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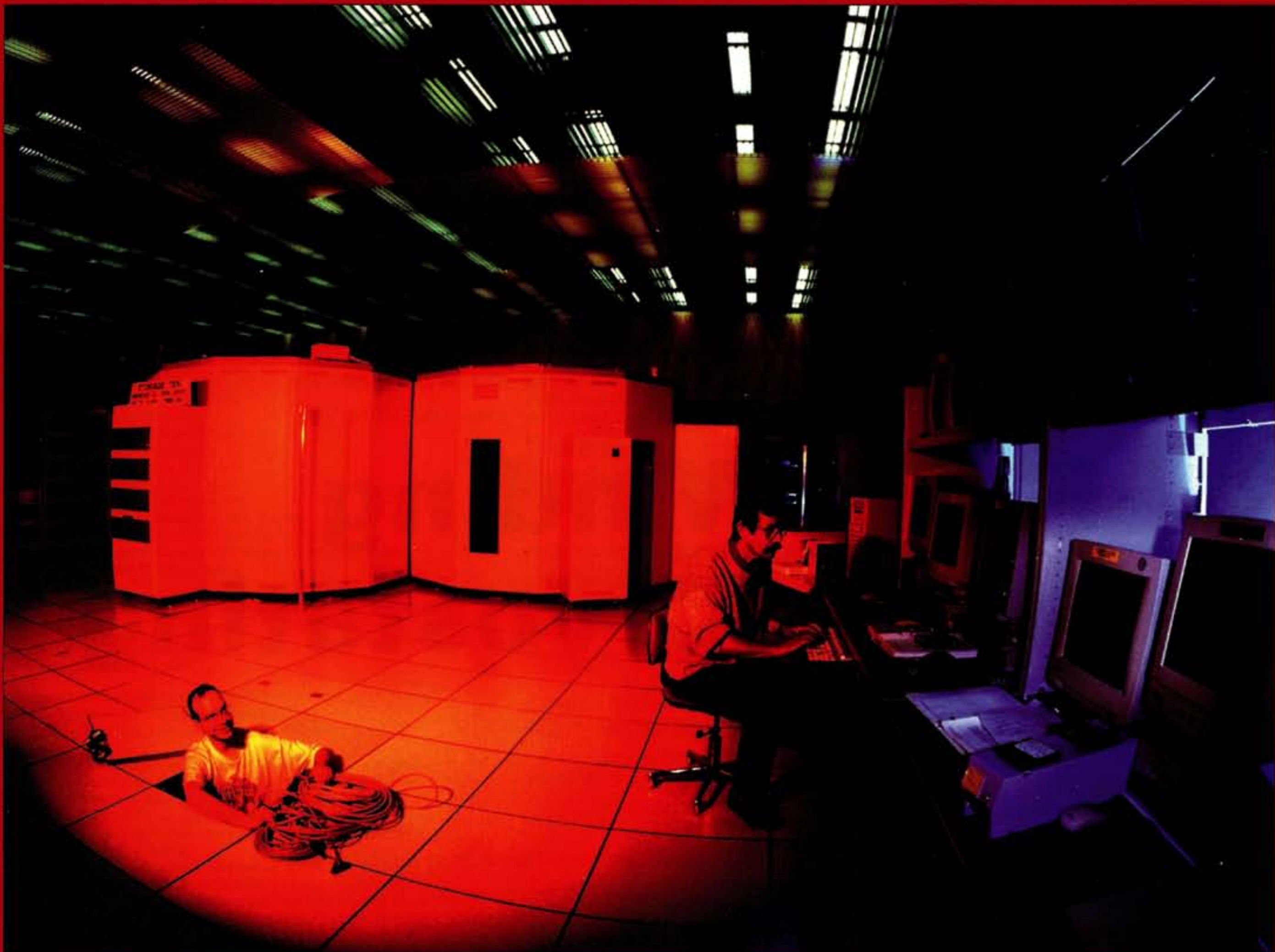

Computing testbed for the world

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

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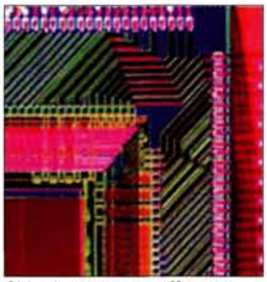
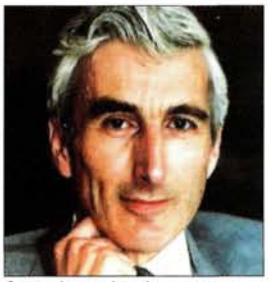

Chips have more to offer p11


Changes at Cornell p22


Cosmology prizewinner p29

Cover: En route to a computing testbed for the world – CERN's four-silo STK (Storage Tek) tape library and its control area. Each silo can contain up to 6000 storage slots, with cartridges of up to 50 Gbyte capacity that have a data transfer rate of up to 12 Mbyte/s (p5).

CERN

Green light for massive increase in computing power for LHC data

The first phase of the impressive Computing Grid project for CERN's future Large Hadron Collider (LHC) was approved at a special meeting of CERN's Council, its governing body, on 20 September.

CERN is gearing up for an unprecedented avalanche of data from the large experiments at the LHC (*CERN Courier* October p31). After LHC commissioning in 2006, the collider's four giant detectors will be accumulating more than 10 million Gbytes of particle-collision data each year (equivalent to the contents of about 20 million CD-ROMs). To handle this will require a thousand times as much computing power than is available to CERN today.

Nearly 10 000 scientists, at hundreds of universities round the world, will group in virtual communities to analyse this LHC data. The strategy relies on the coordinated deployment of communications technologies at hundreds of institutes via an intricately interconnected worldwide grid of tens of thousands of computers and storage devices.

The LHC Computing Grid project will proceed in two phases. The first, to be activated in 2002 and continuing in 2003 and 2004, will develop the prototype equipment and techniques necessary for the data-intensive scientific computing of the LHC era. In 2005, 2006 and 2007, Phase 2 of the project, which will build on the experience gained in the first phase, will construct the production version of the LHC Computing Grid.

Phase 1 will require an investment at CERN of SwFr 30 million (some €20 million) which will come from contributions from CERN's member states and major involvement of industrial sponsors. More than 50 positions for young professionals will be created. Significant investments are also being made by participants in the LHC programme, particularly in the US and Japan, as well as Europe.

This challenge of handling huge quantities of data now being confronted by CERN will be faced subsequently by governments, commerce and other organizations. The LHC will be a computing testbed for the world.

CERN's particle physics experiments require massive data storage installations.

Openlab attracts big names

To push the LHC computing effort, CERN has set up the openlab for DataGrid applications. Already, three leading information technology firms – Enterasys Networks, Intel and KPNQwest – are collaborating on this project in advanced distributed computing. Each firm will invest SwFr 2.5 million (€1.6 million) over three years.

CERN already coordinates one major Grid computing effort – the EU-funded DataGrid project (*CERN Courier* March p5). An important aim of the CERN openlab is to take the results of these projects and apply them in the LHC Computing Grid.

The World Wide Web, which was developed at CERN during the run-up to research at the LEP collider, allows easy access to previously prepared information. Grid technologies will go further, searching out and analysing data from tens of thousands of interconnected computers and storage devices across the world.

This new capability will enable data stored anywhere to be exploited much more efficiently. Particle physics is blazing a scientific Grid trail for meteorologists, biologists and medical researchers.

See "http://www.cern. ch/openlab".

DESY

International team breaks through to maximum light amplification

In a major boost for future plans, an international team based at DESY has achieved maximum light amplification from a free-electron laser (FEL) for ultraviolet radiation. The amplification of 10 million is the theoretically expected peak performance for such a device and is over a thousand times the brightness so far achieved in this region of the electromagnetic spectrum.

The FEL at DESY produces ultraviolet light with wavelengths of between 80 and 180 µm – the shortest wavelengths produced in this way. Maximum light amplification ("saturation") was obtained with a wavelength of 98 µm.

The latest results were produced at DESY's TESLA Test Facility (TTF) using the self-amplified spontaneous emission principle (SASE), first proposed and investigated elsewhere in the early 1980s. In SASE, electrons brought to high energies in a suitable accelerator subsequently traverse a slalom-like course of magnets, emitting laser-like bundles of radiation as they do so.

The TESLA test facility at the DESY laboratory, Hamburg, has achieved record results for a free-electron laser.

The electrons and the emitted radiation act on each other. The tiny bunches of electrons try to match the wavelength of the radiation, thereby becoming denser and radiating more intensely. This microbunching continues until all of the electrons oscillate in unison. Unlike traditional lasers, the SASE approach is not limited to specific wavelengths and it can be scaled appropriately.

The SASE FEL at DESY has shown for the first time that the self-amplifying effect does lead to the theoretically calculated amplification in the ultraviolet regime. Similar amplification factors were demonstrated last year at institutes in the US in the visible light range (500 µm).

Soon, the existing DESY TTF will be upgraded to a 300 m FEL to attain wavelengths of less than 6 µm – the regime of soft X-rays. As well as a research facility in its own right, it will serve as a testbed in the international TESLA project for a superconducting linear electron–positron collider. As well as supplying beams for particle physics research, this will also apply SASE technology to produce ever shorter wavelength X-rays (*CERN Courier* July 2000 p26).

HISTORY

History centre publishes archiving guidelines

According to a recently released report by the American Institute of Physics (AIP) Center for the History of Physics, the documentation of collaborative scientific research needs urgent attention. The problems that need to be addressed range from the way in which the contributions of distinguished individuals (or records of a project conducted by one institution) are preserved, to the fact that, almost without exception, research institutions and federal science agencies fail to provide adequate support to programmes to save records of significant research.

To remedy this, the AIP History Center has issued *Documenting Multi-Institutional Collaborations* – the final report of its decade-long study of multi-institutional collaborations in physics and allied fields.

The main recommendations of the report are that:

- scientists and others should take special care to identify past collaborations that have made significant contributions;
- research laboratories and other centres should set up a mechanism to secure records of future significant experiments;
- institutional archives should share information.

The report makes a broad distinction between "core records" – to be saved for all collaborations – and other records to be saved for "significant collaborations".

For more details, see p27.

CERN

School returns to Switzerland

For the first time since its inception nearly 40 years ago, the European School of High-Energy Physics was held in Switzerland at Beatenberg in the Bernese Oberland. Running from 26 August to 8 September, it attracted 95 students from 30 countries. This year's event was organized in association with the University of Bern, with Klaus Pretzl as school director. Funds for students from former Soviet Union countries came from the INTAS international association.

Above: impressive backdrop at the 2001 European School of High-Energy Physics, held at Beatenberg in the Swiss Bernese Oberland. On the left loom the Eiger and Mönch peaks, with the Jungfrau summit obscured by a small cloud. Left: participants at the 2001 European School of High-Energy Physics at the Jungfraujoch station, 3580 m above sea level.

These schools have become a major event in the particle physics calendar. The tradition began in 1962 with a one-week course at St Cergue, Switzerland, for young students and senior physicists using the emulsion technique at CERN. The 1963 school also took place at St Cergue, but with the emphasis on physics rather than on techniques.

In 1964 the courses moved outside Switzerland and the programme was extended to include bubble chamber as well as emulsion techniques. By 1965 the focus had switched to teaching theoretical elementary particle physics to young experimentalists, where it has remained ever since.

International participation widened in 1970 when the school was held in Finland, in collaboration with the Joint Institute for Nuclear Research (JINR), which is based in Dubna, near Moscow. The following year, JINR organized a school in Bulgaria, in collaboration with CERN, after which biennial joint schools continued up to and including 1991, when the last JINR-CERN school has held in the Crimea in the USSR.

With the changed political scene in Europe, schools continued to be organized jointly every year, but under the title European School for High-Energy Physics, and with a four-year cycle consisting of three annual schools in CERN member states and the fourth in a JINR member state.

In 1993 the first such school took place, appropriately, in Zakopane, Poland, a member state of both CERN and JINR. Since then the school has been held in Sorrento, Italy (1994); Dubna, Russia (1995); Carry-le-Rouet, France (1996); Menstrup, Denmark (1997); St. Andrews, Scotland (1998); Bratislava, Slovakia (1999); Caramulo, Portugal (2000); and Beatenberg, Switzerland (2001).

TRANSPARENT PHYSICS

Quaero makes particle detector

A major step towards "transparent" particle physics has come from a new scheme that opens up data collected by the DO experiment at Fermilab's Tevatron proton–antiproton collider.

When physicists started to study the behaviour of the atomic nucleus 90 years ago, they carefully watched scintillating screens for the tiny flashes produced as alpha particles were scattered by nuclear targets. The scintillating screen was the detecting medium and the experimenters' own eyes provided the "read-out".

Opening up the data – the DO collaboration at Fermilab's Tevatron (left) and University of Chicago physicist Bruce Knuteson (right).

Later came track chambers, such as cloud and bubble chambers. These were of immense appeal because physicists could directly see what happened in particle interactions. However, these instruments have been relegated to science museums, and today's research relies instead on fast electronics. When today's high-energy particle beams are made to collide, the big detectors surrounding the collision point are the physicists' "eyes".

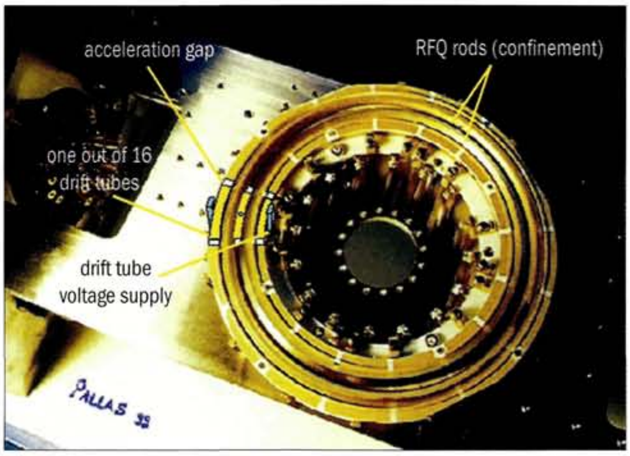
One of the big challenges facing a newborn baby is to make sense of all of the jumbled visual signals that it sees and to learn to recognize and interpret patterns – people, objects and their surroundings. In the

STORAGE RINGS

Table-top device makes crystalline beams

A model set up at Munich's Ludwig-Maximilians University has for the first time achieved a high level of "crystallization" of particle beams in a ring.

The particles orbiting in conventional circular accelerators are controlled by carefully arranged electric and magnetic fields. One long-sought-after aim is to freeze out the relative motion of the particles in the ring so that the accelerator fields hold them firmly in place, similar to atoms in a crystal lattice, giving beams of unprecedented brilliance.



Overview of the 12 cm diameter PALLAS storage ring at Munich's Ludwig-Maximilians University, which has achieved a high level of "crystallized" particle beams.

The first signs of such behaviour were seen some 20 years ago at Novosibirsk using the then new electron cooling approach, which was pioneered at Novosibirsk. The behaviour has since been reproduced – notably at the ESR storage ring at Darmstadt's GSI laboratory. The extremely precise momentum definition needed to achieve such conditions makes for very accurate mass spectrometry.

However, the beam ordering seen under these conditions is far from complete and can be understood as particles losing their ability to overtake each other. Three-dimensional arrangements of ions have been achieved in particle traps using additional techniques, such as laser cooling to damp the residual motion of particles.

Physicists at Ludwig-Maximilians University built a special table-top storage ring that uses the radiofrequency quadrupole (RFQ) technique normally used in linear accelerators. Their 12 cm diameter PALLAS ring can be likened to a ring-shaped quadrupole ion guide. The radial confinement of the ions, as well as the bending, is provided by the RFQ ring electrodes. The ring is additionally equipped with drift tubes uniformly distributed around the circumference. These generate static electric fields, which can be used to transport and position ions longitudinally and to bunch the beam.

The ion beam attained a velocity of 2800 m/s – equivalent to a beam energy of 1 eV. The number of ions involved, some 10^5, is small by the standards of particle accelerators and storage rings, but the ideas could be scalable to larger machines.

Reference

T Schätz, U Schramm and D Habs 2001 *Nature* **412** 717.

datasets available for all

same way, the physicists operating a large electronic detector have to convert the raw impulses received by the various detector components and be able to say, for example, that a certain bunch of signals represents a 50 GeV pion travelling in a certain direction. Tracking is still there but the tracks are the results of computers analysing the impulses recorded in successive layers of the detector rather than direct "snapshots".

Analysing the results of an experiment thus has to be carried out by physicists who "know" the detector. Another physicist who is not intimately acquainted with the detector but who has a hypothesis and wants to test this against actual data has to ask physicists from the experiment for help.

In the new development – called Quaero from the Latin for "I search" – the interpretation of certain datasets collected by the Fermilab D0 experiment from 1992 to 1996 has already been done and is openly available to other physicists to use as a testbed for models and theories. The data are classified according to the type of particles produced and include several of the datasets that led to the discovery of the top quark at Fermilab in 1995. This opening up of carefully collected data has become standard practice in astronomy.

Chicago physicist Bruce Knuteson, who masterminded Quaero, is currently at CERN to see if similar procedures can be established for the data archives of the four big experiments at CERN's LEP electron–positron collider, which closed last year. He is optimistic. Electrons and positrons are point-like, so electron–positron collisions are "cleaner" and less complicated than the proton–antiproton interactions studied at the Tevatron. Protons and antiprotons are in fact bunches of quarks and gluons, each of which can have its own collision products.

In the past, testing a model against actual data could take at least a few years. Quaero can do this in an hour. Until now there was no way of publishing a complete dataset of a high-energy physics experiment. Published plots show data in just two dimensions, making it difficult for another physicist to take the data as presented in a publication and translate them into some other context. The Quaero paper has been accepted for publication in *Physical Review Letters*.

