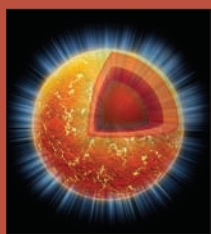


CERN COURIER

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Prospecting with geo-neutrinos



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Do neutron stars
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First LHC experience
dominates
CHEP 2010
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How CMS serves up a
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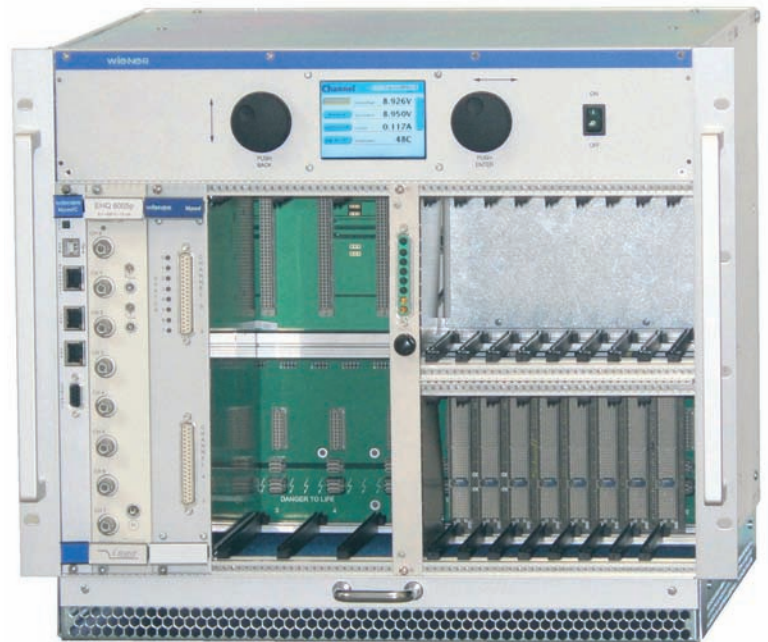
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On the cover: Inside the steel sphere of the Borexino experiment at Gran Sasso, lined with 2200 photomultiplier tubes to observe light produced by neutrino interactions in a central volume of 300 tonnes of liquid scintillator. Borexino is one of two experiments now beginning to observe geo-neutrinos (p19). (Image credit: Borexino collaboration/INFN.).

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News

CERN

Beams are back in the LHC

The LHC is back in action again after the technical stop that began on 6 December, with initial preparations for the 2011 run in full swing. On 19 February the previous few weeks of careful preparation paid off, with circulating beams being rapidly re-established. There then followed a programme of beam measurements and re-commissioning of the essential subsystems. The initial measurements show that the LHC is in good shape and magnetically little-changed from last year. The first collisions of 2011 were produced on 2 March, with stable beams and collisions for physics planned for later in the month.

In addition to the maintenance work, a number of modifications were made to the LHC during the technical stop. These included the installation of small solenoids to combat the build-up of electrons inside the vacuum chamber with increasing proton beam intensity; the replacement of a number of uninterruptible power-supply installations for essential systems such as the cryogenics; the installation of additional capacitors on the quench-protection system to prepare for a possible increase in beam energy in 2011;

plus a host of other improvements to RF, beam instrumentation, power converters and kickers, etc.

During the same period similar maintenance took place on the injector chain, namely LINAC2, the Booster, the Proton Synchrotron (PS) and the Super Proton Synchrotron (SPS). An example of this work is the programme to exchange eight magnets in the SPS machine. This is part of regular preventive maintenance in which the SPS magnets are exhaustively tested at the end of each year and those presenting any initial signs of weakness are changed during the accelerator stop.

At the PS, the technical stop was used to begin the commissioning of the new PS main power supply (POPS), which will replace the old rotating machine that has powered the PS magnets since 1968. The PS power supply must be capable of delivering extremely high-power (60 MW) electrical pulses to the magnets and then reabsorbing the energy at each accelerator cycle, less than 2s later. The rotating machine has been replaced by an enormous system of power converters and capacitors. The system is crucial because



The new PS power-supply system is made up of six containers, each with 60 tonnes of capacitors and eight power converters.

the PS is one of the lynchpins of CERN's accelerator complex and any failure in the electrical system would practically paralyse all of the experiments.

POPS was inaugurated and tested on 10 SPS test magnets in 2010 and then hooked up to the 101 PS main magnets for testing on 31 January 2011. This system was tested with gradually increasing intensities, right up to 6000 A. It then took a few days to pass the operation of POPS from the specialists controlling it locally to the CERN Control Centre prior to the crucial beam test on 11 February.

Simon van der Meer 1925–2011

Many people in the high-energy physics community were deeply saddened to learn that Simon van der Meer passed away on 4 March. A true giant of modern particle physics, his contributions to accelerator science remain vital to the operation of accelerators such as the LHC.

Simon studied electrical engineering at Delft University. After a short time with Philips, he came to CERN in 1956 and remained with the laboratory until his retirement in 1990. He is best known for his invention of stochastic cooling, which made possible the conversion of CERN's Super Proton Synchrotron to become the world's first proton-antiproton collider. He was awarded the Nobel Prize in Physics, jointly with Carlo Rubbia, in 1984 for the decisive contributions to this project, which led to the discovery of the W and Z particles.

Simon also developed the magnetic horn, which allows the production of focused beams of neutrinos, as well as the eponymous technique to measure luminosity in particle colliders: "van der Meer scans".

A full tribute and obituary will appear in a later issue of *CERN Courier*.



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COSMIC RAYS

PAMELA data challenge theory for cosmic-ray acceleration

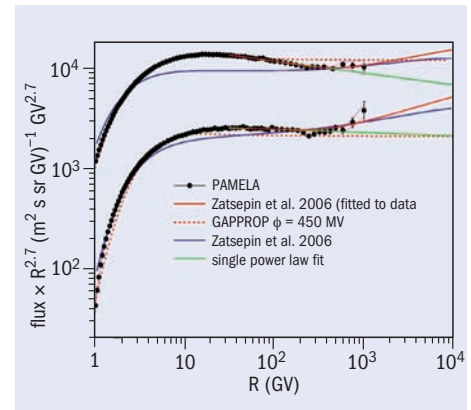
The satellite experiment Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics (PAMELA) has reported finding differences between the shapes of the energy spectra of protons and helium nuclei in the cosmic radiation. The data thus seem to go against the generally accepted idea that cosmic rays gain their energy through acceleration in the remnants of supernovae, prior to diffusing through the Galaxy. The collaboration argues that more complex processes are needed to explain their observations.

PAMELA, which is run by a collaboration between several Italian institutes with additional participation from Germany, Russia and Sweden, went into space on a Russian satellite launched from the Baikonur cosmodrome in June 2006

(*CERN Courier* September 2006 p8).

The experiment consists of a magnetic spectrometer comprising a silicon tracker in a 0.48 T field produced by a permanent magnet, together with a time-of-flight system, an electromagnetic silicon-tungsten calorimeter, a "shower-tail catcher" scintillator and a neutron detector, all of which are shielded by an anticoincidence system. Its six-plane double-sided silicon micro-strip tracker provides information on absolute charge and track-deflection. The silicon-tungsten tracking calorimeter and the neutron detector are used in performing lepton-hadron discrimination.

The recent report is based on precision measurements of the proton and helium spectra in the rigidity range 1 GV–1.2 TV, which indicate that the spectral shapes of the two species are different and cannot be well described by a single power law. This challenges the conventional wisdom on the acceleration and propagation of cosmic rays. The data reveal a hardening in the spectra around 200 GV, which the collaboration says could be interpreted as an indication of different populations of cosmic-ray sources. One example of a multi-source model cited in the report published in *Scienceexpress* is that by V I Zatsepin and N V Sokolskaya (the



Proton (top points) and helium (bottom points) data measured by PAMELA in the rigidity range 1 GV–1.2 TV. The shaded area represents the estimated systematic uncertainty. The lines represent the fit with a single power law and the Galprop and Zatsepin models.

blue curves in the figure), which considered novae stars and explosions in "superbubbles" as additional cosmic-ray sources.

• Further reading

O Adriani *et al.* 2011 *Science*, doi: 10.1126/science.1199172.

AIDA makes EU-funded access to European facilities available

Access to six European test facilities is now available as part of a new EU project funded by the FP7 Capacities Programme. The Advanced European Infrastructures for Detectors at Accelerators (AIDA) project was launched in February and will last for four years (*CERN Courier* March 2011 p7).

Three of AIDA's nine work packages are dedicated to transnational access. Under this scheme, researchers from EU member states (including FP7-associated countries) can apply for access to facilities at DESY, CERN, the Jožef Stefan Institute (JSI), the Université catholique de Louvain (UCL) and the Karlsruhe Institute of Technology (KIT). Access is offered free to the users. In addition, travel and subsistence costs can be covered by the EU funding. The majority of the user group must not be based in the same country as the facility (CERN, as an international organization, is not subject to

this requirement). In addition, the research team should publish the results from the experiments carried out at the AIDA facility.

The primary criterion for selection of a proposal will be scientific merit but factors such as previous use of the facility and availability of similar facilities in the user's home country will also be taken into account. User groups who have not accessed such facilities before are strongly encouraged to apply to this scheme.

At DESY there will be access to test beams of electrons with energies of up to 6 GeV. One of four different test areas can be used for the work. All areas have magnet control to select momentum and access to beam telescopes can be provided on request.

In the CERN East Area there will be access to several beam lines providing protons, neutrons or mixed particles with energies in the range 1–25 GeV. In the North



Area, proton and electron beams of several hundred giga-electron-volts are available.

There is also access to three European irradiation facilities. At JSI in Slovenia, access to the Triga-Mark-III reactor will provide neutron irradiation facilities. At UCL in Belgium access to deuterons and protons will be available. Protons for irradiation will also be available at KIT in Germany.

• For further details and to apply to the scheme, please visit: <http://aida.web.cern.ch/aida/activities/access/>.

LHC PHYSICS

ALICE gets with the flow

With data from the first heavy-ion run at the LHC, the ALICE collaboration has made the first observation of elliptic flow of charged particles in lead-lead collisions at 2.76 TeV per nucleon pair.

Flow is an interesting observable because it provides information on the equation of state and the transport properties of matter created in a heavy-ion collision. The azimuthal anisotropy in particle production is the clearest experimental signature of collective flow; it is caused by multiple interactions between the constituents of the created matter and the initial asymmetries in the spatial geometry of a non-central collision. The second Fourier coefficient of this azimuthal asymmetry is known as elliptic flow.

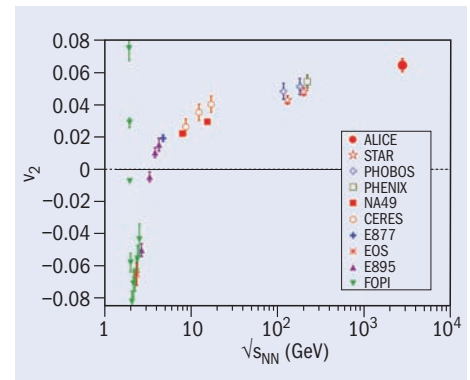
The magnitude of the elliptic flow depends strongly on the friction in the created matter, which is characterized by the ratio of shear viscosity to entropy ratio: η/s . A good fluid, such as water, has a small value of η/s and supports flow patterns such as waves in the ocean. By contrast, in a poor fluid, such as honey, flow patterns disappear quickly. Measurements of elliptic flow at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven already revealed the fascinating fact that the hot and dense matter created in

the collision there flows as a good fluid with almost no friction.

Surprisingly enough, the first theoretical calculation of η/s in heavy-ion collisions did not come from lattice QCD or transport theory – but from string theory. First calculations showed that in a strongly coupled $N = 4$ supersymmetric Yang Mills theory with a large number of colours, η/s can be calculated using a gauge/gravity duality. The famous anti-de Sitter/conformal field theory (AdS/CFT) conjecture yields a ratio of $\eta/s = h/4\pi k_B$, which was argued to be a lower bound for any relativistic thermal field theory.

At RHIC, a precise determination of the friction in the partonic fluid is complicated by uncertainties in the initial conditions of the collision, the relative contributions from the hadronic and partonic phase, and the unknown temperature dependence of η/s . Because this temperature dependence is unknown, it was not even clear if the elliptic flow would increase or decrease when going from RHIC to the LHC. A measurement of elliptic flow at the LHC was therefore one of the most anticipated results.

The measurements at 2.76 TeV by ALICE show that the elliptic flow of charged particles increases by about 30% compared



Elliptic flow v_2 at 2.76 TeV compared with results from lower energies.

with flow measured at the highest RHIC energy of 0.2 TeV. This result indicates that the hot and dense matter created in these collisions still behaves like a fluid with almost zero friction, providing strong constraints on the temperature dependence of η/s .

This first measurement also shows that elliptic flow – and thus the properties of the created matter – can be studied with unprecedented precision at the LHC. This is because of the increase in particle multiplicity compared with RHIC and the increase in the elliptic flow itself.

Further reading

K Aamodt et al. ALICE collaboration 2010 Phys. Rev. Lett. 105 252302.

ATLAS goes in search of new physics

Only a few months after the end of the 2010 data taking, the ATLAS experiment is entering its discovery phase at the LHC. The collaboration has already released its first results on the full data for searches for the Higgs boson, for supersymmetry (SUSY) and for other extensions of the Standard Model. The sensitivity of these results, reported here for Higgs and SUSY, is better than expected from simulation studies made in the past, but so far none of the ATLAS searches have shown signs of new physics.

One specific example is the release of the first limits from ATLAS on the Higgs boson production cross-section in the WW decay channel, shown in figure 1 (ATLAS collaboration 2011a). Already with only

35 pb^{-1} of data, the best expected sensitivity is only 2.4 times that of the predictions from the Standard Model for a Higgs mass of 160 GeV, the region already excluded by experiments at Fermilab's Tevatron. Excellent detector performance and good control of the backgrounds achieved using data-driven methods resulted in better limits than anticipated. This bodes extremely well for the 2011 run where the very good performance of the detector and analyses, combined with the predicted accelerator performance, should allow ATLAS to draw some much-anticipated conclusions on the search for the Higgs boson.

Another of the very active areas for ATLAS searches is the hunt for particles predicted by SUSY. This conceptually elegant theory predicts that for each known particle of the Standard Model, there exists a super-partner, where the partners of bosons are fermions and vice-versa. The model could also give a suitable candidate for dark matter: a stable neutral super-particle with no decays to known particles.

The ATLAS collaboration recently

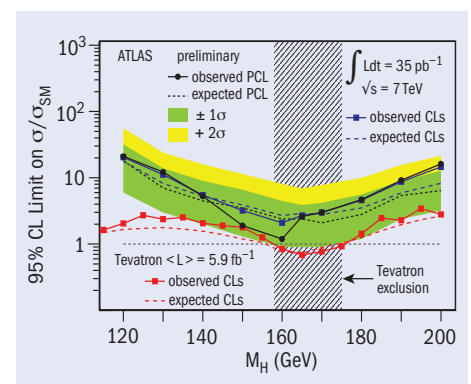


Fig. 1. First-observed (and expected) Higgs cross-section limits from ATLAS in the $H \rightarrow WW$ channel compared to the latest Tevatron combined limits (ATLAS collaboration 2011b).

submitted its first results for SUSY searches for publication. One of these searches is in the final state with jets, missing energy and no leptons (ATLAS collaboration 2011b). To make sure no potential signal was missed in this analysis, the search was optimized

News

and carried out combining several different signal topologies. No excess of events over the expected backgrounds is observed. The limits from this study provide the strongest constraints on the mass scales of SUSY to date (figure 2). The interpretation of these results in the minimal supergravity grand unification (mSUGRA) model excludes, at 95% confidence level, super-partners of the gluon and quarks with masses below 775 GeV, assuming they have the same mass.

ATLAS has recently completed many other analyses in the search for evidence for SUSY. These include a search with similar final states but with one (ATLAS collaboration 2011c) or two leptons, as well as a search requiring at least one jet to come from a b-quark. There are also results for searches for the super-partners of the neutrinos decaying into electron-muon final states and for stable hadronizing

super-partners of quarks and gluons.

These Higgs and SUSY results are not the complete picture of ATLAS searches. A large number of topologies and final states have been studied, and limits at the tera-electron-volts scale have been set on several scenarios of new physics. These limits are in many cases the most stringent to date. The collaboration anticipates promising opportunities for discoveries with much larger data sets in 2011-2012.

● **Further reading**

ATLAS collaboration 2011a ATL-CONF-2011-005. ATLAS collaboration 2011b arXiv:1102.2357 [hep-ex], accepted by *Phys. Rev. Lett.* ATLAS collaboration 2011c arXiv:1102.5290 [hep-ex], submitted to *Phys. Lett. B*. For these results and more, see <https://twiki.cern.ch/twiki/bin/view/AtlasPublic>.

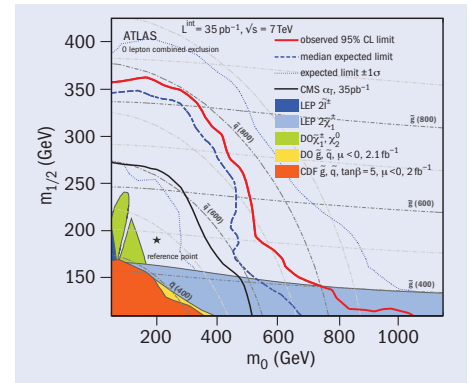


Fig. 2. Exclusion in the m_0 $m_{1/2}$ plane of mSUGRA parameter space for $\tan\beta = 3$, $A_0 = 0$ and $\mu > 0$. The new ATLAS limits are compared with CMS, Tevatron and LEP excluded regions (ATLAS 2011c and references therein).

CMS pursues the Higgs boson

The CMS collaboration has announced its first results on the measurement of the W^+W^- production cross-section and on the related search for the Higgs boson in proton-proton collisions at the LHC at 7 TeV in the centre-of-mass. This is the first paper by CMS that includes searches for the Higgs boson.

The data used for the analysis, recorded in the 2010 LHC proton runs, corresponds to an integrated luminosity of $35.5 \pm 3.9 \text{ pb}^{-1}$. Each W is observed through its decay into a charged lepton (electron or muon) measured in CMS; the corresponding neutrino escapes undetected (figure 1). Thirteen candidates were reconstructed in the data, while a total background was estimated of 3.29 ± 0.45 (stat.) ± 1.09 (syst.) events. The production cross-section was measured to be 41.1 ± 15.3 (stat.) ± 5.8 (syst.) ± 4.5 (lumi.) pb. This is in good agreement with the prediction from next-to-leading-order QCD calculations.

The result is of particular interest because it is highly sensitive to possible non-Standard Model contributions to the self-interactions of the W bosons, specifically the $WW\gamma$ and WWZ triple gauge boson couplings. It is also an irreducible background in the decay of the Higgs boson to W^+W^- .

The data from the first year's LHC run are insufficient to be sensitive to the Standard Model Higgs; for that, at least ten times the number of collisions will be necessary. However, a possible extension of the Standard Model incorporates a fourth family of fermions with very large masses. The presence of this fourth family substantially

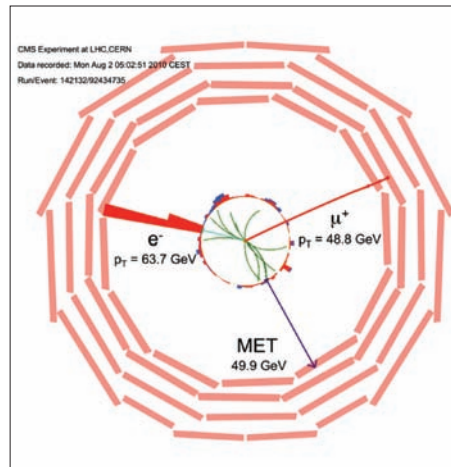


Fig. 1. Event Display of a W^+W^- candidate recorded by the CMS experiment.

increases the production cross-section of Higgs bosons via gluon fusion and also alters the decay branching fractions. Higgs production could be enhanced by a factor of about nine, such that Higgs particles could be observed in the 2010 CMS data sample.

To select $H \rightarrow W^+W^-$ candidates, the CMS analysis uses additional observables such as the transverse momentum of the leptons, the azimuthal angle difference between the dileptons, and the dilepton mass. The analysis found no evidence of the Higgs boson in the 2010 data sample. This enables the Higgs mass range of 144–207 GeV/c^2 to be excluded, at a 95% confidence level, for physics models that include a fourth

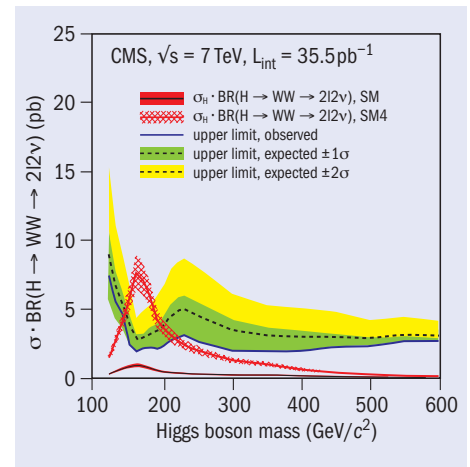


Fig. 2. Product of the production cross-section and branching fraction for the decay $H \rightarrow WW \rightarrow 2 \text{ leptons} + 2 \text{ neutrinos}$, as a function of the Higgs boson mass, showing the mean expected exclusion rates and the 95% confidence level limits derived from the CMS data. SM and SM4 denote the Standard Model predictions with three generations and four generations (of leptons and quarks) respectively.

generation of leptons and quarks. This constraint is more stringent for high masses than similar results from the Tevatron collider at Fermilab.

● **Further reading**

CMS collaboration 2011 arXiv:1102.5429v2 [hep-ex].

LHCb sets limits on rare B decays to dimuons

The decay of B^0 and B_s^0 mesons exclusively to dimuons ($\mu^+\mu^-$) is one of the most important channels in the search for new physics in the flavour sector at the LHC. In the Standard Model, the decays are rare because they can proceed only by processes involving loop diagrams and are in addition helicity-suppressed. However, new particles, in particular those that arise in models with an extended Higgs sector, can augment the decay rates and thus provide signs of new physics.

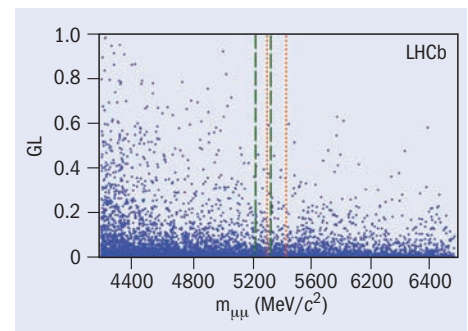
LHCb has published its first results for this important channel after searching for dimuon decays of both B^0 and B_s^0 in data collected at the LHC in proton–proton collisions at 7 TeV in the centre-of-mass. For the analysis, the collaboration used data from an integrated luminosity of around 37 pb^{-1} collected between July and October 2010.

