of the effect with the Standard Model. The test consists of comparing CP violation in $B^0 \to K^+\pi^-$ with that in $B^0_s \to K^-\pi^+$. The B factories at KEK and SLAC did not have the possibility of accumulating large enough samples of B^0_s decays and, despite much effort by the CDF collaboration at Fermilab's Tevatron, CP violation had until now not been seen in $B^0_s \to K^-\pi^+$ with a significance exceeding 5σ.

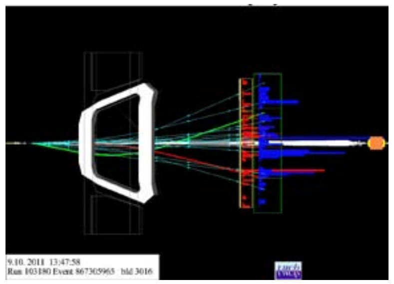


Fig. 1. The analysis studied the decays of B^0 and B^0_s mesons into K and π mesons. In this event a decay produces a negative K (red track) and a positive π (green track).

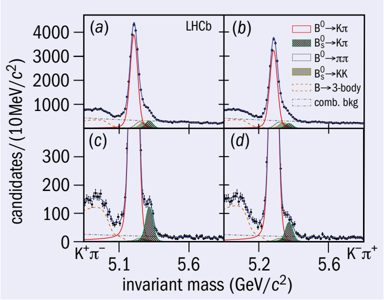


Fig. 2. Invariant mass spectra obtained using the event selection adopted for the best sensitivity on (a, b) ACP ($B^0 \to K^+\pi^-$) and (c, d) ACP ($B^0_s \to K^-\pi^+$). Panels (a) and (c) show the $K^+\pi^-$ invariant mass, whereas panels (b) and (d) show the $K^-\pi^+$ invariant mass. The results of the unbinned maximum likelihood fits are overlaid. The main components contributing to the model used in the fit are also shown.

Using a data sample corresponding to an integrated luminosity of 1.0 fb^{-1} collected by the experiment in 2011, the LHCb collaboration measured the direct CP-violating asymmetry for $B^0_s \to K^-\pi^+$ decays, ACP ($B^0_s \to K^-\pi^+$) = 0.27 ± 0.04 (stat.) ± 0.01 (syst.), with a significance of more than 5σ. In addition, the collaboration improved the determination of direct CP violation in $B^0 \to K^+\pi^-$ decays, ACP ($B^0 \to K^+\pi^-$) = –0.080 ± 0.007 (stat.) ± 0.003 (syst.), which is the most precise measurement of this quantity to date. The four plots in figure 2 show different components of the $K^+\pi^-$ invariant mass. The upper plots indicate the well established difference in the decay rates of B^0 mesons. The enlargements in the lower plots reveal that a difference is also visible around the mass of the B^0_s meson. The measured values are in good agreement with the Standard Model expectation.

Only the data sample collected in 2011 was used to obtain these results, so LHCb will improve the precision further with the total data set now available, which more than trebled with the excellent performance of the LHC during 2012.

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

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

First jet measurements with ALICE

When quarks and gluons (partons) in opposing beams at high-energy hadron colliders meet they can scatter violently to produce correlated showers of particles, or "jets". In proton–proton (pp) collisions, the rate of such events can be predicted using state-of-the-art QCD calculations and compared with the measurements. However, in heavy-ion collisions, jets are expected to be modified by the interaction of the scattered partons with the surrounding excited nuclear matter – the quark–gluon plasma, or QGP. Jets and this phenomenon of "jet quenching" thus provide important diagnostic probes of the QGP.

ALICE, which is devoted to a broad study of the QGP at the LHC, first observed jet quenching in lead–lead (PbPb) collisions through the suppressed production rate of high-momentum single hadrons (*CERN Courier* June 2011 p17). Fully reconstructed jets are measured using the high-precision tracking of charged particles in the ALICE central barrel, together with a measurement of the energy of neutral particles in the EMCal (figure 1). The EMCal is a lead–scintillator sampling calorimeter covering $|\eta| < 0.7$ and 100° in azimuth, which consists of 11,520 separate towers, each subtending $\Delta\eta \times \Delta\phi = 0.014 \times 0.014$. A late addition, its installation was completed in January 2011.

This "tracking+EMCal" method of reconstructing jets differs from the more traditional approach with hadronic plus electromagnetic calorimetry and provides a systematically different way to study jets. The first step for ALICE in the study of fully reconstructed jets in heavy-ion collisions is nevertheless to measure jets in the simpler environment of pp collisions, to determine the expected production rate for jets.

Fig. 1. One of ten EMCal super-modules, before installation. (Image credit: T Awes.)

In March 2011, the LHC delivered a three-day run with pp collisions at $\sqrt{s} = 2.76$ TeV to provide the reference measurements for PbPb collisions at the same centre-of-mass energy. During this brief run, the recently commissioned EMCal was employed as a fast trigger for jets, allowing ALICE to accumulate an integrated luminosity of 13.6 nb^{-1}. Jet reconstruction was then carried out using two resolution parameters, R = 0.2 and 0.4, which define the maximum distance in phase space over which particles are clustered. An overall systematic uncertainty of 18–20% was achieved for the jet cross-section in the 20–125 GeV/*c* momentum range of the measurement.

Figure 2 shows the ratio of the inclusive differential jet cross-sections for R = 0.2 and R = 0.4, together with the predictions from QCD. This cross-section ratio is sensitive to the distribution of energy within jets and is of particular interest in the study of jets in heavy-ion collisions. The theoretical calculation agrees with the measured ratio if "hadronization" effects, which arise because the experiment measured hadrons and not partons, are taken fully into account.

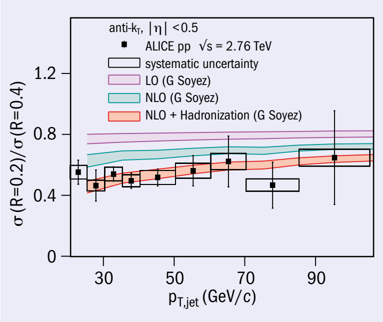


Fig. 2. Ratio of the inclusive differential jet cross-section for R = 0.2 and R = 0.4, with state-of-the-art (leading order (LO) and next-to-leading order (NLO)) QCD calculations. Data points are placed at the centre of each bin.

These results demonstrate that ALICE can measure jets well with the advantage of precise determination of the jet structure, which is of crucial importance for studies of jet modification in PbPb collisions.

Further reading

ALICE collaboration 2013 *Phys. Letts. B* **722** 262.

Luminosity-independent measurement of the proton–proton total cross-section at 8 TeV

The TOTEM collaboration has published the first luminosity-independent measurement at the LHC of the total proton–proton cross-section at a centre-of-mass energy of 8 TeV. This follows the collaboration's published measurement of the same cross-section at 7 TeV, which demonstrated the reliability of the luminosity-independent method by comparing several approaches (*CERN Courier* April 2013 p8).

The method requires the simultaneous measurements of the inelastic and elastic rates, as well as the extrapolation of the latter down to a four-momentum transfer squared, $|t| = 0$. This is achieved with the experimental set-up consisting of two telescopes, T1 and T2, to detect charged particles produced in inelastic proton–proton collisions, and Roman Pot stations to detect elastically scattered protons at very small angles.

The analysis at 8 TeV was performed on two data samples recorded in July 2012 during special fills of the LHC with the magnets set to give the parameter $\beta^* = 90$ m (*CERN Courier* November 2012 p7). During these fills, the Roman Pots were inserted close to the beam, allowing the detection of around 90% of the nuclear elastic-scattering events. Simultaneously, the inelastic scattering rate was measured by the T1 and T2 telescopes.

By applying the optical theorem, the collaboration determined a total proton–proton cross-section of 101.7 ± 2.9 mb, which is in good agreement with the extrapolation from lower energies. The method also allows the derivation of the luminosity-independent elastic and inelastic cross-sections: $\sigma_{el} = 27.1 \pm 1.4$ mb and $\sigma_{inel} = 74.7 \pm 1.7$ mb. The two measurements are consistent in terms of detector performance, showing comparable systematic uncertainties, and they are both in good agreement with the extrapolation of the lower-energy measurements.

Further reading

TOTEM collaboration 2013 CERN-PH-EP-2012-354, accepted by *Phys. Rev. Letts.*

NEUTRINOS

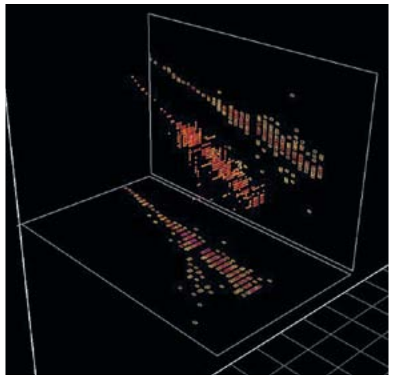
NOvA detector records first 3D tracks

The NOvA neutrino detector that is currently under construction in northern Minnesota has recorded its first 3D images of particle tracks. Researchers started up the electronics for a section of the first block of the NOvA detector in March and the experiment was soon catching more than 1000 cosmic rays a second.

Once completed in 2014, the NOvA detector will consist of 28 blocks with a total mass of 14,000 tonnes. The blocks are made of PVC tubes filled with scintillating liquid. It will be the largest free-standing plastic structure in the world.

Fermilab, located 810 km south-east of the NOvA site, will start sending neutrinos to Minnesota in the summer. The laboratory is finalizing the upgrades to its Main Injector accelerator, which will provide the protons that produce the neutrino beam. The upgraded accelerator will produce a pulse of muon neutrinos every 1.3 seconds and the goal is to achieve a proton-beam power of 700 kW. A smaller, 330-tonne version of the far detector for NOvA will be built on the Fermilab site to measure the composition of the neutrino beam before it leaves the laboratory.

The neutrino beam will provide particles for three experiments: MINOS, located 735 km from Fermilab in the Soudan Underground Laboratory, right in the centre of the neutrino beam; NOvA, which is located off axis to probe a specific part of the energy spectrum of the neutrino beam, optimal for studying the oscillation of muon neutrinos into electron neutrinos; and MINERvA, a neutrino experiment located on the Fermilab site.



This 3D image shows the production of a large shower of energy by a cosmic-ray muon as it passes through the NOvA far detector in Minnesota. (Image credit: NOvA collaboration.)

When completed, the NOvA detector will comprise 28 detector blocks, each measuring about 15 m tall, 15 m wide and nearly 2 m deep. (Image credit: Fermilab.)

The NOvA collaboration aims to discover the mass hierarchy of the three known types of neutrino – which type of neutrino is the heaviest and which is the lightest. The answer will shed light on the theoretical framework that has been proposed to describe the behaviour of neutrinos. Their interactions could help to explain the imbalance of matter and antimatter in today's universe; there is even the possibility that there might be still more types of neutrino.

The NOvA detector will be operated by the University of Minnesota under a co-operative agreement with the Office of Science of the US Department of Energy (DOE). About 180 scientists, technicians and students from 20 universities and laboratories in the US and another 14 institutions around the world are members of the NOvA collaboration. The scientists are funded by the DOE, the US National Science Foundation and funding agencies in the Czech Republic, Greece, India, Russia and the UK.

DARESBURY

VELA: the small accelerator with a big potential

A new particle accelerator in the UK has achieved a significant electron acceleration milestone. On 5 April, the Versatile Electron Linear Accelerator (VELA) produced its first electron beam, an important step on the way to being ready for commercial and research use this summer.

VELA, which is situated at the Daresbury Laboratory of the Science and Technology Facilities Council, is designed to be one of the most flexible particle accelerators of its type. The medium-term aim is to develop the 6 MeV injector with additional linac sections in order to achieve 250 MeV beams at 400 Hz with bunch charges in the range 50–250 pC. At present, the beam pulses are generated by targeting a copper photo-cathode with a UV laser.

With stable, reliable beams over a broad range of energies, VELA will provide interesting new opportunities for users and collaborators. The facility is exceptional in offering access on "both sides of the wall", allowing users not only to perform conventional studies on samples but also to access the accelerator itself. This opens up the possibility of testing a variety of accelerator components or items for beam diagnostics.

One of the primary collaborating institutes currently working on VELA is Strathclyde University. The team from Strathclyde has provided a significant level of hardware that will allow a demonstration of the capability of RF injectors for use with laser-driven plasma wakefield accelerators (*CERN Courier* June 2007 p28). The researchers plan to install an RF injector for Strathclyde's project Advanced Laser-plasma High-energy Accelerators towards X-rays (ALPHA-X), but to date they have not been able to demonstrate a suitable performance capability. Working with VELA, however, they have developed a system that is directly suited to their application and its design is being qualified, enabling its use at the university's facility.

The plan for VELA is to continue collaborations with other leading institutions and with industry. The aim is that the facility will allow the development of technological advances in accelerator design, for use not only in research but also in industry.

Sciencewatch

Compiled by John Swain, Northeastern University

CLARITY turns tissue transparent

A new technique called CLARITY promises to revolutionize biology by making normally opaque tissue clear. It has already been used to make a brain transparent, so that its detailed structure and connections between cells can be seen in 3D without having to slice it up.

Karl Deisseroth and colleagues at Stanford University soaked tissue of a mouse brain in acrylamide, formaldehyde and a heat-activated initiator that forms a hydrogel mesh to support the tissue. Adding a negatively charged detergent and applying an electric field allows all of the lipids to be pulled out. What then remains is an optically transparent but macromolecule permeable structure, which permits multiple staining and destaining to highlight features – in particular in 3D imaging and analysis. With this technique an optical microscope reveals individual neurons and their connections as if they were embedded in glass.

Intact adult mouse brain before, left, and after the two-day CLARITY process. In the image on the right, the fine brain structures can be seen faintly as areas of blurriness. (Image credit: Deisseroth lab.)

● Further reading
Kwanghun Chun *et al.* 2013 *Nature* doi:10.1038/nature12107. For a video, see http://0-www.nature.com.ilsprod.lib.neu.edu/news/see-through-brains-clarify-connections-1.12768.

Ion propulsion for efficient travel

Normal aircraft achieve thrust by pushing air from the back end. However, the use of ions, electrically accelerated before being shot out, has usually been considered suitable only for space flight. Not so, argue Kento Masuyama and Steven R H Barrett of Massachusetts Institute of Technology.

Based on experimental work, they show that ionic wind could provide 110 newtons of thrust per kilowatt – which is a staggering improvement over the 2 N/kW for a jet engine. In addition to offering high efficiency, ion propulsion is also silent and gives off no heat signature. Interestingly, lower-velocity ion jets are more efficient, wasting less kinetic energy in the wake.

● Further reading
Kento Masuyama and Steven R H Barrett 2013 *Proc. Roy. Soc. A* **469** 20120623.

Coelacanth sequenced

The African coelacanth is a "living fossil" – a creature 1.5 m long that was assumed to be extinct until one was accidentally caught by a fisherman in 1938. It represents a type of fish previously thought to have died out 70 million years ago and now its genome has been sequenced.

Analyses of the genome are expected to hold clues as to how fins became limbs. Early work shows that non-coding parts of the genome seem to have changed quickly over time, suggesting that these pieces, which play a role in gene expression, may be significant in evolutionary change. Also, it seems that the lungfish – not the coelacanth – is the closest living relative of the first four-legged vertebrates.

● Further reading
Chris T Amemiya *et al.* 2013 *Nature* **496** 311.

Seeing dreams by reading minds?

It sounds like science fiction but Y Kamitani of the National Institute of Science of Information and Communications Technology in Kyoto and colleagues can read your mind while you dream. Volunteers slept while their brains were imaged by functional MRI but were woken up when EEG signals indicated that they were "seeing" something.

By asking the volunteers what was in their dreams and correlating it with brain activity, the researchers could learn to predict what people were dreaming about within about 20 broad categories. The accuracy is about 60%, which is much more than chance. There is some discussion as to whether the team is really seeing dreams or hypnagogic hallucinations that appear as people drop off to sleep. Nevertheless, it mounts up to reading someone's thoughts from brain activity patterns.

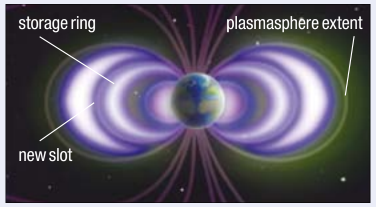
● Further reading
T Horikawa *et al.* 2013 *Science* **340** 639.