If Quaero is extended to LEP data, then anyone who wants will be able to sift for Higgs particles or other physics.

Further information

Visit "http://quaero.fnal.gov".

PHYSICSWATCH

Edited by Archana Sharma

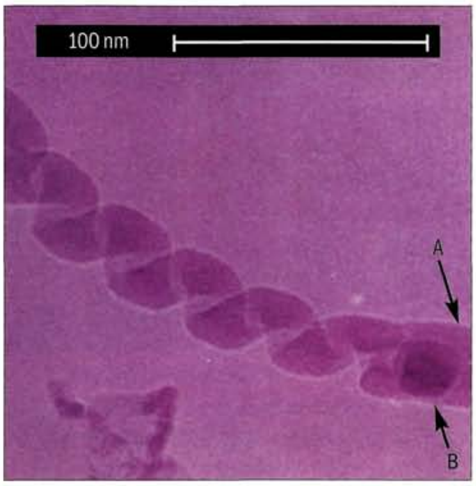
Except where otherwise stated, these news items are taken from the Institute of Physics Publishing's news service, which is available at "http://physicsweb.org".

Technology gets a nanospring for possible future detectors

Twist a nanowire into a helix and what do you get? A nanospring, of course. Although wires that are tens of nanometres in diameter are not actually wrapped to make springs, they are grown that way through a process known as vapour-liquid-solid (VLS) growth mode. VLS growth occurs when a catalyst droplet resting on a surface absorbs wire-building material from a surrounding vapour. Once the concentration of the building material reaches supersaturation in the droplet, a portion of the material is secreted out of the droplet base and a wire gradually forms. The material deposition can be asymmetric and the wire develops into a helical nanospring.

Until recently the mechanism that leads to this asymmetry has been unclear, but now researchers at the University of Idaho have proposed a model that sheds new light on nanowire formation. It seems that a small catalyst droplet, which is roughly the same diameter as a growing nanowire, remains centred on top of the wire. The resulting growth is linear. However, if the droplet exceeds the wire diameter, its balance atop the structure is uncertain and a small perturbation can bump the droplet to one side, abruptly nudging the growth pattern from straight to helical.

Nanosprings can be used to make highly sensitive magnetic field detectors. Alternatively, nanosprings could serve as positioners, or even as tiny conventional springs, for nanomachines of the future.

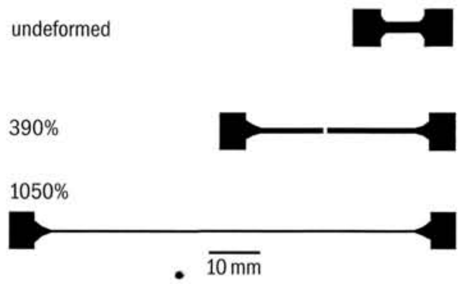


A scanning electron microscope captured this image of the transition from linear to helical growth in a boron carbide structure built up through a process known as vapour-liquid-solid growth mode. Up to point A, the nanowire had grown linearly. A small perturbation disturbed the droplet responsible for depositing material as it passed point B, transforming the nanowire into a nanospring (left).

Further reading

D N McIlroy *et al.* 2001 *App. Phys. Lett.* 3 September.

New ceramics can be stretched faster



New ceramics retain their shape under extreme stretching.

A ceramic devised in Japan can be rapidly stretched to 10 times its initial length and retain its new shape. The new mixture can also be deformed a thousand times as fast as existing superplastic ceramics, which snap if bent or pulled too fast. This has made it difficult for ceramics to profit from the swift moulding techniques that are used for metals and polymers.

Ceramics contain metals and other elements, such as metal oxides, or combinations of non-metals, such as silicon carbide. Most are brittle, like pottery. Engine and turbine parts are made from the few, such as silicon carbide, that are extremely tough and resist corrosion better than metals. Superplasticity arises in ceramics consisting of tiny grains that can slide over one another, and the sliding is better if the grains are very small. The new material's grains are less than one-thousandth of 1 mm (1 μm) across. Grain sliding can cause two problems. First, it leaves holes that have to be filled by loose atoms. Second, it can be accompanied by grain growth. As grains get bigger, they are more likely to crack. The faster the deformation, the more likely it is that holes will form and grains will grow.

Researchers at the Japanese National Institute for Materials Science in Tsukuba have minimized both of these problems with their blend of zirconium oxide, magnesium aluminate spinel and alumina. At 1650 °C the ceramic can be stretched very far, very fast.

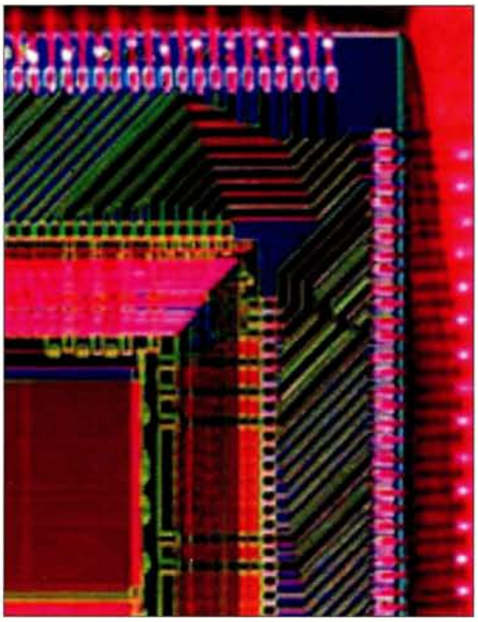
Further reading

B N Kim *et al.* 2001 *Nature* **413** 288–291.

Silicon chips can offer much more capacity

Silicon chips could hold thousands of times more transistors than the billions that they house today, researchers at Georgia Institute of Technology have calculated. This opens up the prospect of trillion-transistor chips and of "terascale integration" (TSI) circuits. Such a level of miniaturization would increase computer speed and capability by as much as the difference between the machines of today and the cumbersome microcomputers that appeared in the early 1980s.

Neither fundamental physics nor materials science rules out TSI, although the technical challenges are immense. TSI would require devices – made from layers of electrically conducting silicon and insulating silica – that are much smaller than today's. Silica layers, for example, would have to be less than one-millionth of 1 mm (1 nm) across, and components would need to be less than 10 nm wide. Existing methods cannot carve such fine-scale silicon circuits, so new fabrication techniques will be needed.



One of today's silicon chips – soon to be a museum-piece?

At the fundamental level, the uncertainty principle of quantum mechanics restricts how fast devices can switch between two states – "on" and "off" – and the speed of light ultimately limits how quickly signals can travel.

In terms of materials, layer thickness is limited by silica's "leakiness" (*CERN Courier* October p11), which interferes with the electrical isolation of the silicon terminals in transistors. Another big restriction comes from the accuracy with which dopant atoms can be mixed with very small volumes of silicon. Dopants fine-tune the electrical properties of silicon. If they are unevenly distributed at small scales, the device can fail. Nevertheless, they seem to be on schedule for 2011.

Further reading

J D Meindl *et al.* 2001 *Science* **293** 2044–9.

Anomalous acoustoelectric effect creates a counter wind that pulls charges

Just as wind drags autumn leaves along a street, when an acoustic wave propagates through an electrically conducting surface, it can drag electric charge along with it. This "acoustic wind", known more formally as the acoustoelectric (AE) effect, has been discovered by a Russia–Poland–Ukraine collaboration.

Studying the electric current produced by the AE effect can provide important information on how electrically charged particles interact with the crystal lattice of a conducting material. Such materials include "manganites" – manganese-based compounds that can exhibit "colossal magnetoresistance" – in which electrical conductivity becomes tremendously sensitive to external pressure and applied magnetic fields.

Investigating the AE effect in a manganite thin film on a lithium niobium oxygen (LNO) substrate, the researchers observed an unusual effect. Sending an acoustic wave in a certain direction produced a much weaker electric current than expected for that direction. The reason is that, in addition to the ordinary acoustic wind, a counter wind was "blowing" against the acoustic wave. The counter wind arose from the fact that the substrate was "piezodielectric" – one in which electric fields were generated by pressure.

When the acoustic wave created an alternating pattern of compression and expansion in the substrate, the compressed regions produced electric fields that pointed in the direction of the counter wind and interacted with the electrons on the thin film. Since the manganites increase their conductivity dramatically when compressed, this encouraged a flow of electrons in the reverse direction.

While this anomalous AE effect is probably too weak for technological applications, measuring it could provide a new method for studying the effects of pressure on a conducting material. This could be useful when conventional measurement methods are difficult, as is the case for thin films or quantum wells, wires or dots.

Further reading

Y Ilisavskii *et al.* 2001 *Phys. Rev. Lett.* 1 October.

Superconducting tool to test chips

A superconducting single-photon detector built by a Russia-US collaboration has immediate applications in testing computer chips and, more speculatively, for interplanetary communication.

The researchers fabricated extremely thin strips of niobium nitride – a metallic compound that becomes superconducting near absolute zero. The detector was made using these strips, each only 1 μm wide and several atoms thick.

The detector enabled the researchers to "see" single visible and infrared photons, because the superconducting strips lack the electrical noise that ordinarily obscures a single-photon signal.

The detector can record the small amount of infrared light that is released when a transistor switches on or off. The detector can detect bursts as short as picoseconds, so it could be used to monitor the performance of high-speed transistors.

Further reading

G N Gol'tsman *et al.* 2001 *App. Phys. Lett.* 6 August.

Edited by Emma Sanders

Observers decipher more primordial helium to unravel the history of the early universe

Observations of helium give new clues as to how matter evolved in the early universe.

The primordial helium gas left over from the Big Bang is spread thinly through space between galaxies. NASA's Far Ultraviolet Spectroscopic Explorer (FUSE), which was launched in June 1999, observed the light from a distant quasar and measured the absorption of helium over 20 days. Simultaneous observations using the Hubble Space Telescope measured the light at longer ultraviolet wavelengths, where the spectrum is unaffected by helium.

Measuring how the absorption varies across the spectrum of the quasar reveals how the gas evolved as the universe got older.

This technique has been used many times before to study the intergalactic medium using the Lyman-α line of atomic hydrogen. The difficulty of using helium is that the absorption line occurs in the far-ultraviolet, where the Earth's atmosphere is opaque, hence the need for a space telescope.

The new observations trace the architecture of the universe back to very early times. The helium structure arose from small gravitational instabilities that were seeded in the chaos just after the Big Bang. The excellent resolution of the results shows up the variations that existed in the young universe, when galaxies were forming and when quasars were at their most active.

The nuclei of helium atoms were formed in the first few minutes after the Big Bang. As the universe expanded, the nuclei captured electrons to form a cool gas of neutral atoms. This gas was then reheated and ionized by the radiation from the first energetic objects in the universe.

Reference

Science **293** 1112.

Are fundamental constants evolving?

Making a return appearance on the physics stage is a report of the possible evolution of the fine structure constant, α.

This constant, which governs fine structure in the emission and absorption spectra of atoms, is defined by other fundamental constants: the charge of the electron, the Planck constant and the speed of light. If α were to vary, then at least one of the other "constants" would have to change as well. If the speed of light were evolving, this would have important implications for recent cosmological observations, such as the apparent need for negative gravitational pressure and a cosmological constant.

The new results are based on the spectroscopy of gas clouds using light from distant quasars and then comparing the spectral lines with those observed in the laboratory today. The results suggest that α is evolving with time. The reported fractional change is minute, being -0.72×10^{-5} over the redshift range from $z = 0.5$ to 3.5. However, even such a minute change would have tremendous significance. The researchers have not yet identified any systematic effects that could otherwise explain the results.

Reference

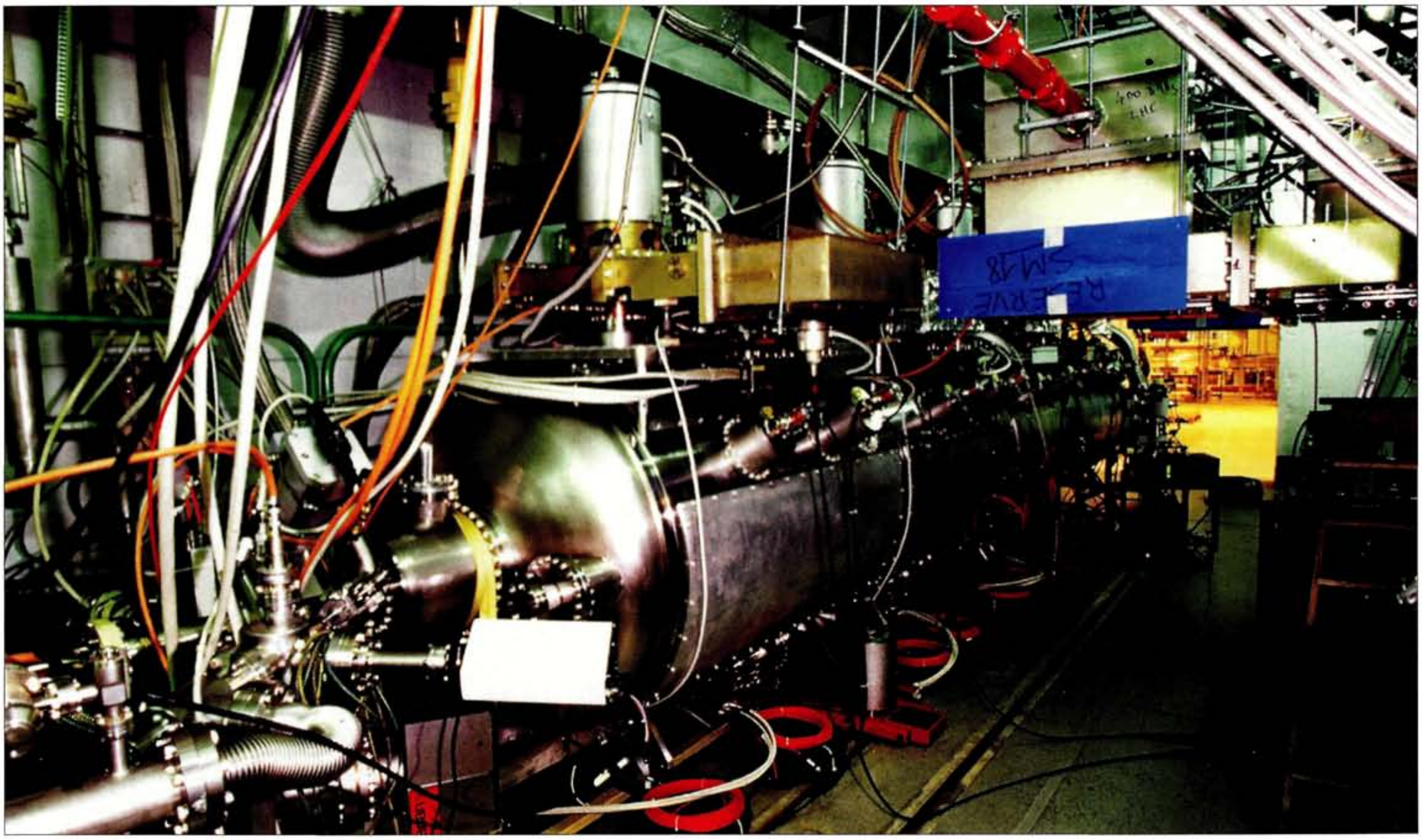
Phys. Rev. Lett. 2001 **87** 091301.

Picture of the month

This image of the Eagle nebula is made up of data from the European Space Agency's Infrared Space Observatory (ISO). It reveals the dust clouds that surround the star-forming region in the centre of the nebula. The dust, at around −100 °C, can be seen as a bluish fog. ISO finished observing in May 1998, but new discoveries are still being made from the rich stock of accumulated data.

Experts share news of radiofrequency progress

Superconducting technology is becoming the standard route for supplying power to high-energy particle beams. The latest specialist workshop, which was held in Japan, provided a valuable window on progress.



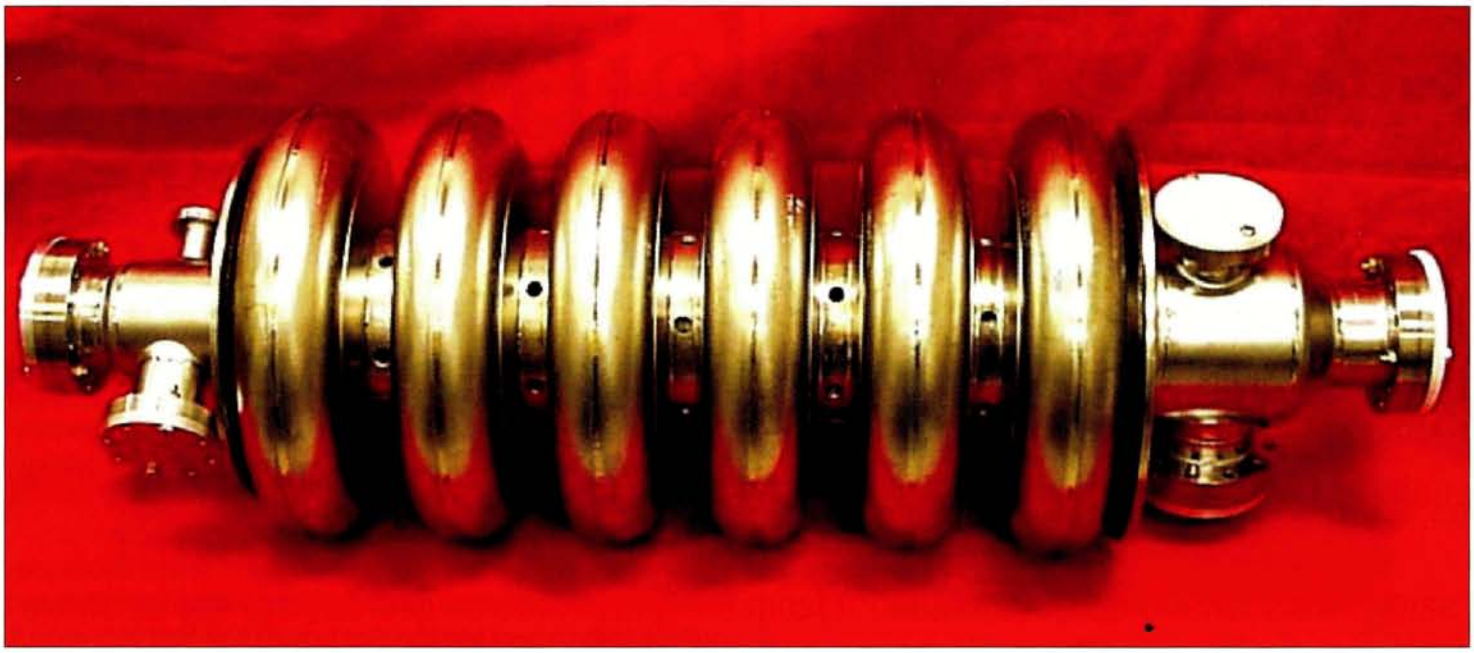
A superconducting radiofrequency cavity for CERN's LHC collider undergoing extensive power testing.

