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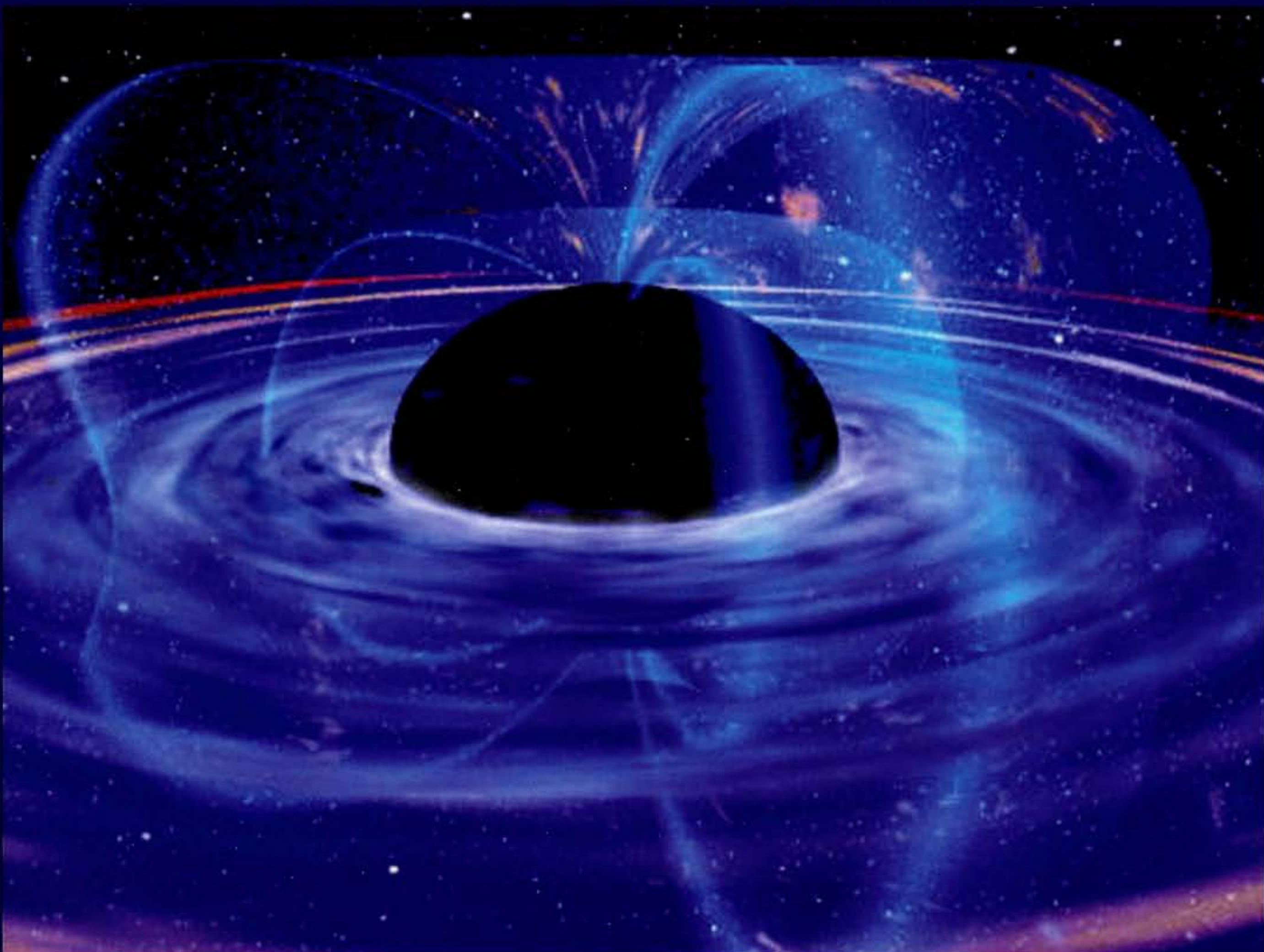

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Covering current developments in high-energy physics and related fields worldwide

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Pull-out guide to research suppliers – see centre pages

Cover: Why does a black hole produce more X-rays than expected? For a possible answer, see the Picture of the Month on p17.

CERN

Going into the cold: LHC systems reach an important milestone

The technical systems for CERN's forthcoming Large Hadron Collider (LHC) reached an important milestone earlier this year with the successful commissioning of String 2 – a chain of prototype LHC magnets complete with all of the necessary powering, control and protection systems. String 2 is the final testbed for validating LHC systems before the new accelerator is installed in its tunnel ready for its start-up in 2006.

When the LHC starts up in five years' time, it will be the world's largest superconducting installation of any kind. Nearly all of its main magnets, some 2000 in total, will be bathed in superfluid helium at 1.9 K. Such a low temperature is required to keep the magnets superconducting, but maintaining it presents many challenges. The cold mass of each magnet is installed inside a vacuum vessel and rests on high-tech composite feet that are actively cooled from room temperature to 1.9 K over 25 cm. A similar active cooling scheme is used for the cables that monitor the magnets.

The String 2 test installation for CERN's Large Hadron Collider.

String 2 is the first LHC systems testbed to be built to the LHC's final design and it is the last chance for LHC engineers to validate their design choices before the installation of the new accelerator underground. In its current configuration, String 2 consists of three prototype dipole magnets, two quadrupoles, and a full-scale prototype distribution line for the cryogenic fluids that cool the magnets. Three more dipoles are scheduled to be added, which will turn String 2 into a full cell of the LHC accelerator. Completing the String 2 set-up are 15 electrical powering circuits with final-design power converters, and a digital current regulation system capable of measuring magnet currents to a few parts per million.

String 2 was cooled down to 1.9 K in mid-September for systems validation tests. The LHC's superconducting magnets are sensitive devices. If any part of their cable winding heats up, it provokes what is known as a quench – the magnet ceases to superconduct and the energy stored inside it has to be dissipated. Testing the systems that detect quenches and protect the magnets was the first part of the validation programme and was carried out before the magnets were ramped up to nominal current of 11 850 A on 27 September. A full programme of system validation tests in which the entire String is being put through its paces is now under way. All systems are being tested in normal running conditions, during the ramping up and down of the magnet currents, and during provoked quenches.

Accident ruins major detector

On 12 November, thousands of photomultipliers imploded in the huge Superkamiokande detector in Japan, which has produced important results on neutrino physics.

The detector uses 50 000 tonnes of pure water, 1000 m below ground, and it is monitored by 11 200 large (50 cm diameter) photomultiplier tubes. Most of these tubes were destroyed, also wreaking havoc with the detector infrastructure.

Superkamiokande director Yoji Totsuka vowed: "We will rebuild the detector."

Correction

In the November issue of *CERN Courier* (in the picture story about Andrzej Bialas on p29) we unfortunately described the historic Jagellonian University as being located in Warsaw. It is, of course, in Cracow. The university, which was founded in 1364, is one of the oldest in Europe. We regret the error.

CHINA

BES accumulates 51 million J/psi events

While plans to update the Beijing Electron–Positron Collider (BEPC) and the Beijing Spectrometer (BESII) experiment go ahead (*CERN Courier* October p6), the BES experiment has completed its second highly successful run at the J/psi resonance this year.

The first run began in November 1999 and lasted until May 2000. The second lasted from December 2000 until May 2001. BES accumulated 24 million and 27 million J/psi events in the two running periods respectively, making a total of 51 million events (figure 1). This is the world's largest sample of J/psi events produced from electron–positron annihilation. Previous large data samples of 6–8 million J/psi events were collected by MARKIII (SLAC, Stanford), DM2 (DCI, Orsay) and BES (Beijing) experiments. The new sample will allow the properties and decays of the J/psi to be studied with unprecedented precision.

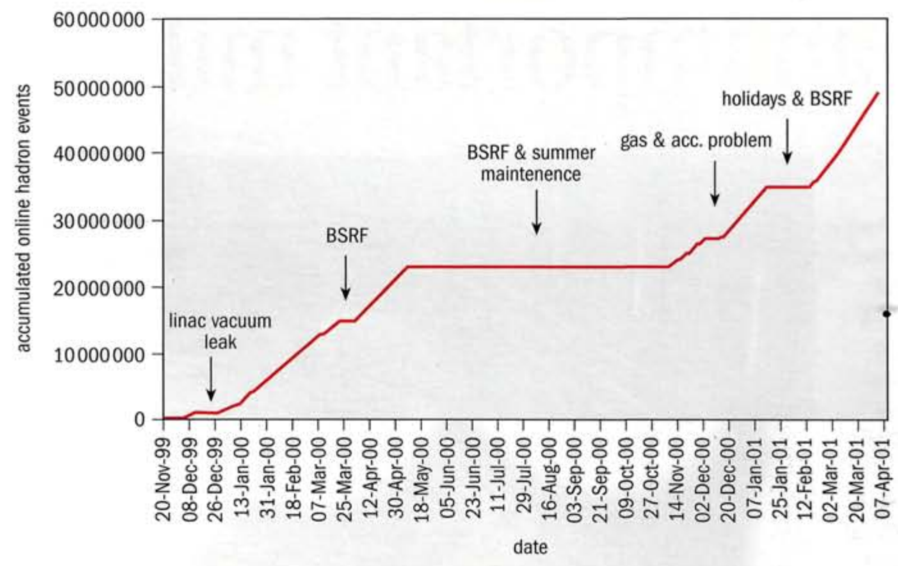
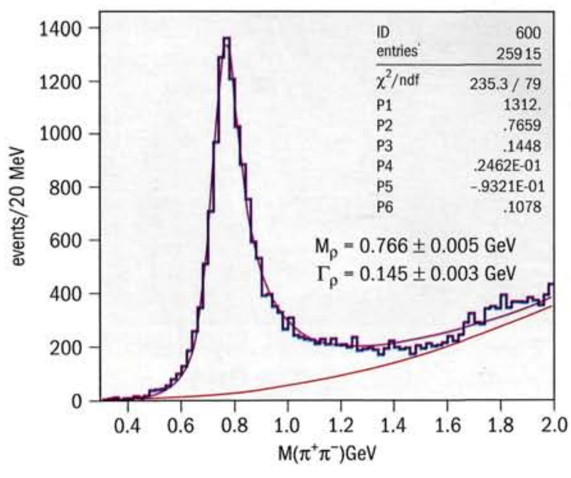


Fig. 1: Record score – accumulated J/psi events collected with the BESII experiment at the Beijing Electron–Positron Collider. BSRF means Beijing Synchrotron Radiation Facility.



The resonance peak showing the production of rho mesons in the decay of J/psi into a rho and a pion. The rho decays into a pion pair.

The discovery in 1974 of the J/psi particle, composed of a charmed quark and antiquark, was crucial in establishing the quark model. In this model, almost all observed mesons and baryons can be described as composite objects made of quarks that are held together by the strong nuclear force. The theory that describes this is called quantum chromodynamics (QCD). In this theory, the carriers of the strong nuclear force are gluons and the quarks are held together by the exchange of gluons.

However, QCD also predicts the existence of exotic hadrons. These are glueballs, which are made up entirely of gluons, and hybrids, which contain both quarks and gluons. Masses of glueballs and hybrids are predicted by lattice QCD calculations and other theoretical models. Establishing the existence of exotic hadrons experimentally is very important in order to confirm QCD.

Many experiments have searched and some exotic hadron candidates have been reported (*CERN Courier* October 1997 p14, for example), but they have not yet been confirmed to everyone's satisfaction. J/psi decays are excellent places to search for these exotic particles.

During the latest BES run, the luminosity increased gradually. A peak BEBC luminosity of $5 \times 10^{30}\ cm^2/s$ was attained and a record number of 0.42 million J/psi events were accumulated in one day. After completion of the first round of reconstruction of all J/psi events, careful off-line calibration of the data shows that the BES detector performed well with a barrel time-of-flight resolution of 180 ps, energy loss rate resolution of 8% and a momentum resolution of 1.78%.

According to QCD, radiative decays of J/psi particles, where a photon is also produced in the decay, are regarded as an important process to search for glueballs. Physicists at BES have started to study radiative decays of J/psi particles, including those producing a pair of neutral kaons, a proton–antiproton pair and so on. Searches for possible 0^{++} and 2^{++} glueball candidates will be made. BES is carrying out detailed analyses on many different J/psi decays to determine the spin and parity of the final states.

The large J/psi sample will also allow many other studies. Hadronic decays of the J/psi provide a wealth of opportunities for searching for hybrids; studying light meson spectroscopy; observing excited baryonic states; measuring SU(3) mixing angles; and probing lepton flavour violation and CP violation.

Weiguo Li and Frederick A Harris.

GREECE

DELPHI goes home to Delphi

Although CERN's LEP electron-positron collider finished operating in November 2000, analysis of the enormous amount of data it produced will continue for some time. On 19–25 September the collaboration of the DELPHI experiment held a meeting in Delphi, on the slopes of Mount Parnassus in Greece, to discuss recent results.

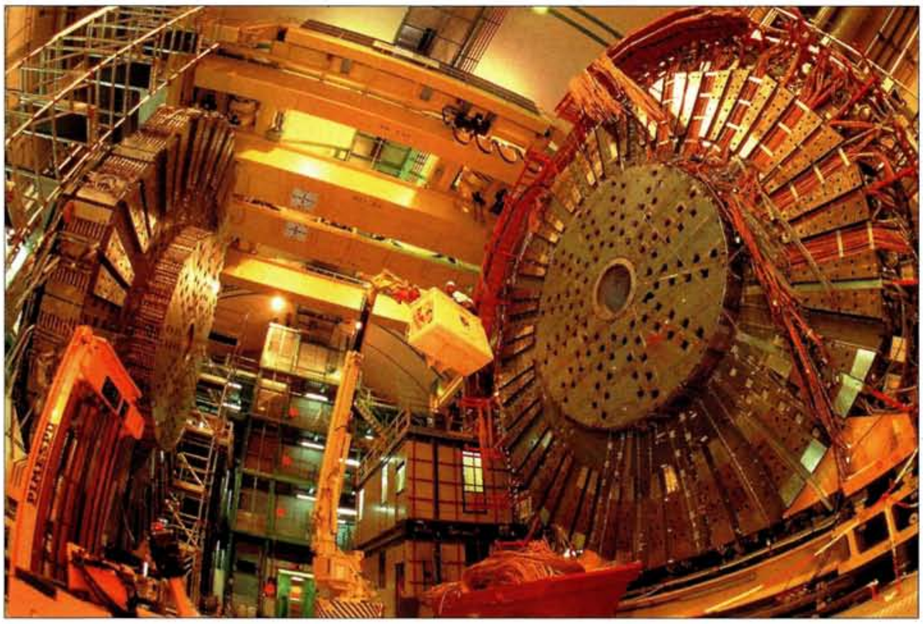
The name DELPHI is an acronym (DEtector with Lepton, Photon and Hadron Identification), but the collaboration includes several groups from Greece. When the name was chosen, in 1982, these groups immediately invited the collaboration to hold a meeting in Delphi. This took place in June 1983, at the start of DELPHI construction.

The return to Delphi in 2001 was therefore something of a sentimental journey. However, only eight people participated in both meetings. An impressive number of young people now working on DELPHI analysis were only in high school at the start of the experiment.

The meeting was organized by DELPHI's three Greek groups (National Technical University, University of Athens and Demokritos) under the chairmanship of Theodora Papadopoulou of NTUA.

The opening session was addressed by NTUA rector Themistoclis Xanthopoulos. Although himself an engineer, Xanthopoulos stressed the need for supporting fundamental research and he expressed concern that, with the increasing emphasis on the market economy in university education, funding for basic research would come under great pressure.

Talks concentrated on the progress towards the finalization of the precision measurements of the parameters of the W and Z bosons; their couplings; testing the Standard Model at the highest energies yet obtainable; and the searches for new particles.



The DELPHI experiment being dismantled at CERN.

The DELPHI collaboration returns to its spiritual home.

The searches for the particles predicted by supersymmetry seem to have drawn a clear blank throughout the entire LEP2 energy range, already ruling out most versions of the model. On the other hand, the search for the elusive Higgs boson – the origin of electroweak symmetry breaking and the boson responsible for particle masses – ended on an ambiguous note, with some suggestion that LEP had been on the verge of a major discovery (*CERN Courier* March p25). A session called "Elementary particle physics – theory and experiment" was attended by 60 physics teachers from local high schools.

The opinion of all of the participants was that the meeting was a worthy successor to the 1983 meeting. It was remarkable to witness how LEP and DELPHI, together with all of the other experiments, had surpassed the design expectations formulated some 20 years ago.

The meeting highlighted the important contributions being made by Greek high-energy physicists and hopefully will contribute to assuring support for this significant work.

DETECTORS

Specialists re-evaluate transition radiation

Transition radiation is playing an increasingly important role in the armoury of detection techniques for particle physics. A recent specialist workshop at Bari surveyed progress in this area.

When a fast-charged particle crosses the boundary between two media with different dielectric constants, the abrupt change in the electric field triggers the emission of electromagnetic radiation. If the particle energy is very high, the emitted photons are soft X-rays that can be collected easily.

Transition radiation was first predicted by V L Ginzburg and I M Frank in 1944, and in 1957 G M Garibian showed the feasibility of functional transition radiation detectors (TRDs). Since then TRDs have been successfully used in a number of experiments, mainly in high-energy particle physics and astrophysics.

Transition radiation has three major features that influence the design of these detectors:

- the total radiation energy emitted at the boundary is proportional to the particle's Lorentz factor – the ratio of its total energy to its rest mass energy;
- the average number of photons emitted per boundary is rather small – about 1/137;
- the emitted photons travel in practically the same direction as the charged particle.

The first feature suggests two major applications – either to discriminate between particles with different masses and the same momentum or to measure the energy of a known particle.

The second feature means that, in order to have a significant number of photons, many boundaries are required. This can be achieved either by means of "regular radiators" built with many evenly spaced foils or with "irregular radiators" made of foams or fibres.

The third feature is something of a drawback, because the charged particle, if not deflected, releases energy by ionization in the same region as where the emitted photons must be detected: this effect requires careful design of the radiation detector and adequate data analysis techniques.

Beam testing at CERN for a carbon-fibre transition radiator used in conjunction with silicon strip detectors and a permanent magnet to separate the particles from the emitted X-ray transition radiation.

