INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

# CERN COURIER

VOLUME 40 NUMBER 10 DECEMBER 2000

## Dancing to the tempo of LEP

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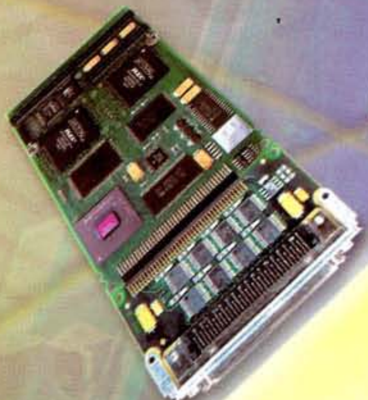

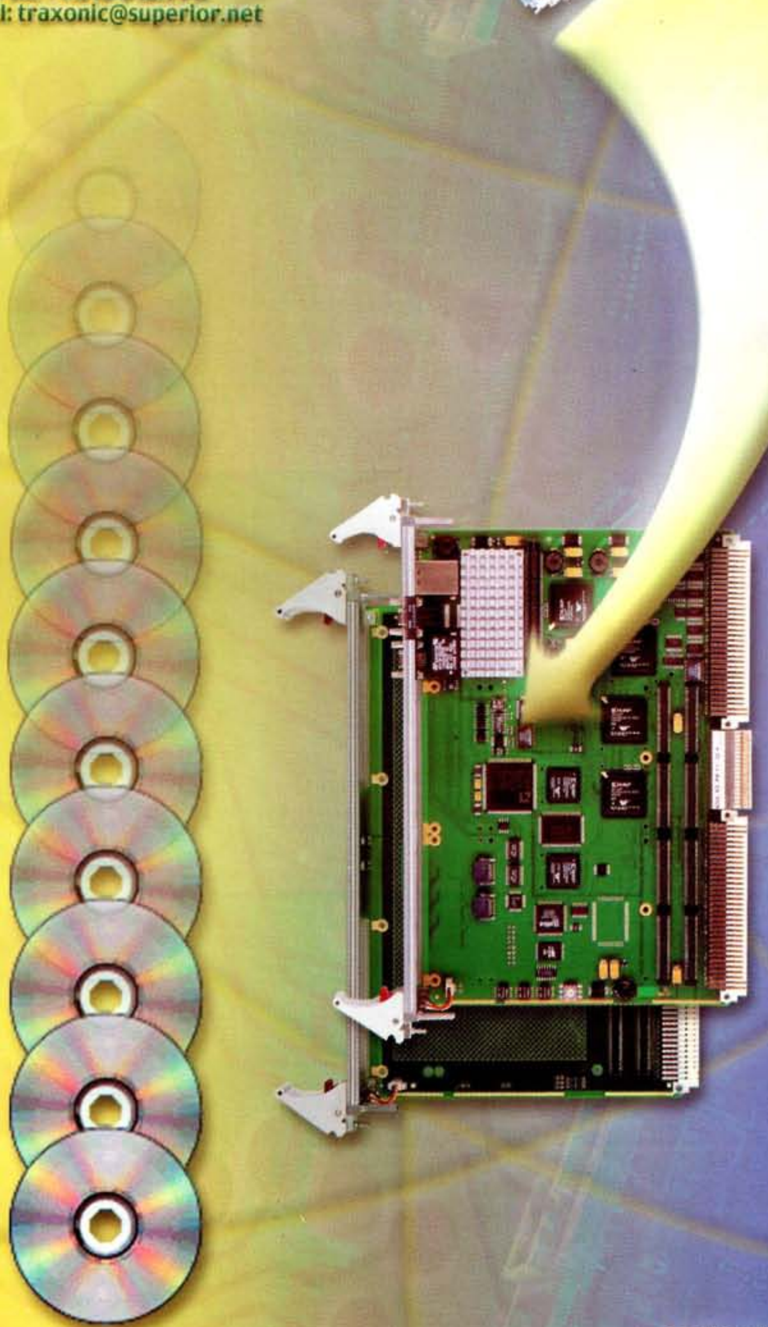

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# CERN COURIER

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**Cover:** One of the highlights of CERN's LEP celebration on 9 October was a special ballet performance by pupils of the Rudra–Béjart Ballet School, Lausanne (p24).


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

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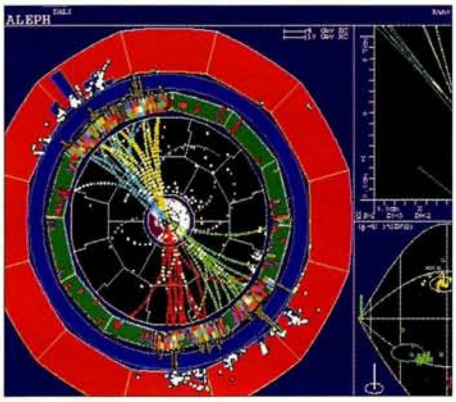
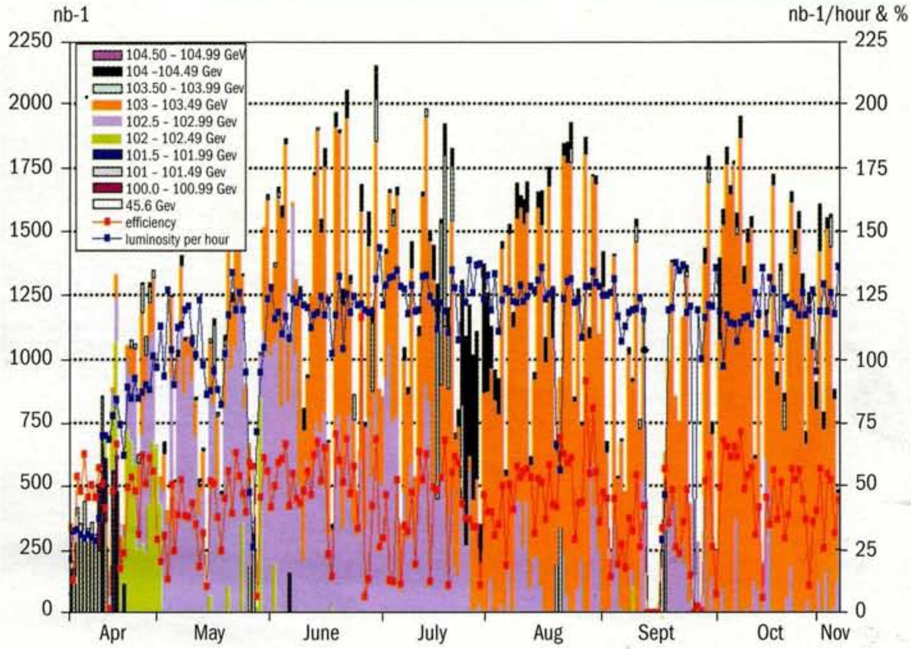
# LEP reaps a final harvest




*A glimpse of the Higgs before the door closed? An electron–positron collision at LEP as seen by the ALEPH detector, showing the production of four closely confined sprays ("jets") of particles, labelled in red, yellow, blue and green. The red/yellow pair and blue/green pair each emerge back to back, all showing signs (top right) of having produced B particles (containing heavy quarks). The suggested explanation is the production of a Z particle (giving the red/yellow pair) together with a Higgs, giving the blue/green pair.*




*Daily integrated luminosity (a measure of the number of electron–positron collisions) achieved by CERN's LEP machine in 2000, its final year of running, showing a healthy bonus accumulated during the additional "stay of Higgs execution" running period which ended early in November. The machine was initially scheduled to be closed for good towards the end of September.*

CERN's LEP electron–positron collider stubbornly refused to lie down quietly in 2000. The world's largest synchrotron storage ring was scheduled to be closed forever at the end of September, and dismantled to make way for the LHC proton collider to be built in the same 27 km tunnel.

However, with tantalizing glimpses of the long-awaited Higgs particle appearing at the last gasp, LEP was accorded a six-week stay of "Higgs execution" (November p5). The machine duly finished its 2000 run on 2 November. In a specially convened meeting of the LEP Experiments Committee on 3 November, LEP physicists revealed the fruit of these extra few weeks of autumn running.

The Higgs particle, which breaks electroweak symmetry and endows particles with mass, is the missing link in the Standard Model of particle physics, and a major objective at LEP. As LEP's energy was increased over the years, more and more Higgs territory has been covered without finding any signs of the elusive particle – until this year.

To boost the energy of LEP's particles, from 1996 the machine was equipped with superconducting radiofrequency accelerating cavities. The remarkable success of this scheme, together with astute planning and skilled machine operations, have enabled LEP to reach collision energies of up to 209 GeV, beyond its planned energy horizon.

For the past several years, LEP has been running in exactly the energy band where the Higgs had been most expected. Each time the energy was increased, physicists held their breath. As data started to accumulate above 206 GeV late this summer, a few electron–positron events suggested Higgs production with a mass of around 114–115 GeV.

In these events, a LEP electron–positron pair could produce a Higgs back-to-back with another particle. However, the Higgs signals are right at the extreme edge of LEP's kinematic reach, and are difficult to disentangle from more common processes, notably the production of Z and W particle pairs.

The particles can decay in a number of ways. The initial candidates saw four confined sprays ("jets") of particles, two from the Higgs. However, other decay patterns are possible, and the recent run has also revealed events with two slices of "missing mass", indicating the production of two otherwise invisible neutrinos, and other signals.

In the combined results of the four LEP experiments – ALEPH, DELPHI, L3 and OPAL – confidence in the candidate Higgs signal therefore slightly increased as a result of the autumn run, but still fell short of the level needed to claim a physics discovery. The experiments therefore requested a further extension of LEP running in 2001.

However, with the LHC knocking loudly on the door, this has been ruled out. LEP has run for the last time, and its ultimate findings point the way to future physics at the LHC.

At the 3 November meeting where the latest LEP results were disclosed, there was an ovation for the LEP operations team which had delivered the high-energy goods and provided such a cliffhanger finish to the machine's 11 year career (p24).

# Giant step for the ATLAS magnet

*The ATLAS experiment's prototype B-0 toroid coil arrives at CERN from the CEA laboratory in Saclay on 6 October.*

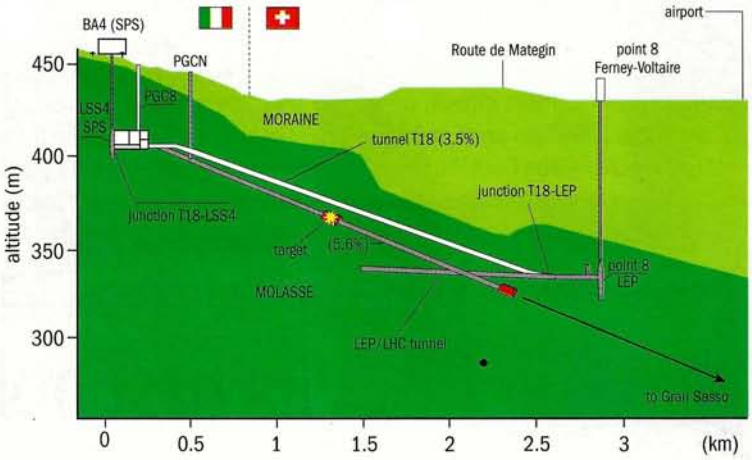
The title of "largest superconducting toroid magnet in the world" has traditionally been bestowed on the magnets of nuclear fusion reactors. However, that all changed in September when engineers from France's CEA-Saclay and Italy's INFN-LASA put the finishing touches to the ATLAS experiment's barrel module zero (B-0) toroid coil at CEA laboratories near Paris.

The ATLAS collaboration, which is preparing to do physics at CERN's Large Hadron Collider, is building a particle detector like none before. Instead of constructing a compact detector based around a solenoid magnet, ATLAS has opted to use a large air-cored toroidal system enclosing a small central solenoid. Not surprisingly, the collaboration's B-0 toroid coil is a prototype like no other. At 9 m in length it is already by far the largest toroid coil ever built, but it will be dwarfed by the eight 25 m coils forming the toroid of the final magnet system. Its purpose has been to test each stage of the manufacturing process, with the results from each step being fed directly into the manufacture of the larger modules – already well under way. The rationale is that to go from the 5 m dimensions of existing toroids to 25 m in a single step would be too much of a leap into the unknown. CERN therefore entered into partnership with CEA-Saclay and INFN-LASA to produce a coil of intermediate size. Supported by the ATLAS collaboration, CEA and INFN have worked together to finance and build the device, which was delivered to CERN in October for testing to begin early next year.

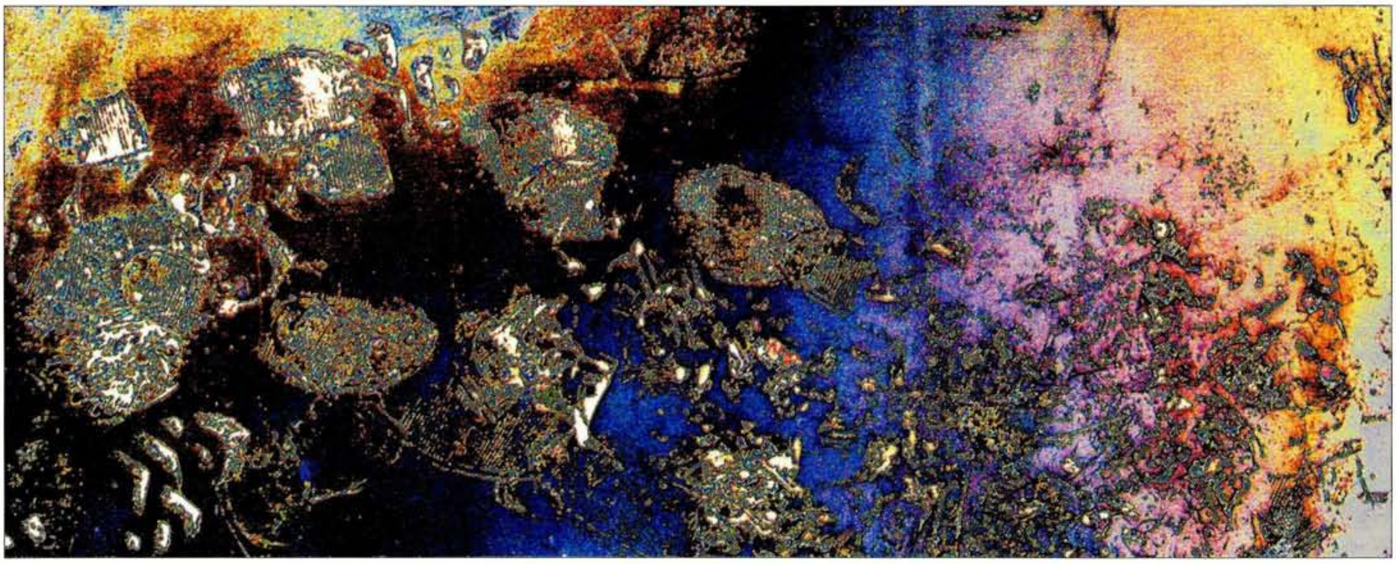
Although an important milestone for ATLAS in their own right, the tests represent just a small part of the B-0 coil's importance to the ATLAS magnet project. Fabrication of its superconductor was complete by 1998, and with lessons learned from that, production of the superconductor for the full-scale toroids began the same year. Similarly, coil winding for the B-0 coil immediately fed into the winding of the full-scale coils, B-0 cryostat manufacture fed into the full-scale cryostats, and the recently learned lessons of integrating the 9 m coils into their cryostat will soon be helping the companies making the full-scale toroid coils with their integration.

All along, progress on the full-scale coils has proceeded in lock-step with that of their smaller relative, to the extent that when CEA and INFN were preparing to integrate their coil and cryostat in July, the Italian firm Ansaldo was putting the finishing touches to the first of its full-scale coil windings. ATLAS's first 25 m toroid coil is due to arrive at CERN by the end of 2001 for testing at a recently-completed test facility. By that time the B-0 will have fulfilled its final role as commissioning coil of the new test set-up.

# Long haul journey gets 'under' way


*Left: CERN director-general Luciano Maiani at the controls of the excavator for the groundbreaking of the CERN Neutrinos to Gran Sasso project. Right: plan of the underground neutrino production area. Tunnel T18 takes particles from the SPS synchrotron to the LHC.*



*Physics footwork – boot prints made during the groundbreaking of the project given an artistic treatment by the CERN photographers.*

On 20 October, CERN director-general Luciano Maiani bravely took over the controls of an excavator for the groundbreaking of the CERN Neutrinos to Gran Sasso project.

In this scheme, approved by the CERN Council in December 1999 (January p5), a beam of high-energy neutrinos will be sent from CERN to detectors at the Italian Gran Sasso laboratory 730 km away.

To provide the neutrinos, high-energy protons will be tapped from the SPS synchrotron via a new extraction line. Mesons produced when these protons strike a target will be focused by a magnetic horn and reflector system into a well-defined beam pointing towards Gran Sasso.

The focused mesons will decay in an underground tunnel over a flight path of about 1 km, producing a neutrino beam. A beam stop will remove most of the residual particles. As highly penetrating particles, neutrinos need no tunnel, and will coast at the speed of light under Geneva Airport, the bedrock of the Alps and the spine of Italy. Arriving at their destination, even then most of them will pass through the waiting detectors and continue on their way – 1 tonne of dense matter can stop only a few in every billion billion neutrinos.

The aim of the project is to study the behaviour of high-energy neutrinos over a long distance. Most of the neutrinos created at CERN are of the muon variety, releasing muons if they interact with matter. In order to explain the behaviour of neutrinos arriving from the Sun and from cosmic-ray interactions in the upper atmosphere, physicists suspect that muon-type neutrinos tend to change their ticket during a long haul flight, sometimes instead producing tau particles.

The plan is that the OPERA detector, to be built at Gran Sasso, will look for these transformed neutrinos as soon as the first neutrinos are delivered, with the ICARUS detector (November p8) subsequently providing additional capabilities.

# SLAC B factory exceeds design luminosity

The PEP-II B factory at the Stanford Linear Accelerator Center (SLAC) completed its first experimental run at the end of October after achieving record collision rates and producing more than 23 million pairs of B mesons. Funded by $177 million from the US Department of Energy, this innovative electron-positron collider has exceeded most of its challenging design goals.

PEP-II was originally designed to attain a peak luminosity of $3.0 \times 10^{33}/cm^2/s$. Its designers expected the collider to take about two years to reach such a high luminosity, well beyond that of any other machine before, especially given the added complexity of its unequal beam energies. However, the team of physicists commissioning the machine, led by John Seeman of SLAC, passed this mark on Sunday 29 October – hardly 17 months after the first collisions had been recorded in May 1999. PEP-II now holds the world's record for peak luminosity, at $3.1 \times 10^{33}/cm^2/s$.

In machine physics runs during the last three days of October, PEP-II also hit a new record for positron current, reaching the design value of 2.14 A in 1660 circulating bunches. Things look good for the upcoming 2001 run, which will begin in February and have a luminosity goal of $5 \times 10^{33}/cm^2/s$.

# RHIC handles its first polarized protons

Soon after commissioning with high-energy beams of heavy nuclei (October p5), Brookhaven's Relativistic Heavy Ion Collider (RHIC) tested the second string to its bow when it underwent its first two-week test of transferring, storing, measuring and accelerating polarized (spin-oriented) protons. The run culminated in the acceleration of polarized protons to 32 GeV.

Spin is an intrinsic angular momentum of elementary particles and nuclei. To collect and then accelerate protons where most of the spins are in the same direction requires a special source. Special equipment is also required to keep the protons spinning in the same direction as they are accelerated.

A new polarized proton source was installed for the RHIC experiments, a new device was installed to measure the proton degree of polarization, and a special string of magnets was installed to maintain the polarization through acceleration.

The type of magnet string to control polarization was invented at Novosibirsk, Russia, and therefore dubbed a "Siberian Snake" in the trade. In the Brookhaven test, polarized protons from the new source were accelerated in the Alternating Gradient Synchrotron before being transferred to RHIC.

*Brookhaven technician Chris Cleary puts together the "Siberian Snake" magnet string used to control spin-oriented (polarized) protons at the RHIC collider.*

The new polarimeter measured stable polarization in RHIC at injection and after acceleration. When the Siberian Snake was turned off, no polarization was seen after acceleration.

