INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

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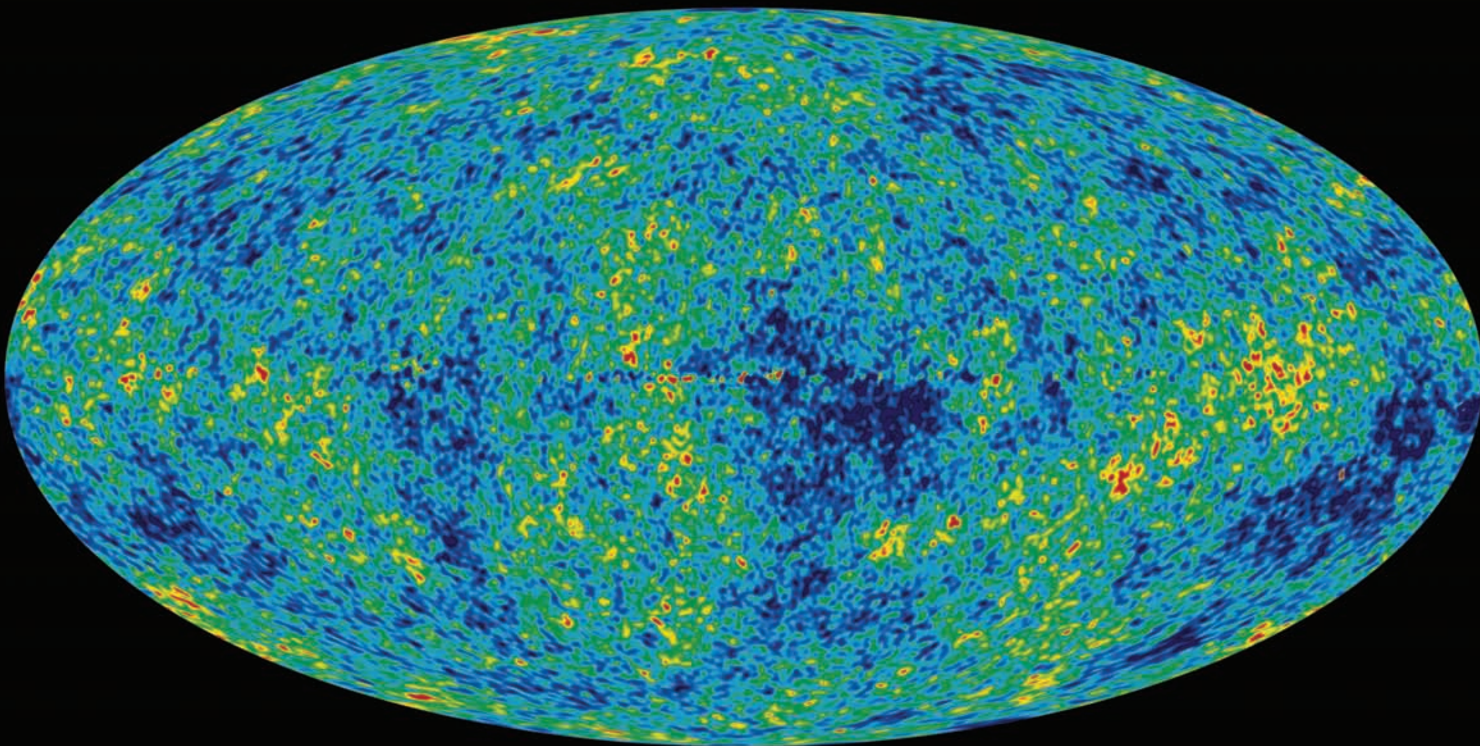

WMAP reveals neutrino background

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It's not just a man's world at the LHC p20

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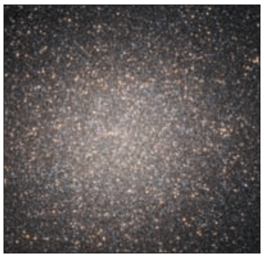

Can you see any black holes? p8

Wolf Singer's passions p17

Accelarator pioneers p36

Cover: The cosmic microwave temperature fluctuations from the 5-year WMAP data seen over the full sky. These latest results from WMAP reveal the contribution of the "cosmic neutrino background" for the first time (p8). Courtesy NASA/WMAP Science Team.

BRUKER

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NEWS

LHC NEWS

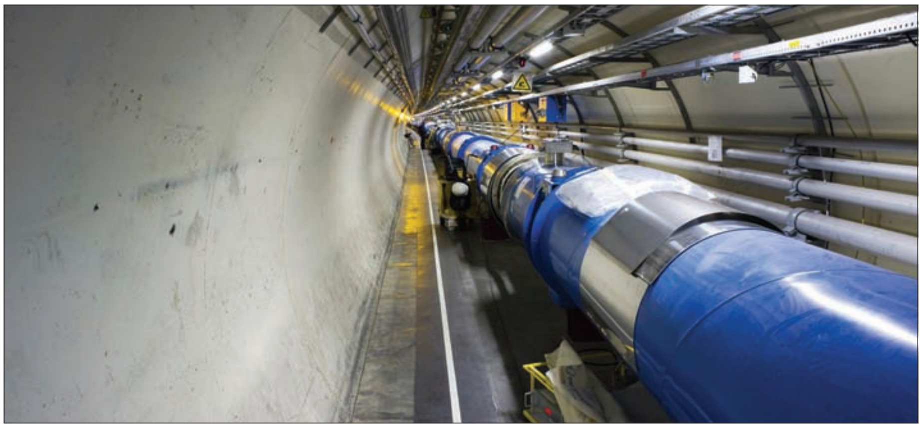
LHC hardware commissioning continues to make solid progress

Commissioning the LHC is making steady progress towards the target of achieving a complete cool down by the middle of June, allowing the first injection of beams soon after. This will come almost exactly 19 years after the start up of LEP, the machine that previously occupied the same tunnel. The LHC's first collisions will follow later.

Half of the LHC ring – between point 5 and point 1 – was below room temperature by the first week of April, with sectors 5-6 and 7-8 fully cooled. The next step for these sectors will be the electrical tests and powering up of the various circuits for the magnets. From late April onwards, every two weeks the LHC commissioning teams will have a new sector cooled to 1.9 K and ready for testing.

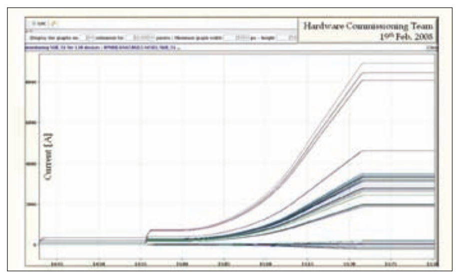
Sector 7-8 was the first to be cooled to 1.9 K in April 2007 (*CERN Courier* May 2007 p5), and the quadrupole circuits in the sector were powered up to 6500 A during the summer. The valuable experience gained here allowed the hardware commissioning team to validate and improve its procedures and tools so that electrical tests on further sectors could be completed faster and more efficiently. Each sector has 200 circuits to test.

The next electrical tests were carried out on sector 4-5 from November 2007 to mid-February 2008. Once the temperature had been stabilized at 1.9 K by the beginning of December, the circuits were powered up to an initial 8.5 kA. The main dipole circuit was then gradually brought up to 10.2 kA during the last week of January 2008, with the main quadrupole circuits reaching 10.8 kA in February. At this current the magnets are capable of guiding a 6 TeV proton beam.



The LHC tunnel between points 1 and 8, one of the sections on its way to 1.9 K at the beginning of April.

During this testing of sector 4-5, however, a number of magnet-training quenches occurred for both dipole and quadrupole circuits. Three dipoles in particular quenched at below 10.3 kA, despite having earlier been tested to the nominal LHC operating current of 11.8 kA. It appears that retraining of some magnets will be necessary, which is likely to take a few more weeks. CERN's management, with the agreement of all of the experiments and after having informed Council at the March session, decided to push for collisions at an energy of around 10 TeV as soon as possible this year, with full commissioning to 14 TeV expected to follow over the winter shutdown. Past experience indicates that commissioning to 10 TeV should be achieved rapidly, with no quenches anticipated.



In electrical tests for sector 4-5 in February, 138 superconducting circuits ramped in unison to a current equivalent to a beam energy of 5.3 TeV.

Sector 5-6 will be the next to cross the 10 kA threshold; electrical tests here began in April. Sector 4-5, meanwhile, was warmed up again to allow mechanics to connect the inner triplet magnets, which were modified after a problem arose during pressure testing last year (*CERN Courier* September 2007 p5).

Sommaire

B PHYSICS

Belle sees a difference in direct CP violation between charged and neutral B decays

The Belle collaboration, working at the KEKB facility at KEK, has observed a difference in the direct CP asymmetry for decays of charged and neutral B mesons into a kaon and a pion. This result is consistent with previous measurements from Belle and BaBar, but is more precise.

Two types of CP violation have previously been observed in two neutral meson systems, the K^0 and B^0. In these, the CP violation arises either in the mixing between the K^0 or B^0 and its antiparticle or – in direct CP violation – in the decay of these neutral mesons. The observed effects in both cases are larger for the B^0 system than for the K^0 system, but they are consistent with the Standard Model and the mechanism for CP violation first proposed by Makoto Kobayashi and Toshihide Maskawa.

Now the Belle collaboration has found that direct CP violation differs between the charged decay $B^{\pm}\to K^{\pm}\pi^0$ and the related neutral decay to $K^{\pm}\pi^{\mp}$. In 535 million $B\overline{B}$ pairs observed at KEKB, Belle found 2241±157 $K^+\pi^-$ and 1856±52 $K^-\pi^+$ events, leading to an asymmetry for $\overline{B}^0\to K^-\pi^+$ versus $B^0\to K^+\pi^-$ of $A_0 = -0.094\pm0.018\pm0.008$, which favours $B^0\to K^+\pi^-$. For the final states expected for the corresponding charged decays the collabroation found 1600+57/−55 $K^{\pm}\pi^0$ events, giving an asymmetry $A_{\pm} = +0.07\pm.03\pm0.01$, with more $K^-\pi^0$ events. The opposite signs of these two asymmetries suggest that different CP violation effects are at work in charged and neutral B mesons.

The causes of this difference in CP asymmetry is uncertain. The large observed deviation might be explained by either strong interaction effects or new physics – specifically a new source of CP violation, something that is needed to explain the domination of matter over antimatter in the universe. To understand whether new physics is indeed involved in $B\to K\pi$ decay, further study of CP violation in other modes is needed. Direct CP violation in $B^0\to K^0\pi^0$ and mixing in the $B_s\overline{B}_s$bar system would be good candidates, but experimental measurements on these systems are not yet precise enough, and much more data are needed. The search for new physics in CP violation will be one of the major goals of the B factory upgrade at KEK as well as other future B physics facilities.

Futher reading

The Belle Collaboration 2008 *Nature* **452** 332.

DETECTORS

Particle physics proves that arsenic didn't kill Napoleon

A meticulous new examination performed at the INFN laboratories in Milano-Bicocca and Pavia in Italy has shown that arsenic poisoning did not kill Napoleon. The researchers demonstrated that there is no evidence of a significant increase in the levels of arsenic in the emperor's hair during the final period of his life.

Physicists performed the study using a small nuclear reactor located at the university in Pavia, which was built for the Cryogenic Underground Observatory for Rare Events (Cuore) experiment. Currently in development at the INFN's National Laboratories in Gran Sasso, the completed Cuore facility will be the most advanced experiment for studying the rare phenomenon of neutrinoless double-beta decay and for measuring neutrino mass.

To examine Napoleon's hair, the team used the technique of neutron activation, which has two important advantages: it does not destroy the sample and it provides extremely precise results, even from samples with a small mass. The researchers placed Napoleon's hair in the core of the nuclear reactor in Pavia and used neutron activation to establish that all of the hair samples contained traces of arsenic. They chose to test for arsenic in particular because various historians have hypothesized that guards poisoned Napoleon during his imprisonment in Saint Helena. A diverse sample of hairs from different periods of Napoleon's life were examined, along with hair samples from people living today, to compare arsenic levels.

The examination produced some surprising results. First, the level of arsenic in all of the hair samples from 200 years ago is 100 times as great as the average level detected in samples from people living today. In other words, people at the beginning of the 19th century evidently ingested arsenic from the environment in quantities that are today considered dangerous. The other surprise is that there was no significant difference in arsenic levels between when Napoleon was a boy and during his final days in Saint Helena. According to the toxicologists who participated in the study, this provides evidence that this was not a case of poisoning, but rather the result of a lifetime's absorption of arsenic.

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.

SCIENCEWATCH

Compiled by Steve Reucroft and John Swain, Northeastern University

Fibre event horizon could test Hawking radiation

You can think of a black hole as an object whose escape velocity is greater than or (in the limit) equal to the speed of light, but what happens if you pick a situation where the speed of light is less than it is *in vacuo*?

Such laboratory analogues of real black holes have long been of interest, and the latest, by Ulf Leonhardt of the University of St Andrews and colleagues, comes closest to providing an analogue of Hawking radiation, which should be emitted at the event horizon of a black hole.

The model is simple and beautiful. A pulse of infrared light is sent down a fibre with a second pulse of longer wavelength and faster light sent in close behind.

The light in the first pulse reduces the local index of refraction of the fibre so that the second one slows down as it approaches, eventually "piling" up and then "sliding back". The system is really closer to a white hole (i.e. a black hole in reverse). However, the strongly varying index of refraction with position should mimic the varying geometry of space–time near a black hole and pull photons out of the vacuum in much the same way that Hawking predicted. Experiments should prove interesting.

Further reading

T G Philbin *et al*. 2008 *Science* **319** 1367.

Sea cucumbers inspire polymer research

Some biological systems such as the sea cucumber can change their stiffness in remarkable ways, and now engineers have figured out how to mimic this in a family of polymer nanocomposites. Christoph Weder of Case Western Reserve University and colleagues, have investigated materials consisting of a rubber-like polymer that contains rigid cellulose nanofibres.

The researchers demonstrated reversible reductions in the tensile modulus by factors of 40 and more in response to chemical changes. Work is now under way to see if the same can be achieved in response to electrical or optical stimuli, which could lead to all sorts of interesting applications. The researchers are interested in biomedical applications, in particular for implants that can record brain activity for use with medical conditions such as Parkinson's disease.

The sea cucumber's ability to change stiffness has inspired research with medical applications. (Courtesy Isabel Poulin/Dreamstime.com.)

Further reading

J R Capadona *Science* **319** 1370.

Compound enables self-cleaning cloth

Clothes that clean themselves could soon be available based on the work by Walid Daoud of Monash University in Churchill, Australia, and colleagues, and at Hong Kong Polytechnic University in Kowloon. The idea is to coat clothing fibres with tiny particles of titanium dioxide, which acts as a catalyst to break down dirt and stains when illuminated with sunlight.

The catalyst will also work, though less well, in ordinary light, and it also inhibits the growth of bacteria.

Ultimately the compound could help to reduce the amount of detergent, energy, and water used in washing clothes.

Further reading:

W A Daoud *et al*. 2008 *Chemistry of Materials* **20** 1242.

The physics of pastis

Pastis, ouzo, absinthe and many others lumped under the rubric "PLBs" (pastis-like beverages) owe most of their cloudiness on mixing with water to the formation of a cloud of droplets of an oily substance, trans-anethol. The anethol, which gives the drink its distinctive flavour, is soluble in the alcohol (ethanol) in the bottled beverage but insoluble in water.

Erik van der Linden of Wageningen University in the Netherlands and colleagues have made a detailed study of "la louche" and found that experiment defies conventional theory. For example, they found that the growth rate of the droplets of oil decreases as the concentration of ethanol increases, in exact contradiction to predictions. Apart from providing something to talk about over a drink, a better understanding of this spontaneous emulsification process could impact on the chemical industry.

Further reading

E Scholten, E van der Linden and H This 2008 *Langmuir* **24** 1701.

Bacteria and snow

Sometimes things that are right under your nose are surprisingly poorly understood. David Sands of Montana State University in Bozeman and colleagues have looked at snow samples from various parts of the world and at various temperatures, and studied ice nucleators of biological origin (i.e. microorganisms that help crystals of ice to form). Despite the fact that such nucleators have been know to exist for nearly 40 years, this new research suggests that they may play a more important role than had ever been imagined.

