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CERN COURIER

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

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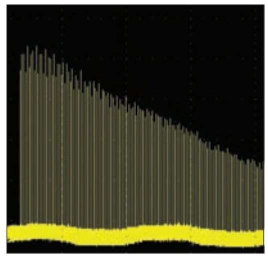


Cover: An aerial view of ALBA, a third-generation synchrotron light source under construction near Barcelona (p31). (Courtesy CELLS.) .

NEWS

CERN

Incident in sector 3-4 of the LHC

Commissioning of the LHC came to an abrupt halt at midday on 19 September, when an incident occurred in sector 3-4 that resulted in a large helium leak in the LHC tunnel. The time necessary for the investigation and repairs precludes a restart before CERN's obligatory winter-maintenance period, pushing the date for restart of the accelerator complex to early spring 2009.

The incident occurred only nine days after the successful "first-beam" day (p26). During a period with no beam, owing to the replacement of a faulty transformer, the commissioning team was completing work to allow the machine to run at 5 TeV per beam, originally planned for later this year. All but one of the eight sectors had already been commissioned to 5.5 TeV before start up, and it was while bringing the magnets in sector 3-4 up to the appropriate field strengths that the incident happened. Indeed, it was the last circuit to be tested, and it had reached a current equivalent to just higher than 5 TeV.

Preliminary investigations indicate that the most likely cause of the problem was a faulty electrical connection between two magnets, which probably melted at high current, leading to a rupture of the helium vessel and the release of high-pressure gas into the cyrostat. The gas then discharged into the tunnel through the pressure-relief valves designed for this purpose. At the same time, the quench-protection circuits on some 100 magnets fired, all working perfectly to protect the magnets as foreseen. A sector consists of 154 main superconducting dipoles plus straight sections with 40 main quadrupoles and various other magnets. CERN's strict safety regulations ensured that at no time was there any risk to people.

The LHC, like other major particle accelerators, has been built at the cutting edge of technology but with unprecedented complexity, owing to its unique two-in-one superconducting magnet system. No fewer than 123 000 interconnections were needed for the 27 km ring, including 65 000 electrical connections with superconducting cables. All the other circuits had passed their tests to 9000 A with flying colours.

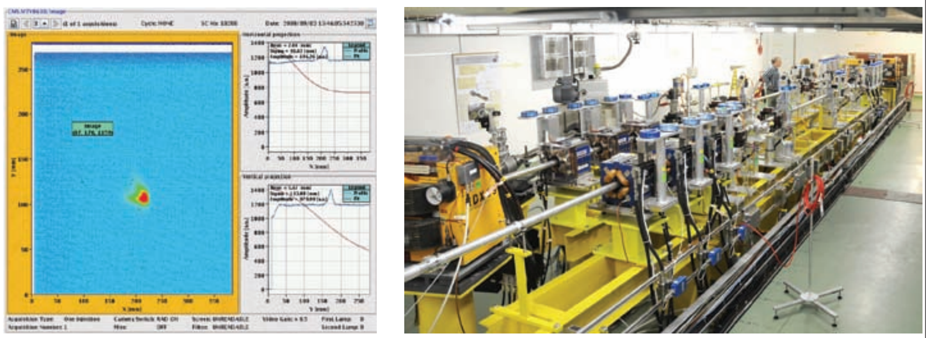
A full investigation of the incident is underway, but the whole sector must be warmed up to room temperature and the magnets involved opened up for inspection before this can be completed. Only at this stage will the extent of collateral damage caused by the sudden release of helium be fully known. The warm up is expected to be completed towards the end of October.

CERN

Successful test for CLIC

The Compact Linear Collider (CLIC) study collaboration has for the first time sent beam right to the end of the drive beamline in the CLIC Test Facility (CTF3). Early in the afternoon of 3 September, all eyes in the CTF3 control room were fixed on the camera display that showed a small beam-profile screen installed at the far end of their accelerator complex. A few minutes later the first bunch of electrons was lighting up this monitor.

Building on this success, a major effort will now go into commissioning the whole CTF3 complex to reach nominal beam parameters. CLIC's accelerating principle is based on a two-beam scheme: a drive beam provides power for the accelerating structures, which accelerate the main beam (*CERN Courier* September 2008 p15). The programme for CTF3 foresees bringing the linac into operation for initial acceleration of the main beam, then installing and testing a first decelerating structure in the drive-beam line.



Left: For the first time a bunch of electrons lights up the beam screen at the far end of the drive beamline in the CLIC Test Facility. Right: A view of beam lines in the CLIC experimental hall.

Sommaire

NOBELS

Nobel rewards for work on broken symmetry

Broken symmetry in particle physics is the underlying theme for the 2008 Nobel Prize in Physics. Yoichiro Nambu, emeritus professor at the University of Chicago, has received a half share of the prize "for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics"; Makoto Kobayashi, emeritus professor at KEK, and Toshihide Maskawa, former director of the Yukawa Institute for Theoretical Physics at Kyoto University, share the other half "for the discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature". The work of the three theoreticians underpins significant parts of the current Standard Model of particle physics, and is also reflected in key questions that are driving current experimental research in the field.

Nambu left his native Japan for the US in 1952, and has been at the University of Chicago since 1958. He has made several important contributions to particle physics, but it was the theory of superconductivity published in 1957 by John Bardeen, Leon Cooper and Robert Shrieffer that led Nambu towards spontaneous symmetry breaking in particle physics. In 1960 he looked at how to maintain gauge invariance (the underlying symmetry of electromagnetism) in a field theory of superconductivity – a phenomenon that spontaneously breaks gauge invariance (Nambu 1960). He went on to develop these ideas in field theories for elementary particles, and to bring in the concept of spontaneously broken symmetry not just in matter but in empty space (*CERN Courier* January/February 2008 p17). In particular, this led to ideas about the generation of mass (Nambu and Jona-Lasinio 1961).

Three of the people who took note of these ideas were Robert Brout, François Englert and Peter Higgs, whose work is now encapsulated in the Brout–Englert–Higgs (BEH) mechanism for generating mass through spontaneous symmetry breaking in the Standard Model (*CERN Courier* October 2008 p83). All three acknowledge Nambu's influence on their work in 1964. Some 40 years later, the search for the scalar boson (Higgs particle) associated with the field required by the BEH mechanism is an important element in the physics to be studied at the LHC at CERN.

Makoto Kobayashi and Toshihide Maskawa. (Courtesy KEK.)

Yoichiro Nambu. (Courtesy University of Chicago.)

In 1972 two Japanese theorists at the University of Kyoto began to look at a different broken symmetry. Kobayashi and Maskawa decided to investigate the violation of CP symmetry in weak interactions (which had been discovered in the neutral kaon system in 1964) in the context of renormalizability. At the time only three quarks were known, but building on work on unitary symmetry in weak decays by Nicola Cabibbo and the need for four states to suppress strangeness-changing neutral currents, Kobayashi and Maskawa concluded that "no realistic models of CP violation exist in the quartet scheme without introducing any other new fields" (Kobayashi and Maskawa 1973). However, one option that they showed would work was to broaden the quartet of states to six. This led to a 3 × 3 unitary mixing matrix, which included a phase that imposed CP violation in certain transitions. The paper did not arouse much excitement at first, but within the next two years, not only was the fourth quark, c, discovered, but also a third charged lepton, τ, indicating a third generation of leptons and hence a third generation of quarks.

Since then, not only have the fifth and sixth quarks, b and t, been discovered, but CP violation has also been found in the neutral b-quark system, the B-mesons. The Cabibbo–Kobayashi–Maskawa matrix has become an intrinsic part of the Standard Model, which is being tested with high precision with neutral kaons and in particular with B-mesons at the B-factories and in future at the LHC. At the same time, CP violation in general remains a puzzle, as the effect observed in weak interactions is by no means sufficient to account for the domination of matter over antimatter in the universe.

Further reading

M Kobayashi and T Maskawa 1973 *Prog. Theor. Phys.* **49** 652.
Y Nambu 1960 *Phys. Rev.* **117** 648.
Y Nambu and G Jona-Lasinio 1961 *Phys. Rev.* **122** 345

NEW PARTICLES

D0 observes b-version omega

The D0 collaboration at Fermilab's Tevatron has made the first observation of the Ω_b^-, consisting of two s quarks and a b quark. This follows the discovery at Fermilab of the strange b baryon, Ξ_b^-, in 2007, and echoes that of the original Ω^- particle.

The prediction of the original Ω^- dates back to the early 1960s, when assigning the known baryons to symmetry groups according to properties including spin, isospin and strangeness hinted at the existence of a new, triply strange spin–3/2 baryon with a charge of –1. In a triumphant interplay between experiment and theory, the particle was discovered in 1964 in a photograph made at the 80 inch bubble chamber at Brookhaven National Laboratory. Subsequent events turned up soon after at CERN (p12). The success of the symmetry group structure led to the quark model, with three initial types or "flavours" of quark, u, d, and s, where the s quark endows the property of strangeness. The Ω^- is a baryon, consisting of three quarks, sss.

The subsequent decades revealed three additional flavours of quark, c, b and t, and the quark model now predicts the existence of baryons made of quarks of all flavours but t. (The heavy top quark, t, decays too quickly to form bound states.) This leads to new multiplets of spin–1/2 and spin–3/2 baryons of u, d, s and b quarks. The newly discovered Ω_b^- baryon is a heavy cousin of the Ω^-, with a b quark replacing one of the s quarks occupying the position indicated in figure 1 for the spin–1/2 baryons.

Sifting through the data collected at the proton–antiproton collisions at the Tevatron during 2002–2006, the D0 collaboration identified 18 Ω_b^- candidate events at a mass of 6.165 ± 0.017 GeV/c^2, approximately six times as great as the proton mass (Abazov *et al.* 2008). This makes it the heaviest baryon observed so far. The Ω_b^- candidates were reconstructed from decay daughter particles: $\Omega_b^- \rightarrow J/\psi\Omega^-$, $J/\psi \rightarrow \mu^+\mu^-$, $\Omega^- \rightarrow \Lambda K^-$ and $\Lambda \rightarrow p\pi^-$. While the Ω^- and Λ have decay lengths of a few centimetres, the Ω_b^- travels only a millimetre or so before decaying. The analysis uses a sample of events with muon pairs from J/ψ decays, followed by successive reconstructions of Λ and Ω^- particles from charged tracks before a final combination of J/ψ and Ω^- candidates. Figure 2 shows the effective mass spectrum of the J/ψ and Ω^- combinations, with a peak of more than 5σ significance and the observation of the Ω_b^-.

The Ω_b^- now joins the $\Sigma_b^{\pm}$ and Ξ_b^- baryons recently observed at the Tevatron (*CERN Courier* July/August 2007 p6). These new states allow detailed study of the strong force, which holds quarks together to form all baryons, and the weak force, which is responsible for their decays.

Further reading

V M Abazov *et al.* The D0 Collaboration. 2008 subm *Phys. Rev. Lett.* http://arXiv:0808.4142v1 [hep-ex].

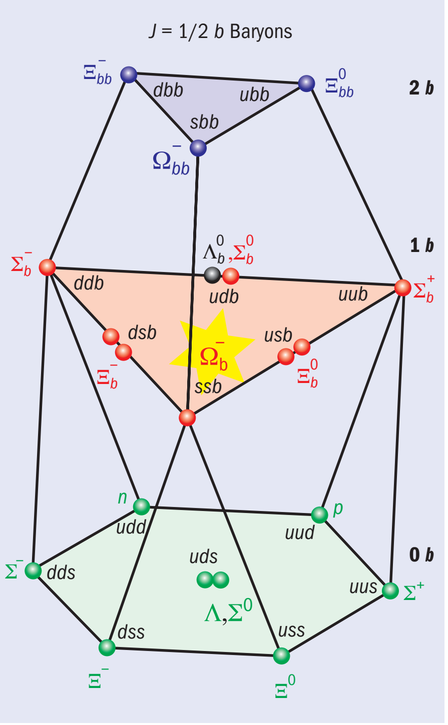


Fig. 1. An illustration of the spin-1/2 multiplet showing the position occupied by the Ω_b^-.

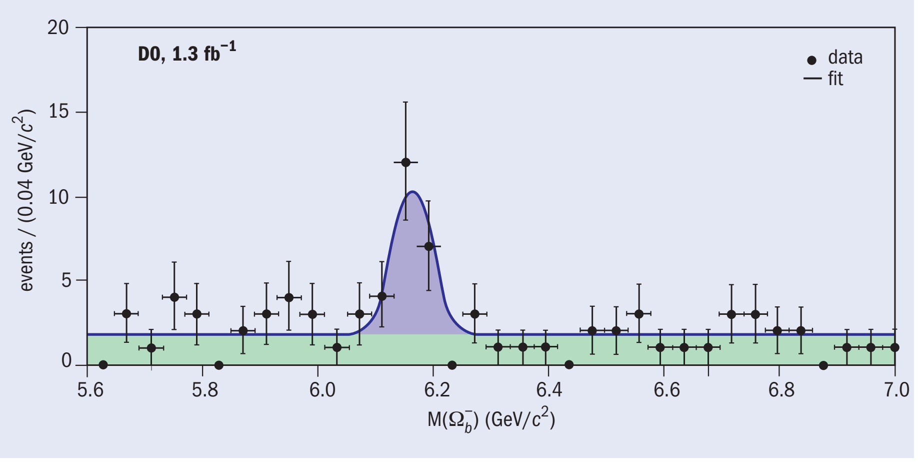


Fig. 2. The mass distribution for the Ω_b^- candidates after all selection criteria have been applied.

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.

NEW PARTICLES

Belle finds more exotic mesons

The Belle collaboration has announced the discovery at the Japanese B-factory, KEKB, of three new exotic sub-atomic particles, which they have labelled the Z_1, Z_2 and Y_b. The Z_1 and Z_2 states appear to be particles consisting of four quarks, while the Y_b may be the first clear example of an exotic hybrid particle, containing an excited gluon in addition to a quark–antiquark pair.

In the past few years, a number of peculiar new particles, including the X(3872), Y(4260), X(3940) and Y(3940), have been found both at Belle and at the BaBar experiment at SLAC. Last year, the Belle team reported the first exotic particle containing a c and $\bar{c}$ quark with non-zero electric charge, the Z(4430) (*CERN Courier* May 2005 p7 and *CERN Courier* January/February 2008 p7).

The Belle collaboration has now found further new particle states in the decay products of B mesons produced at KEKB. The team searched for states decaying into a π and χ_{c1}, a well known charmonium meson, and found mass peaks at 4051 MeV and 4248 MeV (figure 1), which they have named the Z_1 and Z_2 respectively (Mizuk *et al.* 2008). Like the Z(4430), the states have non-zero electric charge and could be further examples of particles consisting of four quarks – a c and $\bar{c}$ bound together with a quark and different antiquark, as in $cu\bar{c}\bar{d}$, for example.

The Y_b state was found in a different way: in an energy scan of the KEKB accelerator where the Belle team observed a dramatic increase in the production rate of the upsilon together with two pions at an energy of 10 890 MeV (figure 2). This indicates the production of a new particle decaying into an upsilon and two pions. This could be the first example of an exotic bottomonium particle, consisting of a bound state of a b and $\bar{b}$ together with an excited gluon, although there are other possible interpretations.

Further reading

R Mizuk *et al*. The Belle Collaboration 2008 subm. *Phys. Rev. D* http://arxiv.org/abs/0806.4098.

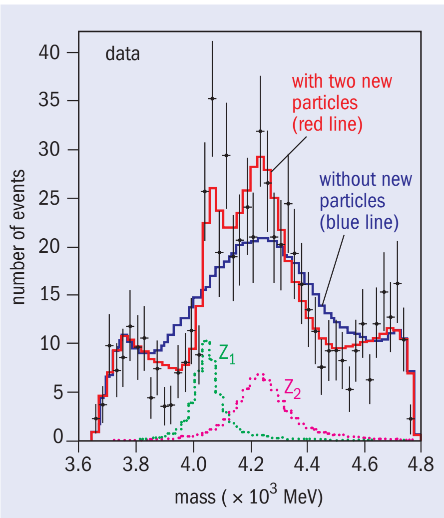


Fig. 1. Distribution of mass for the combination of a π and a χ_{c1} meson. The peaks at 4050 MeV and 4250 MeV correspond to the Z_1 and Z_2 particles.

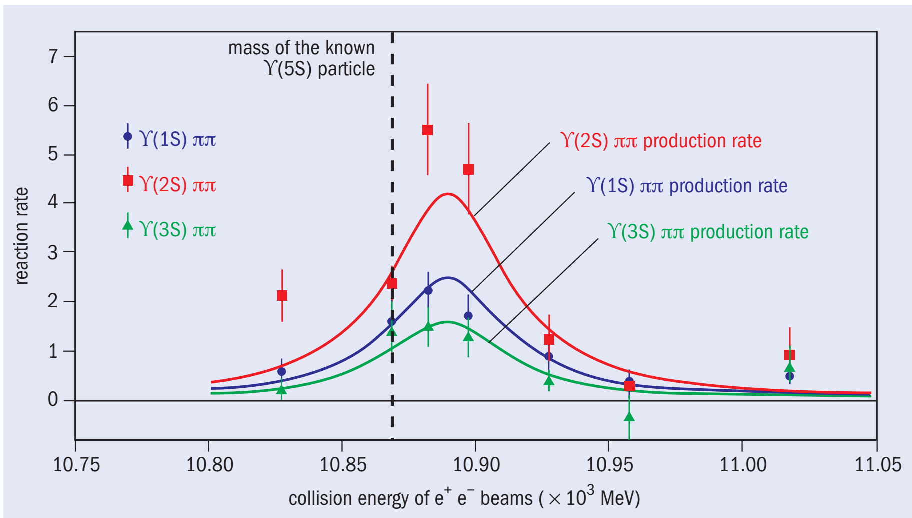


Fig. 2. Measured production rate of an upsilon and two pions as a function of the collision energy of the e^+ and e^- beams. The production rate peaks at 10 890 MeV for all the three types of upsilon-mesons ((1S)-blue, (2S)-red,(3S)-green); the dashed line indicates the mass of the Υ(5S).

ASTROPARTICLE PHYSICS

ASPERA names its magnificent seven

In the same room that hosted the first Solvay conference in 1911 at the Hotel Metropôle in Brussels, on 29–30 September the AStro Particle ERAnet (ASPERA) network presented the European strategy for astroparticle physics. As a result of two years of intensive coordination and brainstorming work, the document highlights seven large-scale projects that should shed light on some of the most exciting questions about the universe.

Questions surrounding dark matter, the origin of cosmic rays, violent cosmic processes and the detection of gravitational waves are among those that the "magnificent seven" of ASPERA's roadmap will address. Specifically, the projects are: CTA, a large array of Cherenkov Telescopes for detection of cosmic high-energy gamma rays; KM3NeT, a cubic kilometre-scale neutrino telescope in the Mediterranean sea; tonne-scale detectors for dark matter searches; a tonne-scale detector for the determination of the fundamental nature and mass of neutrinos;

a megatonne-scale detector for the search for proton decay, neutrino astrophysics and the investigation of neutrino properties; a large array for the detection of charged cosmic rays; and a third-generation underground gravitational antenna.

Each of these large-scale projects may cost several hundred-million euros, and therefore needs to gather funds through large international collaborations that extend beyond Europe. The ASPERA conference gathered about 200 scientists and officials from funding agencies around the world. Representatives from Canada, China, the EU, India, Japan, Russia and the US agreed on the importance of defining a global strategy and coordinating efforts worldwide. In line with this approach, the Astroparticle Physics European Coordination (the initiator of the ASPERA network) is starting negotiation with the OECD Science Global Forum.

The EU will nevertheless remain a major actor, having funded ASPERA and will fund the follow-up, ASPERA2. It also supports the European Strategy Forum on Research Infrastructures (ESFRI). The ESFRI committee released a first road map in 2006 and is expected to release an updated road map at the end of 2008, including some of the projects selected by ASPERA.

PUBLISHING

JINST provides open access to LHC articles

Seven major articles on the LHC and its detectors have been published electronically in a special issue of the *Journal of Instrumentation* (*JINST*). Together they form the complete scientific documentation on the design and construction of the LHC machine and the six detectors (ALICE, ATLAS, CMS, LHCb, LHCf and TOTEM), and thus on the entire LHC project.

This landmark publication is probably the first time for a major new accelerator project to be documented in such a comprehensive, coherent, and up-to-date manner prior to going into operation. The papers should for many years to come serve as key references for the stream of scientific results that will begin to emerge from the LHC after the first collisions next year. They provide a much-needed update of the *Technical Design Reports*, some of which are now 10 years old.

Although published in a refereed scientific journal, the articles are completely free to download and read online under an Open Access scheme, without requiring a journal subscription. *JINST* is an online-only journal published jointly by the International School for Advanced Studies in Trieste, Italy, and the Institute of Physics Publishing in Bristol, under the scientific direction of Amos Breskin from the Weizmann Institute of Science in Rehovot. Since commencing in 2006, it has quickly become popular in the LHC community as a platform for publishing techical papers.

With 1600 pages authored by 8000 scientists and engineers the special issue is the most significant manifestation of CERN's Open Access policy thus far. It is an important milestone on the road to converting all particle-physics literature to Open Access under the initiative of the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP^3).

Further reading

For the special LHC issue of *JINST*, entitled *The CERN Large Hadron Collider: Accelerator and Experiments*, see www.iop.org/EJ/journal/-page=extra.lhc/jinst. (To pre-order printed versions e-mail library.desk@cern.ch with "JINST papers" as the subject.) For details on SCOAP^3, see www.scoap3.org.

JEFFERSON LAB

DOE approves 12 GeV upgrade for CEBAF

On 15 September, the Thomas Jefferson National Accelerator Facility (Jefferson Lab) received approval from the US Department of Energy (DOE) to begin construction of a $310 million upgrade to the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF). The upgrade project has been a high priority for the DOE's Office of Science since it published its landmark report, *Facilities for the Future of Science: A Twenty Year Outlook*, in 2003.

The construction approval, known as Critical Decision 3, concludes an exhaustive, multi-year review process that clearly established the scientific need, merit and quality of the 12 GeV CEBAF upgrade project that will see DOE's Jefferson Lab double the energy of its accelerated electron beam from 6 GeV to 12 GeV.

It will also construct a new experimental hall and upgrade the equipment in its three existing experimental halls. Construction funds are requested in the US president's fiscal year 2009 budget request and project completion is planned for 2015.

