

INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 40 NUMBER 4 MAY 2000



Searching for dark matter

STATISTICS

How to gain confidence in experimental data p17

INSTRUMENTATION

Nuclear physics techniques attract a wider audience p23

SUPERSYMMETRY

Sergio Ferrara reviews Steven Weinberg's latest book p37

A wide therapeutic view



How can you benefit from us?

Why Clinique de Genolier?



How ?

- By being privately insured
- By being semi-privately insured
- Medical or accident insurance



Why ?

- Clinique de Genolier is not more expensive than public hospitals and you are covered by your insurance
- You can choose your doctor
- We offer quality service and high level of comfort
- Genolier is only 25 minutes away from Geneva



What about your doctor?

- At Clinique de Genolier your referring doctor may take part in the management of your care at all times
- Do not hesitate to ask his advice

Clinique de Genolier • CH - 1272 Genolier
Tel. 022/366 90 22 • Fax 022/366 90 13
E-mail: CDG@cdg.ch • Internet: www.cdg.ch

CDG
Clinique de Genolier
Healthy Countryside

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): Q 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 controller: Kate Boothby
Production editor: Kerry Harding
Technical illustrator: Alison Tovey
Advertising manager: Jo Nicholas
Recruitment sales: Andrew Hardie and Jayne Purdy
Advertisement production: Katie Graham
Product manager: So-Mui Cheung

Advertising: Jo Nicholas, 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: Mrs Pieri or Mrs Montanari, 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

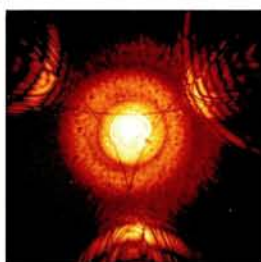
Printed by: Warners (Midlands) plc, Bourne, Lincolnshire, UK

© 2000 CERN
ISSN 0304-288X



CERN COURIER

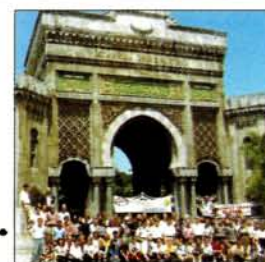
VOLUME 40 NUMBER 4 MAY 2000



Photonic crystals p9



Scintillators in calorimetry p23



School in Istanbul p30

News

CMS changes to silicon track. New class of gamma-ray sources is discovered. New precision result on CP violation. Rutherford Appleton gains 'Diamond' synchrotron source. Brookhaven and China to join forces in research. Harping on about hadrons.

5

Physicswatch

Astrowatch

Features

Not enough stellar mass objects to fill the galactic halo?

Looking for dark matter through microlensing

Physicists brim with confidence

How to handle experimental results

Swedish accelerators take a look at the past

The 50th anniversary of accelerator-based research at Uppsala

Scintillations in Seattle

Ingenuous instrumentation interest

Computer control of physics is increasing

Running and monitoring large research installations

People

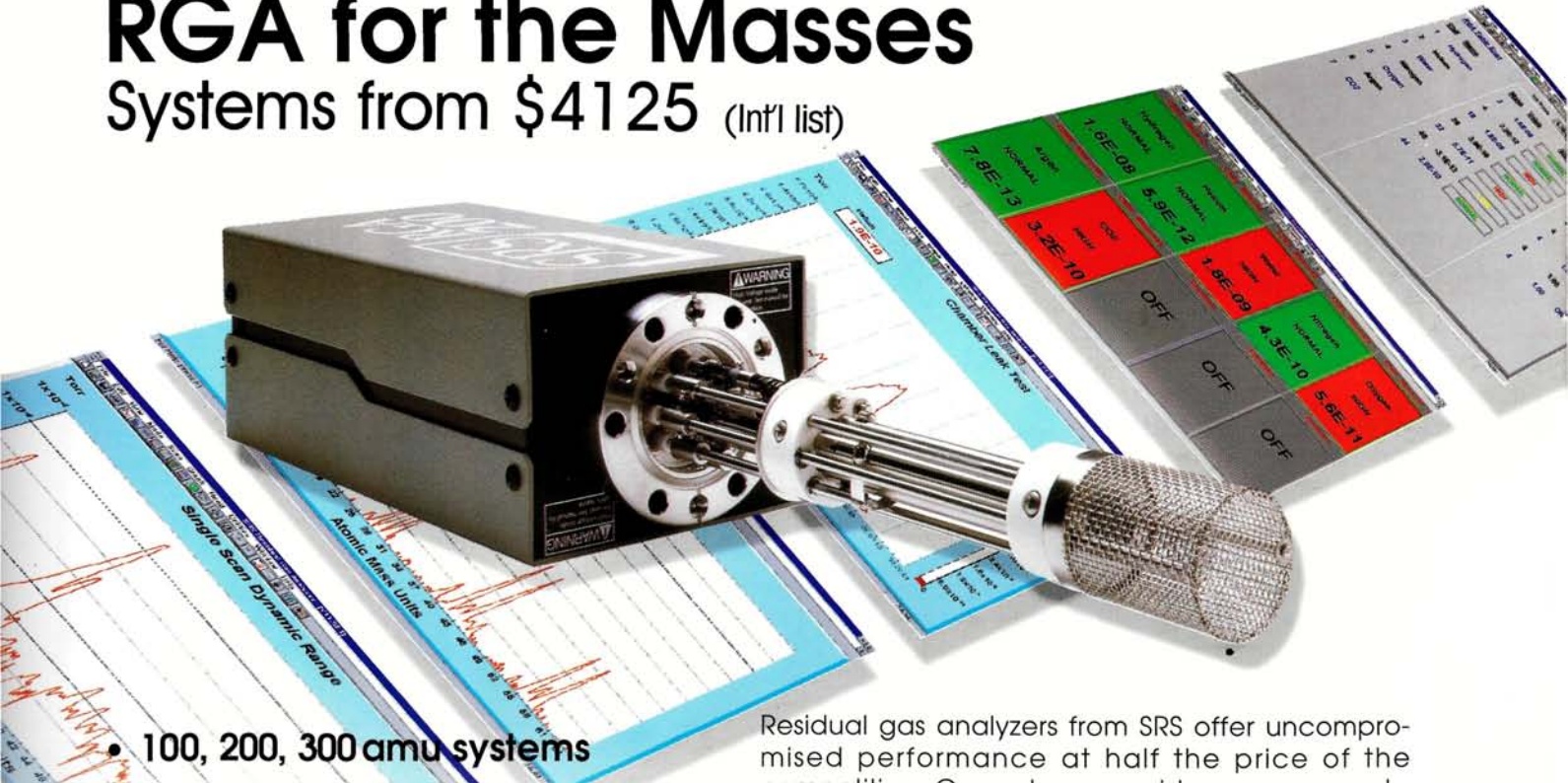
Recruitment

Bookshelf

Cover: The Large Magellanic Cloud (LMC), the brightest galaxy visible from our own Milky Way Galaxy. LMC stars have been used in searches for gravitational microlensing effects due to intervening dark stars (p13).

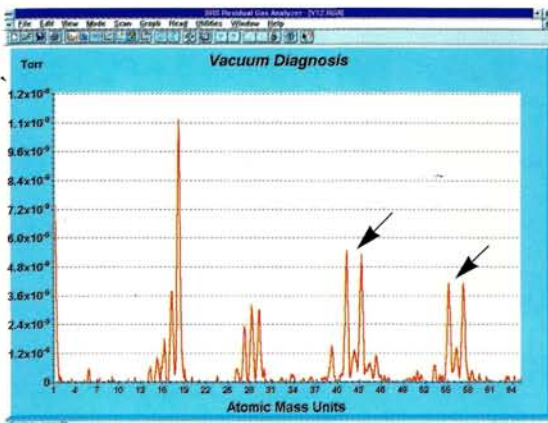
RGA for the Masses

Systems from \$4125 (Int'l list)

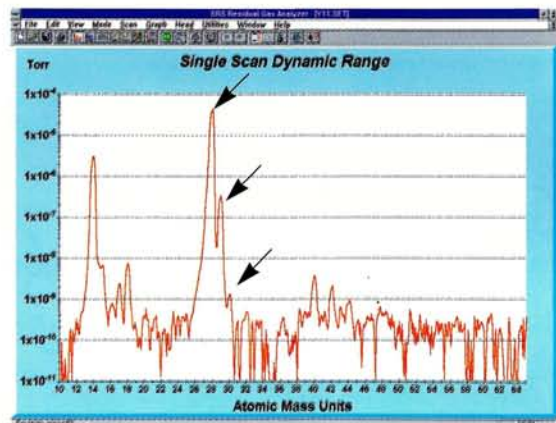


- 100, 200, 300 amu systems
- Partial pressure to 10^{-14} Torr
- 6 orders of magnitude dynamic range in a single scan
- Real-time Windows® software
- Mass spectra, leak detection and pressure vs. time modes
- Multi-head operation
- Optional Electron Multiplier

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 ThO₂Ir 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 (¹⁴N₂, ¹⁴N ¹⁵N, ¹⁵N₂) are clearly detected in a single scan.