They find no signal for either of the

dimuon decays in this data sample: the observed numbers of events are consistent with the expectations for background. This allows the collaboration to place upper limits on the branching ratios for the two decays: $B(B_s^0 \rightarrow \mu^+\mu^-) < 5.6 \times 10^{-8}$ and $B(B^0 \rightarrow \mu^+\mu^-) < 1.5 \times 10^{-8}$ at 95% confidence level (CL). This is to be compared with Standard Model expectations of $B(B_s^0 \rightarrow \mu^+\mu^-) = 0.3 \times 10^{-8}$ and $B(B^0 \rightarrow \mu^+\mu^-) = 0.01 \times 10^{-8}$.

While there have previously been searches for $B^0(s) \rightarrow \mu^+\mu^-$ at e^+e^- colliders, the highest sensitivity has so far been achieved at Fermilab's Tevatron, thanks to the large $b\bar{b}$ cross-section at hadron colliders. The most restrictive published limits at 95% CL come from the DØ collaboration's analysis of 6.1 fb^{-1} , yielding $B(B_s^0 \rightarrow \mu^+\mu^-) < 5.1 \times 10^{-8}$, and the CDF collaboration's analysis of 2 fb^{-1} yielding $B(B_s^0 \rightarrow \mu^+\mu^-) < 5.8 \times 10^{-8}$ and $B(B^0 \rightarrow \mu^+\mu^-) < 1.8 \times 10^{-8}$.

With less than 40 pb^{-1} , LHCb has therefore already approached the sensitivity of existing measurements. This was possible thanks to the large acceptance and trigger efficiency of the experiment, as well as the increase in the $b\bar{b}$ cross-section at the higher energy of the LHC. With a much larger amount of



Scatter plot of the geometrical likelihood (GL) – a quantity that combines information from the vertex structure of the event and the transverse momentum of the B candidate – versus the invariant mass of selected muon pairs. The search windows for the signal regions for the B^0 and B_s^0 decays are marked with dashed and dotted lines respectively. Signal events would be uniformly distributed in GL , whereas background comes to a peak at low GL . The observed distribution is consistent with being only background.

data expected in 2011, the experiment should be able to explore smaller branching ratios, down to the interesting level of 10^{-8} .

NUCLEAR PHYSICS

Rare isotope facility is set for 2020

The Facility for Rare Isotope Beams (FRIB) Project, which was awarded two years ago to Michigan State University by the US Department of Energy Office of Science (DOE-SC) is making significant progress towards start-up in 2020. An important milestone was passed in September 2010 when DOE-SC approved the preferred alternative design in Critical Decision-1 with an associated cost up to \$614.5 million and a schedule range from the autumn of fiscal year 2018 to spring of 2020.

When FRIB becomes operational, it will be a new DOE national user facility for nuclear science, funded by the DOE-SC Office of Nuclear Physics and operated by Michigan State University (*CERN Courier* March 2009 p7). FRIB will provide intense beams of rare isotopes – short-lived nuclei not normally found on Earth. The main focus of FRIB will be to produce such isotopes, study their properties and use them in applications to address national needs. FRIB will provide researchers with the technical capabilities not only to investigate rare isotopes, but also to put this knowledge to use in various applications, for example in materials science, nuclear medicine and

the fundamental understanding of nuclear material important to stewardship of nuclear-weapons stockpiles.

An optimization from the layout initially proposed for FRIB to the preferred alternative design moves the linac from a straight line extending to the northeast through Michigan State University's campus to a paperclip-like configuration next to the existing structure at the National Superconducting Cyclotron Laboratory (NSCL). The linac will have more than 344 superconducting RF cavities in an approximately 170 m-long tunnel about 12 m underground and will accelerate stable nuclei to kinetic energies of a minimum of 200 MeV/nucleon for all ions, with beam power up to 400 kW. (Energies range from 200 MeV/nucleon for uranium to above 600 MeV for protons.)

The Critical Decision (CD)-2 review to approve the performance baseline is planned for spring 2012 and the CD-3 review to approve the start of construction is planned for 2013. The selected architect/engineering firm and FRIB construction manager are exploring options to advance civil construction to the summer of 2012.



The FRIB preferred alternative design, approved by the DOE-SC. The NSCL is shown with current construction for office space and experimental areas highlighted in yellow. Grey roofs indicate new construction for FRIB. The dashed line outlines underground facilities. (Image credit: FRIB.)

Recent meetings between NSCL and FRIB User Groups have put a merger in the works, expected to be initiated this year with the final merger for more than 800 members and functions by the end of the year or early in 2012.

● For more information on the FRIB project, see www.frib.msu.edu. For more about the FRIB User Group, see www.fribusers.org.

NUCLEAR PHYSICS

Upgrade of Nuclotron paves the way for NICA

The successful completion of the upgrade to the Nuclotron at JINR marks the end of an important first step in the construction of the Nuclotron-based Ion Collider Facility and Multi-Purpose Detector (NICA/MPD) project (*CERN Courier* January/February 2010 p13). NICA, which is JINR's future flagship facility in high-energy physics, will allow the study of heavy-ion collisions both in fixed-target experiments and in collider experiments with $^{197}\text{Au}^{79+}$ ions at a centre-of-mass energy of 4–11 GeV (1–4.5 GeV/u ion kinetic energy) and an average luminosity of $10^{27} \text{ cm}^{-2} \text{ s}^{-1}$. Other goals include polarized-beam collisions and applied research.

NICA's main element is the Nuclotron, a 251 m circumference superconducting synchrotron for accelerating nuclei and multi-charged heavy ions, which started up in 1993. It currently delivers ion beams for experiments at internal targets and has a slow extraction system for fixed-target experiments. By 2007, it was accelerating proton beams to 5.7 GeV, deuterons to 3.8 GeV/u and nuclei (Li, F, C, N, Ar, Fe) to 2.2 GeV/u.

The Nuclotron upgrade – the Nuclotron-M project – was a key part of the first phase of construction work for NICA. It included work to develop the existing accelerator complex for the generation of relativistic ion-beams with atomic masses from protons to gold and uranium, at energies corresponding to the maximum design magnetic field of 2 T. The goals were to reach a new level in beam parameters and to improve substantially the reliability and efficiency of accelerator operation and renovate or replace some of the equipment.

The Nuclotron facility includes a cryogenic supply system with two helium refrigerators, as well as infrastructure for the storage and circulation of helium liquid and gas. The injection complex consists of a high-voltage pre-injector with a 700 kV pulsed transformer and an Alvarez-type linac, LU-20, which accelerates ions of $Z/A \geq 0.33$ up to an energy 5 MeV/u. The wide variety of ion types is provided by a heavy-ion source, ESIS "KRION-2", a duoplasmatron, a polarized deuteron source,



In the Nuclotron tunnel, A Butenko, left, and H Khodzhibagiyan discussing details of the facility construction. (Image credit: JINR.)

POLARIS, and a laser ion-source for light ions.

As a key element of the NICA collider injection chain, the Nuclotron has to accelerate a single bunch of fully stripped heavy ions (U^{92+} , Pb^{82+} or Au^{79+}) from 0.6–4.5 GeV/u with a bunch intensity of about $1\text{--}1.5 \times 10^9$ ions. The particle losses during acceleration must not exceed 10% and the magnetic field should ramp at 1 T/s. To demonstrate the capacity of the Nuclotron complex and satisfy these requirements, the general milestones of the Nuclotron-M project were specified as the acceleration of heavy ions (at atomic numbers larger than 100) and stable and safe operation at 2 T of the dipole magnets.

The upgrade, which started in 2007, involved the modernization of almost all of the Nuclotron systems, with time in six beam runs devoted to testing newly installed equipment. Two stages of the ring vacuum system were upgraded and cryogenic power was doubled. A new power supply for the electrostatic septum of the slow extraction system was constructed and tested, and new power supplies for the closed-orbit corrector magnets were also designed and tested at the ring. The ring's RF system was upgraded to increase the RF voltage and for tests of adiabatic trapping of particles into the acceleration mode. Vacuum conditions at the Nuclotron's injector were improved to increase the acceleration efficiency. A completely new power-supply system as well as a quench protection system for magnets

and magnetic lenses were also constructed, including: new main power supply units; a new power supply unit for current decrease in the quadrupole lenses; 10 km of new cable lines; and 200 new quench detectors. In parallel, there was also progress in the design and construction of new heavy-ion and polarized light-ion sources.

Following the Nuclotron's modernization, in March 2010 $^{124}\text{Xe}^{42+}$ ions were accelerated to about 1.5 GeV/u and slow extraction of the beam at 1 GeV/u was used for experiments. In December, the stable and safe operation of the magnetic system was achieved with a main field of 2 T. During the run the power supply and the quench protection systems were tested in cycles with the bending field of 1.4, 1.6, 1.8 and 2 T at the plateau. The field ramped at 0.6 T/s and the active time for each cycle was about 7s. A few tens of the energy evacuation events were acquired; in all of them the process was in the nominal regime.

In parallel with the upgrade work, the technical design was prepared for elements in the collider injection chain (a new heavy-ion linear accelerator, booster synchrotron and LU-20 upgrade programme). In addition, the technical design for the collider is in the final stage. The dipole and quadrupole magnets for the collider, as well as for the booster, are based on the design of the Nuclotron superconducting magnets. These have a cold-iron window-frame yoke and low-inductance winding made of a hollow composite superconductor; the magnetic-field distribution is formed by the iron yoke. The fabrication of these magnets gave JINR staff a great deal of experience in superconducting magnet design and manufacturing.

The prototype dipole magnet for the NICA booster was made in 2010 and construction of the magnet model for the collider, based on the preliminary design, is in the final stage. To construct the booster and collider rings, JINR needs to manufacture more than 200 dipole magnets and lenses during a short time period. The working area for magnet production and test benches for the magnet commissioning are currently being prepared.

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.

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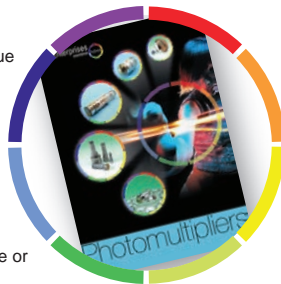
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Did Vikings navigate by polarized light?

It is well known that the Vikings dominated the seas of the North Atlantic between 900 and 1200 AD, but it has been something of a mystery as to how they navigated them. Old stories spoke of “sunstones” that could locate the Sun even with dense fog or cloud cover, but how did such instruments work?

Danish archaeologist Thorkild Ramskou suggested in 1967 that the key could be polarization of light in the sky, but there has been no demonstration of this idea in practice. Now, Gábor Horváth of Eötvös Loránd University in Budapest has shown how calcite, a natural polarizer, might have been used.

The idea is to point the crystal at the sky in one direction and turn it until it looks the



Vikings may have navigated far and wide with the aid of calcite crystals. (Image credit: 3drenderings/dreamstime.com.)

brightest. Because sunlight is polarized on scattering, this provides a way to find a line pointing towards the Sun. Repeating the process gives a second line and a good estimate of the location of the Sun in the sky. Then, holding a torch over a sundial in such a position as to emulate the Sun allows navigation data to be extracted from the shadow and the Sun’s location.

The basic principle appears to work – although perhaps not too well on the cloudiest of days. There may be some truth in the old tales of navigation using so-called “sunstones” after all.

● Further reading

G Horváth *et al.* 2011 *Phil. Trans. Roy. Soc. B* **366** 772.

Synchrotron radiation probes art and fossils

Van Gogh once complained to his brother about painting sunflowers: “I am working every morning from sunrise on, for the flowers fade so quickly.” Now, it turns out that the yellows in his paintings are also fading – or, more precisely, going brown. This deterioration has been tracked down to the slow reduction of chromium (VI) in yellow pigments to chromium (III), which forms green compounds and produces an overall browning effect. This non-destructive spectroscopic sleuthing was done by Letizia Monico of the University of Perugia and the University of Antwerp and colleagues using intense X-rays from the European Synchrotron Radiation Facility (ESRF) in Grenoble.

X-rays from the ESRF have also been useful to Alexandra Houssaye and colleagues of the National Museum of Natural History in Paris to make 3D images of a 95-million-year-old fossil of a snake with legs. There are only three fossils in the world of snakes with legs and the work supports the idea that snakes started out with legs – like lizards – and then lost them gradually. The fossil studied only had one leg exposed, but the other one, buried in rock, could still be seen in detail thanks to the ESRF.

● Further reading

L Monico *et al.* 2011 *Anal. Chem.* **83** 1214.
A Houssaye *et al.* 2011 *J. Vertebrate Paleontology*
doi: 10.1080/02724634.2011.539650.

Numbers need language

It has long been suspected that language influences thought. Now Elizabeth Spaepen of the University of Chicago and colleagues have found a striking example to support this idea. It seems that numbers make no sense without language.

The team studied “homesigners”: profoundly deaf Nicaraguans who have learnt no language – spoken or sign – but communicate through “homemade” gestures. Despite their handicap, they show no congenital cognitive defects, hold jobs, make money, and develop relationships with friends. They also perform well in mental rotation tests.

However, the homesigners seem unable to perform simple tasks involving numbers greater than about three. For example, they might hold out 9 fingers to represent the number 10. Apparently a precise understanding of cardinal numbers requires that people learn the associated linguistic terms.

● Further reading

E Spaepen *et al.* 2011 *Proc. Nat. Acad. Sci.*
doi:10.1073/pnas.1015975108.

Fruit flies feel the smell

A controversial theory of how the sense of smell works has found new support thanks to deuterium. Luca Turin, now at

Massachusetts Institute of Technology, suggested in 1996 that smell sensors could be based on the vibrations of a scent molecule when it is attached to a receptor (Burr 2003). With colleagues at the Institute of Cellular and Developmental Biology of the Alexander Fleming Biomedical Research Centre in Vari, he has found new support for his idea.

The group compared normal acetophenone molecules – often used in cherry flavouring – with ones in which three hydrogen atoms in a methyl group were replaced by deuterium. While the molecules should remain similar chemically, vibrations of the carbon–deuterium bonds should be of significantly lower frequency than those of carbon–hydrogen, because deuterium is heavier. They then found that fruit flies demonstrated preferences for one over the other and that those preferences could be reinforced or reversed by training with electric shocks (Franco *et al.* 2011).

With similar results for normal and deuterated octanol (a component of pheromones) and benzaldehyde (which smells like almond), it seems that Turin may well be on to something. However, humans do not seem to be able to tell the difference. Whether this is a reflection of a lesser degree of sensitivity in the human nose remains a subject for future research.

● Further reading

Chandler Burr 2003 *The Emperor of Scent*, Random House.
M I Franco *et al.* 2011 *Proc. Nat. Acad. Sci.* **108** 3797.

Astrowatch

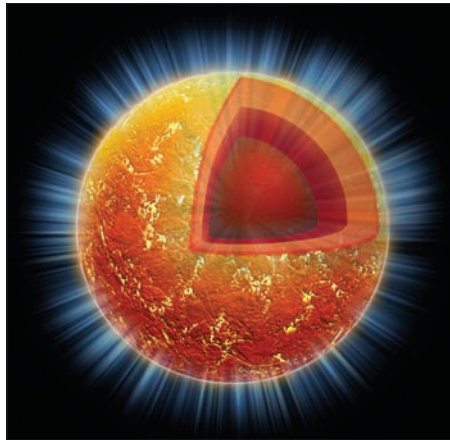
COMPILED BY MARC TÜRLER, ISDC AND OBSERVATORY OF THE UNIVERSITY OF GENEVA

Superfluidity at work in neutron star's core

The rapid decline in temperature of a young neutron star in the supernova remnant Cassiopeia A (Cas A) suggests superfluidity and superconductivity at its core. This conclusion, based on observations by NASA's Chandra X-ray Observatory, gives new insights into nuclear interactions at ultra-high densities.

Cas A was the "first light" target of the Chandra satellite. Only a month after launch, the image released on 26 August 1999 revealed the filamentary structure of the supernova remnant with details that competed with the best optical images – an incredible achievement for X-ray instrumentation. A tiny spot at the heart of the nebula was identified as a neutron star (*CERN Courier* October 2004 p19). It has previously remained unnoticed because no pulsations were detected from Cas A, unlike from the pulsar in the Crab Nebula, which is a neutron star spinning 30 times a second (*CERN Courier* January/February 2006 p10, November 2008 p11). Another oddity of Cas A is that nobody noticed the onset of the supernova some 330 years ago, except maybe John Flamsteed, who reports the observation of a sixth magnitude star in August 1680 near the position of the remnant. The explosion of the massive star only 11 000 light-years away should have been visible from Europe, unless it was heavily obscured by dust (*CERN Courier* January/February 2006 p10).

Recent observations of Cas A by Chandra have now revealed another surprise about its neutron star: that its surface has cooled by about 4% in 10 years. According to two independent studies, this dramatic drop in temperature is evidence for superfluid and



This illustration shows a cut-out of the interior of the neutron star. Densities increase from the orange crust to the red core and the inner red ball, where the superfluid resides. (Image credit: NASA/CXC/M Weiss.)

superconducting matter in the interior of the ultra-dense star. Dany Page from the National Autonomous University of Mexico and colleagues submitted their results to *Physical Review Letters* just two days before the submission of another letter to the *Monthly Notices of the Royal Astronomical Society* by Peter Shternin of the Ioffe Institute in St Petersburg and collaborators.

While superfluidity is observed only at temperatures near absolute zero on Earth, theorists have estimated that this friction-free state of matter may survive temperatures of hundreds of million degrees in the ultra-dense core of neutron stars. The nuclear density of neutron stars – one teaspoon of their material has a mass of

the order of a 1000 million tonnes – forces protons and electrons to merge, resulting in a star composed mostly of neutrons. The new results suggest strongly that the remaining protons in the star's core are in a superfluid state and – because they carry a charge – also form a superconductor.

Both teams further show that the rapid cooling in Cas A can be explained by the formation of a neutron superfluid in the stellar core within about the past 100 years, as seen from Earth. This should continue for a few decades before slowing down. The cool-down is caused by the production of superfluid neutron pairs – so-called Cooper pairs – accompanied by the emission of two neutrinos per pair, which escape from the star and carry away energy.

With Cas A, astronomers have been lucky to catch a young neutron star just in the transition to superfluid state. It allows them to set the critical temperature for the onset of superfluidity for neutrons interacting via the strong force to about 500 million degrees. The results are also important for understanding properties of neutron stars, such as magnetar outbursts and "glitches". The latter are the sudden spin-up of pulsars, probably as a result of quakes in the crust of the neutron stars. There has been previous evidence for superfluidity, but at subnuclear densities in the crust. The research into Cas A provides the first direct evidence for superfluid neutrons and protons in the core of the star.

• Further reading

SH Shternin *et al.* 2011 *MNRAS Letters*, in press.
D Page *et al.* 2011 *Phys. Rev. Letts.* **106** 081101.

Picture of the month

The XMM-Newton and Herschel satellites of the European Space Agency joined forces to reveal invisible facets of the Andromeda galaxy. At a distance of 2.5 million light-years, the nearest major galaxy to the Milky Way appears here in X-rays (blue and white) and far-infrared (red and orange). While Herschel's view at 250 μm outlines the spiral structure of the gas and dust, XMM-Newton pinpoints the position of hundreds of X-ray sources. The latter are mostly supernova remnants, the aftermaths of powerful explosions ending the lives of massive stars, and binary systems, pairs of stars consisting of a compact stellar remnant – a white dwarf, neutron star or black hole – accreting gas from a companion star. (Image credits: infrared: ESA/Herschel/PACS/SPIRE/J Fritz, U Gent; X-ray: ESA/XMM-Newton/EPIC/W Pietsch, MPE.)



CERN Courier Archive: 1968

A LOOK BACK TO CERN COURIER VOL. 8, APRIL 1968, COMPILED BY PEGGIE RIMMER

CERN

At the Proton Synchrotron

The majority of the experiments at the 28 GeV proton synchrotron PS are concerned with accumulating information on the properties of the newly discovered particle resonances or of the more familiar elementary particles. This methodical work has been called the new spectroscopy, analogous to the atomic spectroscopy earlier this century. Other experiments are attacking fundamental problems such as the questions of symmetry or the limits of application of quantum electrodynamics.

Experiment S 50 is being done by a CERN-Heidelberg team in the m4b beam (the branch of the separated m beam that can give pions, kaons or protons up to a momentum of about 2 GeV/c.) A negative kaon beam of momentum 1.65 GeV/c is directed onto a polyethylene target to produce the negative Xi hyperons. The aim is to measure the branching ratio of the Xi decay into an electron plus a lambda, compared with the decay into a pion plus a lambda.

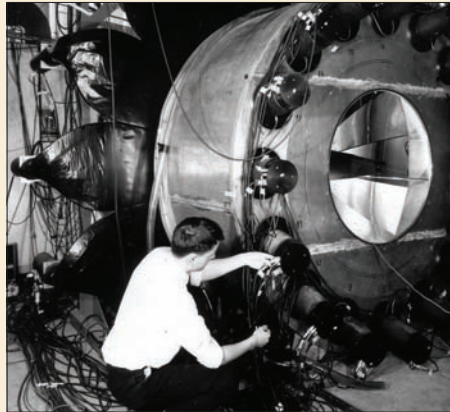
● Compiled from pp70–71 and 73.

HPD Mark 2

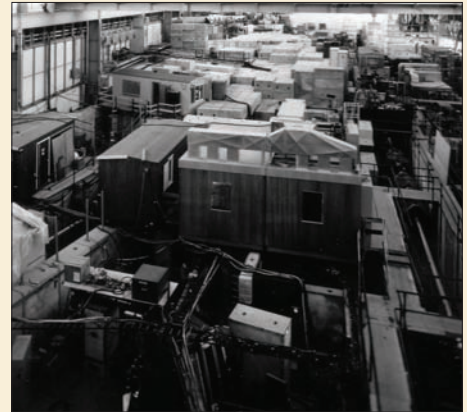
About 5 million pictures were taken in 1967 by the three bubble chambers operating at the PS: 2 100 000 for the 2 m hydrogen chamber in the East Hall (including 523 000 in deuterium), 1 700 000 for the 81 cm hydrogen chamber in the North Hall, which has recently taken its ten-millionth picture, and over 1 125 000 in the heavy liquid chamber operating in the East Hall during the neutrino experiments.

The frightening job of examining and measuring this vast number of pictures has to be confronted. The majority are dispersed for analysis to universities and research centres throughout Europe. CERN has one of the latest attacks on this problem.

The HPD (Hough Powell Device, named after its inventors P Hough and B W Powell) involves an almost fully automatic method of measuring bubble-chamber (and optical spark-chamber) photographs. A small spot of light is made to travel backwards and forwards across each photograph, scanning for particle tracks. The tracks modulate the light signal passing through the film to photomultipliers making information on track positions available in electronic form to be passed to a computer.

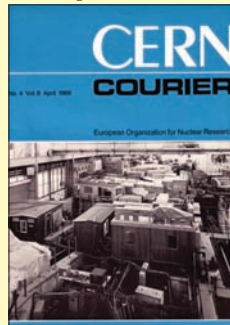


The gas Cherenkov counter used in S 50 to distinguish between electrons and pions from the Xi decay. Behind is a great wheel of scintillation counters to detect the decay products of the Xi. (See story left.)



In the East Hall looking towards the PS. Wooden huts house the small computers being used on-line in electronics experiments clustered around the slow ejected beam. From the April cover (below).

Compiler's Note



way into other track-tracing applications such as the digitization of maps, hence pioneering spin-off.