The ultimate goal is to collide spin-polarized proton beams together next year to yield insight into the spin structure inside the proton. RHIC is the first machine in the world capable of colliding such beams.

In 1995, the Japanese Institute of Physical and Chemical Research, RIKEN, first agreed to provide funding to equip RHIC for work with high-energy spin-polarized protons. This led to the establishment of the RIKEN Research Centre at Brookhaven, a major partner in this work, along with groups from Brookhaven and across the world, including RIKEN and KEK in Japan, ITEP Moscow, Argonne, the Universities of New Mexico and Indiana, and members of the STAR and PHENIX experimental collaborations at RHIC. RIKEN also provided funds for the Siberian Snake and polarimeter.

# Korean physics centre is inaugurated

On 15 September, the Centre for High-Energy Physics (CHEP) in Korea was formally inaugurated at Kyungpook National University, Taegu. Last June the CHEP, in which most Korean high-energy physicists participate, was finally approved as one of the designated Excellent Research Centers supported by the Korean Ministry of Science and Technology through its Korea Science and Engineering Foundation. It was a significant occasion, since Korean high-energy physicists have waited a long time for such a centre to focus and coordinate their research.

To mark the ceremony, Samuel C C Ting, 1976 Nobel Laureate in Physics, delivered a special lecture on "Research directions of high-energy physics in the 21st century". The ceremony also included congratulatory addresses from Han Jung-Kil, vice-minister of Science and Technology, and Rhee Shang-Hi, chairperson of the Science, Technology, Information and Telecommunication Committee of the National Assembly. Representatives of the CMS (CERN) and CDF (Fermilab) collaborations also attended the ceremony.

The CHEP, under director Dongchul Son, consists of 22 faculties, 28 physicists and about 120 graduate students from 12 institutions in Korea, and will be supported at least for the next nine years. The centre will initially focus activities on several experiments, including AMS, CMS, CDF and BELLE, in which the Koreans are currently participating. In coming years it will concentrate on fewer experiments while exploiting domestic ones, and aims to play a more visible role in the world high-energy physics community.


*Inaugurating a new centre for Korean physics – right to left: S C C Ting, MIT, 1976 Physics Nobel Laureate, spokesperson of the AMS collaboration; Dongchul Son, Kyungpook National University (KNU), director of the Centre for High-Energy Physics; Chan Suk Park, president of KNU; Jung-Kil Han, vice-minister of Science and Technology of Korea; Tong Soo Park, KNU; Seog-Ki Min, president of the Korean Physical Society; Shang-Hi Rhee, chairperson of the Science, Technology, Information and Telecommunication Committee of the National Assembly of Korea; and D Blechschmidt, CERN, resources manager of the CMS collaboration.*

# Diamonds are forever...

*Diamond targets for photon polarization experiments at CERN.*

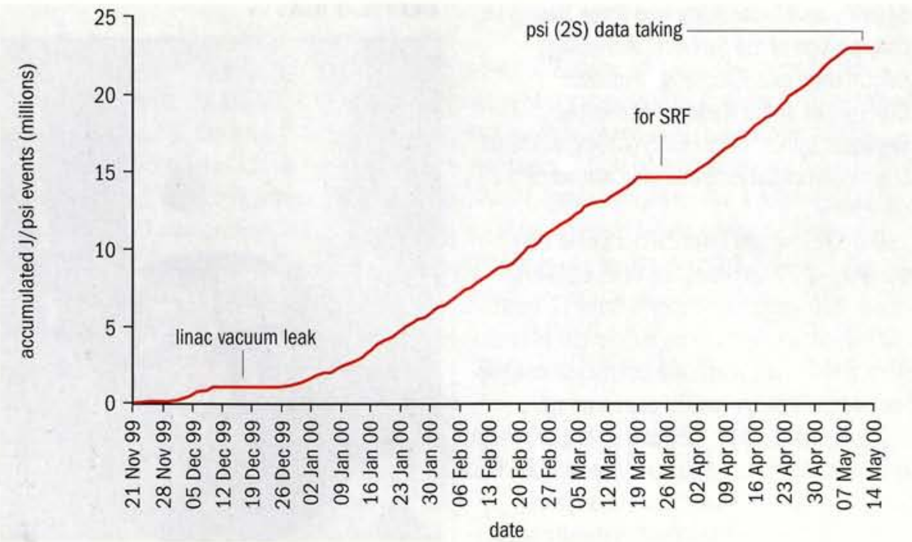
At a graduation ceremony at Witwatersrand University, Johannesburg, South Africa, technician Mik Rebak was awarded an honorary MSc for his ingenious work in engineering diamond targets in nuclear and atomic physics. These targets have been used in research at (among others) Witwatersrand, CERN, the Paul Scherrer Institute (Switzerland), the European Synchrotron Radiation Facility (Grenoble), the Rutherford Appleton Laboratory (UK), TRIUMF (Canada), Darmstadt Technical University, the Max Planck Institutes of Nuclear Physics at Heidelberg and Solid State Physics at Stuttgart, Aarhus (Denmark), the US Naval Laboratory in Washington, and Vanderbilt University, Tennessee.

The diamonds are both natural and synthetic, supplied by De Beers Industrial Diamonds. At CERN, the diamond targets were used in experiments using electron beams with energies of up to 250 GeV to investigate strong field and coherent effects in quantum electrodynamics, and are being used as a quarter-wave plate to produce high-energy circularly polarized photons.

At the same ceremony, Achim Richter of Darmstadt Technical University and former chairman of CERN's ISOLDE Experiments Committee was awarded an honorary doctorate (p41).

For more information, see "http://www.src.wits.ac.za/users/mr_portfolio/index.html".

# Charmed particles in Beijing




*Accumulation of J/psi events with the BESII spectrometer at the BEPC electron–positron collider in Beijing.*

The world's largest data sample of J/psi particles produced directly from electron–positron annihilation has been accumulated with the BESII spectrometer at the BEPC collider in Beijing. The discovery of this particle in 1974 heralded a revolution in particle physics. In the remarkable progress made since then, the J/psi, composed of a charmed quark bound to a charmed antiquark, continues to provide a useful benchmark.

The BES collaboration successfully completed a scan of R (the ratio of hadron to muon pair production) over 85 scan points in the important collision energy region of 2–5 GeV in 1999 (September 1999 p8). Precision R values in this energy region are crucial for the accurate determination of the quark–gluon coupling constant alpha at the Z mass and the interpretation of the muon (g–2) measurement at Brookhaven, which are essential for precision tests of the Standard Model and for narrowing the mass window for Higgs particle searches.

After finishing the R scan, the collaboration turned its attention to other charmonium (charmed quark–antiquark bound states) physics with the goal of accumulating $5 \times 10^7$ J/psi events, about six times higher than the world's existing largest J/psi sample.

The detector was turned on in mid-November 1999. Data-taking started in December 1999 and ended in mid-May with about $2.2 \times 10^7$ J/psi events accumulated as planned.

In addition, special data runs were taken at 3.0 GeV and at the J/psi resonance peak for the study of quantum electrodynamics background and the trigger efficiency. Data runs were also taken at the peak of the psi(2S) resonance to help in the determination of the total number of J/psi events.

The J/psi run shows that with BESII and the upgraded BEPC, both the hadronic rate and the integrated luminosity accumulated per day have been increased by a factor of two to three compared with BESI. Also, the upgraded barrel time-of-flight system with a time resolution of about 180 ps significantly improves particle identification.

All the accumulated data has been reconstructed. Preliminary physics analysis shows that the data quality is excellent and that the detection efficiency is higher than the J/psi data collected with the BESI detector.

BES continued accumulating J/psi events in the autumn and hopes to reach the total of about $5 \times 10^7$ events before next summer.

With this world's largest J/psi event sample, the BES collaboration can systematically study light hadron spectroscopy; excited baryonic states such as $N^*$, $\Lambda^*$ and $\Sigma^*$; search for glueballs, chiral partners and exotic states; and probe lepton flavour violation and CP violation using J/psi decays. The collaboration is very excited about the physics that can be done with this unique huge sample.

*Zhengguo Zhao and Frederick A Harris.*

# Physics as you lake it

*Physicists suitably clad for August enjoy a cruise on Lake Windermere in the English Lake District during the Photon 2000 meeting.*

At the end of August nearly 100 physicists met in Ambleside in England's beautiful Lake District for the Photon 2000 conference organized by Lancaster University. Held roughly every two years, this conference concentrates on theoretical and experimental advances in the understanding of the high-energy behaviour of the photon, particularly the way it interacts with quarks – the production of matter from light.

In the first talk, Maria Krawzyck pointed out that this year is the 100th anniversary of Planck's quantization of electromagnetic phenomena, which led to the concept of the photon.

The large volume of data coming from CERN's LEP electron–positron collider in the last few years provides a unique tool to study the collisions of high-energy photons, and all four LEP experiments presented exciting new results in this field.

These results are complemented by the study of photons in their collisions with protons in data coming from the two experiments at the HERA electron–proton collider at DESY, and the very high volumes of data from the CLEO detector at Cornell's CESR electron–positron ring which provide precise measurements at lower energies.

At the end of the conference delegates looked forward to their "dream machine", a dedicated high-energy photon collider, which is one option available for the new generation of linear electron–positron colliders now being planned.

Copies of the Photon 2000 talks can be viewed at "http://photon2000.lancs.ac.uk/photon2000/timetable.html".

# CAPP off at music and physics festival

*Participants at this year's CAPP 2000 meeting in Verbier, Valais, Switzerland, visit the Pierre Gianadda Foundation in Martigny.*

In July 1994 Swedish musical personality Martin Engstrom launched the Verbier Festival and Academy in Valais, Switzerland, which has gone on to become a regular feature of the late-July arts calendar. This festival has attracted prominent figures from the musical and theatrical world, such as Zubin Mehta, Isaac Stern and Isabelle Huppert. It is now a valuable step on the ladder for aspiring young artists.

CERN physicist André Martin and his wife Schu knew Aspen, in the Rocky Mountains, where there is a very successful annual summer symbiosis of music, mountains and physics, with the famous Music Festival on one hand and the Aspen Center for Physics on the other. It was tempting to propose scientific activities in conjunction with the Verbier Music Festival.

In the summer of 2000 this was realized for the first time through a conference entitled CAPP (Cosmology and Astroparticle Physics) 2000, organized by Ruth Durrer, Juan Garcia-Bellido, André Martin and Misha Shaposhnikov. About 100 participants came from as far afield as Australia and Korea, to Verbier's "Centre Culturel du Hameau".

Prestigious lecturers also came from all over the world. The programme covered both theoretical and experimental physics. One focus was the extremely accurate measurements of the structure of cosmic microwave background radiation by the balloon experiments Boomerang and Maxima at the South and North poles, respectively. This, combined with new measurements of the Hubble galactic recession parameter, leads to a picture of the universe which is asymptotically flat ($\Omega = 1$), with an accelerating expansion, a non-vanishing cosmological constant and an age of between 14 and 18 billion years, fitting most inflationary models.

$\Omega = 1$ is the result of $\Omega = 0.3$ for matter and 0.7 for the vacuum. The former retains a need for invisible "dark matter", also needed to explain the observed rotation of galaxies. Although definite cases of gravitational lensing have been seen (May p13), their interpretation does not seem to fit with the Massive Astronomical Compact Halo Object (MACHO) picture.

On the other hand the Weakly Interacting Massive Particle (WIMP) interpretation of dark matter is still possible, which would also be an indication in favour of supersymmetry.

Among the projects for the future, more refined detectors of the cosmic microwave background such as the Planck mission and the Virgo project for detecting gravitational waves were described. Tremendous progress has been made in recent years thanks to the new instruments, and this looks set to continue. In particular the continued detailed analysis of fluctuations in the cosmic microwave background radiation will lead to a further confirmation of the inflationary models.

Returning to the music festival, a public lecture "L'Univers, passé, présent et futur" given in "Café Schubert" (where musicians attending the festival are habitually interviewed), was well received by an audience including Swiss Federal Councillor Pascal Couchepin.

# CONFERENCE on INSTRUMENTATION 2001

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H. Kagan (Ohio - State, USA)
T. Kondo (KEK - Ibaraki-ken, J)
A. Menzione (INFN - Pisa, I)
H.H. Wieman (LBNL - Berkeley, USA)

## Invited Speakers

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R. Bellazini (INFN - Pisa, I)
H. Dijkstra (CERN - Geneva, CH)
D. Manlow (Princeton Univ., USA)
N. Pavel (Univ. Siegen, D)
M.Price (CERN - Geneva, CH)
H. Pernegger (MIT - Cambridge, USA)
W. Smith (Univ. of Wisconsin, USA)
A. H. Walenta (Univ. Siegen, D)

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**Institute for High Energy Physics of the Austrian Academy of Sciences**

**Topics:** **February 19 - 23, 2001**

Instrumentation in High Energy and Nuclear Physics, Synchrotron Radiation and Neutron Experiments, Astrophysics, Biology, Medicine; associated Electronics

**Satellite Workshop on Applications,** February 24, 2001 (W. Bartl, B. Sitar)

Registration deadline: January 8, 2001

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Edited by Alison Wright

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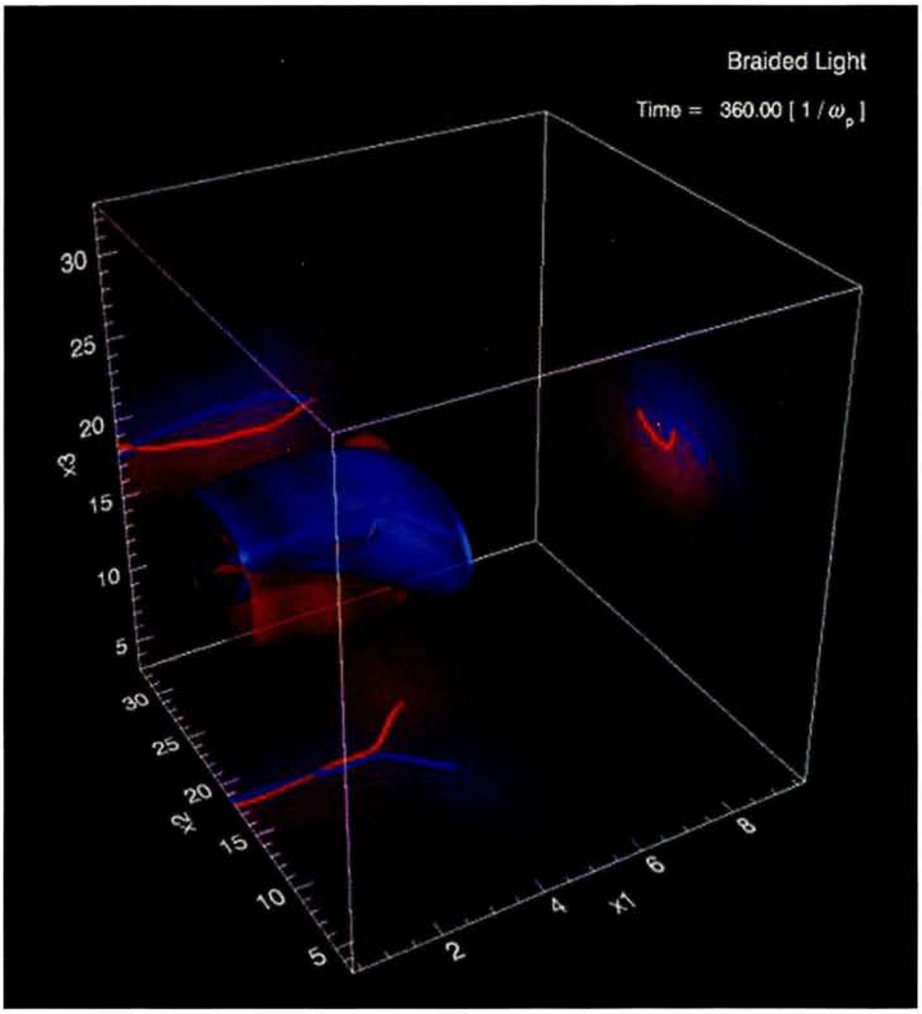
# Lasers create braids




*A simulation showing how in a special plasma environment two beams can braid around each other. The blue and red lines show the calculated centroids for two laser beams. The lines on the box walls are projections of the centroids for the three dimensions.*

Intense laser beams travelling in a plasma twist around each other to form a braid of light, say UCLA physicists. Although Maxwell's equations state that light beams in a vacuum do not interact, in a nonlinear medium such as a plasma there is a self-interaction, principally generated by relativistic mass corrections.

Starting from the Schrodinger equation, with added nonlinearity, the physicists calculated that the beam centroids of two gaussian laser pulses would move like point particles with a mass proportional to the power of each pulse. The force between the pulses is always attractive and depends on the beam spot sizes; as the beam separation increases, the spiralling period increases exponentially.

The braiding effect happens because the beam tails rotate faster than the heads. This is partly due to the smaller beam spot size in the tail, but the researchers also noticed a significant contribution from Raman scattering, as the tails get caught in the wake of plasma waves. Experimental studies are now underway in California and Portugal, with the prospect of future application in optical steering. The braiding effect might also occur when streams of photons emanate from supernovas and gamma-ray bursters. *AIP*

# Electro-optical effect detects particles

Brookhaven physicists have demonstrated that charged particle beams can be detected by the electro-optical effect induced in optical crystals.

This ultrafast mode of particle detection is based on birefringence produced in an optical medium by an electrical field: the anisotropy of refractive index in the medium means that for orthogonal components of polarization, the velocity of propagation is different – a phase difference will develop, such that light that was originally linearly polarized will now appear elliptically polarized.

Using a photodiode, the researchers traced the modulation of transmitted laser light in an $LiNbO_3$ crystal and measured the induced ellipticity as a 1 mm diameter 45 MeV electron beam, carrying up to 1 nC in 10 ps bursts, passed within a few millimetres of the crystal. The ellipticity can then be directly related to the electric field of the charged particle beam.

The team suggest these results will lead to the construction of beam profile detectors with excellent time resolution based on parallel rows of $LiNbO_3$ crystals, and that even single particle detection could be achieved with this technology. *Nucl. Inst. Meth. A*

## Want to write for the Courier?

**With Alison Wright moving on to higher things, *CERN Courier* is looking for someone to edit its popular Physicswatch news feature. Physicswatch monitors current developments outside the particle and nuclear physics, astrophysics and astronomy sectors covered in the rest of the magazine, particularly in areas of potential interest to specialists in accelerators and detectors.**

**The post is unpaid, but is a good opportunity for a trained physicist to exploit their interest in science communication and journalism. The Physicswatch Editor would work in close collaboration with the Editor of *CERN Courier*.**

**For more information, see past issues ("http://www.cerncourier.com") or contact the Editor at "gordon.fraser@cern.ch".**

# Crystal defects aid optical communications

Scientists in Japan have demonstrated a new device that could lead to the development of all-optical circuits. This verifies predictions that photons can be manipulated inside photonic crystals (May p9) by introducing particular defects in the photon bandgap structure.

In a photonic crystal, the dielectric constant of the material varies periodically, so certain frequencies of electromagnetic radiation cannot propagate. Making a strip of defects in the crystal forms a path for "forbidden-frequency" waves, and the crystal becomes a waveguide.

On a thin slab of just such a waveguide (a 0.25 μm InGaAsP layer on an InP substrate), the researchers introduced another crystal defect close to the forbidden-frequency path. Usually photons cannot escape the two-dimensional waveguide because the refractive index of the air above and below the plane is very different to the refractive index of the material. However, the extra defect acts as a coupler from the in-plane to the vertical direction – photons propagating through the waveguide are trapped by the defect, which then efficiently emits them into free space. The defect acts as an optical resonator, with a resonant frequency determined by the size of the defect and the lattice constant of the photonic crystal.

The researchers expect that, thanks to its small size and flexibility, their new device will have an enormous impact on global communications networks.

# Short-pulse lasers lead to tabletop positrons

Experiments at the Max Planck Institute for Quantum Optics at Garching, near Munich, have shown how positrons can be generated by high-power, short-pulse laser beams.

The femtosecond time intervals obtainable with modern lasers can probe the "evolution" of very fast processes. Ahmed H Zewail of Caltech was awarded the 1999 Nobel Prize for Chemistry for showing how such techniques can be used to study how atoms take part in chemical reactions.