Storage rings in the sky

The Van Allen belts are two realistic electron storage rings in space around the Earth – but sometimes they are joined by a third. D N Baker of the University of Colorado in Boulder and colleagues found that on 2 September 2012 a third ring of high energy (> 2 MeV) electrons appeared between the usual two belts and persisted for more than four weeks before an interplanetary shock wave from the Sun blew them away.

The third belt was detected by the two NASA Radiation Belt Storm Probe spacecraft that loop between the known belts. It seems that even 50 years after the original belts were discovered, this natural particle accelerator system is not yet fully understood.

● Further reading
D N Baker *et al.* 2013 *Science* **340** 186.



Schematic diagram showing Earth, the outer and inner radiation belts, and the more distended plasmasphere and unexpected three-belt structure observed in September 2012.

Astrowatch

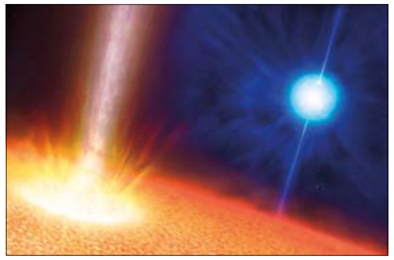
Compiled by Marc Türler, ISDC and Observatory of the University of Geneva

Why do some gamma-ray bursts last hours?

Three unusually long-lasting stellar explosions discovered by NASA's Swift satellite represent a new class of gamma-ray bursts (GRBs). Astrophysicists conclude that they probably arose from the catastrophic death of supergiant stars hundreds of times larger than the Sun.

GRBs are extremely powerful flashes of gamma rays observed from a random direction on the sky about once a day. They are traditionally classified as short- and long-duration events. Short bursts last 2 s or less and are thought to represent a merger of compact objects (neutron stars or black holes) in a binary system. Long GRBs last up to several minutes and are probably associated with the birth of a black hole during the supernova explosion of a massive star (*CERN Courier* September 2003 p15). Both scenarios give rise to powerful jets that propel matter at nearly the speed of light in opposite directions. As they interact with matter in and around the star, the jets produce a spike of high-energy radiation (*CERN Courier* December 2005 p20).

While most of the thousands of GRBs observed so far fall into these two categories, there are also peculiar sub-energetic bursts (*CERN Courier* September 2004 p13) and unrelated gamma-ray events that arise from the tidal disruption of a star by a supermassive black hole (*CERN Courier* July/August 2011 p14). Now, three recent GRBs with extremely long duration are making astronomers consider an additional category.


An artist's impression of two stars of very different size creating gamma-ray bursts (GRBs). In both cases, the GRB is produced by a jet punching through the star, but in the case of the ultralong GRBs the much larger size of the star creates a much longer-lived jet. (Image credit: Mark A Garlick, used with permission by the University of Warwick.)

The first evidence of the need for a new class of GRB came from the analysis of GRB 111209A, which erupted on 9 December 2011 and remained active for 7 hours as observed by NASA's Swift spacecraft and several other gamma-ray, X-ray and optical instruments. The detailed study, led by Bruce Gendre while at the Italian Space Agency's Science Data Centre, shows that the burst is a genuine GRB at a redshift of $z=0.677$ but with an outstanding long duration and a high total flux.

An earlier event, GRB 101225A, exploded on Christmas Day 2010 and produced high-energy emission lasting at least two hours. Because the distance to this atypical GRB was unknown, astronomers thought that this so-called "Christmas burst" could be of a radically different nature. One group suggested an asteroid or comet falling onto a neutron star within the Galaxy, while another team suspected a merger of a neutron star with an evolved giant star to be at the origin of the burst. Both scenarios are disproved by the recent measurement of the redshift of the host galaxy by Andrew Levan of the University of Warwick and his team. They place the Christmas burst 7000 million light-years away ($z=0.847$), implying that the burst was far more powerful than first thought. Levan and colleagues link it with the similar GRB 111209A and another recent burst, GRB 121027A, all of extremely long duration.

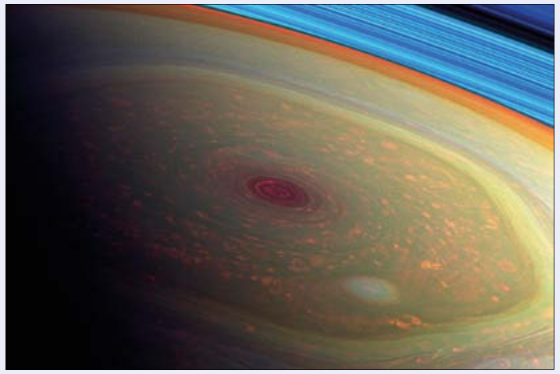
Both studies propose that the ultralong duration of such atypical bursts is related to the size of the collapsing star. The duration of the event would be proportional to the time that it takes for matter to fall towards the new-born black hole at the stellar core or for the particle jets to drill their way through the star. In either case, the bigger the star the longer the duration. The likely candidates for ultralong GRBs would thus be supergiant stars with a size of hundreds of times the Sun's diameter. Gendre's team goes further, suggesting that GRB 111209A marked the death of a blue supergiant containing modest amounts of elements heavier than helium. This would imply that ultralong-duration GRBs would have been much more common in the distant past of the universe, when matter was not yet enriched in the heavy elements produced by massive stars.

● Further reading

B Gendre *et al.* 2013 *ApJ* **766** 30.
A Levan *et al.* 2013 subm. to *ApJ* arXiv:1302.2352.

Picture of the month

This spectacular, vertigo inducing, false-colour image from NASA's Cassini mission highlights the storms at Saturn's north pole. The image was taken with Cassini's wide-angle camera by combining spectral filters sensitive to near-infrared light. The colour-coding corresponds to different altitudes in the planet's atmosphere: red indicates deep, while green clouds are at higher altitude. The eye of a hurricane-like storm appears dark red and swirls at 150 m/s inside a large, mysterious hexagonal jet stream frame (yellowish green). Low-lying clouds circling inside this feature appear orange. A second, smaller vortex pops out in teal at the lower right of the image. The rings of Saturn appear in vivid blue at the top right. It is only now – more than 8 years after Cassini's approach to Saturn (*CERN Courier* September 2004 p13) – that such a picture could be taken during the Saturnian summer season. (Image credit: NASA/JPL-Caltech/SSI.)



CERN Courier Archive: 1970

A look back to CERN Courier vol. 8, June 1970, compiled by Peggie Rimmer

CERN

Preparing for a third 'g-2'

Preparations are well advanced for a third experiment to measure the "g-2" of the muon [2 × the anomalous magnetic moment]. The second experiment improved the experimental accuracy of this parameter by a factor of 20 over its predecessor, giving a value of $(116616 \pm 31) \times 10^{-8}$ compared with the theoretical prediction of $(116588 \pm 1) \times 10^{-8}$. The third hopes to improve the accuracy by a factor of 10.

The interest in further decimal places is a search for a difference between the muon and the electron (seemingly identical particles whose mass difference could be due to a force felt by muons but not by electrons) and a test of the validity of quantum electrodynamics QED down to extremely small distances.

To achieve greater accuracy, the experiment will use new apparatus, a 14 m diameter muon storage ring consisting of forty bending magnets and an electrostatic quadrupole, to be installed in the West Experimental Hall. The main differences are:

1) Unlike the previous storage ring, the magnetic field in the ring will be constant to eliminate the effect of radial variations in the muon orbits.

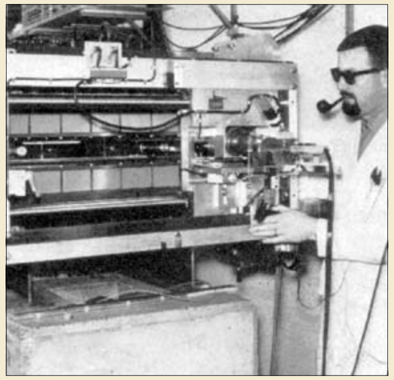
2) Vertical focusing will be achieved by using an electrostatic quadrupole. Normally the muon magnetic moment is sensitive to the electric field, but there is a "magic" energy (3.1 GeV) at which it is no longer sensitive. This energy has therefore been selected for the stored muons.

3) Previously, protons ejected from the PS were directed onto a target inside the muon storage ring, giving a considerable energy spread to the pions produced (which decay to give the muons). In the new experiment, pions will be generated in a target outside the ring and only those with accurately monitored momentum will be injected, by means of a pulsed inflector.

4) A higher intensity muon beam, several hundreds instead of a few tens of muons, will be stored, partly due to increased PS intensity.

5) Operating at 3.1 GeV (rather than 1.3 GeV) will make it possible to observe the muons for about two and a half times as long, due to the relativistic effect of time dilation.

The experiment is unusually complex. A year's running is anticipated to get to know the apparatus, and actual data-taking will also require about a year. It should finish in 1974 and final analysis of the results may then take until 1975. It is a long haul for a few decimal places but they are very important places.


Half-scale model of a set of two magnets for the muon storage ring of the new g-2 experiment. The model is equipped with a device for measuring the magnetic field.

● Compiled from texts on pp185–186.

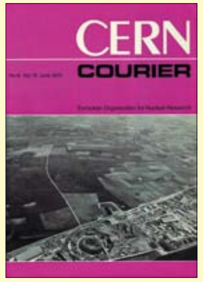
43rd session of CERN Council: collaboration with ESO

The possibility of collaboration between the European Southern Observatory organization and CERN was first brought to the attention of the Council last December. At the June meeting, the text of a formal Agreement was presented and Council was unanimously in favour of collaboration. The Director General [Bernard Gregory] was authorized to finalize the text with the Director General of ESO, Prof. A Blaauw, to be sent to delegations for comments before being signed.

ESO are constructing a large (3.6 m) optical telescope to be installed at La Silla in Chile. Under the terms of the Agreement, a Division of ESO will come to CERN where the final design, construction and testing will be carried out. The Division, comprising about 50 astronomers, engineers and technicians, will be able draw on CERN's experience in the engineering and administrative aspects of implementing large projects.

● Compiled from texts on pp146–147.

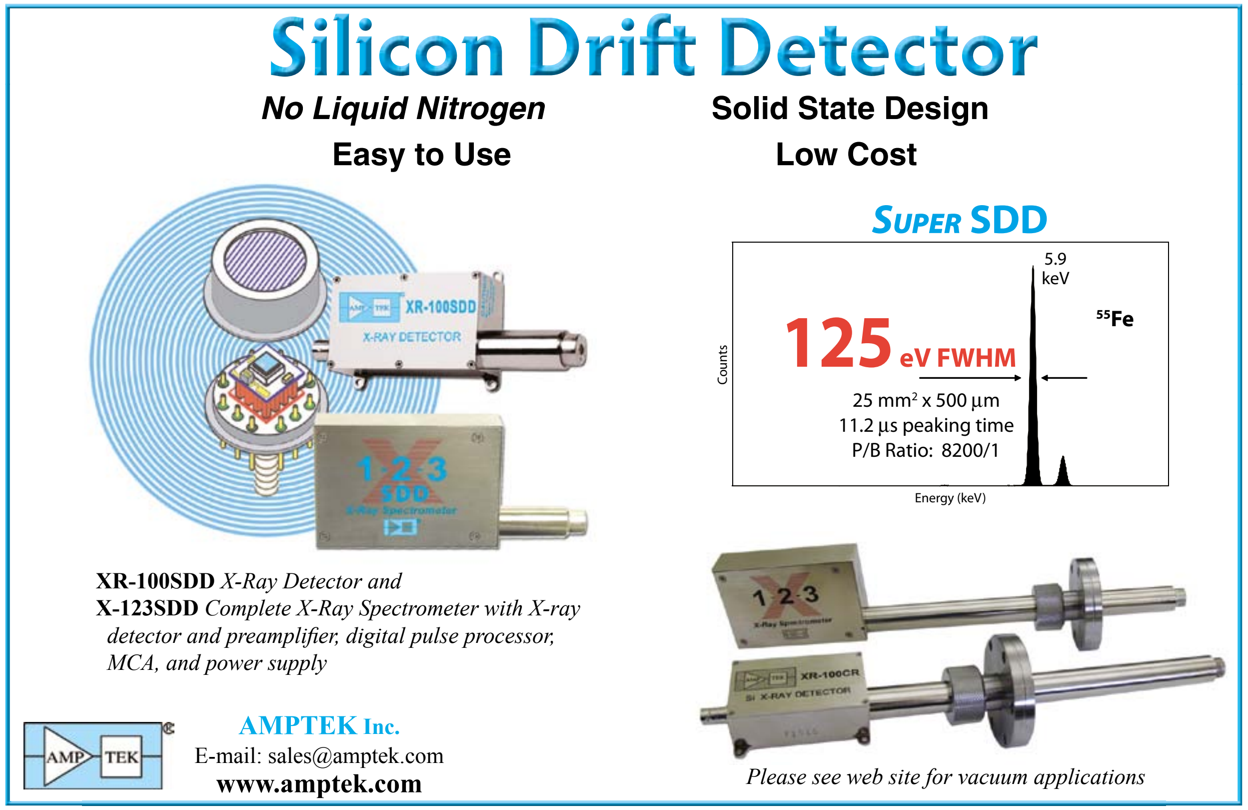
Compiler's Note



The ESO Convention had been signed in 1962 but progress was hampered by financial and political difficulties. Collaboration with CERN, suggested to help the 3.6 m telescope project get underway, proved effective and in November 1976 the telescope saw its "first light" (*CERN Courier* October 2012 p26). ESO now has an impressive set of telescopes operating in the high, dry Chilean deserts, the latest being the Atacama Large Millimeter/submillimeter Array ALMA, inaugurated in March this year. Apart from a joint pension fund, CERN and ESO now operate independently but with some common goals, such as unveiling the nature and distribution of the dark matter and dark energy that dominate the universe.

In Standard Model calculations of the anomalous magnetic moment of the electron, the QED component dominates and the result agrees with the measured value to more than 10 significant figures, the most accurately verified prediction in the history of physics. In the case of the muon, because of its larger mass, this parameter has contributions from the weak interaction, hadronic couplings and physics beyond the Standard Model, such as supersymmetry. So measurements of the anomalous magnetic moment of the muon now serve as a probe for new physics rather than a test of QED.

Supersymmetric particles are candidates for dark matter. None have yet been detected, although there are intriguing hints, most recently from the Alpha Magnetic Spectrometer AMS, mounted on the International Space Station (*CERN Courier* May 2013 p5).



Chasing new physics with electroweak penguins

Rare transitions of b quarks could cast light on heavy new particles beyond the direct reach of the LHC.

The recent identification of the new particle discovered at the LHC as a Higgs boson with a mass of 125 GeV/c^2 completes the picture of particles and forces described by the Standard Model (*CERN Courier* May 2013 p21). However, it does not mark the end of the story as, unfortunately, the Standard Model is an incomplete description of nature. Puzzles still remain, for example, in explaining the existence of dark matter and the matter–antimatter asymmetry. The answers to these puzzles may lie in the existence of as yet undiscovered particles that would have played a key role in the early, high-energy, phase of the universe and whose existence would help to complete the description of nature in particle physics. The question then is: at what energy scale would these new particles appear?

Particle physics provides no certain knowledge about this scale but the hope is that the new particles might be produced directly in the high-energy proton–proton collisions of the LHC. However, new particles could also be observed indirectly through the effects of their participation as virtual particles in rare decay processes. By studying such processes, experiments can probe mass scales that are much higher than those accessible directly through the energy available at the LHC. This is because quantum mechanics and Heisenberg's uncertainty principle allow virtual particles to have masses that are not constrained by the energy of the system. Searches based on virtual particles are limited by the precision of the measurements, rather than the energy of the collider.

Rare potential

One promising place to look for contributions from new virtual particles is in the rare transitions of b quarks to s quarks in which a muon pair (dimuon) is produced: $b \to s\mu^+\mu^-$. Described by the Feynman diagrams shown in figure 1 (overleaf), these involve what are known as "flavour-changing neutral currents" because the initial quark changes flavour without changing charge. In the Standard Model, transitions of this type are forbidden at the lowest perturbative order – that is, at "tree-level", where the diagrams have only two vertices. Instead, they are mediated as shown in figure 1 (p16) by higher-order diagrams known as "electroweak penguin" and "box" diagrams. For this reason the Standard Model process is rare, which enhances the potential to discover new high-mass particles.

