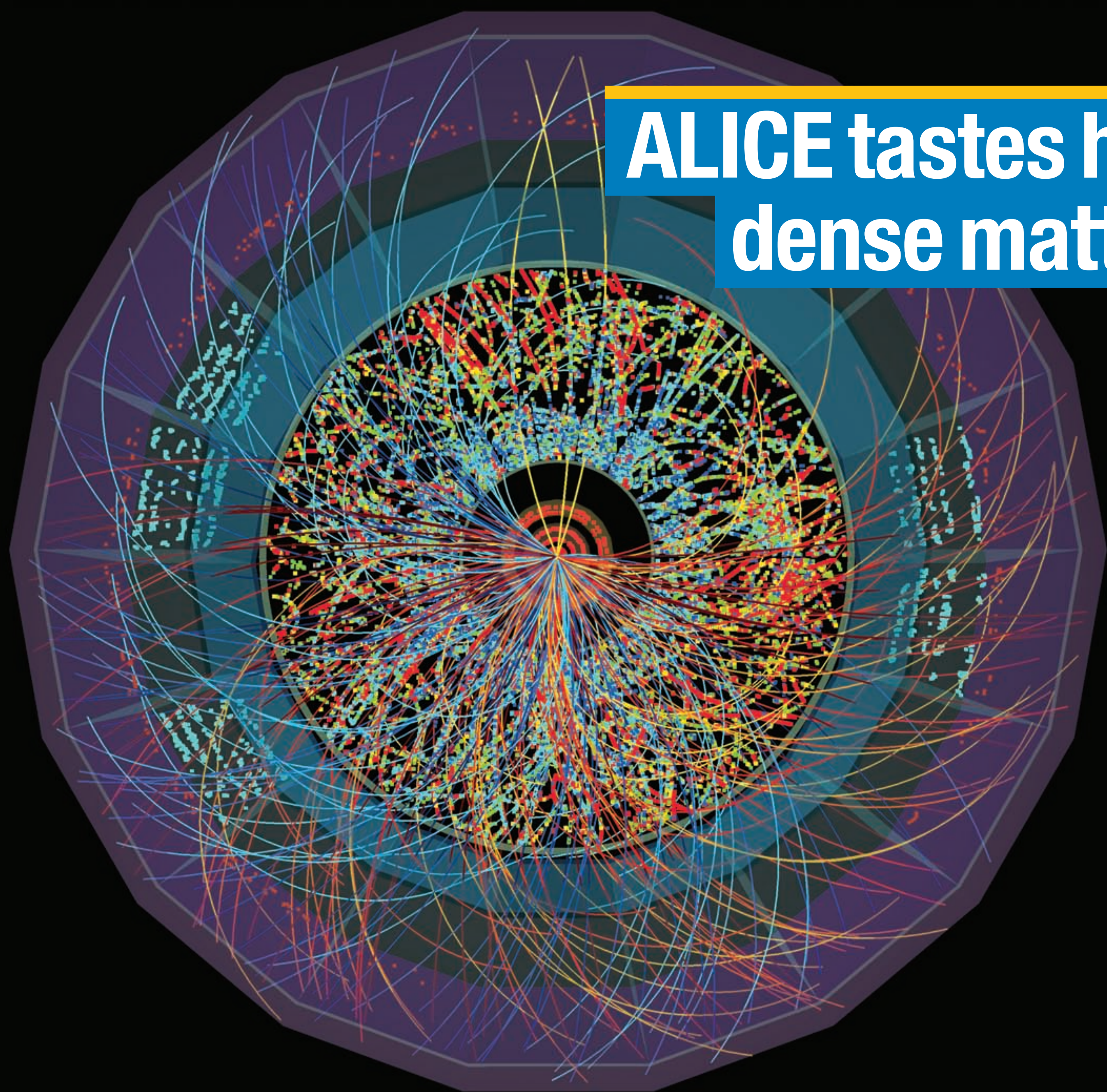
INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERNCOURIER

VOLUME 51 NUMBER 5 JUNE 2011



ALICE tastes hot dense matter

TRIBUTE

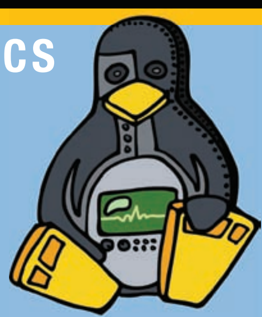
Colleagues recall a Nobel laureate and friend

p24

ELECTRONICS

Welcome to the repository for open hardware

p13



BEAUTY IN AMSTERDAM

Reporting from the conference on B-meson physics **p21**

Since 1959

Source for trouble free Crate Design

A Phoenix Mecano Company

NIM Crates - The Originals

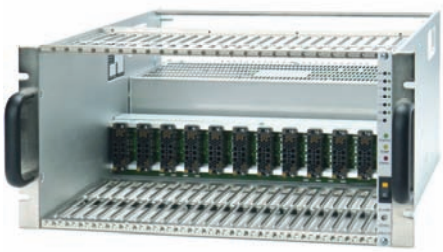
NIMcompact

BUDGET NIM CRATES

NIMcompact 12 Slot 5U x 19'' and 7 Slot 5U transportable
Linear slot power supply 150W occupies two slots at right side

NIMpact 12 Slot 5U x 19''
Linear power supply 300W or **New 600W**, optional ventilated

NIMpact 300W ventilated



CERN type non-ventilated

CERN SPEC. TYPE NIM CRATES

With very ruggedized mechanics
Fan tray and Power Supply easy to replace
CANbus interface for remote monitoring and control optional
Linear power supplies 300W, 600W or low noise switching up to 2kW

Full in accordance with CERN Spec. assures world wide compatibility

CERN type 600W ventilated

NIM 6000 ventilated

6000 SERIES NIM CRATES

powerful high performance crates with lowest noise switching power supplies

TCP/IP-CANbus-RS232 interface for remote monitoring and control
Programmable power supply, working also in WIENER VME 64 and 64x crates due to plug & play technology (automatic voltage programming)

Fan trays with three or six fans feature efficient cooling of inserted modules even at highest power

Type	Power / W	Technology	± 6VDC / A	± 12VDC / A	± 24VDC / A	PARD/mV_{pp}	115VAC / A
NIMcompact	150	linear	5 / 8	3 / 1,5	1,5	3 / 5 / 10	0,25
NIMpact	300	linear	7 - 15	3,4 - 15	3,4 - 6,9	<5	0,5
NIMpact	600	linear	15 - 40	8 - 15	7	<5	0,5
NIM Cern	300	linear	0 / 17	15 / 3,4	1 / 3,4	<3	0,5
NIM Cern	600	linear	20 / 46	15 / 8	2 / 8	<3	0,5
NIM PS Cern	1920 (2300)	switched	80 (100)	20 - 23	10 - 11,5	<10	-
NIM 6000	1650	switched	45	23	11,5	<10	-
NIM 6000	3000	switched	115	23	23	<10	-
NIM 6000	3000	switched	115	46	11,5	<10	-

Periodic and Random Distortion PARD measured at full load. Special output current ranges on request. All DC outputs with Crowbar protection.

WIENER, Plein & Baus GmbH - Muellersbaum 20, D51399 Burscheid (Germany)
Fon:+49 2174 6780 – FAX: +49 2174 678 55
Web: www.wiener-d.com

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
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) Ilka Flegel, Ute Wilhelmsen
EMFCSC (Italy) Anna Cavallini
Enrico Fermi Centre (Italy) Guido Piragino
Fermi National Accelerator Laboratory (US) Judy Jackson
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) Youhei Morita
Lawrence Berkeley Laboratory (US) Spencer Klein
Los Alamos National Laboratory (US) Rajan Gupta
NCSL (US) Ken Kingery
Nikhef (Netherlands) Paul de Jong
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) Peter Barratt
TRIUMF Laboratory (Canada) Marcello Pavan

Produced for CERN by IOP Publishing Ltd
IOP Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel +44 (0)117 929 7481

Publisher Susan Curtis
Production editor Jesse Karjalainen
Technical illustrator Alison Tovey
Group advertising manager Ed Jost
Recruitment advertisement manager Chris Thomas
Advertisement production Katie Graham
Marketing & Circulation Jo Pittam

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

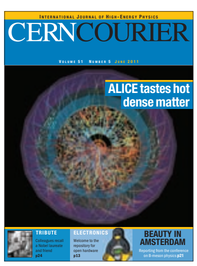
Printed by Warners (Midlands) plc, Bourne, Lincolnshire, UK

 ISSN 0304-288X

IOP Publishing CERN

CERNCOURIER

VOLUME 51 NUMBER 5 JUNE 2011



On the cover: One of the first lead–lead collisions recorded by the ALICE experiment at the LHC on 9 November 2010. The shaded structures represent a perspective view of the detector elements. The lines are the reconstructed particle trajectories and the colour scale indicates the energy of the particles. The heavy-ion run in November gave ALICE its first taste of hot dense matter at the LHC (p17).

nEXT300D Turbopump


nEXT Turbopumping System


STPiX2206C
Maglev Turbopump

VACUUM & ABATEMENT ***INNOVATIVE TECHNOLOGY*** ***GLOBAL STRENGTH*** ***LOCAL SUPPORT***

Think Turbopump, Think Edwards...

Did you know Edwards is the leading manufacturer and supplier of turbopumps worldwide?

nEXT turbopumps for pumping speeds up to 400l/s
- Optimal pumping speeds and compression ratios
- True end user serviceability without complex tooling

STP maglev turbopumps, for pumping speeds from 300 to 4500l/s
- Very low noise and vibration
- Zero maintenance in most R&D applications

Whatever your turbopump requirement, whether discreet pump or ready made pumping stations, be assured Edwards has the solution and application expertise to meet your needs.

Think Turbopump,Think Edwards:
www.edwardsvacuum.com
turbo@edwardsvacuum.com

EDWARDS
WWW.EDWARDSVACUUM.COM

News

CERN

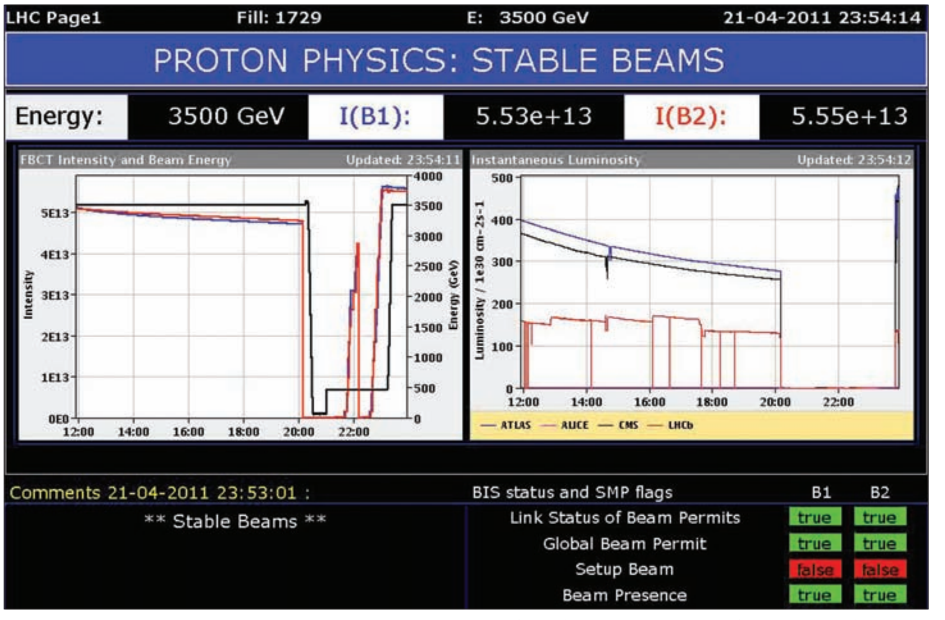
LHC sets world record beam intensity

Just before midnight on 21 April, the LHC set a new world record for beam intensity at a hadron collider when its beams collided with a peak luminosity of 4.67×10^{32} m^{-2}s^{-1}. This exceeds the previous world record of 4.024×10^{32} cm^{-2}s^{-1}, which was set by Fermilab's Tevatron collider in 2010, and marks an important milestone in LHC commissioning. The new record, made with 480 bunches per beam, lasted only a couple of days before collisions with 768 bunches per beam delivered around 8.4×10^{32} cm^{-2}s^{-1}. By the time a period of machine development began in the first week in May, the integrated luminosity for ATLAS and CMS for 2011 had reached more than 250 pb^{-1}.

Early in April, a period of "scrubbing" took place to improve the surface characteristics of the beam pipe (*CERN Courier* May 2011 p7). This run saw more than 1000 high-intensity bunches per beam circulating at 450 GeV with 50 ns spacing. Given the potential luminosity performance (more bunches, higher bunch intensity from the injectors), the decision was taken to continue the 2011 physics run with this bunch spacing.

For 50 ns injection into the LHC, the Super Proton Synchrotron (SPS) takes batches of 36 bunches from the Proton Synchrotron. Since the scrubbing run, the LHC has passed through 228, 336, 480 and 624 bunches per beam to reach the latest total of 768. Each step-up of 144 bunches represents two extra injections of 72 bunches (2×36) from the SPS. This is a considerable amount of beam power and the injection process needs to be carefully tuned and monitored. A few days is spent delivering physics after each step-up to check the performance of the machine and make sure that no intensity-dependent effects are compromising machine protection.

The push-up in the number of bunches will continue towards a potential maximum for the year of around 1400.

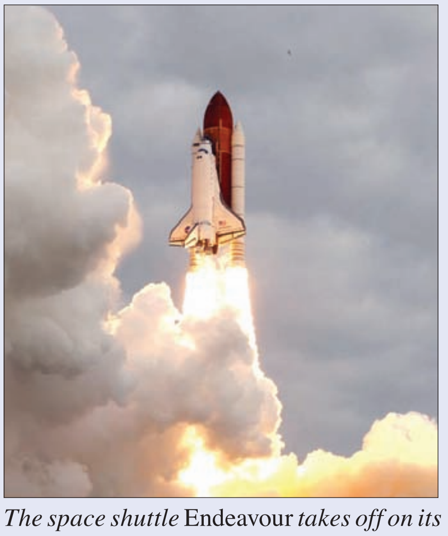


The "Page 1" screen for the LHC, just as it reached the luminosity record on 21 April.

AMS takes off

The space shuttle *Endeavour* launched successfully on its 25th and final spaceflight on 16 May at 08.56 a.m. local time. It carried the Alpha Magnetic Spectrometer (AMS-02), designed to operate as an external module on the International Space Station (ISS). *Endeavour* was scheduled to dock with the ISS nearly 48 hours later, on 18 May, for a 16-day mission. A problem with an auxilliary power unit had led to the last-minute postponement of the earlier planned launch on 29 April.

AMS will study the universe and its origin by searching for antimatter and dark matter while performing precision measurements of the composition and flux of cosmic rays. There will be more about the mission in the next issue of *CERN Courier*.



The space shuttle Endeavour *takes off on its final mission. (Image credit: NASA.)*

Sommaire en français

News

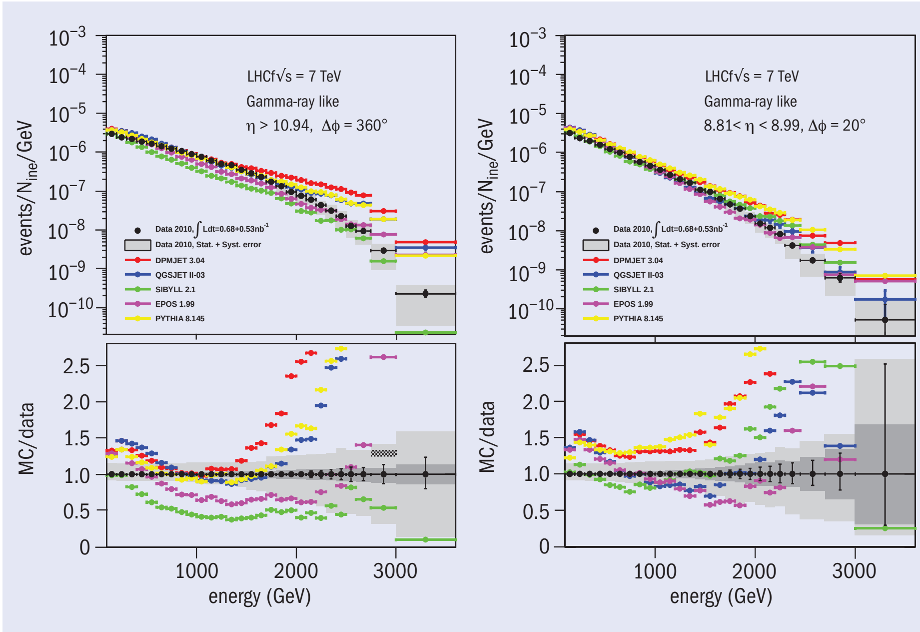
LHC PHYSICS

LHCf measures very forward photons

The LHCf collaboration has measured the production spectrum of photons using the highest-energy accelerator beams in the world, at CERN's LHC machine. With proton beams at 3.5 TeV the total collision energy is equivalent to when protons of 2.5×10^{16} eV strike a stationary target, which is an energy region that is of interest to cosmic-ray physicists.

The LHCf experiment consists of two independent calorimeters installed on either side of the ATLAS interaction point at the LHC. Using data obtained in 2010 during proton runs at 7 TeV in the centre-of-mass, the collaboration has measured the photons emitted into two very forward regions, that is, close to zero degrees to the beam direction, in the pseudo-rapidity ranges from 8.81 to 8.99 and from 10.94 to infinity (Adriani *et al*. 2011). To minimize contamination from beam-gas background and pile-up events, the team chose a limited but best dataset corresponding to an integrated luminosity of $0.68\,nb^{-1}$. After selecting single photon-like events in common pseudo-rapidity ranges, they obtained consistent energy spectra from two detectors.

The collaboration has compared its data with the predictions from various hadron interaction models used in the study of cosmic-ray air showers, together with PYTHIA 8.145, which is popular in the high-energy-physics community. As the figure shows, there is significant deviation between the data and model above 2 TeV in the higher rapidity region. Three well known models – DPMJET 3.04, QGSJET II-03 and PYTHIA 8.145 – predict significantly higher photon yields than the experiment finds above 2 TeV, but agree reasonably well with the data at 0.5–1.5 TeV. The other models – SIBYLL 2.1 and EPOS 1.99 – do not predict such high photon yields but predict a smaller yield over the whole energy range.



Comparison of the measured single-photon energy spectra (black) with the predictions of Monte Carlo simulations (colour), with the spectra above and the ratios of Monte Carlo results to experimental data below. The left (right) panel shows the results for the large (small) rapidity range. Error bars and grey shaded areas indicate experimental statistical and systematic errors, respectively. The blue shaded area indicates the statistical error of the MC data set.

The difference is less marked in the lower rapidity region, but nevertheless none of the models shows perfect agreement with data.

The energy spectra of collision products at high-rapidities are crucial to understand correctly the development of cosmic-ray-induced air showers. Following recent notable improvements in observations of ultra-high-energy cosmic rays (UHECR), it is becoming increasingly important to reduce the uncertainty in the hadron interaction models (*CERN Courier* July/August 2006 p6). The impact of the current LHCf results on cosmic-ray physics is now under study as the collaboration works together with theorists on further analyses of the data on neutral pions and neutrons. The data will also cast light on the energy dependence of hadron interactions and the extrapolation into the UHECR energy range. At the same time, the collaboration is studying the feasibility of data-taking during ion collisions (ion–ion and/or proton–ion), which would give a better simulation of cosmic-ray-air collisions.

● **Further reading:**

O Adriani *et al.* 2011 arXiv 1104.5294 [hep-ex].

CMS measures single-top production at 7 TeV

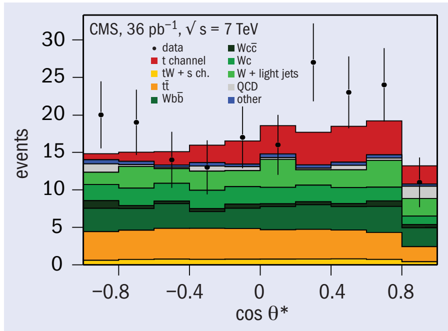
The top quark was first observed in the mid-1990s by the CDF and DØ experiments at the Tevatron collider at Fermilab. These were produced and observed as top-antitop pairs, but it was not until 2009 that the two experiments reported the observation of single-top quarks (*CERN Courier* April 2009 p9). The ATLAS and CMS experiments at the LHC reported the first signs of top-antitop last summer, just a few months after the first collisions at a centre-of-mass energy of 7 TeV. Now, CMS has completed two complementary single-top analyses using the full data sample of 2010; that is, an integrated luminosity of $36\,pb^{-1}$.

Such single tops are much more difficult to observe experimentally because they are produced at a lower rate and have a less distinctive signature compared with top-antitop pairs. This makes it more difficult to distinguish single-top events from the background physics processes.

In their recent analyses, the CMS collaboration focused on the production of single top via the so-called "t-channel W boson exchange" process in which the top quark emerges from the exchanged W together with a light quark. They observed the top quark through its decay into a W boson and a b-quark. The W boson was detected in turn through its decay to a charged lepton (electron or muon) plus a neutrino, while the jet from the b-quark was tagged by the high-precision silicon tracking detectors in CMS.

The two analyses establish the observation of single-top production by CMS with a statistical significance of about 3.5 σ. One analysis exploited the angular characteristics between the light quark jet and final-state lepton, shown in the figure, while the other used a multivariate analysis technique to separate the signal from the background. Data-driven background estimates were used in both these analyses. The two analysis methods were combined to yield a cross-section for single-top production in proton–proton collisions at 7 TeV of 83.6± 29.8 (stat+syst.)± 3.3 (lumi.) pb. This result agrees well with the rate predicted by the Standard Model.