High-power laser pulses can also rip electrons from atoms, and the giant Petawatt laser at Livermore has shown how these electrons can create gamma rays which in turn can make electron–positron pairs when they hit a 2 mm lead converter. The energy of the positrons is a few mega-electron volts.

The authors say that the advent of positron production using femtosecond laser pulses could lead the way to tabletop positron sources for applications in material science.

Femtosecond lasers have also been used to drive synchrotron radiation (July p31). *AIP*

Edited by Emma Sanders

# Remotest gamma burst seen

A violent burst of gamma rays detected on 31 January has been pinpointed to a galaxy at a redshift of 4.5, making it the most remote such burst ever observed. Its brightness was enormous – 10 000 times that of the emission from all the stars in the host galaxy.

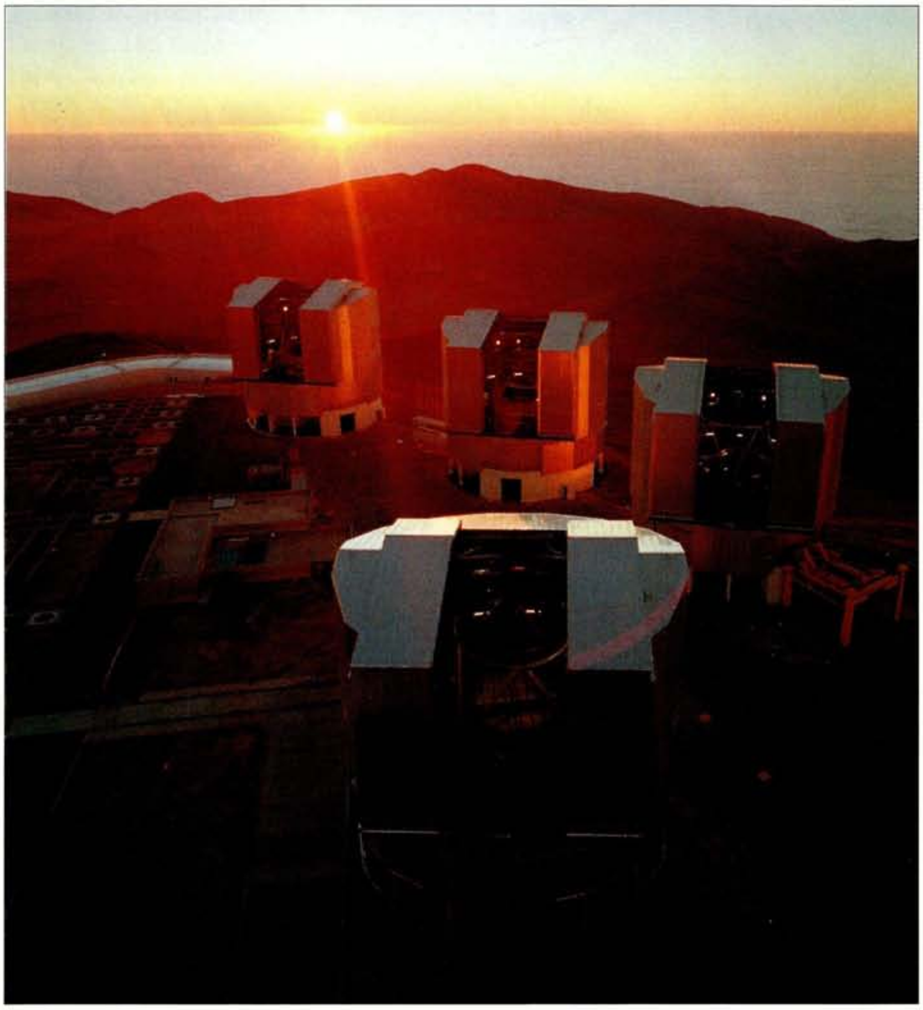
The mechanisms fuelling gamma-ray bursts (GRBs) are still unknown. They are by far the most powerful events known to occur since the Big Bang itself. Candidates include explosions called hypernovae, or the mergers of two black holes.

The optical counterpart to the January GRB was identified using the Antu telescope at the European Southern Observatories site in Chile and its distance deduced from spectroscopic observations. Attention is now focusing on the properties of the host galaxy.

Meanwhile, a new telescope has entered the picture. The Hete-2 satellite, launched by NASA last October is expected to detect hundreds of GRBs a year during its four year lifetime. The experiment is a collaboration between the US, France and Japan.

# Final VLT telescope observes first light

This autumn saw a double milestone for the European Southern Observatories' Very Large Telescope (VLT) interferometer at the Paranal observatory, Chile. The fourth and final 8.2 m telescope of the VLT array saw first light and the 168 m long interferometric tunnel was inaugurated following the installation of the first delay line. The remaining two lines will be installed by February, and the full interferometer should see first light soon afterwards.



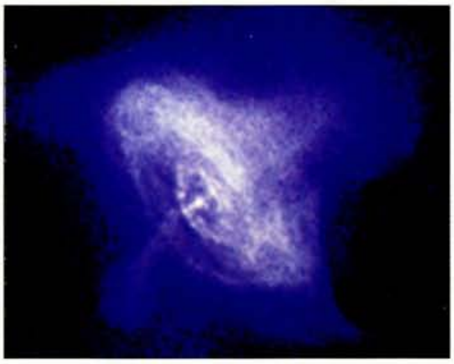
*The Paranal observatory in Chile – 2635 m above sea level. (ESO.)*

# Chandra shows Crab pulsar rings

The Crab supernova remnant is the remains of a star seen to explode in 1054 AD. In the explosion, the outer layers of the star were blasted off, leaving a dense rotating neutron star, or pulsar, in the centre. Emission from the neutron star energizes the supernova remnant of gas, which still glows brightly almost 1000 years later.

Observations using the Chandra X-ray satellite show for the first time tilted rings or waves of high-energy particles that appear to have been flung outward over a light year from the neutron star, and high-energy jets of particles blasting off perpendicular to the spiral.

The images will be used to understand how the neutron star transmits energy to the surrounding interstellar medium.



*Emission ring around the Crab pulsar. (NASA.)*

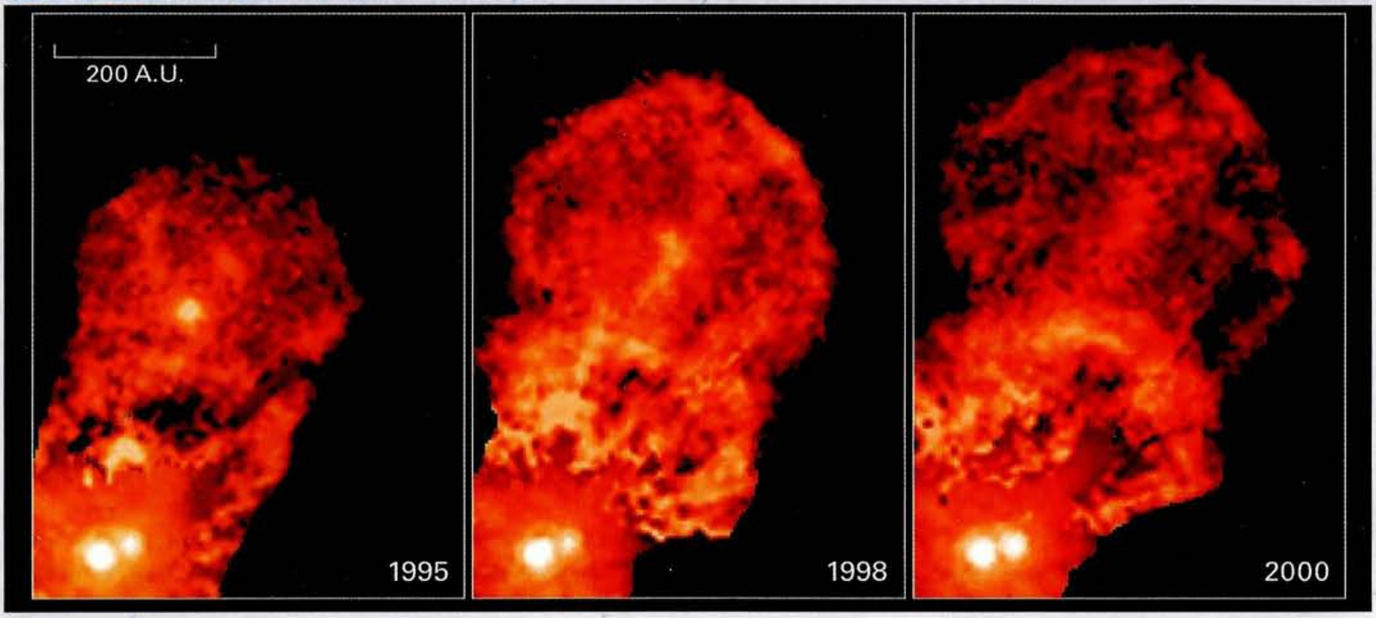
# Sugar in space

The prospects for life in the universe have just got sweeter with the first discovery of a simple sugar molecule in space. Glycolaldehyde can combine with other molecules to form the more complex sugars ribose and glucose. Ribose is a building block of nucleic acids such as RNA and DNA.

The molecule was found in a giant cloud of gas and dust near the centre of the Milky Way where new stars are forming. Radio waves are emitted when molecules change from one rotational energy state to another. The precise frequencies emitted by a particular molecule form a unique "fingerprint".

The discovery was made using the US National Science Foundation's radio telescope on Kitt Peak, Arizona. In August, the foundation inaugurated a new 100 m radio telescope at its Green Bank site in West Virginia.

## Picture of the month



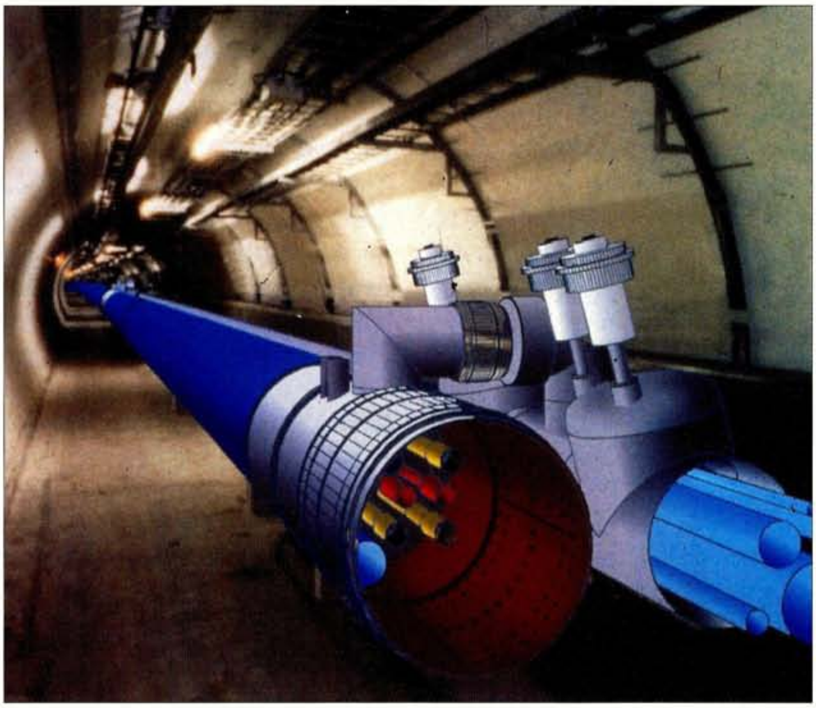

A bubble of hot gas extends nearly 96 billion km from the binary stars XZ Tauri at temperature of over 9700 degrees. These three images, taken using the Hubble Space Telescope, show the bubble is expanding at around 540 000 km per hour. The gas in the bubble comes from sporadic outbursts from one of the young central stars which are 450 light years from Earth in the Taurus-Auriga molecular cloud, one of the nearest stellar nurseries to our planet. (NASA/ESA.)

# Supersymmetry physics on (and off) the brane

**The search for supersymmetry, or other physics beyond the Standard Model (SM) is becoming ever more tantalizing. The idea that the SM is theoretically incomplete is an old one. There is now a whole range of innovative and experimentally striking suggestions for this new physics that underlies the SM. A recent conference at CERN, Supersymmetry 2000, surveyed the scene.**

For all its spectacular experimental successes, the Standard Model (SM) fails to give us solutions to such basic problems as why there are three copies (generations) of quarks and leptons, why there are three different gauge forces (the strong, weak and electromagnetic, with differing strengths), and how gravity should be included in a consistent quantum theory along with the gauge forces.

Supersymmetry (SUSY) is the leading contender for physics beyond the SM. Although SUSY has been around for some time and has so far had no direct experimental support, indirect experimental hints and progress in understanding the theoretical possibilities allowed for in a SUSY world have led to a new feeling of excitement. With these new ideas on the market, the Supersymmetry 2000 (SUSY2K) conference, held recently at CERN, attracted a large crowd and showed how the new SUSY ideas can help.



*CERN's future LHC collider is expected to produce Higgs bosons galore, and (if they are there) supersymmetric particles as well. It will also be able to probe the existence of extra dimensions at shorter scales than any previous experiments.*

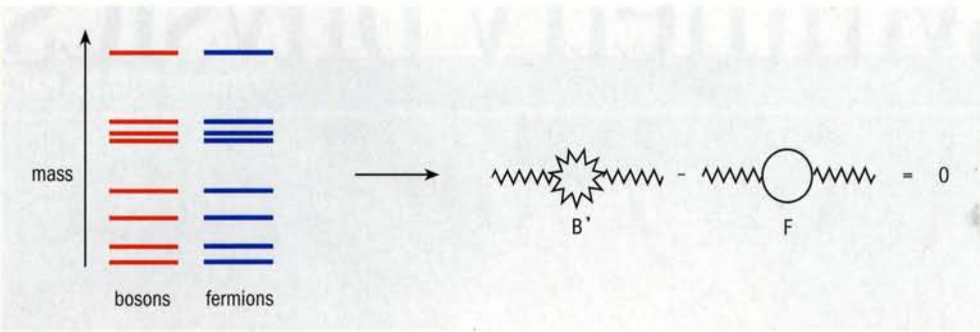
SUSY makes precise predictions for the quantum numbers and selection rules for many new particles. What is much more difficult is predicting the masses of these additional supersymmetric particles. The reason for this is that SUSY must be a so-called "broken" or hidden symmetry, and the mechanism of communication of SUSY breaking to the SM and its superpartners is inevitably indirect, not well constrained, and is poorly understood.

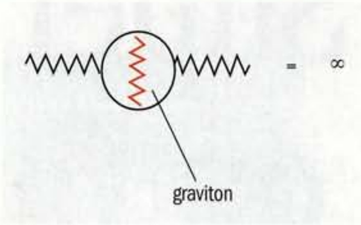
As a comparison, the unification of weak and electromagnetic gauge forces in the electroweak sector is also "broken" or hidden – with the Higgs mechanism leading to very different masses for the electromagnetic photon and the W and Z carriers of the weak force.

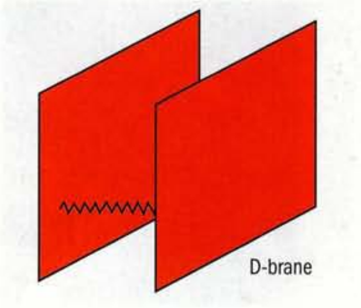
For SUSY, such a direct coupling to the sector that breaks SUSY (analogous to the direct coupling of the electroweak force to the Higgs) is not possible, because such a coupling leads to sum rules for the masses of the unobserved superpartners (see box) that are definitively excluded. Thus an indirect communication of SUSY breaking must be employed.

### Mass communication

Many attractive new communication mechanisms for SUSY breaking were reviewed at the SUSY2K conference. In "archetypal" SUSY breaking, gravity takes on the role of communicating between the SUSY breaking sector and the conventional world, and, until ▷




*Above: in supersymmetric field theories, the spectrum of matter particles (fermions) matches that of the force particles (bosons). Since the two respective contributions to quantum self-energy effects have opposite sign, they cancel out, so that the resultant theory is better behaved. Right (top): the graviton is the quantum force carrier of gravity. In conventional quantum field theory, graviton processes with loops do not make sense because of incurable divergencies. Right (bottom): "brane new world" – gauge forces and matter confined to live on coincident branes arise from open strings with endpoints on the branes.*

recently, this gravity-mediated SUSY breaking was considered as the most plausible possibility.

However, during the last few years many innovative new mechanisms have been proposed – "gauge mediation" (with heavy messenger particles communicating the breaking), "anomaly mediation" (via symmetries that are broken at the quantum but not at the classical level), and "gaugino mediation" (when the SUSY partners of the SM gauge bosons take on the mediating role).

These different mechanisms have characteristic mass spectra and experimental signatures. Supersymmetry might not manifest itself as neutrino-like invisible events detectable only through "missing" energy, but in several other ways, for example in events producing additional photons or stable charged particles, or models with supersymmetric particles that are nearly degenerate in mass. Experiments at LEP and elsewhere have been looking for these various possibilities, but without any luck so far (see box).

### Problem solving

One of the theoretical motivations for these new models is the "flavour problem", namely that of understanding the relations between the different generations of particles. Experiments observe many approximate flavour symmetries in today's non-SUSY SM; however, these symmetries are usually violated in typical gravity-mediated SUSY breaking schemes.

Another motivation for some of the new communication ideas (anomaly and gaugino mediation) has been provided by new ideas for physics beyond the SM, such as extra dimensions beyond those accessible to us (March p7) and multidimensional "branes" (April 1999 p13).

Many new ideas have also been stimulated by the exact non-perturbative results that have allowed theorists to construct explicit models of SUSY breaking, and motivated attempts to merge SUSY breaking with the visible particles. One approach involves composite (sub-quark) models, where some of the SM states are composites of a strongly interacting sector.

### Extra dimensions – are we the scum of the universe?

A natural focus of the workshop was extradimensional models, in which the world we experience is complemented by extra (but to us invisible) spatial dimensions. These models have the common feature that our SM world is realized as localized degrees of freedom living on a generalized 3-spatial-dimensional membrane ("3-brane") embedded in a universe possessing a larger number of dimensions.

In this approach, it is possible that the fundamental scale of

## Particles and sparticles

**Standard Model (SM) particles come off the shelf in two kinds – fermions (matter particles) such as quarks, electrons, muons, etc.) and bosons (force carriers) such as photons, gluons, Ws and Zs. A feature of SUSY is that every matter particle (quark, electron...) has a boson counterpart (squark, selectron...) and every force carrier (photon, gluon) has a fermion counterpart (photino, gluino, chargino, neutralino...).**

**This doubling of the spectrum is due to the fact that SUSY is a quantum-mechanical enhancement of the properties and symmetries of the space–time of our everyday experience – such as translations, rotations and Lorentz boosts.**

**SUSY introduces a new form of dimension – one that is only defined quantum mechanically, and does not possess the classical properties we associate with a new dimension, such as continuous "extent".**

**The doubling of the particle population can fix several of the problems afflicting today's SM, for instance why the different forces – gravity, electromagnetism, weak and strong – appear to operate at such vastly different and apparently arbitrary scales (the "hierarchy problem"). The extra particles provided by SUSY are also natural candidates for exotica such as the missing "dark matter" of the universe.**

> One of the most important issues is that of possible supersymmetry remnants of the Big Bang, which could play the role of the invisible "dark matter" known to pervade our universe.

gravity might be the TeV scale, rather than the embarrassingly distant Planck scale ($10^{19}$ GeV), potentially eliminating the hierarchy problem (see box).

This requires a fundamental rethinking of cosmology and the high-energy behaviour of SM physics. Many questions are being reformulated in terms of the geometry of the extra dimensions – their sizes and shapes, and the fields localized on them. In the same way that general relativity introduced geometry as the natural explanation of gravity, so concepts of geometry and locality replace the ideas of symmetry usually used in field theory.

Superstring theory naturally incorporates such branes and gives, at least in toy models, explicit realizations of the brane-world idea. One major question is the radiative stability of such models – that their predictions are compatible with accompanying virtual quantum effects.

Without SUSY, the apparently haphazard hierarchy of the different forces of nature, with each force having very different associated mass scales, is not stable (or rather requires fine tuning). SUSY can take care of this problem, and new light may be cast by brane physics.

At the moment there are two main approaches to the construction of extra-dimensional models. Originally, it was thought that the geometry of the extra coordinates should be distinct from our space – the universe at large could be viewed as the product of two spaces. In this case, a solution to the hierarchy problem requires large extra dimensions and quantum gravity physics at the TeV scale.

