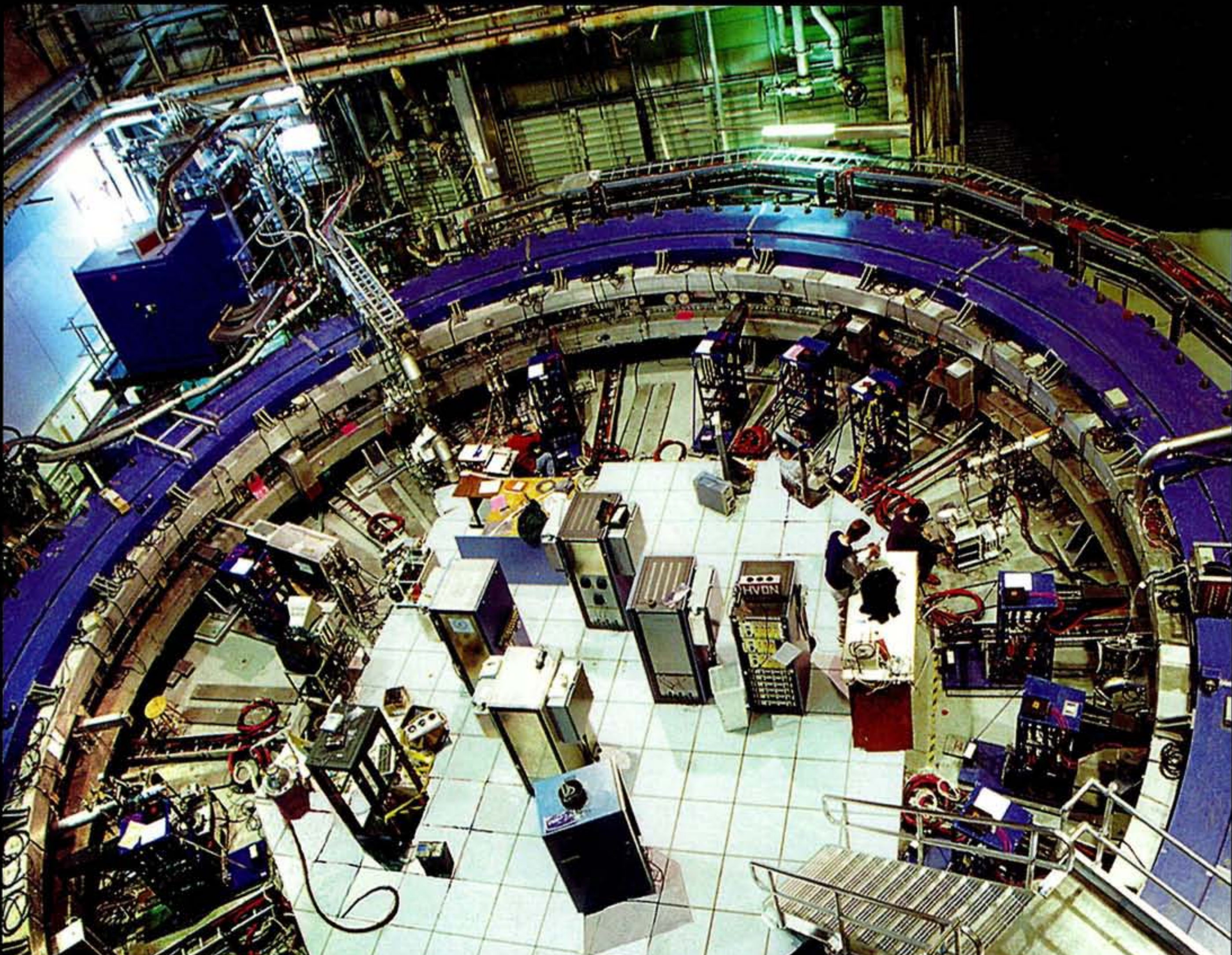
INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 42 NUMBER 7 SEPTEMBER 2002

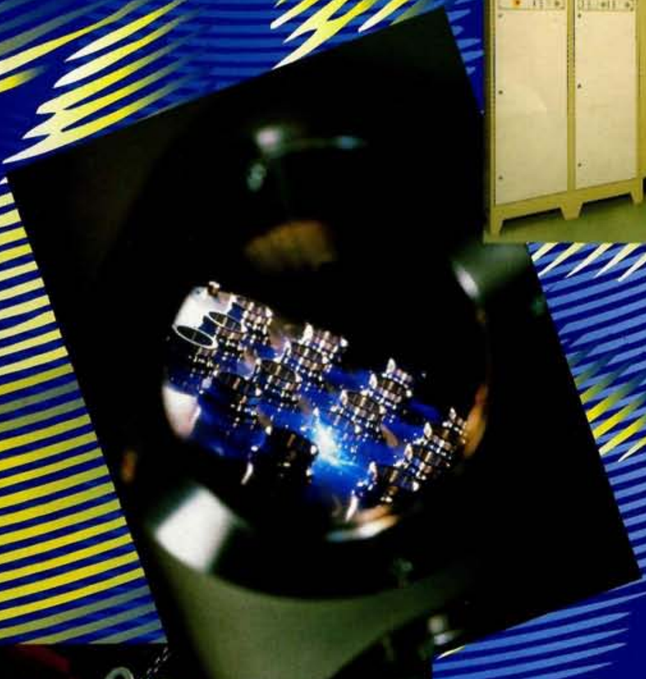


Measuring muons more precisely

CERN
External Review Committee affirms LHC as global priority p5

LINEAR COLLIDERS
German Science Council delivers positive report on TESLA p6

ANNIVERSARY
Celebrating Paul Dirac's centenary year p15




DANFYSIK

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

CERN Courier (ISSN 0304-288X) is distributed to member state governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly, except for January and August, in English and French editions. The views expressed are not necessarily those of the CERN management.

Editor James Gillies
CERN, 1211 Geneva 23, Switzerland
Email cern.courier@cern.ch
Fax +41 (22) 782 1906
Web http://www.cerncourier.com

Advisory Board R Landua (Chairman), F Close, E Lillestøl, H Hoffmann, C Johnson, K Potter, P Sphicas

Laboratory correspondents:
Argonne National Laboratory (US): D Ayres
Brookhaven, National Laboratory (US): P Yamin
Cornell University (US): D G Cassel
DESY Laboratory (Germany): Ilka Flegel, P Waloschek
Fermi National Accelerator Laboratory (US): Judy Jackson
GSI Darmstadt (Germany): G Siegert
INFN (Italy): A Pascolini
IHEP, Beijing (China): Qi Nading
Jefferson Laboratory (US): S Corneliussen
JINR Dubna (Russia): B Starchenko
KEK National Laboratory (Japan): A Maki
Lawrence Berkeley Laboratory (US): Christine Celata
Los Alamos National Laboratory (US): C Hoffmann
NIKHEF Laboratory (Netherlands): P Mulders
Novosibirsk Institute (Russia): S Eidelman
Orsay Laboratory (France): Anne-Marie Lutz
PSI Laboratory (Switzerland): P-R Kettle
Rutherford Appleton Laboratory (UK): Jacky Hutchinson
Saclay Laboratory (France): Elisabeth Locci
IHEP, Serpukhov (Russia): Yu Ryabov
Stanford Linear Accelerator Center (US): M Riordan
TRIUMF Laboratory (Canada): M K Craddock

Produced for CERN by Institute of Physics Publishing Ltd
Institute of Physics Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel. +44 117 929 7481
Email jo.nicholas@iop.org
Web http://www.iop.org

Publishing director Richard Roe
Publisher Jo Nicholas
Art director Andrew Giaquinto
Production Kerry Harding and Laura Churchill
Technical illustrator Alison Tovey
Advertising manager Chris Thomas
Deputy advertising manager/Display sales Jayne Purdy
Recruitment sales Ed Jost and Debra Wills
Advertisement production Katie Graham, Joanne Scriven
Product manager Laura Serratrice

Advertising Chris Thomas, Jayne Purdy, Ed Jost or Debra Wills
Tel. +44 117 930 1031
Email sales@cerncourier.com
Fax +44 117 930 1178

General distribution Jacques Dallemagne, CERN, 1211 Geneva 23, Switzerland. Email jacques.dallemagne@cern.ch
In certain countries, to request copies or to make address changes, contact:
China Chen Huaiwei, Institute of High-Energy Physics, PO Box 918, Beijing, People's Republic of China
Germany Gabriela Heessel or Veronika Werschner, DESY, Notkestr. 85, 22603 Hamburg 52. Email desypr@desy.de
Italy Loredana Rum or Anna Pennacchietti, INFN, Casella Postale 56, 00044 Frascati, Roma
UK Mark Swaisland, CLRC, Daresbury Laboratory, Keckwick Lane, Daresbury, Warrington WA4 4AD. Email m.swaisland@dl.ac.uk
US/Canada Published by *Cern Courier*, 6N246 Willow Drive, St Charles, IL 60175. Periodical postage paid in St Charles, IL. Fax 630 377 1569. Email vosses@aol.com. Postmaster: Send address change to: Creative Mailing Services, PO Box 1147, St Charles, IL 60174

Published by European Organization for Nuclear Research, CERN, 1211 Geneva 23, Switzerland. Tel. +41 (22) 767 61 11
Telefax +41 (22) 767 65 55

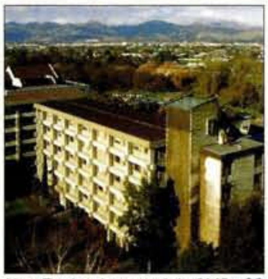
Printed by Warners (Midlands) plc, Bourne, Lincolnshire, UK

ISSN 0304-288X

CERN COURIER

VOLUME 42 NUMBER 7 SEPTEMBER 2002

German boost for TESLA p6



New Zealand groups join CMS p29

Lederman celebrates 80th p36

Cover: Researchers at the US Brookhaven National Laboratory's muon g-2 ring collected data from 1997 to 2000. A first result based on a partial data set was announced in 2001 and showed an apparent discrepancy with the Standard Model of particle physics. When theoretical calculations were redone agreement was restored. With the increased precision of the experiment's final result, however, the discrepancy re-emerges (p8). Photo: BNL.

CES Physics News

Available Now!

Where the Real-Time is at!

RIO3 8064

Hardware

A new RIO3 doubles the computing speed to make VME 2eSST speeds:

- The new RIO3 8064Sx is the first VME PowerPC processor with external L3 cache
- The RIO3 CPUs are the fastest VME machines featuring VME 2eSST at 180 MBytes/s
- PowerPC 7455 CPU starting at 800 MHz with 2 MBytes L3 cache
- Backward compatible with other RIO3s

Linux Toolkit

2nd Generation of Linux on CES Processors

Improved toolkit available from August:

Same facilities as LynxOS® and VxWorks® BSPs

Real Usable VME Support

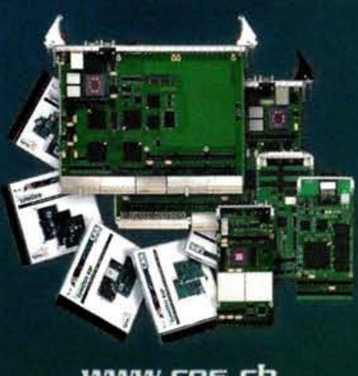
- Single shot and DMA transfers including linked lists DMAs
- Programmable interrupt handling
- VME 2eSST support at 180 MBytes/s

Real Convivial Environment

- RAM disk support allows multiple systems to boot from the same server sharing the same NFS file system
- Multiple boot modes including network (TFTP, BOOTP), PMC hard disk and FEPROM
- HTML and PDF on-line document files

Real Open Software Environment

- Allows to run LynxOS® / VxWorks® on MFCCs (Multifunction Computing Core PPMCs)



Rely on CES as a discrete, efficient and dependable partner !

CES

CREATIVE ELECTRONIC SYSTEMS

CES Germany
Am Spielacker
D-63571 Gelnhausen
GERMANY
(tel) 00.49.60.51.96.97.41
(fax) 00.49.60.51.96.97.38
norbert.loerch@ces.ch

38 avenue Eugène Lance
1212 Grand-Lancy 1 / Geneva
SWITZERLAND
(tel) 00.41.22.884.51.00
(fax) 00.41.22.794.74.30
ces@ces.ch

www.ces.ch

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

CERN

Committee affirms LHC as global priority

Following the funding shortfall for CERN's Large Hadron Collider (LHC) that emerged last September, the laboratory established five task-forces to examine ways of redeploying resources to the new accelerator. In parallel, the laboratory's governing body, Council, established an External Review Committee (ERC) under the chairmanship of Robert Aymar, director of the International Thermonuclear Experimental Reactor. The task-force recommendations were presented to Council in March, and form the basis of a medium-term plan that was submitted to Council for approval in June. Elements of the plan include a cutback in the ongoing research programme (with the Proton Synchrotron and Super Proton Synchrotron accelerators shutting down for all of 2005), redeployment of personnel to the LHC, new accounting and reporting measures and a reduction in accelerator R&D.

The ERC presented its final report to the June meeting of Council. Covering immediate measures to resolve the current problems as well as structural changes for the longer term, the report's recommendations were accepted by Council as a well balanced set of measures for the future of CERN. Council noted the coherence between the ERC's recommendations and the management's medium-term plan, issuing a statement saying that it "believes that the ERC report and the management proposals are an important step towards solving the problems identified and re-establishing an atmosphere of trust".

Robert Aymar's review committee found the technical basis of the LHC to be sound, but criticized CERN for weak cost awareness.

In its report, the ERC found CERN to be a laboratory "justifiably proud of its past success and of its worldwide reputation" – success that "speaks loudly for its permanent asset: a competent and dedicated staff". The committee also found that "the technical basis of the LHC accelerator is sound", and affirmed that the LHC is "the worldwide priority in high-energy physics: the support to CERN for this objective will not fade out". However, the ERC did find that the crisis that became apparent last year arose from "serious weaknesses... in cost awareness and control, as well as in contract management and financial reporting".

The report makes various recommendations to improve financial procedures at CERN, including a transition to "earned value" reporting and to integrated personnel and materials accounting, which are currently treated separately. The ERC also looked at non-LHC related scientific activities at CERN and recommended a significant transfer of staff to the LHC.

CERN's management is now preparing an action plan and timetable for the detailed implementation of the ERC's recommendations for presentation to Council this month. The management will also prepare, for Council in December, a proposal for the revision of the 1996 financial framework for the LHC, with the completion of the LHC as the all-out priority in the years to come. This revision will include the cost-to-completion for the LHC project, the resources for the non-LHC programme and a new long-term financial framework and staff plan for the organization.

With a clear convergence between the ERC and CERN management, the June meetings of the laboratory's Council ended in an atmosphere of renewed confidence in the laboratory's ability to deliver the LHC, and in its long-term future. This was underlined by Council's approval of an expenditure figure of SwFr 1217 million (€840 million) for 2003 and the release of SwFr 33 million from the 2002 CERN budget that had been frozen pending clarification of LHC funding issues.

NORTH AMERICA

Canada steps onto the international stage

Canadian particle physics received a boost earlier this year when the Canadian Foundation for Innovation announced support for nine infrastructure projects for international research. These include two projects in particle physics – a new International Facility for Underground Science and the KOPIO experiment. The nine projects, which are aimed at promoting Canada's position in scientific research, were selected by a national competition with input from international experts.

The International Facility for Underground Science will be based at the site of the Sudbury Neutrino Observatory (SNO) at the Creighton mine in Ontario. Here the intention is to expand the site to become a facility for further experiments, in particular with international participation. Its administrative centre will be at Carleton University.

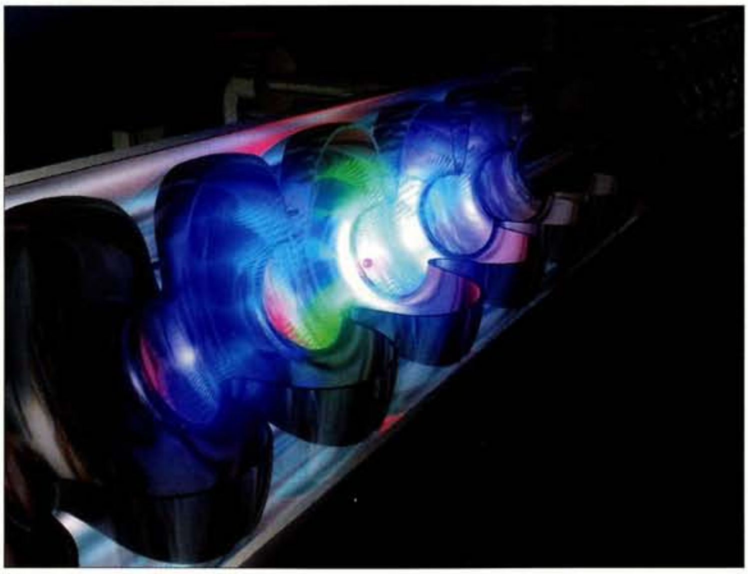
Snow at SNO – a wintry approach to the Creighton mine's number 9 shaft.

The aim of the KOPIO project, in which Canadian physicists are playing a leading role, is to use the Alternating Gradient Synchrotron at the Brookhaven National Laboratory to create an intense beam of kaons for the study of very rare decays, which can provide a window into the small differences between matter and antimatter (*CERN Courier* March p4).

TESLA

German Science Council endorses TESLA

On 15 July 2002 the German Science Council published its evaluation of large-scale facilities for basic research in natural science. The council gave the TESLA superconducting linear electron-positron collider, planned by Hamburg's DESY laboratory and a host of international partners, a strong nod of approval, deeming the project to be worthy of support subject to a number of conditions. The council requested a detailed proposal for TESLA to include the vital aspect of international participation, and requested a revised technical proposal for the TESLA X-ray laser based on a separate linear accelerator. In its statement the council stressed that TESLA is a world-leading development test-bed for superconducting linear accelerators, RF components and linac-driven free electron lasers, and that the technical aspects of the project have reached a high degree of maturity.



The German Science Council's positive assessment of the TESLA linear collider is a vote of confidence for particle physics.

Development work for the TESLA project is currently being carried out within a large international collaboration under the overall leadership of DESY. Some 45 institutes from 11 countries are involved in developing and testing the TESLA accelerator and free electron laser technology. According to the TESLA Technical Design Report, published in March 2001, TESLA would be constructed as a linear collider with integrated X-ray lasers – two 15 km linear accelerators would face each other in a 33 km tunnel. Particle physics experiments would be located in the middle of the facility, while the electron accelerator would also serve as a driver for X-ray free electron lasers (X-FEL, *CERN Courier* June 2001 p20).

In October 2001 an option was added to the proposal according to which a separate linear accelerator would be built for the X-FEL to avoid direct coupling with the linear collider, thus bringing increased planning and operation flexibility. The separate linear accelerator for the X-FEL would be set up in an additional 5 km tunnel parallel to the main accelerator.

The German Science Council's endorsement of the TESLA project brings with it a strong vote of confidence for particle physics and for a future linear collider. Along with the Japan Linear Collider and the US-based Next Linear Collider, TESLA is one of three projects preparing for such a machine. Particle physicists around the world are broadly united in the belief that a linear collider is the next logical step for particle physics to follow CERN's Large Hadron Collider. For DESY in particular the endorsement is an important landmark, because it gives the laboratory the encouragement to try to build international support around its TESLA proposal.

CERN

CERN–Asia programme offers grants to young postgraduates

Within the framework of the CERN-Asia Fellows and Associates programme, CERN offers three grants every year to East, Southeast and South Asia postgraduates under the age of 33, enabling them to participate in its scientific programme in the areas of experimental and theoretical physics and accelerator technologies. The appointment will be for one year, which might, exceptionally, be extended to two years.

Applications will be considered by the CERN Fellowship Selection Committee at its meeting on 28 January 2003. An application must consist of a completed application form, on which "CERN-Asia Programme" should be written; three separate reference letters; and a curriculum vitae that includes a list of scientific publications and any other information regarding the quality of the candidate. Applications, references and any other information must be provided in English only.

Application forms can be obtained from: Recruitment Service, CERN, Human Resources Division, 1211 Geneva 23, Switzerland. Email Recruitment.Service@cern.ch, or fax +41 22 767 2750. The closing date for applications is 20 November 2002.

The CERN-Asia Fellows and Associates Programme also offers a few short-term Associateship positions to scientists under 40 years of age who are on a leave of absence from their institute. These are open either to scientists who are nationals of the East, Southeast and South Asian countries who wish to spend a fraction of the year at CERN, or to researchers at CERN who are nationals of a CERN member state and wish to spend a fraction of the year at a Japanese laboratory.

● Candidates are accepted from Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, China, India, Indonesia, Japan, Korea, the Laos Republic, Malaysia, the Maldives, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam.

