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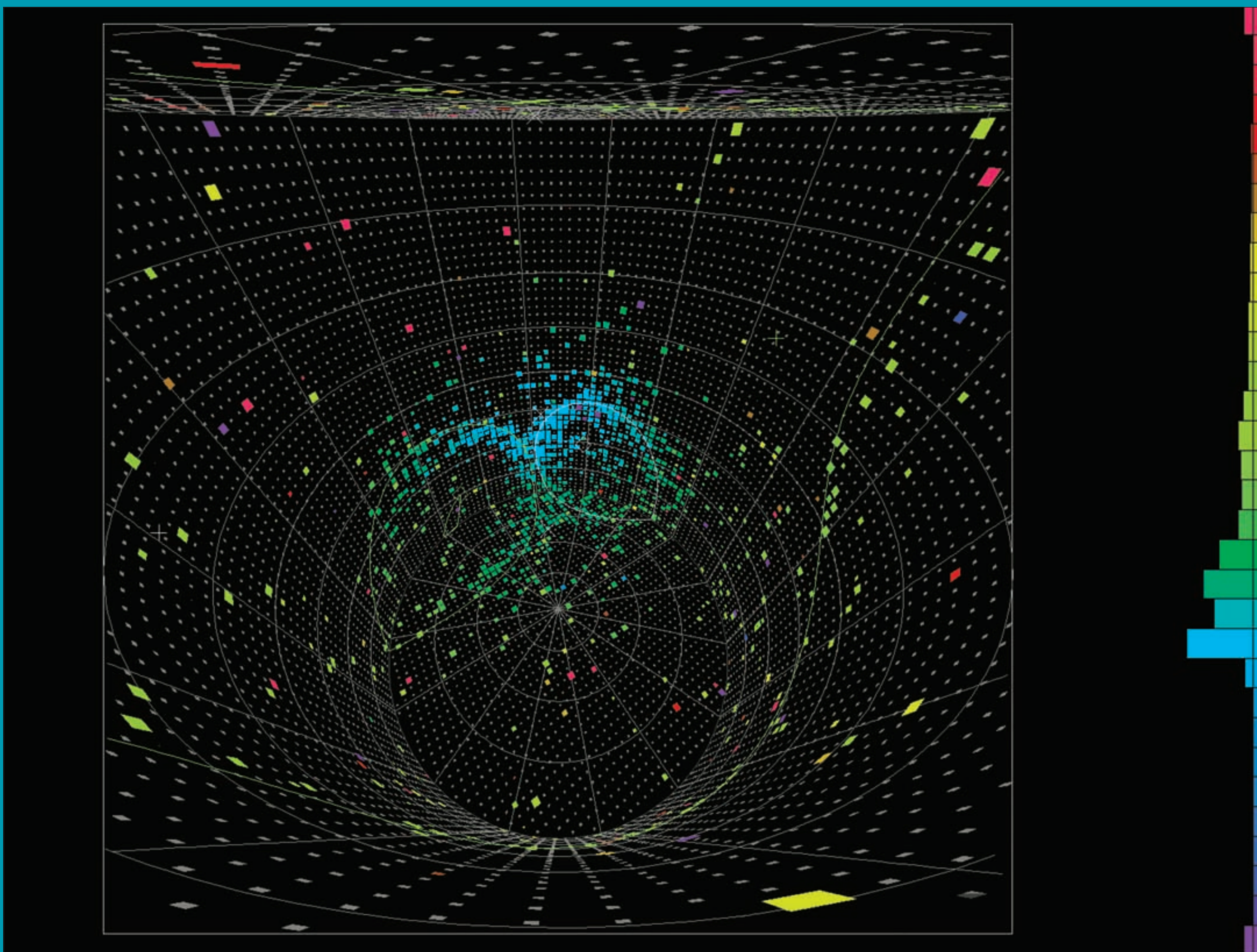

T2K sees first long-distance neutrino

NUCLEAR PHYSICS
Team at GSI traps a heavyweight p7

CONTROL SYSTEMS
The story behind the SPS touch screens p13

BOOKSHELF
From zeptospace to the mysterious universe p40

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

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CERN COURIER

VOLUME 50 NUMBER 3 APRIL 2010

A nobelium success p7

A forerunner to the iPod Touch? p13

A close friendship p27

Cover: The first T2K event in Super-Kamiokande, where the spots indicate the phototubes that have detected light (p8). (Courtesy Kamioka Observatory, ICRR (Institute for Cosmic Ray Research), the University of Tokyo and the T2K collaboration.)

ASTROPARTICLE PHYSICS

AMS begins journey to Florida

The Alpha Magnetic Spectrometer (AMS) left CERN on 12 February on the first leg of its journey to the International Space Station (ISS). The special convoy carrying the experiment arrived four days later at the European Space Agency's research and technology centre (ESTEC) in the Noordwijk region of the Netherlands, after a journey of 600 km. AMS will then fly to the Kennedy Space Center in Florida before lifting off aboard the space shuttle, probably in July.

With an 8.5-tonne load filled with superfluid helium, this was no ordinary shipment. The AMS detector was inserted into a support structure and surrounded by protective plastic foil before being placed in a box and loaded onto the special vehicle, which also carried a diesel generator running a pump to keep the helium at 2 K. Some 20 members of the AMS collaboration followed the detector on its journey.

The detector components of AMS were constructed by an international team with significant contributions from France, Germany, Italy, Portugal, Spain and Switzerland, as well as from China, China (Taipei) and the US. Assembly then took place at CERN with help from the laboratory's engineering services.

From 4–9 February, the detector was put through its paces using a test beam from the Super Proton Synchrotron (SPS). The AMS team used protons from the SPS to check the detector's momentum resolution. It also tested the detector's ability to distinguish electrons from protons. This is important for the measurement of cosmic rays, 90% of which are protons and constitute a natural background for other signals. The AMS collaboration will be looking for an abundance of positrons and electrons from space, one of the possible markers for dark matter.

A special convoy transporting AMS arrives at ESTEC in the Netherlands on 16 February in the afternoon, after the 600-km journey from CERN. (Courtesy ESA/Jari Mäkinen.)

The next step in testing has now moved to ESTEC, where ESA's thermovacuum room simulates the vacuum in space. Here the team will test the detector's capacity to exchange heat and thus maintain its thermal balance. This is essential to the functioning of the detector's electronics and superconducting magnet, the first of its kind to be launched into space. If all goes well, towards the end of May the detector will embark on a journey to NASA's Kennedy Space Center aboard a C5 aircraft owned by the US Air Force. There, it will board the last-but-one flight of the space shuttle *Discovery* (mission STS-134). Lift-off is scheduled for July.

Once docked to the ISS, AMS will examine fundamental issues about matter and the origin and structure of the universe directly from space. Its central aim is to search for dark matter and antimatter. Its data will be transmitted from the ISS to Houston and on to the detector control centre at CERN, as well as to a number of regional physics-analysis centres that have been set up by the collaborating institutes.

Sommaire

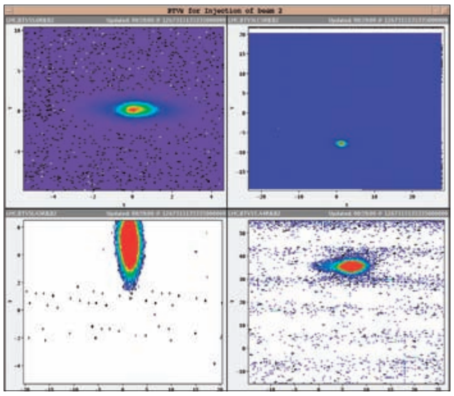
LHC NEWS

Beam returns for the start of the longest run

In the early hours of 28 February, beam was circulating again in the LHC at the start of operations that are scheduled to continue for the next 18 to 24 months. The objective is to deliver 1 fb^{-1} of data to the experiments at 7 TeV in the centre of mass, so providing enough data to make significant advances across a range of physics channels.

This restart followed a break of several weeks during which LHC teams carried out essential work to ensure the correct functioning of the magnets at high current. They verified several thousand channels of the new quench-protection system (nQPS) and measured precisely the resistance of the 10 000 splices connecting the magnets, finding no unacceptably anomalous values.

Once work on the nQPS had been completed, it was the turn of the hardware-commissioning team to test the main dipoles and quadrupoles of the LHC up to a current of 6 kA. This will allow proton collisions at 7 TeV in the centre of mass during the coming run. After completing these tests the hardware-commissioning team handed over to the operations team.



The first beam shot of Beam 2 in the LHC, early on the morning of 28 February.

Their initial operations centred on tests without beam to verify the correct functioning of all of the machine systems in unison. Late on 27 February the LHC was ready to receive beam again, and by just after 4.00 a.m., protons had circulated in each direction round the machine. For the operations team this was the beginning of a period of optimization at the injection energy of 450 GeV, investigating parameters associated with beam injection, collimation and the beam-abort systems etc., as well as studies to improve the beam lifetime. The first ramps – without beam – were made on the evening of 9 March to an energy of 1.18 TeV, the highest level that was achieved in 2009. Ramps to 3.5 TeV per beam are scheduled for later in March, with collisions planned for the end of the month.

● For the latest LHC news see, www.cern.ch/bulletin, as well as www.cern.ch and www.twitter.com/cern.

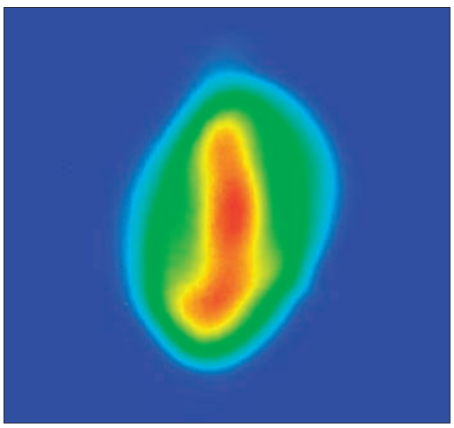
LIGHT SOURCES

ALBA's booster accelerator in operational test

The first operational tests of the booster accelerator for the ALBA synchrotron light source in Barcelona took place in January. The results show that all of the components, subsystems and equipment perform according to specification. This was the main objective of the tests, which were performed over a short period so as not to interfere excessively with the installation of the storage ring and the beamlines.

ALBA is a third-generation synchrotron light-source facility co-financed by the Catalan and Spanish governments, which is now in its last phase of construction at Cerdanyola del Vallès, Barcelona (*CERN Courier* November 2008 p31). The facility, which is being constructed and operated by the CELLS consortium, will provide synchrotron light of world-class quality (brilliance) for research in a range of scientific disciplines.

The facility consists of three accelerators – the linac, booster and storage ring – and seven beamlines (in the initial phase). The linac creates the electron beam and accelerates it up to 100 MeV. The beam is then injected into the second accelerator, the booster, where the energy increases to 3 GeV. This is the critical part of the accelerator chain. Ultimately, the beam will be injected into the storage ring and stored to produce synchrotron light.



Beam in the linac-to-booster transfer line just before the booster. (Courtesy ALBA.)

The operational test of the booster began on 21 December 2009, when beam was transported from the linac to the booster for the first time. After a Christmas shut-down, tests recommenced on 11 January and on the following day, beam made the first turns round the machine – and produced the first synchrotron light seen in Spain. On 19 January the ALBA team was able to accelerate the beam to 600 MeV and two days later they achieved 2.7 GeV with a circulating beam of 0.7 mA. The two-week test finished on 24 January to allow for further installation work.

ALBA's booster was completely designed, assembled and tested by the ALBA team, making it the first high-energy accelerator built in Spain. With its design, it also has the smallest emittance (beam size) in the world for an accelerator of its kind. The next milestones will be the operation of the storage ring, in the autumn, followed by the operation of the complete facility, expected for the beginning of 2011.

NUCLEAR PHYSICS

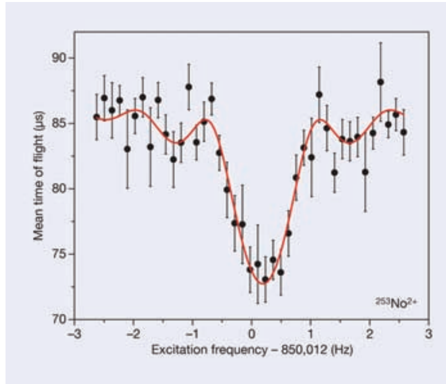
GSI team first to trap superheavy element

An international team of researchers at GSI Darmstadt has successfully contained atoms of nobelium (atomic number 102) in an ion trap. This is the first time that a superheavy element has been trapped. It allowed the team to measure the mass of three isotopes of the element with unprecedented accuracy.

The measurements took place in the SHIPTRAP facility at GSI, which combines an ion trap with the Separator for Heavy Ion reaction Products (SHIP) – a velocity filter that has already been used in the discovery of six superheavy elements at GSI. SHIPTRAP consists of a stopping cell, an RFQ buncher and a double Penning trap system inside a 7 T superconducting magnet. The cell of high-purity helium stops and thermalizes radioactive nuclei, which SHIP delivers at energies of a few 100 keV/u. The stopped ions are extracted into the RFQ structure where they are cooled, accumulated, and bunched. The ions then enter the first Penning trap, where they are selected according to mass by a buffer-gas cooling technique with resolving power of about 50 000. Finally, a purified sample of ions is injected into the second Penning trap where their mass is determined precisely via their cyclotron frequency.

The nobelium ions were produced in fusion reactions of a beam of ^{60}Ca and a target of lead foil ($^{206-208}$Pb). They were then separated out from the beam in the SHIP velocity filter, passing at a rate of less than one ion per second (in the case of ^{252}No) into the stopping cell. The decelerated ions were extracted into the RFQ within a few milliseconds and then injected in pulses into SHIPTRAP's double Penning trap system.

Michael Block, head of the research team, sets up the ion trap SHIPTRAP at GSI, which uses a double Penning trap system. (Courtesy G Otto/GSI.)



Cyclotron resonance curve for ^{253}No^{2+}. The solid line is a fit of the theoretical line shape to the experimental data (filled black circles). (Block et al. 2010.)

By directly comparing the cyclotron frequency of the nobelium ions in SHIPTRAP with the frequency of precisely known reference ions, the research team was able to determine the masses of the nobelium isotopes $^{252-254}$No to uncertainties of about 10 keV/c^2 – a relative precision of 0.05 ppm (Block *et al.* 2010). ^{254}No is now the heaviest radionuclide to have its mass measured directly and ^{252}No is the lowest-production-rate radionuclide whose mass has been measured with a Penning trap.

These mass values provide new, accurate reference points in the region of superheavy elements. The technique also holds promise for identifying elements on the way to the predicted "island of stability". One of the next goals of SHIPTRAP is to extend these accurate mass measurements to the transactinide region, starting with long-lived rutherfordium isotopes that terminate decay chains originating from $Z = 116$.

- Element 112, first observed at GSI in 1996, now officially carries the name copernicium and the chemical symbol Cn, after approval by the International Union of Pure and Applied Chemistry (IUPAC). The name honours scientist and astronomer Nicolaus Copernicus (*CERN Courier* September 2009 p7). The discoverers had suggested Cp as the symbol, but as this abbreviation has other scientific meanings, they agreed with IUPAC on Cn. Copernicium is the heaviest element officially recognized by IUPAC.

Further reading

M Block *et al.* 2010 *Nature* **463** 785.

ANTIMATTER

STAR finds heaviest antinucleus

Studies of high-energy collisions of gold ions by the STAR collaboration at the Relativistic Heavy Ion Collider (RHIC), Brookhaven, have revealed evidence of the most massive antinucleus to date. The new antinucleus is an antihypertriton – a negatively charged state containing an antiproton, an antineutron and a $\bar{\Lambda}$. It is also the first antinucleus containing a strange antiquark.

The new state is related to antihelium-3, with the $\bar{\Lambda}$ replacing one of the neutrons. The STAR team identified it via its decay into antihelium-3 and a positive pion. Altogether, in an analysis of hundred million collisions, they found 70 ± 17 antihypertritons and 157 ± 30 hypertritons (consisting of pnΛ).

In heavy-ion collisions only a tiny fraction of the emitted fragments are light nuclei, but these states are of fundamental interest. The STAR team finds that the measured yields of hypertritons (antihypertritons) and helium-3 (antihelium-3) are similar. This suggests an equilibrium in the populations of up, down, and strange quarks and antiquarks, contrary to what is observed at lower collision energies.

Further reading

B I Abelev *et al.* (STAR Collaboration) *Science*. DOI: 10.1126/science.1183980.

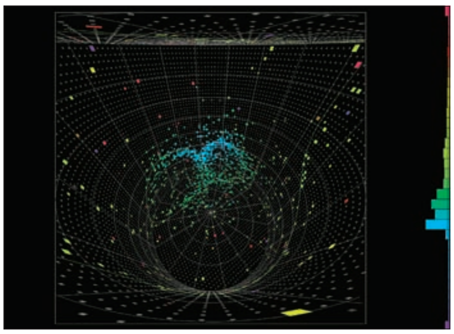
NEUTRINOS

Super-Kamiokande sees first T2K event

The international Tokai-to-Kamioka (T2K) collaboration announced the first detection of a long-distance neutrino in the Super-Kamiokande detector on 24 February. The neutrino had travelled 295 km under the Earth's surface from the beamline at the Japan Proton Accelerator Research Complex (J-PARC) in Tokai, north of Tokyo, to the gigantic Super-Kamiokande underground detector in an old mine near the west coast of Japan.

The T2K experiment uses a high-intensity proton beam at J-PARC in Tokai to generate neutrinos that travel to the 50 kt water Cherenkov detector, Super-Kamiokande (*CERN Courier* July/August 2008 p19). The experiment follows in the footsteps of KEK-to-Kamioka (K2K), which generated muon neutrinos at the 12 GeV proton synchrotron at KEK. With the beam generated at the J-PARC facility, T2K will have a muon-neutrino beam 100 times more intense than in K2K.

The experiment has been built to make high-precision measurements of known neutrino oscillations, and to look for the so-far unobserved type of oscillation that would cause a small fraction of the muon-neutrinos produced at J-PARC to become electron-neutrinos by the time they reach Super-Kamiokande.



The first T2K event in Super-Kamiokande: the spots indicate the phototubes that have detected light. The two circles of hits indicate that a neutrino interaction has probably produced a π^0, perfectly in time with the arrival of a pulse of neutrinos from J-PARC. Another faint circle surrounding the viewpoint of this image shows that a third particle was created in the interaction. (Courtesy T2K.)

COLLABORATION

Romania takes first steps to join CERN

On 11 February the Romanian minister of education, research, youth and sport, Daniel Petru Funeriu, and CERN's director-general, Rolf Heuer, signed an agreement that formally recognizes Romania as a candidate for accession to membership of CERN.

Romania's pre-membership will cover a five-year period during which the country's contributions will increase to normal member-state levels, in parallel with Romania's participation in CERN projects. At the end of this five-year period CERN Council will decide on Romania's application for full membership, as the organization's 21st member state.

Romania entered into direct collaboration with CERN in the early 1990s. In recent years the country has constantly increased its expenditure on R&D, in particular since the country's accession to the EU in January 2007. Romania is involved in three LHC experiments: ATLAS, ALICE and LHCb. It also contributes to the DIRAC and ISOLDE programmes and to Grid computing.

Romanian minister Daniel Petru Funeriu (left) and CERN's director-general Rolf Heuer.