With the upgrade, researchers at Jefferson Lab plan to investigate quark confinement further and to map in detail the distributions of quarks in space and momentum, culminating in measurements that will provide a 3D picture of the internal structures of protons and neutrons. They also plan to study the role of quarks in the structure and properties of atomic nuclei, as well as how these quarks interact with a dense nuclear medium. Once completed, the upgraded facility will allow studies of the limits of the Standard Model.

An aerial view of CEBAF indicates the accelerator (dashed line) and existing halls (circles). (Courtesy Jefferson Lab.)

SCIENCEWATCH

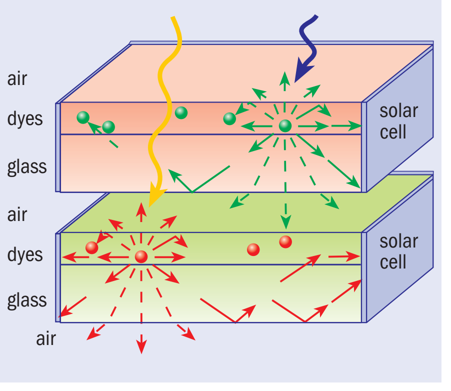
Compiled by Steve Reucroft and John Swain, Northeastern University

Organic dyes bring increased solar power

Particle physicists have long been familiar with the idea of shifting the wavelength of light to make detection easier – now the same idea could prove a boon for solar power. Michael Currie and colleagues from the Massachusetts Institute of Technology have shown that planar waveguides with a thin film of organic coating on one side and solar cells on the edges can produce significantly more power than the solar cells on their own.

Their "organic solar concentrators" consist of a thin film of organic dye deposited on glass with a high refractive index. The dye absorbs solar radiation and then re-emits it at longer wavelengths, with some 80% of the re-emitted photons being trapped within the glass by total internal reflection. The team constructed concentrators in tandem so that light passing through the first structure could be absorbed by the second. Standard solar cells mounted on the edges of the device collect the wavelength-shifted photons.

The researchers report quantum efficiencies above 50% and suggest that, ultimately, the devices could achieve 10-fold increases in power compared with standard solar cells – and this is achieved without the need for solar tracking.



Two organic solar concentrators in tandem, the upper one absorbing shorter wavelength light than the one below. (Currie 2008.)

Further reading

M J Currie *et al*. 2008 *Science* **321** 226.

Tequila can turn into diamonds

Sometimes the most unlikely substances turn out to have valuable properties, but few would have guessed that tequila would be good for making diamonds. Javier Morales of the University of Nueva Leon in Mexico and colleagues have found that the heated vapour from 80-proof (40% alcohol) "tequila blanco", if deposited on silicon or stainless steel at 850 °C, will form diamond films.

The researchers grew the films with pulsed liquid injection chemical vapour deposition techniques and then characterized the deposits using scanning electron microscopy and Raman spectroscopy. The spherical crystallites, 100–400 nm in size, show the characteristic 1332 cm^{-1} Raman band of diamond.

An appropriate mixture of hydrogen, oxygen and carbon is needed for this to work, and it seems that at least some tequilas are up to the job. Acetone and water mixtures also work, but you can't drink the leftovers from your experiment.

Further reading

J Morales, L M Apátiga and V M Castaño 2008 http://arxiv.org/abs/0806.1485.

Fruit flies, light, and magnetism

The means by which animals sense magnetic fields are not well understood, but some progress has been made in this area by studying fruit flies. Robert Gegear and colleagues at the University of Massachusetts have found that without the ultraviolet-A/blue-light photoreceptor molecule cryptochrome, fruit flies lose their ability to detect magnetic fields.

Interestingly, these insects also are unable to detect magnetic fields without the presence of UV-A or blue light, but the details of just how light, cryptochrome and magnetic fields all work together is still unclear.

Further reading

R J Gegear *et al*. 2008 *Nature* **454** 1014.

Supercritical sea smokers

Sea water has a supercritical point at a pressure of 298 bar and a temperature of 407 °C, where it becomes something that blurs the boundary between liquid and gas. However, this state has never been seen in nature – until now.

Andrea Koschinsky and colleagues of Jacobs University, Bremen, found this strange stuff at two "black smokers" on the Mid-Atlantic ridge. More dense than steam but less so than water, it may be produced when water seeps into cracks in the seabed, heating up and being subjected to increasing pressure until going supercritical and spewing upwards again.

Further reading

A Koschinsky *et al*. 2008 *Geology* **36** 615.

Ice can freeze at room temperature

Under extreme conditions of confinement, water can act strangely – including, it seems, freezing at room temperature. K B Jinesh and J W M Frenken – at the lab named after the father of low-temperature physics, Kamerlingh Onnes, Leiden University – dragged the sharp tungsten tip of a high-resolution friction-force microscope over a graphite surface coated with water. They found that water nucleating under the tip can actually turn into solid ice (admittedly not much of it, but ice nonetheless). They even see the ice break and refreeze via the stick-slip motion of the tip.

Further reading

K B Jinesh and J W M Frenken 2008 *Phys. Rev. Lett.* **101** 036101.

ASTROWATCH

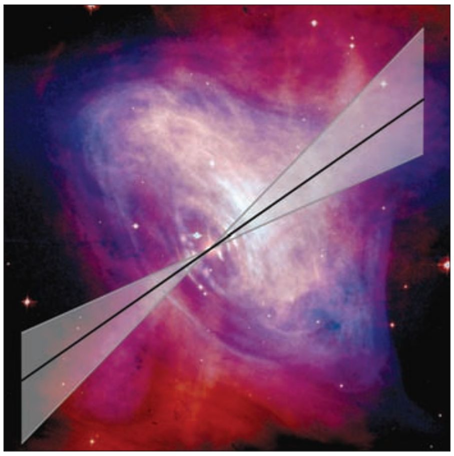
Compiled by Marc Türler, ISDC and Observatory of Geneva University

INTEGRAL pinpoints acceleration

Several sources of very high-energy gamma-rays are associated with pulsars, revealing that these spinning neutron stars are extremely powerful particle accelerators. The discovery with ESA's International Gamma-ray Astronomical Laboratory (INTEGRAL) satellite that the gamma-ray emission of the Crab Nebula is strongly polarized along the direction of its spin axis locates the acceleration site in the close vicinity of the pulsar.

The Crab Nebula is the aftermath of a supernova explosion witnessed by Chinese and Arab astronomers in the year 1054. The core of the dying star collapsed to form a neutron star while the outer layers were expelled; their on-going interaction with the interstellar medium produces the beautiful remnant seen nowadays (*CERN Courier* January/February 2006 p10). A neutron star can be thought of as a giant atomic nucleus about 20–30 km across, in which each cubic millimetre weighs about 100 000 tonnes. The neutron star at the centre of the Crab Nebula is actually a pulsar sending radiation pulses 30 times per second, each time the magnetic pole of the spinning neutron star points towards the Earth.

The high-resolution X-ray image of the Crab Nebula obtained by NASA's Chandra satellite revealed a complex geometry with a collimated jet, thought to be aligned with the spin axis of the neutron star surrounded by a toroidal, donut-shaped structure. However, the much lower resolution of current hard X-ray and gamma-ray instruments cannot locate precisely the site of high-energy emission within the Crab Nebula.



Gamma-ray polarization direction with grey error area superimposed on a composite image of the Crab Nebula in X-rays (blue) and in optical (red) taken by the Chandra and Hubble space telescopes. (Courtesy NASA/CXC/ASU/J Hester et al. *(for the Chandra image); NASA/HST/ASU/J Hester* et al. *(for the Hubble image).)*

A possible clue comes from the study of the polarization properties of the high-energy radiation, a difficult task that has now been achieved for the first time by European astronomers analysing data from the INTEGRAL's spectrometer. The study, led by Anthony Dean of the University of Southampton, is based on more than 600 individual observations of the Crab taken between February 2003 and April 2006.

The polarization of a gamma-ray photon can be derived if it is scattered off an electron from one detector element to another. This Compton-scattering has a preferred direction related to the polarization angle of the incoming photon. About half a million such events were detected from the Crab Nebula during the quiescent phase of the pulsar cycle, with photon energies between 0.1 and 1 MeV. These data were then fitted to the results of intensive Monte Carlo simulations using GEANT4. The best fit was obtained for a polarization of $46 \pm 10\%$ and a polarization angle of $123° \pm 11°$, closely aligned with the direction of the pulsar spin and the X-ray jet.

This large fraction of polarized photons implies that the high-energy electrons emitting them are accelerated with a high degree of order in a structure apparently closely linked to the spin axis of the pulsar. By considering either synchrotron radiation or curvature radiation, Dean and colleagues estimate a typical electron energy of 10^{14} to 10^{15} eV. This is about 1000 times the energy reached by CERN's LEP collider and is enough to explain the production – by interactions with visible or microwave photons within the Crab Nebula – of the very high-energy gamma-rays detected by Cherenkov telescopes (*CERN Courier* January/February 2005 p30).

Further reading

A J Dean *et al*. 2008 *Science* **321** 1183.

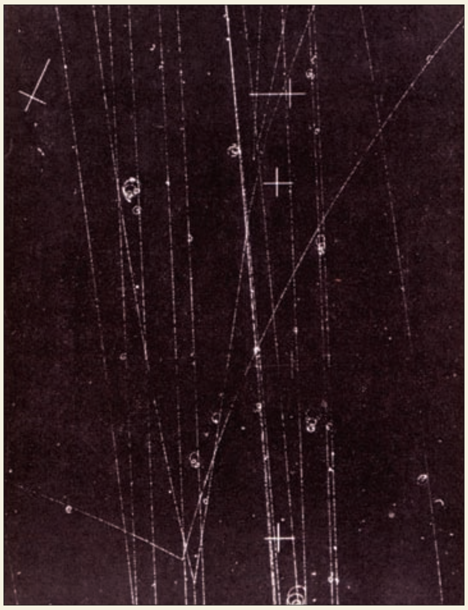
Picture of the month

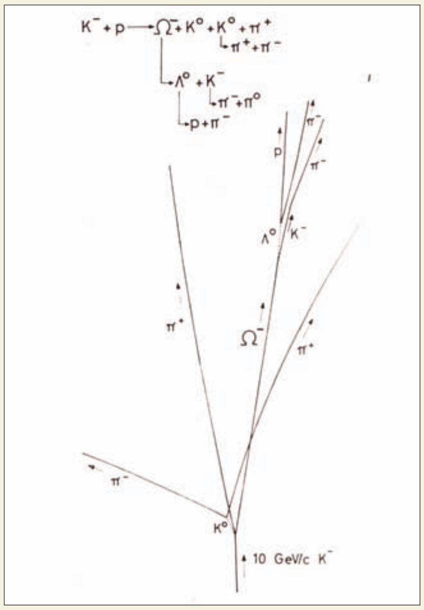
No, this is not the famous Bullet Cluster image (*CERN Courier* October 2006 p9), but it is exactly the same phenomenon seen in another collision of two galaxy clusters called MACS J0025.4-1222. The X-ray image by NASA's Chandra satellite is superimposed in pink colour on an optical image by the Hubble Space Telescope. The blue diffuse structures are not detected directly, but show the distribution of mass in the cluster derived through the analysis of the orientation of background galaxies influenced by weak gravitational lensing (*CERN Courier* January/February 2007 p11). With Chandra mapping ordinary matter, mostly in the form of hot gas glowing in X-rays, and Hubble essentially mapping the distribution of the dominant dark matter, this image shows how the frontal cluster collision has separated non-interacting dark matter (blue) from ordinary matter (pink). (Courtesy NASA, ESA, CXC, M Bradac (University of California, Santa Barbara, US), and S Allen (Stanford University, US).)

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

NEW PARTICLES

Specimens of omega-minus found in Europe





Photograph of an interaction between a negative kaon and a proton, taken with the 152 cm British bubble chamber at CERN, in which one of the products was an omega hyperon. As the diagram indicates, the omega decayed into a lambda (neutral and therefore leaving no track) and a negative kaon, after which the lambda in turn decayed into a proton and a negative pion whilst the kaon disintegrated into a negative pion and a neutral pion (again invisible). Two neutral kaons and a positive pion were also produced in the initial interaction and one of these kaons decayed into two charged pions.

At the Oxford conference in September, three examples were reported of the famous omega-minus particle, which had been sought for several years in Europe but which had seemed more and more to be a native only of the USA. This is the particle that was predicted as a consequence of the "eightfold-way" version of the symmetry theory SU3 and provided striking confirmation of the theory when it was discovered in an experiment at Brookhaven National Laboratory early in 1964 (*CERN Courier* March 1964 p27). Until recently only five examples had been found, all in photographs obtained on that side of the Atlantic.

Two of the new examples were photographed in the 152 cm British hydrogen bubble chamber at CERN, during a run with 6 GeV/*c* negative kaons. The best one, for which details have been published in *Physics Letters* (Vol. 19, pp. 152–4, 1 October 1965), was found after 400 000 photographs had been scanned, in which the sum of all the kaon tracks amounted to some 5000 km! From analysis of the many tracks appearing on the photograph it was deduced that the omega was produced in an interaction between a negative kaon and a proton in which a neutral kaon and a positively charged kaon were also produced. The mass of the omega was calculated as 1666 ± 8 MeV and its lifetime 1.85×10^{-10} second.

The second example reported at Oxford was not so clearly defined, but the most likely explanation of the event in question is that an omega minus was formed. The third omega, revealed in the photograph shown (with its explanation), was also produced in the British bubble chamber at CERN, but this time in the experiment that used a radio-frequency-separated beam of kaons of 10 GeV/*c* momentum.

Underlining the difference in effort required nowadays to find such an "elementary particle", compared with that needed to discover the neutron, say, or the positron, is the fact that the paper in *Physics Letters* appears under the name of the "Birmingham, Glasgow, Imperial College, Munich, Oxford and Rutherford Laboratory Collaboration". Underneath are the names of the 51 university and other physicists involved! Acknowledgements are also given to the crews of the CERN proton synchrotron and the British bubble chamber, the computing unit at Imperial College, the computer programming staff at the Rutherford Laboratory, and the scanning and measuring teams. The 10 GeV/*c* negative-kaon experiment that has produced the third omega is being carried out by a collaboration of groups in Aachen, Berlin, CERN, London (Imperial College) and Vienna. In this respect, at least, the claims of CERN to be both an inspiration and a servant of physics in Europe seem to be not without foundation!

● Compiled from "Last month at CERN" pp167–168.

COMPILER'S NOTE

The omega-minus was the iconic particle of the mid-20th century, the single missing piece in the "eightfold-way" description of hadrons. Its discovery led to the quark model that dramatically clarified our understanding of "elementary particles". The Higgs mechanism, contemporary with the eightfold-way, was proposed to explain how particles acquire their masses. The Higgs boson, today's iconic particle, is the single missing piece in the Standard Model of particles and their interactions. Researchers at the LHC are hoping that it will prove to be present in Europe even if not strictly speaking native.

As the time lag indicates, hunting the Higgs particle(s) has required a much greater effort than tracking down the omega-minus. In 1965, the *Physics Letters* paper mentioned had 51 authors from five home institutes in two countries. The ATLAS experiment at the LHC presently has some 2500 collaborators from 169 universities and labs in 37 countries; CMS is of similar size. CERN's founders surely didn't foresee that one day the laboratory would become an inspiration and servant of physics for the whole world!

Fermi Gamma-ray Space Telescope sees first light

With exceptional resolution and sensitivity, the latest orbiting gamma-ray telescope based on detection techniques from particle physics is opening a new window on the high-energy universe.

On 26 August, NASA and the US Department of Energy announced the first-light results of the Gamma-Ray Large Area Space Telescope (GLAST). At the same time GLAST changed its name to the Fermi Gamma-ray Space Telescope. Built in an international collaboration of astrophysicists and particle physicists with important contributions from research institutions in France, Germany, Italy, Japan, Sweden and the US, Fermi is expected to discover thousands of new sources of different classes, thus tackling many unresolved questions of fundamental physics, astronomy and cosmology. The telescope is already detecting high-energy gamma-rays from a wealth of cosmic sources – including super-massive black holes in active galactic nuclei, supernova remnants, neutron stars, galactic and solar system sources, and gamma-ray bursts (GRBs) – with more than 30 times the sensitivity of its successful predecessor, the Energetic Gamma Ray Experiment Telescope (EGRET).

Gamma-rays are produced by the interaction of high-energy charged particles with local matter, magnetic fields or ambient photons, and thus give insight into the physical conditions prevailing in these exotic sources. The physics of the particle acceleration mechanisms believed to be operational in many of these objects was first proposed by Enrico Fermi, who is now honoured with the new name of the telescope. Through investigation of the most extreme places in the universe, Fermi will shed light on many fundamental physics questions, such as, the nature of the ubiquitous dark matter. Dark matter particles could decay or annihilate into gamma-rays and possibly give rise to unambiguous signatures in gamma-ray spectra, which could be used to infer or constrain the properties of the original particles. In understanding dark matter, observations with Fermi will therefore be an essential complement to searches for new particles at CERN.

The main instrument on board Fermi is the Large Area Telescope (LAT), which detects gamma-rays between 20 MeV and 300 GeV (Michelson *et al.* 2008). The addition of the secondary GLAST Burst Monitor (GBM) – an instrument primarily dedicated to the detection of GRBs between 8 keV and 30 MeV (von Kienlin *et al.* 2001) – gives Fermi a total coverage of seven decades in energy. The aspect ratio of the LAT allows for a large field of view, observing 20% of the whole visible sky at any instant, while the GBM provides complete sky coverage for the detection of GRBs.

Fermi was launched by NASA on 11 June from the Cape Canaveral Air Station in Florida, for a 5–10 year long mission (figure 1). The first 60 days of data taking constituted the commissioning phase, which went smoothly thanks to the thorough preparatory work undertaken by the whole international Fermi Mission team. During this period, teams undertook the calibration and verification of the performance of the different subsystems. Background rejection, a key element to the success of the mission, proved very satisfactory. Then, on 14 August Fermi entered the phase of nominal science operations, surveying the complete gamma-ray sky every three hours.

Fig. 1. Launch of the Fermi Gamma-ray Space Telescope on 11 June from Cape Canaveral Air Station in Florida. (Courtesy NASA.)

Figure 2 shows the LAT all-sky image released on 26 August. Created using only 95 hours of "first light" observations from the early commissioning phase, this corresponds in source sensitivity to a whole year of observations by EGRET (Thompson *et al.* 1993). The map shows gas and dust in the plane of the Milky Way emitting gamma rays owing to collisions with cosmic rays. Other clearly visible sources include the Crab, Geminga and Vela pulsars in our own Galaxy as well as the blazar 3C454.3, an active galaxy located 7.1 billion years away. This source appears particularly bright in the map as it was in a flaring state at the time of the acquisition, as the Fermi/GLAST collaboration announced through the *Astronomer's Telegram* (*Atel* **1628** 2008).

Fermi has since witnessed the intrinsically dynamic nature of the gamma-ray sky with the detection of another three active galactic nuclei in a high flaring state (*Atel* **1650**, **1701** and **1707** 2008) and ▷

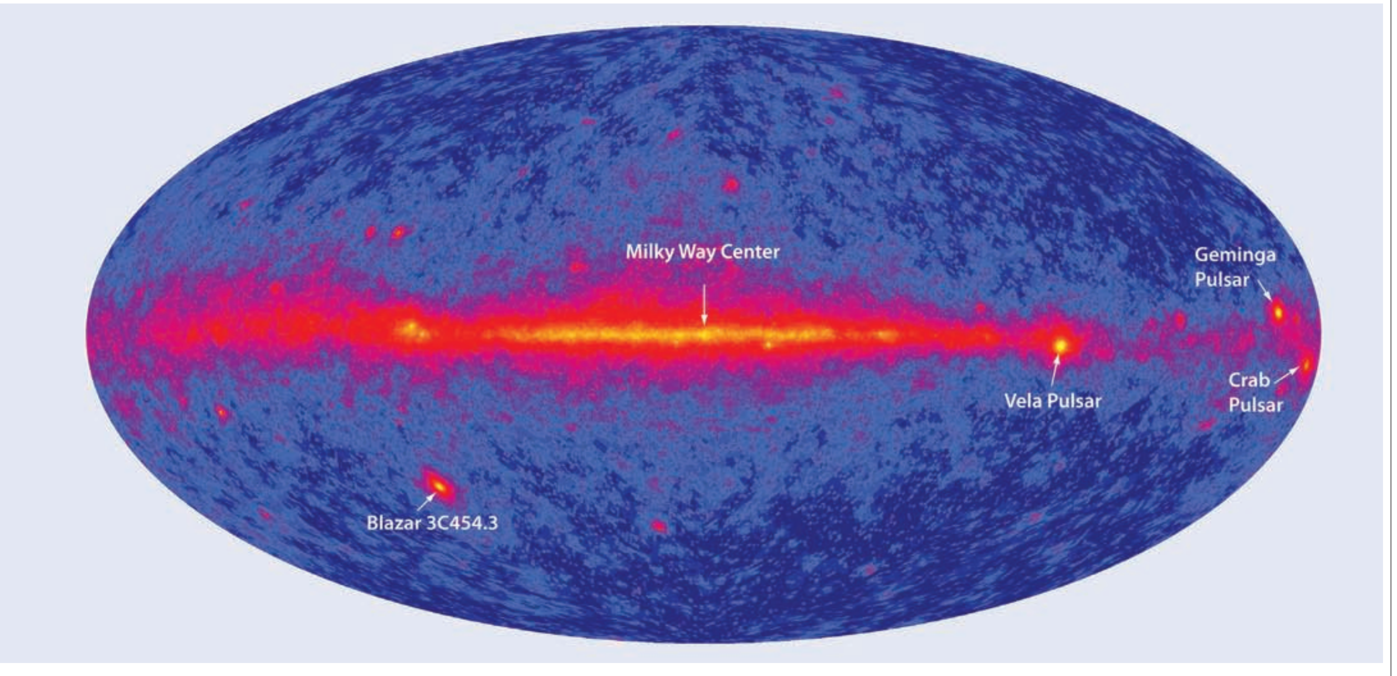


Fig. 2: Fermi's "first light" all-sky gamma-ray map showing major sources detected. (Courtesy the International Fermi LAT Collaboration.)

the detection of two GRBs with giga-electron-volt energy emission (*GCN circulars* **8183** and **8246** 2008). These bursts were detected by the LAT in coincidence with the GBM, which has also detected another 30, lower-energy bursts since its turn-on on 25 June.