Radiofrequency (RF) electric fields provide the motive power for high-energy accelerators. In the continuing bid for higher energies, superconducting techniques are increasingly being used to obtain maximum electronvolts from the wall plug.

The traditional biennial meeting of experts in RF superconductivity reflects the continual and impressive progress being made. The tenth workshop was jointly organized by the Japanese KEK and JAERI laboratories and held in Tsukuba on 6-11 September under the chairmanship of Shuichi Noguchi.

The first day's sessions were devoted to laboratory review talks in the traditional alphabetic order. First to deliver was Argonne National Laboratory, where R&D to design and finalize accelerating structures for the Rare Isotope Accelerator (RAI) is gaining momentum. The last of the reviews was from Wuppertal University, where high-critical-temperature materials are being examined both for their RF properties and for possible applications, such as in superconducting RF filters.

Evidently, all laboratories in the TESLA collaboration for a superconducting linear electron–positron collider had put in a major effort to finalize the technical details for their machine proposal with its incorporated X-ray Free Electron Laser presented earlier this year (*CERN Courier* June p20). The very ambitious goal of $2000 per superconducting MV, pronounced long ago by the late Bjorn Wiik, who was one of the driving forces for TESLA, has nearly been achieved. Reliable but inexpensive fabrication, final surface treatment and assembly techniques are essential for building the



State of the art – an 805 MHz prototype six-cell solid niobium cavity (β = 0.61) built at the US Jefferson Laboratory for the Spallation Neutron Source that is under construction at Oak Ridge and for which the Jefferson Laboratory is responsible for cavity production in close collaboration with Los Alamos. The total length of the device is 107 cm and the active length (cells only) is 67.5 cm. The stiffener rings with holes for helium passage can be seen between the cells.

required 20 000 cavities. Manufacturing by hydroforming or by spinning several cells from one tube were reviewed extensively. For surface treatment, electropolishing and high-pressure water rinsing are now standard.

Similar techniques will be applied for the improved cavities for the upgrade of the Jefferson Laboratory's CEBAF machine to 12 GeV. CERN's effort to produce the LHC 400 MHz superconducting modules in niobium copper technology was covered. CERN also collaborates with several laboratories using its existing facilities from the increased energy effort at LEP2. These remain operational for the preparation and future maintenance of cavities for CERN's future LHC collider.

Proton machines

Another effort is focused on high-current superconducting proton (or light ion) linacs. Beam energies (per nucleon) will largely exceed those reliably delivered for many years by ATLAS (Argonne) or ALPI (INFN-Legnaro), coming close to or even exceeding 1 GeV. This covers a large number of projects or studies: the Spallation Neutron Source (SNS) under construction at Oak Ridge, for which the Jefferson Laboratory is in charge of cavity production in close collaboration with Los Alamos; the "joint project" of JAERI and KEK (*CERN Courier* March p8); the European Spallation Source; the French 700 MHz proton linac; the Advanced Accelerator Applications project at Los Alamos; the Italian TRASCO; and CERN's SPL (*CERN Courier* July p6).

These proton linacs and the RAI at Argonne now unify the superconducting RF community, which has been split until now into "low beta" (below say β = 0.2, where β is the ratio between the beam particle velocity and that of light) and "high beta" (practically β = 1) applications, with nothing in between. To study fully superconducting options for these machines, the length of the typically "elliptical" β = 1 cavities – such as those used for LEP2 – is squeezed down to about β = 0.5, where mechanical stability problems start to arise.

At the other end of the range the typical low-β spoke resonators or H-mode structures are being "stretched" to about the same β, hence supplying superconducting resonators suitable for all β. This includes even a very-low-energy superconducting radiofrequency quadrupole under development at INFN-Legnaro in Italy.

Phenomenal reliability

Due to the high-power demand per cavity, high-performance power couplers with very high reliability are needed. The KEK 500 MHz coupler, as used for the eight KEK B-factory cavities, has been the starting point for the SNS coupler design. It was stated that in many cases the cost for a coupler and a bare cavity are about equal – something to remember when looking for cost savings.

The workshop reviewed what had been achieved at the world's largest superconducting RF system so far, with about 3500 MV total voltage, for CERN's LEP2 electron–positron collider which closed last year. The system had largely outperformed its initial design goals and routinely allowed stored beams of up to 104 GeV for the (unfortunately inconclusive) search for the mysterious Higgs boson (*CERN Courier* March p24).

It was remarkable that none of the nearly 300 power couplers broke during the whole life of LEP2 and only a small fraction of the machine downtime was due to superconducting RF – a much smaller fraction than due to conventional equipment faults. ▷

It was remarkable that none of the nearly 300 power couplers broke during the whole life of LEP2 and only a small fraction of the machine downtime was due to superconducting RF.

This proven reliability has led the way to the wide acceptance by funding agencies of a superconducting option for newly approved projects such as SNS.

Free electron lasers (FEL) need short, low-emittance bunches that can only be realized in linacs, but the unused beam energy is lost. This gave rise to the Energy Recovery Linac concept, where the possibly blown-up "spent" beam is recirculated 180° out of phase through the linac, thus supplying most of the energy for the following bunches. This scheme has been successfully demonstrated at Jefferson and gives hope for very energy-efficient machines. Other projects tend to apply the same technique and Cornell is even looking at a high-brightness synchrotron light source using this scheme.

Overcoming difficulties

Theoretical considerations as well as studies at several laboratories have complemented these efforts. Different surface treatments and surface analysis have been applied to push high field performance and reliability of production. The old enemies, multipacting and field emission, were also examined.

Microphonics (detuning by externally driven cavity vibrations) and Lorentz detuning (deformation by the electromagnetic forces inherent to the RF field) are a serious nuisance for many applications. A new session covered cavity RF control, fighting these effects by feedback, feedforward or even fast piezo actuators, currently being studied at DESY.

In this context a much stiffer cavity is advantageous. Stiffeners and their optimum parameters were discussed, but thick-walled cavities made from copper with a thin inner niobium layer are also being looked at. The sputter technique developed at CERN produces superconducting layers well adapted for LEP2, but because of the decrease of resonance Q-value with increasing field ("Q-slope") it is prohibitive for the large fields needed for TESLA. Parallel efforts to understand the Q-slope and remove it are ongoing, but studies are also proceeding at INFN-Rome2 and Jefferson to examine other methods for producing niobium film on copper.

The trend towards the closer collaboration of laboratories around the world is an integral part of the effort to advance towards a common production method with reliable cavities having performances close to theoretical limits and at the lowest possible cost. This supplants traditional friendly laboratory rivalry.

It is commonplace now for a test cavity produced by new methods at one laboratory to be sent round the world to another laboratory for surface treatment, finally being tested in an equally distant third laboratory, using the most advanced equipment available at each stage of the process.

For the first time the workshop included a weekend, with Saturday a working day and with the option of a Sunday excursion to nearby Kamakura, a historical Japanese site. Around 160 participants were registered, including about 50 from Japan. As always, manufacturers of raw materials, parts or full systems exhibited their latest products and sponsored the workshop.

The next workshop is planned to be held in northern Germany in 2003, organized by DESY in the name of the TESLA collaboration.

Joachim Tückmantel, *CERN.*

Astroparticle physicists gain increased support

Understanding what happens in the largest objects of the universe in terms of interactions between the smallest particles of matter might seem a tall order, but funding agencies see that, as well as addressing the most fundamental problems of the universe at large, astroparticle physics also has immense appeal. In this article we take a look at the astroparticle scene in Germany, one of CERN's largest member states.

Focus for astroparticles – DESY Zeuthen.

An interesting future

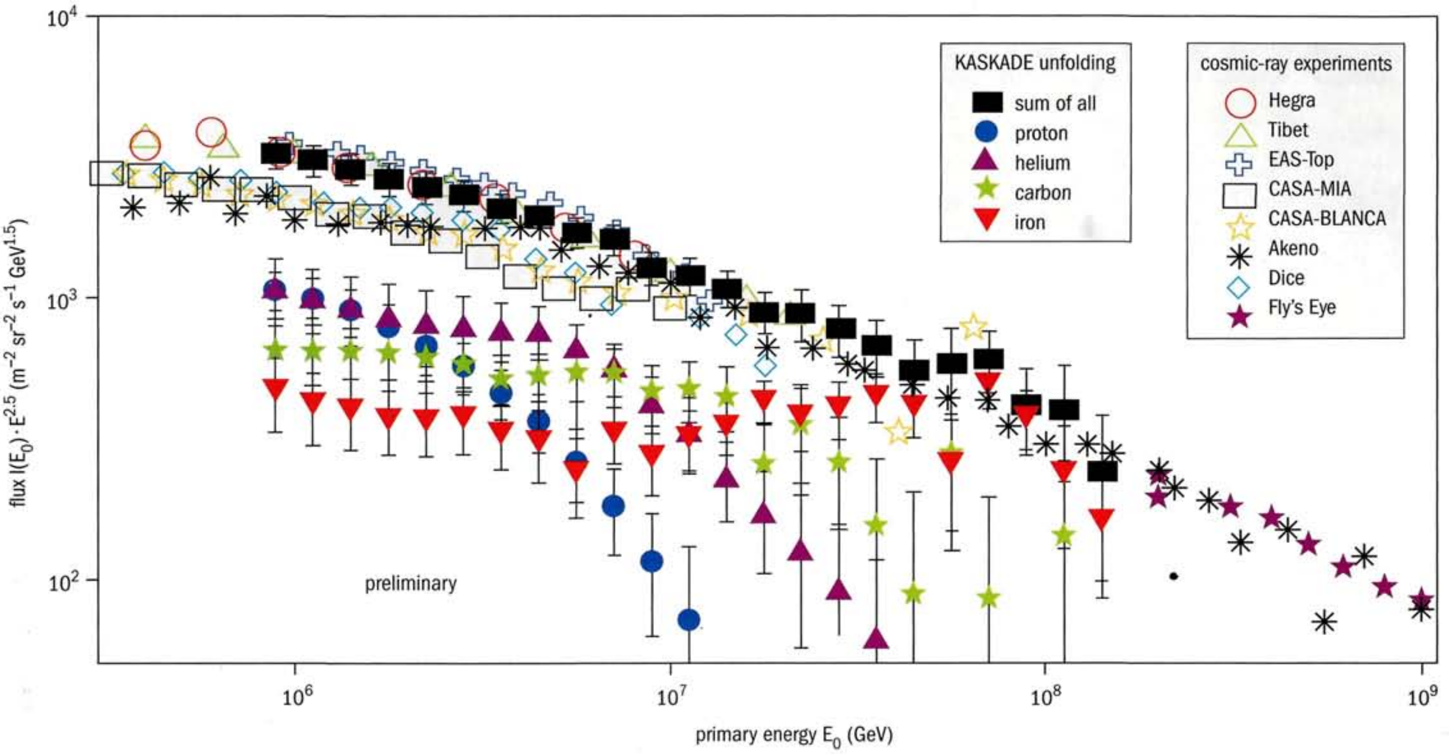
Following an initiative of the German Ministry for Education and Research (BMBF) and a successful first meeting in October 1999, a second workshop on astroparticle physics took place at DESY Zeuthen in June. The stimulating presentations and discussions showed again what can be achieved by a close collaboration between scientists and their funding agency. The results hint at an interesting future and vindicated the BMBF in its decision to provide increased funding for research projects in astroparticle physics.

High-energy and nuclear physicists, astronomers, astrophysics specialists, astroparticle physicists and ministry representatives all provided input for a recent workshop on astroparticle physicists sponsored by the German Ministry for Education and Research (BMBF). Such cross-disciplinary input sparked many interdisciplinary discussions and was immediately fruitful.

After initial special lectures for students, the science talks proper reviewed the cosmic background radiation at all wavelengths, presented by D Lemke from the Max-Planck Institute (MPI) for Astronomy in Heidelberg; the evidence for dark matter in the universe (P Schneider, Bonn); properties of black holes (H Falcke, MPI for Radioastronomy, Bonn); the connection between astroparticle physics and particle physics (A Ringwald, DESY); and cosmology with new experiments (F Aharonian, MPI for Nuclear Physics, Heidelberg, and G Sigl, Institut d'Astrophysique de Paris).

Other talks focused on currently running or planned experiments. Now widely exploited is the technique of imaging atmospheric Cherenkov-light telescopes (IACTs), in which the primary cosmic photon is measured by the Cherenkov light emitted by the photon-induced particle shower in the Earth's atmosphere.

In the past 10 years such experiments have progressed from prototypes to precision tools. The results are puzzling. IACTs were ▷



The energy spectrum of charged cosmic rays around the "knee" (talk by K-H Kampert) including, energy spectra for different mass groups, as presented by the KASCADE collaboration. The data suggest that, for different primaries, the energy of the "knee" depends on the "rigidities" of the particles as they traverse high magnetic fields. This may be interpreted as indirect evidence for models that describe the acceleration of the primary cosmic-ray particles as fully ionized nuclei in turbulent magnetic fields (in supernova remnants, for example).

originally aimed at finding where galactic charged cosmic rays are accelerated, but to date no convincing acceleration sites have been pinned down. However, totally unexpected, highly variable, extragalactic sources have been discovered that emit photons with energies of up to at least 16 TeV (G Heinzelmann, Hamburg).

The detailed energy spectra obtained are difficult to understand and may conflict with our present understanding of intergalactic background radiation fields. New experiments (W Hofmann, MPI for Nuclear Physics, Heidelberg, and E Lorenz, MPI for Physics, Munich) with significantly improved sensitivities will start data-taking in 2002 and are bound to find more surprises. Their energy threshold will be lowered to match the upper end of the energy range accessible by satellites (G Kanbach, MPI for Extraterrestrial Physics, Garching) so that the last energy gap for observational astrophysics with high-energy photons will be closed.

Cosmic rays

While the IACTs are fighting the air showers induced by charged cosmic rays as unwanted background, other experiments concentrate on these showers to understand the origin of cosmic rays. The ambitious aim is to collect detailed data on the energy spectrum and the mass composition. The most interesting of the energy regions are the "knee", around 10^{16} eV where the index of the energy spectrum suddenly changes, and the highest energies above 10^{19} eV.

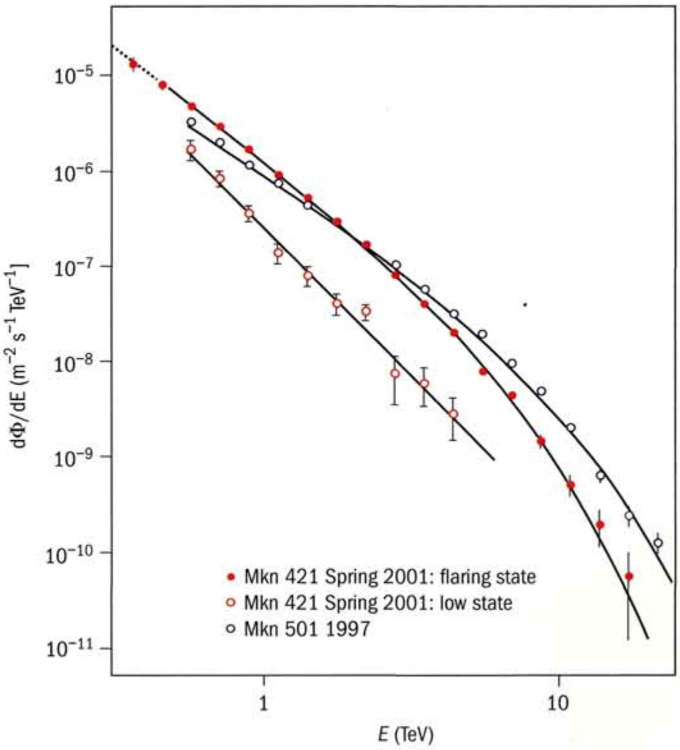
Due to the very low cosmic-ray flux at these energies, direct measurements by balloons or satellites (M Simon, Siegen) are not possible. The only experimental approach realized so far uses extended ground-based installations catching data of the induced air showers. Physicists encounter several challenges. One is the result of the absence of accelerator-based measurements of particle interactions in the relevant kinematic regions. Not only must the astrophysical questions be answered, but also reliable interaction models to simulate the air shower developments must be worked out in parallel.

K-H Kampert (Karlsruhe) presented the progress around the "knee" where detailed multiparameter analyses may soon allow firm conclusions to be drawn. At the highest energies, new, extended experiments will provide large event numbers (H Blümer, Research Centre, Karlsruhe) and tackle the mystery of the cosmic rays beyond the Greisen–Zatsepin–Kuzmin cut-off energy near 10^{20} eV.