CERN and JINR sign new agreement

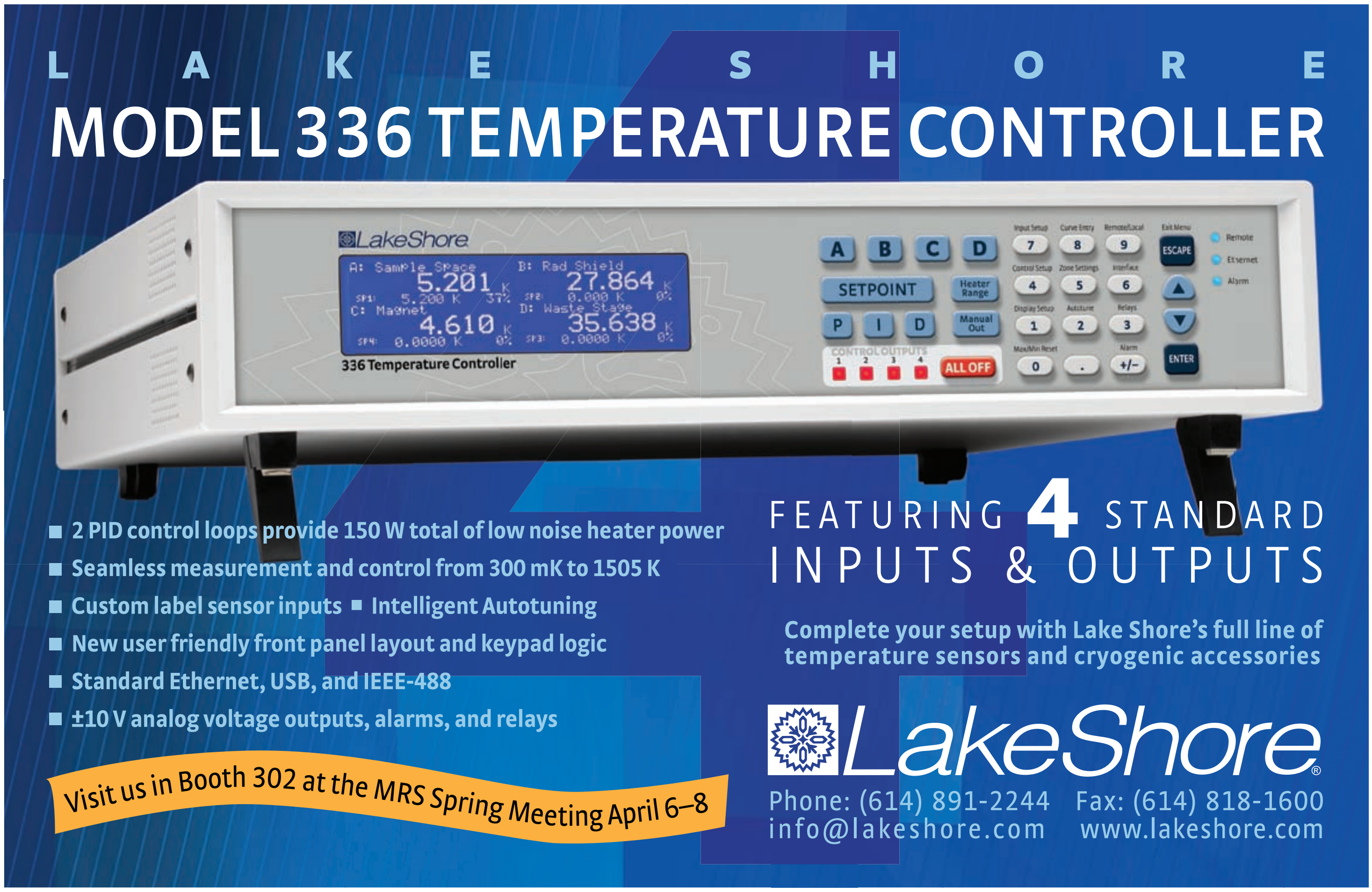
CERN and JINR have a long and successful history of collaboration – the first informal meeting on international co-operation in the field of high-energy accelerators took place at CERN in 1959 – and both provided a bridge between East and West for decades. In 1992 they signed a co-operation agreement that included an important number of protocols covering JINR's participation in the construction of the LHC and the ALICE, ATLAS and CMS detectors, as well as in information technology. JINR has also made valuable contributions to smaller experiments at CERN.

Now that the major obligations undertaken by JINR for the construction of the LHC and its experiments have been met, CERN and JINR have decided to continue and reinforce their co-operation in the fields of particle physics, accelerator physics and technologies, educational programmes and the development of administrative and financial tools, mutually contributing to the scientific programmes of both laboratories. On 28 January, JINR's director Alexei Sissakian and CERN's director-general, Rolf Heuer, signed a new enlarged agreement to continue and enhance their co-operation in the field of high-energy physics.

JINR's director Alexei Sissakian (right) shakes hands with CERN's director-general Rolf Heuer.

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 your proposal to the editor at cern.courier@cern.ch.**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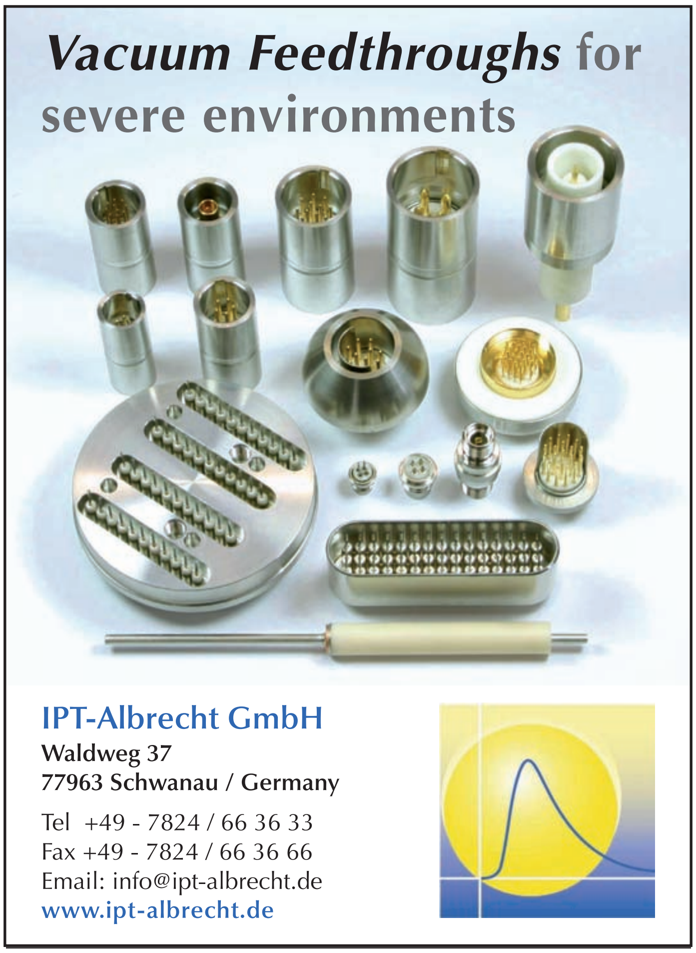
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SCIENCEWATCH

Compiled by John Swain, Northeastern University

Photosynthesis exhibits quantum coherence

Common wisdom has it that quantum effects should not be relevant for biology because the systems involved are too warm and noisy for coherence to be maintained. Now Elisabetta Collini of the University of Toronto in Canada and colleagues have used two-dimensional photon-echo spectroscopy to study the light-harvesting protein "antennae" that make up part of the photosynthetic apparatus of some species of algae.

These antennae contain eight pigment molecules, two of which can be optically excited into a superposition of energy states that couple coherently to the other pigment molecules. This allows the system to rapidly compute how best to direct the energy flow across the protein. The coherent energy transfer requires that coherence be maintained for 400 fs – which may not sound much but is far longer than would be naively expected for such a complex molecule at room temperature.

In a sense, it turns out that nature has already implemented room-temperature quantum computing in plants.

Further reading

Elisabetta Collini *et al.* 2010 *Nature* **463** 644.

Dinosaur feathers show their colours

Research over recent years has made it increasingly clear that dinosaur fossils contain significant amounts of relatively well preserved organic material, in addition to the more obvious mineralized bone. Michael Benton of the University of Bristol and colleagues have now managed to determine some of the colours of the feathers of dinosaur *Sinosauropteryx*, using 125-million-year-old fossils from the Jehol formation in the Liaoning province in China.

The team identified two types of colour-bearing orgenelles – eumelanosomes and phaeomelanosomes – which strongly suggest that the striped tail of the metre-long beast originally had reddish-brown stripes alternating with lighter stripes. These lighter ones might, with less certainty, have been white. The role that this pigmentation played in the life of these dinosaurs is still not known.

Fossil of Sinosauropteryx *showing tufts of simple filaments along the back of the head, the back and the tail. The darker bands on the tail were reddish in colour. (Courtesy the Nanjing Institute.)*

Further reading

F Zhang *et al.* 2010 *Nature* **463** 1075.

Spider webs collect water vapour

Most people think of spider webs as passive things but Yongmei Zheng of the Beijing University of Aeronautics and Astronautics and colleagues have shown that the webs of the *Uloborus walckenaerius* spider respond dynamically to water for efficient collection.

Exposure to water vapour makes the hydrophilic web fibres restructure into spindle-knots separated by elongated joints. Water collects everywhere, but that which collects on the joints moves toward the knots, driven by a surface-energy gradient between water on the smooth joints and rougher knots. The roughness arises from the different arrangements of nanofibrils – something that the researchers reproduced in artificial fibres. The work could have important applications in collecting water and controlling chemical reactions using similar flows.

Further reading

Yongmei Zheng *et al.* 2010 *Nature* **463** 640.

Faster transistors

Graphene – a substance made of a monatomic layer of carbon atoms – is about as thin as any material can be and now it has been made into fast transistors. Yu-Ming Lin and colleagues at the IBM T J Watson Research Center in the US used wafer-scale synthesis and fabrication techniques to make field-effect transistors that work at up to 100 GHz. This is the highest cut-off frequency for any graphene device and is twice the speed of current silicon transistors.

Further reading

Y-M Lin *et al.* 2010 *Science* **237** 662.

New route to radiation damage

Researchers have identified a new mechanism that could play a significant role in how radiation damages living tissue. Two groups – T Jahnke of the University of Frankfurt and colleagues and Melanie Mucke of the Max-Planck Institute for Plasma Physics and colleagues – have observed a new source of low-energy, biologically damaging electrons arising from intermolecular Coulomb decay.

This three-step process starts when an inner-valence electron is knocked loose from a pair of hydrogen-bonded water molecules. When a higher-energy electron drops down to fill the vacated space, the energy released knocks another electron out of the other water molecule. The two water molecules, now both positively charged, fly apart. Despite the complexity of the process, it appears to be responsible for a significant number of low-energy electrons, which can be damaging to DNA despite having energies below 20 eV.

Further reading

T Jahnke *et al.* 2010 *Nature Physics* **6** 139.

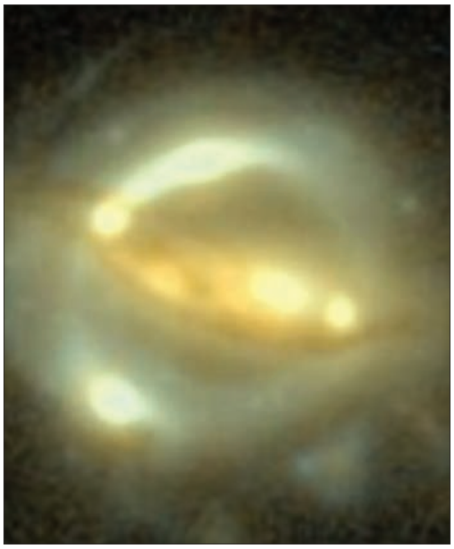
M Mucke *et al.* 2010 *Nature Physics* **6** 143.

Compiled by Marc Türler, ISDC and Observatory of Geneva University

Gravitational lensing constrains cosmology

When two sources at various distances happen to be aligned on the line of sight, the gravitational field of the nearer galaxy distorts the image of the distant galaxy into multiple arc-shaped images (*CERN Courier* April 2008 p11). The distortion can even form a complete ring if the alignment is perfect and the lensing galaxy has an almost spherical shape. This effect is called an "Einstein ring" because the image distortion results from bending of the light path by the curvature of space–time around the lensing galaxy, as predicted by Albert Einstein's theory of general relativity.

Gravitational lensing has proved a powerful tool to detect Earth-like extrasolar planets, measure the distribution of dark matter and discover the most distant galaxies (*CERN Courier* March 2006 p12, January/February 2007 p11, April 2008 p11). Now, Sherry Suyu of the Argelander Institute for Astronomy in Bonn and an international team of collaborators have demonstrated with a detailed study of the gravitational lens B1608+656 that gravitational lensing can also measure the age and composition of the universe with an accuracy that is comparable to other methods (Suyu *et al.* 2010). The study is based on work published a year ago and on radio-monitoring observations taken between 1996 and 2000 (Suyu *et al.* 2009, Fassnacht *et al.* 2002). The latter measurements by the Very Large Array in New Mexico allowed the determination of differences in the lengths of the bent light paths for each of the four apparent images of the background galaxy. These differences are inferred from the time delay of variations observed in each of the four views of the same lensed radio source located in the distant galaxy.



Hubble image of the gravitational lens B1608+656. In the centre is a pair of foreground galaxies that are gravitationally lensing a background galaxy, which appears as four bright spots circling the foreground galaxies. (Courtesy Sherry Suyu/Argelander Institut für Astronomie.)

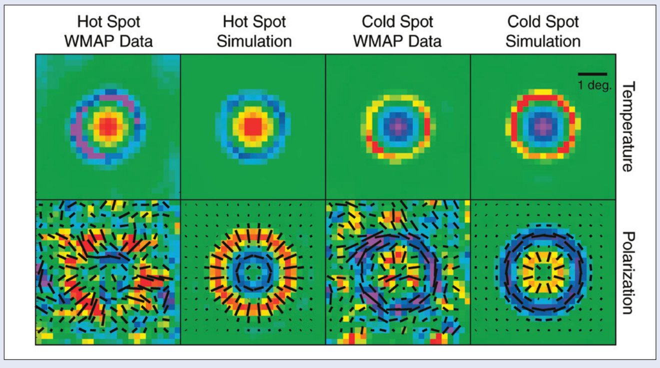
Apart from precise time-delay determinations, there is another difficulty to master before being able to derive accurate measurements of cosmological parameters by gravitational lensing: the modelling of the mass distribution of the lensing galaxy. This was particularly difficult in the case of B1608+656 because the lens is produced by a pair of galaxies, but it proved possible thanks to a high-resolution image taken by the Hubble Space Telescope. Finally, the team used a Bayesian statistical approach to develop a complete description of the lens by combining the Hubble image, stellar-velocity dispersion measurements and the time delays between the multiple images.

This detailed analysis of the gravitational lens B1608+656 over several years yields accurate determinations of cosmological parameters, especially when combined with constraints from the five-year measurements by the Wilkinson Microwave Anisotropy Probe and assuming a flat spatial geometry. The Hubble constant is determined to be $69.7 + 4.9/-5.0$ km s^{-1} Mpc^{-1} and the equation of state parameter to be $w = -0.94 + 0.17/-0.18$ (where $w = -1$ corresponds to a cosmological constant). These uncertainties are similar to those obtained with baryon acoustic oscillation data, showing that the gravitational-lens technique is now sufficiently mature to compete with other cosmological probes. In the near future, repeated surveys of the sky should detect several tens of suitable gravitational lenses for similar studies and hence further constrain cosmology through the careful analysis of the effects of space–time deformations.

Further reading

S M Suyu *et al.* 2010 *ApJ* **711** 201.
S M Suyu *et al.* 2009 *ApJ* **691** 277.
C D Fassnacht *et al.* 2002 *ApJ* **581** 823.

Picture of the month



This image illustrates the most interesting visual result from the seven-year release of observations from the Wilkinson Microwave Anisotropy Probe (WMAP). It compares stacked images of hot and cold spots in the cosmic microwave background (CMB) with simulations. The good match found both in temperature and polarization suggests that the spots are indeed caused by sound waves propagating in the early universe and leaving an imprint in the CMB when radiation and matter decoupled 380 000 years after the Big Bang. In general, the new data released on 26 January mainly confirm the previous results and reinforce the standard ΛCDM model with improved statistics (*CERN Courier* May 2008 p8). (Courtesy NASA/WMAP Science Team.)

CERN COURIER ARCHIVE: 1967

A look back to *CERN Courier* vol. 7, April 1967, compiled by Peggie Rimmer

COLLABORATION

Molecular-biology conference

The European Conference on Molecular Biology, convened and organized by the Swiss government, was held at CERN from 4 to 6 April, under the presidency of Mr Olivier Reverdin (Switzerland). Representatives from 16 countries (the 13 Member States and the three Observer States of CERN) attended the conference and eight international organizations also sent observers.

During the opening session, Mr Willy Sprühler, Conseiller fédéral and Chef du Département politique suisse, gave the address of welcome. He said that he was convinced of the high interest of molecular biology not only for the scientists themselves but also for the whole of humanity. He defined molecular biology as "giving meaning to the phenomenon of Life at the level of molecules constituting living cells". He concluded by saying that the Swiss government had decided to call the conference to give those European countries who wished to make a combined effort in this field of fundamental research, the chance to review the situation and to examine the possibilities of co-operation.

Prof. Gregory, Director-General of CERN, said that the presence of representatives from the Member States and Observer States of CERN was a good augury for the success of the conference. The existence of the European Molecular Biology Organization (EMBO), set up by many of the leading molecular biologists in Europe, indicated the enthusiasm of the scientists to form an international organization. In molecular biology, as in other fields of science, it was vital to preserve research in the universities and to maintain the balance between research and teaching.

In conclusion, Prof. Gregory said that if the decision was taken to set up a European Laboratory for molecular biology there would be real value in placing it in the neighbourhood of CERN. Such a decision would be warmly welcomed by the European Organization for Nuclear Research.

During the conference, which was held in closed session, a broad exchange of views led to the conclusion that the states represented were conscious of the importance of molecular biology and of the desirability of fuller European co-operation in this field. The conference also recommended that the European governments ensure the continuation and development of EMBO. This organization was invited to pursue its studies into what might become a European Molecular Biology Laboratory, the creation of which EMBO had recommended.

A second European Conference on Molecular Biology will be held before the end of the year. In the meantime, a working group will prepare the draft of an appropriate structure for European co-operation.

● From the article on p70.

COMPILER'S NOTE

Today's iPod generation of physicists may be amused, possibly surprised, by the fact that CERN's central data-analysis computers used to arrive in large freight planes, took days if not weeks to set up, and had a reliability of 98.5%. This was deemed sufficient for analysing bubble chamber films – once dry. Trucks and trains transported some 1.5 million events a year from CERN to universities around Europe. If we assume 10 kB of digitized data per event (a guesstimate that could need correction) this is a bandwidth of around 1.5×10^{10} bytes each year.

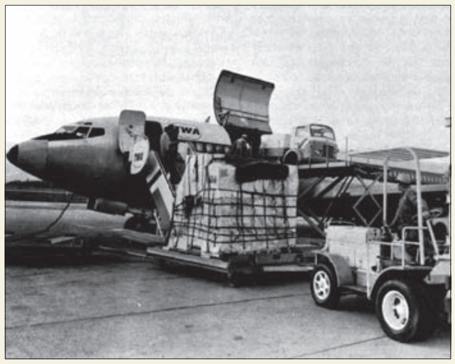
The LHC experiments, with their CPU farms and worldwide computing Grid, will deliver a million times more data – around 1.5×10^{16} bytes a year (15 petabytes) – from the so-called Tier 0 centre at CERN to a dozen Tier 1 academic institutions in Europe, Asia and North America, and from there to 170 Tier 2 centres in 34 countries. A million is a lot, and Europe is CERN's backyard, but I am still impressed by the throughput of those 1960s' tapes and delivery vans.