In a more recent approach, highly-curved geometries have been proposed, which tightly constrain the brane in which we live. In this very different geometry, gravity is concentrated away from our world, explaining its observed weakness for us. Both schemes have very specific signatures for experiments at high-energy colliders.

### Seeing SUSY

All current major high-energy collider experiments are desperately seeking SUSY and/or extra dimensions. One of the crucial searches is for a Higgs boson: SUSY suggests that one might well be visible at CERN's LEP electron–positron collider.

Future collider experiments are also gearing up to look for new particles. The Fermilab Tevatron will resume the sparticle and Higgs searches after LEP is retired, and has quite good prospects. In the longer run, the LHC is expected to produce Higgs bosons and any supersymmetric particles. It will also be able to probe for extra dimensions at shorter scales than any previous experiments. There is optimism that the next generation of collider experiments will break out of the SM straitjacket.

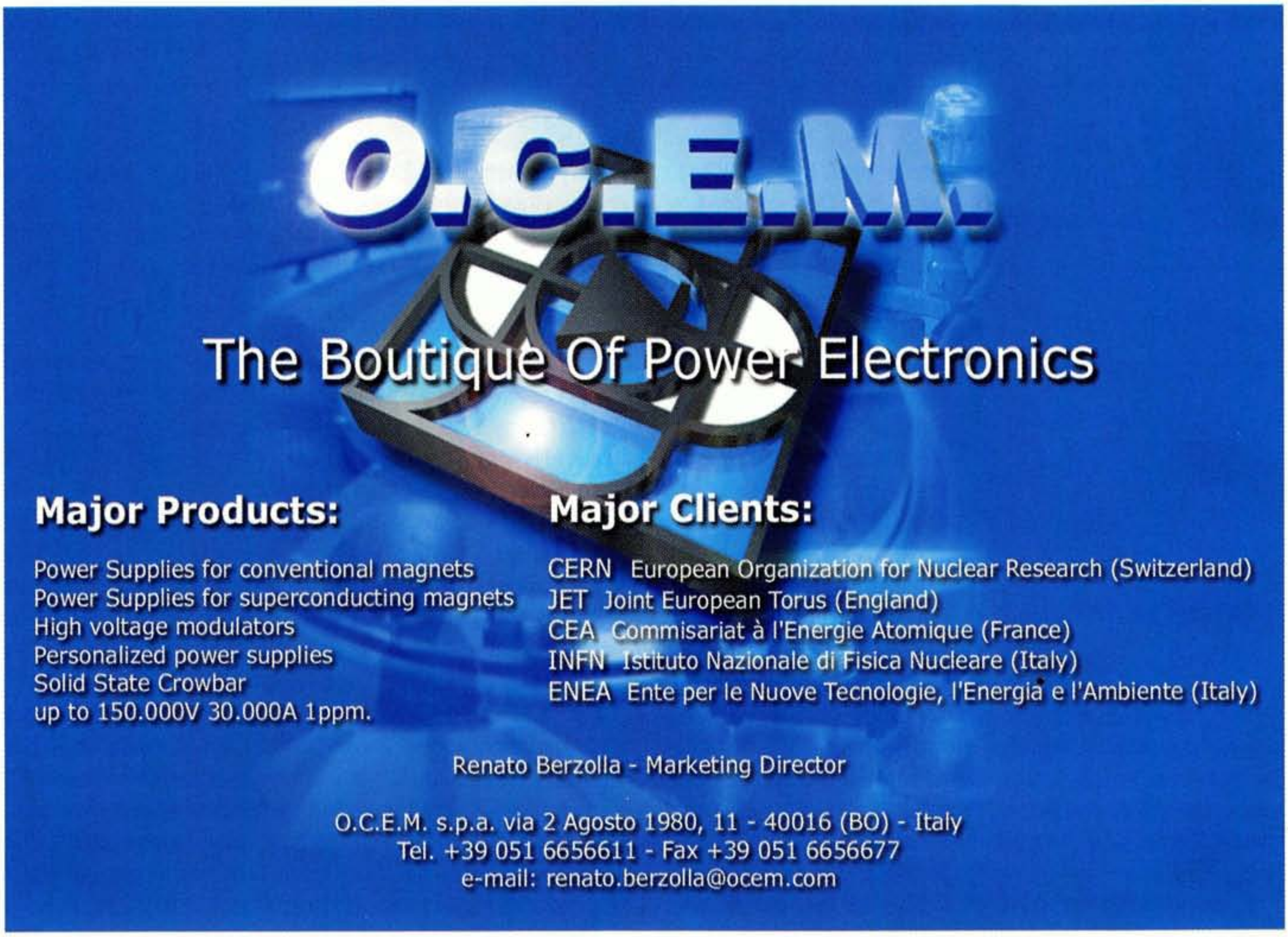
The issue of the cosmological constant – the energy density of free space – has been the most striking problem in quantum field theory for many years. Experimentally, it has long been known that it is very close to zero. According to the latest observations a (very) small non-zero value is now preferred, and this is further supported by cosmic microwave background observations by the BOOMERANG and MAXIMA collaborations.

However, the result of theoretical calculations in quantum field theory is naturally a number at least 60 orders of magnitude bigger. SUSY has long held out the promise of a resolution to this dilemma, but so far has not been able to claim a solution. However, many new ideas of how to approach this problem are also suggested by brane theories and were discussed at SUSY2K.

### Dark matter

If SUSY is correct then it would have played an important role in the Big Bang. For example, SUSY might have played a role in the generation of the observed matter in the universe. However, one of the most important issues is that of possible SUSY remnants of the Big Bang, which could play the role of the invisible "dark matter" known to pervade our universe. One of the most attractive features of SUSY is that it provides quite naturally a candidate, the "neutralino". Experimental searches for such particle dark matter are just beginning to reach the range suggested by theory. However, SUSY must also contend with the strong upper limits on various unwanted supersymmetric particles such as gravitinos.

SUSY2K showed that supersymmetry is assured of an exciting future. □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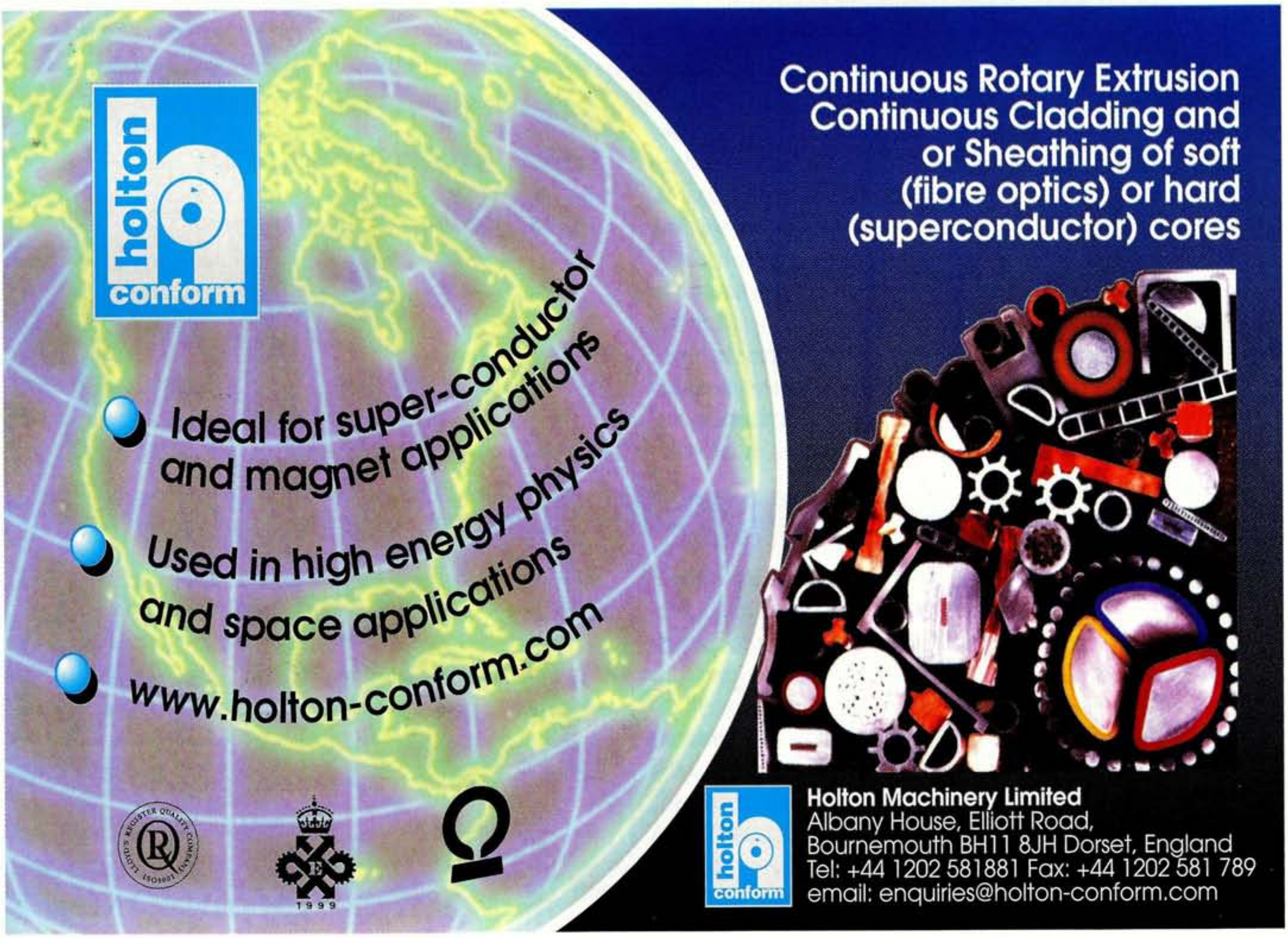
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# Past, present and future

Germany's impressive scientific traditions are a role model for other nations. A recent European committee meeting in Berlin painted a lively and informative picture of the current German scene.

European Committee for Future Accelerators (ECFA) delegates outside the historic Magnus-Haus, situated in the cultural heart of Berlin.

Speaking up for German students – Claus Beier (left) of Heidelberg's Kirchhoff Institute with German ECFA delegate Karlheinz Meier of Heidelberg.

The European Committee for Future Accelerators (ECFA) continued its continual tour of CERN Member States when it met in Berlin in September for an update on the status of particle physics in Germany. (The mission explicitly left out activities directly related to the major DESY laboratory in Hamburg. DESY, a key player on the national and international scene, gets a special treatment – it is visited every second year by ECFA, while each CERN Member State is normally visited only every six years.)

The ECFA meeting took place at the historic Magnus-Haus in the cultural heart of Berlin, across the road from the Pergamon Museum. The building was donated to the Physical Society of the former DDR in 1958 to commemorate the centenary of the birth of Max Planck (1858–1947). It has a distinguished scientific history – among its famous 18th century inhabitants was Joseph Lagrange, one of the founders of analytic mechanics.

## Physics history

Berlin is filled with echoes of physics from the past. It was here, 100 years ago, that the concept of the quantum of action was conceived by Planck, initiating the quantum paradigm, one of the greatest scientific revolutions of the 20th century.

Albert Einstein, the torch bearer of a second revolution, relativity, spent a considerable part of his life in Berlin. He was the first director of the Kaiser Wilhelm Institute there, and it was in Berlin that he presented his theory of general relativity.

## Quantum century

As the 100th anniversary of quantum theory, the year 2000 was declared in Germany to be the "Year of Physics" (see "www.physik-2000.de" for further information). The Federal Ministry of Education and Research initiated and supported more than 200 physics "events" throughout the country.

Hermann Schunck, representing the Ministry, told ECFA that the "Year of Physics" has been a great success. The grand finale takes place in Berlin in December, with a week of symposia and other events around 14 December, the date when Planck presented his work for the first time.

The Ministry believes in the importance of basic science, Schunck stressed. The Ministry is following closely what happens in particle physics in order to be able to plan for the future. Schunck gave a survey of questions in particle physics to be addressed over the next 20 years – questions related to the Higgs particle, properties of neutrinos and CP violation, among others. He concluded that at the present time, a linear collider, to be commissioned about five ▷

## A German PhD student speaks up

During the ECFA meeting in Berlin, Claus Beier, a graduate student in experimental particle physics from Heidelberg, gave a very personal account of his professional life. He felt that his undergraduate studies had given him a "solid training in a wide variety of physical sciences".

His reasons for going into particle physics were: "it's fun or fascinating"; "the atmosphere is international"; "it gives useful experiences in computing or hardware"; and "it gives good job opportunities". "Research is like a roller-coaster ride," he said.

However, other duties such as teaching, travelling and giving talks can be onerous. The solution is usually long working hours for a modest annual income (DM 25 000–35 000).

Working in a big collaboration (400 scientists), Beier had found the biggest problem to be insufficient flow of information, due to such "trivial things" as lack of documentation. The graduate student inherits vital but incomprehensible "computer code". What a waste of time to have to re-do the job!

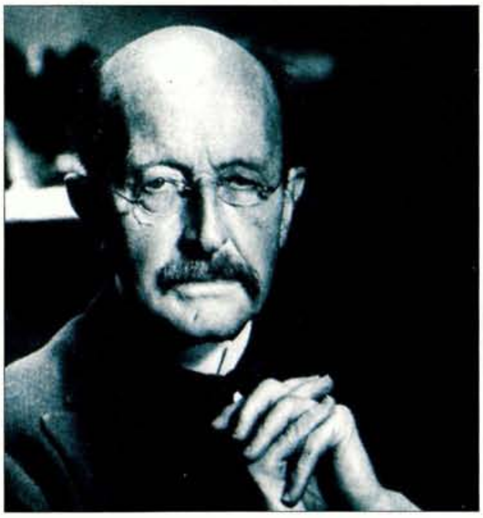
What he valued most was academic freedom, the international atmosphere. and the fact that he is constantly learning something new. Beier concluded that the research in particle physics has given him invaluable experiences for "the life after", as he put it. Permanent jobs in research are scarce, so a life in industry is more appealing "because it offers higher income, more free time and permanent employment", he said.

years after CERN's LHC circular machine, looks to be the most obvious major project for the future.

### German organization

The funding of basic science in Germany is more complicated than in most other European countries, due to the country's decentralized federal structure. These intricacies were described by several speakers, including Schunck, Rolf Heuer of DESY and Konrad Kleinknecht of Mainz.

Germany's16 states (Länder) have considerable autonomy, with each state (Land) having its own local government. In addition, there is of course the Federal Government. Education is the business of the local governments. As in most European countries, in Germany a great deal of basic research is carried out at universities. However, these are governed by local State rules. The researchers at the universities often carry a rather heavy load of other duties such as teaching and administration.



*This year is the centenary of the discovery of quantum theory by Max Planck in Berlin.*


*2000 is "The Year of Physics" in Germany.*

The local funding is in general far from adequate to allow university researchers to take part in research elsewhere. Speaking for the university environment, Kleinknecht noted that for research in particle physics, the federal funding is absolutely necessary.

Science knows no geographic frontiers and a great deal of coordination of research activities at the various universities and research centres is required. In this respect, the role of the Federal Government, especially its Ministry of Education and Research, is vital. The Ministry's annual funding for basic physics is about DM 1.5 billion. This Ministry funds major national research centres and is an indispensable link between Germany and the various international research centres such as CERN. Two of its programmes for funding research by university groups at large research centres are "Structure and Interactions of Fundamental Particles", which has a budget of DM 75 million for a three year period and "Hadron and Nuclear Physics", the budget of which is DM 66 million, again for three years.

Another important organization is the German Science Council (Deutsche Forschungs Gemeinschaft; DFG), a federal research council financed 60% by federal funds and 40% by the Länder. This organization does not directly support projects in particle physics. However, it provides annual funding for particle physics at the level of DM 14 million, supporting PhD students, who for example can work at CERN, and prestigious fellowships.

### German Research Societies

One very special feature of Germany is that it has scientific "Societies" which have a large number of institutes devoted to research in various areas.

The society which is most relevant to particle physics is the prestigious Max Planck Society. This is funded 50% by the Federal Government and 50% by the Länder. It has some 80 institutes and centres devoted to basic research, and employs about 12 000 people. The Society can restructure itself as it sees fit, for example by creating, merging or dismantling its own institutes. This allows for much more flexibility than would be possible at universities.

The Max Planck Institutes in Heidelberg and Munich focus on particle physics. The major duty of a researcher at a Max Planck Institute is indeed research, so there is a considerable disparity between the responsibilities of these researchers and those at the universities.

### Some facts and figures

Physics is taught at about 60 universities. Enrolment was increasing until the late 1980s. At about that time approximately 1500 PhDs in physics were being awarded per year. Since then there has been a dramatic drop in the enrolment rate due to several reasons, one of which has been purely demographic.

Nowadays, job opportunities for physicists are good – perhaps too good. There is a great temptation not to continue for a PhD but to work in industry for a much higher salary. Age is also an issue. Germans go to school for 13 years before entering university. Afterwards, in physics, the student does "diploma" work which usually takes five years. Add to that military service or equivalent community service, and four to five additional years for getting the PhD, and the result is that the average age for obtaining a physics PhD is 29 years.

The number of annual diploma exams has fallen from a maximum of 3500 to 2000, and is set to fall further. Since industry needs about 3500 new diploma or PhD physicists per year, and since PhD exams will stay for a few years at 1400, and then decline, there is a shortage of physicists in the university/research sector.

Currently, research in experimental particle physics is carried out at 16 universities, and for theory, 23. There are about 210 staff and 50 PhD students in experimental particle physics at the universities. The corresponding numbers at the Max Planck Society are 90 and 60, respectively. However, these latter numbers include both theorists and experimentalists as well as those working in astroparticle physics.

In addition to those who work at the Max Planck Society, there are about 240 particle theorists at the universities and other research centres, not counting PhD students.

**Projects**

German scientists have traditionally made significant contributions to experimental particle physics. For example, the very first neutrino neutral current event from the Gargamelle bubble chamber at CERN was found at Aachen in 1973. Later, German teams played a major role in several neutrino experiments at CERN. The German neutrino tradition is currently being continued by participation in OPERA for the CERN/Gran Sasso project (p7).

The first observation of direct CP violation at CERN is another example of how German researchers have made an essential contribution. Germany is omnipresent in all sectors of physics at CERN, in all four LEP experiments and all four of the large future LHC experiments, as well as in fixed-target experiments such as NA48 and COMPASS. Making antiatoms from antiprotons is another German speciality at CERN.

Outside Europe, other major projects in which German particle physicists participate include the BaBar experiment at SLAC, Stanford, and CDF and D0 at Fermilab as well as heavy-ion experiments at RHIC, Brookhaven. There is also a broad spectrum of non-accelerator particle physics activities such as the historic Gallex solar neutrino experiment, the neutrino mass experiment at Mainz, and double beta-decay studies. Another closely related domain is astroparticle physics, where German physicists are participating in major projects such as AMS, AMANDA and Auger.

As described by Thomas Mannel from Karlsruhe, almost all current topics in theoretical particle physics are being investigated in Germany. Phenomenology, lattice gauge theories and string theory are notable examples.

**National laboratories and R&D**

Germany is very special in Europe in that is has several large research centres for particle and nuclear physics – DESY in Hamburg, DESY-Zeuthen (Berlin), GSI (heavy ions) in Darmstadt, KFA in Jülich and FZ in Karlsruhe.

Such a strong home base gives German scientists several advantages. As well as having their own research programmes, these centres also engage in R&D activities. For example, as pointed out by Norbert Wermes of Bonn, a great deal of work is being carried out on detector R&D for high-energy physics, not only at DESY but also at GSI Darmstadt, FZ Karlsruhe and the Max Planck Institutes in Munich and Heidelberg, as well as at 17 universities.

These efforts are funded primarily by the Ministry of Education and Research, and to a lesser extent by the German Research Council, the European Union and the Länder.

There have been interesting spinoffs from these developments. For example, a scintillator/optical fibre development has been shown to be useful for measuring dose distribution in medicine. Another example given by Wermes was a prototype chip which was developed for the ATLAS detector at LHC, but which can also be used for X-ray imaging.