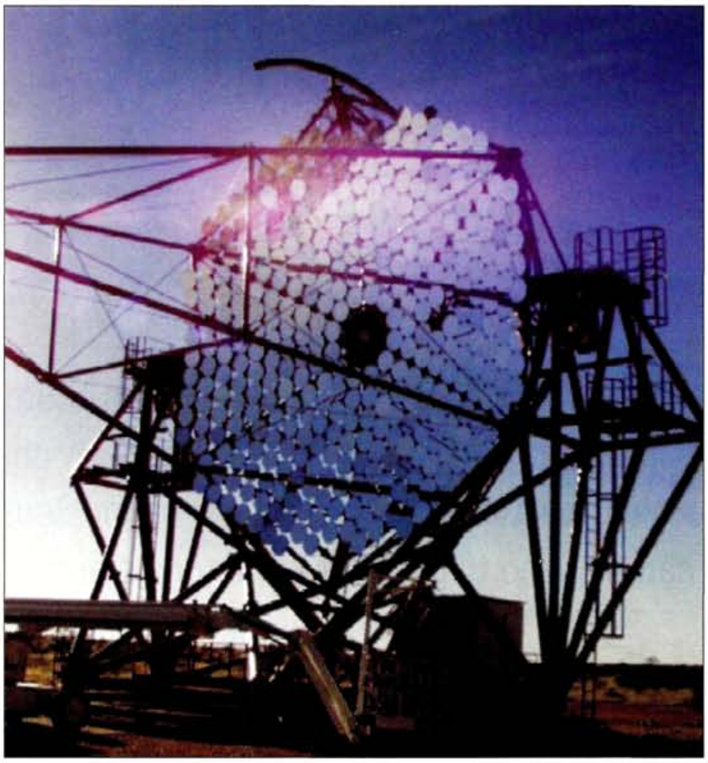
Multiparameter analyses of cosmic-ray air showers around the "knee" may soon allow firm conclusions to be drawn.

Neutrinos and dark matter

Most experiments for high-energy neutrino astronomy are still in the prototype and development phase (L Köpke, Mainz, and J Brunner, Centre de Physique des Particules, Marseille). The Amanda experiment, using ice from Antarctica as a particle detector, is already able to identify neutrinos from interactions of the cosmic radiation



The energy spectra of two distant active galactic nuclei (AGNs) as measured precisely by the HEGRA experiment (presented at the Zeuthen meeting by G Heinzelmann). It is hoped that spectra of this kind will allow a better understanding of the properties of AGNs and will simultaneously make the measurement of the intergalactic infrared radiation possible. The energy spectra should exhibit a cut-off due to interactions of TeV-photons with infrared photons leading to electron–positron pair production.



*The HESS telescope takes shape in Namibia (*CERN Courier *September p30). Such imaging atmospheric Cherenkov-light telescopes provide a new window for cosmic-ray research.*

in the atmosphere, and it is now hoping to find the first neutrinos from cosmic sources. The workshop benefited from the timely publication of the SNO measurement on solar neutrinos (*CERN Courier* September p5), which was reviewed together with results from experiments on atmospheric neutrinos by S Schönert (MPI for Nuclear Physics, Heidelberg).

J Jochum (Technical University, Munich) described exciting direct searches for dark matter. The sensitivities of new experiments will open up regions where signals are expected from cosmology and supersymmetry. In the hunt for the first supersymmetric particle, perhaps we will see strong competition between these installations and the LHC detectors at CERN. The race is on.

Broadening support

A special session with BMBF representatives looked at the funding situation in Germany and Europe. H-F Wagner's introductory talk and a review of the funding situation in Germany by Wagner and J Richter described both what the BMBF expects and what it could provide. Reciprocally, scientists' views of the forthcoming challenges helped to focus BMBF support onto the central science questions.

Following the initial phase in 2000, in which BMBF astroparticle physics funding concentrated on IACT experiments, the field of supported projects will broaden considerably this year and next. Also, the first steps to organize an astroparticle physicists community in Germany were agreed (see "http://www.astroteilchenphysik.de" – an English version is in preparation).

The scientists expect further impetus from the Astroparticle Physics European Co-ordination (ApPEC) initiative – a network founded by the BMBF and the funding agencies of France, Holland, Italy and the UK (*CERN Courier* July/August p15).

In his summary, DESY research director R Klanner underlined the consensus views of the workshop: the fundamental questions about the birth and development of the universe, dark matter and dark energy, and about the origin of mass and forces can probably be answered only by the combined effort of astrophysics, cosmology, physics and astroparticle physics. As well as complementing and enriching each other via their scientific and technological progress, these research topics also have enormous public appeal, making them ideal vehicles for "outreach" – bringing living science into the public arena.

The workshop showed once again how astroparticle physics is a very lively field with many upcoming new experiments. These could finally solve decades-old riddles, like the origin of cosmic rays and the existence of non-baryonic dark matter.

R Klanner proposed DESY Zeuthen as the host of the third workshop in the series in 2003.

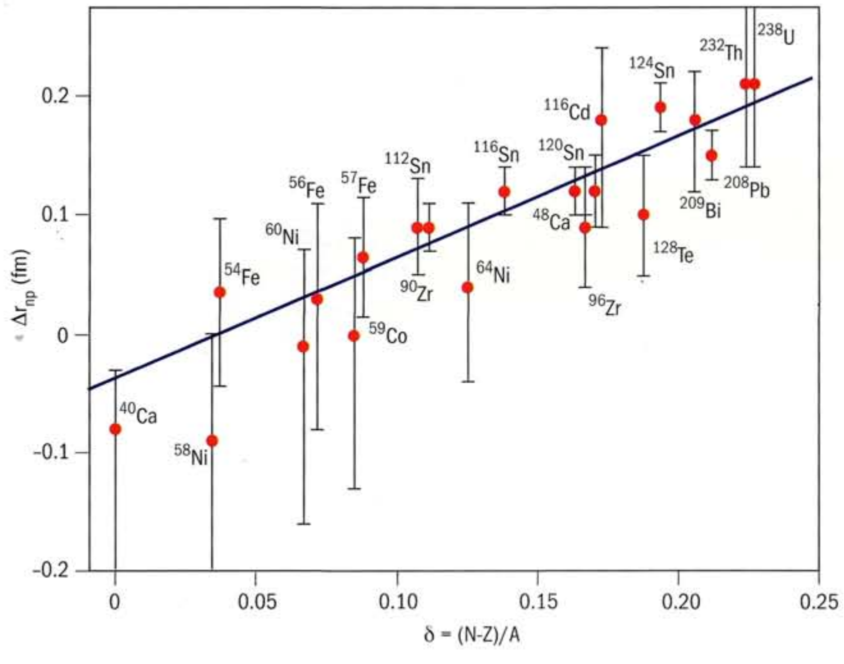
Further information

For more details of the workshop, visit "http://www.astroteilchenphysik.de".

Axel Lindner, *DESY.*

Experiment boosts the idea of a nuclear halo

The availability of relatively copious sources of antiprotons has stimulated the study of "exotic" atoms, in which a negatively charged antiproton replaces an orbital atomic electron. When they approach the nucleus these antiprotons feel the nuclear force and can be used to probe nuclear forces and structure. A new result from CERN underlines the existence of an outer nuclear "halo" composed mainly of neutrons.



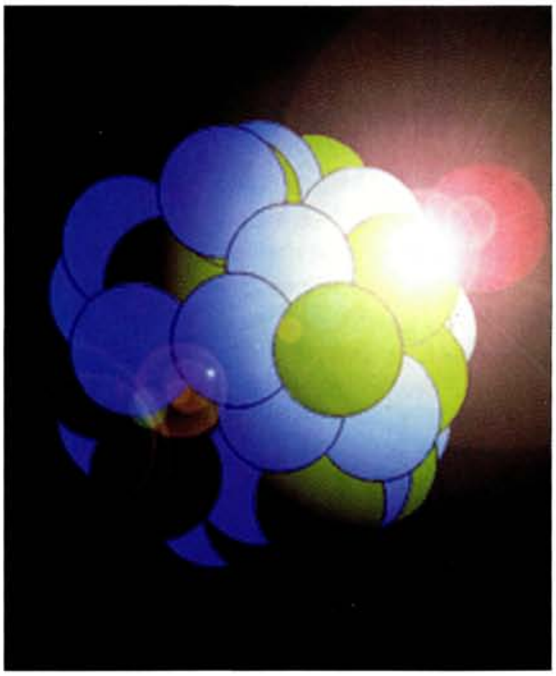


Fig. 1: The more neutrons, the more they tend to live on the nuclear periphery. Left: results from an experiment at CERN's low-energy antiproton ring (LEAR) show that the difference between the radii of nuclear neutron and proton distributions (vertical axis) increases with the bulk neutron excess of the nucleus (horizontal axis). Right: nuclei contain protons (shown in blue) and neutrons (shown in brown). An antiproton grazing the nuclear surface readily annihilates with a subnuclear particle. The results of these annihilations reflect the relative proton–neutron composition of the nuclear periphery.

Our everyday world is made up of atoms in which protons and neutrons are packed together by the strong nuclear force into a tiny core of positive electric charge, surrounded by a sparse cloud of "orbiting" electrons, these carrying an equal and opposite negative electric charge.

The electron orbits are hundreds or thousands of times larger than the nucleus. Seen from an orbiting electron, the central nucleus looks far away and rather structureless, in the same way that the Sun appears to us as a distant homogeneous sphere.

By making artificial atoms in which electrons are replaced by other, heavier particles that pass very close to the nucleus, physicists are able to get a close look at the centre of the atom in the same way that space probes, such as the SOHO satellite, see a very different picture when approaching the Sun's surface.

Being electrically charged, protons can be mapped by probing the nucleus with charged particle beams, like electrons. Neutrons are more difficult to map, especially at the outer, less dense edges of the nucleus. Over the years, experiments using a variety of techniques have suggested the existence of a neutron "halo" – a sort of uniform nuclear stratosphere, relatively isolated from the "weather" at the centre of the nucleus. An experiment at CERN has given fresh support to this idea.

Many of the particles commonly produced by high-energy beams can carry negative charge. Examples are the muon, the pion, the kaon, hyperons and the antiproton. Normally these particles travel so fast that they tear past target atoms, ripping out electrons in their wake. However, as the particles lose energy and slow down, they can eventually reach a point where they knock out an electron for the last time and become captured by the electric field of the neighbouring nucleus, thus forming an "exotic" atom.

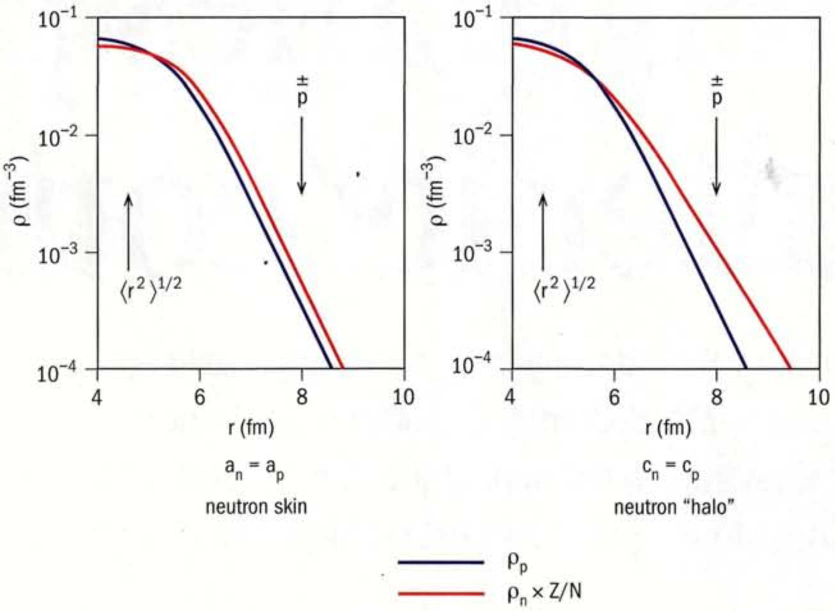


Fig. 2: the neutrons tend to populate an outer nuclear "halo" (right), the neutron density of which increases with distance from the nuclear centre, rather than a nuclear "skin" (left) with a constant thickness.

In such an atom the intruder orbital particle is much heavier than the electron that it has replaced, so its orbit is consequently smaller. A muon, for example, is 200 times as heavy as an electron and is able to pass correspondingly closer to the nucleus. However, a muon, like an electron, does not feel the strong nuclear force, even at very close distances.

Strongly-interacting particles such as the pion, the kaon, hyperons and the antiproton do feel the strong force of the nucleus. In addition, the strongly interacting particles are heavier still (an antiproton being 2000 times heavier than an electron) so that they can get very close to an atomic nucleus. Exotic atoms are therefore a good laboratory for studying the periphery of the nucleus.

Nuclear tools

The availability of copious sources of antiprotons at the antiproton factories at CERN and Fermilab from the 1980s has opened a new chapter in antiproton physics, and the study of antiprotonic atoms is one of the beneficiaries.

One of the experiments at CERN's LEAR low-energy antiproton ring, by a CERN/Munich/Warsaw collaboration, set out to look at the neutron-proton distributions in a range of nuclei. LEAR was closed in 1996 but the results of the difficult experiment have now been published.

Several techniques could be used. In one approach, the physicists waited for the orbital antiprotons to be swallowed up by the nuclei. The antiproton then annihilated with a nuclear particle, forming a nucleus one mass lighter than the parent. The appearance of such a nucleus signalled the disappearance of an antiproton. The daughter nuclei could be analysed radiochemically and the resultant nuclear yields, which depend on whether the antiproton was annihilated with a proton or with a neutron, measure the neutron and proton densities at the outermost layer of the nucleus.

This was done for 19 medium and heavy nuclei, from calcium to uranium. The results reveal that the outer nuclear density extends much further than the effective charge radius of the nucleus, showing that neutrons populate the nuclear periphery. Also, the more neutrons in a particular isotope, the more they tend to settle near the surface.

In the second approach, physicists look at the detailed spectroscopy of the antiprotonic atoms. In these atoms the intruder antiprotons have definite energy levels, analogous to those of the electrons in ordinary atoms. When the atoms are nudged, orbital particles, whether electrons or antiprotons, can shift from one energy level to another, emitting or absorbing quanta of radiation. While for the electrons of ordinary atoms these are usually quanta of visible light, for the more compact antiprotonic atoms the quanta are in the X-ray region.

For atomic electrons, the Pauli Exclusion Principle restricts the atomic seating accommodation. However, single antiprotons see no such competitor particles and can sit in whatever available energy level they like.

The energies (wavelengths) of these spectral lines can be calculated from atomic quantum mechanics that take into account the electromagnetic attraction between the nucleus and the orbital particle. The antiproton, as it passes by the nucleus, is also affected by the nuclear force. This can both shift and blur the X-ray signal.

These deviations from the purely electromagnetic predictions give an indication of nuclear effects. In the LEAR experiment, physicists measured these for 34 different nuclear targets, ranging from oxygen-16 to uranium-238.

The key parameter in each case is the difference between neutron and proton populations at large radii. The two different approaches are in broad agreement, showing that the more neutrons there are, the more they tend to live on the nuclear periphery (figure 1). The neutrons also tend to populate an outer nuclear halo, the neutron excess of which increases with distance from the nuclear centre, rather than a nuclear skin with a constant neutron excess (figure 2).

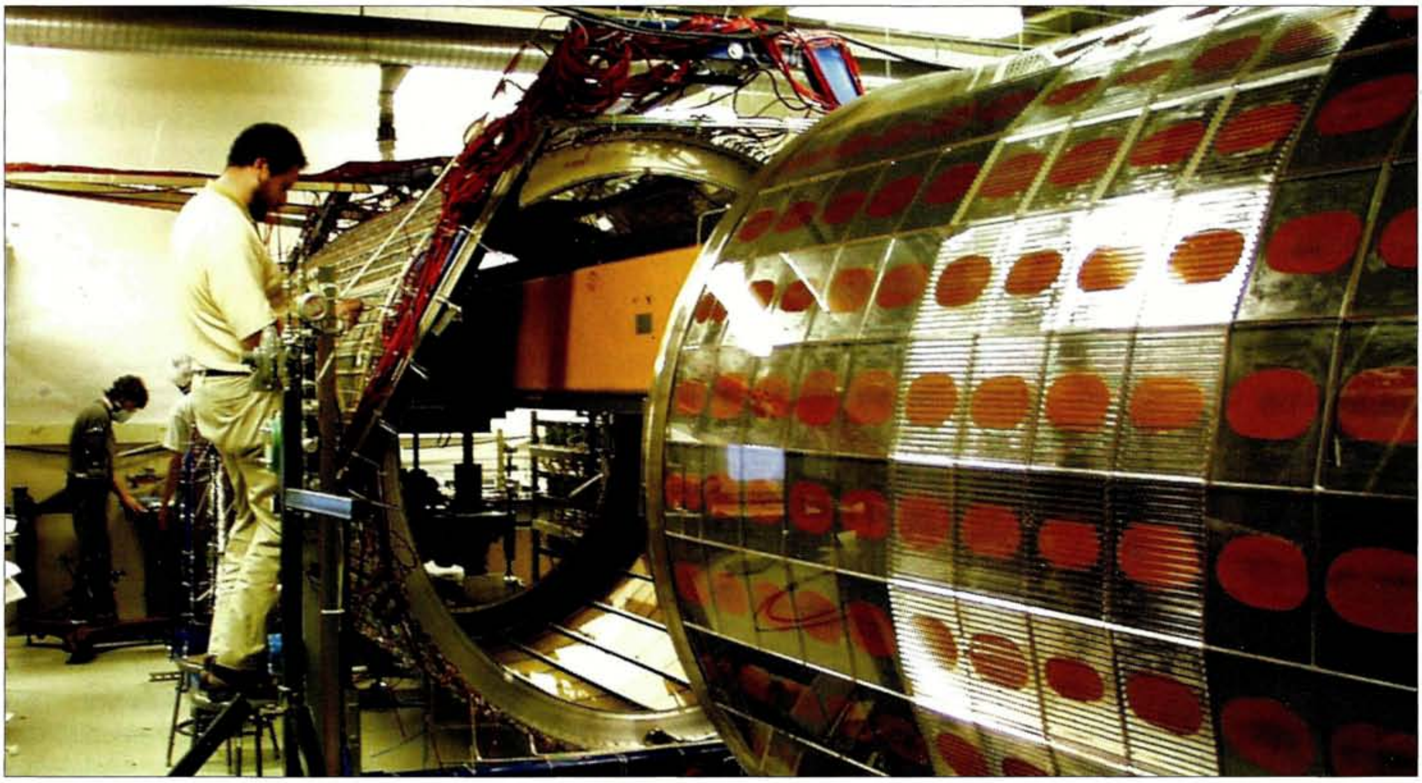
Another antiproton experiment at CERN (*CERN Courier* October p35) uses antiprotonic atoms as a precision laboratory for measurements of the antiproton itself. □

Reference

A Trzcinska et al, 2001 *Phs Rev Lett* **87** 082501-1.