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>

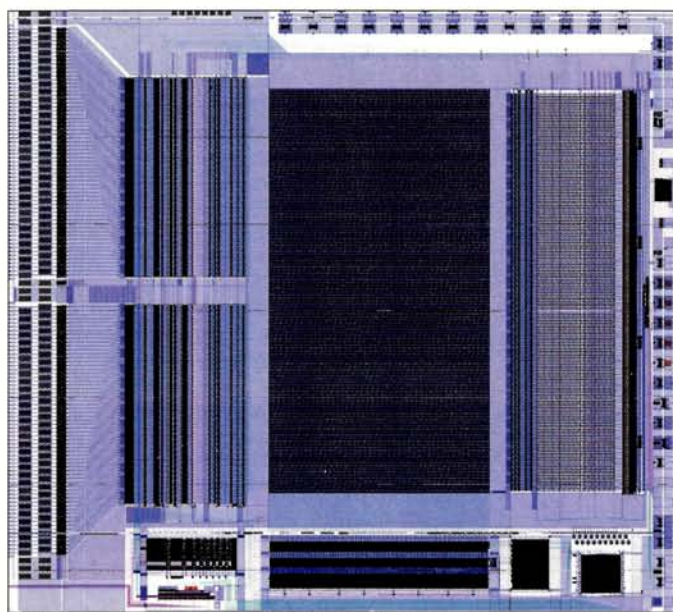
CMS changes to silicon track

The collaboration for the Compact Muon Solenoid (CMS) experiment at CERN's future LHC collider will base its tracker entirely on silicon sensor technology using fine feature size electronics (subject to the approval of an addendum to the experiment's Tracking Technical Design Report by the LHC committee).

The tracker is the innermost module of the huge detector, picking up signals from particles that are produced by the colliding LHC beams. Building such a 6 m long and 2.5 m diameter high-technology precision instrument for the demands of LHC physics is a major challenge.

The decision to go all-silicon follows unexpectedly rapid recent advances in read-out for microstrip detectors, in the fabrication of sensors on 6 inch diameter silicon wafers, and automated assembly techniques for an all-silicon detector. It is a significant departure from the CMS baseline tracker proposal, which foresaw a central region of silicon devices surrounded by microstrip gas chambers (MSGCs; *CERN Courier* March 1999 p15).

The decision was a difficult one for CMS, coming soon after the successful demonstration, in beam tests at the Paul Scherrer Institute in Switzerland, that MSGCs would be equal to the task of particle tracking at the LHC.



Chipping in – the layout of the 7.2 × 8 mm APV25 read-out chip designed by the CMS experiment at CERN's LHC collider.

In the mid-1990s MSGCs seemed to offer an economical alternative to silicon. In early implementations, however, their performance was found to deteriorate significantly with increased exposure to ionizing particles. This would have ruled them out for prolonged use at the LHC, where unprecedented particle fluxes are expected.

Nevertheless, solutions to these teething problems seemed to be available and CMS chose MSGCs as their baseline proposal, on the condition that certain milestones were reached. These were successfully achieved, but silicon-related technology was advancing

in parallel, reducing the cost advantage that MSGCs offered.

A decisive factor in reducing the tracker's price tag, by almost 6.5 million Swiss francs, was the development by CMS of a CMOS read-out chip using low-cost technology, originally aimed at increasing the compactness of computer chips. With a feature size of 0.25 μm compared with the 1 μm of conventional CMOS chips, the new APV25 chip is certainly compact. What the computer industry did not plan for, however, is that it is also extremely radiation-hard, with lower noise and power consumption than a conventional CMOS chip. This combination of features is ideal for CMS's needs. It also provided important input to the choice of

an all-silicon detector.

The other decisive factor is that silicon detectors are already widely available from industry in large quantities, and their price has been falling. Coupled with new automated assembly techniques developed at CERN, silicon therefore gave CMS the greatest chance of completing its full tracker on time and budget for LHC start-up.

"We believe that a new era is being entered, of assembling an enormous detector using automated assembly techniques," said Geoff Hall of the CMS collaboration, "which is only possible today with silicon."

New class of gamma-ray sources is discovered

The discovery of mysterious gamma-ray bursters in the late 1960s opened up a new chapter in astronomy. Now gamma-ray astronomy has taken another surprising turn with the revelation that many of the previously unidentified high-energy gamma-ray sources in our galaxy, the Milky Way, comprise a whole new

class of mysterious objects that "shine" continuously instead of coming in bursts.

The known gamma-ray universe contains many yet-unidentified gamma-ray sources, listed in a 271-source catalogue compiled by the Energetic Gamma Ray Telescope Experiment aboard NASA's Compton Gamma Ray Observatory spacecraft. Scientists have struggled to associate these unidentified sources with known objects emitting other types of light.

Of the unidentified gamma sources in our galaxy, about half lie in a narrow band along the galactic plane. These may be well known

classes of objects that simply shine too faintly in other types of light to be identified – gamma rays pass through intervening material much more easily than other types of radiation.

The other half of the unidentified galactic gamma sources – the new class – are closer to Earth. These lie just off the Milky Way plane and seemingly follow the Gould Belt – a ribbon of nearby massive stars and gas clouds that winds through the Milky Way plane. However the mechanisms of powerful gamma-ray emitters, whether in bursts or more prolonged, remains a mystery. See "<http://pao.gsfc.nasa.gov/gsfsc/spacesci/structure/cgro.htm>".

New precision result on CP violation

The latest precision measurement of CP violation, matter-antimatter asymmetry, by the big NA48 experiment at CERN underlines the importance of understanding this delicate mechanism, which probably played a major role in shaping the particle scenario that emerged from the Big Bang.

In CP (charge/parity) symmetry the physics of left-handed particles is the same as that of right-handed antiparticles. This idea was suggested after physicists had been shocked in 1956 to discover that the weak interactions of atomic nuclei (beta decay) can differentiate between left and right – weak interactions violate P (parity) symmetry.

In 1964, physicists received another shock when they discovered that the more elaborate CP symmetry is also flawed. Under certain circumstances, nature differentiates between matter and antimatter – what are labelled as particles and as antiparticles is not arbitrary.

The reason for CP violation is still not understood, but whatever it is, it probably helped to shape a universe that was matter-antimatter symmetric immediately after the Big Bang into the matter-dominated universe that we know. To our knowledge, antiparticles do not exist naturally and can only be synthesized when high-energy interactions produce particle-antiparticle pairs.

Last year, two major experiments, KTeV at Fermilab (*CERN Courier* April 1999 p5) and NA48 (*CERN Courier* September 1999 p6), reported a non-zero value for a vital CP violating parameter that shows that CP is violated directly in the actual decays of the component quarks. CP violation is not simply



Detail of electronics installation for readout from the liquid krypton calorimeter of the NA48 experiment at CERN, prior to being hidden from view inside the cryostat.

due to the subtle mixing of neutral particles and antiparticles.

The traditional stage for CP violation is an enigmatic particle – the neutral kaon. It exists in two forms – particle and antiparticle of each other, which are only distinguished by a quantum number – strangeness – that is not conserved in weak interactions. Because of this the two neutral kaons get mixed up.

If CP were good, the neutral kaon would exist in two forms – a short-lived variety decaying relatively easily into two pions, and a long-lived version for which the two-pion decay is not allowed and that has to struggle to produce three pions instead. However, owing to CP violation, this distinction is not total – three parts per thousand of long-lived kaons produce two pions.

To establish whether direct CP violation via the quark decay route contributes to this, physicists must carefully compare two ratios. The first is the rate of long-lived kaons decaying into two neutral pions compared with that into two charged pions, and the second is the equivalent pion-pair decay ratio for short-lived kaons. Making these measurements, involving

very similar particle signatures, is extremely difficult.

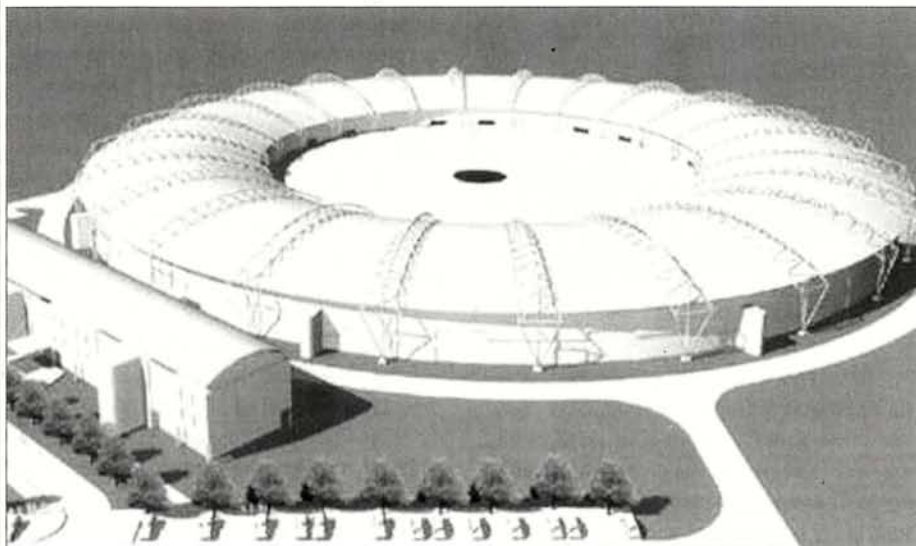
If these two ratios are not exactly equal, then quark effects do contribute to CP violation. The relevant parameter used by physicists is the difference of this ratio of ratios from unity, divided by a numerical factor. For several years the situation had been unclear, until last year when KTeV reported a parameter of $28 \pm 4.1 \times 10^{-4}$ (thought by theorists to be uncomfortably high), and NA48, using data collected in 1997, which reported $18.5 \pm 7.3 \times 10^{-4}$. The new NA48 number is $14 \pm 4.3 \times 10^{-4}$, including 1998 data, with several times the number of kaon decays seen previously. The resulting new world average result is less surprising to theorists.

Data from 129 days of NA48 running in 1999 are still being analysed, but after this run was complete an accident destroyed the experiment's carbon fibre beam pipe and damaged some of the detector modules. The apparatus is being repaired to enable more data to be collected and to improve the precision of its final result.

cerncourier.com

Explore Absorb Search Discover Browse Digest Surf Link Bookmark

Rutherford Appleton gains 'Diamond' synchrotron source



Artist's impression of the Diamond SRS, to be built at the Rutherford Appleton Laboratory.