Such a rapid detection of the elusive single top, despite the challenging background conditions, shows that the experiments are well prepared to detect and measure signals of new physics. These may soon manifest themselves as the LHC continues to produce ever more data at the high-energy frontier.



The cosine of the angle between the charged lepton and the light quark jet, as measured in the top-quark rest-frame. The single-top signal is shown (in red) together with the different background components.

ATLAS explores new frontiers with high-p_T jet measurements

The ATLAS collaboration has announced its latest cross-section measurements of inclusive jet and dijet production, which involve final states containing at least one or two jets, respectively. Each jet is the result of a parton (quark or gluon) that emits radiation through the strong force, creating a collimated spray of hadrons.

These high-p_T jet measurements confront QCD, the theory of the strong force, in a large and previously unexplored kinematic region in jet transverse-momentum and dijet invariant-mass. The measurements constitute one of the most stringent tests of QCD ever performed. They probe predictions of perturbative QCD, constrain the density of partons within the proton and are sensitive to new physics scenarios, such as quark compositeness, which may become apparent at very short distance scales.

The analysis uses the full data sample collected in LHC proton–proton collisions at 7 TeV during 2010, corresponding to an integrated luminosity of 37 pb^{-1}. The results extend far beyond the kinematic reach achieved at the Tevatron, as do recent results from CMS (CMS collaboration 2011). The ATLAS results extend to 1.5 TeV in jet transverse-momentum (as in figure 1) and to 4.1 TeV in dijet invariant-mass. These jet measurements also provide unprecedented coverage out to forward rapidities of $|y|<4.4$. Next-to-leading order perturbative QCD predictions are found to be in good agreement with the measured data across 10 orders of magnitude in cross-section (figure 2).

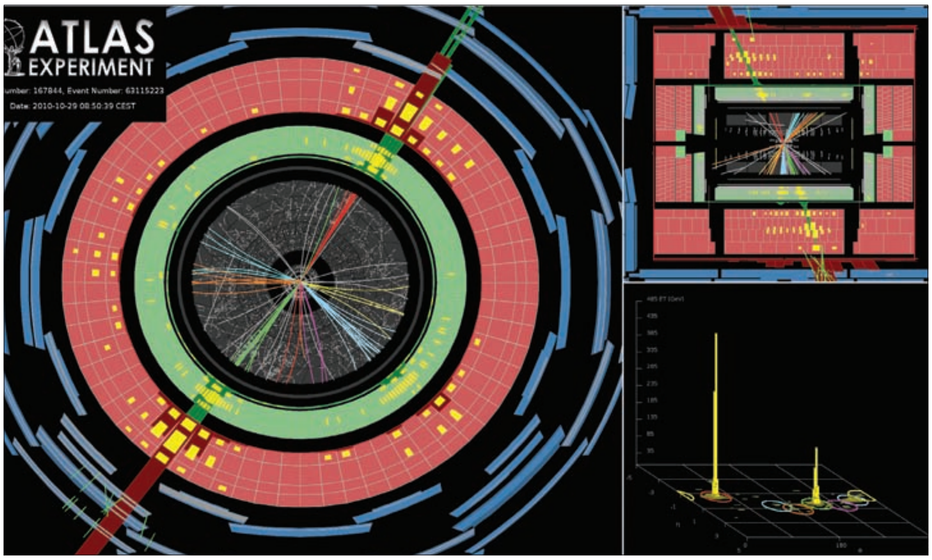


Fig. 1. Event display of the highest transverse momentum jet collected by ATLAS during a 2010 run, which has p_T of 1.5 TeV. The second leading jet in the event has p_T of 1.0 TeV.

The jet cross-section measurements have been corrected for detector effects, and the analysis exploits a greatly improved understanding of the detector performance. The dominant source of systematic uncertainty is in the calibration of the jet energy scale, which has been determined to within 2.5% for central jets with p_T above 60 GeV.

A publication is currently in preparation. Work is on-going to reduce the systematic uncertainties further and the collaboration will extend the kinematic reach of these exciting high-p_T jet measurements with much larger datasets in 2011–2012.

● **Further reading:**

For these results and more, see https://twiki.cern.ch/twiki/bin/view/AtlasPublic.

ATLAS collaboration 2011 ATLAS-CONF-2011-047.

CMS collaboration 2011 arXiv:1104.1693.

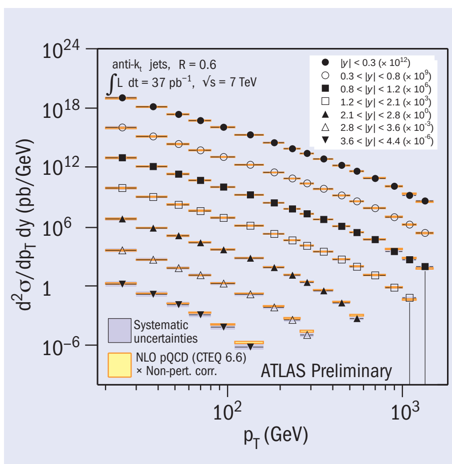


Fig. 2. Inclusive jet p_T spectrum in different rapidity bins measured by ATLAS. The results are in good agreement with predictions of next-to-leading order perturbative QCD (NLO pQCD).

News

HEAVY IONS

RHIC reveals heaviest antimatter

Members of the international STAR collaboration at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory have observed antihelium-4. This is the heaviest antinucleus detected so far, following the discovery of the first antihypernucleus (an antiproton, an antineutron and a $\bar{\Lambda}$) by the same collaboration just a year ago. After sifting through 0.5×10^{12} tracks in data for 10^9 gold–gold collisions at centre-of-mass energies of 200 GeV and 62 GeV per nucleon–nucleon pair, the STAR collaboration found 18 events with the signature of the antihelium-4 nucleus, which is distinguished by its mass together with its charge of -2.

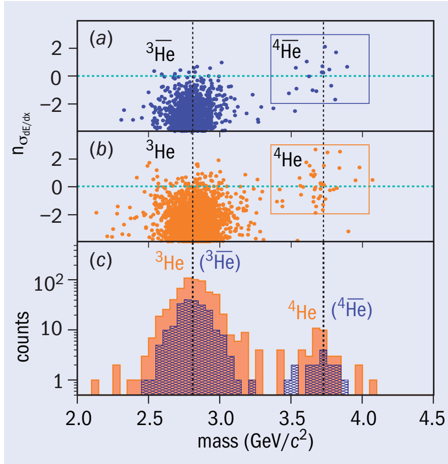
While the curvature of the tracks in the magnetic field of the STAR detector provide a momentum measurement, key information also comes from the mean energy-loss per unit track length, $\langle dE/dx\rangle$, in the gas of the TPC and from the time of flight of particles arriving at the time-of-flight barrel that surrounds the TPC. The $\langle dE/dx\rangle$ information helps in identification by distinguishing particles with different masses or charges, the time of flight being needed for identification at higher momenta, above 1.75 GeV/c. The figure shows the identification of isotopes based on energy loss and mass calculated from momentum in the region of helium-3 and helium-4 for both positive and negative particles, with 18 counts for antihelium-4.

The team used this observation to calculate the antimatter yield at RHIC and found that the production rate falls by a factor of $1.6 +1.0/–0.6\times10^3$ ($1.1 +0.3/–0.2\times10^3$) for each additional antinucleon (nucleon). This is in line with the expectations from coalescent nucleosynthesis models, as well as from thermodynamic models.

The finding ties in with the scientific goals of the Alpha Magnetic Spectrometer launched on 16 May (p6), which will search for antimatter in space. It also nicely marks the centenary of the paper by Ernest Rutherford in which he analysed the scattering of helium nuclei (alpha particles) on gold and first established the existence of the atomic nucleus (*CERN Courier* May 2011 p20).

● **Further reading:**

STAR collaboration 2011 *Nature* online doi:10.1038/nature10079.



Isotope identification based on energy loss and mass calculated from momentum per charge and time of flight. a, b) The masses of ^{3}He ($^3\overline{He}$) and ^{4}He ($^4\overline{He}$) are indicated by the black vertical dashed lines. The light blue horizontal dashed line marks the position of zero deviation from the expected value of $\langle dE/dx\rangle$ for ^{4}He ($^4\overline{He}$). The rectangular boxes highlight areas for ^{4}He ($^4\overline{He}$) selections. c) A projection of entries in a and b onto the mass axis (STAR collaboration 2011).

FACILITIES

Italy approves long-term funding for the SuperB project

The Italian government has approved the long-term funding of the SuperB project. Mariastella Gelmini, the Italian minister for university education and research, announced on 19 April that the Interministerial Committee for Economic Programming had approved the National Research Plan 2011–2013. This sets out the future direction of 14 flagship projects, including SuperB.

The SuperB project is based on the principle that smaller particle accelerators, operating at a low energy can still give excellent scientific results complementary to the high-energy frontier. The project centres on an asymmetric electron–positron collider with a peak luminosity of 10^{36} cm^{-2} s^{-1}. Such a high luminosity will allow the indirect exploration of new effects in the physics of heavy quarks and flavours at energy scales up to 10–100 TeV, through studies at only 10 GeV in the centre-of-mass of large samples of B, D and τ decays. At full power, SuperB should be able to produce 1000 pairs of B mesons and the same number of τ pairs, as well as several thousand D mesons every second. The design is based on ideas developed in Italy and tested by the accelerator division of the National Laboratories of INFN in Frascati using the machine called Daϕne.

Sponsored by the National Institute of Nuclear Physics (INFN), Super B is to be built in Italy with international involvement. Many countries have expressed an interest in the project and physicists from Canada, France, Germany, Israel, Norway, Poland, Russia, Spain, the UK and the US are taking part in the design effort.

The Istituto Italiano di Tecnologia is co-operating with INFN on the project, which should help in the development of innovative techniques with an important impact in technology and other research areas. It will be possible to use the accelerator as a high-brilliance light source, for example. The machine will be equipped with several photon channels, allowing the extension of the scientific programme to the physics of matter and biotechnology.

__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.

Sciencewatch

COMPILED BY JOHN SWAIN, NORTHEASTERN UNIVERSITY

Lasers take inspiration from the birds

Traditional lasers use mirrors to trap light in an amplifying medium, but the brightly coloured feathers of birds like parrots and kingfishers suggest another approach. Such birds owe their colours not to pigments, but to light bouncing off tiny air pockets inside the otherwise transparent material of the feathers. Their arrangement is ordered at short distances like a photonic crystal, with the spacing setting the colour, but disordered on larger scales.

Motivated by this, Heeso Noh of Yale University and colleagues mimicked this structure in gallium arsenide by creating a regular array of embedded quantum dots containing an amorphous array of air holes. The team etched an array of holes roughly 150 nm wide into a gallium arsenide film. When illuminated, this strange structure lased – the first time that laser action has been seen in such a material.

Random lasers have been made before, but this new material is much more efficient and, remarkably, despite having no photonic bandgap, exhibits wavelength peaks that can be tuned by varying the details of how the material is made.

● **Further reading**

Heeso Noh *et al.* 2011 *Phys. Rev. Letts.* **106** 183901.

Bouncing light: kingfishers do it without mirrors. (Image credit: Juan Pablo Fuentes Serrano/dreamstime.com.)

A saltwater–freshwater battery

A new type of battery based on the entropy difference between fresh and salty water could be the basis for a vast new source of renewable energy. Yi Cui of Stanford University and colleagues built their battery with one electrode made of sodium manganese oxide nanorods that selectively take up and release sodium ions, and a silver electrode that does the same for chloride ions. The electrodes can be put in fresh water and the battery charged, then moved to sea water where electrical energy can be extracted.

The cyclical process can be repeated indefinitely with a net gain in energy each cycle from the mixing of saltwater and freshwater, with efficiencies as high as 74%. Such batteries could produce as much as 13% of the current world energy consumption from places where fresh and salt water mix naturally.

● **Further reading**

Fabio La Mantia *et al.* 2011 *Nano Letters* doi:10.1021/nl200500s.

Alcohol helps to induce a state of… superconductivity

Alcohol often plays a role in physics, typically in the context of discussions over drinks, but now it seems that it may have a much more direct mode of action in some superconductors. Keita Deguchi of the National Institute for Materials Science in Tsukuba, Japan, and colleagues have shown that hot alcoholic beverages can induce superconductivity in an iron tellurium sulphide material.

Beer, sake, shochu, whisky and white wine all work, but the best results are obtained by heating with red wine for 24 hours. The mechanism involved is still not known. It may have do with alcohol supplying oxygen to the material, but pure mixtures of ethanol and water do not work as well as any of the actual beverages. Exposure to air alone will also do the trick, but that takes months, so the alcohol treatment makes quite a difference. Because this year marks the 100th anniversary of the discovery of superconductivity, some further research with champagne may be appropriate.

● **Further reading**

K Deguchi *et al.* 2011 *Superconductor Science and Technology* **24** 055008.

Swimming in sand

Some lizards swim through sand much as fish swim through water. Now it seems that they do it about as well as possible and that their behaviour can be copied. Ryan Maladen of the Georgia Institute of Technology in Atlanta and colleagues used a model that they had developed earlier for motion in granular media (resistive-force theory, which takes into account the fact that sand can both be like a solid and a liquid) together with X-ray videographs of sandfish lizards (*Scincus scincus*) to study in detail how the creatures move.

The researchers found that the lizard's sinusoidal body writhings that propel it are more or less optimal. The team also managed to make segmented robots that, when stuffed into a sock and wrapped in a spandex "swimsuit", could swim through sand just like the lizards. Apart from its intrinsic interest, this work could lead to new robots that might help to burrow through dirt or mud after earthquakes or landslides.

● **Further reading**

R D Maladen *et al.* 2011 *Proc. Roy. Soc.* doi:10.1098/rsif.2010.0678.

Language out of Africa

Human genetic and phenotypic diversity falls off with distance from Africa – a fact that can be understood if people originally came from Africa, migrating outwards with intermediate bottlenecks each of which would give reductions in diversity. Quentin Atkinson of the University of Auckland has found a similar falloff in the diversity of phonemes – units of sound that make up words – in modern spoken languages.

Using data from 504 languages in the database of the *World Atlas of Language Structures* he finds strong support for the idea that spoken language originated in Africa. With the origin of language earlier than the African exodus some 50 000 to 70 000 years ago, it may well have arisen around the same time indicated by the earliest archaeological evidence for symbolic culture in Africa (some 80 000 to 160 000 years ago). So, the two developments could be related.

● **Further reading**

Quentin D Atkinson 2011 *Science* **332** 346.

Astrowatch

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

Gravity Probe B confirms Einstein's general relativity

The final results of the Gravity Probe B (GP-B) satellite confirm two key predictions of Albert Einstein's general theory of relativity: the geodetic and frame-dragging effects. The precise determination of these two effects, first proposed 50 years ago, seals the success of this extremely challenging mission.

The history of Gravity Probe B started in 1961 with a proposal to NASA to develop a relativity gyroscope experiment. A refined "Proposal to develop a zero-G, drag-free satellite and to perform a gyro test of general relativity in a satellite" was submitted in November 1962 and funded one year later. Defining the mission was relatively simple but solving all of the technological challenges to obtain the desired precision became an odyssey.

The basic idea is to place gyroscopes and a telescope in a polar-orbiting satellite; to align both the telescope and the spin axis of each gyroscope with a distant reference point, a guide star; and to keep pointing at this star for a year while measuring the drift in the spin-axis alignment of each gyroscope. The problem is that this has to be achieved with an accuracy of 1 milliarcsecond (mas). In practice, the gyroscopes are four perfect spheres the size of a ping-pong ball with a spin rate of around 70 Hz, which are made of quartz coated with niobium. They have to be kept without any contact inside a quartz housing with an inner radius only 32 μm larger than the balls. One of the gyroscopes is even left free-floating and the entire spacecraft is moved round to keep the device in its housing. Everything has to be completely isolated magnetically and cooled to 1.8 K to achieve superconductivity in the niobium coating that is used to measure the spin axis of the gyroscopes.

One of the four gyroscopes – a perfect niobium-coated quartz ball – and its housing equipped with six electrodes to suspend the ball electrically, and a channel to spin it up with a stream of helium. (Image credit: Gravity Probe B.)

On 4 May, the GP-B team proudly announced: "After 31 years of research and development, 10 years of flight preparation, a 1.5-year flight mission and 5 years of data analysis, our GP-B team has arrived at the final experimental results for this landmark test of Einstein's 1916 general theory of relativity." The results are values for two measurements: a geodetic drift rate of –6601.8±18.3 mas/yr and a frame-dragging drift rate of –37.2±7.2 mas/yr. Both effects are clearly detected and the values are consistent with the predictions of general relativity of –6606.1 mas/yr and –39.2 mas/yr, respectively. The final results are an error-weighted average of the drifts of the spin axes measured on the four individual gyroscopes. The geodetic effect – the deformation of space–time around the Earth – leads to a drift in the north-south direction, while the frame-dragging or Lense–Thirring effect – the entrainment of space–time by the daily rotation of the Earth – results in a west-east drift.

The eventual publication of the results from data acquired between 28 August 2004 and 14 August 2005 must be a relief for Francis Everitt, the principal investigator of GP-B and his team at Stanford University. Extracting the signal from the noise and accounting for all of the systematic effects was a difficult process. The final uncertainty on the frame-dragging effect remains relatively high (19%) and far from the prelaunch goal of achieving an accuracy of 1% (*CERN Courier* June 2004 p13). It does not supersede the accuracy obtained with the LAser GEOdynamics Satellites (LAGEOS) published shortly after the launch of GP-B, although the uncertainty on these measurements remains controversial (*CERN Courier* December 2004 p15). Perhaps the success of the GP-B mission resides more in the extraordinary technological achievements than in the actual results.

Further reading

C W F Everitt *et al.* 2011, *Phys. Rev. Lett.*, in press.

Picture of the month

This stunning, colourful image depicts a small region of the Lagoon Nebula. Also known as Messier 8 (M8) it is located some 5000 light-years away in the direction of the Galactic centre and the constellation Sagittarius. Seen through small telescopes and binoculars as a fuzzy glow, M8 is a region of intense star formation with a characteristic pink hue from ionized hydrogen (Balmer H-α recombination line). While red is indeed the hydrogen emission in this image by the 8-m Gemini South telescope on Cerro Pachón in the Chilean Andes, the other colours are false. Ionized sulphur emission is coded in green and infrared starlight in blue. (Image credit: Julia I Arias and Rodolfo H Barbá Departamento de Física, Universidad de La Serena, Chile; and ICATE-CONICET, Argentina.)

CERN Courier Archive: 1968

A look back to CERN Courier vol. 8, June 1968, compiled by Peggie Rimmer

Home and away

CERN/Serpukhov collaboration

Collaboration with the Institute of High Energy Physics IHEP at the Serpukhov Laboratory, USSR, is fulfilling the highest hopes. At a meeting of the Joint Committee (which has six representatives from each Laboratory) at CERN at the beginning of June, details of the fast ejection system to be provided by CERN were agreed, and a CERN team is preparing to join Soviet colleagues for the first collaborative experiment at the newly commissioned 70 GeV proton synchrotron – the highest-energy machine in the world.

Performance of the accelerator itself is very promising. Protons have been accelerated to 76 GeV and energies even above this may prove possible. The linear injector has produced the remarkably high current of 100 mA at 100 MeV, an outstanding achievement for a linac of such high energy, and the present machine intensity is 3×10^{11} particles per pulse.

The first experiment in the CERN/Serpukhov collaboration is of a type often known as a "yield experiment", usually among the first to be done on a new machine. It gives information on the number of the different types of secondary particles yielded by targets bombarded by the accelerated proton beam. It does not make heavy demands on the machine performance and yet knowledge of the different yields is very important for optimizing the layout of secondary-particle beams in the experimental hall. Following the yield study

The Serpukhov linear accelerator/injector with the vacuum lids removed. (Image credit: Serpukhov.)

will be a programme of measurements of total cross-sections, another "first thing to do" when a new energy range becomes available.

CERN scientists will probably go to Serpukhov in groups of about six at a time for periods of three to six months and, whenever possible, their families will go with them. They will be drawn from the team that did the equivalent experiment at CERN – J Allaby, A Diddens, A Klovning, E Sacharidis, K Schlüpmann, A Wetherell, F Binon, P Duteil, R Meunier, J P Peigneux, J P Spighel and J P Stroot.

● Compiled from text on pp123, 128 and 134.

TRIUMF

In April the Canadian government announced initial grants amounting to \$1.3 m for a cyclotron to be built at the University of British Columbia. The project, known as TRIUMF, an acronym for TRI-University Meson Facility, was initially proposed by three Universities – Victoria, Simon Fraser and British Columbia. The University of Alberta joined in 1967.

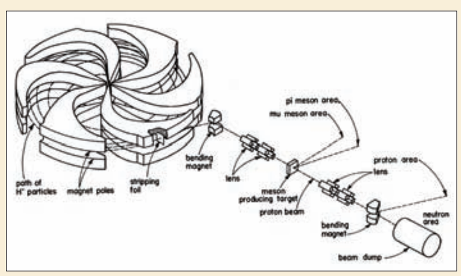
TRIUMF is intended to provide an advanced instrument for intermediate-energy physics to serve particularly the scientists on the west coast of Canada and is expected to be in operation by 1974.

By incorporating two comparatively recent advances in cyclotron technology, it will be able to produce protons in the energy range 200–500 MeV with a beam intensity a thousand times higher than at existing equivalent machines. Research will be possible using the proton beam itself, intense beams of pions and muons and a high flux of thermal neutrons, with the great advantage that all these beams can be produced and used simultaneously (see drawing).

