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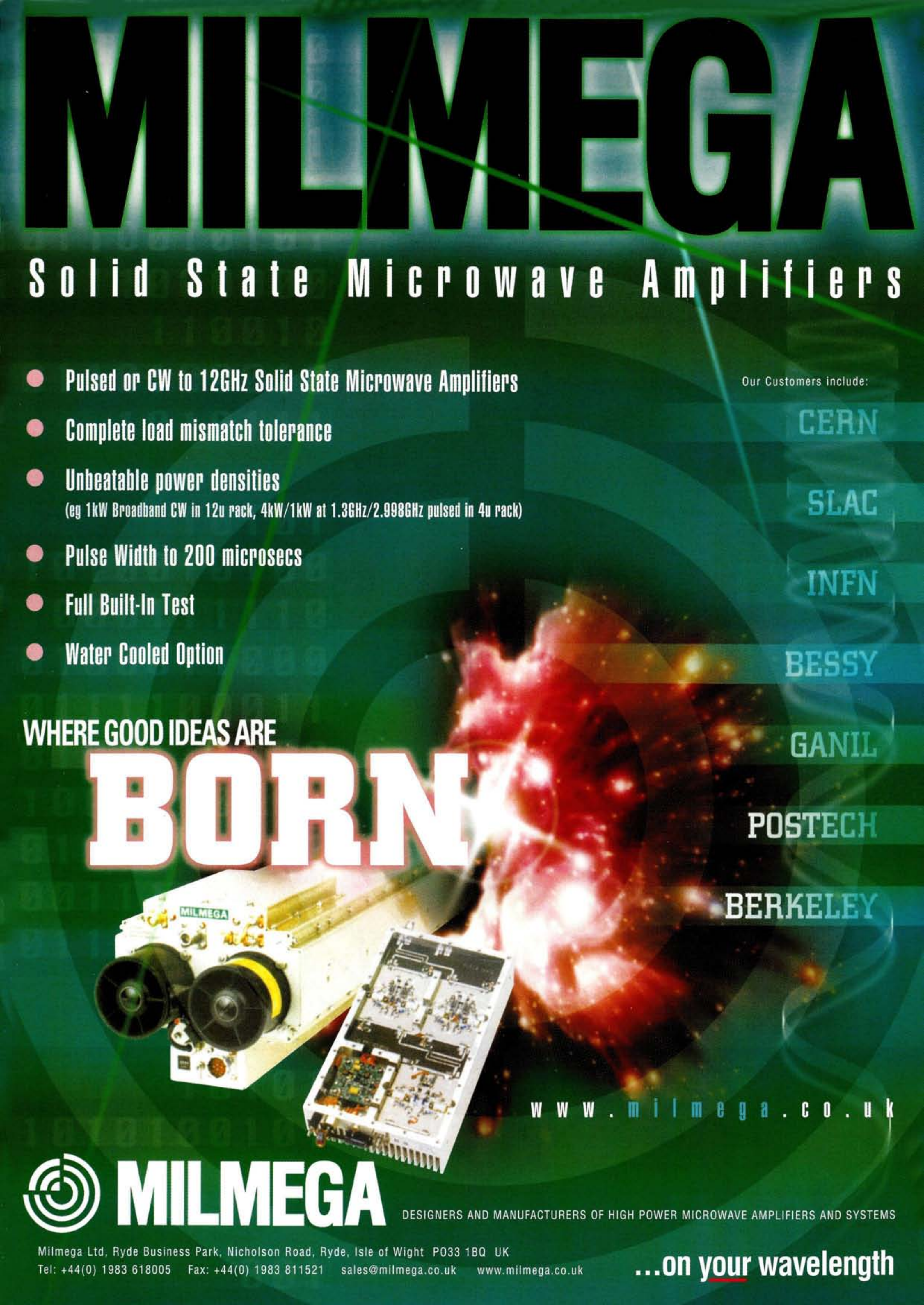
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HESS telescope inaugurated p7

Fermilab profile p32

Honour for LHC's Evans p45

Cover: Members of the ATHENA collaboration with the apparatus that first produced cold antihydrogen at CERN in August. Two separate traps inside these magnets were used to contain the ingredients of antihydrogen – antiprotons and positrons. These were then opened, allowing the particles to come together in a third (mixing) trap where antihydrogen atoms formed. These were then detected when they annihilated with the walls of the trap. (p5).

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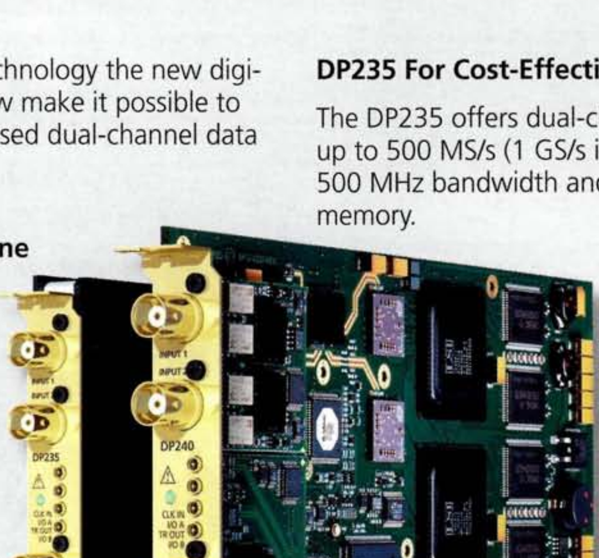

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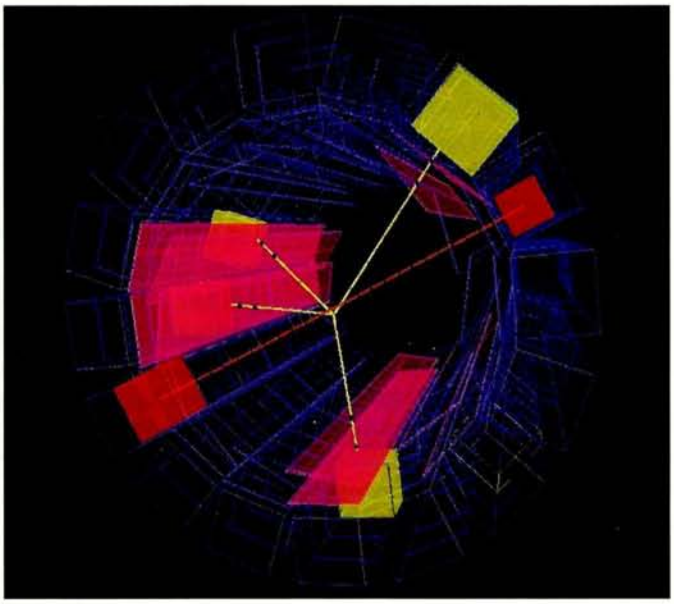
FUNDAMENTAL SYMMETRY

Cold antiatoms produced at CERN

Physicists working at CERN's Antiproton Decelerator (AD) have announced the first controlled production of large numbers of antihydrogen atoms at low energies. This is an important step on the way to testing the fundamental symmetry CPT through comparison of hydrogen with antihydrogen.

The hydrogen atom is the most completely understood atomic system, with its first excited state being pinned down to just 1.8 parts in 10^{14}. Antihydrogen, on the other hand, is almost completely unknown. A comparison of the two systems would give a very precise test of CPT symmetry, which is assumed to be conserved in the Standard Model of particle physics. CPT is the combination of charge conjugation, parity and time reversal. The violation of the CP combination is well established in kaon and B-meson decays, but so far, no experiments have shown evidence that CPT is not conserved in nature.



The ATHENA experiment has made the first observation of cold antihydrogen atoms. The red blocks measured in the experiment's caesium iodide calorimeter indicate photons from the positron annihilation. The yellow lines correspond to charged particles from the antiproton annihilation. These are detected by silicon detectors (pink) and the calorimeter (yellow blocks).

This latest development at CERN follows the production of small numbers of fast-moving antihydrogen atoms at CERN and Fermilab in the US in the mid-1990s. It is the result of several years of development work into the antiparticle trapping and mixing systems needed to produce slow (cold) antihydrogen atoms that can themselves be trapped for further study. ATHENA, one of two CERN experiments that plan to study antihydrogen, has been the first to produce cold antihydrogen atoms.

Says CERN director-general, Luciano Maiani: "The controlled production of antihydrogen observed in ATHENA is a great technological and scientific event. Even more so because ATHENA has produced antihydrogen in unexpectedly abundant quantities." Giving due credit to the ATRAP experiment (which also aims to study antihydrogen), he went on to say: "I'd like to recognize the contribution of ATRAP, which has pioneered the technology of trapping cold antiprotons and positrons, an essential step towards the present discovery." Last year the ATRAP experiment was the first to use cold positrons to cool antiprotons.

The ATHENA collaboration of 39 scientists from nine institutions worldwide has built on these techniques with the addition of a high-yield positron accumulator and powerful particle detector. The abundant numbers of positrons from the accumulator, coupled with good granularity and background rejection from the detector, allowed the collaboration to see its first clear signals for antihydrogen in August – appropriately, the 100th anniversary of the birth of theorist Paul Dirac, who predicted the existence of antimatter in the late 1920s.

The ATHENA collaboration estimates that some 50 000 antihydrogen atoms were created in its apparatus before announcing their result. Antiprotons decelerated by the AD to a leisurely pace – by CERN's standards – of a tenth of the speed of light were first trapped in an electromagnetic cage. From each AD pulse of 2×10^7 antiprotons, some 10 000 were caught. The next stage was to mix them with about 75 million cold positrons collected from the decay of a radioactive isotope and caught within a second trap. Finally, the trap doors were opened, allowing the antiprotons and positrons to mix in a third trap. It is here that cold antihydrogen atoms formed.

ATHENA observes antihydrogen atoms when they annihilate with the walls of the mixing trap. Two photons from the positron annihilation are localized in space and time with charged particles coming from the antiproton annihilation. The next steps are to trap antihydrogen atoms and add a laser spectroscopy system. This will allow the CPT studies to begin.

NOBEL

2002 Nobel Prize for Physics is announced

The Royal Swedish Academy of Sciences has awarded this year's Nobel Prize for Physics to three astrophysics pioneers. Raymond Davis Jr and Masatoshi Koshiba share one half of the award "for pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos". The second half goes to Riccardo Giacconi "for pioneering contributions to astrophysics, which have led to the discovery of cosmic X-ray sources".

Cosmic neutrinos

Neutrinos were postulated by Wolfgang Pauli in 1930 and first detected by Frederick Reines and Clyde Cowan in the mid-1950s using a detector placed close to a nuclear reactor. Soon after, Ray Davis proposed building an underground detector to look for neutrinos coming from the Sun. The majority of reactions in the Sun generate neutrinos with energies too low to be detected with the technology of the 1950s, but one relatively rare reaction – the decay of boron-8 – produces neutrinos of up to 15 MeV. This is high enough to be detected by the technique elaborated by Bruno Pontecorvo and Luis Alvarez, who had suggested in the 1940s that such neutrinos could interact with chlorine atoms to produce a radioactive isotope of argon with a half-life of around 35 days. By 1967, Davis had installed a tank filled with 615 tonnes of the common cleaning fluid tetrachloroethylene in the Homestake gold mine in South Dakota, US. His background in chemistry had allowed him to devise the techniques for extracting the argon atoms every few weeks and counting their number – a feat equivalent to finding a particular grain of sand in the Sahara desert.

What Davis discovered came as a surprise – he detected only about half the number of neutrinos expected from the standard solar model. This meant the experiment was wrong, the standard solar model was wrong, or something was happening to the neutrinos on their way from the Sun.

Davis's experiment ran continuously from 1967 to 1994, and was joined in 1987 by the huge Kamiokande water Cerenkov detector, built in Japan by a team led by Koshiba. This provided a confirmation that Davis's experiment was right, and focused attention on the hypothesis proposed by Pontecorvo and Vladimir Gribov in 1968 – one year after Davis's first results – that neutrinos oscillate, or change flavour on their way from the Sun. Both the Homestake and Kamiokande experiments are sensitive only to electron-type neutrinos. ▷

MIDDLE EAST

SESAME opens the door to Middle East co-operation

The SESAME (Synchrotron Radiation Light for Experimental Science and Applications in the Middle East) project to build a synchrotron light source in the Middle East took a step closer to reality in June, when it received unanimous approval from the UNESCO executive board. The board endorsed SESAME as "a model that should be made known to other regions", and described it as a quintessential UNESCO project.

The BESSY 1 synchrotron sets sail from Germany, bound for a new life as the core of the third-generation SESAME light source in Jordan.

The idea for SESAME dates back to 1997 when, at a seminar on Middle East Scientific Co-operation (initiated by CERN's Sergio Fubini), Herman Winick of SLAC and Gustav-Adolf Voss from DESY suggested using components of Berlin's BESSY 1 machine, scheduled to be closed down in 1999, as the core facility for a new laboratory in the Middle East (*CERN Courier* March 2000 p17). Soon after, an interim council was established along identical lines to CERN under the auspices of UNESCO. Like CERN before it, SESAME is a project designed not only to advance science and technology, but equally importantly to help bring peace and stability to a troubled region through scientific collaboration. Former CERN director-general, Herwig Schopper, chairs its interim council.

In 2000, Jordan was chosen to host the new facility (*CERN Courier* June 2000 p6); 13 interim council member states undertook to provide $50 000 (€50 000) per year each for three years from 1 January 2001 for preparatory work, and the US State Department and Department of Energy contributed $200 000.

The endorsement of the SESAME project by UNESCO's executive board is an important step towards establishing SESAME as an independent international scientific organization. As soon as six potential member states have deposited their agreement of the new laboratory's statutes with UNESCO, SESAME will gain its independence and the interim council will give way to a governing council, again based on the CERN model.

So far Bahrain, Iran, Jordan, the Palestinian Authority and Turkey have formally decided to join SESAME. Other member states of the interim council are Egypt, Greece, Israel, Morocco, Oman, Pakistan and the United Arab Emirates.

Armenia and Cyprus, originally members of the interim council, have changed their status to observer. For Armenia, the change of status came when the country took the decision to build its own light source (*CERN Courier* October p7). Other observers are France, Germany, Italy, Japan, Kuwait, the Russian Federation, Sudan, Sweden, the UK and the US. Kuwait has indicated that it intends to become a full member of SESAME.

Originally conceived as a 1 GeV machine, the interim council has already approved plans presented by technical director Dieter ▷

Kamiokande was also able to trace the direction of incoming neutrinos, confirming that they came from the Sun.

Koshiba went on to build the larger Superkamiokande experiment, which saw evidence for neutrino oscillation in neutrinos produced in the atmosphere by cosmic rays. Solar neutrino oscillation has since been confirmed by the Sudbury Neutrino Observatory in Canada (*CERN Courier* June p5).

X-ray sources

It was not until 1949 that X-ray astronomy got off the ground. X-rays from cosmic sources are almost entirely absorbed by the Earth's atmosphere, and it was only in the 1940s that rocket technology had advanced sufficiently to allow Herbert Friedman and colleagues to launch detectors to a sufficiently high altitude to make significant measurements. These experiments showed that X-ray radiation comes from areas on the surface of the Sun with sunspots and eruptions, and from the surrounding corona. Their observations were, however, confined to the solar system.

When in June 1962, Giacconi's group launched an instrument consisting of three Geiger counters equipped with windows of varying thickness aboard a rocket, they became the first to record a source of X-rays beyond the solar system. Designed to see whether the Moon could emit X-rays under the influence of the Sun, the experiment instead located a source at a far greater distance, and observed an evenly distributed X-ray background. These discoveries gave an impetus to the development of X-ray astronomy.

The first source to be identified with a visible object was Scorpio X-1; other important sources were the stars Cygnus X-1, X-2 and X-3. Most proved to be binary systems in which a visible star orbits around a dense compact object such as a neutron star or a black hole. Detailed studies using short flights on rockets were, however, difficult, so Giacconi initiated construction of the UHURU satellite, which was launched in 1970. This was 10 times more sensitive than the rocket experiments, and was itself succeeded by the Einstein X-ray observatory – the first X-ray telescope capable of generating sharp images at X-ray wavelengths. Giacconi's most recent accomplishment is the Chandra observatory, named for astrophysicist Subrahmanyan Chandrasekhar. Initiated by Giacconi in 1976, Chandra was launched in 1999 and has provided remarkable images of the X-ray universe.

Giacconi's pioneering efforts in X-ray astronomy have changed our view of the universe. Some 50 years ago, the universe appeared largely to be a system in equilibrium. Today, we know that it is also the scene of extremely rapid developments in which enormous amounts of energy are released in processes lasting less than a second, in connection with objects not much larger than the Earth. Studies of these processes, and of the central parts of active galaxy cores, are largely based on data from X-ray astronomy.

Einfeld to upgrade SESAME from the 0.8 GeV BESSY 1 machine to 2 GeV, resulting in a third-generation light source with 13 positions for insertion devices. Advisory committees have been appointed, and tangible progress was made in June, when the BESSY 1 machine set sail from Germany bound for the Jordanian port of Al-Aqabe. A request has been made to the European Union (EU) for €8 million for the installation and upgrade of the machine. An evaluation panel has submitted a report to the EU, but its contents have not yet been made public.

A seminar organized and financed by the Japanese Society for the Promotion of Science to discuss the scientific programme, including the first beamlines, was held in the Jordanian capital Amman in October. Several laboratories have offered beamline equipment, and financial support for beamlines is being sought from the International Atomic Energy Authority in Vienna and from US agencies. Meanwhile, the Jordanian government has agreed to finance the building that will house the centre at a campus of the Al-Balqa' Applied University in Allan, 30 km from Amman.
A ground-breaking ceremony in the presence of the Jordanian king, HM Abdullah II, and the director-general of UNESCO, Koïchiro Matsuura, is planned for 6 January 2003.

ASTROPHYSICS

Gamma-ray facility inaugurated in Namibia

The first telescope of the high-energy stereoscopic system (HESS), named in honour of Victor Hess, the discoverer of cosmic radiation, was officially inaugurated in Namibia in September. HESS is a system of large Cerenkov telescopes intended for high-energy gamma-ray astrophysics.

The HESS collaboration identified the Gamsberg area of Namibia as an ideal location for a high-energy gamma-ray observatory in January 1998. With the support of the Namibian government and local landowners, construction began in 1999. HESS was originally conceived as a two-phase project, with four telescopes being installed in the initial phase and a further 12 identical telescopes being added later. The first telescope began operation this summer, with phase one scheduled for completion by 2004. Options for phase two are currently being studied.

Werner Hofmann of the HESS collaboration (right) discusses telescope technology with Namibian Minister of Higher Education, Training and Employment Creation, Nahas Angula, at the inauguration of the first HESS telescope. (HESS collaboration.)

The physics motivation behind HESS is to pinpoint the origins of high-energy cosmic rays through the study of cosmic gamma rays from around 100 GeV to several TeV. Although Hess began the work that led to the discovery of cosmic rays in 1911, there is still very little known about their origins. The majority of primary cosmic rays are atomic nuclei, whose trajectories through space are influenced by interstellar and intergalactic magnetic fields. Such fields, however, do not affect gamma rays, and so their detection will point right back to the source.

CERN

LHCb receives delivery from Russia

The LHCb collaboration, dedicated to studying CP violation in B-meson decays at CERN's Large Hadron Collider (LHC), has received the first components of its calorimeter system from Russia. The first 1200 of 3300 electromagnetic calorimeter (ECAL) modules and the first two of 52 hadron calorimeter (HCAL) modules were delivered to CERN in September. The so-called shashlik-type (lead-scintillator sandwich) ECAL modules are being produced by Russia's Institute for Theoretical and Experimental Physics in collaboration with CERN. The HCAL tile calorimeter is the responsibility of the Institute of High Energy Physics in Protvino, with contributions from the Horia Hulubei National Institute for Physics and Nuclear Engineering in Bucharest, Romania; the Institute of Physics and Technologies in Kharkiv, Ukraine; and CERN. Series production of a Preshower detector is under preparation at the Institute for Nuclear Research in Moscow. The fast 40 MHz calorimeter detector readout electronics are the responsibility of French (Annecy, LAL-Orsay and Clermont-Ferrand) and Spanish (Barcelona) LHCb groups.

LHCb's calorimeter has been designed for speed, since it will be used for triggering on collisions arising from the LHC's 40 MHz bunch crossing rate. All three sub-detectors (Preshower, ECAL and HCAL) are based on fast scintillators with wavelength-shifting fibre readout. The HCAL (which will be used exclusively for triggering) uses iron as its passive medium, while the ECAL uses lead. While also participating in the trigger, another important function of the ECAL will be to reconstruct neutral pions and photons from B-meson decays. Production is set to continue at a rate of 10 ECAL modules per day and one HCAL module every two weeks.

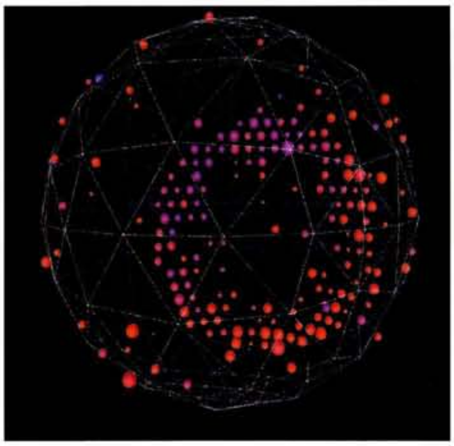
Members of the LHCb collaboration begin to unpack the first 1200 modules of their ECAL in September. To the right are the first two of 52 HCAL modules to arrive at CERN.

NEUTRINOS

MiniBOONE goes live at Fermilab

The MiniBOONE experiment at Fermilab in the US saw its first neutrinos in September. Designed to test the controversial neutrino oscillation result from the Los Alamos LSND experiment, which is so far the only accelerator-based signal for oscillation, the experiment will take data for two years. That will allow the MiniBOONE collaboration to study the entire LSND allowed region with high sensitivity.

The LSND result remains controversial, since it is difficult to reconcile with oscillation results from Superkamiokande in Japan and the Sudbury Neutrino Observatory in Canada without invoking an extra type of neutrino. Confirmation would therefore require a major rethink of current particle theory. If the LSND result is correct, MiniBOONE expects to see around 1000 electron neutrinos in the pure muon-neutrino beam over the next two years.



This ring of lit-up phototubes inside the MiniBOONE detector indicates the collision of a muon-neutrino with an atomic nucleus in the mineral oil that fills the detector. (Fermilab Visual Media Services.)

COMPUTING

Grid technology developed by ALICE

The ALICE experiment, which is being prepared for CERN's Large Hadron Collider, has developed the ALICE production environment (AliEn), which implements many components of the Grid computing technologies that will be needed to analyse ALICE data. Through AliEn, the computer centres that participate in ALICE can be seen and used as a single entity – any available node executes jobs and file access is transparent to the user, wherever in the world a file might be.

For AliEn, the ALICE collaboration has adopted the latest Internet standards for information exchange (known as Web Services), along with strong certificate-based security and authentication protocols. The system is built around open-source components and provides an implementation of a Grid system applicable to cases where handling many distributed read-only files is required.

AliEn aims to offer a stable interface for ALICE researchers over the lifetime of the experiment (more than 20 years). As progress is made in the definition of Grid standards and interoperability, AliEn will be progressively interfaced to emerging products from both Europe and the US. Moreover, it is not specific to ALICE, and has already been adopted by the MammoGrid project (supported by the European Union), which aims to create a pan-European database of mammograms.

ALICE is currently using the system for distributed production of Monte Carlo data at more than 30 sites on four continents. During the last year more than 15 000 jobs have been run under AliEn control worldwide, totalling 25 CPU years and producing 20 Tbyte of data. Information about AliEn is available at http://alien.cern.ch.

HEP email news wire

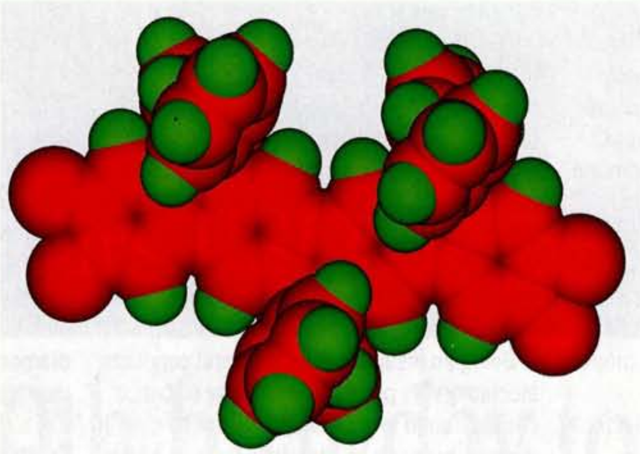
Fermilab and SLAC announced the launch of an email news wire for high-energy physics and related fields in September. Available at http://www.interactions.org/, the news wire is the first element of a service that aims to group information from the world's particle physics laboratories on a single website.

Edited by Archana Sharma

Impurities shed light on polymers

A dash of impurity could show the way to more efficient light-emitting diodes (LEDs) made from plastics – organic optoelectronic devices. According to a recent paper in *Physical Review Letters*, palladium atoms present at extremely small quantities in a polymer LED cause the material to phosphoresce.

Polymer LEDs are devices made from conjugated polymers – repeating chains of organic molecules rich in double bonds between carbon atoms. They offer the promise of producing LEDs from moulded plastic. These would be easily tunable from one colour to another. The caveat is that much of the electrical energy applied produces heat instead of light.



Small levels of palladium impurity in this polymer have unexpectedly caused it to phosphoresce, opening a route to better polymer LEDs. (J Lupton, MPI for Polymer Research, Mainz.)

Researchers in Germany have now found that a new conjugated polymer for LEDs emits a pink glow, rather than the blue-green they expected. This shift also endured even after the voltage was turned off. Investigations revealed the presence of palladium atoms, (left over from the catalyst used to synthesize the polymer) at a level of 80 ppm, or one for every 1700 units of the polymer.