In particular the group studied biological ice nucleators that are active at temperatures above –10 °C, in places as varied as Antarctica, France and Montana, and discovered that they are common in fresh snow worldwide. The results could have interesting implications for feedback between the biosphere and the climate.

Further reading

B C Christner *et al*. *Science* 2008 **319** 1214.

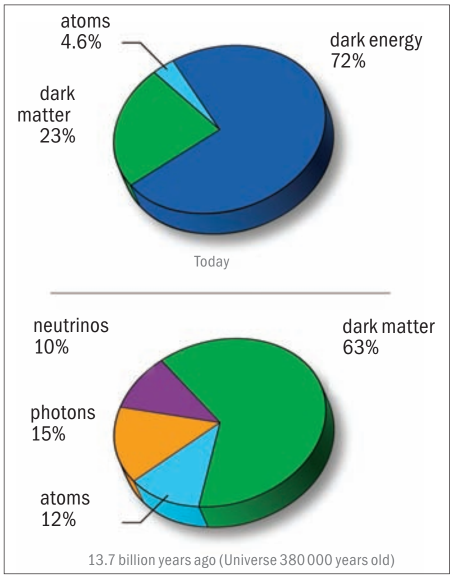
Compiled by Marc Türler, INTEGRAL Science Data Centre and Observatory of Geneva University

WMAP 5-year results reveal neutrinos and tighten inflation

After five years observing the oldest light in the universe, NASA's Wilkinson Microwave Anisotropy Probe (WMAP) is refining our understanding of the universe. It finds evidence for cosmic neutrinos permeating the universe and discriminates models for the burst of expansion in the universe's first fraction of a second.

Each cubic centimetre of space contains about 400 photons from the Cosmic Microwave Background (CMB). They come from all directions in space but from a given time about 380 000 years after the Big Bang. It is the time of decoupling of light and matter making the universe transparent to radiation. The decoupling results from the formation of the first atoms by the combination of electrons and protons. Although the CMB is almost uniform on the sky, its pattern of very small fluctuations in intensity can be analysed to derive the universe's age, composition and development.

The first three years of WMAP data already provided accurate measurements of the main cosmological parameters (*CERN Courier* May 2006 p12). On 7 March the WMAP science team released an update of these results with the addition of two years of data acquisition and improved calibration. The gain in sensitivity – which scales with the square root of observing time – being only a factor 1.3, it is not surprising that the new results do not drastically change the findings published two years ago. They confirm with increased precision the standard model of cosmology. In this so-called ΛCDM model, the present energy content of the universe is dominated by dark energy with an equation of state suggesting a pure cosmological constant ($w = -0.97 \pm 0.06$) and cold dark matter (CDM) of unknown nature. Their contribution to the energy content of the present universe is of 72±2% and 23±1%, respectively, the remaining being essentially "ordinary" baryonic matter accounting for 4.6±0.2%. The contribution from neutrinos is currently less than 1%, but used to be much higher (around 10%) when the CMB light was emitted.



The matter-energy content of the universe as derived from WMAP observations of the cosmic microwave background: 380 000 years after the Big Bang (bottom chart) and today (top chart). Credits: NASA/WMAP Science Team.

The existence with greater than 99.5% confidence of such a "cosmic neutrino background" from the early universe is a new result from WMAP. Its presence influences the fluctuations of the CMB on the smallest angular scales that are now more accurately measured. The second main finding from the new WMAP data is a refined determination of the epoch of reionization of the universe by the first stars found to have occurred at a redshift of $z = 10.8 \pm 1.4$, about 400 million years after the Big Bang. Finally, various possible inflation scenarios are also better constrained now by a more accurate determination of the scalar spectral index found to be $n = 0.960 \pm 0.014$, meaning a small but significant deviation from scale-invariant density fluctuations.

WMAP is still operating and continuously observing the CMB radiation first identified in 1965 by Arno Penzias and Robert Wilson, who were jointly awarded the Nobel Prize in 1978. The breakthrough of WMAP was to show that the content and evolution of the universe can be derived from the CMB with great precision. ESA's Planck mission to be launched at the end of the year shall soon take over and further refine our understanding of the cosmos.

● The quoted values are derived from WMAP data with additional constraints from Type-Ia supernovae and from the large-scale distribution of galaxies.

Further reading:

Papers of the five-year WMAP observations have been submitted to the *Astrophysical Journal* and are available at: http://lambda.gsfc.nasa.gov/product/map/current/map_bibliography.cfm

Picture of the month

Can you see a black hole in this sharp view of Omega Centauri, the largest and brightest globular cluster in the sky? Certainly not, but the measurement of the stellar mass by the Hubble Space Telescope and the velocity of the inner stars by a spectrograph on the Gemini South telescope in Chile show a discrepancy suggesting the presence of a central black hole of 40 000 solar masses. Black holes of such intermediate mass – between stellar-masses in X-ray binaries and a million solar masses and more in active galactic nuclei – are rare and elusive. This finding bridges this gap and reinforces the idea that Omega Centauri is not a real globular cluster like 47 Tucanae (*CERN Courier* July/August 2006 p10), but a dwarf galaxy stripped of its outer stars by earlier encounters with the Milky Way. (Courtesy NASA/ESA/STScI/AURA [The Hubble Heritage Team].)

CERN COURIER ARCHIVE: 1965

A look back to *CERN Courier* vol. 5, May 1965, compiled by Peggie Rimmer

COLLABORATION

CERN Council discusses news from abroad

The CERN Council held its 29th Session on Thursday 25 March, under its President, Mr J H Bannier of the Netherlands. This was a special meeting to review future plans for high-energy physics in Europe. Unfortunately, the decision on the construction of the PS storage rings at CERN had to be postponed, but nevertheless the meeting afforded a useful occasion for a further exchange of views, especially related to the recently published American proposals.

The US Atomic Energy Commission early this year prepared a report on Policy for national action in high-energy physics. This report was submitted to President Johnson, who in turn transmitted it for consideration to the Joint Committee on Atomic Energy of the US Congress.

Prof. Weisskopf, CERN Director General, reported on his participation in the public hearings on the American programme. Although he had been asked to appear in his capacity as an American citizen and Professor at Massachusetts Institute of Technology, it was his experience as Director General of a European organization with international contacts that was of interest to the committee.

The possibility of creating organizations on a larger scale than CERN for the construction of new accelerators was still in the future, but this did not mean that there was no co-operation. In fact, there was already a "world programme" of accelerators: 70 GeV at Serpukhov (say 1967), 200 GeV in the US (1972?), 300 GeV in Europe (1975?) and 800 GeV in the US (1980s). This programme had not been worked out in committee but was simply the result of give and take arising from the mutual consideration of other people's programmes.

A good example was the American decision not to build storage rings at Brookhaven's AGS and as a consequence the proposed storage rings (ISR) at CERN acquired added significance. Already, physicists in the United States had shown interest in participating in the research carried out at the ISR, and CERN was anxious to foster this kind of collaboration. In a similar way, the Russian 70 GeV proton synchrotron at Serpukhov could provide experience for the 200 GeV accelerator in the US and both could be of use to the 300 GeV machine in Europe. Considerable encouragement is given in the report to the interchange of scientists between the various laboratories.

Remarks on high-energy physics in the US AEC Report

High-energy physics is unique and concerns itself with the most fundamental laws governing the constitution of matter and the elementary particles of which matter is constructed. Although the consequences of the discovery and understanding of fundamental physical laws cannot be foreseen at the time they are made, it has been historically true that in the long run these understandings have had a very great impact on science and technology and on all mankind.
Glenn T Seaborg
Chairman, US Atomic Energy Commission

The field of high-energy physics is one of the most exciting and vigorous fields of basic research in the world today. It is also a field requiring the construction and operation of very complicated and expensive accelerators and auxiliary equipment.
Chet Hollifeld, Melvin Price
Joint Committee on Atomic Energy

In attempting to develop long-range plans for high-energy physics, it should be recognized that it is extremely difficult, and perhaps impossible, to blueprint in advance the detailed course of a basic research programme. Progress in basic research as opposed to progress in applied research does not evolve in accordance with an orderly long-range master plan but follows a course which is continually being modified by the impact of the most recent scientific developments.
Introduction to the AEC report

Science knows no national boundaries; this has been especially true of high-energy physics. It seems to me that this is a particularly fruitful field for international collaboration. Large accelerators are available in the United States, in Western Europe, and in the Soviet Union; and the scientific results are made available everywhere. Effective international co-operation and collaboration can advance not only science but can show the way to greater international understanding.
Lyndon B Johnson
President, US

● Compiled from the articles on pp69–73.

COMPILER'S NOTE

Government funding is vital for research in fields like high-energy physics and astrophysics. If these kinds of investigations are to continue, so must the funding. After half a century of widening collaboration as the scale and cost of projects increased, there is now concern about how to sustain international research programmes in these and similar fields (CERN Courier March 2008 p42 and April 2008 p6).

Progress in applied research requires progress in basic research. The website www.weburbia.com/pg/historia.htm gives a comprehensive timeline of discoveries in natural science, from the theorems of the Greek philosophers to the hypotheses of string theorists via latent heat and the ionosphere. Cut off "funding" at any year in the sequence and consider what might have been the consequences.

Ongoing knowledge acquisition should be a strong argument for ongoing government funding. President Johnson also made the observation that effective international co-operation in science can show the way to greater international understanding, something the world continues to need.

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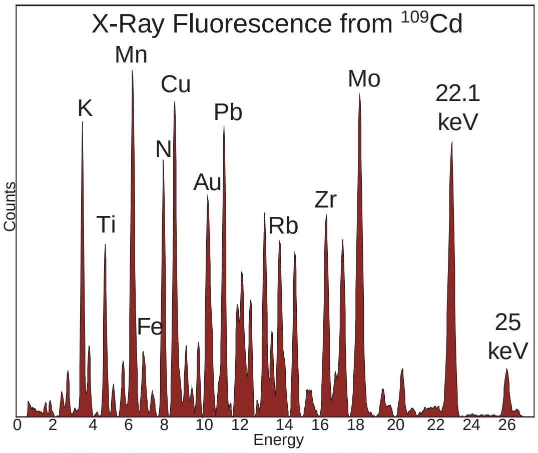

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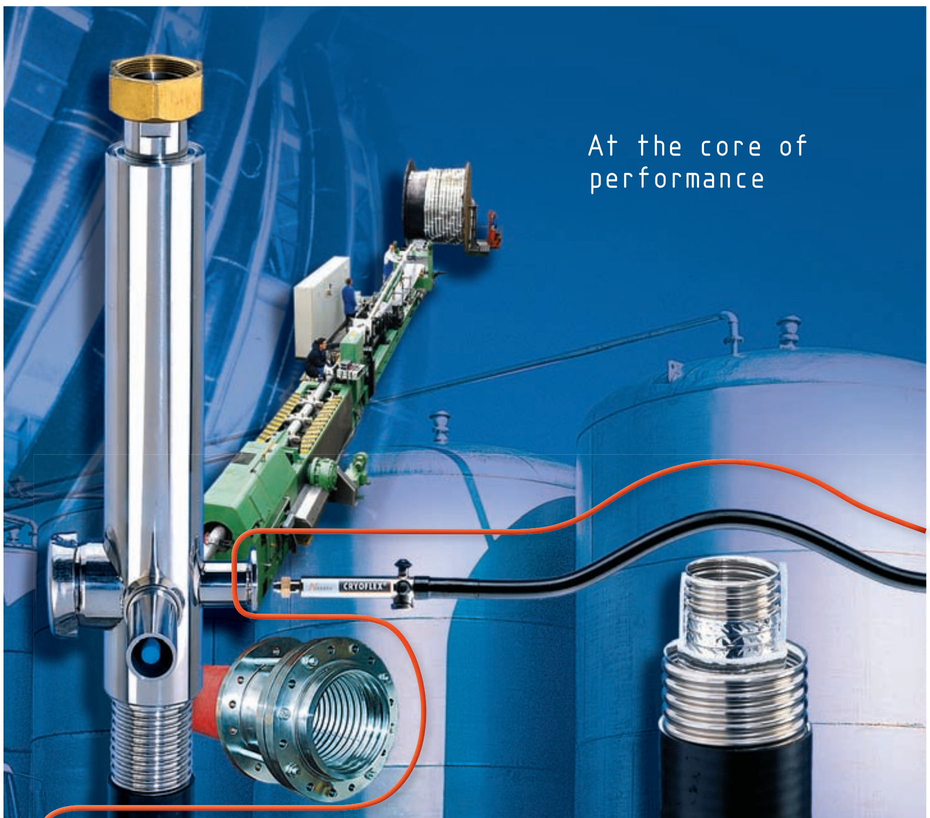

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The founding fathers of the Helmholtz Alliance Physics at the Terascale gathered at their constituting meeting last year. (Courtesy Helmholtz Alliance.)

Terascale Alliance takes off in Germany

A groundbreaking new funding scheme is strengthening German particle-physics research and is radically changing the working lives of physicists for the better.

The next big advances in particle physics are expected to happen at the "terascale". The tremendous complexity and size of experiments at the LHC and the proposed International Linear Collider (ILC) challenge the way that physicists have traditionally worked in high-energy physics. The German project Physics at the Terascale – a Helmholtz Alliance that will receive €25 m over five years from Germany's largest organization of research centres, the Helmholtz Association – will address these challenges.

The Alliance bundles and enhances resources at 17 German universities, two Helmholtz Centres (the Forschungszentrum Karlsruhe and DESY) and at the Max Planck Institute for Physics in Munich. It focuses on the creation of a first-class research infrastructure and complements the existing funding mechanisms in Germany at local and federal level. With the help of the new project, central infrastructures are developed and are shared among all Alliance members. The Alliance will fund many of these measures for the first few years. From the beginning, a central point of the proposal has been that the long-term future of these activities is guaranteed by the universities and the research centres beyond the running period of the Alliance funds.

The Alliance supports four well defined research topics (physics analysis, Grid computing, detector science and accelerators) and a number of central "backbone" activities, such as fellowships, interim professorships, communication and management.

Close-knit infrastructure

What is new about this common infrastructure? Previously, each of these institutes developed their infrastructure and expertise for their own purposes. Now, triggered by the Alliance, different institutes share their resources. Common infrastructures are developed and are made available to all physicists in Germany working on terascale physics. For example, this means that if PhD student Jenny Boek of Wuppertal wants to develop a chip for slow controls, she can now use the infrastructure and take advantage of the expertise in chip design in Bonn.

These central infrastructures can be concrete installations – like a chip development and design laboratory, located at a specific location – or virtual ones, like the National Analysis Facility, which ▷

will help all LHC groups in Germany to participate more efficiently in the analysis of data from the LHC. Common to all of these is that these infrastructures are open to all members of the Alliance, and are initially funded through it.

An important goal of the Alliance is to organize interactions between the different experimental groups and between the experiment and theory communities on all topics of interest for physics analysis at the terascale. This includes meetings and the formation of working groups with members from all interested communities, the organization of schools and other common activities. It can also mean basic services, such as the design and maintenance of Monte Carlo generators, or include exchanges on the underlying theoretical models. In all of these studies, while the focus is initially on the LHC, the role of the ILC will also feature as a future facility of key importance in the field.

In the same spirit, Alliance funds are used to improve the Grid infrastructure significantly in Germany, to serve the global computing needs of the LHC as well as the specific requirements of German physicists to contribute to the data analysis. Funds are provided to supplement the existing Tier-2 structure in Germany by building up Tier-2s at several universities, and to support the National Analysis Facility at DESY. Additional money is provided to allow for significant contributions to improve Grid technologies with the emphasis on making the Grid easier for the general user.

The third research topic, detector development, involves plans for the future beyond the immediate data flow from the LHC. Institutes are already developing next-generation detectors for the ILC and for LHC upgrades. A Virtual Laboratory for Detector Development will provide central infrastructures to support the different groups for these projects. A number of universities and DESY are setting up infrastructures with special emphasis on chip design, irradiation facilities, test beams and engineering support. Again, although these facilities are at specific locations, they serve the whole community.