The LAT is a pair-conversion telescope, which consists of an array of 4 × 4 towers, each comprising a precision converter/tracker and a calorimeter (figure 3). Each tracker module has 18 x-y tracking planes, which contain single-sided silicon strip detectors (400 μm thick with a 228 μm pitch) interleaved with a high-Z converter material (tungsten). The tracker has an active surface of 70 m^2 (comparable to the Inner Tracker of the ATLAS detector at CERN, with just over 60 m^2) and 900 000 digital channels.

Each calorimeter module consists of 96 CsI(Tl) crystals, which are 2.7 cm × 2.0 cm × 2.6 cm in size and are arranged in eight layers of 12 crystals, each forming a hodoscope (x-y) array. The total depth of the calorimeter is 8.6 radiation lengths (out of 10.1 radiation lengths for the whole instrument). The dimensions of the crystals are comparable to the CsI radiation length (1.86 cm) and Moliere radius for electromagnetic showers (3.8 cm). The segmentation allows for spatial imaging of the shower profile and accurate reconstruction of the shower direction, thus making possible the high energy reach of the LAT and improving background rejection.

The tracker is surrounded by an anticoincidence detector (ACD), consisting of 89 plastic scintillator tiles of different sizes, which are read out by wavelength-shifting fibres coupled to photomultiplier tubes. The ACD is used to reject charged cosmic rays and therefore must have a high efficiency for charged particle detection (>0.9997). The segmentation is optimized to limit the effect of "backsplash" (secondaries produced in the interaction of high-energy photons with the heavy calorimeter, giving a signal in the ACD), which reduced the efficiency of EGRET by at least a factor of two at energies above 10 GeV. The calibration of the LAT is based on a combination of in-orbit and ground-based cosmic-ray data, together with beam tests performed at CERN (at the PS and SPS) and GSI (Baldini *et al.* 2007) and Monte Carlo simulations using Geant 4.

The GBM, which is dedicated to the detection of GRBs, includes 12 sodium iodide (NaI) scintillation detectors and two bismuth germanate (BGO) scintillation detectors. The NaI detectors cover the lower part of the energy range, from a few kilo-electron-volts to about 1 MeV, and provide burst triggers and locations. The BGO detectors cover the energy range from about 150 keV to around 30 MeV, providing a good overlap with the NaI at the lower end, and with the LAT at the high end.

Within only a few days of turn-on, using data originally planned for observatory calibration, Fermi has already corroborated many of the great discoveries both of EGRET and of AGILE (Tavani *et al.* 2008). The LAT instrument is already finding new sources. Such spectacular results have only been achieved thanks to an advanced design for the observatory, which makes use of state-of-the-art particle-physics instrumentation that gives Fermi exceptional resolution and sensitivity. As a result, understanding of the high-energy universe is sure to grow tremendously, but even more exciting could be the unexpected, as history shows that opening new observational windows often yields completely unanticipated discoveries.

● The institutions participating in the collaboration built and qualified the LAT subsystems which then were integrated at SLAC. The detectors for the GBM were produced at the Max-Planck-Institute for Extraterrestrial Physics in Garching, and were integrated at the Marshall Space Flight Center in Huntsville, Alabama. Both instruments were integrated with the spacecraft at General Dynamics, in Phoenix, Arizona, to form the Fermi observatory. Environmental testing was then performed both at General Dynamics and at the Naval Research Lab in Washington D C.

Further reading

For more about Fermi and the latest news see http://fermi.gsfc.nasa.gov.

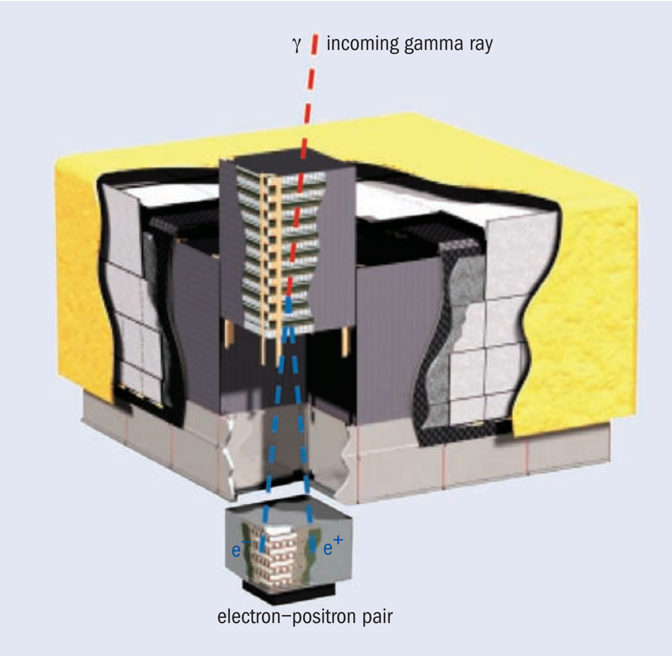


Fig. 3. Schematic diagram showing the construction of the Large Area Telescope, showing the conversion of an incoming gamma ray into an electron–positron pair. (Michelson et al. *2008.)*

Atel **1628** 2008 www.astronomerstelegram.org/?read=1628.
Atel **1650** 2008 www.astronomerstelegram.org/?read=1650.
Atel **1701** 2008 www.astronomerstelegram.org/?read=1701.
Atel **1707** 2008 www.astronomerstelegram.org/?read=1707.
L Baldini *et al.* 2007 *AIP Conf. Proc.* **921**.
GCN Circular **8183** 2008 http://gcn.gsfc.nasa.gov/gcn3/8183.gcn3.
GCN Circular **8246** 2008 http://gcn.gsfc.nasa.gov/gcn3/8246.gcn3
A von Kienlin *et al.* 2001 *ESA SP* **459** 529.
P Michelson *et al.* 2008 in preparation.
M Tavani *et al.* 2008 *NIM-A* **588** 52.
D J Thompson *et al.* 1993 *ApJS* **86** 629.

Résumé

Première lumière du télescope spatial Fermi

Le 26 août, la NASA et le ministère américain de l'Énergie ont annoncé les résultats de la première lumière du télescope spatial à rayons gamma GLAST. À cette occasion, le télescope a été rebaptisé télescope spatial Fermi. Fruit d'une collaboration internationale entre astrophysiciens et physiciens des particules, le télescope spatial Fermi devrait ouvrir une nouvelle fenêtre sur l'univers à haute énergie et découvrir des milliers de nouvelles sources de rayons gamma, et donc traiter de nombreuses questions restées sans réponse dans les domaines de la physique, de l'astronomie et de la cosmologie.

Jan Conrad, *Stockholm University*, **Luca Latronico**, *INFN/Pisa*, **Francesco Longo**, *University and INFN Trieste, and* **Benoit Lott**, *CENBG, Bordeaux, on behalf of the Fermi LAT and GBM collaborations.*

NuPNET looks to future nuclear physics in Europe

Representatives from NuPECC, the EU Commission and national funding agencies have launched a network to allow for more transnational activities in nuclear physics.

Members of the NuPNET consortium surround the co-ordinator, Sydney Galès (sixth from left, front row) and the co-ordination manager, Dorothée Peitzmann (fifth from left, front row) at the kick-off meeting in Paris on 27 March 2008. (Courtesy X Pierre/CNRS-IN2P3.)

At a meeting in Paris on 27 March, representatives from the Nuclear Physics European Collaboration Committee (NuPECC), the EU Commission and 18 national funding agencies launched a network in nuclear physics to enable the community to pilot joint transnational activities.

The idea to create a European network in nuclear physics arose two years ago, when more than 15 representatives of nuclear physics funding agencies and/or similar organizations, a NuPECC delegation and EU officers met in Paris to discuss the possibility of co-ordinating the existing national funding procedures through a new tool of the European Commission. The tool – the European Research Area Network, or ERA-Net – would focus on networking, mutual opening, development and implementation of joint activities. The participants at the meeting unanimously agreed to prepare a proposal, based on the scientific recommendations made by NuPECC in its latest long-range plan with a view to the ERA-Net scheme, for submission as soon as the EU Commission launched the appropriate call within the Framework Programme for European Research and Technology.

The proposal took the name of NuPNET, for Nuclear Physics Network. Under the scientific co-ordination of the French partner, the co-ordination committee composed of members of funding agencies from France, Germany, Italy and Spain, had the responsibility of working out the full proposal. Thanks to the excellent collaboration between the co-ordination committee and the managers of the 18 European institutions that agreed to be part of this new venture, the final proposal was submitted in May 2007 at the first call of the Seventh Framework Programme for European Research and Technology (FP7). Evaluated during the summer of 2007, the NuPNET proposal was accepted by the European Commission in September 2007. Contract negotiations were completed by 11 March 2008 and a budget of €1.3 m has been granted for three years, from March 2008 to February 2011.

The NuPNET project comprises 18 regular members representing 14 countries (see box, p18). NuPECC is an associated member and acts as the Scientific Advisory Body of the NuPNET consortium to provide independent views on the direction of nuclear physics within Europe through its long-range plans, to give advice on scientific issues, and to inform NuPNET on the views of the scientific community. ▷

NuPNET members

- CNRS/IN2P3 (National Institute for Nuclear Physics and Particle Physics of the National Centre of Scientific Research, France)
- GSI (Gesellschaft für Schwerionenforschung, Germany)
- BMBF (Bundesministerium für Bildung und Forschung, Germany)
- INFN (Istituto Nazionale di Fisica Nucleare, Italy)
- FECYT (Fundación Española para la Ciencia y la Tecnologia, Spain)
- MICINN (Ministerio de Ciencia y Innovación, Spain)
- FNRS (Fonds de la recherche scientifique, Belgium)
- FWO V (Fonds Wetenschappelijk Onderzoek-Vlaanderen, Belgium)
- INRNE (Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences, Bulgaria)
- CEA (Commissariat à l'Energie Atomique, France)
- NPI ASCR (Nuclear Physics Institute, Academy of Sciences, Czech Republic)
- HIP (Helsinki Institute of Physics, Finland)
- GSRT (General Secretariat for Research and Technology, Greece)
- NKTH (National Office for Research and Technology, Hungary)
- RuG (Rijksuniversiteit Groningen, Netherlands)
- NCBiR (National Centre for Research and Development, Poland)
- IFIN-HH (National Institute of Physics and Nuclear Engineering, Romania)
- STFC (Science and Technology Facilities Council, United Kingdom).

NuPNET Open Days

NuPNET members need to understand and take stock of the funding systems in force in the partner countries in order to create a common approach. To aid this process, several sessions of Open Days are part of the work programme. The first conference, organized jointly by Germany (the work package leader), Greece and France, was held at the Nuclear Physics Institute in Athens on 8 September. It was attended by 30 scientists and government representatives from 11 European countries. At the meeting, funding agencies from Bulgaria, Greece, Hungary and Romania explained how and to what extent research in nuclear physics is funded in their country.

- The next session will take place in Germany on 30–31 October.

On 27 March 2008, the founding member institutions of NuPNET, the representatives from NuPECC and the EU Commission came together for the traditional "kick-off" meeting. Organized by CNRS/IN2P3, the co-ordinator of the NuPNET project, this first official meeting took place in Paris. The participants agreed that NuPNET's programme will have an important impact on the future of nuclear physics, especially since the ERA-Net proposal – as adopted by the partners and as accepted by the EU Commission – aims, for the first time in the history of nuclear physics, to co-ordinate the various national funding agencies in order to organize better the financing of nuclear physics infrastructures at a European level.

Implementation and governance

The NuPNET project has outlined a stepwise approach to project implementation in the form of four goals. The first is to compare reviewing and funding systems in participating funding agencies; provide a census of resources and agents in nuclear physics and infrastructures that paves the way to common decisions; and liaise with Integrated Infrastructure Initiatives and design studies in FP7 and other European and international initiatives, in particular the European Strategy Forum on Research Infrastructures and the Organisation for Economic Co-operation and Development. This work package is led by Germany.

The second goal is to propose a set of joint transnational activities (based on the science priorities set in the long-range plan of NuPECC) that can be launched by funding agencies thanks to NuPNET co-ordination. Italy leads this work package. The third goal is to launch one or more of those proposed joint transnational activities in the field of nuclear physics infrastructures, in a work package led by Spain. The fourth and final goal is to provide Europe with a sustainable scheme beyond the project duration.

The project is managed by the co-ordinator (CNRS/IN2P3); the governing council (NuPNET member institutions); the co-ordination committee (CNRS/IN2P3) and work package leaders from France, Germany, Spain and Italy; and the Scientific Advisory Body (NuPECC). All parties are involved at the relevant level; however, the governing council is the main decision-making body of the consortium, where only authorized members can vote in the name of the represented member institution. Public bodies interested in joining NuPNET may be invited to attend a meeting of the governing council. The co-ordinator, together with the co-ordination manager, ensures the overall management of the project, whereas the co-ordination committee implements the decisions taken by the governing council and supports the co-ordinator. Now, the work has started. NuPNET has its own logo, a website is being constructed and the first session of Open Days (see box) took place in Athens on 8 September.

Résumé
NuPNET, un réseau européen pour la physique nucléaire

Lors d'une réunion à Paris le 27 mars, des représentants du Comité européen de collaboration pour la physique nucléaire (NuPECC), la Commission européenne et dix-huit organismes de financement nationaux ont lancé un nouveau réseau de physique nucléaire, le NuPNET (Nuclear Physics Network). Ce réseau jouera un rôle considérable pour l'avenir de la physique nucléaire parce qu'il vise, pour la première fois dans cette discipline, à coordonner les organismes de financement afin d'améliorer l'organisation du soutien aux infrastructures de physique nucléaire au niveau européen.

Sydney Galès, *deputy director CNRS/IN2P3 and scientific co-ordinator of NuPNET, and* **Dorothée Peitzmann**, *CNRS/IN2P3 and co-ordination manager of NuPNET.*

Gamma-ray astronomers convene in Heidelberg

A symposium on high-energy gamma-ray astronomy revealed how this young field is rapidly maturing to provide a new view of the universe.

About 300 experts in astroparticle physics attended the γ 2008 symposium in Heidelberg. (Courtesy Christian Föhr, MPI for Nuclear Physics.)

Over the past few years, the quality and diversity of data from modern imaging atmospheric Cherenkov telescopes (IACTs) has revolutionized gamma-ray astronomy. With ground-based instruments, detailed imaging of the gamma-ray sky at 100 GeV to 100 TeV has become a reality and a wealth of information is currently being gathered about the universe. The 4th Heidelberg International Symposium on High-Energy Gamma-Ray Astronomy (γ 2008) was a timely opportunity to review the status and perspectives of this young field of astroparticle physics.

The Heidelberg Symposium is a well established series of conferences organized by the Max-Planck-Institute for Nuclear Physics (MPIK) in Heidelberg, a leading institute of the H.E.S.S. collaboration, which operates an array of four IACTs in Namibia. After fruitful meetings in 1996, 2000 and 2004, the 4th symposium, which took place in July this year, celebrated an important breakthrough in gamma-ray astronomy. More than 50 very-high-energy (VHE) gamma-ray sources – with energies above 100 GeV – have been discovered since the last symposium, when only about 20 such sources were known.

This tremendous progress was reflected in the high-quality contributions at γ 2008. Twenty-six invited speakers reviewed the status of the field and related disciplines, and discussed the perspectives for gamma-ray astronomy and astroparticle physics in general. In addition, 56 spoken contributions and some 200 poster presentations addressed a range of topics. The number of abstracts submitted to the conference was significantly higher than for the 2004 symposium, reflecting again the growing interest in gamma-ray astronomy round the world. Talks were given in plenary sessions, allowing for lively discussions among the 300 experts from different fields of astroparticle physics. A significant amount of time was also devoted to the poster sessions, which took place in the relaxing atmosphere of "coffee and cake", a typical German tradition.

VHE gamma-ray astronomy is currently being driven by four large installations of Cherenkov telescopes: the MAGIC telescope (La Palma, Canary Islands) and the VERITAS telescope array (Arizona, US) in the northern hemisphere; and the H.E.S.S. (Khomas Highlands, Namibia) and CANGAROO-III (Woomera, Australia) arrays in the southern hemisphere. While the northern instruments focus mainly on the observation of extragalactic objects and transient phenomena such as gamma-ray bursts, the southern arrays provide an excellent view of the inner Milky Way and are therefore also devoted to observations of Galactic objects.

As testified in short status reports at the symposium, MAGIC, VERITAS and H.E.S.S. are operating successfully. However, as Ryoji Enomoto of Tokyo University pointed out, the CANGAROO-III array is currently operating only two of its four telescopes, owing to severe mirror deterioration and lack of funding. There were also reports on results from joint observation campaigns on various targets, such as the nuclei of the active galaxies Mkn 421 and M 87. These campaigns provide a way of cross-calibrating the instruments and result in an enhanced energy coverage. Upgrades of MAGIC (with the installation of a second 17 m telescope) and H.E.S.S. (with the installation of a single 28 m telescope in the centre of the existing four 12 m telescopes) to increase their sensitivity are well underway, and first light is expected in late 2008 and 2009, respectively. ▷

This year's symposium took place at the prestigious Heidelberg Convention Centre. (Courtesy Christian Föhr, MPI for Nuclear Physics.)

After almost a decade of successful operation, the Milagro experiment – a 2000 m², large field-of-view water Cherenkov detector in New Mexico – has stopped data taking after mapping the northern gamma-ray sky at multi-tera-electron-volt energies (*CERN Courier* June 2008 p15). Compared to the Cherenkov telescopes that point to regions of the sky, Milagro's wide field of view allowed it to monitor the sky continuously, albeit at a higher energy threshold and with rather worse angular resolution. Although energy estimation is difficult for Milagro, Petra Hüntemeyer of the Los Alamos National Laboratory reported on the experiment's recent success in measuring the energy spectra of sources up to 100 TeV. Plans to replace the instrument by the High Altitude Water Cherenkov (HAWC) project, which would be 10 times more large and more sensitive, were presented in a special session dedicated to future instruments. This session also included discussion of the science issues related to the next generation of gamma-ray instruments.

The key European future project in VHE gamma-ray astronomy is the Cherenkov Telescope Array (CTA). Several tens of medium-sized Cherenkov telescopes will form the core of the CTA observatory, providing a 10-fold boost in sensitivity in the tera-electron-volt energy range compared with current instruments, as well as improved angular resolution. Additional large telescopes at the centre of the array will extend the energy range down to some tens of giga–electron-volts and a widespread halo of telescopes should add enough detection area to reach well into the 100 TeV range. CTA sites in the northern and southern hemispheres should allow full-sky coverage. In this context, the symposium served to foster the already intense communication between CTA and the project for the Advanced Gamma-ray Imaging System in the US, which has similar goals.

Just a few weeks before the conference, the astrophysics community celebrated the successful launch of the Fermi Gamma-ray Space Telescope (formerly GLAST) satellite, a gamma-ray observatory that will provide data in the energy range of approximately 10 MeV to 10 GeV (p13). Together with future ground-based instruments, this instrument will enable gamma-ray observations over seven decades of energy and a direct cross-calibration of ground-based and space-borne instruments for the first time. The perspectives for joint observations between Fermi and the Cherenkov telescopes was an important topic at the meeting, which was discussed by Stefan Wagner of the Landessternwarte Königstuhl in Heidelberg and Stefan Funk of SLAC, among others.

Physics highlights at γ 2008 included the discovery by the H.E.S.S. collaboration of the remnant of the historical supernova SN 1006 in VHE gamma rays. After more than 100 hours of observing time, H.E.S.S. now sees the remains of a massive stellar explosion, which Chinese astronomers reported in 1006, with a statistical significance of six standard deviations above the background. As Melitta Naumann-Godo of the Laboratoire Leprince-Ringuet pointed out, the preliminary image of the object seen by H.E.S.S. resembles the morphology of non-thermal X-ray filaments in the north-west and south-east part of the supernova remnant shell (see figure 1). Because these filaments are produced by synchrotron radiation of electrons that have been accelerated to an energy of about 100 TeV, SN 1006 has long been a prime target for Cherenkov telescopes; it is only the improved sensitivity of the current instruments that has made its discovery possible.

The detection of pulsed emission from the Crab pulsar by the MAGIC collaboration provided another highlight at the symposium. Many of the VHE gamma-ray sources in our galaxy can be identified with pulsar wind nebulae, but no VHE gamma-ray emission had previously been observed from a pulsar itself. The search for pulsed emission – which is well established at energies up to the giga-electron-volt range – matches the continuous efforts to minimize the energy threshold of Cherenkov telescopes. Using a special trigger setup, the MAGIC collaboration succeeded in lowering the threshold of their telescope to 25 GeV, making the detection of pulsed emission possible. Thomas

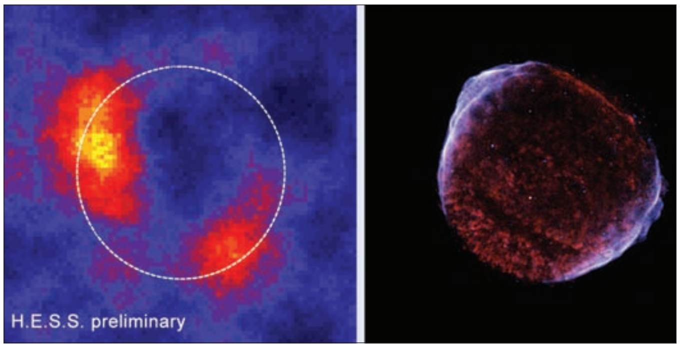


Fig. 1. A preliminary H.E.S.S. gamma-ray map of the SN 1006 supernova remnant (left) beside an X-ray image of the remnant as seen by the X-ray satellite Chandra (right). The circle in the left image indicates the size of the remnant as seen at radio wavelengths. The gamma-ray emission regions line up with the regions of intense X-ray emission. (Courtesy H.E.S.S. and NASA/CXC/Rutgers/J.Hughes et al.*)*

Schweizer of the Max-Planck-Institute for Physics in Munich presented a VHE gamma-ray phasogram from 22 hours of observations of the Crab pulsar, which shows two distinct peaks corresponding to the main pulse and the interpulse. The data are in phase with observations at lower energies and with simultaneous measurements in the optical waveband carried out by the MAGIC collaboration.

Overall, the symposium showed that the stage is set for a bright future in gamma-ray astronomy. As Felix Aharonian of MPIK said in his concluding remarks: “Gamma-ray astronomy has evolved into a new astronomical discipline. Our observations meet all the key features usually attributed to astronomy: imaging, energy spectra, light curves, surveys...”. The community is now looking forward to seeing many new results at the next symposium, which will take place around 2012.