This level of impurity is hard to produce in a polymer using current techniques. Metallorganic polymers also phosphoresce, but each unit in these compounds contains a metal atom. The ubiquitous metal atoms strongly affect the electronic structure and drastically reduce the light-producing efficiency of metallorganics. In contrast, the new material is 99.9% metal-free.

Nevertheless, the small numbers of palladium atoms turn out to play a crucial role. When a voltage is applied to a semiconductor, a positive charge forms at one terminal and a negative charge at the other. These combine to form a neutral "exciton", which rapidly decays into a photon (if it has enough energy) or converts to heat. If a metal atom such as palladium is around, it can convert some less energetic excitons into phosphorescence.

The effect suggests that light-emission can probe the properties of these lower-energy excitons, which researchers have rarely seen directly, as well as the chemistry of related materials. Metal impurities might also help polymer LEDs generate more light or improve the performance of organic dye lasers or single photon-emitters.

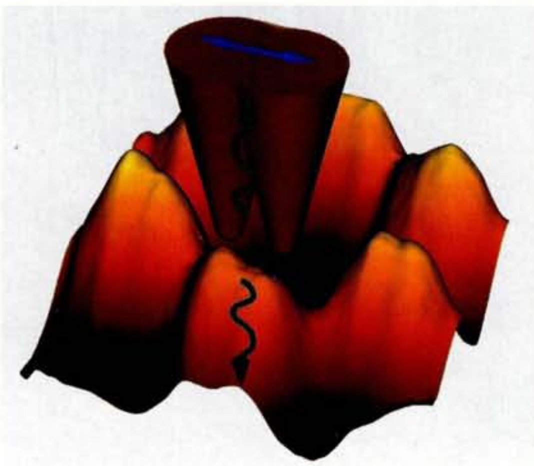
Further reading

J M Lupton *et al.* 2002 Intrinsic room-temperature electrophosphorescence from a pi-conjugated polymer *Phys. Rev. Lett.* **89** 167401.

New technique demonstrates friction at the atomic scale

In a major technical breakthrough, researchers at the University of Augsburg in Germany have employed a special atomic force microscope to measure the friction between a tungsten tip and a silicon surface. Atomic force microscopy uses a sensitive cantilevered arm with a tip just one atom wide to measure the electrostatic attraction between arm and surface. This allows a 3D map to be drawn up based on the force measurements.

Friction is caused by the dissipation of energy as atoms shift out of place and back again when macroscopic objects slide against each other. As long ago as 1929, the British physicist G A Tomlinson described friction as being due to a "plucking action of one atom on to the other", but it has taken until now to show he was right.



In this illustration, each atom appears as a double peak. The microscope probe (red) swings with constant amplitude over a silicon surface. The energy needed to maintain constant amplitude is measured and corresponds to the friction loss between the probe and surface atoms. (Alexander Herrnberger.)

In a variation of the atomic force technique, called frequency modulation lateral force microscopy, the German team drags the tip, which oscillates back and forth, across the surface, giving an excellent measure of friction.

Further reading

F J Giessibl, M Herz and J Mannhart 2002 Friction traced to the single atom *Proc. Natl. Acad. Sci. USA* **99** 12006–12010.

Diamonds increase their worth in research

The beauty of diamonds has always belied their utility. They are known as the hardest, most thermally conductive and chemically resistant material. Diamond coating technology has been applied to produce superior abrasives and cutting tools, such as diamond-turning machinery for optics fabrication. However, the technique also promises applications in electronics and optics if methods for epitaxial growth can be perfected. Researchers from Sweden and the UK have made films of synthetic diamond that have electrical properties approaching those of silicon.

The electrons and holes that carry electrical currents in semiconducting materials are twice as mobile in these new films as in their forerunners. Devices based upon them, such as transistors, might work fast enough to compete with silicon.

The researchers have improved the microwave plasma chemical-vapour deposition (CVD) process used to make diamond films by breaking off carbon atoms from carbon-rich methane molecules. The new CVD technique produces thick, high-quality diamond films. Earlier, CVD generated a disorderly mosaic of tiny crystallites in which the boundaries between grains disrupted the flow of an electrical current.

Being an insulator, pure diamond conducts electricity very poorly. However, like silicon, it can be turned into a semiconductor by mixing in small amounts of impurities such as boron or nitrogen. For this study, boron-doped diamond was made by adding diborane, a boron-hydrogen compound, to the CVD mixture of methane and hydrogen. Industrial diamond was used as the support that helped the films' carbon atoms to line up properly.

Diamond microelectronics has a long way to go in replacing silicon, but diamond devices may function in situations where silicon electronics fails. For example, diamond chips could work at temperatures of several hundred degrees, whereas silicon devices generally fail above 150°C. Diamond can also carry much more power than silicon, so diamond-based devices could be smaller than silicon ones.

Further reading

J Isberg *et al.* 2002 High carrier mobility in single-crystal plasma-deposited diamond *Science* **297** 1670–1672.

Edited by Emma Sanders

Happy 40th birthday to ESO

This autumn, the European Southern Observatory (ESO) celebrates its 40th anniversary. As current ESO director Catherine Cesarsky looks back fondly on the last four decades, she remembers "one full generation of scientists, a wonderful time during which many of our dreams, our hopes, and our goals have finally come true."

ESO has proved to be a real success story, crowned today with the world-class Very Large Telescope (VLT) array, which provided the first interferometric fringes from all four telescopes just in time for the anniversary celebrations.

In the early days, ESO was based at CERN. The Geneva laboratory housed the science department, and also the team that produced the Sky Atlas for ESO and the UK Schmidt telescope. The first ESO observatory went into operation in 1968 at La Silla on a remote mountain top in the Atacama desert, Chile. The first telescope was a 1 m photometric model. Today, the site is home to nine telescopes, including the 3.5 m New Technology Telescope and the Swedish ESO Submillimetre Telescope, the only large submillimetre telescope in the southern hemisphere.

Construction started at ESO's Paranal observatory in 1994. The observatory now houses the VLT's four 8.2 m telescopes, and other smaller auxiliary telescopes are due to be installed in 2003.

The 40th anniversary is also the ideal occasion to look to the future, as ESO prepares for ALMA, an array of submillimetre antennae, and OWL, the ground-based, fully steerable, 100 m optical telescope (*CERN Courier* September 2000 p15). Says Cesarsky: "The challenges ahead are commensurate with the achievements of today."

The barren plateau 5000 m up in the Chilean Andes that will host the ALMA array. (ESO.)

VLT to help map the universe

Attempting to measure the evolution of the universe requires a huge sample of objects. Observations of millions of galaxies, looking further and further back in time, are needed to make an enormous 3D map of the universe. This type of galactic surveying is being carried out by several groups worldwide, and now the Very Large Telescope (VLT) is set to make a major contribution to this, the biggest map in the universe.

One of the instruments to be installed this year at the VLT is a multi-object spectrograph called VIMOS that can obtain spectra of up to 6400 individual objects in a single exposure. This is two or three times more efficient than existing counterparts.

In the future, the VLT will also be equipped with NIRMOS, the infrared equivalent to VIMOS, which will detect emission from galaxies whose optical emission is obscured by intervening dust. Together, VIMOS and NIRMOS will allow astronomers to map a time interval spanning more than 90% of the age of the universe.

Picture of the month

This image of the nearby spiral galaxy NGC 300 was obtained using ESO's 2.2 m telescope at La Silla in Chile. The observations are part of the 15 Tbyte of data that make up the ESO Science Data Archive, which is available to astronomers for analysis. This particular image is a good example of the wide range of astronomy resulting from ESO observations, as it is being used to make measurements of Cepheid variable stars to improve distance calculations, to study gravitational lensing of distant galaxies, to measure dark matter content, to study the history of star formation, and much more besides! (ESO.)

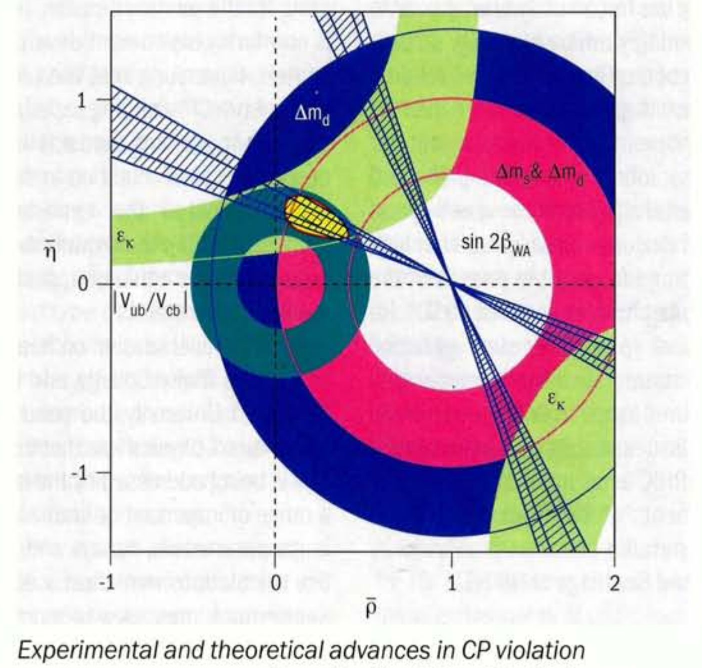
Correction

The list of countries participating in the INTEGRAL mission was incorrectly reported in last month's edition of *CERN Courier*. Countries contributing to the mission are: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK, the US, Russia, the Czech Republic and Poland.

High-energy conference highlights precision results

This year's Rochester International Conference on High Energy Physics, held in Amsterdam, provided a showcase for precision results, and pointed the way forward for particle physics at future facilities. **Paula Collins** and **Piet Mulders** report.

More than 900 physicists participated in the 31st International Conference on High-Energy Physics (ICHEP2002), held in Amsterdam on 24–31 July. The Dutch National Institute for Nuclear Physics and High Energy Physics (NIKHEF) organized the conference, and almost all of its graduate students took part as assistants to the chairpersons, convenors or speakers. The participants stayed all over the city, and converged on the RAI conference centre each morning – easily distinguished by their bright orange conference bags. In the tradition of the Rochester conferences, the subjects were wide-ranging, with a mixture of new results and review talks providing a comprehensive overview of high-energy physics today and directions for the future. Social events were organized in several beautiful old and new buildings, including the conference dinner in the Amsterdam opera house, and a public lecture in the auditorium of the University of Amsterdam, delivered by the winner of the 1999 Nobel Prize for Physics, Professor Gerard 't Hooft of Utrecht University.

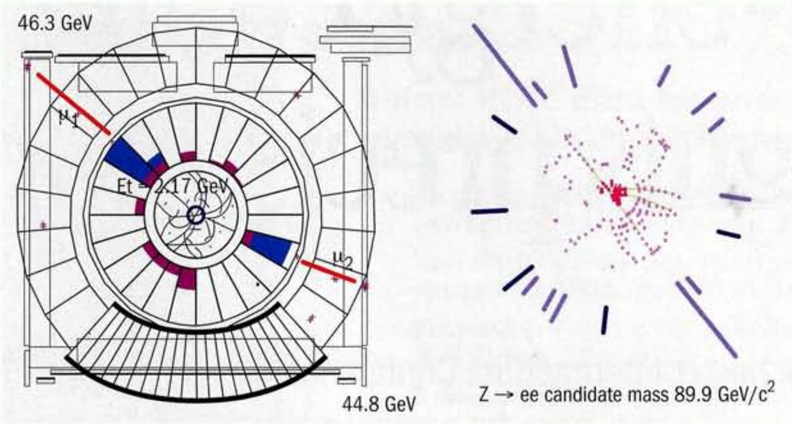


Experimental and theoretical advances in CP violation measurements were reviewed by Yossi Nir of the Weizmann Institute. This Standard Model fit to the experimental data takes into account the most significant measurements. The unitarity triangle, which describes the CP violating mechanism, can be drawn in this so-called "rho eta" plane. The apex of the triangle is presently constrained to lie within the shaded yellow area. The existence of such an area, consistent with all the constraints, implies that the Standard Model is very likely to account for the observed CP violation. The smallness of this area illustrates the excellent precision that has been achieved.

Collider physics

The conference began with three days of parallel sessions. After a day off on Sunday, another three days of plenary sessions followed. Highlights were the results on CP violation in systems composed of bottom quarks, neutrino oscillations, and the anomalous magnetic moment of the muon.

The plenary sessions started off with reports from the first year of Run IIa operation at Fermilab's Tevatron. The CDF and D0 detectors have undergone major renovations to take full advantage of the new data set, and the Tevatron is playing its part, with luminosity steadily climbing towards its design value. One exciting development for CDF has been the successful commissioning of a new impact parameter trigger, which uses the newly installed silicon vertex tracker to tag hadronic B-decays, with impressive online reconstruction. Franco Bedeschi of Pisa, reporting in the plenary session, demonstrated the effectiveness of this trigger, showing a signal peak of 33 B-candidates decaying to two charged hadrons. Boston University's Meenakshi Narain presented the upgraded D0 detector, which has also replaced major system components and is operating with completely new trigger configurations. Both detectors were able to showcase first results at the new centre of mass energy of 1.96 TeV. The results on W- and Z-physics, B-physics, charm and jet physics show that everything is in working order, and we can look forward to exciting new data in the next few years. This includes looking for possible experimental signatures of physics beyond the Standard Model, as discussed by Robert ▷



Results from Fermilab's upgraded Tevatron detectors were shown in Amsterdam. These displays show recently collected Z-particle decays into muons for CDF (left) and electrons for D0.

McPherson from the University of Victoria, Canada. This talk drew together data from CERN's Large Electron Positron (LEP) collider, the Tevatron and DESY's HERA collider to outline a roadmap towards possible signs of new physics. One new and unusual form this could take is in the form of so-called "little Higgs theories", as discussed by Martin Schmaltz of Boston. These theories aim to solve the famous hierarchy problem (whereby the forces of nature appear to operate at vastly different and seemingly arbitrary energy scales) and produce a consistent extension of the Standard Model valid up to the 10 TeV range. This new approach is gaining fans in the theoretical community, and is an exciting development to watch out for.

For the field of heavy-ion collisions, John Harris of Yale presented an overview of the various experimental signals for the quark–gluon plasma, while Glasgow's Mark Alford discussed quark matter at high density and temperature, emphasizing the possible phases of the theory of strong interactions, quantum chromodynamics (QCD). He also reviewed the status of theoretical approaches such as lattice gauge calculations, and technical issues such as the necessary resummation of so-called hard thermal loops in finite temperature field theory. Several other technical issues, results of experiments at CERN, and results and plans for the RHIC accelerator at Brookhaven, as well as the outlook for experiments at CERN's Large Hadron Collider (LHC) were discussed in parallel sessions convened by Paolo Giubellino of Turin and Raimond Snellings of NIKHEF.

Particle symmetries

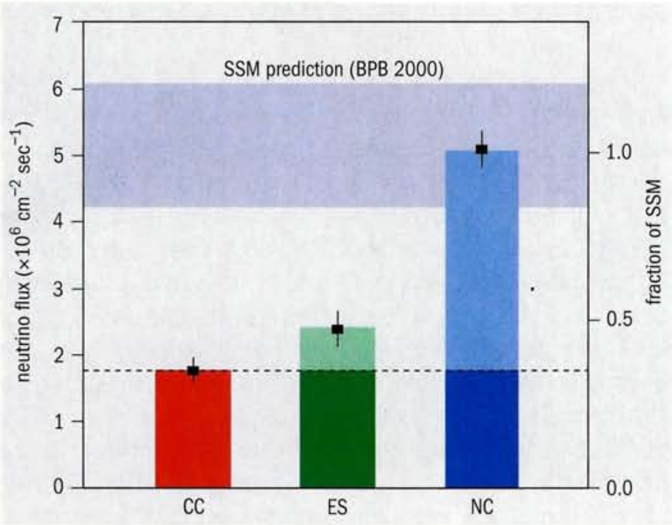
The parallel session on CP violation kicked off with a presentation of the result from the final analysis of data from the NA48 experiment at CERN, and recent results from Fermilab's KTeV, before moving on to the latest results from the B-factory experiments BaBar at SLAC in the US and BELLE at KEK in Japan. This reflects the culmination of great achievements in the Kaon sector of CP violation – marked by increasingly precise experimental results yet with interpretations blurred by strong interaction effects in the K-meson system – and the opening of the exciting beauty era, where many effects are large and have a cleaner interpretation.

The electron–positron colliders at SLAC and KEK have delivered between them around 180 million b quark–antiquark pairs. To put this in perspective, this is already over a factor 40 more than had been seen in total at LEP – and the data are being put to good use. In the plenary session, Masanori Yamauchi of KEK presented the new results from BELLE, and Jean Karyotakis of LAPP in Annecy, France, showcased the work from BaBar. Both experiments have updated measurements of sin2β (obtained from the asymmetry between neutral B and anti-B meson decay rates), and in addition are starting to explore the more challenging channels, such as B-decays into charged pion pairs where the two experiments currently show intriguingly different asymmetries, and new data are eagerly awaited.

Data on rare decay modes were also presented. As Yossi Nir of the Weizmann Institute in Rehovot, Israel, summarizing for the plenary session, pointed out, the study of CP violation is now firmly experiment driven. He placed the results in theoretical context, illustrating that the constraints on the CKM quark-mixing matrix from CP-violating experiments are more powerful than those from CP-conserving measurements. However, the Standard Model description of CP violation in the B and K sectors still looks healthy. Nir emphasized the importance of future measurements in processes where the contribution from new physics mechanisms is expected to be enhanced, such as the forthcoming electric dipole moment experiments.

In the parallel session on heavy quarks, convened by Sinéad Ryan of Dublin's Trinity College and Elisabetta Barberio of the Southern Methodist University, the need for precision lattice calculations in heavy-quark physics was mentioned in many experimentalists' talks. This is being addressed by the lattice community with calculations of a range of important quantities such as quark masses, unitarity triangle parameters, decays and meson-mixing parameters. New lattice calculations were discussed, and a new method for determining heavy-quark masses was reported. In spectroscopy, and for many other quantities, the largest uncertainty is now quenching (in the quenched approximation valence quarks are treated exactly, and the sea quarks are treated as a mean field). The first steps at removing this approximation have already been taken, and the next few years will see remarkable progress in lattice calculations and a new era of precision B-physics from the lattice.

In the plenary sessions, the lattice calculations were summarized by Laurent Lellouch of Marseilles, who discussed the various approximations, treatment of heavy quarks and the use of chiral perturbation theory for extrapolations in the light-quark sector. Achille Stocchi of Orsay summarized experimental results on heavy-hadron physics, including spectroscopy, lifetimes and decay modes. He stressed the richness of charmed baryon spectroscopy, where Cornell's CLEO experiment dominates and 22 charmed baryons have already been found. A further result from CLEO was the observation of the upsilon-1D state, which is the first new narrow b-b state to be observed in 19 years. He also emphasized how the BaBar and BELLE results in the B-sector have led to a situation where one now has to look for precision effects.



The SNO experiment has provided direct evidence that electron neutrinos leaving the sun change flavour. The neutrinos interact in the heavy water of the experiment in three different ways, with the electron neutrinos behaving differently from muon and tau neutrinos. All three neutrinos, if they have sufficient energy, can break apart a deuteron. This is the neutral current interaction, identified by the gamma ray released by the subsequent neutron capture. The charged current interaction disintegrates the deuteron to give two protons and an electron, identified by its cone of Cerenkov light. This interaction is unique to electron neutrinos. A third type of interaction is elastic scattering of neutrinos on electrons, which is dominated by electron neutrinos, but in which the other flavours participate at a lower level. By simultaneously measuring the rate and characteristics, SNO can over-constrain the problem. This plot shows the rates of the three different reactions, compared to solar model expectations. The red bar, representing the charged current interaction, shows a clear deficit of electron neutrinos. The blue bar shows the sum of all neutrino species contributing to the neutral current interaction. Here the deficit has clearly been recovered. This evidence, along with a detailed analysis of the spectra, enabled SNO to show direct evidence for neutrino flavour transformation at the 5.3 sigma level.

Neutrinos

In the parallel session on neutrinos, as well as in the plenary talk by Sussex University's David Wark, the Sudbury Neutrino Observatory (SNO) results were highlighted. The data show convincingly, and without reference to other experiments, evidence for solar neutrino oscillations, in particular those of electron neutrinos into other types. The data can be combined with new Superkamiokande results on spectral distortions and day-night asymmetries of elastic neutrino interactions to constrain the oscillation parameters and mass-squared difference between the neutrino types. The strongly favoured region lies close to maximal mixing, with maximal mixing itself disfavoured. The possibility of oscillation to a fourth (purely sterile) neutrino is excluded (at the 5 sigma level). SNO has entered a new phase of data-taking where two tonnes of salt have been added to the heavy water to increase the neutron capture efficiency. The precious heavy water will be purified in 2003 via a process of reverse osmosis, and SNO will enter a third phase of data-taking with discrete neutron counters. Many forthcoming experiments that will further probe this region were presented. These included KamLAND, designed to detect neutrinos originating from commercial nuclear reactors, and the forthcoming BOREXINO experiment.

Another oscillation regime is that of atmospheric muon neutrinos, probably oscillating into tau neutrinos. Results were presented from the KEK to Kamioka (K2K) long baseline experiment, which together with most other experiments currently points at a global picture with maximal mixing in the muon-to-tau neutrino oscillation sector. The outstanding issue of the discrepant results from the LSND experiment at Los Alamos will be investigated by MiniBooNE (p8), which showed pictures from first data-taking. Speakers looked forward to future results from experiments such as MINOS, OPERA and Hyper-K in discussions of this very active field. The current status was reviewed in the talk of Concha Gonzalez-Garcia of Stony Brook, Valencia and CERN, who reminded us how much has changed since the assumptions of 10 years ago, when the solar neutrino solution was believed to be naturally small mixing angle, and the atmospheric neutrino anomaly was seen as a possible experimental problem. She proceeded to summarize the beautiful advances since then in both experiment and theory, and also discussed the implications – the most direct and yet striking one being the existence of physics beyond the Standard Model. Among possible scenarios, is the idea that leptogenesis coming from CP violation in heavy-lepton decays in the early universe may be transformed into a baryon-antibaryon asymmetry via sphalerons ("lumps" in the field energy where matter and antimatter can be created) at the electroweak energy scale.

Strong interactions

Naomi Makins of Illinois summarized QCD at low momentum transfer (Q^2), discussing current electron-nucleon deep-inelastic scattering experiments at DESY, including the spin programme and future programmes at CERN (with the COMPASS experiment) and Brookhaven. In very lively discussions in the soft QCD parallel sessions, many (mainly experimental) results were submitted corresponding to a variety of topics such as Bose-Einstein condensation, colour flow, deep-inelastic spin physics and diffraction in high-energy processes. These represent activities that investigate QCD dynamics at the confinement scale in many different ways.

Theoretical and experimental views of QCD at high energy were discussed by Stefano Frixione of CERN and Ken Long of Imperial College, London. From the theoretical side, considerable progress has been made in implementing higher-order computations in the analysis of jets and heavy-flavour production. The QCD analyses of the experiments are consistent, leading to an accurate determination of the strong coupling constant, α_s.

Special parallel and plenary sessions were devoted to computational methods in quantum field theory. While Zvi Bern of UCLA emphasized new methods and developments for computational efforts, Matthias Kasemann of Fermilab discussed computing and data analysis for future high-energy experiments. Starting with the ▷

The latest measurement for the muon's anomalous magnetic moment implies a 2-3 standard deviation discrepancy with theory and may open a window to new physics interpretations.

present situation at BaBar, BELLE, CDF and D0, he moved on to technological developments such as the Grid, which must form the basis of the LHC computing.

Martin Grünewald of University College, Dublin, presented the major electroweak developments such as the anomalous magnetic moment of the muon, the weak mixing angle from NuTeV, asymmetries at the Z-peak, triple gauge couplings and W-boson parameters. He also discussed the search for Higgs bosons, and the opportunity available for the Tevatron in this search. In the electroweak parallel session, convened by John Hobbs of Stony Brook and Dmitri Bardin of the Joint Institute for Nuclear Research, many precision results were presented by LEP collaborations, who are still carefully analysing data two years after the collider was shut down.

Paris Sphicas of CERN looked at the physics potential of the LHC covering Higgs searches, supersymmetry, other extensions of the Standard Model, extra dimensions and TeV-scale gravity effects such as black hole production.

In the crowded astrophysics and cosmology parallel sessions, an important topic was the ultra-high-energy rays, in particular those with energies above the Greisen–Zatsepin–Kuzmin (GZK) cut-off due to collisions of protons with cosmic microwave background photons. Another topic was weakly interacting massive particles (WIMPs), for which new results from the Edelweiss experiment narrow down the windows in a cross-section – mass plot. In his plenary talk, Thomas Gaisser of the Bartol Research Institute also discussed what he called multi-messenger astronomy provided by galactic protons, photons, neutrinos and gravitons. Marc Kamionkowski of Caltech discussed how astrophysical experiments now indicate that we have a flat universe with an energy density of which 70% is in the form of a negative pressure (cosmological constant), 25% is in the form of dark, as yet unknown, matter, and only 5% is the familiar luminous matter.

A highlight of the plenary session was a presentation from Yannis Semertzidis of Brookhaven of the new result for the muon's anomalous magnetic moment ($g = 2.0023318406 \pm 0.0000000016$). This incredibly precise number comes from a measurement of the decays of 4 billion positive muons delivered from Brookhaven's Alternating Gradient Synchrotron. It represents a challenge to theory, which must calculate the expected value taking into account tiny electroweak corrections. The new measurement implies a 2-3 standard deviation discrepancy with theory and may open a window to new physics interpretations.