For the record, in 1971 Heidelberg was chosen as the site for the main European Molecular Biology Laboratory (EMBL); in 1973 a draft accord to establish the laboratory was signed in Geneva; and in 1974 it became a legal entity, with Sir John Kendrew as its first director-general.

CERN

Data handling: by freight and on film

The CDC 6400 computer arrived at Cointrin airport on 30 March. The main installation work at CERN was completed over the following few days and commissioning of the computer began on 3 April; this represented a gain of about two weeks over the original schedule. Prior to its dispatch from Minneapolis the 6400 was submitted to the stringent CERN reliability test and showed a reliability of 98.5%.

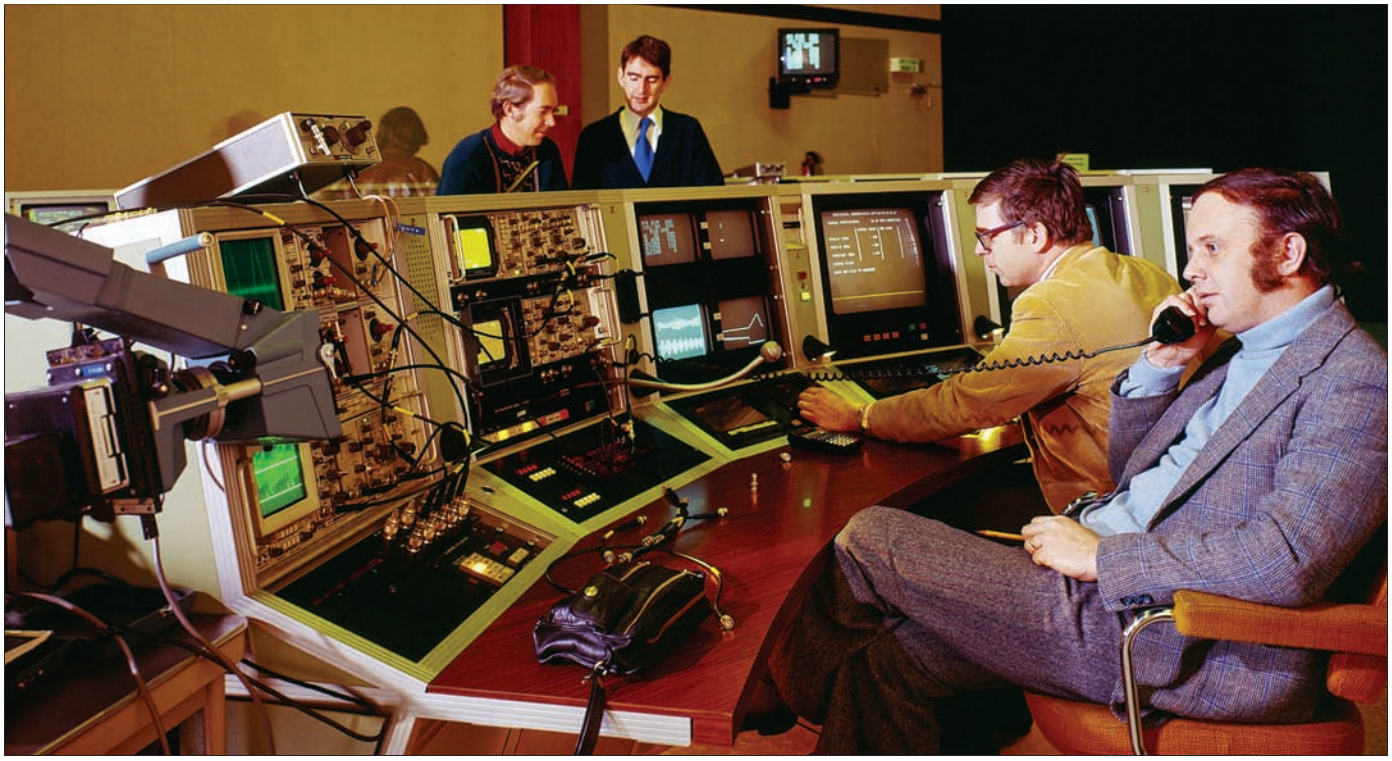


(Photo Interpresse.)

The picture below gives an idea of the volume of information coming from research with bubble chambers. The two hydrogen bubble chambers at CERN took 2 161 000 pictures in 1966: 1 423 000 of these went to universities throughout Europe for analysis.

A curtain of bubble chamber film; the films are being hung up to dry after processing.

● Photographs on p67 and p71.



The SPS control room in 1977. Ted Wilson and Rae Stiening are at the desk, with its touch screens; Bent Stumpe and George Shering stand behind.

The first capacitative touch screens at CERN

In 1976, mastering the controls of the new big accelerator – the SPS – required some creative thinking and led to the invention of what was probably the world's first capacitative touch screen, the forerunner to the screens on the latest handsets.

"The proton synchrotron currently being built by CERN (the SPS) will be controlled centrally from three control desks, each with its own minicomputer. Only a few knobs and switches must control all of the many thousands of digital and analogue parameters of the accelerator, and an operator will watch the machine on at most half-a-dozen displays ... An advantage of the new form of control is that since there are so few controls and displays, they may be made more elaborate and powerful."

Thus begins a CERN report written in May 1973 by Frank Beck and Bent Stumpe of the controls group (Beck and Stumpe 1973). It describes two devices: the touch screen and the computer-controlled knob. CERN's member states had approved the construction of the Super Proton Synchrotron (SPS) in February 1971. With its circumference of nearly 7 km, it was a giant machine for its day – some 10 times the size of the Proton Synchrotron (PS) that had started up in 1959. The scale of the new machine meant that control via individual cables linking directly to a central control room – as was done for the PS – would be economically unfeasible. One of the first tasks of the nascent SPS controls group, therefore, was to find a practical and economical solution.

The timing was just right for developing central control supported by computers. Industry was beginning to commercialize minicomputers, so the idea began to take shape of equipping sectors locally with minicomputers controlled by message transfer from the central control room. This would overcome the enormous requirement ▷

for cables. The next question was how to create an "intelligent" system based on minicomputers to replace the thousands of buttons, switches and oscilloscopes that a conventional control system would need for a machine as large as the SPS.

A human has only two hands, but if control devices could be redefined fast enough by computer, then only one button (or knob or pointing device) would be needed to do the job of controlling many different devices or parameters. The main uses of the "master button" would be to select accelerator subsystems for control and monitoring, as well as to select from hundreds of analogue signals the ones to show on displays at any one time. The minicomputers made by Norsk Data at the time seemed to be powerful enough for such a system.

Frank Beck, who was to become head of the SPS Central Controls, was aware of the possibilities offered by existing touch screen technology in which a panel of buttons with labels written by computer can be changed simply by touch to control different aspects of a system. By presenting successive choices that depend on previous decisions, the touch screen would make it possible for a single operator to access a large look-up table of controls using only a few buttons.

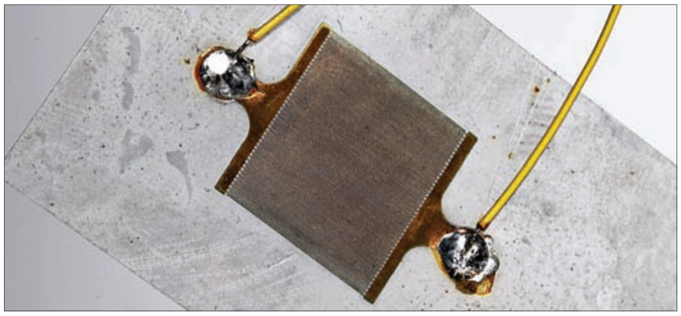
It was clear that the only practical way to create buttons with variable labels by computer at that time was on a cathode-ray tube (CRT) screen. The question then was how the computer could detect which button was being selected. The rather complicated mechanical designs that existed did not seem suitable for the SPS control system. For example, David Fryberger and Ralph Johnson at SLAC had invented a device based on acoustic waves – Rayleigh waves – travelling in the surface of a sheet of glass, which had already been used for accelerator control (Fryberger and Johnson 1971). This worked but required a bulky frame around the screen. Beck discussed this with his colleague Stumpe, from the Data Handling Division, and asked if he could suggest a better technical solution.

In a handwritten note dated 11 March 1972, Stumpe presented his proposed solution – a capacitative touch screen with a fixed number of programmable buttons presented on a display. It was extremely simple mechanically. The screen was to consist of a set of capacitors etched into a film of copper on a sheet of glass, each capacitor being constructed so that a nearby flat conductor, such as the surface of a finger, would increase the capacity by a significant amount. The capacitors were to consist of fine lines etched in copper on a sheet of glass – fine enough (80 μm) and sufficiently far apart (80 μm) to be invisible (*CERN Courier* April 1974 p117). In the final device, a simple lacquer coating prevented the fingers from actually touching the capacitors.

Stumpe was immediately recruited into the controls group to develop the necessary hardware and the first capacitor to prove that the idea worked was produced at CERN in 1973. Chick Nichols was able to use ion-sputtering equipment available in one of the workshops to evaporate a fine layer of copper or gold on a flexible, transparent Mylar sheet to make the first working device. A prototype glass screen with nine touch buttons followed soon after.

The fineness of the lines and their pitch meant that a great deal of care was needed to produce the screen, but it turned out to be possible with the techniques normally used to make printed circuit boards. At first, placing the copper layer on the glass appeared difficult and it proved impossible to get reliable adherence with vacuum deposition. However, ion sputtering gave better results. By ensuring that the glass was scrupulously clean and by depositing the copper slowly – an hour for a layer of about 10 μm – it was possible to get adherence strong enough to allow soldered connections to the glass.

A view of part of the PS control room in 1974, showing rows of individual units with many knobs, switches and oscilloscopes.



The prototype capacitor of a "touch button" developed at CERN in 1972.

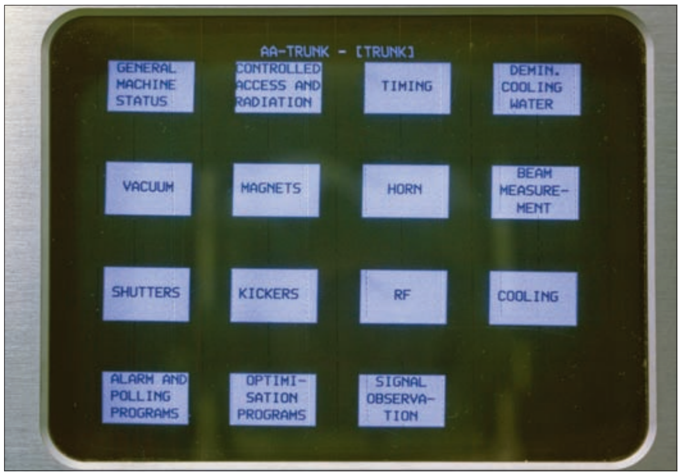
The capacitance of each button was about 200 pF, increasing by about 10% when a finger came close. The method chosen to detect the change in capacitance was to use a phase-locked oscillator circuit, which had recently become available as a single integrated-circuit chip. One circuit acted as a reference oscillator, while each button had a similar circuit. The oscillator attached to a button locked in to the frequency of the reference oscillator (120 kHz), so that a change in capacity altered the phase but not the frequency. The phase shift was converted to a voltage shift, which indicated that the button had been touched. The circuit was very immune to noise and transients. Moreover, any drifts would be common to both oscillators, so good thermal stability could be obtained with commercial components.

Into production

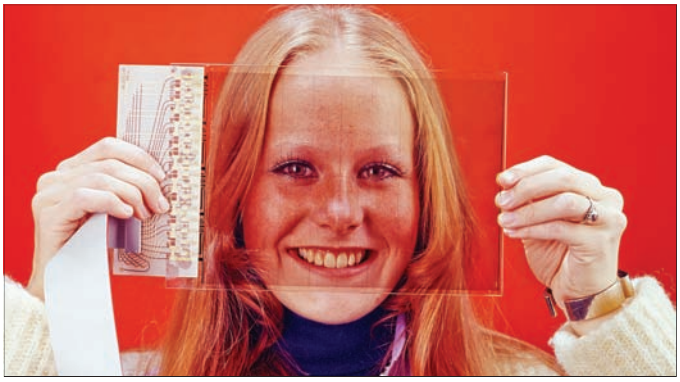
As soon as it was clear that the system could successfully recognize which of the nine buttons was touched, Beck showed the prototype to those in charge of the SPS project. Even before reliability tests had been performed, the decision was taken to use the touch-screen system and begin development of the control software on the first minicomputers (Nord 1, and later Nord 10) that CERN had received from Norsk Data. This was definitely a risk, but had the decision not been made then the control group would have had no option but to use conventional technology for central control of the SPS. Tests later proved the reliability of the technique.

The next step was the development of a more practical touch screen with 16 buttons. The new central SPS control room needed several devices and industry was soon involved. Manufacturing of

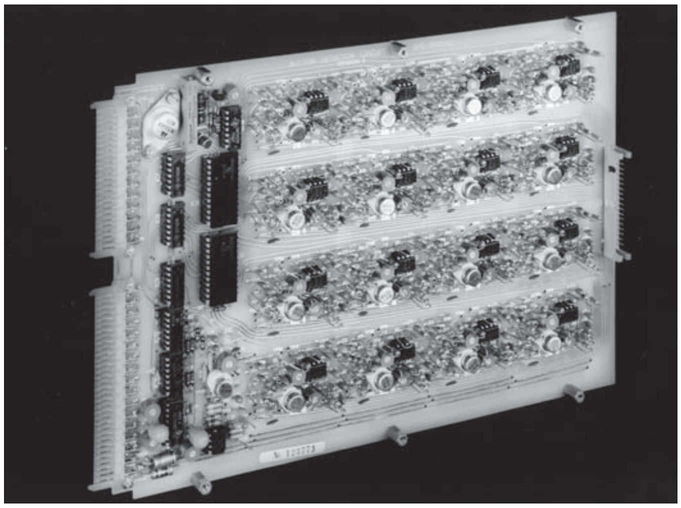
The Touch Terminal as developed for the Antiproton Accumulator (AA).



A close-up of the screen-based controls of the Touch Terminal for the AA.



The transparent capacitative touch screen, with its invisible capacitors formed from fine lines of copper on glass.



The circuit board for the 16-channel touch screen.

the touch screen itself proceeded in collaboration with a Danish company, Ferroperm. This led to the development of a robust glass screen with reduced surface reflections. At the same time another Danish company, NESELCO, became involved in producing the electronic modules needed to drive the touch screen.

When the SPS started up in 1976 its control room was fully equipped with touch screens – apparently the first application of the capacitative touch screen in the world. Touch screens later took their place in modernized control systems for the PS, which had preceded the SPS by nearly 20 years, as well as for the subsequent and much bigger Large Electron Positron collider. Some of these screens continued to operate until the new CERN Control Centre took over operations in 2006 – a lifetime of 30 years.

In 1977 CERN demonstrated the potential of the new touch screen for industrial control in no lesser a place than the huge and famous Hanover Fair. In the hall for new industrial inventions, CERN presented the "Drinkomat", with a complete operational console similar to the one used to control the SPS, including a Nord 10 computer. The system was built by Alain Guiard, who at the time was using a touch screen to control a large film-development installation at CERN, which allowed exact control of the liquids used in the process. Through multiple choices on a touch screen, the Drinkomat allowed people to mix drinks and follow the process visually, foreshadowing the machines that came into CERN's cafeterias nearly 30 years later.

By 1977 the capacitative touch screen was already available commercially and being sold to other users within CERN and to other research institutes and companies wishing to use the screens in their own control systems (Crowley-Milling 1977). Its use spread around the world: JET and the Rutherford Laboratory in the UK; KEK, Mitsubishi and the TOYO corporation in Japan; the Rigshospitalet in Denmark and the Hahn-Meitner Institute in Germany.

One reason behind the success of the system was a decision at CERN to build electronic modules in the CAMAC system, used not only all over CERN but throughout the world. This made it easy for users to buy individual modules for integration into their own systems. By 1980, more than 10 different CAMAC modules developed at CERN had been brought to the market by NESELCO. Furthermore, a CAMAC module with an integrated computer for driving the touch screen was developed in 1977, shortly followed by a CAMAC crate computer using the Motorola 68000 microprocessor. These modules were integrated into an intelligent "Touch Terminal", which was commercialized by NESELCO in 1980; it was the world's first commercial touch-screen computer.

At CERN the Touch Terminal was used for the control of the Anti- ▷

proton Accumulator, which allowed the SPS to become a proton–antiproton collider and gather fame for CERN through the discovery of the W and Z bosons and the subsequent awarding of the Nobel prize to Carlo Rubbia and Simon van der Meer.

The original touch screen had only 16 fixed "buttons" associated with distinct areas of the screen, but already in 1978 it was obvious that a more flexible arrangement for dividing up the screen would have many advantages. Stumpe developed his original concept to create an X–Y touch screen, in which the idea was to sense the position touched via two layers of capacitors corresponding to X and Y co-ordinates. Following prototype work at CERN, development began with NESELCO and the University of Aarhus, supported by the Danish state development funds. The X–Y screen involved new techniques for metallization on various substrates, which became the subject of patent rights. Stumpe was asked to sign a nondisclosure agreement, which he refused to do because CERN required that all inventions should be published. At this point, CERN's involvement with the further development of touch screens came to an end.

The new CERN Control Centre (CCC), which oversees the control of CERN's entire accelerator complex, including the PS, SPS and now the LHC, has no touch screens for accelerator control. Today the use of the ubiquitous mouse as a pointing device provides the same type of computer control. Moreover, PC-based systems with standard displays are inexpensive and easy to install. In 1972, when the touch screen was developed at CERN for controlling the new SPS, the situation was different: nothing was commercially available and every control device had to be invented, including the colour displays.

However, touch screens are undoubtedly not absent from the CCC, as the operators often communicate with colleagues by mobile phones with capacitative touch screens. The idea invented at CERN in 1972 has been reinvented in many applications, from "Drinkomats" to rail and airline ticket machines to the multifunction phones that sit in many pockets – not only in the CCC but all around the world.

Further reading

F Beck and B Stumpe 1973 *CERN* 73-6.
Michael Crowley-Milling 1977 *New Scientist* ***75*** 29 September 790.
D Fryberger and R Johnson 1971 *Nuclear Science IEEE Transactions* **18** 414.

Résumé

Les premiers écrans tactiles capacitifs au CERN

Au début des années 1970, du fait des dimensions du nouvel accélérateur du CERN – le Supersynchrotron à protons (SPS) – il a fallu faire preuve d'ingéniosité pour permettre un contrôle centralisé à partir d'un dispositif simple. C'est ainsi qu'a été inventé le premier écran tactile capacitif, en mars 1972. Lorsque le SPS a démarré en 1976, toute sa salle de contrôle était équipée d'écrans tactiles. Un an plus tard, ces écrans étaient mis sur le marché et vendus à d'autres instituts et entreprises dans le monde. Aujourd'hui, le centre de contrôle qui dirige l'ensemble des accélérateurs du CERN ne dispose d'aucun écran tactile destiné au contrôle des accélérateurs. Toutefois, cette technologie reste présente dans de nombreuses applications, et notamment les téléphones portables.