Further reading

More information about the conference can be found on the γ 2008 web page at www.mpi-hd.mpg.de/hd2008/.

Résumé

L’astronomie gamma à l’honneur à Heidelberg

Ces dernières années, la qualité et la diversité des données fournies par les télescopes atmosphériques modernes d’imagerie Tchérenkov ont révolutionné l’astronomie des rayons gamma. Grâce à des instruments au sol, on peut obtenir une image détaillée du ciel de rayons gamma de 100 GeV à 100 TeV et amasser ainsi de nombreux éléments d’information sur l’Univers. Le 4e colloque international sur l’astronomie des rayons gamma de haute énergie de Heidelberg était l’occasion de faire le point sur cette jeune discipline de l’astrophysique.

Christopher van Eldik *and* **Werner Hofmann**, *Max-Planck-Institute for Nuclear Physics, Heidelberg.*

Exclusive events give new window on LHC physics

Groundbreaking work at the Tevatron has demonstrated that proton–(anti)proton colliders are not only quark–antiquark or gluon–gluon colliders, but also photon–photon and photon–pomeron colliders. **James Pinfold** of the University of Alberta explains.

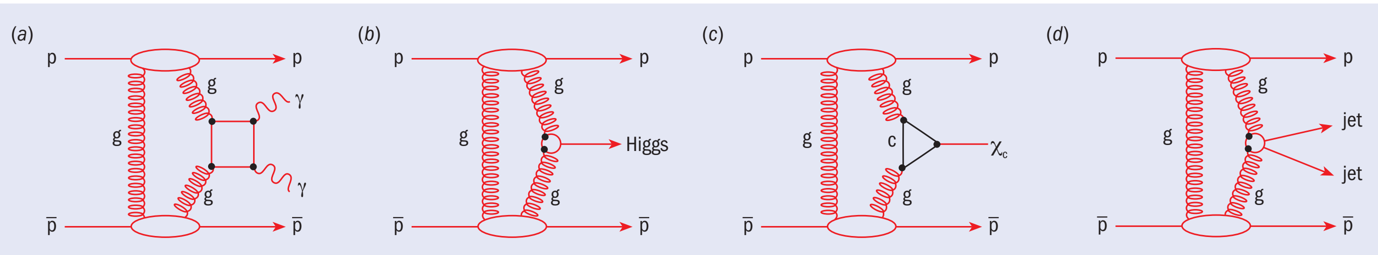


Fig. 1. Diagrams corresponding to studies in exclusive physics at the Tevatron, showing various types of gluon–gluon "fusion" with a third "screening" gluon, creating a photon-pair (a), a Higgs boson (b), a χ_c meson (c), or a jet-pair (d). (This interaction is also termed double pomeron exchange.)

Most reactions at Fermilab's Tevatron occur when the colliding proton and antiproton break apart into quarks and gluons that hadronize to form the particles that fly off into the detector. In exclusive interactions, however, the proton and antiproton avoid the breakup, glancing off each other in a process where the underlying interaction involves some combination of photons and/or gluons.

In 2006, the CDF collaboration at the Tevatron obtained the first clear evidence for exclusive interactions at a proton–(anti)proton collider, when they observed high-energy photon pairs in the central rapidity (barrel) region of the detector, but with nothing else, down to an angle of around 0.1° from the beam (±7.4 units of pseudorapidity). They found only three events initially, against a small background predicted to be at most 0.2 events (Aaltonen *et al.* 2007). These events were consistent with being produced via gluon–gluon "fusion" via a quark "box" where the gluons originate from the beam particles, as shown in figure 1a. An additional "screening" gluon is exchanged to cancel the colour of the interacting gluons and allow the leading hadrons to stay intact. The collaboration has since observed more exclusive two-photon final state candidates in new data.

The search for this unusual two-photon process at the Tevatron was originally proposed in 2001, when CDF physicists first explored the possibility that the Higgs boson could be produced by gluon–gluon fusion as described in figure 1b (Albrow *et al.* 2005). The idea is that if the Higgs field fills the vacuum, it should be possible to "excite the vacuum" into a real Higgs particle in a glancing collision of a proton and antiproton. Theorists had various estimates for the probability of this happening, but their predictions varied widely.

The two-photon process measured in the CDF detector is produced in much the same way as the Higgs would be, but much more prolifically, so making it a "standard candle" for the production of Higgs bosons. Theorists from the Centre for Particle Theory at the University of Durham predicted that there should be only about one clean two-photon event of this kind in data corresponding to 532 pb^{-1} of integrated luminosity taken by CDF in Run II at the Tevatron (Khoze *et al.* 2006). The three events that the CDF collaboration found confirmed this prediction. Thus, the similar process that could produce the elusive Higgs boson must also happen, and could be measured at the LHC, thereby providing measurements of the particle's mass, spin and other properties.

In the process of checking this measurement, the CDF physicists came across another exclusive physics process that had never been seen before at a proton–(anti)proton collider. They found 16 events that are consistent with the QED prediction that photons travelling with the proton and antiproton can interact to produce only an electron–positron pair ($\gamma\gamma \rightarrow e^+e^-$) without breaking up the proton and antiproton (Abulencia *et al.* 2007). In this case the Tevatron acts as a photon "collider". As the backgrounds to this process are similar to the final state discussed above, the CDF team gained further confidence in their exclusive two-photon final state analysis. To date, they have found many more exclusive electron–positron candidate events. QED two-photon processes such as this, which have previously been observed in electron–positron, electron–proton and nuclear collisions, should provide a means of calibrating the momentum scale and resolution of forward proton spectrometers proposed for the ATLAS and CMS experiments at the LHC.

The CDF team then reasoned that they should also see exclusive ▷

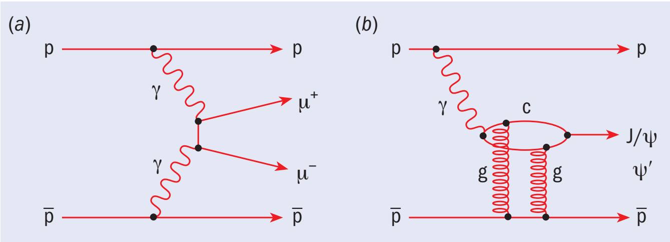


Fig. 2. Diagrams for a) photoproduction and b) photon–pomeron fusion. Both processes have been observed at the Tevatron.

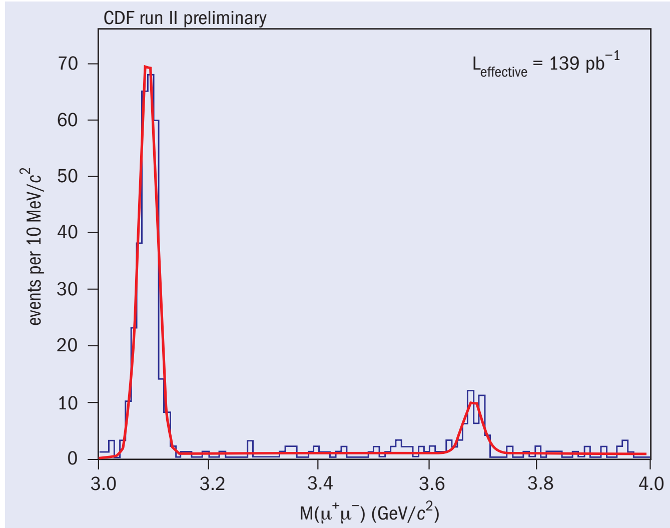


Fig. 3. The invariant mass distribution of exclusive di-muon pairs observed by CDF in the mass range 3–4 GeV/c^2. The larger left peak is the J/ψ, the smaller peak is the ψ(2S). (Courtesy CDF collaboration.)

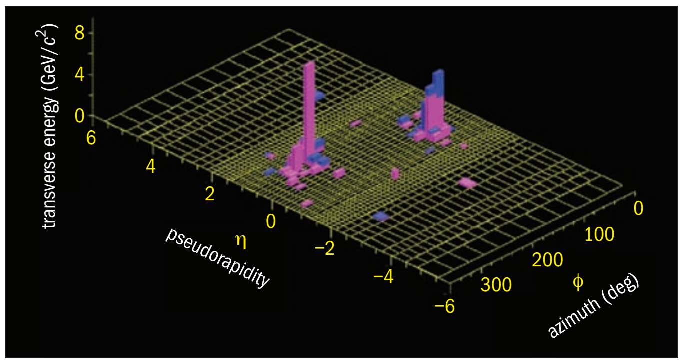


Fig. 4. An exclusive di-jet candidate from CDF. (Courtesy CDF.)

muon-pair events produced by the same QED interaction, as in figure 2a. Apart from an indication of exclusive pair production at the ISR at CERN (Antreasyan *et al.* 1980), this would be another "first" at a proton–(anti)proton collider. In 2007 their supposition was confirmed, but with an added bonus. The expected process, $\gamma\gamma \rightarrow \mu^+\mu^-$, was indeed detected according to QED expectations.

In addition, the CDF physicists recorded, for the first time in hadron-hadron collisions, exclusive photoproduction of the J/ψ and ψ (2S) decaying to a pair of muons (figure 2b). Figure 3 shows the clear, clean signals observed. The team also detected the contribution from exclusive production via gluon–gluon fusion of the χ_c^0, decaying to a muon pair and a soft photon (figure 1c). Evidence for this state in CDF data had also been reported earlier, in 2003 (Wyatt 2003).

An analysis aimed at higher muon-pair masses also revealed the upsilon (Υ). The Υ(1S) and Υ(2S) have been clearly seen in CDF, with the Υ(3S) emerging, to be revealed by the higher statistics that are now available. In the case of the photoproduction of these bottomonium (Υ(1S), Υ(2S)) and the charmonium (ψ(1S), ψ(2S)) states, the Tevatron is acting as a "photon–pomeron collider" (figure 2b). The pomeron is well known from diffractive reactions, which are characterized by the exchange of a quark/gluon construct – the pomeron – with the quantum numbers of the vacuum. Because the exchange is colourless, in these reactions a large region in pseudorapidity space is left empty of particles (the "rapidity gap"). In perturbative QCD, the lowest order prototype of the pomeron is a colour-neutral system of two gluons.

This photoproduction of charmonium and bottomonium was previously studied in collisions at DESY's electron–proton collider, HERA, with similar kinematics ($\sqrt{s}$ = 100 GeV) and the cross sections are in agreement. A comparison of the J/ψ and ψ(2S) cross sections with predictions from HERA data is sensitive to a possible contribution from the elusive and enigmatic odderon. This is a partner of the pomeron with charge conjugation odd (C-odd) and in QCD is formed from three gluons in a colour-neutral state. Unfortunately these predictions have a spread, weakening the sensitivity of CDF's search for odderon exchange, but still allowing a useful limit to be set on the production of odderons in this mode.

After publishing results on exclusive lepton-pair and photon-pair production, the CDF collaboration scored a hat-trick in 2008 when it published results on exclusive di-jet production, as in figure 1d (Aaltonen *et al.* 2008). Using a Roman Pot deployed tracker some 66 m from the interaction point to tag the unbroken antiproton in conjunction with a large rapidity gap on the deflected proton side, the team defined a sample of potentially exclusive events. The greater the share of the mass of the central system that the two jets enjoyed, the "more exclusive" the events were expected to be. This expectation was borne out by the Monte Carlo simulation (Monk and Pilkington 2005) for central exclusive production and in agreement with the predictions of the Durham Group (Khoze *et al.* 2007). Figure 4 shows an event display of an exclusive di-jet candidate. Also, as the di-jet fractional share of the overall central mass of the event tended to one – and the exclusive di-jet sample became purer and purer – evidence for b-jet suppression was seen, as theoretically expected. As in the case of exclusive gamma-gamma and χ_c^0 production, this is an example of the Tevatron acting as a gluon–gluon collider. The detection at the Tevatron of these exclusive processes, resulting from gluon–gluon interactions, strongly suggests that exclusive production of the Higgs boson by the similar process would be detected at the LHC.

Although forward proton detectors have been used to study Standard Model physics for a couple of decades, the new landscape revealed by exclusive physics at hadron colliders has been fully realized only in the past few years. In this arena, the LHC is not only preparing to take the baton from the Tevatron, but also to enter the race with greatly improved tools. The FP420 R&D project is planning to provide the means to measure the displacement and angle of the outgoing protons from exclusive interactions by deploying high precision "edgeless" silicon trackers less than a centimetre from the beam, at ±420 m from the beam intersection points of the ATLAS and CMS experiments at the LHC (Albrow *et al.* 2008). This gives these experiments the ability to calculate the proton momentum loss and transverse momentum, allowing the mass of the centrally produced system to be reconstructed with a resolution of a few GeV/c^2 per event whatever the central system. Broadly speaking then, in the exclusive physics arena, the LHC becomes a "multi-collider", where the gluon–gluon, photon–photon, or photon–pomeron beam energy is known.

The ability of the FP420 detectors to measure intact protons from an exclusive interaction, in conjunction with the associated centrally produced system using the current ATLAS and/or CMS detector, will provide rich new perspectives at the LHC on studies in QCD, electroweak physics, the Higgs sector and beyond Standard Model physics. In some scenarios, these detectors may be the primary means of discovering new particles at the LHC, with unique ability to measure their quantum numbers. The addition of the FP420 detectors will thus, for a relatively small cost, significantly enhance the discovery and physics potential of the ATLAS and CMS experiments. The existence proof provided by the exclusive physics results from the Tevatron shows that such a programme is feasible.

Further reading

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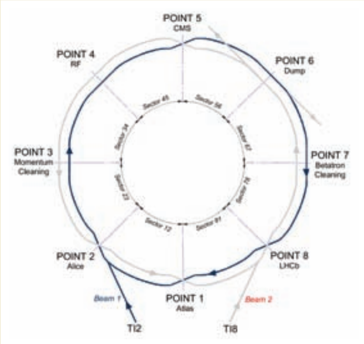
Résumé

Événements exclusifs au Tevatron

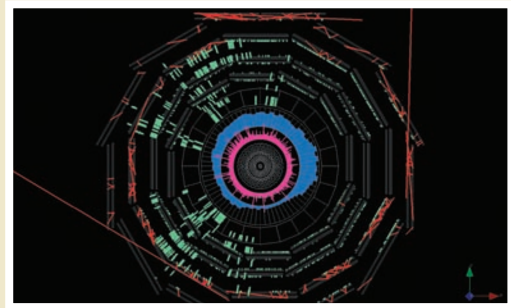
Des travaux innovants effectués au Tevatron, au laboratoire Fermi, ouvrent de nouvelles perspectives sur la physique au LHC. Dans la plupart des événements observés au Tevatron, le proton et l'antiproton entrés en collision se décomposent en quarks et en gluons, et forment alors les particules enregistrées par le détecteur. Lors des interactions « exclusives », cependant, le proton et l'antiproton ne se désintègrent pas en raison de l'interaction d'autres particules. Des études de ces interactions ont démontré que les collisionneurs proton–(anti)proton donnent lieu non seulement à des collisions quark–antiquark ou gluon–gluon, mais aussi à des collisions photon–photon et photon–pomeron.

James Pinfold, *University of Alberta, is a member of ATLAS and the FP420 project and a member of the CDF group performing studies of exclusive physics.*

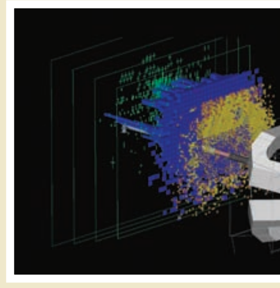


The plan for the day: Beam 1 is to go clockwise from injection just before Point 2. Then it will be the turn of Beam 2, travelling in the anticlockwise direction from close to Point 8.

It's 9 a.m. and the Silicon Pixel Detector in ALICE lights up with particle "debris" created as beam in the transfer line from the SPS hits the beam stop before Point 2.



At 9.50 a.m. CMS records the first beam-induced events as Beam 1 hits the collimator at Point 5, leading to particles flying into the detectors. Energy deposits are visible in the electromagnetic (pink) and hadronic (blue) calorimeters, as are hits in the resistive plate chamber (green) and drift-tube (red) muon systems.



At 10.12 a.m. the operations to allow Beam 1 through to Po these first manoeuvres, LHCb tracking detectors are not sw the muon detectors, calorime ring imaging Cherenkov detec particles produced by the bea

LHC first beam: a

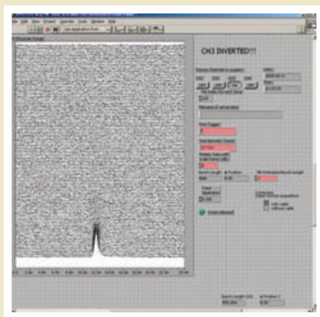
When CERN's LHC took its first steps with a proton beam, it excelled all expectations.

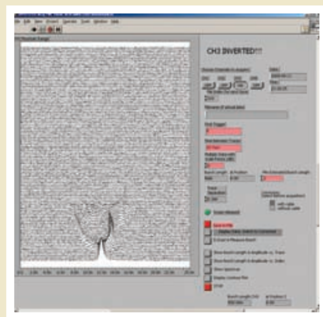
At a little before 10.30 a.m. on 10 September, two dots on a colour screen in the CERN Control Centre (CCC) marked the successful first complete turn of protons clockwise round the LHC. It was less than an hour since the operations team began injecting Beam 1 into the machine – under the watchful eyes of the world (*CERN Courier* October 2008 p7). Lyn Evans, LHC project leader, was more than satisfied: "It was beyond my wildest dreams to get beam so quickly."

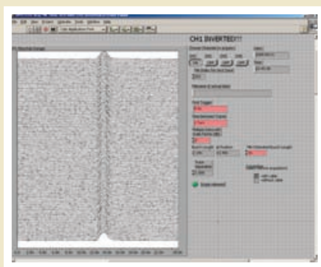
By the end of the day, not only had the anticlockwise beam, Beam 2, also completed its first circuit but it had made some 300 turns of the machine. It was a heady experience, which was followed by a few more days of steady progress, until a breakdown in a magnet interconnection brought commissioning to a halt until next spring (p5). However, those few days have already demonstrated that, in Evans' words, "the machine works beautifully".

The operations team had been preparing the SPS for injection since 8.00 a.m. and the start-up procedure with Beam 1 began promptly. At 9.30 a.m. they were ready to start, turning on the kickers to direct the beam onto a beam stop just before the interaction point at Point 2. The plan was to send in the beam one bunch at a time and open up the LHC ring step by step. At each of the four points occupied by the LHC experiments, the beam would initially be stopped by closed collimators to allow corrections to be made, if necessary. The collimators would then be opened to allow the subsequent beam shots to proceed through the detector and farther round the ring.

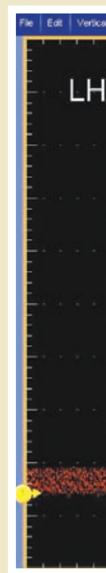
The sequence worked like clockwork: beam to collimators, collimators open, beam to next collimators and so on. Each of the major LHC detectors – ALICE (Point 2), CMS (Point 5), LHCb (Point 8) and ATLAS







"Mountain range" plots. With no RF (top left), there is debunching after 25 × 10 turns. With the wrong phase (top right), the bunch becomes split. The correct injection phasing and frequency (left) lead to capture of the bunch for many turns.

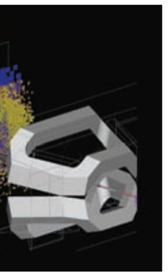


A "champa

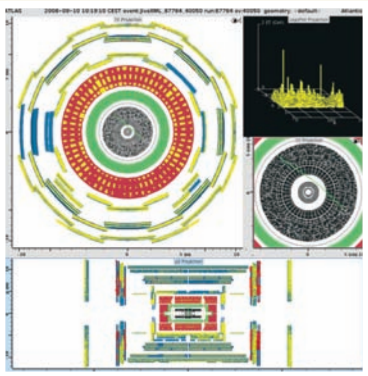
(Point 1) – lit up in turn with the first beam-related particles as bunches in Beam 1 hit the nearby collimators, creating particle "debris".

The procedure with Beam 2 (in the anticlockwise direction) was almost as smooth. Minor problems with cryogenics delayed the start until 1.30 p.m. and slowed progress from injection at Point 8 to Point 6, where beam arrived at 1.55 p.m. Small difficulties with the beam meant that it did not reach CMS at Point 5 for another 30 minutes. However, Beam 2 had made its first complete turn by 3 p.m.

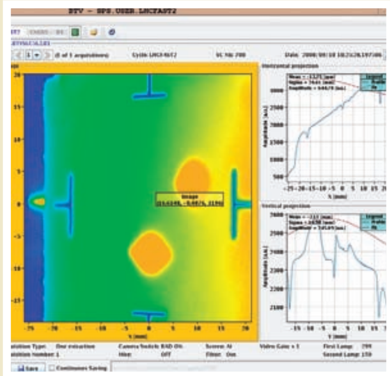
After a well deserved pause, to let the day's achievements sink in and to gather thoughts, at 4 p.m. work in the CCC turned to the more earnest matters of studying the properties of Beam 2, and setting it



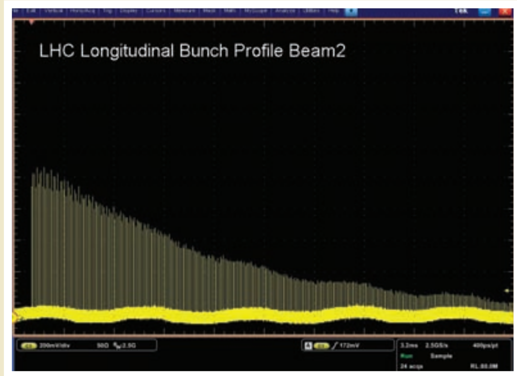
…ons team begins …to Point 8. During …LHCb's sensitive …t switched on, but …rimeters and the …etectors record …e beam.



At Point 1, the ATLAS detector records this event at 10.19 a.m. This is the final interaction point before the beam gets back to where it started.