The UK's Synchrotron Radiation Source (SRS) at Daresbury, near Manchester, is to be replaced by a new machine at the Rutherford Appleton Laboratory near Oxford that should be operational in 2006. Funded by the UK and French governments and by the Wellcome Trust, the "Diamond" synchrotron, operating at several gigaelectron-volts, will serve a several thousand-strong academic and industrial research community spanning a range of scientific disciplines.

Daresbury's 2 GeV SRS source, completed in 1980, will eventually be phased out, but over the next few years will benefit from additional beamlines. A recent addition is BALLAD (Belfast and Leicester Line at Daresbury).

The SRS was one of the first electron accelerators to be built solely for providing synchrotron radiation. Low-wavelength electromagnetic synchrotron radiation is emitted by high-energy electron beams as they are bent, and saps the power of high-energy synchrotrons. In the mid-1950s, scientists realized that this intense radiation could be used in its own right to study molecular and other structures over a range of pure and applied research. Synchrotron radiation users began to group around high-energy electron machines built for particle physics, but such was the appeal of synchrotron radiation research that purpose-built synchrotron

radiation sources became popular.

In modern synchrotron sources, the radiation is produced by "insertion devices" placed in the straight sections of the synchrotron to "shake" the beam, rather than using the radiation emitted as the electrons are bent round the arcs of the machine.

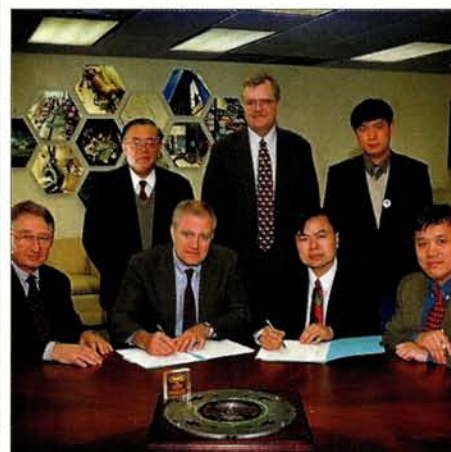
The Daresbury lab was established in the 1960s to house the 4 GeV National Institute Northern Accelerator (NINA) electron machine to complement the Nimrod proton machine at Rutherford. With the UK's decision in the early 1970s to close its national particle accelerators and concentrate particle physics research at CERN, a plan emerged for a dedicated synchrotron electron source – the SRS – to replace NINA and to benefit from the existing Daresbury infrastructure.

A scheme for a major new French national synchrotron radiation source – Soleil – was cancelled last year and France decided instead to become a major partner in Diamond. The substantial Diamond support from the Wellcome Trust, the world's largest biomedical research charity, underlines the broad appeal of synchrotron radiation as a research tool.

The cancellation of the original French scheme and the switching of UK synchrotron radiation sources from Daresbury to Rutherford have both been the subject of intense debate.

Brookhaven and China to join forces in research

Representatives of the National Natural Science Foundation of China (NNSFC) visited Brookhaven on 23–25 February to learn more about the scientific programme of Brookhaven's new RHIC heavy ion collider and to explore opportunities for increased collaboration. A possible upgrade to the STAR experiment, to extend its particle identification capability, was a major focus of the discussion. The delegation also visited the Lawrence Berkeley National Laboratory, and a joint symposium to discuss practical aspects of the STAR upgrade is planned for Beijing this fall. The visit culminated in the signing of an agreement to cultivate future interest and collaboration on the RHIC scientific programme between institutions supported by the NNSFC and Brookhaven.



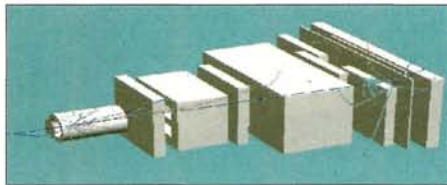
Agreeing to cultivate collaboration in research at Brookhaven's new RHIC heavy ion collider between institutions supported by the National Natural Science Foundation of China and Brookhaven. Left to right, back row: NNSFC vice-president Wang Naiyan; STAR experiment deputy spokesman Tim Hallman; and Feng Liu of the Institute of Particle Physics, Wuhan, China. Signing the agreement (seated in front) are Brookhaven deputy director for Science and Technology Peter Paul; Brookhaven director John Marburger; NNSFC Math and Physical Science Department deputy director Peiwen Ji; and NNSFC International Collaboration Bureau deputy director Qing Chang.

Harping on about hadrons

With excitement mounting over new possibilities for "neutrino factories" using muon storage rings (*CERN Courier* April 2000 p17), a new experiment at CERN will study in detail the yield of pions produced by high-energy protons. The results will provide valuable input to these neutrino factory designs.

The Hadron Production Experiment at the CERN PS proton synchrotron (HARP) is a collaboration of institutes in Austria, Belgium, Bulgaria, France, Italy, Russia, Spain and the UK as well as CERN and the JINR in Dubna, near Moscow.

For a neutrino factory, an intense proton driver accelerator would pile several megawatts of beam power into a specially designed target to make pions, which would then be magnetically collected. These pions would then decay into muons, which in turn would give neutrinos. Existing data on the yield of pions by protons are inadequate for



Schematic of a particle collision in the HARP experiment at CERN. Note the wide angle covered downstream (right).

the detailed design of the proton driver and target for such a machine.

HARP has another major objective. The quest for a better understanding of the phenomenon of neutrino oscillation requires an improved knowledge of atmospheric neutrino fluxes. The yield of neutrinos by cosmic rays from outer space hitting nuclei in the atmosphere is a vital input to any calculation on atmospheric neutrino effects. This neutrino flux requires a knowledge of the energy and com-

position of the primary cosmic rays, and the subsequent production of secondary particles by collisions with nitrogen and oxygen nuclei. The former is steadily improving from information gathered in a new round of balloon flights, but the latter needs additional effort.

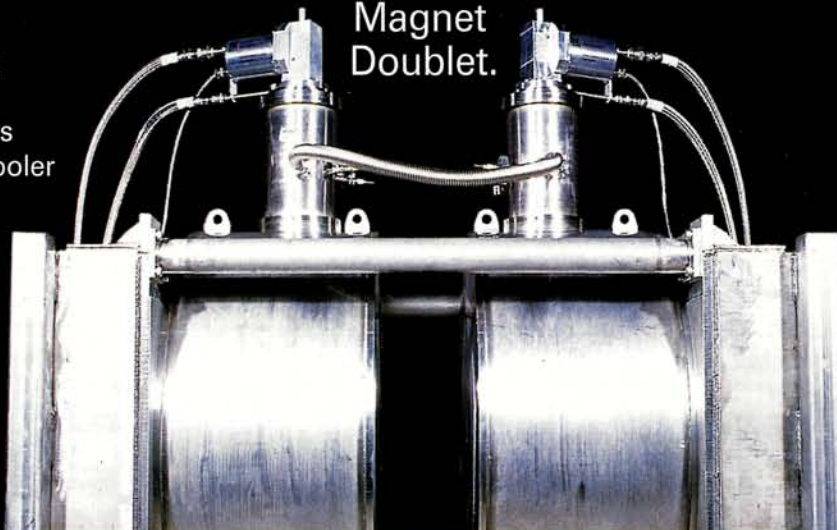
HARP will use protons of up to 15 GeV from CERN's proton synchrotron and detector elements salvaged from previous major experiments at CERN and elsewhere - the prototype Time Projection Chamber from the Aleph experiment at CERN's LEP electron-positron collider, drift chambers from the Nomad neutrino experiment at CERN, calorimeter modules from the Chorus neutrino experiment at CERN, a spectrometer magnet from Orsay, etc. The aim is to study secondary particle production over a range of angles and energies. With its legacy of inherited equipment, HARP will be up and running very quickly, and expects to take data next year.

Seeing Double?

No. It's just the world's first-of-its-kind, Cryogen-free Superconducting Magnet Doublet.

Everson Products:

- Superconducting magnets
- Resistive magnets
- Integrated cryocooler systems
- Liquid cryogen dewars
- Variable-temperature cryostats
- Low-temperature He-3 cryostats
- Power supply instrumentation



Everson Services:

- Engineering design
- Finite element and CAD
- Magnetic analysis
- Thermal analysis
- Instrumentation design
- Conductor insulation
- Special tooling

We service a wide variety of market applications, so call us today.

2000 City Line Road, Bethlehem, PA 18017
(610) 264-8611, FAX: (610) 264-1040
www.eversonelec.com



**everson
electric
company**

We put quality in motion.

Edited by Alison Wright

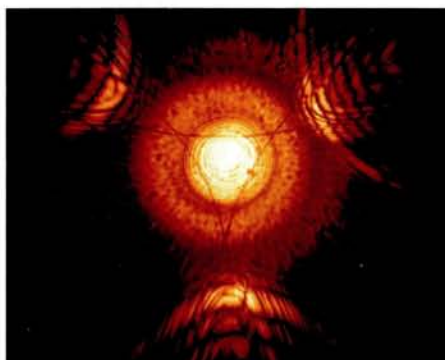
Except where otherwise stated, these news items are taken from the Institute of Physics Publishing's news service, which is available at "http://physicsweb.org".

Holograms make photonic crystals

Oxford physicists have revealed a new holographic technique for making three-dimensional photonic crystals.

Photonics is the technology in which data are transmitted and processed by photons. In a photonic crystal, the dielectric constant of the material varies periodically on a length-scale comparable to the desired wavelength of operation. As waves scatter between each unit cell of the structure, multiple interference opens a "photonic bandgap" – a range of frequencies at which no waves can propagate through the crystal, analogous to the electronic bandgap in semiconductors.