Fostering young talent

The Alliance also wants to increase the involvement of universities in accelerator research in Germany. Through a number of programmes – for example a school for students on accelerator science or lectures at universities – the Alliance tries to increase the involvement of universities in accelerator research over the long term. Rolf Heuer of DESY, one of the initiators of the project, explains the motivation: "Germany led the way to the TESLA technology collaboration and its success, and we want to stay at the forefront of accelerator development. Without it, progress in many areas of science will not be possible."

A substantial part of the Alliance's funding goes into the creation of more than 50 positions for young scientists and engineers all over Germany. The five Alliance Young Investigators groups and the Alliance fellowships play a special role: they are supposed to attract young physics talents from all over the world to Germany and to the terascale. Many of these positions are tenure-track, something quite rare in Germany. In addition, positions are created to support the infrastructure activities, to set up the central tasks and support the work of the Alliance. More than 250 people have already applied for the new positions over the last eight months.

A significant fraction of the accepted applications are from women. This is in accordance with the Alliance's aim to enhance the role of women in physics. One way to attract smart and ambitious young people to the German research landscape is the dual career option – the Alliance pays half a salary for the partner to work at the same institution. So when Karina Williams, now in the final year of her particle physics phenomenology PhD at Durham University in the UK, applied for postdoctorate positions, she made sure that the places where she applied would also have a job for her partner. It worked out at Bonn University, where she and her partner start later this year. "I think it's wonderful that schemes like this exist," she says. "I know so many people who have either had to put up with very long-distance relationships or left the subject because their partner could not get a job nearby. When I first started applying for jobs, I was told that long-distance relationships were just part of the postdoc life."

Centralized community

DESY plays a special role within the Alliance. It provides unique and basic infrastructures for accelerator research, as well as large-scale engineering support for detector research. This is a tradition that goes back to when DESY ran accelerators for high-energy physics. A new role for DESY is to host central services for the German physics community to support physics analysis in Germany. One of these services is the Analysis Centre, where research will focus on areas of general interest, which are often emphasised less at universities. Examples of these topics are statistical tools or parton distribution functions, where the Alliance will profit from the outstanding expertise at DESY from HERA. Of course it is not only R&D that researchers at the Analysis Centre will pursue; another purpose is to form a kind of helpdesk to answer questions and offer help in organizing topical workshops. Expanding on its role as an LHC Tier-2 centre, DESY is also setting up the National Analysis Facility, a large-scale computer installation to support the user analysis of LHC data. The first processors are already installed in DESY's computing centre, providing fast computing power for efficient analyses by German LHC groups.

Another example of "central services" – like Alliance fellowships, equal opportunity measures or dual career options – is a "scientist replacement" programme. The goal of scientist replacement is to enable senior professors to take up roles of responsibility at the LHC experiments by sponsoring junior professors to replace them at university. Karl Jakobs is physics coordinator at ATLAS and a part-time bachelor. His home and family are in Freiburg in southern Germany, but he has had a flat in Saint Genis-Pouilly near CERN since October last year and a great deal of long-term responsibility within the experiment – something that would have been impossible less than a year ago. Now the Alliance is funding his replacement in Freiburg. In this way, German particle physicists can play leading roles in current and future experiments more easily. This may sound like a trivial thing – but all German professors are obliged both to do research and to teach, binding them to their university and only releasing them during breaks and the occasional half-year sabbatical. Jakobs' classes are currently, until the end of the summer, being taught by Philip Bechtle from DESY. Another example is Ian Brock, scientific manager of the Alliance, whose replacement during his leave of absence from Bonn University is paid for and provided by the Alliance.

The Alliance was officially approved in May last year, funding started in July, and it is already a prominent part of the German

Schools like the Terascale Accelerator School should cement Germany's position at the forefront of accelerator development. (Courtesy DESY.)

Physics at the Terascale

PHYSICS AT THE TERA SCALE Helmholtz Alliance

Coordinated by DESY and funded by the Helmholtz research association, the Helmholtz Alliance "Physics at the Terascale" has 20 partners: three research centres (DESY, Forschungszentrum Karlsruhe and the Max Planck Institute for Physics in Munich) and 17 universities (Rheinisch-Westfälische Technische Hochschule Aachen, Humboldt-Universität Berlin, Rheinische Friedrich-Wilhelms Universität Bonn, Universität Dortmund, Technische Universität Dresden, Albert-Ludwigs Universität Freiburg, Justus-Liebig Universität Giessen, Georg-August Universität Göttingen, Universität Hamburg, Ruprecht-Karls Universität Heidelberg, Universität Karlsruhe (TH), Johannes Gutenberg Universität Mainz, Ludwig-Maximilians Universität München, Universität Rostock, Universität Siegen, Julius-Maximilians Universität Würzburg, Bergische Universität Wuppertal). This means that all universities and research institutions in Germany that work on physics at the terascale are part of the Helmholtz Alliance.

Helmholtz Alliances are a new instrument to foster collaboration between research centres and universities with strong emphasis on lean and efficient management, future generations of scientists and the strategic placement of Helmholtz centres in a successful and sustainable research landscape in Germany. The Terascale proposal, conceived and driven by DESY research director Rolf Heuer, was just right. "It is a model for a future-oriented and sustainable network of expertise. The selection committee unanimously and enthusiastically approved the proposal," said Jürgen Mlynek, president of the Helmholtz Association, in a press release issued by the Alliance partners.

The Helmholtz Alliance has two scientific coordinators (Peter Mättig from Wuppertal and Ties Behnke from DESY) and a scientific manager (Ian Brock from Bonn), as well as a management and an international advisory board. Project boards oversee the four research topics. It will receive €25 m of funding over the next five years.

landscape of particle physics. It had an impressive start and most of the structures of the Alliance have begun working intensively. A major event was the "kick-off" workshop at DESY in December. With 354 registered participants (many of them undergraduate, graduate and PhD students), a large part of the German high-energy physics community was there. The workshop proved a great opportunity for young particle physicists to get to know each other and exchange ideas: Terascale gives them a backbone structure that they will now fill with content.

The Alliance is already changing the way particle physics is done in Germany. The main idea is to establish cooperation among the different pillars of German research in particle physics. Expertise, which is scattered around many different places, is being combined to become more efficient. As Heuer explains: "The Alliance strengthens R&D on LHC physics in Germany, pushes for accelerator physics and prepares for the ILC. It is our hope that this helps in the worldwide effort to unravel the basic structure of matter and to understand how the universe has developed."

Jakobs, meanwhile, is happy to benefit from the arrangement at CERN. "Everything is happening here. You cannot be physics coordinator and not be stationed at CERN. There are regular meetings, you talk to people all the time, watch their progress and coordinate to optimize." As physics coordinator he has to make sure that all ATLAS people who work on Higgs analysis and other special topics work together in a coherent way. There is a complicated sub-group structure and all simulations and data have to be perfectly understood. ▷

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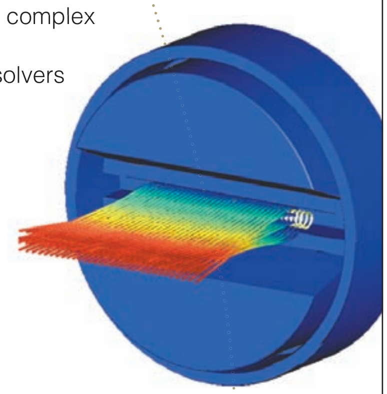

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Funding high-energy physics in Germany

The new tool of the Helmholtz Alliance complements the funding structures for high-energy physics research in Germany by allowing groups to fund nationwide infrastructure measures not exclusively bound to a national laboratory.

Research in high-energy physics is traditionally funded from several sources. German universities receive their funds from the federal states in Germany, which provide the basic infrastructure to research groups and pay the professors and a small number of staff members. The federal government contributes significant funds to national laboratories like DESY and funds the German participation in international research centres like CERN. If the research is done at one of these laboratories, university groups can seek additional funds from the federal government. In a competitive and selective process, the German Ministry of Education and Research (BMBF) distributes research money to university groups to participate in major projects like the LHC.

The research work is organized in so-called BMBF research centres or FSPs (Forschungsschwerpunkte), one for each of the major LHC experiments where German groups are involved. The ATLAS and CMS FSPs complement the efforts of the Alliance. In addition, individuals can receive support from the German Science Foundation, which supports young researchers or smaller-scale R&D projects for example.

"The good thing is that after my job here, I will be able to return to Freiburg with a clear conscience and spend a lot of time analysing the data I helped to prepare," he explains. "Administration, teaching, funding proposals, forms and management – all that takes time at home. It is a great luxury to be able to concentrate on one thing only here: pure physics."

● For more information about Physics at the Terascale, see www.terascale.de. For further information about the Helmholtz research association, see www.helmholtz.de/en.

Résumé

La physique à l'échelle du téra

La dimension et l'extrême complexité des expériences du LHC ainsi que du projet de Collisionneur linéaire international amènent à remettre en cause la façon dont travaillent traditionnellement les physiciens en physique des hautes énergies. Le projet allemand « La physique à l'échelle du téra », financé pour les cinq prochaines années à hauteur de 25 millions d'euros par la plus grande organisation de recherche du pays, l'association Helmholtz, veut répondre à cette nécessité. Le projet a été officiellement approuvé en mai dernier, et, après un démarrage fulgurant, il occupe une place de choix dans les programmes de la physique des particules en Allemagne. Il a déjà commencé à changer certains aspects du travail dans la discipline en Allemagne.

Ties Behnke, *DESY*, **Ian Brock**, *Bonn*, **Peter Mättig**, *Wuppertal*, *and* **Barbara Warmbein**, *DESY*.

Reflections offer new way to bend particles

A move from channelling to reflection of particle beams in bent crystals is not only opening opportunities for applications in accelerators but also, perhaps, in outer space.

Channelling of particles by the arrangement of atoms in crystals has been known for many decades. The effect is nowadays used in accelerators to steer high-energy beams, which are guided by the strong coherent electric field arising from the nuclear charges in bent crystals (*CERN Courier* January/February 2006 p37). Some 20 years ago, Alexander Taratin and S A Vorobiev predicted that the coherent field of a bent crystal could also reflect particles through small angles (Taratin and Vorobiev 1987). It was only in 2006, however, that experiments with 1 GeV and 70 GeV protons made the first observation and measurement of this "volume reflection" effect (Ivanov *et al*. 2006). A year later, a team at CERN's SPS reported a nice demonstration of the effect with 400 GeV protons (*CERN Courier* June 2007 p8).

These studies have found that the range of entrance angles over which ions undergo volume reflection can be much greater than the critical angle of channelling. Furthermore, the experiment at the SPS showed that the probability of reflection far exceeds that of channelling. It is still less than 100%, however, because some particles "stick" to the atomic planes instead of bouncing back – because incoherent scattering (volume capture) traps them into channelled states.

A single-volume reflection at the energy of the SPS is of the order of 14 μrad. It is possible to obtain greater deflection by reflecting the particles from several bent-crystal layers, as figure 1 indicates. This leads to a multiple-volume reflection (MVR) angle that increases in proportion to the number of layers (Taratin and Scandale 2007, Breese and Biryukov 2007). One experimental limitation is that some particles are volume captured with every reflection, therefore reducing the number of reflected particles linearly with the number of reflections, N.

Computer simulations have shown two ways to overcome this limitation and increase the reflection efficiency to remarkably high values (Biryukov and Breese 2007). One way is to arrange each subsequent bent layer to reflect the complete distribution of particles passing through the layer above, including the tail of volume-captured particles. Simulations show that, in this case, the MVR angle grows linearly with N, while the efficiency remains constant, limited mainly by the volume capture in the last layer. The second way to increase reflection efficiency is to suppress the volume-capture process itself. The volume-captured particles occupy the top of the potential well and are easily affected by variations in the crystal curvature – an effect already known from experiments at 70 GeV and from theory. To suppress fully the few per cent probability of volume capture observed in single-volume reflection, the curvature should vary significantly over the length of the crystal so that it quickly releases most of the volume-captured particles.

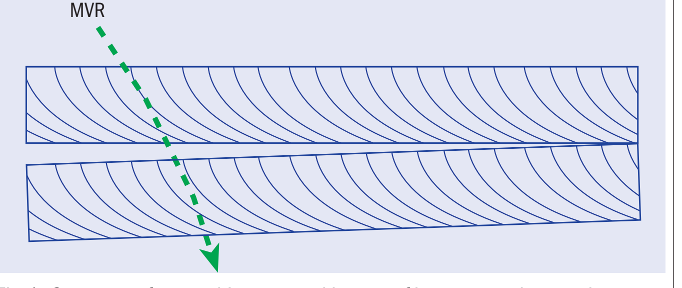

Fig.1. Geometry for stacking several layers of bent crystals together to produce multiple volume reflection (MVR) .

Computer studies of 7 TeV protons show that the rate of volume capture is suppressed by a factor of 20 in a silicon crystal, in which the curvature varies by 40% along its length compared to the same crystal with a constant curvature. Figure 2 (p16) shows a 7 TeV proton beam bent through an angle of about 40 μrad, which could serve well for collimation purposes at the LHC. Here, a structure comprising 20 (110) layers of silicon, each bent through 65 μrad with a radius of 50 m, has deflected 7 TeV protons with an efficiency of 99.95%. This efficiency level by far outperforms the capabilities of channelling in crystals and the angular acceptance of this structure is 65 μrad, which is around 20 times greater than the acceptance of bent-crystal channelling. Such perfect deflection efficiency over a broad angular acceptance makes MVR ideal for collimation.

The near-100% deflection efficiency obtained in the single encounter of a particle with the multilayered structure may be important in many types of accelerators, including linear machines (such as a future International Linear Collider), machines with a short beam lifetime (such as muon or short-cycle machines) and in high-intensity beams with a fast-developing instability. The possibility of an efficiency of close to 100% makes MVR attractive for high-intensity beam applications, where beam losses usually rule out the use of bent-crystal channelling. ▷

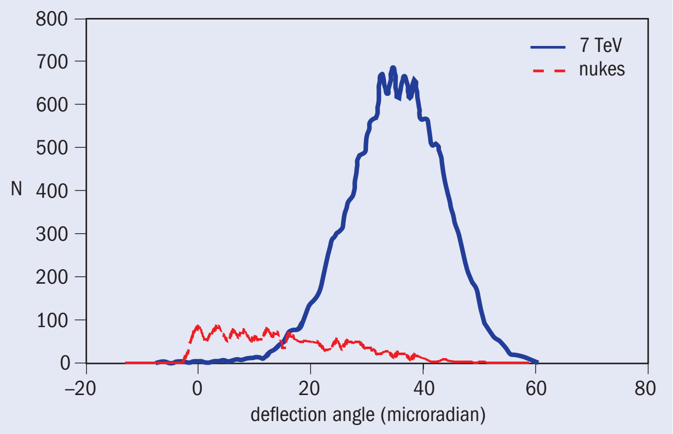

Fig.2. Angular distribution of the protons that are volume reflected (7 TeV) and of those that have interacted ("nukes") in a 20-layer Si (110) crystal.

At an energy of 7 TeV, the crystal material along the beam direction in this example becomes as long as 6.5 cm. Some protons undergo inelastic nuclear interactions in the crystal layers. Figure 2 shows the deflection angle for these protons at the moment of nuclear interaction. On average they are bent by half the bending angle of non-interacting protons, with a bending efficiency of a remarkably high 95%. This is different behaviour compared to both an amorphous target and to bent-crystal channelling, where the products of nuclear interactions move in a forward direction. When using MVR for collimation, not only are the primary particles bent towards an absorber but the debris of the particles that have interacted with the crystal nuclei are also bent towards an absorber with high efficiency.

MVR also provides an attractive mechanism for a space shield that can deflect ions with energies of mega- or giga-electron volts per nucleon. Here, highly efficient deflection over a range of entrance angles at high energies is of paramount importance for the design of a space shield for radiation protection that is based on curved crystals. Such a bent-crystal shield was recently proposed for deflecting cosmic-radiation ions of all atomic numbers away from spacecraft (Breese 2007). A team at the National University of Singapore fabricated a bent-crystal shield with a surface area of 1 × 1 cm^2 that is capable of deflecting ions with energies of up to 100 GeV/nucleon. Figure 3 shows the simulated results of the crystal shield protecting a spacecraft from high-energy ions approaching from a single direction. This adds yet another link between the microcosm of a particle-physics laboratory and the macrocosm of space travel.