One of the two advances which yields the higher performance for the machine is the use of sector-focusing. This involves replacing the conventional cyclotron magnet by specially shaped magnet sectors which introduce strong (or alternating-gradient) focusing and maintain a constant revolution frequency for the particles so that the r.f. accelerating frequency can also be held constant (rather than adjusting to the revolution frequency as in the synchro-cyclotron).

The second development involves accelerating a beam of negative hydrogen ions H^- rather than protons, by adding an electron to the hydrogen atom in the ion source. When the desired energy has been reached, the ion is passed through a very thin foil to strip off the electrons and release the proton. Since the protons are of opposite charge to the accelerated ions, the magnetic field of the cyclotron bends the protons out of the machine, circumventing one of the major problems of cyclotrons, namely extracting accelerated protons. Extraction efficiencies on proton cyclotrons rarely exceed 50%, while TRIUMF will achieve 99%. The idea of H^- cyclotrons has been developed principally at University of California, Los Angeles, where it was first shown to work in 1961.

● Compiled from texts on pp136 and 137.



The layout of extracted beams will allow simultaneous use of mesons, protons and neutrons.

Compiler's Note

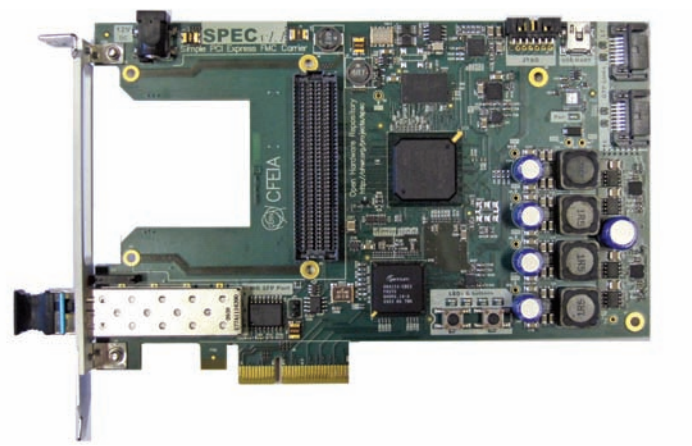
Competition in space science between the Soviet Union and the US intensified when cosmonaut Yuri Gagarin circled the Earth in just 108 minutes 50 years ago. By contrast, contemporaneous Soviet plans to build the world's highest-energy accelerator at Serpukhov triggered a collaborative agreement between CERN and IHEP that would involve not only scientists and engineers but, of necessity, industrialists and politicians.

Co-operation has remained a cornerstone of CERN policy since its foundation, despite fluctuating international tensions and conflicts, especially during the difficult years of the Cold War. By now, non-member-state users make up some 37% of the 10 000 researchers at CERN, representing 52% of the 600 participating universities and institutes. Notably, around 22% of non-member-state users are from the Russian Federation and 45% from the US. Might a Nobel Peace Prize be in order one day?

Electronics

Hardware joins the open movement

The Open Hardware Repository enables electronics designers to collaborate in the design process. Now, CERN has released an Open Hardware Licence to allow this knowledge to be shared.

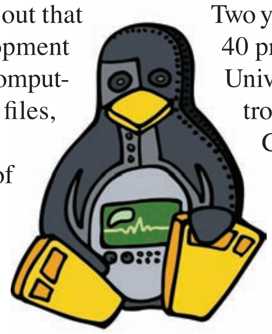


A circuit board designed within the context of the Open Hardware Repository. The reverse side bears the licence statement: "Licensed under CERN OHL www.ohwr.org/cernohl."

"Designing in an open environment is definitely more fun than doing it in isolation, and we firmly believe that having fun results in better hardware." It is hard to deny that enthusiasm is inspiring and that it can be one of the factors in the success of any enterprise. The statement comes from the Manifesto of the Open Hardware Repository (OHR), which is defined by its creators as a place on the web where electronics designers can collaborate on open-hardware designs, much in the philosophy of the movement for open-source software. Of course, there is more to this than the importance of enthusiasm. Feedback from peers, design reuse and better collaboration with industry are also among the important advantages to working in an open environment.

The OHR was the initiative of electronics designers working in experimental-physics laboratories who felt the need to enable knowledge-exchange across a wide community and in line with the ideals of "open science" being fostered by organizations such as CERN. "For us, the drive towards open hardware was largely motivated by well meaning envy of our colleagues who develop Linux device-drivers," says Javier Serrano, an engineer at CERN's Beams Department and the founder of the OHR. "They are part of a very large community of competent designers who share their knowledge and time in order to come up with the best possible operating system. They learn a lot and have lots of fun in the process. This enables them to provide better drivers faster to our CERN clients," he continues. "We wanted that, and found out that there was no intrinsic reason why hardware development should be any different. After all, we all work with computers and the products of our efforts are also binary files, which later become pieces of hardware."

One of the main factors leading to the creation of the OHR was the wish to avoid duplication by simply sharing results across different teams that might be working simultaneously towards the solution of the same problem. Sharing the achievements of each researcher in the repository also results in an improved quality of work. "Sharing design effort with other people has forced us to be better in a number of areas," states Serrano. "You can't share without a proper preliminary specification-phase and good documentation. You also can't share if you design a monolithic solution rather than a modular one from which you and others can pick bits and pieces to use in other projects. The first time somebody comes and takes a critical look at your project it feels a bit awkward, but then you realize how much great talent there is out there and how these people can help, especially in areas that are not your main domain of competence."



The Open Hardware Repository logo, with more than a passing resemblance to a well known mascot for free and open-source software.

Under licence

Two years after its creation, the OHR currently hosts more than 40 projects from institutes that include CERN, GSI and the University of Cape Town. Such a wealth of knowledge in electronics design can now be shared under the newly published CERN Open Hardware Licence (OHL), which was released in March and is available on the OHR. "In the spirit of knowledge sharing and dissemination, this licence governs the use, copying, modification and distribution of hardware design documentation, and the manufacture and distribution of products," explains Myriam Ayass, ▷

Electronics

White Rabbit keeps to time

The White Rabbit (WR) project is a perfect embodiment of open-hardware concepts and practice. CERN and GSI started the project with the aim of designing the next-generation timing system for their accelerators. After taking the strategic decision to use an Ethernet-based physical layer, it soon became apparent that this technology could be used in many other areas, such as metrology, astronomy and the study of the atmosphere.

WR takes ideas from existing networking standards, such as IEEE 1588 (Precision Time Protocol, PTP) and Synchronous Ethernet, and adds know-how on fine timing from the accelerator world to provide seamless sub-nanosecond synchronization to more than 1000 Ethernet nodes with typical link lengths of 10 km. The initial team was good with timing hardware but did not know much about network technologies in the beginning of the project. Now there are many network experts on board, and we are designing an Ethernet switch that has demonstrated 200 ps synchronization over 5 km of fibre.

There are potential users in Europe, America and Asia, and because some of them become developers, the team keeps getting bigger and bigger. There are also companies that have expressed interest in commercializing WR switches and nodes in different formats, so the design team will not be overwhelmed with support requests. These companies would have been less enthusiastic if WR had not been interoperable with existing Ethernet networks. This demonstrates that embracing standards proved a good choice, not only technically but also considering the total cost of ownership. Standards also helped avoid confusion concerning the specifications, something that is important in a geographically distributed project.

Keeping the project open has been the key to its success. In particular, we have been able to attract many talented individuals and companies, and have built on existing open bricks such as Linux, without which the ambitious goals of the project would have been unreachable.

● For more information, see www.ohwr.org/projects/white-rabbit/wiki.

● *Javier Serrano, CERN.*

legal adviser of the Knowledge and Technology Transfer Group at CERN and author of the CERN OHL. The documentation that the OHL refers to includes schematic diagrams, designs, circuit or circuit-board layouts, mechanical drawings, flow charts and descriptive texts, as well as other explanatory material. The documentation can be in any medium, including – but not limited to – computer files and representations on paper, film, or other media.

The introduction of the CERN OHL is indeed a novelty in which the long-standing practice of sharing hardware design has adopted a clear policy for the management of intellectual property. "The CERN OHL is to hardware what the General Public Licence is to software. It defines the conditions under which a licensee will be able to use or modify the licensed material," explains Ayass. "The concept of 'open-source hardware' or 'open hardware' is not yet as well known or widespread as the free software or open-source software concept," she continues. "However, it shares the same principles: anyone should be able to see the source (the design documentation in case of hardware), study it, modify it and share it. In addition, if modifications are made and distributed, it must be under the same licence conditions – this is the 'persistent' nature of the licence, which ensures that the whole community will continue benefiting from improvements, in the sense that everyone will in turn be able to make modifications to these improvements."

Despite these similarities, the application of "openness" in the two domains – software and hardware – differs substantially because of the nature of the "products". "In the case of hardware, physical resources must be committed for the creation of physical devices," Ayass points out. "The CERN OHL thus specifically states that manufacturers of such products should not imply any kind of endorsement or responsibility on the part of the designer(s) when producing and/or selling hardware based on the design documents. This is important in terms of legal risks associated with engaging in open-source hardware, and properly regulating this is a prerequisite for many of those involved."

The OHR also aims to promote a new business model in which companies can play a variety of roles, design open hardware in collaboration with other designers or clients and get paid for that work. As Serrano explains: "Companies can also commercialize the resulting designs, either on their own or as part of larger systems. Customers, on their side, can debug designs and improve them very efficiently, ultimately benefiting not only their own systems but also the companies and other clients."

"The fact that the designs are 'open' also means that anyone can manufacture the product based on this design – from individuals to research institutes to big companies – and commercialize it. This is one approach of technology transfer that nicely combines dissemination of the technology and of the accompanying knowledge," adds Ayass. This combining of an innovative business model and the OHL is finding a positive response in the commercial world. "We are very excited because we are proving that there is no contradiction between commercial hardware and openness," says Serrano, who concludes: "The CERN OHL will be a great tool for us to collaborate with other institutes and companies."

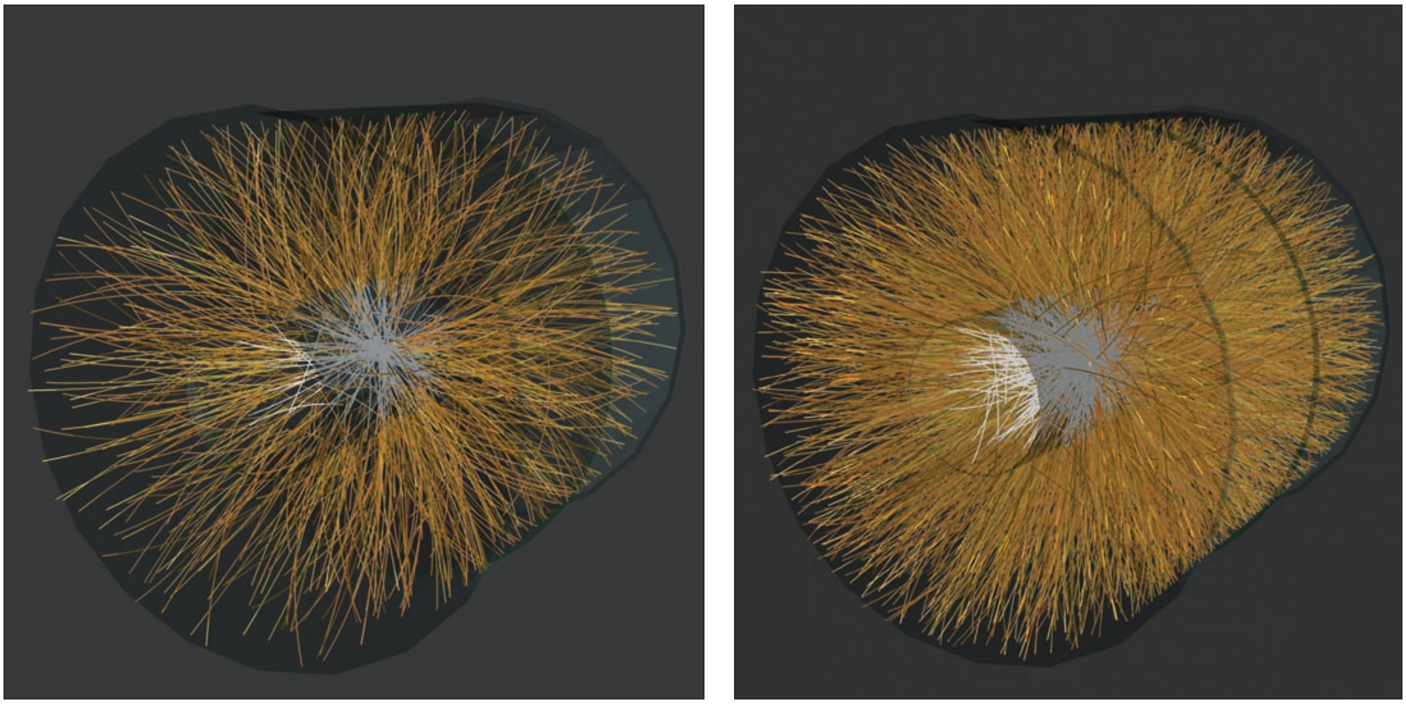
● For more about the OHR see www.ohwr.org. For more about the CERN OHL, see www.ohwr.org/cernohl.

Résumé

Libre accès pour le matériel

Le répertoire du matériel libre est un lieu situé sur le web qui permet aux concepteurs d'électronique de collaborer sur des modèles de matériel « libres ». Ce projet a été lancé à l'initiative de concepteurs travaillant dans des laboratoires de physique expérimentale qui ont estimé nécessaire de faciliter les échanges à très grande échelle, pour aller dans le sens d'une science « ouverte ». Deux ans après sa création, le répertoire compte plus de 40 projets issus d'instituts tels que le CERN, GSI Darmstadt et l'Université du Cap. À présent, le CERN propose une licence de matériel libre, qui permet un partage de connaissances très précieux dans le contexte d'une politique claire en matière de propriété intellectuelle.

Marina Giampietro, CERN.



Heavy-ion collisions in ALICE range from those with low multiplicity (relatively few charged particles, left) to those with much higher multiplicity (right), which can have thousands of tracks.

ALICE enters new territory in heavy-ion collisions

The first run with colliding beams of lead ions in the LHC has already provided the ALICE experiment with a taste of hot dense matter at higher energies than ever before.

The goal of ALICE (A Large Ion Collider Experiment) is to measure the properties of strongly interacting matter generated in heavy-ion collisions at the LHC at CERN. On 7 November 2010, the LHC became the world's most energetic heavy-ion accelerator when lead nuclei collided at a centre-of-mass energy $\sqrt{(s_{NN})} = 2.76$ TeV per colliding nucleon pair. This is an energy more than 10 times higher than that of the previous record holder, the Relativistic Heavy-Ion Collider (RHIC) at Brookhaven National Laboratory in New York.

Quantum chromodynamics (QCD), the theory of strong interactions, predicts that at a temperature of about 170 MeV (2×10^{12} K), nuclear matter undergoes a phase transition from its normal hadronic state to a deconfined partonic phase, the quark-gluon plasma (QGP). This is about 100 000 times hotter than the core of the Sun, and such extreme conditions occur only under special circumstances. One such circumstance is the early universe, where the QGP filled all space a few microseconds after the Big Bang; another is the head-on collision of heavy ions at the LHC and RHIC, where a QGP may be created for a fleeting instant.

RHIC has now been running for a decade. One of its spectacular findings was that the matter generated in heavy-ion collisions flows like a liquid with very low internal resistance to flow, almost at the limit of what is allowed for any material in nature. This tells us that the constituents of this matter are quite different from freely interacting quarks and gluons. This almost-perfect fluid has been found to be opaque to even the most energetic partons (quarks and gluons), which appear as "jets" of particles from the collisions – an effect known as jet quenching. The physical mechanisms underlying these phenomena are not well understood. One of the first ▷

LHC physics

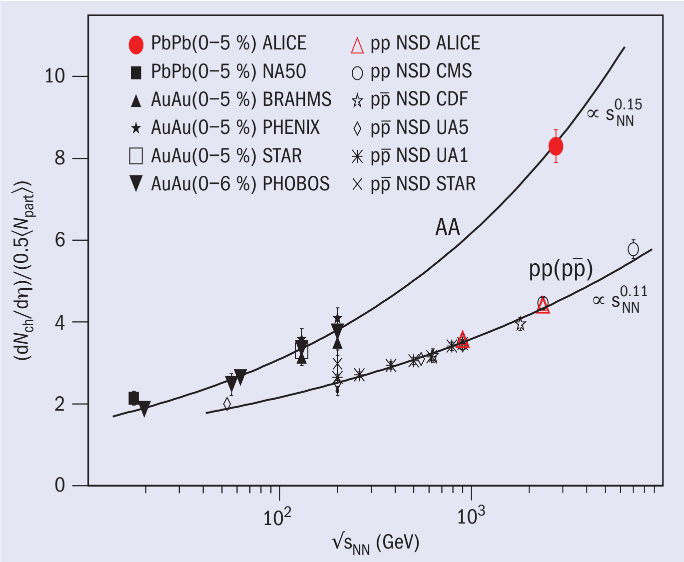


Fig. 1. The charged-particle density in pseudorapidity (η) per participating nucleon pair as a function of collision energy in the centre-of-mass for central nucleus–nucleus collisions and proton–proton (proton–antiproton) collisions (Aamodt et al. *2010a). The particle multiplicity at the LHC is larger than ever.*

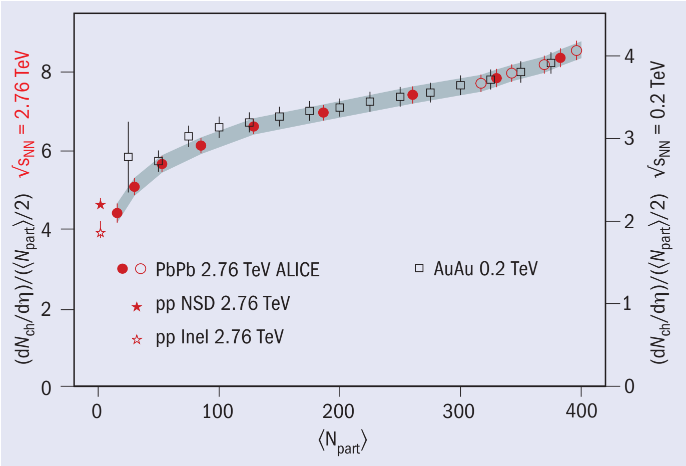


Fig. 2. The dependence of the number of produced particles per participating nucleon pair ($dN_{ch}/d\eta$)/($<N_{part}>/2$) on centrality (N_{part} – number of participating nucleons) for lead–lead collisions at 2.76 TeV at the LHC (left vertical scale) and gold–gold collisions at 0.2 TeV at RHIC (right vertical scale). There is more particle production at the LHC but the dependence on centrality is similar to that at RHIC (Aamodt et al. *2011).*

tasks of heavy-ion studies at the LHC is to "rediscover" these effects and probe them further with new tools as the basis for a much broader and deeper study of the QGP in the coming years. So what have we learnt at the LHC from heavy ions so far?

"Calibrating" at the LHC

To explore the features of hot QCD matter we have to calibrate our tools. Interpretation of the complex interaction of heavy-ions relies on theoretical modelling, beginning with the initial conditions of the hot system – the fireball – at the instant after the collision. One of the crucial inputs for calibrating the models is the distribution of the multiplicity (total number) of particles produced in a collision. This tells us a great deal about how the quarks and gluons in the incoming nuclei transform into the particles (pions, kaons, and so on) observed in the detector.

The number of generated particles is correlated with the impact parameter of the collision; that is, the distance between centres of the colliding nuclei. Small impact parameters, in which the colliding nuclei hit each other nearly head-on so that the largest number of incoming protons and neutrons "participate" in the collision, generate the most particles. Thus, ordering the ensemble of measured collisions according to their multiplicity allows them to be sorted into different classes of impact parameter. The number of created particles can also tell us about the energy density reached within the collisions and the temperature of the fireball.

Multiplicity measurements by the ALICE experiment show that the system created at the LHC initially has much higher energy density and is at least 30% hotter than at RHIC, resulting in about double the particle multiplicity for each colliding nucleon pair (Aamodt *et al*. 2010a). Figure 1 shows the energy dependence of particle production with the new measurement obtained at the LHC.

Perhaps surprisingly, despite their vastly different collision energies, the growth in particle multiplicity from RHIC to the LHC is similar at all impact parameters, as figure 2 shows (Aamodt *et al*. 2011). These measurements by ALICE also show that various predictions driven either by phenomenological extrapolation from the lower energies or by colour-charge density-saturation models are inadequate at the LHC.

A perfect liquid at the LHC?

Off-centre nuclear collisions, with a finite impact parameter, create a strongly asymmetric "almond-shaped" fireball. However, experiments cannot measure the spatial dimensions of the interaction (except in special cases, for example in the production of pions, see *CERN Courier* May 2011 p6). Instead, they measure the momentum distributions of the emitted particles. A correlation between the measured azimuthal momentum distribution of particles emitted from the decaying fireball and the initial spatial asymmetry can arise only from multiple interactions between the constituents of the created matter; in other words it tells us about how the matter flows, which is related to its equation of state and its thermodynamic transport properties.