The fabrication of three-dimensional photonic crystals to operate in the visible spectrum had until now remained an experimental challenge, but the new method using



Light is strongly diffracted by a photonic crystal, made by a new holographic technique. The three dark lines crossing the central diffraction maximum and the bright arcs round it are Kossel lines, characteristic of three-dimensional diffraction.

holographic lithography is cheap, quick and easily extended to large-scale production.

Four laser beams are fired into a thin epoxy film, where they meet and interfere, setting up a periodic, submicrometre structure of exposed and unexposed areas. Highly exposed film is insoluble, but the unexposed areas can be dissolved to reveal a three-dimensional polymer structure filled with air holes. Varying the intensity and polarization of the lasers determines the distribution of dielectric material in a unit cell, which in turn determines the photonic band structure.

Scanning electron micrographs of such a crystal reveal a defect-free structure, perfectly ordered on scales of many hundreds of lattice constants, that could also act as a template for making higher-refractive-index crystals.

New 'left-handed media' boast some unusual properties

US physicists have created a new class of composite material with unusual electromagnetic properties. Predicted to exist by a Russian physicist in 1968, but not technically possible until now, the "left-handed media" have the reverse effect on electromagnetic radiation as normal "right-handed media".

The first such composite, designed for incoming microwaves, is made of a series of thin copper rings and ordinary copper wire strung parallel to the rings. Its unique left-handedness arises because it possesses simultaneously negative dielectric constant and negative magnetic permeability, the properties that determine how it interacts with electromagnetic radiation.

The result, if imagined for the visible spectrum, is that light entering the material refracts in the reverse direction to normal. Light rays, normally diverged in any ordinary concave lens, are focused by these new structures. The materials are expected to find wide application in areas such as wireless communications.

APS

Magnetic dots heat up data handling

Hot on the heels of the silicon microchip, the single electron transistor (SET; December 1999 p13) seems set to generate the next revolution in data processing and storage.

Arrangements of SETs, called Quantum Cellular Automata (QCA) because they use quantum mechanical tunnelling of charge between quantum dots to change logic state, have recently shown their ability to perform logic operations. However, currently, unless the SET dots are less than 2 nm across, the electronic QCA will only work at millikelvin temperatures.

Cambridge physicists have now turned their attention to magnetic QCAs instead. They have created QCA networks of dots, made from a common magnetic alloy on a silicon substrate, that work at room temperature. Each dot is 110 nm across and 10 nm thick with a pitch of 135 nm.

The quantum mechanical interactions in a magnetic QCA are exchange interactions between spins in a single dot, forming a single giant classical spin. The direction of the dot's magnetization vector can be considered to indicate a logic state. Magnetostatic interactions between nearest neighbours along the chain of dots allow the propagation of information, but also force the magnetiza-

tion to point along the direction of the chain, to either the left or the right, producing a natural binary logic system.

The logic state can be set by applying a single magnetic pulse at the input dot. Oscillating magnetic fields can then reverse the magnetic state of the chain of dots, changing the logic state, as a magnetic soliton propagates along the chain. This soliton, like a domain wall in a bulk material, separates regions of left and right magnetization. In theory, solitons propagate without loss, but small fluctuations in the shape of the dots will cause a soliton to dissipate energy as it propagates. To minimize losses requires an accuracy on dot circularity of better than $\pm 2\%$ – a far less stringent requirement than that for electronic QCAs, and easily achievable.

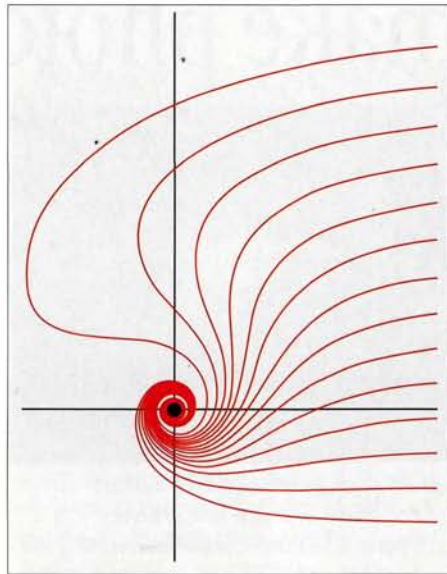
Magnetic QCAs should also be very stable against data errors caused by thermal fluctuations, even down to dot diameters of 20 nm. Integration densities could reach 250 000 million/cm² with only about 1 W of typical power dissipation and across-chip clock frequencies of up to 100 MHz. The researchers believe that the magnetic QCA "has enormous potential" to meet the requirements of digital processing of the future.

Optical black holes could be made in the lab

Black holes could be created in the laboratory, claim physicists from Sweden and Scotland. Their calculations show that, thanks to some recent advances in condensed matter physics, it is theoretically possible to create an optical black hole to attract and trap specific colours of light in just the same way as an astronomical black hole attracts and consumes matter.

The researchers unearthed a 1923 paper in which Walter Gordon, starting from Einstein's idea of gravity mediated by changes in the metric of space and time, realized that space-time is effectively a medium and that consequently, any moving dielectric medium acts on light as an effective gravitational field. However, to see effects as dramatic as a black hole, the velocity of light in the medium must be low compared with the velocity of the medium.

Recent results from US physicists working with Bose-Einstein condensates (BEC) suggest that this is feasible: quantized vortices



Trajectories of light rays, when dragged by a vortex core, spiral into the singularity to form an optical black hole.

have been generated in a BEC of rubidium atoms, while light has been slowed down inside a BEC to a mere 50 cm/s, and even 1 cm/s may soon be achieved.

A BEC vortex, swirling faster than the light can move, would drag the light into its centre, where it would eventually be absorbed by the gas. An event horizon – a radius of no return – would form about the vortex, just like the Schwarzschild radius of an astronomical black hole.

Then, some spectacular effects of general relativity could be seen in a terrestrial laboratory, perhaps demonstrating an analogue of Hawking radiation from black holes (obscured by the cosmic background radiation and so far never observed in astronomy) and even exploring prototype theories of quantum gravity.

However, the experimental difficulty in generating sufficiently fast and durable BEC vortices means that a home-grown black hole is probably still about five years away. *AIP*



UNUSUAL

REQUESTS



Goodfellow is an established specialist supplier of small quantities of metals & materials for research, development, prototyping and design.



Our product range is renowned for being the most comprehensive of any source in the world.

Whilst we can't guarantee to make fairy tales come true, we can help with your unusual requests for materials. Contact us now for a copy of our new product guide and find out what we can do for you.

Goodfellow

Goodfellow Cambridge Limited
Cambridge Science Park, Cambridge, CB4 4DJ
Telephone: +44 1480 424 800
Facsimile: +44 1480 424 900
Email: info@goodfellow.com
Web: www.goodfellow.com

ASTROWATCH

Edited by Emma Sanders

Gemini mirror goes on the road



The Gemini mirror crosses Paris en route to Chile... (Gemini.)



...negotiates the Puclaro Dam tunnel in Chile...



...approaches its destination, at Pachón...



...and is finally unveiled on the 3250 m summit of Cerro Pachón.

Particle physicists are familiar with the trials of moving large, unwieldy pieces of equipment on epic voyages around the globe. They are not alone.

The 24 ton, 8.1 m mirror of the Gemini South telescope was fused from ultra-low-expansion glass in the US last year. It travelled by ship to Paris for polishing, then in February

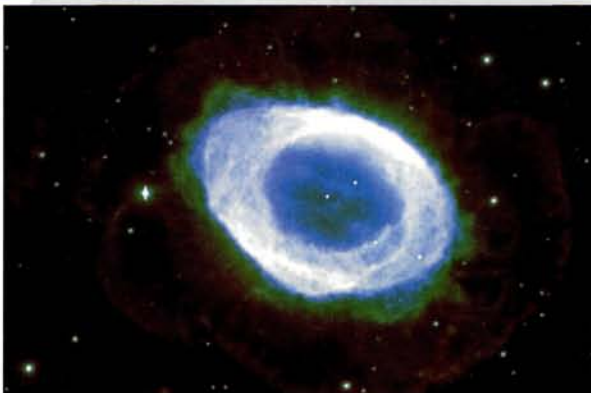
it was transported by barge, then container ship to Chile. On arrival there, the transport difficulties were not over. On a four-day road trip to the 3250 m summit of Cerro Pachón, one of the tunnels had to be widened by 2 m so that the mirror could pass.

As its name suggests, Gemini is a twin. This whole rigmarole was also carried out for the

northern hemisphere telescope, Gemini North, in Hawaii.

Partners for the project are the UK, the US, Canada, Chile, Australia, Brazil and Argentina. Gemini South is expected to see first light before the end of the year. Gemini North became operational last year (*CERN Courier* September 1999 p16).

Picture of the month



The Ring Nebula. The hot central white dwarf star emits ultraviolet radiation that illuminates the surrounding shell of gas. These observations, using the Japanese 8.2 m Subaru telescope at the summit of Mauna Kea in Hawaii, show a faint outer halo, observed clearly for the first time. This will improve understanding of the gas flow from the central star during its preceding red giant stage. After all core hydrogen had been burned, the star's surface expanded outwards and the central part of the star contracted to form the white dwarf. The Subaru telescope opens to astronomers later this year. In the future, the telescope will be operated remotely from the Mitaka campus of the National Astronomical Observatory in Japan. (Subaru.)

Free-floating planets prove too light for dark matter

The most sensitive search ever undertaken for small substellar objects has revealed 13 free-floating planets and more than 100 young brown dwarf stars in an active star-forming region of the Orion Nebula. The discovery was made using the new infrared camera at the UK Infrared Telescope (UKIRT) in Hawaii.