John Ellis on the origin of penguins

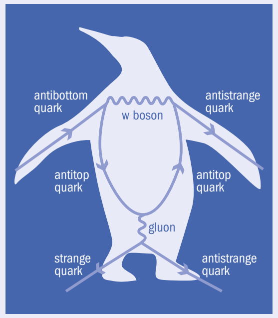
"Mary K [Gaillard], Dimitri [Nanopoulos], and I first got interested in what are now called penguin diagrams while we were studying CP violation in the Standard Model in 1976 ... The penguin name came in 1977, as follows.

In the spring of 1977, Mike Chanowitz, Mary K and I wrote a paper on GUTs [grand unified theories] predicting the b quark mass before it was found. When it was found a few weeks later, Mary K, Dimitri, Serge Rudaz and I immediately started working on its phenomenology.

That summer, there was a student at CERN, Melissa Franklin, who is now an experimentalist at Harvard. One evening, she, I and Serge went to a pub, and she and I started a game of darts. We made a bet that if I lost I had to put the word penguin into my next paper. She actually left the darts game before the end, and was replaced by Serge, who beat me. Nevertheless, I felt obligated to carry out the conditions of the bet.

For some time, it was not clear to me how to get the word into this b-quark paper that we were writing at the time ... Later ... I had a sudden flash that the famous diagrams look like penguins. So we put the name into our paper, and the rest, as they say, is history."

John Ellis in Mikhail Shifman's "ITEP Lectures in Particle Physics and Field Theory", hep-ph/9510397. Reproduced here courtesy of symmetry *magazine.*



The original penguin diagram for b→s decay, where a gluon produces an $s\bar{s}$ pair. LHCb is investigating electroweak decays where a $\mu^+\mu^-$ pair is produced from a photon or a Z boson.

Studies of flavour-changing neutral currents have paved the way for discoveries in particle physics in the past, specifically in the decays of K mesons, where s quarks change to d quarks. Investigations of mixing between the mass eigenstates of the neutral kaon system and of rare K-meson decays led to the prediction of the existence of a second u-like quark (the charm quark, c), at a time when only three quarks were known (u, d and s). It was 10 years before the existence of the c quark was confirmed directly. Similarly, the observation of CP violation in neutral kaons led to the prediction of the third generation of quarks (b and t). Now, the study of flavour-changing neutral-current processes related to the third generation ▷

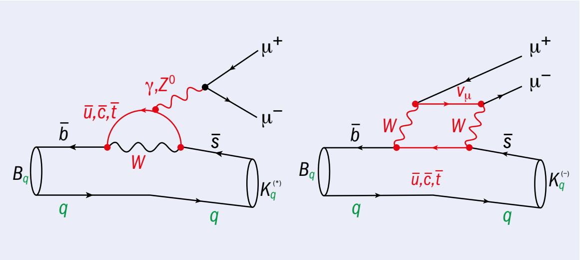


Fig. 1. Feynman diagrams for B-meson decay to a K or K^* meson and two muons ($b\to s\mu^+\mu^-$ at quark level). The diagram on the left dominates and is known as an "electroweak penguin"; the diagram on the right is a "box" diagram. The spectator quark, q, can be of u or d type.

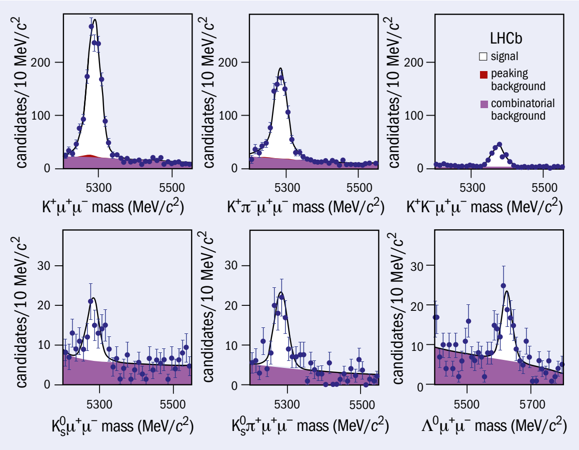


Fig. 2. Invariant mass distributions for several $b\to s\mu^+\mu^-$ transitions reconstructed at LHCb. Signals from $B^+\to K^+\mu^+\mu^-$ (LHCb collaboration 2013d) $B^0\to K^*\mu^+\mu^-$, $B_s\to\phi\mu^+\mu^-$, $B^0\to K_S^0\mu^+\mu^-$, $B^+\to K^{*+}\mu^+\mu^-$ and $\Lambda_b\to\Lambda\mu^+\mu^-$ (LHCb collaboration 2013e) are clearly visible. These plots were obtained with 1 fb^{-1}, a third of LHCb's total data set. The decay modes in the bottom row contain either a long-lived K_S^0 or a Λ, which are challenging to reconstruct.

of quarks – in particular the rare $b\to s\mu^+\mu^-$ transitions – could soon provide similar evidence for the existence of new particles.

Several $b\to s\mu^+\mu^-$ transitions have already been observed by the Belle, BaBar and CDF experiments at KEK, SLAC and Fermilab respectively. So far, the results have been limited by the small size of the data sets but with the LHC, a new era of precision has begun. The collider is the world's largest "factory" for producing particles that contain b quarks: in one year, it produced about 10^{12} b hadrons in the LHCb experiment, while running at a centre-of-mass energy of 7 TeV with an instantaneous luminosity in the experiment of $4\times10^{32}\,\mathrm{cm^{-2}\,s^{-1}}$. ATLAS and CMS have also recently joined the game, showing their first results on the $B^0\to K^{*0}\mu^+\mu^-$ decay at the BEAUTY 2013 conference (ATLAS collaboration 2013 and CMS collaboration 2013).

The LHCb detector is characterized by excellent vertex and momentum resolution (coming from its tracking systems) and impressive particle-identification capabilities (from its two ring-imaging Cherenkov detectors). Combined with the large b-hadron production rate, these features allow LHCb to reconstruct clean signals of rare b-hadron decays (figure 2). These processes have branching fractions below 10^{-6} and at most occur once in every 100 million collisions.

The branching fractions of these decays are sensitive to new physics but their interpretation is unfortunately complicated. The b quark has hadronized, so the observations relate to hadronic rather than quark-level processes. A lack of detailed understanding of the hadronic system limits the usefulness of the branching-fraction measurements in the search for new physics.

Angles and asymmetries

Fortunately, the branching fractions of these decays are not the only handles for investigating new particle contributions. It is often much more instructive to look at the angular distribution of the particles coming from the decay. However, such angular analyses are experimentally challenging because they require a detailed understanding of how both the geometry of the detector and the reconstruction of the event bias the angular distribution of the particles.

The decays $B^0\to K^{*0}\mu^+\mu^-$ and $B_s\to\phi\mu^+\mu^-$ have been shown to be highly sensitive to a variety of new physics scenarios (LHCb collaboration 2013a and 2013b). These decays are characterized by three angles: θ_K, which describes the K^* or ϕ decay; θ_l, which describes the dimuon decay; and Φ, the angle between the K^* or ϕ and the dimuon decay planes.

The angular distribution of the particles depends on the properties of the underlying theory. For instance, two features of the Standard Model drive the angular distribution: the photon exchanged in the penguin diagram of figure 1 is transversely polarized, while the charged-current interaction (the W exchange) is purely left-handed. The angle in the dimuon system also has an intrinsic forward–backward asymmetry that arises from interference between the different diagrams. The forward–backward asymmetry can be studied as a function of the mass of the dimuon system, which can be anywhere between twice the muon's mass and the difference between the mass of the B and the mass of the K^* or ϕ.

In the Standard Model, the forward–backward asymmetry has a characteristic behaviour, changing sign at a dimuon mass of around 2 GeV/c^2. It turns out that this point can be predicted with only a small theoretical uncertainty. Figure 3 shows LHCb's measurement of the forward–backward asymmetry in the decay $B^0\to K^{*0}\mu^+\mu^-$. In addition, the angle Φ can be used to test nature's left-handedness, through an observable called $A_T^{(2)}$.

So far, measurements of both the forward–backward asymmetry and $A_T^{(2)}$ show good agreement with the predictions of the Standard Model. While there is no evidence for any disagreement, it is nevertheless important to emphasize that the room for new physics is still large given the statistical uncertainty of the present measurements.

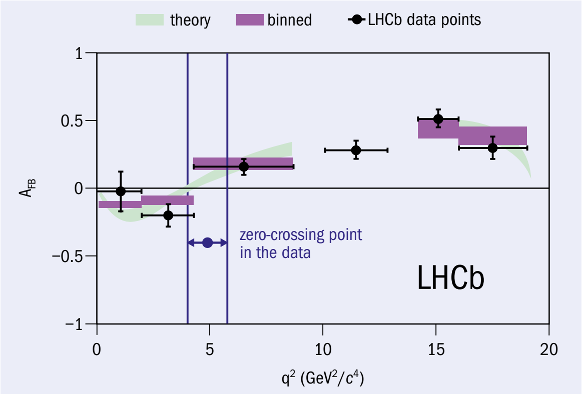


Fig. 3. Forward–backward asymmetry, A_{FB}, of the dimuon system as a function of the dimuon invariant-mass-squared (q^2) for $B^0\to K^{*0}\mu^+\mu^-$. The region where A_{FB} changes sign is also shown. There is remarkable agreement between the experimental result and the predictions of the Standard Model.

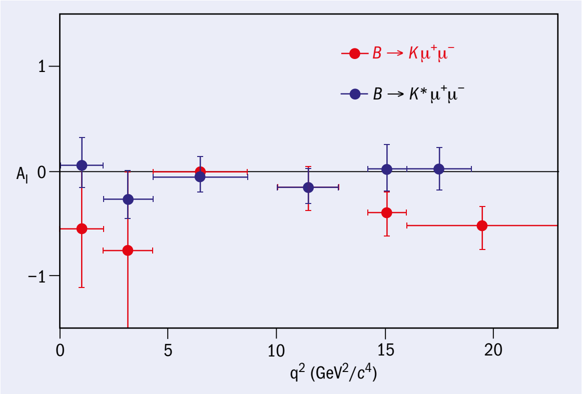


Fig. 4. The isospin asymmetry, A_I, measured by LHCb between the $B^0\to K^{*0}\mu^+\mu^-$ and the $B^+\to K^{*+}\mu^+\mu^-$ decays and between the $B^0\to K^0\mu^+\mu^-$ and the $B^+\to K^+\mu^+\mu^-$ decays, as a function of the dimuon invariant-mass-squared (q^2). The Standard Model predicts a small isospin asymmetry for both sets of decays.

Another way to decrease the theoretical uncertainty associated with the hadronic transitions is to form asymmetries between specific decay modes – for example, CP asymmetries between particle and antiparticle decays. In the Standard Model, the decay $B^0\to K^{*0}\mu^+\mu^-$ and its CP conjugate are expected to have the same branching fraction to about 1 part in 1000. With the large LHC data samples, LHCb has verified this at the level of 4% (LHCb collaboration 2013e).

Another example concerns so-called isospin asymmetries between decays that differ only in the type of spectator quark (u or d), labelled q in figure 1. The isospin asymmetry between B^0 and B^+ decays is defined as:

$$A_I = \frac{\mathcal{B}(B^0\to K^{(*)0}\mu^+\mu^-) - (\tau^0/\tau^+)\mathcal{B}(B^+\to K^{(*)+}\mu^+\mu^-)}{\mathcal{B}(B^0\to K^{(*)0}\mu^+\mu^-) + (\tau^0/\tau^+)\mathcal{B}(B^+\to K^{(*)+}\mu^+\mu^-)}$$

This is formed using the branching fractions of the B^0 and B^+ decays and the ratio τ^0/τ^+ of the lifetimes of the B^0 and the B^+. In the Standard Model, the spectator quark is expected to play only a limited role in the dynamics of the system, so isospin asymmetries are predicted to be tiny. Experimentally, A_I is measured as a double ratio with respect to the decay channels $B^0\to K^{(*)0}J/\psi$ or $B^+\to K^{(*)+}J/\psi$, which give the same final states after the J/ψ decays to $\mu^+\mu^-$ and are well known from previous measurements.

Isospin asymmetries have been measured for both $B\to K^*\mu^+\mu^-$ and $B\to K\mu^+\mu^-$ by the BaBar, Belle, CDF and LHCb experiments. All of these measurements are in good agreement with each other and favour a value for $A_I(B\to K^*\mu^+\mu^-)$ that is close to zero and a negative value for $A_I(B\to K\mu^+\mu^-)$. The LHCb experiment observes a negative isospin asymmetry in this channel at the level of four standard deviations (from zero) as figure 4 shows (LHCb collaboration 2012). This unexpected result is yet to be explained. Indeed, most extensions of the Standard Model do not predict a significant dependence on the charge or flavour of the spectator quark.

Looking to the future

The LHCb experiment has already on tape a data set that is roughly three times larger than that used in its results published so far. Even with only 1 fb^{-1} of integrated luminosity currently analysed, LHCb has larger samples than all previous experiments combined in most of the channels shown in figure 2. Furthermore, while the selected current data sets contain hundreds of events, the samples will be of the order of tens of thousands of events once the experiment has been upgraded. With these larger data sets the LHCb collaboration will be able to chase progressively smaller and smaller deviations from the Standard Model. This will allow them to probe ever higher mass scales, far beyond those that can be accessed by searching directly for the production of new particles at the LHC. A new era in precision measurements of flavour-changing neutral currents is now opening.

● Further reading

ATLAS collaboration 2013 ATLAS-CONF-2013-038.
CMS collaboration 2013 CMS-PAS-BPH-11-009.
LHCb collaboration 2013a LHCb-PAPER-2013–019.
LHCb collaboration 2013b LHCb-PAPER-2013–017.
LHCb collaboration 2013c LHCb-PAPER-2013–025.
LHCb collaboration 2013d *JHEP* **02** 105.
LHCb collaboration 2013e *Phys. Rev. Lett.* **110** 03180.
LHCb collaboration 2012 *JHEP* **07** 133.

Résumé

Traquer la nouvelle physique avec des pingouins électrofaibles

Les transitions rares quarks b – quarks s lors desquelles est produite une paire de muons sont propices à la recherche des effets de nouvelles particules ayant des masses supérieures à celles qu'il est possible d'obtenir par des recherches directes. Ces processus, dans lesquels le quark initial change de saveur sans changer de charge, sont décrits par les « diagrammes en pingouin ». Plusieurs transitions de ce type ont été observées par les expériences auprès d'autres machines, mais les résultats ont été limités par la petite taille des échantillons de données. À présent, le LHC ouvre une nouvelle ère de précision, et l'expérience LHCb analyse les données à la recherche de ces désintégrations rares.

Nico Serra, University of Zurich, and **Tom Blake**, CERN.

Nuclotron tests out stochastic cooling in Dubna

Recent runs of JINR's Nuclotron have tested the stochastic-cooling system being prepared for the future NICA facility.

Nikolay Shurkhno (JINR) and Rolf Stassen (FZJ) test the ring slot coupler at Jülich. (Image credit: FZJ.)

The Nuclotron-based Ion Collider fAcility (NICA) is the future flagship project of the Joint Institute for Nuclear Research in Dubna. In addition to the existing Nuclotron, this accelerator-collider complex will include a new heavy-ion linear accelerator, a superconducting 25 Tm booster synchrotron and two rings for a superconducting collider (*CERN Courier* January/February 2012 p13). The new facility will ultimately provide a range of different ion beams for a variety of experiments with both colliding beam and fixed targets (see box, overleaf).

Construction of the 3 MeV/u heavy-ion linear accelerator is now under way in co-operation with the BEVATECH Company in Germany; its commissioning in Dubna is scheduled for the end of 2013. Serial production of superconducting magnets for the booster is expected to start in early 2014. The Technical Design Report for the collider complex has meanwhile been approved. As the first step in the realization of the NICA heavy-ion programme, Baryonic Matter at Nuclotron (BM@N) – a new fixed-target experiment developed in co-operation with GSI, Darmstadt – has been approved by JINR's Programme Advisory Committee and Scientific Council and is now under construction.

