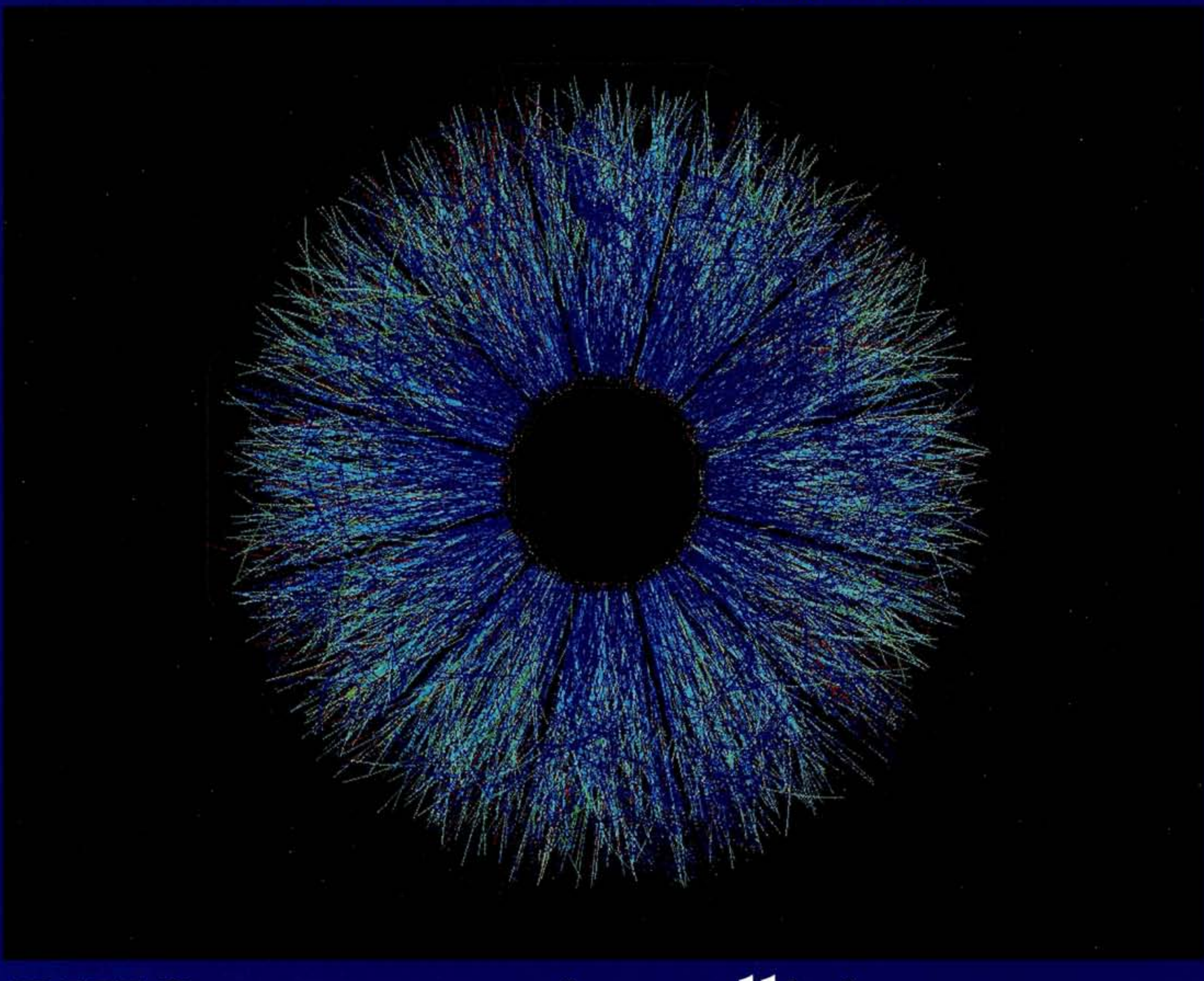
INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 40 NUMBER 8 OCTOBER 2000



RHIC ramps up its collision energy

ASTRONOMY
Increased precision brings new insights and understanding p15

CAREERS
Students working at CERN start off on the right foot p20

PROTONS IN JAPAN
High-intensity source has multiple applications p23


Catch us online at
www.vacgen.com

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

CERN Courier is distributed to Member State governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly except January and August, in English and French editions. The views expressed are not necessarily those of the CERN management.

Editor: Gordon Fraser
CERN, 1211 Geneva 23, Switzerland
E-mail cern.courier@cern.ch
Fax +41 (22) 782 1906
Web http://www.cerncourier.com
News editor: James Gillies

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

Laboratory correspondents:
Argonne National Laboratory (USA): D Ayres
Brookhaven, National Laboratory (USA): P Yamin
Cornell University (USA): D G Cassel
DESY Laboratory (Germany): Ilka Flegel, P Waloschek
Fermi National Accelerator Laboratory (USA): Judy Jackson
GSI Darmstadt (Germany): G Siegert
INFN (Italy): A Pascolini
IHEP, Beijing (China): Qi Nading
Jefferson Laboratory (USA): S Corneliussen
JINR Dubna (Russia): B Starchenko
KEK National Laboratory (Japan): A Maki
Lawrence Berkeley Laboratory (USA): Christine Celata
Los Alamos National Laboratory (USA): C Hoffmann
NIKHEF Laboratory (Netherlands): Margriet van der Heijden
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 (USA): M Riordan
TRIUMF Laboratory (Canada): M K Craddock

Produced for CERN by Institute of Physics Publishing Ltd
IOP Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel. +44 (0)117 929 7481
E-mail jo.nicholas@ioppublishing.co.uk
Web http://www.iop.org

Head of magazines: Richard Roe
Publishing manager: Jo Nicholas
Art director: Andrew Giaquinto
Production editor: Kerry Harding
Technical illustrator: Alison Tovey
Advertising manager: Jo Nicholas
Display sales: Chris Thomas
Recruitment sales: Andrew Hardie and Jayne Purdy
Advertisement production: Katie Graham
Product manager: So-Mui Cheung

Advertising: Jo Nicholas, Chris Thomas, Andrew Hardie or Jayne Purdy
Tel. +44 (0)117 930 1026
E-mail sales@cerncourier.com
Fax +44 (0)117 930 1178

General distribution: Jacques Dallemagne, CERN, 1211 Geneva 23, Switzerland. E-mail jacques.dallemagne@cern.ch
In certain countries, to request copies or to make address changes, contact:
China: Chen Huaiwei, Institute of High-Energy Physics, P.O. Box 918, Beijing, People's Republic of China
Germany: Gabriela Heessel or Veronika Werschner, DESY, Notkestr. 85, 22603 Hamburg 52. E-mail desypr@desy.de
Italy: Loredana Rum or Anna Pennacchietti, INFN, Casella Postale 56, 00044 Frascati, Roma
United Kingdom: Su Lockley, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX. E-mail U.K.Lockley@rl.ac.uk
USA/Canada: Janice Voss, Creative Mailing Services, P.O. Box 1147, St Charles, Illinois 60174. Tel. 630-377-1589. Fax 630-377-1569

Published by: European Laboratory for Particle Physics, CERN, 1211 Geneva 23, Switzerland. Tel. +41 (22) 767 61 11
Telefax +41 (22) 767 65 55

USA: Controlled Circulation Periodicals postage paid at St Charles, Illinois

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

ISSN 0304-288X

IoP

CERN COURIER

VOLUME 40 NUMBER 8 OCTOBER 2000


First RHIC data p5


Synchrotron radiation p26

Neutrino physics meeting p31

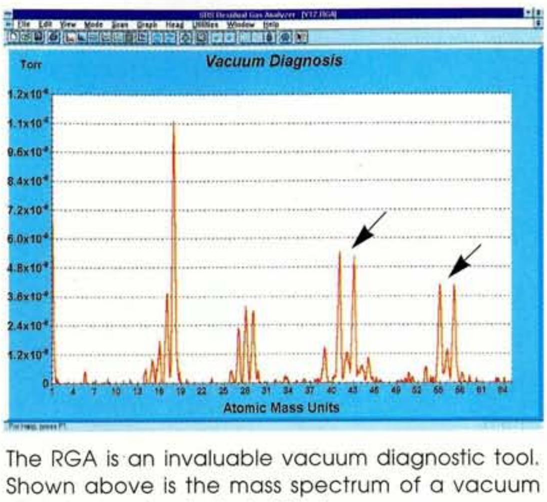
Cover: STAR-gazing. The result of colliding high-energy beams in the Relativistic Heavy Ion Collider at Brookhaven as seen by the Time Projection Chamber of the STAR experiment (p5).

RGA for the Masses

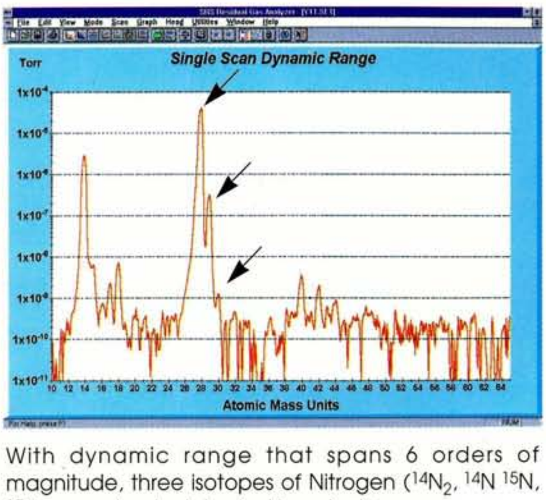
Systems from $4125 (Int'l list)

- **100, 200, 300 amu systems**
- **Partial pressure to 10^{-14} Torr**
- **6 orders of magnitude dynamic range in a single scan**
- **Real-time Windows® software**
- **Mass spectra, leak detection and pressure vs. time modes**
- **Multi-head operation**
- **Optional Electron Multiplier**

Residual gas analyzers from SRS offer uncompromised performance at half the price of the competition. Our systems provide mass ranges to 300 amu, detectable partial pressures to 10^{-14} Torr and better than 1 amu resolution. With our interactive Windows® software package you can fully control the RGA sensor, acquire data and analyze your vacuum system in real-time. The simple, rugged quadrupole mass spectrometer attaches directly to a 2 3/4" CF flange. A dual ThO_2Ir filament and a unique continuous dynode electron multiplier provide increased stability and longer life than other designs. Both are field replaceable in a matter of minutes – a first for RGAs! If your application involves residual gas analysis, leak detection or vacuum processing, contact us for a copy of our RGA systems brochure and demo software package.



The RGA is an invaluable vacuum diagnostic tool. Shown above is the mass spectrum of a vacuum chamber contaminated with oil.

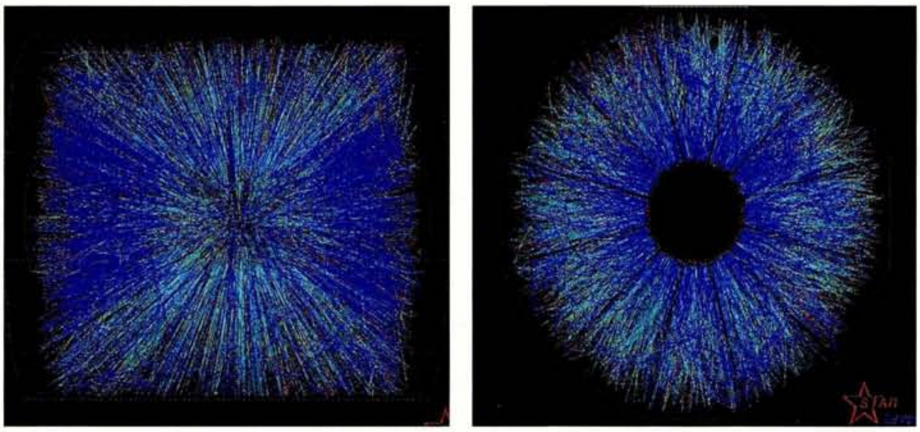


With dynamic range that spans 6 orders of magnitude, three isotopes of Nitrogen ($^{14}N_2$, $^{14}N\,^{15}N$, $^{15}N_2$) are clearly detected in a single scan.

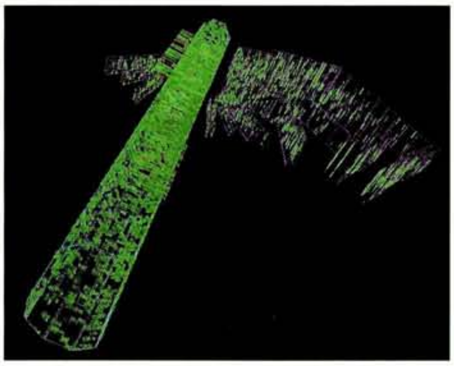
SRS

Stanford Research Systems
1290-D Reamwood Avenue, Sunnyvale, CA 94089
Telephone (408)744-9040 • FAX (408)744-9049
Email: info@srsys.com • WWW: http://www.srsys.com/srsys

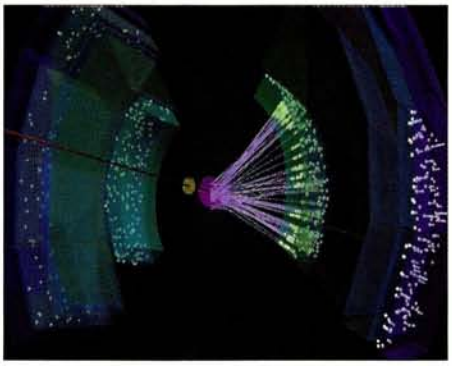
RHIC starts producing data



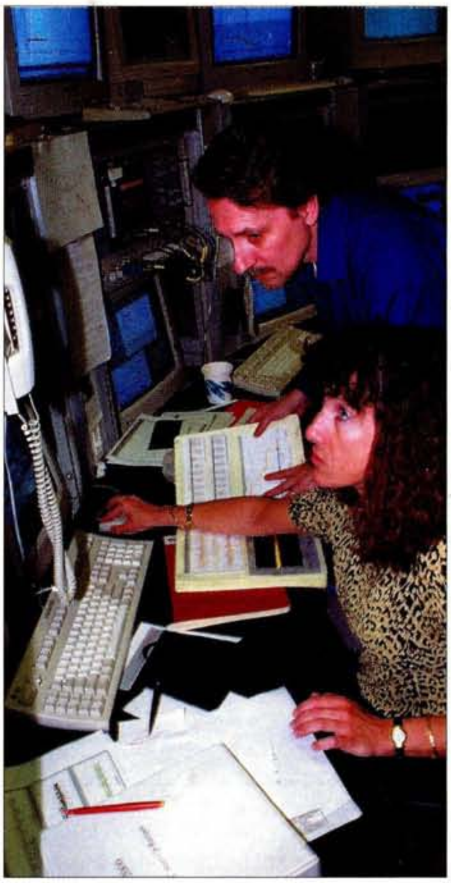
Side view (left) and end view (right) in the STAR Time Projection Chamber of a gold–gold collision at a collision energy of 130 GeV.



The PHOBOS detector's response to particles produced in a gold ion collision. The green points show where particles hit the silicon.



Outlines of the two PHENIX central arms. The dots are hits in the detector. The white lines on the right are calorimeter clusters with lengths corresponding to energy. The pink lines are projections of the drift chamber tracks to the vertex. The copper tube is the beam pipe.



Colliding under controlled conditions – Fulvia Pilat and Thomas Roser at work in the RHIC/AGS control room at Brookhaven.

After achieving first collisions of gold ion beams on the night of 12 June (July p5), the gleaming new Relativistic Heavy Ion Collider (RHIC) facility at Brookhaven wasted no time in ramping up in energy and intensity and starting the process of analysing data.

A few days after the first gold ions collided at a collision energy of 56 GeV/nucleon, all four of the RHIC detectors (BRAHMS, PHENIX, PHOBOS and STAR) began recording data at a collision energy of 130 GeV/nucleon. By the end of July the first physics result – a measurement of charged particle density at mid-rapidity for central gold–gold collisions at these two energies – was submitted for publication by the PHOBOS collaboration.

With these data points in hand, and further analysis results in the pipeline from each of the four experiments, theorists who were at Brookhaven to attend a series of summer workshops immediately began to ponder the first glimpse of high-density matter in this new energy regime.

In the meantime the machine staff shifted focus from first collisions to achieving sustained collider operation. The goal for machine operation over the summer was to bring the collider and its injector complex, consisting of tandem Van de Graaff, booster and AGS synchrotron, to the level at which all of the experiments would obtain an initial data run with event rates approaching 10% of the final design luminosity.

By mid-August, RHIC's two superconducting rings were routinely colliding stored beams of gold ions, with the full complement of 55 ion bunches in each ring, beam lifetimes of more than 4 h and some storage cycles lasting 10 h and more. The four experiments simultaneously recorded data throughout these runs, transferring data to the RHIC Computing Facility at peak rates of more than 40 Mbyte/s.

RHIC ran through mid-September, with continued data taking as well as accelerator physics work to complete the commissioning of the collider systems. A comprehensive look at the first physics results from this year's run will take place at the Quark Matter 2001 meeting on 15–20 January, which is being jointly hosted by the State University of New York at Stony Brook and Brookhaven. It is expected that the collider will start up again early in 2001 and begin operating soon after at the full design energy of 200 GeV/nucleon for gold–gold collisions.

Tom Ludlam, Brookhaven.

B factories give first results: PEP-II at SLAC...

The PEP-II collider at SLAC – nearly attaining design performance after only a year of physics operations.

The PEP-II asymmetric B factory at the Stanford Linear Accelerator Center (SLAC) continues to exceed expectations, having nearly reached its design performance after only a year of operations. This innovative electron-positron collider was designed and built by SLAC and the Lawrence Berkeley and Lawrence Livermore National laboratories with $177 million from the US Department of Energy, and it has been creating millions of B meson pairs.

A collaboration of more than 500 physicists who designed and built the 1200 t BaBar detector is eagerly sifting through this burgeoning mountain of data. Coming to Stanford from Canada, China, France, the UK, Germany, Italy, Norway, Russia and all across the US, they are searching for evidence of CP violation – an asymmetry between matter and antimatter – in B meson decays.

As reported at the International Conference on High Energy Physics in Osaka, Japan (September p5), the SLAC B factory recently hit a peak luminosity of 2.3×10^{33} $cm^{-2}s^{-1}$ – 76% of its goal of 3.0×10^{33}. When combined with better than expected operating efficiencies on both the collider and the BaBar detector, this facility has exceeded its expected daily output of B meson events on several different occasions. Having already created more than 10 million B meson pairs, or more than has been recorded on all previous accelerators, it is indeed operating like a factory, thanks to the untiring efforts of the commissioning team, led by John Seeman.

A distinctive feature of the B factory and the reason that it is called "asymmetric" is that the electrons and positrons circulate at different energies. When an electron and a positron meet and annihilate, the B meson and its antiparticle that are often produced lurch forward in the direction of the more energetic electron beam. This feature makes it much easier to isolate the daughter particles that arose from each of the two B decays and to determine the time that elapsed between them. Knowing this time difference is vital for physicists trying to measure any CP-violating asymmetries among B mesons.

Normally a new particle collider with such innovative features must be coaxed through a long tuning period, often taking several years, before it performs at its full potential. The particle detector surrounding the collision point is another complex, sensitive device that must be carefully adjusted to function as designed. However, the entire B factory – both collider and detector – has come on line smoothly and in record time, to the delight of the hundreds of BaBar scientists now trying to cope with the flood of new data.

At Osaka, BaBar spokesman David Hitlin of Caltech presented results based on more than 9 million B meson pairs. In addition to precision measurements of B meson lifetimes and mixing parameters as good as any that have been made by the CLEO collaboration at Cornell, he revealed a surprisingly large branching ratio for decays into pion pairs – more than twice the CLEO value. This preliminary result augurs well for further measurements of a possible CP asymmetry in these decays, but it must be confirmed by further measurements on BaBar and KEK's Belle experiment.

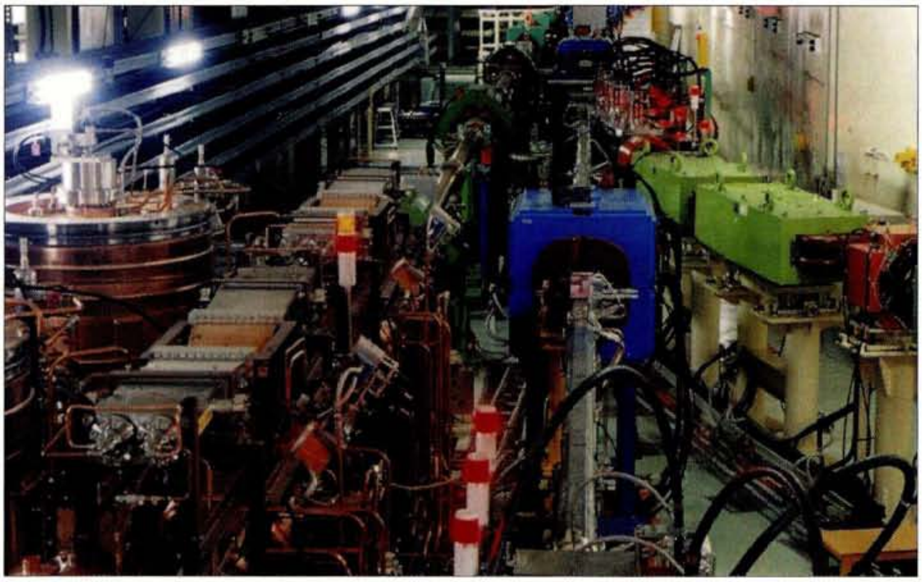
By far the most anticipated number that Hitlin presented was the collaboration's preliminary result for the CP-violation parameter sin 2β, which is extracted from decays of neutral B and anti-B mesons into a J/psi particle and a short-lived neutral kaon. Any significant difference between these two decay rates corresponds to a non-zero value of sin 2β and gives solid evidence for CP violation.

The preliminary value that Hitlin announced at Osaka, based on 120 such "golden events", was 0.12 ± 0.37 (stat) ± 0.09 (syst) – consistent with no CP violation at all.

However, the errors are large at this early stage. They will come down steadily as millions more B mesons are produced and recorded over the next few months. "The rapid launch of the B factory has given us our first glimpse into the new domain of CP violation measurements in the B meson system," observed Hitlin. "We hope to double our data by the end of October and to begin to make truly definitive tests of the Cabibbo-Kobayashi-Maskawa mechanism for this intriguing phenomenon."

Michael Riordan, SLAC.

...and Belle at KEKB, Japan



The KEKB collider at KEK, Japan – first year of operation.

The Belle experiment at the KEKB asymmetric-energy electron–positron B meson factory recently completed a successful first year of operation. The KEKB luminosity, which was about 10^{31} cm^{-2}s^{-1} at start-up in June 1999, reached 2×10^{33} by the end of July 2000. This was achieved with only a fraction of the design values for beam currents in each ring, so the prospects for ultimately achieving the design goal of luminosity of 10^{34} seem good.

The beam currents were limited by the excessive heating of some accelerator components. These are being replaced by more robust versions during the current shutdown. In addition, four more superconducting radiofrequency accelerating cavities are being installed in the high-energy electron ring. With these improvements there should be no technical problems to limit the beam currents below design values.

The luminosity was also limited by an instability that causes the low-energy positron vertical beam size to grow at high-beam currents. This beam blow-up problem may be caused by photoelectrons produced by synchrotron radiation X-rays hitting the walls of the vacuum chamber and attracted to the positively charged positron beam bunches.