The hot and dense matter at the LHC also behaves like a fluid with almost zero viscosity

The measured azimuthal distribution of particles in momentum space can be decomposed into Fourier coefficients. The second Fourier coefficient (v_2), called elliptic flow, is particularly sensitive to the internal friction or viscosity of the fluid, or more precisely, η/s, the ratio of the shear viscosity (η) to entropy (s) of the system. For a

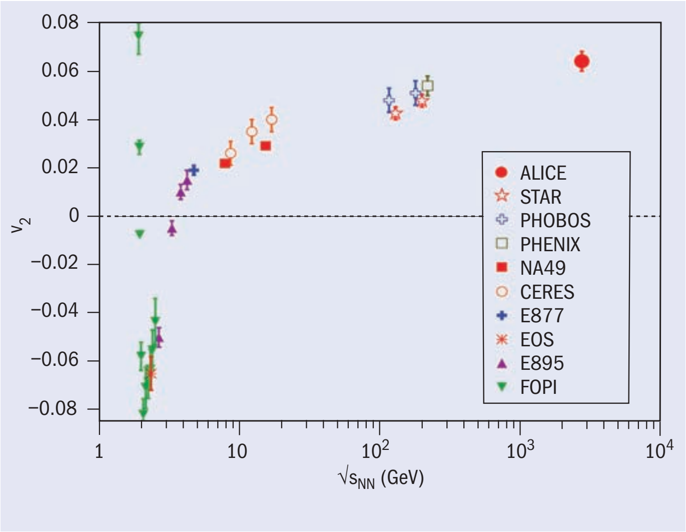
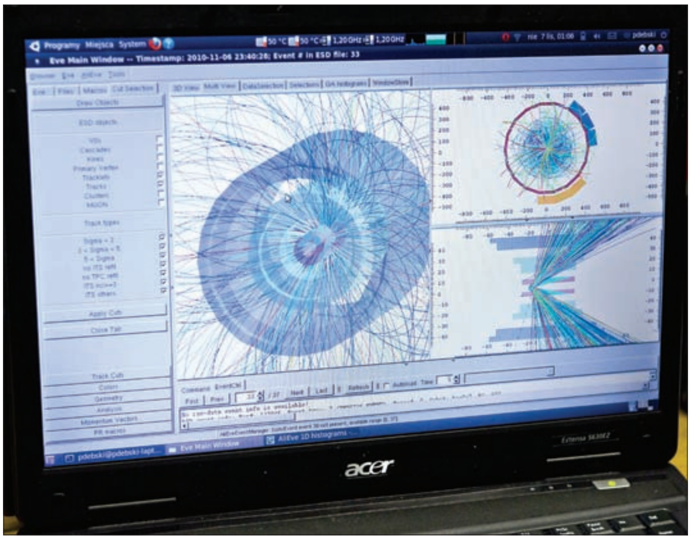


Fig. 3. Elliptic flow v_2 *at 2.76 TeV compared with results from lower energies (Aamodt* et al. *2010b). Hot QCD matter made at the LHC flows, like a fluid with almost zero viscosity.*



A computer screen in the ALICE control room shows an event display on the night of the first heavy-ion collisions in the LHC in November 2010

good fluid such as water, the η/s ratio is small. A "thick" liquid, such as honey, has large values of η/s. Comparison of the elliptic flow measured in heavy-ion collisions at RHIC with theoretical models suggests that the hot matter created in the collision flows like a fluid with little friction, with η/s close to its lower limit – the theoretical limit for a perfect fluid limit – given by $\eta/s = \hbar/4\pi k_B$, where $\hbar$ is Planck's constant and k_B is the Boltzmann constant.

In heavy-ion collisions at the LHC, the ALICE collaboration found that the elliptic flow of charged particles increases by about 30% compared with flow measured at the highest energy at RHIC of 0.2 TeV (figure 3). However, hydrodynamic calculations tuned to reproduce the results at RHIC – when recalibrated to the LHC energy regime – reproduce the new measurements well. The hot and dense matter at the LHC also behaves like a fluid with almost zero viscosity (*CERN Courier* April 2011 p7). With these measurements, ALICE has just begun to explore the temperature dependence of η/s and we anticipate many more in-depth flow-related measurements at the LHC that will constrain the hydrodynamic features of the QGP even further.

Partonic energy loss

A basic process in QCD is the energy loss of a fast parton in a medium composed of colour charges. This phenomenon, "jet quenching", is especially useful in the study of the QGP, using the naturally occurring products (jets) of the hard scattering of quarks and gluons from the incoming nuclei. A highly energetic parton (a colour charge) probes the coloured medium rather like an X-ray probes ordinary matter. The production of these partonic probes in hadronic collisions is well understood within perturbative QCD. The theory also shows that a parton traversing the medium will lose a fraction of its energy in emitting many soft (low energy) gluons. The amount of the radiated energy is proportional to the density of the medium and to the square of the path length travelled by the parton in the medium. Theory also predicts that the energy loss depends on the flavour of the parton.

Jet quenching was first observed at RHIC by measuring the yields of hadrons with high transverse momentum (p_T). These particles are produced via fragmentation of energetic partons. The yields of these high-p_T particles in central nucleus–nucleus collisions were found to be a factor of five lower than expected from the measurements in proton–proton reactions. ALICE has recently published the measurement of charged particles in central heavy-ion collisions at the LHC. As at RHIC, the production of high-p_T hadrons at the LHC is strongly suppressed. However, the observations at the LHC show qualitatively new features (see box p20). The observation from ALICE is consistent with reports from the ATLAS and CMS collaborations on direct evidence for parton energy loss within heavy-ion collisions using fully reconstructed back-to-back jets of particles associated with hard parton scatterings (*CERN Courier* January/February 2011 p6 and March 2011 p6). The latter two experiments have shown a strong energy imbalance between the jet and its recoiling partner (G Aad *et al.* 2010 and CMS collaboration 2011). This imbalance is thought to arise because one of the jets traversed the hot and dense matter, transfer-

LHC physics

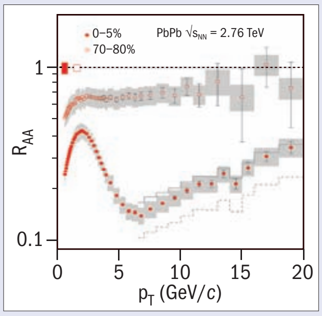
ALICE measures suppression of high-transverse-momentum particles in heavy-ion collisions

The dominant production mechanism for high-transverse-momentum (high p_T) hadrons in high-energy nuclear collisions is the fragmentation of high-p_T partons that originate in hard scatterings in the early stage of a collision. Recent results from the ALICE experiment at the LHC show that particle production at high p_T in central lead–lead (Pb–Pb) collisions at $\sqrt{s_{NN}}$ = 2.76 TeV is significantly suppressed compared with expectations from an independent superposition of nucleon-nucleon collisions (Aamodt *et al.* 2011). Such nuclear effects of the medium are commonly expressed in terms of the nuclear modification factor R_{AA}, which is defined as the ratio of the charged-particle p_T spectrum in Pb–Pb collisions to that in proton–proton collisions, scaled by the number of binary nucleon–nucleon encounters in the Pb–Pb collision. If no nuclear modification is present, R_{AA} is unity at high p_T.

The figure shows R_{AA} as measured for Pb–Pb collisions in the ALICE experiment at the LHC. In peripheral collisions (70–80%), where the colliding nuclei overlap only partially, the suppression is moderate and almost independent of transverse momentum for p_T >2 GeV/*c*. By contrast, strong suppression is observed in central (head-on) collisions (0–5%) and is most pronounced in the range 5–8 GeV/*c*.

QCD predicts that at high energy-density nuclear matter undergoes a phase transition to quark–gluon plasma (QGP) – a state of matter characterized by deconfined colour charges and governed by partonic degrees of freedom. The high-p_T suppression observed in nuclear collisions is generally attributed to large energy loss by the colour-charged partons as they propagate through hot and dense deconfined QCD medium. This is directly related to the transport properties of the QGP.

The suppression observed at the LHC exceeds that previously reported by experiments at lower energies at RHIC at Brookhaven. In recent theoretical calculations this finding was related both to the larger total charged-particle multiplicity observed at the LHC, pointing to a higher, initial gluon density in the medium, and to the longer lifetime of the hot and dense system (Aamodt *et al.* 2011b). Moreover, the observed suppression at the LHC decreases significantly as p_T increases for $7<p_T<20$ GeV/*c*. This phenomenon is qualitatively new and may be related to the less steeply falling p_T spectrum of scattered partons at the LHC compared with RHIC. Future studies of R_{AA} at higher p_T – as well as a detailed analysis of its dependence on centrality and particle species – will allow for a more detailed discrimination of different energy-loss scenarios and enable a systematic investigation of the properties of QGP.



This plot shows the level of particle absorption by the medium formed in heavy-ion collisions at the LHC. For head-on collisions (solid red circles), fewer particles are seen emerging with large transverse momenta p_T than in peripheral collisions (open circles).

● Further reading

K Aamodt *et al.* (ALICE collaboration) 2011a *Phys. Lett. B* **696** 30.
K Aamodt *et al.* (ALICE collaboration) 2011b *Phys. Lett. B* **696** 328.

● *Harald Appelshaeuser, University of Frankfurt.*

ring a substantial fraction of its energy to the medium in a way that is not recovered by the reconstruction of the jets.

With the first findings on hydrodynamic features of the medium created at the LHC and its opaqueness to energetic partons, the LHC has, to a large extent, reproduced measurements at RHIC. The measurements at the LHC will, however, profit from the denser medium and its longer lifetime. The vast kinematic reach provided by the higher-energy collision system enables qualitatively new measurements of the QGP.

On 23–28 May, Quark Matter, a key conference in heavy-ion physics, takes place in Annecy. The most recent experimental results and theoretical state-of-the-art concepts and calculations will be presented, targeted at the detailed understanding of QGP at RHIC and at the LHC. The ALICE collaboration will report on the observations discussed here and will also present new, in-depth studies of the elliptic flow with respect to the type of particle and its mass. Also, the first studies addressing the interplay between collective features of the medium and jet production at the LHC will be shown. Moreover, ALICE will present its first insight into the energy loss of heavy flavour (charm and bottom quarks) in the hot QCD medium. In the coming years, all of these crucial measurements will help to uncover the key properties of the QGP at the LHC.

● Further reading

K Aamodt *et al.* (ALICE collaboration) 2010a *Phys. Rev. Lett.* **105** 252301.
K Aamodt *et al.* (ALICE collaboration) 2010b *Phys. Rev. Lett.* **105** 252302.
K Aamodt *et al.* (ALICE collaboration) 2011 *Phys. Rev. Lett.* **106** 032301.
G Aad *et al.* (ATLAS collaboration) 2010 *Phys. Rev. Lett.* **105** 252303.
CMS collaboration 2011 arXiv:1102.1957 [nucl-ex].

Résumé

ALICE aborde de nouveaux territoires

En novembre 2010, des faisceaux d'ions plomb sont entrés en collision frontale pour la première fois au LHC du CERN. L'expérience ALICE a ainsi pu commencer à étudier les collisions d'ions lourds à des énergies plus élevées que celles obtenues précédemment à l'installation RHIC de Brookhaven. Les premiers résultats montrent que le système créé au LHC est initialement plus chaud d'environ 30% que celui observé au RHIC. La matière dense et chaude produite continue à se comporter comme un liquide presque parfait, opaque aux partons même très énergétiques (quarks et gluons).

Mateusz Ploskon, Lawrence Berkeley National Laboratory, on behalf of the ALICE collaboration.

Beautiful times in Amsterdam

The first results from the LHC, as well as recent results from the Tevatron, were among the highlights of Beauty 2011 – the latest conference in the series on physics involving the beauty quark.

The 13th International Conference on B-Physics at Hadron Machines (Beauty 2011) was held at the Felix Meritis building in the historic centre of Amsterdam on 4–8 April. Hosted by Nikhef, the National Institute for Subatomic Physics of the Netherlands, the meeting attracted about 100 participants, including experts from Europe, America and Asia. There were 60 invited talks.

The main topic was the physics of B_q mesons, which consist of a b ("beauty") quark and an anti-q quark, where q can be an up, down, strange or charm quark. These particles offer interesting probes for precision tests of the Standard Model. In this context, asymmetries between decay rates of B and $\overline{B}$ mesons, which violate the charge-parity (CP) invariance of weak interactions, play a key role. Such observables and various strongly suppressed rare decays of B mesons show a sensitivity to "new physics", thanks to the possible impact of the contributions of new particles to virtual quantum loops.

The search for these indirect footprints of physics beyond the Standard Model through high-precision measurements is complemented by the search for direct signals of new particles at high-energy colliders. Here, physicists aim to produce new particles (such as supersymmetric squarks or new gauge bosons) and to study their decays in general-purpose detectors – ATLAS and CMS, in the case of the LHC at CERN. The exploration of heavy flavours, and the B-meson system in particular, is the target of the LHCb experiment, which is exploiting the many B mesons that are produced in the proton–proton collisions at the LHC.

Studies of CP violation

The Beauty conferences traditionally have a strong focus on studies of B mesons at hadron machines. In the previous decade, this field was the domain of the CDF and DØ experiments at the Tevatron, the proton–antiproton collider at Fermilab. The electron–positron B factories at SLAC and KEK, with the BaBar and Belle detectors respectively, were the first to establish CP violation in the B-meson system, while the Tevatron experiments have extended the measurements into the B_s-meson sector, which is still poorly explored. These studies have shown that the Cabibbo-Kobayashi-Maskawa matrix is the dominant source of flavour and CP violation, in accordance with the Standard Model.

Participants of Beauty 2011 gather for the group photo on the staircase of the conference site, the Felix Meritis building in the old centre of Amsterdam. (*Image credit: Marco Kraan/Nikhef.*)

The Beauty conferences traditionally have a strong focus on studies of B mesons at hadron machines

However, there is evidence that this model is not complete and recent studies of B_s-decays by the CDF and DØ collaborations give a hint of new sources of CP violation in a quantum-mechanical phenomenon, B_s-$\overline{B}_s$ mixing – although the uncertainties are still too large to draw definite conclusions. In specific scenarios for physics beyond the Standard Model (such as supersymmetry and models with extra Z' bosons), it is actually possible to accommodate the effect of new physics of this kind.

The first physics results from the LHC experiments were the main highlight of Beauty 2011. It was impressive to see the ▷

Conference

wealth and high quality of the data presented. The LHCb collaboration's presentation of the first analysis of the CP-violating observables of the $B_s \rightarrow J/\Psi\phi$ decay was particularly exciting. Although the experimental errors are still large, it is intriguing that the data seem to favour a picture similar to the results from CDF and DØ, mentioned above. Fortunately, the LHCb experiment should be able to reduce the uncertainties significantly within a year, with the prospects of revealing new phenomena in B_s-$\bar{B}_s$ mixing.

Quantum loops

Another exciting decay in which to search for new physics is the rare decay $B_s \rightarrow \mu^+\mu^-$, which originates from quantum-loop effects in the Standard Model. New particles running in the loops or even contributing at the tree level may significantly enhance the decay rate. So far, this decay has been the domain of the CDF and DØ experiments; they have put upper bounds on the branching ratio that are still about one order of magnitude above the Standard Model prediction. Now LHCb has entered the arena, presenting a first upper bound that is similar to the results from the Tevatron. The constraints from LHCb, and soon those from ATLAS and CMS, will quickly become stronger and it will be interesting to see whether eventually a signal for $B_s \rightarrow \mu^+\mu^-$ will emerge that is significantly different from the predictions of the Standard Model.

In addition to these key channels that are facilitating the search for new physics in B decays in the early phase of the LHC, the conference covered a range of other topics. Results on heavy-flavour production were presented with the first LHC data collected in the ATLAS, CMS, LHCb and ALICE experiments. Another interesting topic was charm physics, with results from the BES III experiment, CDF and the first analyses from LHCb. A summary was given of B-factory results on the measurement of CP violation and the unitarity triangle parameters and the status of lepton-flavour violation and models of physics beyond the Standard Model was also presented. Moreover, the potential of upcoming B-physics experiments – SuperB, SuperKEKB and the LHCb upgrade – was discussed.

The many experimental presentations were complemented by theoretical review talks. Theory also figured in the conference summaries, in which Andrzej Buras of the Technische Universität München developed a vision for theory for 2011 and beyond, while the outgoing LHCb spokesperson, Andrei Golutvin, highlighted the experimental results. The discussions about physics also continued in an informal way during a tour on historic boats through the canals of Amsterdam, with people enjoying the spectacular weather and a visit to the Hermitage museum where the conference dinner was held.

Beauty 2011 showed that these are exciting times for B physics, with plenty still happening at the Tevatron and the first physics results from the LHC. It will be interesting to see whether the data collected by LHCb and the general-purpose detectors in 2011 will already reveal new physics in the B-meson sector. Flavour physics is moving towards new frontiers and is a fascinating part of the LHC adventure. Correlations between various flavour-physics observables and the interplay with the direct searches for new particles will play a key role in obtaining insights into the physics lying beyond the Standard Model.

For further information and the slides of the presentations, visit the conference webpage www.beauty2011.nikhef.nl.

Students hear the latest news at the Beauty 2011 conference. (Image credit: Marco Kraan/Nikhef.)

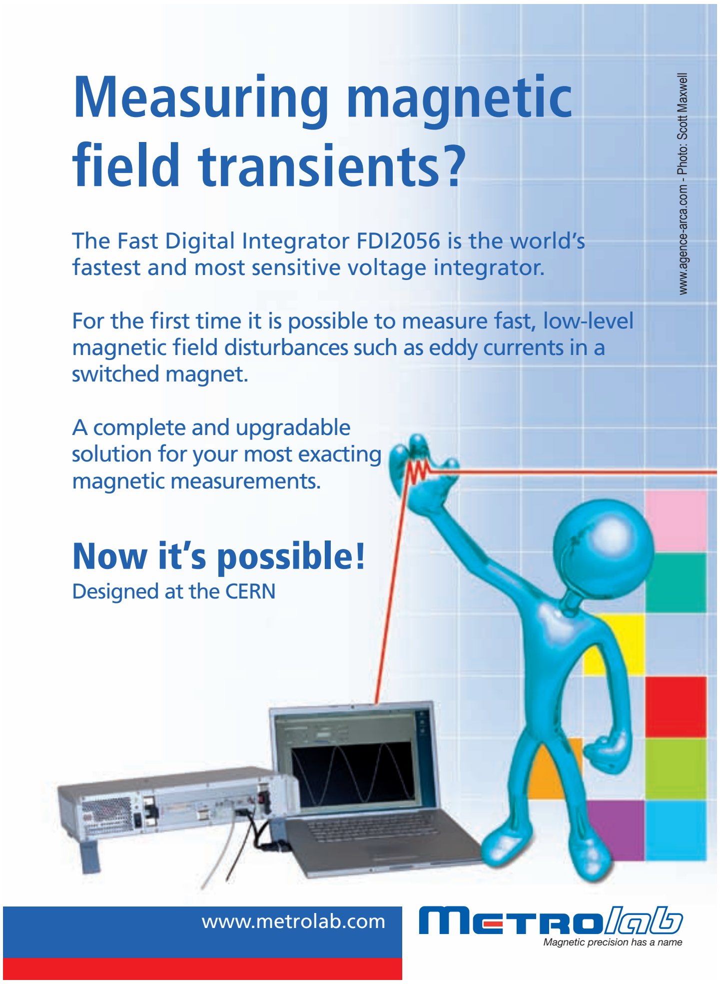
Résumé

La beauté à Amsterdam

Les premiers résultats du LHC, ainsi que les résultats récents du Tevatron, ont été à l'honneur lors de la conférence Beauty 2011, qui s'inscrit dans une série de conférences sur la physique du quark beauté. Accueillie par le NIKHEF (Institut national de physique subatomiques des Pays-Bas), elle a rassemblé une centaine de participants, dont des spécialistes éminents venus d'Europe, d'Amérique et d'Asie. L'accent a été mis particulièrement sur la physique des mésons B_s, domaine où les mesures précises de confirmation du Modèle standard pourraient conduire à une nouvelle physique. Jusqu'à présent, ce domaine a été exploré surtout par les expériences du Tevatron, qui ont trouvé quelques effets surprenants qui font maintenant l'objet de recherches au LHC.

Robert Fleischer, Nikhef.

If you need Metals & Materials...
Pure Metals, Alloys, Polymers, Ceramics, as well as many Composites and Compounds in various forms including foil, rod, tube, wire, powder, etc.
...you need
GoodFellow
Goodfellow Cambridge Limited, Ermine Business Park, Huntingdon, PE29 6WR
Tel: 0800 731 4653 OR +44 1480 424 800, Fax: 0800 328 7689 OR +44 1480 424 900
E-mail: info@goodfellow.com
www.goodfellow.com



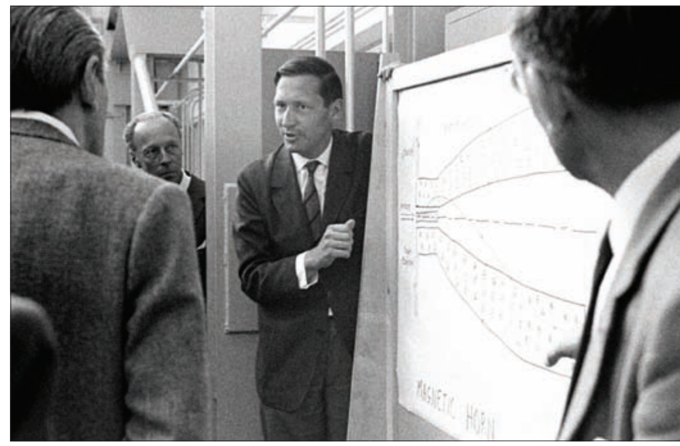
Measuring magnetic field transients?
The Fast Digital Integrator FDI2056 is the world's fastest and most sensitive voltage integrator.
For the first time it is possible to measure fast, low-level magnetic field disturbances such as eddy currents in a switched magnet.
A complete and upgradable solution 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

SCIONIX
Neutron detection with scintillators: an alternative to He-3
fast neutrons
slow neutrons
gamma rays
noise
241Am
LiI(Eu), liquid cells
10B, Gd loading
SCIONIX Holland B.V.
Tel. +31 30 6570312
Fax. +31 30 6567563
Email. sales@scionix.nl
www.scionix.nl
Contact us for more information

Tribute

Simon van der Meer: a quiet gi

An overhead image of a magnetic horn ("the monster").