Among other notable talks was that of Jan de Boer of Amsterdam University, who summarized developments in string theory and mathematical quantum field theory, with many attempts to get realistic models from string theory. Greg Loew of SLAC discussed future accelerators, emphasizing the recent R&D for linear collider technology, and the future milestones of the International Linear Collider Technical Review Committee. Paula Collins of CERN reviewed the developments in detector technology that will provide the foundation for experiments at future facilities, in particular the increasingly precise and robust silicon-based devices.

Frank Wilczek of MIT gave the conference summary. He emphasized the triumph of quantum field theory both in QCD and electroweak physics, the importance of precision measurements, and the possibilities of extending our knowledge beyond the Standard Model by using and completing the CP violation experiments, the neutrino oscillation experiments and astrophysical experiments.

Immediately after the close, conference chair Ger van Middelkoop was presented with the Dutch royal decoration of *Officier in de orde van Oranje-Nassau* for his numerous contributions to nuclear and particle physics, marking a fitting conclusion to both a stimulating conference and a long and distinguished scientific career.

Further reading

All presentations are available at http://www.ichep02.nl/. Proceedings to be published by Elsevier Science BV.

Paula Collins, *CERN, and* **Piet Mulders**, *NIKHEF/Vrije Universiteit Amsterdam.*

A tunnelling machine digs the last few metres of the decay tunnel for the CERN neutrinos to Gran Sasso beamline in May.

Neutrino discoveries lead to precision measurements

The science of neutrino physics has reached a watershed, with discovery giving way to precision measurements. **Michael Altmann** reports from the XXth International Conference on Neutrino Physics and Astrophysics.

"We return from this conference in the firm belief that this novel phenomenon indeed does occur," Friedrich Dydak of CERN told a journalist following the XXth International Conference on Neutrino Physics and Astrophysics (Neutrino 2002), held at Munich Technical University. He was referring to neutrino oscillations, the periodic transformation between neutrinos of different flavour.

The Sudbury Neutrino Observatory's (SNO) confirmation of oscillations (*CERN Courier* June p5) was a highlight in an unprecedented wealth of fundamentally important new results. These results, along with their far-reaching implications, attracted some 450 scientists from all over the world to attend Neutrino 2002. The conference, held on 24–30 May, was jointly organized by Munich Technical University and the Max Planck Institute of Physics (MPI). Presentations and discussions underlined neutrino physics as currently being among the most exciting and rewarding fields of research.

With the discoveries of neutrino masses and lepton-flavour mixing having been established in recent years in studies of solar and atmospheric neutrinos, the field is currently in the transition to a new era. There is a general consensus that the next natural step is precision studies of the neutrinos' intrinsic parameters. This will put additional emphasis on terrestrial experiments. However, neutrino astronomy is also rapidly evolving – neutrinos are being used as unique tools for astrophysical observations, promising insights into long-standing mysteries such as the origin and acceleration ▷

mechanisms of ultra-high-energy cosmic rays.

The conference started with SNO's confirmation of neutrino oscillations in their measurement of solar boron-8 neutrinos, detailed by Aksel Hallin of Queen's University, Canada. Neutrino interactions in SNO's 1000 tonne heavy-water target allow separate determination of the fluxes of solar electron neutrinos ($\Phi(\nu_e)$), and of all active flavours together ($\Phi(\nu_e) + (\Phi(\nu_\mu) + (\Phi(\nu_\tau)$). While determination of the latter shows perfect agreement with predictions from solar model computations, a substantial ν_e deficit is observed. This constitutes the first direct observation of neutrino flavour transition, thus confirming the indirect evidence gathered by earlier solar neutrino experiments. Among the processes that could account for the observed phenomena, neutrino oscillation is the favoured explanation. Taking the SNO result together with those of the GALLEX/GNO experiment at Italy's Gran Sasso laboratory; the Russian-American SAGE experiment; Japan's Superkamiokande; and the pioneer of them all, Ray Davis' experiment in the Homestake mine (all of which presented their latest results), possible values for the neutrino mass squared difference Δm^2 and mixing angle $\tan^2\phi$ can be restricted to a few well defined areas.

Global analyses tend to favour the so-called large mixing angle (LMA) region with parameters in the range $3 \times 10^{-5}\,eV^2 \leq \Delta m^2 \leq 3 \times 10^{-4}\,eV^2$ and $0.25 \leq \tan^2\phi \leq 0.8$. This region, which was first identified as a possible solution to the solar neutrino puzzle in 1992 with the first results from GALLEX, offers an attractive feature – it can be tested and further scrutinized by entirely terrestrial experiments. A key role will be played by the Japanese experiment KamLAND, which aims to detect electron antineutrinos emitted by nuclear power reactors situated within distances of a few hundred kilometres.

Low-energy neutrinos

For parameters in the LMA region, neutrino oscillations will lead to a substantial, energy-dependent suppression of the recorded electron antineutrino flux. First data from KamLAND are expected this autumn. However, KamLAND is not particularly sensitive in investigating the high Δm^2 part of the LMA region. To achieve this goal, a substantially shorter baseline of around 20 km would be necessary. Stefan Schönert of MPI Heidelberg presented such a concept in his talk on future projects in the field of low-energy oscillation physics.

Schönert also gave a summary of the Third International Workshop on Low Energy Solar Neutrinos (LowNu 2002), which had taken place at Heidelberg as a topical satellite meeting prior to the conference. With an attendance of about 80, and some 30 presentations comprehensively covering ongoing activities, the workshop focused on experimental projects, common techniques and challenges, as well as future physics impact. It identified as the main goal for the forthcoming years the exploration of the primary pp, berylium-7, pep, and, if possible, the CNO solar neutrino fluxes, in real time and with energy information via both elastic ν_e scattering (es) and charged-current (cc) interaction. With its measurements of high-energy boron-8 neutrinos, SNO has already pioneered such techniques and impressively illustrated their potential for determining intrinsic neutrino parameters and testing our understanding of stellar energy-generation mechanisms. Extending the es versus cc measurement to the medium and low-energy branches of the solar neutrino spectrum is yielding increased precision for both these issues. A first step will be the es measurement of solar berylium-7 neutrinos in the BOREXINO experiment, currently being prepared at Gran Sasso.

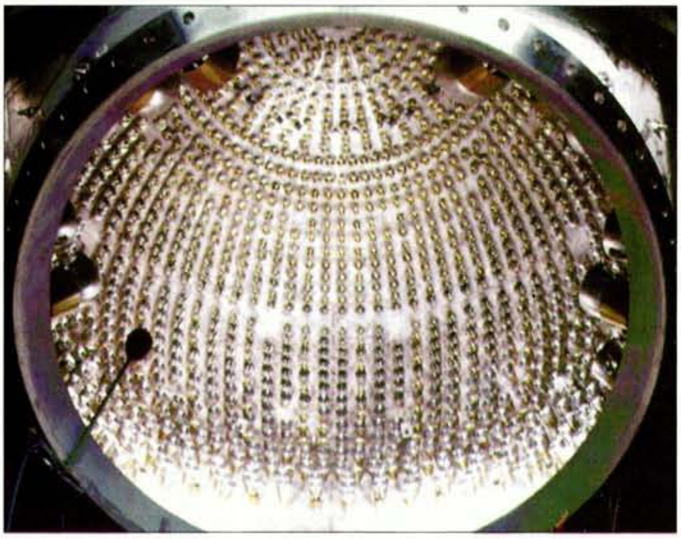
Some 450 participants attended the Neutrino 2002 conference. In the front row are (left to right) Superkamiokande spokesman Yoji Totsuka; co-chair Norbert Schmitz; SNO spokesman Art McDonald; founder of the conference series George Marx; Angel Morales; and conference chair Franz von Feilitzsch.

Atmospheric neutrinos

At the 1998 neutrino conference, the Superkamiokande collaboration reported evidence for oscillations of neutrinos produced by the interaction of cosmic rays with the Earth's atmosphere. This year, Masato Shiozawa of the University of Tokyo presented a new analysis comprising about five years of data. The collaboration has identified tau-like events at multi-GeV energies, supporting the channel ν_μ to ν_τ as the predominant oscillation mode of atmospheric muon neutrinos. Moreover, oscillations into a hypothetical sterile neutrino are strongly disfavoured by this analysis. Superkamiokande's preferred parameter range is $1.6 \times 10^{-3}\,eV^2 \leq \Delta m^2 \leq 3.9 \times 10^{-3}$ at essentially maximal mixing.

Though the analysis of atmospheric neutrino data generally relies on a ratio determination of electron to muon neutrinos, and is therefore rather insensitive to uncertainties in the absolute fluxes, a reliable understanding of neutrino generation in the atmosphere is of interest nonetheless. Thomas Gaisser of the University of Delaware reported the substantial progress achieved over recent years in modelling the processes involved. Meanwhile, the first reliable 3-D computations have become available. Among other phenomena, which still have to be incorporated into the analysis of the experimental data, predictions for the high-energy range above around 100 GeV will turn out to be useful for calibrating future neutrino telescopes.

As for solar neutrinos, the parameters giving rise to oscillations of atmospheric neutrinos are accessible for test in terrestrial experiments due to the LMA. In the KEK to Kamioka (K2K) project, a neutrino beam produced at Japan's KEK proton synchrotron is directed over a distance of 250 km towards the Superkamiokande detector. For the currently available data set (recorded before the detector's



The BOREXINO detector under construction at Gran Sasso will use some 2240 photomultipliers to record the light flashes emitted from the experiment's 300 tonnes of liquid scintillator target after a solar neutrino interaction. The experiment will start data-taking in 2003.

devastating accident of November last year; *CERN Courier* May p7), some 80 events were expected in the absence of oscillations, whereas only 56 events were observed. This number is in good agreement with the neutrino parameter set favoured by Super-kamiokande's atmospheric neutrino measurements.

Future long-baseline experiments

To further substantiate the evidence for oscillations gathered with atmospheric neutrinos, future experiments are aimed at directly mapping the oscillatory signature and at performing tau appearance studies. Two new projects are currently being prepared in the US and Europe to further investigate the parameter region favoured by current data. Both are situated at a baseline of 732 km. The American MINOS detector in Minnesota's Soudan mine will receive a muon neutrino beam from Fermilab, whereas the European CERN neutrinos to Gran Sasso (CNGS) project will send a beam from CERN to the ICARUS and OPERA detectors, to be installed at Gran Sasso.

In contrast to K2K, which operates at an energy below the tau production threshold, these new projects will use beams of much higher energy. MINOS is a massive 5.4 kt steel/scintillator calorimeter, whereas the ICARUS collaboration chose a novel approach with their liquid argon Time Projection Chamber. OPERA will identify taus in a large-scale sandwiched lead/emulsion detector. MINOS is scheduled to start data-taking by 2005. OPERA and ICARUS will be operational from 2006.

However, these projects are only the next step in accelerator-based long-baseline studies. Plans for much more ambitious next-to-next-generation beams and detectors in Japan, Europe and the US were presented and extensively discussed. Such superbeams, and ultimately a neutrino factory, will open the door to precision physics with accelerator-produced neutrinos. If LMA is indeed the parameter region realized in nature, a determination of Δm^2 and of elements of the lepton-mixing matrix to an accuracy in the few per-cent range seems feasible. Even matter effects and leptonic charge-parity (CP) violation could be experimentally accessible. However, the challenges for producing neutrino beams with the required intensity and quality are enormous, and in view of the technical complexity it is probably not unrealistic to estimate the need for at least another decade of R&D before a neutrino factory can be built.

Current accelerator experiments

The conclusions to be drawn from the current short-baseline accelerator-based experiments are still unclear. On one hand, the positive effect detected by the Los Alamos LSND experiment in its search for neutrino oscillations persists, whereas the Karlsruhe–Rutherford Laboratory experiment KARMEN sees no indication for oscillations. However, KARMEN cannot exclude the entire parameter space favoured by LSND, so the final answer will have to wait for Fermilab's MiniBoone experiment (p8). The result from MiniBoone is eagerly awaited, particularly because it could be decisive for the fundamental question of whether a fourth neutrino flavour exists. If LSND is correct, the existence of such a fourth generation, which has to be sterile with respect to weak interaction, is an inevitable consequence.

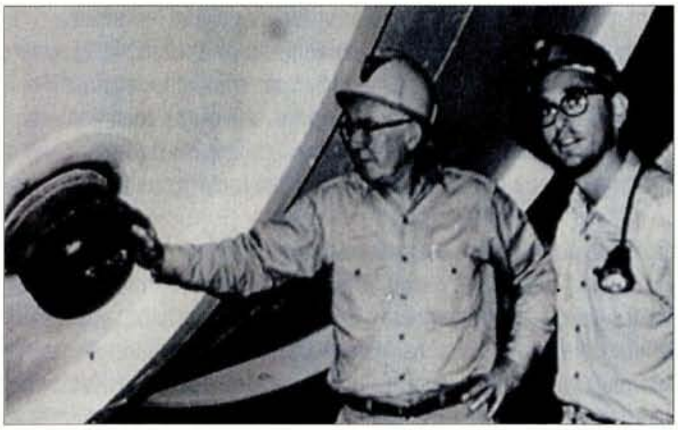
Intrinsic neutrino properties

Neutrino oscillations imply that neutrinos are massive. However, oscillation experiments only give information on the mass difference, not on the mass eigenvalues themselves. Knowledge of the absolute masses is crucial for judging the role neutrinos play in astrophysical processes and cosmology. A degenerate neutrino mass scale in the few-eV range, for example, would imply that neutrinos contribute substantially to the mass of the universe. Absolute neutrino masses can be tested by direct kinematical methods. With the present Mainz and Troitsk experiments (which investigate the spectral shape of tritium decay close to the endpoint) having reached their sensitivity limit of 2.2 eV for the mass of the electron neutrino, the large-scale Karlsruhe tritium neutrino experiment KATRIN project was put forward as a follow-up. KATRIN will start data-taking in 2007, and intends to achieve sub-eV sensitivity.

Another long-standing fundamental question is whether neutrinos are of Majorana type (their own antiparticles). A recent claim of possible evidence for neutrinoless double-beta decay (*CERN Courier* March p5), a phenomenon that can occur only for Majorana-type neutrinos, has attracted considerable attention. Following a presentation of Oliviero Cremonesi from Milan University, who reviewed the various experiments, there was a vigorous discussion on the statistical significance and trustworthiness of the analysis leading to the claimed evidence. No consensus has yet been reached, and it remains for future experiments and improved statistics to settle this question.

Neutrinos in astrophysics and cosmology

Massive neutrinos play an important role during core collapse supernova explosions, as John Beacom of Fermilab pointed out. However, both the energy released in the form of neutrinos of the second and third flavour and their mean temperature are still uncertain. They have not yet been measured, and the models depend on many assumptions. The new KamLAND and BOREXINO scintillator detectors, however, can determine these parameters to an accuracy of ▷



Where it all began – Ray Davis shows John Bahcall the tank containing 100 000 gallons of perchloroethylene in the Homestake mine shortly before his pioneering experiment began operation.

10%, thereby offering the potential to substantially improve our knowledge of supernova physics.

Precision measurements of the large-scale structure of our universe and the cosmic microwave background radiation can be used to probe intrinsic neutrino properties, most notably absolute neutrino masses and the hypothesis of sterile neutrinos. Combining cosmic microwave background data from NASA's MAP and ESA's Planck missions, and the Sloan Digital Sky Survey, should allow a limit of under 0.3 eV to be established – a sensitivity comparable to that of the terrestrial KATRIN experiment.

Cosmology sometimes teaches us lessons about neutrino properties, but sometimes the inverse is also true. Tsutomu Yanagida of Tokyo showed how massive neutrinos could lead to baryon asymmetry by means of leptogenesis. Inevitable consequences of the proposed mechanism, however, are neutrinoless double-beta decay and leptonic CP violation. Steve King of Southampton pointed out that these two phenomena also turn out to be decisive among the many different models proposed to explain neutrino masses (and their obvious smallness) and mixing angles.

Dark matter

Many of the theories beyond the Standard Model not only explain massive neutrinos, but also predict additional, exotic particles that constitute appealing candidates to contribute to the universe's dark matter. A prime candidate among them is non-relativistic weakly interacting massive particles (WIMPs) such as the neutralino. Oxford's Yorck Ramachers presented the large number of experiments searching for WIMPs that are operational or being prepared, along with the different experimental techniques they employ.

For several years the Italian DAMA experiment, a 100 kg sodium iodide detector, has been observing evidence for a WIMP signal, a claim that could have enormous consequences for particle physics, astrophysics and cosmology. Clearly, such a claim needs confirmation by independent experiments. The French EDELWEISS group, which operated a 320 g cryogenic detector, reported that they have now reached a sensitivity comparable to that of DAMA, an achievement made possible by the active background rejection their detector is capable of. However, the EDELWEISS data exclude most of the parameter region favoured by DAMA. With the upgrade phases of the German-British-Italian CRESST experiment, the US CDMS search and EDELWEISS that are currently being installed, the sensitivity region will be expanded by at least two orders of magnitude towards lower coupling strengths within a few years. This will not only give the final answer to whether the DAMA evidence is real, but also probe a substantial part of the parameter region predicted by the most economical supersymmetric extension to the Standard Model (the minimal supersymmetric Standard Model).

Neutrino telescopes

Eli Waxman of Israel's Weizmann Institute explained that many different objects and processes in the universe are expected to emit high-energy neutrinos, among them gamma-ray bursts, active galactic nuclei and supernova remnants. So far, however, the first-generation neutrino telescope at Lake Baikal and the AMANDA detector at the south pole, limited in sensitivity by their size, have not identified any point sources, but rather posed flux limits. To explore the region up to a distance of 10^{10} light-years and to investigate the expected diffuse flux of high-energy neutrinos, detector masses in the gigatonne range, corresponding to instrumented volumes of about a cubic kilometre, are required. Experience with Baikal and AMANDA has demonstrated that such huge detectors are feasible. In fact, with the IceCube project in Antarctica and the prototype installations of NESTOR and ANTARES in the Mediterranean, construction of these next-generation detectors has already begun. Undoubtedly, they will open up new avenues in neutrino astronomy.

Outlook

"Where do we stand and where are we going?" This was the question addressed by the two concluding talks. Michel Spiro of Saclay and Boris Kayser of Fermilab summarized in turn the most striking neutrino topics from an experimental and a theoretical perspective. Though the establishment of massive neutrinos is a fundamental breakthrough, many open questions and problems for further experimental and theoretical investigations remain. Mass eigenvalues and mixing angles are still to be determined. The questions of leptonic CP violation, dipole moments, mass hierarchy schemes and decay modes remain open. And the fundamental issue of whether the neutrino is of Dirac or Majorana nature still needs to be resolved. Moreover, there are many new applications of neutrinos as tools and messengers in astronomy, astrophysics and cosmology on the horizon to keep neutrino physics and neutrino astrophysics at the forefront of modern research. We may look forward to new fundamental results and discoveries to be discussed at the next neutrino conference, to be held in Paris in 2004.

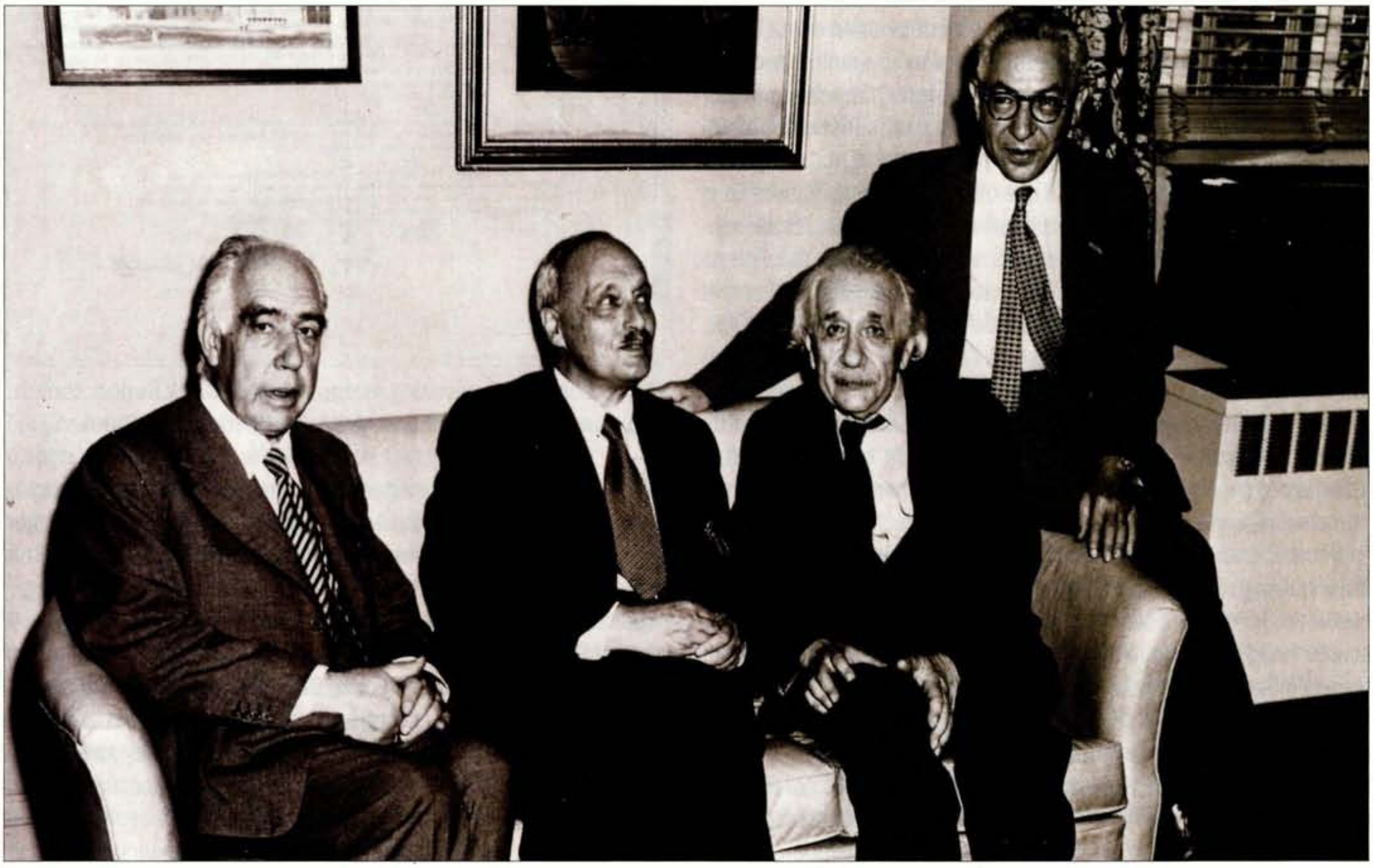
Further reading

Transparencies are available at http://neutrino2002.ph.tum.de for Neutrino 2002 and at http://www.mpi-hd.mpg.de/nubis/www_lownu2002 for LowNu 2002

Michael Altmann, *Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), Munich, Germany.*

Physicists and the decision to drop the bomb

At the University of Chicago's 2001 reunion in honour of Enrico Fermi, **Nina Byers** gave a talk entitled "Fermi and Szilard". This article is adapted from the original talk.



Left to right: Niels Bohr, James Franck, Albert Einstein and Isador Rabi at Princeton in October 1954. (AIP Emilio Segrè Visual Archives, Margrethe Bohr Collection.)

The tide of the Second World War turned in the Allies' favour in 1943. In January the siege of Leningrad ended, and in February the Germans surrendered at Stalingrad and were in retreat before the Soviet Armies. The Anglo-American carpet-bombing of German cities was under way. In the Pacific, Japanese aggression had been checked the previous May in the battle of the Coral Sea. The fear that the German war machine might use atomic bombs[1] was abating. However, many Manhattan Project scientists found another fear was taking its place – that of a post-war nuclear arms race with worldwide proliferation of nuclear weapons.

Physicists had little doubt in 1944 that the bombs would test successfully, though the first test was not until 16 July 1945. In the Los Alamos Laboratory there was a race against the clock to assemble the bombs. It is perhaps remarkable that in spite of Germany's imminent defeat, and the fact that it was common knowledge that Japan did not have the resources needed for atomic bomb manufacture,[2] few lab workers questioned whether they should continue work on the bombs. Joe Rotblat, the president of the Pugwash Conferences on Science and World Affairs and a recipient of the 1995 Nobel Peace Prize, was a notable exception (see http://www.pugwash.org/award/Rotblatnobel.htm and http://www.nobel.se/peace/laureates/1995/rotblat-cv.html). Richard P Feynman, in an inter- ▷

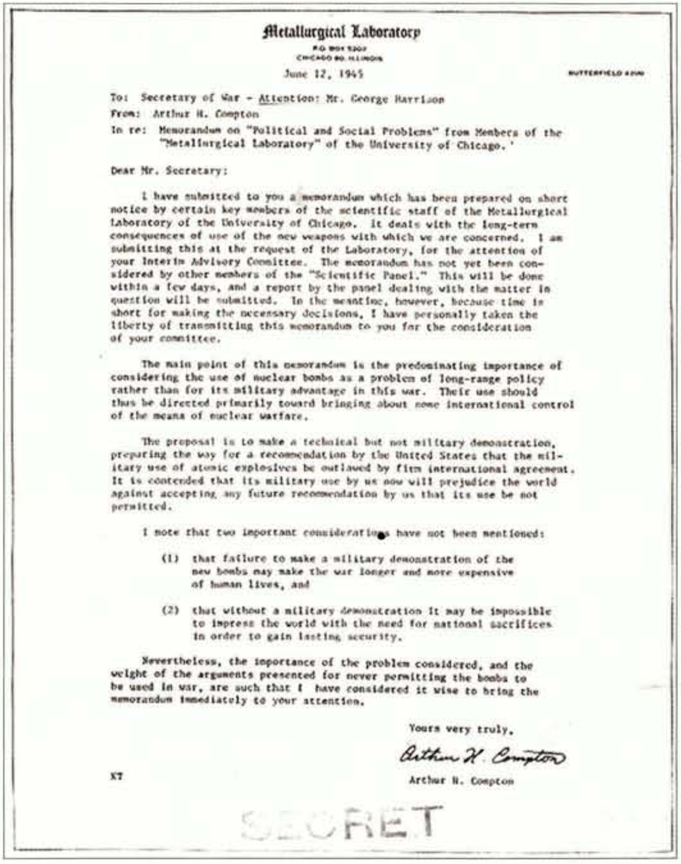
view with the BBC shortly before his death, was asked how he felt about his participation in the effort, and rather ruefully replied that in the race against time he forgot to think about why he joined it.