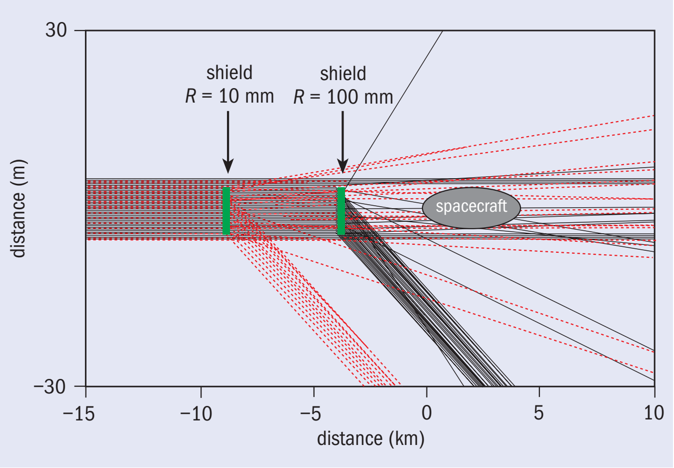

Fig.3. Simulation for two shields with R = 10 mm and R = 100 mm deflecting iron ions approaching from the left, with energies of 200 MeV/nucleon (red) and 2 GeV/nucleon (black). The shields are located 5 km and 10 km to the left of the spacecraft, with surface areas of 10 × 10 m^2, slightly larger than the cross section of the spacecraft.

Further reading

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Résumé

La réflexion pour courber la trajectoire des particules

Passer de la canalisation des faisceaux de particules à la réflexion dans des cristaux courbés ouvre la voie à des applications intéressantes, non seulement pour les accélérateurs, mais aussi pour l'exploration de l'espace. La technique consistant à canaliser les particules en utilisant la disposition des atomes dans les cristaux est connue depuis des décennies. Elle est aujourd'hui utilisée dans les accélérateurs pour diriger des faisceaux de haute énergie. Or le champ électrique cohérent dû aux charges des noyaux dans un cristal courbé peut aussi produire une réflexion des particules selon des petits angles. Les études montrent que, non seulement la probabilité d'une réflexion excède celle d'une canalisation, mais que, dans le cas d'une réflexion l'acceptance angulaire est plus grande, y compris dans une structure comportant plusieurs couches de cristaux courbés.

V M Biryukov, *Institute for High Energy Physics, Protvino, and* **M B H Breese**, *National University of Singapore.*

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Neuroscience explores our internal universe

During a visit to CERN, eminent neuroscientist **Wolf Singer** talked with **Carolyn Lee** about his research into the mysteries of the brain and also his passion for communication.

Neuroscientist Wolf Singer engages the audience at CERN during his colloquium on "The brain, an orchestra without conductor".

When physicists at CERN try to understand the basic building blocks of the universe, they build gigantic detectors – complex, intricately wired instruments that are capable of measuring and identifying hundreds of particles with extraordinary precision. In a sense, they build "brains" to analyse the particle interactions. For prominent neuroscientist Wolf Singer, director of the Max Planck Institute for Brain Research in Frankfurt, the challenge is quite the opposite. He and other researchers are trying to decode the dynamics of a mass of intricate "wiring", with as many as 10^{11} neurons connected by 10^{14} "wires". The brain is the most complex living system, and neuroscientists are only beginning to unravel its secrets.

Until recently, according to Singer, the technical tools available to neuroscientists were rather primitive. "Until a decade ago, most researchers in electrophysiology used handmade electrodes – either of glass tubes or microwires – to record the activity of a single element in this complex system," explained Singer. "The responses were studied in a meticulous way and it was hoped that a greater understanding would arise of how the brain works. It was believed that a central entity was the source of our consciousness, where decisions are made and actions are initiated. We have now learned that the system isn't built the way we thought – it is actually a highly distributed system with no central coordinator."

Myriads of processes occur simultaneously in the brain, computing partial results. There is no place in this system where all of the partial results come together to be interpreted coherently. The fragments are all cross-connected and researchers are only now discovering the blueprint of this circuitry.

This mechanism poses some new and interesting problems that have intrigued Singer for many years. How is it possible for the partial results that are distributed in the brain to be bound together in dynamical states, even though they never meet at any physical location? Singer gives the example of looking at a barking dog. When this happens, all 30 areas of the cerebral cortex that deal with visual information are activated. Some of these areas are interested in colour, some in texture, others in motion and still others in spatial relations. All of these areas are simultaneously active, processing various signals and applying memory-based knowledge in order to perceive a coherent object. A tag is needed in this distributed system at a given moment of time so as to distinguish between the myriads of neurons activated by a particular object or situation, and those activated by simultaneous background stimuli. In 1986 Singer discovered that neurons engage in synchronized oscillatory activity. His hypothesis is that the nervous system uses synchronization to communicate.

Singer stresses that researchers in his field are closer to theorists in high-energy physics, because the tools necessary to decode the large amount of data generated by the brain's activity do not exist ▷

yet. "This morning when I toured the ATLAS experiment, I heard how the data generated at the collision point is much richer, but physicists use filters to extract the most interesting data, which they formulate in highly educated ways," said Singer. "The amount of data generated by the sensory organs is more than the brain could digest, so it reduces redundancy. Due to this enormous amount of data, the brain, by evolution, developed a way to filter it all. The most important information for us is based on survival, such as where food can be found or how our partners look."

Brain function and communication

Singer began his career as a medical student at the Ludwig Maximilian University in 1962 in his hometown of Munich. He was inspired to specialize in neuroscience after attending a seminar by Paul Matussek and Otto Creutzfeldt, who discussed schizophrenia and "split brain" patients. After his postgraduate studies in psychophysics and animal behaviour at the University of Sussex, he worked on the staff of the Department of Neurophysiology at the Max Planck Institute for Psychiatry in Munich and completed his Habilitation in physiology at the Technical University of Munich. In 1981 he was appointed director at the Max Planck Institute for Brain Research in Frankfurt and in 2004 he co-founded the Frankfurt Institute for Advanced Studies.

The 20th century brought many advances in fundamental physics, including the discovery of elementary particles. During this same period, neuroscience provided greater illumination of the brain's functions. One of the most significant is the identification of individual nerve cells and their connections by Camillo Golgi and Santiago Ramón y Cajal, winners of the Nobel Prize for Medicine in 1906. Another important advance was the introduction of the discontinuity theory, which regards neurons as isolated cells that transmit chemical signals to each other. This understanding allowed neuroscientists to determine the way in which the brain communicates with other parts of itself and the rest of the body.

Some of the results of the first studies of the relationships between function and the different areas of the brain were made using patients injured during the First World War. Later, with the discovery of magnetic imaging to study brain function, researchers were able to turn to non-invasive methods, but there is still much more development needed. With procedures such as magnetic resonance imaging, a neurologist can find out where a signal originates; but the signal is indirect, coming from the more oxygenated areas. A magnetic field of 3 T applied to an area of a square millimetre can show which part of the brain is activated (e.g. by emotions and pain) and reveal the various networks along which the signals travel.

At the same time, neuroscientists are trying to decode the system and explain how biophysical processes can produce what is experienced in a non-material way – a meta-to-mind kind of riddle – with new entities and the creation of social realities such as sympathy and empathy. This is leading to a new branch of neuroscience, known as social neuroscience.

In other research, colleagues of Singer are studying the effects of meditation on the brain. They found that it creates a huge change in brain activity. It increases synchronization and is in fact a highly active state, which explains why it cannot be achieved by immature brains, such as in small children. Buddhist monks use their attention to focus the "inner eye" on their emotional outlet and so cleanse their platform of consciousness. In 2005 Singer attended the annual meeting for the Society of Neuroscience in Washington, DC, together with the Dalai Lama. Their meeting resulted in discussions about the synchronization of certain brain waves when the mind is highly focused or in a state of meditation.

Singer is also no stranger to controversy. His ideas about how some of the results of brain research could have an impact on legal systems caused a sensation in 2004. His theory that free will is merely an illusion is based on converging evidence from neurobiological investigations in animals and humans. He states that in neurobiology the way in which someone reacts to events is something that he or she could not have done much differently. "In everyday conditions the system is deterministic and you want your system to function reliably. The system is so complex and we are constantly learning new things," explained Singer. There are many factors that determine how free someone is in their will and thinking. Someone could have false wiring in the part of the brain that deals with moral actions, or perhaps does not store values properly in their brain, or could have a chemical imbalance. All of these biological factors contribute to how someone reacts in a given situation.

Singer feels strongly that the general public should be aware of what scientists are working on and that enlightenment is essential. "Science should be a cultural activity," he said, adding that in society the people who are considered "cultured" generally are knowledgeable in art, music, languages and literature, but not well versed in mathematics and science.

In 2003 he received the Communicator Prize of the Donors' Association for the Promotion of Sciences and Humanities and the Deutsche Forschungsgemeinschaft in Germany. Communicating his passion to the young has been a challenging and yet highly rewarding experience. He works to engage society in discussions about the research in his field, providing greater transparency and comprehension. His dedication to improving communication between scientists and schools is evident in the programme that he has initiated: Building Bridges – Bringing Science into Schools. This creates a stronger dialogue between scientists, students and teachers.

● For Wolf Singer's colloquium at CERN, "The brain, an orchestra without conductor", see http://indico.cern.ch/conferenceDisplay.py?confId=26835.

Résumé

Les neurosciences explorent notre univers intérieur

Wolf Singer est un éminent spécialiste des neurosciences. Il est directeur de l'Institut Max-Planck pour la recherche sur le cerveau de Francfort et il est très soucieux de communication. À l'inverse des physiciens du CERN, qui construisent des détecteurs au câblage très complexe pour étudier les collisions de particules, Singer, avec ses collègues, essaye de décoder la dynamique du «câblage» du cerveau, où quelque 10^{11} neurones sont reliés par 10^{14} «fils». De plus, la recherche montre à présent que l'ensemble constitue un système très réparti sans gestion centrale. À l'occasion d'une visite au CERN, Singer évoque avec Carolyn Lee ses recherches sur les mystères du cerveau, et sa passion pour la communication.

Carolyn Lee, *CERN.*

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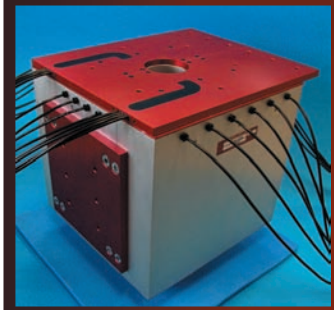

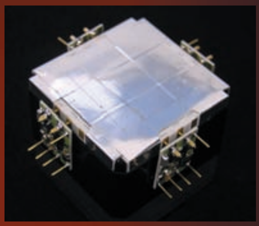

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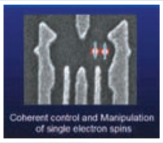

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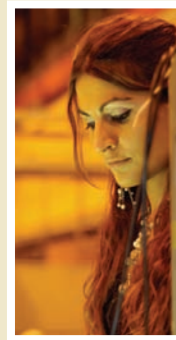


The Large Hadron Collide

Paola Catapano went in search of some of the women working on the LHC project, to find out about their work at CERN and talk about life in a mainly male environment.

In particle physics, as in much of the rest of physics and engineering, the practitioners are generally men. However, women do become involved and some even break through to important positions. In a series of interviews made for the Italian magazine, *Newton*, Paula Catapano found out more about some of the women working on different aspects of CERN's LHC, from environmental impact and radiation safety to the complex experiments. Their answers give some idea of what makes these talented women tick, as well as an insight into their views on working in a "man's world".

Ana-Paula Bernades. Portuguese and French. Environmental engineer.

Thirty-five years old and the mother of a three-year-old child, Ana-Paula Bernades graduated in environmental engineering at the Grenoble Polytechnic. She arrived at CERN in 1999 and soon after started work on building safety and ergonomics. In 2003 she became section leader within CERN's Safety Commission and has since worked on the LHC's environmental impact, particularly on the management of acoustic disturbances generated by the sites around the 27 km ring, in collaboration with EdF. When the LHC begins operating, she will be in charge of personnel safety training and will be a consultant on general safety, acoustics and ergonomics.

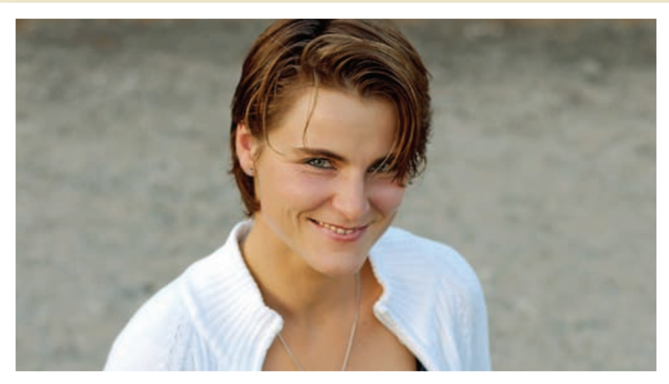
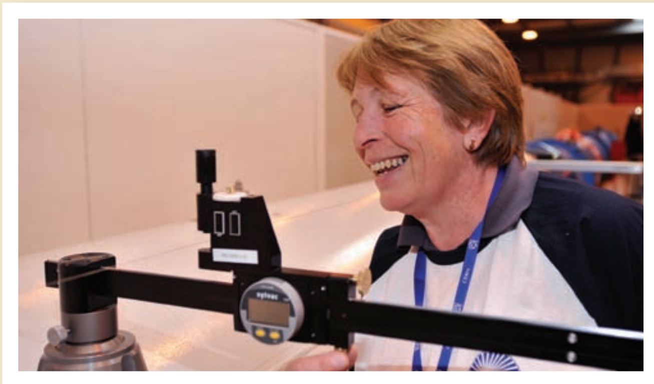
Did you have any particular difficulty in working as a woman in a male-dominated environment?

Not really. Being a woman in the world of safety is an advantage. In this field it is impossible to force things, in a typically male manner, so this makes you develop negotiation techniques to convince your counterparts at CERN to invest money and time on safety issues.





er runs on woman power

Isabel Brunner. German. Radiation protection engineer.
Isabel Brunner is 33 years old and has two children aged 2 and 4. A graduate of the Berufsakademie in Karlsruhe, she came to CERN in 1999 as the radiation protection engineer responsible for radiation protection in the SPS West Area, the RF test facilities and the n-TOF installation. Her current tasks include radiological responsibility for the SPS North Area, the RF installations in the SPS complex and the LHC. She is the radiation protection engineer responsible for the LHC injection test and will participate in the operational radiation protection of the LHC. Measurements she made during cold tests of RF modules for the LHC provided input data for the shielding at Point 4, where the RF is located.

Have you ever encountered any disadvantages/differences in your studies and career as a result of being a woman?
My answer is a clear "no". Even during my two pregnancies – where I was not able, or allowed, to perform my work in radiation controlled areas – I can't say that I had any disadvantages. I like my job and I have a great supervisor who treats everyone as an equal. However, working in a "man's world" is not always easy and it needs plenty of self-esteem and force to stand up and get your point through. I've only had one conflict regarding gender differences, and I put an end to it when I confronted the person. This was not easy, but eventually it was the best solution to the problem.

Monique Dupont. French. Surveyor.
Monique Dupont arrived at CERN in 1978 as "industrial support" within the team looking after the topography of buildings, which at the time was expanding. Today she is a member of the metrology group, comprised of 40 people. She has worked on the alignment of magnets for each new accelerator at CERN, as well as on their realignment at each shut down. These highly accurate measurements involve the use of hi-tech instruments, often designed within the metrology group. Since 1996, she has studied and worked on the alignment for the LHC, which has more than 1800 magnet systems. To check the curvature of the magnets, the group used microprobes in the beam tube, making a measurement every 50 cm with laser technology.

Have you experienced any difficulties as a woman working in a typically male career?
I was the only woman in a school of 1000 students. The profession did not attract women at the time – probably because the surveyor's work is principally outside and the instruments were heavy. Nowadays modern technologies enable you to work comfortably and I think for this reason that the number of women surveyors has increased. In my group, I have always been welcomed and appreciated for my work, but maybe CERN is an exception. The environment here is so international that there are really no differences of race, culture, religion or even gender. ▷

Fabiola Gianotti. Italian. Experimental physicist.