Simon van der Meer explaining the concept of the magnetic horn to visitors in 1962.

Simon at a farewell party for Heribert Koziol in 2001.

Colleagues and friends recall the work of Simon van der Meer, who made several important contributions to physics during his 35 years at CERN. These included the invention of stochastic cooling, which brought him a share of the Nobel Prize in 1984.

Simon van der Meer was born in 1925 in The Hague, the third child of Pieter van der Meer and Jetske Groeneveld. His father was a school teacher and his mother came from a teacher's family. Good education was highly prized in the van der Meer family and the parents made a big effort to provide this to Simon and his three sisters. Having attended the gymnasium (science section) in The Hague, he passed his final examination in 1943 – during German occupation in wartime. He stayed at the gymnasium for another two years because the Dutch universities were closed, attending classes in the humanities section. During this period – inspired by his excellent physics teacher – he became interested in electronics and filled his parents' house with electronic gadgets.

In 1945 Simon began studying technical physics at Delft University, where he specialized in feedback circuits and measurement techniques. In a way, this foreshadowed his main invention, stochastic cooling, which is a combination of measurement (of the position of the particles) and feedback. The "amateur approach" – to use his own words – that he practiced during his stay at Delft University later crystallized in an ability to see complicated things in a simple and clear manner. In 1952 he joined the highly reputed Philips research laboratory in Eindhoven, where he became involved in development work on high-voltage equipment and electronics for electron microscopes. Then, in 1956, he decided to move to the recently founded CERN laboratory.

As one of his first tasks at CERN, Simon became involved in the design of the pole-face windings and multipole correction lenses

iant of engineering and physics

for the 26 GeV Proton Synchrotron (PS), which is still in operation today, as the heart of CERN's accelerator complex. Supervised by and in collaboration with John Adams and Colin Ramm, he developed – in parallel to his technical work on power supplies for these big magnets – a growing interest in particle physics. He worked for a year on a separated antiproton beam, an activity that triggered the idea of the magnetic horn – a pulsed focusing device for charged particles, which traverse a thin metal wall in which a pulsed high current flows. Such a device is often referred to as a "current sheet lens". The original application of the magnetic horn was for neutrino physics. Of the secondary particles emerging from a target hit by a high-energy proton beam, the horn selectively focused the pions. When the pions then decayed into muons and neutrinos, an equally focused and intense neutrino beam was obtained. The magnetic horn found many applications all around the world, for both neutrino physics and the production of antiprotons.

In 1965 Simon joined the group led by Francis Farley working on a g-2 experiment for the precision measurement of the magnetic moment of the muon. There, he took part in the design of a small storage ring (the g-2 ring) and participated in all phases of the experiment. As he stated later, this period was an invaluable experience not only for his scientific life but also through sharing the vibrant atmosphere at CERN at the time – which was full of excitement – and the lifestyle of experimental high-energy physics. It was also about this time, in 1966, that Simon met his future wife, Catharina Koopman, during a skiing excursion in the Swiss mountains. In what Simon later described as "one the best decisions of my life", they married shortly afterwards and had two children, Ester (born 1968) and Mathijs (born 1970).

In 1967, Simon again became responsible for magnet power supplies, this time for the Intersecting Storage Rings (ISR) and a little later also for the 400 GeV Super Proton Synchrotron (SPS). During his activities at the ISR he developed the now famous "van der Meer scan", a method to measure and optimize the luminosity of colliding beams. The ISR was a collider with a huge intensity, more than 50 A direct current of protons per beam, and it was in 1968 – probably during one of the long nights devoted to machine development – that a new and brilliant idea to increase luminosity was conceived: the concept of stochastic cooling.

A Nobel concept

"The cooling of a single particle circulating in a ring is particularly simple" (van der Meer 1984), provided that it can be seen in all of the electronic noise from the pick-up and the preamplifiers. "All" that is needed is to measure the amount of betatron oscillation at a suitable location in the ring and correct it later with a kicker at a phase advance of an odd multiple of 90° (figure 1). But the devil (closely related to Maxwell's demon) is in the detail. Normally, it is not possible to measure the position of just one particle because there are so many particles in the ring that a single one is impossible to resolve. So, groups of particles – often referred to as beam "slices" or "samples" – must be considered instead.

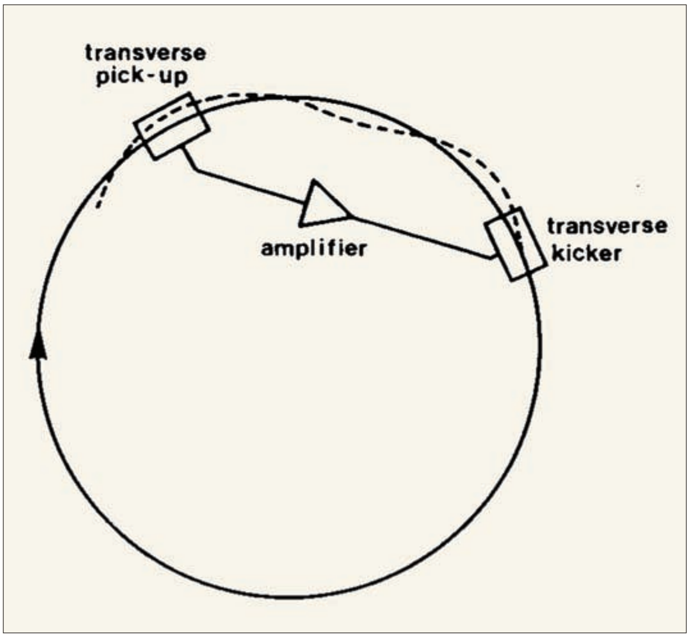


Fig. 1. The concept of transverse stochastic cooling.

For such a beam slice, it is indeed possible to measure the average position with sufficient precision during its passage through a pick-up and to correct for this when the same slice goes through a kicker. However, the particles in such a slice are not fixed in their relative position. Because there is always a spread around the central momentum, some particles are faster and others are slower. This leads to an exchange of particles between adjacent beam slices. This "mixing" is vital for stochastic cooling – without it, the cooling action would be over in a few turns. Stochastic cooling does eventually act on individual particles. With the combination of many thousands of observations (many thousands of turns), a sufficiently large bandwidth of the cooling system's low-noise (sometimes cryogenic) electronics and powerful kickers, it works.

At the time, there were discussions about a possible clash with Liouville's theorem, which states that a continuum of charged particles guided by electromagnetic fields behaves like an incompressible liquid. In reality, particle beams consist of a mixture of occupied and non-occupied phase space – much like foam in a glass of beer. Stochastic cooling is not trying to compress this "liquid" but rather it separates occupied and non-occupied phase space, in a way similar to foam that is settling. Once these theoretical questions were clarified there were still many open issues, such as the influence of noise and the required bandwidth. With a mild push from friends and colleagues, Simon finally published the first internal note on stochastic cooling in 1972 (van der Meer 1972).

Over the following years, the newly born bird quickly learnt ▷

Tribute

to fly. A first proof-of-principle experiment was carried out in the ISR with a quickly installed stochastic cooling system. Careful emittance measurements over a long period showed the hoped-for effect (Hübner *et al*. 1975). Together with the proposal to stack antiprotons for physics in the ISR (Strolin *et al*. 1976) and for the SPS-collider (Rubbia *et al*. 1977), this led to the construction of the Initial Cooling Experiment (ICE) in 1977. ICE was a storage ring built from components of the g-2 experiment. It was constructed expressly for a full-scale demonstration of stochastic cooling of beam size and momentum spread (electron-cooling was tried later on, *CERN Courier* September 2009 p13). In addition, Simon produced evidence that "stochastic stacking" (stacking in momentum space with the aid of stochastic cooling) works well as a vital tool for the production of large stacks of antiprotons (van der Meer 1978).

Once the validity of the method had been demonstrated, Simon's idea rode on the crest of a wave of large projects that took life at CERN. There was the proposal by David Cline, Peter McIntyre, Fred Mills and Carlo Rubbia to convert the SPS into a proton–antiproton collider. The aim was to provide experimental evidence for the W and Z particles, which would emerge in head-on collisions between sufficiently dense proton and antiproton bunches. Construction of the Antiproton Accumulator (AA) was authorized and started in 1978 under the joint leadership of Simon van der Meer and Roy Billinge. The world's first antiproton accumulator started up in 3 July 1980, with the first beam circulating the very same evening, and by 22 August 1981 a stack of about 10^{11} particles had been achieved (Chohan 2004). The UA1 and UA2 experiments at the SPS had already reported the first collisions between high-energy proton and antiproton bunches in the SPS, operating as a collider, on 9 July 1981.

The real highlight arrived in 1982 with the first signs of the W boson, announced on 19 January 1983, to be followed by the discovery of the Z, announced in May (*CERN Courier* May 2003 p26). This was swiftly followed by the award of the Nobel Prize in physics in 1984 to Simon and Carlo Rubbia for "their decisive contributions to the large project which led to the discovery of the field particles W and Z, communicators of the weak force" (*CERN Courier* December 2009 p30).

Simon participated actively in both the commissioning and the operation of the AA and later the Antiproton Accumulator Complex (AAC) – the AA supplemented by a second ring, the Antiproton Collector (AC). He contributed not only to stochastic cooling but to all aspects, for example writing numerous, highly appreciated application programs for the operation of the machines.

He was certainly aware of his superior intellect but he took it as a natural gift, and if someone else did good work, he valued that just as much. When there was a need, he also did "low level" work. Those who worked with him remember many occasions when someone had a good suggestion on how to improve a controls program, Simon would say, "Yes, that would be better indeed", and next morning it was in operation. He was often in a thoughtful mode, contemplating new ideas and concepts. Usually he did not pass them on to colleagues for comments until he was really convinced himself that they would work. Once he was sure that a certain concept was good and that it was the right way to go, he could be insistent on getting it going. He rarely made comments in meetings, but when he did say something it carried important weight. He was already highly respected long before he became famous in 1984.

Simon at the controls of the Antiproton Accumulator.

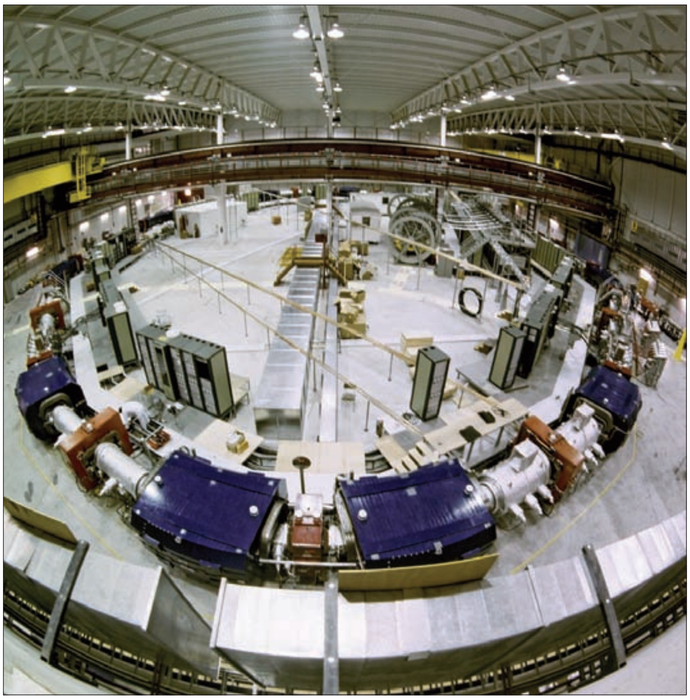
Cooling around the world

In the following years, Simon was extremely active in the conversion and the operation of the AA, together with the additional large-acceptance collector ring, the AC. These two rings, with a total of 16 stochastic cooling systems, began antiproton production in 1987 as the AAC – and remained CERN'S work-horse for antiproton production until 1996. Later, the AA was removed and the AC converted into the Antiproton Decelerator (AD), which has run since 2000 with just three stochastic-cooling systems. These remaining three systems operate at 3.5 GeV/*c* and 2 GeV/*c* respectively during the deceleration process and are followed by electron cooling at lower momentum.

Stochastic cooling was also used in CERN's Low Energy Antiproton Ring (LEAR) in combination with electron cooling until the mid-1990s. In a nutshell, stochastic cooling is most suited to rendering hot beams warm and electron cooling makes warm beams cold. Thus the two techniques are, in a way, complementary. As a spin-off from his work on stochastic cooling, Simon proposed a new (noise assisted) slow-extraction method called "stochastic extraction". This was first used at LEAR, where it eventually made possible spills of up to 24-hour duration. Prior to that, low-ripple spills could last at best a few seconds.

Simon would see the worldwide success of his great inventions not only before his retirement in 1991, but also afterwards. Stochastic cooling systems became operational at Fermilab around 1980 and later, in the early 1990s, at GSI Darmstadt and Forschungszentrum Jülich (FZJ), as well as at other cooling rings all over the world. The Fermilab antiproton source for the Tevatron

Tribute



A fish-eye view of the Antiproton Accumulator in 1980.

Simon van der Meer, right, and Carlo Rubbia celebrate their awarding of the Nobel Prize in 1984 with a toast at CERN.

started operation in 1985. It is in several aspects similar to the CERN AA /AC, which it has since surpassed in performance, leading to important discoveries, including that of the top quark.

For many years, routine application of stochastic cooling was limited to coasting beams, and stochastic cooling of bunched beams in large machines remained a dream for more than a decade. However, having mastered delicate problems related to the saturation of front-end amplifiers and subsequent intermodulation, bunched stochastic cooling is now in routine operation at Fermilab and at the Relativistic Heavy Ion Collider at Brookhaven. Related beam-cooling methods, such as optical stochastic cooling, are also being proposed or under development.

The magnetic horn, meanwhile, has found numerous applications in different accelerators. The van der Meer scan is a vital tool used for LHC operation and stochastic extraction is used in various machines, for example in COSY at FZJ (since 1996).

After his retirement, Simon kept in close contact with a small group of his former colleagues and friends and there were more or less regular "Tuesday lunch meetings".

"Unlike many of his Nobel colleagues, who almost invariably are propelled to great achievements by their self confidence, van der Meer remained a modest and quiet person preferring, now that he had retired, to leave the lecture tours to other more extrovert personalities and instead look after his garden and occasionally see a few friends. Never has anyone been changed less by success", wrote Andy Sessler and Ted Wilson in their book *Engines of Discovery* (Sessler and Wilson, 2007). At CERN today, Simon's contributions continue to play a significant role in many projects, from the LHC and the CERN Neutrinos to Gran Sasso facility to the antimatter programme at the AD – where results last year were honoured with the distinction of "breakthrough of the year" by *Physics World* magazine (*CERN Courier* January/February p7 and March p13 and p17).

We all learnt with great sadness that Simon passed away on 4 March 2011. He will stay alive in our memories for ever.

● Further reading

V Chohan 2004 Infinitely CERN (Hurter) 116.
K Hübner *et al.* 1975 *Nucl. Instrum. Meth.* **125** 201.
C Rubbia *et al.* 1977 *Proc. Int. Neutrino Conf.,* Aachen, 1976 (Vieweg, Braunschweig) 638.
A Sessler and E Wilson 2007 *Engines of Discovery* (World Scientific) 99.
P Strolin *et al.* 1976 *CERN/EP* 76-05.
S van der Meer 1972 *CERN/ISR-PO* 72-31.
S van der Meer 1978 *CERN/PS/AA* 78-22.
S van der Meer 1984 Nobel Lectures, Physics 1981–1990 (World Scientific) 291.

Résumé

Simon Van der Meer : un géant de la technologie et de la physique

Dans cet hommage, des collèges et des amis évoquent le travail de Simon van der Meer, qui a apporté plusieurs contributions importantes à la science des accélérateurs au cours de ses 35 années au CERN. Il est connu surtout pour son invention du refroidissement stochastique, procédé grâce auquel le Supersynchrotron du CERN a pu devenir le premier collisionneur proton-antiproton du monde. Il a reçu le prix Nobel de physique, conjointement avec Carlo Rubbia, en 1984 pour sa contribution décisive à ce projet, qui a conduit à la découverte des particules W et Z. Il a également participé au développement de la corne magnétique qui permet de produire des faisceaux focalisés de neutrinos.

Fritz Caspers, **Heribert Koziol** and **Dieter Mohl**, on behalf of Simon's colleagues and friends.

EU projects

TIARA aims to enhance accelerator R&D in Europe

The European Commission and partners from research centres and universities have launched TIARA-PP, a three-year preparatory-phase project co-ordinated by CEA Saclay with the aim of further structuring accelerator science and technology in Europe.

Particle accelerators are vital state-of-the-art instruments for both fundamental and applied research in areas such as particle physics, nuclear physics and the generation of intense synchrotron radiation and neutron beams. They are also used for many other purposes, in particular medical and industrial applications. Together, the "market" for accelerators is large and steadily increasing year on year. Moreover, R&D in accelerator science and technology, as well as its applications, often leads to innovations with strong socio-economical impacts.

New accelerator-based projects generally require the development of advanced concepts and innovative components with continuously improving performance. This necessitates three levels of R&D: exploratory (validity of principles, conceptual feasibility); targeted (technical demonstration); and industrialization (transfer to industry and optimization). Because these developments require increasingly sophisticated and more expensive prototypes and test facilities, many of those involved in the field felt the need to establish a new initiative aimed at providing a more structured framework for accelerator R&D in Europe with the support of the European Commission (EC). This has led to the Test Infrastructure and Accelerator Research Area (TIARA) project. Co-funded by the European Union Seventh Framework Programme (FP7), the three-year preparatory-phase project started on 1 January 2011, with its first meeting being held at CERN on 23–24 February.

The approval of the TIARA project and its structure continues a strategic direction that began a decade ago with the report in 2001 to the European Committee for Future Accelerators from the Working Group on the future of accelerator-based particle physics in Europe, followed by the creation of the European Steering Group on Accelerator R&D (ESGARD) in 2002. This was reinforced within the European Strategy for particle physics in 2006 (*CERN Courier* September 2006 p29). The main objective is to optimize and enhance the outcome of the accelerator research and technical developments in Europe. This strategy has been developed and implemented with the incentive of the Framework Programmes FP6 and FP7, thanks to projects such as CARE, EUROTeV, EURISOL, EuroLEAP, SLHC-PP, ILC-HiGrade, EUROnu and EuCARD (*CERN Courier* June 2010 p10). Together, these programmes represent a total investment of around €190 million for the period covered by FP6 and FP7 (2004 to 2012), with about €60 million coming from the EC.

The overall aim of TIARA is to facilitate and optimize European R&D efforts in accelerator science and technology in a sustainable way. This endeavour involves a large number of partners across Europe, including universities as well as national and international organizations managing large research centres. Specifically, the main objective is to create a single distributed European accelerator R&D facility by integrating national and international accelerator R&D infrastructures. This will include the implementation of organizational structures to enable the integration of existing individual infrastructures, their efficient operation and upgrades, as well as the construction of new ones whenever needed.

Project organization

The means and structures required to bring about the objectives of TIARA will be developed through the TIARA Preparatory Phase project, at a total cost of €9.1 million, with an EC contribution of €3.9 million. The duration is 3 years – from January 2011 to December 2013 – and it will involve an estimated total of 677 person-months. The project is co-ordinated by the French Alternative Energies and Atomic Energy Commission (CEA), with Roy Aleksan as project co-ordinator, François Kircher as deputy co-ordinator, and Céline Tanguy as project-assistant co-ordinator. Its management bodies are the Governing Council and the Steering Committee. The Governing Council represents the project partners and has elected Leonid Rivkin, of the Paul Scherrer Institute, as its chair. The Steering Committee will ensure the execution of the overall project's activities, with all work-package co-ordinators as members.

The project is divided into nine work packages (WP). The first five of these are dedicated to organizational issues, while the other four deal with technical aspects.

WP1 focuses on the consortium's management. Its main task

TIARA's Governing Council

The consortium is overseen by the Governing Council, which includes eleven participants from eight countries:

- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), France
- European Organization for Nuclear Research (CERN)
- Centre National de la Recherche Scientifique (CNRS), France
- Centro de Investigaciones Energeticas, Mediombientales y Technologicas (CIEMAT), Spain
- Stiftung Deutsches Electronen-Synchrotron (DESY), Germany
- GSI Helmholtzzentrum für Schwerionenforschung GmbH (GSI), Germany
- Istituto Nazionale di Fisica Nucleare (INFN), Italy
- Paul Scherrer Institut (PSI), Switzerland
- Science and Technology Facilities Council (STFC), UK, also representing Cockcroft Institute, Imperial College London and John Adams Institute.
- Uppsala Universitet, Sweden, also representing the universities of Aarhus in Denmark, Helsinki and Jyväskylä in Finland, Oslo in Norway, and Lund and Stockholm in Sweden
- The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences (IFJ PAN), Poland, also representing the University of Science and Technology in Krakow, the Cracow University of Technology, the Technical University of Lodz, the Andrzej Soltan Institute in Swierk, the Warsaw University of Technology and the Wroclaw University of Technology

The membership of the Governing Council includes: Roy Aleksan (CEA), Steve Myers (CERN), Alex Mueller (CNRS), Jose M Perez Morales (CIEMAT), Hartmut Eickhoff (GSI), Reinhard Brinkmann (DESY), Umberto Dosselli (INFN), Leonid Rivkin (PSI), John Womersley (STFC), Tord Ekelöf (Uppsala) and Marek Jezabek (IFJ PAN).