Although the appeal of small lumps of gas and rocks may not be immediately obvious, some astronomers hope that such objects might help to solve one of the great mysteries of cosmology. Invisible dark matter makes up 90% of our universe and possible candidates include just such small, faint objects.

Previously, only two free-floating planets had been discovered. The fact that there are 13 in one small region of the sky makes it likely that there be many more in other star-forming areas across the universe. The survey also revealed more than 100 young brown

dwarf stars. These dull mini-stars are too tiny to shine brightly because their cores never heat up enough to trigger the fusion of hydrogen. A small amount of energy is generated by the fusion of deuterium.

Despite the large number of objects discovered in the new survey, their total mass is nevertheless low compared with the total mass of the stars. Indeed, if this is a typical cluster, it is unlikely that planets and brown dwarves contribute significantly to dark matter.

● For more dark matter developments, see p13.

JAS'2000

JOINT CERN-JAPAN-JINR-RUSSIA-USA

ACCELERATOR SCHOOL will organize a course on

FRONTIERS OF ACCELERATOR TECHNOLOGY:
HIGH QUALITY BEAMS

On a river-boat between St.Petersburg and Moscow
from 1 July to 14 July 2000

This international program provides an excellent educational opportunity for graduate students, postdocs, research scientists and engineers in university departments which use particle accelerators and in manufacturing companies which specialize in equipment for accelerators in this important and growing field. The School consists of approximately 9 working days of intensive lectures and mini-courses on the wide range of technologies that form the base of the beam/accelerator field. In particular the school will focus on the physics and technology of attaining high quality particle and photon beams for scientific research and for industrial applications.

Programme Advisory Committee

Chairman **A. SKRINSKY**

Europe: **E.Wilson, S.Turner**

Japan: **S.Kurokawa, T.Shintake**

Russia: **I.Meshkov, E.Perevedentsev, G.Shirkov**

US: **S.Y.Lee, S.Holmes, J.Galayda**

LATE APPLICATIONS WILL
STILL BE ACCEPTED

Further information and application forms are available
on School Web site: <http://sunse.jinr.ru/jas2000.html>
e-mail: jas2000@sunse.jinr.ru

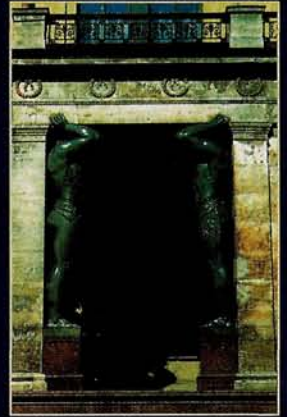


Local organizing committee

I.Meshkov
G.Shirkov
N.Tokareva
N.Dokalenko
V.Zhabitsky
V.Katrasev
L.Soboleva
T.Stepanova
O.Strekalovsky
E.Shirkova



St. PETERSBURG



2000

Our products:

- High & Low Voltage Power Supplies
- High efficiency >90%
- High Density modular and standalone
- Radiation Hard & EMI Tolerant
- Modem, Ethernet, CANbus controllers
- Data loggers for automated measurement
- Custom Design

Applications:

- Physics Research -
- Silicon strip detectors -
- Electrostatic Field -
- Space Research -
- Medical Imaging -
- Telecom Industries -
- Remote Measurements -

DPS

ELECTRONIQUE • INFORMATIQUE
15, Rue Pré-de-le-Fontaine, CH - 1217 Meyrin/Genève
Tél. +41-22 785 07 20 Fax +41-22 785 07 35
Email : electronics@dps.ch - Internet : <http://www.dps.ch>

..... Design, Production and Services

Not enough stellar mass objects to fill the galactic halo?

The universe contains a lot more than meets the eye. Sophisticated experiments search diligently for this invisible dark matter. Here *Alain Milsztajn* of Saclay describes the latest results to emerge from the microlensing technique.

The mass of our galaxy (the Milky Way) can be computed from the dynamics of its rotation and of the motion of its satellites. It can also be evaluated by adding up its visible components, primarily stars. That these two estimates disagree by a factor of 5-10 constitutes the problem of galactic dark matter.

Either the Newtonian/Einsteinian laws of dynamics are wrong at the galactic scale, or there exists some form of galactic matter that does not emit or absorb enough electromagnetic radiation to be directly "visible". Studies of many other spiral galaxies confirm that this problem is not unique to the Milky Way.

Originally proposed in 1986 by B Paczynski of Princeton, gravitational microlensing is a novel and indirect way to search for galactic dark matter through the deflection and magnification of the light of extragalactic stars. The search for microlensing has recently shed new light on the galactic dark matter puzzle.

Microlensing

In 1990, three groups began the search for gravitational microlensing. The main problem was the inherent large scale of such surveys. To produce a detectable magnification of the light of a distant star, an intervening compact massive object has to come closer to the star's line of sight than one milli-arcsecond, or five nanoradians (the angle subtended on Earth by an Apollo mission lunar jeep); the tighter the alignment, the larger the magnification.



Two galaxies stand out in the Southern Hemisphere sky: the Large Magellanic Cloud (left) and the Small Magellanic Cloud. These are two of the closest galaxies to our Milky Way galaxy. Stars in both of these galaxies have been used in searches for gravitational microlensing effects owing to intervening dark objects. (W Keel, University of Alabama in Tuscaloosa, Cerro Tololo, Chile.)

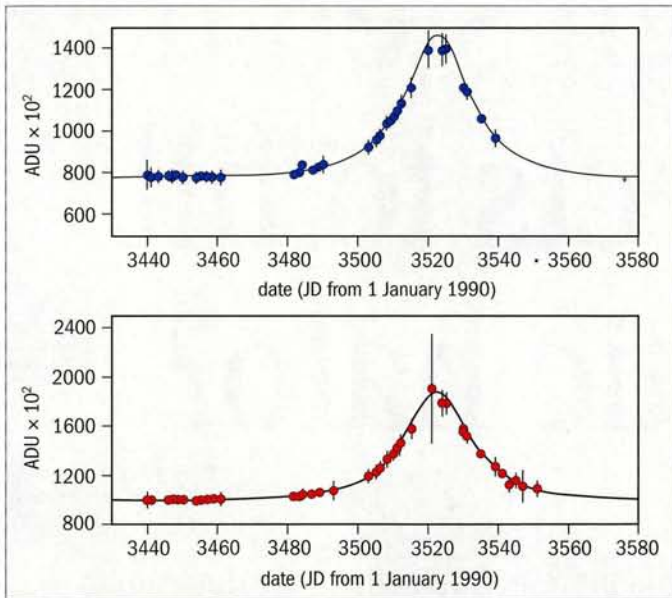
This happens so seldom that one expects less than one star in a million to be affected significantly at any given time, hence the necessity to survey some 10 million stars over many years. In contrast, variable stars are more than a thousand times as frequent and constitute a serious experimental background.

The shape of microlensing magnification is predictable and does not depend on the wavelength, contrary to most variable stars. The phenomenon is transient, because of the motion of the dark lensing object with respect to the distant star. Its duration scales as the square root of the lensing object mass, and this can be used to estimate these masses.

To simplify, one could say that two of the groups, EROS (Expérience de

Recherche d'Objets Sombres - an experiment to search for dark objects) and MACHO (Massive Astronomical Compact Halo Objects), were most concerned with the dark matter problem. To probe the content of the galactic halo, they chose to monitor stars in the Magellanic Clouds - two irregular dwarf galaxies, satellites of the Milky Way, that lie close to the celestial South Pole.

The third group, OGLE (Optical Gravitational Lensing Experiment), chose to look first for microlensing where it was bound to find some - the centre of our galaxy. The microlensing rate there owing to known low-mass stars was expected to be about one in a million per year. In contrast, the rate towards the Magellanic Clouds could be anywhere between zero, if there are no compact dark objects in



Microlensing signal ("light curve") from a bright Galactic Bulge star, as seen by the EROS detector. The blue dots indicate visible light and the red dots show red light. An intervening but otherwise invisible object crossing the line of sight briefly boosts the brightness. Days (horizontal axis) are counted since 1 January 1990. The curves show the best fit to the microlensing hypothesis. The observed magnification is independent of the wavelength.

the galactic halo, and about a thousand times the galactic centre rate, if the halo is swarming with lunar mass dark bodies.

The main goal of EROS and MACHO was to detect a few microlensing events caused by brown dwarfs – would-be stars not massive enough to burn via thermonuclear reactions. These objects, between a tenth and a hundredth the size of the Sun, would give rise to a microlensing rate of the order of the expected galactic centre rate.

Divergence

In September 1993 the discovery of the first microlensing candidates by the three groups aroused high hopes that the galactic dark matter problem was about to be solved. However, in the following years a gradual divergence appeared between the EROS and MACHO results. Based on two years of Large Magellanic Cloud (LMC) CCD camera images, the MACHO group presented its result as pointing to a galactic halo half-full of 0.5 ± 0.2 solar mass objects, and compatible with being totally comprised of such objects.

In contrast the EROS group observed such a small number of candidate microlensing events that it published only upper limits, first based on a photographic plate LMC survey (1990–4), and then on a survey, started in 1996, of the Small Magellanic Cloud (SMC), which uses two large CCD cameras. The EROS limits excluded, in particular, a halo full of 0.5 solar mass objects.