Film-measuring machines were a mix of mechanics, electronics and computers that allowed teams of “old school” inventors and “new school” programmers to give full rein to their ingenuity. One of these devices, worthy of Heath Robinson, reputedly had a fishing net strung below the scanning table to catch the little magnets that occasionally fell off the underside instead of gliding along beneath magnetic partners being moved around on top by the “scanning girls”. Apocryphal? Maybe. These machines spearheaded the use of small computers for physics data handling but, as Otto Frisch said of SWEEPNIK, “small” meant the size of a wardrobe and costing more than £10 000. They gave rise to early joint ventures between the academic and business worlds and some found their

The HPD was first proposed in 1960 and, following a collaborative effort by Berkeley, Brookhaven, Rutherford Laboratory and CERN, a prototype HPD Mark 1 came into operation at CERN in mid-1961, initially connected to an IBM 709 computer.

The Rutherford Laboratory considered having the mechanical parts designed and constructed commercially to help standardize the machines and make them more readily available for other laboratories and universities. CERN joined in this effort, which resulted in an HPD Mark 2 being delivered to CERN in September 1964.

By now, Mark 2, connected to the CDC 6600 computer, is in “production” measuring film from the 2 m bubble

chamber. With a smaller spot size and greater light intensity, the duration of one scan line has been reduced from 6 ms to 2.5 ms, enabling Mark 2 to carry out measurements faster and more accurately than its predecessor.

Some preliminary examination is still necessary; each picture is examined (on “Milady” scanning tables) and information is passed to the computer on the number of the frame recording an interesting event, the type of event and the rough position of each relevant track. A system known as “minimum guidance”, which would involve telling the computer only the position of the event vertex, is being developed.

● Compiled from pp75, 79–80.



CHEP 2010 opened with a spectacular, 20-minute drum ceremony. (Image credit: ASGC Taipei.)

Computing conference goes to Taipei

The highly successful first experience with data from the LHC dominated the latest in the international conference series on computing in particle and nuclear physics.

The conferences on Computing in High Energy and Nuclear Physics (CHEP), which are held approximately every 18 months, reached their silver jubilee with CHEP 2010, held at the Academia Sinica Grid Computing Centre (ASGC) in Taipei in October. ASGC is the LHC Computing Grid (LCG) Tier 1 site for Asia and

the organizers are experienced in hosting large conferences. Their expertise was demonstrated again throughout the week-long meeting, drawing almost 500 participants from more than 30 countries, including 25 students sponsored by CERN's Marie Curie Initial Training Network for Data Acquisition, Electronics and Optoelectronics for LHC Experiments (ACEOLE).

Appropriately, given the subsequent preponderance of LHC-related talks, the LCG project leader, Ian Bird of CERN, gave the opening plenary talk. He described the status of the LCG, how it got there and where it may go next, and presented some measures of its success. The CERN Tier 0 centre moves some 1 PB of data a day, in- and out-flows combined; it writes around 70 tapes a day; the worldwide grid supports some 1 million jobs a day; and it is used by more than 2000 physicists for analysis. Bird was >

CHEP 2010

particularly proud of the growth in service reliability, which he attributed to many years of preparation and testing. For the future, he believes that the LCG community needs to be concerned with sustainability, data issues and changing technologies. The status of the LHC experiments' offline systems were summarized by Roger Jones of Lancaster University. He stated that the first year of operations had been a great success, as presentations at the International Conference on High Energy Physics in Paris had indicated (*CERN Courier* November 2010 p19). He paid tribute to CERN's support of Tier 0 and he remarked that data distribution has been smooth.

In the clouds

As expected, there were many talks about cloud computing, including several plenary talks on general aspects, as well as technical presentations on practical experiences and tests or evaluations of the possible use of cloud computing in high-energy physics. It is sometimes difficult to separate hype from initiatives with definite potential but it is clear that clouds will find a place in high-energy physics computing, probably based more on private clouds rather than on the well known commercial offerings.

Harvey Newman of Caltech described a new generation of high-energy physics networking and computing models. As the available bandwidth continues to grow exponentially in capacity, LHC experiments are increasingly benefiting from it – to the extent that experiment models are being modified to make more use of pulling data to a job rather than pushing jobs towards the data. A recently formed working group is gathering new network requirements for future networking at LCG sites.

Lucas Taylor of Fermilab addressed the issue of public communications in high-energy physics. Recent LHC milestones have attracted massive media interest and Taylor stated that the LHC community simply has no choice other than to be open, and welcome the attention. The community therefore needs a coherent policy, clear messages and open engagement with traditional media (TV, radio, press) as well as with new media (Web 2.0, Twitter, Facebook, etc.). He noted major video-production efforts undertaken by the experiments, for example ATLAS-Live and CMS TV, and encouraged the audience to contribute where possible – write a blog or an article for publication, offer a tour or a public lecture and help build relationships with the media.

There was an interesting presentation of the Facility for Antiproton and Ion Research (FAIR) being built at GSI, Darmstadt. Construction will start next year and switch-on is scheduled for 2018. Two of the planned experiments are the size of ALICE or LHCb, with similar data rates expected. Triggering is a particular problem and data acquisition will have to rely on event filtering, so online farms will have to be several orders of magnitude larger than at the LHC (10 000 to 100 000 cores). This is a major area of current research.

David South of DESY, speaking on behalf of the Study Group for Data Preservation and Long-term Analysis in High-Energy Physics set up by the International Committee for Future Accelerators, presented what is probably the most serious effort yet for data preservation in high-energy physics. The question is: what to do with data after the end of an experiment? With few excep-



Wong Chi-Huey, president of Academia Sinica, welcomed the participants to the conference. (Image credit: ASGC Taipei.)

It is clear that clouds will find a place in high-energy physics computing

which data to store. Going beyond the raw data, this must also include software, documentation and publications, metadata (log-books, wikis, messages, etc.) and – the most difficult aspect – people's expertise.

Although some traditional plenary time had been scheduled for additional parallel sessions, there were still far too many submissions to be given as oral presentations. So, almost 200 submissions were scheduled as posters, which were displayed in two batches of 100 each over two days. The morning coffee breaks were extended to permit attendees to view them and interact with authors. There were also two so-called Birds of a Feather sessions on LCG Operations and LCG Service Co-ordination, which allowed the audience to discuss aspects of the LCG service in an informal manner.

The parallel stream on Online Computing was, of course, dominated by LHC data acquisition (DAQ). The DAQ systems for all experiments are working well, leading to fast production of physics

tions, data from an experiment are often stored somewhere until eventually they are lost or destroyed. He presented some reasons why preservation is desirable but needs to be properly planned. Some important aspects include the technology used for storage (should it follow storage trends, migrating from one media format to the next?), as well as the choice of

results. Talks on event processing provided evidence of the benefits of solid preparation and testing; simulation studies have proved to provide an amazingly accurate description of LHC data. Both the ATLAS and CMS collaborations report success with prompt processing at the LCG Tier 0 at CERN. New experiments, for example at FAIR, should take advantage of the experiment frameworks used currently by all of the LHC experiments, although the analysis challenges of the FAIR experiments exceed those of the LHC. There was also a word of caution – reconstruction works well today but how will it cope with increasing event pile-up in the future?

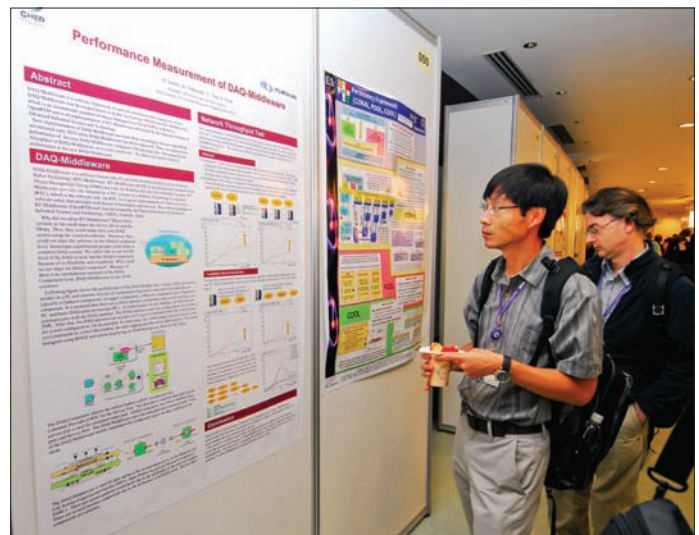
Presentations in the software engineering, data storage and databases stream covered a heterogeneous range of subjects, from quality assurance and performance monitoring to databases, software re-cycling and data preservation. Once again, the conclusion was that the software frameworks for the LHC are in good shape and that other experiments should be able to benefit from this.

The most popular parallel stream of talks was dedicated to distributed processing and analysis. A main theme was the successful processing and analysis of data in a distributed environment, dominated, of course, by the LHC. The message here is positive: the computing models are mainly performing as expected. The success of the experiments relies on the success of the Grid services and the sites but the hardest problems take far longer to solve than foreseen in the targeted service levels. The other two main themes were architecture for future facilities such as FAIR, the Belle II experiment, at the SuperKEKB upgrade in Japan, and the SuperB project in Italy; and improvements in infrastructure and services for distributed computing. The new projects are using a tier structure, but apparently with one layer fewer than in the LCG. Two new, non-high-energy-physics projects – the Fermi gamma-ray telescope and the Joint Dark Energy Mission – seem not to use Grid-like schemes.

Tools that work

The message from the computing fabrics and networking stream was that “hardware is not reliable, commodity or otherwise”; this statement from Bird’s opening plenary was illustrated in several talks. Deployments of upgrades, patches, new services are slow – another quote from Bird. Several talks showed that the community has the mechanism, so perhaps the problem is in communications and not in the technology? Yes, storage is an issue and there is a great deal of work going on in this area, as shown in several talks and posters. However, the various tools available today have proved that they work: via the LCG, the experiments have stored and made accessible the first months of LHC data. This stream included many talks and posters on different aspects and uses of virtualization. It was also shown that 40 Gbit and 100 Gbit networks are a reality: network bandwidth is there but the community must expect to have to pay for it.

Compared with previous CHEP conferences, there was a shift in the Grid and cloud middleware sessions. These showed that pilot jobs are fully established, virtualization is entering serious large-scale production use and there are more cloud models than before. A number of monitoring and information system tools were presented, as well as work on data management. Various aspects of



Four days of poster sessions allowed for almost 200 submissions to go on display. (Image credit: ASGC Taipei.)

security were also covered. Regarding clouds, although the STAR collaboration at the Relativistic Heavy Ion Collider at Brookhaven reported impressive production experience and there were a few examples of successful uses of Amazon EC2 clouds, other initiatives are still at the starting gate and some may not get much further. There was a particularly interesting example linking CernVM and Boinc. It was in this stream that one of the more memorable quotes of the week occurred, from Rob Quick of Fermilab: “There is no substitute for experience.”

The final parallel stream covered collaborative tools, with two sessions. The first was dedicated to outreach (Web 2.0, ATLAS Live and CMS Worldwide) and new initiatives (Inspire, see *CERN Courier* April 2010 p19); the second to tools (ATLAS Glance information system, EVO, Lecture archival scheme).

● For presentations at CHEP 2010, see <http://indico2.twgrid.org/conferenceTimeTable.py?confId=3>. The next CHEP will be held on 21–25 May, 2012, hosted by Brookhaven National Laboratory, at the NYU campus in Greenwich Village, New York, see www.chep2012.org/.

Résumé

Conférence CHEP à Taipei

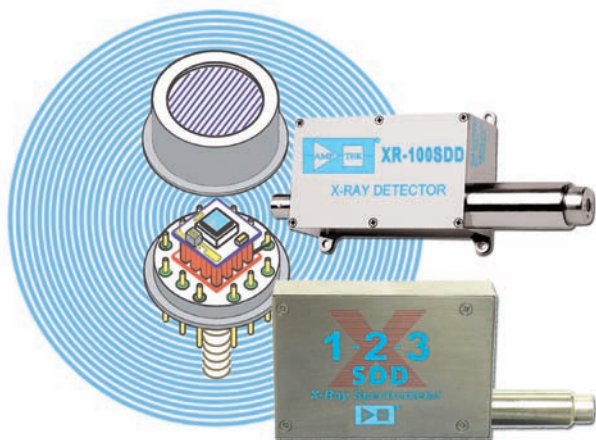
Près de 500 participants issus de plus de 30 pays ont participé à la conférence CHEP 2010, la dernière édition de la conférence sur le calcul en physique des hautes énergies et physique nucléaire, qui se tient tous les 18 mois environ. L'expérience des données du LHC, qui est une réussite remarquable, a été au centre de cette édition. Il a été question notamment de la performance de la Grille de calcul pour le LHC, de l'acquisition en direct de données des expériences, et du traitement et de l'analyse distribués. Il a beaucoup été question également de l'informatique en nuage (cloud computing), domaine dans lequel plusieurs équipes commencent à disposer d'une certaine expérience.

Alan Silverman, CERN.

Silicon Drift Detector

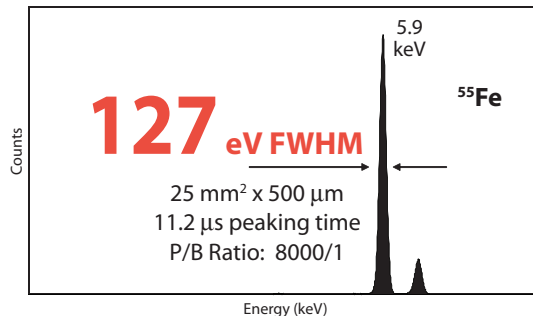
No Liquid Nitrogen
Easy to Use

Solid State Design
Low Cost

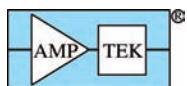


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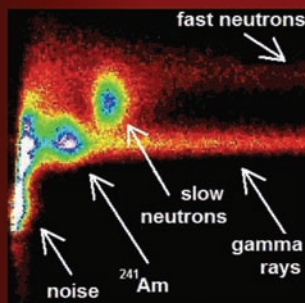
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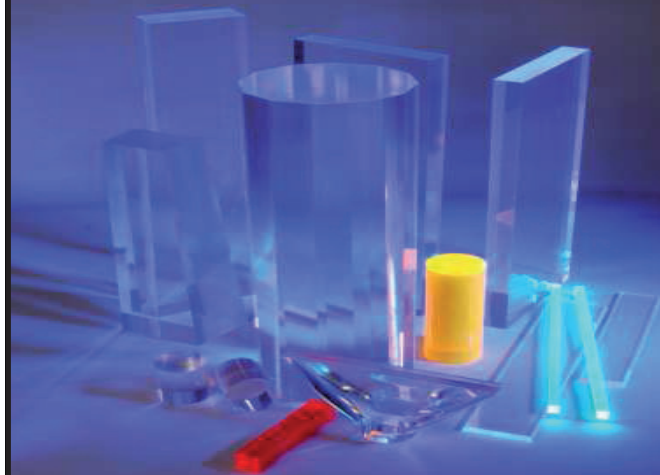
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Looking into the Earth's interior with geo-neutrinos

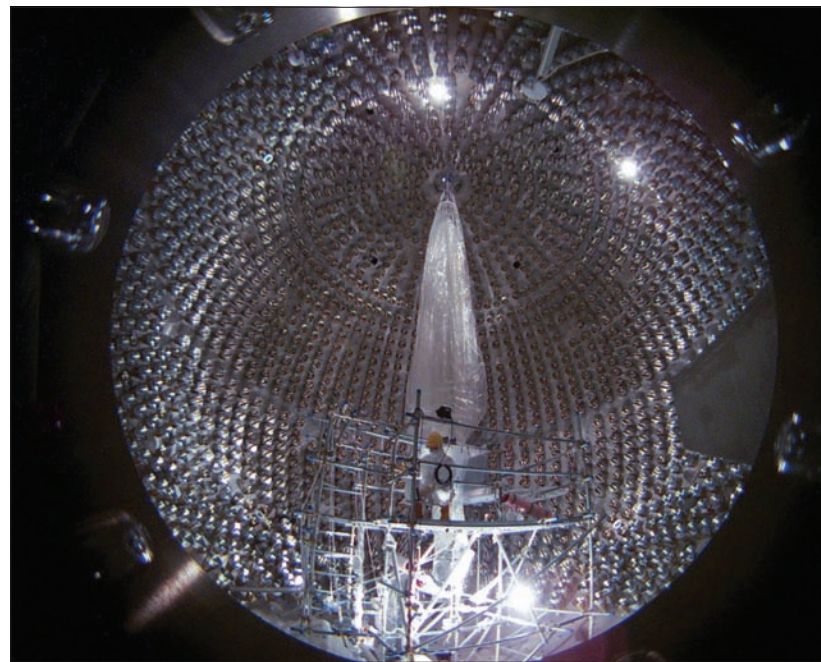
Measurements recorded by the Borexino and KamLAND neutrino experiments are revealing information about the Earth's heat production and promise to cast some light on one of the important questions in science.

The journal *Science* celebrated its 125th anniversary in 2005 and in a special issue listed what it considered to be the top 25 questions facing scientists during the next quarter of a century (Kerr 2005). These questions included: how does the Earth's interior work?

The main geophysical and geochemical processes that have driven the evolution of the Earth are strictly bound by the planet's energy budget. The current flux of energy entering the Earth's atmosphere is well known: the main contribution comes from solar radiation ($1.4 \times 10^3 \text{ W m}^{-2}$), while the energy deposited by cosmic rays is significantly smaller (10^{-8} W m^{-2}). The uncertainties on terrestrial thermal power are larger – although the most quoted models estimate a global heat loss in the range of 40–47 TW, a global power of 30 TW is not excluded. The measurements of the temperature gradient taken from some 4×10^4 drill holes distributed around the world provide a constraint on the Earth's heat production. Nevertheless, these direct investigations fail near the oceanic ridge, where the mantle content emerges: here hydrothermal circulation is a highly efficient heat-transport mechanism.

The generation of the Earth's magnetic field, its mantle circulation, plate tectonics and secular (i.e. long lasting) cooling are processes that depend on terrestrial heat production and distribution, and on the separate contributions to Earth's energy supply (radiogenic, gravitational, chemical etc.). An unambiguous and observationally based determination of radiogenic heat production is therefore necessary for understanding the Earth's energetics. Such an observation requires determining the quantity of long-lived radioactive elements in the Earth. However, the direct geochemical investigations only go as far as the upper portion of the mantle, so all of the geochemical estimates of the global abundances of heat-generating elements depend on the assumption that the composition of meteorites reflects that of the Earth.

The uranium and thorium decay chains and ^{40}K contribute about 99% of the total radiogenic heat production of the Earth; how-



Inside the stainless-steel vessel of the Borexino experiment during the installation of the inner nylon vessels used to hold the liquid scintillator. (Image credit: Borexino collaboration.)

ever, both the total amount and the distribution of these elements inside the Earth remain open to question. Thorium and uranium are refractory lithophile elements, while potassium is volatile. The processes of accretion and differentiation of the early Earth, as well as the subsequent processes of recycling and dehydrating subducting slabs, further enhance the concentrations of these radioactive elements in the crust. According to Roberta Rudnick and Shan Gao, the radiogenic heat production of the crust is $7.3 \pm 1.2 (1\sigma)$ TW (Rudnick and Gao 2003).

The expected amount and distribution of uranium, thorium and potassium in the mantle are model dependent. The Bulk Silicate Earth (BSE) is a canonical model that provides a description of geological evidence that is coherent within the constraints placed by the combined studies of mantle samples and the most primitive of all of the meteorites – the CI group of carbonaceous chondrites – which have a chemical composition similar to that of the solar photosphere, neglecting gaseous elements. The model predicts a radiogenic heat production in the mantle of about 13 TW. However, it needs to be tested because, on the grounds of available ▷

Neutrinos

Decay	Natural isotopic abundance	E_{\max} (MeV)	Q (MeV)	ϵ_H [W/kg]	ϵ_ν [ν /kg s]
$^{238}\text{U} \rightarrow ^{206}\text{Pb} + 8\ ^4\text{He} + 6e^- + 6\bar{\nu}_e$	0.9927	3.26	51.7	0.94×10^{-4}	7.41×10^7
$^{232}\text{Th} \rightarrow ^{204}\text{Pb} + 6\ ^4\text{He} + 4e^- + 4\bar{\nu}_e$	1.0000	2.25	42.7	0.27×10^{-4}	1.62×10^7
$^{40}\text{K} \rightarrow ^{40}\text{Ca} + e^- + \bar{\nu}_e$ (89%)	1.17×10^{-4}	1.31	1.31	2.55×10^{-9}	2.71×10^4
$^{40}\text{K} + e^- \rightarrow ^{40}\text{Ar} + \nu_e$ (11%)	1.17×10^{-4}	0.04	1.51	0.78×10^{-9}	/

Properties of ^{238}U , ^{232}Th and ^{40}K and of their (anti)neutrinos. The table presents the natural isotopic mass abundance, antineutrino maximal energy (or neutrino energy), Q value, antineutrino and heat production for unit mass at natural isotopic composition.



In 2005, the KamLAND detector in Japan was the first to detect geo-neutrinos. (Image credit: Berkeley KamLAND group.)

geochemical and/or geophysical data, it is not possible to exclude the theory that the radioactivity in the Earth today is enough to account for the highest estimate of the total terrestrial heat. Some models are based on a comparison of the planet with other chondrites, such as enstatite chondrites, and alternative hypotheses do not exclude the presence of radioactive elements in the Earth's core. In addition, other models suggest the existence of a geo-reactor of 3–6 TW induced by important amounts of uranium present around the core. The debate remains open.

Neutrinos from the Earth

Geo-neutrinos are the (anti)neutrinos produced by the natural radioactivity inside the Earth. In particular, the decay chains of ^{238}U and ^{232}Th include six and four β^- decays, respectively, and the nucleus of ^{40}K decays by electron capture and β^- decay with branching ratios of 11% and 89%, respectively. The decays produce heat and electron antineutrinos, with fixed ratios of heat to neutrinos (table 1). A measurement of the antineutrino flux, and possibly of the spectrum, would provide direct information on the amount and composition of radioactive material inside the Earth and so would determine the radiogenic contribution to the heat flow.

The Earth emits mainly in electron-antineutrinos, while the Sun shines in electron-neutrinos. The order of magnitude of the antineutrino flux on the surface, following the model hypotheses, could be $10^6\text{ cm}^{-2}\text{ s}^{-1}$ from uranium and thorium in the Earth and $10^7\text{ cm}^{-2}\text{ s}^{-1}$

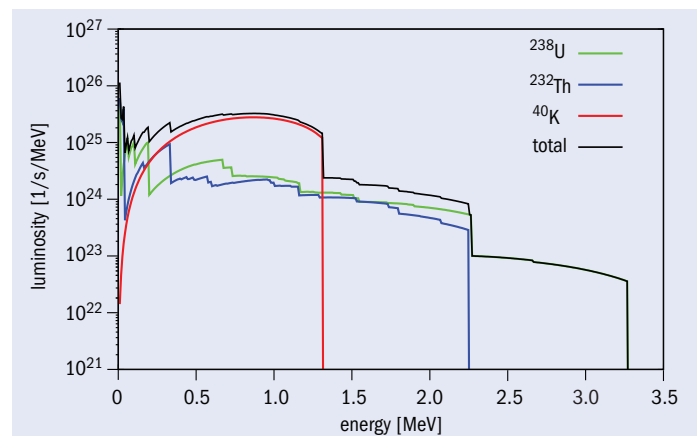


Fig. 1. The differential geo-neutrino luminosity assuming the following global abundances (according to the BSE model): $a(^{238}\text{U}) = 13.4\text{ ppb}$, $a(^{232}\text{Th}) = 53.6\text{ ppb}$ and $a(^{40}\text{K}) = 157.4\text{ ppm}$.

from potassium, as compared with a neutrino flux of $6 \times 10^{10}\text{ cm}^{-2}\text{ s}^{-1}$ from the Sun. Given the two types of crust (continental and oceanic) and their different composition and thickness, the expected flux of geo-neutrinos differs from place to place on the Earth's surface. Moreover, considering that this variation can be as much as an order of magnitude, a detector's sensitivity to geo-neutrinos coming from the mantle and the crust will depend on its location.