In the meantime, the modernized Nuclotron, which will be a key element of the future facility, is being used for basic research in accelerator physics and techniques, the development of modern diagnostics and the testing of prototypes for the collider and booster systems. This is in addition to the implementation of the current physics programme at the superconducting 45 Tm synchrotron. Development work for NICA performed during recent Nuclotron runs include the testing of elements and prototypes for the Multipurpose Detector using extracted deuteron beams; the transportation of the extracted beam (C^{6+} ions at 3.5 GeV/u and deuterons at 4 GeV/u) to the point where the BM@N detector is under construction; tests of the Nuclotron operating with a long flat-top of the high magnetic field (up to 1000 s, 1.5 T) to simulate the operating conditions of the magnetic system for the collider; and operational tests of the automatic control system based on the TANGO platform, which has been chosen for the NICA facility.

A particularly important step concerned the construction, installation and testing at the Nuclotron of the prototype for the collider's stochastic cooling system. This is of major importance for NICA's heavy-ion programme because beam cooling during collisions is essential for providing maximal luminosity across the whole energy range of 1–4.5 GeV/u. Operational experience of stochastic cooling and experimental investigations of the beam-cooling process at the Nuclotron are therefore a necessity.

The design and construction of the stochastic-cooling channel at the Nuclotron began in mid-2010 in close collaboration with the Forschungszentrum Jülich (FZJ). All stages of the work have been strongly supported by the director of the FZJ's Institute for Nuclear Physics (IKP), Rudolph Mayer. This R&D is also important to IKP FZJ for testing elements of the stochastic-cooling system designed for the High-Energy Storage Ring (HESR), which will form part of the future international Facility for Antiproton and Ion Research in Darmstadt.

The main task of beam cooling at the HESR will be to accumulate a beam with 10^{10} antiprotons above 3 GeV at a momentum resolution down to 10^{-5} for the PANDA experiment. To enhance beam-cooling performance, new ring slot couplers have been developed at FZJ for the pick-up and kicker structures. The pick-ups were tested successfully at the Cooler Synchrotron at FZJ in experiments with the internal target of the Wide-Angle Shower Apparatus.

A pick-up and kicker, each assembled from 16 rings designed for a 2.4 GHz bandwidth, were produced at FZJ for testing at JINR, as the institutes joined forces to prepare for an experiment on stochastic cooling at the Nuclotron. The kicker structure was installed in the room-temperature section of the Nuclotron, with the pick-up ▷

NICA's objectives

The NICA facility will provide experiments with:

- extracted ion beams (from protons up to gold or uranium nuclei) at kinetic energies up to 13.8 GeV (for protons), 6 GeV/u (for deuterons) and 4.5 GeV/u for heavy nuclei. The fixed-target experimental BM@N is under construction by a JINR-GSI collaboration;
- colliding heavy-ion beams with a kinetic energy in the range 1–4.5 GeV/u at a luminosity of 10^{27} cm^{-2} s^{-1};
- colliding heavy and light ions with the same energy range and luminosity;
- colliding polarized beams of light ions in the kinetic energy range 5–12.5 GeV/u for protons and 2 – 5.8 GeV/u for deuterons, at a luminosity level not less than 10^{31} cm^{-2} s^{-1}.

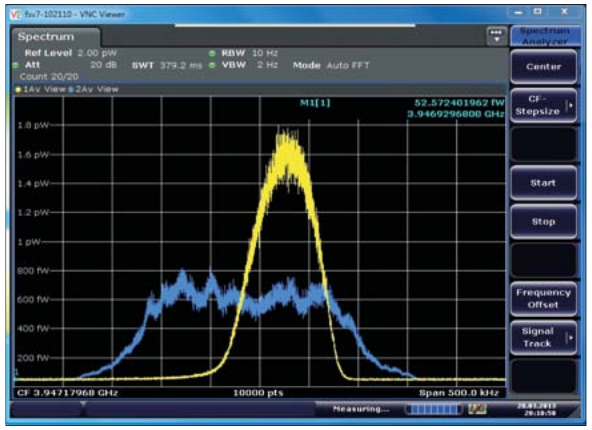
NICA's beams will be available to these experimental areas and facilities:

- 10,000 m^2 experimental hall for fixed-target experiments, using slow, extracted beams from the Nuclotron;
- the dedicated experimental hall for applied research on extracted ion beams from the booster;
- the collider of heavy and light polarized ions, equipped with the MultiPurpose Detector and the Spin Physics Detector for fundamental research;
- an internal target station in the Nuclotron cryomagnetic system for research, including relativistic atomic physics and spin physics.

structure in the cold section on the opposite side of the 251-m circumference ring, operating at 4.5 K. The first experiments aimed at achieving longitudinal cooling using the filter method. The notch filter and tunable system-delay were implemented on optical lines and a maximum power of 20 W was chosen for the final amplifier.

Construction of the system, its assembly and the cryogenic tests were completed in the autumn of 2011. Then, in December 2011, the equipment was tested for the first time in Nuclotron run 44 with C^{6+} and deuteron beams. The performance of the system was improved following the results of these first tests, and the software required to adjust the system was developed. This enabled the recent successful test during Nuclotron run 47 in February and March this year, when the system was adjusted to cool the coasting 3 GeV/*u* deuteron beam and on 20 March the decrease in its momentum spread was demonstrated (figure 1).

To make the effect more observable, the initial momentum spread was increased artificially by manipulation of the RF voltage at the final stage of the beam acceleration. The beam-cooling time of about 360 s is in reasonable agreement with the simulations. Details of this experiment are to be presented at the COOL13 conference in June. Another important result from the recent run was the increase of the maximum deuteron beam energy delivered for physics experiments up to 4.8 GeV/*u*.


fw7-102110 - VNC Viewer

Spectrum

Ref Level 2.00 pW   RBW 10 Hz
Att 20 dB   SWT 379.2 ms   VBW 2 Hz   Mode Auto FFT
Count 20/20

1Av View 2Av View

M1[1] 52.572401962 fW 3.9469296800 GHz

CF 3.94717968 GHz   10000 pts   Span 500.0 kHz

Fig. 1. A longitudinal Schottky spectrum of the 3 GeV/u deuteron beam at 3500th harmonic of the revolution frequency, showing the initial spectrum (blue curve) and after eight minutes of cooling (yellow curve). The beam intensity is 2 × 10^{9} ions.

The experimental investigation of stochastic cooling was a complex test of machine performance. During the Nuclotron run, the cryogenic and magnetic systems, power supply and quench-protection systems, cycle control and diagnostic equipment were operated stably in a mode in which the circulation time of the accelerated beam at the flat-top of the magnetic field gradually increased from a few tens of seconds up to eight minutes. The safe operation of the magnetic system was guaranteed by a new quench-detection system commissioned during the run. It permits a prompt change in the number of detectors, combining the work on the group and individual detectors. The detectors for this new method and their automatic control systems were developed at the Nuclotron and have been chosen for manufacture and installation on the NICA booster. The system provides monitoring of the statuses of all of its components, as well as signal testing of external systems, and also indicates malfunctions.

These tests were the result of an international team effort: A Sidorin, N Shurkhno, G Trubnikov (JINR, Dubna) and R Stassen (IKP FZJ) supervised all stages of the system design and participated in the Nuclotron shifts dedicated to testing and adjusting the equipment; T Katayama and H Stockhorst (GSI and IKP FZJ) performed simulations of the cooling-process dynamics and experimental measurements; L Thorndahl and F Caspers (CERN) contributed to the design and simulation of RF structures.

Résumé

Le Nuclotron teste le refroidissement stochastique à Doubna

Le projet NICA (collisionneur d'ions appuyé sur le Nuclotron) est le futur projet-phare de l'Institut unifié de recherche nucléaire de Doubna. Outre le Nuclotron actuel, ce complexe accélérateur-collisionneur inclura un nouvel accélérateur linéaire d'ions lourds, un synchrotron booster supraconducteur et deux anneaux constituant un collisionneur supraconducteur. Alors que la conception et la construction de ces nouveaux éléments sont en cours, le Nuclotron modernisé est utilisé, entre autres, pour tester les prototypes des systèmes du collisionneur et du booster. Une étape particulièrement importante a été la construction, l'installation et l'essai du prototype de système de refroidissement stochastique pour le collisionneur.

Grigory V Trubnikov, Laboratory of High-Energy Physics, JINR.

Towards a Higgs boson: first steps in an incredible journey

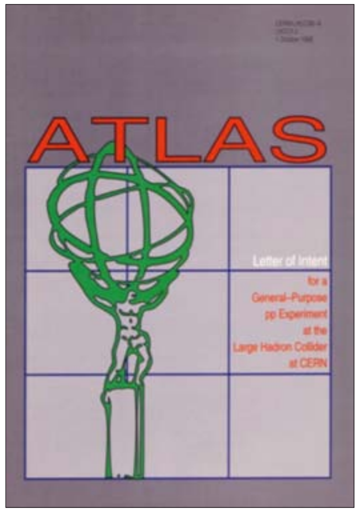
Twenty years ago, in June 1993, ATLAS and CMS received the provisional go-ahead to submit technical proposals. Thus began a difficult but amazing path to last year's major discovery.

The idea that the tunnel for the future Large Electron–Positron (LEP) collider should be able to house at some time even further in the future a Large Hadron Collider (LHC) was already in the air in the late 1970s. Moreover – thankfully – those leading CERN at the time had the vision to plan for a tunnel with a big enough diameter to allow the eventual installation of such an accelerator. In the broader community, however, enthusiasm for an LHC surfaced for the first time in 1984, promoted in part by members of CERN's successful proton–antiproton collider experiments and their discovery of the W and Z bosons the previous year (*CERN Courier* May 2013 p27). A workshop in Lausanne on the "Large Hadron Collider in the LEP Tunnel" organized jointly by the European Committee for Future Accelerators (ECFA) and CERN brought together working groups that comprised machine experts, theorists and experimentalists.

With the realization of the great physics potential of an LHC, several motivating workshops and conferences followed where the formidable experimental challenges started to appear manageable, provided that enough R&D work on detectors could be carried out. Highlights of these "LHC experiment preliminaries" were the 1987 Workshop in La Thuile for the so-called "Rubbia Long-Range Planning Committee" and the large Aachen ECFA LHC Workshop in 1990. Last, in March 1992 the famous conference "Towards the LHC Experimental Programme" took place in Evian-les-Bains, where several proto-collaborations presented their designs in "expressions of interest". Moreover, CERN's LHC Detector R&D Committee (DRDC), which reviewed and steered R&D collaborations, greatly stimulated innovative developments in detector technology from the early 1990s.

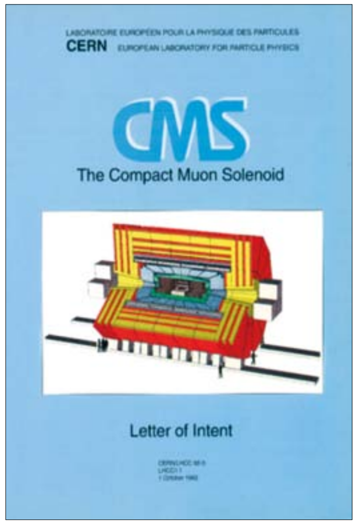
Designs for a Higgs

The detection of the Standard Model Higgs boson played a particularly important role in the design of the general-purpose experiments. In the region of low mass ($114 < m_H < 150$ GeV), the two channels considered particularly suited for unambiguous discovery were the decay to two photons and the decay to two Z bosons, where one or both of the Z bosons could be virtual. Because the natural width of the putative Higgs boson is < 10 MeV, the width of any observed peak would be entirely dominated by instrumental mass-resolution. This meant that in designing the general-purpose detectors, considerable care was placed on the value of the magnetic-field strength, on the precision-tracking systems and on high-resolution electromagnetic calorimeters. The high-mass region and signatures from supersymmetry drove the need for good resolution for jets and missing transverse energy, as well as for almost full 4π calorimetry coverage.


ATLAS

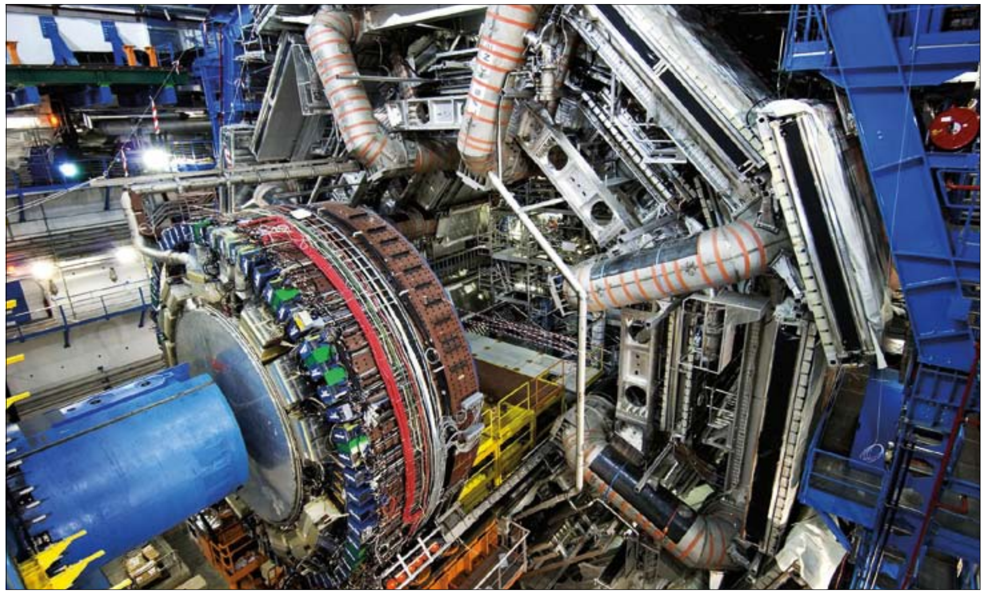
Letter of Intent
for a
General-Purpose
pp Experiment
at the
Large Hadron Collider
at CERN

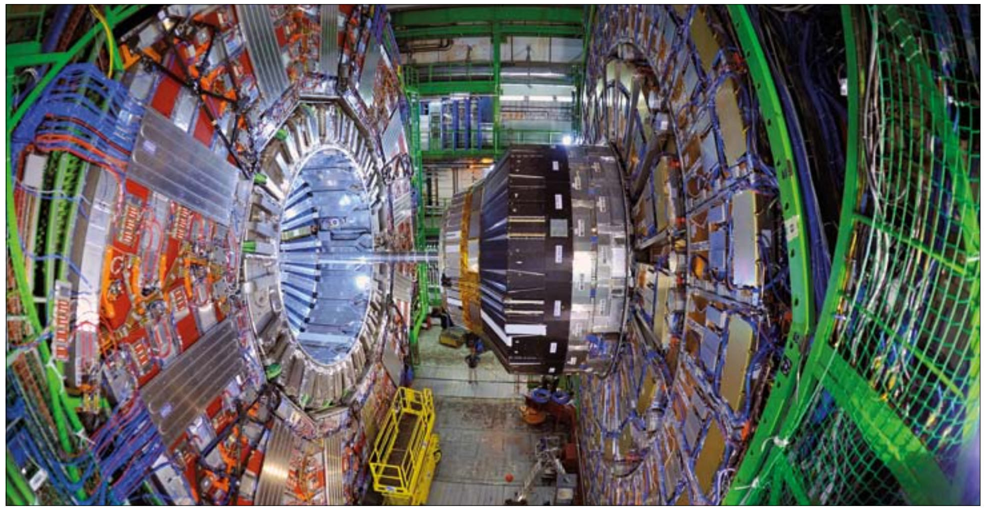
The ATLAS and CMS collaborations submitted letters of intent to the LHCC on 1 October 1992. The following year, on 8–9 June, these were recommended to proceed to technical proposals.


LABORATOIRE EUROPÉEN POUR LA PHYSIQUE DES PARTICULES
CERN EUROPEAN LABORATORY FOR PARTICLE PHYSICS

CMS
The Compact Muon Solenoid

Letter of Intent


One end of the barrel of the ATLAS detector during the installation phase in February 2007. The calorimeter endcap is still retracted before its insertion into the barrel toroid magnet structure.