At 46 years old, Fabiola Gianotti is a woman who has reached one of the highest peaks during her career at CERN – that of deputy spokesperson for the largest LHC collaboration, ATLAS. She graduated at the University of Milan and completed her PhD at CERN. When physics allows, she finishes her day jogging or playing the piano – she has a professional diploma from the Milan conservatory. At the LHC, and with her experiment in particular, she would like to find dark-matter particles because of their connection with the universe. "That would be really fantastic." She is also hoping for a surprise to come from the LHC: "Something really amazing, completely new and unexpected."

Is it an obstacle to be a woman in a typically male career?

Physics is, unfortunately, often seen as a male subject; sterile and without charm or emotion. But this is not true, because physics is art, aesthetics, beauty and symmetry. Women have obstacles in the field for merely social reasons. Research does not allow you to make life plans. And the difficulties for women with a family are many. Something should be done, for instance, to develop more structures that would enable women with children to go through a physics career without too many obstacles, starting with nursery schools.

Virginia Greco. Italian. Electronics Engineer.

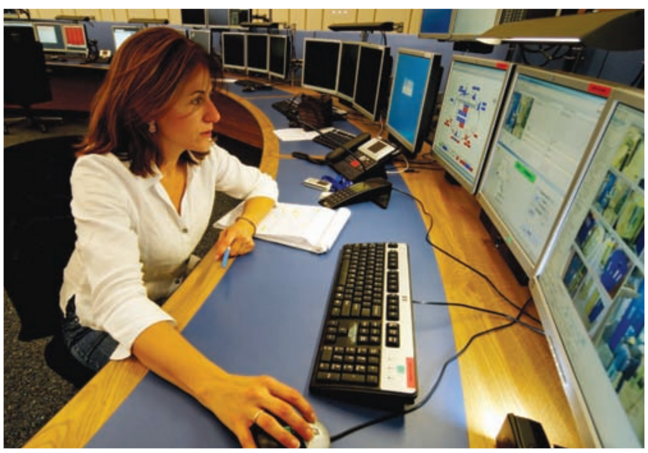
Born in the southern Italian city of Lecce, Virginia Greco is 29 and has a degree in electronics engineering from Pisa University. She is part of a team of engineers in charge of the design and installation of electronics for data acquisition in TOTEM, one of the LHC's smaller experiments designed to focus on forward particles. Research has always been her passion and has brought her to work in many different international laboratories, from Fermilab to CERN. She also studies theatre, has worked as a radio journalist and is interested in politics, movements in ecology and international cooperation.

Was being a woman an obstacle in your career?

Undoubtedly. In Italy, in all technical and scientific environments, there's a substrate of machismo. Some professors and male colleagues at my university were often convinced that, as a woman, I would never reach the level of a man, but I was never the victim of any real discrimination. In general, I think women have to make more effort than men to be taken seriously, to show they're worth something and that they have the same skills as men. At the moment I am working in a very open international environment. I have only been here a short time and cannot make any final statements. However, I have the feeling that CERN is a meritocratic place where efficiency and productivity count more than any prejudice. But I still keep my eyes open for possible obstacles, so as not to stumble on them.

Monica Pepe Altarelli. Italian. Experimental physicist.
Monica Pepe is married to a theoretical physicist and is the mother of two children aged 18 and 13. She became a physicist almost by accident, after "risking" a career first as an actress and then as an architect. Having come to CERN with a postdoctorate research grant in 1983, she now leads a team of 60 CERN physicists in LHCb, a collaboration of 700 physicists from 48 universities in 14 countries. Her main role is to coordinate interaction between the LHCb collaboration and CERN, and to manage the manpower and financial resources of the team. In addition to this largely managerial role, she also handles the technical work of preparing the online data quality monitoring, which will be crucial for acquiring immediately full control of the quality of data collected by the detector once it sees collisions in the LHC. The only "luxuries" she can afford in her little spare time are two hours of yoga per week at lunchtime and jogging with her dog on Sundays.

Is being a woman an obstacle for a physicist's career?
I was never hindered in my career by the fact of being a woman. In general, I have never seen it as a problem. And from some points of view it has even been an advantage, since people tend to remember you more easily. The real difficulty is conciliating family, children and work. In my case we had to invest a lot of organizational effort, help from my family (my parents), my partner's availability and understanding, and an important economic investment in baby sitters and carers. I've been lucky because both my husband and I have good positions from the same employer (CERN). But it is clear that working days are really long when you have small kids. The advantage is that working as a physicist you can afford some flexibility in organizing your time, which is very helpful. I always think that I will have to help my daughter Giulia, who has just started her architectural studies at EPFL Lausanne, the same way as my mother has helped me.



Eva Sanchez Corral. Spanish. Computer engineer.
Forty-three years old and the mother of eight-year-old twin boys, Eva Sanchez Corral gained her degree in computer engineering from the Madrid Polytechnic University in 1989. She came to CERN in 1991 as a CERN fellow and today she is one of three women in the LHC access-control group.

Any difficulty working in a predominantly male environment?
Today we are three women in my team, and I find that extraordinary. When I arrived at CERN in 1994 I was the first "staff" woman engineer in the whole group. In the beginning, my colleagues, all men and older in general, looked at me with curiosity and even with a defiant attitude. They treated me in the way men usually treat women, rather than as a colleague. Then, little by little, the old staff were replaced by young engineers, and a few were also women. So the group started treating us as a new resource. Today, our managers especially realize that women can really make a valuable contribution to team work. We are more flexible, have more energy, we are less individualistic and are good at conflict solving and negotiating. These qualities are particularly appreciated now during LHC commissioning. The real challenge for us is when children come. It's really two jobs, and it demands a super level of organization between home and the office. Luckily they are not kids forever – they grow up and when they are older, our partners can help more. ▷

Gilda Scioli. Italian. Experimental physicist.
Gilda Scioli is 30 years old and is from Abruzzi in central Italy. After grammar school in Lanciano, she gained a degree in physics from the University of Bologna and arrived at CERN in a postdoctoral role in the ALICE collaboration. She helped construct the complex detectors that will record the 50 000 collisions per second between lead nuclei.

Why do you think there are more men than women in the world of physics?
Because being a researcher is not an easy profession for women. What we do can only be done here. But if I had a small child and an experiment to do, what should I do? Do I say good-bye to everybody, leave for a year and ask my husband to breast-feed the baby?

Archana Sharma. Indian. Experimental physicist.
Archana Sharma is married and has an 18-year-old son. She has a PhD in physics from Delhi University and another from Geneva University. She came to CERN in 1989 as a student in the famous Charpak–Sauli group, and after many temporary contracts, where she worked mainly on the development of particle detectors, she is now a CERN staff member within the CMS Collaboration. In CMS, she works in the Technical Coordination Group, which is in charge of integration, installation and commissioning of the experiment.

Is being a woman an advantage or a disadvantage for tackling such a big responsibility?
This job requires both a good knowledge of particle detector technology, which is my field, and also excellent communication skills to be able to interact with people from diverse countries and cultures – such as the physicists from China, Pakistan, Russia and the US. And women are natural communicators. The real challenge, however, is the juggling act: work doesn't stop when you get home, where there's a family to look after.

● Based on an article that first appeared in *Newton* (http://newton.corriere.it/inedicola.shtml). To download the original article, see http://cms-project-cmsinfo.web.cern.ch/cms-project-cmsinfo/Media/Publications/CMStimes/2007/12_17/docs/Article.pdf.

Résumé
Les femmes du LHC

Le monde de la physique des particules est généralement dominé par les hommes, comme du reste l'ensemble de la physique et le métier d'ingénieur. Pourtant, les femmes commencent à percer. Dans une série d'entretiens réalisés à l'origine pour le magazine italien Newton, *Paula Catapano rencontre des femmes travaillant sur différents aspects du LHC, allant de l'impact environnemental aux détecteurs des expériences, en passant par la protection contre les rayonnements. Ces femmes talentueuses nous expliquent ce qui les inspire et quelles sont les difficultés qu'elles rencontrent dans un monde d'hommes.*

Paola Catapano, *CERN, with photos by* **Mike Struik**, *CERN.*

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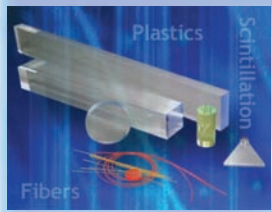


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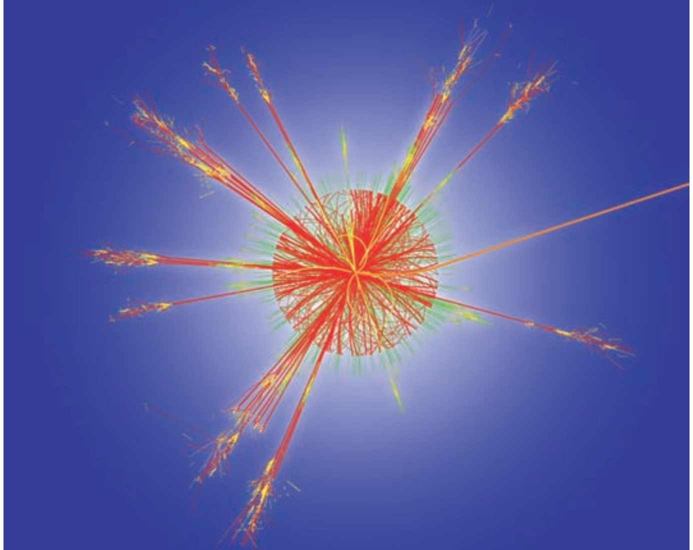

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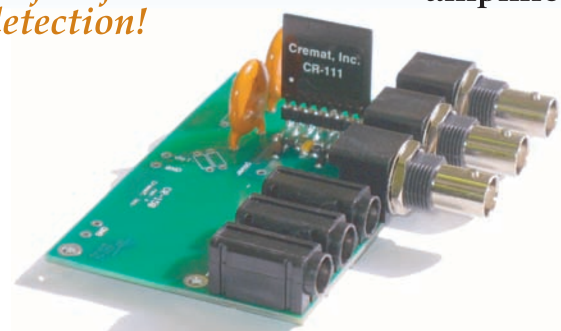

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The director-general of the International Fusion Energy Organization (ITER), Kaname Ikeda (right), and CERN director-general Robert Aymar signed a cooperation agreement on 6 March.

The CERN–ITER committee holding their first meeting in Cadarache in February. From left to right, Arnaud Devred, ITER, Lucio Rossi and Philippe Lebrun, CERN, and Neil Mitchell, ITER. (Courtesy ITER.)

COLLABORATION

CERN and ITER begin cooperation

CERN and the International Fusion Organization (ITER) signed a first cooperation agreement at a meeting on 6 March. The agreement was approved by the councils of the two organizations last year, with the aim of sharing knowledge and information on technologies.

One of the main purposes of this agreement is for CERN to give ITER, through the provision of consultancy services, the benefit of its experience in specific technologies developed for the LHC project, as well as in administrative domains such as finance, procurement, human resources and informatics.

Currently in its start-up phase at its Cadarache site, 70 km from Marseilles, ITER will focus its research on the scientific and technical feasibility of using fusion energy as a future source of power generation on Earth. In doing so, the organization will need to call on certain key technologies, such as superconductivity, cryogenics, control systems and data acquisition, which are already in use at CERN.

The steering committee meeting for the cooperation agreement held its first meeting in Cadarache earlier this year, on 14 February. This meeting marked the first step towards sharing the key common technologies involved in the LHC and ITER, such as superconductivity, magnet coils and cryogenics. The collaboration has already assisted the ITER organization and domestic agencies in preparing technical specifications for the procurement arrangements for the toroidal field coils. These procurements are among the largest individual items for ITER and work is due to start later this year.

APPOINTMENTS

Neil takes the reins at JLab's FEL division

George Neil has been named associate director at the Thomas Jefferson National Accelerator Facility (Jefferson Lab) with responsibility for the free-electron laser (FEL) division. He has served as acting associate director for FELs since March 2007 and as the programme's deputy since 1996.

Neil's professional career has spanned many areas, including plasma physics, nuclear engineering, lasers and accelerator technology development. He spent 10 years at TRW Defence and Space Systems Group in Los Angeles, with responsibility for isotope separation sources and FEL development. That was followed by three years as FEL chief scientist for TRW at the Lawrence Livermore National Laboratory in California. Among his many honours, Neil is a Fellow of the American Physical Society. He is also a co-winner of the 2000 International FEL prize and the 2005 R&D 100 award.

Jefferson Lab's FEL uses superconducting radio-frequency technology to convert electron-beam energy into light, which is used to conduct defence, industrial and academic research. It is the world's most powerful tunable FEL and incorporates a unique energy-recovery design.

George Neil. (Courtesy Jefferson Lab.)

KEK invites nominations for director-general position

The Japanese high-energy research organization, KEK, is calling for nominations for the next director-general, whose term of office will begin on 1 April 2009.

KEK is an inter-university research institute corporation open to domestic and international researchers. It is comprised of the Institute of Particle and Nuclear Studies, the Institute of Materials Structure Science, the Accelerator Laboratory, and the Applied Research Laboratory. The organization pursues a wide range of research activities based on accelerators, including particle and nuclear physics, material sciences, biosciences, accelerator physics and engineering.

The term of the new director-general will start one year before the next period of medium-term goals and plans (April 2010 to March 2016), and therefore he/she is anticipated to play a central role in establishing the plans in this period. One term in the position consists of three years, which can be extended up to nine years.

● The deadline for nominations is 10 June 2008. For more information, see www.kek.jp/intra-e/press/2008/newdg.html.

CELEBRATION

Shirokov reaches his 80th birthday

On 3 March, the Russian physicist Dmitri Shirkov celebrated his 80th birthday. Shirkov started his career in physics working on nuclear reactors and neutron diffusion back in 1955 and in 1956 joined the newly established JINR in Dubna. In the mid-1950s he began working with the mathematician and physicist Nikolai Bogoliubov in quantum field theory, and made a fundamental contribution to the axiomatic formulation of perturbation theory for the scattering matrix and to the creation of the renormalization group method. These results formed part of their famous monograph *Introduction to the Theory of Quantized Fields,* which was first published in 1957 and then later translated into English and French. This book, with seven editions, made him known worldwide; it was a bible to generations of mathematically oriented particle physicists.

Dmitri Shirkov. (Courtesy JINR.)

In 1960 Shirkov moved to Novosibirsk, Russia, where he founded the Theoretical Physics Department of the Mathematical Institute and the Chair of Theoretical Physics at Novosibirsk University. At that time, together with his co-workers, he developed dispersion theories of strong interactions at low energy.

Shirkov returned to JINR in 1971 and continued his research into the application of the renormalization group method and formulated the hypothesis of a finite renormalization of the coupling. He initiated a well known series of papers by Dubna theorists on multiloop calculations in QCD and developed the method of summing the asymptotic series that was used to effect in critical phenomena. Shirkov also put forward a general view of the nature of renormalization group transformations in various fields of physics, and introduced a notion of functional self-similarity, generalizing scaling laws. For the past decade, together with his co-workers, he has developed a new approach to QCD based on the renormalization group, analyticity and causality.

From 1993 to 1997 Shirkov was director of the Bogoliubov Laboratory of Theoretical Physics at JINR. He has also devoted much effort to training young scientists, teaching first at Novosibirsk and then at Moscow State University for more than 40 years.

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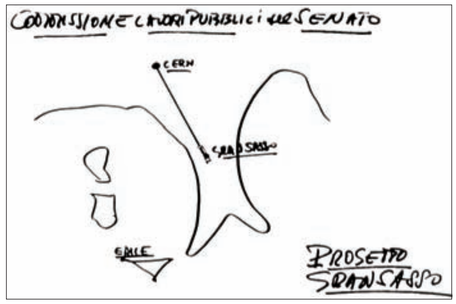
AWARDS

JINR honours Zichichi with the 2007 Bruno Pontecorvo prize

During the 103rd session of the JINR Scientific Council, Alexei Sissakian, director of JINR, announced that Antonino Zichichi of INFN/Bologna and CERN is to be awarded the 2007 Bruno Pontecorvo prize. The official ceremony for the prize – one of the most prestigious Russian physics awards – will take place in September in Dubna.