The first meeting of the TIARA Preparatory Phase Governing Board at CERN on 23 February. Top, left to right: Roy Aleksan (CEA), Jean-Pierre Koutchouk representing Steve Myers (CERN), Bernard Launé representing Alex Mueller (CNRS), Jose M Perez Morales (CIEMAT), Hartmut Eickhoff (GSI), Reinhard Brinkmann (DESY). Bottom: Franco Cervelli representing Umberto Dosselli (INFN), Leonid Rivkin (PSI), Tord Ekelof (UU), John Womersley (STFC), Marek Jezabek (IFJ PAN), François Kircher (CEA). (Image credit: TIARA management team.)

is to ensure the correct achievement of the project goals and it also includes communications, dissemination and outreach. The project office, composed of the co-ordinator and the management team, forms the core of this work package, which is led by Aleksan, the project co-ordinator.

The main objective of WP2, also led by Aleksan, is to develop the future governance structure of TIARA. This includes the definition of the consortium's organization, the constitution of the statutes and the required means and methods for its management, as well as the related administrative, legal and financial aspects.

WP3 is devoted to the integration and optimization of the European R&D infrastructures. Based on a survey of those that already exist, its objective is to determine present and future needs and to propose ways for developing, sharing and accessing these infrastructures among different users. This work package will also investigate how to strengthen the collaboration with industry and define a technology roadmap for the development of future accelerator components in industry. It is led by Anders Unnervik of CERN.

The main objective of WP4 is to develop a common methodology and procedure for initiating, costing and implementing collaborative R&D projects in a sustainable way. Using these procedures, WP4 will aim to propose a coherent and comprehensive joint R&D programme in accelerator science and technology, which will be carried out by a broad community using the distributed TIARA infrastructures.

The development of structures and mechanisms that allow efficient education and training of human resources and encourage their exchange among the partner facilities is the goal of WP5. The main tasks are to survey the human and training resources and the market for accelerator scientists, as well as to establish a plan of action for promoting accelerator science. This work package is led by Phil Burrows of the John Adams Institute in the UK.

WP6 – SLS Vertical Emittance Tuning (SVET) – is the first of the technical work packages. Its purpose is to convert the Swiss Light Source (SLS) into an R&D infrastructure for reaching and measuring ultrasmall emittances, as will be required for damping rings at a future electron–positron linear collider. This will be ▷

EU projects

done mainly by improving the monitors that are used to measure beam characteristics (position, profile, emittance), and by minimizing the magnetic field errors, misalignments and betatron coupling. This work package is led by Yannis Papaphilippou of CERN.

The principal objective of WP7 – Ionization Cooling Test Facility (ICTF) – is to deliver detailed design reports of the RF power infrastructure upgrades that the ICTF at the UK's Rutherford Appleton Laboratory requires for it to become the world's laboratory for R&D in ionization cooling. The design reports will include several upgrades necessary to make the first demonstration of ionization cooling. Ken Long of Imperial College, London, leads this work package.

The goal of WP8 – High Gradient Acceleration (HGA) – is to establish a new R&D infrastructure by upgrading the energy of SPARC, the advanced photo-injector test-facility linac at Frascati. The upgrade will use C-band terawatt high-gradient accelerating structures to reach 250 MeV at the end of the structure. It will be crucial for the next generation of free-electron laser projects, as well as for the SuperB collider project. The work package is led by Marica Biagini of the Frascati National Laboratories.

WP9 – Test Infrastructure for High Energy Power Accelerator Components (TIHPAC) – is centred on the design of two test benches aimed at the future European isotope-separation on-line facility, EURISOL. These will be an irradiation test facility for developing high-power targets and a cryostat for testing various kinds of fully equipped low-beta superconducting cavities. These infrastructures would also be essential for other projects such as the European Spallation Source and accelerator-driven systems such as MYRRHA. The work package is led by Sébastien Bousson of CNRS/IN2P3/Orsay.

● For more information about the TIARA project, see the website at www.eu-tiara.eu.

Résumé

TIARA : renforcer la R&D sur les accélérateurs en Europe

Fruit d'une longue réflexion impliquant entre autres le Conseil du CERN, l'ECFA et le groupe ESGARD, TIARA a débuté le 1er janvier 2011, pour une durée de 3 ans. Ce projet vise à amplifier, optimiser et structurer de façon pérenne la recherche et le développement dans le domaine des sciences et technologies des accélérateurs de particules. La phase préparatoire de TIARA est dotée d'un budget de 9,1 M€, avec une participation de la Commission européenne à hauteur de 3,9 M€ (FP7). 11 instituts (issus de 8 pays différents) participent à ce projet, auquel sont également associés plus de 26 laboratoires ou universités.

Roy Aleksan, CEA and TIARA co-ordinator, **François Kircher**, CEA and TIARA deputy co-ordinator, **Céline Tanguy**, CEA and TIARA co-ordinator assistant.

Faces & Places

AWARDS

Sinclair is awarded first CAP-TRIUMF Vogt Medal

David Sinclair, recognized for his leadership in the SNO experiment. (Image credit: Carleton University.)

David Sinclair is to receive the inaugural Canadian Association of Physicists (CAP)-TRIUMF Vogt Medal for his exceptional vision and contributions to the study of neutrino physics in the pioneering Sudbury Neutrino Observatory (SNO) and for exemplary leadership in establishing the SNOLAB facility.

Named in honour of Erich Vogt, a Canadian nuclear physicist and one of the founders of TRIUMF, the CAP-TRIUMF Vogt Medal has been established to recognize outstanding experimental or theoretical contributions to subatomic physics.

In 2002 the SNO experiment, situated 2 km underground in the Vale/Inco Creighton Mine near Sudbury, Ontario, solved the long-standing solar neutrino problem by finding direct evidence that neutrinos change type as they escape through the Sun (*CERN Courier* May 2007 p26). Sinclair, who is professor of physics at Carleton University, Ontario, and a senior scientist at TRIUMF, was one of the leaders of the experiment.

Sinclair returned to Canada to participate in the SNO project after 16 years at Oxford University, where he worked on research on the structure of nuclei and also designed the first dedicated carbon-dating facility, which was used to date the Turin Shroud. He is now director of facilities development for SNOLAB – an expansion of the facilities constructed for SNO – and is currently developing a detector, EXO, to search for neutrino-less double beta decay. He will receive the medal during the 2011 CAP Congress on 16 June.

PHYSICS IN INDIA

Atul Gurtu retires from the Tata Institute

Atul Gurtu. (Image credit: TIFR.)

Atul Gurtu, a senior professor at the Tata Institute of Fundamental Research (TIFR) in Mumbai, has retired after a career in particle physics spanning four decades. During this time he has been deeply involved in particle-physics research in India and committed to fostering relations with international laboratories and institutions.

As part of the TIFR team in the era of the Large Electron-Positron (LEP) collider at CERN, Gurtu played a key role, together with Som Ganguli and several doctoral students, in the precision measurement of the properties of the Z boson and the determination of the mass and width of the W boson. In recognition of this, Gurtu was invited to join the LEP Electroweak Working Group at its inception in 1991. He was nominated by CERN to be a contributor on the properties of W and Z particles for the Particle Data Group, of which he continues to be a member.

Since the mid-1990s he has been at the heart of Indian participation in the CMS experiment at the LHC, becoming the spokesperson of the India-CMS group in 2003. He oversaw the successful contribution of Indian groups to CMS and laid the ground for many Indian researchers and students to analyse physics data. He has been deeply involved in the Grid-related activities of the India-CMS and India-ALICE groups, as well as participating in setting up the Tier-2 centre of the Worldwide LHC Computing Grid at TIFR.

Gurtu has also been active in organizing and promoting Indian participation in future facilities, such as the International Linear Collider, and has been the Indian representative on the Funding Agencies for Large Colliders committee since 2004. More recently, he has worked towards a possible formal participation of India in CERN and was the Indian link-person with CERN.

Following his retirement, he will continue to work with CMS and to press the case for deepening the ties between India and CERN to the mutual benefit of both.

SCHOOLS

Successful course heralds rebirth of accelerator school

The Joint US-CERN-Russia-Japan School held a course on Synchrotron Radiation and Free Electron Lasers on 6–15 April, at the Ettore Majorana Foundation and Centre for Scientific Culture in Erice. With a programme of lectures, discussion sessions and student presentations, it attracted 65 participants from 22 different countries, with around half from Europe and the other half from Russia, Asia and the Americas. In addition to the academic programme, the students had the opportunity during a one-day excursion to visit archaeological sites at the Temples of Segesta and Selinunte.

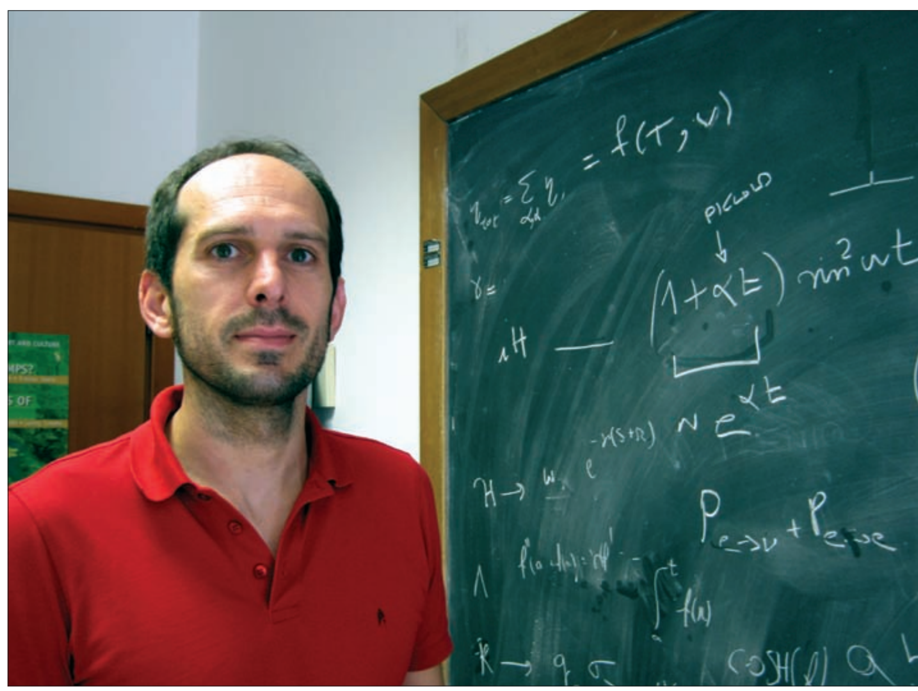
Feedback from the participants was extremely positive, praising the expertise and enthusiasm of the lecturers, as well as the high standard of the lectures. The course was the first to be organized under the umbrella of the Joint US-CERN-Russia-Japan School for nearly a decade. Its success is encouraging the organizers to re-launch the Joint International Accelerator School, which ran on a roughly two-year cycle from 1985 to 2002. The next school would be held somewhere in Asia.

Roger Bailey, left, and Bill Barletta, representing the CERN and US elements of the Joint Accelerator School.

QUANTUM MECHANICS

European researchers prepare for fundamental Action

Quantum mechanics is arguably the most successful physical theory in the history of science. It set out to explain the atomic structure of matter and has since led to revolutionary technologies. Despite many successes, however, the debate about the precise formulation of the theory, its range of validity and the quantum-to-classical transition, it is still open. These open problems continue to be the subject of intense theoretical and experimental research, leading to novel and cutting-edge experiments, with the promise of further technological developments. Now, for the first time, a network is to co-ordinate research in this fascinating area of physics.



Angelo Bassi from the University of Trieste chairs the COST Action on Fundamental Problems in Quantum Mechanics. (Image credit: A Bassi.)

Within the context of the intergovernmental framework for European collaboration on science and technology (COST), European members of the quantum-foundations community met in Brussels on 11 April for the first meeting of the COST Action, "Fundamental Problems in Quantum Physics". This project is establishing the first network in the world dedicated to quantum mechanics and its fundamental and fascinating problems.

The Action involves the participation of more than 40 scientists from 20 European and neighbouring countries, and will co-ordinate scientific research, meetings, training schools, workshops and conferences within the community over the next four years. During this first meeting, Angelo Bassi of the University of Trieste and Deltef Dürr of Ludwig-Maximilian University, Munich, were elected as chair and deputy-chair of the Action, respectively, and four working groups were established. These reflect the four major research topics involved.

The working group on "Quantum theory without observers" is chaired by Nino Zanghì, of the University of Genoa. As John Bell stated: "The formulations of quantum mechanics that you find in the books involve dividing the world into an observer and an observed, and you are not told where that division comes – on which side of spectacles it comes, for example, or at which end of my optic nerve [...] So you have a theory that is fundamentally ambiguous [...]" (*The Ghost in the Atom*, 1986). This is the famous "measurement problem" of quantum mechanics and the aim of research in this area is to resolve the ambiguity by giving a consistent, paradox-free formulation of quantum theory.

"Effective descriptions of complex systems" forms the topic of the second working group, with Irene Burghardt, of the Goethe University, Frankfurt, as chair. One of the fast-growing areas of research in quantum mechanics is the quantum-to-classical transition. The issues at stake are not only conceptual – how the classical world emerges from the underlying quantum dynamics – but also technological. Novel advances in molecular physics, the most fascinating being energy transfer in photosynthetic systems, will depend a great deal on whether these complex systems retain quantum properties or behave classically. The problem is much debated. The general question is to understand how phenomenological laws, like transport equations describing the behaviour of molecular systems, derive from the underlying microscopic dynamics, which is quantum mechanical.

The third working group, "Quantum theory meets relativity", is chaired by Fay Dowker, Imperial College London. The post-Einsteinian world view is that of a four-dimensional universe in which the laws of physics obey the principle of relativity. However, the marriage of relativity and quantum mechanics turns out to be problematic. First, infinities in quantum field theories indicate that they are not the final theories of nature. Second, the Bell inequalities prove the nonlocality of nature, which deepens the tension with relativity. Third, the problem of quantizing gravity has not been fully resolved. Releasing the tension between quantum mechanics and relativity is a major open problem.

Last, Beatrix Hiesmayr of the University of Vienna chairs the working group "From theory to experiments". Recently, the Nobel laureate Anthony Leggett stated: "I'm inclined to put my money on the idea that if you push quantum mechanics hard enough it will break down and something else will take over – something we can't envisage at the moment" (*New Scientist*, 2010). The spectrum of research is wide, and ranges from quantum optics, to molecular, atomic and subatomic physics. Experiments that aim to push quantum superpositions towards the macroscopic scale, involving a larger and larger number of particles, are particularly popular. The most famous experiments are diffraction of macromolecules, opto-mechanical interferometers, as well as superconducting-devices. The technological efforts required are enormous – but so, too, are the expected future pay-offs.

● For more information, see www.cost.esf.org/domains_actions/mpns/Actions/mp1006.

DETECTORS

Industry meets academia on silicon photomultipliers

On 16–17 February, CERN hosted the first industry/academia matching event on silicon photomultipliers (SiPMs) and related technologies. It was promoted by HEPTech, the technology-transfer network created by CERN and its member states to enhance technology transfer in the high-energy-physics community. The event attracted around 140 participants from academia (67%) and industry (33%), representing 43 public research organizations and 21 companies.

SiPMs represent the state of the art in low-light detection, with single-photon sensitivity and genuine photon-number resolving capability. Their characteristics and costs make them increasingly attractive to particle-physics experiments and for research applications, notably in medical imaging and fluorescence detection in life science. However, turning an SiPM into a real detecting device or instrument requires the development of appropriate front-end electronics and data-acquisition systems, together with the resolution of non-trivial issues related to the integration of a large number of sensors. These developments fall into the domain of particle physics, which has pioneered the use of SiPMs over the past decade. Today, this community has significant expertise and technological know-how that can be beneficial to other fields.

An industry exhibition stand on display during the event.

The event, organized over two half-days, aimed to foster an exchange between various stakeholders from industry and academia, as well as to provide an overview of state-of-the-art technologies and define a roadmap towards collaborative R&D for the development of key solutions for SiPMs in different applications. The programme was split into two parts: on the first day, review talks addressed ongoing developments on the sensors and their applications in various domains; on the second day, companies presented their profiles, products and development projects.

The first day started with an overview of SiPM production and readout electronics and their use in high-energy physics experiments. A review of the application of SiPMs in medical imaging followed. In this field, many groups are carrying out an enormous R&D effort, in particular to improve the light-detection efficiency and the timing performance of SiPM-based

Faces & Places

detection modules. The astroparticle-physics community has also demonstrated an increasing interest in the use of SiPMs, namely for photon detection in future experimental set-ups. Interesting perspectives for the use of SiPMs also exist in life-science imaging, a domain that increasingly needs the excellent timing characteristics of these devices.

The presentation of the industry view on medical imaging highlighted the importance of taking into account market constraints, business prospects and proper intellectual-property management when transferring such technologies to industry. The series of review talks ended with a field report on the technology transfer of an SiPM readout kit, illustrating the transfer potential of technologies and expertise that are available in the particle-physics community.

The second day was reserved for companies to present their product portfolio and research capabilities, as well as their availability to participate in joint R&D programmes with academia. It gave a taste of how industry is actively extending the development of this technology as well as its eagerness to increase business prospects.

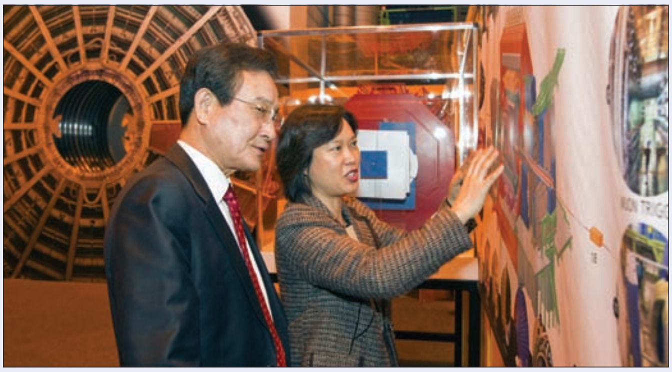
An important aspect of the event was the possibility for the different communities to make contact and merge their interests. There were lively discussions around the demonstrations that were set-up by researchers to promote their technologies. There were also opportunities to meet at the various company booths. Sixteen technology fact-sheets were made available on the event's website, including job offers and CVs, which turned the meeting into a true market place for everyone involved.

A feedback questionnaire that circulated soon after the event showed that the participants were highly appreciative of the organization, venue and structure, reflecting the importance of selecting the speakers in a way that keeps a good balance between their personal visions and the needs of the community they represent. Many participants recognized that carrying out collaborative R&D with industry is crucial for academia to have access and to acquire expertise in this field for its own research purposes.

The participants expressed their strong interest in a follow-up event, with more emphasis on technology-transfer aspects and related services with a view to increasing the effectiveness of collaboration between academia and industry.

● For more details about the HEPTech network, see www.heptech.org, and for the SiPM event, see http://indico.cern.ch/internalPage.py?pageId=0&confId=117424.

Visits



Jae-Ill Byun, left, Korean chair of the education and scientific technology committee in the national assembly, right, visited CERN on 15 March. Here he is at the ALICE exhibition with **Jin Sook Kim**, a member of the ALICE collaboration and Gangneung-Wonju National University.

Phil Mjwara, director-general, department of science and technology, ministry of science and technology for the Republic of South Africa, centre, was welcomed to CERN on 21 March by **John Ellis**, CERN adviser for South Africa, left, and **Felicitas Pauss**, head of international relations. His visit included the CERN Control Centre, the ATLAS visitor centre and the ISOLDE facility.

Israeli president **Shimon Peres**, second from left, came to CERN on 29 March. During his visit he toured the ATLAS underground experimental area with **Giora Mikenberg**, left, of the ATLAS collaboration, Weizmann Institute of Sciences and Israeli industrial liaison office, **Rolf Heuer**, CERN's director-general, and **Fabiola Gianotti**, ATLAS spokesperson. The president also visited the CERN computing centre and met Israeli scientists working at CERN.

On 20 April, **José Manuel Barroso**, president of the European Commission, left, visited CERN. His tour included the CMS control room and the CMS underground experimental area, together with **Guido Tonelli**, the CMS spokesperson.

Faces & Places

A Ukrainian task force, led by **Volodymyr Semynozhenko**, left, head of the Ukrainian Agency for Science, Innovation and Information, visited CERN on 17–18 March. Seen here with him at the ALICE exhibition are, from left to right: **Boris Grinyov**, first deputy-head of the State Agency on Science, Innovation and Information of the Ukraine; **Gennady Zinovjev**, ALICE and the Bogolyubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine; **Yu Avksentiev**, deputy-minister, Cabinet of Ministers of the Ukraine; **Yuriy Panasiuk**, deputy-head, Trade and Economic Mission to the Permanent Mission of the Ukraine to the UN office and other international organizations in Geneva; and **Paolo Giubellino**, the ALICE spokesperson.

Meetings

Muon Collider 2011: Physics – Detectors – Accelerators will take place in Telluride, Colorado on 27 June – 1 July. The workshop will review the physics case for a muon collider, accelerator R&D progress, the outstanding challenges, future plans and opportunities for new and existing groups to participate in further research and development. For more information, see http://conferences.fnal.gov/muon11 or contact Cynthia M Sazama, e-mail: sazama@fnal.gov.

The International Workshop on Early Physics with Heavy-Ion Collisions at the LHC (**EPIC@LHC**) will be held in Bari on 6–8 July. The aim is to bring together experimentalists and theoreticians to discuss the results of the first measurements with heavy-ion collisions provided by the LHC at the end of 2010. Results from ALICE, ATLAS and CMS will be presented, together with recent results and progress from experiments at RHIC and the SPS. The workshop will help to refine the perspectives and guide the future studies on heavy-ion collisions at the LHC. For more information, see www.ba.infn.it/EPIC.