The Bari workshop examined the latest results and evaluated the future evolution of these detectors. The main subjects covered were the use of TRDs in currently operating experiments; the development of new concepts for radiators and radiation-detection devices; and the progress in engineering and electronics, mainly in view of high-rate accelerator experiments and high-performance set-ups to be operated on satellites.

After an overview by C Fabjan (CERN) on the renaissance of particle identification, K Ispiryan (Yerevan) gave a historical review of the pioneering theoretical and experimental steps in the field and later discussed the feasibility of a ring TRD, which is conceptually similar to a ring imaging Cherenkov detector.

M Cherry (Louisiana) gave a survey of applications in cosmic-ray and high-energy physics, and B Dolgoshein (Moscow) introduced new concepts for particle identification by TRDs. The installation and performance of a TRD in the future experiment AMS02 on the International Space Station was described by T Kirn (Aachen), while E O'Brien (Brookhaven), A Romaniouk (Moscow) and J Wessels (Heidelberg) presented, respectively, PHENIX, ATLAS and ALICE – the detectors to be included in large accelerator experiments.

A crucial TRD element is the X-ray detection device. F Gargano and M N Mazziotta (Bari) examined the possibility of using silicon detectors instead of the traditional gas chambers, while V Tikhomirov (Moscow) discussed the feasibility of a radiator/detector combination based on a two-component scintillator. D Cambiaghi (Brescia) talked about the mechanical design of instruments for a space environment.

The workshop paid attention to the process of the design, development and testing of TRDs, illustrated by several examples: from the GEANT simulations by P Nevski (CERN) to the design considerations for the transition radiation tracker (TRT) in ATLAS by H Danielsson (CERN) and the study of xenon-based gas mixtures by V Sosnovtsev (Moscow). The physics goals, trigger architecture and prototype tests of the TRD for the ALICE experiment were described by A Andronic (GSI-Darmstadt), B Vulpescu and V Angelov (Heidelberg).

TRDs also have valuable applications in cosmic-ray physics. F Loparco (Bari) presented the muon energy measurement performed by the TRD of the MACRO underground experiment, while F Cafagna and P Spinelli (Bari) showed the particle identification features of the TRD of the PAMELA satellite experiment.

The next workshop in the series is tentatively planned for May 2003.

The workshop was organized with the support of the Italian Institute for Particle Physics (INFN), the Italian Space Agency (ASI) and the physics department of Bari University and Polytechnic. The proceedings will be published by INFN-LNF SIS-Pubblicazioni.

Piergiorgio Fusco, Nicola Giglietto and Paolo Spinelli, Bari.

DETECTORS

Aging workshop provides a useful review of the long-term use of gaseous detectors

About 90 detector experts participated in the international workshop on aging phenomena in gaseous detectors at DESY.

Detectors, like people, encounter problems as they get older. However, with foresight and experience, these problems can be minimized and even overcome. The recent international workshop on aging phenomena in gaseous detectors, which was held at DESY in Hamburg on 2–5 October, saw some 90 experts from 17 countries grappling with the dreaded "aging effects" that occur in gaseous particle detectors.

The workshop provided a long-overdue exchange of experiences concerning this specialized topic, which is of increasing importance in the high-rate era of today's collider projects. The previous workshop on the subject had been held at Berkeley more than 15 years ago.

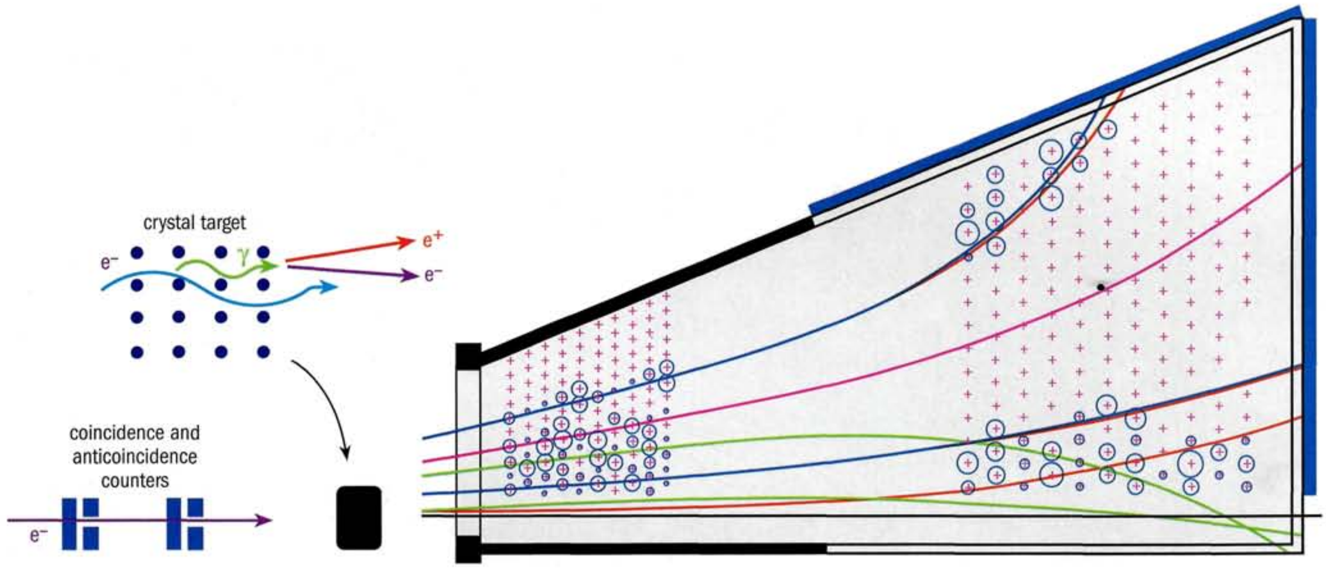
Through 50 talks and posters the participants reviewed aging effects that can seriously impede the operation of gaseous detectors or even render them inoperable. Besides the well known, yet still poorly understood, aging due to gas polymerization, lesser-known anode swelling and etching effects in gas mixtures containing oxygen and fluorine compounds (CF_4, for example) were widely discussed. Presentations on gases and materials for detectors and gas systems stressed that very careful selection and testing of all system components are imperative to ensure the survival of detectors.

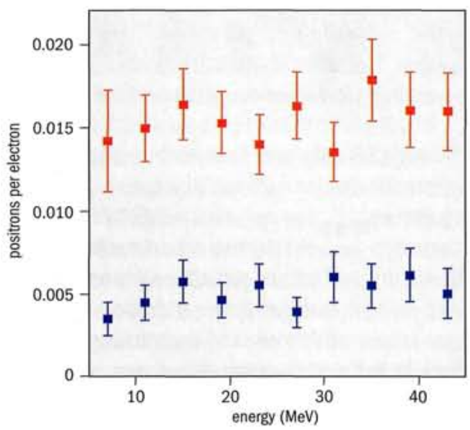
The long-term experience with large drift chamber operation in experiments at various colliding beam machines – HERA (DESY), LEP (CERN) and the Tevatron (Fermilab) – were reviewed as well as more recent high-rate results from HERA-B detectors and prototype detectors for LHC experiments at CERN. Aging in classical drift chambers and tubes, and in various forms of microstrip gas detectors, was discussed. Special sessions dealt with aging problems in photosensitive detectors and resistive plate chambers, in the BaBar and BELLE experiments at the new B particle factories, for example.

Transparencies and videos of talks as well as posters are available at the workshop Web site at "http://www.desy.de/agingworkshop". The proceedings of the workshop will be published as a special issue of *Nuclear Instrumentation and Methods A*.

PARTICLE SOURCES

Channelling produces new sources





Above: the experimental set-up for monitoring positron production by different targets.
Left: a comparison of the positron energy spectra obtained for a tungsten crystal oriented on its <111> axis (top) and for an amorphous target of the same thickness.

For future electron–positron linear colliders, high-intensity electron and positron beams are needed. These must be sufficiently well defined (low-emittance) in order to reach a high luminosity at the collision point. While intense electron beams can be produced without major difficulty, the production of intense positron beams is more of a problem.

A significant R&D effort is under way in many laboratories to find a positron source satisfying the requirements of intensity and emittance and being reliable over long periods of time. Recently an experiment on a special kind of positron source carried out at CERN yielded promising results.

The basic route to creating positrons is via the production of hard photons (gamma rays) by electron–positron pairs in a material. In conventional sources, a powerful electron beam hits an amorphous target (without any particular crystal orientation). In such a target the electrons are attracted by the nuclei and radiate photons (*bremsstrahlung*). These in turn produce electron–positron pairs in the target. The rates for these two successive steps increase by the square of the atomic number of the target, so that heavy nuclear materials, such as tungsten, are preferred.

Another approach is to use a crystal, the atomic rows of which are aligned with the incident electron beam, instead of an amorphous target. Here the electrons will be attracted not only by the individual nuclei but also by many successive nuclei of a same row, as though the atomic mass were multiplied by the number of successive nuclei. This gives more intense radiation (coherent *bremsstrahlung*).

An electron can even revolve around the atomic row many times. It is then "channelled" and radiates as though it were a helicoidal undulator, the period of which would be in the order of 1 μm, with a field equivalent to thousands of Teslas. This channelling radiation, which is even more intense than coherent *bremsstrahlung*, gives more electron–positron pairs.

Crystal targets are therefore thinner than amorphous ones that give the same number of positrons. This is useful for limiting the energy deposited in the target and, hence, the heating.

The aim of the WA103 experiment, carried out at CERN in 2000 and 2001 after similar experiments at Orsay (France) and KEK (Japan), was to observe and measure the enhancement of positron production by a crystalline source and to measure the energy and angular distributions of the emitted positrons.

An electron beam of 5–40 GeV was used in the West Hall of CERN's SPS synchrotron. Two incident energies were selected – 6 GeV and 10 GeV – the former corresponding to the choice of the Next Linear Collider; the latter to

# of positrons

the Japanese Linear Collider.

The experimental set-up accommodated different kinds of target – all crystal (8 mm) or compound (4 mm crystal followed by 4 mm of amorphous target). The emitted positrons are detected in a drift chamber partially in a magnetic field. The part of the chamber outside the magnetic field provides the positron emission angle, while that in the magnetic field provides the positron momentum. The emitted photons are monitored in a preshower detector and in a "spaghetti" calorimeter (scintillating fibres in lead).

Different laboratories took part: LAL-Orsay (acquisition electronics and goniometer); IPN-Lyon (simulations and goniometer control); the Max-Planck Institute, Stuttgart (tungsten crystals); the Budker Institute, Novosibirsk (conception and realization of the drift chamber, track reconstruction programme and simulations); and the institutes of Kharkov and Tomsk (photon detectors). The spaghetti calorimeter was provided by LNF-Frascati. The tests on the detectors were carried out at LAL-Orsay with the participation of the Budker Institute and IPN-Lyon physicists. Data-taking was done by Franco-Russian teams in which the physicists from the Budker Institute played an essential role. In this long collaboration, physicists from the College de France-Paris participated in the initial simulations.

The first results showed the channelling enhancement, which was close to that predicted by simulations. Comparison of the positron energy spectra obtained for a tungsten crystal oriented on its <111> axis and for an amorphous target of the same thickness showed a positron yield boosted by a factor of 3–4 for a 4 mm target and a 10 GeV electron beam.

A boost slightly larger than 2 is seen for the 8 mm crystal target. A large number of soft positrons were also seen, which is very interesting for the accelerator acceptance downstream of the target. The observations made on the photon detectors confirmed the enhancement of the number of photons and of the radiated energy.

This appears to be a very promising avenue for future linear colliders.

COSMOLOGY

Arctic Circle maintains the freshness of ancient physics

A recent meeting underlined the continual freshness of studying the ancient history of the universe. Cosmology, which studies the structure of the universe, has been developing rapidly in the past few decades. The number of articles on cosmology, astrophysics and even astronomy in recent issues of *CERN Courier* testifies to this. Improved observational means and an increased understanding of particle phenomena in the early universe have transformed cosmology from a speculative philosophy into an exact science, yielding diversified knowledge about the laws of nature.

In summarizing the recent COSMO-01 meeting in Rovaniemi, Finland, Mike Turner of Fermilab and Chicago showed a suitably regional portait of dark matter candidates.

In 1997 particle physicists interested in cosmology recognized the need for a regular workshop dedicated to particle astrophysics and particle cosmology. Particle astrophysics includes, in broad terms, studies of and searches for relic particles and other remnants from the early universe constituting dark matter, as well as neutrino astrophysics, which gives important information about neutrino properties. Particle cosmology deals with particle aspects of the physics of the very early universe: inflation, reheating, cosmological aspects of Grand Unified Theories and strings, baryogenesis, phase transitions and other aspects of symmetry breaking. To complete the picture, particle physicists also need to make contact with purely gravitational issues, with the possible need to rewrite general relativity and with purely astronomical work leading to the determination of cosmological parameters.

The first workshop in the series, COSMO-97, was held in the Lake District, England; COSMO-98 was held in Asilomar, California; COSMO-99 was held in Trieste, Italy; and COSMO-2000 was held in Cheju Island, Korea. This year's meeting, COSMO-01, was held in Rovaniemi, Finland, right on the Arctic Circle, on 30 August – 4 September. In Finland, research in cosmology started in the early 1980s and today it is one of the most fruitful research fields in the physics department of the University of Helsinki and in the Helsinki Institute of Physics. New impetus and new resources have arrived since Finland joined the European PLANCK project, in which Finnish theoreticians and instrument builders have specific responsibilities.

The Rovaniemi programme comprised 33 invited plenary talks and 63 contributed talks in two parallel sessions. The plenary speakers treated aspects of inflationary cosmology, quintessence cosmology, string cosmology, extra dimensions, the ekpyrotic universe, baryogenesis, Big Bang nucleosynthesis, phase transitions, the angular power spectrum of the cosmic microwave background, large-scale structure, magnetic fields, dark matter, cosmological parameters, neutrino astrophysics and ultrahigh-energy cosmic rays.

The proceedings of the workshop will be published in the SLAC electronic conference proceedings archive and in the Los Alamos arXive astro-ph. Meanwhile, all of the presented material in both plenary and parallel sessions is linked to the workshop Web site at "http://www.physics.helsinki.fi/cosmo_01".

The next workshop in this series will be held on 18–21 September 2002 in Chicago.

Matts Roos, Helsinki.

PHYSICS

Why do high-energy collisions contrive to produce so few particles most of the time?

The collisions produced by the new generation of high-energy hadron machines – Fermilab's revamped Tevatron for protons on antiprotons, Brookhaven's RHIC for heavy ions and CERN's LHC for protons and heavy ions – create (or will create) lots of secondary particles. The study of these high-multiplicity collisions is a central feature of modern particle physics.

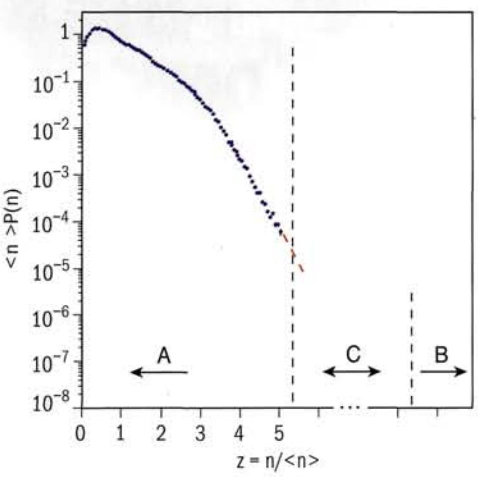
More than 90% of the events in high-energy experiments are inelastic, providing a broad background for more specific processes investigated using the conventional Standard Model. A "new" approach highlights a seldom investigated region of Very High Multiplicity (VHM) physics.

Although producing many particles, these VHM events (region C in the figure) are rare, making up only about 10^{-7} of the total cross-section at the LHC energy. However, their investigation is thought to be extremely important, not only as background for modern experiments, but also to address fundamental questions.

In principle, all of the collision energy is available to make new particles. However, in practice, most of the secondary particles emerge carrying a lot of kinetic energy, so that less energy is available for the production of additional particles.

What suppresses the production of additional particles?

Confining attention to the small VHM region where many additional particles are created could help to elucidate the question and possibly shed more light on the underlying colour charge confinement phenomenon.



Particle production: the lower multiplicity region (A) is the result of processes with well known multiperipheral kinematics. The next region (B) includes processes near the kinematical limit, where the momenta of produced particles are smaller than their mass. The VHM events (C) are extremely rare, making up only about 10^{-7} of the total cross-section at the LHC energy. (The horizontal axis is the ration of observed multiplicity to the mean value. The vertical axis is proportional to the ratio of the specific reaction rate – cross-section – to the total cross-section.)

VHM processes may also have played an important role in the evolution of the universe in the immediate aftermath of the Big Bang, because VHM states may be produced only via a high-energy density of initial states. The VHM states have remarkable "calmness" and "coldness", and they provide a bridge between kinetic energy and rest mass.

An initial approach is to look at multiple hadron production as a thermal dissipation of incident kinetic energy into produced mass, using Schwinger–Keldysh real-time thermodynamics (Manjavidze and Sissakian 2001). This has analogies with previous work by Bogolyubov.

This shows that the domain where complete thermalization is achieved is just the VHM domain. If so, the minority VHM physics may be especially "simple". However, standard physics approaches are no longer valid for these rare processes. Recent workshops in Dubna and in Varna, Bulgaria focused on these questions.

With so much understanding at stake, it is important that experiments at the LHC, the Tevatron and the RHIC turn their attention to this problem. The third workshop on VHM physics will held in Dubna on 3–6 June 2002.

Reference

J Manjavidze and A Sissakian 2001 *Phys. Rep.* **346** 1.

N Giokaris, Fermilab and University of Athens.

UNDERWATER

Antares detector deployment progress is on target for 2004

The Antares undersea neutrino experiment, scheduled for deployment 2400 m down in the Mediterranean off the south coast of France, successfully laid its sea cable at the beginning of October. This is the first important milestone on the way to the deployment of a full detector by 2004.