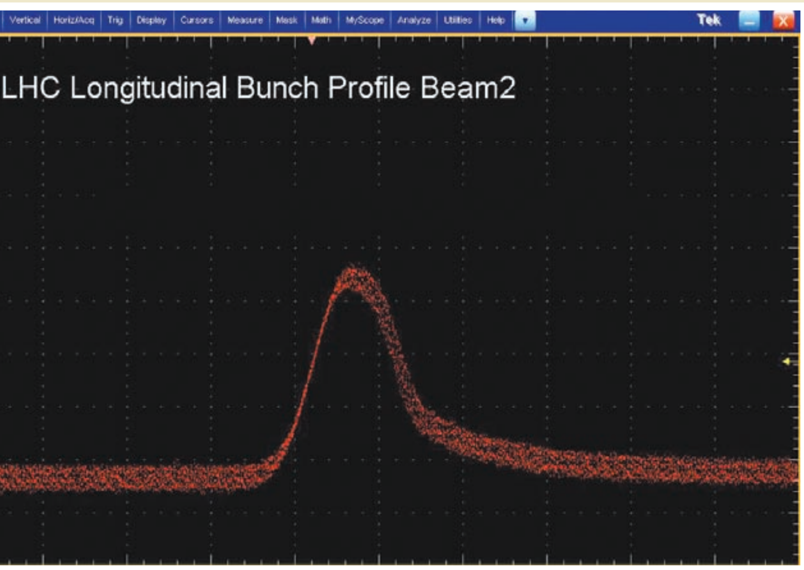


It's 10.26 a.m. and the screen in the CCC shows the two spots that indicate that beam has for the first time made a complete circuit of the LHC.



At 9.30 p.m. Beam 2 completes at least 300 circuits of the machine. The beam appears to decay as it becomes debunched because there is, as yet, no capture by the RF systems.

… day to remember



…ampagne moment" for Lyn Evans on 11 September – a perfect longitudinal beam profile.

up for multiple turns. Measurements over the next few hours of the kick response and dispersion showed a truly well behaved beam. By 9.30 p.m., Beam 2 orbited the LHC for at least 300 turns, just 12 hours after the first injection with Beam 1.

As the start-up of 10 September came to a close, the real work for the operations team was only just beginning. A bunch of particles travelling round the ring is a major step. However, for an accelerator the key lies in capturing the particles with the RF system that provides the accelerating electric fields – and keeping the bunches in time with the RF on the thousands of turns per second that occur during normal operation.

An essential step on the day after first beam was to turn on the RF and investigate the bunch lifetime. This was, according to Evans, one of the many worries that he had from the days when CERN gained valuable experience with its pioneering conversion of the SPS into a proton–antiproton collider. Noise from the klystrons that provide the RF power can propagate and debunch the particles.

The first tests on 11 September showed that Evans need not have worried, because the so-called "mountain range" plot revealed clearly the effects on an individual bunch on successive turns in Beam 2. Without the RF, the bunch simply broadens as particles stray from the perfect orbit round the machine; the mountain range rapidly broadens and flattens out. With the RF at the correct phase and frequency, the bunches are captured and the mountain range becomes a long, continuous narrow ridge as turn after turn the whole bunch of particles passes the same point at the right time. The result by the end of the day was what Evans called the "real champagne moment" – a perfect longitudinal bunch profile, only a day after first beam.

Résumé

Premier tour de faisceau dans le LHC : un jour mémorable

Le 10 septembre 2008, peu avant 10 h 30, deux points lumineux sur un écran au Centre de contrôle du CERN marquent le premier tour complet d'un faisceau de protons en sens horaire, dans le Grand collisionneur de hadrons (LHC). Il a fallu moins d'une heure pour arriver à ce résultat après le début de l'injection du faisceau dans le collisionneur, près du point 2, sous les yeux du monde entier. À la fin de la journée, non seulement le second faisceau avait circulé sans problèmes dans le sens anti-horaire, mais il avait également effectué quelque 300 tours.

The Higgs and the LHC

Martinus Veltman shares his thoughts on our present understanding of the Higgs sector.

Dedicated to the memory of Francisco (Paco) Ynduráin, a good friend and excellent physicist (p38).

The LHC is gearing up to do real physics, and after all the astrophysical nonsense about the Big Bang and black holes we now face the cold reality of experiment. In this context, it may be useful to summarize our knowledge of the Higgs system to date, which is the purpose of this article.

First, let me make a clear statement. Our present knowledge of the Standard Model is of course way beyond the knowledge of, say, 1959, when the PS at CERN started up. Clearly there have been many unanticipated discoveries, not to mention theoretical evolution. The Standard Model is chock full of facts crying out for explanation, such as the existence of three generations of quark–lepton families, or the many unexplained parameters of the model, such as the particle masses. That latter problem has, in today's Standard Model, shifted to the many different particle–Higgs couplings, and is still not totally understood. Consider this: between the neutrino masses (10^{-3} eV) and the top quark mass (1.75×10^{11} eV) there is a difference of 14 unexplained orders of magnitude. Why? How? We can say nothing meaningful about these things and we have no idea if the LHC will illuminate the problem; at the very least, realizing all this, we should not have the arrogance to think that we know what is going to happen.

That being said, let's see what we know. Our knowledge of the Higgs sector derives from the measurement of radiative corrections (plus the lower limit on the Higgs mass from direct experimentation at LEP), and the only quantities that depend on the details of the Higgs sector are radiative corrections to the masses of the vector bosons, including the photon. The masslessness of the photon is not automatic within the Standard Model, which provides a serious constraint.

Thus the measured radiative corrections are those affecting the W and Z masses, which come about – theoretically – through self-energy diagrams such as illustrated in figure 1. We really do not know what the X-line in the figure represents. It could be the propagator of one or more particles of distinct mass, or even some smeared-out mass (if the Higgs is heavy and strongly interacting), or of some continuous distribution. These various possibilities have been scrutinized for quite some time, but no definite view has emerged. Even so, it is useful to take a specific model, namely the simplest Higgs sector with one physical Higgs.

In the first instance, in a renormalizable theory, masses are free parameters – to be renormalized and taken from experiment – and therefore radiative corrections are invisible. Nonetheless there are two facts that allow us to come to some conclusions.

The first fact is that the photon mass is zero. Such a mass is not subject to renormalization and we may thus ask under what circumstances the Higgs sector produces a photon mass of zero. It happens that the simplest Higgs model (with just one physical Higgs) produces a massless photon, while adding degrees of freedom to the Higgs sector in general destroys this prediction. To get a zero photon mass in more complicated Higgs systems requires tuning of parameters, in other words, the prediction of zero photon mass is lost. This, in my opinion, is a strong argument against more complicated Higgs systems. To abandon a prediction that agrees with experiment is not something one should do lightly. However, this is not without some nasty consequences.

Martinus Veltman contemplates what the Higgs sector might reveal.

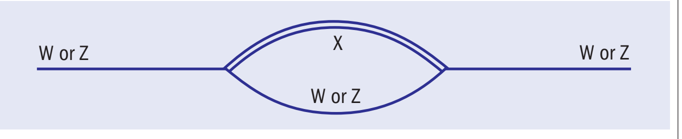


Fig. 1. Radiative corrections to the W and Z masses arise through self-energy diagrams like this.

Here I must mention the strong CP violation contained in the strong interactions in QCD. This effect, which indeed is not observed, is commonly explained away (in the Peccei–Quinn approach) by using two Higgs systems. While it is easy within such a model to tune the photon mass to zero, it is nonetheless a fact that the prediction of zero mass is lost. On top of that, in these models there is normally a particle of very small mass (the axion) of which there is no evidence experimentally. This is a worrying problem, for which there is no generally accepted solution, although there are some attempts at resolving it.

In addition, there is supersymmetry. In supersymmetry one inevitably has more than one Higgs system, so a priori that ruins the prediction of zero photon mass of the simplest Higgs model. The simplest supersymmetric model accidentally escapes this problem and predicts a zero photon mass; however there are other difficulties with this model.

The second fact concerns the vector-boson masses. The simplest Higgs model predicts a certain ratio between the W and Z masses, which is not subject to renormalization. The associated parameter

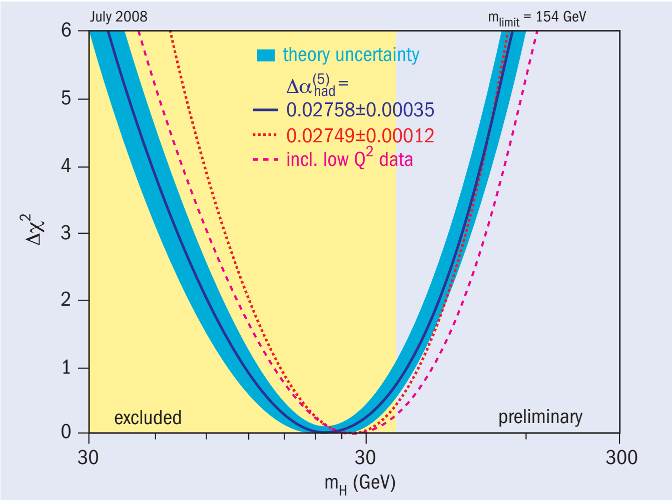


Fig.2. The "$\Delta\chi^2$" curve derived from high-Q^2 precision electroweak measurements, performed at LEP and by SLD, CDF, and D0, as a function of the Higgs-boson mass, assuming the Standard Model to be the correct theory of nature. The yellow area is excuded by the non-production of the Higgs. (Courtesy LEP Electroweak Working Group.)

is the ρ parameter and, assuming that the only things that change the ratio arise from radiative corrections, one obtains a prediction for the Higgs mass (assuming the simplest model). This is the source of the predictions on the limits on the Higgs mass that are commonly quoted (figure 2). It should be pointed out that the corrections to the mass ratio also contain a prediction for the top quark mass that agrees very well with the observed value. So, indeed, we must assume that the Higgs sector is such that the prediction for the mass ratio of the W and Z bosons is that given by the simplest Higgs sector. This puts severe limits on theoretical models for the Higgs sector.

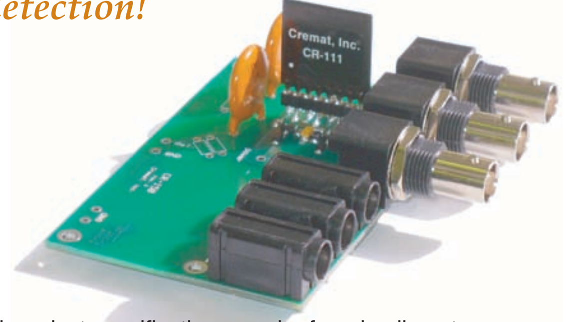
It is clear that our knowledge of the Higgs sector is scanty, and in particular a Higgs system with a very heavy Higgs is quite possible. The latter would probably produce a wide resonance for the X in figure 1, and it would be hard to make precise statements on the decays of such a resonance. Well, let us hope that the LHC clarifies the matter.

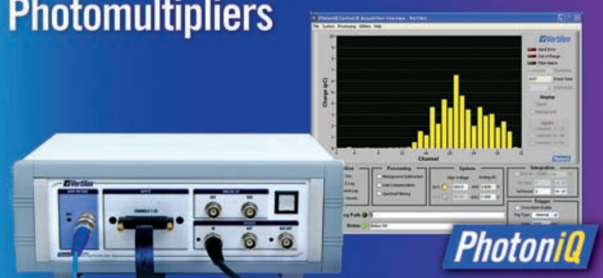
Résumé

Le Higgs et le LHC

À l'heure où le LHC se prépare aux premières données, Martinus Veltman fait le point sur ce que nous savons sur le secteur de Higgs, dans cet article dédié à la mémoire de Francisco Yndurain. Nos connaissances en la matière proviennent de la mesure des corrections radiatives (et des expériences menées au LEP qui ont permis d'établir une limite inférieure pour la masse du Higgs) ; les corrections radiatives des masses des bosons vecteurs, dont le photon, sont les seules grandeurs à dépendre des paramètres du secteur de Higgs.

Martinus Veltman, *Nikhef.*





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Since the early 1980s CECOM has divided its work between the fields of scientific research and civil–military/aeronautics. These applications have characterized CECOM's skills: the stringent requirements of aeronautic applications, in terms of performance, reliability, lifetime and quality assurance have been joined to the flexibility required by the research applications (development of prototypes, UHV requirements, special tests), thus improving CECOM's knowledge and abilities.

These challenges have led to the achievement of the skills and technologies needed for designing, manufacturing and testing prototypes, series components and turnkey systems.

CECOM equipment includes the most up-to-date machinery (NC milling machines 3,4 and 5 axis, NC lathe and wire-eroding machines) for any kind of manufacturing, TIG welding, assembling and testing (two DEA NC machines for dimensional check are available). In our clean room we can perform assembly and leak detection. Our UHV equipment allows us to perform bakeout, RGA test and desorption rate measurements.

In partnership we can manage other technologies – such as vacuum brazing, vacuum firing, EB welding, presswork, galvanic treatments, laser cutting, plasma cutting, sputtering, and the development of electrical systems – which are aimed at the commissioning of turnkey units.

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- INFN, ENEA, DIAMOND LIGHT SOURCE (beam stoppers, photon shutters, RF cavity, aluminium vacuum chamber, vacuum vessels and components).
- CELLS (bellows and vacuum chambers for the straight sections are in progress).
- CCRLC, CNR, DESY, ELETTRA.

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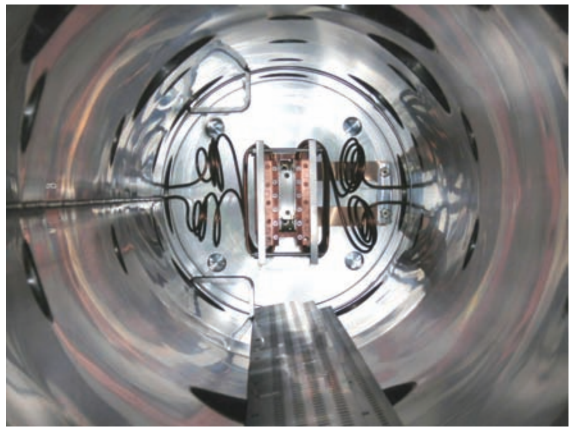
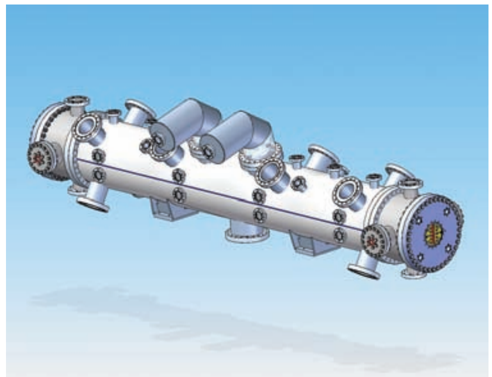




ALBA: a synchrotron light source for Spain

Ramon Pascual, chairman of the ALBA project, describes progress with the design and construction of a new, third-generation light source near the city of Barcelona.

With the exception of the European Synchrotron Radiation Facility, which serves an international community, all existing synchrotron light sources in Europe are located to the north of an imaginary straight line going from Paris to Trieste. To the south, Spain has only a few accelerators and these have been "turnkey" products, mainly in the medical sector; none belongs to a "big" laboratory. For these reasons, in the early 1990s the Autonomous Government of Catalonia began to consider the construction of a new, third-generation synchrotron light source.

The Generalitat de Catalunya and the Spanish Government signed a first collaboration agreement in 1995 and then took a final decision in March 2002 to create CELLS, a consortium for the construction, equipping and operation of a synchrotron light laboratory. The aim was to establish a third-generation synchrotron light source in the municipality of Cerdanyola del Vallès, in a technology area to be built next to the campus of the Autonomous University of Barcelona, some 20 km from the city. CELLS came into being at the end of 2003 with the objective of constructing the ALBA light source. The initial plan, based on an existing preliminary design study, was for a storage ring of 3 GeV with five beamlines in the first phase. This was scheduled to start up at the end of 2008, for a total cost of €164 m shared between the two administrations on a 50:50 basis.

Studies of underground characteristics, which took more than a year, led to final agreement on the 60 000 m^2 site for ALBA. This was followed by project approval for the building and conventional installations, thereby guaranteeing mechanical, electrical and thermal stability. Then in 2006 the governing board of CELLS decided to extend the construction phase to the beginning of 2010, to accept two more beamlines (bringing the total to seven) and to increase the total budget to the end of 2009 to €201 m.

The facility occupies a main building of some 18 500 m^2. This will host the accelerators and the experimental stations, so it must respect restrictive vibration conditions. It is built on a hard floor floating on a bed of gravel 2 m deep. There will also be peripheral auxiliary laboratories, a technical services building of 7600 m^2 (including an auxiliary storage building) and an administrative building of 4000 m^2.

A high-quality 12 MW power supply will be provided by a natural gas power plant that provides thermal and electrical energy, backed up by a dedicated transformer connected to a 220 kV supply line.

A lattice cell being prepared for ALBA's storage ring, with quadrupoles, dipoles and sextupoles. (Photos courtesy CELLS.)

A system of static and dynamic uninterruptible power supplies will guarantee the supply to the most critical parts of the facility.

The main elements of ALBA will be a 100 MeV linac working at a frequency of 3 GHz with a repetition rate of 3 Hz; a booster synchrotron of four-fold symmetry with an energy of 3 GeV, a circumference of 249.6 m and less than 20 nm rad emittance; and a storage ring of 268.8 m circumference located in the same tunnel as the booster. The design of the accelerators is based on the latest, but well proven, technologies. To provide as much space as possible for the installation of insertion devices and diagnostics, the design includes an extremely compact double-bend achromatic lattice of 16 cells with four-fold symmetry. It will consist of 16 pairs of combined dipole and quadrupole magnets with a central field of 1.42 T and a central gradient of 5.9 T/m, located on large girders. The lattice will be complemented by 128 quadrupole magnets and 120 sextupole magnets with more than 100 correctors installed in the sextupoles. The light source will have an emittance of 4.3 nm rad, a current of 400 mA and a critical energy of about 4.8 keV.

ALBA's ultra-high vacuum system is made of stainless steel. To cope with the synchrotron radiation, there are antechambers all around, where water-cooled copper and Glip Cop absorbers stop the synchrotron radiation so as to avoid heating the vacuum chamber. ▷

ALBA's 100 MeV llinac works at 3 GHz with a 3 Hz repetition rate.

ALBA's main building is built on a hard floor floating on a bed of gravel.

The radiofrequency (RF) system is based on inductive output tube (IOT) amplifiers, running at 80 kW with 67% efficiency. There will be 13: one in the booster to feed a five-cell PETRA-type cavity; and 12 in the storage ring to feed six higher-order, mode-free cavities. A new cavity combiner designed for ALBA will combine the power of the IOTs.

To obtain submicron beam stability there will be a diagnostic system based on 120 beam-position monitors and digital electronics distributed around the storage ring. In addition, synchrotron radiation monitors, current transformers, fluorescent and optical-transition-radiation screens, strip lines and annular electrodes will determine the characteristics of the electron beam. In general, standardization, modularity and robustness have been the main concerns in achieving an accelerator with high reliability and easy maintenance.

The ring will have a capacity for more than 30 beamlines. There will be 16 of these in bending magnets, three in insertion devices in long (8 m) straight sections, 12 in medium (4.4 m) straight sections and two in short (2.6 m) straight sections. The remaining straight sections will be dedicated to injection and RF.

The Asociación de Usuarios de Sincrotrón de España proposed the first phase of beam lines, seven of which CELLS accepted after consultation with the Scientific Advisory Committee. These beamlines, which are now under construction, will be dedicated as follows: one to non-crystalline diffraction and one to macromolecular crystallography, both based on in-vacuum undulators; one to photoemission spectroscopy and microscopy and one to X-ray circular magnetic dichroism, both based on normal undulators; one to X-ray absorption spectroscopy based on a multipole wiggler; one for high-resolution powder diffraction based on a superconducting wiggler; and one for X-ray microscopy based on a bending magnet. A call for a second phase of beamlines is now under way and is scheduled for approval by the end of 2009.

At present, the ALBA project is developing roughly according to budget and schedule, with a delay of only a few months, mainly owing to problems related to civil engineering and conventional services. The linac has been installed and its commissioning has finished. The civil engineering and the conventional installations will be completed in December this year. Almost all of the accelerator components have been designed, produced, tested and delivered, and installation will start soon in the main tunnel. The commissioning phase of the booster will start at the beginning of the second half of 2009 and the storage ring and beamlines will start commissioning progressively in spring 2010. By the second half of the same year the first beam lines of ALBA should be open to users.

Résumé

ALBA : une source de rayonnement synchrotron

ALBA, une nouvelle source de rayonnement synchrotron de troisième génération, est en construction près de Barcelone. Elle comprend principalement un linac de 100 MeV fonctionnant à une fréquence de 3 GHz, un synchrotron injecteur de 3 GeV, et un anneau de stockage de 268,8 m de circonférence situé dans le même tunnel que l'injecteur. La phase de mise en service de l'injecteur commencera au second semestre de 2009 et sera suivie par la mise en service de l'anneau de stockage et des lignes de faisceaux. Les utilisateurs devraient pouvoir disposer des premières lignes de faisceaux d'ALBA d'ici au second semestre de 2010.

Ramon Pascual, *is chairperson of the ALBA project.*

AGREEMENTS

Cockcroft Institute collaborates with CERN

In a ceremony on 29 August, CERN signed a comprehensive agreement to establish a long-term framework for scientific collaboration in accelerator research and development with the Cockcroft Institute in the UK. The agreement, which is similar to those made with experiment collaborations, represents the basis for a pioneering model for co-operation in accelerator research new to CERN and the UK.

The agreement is between CERN and the University of Liverpool, acting on behalf of the Cockcroft Institute, which is located on the Daresbury Science and Innovation Campus in north-west England. The institute is a partnership between the Universities of Liverpool, Manchester, Lancaster, the UK Science and Technology Facilities Council (STFC) and the North West Development Agency. Officially inaugurated in 2006 as a national accelerator research and development centre, it provides a focal point for UK scientists and industry to develop leading concepts and technologies for major accelerator projects and derive value for society at large in spin-off applications (*CERN Courier* November 2006 p43).

Left to right: Rolf-Dieter Heuer, John Cockcroft Jr, Swapan Chattopadhyay and Robert Aymar.

The collaboration covers R&D related to technologies for accelerators, the training of physicists and engineers in the development and operation of accelerators, and the participation of qualified scientists and personnel in schools and courses. The accelerator research topics cover three main areas. The first concerns the LHC, and in particular LHC beam commissioning, R&D on future energy and luminosity upgrades, R&D on the LHC injector complex (the Superconducting Proton Linac and PS2) and the conceptual development of the Large Hadron–Electron Collider. Other areas are R&D for the Antiproton Decelerator complex and R&D on multi-tera-electon-volt electron–positron linear colliders via collaboration in the Compact Linear Collider study and the CLIC test facility, CTF3.