The CMS detector while open in June 2009. To the right is one end cap, which slides into the barrel, left.

The choice of the field configuration determined the overall design. It was well understood that to stand the best chance of making discoveries at the new "magic" energy scale of the LHC – and in the harsh conditions generated by about a billion pairs of protons interacting every second – would require the invention of new technologies while at the same time pushing existing ones to their limits. In fact, a prevalent saying was: "We think we know how to build a high-energy, high-luminosity hadron collider – but we don't have the technology to build a detector for it." That the general-purpose experiments have worked so marvellously well since the start-up of the LHC is a testament to the difficult technology choices made by the conceivers and the critical decisions made during the construction of these experiments. It is noteworthy that the very same elements mentioned above were crucial in the recent discovery of a Higgs boson.

At the Aachen meeting in 1990, much discussion took place on which detector technologies and field configurations to deploy. At the Evian meeting two years later, four experiment designs were presented: two using toroids and two using high-field solenoids. In the aftermath of this meeting, lively discussions took place in the community on how to continue and possibly join forces. The time remaining was short because the newly formed peer-review committee, the LHC Committee (LHCC), had set a deadline for the submission of the letters of intent (LoI) of 1 October 1992.

The designs based on the toroidal configurations merged to form the ATLAS experiment, deploying a superconducting air-core toroid for the measurement of muons, supplemented by a superconducting 2 T solenoid to provide the magnetic field for inner tracking and by a liquid-argon/lead electromagnetic calorimeter with a novel "accordion" geometry. The two solenoid-based concepts were eventually submitted separately. Although not spelt out explicitly, it was clear to everyone that resources would permit only two general-purpose experiments. It took seven rounds of intense encounters between the experiment teams and the LHCC referees before the committee decided at its 7th meeting on 8–9 June 1993 "to recommend provisionally that ATLAS and CMS should proceed to technical proposals", with agreed milestones for further review in November 1993. The CMS design centred on a single large-bore, long, high-field superconducting solenoid, together with powerful microstrip-based inner tracking and an electromagnetic calorimeter of novel scintillating crystals.

So, the two general-purpose experiments were launched but the teams could not have foreseen the enormous technical, financial, industrial and human challenges that lay ahead. For the technical proposals, many difficult technology choices now had to be made "for real" for all of the detector components, whereas the LoI had just presented options for many items. This meant, for example, that several large R&D collaborations sometimes had to give up on excellent developments in instrumentation that had been carried out over many years and to find their new place working on the technologies that the experimental collaborations considered best able to deliver the physics. Costs and resources were a constant struggle: they were reviewed over a period of many years by an expert costs-review committee (called CORE) of the LHCC. It was not easy for many bright physicists to accept that ▷

Measuring magnetic field transients?

The Fast Digital Integrator FDI2056 is the world's fastest and most sensitive voltage integrator.

For the first time it is possible to measure fast, low-level magnetic field disturbances such as eddy currents in a switched magnet.

A complete and upgradable solution for your most exacting magnetic measurements.

Now it's possible!
Designed at the CERN

www.agence-arca.com - Photo: Scott Maxwell

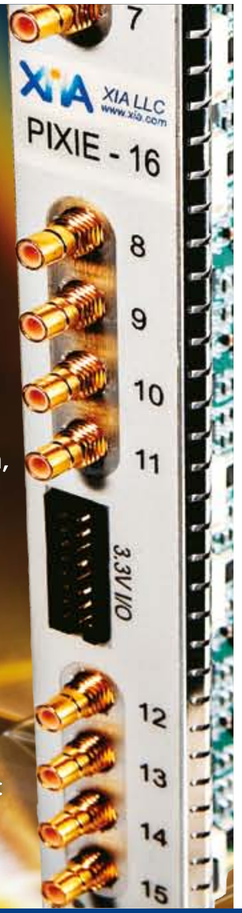
www.metrolab.com
METROLAB
Magnetic precision has a name

Plug in.
Turn on.
Shine.

Contact us for digital signal processors for nuclear physics, nuclear medicine, x-ray analysis and synchrotron research, with optimized algorithms for:
- Single & multi-channel input
- Timing coincidence
- Pulse shape analysis
- High counting rates.

XIA
Instruments that Advance the Art

www.XIA.com
sales@XIA.com +1.510.401.5760



the chosen technology also had to remain affordable.

The years just after the LoI were also the time when the two collaborations grew most rapidly in terms of people and institutes. Finding new collaborators was a high priority on the "to do" list of the spokespeople, who became real frequent-flyers, conducting global "grand tours". These included many trips to far-flung, non-European countries to motivate and invite participation and contributions to the experiments, in parallel (and sometimes even in competition) with CERN's effort to get non-member state contributions to enable the timely construction of the accelerator. It is during this period that the currently healthy mix of wealthy and less-wealthy countries was established in the two collaborations, clearly placing a value on not only material contributions but also intellectual ones. One important event was the integration of a strong US community after the discontinuation of the Superconducting Supercollider in 1993, which had a notable impact on both ATLAS and CMS in terms of the final capabilities of these experiments.

The submissions of the technical proposals followed in December 1994 and these were approved in 1996. The formal approval for construction was given on 1 July 1997 by the then director-general, Chris Llewellyn Smith, based on the recommendations of the Research Board and the LHCC (by then at meeting number 27) after the first of a long series of Technical Design Reports and the imposing of a material cost ceiling of SwFr475 million. These were also the years when the formal framework was set up by CERN and all of the funding agencies, first in interim and finally via a detailed Construction Memorandum of Understanding, agreed on in the new, biannual Resources Review Boards.

● Further reading

For more about this journey in search of a Higgs boson, see "Journey in the Search for the Higgs Boson: The ATLAS and CMS Experiments at the Large Hadron Collider", M Della Negra, P Jenni and T S Virdee 2012 *Science* **338** 1560. For more about the early meetings in Lausanne, Aachen and Evian, see *CERN Courier* October 2008 p9, p11 and p12.

Résumé

A la recherche du boson de Higgs : première étapes d'un incroyable voyage

En juin 1993, ATLAS et CMS, les deux expériences polyvalentes auprès du LHC, ont obtenu le feu vert pour présenter leurs propositions techniques. C'était le début d'un chemin difficile, mais glorieux, qui a conduit à la découverte d'un boson de Higgs l'année dernière. Peter Jenni et Tejinder Virdee ont participé à cette aventure depuis le début. L'un a été porte-parole d'ATLAS, l'autre porte-parole adjoint, puis porte-parole de CMS, dans les premières années des expériences jusqu'en 2009. Ils racontent au Courier *l'histoire de l'approbation de ces projets.*

Peter Jenni, University of Freiburg and CERN, and **Tejinder Virdee**, Imperial College London, have been involved in the LHC adventure from the beginning, together with many colleagues. They served respectively as spokesperson of ATLAS and deputy-spokesperson then spokesperson of CMS, in the early years of the experiments until 2009.

ET Enterprises electron tubes
ADIT

Photomultipliers from ET Enterprises and ADIT Electron Tubes

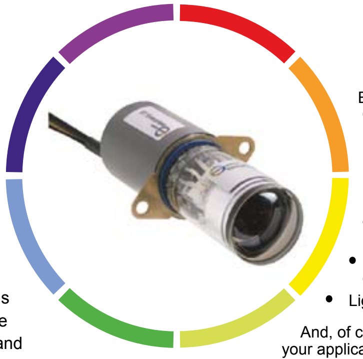
Need to detect light down to single photon level?

Need dark counts as low as a few cps at 20° C?

Need a detection area of up to 200cm^2 or more?

If the answer is yes to any of these questions, then ET Enterprises, and sister company ADIT Electron Tubes in the US, may have the answer with their range of photomultipliers and associated electronics and hardware.

Photomultipliers have always offered significant performance advantages over other types of low-level light detection devices and this is as true today as ever before. But what has changed is that photomultipliers are now much easier to use due to the wide range of ready-to-use associated electronics and HV supplies, and modular analogue and photon counting systems, in many cases operating from low voltage.



Examples of how we can make using photomultipliers easier:

- Sockets and voltage dividers for almost any photomultiplier type and application.
- Magnetic shields.
- Modular signal processing electronics, analogue or digital.
- HV power supplies, including bench-top and compact, low power integral HV bases.
- Light-tight housings including cooling.

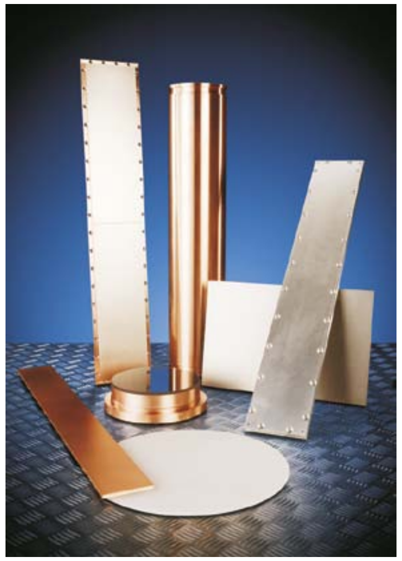
And, of course, we can also supply the photomultipliers for your application. We offer a very wide range, including alternatives to many Photonis types.

ET Enterprises Limited, Riverside Way,
Uxbridge, UB8 2YF, UK
Phone: +44 (0)1895 200880
Fax: +44 (0)1895 270873
sales@et-enterprises.com
www.et-enterprises.com

ADIT Electron Tubes, 300 Crane Street,
Sweetwater, Texas 79556, USA
Phone: (325) 235 1418
Fax: (325) 235 2872
sales@electrontubes.com
www.electrontubes.com

Contact us to learn more about these easy-to-use, highly sensitive light detectors, or try the parameterised search facility on our website.

Testbourne Ltd
Products for Industry, Research & Development



Testbourne Ltd has been supplying high purity metals, alloys & compounds to industries such as photovoltaics, glass coatings, data storage, thin-films, electronics, electro-optics and research establishments for over 30 years. You will find an extensive selection of materials available in fabricated forms including sputtering targets, evaporation materials, powders, wires, rods & sheets.

We can also accommodate any custom requirements you may have.

Visit us at: www.testbourne.com

Unit 2, Hatch Industrial Park, Greywell Road, Hatch, Basingstoke, Hampshire, RG24 7NG, England
Tel: +44 (0)1256 467055, Fax: +44 (0)1256 842929, Email: info@testbourne.com, **www.testbourne.com**

Scenes from some of the European Schools, left to right: Wolfgang Hollic lectures in Bautzen (2009), the poster session in Spain (2004), and the final dinner for the organizers in Austria (2005), with Egil Lillestøl (CERN), fourth from left, and Alexei Sissakian (JINR), second right. (Image credits: S Bethke, left, and E Lillestøl.)

Training young physicists: a 20-year success story

In 1993, a new series of physics schools began in Europe. Organized jointly by CERN and JINR, they have inspired similar ventures in Latin America and Asia.

The original CERN Schools of High-Energy Physics were established in the early 1960s at the initiative of Owen Lock, who played a leading role in their development over the next three decades. The first schools in 1962 and 1963 were one-week events organized at St Cergue in Switzerland, near CERN. However, from 1964 onwards the annual events – by then lasting two weeks – took place in other countries, generally in member states of CERN.

Starting in 1970, every second school was organized jointly with the Joint Institute for Nuclear Research (JINR), CERN's sister organization in the Soviet Union. This collaboration between East and West, even during the Cold War, exemplified how a common interest in science could bring together people from different nations working in harmony with the common goal of advancing human knowledge.

With the changes in the political scene in Europe, and after discussions and an exchange of letters in 1991 between the directors-general of CERN and of JINR, it was agreed that future schools would be organized jointly every year and that the title should change to the European School of High-Energy Physics. In each four-year period, three schools would take place in a CERN member state and the fourth in a JINR member state.

In 1993, the first European School took place in Poland, a country that was a member both of CERN and JINR. The following three schools were held in Italy, Russia and France, with the event in Russia being considered the first to be organized in a JINR member state. The full list of host countries for the first 20 European Schools is shown in the box (overleaf). With the new schools series, Egil Lillestøl replaced Owen Lock as the director of the CERN Schools of Physics, continuing in this role until the 2009 event in Germany, after which he handed over responsibility to the current director, Nick Ellis.

Theory and phenomenology

The target audience for the European Schools is students in experimental high-energy physics who are in the final years of working towards their PhDs. Most of the courses teach theory and phenomenology, concentrating on the physics concepts rather than the details of calculations. This training is highly relevant for the students who will use it in interpreting the results of physics-data analysis, e.g. as they complete the work for their PhD theses. Even if experimental physicists do not usually perform advanced theory calculations, it is of great ▷

This collaboration between East and West exemplified how interest in science could bring people from different nations to work in harmony

importance that they can follow and appreciate the published work of their theory colleagues and also have the necessary background to discuss the phenomenology. This last aspect is addressed particularly through the discussion sessions at the schools.

The scientific programme of the European Schools consists of typically four and a half hours of lectures each day (three lectures, each 90 minutes in duration, including questions), complemented by discussion sessions in groups of about 15–20 students with a discussion leader. The programme includes a poster session where many of the students present their own research work to the other participants, including the teachers and organizers. This way, students get to discuss their own work with some of the leading experts in the field.

A new development in the programme since the 2011 school is the inclusion of projects in which the students from each discussion group collaborate as a team to study in detail an experimental data analysis. With this, on top of the rest of the programme, the students say that they have to work really hard; nevertheless they still seem to enjoy the schools a great deal.

The focus of the schools is mainly on subjects closely related to experimental high-energy physics, so there are always core courses on topics such as field theory and the electroweak Standard Model, quantum chromodynamics, flavour physics and CP violation, neutrino physics, heavy-ion physics and physics beyond the Standard Model. Since 2009 there have also been lectures on practical statistics for particle physicists, which are particularly relevant to the day-to-day work of many of the students.

The core courses are complemented by some more topical lectures, including in recent years the latest results from the LHC and their implications. The programme generally also includes lectures related to cosmology, given the important interplay with particle physics, e.g. in connection with dark matter. Last but not least, the directors-general of CERN and JINR often attend in person and give lectures on the scientific programmes of their respective organizations and their outlook for the coming years; this also gives them an opportunity to meet and discuss informally with some of the most promising young physicists in the field.

The scientific programme, including the choice of subjects to be covered and the selection of the lecturers and discussion leaders who will teach at the school, is decided by a small international organizing committee with representatives from CERN and JINR, together with the person from the host country who will serve as the local director for the school. The same body is in charge of selecting the students who will attend the school, based on the applications and letters of recommendation from the professors or supervisors of the candidates.

Beyond the purely scientific objectives of the schools, the organizers aim to foster cultural exchange and "networking" between participants from different countries and regions. For this reason the students are assigned to shared twin-room accommodation, mixing people from different countries and regions. Similarly, the discussion groups are chosen to have a good mix of nationalities.

The collaborative student projects that were introduced in 2011 go beyond learning about a specific data analysis. Each group of students, with a little assistance from their discussion leader, has to select a published paper describing the analysis that they are to study; they then have to organize themselves to share the work with different individuals or sub-groups addressing distinct aspects of the analysis; they have to work as a team to prepare and rehearse a short talk summarizing what they have learnt; and they have to select a speaker to represent them. All of these skills are important for young physicists working in large international collaborations such as those that run the LHC experiments.

CERN's Geraldine Servant addresses an open-air discussion session during good weather at the 2012 School in France. (Image credit: N Ellis.)

Geographical enlargement

The European Schools have served as a model for similar series that are now organized in other parts of the world. Since 2001 there have been schools every two years in Latin America, catering for the growing high-energy-physics community there. The most recent event was held on 6–19 March this year in Arequipa, Peru.

A second new series of schools – the Asia-Europe-Pacific School of High-Energy Physics – started last year (*CERN Courier* January/February 2013 p45). The first event was held in Japan and the next one is planned for India in 2014. As with the Latin-American Schools, these events will be held every second year, with a programme that is similar to the model of the European Schools.

Thus, the European Schools have inspired other series catering for the needs of young physicists in other parts of the world. This is part of CERN's policy of geographical enlargement and its mission to support scientists from other parts of the world to increase their participation in high-energy physics in general and their collaboration with CERN in particular.