At the University of Chicago Metallurgical Laboratory (Met Lab), the pace of work was less intense. The major problems there were largely solved, and scientists and engineers began to discuss uses for nuclear energy in the post-war world. Realizing the devastation that nuclear weapons could cause, and that they could be made and delivered much more cheaply than conventional weapons of the same power, scientists tried to inform policy makers that the ideas underlying the Manhattan Project could not be kept secret, and that many nations and non-governmental entities would be able to make atomic bombs if fissionable material were available. Prominent among these were Leo Szilard and James A Franck. In their view, international control of fissionable materials was needed. There was discussion of forgoing even a test detonation of the bomb, and then a recommendation that it be used in an uninhabited area to demonstrate its power. They were concerned that actual military use would set a dangerous precedent and compromise the moral advantage the US and Britain might have to bring about international agreements to prevent the use of nuclear energy for weapons of war. Eventually they expressed these views in a report for the secretary of war and President Truman, now famous as the Franck Report (Stoff *et al.* 1991, 49). The report was classified top secret when first submitted, and only declassified years later. Various versions of it have now been published (Grodzins and Rabinowitch 1963; Smith 1965; Dannen 1995).

As the Manhattan Project went forward, some scientists in its leadership became prominent advisers in high government circles. Contrary to the Franck Report proposals, they advised immediate military use of the bombs. However, these scientists, in particular Arthur H Compton and J Robert Oppenheimer, actually mediated between their colleagues – who wished to deny the US and Britain the overwhelming political advantage sole possession of atomic bombs would bring – and political leaders such as Winston Churchill and James F Byrnes, Truman's secretary of state, who wished to have this advantage. In the case of Oppenheimer, it is unclear where his sympathies lay, and this article has no light to shed on that. In the case of Compton, his sympathy with the nationalist goals of government officials is clear from in his own writings. He had a political philosophy markedly different from that of the Franck group. In his book, *Atomic Quest* (Compton 1956), he wrote: "In my mind General Groves[3] stands out as a classic example of the patriot. I asked him once whether he would place the welfare of the United States above the welfare of mankind. 'If you put it that way,' the General replied, 'there is only one answer. You must put the welfare of man first. But show me if you can,' he added, 'an agency through which it is possible to do more for the service of man than can be done through the United States.'"

Bohr, Roosevelt, Churchill and Einstein

Niels Bohr was deeply concerned about a predictable post-war nuclear arms race. In 1944 he urged Manhattan Project leaders and government officials, including President Roosevelt and Prime Minister Churchill, to consider open sharing with all nations, including the Soviet Union, the technology to lay the groundwork for international control of atomic energy. Felix Frankfurter arranged an interview with Roosevelt, who listened sympathetically and suggested they find out what the Prime Minister had to say about this. Bohr then went with his son to London and met with Churchill, who angrily rejected Bohr's suggestion (Gowing 1964). Churchill prevailed, and at their September 1944 Hyde Park meeting Roosevelt and Churchill signed an aide-mémoire rejecting Bohr's proposal.[4] Albert Einstein learned of Bohr's failed efforts, and suggested they could take steps on their own and inform leading scientists whom they knew in key countries.[5] Bohr felt they should abide by wartime security restrictions and not do this.


Metallurgical Laboratory
P.O. BOX 5207
CHICAGO 80, ILLINOIS
June 12, 1945
BUTTERFIELD 4300

To: Secretary of War - Attention: Mr. George Harrison
From: Arthur H. Compton
In re: Memorandum on "Political and Social Problems" from Members of the "Metallurgical Laboratory" of the University of Chicago.'

Dear Mr. Secretary:

I have submitted to you a memorandum which has been prepared on short notice by certain key members of the scientific staff of the Metallurgical Laboratory of the University of Chicago. It deals with the long-term consequences of use of the new weapons with which we are concerned. I am submitting this at the request of the Laboratory, for the attention of your Interim Advisory Committee. The memorandum has not yet been considered by other members of the "Scientific Panel." This will be done within a few days, and a report by the panel dealing with the matter in question will be submitted. In the meantime, however, because time is short for making the necessary decisions, I have personally taken the liberty of transmitting this memorandum to you for the consideration of your committee.

The main point of this memorandum is the predominating importance of considering the use of nuclear bombs as a problem of long-range policy rather than for its military advantage in this war. Their use should thus be directed primarily toward bringing about some international control of the means of nuclear warfare.

The proposal is to make a technical but not military demonstration, preparing the way for a recommendation by the United States that the military use of atomic explosives be outlawed by firm international agreement. It is contended that its military use by us now will prejudice the world against accepting any future recommendation by us that its use be not permitted.

I note that two important considerations have not been mentioned:

(1) that failure to make a military demonstration of the new bombs may make the war longer and more expensive of human lives, and

(2) that without a military demonstration it may be impossible to impress the world with the need for national sacrifices in order to gain lasting security.

Nevertheless, the importance of the problem considered, and the weight of the arguments presented for never permitting the bombs to be used in war, are such that I have considered it wise to bring the memorandum immediately to your attention.

Yours very truly,

Arthur H. Compton

Arthur H. Compton

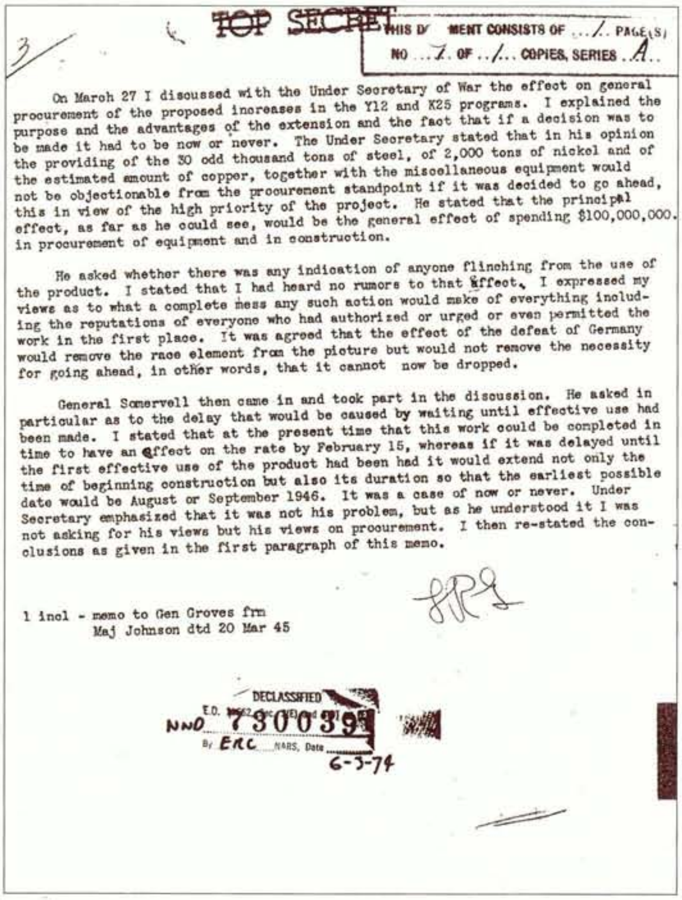
XT

SECRET

Fig. 1. Compton's covering memo for the Franck Report sent to secretary of war Stimson on 12 June 1945. (Gene Dannen.)

The decision to drop the bombs

John A Simpson, a young Met Lab physicist, later recalled that "the wartime scientists and engineers recognized early what the impact of the release of nuclear energy would mean for the future of society and grappled with the question from 1944 onward...I was unaware that James Franck, Leo Szilard and others at the senior level already were exploring these questions deeply. Under the prevailing security conditions the younger scientists had not had an opportunity to become acquainted with these higher-level discussions" (Simpson 1981). These younger scientists organized seminars and discussions despite US Army orders that they meet only in twos and threes[6], and later joined Szilard, Franck and others at the senior level. Eugene Rabinowitch prepared summary documents (Smith 1965). There were two main areas of concern: the urgent question of bomb-



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On March 27 I discussed with the Under Secretary of War the effect on general procurement of the proposed increases in the Y12 and K25 programs. I explained the purpose and the advantages of the extension and the fact that if a decision was to be made it had to be now or never. The Under Secretary stated that in his opinion the providing of the 30 odd thousand tons of steel, of 2,000 tons of nickel and of the estimated amount of copper, together with the miscellaneous equipment would not be objectionable from the procurement standpoint if it was decided to go ahead, this in view of the high priority of the project. He stated that the principal effect, as far as he could see, would be the general effect of spending $100,000,000. in procurement of equipment and in construction.

He asked whether there was any indication of anyone flinching from the use of the product. I stated that I had heard no rumors to that effect. I expressed my views as to what a complete mess any such action would make of everything including the reputations of everyone who had authorized or urged or even permitted the work in the first place. It was agreed that the effect of the defeat of Germany would remove the race element from the picture but would not remove the necessity for going ahead, in other words, that it cannot now be dropped.

General Somervell then came in and took part in the discussion. He asked in particular as to the delay that would be caused by waiting until effective use had been made. I stated that at the present time that this work could be completed in time to have an effect on the rate by February 15, whereas if it was delayed until the first effective use of the product had been had it would extend not only the time of beginning construction but also its duration so that the earliest possible date would be August or September 1946. It was a case of now or never. Under Secretary emphasized that it was not his problem, but as he understood it I was not asking for his views but his views on procurement. I then re-stated the conclusions as given in the first paragraph of this memo.

1 incl - memo to Gen Groves frm
Maj Johnson dtd 20 Mar 45

DECLASSIFIED
NND 730039
By ERC NARS, Date 6-3-74

Fig. 2. General Groves' memo recording his discussion with the undersecretary of war on 27 March 1945. The second paragraph gives Groves' answer to the undersecretary's question regarding "anyone flinching from the use of the product". The product here is an atomic bomb. (Gene Dannen.)

ing a Japanese city; and the international control of fissionable materials and the problem of inspection and verification of agreements. Considerations and conclusions can be found in the Franck Report, and some are discussed below.

Undoubtedly aware of the Bohr meetings with Roosevelt and Churchill, Szilard tried to see Roosevelt to urge that the long-range consequences of the use of nuclear weapons should be taken into account alongside immediate military expediency. He enlisted his friend Einstein's help in getting an appointment.[7] Einstein wrote to Roosevelt urging him to meet Szilard immediately, saying: "I have much confidence in Szilard's judgement." Szilard's memo, prepared in March 1945 for submission to the president, is remarkably prescient (Grodzins and Rabinowitch 1963). He foresaw our present predicament. He wrote: "The development of the atomic bomb is mostly considered from the point of view of its possible use in the present war...However, their role in the years that follow can be expected to be far more important, and it seems the position of the United States in the world may be adversely affected by their existence...Clearly, if such bombs are available, it is not necessary to bomb our cities from the air in order to destroy them. All that is necessary is to place a comparatively small number of such bombs in each of our major cities and to detonate them at some later time. The United States has a very long coastline which will make it possible to smuggle in such bombs in peacetime and to carry them by truck into our cities. The long coastline, the structure of our society, and our very heterogeneous population may make effective control of such 'traffic' virtually impossible." Roosevelt died on 12 April, the letter from Einstein unopened on his desk.

After Roosevelt died Szilard tried, through an acquaintance with connections in Kansas City, to see President Truman. He was given an appointment with James F Byrnes, Truman's designated secretary of state. He brought his memo to Byrnes and tried to discuss the importance of an international agreement to control nuclear energy. He did not get a sympathetic hearing, later recalling that "Byrnes was concerned about Russia's having taken over Poland, Romania and Hungary, and...thought that the possession of the bomb by America would render the Russians more manageable" (Dannen 1995). Leaving the meeting, he said to Harold Urey and Walter Bartky, who had accompanied him: "The world would be much better off if Jimmy Byrnes had been born in Hungary and become a physicist and I had been born in the United States and become secretary of state."

Germany's surrender on 8 May 1945 had little effect on planning the atomic bomb drops. Several historians who have made extensive study of the documentary evidence have concluded that the use of the bomb in Europe was never systematically considered (Stoff *et al.* 1991; Dannen 1995; Sherwin 1975). No mention is found of a drop in Germany or in Europe. On the other hand, documents indicate a common expectation that Japanese forces would be targeted. The minutes of the Military Policy Committee meeting of 5 May 1943 state: "The point of use of the first bomb was discussed and the general view appeared to be that its best point of use would be on a Japanese fleet concentration...it was pointed out that the bomb should be used where, if it failed to go off, it would land in water of sufficient depth to prevent easy salvage. The Japanese were selected as they would not be so apt to secure knowledge from it as would the Germans" (Sherwin 1975). Another indication that the focus was Japan is in the 1944 aide-mémoire of Roosevelt and Churchill where they agreed that "when a 'bomb' is finally available, it might perhaps, after mature consideration, be used against the Japanese" (Stoff *et al.* 1991, 26). General Groves' record of a discussion he had with the undersecretary of war on 27 March 1945 is also of interest in this regard. He says he was asked "whether there was any indication of anyone flinching from the use of the [atomic bomb]. I stated that I had heard no rumours to that effect. I expressed my views as to what a complete mess any such action would make of everything including the reputations of everyone who had authorized or urged or even permitted the work in the first place. It was agreed that the effect of the defeat of Germany would remove the race element from the picture but would not remove the necessity for going ahead" (this now declassified memo was obtained from the National Archives; see Dannen 1995).

After Roosevelt's death a committee was formed by the secretary of war Henry L Stimson to directly advise the president and Congress on issues relating to both civilian and military use of nuclear energy. It was called the Interim Committee because it was constituted without the knowledge of Congress. The members of the committee ▷

were Secretary Stimson (chair); Vannevar Bush, director of the Office of Scientific Research and Development; James Conant, president of Harvard University and director of defense research; Karl Compton, president of MIT; assistant secretary of state William Clayton; under-secretary of the Navy Ralph Bard; and secretary of state-to-be Byrnes. This committee appointed an advisory Scientists Panel consisting of Oppenheimer (chair), Enrico Fermi, E O Lawrence and Arthur Compton. The Interim Committee seems to have played an important, if not crucial, role in President Truman's decision to use the bombs. Notes of its 1 June meeting (Stoff *et al.* 1991, 44) record that "Mr Byrnes recommended and the committee agreed that the secretary of war be advised that, while recognizing that the final selection of the target was essentially a military decision, the present view of the committee was that the bomb should be used against Japan as soon as possible." Historians believe Truman met with Byrnes later that day and made this decision (Rhodes 1986).[8]

The Scientists Panel was present at the previous 31 May Interim Committee meeting where it was agreed that the scientists inform colleagues about the committee (Stoff *et al.* 1991, 41). Arthur Compton told senior staff in the Met Lab about the committee but seems not to have informed them that the committee would advise immediate wartime use (Compton 1956; Smith 1965). Perhaps he didn't know, but that seems unlikely – his brother Karl was on the committee.

The Franck Report was then written, dated 11 June 1945, and sent to Stimson and the Interim Committee. The preamble reads: "We felt it our duty to urge that the political problems arising from the mastering of atomic power be recognized in all their gravity, and that appropriate steps be taken for their study and the preparation of necessary decisions. We hope that the creation of the committee by the secretary of war to deal with all aspects of nucleonics indicates that these implications have been recognized by the government. We feel that our acquaintance with the scientific elements of the situation and prolonged preoccupation with its worldwide implications imposes on us the obligation to offer to the committee some suggestions as to the possible solution of these grave problems." As regards immediate military use of the bombs, they disagreed with the Interim Committee's advice to the president. They found "use of nuclear bombs for an early, unannounced attack against Japan inadvisable. If the United States would be the first to release this new means of indiscriminate destruction upon mankind, she would sacrifice public support throughout the world, precipitate the race of armaments, and prejudice the possibility of reaching an international agreement on the future control of such weapons. Much more favourable conditions for the eventual achievement of such an agreement could be created if nuclear bombs were first revealed to the world by a demonstration in an appropriately selected uninhabited area...To sum up, we urge that the use of nuclear bombs in this war be considered as a problem of long-range national policy rather than military expediency, and that this policy be directed primarily to the achievement of an agreement permitting an effective international control of the means of nuclear warfare."

The authors were the Committee on Political and Social Problems of the Metallurgical Laboratory of the University of Chicago, better known as the Franck Committee. The members were Franck (chair), Donald J Hughes, J J Nickson, Rabinowitch, Glenn T Seaborg, J C Stearns and Szilard. The report is a lengthy, deliberative document consisting of five sections: Preamble; Prospectives of Armament Race; Prospectives of Agreement; Methods of Control; and Summary. Compton, director of the Met Lab, submitted the report to Stimson with a covering memo dated 12 June (Stoff *et al.* 1991, 48). Reading this memo, one cannot help but think that Compton's intention was to obviate the effect of the report.

Leo Szilard with Eleanor Roosevelt. (Bulletin of the Atomic Scientists, courtesy AIP Emilio Segrè Visual Archives.)

The memo suggested that the report need not be given much attention, assuring the secretary that the Scientists Panel would consider it and report back in a few days. Indeed, the panel's report was submitted four days later. It disagrees with the recommendations of the Franck Report and supports the advice the Interim Committee had given. It is relatively brief, essentially reiterating the two considerations Compton erroneously claims were not mentioned in the Franck Report.[9] Entitled "Recommendations on the Immediate Use of Nuclear Weapons", it begins: "You have asked us to comment on the initial use of the new weapon," and goes on to say: "We see no acceptable alternative to direct military use" (Stoff *et al.* 1991, 51). Given Compton's views, and given Oppenheimer's deep involvement with General Groves and the Target Committee, it is not surprising that the Scientists Panel endorsed the immediate use of the bomb.[10]

Arthur Compton's political philosophy was very different from that of the Franck group. He believed that every effort should be taken by the United States to "keep nuclear weapons out of the hands of totalitarian regimes." In 1946 he suggested how to keep the peace in an essay entitled "The Moral Meaning of the Atomic Bomb", published in the collection *Christianity Takes a Stand*. He wrote: "It is now possible to equip a world police with weapons by which war can be prevented and peace assured. An adequate air force equipped with atomic bombs, well dispersed over the earth, should suffice...we must work quickly. Our monopoly of atomic bombs and control of the world's peace is short-lived. It is our duty to do our utmost to effect the establishment of an adequate world police...This is the obligation that goes with the power God has seen fit to give us" (Johnston 1967). Some might conjecture that this sharp difference in political philosophy reflects a European, as opposed to an American, approach to the problem. Some

Americans, like Compton, may have had a more naïve and trusting view of their government than Europeans tend to do, but it is worth noting that there were many Americans who believed, as did the Franck group, that international agreements were necessary to keep the peace.[11]

Why immediate military use?

Massive loss of life was expected in the Allies' invasion of the Japanese islands. The invasion was due to begin on 1 November. In June there was still fighting on Okinawa, but it was drawing to a close. Major military actions planned for summer and autumn were blockade and continuation of the bombing campaign. "Certain of the United States commanders and representatives of the Survey [US Strategic Bombing Survey] who were called back from their investigations in Germany in early June 1945, for consultation, stated their belief that by the coordinated impact of blockade and direct air attack, Japan could be forced to surrender without invasion" (US Strategic Bombing Survey 1946). Nevertheless, following the Interim Committee's advice for immediate military use, the bombs were dropped on 6 and 9 August. Little is said about the drops having been made as soon as the bombs were ready rather than later in the summer or early autumn. Whether or not the bombs were necessary to force a Japanese surrender prior to invasion is still being debated by historians (Nobile 1995; Bernstein 1976). The Strategic Bombing Survey (US Strategic Bombing Survey 1946) concluded that: "Certainly prior to 31 December 1945, and in all probability prior to 1 November 1945, Japan would have surrendered even if the atomic bombs had not been dropped, even if Russia had not entered the war, and even if no invasion had been planned or contemplated." The Soviet Union had massed a very large and well-equipped army on the Manchurian border in the summer of 1945, and on 8 August, precisely three months after VE day, declared war on Japan in accordance with the 11 February 1945 Yalta agreement, which states that:"The Soviet Union, the United States and Great Britain agreed that in two or three months after Germany has surrendered and the war in Europe is terminated, the Soviet Union shall enter into war against Japan on the side of the Allies." The Soviet invasion of occupied Korea and Manchuria began on 9 August, the day Nagasaki was bombed.

It seems that there would have been time before the planned 1 November invasion to attempt to get the Japanese to surrender with a demonstration of the bomb's power, as the Franck Committee suggested. However, this would have been much more complicated than a drop on a city. In his 1960 interview (Dannen 1995), Szilard said: "I don't believe staging a demonstration was the real issue, and in a sense it is just as immoral to force a sudden ending of a war by threatening violence as by using violence. My point is that violence would not have been necessary if we had been willing to negotiate. After all, Japan was suing for peace."[12]

There are many explanations offered for the immediate military use of the bombs. P M S Blackett concluded that it was a clever and highly successful move in the field of power politics (Blackett 1949). I tend to agree with him, especially in light of the post-war years and of the events of today. It is unlikely that the Franck group believed they could influence the course of events. Nevertheless, they tried very hard to have their voices heard. Many felt along with Leo Szilard that "it would be a matter of importance if a large number of scientists who have worked in this field went clearly and unmistakably on record as to their opposition on moral grounds to the use of these bombs in the present phase of the war" (Dannen 1995). The scientists' main message, unheeded then and very relevant now, is that worldwide international agreements are needed to provide for inspection and control of nuclear weapons technology. Their memoranda and reports remain as historic documents eloquently testifying to their concern.

Further reading

B J Bernstein (ed.) 1976 *The Atomic Bomb: the Critical Issues* (Little, Brown & Co, Boston).

P M S Blackett 1949 *Fear, War, and the Bomb* (McGraw-Hill Book Co, New York). Blackett received a Nobel Prize in Physics in 1948 for his work on cosmic rays.

A H Compton 1956 *Atomic Quest* (Oxford University Press, New York).

G Dannen 1995 http://www.dannen.com/szilard.html. This is a very rich website on which a selection of historical documents from Dannen's archive is posted. An interview with Szilard published in *US News & World Report* on 15 August 1960 is reproduced verbatim.

M Gowing 1964 *Britain and Atomic Energy 1939–1945* (Macmillan & Co, London).

M Grodzins and E Rabinowitch (eds) 1963 The Atomic Age: Scientists in National and World Affairs in *Articles from the Bulletin of the Atomic Scientists 1945–1962* (Basic Books, New York). Szilard's memo can also be found as document 38 in Stoff *et al.* 1991 and is on the Web (Dannen 1995).

M Johnston (ed.) 1967 *The Cosmos of Arthur Holly Compton* (Alfred A Knopf Inc, New York).

P Nobile (ed.) 1995 *Judgement at the Smithsonian* (Marlowe & Co, New York).

R Rhodes 1986 *The Making of the Atomic Bomb* (Simon and Schuster, New York).

M J Sherwin 1975 *A World Destroyed* (Alfred A Knopf Inc, New York). See footnote on p209 of First Vintage Books edition (January 1977).

J A Simpson 1981 Some personal notes *The Bulletin of the Atomic Scientists* **37:1** 26.

A K Smith 1965 *A Peril and a Hope* (University of Chicago Press, Chicago).

M B Stoff, J F Fanton and R H Williams (eds) 1991 *The Manhattan Project: a Documentary Introduction to the Atomic Age* (Temple University Press, Philadelphia). There are 95 documents reproduced in this book; many, including the Franck Report, were classified secret or top secret and declassified years after the end of the war. In this article they are referenced by the document number given by Stoff *et al.* (for example, the Franck Report is document 49). The Franck Report can also be found in Smith 1965, Grodzins and Rabinowitch 1963 and Dannen 1995.

US Strategic Bombing Survey 1946 (Washington DC Government Printing Office).