The agreement was signed by CERN's director-general Robert Aymar and acknowledged by Swapan Chattopadhyay, director of the Cockcroft Institute and Sir John Cockcroft chair of physics at the universities of Liverpool, Manchester and Lancaster. Rolf-Dieter Heuer, CERN's future director-general, and John Womersley from STFC were also present. James Fox, contract manager, signed the agreement later for the University of Liverpool.

The ceremony was also attended by John Cockcroft Jr, grandson of Sir John Cockcroft – the accelerator pioneer and Nobel laureate who together with Ernest Walton first succeeded in "splitting" the atom at Cambridge in 1932 (*CERN Courier* December 2007 p25). Prior to the ceremony, he toured the ATLAS experiment and the CERN Control Centre, together with his wife, Rowan.

Chomaz becomes head of CEA IRFU

Philippe Chomaz has taken over as head of the Saclay Institute for Research into the Fundamental Laws of the Universe (IRFU), as from 1 August. He succeeds Jean Zinn-Justin.

A nuclear physicist for the French Atomic Energy Commission (CEA) at the Grand Accélérateur National d'Ions Lourds (GANIL) in Caen, Chomaz became deputy director there in 2005 when GANIL started construction of the new SPIRAL2 facility. He has worked both in experimental and theoretical nuclear physics, but during the past 10 years he has focused on theoretical physics, in particular in nuclear structure, thermodynamics and phase transitions, and nuclear astrophysics. His work has led to progress in general physics, mesoscopic systems, statistical mechanics and quantum mechanics with the definition of phase transitions in small systems, the study of collective vibrations of fermionic systems and the development of stochastic approaches.

In addition to this scientific activity at an international level, Chomaz is deeply involved with outreach and the popularization of science.

Philippe Chomaz now heads the IRFU. (Courtesy Alain Porcher, CEA/IRFU.)

SYMPOSIUM

Cluster brings together particle physics and astrophysics

True to its goal of bridging gaps between the astrophysics and the nuclear/particle physics communities, on 23–26 June the Excellence Cluster Universe held a symposium on "Symmetries and Phases in the Universe" in Kloster Irsee, Bavaria. More than 100 astronomers and physicists came to the meeting to learn about current research in these related disciplines. The 15 talks by renowned researchers were followed by lively discussions, which were highly appreciated by the participants.

Participants take a break to pose for the traditional photo. (Courtesy Excellence Cluster Universe.)

Joe Silk from the University of Oxford opened the symposium with a comprehensive overview of the evolution of structure in the universe, including research areas such as inflation, the cosmic microwave background (CMB), large-scale structure and the role of dark matter. Pierre Binétruy of the Astroparticle and Cosmology Laboratory, Paris, then presented an interesting new approach in which inflation can be understood in terms of models based on string theory and brane worlds.

Particle physicists and cosmologists alike have great expectations for the LHC at CERN. Daniel Denegri from the Saclay Institute for Research into the Fundamental Laws of the Universe gave an overview of the experiments designed to detect the Higgs and supersymmetric particles. The LHC is also expected to play a major role in the hunt for dark-matter candidates. Lars Bergström of Stockholm University reviewed some of the most frequently discussed candidates and possible detection methods.

The matter–antimatter asymmetry in the universe was the topic for DESY's Wilfried Buchmüller. He discussed three different models for forming baryonic matter – electroweak baryogenesis, the Affleck–Dine mechanism and leptogenesis – and the prospects for falsifying them. Gino Isidori from INFN/Frascati contributed to the theme by addressing CP violation and flavour physics.

In a joint session, GSI's Peter Braun-Munzinger and Wolfram Weise from the Technische Universität München focused on QCD. Braun-Munzinger presented recent experimental results on nuclear collisions at ultra-relativistic energies, showing that hadrons are produced in a transition from free quarks and gluons to a phase of bound quarks. Weise gave the theoretical perspective, reviewing recent results from computations in lattice QCD, in particular addressing the issue of phase transitions.

Cosmologist Thanu Padmanabhan from the Inter-University Centre for Astronomy and Astrophysics, Pune, delivered the "Inside story of gravity". According to his findings, gravity can be described as the thermodynamic limit of the statistical mechanics of so-called "atoms of space–time".

The production of the first nuclei in the universe came under scrutiny from Keith Olive of University of Minnesota. He looked at the open issue of primordial deuteron and lithium abundances that are not in accordance with the standard model of the universe. He included both conventional and exotic scenarios, the latter leading to a posteriori modification of the lithium produced in the first few minutes.

George Smoot from the Lawrence Berkeley National Laboratory reviewed current observations and future investigations of the CMB. He provided insight into the progress of the Planck satellite and the role that it will play in combination with results from the Wilkinson Microwave Anisotropy Probe. He also presented a new project to investigate polarization patterns in the CMB, which is scheduled by NASA for 2018.

The origin of gamma-ray bursts (GRBs) remains a controversial issue. In his diverting talk CERN's Alvaro De Rújula presented insights resulting from observations of GRBs and their afterglows by the Swift satellite. According to his findings, GRBs can be explained by the "cannon ball" concept. Roland Diehl from Max-Planck-Institut für extraterrestrische Physik, Garching, who was chair of the session, responded by delivering differing data from observational astronomy. The conflicting statements sparked off an interesting discussion among the audience.

Bernard Schutz from the Albert Einstein Institute, Potsdam, reported on gravitational-wave studies, outlining the ground-based detectors, LIGO and VIRGO, which are designed to observe merging binary neutron stars and black holes. The Laser Interferometer Space Antenna, which is planned for launch in 2018, will observe the merger of massive black holes.

Two talks covered astroparticle physics. Manfred Lindner of the Max-Planck-Institut für Kernphysik talked about neutrinos as a probe of new physics, looking both at recent results and at future developments. Angela Olinto of the University of Chicago reported on recent measurements of ultra-high cosmic rays by the Pierre Auger Observatory. These show a significant correlation between the arrival directions of cosmic rays and the distribution of nearby active galactic nuclei. According to Olinto, these results will have important implications for both astrophysics and particle physics.

AWARDS

Krinsky (left), Röhrs (centre) and Vladimir Litvinenko, chair of the prize committee. (Courtesy DESY.)

Brookhaven and DESY take FEL honours

Samuel Krinsky of the Brookhaven National Laboratory has received the 2008 Free Electron Laser (FEL) Prize. Sponsored by the International Free-Electron Laser Conference, held this year in Gyeungju, Korea, the prize is awarded in recognition of "outstanding contributions to FEL science and technology".

Over the past 25 years, Krinsky and colleagues have contributed significantly to developing two types of FEL used in research: the self-amplified spontaneous-emission free-electron laser (SASE FEL), and the high-gain harmonic-generation free-electron laser (HGHG FEL). Since the mid-1980s, Krinsky has worked on the theory of the SASE FEL, and devices are currently under construction in Europe, Japan and the US. There is also ongoing work in the US and Europe to develop HGHG FEL facilities.

On the same occasion the 2008 Young Investigator FEL Prize was awarded to Michael Röhrs "in recognition of outstanding contributions to free-electron laser (FEL) science and technology". Röhrs was selected for his investigations into the charge distribution within electron bunches at the Free-Electron Laser in Hamburg (FLASH) at an unprecedented time resolution of 20 fs. The work was done at DESY as part of his PhD research at the University of Hamburg.

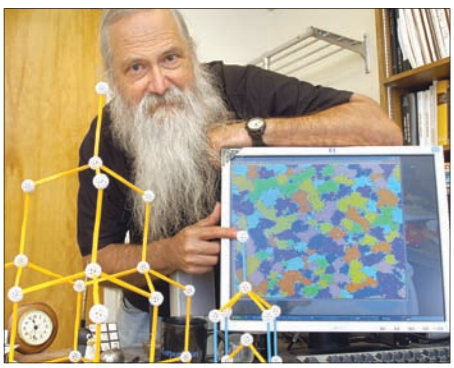
Superstrings earn the 2008 Dirac Medal and Prize

On 8 August the Abdus Salam International Centre for Theoretical Physics (ICTP) announced the award of the 2008 Dirac Medal and Prize to Juan Maldacena of the Institute of Advanced Study, Princeton; Joe Polchinski of the Kavli Institute for Theoretical Physics, University of California, Santa Barbara; and Cumrun Vafa of Harvard University. The announcement of the winners is made each year on the birthday of Paul Dirac, who was a close associate and friend of ICTP.This year the award honours Maldacena, Polchinski and Vafa for their fundamental contributions to superstring theory, with studies that range from early work on orbifold compactifications, physics and mathematics of mirror symmetry, through D-branes and black hole physics, to gauge theory–gravity correspondence. In particular, the citation mentions their contributions to uncovering the strong–weak dualities between seemingly different string theories, which have enabled theorists to learn about regimes of quantum field theory that are not accessible to perturbative analysis. These developments have, for example, found applications in practical calculations in the fluid dynamics of quark–gluon plasma.

Creutz receives this year's Gian Carlo Wick Gold Medal

The World Federation of Scientists (WFS) has chosen Michael Creutz, of the Brookhaven National Laboratory as the recipient of the 2008 Gian Carlo Wick Gold Medal Award. This is given annually to a theoretical physicist for outstanding contributions to particle physics. Creutz received the award at a WFS meeting held in Erice on 19–24 August.

Founded in 1973, the WFS is an association of more than 10 000 scientists from 110 countries the aim of which is to share knowledge among all nations so that everyone can experience the benefits of scientific progress. Gian Carlo Wick, a native of Italy, was an eminent theoretical physicist who led the Theory Group at Brookhaven from 1958 to 1970.

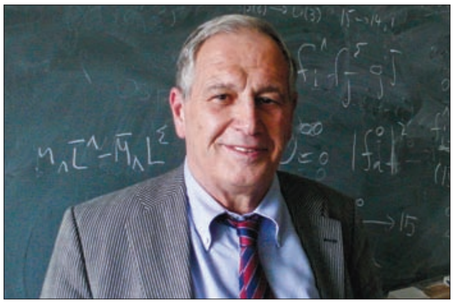


Michael Creutz was chosen by the WFS for the prestigious Gian Carlo Wick Gold Medal award. (Courtesy Brookhaven National Laboratory.)

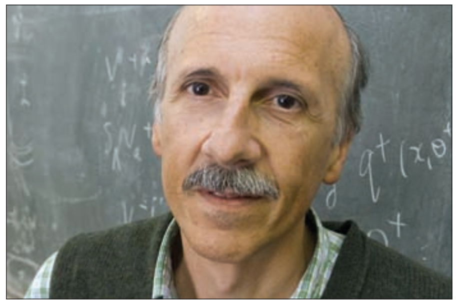
Creutz was honoured for his work on lattice QCD. Specifically, he first demonstrated that properties of QCD could be computed numerically on a four-dimensional lattice through computer-based Monte Carlo techniques. These computational methods have since been applied to numerous theoretical problems in physics, including the physics of Brookhaven's Relativistic Heavy Ion Collider, and they may prove to be relevant in the interpretation of new physics findings at the LHC.

CERN researchers win prestigious ERC grants

On 31 July the European Research Council announced the first successful candidates in the Advanced Grants competition in the domain of physical sciences and Engineering. Two of CERN's theorists, Sergio Ferrara and Ignatios Antoniadis, were among those named. Ferrara has received the grant for research with INFN in supersymmetry, quantum gravity and gauge fields, while Antoniadis was awarded it for studies of mass hierarchy and particle physics at the tera-electron-volt scale.



Ferrara: supersymmetry and quantum gravity.



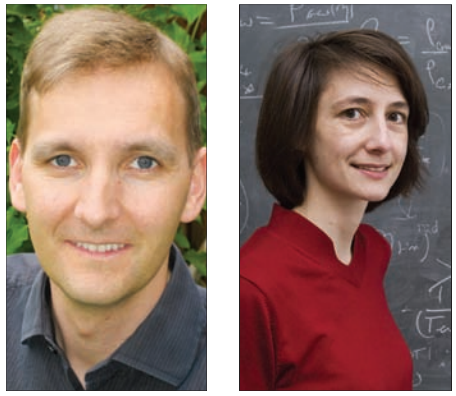
Antoniadis: studies of mass hierarchy.

The first call for Advanced Grant proposals generated 997 applications in this domain by the deadline at the end of February. The peer-review process then ran from March to June. There were 105 successful candidates altogether, with only 13, including Ferrara and Antoniadis, in the area of fundamental constituents of matter.

Only two other theorists were successful with applications in particle physics: David Kosower at the Commissariat à l'Energie Atomique (CEA), Saclay, for modern methods for perturbative gauge theories, and Savas Dimopoulos of Stanford University, who will use his grant to establish a visitor programme at the University of Oxford for physics beyond the Standard Model. In the experimental field, Victor Malka at the Laboratoire d'Optique Appliquée/Centre National de la Recherche Scientifique received an award for his work on developing particle accelerators with intense lasers.

Earlier in the year the ERC began to award Starting Grants aimed at up-and-coming research leaders, 2–9 years after achieving their doctorate. Geraldine Servant, also a theorist at CERN, received a grant for her work on the nature of dark matter and its manifestations. On the experimental side, Andre Mischke of Utrecht University received a grant for work with the ALICE collaboration. In particular, his research project aims to explore the dynamic properties of the quark–gluon plasma using sensitive experimental probes based on heavy-quark correlations.

More than 9000 applications were submitted for the Starting Grants. The ERC hopes to fund some 300 of these. Other beneficiaries in the area of particle physics include Iosif Bena of CEA/Saclay (black holes and string theory), Francesca Di Lodovico at Queen Mary, University of London (measurement of neutrino oscillations in the Tokai-to-Kamioka experiment), Livia Conti of INFN/Padova (studies of noise in gravitational-wave detectors) and Werner Rodejohann (studies of Majorana neutrinos).



Andre Mischke (left) and Geraldine Servant.

Masaki Suenaga, a retired metallurgist who remains an active researcher at Brookhaven, has received the IEEE Council on Superconductivity Award for significant and sustained contributions to applied superconductivity. Suenaga spent much of his early career studying the superconductor niobium-tin, and his research resulted in a process to make the first industrial niobium-tin superconducting wire for use in high-field magnets, such as those used in accelerators. (Courtesy Brookhaven National Laboratory.)

LETTER

Good company

It is good to learn (*CERN Courier* July/August 2008 p7) that neutrons and protons prefer each other's company inside nuclei, but this is hardly a surprise.

As early as 1951, I learned from Viki Weisskopf in Les Houches that it is due in part to the tensor force that the neutron–proton system is bound while neutron–neutron and proton–proton are not. A printed version of this was to appear in the famous Blatt–Weisskopf book. That this happens also in nuclei was to be expected. Yes, it is nice that it is now observed but it is not such a big deal.

André Martin, CERN.

OBITUARIES

Gordon Munday 1922–2008

Gordon Lennox Munday est né en 1922 à Birmingham. Pendant la seconde guerre mondiale, il sert dans la « Home Guard ». Il travaille ensuite chez Philips avant d'intégrer l'Université de Birmingham et d'y obtenir une licence en physique et en chimie.

En 1955, à l'incitation d'un ami physicien, il rejoint à Genève l'équipe qui sous la direction de John Adams construit le PS, le Synchrotron à Protons du CERN. Il a la responsabilité de la construction du système à vide du futur accélérateur. Il établit les spécifications des constituants de ce système, sélectionne et visite les firmes chargées de les construire et supervise leur installation et leur mise en service.

Peu après le démarrage de cette nouvelle machine, le chef de division, Pierre Germain, lui confie la tâche de créer un groupe chargé d'aider les physiciens utilisateurs à préparer et réaliser leurs expériences. Son équipe gère les zones expérimentales, calcule, puis met en place et fait fonctionner les faisceaux dans lesquels les physiciens ont installé leur équipement. Cette activité délicate est cruciale car il s'agit à la fois d'exécuter au mieux le programme expérimental décidé par les autorités scientifiques du Laboratoire, de tenir compte des contraintes techniques formulées par les ingénieurs de l'accélérateur et d'essayer de satisfaire les demandes parfois contradictoires des physiciens.

Une troisième phase de sa carrière débute en 1973 lorsqu'il prend la succession de Peter Standley à la tête de la division Machine PS (MPS). Sous sa direction, le PS initialement conçu pour produire et accélérer des protons et des particules secondaires vers des zones expérimentales dédiées va se transformer progressivement en une machine à fonctions multiples.

Gordon Munday. (Courtesy Denise Munday.)

L'accélérateur devient capable de fournir des faisceaux adaptés à d'autres machines et surtout de satisfaire de nouveaux besoins que personne n'imaginait au moment de sa construction. Le PS devient ainsi injecteur de la nouvelle grande machine du CERN, le Super Synchrotron à Protons SPS. Le PS est également adapté à l'accélération d'ions légers, puis plus lourds et à la production des noyaux hautement instables étudiés dans le séparateur d'isotopes ISOLDE. C'est sous la responsabilité de Gordon Munday que se construit l'accumulateur d'antiprotons (AA). Cette machine permettra ultérieurement de réaliser le programme $p\bar{p}$ et conduira à la découverte des bosons W et Z et à l'attribution du prix Nobel à des physiciens du CERN. Ce sera encore sous son mandat qu'il sera imaginé d'utiliser le PS pour produire et pré-accélérer les électrons et les positons destinés à la grande machine suivante, le LEP.

Enfin et c'est probablement une partie moins connue de son action, il fait minutieusement analyser tous les aspects du fonctionnement du PS. Il lance un programme de développement et de consolidation qui permet à cette machine, conçue et construite dans les années 1950, d'atteindre une fiabilité inégalée, supérieure à celle d'une grande centrale électrique moderne au fonctionnement beaucoup plus simple. Cette solidité technique et opérationnelle bâtie par Gordon assure le fonctionnement régulier du collisionneur protons–antiprotons $Sp\bar{p}S$ et du LEP jusqu'aux années 1990, bien après son départ à la retraite. Son héritage se prolonge bien au-delà, dans les années 2000, avec l'alimentation en protons et en ions du LHC par le PS.

Le rôle de Gordon au PS ne s'est pas limité à des aspects techniques et administratifs. Il a manifesté tout au long de sa carrière des qualités humaines et d'écoute envers ses collaborateurs qui lui ont assuré respect et attachement. Il a contribué à développer et à maintenir l'esprit de corps des membres de sa division, ce qui n'a pas peu influencé ses performances et ses succès. En 1981, à l'issue de son mandat au PS, il rejoint le bureau du Directeur Général et est chargé de diverses missions en relation avec la politique générale de l'Organisation et en particulier l'analyse des futurs besoins en personnel (Staff Policy Group) dans le contexte de restrictions que l'on sentait déjà poindre.

Parti à la retraite en 1987, il reste proche du CERN et de son personnel et accepte la présidence du GAC, le Groupement des anciens du CERN. Il sera leur porte-parole auprès des dirigeants de l'Organisation et réussira à maintenir la prise en compte de leurs préoccupations dans des circonstances qui se révéleront de moins en moins faciles.

Gordon Munday laissera le souvenir d'un scientifique et d'un responsable talentueux et apprécié. Nous adressons nos plus sincères condoléances à sa famille.

Ses anciens collègues et amis du PS.

Klaus Blasche 1940–2008

On 27 July, Klaus Blasche, one of GSI's leading accelerator scientists, passed away at the age of only 68. For more than 40 years and in a number of leading positions, he contributed significantly to the development of the accelerator system at GSI. Already in the 1960s, during his diploma and doctoral theses at the University of Heidelberg and while with the project group of Christoph Schmelzer, the first director of GSI, Blasche evaluated the basic concepts of GSI's Universal Linear Accelerator (UNILAC). This linac came into operation in 1973 and was the first facility worldwide that was capable of accelerating all species of ions, from protons to uranium.

A few years later, discussions began on possible extensions to the UNILAC with a synchrotron, the Schwerionen-Synchrotron (SIS18), and a storage ring, the Experimentier-Speicherring (ESR). After the positive decision in 1985 to construct this synchrotron-storage ring, Blasche became the project leader of the synchrotron and high-energy beam transport complex, which was commissioned only three years later. Blasche also significantly influenced the layout of the further extension of the GSI facility by another synchrotron/storage ring complex for the Facility for Antiproton and Ion Research (FAIR) to be built at GSI.

With his deep knowledge of and experience in accelerator physics and theory Blasche was a highly respected expert and member of various committees. As a member of the Organizing and Scientific Programme Committees of the European Particle Accelerator Conference (EPAC) series he contributed actively to the organization of EPAC 2000, 2002 and 2004. After his retirement in 2005, he continued to work on various accelerator-related subjects, such as the commercial concepts for accelerators used for hadron therapy.

Klaus Blasche. (Courtesy G Otto, GSI.)

With deep sadness, colleagues and friends take leave of him.

Hartmut Eickhoff, GSI.

Francisco ‘Paco’ Ynduráin 1940–2008

Francisco Ynduráin, a leading Spanish physicist and a former member of the CERN Scientific Policy Committee, passed away on 6 June after a long illness, which he fought with dignity, courage and determination. With exemplary presence of mind, until the very end, Paco, as he was known to his friends, discharged his teaching duties and kept untouched his dedication to physics. His last dissertation at the Royal Spanish Academy of Sciences in October 2007 is a shining example of his passion for science.

Ynduráin studied mathematics at the University of Zaragoza and obtained his PhD in physics in 1964. Part of this work was done during a first visit to CERN in 1964. In 1966 he moved to the University of New York and in 1968 he gained a CERN fellowship. It was in the course of the latter that one of us (M. A-B) had the opportunity to meet him, and for 40 years he has enjoyed the privilege of Ynduráin’s friendship and advice. After various positions at the universities of Madrid and Zaragoza, in 1971 Ynduráin became professor of theoretical physics at the Universidad Autónoma in Madrid. In 1996 he was elected a member of the Royal Academy of Sciences.

His scientific career has been extensive. He had outstanding mathematical skills, and physical intuition. He touched on many topics, although his preference was QCD, a subject on which he worked until the very end. His book on the subject, published in 1983, has become a classic, as have some of his reviews.

Paco Ynduráin. (Courtesy Felix Ynduráin.)

Ynduráin was the first among his theoretical colleagues to realize the need to promote experimental physics in Spain. When the country withdrew from CERN in 1969, he understood that the way of return required the consolidation of the fragile experimental community. In 1972 he started to collaborate with the group at the Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT). The International Meeting on Fundamental Physics was a joint undertaking of Ynduráin, Lucien Montanet, Juan-Antonio Rubio and one of us (M.A-B). The organization of this meeting, which is now heading for its 37th edition, revealed key features of Ynduráin: the quest for excellence, the rejection of mediocrity and the supreme value of decency.