The process for the detection of low-energy antineutrinos used by the detectors currently running (KamLAND at Kamioka, Japan, and Borexino at Gran Sasso, Italy) and under construction (SNO+ at SNOLab, Canada), is inverse beta decay with a threshold of 1.806 MeV. Hence, only a fraction of the geo-neutrinos from ^{238}U and ^{232}Th are above threshold (figure 1), and the detection of antineutrinos from ^{40}K

The first attempt to detect geo-neutrinos was made by the KamLAND experiment in 2005.

remains a difficult challenge even for the next generation detectors. These experiments use liquid scintillator as the detecting material: one kilotonne of it contains some 10^{32} protons. As a consequence the event rate is conveniently expressed in terms of terrestrial neutrino units (TNU), defined as one event per 10^{32}

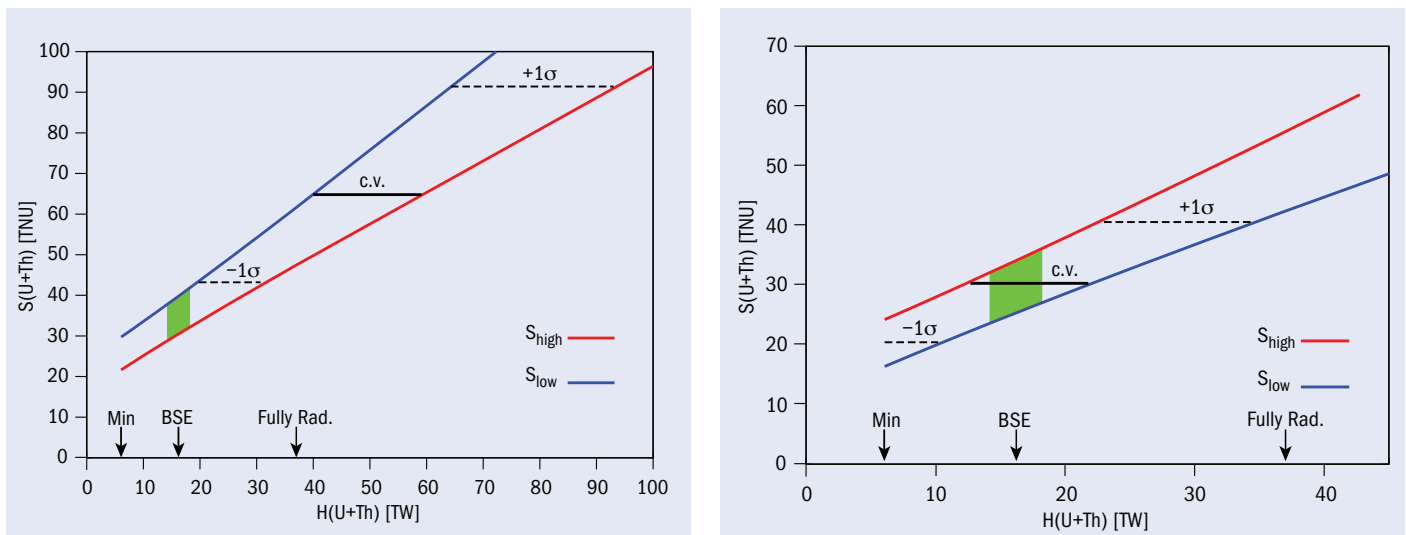


Fig. 2. The predicted signal $S(U + Th)$ from uranium and thorium geo-neutrinos as a function of the radiogenic heat production rate $H(U + Th)$ in the Borexino (left) and KamLAND (right) experiments. The green area denotes the region allowed by the constraint from the BSE model (see p19), while the solid lines (blue and red) show the maximum and minimum geo-neutrino signals on the basis of geochemical and geophysical constraints. The black solid line denotes the central value (c.v.) of the signal measured by each collaboration; the dotted lines are the 1σ uncertainties on this measurement.

target protons a year.

In the underground experiments devoted to the measurement of geo-neutrinos, liquid scintillator – essentially hydrocarbons – provides the hydrogen nuclei that act as the target for the antineutrinos. In these detectors a geo-neutrino event is tagged by a prompt signal and a delayed signal, following the inverse beta decay: $\bar{\nu}_e + p \rightarrow e^+ + n - 1.806 \text{ MeV}$.

The positron ionization and annihilation provide the prompt signal. The energy of the incoming neutrino is related to the measured energy by the relationship: $E_{\nu} = E_{\text{measured}} + 0.782 \text{ MeV}$. The prompt signal is in the energy range (1.02, 2.50) MeV for uranium and (1.02, 1.47) MeV for thorium. The neutron slows down and after thermalization is captured by a proton, making a deuteron and a gamma ray of 2.22 MeV. The gamma ray generates the delayed signal. In large volumes of liquid scintillator the delayed signal is fully contained with an efficiency of around 98%.

The prompt–delayed sequence of the inverse beta decay provides a strong tag for electron antineutrinos, well known since the pioneering experiment of Clyde Cowan and Fred Reines in 1956. There is a correlation in space and time between the prompt and delayed signals. The correlated time depends on the properties of the scintillator and is in the order of 200–250 μs . The correlated distance between the two signals is related to the spatial resolution of the detector (around 10 cm at 1 MeV) and is driven by Compton interactions – with a probability of about 100% it can be less than 1 m.

Any electron-antineutrinos besides the ones produced within the Earth, and any event that can mimic a prompt–delayed signal with a neutron in the final state, can be a source of background. In particular, consider electron-antineutrinos produced by nuclear power reactors. Their energy spectrum partially overlaps the one for geo-neutrinos, but shifted towards higher energies up to about 10 MeV. Some 400 power reactors exist, mainly in North America, Europe, West Russia and Japan. Therefore, depending on the loca-

tion of the underground laboratories, this background can produce a significant interference with the detection of geo-neutrinos.

Among other background sources there are (α, n) reactions resulting from contaminants in the scintillator, such as ^{210}Po , and cosmogenic radioactive isotopes such as ^9Li and ^8He , which are produced by muons crossing the laboratory overburden. ^9Li and ^8He decay through beta-delayed neutron emission with $T_{1/2} = 178.3 \text{ ms}$ and 119 ms, respectively. Using dead-time, a cut of 2 s after each detected muon crossing the liquid scintillator, can reject this background with an efficiency of 99.9%. A high level of radiopurity and a fiducial mass cut will reduce uncorrelated random coincidences, which can arise from impurities such as ^{210}Bi , ^{214}Bi and ^{208}Tl .

Detecting geo-neutrinos

The first attempt to detect geo-neutrinos was made by the KamLAND experiment in 2005, where a signal was detected at the 2σ level (Araki *et al.* 2005). Three years later the same experiment reported a second measurement at 2.7σ (Abe *et al.* 2008). In 2010 Borexino reported evidence of geo-neutrinos at 4.2σ (Bellini *et al.* 2010). This was followed by a measurement in KamLAND with the same significance (Inoue 2010 and Shimizu 2010). The KamLAND and the Borexino experiments both make use of a large mass of organic liquid scintillator shielded by a large-volume water Cherenkov detector and viewed by a large number of photomultipliers (around 2000). In KamLAND in particular, a fiducial mass of around 700 tonnes can be selected, whereas in Borexino the maximum target mass can be as much as 280 tonnes. The statistics of the KamLAND measurement is higher than in Borexino owing to the larger volume and longer exposure; on the other hand the signal-to-noise ratio in the geo-neutrino spectrum window is about 2 for Borexino and about 0.15 for KamLAND.

The interesting quantity is the flux of geo-neutrinos in a given location on the Earth's surface. This depends on the spatial \triangleright

Neutrinos

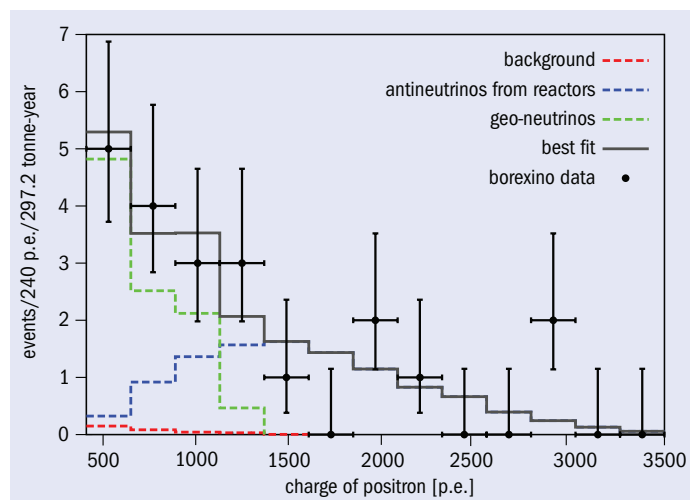


Fig. 3. Borexino's 2010 geo-neutrino measurement. Because of the low background rate, a larger statistical sample allows a spectroscopic observation of the geo-neutrino spectrum. (Adapted from Bellini et al. 2010).

distribution of the heat-generating elements within the Earth. Geo-neutrinos can travel as much as some 12 000 km to the detector. Therefore, the measured flux of geo-neutrinos must include the effect of neutrino oscillations. It turns out that for geo-neutrinos, the global effect of oscillations is reduced to a constant suppression of the flux through an average survival probability, $\langle P_{ee} \rangle$, of around 0.57.

The number of observed geo-neutrino events in KamLAND is $106 + 29 - 28 (+89 - 78)$ at 1σ (3σ) with 2135 live-days and a target mass of about 670 tonnes. Borexino has observed $9.9 + 4.1 - 3.4 (+14.6 - 8.2)$ geo-neutrino events in 482 days and 225 tonnes at 1σ (3σ). The rate in TNU for the Borexino and KamLAND observations corresponds to $64.8 + 26.6 - 21.6$ and $38.3 + 10.3 - 9.9$, respectively. In fits to the detected data in both experiments, the shapes of the geo-neutrino spectra are the same as in figure 1, assuming the chondritic Th/U mass ratio of 3.9. The combined KamLAND and Borexino observation has a significance of 5σ (Fogli et al. 2010). Figure 2 shows the allowed range for geo-neutrino rates in Borexino and KamLAND as a function of the Earth's radiogenic heat. The minimum radiogenic heat of Earth corresponds only to the crust contribution.

The signal-to-noise ratio for reactor antineutrino background in the geo-neutrino energy range is a fundamental parameter for geo-neutrino observations. In Borexino in particular this ratio – neglecting other backgrounds – is around 1.3 because there are no nearby nuclear reactors. Indeed, at Gran Sasso the weighted distance to reactors $\langle L_{\text{react}} \rangle$ is about 1000 km. By contrast, at Kamioka

$\langle L_{\text{react}} \rangle$ is around 200 km with a signal-to-noise ratio of about 0.2. Therefore, at present the significance of the Borexino measurement is limited only by the statistics (figure 3). This indicates that a spectroscopic measurement of the geo-neutrino signal is feasible, taking into account the overall low background rate.

In a few years a third detector, SNO+, with a weighted reactor distance $\langle L_{\text{react}} \rangle$ of around 480 km should be operational. A combined analysis of the Borexino, KamLAND and SNO+ experiments could constrain the radiogenic heat of the mantle. In the long term, LENA – a super-massive detector of about 50 kilotonnes – could observe as many as 1000 geo-neutrinos a year. LENA would be located at the Centre for Underground Physics at Pyhäsalmi in Finland with $\langle L_{\text{react}} \rangle$ of around 1000 km.

• The authors acknowledge some interesting discussions with W F McDonough, R L Rudnick and G Fiorentini.

Further reading

- S Abe et al. KamLAND collaboration 2008 *Phys. Rev. Lett.* **100** 221803.
- T Araki et al. KamLAND collaboration 2005 *Nature* **436** 499.
- G Bellini et al. Borexino collaboration 2010 *Phys. Lett. B* **687** 299.
- G L Fogli et al. 2010 *Phys. Rev. D* **82** 093006.
- K Inoue KamLAND collaboration 2010 *Neutrino* 2010.
- R Kerr 2005 *Science* **309** 87.
- R L Rudnick and S Gao 2003 *Treatise on Geochemistry* Elsevier-Pergamon **3** 1.
- I Shimizu KamLAND collaboration 2010 *Neutrino Geoscience* 2010.

For more about the Earth's interior and geo-neutrinos see:

- D L Anderson 2007 *New Theory of the Earth* Cambridge University Press.
- W F McDonough 2003 *Treatise on Geochemistry* Elsevier-Pergamon **2** 547.
- G Fiorentini, M Lissia and F Mantovani 2007 *Phys. Rep.* **453** 117.

Résumé

Examiner les entrailles de la Terre grâce aux géoneutrinos

Les géoneutrinos sont les (anti)neutrinos produits par la radioactivité naturelle de la Terre. La mesure du flux d'antineutrinos donnerait des informations directes sur la quantité et la composition des matières radioactives à l'intérieur de la Terre. Cela permettrait de déterminer la contribution de la radioactivité au flux de chaleur dans la Terre, et cela donnerait quelques lumières sur l'une des grandes questions de la science : que se passe-t-il à l'intérieur de la Terre ? À l'aide de détecteurs recourant à de grands volumes de scintillateur liquide, les expériences Borexino et KamLAND procèdent actuellement aux premières mesures des géoneutrinos.

Gianpaolo Bellini, University of Milano and INFN, Aldo Ianni, INFN, Gran Sasso Laboratory, and Fabio Mantovani, University of Ferrara and INFN.



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The CMS experiment puts

CMS has addressed the challenge of identifying in real time different kinds of physics at the LHC – from the “bread and butter” of Standard Model processes to signals of new particles – with triggers served up according to a carefully designed menu.

When the LHC operates at peak luminosity, about a 1000 million interactions will be produced and detected each second at the heart of the CMS experiment. However, only a tiny fraction of these events will be of major importance. As in many particle-physics experiments, a trigger system selects the most interesting physics in real time so that data from just a few of the collisions are recorded. The remaining events – the vast majority – are discarded and cannot be recovered later. The trigger system, therefore, in effect determines the physics potential of the experiment for ever.

The traditional trigger system in a hadron-collider experiment is comprised of three tiers. Level 1 (L1) is mostly hardware and low-level firmware that selects about 100 000 interactions from the 1000 million or so produced each second. Level 2 (L2), which is typically a combination of custom-built hardware and software, then filters a few thousand interactions to be sent to the next level. Level 3 (L3), in turn, invokes higher-level algorithms to select the couple of hundred events per second that require detailed study.

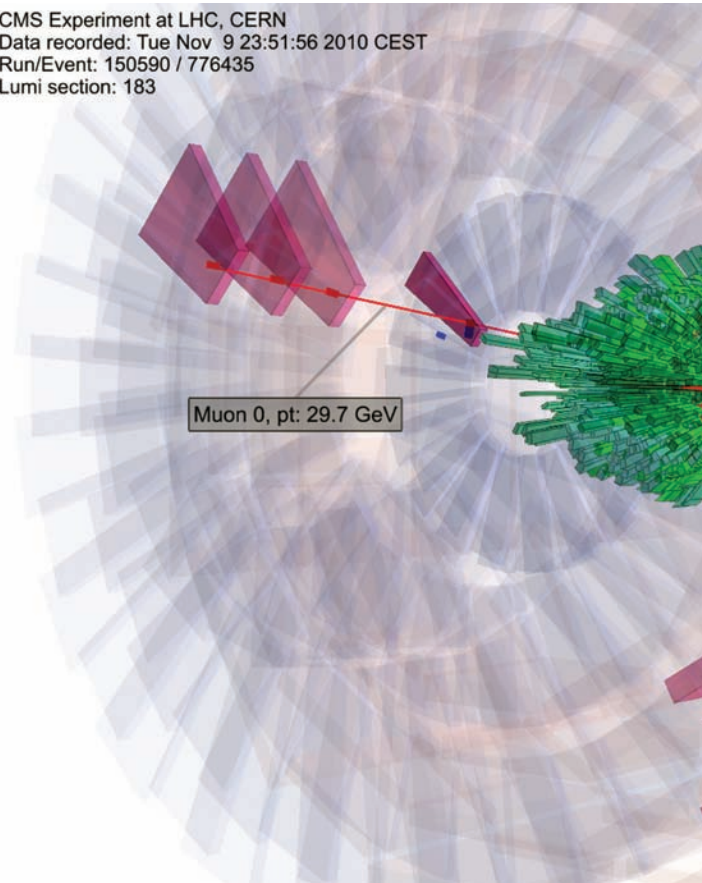
At the LHC, proton bunches cross in the experiments at a rate of up to 40 million times a second – with up to 20 or so interactions per crossing. At CMS, each crossing can produce around 1 MB of data. The aim of the trigger system is to reduce the data rate to about 1 GB/s, which is the speed at which the data-acquisition system can record data. This implies reducing the event rate to around 100 Hz.

The novelty of the CMS trigger system is that the traditional L2 and L3 components are merged into a single system – the high-level trigger (HLT). This is a commercial PC farm that takes all of the interactions from L1 and selects the best 200–300 events each second. Therefore, at CMS the reduction in data rate is carried out in two steps. The L1 trigger, based on custom-built electronics, first reduces the number of events by a factor of around 400, while another factor of about 1000 comes from the HLT.

The data from the collisions are initially stored in buffers, but the L1 electronics still has less than 3 μ s to make a decision and transfer that data on to the HLT. Given this short time frame, the L1 trigger acts only on information with coarse granularity from the muon detectors and the calorimeters, which is used to identify important objects, such as muons and jets. By contrast, the HLT works with a modified version of the CMS event offline reconstruc-



CMS Experiment at LHC, CERN
Data recorded: Tue Nov 9 23:51:56 2010 CEST
Run/Event: 150590 / 776435
Lumi section: 183



This clear candidate event for the decay of a Z boson to two muons was recorded and selected by the muon path in the CMS trigger menu.

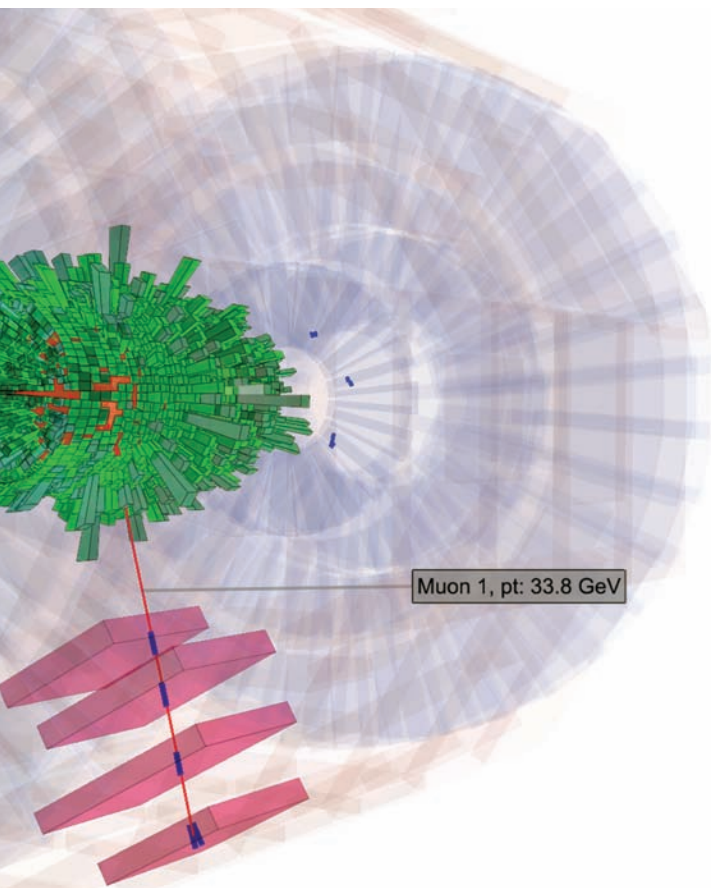
tion software, with full granularity for all of the sub-detectors, including the central tracker. To reduce the time taken, usually only the regions identified by the L1 trigger are read out, and reconstructed in a “regional reconstruction” process.

Such a system has never before operated at a particle collider. The advantage that this design buys is additional flexibility in the online selection system: the CMS experiment can run the more

The trigger system in effect determines the physics potential of the experiment for ever.

sophisticated L3 algorithms on a larger fraction of the collisions. In a three-tier system, experiments do this only on events that have been filtered through the second stage. With a two-tier trigger, CMS can do the more sophisticated filtering earlier in the game, so the experiment can look for more exotic events that might not have been recorded in a tradi-

ts physics onto the menu



Recorded by CMS during the heavy-ion run at the LHC last November. It was

tional trigger system. The price that CMS pays for this flexibility is a higher-capacity network switch and a larger “filter farm” of around 5000 CPUs.

Events à la carte

Running the trigger for a large experiment is a complex process because there are typically many conflicting needs coming from different detector and physics groups within the collaboration. As far as possible, everyone’s needs have to be covered – but this is no easy task. The CMS experiment is sophisticated and can do a great deal of different physics, but it all comes down to whether or not the events have been selected by the trigger. There is a constant struggle to make sure that the collaboration can maximize the physics potential of the experiment as a whole, while at the same time catering to the assorted tastes of the various groups.

The trigger “menu” can be thought of as a selection of triggers to suit all tastes. Some groups order just the entrée of established Standard Model physics, while others look to tuck in to the main course of Higgs particles, supersymmetry (SUSY), heavy-ion

A high-multiplicity trigger

An example of the flexibility of the HLT was seen in the two-particle correlation paper published by the CMS collaboration in September 2010 (*CERN Courier* November 2010 p7). A dedicated trigger was applied to look for this effect by using the HLT to find high-multiplicity events – collisions that produced many charged tracks – in a large fraction of L1-filtered events. In August, one third of the CPUs in the PC farm were dedicated to this one trigger to look for this effect.

At L1, the trigger required a total transverse energy summed over the entire set of CMS calorimeters to be greater than 60 GeV. The HLT then used online tracks reconstructed from the three layers of pixel detectors, which originated within a small cylindrical region around the beam line in an online vertexing algorithm. Events were accepted initially with more than 70 tracks, satisfying further criteria on rapidity, transverse momentum and closest approach to the primary vertex (the one associated with the highest number of tracks). During later, higher-luminosity running, this lower limit on the number of tracks was raised to 85.

physics, CP-violation and so on. Those with a sweet tooth come with their minds set predominantly on the dessert of exotica – all of the new physics that is not related to the main course.