Zichichi has been selected by the international prize committee for his role in the creation of the Gran Sasso National Laboratory and his work on the collider programme and lepton physics at CERN. Committee member, Academician Semen Gershtein said: "Zichichi proposed a very interesting method for searching for a third heavy lepton in uncorrelated electron–muon pairs, which ultimately led to the discovery of the tau lepton. His work is closely related to problems that were interesting to Pontecorvo and undoubtedly made a huge contribution to the field."

Antonino Zichichi, left, with Bruno Pontecorvo, September 1978. (Courtesy Rome University.)



Notes from Zichichi's presentation to the Commission on Public Works of the Italian Senate in a session organized by the senate's president to discuss the proposed Gran Sasso project in 1979.

The Gran Sasso National Laboratory is currently the prime location for the study of cosmic and manufactured neutrinos. From the start, the concept for the laboratory took into consideration the possible study at Gran Sasso of neutrinos produced at CERN, so the big laboratory galleries are oriented towards CERN. The CERN Neutrinos to Gran Sasso project is now under way, having delivered the first neutrino beam in 2006. A prime goal is the investigation of neutrino oscillations, proposed initially by Pontecorvo.

The search for a third lepton has origins in Zichichi's PAPLEP experiment at CERN in the 1960s, which looked for electron–muon final states from proton–antiproton annihilation. This is how a large electromagnetic time-like form factor was discovered but this suppressed the proton–antiproton cross-section by as much as 500, so Zichichi moved to Frascati where, in 1967, he presented a proposal to search for a third lepton (now called the tau) using the electron–positron collider, ADONE.

Pontecorvo was a strong supporter of these activities. When Zichichi reported the PAPLEP results at the international conference in Dubna in August 1964, he received an enthusiastic response from Pontecorvo, who encouraged him to continue the line of research. At the time the bubble chamber was the dominant technology. When Pontecorvo visited Italy in 1978, he expressed his strong support for the Gran Sasso project, which Zichichi had just presented in Rome.

Haguenauer is honoured for technology transfer

Maurice Haguenauer, from the Laboratoire Leprince-Ringuet (LLR) at the Ecole Polytechnique in Paris, has received the Prix de la valorisation et du transfert de technologie (Evaluation and technology transfer prize) of CNRS/IN2P3 for developing instruments with medical applications. The prize is in recognition of his work on developing scintillation fibre hodoscopes for use in hadron therapy, more specifically for imaging the beam profile.

Hadron therapy is gaining ground in the treatment of certain cancers, with new European facilities coming into operation this year at the Centro Nazionale di Adronica Oncologica (CNAO) in Pavia and at the Heidelberg Ion Therapy Centre (*CERN Courier* December 2006 p17). CNAO asked Haguenauer's team at LLR to build a beam profile camera based on scintillation fibre technology. The fibres are arranged in horizontal and vertical layers and are read by a CCD camera.

Haguenauer has participated in important experiments at CERN, in particular the Gargamelle neutrino experiment, which discovered weak neutral currents and first indicated that gluons comprise about 50% of the nucleon. He is also well known for his work on UA4, measuring the real part of the proton–antiproton scattering amplitude – a result that consolidates extrapolations to derive the proton–proton total cross-section at the LHC. Now, within the ATLAS collaboration, he is involved in preparing a measurement of the luminosity and cross-section at the LHC using the Coulomb peak, and at the same time will measure the real part. This has the potential to provide evidence for extra dimensions.

Haguenauer's detector on display at the award ceremony (left); as well as the prize he receives (right). (Courtesy CNRS/IN2P3.)

OBITUARIES

John D Lawson (FRS) 1923–2008

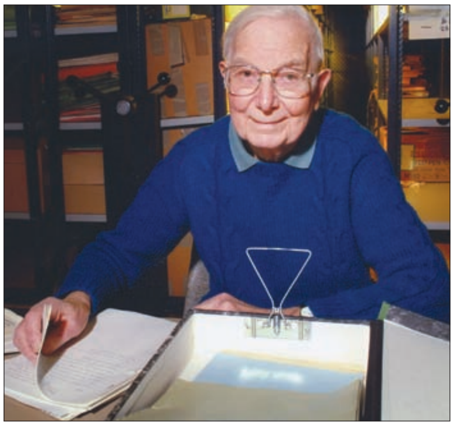
A pioneer of accelerator and fusion physics, John D Lawson, passed away on 15 January at his home in Abingdon, Oxfordshire, England.

John Lawson was educated in classics at an English grammar school. He was nevertheless fascinated by science and studied enough physics to try for a place at Cambridge University. However, because a qualification in chemistry was also required he joined the engineering faculty to do mechanical sciences. He used to remark that his engineering training made him think in a slightly different way from those who had done straight physics.

The Second World War was still raging when he finished his degree, and his first scientific job was with the Telecommunications Research Establishment (TRE) Malvern, where the war effort on radar was underway. He decided to work on antenna design, thinking that it would lead to an outdoor life, trekking over the countryside. Although disappointed to find he had to spend most of his time in the laboratory, he became fascinated with ways of narrowing down the polar diagram of aerials. During this time he hit upon an idea now commonly seen on rooftops around the world – the parabolic dish. While at TRE Malvern he was also involved with the reverse engineering of equipment salvaged from downed German aircraft.

When the war came to an end Lawson's expertise in periodic arrays of antennas led him to work at Harwell, where a small team led by his wartime group leader Don Fry was assembled to build two entirely new types of accelerator: a microwave travelling-wave linac and a synchrotron for measuring nuclear cross sections. Lawson worked on the 30 MeV synchrotron, which first produced beam in 1948 – only two years after the first ever synchrotron accelerator built by Frank Goward at the Woolwich Arsenal. This was the beginning of a long career in accelerator physics, punctuated from time to time by research into nuclear fusion.

With the outbreak of the Korean War in 1950, researchers who had worked on defence projects were encouraged to return to defence work. Lawson, because of his



John D Lawson FRS. (Courtesy RAL/STFC.)

experience with microwaves, joined a group led by Peter Thonemann to build a klystron, a device for producing high-power microwaves. Thonemann was in charge of the development of the ZETA fusion experiment, which first operated in 1952.

It was while working at Harwell in the mid-1950s that he came up with his famous criterion – the Lawson criterion – for net energy gain in a fusion device. Lawson showed that to achieve net power, the fusion plasma must be sustained at a temperature such that the product of the plasma density and confinement time exceed a certain value. The goal of all fusion research is to exceed this product of density and confinement time. The then Harwell director, John Cockcroft, suggested that Lawson present a paper on fusion power in Dublin in September 1957 at the meeting of the British Association for the Advancement of Science. It was the first time that anything was said about fusion in public. ZETA and other experiments were classified because of the fact that they could produce neutrons, but the Lawson criterion was unclassified and so was allowed to be presented. The Lawson criterion remains the holy grail of fusion research.

In the late 1950s Lawson became interested in the new alternating gradient proposal for synchrotrons and found that in the extreme form first proposed, particle resonances from magnetic errors would destroy the beam. Designs of both the AGS at Brookhaven and the PS at CERN were modified to make them work, and Lawson considered this among his main achievements. At the same time, the UK had to decide between a high-intensity, weak-focusing machine and the less predictable intensity of a smaller version of the alternating-gradient proton–synchrotron proposed for CERN. After a "shoot out" in Cockcroft Hall – the Harwell auditorium – Cockcroft made the decision for the high-intensity, weak-focusing machine NIMROD; Lawson claims that his warning that particle resonances might destroy the beam was not the principal reason.

In 1961 Lawson transferred to the newly established National Institute for Research in Nuclear Science next door to Harwell – later to become the Rutherford Laboratory and finally the Rutherford Appleton Laboratory – to continue his work on accelerators and help build NIMROD. He continued to specialize in accelerator design and microwaves, but also played a leading international role in promoting and critically examining ideas for future accelerators. In the early 1980s he recognized the potential that high-power lasers could have for particle acceleration, and set up a small research group in laser plasma accelerators. The remarkable success achieved by plasma accelerators over the past few years is a testament to his vision that one day they may take over from the large conventional accelerators that he called "dinosaurs".

Lawson was particular about scientific accuracy and would point out mistakes in his colleagues' reasoning (and sometimes his own) in a gentlemanly manner. He was one of the few physicists to encourage younger colleagues working in big laboratories to concentrate on new ideas, consequently gaining the respect of all generations for his vision and imagination. Those of us who worked with him will remember not only his penetrating questioning but also his warm and friendly behaviour. He is survived by his wife Kay and daughter Catriona.

Bob Bingham, Centre for Fundamental Physics, Rutherford Appleton Laboratory, and University of Strathclyde, and Ted Wilson, CERN and the John Adams Institute For Accelerator Science, Oxford.

Richard Geller 1927–2007

Richard Geller, whose work led to the sources used worldwide in heavy-ion studies, passed away on 1 July 2007. His presence at the Laboratoire de Physique Subatomique et de Cosmologie (LPSC) in Grenoble was no longer permitted with effect from 30 June 2007, such is the way of administrative decisions. He passed away in the early hours of the following day – a sign perhaps: no physics, no Richard.

Born in Vienna, Richard was a scientist forged out of the difficulties of the Second World War, who became the spearhead for scientific reconstruction in France. He interrupted his secondary studies to join the French resistance and abandoned his studies again in 1948, leaving a prestigious French engineering school to join Frédéric Joliot-Curie as one of the pioneers of the Commissariat à l'Énergie Atomique (CEA). Throughout his life he maintained his independence, instinctively keeping his distance from mainstream thinking. The result culminated in almost 60 years of technical and scientific innovation.

In 1954 Richard prepared his thesis under Yves Rocard and Francis Perrin. For this he conceived and developed the helium spectrometer which is still applied worldwide for leakage detection under vacuum. In 1956, participating in the major project of the time – the Saturne synchrotron at the Centre d'Etudes Nucleaires (CEN) Saclay – he became an accelerator specialist, and worked on the development of the first turbo-molecular pump to provide a good vacuum for the accelerator.

Always curious, from 1958 Richard was drawn towards plasma physics and related technologies, and in 1961 he was invited by Stanford University to study controlled fusion. It was here that he created the "bumpy torus", a collection of connected magnetic mirrors that became an important milestone in the history of magnetic fusion research. A year later he began working with the tool with which he achieved so much: the electron cyclotron resonance (ECR) heating of thermonuclear fusion plasma. As early as 1965 he realized that this technique opened a radically new approach to generating a plasma heavy-ion source for accelerators.

Richard Geller. (Courtesy P Sortais.)

In 1970 Richard moved with the General Ionic Service to CEN-Grenoble, leading in 1976 to the transformation of a magnetic fusion device into an ion source: SUPERMAFIOS (SUPER MAchine For Ion Stripping). Only someone competent in accelerator and plasma physiques could propose the principle of the electron cyclotron resonance ion source (ECRIS) or "Geller source". In doing so Richard became the founding father of a new discipline that had an impact on many areas of physics; the ECRIS conferences that began at this time continue today with enduring success.

The first fully operational source, MINIMAFIOS in 1979, was made thanks to his work with Réné Pauthenet, who introduced the scientists at Grenoble to permanent magnet technologies, allowing the miniaturization of the system. A MINIMAFIOS and the related ECREVIS source were both used on accelerators in 1982. The miniaturization and reliability of these sources enabled uninterrupted delivery of either continuous or pulsed ion beams, allowing the observation of rare events. The revolution that followed has lived on in all fields of physics where heavy ions are involved, whether in atomic physics, nuclear physics, high-energy or quark–gluon plasma physics. The first source dedicated to quark-gluon-plasma experiments was a MINIMAFIOS installed at CERN in 1986 for oxygen beams. Future experiments on heavy ions at the LHC will also benefit from lead beams from an ECR source.

Richard officially retired in 1990 after managing several laboratories at the CNRS and CEA, but retirement from science made no sense to him. He continued his career as consultant at CEN-Grenoble from 1990 to 1992, and thereafter at LPSC until his death. He supported all the projects for secondary ions at different accelerators. In 1997 he showed the way to sources for short-lived radioactive ions, with the 1+/n+ sources that coupled two ion sources to ensure the re-acceleration of secondary ions from production targets. These prototypes have been operational at GANIL, TRIUMF and ISOLDE since 2003, enabling the study of exotic nuclei.

Richard also took an interest in the numerous applications of his sources. Having learned of Bob Wilson's work on hadron therapy, he was the first to promote their use in the battle against cancer. In 1985 he conceived of the first source based exclusively on permanent magnets. Thanks to their ease of use and reliability they enabled all new European hadron therapy projects to be equipped with sources of this kind.

He continued to combat cancer himself for his last three years, but it finally interrupted his last paper, on philosophical arguments concerning time in physics. No one will ever know if his conclusion was similar to his conference conclusion in the early 1980s: "Next time, I will present results about our primitive soup a few microseconds before a time discontinuity called the Big Bang!"

With Richard's death, a tradition of knowledge and humanism has disappeared. Humble, avoiding attention, he received with humour a number of distinctions late in life having refused to accept them earlier. The entire community of accelerator scientists can assure his wife Annie, always present at his side, of the immense respect they had for Richard.

Pascal Sortais, LPSC.

Boris Chirikov 1928–2008

Boris Chirikov, an outstanding physicist at the Budker Institute of Nuclear Physics in Novosibirsk, Russia,who pioneered the physics of chaos, passed away on 12 February. Consequently, world science has lost one of its most eminent scholars.

Chirikov's early scientific interests were in the field of accelerator and plasma physics – he regarded Gersh Budker as his teacher. He started his career in experimental physics with investigations into ionic compensation of high-intensity relativistic beams. He soon became interested in theoretical aspects of the stability of motion of charged particles in accelerators and magnetic traps. His seminal paper of 1959 revealed an unexpected phenomenon of chaotic oscillations that occur in Hamiltonian systems as a result of interaction between nonlinear resonances. Based on these studies, Chirikov proposed his "criterion of overlapping resonances" that turned out to be efficient in finding the conditions under which "deterministic chaos" arises in classical Hamiltonian mechanics. Eventually, this universal phenomenon was found to occur in the very different fields of geophysics, meteorology, astronomy, biology, economics, and social sciences.

In his explorations of stochasticity, Chirikov was strongly influenced by the mathematicians Andrei Kolmogorov and Vladimir Arnold, whose pioneering works initiated the field. Chirikov, however, was

Boris Chirikov. (Courtesy Natalia Kupina/BINP.)

the first to approach the problem as a physicist, opening up new horizons. The analytical approach he developed allowed him to solve many physical problems and predict new effects that were later confirmed experimentally. His review paper of 1979, published in *Physics Reports*, summarizes the main results on classical chaos. Nowadays, cited in a few thousand research papers, this review remains a "bible of chaos" for many researchers worldwide.

In the mid-1970s Chirikov initiated the enthralling hunt for manifestations of dynamical chaos in quantum physics. Investigations by a group that he led provided a basis for the creation of a new field of theoretical physics, "quantum chaos", which attracted the interest of a wide circle of researchers. Since then there have been numerous studies of quantum chaos with applications in nuclear, atomic, molecular and solid-state physics, and so on. Predictions of the theory have been confirmed in experiments with heavy nuclei, complex atoms, quantum dots and superlattices.

Chirikov's brilliant achievements were largely due to his unique research style, which combined intuition with refined analytical methods, simple estimates and numerical simulations. The use of models, as simple as possible but not simpler than necessary, was his maxim, and a creative one it proved to be. His so-called "standard map", which described a planar rotator driven by time-periodic short kicks, became a paradigm of deterministic chaos in both classical and quantum domains.

As a teacher, Chirikov contributed much to the foundation and development of Novosibirsk State University. His bright, original lectures and interesting, non-standard textbooks helped many generations of physicists to find their way in science. His scientific ideas and warm personality will be sorely missed by everybody who worked with him, including his numerous friends and students. Chirikov would have been 80 this year. His former students and collaborators plan to gather in Novosibirsk at the end of May to remember and honour their remarkable colleague and teacher.

His colleagues and friends.