This problem is also being dealt with. Wire coils being wound round the positron beampipe will provide a weak solenoid field that will curl photoelectrons back into the vacuum chamber wall soon after they are produced. Simulations indicate that these will be effective at suppressing photoelectron interactions with the beam.

Happily, many of the novel design features of KEKB appear to be verified. Beam–beam limits to the luminosity have not yet been observed and no deleterious effects caused by the finite beam-crossing angle are evident. This crossing angle scheme, in addition to KEKB's ability to produce high luminosity at relatively low total beam currents, reduces beam-induced background radiation levels in the Belle detector to reasonably comfortable levels.

At the ICHEP 2000 meeting in Osaka (September p5), the Belle group reported preliminary results based on most of its total data sample of more than 6 million B meson particle–antiparticle pairs. It submitted 17 papers, including a number of new results. A clear signal was reported for the interesting B decay into phi and a negative kaon, in which a b quark gives three strange quarks (a gluonic "penguin" process). First observations of charged and neutral B meson decays to J/psi and $K_1(1270)$ were reported. These modes may provide new possibilities for future CP violation studies. Belle's high-quality particle identification system was exploited to make almost background-free first measurements of Cabibbo-suppressed B decays into D* and a kaon.

Other results included competitive measurements of D^0 and D_s lifetimes, the neutral B mixing parameter, exclusive B meson semi-leptonic decay modes, angular correlations in B decays into J/psi and K* and the best limit so far for the rare decay B to rho and a photon. This latter result is interesting because it provides an important constraint on the elusive V_{ts} element of the Kobayashi–Maskawa matrix.

A number of rare decay measurements are dominated by backgrounds from continuum quark–antiquark production processes. Belle did not accumulate much off-resonance running, so new analysis techniques were developed that enable B meson decays to be separated from these continuum events. These techniques enabled Belle to report measurements at interesting levels of precision for rare B decays into a kaon and a pion, into a K* and a photon, and the inclusive photon radiative penguin process.

In a plenary session talk, Belle spokesperson Hiroaki Aihara of Tokyo reported Belle's first results on the relevant CP-violating parameter as 0.45 + 0.44 – 0.45. Although Belle's current data sample is only about half that of BaBar's at SLAC, Belle managed to get a competitive measurement by including many CP eigenstate decay channels, including the important but experimentally challenging J/psi and long-lived kaon B decay.

Although the precision of the Belle measurement is not yet sufficient to make a definitive statement about the Kobayashi–Maskawa theory, the results are important in that they demonstrate that Belle is capable of doing the measurements that it was designed to do.

Belle's research activities are not confined to B-mesons. Three of the Osaka papers deal with tau lepton physics: two on searches for CP violations in the lepton sector and one on a search for lepton-flavour-violating tau decays. In addition, Belle's particle identification capabilities are being exploited to make interesting measurements of the two-photon production of kaon pairs. Although all of the results are preliminary – some of them are based on data that were collected only a few days prior to the start of the conference – and there is still lots of work to be done before they can be published, they demonstrate that all components of the Belle detector and the data analysis software are functioning at near design levels. More important is that they demonstrate that the Belle collaboration is up to the job at hand and able to produce new and interesting results in a timely manner.

Summer students benefit from CERN visit

The class of 2000 – CERN's summer students pose in front of the chamber of the Big European Bubble Chamber in the Microcosm Garden.

CERN always has plenty of visitors, but never more so than in the summer, when the itinerant population is boosted by several hundred students from CERN member states and further afield. CERN's Summer Student Programme offers undergraduate students in physics, computing and engineering a unique opportunity to join in the day-to-day work of research teams participating in experiments at CERN.

Beyond the outstanding first-class scientific value of their stay, the students find working in a multidisciplinary and multicultural environment an extremely enriching experience – an opportunity to make valuable and long-lasting contacts with other students and scientists from all over Europe.

In addition to the work with the experimental teams, summer students attend a series of lectures specially prepared for them. Scientists from around the world share their knowledge about a range of topics in the fields of theoretical and experimental particle physics and related technologies.

Victor Weisskopf, field theory pioneer and CERN director-general in 1961–1965, had a particular interest in education. During his mandate as director-general, he gave a series of introductory lectures on particle physics (maintaining that "the best way to get a basic understanding of anything is to teach it"). For many years after he left CERN, Weisskopf returned every summer to address an eager audience. These lectures also developed into a book, *Concepts of Particle Physics* (two volumes), written with Kurt Gottfried.

Many generations of CERN summer student alumni vividly recall a relaxed Weisskopf recounting anecdotes about the early days of quantum mechanics. Among them is Melissa Franklin of Harvard (CERN summer student 1977), who lectured this year on "Classic experiments". Sadly, Weisskopf seldom returns to CERN, but the tradition lives on.

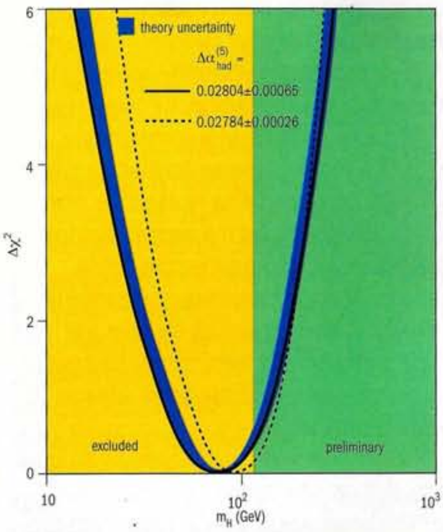
For further information, see "http://cern.web.cern.ch/CERN/Divisions/PE/HRS/Recruitment/summ.html".

LEP hints at Higgs effect

After commencing 2000 operations in fine style (June p5), CERN's flagship machine, the LEP electron–positron collider, has been regularly delivering experiments with beams of 103 GeV or more. The machine has been running in "Higgs discovery mode" – the objective being to uncover at last the mysterious mechanism that breaks electroweak symmetry and provides particles with mass.

For the interconsistency of all results amassed so far anywhere, LEP is operating at the most likely place for the Higgs particle to turn up. This is not new, and a lot of potential Higgs territory has already been excluded.

What makes the Higgs hunt so dramatic is that LEP soon has to be decommissioned and dismantled to allow work to begin on CERN's LHC collider, to be constructed in the same 27 km tunnel. Under such pressure and on such fertile physics ground, tantalizing hints of Higgs effects around 114 GeV are being seen. LEP runs until 2 November.



Who will find the Higgs? The mysterious particle that breaks electroweak symmetry should lie within the curves shown. Direct searches have already excluded the yellow region.

Physicswatch will reappear in the next issue. Physicswatch editor Alison Wright has been working for BBC Radio Science on a British Association Fellowship.

Accelerator schools set sail

Participants in this year's international Joint Accelerator School visit the famous wooden church at Kizhi.

Alexander Skrinsky, director of the Budker Institute, Novosibirsk, opens this year's Joint Accelerator School, imaginatively held on a boat sailing from St Petersburg to Moscow via inland waterways.

Every two years, Europe, Japan, Russia and the US collaborate to organize a Joint Accelerator School, giving accelerator physicists and engineers from each region an opportunity to meet experts from most of the world's accelerator laboratories. This year it was Russia's turn to host the school. It chose an unusual setting – on board a river boat sailing from St Petersburg to Dubna and Moscow along the system of inland waterways that link the mouth of the Neva with the Volga.

The title of the school was JAS2000: High Quality Beams, and an international team of more than 20 lecturers addressed the many effects that limit the intensity, luminosity and brilliance of proton and electron beams in both linear and circular machines. Parallel afternoon sessions on insertion and crossing region design, space-charge and beam quality control for linear colliders allowed students to concentrate on a specialist topic of their choice. The school attracted more than 70 students, including 20 from outside Russia.

The boat proved to be an ideal environment for uninterrupted study. Nevertheless, participants still had a chance to visit two great Russian cities on a voyage that also passed through two large lakes – Ladoga and Onega. Historic sites en route included the monastery on Valaam Island, the famous church at Kizhi constructed entirely out of timber and the delightful town of Yaroslavl.

For CERN's Accelerator School (CAS) this was one of three events in a crowded millennium year calendar. In March, CAS and GSI Darmstadt organized a specialist course on radiofrequency engineering at the Lufthansa Training Center, Seeheim, near Darmstadt, and in October there will be a course entitled Introduction to Accelerator Physics, held in Loutraki, near Athens. This has been organized with the help of the Institute of Accelerating Systems and Applications in Athens and the University of Athens. The Loutraki school is designed to be of particular interest to those participating in the SESAME initiative, which will provide a synchrotron light source for eastern Mediterranean countries. Parallel courses will deal with synchrotron light sources, linacs, and muon and neutrino factories.

In addition, the CAS course, Particle Accelerators for Medicine and Industry, will be held at Pruhonice, near Prague, on 9–17 May 2001.

Details of these courses will be posted on the Web site at "http://schools.web.cern.ch/Schools/CAS".

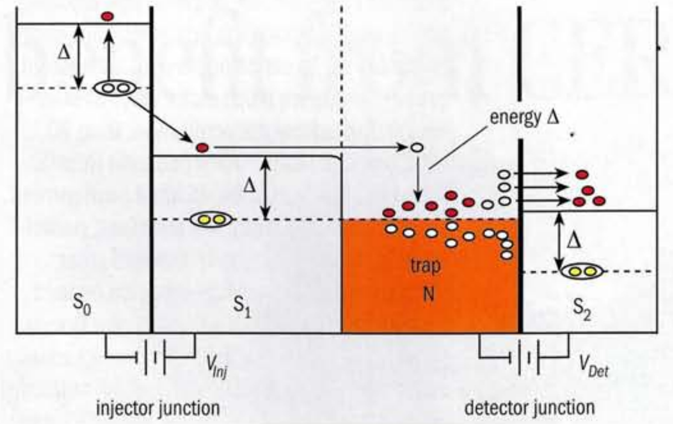
CEBAF reaches 150% of its design energy

Jefferson Laboratory's CEBAF accelerator, which was originally designed to provide 4 GeV continuous-wave electron beams, has demonstrated 6 GeV continuous-wave operation. In early August the superconducting radiofrequency (SRF) machine reached 6.07 GeV at a substantial current of 109 μA.

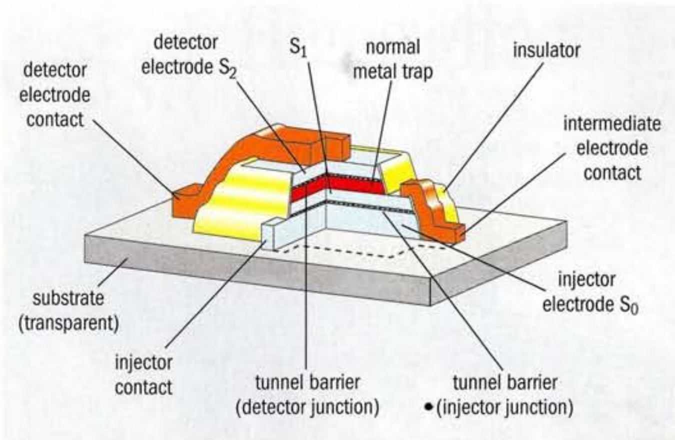
Energies in the 5.65 GeV range had already become routine as a result of incremental improvements since CEBAF began operation in the mid-1990s. Once 6 GeV has become the routine energy level, nuclear physics users will capitalize on it during the coming years, pending the completion of a proposed 12 GeV upgrade, which is to be discussed later this year by the US Nuclear Science Advisory Committee.

The Jefferson Laboratory's SRF electron-acceleration technology also drives the laboratory's Infrared Demonstrator Free-Electron Laser and is now beginning to see application elsewhere as well. Under a $70 million contract, the laboratory is providing SRF and related cryogenic engineering, assembly and installation support for the Spallation Neutron Source project at Oak Ridge National Laboratory, Tennessee.

Enter the quasiparticle trapping transistor



In superconductors the conduction electrons are bound into pairs and an energy gap, Δ, is formed where 2Δ is the pair-binding energy. (The films S_0, S_1 and S_2 are superconducting and N is a normal metal.) Pairs can be broken by thermal fluctuations, by a tunnel junction with voltage bias energy greater than 2Δ or by the absorption of radiation, to create electronic excitations called quasiparticles. In the quatratran these quasiparticles, injected into an intermediate superconducting film, are trapped in an adjacent normal metal film where each one gives up its energy, Δ, to exciting many free electrons. This effectively increases the temperature of the electrons and increases the current in a second tunnel junction.



A "quatratran". Electronic signals can be amplified by applying a voltage (or current) to the injector electrode. Current gains as high as 70 and signal power gains of 1000 have been observed. A signal can also be produced by electromagnetic radiation passing through the transparent substrate and being absorbed in the injector electrode. A unique feature of this quatratran is that it can act analogously to either a pnp *or an* npn *transistor simply by reversing the polarities of the power supplies. There are also two more devices with negative current gain, obtained by reversing just one polarity, making many possibilities for the large-scale integration of new types of electronic circuit.*

A new device that can operate in close proximity to highly sensitive superconducting sensors could open up new detector possibilities. For years a superconducting three-terminal device with transistor-like properties has been the missing link in the development and utilization of superconducting electronics.

A superconducting computer was the major goal of Josephson junction technology in the 1980s. Since then the field of superconducting electronics has broadened tremendously. There are extensive developments with superconducting quantum interference devices, logic circuits and passive microwave components with many applications to telecommunications.

Now a Naples-Oxford collaboration has fabricated a superconducting device that behaves in a similar way to a transistor – the "quasiparticle trapping transistor", or quatratran – and it demonstrates large current- and power-amplifying capability at liquid-helium temperature (Pepe *et al.* 2000).

Quatratrans can operate in close proximity to the sensitive superconducting sensor arrays that are increasingly being used in astronomy, X-ray microanalysis and time-of-flight mass spectrometry. They can also be fabricated to act as radiation detectors with internal amplification. Conventional semiconductor transistor-like devices do not work well at low temperatures and dissipate too much power.

The idea of quasiparticle trapping (Booth 1987) grew out of attempts to develop a solar neutrino detector based on superconducting indium. Extensions of the idea are being applied to cryogenic detectors, which are being used to search for possible weakly interacting massive particles that may constitute the dark matter of the universe (Irwin *et al.* 1995), and to superconducting tunnel junction detectors being used in arrays of single-photon-counting spectrometers in astronomy (Peacock 2000; Peacock *et al.* 1996).

Another idea by a Harvard-Oxford collaboration led to the concept of a superconducting transistor (Booth *et al.* 1999; 2000). A collaboration between Oxford and the Naples group, which has a long tradition in superconductive device fabrication and studies of Josephson effects and non-equilibrium superconductivity (Barone and Paterno 1982), has produced devices that have very interesting properties.

Possible applications of the device are in the area of the preamplification and read-out of multipixel arrays of superconducting sensors and detectors.

References

A Barone and G Paterno 1982 *Physics and Applications of the Josephson Effect* (Wiley-Interscience).

N E Booth 1987 Quasiparticle trapping and the quasiparticle multiplier *Appl. Phys. Lett.* **50** 293.

N E Booth *et al.* 1999 A superconducting transistor based on quasiparticle trapping *Supercond. Sci. Technol.* **12** 538.

N E Booth *et al.* 2000 The Quatratran *Nucl. Instrum. Methods A* **444** 33.

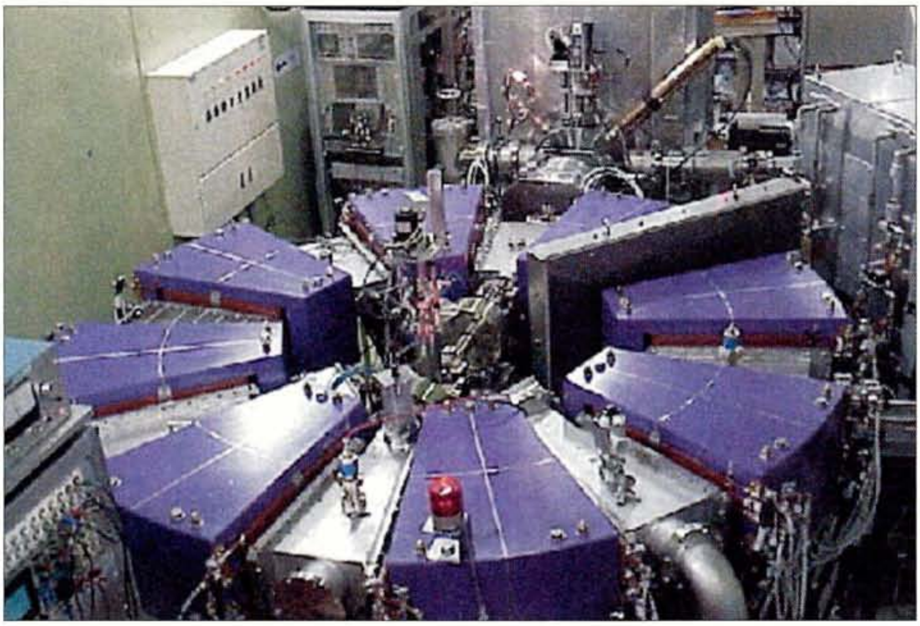
K D Irwin *et al.* 1995 A quasiparticle-trap-assisted transition-edge sensor for phonon-mediated particle detection *Rev. Sci. Instrum.* **66** 5322.

A Peacock 2000 Physics in space *CERN Courier* **40(2)** 22.

A Peacock *et al.* 1996 Single optical photon detection with a superconducting tunnel junction *Nature* **381** 135.

G P Pepe *et al.* July 2000 A superconducting device with transistor-like properties including large current amplification *Appl. Phys. Lett.*

KEK laboratory demonstrates fixed-frequency synchrotron



This 2.5 m diameter experiment at the Japanese KEK laboratory has demonstrated fixed-frequency proton acceleration.

The Japanese KEK laboratory has for the first time demonstrated an alternative method of accelerating protons to high energy – the fixed-field, alternating gradient (FFAG) synchrotron.

In a normal variable frequency synchrotron, the radiofrequency of the applied electric fields (which accelerate the circulating beam) is increased to remain in step with the beam as it becomes increasingly distorted by relativity.

In such a synchrotron the beams circulate inside a magnetic tube, obviating the need for a large magnet to enclose the whole machine (as had been the case for the cyclotron). In the 1950s the idea of strong focusing (alternating gradient) enabled the dimensions of this magnetic tube to be reduced considerably, cutting still further the expensive magnetic investment needed. (In 1959 CERN's PS was the first proton synchrotron to operate using this technique.)

Following the strong focusing revolution, several accelerator specialists realized that ingenious magnetic field designs could also enable the applied electric fields to remain synchronous with the relativistic particles without having to change the radiofrequency. This is the FFAG idea, which was first proposed and demonstrated for electrons by the Midwestern Universities Research Association team in Chicago.

Under the leadership of Yoshiharu Mori, design at KEK started in January 1999 and the first beam was accelerated on 16 June 2000. The fact that these machines use fixed fields allows them to operate at high repetition rates and produce high-intensity beams. The price to pay is large apertures, a larger circumference and consequently massive magnets, which has favoured so far the now classical alternating gradient pulsed synchrotrons and explains why only electron model machines had ever been built.

However, because of their large momentum and transverse acceptances, these machines constitute a promising alternative to the more conventional approaches to muon collection and acceleration (radiofrequency and induction linacs) in a neutrino factory.

This was reported in a poster at the recent European Particle Accelerator Conference in Vienna (EPAC 2000; September p26). An international FFAG workshop was held at CERN immediately after the conference.

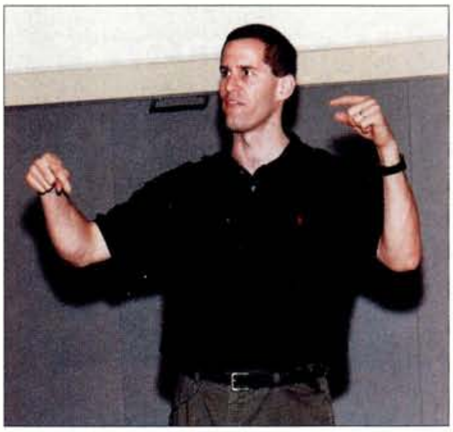
Workshop tackles GLOBUS and Grid

The Grid, a highly distributed computing environment that is seen by many as a step beyond the World Wide Web (June p17), is catalysing many new computing developments. One is GLOBUS, a toolkit that provides Grid building blocks.

At a recent GLOBUS Grid workshop at the UK Central Laboratories of the Research Councils, Steve Tuecke and Lee Liming from Ian Foster's pioneer group at Argonne gave presentations at the Rutherford Appleton Laboratory, while the Daresbury Laboratory joined by videoconference. The sessions were recorded and will be available in RealVideo format (for details see "http://www.dl.ac.uk/TCSC/UKHEC/GridWorkshop/" or contact Rob Allan, e-mail "R.Allan@dl.ac.uk").

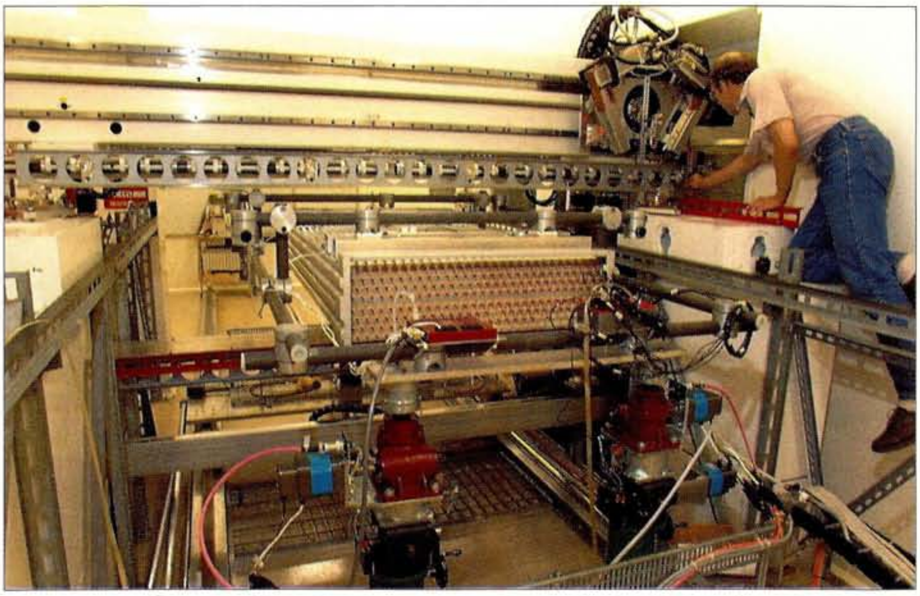
The first day offered an introduction to the computational Grid and the GLOBUS toolkit, together with a user's tutorial. The second day was a developer's tutorial for Grid programming and went into significantly greater technical detail (common services and security, information services, resource management, remote data management, fault management and communications). The final day concentrated on directing the GLOBUS team's expert advice onto current particle physics Grid activities and setting up future projects for collaboration with the Foster group.

The workshop was considered to be a great success and is undoubtedly the start of many focused Grid activities in the UK particle physics community.



Steve Tuecke from Ian Foster's pioneer Grid group at Argonne explains a topological issue at a recent GLOBUS Grid workshop.

ATLAS presents a quality challenge



Verifying the alignment of interferometer beam optics on the ATLAS experiment's X-ray tomograph at CERN. A small muon chamber from Greece, destined for the barrel region of the detector, is on the tomograph. It went on to pass the test with its wires showing an average fluctuation of just 13 μm from their nominal positions. To pass the test, a chamber has to score less than 20 μm.