At a practical level, the menu consists of various paths that fall into one of three categories. First, inclusive trigger paths look at overall properties, such as total energy or missing transverse energy, which are particularly important for detector studies. Second, single-object paths identify objects, for example, an electron or a jet. These are valuable for physics studies, particularly for Standard Model processes. Third, multi-object paths contain a combination of single objects. The trigger menu pulls the various paths together and the filter farm executes the HLT algorithms as much as possible in parallel – the HLT has less than 100 ms to make a decision for a L1 rate of about 50 kHz. Figure 1 (p26) shows rates for several HLT paths for an instantaneous luminosity of $8 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$.

The menu has to cover a range of physics: it must be as inclusive as possible, not only to accommodate more physics needs but also to make room for things that had not been considered when the experiment was running. For example, some theorists might come up with a new idea only after CMS has finished collecting data, but the experiment may have already captured what is needed if it has run with an “inclusive” trigger.

As the luminosity of the LHC increases, so does the collision rate, which means that tighter selection criteria need to be applied and the menu must constantly evolve to accommodate these needs. At CMS, physics groups – as well as detector groups – regularly submit proposals for triggers that they would like to have ▷

LHC experiments

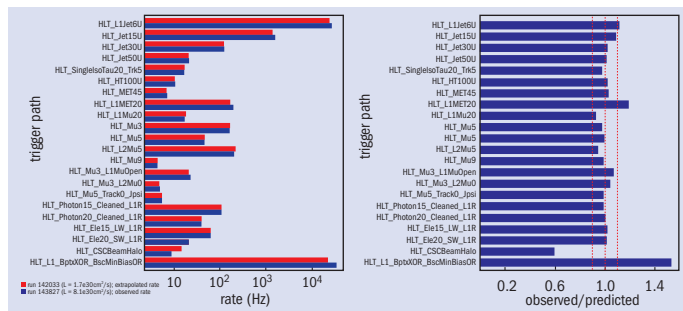


Fig. 1. Left: During the design of trigger menus, rates for a variety of trigger paths from older runs are extrapolated to predict trigger rates at a higher luminosity (red). These predicted rates agree well with the actual observed rates (blue). Right: Ratio of observed rates to predicted rates.

implemented. Requests are merged whenever possible into common triggers to simplify the menu. This makes it easier to maintain the menu as well as to spot mistakes and fix them. In addition, the bandwidth can be maximized if two groups share a trigger. For example, instead of two groups receiving a rate of 2 Hz each, they could devote 4 Hz to a common, more economical, trigger.

Once the proposals have been made, the Trigger Menu Development and HLT Code Integration Groups come up with a menu prototype, rather like a “tasting menu”. This takes all of the proposals into account and tries to implement them in a coherent trigger menu that adheres to every parameter to satisfy all appetites. While attempts are made to accommodate as many triggers as possible, if there are conflicting needs from different groups then the Physics and Trigger co-ordination has the final word.

The Trigger Performance Group then takes the prototype and runs it on “signal” events – using either real data or simulated – from all of the physics groups to test whether the menu picks out what it is supposed to select. If problems are found – and they often are – then the teams go back and fix them to produce the next prototype. At some point, the prototype will appear to be good enough to be deployed by the Trigger Menu Integration Group. This team then puts the menu online to test it, making sure that everything functions as expected. One important aspect of this validation is to verify that the full menu can run at the HLT within the budgeted time (figure 2).

Ever-changing ingredients

The CMS experiment has evolved since the early running period, when it was in commissioning mode, so that by the end of the 2010 the collaboration could maximize the physics output. The trigger system has adjusted in parallel to reflect this changing reality. During the 2010 proton run, the Trigger Studies Group produced more than a dozen menus of L1 and HLT “dishes”, which successfully filtered CMS physics data over five orders of magnitude in luminosity, over the range $1 \times 10^{27} - 2 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$.

Most of the triggers for the LHC start-up in March 2010 covered what was needed to understand the detector, such as calibration, alignment, noise studies and commissioning in general. Since then, these triggers have been gradually reduced to a minimum. The menu is now dominated by physics triggers, including a whole

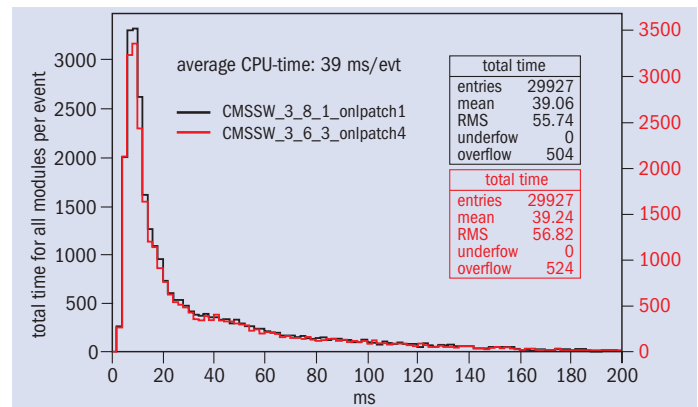


Fig. 2. CPU-processing time at the HLT before (in red) and after (in black) a software upgrade at the end of August 2010. Evaluating the CPU-performance of the trigger menu is part of the validation procedure.

suite of new SUSY triggers that were deployed last September.

As mentioned above, the complexity of the trigger menu increases as a function of luminosity. Because the early interactions were at low luminosities, it was possible to be inclusive – to record as many events as possible. As the luminosity has increased, however, certain triggers have had to be sacrificed. Triggers for Standard Model physics have been the first to be reduced because the priority is to discover new physics. However, a fraction of the trigger bandwidth always goes to Standard Model physics, which is used as a reference.

Sometimes, triggers are removed because they are no longer needed or they have been replaced by more advanced versions. At other times, there is an overlap period to understand what the new trigger does compared with the old one.

The incredible performance of the LHC – which reached the luminosity target for the 2010 proton–proton collisions run of $10^{32} \text{ cm}^{-2} \text{ s}^{-1}$ several weeks earlier than expected – has kept the trigger-system team on its toes. Over the next few years, the evolution of luminosity will continue to require the trigger “chefs” to produce creative menus to cope with the ever-changing range of ingredients on offer.

Résumé

L'expérience CMS met la physique au menu

Lorsque le LHC fonctionnera à sa luminosité de crête, environ un milliard d'interactions se produiront dans le détecteur CMS, mais seuls quelques-unes d'entre elles seront vraiment importantes. Un système de déclenchement innovant à deux étages sélectionne la physique la plus intéressante, en temps réel, et maintient le nombre de données à un niveau gérable. Le système permet de filtrer les événements plus tôt et de façon plus précise, si bien que l'expérience peut rechercher des événements exotiques qui n'auraient pas été enregistrés avec un système de déclenchement traditionnel. Trouver les différents types de physique est la fonction du « menu déclenchement » qui a été mis au point.

Christos Leonidopoulos and Achintya Rao, CERN.

Jülich welcomes the latest spin on physics

Experts from around the world gathered in Jülich to find out about new results and future prospects in spin physics.

The international conference series on spin originated with the biannual Symposia on High Energy Spin Physics, launched in 1974 at Argonne, and the Symposia on Polarization Phenomena in Nuclear Physics, which started in 1960 at Basle and were held every five years. Joint meetings began in Osaka in 2000, with the latest, SPIN2010, being held at the Forschungszentrum Jülich, chaired by Hans Ströher and Frank Rathmann. The 19th International Spin Physics Symposium was organized by the Institut für Kernphysik (IKP), host of the 3 GeV Cooler Synchrotron, COSY – a unique facility for studying the interactions of polarized protons and deuterons with internal polarized targets. Research there is aimed at developing new techniques in spin manipulation for applications in spin physics, in particular for the new Facility for Antiproton and Ion Research (FAIR) at GSI, Darmstadt. The 250 or so talks presented at SPIN2010 covered all aspects of spin physics – from the latest results on transverse spin physics from around the world to spin-dependence at fusion reactors.

The conference started with a review of the theoretical aspects of spin physics by Ulf-G Meißner, director of the theory division at IKP, who focused on the challenges faced by the modern effective field-theory approach to few-body interactions at low and intermediate energies. Progress here has been tremendous but old puzzles such as the analysing power, A_y , in proton-deuteron scattering, refuse to be fixed. These were discussed in more detail in the plenary talks by Evgeny Epelbaum of Bochum and Johan Mess-

chendorp of Groningen. In the second talk of the opening plenary session, Richard Milner of the Massachusetts Institute of Technology (MIT) highlighted the future of experimental spin physics.

It is fair to say that the classical issue of the helicity structure of protons has decided to take a rest, in the sense that rapid progress is unlikely. During the heyday of the contribution of the Efremov-Teryaev-Altarelli-Ross spin anomaly to the Ellis-Jaffe sum rule, it was tempting to attribute the European Muon Collaboration “spin crisis” to a relatively large number of polarized gluons in the proton. Andrea Bressan of Trieste reported on the most recent data from the COMPASS experiment at CERN, on the helicity structure function of protons and deuterons at small x , as well as the search for polarized gluons via hard deep inelastic scattering (DIS) reactions. Kieran Boyle of RIKEN and Brookhaven summarized the limitations on Δg from data from the Relativistic Heavy Ion Collider (RHIC) at Brookhaven. The non-observation of Δg within the already tight error bars indicates that gluons refuse to carry the helicity of protons. Hence, the dominant part of the proton helicity is in the orbital momentum of partons.

The extraction of the relevant generalized parton distributions from deeply virtual Compton scattering was covered by Michael Düren of Gießen for the HERMES experiment at DESY, Andrea Ferrero of Saclay for COMPASS and Piotr Konczykowski for the CLAS experiment at Jefferson Lab. Despite impressive progress, there is still a long road ahead towards data that could offer a viable evaluation of the orbital momentum contribution to J_i 's sum rule. The lattice QCD results reviewed by Philipp Hägler of Munich suggest the presence of large orbital-angular momenta, $L_u \approx -L_d \approx 0.36 (1/2)$, which tend to cancel each other.

The future of polarized DIS at electron-ion colliders was reviewed by Kurt Aulenbacher of Mainz. The many new developments range from a 50-fold increase in the current of polarized electron guns ▷



Spin2010 participants. (Image credit: FZ Jülich.)

SPIN2010

to an increase of 1000 in the rate of electron cooling.

Transversity was high on the agenda at SPIN2010. It is the last, unknown leading-twist structure function of the proton – without it the spin tomography of the proton would be forever incomplete. Since the late 1970s, everyone has known that QCD predicts the death of transverse spin physics at high energy. It took quite some time for the theory community to catch up with the seminal ideas of JP Ralston and DE Soper of some 30 years ago on the non-vanishing transversity signal in double-polarized Drell-Yan (DY) processes; it also took a while to accept the Sivers function, although the Collins function fell on fertile ground. Now, the future of transverse spin physics has never been brighter. During the symposium, news came of the positive assessment by CERN's Super Proton Synchrotron Committee with respect to the continuation of COMPASS for several more years.

Both the Collins and Sivers effects have been observed beyond doubt by HERMES and COMPASS. With its renowned determination of the Collins function, the Belle experiment at KEK paved the way for the first determination of the transversity distribution in the proton, which turns out to be similar in shape and magnitude to the helicity density in the proton. Mauro Anselmino reviewed the phenomenology work at Turin, which was described in more detail by Mariaelena Boglione. Non-relativistically, the tensor/Gamow-Teller (transversity) and axial (helicity) currents are identical. The lattice QCD results reported by Hägler show that the Gamow-Teller charge of protons is indeed close to the axial charge.

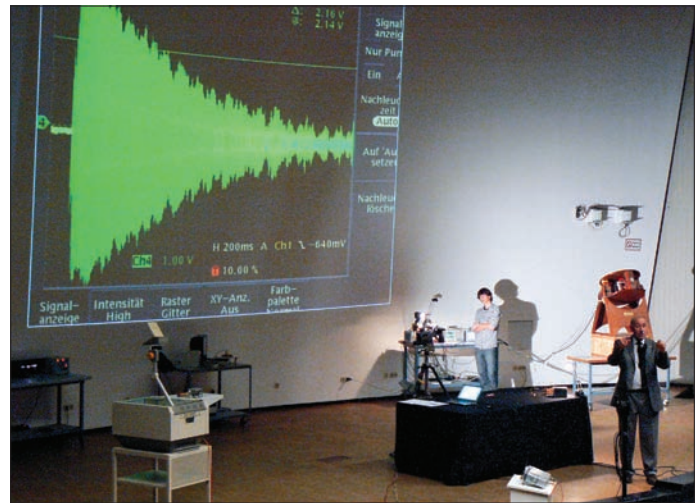
The point that large transverse spin effects are a feature of valence quarks has been clearly demonstrated in single-polarized proton–proton collisions at RHIC by the PHENIX experiment, as Brookhaven's Mickey Chiu reported. The principal implication for the PAX experiment at FAIR from the RHIC data, the Turin phenomenology and lattice QCD is that the theoretical expectations of large valence–valence transversity signals in DY processes with polarized antiprotons on polarized protons are robust.

The concern of the QCD community about a contribution of the orbital angular momentum of constituents to the total spin is nothing new to the radioactive-ion-beam community. Hideki Ueno of RIKEN reported on the progress in the production of spin-aligned and polarized radioactive-ion beams, where the orbital momentum of stripped nucleons shows itself in the spin of fragments.

The spin-physics community is entering a race to test the fundamental QCD prediction of the opposite sign of the Sivers effect in semi-inclusive DIS and DY on polarized protons. As Catarina Quintans from Lisbon explained, COMPASS is well poised to pursue this line of research. At the same time, ambitious plans to measure A_N in DY experiments with transverse polarization at RHIC, which Elke-Caroline Aschenauer of Brookhaven presented, have involved scraping together a “yard-sale apparatus” for a proposal to be submitted this year. Paul Reimer of Argonne and Ming Liu of Los Alamos discussed the possibilities at the Fermilab Main Injector.

Following the Belle collaboration's success with the Collins function, Martin Leitgab of Urbana-Champaign reported nice preliminary results on the interference fragmentation function. These cover a broad range of invariant masses in both arms of the experiment.

In his summary talk, Nikolai Nikolaev, of Jülich, raised the issue of the impact of hadronization on spin correlation. As Wolfgang



Hans-Otto Meyer, right, of Indiana gave a public lecture on the fundamental aspects of spin physics at the Kármán auditorium at RWTH Aachen. Here he explains the result of the free-precession experiment, assisted by Christian Weidemann. The decay curve of the 2 kHz induction signal is visible on the left; transmitted by loud-speakers, it enabled the audience to “hear” the proton spin. (Image credit: E Schneevoigt.)

Schäfer observed some time ago, the beta decay of open charm can be viewed as the final step of the hadronization of open charm. In the annihilation of e^+e^- to open charm, the helicities of heavy quarks are correlated and the beta decay of the open charm proceeds via the short-distance heavy quark; so there must be a product of the parity-violating components in the dilepton spectrum recorded in two arms of an experiment. However, because the spinning D^* mesons decay into spinless Ds, the spin of the charmed quark is washed out and the parity-violating component of the lepton spectrum is obliterated.

The PAX experiment to polarize stored antiprotons at FAIR featured prominently during the meeting. Jülich's Frank Rathmann reviewed the proposal and also reported on the spin-physics programme of the COSY-ANKE spectrometer. Important tests of the theories of spin filtering in polarized internal targets will be performed with protons at COSY, before the apparatus is moved to the Antiproton Decelerator at CERN – a unique place to study the spin filtering of antiprotons (*CERN Courier* July/August 2010 p21). Johann Haidenbauer of Jülich, Yury Uzikov of Dubna and Sergey Salnikov of the Budker Institute of Nuclear Physics reported on the Jülich- and Nijmegen-model predictions for the expected

Will nuclear polarization facilitate a solution to the energy problem?

spin-filtering rate. There are large uncertainties with modelling the annihilation effects but the findings of substantial polarization of filtered antiprotons are encouraging. Bogdan Wojtsekhowski of Jefferson Lab came up with an interesting suggestion for the spin filtering of antiprotons using a high-pressure, polarized ^3He target. This

SPIN2010

could drastically reduce the filtering time but the compatibility with the storing of the polarized antiprotons remains questionable.

Kent Paschke of Virginia gave a nice review on nucleon electromagnetic form factors, where there is still a controversy between the polarization transfer and the Rosenbluth separation of G_E and G_M . He and Richard Milner of MIT discussed future direct measurements of the likely culprit – the two-photon exchange contribution – at Jefferson Lab's Hall B, at DESY with the OLYMPUS experiment at DORIS and at VEPP-III at Novosibirsk.

Spin experiments have always provided stringent tests of fundamental symmetries and there were several talks on the electric dipole moments (EDMs) of nucleons and light nuclei. Experiments with ultra-cold neutrons could eventually reach a sensitivity of $d_n \approx 10^{-28}$ e-cm for the neutron EDM, while new ideas on electrostatic rings for protons could reach a still smaller $d_p \approx 10^{-29}$ e-cm. The latter case, pushed strongly by the groups at Brookhaven and Jülich, presents enormous technological challenges. In the race for high precision versus high energy, such upper bounds on d_p and d_n would impose more stringent restrictions on new physics (supersymmetry etc.) than LHC experiments could provide.

Will nuclear polarization facilitate a solution to the energy problem? There is an old theoretical observation by Russell Kulsrud and colleagues that the fusion rate in tokomaks could substantially exceed the rate of depolarization of nuclear spins. While the spin dependence of the ^3HeD and D^3H fusion reactions is known, the spin dependence of the DD fusion reaction has never been measured. Kirill Grigoriev of PNPI Gatchina reported on the planned experiment on polarized DD fusion. Even at energies in the 100 keV range, DD reactions receive substantial contributions from higher partial waves and, besides possibly meeting the demands of fusion reactors, such data would provide stringent tests of few-body theories – in 2010 the existing theoretical models predict quintet suppression factors which differ by nearly one order in magnitude.

● For all of the talks, see the conference website www.congressa.de/SPIN2010/. The proceedings will be published by IOP Publishing in *Journal of Physics: Conference Series* (online and open-access). The International Spin Physics Committee (www.spin-community.com) decided that the 20th Spin Physics Symposium will be held in Dubna in 2012.

Résumé

Jülich accueille SPIN 2010

Des spécialistes du monde entier se sont rassemblés au Forschungszentrum Jülich à l'occasion du XIX^e colloque international sur la physique du spin, SPIN2010. Les quelque 250 interventions ont porté sur tous les aspects de la physique du spin, et les résultats les plus récents dans différents domaines ont été présentés. Il s'agissait notamment de diverses mesures qui jettent une lumière nouvelle sur les différentes contributions au spin du proton, et en particulier les études de la transversalité. D'autres interventions ont porté sur la proposition de polariser des faisceaux de protons stockés, et sur le rôle de la polarisation dans la fusion nucléaire.

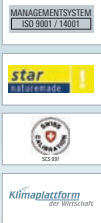
Erhard Steffens, University of Erlangen-Nürnberg.

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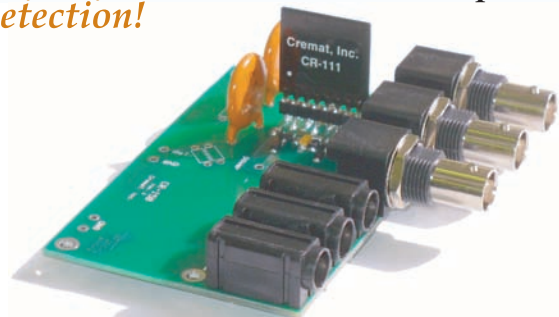
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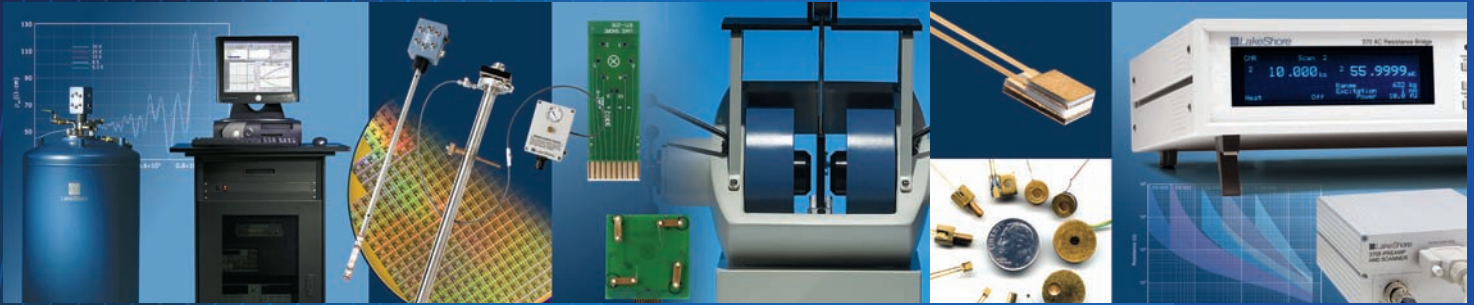
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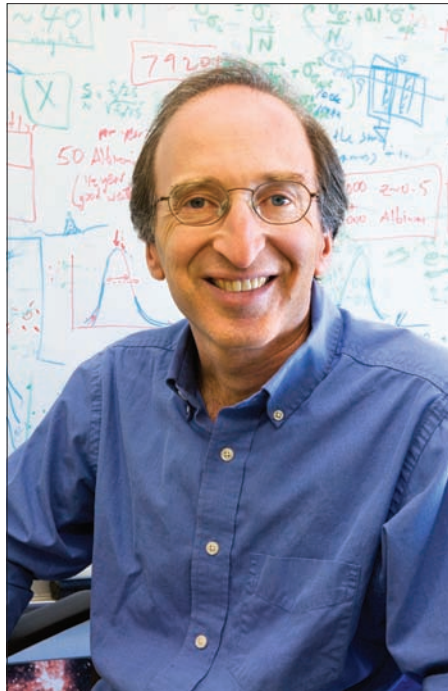
AWARDS

Perlmutter and Riess receive Einstein Medal

Saul Perlmutter and Adam Riess have been awarded the 2011 Einstein Medal. Both receive the medal for their work that indicates that the expansion of the universe is accelerating, an effect that is generally attributed to the existence of “dark energy” (*CERN Courier* September 2003 p23). The Albert Einstein Society in Bern gives the medal to individuals for “outstanding scientific findings, works or publications related to the work of Einstein”.

Perlmutter, of the University of California, Berkeley, is the leader and co-founder of the international Supernovae Cosmology Project based at the Lawrence Berkeley National Laboratory. Riess, of the Space Telescope Science Institute and the Johns Hopkins University, is a leading member of the High-z Supernova Search Team. In 1998, both teams announced that studies of distant supernovae showed that the expansion rate of the universe is accelerating, a finding that the magazine *Science* named “The Breakthrough Discovery of the Year”.

The Einstein Medals will be presented to Perlmutter and Riess during a ceremony held on 27 May in Bern.



Left: Saul Perlmutter. (Image credit: Lawrence Berkeley National Laboratory.) Right: Adam Riess. (Image credit: W Kirk/Homewood Photographic Services.)