NEW PRODUCTS

Cryocomp has announced a new feature added to its V1000 series ½ inch and 1 inch vacuum seal-off valves. The addition is an integrated port on the side of the valves for the purpose of installing a vacuum sensor and to read the vacuum at any time after evacuation is complete and the system sealed off. This eliminates the need for drilling and welding on the system. For further details, tel +1 805 781 3565; or see www.cryocomp.com.

Hamamatsu has introduced a new ImagEM-enhanced camera, the C9100-13. This latest addition to the C9100 series is a back-thinned, electron-multiplier (EM) CCD camera with active built-in EM gain protection. It features a readout rate of 32 frames/s at full spatial resolution, even at low light levels, 16-bit digitization, a maximum quantum efficiency over 90% and cooling down to −90 °C to minimize dark noise. For further details, see www.sales.hammatsu.com.

Hiden Analytical has extended its range of plasma diagnostic tools with the new PSM plasma monitor. This mass-spectrometer system is configured to provide measurement of positive ions, while the EQP II provides both positive and negative ion measurement. The Espion Langmuir probe provides both static and spatial measurement of DC and RF-plasma parameters, including ion and electron densities and electron temperature. For more details, e-mail info@hideon.co.uk; or see www.HidenAnalytical.com.

Lake Shore Cryotronics has introduced the Model 3708, an 8-channel low-noise pre-amplifier/scanner for use with their Model 370 AC-resistance bridge. When combined, the system offers the low voltage, noise floor specification of 2 n$V_{RMS}/\sqrt{Hz}$. The Model 3708 is optimized for ultra-low resistance measurements, including low-voltage Hall effect measurements. For more information, tel +1 614 891 2244; fax +1 614 818 1600; or see www.lakeshore.com/3708preamp.htm.

RECRUITMENT

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UPPSALA UNIVERSITET

Uppsala University announces a position as

Associate professor/ Senior Lecturer in Theoretical Hadron Physics

(with the possibility of being employed as a Professor)

at the Department of Physics and Astronomy, Division of Nuclear and Particle Physics

At the Division of Nuclear and Particle Physics theoretical research in hadron physics with emphasis on phenomenology is conducted in close contact with the experimental research programs at the facilities PANDA at FAIR and at WASA at COSY, Germany. The announced position is intended to strengthen the research in the subfield of theoretical hadron physics that is represented by the PANDA and WASA projects.

The position involves research and teaching to the same extent. The holder should also act as doctoral thesis adviser to graduate students to be involved in the theoretical research projects.

Eligibility and Criteria for Ranking the Candidates

To be eligible for the lectureship a candidate must hold a doctoral degree. Grounds for promotion are scientific and pedagogical proficiency, with equal emphasis on both. "Scientific proficiency" refers to the applicant's own research and "teaching proficiency" refers to teaching, supervision and production of teaching materials.

For further information about the position, please contact Prof. Bo Höistad, phone +46184713857, Bo.Hoistad@tsl.uu.se. Information about the Division of Nuclear and Particle Physics can be found at http://www.isv.uu.se

Applications to this position, having Reg no UFV-PA 2008/388, must be sent in before May 29, 2008. A full advertisement with information about how to apply can be sent for from Anita.Ljungstrom@uadm.uu.se and can be found at http://www.teknat.uu.se/english/index.php

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the Institute of Research into the Fundamental Laws of the Universe of the Physical Sciences Division **DSM / IRFU**

at the **CEA-Saclay** *Research Center*

is expanding its capabilities in the Fusion Research and invites applications for Positions in

Superconducting RF Engineering

The International Fusion Materials Irradiation Facility IFMIF aims at producing an intense flux of 14 MeV neutrons, in order to characterize materials envisaged for future fusion reactors. This facility is based on two high power cw drivers delivering 125 mA deuteron beams at 40 MeV each. In the framework of the agreement on the "Broader Approach" for nuclear fusion, between Japan and the European Union, the IFMIF-EVEDA (Engineering Validation and Engineering Design Activities) project includes two objectives for accelerator activities:

- to validate the technical options with the construction of an accelerator prototype which will be installed and commissioned at full beam current at Rokkasho (Japan) ;
- to produce the detailed integrated design of the future IFMIF accelerator, including complete layout, safety analysis, cost and planning, etc.

An international accelerator team, located at CEA-Saclay (France), is in charge of the coordination of the design studies and of the prototype construction. Since the superconducting technology is just going to be chosen, DSM/IRFU is looking for Superconducting RF engineering candidates. Hereunder you will find two immediate vacancies.

For further information please contact Dr Alban Mosnier, IFMIF-EVEDA Accelerator System Group Leader, **amosnier@cea.fr**

Candidates are invited to send their application including a curriculum vitae, list of publications to CEA-Saclay, Human Resources, Mrs. A.C. Gouze, IRFU/DIR, 91191 Gif/Yvette cedex, France.

Cryomodule Coordinator - You are responsible for the studies and construction of the whole accelerating cryomodule as well as its integration in the rest of the facility. You lead the activities of the team in charge of the development: specifications, realization and testing of prototypes, call for tender and manufacturing follow-up of the cryomodule. You have a PhD in accelerator physics or a related discipline and you have already gained sound experience in superconducting RF.

Radiofrequency Engineer - You are in charge of the design studies of some critical RF components (low-beta superconducting resonator, cw power coupler) and collaborate on the design of the frequency tuner. You participate to the tests of RF prototypes and to the qualification test of the cryomodule. You already are experienced in Superconducting RF systems for particle accelerators and used to RF simulation codes and RF measurements.

cerncourier.com

Staff Scientist in Experimental High Energy Nuclear Physics at the LHC

The Nuclear Science Division (NSD) of Lawrence Berkeley National Laboratory is seeking a scientist with outstanding promise and creative ability in the field of experimental high energy nuclear physics, to join the NSD group working in the ALICE collaboration at the Large Hadron Collider (LHC) at CERN. The appointment will be at the position of career-track Staff Scientist for a five year term, with the expectation of promotion to Staff Scientist following successful review. The successful candidate will have several years of experience beyond the PhD, in experimental nuclear or particle physics.

The Relativistic Nuclear Collisions (RNC) Program in the NSD has active programs in high energy nuclear physics, in both ALICE at the LHC and STAR at RHIC. LBNL has leading scientific and management responsibilities in the international project to construct a large Electromagnetic Calorimeter (EMCal) for ALICE, which will enable the comprehensive study of jet quenching at the LHC. LBNL also plays a leading role in computing for ALICE in the US. The Staff Scientist will initially be based at CERN, with responsibilities for both technical and scientific aspects of the EMCal project. Additional effort supporting the activities of the Staff Scientist will be made available within the framework of the Helmholtz Allianz with GSI.

Applicants are requested to submit in a single attachment a curriculum vitae, publication list, statement of research interest, and the names of at least four references, on-line at:
http://jobs.lbl.gov/LBNLCareers/detailsasp?jid=21618&p=1sid=2033
and by e-mail to **NSD21618@lbl.gov**. Applicants also should arrange for four letters of reference to be sent to **NSD21618@lbl.gov** and to:

Dr. Peter Jacobs
Mail Stop 70AR0319,
Lawrence Berkeley National Laboratory
One Cyclotron Road
Berkeley, CA 94720

This position will be open until filled. We will begin considering candidates **June 1, 2008.** Please reference **Job # 21618.**

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Director of SNOLAB

SNOLAB is Canada's national underground research facility for particle astrophysics located in Sudbury, Ontario at the Creighton Mine operated by Vale Inco Ltd. SNOLAB is the deepest laboratory in the world located 2 km underground and will provide space for a number of international experiments in an ultra-clean environment starting this year. The principal scientific topics under investigation at SNOLAB are the detection of Low Energy Solar Neutrinos, Neutrino-less Double Beta Decay, Cosmic Dark Matter and Supernova Neutrinos. SNOLAB employs approximately 35 scientists, engineers, technicians, and general staff and expects hundreds of scientists from institutions world-wide to participate in experiments. It is operated by the SNO Institute, formed by a consortium of Canadian Universities, and receives capital and operating support from the Canada Foundation for Innovation, NSERC, NOHFC, FEDNOR and The Ontario Ministry of Research and Innovation.

The Director will have overall responsibility for the Scientific Program of SNOLAB and for its operation and development, as well as the authority for critical decisions directed to the securing and management of the operating funds, the safety of all workers, and the development and implementation of policies, internal systems and programs.

The successful candidate will have an advanced degree in a physics related discipline, demonstrated leadership abilities, scientific insight and vision; and an outstanding international research record with more than 10 years experience in a senior role. He/she will have achieved international stature in the fields of particle and/or nuclear physics and will have a proven track record for attracting operational and capital funding for research projects. Qualifications include experience with administrative and financial matters associated with large scale science projects and possess strong communication, interpersonal, negotiating and relationship building skills.

The Director position will be a five-year initial appointment associated with one of the member institutions and is renewable. This position is available January 1, 2009.

Salary will be commensurate with a senior Full Professor salary at a Canadian University. Please note the position is open to all qualified applicants, and in the case of equal qualifications, preference may be given to a Canadian Citizen or Permanent Resident.

Applicants should forward a detailed CV and arrange to have at least three letters of reference to:

Dr. Nigel Lockyer
Chair
SNOLAB Director Search Committee
c/o Ms. S. Moss
SNOLAB Project Office
P.O. Box 159
Lively, Ontario
Canada P3Y 1M3

Consideration of applications will begin August 1, 2008 and will continue until a suitable candidate is found. Please direct any queries to DirectorSearch@snolab.ca

Ruprecht-Karls University of Heidelberg
Kirchhoff Institute for Physics

Doctoral Scholarships

The Heidelberg Graduate Research Group **"New Symmetries and Extra Dimensions"** offers five attractive Ph.D. scholarships to candidates with a very good degree in physics (diploma or master). A good knowledge of the basics of particle physics is required. Successful candidates will work on data analysis with the **ATLAS experiment at the LHC**, in particular on searches for new phenomena (supersymmetry, extra dimensions, mini black holes) or physics of strong interaction. The scholars will be well integrated in an attractive research environment and will be members of the Heidelberg Graduate School of Fundamental Physics. The Graduate Research Group is located at the Kirchhoff Institute for Physics. More detailed information is available online at **http://www.kip.uni-heidelberg.de/atlas/join/scholarship/**.

The University of Heidelberg aims at increasing the number of women in scientific research. Female candidates are explicitly encouraged to apply. Interested candidates should send their applications until **May 16, 2008** to the chair of the Graduate Research Group:

Dr. J. Dingfelder, Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, D-69120 Heidelberg, email: jdingfel@kip.uni-heidelberg.de.

KIT – The cooperation of Forschungszentrum Karlsruhe GmbH and Universität Karlsruhe (TH)

Karlsruhe Institute of Technology

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Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Forschungszentrum Karlsruhe is one of the largest research institutions in Germany and member of the Helmholtz Association of National Research Centres. Presently, Forschungszentrum Karlsruhe (FZK) and Universität Karlsruhe (TH) are merging their activities in the Karlsruhe Institute of Technology, KIT. Within the framework of KIT, applications are requested for the position of

Scientific Director/Head

of the Institute for Data Processing and Electronics
of the Forschungszentrum Karlsruhe in association with
a professorship (W3) at the Universität Karlsruhe (TH)

The Institute for Data Processing and Electronics (IPE) is active in many research areas of KIT and involved in a number of national and international collaborations. In particular, IPE is specialized in the development of data acquisition systems for applications with high data rates and high time resolution, hardware and software triggers as well as of control systems for large-scale experiments, such as the Pierre Auger Observatory or the experiment KATRIN.

Applicants should have an excellent scientific qualification and international reputation in several of the following areas:

- Real time data processing
- Microprocessor systems and analogue electronics
- Embedded parallel systems
- Software engineering for embedded systems
- Interconnection and packaging technology

Candidates are expected to be highly capable of managing interdisciplinary projects and heading a large institute with many research and service tasks. Experience in the instrumentation of large-scale physics experiments is advantageous. The person to be appointed is expected to represent the above scope of topics also by teaching at one of the faculties of physics, electrical engineering and information technology or information science, depending on his/her qualification. Candidates should have a postdoctoral lecturing qualification or equivalent scientific degree.

Applications of qualified women are strongly encouraged, as we wish to increase the proportion of females at the management level. Handicapped persons with equal qualification will be preferred.

Applications, including a CV, a list of publications, documents about previous research and teaching work as well as offprints of the five most important publications shall, up to **May 13, 2008** be addressed to:

Forschungszentrum Karlsruhe GmbH
Dr. Peter Fritz, Mitglied des Vorstands
P. O. Box 3640, 76021 Karlsruhe, Germany

In addition, we would appreciate the submission of your application documents electronically. **E-mail: peter.fritz@vorstand.fzk.de**

Cyclotron Engineer Position at the Copenhagen University Hospital

The PET and Cyclotron Unit, at the Copenhagen University Hospital have an opening for a cyclotron engineer/technician from July 1st 2008.

The unit is equipped with one MC32 Scanditronix cyclotron and one RDS Eclipse CTI/Siemens cyclotron, and a number of PET/CT scanners. A major focus of the unit is cancer diagnostics, both basic and clinical research. The Cyclotron Unit works on development of new isotope production and new equipment for the cyclotrons. The primary responsibilities for the cyclotron engineer/technician will be the operation, periodic quality control, maintenance, trouble-shooting, and repair of the cyclotrons with special emphasis on the RF-systems.

We are inviting applications from candidates, which hold a degree in accelerator engineering or related fields. Specific experience with medical cyclotrons is an advantage and strong skills in electronics (RF systems, etc.) are requested. The successful applicant will be employed on a permanent basis and join the present cyclotron team of 2 physicist and 2 technicians. Starting salary depending on qualifications, app. 35-45.000 Euro per year.

Applications (CV + cover letter) by 13th May 2008 to:

Chief cyclotron physicist Holger Jensen, Ph.D.
PET and Cyclotron Unit, KF-3982, Rigshospitalet,
Blegdamsvej 9, DK-2100 Copenhagen, Denmark.
E-mail holgerj@pet.rh.dk, phone (+45) 3545 1680.

Max Planck Institute for Physics

(Werner Heisenberg Institute)

MAX-PLANCK-GESELLSCHAFT

The *Max-Planck-Institut für Physik* invites applications for a

Postdoctoral position

for the development of novel particle accelerator technologies.

Developing novel particle accelerator techniques is crucial to the future of high energy physics. The *Max-Planck-Institut für Physik* is currently studying Frictional Cooling as a scheme for reducing the phase space of heavy particles, thereby allowing for higher luminosity for novel accelerators such as a Muon Collider. In the Frictional Cooling scheme, low energy particles are brought to equilibrium energy below the Bragg peak before acceleration. A demonstration experiment is under way with protons, and the candidate would take a leading role in this project. A novel acceleration scheme based on Plasma Wakefield Acceleration is also under study, and the successful candidate would be expected to participate in this project as well.

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Max-Planck-Institut für Physik
c/o Franziska Rudert
Föhringer Ring 6
D-80805 München

Further information can be obtained from Prof. Allen Caldwell (EMail: caldwell@mppmu.mpg.de). Applications should be received by 30 April, 2008. The expected starting date for the position is 1 July, 2008.

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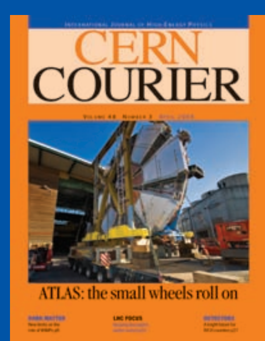

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Contact and further detail:
Dr. Carsten P. Welsch
Kirchhoff Institute for Physics, University of Heidelberg, Im Neuenheimer Feld 227, D-69120 Heidelberg
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BOOKSHELF

Im Wirbel der Atome: Lise Meitner, Eine Frau geht ihren Weg (In the turmoil of atoms: Lise Meitner, A Woman pursues her Way) by Thea Derado, Kaufmann Verlag 2007. Hardback ISBN 9783780630599, €19.95.