Cornell makes plans to alter its course

Cornell University in New York managed for a long time to keep pace with major national laboratories. Experiments at Cornell provided many important contributions to the physics of B mesons – particles containing the fifth "b" quark. With the commissioning of new "B factories", Cornell's physics is set to change direction.

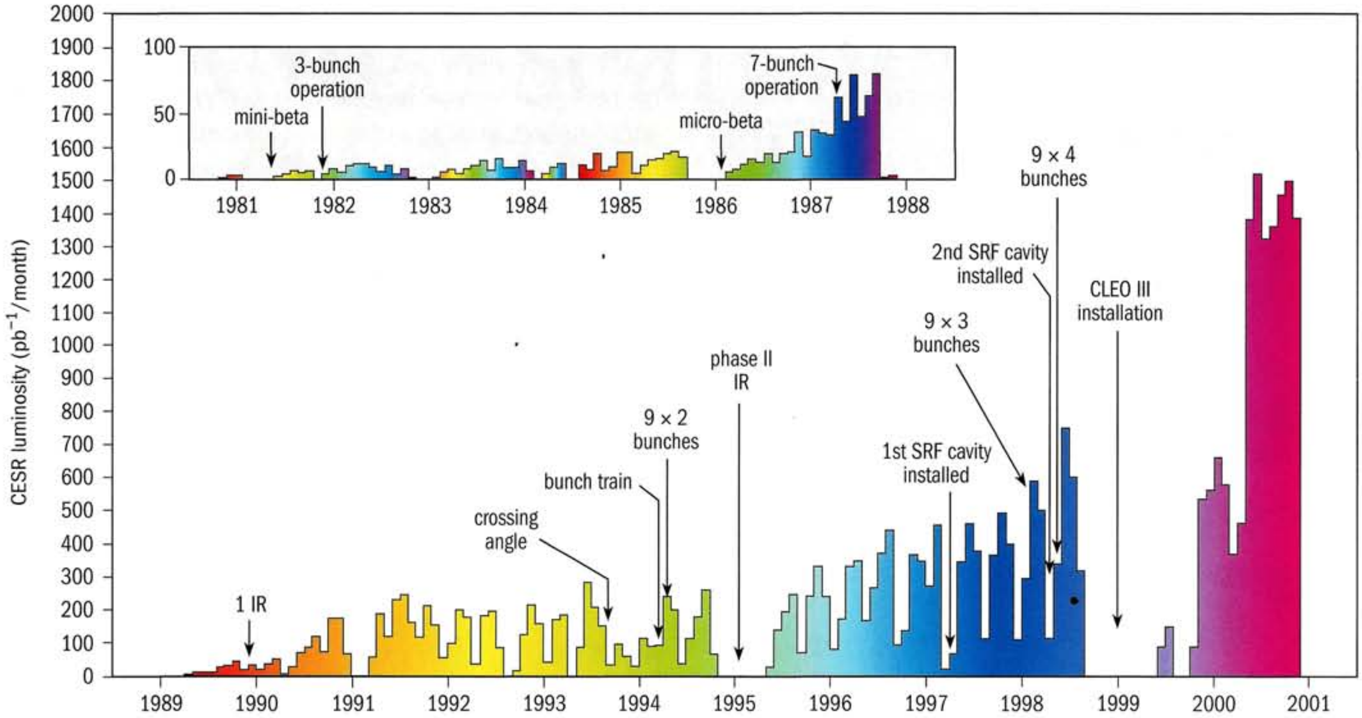


Particle identification – the CLEO RICH detector during assembly.

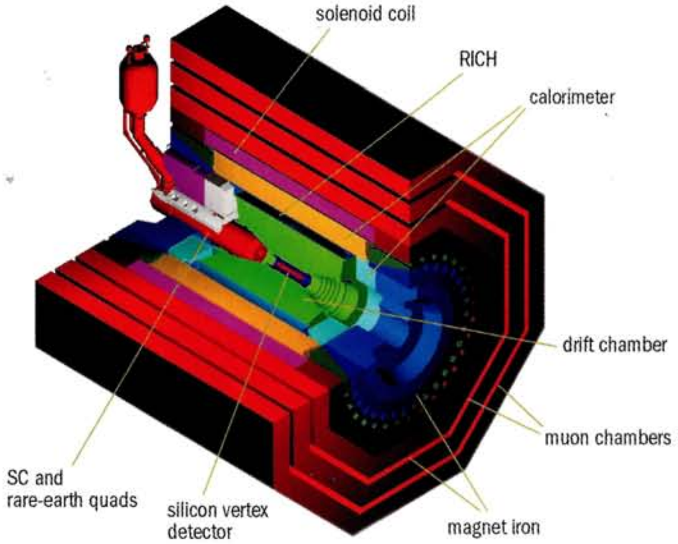
The Cornell electron-positron storage ring (CESR) and the associated particle physics detector, CLEO, completed their latest very successful physics run in June. Running at collision energies on or near the $\Upsilon(4S)$ resonance at 10.6 GeV (a bound state of the fifth "b" quark and its antiquark), the accelerator achieved its highest-ever luminosity (a measure of the particle collision rate) of $1.3 \times 10^{33} cm^{-2}s^{-1}$. This figure has been surpassed by the new B factories at SLAC, Stanford, and KEK, Japan, but for a long time CESR held the world record for electron-positron collision rate.

To accomplish this, CESR stored a total beam current of 740 mA, with each beam having nine trains of particles and five bunches per train. Crucial for obtaining these high currents was the use of superconducting radiofrequency cavities to provide power to the beams. Beginning in June 2000, CESR produced a total integrated luminosity of 13.3 fb^{-1} for the run. At its best, the accelerator was delivering 1.5 fb^{-1}/month – twice that of any previous run.

In anticipation of the run, the CLEO detector (now designated CLEO III) had undergone extensive modifications. A completely new 47-layer central drift chamber was installed. This chamber has end-plates with a stepped "wedding cake" profile to allow for the eventual insertion of superconducting quadrupole magnets close to the interaction region and an outer radius smaller than the previous CLEO drift chamber to allow room for a particle-identification detector.



Lots of electron–positron collisions – the integrated luminosity per month delivered by Cornell's CESR collider over the past 20 years. The integrated luminosity per month delivered by CESR from 1981 to 1988 is shown in the insert and from 1989 to the present in the main plot, indicating the various machine milestones along the way.



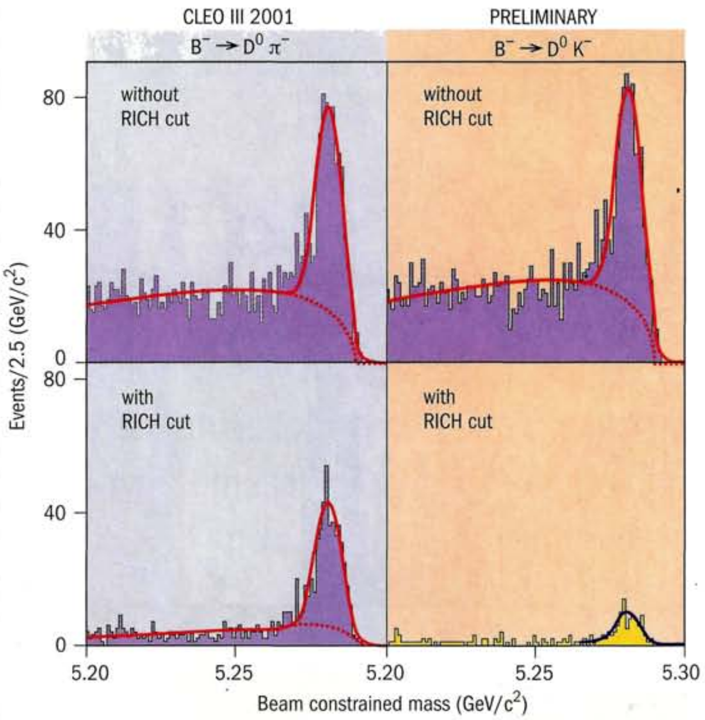
A cutaway view of the CLEO III detector showing the various subdetector components.

The CLEO silicon strip vertex detector during construction. The double-sided silicon wafers are clearly visible. These will surround the beam pipe.

This latter detector is a ring-imaging Cherenkov counter (RICH) consisting of a solid 1 cm thick lithium fluoride radiator, followed by a 15.7 cm expansion space to allow the Cherenkov cone to enlarge, and then a thin-gap multiwire proportional chamber filled with a mixture of TEA and methane gas as the photodetector. By detecting on average 12 photoelectrons from the Cherenkov ring of each charged particle, the RICH allows the identification of pions and kaons with an efficiency of roughly 85% and a fake rate of less than 1% for a momentum of below 2.0 GeV/c rising to about 10% at 2.5 GeV/c.

A new four-layer, double-sided silicon vertex detector was installed directly around the beam pipe. Covering 93% of the solid angle, at radii of 2.5–10.2 cm from the beam, the silicon detector contains 125 000 channels of read-out. Finally, the CLEO trigger and data acquisition systems were completely redesigned and rebuilt to handle the higher CESR luminosity.

Apart from some efficiency problems with the silicon detector, all of the CLEO III components, new and old, performed exceedingly well during the run, and the experiment accumulated a total integrated luminosity of 9.2 fb^{-1}. Of this, 6.9 fb^{-1} was obtained at the Υ(4S) resonance, corresponding to more than 7 million decays into B particle pairs. ▷



Plots showing the effectiveness of the CLEO RICH detector for identifying particles in B-decay modes. The mass distributions for two B meson decay modes without using particle identification from the RICH are shown in the top two plots, and using particle identification from the RICH in the bottom two plots. Most of the events in the top right plot are background from pions faking kaons. Only the RICH can isolate the small, real signal (bottom right).

While the new detector was accumulating luminosity, analyses of data collected during previous incarnations of the experiment (CLEO II and CLEO II.V) were continuing. During the year 2000 the CLEO collaboration published 30 papers from these analyses and it has already published 22 more in 2001. These papers cover a broad range of topics, including the discovery of six new charmed-baryon states, the observation of 10 new B-decay modes, new limits on neutral D particle mixing and B flavour-changing neutral-current decays, a precise measurement of the Λ_c lifetime, and the improved measurements of the two-photon widths of several charmonium states.

More luminosity

During the present accelerator shutdown, the main activity will be the installation of the aforementioned superconducting quadrupole magnets close to the interaction point. While the previous permanent-magnet quadrupoles had helped greatly in improving the CESR luminosity by squeezing the colliding beams, their fixed magnetic field limited the accelerator's collision energy range.

The new superconducting quadrupoles will provide stronger focusing of the beams, with a possible corresponding 2.5 times increase in luminosity. They will also permit much more flexibility in the accelerator operation, with running now being possible down to a collision energy of 3 GeV.

After the shutdown, the CLEO experiment will begin a programme of running on the three resonances $\Upsilon(1S)$, $\Upsilon(2S)$ and $\Upsilon(3S)$. They anticipate accumulating an integrated luminosity of more than 4 fb^{-1} during this run – an order of magnitude more than the present world's total for these resonances.

With this data available, the collaboration will be able to carry out a large number of measurements, including much-improved determinations of the leptonic and hadronic widths of several of the resonances, new searches for and possible discoveries of more b quark–antiquark bound states and a family of D (charmed) states, and precise studies of the various pion–pion transitions between the three Υ resonances.

New objectives

For the longer term, the CESR and CLEO physicists are considering converting the accelerator into a lower-energy machine, running in the 3–5 GeV collision energy range. This is the region of the J/ψ and ψ charm quark–antiquark bound-state resonances, as well as several ψ' resonances above the threshold for the production of D particle pairs and the threshold for the production of the tau lepton.

The physics potential for a high-luminosity electron–positron collider in this energy range is large and includes 1 to 2% measurements of vital quark transitions (cs and cd), precise determinations of crucial charm meson decay constants and branching ratios, much more sensitive searches for neutral D mixing and non-Standard Model charm and tau lepton decays, and greatly increased statistics with much improved systematic errors on the production of glueballs and quark–gluon hybrid states.

These measurements would provide powerful new contraints on predictions from lattice quantum chromodynamics (QCD). To inform the community of this programme, the CLEO group sponsored a three-day workshop at Cornell in May. More than 120 physicists attended, over a third of whom were not CLEO members.

The plan for the high-luminosity operation of CESR in this lower collision energy range envisages a set of superconducting wiggler magnets to be inserted into the accelerator to decrease the damping time of the beams and increase their horizontal emittance.

The preliminary design calls for 14 superferric wigglers with a total length of 18 m and a peak magnetic field of 2.1 T. Two recently wound, prototype superconducting wiggler coils reached their short-sample current limit, and the first full-length prototype wiggler is scheduled for completion in December. Simulations predict that, with the insertion of the wigglers, the peak luminosity of the lower-energy accelerator, designated CESR-c, should range from about 1 to $5 \times 10^{32} cm^{-2} s^{-1}$ as the collision energy changes from 3 to 5 GeV.

The CESR-c design and the potential CLEO physics programme, correspondingly referred to as CLEO-c, were presented at two recent US HEPAP subpanel meetings and at the 2001 Snowmass Summer Study. A "yellow book" containing both the CESR-c and the CLEO-c project descriptions (CLNS 01/1742) is available via "http://www.lns.cornell.edu/public/CLEO/spoke/CLEOc/ProjDesc.html".

If the CESR-c project is approved by early 2002, the first low-energy collisions could occur by December 2002.

Tom Ferguson, *Cornell.*

HERMES searches for the nucleon's missing spin

While the proton and the neutron are made up of quarks and gluons, the spin of the proton or the neutron is difficult to reconcile with the spins of quark and gluon components. For more than a decade, physicists have struggled to solve this puzzle.

At work on the HERMES detector at Germany's DESY laboratory.

In 1988, CERN's European Muon Collaboration (EMC) experiment stunned the world of physics with the announcement that some of the nucleon's spin was missing. More than a decade later, physicists are still trying to account for the missing spin and the spotlight has moved to the HERMES experiment at Hamburg's DESY laboratory.

A close look inside the nucleon

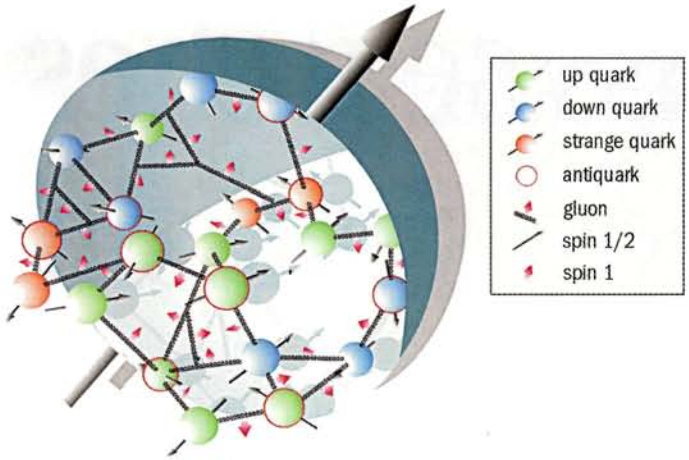
The closer you look, the more you see. That may sound like a common sense maxim, but when it comes to nucleons it takes on an interesting twist. In a simple quark-parton model, a nucleon is made up of three quarks and it is the spins of these quarks that are supposed to give the nucleon its spin. That simple notion was disproved when the EMC experiment gave rise to what was quickly dubbed the nucleon spin crisis, announcing that quarks could account for only around 20% of a nucleon's spin at most.

The EMC result led to several experiments taking a much closer look at what goes on inside nucleons. The three quarks that give a nucleon its identity – the valence quarks – are just the beginning of the story. They swim in a "sea" of virtual quarks and antiquarks that are constantly popping in and out of the vacuum. Moreover, gluons flit about inside nucleons, holding the quarks together. All of these can contribute to a nucleon's spin, and their constant movement generates an intrinsic angular momentum of the nucleon as a whole.

A succession of experiments to pin down the effect ensued at CERN (the NMC and SMC collaborations using muon beams) and at SLAC (with electron beams), and by the late 1990s the spin crisis ▷

had transformed into a puzzle: that of finding out how the nucleon's spin was distributed among its various contributing factors. The CERN and SLAC experiments had confirmed, with greatly improved precision, the original EMC finding that quarks alone could not be responsible for the nucleon's spin. The next task was to measure the contributions of the individual quark flavours and of gluons. The baton passed to DESY, whose HERA measurement of spin (HERMES) experiment had started to collect data in 1995.