Covering a volume of 17 000 m^3, the muon system of the ATLAS experiment at CERN's Large Hadron Collider (LHC) will be one of the largest particle detector systems ever built. Some 46 institutes around the world are involved in constructing its 1200 Monitored Drift Tube (MDT) chambers, which will provide precision measurements of muon trajectories, along with the trigger chambers that will be associated with them. The trigger chambers are being built in China, Israel, Italy, Japan and Russia. Their production is a formidable undertaking in its own right, but it is the precision MDTs that present the larger challenge to the ATLAS collaboration.

Precision is paramount for the MDTs, and uniformity between the modules coming from different parts of the world has to be carefully controlled. To this end the collaboration has established a stringent quality-control procedure for the principal MDT production sites. A total of 17 sites in nine countries are involved in the production of MDTs. Much of the tooling is locally produced, so not all of the sites are identically equipped, yet they must produce identical chambers with wire positions known to 20 μm for all 400 000 channels of the MDT system.

The quality-control procedure begins with a site inspection. Once the okay has been given, a site produces its so-called module-zero chamber and ships it to CERN. A dedicated X-ray tomograph (March p3) then measures the wire positions to ensure that they are all within tolerance before the green light is given for series production to begin. If the module-zero chamber does not pass the tomograph test, a second must be produced before the site can begin production. By the end of July, 11 production sites were operational.

However, the quality-control procedure does not end there. Each tube is entered in a database and barcoded so that, should problems arise in any tube, its entire history can easily be traced. Once a production site is operational, a random sample of about 10% of its production is tested on the CERN tomograph to ensure that standards are being maintained.

The last constructed MDT is scheduled to arrive at CERN in the summer of 2004 for final assembly of MDTs and associated trigger chambers. The complete detector is scheduled to be installed in the ATLAS experimental hall between 2004 and the beginning of 2005, along with the completion of the ATLAS detector, to be ready to register the LHC's first collisions.

CONFERENCE on INSTRUMENTATION 2001

VCI

VIENNA

Advisory Committee

J.-E. Augustin (Univ. Paris VI & VII - Paris, F)
W. Bartl (Hephy - Vienna, A)
A. Breskin (Weizmann - Rehovot, IL)
G. Charpak (CERN - Geneva, CH)
S. Denisov (IHEP - Protvino, RU)
G. Feofilov (Univ. St. Petersburg, RU)
G. Flügge (RWTH - Aachen, D)
H.-J. Hilke (CERN - Geneva, CH)
H. Kagan (Ohio - State, USA)
T. Kondo (KEK - Ibaraki-ken, J)
A. Menzione (INFN - Pisa, I)
H.H. Wieman (LBNL - Berkeley, USA)

Invited Speakers

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

Organising Committee

M. Jeitler, M. Krammer,
S. Kalina (secretary),
G. Neuhofer, M. Regler, A. Taurok

Institute for High Energy Physics of the Austrian Academy of Sciences

Topics:

February 19 - 23, 2001

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

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

Registration deadline: January 8, 2001

Contribution deadline: November 15, 2000

Proceedings: Nuclear Instruments and Methods in Physics Research

Patronage: The Minister of Education, Science and Culture
The President of the Austrian Academy of Sciences
The Rector of the University of Vienna
The Rector of the University of Technology, Vienna
European Physical Society

For more information see: http://wcc.oeaw.ac.at

Institut für Hochenergiephysik
A-1050 Vienna, Nikolsdorfer Gasse 18
Tel. +43-1-544 73 28, Fax +43-1-544 73 28 54, E-mail: wcc@hephy.oeaw.ac.at

Astronomy sets new targets

This month Astrowatch travels to Manchester for the meeting of the International Astronomical Union. *Emma Sanders* reports on two weeks of discussion and discoveries, from the distant universe to new planets on our doorstep.

A cosmic milestone: the Hubble Space Telescope detects Cepheid variable stars in the spiral galaxy NGC 4603. (NASA/ESA.)

Recent years have seen a transformation of many areas of astronomy. New instrumentation makes arcsecond resolution almost commonplace across the whole electromagnetic spectrum, where previously it was the domain of just radio and optical observations. New satellites have opened up windows on the universe in wavelengths such as ultraviolet, X-ray and infrared, where little was previously known. The International Astronomical Union conference in Manchester underlined the new science that can now be done. New precision measurements are settling old problems – how galaxies formed, how the universe will end – and providing new tests for fundamental physics, such as general relativity and magnetic field theory.

Cosmological parameters

"We are entering a new era of precision cosmology," said Malcolm Longair of Cambridge, kicking off the session on New Cosmological Data and the Value of Fundamental Parameters.

His remark provoked a response from Wendy Freedman of Carnegie Observatories in the conference newsletter. She pointed out the need to control systematic effects and to target high accuracy as well as precision. She noted welcome progress with new experiments designed to reduce the systematic errors that have historically dogged all measurements of cosmological parameters. "My ▷

Meeting highlights

"For me the highlight has to be the convergence of different cosmological parameters: microwave background measurements, supernovae studies, large-scale structure and gravitational lensing...all the numbers agree!"

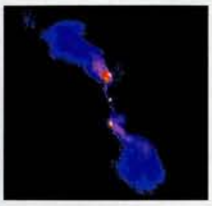
Virginia Trimble, chair of the Division of Astrophysics of the American Physical Society, works at California, Irvine

"I'm very excited about the discovery of a planet around Epsilon Eri, because it's an old friend – I have studied it in the past."

Indeed, the discoveries of no fewer than nine new planets were announced in Manchester. Epsilon Eriidani is particularly interesting as it has a size and orbit similar to those of Jupiter and the observations suggest that there may also be an Earth-sized planet orbiting the central star.

Carole Jordan, University of Oxford

X-ray image. (Chandra/NASA.)



Radio image. (VLA/NRAO.)

"With the first results from Chandra and XMM, it is the first time there is comparable resolution between X-ray and radio observations. One thing I learned this morning was that new X-ray maps of galaxy clusters show the holes where the hot X-ray emitting gas of 100 million degrees has been blown out by the relativistic plasma in the radio jets...they match perfectly with the radio images!"

Sir Martin Rees, Institute of Astronomy in Cambridge

The Antarctic launch site of the Boomerang balloon-borne mission.

own definition of precision would be restricted to measurements at the few percent level, and we are not there yet," she said. "However, I believe we have entered the realm where 10% measurements are possible and factors of two are behind us."

The Hubble constant This sector is an excellent example of such new optimism. Hubble's law states that the further away a galaxy, the faster it appears to recede. The constant of proportionality – the Hubble constant – fixes the age of the universe.

After years of conflict between those who believed the Hubble constant to be 50 and those who found 100, different determinations of this fundamental distance measure are now converging on a value of around 75. Freedman used a new calibration of the period-luminosity relation for Cepheid variable stars and got a value of 75 ± 10 using data from the Hubble Space Telescope. The big uncertainty now comes in the local calibration of the Cepheids: if we knew the exact distance to our nearest neighbour galaxy (the Large Magellanic Cloud), the uncertainty in the Hubble constant would be less than 5%.

However, a word of warning came from Tom Shanks of Durham. The method of using Cepheid variables as standard candles is highly dependent on the composition of these stars: estimations of distances could be in error by as much as 25%.

The symposium also highlighted recent progress in measuring the Hubble constant using the Sunyaev Zel'dovich effect. This occurs when hot gas in clusters of galaxies scatters the cosmic microwave background (CMB) radiation. Values for the constant of 75 and 65 were reported with uncertainties of around 15%. The accuracy of this technique will improve as the resolution of X-ray telescopes increases.

The problem of the oldest stars appearing older than the universe (the "old wine in new bottles" dilemma) seems to have been solved following adjustments of the local distance scale after the Hipparcos mission. Calculations now place the oldest stars at $11–12 \times 10^9$ years old, consistent with the latest value for the age of the universe.

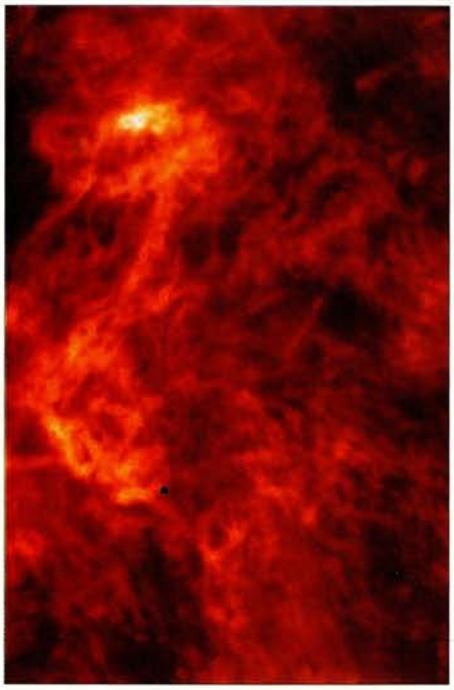
The microwave background Observations of the CMB are the closest that astronomers can get to the beginning of the universe. The CMB dates from 300 000 years after the Big Bang, when radiation uncoupled from matter.

Experimental advances in CMB astronomy mean that high-resolution maps of the sky are becoming available for the first time. The conference was excited about results from the Boomerang and Maxima balloon missions (March p12).

The balloon results have confirmed an overall picture of a spatially flat universe, where $\Omega = 1$ (where Ω is the ratio of matter in the universe to the critical level needed to halt the universe's expansion). This is consistent with the inflation model of the Big Bang.

"The glorious thing is that the peak is right where it should be," said Jim Peebles of

The interacting antennae galaxies imaged by the Hubble Space Telescope. In the infrared, the point between the two galaxies contains 50% of the total luminosity because a bright starburst is completely hidden by the dust. (NASA/ESA.)



Infrared image of the sky from the old IRAS satellite. ISO improves resolution by a factor of 100, showing the background to be composed of many discrete sources. (IRAS.)

Princeton, commenting on the CMB angular power spectrum. The peak shows that the characteristic scale of coherent patches on the CMB sky is about one degree.

However, there are calibration problems with the balloon experiments. Paul Richards from California commented that, to obtain the fit, it was necessary to reduce the values found by Maxima by one standard deviation (8%) and increase those from Boomerang by one standard deviation (20%).

The next set of detectors is not far behind. Three different interferometer arrays will survey small patches of the CMB: the Cosmic Background Imager, the Degree Angular Scale Interferometer and the Very Small Array (November 1999 p13). These instruments are best for the detailed study of CMB structure. Astronomers are eagerly awaiting the next meeting of the American Association for the Advancement of Science in February 2001, when the first results are expected.

An accelerating universe Large-scale structure surveys, such as the Anglo-Australian 2dF and the US Sloan Survey, are starting to yield their first results, giving a better understanding of the evolution of large-scale clustering. Astronomers do not observe enough baryonic or dark matter in the universe to account for a Ω value of 1. This has led to a resurrection of the "cosmological constant" – a kind of vacuum energy density that changes the acceleration of the universe.

This picture is confirmed by observations of type 1a supernovae, which have always essentially the same luminosity and can therefore be used for distance calculations. Observing how their light is redshifted shows how much the universe has expanded. Saul Perlmutter of Berkeley told the conference about plans for a space-based supernova detector called SNAP (SuperNova Acceleration Probe), which would dramatically increase both the statistics – detecting up to 2000 supernovae per year – and the redshift of the supernovae observed.

"What's amazing now is that different lines of analysis are coming together in a story that agrees with what theory tied down years ago," Peebles told *CERN Courier*. "This is deeply impressive and has caused me to up my grades," he said. "A year ago I was against this convergent model; now, if I were writing a report card, I'd say: 'Lambda [cosmological constant] shows great promise, low mass density – very good, homogeneity – excellent!' "

In his summary of the symposium on fundamental cosmological parameters, Martin Rees of Cambridge brought the meeting back down to the ground. It's all very well measuring these parameters with incredible precision, but maybe what we are observing now is just a special case. Just as the ellipse of the Earth's orbit changes each time, are there lots of different versions of these "fundamental" parameters? He added that, in his view, there were two types of cosmologists: the theoretical astrophysicists and the mud wrestlers. He included himself in the latter category.

The formation of galaxies

The optimism from cosmologists was not mirrored in the sessions on the extragalactic infrared background. "We still don't have the right story for how galaxies form," said Peebles.

Michael Harwit of Cornell set the meeting some ambitious targets. What were the first galaxies and how did they evolve? When did stars start to form and how can we explain the distribution of the heavy elements that we observe today? Our understanding of the evolution of galaxies and stars is far from complete and observations are fraught with difficulties. Important clues are certainly to be found in the cosmic infrared background, first detected in 1996. The infrared emission comes from light reprocessed by dust.

Reviewing the current state of affairs, Peebles explained that, looking back to a redshift of 1, galaxy formation had already ▷

finished – galaxies looked as they do today. However, models of star formation suggest that approximately half of all stars formed after this time.

Even less well understood is the nature of galaxies between a redshift of 1 and 2. "Is this the era when galaxies formed?" asked Peebles, "and if the first galaxies were formed by dark matter halos merging at high redshift, why don't we see knots of mass at such distances that would be evidence of this kind of merger?" Different presentations underlined the difficulty in estimating star light in real terms – some estimations varied by a factor of two.

Michael Rowan Robinson from London's Imperial College commented that the majority of the mass of the universe is in low-mass stars that are in low-mass, gas-rich spiral galaxies. High-mass elliptical galaxies formed during the early part of the universe, then after a redshift of 1 came the low-mass stars.

Infrared surveys Catherine Cesarsky, director of the European Southern Observatories (ESO), spoke of a survey conducted at a 15 μm wavelength using ISOCAM, the camera on board the Infrared Space Observatory. A total of 1000 galaxies were observed and the team was looking for comparisons in the Hubble deep field of distant galaxies. She found that the galaxies got brighter as their redshift increased. Most were members of a class of ultraluminous infrared galaxies with a density peak between redshifts of 0.7 and 0.8. These galaxies have been resolved for the first time and account for about 50% of the infrared background radiation. Their study will reveal much about the origins of galaxies that we see today.

Later, Simon Lilly of Toronto explained how he combined results from ISOCAM with observations using SCUBA, the infrared camera on Mt Wilson. This, Cesarsky told *CERN Courier*, was her highpoint of the symposium. She was enthusiastic about the possibilities revealed by the ISOCAM survey, which bode well for similar studies at other infrared wavelengths. "To understand what is going on we really need to find out what the infrared sources are. This is what we are now starting to do for the first time." Cesarsky is keen to work with ESO's Very Large Telescope on the optical identification of ISOCAM sources.

Rees stressed the need to push the observational boundary even further to improve the study of the early galaxies. "The Next Generation Space Telescope will be detecting pregalaxies in the infrared beyond redshifts of 5 – high redshift galaxies are only 1 arcsecond across and very weak, so we need better sensitivity and resolution," he said.

NASA's Space Infrared Telescope Facility (SIRTF) is scheduled for launch in December 2001 and ESA is preparing the Far Infrared and Submillimitre Telescope (FIRST), which is due to be launched in 2007.

The latest advance in instrumentation was a key theme running through the whole conference. Nowhere was this more obvious than in the session on galaxies and their constituents at the highest angular resolutions. This will be covered in part two of the IAU meeting report in next month's *CERN Courier*. Discover the latest observations of black holes, megamasers and jets, and find out about new IAU president Franco Pacini's plans for greater collaboration between particle physics and astronomy.

Emma Sanders, CERN.

Physics acts as a ca

As well as being crucibles of research, today's big physics experiments are also factories for students – almost 700 have graduated from the DELPHI experiment at CERN's LEP electron–positron collider in just over a decade. *Tiziano Camporesi* finds that physics students are quickly being absorbed by an eager jobs market.

Personal skills are a valuable form of technology transfer. The expertise acquired in the big international collaborations running today's major physics experiments is diverse – computing, electronics, project management, etc. In addition are the interpersonal skills gained by being a member of a large international team working on a complex problem. Today's physics students are much in demand.

To investigate this, the DELPHI experiment at CERN's LEP electron–positron collider analysed the careers of 669 students, mainly those involved in DELPHI since it began running for physics in 1989.

Of these students, 338 obtained a PhD, 89 a masters degree and 242 diplomas. Three nations dominate the sample – Italy (140 students), Germany (120) and France (80). Norway and the UK follow, each with about 40 students (figure 1). The distribution of the students reflects the resources given to DELPHI by the respective countries (and refers to the university to which the student is attached rather than their nationality). The attraction of DELPHI for students also increased once the experiment began running (figure 2).

There were seven identifiable career outlets (figure 3):

- research: public-funded jobs in universities and research centres;
- teaching in schools and in universities where there is no research activity;
- computing and simulation, mainly in the private sector;
- management in public administration, the private sector and consultancy;
- business, including entrepreneurs and start-ups, but excluding computing and related activities;
- high technology: electronics and other specialized industries;
- graduate school: further education, but not with the DELPHI experiment.

The 19 different nationalities active in DELPHI in many cases have very different traditions. In certain countries (notably France), choosing to follow a doctoral programme in fundamental research implies a commitment to this as a career. In other countries, for example Germany and Italy, the situation is much more open. Here, the skills

Lots of students – the DELPHI experiment at CERN's LEP electron–positron collider.

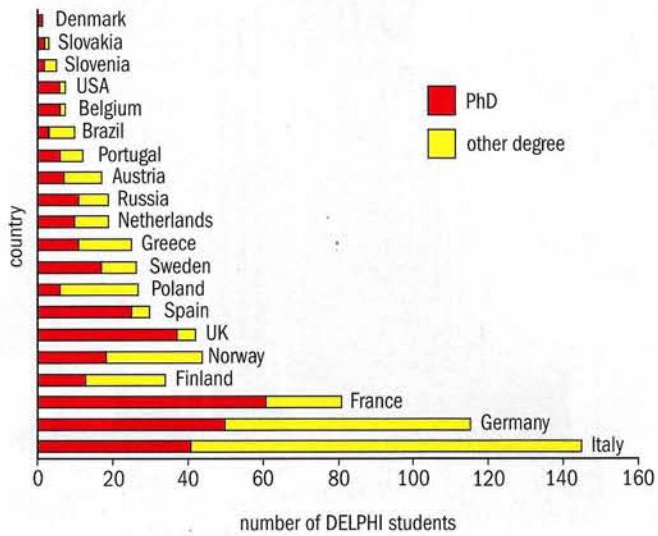


Fig. 1. The nationality of former DELPHI students.

reers stepping stone

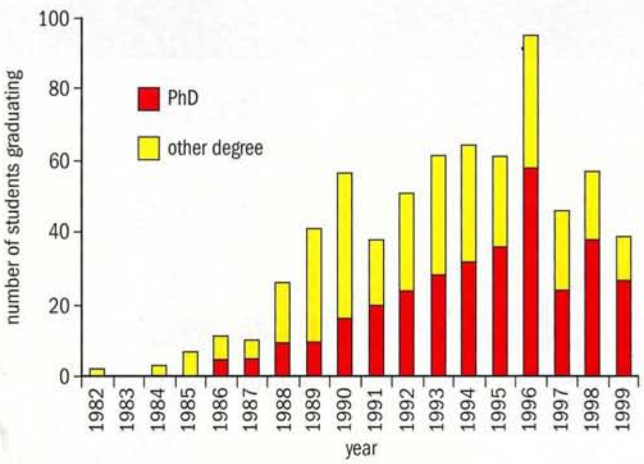


Fig. 2. Graduation dates for DELPHI students – the initial peak in 1990 represents students working on DELPHI preparations and construction, while the 1996 peak corresponds to those working on LEP operating on or around the Z resonance, before the collision energy was substantially increased for LEP2.

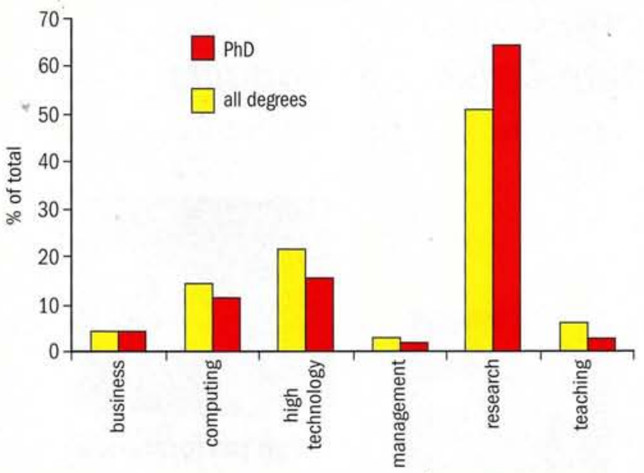


Fig. 3. Where DELPHI students go – the initial career step.

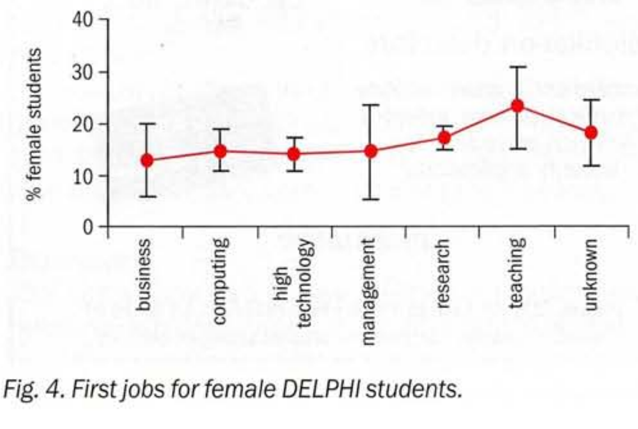


Fig. 4. First jobs for female DELPHI students.

Career moves after first employment

Career category	All degrees (%)	PhD (%)
high technology	24.4	19.5
computing	15.7	13.8
business	7.0	6.4
management	2.8	1.9
total private sector	**49.9**	**41.6**
research	44.3	55.5
teaching	5.8	2.9
total public sector	**50.1**	**58.4**

acquired in the course of thesis work in high-energy physics can be more important than the topic of the thesis.

Research – a job for life?

Working in high-energy physics at CERN means a certain level of dedication, but it is nevertheless striking how most of the students continue with research, at least for an initial period of a few years. Determining whether ex-DELPHIers continued with research later was not so easy, as it is difficult to keep track of students' progress once they have left their degree-awarding institute.

However, a subsample of 158 ex-students in Austria, Germany, Italy, the Netherlands, Norway, Portugal and the UK revealed a subsequent migration out of research to positions in business, high technology and computing. Assuming that this trend is valid for the whole sample gives the result shown above. This shows that about 50% of students eventually leave research for fast-developing sectors of their national economies.

Comparing data collected in 1996 with those in 2000 shows that physics students have become valuable. With job offers already on the table, they are having to wrap up their thesis work in a hurry.

Women on the move

Women make up about 20% of the students involved in the DELPHI experiment today, and, although this has moved down from an all-time high of 30% in 1998, there has been a marked increase over the years. Their initial post-DELPHI job is shown in figure 4. The pattern closely matches that of the overall statistics.

While the study shows that research at an international level is clearly a stimulating environment, most of the students choose not to follow this career path for life. However, whatever they do go on to do, their stay at CERN certainly played a major role.