COOL11, the Workshop on Beam Cooling and Related Topics will take place at the Pansionat "Dubna" in Alushta, Crimea, on 12–16 September. The main goal is to highlight the state of the art in the physics and engineering of beam cooling systems and related techniques, including electron, stochastic, laser and muon (ionization) cooling. The programme includes applications of beam cooling to traps, heavy ion and antiproton beams. Presentations of new developments and techniques as well as of the status of existing and future facilities are invited. For more information, see http://cool11.jinr.ru.

The **6th International Accelerator School for Linear Colliders** will take place on 6–17 November at the Asilomar Conference Center, Pacific Grove, California. Organized by the ILC Global Design Effort, the CLIC study and the ICFA Beam Dynamics Panel, the school is hosted by SLAC and sponsored by several funding agencies and institutions. The first two and a half days will be an introductory overview of TeV-scale lepton colliders, followed by two elective courses, on accelerator physics and RF technology. The school will accept a maximum of 70 students from around the world. They will receive financial aid for attending, including travel (full or partial). There will be no registration fee. The application deadline is 30 June. For more information, see www.linearcollider.org/school/2011 or e–mail lcschool@slac.stanford.edu.

Celebration

Sergei Matinyan celebrates his 80th year

January 2011 marked the 80th birthday of Sergei Matinyan, a prominent Armenian theoretician and outstanding mentor.

Born in Tbilisi, Georgia, Matinyan established the first high-energy physics laboratory there before moving to Armenia in 1970 as deputy to Artem Alikhanian in the Yerevan Physics Institute and head of the theory laboratory. He was instrumental in organizing the Soviet-American workshops on gauge theories held in Yerevan in 1980s. Attended by many major figures, these were essential events at the time of the Iron Curtain.

He has obtained important results, particularly in the asymptotic theory of hadron interactions, ground-states in non-Abelian Yang-Mills theory and chaos in fundamental physical theories. Recent work has been on nanoscience. Under his supervision, some three dozen students have gained PhDs in quantum field theory, phenomenology, grand unification, supersymmetry (supergravity) and statistical mechanics.

Sergei Matinyan, now 80, is a well known theoretician. (Image credit: Yerevan Physics Institute.)

OBITUARIES

Emilio Pagiola 1937–2011

CERN physicist Emilio Pagiola passed away on 22 February following a long illness.

After obtaining a degree in physics from the University of Padua, Emilio joined CERN in March 1966 as an experimental physicist in the Track Chamber Division – at a time when the bubble-chamber technique was an important part of high-energy physics research. As a member of the CERN-Heidelberg-Saclay collaboration, he was active in low-energy formation experiments using beams from the Proton Synchrotron. His particular contribution was a novel partial-wave analysis of $\bar{K}$-N interactions. This was a time of resonance hunting, leading to the SU(3) classification scheme of Murray Gell-Mann and Yuval Ne'eman as well as the quark model of Gell-Mann and George Zweig. In this work, Emilio made many contributions to the analysis software and built a wide reputation as a computer wizard.

In particular, he made significant contributions to the editing programme PATCHY used for maintaining source material and managing large volumes of source code. It allowed multilevel replacements of material at the level of single FORTRAN statements, as well as the selection of versions according to control cards. Although intended for use only at CERN, PATCHY turned into a general-use editing package on many systems using CERN programs. Emilio also contributed to other software packages, such as HYDRA, a modular program for bubble-chamber data analysis.

Less known is Emilio's contribution to the early version of the popular HBOOK histogram package – the ancestor of the PAW and ROOT analysis systems. HBOOK was derived from a subroutine named HISTME, written by Emilio, to which three entry points were added: HBOOK, HFILL and HISTDO.

Emilio Pagiola. (Image credit: S Pagiola.)

In the mid-1970s, with the start of the Super Proton Synchrotron at CERN, a programme of neutrino physics using the Big European Bubble Chamber (BEBC) was initiated. The measurement devices (ERASME) had been developed to measure events in hydrogen, and had to be adapted to handle neutrino interactions in neon, which are more complex because of converted photons and secondary interactions. Emilio led the ERASME team in a crash effort to produce an interactive measurement system that could easily guide a physicist or a scanner through the difficult measurement of such events. This interactive system was a great success and was used throughout the BEBC neutrino programme. Emilio also co-authored several papers reporting results from these experiments.

He was one of the first to recognize and exploit the possibilities of interactive graphics as an analysis tool and, in particular, was the first – in the 1980s – to bring the NeXT computer to CERN. This was a crucial tool in the development at CERN of the World Wide Web, as described in *How the Web Was Born*, the book by James Gillies and Robert Cailliau. Emilio's knowledge of computers and computing was outstanding and he was always several years ahead of the majority of physicists in recognizing the best software and hardware tools that could be used. For example, he dedicated much effort in CERN's Physics Division to obtain the desktop computing facilities that all physicists now take for granted.

Emilio was a scientist gifted with unconventional intelligence, a critical mind and broad culture, ranging from science to history, politics and finance. His passion for music was legendary. Up until the end of the 1970s, he was part of a small group of about 10 physicists – calling themselves the Red Guard – who met once a week for a brainstorming session in the office of the division leader, Charles Peyrou, to discuss subjects of physics or mathematics not necessarily directly connected to CERN's scientific programme.

After retiring from CERN in 2002, and even during the years of his illness, Emilio continued to come to the laboratory to meet colleagues and friends and to discuss the latest developments in the field with them. His ideas and criticisms were always much appreciated.

Emilio will be sorely missed. Much sympathy goes to his wife Maria, their two sons Stefano and Federico, and their families.

● *His friends and colleagues.*

Peter Harold Sharp 1940–2011

Peter Sharp, a talented experimental physicist, a superb strategist, a trouble-shooter par excellence and an eternal optimist, passed away on 11 March.

Peter began his scientific career in 1960 at the UK Atomic Energy Authority at Harwell, working on the development of the NIMROD accelerator for the Rutherford High Energy Laboratory. Two years later, he started his undergraduate studies and obtained his bachelor's degree from the University of London in 1965. On his return he began working towards his PhD, which was awarded in 1971 on an experiment at NIMROD. He remained at what became the Rutherford Appleton Laboratory (RAL) until 2000, when he joined the CMS experiment at CERN.

Peter's achievements at RAL included two ground-breaking projects. As leader of the RAL group on the WA69 experiment at the Omega Spectrometer at CERN he was responsible for the construction of a large ring-imaging Cherenkov detector in the early 1980s – the first major use of this kind of detector. Then, as head of the Electronics Division at RAL (from 1986) he was heavily involved in the construction of the first pipelined electronics and trigger system for the ZEUS experiment at HERA, DESY, which was to be – in some senses – a prototype for experiments at the LHC. In 1995 Peter became director of technology and in 1998 director of instrumentation at the UK Central Laboratory of Research Councils, based at RAL.

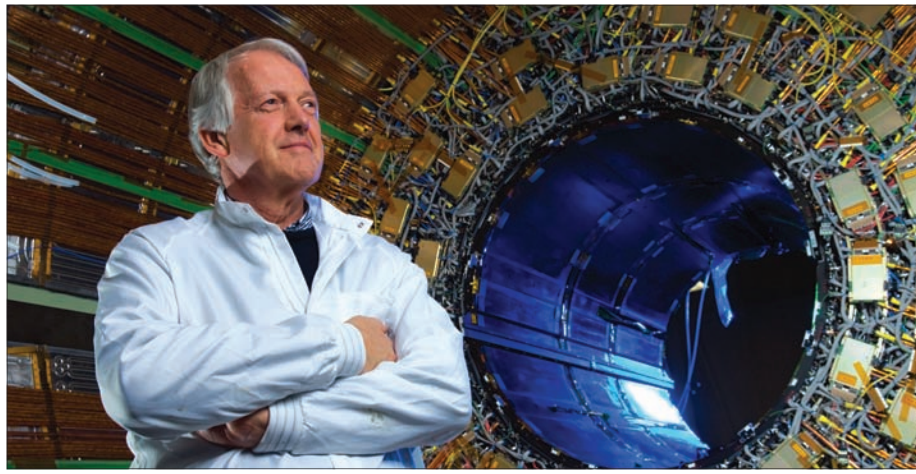
The wide scope of Peter's knowledge of instrumentation in particle physics meant that his advice was continually sought by the peer-review bodies of major laboratories in the field. He provided this to great effect, especially through the Detector Research and Development Committee and the LHC Committee at CERN, and the Topical Workshops on Electronics for Particle Physics.

However, it is in the past decade that many of us came to appreciate Peter's unique talents. His contribution to the successful completion and commissioning of CMS was immense. It is no exaggeration to say that the smoothly running scientific instrument that is CMS today owes a great deal to Peter's skill, foresight, leadership and tenacity – and, not least, his powers of persuasion.

His impact on LHC experiments started in the early 1990s. He was one of the few people who drove the development of the radiation-hard deep-submicron (DSM) electronics that have had a major impact on CMS and other experiments. Peter had the vision to see what was needed: investment in people and commercial design-tools; and a systematic approach to requirements, specifications and reviews. He understood the importance of, and built links to, industry and fostered closer links with CERN and other European laboratories. The use of DSM technology was to become a crucial element in the design of CMS and is now recognized as a key underlying technology.

DSM technology was first used in CMS in 1999 for the redesign of the electronics chain for the tracker and subsequently in the redesign of the electronics chain for the crystals of the electromagnetic calorimeter. The challenge of meeting the calorimeter's exacting performance requirements and escalating costs were causing concern for its timely success. Peter, by then the electronics co-ordinator for CMS, played a crucial role in the redesign, the restructuring of the electronics project and in working out a plan of production that could fit into the highly compressed time remaining before the LHC became operational.

His many skills were soon called on again, this time in the CMS tracker project, where the challenges of large-scale component manufacture and the complexity of timely assembly and integration were a concern. Peter recommended restructuring the project and was asked to step in. He offered crucial technical oversight and leadership during a pivotal period in the construction, which resulted in the high-quality silicon tracker CMS now has.



Peter in front of the CMS tracker during its construction. (Image credit: S Boreham/STFC.)

Throughout all of these challenges, Peter's bold personality was there for all to see, marked by charm, integrity and generosity of spirit. His long and valiant battle against severely debilitating illnesses over the last two years only served to emphasize the optimism and total commitment that characterized his professional life. His keen intellect was never dimmed and the latest news from CMS was what he most wanted to hear. True to form, up until his last days, he was enquiring about the experiment, still discussing its upgrades – forever looking forward into the future to the new challenges in his own inimitable way.

Peter is survived by his wife, Betty, and their daughter Cathy and son Jonathan.

● *His friends and colleagues.*

Faces & Places

Maximilian Kreuzer 1960–2010

Theoretical physicist Maximilian (Max) Kreuzer, professor at the Vienna University of Technology (TU Vienna), passed away on 26 November, just two years after learning that he had an aggressive blood cancer. He did not lose hope but fought the disease heroically and with a clear mind, keeping up his scientific work until the end. He had established a vibrant string-theory group at TU Vienna with a sizeable number of students and postdocs.

Max is well known in the string-theory community for his work with Harald Skarke on the classification of reflexive polytopes in four dimensions and hence of a huge class of Calabi-Yau manifolds. (These are used by string theorists to compactify 10-dimensional superstring theories into 4-dimensional ones, at the same time encoding particle-physics models in the geometry of hidden dimensions.) Prior to their work, only the 16 two-dimensional reflexive polytopes had been classified completely. In 2000, following several years of computer-assisted work, he and Skarke obtained all 473 800 776 reflexive polytopes in four dimensions and an equally voluminous catalogue of Calabi-Yau manifolds and their topological properties.

Max studied physics and mathematics at TU Vienna, where he graduated in 1986 as a student of Wolfgang Kummer with a thesis on grand unification, before starting his postdoctoral career at the University of Hanover. There, he made himself known by solving a problem of classification, namely of anomalies in quantum field theory, in well cited work with Norbert Dragon and Friedemann Brandt. He was drawn into superstring theory during his next postdoctoral position at the University of California, Santa Barbara.

Max Kreuzer. (Image credit: TU Vienna.)

As a CERN Fellow (1991–1993), Max continued his work on string theory and evolved into one of the world experts on the construction of Calabi-Yau manifolds. Many people remember him from those days as a likeable, witty colleague with a sharp mind. During that time, his daughter Maria was born. After he left for Vienna, he kept close ties with the Theory Division (TH) at CERN, not least via the numerous PhD students he sent. Suzy Vascotto, who was in the TH secretariat when Max was a fellow at CERN, says, "I don't know why his smile has kept so fresh and clear in my memory, as there were so many people around before and after him in TH. But some people have stood out over the years, and he was one of them."

Max will be remembered like this by all who had the privilege of working with him and becoming his friend.

● *Wolfgang Lerche, CERN, Anton Rebhan, Vienna University of Technology.*

A commemorative scientific meeting will take place at the International Erwin Schrödinger Institute, Vienna, 25–28 June, organized by Ludmil Katzarkov, Johanna Knapp, Anton Rebhan, and Emanuel Scheidegger.

New products

Lake Shore Cryotronics Inc has introduced the new Model 335 temperature controller, the first two-channel model with user-configurable heater outputs delivering a total of 75 W of low-noise heater power. Output 1 functions as a current output while output 2 can be configured in current or voltage mode. The controller's zone-tuning feature allows seamless measurement and control of temperatures from 300 mK to more than 1500 K. For more information, tel +1 614 891 2244; e-mail info@lakeshore.com; or see www.lakeshore.com/temp/cn/335po.html.

Maxon Motor has announced the new brushless direct current motor EC 40. The palm-sized motor features a neodymium permanent magnet, stainless-steel housing and welded flanges. It has a flat speed/torque gradient of about 3.6 rpm/mNm, mechanical time constant of 2.1 ms, permissible speed of 18 000 rpm and 89% efficiency. For more information, contact Pierre Lebet, e-mail pierre.lebet@maxonmotor.com; or visit www.maxonmotor.ch.

Narda Safety Test Solutions GmbH has introduced the EHP-50D isotropic field analyser, an improved version of the probe for measuring low-frequency electromagnetic fields from 5 Hz to 100 kHz. Simultaneous measurement of all three axes coupled with a dynamic range of up to 150 dB ensures that signals can be captured quickly, reliably and over a wide range. Equipped with a datalogger and lithium-ion battery, the EHP-50D can operate for up to 24 hours in stand-alone mode. For more information, tel +49 7121 9732 777; e-mail support@narda-sts.de; or see www.narda-sts.com.

Pfeiffer Vacuum has announced a new version of the gas-cooled Roots pump OktaLine G, with pumping speeds in the range 250–12 000 m^3/h. It is ideal for low- and medium-vacuum applications in research and development. The heated gas is cooled on the pressure side and partially returned to the suction chamber, allowing for continuous operation in high pressure ranges. Energy-efficient drives and the use of frequency converters lower energy consumption by up to 20%. For further details, e-mail Nicole.Ackermann@pfeiffer-vacuum.de; or visit www.pfeiffer-vacuum.com.

Physik Instrumente LP has released a new miniature hexapod parallel positioner for vacuum applications. The M-811.STV vacuum-compatible hexapod measures 130 mm in diameter and 115 mm in height for easy integration into vacuum chambers. It has a load capacity of 11 lb (5 kg), actuator resolution of 0.04 μm, repeatability of ±0.5 μm, velocity to 10 mm/s and includes digital controller and software. A non-vacuum version is also available. For more information, e-mail info@pi-usa.us, or see www.pi-usa.us.

Recruitment

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

The Max Planck Institute for Physics invites applications for a

Postdoctoral position

to participate in a new effort on proton-driven plasma wakefield acceleration.

The concept of proton-driven plasma wakefield acceleration has recently been proposed as a means of accelerating a bunch of electrons to high energies with very high gradients. Initial calculations are promising, as shown in Nature Physics 5, 363 - 367 (2009), and a demonstration experiment is now under consideration. The focus of the work will be on developing time- and frequency domain characterization techniques for the plasma wakefields and for the drive and witness bunches. An experimental technique under consideration to extract information on electric fields is single-shot electro-optical sampling based on dispersive Fourier transform.

Formal requirement for this position is a PhD in experimental nonlinear optics, plasma or terahertz physics. Previous experience in plasma wakefield experiments, particle and/or accelerator physics are an advantage.

Salary and benefits are commensurate with public service organization (TVöD) rules. The contract is initially limited to 2 years with the possibility of an extension. The Max Planck Society is an equal opportunity employer. The goal is to enhance the percentage of women where they are underrepresented. Women, therefore, are especially encouraged to apply. The MPG is committed to employing more handicapped people. Applications of handicapped people are particularly welcome.

Further information can be obtained from Dr. Olaf Reimann (reimann@mpp.mpg.de). Interested applicants should submit their application by **July 15, 2011**, including a cover letter, a statement of research interests, a curriculum vitae, a list of publications, and arrange for three letters of support to be sent to

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)
Ms. Ina Wacker
Föhringer Ring 6, 80805 München, Germany

MAX-PLANCK-GESELLSCHAFT

EUROPEAN SPALLATION SOURCE

European Spallation Source AB is preparing to construct a world-leading European materials research centre in Lund, Sweden. ESS is partnered by a large number of European countries.

Be part of the future!

We are looking for highly qualified:

- SENIOR INTEGRATION ENGINEER
- CAD QUALITY DESIGN COORDINATOR
- BEAM EXTRACTION ENGINEER
- BEAM DIAGNOSTICS ENGINEER
- GROUP LEADER
  - NEUTRON OPTICS
  - CHOPPER

See all our positions at: www.esss.se/careers

High Energy Accelerator Research Organization (KEK)

Call for Nomination for Next Director-General of KEK

KEK, High Energy Accelerator Research Organization, invites nominations for the next Director-General whose term will begin April 1, 2012.

The role of Director-General, therefore, is to promote with long-term vision and strong scientific leadership, the highly advanced, internationalized, and inter-disciplinary research activities of KEK by getting support from the public. The successful candidate is also expected to establish and carry out the medium-term goals and plans.

The term of appointment is three years. When reappointed, the term can be extended up to 9 years.

We widely accept the nomination of the candidates regardless of their nationalities.

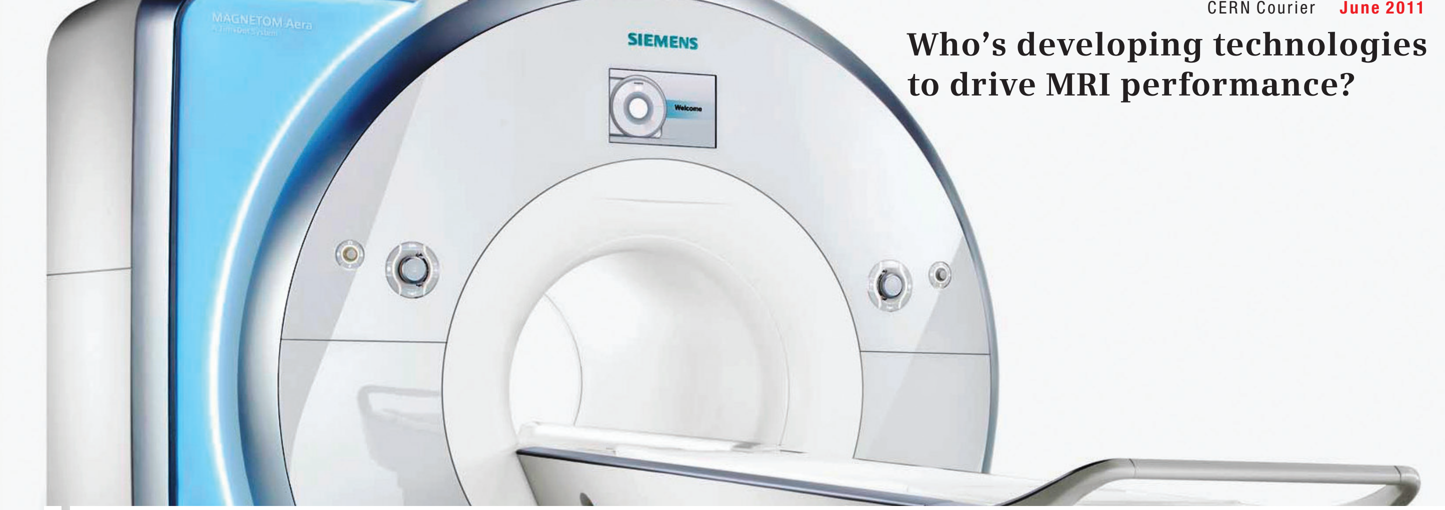
We would like to ask you to recommend the best person who satisfies requirements for the position written above.

Nomination should be accompanied by:
1) letter of recommendation,
2) brief personal history of the candidate, and
3) list of major achievements (publications, academic papers, commendations and membership of councils, etc.).

The nomination should be submitted to the following address **no later than July 8, 2011**: Documents should be written either in English or in Japanese.

Inquiries concerning the nomination should be addressed to:

General Affairs Division
General Management Department
KEK, High Energy Accelerator Research Organization
1-1 Oho, Tsukuba, Japan 305-0801
Tel +81-29-864-5114
Fax +81-29-864-5560
Email: shomu@mail.kek.jp



Who's developing technologies to drive MRI performance?

Dare to ask.

At Siemens, we're all given the chance to contribute to our innovative work.

Nowhere more so than here in Siemens Magnet Technology. We produce 40% of the world market of superconducting magnets used in MRI scanners. We're proud of the vital contribution they make to transforming healthcare everywhere, and of the innovative technologies we've developed that make this possible. We've been recognised with the Cranfield University award for Process Innovation as well as the prestigious MX award for Engineering Product Innovation from the Institute of Mechanical Engineers.