HERMES uses the polarized (spin-oriented) positron or electron beam of DESY's HERA collider incident on a polarized gas-jet target. This, coupled with the HERMES detector's powerful particle identification capability, has allowed the collaboration to measure precisely the contributions to nucleon spin of each valence quark flavour. HERMES' results are in perfect agreement with earlier results and show that the "up" valence quarks spin the same way as the nucleon as a whole, while the "down" valence quarks spin the opposite way.



The closer you look, the more there is to see, especially inside the nucleon. The three valence quarks that give the nucleon its identity swim in a sea of quarks and antiquarks held together by gluons. All contribute to the nucleon's spin, and finding out how is HERMES' business.

HERMES has also published a first estimate of the gluon contribution to a nucleon's spin. HERA's lepton probes do not see electrically neutral gluons directly, so this is a difficult measurement to make. HERMES has achieved it by exploiting the process of photon–gluon fusion. When an electron scatters from a quark in a nucleon, it does so through the exchange of a virtual photon, and this photon can interact with gluons as they dissociate into quark–antiquark pairs.

In HERMES' first phase of running, from 1995 to 2000, the experiment showed that gluons do indeed contribute to a nucleon's spin, spinning in the same direction as the nucleon. Future analyses will use the HERMES detector's particle identification capabilities to quantify the gluon contribution by studying processes involving charm quarks, which give a precise handle on gluons.

Sea quarks

Where future HERMES analyses can contribute the most, however, is in measuring the flavour decomposition of the sea quark contributions. Data already analysed show that, taken as a whole, the sea quarks contribute very little to the nucleon's spin. However, the CERN and SLAC experiments have hinted that the strange quarks in the sea could be strongly polarized with a spin in the opposite direction to that of the nucleon. This will be thoroughly investigated when the data collected during HERMES' first phase of running are fully analysed, allowing the collaboration to measure the contribution of each quark flavour individually for the first time.

In its second phase of running, starting in December, HERMES will be turning its attention through 90°. Whereas all measurements up to now have been with beam and target polarized longitudinally (in the beam direction), when HERMES resumes data collection it will be with a transversely polarized target. This will allow the collaboration to measure the transverse component of the quarks' spins. In the first phase of HERMES running, the experiment caught a glimpse of this so-called transversity. In phase two, the collaboration will make a thorough measurement of the effect, slotting in another piece of the nucleon spin puzzle.

HERMES has recently been joined by new experiments – PHENIX and STAR at the US Brookhaven laboratory and COMPASS at CERN – which have started to investigate the gluon contribution to the nucleon's spin. PHENIX and STAR will use polarized beams at the RHIC collider while COMPASS, like the original EMC experiment, uses high-energy muon beams.

More than a decade since the spin crisis first broke, there's still some way to go before we understand in detail how spin 1/2 quarks and spin 1 gluons conspire to give nucleons a spin of 1/2. With a multipronged attack from several laboratories, however, a full understanding cannot be far off. □

Report urges scientists to secure their records

A new report underlines the importance of keeping scientific records to safeguard our scientific heritage. Once an experiment is complete, its responsibilities are not over.

According to a recently released report by the American Institute of Physics (AIP) Center for the History of Physics, there are many problems facing the documentation of collaborative research. These range from the way in which the contributions of distinguished individuals (or records of a project conducted by one institution) are preserved, to the fact that, almost without exception, research institutions and federal science agencies fail to provide adequate support to programmes to save records of significant research.

To help to find solutions, the AIP History Center has issued *Documenting Multi-Institutional Collaborations* – the final report of its decade-long study of multi-institutional collaborations in physics and allied fields.

Data archives – a tape vault at CERN.

The main recommendations of the report are that:

- scientists and others should take special care to identify past collaborations that have made significant contributions;
- research laboratories and other centres should set up a mechanism to secure records of future significant experiments;
- institutional archives should share information.

The long-term study focused on high-energy physics, space science, geophysics, ground-based astronomy, materials science, medical physics, nuclear physics and an area called computer-mediated collaborations. The main goal of the project was to learn enough about these transient communities to be able to advise on how to document them.

The study was built on interviews with more than 600 scientific collaborators; numerous site visits to archives, records offices and US federal agencies; and advice from working groups of distinguished scientists, archivists, records officers, historians and sociologists. The study group gathered and analysed data on characteristics of collaborations, such as their formation, decision-making structures, communication patterns, activities and funding.

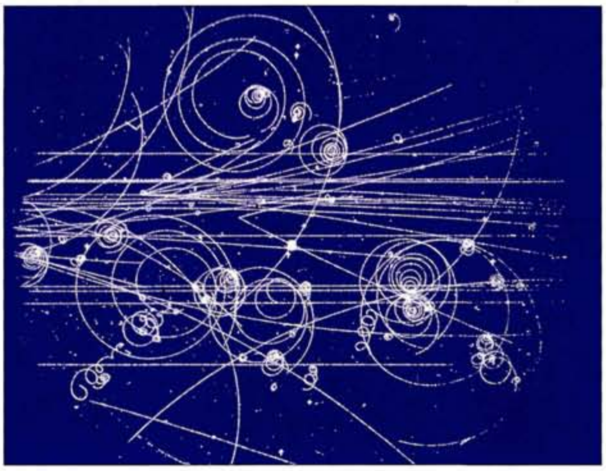
According to the report, scientists in multi-institutional collaborations are well aware that their way of doing research is unlike that of others working alone or in small groups. All too often, however, scientists fail to realize how records needed to document research are prone to destruction. It may appear to them that their recollections and those of their colleagues are sufficient. This is thought to be unfortunate from the standpoint of present needs. From the standpoint of the future it is disastrous, for even the imperfect recollections will die with the scientists and later generations will never know how some of today's important scientific work was done. For particle physics, the report has some specific suggestions.

Core records

The report makes a broad distinction between "core records" – those records to be saved for all collaborations – and records to be saved for "significant collaborations". The definitions of the former are slanted towards traditional US procedures with Department of Energy or National Science Foundation funding for experiments carried out at major US laboratories. However, these can be paraphrased unambiguously for a more global audience without too much trouble.

The additional records for significant collaborations include correspondence between the experiment spokesperson, the experiment collaboration and laboratory administrators. Intra- ▷

collaboration meetings, collaboration groups, inter-institutional committees, and project management and engineering documents are also deemed to be important under this heading.



Bubble chamber tracks are useful for exhibitions and for educational purposes.

Logbook guidelines

Turning to guidelines for technical records, experiment or "running" logbooks are deemed to be of significant value. These may require the co-operation of a member of the collaboration to decipher handwriting or "translate" shop talk, and the report recommends a tape-recorded interview by a knowledgeable historian or archivist and welcomes the fact that some experiment logbooks – or portions of them – are being computerized. Collaborations tend to generate a variety of other logbooks, the most common being the detector component logbooks. Appraisals should be conducted by a knowledgeable archivist or historian in conjunction with a physicist familiar with the experiment. Material of archival value should be preserved at the group's institutional archives.

Raw data tapes are not deemed to be useful to individuals outside the collaboration. Data Summary Tapes (DSTs), on the other hand, may be of some use to particle and nuclear physicists outside the collaboration for a limited period of time. Their use probably requires accessibility to collaboration members as well as documented software. DSTs should therefore be retained for up to 10 years.

A number of accelerator laboratories and experimental groups maintain computer programs and software. Future historians will be interested in the programs for detector trigger systems and for data analysis. The full working program is not needed – only sufficient documentation to know how the software was laid out, its logic and who did what. In addition, software should be retained for those few raw-data tapes and DSTs that are selected for preservation.

Whereas track chamber experiments producing photographic film have ceased, emulsion experiments continue, producing particle tracks in emulsion stacks that are studied with special microscopes. Such photographic data should be kept in very limited quantity to illustrate discoveries. Bubble chamber records have some usefulness for exhibit and educational purposes.

Special databases

Since 1974, the international databases maintained for the particle physics community have included the Experiments database maintained by the Particle Data Group at the Lawrence Berkeley Laboratory and the HEP Publications Database maintained by the Stanford Linear Accelerator Center (SLAC) and the Deutsches Elektronen-Synchrotron (DESY) laboratory in Hamburg. CERN also provides a valuable service. The Experiments database includes reports on all of the approved experiments. Unfortunately, as membership information is updated, the historical data are wiped out.

The HEP Publications Database is a vast bibliographic record that includes preprints, conference talks, theses, refereed physics articles (many with links to laboratory experiment numbers) and instrumentation articles – all with citations. The list of authors and their affiliations is very detailed.

The report recommends improvements because of the great value of these databases for historical and sociological purposes. A historical data set of the Experiments database would be useful. The report also hopes that work on the part of the laboratories will continue to enrich the HEP Publications Database by linking physics articles with experiment numbers. This effort should be extended to instrumentation articles.

The final report, *Documenting Multi-Institutional Collaborations*, is accompanied by *Highlights and Project Recommendations,* which provides excerpts from the full report and a set of recommendations. This material is available on request from the AIP History Center, One Physics Ellipse, College Park, MD 20740 3843; e-mail "chp@aip.org". These and other project reports will also be found at "http://www.aip.org/history/pubslst.htm#collabs". □

PEOPLE

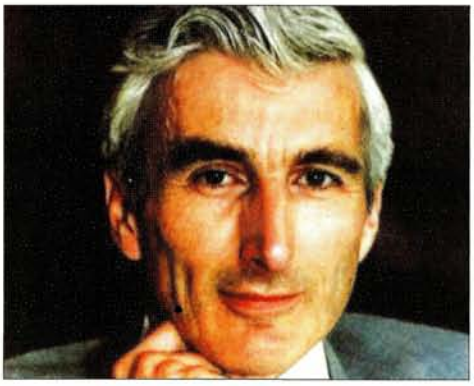
AWARDS

Martin Rees wins major cosmology prize

Distiguished astrophysicist Sir Martin Rees has won the Peter Gruber Foundation's 2001 Cosmology Prize for his fundamental and diverse contributions to our understanding of the universe. The Gruber prize – the world's only award for cosmology – recognizes Rees's studies of the cosmic microwave background, quasars, black holes and gamma-ray bursts. Rees is both British Astronomer Royal and Royal Society Research Professor at Cambridge University.

In 1968, together with Dennis Sciama, he predicted that fluctuations in the microwave background were due to the uneven distribution of matter in the universe. His research into the structure and evolution of the universe has also sparked many other research efforts. Elsewhere, his work as a spokesperson, educator, writer and public speaker have raised the profile of astrophysics and brought it to a wider audience.

The prize, which consists of a gold medal and a cash award of $150 000, was presented on 2 November in Bern, Switzerland, where Einstein formulated his special theory of relativity 100 years ago.



Sir Martin Rees – Gruber prizewinner.

Lifetime award

Peter Komarek (left) receives an IEEE lifetime award from Romeo Perin of CERN.

At this year's international magnet technology conference, hosted by CERN in Geneva, Peter Komarek, deputy director of the Forschungszentrum, Karlsruhe, received a coveted Institute of Electrical and Electronics Engineers (IEEE) award for a lifetime's contributions to the science and applications of superconducting magnets from the conference organizing committee chairman Romeo Perin of CERN.

Particle physicist Andrzej Bialas (right) of Warsaw's Jagellonian University has been elected president of the Polish Academy of Arts and Sciences, the first physicist to achieve this office. Earlier this year he was part of a delegation from the academy that was received by Pope John Paul II.

Federal honour for DESY physicist

Federal German President Johannes Rau (right) awards Paul Söding of DESY the German Federal Cross of Merit (First Class) for his research work and his dedication in bringing together science and scientists from the old and new German federal states. Paul Söding served as DESY research director from 1982 to 1991 in the run-up to the HERA electron-proton collider. He subsequently moved to Brandenburg to become the director of DESY, Zeuthen – formerly the Institute for High-Energy Physics, East Berlin. ("Bilderdienst@bpa.bund.de" Bundesbildstelle.)

MEETINGS

The European Workshop on the QCD Structure of the Nucleon will be held on 3–6 April 2002 at Castello di Ferrara in Italy.

Semi-inclusive deep-inelastic scattering is the main tool of the present generation of fixed-target facilities at several major laboratories. These experiments, as well as the new nucleon spin studies in proton–proton collisions at RHIC, will significantly improve our knowledge of the longitudinal spin (helicity) structure of the nucleon, especially the sea quark and gluonic component, and explore its still-unknown transverse spin structure.

Physics topics at the workshop will include new distribution and fragmentation functions (including transversity); generalized parton distributions; exclusive reactions (including diffraction); nuclear effects; lattice QCD; chiral perturbation theory; and future facilities.

The international organizing committee is co-chaired by E De Sanctis (INFN, Frascati) and W-D Nowak (DESY, Zeuthen).

More information is available at "http://www.desy.de/qcd02".

The VIIIth International Conference on Instrumentation for Colliding Beam Physics (INSTR02) will be held at the Budker Institute of Nuclear Physics, at Novosibirsk in Russia, on 28 February – 6 March 2002. The conference continues the tradition of regular scientific meetings that began in Novosibirsk in September 1977. The previous meeting was organized by Hamamatsu, Japan, in 1999. The conference will focus on recent progress in experimental methods used at existing and designed colliders. For further information, contact Alex Bondar at "instr02@inp.nsk.su" or visit "http://www.inp.nsk.su".

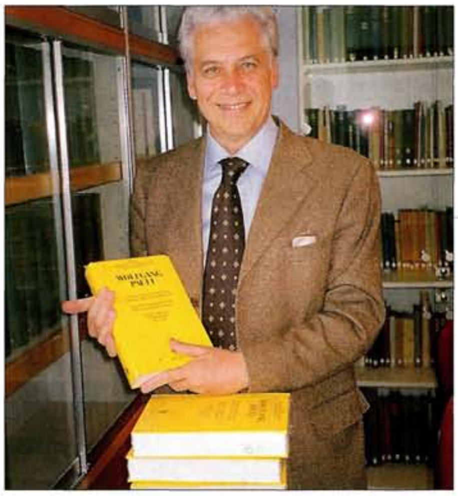
Magnetic moment – when past and present members of CERN's distinguished scientific policy committee came to the laboratory for this year's annual meeting, they saw preparations for the superconducting magnets for CERN's LHC collider. Tom Taylor (right), deputy leader of CERN's LHC Division, updates 1999 Nobel laureate Martin Veltman (centre) and John Dowell of Birmingham.

Visiting Brookhaven recently was US Senator Hillary Rodham Clinton, seen here learning about the RHIC heavy-ion collider. Showing her round the laboratory are (from left) chairman of the collider-accelerator department, Derek Lowenstein; STAR experiment spokesman John Harris of Yale; and Brookhaven director John Marburger.

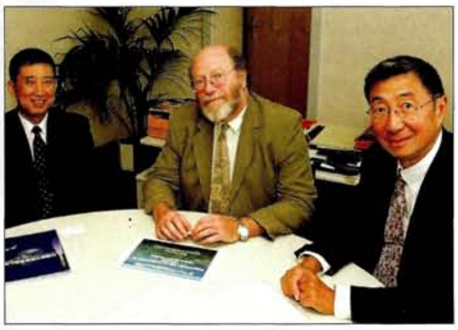
Rutherford Web site

Following the publication of his book *Rutherford – Scientist Supreme* (*CERN Courier* September 2000 p48), dedicated New Zealand physicist John Campbell has launched a Rutherford Web site at "http://www.rutherford.org.nz".

Campbell contends that while the great man's scientific career is well documented, Rutherford's New Zealand origins have remained relatively obscure.



The new chairman of the Pauli Committee at CERN, Gabriele Veneziano, proudly displays volume 4/3 of the *Scientific Correspondence of Wolfgang Pauli*, the sixth volume in a series of seven that should be completed next year (*CERN Courier* September 2000 p30).



Chinese Aviation Minister Wang Liheng (left) at CERN on 7 September with CERN research director Roger Cashmore (centre) and 1976 Physics Nobel prizewinner Sam Ting. Prof. Liheng is also president of China Aerospace Science and Technology Corp.

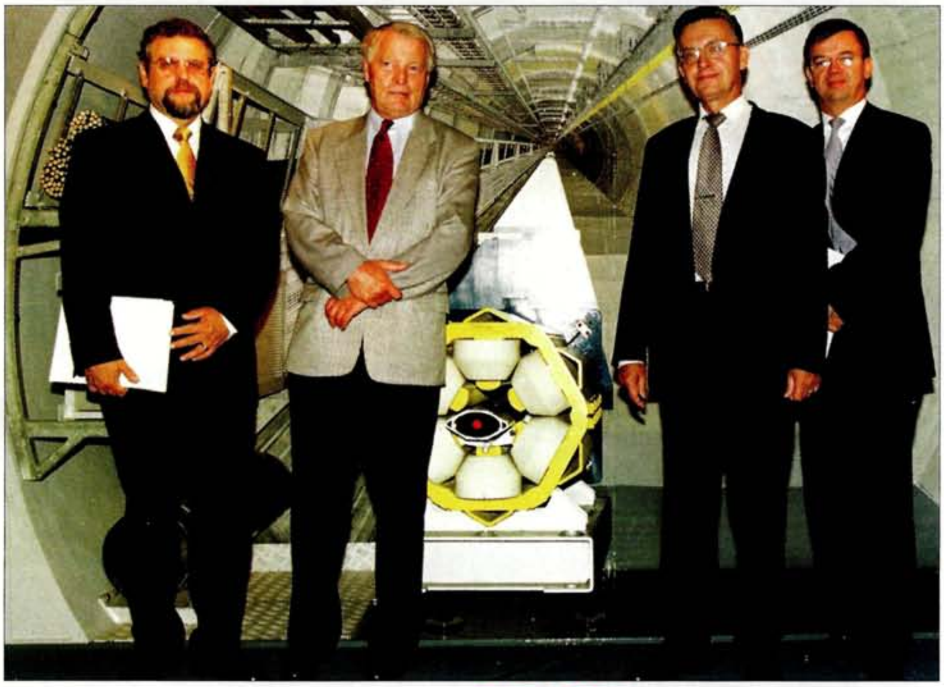
Teachers produce a class act

High-school teachers Patricia Mason (left) and Pat Brettnacher.