Despite these somewhat inconsistent results, agreement was reached on one important point: because all microlensing candidates observed by MACHO and EROS lasted longer than a month, the halo could contain no more than 10–20% of dark objects in the

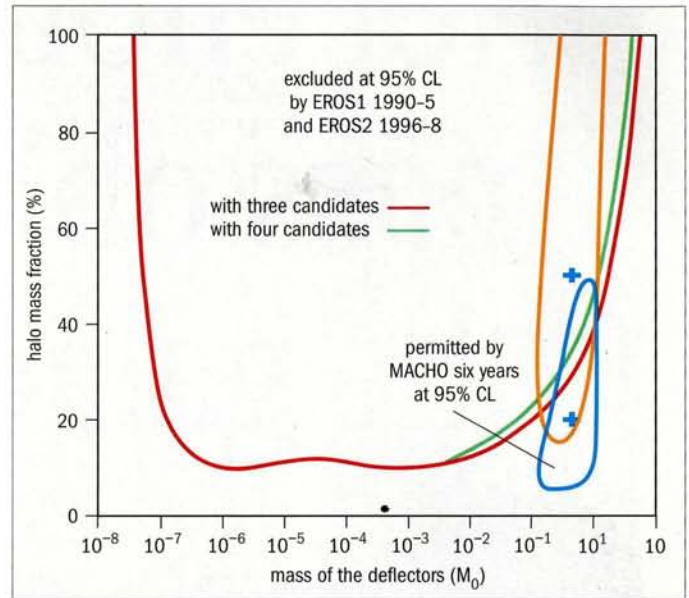


Figure 1: The EROS experiment excludes, at a 95% confidence level, that the galactic halo contains a fraction of objects of solar mass above the plain red curve. (The green curve indicates how the limit would change if the SMC event were due to a halo lens.) MACHO finds a microlensing rate consistent with a mass fraction of 20% and half a solar mass object (blue contour). The orange contour shows the former MACHO result that was compatible with a galactic halo made up of dark objects.

wide mass range between the mass of planet Mercury and one-tenth that of the Sun, that is from 10^{-7} to 0.1 solar masses. This excluded brown dwarfs – the dark matter candidate that had been the main motivation for this search (figure 1).

Reconciliation

Fortunately the past months have witnessed a reconciliation of the MACHO and EROS findings. The latter presented results from the first two years of an ongoing six-year survey of 17 million LMC stars that produced a meagre crop of two new microlensing candidates. Combined with their previous limits, this enables them to exclude a galactic halo fully comprised of objects of up to four solar masses – quite a respectable mass for a stellar object. (For a halo of 0.5 solar mass objects, the upper limit is now near 30%; figure 1.)

MACHO has analysed almost six years of LMC images out of seven-and-a-half years of surveying, and it has now stopped taking data. From its 13–17 observed microlensing candidates, it now favours a 20% contribution of 0.5 solar mass objects to the halo mass budget, but these are compatible with halo mass fractions ranging from 8% to 50%.

The duration of the candidates is similar, so that both results are compatible. However, the two groups interpret them differently. The MACHO collaboration favours an interpretation in terms of galactic halo objects. The distribution of stellar luminosities of its microlensing candidates agrees with that of LMC stars, which is to be expected given that the dark lensing objects do not choose the LMC star that they will lens for. The distribution of magnifications is also compat-

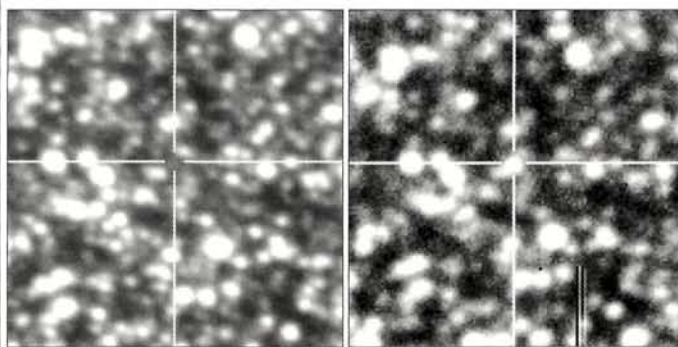


Figure 2: An example of a spectacular microlensing event in the Large Magellanic Cloud, first detected by the MACHO group in May 1999. Left: the position of the corresponding source star is indicated by the cross on this composite image, constructed from 10 EROS images taken many months before the magnification. (The star, barely visible, was not detected by EROS.) Right: the star is magnified by microlensing 40-fold in this image taken two days before maximum magnification.

ible with a random distance of the lens to the star's line of sight.

These two tests could have revealed a possible contamination of the sample by intrinsic variable stars, but they do not shed light on the position of the dark lenses. This can be achieved by studying the spatial distribution of microlensing candidates, which should follow that of LMC stars in the case of halo lenses, or be more peaked towards the LMC centre if the lenses are low-mass LMC stars.

The MACHO group finds that the observed distribution favours halo lenses, but that it cannot completely exclude LMC lenses. The two options are, of course, very different in terms of the galactic dark matter composition.

With three to four microlensing candidates towards the Magellanic Clouds over eight years, EROS has a harder time comparing measured and expected distributions. However, it makes the following observations: compared with MACHO, EROS has chosen to monitor less frequently more stars, spread over a three times wider solid angle. Thus the smaller EROS lensing rate could be interpreted as a spatial dependence of the event rate, favouring the LMC-lens hypothesis. Moreover, while MACHO seems rather confident that its sample is background free, no such claim is heard from EROS.

Small Magellanic Cloud

Finally, there is the question of the SMC, where one candidate was seen by both groups in 1997. This event is longer than those of all EROS or MACHO LMC candidates, which does not favour its interpretation as a halo lens: as the Magellanic Clouds are separated by only 20° in the sky and are at comparable distances from us, one would expect the characteristics of (halo) microlensing events towards both clouds to be very similar.

More quantitatively, the probability of this event being compatible with the LMC event durations is only 3%. On the contrary, as stellar velocities in the SMC are smaller than in those the LMC, it would be natural for SMC microlensing events to last longer if the lenses belong to the Magellanic Clouds.

In addition, the SMC event lasted long enough that the Earth had time to complete three-quarters of its orbit around the Sun during the magnification. This could have led to observable microlensing deformations. Such effects are not seen in EROS and MACHO data, implying that the lens is either a low-mass SMC star or a few solar-mass halo object. In the latter case its mass would not be compatible with that deduced from lenses towards the LMC.

Thus EROS concludes that this particular lens lies in the SMC. Much is expected from the comparison of LMC and SMC events but, because there are only a fifth the number of stars in the latter, no definitive conclusion can yet be reached. Nevertheless, EROS expects to be able to make a statement with an analysis of four years of data. The MACHO analysis of SMC images is also eagerly awaited.

If the MACHO interpretation is correct and there are plenty of half a solar mass objects in the galactic halo, the next challenge is to find out what they are. They cannot be ordinary stars, because these would be bright enough to be visible. One exotic scenario is primordial black holes made in the early universe at the time of the quark-hadron transition. Old white dwarf stars are another possibility: there are counter-arguments to their abundant presence in the halo, but they have the advantage that they could be detected by looking for nearby, dim high-velocity objects. Some groups are conducting such searches, including EROS. One group, led by R Ibatia (Max Planck, Heidelberg), has claimed the detection of a few halo white dwarfs, but their interpretation as halo objects is unconfirmed.

Valuable results

Whatever the future developments involving galactic dark matter, microlensing surveys have already provided concrete results. The lensing probability towards the centre of the galaxy was found by the OGLE and MACHO groups to be three times as large as expected, so that microlensing can teach us much about galactic structure.

The surveys have also yielded many variable stars. This has allowed, for example, studies with unprecedented statistics of Magellanic Cloud Cepheids, a pivotal cosmic yardstick, as well as the discovery of new types of variable stars.

Finally, the monitoring of long microlensing events of bright stars provides a novel way to look for planets around the lenses. Compared with the current, highly successful searches that use precise measurements of stellar radial velocities, microlensing should be sensitive to lower-mass planets orbiting more distant and more typical stars.

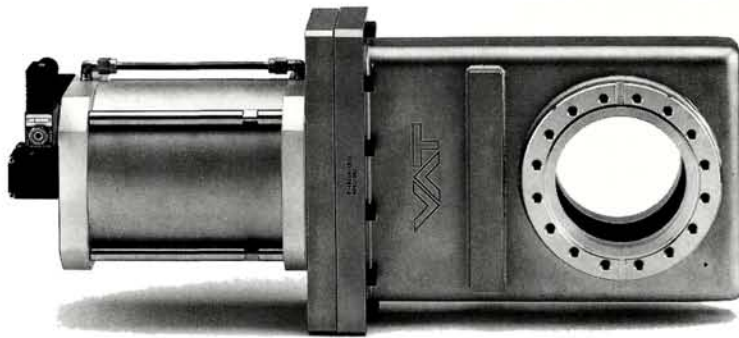
There is a good chance that, after reconciling their results, EROS and MACHO will soon agree. A conclusion that can already be drawn is that the largest part of galactic dark matter does not comprise of dark astronomical objects lighter than a few solar masses.

As far as microlensing is concerned, the search should now be extended to longer events corresponding to heavier lensing objects. In parallel, the groups looking for other dark matter candidates, such as Weakly Interacting Massive Particles, with underground or underwater detectors or at large particle accelerators, will certainly be encouraged by the recent microlensing results.

Alain Milsztajn is a member of the DAPNIA laboratory at Saclay.

All-metal Gate Valves

compact • reliable • unique



- the worldwide proven standard, industrially manufactured (ISO 9001)
- full range from DN 16 to DN 400
- many options available, specials on request

Swiss Headquarters

Tel ++41 81 771 61 61
Fax ++41 81 771 48 30
Email reception@vat.ch

VAT France

Tel 01 69 20 69 11
Fax 01 69 20 90 08
Email france@vatvalve.com

VAT Germany

Tel (089) 46 50 15
Fax (089) 46 37 65
Email vatdeu@t-online.de

VAT U.K.