GRAVITATIONAL WAVES

Meeting heralds global GW detector network

As the curtain is being raised on today's generation of gravitational wave (GW) detectors, the individual project teams met to consider future detectors and the goal of running the global ensemble of instruments as a single array. For this purpose, the annual Aspen Meeting on Advanced Gravitational Wave Detectors descended from its traditional Colorado, US, venue and was held at La Biodola on the Island of Elba, close to the Virgo interferometer site. The Gravitational Wave International Committee sponsors the Aspen meetings, which are usually organized by the US LIGO observatory. On this occasion the meeting moved to Europe to acknowledge the growing international collaboration between all the individual efforts. The meeting drew about 100 scientists from all continents, including representatives from the Germany–UK GEO project, and strong participation from Japan and Australia.

An aerial view of the Virgo site in Cascina, Italy. The Virgo Gravitational Wave Interferometric Detector is being commissioned and the participants visited it at the start of the meeting.

The theme of the meeting was operating the interferometers as a single machine, echoing an idea from Adalberto Giazotto, one of the fathers of the GW interferometric detector field. The GW interferometers are recognizing the more mature GW bar-detector community, which has already coordinated its data-taking and observations. Bar-community participants at the meeting offered concrete examples of how to build a global collaboration that will include interferometers and bars. No less important was the participation of the nascent space-based interferometric detectors for the detection of ultra-low-frequency gravitational waves.

Although the main emphasis was on future developments, the meeting took place as all of the world's present-generation GW interferometers are reaching maturity. This was an occasion to review the extraordinary recent advances of interferometer commissioning by LIGO, GEO, Virgo and Japan's TAMA, and early coincident operation by LIGO, GEO and the Allegro bar in Louisiana. The rapid commissioning and initial data-taking of the new interferometers leads to the challenge of effectively networking them in a single global data acquisition and analysis system.

TAMA, so far the groundbreaker, reported on a coincidence run between itself and LISM, a pilot underground interferometer in the Kamioka mine, the future site of the projected LCGT kilometre-class cryogenic interferometer. TAMA also announced coincidence data collection with LIGO and GEO that will occur this summer as those two instruments perform their first scientific observation periods. Japanese teams also presented impressive advances on cryogenic techniques for third-generation GW interferometers.

Participants at the meeting enjoy a visit to Pianosa Island, near Elba.

LIGO reported on its successful commissioning and rapid progression in sensitivity. The three LIGO interferometers, already exercised as an integrated network, are now, together with GEO, at the TAMA sensitivity. This will make the forthcoming GEO-LIGO-TAMA common data-taking even more interesting. GEO presented its advances and reported on the installation of futuristic all-fused silica and low-thermal-noise mirror suspensions.

Virgo, just finishing the construction of its 3 km vacuum arms, reported on the successes of its Central Interferometer with its advanced low-frequency seismic attenuation chains and its hierarchical mirror control system. Virgo plans to commission its long arms as early as the end of this year. Once Virgo operates as a complete detector it will lead in sensitivity below 50 Hz. Virgo and LIGO are already exchanging environmental data and preparing to integrate the Virgo data in the global network as soon as the complete Virgo is operational.

All the groups are gearing up to treat the data that starts being produced by the interferometers. All the groups are attaching growing importance to simulations for understanding the instruments and the data. Several challenges ahead were discussed, ranging from the development of advanced suspension and seismic isolation systems, and sensors for Newtonian noise estimation, to theoretical thermal-noise issues. Everybody left Elba feeling they had participated in an extremely productive event.

BROOKHAVEN

Muon magnetism study reveals new twist

In the latest twist to the US Brookhaven laboratory's high-precision muon magnetism experiment, researchers announced in July a result slightly at odds with the Standard Model of particle physics.

The Brookhaven experiment measures the quantity g-2 for the muon, where g is the particle's so-called gyromagnetic ratio – the ratio of its magnetic moment to its spin angular momentum. According to classical Dirac quantum theory, this should be exactly two. However, additional small effects can change this value, leading to a non-zero g-2.

The muon storage ring used for Brookhaven's dedicated muon g-2 experiment. (BNL.)

The quantity g-2 is a very sensitive probe for testing the Standard Model, so when in 2001 the Brookhaven team announced a result at odds with Standard Model calculations (*CERN Courier* April 2001 p4), the particle physics world took notice. However, when the theoretical calculations were redone, a small error was found and agreement between theory and experiment was restored (*CERN Courier* January/February p7).

The original Brookhaven measurement was based on an analysis of 10^9 muon decays accumulated in 1999. The result announced in July includes a second data sample, accumulated in 2000, which contains four times as much data as the first. The new measured value of g-2 reinforces the earlier result with a total error of 0.7 ppm compared with the 1.3 ppm for the 1999 data measurement. Along with further refinement of the theoretical calculations, it shows a slight discrepancy with the current Standard Model value, differing by between 1.6 and 2.6 times the estimated error of the measurement. This is too small a discrepancy to claim new physics. Given the precision achieved by the Brookhaven experiment, however, it is bound to attract speculation.

SYNCHROTRON LIGHT

DESY turns storage ring into light source

Hamburg's DESY laboratory is to convert its PETRA storage ring into a third-generation synchrotron radiation source following a €1.4 million grant from the German Federal Ministry of Education and Research to cover the design phase. A formal proposal will be submitted in 2004, allowing reconstruction to begin in January 2007. The new light source, PETRA III, will run at 6 GeV with a current of more than 100 mA. DESY expects the 13–15 planned undulator beam lines to provide the highest brilliance of any storage ring-based

source at start-up. PETRA was used for particle physics research from 1978 to 1986. Since then, as PETRA II, it has formed part of the injector chain for DESY's HERA collider.

ESO

UK signs up to ESO

On 1 July, the UK officially became a member of the European Southern Observatory (ESO). ESO runs the four 8.2 m and smaller telescopes making up the Very Large Telescope array in the Atacama desert, and also the La Silla observatory, Chile. Future projects include the Atacama Large Millimetre Array (ALMA) and the Overwhelmingly Large Telescope (OWL). The UK is the 10th member of ESO. The others are Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Sweden and Switzerland.

ELECTRONIC PUBLISHING

Publishers make JHEP archive available online at no charge

The *Journal of High Energy Physics* (JHEP) archive, 1997–2001, plus current 2002 material has been made available free of charge by Institute of Physics Publishing (publishers of *CERN Courier*) until the end of the year. Institute of Physics Publishing took responsibility for the electronic-only publication of the journal in January, while submission and peer review remain the responsibility of the International School for Advanced Studies (SISSA) in Trieste, Italy.

Up to now JHEP has been financed by SISSA with contributions from Italy's Istituto Nazionale di Fisica Nucleare, CERN and, more recently, other laboratories and universities. With the journal's growing size and importance, however, this is no longer viable and from January 2003 JHEP will be available to institutions for an annual subscription of £600/$900. The 1997–2002 archive will remain free. See http://www.iop.org/journals/jhep.

Edited by Archana Sharma

Scientists produce single-molecule transistor

Imagine a computer crash that does not result in any loss of data – that is what the new "spintronic" transistor promises. Researchers at the Institute of Microstructural Science in Ottawa, Canada, have built a new transistor based on the fundamental property of spin for controlling and switching electrical current.

Normal electronics and microelectronics are based on just the number of electrons; transistors are based on devices that switch states when current passes through them or not. The new spintronic transistor, however, is made from a quantum dot (*CERN Courier* January/February p9), which holds the electrons just like atoms. Electrons may be added one by one with a defined spin state – up or down – which in turn defines whether or not electrical current can pass through the quantum dot. A magnetic field is used to tune the quantum dot so that the spins of the electrons can be aligned. This is the "gate mechanism", which can turn the dot "on" or "off".

Despite being a big challenge, researchers have been able to maintain flowing currents through spintronic devices, which has raised hopes that they could replace bulkier electronics in the future. No practical circuit has yet been operational, but promises of quantum computers that could boost the capacity and power of information technology many times over are in the offing.
Nature Science News

Portable X-ray diagnostics now operational

These pictures of a hand and a fish were taken with a carbon-nanotube X-ray source.

In a revolutionary miniaturization of the conventional X-ray tube, physicists from the University of North Carolina have invented a cheap and portable means for biomedical imaging. Current X-ray tubes have cathodes that operate at temperatures of 1000–1500 °C, giving off X-rays from the heated filament. The new instrument uses the same concept – high-energy electrons strike a piece of metal, stimulating its atoms to emit X-rays. In this device, however, the emission occurs at room temperature and consumes much less power than traditional cumbersome X-ray machines.

A carpet of tiny filaments – carbon nanotubes, each a few millionths of a millimetre across – is laid on a disc. When the disc is negatively charged, a positively charged mesh placed just above it can extract electrons from the tips of the nanotubes. These strike a positively charged copper plate a few millimetres from the mesh, which then emits X-rays. The device can be miniaturized to a small volume, and is capable of providing high-resolution images. Its tightly focused beam also removes the risk of damaging the surrounding tissue. The device could also be used to produce ultrahigh-resolution X-ray images that would be useful in materials sciences as well as in medicine. The researchers have operated their device continuously for more than 10 hours without any signs of degradation.

Reference

Yue *et al.* 2002 *Appl. Physics Letters* **81** 355–357.

Researchers find evidence of double proton radioactive decay

Stable atomic nuclei are characterized by the number of protons and neutrons that they contain. This equilibrium is perturbed by an excess of either protons or neutrons, leading the nucleus to become unstable and disintegrate, usually via beta decay.

Now, for the first time, researchers from the French GANIL and German GSI laboratories have found evidence of the radioactive disintegration of iron-45 by the simultaneous emission of two protons. This mode of decay has been sought after for 40 years, and its discovery will open up new avenues in the study of the structure of atomic nuclei.
CNRS/GSI

Edited by Emma Sanders

VLT discovers early galactic cluster

How the first groups of galaxies formed is one of the biggest mysteries in modern cosmology. Now another piece of the puzzle has been identified by the Very Large Telescope (VLT) in Chile, with the discovery of a cluster of 20 galaxies at a redshift of 4.1. This is the furthest cluster of galaxies ever observed.

Studies of early galaxy clusters provide an important constraint for theories of galactic evolution, but they are extremely difficult to detect. The new observations focused on areas around known radio galaxies (galaxies with particularly strong radio emission). Radio galaxies are excellent tracers for early galaxy formation, as they are found in high-density regions of the early universe that evolve into present-day clusters.

The tactics paid off. The 20 galaxies that were discovered belong to a group that measures approximately 10 million light-years across. This "proto-cluster" confirms that large-scale structures had already formed when the universe was about a tenth of its present age.

Reference

2002 *Astrophys. J.* **569** L11–L14.

New study takes a dim view of quasars

Some of the universe's most luminous objects might not be as bright as they seem. A recent study suggests that around a third of high-redshift quasars may have their emission magnified by a factor of 10 or more through gravitational lensing by galaxies along the line of sight.

Quasars release huge amounts of energy, outshining galaxies of hundreds of billions of stars, from a space the size of our solar system. They are thought to be powered by the accretion of gas onto supermassive black holes in their centre. Extremely bright quasars have recently been found with redshifts of up to 6.28. As luminosity is proportional to mass, some of these bright quasars are expected to house black holes with masses more than a few billion times greater than the sun's.

The number of these enormous black holes, so soon after the Big Bang, poses a problem for models of structure formation. If gravitational lensing does amplify the emission of distant quasars to such an extent, some of these problems would be allayed.

Gravitational lensing typically produces multiple images of a source, as well as magnifying it. These images are expected to be so close together in the sky that new observations using the Hubble Space Telescope or a large ground-based telescope will be needed to test the theory.

Reference

2002 *Nature* **417** 923–925.

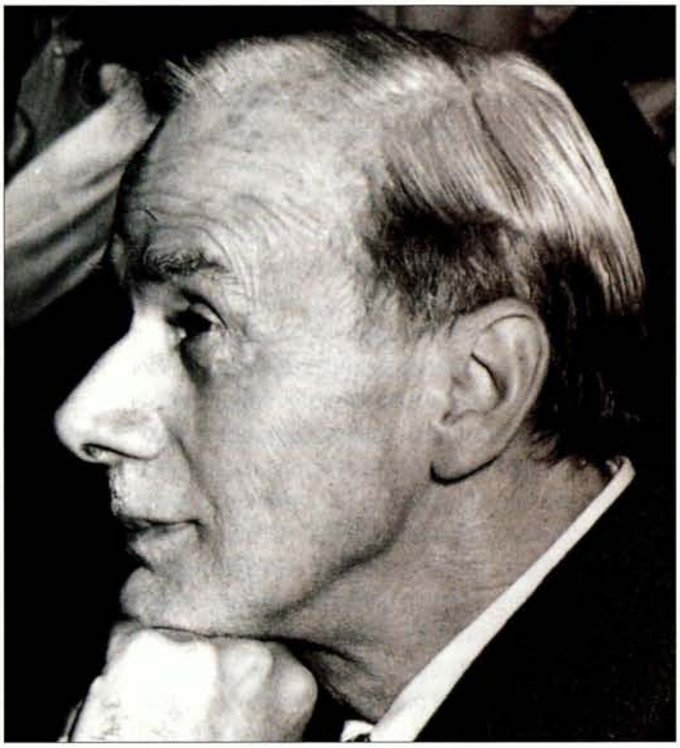
Picture of the month

The Tarantula nebula, imaged at the European Southern Observatory's La Silla site. Located in the Large Magellanic Cloud, the tarantula is the largest emission nebula in the sky: extending over one-third of a degree, it has a diameter of more than 1000 light-years. (ESO.)

Paul Dirac: a genius in the history of physics

This year is the 100th anniversary of Paul Adrien Maurice Dirac who was born in Bristol, England, on 8 August 1902 and died on 20 October 1984 in Tallahassee, Florida, US. **Richard Dalitz** looks back over a remarkable career in physics.

Dirac as a young man in about 1925.



A reflective Dirac in later life attending a conference while still Lucasian Professor.

The year 2002 is the centennial year for Paul Dirac, who was born in Bristol on 8 August 1902. His Swiss father, Charles, was born in Monthey near Geneva in 1866 and migrated to Bristol, England, to become the French teacher at the Merchant Venturers Technical College. His mother was Florence Holten, a Cornish woman who was born in Liskeard in 1878 and became a librarian in Bristol. They married in Bristol in 1899 and had three children: two sons (of which Paul was the younger) and then a daughter. After his primary and secondary education at the technical college, Paul Dirac joined the electrical engineering department of Bristol University in 1918 to train as an electrical engineer. This choice was due to prompting from his father who was concerned about his son's job prospects.

Dirac did well at university, but he did not find a suitable job due to post-war conditions. His desire was to go to Cambridge University to study mathematics and physics. He was accepted by St John's College, Cambridge, in 1921, but was offered only a minor scholarship, insufficient to support him there. Fortunately, he was able to study Applied Mathematics at Bristol University for two years, paying no fees and living at home. After this, in 1923, he was awarded a major scholarship at St John's College and a Department of Scientific and Industrial Research training grant, but even these did not cover the amount he needed to study at Cambridge. In the end he was able to go to St John's College because extraordinary action was taken by the college. He did all his life's work there, from post- ▷

graduate studies in 1923 to retirement from his Lucasian professorship in 1969 (excluding sabbatical leaves). Thus, it turned out that the college made a profitable investment when they gave him a modest increase to the major scholarship they had awarded him.

Paul Dirac died, aged 82, on 20 October 1984 as a Nobel Prize winner (1933) and a member of the British Order of Merit (1973). He was the outstanding theoretical physicist in Britain in the 20th century. In 1995 there was a great celebration of Dirac and his work in London. A plaque was placed in Westminster Abbey as a memorial to him and his achievements, joining similar plaques to Newton, Maxwell, Thomson, Green and other outstanding theoretical physicists. It included Dirac's equation in a compact relativistic form (as Dirac's full equation would not have fitted on the plaque). This was not a form that Dirac would ever have used, although later students of Dirac often used it. As part of the celebration, addresses were given on four topics related to Dirac's work (see P Goddard 1998 in Further reading).

This plaque to commemorate Paul Dirac has been placed in the floor of London's Westminster Abbey, adjacent to Newton's grave. It was made at Cambridge, using green slate, in Cardoso Kindersley's workshop.

Monumental discoveries

Dirac established the most general theory of quantum mechanics and discovered the relativistic equation for the electron, which now bears his name. The remarkable notion of an antiparticle to each particle – i.e. the positron as antiparticle to the electron – stems from his equation. He was the first to develop quantum field theory, which underlies all theoretical work on sub-atomic or "elementary" particles today, work that is fundamental to our understanding of the forces of nature. He proposed and investigated the concept of a magnetic monopole, an object not yet known empirically, as a means of bringing even greater symmetry to Maxwell's equations of electromagnetism. He quantized the gravitational field, and developed a general theory of quantum field theories with dynamical constraints, which forms the basis of the gauge theories and superstring theories of today. The influence and importance of his work has increased with the decades, and physicists daily use the concepts and equations that he developed.

Dirac's first step into a new quantum theory was taken late in September 1925. R H Fowler, his research supervisor, had received a proof copy of an exploratory paper by Werner Heisenberg in the framework of the old quantum theory of Bohr and Sommerfeld, which leaned heavily on Bohr's correspondence principle but changed the equations so that they involved directly observable quantities. Fowler sent Heisenberg's paper on to Dirac, who was on vacation in Bristol, asking him to look into this paper carefully. Dirac's attention was drawn to a mysterious mathematical relationship, at first sight unintelligible, that Heisenberg had reached. Several weeks later, back in Cambridge, Dirac suddenly recognized that this mathematical form had the same structure as the Poisson Brackets that occur in the classical dynamics of particle motion. From this thought he quickly developed a quantum theory that was based on non-commuting dynamical variables. This led him to a more profound and significant general formulation of quantum mechanics than was achieved by any other worker in this field (see P Dirac 1925 in Further reading).

This was a major achievement that marked him out from others in the field. As a young, 25-year-old physicist he was quickly accepted by outstanding physicists. He was invited to speak at their most exclusive conferences, such as the Solvay Congress of 1927 (see Further reading), and joined in their deliberations as an equal.

However, this general formulation allowed him to go much further. With it, he was able to develop his transformation theory, which showed explicitly (see P Dirac 1927 in Further reading) how it was possible to relate a range of different formulations of quantum mechanics, all of them equivalent in their physical consequences, such as Schrödinger's wave equation and Heisenberg's matrix mechanics. This was an astonishing achievement, which led to a deeper understanding of quantum mechanics and its use. This transformation theory was the pinnacle of Dirac's development of quantum mechanics since it unified all proposed versions of quantum mechanics, as well as giving rise to a continuum of other possible versions. In later life Dirac considered this transformation theory to be his own as no other quantum mechanician had found any hint of it. Altogether, Dirac's quantum mechanics takes a simple and beautiful form, with a structure showing elegance and economy of concept, and linked directly with the classical theory. It showed us a new aspect of our universe, both profound and perplexing in its new concepts, and certainly unexpected.

Even as an undergraduate Dirac had been deeply conscious of the importance of special relativity in physics, the theory that Einstein had put forward in 1905 and that Dirac had learned about from lectures by C D Broad, the philosophy professor at Bristol University. Most of his early papers as a postgraduate student were devoted to modifying calculations already in the literature to make them compatible with special relativity. In 1927 Dirac sought to develop a theory of the electron that satisfied this requirement and he published his relativistically invariant equation for the electron early in 1928 (see P Dirac 1928 in Further reading).

Although this goal had been in the minds of many other physicists, none had been able to find a satisfactory equation. He gave an argument, simple and of the utmost elegance, that was based on the requirement that his transformation theory should also hold for relativistic quantum mechanics – an argument that specified the general form this relativistic equation should have, an argument that all physicists have found compelling. His transformation theory requires the equation to be no more than linear in time-derivative,

Dirac lecturing at Cambridge University in 1946.

Paul Dirac, Wolfgang Pauli and Rudolf Peierls in discussion at the International Conference on Nuclear Physics, Birmingham, 1948.

while relativity arguments indicate that the equation can be only linear in the space derivatives also. Dirac's equation is certainly one of the most beautiful physics equations. Professor Sir Nevill Mott, former director of the Cavendish Laboratory, wrote recently: "This [equation] seemed, and still seems to me, the most beautiful and exciting piece of pure theoretical physics that I have seen in my lifetime – comparable with Maxwell's deduction that the displacement current, and therefore electromagnetism, must exist." (See B Kursunoglu and E P Wigner 1988 in Further reading.) Also, the Dirac equation for the electron implied that it should have spin 1/2, and a magnetic moment of $eh/(4\pi m)$, where h is the Planck constant and m is the electron mass, correct to the accuracy of 0.1%.

Dirac's equation and his theory of the electron have remained firm up to the present day. Its predictions have been thoroughly verified for all atomic and molecular systems. It has been demonstrated to hold for all other particles that have the same spin as the electron, such as the protons, the hyperons and all other baryons, when their induced magnetic moments are taken into account; and all known leptons, to say nothing of the fundamental building blocks of all hadrons, the quarks themselves. It is universally applicable and well known by all physicists and chemists, something nobody could deny. Indeed, in 1929 Dirac felt able to state: "The general theory of quantum mechanics is now complete...The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known." (See P Dirac 1929 in Further reading.)