Antares (*CERN Courier* June 2000 p28) will study neutrinos by detecting muons produced through neutrino interactions in the rock or seawater near the detector. In its first incarnation it will have 10 strings of photomultipliers anchored to the seafloor in a 0.1 km^2 array. These will all be powered from and read out through the standard underwater telecommunications cable that was laid in October. A sonar system will monitor the relative positions of the photomultipliers and, somewhat unusually for a particle physics experiment, bioluminescent fish will form an important source of background.

A proof-of-principle experiment was successfully carried out from 1996 to 1999 and, all being well, the Antares collaboration hopes to scale up to a full 1 km^3 after completion of the first phase of the experiment.

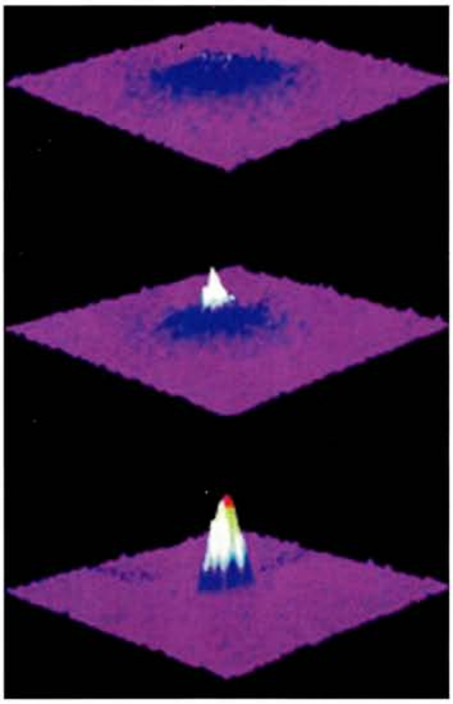
Edited by Archana Sharma

Cold atoms promise versatile atomic chips

Using a microelectronic chip to hold a cloud of cold atoms hovering above it, physicists in Germany may have developed an "atomic chip" that might eventually shunt Bose–Einstein condensates around an atom chip – just as electrons are shunted around a conventional silicon chip.

This tiny circuit creates and manipulates a peculiar state of matter called a Bose–Einstein condensate (p21). Previously these condensates were made using light or magnetic fields to cool and confine a gas of atoms. Electric currents travelling through wires in the atom chip create a confining magnetic field barely 1 mm wide. This field holds a cloud of 1600 rubidium atoms at a height of less than a tenth of 1 mm above the chip surface.

Quantum mechanics dictates that atoms, being so small, have wavelike properties. Normally each wave bobs up and down independently. However, in a Bose–Einstein condensate all of the atomic waves are "coherent" – moving in step, in the same quantum state. Instead of behaving like a collection of atoms, such a condensate behaves as a single superatom – as one quantum-mechanical wave containing many identical particles. Condensates can be fashioned into very small structures, below the resolution limits of existing fabrication techniques. This may permit the increasing miniaturization of electronics.



Bose–Einstein condensate – a new route for microelectronics?

There are also fundamental reasons for wanting to control and manipulate Bose–Einstein condensates. For example, they allow researchers to look at poorly understood aspects of quantum theory, such as the process of decoherence – when coherent quantum systems are disturbed by interactions with their environment. Such studies should be easier with the new atom chip. Because the device confines the condensate on such a small scale and in very tight traps, it will be easier to tailor the properties of the atom cloud to suit a particular experiment.

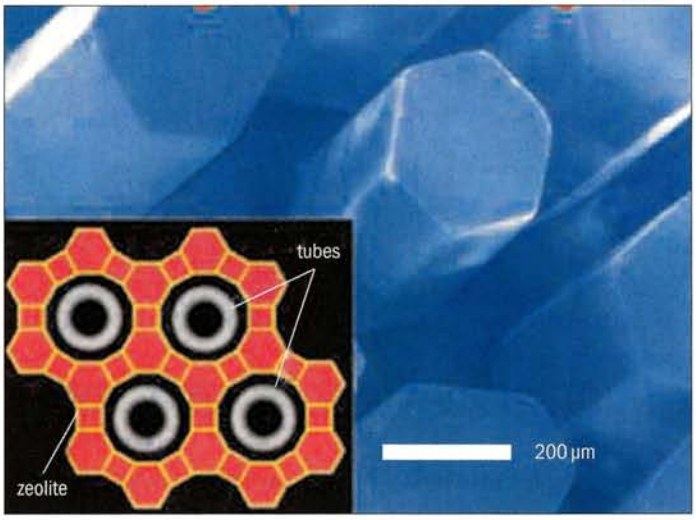
Further reading

W Hansel *et al.* 2001 *Nature* **413** 498–501.

Small-diameter nanotubes can become superconducting

Nanotubes (p15; *CERN Courier* January p26) may be made only of carbon, but their unusual shape and size give them a host of intriguing electronic properties, the most recently discovered being superconductivity.

Physicists in Hong Kong have shown that nanotubes with exceptionally small diameters become superconducting at relatively high temperatures. The researchers used their own technique to synthesize single-walled nanotubes inside the channels of zeolite crystals. The tubes, which have diameters of only 4×10^{-8} cm, appear to become superconducting at about 15 K – much higher than the liquid helium temperatures normally associated with superconductivity.



Carbon nanotubes have intriguing electronic properties.

These latest results have come soon after a report from French and Russian researchers that reveals that small bundles of single-walled nanotubes superconduct – albeit at a low temperature of 0.55 K.

Calculations indicate that the smaller the tube diameter, the higher the superconducting temperature. This is due to the greater curvature of the tube, which increases the interaction between electrons and lattice vibrations (phonons) – a property that is essential for superconductivity.

Some scientists associate this extreme curvature with the superconductivity of fullerenes (large carbon molecules). Alkali metal-doped fullerenes superconduct at up to 40 K and electron hole-doped fullerene crystals superconduct at 52 K. The group will now try doping the nanotubes to see if it can increase the superconducting temperature even further.

Further reading

M Kociak *et al.* 2001 *Phys. Rev. Lett.* **86** 2416.
Z K Tang *et al.* 2001 *Science* **292** 2462.

Dutch team uses nanostructures to produce logic gates, an oscillator and electron beams

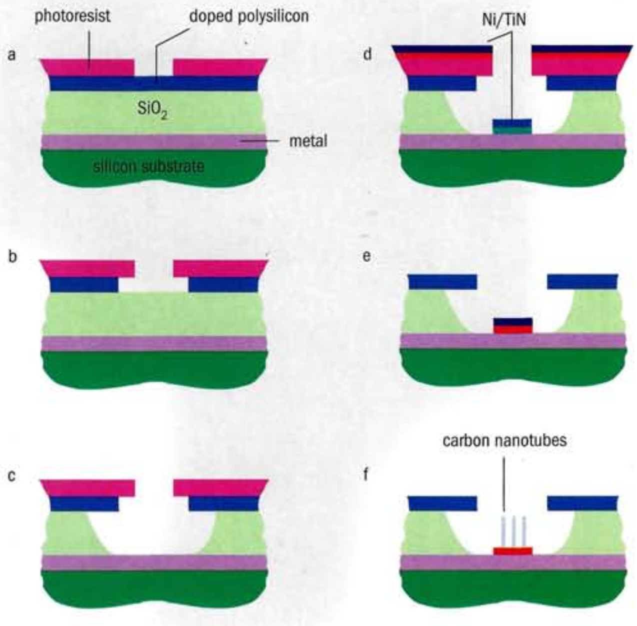
Developments show that carbon nanotubes – rolled-up sheets of graphite about 1 nm in diameter (p14; *CERN Courier* January p26) – could provide the technology of tomorrow.

The ever-shrinking world of electronics has become even smaller following the first demonstration of digital logic circuits made from carbon nanotubes. A research team in the Netherlands used different combinations of "nanotube transistors" to create several devices, including a voltage inverter and a NOR logic gate. As conventional silicon microelectronics approach a fundamental size limit, these devices, operating at room temperature, are an important step towards nanoelectronics.

Nanologic – a carbon nanotube field-effect transistor.

Carbon nanotubes have been used to make a variety of electronic components, including diodes and field-effect transistors (FETs). A FET can be made from a nanotube by attaching gate, source and drain electrodes.

Now several of these FETs have been placed together on a single silicon chip to form different circuits. Their simple inverter device consists of a nanotube FET and a large bias resistance. It converts a high-input voltage to a low one – that is, "one" to "zero" – and vice versa. By adding an extra FET in parallel, the researchers made a NOR gate, needing two "zero" inputs to give a "one" output or two "ones" to give a "zero".



The self-aligned fabrication process for microcathodes.

Any of the standard logic gates can be created using different arrangements of these FETs. The team also created a "static random access memory" and an oscillator. The devices have gains of a factor of 10.

Electron-beam lithography was used to deposit aluminium gate electrodes on a silicon wafer. The nanotubes were placed on top, and gold electrodes were added using an evaporation technique. There are still challenges to overcome, such as the difficulty in positioning the nanotubes accurately on the wafer, but emerging techniques, including a way to grow nanotubes directly on the chip, may solve this problem.

This could lead to electron-beam lithography equipment for chip making that could produce parallel beams as well as electron microscopes, based on a first report of field emission measurements from carbon nanotubes with an integrated gate electrode from a French-UK team.

The nanotubes are used as field-emission sources in the device. The integrated gate electrode enables the device to achieve emissions at low field voltages. The team used a self-aligning technique, similar to the technique used to pattern CMOS gates, to create the gate, the insulator and the base for growing the nanotubes with one lithography mask.

With the gate aperture formed, the nanotubes are grown inside using plasma-enhanced chemical vapour deposition. This ensures that the nanotubes are always centred in the gate apertures, which are just 2 μm in diameter.

The major achievement of this work is the self-alignment of the multiwalled 30 nm diameter carbon nanotubes. The next step is to grow one carbon nanotube per nanohole and to have it perfectly centred in the gate aperture. Preliminary results show that it is possible. A single nanotube per gate would boost the efficiency of the applied field by avoiding the electric field screening when nanotubes are close together. The nanocathode is intended for parallel electron-beam lithography and microscopy. Other applications could be in instrumentation and microwave vacuum amplifiers.

Further reading

A Bachtold *et al.* 4 October 2001 *Science* "http://www.sciencemag.org/cgi/content/abstract/1065824".

Edited by Emma Sanders

Astronomers celebrate sight of two million year old 'baby'

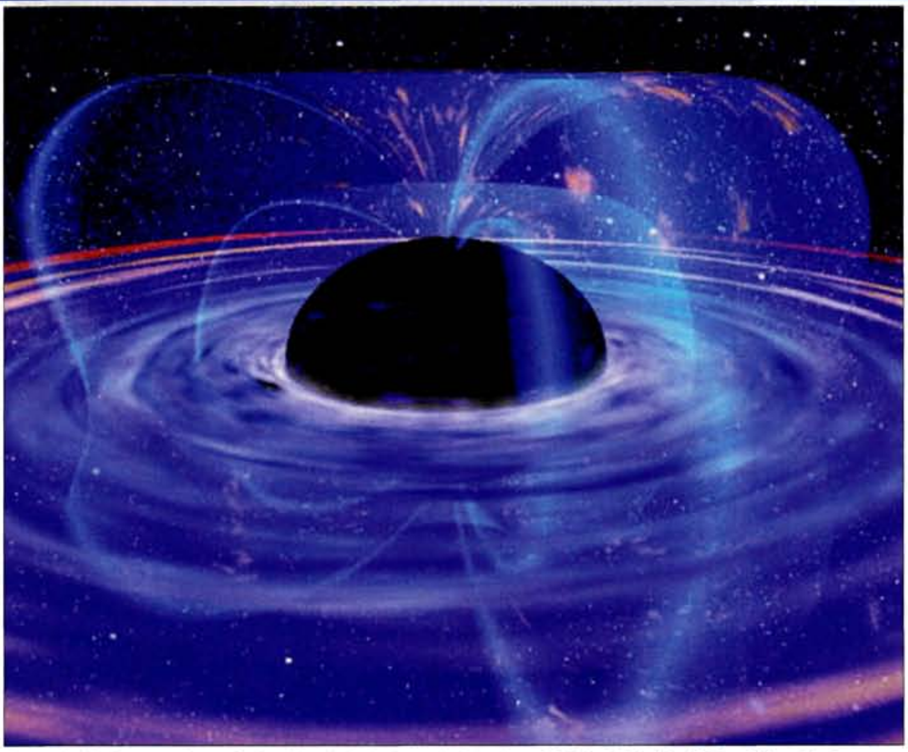
A very small, faint galaxy more than 13.4 billion light-years from Earth is creating a great deal of excitement among astronomers. This protogalaxy, which is just 500 light-years across (a two-hundredth of the size of the Milky Way), is thought to be one of the building blocks of today's galaxies. It may prove to be an important missing piece in the puzzle of how and when the first stars and galaxies formed in the universe.

The discovery was made thanks to the gravitational lensing of light from the distant protogalaxy by a huge cluster of galaxies along the line of sight. The cluster effectively magnified the light from the protogalaxy.

The protogalaxy was first identified from images taken from the Hubble Space Telescope archive, and further observations of its spectrum were made using the two 10 m Keck telescopes in Hawaii. The observations reveal a 2 million year old, 1 million solar mass, galaxy-like object consisting of young hot stars.

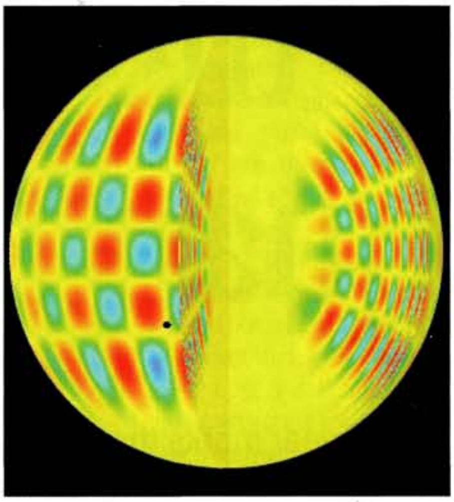
Previous galaxies discovered at high redshifts are extremely bright. This is the first time that a faint protogalaxy has been analysed, owing to the amplification of its signal by the gravitational lens.

Picture of the month



An artist's impression of the black hole in spiral galaxy MCG-6-30-15, 100 million light-years away. Observations were made of X-ray emission corresponding to the presence of iron in the accretion disc around the black hole using the XMM-Newton telescope. The number of photons and their energies measured by XMM-Newton far exceeded what was expected from the established models for accretion discs of supermassive black holes. This led the researchers to suggest that energy may escape from a black hole when it is in a strong magnetic field, which exerts a braking effect. This, like most other things to do with black holes, is a matter for intense debate. (ESA.)

Noisy stars give good vibrations



Acoustic waves in a sun-like star. (European Southern Observatory.)

Sound waves running through a star can help astronomers to reveal its inner properties.

Alpha Centauri A is the nearest star visible to the naked eye, at a distance of a little more than four light-years. New observations show that its pulsation follows a 7 min cycle, very similar to that observed in the Sun. Astroseismology for sun-like stars is becoming an increasingly important probe of stellar theory. The observations were carried out by astronomers from Geneva Observatory using the CORALIE spectrometer on the Swiss 1.2 m Leonard Euler telescope at the European Southern Observatory's La Silla site.

Werner Heisenberg: the Columbus of quantum mechanics

This year marks the centenary of the birth of Werner Heisenberg, pioneer of quantum mechanics and theoretical high-energy physics. *Helmut Rechenberg*, Heisenberg's last postgraduate, co-editor of his collected works and co-author of the multivolume opus *The Historical Development of Quantum Theory*, traces the life of a quantum figurehead.

This year, 5 December marks the centenary of Werner Heisenberg's birth. It is to him that we owe the first breakthrough of modern atomic theory – the invention of quantum mechanics. His famous uncertainty relations were a central part of its interpretation. He also established several fundamental quantum mechanics applications and pioneered the extension of the theory to high-energy phenomena.

Werner Heisenberg, born in Würzburg, came from an academic family and after 1910 grew up in Munich, where he graduated with distinction from high school in 1920. He studied under Arnold Sommerfeld at the University of Munich, obtaining his PhD in July 1923 and then went on to work under Max Born in Göttingen. In 1924 Niels Bohr invited him to Copenhagen. Thus he became a member of the great international post-First World War community of quantum and atomic theorists, including such brilliant talents as Paul Dirac, Enrico Fermi, Friedrich Hund, Pascual Jordan, Oskar Klein, Hendrik Kramers, Wolfgang Pauli and Gregor Wentzel.

Fame through uncertainty: quantum mechanics pioneer Werner Heisenberg in the 1920s.

In the very first semester Sommerfeld gave Heisenberg the difficult problem of explaining the anomalous Zeeman effect of sodium spectral lines. The freshman found a perfect solution – exhibiting, however, unusual half-integral quantum numbers and a strangely behaving atomic core. Simultaneously he studied the classical hydrodynamical turbulence problem. On the publication of Heisenberg's first paper in this field in 1922, Sommerfeld remarked to Heisenberg's father: "You belong to an irreproachable family of philologists, and now you have the misfortune of seeing the sudden appearance of a mathematical-physical genius in your family." In his PhD thesis, Heisenberg suggested the first method for deriving the critical Reynolds number, marking the transition from laminar to turbulent motion. In spite of this brilliant work, he nearly failed the experimental part of the doctoral exam with Willy Wien.

The breakthrough

In 1923, contemporary atomic theory was in a deep crisis. As a way out of the situation, Pauli, who was in Copenhagen, and Born and Heisenberg who were in Göttingen, proposed replacing the semiclassical differential expressions of Bohr and Sommerfeld by corresponding discrete difference terms to predict experimental quantum results (the 1925 Kramers–Heisenberg formula, which predicted the Raman effect, for example). Heisenberg and Pauli claimed that fundamental concepts of the old theory, notably electron orbits, had to be abandoned completely.

In May 1925, in Göttingen, Heisenberg began to describe atomic systems by observables only ("quantum-theoretical" Fourier series). With this, the usual physical quantities, like position q and momentum p of an electron, did not commute but satisfied instead the relation $pq - qp = h/2\pi i$. In June 1925 when Heisenberg was recovering from a severe attack of hay fever on the island of Heligoland, he found that he could satisfy the necessary requirement of energy conservation in atomic processes. His "quantum-theoretical reformulation" was the breakthrough to modern quantum mechanics. Soon Born and Jordan reformulated it as "matrix mechanics" and Paul Dirac as "q number theory", and applied it successfully, as Heisenberg and Pauli did, to various atomic problems.