Tel 0208 346 1999
Fax 0208 343 1104
Email uk@vatvalve.com

VAT Japan

Tel (045) 333 1144
Fax (045) 333 7024
Email info@vatskk.co.jp

VAT USA

Tel (781) 935 1446
Fax (781) 935 3940
Email usa@vatvalve.com

Visit our website at
www.vatvalve.com

Y19901DA

Take Control . . . Lake Shore's New 331 Temperature Controllers



Lake Shore introduces the Model 331 Temperature Controllers, Lake Shore's next generation of mid-price range temperature control instruments.

Intelligently designed and well-integrated for high performance and ease of use, the Model 331 Temperature Controllers are suitable for most cryogenic and many higher temperature measurement and control applications.

The Model 331 Temperature Controllers combine the easy operation and unsurpassed reliability of Lake Shore's Model 330 with improved sensor input and interface capability, including with negative temperature coefficient RTDs.



- Two control loops
- Supports diodes, Cernox™, Rox™, Thermox™, Carbon-Glass™, germanium, platinum, rhodium-iron, and thermocouple sensors
- Two sensor inputs
- Large vacuum fluorescent display
- One-touch access to commonly used functions
- Model 330 emulation mode
- Current reversal
- Autotuning
- Alarms
- IEEE-488 and RS-232 interface

www.lakeshore.com

Lake Shore Cryotronics, Inc.
575 McCorkle Blvd. • Westerville OH 43082
Tel: (614) 891-2244 • Fax: (614) 818-1600
marketing@lakeshore.com

Physicists brim with confidence

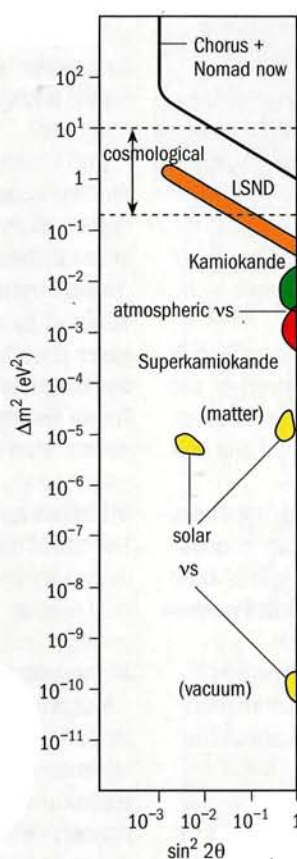
In the quest for new, higher-precision measurements, handling experimental results is an essential and increasingly important part of modern research, but it is rarely discussed in the open. A recent workshop at CERN remedied this.

The first conference for high-energy physicists devoted entirely to statistical data analysis was the Workshop on Confidence Limits, held at CERN on 17–18 January. The idea was to bring together a small group of specialists, but interest proved to be so great that attendance was finally limited by the size of the CERN Council Room to 136 participants. Others were able to follow the action by video retransmission to a room nearby. A second workshop on the same topic was held at Fermilab at the end of March.

Confidence limits are what scientists use to express the uncertainty in their measurements. They are a generalization of the more common “experimental error” recognizable by the “plus-or-minus sign”, as in $x = 2.5 \pm 0.3$, which means that 0.3 is the expected error (the standard deviation) of the value 2.5. In more complicated real-life situations, errors may be asymmetric or even completely one-sided, the latter being the case when one sets an upper limit to a phenomenon looked for but not seen. When more than one parameter is estimated simultaneously, the confidence limits become a confidence region, which may assume bizarre shapes, as happens in the search for neutrino oscillations.

Analysis methods

Why the sudden interest in confidence limits? As co-convenors Louis Lyons (Oxford) and Fred James (CERN) had realized, the power and sophistication of modern experiments, probing rare phenomena and searching for ever-more exotic particles, require the most advanced techniques, not only in accelerator and detector design, but also in statistical analysis, to bring out all of the information contained in the data (but not more!).



With several parameters being estimated simultaneously, confidence limits become a confidence region, which may assume bizarre shapes, as happens when a variety of different experiments search for neutrino oscillations.

As invited speaker Bob Cousins (UCLA) wrote several years ago in the *American Journal of Physics*: “Physicists embarking on seemingly routine error analyses are finding themselves grappling with major conceptual issues which have divided the statistics community for years. While the philosophical aspects of the debate may be endless, a practising experimenter must choose a way to report results.”

One of these “major conceptual issues” is the decades-old debate between the two methodologies: frequentist (or classical) methods, which have been the basis of almost all scientific statistics ever since they were developed in the early part of the 20th century; and Bayesian methods, which are much older but have been making a comeback and are considered by some to have distinct advantages.

With this in mind, the invited speakers included prominent proponents of both of the techniques. In the week leading up to the workshop, Fred James gave a series of lectures on statistics in the CERN Academic Training series. This provided some useful background for a number of the participants. The workshop benefited from a special Web site that was designed by Yves Perrin and that now contains write-ups of the majority of the talks (see “<http://www.cern.ch/CERN/Divisions/EP/events/CLW/>”).

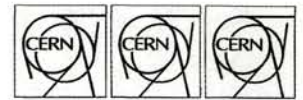
One of the items that caused some amusement was the list of required reading material to be studied beforehand. The rumour that participants would be required to pass a written examination was untrue. Also unfounded was the suggestion that the convenors had something to do with the headline of the CERN weekly *Bulletin* that appeared on the opening day of the workshop: ▷



Louis Lyons of Oxford (top) and Fred James of CERN, co-convenors of the workshop on confidence limits.



bulletin



Dernier délai pour soumission des articles : mardi 12.00 h
Les articles du Bulletin se trouvent également sous
<http://Bulletin.cern.ch/News/>

Deadline for submission of articles : Tuesday 12.00 hrs
Bulletin articles can also be found at
<http://Bulletin.cern.ch/News/>

Semaine du lundi 17 janvier

no 3/2000

Week Monday 17 January

Le CERN affronte le nouveau millénaire avec confiance

CERN confronts the New Millennium with Confidence

Le Conseil du CERN au sein duquel les représentants des 20 Etats membres de l'Organisation décident du programme scientifique et des ressources financières, a tenu sa 114e session le 17 décembre, sous la présidence de M. Hans C. Eschelbacher (DE).

The CERN Council, where the representatives of the 20 Member States of the Organization decide on scientific programmes and financial resources, held its 114th session on 17 December under the chairmanship of Dr. Hans C. Eschelbacher (DE).

CERN's corporate end-year announcement was not meant to refer to the forthcoming workshop on confidence limits and statistical data analysis held at CERN.

"CERN confronts the New Millennium with Confidence".

In his introductory talk, Fred James proposed some ground rules: that all methods should be based on recognized statistical principles and therefore should be labelled either classical or Bayesian; for classical methods, the frequentist properties should be known, especially the coverage; a method is said to have coverage if the 90% confidence limits are guaranteed to contain the true value of the parameter in 90% of the cases, were the experiment to be repeated many times, no matter what the true value is.

Bayesian methods, on the other hand, require the specification of a prior distribution of "degrees of belief" in the values of the parameter being measured, so proponents of Bayesian methods were invited to explain what prior distribution was assumed and how they justified it.

Bayesians were also asked to explain how they define probability and how they reconcile their definition with the probability of quantum mechanics, which is a frequentist probability. James then offered the view that, in the last analysis, a method would be judged on how well its confidence limits fulfilled three criteria:

- Do they give a good measure of the experiment's sensitivity?
- Can they be combined with limits given by other experiments?
- Can they be used as input to a personal judgement about the validity of a hypothesis?

Provocative views

Bayesian methods were illustrated with several examples by Harrison Prosper (Florida) and Giulio D'Agostini (Rome). D'Agostini gave some very provocative views, completely rejecting orthodox (classical) statistics. He said: "Coverage means nothing to me." Prosper presented a more moderate Bayesian viewpoint, explaining that he was led to Bayesian methods because the frequentist approach failed to answer the questions that he wanted to answer. He was aware of the arbitrariness inherent in the choice of the Bayesian prior, but felt that it was no worse than that of the ensemble of virtual experiments necessary for the frequentist concept of coverage. He also found that

the practical problem of nuisance parameters (such as incompletely known background or efficiency) is easier to handle in the Bayesian approach.

Bob Cousins (UCLA) summarized the main problems besetting the two approaches, contrasting the questions addressed by the various methods and the different kinds of input required. The influential 1998 article that he wrote with Gary Feldman (Harvard) on a "unified approach" to classical confidence limits was quickly adopted by the neutrino community and occupied an important place already in the 1998 edition of the widely used statistics section of the *Review of Particle Physics*, published by the Particle Data Group. He summarized his hopes for this workshop with a list of 10 points "we might agree on".

Different approaches

The rest of the workshop largely confirmed Cousins' hopes, because there was little serious opposition to any of his points, and in the final session the most important practical suggestion - that experiments should report their likelihood functions - was actually put to a vote, with the result that there were no voices against.

Variations of the method of Feldman and Cousins were proposed by Carlo Giunti (Turin), Giovanni Punzi (Pisa), and Byron Roe and Michael Woodroffe (Michigan). Woodroffe and Peter Clifford (Oxford) were the two statisticians invited to the workshop. They played an important role as arbiters of the degree to which various methods were in agreement with accepted statistical theory and practice. From time to time they gently reminded the physicists that they were reinventing the wheel, and that books had been written by statisticians since the famous tome by Kendall and Stuart.

Searches for the Higgs boson are being conducted at CERN's LEP Collider and at Fermilab's Tevatron. At LEP, Higgs events are expected to have a relatively clear signature, so selection cuts to reduce unwanted backgrounds can be fairly tight, and the number of candidate events is relatively small.