Beautiful physics

Dirac soon showed that his equation had other, unexpected, implications for these particles. The equation predicted the existence of antiparticles, such as the positron and the negatively-charged antiproton, objects now well known in high-energy physics laboratories. Indeed, all particles have corresponding antiparticles and almost all of them are now known empirically. The positron and antiproton are particularly well known, both being stable in a vacuum, and are now widely used in collider accelerators, with which physicists study physical phenomena at very high energies.

It is important to emphasize here the outstanding beauty of Dirac's equation. It may be difficult to convey this quality to non-scientists, but we can be confident that no physicist would disagree with this statement. The Dirac equation is one of the most outstanding discoveries. Through this work, Dirac uncovered for us all a fundamental and satisfying principle governing our universe, which demonstrates to an unsurpassed degree the elegance of its structure. For this discovery, Dirac's name will be known forever. It is an outstanding monument to his ability and ingenuity, leading us to comprehend at least one aspect of the fundamental forces in this remarkable universe in which we live.

Dirac's name would be high in physics records even if quantum mechanics and transformation theory were his only contributions to knowledge. His discovery of the Dirac equation puts him far above all others – an outstanding genius in the history of physics.

Further reading

P Dirac 1925 The Fundamental Equations of Quantum Mechanics *Proc.R.Soc.Lond.* **A109** 642–653.

P Dirac Electrons and Photons in *5th Conseil de Physique de l'Institut International de Physique Solvay, 24–29 October 1927, Brussels* Gauthier-Villars, Paris 258–263.

P Dirac 1927 The Physical Interpretation of the Quantum Dynamics *Proc.R.Soc.Lond.* **A113** 621–641.

P Dirac 1928 The Quantum Theory of the Electron *Proc.R.Soc.Lond.* **A117** 610–624; ibid **A118** 351–361.

B Kursunoglu and E P Wigner (ed.) 1988 *Reminiscences about a great physicist: Paul Adrien Maurice Dirac* Cambridge University Press 231.

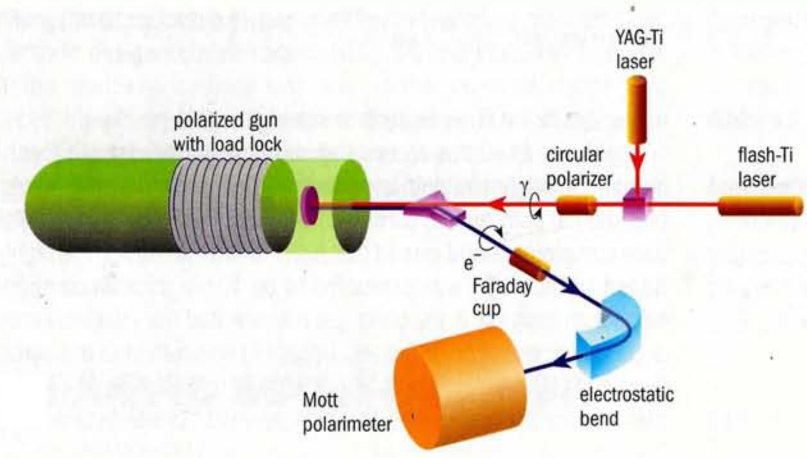
P Dirac 1929 Quantum Mechanics of Many-Electron Systems *Proc.R.Soc.Lond.* **A123** 714–733.

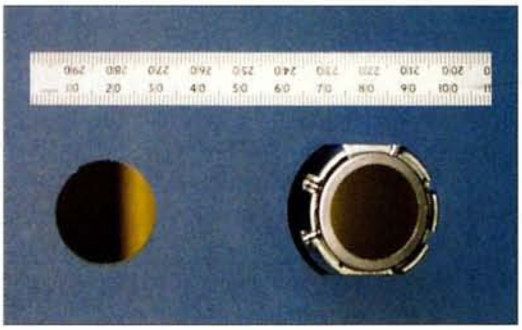
P Goddard (ed.) 1998 *Paul Dirac: The Man and his Work* Cambridge University Press. Contributors: Abraham Pais "Paul Dirac: aspects of his life and work", Maurice Jacob "Antimatter", David I Olive "The Monopole" and Michael F Atiyah "The Dirac equation and geometry". The book also contains Stephen Hawking's Dirac memorial address given at the unveiling of Dirac's plaque at Westminster Abbey.

Richard Dalitz, *Oxford University*

Polarized photocathodes make the grade

Future linear colliders will require high levels of performance from their electron sources. A group at SLAC has recently tested a structure that substantially exceeds current collider polarized electron source pulse-profile requirements. **Jym Clendenin** and **Takashi Maruyama** report.





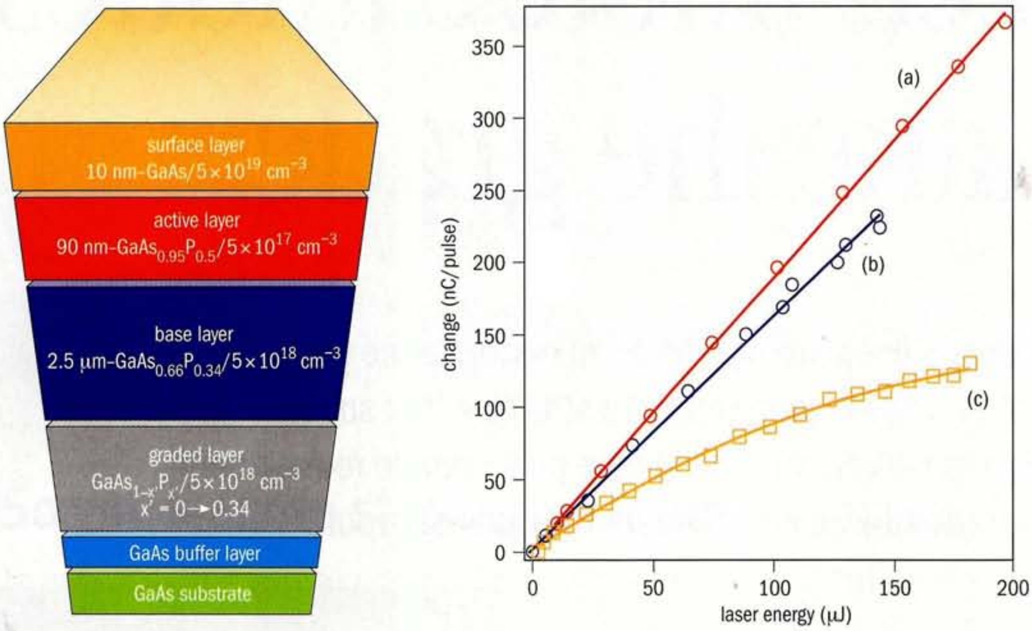
Left: the configuration for SLAC's photocathode experiment. Above: a photocathode crystal before (left) and after mounting in the crystal holder of the SLAC polarized electron source.

A polarized electron source for future electron–positron linear colliders must have at least 80% polarization and high operational efficiency. The source must also meet the collider pulse profile requirements (charge, charge distribution and repetition rate). Recent results from the Stanford Linear Accelerator Center (SLAC) have demonstrated for the first time that the profile required for a high-polarization beam can be produced.

Since the introduction in 1978 of semiconductor photocathodes for accelerator applications, there has been significant progress in improving their performance. Currently, all polarized electron sources used for accelerated beams share several common design features – the use of negative-electron-affinity semiconductor photocathodes excited by a laser matched to the semiconductor band gap, the cathode biased at between –60 and –120 kV DC, and a carefully designed vacuum system. While the earliest polarizations achieved were much less than 50%, several accelerator centres, including Jefferson Lab, MIT Bates and SLAC in the US, along with Bonn and Mainz in Germany, now routinely achieve polarizations of around 80%. Source efficiencies have shown similar dramatic improvement. The Stanford Linear Collider (SLC) achieved more than 95% overall availability of the polarized beam across nearly seven years of continuous operation. These achievements clearly point to the viability of polarized beams for future colliders.

Peak currents of up to 10 A were routinely produced in 1991 in the SLC Gun Test Laboratory by using the 2 ns pulse from a doubled Nd:YAG laser to fully illuminate the 14 mm diameter active area of a GaAs photocathode. However, when the photocathode gun was moved to the linac injector, where a high-peak-energy pulsed laser was available that could be tuned to the band-gap energy as required for high polarization, the current extracted from the cathode was found to saturate at much less than 5 A unless the cathode quantum efficiency (QE) was very high.

The SLC required a source pulse structure of about 8 nC in each of two bunches separated by some 60 ns at a maximum repetition rate of 120 Hz. These requirements were met by doubling the cathode area and by using a vacuum load-lock to ensure a high QE when installing newly activated cathodes. In contrast, designs for the Next Linear Collider and Japan Linear Collider, being pursued by SLAC and the KEK laboratory in Japan, call for a train of 190 microbunches separated by 1.4 ns, with each bunch having a 2.2 nC charge at the source, for a total of 420 nC for the 266 ns macropulse. This is about 25 times the SLC maximum charge. Both the macrobunch and microbunch current requirements for CERN's CLIC concept are somewhat higher, while the 337 ns spacing between microbunches ▷



Left: the high-gradient GaAs–GaAsP cathode structure, thickness and dopant density that was used for SLAC's polarized photocathode experiment. Right: the charge in the electron bunch measured at the electron source as a function of laser energy using a 100 ns pulse with no microstructure. (a) QE of 0.31% and fully illuminated cathode diameter of 20 mm; (b) 0.25% and 14 mm; (c) SLC cathode shown for comparison: 300 ns pulse with QE of about 0.2% (at 10 nC) and 20 mm diameter.

insures that charge will not be a limitation for the TESLA collider being spearheaded by Germany's DESY laboratory (p6).

The limitation in peak current density, which has become known as the surface charge limit (SCL), proved difficult to overcome. Simply designing a semiconductor structure with a high quantum yield was not a solution because the polarization tended to vary inversely with the maximum yield.

Gradient doping

As early as 1992, a group from KEK, Nagoya University and the NEC company designed a GaAs-AlGaAs superlattice with a thin, very-highly-doped surface layer and a lower density doping in the remaining active layer - a technique called gradient doping. The very high doping aids the recombination of the minority carriers trapped at the surface that increase the surface barrier in proportion to the arrival rate of photoexcited conduction band (CB) electrons. Because CB electrons depolarize as they diffuse to the surface of heavily doped materials, the highly doped layer must be very thin, typically no more than a few nanometres. When tested at Nagoya and SLAC, this cathode design yielded promising results in which a charge of 32 nC in a 2 ns bunch was extracted from a 14 mm diameter area, limited by the space charge limit of the 120 kV gun at SLAC.

In 1998 a group from KEK, Nagoya, NEC and Osaka University applied the gradient-doping technique to a strained InGaAs-AlGaAs superlattice structure. They retained 73% polarization while demonstrating the absence of the SCL in a string of four 12 ns microbunches, spaced 25 ns apart, up to the 20 nC space charge limit of the 70 kV gun. In a more recent experiment using a gradient-doped GaAs-GaAsP superlattice, they extracted 1 nC for each of a pair of 0.7 ns bunches separated by 2.8 ns without any sign of the SCL, before reaching the space charge limit of the 50 kV gun. The polarization and QE were 80 and 0.4%, respectively. Other groups, notably at Stanford University, St Petersburg Technical University and the Institute for Semiconductor Physics at Novosibirsk, have also made significant contributions to solving the SCL problem.

A group at SLAC has recently applied the gradient-doping technique to a single strained-layer GaAs–GaAsP structure with results that substantially exceed current collider requirements. These results both complement and extend the 1998 Japanese results. The highly doped surface layer was estimated to be 10 nm thick. To compensate for an increase in the band gap that resulted from the increased dopant concentration, 5% phosphorus (P) was added to the active layer and the percentage of P in the base layer was increased to maintain the desired degree of lattice strain at the interface. Adding P in the active layer shifts the bandgap by about 50 meV towards the blue, reaching 1.55 eV (800 nm). In combination with the reduction of the surface barrier, this ensured a high QE of about 0.3% at the polarization peak. This is similar to the QE of the standard SLC strained GaAs–GaAsP cathodes.

Two laser systems were used to determine the peak charge. A flash-lamp-pumped Ti:sapphire (flash-Ti) system provided flat pulses of up to several hundred nanoseconds long with a maximum energy of about 2 µJ/ns. In addition, up to 20 µJ in a 4 ns pulse was available from a Q-switched, cavity-dumped, YAG-pumped Ti:sapphire (YAG-Ti) laser. With the flash-Ti alone, the charge increased linearly with laser energy up to the maximum available laser energy. Because of the finite relaxation time of the SCL, a flat pulse is a more stringent test of the SCL than if it contained a microstructure. The peak charge per unit time (see graph above) is only slightly lower than the NLC requirement for each microbunch when assuming a 0.5 ns full bunch-width. By extending the laser pulse to 370 ns, a charge of 1280 nC was extracted, far exceeding the NLC macropulse requirement.

To determine if the peak charge required for a microbunch would be charge-limited, the YAG-Ti laser pulse was superimposed on the flash-Ti pulse. The resulting charge increment was consistent with the charge obtained using the YAG-Ti alone. The charge increment was independent of the relative temporal positions of the two laser pulses indicating that the massive total charge of an NLC, JLC or

The superlattice structure appears to be the best candidate for achieving a significantly higher polarization while maintaining a QE above 0.1%.

CLIC macropulse will not inhibit the peak charge required for each microbunch. The maximum charge produced by the YAG-Ti alone was 37 nC, which is more than 15 times the NLC requirement for a single microbunch.

To increase the charge density the laser spot on the cathode was reduced to 14 mm, below which the bunch is space-charge-limited for the maximum laser energy. Again, the charge increased linearly with the laser energy. The linearity remained when the quantum yield was allowed to decrease although, of course, the maximum charge also decreased. Thus it is clear that if sufficient laser energy is available, the linearity of the charge increase will be maintained for total charge and peak charge per unit time when using the new SLAC cathode design and will exceed NLC, JLC and CLIC requirements.

The new SLAC cathode was used in the polarized source for a recent high-energy physics experiment requiring 80 nC at the source in a 300 ns pulse. The improved charge performance provided the headroom necessary for temporal shaping of the laser pulse to allow adequate compensation for energy beam loading effects in the 50 GeV linac. The polarization measured at 50 GeV confirmed the greater than 80% polarization measured in the source development laboratory at 120 keV.

The international effort to improve polarized photocathodes will continue. For instance, tests for the surface charge limit at the very high current densities required by low-emittance guns have yet to be performed. On a broader front, the superlattice structure – in part because of the large number of parameters that the designer can vary – appears to be the best candidate for achieving a significantly higher polarization while maintaining a QE above 0.1%.

Further reading

T Abe *et al.* (American Linear Collider Working Group) 2001 Linear Collider Physics Resource Book for Snowmass 2001 (hep-ex/0106055-8 at http://www.arxiv.org/).

T Maruyama *et al.* 2002 A very-high-charge, high-polarization gradient-doped strained GaAs photocathode (SLAC-PUB-9133) accepted for publication in *Nucl. Instrum. Meth. A*.

K Togawa *et al.* 1998 Surface charge limit in NEA superlattice photocathodes of polarized electron source *Nucl. Instrum. Meth. A* **414** 431.

Jym Clendenin *and* **Takashi Maruyama**, *SLAC*.

Supergravity celebrates quarter of a century

The first complete theory of supergravity appeared 25 years ago last autumn. To mark the occasion, the State University of New York at Stony Brook held a workshop on the subject in December.

Supergravity researchers gathered last December at Stony Brook, where it all began a quarter of a century ago.

The development of supergravity is a landmark in the intertwined histories of gauge field theory and quantum gravity. Culminating the drive towards higher symmetry within quantum field theory, it opens a door to the unification of all forces, and the possibility for extra dimensions. As a candidate theory of everything, supergravity was eclipsed by strings, yet in recent years it has re-emerged as a key component of "modern" string theory, playing an essential role in connecting field theories with string theories, and string theories with each other. Supergravity is as much on theorists' minds now as it was in the mid-1970s. On 3–4 December 2001, an international meeting, "Supergravity at 25", was hosted by the C N Yang Institute for Theoretical Physics at the Stony Brook campus of the State University of New York, to commemorate the anniversary of this protean theory, and to assess its ongoing role today.

The modern era of field theory began with the discovery of nonabelian gauge invariance by Chen Ning Yang and Robert L Mills in 1954. A decade and a half later, Gerard 't Hooft and Martinus Veltman famously proved that a large class of nonabelian gauge theories can be quantized and renormalized consistently.

Before long, the elements of the Standard Model had fallen into place, and theorists hurried forward toward a "grand" unification of the strong and electroweak interactions.

Charmed circle

Gravity, however, remained outside this charmed quantum circle. The force in quantum gravity is carried by the spin-2 graviton, and could not immediately be unified with Standard Model forces, carried by the spin-1 photon, weak bosons and gluons. The same spin-2 graviton leads to particularly aggressive high-energy behaviour. This results in a hopelessly ambiguous theory, through the proliferation of new infinities at each level of calculation. In technical terms, Einstein's gravity is not renormalizable. The first inspirations for supergravity were to address these two problems. The novel element was another form of unification, supersymmetry, which relates bosons and fermions. According to this theory, there exists for every boson in nature a fermionic partner, and vice versa. The fermionic partner of the graviton is the gravitino. CERN will search for superpartners of Standard Model particles at the Large Hadron Collider. Within supersymmetry, it was hoped that gravity would be united with other forces, and, through a special combination of particles and interactions, would even turn out to be finite.

In this context, the progression of field theory from quantum electrodynamics (QED) to supergravity is illustrated in figure 1. The basic interaction of QED is the emission of a photon (γ) from a charged particle, like a quark (q), with an amplitude proportional to the quark's electric charge, (Q_q in figure 1a). We say that the photon is the gauge particle of the electric current. The photon itself, however, is electrically neutral. At the next level of complexity, nonabelian gauge theories like quantum chromodynamics (QCD) introduce an array of "colour" charges, each of which is conserved. In this case, the gluon (G) is the gauge particle of the colour currents, and carries them as well. Thus, when a gluon is emitted (figure 1b), it connects quarks of different colour, with an amplitude proportional to the strong coupling (g_s). All of the colour charges are conserved in the full system of quarks and gluons, and the gluon is represented as a double line to emphasize its colour structure.

In supergravity, currents that describe the flow of energy, momentum and spin combine into a set, called the supercurrent multiplet, analogous to the currents of electric and colour charges in QED and QCD. Part of this multiplet is the energy-momentum tensor, but part is the "supercurrent" itself, a hybrid field with a vector and a spinor index, related to the energy-momentum tensor by a supersymmetry transformation. The spin-2 graviton is the gauge particle of the energy- ▷

momentum tensor, while its "superpartner" the spin-3/2 gravitino (ψ_μ) is the gauge particle of the supercurrent. The gravitino is emitted with an amplitude proportional to the energy carried by this current, multiplied by the square root of Newton's constant (figure 1c). The gravitino (with an extra arrow in the figure to emphasize its spin structure) carries no electric and colour charges, but connects particles with different spin, in this case a quark and scalar supersymmetric partner "squark" ($\tilde{q}$). It thus reveals the underlying unity of the quark and squark within their own supermultiplet, in much the same way that the gluon connects quarks that are unified within a multiplet of three colours.

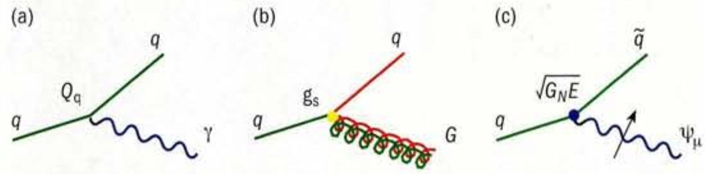


Fig. 1: the progression of field theory from QED to supergravity.

The development of supergravity 25 years ago may be thought of as the exercise of identifying a minimal set of interactions between gravitons and gravitinos that respects general co-ordinate invariance and makes supersymmetry a gauge symmetry. Today this is as routine as writing down the Lagrangian for a Yang-Mills theory. In 1976, however, it was not even clear that it was possible. The task of formulating the minimal supergravity theory was accomplished by Sergio Ferrara, then at the Ecole Normale Supérieure, and Daniel Freedmann and Peter van Nieuwenhuizen of Stony Brook (see further reading list). At the December meeting, they recalled days of alternating hope and despair, which reached a climax one evening in the spring of 1976, when 2000 terms generated by an infinitesimal supersymmetry transformation were miraculously cancelled by computer. With this result, supergravity moved from conjecture to consistency. Their approach, which they called the "Noether method", was based on building the correct transformation laws by retracing the reasoning of Emmy Noether's famous theorem connecting symmetries and conservation laws. Shortly afterwards, Stanley Deser of Brandeis University and Bruno Zumino of CERN gave a useful reformulation (see further reading list), and in the early months and years of supergravity, other approaches gave further insights and dramatic simplifications. A systematization of what quickly became a veritable zoo of supergravity theories was provided by the superspace approach of Julius Wess and Zumino, developed by S James Gates, Jr and Warren Siegel, and the tensor calculus developed by Ferrara and van Nieuwenhuizen, and independently by Kellogg S Stelle of Imperial College, London, and Peter West of King's College, London.