Bent Stumpe *and* **Christine Sutton**, *CERN.*

Creativity and intellect: when great minds meet

Writer and science historian **Arthur I Miller** talks about his interdisciplinary approach to the creative process, which underlies his recent book on Pauli and Jung.

At the City College of New York, Arthur I Miller took large doses of philosophy in addition to physics. This was the start of a path that would lead him to become a well known historian of science and acclaimed author. He earned a PhD in physics at the Massachusetts Institute of Technology and went on to do research in theoretical particle physics. He soon became fascinated with the history of ideas and the role of visual thinking in highly creative research.

Arthur I Miller, writer, science historian and former particle physicist. (Courtesy L Miller.)

In 1991 Miller moved to England where he became professor of history and philosophy of science at University College London. Three years later he founded the Department of Science and Technology Studies, which grew out of the original Department of History and Philosophy of Science. He has lectured and written extensively about his research into the history and philosophy of 19th- and 20th-century science and technology, as well as about cognitive science, scientific creativity and the relationship between art and science.

He is the author not only of academic books but also of several widely acclaimed books meant for a wider audience, including *Einstein, Picasso: space, time and the beauty that causes havoc* (2001), nominated for the Pulitzer Prize, and *Empire of the Stars: friendship, obsession and betrayal in the quest for black holes* (2005). In December he visited CERN to give a colloquium on his latest book, *Deciphering the Cosmic Number: the strange friendship of Wolfgang Pauli and Carl Jung* (2009).

When did your interest in interdisciplinary studies start?

Even though physics was what I focused on at university, my passion has always been those pesky "what is the nature of" questions, such as "what is the nature of charge, of mass, of space, of time, of the mind, and so on". I wanted to understand how scientists made discoveries and how the mind works. Looking into the original German-language papers written by giants of 20th-century physics such as Albert Einstein, Niels Bohr, Werner Heisenberg and Wolfgang Pauli, I came to understand the important role of visual imagery in scientific discovery. I decided to look into this further. I became curious as to how images were generated and stored in the mind, to be called out and used in thinking. I turned to cognitive science, which gave me the means to structure my ideas. This led to my investigation into concepts such as aesthetics, beauty, intuition and symmetry, and how they are used in science and art.

What intrigued you about the lives of Albert Einstein and Pablo Picasso?

The most important scientist of the 20th century, Albert Einstein, and its most important artist, Pablo Picasso, went through their period of greatest creativity and achievements around the same time, and in similar circumstances. In 1905 Einstein discovered his theory of relativity and in 1907 Picasso discovered *Les Demoiselles d'Avignon*, the painting that brought art into the 20th century and that contains the seeds of cubism. Even though they did not know about each other, they were both – each in his own way – identifying connections across the so-called "two cultures" of science and art, and striving to find a solution to the question of how to represent the nature of space and time in a more satisfying manner.

At the beginning of the 20th century, it was in the air that revolutionary changes were about to occur in many fields. Yet some of the greatest thinkers of the period bucked this tide. The great French philosopher-scientist Henri Poincaré was one of them. To my surprise, he turned out to be a common denominator between Einstein and Picasso. Both men were inspired by his book, *Science and Hypothesis*. Poincaré failed because he was unable to rid himself of the notion that time was an absolute and not a relative quantity. Just the opposite of what Einstein found when he combined space and time into a single continuum – space–time – and what Picasso did in his cubism, when he represented multiple perspectives all at once on a single canvas. Einstein studied temporal simultaneity, Picasso spatial simultaneity.

Is there a relationship between historical periods and people's achievements?

Definitely. At that time, people were responding, with different ▷

degrees of success, to the mysterious synchronous effects of the Zeitgeist – the avant-garde, the intellectual tidal wave that swept across Europe. In fact, it was not an accident that Einstein and Picasso worked on the same problem – the nature of space and time. It was the principal problem of the avant-garde. In 1902, two years after his graduation from the ETH, Einstein was employed at the Swiss Federal Patent Office, in Berne, and was out of the academic mainstream. Picasso, on the other hand, was in Paris, in the centre of things. Most scientists thought that Poincaré would make major breakthroughs in physics, although of a sort that supported the claims of Newtonian science regarding space and time. Most artists in Paris considered that André Derain, Henri Matisse's star student, was the one who would make the breakthrough to a radically new conceptual art.

Just as Poincaré could not break away from classical thought, Derain did not take seriously the dazzling developments in science, technology and mathematics. Only Picasso and Einstein were in resonance with the drum beat of the avant-garde. To accomplish their breakthroughs both men realized that they had to discover a new aesthetic: for Picasso it was the reduction of forms to geometry; for Einstein it was a minimalist aesthetic, which allowed him to remove "asymmetries that do not appear to be inherent in the phenomena", as he wrote in the first sentence of his 1905 relativity paper. At their creative moment boundaries between disciplines dissolved and aesthetics became paramount for both of them.

What criteria do you use to compare people in your books?

I look for parallelisms in the working and private lives of highly creative thinkers (Einstein and Picasso). Pairs in opposition are of interest to me in what they say about the human element in science (Chandrasekhar and Eddington) or in a situation in which each learns from the other (Pauli and Jung). For example, Pauli was able to understand the forces that drove his personal life as well as his creative verve. In fact, an important discovery of his – CPT symmetry – stemmed from a dream that he and Jung analysed using Jungian psychoanalysis. Jung learnt enough quantum physics from Pauli to bring to fruition one of his greatest ideas – synchronism.

What can you say about high creativity?

Highly creative researchers are not deterred by mistakes and failures. Rather, they learn from them and turn the situation to their advantage. J Robert Oppenheimer once gave a particularly interesting definition of an expert as "a person who has made all possible mistakes". Some other hallmarks of high creativity are that early in life the highly creative person realizes the field in which he or she is most competent and then mines it. They also exhibit an almost frighteningly focused mind when they work on a problem, to the exclusion of all else. Such was the case with Einstein and Picasso.

Is intuition part of creativity and the intellectual process?

I think that it is in both. There is nothing mysterious about intuition. It comes about mainly through an accumulation of knowledge. People can make an evaluation within a fraction of a second just because they have a lot of experience behind them. Having an intuition for what to do, solving a problem, judging a work of art, means having made a lot of errors and judgements along the way. Intuition is an achievement, albeit with a bit of the irrational mixed in – just like in scientific discovery. I think that there is not much difference between artistic thinking and scientific thinking, even if sometimes scientists want to appear less emotional and artists less rational.

Of course, an objective truth exists – on this every scientist would agree, even in this era of multiverses. There is a real external world "out there" beyond appearances and science is a way of getting a glimpse of it. Today, scientists have only begun to explore concepts like consciousness. One of the reasons I wrote my book about Jung and Pauli was to bring to everyone's attention the high level of their discussions about issues that spanned physics, psychology, biology, religion, ESP, UFOs and Armageddon. They realized that neither physics nor psychology alone could reply to such deep questions such as: "What is the nature of consciousness?" Only an interdisciplinary approach could succeed.

What can you say about interdisciplinary research today?

Beginning in about the 1980s it became evident that, for example, biology needed various forms of technology – and also mathematics and physics. The need for interdisciplinarity soon became evident for physics as well, especially with the advent of health physics, computing physics, nanotechnology and then developments in biology. Nevertheless, most universities maintain a departmental structure and consequently a lack of complete interdisciplinarity. Moreover, there are too many instances where students with a PhD in an interdisciplinary topic have problems in obtaining a job.

One of the stumbling blocks here is the need for a common language across different domains. This lack of communication makes people afraid of an outsider interfering in their field. When I was writing my book on Einstein and Picasso I found that, whereas in most cases artists were easy to deal with, not so for historians of art. Their post-modernistic jargon necessarily closes them off from an interdisciplinary approach. Most of them still consider Picasso's discovery of cubism to have been rooted in African art and the art of Cézanne, ignoring the essential role of science, technology and mathematics in his thinking. Picasso's stunning discovery of cubism formalized the formerly informal language of art and brought it back into contact with science, where it has been ever since.

● For the video of the colloquium by Arthur I Miller, "The strange friendship of Pauli and Jung – when physics met philosophy", see http://indico.cern.ch/conferenceDisplay.py?confId=72258.

Résumé

Créativité et intellect : les grands esprits se rencontrent.

Arthur I Miller, après avoir commencé dans la recherche en physique des particules théorique, s'est très rapidement passionné pour l'histoire des idées et le rôle de la « pensée visuelle » dans la création scientifique. Depuis lors, il a réalisé de nombreuses recherches sur l'histoire et la philosophie des sciences et des techniques des XIX^{e} et XX^{e} siècles, ainsi que sur la science cognitive, la créativité scientifique et la relation entre art et science. Il a aussi écrit plusieurs livres très bien accueillis sur les liens entre différents créateurs. Ici, il nous parle de son approche interdisciplinaire du processus créatif, illustrée par ses ouvrages sur Einstein et Picasso, Chandrasekhar et Eddington, et Pauli et Jung.

Beatrice Bressan, *CERN.*

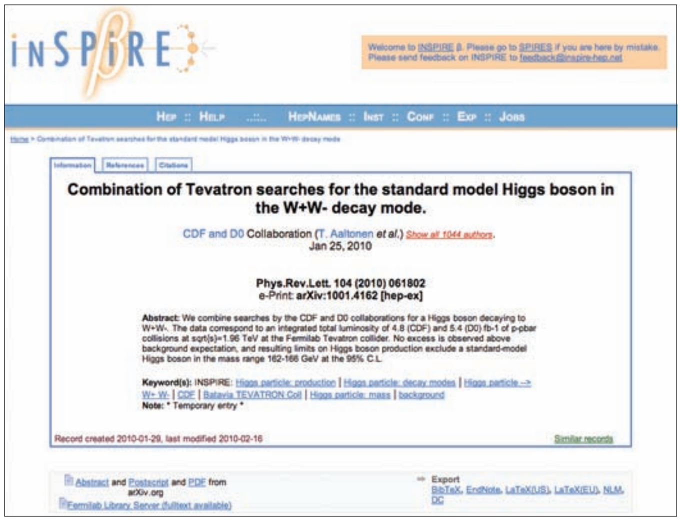
Particle physics INSPIREs information retrieval

Specialists at CERN, DESY, Fermilab and SLAC, working in close collaboration with arXiv, the Particle Data Group and publishers within the field of particle physics, have developed INSPIRE, a new service to provide state-of-the-art information management.

Particle physicists thrive on information. They first create information by performing experiments or elaborating theoretical conjectures. Then they convey it to their peers by writing papers that are disseminated in a preprint form long before publication. Keeping track of this information has long been the task of libraries at the larger laboratories, such as at CERN, DESY, Fermilab and SLAC, as well as being the focus of indispensable services including arXiv and those of the Particle Data Group.

It is household knowledge that the web was born at CERN, and every particle physicist knows about SPIRES, the place where they can find papers, citations and information about colleagues. However, not everyone knows that the first US web server and the first database on the web came about at SLAC with just one aim: to bring scientific information to the fingertips of particle physicists through the SPIRES platform. SPIRES was hailed as the first "killer" application of the then nascent web.

No matter how venerable, the information tools currently serving particle physicists no longer live up to expectations and information management tools used elsewhere in the world have been catching up with those of the high-energy physics community. The soon to be released INSPIRE service will bring state-of-the-art information retrieval to the fingertips of researchers in high-energy physics once more, not only enabling more efficient searching but paving the way for modern technologies and techniques to augment the tried-and-tested tools of the trade.



*INSPIRE's detailed record for the recent joint paper by the Tevatron experiments CDF and DØ on limits on the mass of the Higgs boson (*CERN Courier *March 2010 p6).*

Meeting demand

The INSPIRE project involves information specialists from CERN, DESY, Fermilab and SLAC working in close collaboration with arXiv, the Particle Data Group and publishers within the field of particle physics. "We separate the work such that we don't duplicate things. Having one common corpus that everyone is working on allows us to improve remarkably the quality of the end product," explains Tim Smith, head of the User and Document Services Group in the IT Department at CERN, which is providing the Invenio technology that lies at the core of INSPIRE.

In 2007, many providers of information in the field came together for a summit at SLAC to see how physics-information resources could be enhanced. The INSPIRE project emerged from that meeting and the vision behind it was built from a survey launched by the four labs to evaluate the real needs of the community (Gentil-Beccot *et al.* 2008.). A large number of physicists replied enthusiastically, even writing reams of details in the boxes that were made available to input free text. The bulk of the respondents noted that the SPIRES and arXiv services were together the dominant resources in the field. However, they pointed out that SPIRES in particular was "too slow" or "too arcane" to meet their current needs.

INSPIRE responds to this directive from the community by combining the most successful aspects of SPIRES (a joint project of DESY, Fermilab and SLAC) with the modern technology of Invenio (the CERN open-source digital-library software). "SPIRES' underlying software was overdue for replacement, and adopting Invenio has given INSPIRE the opportunity to reproduce SPIRES' functionality using current technology," says Travis Brooks, manager of the SPIRES databases at SLAC. The name of the service, with the "IN" from Invenio augmenting SPIRES' familiar name, underscores this beneficial partnership. "It reflects the fact that this is an evolution from SPIRES because the SPIRES service is very much appreciated by a large community of physicists. It is a sort of brand in the field," says Jens Vigen, head of the Scientific Information Group at CERN. ▷

However, INSPIRE takes its own inspiration from more than just SPIRES and Invenio. In searching for a paper, INSPIRE will not only fully understand the search syntax of SPIRES, but will also support free-text searches like those in Google. “From the replies we received to the survey, we could observe that young people prefer to just throw a text string in a field and push the search button, as happens in Google,” notes Brooks.

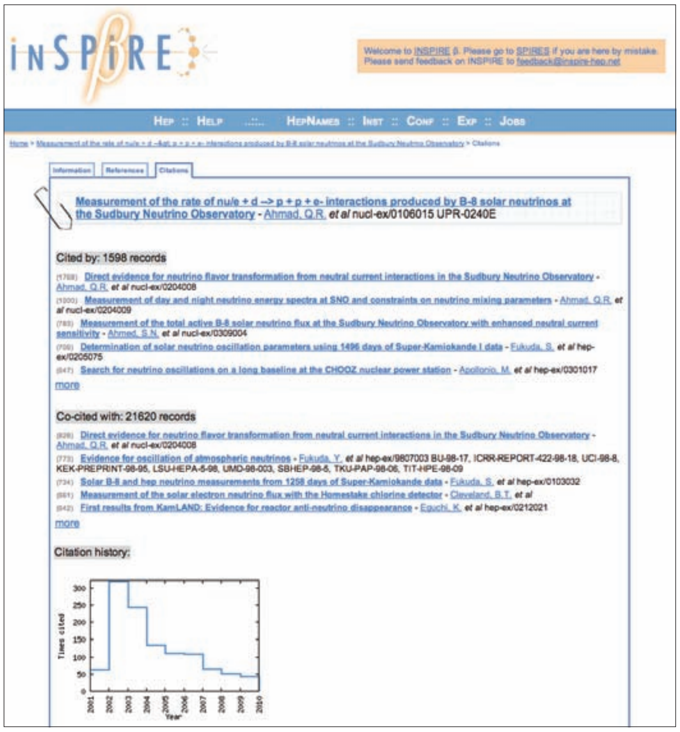
This service will facilitate the work of the large community of particle physicists. “Even more exciting is that after releasing the initial INSPIRE service, we will be releasing many new features built on top of the modern platform,” says Zaven Akopov of the DESY library. INSPIRE will enable authors and readers to help catalogue and sort material so that everyone will find the most relevant material quickly and easily. INSPIRE will also be able to store files associated with documents, including the full text of older or “orphaned” preprints. Stephen Parke, senior scientist at the Fermilab Theory Department looks forward to these enhancements: “INSPIRE will be a fabulous service to the high-energy-physics community. Not only will you be able to do faster, more flexible searching but there is a real need to archive all conference slides and the full text of PhD theses; INSPIRE is just what the community needs at this time.”

Pilot users see INSPIRE already rising to meet these expectations, as remarked on by Tony Thomas, director of the Australian Research Council Special Research Centre for the Structure of Matter: “I tried the alpha version of INSPIRE and was amazed by how rapidly it responded to even quite long and complex requests.”

The Invenio software that underlies INSPIRE is a collaborative tool developed at CERN for managing large digital libraries. It is already inspiring many other institutes around the world. In particular, the Astrophysics Data System (ADS) – the digital library run by the Harvard-Smithsonian Center for Astrophysics for NASA – recently chose Invenio as the new technology to manage its collection. “We can imagine all sorts of possible synergies here,” Brooks anticipates. “ADS is a resource very much like SPIRES, but focusing on the astronomy/astrophysics and increasingly astroparticle community, and since our two fields have begun to do a lot of interdisciplinary work the tighter collaboration between these resources will benefit both user communities.”

Invenio is also being used by many other institutes around the world and many more are considering it. “In the true spirit of CERN, Invenio is an open-source product and thus it is made available under the GNU General Public Licence,” explains Smith. “At CERN, Invenio currently manages about a million records. There aren’t that many products that can actually handle so many records,” he adds.

Invenio has at the same time broadened its scope to include all sorts of digital records, including photos, videos and recordings of presentations. It makes use of a versatile interface that makes it possible, for example, to have the site available in 20 languages. Invenio’s expandability is being exploited to the full for the INSPIRE project where a rich set of back-office tools are being developed for cataloguers. “These tools will greatly ease the manual tasks, thereby allowing us to get papers faster and more accurately into INSPIRE,” explains Heath O’Connell from the Fermilab library. “This will increase the search accuracy for users. Furthermore, with the advanced Web 2.0 features of INSPIRE, users will have a simpler, more powerful way to submit additions, corrections and updates, which will be processed almost in real time”.



INSPIRE provides citation histories, in this case for the paper that announced the detection of ^{8}*B solar neutrinos in the Sudbury Neutrino Observatory in 2001, a key result in the discovery of neutrino oscillations* (CERN Courier *September 2001 p5).*

Researchers in high-energy physics were once the beneficiaries of world-leading information management. Now INSPIRE, anchored by the Invenio software, aims once again to give the community a world-class solution to its information needs. The future is rich with possibilities, from interactive PDF documents to exciting new opportunities for mining this wealth of bibliographic data, enabling sophisticated analyses of citations and other information. The conclusion is easy: if you are a physicist, just let yourself be INSPIREd!
● The INSPIRE service is available at http://inspire-hep.net/.

Further reading

Anne Gentil-Beccot *et al.* 2009 *J. Am. Soc. Inf. Sci.* **60** 150.

Résumé

INSPIRE : gérer l’information pour la physique des particules

La mise en commun automatique de l’information a été à la base de l’invention du web au CERN en 1989. Peu après apparaissaient le premier serveur web aux États-Unis et la première base de données sur le web, au SLAC, avec un seul objectif : mettre l’information scientifique à la portée des physiciens des particules au moyen de la plateforme SPIRES. Aujourd’hui, des spécialistes, au CERN, à DESY, au Laboratoire Fermi et au SLAC, travaillant en étroite collaboration avec arXiv, Particle Data Group et les éditeurs scientifiques, ont mis au point Inspire, un nouveau service permettant une gestion avancée de l’information. Le système combine les aspects les plus performants de SPIRES (projet commun DESY, Fermilab et SLAC) avec Invenio, le logiciel de bibliothèque numérique « open source » mis au point au CERN.

CAST's first decade of

Konstantin Zioutas takes stock of the first 10 years of the CERN Axion Solar Telescope project, an ingenious product that rolls X-ray astronomy, particle physics and LHC-technology into one.