Ynduráin played a role in the process that in 1983 brought Spain back to CERN, and he was instrumental in the formation of an experimental group at his university, always emphasizing the need for scientific quality and competitiveness. He was a very demanding and motivating teacher and was paramount in inspiring brilliant students. He helped establish a school of creative scientists who started the prestigious Institute of Theoretical Physics at his Universidad Autónoma in Madrid.

Ynduráin was also a man with many cultural interests, with a remarkable taste for music, literature and painting. His appreciation for literature made him a superb science writer. His publications to popularize science and his frequent articles in newspapers have received wide recognition.

Paco was a loyal friend and a fine and noble intellectual who partook in, and promoted, science in Spain. He will be gratefully remembered by those of us who had the great fortune to know him.

Manuel Aguilar-Benítez, CIEMAT, and Luís Álvarez-Gaumé, CERN.

Yoji Totsuka 1942–2008

Yoji Totsuka, the former director-general of KEK and an outstanding contributor to major advances in neutrino physics, passed away on 10 July aged 66.

Totsuka was one of the first generation of students to study under Masatoshi Koshiba, the 2002 Nobel Prize laureate in physics, at the graduate school of the University of Tokyo. Receiving his PhD in 1972, he began his career working as a research associate at the University of Tokyo on the Double-Arm Spectrometer, an experiment at the DORIS electron–positron collider at DESY, Hamburg. Later he joined other experiments at DESY, including JADE – one of the four experiments that discovered the gluon in electron–positron collisions at the PETRA collider. The Tokyo group constructed an electromagnetic calorimeter for JADE using 3000 lead-glass blocks and 3000 photomultiplier tubes. Together with Hamamatsu photonics, a manufacturer of photomultiplier tubes, the Tokyo group made use of their experience in fabricating and handling this large number of tubes for JADE in subsequent experiments, in particular the OPAL experiment at LEP and the Kamiokande proton-decay and neutrino detector.

In 1981, Totsuka was called back to Japan by Koshiba to build Kamiokande, a novel (at that time) water Cherenkov detector using ultra-pure water as a target and a source

Yoji Totsuka. (Courtesy ICRR/University of Tokyo.)

of proton decay surrounded by some 1000 photomultiplier tubes. The observation of neutrinos from a supernova (SN 1987a) that had exploded 150 000 years ago in the Large Magellanic Cloud yielded the first direct information from the core of a collapsing star in its final stage of evolution. In 2002, Koshiba received a share of the Nobel Prize in physics for this achievement. In 1988 Totsuka took over the role of Kamiokande spokesperson from Koshiba and became a leading scientist there.

Totsuka's dedication to neutrino physics continued. He worked as Koshiba's right arm and led the experiment with physics insight, as well as technical excellence when it came to the design and construction of Super-Kamiokande, which brought Totsuka and his colleagues the discovery of atmospheric neutrino oscillations in 1998. Since its commissioning, Super-Kamiokande has been a centre for neutrino physics and Totsuka a spearhead of the neutrino physics community.

Totsuka worked on Kamiokande and Super-Kamiokande for more than 20 years. He was a man of iron will and decisive action. After a disastrous accident in 2001 that ruined more than half of the photomultiplier tubes, his strong will to recover the experiment as quickly as possible, together with his swift decision and action, persuaded the funding agency to support the reconstruction project that resulted in a sturdy new detector only five years later.

Totsuka served as the director of the Institute of Cosmic Ray Research at the University of Tokyo, from 1997 to 2000. In October 2002 he moved to KEK and worked as the director-general from 2003 to 2006. He was later professor emeritus of KEK and the University of Tokyo.

Totsuka was a prominent leader both in non-accelerator and accelerator neutrino experiments, and he received numerous awards for his work. He established the financial and international organization schemes for the KEK-to-Kamioka and Tokai-to-Kamioka accelerator-based long-baseline neutrino oscillation experiments. He was also very proactive in pushing forward international co-operation among members of many large particle laboratories. He was an outstanding physicist and his death brings the loss of a tremendous talent and a great force in the particle physics community world-wide.

Atsuto Suzuki, director-general KEK.

Florian Goebel 1972–2008

Florian Goebel, who is well known in the high-energy physics community, lost his life in an accident at work on the MAGIC-II telescope on the island of La Palma in the Canary Islands on 10 September 2008.

Born in Cologne in October 1972, Florian studied physics at the University of Heidelberg. Working in astroparticle physics on a Fulbright fellowship he later graduated from the State University of New York in Stony Brook. In 2001 he joined the ZEUS experiment at DESY in Hamburg, where he was involved in the construction and installation of the ZEUS Forward Plug Calorimeter. His doctoral thesis won the

Florian Goebel. (Courtesy Karl Goebel.)

2001 DESY prize for submitting the best thesis of the year.

In 2002, Florian joined the MAGIC project at the Max Planck Institute for Physics in Munich (MPP), contributing to the commissioning and debugging of the first MAGIC telescope. His work on the development and later upgrade of the data-acquisition system greatly improved the data quality and enhanced the sensitivity of the telescope.

Using the MAGIC telescope to observe the spectra of distant sources, Florian and his colleagues studied the extragalactic background light, which reveals information about the star-formation rates and the structure formation of the universe. He proposed and undertook monitoring of the bright nearby active galaxies to search for very fast flares in order to test the quantum gravity effect and to see the correlation between high-energy gamma rays observed by MAGIC and high-energy neutrinos observed by the AMANDA and IceCube experiments.

For the past three years, as a project manager, Florian was responsible for the construction of the MAGIC-II telescope. He scheduled the production, delivery and installation of all elements of the telescope, mirrors, electronics, camera and all necessary software. He designed and produced the camera for the new telescope together with the engineers and technicians at the MPP. Just days before the official inauguration of the telescope, a tragic accident occurred as he was finishing work on the instrument. Out of respect for Florian, the collaboration cancelled the inauguration ceremony.

Florian was an exceptionally friendly and enthusiastic collaborator and a leader with multiple interests in and beyond physics. A brilliant physicist and warm-hearted person, he will be deeply missed.
His colleagues and friends.

NEW PRODUCTS

Cryocomp has released a new vacuum-jacketed, mini-liquid-helium valve. The C5000 series, originally known as the CV9, has been redesigned to reduce heat leak and eliminate seat leak. The small, efficient valve is best suited to liquid-helium and nitrogen transfer lines, and is available in globe or angle pattern with manual and pneumatic operation. For further information, see www.cryocomp.com.

Hiden Analytical has announced its ESPION Langmuir-style probe, which automatically reports critical plasma characteristics such as electron density, temperature and energy distribution, ion density, and plasma potential. Fast on-board, software-controlled timing circuitry with an acquisition trigger resolution of 62.5 ns enables ESPION to provide high-resolution segmented temporal analyses in pulsed plasma, at frequencies as high as 3 MHz. For further details contact Peter Hatton, tel: +44 1925 445 225, e-mail info@hiden.co.uk or see www.HidenAnalytical.com.

Janis Research Company Inc has announced the HE-3-SSV-CCR2 cryogen-free helium-3 cryostat. This second-generation system offers significant new features. These include a pulse tube cryocooler to minimize vibration and additional cooling power to pre cool the helium-3 before it is liquefied. The system has an operating range of 0.3K – 300K and can hold a base temperature of 300 mK for 50 hours. A LabVIEW-compatible program for system operation is included. For more information contact Zuyu Zhao, e-mail: zzhao@janis.com, or see www.janis.com/news0808b.html.

Spellman High Voltage Electronics Corporation has extended its modular product line with the introduction of the UM Series of printed-circuit-board-mountable, high-voltage modules. The series spans an output voltage range of 62V – 6kV in three power offerings of 4, 20 and 30 W. An optional enhanced interface provides current-programming capability and positive polarity, buffered, low output-impedance voltage and current monitor signals. A second voltage-programming input is also provided for negative polarity. For further information, see www.spellmanhv.com/um, or call +1 631 630 3000.

TREK Inc has introduced a new electrostatic voltage sensor, Model 875. Designed for the in-line monitoring of electrostatic charge build-up it features a measurement probe with automatic calibration technology. Designed with DIN packaging, it mounts on a 35 mm DIN rail, and covers a range of +/– 500 V DC or peak AC, with an accuracy of +/– 5% and a speed of 25 ns. Buffered output voltage and current monitors allow remote monitoring and alarm functions. For more information, see www.trekinc.com/products/875.asp.

MEETINGS

The **5th Vienna Central European Seminar on Particle Physics and Quantum Field Theory** is to be held in Vienna on 28–30 November. The title is Highlights in Computational Quantum Field Theory. There will be presentations on Monte Carlo event generation for collider experiments and Grid technology. In perturbative quantum field theory, the automation of loop and precision calculations will be covered. At the non-perturbative level, advances in lattice QCD, simulations of M-theory, and supergravity will feature. For further details, see www.univie.ac.at/vienna.seminar/2008/.

The **X-Band Structures and Beam Dynamics Workshop** will be held at the Cockcroft Institute of Accelerator Science and Technology, Daresbury, on 1–4 December. This is the 44th ICFA Workshop under the sponsorship of the ICFA BD panel. The purpose is to explore a range of RF and beam dynamics issues associated with X-band accelerators. Both fundamental and technological aspects of linacs and drive beams will be explored through invited talks and contributed papers. For further information, see www.cockcroft.ac.uk/events/X-Band/.

CHEP'09, the 17th International Conference on Computing in High Energy and Nuclear Physics, will take place on 21–27 March 2009 in Prague. The CHEP conferences provide an international forum to exchange information on computing experience and needs for the high-energy and nuclear-physics community, and to review recent, ongoing, and future activities. A WLCG Meeting will be held on from 21–22 March prior to CHEP 2009. For further information see www.particle.cz/conferences/chep2009/.

HIAT09, the 11th International Conference on Heavy Ion Accelerator Technology, will take place in Venice on 8–12 June 2009. The HIAT conferences focus on experience at existing facilities, achievements in heavy-ion accelerator physics and technology, progress on approved projects, trends in the design of heavy-ion accelerators, and their main systems and components. For further information, see http://hiat09.lnl.infn.it/.

RECRUITMENT

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The Indiana University Cyclotron Facility (IUCF) is a multidisciplinary institution supporting research in Accelerator Physics, Condensed Matter and Materials Physics, Medical Physics and Nuclear Physics and Chemistry. IUCF is also developing two major new research facilities – The LENS Neutron Source and the ALPHA electron storage ring. LENS is a pulsed neutron source supporting the study of large scale structures and neutron radiation effects testing. ALPHA will consist of a 60 MeV long pulse LINAC and electron storage ring to support accelerator physics research, radiation effects testing and the development of an Inverse Compton Scattering X-ray source. Several positions are now available to support these research and development activities at IUCF.

Postdoctoral Position in Accelerator Physics (1) – to participate in the design, construction and commissioning of the LINAC and Storage Ring. The successful candidate will have a PhD in Accelerator Physics, Nuclear Physics or Electrical Engineering. Experience with electron LINACS, vacuum systems, and controls is highly desirable.

Postdoctoral Position in Accelerator Physics (2) – to participate in the development of optical diagnostics for electron beams based on laser wires and Inverse Compton Scattering. The successful candidate will have a PhD in Accelerator Physics, Nuclear Physics, Condensed Matter Physics or Optics. Experience with lasers and optical systems is essential.

Staff Position in Accelerator Physics – to support the development of a high intensity electron linear accelerator and storage ring facility. The successful candidate will have a PhD in accelerator physics or related field and a minimum of five years experience in an accelerator laboratory environment. The candidate will have a demonstrated ability to lead a team of scientists, engineers and technicians to design, deploy and commission a synchrotron and must have a working knowledge of accelerator operations, accelerator controls, and beam diagnostics. Experience in electron accelerators is a strong asset. Applicants for this position should apply online at **http://www.indiana.edu/~uhrs/jobs/index.html.**

Interested postdoctoral applicants should send a CV and a statement of research interests, along with 3 names for reference to: **Dianne Dupree, IUCF, 2401 Milo B. Sampson Lane, Bloomington, IN 47408**, or to **didupree@indiana.edu**.

Indiana University is an Affirmative Action, Equal Opportunity Employer committed to excellence through diversity. The University actively encourages applications of women, minorities, and persons with disabilities. Applications will be reviewed until a suitable candidate is identified.

Director
Center for Accelerator Science
Old Dominion University

Old Dominion University invites applications for the position of Director of the Center for Accelerator Science. The newly created Center builds upon the existing collaboration between ODU and the Thomas Jefferson National Accelerator Facility (Jefferson Laboratory) in accelerator science and technology. The Center will initially focus on super conducting RF cavities, accelerator design, and high current DC and RF guns. The director is expected to hold appointment as a tenured faculty member in the ODU Physics Department and is jointly funded by ODU and Jefferson Laboratory.

The successful applicant will be responsible for building an internationally recognized, interdisciplinary research and teaching program that will address current and future challenges in accelerator science and technology. The Director will provide leadership to obtain external funding for a broad range of projects, attract faculty and staff, and establish national and international collaborations. As a member of the Physics faculty,the Director will have teaching responsibilities as well.

Old Dominion University is a public institution located in Norfolk, Virginia, serving 23,000 students. The ODU Physics department (**http://sci.odu.edu/physics/**) has internationally recognized research groups in experimental and theoretical nuclear physics, experimental and theoretical atomic and few-body physics, accelerator physics and material science. Within ODU, many opportunities exist for interdisciplinary collaborative research with groups in Mathematics, Oceanography, Chemistry, Computer Science, Material Science and Engineering. Jefferson Laboratory, with its ongoing and possible future partnerships in developing next generation accelerators, provides further exciting opportunities. The proximity of the Eastern Virginia Medical School, the Applied Research Center at Jefferson Laboratory, NASA Langley, the Virginia Modeling, Analysis, and Simulation Center, and nearby universities creates an intellectually stimulating environment.

Applicants must have a Ph.D. in accelerator, particle or nuclear physics, or related field, and extensive experience beyond the Ph.D., including outstanding contributions to accelerator science or related fields. Applicants should submit a letter of application describing the individual's qualifications for the position, a curriculum vitae, and names and contact information of four references to: **Director Search Committee, Department of Physics (Room 306), Old Dominion University, 4600 Elkhorn Ave., Norfolk, Virginia, 23529** or email **Dr. Lepsha Vuskovic – vuskovic@odu.edu**. Review of applications will begin on November 24 and continue until the position is filled.

Old Dominion University is an affirmative action, equal opportunity institution and requires compliance with the Immigration Reform and Control Act of 1986.

OLD DOMINION UNIVERSITY

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December issue

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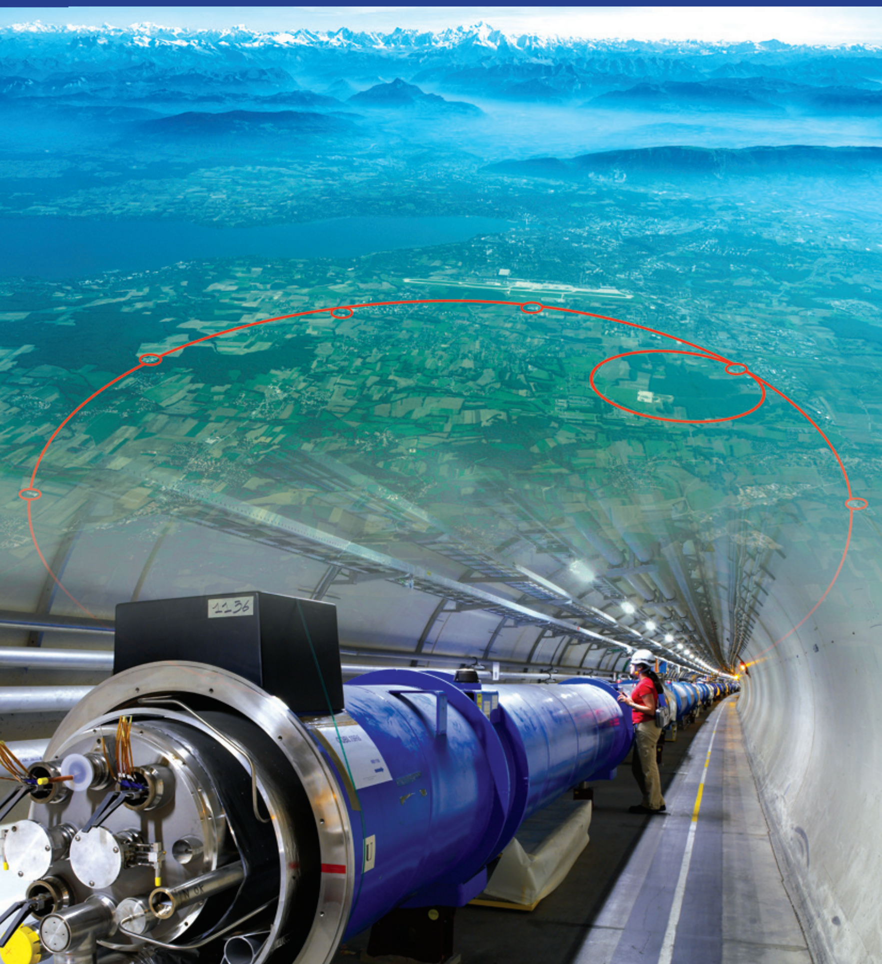
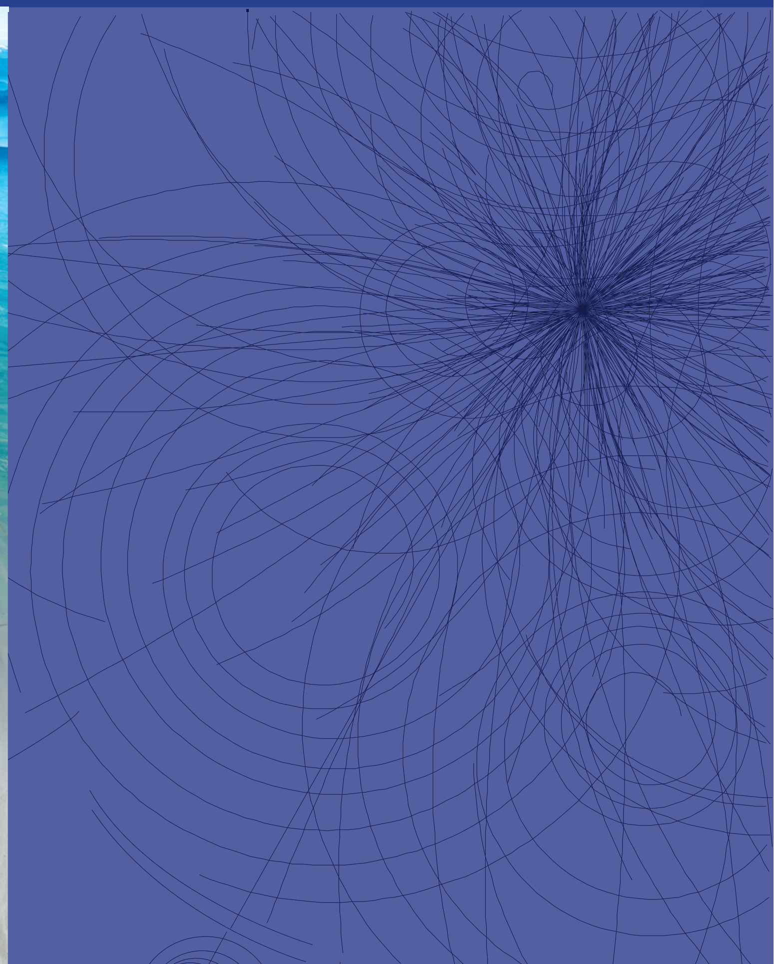




The University of Mississippi

High energy theory

The Department of Physics and Astronomy at The University of Mississippi invites applications for a two year postdoctoral position in high energy theory beginning in the Fall of 2009.

Job Responsibilities: the high energy theory group currently includes one full-time faculty member (Dr Alakabha Datta). The interest of the group is high energy phenomenology. All applicants working in phenomenology are encouraged to apply though preference may be given to applicants working in flavor physics. The physics and astronomy department at the University of Mississippi also has a very active experimental high energy physics group and a gravitataional group. The candidate is expected and encouraged to interact with the high energy experimental and the gravitational groups. Qualifications/Skills: the candidate should have a PhD in high energy theory. The candidate should have a clear sense of initiative, motivation, and have excellent communication skills.

The search committee will begin reviewing applications immediately. Review of applications will continue until the position is filled or an adequate applicant pool is established.

We require three reference letters.

Applicants should apply online at **http://www.olemiss.edu/depts/HR/** where a CV and statement of research interests should be posted.

The reference letters can be sent directly to Alakabha Datta at datta@olemiss.edu or submitted at the HR website provided.

The University of Mississippi is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA employer.

Research Scientist for Hadron Physics, one position for an experienced experimental physicist.

Starting April 01, 2009.

The successful applicant is expected to take an integral role in hadron physics, a collaborative work to understand the origin of the hadron mass, J-PARC E15 experiment 1), and also responsible for the future project of the laboratory 2).

In principle, this is a tenured fulltime position (mandatory retirement at age 60). However, depending on the screening results, the successful candidate may be offered a five-year contract as a fixed term employee with provision for a transfer to a tenured position upon a successful review to be held at the end of the first 3 years. If hired as a fixed-term contract employee, annual salary and work conditions will conform to those for a tenured employee.

* Commuting and housing allowances will be paid and social security premiums will be deducted.

* Days off: Saturdays and Sundays, national holidays, Year-end holidays (Dec. 29-Jan. 3), and RIKEN Founding Day.

* All other provisions will conform to RIKEN's rules and regulations.

* The successful candidate will be eligible to be exempted from the repayment of JASSO loans (Japan Student Services Organization).