Supergravity today

Participants at the symposium included the original authors, along with others, such as Marc Grisaru of Brandeis University, who recalled classic investigations into the new theory. Many presentations, however, addressed the role of supergravity today. It fell to string theory to provide a finite quantum theory of gravity, matter and other forces. Our grasp of string theory is incomplete, however, because we lack an understanding of its ground (vacuum) state, and in the larger sense, its non-perturbative spectrum of states. This is one area where supergravity is central to the study of string theory. At the meeting, aspects of the dualities between different string theories were discussed by Bernard Julia of the Ecole Normale Supérieure, Igor Klebanov of Princeton, and West. These dualities have led to a compelling conjecture that all the consistent (10-dimensional) string theories are actually different vacua of a single underlying theory, M-theory, whose low-energy limit is 11-dimensional supergravity. Properties of 11-dimensional supergravity do indeed shed light on string theories in 10 dimensions. In addition, many special solutions to the supergravity equations of motion can be identified with objects in string theory called D-branes, a theme discussed at the conference by Gary Gibbons of Cambridge University, Pietro Fré of Turin, and Kostas Skenderis of Princeton. D-branes are central to a program described by Ashoke Sen of India's Harish-Chandra Research Institute, for a closed-string theory based on open strings, and aspects of D-brane dynamics were discussed by Michigan's Michael Duff, Stockholm's Ulf Lindström, and John Schwarz of Caltech. Bernard de Wit of Utrecht and Ferrara discussed recent developments in supergravities with more than one supersymmetry.

Supergravity is also central to a remarkable discovery called the AdS/CFT correspondence, which relates supergravity in higher-dimensional anti-de Sitter (AdS) space-time (a space-time with constantly negative curvature) to strongly coupled gauge field theories (CFT). This correspondence, which relates quantum correlations in the field theory to classical solutions of supergravity, was discussed by Freedman, Klebanov, Emery Sokatchev from CERN, Ergin Sezgin from Texas A&M, Arkady Tseytlin from Ohio State and Nicholas Warner from the University of Southern California (USC). Supergravity's possible role in cosmology was discussed by Renata Kallosh of Stanford.

In part, the meeting celebrated the influence of supergravity (thousands of papers have the word in their title, and thousands more list it as a keyword). Even more impressively, it demonstrated its vitality. Though supergravity is 25 years old, the conference had the excitement and energy characteristic of a recent discovery. Only half in jest, some participants looked forward to new and unexpected developments to be celebrated on supergravity's 50th birthday.

Further reading

The programme of the meeting, along with scanned transparencies, may be found at http://insti.physics.sunysb.edu/itp/sg25/.

Daniel Z Freedman, P van Nieuwenhuizen (SUNY, Stony Brook) and S Ferrara (Ecole Normale Supérieure) 1976 Progress toward a theory of supergravity *Phys. Rev.* **D13** 3214–3218. (Also in S Ferrara, (ed.) 1987 *Supersymmetry* vol. 2 (North-Holland and World Scientific Publishing) 868–872, and in A Salam and E Sezgin (ed.) 1989 *Supergravities in Diverse Dimensions* vol. 1 (World Scientific Publishing) 512–516.

S Deser and B Zumino (CERN) 1976 Consistent supergravity *Phys. Lett.* **B62** 335.

Martin Roček, Warren Siegel, George Sterman *and* **Peter van Nieuwenhuizen**, *C N Yang Institute, SUNY, Stony Brook.*

Testing models for quantum gravity

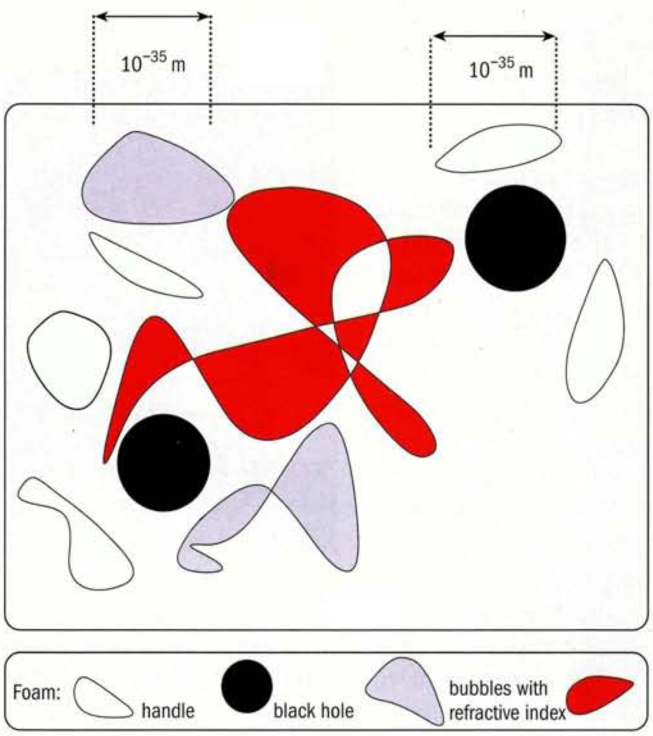


Fig. 1. An artist's impression of space–time foam in some models of quantum gravity: tiny (average size 10^{-35} m) and short-lived (average lifetime 10^{-43} s) fluctuations of space–time, with non-trivial topology and/or singular geometry (such as black holes), give the ground state of quantum gravity the nature of a stochastic medium. Propagation of ordinary matter in such backgrounds may result in non-trivial "optical properties" such as a refractive index, modifications of dispersion relations, deviations from normal quantum-mechanical evolution, light-cone fluctuations and violations of Lorentz invariance.

General relativity made Einstein an instant success. However, reconciling the theory with quantum mechanics has proved to be a formidable task, which is far from complete. **Nick Mavromatos** explains.

The theory of general relativity provides an appealing way of understanding gravitational dynamics, by perceiving the nature of the gravitational force as being due to a non-trivial geometry of space–time.

The predictions of this revolutionary theory were verified experimentally almost immediately after its proposition, making Einstein an instant success. However, general relativity is a purely classical theory. Quantizing it has so far proved to be a formidable task, which is far from complete. Due to the theory's unconventional form, as compared with the rest of the fundamental interactions in nature, a mathematically consistent and complete theory of quantum gravity remains elusive.

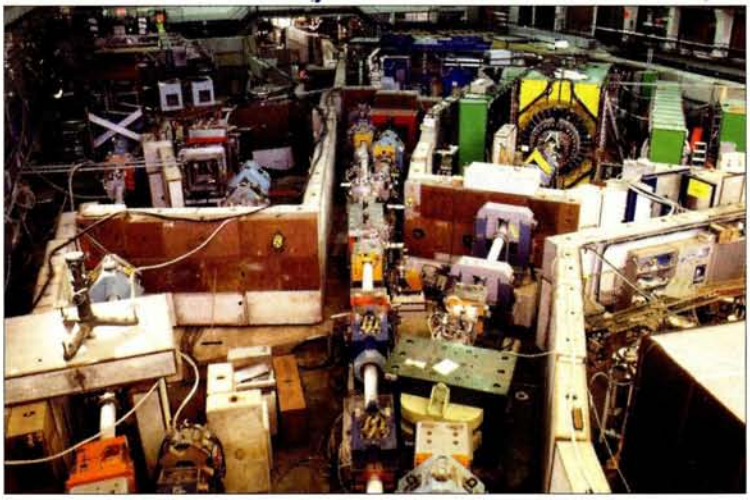
Theoretical approaches

The discovery of string theory opened up novel and unconventional ways of attacking the problem. By viewing gravitons, the hypothesized carriers of the gravitational interaction, as one of the excitations of the (closed) superstring ground state, the first mathematically consistent framework of unification of gravity with the rest of the fundamental interactions (strong and electroweak) could be achieved. However, this approach is also incomplete. The last decade has revealed a much richer structure of the theory, consisting not only of one-spatial-dimensional objects (strings), but also of higher-dimensional membrane solitonic structures (such as D-branes) whose dynamics are still not well understood. String theory itself, however, has not yet given a complete answer to the question of what happens when quantum matter interacts with singular space–time backgrounds such as black holes.

In the framework of local field theory, John Wheeler and Stephen Hawking have suggested that microscopic quantum space–time fluctuations of black hole type, with size of the order of the Planck length (10^{-35} m), characterize the quantum-gravity vacuum, giving it a "space–time foamy" nature (figure 1). Interaction of matter with such backgrounds may result in the loss of quantum coherence. This in turn could lead to significant deviations from the standard quantum-mechanical behaviour of matter particles, even at scales much lower than the characteristic quantum-gravity (Planck) energy scale of 10^{19} GeV. This is because gravity is a non-renormalizable interaction, with a dimensionful coupling constant, and so it may manifest itself at much lower scales. An example of such a phenomenon is provided by the so-called charge-parity (CP) discrete symmetry, whose violation manifests itself at scales much lower than the characteristic scale of the underlying weak interactions responsible for the effect.

However, the existence of space–time foam effects has been questioned, in particular by string theorists. In superstrings, for ▷

certain specific classes of black holes, it is possible to count precisely the microstates that constitute the internal black hole structure by virtue of string dualities (certain discrete gauge symmetries of strings). This has prompted the conjecture that in string theory there is no loss of information during the interaction of string matter with singular space-time backgrounds, and therefore no loss of quantum coherence. If this is true for every singular space-time background, it would be a manifestation of the so-called holographic conjecture of 't Hooft and Susskind, according to which any information that enters the horizon of a black hole (a sort of space-time boundary) is encoded on the boundary and no information is lost.



CERN's CPLEAR experiment displayed sensitivity not far from the theoretically estimated magnitude of CPT violating effects in minimal-suppression quantum-gravity models. A new generation of experiments, at Frascati and Fermilab, should reach the required level of sensitivity.

Unfortunately, the situation may not be that simple. Physicists have so far been unable to demonstrate the holographic principle rigorously outside certain restricted classes of stringy black hole backgrounds. Moreover, within the modern context of brane theory there have been theoretical arguments demonstrating that it is impossible to describe the formation of a black hole by collapsing string matter, or the final stage of its evaporation by purely unitary quantum methods.

Liouville strings

It is at this point that alternative paths within the string framework have been proposed. One is the so-called Liouville (non-critical) string, a sort of non-equilibrium string theory allowing for a stochastic description of space-time foam backgrounds. In such models, gravitational degrees of freedom, unobservable by low-energy observers, constitute an "environment" that results in the non-equilibrium nature of the underlying string theory. Technically speaking, the foam background is not conformal (its world-sheet dynamics are not invariant under special local-scale transformations). Nevertheless, with certain restrictions such theories are still mathematically consistent.

Time plays a particularly special role in Liouville strings, where it is identified with a world-sheet renormalization-group scale, the Liouville mode itself. In such a picture, the irreversibility of the temporal flow is guaranteed by powerful remormalization-group-flow theorems of the 2D world-sheet geometry. Such an irreversible flow has immediate consequences for entropy production, associated with the non-equilibrium nature of the Liouville string.

On the other hand, it has been argued that a Liouville-string irreversible time flow may play an important role in cosmological scenarios, in particular in relaxation models of the universe, allowing for the possibility of an exit from an accelerating universe (de Sitter) phase, as well as a relaxing-to-zero vacuum energy. Such models provide a natural explanation for the smallness of the present-era value of the cosmological constant, consistent with recent astrophysical claims. It is therefore interesting to note that the same mathematical framework of the Liouville string, which provides a picture for the space-time foam, can also describe a cosmological model of the universe with correct phenomenology.

The fundamental issue of the nature of time probably holds the key to unravelling a consistent theory of quantum gravity. The relevant phenomenology, therefore, which has already enjoyed almost two decades of intense research, may also contribute significantly to an understanding of such fundamental questions.

For the time being, however, string theories seem to suffer from an important drawback, which probably prevents a complete understanding of quantum gravity issues within this framework. This is their background dependence – the fact that the whole formalism of strings, at least so far, is based on specific space-time backgrounds. A satisfactory theory of quantum gravity is expected to be capable of describing the generation of the space-time structure in a dynamical way from more fundamental units. This may be possible in string field theory, but the subject is at present in its infancy.

This property of background independence seems to characterize another major approach towards the quantization of gravity, the so-called loop quantum gravity. This is a way of canonically quantizing gravity starting from a theory of abstract "spin-foam networks". These are the fundamental units from which the fabric of space-time is generated dynamically in a mathematically self-consistent and elegant formalism, and hence the approach is background independent by design. At present it is not known whether the theory is related to (Liouville) string theory. Moreover, no significant progress has been made towards an understanding of issues relating to information loss in quantum black hole backgrounds or the unification of gravity with the rest of the interactions. There is intense ongoing research in this field, and such questions may soon be tackled. For our purposes it is sufficient to mention that loop quantum gravity, like Liouville strings, appears to provide a theoretical framework for a discussion of stochastic space-time foam dynamics.

Experimentally falsifiable predictions

It is of primary importance to attempt to make physical, experimentally falsifiable predictions from these different frameworks of quantum gravity. At first sight this may seem wishful thinking for any theory

CERN COURIER

cerncourier.com

Dear R ad r

To make sure that *CERN Courier* provides you with the information that you want, please take a moment to fill in this questionnaire. By completing the survey online at **cerncourier.com**, not only will you have the chance to have your say, but you will also be entered into a FREE prize draw for the chance to win £100 worth of amazon.com vouchers. If you wish, you can return the questionnaire by post to Laura Serratrice at the address at the foot of the page, but please note that any forms received by fax or post will **not** be entered in the prize draw.

Thank you for your time.

Jo Nicholas
Publisher

Please enter your personal details below and answer questions 1 to 34

Title ______________________________

Name ______________________________

Address ______________________________

____

____

Postcode ______________________________

Tel. ______________ **Fax** ______________

Email ______________________________

Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE, UK.
Tel. +44 117 930 1018. Fax +44 117 930 1178. Web **cerncourier.com**.

CERN COURIER Reader Survey

Complete this survey online at **cerncourier.com** and you could win £100 worth of amazon.com vouchers.

1 How old are you?

- ☐ under 16
- ☐ 16–20
- ☐ 21–30
- ☐ 31–40
- ☐ 41–50
- ☐ 51–60
- ☐ over 61

2 Are you

- ☐ male?
- ☐ female?

3 What is the highest qualification you hold?

- ☐ PhD/DPhil
- ☐ MSc/MA
- ☐ MPhys/MSc
- ☐ BSc/BA
- ☐ other – please specify ____________

4 Please select the type of organization/area of industry you work in

- ☐ school/college
- ☐ university
- ☐ other educational establishment
- ☐ hospital
- ☐ government/research council laboratory
- ☐ international organization/laboratory
- ☐ aerospace
- ☐ electronics/IT/communications
- ☐ instrument industry
- ☐ manufacturing industry
- ☐ nuclear industry
- ☐ power/utilities
- ☐ financial services
- ☐ other – please specify ____________

5 Have you made a career move in the last three years?

- ☐ yes
- ☐ no

6 If yes, did you

- ☐ move from academia to industry?
- ☐ move from industry to academia?
- ☐ move within academia?
- ☐ move within industry?
- ☐ other – please specify ____________

7 Please select one of the following that best describes your position

- ☐ undergraduate student
- ☐ postgraduate student
- ☐ postdoctoral researcher
- ☐ lecturer reader professor
- ☐ physicist in a government laboratory
- ☐ physicist in an international organization/laboratory
- ☐ physicist in industry: research and development
- ☐ physicist in industry: production
- ☐ physicist in industry: management
- ☐ physicist in industry: other
- ☐ engineer in industry
- ☐ other – please specify ____________

8 Indicate which of the following fields you work in

- ☐ cryogenics
- ☐ subatomic physics
- ☐ particle physics
- ☐ nuclear physics
- ☐ synchrotron radiation
- ☐ astrophysics and astronomy
- ☐ space research
- ☐ cosmology
- ☐ medical physics
- ☐ education
- ☐ solid-state physics
- ☐ computing, software and information technology
- ☐ detector developments and imaging
- ☐ radiofrequency, power supplies and engineering
- ☐ vacuum
- ☐ imaging, materials and instrumentation
- ☐ electronics and data communication
- ☐ media
- ☐ other – please specify ____________

9 Do you have purchasing power?

- ☐ yes
- ☐ no

10 If no, do you have any influence in purchasing?

- ☐ yes
- ☐ no

11 Are you a

☐ recruiter?

☐ jobseeker?

12 How often do you read the recruitment section of *CERN Courier*?

☐ every issue

☐ every other issue

☐ less often

13 How often do you visit the *PhysicsJobs* website?

☐ daily

☐ weekly

☐ every two weeks

☐ monthly

☐ every six months

☐ less often

14 At what time of the year do you recruit physics graduates?

☐ spring

☐ summer

☐ autumn

☐ winter

☐ any time

15 When recruiting, what do you value most in *CERN Courier*?

☐ the qualified readership of *CERN Courier*

☐ the wide reach of *PhysicsJobs*

☐ both

16 If you have never used *CERN Courier* for recruitment purposes, please explain why

____

____

____

____

17 Which other job websites do you use?

☐ TeleJob

☐ TIPTOP Jobs On-Line

☐ HEPIC (hep.net)

☐ pro-physik.de

☐ *Physics Today* jobs site

☐ jobs.ac.uk

☐ your organization's website

☐ other – please specify ____________________

____

18 How do you obtain your copy of *CERN Courier*?

☐ by post

☐ through your place of work

19 When does your copy of *CERN Courier* arrive?

☐ at the beginning of the month

☐ in the middle of the month

☐ at the end of the month

20 How long have you been a reader of *CERN Courier*?

☐ less than a year

☐ between one and four years

☐ more than four years

21 How thoroughly do you read your copy of *CERN Courier*?

☐ a quick glance through

☐ only selected sections

☐ from cover to cover

22 Approximately how long do you spend reading an issue of *CERN Courier*?

☐ up to 15 minutes

☐ 15 to 30 minutes

☐ 30 minutes to 1 hour

☐ 1 to 2 hours

☐ 2 hours or more

23 How many of the last six issues have you read or looked through?

☐ 1–2

☐ 3–4

☐ 5–6

24 Which sections do you regularly read?

☐ News

☐ Physicswatch

☐ Astrowatch

☐ Bookshelf

☐ Viewpoint

☐ People

25 How do you find the level of the articles?

☐ much too difficult
☐ too difficult
☐ about right
☐ too basic
☐ much too basic

26 How often do you refer to back issues of *CERN Courier*?

☐ never
☐ from time to time
☐ often

27 How many other people read or look at your copy of *CERN Courier*?

☐ 0 ☐ 1-3 ☐ 4-10 ☐ 11-20 ☐ 21+

28 Which of the following publications do you read?

☐ *Physics World*
☐ *Physik Journal*
☐ *Physics Today*
☐ *Research & Development*
☐ *Synchrotron Radiation News*
☐ *Europhysics News*
☐ *Microscopy and Analysis*
☐ *Opto & Laser Europe*
☐ *Laser Focus World*
☐ *Compound Semiconductor*
☐ *Wireless Europe*
☐ *FibreSystems Europe*
☐ *The Industrial Physicist*
☐ *Scientific American*
☐ *New Scientist*
☐ *Nature*
☐ *Science*
☐ *Photonics Spectra*
☐ *European Semiconductor*
☐ *Materials World*

29 What do you like most about *CERN Courier*?

____
____
____
____
____
____

30 What do you like least about *CERN Courier*?

____
____
____
____
____
____
____
____

31 What would you like to see more of?

☐ letters
☐ conference reports
☐ people
☐ news

32 In what direction do you think *CERN Courier* should develop?

____
____
____
____
____
____

33 Which topics/areas do you feel are not covered sufficiently?

____
____
____
____
____
____

34 Do you think the layout, design and illustrations in *CERN Courier* are:

☐ excellent
☐ good
☐ average
☐ poor

Please return your completed questionnaire to Laura Serratrice, Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE, UK. Fax +44 117 930 1178.