In 1983, when I was thinking about how axions may be produced and detected by their conversion to photons in a magnetic field, it struck me suddenly that there is no need to produce axions because the Sun does that for us. The solar axion flux is much larger than any that we could produce on Earth, and it is here free of charge. Our job is simply to detect these solar axions

– Pierre Sikivie of University of Florida.

Axions are one of the favoured candidates for the mysterious dark matter created in the early universe. A variety of observatories located on Earth and in outer space form a quasi-network that can target specific places in the search for these particles, such as the galactic centre, the inner Earth and the Sun's hot core. The CERN Axion Solar Telescope (CAST) points at the Sun – its aim being the direct detection of axions or other exotic particles with similar properties.

While relic axions from the early universe should propagate with a velocity of about one thousandth of the speed of light, solar axions – with a broad spectral shape of around 4–5 keV kinetic energy – are relativistic. The open window for the axion rest mass is currently in the micro-electron-volt to electron-volt range. The several orders of magnitude difference in kinetic energy associated with the two origins make for different experimental search techniques: microwave cavities for relic axions versus X-ray detectors for solar axions. However, both techniques use a magnetic field as the catalyst that allows axions to become photons

Accelerator laboratories, with their powerful magnets are natural locations for axion helioscopes – the instruments used to search for axions from the Sun. The first experiment to look at the Sun, which incorporated a 2.2-m iron-core magnet, was set up by a Rochester-Brookhaven-Fermilab (RBF) collaboration in the early 1990s. It was followed by the Sumico experiment based on a 2.3-m long superconducting magnet at the University of Tokyo, which is still in operation. The CAST helioscope at CERN uses a decommissioned LHC-dipole test magnet, with a field of 9 T and two tubes – originally designed to house the beam pipes – that are 9.2 m long and have an aperture of 43 mm. The dipole is one of four original prototypes and was rescued at the last minute before it was about to be scrapped along with the others. A comparison of CAST's performance with its two predecessors in Brookhaven and Tokyo shows that the LHC magnet was good choice.

The CAST helioscope in 2003, comprising the reclaimed former LHC dipole magnet prot Davenport, Claude Détraz, Konstantin Zioutas, Klaus Barth, Ioannis Giomataris, and He

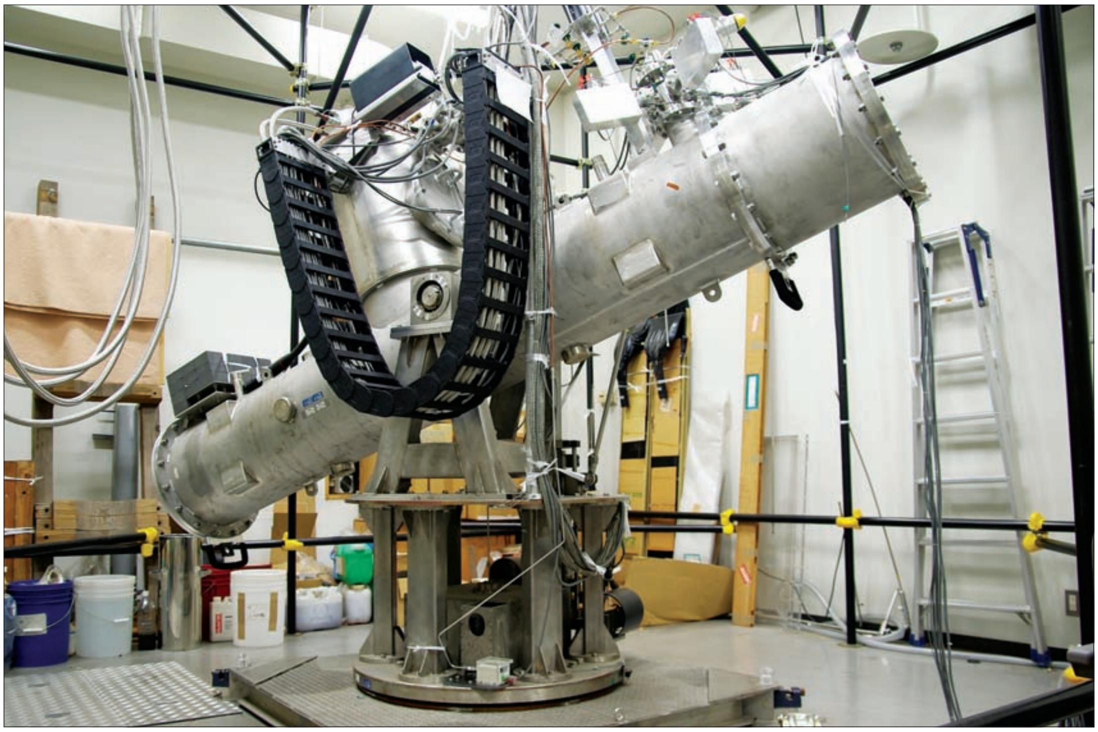
The possibility that a bending magnet could be used to make visible the "dark" Sun was – and still is – inspiring and motivating. To transform the multi-tonne superconducting, superfluid-helium-cooled magnet from a static LHC prototype dipole into a helioscope that can track the Sun with millimetre precision involved delicate engineering work and cryo-expertise. Thankfully, Louis Walckiers in the Accelerator Technology Division supported the idea, even though we had both just failed to prove with the same magnet that the biomechanics of cell-structure formation becomes confused in a 9 T environment.

Recycling space technology

Position-sensitive X-ray detectors of the MicroMegas type, invented by Georges Charpak and Ioannis Giomataris at CERN, now cover three of the ends of the tubes through the magnet, making CAST the only axion helioscope to have implemented such technology. For the fourth exit, together with Dieter Hoffmann and Joachim Jacoby of TU Darmstadt we were able to recover an excellent X-ray imaging telescope from the German space programme, which was delivered by Heinrich Bräuninger from the Max Planck Institute for Extraterrestrial Physics in Garching. With state-of-the-art X-ray optics and low-noise X-ray pixel detectors at the focal plane, this not only improves the signal-to-noise ratio substantially but also allows for the unambig-

f solar-axion research

prototype A1. From left to right: Martyn
d Heinrich Bräuninger.



"CAST is a big successor to Sumico, the Tokyo axion helioscope, although Sumico is still alive and searching for axions in the higher mass region." – Makoto Minowa, University of Tokyo and Sumico collaboration. (Courtesy M Minowa.)

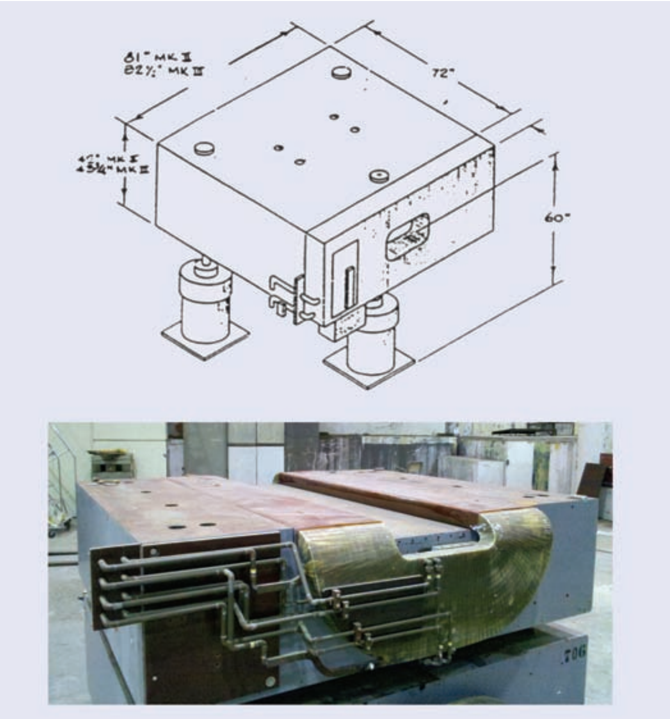
uous identification of the axion signal. Its CCD imaging camera simultaneously measures the expected solar-axion signal spot and the surrounding background. This is an important feature that makes CAST unique as an axion helioscope. With most of the components located, CAST received formal approval at CERN in April 2000.

In the same way that much of the CAST equipment was recycled from particle physics so, too, was its working principle: the Primakoff effect, known since 1951, which regards the production of neutral pions by the interaction of high-energy photons with the high electric field of the nucleus as the reverse of the decay into two photons. The expectation is that the quasi-stable axion should "decay" in the presence of a magnetic field into a photon emitted exactly along the axion's trajectory. In principle this allows for a perfect axion telescope thanks to the spatial resolution of the X-ray telescope.

The Primakoff effect deserves to be a textbook example of macroscopic quantum-mechanical coherence, which, in astrophysical magnetic fields, can extend over kiloparsecs – although only for very small axion rest masses. For CAST, coherence holds over the whole length of the magnet, around 9 m, provided that the particle rest mass is below 0.02 eV/c^2 when the two pipes are vacuum-pumped. To extend the detection sensitivity to higher masses, adding a certain amount of helium as a refractive gas to the 1.8 K cold magnetic pipes restores coherence for a rest mass up to around 1 eV/c^2 from a few millimetres up to 9 m but for a narrow range in solar axion rest mass. With this adaptation, suggested in 1988 by two collaboration members Karl van Bibber and Georg Raffelt, and implemented during 2005 and 2006, CAST has become a scanning experiment. The rest-mass range for solar axions that will be scanned by the end of 2010 fits the cosmologically derived upper limit of about 1 eV/c^2, from the Wilkinson Microwave Anisotropy Probe (WMAP) data, and the lower limit around 1 μeV/c^2, which arises because axions with lower rest mass would be produced earlier in the early universe, with a total mass exceeding that of the critical density ("overclosure").

The precise pressure settings for the helium gas and controlled changes in the very cold magnet pipes are highly demanding and are not without risk. CAST has benefited greatly from CERN's world-class cryogenic expertise in this respect, with its reliable user-friendly gas system designed by Tapio Niinikoski and his PhD student Nuno Elias. At present an extensive thermodynamic simulation is being performed with the aim of reconstructing the changing conditions of the helium gas as the magnet tracks the Sun. For example, to achieve the homogeneity in gas density necessary to keep coherence, the temperature variations along the 9-m long pipes should be in the milli-kelvin range; this is made possible by the surrounding bath of superfluid liquid helium at about 1.8 K.

CAST is also a "special" experiment when compared with others ▷



"The solar axion experiment in BNL was put together in 1990 in a few months, using a standard 2.2 T dipole magnet. It was a lot of fun. Alas, no axions were observed but the limits keep improving in an impressive way." – Yannis Semertzidis, Brookhaven. (Courtesy Brookhaven.)

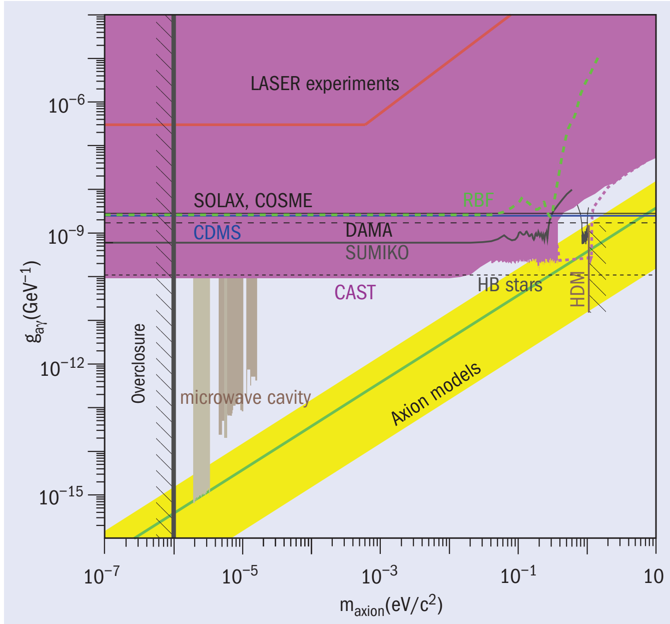


Fig. 1. Axion–photon coupling versus the rest mass of QCD-inspired axions, showing the limits achieved by the helioscopes RBF, Sumico and CAST in the context of axion searches in general. It also shows astrophysically and cosmologically derived conclusions from HB stars and the hot dark matter (HDM) limit for hadronic axions inferred from WMAP observations, and the lower limit related to overproduction of dark-matter axions (overclosure of the universe).

because its highly sensitive magnet and low-background detectors must operate while in motion, even though the speed of about 2 m an hour is almost imperceptible. In addition, CAST's equipment must withstand quenches of the superconducting magnet. After each quench the gas control system must cope with extreme conditions within seconds. However, during 15 000 hours of operation with the magnet on, and more than 2000 hours of solar tracking, CAST has survived potentially catastrophic events because its safety features have – thanks to the careful work of CERN's Martyn Davenport – never failed simultaneously.

Scientific return

While CAST has failed so far to find direct evidence for solar axions, it has been able to provide new robust limits on the interaction of solar axions with a magnetic field, i.e. the sea of virtual photons (figure 1). Its experimentally derived limit dominates the relevant phase space and competes with the best astrophysically derived lower value for the coupling constant, $g_{a\gamma}$. CAST is now moving into a theoretically motivated region, having almost fulfilled the original expectations set a decade ago with all of the input uncertainties at that time.

Moving beyond the initial proposal, CAST has in parallel explored – for the first time for a solar axion search – the region of high-energy solar axions, following the proposal of collaboration member Juan Collar. It has also made the first measurements below 1 keV, covering so far the range of around 1–3 eV. Moving to energies above this is possible; however, it will require larger energy steps and some new state-of-the-art detector technology to explore this interesting energy region that covers of most Sun's puzzling X-ray activity.

Without detecting any solar-axion signature so far, the question arises: what is the scientific return from CAST? Certainly, the first benefit is educational, with students completing some 10 PhD theses and an equal number of diploma theses. There have also been several CAST summer students at CERN. On the research side, CAST has helped to revive axion activities around the world, fitting between pure axion searches in the laboratory and a variety of astrophysical/cosmological observatories that usually did not have axions in their original list of objectives. The state-of-the-art detectors in these observatories cover photon energies from micro-electron-volts upwards. With CAST, the implementation of X-ray optics in axion helioscopy has become widely accepted as a necessary ingredient for future scaled-up versions.

While CAST's results have became a reference in the relevant field, they have also been used by other teams to search, for example, for "paraphotons" – sterile massive photons from the "hidden sector". Furthermore, two members of the CAST collaboration, Milica Krčmar and Biljana Lakić, have used the experiment's results to explore theories of large extra dimensions, which predict "massive" axions of the Kaluza-Klein type. Interestingly, such massive exotica could be gravitationally trapped in the Sun and could build a bright halo, as a result of their spontaneous decay, as we have suggested with Luigi Di Lella of CERN.

The axion signal that the CAST collaboration aims to observe while tracking the Sun consists of excess X-rays emerging from the magnet tubes. Interestingly, there is abundant solar X-ray emission of otherwise unknown origin, which is further enhanced just above the magnetized photosphere. For more than 70 years, known physics has failed to explain this intriguing behaviour, which could, however, arise from the conversion or decay of axions or other similar exotica near the Sun's restless surface (*CERN Courier* June 2008 p19). The outermost solar layers, i.e. the photosphere, might act occasionally as scaled-up and highly effective catalysts of axions or similar particles, emitting large numbers of X-rays (like a fine-tuned CAST might do one day). Then, extending Sikivie's original idea, the otherwise mysterious solar surface makes these axions visible as X-rays. New X-ray observatories in space are already providing more and more exciting evidence that something new and interesting is going on in the Sun's outer layers. The complete axion scheme may make the Sun even more special than it already is.

Such a solar scenario might eventually point to a "superCAST", which in 5 to 10 years may well make the present CAST look like an old fashioned miniature device – provided that Sikivie's pioneering idea behind CAST is not replaced by a novel conceptual design. For example, together with Andrzej Siemko of CERN we have proposed using a quadrupole magnet as a potentially better axion catalyst than the dipole magnets used at present in almost all axion experiments. This idea, which was also discussed theoretically by Eduardo Guendelman in 2008, is motivated observationally because otherwise puzzling solar X-ray activity correlates not only with magnetic fields but even more with places of varying field vector.

Alvaro De Rújula commented in 1998 that "axion searches are mandatory, fun, creative – and proceeding". His words are just as true today, as the CAST project continues into its second decade.

● I am very grateful to all members of the CAST collaboration, to CERN for its hospitality and support, including the librarians, and to my colleagues at the University of Patras for their real help.

This article is dedicated to the memory of the following members of the CAST collaboration who have sadly passed away since the project's inception: Engin Abat, Engin Arik, Fatma Senel Boydag, Ozgen Berkol Dogan, Angel Morales and Julio Morales.

Further reading

For more about axion searches with helioscopes and astrophysical signatures for axion(-like) particles see K Zioutas *et al.* 2009 *New J. Phys.* **11** 105020.

For the latest news on axions, see www.phys.ufl.edu/research/Axions2010/ and http://axion-wimp.desy.de/.

Résumé

CAST : dix ans de recherche sur les axions solaires

L'axion est l'une des particules candidates pour la structure de la mystérieuses matière noire apparue au tout début de l'Univers. Or ces particules pourraient exister maintenant dans la partie centrale, chaude, du Soleil. C'est pourquoi le télescope de l'expérience CAST (CERN Axion Solar Telescope) est pointé en direction du Soleil, le but étant de détecter des axions ou d'autres particules exotiques ayant des propriétés similaires. Dix ans après l'approbation formelle du projet au CERN, Konstantin Zioutas décrit ce programme de recherche combinant astronomie des rayons X, physique des particules et technologies du LHC, et fait l'inventaire des résultats obtenus. Il évoque également la possibilité d'élucider certaines caractéristiques inexpliquées du Soleil, et d'ouvrir de nouvelles perspectives pour ce domaine de recherche.

Konstantin Zioutas, *University of Patras.*

Murray Gell-Mann: my contemporary and friend

André Martin recalls some of the important steps that he witnessed in the scientific life of theoretical physicist Murray Gell-Mann, whose 80th birthday has recently been honoured.

Murray Gell-Mann and I were born a few days apart in September 1929. Being born on almost the same date as a genius does not help much, except for the fact that by having the same age there was a non-zero probability that we would meet. And indeed this is what happened; furthermore, we and our families became friends. Because I was unable to attend the meetings in honour of Murray, I am making this testimony on the occasion of his 80th birthday.

Murray's family was much affected by the crash of October 1929. His father had to change jobs completely. If this had not happened, it is possible that Murray might have become a successful businessman instead of a brilliant physicist. Everybody knows that Murray is immensely cultured and has multiple interests. I can quote a few at random: penguins, other birds (tichodromes for instance), Swahili, Creole, Franco-Provençal (and more generally the history of languages), pre-Columbian art and American-Indian art, gastronomy (including French wines and medieval food), the history of religions, climatic change and its consequences, energy resources, protection of the environment, complexity, cosmology and the quantum theory of measurement. However, it is in the field of theoretical particle physics that he made his most creative and important contributions. For these, I personally consider him to be the best particle-physics theoretician alive today.

Margaret and Murray Gell-Mann pictured in Bois Conti, near Geneva, around 1980. (Courtesy A Martin.)