• This article is adapted from "Fermi and Szilard" (http://xxx.lanl.gov/html/physics/0207094) by the author. ▷

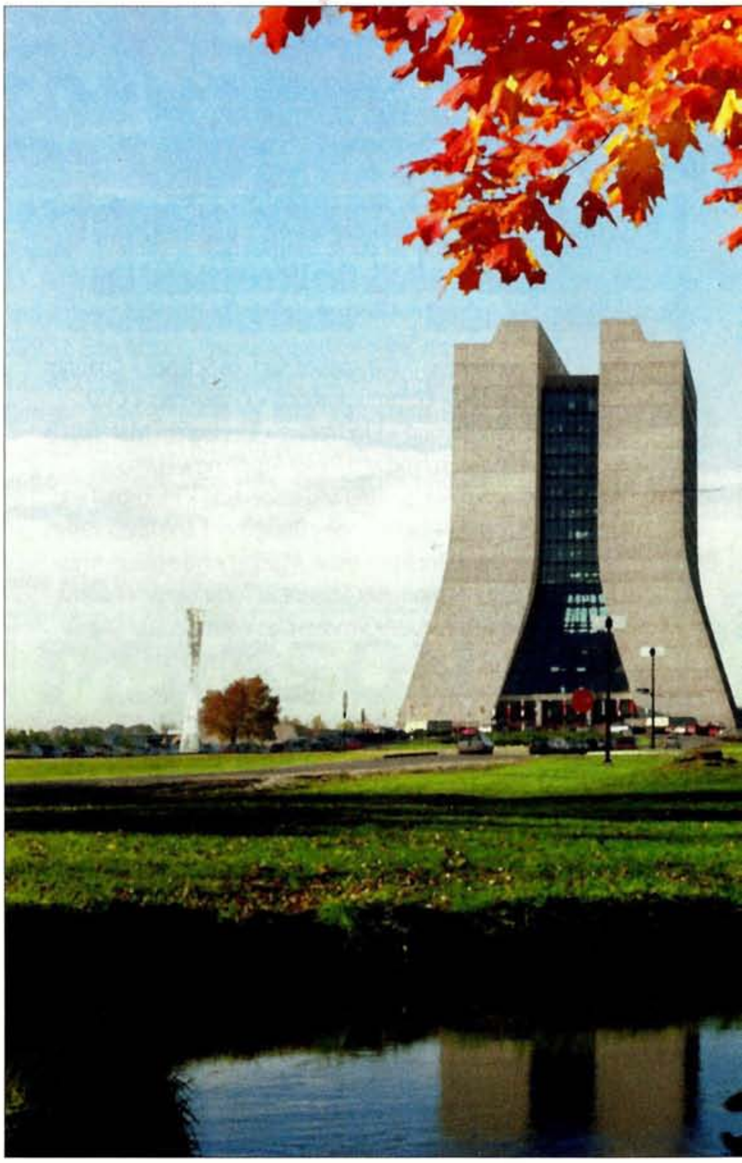
Footnotes

1. Though nuclear more accurately describes the energy source, the term atomic rather than nuclear was chosen by Henry deWolf Smyth in the first published description of the work of the Manhattan Project, 1945 *Atomic Energy for Military Purposes* (US Government Printing Office, Washington DC). He explained this choice was because atomic would be more cognitive to the general public.
2. Nishina, Hagiwara and other Japanese physicists were working on the problem, but it was realized *inter alia* that hundreds of tonnes of uranium ore and a tenth of Japanese electrical capacity would be needed for ^{235}U separation (Rhodes 1986 pp 457–459).
3. Brigadier General Leslie R Groves was the US Army general in charge of the Manhattan Project.
4. The aide-mémoire signed by the two heads of state states that "the suggestion that the world should be informed regarding Tube Alloys [the British term for the bomb project], with a view to an international agreement regarding its control and use, is not accepted" (Stoff *et al.* 1991, 26).
5. See Gowing 1964; also F Jerome 2002 *The Einstein File* (St Martin's Press, New York).
6. This order was evaded by scheduling these meetings in a small room with a large anteroom. While a scheduled meeting took place, people waiting in the anteroom could have a discussion.
7. In 1939 Szilard had enlisted Einstein's help in obtaining government funding for studies of neutron-induced uranium fission, and the result was the famous 2 August 1939 letter from Einstein to President Roosevelt informing him of the possibility of an atomic bomb.
8. Stimson recorded in his diary for 6 June a conversation with Truman indicating that the decision had been already made (Stoff *et al.* 1991, 45).
9. It is clear the Franck Committee was fully aware of Compton's point (1), had given it serious consideration and concluded that in the long run many more lives could be saved if effective international, worldwide control of nuclear power were achieved. Compton's important consideration (2) is, remarkably, a weak statement of a concern dealt with in depth in the Frank Report (figure 1).
10. Compton reports that Lawrence was reluctant to go along with this advice but was persuaded to do so (Compton 1956).
11. Among them were Robert Wilson, Glenn Seaborg, Katherine Way and others who signed Szilard's petition to the president (Dannen 1995). See http://www.dannen.com/decision/45-07-17.html.
12. According to the Strategic Survey Report (US Strategic Bombing Survey 1946): "Early in May 1945 the Supreme War Direction Council [of Japan] began active discussion of ways and means to end the war, and talks were initiated with Soviet Russia, seeking her intercession as mediator."

Nina Byers, *UCLA*.

Fermilab: a laboratory

Since its foundation in 1967, creeping urbanization has taken away some of Fermilab's remoteness, but the famous buffalo still roam, and farm buildings evocative of frontier America dot the landscape – appropriately for a laboratory at the high-energy frontier of modern research.



The familiar lines of Wilson Hall rising from the prairie dominate the

The US National Accelerator Laboratory formally saw the light of day on 21 November 1967, when President Johnson signed the bill that brought it into existence. Robert R Wilson moved from Cornell (*CERN Courier* January/February p13) to become its founding director, and two years later he famously told Congress that the laboratory's contribution was not to the defence of America, but rather to what made the nation worth defending. In 1974, the National Accelerator Laboratory became the Fermi National Accelerator Laboratory – Fermilab – at a dedication ceremony attended by Enrico Fermi's widow, Laura.

Fermilab has since gone on to gain an enviable reputation as a place where discoveries are made. The bottom quark made its first appearance there in 1977, and the top quark joined it in 1995. In 2000, Fermilab researchers announced the first direct observation of the tau neutrino, filling the final slot in the Standard Model's three families of matter particles. The laboratory is justifiably proud of these achievements, and quietly reminds the world of them in its generic email address of topquark@fnal.gov.

Fermilab today

Today, all eyes are on run II of Fermilab's Tevatron proton–proton collider (*CERN Courier* July/August 2001 p16), but that is just one part of a broad research programme. The laboratory is also a focus for US involvement in CERN's Large Hadron Collider (LHC), and the Compact Muon Solenoid (CMS) experiment preparing for physics at the LHC. A two-pronged neutrino programme is just getting under way (p8), and with leading roles in the Pierre Auger project, the Cryogenic Dark Matter Search (CDMS) and the ambitious Sloan Digital Sky Survey, Fermilab is increasingly involved in non-accelerator research.

Tevatron's run II started in April 2001 and is scheduled to last six years. After a slow start, the collider's luminosity is steadily climbing. Run II makes the two collider experiments CDF and D0 the main focus of Fermilab's research in the short term. With the Tevatron being the world's highest-energy particle collider until the LHC assumes that mantle in 2007, they represent Fermilab's best immediate hope of adding new discoveries to its already impressive tally in the coming years.

Both CDF and D0 have undergone major upgrades for run II, and the collaborations have also experienced important demographic changes, reflecting the increasing globalization of particle physics. The CDF experiment began as a collaboration of physicists from the US, Italy and Japan. Today, it has 600 members from 11 countries. At D0, the change has been even more dramatic. Since 1996, when the French Saclay laboratory was the collaboration's sole non-US institution, the number has grown to 30. D0's upgrade has seen an order-of-magnitude jump in the number of detector readout channels, and the establishment of a computing grid structure for data analysis connecting data farms at Fermilab, Lyons in France, Lancaster in the UK, and Amsterdam in the Netherlands. Both experiments list their pri-

t the frontier of research

ilab landscape. (Fermilab Visual Media Services.)

orities for run II as top quark studies and the search for Higgs bosons.

Looking towards the medium term, Fermilab is developing a broad neutrino programme based on two complementary new neutrino beams. One uses a short baseline and a low-energy beam, while the other has a long-baseline, high-energy beam configuration. The Mini Booster Neutrino Experiment (MiniBOONE) is the first experiment to begin data-taking. It is a 500 m baseline experiment that started up in September. Using a proton beam from Fermilab's 8 GeV booster ring, the MiniBOONE collaboration has optimized the energy-to-baseline ratio to test the contested oscillation result announced by the Los Alamos laboratory's LSND experiment in 1996. By looking for electron-neutrinos in the essentially pure muon-neutrino beam from the booster, MiniBOONE aims to provide the first unambiguous accelerator-based observation of neutrino oscillations. If oscillations are observed, the "Mini" prefix will be dropped and a second detector will be added further downstream. This will allow the collaboration to make precision measurements of oscillation parameters, and to search for violation of charge-parity (CP) and time-reversal (T) symmetry in the neutrino system.

Fermilab's second neutrino experiment, the Main Injector Neutrino Oscillation Search (MINOS), is scheduled to start data-taking in 2005. MINOS will have a near detector on the Fermilab site and a far detector some 735 km away in Minnesota's Soudan mine. It takes its primary beam from the 120 GeV main injector, providing a very different energy-to-baseline ratio from MiniBOONE. Fermilab neutrino physicists are also enthusiastic about developing the neutrino programme to include experiments that will probe the strange quark content of the proton through neutrino-proton elastic scattering.

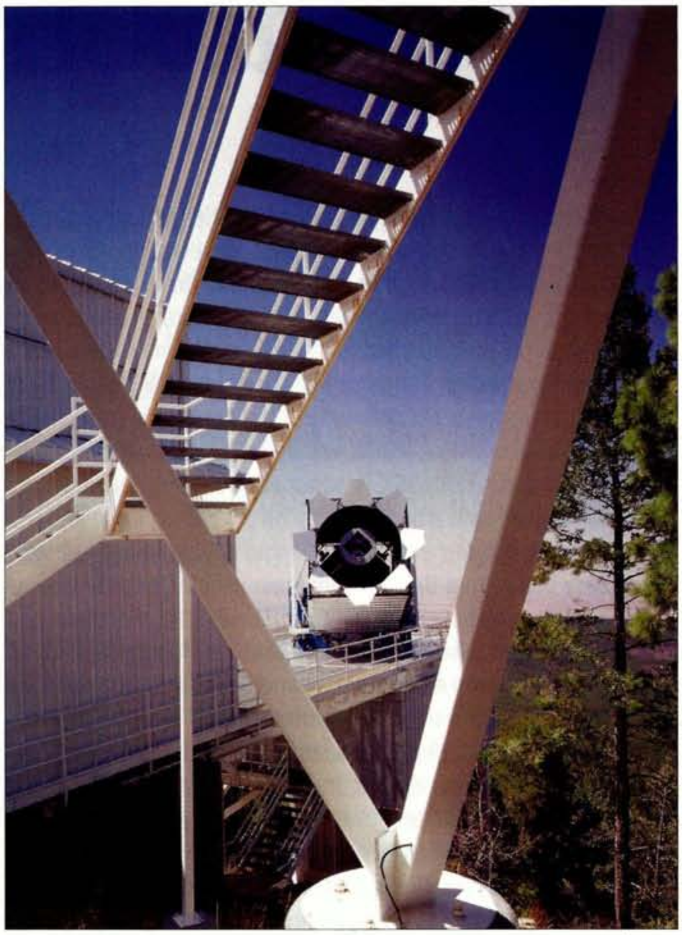
Completing the accelerator research picture are two more fixed-target experiments foreseen for the main injector. The CKM experiment received scientific approval in 2001. Starting in 2006, it will study the decay of positive kaons into pions accompanied by a neutrino-antineutrino pair. This rare decay, forbidden in the Standard Model at tree level but possible through quark loops, gives a direct measure of the Cabbibo-Kobayashi-Maskawa (CKM) quark mixing matrix element V_{td} that describes transitions between top and down quarks. Two years later, CKM is scheduled to be joined by BTeV, an experiment dedicated to advancing the study of CP violation in B mesons, recently begun at SLAC's BaBar experiment in California and the Belle experiment at Japan's KEK laboratory.

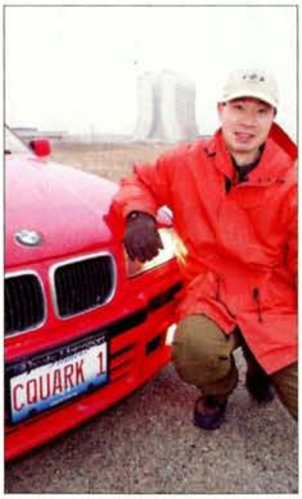
Fermilab and the LHC

With a \$167 million (€167 million) share of the total US contribution of \$531 million to the LHC project, Fermilab has a major stake in what will soon be the world's flagship particle physics research facility. Fermilab coordinates both the US-LHC accelerator project and US participation in the CMS experiment.

The US LHC accelerator project involves Fermilab, Brookhaven and the Lawrence Berkeley National Laboratory (LBNL). It is responsible for the four interaction regions and the radiofrequency straight section of the LHC, for testing superconducting cable for the main magnets, and for accelerator physics calculations. Integrated "inner-triplet" magnet systems (*CERN Courier* October 2001 p28) will bring the LHC's proton beams into collision. They are being built at Fermilab using high-gradient quadrupoles produced by Fermilab and KEK, corrector coils provided by CERN, dipoles from Brookhaven, cryogenic feedboxes from LBNL, and absorbers provided by LBNL to protect the superconducting magnets from collision debris. The inner triplets have now entered the production phase, and are on schedule to be delivered to CERN by the end of 2004.

The US contribution to CMS is also coordinated from Fermilab. ▷





Far left: the Sloan Digital Sky Survey's 2.5 m telescope at Apache Point has embarked on the most ambitious sky survey ever undertaken. Left: Fermilab physicist Harry Cheung proclaims his profession proudly from the license plate of his car. Below: the Tevatron (back) and main injector support a wide range of particle physics research from the flagship collider experiments CDF ad D0 to the future MINOS long baseline neutrino project. (Fermilab Visual Media Services.)

US CMS researchers account for around 20% of the collaboration's total, and are involved in many of the detector's subsystems. There are plans to establish a virtual CMS control room at the laboratory, so that US physicists don't have to cross the Atlantic to run shifts.

Non-accelerator programme

With the growing convergence between astrophysics and particle physics, Fermilab is playing an increasingly important role in non-accelerator-based studies. The laboratory has responsibility for data handling for the ambitious Sloan Digital Sky Survey. Using an observatory at Apache Point in New Mexico, the survey aims to map in detail over a quarter of the entire sky, determining the distance and brightness of more than 100 million celestial objects over a period of five years. The data amassed by the survey will provide invaluable information about the large-scale structure of the universe, allowing discrimination between models of the universe's evolution.

Fermilab also plays a managerial role in the Pierre Auger Project (*CERN Courier* March p6). With two giant detector arrays each covering an area of 3000 km^2, the Auger observatory will study the direction and composition of the cosmic ray showers above 10^{19} eV that arrive at the Earth in apparent defiance of the Greisen–Zatsepin–Kuzmin (GKZ) cut-off. According to this, space should be opaque to cosmic rays of such high energy, making their origin something of a mystery.

Completing Fermilab's triplet of non-accelerator experiments is CDMS, currently installed at an underground facility at Stanford, California. For its second stage, the detector will move to the Soudan mine to carry out its search for weakly interacting massive particle (WIMP) candidates for dark matter.

Accelerators for the future

Fermilab's 2001–2006 institutional plan states that the post-LHC energy frontier is the challenge of the future, and outlines its plans to meet that challenge. The laboratory is engaged in research and development projects for a possible muon collider, with work concentrating on the cavities embedded in a solenoidal field that would form part of the cooling scheme for a muon beam. A small study group has also investigated the possibility of a Very Large Hadron Collider with energies up to 100 TeV. Research continues on next-generation accelerator magnets, both superconducting and superferric.

Top priority, however, is a linear collider. Fermilab is involved in the Next Linear Collider and TESLA projects; it built the photoinjector for the TESLA Test Facility at Hamburg's DESY laboratory, and retains an identical device that is being used with teams from UCLA to study plasma acceleration. Most particle physicists agree that a linear collider is the logical next step for high-energy physics, and many laboratories are involved in preparatory work for such a machine. When it comes to choosing a location, Fermilab's director Mike Witherell believes his laboratory has much to offer. Keeping a major regional facility for particle physics in the US remains a priority for Fermilab.

James Gillies, *CERN*.

How European physics reached across the Wall

In the early 1960s, East German physicists collaborated with CERN, despite the restrictions that existed as a result of the Berlin Wall. **Thomas Stange**, author of a book on the history of the Zeuthen laboratory near East Berlin, tells the tale.

When Victor Weisskopf became director-general of CERN in July 1961, the laboratory had just about concluded a time of transition. With the commissioning of the Proton Synchrotron (PS) the year before, the European particle-physics community had turned to CERN, hoping to participate in the most advanced experimental possibilities available in Europe at the time. This had made it necessary to devise a procedure to decide which experiments to run and, hence, which groups to admit.

In setting up the Emulsion Experiments Committee, Track Chamber Committee, Electronic Experiments Committee and, coordinating their propositions, the Nuclear Physics Research Committee, the organization tried to channel the ideas of the groups that requested access to precious machine time. Among the groups that declared their interest were some from Eastern Europe; thus one of the political issues Weisskopf had to face during his term was how to deal with requests from institutes on the other side of the Iron Curtain. In his autobiography, *The Joy of Insight*, Weisskopf commented that he found it deplorable that CERN did not have any Eastern European members, and he tried to secure the participation of these countries by other means, despite difficulties on both sides.

In the 1950s photographic emulsion was, beside the cloud chamber, the dominant method for the detection of highly energetic cosmic-ray particles. Following a 1955 initiative of Cecil Powell, a developing bath for emulsions was installed in the Zeuthen laboratory.

The role of cosmic-ray physics

One assumes that the question of East German access to CERN must have been particularly delicate. In August 1961, the Berlin Wall was erected, and the West German government continued to threaten diplomatic sanctions to every country or international organization that dared to recognize East Germany as a veritable state (the so-called Hallstein doctrine). Yet in 1963, Karl Lanius, the head of the Research Laboratory for High Energy Physics in Zeuthen near the southern outskirts of East Berlin, was already preparing for the first one-year stay of one of his scientists at CERN. How did this come about?

To answer this question we need to go back to the days before the big accelerators took over and high-energy physics was primarily the study of cosmic rays. These studies lived through a golden age after the end of the Second World War and played, in the shadow of nuclear energy (the physics topic of the time), an important political role. First, a number of sensational discoveries were made by two English groups; the identification of the pion (by Powell) and the so-called V particles or kaons (by Rochester and Butler) led many nuclear physicists to turn to the study of cosmic rays. Second, the equipment needed to work on the topic was such that many groups all over Europe could afford it, no matter how strongly their science and economy had been affected by the war. Finally, this type of physics was so basic that politics interfered far less than in so many other, more applied fields of research. The particle physicists, building up old and new personal networks throughout the 1950s, therefore became forerunners in the establishment of multinational collaborations, and helped to bridge the gap between Eastern and Western European science in the first post-war years.

A major figure at the time was Cecil Powell, the discoverer of the pion and Nobel laureate for physics in 1950. Powell, who later became a prominent figure in the Pugwash movement, believed ▷

that science should endeavour to overcome political tensions. In those days his laboratory in Bristol became a meeting place for many young scientists from various Western European countries. Klaus Gottstein, a student of Heisenberg, later remembered his stay in Bristol: "Young people from a dozen nations or more worked together, discussed together, fought together, celebrated their parties together long before CERN existed. I could not help thinking that the world would be better off if a similar spirit of co-operation would be prevailing in the field of politics also..."

Powell's is the most prominent example for the establishment of a principle that rules high-energy physics to this day – the international distribution of labour. The principle also worked in Eastern Europe, but for a number of years contact between the East and West remained scarce. However, all this was to change.

JINR and CERN

In October 1955, Powell, in collaboration with several Italian institutes, exposed emulsions in the Po Valley. To this end he and his team launched balloons that carried the photosensitive material to heights of about 30 km above sea level. Developing and studying the emulsions was tedious, and any help and financial support, however modest, was welcome. To secure such assistance Powell had proposed involving East European institutes and had travelled, with the silent consent of the British Foreign Office, to Moscow for consultations in September. As a result universities in Moscow (Dobrotin and Vernov) and Warsaw (Danysz) were to receive two of the five emulsion packages to be exposed, of which they eventually passed on plates to groups in Budapest, Prague, Krakow and Zeuthen.

Powell's initiative had followed the first International Conference on the Peaceful Uses of Atomic Energy held in Geneva in August 1955, an event that facilitated a first wave of visits and collaborations across the Iron Curtain. Already during the conference, a number of East European and Soviet scientists took the opportunity to visit the CERN site. Yet the underlying political motive of the Soviet Union and the US was not so much to allow free collaboration, but rather to draw third countries onto their respective sides. Therefore, when the Soviet Union noticed that CERN had started to attract the interest and attention of some of its satellite states, it hastened to propose the foundation of an "Eastern Institute for Nuclear Research". The proposal could not be refused by countries such as Poland, Hungary, Czechoslovakia or East Germany, but it must be noted that the Soviet Union added considerable weight to its initiative by offering to include the 10 GeV Synchrophasotron in the new institute, which became the most powerful accelerator in the world between 1957 and the advent of the PS. Eventually, in March 1956, 11 East European and Asian countries gathered in Moscow to found the Joint Institute for Nuclear Research (JINR), situated in Dubna.

After this political act, scientific interests regained ground, and in 1957, JINR proposed an exchange of scientists between CERN and Dubna. For several reasons it took two years before the administrative and political questions connected to such a collaboration were answered. All CERN member states agreed that from a scientific point of view such an exchange would be highly desirable; only the German delegation to CERN voiced the concern that the "Soviet-occupied zone" (i.e. East Germany) could attempt to send physicists to Geneva via Dubna in order to bring itself closer to international recognition. The first exchange started in the latter half of 1960. As the group that arrived at CERN consisted of three Russian theorists, the German reservation did not come to bear. However, a second group, which came to CERN in autumn 1961, included an East German by the name of Walter Zöllner. Had the position of the West German government changed?

Karl Lanius (right), here seen talking to a laboratory assistant, became head of the Zeuthen institute in 1962, not least thanks to his success in the international collaborations at JINR and CERN.

The East German case

The friendly relations between JINR and CERN, but also shortcomings in the political and scientific situation in Dubna, encouraged groups in Eastern Europe to seek direct admission to CERN. One of the first to do so was Marian Danysz of Poland. Lanius, in turn, received word from West Germany, where he had established various valuable contacts in previous years. In December 1960, Gottstein in Munich advised him to send a letter of interest to the newly formed Emulsion Experiments Committee if he wanted to participate in the exposure of emulsions at the PS. Lanius did this, and was immediately invited to the next meeting of the committee in February 1961.

The man who answered Lanius's request was Owen Lock, one of the two secretaries of the committee. Before sending his telegram to Zeuthen he had asked his former teacher and chairman of the committee, Powell, for his consent. Powell agreed without hesitation. In an exchange of letters after the meeting, Lock also mentioned to Lanius that he had spoken with Weisskopf, the director-general designate, about "the development of good contacts between CERN and groups of non-member state countries. He was much in favour of such contacts and asked us to do everything possible to foster them." Three months later Lanius became one of three co-opted members of the committee. The two others were Cormac O'Ceallaigh of Ireland, and Danysz.

This was a considerable success for Lanius, whose new status was imperilled by the erection of the Berlin Wall, which began on 13

The first East German to come for a longer stay to CERN was Walter Zöllner. This picture, first published in CERN Courier *in October 1962, shows him between two colleagues from JINR and the two CERN scientists who later went to Dubna in exchange. Left to right: Vladimir Nikitin, Peter Kirstein, Walter Zöllner, Karl-Martin Vahlbruch and Adolf Mukhin.*

August 1961. For a few months travel to the West was almost impossible, and Lanius did not get permission to go to the meeting in October. Yet through the intercession of several government officials, he was allowed to travel to Geneva again in November 1961.

Eventually, the institute in Zeuthen did not take part in emulsion experiments; rather Lanius used his visits to CERN to ensure participation in a collaboration that carried out a bubble chamber experiment with 4 GeV pions. Again, it was his West German contacts – Gottstein in Munich and Martin Teucher in Hamburg – that helped him in this. Asked if it would be all right to pass exposed films to East Germany, Weisskopf replied that there was no objection at all on the part of CERN to give pictures to Dr Lanius in East Berlin.

The first delegations

Up to this point Weisskopf had preferred not to make this a political issue. This changed in 1962 when the "eminence grise" of East German physics, Robert Rompe, sent him a letter asking if it were possible to delegate two young scientists to CERN for a few months. This question tackled a central point of the organization's policy, and thus Weisskopf had to put it before the CERN Council. The outcome was quite diplomatic: CERN could not, Weisskopf wrote to Rompe, accept requests from governments of non-member states, but only from individual institutes. "Any political motives are to be left completely out of consideration in this." Unfortunately, the minutes of the relevant Council meeting are lost, but Weisskopf's Solomonic statement indicates that the political body of CERN followed the director-general in his will not to let politics interfere in improving relations with the Eastern European physics community.

A year later, Lanius felt it was time to prepare the first long-term delegation of one of his scientists. Weisskopf's consent was easily received; the problem was rather to "sell" the importance of the CERN collaboration to the appropriate political institutions in his country. Thus, when in June 1963 Lanius wrote to a government official that it was unknown if Weisskopf's successor would be similarly interested in fostering the ties with the socialist countries, he certainly anticipated that this argument was a good way to get visa formalities dealt with more quickly. On 4 March the second highest party committee, the secretariat of the East German communist party, agreed to the delegation of Dr Arnold Meyer to CERN for one year. Interestingly, Meyer had already left for Geneva a few days earlier.

In the following years, Lanius succeeded in sending further staff members to CERN for longer stays, and with the establishment of a separate budget for visiting scientists from non-member states, these were usually even paid for by CERN funds.

The files in the CERN archives do not reflect why the West German government loosened its formerly rigid position towards the admission of East German physicists to CERN. The most obvious explanation seems to be that the crisis in German-German relations, which followed the erection of the Berlin Wall, brought about a subtle but decisive change. Bonn kept insisting that CERN should give no pretext to the East German government to use the international laboratory to legitimize its existence. However, it obviously wished to counter the terrible act of the East German government by demonstrating the advantages of a liberal, open science community.

The decision adopted in 1962 by CERN Council referred the matter back to the merely administrative level, and to the benevolence of the director-general. The trick was simply to keep contacts and exchanges as far away from politics as possible. By leaving it at this, East German high-energy physics could participate in various CERN experiments throughout the decades until 1990, when the two German states finally reunited.

Weisskopf lived to see his dream of the 1960s fulfilled in ample measure. CERN is now a truly international laboratory with almost all of the Eastern European countries as member states, and close contacts via co-operation agreements with effectively all of the remaining nations, in addition to organizations and countries such as UNESCO, Russia, Israel, Brazil and the US.

Further reading

A Herrmann *et al.* 1990 *The History of CERN* vol. 2 (North-Holland, Amsterdam/Oxford/New York/Tokyo).