It was in 1926 that Erwin Schrödinger created wave mechanics, formally equivalent to matrix mechanics, but working with differential equations and continuous wavefunctions. Schrödinger claimed that nature exhibited no "quantum jumps" at all. Heisenberg, from spring 1926 a lecturer and Bohr's principal assistant in Copenhagen, contradicted this and in early 1927 derived the central result of the physical interpretation: simultaneous measurements of momentum and position of an atomic particle were limited by the famous uncertainty relation: $\Delta p.\Delta q \sim h$. This relation had radical consequences – the classical causality law or, expressed more generally, the possibility of a strict separation of object and subject, ceased to be valid in quantum science.

Werner Heisenberg (right) at CERN in 1960 with Giuseppe Fidecaro (left) and Edoardo Amaldi.

In the fall of 1927, Heisenberg became professor of theoretical physics at Leipzig. Together with Peter Debye and Friedrich Hund he established a new centre of atomic physics there. His first students, Felix Bloch and Rudolf Peierls, pioneered with him the quantum mechanics of solids (ferromagnetism, metals and semiconductors).

High-energy theory and elementary particles

Heisenberg's main interest, however, was a relativistic extension of quantum mechanics: with Pauli he formulated Lagrangian quantum field theory (1929). They tried to cope with the emerging divergence difficulties, achieving some progress with "renormalization" procedures (Heisenberg 1934; Weisskopf 1934). Originally they were led to expect that quantum mechanics would not apply any more at high energy. However, after the discovery of the neutron in 1932, Heisenberg proposed a quantum-mechanical theory of the atomic nucleus based on new exchange forces.

During the 1930s, nuclear theory progressed enormously, mainly through work in the US and in Japan (notably by Hideki Yukawa with his meson theory) and further at Leipzig (despite the Nazi government depriving Heisenberg of excellent students and collaborators after 1933).

From 1932 Heisenberg also turned his attention to the high-energy phenomena observed in cosmic radiation. He suggested several new ideas, such as "explosive showers", and in 1938, with his student Hans Euler, he solved the problem of the so-called "hard component" (unstable "mesotrons"). These efforts aimed ultimately at an ambitious goal that he and Pauli had envisaged: a unified quantum field theory, describing all elementary particles and their interactions, without any divergences and allowing all of their properties (such as masses and coupling constants) to be calculated. More than 30 years later they still had not reached their goal.

However, during their labours, Heisenberg and Pauli created many concepts of modern high-energy physics, such as isotopic spin (Heisenberg, 1932), spin-statistics theory (Pauli and Fierz, from 1937 to 1941), and the symmetry breaking caused by a degenerate vacuum (Heisenberg and Pauli 1958). In addition, in 1942 Heisenberg proposed the so-called "S-Matrix theory", which was widely discussed after the Second World War as a phenomenological approach in quantum electrodynamics and strong-interaction theory. Another noteworthy result was the logarithmically rising total cross-section for particle collisions at higher energies (Heisenberg 1954).

Science, politics and international relations

During the Third Reich (1933–1945), Heisenberg's life and work was made difficult not only by racism directed against his Jewish teachers, colleagues and students, but also by outright attacks on him and his scientific work. Nazi partisans considered quantum and relativity theories to be "degenerate, Jewish physics", the defenders of which "had to disappear like the Jews". In spite of these attacks, and in spite of generous offers to accept prestigious chairs in the US, Heisenberg remained in Germany, believing that he did not have the moral right to abandon his students and his country during such difficult times.

During the Second World War he was drafted into the secret German atomic energy project, working on a nuclear reactor, but not on a bomb. In 1942 he moved to Berlin to take over the directorship of the Kaiser Wilhelm-Institut für Physik (which eventually became the Max Planck Institute).

After the war he successfully helped to renew science in the Federal Republic of Germany and to re-establish international scientific relations, assisted by many friends in Europe and beyond. Thus he became a co-founder and ardent supporter of CERN (and the first chairman of its scientific policy committee). He considered international co-operation, especially in the most fundamental fields of science (such as high-energy physics), to be a "main tool to reach understanding between peoples". As president of the Alexander ▷

Heisenberg speaking at the inauguration of CERN's Intersecting Storage Rings in 1971. Also on the podium were (left to right) Edoardo Amaldi; former CERN director-general Victor Weisskopf; French Secretary of State Marcel Anthonioz; and CERN director-general Willibald Jentschke.

von Humboldt Foundation, he invited hundreds of young research scholars from all around the world to work at German universities and scientific institutes, and high-energy physics received a substantial share of these fellowships.

Werner Heisenberg died on 1 February 1976 in Munich. To commemorate his 80th anniversary, the Max Planck Institute for Physics (which he had transferred in 1958 from Göttingen to Munich) was given the additional name "Werner-Heisenberg-Institut".

The centenary is being marked by several special events. From 26–30 September a meeting with the title "100 years of Werner Heisenberg" was held by the Alexander von Humboldt Foundation at Bamberg; from 4–7 December a Heisenberg centennial event at the Max Planck Institute and Ludwig-Maximilians University, Munich, includes a two-day symposium with nine distinguished speakers from abroad; and from 3 December to January 2002 there is a Heisenberg exhibition at the University of Leipzig and at the Max-Planck-Haus, Munich. For more information, see "http://www.heisenberg-centennial.de".

Helmut Rechenberg, *Max Planck Institute for Physics, Munich.*

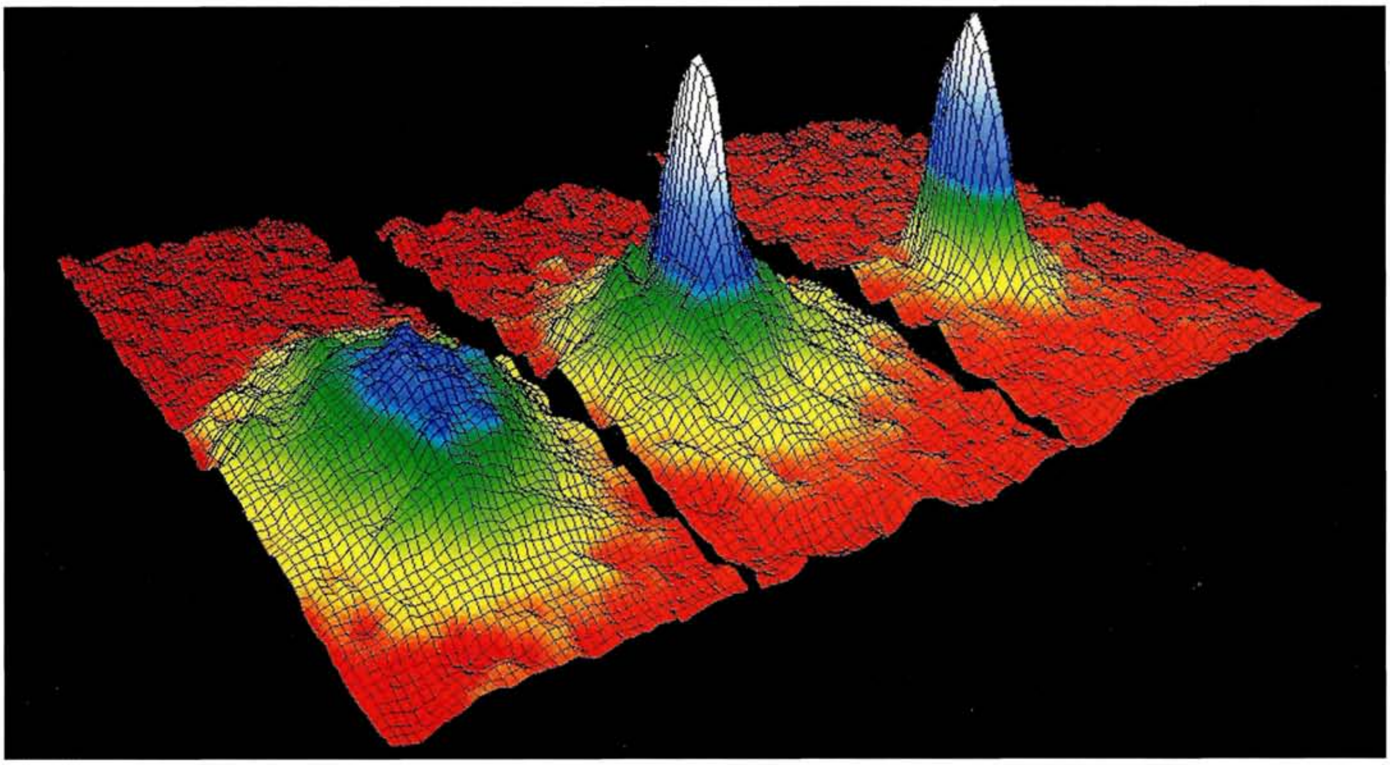
Further reading

David Cassidy 1992 *Uncertainty: the life and science of Werner Heisenberg* (Freeman).

Jagdish Mehra and Helmut Rechenberg *The Historical Development of Quantum Theory* 5 volumes (Springer).

Bose–Einstein condensation revisited

The award of the 2001 Nobel Prize for Physics to Eric Cornell, Wolfgang Ketterle and Carl Wieman for their "achievement of Bose-Einstein condensation in dilute gases of alkali atoms and for early fundamental studies of the properties of the condensates" is the latest chapter in a long history.



Nobel condensate – how alkali metal atoms come together as the temperature is decreased. The image shows Bose–Einstein condensation at, from left to right, 400, 200, and 50 nK.

One hundred years ago, some physicists began to suspect that electromagnetic radiation was packaged – or "quantized" – rather than being a continuous stream. This followed Max Planck's discovery that the spectrum of light from a hot object could be explained only if the radiators sat in discrete energy states. By 1905 Albert Einstein concluded that the radiation itself was emitted as bursts of energy – light quanta – later to be called photons. Einstein's key explanation earned him the 1921 Nobel Prize for Physics.

In 1924 Satyendra Nath Bose (see box) from Dacca University, in what was then India, wrote to Einstein asking for his help in getting a paper published. Bose had already sent it to the *Philosophical Magazine*, where it had been turned down. The paper showed how Planck's distribution law for photons could be derived from first principles. Duly impressed, Einstein translated it into German, and the paper was published in 1924 in *Zeitschrift für Physik*.

As a result, Einstein temporarily turned away from his dogged but unsuccessful search for a unified theory of gravitation and electromagnetism and started work on the quantum theory of radiation. Thus was born the concept of "Bose-Einstein" statistics for quanta ("bosons") carrying an integer value of intrinsic angular momen- ▷

Satyendra Nath Bose 1894–1974

Satyendra Nath Bose was born in Calcutta, the son of a railway worker. An outstanding physics student, he also had a talent for languages and translated milestone physics material from French and German into English for local publication. One of his efforts was a text by Einstein on General Relativity, the English-language rights for which had meanwhile been acquired by a London publisher. At Bose's request, Einstein himself intervened and allowed the Bose translation to be used inside India.

It was this episode that gave Bose, working in Dacca, the confidence to approach Einstein again in 1924 with the new derivation of the Planck radiation law: "Respected Sir, I have ventured to send you the accompanying article for your perusal and opinion." Einstein was impressed: "The Indian Bose has given a beautiful derivation of Planck's law." Soon physics history was made. Bose and Einstein met in Berlin in 1925. Bose returned to Dacca and in 1945 moved to Calcutta, where he spent the remainder of his career.

Satyendra Nath Bose – enshrined in particles.

His name is now enshrined in physics. A "boson" is a particle of integer spin that obeys Bose–Einstein statistics and is the counterpart of a "fermion", which is a particle of half-integer spin that obeys Fermi–Dirac statistics. Unlike Dirac, Einstein and Fermi, Bose did not achieve a Nobel prize. However, in 1930 Venkata Raman, also of Calcutta, earned the Nobel Prize for Physics for the light-scattering effect that bears his name. He was the first scientist from outside Europe and the US to earn the coveted award.

tum (spin). There is no limit to the number of bosons that can simultaneously occupy any one quantum state.

Einstein noted that if the number of such particles is conserved, even totally non-interacting particles should undergo a change of behaviour at low enough temperatures – Bose–Einstein condensation. Bose had not predicted this because he was looking at photons, which can simply disappear when the energy of the system is decreased.

The condensation that Einstein predicted derives from the fact that the number of states available at very low energy becomes exceedingly small. With less and less room for all of the particles when the temperature is decreased, they accumulate (condense) in the lowest possible (ground) energy state.

Superbehaviour and its effects

Even before this was going on, the liquefaction of helium by cryogenic pioneer H Kamerlingh Onnes (1913 Nobel Prize for Physics) opened up new areas of physics study. Materials cooled by liquid helium to within a few degrees of absolute zero showed bizarre behaviour. However, it took time for the real nature of these effects, which are now known as superconductivity and superfluidity, to become clear. Superconductivity is the virtual disappearance of electrical resistance at liquid-helium temperatures, and superfluidity is the virtual disappearance of viscosity as we know it. Superfluid helium flows without resistance, as if no internal frictional forces act in the liquid. (Appropriately, these properties are being exploited to the full in the cryogenics for CERN's new LHC collider, the superconducting magnets of which will be cooled by superfluid helium at 1.9 K).

In 1938 Fritz London suggested that superfluidity could be caused by the bosonic condensation of helium-4 atoms, which have integer spin. This was supported by the fact that no similar effect had then been seen with the rarer helium-3 isotope, the atoms of which do not have integral spin (see below).

In the 1950s, O Penrose and L Onsager related superfluidity to the long-range order displayed by a highly correlated bosonic system. This gave an estimate of the amount of condensed atoms in the liquid – only about 8%, because strong interactions in liquid helium make it deviate significantly from the ideal non-interacting gas.

Superfluid helium flows without resistance, as if no internal frictional forces act in the liquid. This was explained by a phenomenological theory devised by L D Landau in 1941, eventually earning him the 1962 Nobel Prize for Physics. In this theory, superfluidity derives from the fact that when the available energy is low enough, only long-wavelength phonons (the vibration quanta of the medium) can be excited.

Electron pairs

Although superconductivity was first seen in 1911, reaching a full theoretical explanation took nearly 50 years. In 1957 J Bardeen, L N Cooper and J R Schrieffer ("BCS") proposed a theory based on phonon-mediated interactions between the electrons of the metal. This earned them the 1972 Nobel Prize for Physics.

The BCS theory showed that superconductivity is due to strong correlations between electrons of opposite spin. This creates a highly coherent state that is insensitive to perturbations, hence the lack of electrical resistance. Electron pairs can be considered as bosonic particles and the superconductivity transition is similar to Bose–Einstein condensation.

Earlier, V L Ginsburg and Landau had suggested a phenomenological theory. Although the implications of this approach emerged only slowly, it did lead to new developments in spontaneous symmetry breaking, which turned out to be crucial for particle physics in what is now known as the "Higgs mechanism".

Helium-3 atoms, which have half-integer spin, are not bosons and should not condense like helium-4 to become superfluid. However, in the same way that electron pairs make materials superconducting at low temperatures, the BCS mechanism also opens up the possibility of superfluid helium-3. The discovery of superfluid helium-3 earned the 1996 Nobel Prize for Physics for David Lee, Douglas Osheroff and Robert Richardson.

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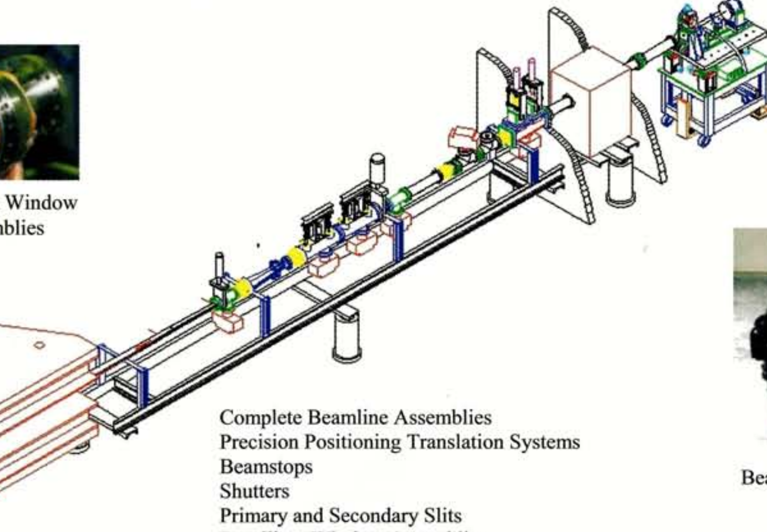

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Spectrometer for Beamline BL12XU at Spring-8 Japan

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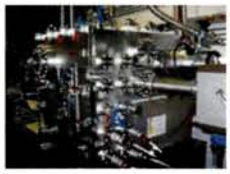
Translation System for LANSCE facility at Los Alamos National Laboratory

Beam line components for Advanced Photon Source



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Eurotherm Automation	www.eurotherm.tm.fr	33 (0)478 66 45 00						●											●			●										
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GMW Associates	www.gmw.com	1 650 802 8292	●	●					●				●		●		●							●				●				
Goodfellow Cambridge Ltd	www.goodfellow.com	44 (0)1480 424 800								●						●																
High Voltage Technology	www.highvoltagetechnology.com	44 (0)1371 875 668		●	●	●	●																									
Janis Research	www.janis.com	1 978 657 8750								●																						
Knürr AG	www.knuerr.ch	41 (0)1 806 5454	●	●															●	●												
Kurt J Lesker Company Ltd	www.lesker.com	44 (0)1424 719 101	●	●	●	●	●	●								●	●											●				
Lake Shore Cryotronics	www.lakeshore.com	1 614 891 2243							●					●																		
Mclennan Servo Supplies	www.mclennan.co.uk	44 (0)8707 700 700																●				●	●									
MTA-ITA LAI/KFKI	www.kfki.hu/mta-ita_lai	36 1 392 2243													●																	
Pearson Electronics	www.pearsonelectronics.com	1 650 494 6444	●	●	●		●															●										
Pulse Power & Measurement Ltd	www.ppm.co.uk	44 (0)1793 784 389	●	●	●		●	●																								
Redcliffe Magtronics	www.redmag.co.uk	44 (0)117 977 1404	●	●	●		●		●	●				●	●	●					●			●				●				
Scanditronix Magnet AB	www.scxmagnet.se	46 (0)472 486 80							●								●							●								
SCHAEFER Technology	www.schaefer-tec.com	49 (0)6103 790 85	●	●		●				●					●						●			●				●				●
Sigmaphi	www.sigmaphi.fr	33 (0)297 42 5555							●	●																						
Stäubli Faverges	www.staubli.com	33 (0)4 50 65 60 60									●	●																				
Thales Electron Devices	www.thales-electrondevices.com	33 (0)130 703 500																											●	●		
TMD Technologies	www.tmd.co.uk	44 (0)20 8573 5555	●	●											●	●							●							●	●	
Universal Voltronics Corp	www.voltronics.com	1 203 740 8555	●	●	●																											
Vision Electric	www.vision-electric.de	49 (0)6333 27570	●	●				●	●							●									●							

The Nobel century

In 1901 the first Nobel prize award ceremony was held at what is now called the Old Royal Academy of Music in Stockholm. In Christiania (now Oslo), the names of the Nobel laureates were announced in the Storting (the Norwegian Parliament – in 1905 Norway reverted to being a separate monarchy).