The huge upheavals which occurred due to the German national reunification affected the country's science budget. However, there is now optimism in the air, at least for science. In the latest budget, two domains do rather well – education and traffic infrastructure, Schunck pointed out. □

# LEPilogue: marking the end of an era

As the era of CERN's LEP electron–positron collider draws to a close, that of CERN's next major machine – the LHC proton collider – is set to begin. A special celebration event at CERN marked this major milestone in the laboratory's history.

On 9 October, CERN revelled in the kind of festival of pomp and protocol that only large international organizations can enjoy. In a proud display on a scale not seen at the laboratory since the official inauguration of the LEP electron–positron collider in November 1989, VIP representatives, including Swiss President Adolf Ogi, came from all 20 CERN Member States, and from countries further afield participating in CERN's research programme, together with local dignitaries. They converged on a soccer-pitch sized experimental hall specially converted into an indoor amphitheatre and exhibition area.

The occasion – the LEP celebration – marked the end of the era of CERN's LEP electron–positron collider – more than 20 years of detailed preparation, planning and construction, including 11 years of operation which changed the face of physics. LEP is scheduled to be dismantled soon so that its 27 km tunnel can become the home for the ambitious LHC proton collider, which is due to come into operation in 2005.

LEP was supposed to be switched off in September to allow LHC construction proper to get underway, but tentative glimpses of new physics results (November p5) motivated additional LEP running. The carefully collected new data have yet to reveal all their secrets.

The possibility is that the LEP experiments might have caught a glimpse of the long-awaited Higgs particle, which breaks electroweak symmetry and pervades the whole of space to endow particles with mass (p5).

*Ballet by the Rudra–Béjart ballet school, Lausanne.*

*Maurice Béjart mounted the commemorative ballet.*

### On the day

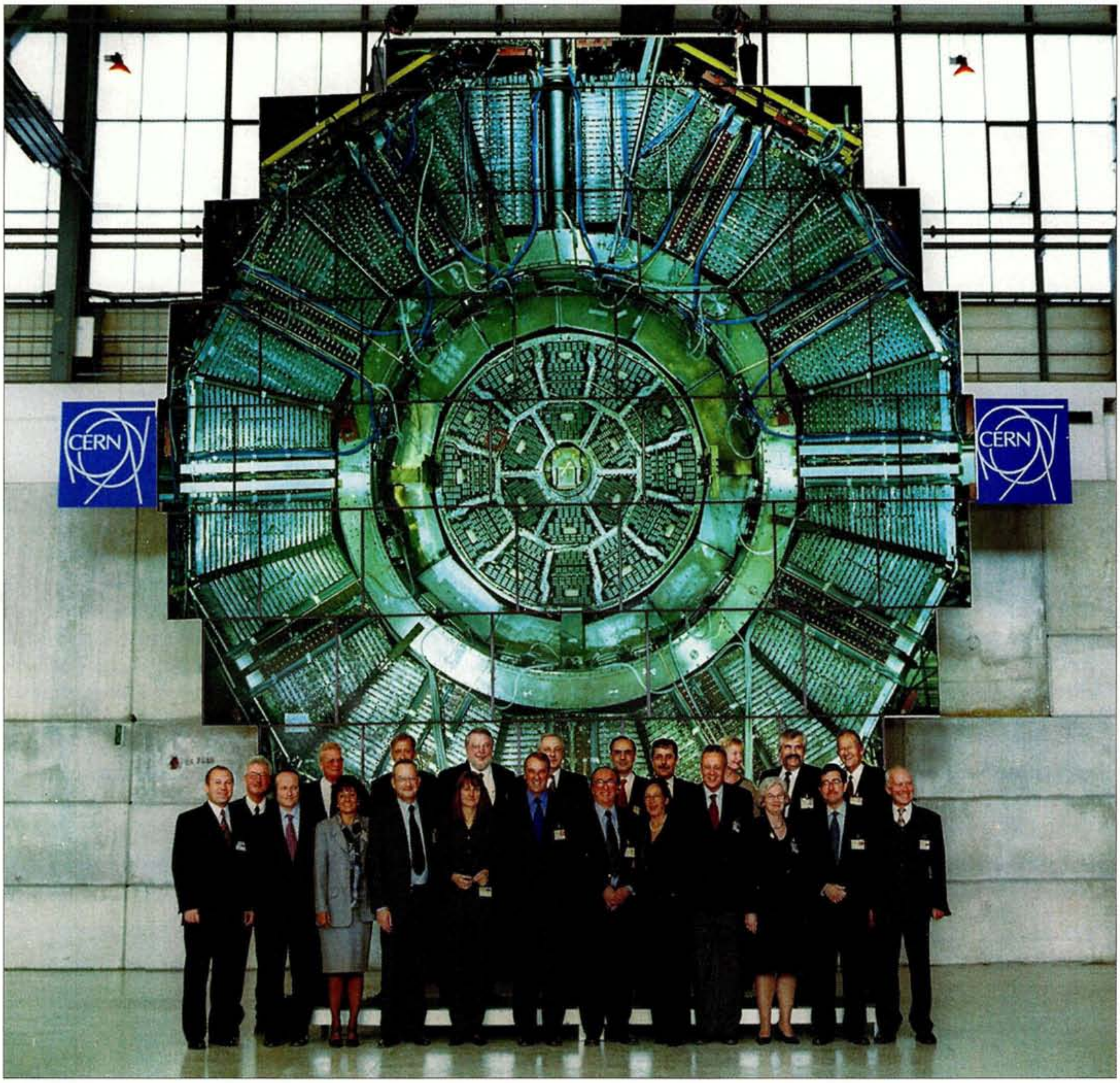
After the proceedings were opened by CERN director-general Luciano Maiani, 1999 Nobel laureate Martin Veltman summarized the state of our knowledge of the world of elementary particles.

"It happens that the theory and the data found by LEP allow us to guess properties of the Higgs particle. On the basis of that, we have a reasonable hope that it may be seen with the LHC, the machine that will take the place of LEP," maintained Veltman.

"This is by no means sure, but there is reasonable hope. It may in fact just be within reach of LEP, that by means of an unbelievable tour de force of the CERN engineering staff has been upgraded substantially. However, seeing it is one thing, studying it is another matter.

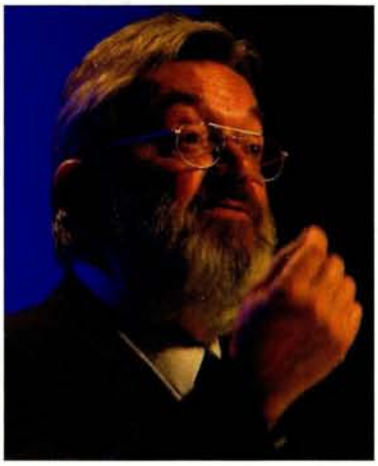
"Thus, to us, this extremely strange Higgs force may be the door to understanding other mysteries of particle physics. No one can even guess what there is. It may be utterly strange. It may have enormous consequences for our understanding of this world, including the structure of the whole universe. We must know. The LHC may well be the key to this knowledge."

Opening the galaxy of speeches from high-level government representatives was an ebullient Adolf Ogi, President of the Swiss Confederation. "CERN is shaping the scientific future of our continent," he said.




*Family photo – distinguished guests pose in front of a photo of the ALEPH detector at LEP. Left to right: (front row) Lubomir Fogas, Deputy Prime Minister, Slovak Republic; Roger-Gérard Schwartzenberg, Minister of Research, France; Anna Birules, Minister of Science and Technology, Spain; Lord Sainsbury, Minister of Science, UK; Edelgard Bulmahn, Minister of Education and Research, Germany; Adolf Ogi, President of the Swiss Confederation; Luciano Maiani, CERN director-general; Mrs Maiani; Philippe Busquin, Commissioner for Research, European Council; Agneta Bladh, State Secretary of Education and Science, Sweden; Mariano Gago, Minister of Science and Technology, Portugal; Andrzej Wiszniewski, Minister of Science, Poland; (back row) Hans C Eschelbacher, President of CERN Council; Paul Levaux, former CERN Council President, Belgium; Dimitar Dimitrov, Minister of Education and Science, Bulgaria; John O'Fallon, US Department of Energy; Mikhail Kirpichnikov, First Vice-Minister for Science, Russia; Dimitris Deniozos, Secretary General for Research and Technology, Greece; Edip Safter Gaydali, State Minister, Turkey; Randi Overland, State Secretary of Education, Norway; Gabor Szabo, Deputy State Secretary, Hungary; and Wolfgang Kummer, former CERN Council President, Austria.*

Ministerial speeches came in turn from French Minister of Research Roger-Gérard Schwartzenberg, German Minister of Education and Research Edelgard Bulmahn, UK Science Minister Lord Sainsbury, Italian Minister for Universities, Science and Technology Ortensio Zecchino, Spanish Minister of Science and Technology Anna Birules, Polish Minister of Science Andrzej Wiszniewski, Slovak Deputy Prime Minister Lubomir Fogas, Bulgarian Minister of Education and Science Dimitar Dimitrov, Portuguese Minister of Science and Technology Mariano Gago, and European Commissioner for Research Philippe Busquin. ▷



*Far left: President of the Swiss Confederation Adolf Ogi (right) with CERN director-general Luciano Maiani (centre) and Emilio Picasso, who directed construction of LEP from its approval in 1981 through to formal completion in 1989. Left: facts and mysteries in particle physics – 1999 Nobel Physics prizewinner Martin Veltman.*

"CERN is a convincing demonstration of the level of excellence which Europeans can achieve when they combine their forces. Its example should encourage us to pursue these efforts as far and for as long as necessary," said Commissioner Busquin.

CERN Member States Austria, Belgium, the Czech Republic, Denmark, Finland, Greece, Hungary, Norway, the Netherlands and Sweden were also represented.

For CERN Observer States and other countries participating in the CERN research programme were Russian First Minister for Science Mikhail Kirpichnikov, Turkish State Minister Edip Safter Gaydali, John O'Fallon of the US Department of Energy, Director of Monbusho (Japan) International Scientific Affairs Keisuke Yoshio, and Indian Ambassador Savitri Kunadi. Following the speeches, delegates formally unveiled a commemorative plaque (see box).

**Ballet**

Especially memorable was a ballet performance by the Rudra-Béjart Ballet School, Lausanne, for which pupils from all over the world are selected by Maurice Béjart himself. The elements of the show were prepared by School Director Michel Gascard, while Béjart mounted the ballet and integrated its separate elements.

The area adjoining the indoor theatre/auditorium housed a specially-mounted exhibition of CERN's proud achievements – the World Wide Web, LEP's physics accomplishments, and some examples of the technology and construction for major experiments.

After the show, the amphitheatre was taken over for a two-day science symposium covering the inception and construction of LEP and its experiments, and the science and developments that have emerged.

## LEP commemorative plaque

**"We, the Participating Countries, recognize the outstanding scientific achievements of LEP that have illuminated the family structure of fundamental particles and the texture of our universe.**

**"LEP has stimulated new ideas and technologies with applications reaching far beyond the realms of fundamental physics – best known in the World Wide Web.**

**"LEP has set new standards for international scientific collaboration, giving scientists from all over the world the opportunity to work together and push back the limits of the unknown. Worldwide contacts and relations have been established by using the new instruments and techniques developed at CERN and by the particle physics community.**

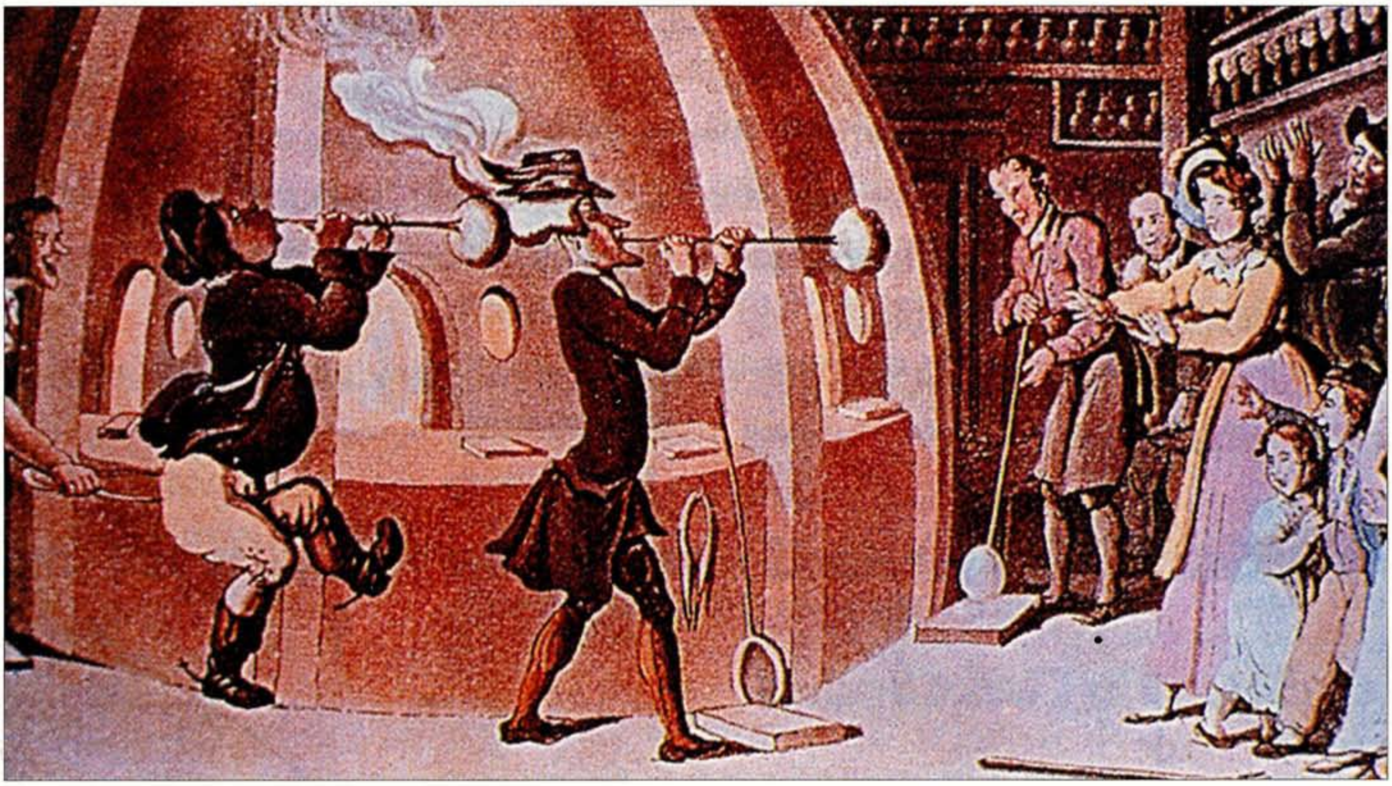
**"LEP achievements open the way for a new challenge, the Large Hadron Collider (LHC), which will allow us to go deeper in the exploration of the structure of matter, space and time.**

**"The LHC goes beyond international collaboration towards true global partnership in science. This partnership is enhanced by technical excellence and improved communications networks.**

**"CERN shall remain at the forefront of science as a world-class laboratory to broaden our knowledge and train young generations of scientists. CERN shall continue its role as a vehicle for innovation to improve the quality of life and mutual understanding among people.**

**"We congratulate CERN and its partners on their exciting achievements with LEP. Now the baton is passed to the LHC. We look forward to launching soon the new scientific programme that will lead to more far-reaching discoveries."**


*Delegates applaud the unveiling of a commemorative plaque.*



Glass blowing in the 17th century – not much has changed, except that today's glassblowers control their intake at lunch!

# Manufacturers put their heads in the sand

**The special demands of particle physics experiments can be a challenge to suppliers. Specialist firm Electron Tubes mounted a programme for photomultiplier housings.**

Increasingly in physics and astrophysics research the challenge lies in extracting very rare events from a tangle of unwanted but inescapable background processes.

In the Borexino experiment (currently under construction), one of the objectives is to measure the rate of neutrino events from the very low-energy beryllium-7 process, originating in the Sun. The energies of interest are lower than those of other neutrino experiments requiring a detection threshold of less than 1 MeV in a scintillator medium of some 300 t.

An important aspect of this experiment is the continuous purification of the scintillator, which involves the formidable industrial process of reverse osmosis on a grand scale. Needless to say, those parts of the experiment that cannot be continuously refined, such as the photomultiplier, need to be intrinsically pure.

In the dark-matter experiments of DAMA at Gran Sasso, Italy, and UKDMC at Boulby, UK, WIMP and other rare events from weakly interacting particles are being sought in scintillator-based detectors. Experiments using massive NaI(Tl) crystals, with elaborate anticoincidence, operating deep underground, use highly refined scintillator material and demand special photomultipliers.

### Low radioactivity

To match the advances achieved in reducing levels of radioactivity in the scintillators, manufacturers have had to scrutinize the materials used in the internal metal and ceramic parts of the photomultiplier, as well as in the glass envelope, where major sources of activity lie.

Fused silica (quartz) has very low radioactivity and is commercially available as an optional window material in photomultipliers. However, the highly desirable all-quartz photomultiplier is unattainable – essentially because of the mismatch in the expansion coefficients of quartz, and also the metal pins at the base of the photomultiplier making it impossible to manufacture. ▷

## Photon detection for biomedical applications

Instrumentation for clinical analysis increasingly depends on bioluminescence, chemiluminescence and fluorescence. The amounts of light are small and often require photon counting, so highly sensitive, low-noise detectors are needed. The most flexible and cost-effective detector for this purpose is a photomultiplier tube (PMT), which in most cases is the only option.

Electron Tubes has developed a range of integrated light-detection assemblies specifically aimed at the needs of the biomedical instrument designer. These include a PMT and all associated electronics and signal processing, so the customer needs to provide only a low-voltage input and interface to a digital (normally TTL) or analogue current or voltage output.

Compact Peltier coolers are available that maintain the PMT at a constant temperature up to 40 °C below ambient.

The mechanical design can be customized to simplify final assembly of the instrument by the customer.

More information is available at "www.electrontubes.com".

Glass envelopes.

| Material | Concentration level K (ppm) | Th (ppb) | U (ppb) |
|---|---|---|---|
| standard glass | <60 000 | <3000 | 2000 |
| low background glass | 300 | 250 | 100 |
| ultra-low background glass | 60 | 30 | 30 |
| fused silica (quartz) | <10 | <10 | <10 |

Potassium is an important constituent of all commercial glass because its addition to the melt facilitates the working of the glass and ensures the optical quality. However, it contains a small proportion of the long-lived radioactive isotope potassium-40, making its presence in glass unacceptable from an experimental physics perspective.

The long-lived decay products of thorium and uranium are ubiquitous, particularly in sand, a major constituent of all glass. Radioactive decays from these sources produce a spectrum of gammas, ranging from 100 to 2700 keV, which encroach on the low-energy region of interest to low background experiments.

The practicalities of manufacturing low-background photomultipliers ultimately rely on the use of glass. Electron Tubes Ltd has located a source of low-activity sand and has worked with specialist glass companies to devise suitable manufacturing processes.

### Glassblowing

The glass mixture has to be maintained at extremely high temperatures, making it very corrosive. The design and material of the melting pot are critical to avoid contributing radioactive isotopes to the glass mixture or cracking within the first few days of operation. Glassblowing lasts only a few hours of each day. The pot is filled with material, and only when the melt is judged to be of acceptable quality and optimal working temperature does blowing begin.

Glassblowers work rapidly, producing a bulb every 1 or 2 min. When the level of the melt drops below some desirable level, or it ceases to work properly, the process is abandoned until the next day, when the cycle is repeated. A good day may produce 20 envelopes, a bad day nothing and the mechanical properties of the pot are continually degrading under continuous heat cycling. Replacing the pot and commissioning the furnace takes up to one month with a complete break in output.

The table indicates the progress that has been made in the attainable radiopurity levels of low-background glass. Levels of potassium, thorium and uranium are measured in parts per million or billion.

In conclusion, current experiments at the forefront of science rely on a technology that has hardly changed over the centuries. Glassblowing demands the skills of a dwindling group of craftsmen, working by feel and by eye, unsung and largely unappreciated. How different the world of physics – or is it? □

# RECRUITMENT

For advertising enquiries contact *CERN Courier* recruitment/classified, IOP Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK.
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Rates per single column cm: Mono £32, Single colour £36, Full colour £38. Please contact us for more information on publication dates and deadlines.