Bright beginnings

I met Murray for the first time at Les Houches in 1952, one year after the foundation of the school by Cecile Morette-DeWitt. It was immediately obvious that he was extremely bright. Then he was invited by Maurice Levy to the Ecole Normale and gave some lectures at the Institut Henri Poincaré. He gave these in French, which had an amusing consequence as a result of a practical joke by Maurice. For months, as they worked together, speaking French, whenever Murray had said something like "ces deux termes s'annulent" (these two terms cancel) Maurice repeated it, substituting "se chancellent" for "s'annulent." Now Murray knew that "chanceler" means to wobble and not to cancel, but he finally supposed that in English-influenced French scientific jargon, "chanceler" could mean "to cancel." Otherwise, why would Maurice keep using that word? When Murray actually employed the word in one of his lectures, Maurice went into paroxysms of laughter.

In 1955 I attended my first physics conference, in Pisa. After a breakfast with Erwin Schroedinger, I took the tram and met Murray. In the afternoon, at the University of Pisa, he made the first public presentation of the strangeness scheme. The auditorium was packed. I was completely bewildered by this extraordinary achievement, with its incredible predictive power (which was very soon checked) including the $K\bar{K}$ system. I had already left Ecole ▷

Normale-Orsay for CERN when he and Maurice wrote their famous paper featuring for the first time what was later called the "Cabbibo angle".

I then had the luck to be sent to the La Jolla conference in 1961. There I met Nick Khuri for the first time, who became a close friend, and I heard Murray presenting "the Eightfold Way" (i.e. the SU(3) octet model). Also attending were Marcel Froissart, who derived the "Froissart Bound", and Geoff Chew, who presented his version of the S-matrix programme. Both were most inspiring for my future work. What I did not realize at the time was that the Chew programme had been largely anticipated by Murray, who first was involved in the use of dispersion relations and then noticed, in 1956, that the combination of analyticity, unitarity and crossing symmetry could lead to field theory on the mass shell, with some interesting consequences (as exemplified by Froissart's work and by my later work on the subject).

In 1962, during the Geneva "Rochester" conference, I was again present when Murray, after a review of hadron spectroscopy by George Snow, stood up and pointed out that the sequence of particles Δ, Σ^*, Ξ^* could be completed by a particle that he called Ω^- to form a decuplet in the SU(3) scheme. He predicted its mode of production, its decay, which was to be weak, and its mass. This was followed by a period of deep scepticism among theoreticians, including some of the best. However, at the end of 1963, while I was in Princeton, Nick Samios and his group at Brookhaven announced that the Ω^- had been discovered, with exactly the correct mass within a few mega-electron-volts. Frank Yang, one of the sceptics, called it "the most important experiment in particle physics in recent years". I missed the invention of the quarks, being in Princeton, far from Caltech, where Murray was, and from CERN where George Zweig was visiting. I met Bob Serber but I was completely unaware of his catalytic role in that discovery.

Close friends

My next important meeting with Murray was in Yerevan in Armenia in 1965, where Soviet physicists had invited a group of some eight western physicists. This time Murray came with his whole family: his wife, Margaret – a British archaeology student whom he met in Princeton – and his children, Lisa and Nick. During the following summer, which the Gell-Manns spent in Geneva, our families met several times. I remember once when my children, seeing a portrait of Lisa by the famous Armenian painter H Galentz, said: "This is a green Lisa." The Gell-Manns spent another year at CERN before Harold Fritzsch, Gell-Mann, and Heinrich Leutwyler wrote the "Credo" of QCD.

Margaret and Murray came to Geneva again for the academic year 1979/80. They were living in an apartment in the same group of buildings as us. Schu, my wife, then became a close friend of Margaret, who was a typically British girl: very reserved, very intelligent and possessing a good sense of humour. An example of how she was very modest is that, while we knew that she had been digging at Mycenae for an archaeologist named Alan Wace, we found out only long after her death that she had played a personal role in destroying a theory of Sir Arthur Evans, who claimed wrongly that the Cretans had dominated the Mycenaeans during a certain part of the late-Minoan period – while the reverse was true. In fact, she was the first to discover a Linear B tablet at Mycenae. Although Carl Blegen had found Linear B tablets at Pylos long before, finding them at Mycenae as well was important additional evidence once Michael Ventris had proved that the language of Linear B was an early form of Greek, and that Margaret's boss was right. He had suffered terribly from his refusal to agree with Evans.

An extraordinary friendship grew up between Margaret and Schu. When the Gell-Manns left Geneva for Pasadena, Margaret knew that there was something wrong with her health. Back in the US she discovered that she had cancer. I do not know the number of transatlantic trips that we made – sometimes both of us, sometimes Schu alone – to help Margaret. This included stays in Aspen during the summers of 1980 and 1981. In between, Schu and Margaret had an extensive correspondence. Schu decided to initiate Margaret into French poetry. In particular, she sent Margaret poems by Jacques Prévert and Paul Eluard. On Margaret's grave, in Aspen, Murray put the inscription: "Mais ou en est ce léger sourire" (Eluard, about Nuesch, his late wife). After Margaret's death, we all kept in touch because Murray has one remarkable quality: faithfulness in friendship.

● I am grateful to my wife, Schu, and to Murray for suggestions and corrections.

Further reading

For more about the conference held in February in honour of Murray Gell-Mann's 80th birthday, see www.ntu.edu.sg/ias/upcomingevents/GM80Conference/Pages/default.aspx.

Résumé

Murray Gell-Mann : un contemporain et un ami

André Martin évoque ici des étapes importantes de la carrière de Murray Gell-Mann, lauréat du prix Nobel, dont le 80e anniversaire a été célébré récemment à Singapour. Les deux théoriciens, nés à quelques jours d'intervalle en septembre 1929, se sont croisés pour la première fois aux Houches en 1952. Par la suite, ils ont participé aux mêmes conférences, au cours desquelles Murray Gell-Mann a présenté publiquement la notion d'étrangeté (1955), puis la « voie octuple », soit le modèle de l'octet SU(3) (1961), puis a prédit la particule appelée Ω^- (1962). Ils sont par la suite devenus de grands amis.

André Martin, *CERN.*

APPOINTMENTS

GSI appoints third managing director

With the appointment of Hartmut Eickhoff as technical director in mid-February, the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt has three managing directors for the first time. With this strengthening of the management the centre is prepared for the implementation of the international Facility for Antiproton and Ion Research (FAIR). Horst Stöcker and Christiane Neumann are scientific director (and CEO) and administrative director respectively.

As technical director, Eickhoff 's responsibility includes the operation of the scientific and technical facilities, and the upgrading and conversion of the GSI accelerator facility as an injector for FAIR. He has worked at GSI for many years and has been head of the accelerator division since 2005 – a position he retains.

Eickhoff received his doctorate in the field of nuclear physics in Munster. From 1980 he worked on the design for the heavy-ion synchrotron SIS18 and the ESR storage ring at GSI and also enhanced these accelerators. In 1995 he took responsibility for the accelerator modification for GSI's pilot project in tumour therapy with carbon ions and from 1998-2005 he led the accelerator project for the Heidelberg Ion-beam Therapy centre at the University Hospital of Heidelberg.

Hartmut Eickhoff. (Courtesy G Otto, GSI.)

Pennington to lead J-Lab Theory Center

Michael Pennington has been named the new associate director for theoretical and computational physics at the US Department of Energy's Jefferson Lab. He will begin his duties on 1July.

Pennington received his PhD in theoretical physics in 1971 from Westfield College, University of London. He joined Durham University in 1978, where he is currently a professor of mathematical sciences and physics, and dean for educational outreach.

He has served as a distinguished visiting professor at the University of Adelaide and as a visiting scientist and Fulbright Scholar in the High Energy Theory Group at Brookhaven National Laboratory. He has also been a fellow in the Theory Division at CERN, a research associate at the Rutherford Laboratory and a physicist in the High Energy Theory Group at Lawrence Berkeley National Laboratory.

Since 2007, Pennington has served as a member of Jefferson Lab's Program Advisory Committee. He has participated as a member of the CERN SPS Committee and as a member of the DAΦNE Physics Working Group. In 2009, he was named an Outstanding Referee by the American Institute of Physics.

Pennington moves to Jefferson Lab. (Courtesy Durham University.)

AWARDS

AIP honours Voss with Tate Medal

The American Institute of Physics (AIP) has awarded the Tate Medal for International Leadership in Physics to Gustav-Adolf Voss. He received the medal on 14 February at a meeting of the American Physical Society in Washington in recognition of his outstanding success in promoting international physics for many years, especially for his effective support of Soviet and eastern European physicists after the breakup of the Soviet Union, his stimulation of the development of accelerator technology throughout Europe, and his leadership in the construction of the synchrotron radiation source SESAME in Jordan, which is to be used as a collaborative facility by nine countries in the Middle East.

Voss was the successful project leader for the PETRA and HERA storage rings at DESY and a member of the DESY directorate and head of the accelerator division from 1973 until 1994. He shaped the research centre with his unorthodox, internationally oriented and very effective methods, bringing together the best experts from all around the world. For his lifetime achievements in accelerator physics, he was the first to be awarded with the golden DESY pin in September 2009.

Gustav-Adolf Voss. (Courtesy DESY.)

CELEBRATION

University of Michigan honours Alan Krisch

On 14 November 2009, colleagues and friends from around the world gathered at the University of Michigan in Ann Arbor for a Spin Physics Symposium to honour Alan Krisch, who recently turned 70.

After gaining his PhD at Cornell under Giuseppe Cocconi, Alan moved to Michigan in 1964 and has stayed there ever since – as a full professor for the past 41 years. The first part of the symposium centred on Alan's many important contributions to spin-physics, after a first talk in which Homer Neal reminded the audience of Michigan's long association with spin: from Uhlenbeck and Goudsmit, Dennison and Crane, to the recent activities in high-energy, nuclear and atomic spin-research.

Michigan's Carl Akerlof reviewed Alan's early experiments. The first was his 1962–63 thesis experiment at Brookhaven's Alternating Gradient Synchrotron (AGS), on 30 GeV large-angle proton–proton elastic scattering. This was followed by the 1965–66 measurement of π^--p elastic scattering at 180° for different momenta at Argonne's Zero Gradient Synchrotron (ZGS). It was Alan's first experiment as spokesperson, at the age of 25 – an outstanding success "that put the ZGS on the map", as Argonne's former high-energy physics director Malcolm Derrick commented. The 1966 experiment on proton–proton elastic scattering at 90°_{cm} showed a kink in the elastic cross-section near a beam momentum of 8 GeV/*c*: the first evidence for objects (or layers) inside the proton.

Marvin Marshak of Minnesota recalled Alan's first "p + p → p/π/K + anything" experiments at the ZGS to test his so-called "onion" model. It did not confirm Alan's prediction that heavier particles were produced in the proton's inner layers, but the papers in *Physics Review Letters* of 1967 and 1968 contained the first definition of the concept of "inclusive" cross-sections (the name "inclusive" being coined later by Richard Feynman).

Alan pursued inclusive measurements at much higher energies at CERN's Intersecting Storage Rings (ISR) in the Argonne–Bologna–CERN–Michigan collaboration. The Argonne–Michigan team was the first from the US to work at the ISR and the collaboration was among the first to take data in 1971.

Alan Krisch, left, engaged in conversation with Ernest Courant. (Courtesy John Trotter.)

Marshak recalled how the ZGS appeared in 1960 as a unique facility for accelerating polarized protons but it had to wait for a driving force like Alan to develop the world's first high-energy, polarized-proton beam in the years 1970–1973, along with Larry Ratner, Everett Parker and many others. Alan embraced the idea that the structure being suggested by the experiments could best be probed by preparing either the beam or target protons, and later both, in a specific spin state. Michigan's Polarized Proton Target (PPT) used dynamic nuclear polarization, a technique first developed at Saclay and Berkeley. In six years there were a total of 43 polarized-proton and four polarized-deuteron experiments conducted at the ZGS. It was then (1974) that Alan started the series of Spin Physics Symposia, where progress and ideas are still debated today. Alan was leader of the effort – together with Larry Ratner, Kent Terwilliger, Ernest Courant, Vernon Hughes, Thomas Roser and many others – that led to the acceleration of the first strong-focusing polarized proton beam at the AGS during the years 1978–1985.

Alan was right. As Don Crabb of Virginia commented, Alan's team found large spin effects in double-spin experiments at the ZGS. First, they found a large spin-dependence in the transversely polarized pp total cross-section. Then, in 1977 and 1978, at 12 GeV/*c*, near 90°, they found the spin-parallel pp elastic cross-section $\sigma(\uparrow\uparrow)$ to be four times larger than the anti-parallel spin cross-section $\sigma(\uparrow\downarrow)$. A similar experiment with the scattering angle fixed at 90°_{cm} confirmed that the huge spin effect was a result of the hard scattering of the proton's constituents, and not a consequence of particle identity. However, this $\sigma(\uparrow\uparrow)/\sigma(\uparrow\downarrow)$ ratio was a factor of two too large to be caused by three spin-½ quarks in the quark-interchange model proposed by Stan Brodsky and others.

Large spin effects were also found at the AGS after the ZGS shut down in 1979. Alan's team studied the single-spin elastic cross-section's up–down asymmetry $A_n = (\sigma\uparrow-\sigma\downarrow)/(\sigma\uparrow+\sigma\downarrow)$: A_n was growing rapidly at large transverse momentum, in contradiction with QCD. To confirm the data, the team developed a radiation-doped ammonia PPT, working at 1 K in a 5 T magnetic field, which could be used in a beam of 10^{11} protons/s (20 times more intense) with an average polarization of 85%. The large and growing A_n was confirmed with higher precision.

Then, following Alan's long-standing interest in "Siberian snakes", the team moved to the Indiana University Cyclotron Facility to study spin manipulations with collaborators from Indiana (1986–2002). The acceleration and successful collision of the world's first beams of 100 GeV (and then 250 GeV) polarized protons at Brookhaven's RHIC is a direct fall-out from the research by Alan and his collaborators. Thomas Roser discussed the first test in 1989. These studies were continued in 2002–2009 at the Jülich Cooler Synchrotron. Hans Ströher of Jülich, in a paper delivered by Dennis Sivers, reviewed the highlights, including the very high-efficiency proton spin-flipper, and the spin-manipulation of tensor-polarized deuterons.

In the afternoon, the symposium reviewed the present and future status of spin physics, with talks by Jacques Soffer, Naomi Makins, Richard Milner, Jonas Sandberg and Abhay Deshpande.

Engaging nature's huge problems, sceptical, meticulous, innovative, persistent: that is how Michigan's Homer Neal summed up Alan, when offering him a spin-inspired sculpture made in the Michigan workshop at the end of the symposium.

For the full programme and all the talks, see http://spin-symposium.physics.lsa.umich.edu.

SCHOOLS

Ankara hosts inaugural ISOTDAQ school

A student group learns about FSM design and implementation. Each student received a readout board like the one used in this exercise (yellow object near centre). (Courtesy Francesa Pastore.)

The school's participants outside the TAEK building. (Photo and article courtesy Yi Ling Hwong.)

The 1st International School of Trigger and Data Acquisition (ISOTDAQ) took place on 1–7 February in Ankara. This pioneering project was an initiative by CERN's Turkish community and became possible through major contributions from CERN and various members of the LHC experiments. The project was jointly funded by the ACEOLE project under the Marie Curie Action Fellowship Programme, CERN, the Turkish Atomic Energy Authority (TAEK) and Boğaziçi and Çukurova Universities. TAEK hosted the event.

This new school's target audience is masters and doctoral students who intend to continue their careers in the field of accelerator physics or particle physics, specializing in trigger and data acquisition. The topics covered included trigger hardware and software, data-acquisition hardware and software, and data-transfer technologies. The school attracted some 100 applicants from 11 nations, of whom 40 were selected.

With the aim of striking a balance between theory and practice, the lectures were accompanied by 11 lab sessions, each 2 hours long. The lab equipment was shipped from CERN (half a tonne) and supporting universities. The labs covered different topics, such as finite-state machine (FSM) design, field-programmable gate-array programming, and cosmic-muon measurements using VME-bus technology. Twenty-seven experts from all four major LHC experiments and CERN volunteered as lecturers and lab instructors.

A pre-school lecture programme took place one day before the school started to prepare the students with the necessary computing skills. Over the next seven days, the participants gathered on the 11th floor of the TAEK headquarters to attend lectures and take part in the lab sessions, engaging in lively debates on the various topics covered during the lectures. "Get your hands dirty," said Gökhan Ünel aptly in his welcoming speech at the opening ceremony, quoting Confucius as the motto for the school: "I hear and I forget. I do and I understand."

The students were also treated to an excursion day to the city of Ankara for a taste of traditional Turkish cuisine and culture. This included visits to the Museum of Anatolian Civilizations and the mausoleum of M K Atatürk, the founding father of the Turkish Republic.

On the last day of the school, the instructors were pleasantly surprised by a humorous closing lecture from the students before the school was brought to an end with a ceremony where participation certificates were presented to the students. Each student also received a minimalist TDAQ device as a gift from the school. This hardware is meant to encourage the students to express their own creativity. Those who successfully complete a project with it within two weeks will also receive an achievement certificate from TAEK.

This inaugural school received a positive evaluation from the students and encouraging feedback from the TDAQ community. It also caught the attention of the Turkish national radio and television network, TRT. Extensive interviews with students and instructors appeared in a documentary aired in March. What started off as an ambitious project has turned out to be a remarkable learning process for everyone involved. The event's success has laid a solid groundwork for turning it into an annual school, with the next ISOTDAQ scheduled for 2011.

For slides and video recordings of the lectures, see http://isotdaq.web.cern.ch.

MEETINGS

The **12th Topical Seminar on "Innovative Particle and Radiation Detectors" (IPRD10)** will take place at the University of Siena, Italy, on 7–10 June. Attendance will be by invitation: interested physicists should write to the organizing committee, giving name, address, affiliation and, if applicable, the title of a contribution. The deadline for submitting an abstract is 15 March, but post-deadline contributions will also be considered. A limited number of grants covering the conference fees is available for young PhD students wishing to attend. For more details, see www.bo.infn.it/sminiato/siena10.html; e-mail: kaos@bo.infn.it; or contact F.-L. Navarria, Dip. di Fisica, V.le Berti Pichat 6/2, I-40127 Bologna.

The **11th International Workshop on Tau Lepton Physics (Tau 2010)** will take place at the University of Manchester, on 13–17 September. Invited plenary speakers will cover experimental and theoretical aspects in topics in tau physics, including: static properties of the tau; tests of lepton universality; semihadronic decays; strange decays; decays of heavy quarks to tau; CP violation; lepton–flavour violation; muon and tau g-2; neutrino physics; tau physics at hadron colliders; and future prospects. There will be a poster session, to which anyone can contribute. There will also be plenty of time for discussions. For more details, see www.manchester.ac.uk/tau2010.

OBITUARY

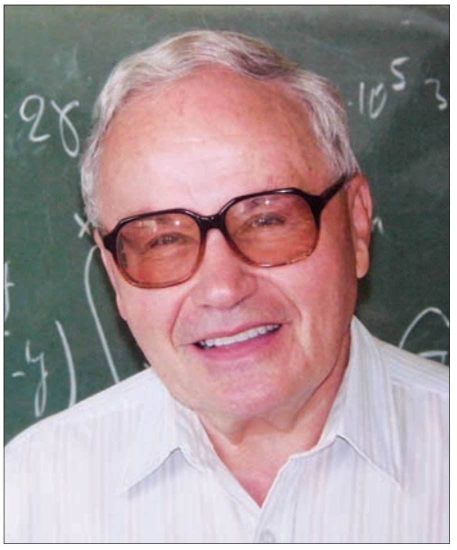
Vladimir Nikolaevich Baier 1930–2010

Vladimir Baier, professor of physics and an eminent Russian scientist, died on 19 February. With his passing, Russian science has lost an outstanding and world-renowned researcher.