The winner of the first Nobel prizes were: physics – Wilhelm Röntgen for his discovery of X-rays; chemistry – J H'van't Hoff for his work on chemical dynamics; medicine and physiology – Emil Adolf von Behring for his work on serum therapy, especially its application against diphtheria; literature – Sully Prudhomme (René François Armand Prudhomme); peace – Jean Henri Dunant, founder of the Red Cross in Geneva, and Frédéric Passy, founder of the first French peace society.

To commemorate the centennial of the first Nobel awards, all of the living laureates have been invited to participate in a Centennial Week in December. Beginning with lectures at various universities around Sweden and Norway, the week culminates with the Nobel festivities on 10 December in Stockholm and Oslo. Several hundred laureates are expected to participate in the event.

Einstein in Berlin at about the time that he heard from Bose, who had translated a text on General Relativity.

Pairing effects, this time between nucleons rather than electrons, can also play a role in nuclear physics.

The ultimate candidates for Bose-Einstein condensation were atoms. However, the experimental challenges were formidable and had to await the development of suitable trapping and cooling techniques to confine and groom the atomic states.

In 1995, some 70 years after Einstein's original prediction, those who went on to earn this year's Nobel prizes succeeded in achieving this extreme state of matter. Cornell and Wieman produced a pure condensate of about 2000 rubidium atoms at 20 nK. Independently, Ketterle performed experiments with sodium atoms. His condensates contained more atoms and could therefore be used to investigate the phenomenon further. Making two separate condensates merge into one another, he obtained very clear interference patterns, showing that the condensate contained coherent atoms. Ketterle also produced a stream of small drops that fell under the action of gravity – a primitive "laser beam" using matter rather than light.

To achieve the very low temperatures needed for Bose-Einstein condensation, physicists have to exploit laser cooling, in which atoms lose energy via the continued absorption and emission of photons of radiation. Steven Chu, Claude Cohen-Tannoudji and William Phillips were awarded the 1997 Nobel Prize for Physics for their development of these techniques.

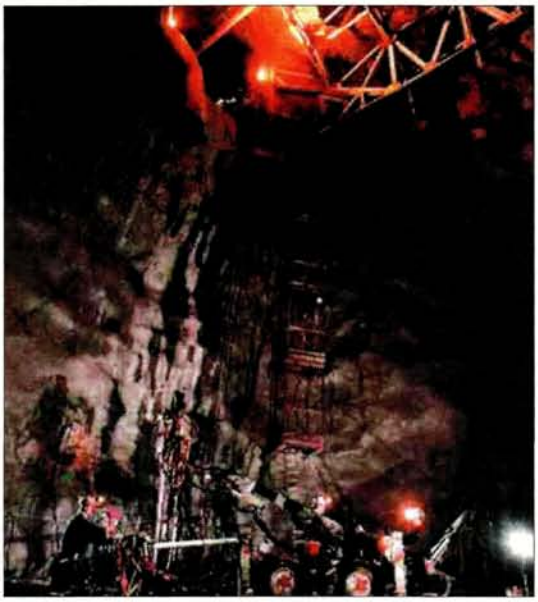
Since these pioneer experiments, Bose-Einstein condensation has been achieved in a variety of chemical elements (see "http://amo.phy.gasou.edu/bec.html"). One of the latest developments is a Bose-Einstein condensate on a microelectronic chip (see p14). These achievements are a tribute to the ingenuity and perseverance of experimenters, and they demonstrate the subtle interplay of many new scientific techniques. □

The Sudbury Neutrino Observatory – Canada's eye on the universe

Some 2000 m underground in a working nickel mine, physicists have installed one of the world's most sensitive instruments for observing the universe. Operational since 1999, the Sudbury Neutrino Observatory has ambitious plans for the future. *James Gillies* reports.

It all began 1.8 billion years ago when geologists believe that a meteorite struck the Earth, creating what is now the Sudbury basin in Canada. The impact allowed a rich seam of nickel-copper ore to rise through the Earth's crust around the rim of the crater. Today the Sudbury basin is circled with the world's largest concentration of nickel mines, and, in one of them, scientists accompany the miners on their morning descent to the 6800 ft (2000 m) level.

The Sudbury landscape still has an unearthly quality about it. Early mining efforts stripped away trees to provide fuel for smelting the ore, with the result that in the 1960s the Sudbury basin resembled something close to a moonscape. NASA even sent moonshot astronauts there for training. Today the trees are coming back, thanks to a large degree to the mines themselves, where underground nurseries provide warm stable conditions for trees to grow.



2000 metres underground – excavation of the underground cavity for the Sudbury Neutrino Observatory detector.

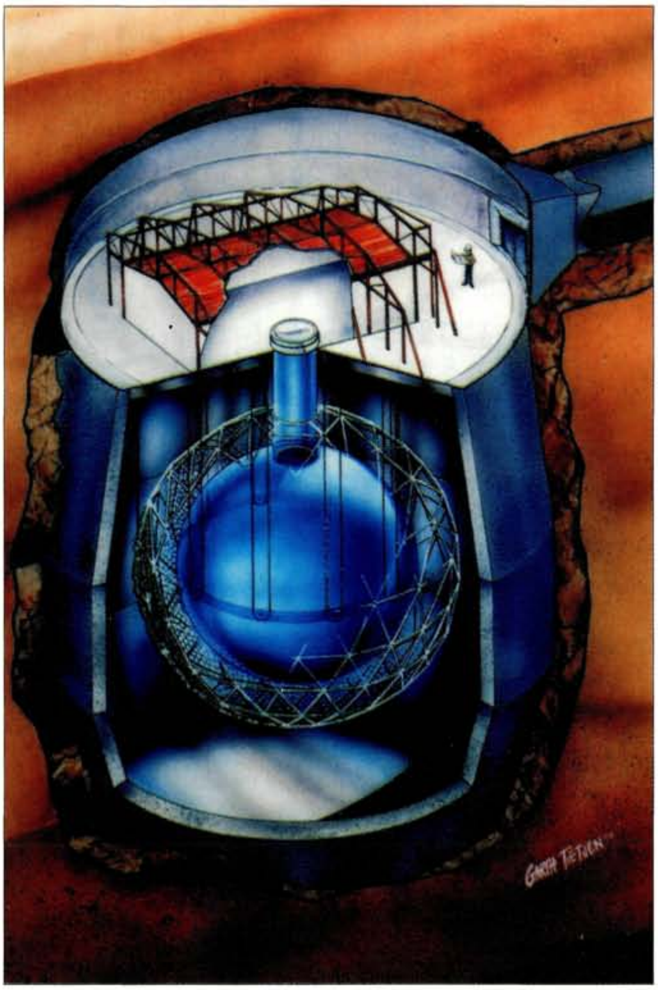
"All you have to add is light," said Art McDonald, director of the Sudbury Neutrino Observatory (SNO) as we stepped off the lift 2000 m underground. Here the rock is constantly at a temperature of 40°C, making for a sticky 1.5 km walk along the "SNO drift" – the tunnel connecting the mine shaft to SNO's underground laboratory.

Cleanliness is the key

Visiting SNO is an adventure in itself. Scientists and miners are indistinguishable in all but their conversation as they descend in the lift. Overalls, miners' lamps and safety harnesses are the order of the day. Everything to be taken into the lab must be carefully wrapped in plastic to protect it from the omnipresent mine dust. Arriving at the lab, boots are rinsed down, clothes are removed and everyone takes a shower before changing into a clean set of overalls and entering the lab.

Scrupulous attention to cleanliness is one of the keys to SNO's success. Incredibly, the laboratory maintains class-100 clean-room conditions in the most sensitive areas and all areas are class-3000 or better. That means that everywhere within the laboratory there are fewer than 3000 particles of 1 µm or larger per 1 m^3 of air. A typical room would give a count of around 100 000 particles and the SNO drift considerably more. Even more impressive is that these clean conditions were maintained throughout the construction of the experiment.

The emphasis on purity does not end with the air. Systems for purifying the SNO detector's light and heavy water fill most of the available space. The 33 m deep, 22 m diameter chamber that houses the detector is lined with several layers of plastic material that help to keep the radiation level from uranium and thorium a full nine orders of magnitude lower than in the surrounding rock.


A schematic of the SNO detector.

Herb Chen's experiment

SNO began collecting data in 1999, but its history goes back much further. In 1984 Herb Chen of the University of California at Irvine first pointed out the advantages of using heavy water as a detector for solar neutrinos. Two reactions – one sensitive only to electron-type neutrinos, the other sensitive to all neutrino flavours – would allow such a detector to measure neutrino oscillations directly. The Creighton mine in Sudbury – among the deepest in the world – was quickly identified as an ideal place for Chen's proposed experiment to be built and the SNO collaboration held its first meeting in 1984.

There were substantial obstacles to overcome before the experiment could be realized, not least of which was the cost of the heavy water. It was clear from the start that industrial partners would have to be found. INCO, the company operating the Creighton mine, became a key player, putting its infrastructure at SNO's disposal and blasting out a new cavern for the experiment far away from ongoing mine activity. Another key partner was found in the form of Atomic Energy of Canada Limited, which provided C$330 million of heavy water on loan, free of charge. "In a sense we're doing a greater than C$600 million project for less than C$100 million in terms of capital cost," explained McDonald.

The experiment was approved in 1990. Excavation took three years and installation a further five. The detector consists of a 12 m diameter acrylic sphere containing 1000 tonnes of heavy water surrounded by light water and viewed by 10 000 photomultipliers. Filling the sphere with heavy water, flooding the cavern with light water and calibrating the detector was complete by November 1999, allowing data taking to begin.

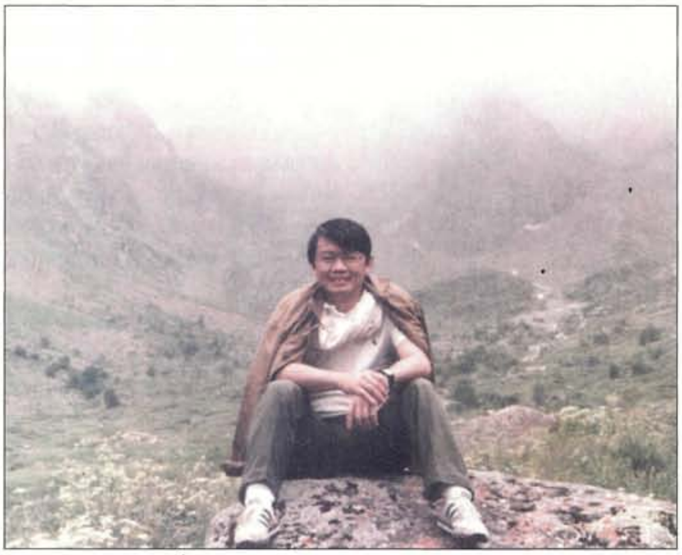
In its first phase of running – to June 2001 – SNO's analysis concentrated on the measurement of boron-8 electron neutrinos from the Sun. These are detected at SNO via the charged current process of electron neutrinos interacting with deuterons to produce a pair of protons and an electron. First results published in 2001, taken together with Superkamiokande's previous measurement (*CERN Courier* September p5) via the elastic scattering of boron-8 neutrinos from electrons with low sensitivity to neutrino types other than electron neutrinos, provide compelling evidence for neutrino oscillation.

The next step for SNO was to measure the total boron-8 neutrino flux to give a complete measurement that is independent of the Superkamiokande result. To do this, salt has been added to the heavy water. Salt increases SNO's sensitivity to the flavour-blind process of neutral current neutrino-deuteron interactions, which are identified by the detection of the photon emitted when the deuteron's neutron is captured. Capture on heavy water results in a 6.25 MeV photon, whereas capture on chlorine releases an 8.6 MeV photon that is more easily detected. Moreover, the neutron capture probability in SNO's heavy water is around 25%, whereas in salt it rises to 85%. Radioactivity levels are also low for this phase of the experiment and data analysis is under way.

In a third phase of running, scheduled to begin in the second half of 2002, the salt will be removed and replaced by helium-3-filled proportional counters. These will give the experiment an independent sensitivity to the neutral current process and allow distortions in the solar boron-8 spectrum to be measured more accurately than before.

Supernovae warning

Solar neutrinos form just one strand of SNO's research programme. The experiment's ability to single out electron-neutrino interactions and its high sensitivity to other neutrino types gives it a powerful tool for investigating supernovae by observing the time development between different neutrino types emerging from the explosion. SNO's data-acquisition system, normally running at around 10 Hz, is set up to buffer several hundred events in a window lasting just a few seconds if necessary, and it also alerts the shift crew whenever the event rate rises significantly. This initiates an analysis procedure, designed to identify whether noise or physics is responsible for the rise. SNO will be part of the Supernova Early Warning System (SNEWS) along with the LVD (Gran Sasso), Superkamiokande (Japan) and Amanda (South Pole) experiments. Signals sent to a central computer in Japan can be studied for time coincidences and the astronomical community can be alerted in the case of a ▷



Neutrino observatory pioneer – in 1984 Herb Chen of UC Irvine first pointed out the advantages of using heavy water as a detector for solar neutrinos. He died in 1987, long before the Sudbury Neutrino Observatory became operational.

The SNO heavy-water purification plant.

supernova. The neutrino burst can precede light by several hours.

The detector's location 2000 m below a flat surface also makes it a particularly powerful instrument for observing neutrinos created via cosmic-ray interactions in the atmosphere. In contrast with detectors under mountains, SNO has a 45° window for measuring downward-moving neutrinos. A clear distinction between downward and upward-moving neutrinos will allow SNO to make a model-independent measurement of atmospheric neutrinos over a three- to four-year timescale.

SNO has a well defined programme until 2006 and ambitious plans thereafter. The scientists envisage a shift in emphasis towards more subtle neutrino physics and possible improvements to the SNO detector. Seasonal variations and correlations with the solar cycle are on the agenda. SNO will also turn its attention to other neutrino oscillation processes in the Sun.

Canadian scientists are hopeful of extending the laboratory beyond the one experiment that it currently houses. The Canadian government has recently launched the Canadian Foundation for Innovation International Programme to generate world-class international research facilities in Canada, and Sudbury is a strong contender. Having passed the first round of selection, the laboratory has been invited to submit a detailed proposal by February. Under this C$30 million plan, the Sudbury site would acquire a new experimental hall to house at least two new experiments. Final selection is scheduled for June 2002.

Herb Chen didn't live to see his brainchild realized. He died in 1987, but his presence at Sudbury is still very strongly felt. Copies of his 1984 *Physical Review Letters* paper hang proudly around the laboratory and his portrait graces the entrance. SNO has put Sudbury firmly on the physics map, but it hasn't lost sight of its roots. "The SNO team is working very hard to accomplish the full physics objectives while maintaining Herb's memory as a constant inspiration," explained McDonald. □

Further reading

Herb Chen 1984 *Phys. Rev. Lett.* **55** 14.
SNO Collaboration 2000 *Nuclear Instruments and Methods* **A449** 172–207.
SNO Collaboration 2001 *Phys. Rev. Lett.* **87** 07301 1–6

Database lists the top-cited physics papers

Citation tracking can point to the most influential trends in research. *Heath O'Connell* and *Michael Peskin* analyse the chart for the year 2000 and report the hottest topics in high-energy physics.

A family photograph from the international Particle Data Group. Its annual Review of Particle Physics encapsulates all of the latest experimental developments and measurements, and it is invariably the top-cited particle physics paper of the year. The group effort involves many more people than appear here. Left to right, front row: Maury Goodman (Argonne), Charles Wohl (Lawrence Berkeley Laboratory – LBL), Keith Olive (Minnesota), Kenzo Nakamura (KEK) and John March-Russell (CERN). Middle row: Michael Barnett (LBL), Vitaly Lugovsky (Protvino), Gail Harper (LBL), Betty Armstrong (LBL), Ken-ichi Hikasa (Tohoku), Wei-Ming Yao (LBL), Alberto Masoni (INFN Cagliari) and Petr Vogel (Caltech). Back row: Boris Filimonov (Protvino), Orin Dahl (LBL), Paul Gee (LBL), Matts Roos (Helsinki), Tom Trippe (LBL), Andreas Piepke (Alabama), Michelangelo Mangano (CERN), Gianni Conforto (Urbino), Ron Workman (George Washington University), Don Groom (LBL), Masaharu Tanabashi (Tohoku), Michael Doser (CERN) and Ramon Miquel (LBL).

The SPIRES-HEP database maintained by the library at the Stanford Linear Accelerator Center (SLAC) connects preprint or eprint versions to articles published in journals or conference proceedings, providing access to all phases of the publication history. The database lists virtually every high-energy physics paper published or even preprinted over the past 30 years.