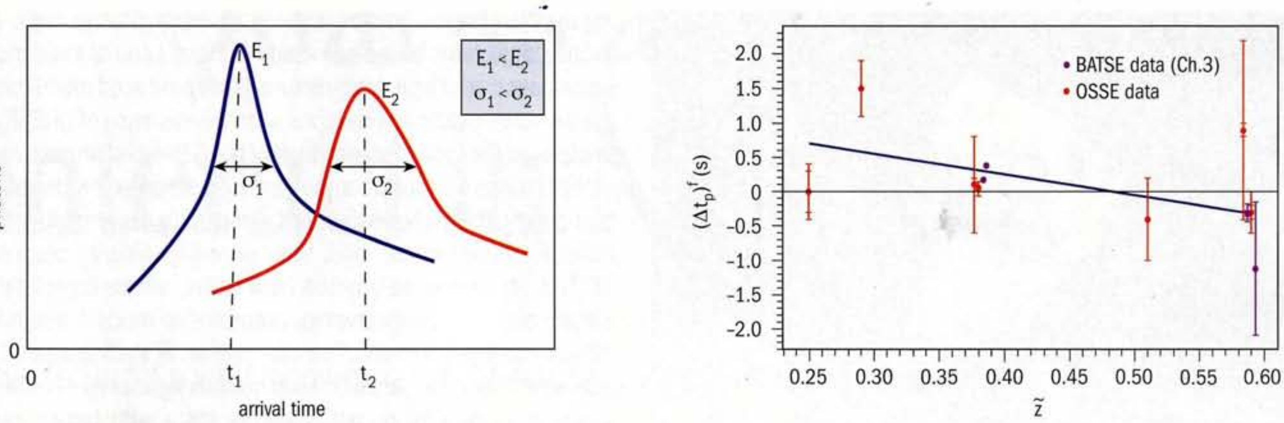


Fig. 2. A typical search for microstructure in the light curves of a GRB can be used for placing bounds on (or detecting) the non-trivial refractive index and light-cone fluctuation effects of some models of stochastic quantum gravity. In Liouville-string models, higher-energy channels are delayed more, due to a subluminal refractive index effect of quantum gravity, and the width of the GRB pulse is wider, due to stochastic fluctuations, compared with lower-energy channels. The linear-regression plot shows the correlation of the difference in arrival times of the peaks of the GRB between two energy channels Δt_p with the redshift z, which is a characteristic feature of such effects. At present, the number of GRBs whose distances are known is statistically insignificant, but it is hoped that new GRB dedicated searches will be able to provide statistically significant populations of GRB with known redshifts. This would allow more stringent bounds, or detection, of stochastic quantum-gravity effects.

of quantum gravity, whose fundamental length scale is far too small to be directly visible. However, since gravity is a non-renormalizable interaction, effects associated with it might be visible at energy scales much lower than the Planck scale.

One possible imprint of quantum gravity at lower scales might be the loss of quantum coherence that characterizes certain models of quantum gravity. The imprint would be a violation of CPT symmetry (T=time reversal), whose conservation is a theorem of any local unitary field theory without gravity, but whose failure is almost guaranteed in a theory with highly curved space–time structure such as a space–time foam. The violation of such symmetry occurs through a modification of the standard quantum-mechanical evolution of matter, which is somewhat similar in nature to the behaviour characterizing open systems in stochastic media. One of the most sensitive probes for such effects is neutral kaons and other mesons. The recently completed CPLEAR experiment at CERN has sensitivity not far from the theoretically estimated magnitude of such CPT violating effects in minimal-suppression models. If the Planck energy scale minimally suppresses quantum-gravity effects, then such effects could be falsified at new experimental meson facilities, for example at Frascati in Italy and Fermilab in the US.

A second effect, which may also be falsified in the immediate future, is a sort of mean-field effect of quantum-gravity foamy situations, according to which the propagation of ordinary particles in this medium results in a modification of the particle's dispersion relation. This effect was first predicted in the framework of Liouville strings. A similar effect has since been shown to characterize the loop-gravity approach. Modified dispersion relations have also been postulated independently at a phenomenological level by researchers proposing a thermal-like nature of the quantum gravity environment or inspired by condensed matter situations. A modification of the dispersion relation for photons or other particles with no mass implies a non-trivial refractive index in vacuo, in other words a frequency-dependent velocity of light. The origin of this effect can be traced back to the spontaneous violation of Lorentz invariance that may characterize the ground state of such theories.

Such effects are also known to describe local field theory situations in non-trivial vacua, such as thermal vacua, or quantum field theories in the vicinity of black hole backgrounds, even allowing for superluminal signals without violations of causality. However, the effect predicted by the stringy (Liouville) approach to quantum gravity has two distinctive features: the effect always leads to subluminal signals, and it is enhanced with increasing energy of the particle probe, in contradistinction to the field-theoretical cases where the effect decreases with energy. In contrast to the stringy case, the loop gravity approach predicts superluminal signals as well.

The Liouville approach to quantum gravity also predicts stochastic light-cone fluctuations. The latter have also been conjectured to characterize some non-trivial theories of local quantum gravity involving coherent gravitons. Light-cone fluctuations imply stochastic fluctuations of the speed of light in vacuo, which will imply stochastic fluctuations in the arrival times of photons of the same frequency in contrast to the refractive index effect, which implies arrival-time fluctuations for photons of different frequencies. The stochastic effect in string theory is suppressed (as compared with the refractive index effect) by powers of the (weak) string coupling expressing the strength of the interactions of string matter.

Astrophysical probes

One of the first probes suggested for the experimental falsification of the refractive index and the stochastic light-cone fluctuation effects was gamma-ray bursts (GRBs). Experimental tests of such effects would look for microstructure in the arrival time of light beams from a GRB (figure 2) and a correlation with distance (redshift). If the emission of photons at various energies were simultaneous within the standard quantum mechanical limits, then a refractive index ▷

Experiments such as NASA's GLAST will be able to differentiate between some quantum gravity models by studying gamma-ray bursts. (Hytec.)

effect would imply differences in the arrival times of photons at different energies. In Liouville string models the subluminal nature of the effect implies that the higher energies would be delayed more. In contrast, loop-gravity-inspired models are characterized by both superluminal as well as subluminal propagation, and as a result there would be birefringence effects, which are absent in the stringy models. On the other hand, as far as stochastic light-cone fluctuations are concerned, there would be fluctuations in the arrival times of photons at the same energy. A systematic theoretical error analysis is needed, however, given that it is possible that photons at different energies are not emitted simultaneously.

Some of the GRBs observed so far are characterized by microstructures in their light curves of less than a millisecond, and are likely to emit gamma rays in the GeV or even TeV energy regions. Since many of these GRBs are known to be at cosmological distances (of the order of 3000 Mpc or larger), the sensitivity of these high-energy channels to the quantum-gravity refractive index and stochastic effects is such that they can be falsified with the next generation of satellite GRB-dedicated facilities, such as NASA's Gamma-ray Large Area Space Telescope (GLAST) and the AMS experiment. Similar sensitivities might be achieved by terrestrial and extraterrestrial interferometric devices, which are also capable of detecting these stochastic quantum-gravity effects as part of the noise in the resulting interference patterns.

Other astrophysical probes of the stochastic quantum-gravity effects may be provided by ultra-high-energy cosmic rays (UHECR) with energies above 10^{19} eV, as well as by TeV photons. The presence of such events seems puzzling from the point of view of Lorentz invariance – standard kinematics imply the existence of energy thresholds, the Greisen, Zatsepin, Kuzmin (GZK) cut-off, above which certain reactions would prevent such energetic particles from reaching the observation point, assuming an extra-galactic origin. Some exotic suggestions have been made to relate Lorentz invariance violation associated with the quantum-gravity-induced modification of the particle's dispersion relations with the existence of UHECR or TeV photons, in the form of an abolition of the GZK cut-off in such models.

High-energy cosmic neutrinos are also sensitive probes of quantum-gravity effects. For instance, if a minimally suppressed refractive index for neutrinos is valid, then ultra-high-energy neutrinos of 10^{19} eV, which may be emitted from GRBs, will be completely dispersed and thus unobservable, according to models with minimal Planck-scale suppression. The observation of such energetic particles would therefore exclude such models right away. Minimal suppression models of quantum-gravity foam with baryon-number violating interactions are in fact already excluded on the basis of solar and extra-galactic neutrino observations, since such effects would lead to neutrino oscillations in direct conflict with the experiment.

Last, but not least, bounds on stochastic effects significantly more stringent than those placed by astrophysical observations may be obtained by means of atomic physics experiments. Such experiments are mainly concerned with measurements of quantum-gravity induced corrections to the gyromagnetic ratio of charged particles, which can be measured with high accuracy.

In summary, a plethora of relatively low-energy measurements can be made, some of which are already on the verge of excluding Planckian physics models. Any future experimental attempt to bind models of quantum gravity should therefore be encouraged, since they present the only way to arrive at a true theory of quantum gravitation, which will probably lead to a better understanding of the structure of space-time itself. The concept of a phenomenology of quantum gravity may soon no longer be considered oxymoronic.

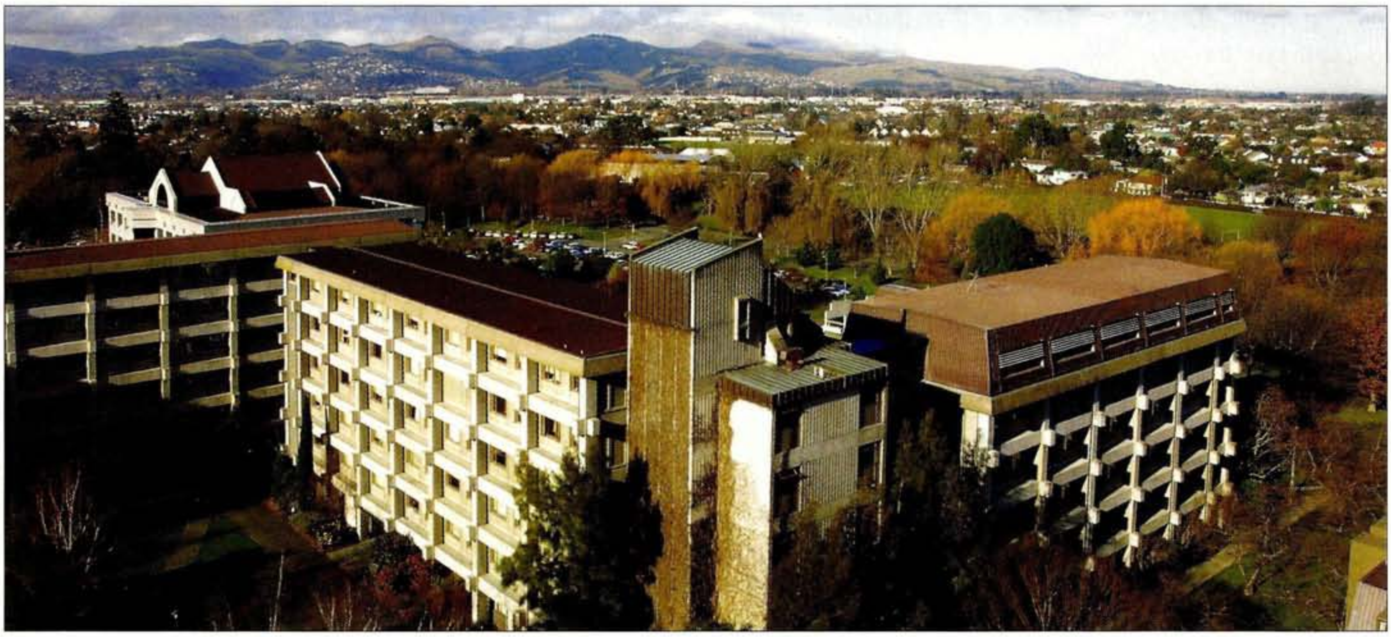
Further reading

R Adler *et al.* 1995 CPLEAR collaboration *Phys. Lett.* **B364** 239.
G Amelino-Camelia *et al.* 1998 *Nature* **393** 763 (astro-ph/9712103 at http://www.arxiv.org/.
J Ellis, N E Mavromatos and D V Nanopoulos 1993 *Erice Subnucl. Series* **31** 1 (hep-th/9304133 at http://www.arxiv.org/).
J Ellis, K Farakos, N E Mavromatos, V Mitsou and D V Nanopoulos 2000 *Astrophys. J.* **535** 139.
J Ellis, N E Mavromatos and D V Nanopoulos 2000 *Phys. Rev.* **D62** 084019 (gr-qc/0006004 at http://www.arxiv.org/).
R Gamibini and J Pullin 1999 *Phys. Rev.* **D59** 124021. (gr-qc/9809038 at http://www.arxiv.org/).
R Gamibini and J Pullin 2001 gr-qc/0110054 at http://www.arxiv.org/.
L J Garay 1999 *Int. J. Mod. Phys.* **A14** 4079 (gr-qc/9911002 at http://www.arxiv.org/).
L Gonzalez-Mestres 1997 physics/9704017 at http://www.arxiv.org/.
Hong-wei Yu and L H Ford 1999 *Phys. Rev.* **D60** 084023 (gr-qc/9904082 at http://www.arxiv.org/).
N E Mavromatos 2000 Dark matter in astro and particle physics *Proc. Heidelberg 2000* **209** ed. H V Klapdor-Kleingrothaus (Springer, Berlin) (gr-qc/0009045 on http://www.arxiv.org/).
Subir Sarkar 2002 gr-qc/0204092 on http://www.arxiv.org/.

Nick E Mavromatos, *King's College, University of London.*

Quarks and Kiwis interact in New Zealand

New Zealand's well known natural beauty goes hand-in-hand with geographical isolation. But now a new research initiative is set to strengthen the bonds between the land of Ernest Rutherford and the international particle physics community.



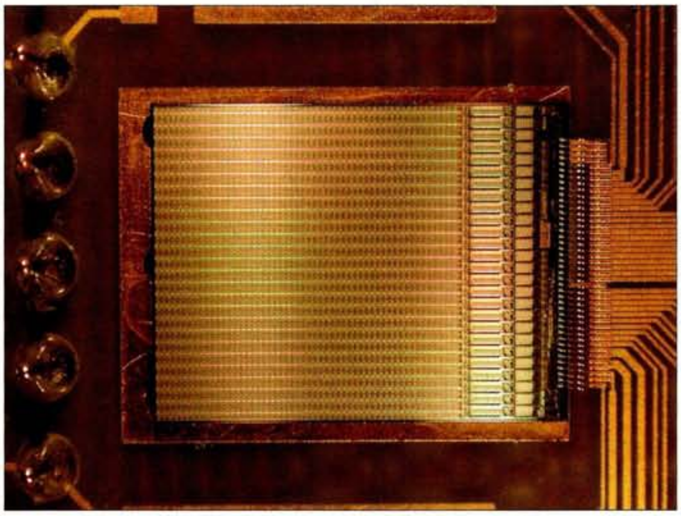
A view from the Department of Physics and Astronomy at the University of Canterbury looks east over the city of Christchurch.

In June, two New Zealand universities formally applied to join the CMS experiment at CERN's Large Hadron Collider (LHC). This marked the launch of an initiative to establish a New Zealand high-energy particle physics and instrumentation programme called NZ_CMS. The basis of this programme is the formation of an experimental particle physics and instrumentation research group within New Zealand that not only contributes directly to the CMS experimental programme, but does so in a way that also optimizes the benefits for New Zealand, its industry and its young researchers. The application was made on behalf of six staff from the universities of Auckland and Canterbury, and also includes several graduate students. In addition, NZ_CMS is receiving support from staff and university groups within the two universities in the fields of electrical engineering, computer science, medical imaging, nanotechnology and optics.

The CMS pixel system was identified as the area where NZ_CMS should contribute, as it provides the best match in terms of personnel, resources, and the focus on instrumentation development sought by Auckland, Canterbury, and the New Zealand government. Over the last year members of NZ_CMS have been working within the CMS pixel community, ensuring a smooth integration into CMS as well as establishing the connections and the technology transfer necessary for the continued development of the programme.

Pixel systems

NZ_CMS has benefited greatly from input from New Zealand, the CMS management and the CMS pixel group at the Paul Scherrer Institut (PSI) in Villigen, Switzerland. Realistic goals have been outlined for long-term benefits and contributions to CMS, whist enabling NZ_CMS to establish itself within the New Zealand academic climate, as well as allowing the shorter-term goals attractive to funding agencies to be achieved. Roland Horisberger, the CMS pixel detector project leader, and the PSI group have strongly supported NZ_CMS, facilitating pixel technology transfer to New Zealand and helping to define the scope of the NZ_CMS deliverables. At present, members of NZ_CMS are working within the PSI pixel group on the pixel control systems and services. As the NZ_CMS collaboration devel- ▷



This CMS pixel readout chip, measuring 8 mm × 12 mm and holding around 400,000 transistors, is to be the basis of the NZ_CMS pixel testing programme.

A delegation from CERN and the CMS collaboration visited New Zealand in January. At the Tamaki campus are (left to right) NZ_CMS team leader Alick Macpherson; David Krofcheck of the University of Auckland; Ralph Cooney, pro-vice chancellor for the Tamaki campus; and Diether Blechschmidt of CERN.

ops, it is expected that the New Zealand–PSI connection will be strengthened, and a training-exchange programme for students, engineers and researchers will be established.

As a sign of the enthusiasm and support for NZ_CMS, the development from initial idea to application for CMS membership has taken only a year and a half, and it has already secured preliminary funding for pixel instrumentation research. The initiative was first presented at the New Zealand Institute of Physics conference in July last year, which was followed by a visit from a CMS-CERN delegation to New Zealand in January.

The week-long itinerary of the delegation, led by John Ellis (representing CERN) and Diether Blechschmidt (representing CMS), included formal meetings with the minister of research, science and technology, the Royal Society of New Zealand and the Universities of Auckland and Canterbury. The delegates also visited Industrial research Ltd (a Crown Research Institute of some 400 staff) and participated in the 18th International Workshop on Weak Interactions and Neutrinos (WIN 2002) held at Canterbury. There was also time for a public lecture by Ellis entitled "From Rutherford to Higgs" in which he described particle interactions using vocabulary from the sport of rugby.

Following the delegation's visit, Steve Thompson, chief executive officer of the Royal Society of New Zealand, made an official information visit to CERN. Soon afterwards initial funding was obtained from the New Zealand government and it was decided to proceed with the NZ_CMS application to join CMS. It is now hoped that concurrent with the NZ_CMS application New Zealand and CERN can negotiate and sign an agreement on co-operation. This would facilitate the development of the country's participation in the LHC.

Current programmes

In an effort to build on its strengths and resources, NZ_CMS is endeavouring to work in conjunction with the country's existing particle physics programmes. Current areas of research in New Zealand include heavy-ion physics at Auckland, ultra-high-energy neutrino physics at Canterbury and theoretical physics at Massey University.

In addition to the University of Auckland's taking a leading role in the NZ_CMS pixel programme with the establishment of a pixel laboratory at its Tamaki campus, Auckland's David Krofcheck is augmenting NZ_CMS's contribution to CMS through reaction-plane studies for the CMS Heavy Ions programme. This follows on from work done with gold-gold collisions at the E895 experiment at Brookhaven in the US. E895 used the Alternating Gradient Synchrotron (AGS) to deliver gold beams of 2, 4, 6 and 8 GeV per nucleon to measure the excitation functions of collective nuclear matter "flow". The NZ_CMS Heavy Ions group currently consists of three researchers and is based entirely at the University of Auckland.

As far as Canterbury is concerned, its particle physics group is participating in the Radio Ice Cherenkov Experiment (RICE) in Antarctica. RICE is a neutrino telescope at the south pole using radio antennas to detect the coherent emission of radio-wavelength Cherenkov radiation from the electromagnetic shower of particles produced when an ultra-high-energy electron neutrino interacts in the ice. The Canterbury group is involved in the Monte-Carlo simulation of the shower and the subsequent detection of the Cherenkov pulse, and the investigation into other possible physics sources such as the transition radiation from air showers. The absence of any neutrino events in the data analysed to date implies upper limits for the neutrino flux comparable to the air shower experiments AGASA and Fly's Eye over the neutrino energy range of around 10^7–10^{12} GeV.

With research into medical imaging instrumentation, digital-signal processing and nanotechnology, Canterbury is also looking to establish instrumentation applications associated with pixel systems and pixel data visualization. These would tie in with its new HITLab NZ, the annex of the Human Interface Technology Laboratory (HITLab) at the University of Washington in Seattle. The HITLab consortium is a world leader in virtual-reality technology such as remote surgery and virtual retinal display, which scans images directly into the retina of the eye.

An additional aspect to be developed is online and offline computing, with a contribution from New Zealand now being possible thanks to the installation of the high-bandwidth transpacific Southern

> NZ_CMS is also a way to combat the continued "brain drain" of young researchers who venture overseas for graduate and career opportunities – often never to return.

Cross Cable, which started operation in late 2000. The cable removes the bandwidth bottleneck between Australasia and the United States, and delivers 120 Gbit/s of fully protected capacity (the equivalent of eight full-length motion pictures every second). An upgrade in early 2003 will double capacity to 240 Gbit/s. At present, the currently available bandwidth to the US from within the universities is around 100 Mbit/s. This removal of bandwidth constraints, coupled with a developing interest in GRID research within New Zealand's IT community, has prompted discussion of possible contributions to online and offline computing within the context of NZ_CMS.