O Lock (1975) A History of the Collaboration between the European Organization for Nuclear Research (CERN) and the Joint Institute for Nuclear Research (JINR) and with Soviet Research Institutes in the USSR 1955–1970 *CERN Yellow Report* **75-7**.

O Lock 1997 Cecil Powell: pions, peace and politics *Physics World* **10** (11) 35–40.

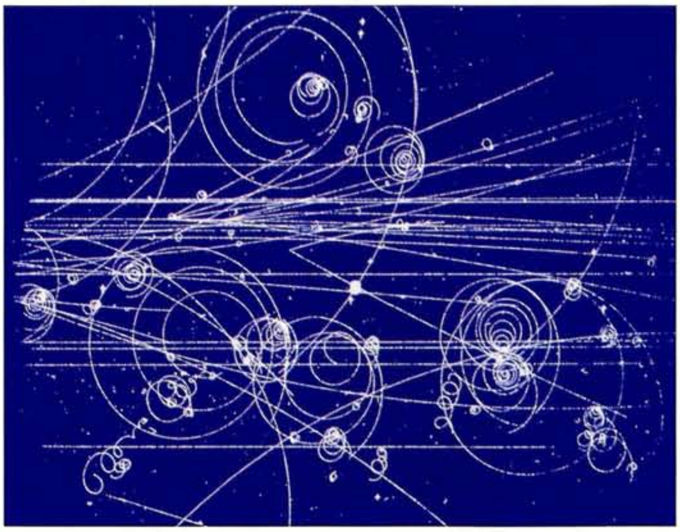
Victor Weisskopf 1991 *The Joy of Insight* (Basic Books, New York).

Thomas Stange 2001 *Institut X. Die Anfänge der Kern- und Hochenergiephysik in der DDR* (B G Teubner, Stuttgart/Leipzig/Wiesbaden).

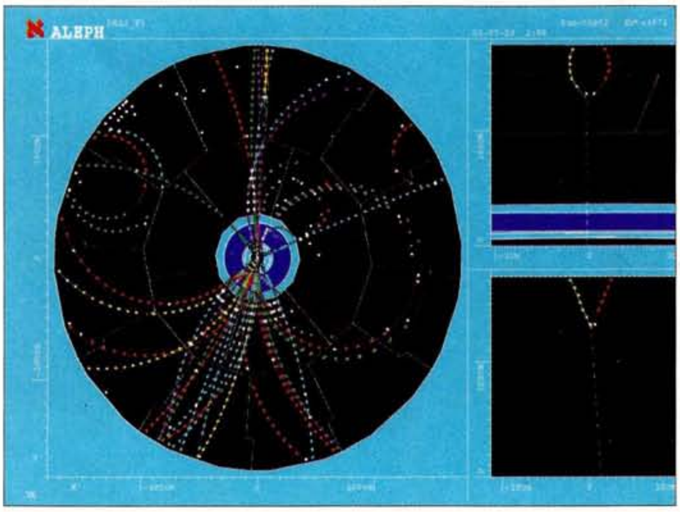
The author would like to thank Owen Lock for his helpful advice and for proof-reading the manuscript.

Thomas Stange.

More to physics than meets the eye



A classic bubble chamber photograph. Millions of such interactions were studied during the 1960s and 1970s.



Left: end-on display of particle tracks in the time projection chamber of the ALEPH experiment at CERN's LEP electron–positron collider. Right: magnified view of a track detail, seen end-on with the vertical scale compressed (top) and a similarly compressed side view (bottom), together showing how an invisible neutral particle has decayed and produced two visible tracks.

Handling, presenting and understanding the complex track patterns produced in the collisions of high-energy particles calls for considerable ingenuity. **Gordon Fraser** talks to CERN collision display specialist Hans Drevermann.

Physics is the study of natural phenomena by humans equipped with brains. Without humans there would still be nature, but without brains there would be no understanding. The mechanisms of the brain therefore have a direct bearing on the way we see physics.

The brain is equipped with memory and various levels of processing for the data from readout systems linked to delicate sensory organs such as the eyes and ears. Through these sensors, the brain is subjected to a stream of confusing input. Consciousness is the process of interpreting and making sense of all this data.

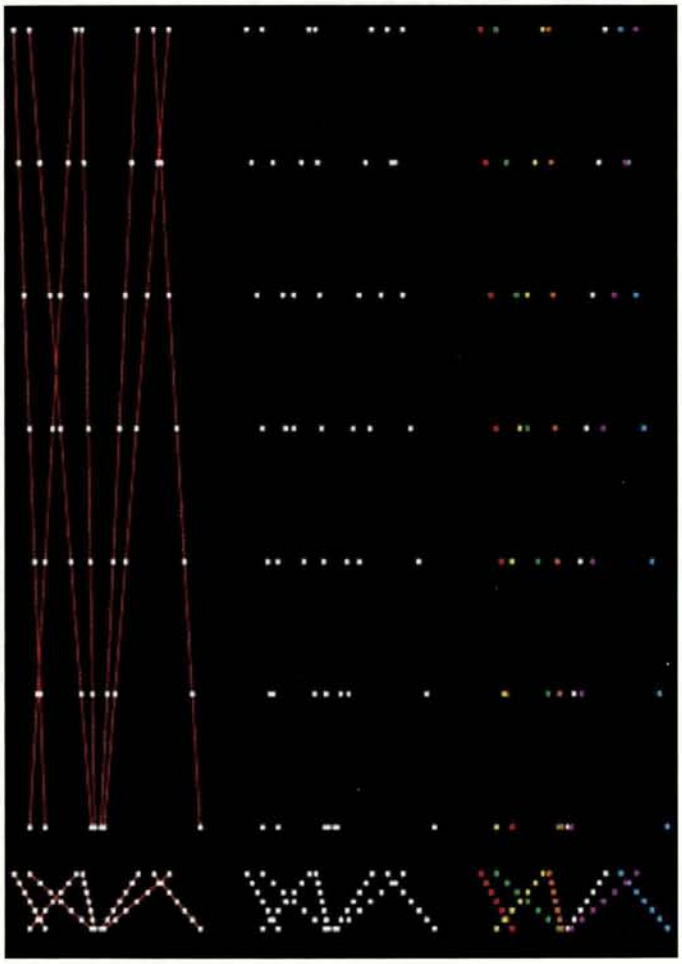
The brain becomes conditioned to recognize certain signals as being important, and rejects the rest. A baby soon learns to differentiate the image of its mother's face from the surrounding visual clutter. Later, it learns how to filter language from unresolved noise, and later still, to recognize the systematic shapes of written words. On encountering a word for the first time, the brain must absorb it letter by letter, and then work out what the new word means. Once learned, words are no longer read letter by letter. Instead, the brain directly perceives the pattern of the whole word. Such pattern recognition is a much faster process, but can be error-prone, as anyone who has proofread a document will have discovered.

Modern computers can process basic information much faster than any human brain. However, computers have yet to match the brain's remarkable ability to perceive and recognize patterns and make judgements. (An example of this ability is given by caricatures, in which a well known face is immediately recognizable from a rudimentary sketch that exaggerates key features.)

Making the invisible visible

Quantum physics underlies the rest of physics, but it is very different to everyday experience. One way of sidestepping this difficulty is the technique of particle tracking. The elementary particles taking part in a collision are themselves invisible, but if the collision is suitably choreographed, its results can be reconstructed.

One of the first tracking detectors was the cloud chamber, which was developed by C T R Wilson, and with which Patrick Blackett dramatically revealed the splendour of a subatomic collision process at Cambridge in the 1920s. A cloud chamber is filled with gas or vapour made metastable by a sudden expansion. A ▷



Pattern recognition by the human eye can be dramatically improved by changing the geometry or viewpoint. Top: three views using a natural scale. Related points have been joined (left) to reveal particle tracks. If the lines are removed (centre), the eye can no longer pick out the tracks, even if the related points are indicated by colour (right). Bottom: if the vertical scale is artificially compressed, the tracks immediately become clear.

The human eye has an amazing ability to extrapolate, linking bits of images when the total view is obscured by an irregular obstacle. It is as though the eye can "see" through the obstacle and perceive the full image. Hans Drevermann has sketched a snake hidden by parts of a black detector (bottom). Paint the detector in the background colour (top), and the snake is difficult to recognize. If the eye can discern intervening obstacles, a partially hidden object can still be perceived.

charged particle passing through the chamber rips electrons from the gas atoms, and the resulting ionization causes local condensation, leaving a visible trail behind the particle, just as a high-flying aeroplane leaves a white vapour trail in its wake.

From bubbles to electronics

Cloud chambers worked very well when physicists studied cosmic rays or used low-energy, low-intensity laboratory sources of particles, such as radioactive nuclei. However, cloud chambers were ill-suited to recording nuclear collisions using beams supplied by the post-Second World War high-energy accelerators.

The invention of the bubble chamber by Donald Glaser in 1952 rose to the new challenge. This chamber used a liquid target, rather than gas, offering a proportionally denser obstacle to particle beams. It could also be made larger. Many generations of research physicists explored elementary particles via this route, and glorious photographs of particle interactions gave a fresh view of an otherwise invisible world. The bubble chamber did for the physics of the microworld what the Hubble Space Telescope is doing for astronomy.

However, the graphic images provided by bubble chambers brought new problems. The main one was that there were far too many pictures. Researchers had to carefully sort through millions of photographs from bubble chamber exposures to find what was new.

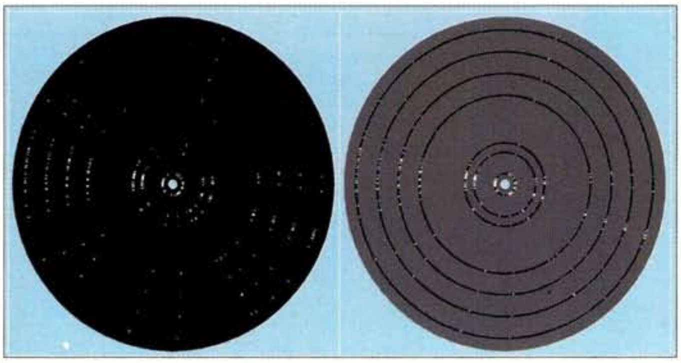
Experience taught researchers how to project the photographs onto a horizontal table where they could be viewed from different angles (particularly at grazing incidence) to reveal tracks and details that did not show up initially. Electronic instruments were developed to digitize and analyse bubble chamber information, but the pattern recognition abilities of the human eye remained unsurpassed.

About 20 years ago, the advent of high-intensity beams and fast electronics eventually led to new detector techniques and to the demise of the bubble chamber. Information on particle trajectories from today's colliding beam machines is now recorded electronically. This has the immediate advantage of being partly 3D, and also enables the detector to be "triggered" for special physics situations. A bubble chamber could be compared to a TV camera monitoring traffic at a busy junction. This is useful for general information, but not for spotting speeding cars. For this, a radar gun monitors all passing cars, but only triggers the camera if the car is speeding.

With digital information, the door was also open to automatic pattern recognition, in which a computer could be "taught" to recognize a particular kind of behaviour. Without fast-tracking the analysis in this way, discoveries would become unacceptably rare.

Dali

In a big particle detector like ALEPH at CERN's LEP electron–positron collider, the tracking is carried out in a central cylinder surrounding the point where the particles collide. The remainder of the detector picks up supplementary information (notably energy), differentiates between different kinds of particles, and monitors penetrating muons as they exit the apparatus. Such an electronic detector records discrete hits in successive planes of sensors, and these hits have to be analysed to build up a complete picture of the collision event. (In the same way, a TV image is built up of separate pixels, but from a distance the image looks continuous.)



Physics images can be presented in a way that exploits the pattern recognition abilities of the human eye and brain. This display for the ATLAS detector for CERN's Large Hadron Collider simulates the hits made by particles crossing successive planes of sensors. The tracks are difficult to discern in this radial "explosion" (left). However, a display interposing annular screens where there are no hits makes them easier to see (right).

A track reconstruction procedure helps to reveal trajectories. Because of the number and complexity of the collisions, this track reconstruction must be done by computer. It must also be done accurately and reliably. If only a few collisions are being selected for the fast-tracked "discovery lane", each one must be exactly right.

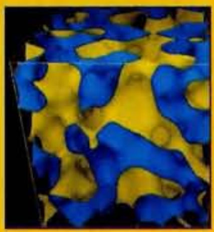
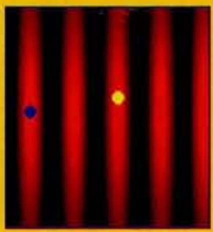
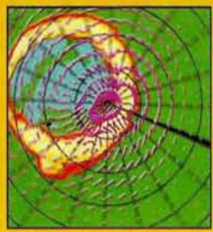
An approach pioneered by Hans Drevermann at the ALEPH experiment uses special techniques to check the findings of the track reconstruction procedures. The "Dali" system provides a new generation of classic pictures of electronically recorded particle tracks that rival those of the bubble chamber era. To achieve this, colour and projection, as well as sheer ingenuity, play important roles. The result is an intuitively appealing way of presenting the collisions, which is invaluable for illustrating talks and physics publications.

Dali uses a number of visual tricks to enhance track visibility. One is a "fish-eye" view which artificially "inflates" the central tracking region compared with the rest of the detector. Other Dali techniques involve unconventional transformations of radial co-ordinates that help reveal momentum and direction of track curvature (thereby giving a handle on what kind of particle is involved). In this work, the use of colour has developed into an art form.

Tracking is not the only aspect of recording and interpreting what happens in a collision process. After passing through the central tracker, the emerging particles deposit energy in calorimeters. These are cellular, and the deposited energy is usually spread over a number of adjacent cells. This too has to be displayed.

Together, these imaging ideas have provided a new standard for displaying particle collisions. As well as aiding actual physics analysis, these displays provide a "trademark" presentation of results at meetings and conferences, where images that are immediately recognizable and intuitively understandable are at a great advantage. They also help the physicist to perceive and understand what he is studying. The experience gained over more than 10 years with the ALEPH event display system will now be harnessed for the next generation of CERN experiments at the Large Hadron Collider.

Gordon Fraser, *CERN.*

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PEOPLE

Project leader for CERN's Large Hadron Collider, **Lyn Evans** (third from left), was made an honorary fellow of the University of Wales, Swansea at the University's 2002 graduation ceremony this summer. Evans, a former Swansea student, graduated in 1969. Making the award were (left to right), university vice-chancellor **Robin Williams**, physics professor **Mike Charlton** and university president **Sir David Williams**

Among the recipients of the UK Institute of Physics awards for 2002 is CERN's **Steve Myers**, who receives the Duddell Medal and Prize for his contributions to the development of major charged-particle accelerator projects at CERN. As head of the commissioning group for the Large Electron Positron (LEP) collider, says the citation, his contributions have had "a direct impact on the results from LEP, which have reached a precision and extent far beyond expectation and are key in defining the Standard Model of particle physics".

In Paul Dirac's centenary year, the Institute's Dirac Medal and Prize goes to Christopher Michael Hull of Queen Mary, University of London, "for his pioneering work in superstring theory".

At a meeting of the Indian Department of Atomic Energy (DAE)–CERN joint committee at CERN in September, **Dilip Bhawalkar**, director of India's Centre for Advanced Technology, and Large Hadron Collider (LHC) project leader **Lyn Evans** signed the final addenda for the first Indian contribution to the LHC. The main component of this contribution covers corrector magnets for the accelerator's main dipoles and quadrupoles. During their visit, members of the DAE delegation visited the assembly laboratory, where Indian engineers working at CERN under the CERN–India co-operation agreement are involved in taking magnetic measurements of the LHC magnets.

MEETING

The Royal Society in London is hosting a two-day discussion meeting on "The search for dark matter and dark energy in the universe" on 22–23 January with invited speakers from North America and Europe. There will also be a public lecture by Rocky Kolb of Fermilab on the evening of 22 January. The programme of the meeting is available through the Royal Society's website at http://www.royalsoc.ac.uk/events. Attendance is free, but pre-registration is required, either through the website or by contacting Hannah Jemmett at the Royal Society (tel. +44 20 7451 1575; email hannah.jemmett@royalsoc.ac.uk).

Karen Worth was among the speakers at a memorial symposium held at CERN on 17 September in honour of her father, Victor Weisskopf, who died earlier this year (*CERN Courier* June p28). Weisskopf was director-general of CERN from 1961 to 1965.

During the course of her two-day stay in Hamburg in August, HRH Princess Maha Chakri Sirindhorn of Thailand visited the DESY laboratory. She was shown around by director-general Albrecht Wagner, with whom she discussed the possibilities of a future collaboration between Thailand and DESY. Chao Fah Maha Chakri Sirindhorn is the third child of King Bhumibol Adulyadej and Queen Sirikit, and is crown princess of Thailand. A trained historian and linguist, she actively supports many projects in the fields of education, agriculture and irrigation, and is very popular in Thailand. She visited CERN in 2000.

CERN research director Roger Cashmore (left) inspects a straw tracker module for the ATLAS experiment at the Laboratory for Particle Physics of Dubna's Joint Institute for Nuclear Research (JINR). Also in the photograph are (left to right) JINR vice-director Alexei Sissakian, Nicolas Koulberg of CERN, and Vladimir Peshekhonov and Vladimir Kekelidze, both of JINR. Cashmore and Koulberg were part of a CERN delegation that visited JINR on 6–7 August for a meeting of the joint committee on CERN–JINR co-operation.

Call for proposals

The Legnaro National Laboratories (LNL) of Italy's National Institute of Nuclear Physics have been recognized by the European Commission as a Major Research Infrastructure for the period 1 November 2000 - 31 October 2003. The contract offers European research groups performing experiments at LNL facilities the opportunity to be refunded for subsistence and travel. Groups from all European countries and the associated states are eligible. Calls for proposals are issued twice a year, with deadlines for submission usually falling in January and June. The next deadline is 13 January 2003. Proposals will be evaluated on the basis of their scientific merit by user selection panels. Further information and application forms are available at http://www.lnl.infn.it/~lsf_secr or email lsf_secr@lnl.infn.it.

Sir Denys Wilkinson (centre) is pictured with speakers at a Symposium on Symmetry and the Weak Interaction held at Canada's TRIUMF laboratory in September to celebrate his 80th birthday and his contributions to the laboratory over the past 15 years. On the left: TRIUMF associate director **Jean-Michel Poutissou** and **Victor Flambaum** of the University of New South Wales. On the right: TRIUMF's **Peter Jackson** and **Clark Griffith** of the University of Washington.

Earlier in the year, the University of Oxford Physics Department renamed its Nuclear Physics Laboratory after Wilkinson in recognition of the key role he played in creating what was then the Department of Nuclear Physics in the 1960s. The Denys Wilkinson Building now houses the university's subdepartment of particle physics, numbering over 100 researchers, students, engineers and technicians.

Large Hadron Collider (LHC) project leader **Lyn Evans** (right) handed a Golden Hadron award to **Alexander Skrinsky** of Russia's Budker Institute of Nuclear Physics (BINP) on 14 September. Two other LHC suppliers, Belgian firm Cockerill-Sambre and US company Wah-Chang, received Golden Hadrons earlier in the year (*CERN Courier* October p32) at a ceremony that Skrinsky was unable to attend. The award recognizes the Russian institute's particularly high-quality production of 360 dipole magnets and 185 quadrupole magnets for the LHC's proton beam transfer lines.

CERN Courier romance – the magazine's advertising manager **Chris Thomas** and product manager **Laura Serratrice** tied the knot at Quakers Friars in Bristol, UK, on 5 October.

Submissions invited for G N Flerov prize

In June 2003, the Joint Institute for Nuclear Research (JINR) will award the G N Flerov prize to the winner of a contest for outstanding research in nuclear physics. The winner will also receive $1000. The contest is for individual participants only. Participants should send an abstract of their research, enclosing copies of major contributions, to be received by 1 February 2003, to: Dr Andrew G Popeko, JINR, Flerov Laboratory for Nuclear Reactions, Dubna, Moscow Region, 141980, Russia. Fax +7 09621 65083; email popeko@jinr.ru.

Finland starts CERN co-operation network for schools

High-school student and teacher programmes at CERN organized for Finnish schools by the Helsinki Institute of Physics (HIP) have proved so successful that they have attracted the interest of Finland's National Board of Education. Positive feedback from schools accompanied by newspaper articles and conference presentations by students and teachers has led the board to launch a CERN co-operation school network in conjunction with the HIP and two high schools in Jyväskylä (Cygnaeus High School and Jyväskylän Lyseo Upper Secondary School). This network, announced at a conference at the University of Jyväskylä on 13 September, includes more than 40 schools, seven universities, physics institutes and teacher training centres. Its main aim is to develop the role of particle physics in school curricula in co-operation with CERN. At the conference, two schools – Pyhäjoki Upper Secondary School and Jyväskylän Lyseo Upper Secondary School – were rewarded for their efforts in bringing particle physics at CERN into their work. Students from Pyhäjoki and Raahe Upper Secondary Schools and the Normal Lyceum of Helsinki also received prizes for work they produced and published after a visit to CERN.

Riitta Rinta-Filppula (left), who organizes Finnish school visits to CERN, with teachers who were rewarded for their efforts in bringing particle physics into the classroom.

Teachers meet particle physicists in Frascati

Italy's National Institute for Nuclear Physics (INFN) put schools at the top of the agenda in September when it held its second "Encounters in Physics" meeting at the Frascati National Laboratories near Rome. Some 200 teachers attended a three-day workshop comprising a series of lectures by leading scientists and practical work illustrating some basic principles of particle physics. Following the first encounters in 2001, INFN researchers returned the compliment by visiting participating teachers in their schools and organizing visits and work experience at Frascati for students.

Participants at the INFN's Encounters in Physics meeting visit the ATLAS laboratory at Frascati. (Roberto Baldini, Frascati National Laboratories.)

Marie Curie fellowships showcased at CERN

Left: CERN's David Plane (left) introduced Theodore Papazoglou of the EU, who outlined the role of Marie Curie Fellowships in the forthcoming sixth research framework programme. Above: Marie Curie fellows from many disciplines of physics and technology came to CERN in October for an EU workshop to showcase the scheme.

CERN became a showcase for European Union (EU) research on 3–4 October when it hosted a workshop for EU-funded Marie Curie fellows working in various fields of physics and technology.

The Marie Curie scheme gives young European researchers the mobility to go to wherever in the continent the best facilities in their chosen field happen to be, and it is a key plank in the EU's strategy of creating a European Research Area.

Among the highlights of the meeting was a foretaste of the sixth EU research framework programme (FP6) from Theodore Papazoglou of the EU's Marie Curie fellowship office. FP6 aims to move firmly towards the creation of a European Research Area, with emphasis on integrating research across national borders in fields ranging from information technology to sustainable development. A total of 11 500 expressions of interest were received for FP6 before the deadline of 7 June, and a call for proposals will be made in November.

CERN director-general Luciano Maiani opened the workshop with a discussion of the role of large-scale facilities and centres of excellence. In the closing keynote speech, Maurice Jacob, former president of the European Physical Society, addressed the importance of physics in today's knowledge-based society. CERN is currently host to some 20 Marie Curie fellows.

OBITUARIES

Bunji Sakita 1930 – 2002

Professor Bunji Sakita, distinguished professor of physics at the City College of New York (CCNY), passed away on 31 August while in Japan, after a year-long struggle with cancer. Sakita was born in 1930 in the Toyama area of Japan. He received his first degree from Kanazawa University in 1953, and his Masters from Nagoya University in 1956 as part of Sakata's group. He was among several students recruited by Robert Marshak to come to Rochester University, and received his doctorate in 1959 under Charles Goebel. He went on to a postdoctoral position and a professorship at the University of Wisconsin. During this time, and while visiting the Argonne National Laboratory, Sakita wrote a series of influential papers on the quark model, introducing the new symmetry group SU(6), which generated considerable scientific interest among physicists as it united spin and isospin.

At Wisconsin, Sakita wrote some of the fundamental papers on the "dual resonance model", which now forms the foundation of string theory. With Goebel, he generalized the Veneziano amplitude to the many-particle case. With K Kikkawa and M Virasoro, he showed how to correct a crucial defect in the theory (unitarity) by including loop diagrams, much like Feynman diagrams. With his student C S Hsue, and with J L Gervais, he then generalized this to the functional formalism, based on Riemann surfaces, which today provides the most powerful formulation of string theory. Sakita and Virasoro also showed how ordinary field theories, in the infinite loop limit, can create fishnet diagrams which approximate string theory (which helped form

Bunji Sakita 1930 – 2002.

some of the basis of the 1/N approximation). In these seminal papers, we see the foundations of string perturbation theory, the string functional formalism, and conformal field theory.

After J Schwarz, A Neveu and P Ramond introduced spin into the dual resonance model, Sakita and Gervais revealed the supersymmetry underlying the theory by writing down the first linear supersymmetric action, which today forms the basis of the superstring action. (Different versions of supersymmetry were also discovered in the Soviet Union at around this time.) B Zumino and J Wess, stimulated by the paper of Sakita and Gervais and by a seminar Sakita gave at CERN in the spring of 1973, then generalized this to a variety of quantum field theories defined in four dimensional space-time, rather than the two-dimensional world sheet. This led to the beginning of the application of supersymmetry to the physical world. (Sakita fondly remembers, in his memoirs, talking to Zumino in the CERN coffee lounge. Sakita said: "If you allow me to use anti-communting c-numbers, Gervais and I have written down a transformation of a fermi field to a bose field in the Nuclear Physics paper." Zumino replied" "It's OK to use anti-communting c-numbers. Schwinger has frequently used them.")

With the rapid expansion of the graduate physics programme at CCNY in the 1970s, Sakita followed Robert Marshak (who became president of the college) and joined the faculty at CCNY as distinguished professor in 1970. He presided over a rapid growth of the high-energy group, which developed string field theory, superconformal gravity, and research in strong coupling theory and collective co-ordinates. He received the Guggenheim Fellowship in the 1970s and was awarded the Nishina Prize in Physics in 1974. With Gervais and his student A Jevicki, he wrote a series of papers presenting the general formalism of collective co-ordinates and its full perturbation theory, allowing one to link point particle theories into those describing extended objects. This was extended to gauge theories with his student S Wadia, and Gervais. With his student J Alfaro, he applied the method of stochastic quantization to large N theories.