As we grow, as we continue to deliver exceptional technology and solutions, we're looking for a **Principal Applied Physicist** (Job ID: 37878) and a **Principal Cryogenics Engineer/Scientist** (Job ID: 48576) to join us in Eynsham, Oxon. If you want to tackle challenging engineering and physics problems with the leader in the field, and help improve people's lives, then visit **www.siemens.co.uk/careers** click on current vacancies and type the Job ID into the requisition field.

siemens.co.uk/careers

SIEMENS

MICHIGAN STATE UNIVERSITY

Michigan State University (MSU) invites applications for faculty positions at NSCL. NSCL faculty normally have joint appointments in a major academic department, such as Physics, Chemistry or Engineering, where they are expected to teach. Applications are particularly encouraged in growing areas of research and technology important to NSCL and the future DOE Facility for Rare Isotope Beams (FRIB). These areas include laser-based nuclear and atomic spectroscopy, nuclear structure physics, nuclear astrophysics, the study of fundamental interactions with rare isotope beams, societal applications of rare isotopes including homeland security and uses in medicine, and accelerator physics / engineering.

Successful candidates will have a PhD and are expected to develop leadership roles in research and technology development at NSCL, contribute new capabilities to the laboratory, and contribute to NSCL's graduate and undergraduate education programs. Depending upon the qualifications of the successful applicants, each position can be filled at the assistant, associate, or full professor level, with a competitive salary.

Information about NSCL can be found at nscl.msu.edu; information about NSCL faculty appointments can be found at **http://www.hr.msu.edu/documents/facacadhandbooks/NSCLFacPos.htm.**

Applications will be reviewed starting May 2011 and the search will continue until the positions are filled. Applicants should send a letter of application, a résumé, including a list of publications, and the names and addresses of at least three references to **Ms. Chris Townsend, NSCL, Michigan State University, East Lansing, MI 48824-1321.**

MSU is committed to achieving excellence through cultural diversity. The university actively encourages applications and/or nominations of women, persons of color, veterans and persons with disabilities. MSU is an affirmative action, equal opportunity employer.

NSCL

Turnkey solutions for research, development and pilot production

Complex vacuum systems.

Our vacuum systems simply offer more. Your process will be improved by the performance of our systems! The UNIVEX 450 C vacuum systems are equipped with PLC and integrated visualization and offer optimized system monitoring and control. Typical applications are high vacuum systems, analytical and calibration systems as well as experimental coating systems for industrial and university research. We offer standardized as well as customized universal, fully automatic cluster systems for the production of functional coatings, respectively coating systems for a variety of sizes where the sequence of the layers can be freely selected.

Get the details at oerlikon.com/leyboldvacuum

Oerlikon Leybold Vacuum GmbH
Bonner Strasse 498
D-50968 Köln
T +49 (0)221 347-0
F +49 (0)221 347-1250
info.vacuum@oerlikon.com
www.oerlikon.com/leyboldvacuum

œrlikon
leybold vacuum

Bookshelf

Induction Accelerators

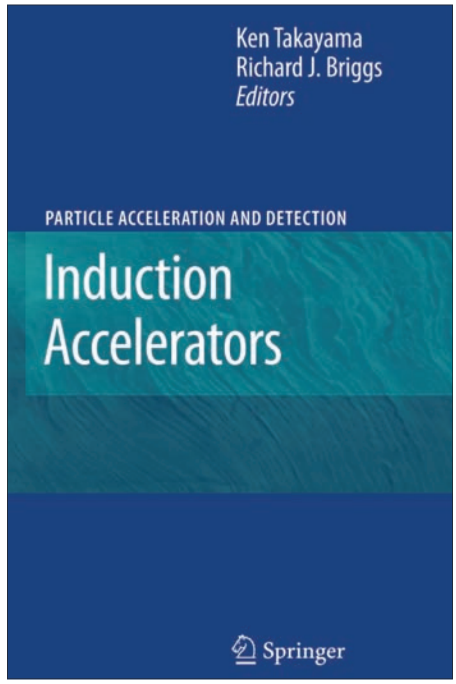
By Ken Takayama and Richard Briggs (eds.)
Springer
Hardback: €126.55 £108 $169

Of the nearly 30 000 particle accelerators now operating worldwide, few types are as unfamiliar to most physicists and engineers as induction accelerators. This class of machine is likewise poorly represented in technical monographs. *Induction Accelerators*, a volume of 12 essays by well known experts, forms a structured exposition of the basic principles and functions of major technical systems of induction accelerators. The editors have arranged the essays in the logical progression of chapters in a textbook. Nonetheless, each has been written to be useful as a stand-alone text.

Apart from the two chapters about induction synchrotrons, the book is very much the product of the "Livermore/Berkeley school" of technology of induction linear accelerators (linacs) started by Nicholas Christofilos and led for many years by Richard Briggs as the Beam Research Program at the Lawrence Livermore National Laboratory. The chapters by Briggs and his colleagues John Barnard, Louis Reginato and Glen Westenskow are masterful expositions marked by the clarity of analysis and physics motivation that have been the hallmarks of the Livermore/Berkeley school. A prime example is the presentation of the principles of induction accelerators that, despite its brevity, forms an indispensable introduction by the master in the field to a discussion (together with Reginato) of the many trade-offs in designing induction cells.

One application of induction technology made important by affordable, solid-state power electronics and high-quality, amorphous magnetic materials is the induction-based modulator. This application grew from early investigations of magnetic switching by Daniel Birx and his collaborators; it is well described by Edward G Cook and Eiki Hotta in the context of a more general discussion of high-power switches and power-compression techniques.

Invented as low-impedance, multistage accelerators of high-current electron beams, induction machines have always had the central challenge of controlling beam instabilities and other maladies that can spoil the quality of the beam. Such issues have been the focus of the major scientific contribution of George Caporaso

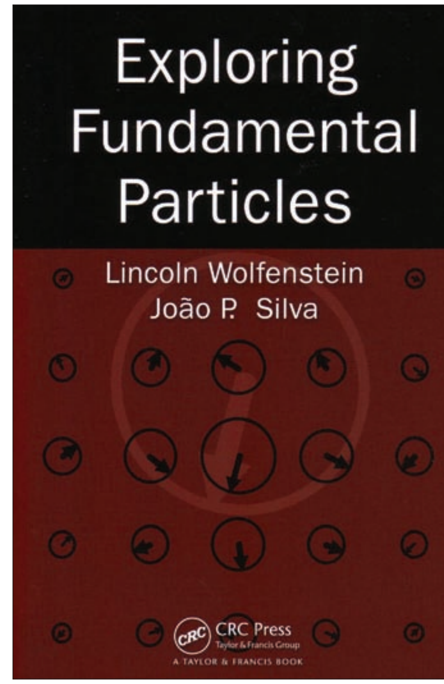


and Yu-Jiuan Chen, who – in the most mathematical chapter of the book – discuss beam dynamics, the control of beam break-up instability and the suppression of emittance growth resulting from the combination of misalignment and chromatic effects in the beam transport.

In ion induction linacs proposed for use as inertial-fusion energy drivers, an additional class of instabilities is possible, namely, unstable longitudinal space–charge waves. These instabilities are analysed in a chapter by Barnard and Kazuhiko Horioka titled "Ion Induction Linacs". It is followed by a description of the applications of ion linacs, especially to heavy-ion-driven inertial fusion and high-energy density research. These chapters contain the most extensive bibliographies of the book.

The use of induction devices in a synchrotron configuration was studied at Livermore and at Pulsed Sciences Inc in the late 1980s. However, it was not until the proof-of-concept experiment by Takayama and his colleagues at KEK, who separated the functions of acceleration and longitudinal focusing, that applications of induction accelerators to producing long bunches (super-bunches) in relativistic-ion accelerators became a possibility for an eventual very large hadron collider. These devices and their potential applications are described in the final chapters of the book.

Both physicists and engineers will find the papers in *Induction Accelerators*



well written with ample – though not exhaustive – bibliographies. While the volume is not a textbook, it could profitably be used as associated reading in a course about accelerator science and technology. *Induction Accelerators* fills a void in the formal literature on accelerators. It is a tribute to Nicholas Christofilos and Daniel Birx, the two brilliant technical physicists, to whom this volume is dedicated. I recommend it highly.

● *William Barletta, director of the US Particle Accelerator School and adjunct professor of physics at MIT and UCLA.*

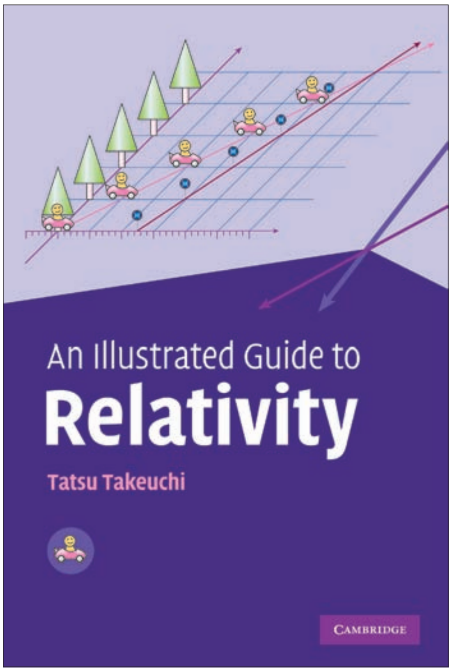
Exploring Fundamental Particles

By Lincoln Wolfenstein and João P Silva
Taylor & Francis; CRC Press 2011
Paperback: £30 $49.95
E-book: $49.95

Writing a book is no easy task. It surely requires a considerable investment of time and effort (it is difficult enough to write short book reviews). This is especially true with books about complex scientific topics, written by people who are certainly not professional writers. I doubt that the authors of the books reviewed in the *CERN Courier* have taken courses on how to write bestsellers. Being such hard work, the authors must have good reasons to embark on the daunting challenge of writing a book.

When I started reading *Exploring Fundamental Particles*, I immediately wondered what could have been the reasons

Bookshelf



that triggered Lincoln Wolfenstein and João Silva to write such a book. After all, there are already many "textbooks" about particle physics, both in generic terms and in specific topics. For instance, the puzzling topic of CP violation is described in much detail in the book *CP Violation* (OUP 1999), by Gustavo Branco, Luís Lavoura and João Silva (the same João Silva, despite the fact that João and Silva are probably the two most common Portuguese names). There are also many books about particle physics that address the "general public", such as the fascinating *Zeptospace Odyssey* (OUP 2009), by Gian Giudice (*CERN Courier* April 2010 p40), which is a nice option for summer reading, despite the somewhat weird title (the start-of-section quotations are particularly enjoyable).

Exploring Fundamental Particles follows an intermediate path. It addresses a broad spectrum of physics topics all of the way from Newton (!) and basic quantum mechanics to the searches for the Higgs boson at the LHC – building the Standard Model along the way. And yet, despite its wide scope, the book focuses with particularly high resolution on a few specific issues, such as CP violation and neutrino physics, which are not exactly the easiest things to explain to a wide audience. The authors must have faced difficult moments during the writing and editing phases, trying hard to keep the text readable for non-experts, while giving the book a "professional touch".

This somewhat schizophrenic style can be illustrated by the fact that while the book is submerged in Feynman diagrams, some of them are quite hard to digest ("Penguins" and other beasts), it has no equations at all (not even the ubiquitous $E=mc^2$) – maybe for fear of losing the reader – until we reach the end of the book (the fifth appendix, after more than 250 pages, where we do see $E=mc^2$). The reading is not easy (definitely not a "summertime book") so, for an audience of university students and young researchers, adding a few equations would have improved the clarity of the exposition.

I also found it disturbing to see the intriguing discussions of puzzling subjects interrupted by trivial explanations on how to pronounce "Delta rho", "psi prime" etc. These parenthetical moments distract the readers who are trying to remain concentrated on the important narrative and are useless to the other readers. (If you do not know how to pronounce a few common Greek letters, you are not likely to survive a guided tour through the CKM matrix.)

I hope the authors (and editor) will soon revise the book and publish a second edition. In the meantime, I will surely read again a few sections of this edition; for certain things, it is really quite a useful book.

● *Carlos Lourenço, CERN.*

An Illustrated Guide to Relativity

By Tatsu Takeuchi
Cambridge University Press
Hardback: £45
Paperback: £16.99
E-book: £23

When I was an undergraduate my special-relativity professor, Yashusi Takahashi, was trying to write a book to teach special relativity using diagrams. Certainly, diagrams figured highly in our course material, but so did equations. In *An Illustrated Guide to Relativity*, Tatsu Takeuchi has taken things one step further and produced a textbook about special relativity that uses no equations at all.

This approach works well in the early chapters. The concept of the space–time diagram is introduced for Galilean rest frames and Takeuchi shows how two different rest frames can be superimposed on a single diagram by changing the angle of the grid. However, once he reaches Lorentz frames, I found myself yearning for an equation to give me a more complete picture – beyond just pictures.

That said, the book is well written and entertaining. I like the drawings as well as Takeuchi's self-deprecating sense of humour. He gets across early on how odd it is that the speed of light is the same in all inertial frames, and shows clearly why this leads to the breakdown of Galilean transformation – showing that the invariance of the speed of light affects simultaneity.

Each page is self-contained, which makes it easy to get through, and the challenges of special relativity – such as the twin paradox and Lorentz contraction – are well explained. There is even a useful section of exercises at the back that you can use to test your understanding.

So, it's a worthwhile book. For those who are non-mathematically minded, it is all you need to gain a good understanding of Einstein's special theory of relativity. For those who like a good equation, it's still a great companion.

● *Catriona Charlesworth, St Jean de Gonville.*

Books received

Spectral Distributions in Nuclei and Statistical Spectroscopy

By V K B Kota and Rizwan ul Haq (eds.)
World Scientific
Hardback: £91 $147
E-book: $191

This first, comprehensive review of statistical spectroscopy begins with an introductory overview of the subject of spectral distributions initiated by J Bruce French in the 1960s, followed by a collection of original papers that continue to give new insight into the average properties of spectra. The purpose is to highlight the considerable advances made in the application of statistical spectroscopy to nuclear structure and to encourage new directions in random matrix theory, many-body chaos and statistical mechanics of finite quantum systems such as nuclei, atoms, molecules, quantum dots etc.

Physics Over Easy: Breakfasts with Beth and Physics (2nd edition)

By Leonid V Azároff
World Scientific
Hardback: £36 $54
Paperback: £16 $24

During a sequence of meals, the author relates the principal features of physics in easy-to-understand conversations with his wife. Beginning with the studies of motion by Galileo and Newton through to the revolutionary theories of relativity and quantum mechanics in the 20th century, this book covers the all-important aspects of electricity, energy, magnetism, gravity and the structure of matter and atoms. The second edition includes nanoparticles, Bose–Einstein condensates, quantum entanglement and quantum computers. It describes our improved understanding of how the universe was formed in an inflationary Big Bang and the life of stars.

Inside Story

Glass, copper, pen and ink

Jan Hladký, a member of ALICE, is an artist whose pictures may seem familiar.

From the exhibition at CERN. Bottom left: Jan Hladký with Old Preprints *(glass). Top:* Strange Resonances *(glass and copper), a topical subject. Bottom right:* Sendai *(1986), to whose people the exhibition was dedicated.*

Jan Hladký has been working in particle physics for more than 50 years as an experimental physicist at the Institute of Physics of what is now the Czech Academy of Sciences in Prague. Over the years he has had the opportunity to attend conferences in various countries, and each time he goes he takes pen, ink and watercolours so that between sessions he can capture the essence of the place that he is visiting. His sketches are probably best known from the covers of some of the proceedings – the 1987 "Lepton–Photon" conference, for example, has a classic view of Hamburg.

Hladký grew up in a place some 50 km from Prague, where his mother's family had inherited a castle – rebuilt in 1777 by Empress Maria Theresa. With its frescos and sculptures the castle provided an artistic influence, while family members had an interest in both art and science. His father was a doctor but kept many art books and an uncle was a professor of thermodynamics and a member of the Czech Academy of Sciences and Arts. Born in 1934, much of Hladký's later childhood was overshadowed by the Second World War and the subsequent communist take over of his country, but a teacher at his secondary school also fostered in him a serious interest in art.

Following the family's scientific interests, Hladký graduated as an engineer at the Agriculture University in Prague but at the same time studied physics at the Charles University, before joining the Institute of Physics in 1957. His work took him first to the cosmic-ray observatory of Lomincký Peak in the High Tatras mountains. In the 1960s he became a visiting scientist at other research centres, in particular JINR in Dubna, where he obtained his PhD.

The political climate in then Czechsolvakia chilled noticeably after the "Prague spring" of 1968, and from 1970 Hladký was refused permission even to visit JINR. His position in the Institute of Physics became unclear, mainly because he was not a member of the Communist Party. However, art was still allowed as a free profession, so he kept up his interest – in part to have a profession "in reserve" should he lose his post in physics.

It never came to that, but Hladký continued his art and found enjoyment in creativity during two decades when he had little direct contact with experiments or collaboration members in particle physics. Two exceptions in the 1980s were a visit to CERN for a month at the start of the NA4 experiment (he was head of the group at the Institute) and one to Sendai, Japan, for Neutrino '86 (allowed because Japan is not in the West).

During all of this time, Hladký had developed his own style of sculpture based on recycled materials, in particular glass, but also, for instance, copper that was no longer needed by experiments at Dubna. During the 1970s he began using broken glass from a factory near his father's house – an interesting "twist" on the high-class Bohemian crystal of his home region – and in 1987 he was accepted as a member of the glass section of the Syndicate of Czechoslovak Fine Artists for this "new direction" in Czech glass work.

With the fall of the Iron Curtain, Hladký could travel once again and from 1990 often visited DESY as a member of the H1 collaboration on the HERA collider. He has also attended many conferences, from Jerusalem to London to New York. He has organized exhibitions of his work in several of these places, most recently at CERN at the end of April. He dedicated the exhibition to the victims of the recent earthquake and tsunami in Japan, one of the few places he had been able to visit in the 1970s.

● *Christine Sutton, CERN.*

CAEN *Tools for Discovery* Electronic Instrumentation

Waveform Digitizers Family NEW entry

742 Switched Capacitor Digitizer series

VME/V1742 (32ch), Desktop/DT5742 (16ch), NIM/N6742 (16ch) — **12 bit resolution 5 GS/s**

- This units are an excellent mix of performance and high density (32/16 ch) of Data Acquisition Channels in one single board.
- Based on the PSI (Paul Scherrer Institute) switched capacitor array **"DRS4-Domino"**
- The analog input signals are continuously sampled by the DRS4s in a circular analog memory buffer; 1024 storage cells per channel (200 ns recorded time per event @ 5GSample/s)
- Programmable sampling frequency is **5GS/s, 2.5GS/s and 1GS/s**

761 Interleaved Digitizer series

VME/V1761 (2ch), Desktop/DT5761 (1ch), NIM/N6761 (1ch) — **10 bit 4 GS/s Waveform Digitizer**

- Clock In/Out, Triggers and 16 GPIOs available on the Front panel for multi-board synchronisation
- Memory buffer: 7.2 or 57.6 MSample/channel divided in 1 to 1024 independent read/write buffers

Available in VME, NIM and Desktop Form Factors

- Innovative and revolutionary daisy chainable Optical Link:
  - One PCI card A2818 (1 Optical Link) can control up to 8 ADC boards (e.g. 256 channels of model 742)
  - One PCIe card A3818 (4 Optical Links) can control up to 32 ADC boards (e.g. 1024 channels of model 742)
- USB2.0 port for NIM and Desktop boards
- Drivers, Libraries (C and LabView), Demos and Software tools for Windows and Linux

Digitizers Selection Table

Model [1]	Form Factor	N. of ch. [4]	Max. Sampling Frequency (MS/s)	N. of Bits	Input Dynamic Range (Vpp) [4]	Single Ended / Differential Input	Bandwidth (MHz)	Memory (MS/ch) [4]	DPP firmware [5]
x724	VME	8	100	14	0.5 / 2.25 / 10	SE / D	40	0.5 / 4	TF
	Desktop/NIM	4 / 2				SE			
	PCIe	2				SE			
x720	VME	8	250	12	2	SE / D	125	1.25 / 10	CI, NG
	Desktop/NIM	4 / 2				SE			
	PCIe	2				SE			
x721	VME	8	500	8	2	SE / D	250	2	no
x731	VME	8 - 4	500 - 1000	8	2	SE / D	250/500	2/4	no
	PCIe	2				SE			
x751	VME	8 - 4	1000 - 2000	10	1	SE / D	500	1.8 / 14.4 - 3.6 / 28.8	NG
	Desktop/NIM	4 - 2				SE			
x761	VME	2	4000	10	1	SE / D	TBD	7.2 / 57.6	no
	Desktop/NIM	1				SE			
x740	VME	64	65	12	2 / 10	SE	30	0.19 / 1.5	no
	Desktop/NIM	32							
x742	VME	32+2	5000 [2]	12	1	SE	500	0.128 [3]	no
	Desktop/NIM	16+1							

(1) The x in the model name is V1 for VME, VX1 for VME64X, DT5 for Desktop and N6 for NIM
(2) Sampling frequency of the analog memory (switched capacitor array); A/D conversion takes place at lower speed (dead-time)
(3) The memory size for the x742 is 128/1024 events of 1024 samples each
(4) The indication *"size 1/ size 2"* denotes different options
(5) DPP-TF: Pulse Height analysis (Trapezoidal Filters), DPP-CI: Charge Integration (digital QDC), DPP-NG: γ-n Discrimination

www.caen.it

Small details *Great differences*

Meet us at the following events:

TIPP 2011 *- Technology and Instrumentation in Particle Physics 2011* — June 13 - 17, 2011

Hadron2011 *- XIV International Conference on Hadron Spectroscopy* — June 13 - 17, 2011

Vertex 2011 *- 20th International Workshop On Vertex Detectors* — June 19 - 24, 2011

ICPP-Istanbul II *- 2nd International Conference on Particle Physics* — June 20 - 25, 2011

HRDP6 *- High-Resolution Depth Profiling* — June 27 - 30, 2011