## Faculty Positions in Chemistry

**at the Swiss Federal Institute of Technology Lausanne (EPFL)**

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

The EPFL, in close collaboration with the University of Lausanne (UNIL), plans a substantial expansion in the basic sciences, including a significant reinforcement in chemistry, physics, and math, and a major new effort in biological sciences and engineering that involves the creation of a center of functional genomics.

As part of this broad program, the Chemistry Department anticipates making several tenure-track junior-level and potentially senior-level appointments over the next few years. We seek outstanding individuals in all areas of chemistry. Successful candidates must develop an independent, internationally recognized program of scholarly research as well as excellent teaching at both the undergraduate and graduate level. Substantial start-up resources will be available. Women are encouraged to apply.

Applications, including CV, publication list, concise statement of research interests (3 pages or less) and three letters of reference, should be sent by December 31, 2000 to: Professor Thomas Rizzo Head, Department of Chemistry, EPFL CH-1015 Lausanne, Switzerland

THE UNIVERSITY
OF BIRMINGHAM

SCHOOL OF PHYSICS AND ASTRONOMY

**TWO LECTURESHIP POSITIONS IN EXPERIMENTAL PARTICLE PHYSICS**

The successful candidates will be working on the Heavy Ion Programme and the H1 Experiment respectively as well as taking part in undergraduate and graduate teaching. Applicants should have a PhD or equivalent in particle physics and preferably several years post-doctoral experience in the field.

Starting salary on scale £18,731 - £30,967 a year.

**Application forms (returnable by 31 January 2001) and details from Personnel Services, The University of Birmingham, Edgbaston, Birmingham B15 2TT, tel: 0121 414 6486, web: (http://www.bham.ac.uk/personnel/). Please quote reference S35552/00**

Working towards equal opportunities

**Faculty Position in Theoretical Particle Physics**

## Cornell University

The Department of Physics at Cornell University invites applications for a tenure track Assistant Professor appointment in theoretical particle physics, to begin in Fall 2001 or later.

Outstanding applicants at a more senior level may also be considered. We are seeking highly qualified candidates committed to a career in research and teaching. We especially encourage applications from candidates with an active interest in the interface of string theory, gravity, brane physics, and field theory. However, outstanding candidates in any area of theoretical particle physics will also be seriously considered.

Applicants should send their curriculum vitae, publications list, a brief description of their research interests and arrange for three letters of reference to be sent to Professor Henry Tye, Search Committee Chair, Newman Laboratory of Nuclear Studies, CornellUniversity, Ithaca, NY 14853.

**To receive the fullest consideration, applications should be received by January 1, 2001.**

*Cornell University is an equal opportunity, affirmative action employer.*

# Faculty Positions in Physics

**at the Swiss Federal Institute of Technology Lausanne (EPFL)**

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

The EPFL, in close collaboration with the University of Lausanne (UNIL), plans a substantial expansion in the basic sciences, including a significant reinforcement in physics, chemistry and mathematics and a major new effort in biological sciences and engineering that involves the creation of a center of functional genomics.

As part of this broad program, the Physics Department anticipates making several tenure-track junior-level appointments and senior-level appointments. We seek outstanding individuals with an interdisciplinary vision and a strong record of accomplishments. Successful applicants will initiate independent, creative research programs and participate in both undergraduate and graduate teaching. Substantial start-up resources will be available.

The first four appointments are expected next year in the areas of nanophysics, biological physics, theory (condensed matter or quantum optics), complex systems, time-resolved crystallography. Women candidates are particularly encouraged to apply. For further information, see http://dpwww.epfl.ch.

Applications, including curriculum vitae with publication list, brief statement of research interests (three pages or less) and the names and addresses (including e-mail) of at least five references, must be sent before January 15, 2001, to: Professor Giorgio Margaritondo, Head, Department of Physics, EPFL, CH-1015 Lausanne, Switzerland.

## U.S. DEPARTMENT OF ENERGY

EXCEPTED SERVICE POSITION

**SENIOR TECHNICAL ADVISOR FOR HIGH PERFORMANCE COMPUTING**

EJ-1550-V

OFFICE OF SCIENCE

OFFICE OF HIGH ENERGY AND NUCLEAR PHYSICS

**$101,566 - $130,200 per annum**

VACANCY ANNOUNCEMENT NUMBER: ETR 00-EXC-50-002A2

The U. S. Department of Energy is seeking applicants for the Excepted Service position of Senior Technical Advisor for High Performance Computingwithin the Office of High Energy and Nuclear Physics in the Office of Science. The incumbent provides expert scientific advice and detailed technical analyses to the Associate Director for the evaluation of research programs, facility operations, and their associated resources to attain a planned course of action for the overall High Energy and Nuclear Physics, High Performance Computing mission. The scope of the incumbent's advisory responsibilities includes providing scientific judgment, program and strategic planning, policy development, budget formulation, and the measurement of program performance by peer review and other metrics. The incumbent serves as the recognized authority and expert in DOE in diverse areas of High Energy and Nuclear Physics, High Performance Computing.

Please refer to DOE Vacancy Announcement ETR 00-EXC-50-002A2 (which can be accessed via the Internet at

**http://www.hr.doe.gov/pers/doejobs.htm**)

for specific instructions on how to apply for this position. Applicants must comply with the instructions that are in the vacancy announcement in order to be eligible for consideration. Announcements can be mailed to you by calling 301-903-1577.

**Applications must be postmarked no later than January 11, 2001, and should be sent to the U.S. Department of Energy, ExecutiveResources Division, Room 4E-084, 1000 Independence Avenue, SW, Washington,DC 20585.**

*The Department of Energy is an equal opportunity employer.*

## POSTDOCTORAL POSITION
## PHYSICS DIVISION ATLAS EXPERIMENT
### LAWRENCE BERKELEY NATIONAL LABORATORY

The Physics Division at Lawrence Berkeley National Laboratory (LBNL) has a postdoctoral opening with the ATLAS experiment at the Large Hadron Collider at CERN. The successful candidate will have an important role in the development and construction of the silicon pixel detector of the ATLAS tracking system.

The successful candidate will have a key assignment in the development and later fabrication of the silicon pixel detector system. The immediate emphasis will be on laboratory and test beam measurements of silicon detector/electronics assemblies and preparations for production of these assemblies at LBNL. The candidate will also have the opportunity to participate in the analysis of data from one of the ongoing experiments that LBNL is currently participating in. Experience with silicon detector systems or other complex electronics/detector systems is preferred. A PhD in experimental particle physics or equivalent experience is required.

For more information visit: http://www.lbl.gov or http://www-atlas.lbl.gov/. Applications, including CV, list of publications, description of research interests, and three letters of recommendation, should be submitted via email to gensciemployment@lbl.gov. Reference Job #PH/011637 in your cover letter. Or mail to: Lawrence Berkeley National Laboratory, c/o Katrina Printup, One Cyclotron Road, MS 50-4037, Berkeley, CA 94720. Or fax: (510) 486-4808. Berkeley Lab is an AA/EEO employer.

BERKELEY LAB

# FACULTY POSITION IN EXPERIMENTAL ATOMIC AND MOLECULAR PHYSICS

Department of Physics
Université Catholique de Louvain

The Rector of the Catholic University of Louvain (UCL) in Louvain-la-Neuve, Belgium, invites applications for a full-time academic position beginning in fall 2001. Applicants will have a Ph.D. or equivalent and postdoctoral experience in experimental atomic and molecular physics.

The appointed person is expected to teach physics courses in the university and play a leading role in both shaping and implementing the research program in experimental atomic and molecular physics. This program presently includes quantum optics, the study of cold atoms, condensates, molecules and aggregates and their interaction with intense laser pulses. All these activities are pursued within national and international collaborations.

Only a good knowledge of English is required initially but, since the appointed candidate is to teach in French, she/he should acquire a reasonable command of the language within two years. Rank and salary will depend upon qualification and experience.

The successful candidate should sustain a strong program of research with significant undergraduate and graduate involvement. Although she/he will be primarily based in Louvain-la-Neuve, her/his research within the atomic and molecular group will imply stays abroad in one of the large European centers for physics with lasers.

Candidates should submit a letter of application, a curriculum vitae, a copy of their final diploma, a list of publications, four letters of recommendation, a copy of their five most representative publications. In addition they should describe their research project within the next five years (2 pages) and explain their pedagogical views and the type of teaching they want to promote (2 pages). All these documents should be sent to:

**Professor M. Crochet, Rector, The Catholic University of Louvain, Halles Universitaires, place de l'Université 1, B-1348-Louvain-la-Neuve, Belgium.**

***The closing date for applications is January 15, 2001.***

For further information, please consult:
http://www.phys.ucl.ac.be/offres_en.html.
You can also write or call Prof. J.P. Antoine, Chairman of the Department of Physics, chemin du Cyclotron 2, B-1348-Louvain-la-Neuve, Belgium. Tel. +32-10-473283. Fax +32-10-472414 (E-mail : antoine@fyma.ucl.ac.be)

# Research Associate Positions University of Chicago

## Experimental High Energy Particle Physics and Accelerator Physics

An experimental particle physics group (Profs K.J.Kim/M.Oreglia/Y.Wah) at the University of Chicago is seeking recent Ph.D. graduates in high energy and accelerator physics for several Research Associate positions to work on experiments investigating matter anti-matter asymmetries (CP violation), muon collider/neutrino factory, and other important high energy phyiscs topics. These positions presents marvelous opportunities for motivated individuals to make significant impacts on current and future forefront experiments including KAMI (Kaon at Main Injector), KTeV (Kaon at Tevatron), MuCool (Muon Cooling at Fermilab) and others.

The successful candidates are expected to play a leading role in the KTeV data analysis, KAMI design and construction, development of ionization cooling schemes and diagnostics, MuCool related R&D, and many possible projects. It is highly desirable to have good experimental skills with detectors, vacuum and cryogenic systems, and complex instruments. The initial appointment will be for three years, with possible extension. Applicants should send a curriculum vitae, list of publications and arrange to have three letters of recommendation sent to :

**Prof. Yau W. Wah, The Enrico Fermi Institute, The University of Chicago, 5640 South Ellis Ave, Chicago, IL 60637, or via e-mail to chgohire@hep.uchicago.edu.**

# —— APPLICATIONS PHYSICIST ——

The Beams Division of Fermi National Accelerator Laboratory (Fermilab) has an exciting opportunity for an Applications Physicist. The successful candidate will work in the neutrino factory/muon collider group. This group is taking a leading role in the design, simulation, development, and testing of a muon cooling channel needed for a new very intense muon source. This is one of the most critical and challenging tasks in the development of neutrino factories and muon colliders.

Duties will include cooling channel studies based on analytical calculations and computer simulations. It is likely that new cooling lattices will have to be developed that can cool 6-dimensional phase space. A broad knowledge of accelerator physics is desirable. Experience with the simulation of large and highly correlated 6D phase space within solenoid channels is advantageous. Requirements of this position are extensive experience with the beam dynamics of linear and circular accelerators, and experience with both analytical and numerical techniques. A Ph.D. or equivalent experience is required.

Located 40 miles west of downtown Chicago, on a campus-like setting. Fermilab provides competitive salaries and exceptional benefits, including medical/dental/life insurance, tuition reimbursement, fitness center, on-site daycare, and access to our 6,800 acre nature preserve. Applicants are requested to forward their curriculum vitae and a list of at least three references to **Dr. John Marriner, Fermi National Accelerator Laboratory, P.O. Box 500, M.S. 306, Batavia, Illinois 60510-0500 U.S.A.**

Fermilab

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LNF

**Laboratori Nazionali di Frascati dell'INFN**
European Union "Improving" Programme
Marie Curie Training Site
**Post-Graduate Fellowships**

We invite applications for three-month to one-year fellowships for doctoral training at the Laboratori Nazionali di Frascati (LNF) of the Istituto Nazionale di Fisica Nucleare (INFN), in the field of **neutrino physics**. Neutrino masses and oscillations are the current best explanation of the atmospheric and solar neutrino anomaly. The Frascati researchers are involved in MACRO, at Gran Sasso, one of the experiment for which the atmospheric anomaly is particularly evident. They are also involved in two future experiments for neutrino oscillations: Monolith and Opera. Further information about this research area can be obtained from Dr. F. Ronga, tel. 39-06-94032914, e-mail francesco.ronga@lnf.infn.it.

Applicants must be nationals of a European Union member state (excluding Italy) or an associated state. They should have a degree in physics and should be persuing doctoral studies in a research area similar to that described above. Fellows will receive an allowance of 1200 euro/month. Travel costs to and from the Frascati Laboratories will be reimbursed. More information can be obtained by visiting our web site www.lnf.infn.it/cee/mcts.html.

Applicants should send a letter of application and a C.V. and arrange for two letters of recommendation from independent referees and for a letter from the supervisor in the home university, who recognizes the stay at the Training Site as an integral part of the doctoral studies.

All documents must be sent by **31/1/2001**, to: Marie Curie Training Sites, EU Programmes, Laboratori Nazionali di Frascati dell'INFN, Via E. Fermi 40 - 00044 - Frascati (Italy). Fax +39 06 9403 2475, E-mail to: tari@lnf.infn.it.

*The LNF are an equal opportunities environment.*

## Radioactive Beam Physicist
## National Superconducting Cyclotron Laboratory

**MICHIGAN STATE UNIVERSITY**

The National Superconducting Cyclotron Laboratory invites applicants for immediate openings for 2 beam physicist positions. The NSCL is currently constructing the Coupled Cyclotron upgrade project, which includes a new A1900 fragment separator. Commissioning of the project is scheduled to be completed by July 2001. The successful candidates will be responsible for production, identification, and delivery of secondary beams to experiments set up by the facility's users; using and maintaining nuclear particle detectors. The NSCL has a staff of approximately 130 people and is funded by the National Science Foundation for research in nuclear and accelerator physics, and related instrumentation R&D. Excellent benefits including health/dental plans, generous retirement plan, and educational assistance.

Appointments will be made at any of three ranks in the NSCL Continuing Appointment System that approximately parallels the university tenure-stream faculty system (see CA Handbook at: www.msu.edu/unit/facrecds/policy/nscl01.htm). Appointment level and salary will be commensurate with experience, demonstrated capability and the overall NSCL salary structure.

**Requirements:** a Ph.D. in experimental nuclear physics or applied physics with experience in radioactive beam techniques, ion optics, and nuclear detection methods. Duties of this position involves: walking, climbing stairs.

**Please send a current C.V. and the names of three references to: Ms. Chris Townsend, NSCL, Michigan State University, East Lansing, MI 48824-1321 or to Townsend@nscl.msu.edu.**

For information about our Lab, see http://www.nscl.msu.edu.

*Michigan State University is an affirmative action/equal opportunity institution.*

## POSTDOCTORAL AND SCIENTIST POSITIONS IN SUPERNOVA COSMOLOGY PROGRAM
### LAWRENCE BERKELEY NATIONAL LABORATORY

The Supernova Cosmology research group of Berkeley Lab, under the direction of Saul Perlmutter, has multiple positions available, ranging from Postdoctoral to Scientist. This is an exciting opportunity for a wide range of investigations concerning cosmological parameters, the acceleration of the universe, and the "dark energy" explanations for the acceleration.

Projects include high-redshift supernova studies of the cosmological parameters, intensive discovery and follow-up of low-redshift supernovae to understand these cosmological tools, and the development, design, and instrument-prototype construction of a dedicated space-based telescope facility. Candidates should have interests and abilities in any or all of the following: astronomical instrumentation (ground- and space-based), observation or theory related to supernovae (types Ia and II) or cosmology, and/or novel real-time data analysis techniques. Instrumentation development includes both optical and near-IR images, wide-field imagers using Berkeley Lab's novel CCDs, and development of multichannel integral field spectrographs.

Requires PhD or equivalent experience in astronomy and/or physics. Applications, including CV, list of publications, description of research interests and skills, and three letters of recommendation, should be sent to Postdoctoral and Scientist Positions, E.O. Lawrence Berkeley National Laboratory Search Committee, c/o Ms. Katrina Printup, One Cyclotron Road, Mailstop 50-4037, Berkeley, CA 94720 or e-mailed to gensciemployment@lbl.gov (inquiries should also be forward to this e-mail address). Reference Job# PH/011940/011975 in your cover letter. Applications should be received by Jan 5, 2001. http://supernova.lbl.gov and http://snap.lbl.gov. Berkeley Lab is an AA/EEO employer.

## *The National High Magnetic Field Laboratory (NHMFL) at Florida State University*
**is seeking applicants for:**

### I. Two scientific staff positions in Magnet Design and Analysis.
**(one senior and one entry-level)**

The selected candidates will join a diverse and dynamic group involved in all aspects of magnet development and technology. They will be expected to participate in on-going projects and initiate new externally funded activities. These are 12-month research staff positions.

Candidates should have a strong background in mathematics, physics and engineering with work experience in magnet technology. A working knowledge of FORTRAN programming, finite element analysis and use of commercial codes such as ANSYS is highly desirable. Experience with the technology of electromagnet design and fabrication practice is also an asset.

The senior position requires a Doctoral degree in Engineering, Physics or a closely related field or an equivalent combination of education and experience. It is preferred that candidates for the entry-level position also have a Doctoral degree although a Bachelors or Masters degree and significant relevant professional experience will also be considered.

### II. Program Manager - Magnet Technology

The selected candidate will be responsible for leading major programs within the NHMFL Magnet Science and Technology group as well as contributing technically to magnet design and development activities. This is a 12-month research staff position.

Candidates should have experience with a variety of magnet technologies through project management and engineering. Industrial experience is an asset. Government contracting experience is also desirable. A strong analytical and technical background is viewed to be as important as excellent verbal and written skills. A Doctoral degree in Engineering, Physics or a closely related field or a Masters degree with an equivalent combination of education and experience is required.

Interested candidates for these positions should contact or send a letter of inquiry, resume and list of three individual references to: *Dr. Steven W. Van Sciver, Director of Magnet Science and Technology, NHMFL 1800 E. Paul Dirac Drive Tallahassee, FL 32310 Fax: 850-644-0867 e-mail:vnsciver@magnet.fsu.edu*

**GSI Darmstadt**

the National Laboratory for Heavy-Ion Research, a member institute of the Helmholtz-Society of German Research Centers, invites applications for a staff position of an

## Experimental Physicist
**Ref. 1100-00.51**

in the framework of the FOPI experiment at the SIS/ESR accelerator of the institute. The person is expected to take a leading responsibility within the international collaboration; she/he should direct the physics analyses and participate especially in the operation and the upgrade of the existing facility. She/he will play an active role in defining the future research program of FOPI and of the laboratory as a whole.

Candidates should have a Ph.D. in experimental nuclear physics, a several years' experience in (ultra-)relativistic heavy ion collisons and should be active in this field. They should be interested in the hard- and software aspects of a big detector facility; the ability to work in the environment of a large international community requiring excellent communication and leadership skills is mandatory.

The appointment is permanent, The salary is according to the Bundesangestelltentarifvertrag (up to BAT Ia).

Women are especially encouraged to apply for the position. Handicapped applicants will be given preference to other applicants with the same qualification.

Applications containing a curriculum vitae, a list of publications and the names of three referees should be sent by January 5, 2001 to

**GESELLSCHAFT FÜR SCHWERIONENFORSCHUNG MBH**
**PERSONALABTEILUNG**
**PLANCKSTR. 1**
**D-64291 DARMSTADT**

## PROJECT SCIENCE COORDINATOR FOR SUPERNOVA COSMOLOGY GROUP
**LAWRENCE BERKELEY NATIONAL LABORATORY**

The Supernova Cosmology research group of Berkeley Lab, under the direction of Saul Perlmutter, is searching for a project coordinator to provide science support for the scientific team effort. This person will coordinate the activities of the scientific team, track deadlines, write proposals, and troubleshoot potential bottlenecks in the scientific workflow.

This position will play a key role in advancing the group's investigations concerning cosmological parameters, the acceleration of the universe, and the "dark energy" explanations for the acceleration. Projects include high-redshift supernova studies of the cosmological parameters, intensive discovery and follow-up of low-redshift supernovae to understand these cosmological tools, and the development, design, and instrument-prototype construction of a dedicated space-based telescope facility.

The candidate should have demonstrated abilities in scientific writing, team building, and project organization. Ideally, the candidate would also be able to make direct scientific contributions based on interest and experience with any or all of the following: astronomical instrumentation, observation or theory related to supernovae or cosmology, and statistical data analysis techniques.