Major laboratories increasingly attract physics teachers who are anxious to keep track of research trends. Among those visiting CERN this summer were science teacher Patricia Mason and English teacher Pat Brettnacher from Delphi Community High School (Delphi, Indiana), who combine their students once a year for an interdisciplinary writing project.

They take their students to Chicago each November to tour Fermilab and Argonne National Laboratories, where they observe what is happening in fundamental physics. Students are required to visit the CERN Web site for their related writing project, in which they have to explain, to the satisfaction of both teachers, a major research facility or topic. For more information, visit "www.delphi.k12.in.us/physcent".

Patricia Mason has been honoured for her work by being given the Great Lakes Regional High School Chemistry Teaching award by the American Chemical Society.



Czech Minister for education, youth and sport, **Eduard Zeman** (second from right), at CERN on 7 September with (from left) **Ivan Pinter** of the Czech Permanent Mission in Geneva; **Ivan Lehraus** of CERN; and Czech ambassador **Milan Hovorka**.

Dezso Kiss 1929–2001

Dezso Kiss, one of the pioneers of Hungarian experimental nuclear and particle physics, and from 1989 to 1992 director-general of the Joint Institute for Nuclear Research (JINR, Dubna), died on 24 June in Budapest at the age of 73.

After studying at the Eötvös University in Budapest, he wrote his PhD thesis on cosmic-ray physics. Later his interest turned to low-energy nuclear physics. He carried out neutron physics experiments at the research reactor of the Central Research Institute for Physics (KFKI, Budapest) and later at the pulsed fast reactor at the JINR.

After 1968, under his leadership, the High-Energy Physics Department of KFKI expanded its activity from bubble chamber picture analysis to the construction of detectors for electronic experiments. Using the opportunity provided by the new Serpukhov accelerator, he organized the first Hungarian team directly involved in experimental work at highest energies.

Dezso Kiss – Hungarian pioneer.

In 1975 Kiss spent a year at CERN taking part in the preparation of the CHARM neutrino experiment. From 1976 to 1979 he was deputy director of the JINR, and he initiated a common project of the Dubna and Serpukhov institutes to build a large neutrino detector.

From1984 Kiss had been engaged in the Soviet (Russian)-German-Hungarian neutrino experiment at Lake Baikal.

He was a founding member of the KFKI – the largest Hungarian research institute – where he held several major appointments. From 1979 to1992 he served as its deputy director-general. He was elected corresponding member of the Hungarian Academy of Sciences in 1976 and became a member in 1985. He was full professor of the chair for Atomic Physics of Eötvös University. He took part actively in science policy and was a member of different international scientific bodies. He served on the IUPAP, ICSU and EPS committees. In1993–1996 he was the president of the Eötvös Physical Society in Hungary. He was the writer and editor of numerous scientific books and a champion of science popularization.

K Szego and G Vesztergombi.

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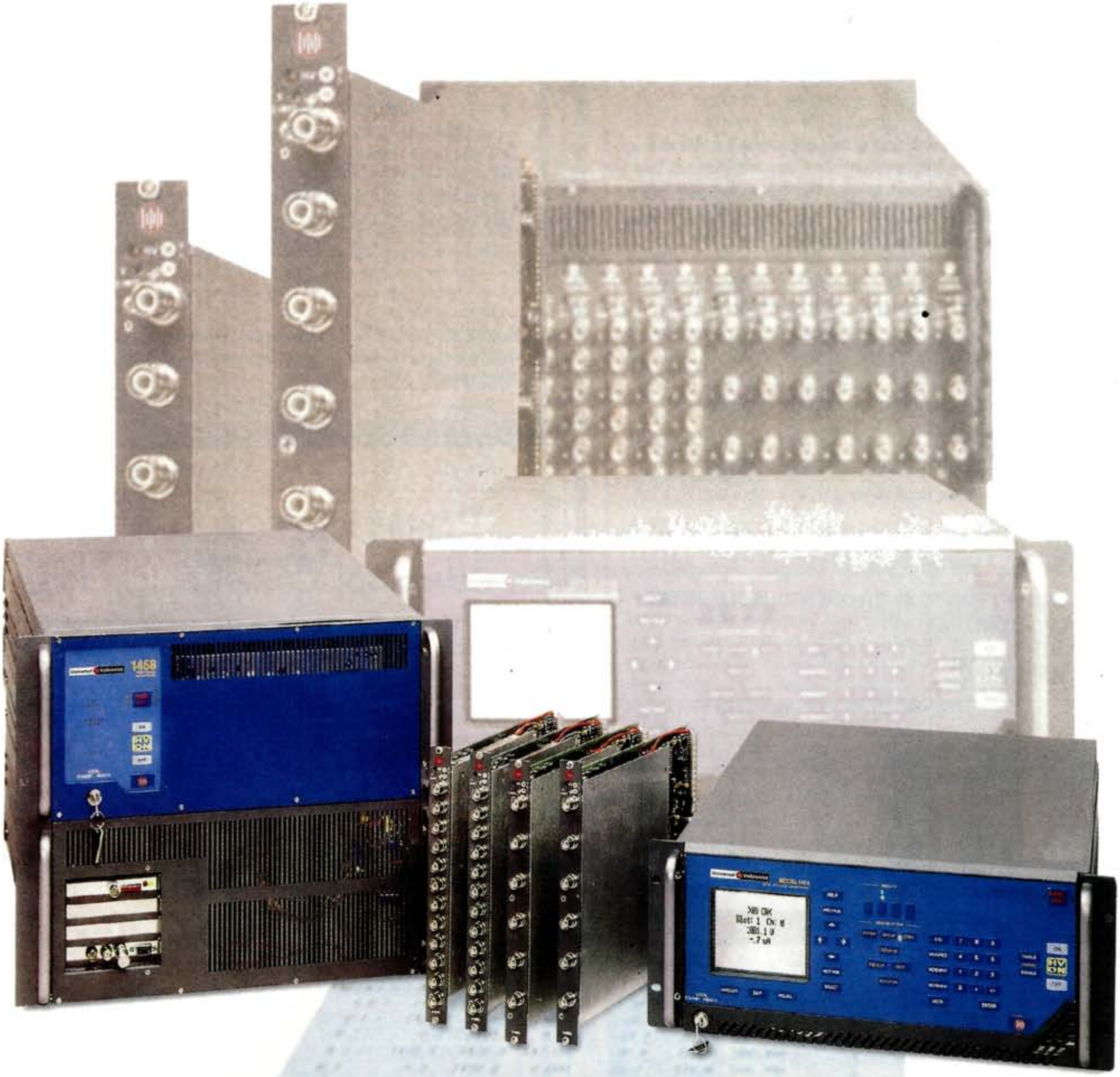

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A Diploma or Master degree in nuclear or particle physics or electronics is required. Practical experience in the design of fast analog electronics, in fast pulse analysis, in development and simulation of integrated (ASIC) and discrete analog circuits is required. Experience in detector systems and data acquisition of nuclear or high energy experiments would be appreciated.

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

Applications including the code should be submitted not later than November 30, 2001 to

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Further information and instructions on how to apply are available at http://www2.physics.ox.ac.uk/pnp/jobs/atlas-fp.htm The application deadline is 30th November 2001.

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Berkeley
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RESEARCH FELLOW AT THE BERKELEY CENTER FOR THEORETICAL PHYSICS

The University of California at Berkeley has begun the endowment of a new Center for Theoretical Physics, which will initially focus on Particle Theory.

The Center is now conducting a search for a long term Assistant Researcher, a fixed term appointment with funding for 5 years, to begin in the Fall of 2002, with an annual salary in the range of $53,600-$59,600. We are searching for an outstanding junior researcher, with a PhD, who will interact with members of our theory group and with our visitors, with preference given to exceptionally qualified candidates in string theory.

Applicants who wish to apply for this position should have an application with CV and letters of reference sent to Professor Petr Horava, Physics Department, University of California, Berkeley, CA 94720-7300, USA postmarked by December 1, 2001. Applicants who applied for particle theory postdocs at UC Berkeley and LBNL and who are interested in this position, should forward letters of interest to the same address.

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

POSTDOCTORAL FELLOW
CENTER FOR COSMOLOGICAL PHYSICS

THE NSF has just established the Center for Cosmological Physics (CfCP) at the University of Chicago. Research at the Center focuses on interdisciplinary topics in Cosmological physics: characterizing the Dark Energy, studying the inflationary era, and understanding the highest energy cosmic rays. Studies of the CMB (polarization anisotropies and the Sunyaev-Zeldovich effect) and Cosmic Infrared Background; analysis of Sloan Digital Sky Survey and other large-scale structure data; high-energy astrophysics with photons and cosmic rays, and numerous topics in theoretical cosmology constitute the initial slate of activities. The CfCP will have active visitor, symposia, and education/outreach programm.

Several Center Fellow positions are now open. Center Fellows have the freedom to work on any of the efforts in our Center.

We seek candidates with a recent Ph.D. in physics, astrophysics, or related fields, with an interest in pursuing experimental or theoretical interdisciplinary research in cosmology. PRIOR EXPERIENCE IN COSMOLOGICAL PHYSICS IS NOT A REQUIREMENT. Positions are for two years, with possible renewal for a third.

A CV, statement of research interests, and at least three letters of recommendation should be sent to **centerfellow@cfcp.uchicago.edu**

or to **Bruce Winstein, Director, Center for Cosmological Physics, Enrico Fermi Institute, 5640 S. Ellis Avenue, Chicago, IL 60637.**

Information about the CfCP can be found at **http://cfcp.uchicago.edu/**

Women and minorities are encouraged to apply. Applications are now being accepted for positions which are available immediately. The deadline is December 10th for positions which will begin July 1, 2002.

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For further information please contact Dr. Egger (Tel. +41 56 310 3671, email Johny.Egger@psi.ch).

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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.

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ACCELERATOR PHYSICISTS

ISIS Facility

Applications are invited for up to two vacancies in the Accelerator Theory and Future Projects Group, which is part of the ISIS Accelerator Division at the Rutherford Appleton Laboratory. The Group is involved with development of the existing ISIS facility and collaborates with laboratories worldwide in theoretical studies for future accelerator projects

The group is currently engaged in two main areas of study: the design of a proton driver and muon accelerator for a neutrino factory, and conceptual work for the proposed European Spallation Neutron Source (ESS). The idea of an accelerator-driven facility to produce a controlled source of neutrinos for particle physics research is generating increasing interest in Europe, the USA and Japan. The RAL group collaborates with CERN on a proton driver approach using a high energy superconducting linac plus accumulator and compressor rings and is comparing this with rapid cycling synchrotron options. Studies have also commenced on the front end stages for a low frequency muon linac. Work on the ESS has similarly involved linac and ring design, with computer modelling of most aspects of the accelerator system. The group assists with a number of upgrade plans for ISIS, near term and long term. Close contact is maintained with international laboratories, particularly Fermilab, Brookhaven, JAERI/KEK and CERN. While it is anticipated that the postholder will play a full part in the whole range of projects, there will be opportunities for related, but purely theoretical, avenues of research. A set of fast parallel-processors is available and the development and use of three-dimensional accelerator modelling codes, including space charge and image effects, is of prime importance.

Candidates should have a first degree in Physics or Mathematics. A Ph.D. or some equivalent experience in accelerator theory would be of benefit. A sound mathematical background and knowledge of computer modelling techniques would be an advantage.

Starting salary will be up to £19,000 (standard pay) on a pay range from £15,200 (min) to £21,850 (max) or up to £24,620 (standard pay) on a pay range from £19,700 (min) to £27,080 (max) depending on experience. A non-contributory pension scheme and a generous leave allowance are also offered.

Application forms and a full job description can be obtained from: HR Operations Group, Human Resources, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX. Telephone (01235) 445435 quoting reference VN1968R. More information about CCLRC can be obtained from CCLRC's World Wide Web pages at http://www.cclrc.ac.uk

For an informal discussion about the vacancy please contact Dr C.R. Prior, telephone (01235) 445262, or e-mail c.r.prior@rl.ac.uk

All applications must be returned by 16 November 2001.

Interviews will be held on 5 December 2001.

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The National Science Foundation has established a Center for Cosmological Physics at the University of Chicago. Ed Blucher, John Carlstrom, Sean Carroll, James Cronin, Joshua Frieman, Wayne Hu, Stephan Meyer, Angela Olinto, Randall Landsberg, Simon Swordy, Michael Turner and Bruce Winstein are charter members.

The Center focuses on phenomena outside the Standard Model of Particle Physics which can be explored on a cosmological scale. Initial thrusts include: characterization of the Dark Energy, testing if the Universe underwent a period of inflation, and understanding the highest energy cosmic rays.

The Assistant Director will manage our Center while simultaneously participating in research.

Responsibilities will include budget analysis and preparation of scientific reports. He or she will supervise an Administrative Assistant, a secretary, and a part-time budget officer; organize symposia; and work with the Director and advisory groups to develop scientific goals and plan for future initiatives. The initial term is for 5 years.

Qualifications: Ph.D. in physics or astronomy. Significant post-doctoral experience (not necessarily in Cosmology) which includes management and supervisory responsibilities is desirable. Salary commensurate with experience.

Applications will be accepted until the job is filled. Applications should include a CV, publication list and 3 letters of recommendation from those familiar with the management capabilities of the applicant. Women and minorities are encouraged to apply.

Direct Applications to:

Professor Bruce Winstein
Director, Center for Cosmological Physics
Enrico Fermi Institute
5640 S. Ellis Avenue, Chicago, Il 60637
bruce@cfcp.uchicago.edu
http://cfcp.uchicago.edu/.

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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.

For the group – F1–"ZEUS-Experiment" we are looking for an

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The candidate should be highly qualified to take a leading role in the research program of the ZEUS experiment at the electron-proton storage ring HERA. He/She should take considerable responsibility in physics analysis, participate in the operation and upgrade of the detector and take part in shaping the future research program of DESY.

Applicants should have a Ph.D. in physics, several years of experience in experimental particle physics and should be active in research in this field. They should have an established record in data analysis and in hardware and software for particle physics detectors. Excellent communication skills and the ability to lead larger collaborative efforts are essential.

The salary and the social benefits correspond to those in public services (BAT Ib).

Deadline for applications: 15.11.2001

Handicapped applicants will be given preference in case of equal qualifications.

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

Please send your application documents to:

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Research Position in Experimental High Energy Physics

University of Colorado, Boulder

The experimental high energy physics group at the University of Colorado has openings for persons with a strong computing background and with a strong interest in experimental High Energy research. The persons are to participate in the BaBar experimental program at the Stanford Linear Accelerator Center, and may participate in NLC detector simulation studies. In particular, these persons will participate in every aspect of the BaBar data analysis. They will work with Colorado graduate students in BaBar and may help guide a group of undergraduates working on NLC detector simulation, particularly in design of calorimetry based on the energy flow concept. The applicant should have a Ph.D. degree and is expected to have a strong C++ software language background.

Applicants should send a Curriculum Vitae and arrange to have three letters of recommendation sent to

Prof. Uriel Nauenberg, Department of Physics, 390 UCB,
University of Colorado, Boulder, CO 80309-0390.

All applications should be received by March 1, 2002.
You can also communicate via email, **uriel@cuhep.colorado.edu.**

The University of Colorado at Boulder is committed to diversity and equality in education and employment.

A postdoctoral position is available with the Groupe de Physique des Particules, at the

UNIVERSITÉ DE MONTRÉAL

The position is available for two years, with a possible extension for one more year. The appointed candidate is expected to participate in the OPAL and ATLAS experiments at CERN, but will be resident in Montreal.

He/she would contribute to physics analyses and studies of detector performance, by Monte Carlo simulations and test beam measurement.

Good knowledge of Object Oriented Programming is desirable.

In accordance with Canadian Immigration laws, priority will be given to Canadian citizens or permanent residents, but any interested candidate is invited to apply.

The deadline for application is December 15th.

Please send applications and the name of three referees to

G. Azuelos (azuelos@lps.umontreal.ca), Pavillon René J-A Lévesque, Université de Montréal, CP 6128, Montréal, Qc, H3C 3J7, Canada

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For any further information please contact Dr. Patrick Marchand, (Tel. +41 56 310 40 26, e-Mail: patrick.marchand@psi.ch).

Please send your application to: PAUL SCHERRER INSTITUT,
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Further job opportunities: www.psi.ch

UNIVERSITY OF FLORIDA

POSTDOCTORAL RESEARCH ASSOCIATE EXPERIMENTAL HIGH ENERGY PHYSICS

The High Energy Experiment Group at the University of Florida has an immediate opening for a postdoctoral research associate to conduct physics simulations and to develop selection algorithms for the CMS experiment at CERN.The UF group leads the CMS Muon project, is developing a track-finding processor for the Level-1 trigger of the CMS Endcap Muon System, and participates in the development of triggers for the higher levels through its leadership role in the Muon Physics Group of CMS. The successful candidate is expected to initiate a strong research program in the simulation and selection of physics channels from the Level-1 trigger of the experiment through to offline reconstruction. These studies are aided by the large computational resources associated with the prototype CMS regional computing center under development at UF. In addition to our CMS activities, the UF group is actively engaged in the operational support and analysis of recent data taken by the CDF experiment at Fermilab from Run II of the Tevatron. Candidates should have excellent data analysis and programming skills and a Ph.D. in high energy physics.