APPOINTMENTS

Krücken takes over as new science leader at TRIUMF

On 1 February Reiner Krücken of Technische Universität München (TUM) took the helm of TRIUMF’s science programme as head of the Science Division. Krücken succeeds Gordon Ball, who stepped down into active retirement at the laboratory.

Krücken brings worldwide expertise in nuclear physics to TRIUMF, including deep familiarity with rare-isotope beam facilities in Europe, the US and Asia. His research interests include: nuclear structure, reactions and astrophysics; hadron properties in hot, dense nuclear matter; detector development; biological and medical applications of nuclear methods; particle-induced light emission in dense gases and liquids; and transmutation of nuclear waste. He earned his PhD in nuclear physics from the University of Cologne and worked at Lawrence Berkeley National Laboratory and

the Wright Nuclear Structure Laboratory at Yale before moving to TUM in 2002. At TUM, he led the German research foundation’s cluster of excellence team on the “Origins and Structure of the Universe”.

The Advanced Rare Isotope Laboratory (ARIEL) project was key to attracting Krücken to TRIUMF. When completed, ARIEL will have a competitive advantage in a number of areas involving isotopes for science and medicine and has the potential to transform Canada’s global position in nuclear physics. Krücken is already organizing a summer workshop with international involvement to develop ARIEL’s initial scientific programme.

With this appointment, TRIUMF’s scientific programme in nuclear and particle physics and condensed matter will be in good hands for years to come.



Reiner Krücken has transferred to TRIUMF. (Image credit: TUM.)

Faces & Places

INDUSTRY

Germany and Holland show off their wares at CERN

Companies from two of CERN's member states have recently taken the opportunity to display their products and services at CERN.

First, in November, the main building was transformed into a showcase for industry from the Netherlands, in the exhibition Holland@CERN, which was opened by the ambassador for the Netherlands at the United Nations and sponsored by the Dutch Economic Agency, EVD. It was the first time in almost 15 years that Dutch companies have exhibited at CERN and this time 24 of them were there to show their wares. A further three companies participated in the B2B – “business to business” – meetings that took place during the exhibition. The programme of events also included a series of talks on purchasing

at CERN and future programmes for the LHC upgrade, Compact Linear Collider study and the upgrade for the European Synchrotron Radiation Facility (ESRF) in Grenoble. A delegation from the ESRF also attended the exhibition.

In January it was the turn of representatives from 30 German companies in sectors related to particle physics to meet scientists, engineers and other potential purchasers at the 11th Germany at CERN exhibition. The main subjects covered electrical engineering, electronics, informatics, mechanical engineering, vacuum and low-temperature technologies, instrumentation and safety. The exhibition was organized by the German Federal Ministry of Education and Research.



Sigurd Lettow, right, CERN's director for administration and general infrastructure, tours Holland@CERN.



CERN's director-general, Rolf Heuer, centre, meets participants in the 11th Germany at CERN exhibition.

CERN took part in the Technology World exhibition in London on 7–8 December. This offered the opportunity to present CERN to the then UK minister of state for business and enterprise, Mark Prisk, centre left, seen here in discussion with Dante Gregorio of CERN's Finance and Purchasing Department. (Image credit: UKTI BG.)



LETTERS

Beyond the ISR

Thank you for the three excellent articles on the Intersecting Storage Rings (*CERN Courier* January/February 2011), a genuine all-round achievement, a pleasure to read and an occasion to bring up reminiscences. (No doubt you are aware of the faulty figure 1 on p27, surely not by co-author Kurt Hübner).

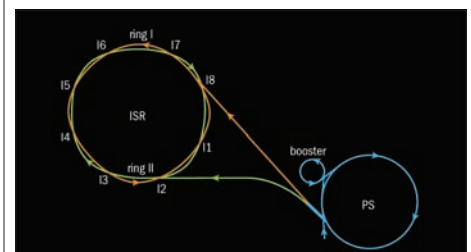
Looking at this series and at other CERN publications, I nevertheless could imagine a two-fold extension on the theme of accelerator articles:

1. As hinted at, for instance, in the articles on the Proton Synchrotron at 40 years (*CERN Courier* December 1999 p15) and on CERN at 50 years (*CERN Courier* January/February 2004 p23), and while not wishing in any way to detract from the achievements reached with any single accelerator/storage ring, is it not the working together of all of them (and the experimental areas) in a precise way and in a combination with the potential to change from pulse to pulse that is a distinctive strength of CERN? And would this also deserve to be presented in detail on some occasion?

2. That desirability, in my view, would apply also to the topic of “phase-space density” and how at least to avoid its dilution. I am aware that this is not easy to convey understandably to non-expert readers. (Although Simon van der Meer explained in his Nobel Lecture in Stockholm how he got round Liouville's theorem in order to increase phase-space density, few authors have tried to make it a theme for general audiences). However, if it had not been dealt with so successfully, collider luminosities would have been markedly lower and presumably physics results would not have been the same.

● Helmut Reich, Glion, Vaud.

Editor's note: The error in the figure showing the layout of the ISR and PS was indeed not the fault of the authors, but of an inversion that occurred during redrawing. Many apologies. The correct figure is reproduced here.



The ISR consisted of two interlaced proton-synchrotron rings, both 300 m in diameter, receiving protons from the PS.

New physics at the ISR

Neither science nor civilization could exist without memory. This statement by Enrico Fermi was the driving force for the celebration of the 40th anniversary of the first proton–proton collisions at the highest energy possible on Earth, thanks to Victor Weisskopf, CERN’s director-general (1961–1965), and to Kjell Johnsen, the ISR project leader.

The Bologna-CERN-Frascati group was engaged for a decade in the search for new physics at the ISR. The most interesting result concerns the effective energy and universality features. Before the discovery of the effective energy it was taken for granted that each pair of interacting particles had the privilege of producing its own final state of particles. The effective energy led to the most unexpected result: all pairs of interacting particles – no matter if the interaction is strong, electromagnetic or weak – produce the same final state. This is the origin of the universality features, which show up in the following quantities: the fractional energy distribution, $d\sigma/dx$; the average number of charged particles, $\langle n_{ch} \rangle$; the ratio of the average energy in the charged channel to the total energy, $\langle E_{ch} \rangle / \langle E_{total} \rangle$; the transverse momentum distributions, $d\sigma/dp_T^2$; the normalized transverse momentum distribution; the event planarity; the two-particle correlations; the scale-breaking effects.

As Weisskopf later said: “One of my contributions to CERN was the decision to construct the [world’s] first proton–proton

collider, the ISR. The ISR allowed [us] to reach the highest collision energy in the interaction between protons. I am therefore very happy that it is thanks to a series of experiments performed by Zichichi and collaborators with the ISR that the multitude of final states produced when particles interact strongly, electromagnetically and weakly can be put on the same basis. In particular, the fact that each pair of hadronic particles ($\pi\pi$), (pp), ($\bar{p}p$), (Kp) etc, was producing its own final state, with different properties, such as the average charged multiplicity, the fractional momentum distribution of the secondary particles, and so on, was very disturbing. In fact, the properties of these final states appeared to depend on the nature of the pair of interacting elementary particles. This was called by Gribov the hidden side of QCD. Here QCD had no quantitative predictions but qualitative ones. If all baryons and mesons are made of the same constituents, quarks and gluons, then the multihadronic final states should show universality features. It is exactly here that Nino succeeded to solve the problem with his new quantity entering in all processes: the effective energy. He had the right idea at the right time. In fact, the universality features are experimentally hidden insofar as the effective energy is not introduced in the analysis. It is for me very gratifying that the discovery of the effective energy was implemented at the CERN ISR. Moreover, I like it because it still has to be quantitatively explained by QCD” (Weisskopf 2000).

And now Vladimir Gribov: “In the physics community there was a sort of gentlemen’s agreement: please do not speak about results in contrast with the so-much searched for gauge interaction to describe hadronic phenomena. These hidden results were the hadronic systems produced in the interactions between pairs of hadrons; they were all different. Each pair of interacting particles, when producing systems consisting of many hadronic particles, had its own final state. No one knew how to settle this flagrant contradiction. I wish I had the idea of the effective energy” (Gribov 1997).

The purpose of this short note is to let people know that many discoveries were made with the ISR.

● Antonino Zichichi, on behalf of the Bologna-CERN-Frascati (BCF) Group.

Further reading

V V F Weisskopf 2000 *The Creation of Quantum Chromodynamics and the Effective Energy, Proceedings of 1998 Galvani Bicentenary Celebrations*. World Scientific Series in 20th Century Physics **25** 1.

V N Gribov 1997 *Effective Theories and Fundamental Interactions, Proceedings of the International School of Subnuclear Physics* (Erice 1996) **34** 500.

For a complete report, see:

G Veneziano 2000 *World Scientific Series in 20th Century Physics* **25** 57 and 341–351.

Editor’s note: There will be more on discoveries at the ISR in a future issue.

SCHOOLS

Roger Bailey takes over as head of CAS

After eight years of growth in popularity for the CERN Accelerator School (CAS), Daniel Brandt has handed the baton over to Roger Bailey, who was until now head of LHC operations.

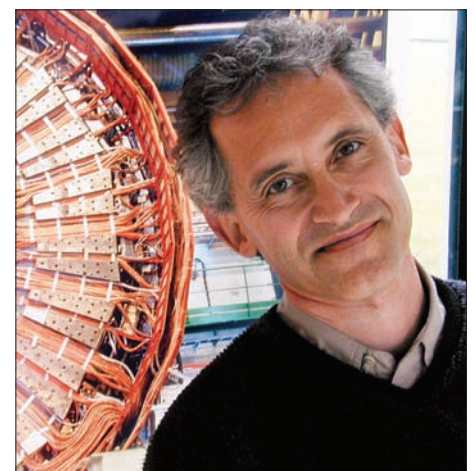
Established at the beginning of 1983, CAS has developed to include two courses a year offered to hundreds of students from all over the world. Courses are held in CERN member states and are taught by physicists from CERN and other institutions. Students worldwide are welcome to participate, although the popularity of the school has meant places are often limited.

Following Brandt’s successful management, Bailey joins the newly formed Office of the Director of Accelerators and Technology at CERN and becomes the new head of CAS.

“Daniel has left the CERN Accelerator School in great shape,” says Bailey. “In the short term, I see no reason to make any significant changes to the way that the regular schools are run. We are, however, looking into the possibilities of offering courses on accelerator physics to an even wider community in the not too distant future.”

The next CAS course will be held in the framework of the Joint US-CERN-Japan-Russia School on Particle Accelerators on the topic of Synchrotron Radiation and Free Electron Lasers. It will take place in Erice on 5–16 April. It will be followed by the first specialized CAS course of the year, on the subject of High Power Hadron Machines.

This course will take place in Bilbao on 24 May – 2 June.



Roger Bailey, the new head of the CERN Accelerator School.

Faces & Places

OBITUARIES

Tetsuji Nishikawa 1926–2010

Tetsuji Nishikawa, former director-general of KEK, passed away on 15 December 2010. He was 84. The first son of Shoji Nishikawa, a renowned physicist and professor at the University of Tokyo, Tetsuji Nishikawa showed an extraordinary talent as a physics student and became a professor of physics of the same university in 1961 at the age of 34.

He was a man of extraordinarily wide interests. His initial research was in the field of atomic and molecular physics using microwave technology but he gradually shifted towards accelerator science and high-energy physics. One of his contributions to accelerator physics is the invention of the alternating periodic structure (APS) for linear accelerators, work done while he was at Brookhaven National Laboratory (1964–1966). He became a world expert on beam dynamics. From his laboratory came many excellent physicists, all of whom contributed a great deal to the later development of high-energy physics in Japan. These include Kunitaka Kondo, Yorikiyo Nagashima, Yoshitaka Kimura, Tsuneyoshi Kamae, Toshio Suzuki, Kenzo Nakamura and Shin-ichi Kurokawa, to name but a few.

He was a man of extraordinary patience. After a decade of negotiations with the government and of tireless discussions within the scientific community during the 1960s, high-energy physicists, led by Shigeki Suwa and Nishikawa, finally succeeded in starting KEK (the National Laboratory for High Energy Physics, now called the High Energy Accelerator Research Organization) in 1969 and in constructing the 12 GeV proton synchrotron. One of the most important contributions that this accelerator has made to high-energy physics is the first long-baseline neutrino experiment in which a neutrino beam was sent to the Kamiokande



Tetsuji Nishikawa. (Image credit: KEK.)

facility 200 km from KEK. This finally confirmed the oscillation of muon-neutrinos to electron- or tau-neutrinos. Moreover, KEK became a model in Japan for the development of national inter-university research institutes. Later, many research laboratories in different disciplines were created with the same organizational and management structure as KEK.

He was a man of extraordinary insight into the future. Nishikawa supported the development of a neutron beam from the KEK proton synchrotron, as initially suggested by a group at Tohoku University led by Motoharu Kimura. The KEK parasitic neutron facility was completed in 1980 and eventually upgraded substantially in the current Japan Proton Accelerator Research Complex (J-PARC). Nishikawa also realized the importance of hadron beams in cancer treatment and, together with the medical

school of Tsukuba University, he constructed a cancer-treatment facility at the booster synchrotron (500 MeV). The success of this facility continued with the construction of the National Institute of Radiological Sciences in Chiba Prefecture. Another example is his insight into synchrotron radiation facilities. The world's first dedicated synchrotron radiation facility was built at the Institute for Nuclear Study in the University of Tokyo, based largely on the foresight of Taizo Sasaki. Nishikawa decided to build the KEK Photon Factory, together with Kazutake Kora, with strong support from the synchrotron radiation user-community. The facility was completed in 1982.

He was a man of extraordinary wisdom in laboratory management and project design. After the completion of the KEK Photon Factory he decided to build TRISTAN, the world's highest energy e^+e^- collider. The KEK photon factory injection linac was used as an injector for TRISTAN, which was completed in 1986. The collider was later transformed into a B-Factory

He was an extraordinary human being. Together with the late Shigeki Suwa, he was one of the founding fathers of KEK and the Japanese high-energy physics community. I always think that what he accomplished in Japan is comparable to what Panofsky did in the US. Indeed, Nishikawa and Panofsky were good friends and together, more than 30 years ago, they initiated the US-Japan Collaboration scheme. They also worked hard to launch the Superconducting Super Collider; unfortunately, the project was cancelled during its construction.

Those of us who knew him and worked with him feel a great loss. *Adieu, Professeur Nishikawa. Sayonara, Nishikawa-sensei.*
● Hirohisa Sugawara, KEK.

NEW PRODUCTS

Aurea Technology has launched the newly designed SPD_A_M2, an all-in-one DUAL single-photon counting module. The SPD_A_M2 is a series of ultra-low-noise, high-quantum efficiency near infrared, 900–1700 nm, single photon detectors. The detector's Geiger-mode InGaAs avalanche photodiode and thermoelectric coolers ensure a low and stable dark count, with a performance superior to 5.0×10^{-6} ns. The SPD_A_M2 series also provides

plug-and-play connections to personal computers via USB. For more information, tel +1 415 465 2280 or e-mail info@areatechnology.com.

The Berkeley Nucleonics Corporation has a new digital delay/pulse generator, available from **Southern Scientific**. The Model 575 provides multichannel, 250 ps resolution timing, delay, gate, pulse and synchronizing signals for laser timing and nuclear

instrumentation testing. It is available in two-, four- and eight-channel configurations, with optional ethernet, high-voltage and dual-input trigger capacity. For more information, see www.ssl.gb.com.

Goodfellow Cambridge Ltd can supply custom glass formulations for use in a range of technical fields. These can be supplied in quantities as small as 1 kg, with custom particle-size distributions and

Faces & Places

properties tuned for specific applications. Modifications can also be carried out to existing compositions to adjust properties such as colour, viscosity and density. For more information, tel +44 1480 424 800, e-mail info@goodfellow.com or see www.goodfellow.com.

Highland Technology Inc has announced the PH200, the first in the “PH” series of extreme-performance photonic instruments. The PH200 Nanowatt Photoreceiver is a free-space optical/electrical converter that provides near shot-noise performance in a rugged, compact package. The photon feedback architecture delivers a bandwidth greater than 1 MHz, with an unprecedented combination of linearity, bandwidth, and dynamic range for 10 nA to 100 μ A photodiode signals. For more information, tel +1 415 551 1700, e-mail info@highlandtechnology.com or visit www.highlandtechnology.com.

Specialised Imaging now supplies their renowned SIM-D Ultra Fast Framing Camera in a new multispectral imaging configuration. The SIM-D can fit up to 16 filters with wavelength from 400 nm to 850 nm within the optical system. Coupled with the ability to take images at exposures down to 3 ns with 0 interframe time, this enables the accurate study of wavelength dispersion when materials are stressed, as well as temperature measurement, and calorimetry applications. For more information, tel +44 1442 827 728 or e-mail info@specialised-imaging.com.

Unitemp has launched a new constant temperature and humidity chamber, the LHU-123. This versatile product has a temperature range from -20°C to 85°C and a relative humidity range of 40 to 95%rh with a temperature of $\pm 0.5^{\circ}\text{C}$ and $\pm 3\%$ rh. Program operation can be run on 9 steps per pattern and can specify ramp time for each step. The LHU-123 model’s cross-control system lowers the maximum current during operation, reducing the amount of required power. For more information, contact Paul Brown, tel +44 1628 850 611 or e-mail paul@unitemp.co.uk.

ZTEC Instruments has introduced a low-noise direct path option for the high-resolution 4400 digital oscilloscopes series, including specifically the ZT4421, ZT4422, ZT4431, ZT4432, ZT4441 and the ZT4442. The direct path option provides an alternative analogue signal-conditioning analogue front end to ZTEC’s popular 12-bit, 13-bit and 14-bit series of digitizers and digital oscilloscopes. For more information, tel +1 505 342 0132 or visit www.ztecinstruments.com.

VISITS



Octavi Quintana Trias, director of EURATOM, left, accompanied by **Roger Garbil** of the European Commission Directorate-General for Research, centre, was welcomed to CERN on 11 January by the deputy spokesperson of CMS, **Joe Incandela**. Their tour included the CMS experiment and a look inside the LHC tunnel.

It was the turn of Korean vice-minister II of education, science and technology, **Kim Chang-Kyung**, to tour the CMS experimental area at CERN on 19 January. He also had the opportunity to view part of the LHC tunnel, as well as to visit the CERN Control Centre.



Michael Boddenberg, Hessian Minister for Federal Affairs and Representative of Hessen in the Federal Government, right, visited CERN on 20 January. His tour included the ALICE experiment, the LHC tunnel, the CERN Computer Centre and CERN Control Centre.

Didier Burkhalter, Swiss federal councillor, head of the Interior Federal Department, right, came to CERN on 25 January. His visit included a tour of the ATLAS experimental area with former ATLAS spokesperson, **Peter Jenni**, left. The federal councillor was accompanied by his wife, **Sabine Friedrun Burkhalter**.



Faces & Places



On 25 January **Avi Hasson**, the Israeli chief scientist for the ministry of industry, trade and labour, seated, visited CERN, including the ATLAS experiment. Here he signs the guestbook with, from left to right, **John Ellis**, CERN's adviser for Israel, **Giora Mikenberg**, ATLAS collaboration and Weizmann Institute of Sciences, Israeli Industrial Liaison Office, and **Peter Jenni**, former ATLAS spokesperson.

German state secretary of the ministry for innovation, science and research of North Rhine-Westphalia, **Helmut Dockter**, visited CERN on 28 January and had the opportunity to see the ATLAS experimental area. His tour also included touring the CERN Control Centre and viewing the LHC tunnel.



Michael Russell, Scottish cabinet secretary for education and lifelong learning, left, was welcomed to CERN on 7 February by **Paul Collier**, head of the beams department, and presented with a temperature-sensitive mug depicting the history of the universe. The visit included the CERN Control Centre, as well as practical exercises in the Teachers' Laboratory and a meeting with Scottish scientists working at CERN.



On 31 January, **José Ángel Gurría**, secretary-general for the Organization for Economic Co-Operation and Development, left, was welcomed to CERN by **Felicitas Pauss**, head of international relations at CERN, centre, and **Sigurd Lettow**, director for administration and general infrastructure. During the visit he toured the LHC tunnel and the ATLAS experimental area.

Turkish minister of foreign affairs, **Ahmet Davutoğlu**, left, received a general introduction to CERN by CERN's director for research and scientific computing, **Sergio Bertolucci**, right, on 28 February. During his visit he signed the CERN guestbook, spoke to Turkish scientists and toured the ATLAS Visitor Centre.



Gabriel Rodriguez, the Chilean ambassador and director of the directorate of energy, science and technology, and innovation, ministry of foreign affairs, left, was welcomed to CERN on 1 February by **Rüdiger Voss**, CERN adviser for non-member states. The ambassador visited the ATLAS experiment, CERN Control Centre and the CERN Computing Centre.

MEETINGS

The Royal Society, London, is holding a discussion meeting on **Physics at the high energy frontier – the Large Hadron Collider project** on 16–17 May. The aim is to discuss the scientific, technical, sociological, political and financial challenges of bringing this huge international project to fruition. It will bring together leading figures in high-energy physics, including the director-general of CERN, the director of Fermilab and spokespersons of three major experiments. The meeting is free to attend but pre-registration (online) is essential. For further information and to access the online registration form, visit <http://royalsociety.org/events>.

Quark Matter 2011 will take place in Annecy on 23–28 May. The Quark Matter conferences aim to bring together specialists in experimental and theoretical heavy-ion physics from around the world. This year the meeting will discuss the first heavy-ion results at the new energies of the LHC, as well as the technologies needed for more

powerful experimental and software tools. The conference will be preceded by a student day on 22 May. For further information about the programme and how to register, see <http://qm2011.in2p3.fr>.

Physics at the LHC 2011 will be held in Perugia on 6–11 June. The conference provides a traditional forum for the LHC experiments to discuss latest results and new ideas. It consists of invited and contributed talks, as well as posters, covering experiment and theory. Topics cover the range of LHC physics from Higgs and supersymmetry to diffraction and forward physics. The conference is sponsored by CERN, INFN and University of Perugia. For further information about the programme and how to register, see www.pg.infn.it/plhc2011/.

The **XXV International Symposium on Lepton Photon Interactions at High Energies** will be held at the Tata Institute of Fundamental Research, Mumbai on 22–27 August. Following the traditional

format, the programme will feature plenary reports covering topics of major interest to the particle-physics community and a poster session for students and young post-docs. Unlike past symposia, there will be no country-wise quota of delegates for this symposium. Interested parties can obtain an invitation letter for attending by completing the invitation-request form on the symposium webpage <http://www.tifr.res.in/~lp11>.

The **International Workshop on e^+e^- collisions from ϕ to ψ (PHIPSI11)** will be held at the Budker Institute of Nuclear Physics, Novosibirsk, on 19–22 September. The aim is to discuss in detail the state of the art of various problems in hadronic physics at low energy e^+e^- colliders and the potential of existing and future facilities. The workshop will be followed by the satellite meeting of the Working Group on Radiative Corrections and Monte Carlo Generators on 23–24 September. For further information about the programme and how to register, see <http://phipsi11.inp.nsk.su>.