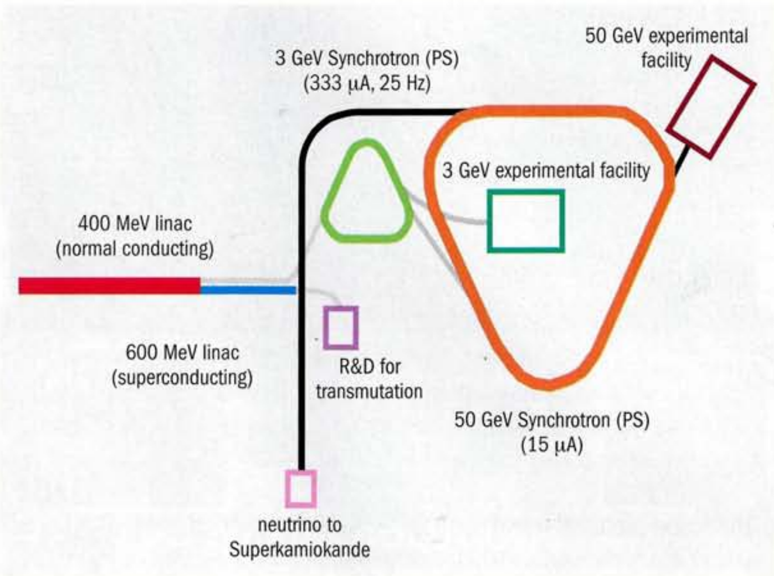
More information about DELPHI is available at "http://delphi.web.cern.ch/Delphi/Welcome.html". □

Proton collaboration is under way in Japan

In Japan the KEK high-energy physics laboratory and the Japan Atomic Energy Research Institute are working together to finalize preparations for a major new high-intensity proton source, with applications in a number of sectors.

In Japan, plans for a major new proton complex also reflect a major administrative reorganization. Originally, the KEK high-energy laboratory had a hadron accelerator project called the Japan Hadron Facility (JHF), which consisted of a 50 GeV proton synchrotron and a 3 GeV booster ring where the projected power of the latter was 0.6 MW.

The Japan Atomic Energy Research Institute (JAERI), on the other hand, had a high-power spallation neutron source project with a proton linac, in which 3 MW pulsed beams were planned for neutron scattering and 5 MW continuous beams were planned for nuclear transmutation.



Schematic of the proposed high-intensity proton facility to be built by a collaboration of the Japanese KEK high-energy physics laboratory and the Japan Atomic Energy Research Institute.

Since both projects share a common goal to attain high-power proton beams, in the summer of 1998 the Government suggested a joint effort between KEK and JAERI for a single high-intensity proton facility in Japan.

Monbu-sho (the Ministry that supports KEK) and STA (the Science and Technology Agency, which supports JAERI) will merge in January 2001. Therefore, the 1998 suggestion also implied that the government wanted to initiate a project supported by both agencies.

Endorsement

After lengthy discussions, KEK and JAERI agreed in March 1999 to collaborate to create a single high-intensity proton accelerator proposal and a formal memorandum of understanding was signed by the directors of the two institutions. A joint proposal was published and reviewed in April 1999 by an international committee chaired by Yanglai Cho of Argonne. The committee strongly endorsed the proposal.

The project, which is to be constructed at the JAERI Tokai site, will consist of:

- a 400 MeV proton linac (normal conducting) to inject beams into the 3 GeV proton synchrotron;
- a superconducting linac to accelerate protons from 400 to 600 MeV, and used primarily for experiments toward nuclear transmutation;
- a 25 MHz 3 GeV proton synchrotron with 1 MW power, primarily for life and material sciences with neutrons and muons;
- a 50 GeV proton synchrotron delivering 15 μA and two extraction modes – slow extraction for kaon, pion and primary beams, and fast extraction for neutrino beams to the Superkamiokande detector.

The budget of the project is about Y189 billion (approximately $1.89 billion when $1 = Y100). According to a new law in Japan, any major scientific project must satisfy a government-organized third-party review committee. In this case the third-party committee must include a range of people, such as scientists (physicists, chemists, biologists, etc), institutional administrators, journalists, economists and company presidents.

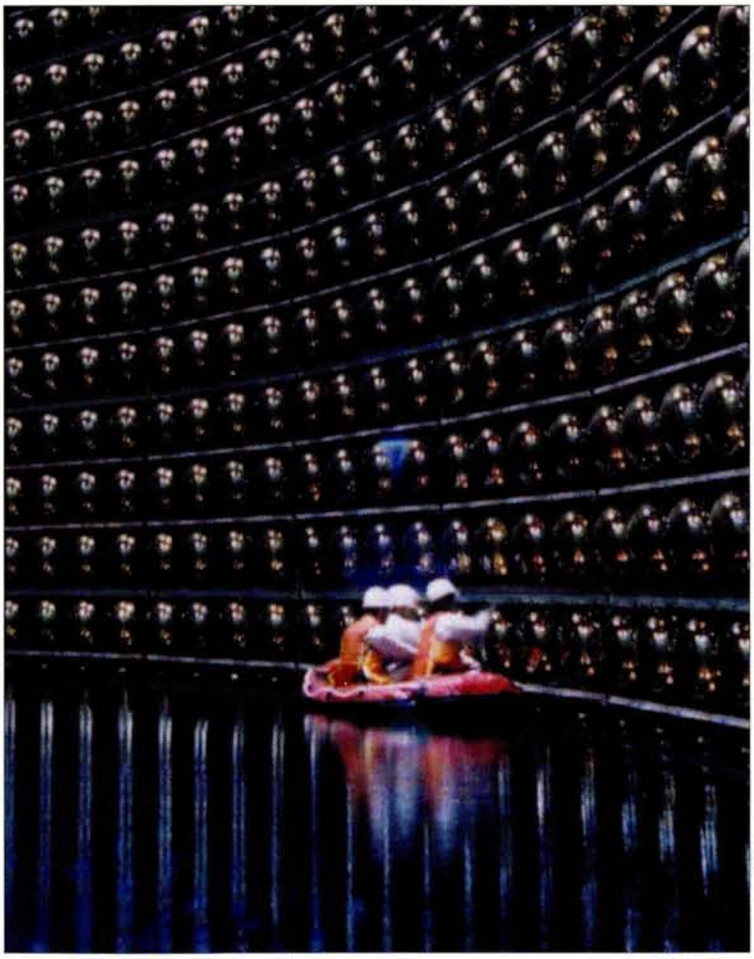
The Joint Project was assigned as the first case for such a third-party review, and the committee members were nominated in the late autumn of 1999. Their draft report strongly supports the project, despite its cost. This report will influence the policy decision, and ▷

it is hoped that official approval will be given for construction to start in the financial year beginning in April 2001.

Accelerator network

Phase I of the project comprises a 600 MeV linac, a 3 GeV 1 MW rapid-cycling synchrotron (RCS) and a 50 GeV main synchrotron. The Phase I facility could be upgraded to a 5 MW neutron source, which would be Phase II of the project.

One half of the 400 MeV beam from the linac will be injected to the RCS, while the other half will be further accelerated to 600 MeV by a superconducting (SC) linac. The 3 GeV beam from the RCS will be injected to the 50 GeV synchrotron. The 600 MeV beam from the SC linac will be transported to the experimental area for an accelerator-driven nuclear waste transmutation system (ADS). The 3 GeV beam from the RCS will be mainly used to produce pulsed spallation neutrons and muons. The muon-production and neutron-production targets will be located in series in the Life and Materials Science Experimental Area. Ten percent of the beam will be used for muon production.



One of the clients of the new Japanese proton facility would be the Superkamiokande underground neutrino experiment, 300 km from the Tokai site. Here, researchers are carefully cleaning the photodetectors as the neutrino target volume is filled with water.

The 50 GeV beam will be slow extracted to the Particle and Nuclear Physics Experimental Area and fast extracted for the neutrino experiment at the Superkamiokande detector 300 km away.

Producing the protons

A volume-production type negative hydrogen ion (H^-) source is designed to produce a peak current of 53 mA with a pulse length of 500 μs and a repetition rate of 50 Hz. About 53% of the beam will be accelerated after the beam is chopped at both the 50 keV low-energy beam transport and the 3 MeV medium-energy beam transport.

The radiofrequency quadrupole (RFQ) linac will accelerate the beam up to 3 MeV, the conventional drift-tube linac (DTL) up to 50 MeV and the separated DTL (SDTL) up to 200 MeV. Here, an acceleration frequency of 324 MHz was chosen. The frequency will be increased by a factor of three at 200 MeV.

If the present scheme is successful, one of the most important key technologies will be in place.

Among the possible candidates for the coupled-cavity linac to be used from 200 to 400 MeV, the annular-ring-coupled structure (ACS) is most preferable because of its axial symmetry. Several prototypes of the L-band ACS have been developed and powered beyond the design value. The 400 MeV H^- beam from the linac will be injected into the RCS during 500 μs, limited by the sinusoidally varying magnetic field of the 25 Hz RCS.

The beam will be chopped at twice the ring radiofrequency of 1.36 MHz (two bunches per ring) to avoid beam loss during injection. The RCS will thus accelerate two bunches (4×10^{13} protons per bunch) every 40 ms. Eight of the 10 buckets of the 50 GeV ring will be filled by four cycles of the RCS. Then the 50 GeV synchrotron will ramped for 1.9 s. The beam will be slowly extracted during 0.7 s. Afterwards it will take 0.7 s for the synchrotron to be ready for the next injection. In total, the period of one beam cycle will be 3.42 s, corresponding to an average current of 15.4 μA.

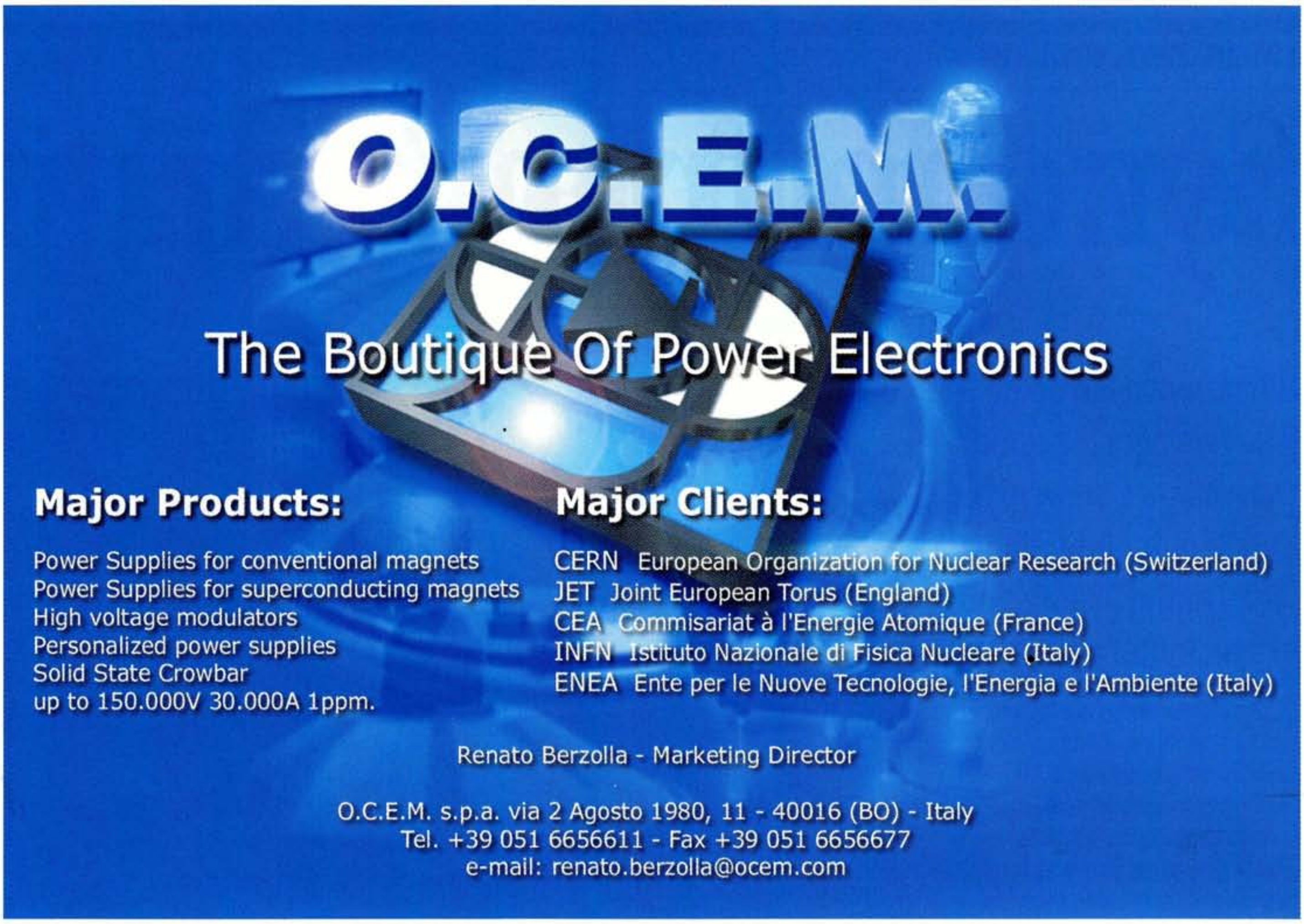
The purpose of the SC linac is to develop the necessary accelerator technology for the ADS nuclear waste transmutation experiment. If the present scheme is successful, one of the most important key technologies will be in place.

Construction of the 60 MeV proton linac began on the KEK site in 1998. The beam commissioning of the ion source and the RFQ linac will begin soon. Since these two components were designed for a peak current of 30 mA, they will be replaced for the JHF project. However, the beam could be used for testing the DTL and SDTL.

After construction and beam commissioning of the 60 MeV linac have been completed in the JAERI–KEK collaboration, the linac will be shipped to Tokai for the Joint Project.

More information about the collaboration is available at "http://jkj.tokai.jaeri.go.jp/".

Shoji Nagamiya *and* **Yoshishige Yamazaki**, *JAERI–KEK Joint Project Newsletter.*



Since the dawn of the electronic age, no other company has revolutionised interconnection like 3M. And today, no other single manufacturer can match the range of interconnection products that 3M make. Because, if the connector you require isn't already in our catalogue, our technicians can work with you to design a product which exactly fits your needs.

For more information about our world beating range, call our Customer Information Services line on 0041(0)1 724 93 52, or visit our website at http://www.3m.com/interconnects/

3M *Innovation*

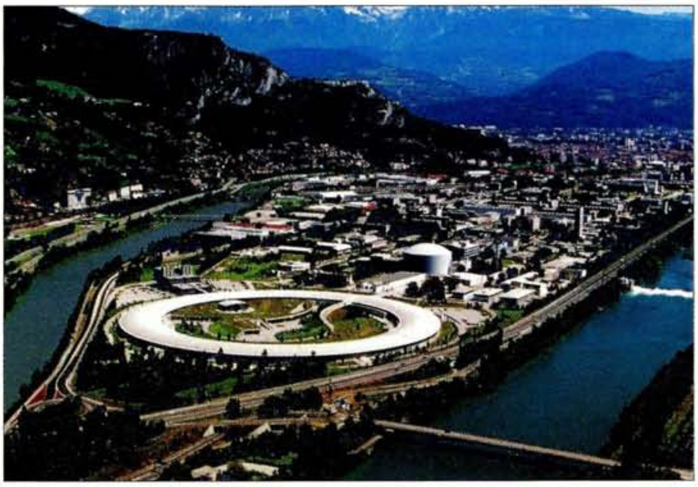
Synchrotron radiatio

What began life as an unwanted energy loss has become a major research industry. *Dominique Cornuéjols* of the European Synchrotron Radiation Facility in Grenoble looks at the history and accomplishments of synchrotron radiation.

Picture five men around a tabletop ring. From this insignificant 1947 General Electric synchrotron, where the production of light from a particle accelerator was first observed, the newborn beam – "synchrotron radiation" – eventually went on to attract much interest.

However, it began its career on the wrong foot. The emission of light means a loss of energy in accelerator physics, where the main objective is to increase the energy. Who could have foreseen the dramatic evolution that would lead to the construction of large storage rings (erroneously called "synchrotrons") to which thousands of scientists rush every year for a few days use of this precious light?


Small beginnings – around the vacuum chamber of a 1947 General Electric synchrotron. (NSLS, Brookhaven.)


Synchrotron radiation today – aerial view of the European Synchrotron Radiation Facility in Grenoble.

Synchrotrons to storage rings

In the beginning, the new light beam was considered a nuisance for particle physics and was too poor to be of interest in other fields. A succession of technological advances went on to propel synchrotron radiation to the forefront of scientific research as an instrument of choice for the study of matter at the atomic and molecular scales.

First there was a switch from synchrotrons to storage rings, with the latter offering a stable beam. Then the rings became larger and their energies rose. Initially, synchrotron radiation was restricted to the visible and near-visible spectral regions, which were already covered by other intense light sources, such as lasers. The spectral range widened progressively, and today it spreads from infrared to gamma rays for the largest rings, with the highest concentration of photons in the X-ray domain.

Access to X-rays has been essential. Their wavelengths are comparable with interatomic distances, so X-ray diffraction by crystalline samples is possible, allowing structures to be analysed at the atomic scale. The other experimental techniques (such as absorption spectroscopy, imaging and scattering) also benefit from the shortening of the wavelength, thus offering a better resolution.

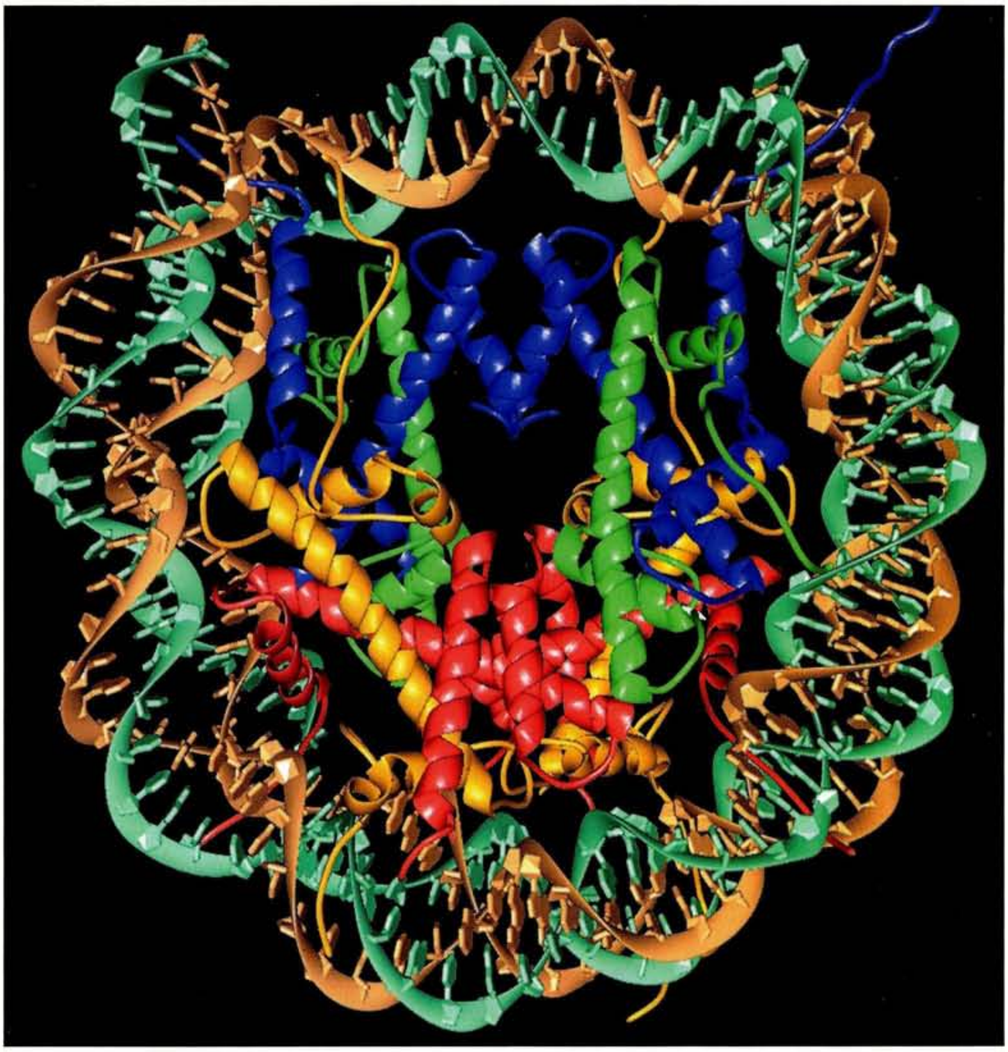
Brilliance

Spectral continuity is certainly a crucial asset of synchrotron radiation. Scientists can select the wavelength best adapted to their study using the beamline monochromator, and they are able to modify their selection during the experiment. Another interesting property, particularly in the X-ray range, is polarization – a synchrotron beam is naturally polarized in the horizontal plane and can also be polarized circularly. Last but not least, the beam is pulsed – a succession of flashes, each lasting about 100 ps, permits the dynamic study of very fast chemical or biological reactions.

However, the most dramatic progress in the past few years has been in the intensity and the collimation of the beam. These two qualities are lumped together in the figure of merit known as brilliance, which compares the optical quality of different sources. Today, the brilliance of the best synchrotron beams is a thousand billion times that of a conventional X-ray source. An excellent brilliance is also accompanied by another quality of the beam – coherence – which used to be laser-specific. Moreover, coherence is obtained by synchrotrons in the X-ray domain that is still difficult for lasers.

How can one explain such an exceptional increase in brilliance?

n is brighter than ever



Synchrotron radiation in action – the structure of the nucleosome core, with the DNA wound round proteins called histones. (T J Richmond, Zürich.)

There are two main reasons. The first is the use of special magnetic structures called undulators inside the storage rings. Small permanent magnets are mounted on two jaws with a variable opening. Alternating the magnets' polarity makes the electrons oscillate inside the structure.

At each oscillation, photons are emitted as a very narrow beam. For instance, if the undulator comprises 100 magnets, the many cones of light superimpose and, by interference, produce a spectrum made of peaks, with the photons accumulated at certain energies. In this way the brilliance of the light beam is considerably increased at the position of the peaks.

By moving the jaws and thus modifying the gap, it is possible to shift the peaks to give the desired energy. Scientists thus benefit from an intense beam for any energy in the accessible range. The most recent machines, known as "third generation" machines, make intensive use of such undulators.

The second explanation for the gain in brilliance is the improvement of the machines, leading to an almost perfect control of the trajectory and shape of the electron beam. The third-generation machines have very low emittances (the product of the size of the beam and its divergence) – the lower the emittance, the higher the brilliance.

Beamlines

However, the performance of the machine alone is not enough to carry out an experiment using synchrotron light. On the beamline, the beam needs to be treated (essentially monochromatized and focused) to illuminate the sample under optimal conditions.

The third-generation machines have imposed new constraints on the optics. Indeed, due to the intensity of the beam, the heat load is very high and it is necessary to cool the optics (usually with liquid nitrogen). Focusing – always a problem when dealing with X-rays – implies going to the limits of the usual technologies (mirrors) or inventing new devices (lenses) to obtain the microbeams required in a large number of experiments.

The success of sophisticated synchrotron experiments requires highly specialized beamlines. The optics are optimized according to the technique or the research domain. The sample environment has also become a priority: scientists increasingly attempt to reproduce specific experimental conditions. Mechanical constraints, various atmospheres, pressure and temperature are all parameters that have to be controlled in order to carry out experiments, such as those involving catalysis.