Sakita's interests were broad and varied, always seeking out the fundamental basis found in physical systems. In later years, he turned his attention to problems in solid-state physics, especially two-dimensional systems which exhibit W symmetry, and also physical characteristics found in high-energy physics (for example the fractional Hall Effect) with his colleagues S Iso and D Karabali.

Sakita leaves behind two children, Mariko and Taro. His warmth, leadership, modesty, and vision will be sorely missed by his students and colleagues all over the world and especially at CCNY.

Antal Jevicki, Brown University; Michio Kaku and Parameswaran Nair, CCNY; and Spenta R Wadia, Tata Institute of Fundamental Research, Mumbai.

Karl Brown 1925 – 2002

Accelerator pioneer Karl Brown died on 29 August in Stanford, California, where he had spent most of his working life. Professor emeritus of applied research at the Stanford Linear Accelerator Center (SLAC), Brown pioneered the development of linear accelerators for research, as well as for cancer treatment.

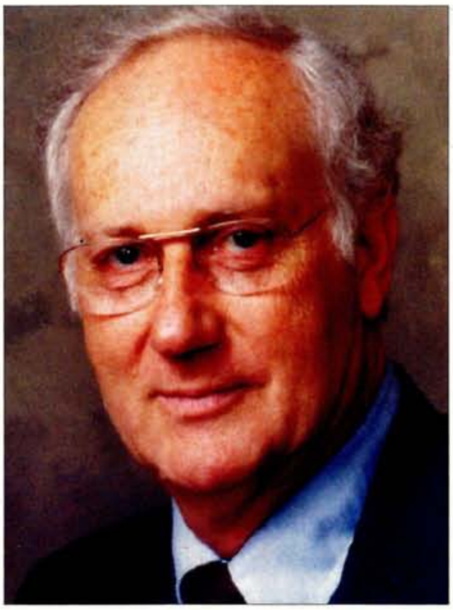
Brown attended the University of Utah as an electrical engineering student, but in 1946 he transferred to Stanford to work on particle accelerators. This move was the beginning of a Stanford career spanning more than half a century. He earned his doctorate in 1953 for the commissioning of the Mark II accelerator, following which he joined the Stanford physics department's Hansen laboratories. In the early 1960s, when Wolfgang Panofsky conceived the idea for the Stanford linear accelerator, Brown became a member of the core team of young scientists who designed and built the 2 mile long accelerator under Panofsky's direction.

In 1958, Brown was the first to use matrix algebra to calculate magnetic-optical aberrations in charged particle spectrometers, used by physicists for the precise analysis of nuclear and subnuclear structure. He developed a computer code called TRANSPORT to facilitate the equipment design process. This code later became a tool used worldwide to design spectrometers, beamlines and ▷

accelerators ranging in energies up to 1 TeV.

Brown also introduced the use of sextupole magnets to enhance the performance of spectrometers at SLAC. In the 1960s, he proposed making a colliding beam machine using two linear accelerators at SLAC. Later, he designed achromatic magnetic optical systems, which focus beams largely independent of their energies. His designs made it possible to achieve beam spots of a micron or less. They found application in particle colliders as well as in medical diagnosis and treatment. Travelling worldwide to assist in design of spectrometers and beam transport systems, Brown took sabbaticals in 1959 at Orsay in France, from 1972 to 1973 at CERN to work on the SPS and LEP, and from 1992 to 1994 at the ill-fated Superconducting Super Collider in Texas.

Though internationally renowned as an expert in beam optics for spectrometers and high-energy particle accelerators, Brown's greatest satisfaction came from his contributions toward the development of small linear accelerators for radiation therapy. As a graduate student in the 1950s, he was part of a small research team at Stanford that designed the first linear accelerator in the US to be used successfully to treat a cancer patient. In the late 1960s, Brown initiated and led the development by Varian Associates of the first commercially successful line of such machines, the CLINAC series. The present-day incarnation of the CLINAC treats more than 100 000 patients a day worldwide.



Karl Brown 1925 - 2002.

A fellow of the American Physical Society, Brown was awarded the 1989 prize for achievement in accelerator physics and technology by the US Particle Accelerator School.

"He is probably best known internationally for his development of the programs which make it possible to easily trace the path of particles through complex magnetic beam transport systems," said long-time friend Panofsky. "However, his contributions go well beyond that, and we all are extremely sad about his passing."

PRODUCTS

A series of 6 kW smart digital controlled DC power supplies has been announced by **Xantrex Technology** of Vancouver, Canada. The company's nine-model XDC range is designed for applications requiring high power in a small package. Output ranges from 0–10 V to 0–600 V in voltage, and from 0–600 A to 0–10 A in current. Further information is available from kim.grecia@xantrex.com, or at http://www.xantrex.com.

Swiss company **Sentron AG** announces two new integrated Hall sensors that respond to magnetic field parallel to the chip surface. Both are complete integrated CMOS systems including Hall elements, biasing circuit, amplifier and programming of gain, offset and temperature coefficient. The CSA-1 is a single axis sensor with sensitivity up to 300 mV/mT. The 2SA-1 is a two-axis sensor. Information is available at http://www.sentron.ch.

Slovenian company **Instrumentation Technologies** has announced a reconfigurable integrated beam-position monitoring system DBPM2. The instrument boasts submicrometre resolution and over 100 dB dynamic range. It consists of analogue processing, data acquisition and digital signal processing building blocks with a simple memory-mapped VME interface. Email info@i-tech.si or see http://www.i-tech.si.

LETTERS

CERN Courier welcomes feedback but reserves the right to edit letters. Please email cern.courier@cern.ch.

Fortran still going strong

In "Particle physics software aids space and medicine" (*CERN Courier* June p33), Maria Grazia Pia and Jürgen Knobloch write: "The predecessors of the Geant4 toolkit – which were written in the now almost obsolete Fortran language..."

Fortran may be falling into disuse in the particle physics community, but that it is "almost obsolete" is a myth. There have been three standards since 1966, and a fourth is nearing publication. Perhaps the authors, and the rumour they are repeating, were referring to Fortran 66. In that case, they were understating their case: Fortran 66 is not "almost obsolete" – it is definitely obsolete, and has been so for 26 years.

It has been said that more people are using Fortran than ever before, but a smaller fraction of the people who develop software are using it. That is, the market is growing, but the market share is shrinking. I cannot find concrete support for this assertion (at least the first part of it), but there is some anecdotal evidence; at least one Fortran compiler vendor cites a continuous yearly increase of sales volume.

I would be curious to know why some consider Fortran to be "nearly obsolete"? If one compares Fortran to other languages, one doesn't find it wanting for features. Indeed, one finds many features tailor-made for its application domain – numerical computation – that are lacking in other languages.

Van Snyder, Jet Propulsion Laboratory, California Institute of Technology.

Jürgen Knobloch replies:

The term "obsolete" in our article was certainly inspired by the situation in the particle physics community. The major experiments in the field have decided to develop their new software in object-oriented technology – currently mostly in C++. The FORTRAN and C-based CERN library has not received any new developments since 1996, and a final release was delivered this year.

Going to work at CERN? For information, contact **Users.Office@cern.ch**

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Die Bewerbung geeigneter Schwerbehinderter ist erwünscht. Bewerbungen mit Lebenslauf, wissenschaftlichem Werdegang, Schriftenverzeichnis und Angaben über die bisherige Lehrtätigkeit sind bis zum 7.12.2002 zu richten an den **Dekan des Fachbereichs Physik der Universität Dortmund, D-44221 Dortmund.**

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POSTDOCTORAL CANDIDATE

The Physics Division of the Lawrence Berkeley National Laboratory is seeking a postdoctoral candidate to participate in the ATLAS Experiment at the Large Hadron Collider at CERN. The Physics Division has important roles in the silicon strip detector and silicon pixel detector for ATLAS and requires a candidate to work on assembly and testing at Berkeley Lab. The successful candidate will also have the opportunity to be involved in data analysis from one of the ongoing experiments with Berkeley Lab participation. This is a two-year term position with possibility of renewal and requires frequent travel to CERN.

To qualify, you should have a PhD in Experimental High Energy Physics or equivalent experience and demonstrated strong potential for outstanding achievement as an independent researcher. Experience with silicon detector systems or other complex electronics/detector systems is preferred.

Candidates should submit an application with CV and three letters of recommendation via e-mail to gensciemployment@lbl.gov (no attachments) or mail to Lawrence Berkeley National Laboratory, Attn: Madelyn Bello, One Cyclotron Road, MS 50A4037, Berkeley, CA 94720-8152. Applications and letters should reference Job # PH/015204/JCERN. Berkeley Lab is an EEO/AA employer.

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Prof Matthias Neubert, Search Committee Chair, Newman Laboratory of Elementary-Particle Physics, Cornell University, Ithaca, NY 14853

Applications received before November 1, 2002 will receive fullest consideration, although later applications may also be taken into account.

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Contact: To apply, please send your CV to Robert Pearce, Head of Vacuum Systems and Machine Operations, J20/0/41, Culham Science Centre, Abingdon, Oxfordshire OX14 3DB or by e-mail to robert.pearce@jet.uk quoting reference CD/MO/13.

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Job Opportunities on Diamond

An opportunity to join the Diamond Light Source team !

The Diamond synchrotron light source is the largest scientific facility to be built in the UK for over thirty years and will be located at Rutherford Appleton Laboratory in Oxfordshire. The Diamond facility will consist of three accelerators - a 100 MeV linac, a 3 GeV booster synchrotron and a 562 m circumference 3 GeV storage ring. Diamond should be operational towards the end of 2006 with an initial complement of 7 synchrotron radiation beamlines.

Diamond Light Source Ltd., the joint venture company responsible for the construction and operation of Diamond, has a number of openings for physicists and engineers of different grades within the Diamond Technical Division:

Group Leader Positions

- DLS0003 Group Leader for accelerator physics
- DLS0004 Group Leader for d.c. and pulsed magnets
- DLS0005 Group Leader for vacuum
- DLS0006 Group Leader for radio-frequency and linac systems
- DLS0007 Group Leader for beam diagnostic and feedback systems

Other Positions

- DLS0008 Accelerator physicists
- DLS0009 Vacuum scientists and engineers
- DLS0010 Vacuum technicians
- DLS0011 Radiofrequency and linear accelerator systems physicists/engineers
- DLS0012 Physicists/engineers for magnet systems
- DLS0013 Physicist for insertion device systems
- DLS0014 Beam diagnostic physicist/engineers
- DLS0015 Control system electronics engineers
- DLS0016 Control system software engineers
- DLS0017 Control system relational database software engineer
- DLS0018 Mechanical project engineers
- DLS0019 Mechanical design engineers
- DLS0020 Electrical project engineers
- DLS0021 Electrical design engineers
- DLS0022 CAD/CAE Systems manager
- DLS0023 Power supply engineers
- DLS0024 Health physicists

Salary on appointment will be made on the following scales depending on qualifications and experience: Grade 3 (Group Leader): £33,860-£46,560; Grade 4: £27,840-£38,290; Grade 5: £21,940-£30,160; Grade 6: £16,920-£23,490. See detailed job descriptions for details.

Successful candidates for all posts are likely to have self motivation, ability to work effectively in a team and good interpersonal and communication skills as well as academic qualifications appropriate to the specific post. Group leaders will also be expected to have good project and people management skills. Relevant experience, preferably in an accelerator environment, is highly desireable but not essential in all cases as appropriate training will be given.

Appointments will be made by Diamond Light Source Ltd. Posts will be based at CLRC's Rutherford Appleton Laboratory. It may be necessary for some time to be spent initially at CLRC's Daresbury Laboratory near Warrington, Cheshire.

For an informal discussion about any of these posts please contact in the first instance Emma Medlock, PA to the Technical Director, Tel: +44 (0)1235 446992 or E.mail: emma.medlock@diamond.ac.uk

Further information about these and future posts, and how to apply, is available from our web site at: http://www.diamond.ac.uk or can be obtained from: HR Operations, Human Resources Division, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX. Telephone +44 (0)1235 445435 (answerphone) or E.mail recruitment@diamond.ac.uk quoting the appropriate vacancy number. This information will be available from Friday 18th October.

Applications must be received by 12:00 midday on Monday 11th November 2002.

diamond

UNIVERSITY OF WISCONSIN MADISON

MATHEMATICAL PHYSICS/STRING THEORY CLUSTER HIRING

The Department of Mathematics and Physics anticipate an opening for one or two positions to begin August 25, 2003, at either the tenure track (assistant professor) or tenured (associate/full professor) level. This cluster hiring is a part of the Madison Initiative and is intended to establish a prominent research group connecting the existing groups in particle physics phenomenology in the Physics Department and topology/geometry in the Mathematics Department. Applications are especially encouraged from theorists pursuing innovative research in string theory quantum gravity, physics with extra dimensions, quantum field theory, supersymmetry, and unification theories; as well as from mathematicians working on aspects of string theory or related topics. Successful candidates will be encouraged to participate in interdisciplinary research which will strengthen ties between the two departments. Joint appointments in the Mathematics and Physics Departments are contemplated.

Candidates should exhibit evidence of outstanding research records, normally including achievements significantly beyond the doctoral dissertation. A strong commitment to excellence in instruction at both undergraduate and graduate levels is also expected. Applicants should send a curriculum vitae which includes a publication list, and brief descriptions of research and teaching accomplishments and goals to:

Math/Physics Cluster Hiring Committee Dept. of Mathematics, Van Vleck Hall University of Wisconsin Madison 480 Lincoln Drive Madison, WI 53706-1388

Applicants should also arrange to send to the above address, three letters of recommendation, which should address the applicant's research potential and teaching experiences. Review of applications will begin on November 1, 2002. Applications will be accepted until the positions are filled. Additional letters will be solicited by the hiring committee for senior appointments.

The Departments of Mathematics and Physics are committed to increasing the number of women and minority faculty. The University of Wisconsin is an Affirmative Action, Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

Additional departmental information is available on the websites
http://www.math.wisc.edu; http://www.physics.wisc.edu
Information about the cluster hiring initiative is available at
http://wiscinfo.doit.wisc.edu/cluster/

MIT

POSTDOCTORAL ASSOCIATE

The MIT/Bates Linear Accelerator Center in Middleton, Massachusetts is a user laboratory providing polarized electron beams of up to 1 GeV for Nuclear and Hadron Physics research. A storage ring provides CW currents above 100 mA on polarized internal targets and a new large-acceptance spectrometer, BLAST.

We are searching for a postdoctoral candidate in accelerator physics to participate in the operation, upgrade, and optimization of the Bates beam delivery system with emphasis on new lattices and energy ranges of the storage ring. There are also opportunities to work on a self-polarizing 10 GeV electron storage ring design for a high-luminosity electron-ion collider (EIC) envisage to be built at the Brookhaven RHIC facility.

The successful candidate is expected to have a PhD in accelerator physics or equivalent expertise in electron storage ring design. Experience in electron self-polarization is desirable. Should be comfortable working in a small accelerator physics group participating in the operational needs of the laboratory.

Interested candidates may apply online at: **web.mit.edu/personnel/www/resume.htm**
If you do not have access to the web, a cover letter and resume may be submitted to: **MIT Human Resources, Job No. 02-0776, PO Box 391229, Cambridge, MA 02139-0013.** EOE.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
An Equal Opportunity/Affirmative Action Employer
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web.mit.edu/personnel/www

Deutsches Elektronen-Synchrotron
Research at HASYLAB

DESY is one of the leading accelerator centers worldwide. The research spectrum ranges from elementary particle physics and solid state physics to molecular biology.

Particle accelerators produce most brilliant electromagnetic radiation for a variety of innovative applications. For a research position at the Hamburger Synchrotronstrahlungslabor HASYLAB we are seeking a

Beamline scientist for synchrotron radiation research – PETRA III project

for a permanent position.
HASYLAB is operating 40 beamlines with more than 80 different instruments at the storage rings DORIS and PETRA. To satisfy the growing need for high brilliance undulator radiation in future DESY plans to convert PETRA to a dedicated third generation synchrotron radiation source starting in 2007.
To compile the proposal for the new undulator beamlines and to establish a new field of research at PETRA III we are seeking a recognised scientist capable of designing and building beamlines and experimental stations. The successful applicant may use 1/3 of his/her time for own research projects. The applicant is expected to hold a degree in physics or a comparable qualification. Long-standing experience in operation and development of synchrotron radiation beamlines is required.

Salary and benefits are commensurate with public service organisations (BAT Ib). DESY operates flexible work schemes, such as flexitime or part-time work.
DESY is an equal opportunity, affirmative action employer and encourages applications from women.

Deutsches Elektronen-Synchrotron DESY
member of the Helmholtz Association
code: 133/2002 • Notkestraße 85 • D-22603 Hamburg • Germany
Phone +49 (0) 40 8998-4534 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applicants: 15.12.2002

UH

University of Hamburg Institute for Experimental Physics

ZEUS Experiment and Detector Development

The Group *ZEUS Detector and Detector Development* at the Institute of Experimental Physics invites applications for a

Wissenschaftlicher Assistent (C1)

The position is open for three years, starting 1st January 2002 with the possibility of an extension by another three years.

The candidate is expected to play an important role in the running and analysis of data from the ZEUS experiment. Active participation in the development programme on solid state detectors for future accelerators is welcome. The teaching requirement is 4 hours/week during the semester which includes tutoring, labs, seminars and the supervision of diploma and PhD students.

Candidates should have an excellent PhD in experimental particle physics.

The University of Hamburg is an equal opportunity/affirmative action employer and welcomes the application of qualified women. Handicapped applicants will be given preference in case of equal qualifications.

Applications including a CV, academic records and list of publications should be sent by 1st December 2002 to:

Prof. Dr. B. Sonntag, Inst. für Experimentalphysik, Luruper Chaussee 149, D-22761 Hamburg

Further information can be obtained from **Robert.Klanner@desy.de** or under **+49 40 8998 2558**

Computer Center Director (Position #PR2031)

Thomas Jefferson National Accelerator Facility is a DOE-sponsored laboratory operated by the Southeastern Universities Research Association. Jefferson Lab's primary mission is to study strongly interacting matter with multi-GeV electromagnetic probes. The experimental program includes both high energy nuclear physics and low energy particle physics. The Laboratory routinely operates up to 5.7 GeV beam energy.

Jefferson Lab is seeking a qualified individual to head the lab-wide Computer Center. The successful applicant will be responsible for the management and operation of the Center whose key functions include design, implementation and operation of the petabyte scale off-line data reduction facilities, general scientific computational and networking environment, and business and scientific desktop environments. In addition, the Center includes helpdesk, telecommunications and cyber security functions. The successful applicant will also be responsible for leadership and management of the Computer Center staff, interactions regarding computing with the divisions and departments across the Lab, and with the Lab's user community and collaborating institutions.

Minimum qualifications include a Ph.D. in Nuclear or High Energy Physics plus 7 years experience, or the equivalent combination of education and relevant experience. Two to three years of management experience and three to five years experience programming and performing systems work in a scientific research, engineering or similar environment are desired. Excellent written and verbal communication skills are essential.

For prompt consideration, please send resume and salary history to: Jefferson Lab, ATTN: Human Resources Administrator, 12000 Jefferson Avenue, Newport News, VA 23606, Fax: 757-269-7559, E-mail: jobline@jlab.org. Please specify position number and job title when applying. **For more information on this position, contact Dr. Roy Whitney (whitney@jlab.org).**

Proud to be an Equal Opportunity, Affirmative Action Employer

Jefferson Lab

EUROPEAN SYNCHROTRON RADIATION FACILITY

ESRF

Opportunities at Europe's 3rd generation synchrotron

Scientist and Post-doctoral positions at the ESRF in Grenoble, France

Take advantage of pursuing research in a unique international environment in France at the ESRF. Our facility operates one of the brightest X-ray sources in the world and it is used by several thousand scientists for both fundamental and applied research, in a wide range of disciplines:

Physics, Chemistry, Crystallography, Earth Science, Structural Biology and Medicine, Surface and Materials Science...

You will be provided with the means to develop your own research and to operate your team's beamline. You will work in close contact with, and advise, external users, which will give you the possibility to form useful collaborations.

We also offer PhD positions.

Have a look at our website for a full description of our vacancies and activities: http://www.esrf.fr, and contact us at recruitm@esrf.fr or fax #: +33 (0)4 76 88 24 60

ESRF, Personnel Service, BP220, F-38043, Grenoble cedex 9, FRANCE.

The Institute of Particle Physics of Canada – Research Scientist

Applications are invited for a position as a Research Scientist with the Institute of Particle Physics of Canada (IPP). Candidates should preferably have three years of postdoctoral experience and a demonstrated record of accomplishment in experimental high energy particle physics. The Research Scientist appointment is associated with an academic research position at a Canadian University and includes the right to hold research grants and to supervise graduate students. This position can become permanent after three years of employment.

Research Scientists are expected to participate in the IPP Program. The current core experiments of the program are:

- **p-p collisions at the LHC (ATLAS)**
- **neutrino physics with the SNO detector**
- **e-p collisions at HERA (ZEUS)**
- **p-p collisions at the TEVATRON (CDF)**
- **B physics at the SLAC B-factory (BABAR)**
- **rare kaon decays at Brookhaven (E949)**

For further information see the website http://www.ipp.ca.

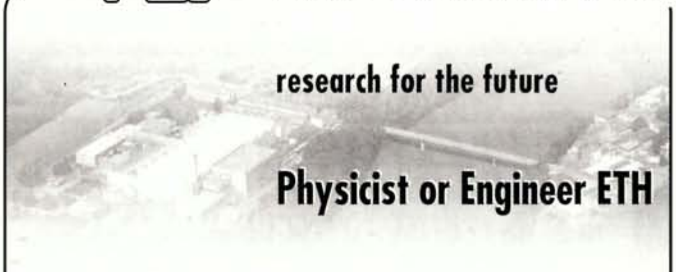
The choice of experiment and university affiliation will be determined by mutual agreement between the candidate and the IPP.

Send a curriculum vitae and a statement of research interests, and arrange to have at least three letters of reference sent, for receipt before January 15, 2003, to:

Prof. R.K. Keeler, Director
Institute of Particle Physics
Department of Physics and Astronomy
University of Victoria
P.O. Box 3055 Stn Csc
Victoria, BC V8W 3P6 Canada
fax: 250-721-7752
email: rkeeler@uvic.ca

In accordance with immigration regulations, preference will be given to citizens or permanent residents of Canada.

PSI PAUL SCHERRER INSTITUT



Your Tasks

- Participation in the design, fabrication, testing and comissioning of components for RF-systems of the PSI accelerators
- Cooperation in the continuing development, performance optimization and maintenance of RF equipment and subsystems, with emphasis on the Synchrotron Light Source (SLS) RF systems.
- Taking full responsibility for a subsystem of an accelerator RF system, after suitable introduction and training.

Your Profile

You have a degree in physics or engineering (preferably RF or telecommunication). A solid experience in the field of RF systems for particle accelerators, as well as a background in the utilization of numerical tools used for RF system design (components and structures) would be an advantage. Emphasis is placed on your ability to work in a team efficiently. We would also like you to contribute to the overall performance of the RF section with creative and new ideas.

Dr. M. Pedrozzi will be pleased to answer any questions concerning this position. His phone number is: +41 056 310 32 42, e-mail: marco.pedrozzi@psi.ch

We are looking forward to your application: PAUL SCHERRER INSTITUTE, Human Resources, Mr. Thomas Erb, ref. code 851, 5232 Villigen PSI, Switzerland

Further jobs: www.psi.ch

UNIVERSITY OF CALIFORNIA AT DAVIS
UCD PHYSICS

Faculty Position
High Energy Theoretical Physicist
Department of Physics
University of California, Davis

The Department of Physics at the University of California at Davis invites applications for a faculty position in theoretical high energy physics. Appointment at any level is possible depending upon qualifications and experience. The successful candidate will be the first of three planned new appointments directed toward pursuit of exciting new ideas and challenges associated with the interface between formal theory and phenomenology. Priority will be given to candidates with recognized leadership in this area and the ability to help plan and implement the High Energy Frontier Theory Initiative (HEFTI). The successful candidate should also have a strong interest in interpreting new phenomena as the relevant experimental data becomes available. Interaction and overlap with the particle cosmology group is anticipated. A formal High Energy Frontier Theory Institute is a strong possibility.

The existing high energy group consists of five theoretical and six experimental faculty. The theorists have a broad spectrum of interests including supercollider physics and phenomenology, supersymmetric modeling and superstring phenomenology, Higgs physics, brane models, lattice QCD, weak-interaction and heavy quark physics, solvable models, and quantum gravity. The experimentalists have major efforts at Fermilab and are active members of the LHC CMS collaboration.

The successful candidate will have a Ph.D. in physics or the equivalent and be expected to teach at the undergraduate and graduate levels.

This position is open until filled; but to assure full consideration, applications should be received no later than January 2, 2003. The targeted starting date for appointment is July 1, 2003. To initiate the application process, please mail your curriculum vitae, publication list, research statement, and the names (including address, e-mail, fax, and phone number) of three or more references to:

Professor Winston Ko, Chair
Department of Physics
University of California, Davis
One Shields Avenue
Davis, CA 95616-8677

Further information about the department may be found on our website at **http://www.physics.ucdavis.edu.**

The University of California is an affirmative action/equal opportunity employer. The University undertakes affirmative action to assure equal employment opportunity for minorities and women, for persons with disabilities, and for special disabled veterans, Vietnam era veterans, and any other veterans who served on active duty during a war or in a campaign or expedition for which a campaign badge has been authorized.

University of Durham — Institute for Particle Physics Phenomenology

Postdoctoral Research Associates in Phenomenology

The Institute for Particle Physics Phenomenology (IPPP), a joint venture of the University of Durham and the UK Particle Physics and Astronomy Research Council (PPARC) was established in October 2000. A number of Postdoctoral Research Positions will be available from next year.