Welcome to LT-26

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Medizinische Fakultät Carl Gustav Carus - Reformfakultät des Stifterverbandes für die Deutsche Wissenschaft

OncoRay - National Center for Radiation Research in Oncology Dresden aims to develop innovative methods for biologically individualized, technologically optimized radiation therapy for improving cancer treatment. OncoRay has been established in 2005 as an interdisciplinary research center by the Dresden University of Technology, the University Hospital Dresden and the Helmholtz-Center Dresden-Rossendorf. It is located at the Medical Faculty and offers high-level research facilities, internationally acknowledged expertise in translational cancer and radiation research, and a dedicated postgraduate school with an MSc and a PhD program.



The research group "In-vivo dosimetry for novel types of radiation" (head: Dr. Uwe Dersch) invites for applications for the positions:

Two PhD Students

The salary is according to the TV-L dispositions. Contract is first limited to 2 years, subject to the funding.

Requirements:

- Excellent final degree in physics or applied natural science, diploma.
- Practical experience in development, test and operation of semiconductor detectors obtained in a previous project appreciated.
- Knowledge of programming language C/C++ and experience in data analysis and hardware related software development.
- Highly motivated person with hands-on mentality and strong interest in experimental science and engineering for medical imaging.

Tasks:

Working for the BMBF supported research project "Development of a prototype camera to realize in-vivo dosimetry in real time for hadron beam therapy" - an interdisciplinary team of engineers, physicists, technicians and technical assistants develops with support of internal and external partners a complex detector system to monitor the position of the particle beam during tumor treatment.

The successful candidates will participate in the development of the detector system and its associated electronics. In teamwork they will build, test and optimize a position and energy sensitive detection system for x-rays and electrons. The system will finally be installed and operated in the OncoRay beamline in Dresden. Further tasks are scientific supervision of bachelor and master theses and support in teaching the master course "Medical Radiation Sciences".

Women are explicitly invited to apply. Handicapped persons will be preferred in case of equal qualification. For further information please contact Mr. Stefan Pieck, Email: Stefan.Pieck@oncoray.de.

Please address your comprehensive application with **registration number ZIK0911039** until **8 April 2011** to: **National Center for Radiation Research in Oncology Dresden, Medical Faculty Carl Gustav Carus, Technische Universität Dresden, Attn. Mr. Stefan Pieck, Scientific Coordinator, Fetscherstraße 74, 01307 Dresden**

We kindly ask you to apply preferably via our online form to make the selection process faster and more effective. Of course, we also consider your written application without any disadvantages.



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The research group (head: Dr. Uwe Dersch) "In-vivo dosimetry for novel types of radiation" invites for applications for a position as an:

Engineer Electronics & Data Acquisition

The salary is according to the TV-L dispositions. Contract is first limited to 3 years, subject to the funding.

Requirements:

- Excellent final degree in electronic engineering, diploma, PhD welcome.
- In depth practical experience in design, development, integration and test of data acquisition systems and electronics for semiconductor based radiation detector systems in medical imaging, astrophysics or high energy physics application.
- Profound programming skills in C/C++ and proven experience in data analysis and hardware related software development.
- Highly motivated person with hands-on mentality and strong interest in electrical engineering for medical imaging

Tasks:

Working for the BMBF supported research project "Development of a prototype camera to realize in-vivo dosimetry in real time for hadron beam therapy" - an interdisciplinary team of engineers, physicists, technicians and technical assistants develops with support of internal and external partners a complex detector system to monitor the position of the beam during tumor treatment.

The successful candidate will design, develop and test the electronic system, e.g. the real time data acquisition system, for the position and energy sensitive x-ray detection system. This system will finally be installed and operated in the OncoRay beamline in Dresden. For this demanding engineering task the successful candidate will closely work together with the group, partners in science and industry and will technically advise students and personnel.

Women are explicitly invited to apply. Handicapped persons will be preferred in case of equal qualification. For further information please contact Mr. Stefan Pieck, Email: Stefan.Pieck@oncoray.de.

Please address your comprehensive application with **registration number ZIK0911040** until **8 April 2011** to: **National Center for Radiation Research in Oncology Dresden, Medical Faculty Carl Gustav Carus, Technische Universität Dresden, Attn. Mr. Stefan Pieck, Scientific Coordinator, Fetscherstraße 74, 01307 Dresden**

We kindly ask you to apply preferably via our online form to make the selection process faster and more effective. Of course, we also consider your written application without any disadvantages.

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Lecturer in Science and Engineering (two posts) (Ref: EPS/11799)

Specializing in any of the following areas: Accelerator, Laser, Material, Microwave, Energy, Photon and Instrumentation Sciences

**Salary: £36,862 - £45,336 per annum
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Particle accelerators serve a wide variety of purposes. They are used as innovative tools for "discovery-class" scientific research and invention at many of the most prestigious national and international institutes and laboratories. Accelerators also serve society in critical areas of need in energy, security, health and medicine.

The Cockcroft Institute in the UK is a unique international centre specifically responsible for research and development in particle accelerators, colliders and light sources for advancing the frontier of particle and nuclear physics, photon and neutron sciences and various applications to society in the areas of health, medicine, energy and security. The University of Manchester is a major stakeholder and one of the founding members, of The Cockcroft Institute - a partnership of the Universities of Liverpool, Manchester and Lancaster, the Science and Technology Facilities Council including its Daresbury and Rutherford Appleton Laboratories, UK industry and economic development agencies.

As part of this important, internationally-leading activity at The Cockcroft Institute, candidates will also have the opportunity to take advantage of the unique research centres provided at the University of Manchester, including the Dalton Nuclear Institute, Photon Science Institute and the Jodrell Bank Centre for Astrophysics. Applications are invited from Physical and Applied Scientists and Engineers with a PhD degree at the top of their profession seeking an academic career specialising in Particle Accelerator Science and Engineering with a focus on applications to any of the disciplines of

Physics, Energy, Optoelectronics, Photonics, Material, Quantum Electronics, Quantum Optics and various electrical engineering disciplines of sensors, instrumentation and ultrafast signal processing, and electromagnetic modelling. Significant start-up laboratory equipment and infrastructure is expected to be made available to the appointed faculty from the Cockcroft and Photon Science Institutes. The successful candidate will be expected to work synergistically with existing Cockcroft faculty at the University of Manchester.

Candidates are sought with interest in areas such as conception and design of particle colliders, novel light sources and free electron lasers, for fundamental research as well as for developing cost- and energy-efficient photo-voltaic nano-structures towards solar energy, conception and design of high current proton accelerators for fundamental research and towards accelerator-driven subcritical reactors and various applications of proton and photon beams for health, medicine and security. These represent exciting and challenging opportunities for someone wishing to excel and lead a significant contribution to world-wide development of tomorrow's particle accelerator systems for science and society.

The Faculty appointment will provide a prestigious start to an academic career with a demonstrable international research dimension.

The successful candidate will already have an extensive track record in internationally-leading research in any of the areas of theoretical, computational or experimental particle accelerator, laser and photon beam physics in

any of the following areas: linear and nonlinear charged particle dynamics; collective dynamics of beam and plasma instabilities; microwave, radio-frequency, terahertz and optical sciences and engineering; power engineering; materials science including nanostructures and photovoltaics; charged particle and optical beam diagnostics and digital electronics, optronics, photonics, sensors and instrumentation. S/he will have a high-impact publication record commensurate with such experience. S/he will also demonstrate proven ability to lecture at postgraduate and undergraduate level at the highest levels of quality and support / encourage taught course and research students. An understanding of current global priorities for particle accelerator science and related applications will be important, together with the ability to contribute to and develop existing taught provision in related areas of curricula with an international dimension.

Active involvement and collaboration with the existing Cockcroft faculty and specialist research areas within the University of Manchester, along with relevant activities particularly with the other partners in the Cockcroft Institute will be encouraged.

Application forms and further particulars are available from our website
<http://www.manchester.ac.uk/jobs>.

If you are unable to go online you can request a hard copy of the details from EPS HR Office, The University of Manchester, Sackville Street Building, Manchester, M60 1QD, Tel: 0161 275 8837; Fax: 0161 306 4037 or email: eps-hr@manchester.ac.uk.

The closing date for applications is: Tuesday 17 May 2011

For further information about the Cockcroft Institute, visit <http://www.cockcroft.ac.uk> or contact Prof. Swapan Chattopadhyay (swapan@cockcroft.ac.uk)



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The research group (head: Dr. Uwe Dersch) "In-vivo dosimetry for novel types of radiation" invites for applications for a position as an:

Expert in Semiconductor Radiation Detectors

The salary is according to the TV-L dispositions. Contract is first limited to 3 years, subject to the funding.

Requirements:

- Excellent final degree in physics or applied natural science, PhD welcome.
- In depth practical experience in development and test of novel types of semiconductor detectors - preferably also scintillation detectors - for application in particle tracking and spectroscopy.
- Excellent programming skills in C/C++ and proven experience in data analysis and hardware related software development.
- Highly motivated person with hands-on mentality and strong interest in experimental science and engineering for medical imaging.

Tasks:

Working for the BMBF supported research project "Development of a prototype camera to realize in-vivo dosimetry in real time for hadron beam therapy" - an interdisciplinary team of engineers, physicists, technicians and technical assistants develops with support of internal and external partners a complex detector system to monitor the position of the particle beam during tumor treatment. The successful candidate will develop, test and optimize a detector system with associated electronics to build a position and energy sensitive detection system for x-rays and electrons. This system will finally be installed and operated in the OncoRay beamline in Dresden. For this demanding task the successful candidate will closely work together with the group as well as with partners from science and industry and he will technically advise students and personnel.

Women are explicitly invited to apply. Handicapped persons will be preferred in case of equal qualification. For further information please contact Mr. Stefan Pieck, Email: Stefan.Pieck@oncoray.de.

Please address your comprehensive application with **registration number ZIK0911041** until **8 April 2011** to: **National Center for Radiation Research in Oncology Dresden, Medical Faculty Carl Gustav Carus, Technische Universität Dresden, Attn. Mr. Stefan Pieck, Scientific Coordinator, Fetscherstraße 74, 01307 Dresden**

We kindly ask you to apply preferably via our online form to make the selection process faster and more effective. Of course, we also consider your written application without any disadvantages.



Postdoctoral Research Associate - Muon Cooling

The Center for Accelerator and Particle Physics at the Illinois Institute of Technology has an opening for a postdoctoral research associate. The main focus of activity will be the Muon Ionization Cooling Experiment (part of the worldwide R&D program for a future Neutrino Factory or Muon Collider) and design studies for a future six-dimensional muon cooling experiment. Applicants must have a Ph.D. in particle physics, accelerator physics, or a related field. Please send curriculum vitae and names of three references to:

Prof. Daniel Kaplan, Physics Division, Illinois Institute of Technology,
3101 S. Dearborn St., Chicago, IL 60616, USA

or (preferably) by email to kaplan@iit.edu. Further information on the activities of our group may be found at <http://capp.iit.edu> on the World-Wide Web.

Illinois Institute of Technology is an Equal Opportunity employer and encourages applications from qualified women and minorities.

The Excellence Cluster for Fundamental Physics

'Origin and Structure of the Universe'



RESEARCH FELLOWS in Astrophysics, Cosmology, Nuclear and Particle Physics

The Cluster of Excellence 'Origin and Structure of the Universe' is a joint research institution at the Technical University Munich funded by the Excellence Initiative of the Federal Government of Germany. It is a co-operation by the physics departments of the Technical University Munich and the Ludwig-Maximilians University, four Max-Planck Institutes (MPA, MPE, MPP, IPP) and ESO. The main goal of the Cluster is to solve fundamental questions of astrophysics and cosmology by interdisciplinary research.

For our **FELLOWSHIP PROGRAM** we are looking for excellent young scientists who will pursue their individual research activities and are interested in a strong collaboration with existing Cluster research groups. We expect candidates with **at least two years of postdoc experience** in independent research. Fellows benefit from an ideal scientific infrastructure at the Campus Garching and the attractions of the Munich area. The successful candidates will receive a **2-years fellowship** and a **budget** for their running costs.

The advancement of women in the science is an integral part of the cluster and the university's policy. Women are therefore especially encouraged to apply. Persons with disabilities will be given preference to other applicants with equal qualifications.

Application

Applicants should prepare a covering letter and the following documents as PDF files: a CV, a publication list, PhD certificate, past research activities and a research plan. These files can be uploaded in the job section on the Cluster website www.universe-cluster.de. Further, applicants are asked to arrange for three letters of recommendation to be sent by the referees by e-mail to andreas.mueller@universe-cluster.de. The closing date for receipt of applications is **30 April 2011**.

Contact

Technische Universität München · Excellence Cluster Universe
Dr. Andreas Müller · Boltzmannstrasse 2
85748 Garching · Germany

Detector Physicist



UCL invites applications for an immediate opening for a detector physicist funded as a core-physicist on the UCL STFC rolling grant who will have responsibility for the development and construction of detectors for the HEP group. The successful candidate will have in-depth knowledge in detector physics and hands-on experience in developing, building and commissioning modern as well as traditional detector systems used in particle physics (scintillator and gaseous detectors, semi-conductor detectors, cryogenic equipment etc.). Familiarity with detector readout technologies is also expected. Apart from his/her own research work the appointee will liaise closely and manage a team of engineers and technicians involved in detector projects.

Salary will be in the range from £31,905 to £38,594 per annum inclusive of London Allowance.

The closing date for applications is 15 April 2011.

Further details about the position and the application procedure can be found at http://www.hep.ucl.ac.uk/positions/detector_physicist_Mar2011.shtml.



Cornell Laboratory for
Accelerator-based Sciences
and Education (CLASSE)

Senior Research Associate

Cornell Laboratory for
Accelerator-based Sciences and Education

The Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE) seeks an individual to take a lead role in the management and development of major accelerator systems. The specific research and development activities will be in one of the accelerator-associated fields that are part of the mission of CLASSE (x-ray science, accelerator science, or elementary particle physics). These activities will be determined in consultation with the CLASSE Director, to whom this position reports. Duties will also include: overseeing accelerator radiation protection and safety systems; performing radiation shielding calculations using Monte Carlo codes such as MARS, FLUKA, EGS5, or MCNPX; calculating radioactivity induced in materials by stray radiation fields around electron accelerators; assessing radiation damage in electronics; making measurements of photon and neutron spectra over a wide energy range; reviewing and approving safety analysis documents for laboratory operations, working with staff at all levels to analyze and set procedures for unusual or new safety issues.

Requirements: A PhD in one of the physical sciences or engineering, and several years of experience in experimental high-energy accelerator physics or nuclear science and engineering. Must be familiar with: biological effects from natural and man-made sources of environmental radioactivity; federal, state, and local laws governing radiation; photon and neutron dosimetry; and occupational, chemical, biological, and laser safety. A high level of people skills and mature judgment are essential.

Please send a cover letter, including curriculum vitae and a publications list to Dr. Maury Tigner, Newman Laboratory, Cornell University, Ithaca, NY 14853, and arrange for three letters of recommendation to be sent. Correspondence may be directed to search_classe@cornell.edu.

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Mathematical, Physical and Life Sciences Division
Department of Physics

University Lectureship in Accelerator Science

University of Oxford & STFC Rutherford Appleton
Laboratory in association with Wolfson College Oxford
and a

Departmental Lectureship in Accelerator Science

University of Oxford

The John Adams Institute for Accelerator Science (JAI) in Oxford wants to appoint a University Lecturer in Accelerator Science (permanent academic post) on a joint appointment with STFC's Rutherford Appleton Laboratory, and a Departmental Lecturer in Accelerator Science (a 5-year fixed term appointment). Current projects include novel compact light sources and FELs based on laser-plasma acceleration, linear collider, neutrino factory, the Muon Ionisation Cooling Experiment (MICE), non-scaling Fixed-Field Alternating Gradient accelerators and plasma accelerator diagnostics. Applications are welcome in any area of accelerator science, especially those aligned with the strategic interests of the JAI, for example the development of compact light sources, areas of synergy between laser and plasma physics and accelerator physics, and areas where accelerator science may prove beneficial in technology, energy and medicine. This work involves close international collaboration. Details about the JAI can be found at <http://www.adams-institute.ac.uk>.

University Lectureship in Accelerator Science, jointly with the STFC Rutherford Appleton Laboratory

Salary on the scale £42,733 - £57,431

The appointee will undertake lecturing, research and administration within the JAI and the Department of Physics in Oxford, and will undertake research at the Rutherford Appleton Laboratory. The successful candidate will be offered a supernumerary Fellowship at Wolfson College Oxford; upon completion of a satisfactory review after an initial period of employment (normally five years), a University Lecturer is eligible for reappointment until retiring age.

Departmental Lectureship in Accelerator Science

Salary on the scale £29,099 - £39,107

This is a 5-year fixed-term appointment. The Appointee will undertake lecturing, research and administration within the JAI and the Department of Physics in Oxford.

Informal enquiries about either post may be made to Professor Andrei Seryi, email: Andrei.Seryi@adams-institute.ac.uk, and further particulars are available at <http://www.physics.ox.ac.uk/pp/jobs/JAI-UL-DL-fp.htm>. The deadline for applications is 1st June 2011. Interviews will be held in mid June to early July; candidates should consult the web-site for the exact date and keep this date free in case they are called for interview.

Applicants should submit before the deadline a letter of application setting out how they meet the criteria set out in the further particulars, supported by a curriculum vitae, list of publications, a statement of research interests to Mrs. Sue Geddes, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK, email: s.geddes@physics.ox.ac.uk, FAX 0044-1865-273417. In addition, candidates should arrange for the three letters of reference to be sent to Mrs. Sue Geddes by the closing date. Applicants should state whether they wish to be considered for the University Lectureship, Departmental Lectureship or both.

Committed to equality and valuing diversity



EUROPEAN
SPALLATION
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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.

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Bruker BioSpin is the world leader in the design and manufacture of magnet systems for specialized MRI scanners and other applications. The magnet systems include, e.g., superconducting magnets. Our headquarter is located in Wissembourg, Alsace, France (50 km North of Strasbourg, 30 km West of Karlsruhe). In order to strengthen our magnet engineering team, we are seeking Engineers/ Physicists to join our team, offering excellent opportunities for career progression within the Bruker organisation, as:

R&D Engineers "Magnet Systems"

You will help maintain our state of the art competence in magnet design, analysis techniques and manufacturing processes. This role offers the opportunity to further our understanding in areas such as electromagnetic design, analytical and numerical modelling, and, e.g., superconductor technology, as applied to our magnets systems. You will contribute to the development of new products and enabling technologies that will help secure our market-leading position.

The focus of this position will be on electromagnetic design, analytical and numerical modelling and requires strong skills in mathematics and linear systems theory. Further skills in engineering mechanics, cryogenics, superconductor technology can be advantageous.

Fluency in English is mandatory.

The role requires strong analytical skills, a creative approach to problem-solving, and the ability to work effectively within multi-disciplinary teams. Applications are encouraged from individuals with recent graduate or post-graduate degrees in Physics or Electrical Engineering, as well as those with a professional background in a relevant industry or science.

Bruker has the corporate values of Innovation, Excellence and Responsibility and within the context of these applications, Bruker Biospin SAS will commit resources to support full professional body membership for the successful candidate.

Contact: drh@bruker.fr

think forward

Oxford Instruments

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Oxford Instruments plc is a rapidly expanding global company that can offer outstanding career opportunities. We use innovation to turn smart science into world-class products that support research and industry to address the great challenges of the 21st Century. If you would like to join a vibrant and successful high technology business then have a look at the current vacancies on our website which include:

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- **RF Electronics Engineer** (UK) ref 108
- **EDX/WDX Sales and Applications Specialist** (Central Europe) ref 107

To apply for any of these roles, please visit our website or send your CV, with the role reference number, to vicki.potter@oxinst.com

www.oxford-instruments.com



Massachusetts Institute of Technology

Associate Director

The MIT Laboratory for Nuclear Science has an opening for the position of Associate Director. The responsibilities for this position include the following: broad, comprehensive responsibility for independently directing all administrative functions of the organization; assisting the Director and senior research management in implementing the goals of the laboratory, which supports a large program of research and educational activities in particle and nuclear physics with ~ 25 M\$ annual research volume and with about 250 faculty, staff, researchers, and students; on behalf of the Director acting as key administrative liaison both inside and outside MIT; assisting in the development of long-range plans for research and staffing levels; analyzing the fiscal status of the Laboratory, assisting faculty and staff in developing grant or contract proposals and in meeting reporting requirements; assisting the MIT Office of Sponsored Programs in contract negotiations; providing interface and promoting effective relationships with sponsors, MIT administration, affiliated organizations, and national and international collaborative efforts; overseeing all administrative elements within the Laboratory, including budgets, service centers, personnel, public relations and other outreach programs, and resource allocation; initiating and coordinating the preparation of special reports, such as reports to sponsor, five-year plans, reports to the MIT President, and public relations documents.

A Ph.D. in a science-related field, or equivalent combination of education and experience, and significant experience in research administration are highly desirable. Familiarity with a scientific research environment is necessary, as is the proven ability to interact effectively with sponsors and other offices in an MIT-like administrative environment.

Please send CV to: **Kenneth L. Hewitt, 26-516, Massachusetts Institute of Technology, 77 Massachusetts Ave. Cambridge, MA 02139-4307**
Email: khewitt@mit.edu

<http://web.mit.edu>

Muon Accelerator Program Director

Fermi National Accelerator Laboratory (Fermilab) is seeking a scientist of international stature and a proven record of accomplishment for the position of the US Muon Accelerator Program Director. The U.S. DOE Office of High Energy Physics's Muon Accelerator Program was created in 2010 to unify the R&D activities in the U.S. aimed at developing the concepts and technologies required for Muon Colliders and Neutrino Factories. These muon based facilities have the potential to discover and explore new exciting fundamental physics, but will require the development of demanding technologies and innovative concepts. The MAP aspires to prove the feasibility of a Muon Collider within the next 5 years, and to make significant contributions to the international effort devoted to developing Neutrino Factories.

The Director is expected to provide leadership and vision for the R&D program, to lead the muon accelerator activities in the US as it enters this present focused R&D phase, and to play a strategic international role in shaping the muon accelerator landscape beyond the US. The Director will oversee all MAP efforts, engage with other laboratories, universities and companies to strengthen the current MAP collaboration and serve as the primary interface with the collaborating institutions.

The successful candidate must have a Ph.D. in Physics or Engineering and a proven record of success in handling responsibilities at a senior management level.

Applications should be sent directly to Dr. Stuart D. Henderson, Chair of the Search Committee stuarth@fnal.gov. Applications should include a curriculum vitae, publication list, and three letters of reference and should be received by April 29, 2011.



Fermilab is an Equal Opportunity Employer M/F/D/V

Bookshelf

Neutrino

By Frank Close

Oxford University Press

Hardback: £9.99

“Of all the things that make the universe, the commonest and weirdest are neutrinos.” Thus starts Frank Close’s latest book, *Neutrino*, a fascinating look into one of the most compelling and surprising scientific advances of the past century.

With its very basic title, a reader might imagine that this book, written by a leading particle theorist, would be an accurate but dry discourse on the eponymous particle. They would be surprised to find a moving book centred on the lives and work of three individuals: Ray Davis, John Bahcall and Bruno Pontecorvo. *Neutrino* manages to capture not only their impressive scientific contributions but something of their personalities and the times, through an excellent choice of quotes and stories from friends and colleagues. Consequently it is a book that is brief, scientifically accurate and full of drama.