Interested applicants should send a curriculum vitae, and arrange for three letters of recommendation to be sent to:

Prof. Darin Acosta, Department of Physics, University of Florida, P.O. Box 118440, Gainesville, FL 32611, USA

E-mail: acosta@phys.ufl.edu

FAX: 352-392-8863

Applications will be considered until the position is filled.

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Science Serving Society

Postdoctoral Position in Superconducting Accelerator Technology

The Accelerator Engineering & Physics Group (LANSCE-1) in the Los Alamos Neutron Science Center Division is seeking postdoctoral candidates to work in the field of superconducting accelerator technology. Successful candidates are expected to carry out the design of superconducting accelerator cavities, participate in laboratory testing of superconducting accelerator cavities, and carry out research into methods of improving the performance of such cavities.

LANSCE-1 has a long-standing commitment in the field of superconducting accelerator technology. To date, most of the applications have been for proton linacs, and the current emphasis is for waste transmutation for the Advanced Accelerator Applications Program. The present activities are concentrated on low-beta elliptical cavities and multi-cell spoke resonator cavities for protons at non-relativistic energies.

For further technical details, contact Tsuyoshi Tajima at: **tajima@lanl.gov**, or see: **http://int.lansce.lanl.gov/lansce1/index_1.htm** (LANSCE-1), **http://int.lansce.lanl.gov/organization/index_org.htm** (LANSCE), **http://laacg1.lanl.gov/scrflab/** (LANSCE-1 SC Lab), and **http://aaa.lanl.gov/** (AAA Program).

A Ph.D. in Physics, Applied Physics, Electrical Engineering, or a related field completed within the last five years or soon to be completed is required. Find details about the Postdoctoral Program at: **http://www.hr.lanl.gov/postdoc/**.

For consideration, submit a resume and publications list with a cover letter outlining current research interests to **postdoc-jobs@lanl.gov** **(reference CERN-PD017919)**, or submit two copies to: **Postdoc Program Office, CERN-PD017919, MS-P290,** Los Alamos National Laboratory, Los Alamos, NM 87545.

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THE SWEDISH RESEARCH COUNCIL

The Swedish Research Council invites applications for three positions intended only for WOMEN scientists active within areas of the Engineering Sciences mainly dominated by male scientists.

The Council´s intention in creating these positions is to contribute to the recruitment of researchers and to the renewal of research in Sweden, aiming also to improve the balance between the sexes within the engineering sciences. The programme is aimed primarily at women scientists with a doctorate who have recently established themselves as researchers and have started an active research career. The positions are for three plus three years and will be at appropriate university departments in Sweden to be chosen by the candidate in consultation with the Council and the suggested university. The applicant is kindly requested to state at which university she would like the position. The university decides on tenure. Duties can commence from July 1, 2002.

A curriculum vitae should be appended including a list of publications, a short research plan, a description (no more than six pages long) of scientific achievements and pedagogical skills and a maximum of ten reprints of scientific papers.Other documents to which the applicant wishes to refer could also be included.Four copies of the application and all appendixes and reprints should be submitted.

Applications should reach the The Swedish Research Council, 103 78, Stockholm, Sweden, by November 15, 2001.

Further information can be obtained from
Ms Natalie Lunin at the Secretariat of VR,
phone no +46 8 546 44 232, fax no +46 8 546 44 180.
e-mail-address Natalie.Lunin@vr.se

AALBORG university

Assistant Professors in Physics
Aalborg University, Denmark (Academic)

Applications are invited for 3-year positions at the level of Assistant Professor at the Faculty of Engineering and Science, Department of Physics, available from January 1, 2002 (position number 200021).

The department has existing strength in optics and materials science. The activities in optics include both theoretical and experimental aspects of quantum optics, near-field optics, non-linear surface optics, and optics applied to low-dimensional systems like surfaces, thin films and nanostructures. Current research interests in the materials science program focus on surface science, surface reactions, structure of interfaces, and surface alloying. The experiments are based on modern surface science spectroscopies including application of synchrotron radiation.

Teaching will be related to the study programme of B.Sc. in Mathematics and Physics and the study programme of M.Sc. in Modern Optics, Laser Technology and Materials Science, but also in other study programmes at the University.

For further information please contact Head of Department Anders Borup, phone: +45 9635 9216 or E-mail: abfys@physics.auc.dk.

The full text with information regarding qualifications, terms of employment, and guidelines for processing employment cases can be seen on: http://www.auc.dk/stillinger.htm. This can be required at the Faculty of Engineering and Science, telephone no. + 45 9635 9632.

The application marked with the position number, including CV, diploma, particularly relevant publications, other documentation as well as a complete list of the enclosed documentation, all in triplicate must reach Aalborg University no later than 12 November 2001 with the morning post.

Applications are to be forwarded to:

Aalborg University, Faculty of Engineering and Science, Fredrik Bajers Vej 7F, DK-9220 Aalborg East, DENMARK

K·STATE
Kansas State University

Research Associate Positions (2) High Energy Physics

Two experimental postdoctoral positions are immediately available in the High Energy Physics group at Kansas State University in Manhattan, Kansas. K-State carries signifigant responsibilities for the silicon tracker upgrade of the D0 experiment at Fermilab and the silicon outer barrel tracker for the CMS experiment at CERN. Further projects exist in the electronics and mechanics of the Whipple/Veritas gamma ray telescope. The successful applicant will assume a leadership role in one of these endeavors and will vigorously engage in physics analysis at either D0 or VERITAS.

Interested parties should send a resume, list of publications, and three letters of recommendation to:

Prof. Tim Bolton
Dept. of Physics
116 Cardwell Hall
Kansas State University
Manhattan, KS 66506-2601

The application deadline is December 1, 2001, but the deadline may be extended beyond this date until the positions are filled.

Kansas State University is an affirmative action equal opportunity employer and actively seeks diversity among its employees.

JUNIOR FACULTY POSITION THEORETICAL HIGH ENERGY PHYSICS

Yale University is seeking candidates for a Junior Faculty position in theoretical high-energy physics.

Interested candidates should send a curriculum vita and publication list, and arrange for three reference letters to be sent to:

Thomas Appelquist, Yale University, P.O. Box 208120, New Haven CT 06520-8120 USA,

before November 30, 2001.

Yale is an affirmative action/equal opportunity employer. Applications are encouraged from women and members of minority groups.

Spin in Particle Physics Elliot Leader, Cambridge University Press, ISBN 0521352819, hbk £90/$130.

Elliot Leader's book – in the series of Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology – is a thorough introduction to the theory and experimental study of high-energy spin physics.

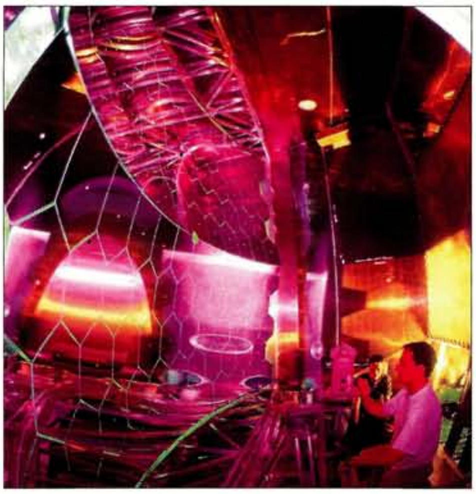
Both theoretically and experimentally, spin physics has always been a challenge. In recent years there has been considerable growth in research activities related to spin phenomena and their theoretical interpretation. There is an extensive list of review papers but few books devoted to the subject.

However, Leader's book provides a comprehensive introduction, with a pedagogical approach to high-energy spin physics. The novelty of the book is also in the rather detailed description of experimental techniques and apparatus, as well as the standard theoretical part. A large number of appendices with technical details and formalism are valuable for the pedagogical treatment of spin problems and make for quick reference.

A significant part of the monograph deals with the problem of nucleon spin structure – the topic widely discussed since 1988 when the results of the European Muon Collaboration showed that the spin of the proton is not the sum of the spins of its individual quarks.

The small-x behaviour of the polarized structure function is one of the unsolved problems en route to a final resolution of the overall nucleon spin puzzle and is discussed from different points of view. The gluon anomaly and a general perturbative QCD approach to the nucleon spin problem are discussed in detail, including the evolution, scheme-dependence and phenomenology of the polarized parton distributions.

Alongside these topics, an introduction to the parton model, the Standard Model, QCD and the general formalism of polarized deep-inelastic scattering is presented. The helicity structure of QCD interactions is considered thoroughly and fermion spin structure is analysed for the case of massive and massless spinors. Possibilities of testing Standard Model and perturbative QCD predictions in the two-spin and parity-violating single-spin asymmetries measured at large angles are listed. Such experiments are useful tools for the detection of gluon polarization,



Mirrors for the Ring Imaging Cherenkov detectors of the COMPASS experiment at CERN. COMPASS is the latest in a long line of spin-sensitive experiments using CERN high-energy muon beams.

which is a possible solution of the nucleon spin problem.

Another outstanding problem of spin physics is the observation of significant single-spin transverse asymmetry. In the framework of perturbative QCD, the polarization of an individual quark in a hard subprocess should vanish because of the vector type of the QCD interaction, which leads to chirality conservation. However, experimentally there is a mass of data showing large asymmetries or large polarizations, in both elastic and semi-inclusive reactions.

The different mechanisms for producing non-zero, single-spin transverse asymmetries, including final-state interactions, are considered. All such explanations are in fact beyond the standard QCD parton model. The most prominent single-spin asymmetry was observed in inclusive hyperon production, where over two decades ago it was discovered that highly polarized Λ hyperons are produced in the collision of unpolarized protons. Most dramatic is that despite the large hyperon polarization, it has no tendency to decrease with the transverse momentum of the produced hyperon, as could be expected from perturbative QCD mechanisms. This whole area of high-energy physics is a challenge for the theory of strong interactions. Only phenomenological models have had any success in the quantitative description of hyperon polarization data.

One chapter is devoted to spin effects in elastic scattering at high energy, which is a most fundamental type of reaction and where a lot of experimental data exist at low and medium energies. There are also high-energy data that demonstrate a rising dependence of analysing power in proton–proton scattering with transferred momentum. A conclusion made in the book clearly indicates that QCD demands the opposite behaviour of the analysing power in elastic proton–proton scattering, but there are no specific predictions for analysing power based on QCD and it does not provide an estimate for where the decreasing behaviour begins. The experimental study of this process is an indispensable source of knowledge on the nucleon wavefunction and a clear and unambiguous way to check perturbative QCD as well as the models based on the non-perturbative approaches to hadron dynamics.

Significant attention is devoted to technical problems, in particular the mechanisms of polarized hadron and electron production and acceleration. In particular, polarized proton sources, polarized targets, difficulties in the acceleration of polarized particles (including "Siberian snakes") and polarization at LEP, HERA and SLC are described. This increases the potential reader audience. Besides these problems, the book treats in detail the polarimetry issues that are essential for modern experimental high-energy spin physics, especially for the experimental programme with polarized protons at RHIC.

The first five chapters of the book consider the basic formalism and definitions of spin, helicity, spin-density matrix, transition amplitudes and observables of a reaction. The properties of helicity states and wavefunctions under Lorentz and discrete transformations are described in a clear, pedagogical manner. For example, an intelligible derivation of the famous Thomas precession is presented.

In conclusion, it should be stressed that in the light of ongoing major experimental studies (for example, COMPASS at CERN, RHIC-SPIN at Brookhaven and SPIN@U70 at IHEP), this book is useful and timely, describing the state of the field and providing reference points for the interpretation of forthcoming experimental data in high-energy spin physics – a subject that underwent rapid growth during the last decades of the past century. The book is suitable for students at graduate level and will be of interest to the broad high-energy physics community.

Nikolai Tyurin, IHEP, Protvino.

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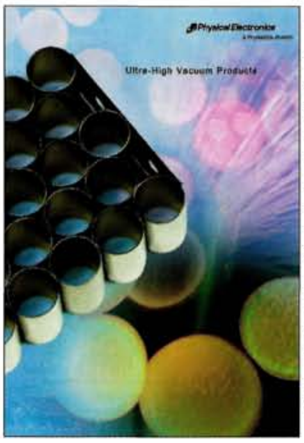

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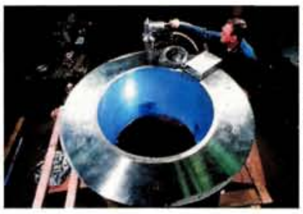

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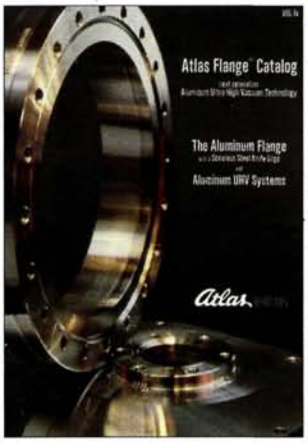

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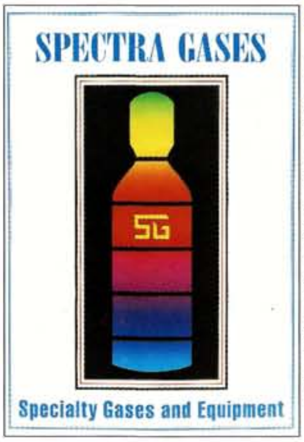

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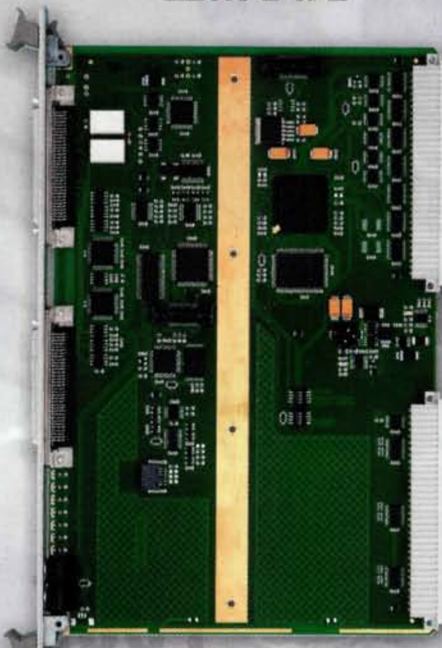

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Time to market, but not at the cost of short-term compromise.

Instrumentation for Measurement & Control

▶ Magnetic Field

THM-7025

Application	Product	Specifications: Range	Resolution	Bandwidth
Linear sensing. Non-contact measurement of position, angle, vibration. Small size, low power.	CYH-22 1-axis Hall element	± 20mT	± 4μT	DC to 10kHz
	2D-VD-11 2-axis Hall element	User option	± 30μT	DC to 10kHz
	3D-H-30 3-axis Hall element	User option	± 100μT	DC to 10kHz
High sensitivity and accuracy for low fields. Site surveys and monitoring. Active field cancellation.	MAG-01 1-axis Fluxgate Teslameter	± 2mT	± 0.1nT	DC to 10Hz
	MAG-03 3-axis Fluxgate Transducer	± lmT	± 0.1nT	DC to 3kHz
Linear measurement. Feedback control. Mapping, quality control.	YR100-3-2 Hall Transducer, 1-axis	± 2T	± 12μT	DC to 10kHz
	3R100-2-2 Hall Transducer, 3-axis	± 2T	± 12μT	DC to 10kHz
Hand-held, low-cost, 3-axis for magnet and fringe fields.	THM 7025 Hall Teslameter, 3-axis	± 2T	± 10μT	DC
Precision measurement and control. Laboratory and process systems.	DTM-133 Hall Teslameter, 1-axis	± 3T	± 5μT	DC to 10Hz
	DTM-151 Hall Teslameter, 1-axis	± 3T	± 0.1μT	DC to 3Hz
Calibration of magnetic standards. Very high resolution and stability (total field).	2025 NMR Teslameter (total field)	± 13.7T	± 0.1μT	DC
	FW101 NMR Teslameter (total field)	± 2.1T	± 0.5nT	DC
Precision flux change measurement.	PDI 5025 Digital Voltage Integrator	40 V.s	±2E-8V.s	1ms to 2^{23}ms

Field units: 0.1nT = 1μG, 100nT = 1mG, 100μT = 1G, 1mT = 10G, 1T = 10,000G

▶ Electric Current (isolated measurement)

IPCT

Application	Product	Specifications: Range	Resolution	Bandwidth
High sensitivity for low currents, currents at high voltage, differential currents.	IPCT Current Transducer	± 2A	± 10μA	DC to 4kHz
	MPCT Current Tranducer	± 5A	± 10μA	DC to 4kHz
Linear sensor for low-noise, precision current regulated amplifiers and power supplies.	864I-2000 Current Transducer	± 2000A	<4ppm	DC to 300kHz
	866-600 Current Transducer	± 600A	<4ppm	DC to 100kHz
Instruments for calibration, development, quality control.	860R-600 Current Transducer	± 600A	<5ppm	DC to 300kHz
	860R-2000 Current Transducer	± 2000A	<8ppm	DC to 150kHz
	862 Current Transducer	± 16kA	<5ppm	DC to 30kHz
Passive sensor for rf and pulse current.	FCT Fast Current Transformer	1:5 to 1:500	limited by following amplifier	150Hz to 2GHz
Passive sensor for pulse charge.	ICT Integrating Current Transformer	± 400nC	± 0.5pC	1μs to<1ps

▶ Distributed I/O

CNA

FTR

Application	Product	Specifications: Range	Resolution	Bandwidth
High resolution Input/Output modules that can be placed locally at the transducer or controlled unit. High Voltage and/or high noise environments. PC, PCI, VME, CAMAC host computer options.	DNA for DeviceNet	± 100mV to ± 10V	16 bit	DC to 150Hz
	CNA with fiber optic communication	± 100mV to ± 10V	16 bit	DC to 150Hz
	FTR fiber optic to RS-232-C			50 to 200kB

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