The third component of New Zealand's existing particle physics programme is the theoretical physics group at Massey University, which focuses on nucleon-structure functions and deep inelastic scattering calculations. Their interest in NZ_CMS is ongoing, as experiments at the LHC are an excellent opportunity for studying quark and gluon distribution functions. Detailed knowledge of these distribution functions is needed for much of the physics that will be performed at the LHC, and the NZ_CMS programme will enable the Massey group to participate directly in a facility that should contribute significantly to this area of research.

Finally, the NZ_CMS initiative should be seen as part of the resurgence in New Zealand particle physics that looks to work in close collaboration with both the country's established research groups and our international collaborators (PSI and CMS/CERN). This is a significant step towards New Zealand's participation in the truly global "big science" projects associated with modern high-energy particle physics laboratories, and is based on access to research at the frontier of particle physics.

The NZ_CMS initiative is also a way to combat New Zealand's perceived geographical isolation and the continued "brain drain" of young researchers who venture overseas for graduate and career opportunities – often never to return.

This brain drain is, of course, not a new phenomenon. One of the best documented cases is a young Kiwi (New Zealander) called Ernest Rutherford, who left the country in 1895 to work with J J Thompson at Cambridge University's Cavendish Laboratory. NZ_CMS intends to reunite quarks and Kiwis in New Zealand!

Phil Butler, *University of Canterbury, and* **Alick Macpherson**, *CERN/PSI/University of Auckland.*

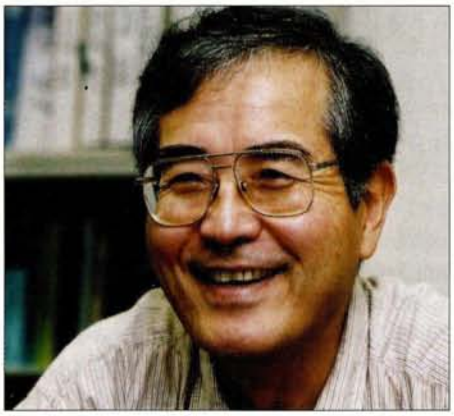
APPOINTMENTS

KEK chooses director-general

On 24 June the KEK board of councillors recommended Yoji Totsuka to the Japanese minister of education and science as the next director-general of KEK, to take over from Hirotaka Sugawara. Totsuka's term of office will run for three years from 1 April 2003.

Totsuka, now professor of physics at the University of Tokyo's Institute for Cosmic Ray Research (ICRR), is well known as the leader of the SuperKamiokande group. He began his research career by studying a large emulsion stack that had been exposed to cosmic rays. Totsuka then switched to a counter experiment in the tunnel of Kamioka mine. This was his first connection with Kamioka. After his doctoral work there he moved to Europe with his colleagues to participate in the DASP experiment at DESY. The group continued their electron-positron experiment with JADE at PETRA.

In the early 1980s, Totsuka returned to Tokyo to start a proton-decay experiment at Kamioka. Under the leadership of Masatoshi Koshiba he built the giant Kamiokande water Cherenkov detector. Although proton decays did not show up, neutrinos from supernova SN1987A in the Large Magellanic Cloud paid the detector a visit. Totsuka inherited the Kamiokande leadership from Koshiba and led the building of a detector that was 10 times larger – SuperKamiokande, which gave the first clear evidence of neutrino oscillation using atmospheric neutrinos.



KEK's new director-general Yoji Totsuka.

Totsuka served as the director of the Institute for Cosmic Ray Research from 1997 to 2001. He has received various prizes and medals including a Nishina Memorial Prize, the Rossi Prize from the American Astronomical Society, a Purple Ribbon Medal from the Japanese government and the Panofsky Prize from the American Physical Society.

New director takes over at NORDITA

Petter Minnhagen, a professor of theoretical condensed matter physics at the University of Umeå, Sweden, has been appointed the director of The Nordic Institute for Theoretical Physics (NORDITA) in Copenhagen. He takes over from Paul Hoyer, who returns to his professorship of theoretical physics at the University of Helsinki. NORDITA was founded in 1957 and is funded by the five Nordic countries – Denmark, Finland, Iceland, Norway and Sweden – through the Nordic Council of Ministers. Its current research areas include astrophysics and cosmology, biological physics, condensed matter physics and nuclear physics, as well as particle physics.

The early histories of NORDITA and the CERN Theory Division are intimately related. Indeed, the CERN Theory Division was born in Copenhagen in 1952, under the leadership of Niels Bohr, and moved to Geneva five years later. The CERN Theory Division thus provided the nucleus on which NORDITA was founded. For further information see www.nordita.dk.

Toasting NORDITA's change in leadership are outgoing director Paul Hoyer (right) and his successor Petter Minnhagen.

Bernard D'Almagne assumed the directorship of the French Linear Accelerator Laboratory (LAL) in Orsay on 1 May 2002, taking over from Francois Richard.

D'Almagne has spent most of his career at LAL working on CERN experiments. Notably, he directed the construction of a number of powerful detectors. These include the OLGA lead-glass calorimeter, which underlined the success of the CERN photoproduction experiments WA4 and NA14, the large wire proportional chambers of NA14, the quartz radiators for the DELPHI RICH detector as well as the electronics for its silicon microstrip detector, and the electronics and trigger system used in the electromagnetic calorimeter of LHCb.

He interrupted this impressive series of technical achievements from May 1998 to November 1999 when he occupied the post of scientific deputy director of France's institute for nuclear and particle physics (IN2P3). During this time he also became interim director of IN2P3. He was a member of CERN's SPS committee from 1990 to 1993, and its president from 1995 to 1998. From 2001 to April this year he was deputy spokesman of the LHCb experiment.

D'Almagne takes the reins of a laboratory that plays a major role in many significant experiments at CERN, Fermilab and SLAC, as well as experiments in neutrinos and cosmology. LAL is also a major player in accelerator R&D and construction – LAL built the linear injector for CERN's LEP collider, and the lab is also involved in the CLIC and TESLA linear collider projects.

European Physical Society names its latest president

Martin Huber, a professor at Switzerland's ETH in Zurich and a former head of the European Space Agency's Space Science department, was elected president of the European Physical Society (EPS) at this year's EPS council meeting in Berlin. He will serve one year as vice-president before taking up office in April 2003.

Huber is currently a visiting scientist at the International Space Science Institute (ISSI) in Bern, and has recently worked at the Smithsonian Astrophysical Observatory. Until the mid-1970s he worked at the Harvard College Observatory in laboratory astrophysics. Returning to Europe, he took a position in ETH's new Atomic Physics and Astrophysics group. When Switzerland joined the European Southern Observatory in 1980, Huber became a member, and later chairman, of its Observing Programme Committee.

Martin Huber will become president of the European Physical Society in April 2003.

Later, he was involved in the definition of ESA's long-term science programme Horizon 2000 as a member of the agency's Space Science Advisory Committee and chair of its Solar System Working Group.

In the EPS, Huber has chaired the Astrophysics Division, transforming it into the Joint Astrophysics Division of the EPS and European Astronomical Society when the latter was founded in 1990.

AWARDS

Slovak team wins national award

The Slovak Academy of Sciences has awarded a prize for outstanding results to a team of scientists from the Institute of Experimental Physics in Košice, the P J Šafárik University in Košice, the Comenius University in Bratislava and CERN. Ladislav Šándor, Anton Jusko, Ivan Králik, Karel Šafařík, Jozef Urbán and Roman Lietava received the award for work on the production of strange baryons and antibaryons in lead-lead collisions at the WA97 and NA57 heavy-ion experiments at CERN. This work provided one of the main pieces of evidence for the formation of a new state of matter (*CERN Courier* June 2000 p25). The award was presented on 21 June in the Smolenice castle near Bratislava.

Left to right: Jozef Urbán, Ivan Králik and Ladislav Šándor receive their award from the president of the Slovak Academy of Sciences, Štefan Luby, and vice-president Karol Karovič.

Berlin's Humboldt University has presented the 2002 Lise Meitner Prize to Boris Körs. The prize rewards outstanding PhD thesis work in physics, and is awarded by the Association of Friends and Sponsors of the Institute of Physics. Körs's thesis, "Open Strings in magnetic background fields", demonstrates that Standard Model gauge theories can be incorporated into superstring theories. Körs now holds a postdoctoral position at the University of Utrecht's Spinoza Institute.

The University of Liverpool recently held an "Erwinfest" to celebrate the career of one of its most illustrious sons. Erwin Gabathuler retired from Liverpool's Sir Chadwick Chair of Physics in June after nearly 20 years at the university. During this time, he led experiments in Europe and the US concerned with the interactions of leptons, photons and hadrons. He also served as research director at CERN, and led the Liverpool particle physics group through a period in which it has achieved distinction in experiments at all the major accelerator laboratories worldwide.

Gabathuler himself has taken a particular interest in the H1 experiment at DESY, the CPLEAR experiment at CERN and the BaBar experiment at SLAC. He has also served as chair of the UK Particle Physics Committee and on many national and international panels concerned with the wellbeing of particle physics both in the UK and on the world stage. He is continuing with many of these commitments in his capacity as emeritus professor of physics at the University of Liverpool.

Speakers at the Erwinfest, a two-day meeting sub-titled "Quarks and symmetries – a perspective to celebrate the career of Erwin Gabathuler", covered all aspects of Gabathuler's distinguished scientific career. More than 80 people attended from laboratories around the world.

Bogoliubov prize for young scientists

The Joint Institute for Nuclear Research (JINR) announces the N N Bogoliubov prize for young scientists. The prize, established in 1999 in memory of the eminent physicist and mathematician Nikolai Nikolaevich Bogoliubov (1909–1992), is awarded to researchers up to 33 years old for outstanding contributions in the fields of theoretical physics related to Bogoliubov's interests. As a rule, it is awarded to a scientist who has shown early scientific maturity and whose results are recognized worldwide.

Entries should try to emulate Bogoliubov's skill in using sophisticated mathematics to attack concrete physical problems. The prize is awarded once every two years in August. Entries for the 2003 prize (including CV and a one- or two-page abstract of submitted papers) should be sent to the Directorate of the Bogoliubov Laboratory of Theoretical Physics of the JINR before 1 May 2003 (Dr V I Zhuravlev, Scientific Secretary of Bogoliubov Laboratory of Theoretical Physics, JINR, Joliot-Curie Str. 6, 141980 Dubna, Moscow Region, Russia; email premia01@thsun1.jinr.ru).

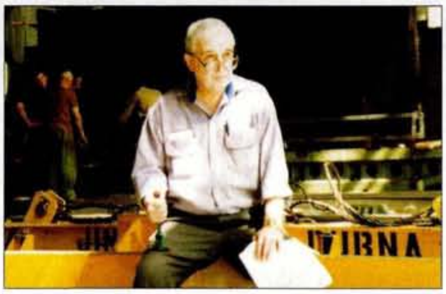
Bogoliubov's main interests were nonlinear mechanics, statistical physics, quantum field theory and elementary particle theory.

Bebo White of the Stanford Linear Accelerator Center (SLAC) joined the likes of Francis Ford Coppola and David Bowie as a member of the International Academy of Digital Arts and Sciences (IADAS) in May. Modelled on the academies for the more traditional media, the IADAS is dedicated to the creative, technical, and professional progress of the Internet and interactive media. Every year, it presents the "Webby" awards, which have come to be recognized as the leading international honours for websites. White was one of SLAC's original WWW Wizards, who made the SLAC website a reference for particle physicists. See http://www.iadas.net/.

The theoretical physicist and well-known popularizer of science **Frank Close** has won a 2002 GlaxoSmithKline/Association of British Science Writers award for his article "Dark side of the moon" published in the UK's *Guardian* newspaper on 9 August 2001. These awards are normally intended for professional science writers, leading one magazine editor to comment that it was nice to see a scientist mixing it with the pros.

CERN's **Cristoforo Benvenuti** has been awarded the American Vacuum Society's Gaede-Langmuir Award for 2002. Conferred every two years, the award is one of the leading prizes in the vacuum field. Its very first winner in 1978 was Pierre Auger, one of CERN's founding fathers.

Benvenuti has been singled out for his work on getters, which made their name at CERN with the LEP electron-positron collider. Getters are materials that capture gas molecules thereby acting as vacuum pumps. In LEP, the getter was laid out in strips running right round the machine. For LEP's successor, the Large Hadron Collider, Benvenuti had the idea of covering the walls of the vacuum chamber with a thin film of getter. This prevents the walls of the chamber from generating gas and means that the whole chamber becomes its own pump. Several kilometres of the future accelerator will be fitted with vacuum chambers coated in this way. Benvenuti's innovation has led to two patents and has been adopted by other accelerator laboratories. The prize-giving ceremony will be in November at the Society's 49th International Symposium to be held in Denver, US.



Julian Budagov celebrated his 70th birthday in July soon after overseeing the completion of a major Joint Institute for Nuclear Research (JINR) contribution to the ATLAS experiment at CERN. The Dubna-based JINR was responsible for constructing 65 21-ton modules for the experiment's hadron barrel tile calorimeter, the last of which was complete by June.

Leon Lederman confronted a bewildering array of candles in June during his 80th birthday celebrations at Fermilab, the US national laboratory he directed from 1978 to 1989. Lederman, 1988 physics Nobel laureate with Melvin Schwartz and Jack Steinberger "for the neutrino beam method and the demonstration of the doublet structure of the leptons through the discovery of the muon neutrino", has long been an advocate of good science education. Today, staff of Fermilab's Lederman Science Education Center and education department train and work with 6000–7000 teachers every year, while Lederman himself promotes a physics–chemistry–biology sequence for science teaching, arguing that physics provides the conceptual underpinning for many other fields.

"I am working hard on changing the current high-school science curricula...trying to dump the hundred-year-old biology–chemistry–physics sequence," he explained. "If you think finding the Higgs particle is hard..." The candles, on the other hand, presented Lederman with less of a challenge.

MEETINGS

The 2002 US–CERN–Japan–Russia Joint Accelerator School will be held on 6–14 November in Long Beach, California, US, covering the field of linacs. The registration fee is $800 (with limited financial assistance available), and the deadline for applications is 1 October. See http://uspas.fnal.gov.

Jefferson Lab is organizing an **International workshop on hydrogen in materials and vacuum systems** on 11–13 November. This is an informal workshop combining scientific, technological and industrial perspectives to engage new ideas in the science, engineering and art of hydrogen in materials and vacuum systems. There is a nominal registration fee to cover expenses and proceedings. See http://www.jlab.org/hydrogen/index.html.

The First "FrontierScience" Conference will be held in Frascati, Italy, on 6–11 October. Topics include heavy quark production and spectroscopy; semileptonic decays; CP violation; mixing; hot trends in instrumentation; the future in flavour and new frontiers. The conference is chaired by Franco L Fabbri. See http://frontierscience.lnf.infn.it or email frontierscience@lnf.infn.it.

Experimental particle physicist Dowell retires

About 80 people attended a half-day meeting at the University of Birmingham, UK, on 3 July to mark the retirement of John Dowell. Speakers were Malcolm Derrick from the Argonne National Laboratory, Chris Damerell from the Rutherford Appleton Laboratory, John Garvey from Birmingham, Carlo Rubbia from CERN, Peter Kalmus from Queen Mary University of London, and Nick Ellis from CERN. Their talks charted most of Dowell's career in experimental particle physics. In 1955, Dowell was a research student on the Birmingham 1 GeV proton synchrotron. He went on to work at NIMROD – the 7 GeV accelerator at the Rutherford Laboratory – before moving to the OMEGA spectrometer and then the UA1 experiment at CERN. At present he is a member of the H1 collaboration at DESY in Hamburg, and the ATLAS experiment at CERN.

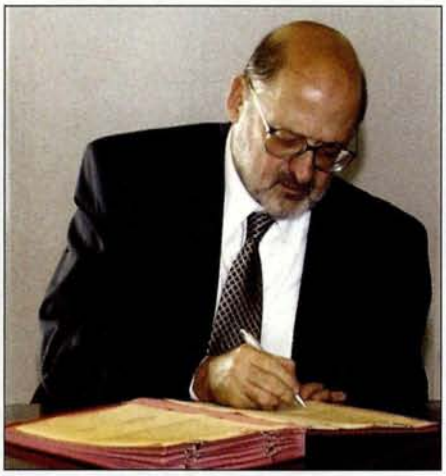
Our understanding of particle physics has increased enormously during Dowell's career, going from a study of proton–proton elastic scattering at 1 GeV, through hadron spectroscopy, to a deep understanding of interactions at the quark level. One outstanding highlight was the discovery of the W and Z bosons produced in proton–antiproton collisions at 540 GeV and observed by the UA1 experiment. For his contribution to this discovery Dowell was elected a fellow of the Royal Society in 1986.

John Dowell retired in July.

Dowell has also made a significant contribution to determining the direction of particle physics research in the UK and in CERN. He was chairman of the UK Particle Physics Committee from 1981 to 1985, a period which overlapped with the Kendrew Committee set up to evaluate the quality and level of UK involvement in particle physics. He was co-spokesperson for the UA1 experiment from 1985 to 1988, chairman of the LEP Committee from 1993 to 1996 and chairman of the ATLAS Collaboration Board from 1996 to 1997. As an *ex officio* member of CERN's Scientific Policy Committee from 1993 to 1996 he was at the heart of European debate on the direction of particle-physics research.

VISITS

Boris Paton, president of the National Academy of Sciences of the Ukraine (left) and CERN director for collider programmes, **Roger Cashmore**, frame a statue of the Goddess of Fortune presented to CERN by Dr Paton during a visit to the laboratory in June. The statue will be prominently displayed at the laboratory. Ukrainian cooperation with CERN dates back to a 1993 co-operation agreement, and Ukrainian physicists are currently involved in the ALICE and CMS experiments being prepared for the laboratory's Large Hadron Collider. Dr Paton's visit paves the way for expanded Ukrainian involvement with CERN. In an expression of intent signed during Dr Paton's visit, the two parties agreed to increase Ukrainian involvement in CERN research and educational programmes, including participation in the LHCb experiment and in Grid computing projects.



During a visit to CERN on 18 July, the Brazilian Minister of State for Science and Technology, **H E Ronaldo Mota Sardenberg**, signed a joint statement with the laboratory's director-general, Luciano Maiani, expressing interest in closer links between Brazil and CERN. Brazil has a strong tradition in particle physics, and is a long-standing partner of CERN.

The joint statement seeks to deepen this partnership, supporting the long-term continuation of a Co-operation Agreement first established in 1990, and encouraging strengthened Brazilian participation in CERN's Large Hadron Collider (LHC) project. Brazilian physicists are already involved in the LHCb, ATLAS and CMS experiments preparing for the LHC. The minister and the director-general also agreed to study the possibility of Brazil joining CERN-led Grid computing infrastructure projects.

A working group is to be established to examine ways of strengthening Brazil's links with CERN, and to prepare the way for a request from Brazil to CERN Council for Brazil to become an Observer at the Council. Observer status allows a country's representatives to attend Council meetings but not to participate in votes, which are the prerogative of the organization's member states. If admitted, Brazil would join Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO as an Observer.

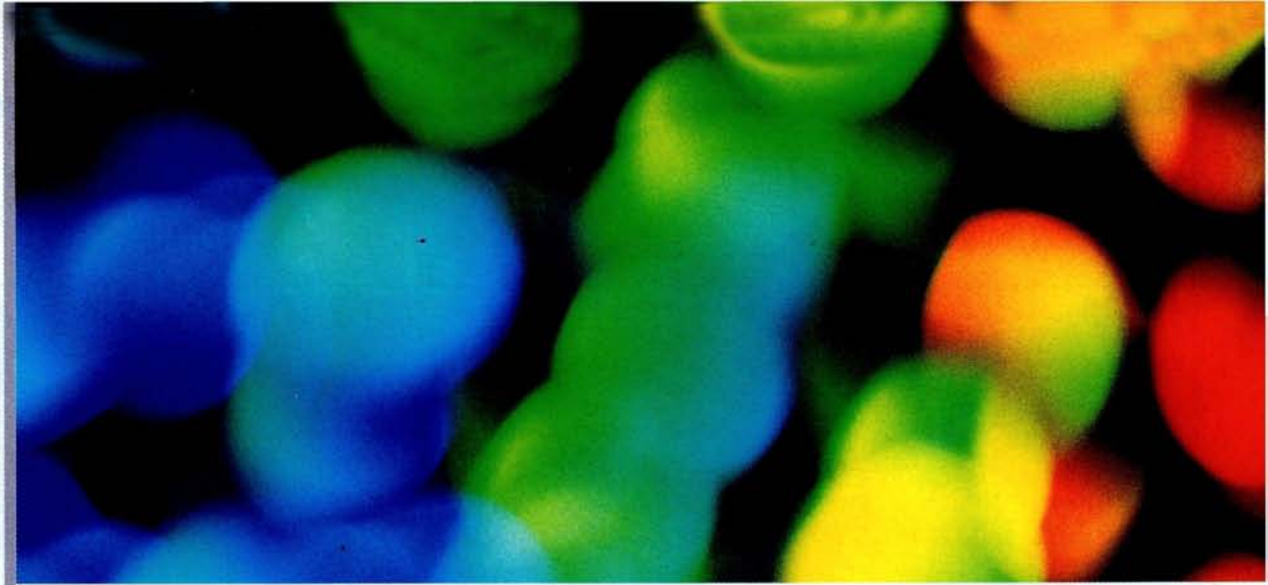
John Marburger (second from right), science adviser to the US president and director of the US Department of Energy's Office of Science and Technology Policy, addressed a meeting of the directorate of Dubna's Joint Institute for Nuclear Research in June.