The neutrino’s origins in the early 20th century studies of radiation, stellar astrophysics and neutrino oscillations are all carefully and clearly explained. This book fills in many of the gaps left by more cursory treatments, in particular the road from Wolfgang Pauli’s proposal of the neutrino to the development of the theory of beta decay by Enrico Fermi. But the pedagogic scope is wisely limited and the author does not shy away from leaving the scientific explanations to a footnote if they are incidental to the main storyline.

Neutrino also manages to capture the full spectrum of ideas, events and relationships that play a part in particle physics. The path between brilliant theoretical insight and triumphant experimental verification can be long and precarious. The prosaic (and often deciding) factors – the casual encounter with a colleague that sparks a new idea, incorrect theoretical assumptions identified and corrected, incremental advances in technology, site selection, the vagaries of funding decisions, politics, the role of industrial partners, and just plain luck – are accurately and entertainingly discussed.

That this book succeeds on a number of levels is a credit to the author’s deep knowledge of the physics and his meticulous research, as well as a concise and imaginative writing style. The omission of the LSND and MiniBooNE experiments is the only notable absence, though hardly surprising since the experimental



situation here is far from resolved. If the signatures of antineutrino appearance from these experiments stand up to further investigation, neutrinos will have proved to be even weirder than we thought and will provide the author with rich material for a second edition.

● Hugh Gallagher, Tufts University.

How to Teach Quantum Physics to Your Dog

By Chad Orzel

Oneworld

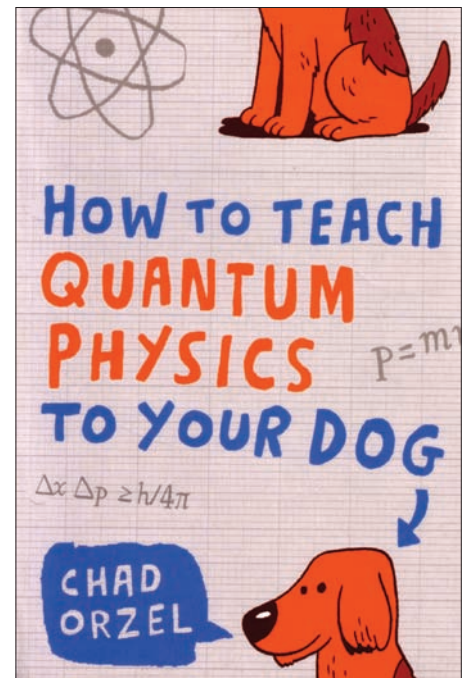
Hardback: £7.99

When I first sat down with *How to Teach Quantum Physics to Your Dog* I was expecting a little light reading, something to pick up on Sunday after lunch. After all, if a dog could understand it, surely someone who has a PhD in physics wouldn’t find it too challenging? I was wrong.

Initially Chad Orzel’s analogies with squirrels and dog wavefunctions are both amusing and enlightening, but as the book moves on they don’t make his subject any clearer. By the time he has reached incoherence it is hard to see how anyone without a good grounding in physics would cope. But it is worth persevering.

Orzel’s style – especially his references to dog treats, bunnies and squirrels – get irritating at times, but despite this I found myself enjoying the book.

To quote Orzel, “quantum mechanics is often subtle and difficult to understand”. His



book reminds us why that is, and overall he succeeds in making it a little clearer.

● Catriona Charlesworth, St Jean de Gonville.

Field Computation for Accelerator Magnets: Analytical and Numerical Methods for Electromagnetic Design and Optimization

By Stephan Russenschuck

Wiley

Hardback: £165 €204 \$275

The LHC is an amazing engineering achievement supported by a long programme of developments. CERN has been encouraging the development of technologies required to complete the project since the late 1960s (for example, the GESSS collaboration between the Saclay, Karlsruhe and Rutherford Laboratories). The quality of this work has been recognized internationally and it has contributed to spin-off activities, especially in the development of superconductors and in magnetic-field computation. With the completion of the LHC, and recognizing CERN’s desire to maintain the competences required to design accelerators, it is the right time to publish a book on the computer methods developed to design the LHC magnets.

In this book, Stephan Russenschuck provides an extremely useful and comprehensive description of magnetic-field computation for particle-accelerator

Bookshelf

magnets. It gives practical information and describes simple methods of analysis; in addition, it includes the abstract mathematics necessary to understand the finite element methods that were developed specifically for the design of the magnets for the LHC's main ring. The final chapter examines optimization methods, particularly those implemented in the ROXIE software.

The successful design of the LHC magnets required highly accurate field-computation methods that were capable of modelling effects such as conductor and cable magnetization, which are uniquely important to accelerators. Even the LHC's superconducting magnets quench, when a small resistive volume diffuses rapidly through the coil structure, driven forward by the heat it generates. This book's chapters describe methods for modelling these effects, and demonstrate the accuracy of the results by comparison with measurements. The appendices include practical information about cryogenic material properties required for quench analysis.

This is a well presented book that makes excellent use of computer graphics to show results and explain phenomena. The graphics showing interstrand coupling currents in conductors and cables are particularly clear and help to make this chapter easy to understand.

Russenschuck has written a valuable addition to the library of those involved in the design of accelerator magnets.

● *John Simkin, Vector Fields Software.*

Sonne, Mond und Sterne... 52 kosmische Antworten

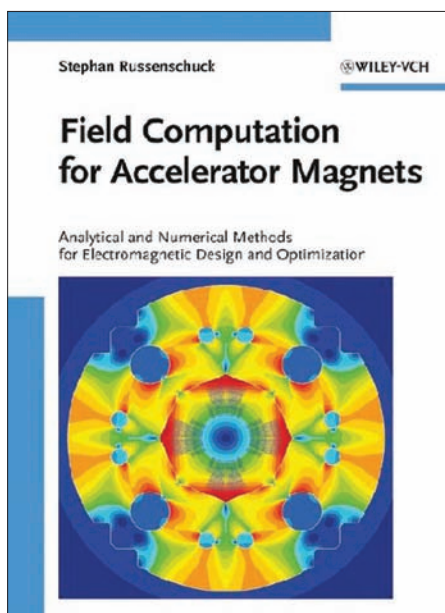
By Franz Kerschbaum and Franz Simbürger

Seifert Verlag

Paperback: €10.90 SFr19.70

The general public shows an ever-growing interest in following the latest advances in scientific research, in particular when it comes to some of the most fundamental questions of mankind, such as how big and old is our universe, how is it structured, what is dark matter and energy, why is it that our Sun shines and will it shine forever?

To answer many of these questions for a broad audience, Franz Kerschbaum, head of the Institute for Astronomy at the University of Vienna, took part in a weekly radio programme by the ORF (Austria's public TV and radio broadcaster). Called *Wissen aktuell* and mediated by Franz Simbürger, the series was so successful that the questions and their concise answers have been made into a book, interspersed with some spectacular illustrations.



The 52 questions introduce the reader to many astrophysical objects and the associated scientific research: dwarf stars, pulsars, black holes, dark matter, the cosmic-ray background, etc. They also address more practical aspects concerning the universe, the Sun and our planetary system: how to look for new planets, why we need space telescopes, the dimensions of the Solar system, etc. An advantage of the book over the radio programme is that readers can easily combine information from the individual contributions.

Despite being concise, this book contains plenty of information and places events in historical context. For instance, we are reminded of the revolutionary discoveries made by Galileo Galilei, despite the simplicity of his "spyglass" compared with today's amateur and scientific telescopes, and of the fact that the Phoenicians and Greeks already knew that the Earth is round, long before the Portuguese and Spanish sailed around the "globe".

This book is particularly suited to curious high-school students who – when lying on the grass, looking at the sky – might ask themselves questions such as, why is the sky so blue (or red at sunset), why do stars scintillate, what is a shooting star, why is Earth the only (currently known) planet where life exists? It is also a good entry point for learning more about the fascinating fields of astrophysics and cosmology.

It is just a pity that the word *Millionen* (million) was written as *Milliarden* (thousand million), misleading the naive reader into thinking that the Herschel and SOHO satellites orbit the Earth at 1.5 *Milliarden* km, a distance 10 times larger



than the distance from the Earth to the Sun.

● *Hermine K Wöhri, CERN.*

Books received

Practical Guide to Computer Simulations

By Alexander K Hartmann

World Scientific

Hardback: £67 \$108

Paperback: £40 \$64

After working through this book, the reader will possess the necessary background knowledge, from program design, programming in C, fundamental algorithms and data structures, all of the way to data analysis, presentation and publishing. In each of these fields, no preliminary knowledge is assumed. All techniques are explained using many examples in C; the C codes, as well as solutions to the exercises, are available in the accompanying CD-ROM. The techniques described are independent of the fields of research and hence are suitable for projects in physics, chemistry, computer science, biology and engineering. The general-purpose nature also means that problem-dependent algorithms are not included.

Scientific Computation

By Gaston H Gonnet and Ralf Scholl

Cambridge University Press

Hardback: £35 \$68

E-book: \$52

Using real-life applications, this graduate-level textbook introduces different mathematical methods of scientific computation to solve minimization problems using examples

ranging from locating an aircraft, finding the best time to replace a computer, analysing developments on the stock market and constructing phylogenetic trees. The book focuses on several methods, including various optimization procedures. Each chapter solves several realistic problems while introducing the modelling optimization techniques and simulation as required. This allows readers to see how the methods are used, making it easier to grasp the basics.

Networks: An Introduction

By MEJ Newman

Oxford University Press

Hardback: £45 \$85

The scientific study of networks, including computer, social and biological networks, has received an enormous amount of interest over the past few years. The rise of the internet and the wide availability of inexpensive computers have made it possible to gather and analyse network data on a large scale, and the development of new theoretical tools has allowed the extraction of new knowledge from many different kinds of networks. Important developments have occurred

in many fields, including mathematics, physics, computer and information sciences, biology and the social sciences. This book brings together, for the first time, the most important breakthroughs in each of these fields and presents them in a coherent fashion, highlighting the strong connections between work in different subject areas.

Classical and Quantum Dynamics of Constrained Hamiltonian Systems

By Heinz J Rothe and Klaus D Rothe

World Scientific

Hardback: £62 \$62

E-book: \$117

This is an introduction to the field of constrained Hamiltonian systems and their quantization – a topic that is of prime interest to theoretical physicists who wish to obtain a deeper understanding of the quantization of gauge theories, such as describe the fundamental interactions in nature. Beginning with the early work of Dirac, this book covers the main developments in the field up to more recent topics, such as the field–antifield formalism of Batalin and Vilkovisky (including a short discussion of how gauge anomalies may

be incorporated into this formalism). All topics are well illustrated with examples that emphasize points of central interest. The book is aimed at graduate students and researchers in theoretical and mathematical physics, quantum mechanics and quantum field theory.

Modern Atomic and Nuclear Physics: Problems and Solutions Manual (Revised Edition)

By Fujia Yang and Joseph H Hamilton

World Scientific

Hardback: £13 \$19

This “problems and solutions” manual is intended as a companion to an earlier textbook, *Modern Atomic and Nuclear Physics (Revised Edition)*, also by World Scientific. This manual presents solutions to many end-of-chapter problems in the textbook. These solutions are valuable to instructors and students working in the modern atomic field. Students can master important information and concepts in the process of looking at solutions to some problems, and become better equipped at solving other difficulties that the instructors propose.



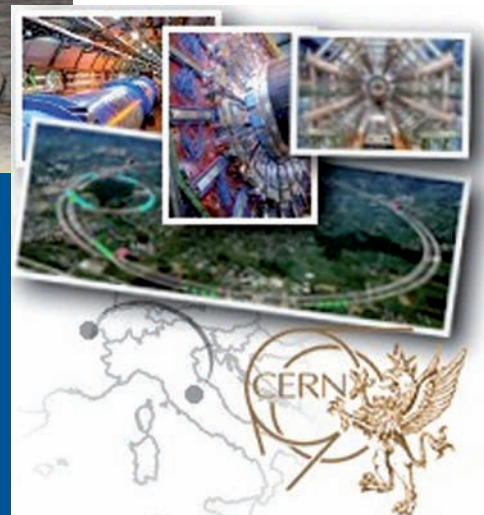
Physics at LHC 2011

Perugia, Italy, 6–11 June 2011

Congress Center Gio

Chairs: G Mantovani, G Mitselmakher, L Rossi

www.pg.infn.it/plhc2011 e-mail: plhc2011@pg.infn.it



Inside Story

The discovery of superconductivity

Dirk van Delft and Peter Kes describe events surrounding the discovery that made possible the powerful magnets used today in particle accelerators such as the LHC.

One hundred years ago, on 8 April 1911, Heike Kamerlingh Onnes and his staff at the Leiden Cryogenic Laboratory were the first to observe superconductivity. In a frozen mercury wire, contained in seven U-shaped capillaries in series, electrical resistance suddenly seemed to vanish at 4.16 K.

The discovery of superconductivity may have been accidental, but nonetheless the experiment was part of a carefully considered research programme at Leiden. Studying the behaviour of the electrical resistance of metals (such as gold and platinum) at low temperatures was interesting from both a practical and a theoretical point of view. Practical, because the fact that metal resistors were dependent on temperature made it possible to use them as (secondary) thermometers – thereby raising the possibility of a welcome addition to the (primary) gas thermometer that, although accurate, was cumbersome to use and slow in response. Theoretical, because Paul Drude had already applied the kinetic theory of gases to an electron gas in a metal in 1900, and on that basis had deduced the linear decrease in resistance with absolute temperature, while William Thomson (Lord Kelvin) had predicted one year later that at extremely low temperatures, the conducting electrons would, in fact, become “frozen solid” to the atoms, such that at absolute zero, resistance would become infinite.

Using liquid hydrogen as a coolant, Jacob Clay and other students of Kamerlingh Onnes had succeeded in carrying out experiments down to 14 K (the freezing point of hydrogen) at the Leiden Physics Laboratory, starting in 1906. It was noted during these experiments that, although the resistance of gold and platinum wire did fall

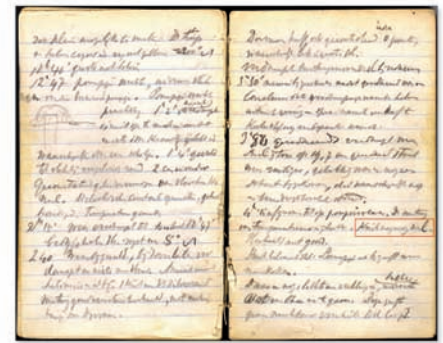
with decreasing temperatures, at the same time it started to level out. The successful liquefaction of helium on 10 July 1908 gave a massive boost to this research because, at a stroke, temperatures as low as 1 K had suddenly been made achievable. The result of these new measurements was that at such low temperatures, resistances reached a sort of residual value that became lower the purer the platinum or gold could be made.

The logical next step was the choice of mercury because, via distillation, the metal could be made extremely pure. The capillary construction, a masterpiece of the Leiden-based glass-blower Kesselring, was installed in the helium cryostat next to the liquefactor. The actual goal of the experiment was the test of the transfer system for liquid helium. During the decisive experiment on 8 April 1911, Kamerlingh Onnes and Gerrit Jan Flim, head of the cryogenic laboratory and master instrument maker, were responsible for the cryogenic installations. Measuring the temperature (using a gas thermometer) was the task of Cornelis Dorsman, while the resistance of the mercury wire (and of gold) was determined via an electrical bridge circuit with a mirror galvanometer. The galvanometer was placed in a room at a safe distance from the throbbing pumps, on a vibration-proof column, and was monitored by Gilles Holst (who communicated via a speaking tube). The result of these experiments was that the mercury resistance did, indeed, fall to zero.

In December 1912, mercury as a superconductor was joined by tin and lead, metals with a transition temperature of 3.8 and 7.2 K, respectively. From then on, there was no need to experiment with fragile mercury capillaries. Experiments could now be carried out with handy coils of wire.

The stakes were high: nothing less than a compact, powerful superconducting magnet. At the start of the century, Jean Perrin had already put forward the idea of a liquid-nitrogen-cooled magnet of copper wire, with a magnetic field of 100 kG.

At the third International Congress of Refrigeration in Chicago, in the autumn of 1913, Kamerlingh Onnes once again raised the issue of the super magnet. “The solution to the problem of obtaining a field of 100 000



A crucial page from the entry for 8 April 1911 in Kamerlingh Onnes's notebook. The highlighted sentence *Kwik nagenoeg nul* means “Mercury's resistance is practically zero [at 3.0 K]”, thus announcing the first observation of superconductivity. (Archive of the Boerhaave Museum, Leiden).

gauss could be obtained by a coil of, say, 30 cm in diameter, and the cooling with helium would require a plant that could be realized in Leiden with a relatively modest financial support,” he wrote in his summary of the cryogenic work in Leiden. “Since we may confidently expect an accelerated development of experimental science, this future ought not to be far away.”

It was not until the 1960s that the powerful superconducting magnet was finally introduced, thanks to niobium-titanium wire. This is a conventional superconducting material with a high threshold field, a large current density and a transition temperature (T_c) of 9 K. MRI scanners and deflection magnets in particle accelerators still make use of magnets of this kind.

- To commemorate this milestone in the history of science, a special, one-day symposium entitled “100 Years of Superconductivity” will be held in Leiden, the Netherlands, on 8 April 2011, the centennial anniversary of the discovery. Visit the website at www.museumboerhaave.nl/nl/superconductivity.

- Dirk van Delft, Museum Boerhaave and Leiden University, and Peter Kes, Leiden University. This article is based on extracts from “The discovery of superconductivity”, Dirk van Delft and Peter Kes, 2011, *Europhysics News* 42 21. It is published with the kind permission of the authors and Europhysics News.

Single Photon Counting
No Noise
High Dynamic Range
Fast Frame Rate
Adjustable Energy Threshold

DECTRIS X-ray detector systems

DECTRIS offers a wide variety of detector systems for a broad range of applications

PILATUS 2-D detector systems

PILATUS detector systems are based on CMOS hybrid-pixel technology and deliver outstanding results in various applications. A wide range of models ensures that a suitable PILATUS detector can be chosen for every measurement.



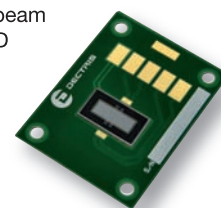
MYTHEN 1-D detector systems

MYTHEN is a one dimensional silicon strip detector system, which can be combined to form multi-detector arrays covering large angles (MYTHEN 6K).



XBPM Beam Position Monitors

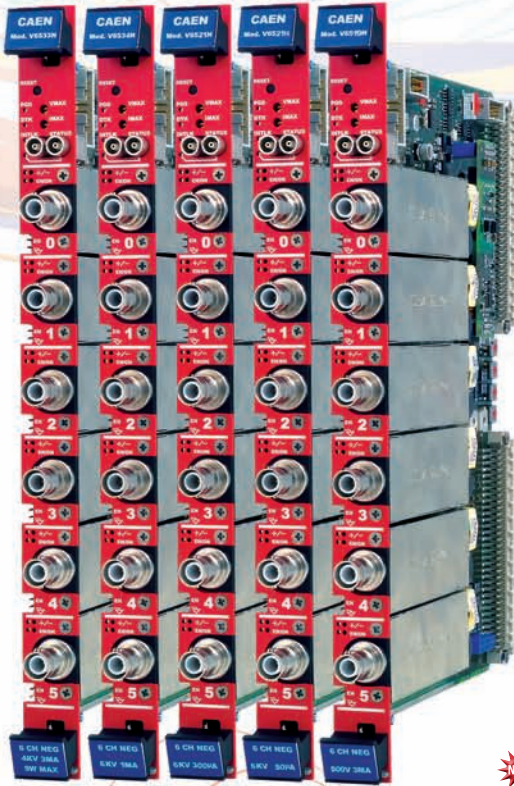
XBPM4 is a 4-quadrant x-ray beam position monitor based on CVD diamond technology, suitable for hard x-ray synchrotron beam lines.



VME Programmable HV Power Supply Family

Up to 6kV, up to 3mA (common floating return)

High Performance - Low Cost - Low Ripple - High Resolution



The V6500 family is composed by 1-unit wide VME 6U modules housing 6 High Voltage Power Supply Independent Channels. The VME interface is VME64 standard compliant (A24/A32/D16). Module control via OPC Server. C and LabView Libraries.

Optional Software Tool for remote control (*):

- Monitor and setting of all the channel parameters
- Java Application, Windows and Linux supported

(*Available on Q3)

- Available with positive, negative or mixed polarity
- SHV coaxial output connectors
- Optional A6580 DC Input Power Equalizer
- Optional Imon-Zoom available
- Individual channel enable
- Interlock logic per board
- General purpose instruments for use with: Photomultiplier tubes, Germanium detectors and many others devices

Model (1)	V Full Scale (res)	Maximum Current (2)	Iset/Imon resolution	Rump UP/DWN	Ripple Typ (Max)
V6519 P/N/M	500 V (10 mV)	3 mA	50 nA (5 nA zoom) (3)	50 V/s	5 mVpp (10 mVpp)
V6521 P/N/M	6 kV (0.1 V)	300 μA	5 nA (0.5 nA zoom) (3)	500 V/s	5 mVpp (10 mVpp)
V6521H P/N/M	6 kV (0.1 V)	20 μA	1 nA (0.05 nA zoom) (3)	500 V/s	5 mVpp (10 mVpp)
V6533 P/N/M	4 kV (0.1 V)	3 mA (9W max)	50 nA (5 nA zoom) (3)	500 V/s	10 mVpp (20 mVpp)
V6534 P/N/M	6 kV (0.1 V)	1 mA	20 nA (2 nA zoom) (3)	500 V/s	10 mVpp (25 mVpp)

(1) P: Positive, N: Negative, M: Mixed (3 ch Positive, 3 ch Negative). (2) Maximim Board Output Power: 25 W or 48W with A6580. (3) Optional.

VME Powered Crates and Controllers



VME8010/VME8011
Low Cost: 21 slot, VME64, integrated or removable Power Supply, integrated Fan Unit.

VME8100 series
Enhanced: 21 slot, VME64 or VME64X, removable Power Supply, removable smart Fan Unit, CAN bus, TCP/IP, RS232 and USB 2.0 control.



VME8004
Mini Crate: 2U, 4 slot, VME64.



VME8002
Mini Crate: 9 slot, VME64, integrated fan unit and removable power supply, CAN bus interface.



VME8001
Mini Crate: 1U, 2 slot, VME64.



V2718
VME-PCI Optical Link Bridge

A2818/A3818
VME PCI/PCle

V1718
VME-USB 2.0 Bridge

www.caen.it

Small details Great differences

Meet us at the following events:

IOP Nuclear and Particle Physics Divisional Conference
April 04 - 07, 2011

DIPAC2011 - 10th European Workshop on Beam Diagnostics and Instrumentation for Particle Accelerators
May 16 - 18, 2011

NSTAR2011 - The 8th International Workshop on the Physics of Excited Nucleons
May 17 - 20, 2011

RICAP 2011 - 3rd Roma International Conference on Astro-Particle physics
May 25 - 27, 2011