The European Schools continue to attract a large number of applications from highly qualified candidates, despite the emergence of many other excellent schools that offer alternative training. For example, the 2013 school, which takes place on 5–18 June in Hungary, was oversubscribed by more than a factor of two compared with the target of around 100 students. This implies a rigorous and highly competitive selection process, focusing on students with the most promise for an outstanding career in high-energy physics and who are at the optimum stage in their studies to benefit from the school.

Critical to the success of the schools are the lecturers and discussion leaders who teach there, selected for their qualities as first-class researchers and also as teachers. They come from institutes in many countries, including ones that are not member states of either CERN or JINR. The European Schools have benefited from the strong support, and often the presence as lecturers, of successive directors-general of both CERN and JINR. The organizers are extremely grateful to the many people from the worldwide high-energy-physics community who every year contribute to the success of the schools, a success that can be judged from the positive feedback received from the students who participate.

Host countries of European Schools

1993 Zakopane, Poland
1994 Sorrento, Italy
1995 Dubna, Russia
1996 Carry-le-Rouet, France
1997 Menstrup, Denmark
1998 St Andrews, United Kingdom
1999 Častá-Papiernička, Slovakia
2000 Caramulo, Portugal
2001 Beatenberg, Switzerland
2002 Pylos, Greece
2003 Tsakhkadzor, Armenia
2004 Sant Feliu de Guíxols, Spain
2005 Kitzbühel, Austria
2006 Aronsborg, Sweden
2007 Třešť, Czech Republic
2008 Herbeumont-sur Semois, Belgium
2009 Bautzen, Germany
2010 Raasepori, Finland
2011 Cheile Gradistei, Romania
2012 Anjou, France
2013 Parádfürdő, Hungary

● **Further reading**

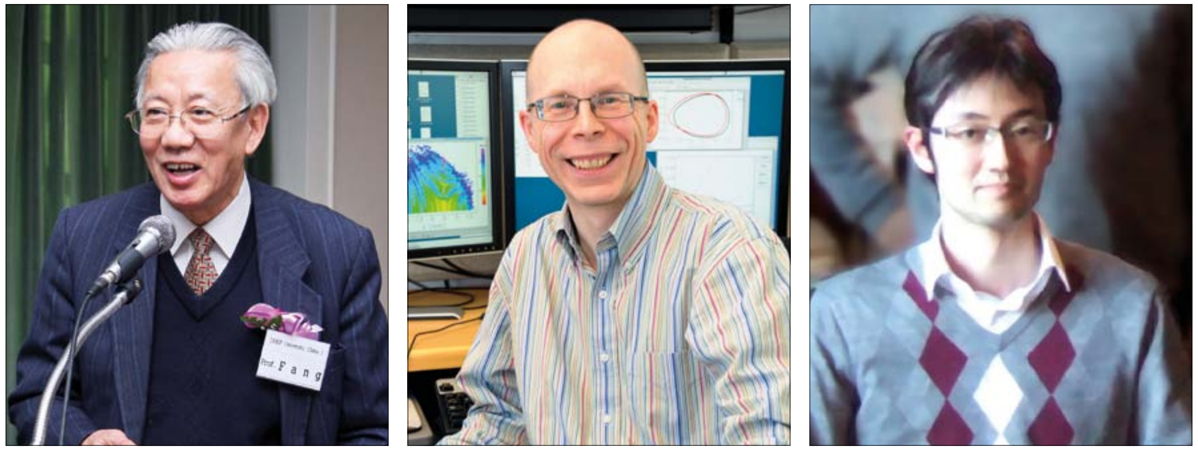
For more about all of the schools, see: http://physicschool.web.cern.ch/PhysicSchool/.

Résumé

Formation des jeunes physiciens : 20 ans de succès

En 1993 a été lancée une nouvelle série d'écoles de physique en Europe, prenant la suite des Écoles CERN de physique des hautes énergies qui existaient depuis les années 1960. A partir de 1970, une école sur deux a été organisée conjointement avec l'Institut unifié de recherche nucléaire (JINR). Puis, au début des années 1990, il a été décidé d'organiser chaque année conjointement une école européenne de physique des hautes énergies. Ces écoles européennes ont eu beaucoup de succès et continuent à attirer beaucoup de candidats hautement qualifiés. Elles ont également fait des émules en Amérique latine et en Asie.

Nick Ellis, CERN, current director of CERN Schools of Physics.



Left to right: Prizewinners Shouxian Fang, Michael Borland and Hiroshi Imao. (Image credits: S Fang, R Fenner/APS, H Imao.)

AWARDS

ACFA and IPAC announce accelerator prizes

The Asian Committee for Future Accelerators (ACFA) and the fourth International Particle Accelerator Conference, IPAC'13, have awarded the ACFA/IPAC'13 Accelerator Prizes for outstanding and original contributions to the field. The awards, decided by the Prizes Selection Committee, chaired by Jia-er Chen of the National Natural Science Foundation of China, are to be presented at the conference in Shanghai on 13–17 May.

Shouxian Fang of the Institute for High-Energy Physics, Beijing, receives the prize with no age limit for outstanding work in the accelerator field. He led the team that constructed the Beijing Electron–Positron Collider (BEPC), China's first high-energy accelerator, and has contributed to the Shanghai Synchrotron Radiation Facility, the China Spallation Neutron Source and the Chinese Accelerator-Driven Subcritical System for nuclear-waste transmutation, as well as to proton-therapy accelerators and to initiating the major upgrade of BEPC (BEPCII). He has also promoted accelerator-based science in China through extensive international collaboration and built up a solid bridge between China and other parts of the world in the accelerator field.

The prize for an individual with no age limit having made a recent significant, original contribution to the accelerator field, goes to Michael Borland of the Advanced Photon Source, Argonne, for his original contributions in creating the ELEGANT programme and its self-describing data-sets platform. These are widely applied in the design, simulation and analysis of circular accelerators, energy-recovery linacs and free-electron lasers. His algorithms, methods and software have been adopted at many accelerator facilities around the world, and for numerous developments in the field of beam dynamics and non-linear optimizations.

The third prize, for an individual in the early part of his or her career, having made a recent, significant and original contribution to the field, goes to Hiroshi Imao of RIKEN for his realization of the next-generation charge-state stripper using recirculating helium gas. This stripper makes it possible to increase the intensity of uranium-ion beams by an order of magnitude at RIKEN's Radioactive Isotope Beam Factory and has had immense, worldwide impact on the field of heavy-ion accelerators. He also developed a compact and efficient positron accumulator that has led to the successful production of antihydrogen atoms in the ASACUSA experiment at CERN.

ASTROPARTICLE PHYSICS

Dark matter on the menu in Münster

The first meeting dedicated exclusively to dark-matter theory and experiment in Germany was held earlier this year at the University of Münster. Made possible through the generous financial support of the Helmholtz Alliance for Astroparticle Physics (HAP), the conference – HAP Dark Matter 2013 – was co-organized by Michael Klasen of Münster and Klaus Eitel of the Karlsruhe Institute of Technology (KIT). The 100 participants included senior German dark-matter scientists, many postdocs and students, as well as experts from neighbouring countries such as Belgium, Denmark, France, the Netherlands, Spain, Sweden, Switzerland and the UK.

The scientific programme aimed at a complete coverage of all aspects related to dark matter and ranged from astronomical observations through experimental searches to theoretical interpretations and tools. As the first speaker, Jürg Diemand of Zurich presented fascinating numerical simulations of galactic structures by the Via Lactea collaboration. Thomas Reiprich of Bonn and Justin Read of Surrey followed up with the prospects for galaxy-cluster cosmology using X-ray telescopes, with determinations of the local dark-matter density from stellar kinematics, while Eva Grebel of Heidelberg gave an overview of dark-matter-dominated dwarf galaxies.

Experimental results were reported from: direct searches, for example, with the XENON experiment, described by Christian Weinheimer of Münster; indirect searches with the Fermi Gamma-ray Space Telescope, by Johann Cohen-Tanugi of Montpellier; and the LHC experiments, by CERN's David Berge, CERN. While none of these searches can yet conclusively provide positive evidence, some, as Thomas Schwetz-Mangold of Heidelberg explained, do leave room for speculation on relatively light dark-matter particles. Participants were also curious to see the preparations for the XENON1T experiment, visible during several laboratory tours offered by Ethan Brown of Münster.

With increasing experimental sensitivity and precision, the need for precise theoretical and numerical tools is now evident. This was addressed in talks by Manuel Drees of Bonn and Andrzej Hryczyk of Munich on the so-called Sommerfeld enhancement. Full next-to-leading order calculations, presented by Karol Kovarik of KIT, are integrated into programmes such as micrOMEGAs and DarkSUSY, described by Geneviève Belanger of Annecy and Torsten Bringmann of Hamburg, respectively. Whether dark matter is supersymmetric, as discussed by Laura Covi of Göttingen and Béranger Dumont of Grenoble, or not, as Steen Hannestad of Aarhus, Andreas Ringwald, DESY, and many others argued, still has to be decided. This might be possible at a second HAP Dark Matter meeting, which many of the participants eagerly demanded.

- For more about HAP Dark Matter 2013, see https://indico.desy.de/event/hap-DM. For more about the Helmholtz Alliance for Astroparticle Physics (HAP), see www.hap-astroparticle.org.

The HAP Dark Matter 2013 meeting drew 100 participants. (Image credit: W Hassenmeier.)

PUBLISHING

Progress bridges experimental and theoretical physics

In 1946, three years before he was to receive the Nobel Prize in Physics for "his predication of the existence of mesons", Hideki Yukawa founded the journal *Progress of Theoretical Physics*. Over the years it published many important articles, mainly in theoretical physics, including several that led to the Nobel prize. Now the journal has taken on a new life, by incorporating experimental physics under the title *Progress of Theoretical and Experimental Physics* (PTEP).

The new journal, which is a joint venture between Oxford University Press and the Physical Society of Japan, is fully open access and available only online. Its coverage continues on from its predecessor by including high-energy physics, nuclear physics, astrophysics and cosmology, together with mathematical physics and condensed-matter physics. Now, it also welcomes papers in experimental particle physics, nuclear physics and astrophysics, as well as beam physics, instrumentation and technology. Regular monthly issues began in January 2013, following on from a number of special issues published in 2012.

PTEP is an international journal and welcomes the submission of papers from authors around the world, and as a new initiative places strong emphasis on the *Letters* section. It participates in the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP^3) initiative, launched at CERN last October (*CERN Courier* November 2012). As a result, high-energy physics articles in *PTEP* will from 2014 be published open access in perpetuity and free of charge.

- For more about *Progress of Theoretical and Experimental Physics*, see http://ptep.oxfordjournals.org.

Visits

Carmen Vela Olmo, the Spanish state secretary of science, development and innovation, toured the LHC tunnel during her visit to CERN on 4 April. She was also able to see the ATLAS visitor centre and underground area, as well as meeting the director-general and Spanish physicists and staff members at CERN.

The deputy prime minister of the Russian Federation, **Olga Golodets**, came to CERN on 5 April. In addition to meeting the director-general, she toured the ATLAS control room and underground experimental area, the LHC tunnel, the computer centre and the Antimatter Decelerator. She also met members of CERN's Russian community at CERN.

Shri Sudini Jaipal Reddy, of the Indian ministry of science and technology and ministry of earth sciences, centre seated, met members of the Indian community at CERN during a visit on 8 April. He toured the CMS control room and underground experimental area, as well as the ALICE underground experimental area and the LHC superconducting test hall.

Arts and science

Collide@CERN–Geneva prize awarded to film maker

CERN and the City and the Canton of Geneva have awarded the second Collide@CERN–Geneva prize to the 47 year old film maker Jan Peters, for his proposal to explore the world of CERN from a highly personal perspective. Peters has divided his time between Switzerland and his native Germany for many years. An artist and film maker, he is known particularly for personal documentaries charting his own life and his films have won prizes at festivals around the world. During his residency at CERN, he intends to address the links between science and art, politics and philosophy. In awarding him the Collide@CERN–Geneva prize, the jury recognized Peters as someone "who makes profoundly personal films that probe and dissect reality". Peters is expected to take up his three-month CERN residency in autumn 2013. He is the second winner of the Collide@CERN–Geneva award, which is part of a three-year partnership between CERN and the City and the Canton of Geneva.

Meeting

NA-PAC'13, the 2013 **North American Particle Accelerator Conference**, will take place on 30 September – 4 October in Pasadena. It will bring together scientists, engineers, students and industrial exhibitors for an information-sharing experience focused on technology. Students are encouraged to find out more about the grant programme and to apply to present their work in the special student poster session that will take place during registration on 29 September. There will also be an industrial exhibition during the first three days of the conference. For further details about deadlines for registration and all other aspects, see www.napac13.lbl.gov.

Correction

In the text in "New boson's mirror image looks like the Higgs" (*CERN Courier* January/February 2013 p10) the reference to the colours in figure 2 were unfortunately reversed. It should of course read: Figure 2 shows the expected likelihood for a genuine scalar Higgs boson (pink) and a pseudo-scalar boson (blue). Apologies for any confusion.

Obituaries

Henri Cornille 1929–2013

The French theoretical physicist, Henri Cornille, passed away on 23 February, aged 83.

Henri was a typical product of the French education system before 1968, i.e. an elitist system in which someone of modest origin could climb the ladder provided that he was good and courageous. Henri followed the *troisième cycle* organized by Maurice Lévy at the Ecole Normale but it was Roger Nataf (who, like Lévy, was from North Africa) at the Institut de Physique Nucléaire, Orsay, who realized that he had real talents. Nataf sent Henri to work with me at CERN, where we had a fruitful collaboration in the fields of potential scattering and high-energy scattering. Our best result, I believe, was the proof that the ratio of the widths of the diffraction peaks for particle–particle scattering and for particle–antiparticle scattering was approaching unity asymptotically. He was also the inventor of the "Cornille plot", which gives the allowed domain for total and elastic cross-sections when they behave like powers of log s for large energies.

H Cornille. (Image credit: Cornille family.)

Henri never recoiled in the face of difficulty. This is well illustrated by his work with Jean-Michel Drouffe on phase-shift analysis for scattering amplitudes with maximum angular momentum L=4. In this context, one problem that is well posed but not yet completely solved is that given a differential cross-section at an energy such that only elastic collisions can take place, what are the corresponding scattering amplitudes or, equivalently, the phase shifts corresponding to the various partial waves? Are there several solutions except for changing the sign of all phase shifts? J H Crichton has shown that there are cases where there is a two-fold ambiguity. Many theoreticians have worked on this problem and obtained some results, in which more than two solutions have never appeared. In my opinion, the work of Cornille and Drouffe is the most convincing indication that there are never more than two solutions.

After officially retiring, Henri was given the status of emeritus – something rare in France – and continued to work at Saclay. In all of his work, he showed intellectual integrity, perseverance, and imagination. We shall miss him.

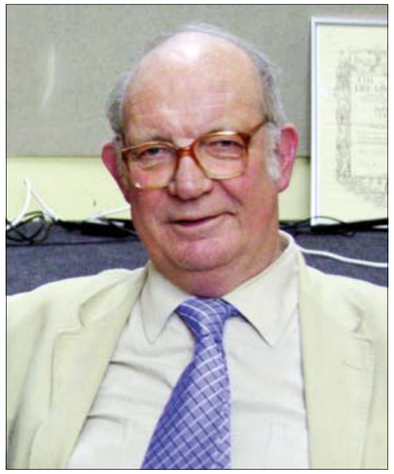
● *André Martin, CERN.*

Peter Norton 1945–2013

Peter Norton, a physicist at the Rutherford Appleton Laboratory (RAL) in the UK, passed away on 2 February.

Peter graduated from Jesus College Oxford in 1966 and joined Arthur Clegg's group at Oxford University working at the Rutherford Laboratory (later RAL) to study elementary particle physics for his DPhil. He then joined the Daresbury Laboratory, where he worked on the PEP experiment to study the details of electroproduction reactions. Such details began to be clarified with the development of the quark model of elementary particles. Central to this understanding were the classic deep-inelastic scattering experiments done at SLAC in the late 1960s.