In addition, most papers now have backward links to the papers that they cite and forward links to the papers citing them. These citation links provide a very effective means of searching the literature. In the past few years SPIRES-HEP has been automatically harvesting reference citations from eprints, creating a web of links that thoroughly indexes the literature. ▷

1: Top-cited articles of 2000

Article	No. of citations
1 Particle Data Group, 1998 Review of particle physics *Eur. Phys. J.* **C3** 1–794.	1236
2 Juan Maldacena, 1998 The large N limit of superconformal field theories and supergravity *Adv. Theor. Math. Phys.* **2** 231–252 (hep-th/9711200).	498
3 Lisa Randall and Raman Sundrum, 1999 An alternative to compactification *Phys. Rev. Lett.* **83** 4690–4693 (hep-th/ 9906064).	446
4 Lisa Randall and Raman Sundrum, 1999 A large mass hierarchy from a small extra dimension *Phys. Rev. Lett.* **83** 3370–3373 (hep-ph/9905221).	414
5 Nima Arkani-Hamed, Savas Dimopoulos and Gia Dvali, 1998 The hierarchy problem and new dimensions at a millimeter *Phys. Lett.* **B249** 263 (hep-ph/9803315).	403
6 Nathan Seiberg and Edward Witten, String theory and noncommutative geometry (hep-th/9908142).	397
7 Edward Witten, 1998 Anti-de Sitter space and holography *Adv. Theor. Math. Phys.* **2** 253–291 (hep-th/9802150).	347
8 Y Fukuda *et al.*, 1998 Evidence for oscillation of atmospheric neutrinos *Phys. Rev. Lett.* **81** 1562–1567 (hep-ex/ 9807003).	325
9 S S Gubser *et al.*, 1998 Gauge theory correlators from noncritical string theory *Phys. Lett.* **B428** 105–114 (hep-th/ 9802109).	316
10 Ignatios Antoniadis *et al.*, 1998 New dimensions at a millimeter to a Fermi and superstrings at a TeV *Phys. Lett.* **B436** 257–263 (hep-ph/9804398).	301

As a by-product of this citation linkage, SPIRES-HEP can easily search out the papers most cited by publications in high-energy physics. The list of papers with the most citations in a given year provides a snapshot of the hottest topics that have engaged the attention of theorists and experimenters. For the past few years, SPIRES-HEP has posted a scientific review of the year's top-cited papers. The whole collection of these reviews can be found on the Web at "http://www.slac.stanford.edu/library/topcites".

We have recently posted the "top-cited" lists for 2000. These materials include a list of the papers with more than 100 citations in the past year and a list of the papers with more than 1000 citations over the history of the SPIRES-HEP database.

So what are, by this measure, the hottest topics of 2000? Table 1 lists the top 10 cited papers and the number of citations of those papers in 2000. These papers represent major areas of activity that are discussed further in the review posted at the SPIRES Web site. The top-cited reference in high-energy physics is always the Review of Particle Properties. Below this in the list, the following areas are represented. (Papers appearing in the "top 10 cited list" are referred to by a number that indicates their position on the list.)

Maldacena's duality

A broad swath of developments in string theory and related areas of mathematical physics has resulted from Maldacena's 1997 paper (2), which propose a relation between supergravity and superstring theories in (d+1)-dimensional anti-de Sitter space and supersymmetric Yang-Mills theories in d-dimensions.

Anti-de Sitter space, the homogeneous space of constant negative curvature, has a boundary in the sense that light signals propagate to space-like infinity in finite time. Maldacena proposed that, for a gravity theory living in the interior of the space, there would be a corresponding, and equivalent, scale-invariant quantum field theory living on the boundary. Subsequently, Witten (7), and Gubser, Klebanov and Polyakov (9), gave a precise relation between correlation functions in the boundary theory and S-Matrix elements for the gravity theory in the interior.

These developments have led to many insights, illuminating both the properties of strongly coupled Yang-Mills theory and quantum gravity theories. It is remarkable that Maldacena's paper has managed, in just three years, to accumulate more than 1600 citations and to vault to position 25 on the all-time citation list.

Extra space dimensions

Though string theory predicts the existence of seven extra space dimensions, these have conventionally been considered to be unobservably small and irrelevant to ordinary particle physics. However, the next three papers on the "top-cited" list involve theoretical models in which extra space dimensions play a direct role in particle physics and, in particular, explain the mass scale of the Higgs boson. Randall and Sundrum (3, 4) have proposed two different scenarios in which our four-dimensional universe is a flat, three-dimensional surface in anti-de Sitter space.

Arkani-Hamed, Dimopoulos and Dvali (5) have proposed a scenario in which our universe is a surface in a large, flat space-time,

2: Top citations within each eprint archive

Archive	Article	No. of citations
GR-QC	S W Hawking, 1975 Particle creation by black holes *Commun. Math. Phys.* **43** 199–220.	61
HEP-EX	Torbjorn Sjostrand, 1994 High-energy physics event generation with PYTHIA 5.7 and JETSET 7.4 *Comput. Phys. Commun.* **82** 74–90.	94
HEP-LAT	Herbert Neuberger, 1998 Exactly massless quarks on the lattice *Phys. Lett.* **B417** 141–144 (hep-lat/9707022).	68
HEP-PH	Y Fukuda *et al.*, 1998 Evidence for oscillation of atmospheric neutrinos. *Phys. Rev. Lett.* **81** 1562–1567 (hep-ex/9807003).	265
HEP-TH	Juan Maldacena, 1998 The Large N limit of superconformal field theories and supergravity *Adv. Theor. Math. Phys.* **2** 231–252 (hep-th/9711200).	465
NUCL-EX	J P Bondorf *et al.*, 1995 Statistical multifragmentation of nuclei *Phys. Rept.* **257** 133–221.	16
NUCL-TH	R Wiringa, V Stoks and R Schiavilla, 1995 An accurate nucleon–nucleon potential with charge independence breaking *Phys. Rev.* **C51** 38–51 (nucl-th/ 9408016).	53

the size of which may approach the millimetre scale. Further consequences of this model are developed in paper 10. Both of the models 4 and 5 will have crucial tests at CERN's LHC collider, which may give direct experimental evidence for the presence of new space dimensions (*CERN Courier* March 2000 p7).

Non-commutative field theory

Many ideas about quantum gravity lead to the idea that space-time co-ordinates are non-commuting operators. Non-commutative Yang–Mills theory, which was invented by Connes, gives a simple field theory model in which consequences of the possible non-commutativity of space can be studied. Paper 6, by Seiberg and Witten, explained the connection between Connes' model and various compactifications of string theory, launching an intense investigation into non-commutative dynamics.

Neutrino physics

In experimental particle physics the most surprising development of the past few years has been the discovery by the Super-kamiokande collaboration of atmospheric neutrino oscillations (8). This experimental result indicates the presence of neutrino mass and large mixing among the lepton generations. It has led to many speculations on the origin of flavour mixing and to a new, intense level of experimentation on neutrino properties.

The complete list of the top 40 cited papers of 2000 and a more detailed scientific review can be found at the SLAC Web site. The site also includes a "top-cited" list for each eprint archive relevant to high-energy physics. In Table 2 the top-cited paper (exclusive of the Particle Data Group's Review of Particle Properties) in each archive is shown.

We make no claim that the papers that we have listed here are currently the most important papers in high-energy physics. Year-by-year accounting is influenced as much by fashion as by logical scientific development. Both the standard electroweak model and string theory spent many years in the cellar of the citation counts before rising to their current prominence. If you favour a trend, a model or an experiment that is not listed here, more power to you. We hope that your insights will be well represented on our lists before the end of the decade.

Heath B O'Connell *and* **Michael E Peskin**, *SLAC.*

AWARDS

Society announces prestigious US awards

The prizes and awards presented annually by the American Physical Society are among the highest honours that physicists can receive. The awards that the society has announced for 2002 include:

The Edward A Bouchet award for promoting the participation of under-represented minorities in physics to **Oliver Baker** of Hampton University, Virginia, who is also a member of the ATLAS experiment at CERN, "for his contribution to nuclear and particle physics; for building the infrastructure to do these measurements; and for being active in outreach activities, both locally and nationally".

The Davisson-Germer prize for outstanding work in atomic physics or surface physics to **Gerald Gabrielse** of Harvard, long-time major figure in low-energy antiproton experiments at CERN and currently spokesman for the ATRAP study at the antiproton decelerator, "for pioneering work in trapping, cooling and precision measurements of the properties of matter and antimatter in ion traps".

The Joseph A Burton Forum award for outstanding contributions to the public understanding of resolution of issues involving the interface of physics and society to **Adrian Melott** of Kansas, "for his outstanding efforts in helping to restore evolution and cosmology to their proper place in the K-12 scientific curriculum. As both a distinguished cosmologist and respected member of the clergy, he played a key role in helping the people of Kansas to reverse their State Board of Education's anti-science action";

The Dannie Heineman prize for outstanding publications in mathematical physics to **Michael Green** of Cambridge and **John Schwarz** of Caltech "for their pioneering work in the development of superstring theory".

The J J Sakurai prize for theoretical particle physics to **William Marciano** of Brookhaven and **Alberto Sirlin** of New York University "for their pioneering work on radiative corrections, which made precision electroweak studies a powerful method of probing the Standard Model and searching for new physics".

The Robert R Wilson prize for outstanding achievement in the physics of particle accelerators to **Alexander Skrinsky** of the Budker Institute, Novosibirsk, who is also a former member of CERN's scientific policy committee, "for his major contribution to the invention and development of electron cooling and for his development of and contributions to the physics of the electron-positron colliders at the Budker Institute".

At the time of writing, not all of the 2002 awards had been announced.

MEETINGS

The second international **Symposium on Applications of Particle Detectors in Medicine, Biology and Astrophysics (SAMBA II)** will be held on 27–29 May 2002 at the International Centre for Theoretical Physics (ICTP), Trieste, Italy. For further information visit "http://www.elettra.trieste.it/sites/samba/" or contact the conference office: Ilde Weffort Paroni, Sincrotrone Trieste, Strada Statale S S 14, km 163.5, 34012 Basovizza, Trieste, Italy; tel. +39 040 375 8522; e-mail "ilde.weffort@elettra.trieste". Other useful contacts for details are A Sharma, e-mail "Archana.Sharma@cern.ch", and R Menk, e-mail "ralf.menk@ elettra. trieste.it".

A **Conference on Advanced Statistical Techniques in Particle Physics** will be held in Durham, UK, on 18–22 March 2002. The event will include invited talks and contributed papers. For more information visit "http://www.ippp.dur.ac.uk/statistics/". Further details are also available from Louis Lyons, e-mail "l.lyons@physics.ox.ac.uk", and James Stirling, e-mail "w.j.stirling@ durham.ac.uk".

The president of Romania, **Ion Iliescu**, signs CERN's VIP visitors' book on 12 October, watched by CERN director-general **Luciano Maiani**. Accompanied by a large delegation that included ministers, advisers and ambassadors, the president saw preparations for CERN's LHC collider and its physics experiments.

Timothy Toohig 1928–2001

A unique gentleman was lost when Timothy Toohig died suddenly on 25 September at the age of 73.

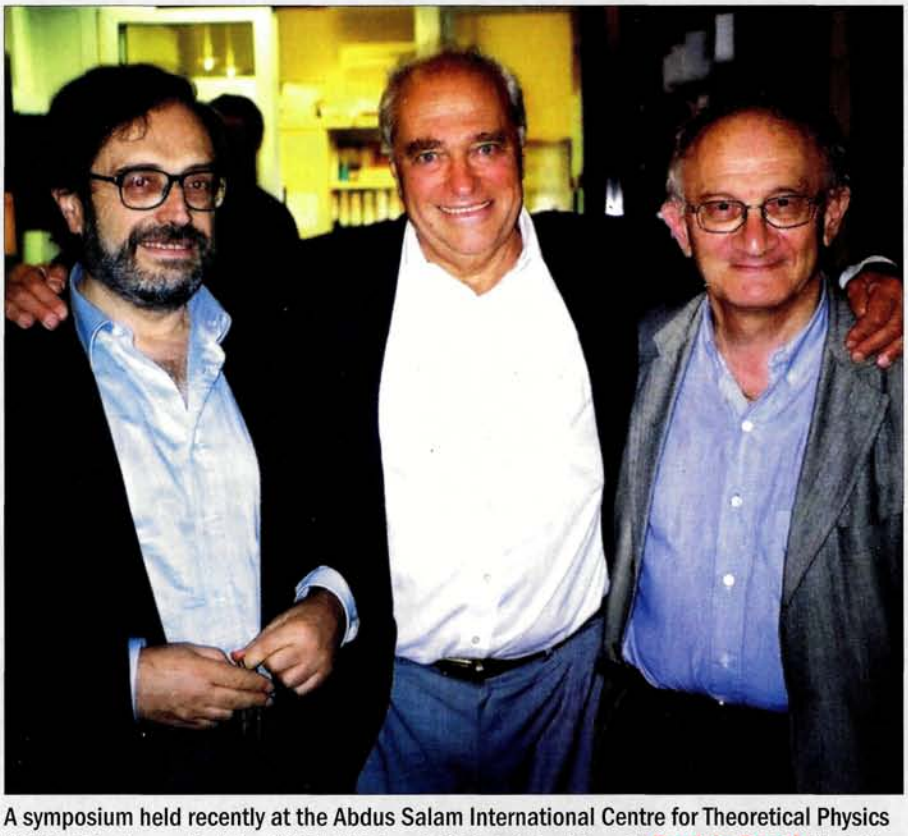
A physicist and a Jesuit priest, Toohig was a mainstay of the US high-energy physics programme for four decades, working at universities, national laboratories and the Department of Energy (DOE). He was a member of the Johns Hopkins University team that discovered the eta meson in experiments at the Berkeley Bevatron. At Brookhaven he was responsible for the first slow-extracted proton beam from the Alternating Gradient Synchrotron. He participated, with a Soviet-US team, in a series of experiments at Fermilab, analysing the properties of mesons. Subsequently he led the US effort in a series of joint experiments on accelerators at Dubna and Serpukhov, studying the channelling of high-energy particles in crystals.

Tim Toohig was responsible for the neutrino experimental area during the initial construction of Fermilab and later for the conventional construction of the Tevatron. He was associated with the US Superconducting Super Collider (SSC) from its conception in 1983, working on design studies at Fermilab and serving as deputy head of the Conventional Facilities Division for the Central Design Group that was set up at Berkeley. He was deputy associate director of the Conventional Construction Division from the establishment of the SSC laboratory in Texas in 1989 until the project ended in 1994.

For several years, Toohig had been working at DOE, on loan from his position as research professor at Boston College. He served as the DOE/NSF programme manager for the substantial US participation in the Large Hadron Collider project at CERN and as the DOE monitor for the Stanford Linear Accelerator Center.

Tim Toohig was a special person in the world of science. His genial good humour and wisdom guided us and we depended on his strength. He was a tireless worker who tried to cut through difficult problems, and a strong arm to lean on when troubles came. His friends were many and all of us will miss Father Tim.

Neil Baggett, US Department of Energy.



A symposium held recently at the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, marked the 70th birthday of distinguished theorist Daniele Amati. He left CERN 14 years ago to head the SISSA International Institute for Advanced Studies, which is adjacent to ICTP. Under his leadership, the institute is thriving, with research ranging from physics to biology and cognitive science. It is also the headquarters of the all-electronic *Journal of High-Energy Physics* (JHEP) – a pioneer in the field (*CERN Courier* January p19). The symposium reflected this broad interest. Daniele Amati is flanked by symposium organizers ICTP director Miguel Virasoro (left) and JHEP director Hector Rubinstein.

NEW PRODUCT

Physical Electronics tailors stability of ion pump uses

Physical Electronics, which is a US-based company that specializes in ultrahigh-vacuum technology, has developed a method for tailoring the speed and stability of ion pump applications without increasing the cost. This is accomplished by changing the fixed historical ratio of cathode materials, titanium and tantalum, from 50 : 50, to a variable ratio ranging from 0 to 85% tantalum.

Titanium is used for fast pumping speeds, while tantalum is used to provide stable vacuum pressure. Using this innovation, applications that require stability from air leaks can be configured to use less tantalum, while applications introducing noble gases can be configured to use more tantalum to ensure greater stability.

More information about this method is available from Physical Electronics, UHV Technologies Group, 6509 Flying Cloud Drive, Eden Prairie, MN 55344; tel. (toll free – US only) 800-237-3603 (international) +1 952-828-6100; fax +1 952-828-6322; e-mail "vacuum@phi.com"; Web site "http://www.phi.com".

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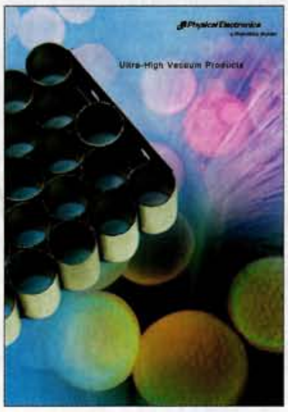

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The Ultra High Vacuum Technologies Group offers ion pumps and other ultrahigh vacuum (UHV) pumping products. We design and manufacture our own UHV products based on the special considerations UHV applications require. Our applications need stable and reliable UHV; so do yours. Ion pumping technologies continue to be the most dependable and economical methods for creating UHV environments in high-energy physics, instrumentation and processing applications. Entrust your UHV system to the UHV experts.

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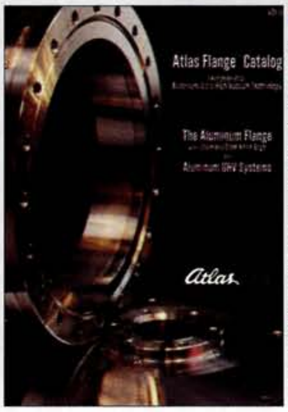

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Faculty Positions in Neurosciences

at the Swiss Federal Institute of Technology Lausanne (EPFL)

The EPFL, in close collaboration with the universities of Geneva and Lausanne, plans a major expansion at the interfaces between life, basic and engineering sciences that involves the creation of a centre of functional genomics.

As part of this broad program, the EPFL will establish the "Brain and Mind Institute" and anticipates making several appointments at the assistant (tenure-track) and full professor level.

The mission of the Brain and Mind Institute is to combine basic sciences and state of the art engineering technologies to study higher brain functions. Research on campus will span from investigation of single molecules to analysis of complex systems and ample opportunities for synergies will be available.

Outstanding individuals, with an interdisciplinary vision and a strong record of accomplishments, are invited to apply. Successful candidates will initiate independent, creative research programs and participate in both undergraduate and graduate teaching. Substantial start-up resources will be available.