More information can be found in:
http://www.riken.jp/engn/r-world/info/recruit/081120.html
1) http://j-parc.jp/NuclPart/pac_0606/pdf/p15-Iwasaki.pdf
2) http://j-parc.jp/NuclPart/pac_0801/pdf/LOI-Iwasaki.pdf

Contact and submission address:
RIKEN Nishina Center for Accelerator-Based Science,
Advanced Meson Science Laboratory,
RIKEN, 2-1 Hirosawa, Wako-shi,
Saitama 351-0198, JAPAN
Masahiko Iwasaki
Tel: +81-48-467-9352
E-mail: advanced_meson@riken.jp

Deadline on 20/11/2008

RIKEN

Université de Genève

FACULTY POSITION IN COSMOLOGY

(MER) - GENEVA, SWITZERLAND

This is a permanent fulltime position with 4 hours of teaching per week. The candidate should pursue a vigorous research program in cosmology. More precisely she/he should work on the problem of dark energy considering as well its theoretical aspects as also methods for experimental investigations of dark energy. The candidate is expected to participate in the supervision of graduate students and teaching on all levels.

Applications have to be sent to **Prof. Ruth DURRER, DPT, Université de Genève, 24, quai Ernest Ansermet, CH-1211 Genève 4, Suisse.**

Additional information can be obtained from **ruth.durrer@unige.ch**.

UPPSALA UNIVERSITET

Chair in Nuclear Physics with specialization in Experimental Hadron Physics

at the Department of Physics and Astronomy, Uppsala University.

Nature of duties: General responsibility for research and research education in Nuclear Physics, supervision at postgraduate level and teaching at all levels are required. The research is intended to be focused on the subfield of nuclear physic referred to as Experimental Hadron Physics. Today the research within the programme is conducted at the facilities PANDA at FAIR and WASA at COSY. Participation in planning of research projects as well as dissemination of information about research and development in the research field, are also included in the assignment. Administrative duties and leadership may be relevant.

For further information about the position please contact Professor Ulf Danielsson, e-mail Ulf.Danielsson@fysast.uu.se, phone +46 18 471 3299.

A full advertisement with information about how to apply can be found at http://www.personalavd.uu.se/ledigaplatser/engindex.html.
Closing date for acceptance of application is **December 18, 2008**.

www.uu.se

NATIONAL TAIWAN UNIVERSITY

Leung Center for Cosmology and Particle Astrophysics

Distinguished Junior Fellowship

The Leung Center for Cosmology and Particle Astrophysics (LeCosPA) of National Taiwan University is pleased to announce the availability of several post-doctoral or Assistant Fellow (assistant professor equivalent) positions in theoretical and experimental cosmology and particle astrophysics, depending on the seniority and qualification of the candidate. Candidates with exceeding qualification will be further offered as LeCosPA Distinguished Junior Fellows with competitive salary.

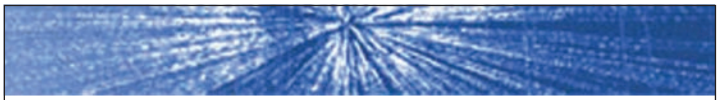
LeCosPA was founded in 2007 with the aspiration of contributing to cosmology and particle astrophysics in Asia and the world. Its theoretical studies include dark energy, dark matter, large-scale structure, cosmic neutrinos, and quantum gravity. The experimental projects range from CMB detection in Hawaii, GZK-neutrino detection in Antarctica, to a micro-satellite GRB telescope, POET.

These positions are available August 1, 2009. Interested applicant should email his/her application with curriculum vitae, research statement, publication list and three letters of recommendation before December 31, 2008 to

Ms. Hui-Chung (Maggie) Wang
hcwang@phys.ntu.edu.tw

Three letters of recommendation should be addressed to
Prof. Pisin Chen, Director
Leung Center for Cosmology and Particle Astrophysics
National Taiwan University

For information about classified advertising in *CERN Courier*, contact Moo Ali:
Tel +44 (0)117 9301264, e-mail moo.ali@iop.org.



CERN, founded in 1954 in Geneva, is the world's most advanced fundamental research institute for particle physics. Over the last 50 years, it has become a prime example of international collaboration with currently 20 European Member States.

The Electrical Engineering Group (EL) of the Technical Support Department (TS) has the mandate to design, procure and operate CERN's electrical power distribution networks. The CERN electrical networks, supplied by 130 kV and 400 kV lines respectively from Switzerland and France, provide electrical power to a number of high-energy particle accelerators, large scale experimental areas, the Organization's computer centre and many office buildings on the various sites. The installed electrical power at the 18 kV level is rated at approximately 500 MVA. CERN is currently looking for a

Senior Electrical Engineer

Electrical power distribution

to **lead the Electrical Engineering Group** (Reference: TS-EL-2008-15-LD)

as well as other

(Senior) Electrical Engineers.

We offer a limited duration contract for a period of 4 years. Its holder may be subsequently considered for the award of an indefinite contract or an extension of the limited duration contract may be granted. CERN is an equal opportunities employer offering challenging work, competitive tax-free salaries, relocation package (where applicable) and comprehensive social benefits in a stimulating environment.

For detailed descriptions of the above vacancies and the application procedure please refer to our website **https://ert.cern.ch**.

You can also obtain additional information by contacting the responsible Human Resources Advisor: **michael.dorn@cern.ch**.

The European XFEL X-Ray Free-Electron Laser

Technical coordinator for "in-kind" contributions (f/m)

Establishing and coordinating the follow-up procedures to monitor the progress of the international "in-kind" contributions to the European XFEL project

The European XFEL will receive substantial contributions from its international partners in the form of contributions "in-kind." These contributions will be manifold: hardware equipment, expert manpower, software. They cover all areas of the European XFEL facility: the accelerator (e.g. cryostats for superconducting cavities, electromagnets, radio-frequency systems, several kilometers of vacuum systems), the undulator beam lines (long permanent magnet devices), the X-ray beam transport lines and the scientific instrumentation.

The technical coordinator for in-kind contributions is expected to assist the European XFEL management in the following areas:

- Preparation and establishing the tools for a close follow-up of the technical progress at the various in-kind contributions
- Monitoring of the technical progress of the in-kind contributions by holding reviews and reporting to the management and associated committees
- Support of the development and enforcement of engineering standards to ensure the correct interfacing of different in-kind contributions

The technical coordinator for in-kind contributions will provide a liaison between the in-kind contributor and the European XFEL management team in all technical areas. We are looking for a person with demonstrated capabilities in the coordination of large-scale technical projects. The candidate should have several years of experience in either mechanical or electronic engineering (degree in engineering) and/or with the coordination of large-scale scientific projects (degree in natural sciences). Knowledge in the area of accelerator technology and/or X-ray beam transport systems would be of advantage but are not mandatory. Experience with management tools for project progress control is required. Good communication and management skills, ability to work in a team and fluent English are expected.

Flexible work schemes are in operation. Handicapped persons will be given preference to other equally qualified applicants. Employment is based on equal opportunity and applications from women are encouraged. There is an English-speaking Kindergarten on the DESY site.

For additional information contact Andreas.Schwarz@xfel.eu

Reference of application E-006

Duration 2.5 years
The contract will initially be made for a fixed duration of two and a half years.
An extension of the contract duration will become possible after the formation of the European XFEL GmbH that is planned to take place in 2008. In the case of excellent performance, the possibility to convert the position to a permanent one exists in principle, once the European XFEL GmbH has been founded.

Application If you are interested in this position, please provide an application letter, a CV and the names of three people whom we could ask for a letter of reference. Proceed as described on www.xfel.eu/XFELjobs/en/application.

Deadline for application 31 December 2008

European XFEL Project Team c/o DESY
Notkestr. 85, D-22607 Hamburg, Germany

BOOKSHELF

Books received

Felix Berezin: Life and Death of the Mastermind of Supermathematics edited by M Shifman, World Scientific. Hardback ISBN 978-981-270-532-7, £41 ($75). Paperback ISBN 9789812705334, £21 ($39).

Felix Berezin was an outstanding Soviet mathematician who was the driving force behind the emergence in the 1960s and 1970s of the branch of mathematics, now known as supermathematics. The integral over the anti-commuting Grassmann variables that he introduced in the 1960s laid the foundation for the path integral formulation of quantum field theory with fermions, the heart of modern supersymmetric field theories and superstrings. This book features a masterfully written memoir by Berezin's widow, Elena Karpel, who narrates a remarkable account of his life and struggle for survival under the totalitarian Soviet regime. Supplemented with recollections by close friends and colleagues, Berezin's accomplishments in mathematics, his novel ideas and breakthrough works, are reviewed in two articles written by Andrei Losev and Robert Minlos.

Scale-free Networks: Complex Webs in Nature and Technology by Guido Caldarelli, Oxford University Press. Hardback ISBN 9780199211517, £49.95 ($115).

This book presents the experimental evidence for scale-free networks and provides students and researchers with theoretical results and algorithms to analyse and understand these features. A variety of different social, natural and technological systems – from the Internet to food webs and boards of company directors – can be described by the same mathematical framework. In all these situations a graph of the elements of the system and their interconnections displays a universal feature: there are few elements with many connections, and many elements with few connections. The content and exposition make this a useful textbook for beginners, as well as a reference book for experts in a variety of disciplines.

Principles of Quantum Computation and Information: Volume II: Basic Tools and Special Topics, by Giuliano Benenti, Giulio Casati and Giuliano Strini, World Scientific. Hardback ISBN 9789812563453 £33 ($58). Paperback ISBN 9789812565280 £22 ($38).

Quantum computation and information is a new, rapidly developing interdisciplinary field. Building on the basic concepts introduced in Volume I, this second volume deals with various important aspects, both theoretical and experimental, of quantum computation and information in depth. The areas include quantum data compression, accessible information, entanglement concentration, limits to quantum computation due to decoherence, quantum error-correction, and the first experimental implementations of quantum information protocols. This volume also includes a selection of special topics, including quantum trajectories, quantum computation and quantum chaos, and the Zeno effect.

Elements of String Cosmology by Maurizio Gasperini, Cambridge University Press. Hardback ISBN 9780521868754 £45. E-book format ISBN 9780511332296 $68.

The standard cosmological picture of our universe emerging from a Big Bang leaves open many fundamental questions, which string theory, a unified theory of all forces of nature, should be able to answer. The first book dedicated to string cosmology, this contains a pedagogical introduction to the basic notions of the subject. It describes the new possible scenarios suggested by string theory for the primordial evolution of our universe and discusses the main phenomenological consequences of these scenarios, stressing their differences from each other, and comparing them to the more conventional models of inflation. It is self-contained, and so can be read by astrophysicists with no knowledge of string theory, and high-energy physicists with little understanding of cosmology. Detailed and explicit derivations of all the results presented provide a deeper appreciation of the subject.

Searching for the Superworld: A Volume in Honor of Antonino Zichichi on the Occasion of the Sixth Centenary Celebrations of the University of Turin, Italy, by Sergio Ferrara and Rudolf M Mössbauer, World Scientific Series in 20th Century Physics, Volume 39. Hardback ISBN 9789812700186 £69 ($128).

The "superworld" is a subject of formidable interest for the immediate future of subnuclear physics to which Antonino Zichichi has contributed with a series of important papers of phenomenological and theoretical nature. These papers represent a must-have collection, not only for their originality, but also for their complete analysis of expected scenarios on the basis of today's knowledge of physics. The contributions are divided into two parts. The first deals with the problem of the convergence of the three fundamental forces of nature measured by the gauge couplings, with the onset of the energy threshold for the production of the lightest supersymmetric particles and with the existence of a gap between the string scale and the GUT scale. The second deals with the study of a theoretical model capable of including supersymmetry with the minimum number of parameters (possibly one), and agreeing with all the conditions established by string theories – this turns out to be a "one-parameter no-scale supergravity" model whose experimental consequences are investigated for present and future facilities aimed at the discovery of the first example of the superparticle.

Quantum Field Theory of Non-equilibrium States by Jørgen Rammer, Cambridge University Press. Hardback ISBN 9780521874991 £45 ($85). E-book format ISBN 9780511292620, $68.

This textbook presents quantum field theoretical applications to systems out of equilibrium. It introduces the real-time approach to non-equilibrium statistical mechanics and the quantum field theory of non-equilibrium states in general. It offers two ways of learning how to study non-equilibrium states of many-body systems: the mathematical canonical way and an intuitive way using Feynman diagrams. The latter provides an easy introduction to the powerful functional methods of field theory, and the use of Feynman diagrams to study classical stochastic dynamics is considered in detail. The developed real-time technique is applied to study numerous phenomena in many-body systems, and there are numerous exercises to aid self-study.

Physics of Semiconductors in High Magnetic Fields by Noboru Miura, Oxford University Press. Hardback ISBN 9780198517566 £65 ($150).

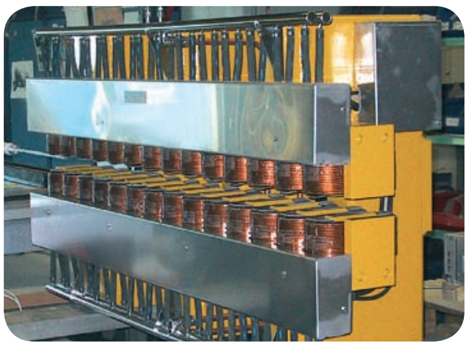
This book describes the basic concepts of various physical phenomena in semiconductors and their modulated structures under high magnetic fields. The topics cover magneto-transport phenomena, cyclotron resonance, far-infrared spectroscopy, magneto-optical spectroscopy, diluted magnetic semiconductors in high magnetic fields, as well as the recent advances in the experimental techniques needed for high field experiments. Starting from the introductory part describing the basic theoretical background, each chapter introduces typical experimental data, obtained in very high magnetic fields mostly in the pulsed field range at 20–100 T. The book will serve as a useful guide for researchers and students with an interest in semiconductor physics or in high magnetic fields.

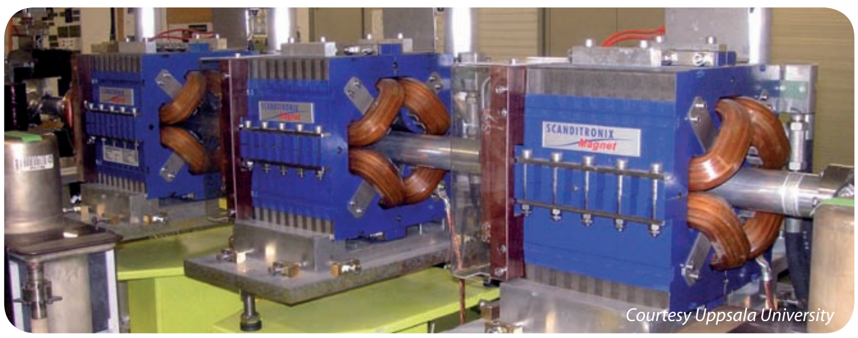
Introduction to 3+1 Numerical Relativity by Miguel Alcubierre, Oxford University Press Series: International Series of Monographs on Physics, Volume 140. Hardback ISBN 9780199205677 £55 ($110).

An introduction to the modern field of 3+1 numerical relativity, this book has been written so as to be as self-contained as possible, assuming only a basic knowledge of special relativity. Starting from a brief introduction to general relativity, it discusses the different concepts and tools necessary for the fully consistent numerical simulation of relativistic astrophysical systems, with strong and dynamical gravitational fields. The topics discussed in detail include: hyperbolic reductions of the field equations, gauge conditions, the evolution of black hole space-times, relativistic hydrodynamics, gravitational wave extraction and numerical methods. There is also a final chapter with examples of some simple numerical space–times. The book is for graduates and researchers in physics and astrophysics.

Zero to Infinity: The Foundations of Physics by Peter Rowlands, World Scientific Series of Knots and Everything, Volume 41. Hardback ISBN 9789812709141 £48 ($88).

This book uses a methodology that is entirely new, creating the simplest and most abstract foundations for physics to date. The author proposes a fundamental description of process in a universal computational rewrite system, leading to an irreducible form of relativistic quantum mechanics from a single operator. This seems to be simpler, more fundamental, and also more powerful than any other quantum mechanics formalism available. The methodology finds immediate applications in particle physics, theoretical physics and theoretical computing. In addition, taking the rewrite structure more generally as a description of process, the book shows how it can be applied to large-scale structures beyond the realm of fundamental physics.





Courtesy Uppsala University

SRF technology comes full circle

Accelerator builders should step back and re-assess decades of R&D into superconducting RF technology says Jefferson Lab's **Ganapati Rao Myneni**.

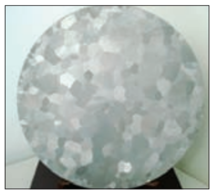
Nearly a half-century ago, researchers at Stanford University began investigating superconducting RF (SRF) acceleration. They would not have been surprised to learn that by 1994, SRF had come into large-scale use in Jefferson Lab's Continuous Electron Beam Accelerator Facility, or that by 2008 it was planned as the enormous, ultra-cold, dynamic-but-delicate heart of the proposed International Linear Collider (ILC). Nor would they be surprised to learn that this complex technology's challenges nevertheless continue to vex accelerator builders. In my view, it's time for the accelerator community to go back to where the pioneers at Stanford began, hit the pause button, and take a careful look at more than four decades of SRF R&D.

Such a renewed learning effort is needed because SRF technology is not only complex and vexing, it's vital and expensive. Some 16 000 SRF accelerating cavities will be made for the ILC from hundreds of tons of the soft, ductile metal niobium, which becomes superconducting when refrigerated to nearly absolute zero. This is a major component of the ILC's immense cost.

Niobium-based SRF is also in use or in planning at other projects – for example, Oak Ridge National Laboratory's Spallation Neutron Source, Fermilab's Project X, the Facility for Rare Isotope Beams, compact accelerators for university laboratories, accelerator-driven systems for nuclear power production in India, DESY's XFEL, and energy-recovering linear accelerators driving fourth-generation light sources, such as Jefferson Lab's free-electron laser.

Though condensed-matter physicists participated when the field began at Stanford, SRF has long since become highly specialized – maybe even too highly specialized. SRF scientists devote careers to the study of elaborate cavity design and preparation processes. Much effort has gone into development and assessment of techniques that have become standard in SRF, such as buffered chemical polishing, electropolishing and high-pressure rinsing of niobium surfaces. Much effort has been expended to overcome or circumvent the contamination problems introduced in pumping to attain the stringent vacuum conditions needed for superconducting operation.

Myneni: "It's time to go back to where the pioneers of Stanford began." (Courtesy Jefferson Lab.)



At high magnification, the micrograph (left) shows the many submicron grain boundaries in polycrystalline niobium after expensive modern-day processing. Without magnification, the photo (right) shows the very few grain boundaries in medium-purity niobium simply sliced from an ingot – a decades old technique. (Courtesy DESY, left, and CBMM Brazil, right.)

Many of these efforts have involved, or have even begun with, the issue of the purity of the niobium material. Yet if you look back, you find that during the 1960s, Stanford's pioneers used niobium of a purity that was not even known. The metal was electron-beam melted into the ingots from which cavities were machined. Without even addressing the purity issue, those early researchers demonstrated high performance and very high quality factors in one type of SRF cavity, the X-band pillbox cavity.

Later, to reduce the cost of larger L-band SRF cavities, researchers at Stanford switched to fine-grain niobium sheets, using 1800 °C annealing to increase the grain size – that is, to enlarge the crystals giving structure to the metal. By reducing the availability of cracks between grain boundaries, this enlargement crucially reduced the potential for hydrogen inclusion in those cracks. Hydrogen, both in the cracks and directly on the material surface, is recognized today as SRF's major performance limiter.

The use of high-purity niobium was not specified until later, although in the 1970s Siemens in Germany used fine-grain niobium of low purity, and demonstrated state-of-the-art peak surface magnetic fields – at levels that would still be impressive today. Researchers at Siemens enlarged the fine-grain structure with 1400 °C annealing, which led to a grain size so large as to have visible boundaries – and thus led also to a reduction in the grain-boundary inclusion of performance-degrading hydrogen.

Thanks to empirical results on three continents, it has now become apparent that SRF can progress using niobium ingot slices of merely moderate purity – that is, niobium with relaxed purity specifications, quite similar to the ingot niobium used originally at Stanford. Optimized and streamlined processes can eliminate or reduce the surface-included hydrogen, resulting in high-performance accelerator structures at reduced cost. This could mean savings of perhaps as much as a few tens of percent on ILC's SRF cavities, and substantial operational cost savings too.

In other words, SRF's efforts have now come full circle. The SRF researchers who followed Stanford's original initiative have done fine work. They have made astute choices based on what they could see. But we now have a half-century of work that we can survey. The time has come to re-assess this entire R&D history. Anything less will fail to do justice to the future of accelerators – and to the future of physics itself.

Ganapati Rao Myneni, Jefferson Lab and University of Virginia.

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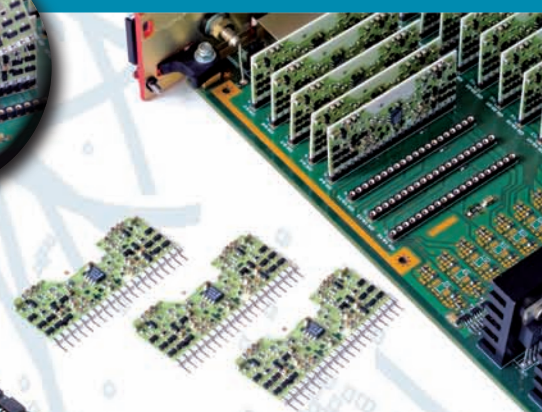
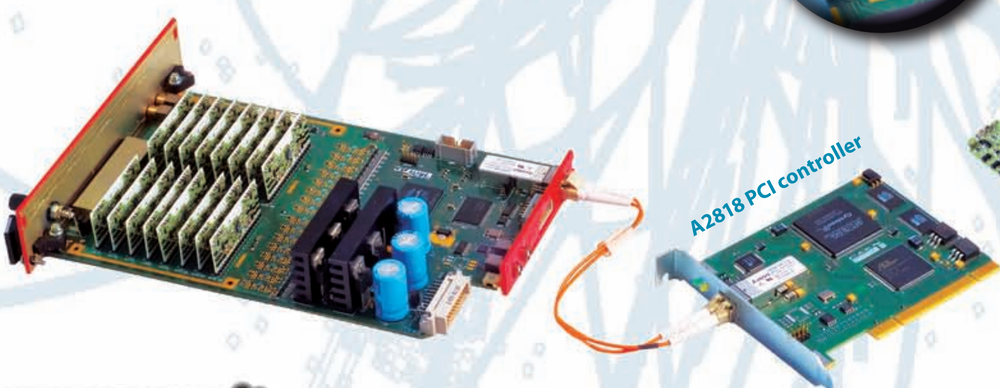
The user can chose in a list of different models provided by CAEN or develop a custom version of the preamplifier to be used on the empty motherboard of the A2792.





A2818 PCI controller

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