Finally, at the end of the beamline comes the detector and the electronics for data acquisition, which, due to the brilliance of ▷

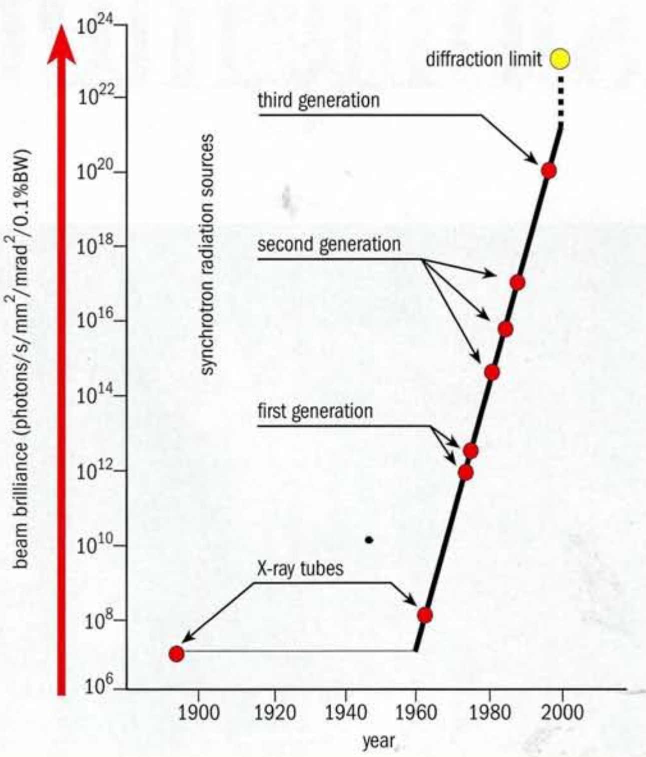
Virtual visit inside a synchrotron

In real life, only particles can enter the tunnel of the storage ring. X-rays are themselves invisible, and the samples exposed to the beams are often too small to be seen, while the optical devices are protected by vacuum.

A new virtual reconstitution overcomes these visibility barriers and simulates what goes on inside a synchrotron. Conceived as a multimedia encyclopedia, the CD-ROM *Synchrotron Light...to Study Matter* opens up the world of synchrotrons via hypertext links, interactive illustrations and multiple entries. The numerous two- and three-dimensional animations, as well as the computer-generated images, make the difficult phenomena easy to understand.

This bilingual English/French CD-ROM has been designed for a very wide public. The scientific content has been produced by the ESRF Information Office in collaboration with scientists. The multimedia development has been made by IMediaSoft, a company specializing in multimedia for science, industry and education. The CD-ROM will be distributed worldwide from October by Springer-Verlag.

For more information see "http://www.esrf.fr/info/CD-ROM".



Increasingly brilliant – the track record of synchrotron radiation.

the beam, must record a large amount of data in a very short time.

Among the many research domains that make use of synchrotron light, the best example is without any doubt that of protein crystallography. In parallel with genomics, a new science is emerging called proteomics (the study of the proteome – the protein inventory of a living being). While a gene sequence can now be rather easily solved using computer automation, the study of proteins is more complex. In fact, the succession of amino acids in a protein does not directly determine its function: the latter depends on the way in which the protein folds in space, thus forming a three-dimensional structure that evolves during the biological reaction.

Hence, the knowledge of the arrangement of atoms in a biological macromolecule has become one of the major objectives of molecular biology and, naturally, of the pharmaceutical industry too. The structure of small molecules (containing up to a few thousand atoms) can be solved by nuclear magnetic resonance. However, for larger molecules the only available technique is X-ray diffraction (if the protein can be crystallized). Although great progress has been made in crystallization techniques, this operation is often difficult (sometimes impossible) and the crystals obtained are not always of the best quality.

In protein crystallography, synchrotron radiation brings numerous advantages compared with traditional X-rays. In particular it allows the study of minute or weakly diffracting crystals. Also, one can solve very large complexes, associating DNA and RNA with proteins. This is the case for viruses and for the ribosome – the manufacturing plant for proteins. The biggest structure ever solved is that of the blue-tongue virus, which contains some 10 million atoms. Moreover, if one succeeds in crystallizing, for example, a unit made of a viral protein and its antibody, one can learn a lot about the shape of the binding site with high resolution, thus helping the discovery and synthesis of new drugs, perfectly targeted and therefore more efficient.

For a long time, protein crystallography yielded only static images. Thanks to the pulsed structure of synchrotron light and to the brilliance of the new sources, it is now possible to take a sequence of images and identify intermediate states on a nanosecond scale.

Nanostructures

Applied research is constantly probing new material behaviour. For example, significant R&D efforts go into studying the properties of the thin magnetic films used in computer hard disks. A better understanding of new magnetic behaviour, such as magnetoresistance, would considerably increase the storage capacity of these devices. The material normally used for hard-disk recording is a permalloy film, with a magnetoresistance of about 3%. In the sandwiches of iron/chromium/iron or iron/copper/iron, the effect can be as high as 100%.

On a closely related subject, some ultrathin magnetic films of only a few atomic layers show a surprising property – "magnetic perpendicular anisotropy". The magnetization is not in the plane of the film as might be expected but is instead perpendicular to it, thus giving the possibility of storing many more bits on a given surface.

The dimensions of these structures are on the nanometre scale, so it should no longer be called microelectronics but rather "nanoelectronics". To study the magnetic properties of these nanostructures, scientists are perfecting new experimental techniques that exploit the qualities of synchrotron radiation. An example is surface diffraction under grazing incidence with an extremely well focused beam, which is used to record only the signal coming from the outermost layers – a technique demanding the highest brilliance.

Another technique perfectly adapted to the study of magnetic

Industrial foam viewed by X-ray microtomography using coherent light from a third-generation synchrotron. (ESRF.)

materials is magnetic circular dichroism, in which light changes from left to right circular polarization, and vice versa. In some materials the interaction of photons with electrons depends on the direction of the polarization. The resulting difference in absorption reveals the magnetic state of the material and allows the separate measurement of the average moment of each element (iron, copper, cobalt, etc) in the material. No other technique can provide this information.

A large number of synchrotron experiments are carried out in the domain of high pressure. Today we know how to reproduce in the laboratory conditions that are close to those at the centre of the Earth. We need high-pressure cells, where two tapering tips made of diamond squeeze a sample of matter: pressures can reach up to 400 GPa. The samples, which are necessarily very small (a few hundred cubic microns), can additionally be heated using a laser beam. Iron, ice and hydrogen are examples of samples that can be scrutinized through their many crystallographic phases, thus delivering precious information on the behaviour of ultracondensed matter.

Medical applications

Medical research makes use of the new possibilities offered by synchrotron radiation for angiography, tomography and radiotherapy. One of the most notable advances of the last few years is the use of the coherence of the beam in imaging methods: microtomography, when associated with "phase contrast", allows the exploration of the three-dimensional structure of biological tissues like bones, as well as composite or porous materials (industrial foams, alloys and even snow) with a reinforced contrast and a remarkable resolution.

X-ray microscopy, on the other hand, requires special optics, called zone plates, which advance the resolution limits for imaging to a few tens of nanometres. Compared with other well known microscopy techniques, synchrotron light again offers many advantages, such as the possibility of intensifying contrast by fluorescence due to the presence of certain elements inside the sample.

The range of disciplines in the variety of subjects studied, the continuity between fundamental and applied research, and the constant improvement of experimental devices and techniques to help scientists to go beyond the frontiers of knowledge all promise a bright future for synchrotron radiation.

Dominique Cornuéjols, *ESRF.*

Second Announcement

Nuclear Science Symposium and Medical Imaging Conference

IEEE

LYON
CONVENTION CENTRE
FRANCE

OCTOBER 15-20, 2000

Radiation Detectors and electronics: Applications in Physics, Industry, Space and Medicine

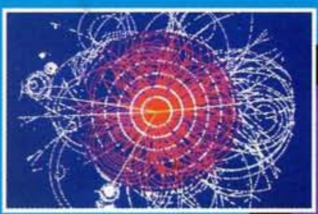
Physics, Engineering and Mathematical Aspects of Medical Imaging

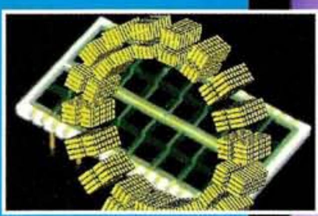
Industrial Exhibition

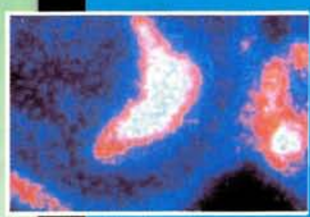
- Short-courses
- Oral presentations in plenary and parallel sessions
- Poster sessions
- Workshops
- Visits to nearby laboratories (CERN, ESRF/LETI)
- Social and companion programme

For more information visit our website at http://NSS2000.in2p3.fr

The deadline for abstract submission is 30 April, 2000.







cea CERN CLRC EFOMP CNRS IN2P3 Forschungszentrum Jülich (INFM) DESY INFN

NSS-MIC General Chairman:
Patrick Le Dû
Dapnia/SPP
CEA Saclay
F-91191 Gif/Yvette, CEDEX
ledu@Lep.saclay.cea.fr

MIC Program Chairman:
Stig A.Larsson
Karolinska Hospital
Department of Hospital Physics
SE-171 76 Stockholm, Sweden
stig@nucmed.ks.se

NSS Program Chairman:
Chris Damerell
Particle Physics Department
Rutherford Appleton Laboratory
Chilton, Didcot, Oxon, OX11 OQX, UK
C.Damerell@rl.ac.uk

How long until the next supernova?

Neutrinos are always interesting and frequently controversial. The biennial neutrino physics meeting, held this year in Sudbury, Canada, welcomed a major new neutrino detector and showed how the complex neutrino picture of the universe is slowly coming together. *Piero Zucchelli* reports.

It is difficult to explain what the biennial neutrino conferences mean for the neutrino physics community. Every two years, hundreds of scientists from all over the world meet to update and compare results, conclusions, opinions, claims and contentions.

Neutrino physics is different from any other field due to the variety of experiments, techniques, measurements, approaches, theories and prejudices associated with it.

Neutrino physics today involves many different fields – the detection of remnant neutrinos from the Big Bang; galactic neutrinos at extreme energies; neutrinos from supernovae, the Sun, the Earth's atmosphere and emitted from the Earth; artificial neutrinos produced from accelerators and nuclear reactors; and laboratory neutrinos from tabletop sources.

Neutrino enthusiasts gathered this summer at Sudbury, Ontario, for their traditional biennial meeting.

These experiments, spanning the 0.1 eV–1 PeV (1000 TeV or 10^{15} eV) energy region and providing information on the same particle, give a good idea of the spirit of the conference – a scientific bazaar where a cosmologist's opinion is confronted with that of a solid-state physicist, and a 50 000 t Cherenkov detector's results have to be understood in the light of the claims from a 10 kg calorimeter. Neutrino 2000, the 19th iteration of the biennial neutrino forum, took place in Sudbury, Ontario.

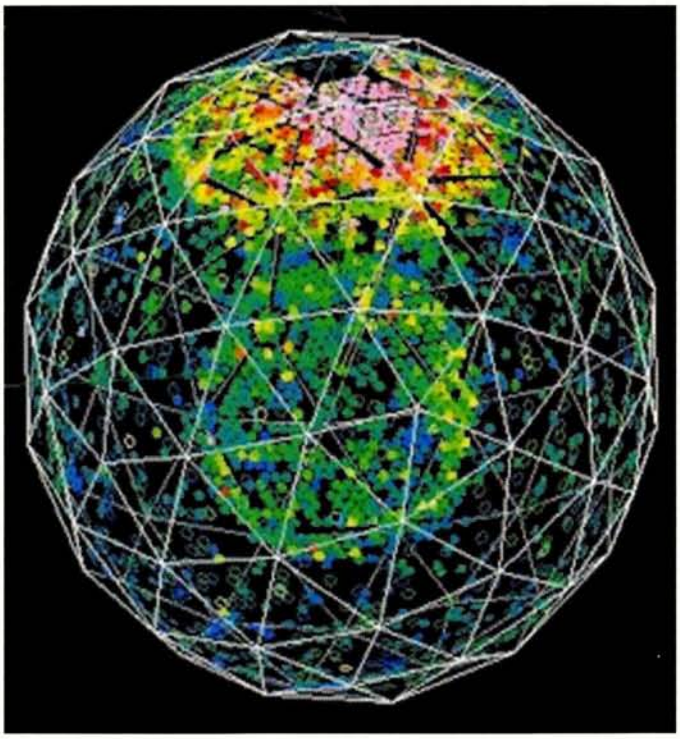
According to the results presented, the only possible conclusion is that neutrinos have mass. The solar neutrino deficit, the atmospheric neutrino oscillation pattern and the Los Alamos Neutrino Detector (LSND) claim in the region of cosmological interest have been confirmed and reinforced.

However, the interpretation of the results is ambiguous and the emergence of a unique picture strongly depends on experimental confirmation and improvements. A wide ongoing programme aims to improve our current experimental knowledge – new solar neutrino experiments such as SNO and Borexino, long-baseline programmes at Fermilab at CERN addressing the atmospheric neutrino signal, and MiniBoone on the verification of the LSND claim.

A worldwide programme for the study of a neutrino factory is also challenging the unprecedented possibility of precision measurements on neutrinos and is advancing rapidly to overcome the difficulties of exploitation.

The Sudbury observatory

In addition to the beautiful Canadian environment and the conference itself, interest was focused on the Sudbury Neutrino Observatory (SNO), a 1 kt heavy-water detector that has been in operation since September 1999. SNO has the unique ability to be able to say if the solar neutrino problem – a neutrino deficit with respect to the theoretical predictions and now observed by a variety of experiments – is indeed due to neutrino oscillations. (Classically, the different neutrino types – electron, muon and tau – lead separate lives. However, with a mass these species can "oscillate" or transform into each other.) ▷



New on the neutrino scene – a neutrino event seen by the SNO. The white lines indicate a geodesic support structure for the 10 000 photomultiplier tubes that detect light (Cherenkov radiation) from the produced particles.

Aerial view of the K2K neutrino beamline at the KEK laboratory in Japan. The extracted protons make the neutrinos emerge at the bottom and are bent towards the top right, where the neutrinos depart for the Superkamiokande target 250 km away.

To achieve this goal at SNO meant solving formidable technological problems – the deepest observatory in the world, shielded by 2000 m of rock in an active nickel mine, with a cosmic ray reaching the detector once every 20 min. The environmental conditions are particularly critical, and the entire laboratory has been constructed by transporting single components down a vertical elevator and a 1.3 km horizontal tunnel. The SNO is a "ship in a bottle".

SNO has an unprecedented purity for a large-scale detector – the purification system extracts daily seven atoms of radon for every ton of heavy water. To achieve this, strict precautions are taken. The laboratory is completely shielded from the still-active mine environment (blasting occurs in neighbouring tunnels), and different levels of cleanliness and dust purity allow the inner core to be a class 10 000 clean room (fewer than 10 000 dust particles per cubic foot).

Since everything reaching the detector goes through the mine, the major source of radon contamination comes from the transfer of material. For example, even Neutrino 2000 visitors in special clothing meant a significant effort to restore normal purity conditions.

SNO uses heavy water – a very precious liquid. However, Canada is the major world producer. Heavy water (produced for nuclear power plants) is usually extracted from freshwater lakes.

Simultaneous detection

The SNO experiment has demonstrated that the design goals have been achieved, and solar neutrino interactions above 2 MeV are indeed measured – less than one per hour – with the expected backgrounds. However, no quantitative statement on the solar neutrino problem was made by SNO at the conference, and scientists are waiting for additional data and improvements that will make SNO the only experiment capable of also detecting the interactions from muon or tau neutrinos coming from the Sun. Since only electron neutrinos are produced in solar nuclear reactions, simultaneous detection of an electron neutrino deficit and a muon or tau neutrino excess would be the final proof that electron neutrinos oscillate.

The conference, as usual, provided new and exciting results. For the first time in such a meeting, long-baseline data were presented. In the K2K project, artificial neutrinos from the Japanese KEK laboratory are detected 250 km away in the Superkamiokande 50 000 t underground detector.

The observed rate is compared with predictions extrapolated from the interaction rate registered by detectors near the source to cross-check, in an independent way, the result claimed by Superkamiokande based on "natural" neutrinos produced by cosmic-ray interactions in the atmosphere.

As with the solar neutrino effect, a neutrino deficit would imply neutrino disappearance, and thus an indication of neutrino oscillation. Still, the meagre data so far (17 events observed while 29 were expected; September p8) did not allow K2K to claim a deficit that would confirm the atmospheric neutrino oscillation signal, but data will naturally increase in the coming years.

Superkamiokande is also able to detect solar neutrinos, and on this subject data were meaningful, excluding possible hypotheses on the solar neutrino problem. In particular, they were able to collect 15 000 solar neutrino interactions with an improved signal-to-noise ratio and lower energy threshold (5 MeV).

These data could disfavour the simple hypothesis of neutrino oscillation in vacuum (space), and instead point more directly to additional oscillations as the neutrinos traverse the Sun, significantly refining the known oscillation parameters.

Limits on neutrino mass?

The neutrino oscillation phenomenon cannot occur if neutrinos are massless. On the contrary, if neutrinos are massive, it is possible that they oscillate. The oscillation is such that not all neutrino oscillation experiments could actually observe it: this depends on a few parameters, such as the neutrino flavour (electron, muon or tau) they can detect, the neutrino flavour emitted from the source, the distance from the neutrino source and the energy of the neutrinos.

Many experiments are therefore currently looking for neutrino masses but are not observing a positive signal, without being in contradiction with the fact that neutrinos have mass and can be seen to oscillate under other conditions. Among these are the CHORUS and NOMAD experiments at CERN, which are currently exploring the oscillation parameters with a sensitivity higher than any other experiment (their new results are about 1000 times as sensitive as Superkamiokande).

All of these experiments are nevertheless contributing to our understanding of neutrino properties. CHOOZ and Palo Verde, for example, have measured the neutrino emission from nuclear power plants but did not observe any oscillation phenomenon. However, their results are crucial, showing that the atmospheric neutrino oscillation claimed by Superkamiokande does not take place between electron neutrinos and muon neutrinos, but between muon neutrinos and something else.

Another group of experiments is pursuing a different strategy – to detect the neutrino masses directly, that is without assuming the oscillation hypothesis but directly "weighing" their mass, as has been done for all other known particles.

Unfortunately, neutrino masses are extremely small, and the current experimental sensitivity of the Mainz and Troitsk experiments allows us to say that the electron neutrino mass is less than a few electronvolts. This is again compatible with all neutrino masses currently claimed (even with the massless neutrino hypothesis) but does not rely at all on the oscillation hypothesis.

Neutrino astrophysics and cosmology

No less important were the neutrino-related conclusions from astrophysics and cosmology. For the first time, supernova modelling was able to describe the stellar explosion mechanism, which is crucial to understand the time distribution of the emitted neutrinos.

At the same time, cosmological measurements are constraining more and more the way neutrinos can be distributed in the universe, pointing to a significant dark matter contribution by neutrinos of a mass of about 1 eV.

Neutrino scientists are eagerly awaiting the next nearby supernova explosion. The 1987 event, were it to happen today, would yield far more data on neutrino properties due to detector improvements. The supernova rate in our galaxy is about three per century, so one of the next neutrino meetings will be more interesting than ever.

Piero Zucchelli, *CERN*.

RECRUITMENT

For advertising enquiries contact *CERN Courier* recruitment/classified, IOP Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK.
Tel: +44 (0)117 930 1026 Fax +44 (0)117 930 1178
Rates per single column cm: Mono £32, Single colour £36, Full colour £38. Please contact us for more information on publication dates and deadlines.

What's the big attraction?
cryogenics, superconductivity and electro-magnetics
£excellent + benefits, Oxford

With a proven ability to interpret customer needs and translate them into innovative, world-class technology, Oxford Instruments is an established and respected business. With a full order book, we're also one with immediate and long-term potential. Join us now, and you could soon be sharing all the benefits: the opportunity to contribute as an individual, and in teams. To work with state-of-the-art technology on front-edge products (and at both component level, or on complete turn-key equipment). Benefit from a culture where continuous improvement refers as much to people as to products and processes. The job titles outlined here are just a small selection of those on offer. Others exist, in general and specialist areas, management and technical.

Cryogenic Engineers

Working with cryogenic systems (including dilution refrigeration and cryostat structures), you'll be involved in the full life cycle, from concept specification and design through to test and installation. An excellent understanding of cryogenic systems and their manufacture, innovative, with customer facing and PC skills.

For this job specialist knowledge should include thermal analysis, cryogenic design and vacuum technology.

Magnet Design & Mechanical Engineers

Taking a lead in the design of superconducting magnet systems (including coil winding and insulation), you'll be involved from concept and specification through to manufacture and testing, so you'll need extensive experience of mechanical design; to include exposure to composite structures, vacuum technology and/or thermal analysis; or Electro-magnetic analysis to include coil design and finite element analysis. A relevant degree, good customer - facing skills and innovative approach are essential.

For an initial discussion, contact Richard Hall on +44 (0) 208 570 5327 or write to him at TMP Worldwide, 3rd Floor, 6 Lampton Road, Hounslow, Middlesex TW3 1JL, UK. Ideally Email your CV to: rhall@tmpw.co.uk

OXFORD INSTRUMENTS

CASE WESTERN RESERVE UNIVERSITY

RESEARCH ASSOCIATE in EXPERIMENTAL PARTICLE ASTROPHYSICS

The Physics Department at CWRU seeks a Research Associate to join the Cryogenic Dark Matter Search Experiment, CDMS II. This second-generation experiment, now funded for a 6-year period, features cryogenic detectors with unprecedented rejection of background events which will push the frontier in the worldwide effort to detect WIMP dark matter. The Research Associate will take a lead role in detector optimization and characterization at a fully-commissioned laboratory at CWRU, and may work in other areas including detector operations, data analysis, and Monte Carlo simulations. Experience with cryogenic detectors desirable but not essential. A Ph.D. or equivalent is required. Send a CV and 3 letters of recommendation to Prof. Dan Akerib, Department of Physics, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, Ohio 44106-7079, or inquiries to dsa5@po.cwru.edu. Preference will be given to applications received by 31 December 2000 but will be accepted until the position is filled.

CWRU is an Equal Opportunity/Affirmative Action employer. Women and minorities are strongly encouraged to apply.

FACULTY POSITION IN ACCELERATOR PHYSICS at

MICHIGAN STATE UNIVERSITY

FACULTY POSITION IN ACCELERATOR PHYSICS

Michigan State University is seeking outstanding candidates to fill a tenure-track position in accelerator physics. The successful candidate will hold either a joint academic appointment in the Department of Physics and Astronomy (www.pa.msu.edu) and the National Superconducting Cyclotron Laboratory (NSCL, www.nscl.msu.edu) or a faculty position within the NSCL.

For either position, applicants with strong interests in contributing to the design of a future Rare Isotope Accelerator (RIA) and other accelerator-based projects are preferred. The successful candidate will be expected to provide a significant increase in the scope and depth of the accelerator physics program and to play a leadership role in developing future facility upgrade options. The Department of Physics and Astronomy maintains a Ph.D. program in accelerator physics and in either position, a successful candidate will have the opportunity to participate in the mentoring of graduate students and in the graduate accelerator physics curriculum. (In a joint academic appointment, a successful candidate will also be expected to actively participate in the academic programs of the Department of Physics and Astronomy.)

The NSCL has the tradition of close interaction between groups providing an ideal mix of a cutting-edge technical infrastructure and an intellectually stimulating open academic environment. The Laboratory is currently completing a major facility upgrade that will increase the intensity of rare isotope beams by about three orders of magnitude and make it the premier rare isotope beam facility in the U.S. for the next decade. The accelerator physics group is comprised of 3 tenured faculty and 7 professional scientific staff in the NSCL. Accelerator physics R&D has strong infrastructure support from experienced design and manufacturing groups. A new program of R&D in superconducting rf technology has been initiated with the requisite facilities now under construction.