Symposia to commemorate Weisskopf and Jentschke

CERN will be holding symposia in memory of two of its former director-generals who died earlier this year. On 17 September, the laboratory will remember Victor Weisskopf, director-general from 1961 to 1965 (*CERN Courier* June p28), and on 31 October, a symposium will be dedicated to the memory of Willibald Jentschke (*CERN Courier* May p40), director-general from 1971 to 1975.

Later in the year, on 16 November, the Massachusetts Institute of Technology, where Weisskopf spent most of his working life, will be holding its own memorial symposium entitled "Viki: Theme and Variations". It will combine reminiscences with talks about modern science, science politics and science education.

In December, the DESY laboratory will hold the first in an annual series of lectures by eminent scientists to commemorate its founding father, Willibald Jentschke.



PRODUCTS

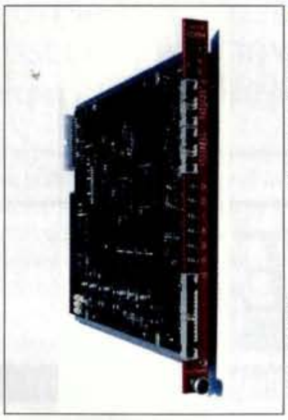
Thermo Vacuum Generators has introduced new high-vacuum gate valves providing fast, quiet, shock-free operation, with up to 500 000 cycles between maintenance. The patented SoftShut mechanism (right) provides fast linear gate motion to position the gate, and precisely controlled vertical motion for sealing. The design allows the gate to fully open or close in 1–3 s depending on valve size, yet virtually eliminates mechanical shock to help reduce particle generation and protect sensitive equipment from shock and vibration. SoftShut valves are used from 2 bar to less than 1×10^{-8} mbar, have gate and body leak rates of less than 1×10^{-9} mbar ls^{-1}, and can be baked at temperatures of up to 200 °C. See www.softshut.com.

VMETRO has announced the CP-MDR customer programmable recorder for embedded real-time applications. Aimed at high-performance data acquisition applications, the CP-MDR comes in a one-slot VME version with one vacant PMC position, and a two VME slot version with four vacant PMC positions. For full information, contact hschibbye@vmetro.no (Europe/Asia) or tbohman@vmetro.com (US).

Advanced Research Systems is offering two new products. The Displex DE204S is a compact low-vibration 4K research closed cycle cryostat providing 150 mW of cooling capacity at 4.2 K, and the Helitran LT-3 OM is a compact 4–400 K optical microscope open-cycle cryostat providing ultralow sample drift and vibration, and fast cool-down. For details, see www.arscryo.com.

Spiricon has announced a new low-cost NIR camera – the SP-1550M, at $1995 – which measures the output of optical telecom devices from 1460 to 1625 nm. Coupled to the LBA-PC series beam analysers, it displays mode field patterns of fibres, laser diodes, LEDs and VCSELs in real time. The camera is a high-resolution CCD sensor with a phosphor coating that up-converts NIR radiation to visible radiation detectable by the CCD. The LBA-PC beam analysers correct for nonlinearity in the up-conversion process, which produces accurate measurements and beam profiles. Contact info@spiricon.com, or visit www.spiricon.com.

SUPPLIER INFORMATION



Cheesecote Mountain CAMAC

CMC203 FERA Driver/Memory/Histogrammer

FERA users, you don't have to feel abandoned any longer, the CMCAMAC FERA driver is shipping! It does a lot more than the venerable 4301, but it can also just drop into an existing 4301 application. The CMC203 has all the 4301 inputs and outputs (the FERABUS output is on the rear panel) and then some. Some of the features are:

- 4301 emulation mode, no changes
- 1 Mword FIFO memory mode, simultaneous write from FERA and read via CAMAC (FASTCAMAC too!)
- Histogram memory mode, 20 bit address allows simultaneous histograms of all channels in the crate.

A complete description is available on the internet. Call or write for more information.

CMCAMAC, 24 Halley Drive, Pomona, NY 10970 USA
Tel. +1 (845) 364 0211
Email info@cmcamac.com Web: www.cmcamac.com

Janis Research Co Inc

ST-400 Ultra High Vacuum Systems

Janis Research offers a complete line of liquid helium, liquid nitrogen, and closed-cycle cooled cryostats for research. These include designs optimized for UHV environments, featuring rapid cool down and UHV compatible materials and fabrication techniques. In addition to standard catalog models, Janis custom designs and builds cryostats to meet specific user requirements.

Janis Research Company, Inc
2 Jewel Drive, PO Box 696
Wilmington, MA 01887-0696 USA
Tel. +1 (978) 657 8750; Fax +1 (978) 658 0349
Email sales@janis.com
Web http://www.janis.com

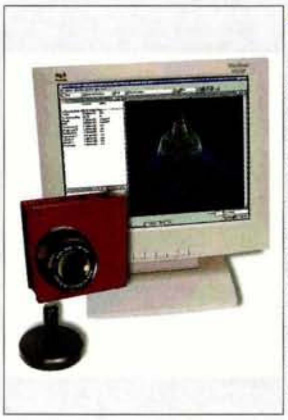
Instrumentation Technologies

DBPM2 System – The unique integrated and reconfigurable beam position monitoring solution with sub-micrometer resolution

Features • Reconfigurability • Over 100dB of dynamic range • Development tool availability

Benefits • Facilitates wide spectrum of position measurement applications: pulsed, closed orbit, first turn(s), turn-by-turn, tune • Suitable for commissioning, regular operations and machine physics studies • User-friendly configuration and control of the system

Instrumentation Technologies d.o.o.
Srebrnicev trg 4a, SI-5250 Solkan, Slovenia
Tel. +386 (0)5 3332300 Fax +386 (0)5 3332305
Email sales@i-tech.si
Subscribe to the I-Tech newsletter - www.i-tech.si



Spiricon Inc

Beam Analysis

Spiricon manufactures instruments for spatial beam analysis. Light emitted from targets in the beam path is imaged onto CCD cameras for complete analysis, including: viewing of the beam profile in both 2D and 3D, measurements of beam width, directional stability, and many others. Spiricon's advanced Ultracal facilitates the most advanced spatial measurements possible.

Spiricon Inc
2600 N. Main St, Logan, UT 84341 USA
Tel. +1 435 753 3729
Fax +1 435 753 5231
Email sales@spiricon.com
Web www.spiricon.com

RECRUITMENT

For advertising enquiries, contact CERN Courier recruitment/classified, Institute of Physics Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK.
Tel. +44 117 930 1026. Fax +44 117 930 1178.
Rates per single column centimetre: mono £36, single colour £38, full colour £40. Please contact us for more information on publication dates and deadlines.

POSTDOCTORAL POSITIONS IN EXPERIMENTAL PARTICLE PHYSICS

The Fermi National Accelerator Laboratory (Fermilab) has openings for postdoctoral Research Associates in experimental particle physics. The Fermilab research program includes experiments with the 2 TeV proton - antiproton collider, neutrino oscillation experiments, fixed target experiments and astroparticle physics experiments. There are positions for recent Ph.D.s to join the collider program which has completed its upgrade and is taking data. There are also opportunities to join the neutrino oscillation experiments MiniBooNE and MINOS, the particle production experiment MIPP, the Cryogenic Dark Matter Search, the Pierre Auger Observatory (cosmic ray) project and data analysis of fixed target experiments. Opportunities also exist to participate in the future BTeV, CKM and LHC-CMS experiments. Positions associated with the experimental program are also available in the Computing Division for candidates interested in modern computing techniques applicable to HEP data acquisition and analysis.

Successful candidates are offered a choice among interested Fermilab experiments, and typically have the opportunity to participate in detector development and commissioning in addition to experiment operation and data analysis. Appointments are normally for three years with the possibility of extension. Every effort will be made to maintain support for a Fermilab RA until she or he has the opportunity to produce physics results.

Applications and requests for information should be directed to **Dr. Michael Albrow, Head - Experimental Physics Projects Department, Particle Physics Division {albrow@fnal.gov}, Fermi National Accelerator Laboratory, MS 122, P.O. Box 500, Batavia, IL 60510-0500.** Applications should include a curriculum vita, publication list and the names of at least three references. EOEM/F/D/V.

Fermilab

A U.S. Department of Energy Laboratory

UNIVERSITY OF TORONTO

POSTDOCTORAL RESEARCH ASSOCIATE POSITIONS
Experimental High Energy Physics

VELUT ARBOR ÆVO

Two postdoctoral research associate positions in Experimental High Energy Physics are available at the University of Toronto. The positions being offered are to work on the ATLAS experiment at CERN. Our group is a major participant in the construction, installation and commissioning of the hadronic sections of the ATLAS forward calorimeter (FCAL). All of the components constructed in Toronto will be delivered to CERN by February 2003. One of the successful candidates will be expected to take a leading role in the completion, installation, and commissioning of this detector. In addition, the group is in the process of installing a large Linux computing cluster, and plans to develop an active role in the preparations for ATLAS data-taking and analysis. One of the successful candidates will be expected to take a leading role in this area. Candidates should supply a resume, a description of research interests and three letters of reference, to

Prof. Robert S. Orr,
Department of Physics,
University of Toronto,
60 St. George St.,
Toronto, Ontario, M5S 1A7,
Canada.

For information send email to **orr@physics.utoronto.ca**. The review of applications will begin immediately, and will continue until the positions are filled.

In accordance with Canadian immigration regulations, this advertisement is directed in the first instance to Canadian citizens or permanent residents. Nonetheless, all qualified applicants are encouraged to apply. The University of Toronto strongly encourages applications by women and members of minority and aboriginal groups.

Deutsches Elektronen-Synchrotron
beam instrumentalization

DESY

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

At DESY several accelerators are in operation for the production of synchrotron radiation and for high energy physics experiments. Our group – MDI –, which is responsible for the beam instrumentalization of these facilities, is looking for a

Physicist (m/f)

Your tasks will comprise development, construction and commissioning of beam diagnosis monitors, mainly using synchrotron radiation. This includes transversal and longitudinal profile monitors with very high resolution. A team of committed technicians and engineers will be available for support.
You should have a degree in physics or a comparable qualification as well as experience in operating accelerators and in beam diagnosis and instrumentalization in combination with profound knowledge of accelerator physics, technology and instrumentalization. For this position you should like teamwork and you should also be able to work as a team leader. Furthermore your work would partly consist of shift work. Your health should also permit the use of a breath protection mask. If you fulfil all these requirements, please send your letter of application and three names of referees to our personnel department.
Please note: This is a replacement for a position becoming vacant due to part time retirement. At first this position will have limited responsibility and pay BAT IIa. After 12/31/2004 you will be given full responsibility at BAT Ib.

Salary and benefits are commensurate with public service organizations. 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.

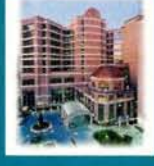
Deutsches Elektronen-Synchrotron DESY
member of the Helmholtz Association
code: 107/2002 • Notkestraße 85 • D-22603 Hamburg • Germany
Phone +49 40/8998-3956 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applicants: open

POSTDOCTORAL RESEARCH POSITIONS
in Medical Imaging

THE UNIVERSITY OF TEXAS MD ANDERSON CANCER CENTER *Making Cancer History*™

Applications are invited for five postdoctoral research positions in medical imaging in the Department of Nuclear Medicine, The University of Texas M. D. Anderson Cancer Center for the development of PET (Positron Emission Tomography) cameras.



Requirements: a Ph.D. in experimental or applied physics obtained within the past five years. Candidates should have work experience in scintillation detector design, fast electronics, C, C++, and data acquisition. Applicants should send their curriculum vitae, list of publications, a brief statement of research interests and must have three letters of recommendation. Send all correspondence to:

Wai-Hoi (Gary) Wong, Ph.D., Director, Nuclear Imaging Instrumentation Development Laboratories, Department of Nuclear Medicine, The University of Texas M. D. Anderson Cancer Center, 1100 Holcombe Blvd., Houston, TX 77030, Mail Box 217.

MDACC is an equal opportunity employer; smoke-free environment. Women and minority candidates are encouraged to apply.

SLAC

Tenured Professorial Position
Experimental Elementary Particle Physics

The Stanford Linear Accelerator Center (SLAC) is seeking an outstanding individual for a tenured faculty position in experimental elementary particle physics at the rank of Associate or Full Professor. We are looking for candidates with significant accomplishments and promise for important future achievements. We are particularly interested in candidates with near term research interests involving the BaBar experiment.

The successful candidate is expected to take a leadership role in the ongoing BaBar activities, in developing new initiatives at the lab and in creative scholarship. As a member of the Academic Council of Stanford University, there will be opportunities to teach and supervise undergraduate and graduate students.

Candidates should submit a curriculum vitae, publication list, a statement of research interests, and the names of four references to

Prof. Persis Drell, SLAC-MS 75, 2575
Sand Hill Rd, Menlo Park, CA 94025.

The deadline for receipt of applications is November 1, 2002.

SLAC is committed to equal opportunity through affirmative action in employment. We strongly encourage qualified minority and women candidates to apply.

CORNELL
UNIVERSITY

COMPUTING PROFESSIONAL/ RESEARCH ASSOCIATE

The elementary particle physics group at Cornell University has an opening for a Computing Professional/Research Associate to work on projects related to the CLEO/CLEOc experiment and R&D for a Linear Collider. The person filling this appointment will have major responsibilities for the upgrade, optimization, and maintenance of the CLEO offline analysis software, databases for calibration and data access, and eventually software development for a Linear Collider. Membership in the CLEO Collaboration and the opportunity for half-time data analysis are possible though such activities are not required.

A PhD in experimental elementary particle physics or advanced degree in Computer Science, and at least 3 years experience with software development are required. Expertise is necessary in the following areas: The UNIX operating system, object-oriented programming, C++, UNIX shell scripting, and large-scale software design. It is also highly desirable for the applicant to have familiarity with the computing tasks common in experimental high energy physics such as data management, physics analysis, and Monte Carlo simulations, as well as LINUX, FORTRAN, and code management and versioning systems.

Please send an application including curriculum vitae, publication list, and resume of computer experience, and arrange for at least three letters of recommendation to be sent to

Prof. Lawrence Gibbons,
Newman Laboratory, Cornell University,
Ithaca, NY 14853.

E-mail correspondence may be directed to **search@lns.cornell.edu**

Cornell is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

LIP

Laboratory for Instrumentation and Experimental Particle Physics

Departmento de Fisica da Universidade de Coimbra, 3004-516 Coimbra, Portugal

The Coimbra branch of LIP anticipates the opening of **staff positions for experimental physicists**. Only applicants with a solid CV in the areas of Experimental Particle Physics or related Instrumentation and, at least, two years experience after PhD will be considered*).

The present activity of LIP-Coimbra ranges from particle physics (ATLAS, HERA-b, and n-ToF) to the development of radiation detection systems, mainly gaseous and liquid noble gas detectors. Besides of the referred to experiments, some areas of application of the detectors under study are imaging (medical PET, with liquid xenon; monitoring of radiotherapeutical beams and neutron radiagraphy, with GEMs; ToF-PET, with fast RPCs), time of flight of charged particles (fast RPCs) and dark matter search (liquid xenon).

For details, candidates may consult **http://www.coimbra.lip.pt**

Questions, declaration of interest or early submission of CVs should be addressed to **seclip@lipc.fis.uc.pt**

*) Post-doctoral fellowships, supported by other programmes, are also available.

VISITING SCIENTIST POSITION

Centre de Physique des Particules de Marseille CPPM

The Centre de Physique des Particules de Marseille invites applications for a visiting scientist position to join the physics group working on LHCb, the study of CP Violation and rare decays in the beauty sector at the LHC. The successful candidate is expected to contribute to the development of the Level 0 muon trigger processor as well as to the preparation of the physics analysis. The visiting scientist position will be for 2 years, based at Marseilles.

Applications including CV, list of publications and references should be addressed to

F. Amat CPPM 163 Av. de Luminy - Case 907 F - 13288 Marseille Cedex 09,
E-mail: **amat@cppm.in2p3.fr**

For more information on the post, contact

R. Le Gac, legac@cppm.in2p3.fr
E. Aslanides, Director of CPPM, aslanides@cppm.in2p3.fr

YOUNG SCIENTIST

Centre de Physique des Particules de Marseille CPPM

The Centre de Physique des Particules de Marseille (CPPM) searchs for A young scientist to participate in ANTARES project, for a two year position based at CPPM in Marseille.

ANTARES is building a neutrino telescope in Mediterranean sea to search for astrophysical sources of neutrinos, dark matter in the form of relic neutralinos and to measure oscillation parameters of atmospheric neutrinos.

Successful candidate should contribute to all aspects of experiment: operations of the first detector elements, deployed from autumn 2002, detector calibrations and first physics analyses of results.

The post is immediately available, to be filled as soon as possible. Send applications (letter of motivations, CV, names of two referees) to:

Francoise Amat - CPPM - 163 Av. de Luminy - Case 907 - F - 13288 Marseille Cedex 09
Phone: **+33 (0)4 91 82 72 08** - Fax: **+33 (0)4 91 82 60 58**
e-mail: **amat@cppm.in2p3.fr**
For further information of the post, contact **John Carr (carr@cppm.in2p3.fr)**

NUS National University of Singapore

RESEARCH FELLOWS, RESEARCH ASSOCIATES and LABORATORY OFFICERS

Singapore Synchrotron Light Source

The National University of Singapore (NUS), Singapore Synchrotron Light Source (SSLS), invites applications for a total of nine positions as **Research Fellows, Research Associates** and **Laboratory Officers**.

For full details, please refer to the SSLS website at

http://ssls.nus.edu.sg

CORNELL
UNIVERSITY

TENURE-TRACK PROFESSORIAL POSITION EXPERIMENTAL ELEMENTARY-PARTICLE PHYSICS

We are seeking an outstanding individual for a tenure-track professorial position in experimental elementary-particle physics at the level of Assistant Professor. In addition to teaching undergraduate and graduate courses, responsibilities will include supervision of graduate students and participation in the research program of the Laboratory for Elementary-Particle Physics, which is based on the CESR e^+e^- storage ring and the CLEO experiment, with future involvement in the international linear collider. CLEO provides a unique opportunity for high precision measurements in the Upsilon family, at the J/Psi, and near the DD and D_SD_S production thresholds. The Laboratory envisions a substantial role in both the particle physics and accelerator development of the linear collider. A PhD in Physics and experience in experimental elementary particle physics is required. The position will be available in summer 2003. Please send an application and at least three letters of recommendation to

Prof. Ritchie Patterson, Search Committee Chair
Newman Laboratory
Cornell University
Ithaca, NY 14853

Applications should include a curriculum vitae, a publication list, and a short summary of teaching and research experience. Electronic submissions and mail inquiries may be addressed to **search@lns.cornell.edu.**

Cornell is an equal opportunity/affirmative action employer.

FELLOWSHIP IN EXPERIMENTAL HIGH ENERGY NUCLEAR PHYSICS

The Lawrence Berkeley National Laboratory's Nuclear Science Division is seeking a scientist with outstanding promise and creative ability in the field of experimental high energy nuclear physics. The appointment will be as Divisional Fellow for a term of five years with the expectation of promotion to Senior Scientist. The successful candidate will have several years of experience beyond the PhD in nuclear or particle physics and will be expected to assume a leadership role in the Relativistic Nuclear Collisions (RNC) Program at LBNL.

The RNC group has a key role in the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. The group currently has a strong physics program in nucleus-nucleus collisions at RHIC and intends to become a major player in spin physics. Candidates having an interest in spin physics at RHIC are encouraged to apply.

Applicants are requested to email a curriculum vitae, list of publications, statement of research interests, and the names of at least five references, no later than October 1, 2002, to afnsemployment@lbl.gov. Please reference job number AF/014946/JCERN in your cover letter. LBNL is an EEO/AA employer.