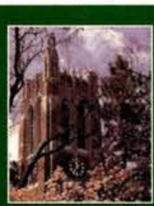
The successful candidates will have excellent research records in any area of particle physics phenomenology, and will have an important role to play in the establishment of the Institute as a world-class centre of phenomenology research and a key facility for the UK particle physics community.

The positions are tenable from 1 October 2003, or from an earlier or later date by agreement. Applications should be sent to:

Professor W J Stirling, Director, IPPP, Department of Physics,
University of Durham, Durham DH1 3LE, United Kingdom

to arrive no later than 10 January 2003. Applications should include a Curriculum Vita, a list of publications, and a brief description of research achievements and goals. Candidates should arrange to have 3 letters of recommendation sent to the above address.

For further information see www.ippp.dur.ac.uk



MECHANICAL ENGINEER
NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY
MICHIGAN STATE UNIVERSITY

The National Superconducting Cyclotron Laboratory of Michigan State University has a staff of approximately 130 people and is funded by the National Science Foundation for research in nuclear/accelerator physics and related instrumentation. We seek a mechanical engineer with experience in scientific research instrumentation and/or accelerator design.

Required: A minimum of a Bachelor's degree in mechanical engineering and 10 years experience in design and production of physics research instrumentation and/or accelerator equipment, or equivalent work in a related field.

Candidates must be capable of producing innovative design solutions to accomplish the conceptual requirements of the NSCL scientific program, be self-motivated to maintain schedules, have the capacity to participate in several projects simultaneously and be able to supervise/direct the work of support personnel.

Appointment level and salary will be commensurate with experience, demonstrated capability and the overall NSCL salary structure.

To Apply: Send resume plus names/contact points of three professional references to

Ms. M. Chris Townsend, Laboratory Administrator,
National Superconducting Cyclotron Laboratory,
Michigan State University,
East Lansing, MI 48824-1321
or e-mail mechanicalengineer@nscl.msu.edu.

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

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

LIP

Applications are invited for a post-doctoral position at LIP-Lisbon (www.lip.pt).

The position is funded by the European Research Training Network 'Physics Reconstruction and Selection at the Large Hadron Collider' **(http://cern.ch/sphicas/PRSATLHC/)**.

The main purpose of the proposed network is to study, design and implement the physics event selection of the CMS experiment in the LHC environment.

The position will be given for 2 to 3 years with a highly competitive salary determined according to qualification. Qualifications required include a PhD or equivalent in High Energy Physics, and a clear demonstration of the ability to carry out a research program. Knowledge of modern programming techniques, Object-Oriented software and C++ will be an asset.

Applicants must satisfy the EU RTN eligibility criteria **(http://www.cordis.lu/improving/networks/faq.htm#q5)**.
The position will remain open until suitable candidates are found.

Applications, including CV and reference letters, should be sent to:
Laboratory for Instrumentation and Experimental Particle Physics
Research Training Network-PRSATLHC
Av.Elias Garcia, nº 14 –1º , 1000-149 LISBON, PORTUGAL
e-mail: natalia@lip.pt

Postdoctoral Position – Search Extended

The Particle astrophysics group has an opening for a postdoctoral scholar. The successful candidate will join the group's research effort in the Pierre Auger Cosmic Ray Observatory. Prior experience with cosmic ray data analysis, electronics, atmospheric monitoring, or stellar photometry is desirable. A Ph.D. in Physics or Astronomy is required. Applicants should send their curriculum vitae, publication list, and statement of research interests, and should have 3 letters of reference sent to
Prof. David Nitz (dfnitz@mtu.edu), Department of Physics,
Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931-1295.
Applications will be accepted until the position is filled.

Michigan Technological University is an equal opportunity educational institution/equal opportunity employer.

HARVARD UNIVERSITY

POSTDOCTORAL RESEARCH FELLOW
EXPERIMENTAL HIGH ENERGY PHYSICS

The High Energy Physics Laboratory at Harvard University has three openings for Postdoctoral Research Fellows. Our research program is funded by the U.S. Department of Energy and includes the ATLAS Experiment at the Large Hadron Collider, studies of proton-antiproton interactions using the Fermilab CDF detector, of neutrino interactions in the MINOS experiment at Fermilab/Soudan, and of e+e- collisions with the SLAC Babar detector.

The first opening is with the ATLAS experiment. The successful candidate will be expected to develop software tools and their integration into a grid-based environment for LHC Computing (and other applications). This position also has flexibility to explore interesting new physics signatures expected at the electro-weak symmetry breaking scale. For questions regarding this opening please contact **Prof. John Huth huth@physics.harvard.edu.**

The second opening is with the CDF experiment. The successful candidate will work on physics analyses and Run2b upgrade electronics. For questions regarding this opening please contact **Prof. Andy Foland foland@physics.harvard.edu** or **Prof. Melissa Franklin franklin@physics.harvard.edu.**

The third opening is with the MINOS experiment. The successful candidate will work on reconstruction and analysis software and other activities depending on the candidate's interests and abilities. For questions regarding this opening please contact **Prof. Gary Feldman feldman@physics.harvard.edu.**

For these positions experience with state-of-the-art detector systems and with the analysis software of a particle physics experiment are appreciated. Interested applicants should send their CV, a statement of interest, and arrange to have three (3) letters of reference sent to:

Dr. George W. Brandenburg, Director
brandenburg@huhepl.harvard.edu
High Energy Physics Laboratory,
Harvard University
42 Oxford Street, Cambridge, MA 02138.

Harvard is an equal opportunity, affirmative action employer.

POSTDOCTORAL FELLOW
CENTER FOR COSMOLOGICAL PHYSICS

The NSF established the Center for Cosmological Physics (CfCP) at the University of Chicago in August 2001. 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, direct detection of DM particles and numerous topics in theoretical cosmology constitute the current slate of activities. The CfCP has active visitors, symposia, and education/ outreach programs.

Up to three 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.

The deadline is December 1, 2002 for positions that will begin in the Summer or Fall of 2003.

THE UNIVERSITY OF CHICAGO

TENURE RESEARCHER POSITION FOR RHIC PHENIX

RIKEN (The Institute of Physical and Chemical Research) invites applications for a tenure researcher position at the laboratory for experimental nuclear/hadron physics. The successful applicant is supposed to be resident at Brookhaven National Laboratory and play a leading role to carry out our experimental activities using polarized proton collisions and heavy ion collisions at Relativistic Heavy Ion Collider RHIC.

In this program we are involved in the PHENIX experiment, and other activities related to the polarized proton acceleration. He/she is also expected to develop and lead future activities of our laboratory which consists of about 20 physicists. Applicants must have Ph.D. and excellent background in experimental nuclear/particle physics.

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

Dr. H. En'yo, Radiation Laboratory, RIKEN, Hirosawa 2-1, Wako, Saitama 351-0198 Japan, before 30th of November 2002.

Email submission in PDF format is also accepted for applicants outside Japan.

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

RIKEN

UNIVERSITY OF FLORIDA

FACULTY POSITION
EXPERIMENTAL PARTICLE ASTROPHYSICS

The Department of Physics, University of Florida, invites applications for a tenure-track Assistant or Associate Professor in the field of Experimental Particle Astrophysics. More senior candidates may be considered in exceptional circumstances. The successful candidate will have a PhD degree, or equivalent, and postdoctoral experience, will be able to teach physics effectively at all levels, and will play a leadership role in a new experimental research effort. Specific examples of research programs of interest include high-energy cosmic rays, cosmic microwave background observations, non-accelerator based neutrino studies, gamma ray astronomy, dark matter searches and gravitational wave detection. Further faculty hires in the field are anticipated. The successful candidate will join an active faculty housed in a new physics building with extensive laboratory space and computer facilities.

Applicants should submit a CV, publication list, and a statement of research interests and plans, and should arrange to have at least three letters of recommendation sent. All correspondence should be sent to:

Chair, EPA Search Committee, Department of Physics,
PO Box 118440, University of Florida, Gainesville, FL 32611-8440.

To ensure full consideration, all application materials should be received by January 15, 2003.

Women and underrepresented minorities are strongly encouraged to apply.

The University of Florida is an Affirmative Action/Equal Opportunity Employer.

For further details on this position, please see:
http://www.phys.ufl.edu/department/jobs/epasearch.html

Postdoctoral Research Associate
Experimental High Energy Physics
Florida State University

We have an immediate opening for a postdoctoral research associate to work on the Fermilab D0 experiment. The successful candidate will contribute to the silicon tracker trigger (displaced vertex trigger) and the Run IIb trigger upgrade, as well as to a physics project of her/his choice, take data-collection shifts, and be resident at Fermilab.

Further information and application instructions are available from
Professor Susan Blessing (blessing@hep.fsu.edu)
or **www.hep.fsu.edu/~blessing/postdoc.html.**

Review of applications will begin immediately and continue until the position is filled.

Florida State University is an affirmative action/equal opportunity employer.

Duke University

Faculty Position in Experiment High Energy Physics

Duke University is seeking to fill a faculty position at the Junior (tenuretrack assistant professor) or Senior (tenured associate or full professor) level in the area of experimental high energy physics.

The Duke High Energy Physics group currently has a major research program in hadron collider physics through participation in the CDF and ATLAS experiments.

We are seeking candidates with outstanding records and exceptional promise for future growth in a new area such as neutrino physics. A strong commitment to excellence in teaching at both the undergraduate and graduate level is also expected. The position is available starting September 2003.

Applications received by January 15, 2003 will be guaranteed consideration.

Please send a resume and research statement to

High Energy Physics Search Committee, c/o Prof. Seog Oh,
Department of Physics, Box 90305, Duke University,
Durham, NC 27708, USA
(email: seog@phy.duke.edu).

Junior candidates should arrange to have three reference letters sent to the same address. Senior candidates should supply the names of up to three references.

Duke University is an affirmative action/equal opportunity educator and employer.

Computational Science Fellow

The Fermilab scientific program relies on advanced computational techniques and methods as an enabling technology towards achieving its scientific goals: for the simulation of accelerators, detectors and physics processes; for the development of the experiment data acquisition, data handling and processing frameworks; for the algorithms and methodologies to extract the physics results from the raw and processed data. The Fermilab Computational Science Fellows Program is designed to attract outstanding computational and computer scientists and provide an opportunity for mutually beneficial collaboration with Fermilab staff members and users. The goal is to provide direct benefit to the laboratory's current and future programs. Each Fellowship will have a duration of up to two years. Candidates must submit proposals describing their joint project with their Fermilab collaborator(s), a curriculum vitae, and a list of four references. Applications and requests for information should be sent to: Ruth Pordes, Chair, Computational Science Fellows Committee. (ruth@fnal.gov), Fermi National Accelerator Laboratory, MS 369, P.O. Box 500, Batavia, IL 60510-0500. EOE/M/F/D/V

Fermilab

US. Department of Energy Laboratory

cerncourier.com

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From Nuclear Transmutation to Nuclear Fission, 1932–1939 by Per F Dahl, IOP Publishing, ISBN 0750308656, £55 ($75/€75).

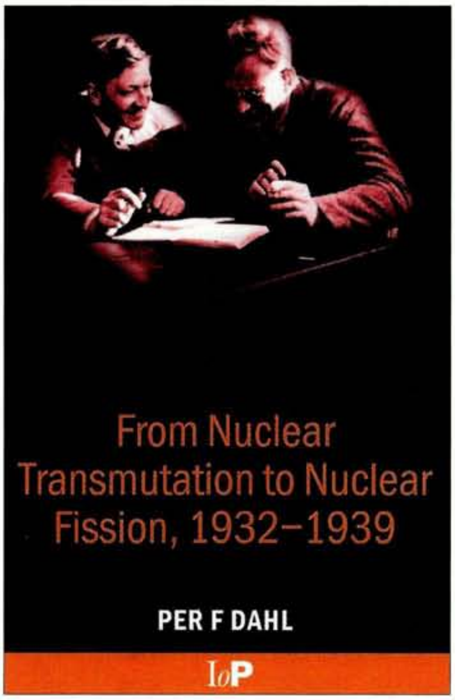
Per Dahl continues to be a careful and conscientious compiler of physics history. After *Flash of the Cathode Rays: A History of J J Thomson's Electron* (1997) and *Heavy Water and the Wartime Race for Nuclear Energy* (1999), his latest volume completes a trilogy published under the Institute of Physics imprint. The *Heavy Water* saga was compelling reading, but *Nuclear Transmutation* reverts to the solid scientific style of *Flash of the Cathode Rays*.

Nuclear Transmutation focuses on the competition between experimental teams in Europe and the US to furnish and exploit high-energy beams of subatomic particles in the quest to understand more about the atomic nucleus. Dahl, as in his other books, takes pains to place this central theme in a much broader context.

The period covered by the book links the twilight of the career of one physics giant named Ernest - Rutherford - with the emergence of another - Lawrence. The two main contenders in the competition were the Rutherford-inspired team of Cockcroft and Walton at Cambridge, and the group led by Lawrence at Berkeley. Their achievements and the subsequent award of the Nobel prize assured them a place in science history. Also prominent were the teams with Merle Tuve and Gregory Breit at the Carnegie Institution of Washington DC; Charles Lauritsen at Caltech; and Robert Van de Graaff at Princeton.

In the 1920s, the interior of the atomic nucleus was a complete mystery, but there was a widespread feeling that systematic studies using high-energy projectiles could reveal more about the nucleus. Each group developed its own technique to produce the necessary high voltages to accelerate projectile particles.

Many of Rutherford's physics achievements came before he arrived at Cambridge in 1919. The road ahead was to be more difficult, demanding inspired teamwork, Rutherford's dogged perseverance in his belief in the neutron, and the development and mastery of new techniques. However, Rutherford knew more than most about two complementary aspects of nuclear transformations: radioactive decay and reactions induced by radioactively emitted particles.



Rutherford's era in Cambridge also coincided with the development of modern quantum mechanics. While the majority of quantum mechanics applications focused on atomic physics, a deeper implication was seen by George Gamow. Radioactive particles tunnel, rather than leap, out of the nucleus. Gamow soon realized that if this were the case, energetic particles could also tunnel their way in.

At Cambridge, Gamow's new ideas immediately raised the research temperature. The payoff came in 1932 when Cockcroft and Walton "split the atom". This, along with Chadwick's discovery of the neutron the same year, was the high-water mark for Cambridge research, and soon the tide there began to ebb.

Dahl recounts how another tide rose in the US. In the mid-1920s, the young Lawrence had been dabbling in nondescript research. He and Tuve were both born in 1901 in the same small South Dakota town. Tuve, working under the astute Gregory Breit, wisely urged Lawrence to concentrate instead on digging deep in a potentially rich new physics vein - beams of subnuclear particles. Lawrence took the idea and ran with it, going on to invent the cyclotron. Dahl explains how Lawrence, obsessed with cyclotron performance, initially missed out on several major physics discoveries in the early 1930s. However, Lawrence's powerful and versatile machines quickly overhauled the rest of the field, and he received the Nobel accolade in 1939, while recognition for Cockcroft and Walton's pioneering achievement did not come until 1951. The lesson from Lawrence was that the development of big physics machines is not an end in itself, and must be complemented from the outset by physics insight and the provision of adequate detectors.

The history of accelerating subatomic particles has a curious Norwegian tradition. Both Lawrence and Tuve had Norwegian roots, as did Tuve's collaborators Lawrence Hafstad and Odd Dahl (who in the early 1950s initially led the team that developed CERN's first large accelerator). In Europe, accelerator pioneer Rolf Wideröe (whose work greatly influenced Lawrence) was also Norwegian. As Odd Dahl's son, Per Dahl is well qualified to document this story.

Towards the end of the 1930s, the physics spotlight turned away from artificially induced reactions to nuclear fission, again a transatlantic affair and with many of the earlier figures continuing to play key roles. Fission, a different kind of physics, is a closing parenthesis in the book.

Dahl contends that the early history of experimental nuclear physics was a race. It was surely more complicated than that. The history of science and technology is full of examples of different approaches to a common goal, where success and failure is not a simple binary outcome. In the quest to study the deep structure of matter using precisely controlled conditions, the Cambridge researchers got off to a flying start because of their unrivalled expertise in studying radioactive decays and nuclear transmutations. However, it was Lawrence who went on to set the industrial standard.

Gordon Fraser, CERN.

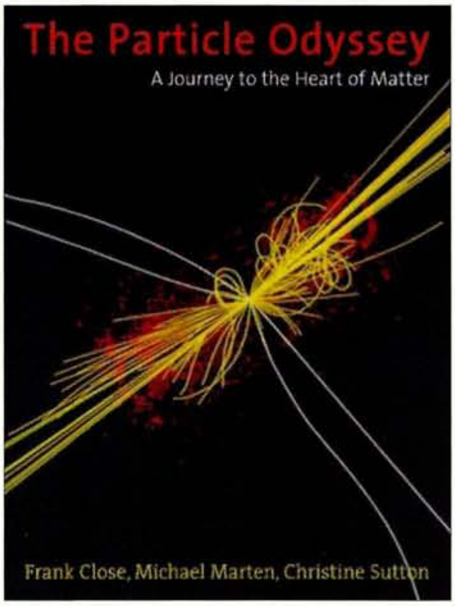
The Particle Odyssey by Frank Close, Michael Marten and Christine Sutton, Oxford University Press (2002), ISBN 0198504861, £29.95 (€48).

Fifteen years ago saw the publication of the most visually stunning, most accessible popular picture book on high-energy physics, *The Particle Explosion*. It resulted from a collaboration between theoretical physicist Frank Close, physicist and journalist Christine Sutton, and founder of the Science Photo Library Michael Marten. Theirs has proved a perfect partnership, bringing together clear explanation and story-telling; scientific ▷

rigour and journalistic flair; and visual impact.

The Particle Odyssey is not simply the same book under a new name. Some 250 of the pictures are entirely new, as are great swathes of text. Clearly, a lot has happened in the past 15 years, not least the complete operational lifetime of LEP, the discovery of the top quark at Fermilab, and the first signs of neutrino oscillations. It is also interesting to note how book design has changed. After leafing through *Odyssey*, *Explosion* seems strangely dated. The new edition has whiter, glossier paper and crisper illustrations, some of them bled off the pages. Every page is eye-catching, and I suspect that considerably more text has been squeezed into the same 240 pages, mostly by greater column width.

The change of title is perhaps revealing too. Back in the 1980s, just after the discovery of the W and Z bosons, it seemed that there had been an explosion of particles, almost more than theory could accommodate. Since then, I suspect, to those patiently wading through the terabytes of data, it has been more like an odyssey to try and catch the last remaining particles within experimental range. It has been interesting to watch high-energy physics as a journalist for the past 15 years. It is not easy to find a news peg in an incremental advance. A few thousand more data points do not make a story; a surprise or a race between laboratories does. As a result, I think I reported the discovery of the top quark three or possibly four times before its final confirmation! On the other hand, it is frustrating when a laboratory won't issue a public announcement even when you know the data are accumulating. This book recounts most of the trials and tribulations from the physicists' point of view, and, by telling many of the stories in their historical sequence, it gives us some very readable tales.



I recommend this book to everyone, whether they have read *The Particle Explosion* already or not; and whether they are complete novices or professional physicists. If you don't know the stories, it's a new adventure. If you do, it's a model of story-telling. And whoever said picture books were only for children? My only hope is that there will be enough new physics for another version in 15 years' time.
Martin Redfern, BBC Radio Science Unit.

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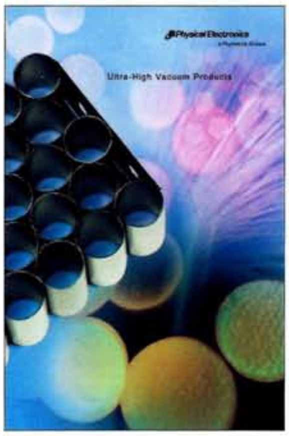

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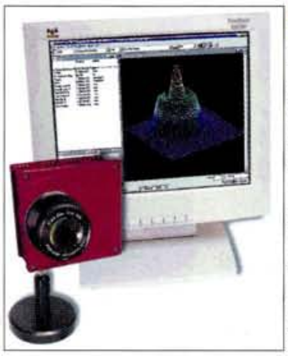

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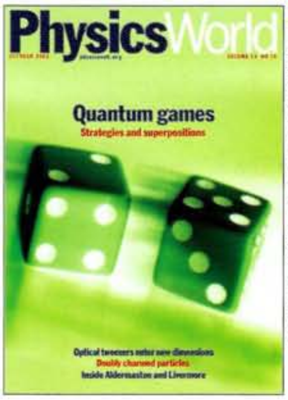

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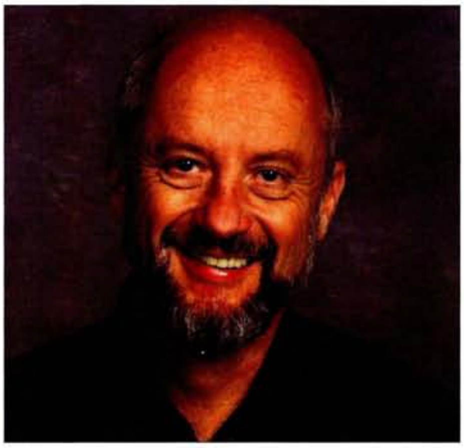
Berkeley Lab: evolving for the future

Originally an accelerator laboratory, LBNL now covers a broad range of fields. Deputy director **Pier Oddone** outlines the vibrancy of the multidisciplinary approach.

Would E O Lawrence recognize his laboratory today? Founded in 1931 by the University of California as a venue for Lawrence's successive generations of ever-larger cyclotrons, today's Lawrence Berkeley National Laboratory (LBNL) is a thriving multidisciplinary institution pursuing basic and applied research across a broad front, with many of the most exciting discoveries occurring at the boundaries between disciplines. Strength in nuclear and particle physics, the foundational sciences of LBNL, is evident in key contributions to the Asymmetric B-factory at SLAC; the development of silicon vertex detectors for CDF, BaBar and ATLAS; major roles in building STAR for the Relativistic Heavy Ion Collider at Brookhaven and the detector for the Sudbury Neutrino Observatory; and the discovery of the accelerating expansion of our universe – to mention a few prominent examples. Yet the activities in these areas comprise only 10% of LBNL's programme.

Growth and diversification notwithstanding, Lawrence would recognize at least three features that continue to define today's laboratory. First, the campus connection. The Radiation Laboratory (Rad Lab) was first established as an entity within UC Berkeley's Physics Department, and though most of its activities migrated in the 1940s to a hillside site adjacent to the campus – and though it is now an institution independent of the campus – the link remains firm. More than 200 faculty scientists and well over 300 graduate students pursue research at the laboratory, and it extends well beyond its physical boundaries to encompass a host of research labs and facilities on the Berkeley campus. Disciplinary strength from the campus faculty – joined with the orientation of the laboratory to solve problems of scale, and the enthusiasm of students and postdocs – create an effervescent mixture that drives the laboratory.

A second constant has been the central role of major facilities. Times have changed, of course, and so has the nature of the facilities appropriate to our urban site. The big, single-purpose machines of particle physics have been replaced with state-of-the-art facilities



of a different scale, which cater to broader, multidisciplinary audiences. The 88 inch Cyclotron remains a productive tool dedicated to the national nuclear science community, but the newer National Center for Electron Microscopy, National Energy Research Scientific Computing Center (NERSC) and Advanced Light Source (ALS) are emblematic of today's multidisciplinary reach. The ALS in particular ties the past to the future; it resides under the dome of the dismantled cyclotron whose size forced the Rad Lab off campus and onto its current hillside site. Its design in the late 1980s relied on the expertise of accelerator physicists who traced their intellectual lineage to Lawrence's hand-picked colleagues. But there ends the resemblance to machines of the past; the ALS is an electron storage ring, a source of synchrotron radiation serving chemists, surface and materials scientists, atomic physicists and structural biologists from around the country. Also notable, but without even a distant parallel from Lawrence's era, NERSC is one of the largest massively parallel computers in the civilian sector, serving more than 2000 users nationally.

Third, and most important, Lawrence would recognize the enduring spirit of team science that gave birth to the oldest of our national laboratories in the first place. Most surprising to him, perhaps, would be the extension of this spirit to encompass much of modern biology. Indeed, the Human Genome Project was the brainchild of the Department of Energy, overseer and principal funding source for the national laboratories, in recognition that old-fashioned bench biology would never get the job done. Three labs, including Berkeley, joined to form the Joint Genome Institute in 1997, a paradigm of team science and a key producer of human genome sequence data. Today, the era of modern biology is well launched – an era characterized by interdisciplinary teamwork. Engineers contribute instrumentation and robotic automation to ongoing genome-sequencing efforts. Computational scientists work to make sense of an exploding quantity of genomic and structural data. And even physicists have turned to such biological challenges as how proteins fold to assume their unique active configurations.

Teamwork and disciplinary fuzziness are also evident at the "nano" frontier. The next national user facility at Berkeley Lab is likely to be the Molecular Foundry, 7500 m^2 of research laboratories and advanced instrumentation designed to bring together biologists, materials scientists, chemists and physicists working at the nanoscale. Cross-fertilization in this area is already evident in such concepts as protein nanowires, DNA scaffolds to array nanostructures, nanocomposites for bone replacement, quantum dots and magnetic nanoparticles as biological probes, and nanomaterials for efficient solar cells.

The constancy of teamwork is perhaps the key point. Computational power and instrumental probes capable of molecular or atomic-level resolution and manipulation are now exposing the physical roots even of fields recently dominated by individual investigators at their workbenches. Thus, a laboratory born of accelerator physics and nurtured by one man's concept of team science has evolved into a multidisciplinary institution and now, logically, a truly interdisciplinary one – a laboratory still recognized for its contributions to particle physics and nuclear science, but increasingly committed to uniting the biological and physical sciences at the frontiers of knowledge.

Pier Oddone, LBNL.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