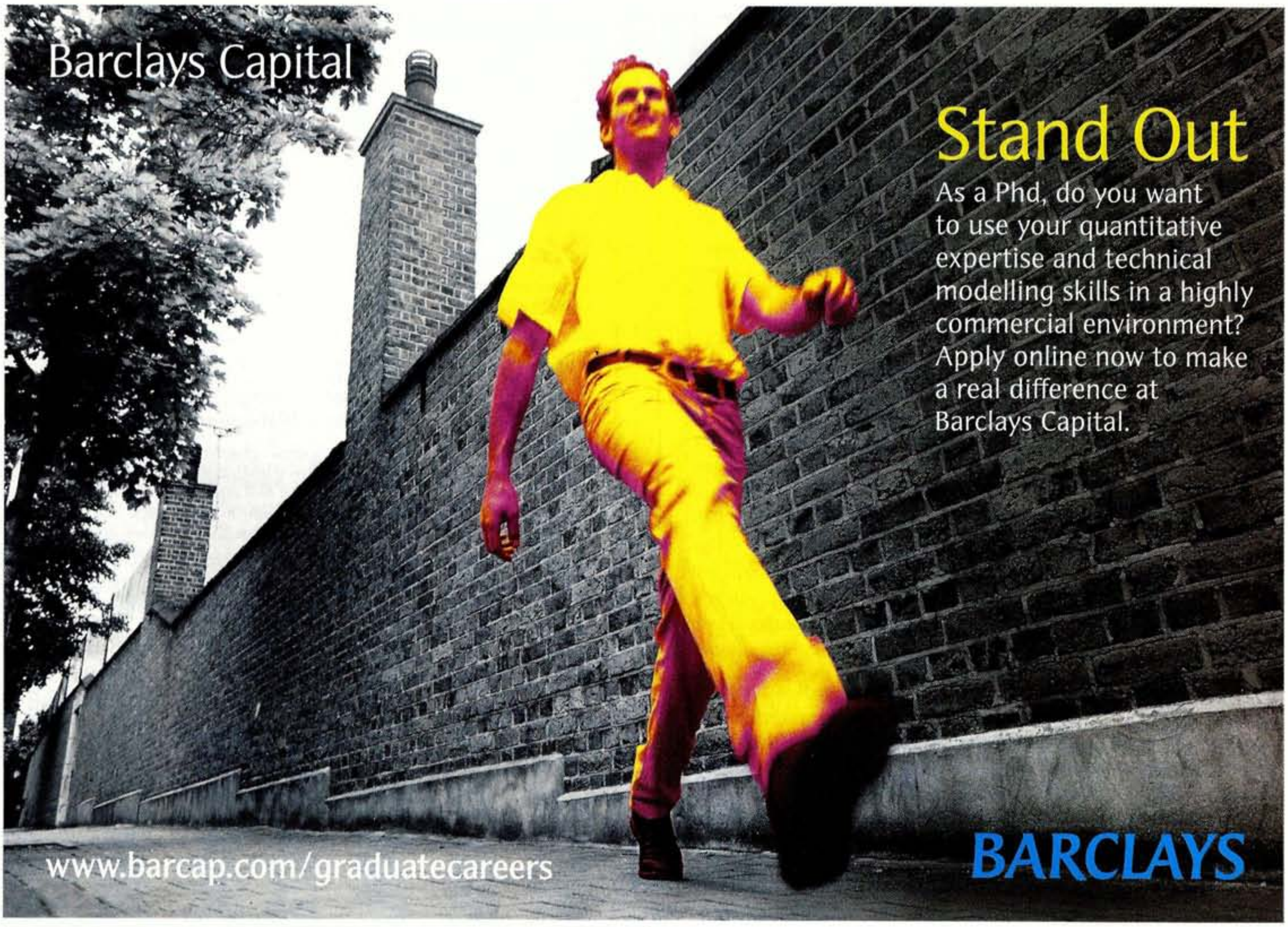
Depending upon the qualifications of the successful applicant, the position can be filled at the assistant, associate, or full professor level. Applicants please send a resume, including a list of publications, and the names and addresses of at least three references to

Prof. Raymond Brock, Chairman, Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824-1116, or to Professor Konrad Gelbke, Director, National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824-13421.

NSCL MSU

Women and minorities are especially encouraged to apply.

MSU is an equal opportunity/ affirmative action institution.



Mechanical Engineering Section Head

National Synchrotron Light Source (NSLS)

Brookhaven National Laboratory's National Synchrotron Light Source Department has an opening for a Mechanical Engineering – Section Head.

Position will report directly to the Chairman of the National Synchrotron Light Source (NSLS) Department, and be a member of the NSLS Management Group. Will be responsible for the management of a 35-person group consisting of mechanical engineers, designers and technicians. The Mechanical Section works with scientists to create from concept through installation, new mechanical and electromechanical devices for electron accelerators, storage rings and experimental beamlines. These designs involve disciplines such as UHV, precision optics, LASERS, high precision mechanical measurement and control, and high electromagnetic fields. Analytical design techniques, such as FEA and thermal analysis are routinely used. Responsibilities will also include maintenance of the research machines and their utility systems. The Section Head will exercise management responsibilities over multiple projects including planning, interpreting and coordinating assigned work; providing technical direction and guidance to staff; evaluating and assessing project results. Candidates should have a MS or PhD in Mechanical Engineering or allied discipline and a minimum of 15 years experience. Should possess a high degree of leadership abilities, communication skills, and knowledge of ESH&Q. Experience in scientific research/user facilities is highly desirable.

Brookhaven offers a stimulating work environment and a comprehensive benefits package. For consideration, please forward your resume, referring to Position # NS 8629, to: Nancy L. Sobrito, Brookhaven National Laboratory, Bldg. 185-HR, P.O. Box 5000, Upton, NY 11973; or fax: 631-344-2871; e-mail: Sobrito@bnl.gov. We are an equal opportunity employer.

BROOKHAVEN NATIONAL LABORATORY

www.bnl.gov

Assistant/associate professor (ud/uhd) F/M in Experimental Physics at the Nuclear Physics Accelerator Institute (KVI)

We offer

- The possibility to perform top research in nuclear and atomic physics at an institute that is recognized by the EU as a 'Large Scale Facility'.
- The availability of advanced research facilities such as the superconducting cyclotron AGOR, a wide range of large detection equipment and sources for highly charged ions and polarised protons and deuterons.
- Participation in a new research line regarding radioactive decay of trapped atoms.
- High-quality technical support.
- Appointment and salary with good terms of employment will be on level of either assistant or associate professor depending on experience.

We are looking for

An enthusiastic scientist of international stature, preferably with expert knowledge in application of trapped and cooled atoms or ions for studies of fundamental physics, in particular in the weak interaction.

Information

More detailed information can be obtained from the Chairman of the selection committee, Prof. dr. M.N. Harakeh, director KVI, phone (+31)-50-3633554, email: M.N.Harakeh@KVI.NL (see also: http://www.kvi.nl/triμp)

Those who would like to draw attention to qualified candidates are requested to contact the chairman of the selection committee, Prof. dr. M.N. Harakeh.

Application

Please send your application addressed to Prof. dr. M.N. Harakeh, together with three letters of reference to the following address before November 1 to **Mrs. A.M. van der Woude, Personnel Officer, KVI, Zernikelaan 25, 9747 AA Groningen, The Netherlands.**

KVI
RIJKSUNIVERSITEIT GRONINGEN

PHYSICIST STAFF SCIENTIST IN SUPERNOVA COSMOLOGY PROGRAM
LAWRENCE BERKELEY NATIONAL LABORATORY

The Lawrence Berkeley National Laboratory invites applications for the position of Physicist Staff Scientist in the Supernova Cosmology Program. This will be a term appointment or, for very well-qualified candidates, a career appointment (Job# Ph012546).

The Supernova Cosmology Research Group is measuring the cosmological parameters using both low- and high-redshift supernovae found in systematic searches at large optical telescopes. It is also involved in the preparation of a satellite-based program of supernova studies known as the SuperNova/Acceleration Probe (SNAP) that should provide opportunity for a wide range of investigations on cosmological parameters and properties. For more details, visit http://supernova.lbl.gov and http://snap.lbl.gov. The appointee will be expected to lead the low-redshift supernovae search, carrying it through from the instrumentation design and building phase to data collection/analysis and publication. He/she will also help lead the ongoing high-redshift supernovae project and will help to develop the science specifications for SNAP. The candidate should have at least two years experience in astrophysical or astronomical observation and data analysis from such observation. Experience with astrophysical instrumentation is desirable. PhD or equivalent experience is required.

Applicants should send a resume, publications list, and the names of three references to Lawrence Berkeley National Laboratory, MS 50-4037, 1 Cyclotron Road, Berkeley CA 94720 or email to: gensciemployment@lbl.gov, referencing job number Ph012546. Berkeley Lab is an AA/EEO employer.

BERKELEY LAB

UPPSALA UNIVERSITET

The Svedberg Laboratory
is a Swedish national research facility with the responsibility to provide resources for accelerator-based research. To serve this purpose the laboratory operates two accelerators, the Gustaf Werner cyclotron and the CELSIUS storage ring. These are controlled through a distributed control system, which consists of UNIX workstations, VME-computers running real-time operating system, PLC-units and micro-controllers. The use of the facility ranges from fundamental sub-atomic physics to applications in medicine and technology. We are now recruiting

a senior research engineer
who will participate in the further development, operation and maintenance of the accelerator control system. Applicants should have a general background as physicists or engineers and have excellent knowledge of C-programming as well as low-level i/o and system-programming. Experience in computer-communication programming is also required. Knowledge of C++, UNIX-administration and relational databases as well as of analog and digital hardware are additional merits.

Since we work with the accelerators together as a group, and have many research groups as users, very good co-operative skills are required.

Information about the laboratory can be found at **http://www.tsl.uu.se**. Further information about the laboratory and the position can be given by Dag Reistad, phone +46-18-471 3177, fax 3833, email **Dag.Reistad@tsl.uu.se**.

The application must reach the Registrar, Uppsala University, Box 256, SE-751 05 Uppsala, Sweden (fax no. +46-18-471 2000) not later than 20 November, 2000. Please mark your application with: UFV-PA 2000/4203.

UCL

UNIVERSITY COLLEGE LONDON

Department of Physics and Astronomy

Research Fellow in Experimental High Energy Particle Physics
(for ATLAS at the LHC)

Applications are invited for the above position, to commence as soon as possible after 1st October 2000.

This position is to work primarily in the area of offline software and physics studies for the ATLAS project at the LHC. We are currently working on the design and implementation of OO physics analysis and reconstruction tools within the context of the new OO framework (Athena/Gaudi), as well as studies of W boson scattering as a probe of Higgs production.

We are looking for a post-doctoral Physicist to join this team. Ideally the candidate will have some OO training and experience, but the most important quality will be the willingness to adopt and apply OO philosophy to physics exploitation at the LHC.

Starting salary will be in the range: UKP £16,775 to £25,213 + £2,134 London Allowance. Informal enquiries can be made to Peter Clarke [clarke@hep.ucl.ac.uk] or Peter Sherwood [peter.sherwood@cern.ch].

Applications, accompanied by a full CV, including a statement of research interests, a publications list, and the names and email addresses of three referees, should be sent to: clarke@hep.ucl.ac.uk

Closing date: **Saturday, 28th October 2000** (although applications after this date may be considered).

[Note to comply with the Data Protection Act: Applications will be processed using a computer data base. Applicants must give their consent to this procedure in their email submission.]

Working toward Equal Opportunity

SCIENTIST

The Main Injector Oscillation Search (MINOS) Department in the Fermilab Particle Physics Division has an opening for a scientist to take a leadership role in construction and physics analysis of the experiment. Strong participation in the detector or beam line construction will provide the successful candidate with an opportunity to optimize the experimental conditions and will provide the understanding of hardware systematics essential to the analysis. This scientist will develop tools necessary to properly analyze neutrino interactions in the MINOS detectors. MINOS is expected to begin data taking in late 2003. The position is for a tenure track Associate Scientist or a tenured Scientist I, depending on qualifications and experience.

A Ph.D. in experimental particle physics. Experience in analyzing complex data sets. Demonstrated ability to lead in the construction or analysis of an HEP experiment. Experience in neutrino physics is not required but is a plus. For consideration as a Scientist I, a candidate should have previous experience at the Associate Scientist (or Assistant Professor) level and must have demonstrated outstanding ability to lead construction and/or analysis efforts.

Applications should be received by November 1, 2000. Applications including a curriculum vitae, a statement of interest, and a list of three references should be sent to:

Fermilab

MINOS Scientist Appointment Search Committee
Attn: Dr. Aesook Byon-Wagner, MS220
Fermilab, P.O.Box 500
Batavia, Il 60510.
E-mail: byon@fnal.gov

EOE

Laboratori Nazionali di Frascati dell'INFN
European Community - Access to Research
Infrastructures action of the Improving Potential Programme

2nd Call for Proposals

The Laboratori Nazionali di Frascati (LNF) of Istituto Nazionale di Fisica Nucleare (INFN), Italy, have been recognized by the European Union as a Major Research Infrastructure, for the period 1 March 2000 - 28 February 2003 (Contract No. HPRI-CT-1999-00088). This Contract offers the opportunity for European research groups, performing or planning a research activity at LNF, to APPLY FOR E. U. FUNDED ACCESS TO THE LNF to cover subsistence and travel expenses.

The only eligible research teams (made of one or more researchers) are those that conduct their research activity in the E.U. Member States, other than Italy, or in the Associated States.

Proposals must be submitted in writing using the Application Forms that can be downloaded from our website. They must describe the research project that the group wishes to carry out at the LNF, including the number of researchers involved, the duration of the project and the research facility of interest. Submitted proposals will be evaluated on the basis of scientific merit and interest for the European Community by a Users Selection Panel of international experts. The results will be communicated to the Group Leaders. Applications must be sent by November 14th, 2000, to:

LNF Director, TARI
INFN, Laboratori Nazionali di Frascati
Via E. Fermi, 40
I-00044, FRASCATI
Fax. ++39-06-9403-2582

More information can be obtained visiting our website at **http://www.lnf.infn.it/cee/**, or from the TARI secretariat, e-mail: tari@lnf.infn.it, fax: ++39-06-9403-2582.

Carl Zeiss Lithos GmbH

Carl Zeiss Lithos is a recently founded startup of **Carl Zeiss's semiconductor technology**, specializing in the development, prototyping and volume manufacturing of electron optical systems for *Electron Projection Lithography (EPL)* - one of the most promising candidates for *Next Generation Lithography (NGL)* to be deployed in the fabrication of next decade's semiconductor chips. We are offering positions for

Electron Optics Designers

who will work on developing new designs of electron optical column modules for our *Electron Projection Lithography (EPL)* systems. Applicants must possess a Ph.D. in a relevant discipline and have significant know-how and experience in designing charged-particle optical devices such as electron imaging systems or beam forming systems for accelerators. Successful candidates will be highly motivated, with excellent knowledge in theoretical and experimental electron optics, including aberration theory and numerical techniques for field calculations.

Carl Zeiss Lithos offers a position with excellent prospects and the opportunity to work at the front line of semiconductor technology within a multidisciplinary environment of an international research consortium.

Applications should be submitted to: Carl Zeiss Lithos GmbH, Ulrich Thalhofer, Halbleitertechnik, Servicebereich Personalwesen, D-73446 Oberkochen, phone (+49) (0)7364 / 20-3573, thalhofer@zeiss.de
For further information please contact: Dr. Dirk Stenkamp, stenkamp@zeiss.de, fax: +49 (7364) 20-3364

GSI Darmstadt

the National Laboratory for Heavy-Ion Research, a member institute of the Helmholtz-Society of German Research Centers, offers

Postdoctoral Positions in Accelerator Physics
Ref. 3000-00.39

Pos. 1: Development of the Unilac
For the operation with high intensity beams theoretical and experimental investigations are to be performed at the heavy ion linear accelerator/synchrotron injector Unilac.
Experience on the fields of ion optics, particle dynamics and with the relevant computer codes would be appreciated.

Pos. 2: Ion source development
For the Unilac three injectors are used with different ion source types for high charge state ions and high current ion beams respectively (ECR-, MUCCIS- MEVVA-ion sources). The task is to further develop these ion sources for different elements, higher beam intensities and improved long term performance.
Experience on the fields of ion sources or plasma physics are expected.

Pos. 3/4: Research and development for pulsed superconducting magnets for a synchrotron
GSI investigates the possibilities to increase beam intensities and energies by an additional larger synchrotron with fast ramped superconducting magnets. For the development, construction and investigation of model- and prototype-magnets two postdoctoral positions are open.
Experience on at least one of the following fields is desired: superconductivity, low temperature physics, cryo-technology or magnet design.

Pos. 5: Studies for and design of UHV-systems
Acceleration of intense ion beams with low charge states in a synchrotron requires extremely low residual gas pressures and extremeley clean surfaces in order to avoid charge exchange losses and instabilities. For a new synchrotron residual gas pressures in the range of 10-12 mbar are necessary for routine operation. Studies on test sections and investigations with prototypes for synchrotron components have to be performed as well as conceptual and design work for the complete synchrotron vacuum system. Experience on the field of UHV-technology or surface physics is required.

Pos. 6: Developments for fast stochastic ion cooling
For the optimum exploitation of fragment ion or antiproton beams a collector-/storage ring facility is considered. The task of the collector ring is the fast pre-cooling of "hot" secondary beams. For this purpose broadband rf-cooling devices shall be developped.

GSI especially encourages women to apply. Handicapped applicants will be given preference in case of equal qualification. Applicants should not be older than 32 years.

The positions have a term of three years with a possible two-year extension and are available immediately. Qualified candidates have perspectives for permanent positions.

Applicants are requested to send a list of publications, curriculum vitae, and the names of three references not later than October 27, 2000, (quoting the appropriate reference and position) to:

GESELLSCHAFT FÜR SCHWERIONENFORSCHUNG MBH
PERSONALABTEILUNG
POSTFACH 11 05 52
D-64220 DARMSTADT

SENIOR FACULTY POSITION IN EXPERIMENTAL PARTICLE PHYSICS

The Department of Physics at the University of Alberta invites applications for a new senior position in experimental particle physics with starting date on or after July 1, 2001. The successful candidate will be appointed with tenure at either the associate or full professor rank depending on qualifications and experience. We are interested in candidates who have an excellent record of leadership and achievement in research and who will complement our existing program. These qualities plus ability and interest in teaching at graduate and undergraduate levels will constitute the important selection criteria.

The current program of experimental research includes:
Collider Physics: The OPAL and ATLAS experiments at CERN.
Fixed Target Experiments: The HERMES experiment at DESY; Rare Kaon Decays (exp. 787 AND E949 at Brookhaven); Tests of Weak Interaction in Muon Decay (exp. 614 at TRIUMF); ISAC Radioactive isotope beam Physics at TRIUMF and Charge Symmetry Breaking (exp. 704 at TRIUMF).
Astroparticle Physics: Alberta Large area Time correlation Array (ALTA) and the STACEE gamma ray experiment.

Potential candidates may find additional information about the research program at **csr.phys.ualberta.ca.**

Applicants should send a curriculum vitae and names of at least three referees who are willing to provide confidential assessments by January 1, 2001 to:

Experimental Particle Physics Search and Selection Committee
Dr. J. Samson, Chair
University of Alberta
412 Avadh Bhatia Physics Laboratory
Edmonton, Alberta, T6G 2J1, Canada
Fax: (780) 492-0714
Email: dept@phys.ualberta.ca

The records arising from this competition will be managed in accordance with provisions of the Alberta Freedom of Information and Protection of Privacy Act (FOIPP).

The University of Alberta hires on the basis of merit. We are committed to the principle of equity of employment. We welcome diversity and encourage applications from all qualified women and men, including persons with disabilities, members of visible minorities, and Aboriginal persons.

RESEARCH POSITIONS IN EXPERIMENTAL HIGH ENERGY PHYSICS

NORTHERN ILLINOIS UNIVERSITY

The Department of Physics at Northern Illinois University has openings for one or more staff scientists or research associates in experimental high energy physics. The primary focus of these positions will be accelerator R&D as part of the Illinois Consortium for Accelerator Research. Currently we are studying muon-beam cooling, a key new technology for a muon collider or neutrino factory, and anticipate expanding our effort into instrumentation R&D. Candidates are required to have a Ph.D. in physics or a related field, or a degree in engineering with significant electronics experience in particle physics applications. The NIU group is also involved in the D0 experiment at the Fermilab Collider, which is undergoing a major upgrade prior to data-taking in 2001. These positions will allow limited participation in D0. Applications, including curriculum vitae and the names of three references, should be sent to Professor David Hedin, Department of Physics, Northern Illinois University, DeKalb, IL 60115 (hedin@niu.edu).

Deadline: Preference will be given to complete applications received by November 1, 2000 and will be continued until the positions are filled.

Northern Illinois University is an equal opportunity/affirmative action employer.

Wilson — Fellowship —

Robert R. Wilson Fellows Program – The Wilson Fellowship program at Fermilab – supports particle physicists early in their careers by providing unique opportunities for self-directed research in experimental particle 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 area 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 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 November 30, 2000.

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

Fermilab

Patricia L. McBride
Chairman, Wilson Fellows Committee
Fermi National Accelerator Laboratory, MS 234
P.O. Box 500
Batavia, IL 60510-0500
email: mcbride@fnal.gov

Fermilab is an Equal Opportunity/Affirmative Action Employer

Thomas Jefferson National Accelerator Facility

JEFFERSON LAB POST DOCTORAL POSITION

POSITION NO: PT2126

Thomas Jefferson National Accelerator Facility is a DOE-sponsored laboratory operated by the Southeastern Universities Research Association. Jefferson Lab's primary mission is to study strongly interacting matter with multi-GeV electromagnetic probes. The experimental program includes both high energy nuclear physics and low energy particle physics. The laboratory routinely operates up to 5.5 GeV beam energy.

Jefferson Lab invites applications for a post doctoral research position in the Hall A group. The base Hall A equipment consists of two identical high-resolution magnetic spectrometers, high power 1,2H and 3,4He cryogenic targets, and an optically pumped polarized 3He target. Operating since early 1997, the Hall A publication and Ph.D. production streams are well established. The experimental program for the next few years includes a further measurement of the proton electric form factor, inclusive measurements of the neutron spin structure functions and a coincidence measurement of proton knockout from 4He. The expected installation of a pair of septum magnets will permit a study of hypernuclear spectroscopy and three parity-violation experiments. The successful candidate will play a role in the preparation, data taking, and analysis for these experiments, and assist in the design of future experiments. Leadership roles in already approved and scheduled experiments are possible by mutual agreement with experiment spokespersons.

A Ph.D. in Experimental Nuclear or Particle Physics or High-Energy Astrophysics is required. Experience analyzing data from intermediate/high-energy experiments is essential, and a background in lepton-nucleus physics would be a plus. The appointment will initially be made for one year and is renewable. Applicants should send a curriculum vitae, copies of any recent (un)published work, and arrange to have letters from three references sent to: Employment Manager, Mail Stop 28A, TJNAF, 12000 Jefferson Avenue, Newport News, VA 23606. Jefferson Lab is an Affirmative Action/Equal Opportunity Employer.

Universität Heidelberg Physikalisches Institut

Postdoctoral Position

Applications are invited for a position as postdoctoral research associate in the relativistic heavy ion group.