Applications, including CV, list of publications, description of relevant skills, experience and research interests, and three letters of recommendation, should be sent to Project Science Coordinator for Supernova Cosmology Group, E.O. Lawrence Berkeley National Laboratory Search Committee, c/o Ms. Katrina Printup, One Cyclotron Road, Mailstop 50-4037, Berkeley, CA 94720 or e-mailed to gensciemployment@lbl.gov (inquiries should also be forward to this e-mail address). Reference Job# PH/012788 in your cover letter. Applications should be received by Jan 5, 2001. http://supernova.lbl.gov and http://snap.lbl.gov. Berkeley Lab is an AA/EEO employer.

BERKELEY LAB

# RF ENGINEER
**(Position #AR3128)**

Jefferson Lab, located in Newport News, VA, is a world-class scientific laboratory centered around a high-intensity, continuous wave electron beam, which provides a unique capability for nuclear physics research. In addition the lab has an active Free Electron Laser (FEL) R&D program which provides an intense laser for materials research. The lab is managed for the Department of Energy by the Southeastern Universities Research Association. We are located in southeastern Virginia, 2 hours south of Washington DC, near Colonial Williamsburg, the Chesapeake Bay and the resort area of Virginia Beach.

Currently we have an excellent opportunity for an RF Engineer. The person will be responsible for the design, development, and implementation of RF subsystems (receivers, RF structures/cavities and transmitters) used in the CEBAF accelerator and Free Electron laser (FEL). Individual will provide job direction to technicians and communicate with accelerator physicists and other engineers to improve performance of the accelerator and FEL. Individual will work to insure that designs and requirements comply within the guideline of Jefferson lab EH&S policies.

The minimum qualifications for this position are a BS degree in electrical engineering (MS preferred) and 5 to 15 years of applicable experience, or an equivalent combination of education, experience, and specific training. Incumbent must have a thorough background in RF and microwaves. Candidates must have low power RF experience (receiver technology, signal processing). In addition high power RF experience (> 1 kW, solid-state, klystrons, RF structures/cavities) is helpful. Experience with RF, Electromagnetic, and other EDA tools such as Eagleware, Ansoft (Harmonica and HFSS), MAFIA, MATLAB etc., is desired. Linear accelerator experience would be helpful. While the candidate must be able to work independently under minimum supervision, the ability to work and communicate effectively in multidisciplinary teams of physicists, engineers, and technicians is of prime importance.

The starting annual salary range will be $56,000-$111,000. For prompt consideration, please send resume and salary history to: Jefferson Lab, Attn: Employment Administrator, 12000 Jefferson Ave., Newport News, VA 23606. Email to: **jobline@jlab.org** or fax to: (757) 269-7559. Further information and complete descriptions of this and other positions can be found by visiting our web site at **http://www.jlab.org/jobline.html** or by calling our jobline at **(757) 269-7359**.

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Jefferson Lab

## RESEARCH FELLOW AT THE BERKELEY CENTER FOR THEORETICAL PHYSICS

The University of California at Berkeley has begun the endowment of a new Center for Theoretical Physics, which will initially focus on Particle Theory. The Center is now conducting a search for a Research Fellow (Assistant Researcher), a fixed term appointment with funding for 5 years, to begin in the Fall of 2001, with an annual salary in the range of $53,600-$59,600. We are searching for an outstanding junior researcher, with a PhD, who will interact with members of our theory group and with our visitors.

All applicants for particle theory postdocs at UC Berkeley and LBNL will automatically be considered for this position. Applicants who wish to apply for this position, but not be considered for a regular postdoc, should have an application with CV and letters of reference sent to Professor Lawrence Hall, Physics Department, University of California, Berkeley, CA 94720-7300, USA postmarked by **January 15th, 2001.**

*The University of California is an Equal Opportunity/Affirmative Action Employer; women, and minorities are encouraged to apply.*

## ACCELERATOR CONTROLS DEPARTMENT HEAD

The Beams Division of Fermi National Accelerator Laboratory (Fermilab) operates and improves the world's highest energy particle accelerator. The accelerator complex is controlled and monitored by a sophisticated state-of-the-art network of computers and microprocessors. The Accelerator Controls Department is responsible for the data acquisition and control of this complex and its associated beam transport lines.

Currently, the Division is seeking a qualified individual to become Head of the Accelerator Controls Department. The successful candidate will determine the current system's strengths and weaknesses and provide leadership in developing a strategy that leads to the next generation control system. Additionally, the Department Head will direct and coordinate the activities of a team of professionals and develop budget requests and staffing/resource allocations.

The ideal candidate will possess an advanced degree and be a scientist or computer specialist with a history of demonstrated leadership skills and management responsibility in a research and development environment. Must have demonstrated knowledge and experience in distributed data acquisition systems and possess the ability to understand data flows and high level languages. An understanding of accelerator control systems is highly desired.

Located 40 miles west of downtown Chicago, on a campus-like setting, Fermilab provides competitive salaries and exceptional benefits, including medical/dental/life insurance, tuition reimbursement, fitness center, on-site daycare, and access to our 6,800 acre nature preserve. Applicants are requested to forward their curriculum vitae and a list of at least three references to **Dr. John Marriner, Fermi National Accelerator Laboratory, P.O. Box 500, M.S. 306, Batavia, Illinois 60510-0500 U.S.A.**

Fermilab

A U.S. Department of Energy Laboratory
Fermilab is an Affirmative Action/Equal Opportunity Employer M/F/D/V

## Physicist

ABB is presently expanding its activities in the fields of alternative and renewable energies and electrical energy storage. At ABB Corporate Research the basics for future energy systems are developed and the results are implemented in the next generation of products.

We are looking for highly qualified people, preferentially **Experimental Physicists**, who are interested to work and contribute in these ambitious and forward-looking fields.

As one of the new collaborators you will have the opportunity to work in a team of motivated and innovative scientists and engineers. Close cooperation and contacts to other ABB companies, to universities, and to customers will be part of the interesting range of activities.

You will develop and evaluate systems and components for alternative power generation solutions and energy storage. In connection with these tasks, you will be involved in the planning and building of prototype devices and of test equipment, in performing electrical and other test measurements, and in the development of materials.

We address physicists, preferably with a PhD and/or industrial experience with excellent technical qualifications. Experience in the field of alternative energies or energy storage is not a prerequisite.

We are looking forward to receiving applications from committed, flexible team players with initiative, who will, in addition, be distinguished by their capacity for independent and innovative work, their system-oriented thinking, and leadership potential.

Please send your complete application documentation to
**ABB Corporate Research Ltd.** Frau Brander-Claessen
Human Resources Manager 5405 Baden-Dättwil Tel.: 056/486 82 12
e-mail: beatrice.brander-claessen@ch.abb.com
Additional information can be found at
http://www.abb.com/chcrc.

**Career Opportunity at ABB**

## Imperial College
of Science, Technology and Medicine

### Research Associate Positions in Experimental Particle Physics

Applications are invited for two Research Associate positions in the High Energy Physics Group at Imperial College, London. The group has a strong experimental programme with teams working on ALEPH at LEP, ZEUS at HERA, BABAR at SLAC, DØ at Fermilab, the UK Dark Matter experiment and with the preparations for both the CMS and LHCb experiments at the LHC. In addition the group is involved in research and development for a future neutrino factory based on the muon collider concept. There is a strong tradition for both analysis and detector and electronics development. The successful applicants will be expected to take a leading role in either the ZEUS experiment or the preparations for the CMS experiment. Further details about the positions, including contact names, can be found at:

http://www.hep.ph.ic.ac.uk/ra.html

The positions are available from February 2001 until 30 September 2002, in the first instance, with a possible two year extension. Salary will be on the RA1A scale in the range £16,775 - £25,213 p.a. plus £2,134 p.a. London Allowance. Applications, comprising a curriculum vitae, a list of publications and the names and addresses of two referees, should be sent by 15 January 2001 to:

**Professor Peter Dornan**
**High Energy Physics Group**
**Blackett Laboratory**
**Imperial College**
**London SW7 2BW**
**E-mail:P.Dornan@ic.ac.uk**

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## CERN COURIER RECRUITMENT BOOKING DEADLINES

January/February: 12 January

Copy deadline: 15 January

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**Tel.** +44 (0)117 930 1090

**Fax** +44 (0)117 930 1178

**E-mail** andrew.hardie@ioppublishing.co.uk

**cerncourier.com**

## MEETINGS

**Snowmass 2001, A Summer Study on the Future of Particle Physics** will take place in Snowmass, Colorado, on 30 June – 21 July 2001 with Ronald C Davidson and Chris Quigg as co-chairmen. Contact Cynthia M Sazama, Conference Office, MS 122, Fermi National Accelerator Laboratory, PO Box 500, Batavia IL 60510-0500; e-mail "sazama@fnal.gov"; fax +1 630 840 8589.

**The XXI Physics in Collision Conference** will take place on 28–30 June 2001. Contact Department of Physics, Seoul National University, Seoul 151-742, Korea. Soo-Bong Kim is the chairman.

For more information, see "http://neutrino.snu.ac.kr/pic2001".

**The 4th Southern European School of the European Physical Society – Physics in Medicine** is being hosted by the Portuguese Physical Society and the University of Algarve at the University of Algarve, Faro on 1–12 September 2001.

The School is intended for young postgraduate and final year graduate physicists, and for hospital technical personnel, from Southern Europe and Northern Africa. Participants will hear the most recent scientific and technological advances in Medical Physics; the talks are designed to broaden the participants' understanding of physics in medicine and to familiarize them with the latest advances in related technological applications.

The main topics to be discussed are: radiation physics and detectors (Maria Conceição Abreu), biophysics (Leonor Cruzeiro-Hansson), brain activity (Eduardo Ducla Soares), cardiovascular physiology (David Evans), respiratory activity (Manuel Paiva), medical physics (João José Pedroso Lima), magnetic resonance imaging (Steffen Petersen), brain modelling (Carla Silva), the status of clinical medical physicists (Marina Téllez), lasers in medical physics (Sigrid Avrillier) and Monte Carlo simulations applied to radiotherapy (Luís Peralta).

The deadline for registration is 30 April 2001. There are some scholarships available; these should be requested by 28 February 2001. For registration forms and further information, please visit "http://www.ualg.pt/eps-school" or e-mail "eps@ualg.pt".


At the opening of the "Poland at CERN" industrial exhibition at CERN on 17 October, 19 specialist high-tech companies displayed their wares. Left to right: **Kazimierz Stepien**, CERN Supplies, Procurement and Logistics Division Leader **Karl-Heinz Kissler**, Ministry of Economy Undersecretary of State **Henryk Ogryczak**, CERN director-general **Luciano Maiani**, State Committee for Scientific Research Under Secretary of State **Malgorzata Kozlowska** and National Atomic Energy Agency President **Jerzy Niewodniczanski**.


**Anil Kakodkar**, director of the Bhabha Atomic Research Centre and chairman-designate of the Indian Atomic Energy Commission and Secretary of India's Department of Atomic Energy signs CERN's VIP visitors' book, watched by LHC project director **Lyn Evans** (left) and research director **Roger Cashmore**. India is a significant supplier of equipment for CERN's LHC collider.


The new INTAS committee of scientists for field 1A – particle and nuclear, theoretical and plasma physics. Left to right: Secretary **Federico Ferrini**, **Noah Brosch** of Israel, **Maurice Jacob** of CERN and **Emilio Migneco** of Italy.

INTAS is an independent association formed by the European Community, its Member States and like-minded countries acting to preserve and promote the valuable scientific potential of the INTAS partner countries through East–West Scientific co-operation. The second CERN–INTAS call for proposals, directed to LHC experiments at CERN, is now open.

An attraction at CERN this summer was an exhibition organized by the Library of ETH, Zurich, to mark the centenary of Wolfgang Pauli (September p30). Seen here at the exhibition are organizers (left to right) **Rudolf Mumerthaler**, **Margit Unser** and **Herbert Funk** from the ETH Library.

# Sidorov turns 70

*Veniamin Sidorov.*

Veniamin Sidorov was 70 on 19 October. An outstanding member of Gersh Budker's Siberian school, he started his career in Kurchatov's Institute after graduating from Moscow in 1953. His inventiveness and experimental skills were shown while creating a unique multichannel time-of-flight neutron spectrometer for nuclear reactions, and later in experiments performed both at the Niels Bohr Institute in Copenhagen and in Moscow.

Since 1961 Sidorov's life has been closely linked to the Institute of Nuclear Physics, Novosibirsk, where he joined the pioneer work on electron colliders. Their successful commissioning earned the Lenin Prize of 1967. Sidorov's laboratory had to develop novel techniques of particle detection for collider experiments. Successful solutions allowed QED tests, studies of vector mesons and observations of the two-photon production, and created a base for future high-precision experiments at electron–positron colliders.

For more than 20 years, Sidorov, with his numerous followers, systematically studied electron–positron annihilation into hadrons using successively complicated detectors, from OLYA and ND to CMD-2 and SND at VEPP-2M, from MD-1 to KEDR at VEPP-4. The low-energy collider VEPP-2M was particularly fruitful: large data samples collected over 25 years significantly improved our knowledge of the properties of light vector mesons.

In 1989 Sidorov and other Novosibirsk physicists were awarded the USSR State Prize for the high-precision measurement of the mass of various particles from the kaon to the upsilon based on the elegant method of resonance depolarization also developed in the Budker Institute.

In the late 1980s Sidorov's interests helped initiate work on low-dose digital X-ray devices for medical diagnostics. First developed and produced at the Budker Institute, they were useful for a range of medical studies and are now in mass production at two Russian factories. His organizing abilities are used in his position as deputy director of one of Russia's largest and most dynamic physics centres.

## AWARDS

**Jim Peebles** of Princeton and **Allan Sandage** of the Carnegie Institute have been jointly awarded the first Gruber Foundation Cosmology Prize. Each winner receives $150 000. Sandage was honoured for "his relentless pursuit of the true values of the Hubble constant, the deceleration parameter and the age of the universe." Peebles "with rigour and imagination advanced our understanding of phenomena which range from the creation of the lightest elements to the formation of galaxies and the cosmic distribution of matter and radiation". The Gruber prize will be awarded annually to an astronomer, physicist or mathematician selected by an international board of cosmologists.

## ELECTION

Bekzhad Yuldashev, director-general of the Institute of Nuclear Physics (INP) in Ulugbek, Tashkent/Uzbekistan has been elected president of the Uzbekistan Academy of Sciences. The INP is a member of the CMS collaboration building a major detector for CERN's LHC programme.

**This year marks the 100th anniversary of the birth of the famous French nuclear physicist Frédéric Joliot-Curie (1900–1958). With his wife Irène, the daughter of Pierre and Eve Curie, he discovered artificial radioactivity in 1934. In the following year, the husband-and-wife team were awarded the Nobel Chemistry Prize. At the anniversary event, a commemorative plaque was unveiled outside the famous Institut du Radium in Paris. Seen here by the plaque are the Joliot-Curies' son Pierre Joliot-Curie and daughter Heléne Langevin-Joliot, themselves both distinguished scientists.**

# Joe Weber 1919–2000

Quantum electronics and gravity specialist Joe Weber died on 30 September. He was primarily known for his pioneering work in quantum electronics and for being the first to think of, design, build and operate a detector for gravitational radiation. He was a brilliant physicist, and a man of great courage and optimism.

Weber was born on 17 May 1919 in Paterson, New Jersey. After his initial education he was appointed to the US Naval Academy by a senator from New Jersey as a result of a competitive examination, and was old enough to take up the appointment after one year. He stated: "I stood first in my class in thermodynamics, differential calculus and other subjects of very little interest to the Navy." He was commissioned as Ensign in June 1940 and posted to the aircraft carrier Lexington (which steamed out of Pearl Harbor on 5 December 1941).

After the sinking of the carrier in the Battle of the Coral Sea (1942), Weber was given command of a submarine chaser. After the war, as a result of early experience as a radio amateur and work with radar during the war, he was put in charge of electronic countermeasures for the Navy, in which capacity he distributed significant quantities of grant money to assorted industrial and university research groups.

A number of them offered Weber jobs when he resigned his commission as Lt Commander in 1948, but he accepted a position as full professor of electrical engineering at Maryland, with the condition that he get a PhD in something, somewhere, soon. He moved to the Physics Department in 1961, and retired in 1989 as Senior Research Scientist and Professor Emeritus. He gave his first public talk of any kind on what is now called quantum electronics (masers and lasers) in a June 1951 meeting of the American Physical Society.

Weber published his first paper in the open literature on the subject in 1953. He received his PhD from the Catholic University of America in 1951 for work with Keith Laidler on the microwave inversion spectrum of ammonia. He became interested in general relativity and trying to build a bridge between theory and the laboratory in the late 1950s. His work was published in *General Relativity and*

*Joe Weber 1919–2000.*

# American Physical Society Prizes

The prestigious prizes and awards of the American Physical Society for 2001 include:

- The Hans Bethe Prize to **Gerald E Brown** of the State University of New York, Stonybrook, for his insightful analyses of the effects of various nuclear constituents on nucleon interactions and nucleon structure, and his contributions to new viewpoints on supernovae, neutron stars and black hole formation;
- The Tom W Bonner Prize to **Claude Lyneis** of Berkeley and **Richard Geller** of Grenoble for their critical leadership in conceiving and developing the electron cyclotron resonance (ECR) ion source and advanced ECR source, which have opened a new era in heavy ion studies of nuclear phenomena;
- The Dannie Heineman Prize to **Vladimir Arnol'd** of the Steklov Institute for fundamental contributions to our understanding of dynamics and of singularities of maps with profound consequences for mechanics, astrophysics, statistical mechanics, hydrodynamics and optics;
- The Keithley Award to **James E Faller** of NIST for the development of sensitive gravitational detectors and their successful application in the study of physics and geophysics;
- The Lilienfeld Prize to **Lawrence Krauss** of Case Western Reserve for outstanding contributions to the understanding of the early universe, and extraordinary achievement in communicating the essence of physical science to the general public;
- The Maria Goeppert-Meyer Award to **Janet Conrad** of Columbia for her leadership in experimental neutrino physics, particularly for initiating and leading the NuTeV decay channel experiment and the Mini-BooNE neutrino oscillations experiment, which are noted for their timeliness and significance in resolving frontier issues in neutrino physics;
- The Lars Onsager Award to **Bertrand Halperin** of Harvard for his wide-ranging contributions to statistical physics and quantum fluids, especially the elucidation of low-dimensional electronic phenomena; and for his exemplary leadership in bringing theory to bear on the understanding of experiments;
- The W K H Panofksy Prize to **Paul Grannis** of the State University of New York, Stonybrook, for his distinguished leadership and vision in the conception, design, construction, and execution of the D0 experiment at the Fermilab Tevatron proton–antiproton collider;
- the J J Sakurai Prize to **Nathan Isgur** of Jefferson Laboratory, **Mikhail Voloshin** of Minnesota and **Mark Wise** of Caltech for the construction of the heavy quark mass expansion and the discovery of the heavy quark symmetry in quantum chromodynamics, which led to a quantitative theory of the decays of c and b flavoured hadrons;
- and the Robert R Wilson Prize to **Claude Pellegrini** of UCLA for his pioneering work in the analysis of instabilities in electron storage rings, and his seminal and comprehensive development of the theory of free-electron lasers.