For the next appointments, an emphasis will be placed on electrophysiology of neural coding, computational neuroscience, imaging, behavioural genetics, and vertebrate as well as invertebrate genetic models of neuronal development and disease.

Applications, including curriculum vitae, publication list, brief statement of research interests (three pages or less) and names and addresses (including e-mail) of at least seven references should be sent to:

The office of the President
EPFL
CH-1015 Lausanne, Switzerland.

For inquiries, contact: life.sciences@epfl.ch.

HEFIN
Hoge-Energiefysica Instituut Nijmegen

PhD Student Positions

Applications are invited for 4-year PhD student positions becoming available in the Dept. of Experimental High Energy Physics of the University of Nijmegen. This Department is part of the High Energy Physics Institute Nijmegen (HEFIN) and a partner of the Dutch joint ventures of NIKHEF and the Research School of Subatomic Physics. It is participating in the D0 experiment at the Tevatron Collider of Fermilab and the ATLAS experiment at the LHC of CERN, but also considers to extend its activities to new directions.
Requirements: We are looking for enthousiast young physicists with (or near) a masters degree or equivalent (experimental or theoretical), who consider fundamental research with advanced computing and detection technologies in an international team an attractive challenge.
Conditions of employment: The contract is for a period of four years and is expected to lead to a PhD degree. Work will be carried out in Nijmegen and at the collider lab. The gross salary will increase from EUR 1433,- per month in the first year to EUR 2047,- during the fourth, supplemented by a considerable relocation allowance. Detailed conditions can be found at www.fom.nl and/or obtained from the addresses below.
Applications: Send your application with C.V. and the names of three referees within one month of the appearance of this ad to: Prof.dr. S. de Jong (sijbrand@hef.kun.nl) or Prof.dr. W. Kittel (wolfram@hef.kun.nl), both HEFIN, University of Nijmegen, Toernooiveld 1, 6525 ED Nijmegen, NL.

MAX-PLANCK-GESELLSCHAFT

Max-Planck-Institut für Kernphysik

We invite applications for a

C3-professorship

The Max-Planck-Institut für Kernphysik (MPI-K) in Heidelberg is seeking a young, experienced experimentalist with her/his main interest in strong-field, short-pulse laser physics for a five-year appointment to a C3-professorship. The person is expected to build and lead an independent research group, to obtain funding and to closely interact with other groups at the MPI-K.

The candidate should have a PhD in experimental physics, a "Habilitation" or a similarly adequate qualification and international reputation in laser physics. We provide excellent working conditions, an inspiring surrounding as well as intense exchange of ideas with the other groups in the division.

At equal level of qualification, candidates with disabilities are given preference. Women are encouraged to apply. Applications with full CV, publication list, and names and addresses of three referees should be sent to
Prof. Dr. Joachim Ullrich (e-mail: J.Ullrich@mpi-hd.mpg.de).

For more information please visit our website at
http://www.mpi-hd.mpg.de/ullrich/.

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文部科学省 高エネルギー加速器研究機構 KEK
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

Call for Nomination for Next Director-General of KEK

KEK, the High Energy Accelerator Research Organization, welcomes nominations for the next Director-General whose term will begin April 2003.

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

The role of Director-General, therefore, is to promote, with long-term vision and strong scientific leadership, the highly advanced, internationalized, and inter-disciplinary research activities of KEK by getting support from the public.

One term in the position is three years, and the maximum period the position can be held is nine years. The candidate should have Japanese citizenship by the time he/she takes the position.

Nomination should be accompanied by the candidate's curriculum vitae and a letter of recommendation for the candidate. The nomination should be sent to the following address no later than February 20, 2002:

General Management Section, General Affairs Division, KEK, High Energy Accelerator Research Organization, 1-1 Oho Tsukuba Japan 305-0801 Tel **+81-298-64-5114** Fax **+81-298-64-5560**

Inquiries concerning the nomination should be addressed to:

Professor Toshimitsu Yamazaki, Vice Chairperson of Board of Councilors of KEK

Email: **yamazaki@nucl.phys.s.u-tokyo.ac.jp**

www.kek.jp

ESRF

EUROPEAN SYNCHROTRON RADIATION FACILITY

Situated in Grenoble in the heart of the French Alps, the ESRF is a leading world-class third generation synchrotron source.

In order to maintain the high level of reliability and availability already attained, and to assist in continued developments, we are now seeking to recruit for our Machine Division an:

Accelerator Physicist

As a member of a team you will perform beam studies, coupled with advanced accelerator computations, aimed at improving the understanding and the performances of the accelerator complex. In conjunction with all technical staff of the Machine Division, you will spend 15% of your time in shift work in the operation of the accelerators.

You will be able to share these tasks with developments in your own specific area of expertise according to your experience.

The level of the position is flexible and will depend on the qualifications of the selected candidate.

You should have a doctorate level education and be an accelerator physicist having at least acquired a few years' experience in the field, preferably in a third generation synchrotron source.

The working language at the ESRF is English.

Have a look at the complete job description (ref.4115) and employment conditions on our website:

http://www.esrf.fr

and contact us at recruitm@esrf.fr or by fax : +33 (0)4 76 88 24 60.

Stanford Linear Accelerator Center (SLAC), a high-energy research facility dedicated to performing world-class research and advancing the critical technologies necessary to understand the basic nature of matter, has the following opportunity available:

ENGINEERING PHYSICIST

Duties: Manages the Experimental Facilities Department (staff of 40) which supports research activities in high-energy physics at SLAC. Currently the research activities supported are the fixed target program in the 50 GeV linac beams in End Station A, the BABAR experiment at the PEP II colliding beam facility, advanced accelerator and test experiments at the end of the linac. In the future, supported facilities may include the LCLS x-ray laser facility. This support includes design and construction of new experiments and supporting particle beam transport lines. This department maintains expertise in experiment and instrumentation design and operation, particle beam transport and radiation shielding, high-vacuum systems, cryogenic systems (including super conducting), gas delivery systems, real-time data acquisition, mechanical, electrical and electronic engineering and project management. The department serves the SLAC management and user community in designing, preparing, installing, operating and tear down of experiments at the facilities. The manager of this department will manage and promote the physics goals and the technical/engineering details of these activities and work with the management of the lab and the users of the facilities towards the efficient use of resources and obtaining timely experimental results from these efforts. The manager will report to lab management on the impact (cost and resources) of new experimental proposals, and implement approved experiments within budget and resource constraints. Above all he/she is responsible for performing these tasks safely while protecting the environment in accordance with all applicable safety and environmental protection regulations.

Skills: Ph.D. degree in Physics or equivalent is required. Background in experimental high-energy physics is highly desired. Extensive experience managing a technical department with engineers and/or physicists, designers, and technicians is required. Demonstrated project management skills in an environment requiring integration of diverse technical disciplines. Familiarity with most of the following disciplines: experimental physics, particle beam transport, radiation shielding, electrical, mechanical, and electronic engineering, high-vacuum systems, data acquisition computing, control systems. Experience with accelerator-based physics experiments is highly desirable. Familiarity with cryogenic systems is desirable. Must have familiarity with OSHA and environmental regulations. Excellent verbal and written skills are required.

SLAC offers competitive compensation and excellent benefits. Send your resume to **SLAC, Employment Dept./Job #22370, 2575 Sand Hill Road, M/S 11, Menlo Park, CA 94025; Fax: 650-926-8699; E-mail: employ1@SLAC.stanford.edu.** EOE

SLAC
STANFORD LINEAR ACCELERATOR CENTER

UNIVERSITAS BERGENSIS

UNIVERSITY OF BERGEN

Faculty of Mathematics and Natural Sciences

Two Openings as Associate Professor at the University of Bergen, Norway

The Department of Physics invites applications for two positions as associate professor – one in experimental particle physics and one in experimental heavy ion physics.

The Experimental Particle Physics Group participates in the ATLAS experiment at CERN, with responsibilities connected to the construction of the SCT and to the BaBar experiment at SLAC, where the focus of the work is on data analysis. The successful candidate is expected to take part in ATLAS, but could also spend time on other activities of the group, and take part in the planning of research activities beyond the current programme.

The Experimental Heavy Ion Physics Group participates in the ALICE experiment, with responsibilities connected to both the PHOS detector and High Level Trigger system. In addition, the group participates in the NA57 experiment at CERN and in the BRAHMS experiment at Brookhaven. The successful candidate is expected to take part in ALICE and in the other activities of the group.

For both positions a doctor's degree is a demand. Postdoctoral experience will be an advantage. The successful candidates are expected to take part in teaching and supervision at all levels.

More at http://www.uib.no/stilling. Supplementary information from Prof. Bjarne Stugu by e-mail Bjarne.Stugu@fi.uib.no (particle physics) and Prof. Dieter Röhrich by e-mail Dieter.Rohrich@fi.uib.no (heavy ion physics).

Submit application in triplicate, sorted into three bundles, each of which must contain a complete overview of the applicant's education and earlier work, confirmed copies of certificates and diplomas, testimonials, and scholarly works including a list of these, to: University of Bergen, Department of Physics, Allég. 55, N-5007 Bergen, Norway, **by 31 January 2002.**

CICERO bs

The **Deutsche Elektronen-Synchrotron DESY** in Hamburg, member of the association of national research centers Hermann von Helmholtz-Gemeinschaft Deutscher Forschungszentren, is a national center of basic research in physics with app. 1,400 employees and more than 3,000 scientific guests from Germany and foreign countries per year. The accelerators in operation are dedicated to particle physics and research with synchrotron radiation.

Within the group – MPY– „Accelerator Physics" we are looking for a

Scientist or Diplom-Engineer (m/f)

as soon as possible for a permanent position.

In the framework of an international collaboration a Free-Electron-Laser is set up at DESY for wavelengths far below the visible. The project is based on the superconducting TESLA test facility, which supplies the technological foundation for a future linear accelerator for electron-positron collision experiments. Within this framework we are searching for a physicist or qualified engineer, both with Ph.D., for the developement, construction and commissioning of sophisticated components of the electron accelerator. The successfull applicant will have responsibility for the coordination of work already in progress and/or for the construction and commissioning of self-developed components.

Part-time employment is possible as far as a full-time filling of the post is guaranteed.

Applicants should have a PhD in physics or electrical engineering and preferrably appropriate experience in accelerator physics and techniques. The ability to coordinate sophisticated technological work in international collaboration is desired.

Interested applicants are invited to send their letter of application and three names of referees to our personnel department.

Payment and social benefits correspond to those in public services (BAT Ib; according to German Civil Service).

Deadline for application: 15.01.2002

Handicapped applicants will be given preference to other applicants with the same qualifications.

DESY supports the careers of women and encourages especially women to apply.

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THE UNIVERSITY OF ARIZONA

Experimental Elementary Particle Physics
Tenure Track Assistant Professor

The Physics Department at the University of Arizona invites qualified applicants to apply for a tenure track junior faculty position in experimental elementary particle physics.

We are seeking candidates who have an outstanding research record and who are committed to excellence in teaching at the undergraduate and graduate levels. A Ph.D. in Physics and/or related field along with postdoc experience is required.

The Arizona group is actively involved in the D0 and KTeV experiments at Fermilab and the ATLAS experiment at CERN.

Please send applications with a cover letter, CV, publications, and three reference letters to **The Particle Physics Search, Ms. Nancy Kern, Department of Physics, The University of Arizona, 1118 E 4th St., Tucson, AZ 85721.**

E-mail applications to **nancy@physics.arizona.edu** are acceptable.

A review of applications will begin on 21 January 2002 and will continue until the position is filled. The University of Arizona is an EEO/AA Employer-M/W/D/V. Reference should be made to Job #22074.

INDIANA UNIVERSITY

Tenure Track Faculty Position in Experimental High Energy Physics and Astrophysics

The Department of Physics at Indiana University invites applications for a tenure track faculty position in Experimental High Energy Physics and Astrophysics to start September 2002. The present activities of the IU group include hadron collider physics in D0 and ATLAS, search for gluonic excitations in Hall D at Jefferson Laboratory, the long baseline neutrino oscillation MINOS, and the space-based supernova search SNAP.

Successful candidates for this position should have demonstrated the potential to lead a first-rate research program which impacts or expands on one or more of the general areas listed above. Candidates should have the ability to teach physics effectively at both the undergraduate and graduate levels. We especially welcome applications from female and minority candidates. Please send applications including curriculum vitae and a statement of intended research directions to the Faculty Search Committee, c/o Prof. James Musser, Dept. of Physics, Indiana University, Bloomington, IN 47405, and arrange to have a minimum of three letters of reference sent to the same address.

For more information, see
http://dustbunny.physics.indiana.edu/facpos/

Applications received by January 15, 2002 will receive priority.

Indiana University is an Affirmative Action/ Equal Opportunity Employer

EMBL

The European Molecular Biology Laboratory (EMBL), an international research organisation with its Headquarters Laboratory in Heidelberg (Germany), Outstations situated in Grenoble (France), Hamburg (Germany) and Hinxton (UK), and a Research Programme at Monterotondo (Italy) invites applications for the following vacancy **in Heidelberg, Germany**

MAINTENANCE ENGINEER
(ref. no. 01/165)

As a member of a small team of qualified personnel, and under the supervision of the Head of the team, the successful applicant will be responsible for the servicing and maintenance of complex scientific equipment, i.e. ultracentrifuges, photo-spectrometers, microscopes, incubators, autoclaves, scintillation counters, refrigerators, vacuum pumps, etc.

Appropriate to the wide range of equipment to be serviced candidates should have a solid technical training and sound knowledge of electronics, electrical engineering, precision mechanics and vacuum techniques. A minimum of three years' experience in servicing such equipment is necessary for this post. Due to the international character of the Laboratory, a working knowledge of English and German is required.

Closing date 31.12.2001

EMBL Web site: http://www.embl-heidelberg.de

EMBL is an inclusive, equal opportunities employer offering attractive conditions and benefits appropriate to an international organisation.

To apply please send your CV, quoting ref. no. 01/165, to:

The Personnel Section, EMBL, Postfach 10.2209, D-69012 Heidelberg, Germany. Fax: +49 6221 387555. email: jobs@embl-heidelberg.de

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Further information under **www.ipp.mpg.de**

Max-Planck-Institute for Plasma Physics requires for its Greifswald branch institute a

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Within a team of physicists, engineers and technicians developing a system for radiofrequency (RF) heating of plasmas you will be responsible for the RF technology, viz. the RF generators (2x2 MW, ca. 20–80 MHz) and the RF measuring and impedance matching facilities. Your duties will comprise conceptual design, supervision of assembly and later operation and further development. You will also be in charge of the technical side of industrial contracts and contacts with other international research institutes.

A degree in RF engineering is required as well as good command of German and English. First experience with RF tetrode amplifiers as well as with high-voltage and high-current technologies is advantageous, but not essential. The work is done in close conjunction with experienced physicists, engineers and technicians and therefore requires ability and willingness for teamwork. It also calls for willingness to actively promote development of complex technical systems.

The employment will be at the branch institute in Greifswald, for about a year or two the workplace will be Garching near Munich for orientation on the existing plant.

We offer an interesting job, the salary will be according to your qualification and education up to salary Ib German civil service pay scale East (BAT-O). During your stay in Garching salary will be according to BAT-West. Employee's contribution will be granted according to the arrangements of the civil service (Bundesdienst Ost).

Handicapped with equal qualifications will be preferred. IPP encourages especially women to apply.

Please send your application to the address given above until the 31th December 2001 and make sure it contains **"Kennziffer 217"**

The George Washington University

Experimental Nuclear Physics Research Scientists

This position is in support of our experimental program on nuclei and nucleons with tagged polarized photons at Jefferson Lab and elsewhere.

- Three-year term, beginning February 1, 2002
- Ph.D. in Medium Energy/ Electromagnetic Interactions
- Expertise in data acquisition and data analysis
- Experience in computational physics
- Experience with particle and radiation detectors

Please send C.V. and statement of research goals, and have three letters of reference sent directly to:

Professor B.L. Berman, Department of Physics, The George Washington University, Washington, DC 20052
Fax: **(202) 994-3001**;
E-mail: **berman@gwu.edu**

The George Washington University is an EO/AA employer.

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http://www.itep.ru/ws2002

PhysicsJobs **@physicsweb.org**

Max-Planck-Institut für Kernphysik, Heidelberg

MAX-PLANCK-GESELLSCHAFT

We offer postdoctoral and Ph.D. appointments to experienced, young experimentalists with atomic/molecular physics background and interest in the physics of intense short-pulse lasers, of ions in traps and storage rings or atomic and molecular collisions.

Postdoctoral appointments will be for two years with the possibility of extension to five years. Ph.D. positions will be for three years.

The salary will be based on the German public service pay scale (BAT). At equal level of qualification, candidates with disabilities are given preference.

Women are encouraged to apply.

Applications with full CV, publication list, and names and addresses of three referees (post-doc) should be sent to

Prof. Dr. Joachim Ullrich (e-mail: J.Ullrich@mpi-hd.mpg.de).

For more information please visit the website at **http://www.mpi-hd.mpg.de/ullrich/**.

TENURE RESEARCHER POSITION FOR RHIC SPIN PROGRAM

RIKEN (The Institute of Physical and Chemical Research) invites applications for a tenure researcher position with our RHIC spin program.

The successful applicant is supposed to be resident at Brookhaven National Laboratory and play a leading role to carry out our experimental activities using polarized proton collisions at RHIC.

In this program we are involved in the PHENIX experiment, and other activities related to the polarized proton acceleration.

Interested candidates should send a vitae (photo attached), list of publication, copies of the important publications (less than 5), two letters of recommendation, abstract of the research history and description of research interest to:

Dr. H. En'yo, Radiation Laboratory, RIKEN, Hirosawa 2-1, Wako, Saitama 351-0198 Japan, before 26th December 2001.