Candidates should have a doctoral degree in experimental nuclear or particle physics. Experience with detectors would be very welcome but is not a condition. The appointment is associated with data analysis of the NA45/CERES experiment and preparation for the LHC experiment ALICE. There the Heidelberg group is involved in the design and construction of the Time Projection Chamber and the Transition Radiation Detector as well as in general physics aspects of the experiment with specific emphasis on the physics of electron pairs.

More information can be found at
http://ceres6.physi.uni-heidelberg.de/physi/ceres.html

FOM

NETHERLANDS' FOUNDATION FOR FUNDAMENTAL RESEARCH ON MATTER (FOM)

DIRECTOR OF THE NATIONAL INSTITUTE - NIKHEF

NIKHEF is a joint venture of FOM with 4 Dutch universities. It is an institute for subatomic physics and as such co-ordinates all experimental high energy nuclear and particle physics in the Netherlands. The director of the FOM institute NIKHEF is also director of the NIKHEF collaboration between FOM and these 4 universities. This position will become vacant on 1 July 2001.

FOM is seeking applications/nominations for this important post.

The FOM institute is one of the three scientific institutes of FOM and as such is the foremost Dutch institute for subatomic physics. The director of the institute plays a critical dual role; in guiding and directing the scientific, technical and administrative functions of the laboratory, and also in co-ordinating the national subatomic physics programme and the Dutch input in the international programmes in this area. As such this appointment is viewed as a challenging and crucial in the Netherlands.

The director's main task will be to develop and guide the scientific policy for the high energy, nuclear and particle physics programme in the Netherlands. The director will also have considerable responsibility for obtaining funding for the institute.

Candidates should be established physicists of high international repute with both scientific vision and managerial skills. Ideally they should have experience in both the Dutch and international arenas with the ability to inspire and lead a world class laboratory.

The successful candidate will be offered a permanent appointment by FOM. However, the initial appointment as director of the FOM-institute will be for a period of 5 years with the possibility of re-appointment for a further period of 5 years. The appointment is at full professorial level.

The terms of employment of the foundation (FOM) are subject to the collective terms of employment (CAO). The employee will become a member of the Foundation State Employees Pension Scheme (ABP).

Further information may be obtained from either Mr. B.J. Geerts, (email geerts@fom.nl) or the chairman of the selectioncommittee Prof. B.de Wit, (email: bdewit@phys.uu.nl)

Nominations and applications, which should include a c.v. and list of publications should be sent to Mr B.J. Geerts, Head of the Human Resources Department PO Box 3021 3502 Utrecht The Netherlands. The closing date is 3 November 2000.

RESEARCH FACILITY ACCESS

EUROPEAN RESEARCH INFRASTRUCTURE BERGEN COMPUTATIONAL PHYSICS LABORATORY

Bergen Computational Physics Laboratory (BCPL) is a Research Infrastructure at the University of Bergen, Norway, with a scientific staff working on modeling of subatomic, atomic and molecular reactions, using supercomputing facilities, including a 52 GigaFlop, 128 processor, CRAY Origin 2000 as its present top facility.

BCPL offers access to researchers or research teams from the EU and its Associated States in order to solve computational physics problems in the above mentioned fields. Short stays (approx. 2-4 weeks) for established researchers are supported by the EC in the framework of the Access to Research Infrastructure activity of the Improving Human Potential program.

Contact: Prof. L.P. Csernai, BCPL, University of Bergen, Allegt. 55, 5007 Bergen, Norway
e-mail: bcpl@fi.uib.no, URL: **http://www.fi.uib.no/~bcpl/**

Faculty Position
Department of Physics
University of California, Davis

The Department of Physics at the University of California at Davis invites applications for a faculty position in observational or theoretical cosmology. This position has a targeted start date of July 1, 2001, which is negotiable. The appointment will be at the tenure-track Assistant or tenured Associate Professor level as determined by qualifications and experience.

This position is the third of four new positions created for our cosmology program. The current cosmology group consists of Professors Andreas Albrecht, Lloyd Knox, and Robert Becker. The cosmology program benefits from full access to Lick and Keck observatories and from overlapping interests with our strong departmental programs in condensed matter, nuclear physics, quantum gravity, and especially with our particle physics program. Outstanding persons in all areas of cosmology will be considered.

The successful candidate will have a Ph.D. in physics or astrophysics and will be expected to teach at the undergraduate and graduate levels and to conduct an active research program in cosmology.

This position is open until filled; but to assure full consideration, applications should be received by November 10, 2000. To initiate the application process, request an application package by writing an e-mail message to **forms@physics.ucdavis.edu**. Those who do not have access to e-mail should send curriculum vitae, publication list, research statement, and the names (including address, e-mail, fax, and phone number) of three or more references to:

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

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

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

Physics Faculty and Postdoctoral Positions

The C. N. Yang Institute for Theoretical Physics at the University at Stony Brook seeks candidates for postdoctoral positions and continues to seek candidates for tenure-track faculty and tenured faculty with anticipated appointment date 1 September 2001. Research fields at the institute include, but are not limited to, gauge field theory, elementary particle theory, statistical mechanics, supersymmetry and superstrings.

For application instructions please see: (http://www.physics.sunysb.edu/ltp/jobs). If your computer manager cannot provide web access, there is a slower alternative-please email for instructions by auto-reply: (jobforms@insti.physics.sunysb.edu). If you cannot connect electronically, please write to: CNYITP Search, University at Stony Brook, Stony Brook, NY 11794-3840.

Review of applications will resume this fall and continue until the positions are filled.

Applications from women, people of color, disabled persons, and veterans are espeially welcome. AA/EOE

STONY BROOK
STATE UNIVERSITY OF NEW YORK

TENURE TRACK POSITION IN THEORETICAL PHYSICS

Department of Physics and Astronomy
University of Victoria

The Department of Physics and Astronomy at the University of Victoria invites applications for a tenure-track position at the rank of Assistant Professor in the area of theoretical particle physics or theoretical particle astrophysics. Applicants are expected to possess an exceptionally strong and internationally recognized research record and outstanding promise for future research accomplishments. The successful candidate will have a commitment to graduate and undergraduate education.

The Department of Physics and Astronomy consists of approximately 17 faculty members working primarily in the research areas of particle physics, astronomy/astrophysics and ocean physics. The department has a successful and productive association with the near-by TRIUMF laboratory. The particle physics group has an ongoing participation in the OPAL and ATLAS experiments at CERN and the BaBar experiment at SLAC. The astronomy group benefits from close relations with the nearby Herzberg Institute of Astrophysics and its staff, telescopes and instrumentation, and also has access to facilities such as the Canada-France-Hawaii and the James Clerk Maxwell telescopes and the Gemini telescopes. See **http://www.phys.uvic.ca** for further information.

The University of Victoria is an equity employer and encourages applications from women, persons with disabilities, visible minorities, and aboriginal peoples. In accordance with Canadian immigration requirements, this advertisement is directed to Canadian Citizens and permanent residents. Others are encouraged to apply, but are not eligible for appointment unless a search among qualified Canadian applicants proves unsuccessful.

Applications, including a curriculum vitae, publication list, statement of present and future research interests, and the names and addresses of at least three referees, should be sent to: **Charles Picciotto, Chair, Department of Physics and Astronomy, University of Victoria, P.O. Box 3055 Stn Csc, Victoria, BC V8W 3P6, Canada**

Applications will be accepted until 31 December 2000, with an intended starting date of 1 July 2001.

POSTDOCTORAL POSITION FOR A PHYSICIST INTERESTED IN BRAIN RESEARCH

The PET (Positron Emission Tomography) group at the Max-Planck-Institut for Neurological Research, Cologne has an opening for a recent PhD in physics to work with the new High Resolution Research Tomograph (see CERN COURIER May 2000 page 23/24). The new tomograph is a newly developed PET system (Siemens/CTI), which is currently optimized for clinical application.

The applicant should preferentially have a background in nuclear or particle physics with programming experience.

For further information contact:

Prof. Klaus Wienhard
email: klaus.wienhard@pet.mpin-koeln.mpg.de
phone: +49-(0)221-478-6056

The application of qualified women is welcomed. Handicapped applicants will be given preference to other applicants with the same qualifications. Candidates are invited to send their application including a curriculum vitae and two letters of recomendation to

PET group, Max-Planck-Institut fuer neurologische, Forschung, Gleuelerstrasse 50, D-50931 Koeln, Germany

MIT

POSTDOCTORAL ASSOCIATE/ STAFF PHYSICIST

The MIT-Bates Linear Accelerator Center invites applicants for an immediate opening for a postdoctoral/staff physicist position. The position is in the Physics Division, which consists of two main groups: the Polarized Injector Group and the Research Support Group (RSG). The successful candidate's primary responsibilities will include operation of the polarized source and research and development to optimize the polarized source for delivering high quality polarized beams to the Bates South Hall Ring (SHR). The SHR is a 1 GeV storage and pulse stretcher electron ring for medium energy nuclear physics. Tasks include photocathode UHV work, operation of high power gas and solid state lasers, beam optics simulation, and Compton beam polarimetery in the SHR. A newly constructed 60 keV test beam setup with a Mott polarimeter is the benchmark for all photocathode developments at Bates. The group must deliver high quality polarized beam to the third phase of the SAMPLE experiment. Will also take a major role in the activities of the Laboratory on beam polarization and manipulation in the ring using a Siberian Snake, spin flipper and the polarized source.

As a member of the Physics Division, the candidate will also assist the RSG group in the construction and commissioning of the BLAST detector. Upon completion, BLAST will be the centerpiece of the Laboratory's physics program, providing a unique world class capability to pursue an internal target physics program using stored polarized electron beams in the SHR.

Requirements: a Ph.D. in experimental nuclear physics or applied physics with experience in any or all of the above areas. Experience in and knowledge of accelerator based photoemission desirable. Bates is located in Middleton, Massachusetts.

Please send a current C.V. and the names of three references to: Mr. Richard Adams, Laboratory for Nuclear Science, MIT, Bldg. 26-516, 77 Massachusetts Ave., Cambridge, Massachusetts, 02139-4307.

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

Texas Tech University

RESEARCH ASSOCIATE POSITION EXPERIMENTAL PARTICLE PHYSICS

The Department of Physics at Texas Tech University (TTU) invites applications for a postdoctoral Reasearch Associate position in experimental particle physics. We are looking for an outstanding physicist who is interested to work with the CDF experiment at Fermilab. The person filling this position will be located at Fermilab and will contribute to the ongoing program of the TTU particle physics group. The group is currently involved in the front-end electronics project for the calorimeters, in online calibration monitoring, in the design and maintenance of the calibration database and in the silicon vertex detector upgrade for CDF. The physics analysis activities of our group are currently focused on B-physics and Electroweak-physics. The TTU group is also involved in the CMS experiment at CERN as well as in generic detector R&D.

This is normally a two-year appointment with the possibility of an extension. Applicants for the position should have a Ph.D. in experimental particle physics. **Please send an application including curriculum vitae and publication list and arrange for three letters of recommendation to be sent to: Prof. Vaia Papadimitriou, Texas Tech University, Physics Department, Box 41051, Lubbock, TX 79409-1051 (VAIA@FNAL.GOV). The vitae and recommendations can be sent either by normal or electronic mail. Inquiries about the position can be sent to VAIA@FNAL.GOV. Applications will be accepted until October 31, 2000 or until the position is filled.**

Texas Tech University is an equal opportunity/affirmative action employer.

PHYSICIST STAFF SCIENTIST IN SNAP PROGRAM

LAWRENCE BERKELEY NATIONAL LABORATORY

The Lawrence Berkeley National Laboratory invites applications for the position of Physicist Staff Scientist in the Supernova/Acceleration Probe (SNAP) Program. This will be a term appointment or, for very well-qualified candidates, a career appointment (Job# Ph012544).

The SNAP Research Group is developing a satellite experiment, with a two-meter optical telescope, to study high-redshift supernovae and thereby measure cosmological parameters. The telescope will utilize a billion-pixel optical imager, a near-IR imager, and a three-arm spectrograph to discover and measure these supernovae. For more details visit http://snap.lbl.gov. The appointee will be expected to play a leadership role in the development and implementation of technologies that are key to the SNAP instrumentation. The candidate should have several years experience in instrumentation systems, data-acquisition systems, and calibration. Experience with silicon vertex detectors, or optical and near-IR imagers is desirable. PhD or equivalent experience is required.

Applicants should send a resume, publications list, and the names of three references to Lawrence Berkeley National Laboratory, MS 50-4037, 1 Cyclotron Road, Berkeley CA 94720 or email to: gensciemployment@lbl.gov, referencing job number Ph012544. Berkeley Lab is an AA/EEO employer.

BERKELEY LAB

UNIVESITÄT DES SAARLANDES

Available positions at the Physics Department, Saarland University

Several positions for PhD-students and one post doc position are available in the scanning probe microscopy and nanostructure research group. The field of research will be in the area of cooperative phenomena in reduced dimensions and of micro/nanoscale structuring of surfaces by means of modern lithographic techniques. A number of scanning probe microscopes, low temperature equipment, thin film deposition techniques, electron beam lithography equipment and a clean room is available for the research in the group's laboratories. The group aims at the completion of doctoral thesis's within less than three years.

The group features a multi-national composition. Fluency in German is no prerequisite for a successful collaboration within the group.

Further information on the group is available at:
http://www.uni-saarland.de/fak7/hartmann/

The salary will be in accordance to the regulations of the Saarland University.

Saarland University plans to increase the number of women in such positions. Qualified women are therefore especially encouraged to apply.

Disabled persons will be hired with some preference.

Please submit applications to:

Saarland University, Prof. Dr. U. Hartmann or Dr. U. Memmert, Experimental Physics, Geb. 22, Postfach 151150, 66041 Saarbruecken, Germany.

INDEX TO DISPLAY ADVERTISERS

FREE LITERATURE

Janis Research Co Inc

Top Loading Liquid He-3 System

Visit us at AVS 2000 Booth 2605. The system has optical access to the sample and includes a sample probe and "vac-lock" with a gate valve, plus an external gas handling system. Typical base temperature is 400 mK with a 24 hour holding time. Contact Janis for more details today!

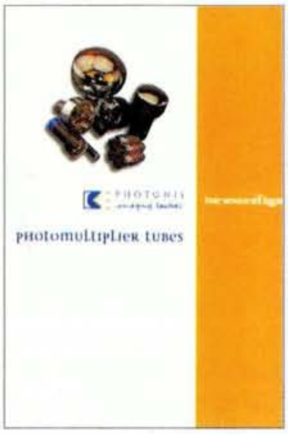
Janis Research Company, Inc
2 Jewel Drive, PO Box 696
Wilmington, MA 01887-0696 USA
Tel. +1 978 657 8750
Fax +1 978 658 0349
Email janis@janis.com
Web http://www.janis.com

Goodfellow

Metals and Materials in small quantities for R&D and prototype development

70 Pure Metals, 200 Alloys, 57 Polymers, 31 Ceramics as well as many Composites and Compounds in 28 forms including foil, rod, tube, wire, powder, etc. The new product guide is now available, detailing standard ex-stock and custom-made items.

Goodfellow Cambridge Ltd, Ermine Business Park, Huntingdon PE29 6WR, UK
Freephone 0800 731 4653
Tel. +44 (0)1480 424800
Fax +44 (0)1480 424900
E-mail info@goodfellow.com
Internet www.goodfellow.com

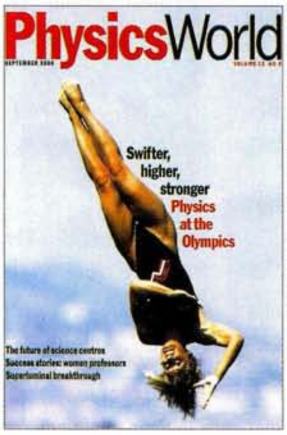


PHOTONIS

New PMT catalogue

The new Photonis catalogue contains a considerably increased range of PMTs for most applications – from nuclear medicine to high-energy physics. We will be pleased to send your free copy. If you do not have our PMT application book (in English), please include your request for a free copy of this useful 300 page book.

Photonis
Tel. +33 555 863700
Fax +33 555 863773
Email g.benoist@photonis.com



PHYSICS WORLD

Physics World – the international voice of physics – is enjoyed monthly by 50 000 research scientists. Join them by subscribing today for two years and receive a 20% discount. Your *Physics World* subscription will include FREE ON-LINE ACCESS to *PhysicsWeb* at "http://www.physicsweb.org".

For further details, please contact our marketing department at:

Tel. +44 (0)117 929 7481
Fax +44 (0)117 930 1178
Email pwld@ioppublishing.co.uk

PEOPLE

LETTERS

There's a (minor) misstatement in Pedro Ferreira's review of the book *Quintessence, the Mystery of the Missing Mass in the Universe* by Lawrence Krauss (June p51). Ferreira says: "he relates the story of the 'Cabrera Monopole', which was never properly explained away". I think it's generally agreed by everybody who has worked with superconducting loop detectors that this was almost certainly a flux jump in the loop. Subsequent experiments (for example J Incandela, M Campbell *et al.* 1984 Flux limit on cosmic-ray magnetic monopoles from a large area induction detector *Phys. Rev. Lett.* **53** 2067, which was the first to put a limit much below Cabrera's, and the first with coincidence detectors) saw similar jumps, but by monitoring coincidence could rule them out as monopoles.

Henry J Frisch, Enrico Fermi Institute, Chicago.

A group of UK science teachers attending a summer workshop at Brunel University made a side trip to CERN, where their host was CERN physicist **Alison Wright** (right). Alison also edits *CERN Courier*'s regular Physicswatch section.

AWARDS

This year's prestigious Dirac medal, awarded by the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, goes to **Howard Georgi** of Harvard, **Jogesh Pati** of Maryland and **Helen Quinn** of SLAC, Stanford, for their "pioneering contributions to the quest for a unified theory of quarks and leptons and the strong, weak and electromagnetic interactions." The early 1970s saw a series of landmark papers on candidate unified theories. Pati and Abdus Salam, working at ICTP, proposed the first scheme to group together quarks and leptons, leading to the awareness that proton decay is possible. Georgi (with Sheldon Glashow) proposed the archetypal SU(5) unification scheme before going on to investigate further possibilities. Georgi and Quinn, collaborating with Steven Weinberg, showed how the strong and electroweak couplings could vary with energy and where such a unification could occur. This is the first time that the medal has gone to a female physicist. The ICTP Dirac medal is awarded in recognition of outstanding contributions to physics and mathematics, but Nobel or Wolf prizewinners are not eligible.

James W Cronin has been awarded the Medal 2000 of the Division of Particles and Fields of the Mexican Physical Society for his contribution to the development of particle physics and astrophysics in Mexico. As a leader of the Auger experiment he supported Mexican involvement. Mexico is now playing an important role in the collaboration. It is the second time that the medal has been awarded. The first was to Leon Lederman last year.

Tel Aviv University's Sackler prize in Physical Sciences went to **Juan Maldacena** of Harvard and **Michael Douglas** of Rutgers for their work in string theory.

CERN–Asia Fellows and Associates programme offers grants

Within the framework of the CERN–Asia Fellows and Associates programme, CERN offers three grants every year to young East, South-east and South Asian* 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 30 January 2001. Applications must consist of a completed application form, on which should be written "CERN–Asia Programme"; three separate reference letters; and a curriculum vitae including a list of scientific publications and any other information about the quality of the candidate. Applications, references and any other information must be provided in English only.

Application forms can be obtained from the Recruitment Office, CERN, Human Resources Division, 1211 Geneva 23, Switzerland; e-mail "Recruitment.Service@cern.ch"; fax +41 22 767 2750. Applications should reach the office before 8 November 2000.

The CERN–Asia Fellows and Associates programme also offers a few short-term associateship positions to scientists under the age of 40 who wish to spend part of the year at CERN or a Japanese laboratory and who are on "leave of absence" from their institute. Applications are accepted from scientists who are nationals of the East, South-east and South Asian* countries and from CERN personnel who are nationals of a CERN member state.

*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.

Beauty's soliloquy

To be, or anti-be: that is the question:
Whether 'tis nobler in theory to suffer
The violation of charge conjugation,
Or to reflect against a sea of parity,
And by opposing violate it? To C, to P;
No more; and by CP to say we end
The heartache and the thousand natural shocks
That matter is heir to – 'tis a transformation
Devoutly to be wish'd.
To C, to P;
To CP: perchance to dream: ay, there's the rub:
For in CP of theory dreams may come,
What we accelerate through this mortal coil,
Must give us pause: there's the respect
That makes calamity of so short life;
For what would bear the whips and scorns of time,
The detector's friction, the lepton's leak,
The pangs of despised interactions, the hadrons decay,
The insolence of weak force and the spins
That patient merit of the unsymmetric takes,
When the quark might its quietus make
With a bare bodkin? Who would accuracy 1.0066 bear,
To grunt and sweat through a weary beam,
But that the dread of something after colliding,
The undiscover'd vertex from whose bang
No particle returns, puzzles the will
And makes us rather bear those ills we have
Than fly to others that we know not of?
Thus data does make cowards of us all;
And thus the native hue of resolution
Is sicklied o'er with the pale cast of thought,
And enterprises of great pit and momentum
With this regard their currents turn awry,
And lose the name of action.

Nina Paley (with apologies to Will Shakespeare). Nina Paley is a freelance illustrator, animator and cartoonist from San Francisco. She recently created cartoons for CERN's forthcoming educational CD-ROM. Her work can be seen at "http://www.ninapaley.com/".

MEETINGS

The 5th International Linear Collider Workshop (LCWS 2000) will be held on 24–28 October at Fermilab. Contact Cynthia M Sazama, MS 122, Conference Office, Fermilab PO Box 500 Batavia, IL 60510-0500, USA; fax +1 630 840 8589; e-mail "sazama@fnal.gov" or see "http://www-lc.fnal.gov/lcws2000/".

Laureates of the lake

This summer the German island town of Lindau on Lake Constance hosted the 50th annual meeting of Nobel laureates. To mark the occasion, coinciding with the centenary of the Nobel foundation, all natural sciences were included. Lindau meetings are normally dedicated in turn to physics, chemistry or medicine and attended by about 20 prize-winners and several hundred students. This year, 50 prizewinners mingled with 700 young scientists from about 50 countries.

Initiated in 1951 under the presidency of Count Bernadotte to help to reintroduce Germany to international science, these meetings, now presided over by his wife Sonja, have over the years inspired several generations of young scientists. The final day traditionally finds everyone aboard a boat to the island of Mainau, seat of the Bernadottes, for the closing ceremony, which was honoured this year by German federal president Johannes Rau.

Former CERN staff member Simon Newman has been attending the Lindau meetings since 1971, when he remembers Werner Heisenberg being in a tight corner. Although Heisenberg had previously withdrawn his earlier objections to new European accelerator plans, in 1971 at Lindau he had to defend his new position against students opposed to spending on "big science".

Mark Oliphant 1901–2000


Australian physics: Mark Oliphant 1901–2000.

Australian scientist and statesman Mark Oliphant died in Canberra on 14 July, aged 98. Born and educated in Adelaide, he was inspired by a 1925 visit to Australia by New Zealander Ernest Rutherford. In 1927, Oliphant moved to Rutherford's Cavendish Laboratory in Cambridge, then the world focus of nuclear physics research. Here he went on to participate in Cockcroft and Walton's work on particle acceleration, and in the discoveries of isotopes. He eventually became assistant director of research at the Cavendish.