In the 1970s, Peter was a founder member of the European Muon Collaboration (EMC) formed to extend the studies of deep-inelastic scattering to the higher energies available at CERN. The purpose of EMC was to probe the quark structure of the nucleon. Peter was responsible for the muon drift chambers, which at that time were among the largest chambers ever made. His sharp intellect and ability to spot confused thinking made invaluable contributions to the experiment's major discoveries of the EMC effect and the spin deficit in the proton.



Peter Norton. (Image credit: E Loutzenhi.)

In the 1980s, he joined the ALEPH collaboration and played a significant role in cementing together a larger UK university involvement in the experiment. This consortium constructed the endcaps of the electromagnetic calorimeter. Peter's calm approach to the design and testing of the huge modules with his colleague Mike Edwards proved invaluable. Their insistence on maintaining a strict testing regime during construction – despite the considerable time pressures – led to an excellent apparatus that worked flawlessly throughout ALEPH's lifetime.

Following ALEPH, Peter was involved in the creation of one of the embryonic groups keen to do experiments at the LHC. Realizing the value of naming the experiment with the first letter of the alphabet, he invented "ASCOT", which later joined "EAGLE" to become the ATLAS collaboration. He was deeply involved in the conception of the experiment and played a significant role in the design of the superconducting toroid-magnet system. Here, he played a pivotal role linking the physics and engineering teams. He retired before the experiment took data but the recent announcement of the discovery of a particle with the hallmarks of the Higgs boson gave him great pleasure. In the final years of his career, as head of a small group at RAL developing new ideas, he was instrumental in re-launching accelerator R&D in the UK, also editing the influential report *Accelerator R&D for Particle Physics* that started the initiative.

Peter was a good man and the world is a poorer place for his passing. He is survived by his wife Yve and daughter Eleanor.
● *His friends.*

NEW PRODUCTS

Heason Technology has added new precision slip ring assemblies and rotary joints to its portfolio, including complete assemblies for rotary-to-stationary transmission of electrical signals, video signals, field buses etc. and power up to 50 A and beyond. The precision devices include long-life gold and other precious-alloy rings and brushes, with up to 96 circuits in standard designs that span miniature capsule units and large-diameter packaged designs – some with through holes. For more details, contact Jon Howard, tel: +44 1403 755800, e-mail jhoward@heason.com or see www.heason.com.

Keithley Instruments Inc has enhanced its Automated Characterization Suite (ACS) software for its high-power semiconductor characterization solutions. The ACS package is optimized for automated wafer-level parameter-test applications, including automated characterization, reliability analysis and known good die testing. The ACS V5.0 update specifically leverages the capabilities of Keithley's Model 2651A (high current) and 2657A (high voltage) System SourceMeter SMU instruments. For details, visit www.keithley.com/products/semiconductor/characterizationsoftware.

Resolve Optics has released the ultracompact Z10 HD Mini Zoom Lens – with 10X, C-mount lens-design – designed to complement small-profile HD cameras. Floating-cell technology allows the moving cells to be compact and light, allowing smaller motors to be used to drive the movements. Low-dispersion glass keeps the lens compact while still providing HD quality. The design also allows for an f/1.8 aperture to be maintained throughout 80% of the zoom travel with a minimum aperture of f/2.8. For further information tel: +44 1494 777100, e-mail sales@resolveoptics.com or visit www.resolveoptics.com/330-000.htm.

The **Siemens** Industry Automation Division's range of temperature sensors now includes the SITRANS TS family. These resistance thermometers and thermocouples are designed for universal use in a modular design that offers a range of sizes, materials, sensors and transmitters. The SITRANS TS100 and TS200 series are available as cable and compact thermometers. The SITRANS TS500 line is designed for applications with low to high process-stresses. For further information contact Peter Jefimiec tel: +49 (911) 895–7975, e-mail peter.jefimiec@siemens.com or see www.siemens.com./sitranst.

Recruitment

FOR ADVERTISING ENQUIRIES, CONTACT *CERN COURIER* RECRUITMENT/CLASSIFIED, IOP PUBLISHING, TEMPLE CIRCUS, TEMPLE WAY, BRISTOL BS1 6HG, UK.
TEL +44 (0)117 930 1264 FAX +44 (0)117 930 1178 E-MAIL SALES@CERNCOURIER.COM
PLEASE CONTACT US FOR INFORMATION ABOUT RATES, COLOUR OPTIONS, PUBLICATION DATES AND DEADLINES.

Accelerators | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

DESY

PARTICLE PHYSICS.

DESY, Hamburg location, is seeking:
Scientist (m/f)

DESY

DESY is one of the world's leading centres for the investigation of the structure of matter. DESY develops, runs and uses accelerators and detectors for photon science and particle physics.

To further strengthen the DESY ATLAS group at the Hamburg site, we are looking for a scientist with experience in detector operation and construction. The ATLAS group participates in the operation of the semi-conductor tracker (SCT) and is strongly engaged in the silicon tracker upgrade for the LHC high luminosity phase. In addition the group is heavily involved in the analysis of the ATLAS data.

The position

- Participate in SCT operation and the silicon tracker upgrade and play a leading role in one of these two areas
- Take responsibility for general tasks of the group and of DESY
- Contribute to the ongoing data analysis

Requirements

- PhD in particle physics
- Established record in detector operation and/or detector construction, preferentially in the area of silicon detectors
- Leadership capabilities

For further information contact Michael Medinnis, phone +49 40 8998-3008.

Salary and benefits are commensurate with those of public service organisations in Germany. Classification is based upon qualifications and assigned duties. DESY operates flexible work schemes. People with disabilities will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. There is a bilingual kindergarten on the DESY site.

Please send your application quoting the reference code, also by email, to:
Deutsches Elektronen-Synchrotron DESY
Human Resources Department | Code: EM055/2013
Notkestraße 85 | 22607 Hamburg | Germany
Phone: +49 40 8998-3392 | Email: recruitment@desy.de
Deadline for applications: 15th June 2013
www.desy.de

The Helmholtz Association is Germany's
largest scientific organisation.
www.helmholtz.de

HELMHOLTZ
GEMEINSCHAFT

KIT
Karlsruhe Institute of Technology

The Karlsruhe Institute of Technology (KIT) is the result of the merger of the Universität Karlsruhe (TH) and the Forschungszentrum Karlsruhe. It is a unique institution in Germany, which combines the missions of a university with those of a national research center of the Helmholtz Association. With 9.000 employees KIT is one of the largest research and education institutions worldwide.

In the **Department of Electrical Engineering and Information Technology** of the Karlsruhe Institute of Technology the

Professorship (W3) for Detector Technology and ASIC Design

combined with the position of a

Founding Director of the KIT ASIC and Detector Laboratory

is to be filled as soon as possible. The professorship is located at the Institute for Data Processing and Electronics.

We are looking for distinguished scientists with outstanding scientific credentials, experience in leading scientific groups and excellent didactical skills. Experience in the instrumentation of large-scale research experiments is an advantage.

Applicants should have experience in several of the following fields:

- Highly integrated mixed-signal CMOS technologies
- Monolithic Active Pixel Sensors (MAPS) or alternative sensor concepts
- 3D integration and packaging and interconnect technologies for detector instrumentation
- Applications of the aforementioned technologies in large-scale experiments of particle astrophysics, particle physics, in the research with photons, neutrons and ions as well as in optics and photonics, medical imaging etc.

The appointee will build-up the ASIC and Detector Laboratory and boost the development of innovative detector technologies. He/She will be able to draw on the infrastructure of the institute, in particular the clean-room with the packaging and interconnect facilities, workshops and the CAD-design office. The position offers an excellent research environment with many opportunities for collaboration within the department and other structures of KIT. This includes the KIT Center of Elementary Particle Physics and Astroparticle Physics (KCETA) and the DFG graduate school KSETA. Participation in the programs of the Helmholtz Association and committed collaboration with the partners of the Helmholtz Portfolio "Detector Technologies and Systems Platform" (Helmholtz Centers, Universities and international partners) is expected.
Participation in the lecture courses of the department is expected. This includes basic courses like "Design of analog and digital circuits" as well as block courses within KSETA.

Applicants must have the degree of Habilitation or demonstrate equivalent scientific qualifications as well as experience in teaching.

KIT aims to increase the number of female professors and especially welcomes applications from women. Handicapped persons with equal qualifications will be preferred. Conditions of Employment: § 47 of the Landeshochschulgesetz (LHG) Baden-Wuerttemberg.

Applications including CV, list of publications, summary of research and teaching activities and prints of the five most significant publications should be sent by **June 14, 2013** to the **Dean of the Department of Electrical Engineering and Information, Karlsruhe Institute of Technology (KIT), Campus South, 76128 Karlsruhe.**

KIT - University of the State of Baden-Württemberg and
National Laboratory of the Helmholtz Association

JOINT US-CERN-JAPAN-RUSSIA SCHOOL ON PARTICLE ACCELERATORS WILL HOLD A COURSE ON

INTRODUCTION TO PARTICLE ACCELERATORS

23 - 31 OCTOBER, 2013

FOR YOUNG SCIENTISTS AND STUDENTS

Application deadline: 30 June, 2013

Further information and application forms:
http://www-conf.kek.jp/accschool
E-Mail: JAS'13@kek.jp

THE FOOT OF MT. FUJI, SHIZUOKA, JAPAN

California Institute of Technology
Software Engineer
Location: Geneva, Switzerland
Open Until Filled

Caltech's High Energy Physics group has a long-standing involvement in the design and development of the computing models in use in the LHC community. In parallel, the group has been pioneering the use of high-speed optical networks for HEP data analysis. Today, we have an opening for an experienced software development engineer to work on integration of advanced networking concepts with the scientific data and workflow management. The new team member will contribute to the development of software related to the use of dynamic circuit networks and pervasive monitoring systems in the software stack of the CMS experiment.

The project is being carried out in collaboration with partner institutes in the CMS and ATLAS experiments; this position is based at CERN, Switzerland.

Job Duties:

- Software development in the framework of the CMS data/workflow management
- Development of algorithms leveraging dynamic circuit APIs work enhancing workflow efficiency
- Integration of network monitoring services (perfSONAR, MonALISA) into data management
- Active participation in collaborations with partner institutes and networks world-wide
- Other duties as assigned.

For full details please go to: www. Jobs.caltech.edu and search for position number 130173

Caltech is an Affirmative Action/Equal Opportunity Employer.
Women, Minorities, Veterans and Disabled Persons are encouraged to apply.

HERIOT
WATT
UNIVERSITY

School of Engineering and Physical Sciences

Lecturer/Reader in Laser Engineering

Lecturer: £29,451 - £36,298 or £37,382 - £44,607

Reader: £45,941 - £53,233

The School of Engineering and Physical Sciences seeks to recruit a member of academic staff, as part of its strategic development of important research activities in Laser Engineering and Applications. The successful candidate must have the knowledge, drive and breadth of vision to develop the leadership necessary for the achievement of high impact research in laser device physics and engineering. The candidate must have a research record consistent with the level of appointment, evidenced by quality research publications and where appropriate by a track record in securing research grant/contract awards. The candidate should have research interests that align with current Applied Photonics activity in the school, with a particular focus on High Power Laser Development and Industrial Applications.

In addition to research activity, the appointed candidate will be expected to contribute fully to all aspects of School activity, in particular the Physics Bachelors and Masters teaching programmes.

For application details see our website **www.hw.ac.uk/jobs** or contact the **Human Resources Office, Heriot-Watt University Edinburgh EH14 4AS** tel **0131-451-3022** (24 hours) email **hr@hw.ac.uk** quoting Ref: 601/13.

Closing date: **31 May 2013.**

Heriot-Watt University is a Charity registered in Scotland, SC000278

POSITIVE ABOUT DISABLED PEOPLE

Distinctly Ambitious
www.hw.ac.uk

ICTP
The Abdus Salam
International Centre
for Theoretical Physics

Post title:	**Associate Officer for Astronomy and Development**
Domain:	Natural Sciences
Post Number:	1ITSC0864TP
Grade:	P-1/P-2
Organizational Unit:	Office of External Activities, International Centre for Theoretical Physics (ICTP)
Primary Location:	Trieste, Italy
Recruitment open to:	Internal and external candidates
Type of contract:	Fixed-Term
Annual Salary:	US$ 75000
Deadline (midnight, Paris time):	**24 June 2013**

Overview of the Functions of the Post

Under the direct guidance of the immediate supervisor, the incumbent will help to manage all aspects of the Agreement between ICTP and the International Astronomy Union and its Office of Astronomy for Development (IAU-OAD). He/She will assist in the fund raising activity at the ICTP in this research area. Essential responsibilities include:

- To help to manage all aspects of the Agreement between the ICTP and the IAU-OAD (providing information about the Associates, Visitors, Meetings and Schools programs that are now available to astronomers in developing countries, coordinating the evaluation of proposals and the selection process of Associates, Visitors, Meetings and Schools, and serving as the principal point of contact for these programs).
- To assist the immediate supervisor to coordinate with the IAU-OAD Task Force for Universities and Research on the creation and implementation of innovative and sustainable programs which use Astronomy for Development (such as the Sabbatical Leave program, the Equipment and Laboratory small grant program, grants for the development and implementation of innovative Undergraduate Astronomy courses and laboratories in developing countries, Technology Internships for training in the use of instrumentation and software, and the establishment of Twinning or cooperative Networks between University-level institutions in developing and developed countries).
- To help in the development of a system for evaluating the outcomes of the ICTP-IAU collaboration.
- Whenever required, to help to develop and teach courses on astrophysical algorithms and databases as part of the ICTP/SISSA High Performance Computing program and to perform research in astrophysics.
- Occasional supervision of ICTP Diploma student theses.

Required Qualifications

Education
- Advanced University degree (Ph.D. or equivalent) in Astrophysics.

Work Experience
- 2 to 4 years of relevant research and teaching experience in astrophysics or closely related fields.
- Experience in the implementation and management of scientific projects.
- Experience in the applications of High Performance Computing to astrophysics.

Skills/competencies
- Excellent analytical skills. Ability to collect, synthesise and analyse information from various sources.
- Ability to work effectively in a multidisciplinary and multicultural environment.
- Capacity to build and maintain partnerships inside and outside the Institute.
- Ability to communicate effectively on complex technical and scientific issues in English.
- Excellent written and oral communication skills in English.
- Good knowledge of databases for astrophysics.

Languages
- Excellent/very good knowledge of English (written and oral).

Desirable Qualifications

Work Experience
- Work experience at international level.
- Experience of fundraising and mobilisation of resources activities.

Benefits and Entitlements

UNESCO's salaries are calculated in US dollars. They consist of a basic salary and a post adjustment which reflects the cost of living in a particular duty station and exchange rates.

Other benefits include: 30 days annual leave, family allowance, home travel, education grant for dependent children, pension plan and medical insurance. More details on the ICSC Web site.

To apply: https://unesco.taleo.net/careersection/2/joblist.ftl

Consortium for Construction, Equipment and Exploitation of the Synchrotron Light Laboratory

Ref. EST/PO/03-13 (Deadline: June 15th 2013)

Head of the Engineering Division of Alba

INSTITUTION

CELLS, the consortium for Construction, Equipment and Exploitation of the Synchrotron Light Laboratory ALBA, is jointly funded by the Spanish State Government and the Generalitat de Catalunya (Catalan Autonomous Government).

ALBA is a 3 GeV low emittance state-of-the-art third generation Synchrotron Light Facility located in Cerdanyola del Vallès near Barcelona. The facility is open to external users with seven Beam Lines. Alba is organized in five Divisions one of them devoted to engineering aspects of the facility.

FUNCTIONS

The successful candidate will take responsibility for the Engineering Division, which provides technical support in design, construction and operation activities of the Consortium. At present the areas of expertise in the facility are civil and mechanical engineering, vacuum, cryogenics, survey and alignment, maintenance and energy supplies.

The Head of Engineering Division reports to the Director of the facility and is a member of the CELLS Management Board. As such is strongly involved in running the laboratory and formulate proposals for the Division annual budgets and staffing plans.

QUALIFICATIONS

- Education: high level university degree in engineering, physics or equivalent.
- 10 years minimum experience in project management in large scientific or technological infrastructures. Experience in accelerator laboratories will be appreciated.
- 5 years minimum experience in the management of human resources teams on the fields mentioned above.
- Recognized leadership, communication and interpersonal skills.
- Adaptability to an international and multidisciplinary environment.
- Sense of responsibility and demonstrated ability to work independently or as a member of a team.
- Good knowledge of English.
- Basic knowledge of Spanish or Catalan or an undertaking to acquire it rapidly.