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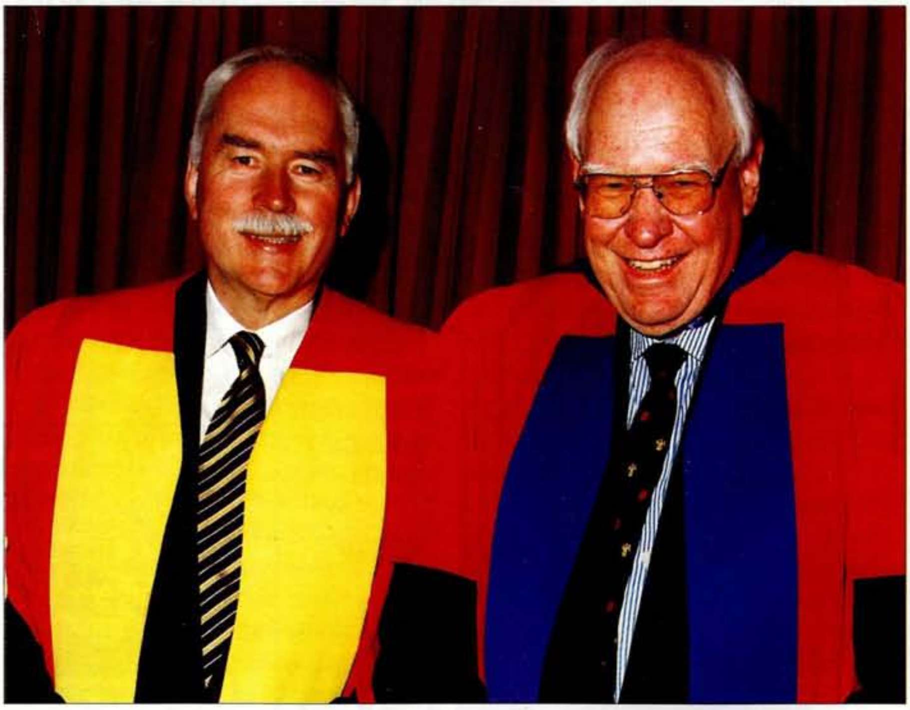
*Gravitational Radiation* in 1961.

He designed and built the first detectors for gravitational radiation (first published data in 1969) including both the bar antenna design (which he used) and the free-mass interferometer (built by his student/postdoc Robert L Forward at Hughes Research Laboratories in the early 1970s).

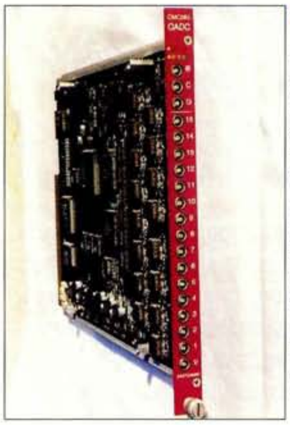
In the 1980s Weber conceived a possible coherent mode for detecting neutrinos (analogous to Mossbauer scattering of gamma rays) using single nearly-perfect crystals of silicon and quartz, and operated prototype detectors as a solar "telescope" near a research nuclear reactor (as part of an effort for the remote detection of nuclear submarines).

Professor Weber was a Life Fellow of IEEE and APS. He was a member of IAU, AAS, the Italian Physical Society and the Astronomical Society of the Pacific, and an honorary member of the Astronomical Society of India. He was awarded Guggenheim and Fulbright fellowships, prizes from the Gravity Research Foundation, Sigma Xi and the NY Academy of Sciences.

His wife, astronomer Virginia Trimble, provided this synopsis.



**At a graduation ceremony at Witwatersrand University, Johannesburg, South Africa, Achim Richter (left) of Darmstadt Technical University and former chairman of CERN's ISOLDE Experiments Committee was awarded an honorary doctorate. He is seen here with Friedel Sellschop of Witwatersrand University (p9).**



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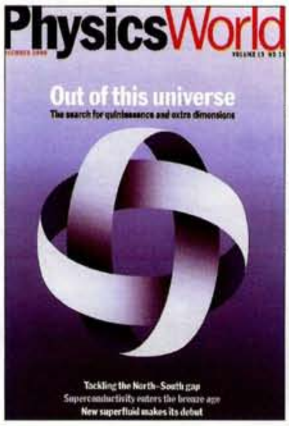


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# BOOKSHELF

**The World Wide Web was conceived at CERN to allow particle physicists easy access to information, wherever it was and they happened to be. It was a great success, so great that it went on to take the whole world by storm – a veritable communications revolution.**

***CERN Courier* News Editor James Gillies teamed up with CERN World Wide Web pioneer Robert Cailliau to write a detailed history of modern telecommunications, particularly as seen through CERN eyes. As the book points out, the fact that the Web was invented at CERN "is no accident".**


*Above left:* CERN Courier *News Editor James Gillies (right) and CERN World Wide Web pioneer Robert Cailliau are seen here with the Next computer on which Cailliau and Tim Berners-Lee launched the world's first Web site at CERN in 1990. The computer on the right registers the number of Web sites currently active throughout the world. The display was specially arranged for the recent LEP celebration at CERN (p24). Below left: The mouse that roared – the first-ever computer mouse in the hand of its inventor Doug Engelbart. It was demonstrated at the 1968 Fall Joint Computer Conference in San Francisco.*

**How the Web was Born** by James Gillies and Robert Cailliau, Oxford University Press, ISBN 0192862073, pbk.

This book is a surprising, ambitious, interesting and courageous account of a series of developments culminating in the invention at CERN of the World Wide Web. It is not only a history of the Web – it covers in considerable detail the necessary evolution of networks, personal computers and software technology which enabled Tim Berners-Lee's brilliant creation of the Web in 1989.

I say "surprising" because it had seemed to me that enough good Internet histories had already been written (Salus 1995; Hafner and Lyon 1996; Randall 1997). Furthermore, Berners-Lee's own account *Weaving the Web* was published only last year (Berners-Lee 1999). However, there is much new material in this book. I call it "ambitious" and "interesting" because it covers all the surrounding areas in depth and is not afraid to follow sidetracks, personalities and anecdotes, which are always the key to attracting and holding a reader's attention.

The book reveals the quirky human attitudes and the bureaucratic and business struggles which make this a real human story rather than just a dateline of cold technological developments. Finally, it is "courageous" because, although written by two CERN authors, it is truthful even about those parts of the story which are not too flattering to CERN.

There is not much to criticize. The first 10 pages on telephones and LANs contribute little, are messy and may deter some readers from reaching the true start of the story. My attention was first aroused on p11 by the phrase: "The Birth of the Internet: On 31 January 1958, the United States launched Explorer I, its first satellite, though few now remember that."

There are some minor slips of detail: for example, STELLA was a CERN satellite project, not an Italian one (p81), and began in 1978, not in 1981 (p317). The proofreading of the book was also not up to my expectations of Oxford University Press.

Essentially, however, this book makes a major contribution. I believe the authors have succeeded with their aim "to tell a story of human endeavour, and to provide a good read in the process". They stress the multiplicity of contributions of many individuals over half a century, including the essential ones and without forgetting the elements of accident and personality which often proved crucial.

Humour abounds: Senator Edward Kennedy, in congratulating the Boston team that had won a contract for an ARPANET Interface Message Processor (IMP), refers to it as an "interfaith" processor. When the first IMP was delivered to UCLA and found in horror to be upside down in its crate, a team member declared this only "meant that it had been turned over an odd number of times". This was after finding that the IMP had survived.

There is also much wisdom, such as that of Frank Heart, manager of the small Bolt, Beranek and Newman team developing the IMP, which he described as follows: "All the software people knew something about hardware, and all the hardware people programmed. It was a set of people who all knew a lot about the whole project. I consider that pretty important in anything very big." Thirty years later, nothing much has changed.

The battles of culture and practice between proprietary, ISO and TCP/IP networking, fought to the death between the late 1960s and the early 1990s, are handled with insight and accuracy. This is required reading for today's younger generation, many of whom surprise me by their casual ignorance of what was for some of us a struggle over many years, dividing colleagues, damaging careers and delaying progress towards the now realized dream of a networked world.

Culture and practice continue to collide in the later chapters, where we approach the fateful few years where all the strands will meet. Berners-Lee's personal trajectory is followed, showing how his curiosity and taste for research was nurtured and amplified by contact with like minds, first by his parents, teachers and other early influential figures, and later by collaboration and discourse with CERN colleagues and the blossoming Internet community. With the Web idea launched outside CERN, the germination and maturation of the software worldwide is then traced in detail, including the NCSA/Mosaic/Netscape saga and the demise of competing products like Gopher and Archie.

The book captures the rare combination of Berners-Lee's talents: steady vision, broad interests and detailed attention. It shows the triumph of a mind that could arrive at something simple, starting from a situation where things were deeply complicated beforehand. The idea that order could be created in the chaotically non-standard environments of document exchange and networking as they stood in the late 1980s was simply unbelievable for practically everyone at that time.

Berners-Lee's success serves as a living ▷

example of the power and the necessity of the KISS principle – "Keep It Simple, Stupid" – which tells us to be humble in the face of the world's ever growing complexity. There is also a quality in him of those inexperienced youngsters, recruited by Data General during a classic underground project to develop the world's fastest minicomputer, specifically because they were too naive to know that certain things "can't be done" (Kidder 1981).

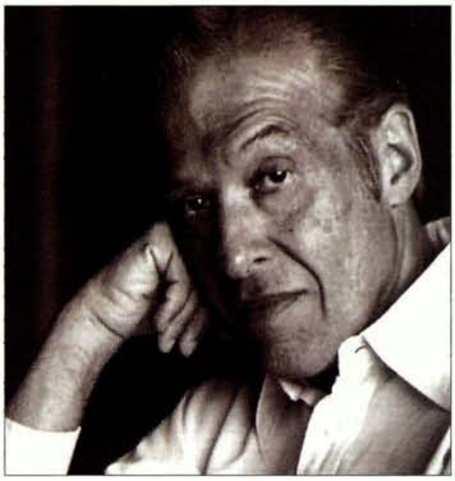
Why, if it was all so simple, did the Web take so long to arrive – 20 years after the start of the Internet? And why at CERN? This latter question is carefully examined by the authors, who say "it is no accident that it happened at CERN" and cite several supporting reasons. For me, the most convincing reason was Berners-Lee's own statement that it was "...a question of being in the right place at the right time...in the right environment", and: "...with great bosses in Peggie Rimmer and Mike Sendall, and a lot of stimulating colleagues, all prepared to think outside the box".

The other burning question addressed by the book is: why did CERN "give away" the Web and lose its creator to MIT? It is a complex matter, taking up the entire last chapter of the book. Starting with Berners-Lee's chance meeting with Michael Dertouzos of MIT/LCS, a complex web of interests and rivalries is traced between US and European players: CERN, INRIA, NCSA, MIT, Mosaic Communications and the European Commission. Bluff, counterbluff and misunderstandings succeeded each other. But the bottom line appears to be that CERN, fighting a life-or-death battle for approval of the LHC project, lacked basic commitment to a non-physics activity, even one of such huge potential.

The book is dedicated to the memory of two people: first to Donald Davies, pioneer of packet switching, the most essential of all Internet components; and second to Mike Sendall, who in 1989 "did not say no to Tim Berners-Lee and consequently the Web got off the ground". Let me wholeheartedly applaud that conclusion: not saying no to the young and starry-eyed is one way the world can advance from chaos to order, from the impossible to the imaginable.

*Ben Segal, CERN.*

• *Ben Segal is currently leader of CERN's Technology for Experiments Section, responsible for development in areas including High Performance and Storage Area Networks and CERN's online Central Data Recording service, and is responsible for Data Management within the new European "Data Grid" Project. From 1985 until 1988, he served as CERN's first TCP/IP coordinator, responsible for the introduction of the Internet protocols within CERN. In 1995, he was a co-founder of the Internet Society (ISOC).*



*Julian Schwinger – seminal papers.*

**Further reading**

K Hafner and M Lyon 1996 *Where Wizards Stay up Late* Simon & Schuster.
P Salus 1995 *Casting the Net* Addison Wesley.
N Randall 1997 *The Soul of the Internet* Thomson.
T Berners-Lee 1999 *Weaving the Web* Harper.
T Kidder 1981 *Soul of a New Machine* Atlantic Monthly Press.

**A Quantum Legacy – Seminal Papers of Julian Schwinger** edited by Kimball A Milton, World Scientific Series in 20th Century Physics, vol. 26, ISBN 9810240066, 808pp, $99/£62.

Julian Schwinger, in the post-war period, pioneered quantum electrodynamics (QED), together with Richard Feynman and Sin-Itiro Tomonaga, and it is for this monumental work that they shared the Nobel Prize for Physics in 1965 – as the Nobel Committee put it: "...for their fundamental work in quantum electrodynamics, with deep-ploughing consequences for the physics of elementary particles".

However, it would be rather diminishing to Schwinger to call the attention of the public only to his most rewarded piece of work; in fact, Schwinger's manifold contribution in almost all areas of theoretical physics has permeated scientific literature ever since. At the age of 16, at the City College of New York in 1934, he wrote his first paper, "On the interactions of several electrons", where he introduced the so-called "interaction representation" in quantum field theory. This is the first of his papers to appear in the collection.

Milton, now a professor at Oklahoma, was one of Schwinger's last post-docs, and followed him when, in 1971, Schwinger moved from Harvard to UCLA. (Incidentally, 1971 was the year of a big earthquake in Los Angeles, as was 1994, the year he died.) Two papers co-authored by the editor are included here.

At the same time as this book, a companion volume appears – a biography of Schwinger, *Climbing the Mountain*, written by Milton himself with Jagdish Mehra, and which was reviewed in last month's issue (p45) by Robert Finkelstein of UCLA, one of Schwinger's closest friends.

The seminal papers chosen to be reproduced in *A Quantum Legacy* (44 of the 185 papers that Schwinger wrote in his lifetime) complement a previous volume, edited by Milton with Christian Fronsdal of UCLA and the late mathematical physicist Moshe Flato of Dijon, which appeared in 1978, on the occasion of Schwinger's 60th birthday. In that volume, 53 publications, specially selected by their author, were included, with his own commentaries for each piece of the collection.

In the present volume, Milton honours the late physicist by including those influential papers that did not appear in the first volume; he also included two unpublished papers, one already alluded to, written when he was a teenager, and the other, written in 1945, "On radiation by electrons in a betatron".

*A Quantum Legacy* opens with an introduction to Schwinger's life, particularly the post-war period and the foundation of QED. In fact, if Richard Feynman's contribution was the most popular, it was Schwinger who first "climbed the mountain", when new experimental data were presented at the Shelter Island Meeting in June 1947 by Lamb and Rutherford, confirming the splitting between the $2S_{1/2}$ and $2P_{1/2}$ states of hydrogen. Results from another experiment by Kusch and Foley proved the existence of the anomalous magnetic moment of the electron (Lamb and Kusch shared the Nobel prize in 1955).

A historical biography of that period, by Silvan S Schweber, unrolling the dramatic sequence of experimental results and theoretical interpretations, appeared in 1994 under the title *QED and the men who made it:*

*Dyson, Feynman, Schwinger and Tomonaga.*

The present collection divides the seminal papers by Schwinger according to the different areas in which he worked: first "Quantum electrodynamics I, II and III" (written between 1948 and 1949), where his formulation of QED was given. Then come "Spin and angular momentum", "Nuclear physics", "Classical electrodynamics", "Quantum field theory", "Many-body theory" and "Magnetic charge". These are followed by two chapters with several invited papers and popular talks by Schwinger on "Quantum mechanics" and "The importance of research". The last five chapters contain mainly Schwinger's work of the Los Angeles period, on "Source theory", "Deep inelastic scattering", "Casimir effects", "Supersymmetry" and "Statistical atoms".

As the editor concludes: "It is impossible to do justice in a few words to the impact of Julian Schwinger on physical thought in the 20th century. His legacy includes theoretical tools such as the proper-time method, the quantum action principle and the effective action techniques. Many formulations bear his name: the Rarita-Schwinger equation, the Lippman-Schwinger equation, the Tomonaga-Schwinger equation, the Dyson-Schwinger equation, the Schwinger model for dynamical mass generation, and so forth."

I share his opinion that it is hard to imagine what physics would be like at the end of the millennium without the contributions of Julian Schwinger, a private man but a great scientist and a superb teacher with dozens of the now best established theoretical physicists among his students, including three Nobel laureates: Sheldon Glashow (elementary particles), Benjamin Mottelson (nuclear physics) and Walter Gilbert (molecular biology).
*Sergio Ferrara, CERN.*

## Books received

**The Cambridge Handbook of Physics Formulas** by Graham Woan, Cambridge University Press, 218pp, ISBN 0521575079 £12.95/$19.95 (pbk); ISBN 0521573491 £35/$54.95 (hbk).

A useful reference work, packed with data as well as equations.

**Gateways into Electronics** by Peter Carroll Dunn, Wiley, ISBN 0471254487, 658pp.

This textbook aims to enable students in engineering and the experimental sciences to gain a quantitative understanding of modern electronics and thus design their own instrumentation. It contains numerous exercises and examples for students to work through.

**Quantum Computation and Quantum Information** by Michael Nielsen and Isaac Chuang, Cambridge University Press, ISBN 0521632358, £80/$130 (hbk); ISBN 0521635039 £29.95/$47.95 (pbk).

In such a new and fast-developing field such as quantum computing, it is always good to have an authoritative introduction for newcomers. This book is designed to be accessible by those who do not necessarily have a background in quantum physics. □

# VIEWPOINT

# The internationalism of science as an ideal

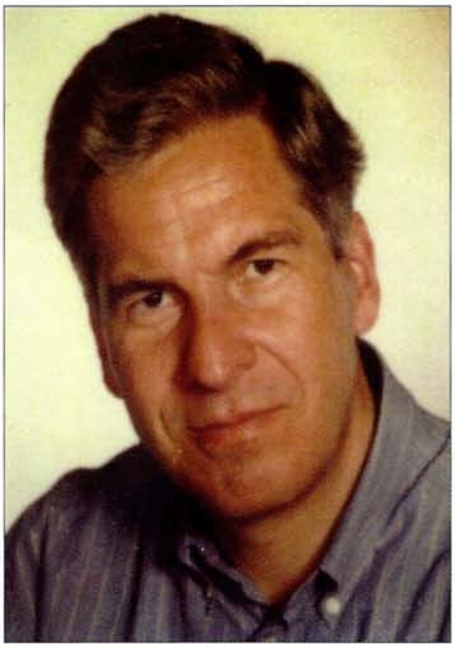
The Olympic Games are held up as the most international of all events. It is accepted that the athletes "compete for their nation" and make up "national teams". These are (unofficially) ranked according to how many medals they win, and the "most successful nations" show up. This success is taken as a benchmark of the effectiveness of training, the mood of a nation, and so on. One is tempted to compare this to the situation in science. Here the credo is: science is international. But is this really true?

There is of course a compelling reason why science has to be international. The goal of science is to find a complete and provable description of our world. This implies that the description has to be independent of the views of individuals. It must not depend on the national, ethnic, cultural or family background of a scientist or consider any other subjective aspect – science has to be, among other things, international. Only in this way can it develop a universal idea of the world.

Nevertheless, national feelings are real for a large majority, as the Olympic Games show. Does this mean that scientists have reached a higher state of collaboration and culture?

The answer is a clear yes. Excellent proof of this is CERN. Anyone who has worked there will confirm that one loses one's nationality. In his book *The Joy of Insight* (Basic Books 1991), Victor Weisskopf, who served as CERN's director-general from 1961 until 1965, wrote: "I insisted that anyone who entered CERN be regarded as a European and no longer a citizen of some nation."

Very little attention is paid to physicists' nationality – only the quality of their scientific work counts. This is unavoidable because the ever-increasing complexity and size of physics projects surpasses individual abilities. The collaboration, imposed initially by the requirements of the project, becomes a habit and finally a conviction. This mechanism works equally well in all parts of the world.



While international collaboration has become the backbone of Big Science, national undercurrents could erode these achievements. *Thomas Walcher* looks at some of the potential problems for physics journals.

However, we also know that this conviction is challenged. Nations try to gauge the performance of science as they do with other activities – sport, art, the economy, and so on.

This leads to a dilemma. On the one hand, Nobel prizes are counted, evaluations by national agencies carried out, publications counted and their impact assessed. Are national science administrators swimming against the tide of international science?

Here a particular role is played by scientific journals. The visibility and quality of national journals have been and are still taken as a measure of national scientific excellence. Such ambitions lead, however, to deplorable situations, such as favouring the work of one nation to the detriment of others.

The only solution to this problem is that publishing culture has to follow that of science itself and abandon nationalism. Several competing international journals should be maintained in the interest of science. However, since national feelings are so strong and not all scientists can work at CERN, it may be necessary to install an international "ombudsboard" to referee what goes on and pass judgement as necessary.

A frequently formulated hope is that national cultures too could embrace scientific internationalism. This feeling has developed as contacts between scientists improve due to cheaper travel and improved communications.

Knowing other people helps to overcome the feelings of insecurity and personal insufficiency for which ardent nationalism naturally compensates. The need for exchange is the key – it is no accident that the World Wide Web was invented at CERN and not by Microsoft.

*Thomas Walcher, Mainz.*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