Using letters, articles and biographies the author of this book paints a lively and private picture of the tragic life of Lise Meitner, which was thorny for two reasons: she was Jewish and a woman. Born in 1878 Meitner attended school in Vienna but could pass her maturity examination only after expensive private lessons. After studying in Vienna, she moved to Berlin in 1907, and for many years had to earn her living by giving private teaching lessons. Eventually she was accepted by the radiochemist Otto Hahn as a physicist collaborator at the Kaiser Wilhelm Institute in Berlin (but without pay), and so began a creative co-operation and a lifelong friendship. Since women were not allowed to enter the institute, Meitner had to do experiments in a wood workshop in the basement accessible from a side entrance.

Derado describes Meitner's scientific achievements in an understandable way, particularly experiments leading to nuclear fission and the discovery of protactinium. The technical terms are explained in an appendix.

During her stay in Berlin, Meitner met all the celebrities in physics at the time, such as Max Planck, James Franck, Emil Fischer and Albert Einstein, whose characters are all described in a colorful fashion. She developed warm relations with Max von Laue, one of the few German physicists who had bravely withstood the Nazi regime. Apart from science, music played an important role in her life, and through music Meitner made friends with Planck's family and happily sang Brahms' songs with Hahn in the wood workshop.

During the First World War Meitner volunteered for the Austrian army as a radiologist. Working in a military hospital she learned the horrors of war. These experiences, and discussions with Hahn and Einstein led to some inner conflicts. During the persecution of the Jews by the Nazis, Meitner enjoyed a certain protection thanks to her Austrian passport, yet after the annexation of Austria it became impossible for her to leave Germany legally. Neglecting her colleagues' warnings she hesitated too long, until in July 1938 she saved herself by escaping to Holland. Hahn gave her a diamond ring that he had inherited from his mother as a farewell present.

After a short stay in Holland Niels Bohr arranged for Meitner to stay at the Nobel Institute in Stockholm, which was directed by Manne Siegbahn, and finally in 1947 she obtained a research professorship at the Technical University in Stockholm. I was able to work with her there for a year and can confirm many of the episodes mentioned in the book. She was a graceful little person, with a combination of Austrian charm, Prussian orderliness and a sense of duty; she was also very kind and motherly.

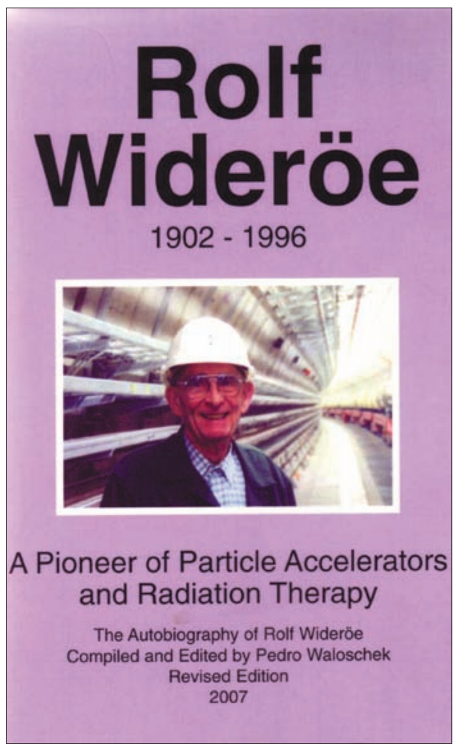
Derado discusses, of course, why Meitner did not share the Nobel Prize with Hahn in 1944. Her merits were uncontested, and even after the publication of the Nobel Prize documents questions remain unanswered. It seems that being a woman had negative influences. However, numerous German and international honours and awards, as well as an overwhelming reception in the US, have compensated to a certain extent.

Meitner never married, but various family ties played an important role in her life. She was particularly attached to her nephew Otto Frisch, with whom she interpreted nuclear fission. She spent her last days with him in Cambridge, where she died in 1968.

In all, this book provides an historically accurate account, at the same time from a female perspective, of the turbulent life of one of the greatest scientists of the 20th century. It is worth reading, not only for those interested in history, but also perhaps as encouragement for young women scientists.
Herwig Schopper, University of Hamburg and CERN.

Rolf Wideröe 1902–1996. The autobiography of Rolf Wideroe, compiled and edited by Pedro Waloschek, Books on Demand. Paperback ISBN 9783837005578, €16.
Bruno Touschek and the art of physics by Enrico Agapito and Luisa Bonolis, INFN. DVD. Available in Italian or English editions from pancheri@lnf.infn.it
Good books for students of particle physics are often careful to lay a clear historical trail of who first did what in both experiment and theory. Try to dig deeper to find out more about the pioneers, however, and the literature becomes patchy. While some physicists have reached an almost legendary status, others are more difficult to track down. It is interesting, then, to have the opportunity to find out more about some of the "unsung" heroes of the subject.

Rolf Wideröe does of course appear in many

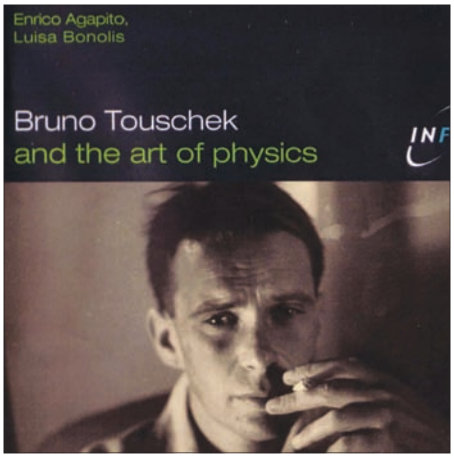


introductions to particle physics. His linac of 1927 famously inspired Ernest Lawrence to invent the cyclotron. Less well known is that Wideröe had already in 1922 worked out the principles for a "ray transformer" – in effect, a betatron accelerator – and that his ideas for colliding storage rings and the synchrotron date back to the mid-1940s.

This autobiography by Wideröe was first published in 1994, when he was 92 years old. Pedro Waloschek compiled and edited material from various sources for Wideröe to correct and modify. He also provided a chronology and extra background information, and in this new edition of the English translation, he has corrected a few errors and added some new pictures. The end-product is a fascinating first-person account of the life of a highly inventive Norwegian engineer, who studied in Germany in the 1920s, went into industry in Norway in the 1930s, and ultimately settled in Switzerland after the Second World War, working for Brown Boveri and Company (BBC). He also taught at the Swiss Federal Institute of Technology, Zurich and became highly respected for his contributions to radiation therapy.

Wideröe's life story is inextricably linked with the betatron. In 1943, hoping to free his brother from imprisonment by the Germans, he agreed to go to Hamburg to build a 15 MeV machine. At the end of the war, while the betatron ended up at Woolwich Arsenal in Britain, Wideröe found himself imprisoned in Norway, accused of collaboration with the Germans. In the book he explains that he was cleared and released after the intervention, probably, of physicist Odd Dahl. In 1946 he moved to Switzerland to build the first of many betatrons for BBC, mainly for X-ray therapy in hospitals. With many years spent in industry, his ideas were often the subject of patents, two of which are reproduced in the book, including the one that represents the first proposal for a storage ring.

In his introduction, Waloschek recounts how he first heard of Wideröe in 1958 from a friend, Bruno Touschek, who was to earn his own place in the accelerator "hall of fame", with the first proposal for an electron–positron storage ring. Born in Vienna in 1921, Touschek was still a student when he worked with Wideröe in Hamburg in 1943 on theoretical calculations for betatrons. Arrested by the Gestapo for reading foreign magazines, he was allowed to



continue working in prison, and Wideröe and colleagues were able to provide him with food and cigarettes. Following the war, Touschek obtained his diploma thesis at Göttingen on the theory of the betatron, and after a PhD from Glasgow, he arrived at Rome University in December 1952.

The film on Touschek, produced with support from INFN, brings to life this creative theoretical physicist who pioneered one of the most important accelerator techniques for modern particle physics. In Rome, he joined the band of researchers under Edoardo Amaldi who were rebuilding Italian physics after the Second World War. The creation of INFN in 1953 led to the construction of a 1100 MeV electron synchrotron at Frascati near Rome. This aroused the interest of Touschek, who until then had been working on mainly theoretical topics since his arrival in Rome. However, he felt that the synchrotron would not yield the most important physics, and came back to an idea first put to him in Hamburg by Wideröe – to collide beams, and in particular electrons and positrons.

After Touschek's initial proposal in February 1960 to convert the synchrotron to an electron–positron collider, the Frascati laboratory decided instead to build a new small ring to test the ideas. This was the 250 MeV ring, AdA. A year later the first particles were circulating, with lifetimes of several hours, but injection from the synchrotron was very inefficient. So in summer 1962, AdA was moved to the linac at Orsay, and in 1963 it successfully stored 10 million of each kind of particle, although the beam lifetime was now limited. Touschek realised that this was due to intra-beam scattering in the more intense beams – the effect that now bears his name. AdA was followed by ADONE at Frascati, and SPEAR at SLAC, where the J/Ψ was discovered in 1974.

Touschek's work was the inspiration later for Carlo Rubbia, who masterminded proton–antiproton collisions at CERN, as well as for the LEP project, AdA's giant successor. He came to CERN to advise on these projects, but by then was ill and was to die in 1978 back in Austria, before he could see their ultimate success. The film documents all this history and more, with commentary from many key people involved, and cartoons by the gifted Touschek. It provides a fascinating account and is well worth watching.

Christine Sutton, CERN.

Books received

Interactions of Photons and Neutrons with Matter (second edition) by Sow-Hsin Chen and Michael Kotlarchyk, World Scientific. Hardback ISBN 9789810242145, £45 ($78).

This book is based on lecture notes developed for a one-semester graduate course entitled "Interaction of Radiation with Matter", taught in the Department of Nuclear Science and Engineering at the Massachusetts Institute of Technology.

The main objective of the course is to teach enough quantum and classical radiation theory to allow students in engineering and the applied sciences to understand, and have access to, the vast literature on applications of ionizing and non-ionizing radiation in materials research.

Rotation and Accretion Powered Pulsars (World Scientific Series in Astronomy and Astrophysics – Volume 10) by Pranab Ghosh, World Scientific. Hardback ISBN 9789810247447, £83 ($152).

This introduction to pulsars is the first to treat rotation-powered pulsars and accretion-powered pulsars simultaneously with equal importance, stressing the fact that both are rotating, magnetic neutron stars operating under different conditions during different parts of their lives. It also presents the accurate verification of Einstein's theory of general relativity through timing studies of binary pulsars, which led to the award of the Nobel Prize to Hulse and Taylor in 1993. Graduates and upper-level undergraduates, as well as researchers and teachers in astrophysics, astronomy, general relativity and related subjects will find this interesting.

VIEWPOINT

A vision for the future of CERN

While the LHC will excite the imaginations of high-energy physicists in the next decade, according to **John Ellis**, CERN's international partnerships will provide the framework for its future projects.

CERN is a *de facto* global laboratory, with the LHC set to be the centre of particle-physics research for a decade or more, and comprises the largest scientific user community in the world. More than just a particle factory, CERN is a knowledge factory, enabling scientists to make discoveries, disseminate them and train younger generations. CERN is an example to the world of international scientific, technical and human collaboration.

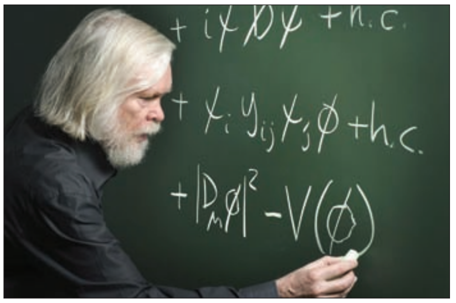
The Council recognized – in the European Strategy for Particle Physics – that the next five years will be crucial, not only for CERN but for the future of particle physics in general. The start of LHC exploitation will provide a unique capability to explore new experimental vistas and an opportunity to seek support for possible new projects, such as upgrading the LHC itself and for a successor to explore the LHC's breakthroughs.

Gathering the necessary support will require motivating and mobilizing the energies of all CERN stakeholders, both internal and external. Not only is it essential that the LHC be a technical success, but also that the implications of its discoveries for possible new projects be evaluated promptly and convincingly. This new physics should excite the imaginations not only of high-energy physicists, but also the wider scientific community and the general public – even schoolchildren and politicians. Only then could the future of accelerator-based research into the fundamental nature of matter – and any major new project – be assured.

Even so, it will be essential to optimize the deployment of the resources available for particle physics at CERN and other European laboratories. Any new project will surely be global in nature, so it will also be necessary to amplify the dialogue with our prospective partners in other regions of the world.

Possible directions

The European Strategy for Particle Physics also recognizes the importance of R&D on possible future projects in the period before



LHC results set the favoured direction for particle physics (*CERN Courier* September 2006 p29). The Proton Accelerators for the Future group that advises the director-general has already made an initial plan for upgrading CERN's Proton Accelerator Complex (Garoby 2007). Following these studies, the director-general set out the R&D priorities that have been approved by CERN Council.

Another report, by the CERN advisory group on Physics Opportunities with Future Proton Accelerators (POFPA) (Blondel *et al.* 2006), also reviewed some of the scientific motivation for upgrading the LHC. This report discusses possible synergies of upgrades of the LHC injector chain with research programmes in fixed-target physics, neutrino physics and nuclear physics.

Beyond the LHC, there is a general consensus that the priority for the next major international project is a linear electron–positron collider. The International Linear Collider (ILC) concept is potentially very interesting if the LHC reveals new physics within its energy range. Nevertheless, even in this case, physics will eventually require higher energies, hence the need for R&D on the Compact Linear Collider (CLIC) concept, within the international framework provided by the CLIC Test Facility 3 collaboration. CLIC, however, is ambitious; significant technical hurdles remain to be overcome before its feasibility can be demonstrated.

In view of the different options for the location, energy and timescale of a future linear electron–positron collider, CERN should collaborate with partners in Europe and elsewhere on R&D for a possible next-generation neutrino project. This might be based on the "super-beam" and "beta-beam" concepts, or it might be a full-blown "neutrino factory" based on a muon storage ring. The choice between these options will depend on technical feasibility as much as new results in neutrino physics, such as measurements of – or constraints on – the third neutrino-mixing angle.

In parallel with these major projects, the European Strategy recognizes the importance of a variety of smaller-scale projects at CERN that address complementary issues in particle and nuclear physics. Many of these, such as the Antiproton Decelerator, ISOLDE, nTOF and some fixed-target experiments are of unique global scientific interest. Such projects broaden the appeal of CERN and help train many young physicists. The POFPA report underlined the interest of several proposals for the future, in addition to those that would be made possible by upgrades of the LHC injector chain.

While the laboratory's technical strength is the bedrock upon which any future CERN project will be built, this is likely to be even more global in nature than the LHC, with CERN becoming recognized explicitly as a "world laboratory". Hence, CERN will need to nurture and build on its existing international partnerships with Canada, Japan, Russia and the US, while collaboration with emerging powers such as China and India should be expanded. CERN's growing contact with other world regions such as the Middle East and Latin America will also become more important. CERN's future plans should be discussed with its international collaborators in a spirit of partnership, in which the interests of all regions of the world are respected.

● R Garoby 2007 (http://doc.cern.ch/archive/electronic/cern/preprints/ab/ab-2007-074.pdf) and A Blondel *et al.* 2006 (http://arXiv.org/pdf/hep-ph/0609102).

John Ellis, CERN.

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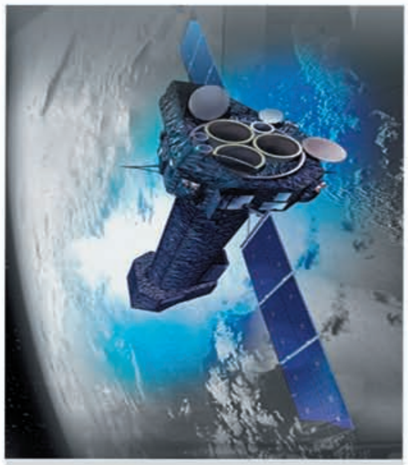

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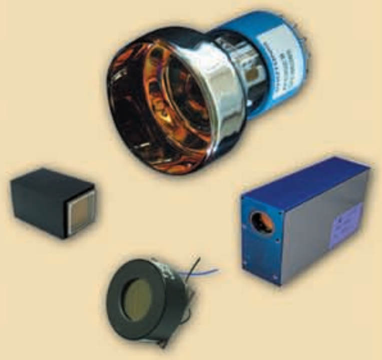

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