Contact

Applications shall be submitted by CELLS web application before June 15th 2013, 24:00 local time to:
http://www.cells.es/Jobs/JobOffers/ViewJobs?division=Engineering

---

European XFEL SEIZE THE CHANCE

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

EXCITING OPPORTUNITIES

Find out more about our exciting opportunities for scientists, engineers and graduate students. Help develop X-ray instrumentation and other systems. Help create a research facility of superlatives that will provide X-rays of unique quality for cutting-edge research in physics, chemistry, the life sciences and materials science.

WORKING AT EUROPEAN XFEL

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

JOIN OUR NETWORK

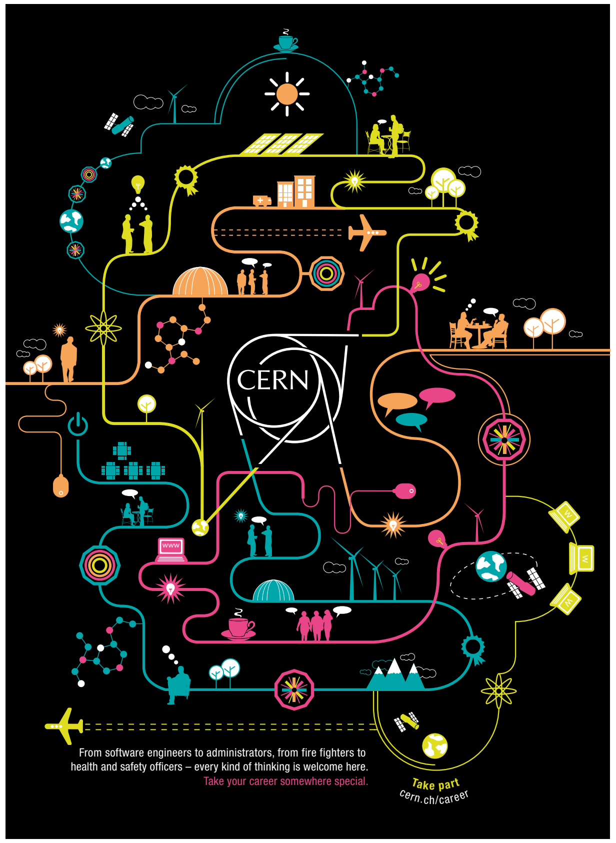
Join our network of international research institutions, programmes and collaborations. Discuss problems and solutions with colleagues from all over the world.

COME TO HAMBURG

Economically and culturally, Hamburg is the centre of Northern Germany. With its long history in trade, Hamburg has always been an outward-looking city and one of Germany's gateways to the world. Work and live in Hamburg, one of the most beautiful and interesting cities in Europe!

European XFEL GmbH, Albert-Einstein-Ring 19, 22761 Hamburg, Germany
Mailing address: Notkestr. 85, 22607 Hamburg, Germany

www.xfel.eu



From software engineers to administrators, from fire fighters to health and safety officers – every kind of thinking is welcome here.
Take your career somewhere special.

SLAC NATIONAL ACCELERATOR LABORATORY

Associate Laboratory Director
Stanford Synchrotron Radiation Lightsource

The SLAC National Accelerator Laboratory, at Stanford University, is seeking applications for the position of Director of Stanford Synchrotron Radiation Lightsource (SSRL). Reporting to the Laboratory Director, the Associate Laboratory Director (ALD) will lead a world renowned laboratory, producing extremely bright X-rays used to study our world at the atomic and molecular level. SSRL enables research that benefits every sector of the American economy and leads to major advances in energy production, environmental remediation, nanotechnology, new materials and medicine. SSRL also provides unique educational experiences and serves as a vital training ground for students in the sciences. Partnering with companies in industry, SSRL instruments help bring discoveries and innovations from theory to reality. Nobel prizes have been awarded for research carried out, in part, at SLAC's SSRL.

The SSRL ALD will be an internationally recognized Scientist with established leadership credentials, strategic thinking and execution skills, excellent communication skills, commitment to excellence and capability to expand the capacities of SLAC's pioneering synchrotron facilities. The Director will serve on SLAC's Executive Council, lead a directorate of accomplished scientists and administrators, serve as advisor to the Lab Director, as well as to national and international committees, represent SLAC and the Lab Director in communications with congress, DOE, private industry, local government and citizens groups and Stanford University. The successful candidate is expected to assume a tenured position on the SLAC Faculty.

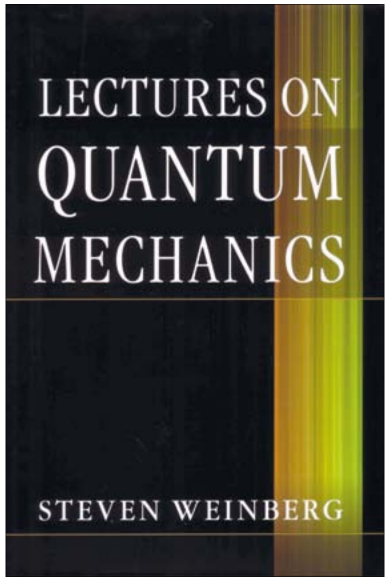
SLAC, one of the world's leading research laboratories, is a U.S. Department of Energy, Office of Science multi-program laboratory operated by Stanford University for 50 years.

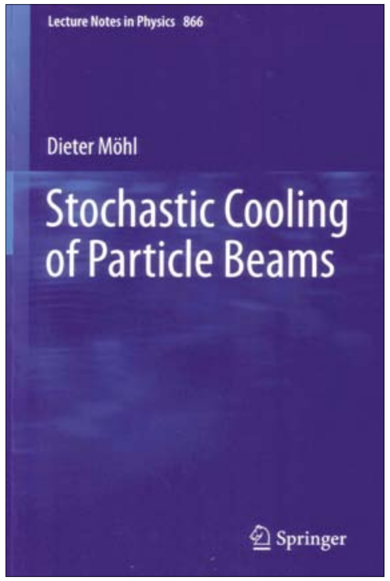
For additional information or to be considered for candidacy please contact/send application materials to:
Lisa Mongetta, Manager, SLAC Staffing Services
2575 Sand Hill Road, Menlo Park, CA 94025
650-926-2733 email: mongetta@slac.stanford.edu

The SLAC National Accelerator Laboratory values diversity and is an Affirmative Action, Equal Opportunity Employer.

The Linac Coherent Light Source at SLAC National Accelerator Laboratory is an Office of Science user facility operated for the Department of Energy by Stanford University.

Bookshelf





Lectures on Quantum Mechanics

By Steven Weinberg

Cambridge University Press

Hardback: £40 $75

This is a beautifully written book that is crafted with precision and is full of insight. However, this is for most people not the book from which to learn quantum mechanics for the first time. The cover notes acknowledge this and the book is advertised as being "ideally suited to a one-year graduate course" and "a useful reference for researchers". That is not to say that it deals only with advanced material – the theory is built up from scratch and the logical structure is quite traditional.

The book starts with a careful exposition of the early history and the Schrödinger-equation analysis of the hydrogen atom and the harmonic oscillator, before moving on to cover the general principles, angular momentum and symmetries. The middle part of the book is concerned with approximate methods and develops the theory starting from time-independent perturbations and ending with the general theory of scattering. The final part deals mainly with the canonical formalism and the behaviour of a charged particle in an electromagnetic field, including the quantization of the field and the emergence of photons. The final chapter covers entanglement, the Bell inequalities and quantum computing, all in a mere 14 pages.

Perhaps what distinguishes this book from the competition is its logical coherence and depth, and the care with which it has been crafted. Hardly a word is misplaced and Weinberg's deep understanding of the subject matter means that he leaves no stone unturned: we are asked to accept very little on faith. Examples include Pauli's purely algebraic calculation of the hydrogen spectrum, the role of the Wigner-Eckhart theorem in a proper appreciation of the Zeeman effect and in atomic selection rules, as well as the emergence of geometrical phases. There is also a thoughtful section on the interpretations of quantum mechanics.

Weinberg has a characteristic style – his writing is full of respect for the reader and avoids sensational comments or attempts to over-emphasize key points. The price we pay is that the narrative is rather flat but in exchange we gain a great deal in elegance and content – it is for the reader to follow Weinberg in discovering the joys of quantum mechanics through a deeper level of understanding: I loved it!

- *Jeff Forshaw, University of Manchester.*

Stochastic Cooling of Particle Beams

By Dieter Möhl

Springer

Paperback: £31.99 €36.87 $39.50
E-book: £24.99 €29.74 $49.95

Over the past decades, stochastic cooling of particle beams has grown, thrived and led to breathtaking results in physics from accelerator labs around the world. Now, great challenges lie ahead in the context of future projects, which strive for highly brilliant secondary-particle beams. For newcomers and researchers alike, there is no better place to learn about stochastic cooling than this book.

Dieter Möhl was one of the foremost experts in the field; ever since the beginning of the adventure in the 1970s, in the team of Simon van der Meer at CERN. Here he has surpassed himself to produce a personal book based not only on his masterful lectures over the years, but also covering, in the proper context and depth, additional subjects that have previously been dispersed across the specialized literature. He goes further by illustrating concepts with his recent personal studies on future projects (e.g. the accumulator ring RESR for the FAIR project) and is well placed to suggest innovations (e.g. alternative methods for stacking and momentum cooling, "split-function" lattices). Insightful remarks based on his experience, invaluable calculation recipes, realistic numerical examples, as well as an excellent bibliography go together to round up the whole book.

In this self-contained book, Möhl provides a superb pedagogical and concise treatment of the subject, from fundamental concepts up to advanced subjects. He describes the analytical formalism of stochastic cooling, stressing, whenever important, its interplay with the machine hardware and beam diagnostics.

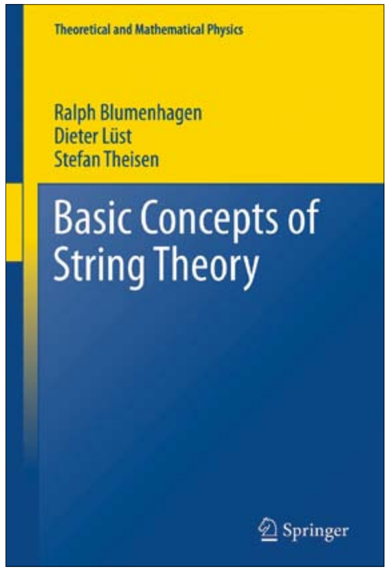
The first six chapters introduce the ingredients of the state of the art of stochastic cooling. With deep insight, Möhl explains in chapter 2 all of the different techniques for betatron and/or momentum cooling. This is the most thorough yet compact overview that I know of, a great service to system designers and operators. In both the time-domain and frequency-domain pictures, the reader is guided step by step and with great clarity into delicate aspects of the subject (for instance, the mixing and power requirements) as well as rather complex calculations (such as for betatron cooling, the feedback via the beam and the cooling by nonlinear pickups and kickers). A great help to newcomers and a handy reference for the experts comes in the form of the comprehensive summary on the pickup and kicker impedances in chapter 3 as well as the discussion of the Schottky noise in chapter 4.

Chapter 7 deals with the Fokker-Planck equation and remarkably summarizes

its most important application, namely in modelling the beam accumulation by stochastic cooling. The notoriously difficult bunched-beam cooling, which is of great interest for future colliders, is lucidly reviewed in chapter 8.

Dieter Möhl had practically finished the book when he unexpectedly passed away (*CERN Courier* January/February 2013 p44). Throughout this work of reference, his modesty and generosity emerge together with the quintessence of stochastic cooling, as part of his legacy.

- *Christina Dimopoulou, GSI/Darmstadt.*



Basic Concepts of String Theory

By Ralph Blumenhagen, Dieter Lüst and Stefan Theisen

Springer

Hardback: £72 €84.35 $99
E-book: £56.99 €67.82 $69.95

This new textbook features an introduction to string theory, a fundamental line of research in theoretical physics during recent decades. String theory provides a framework for unifying particle physics and gravity in a coherent manner and, moreover, appears also to be consistent at the quantum level. This sets it apart from other attempts at that goal. More generally, string theory plays an important role as a generator of ideas and "toy" models in many areas of theoretical physics and mathematics; the spin-off includes the application of mathematical methods, originally motivated by and developed within string theory, to other areas. For example, string theory helps in the understanding of certain properties of gauge theories, black holes, the early universe and heavy-ion physics.

Thus any student and researcher of particle physics should have some knowledge of this important field. The book under discussion provides an excellent basis for that. It encompasses a range of essential and advanced topics, aiming at mid- to high-level students and researchers who really want to get into the subject and/or would like to look up some facts. For beginners, who just want to gain an impression of what string theory is all about, the book might be a little hefty and deterring. It really requires a serious effort to master it, and corresponds to at least a one-year course on string theory.

The book offers a refreshing mix of basic facts and up-to-date research, and avoids giving too much space to formal and relatively boring subjects such as the quantization of the bosonic string. Rather, the main focus is on the construction and properties of the various string theories in 10 dimensions and their compactifications to lower dimensions; it also includes thorough discussions of D-branes, fluxes and dualities. A particular emphasis is given to the two-dimensional world-sheet, or conformal field-theoretical point of view, which is more "stringy" than the popular supergravity approach. Filling this important gap is one of the strengths of this book, which sets it apart from other recent, similar books.

This is in line with the general focus of the book, namely the unification aspect of string theory, whose main aim is to explain, or at least describe, all known particles and interactions in one consistent framework. In recent years, additional aspects of string theory have been become increasingly popular and important lines of research, including the anti-de-Sitter/conformal-field-theory (AdS/CFT) correspondence and the quantum properties of black holes. The book barely touches on these subjects, which is wise because even the basic material would be more than would fit into the same book. For these subjects, a second volume may be in order.

All in all, this book is a perfect guide for someone with some moderate prior exposure to field and string theory, who likes to get into the principles and technical details of string model construction.

- *Wolfgang Lerche, CERN.*

Inside (photo)story

Pictures from a laboratory

In September, amateur and professional photographers had the opportunity to explore particle-physics laboratories around the world in the second Particle Physics Photowalk.

For the second Global Particle Physics Photowalk, 10 of the world's leading particle-physics laboratories offered rare, behind-the-scenes access to their scientific facilities to hundreds of photographers. The participating laboratories then made their selections, nominating 10 photographs to be judged separately by an international jury – photographers Stanley Greenberg from the US, Roy Robertson from the UK, Andrew Haw from Canada and Luca Casonato from Italy – as well as by a "people's choice" of more than 1250 photography enthusiasts who voted online.

The photographs shown here are the winners of the two competitions: one chosen by the jury (bottom) and one by the "people's choice" (top). Italy took top honours in both competitions among a strong field. The top 39 photographs, including the six winners of both competitions, are now available online at www.flickr.com/photos/interactions_photos/sets/72157632715630871.

This second Particle Physics Photowalk was organized by the InterActions Collaboration, whose members represent particle-physics laboratories in Asia, North America and Europe. The first such event was organized in 2010 (*CERN Courier* December 2010 p28).

- *The participating Particle Physics Photowalk laboratories were: Brookhaven National Laboratory (US), Catania National Laboratory (Italy), Chilbolton Observatory (UK), Daresbury Laboratory (UK), Fermi National Accelerator Laboratory (US), Frascati National Laboratory (Italy), Gran Sasso National Laboratory (Italy), Rutherford Appleton Laboratory (UK), TRIUMF (Canada) and the UK Astronomy Technology Centre.*

Winner of the People's Choice Competition, this image shows an access tunnel connecting the experiment caverns of the Gran Sasso National Laboratory of the Italian Institute for Nuclear Physics (INFN). (Image credit: Nino Bruno.)

Winner of the Jury Competition, this image shows colourful close-up detail of the KLOE detector at INFN's Frascati National Laboratory. (Image credit: Joseph Paul Boccio.)


Touch screen for local control
NIM and standalone in ONE unit

CERNCOURIER

VOLUME 53 NUMBER 5 JUNE 2013

Contents