In 1938 Oliphant moved to Birmingham, where he initially pushed the construction of a cyclotron and the department under his direction became a focal point of UK physics. At about the same time, Rudolf Peierls became professor of applied mathematics, and Otto Frisch joined Oliphant. With the advent of the Second World War, Oliphant quickly became a major force in the UK's applied research effort. Following his suggestion, John Randall and Henry Boot at Birmingham developed the cavity magnetron, a key device ("the most valuable cargo ever") that enabled radar equipment to become smaller and more portable.

It was Oliphant who relayed the historic 1940 Frisch–Peierls memorandum (pointing out the possibility of a fission bomb) to higher authority for appropriate action. Increasingly involved in the subsequent UK wartime atomic energy research programme, he eventually transferred to the Manhattan Project, working with Ernest Lawrence on uranium separation. During this time he had the idea of what would eventually become the synchrotron – a machine to accelerate charged particles to higher energies than the classic cyclotron. However, his suggestion could not anticipate the essential discovery of phase stability.

Back in Birmingham after the war, Oliphant completed the Nuffield cyclotron and pushed for an ambitious 1 GeV proton synchrotron, the most powerful particle accelerator outside the US. This was not commissioned until after he returned to Australia in 1950 to become founding director of the research School of Physical Sciences at the Australian National University, Canberra, a post he held until 1963. However, his attempts to put Australia on a "big science" footing did not meet with success. He helped to found the Australian Academy of Science and served as its first president. From 1971 until 1976 he served as governor of South Australia. In his home country he was revered for his accomplishments but had a reputation for outspoken views.

Abraham Pais 1918–2000

Abraham Pais, eminent physicist and meticulous writer, died in Copenhagen on 28 July. The 20th century was characterized by tremendous strife and political upheavals on one hand, and by unprecedented progress in science and technology on the other. Pais influenced the latter and was himself deeply influenced by the former. In his autobiography *A Tale of Two Continents* (1997 Oxford), he concluded: "We do not know where we are going, nor even where we ought to be going."

Pais was born in Amsterdam into a Sephardic Jewish family whose special traditions and roots went back over many centuries. This background remained a force throughout his life. After initial studies in Amsterdam, and with mathematical physics aspirations, he moved to George Uhlenbeck's school in Utrecht. Here he encountered several leading European physicists, including Léon Rosenfeld, and made regular pilgrimages to Leiden for discussions with quantum theory pioneer Hendrik Kramers.

In 1940 the Netherlands were occupied and the German administration imposed 14 July 1941 as the deadline for Jewish students to be able to earn a doctorate. Rosenfeld had asked Pais to cast meson theory in terms of projective relativity. The highly motivated student succeeded with five days to spare. Pais claims that his intense focus on this work isolated him from the calamitous events going on all around. After trying to embark on a

Abraham Pais 1918–2000.

scientific career under impossible circumstances, in 1943 he went into hiding to avoid deportation. Two years later he was arrested, and then released, indirectly because of a plea that Kramers had written to Heisenberg.

Returning to science post-war, Pais soon received offers from Niels Bohr's institute in Copenhagen and from Princeton's Institute for Advanced Study. In 1946 he moved to Copenhagen where he and Christian Møller, working on the decays of newly discovered particles, coined the word "lepton". He also worked with Bohr on contemporary quantum issues.

In 1946 Pais took up a position at Princeton IAS at a time when a wind of change was blowing through quantum field theory. In 1947 he attended the famous Shelter Island conference, which marked the birth of modern quantum electrodynamics.

After continued forays into field theory, the mysteries of the newly discovered particles began to intrigue him. In 1951 he was the one who showed that the new particles (subsequently called "strange") had always to be produced in pairs – a phenomenon that came to be called "associated production". Working with Murray Gell-Mann, who was also intrigued by the plethora of new particles, he looked at their possible classifications. This work led to their suggestion that mixtures of neutral kaon states could have different symmetry properties, and therefore decay in different ways. This set the scene for the subsequent discovery of CP violation. Continuing with neutral kaons, in 1955 Pais, now working with Oreste Piccioni, pointed out the possibility of "regeneration", one of the most bizarre quantum phenomena.

Pais became a naturalized US citizen in 1954. In 1963 he moved to Rockefeller University, New York City, where he immediately became active in attempts to extend the pattern of particle symmetries.

In 1972 a chance invitation to write a review article launched him on an entirely new career as a writer. Benefiting from widespread contacts made during his research career, his subsequent output was prolific: besides numerous contributions to anthologies and festschrifts, it began with the classic 1982 Einstein biography *Subtle is the Lord* (Pais got to know Einstein well at Princeton) and continued with the informative *Inward Bound: of Matter and Forces in the Physical World* (1986); then another classic, *Niels Bohr's Times, in Physics, Philosophy and Polity* (1991); an autobiography, *A Tale of Two Continents: a Physicist's Life in a Turbulent World* (1997); a second Einstein volume, *Einstein Lived Here* (1994); and, most recently, *The Genius of Science: a Portrait Gallery of 20th-Century Physicists* (2000).

Pais received major awards in the US and in the Netherlands for both his physics and his writing.

The left-handed cellist

In his autobiography *A Tale of Two Continents: a Physicist's Life in a Turbulent World* (1997), Abraham Pais writes of how he wrote his 1986 masterpiece *Inward Bound: of Matter and Forces in the Physical World*.

"Selecting pictures for *Inward Bound* caused me some problems. The book deals with so many personalities...which to choose? I simply could not make up my mind...as a result the book has no pictures at all. Except for one on the dust jacket. One day I received my copy of the *CERN Courier*, and saw...the picture I had been vaguely looking for."

This montage of a metal sculpture against a backdrop of bubble chamber tracks by Marcel Stürzinger and Gilbert Cachin marked the 25th anniversary of CERN Concerts in 1984. The photo was published on the cover of that year's November issue of CERN Courier. *Abraham Pais spotted it as a cover/jacket subject of his 1986 masterpiece* Inward Bound: of Matter and Forces in the Physical World. *The image as reproduced for the book was reversed – the cellist appears to be bowing left handed.*

John Thresher 1929–2000

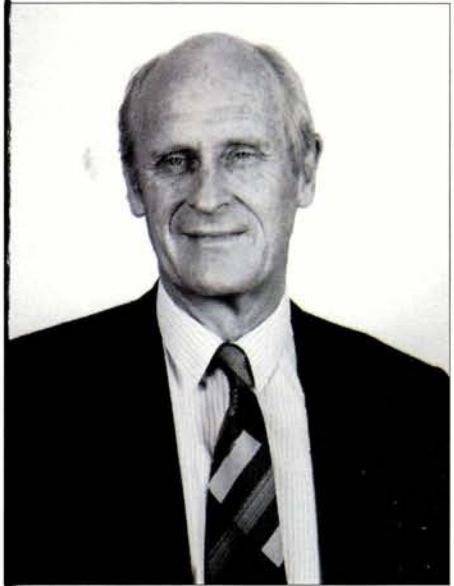
Former CERN research director John Thresher died suddenly on 25 August. South African by birth, he obtained his bachelor's degree in electrical engineering at Cape Town and his DPhil at Oxford in 1956, where he had won a prestigious Rhodes Scholarship. He started his career at the UK Atomic Energy Research Establishment, Harwell, and then spent two years at the Berkeley Bevatron before returning to the UK in 1963, joining what is now the Rutherford Appleton Laboratory (RAL).

At RAL, with Paul Murphy and Phil Duke, Thresher formed a counter group that initiated a series of comprehensive and successful measurements of pion-proton elastic and charge exchange scattering. It was largely for this work that he (together with Paul Murphy) received the Rutherford medal of the Institute of Physics in 1980.

Thresher's association with CERN began in 1968 when he and his group worked on a CP violation experiment at the Proton Synchrotron and later at the SPS on a programme of measurements in the hyperon beam. In 1975 he became head of RAL's High Energy Physics Division and in 1981 associate director for particle physics. This key position involved coordinating all UK particle physics experiments funded and supported through RAL.

From 1986 to 1991, Thresher was CERN director of research with responsibility for the new LEP experimental programme. All of the LEP experiments owe a great debt to him for his tireless support and encouragement both before and after LEP start-up in 1989. He retired in 1992.

Thresher will be remembered by his friends and colleagues worldwide for his drive, dedication, enthusiasm, experimental skill and enormous capacity for work. He delighted in the success of his colleagues, especially the younger ones, and fostered many of their careers. He never lost his sense of wonder at the beautiful world we live in and that he



ohn Thresher 1929–2000.

elped so signally to understand better, both s an active researcher and as a wise and ighly effective administrator. He will be nissed but not forgotten.

eorge Kalmus.

James Hamilton 1918–2000

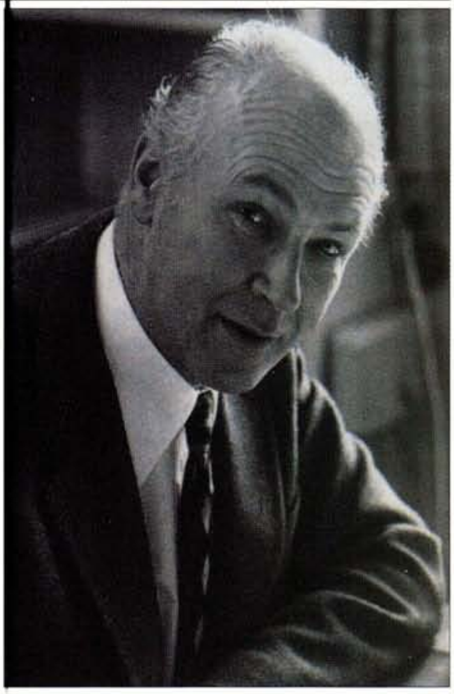
Born in Sligo, Ireland, James Hamilton got his MSc at Queen's University, Belfast, on the eve of the Second World War. He received his PhD from Manchester in 1948 and then became university lecturer in mathematics and fellow of Christ's College, Cambridge (1950–1960). He was professor of physics at University College, London, from 1960 until 1964, before joining the Nordic Institute for Theoretical Physics (NORDITA) in Copenhagen.

As NORDITA professor of elementary particle physics, Hamilton shaped the institute's research in the field during a crucial period and trained a whole generation of young Nordic physicists. During a period before his retirement at the end of 1985, he also served as NORDITA director. He spent an active retirement in Cambridge, continuing with his research and frequently visiting the university.

After early work on problems related to the interaction of radiation with atoms, Hamilton turned to high-energy physics and produced the well known treatise *The Theory of Elementary Particles* (1959 Oxford). His interests centred on S-matrix theory and he had a leading role in the efforts to understand the structure of resonances and scattering amplitudes using unitarity and analyticity. Some of his results are summarized in his book with B Tromborg, *Partial Wave Amplitudes and Resonance Poles* (1972 Oxford).

Hamilton's most important contribution was probably the development of sophisticated techniques for making very precise amplitude analyses of low-energy hadronic interactions, notably of the pion-nucleon interaction. Here, using dispersion relations among other tools, he and his collaborators were able to improve on the art of phase shift analysis, thereby helping to pave the way to a better understanding of reaction mechanisms and crucial concepts such as Finite Energy Sum Rules and Dolen-Horn-Schmidt duality. His insistence on such sophisticated analysis formed a school that he took with him to Scandinavia and NORDITA. He strongly cared for the young Nordic fellows whom he guided.

Hamilton had a life-long interest in mathematical aspects of elementary particle physics and questions related to causality. He continued to work on these questions during his retirement and published the book *Aharonov-Bohm and other Cyclic Phenomena* (1997 Springer) just a few years before his

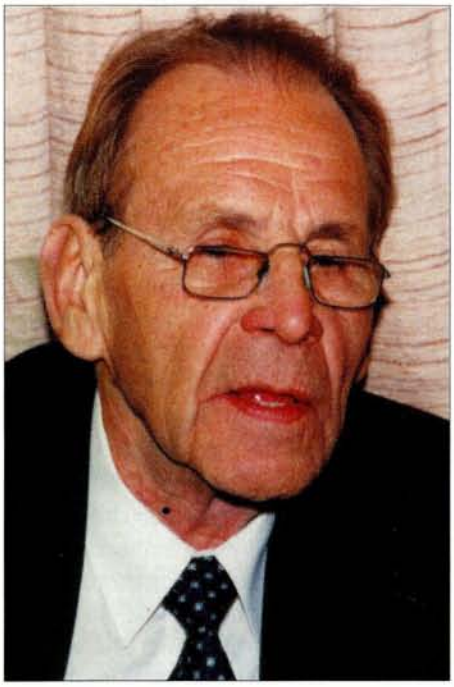


James Hamilton 1918–2000.

death. Hamilton left an important legacy in elementary particle physics. His friendly spirit will be warmly remembered, particularly by his students and colleagues in the Nordic countries and in the UK.

Paul Hoyer, NORDITA, and Jens Lyng Petersen, Niels Bohr Institute.

Wolfgang Koch 1933–2000



Wolfgang Koch 1933–2000.

DESY physicist Wolfgang Koch died suddenly on 26 June at the age of 67. He was best known for his outstanding mastery of spin analysis in hadronic reactions. His lectures at the Herceg Novi Easter School in 1964 and at CERN in spring 1965 are still, more than 35 years later, used by students analysing hadronic final states in experiments at HERA and at LEP. In the DESY library they have updated his article by introducing the new names of particles – the only thing that had to be changed in these decades.

Koch studied physics at the Technische Hochschule in Karlsruhe, where his 1957 diploma thesis was a study of the ferroelectric properties of polycrystalline barium titanate. He then went to Bern to work in the institute of F G Houtermans, where he received his PhD in 1959 and stayed for two more years, studying the interaction of negative K-mesons in photo-emulsions.

Coming to CERN in 1961, he continued his work with kaons, this time with the 1 m heavy liquid bubble chamber. He joined the CERN/MPI-Munich collaboration as a founding member and was offered a senior position at the Max Planck Institute. The work culminated in the high statistics study of $\pi^- p$ producing $\pi^-\pi^+ n$ at 17 GeV/c (1974). The analysis employed the angular distribution moments of the two-pion system, outlined in his 1964 lectures. The 1974 publication is still a cornerstone for hadron spectroscopy.

In 1973 Koch transferred to DESY as *Leitender Wissenschaftler* (leading scientist). He worked successively on the DASP, TASSO, Crystal Ball and ZEUS experiments until retiring in 1998. These experiments discovered the chi charmonium states (confirming experimentally the charm hypothesis) in 1975, the gluon in three-jet events in 1979 and bottomium spectroscopy in 1983. His analysis of TASSO data showed that the momentum distribution of charged particles in a jet can be used to measure the charge of the partons. A long-range correlation between the two jets in electron–positron annihilation could be observed. For ZEUS, together with PhD students, he studied the exclusive photo- ▷

Tom Ypsilantis 1928–2000

Light heavyweights. At a conference in Moscow in 1984, Tom Ypsilantis (left), co-inventor of the Ring Imaging Cherenkov counter, met Pavel Cherenkov (right), pioneer of the light which now bears his name. Behind them is Pavel Sorokhin of Kharkov.

Detector virtuoso Tom Ypsilantis died in Geneva on 16 August. Born in 1928 into a Greek family living in Salt Lake City, he studied physics at Berkeley where he obtained his master's degree and then became a graduate student of Emilio Segrè. Together with Owen Chamberlain and Clyde Wiegand, he joined the historic 1955 experiment at the new Bevatron that observed the first antiprotons. It was the subject of his PhD thesis.

After postdoctoral positions in the US and after playing a pioneer role in teaching modern physics in Greece, he came to CERN in 1968 and met Jacques Séguinot. This was the origin of a lifelong friendship and, at the same time, of a series of proposals and realizations of innovative particle detectors. Ypsilantis was a most inventive physicist, always ready to discuss his ideas and to share them with others. His imagination was conceiving instruments that, being well in advance of their time, were often difficult to construct, and here Séguinot had a lot to contribute. Ypsilantis and Séguinot, working in Max Ferro-Luzzi's group, proposed the technique later named Ring Imaging Cherenkov (RICH) counter. Together with Tord Ekelöf they introduced this technique for high-energy physics: the first large-scale application was for the DELPHI experiment at LEP. More recently they worked in the framework of the LAA Project on noble-liquid calorimetry and on a very large water neutrino detector based of the fast-RICH technique. The "AquaRICH" was described by Ypsilantis as "a Superkamiokande with spectacles". He also made a major contribution to the LHCb experiment at CERN.

His scientific goal was the invention and construction of detectors capable of opening new avenues in experimental particle physics. He was so knowledgeable in this field that in 1995 he became editor of *Nuclear Instruments and Methods*. To realize his dreams, he never considered personal interests or, even less, career advancement. Thus, over the years he was associated with CERN, Ecole Polytechnique, Collège de France and recently, INFN. At times he was even without a position and a salary, but still he continued to work as ever. He will be sadly missed by the high-energy physics community.

His friends.

The Ypsilantis connection

Tom Ypsilantis came from a distinguished family. In 1821, Prince Alexander Ypsilantis, a general in the Russian army, led a charge across the Danube against the Ottoman Turks. It was the beginning of Greek independence.

production of vector mesons and their spin alignment and helped to introduce the hadron-electron separator.

His clever programs, for example for the calculation of thrust, have inspired students. His many lectures and seminars at schools and conferences were brilliant, very critical and of extreme clarity, reflecting his deep understanding. We have all profited from his presentations and from many discussions with him.

Koch also assumed various responsibilities in the DESY laboratory with the same care that we knew from him in physics. He was chairman of the *Wissenschaftliche Ausschuss* (scientific committee) and of the Computer Users Committee (while there was a lack of computing time) and organized the weekly physics seminars. In 1975 he had a serious heart attack and he had several operations in the ensuing years.

Physics has lost a person who made visible and important contributions. Those who worked with him will miss a friend who could always be relied on to give good advice.
Hans Bienlein, DESY.

Hendrik Casimir 1909–2000

Hendrik Casimir (1909–2000).

Although he spent much of his professional life in industry, Hendrik Casimir was one of the great Dutch theoretical physicists. Graduating from Leiden in 1928, he researched at Leiden (with Paul Ehrenfest), Copenhagen (Niels Bohr) and Zürich (Wolfgang Pauli), before returning to Leiden in 1933 at Ehrenfest's insistence. When Ehrenfest committed suicide in 1933, Casimir acted as head of Leiden theoretical physics until the arrival of Hendrik Kramers.

In 1938, Casimir was a visiting lecturer in Utrecht while George Uhlenbeck was visiting Columbia. At Utrecht his pupils included Abraham Pais (see p46), who talked of "lucid lectures". In 1946 he moved to the Philips research laboratory in Eindhoven. His many physics contributions include the elucidation of mathematical operators for handling the quantum mechanics of rotations (the Casimir Operator) and predicting the quantum mechanical attraction between closely spaced conducting plates (the Casimir Effect). He helped found the European Physical Society and became its president in 1972. In 1979 he was one of the key speakers at CERN's 25th anniversary celebrations.

BOOKSHELF

The Physics of Particle Detection by Dan Green, Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology, 361 pp, 0 521 66226 5, £65/$100.

The 12th volume of the *Cambridge Monograph Series on Particle Physics, Nuclear Physics and Cosmology* again concerns particle detectors. In this case the main emphasis is not on the construction of these devices but rather on the underlying physics.

Dan Green has worked in particle detection and identification in many laboratories – from Stony Brook to the ISR, and from Fermilab to the preparation of LHC experiments.

The book begins with a recollection of the size and energy scales involved in different physical processes. The order of magnitude of atomic and nuclear processes is explained by fundamental physics principles and illustrated using everyday examples. The introductory chapter provides the basic numerical data needed to characterize the interaction probabilities of different particle species.

The main body of the book is subdivided into non-destructive measurements, such as time, velocity, ionization, position and momentum measurements, where the interaction of the incident particle transfers very little energy to the detecting medium; and destructive techniques, such as electron and hadron calorimetry, where the lost energy is a significant fraction of the kinetic energy carried by the particle. Characteristic features of different detectors are partially derived using dimensional arguments. For practical operations, rules of thumb are provided.

All of the methods presented aim to identify the incident particles, a goal that can often only be achieved by combining different techniques. Such a complete set of measurements is presented in the final chapter, using the example of a general-purpose detector.

The author successfully explains the operation of each type of detector from first principles, without rigorously deriving the theoretical background. Readers interested in the theory are referred to the appendices.

The presented applications of particle detectors are illustrated with many numerical examples, which clearly show that Green has "hands-on" experience in constructing and optimizing these devices. Some of the home experiments, however, like deflecting the electron beam of a TV set with a permanent magnet, should be treated with caution. This is fine on a black-and-white screen but can produce irreversible damage on a colour TV.

Various interaction processes are visualized using bubble and cloud chamber events, although these old-fashioned detectors are not described in detail. There is no mention of nuclear emulsions, and very little on neutrino interactions, even though the search for neutrino oscillations and the first direct observation of the tau neutrino have demonstrated that exotic and rare processes can breathe new life into old technologies. There is certainly some demand for the basics of neutrino interactions from the growing number of experiments in astroparticle physics.

Many of the instructive diagrams are taken, with good reason, from the relevant chapters of the excellent *Review of Particle Physics* by the Particle Data Group.

This book presents an attractive and comprehensive introduction to the physics of particle detection. The reader is guided by practical examples from everyday experience. It will be of interest to physics students and will also be a valuable reference for the experienced detector builder. The design of actual particle detectors may be subject to change over the coming years, but the underlying physics principles will stay the same. The book will thus remain useful for some time. The publishers should also be encouraged to issue an affordable paperback edition.
Claus Grupen, Siegen.

Books received

Cosmic Strings and Other Topological Defects by Alexander Vilenkin and E Paul S Shellard, Cambridge Monographs on Mathematical Physics, 0 5216544769 (pbk), £75/$115.

Now in paperback, this comprehensive textbook looks at a fruitful area of inflationary cosmological dynamics.

Knots and Feynman Diagrams by Dirk Kreimer, Cambridge Lecture Notes in Physics, Cambridge University Press 0 521587611 (pbk), £20.95/$34.95.

This book should be useful for theoretical physicists and for mathematicians.

NEW PRODUCTS

Fast isotope detection and identification
Berkeley Nucleonics has developed the portable Model 935 SAM that will detect, identify and quantify mixed isotopes in real time. A new concept in spectroscopy utilizes a sodum iodide detector and a patented process to identify mixed isotopes from a large library of over 90 isotopes within 1 s. An additional 1 s of processing confirms the initial result. Confidence levels of more than 97% are achieved, even when weak sources are below background levels of intensity. Sensitive nuclear materials, medical and industrial isotopes are identified, even in the presence of high background.

Time-slice technology coupled with background subtraction will quickly identify contraband moving through a checkpoint, even when masking is attempted by another isotope.

See "http://www.berkeleynucleonics.com".

Programmable precision pulse generator
The Model PB-5 from Berkeley Nucleonics provides unprecedented performance in a precision pulse generator. It includes a full-featured, highly flexible ramp generator and complete programmability. The PB-5 surpasses or equals all existing designs in the important performance areas of resolution, linearity and stability. The pulse repetition rates, which are variable over a broad range, go up to 0.5 MHz. The higher rates are required when testing for MCA and PHA linearity because of the large number of data points required for a statistically valid test. The built-in ramp generator allows control of ramp duration, the number of ramps and the ramp limits.

See "http://www.berkeleynucleonics.com".

PC for photon counting
Electron Tubes has launched a new PC interface that can respond directly to TTL pulses without needing an internal card. Although specifically designed for all Electron Tubes TTL photon-counting packages and TTL amplifier discriminators, it can be used with most sources of TTL pulses. The CT2 module connects to a PC and is supplied with software that allows measurements to be made immediately.

See "http://www.electrontubes.com".