Baier started his academic career in 1955 as a postgraduate student in the Lebedev Physical Institute of the USSR Academy of Sciences in Moscow. He worked there under the supervision of 1958 Nobel laureate Igor Tamm, of which he was always proud. After receiving his PhD in 1959, Baier joined the newly founded Institute of Nuclear Physics in Novosibirsk, led by Gersh Budker.

Baier was one of the first to envision the construction of electron–positron colliders. As early as October 1959, he shared his idea of colliding-beam experiments with Budker, who initially considered it insane. This was well in advance of the launch of the first electron–electron collider VEP-1 in what is now the Budker Institute of Nuclear Physics. Attitudes soon changed, however, and Baier took an active part in making his idea a reality.

Baier obtained a number of fundamental results in QED. Some of them were included in the world-famous *Course of Theoretical Physics* by Lev Landau and Evgeny Lifshitz. His works were devoted to single and double bremsstrahlung and electroproduction in collisions of high-energy electrons, radiative corrections to cross-sections at high-energy, radiative polarization and radiative-return theory. Together with his colleagues, Baier did much to advance the quasi-real photon/electron method, which lies at the root of the parton model – one of the main tools in the modern theory of strong interactions at high energy. The operator approach to QED in an external field was also developed under Baier's leadership. This approach became a clue to the construction of the general theory of processes in periodic structures such as the laser wave, undulator, and monocrystal. His group did thorough research into the channelling of relativistic particles in a crystal. Their scientific results were published in three monographs and numerous reviews.



Vladimir Baier. (Courtesy Valentin Baev, BINP.)

For many years Baier combined intensive research and teaching. He made a significant contribution to the establishment and development of Novosibirsk State University. Many generations of students have vivid memories of him and his QED textbooks are still in demand.

A talented scientist and teacher, Baier also had a lively personality. He was unobtrusively sociable and neither avoided – nor sought – communication. He had broad interests and knowledge, so it was interesting to talk to him not only about physics but also about music and literature, history and philosophy, as well as about different varieties of wine and ways to make them, about cars, yachts, and boats. He was a skier, swimmer and a yachtsman.

Vladimir Baier will remain in the memory of those who knew him personally, while his scientific works and methods will continue in physics for a long time. The theoretical schools that he founded and nourished will thrive and flourish and many generations of physicists will remember his name.

Friends and colleagues.

VISIT

The Polish under secretary of state, ministry of science and higher education, Jerzy Szwed, far left, visited CERN on 22–23 February. Here he is at the LHCb experiment, with (from left to right): LHCb spokesperson, Andrei Golutvin; machine protection and electrical integrity group leader, Andrzej Siemko; counsellor to the minister, Maria Klimkiewicz; and LHCb national group leader, Grzegorz Polok, of Henryk Niewodniczanski Institute of Nuclear Physics. Szwed also saw the ATLAS visitor centre, the LHC superconducting magnet test hall, the CERN Control Centre, the CMS centre, the ALICE exhibit and met members of the Polish community at CERN.

LETTER

Niobium heat treatment

Concerning the letter "Progress in superconducting RF" published in the January/February 2009 issue in response to my "Viewpoint" in November 2008 headlined "SRF technology comes full circle", some readers might be interested in the following article, which establishes the basis for the points I made: "High field Q slope and the baking effect: Review of recent experimental results and new data on Nb heat treatments" by G Ciovati, G Myneni, F Stevie, P Maheshwari and D Griffis 2010 *Physical Review Special Topics – Accelerators and Beams* **13** 022002. (See also http://link.aps.org/doi/10.1103/PhysRevSTAB.13.022002).

Ganapati Rao Myneni, Jefferson Lab.

NEW PRODUCTS

Hiden Analytical has introduced its transient mass spectrometer designed for the analysis of fast transient gas events at pressures near atmospheric. The compact bench-top system features the HAL/3F PIC mass spectrometer with pulse ion-counting detector and a fast-response capillary inlet. This allows inlet system response times of less than 150 m/s with measurement speeds up to 500 data points per second over a 7-decade dynamic range. The system monitors species with molecular weights to 300 amu, with higher mass ranges available. For more details, see www.hidenanalytical.com.

Pfeiffer Vacuum has announced the Duo 125 and Duo 255 rotary vane pumps for applications that require pumping speeds between 120 and 250 m^3/h in the low- and medium-vacuum ranges. They are suitable for high-vacuum pumping stations in combination with turbopumps or as backing pumps for Roots pumps. Another new product is the robust turbopump, HiPace 60. Its integrated drive electronics reduce the need for cabling. A variety of drive versions, including Profibus and DeviceNet, are available. For more details, see www.pfeiffer-vacuum.net.

Physik Instrumente LP has developed the N-216 NEXLINE high-load piezo linear motors. These ultra-precision nanopositioning actuators provide travel ranges to 20 mm and push/pull forces to 600 N (130 lb). The operating principle is based on co-ordinated motion of a number of highly preloaded linear and shear piezo elements acting on a ceramic runner. For more details, see www.pi.ws.

Resolve Optics Ltd has introduced the Model 290 motorized non-browning zoom lens that includes a range of features to assist operation in environments subject to radiation. The Model 290 uses special glass that can withstand long-term exposure to high levels of radiation (up to a total dose of 100 Mrad) and temperatures (55°C) without discolouration. Operating at f/1.8, the Model 290 provides high image-resolution and minimum geometric distortion from 400–750 nm. For more details, see www.resolveoptics.com.

Userful Corporation has released Userful Multiplier V.3.7, the latest version of software that turns 1 PC into 10. Expanding multilingual support enables more countries to take advantage of this product and allows computer access in multiple official languages simultaneously. In addition, there is improved USB device support, including hot-plugging of 2-way audio devices. The Userful Multiplier V.3.7 supports all major Linux distributions and is available in 64-bit and 32-bit packages in both RPM and DEB formats. For more details, see www.userful.com.

RECRUITMENT

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The Physics Department at Brookhaven National Laboratory seeks to fill a Postdoctoral Research Associate position in Physics. Requires a Ph.D. in physics with emphasis on experimental particle or nuclear physics.

The candidate will participate in the activities of the group including the design of the Long Baseline Neutrino Experiment, especially the large water Cherenkov detector planned for DUSEL in South Dakota. There will be opportunity to participate in the Daya Bay reactor neutrino experiment in China that will have superb sensitivity to $sin22\theta13$ and will begin data-taking soon. Participation in the MINOS experiment (Fermilab-Soudan) may also be possible. Travel to DUSEL, Fermilab, Minnesota and/or China should be expected. The candidate will work within the electronic detector group and will have broad associations with other groups in the laboratory and throughout the world to carry out his/her function.

The Electronic Detector Group in the Physics Department currently has ten physicists at various career levels with major current responsibilities in neutrino physics and a long history of research in fundamental particle physics. Under the direction of S. Kettell, Physics Department.

Please go to http://www.bnl.gov/hr/careers/ and click on Search Job List to apply for this position. Please apply to Job ID # 14944.

BNL policy states that Research Associate appointments may be made to those who have received their doctoral degrees within the past five years.

Brookhaven National Laboratory is an equal opportunity employer committed to building and maintaining a diverse workforce.

The Department of Physics (**http://physics.syr.edu**) invites applications for a

Tenure-Track Assistant Professor in Experimental High Energy Physics.

The appointment will be made jointly with Fermilab. The department currently has a strong research group in experimental high energy physics (Profs. Sheldon Stone, Marina Artuso, Tomasz Skwarnicki and Steven Blusk), currently involved in the LHCb experiment.

The successful candidate is expected to concentrate research activities in future neutrino physics associated with Fermilab. Current research opportunities also exist with the LHCb experiment.

A Ph.D. degree in Physics with a specialization in High Energy Physics is required. Responsibilities include teaching Physics on all levels (undergraduate-lower and upper levels and graduate), and guiding graduate students to advanced degrees including dissertation research.

Two years of post-doctoral research and some college teaching is desirable. All applicants should have a substantial record of research accomplishments and a strong interest and ability to teach effectively at both the graduate and undergraduate levels.

For full consideration, candidates must complete an online Dean/Senior Executive/Faculty Application at **http://www.sujobopps.com (job #025789)**. As part of your application, please upload three documents: (1) your formal letter applying for the position, (2) your curriculum vitae (with publication list, etc.), and (3) a personal statement of research and teaching interests (as an "other document"). In addition to the online application, please arrange for three (3) letters of recommendation to be sent to **Professor Sheldon Stone**

Department of Physics, 201 Physics Bldg.,
Syracuse University, Syracuse, NY 13244-1130 USA
(Email - **stone@physics.syr.edu**).

The position will remain open until filled.
More information is available at: **http://physics.syr.edu/hep/hep_page.html**

Syracuse University is an equal opportunity affirmative action employer.

KIT Karlsruher Institut für Technologie

Karlsruhe Institute of Technology (KIT) is the result of the merger of university Karlsruhe and research center Karlsruhe. It is a unique institution in Germany, which combines the mission of a university with that of a large-scale research center of the Helmholtz Association. With 8.000 employees and an annual budget of EUR 650 millions, KIT is one of the largest research and education institutions worldwide.

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Your work will focus on the development of power distribution systems and of systems with pulsed power supply in scientific applications, such as pixel detectors for synchrotron radiation or future large-scale particle physics experiments. At the same time, potential commercial applications shall be identified. Your tasks shall include:

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Your work will be associated with business travels in Germany and abroad and, hence, it will be suited for part-time employment with certain restrictions only.

Candidates should have studied physics or electrical engineering, completed by a Ph.D. in addition, candidates are required to have:

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We prefer to balance the number of female and male employees in our company. In this case, we therefore kindly ask female applicants to apply to this job. If qualified, handicapped applicants will be preferred.

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DESY is seeking a leading senior scientist in the accelerator division with the following responsibilities:

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- Coordination of international contributions within the XFEL accelerator consortium
- Coordination of further developments at DESY in physics and technology for superconducting accelerators
- Liaison with worldwide ongoing R&D programmes in the field of superconducting RF technology, e. g. in the TESLA technology collaboration and the ILC global design effort

Requirements

- PhD in physics or engineering
- Several years experience in construction and operation of accelerators based on superconducting RF technology
- Several years experience in planning and organizing complex, large scale projects
- Excellent communication and leadership skills

For further information, please contact Prof. Dr. Helmut Dosch (desy-director@desy.de, phone +49 40 8998-3000) or Dr. Reinhard Brinkmann (Reinhard.brinkmann@desy.de, phone +49 40 8998-3197).

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Human Resources Department | Code: 30/2010
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Phone: +49 40 8998-3392 | E-mail: personal.abteilung@desy.de
Deadline for applications: 16 May 2010
www.desy.de

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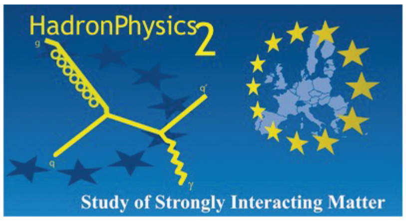

Transnational Access to Research Infrastructures
COSY – Forschungszentrum Jülich
HadronPhysics2 - Integrating Activity
Contract No. 227431
01/01/2009 – 30/06/2011

For European users outside Germany the access to the cooler synchrotron COSY is supported by the European Community - Transnational Access and Integrating Activities – Program for the time period from 1/1/2009 till 30/06/2011. It is one of the three activities (networking, joint research, transnational access) of the Integrating Activity "Strongly Interacting Matter" (acronym: "HadronPhysics2") financed by the European Commission.

COSY delivers polarized and unpolarized proton and deuteron beams up to 3.7 GeV/c momentum at internal and external target stations equipped with extended detector installations. The EC support provides access to COSY "free of charge" and covers the travel and subsistence expenses of the external users. Detailed infomation can be found at:
www.fz-juelich.de/ikp/tmr-life.html.

EMBL

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The ideal candidate has a degree in engineering, electronics or physics and at least 5 years practical experience in a similar position (electronics, optics or mechanical engineering). The ability to manage and organise the work of a small team is mandatory. Industrial training at instrument manufacturers as well as good knowledge of measurement techniques in bio-analytical instrumentation is advantageous. Further essentials: proficiency in MS Office, expertise with database tools and strong communication skills – fluency in English and a good working knowledge of German.

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With the United States' highest flux reactor-based neutron source for condensed matter research (the High Flux Isotope Reactor) and the world's most intense pulsed, accelerator-based neutron source (the Spallation Neutron Source), ORNL is becoming the world's foremost center for neutron science. Research at these facilities encompasses the physical, chemical, materials, biological, and medical sciences and will provide opportunities for up to 2000 researchers each year from industry, research facilities, and universities all over the world. To learn more about Neutron Sciences at ORNL go to: http://neutrons.ornl.gov.

PURPOSE: This position will provide oversight of accelerator operations and the accelerator operations team during shutdowns, upgrades and production running of SNS accelerator systems. Provide technical and administrative expertise during accelerator operations and coordinate development activities.

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- Maintain operation of the SNS Particle Accelerator Systems within the established Accelerator Operations Envelope (OE) and Accelerator Safety Envelope (ASE).
- Develop and execute operations, maintenance and commissioning plans for accelerator systems.
- Provide technical oversight during operations, maintenance and commissioning of all SNS accelerator systems.
- Provide administrative oversight of Accelerator Operations Coordinators, Accelerator Control Room Shift Supervisors and Control Room Accelerator Specialists as required.
- Update and add to the SNS Accelerator Systems Operations Procedures Manual as required.
- Participate in documenting and implementing the development plans within budgetary and schedule constraints.
- Analyze data and prepare reports on the performance metrics for SNS accelerator systems.
- Assist in developing and execute plans for improving the performance of SNS accelerator systems.
- Manage the hiring of the Accelerator Operations Group staff.
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- Maintain a strong commitment to the implementation and perpetuation of values and ethics.

QUALIFICATIONS REQUIRED:
At least 10 years experience in design, construction or operation of a particle accelerator and related control systems or an equivalent combination of education and experience. Prior experience in managing or directing physicists, engineers, technicians and accelerator operators desired. A BS degree in physics, engineering or a related field is required and MS degree preferred. Must have excellent written and verbal communications skills. Must be detail oriented.

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

Postdoctoral Positions Gamma-Ray Astrophysics (MAGIC and CTA)

The Max Planck Institute for Physics does fundamental research in particle and astroparticle physics from both an experimental and a theoretical perspective. Our research activities in astroparticle physics comprise participation in the gamma ray telescope MAGIC at the Roque de Los Muchachos Observatory at La Palma (Spain), the future space mission EUSO, and the CRESST dark matter search at Gran Sasso (Italy).

We invite applications for postdoctoral positions in high energy gamma ray astrophysics to strengthen our experimental astroparticle physics group. MAGIC is the world's largest ground-based Imaging Atmospheric Cherenkov telescope stereo system studying the deep universe with high energy gamma rays above 50 GeV. The scientific objectives are the study of high energy astronomical objects, e.g. AGNs, GRBs, Pulsars, and SNRs, and the investigation of fundamental physics. The system has been operating in stereo mode since summer 2009. Please see the MAGIC web site (http://www.magic.mppmu.mpg.de/). In parallel, the institute's experimental astroparticle physics group is heavily involved in the next generation project CTA (Cherenkov Telescope Array), which aims at a 10 times better sensitivity than that of currently working IACTs, and covers a wider energy range between a few 10s GeV and 100 TeV.

We are looking for postdoctoral researchers who can contribute to the MAGIC experiment and also to the development of the next generation project CTA. Candidates with an experimental background in cosmic-ray physics, gamma-ray physics, or neighbouring fields, such as elementary particle physics and astrophysics, are invited to apply.

The positions are limited to a period of initially two years, with the possibility of an extension by up to four years. Salary and benefits are in accordance with the German public service pay scale (TVöD). The Max Planck Society wishes to increase the participation of women wherever they are underrepresented; therefore, applications from women are particularly welcome. Following its commitment to an equal opportunities employment policy, the Max Planck Society also especially encourages handicapped persons to submit their applications.

For further information please contact Prof. Masahiro Teshima, e-mail: mteshima@mppmu.mpg.de. Interested scientists should send their applications (including a CV, list of publications and research interest) until 30 April 2010 and arrange for two recommendation letters to be received by the same date at

Max Planck Institute for Physics
(Werner-Heisenberg-Institut)
Ms. Sybille Rodriguez
Föhringer Ring 6, 80805 München, Germany
e-mail: rodi@mppmu.mpg.de

MAX-PLANCK-GESELLSCHAFT

EUROMAGNET CALL FOR PROPOSALS FOR MAGNET TIME

The next deadline for applications for magnet time at
the **LABORATOIRE NATIONAL DES CHAMPS MAGNETIQUES INTENSES**
(ex GHMFL & LNCMP / www.lncmi.cnrs.fr)
the **HIGH FIELD MAGNET LABORATORY** (www.ru.nl/hfml/)
and the **HOCHFELD LABOR DRESDEN** (www.fzd.de/hld)
is May 15th, 2010.

Applications can be done trough an on-line application form on the website: http://www.euromagnet.org from April 15th, 2010.

Scientists of EU countries and Associates States* are entitled to apply under FP7 for financial support according to the rules defined by the EC.
*listed on ftp://ftp.cordis.europa.eu/pub/fp7/docs/third_country_agreements_en.pdf

For further information concerning feasibility and planning, please contact the facility of your choice.

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 on the postdoc level who will pursue their individual research activities and are interested in a strong collaboration with existing Cluster research groups. Fellows benefit from an ideal scientific infrastructure at the Campus Garching and the attractions of the Munich area. The duration for **contract is 2 years**. Fellows receive their **own budget** for 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, certificates (diploma, PhD), 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 e-mail to andreas.mueller@universe-cluster.de. The closing date for receipt of applications is **30 April 2010**.

Contact

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

Westfälische Wilhelms-Universität Münster

Zertifikat seit 2008 audit familiengerechte hochschule

The Institute for Theoretical Physics at the Department of Physics of the Westfälische Wilhelms-University Münster invites applications for a tenured

Professorship in Theoretical Physics - Particle Theory - (salary scale W3)

starting in the winter term of 2010.

The successful candidate should hold a PhD in theoretical physics and should have a strong research and teaching record in the field of quantum field theory or particle theory. The candidate is expected to seek close collaboration with the other theoretical and experimental research groups at the department in the area of particle physics. Teaching obligations include all areas of theoretical physics at the B.Sc. and M.Sc. level. In addition, the successful candidate is expected to participate in the academic administration of the department as well as in the further development of curricula of the B.Sc. and M.Sc. programs as well as graduate programs.

The Westfälische Wilhelms-University Münster is an equal opportunity employer and is committed to raising the proportion of women scientists in academic positions. Consequently, we actively encourage applications from suitably qualified women. Women with the qualifications and disciplinary expertise required will be preferentially considered. We also welcome applications from candidates with severe disabilities who, with suitable qualifications, will be preferentially considered.

Applications with a C.V., including teaching experience and publication list, copies of degree certificates, and a statement of past and future research interests, should be made by **April 30th, 2010** to the Dean of the Faculty of Physics:

Dekan des Fachbereichs 11 (Physik)
Herrn Prof. Dr. Johannes P. Wessels
Wilhelm-Klemm-Str. 9, 48149 Münster, Germany

www.uni-muenster.de

KENT STATE UNIVERSITY

[Job No. 991007]

Tenure Track Faculty Position in Theoretical Physics

Kent Campus, Kent OH

We wish to add support to one of two areas: A) Strong interaction theory related to nuclear matter at high energy density or temperature as typified by experiments such as at RHIC/LHC, or B) Condensed matter theory complementing existing strengths in the department, which include correlated and quantum matter, low temperature physics, and soft matter.