BERKELEY LAB

UNIVERSITY OF OXFORD

Mathematical and Physical Sciences Division

Department of Physics
in association with St Edmund Hall

University Lecturership in Experimental Particle Physics

Applications are invited for a University Lecturership in the field of experimental particle physics. This is a permanent post and is associated with a Tutorial Fellowship at St Edmund Hall, under arrangements described in the further particulars. The combined University and College salary will be according to age on a scale up to £41,570 p.a.

The LHC will open up new windows on physics when it starts operation in 2006. This includes the origin of mass as well as physics beyond the Standard Model. We are looking for an outstanding physicist to build an analysis engine for ATLAS physics results. The enormous data sets that will be generated by ATLAS will require very significant new computing resources which will only be available through the Grid. The successful candidate will develop Grid capabilities at Oxford towards this goal. In the longer term the candidate will contribute to the development of LHC physics and experimental particle physics more generally at Oxford. Questions can be addressed to Dr Tony Weidberg, t.weidberg@physics.ox.ac.uk

Further particulars of this post and information on how to apply are available on http://www2.physics.ox.ac.uk/pnp/lect02-fp.htm or from Mrs Sue Geddes, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK, e-mail: s.geddes@physics.ox.ac.uk fax: +44 (0)1865 273417. The application deadline is 1st October 2002.

The University is an Equal Opportunities Employer.

PhD-Position in Experimental Particle Physics

The Faculty of Physics of the **University Freiburg** is inviting applications for a **PHD-position for experimental high energy physics** for the ZEUS experiment at the electron-proton storage ring HERA, at DESY, Hamburg. The position will start with a grant and will turn after one year into a BAT IIa/2.

The field of activity is the participation in the running of the ZEUS detector during the upcoming high luminosity period, and the physics analysis of the data. As a side activity detector development for TESLA is possible.

Some teaching support at the University Freiburg is required, the residence can be in Hamburg, however.

For the position a Diploma thesis or equivalent degree in experimental particle physics is required.

Interested candidates should send the usual information (cover letter, curriculum vitae, examination grades, and more than one name of referees) to

Prof. Dr. A. Bamberger
Universitaet Freiburg
Fakultaet fuer Physik
Hermann-Herder-Str. 3
D-79104 Freiburg

Tel. +49 761 203-5714, Fax. 203-5931

More information via: **bamberger@physik.uni-freiburg.de** See also: **http://frzsun.physik.uni-freiburg.de:8080/**

PSI
PAUL SCHERRER INSTITUT

Experimentalphysiker/in

www.psi.ch

CANBERRA

pantechnik
a CANBERRA EURISYS Company

Postdoctoral Position in Accelerators Design

PANTECHNIK offers a postdoctoral position for one year starting end 2002 - beginning 2003. The student has to be from an EC country other than France. The work will be on accelerators design. We will submit a design report for a 0,5 to 2 MeV per nucleon accelerator, using an ECR ion source plus the design of irradiation station for polymer films. A background in accelerators science or in nuclear instrumentation will be appreciated.

Please send your application to:

PANTECHNIK – 12 rue A. Kastler –14000 CAEN – France
Email: pantechnik@compuserve.com

Radiation Protection Supervisor/ Assistant Manager

Euro Nuclear Services, Coevorden, NL

Qualification: Health Physicist Level III (Netherlands)

Duties: responsible for Netherlands nuclear materials license, including routine monitoring and records, assist plant supervision as needed.

Annual Salary: 40-65K Euro.

Contact **Mike Fuller, UniTech Services Group., Inc, mikef@u1st.com 413 543 6911**

Universität Heidelberg

An der **Fakultät für Physik und Astronomie der Ruprecht-Karls-Universität Heidelberg** ist zum frühestmöglichen Zeitpunkt eine

C3-Professur für Experimentalphysik (Experimentelle Teilchenphysik)

zu besetzen. Die Stelle ist am Kirchhoff-Institut für Physik angesiedelt.

Der/die zukünftige Stelleninhaber/in soll auf dem Gebiet der experimentellen Teilchenphysik mit Beschleunigern ausgewiesen sein. Praktische Erfahrungen bei Planung und Aufbau von Experimenten und in der Datenanalyse werden erwartet. Der Schwerpunkt der zukünftigen Arbeiten soll auf dem Gebiet der Physik mit dem ATLAS Detektor am Large Hadron Collider Projekt (LHC) liegen, eine weitere Aktivtät an einem laufenden Beschleunigerexperiment is möglich.

Formale Einstellungsvoraussetzungen sind ein abgeschlossenes Hochschulstudium der Physik, didaktische Eignung, Promotion und Habilitation oder der Nachweis gleichwertiger wissenschaftlicher Leistungen.

Die Stelle steht unbefristet zur Verfügung.

Bei der Berufung in ein Professorenamt ist das Dienstverhältnis gemäß § 67 Abs. 1 UG grundsätzlich zu befristen. Ausnahmen sind möglich, wenn Bewerber/innen aus dem Ausland oder aus dem Bereich außerhalb der Hochschulen sonst nicht gewonnen werden können. Soll das Dienstverhältnis nach Fristablauf fortgesetzt werden, bedarf es nicht der erneuten Durchführung eines Berufungsverfahrens.

Die Universität Heidelberg strebt eine Erhöhung des Frauenanteils unter den Hochschullehrern an und bittet dementsprechend qualifizierte Wissenschafterlerinnen nachdrücklich um ihre Bewerbung

Bewerbungen mit den üblichen Unterlagen senden Sie bitte bis zum **15.9.2002** an den Dekan der Fakultät für Physik und Astronomie, Albert-Ueberle-Str. 11, D-69120 Heidelberg.

UNIVERSITY OF ROCHESTER

TENURE TRACK FACULTY POSITION IN EXPERIMENTAL PARTICLE PHYSICS

The Department of Physics and Astronomy

at the University of Rochester invites applications for a tenure-track position in experimental particle physics at the Assistant Professor level, with the appointment to begin on July 1, 2003 or later.

We seek outstanding candidates to either strengthen or complement our current activities in experimental particle physics, which include programs within the CDF, D0, CLEO, and CMS (LHC) experiments, and new R&D efforts started recently on neutrino oscillations for experiments to be performed at the JAERI 50 GeV PS in Japan, and experiments at anticipated linear colliders.

The successful candidate is expected to initiate an independent research program, either within these collaborations, or in experiments not currently pursued by Rochester faculty. Candidates should have outstanding records in research, and strong commitments to excellence in undergraduate and graduate teaching. To ensure full consideration, applications should be received well before December 1, 2002.

Salary will be competitive, and applications from women and members of underrepresented minority groups are encouraged. Applicants should submit a curriculum vitae, a list of publications, and a description of their proposed research, and should arrange for five (or more) letters of recommendation to be sent to:

Professor Arie Bodek, Chair Department of Physics and Astronomy
University of Rochester
Rochester, New York 14627-0171

Robert R. Wilson — Fellows Program —

The Wilson Fellowship program at Fermilab supports physicists early in their careers by providing unique opportunities for self-directed research in experimental physics. The Fermilab experimental particle physics program includes collider physics at the energy frontier, studies of lepton flavor oscillations, quark flavor physics and astroparticle physics.

The fellowships are awarded on a competitive basis to Ph.D. physicists of exceptional talent as evidenced by their contributions to the field in their postdoctoral work. Fellows will work at Fermilab in areas of experimental particle physics of their choice.

Wilson Fellowships are tenure track positions with an initial term appointment of three years.

Each candidate should submit a research statement describing a proposed research program and a curriculum vitae; and should arrange to have four letters of reference sent to the address below. Application materials and letters of reference should be received by October 31, 2002.

Materials, letters and requests for information should be sent to:

Patricia L. McBride,
Chair, Wilson Fellows Committee
Fermi National Accelerator Laboratory, MS234
P.O. Box 500
Batavia, IL 60510-0500
email: mcbride@fnal.gov
www.fnal.gov/pub/wilson_fellowships.html

Fermilab

A U.S. Department of Energy laboratory.
Fermilab is an equal opportunity/Affirmative Action Employer

MIT

The Department of Physics of the Massachusetts Institute of Technology invites applications for junior faculty positions. Faculty members at MIT teach undergraduate and graduate physics courses, serve as mentors and advisors, and oversee students' research projects. Candidates must show promise in teaching as well as in research. Preference will be given to applicants at the Assistant Professor level. **Applicants should submit by regular mail a curriculum vitae (include email address), a publications list, a brief description of research interests and goals, and should have at least three letters of reference sent directly to the appropriate committee chair listed below.**

EXPERIMENTAL PARTICLE AND NUCLEAR PHYSICS

Currently, the research groups in the division and LNS have strong interests in QCD (PHOBOS, BLAST, Jefferson Lab., Mainz and HERMES), flavor physics and Electroweak Symmetry breaking (BaBar, CDF, ATLAS, and CMS), dark matter searches (AMS and axions) and neutrino physics (SuperKamiokande and Borexino). Strong candidates in new areas of experimental nuclear and particle physics are particularly welcome. (See http://pierre.mit.edu/ for a description of current research activities). Application materials, specified above, should be sent directly to: **Professor Peter Fisher, Chair, Experimental Particle and Nuclear Physics Search Committee, Massachusetts Institute of Technology, 77 Massachusetts Avenue, 44-118, Cambridge, MA 02139-4307.**

PARTICLE THEORY

This search is focused on high-energy theory covering the energy scales from just beyond the standard model to the Planck scale. Current faculty in the Center for Theoretical Physics span a broad range of interests, including QCD, electroweak physics, unification, cosmology, and string theory. Candidates will be evaluated on the basis of potential contributions to the research programs carried out in the Center for Theoretical Physics. Application materials, specified above, should be sent directly to: **Professor Washington Taylor, Chair, Particle and Nuclear Theory Search Committee, Center for Theoretical Physics, 77 Massachusetts Avenue, 6-308, Cambridge, MA 02139-4307. The deadline for applications is December 1, 2002.**

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

INDEX TO DISPLAY ADVERTISERS

The index is provided as a service and, while every effort is made to ensure its accuracy, *CERN Courier* accepts no liability for error.

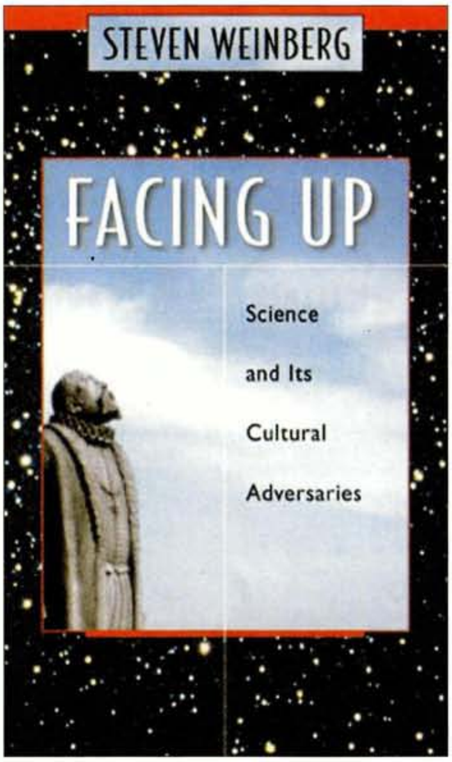
BOOKSHELF

Facing Up: Science and its Cultural Adversaries by Steven Weinberg, Harvard University Press, ISBN 067400647X, £17.95 (€28).

These 23 essays written by Steven Weinberg from 1985 to 1999 make a nice collection around the theme of reductionism. Each is preceded by a page or so describing the context, which is often a valuable addition to the main texts of the essays. Professor Weinberg's introduction to the set led me to believe that the book would be about facing up to the reality of a neutral universe: Tycho Brahe's statue looking up to the sky is on the cover. The secondary title is more apt: the majority of the essays are in defence of the scientific approach to understanding our surroundings. Flaws in other approaches, especially constructionist, are pointed out.

Weinberg makes a strong case for reductionism. Phenomena can be explained in terms of others, but these explanations come in a hierarchy, which clearly points back to a theory of everything, as yet to be discovered. Physics is closest to this origin and physicists are closing in.

Not being a physicist myself, I found that many of the essays are brilliant formulations of our understanding of physics, better than anything I have read before. Apart from two more or less political statements, which I felt were out of place, the collection is very homogeneous. However, this is also its weak side: points are necessarily repeated and I will now certainly remember that the Standard Model has 18 parameters that we cannot yet calculate. From 1985 to 1999 many things happened to high-energy physics, such as the cancellation of the Superconducting Super Collider. Unless one knows the dates of these events, it is somewhat confusing to the non-physicist to follow the arguments as there is neither a synoptic nor a statement of the current state of affairs.



One thing I am not so sure of is the "emergence" argument. According to Weinberg, apart from historical accidents (initial conditions), what we observe can be understood exclusively in terms of the hierarchy of explanations, with physics at the root. However, computer simulations (for example of neuronal systems) seem to indicate that more than one underlying "physics" can indistinguishably lead to the same behaviour, by construction. Does that not mean that the mathematics governing this behaviour is independent of those physics? Then there may be independent sciences after all.

My favourite essays are the one in which Weinberg takes the humorous view that non-physicists are somewhat odd, and the 19-page overview of the history of physics in the 20th century. The latter is by far the clearest article on the fundamental ideas behind relativity and quantum mechanics that I have encountered.

The argument that science advances and that it does so independently of the cultural background is certainly in agreement with my own limited experience. Wherever in the world you walk into a university you suddenly feel this, whether lunch is eaten with chopsticks or a totalitarian regime has just been shed.

I greatly enjoyed this collection – it makes me want an entire book in which Weinberg expands on the individual views rather than repeating them in the condensed form of the essays. We need more of this eminently clear exposure of how science works.

Robert Cailliau, CERN.

Heavy Flavour Physics – Theory and Experimental Results in Heavy Quark Physics edited by C T H Davies and S M Playfer, Institute of Physics Publishing, ISBN 0750308672, £40.00 (€63).

A graduate text based on lectures originally presented at the 55th Scottish Universities Summer School in Physics, held at St Andrews in 2001. The school was a NATO Advanced Study Institute.

Quantum field theory and critical phenomena – fourth edition by Jean Zinn-Justin, Oxford University Press, ISBN 0198509235, £55 (€87).

Particle physics: a world without borders

It's about time particle physics laboratories collaborated in their communication, says **Judy Jackson**.

Belorussian, Catalan, Taiwanese, Afrikaans, Japanese, Persian, Russian, Mandarin, Hebrew, Italian, Tagalog, Croatian, Malayalam, Serbian, German, Korean, Swedish, Cantonese, Turkish, Arabic, Romanian, Gujarati, Welsh, Georgian, Lëtzebuergesch...

These are just some of the more than 60 languages spoken by collaborators on Fermilab's CDF and D0 experiments, as determined by a quick and utterly unscientific survey in mid-July. A poll of collaborations at CERN, DESY, KEK or any of the world's particle physics laboratories would reveal a comparable population of polyglots – men and women from every corner of the world who have come together to explore the nature of matter and energy, space and time. Particle physics is truly one community, without borders.

Moreover, when it comes to advances in research at the world's handful of particle physics laboratories, we are all in this together, for better or worse. When CERN gets a cold, Fermilab sneezes, and vice versa. At the moment, the particle physics world is watching as Fermilab struggles to fulfil the promise of Run II at the Tevatron; and CERN's current LHC budget and schedule challenges have strong implications for the future of every physics laboratory. On a brighter note, a physics discovery at laboratory A inevitably builds upon work at laboratories B and C. It all comes together in one worldwide particle physics enterprise.

Yet while particle physics collaborations are international, particle physics communication is not. For the most part, each region and each laboratory communicates for itself, with little coordination on issues, strategies, resources and messages. Does a press release from one laboratory (my own, for example) trumpeting a new experimental result give more than a nod to the work at other laboratories that made the result possible? It's doubtful. With difficult news to break, does one laboratory seek support from the others? Provide a clue that it's coming? Not likely. In planning communication strategies, do communicators coordinate their efforts?

Probably not. Global Communication Network? Forget it. When it comes to communication, every laboratory is an island.

Standard model of communication

It is high time particle physics communication caught up with the reality of particle physics collaboration. To achieve the kind of future that particle physicists everywhere would like for their field, the Standard Model of Physics Communication will have to change.

In December 2001, communicators from six of the world's physics laboratories met at DESY in Hamburg to form a worldwide collaboration for physics communication. The immediate stimulus for the meeting was a message from Petra Folkerts, communication director at DESY, to Fermilab on 12 September 2001:

"I want to say that we are all with you in these days. I myself can't find the right words to express my feelings after this terrible 11 September. From my point of view now it's absolutely important that we outreach people around the world will meet as soon as possible, not only to figure out how to help international particle physics stay alive, but how we, in our field of activity, can set visible footprints for the significance of peaceful collaboration across all borders."

The message gave impetus to a project that communicators at particle physics laboratories had pondered for some time, and led to the formation of an international laboratory communication council. Membership has grown to 10 laboratories from five countries.

Initial actions of the council include the development of a particle physics image bank comprising the best photographs and graphic resources from the world's laboratories, appropriately captioned and credited – one-stop shopping for reporters, physicists, students, teachers and policy makers who need outstanding graphics to tell the particle physics story. The image bank will live on a new website – interactions.org – devoted not to the support of any one laboratory or region, but to all. Advance coordination of press releases among member laboratories has already begun, not only to enhance the recognition of discoveries wherever they occur, but also to foster the recognition of the interconnected nature of advances in particle physics throughout the world. The collaboration plans staff exchanges, workshops and panels at international physics conferences.

The time has passed when one laboratory or one sector of the particle physics field could profit at the expense of another. Progress at every laboratory and in every region depends on the success of particle physics everywhere. As the early American experimental physicist Benjamin Franklin told his colonial colleagues in 1776: "We must all hang together, or assuredly we shall hang separately." The Quark Wars are over. The laboratory communication council represents a recognition of this reality by the world's particle physics communicators. As Folkerts stressed in her message of September 2001, it is a collaborative endeavour.

Whether they speak Gujarati or Georgian, Swedish or Romanian, Tagalog or the Queen's English, I hope that particle physicists everywhere will support this worldwide venture in physics communication.

Judy Jackson, Fermilab.

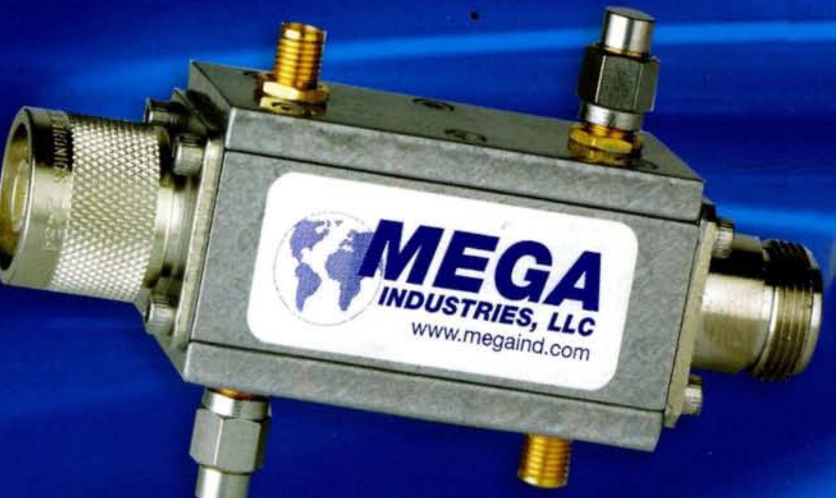
Precision RF system measurement and superior diagnostics

Type "N" Dual Directional Couplers

Mega Performance

Now you can have precision RF power system measurement and superior diagnostics at competitive pricing *plus:*

- Higher directivity
- Broader frequency range
- Greater efficiency
- Higher power



Mega Reliability

Mega Industries' **Type "N" Dual Directional Couplers** are manufactured to exacting electrical and mechanical tolerances to provide maximum reliability and performance.

Mega Versatility

Mega Dual Directional Couplers meet or exceed system standards for the broadest range of industries and applications including:

- Wireless Communications
- Military
- Commercial
- Broadcast
- Satellite
- Research

Type "N" Dual Directional Coupler

Mega P/N	0G9Y7-67714-701
Frequency	1.70–2.80 GHz
Power	1000 Watts Maximum
Coupling	30dB +/- 1.5dB Fwd. 30dB +/- 1.5dB Rev.
Directivity	25dB
Insertion Loss	0.05dB
Maineline Connectors	Type "N"
Secondary Line Connectors	SMA
Termination Load	1 Watt

MEGA INDUSTRIES

CALL MEGA TODAY! 207-854-1700

For the highest quality Type "N" Dual Directional Couplers, waveguide components, coaxial products, and on-time delivery, call Mega today!

28 SANFORD DRIVE, GORHAM, ME 04038 TELEPHONE: 207-854-1700 FAX: 207-854-2287 E-MAIL: SALES@MEGAIND.COM WWW.MEGAIND.COM