For further information contact:
Hideto En'yo: Fax: +81-48-462-4641, E-mail: enyo@riken.go.jp, or refer to **http://www.riken.go.jp/** and **http://www.rarf.riken.go.jp/lab/radiation/.**

RIKEN

EMBL

The European Molecular Biology Laboratory (EMBL), an international research organisation with its Headquarters Laboratory in Heidelberg (Germany), Outstations situated in Grenoble (France), Hamburg (Germany) and Hinxton (UK), and a Research Programme at Monterotondo (Italy) invites applications for the following vacancy **in Heidelberg, Germany**

APPLICATIONS DEVELOPER/ ANALYST (ref. no. 01/166)

The successful candidate will be responsible for analysing, adapting, and developing the financial database applications for the Laboratory's administration. The position is assigned to the Computer and Networking Group. This environment provides a stimulating wealth of modern computational machinery, networking, and programming tools. The Applications Developer will closely co-operate with the Administration on improving the tools used to serve the requirements of a dynamic research community. Opportunities exist for continued training and development of skills.

Excellent working knowledge of both English and German is required to succeed in this job.

For full details of this post please visit our web site
EMBL Web site: http://www.embl-heidelberg.de/

Further information can be obtained from
Hans.Doebbeling@embl-heidelberg.de, tel: +49 6221 387 247

To apply please send your CV, quoting ref. no. 01/166, to:

The Personnel Section, EMBL, Postfach 10.2209, D-69012 Heidelberg, Germany. Fax: +49 6221 387555. email: jobs@embl-heidelberg.de

UCLA

THE DEPARTMENT OF PHYSICS AND ASTRONOMY
at UNIVERSITY OF CALIFORNIA, LOS ANGELES (UCLA)

invites applications for a faculty appointment in the area of

EXPERIMENTAL ASTROPARTICLE PHYSICS

Preference will be given to junior applicants for a position at the assistant professor level, but senior applicants will also be considered. We are particularly interested in an experimentalist who will complement and strengthen the UCLA program in astroparticle physics, which currently includes the areas of high-energy astrophysics using gamma-rays, neutrinos, and cosmic rays, direct detection of dark matter, and cosmology.

Researchers with experimental backgrounds in particle physics or high energy astrophysics are encouraged to apply. The successful candidate will be expected to conduct a vigorous research program and to teach at the undergraduate and graduate levels.

Applications should be received by January 15, 2002.
Applicants should send a letter of interest, curriculum vitae with a list of publications, and a statement of research interests to:

Professor Claudio Pellegrini, Chair Attention:
Astro-Particle Search UCLA
Department of Physics and Astronomy
Box 951547 Los Angeles, CA 90095-1547

Applicants should arrange for at least three reference letters to be sent to the same address.

UCLA is an Affirmative Action / Equal Opportunity Employer.

univer sität mainz

Johannes Gutenberg - Universität Mainz

The Institut für Kernphysik of the Physics Department of the Johannes Gutenberg-University Mainz, Germany, is looking for an

Accelerator Physicist

to participate in the ongoing work of the extension of the Mainz Microtron (MAMI-C).

Since 1990 the Institut für Kernphysik operates very successfully, supported by the Deutsche Forschungsgemeinschaft (DFG), the normal conducting 855MeV cw electron accelerator MAMI-B, consisting of an cascade of three racetrack microtrons feed by an 3.5MeV injector linac, to conduct nuclear physics experiments and to produce and use coherent X-rays. In the framework of the Sonderforschungsbereich SFB443 "Many-body structure of strongly interacting systems", founded in 1999, a program to increase the end energy of this unique accelerator to 1.5GeV by adding a fourth stage was started. This project is financed by the Hochschulbauförderung (HBFG). The fourth stage will be realised as a so called harmonic double-sided microtron (HDSM), a new kind of accelerator based on the experience gained with the racetrack microtrons, consisting of two linear accelerators at 2.45GHz and 4.90GHz respectively and two special 180degree bending systems.

Tasks of the successful candidate will be•

- to work on the final design, construction and first operation of MAMI-C in the fields of rf-engineering, beam diagnostic, beam dynamics, computer control, magnet and vacuum technology.
- to familiarise himself with the operation of the existing accelerator.
- to instruct engineers, technicians and workshop staff.
- to negotiate with industry and control their deliveries.

For this position, we seek candidates

- with an excellent diploma/masters degree or Ph.D. in experimental physics.
- with proven abilities to instruct and motivate technicians and workshop staff.
- with good knowledge of the English and German language.

Some experience with the work at an accelerator facility is desirable.

The contract will be at first limited to the 31.12.2004, the salary is according to the German civil service BAT-IIa.

The Johannes Gutenberg-University encourages especially women to apply. Due to German law handicapped applicants will be given preference in case of equal qualifications.

Applications containing a full CV should be sent by January 15th 2002 to:

Institut für Kernphysik, Universität Mainz, Mrs. Huhn, J.-J.-Becher Weg 45, 55099 Mainz, Germany

Department of Electronic and Computer Engineering

BRUNEL UNIVERSITY

Research Fellowships & Assistantships

The Sensors, Instrumentation and Radiation Effects group has currently at least two vacancies to support our PPARC funded research in Particle Physics. The group is a member of the BaBar and CMS collaborations, and is involved in GRID computing (DataGRID, GRIDPP) and detector development. We seek to appoint suitably qualified applicants to support our current experimental activities in these areas.

Applications are invited for positions on BaBar (with a strong interest in data analysis) and CMS (software and hardware development for the ECAL or Tracker). An interest in contributing to the Group's GRID activities would be an advantage. The ideal candidate will have a doctorate in physics, computing, electronics, or a closely related discipline and will have experience in developing software. Candidates without PhD's will be considered if they have relevant experience.

Appointments will be made to either a RA1B (Research Assistant) or RA1A (Postdoctoral Fellow) position, dependent on experience. The salary will be in the range £17,451 to £26,229, plus London Weighting of £1583 pa, and will be dependent on relevant experience. Informal enquiries can be made to Prof. S. J. Watts either by email **(Stephen.Watts@brunel.ac.uk)**, or phone +44 1895 203356.

Please see Brunel Web Pages for an on-line application form. Alternatively for an application form please send a C4/C5 self-addressed envelope to Team B, Human Resources, Brunel University, Uxbridge, Middlesex, UB8 3PH quoting vacancy reference number B6568/1 on both envelopes. You can also email us on **teamb@brunel.ac.uk** or telephone 01895 812304 (24-hour answerphone) quoting vacancy reference number B6568/1.

The closing date for the receipt of applications is 7 December 2001 but applications will be considered at all stages up to appointment.

Laboratoire De L'Aélérateur Linéaire

Physicist/RF Engineer

We have an opening for a physicist/RF engineer to join our particle accelerator group. We are currently involved in international collaborations with DESY (TESLA) and CERN (CLIC). The successful candidate will be expected to contribute to these programmes which involve the construction of accelerator components.

In addition to a knowledge of beam theory, and experience with computer simulation codes, the successful candidate should be familiar with accelerator related technologies. In particular, previous experience with radio-frequency cavities, microwave measurement techniques and beam instrumentation is desirable.

The candidate will be expected to assume responsibility of project leadership in the construction of accelerators or accelerator components.

Candidates should have several years of experience in the field of accelerators and should have obtained an Engineering Diploma (level Grande Ecole) or a Ph.D in physics or electrical engineering. A good command of the English language is essential. Salary will be dependent on experience.

Please write with CV to: **Service du Personnel Laboratoire de L'Aélérateur Linéaire, B.P. 34 91898 Orsay cedex, France.**

Informal enquiries can be addressed to **Dr .T. Garvey** Tel: **33 01 64 46 89 61**; e-mail **garvey@lal.in2p3.fr**

DESY

The **Deutsche Elektronen-Synchrotron DESY** in Hamburg, member of the association of national research centers Hermann von Helmholtz-Gemeinschaft Deutscher Forschungszentren, is a national center of basic research in physics with app. 1,400 employees and more than 3,000 scientific guests from Germany and foreign countries per year. The accelerators in operation are dedicated to particle physics and research with synchrotron radiation.

Within the group – HERA-B we are looking for an

Experimental Physicist (m/f)

as soon as possible for a permanent position.

The candidate is expected

- to take responsibility for the commissioning of the level-1 trigger of the HERA-B detector at the electron-proton accelerator HERA
- to take on a leading role in the research program and data analysis in the HERA-B collaboration
- to take part in the design and preparation of new research projects at DESY

Applicants should have a PhD in physics , several years of experience in experimental elementary particle physics with special emphasis on the areas of data acquisition and triggering techniques and be active in the research in this field. They should have an establishes record in the analysis of particle physics experiments and be able to coordinate the work in close collaboration with the physicists and technicians of the HERA-B experiment.

Please send your letters of application including C.V., list of publications and the names of three referees to our personnel department.

Payment and social benefits correspond to those in public services (BAT Ib; according to German Civil Service).

Deadline for applications: 15.12.2001

Handicapped applicants will be given preference to other applicants with the same qualifications.

DESY supports the careers of women and encourages especially women to apply.

DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY
job offer 99/2001 • Notkestrasse 85 • D-22603 Hambug
Phone +49 40 8998-2524 • www.desy.de

Postdoctoral Research Positions for Academia Sinica, Taiwan

The high energy physics group of the Institute of Physics, Academia Sinica, Taipei, Taiwan, is searching for outstanding postdoctoral candidates. The group participates in the CDF experiment at FermiLab, the ATLAS experiment at CERN and the Alpha Magnetic Spectrometer (AMS) experiment, which is building a particle detector to put on the International Space Station (ISS) to search for antimatter and dark matter.

Interested candidates should submit a letter of application, together with a CV and three letters of recommendation to:

Prof. S. C. Lee, Institute of Physics, Academia Sinica, Taipei 11529, Taiwan, fax : +886 2 2788 8937, E-mail : Shih-Chang.Lee@cern.ch

中央研究院

PHD POSITION in THEORETICAL ASTROPHYSICS starting IMMEDIATELY

(Physics of Jets from Active Galactic Nuclei) at U.of Strasbourg (FR) and U.of Athens (GR)
Supported by EC program "R.T.".
European candidates only (not French nor Greek)
Apply by CV + 2 confidential recommendations to:
heyvaert@astro.u-strasbg.fr and **tsingan@phys.uoa.gr**
Addresses and more details at
http://astro.u-strasbg.fr and **http://www.physics.uoc.gr/~tsingan/**
and **http://www-solar.mcs.st-and.ac.uk/~thomas/platon**

BOOKSHELF

The Genius of Science: A Portrait Gallery by Abraham Pais, Oxford University Press, ISBN 0198506147, hbk £26.50.

The Genius of Science is the last of many books written by Abraham Pais, who died last year (*CERN Courier* October 2000 p46).

Pais was an eminent theoretical physicist who gradually became more and more interested in the history of science and produced the much acclaimed biographies of Einstein and Bohr. He was very interested in people and over the years accumulated a large number of friends, many of whom have made very important contributions to physics. Being an excellent speaker, Pais was often invited to address meetings organized in honour of his prestigious colleagues.

The extended versions of these talks make up most of the contents of this book, which Pais also calls *A portrait gallery of twentieth-century physicists*. Like all of Pais's books, it is very readable and describes in more or less detail the work and characters of 17 physicists who have left their mark on the development of physics – Niels Bohr, Max Born, Paul Dirac, Albert Einstein, Mitchell Feigenbaum, Res Jost, Oskar Klein, Hendrik Kramers, Tsung Dao Lee and Chen Ning Yang, Wolfgang Pauli, Isidor Rabi, Robert Serber, John von Neumann, Viktor Weisskopf, Eugene Wigner and George Uhlenbeck.

The book is well researched and contains countless interesting anecdotes. One sees clearly that the best work is done by young researchers, and that theoretical physicists can be classified as either "golfers or tennis players" – the former do their creative work alone, while the latter are most creative when they can exchange ideas with others. Luckily, Pais was a tennis man who with this book shares with us his love of physics and his deep interest in people.
Don Cundy, CERN.

Abraham Pais – scientific tennis man.

The Physics of Particle Accelerators by Klaus Wille, Oxford University Press, ISBN 0198505493, pbk.

This book is the translation of Klaus Wille's original German edition entitled *Physik der Teilchenbeschleuniger und Synchrotron-strahlungsquellen* (B G Teubner, 1996 Stuttgart), which arose from his long experience with the design and operation of electron sychrotrons at DESY and from a special lecture course on particle accelerators that has been given since 1987 at the University of Dortmund.

The book reflects Wille's background in lepton synchrotrons and is clearly tailored for those who are interested in the design and operation of synchrotron light sources. This is apparent in the original German title, which explicitly mentions the emphasis of synchrotron light sources.

Providing an impressive overview of the different accelerator physics concepts, ranging from the historical to the most common beam diagnostic devices in modern synchrotrons, the book emphasizes two main subjects: linear-beam optics and the theory of synchrotron light sources. All relevant equations are presented so that the reader can easily follow the individual steps in the derivations and can immediately apply the final equations to specific examples. However, at times an illustration of the underlying concepts is hidden beneath the mathematical descriptions or postponed to later sections.

The first main topic of the book provides a comprehensive and concise summary of linear-beam optics and discusses different possibilities for calculating the beam optics functions of an accelerator. This latter topic provides useful insights into the functionality of existing computer codes, which are widely used for the calculation of beam optics functions in large accelerators. It also provides a large set of examples for the transfer maps of the most common elements in a storage ring, allowing the reader to perform hands-on calculations of the beam optics functions for simple accelerator models. However, while the chapter presents a thorough discussion of local-orbit bumps, including specific working examples, it does not comment on tools for global-orbit correction that are at the heart of the day-to-day operation of a modern synchrotron light source.

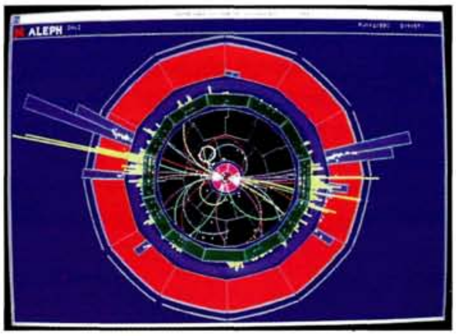
The second main topic of the book – radiative effects – highlights all of the essential equations that are required for estimating the equilibrium beam sizes in the presence of radiation damping and includes a treatment of special "low-emittance" lattices as they are used in modern synchrotron light sources. The book describes special insertion devices of synchrotron light sources and damping rings and it includes a discussion of free electron lasers, which play a central role in modern accelerator physics research, together with a presentation of fourth-generation synchrotron light sources.

In summary, the book provides a vast amount of material and a thorough introduction to the general concepts of particle accelerators. It offers a rich collection of useful equations that are essential for the operation of a storage ring. It clearly emphasizes a discussion of synchrotron light sources and is therefore highly recommended to anybody interested in this field. However, special aspects of other types of accelerator are somewhat neglected or entirely missing. Anybody primarily interested in other machines might not find all of the information that they are looking for. For example, the problem of collective instabilities, which provides fundamental limitations to the beam intensities, is lacking, and the discussion of the normalized beam emittance and luminosity limitations addresses only the limits of lepton storage rings.
Oliver Bruening, CERN.

Au Coeur de la Matière by Maurice Jacob, Editions Odile Jacob, ISBN 2738109802.

In this topical book, CERN theorist Maurice Jacob glibly traces the evolution of our understanding of the underlying structure of matter, from atoms to quarks – and its implications for cosmology. While the subject is not easy, the author manages to attain a remarkably deep level of insight without writing any equations. The many difficult concepts encountered *en route* are not glossed over or paraphrased (even though some of them could be). The presentation of the "Schödinger's cat" enigma is well done. A few explanations, like parity violation, would have benefited from an explanatory diagram. However, event displays from CERN's LEP collider provide vivid examples of basic types of interaction.

An introduction manages to bring into the very first paragraph the enigma of quarks – unlike all other constituents of nature, quarks resist being isolated. The meat of the book goes on to trace in detail the mechanisms of the microworld, to climax on the one hand ▷



Event displays from CERN's LEP collider provide vivid examples of particle interactions.

with the Standard Model and the state of particle physics today and on the other its implications for the Big Bang and the birth of the universe, which was initially just a big particle physics experiment.

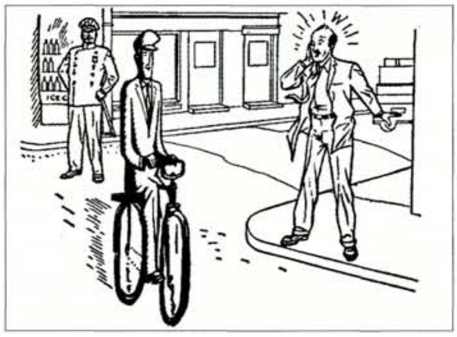
Then comes a series of essays examining basic questions – the baffling concept of time, antimatter and the structure of the vacuum. Two more chapters look at the sociology of particle physics – how post-Second World War collaboration between scientists has catalysed new international understanding and helped overcome political barriers once perceived as insurmountable, and how this collaboration has attained a truly planetary level for the construction of the new LHC collider at CERN.

The final chapter examines the value of particle physics and its contributions to other branches of science – imaging for medicine and other applications, high-performance detectors, new techniques for data handling and parallel computing and underlines the value of research in education and training.

The book always uses CERN as its focus and reflects the vision of the organization's spiritual fathers like Louis de Broglie who first saw the need for large-scale international scientific collaboration amid the ruins of post-war Europe.

The New World of Mr Tompkins by George Gamov and Russell Stannard, Cambridge University Press, ISBN 0521639921, pbk £10.95/$16.95.

Mr Tompkins is a dreamy, bemused character who blunders his way through the intricacies of modern physics.



Mr Tompkins encounters physics.

Russell Stannard's update of George Gamov's famous portrayal appeared in 1999 (*CERN Courier* November 1999 p43). At that time, Gamov's 1965 "science fantasy" anthology was also reissued in paperback. Now the wheel has turned full circle with a paperback version of the new edition. Gamov's original "Mr Tompkins in Wonderland" story appeared in 1940. Clearly there is still a lot of mileage left in Tompkins.

Rack clearance

Multichannel GS/s data acquisition systems used to be expensive. They also would fill up entire instrument racks with power-hungry electronics. But no more. We have shrunk the size, lowered the cost, reduced the power consumption and incorporated exceptional features such as clock synchronization and complete trigger distribution.[1)]

A single crate (no bigger than a desktop PC) can house up to 24 channels at 500MS/s or 1GS/s when deploying an embedded processor, or up to 28 channels (14 at 2GS/s) using a PCI interface.

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1) Rackmount kit available

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