Successful candidates will be expected to teach at the undergraduate and graduate levels and carry out a productive research program that is likely to attract external funding.

Applicants should submit a CV including a list of publications, statements of research and teaching interests, and arrange to have at least three letters of recommendations sent to:

Prof. John Portman, Chair, Theory Faculty Search Committee,
Department of Physics, Kent State University, Kent, Ohio, 44242.
Email: **phystheorysearch@kent.edu.**

Screening of applications will begin February 15, 2010 and continue until the position is filled. Applicants must also fill out an online application at **http://jobs.kent.edu/applicants/Central?quickFind=184625.**

Kent State University is an AA/EEO employer.

Computational Accelerator Physicist

Compact Particle Acceleration Corporation (CPAC) is a start-up company focused on the development of the dielectric-wall accelerator (DWA) and its application to particle therapy and other fields of use. DWA technology will form the basis of a compact, high-gradient particle accelerator that is anticipated to be used in medical, security and defense applications.

CPAC collaborates with TomoTherapy and Lawrence Livermore National Laboratory (LLNL) to optimize the DWA for particle therapy and other applications. CPAC will also work with other commercial partners to develop the DWA for non-medical applications.

CPAC has an opening for a Computational Physicist with broad background in accelerators, beam physics, plasma physics and ion sources. The successful candidate will initially participate in research and development, and design activities for high-gradient compact accelerators for cancer therapy. Particular emphasis will be on modeling accelerator beam dynamics including ion beam extraction from sources and beam transport in the system. The successful candidate will take the initiative in overseeing the integration of the research into prototypes and products. This work will be in collaboration with physicists and engineers at LLNL and elsewhere. The successful candidate will be expected to eventually assume a leadership role within CPAC, independently develop a research program and manage external research and development collaborations.

Qualifications:

- Ph. D. in beam physics or plasma physics or related field or equivalent work experience.
- Strong analytical and computational skills.
- Thorough understanding of high current beam transport, charged beam propagation physics, plasma physics and ion sources.
- Significant experience with computational tools such as Mathematica, Maple or Matlab, and familiarity with particle in cell and beam dynamics codes
- Demonstrated communication skills, both verbal and written, necessary to interact effectively in a diverse team environment, and make effective presentations.
- Ability to work both independently in a goal-oriented environment, and in a large multidisciplinary group; able to balance short term deliverables with long term objectives.
- Must be able to provide concrete evidence of initiative, self motivation, outstanding work ethic, and ownership.
- 10+ years of work experience, with substantial experience in a commercial operation.

If interested in this position, please forward cover letter and resume to **careers@cpac.pro**

SLAC NATIONAL ACCELERATOR LABORATORY

X-Ray Physicist

SLAC National Accelerator Laboratory is one of the world's leading research laboratories in particle physics research. SLAC is now a multipurpose laboratory for astrophysics, photon science, accelerator and particle physics research, and is operated by Stanford University for the U.S. Department of Energy. We currently have an opportunity for an X-Ray Physicist.

Responsibilities:
Employee will be responsible for the design and commissioning of X-ray diagnostics for the LCLS X-ray laser. This will include conceptual design, developing specifications for engineering groups, and performing beam experiments to commission components. Employee will lead research and development efforts to validate the design of unique diagnostics systems. Employee will also contribute to the design of the LCLS upgrades and assist in writing design reports. Employee will be responsible for designing and carrying out beam experiments, including working off shift as needed by the program.

Required Skills:
PhD in physics involving accelerator based X-ray light sources, and at least several years of experience with light sources. Demonstrated ability to lead a Research and Development effort involving accelerators or large scale X-ray systems.

Interested applicants can apply online at:
http://www-public.slac.stanford.edu/hr/jobs/jobdetail.asp?REQID=35239

SLAC is an equal opportunity employer.

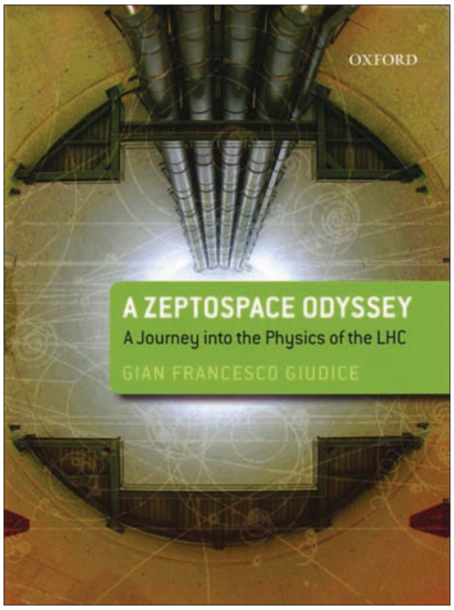
BOOKSHELF

A Zeptospace Odyssey: A Journey into the Physics of the LHC by Gian Francesco Giudice, Oxford University Press. Hardback ISBN 9780199581917, £25 ($45).

If you are of the opinion that working physicists do not care about the history of their discipline or that theorists, like Gian Giudice, have no interest in the details of the experimental machines and detectors, this book will come as a surprise. The same is true if you share the view that it is not possible to describe the frontiers of modern physics – including the most speculative ones – to non-experts in a way that is both faithful and comprehensible. This book does all of that and is enjoyable reading, with the important information that it carries mixed in with many fun facts and anecdotes of all sorts. Not to mention the spot-on explanatory metaphors that are distributed profusely throughout almost every chapter.

One quality of this book is its comprehensive character, with its contents in three approximately equal parts. The first gives a brief but inspired history of particle physics, from J J Thomson's discovery of the electron up to the setting of the Standard Model, without neglecting James Clark Maxwell, quite appropriately, or even Galileo Galilei and Isaac Newton. In the author's words, the expected "results for the LHC" – surely the main inspiration of the book – "cannot be appreciated without some notion of what the particle world looks like". The central section "describes what the LHC is and how it operates" – no more or less than that – in a successful effort to make clear the astonishing technological innovations involved in the LHC enterprise. This is useful reading for everybody, including politicians.

Last but not least, the third section "culminates with an outline of the scientific aims and expectations of the LHC", addressing the central open issues in particle physics and beyond. Here Giudice is also not afraid to venture into the description of interesting theoretical speculations, while always keeping a sober view of the overall subject. "We do not know what lies in zeptospace and the LHC has just started its adventure" is the very last sentence of the book, which I fully support. By the way, "a zeptometre is a billionth of a billionth of a millimetre", not quite but almost the distance that will be explored for the first time by the LHC: hence "zeptospace".



The coming of the LHC is certainly the main inspiration of the book. The awe and excitement brought on by the start of LHC operation exudes from all its pages. But I think there is more to it than that. There is a view of what I like to call "synthetic physics", that is the physics that aims to describe nature, or at least some part of it, in terms of few principles and few equations. In many respects the book pays tribute to "synthetic physics". This is what determines the unity of its style and of its arguments. To whom do I recommend its reading? To everybody, experts or non-experts. I would in particular encourage young people, starting from those who are nearing the end of their high-school studies. I am sure that their efforts will be highly rewarded, not to mention the pleasure they will find. I believe, and I certainly wish, that this book will become required reading for anyone interested in scientific human endeavour, in the reality of our world.

Riccardo Barbieri, Scuola Normale Superiore, Pisa.

Gli anelli del sapere. The Rings of Knowledge by Federico Brunetti (ed.), Editrice Abitare Segesta. Hardback ISBN 9788886116930, €50.

With 350 photographs in about 150 pages, *The Rings of Knowledge* is a beautiful photographic collection interspersed with some text, whose role in putting over the message is almost peripheral. The book is bilingual, English and Italian, and so is aimed at an international audience.

The authors and editor have succeeded in illustrating the Italian contribution to CERN and the LHC. The book particularly emphasizes the role of the Italian National Institute for Nuclear Research (INFN) and its involvement in leading worldwide scientific projects, of which the LHC is the flagship. The pride in contributing to the "LHC era" – as defined by the president of INFN, Roberto Petronzio, in the foreword – sometimes causes the authors to fall into the trap of excessive self-celebration. Statements such as "The LHC could not have been realized without Italy's collaboration" apply equally to many other member states of CERN and could be badly perceived by an international readership.

The most distinctive feature is that Federico Brunetti, the editor, is an architect and photographer from the Industrial Design, Arts and Communication Department of Milan Politecnico. The chapters "The LHC between science and architecture" and "Physics as design" show his astonishment with the "enormous machines", "enormous dimensions", the "never-before-seen extremes of the place". However, they also show that communication is an issue for any specialized discipline, including architecture.

The wording of these chapters is complex and the concepts are described with a sort of jargon that makes reading difficult. In particular, the concept of "beauty" in design and in physics is mentioned several times and in different places but is never really presented in a clear way. This is a pity because it would have been an interesting point to develop in a comprehensible way.

Back to the main point of the book: I

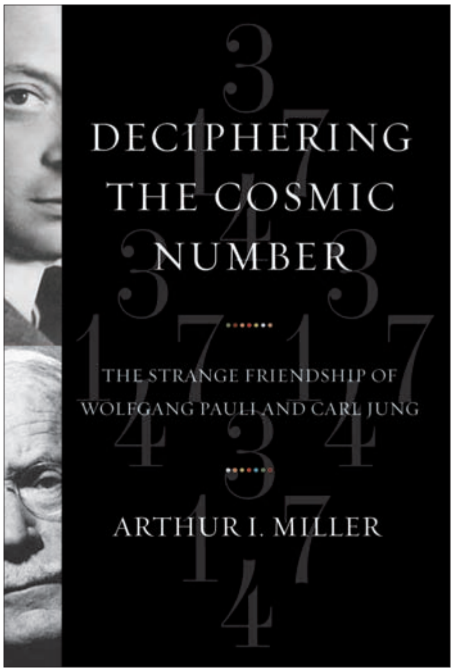
found the photographs really amazing. The square layout is based on Fibonacci's geometric series and shows the link between physics and design. Unfortunately, even this fascinating point is not clearly explained in the text. For example, one caption on page 25 helps the reader's intuition but simpler phrasing would significantly increase the overall enjoyment of the book.
Antonella Del Rosso, CERN.

Deciphering the Cosmic Number: The Strange Friendship of Wolfgang Pauli and Carl Jung by Arthur I Miller, W W Norton. Hardback ISBN 9780393065329, £18.99 ($27.95). Paperback, published as **137: Jung, Pauli, and the Pursuit of a Scientific Obsession**. ISBN 9780393338645, £11.99 ($16.95).

Do you think there is a sense beyond numbers? Do they have any special meaning? Are there some more powerful than others? Many great men throughout the centuries have exercised their minds to find answers to these questions. In his latest book, the distinguished historian of science Arthur I Miller (p17) investigates one of the possible responses in the unique blend of two extraordinary lives, those of Carl Jung and Wolfgang Pauli.

The book tells the story of the fruitful friendship between two of the greatest thinkers of our times, who were obsessed with the power of certain numbers. The two personalities are central to the narrative and the author masters their story with plenty of interesting details that hold our attention with humour. In the course of reading, we sometimes encounter complex physics formulas, but Miller expertly translates them into a refined interpretation that novices can understand.

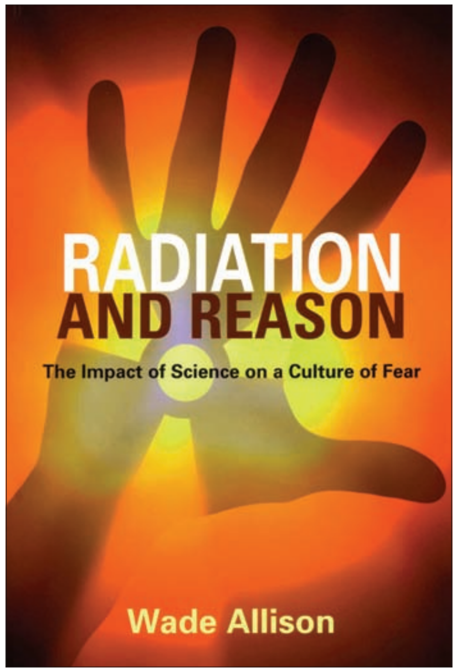
Among the accurate account of the enormous and lasting contributions to their respective fields, such as Pauli's hypothesis of the neutrino in physics and Jung's theory of a collective unconscious in psychoanalysis, we find indeed "the" number: 137. This pure number, the fine structure constant, which to the eyes of a layman may appear harmless and meaningless, was the "step toward the great goal of finding a theory that would unite the domains of relativity and quantum theory, the large and the small, the macrocosm and the microcosm". But it is not only that. Through the unfolding of dreams, mandalas, archetypes and symbols, this number turns out to be the golden gate between rational and emotional, creativity and intelligence, science and belief. This tale provides us with a window across time and space into enlightenments of genius.



Deciphering the Cosmic Number is a revelation of something beyond intuition that compels us to participate in the human torment in those whose lives are marked by the quest to find answers to questions transcending centuries and ages. It describes, looking through a magnifying glass, the lives of two human beings who achieved so much in their fields through a "strange friendship" during the difficult period of the Second World War.
Beatrice Bressan, CERN.

Radiation and Reason: The Impact of Science on a Culture of Fear by Wade Allison, York Publishing Service. Paperback ISBN 9780956275615, £15.

A little more than 20 years ago, Europe witnessed the dramatic accident in the fission reactor at Chernobyl. As international investigations confirmed, the accident was the result of a sinister recklessness whose origin probably lies in the economical collapse of the Soviet Union. That unthinkable accident cast unjustified doubts on the reliability of science and of nuclear technology. As some of us recall, society was pervaded by what Wade Allison at the University of Oxford calls, in his book *Radiation and Reason*, the "culture of fear".



The message of this book is, in a sense, rather provocative and can be summarized as follows: we should not confuse the fear of scientific and technological incompetence (like that leading to the catastrophe of Chernobyl) with the fear of ionizing radiation. However, while the majority of scholars and practitioners would certainly subscribe to the latter statement, not every physicist would concede that the requirements on radiation safety levels are, today, excessively demanding.

With well formulated arguments and plain language, Allison tries to convey the idea that life is far more radiation-hard than present safety requirements actually presume. One joule of deposited energy per kilogram, the gray (Gy), measures the dose absorbed by matter. The sievert (Sv) measures instead the dose absorbed by biological material and it depends on the so-called relative-biological effectiveness of the radiation, which is different for protons, for alpha particles and for gamma rays, for example. How many millisievert (mSv) can the human body tolerate either in one shot or during a whole lifetime? Is it too demanding to set an upper limit of 5 mSv of exposure during the entire life of a human being?

This is just a taste of the intriguing issues discussed in this book, which is not a technical treatise insofar as the author avoids complicated formulas. Still, the absence of technicalities does not prevent a quantitative approach to the main theme, with appropriate graphs, illustrations, diagrams and pie charts. The first four chapters are introductory and could be useful for readers with no background in physical sciences. From the fifth chapter onwards the core of the problem is tackled by starting with the single dose, the multiple dose and some interesting considerations on nuclear energy.

This book should provoke a healthy debate among radiation experts. Physicists and physicians interested in the interplay between science and society will also find in *Radiation and Reason* timely food for thought at a moment when some European countries are revising their energy policies. Despite their necessarily diverse opinions on these delicate themes, readers will probably concur with the general inspiration of the author: one of the few antidotes to the toxin of fear is a healthy Galilean approach – the only way to challenge prejudices is with direct empirical tests.
Massimo Giovannini, CERN and INFN (Milan-Bicocca).

Kann das alles Zufall sein? Geheimnisvolles Universum by Heinz Oberhummer, Ecowin-Verlag. Hardback ISBN 9783902404541, €22 (SFr38.90).

Outreach of science and technology is a big concern of the Austrian astrophysicist Heinz Oberhummer, of the University of Technology in Vienna. Since his retirement in 2006 he lectures regularly in Austrian high schools, has a weekly programme on one of the state's radio channels and leads Austria's participation in the project "Cinema and Science" (www.cisci.net). More exceptionally, he created the "science busters" cabaret (www.sciencebusters.at) to present scientific ideas to people who would not otherwise attend his regular popular-science evenings, fearing that they would be too difficult to follow (an idea triggered by talking to his hairdresser). Given Oberhummer's enthusiasm, it is not surprising that his book *Kann das alles Zufall sein? Geheimnisvolles Universum* (Is it all by chance? Mysterious universe) received the prize for best science book in 2009 awarded by the Austrian Ministry of Science and Research.

The book spans a multitude of astrophysics topics that present our solar system, a tiny whirlpool on the periphery of a bigger one, our galaxy, which is itself an insignificant ring among innumerable other jewels that form larger-scale galaxy clusters to compose "our universe". But the story does not stop there. The concept of "multiverses" is also discussed, including a curious speculation: "The probability is large that in about 100 years' time scientists will look back, concluding that the current decade was the one in which the concept of a universe was superseded by the multiverse." The reader will also learn about how the Sun produces its fuel, how the universe developed and which scientific evidence supports the Big Bang theory. Naturally, the concept of dark matter and dark energy are given deserved prominence, as is the equally puzzling excess of matter with respect to antimatter – no lack of exotic spices to please both the general public and those with a higher level of scientific literacy.

Given his long experience in interacting with interested audiences, Oberhummer does not miss asking some burning questions, such as: "What are the consequences of an asteroid hitting the Earth?", "Why was Pluto denied its status as a planet?", "How heavy would a teaspoon of neutron star be?", or "*Der Urknall: Was hat geknallt?*" ("The Big Bang: what made the bang?"). Equally appealing is his "story of the life of a shining star" and the discussion on whether water has been found anywhere else in our galaxy. While the first three chapters are purely scientific in scope, the last two raise questions of a more "fundamental" nature, including perspectives from philosophy and theology – something that is rarely done in science books. Arriving at the last page, the author does not forget to answer his own cover-page question: Is it all by pure chance?

I found the book interesting. It not only presents facts but discusses many of the latest scientific and conceptual questions, which are certain to stimulate interest among the general public to learn more about this branch of science. And, despite the author's preference for one theory or another, he usually also discusses the other perspectives.
Hermine K Wöhri, Laboratório de Instrumentação e Física Experimental de Partículas, Lisbon.

Books received

Quantum Leap: From Dirac and Feynman, Across the Universe, to Human Body and Mind by Vladimir G Ivancevic and Tijana T Ivancevic, World Scientific. Hardback ISBN 9789812819277, £92 ($166). E-book ISBN 9789812819284, $216.

Starting with both non-mathematical and mathematical preliminaries, this book presents the basics of non-relativistic and relativistic quantum mechanics, as well as non-quantum applications. It then describes the quantum universe in the form of loop quantum gravity and quantum cosmology. Lastly, it turns to the human body and mind, applying quantum theory to electro-muscular stimulation and consciousness.

Foundations of Quantum Chromodynamics: An Introduction to Perturbative Methods in Gauge Theories, 3rd edition, by T Muta, World Scientific. Hardback ISBN 9789812793539, £65 ($86). Paperback ISBN 9789812793546, £41 ($55).

Now in its third edition, this textbook for researchers and graduate students develops the techniques of perturbative QCD in great pedagogical detail, starting with field theory. Apart from extensive treatments of the renormalization group technique, the operator product expansion formalism and their applications to short-distance reactions, it provides a comprehensive introduction to gauge theories. Examples and exercises amplify the discussions on important topics.

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