To make optimum use of the small statistics, it has been found

A classical method is said to have coverage if the 90% confidence limits are guaranteed to contain the true value of the parameter in 90% of the cases, were the experiment to be repeated many times, no matter what the true value is.

that a modified frequentist approach – the CL_s method, described by Alex Read – provides, on average, more stringent limits than a Bayesian method. The required computing time is significant, so techniques to help reduce this were discussed.

In contrast, Higgs searches in proton-antiproton collisions at the Tevatron are far more complicated and result in a larger background. Because of the larger numbers of events, the use of a Bayesian approach is quite reasonable here. These and other searches in the CDF experiment at the Tevatron were described by

John Conway (Rutgers). The final session of the workshop was devoted to a panel discussion that was led by Glen Cowan (Royal Holloway), Gary Feldman, Don Groom (Berkeley), Tom Junk (Carleton) and Harrison Prosper.

Workshop participants had been encouraged to submit topics or questions to be discussed by the panel. As was fitting for a workshop devoted to small signals, the number of submitted questions was nil. This did not prevent an active discussion, with Bayesian versus frequentist views again being apparent. The overwhelming view was that the workshop had been very useful. It brought together many of the leading experts in the field, who appreciated the opportunity to hear other points of view, and to have detailed discussions about their methods. For most of the audience it provided a unique chance to learn about the advantages and limitations of the various methods available, and to hear about the underlying philosophy. Animated discussions spilled over from the sessions into the coffee breaks, lunch and dinner.

New challenges

Several problems clearly remain. Producing a single method that incorporates only the good features of each approach still looks somewhat Utopian. More accessible may be challenges such as how to combine different experiments in a relatively straightforward manner (this will be particularly important in Higgs searches in the Tevatron run due to start in 2001); dealing with “nuisance parameters” (such as uncertainties in detection efficiencies or backgrounds) in classical methods; and reducing computation time. It was also apparent that simply quoting a limit is not going to be enough. If it is to be useful, it is necessary to specify in some detail the assumptions and methods involved.

The organizers are now putting together proceedings, which will include all of the discussions and hopefully summaries of all of the talks. It should appear as a CERN Yellow Report. The audience at this workshop was predominantly from European laboratories. A similar meeting was held at Fermilab on 27–28 March. □

180 000 Euros Refurbished 18 MeV Linac

one year full warranty
maintenance and extended warranty possible

e-gun, accelerating section
80mA pulsed beam, 200Hz
digital control command, modulator, klystron

For more information, please contact us :
e-mail at : jmalglaive@aol.com or call
Jean Charles Malglaive at 33 1 30 83 01 81
fax : 33 1 30 83 01 89

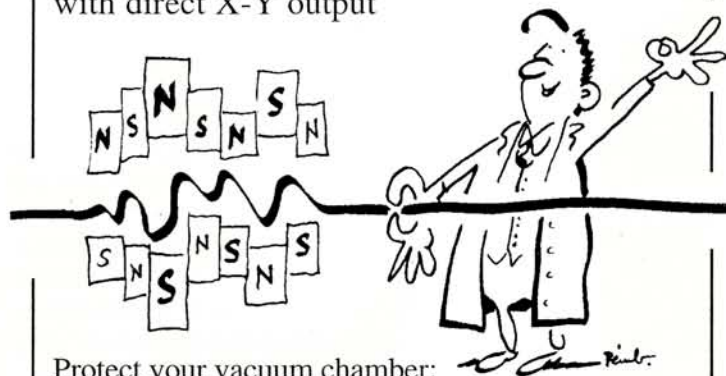
EURO MeV

**Linacs & cyclotrons
Refurbishing & maintenance**

655 avenue Roland Garros
BP 204
F-78532 BUC Cedex
France

Local Feedback for Ondulators and Wigglers

High-resolution BPM
with direct X-Y output



Protect your vacuum chamber:
3-ms interlock
Technical specs at www.bergoz.com

BPMs as used on ALS, APS, BEPC, DAFNE, DELTA, DESY-III, Duke, ETL, Helios, HERA, Hiroshima, LEP, LNLS, LSU, LURE, NSRL, PLS, SIAM, SLS, SPring-8, SRRC, SRS, Tohoku...

U.S.A./Canada:
GMW Associates
sales@gmw.com

Japan:
Repic Corporation
sales@repic.co.jp

bergoz

Instrumentation

Espace Allondon Ouest
01630 Saint Genis-Pouilly, France
sales@bergoz.com

Swedish accelerators

In the years immediately after the Second World War, several countries that were pushing to develop more powerful particle accelerators created an exclusive club. A recent symposium in Uppsala looked back to the first Swedish post-war accelerators.

The first cyclotron in Sweden was a small 80 cm device built in 1938 at the Nobel Institute in Stockholm and capable of accelerating deuterons to 7 MeV. After the Second World War, an ambitious new machine at Uppsala took energies into a new domain.

The 50th anniversary of accelerator-based research at Uppsala, on 8 December 1999, merited a jubilee symposium. Gunnar Tibell, Sven Kullander and Arne Johansson looked back, while Bo Höistad, Göran Possnert, Nils Olsson, Jörgen Carlsson and Curt Ekström surveyed the present scene and looked to the future.

The first two copies of a new book (in Swedish), relating half a century of accelerator-based activities in Uppsala and edited by Torsten Lindqvist, was handed to the vice-chancellor of the university, Bo Sundqvist, and to Helge Tyrén, former professor of high-energy physics.

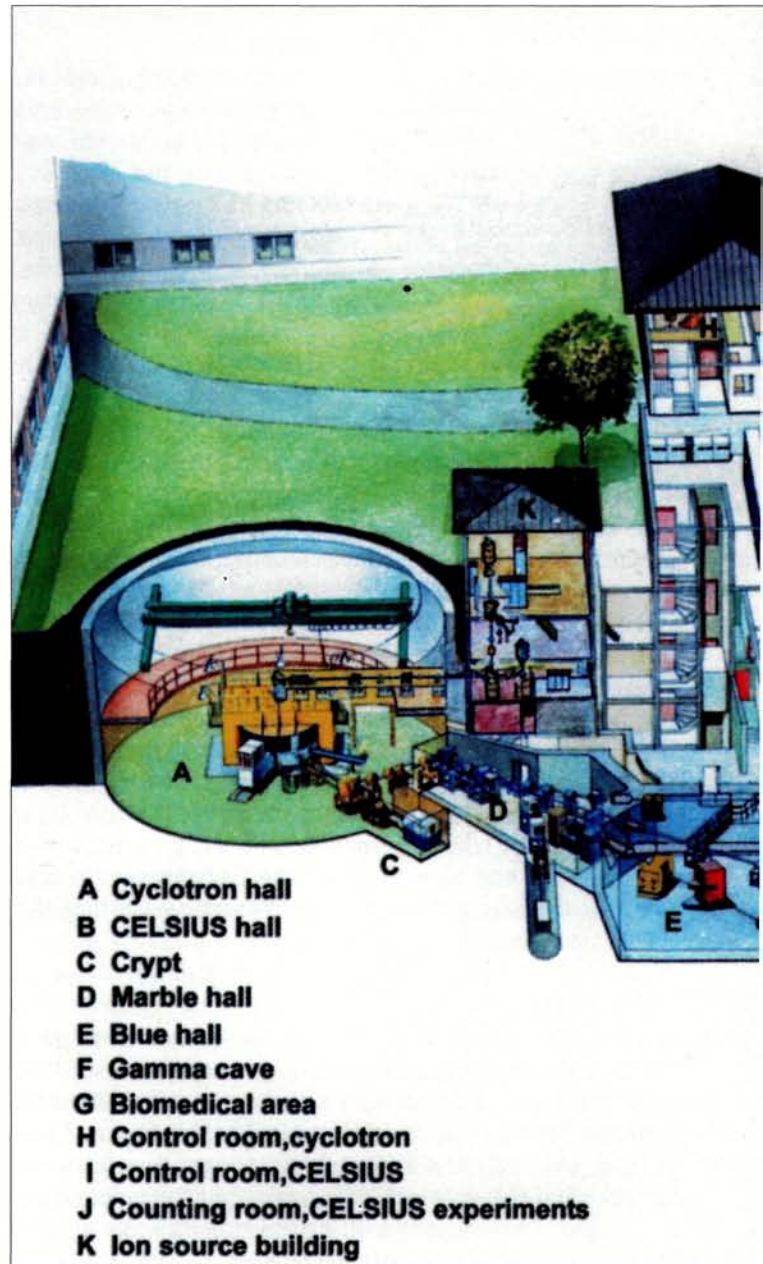
In the early 1940s, Tyrén, a student of 1926 Nobel Chemistry Laureate Theodor Svedberg, had constructed a neutron generator for the production of radionuclides. In Svedberg's discussions with the main customer of these radionuclides, gynaecology professor John Naeslund, plans emerged for a more powerful accelerator – a cyclotron – to increase the quantities of radioactive substances.

Naeslund's wife knew Göteborg textile magnate Gustaf Werner, who was the richest person in Sweden at that time and known for his generosity. The firm Werner & Carlström offered to finance a cyclotron, and one of its research objectives was to see how synthetic fibres were affected by neutron irradiation.

From cyclotron to synchrocyclotron

In 1945 Tyrén visited cyclotron laboratories in the US. The original intention was to obtain drawings of a cyclotron with an energy of about 20 MeV for radioisotope production. However, during the visit he found that a new principle of accelerating particles to much higher energies had just been invented by E McMillan.

This principle of phase stability was tested and shown to work during the spring of 1946, while Tyrén was in Berkeley. The question was whether it was too early to implement this new idea in Uppsala. Tyrén managed to convince Svedberg that, instead of a cyclotron, a synchrocyclotron should be built, and Werner & Carlström had no

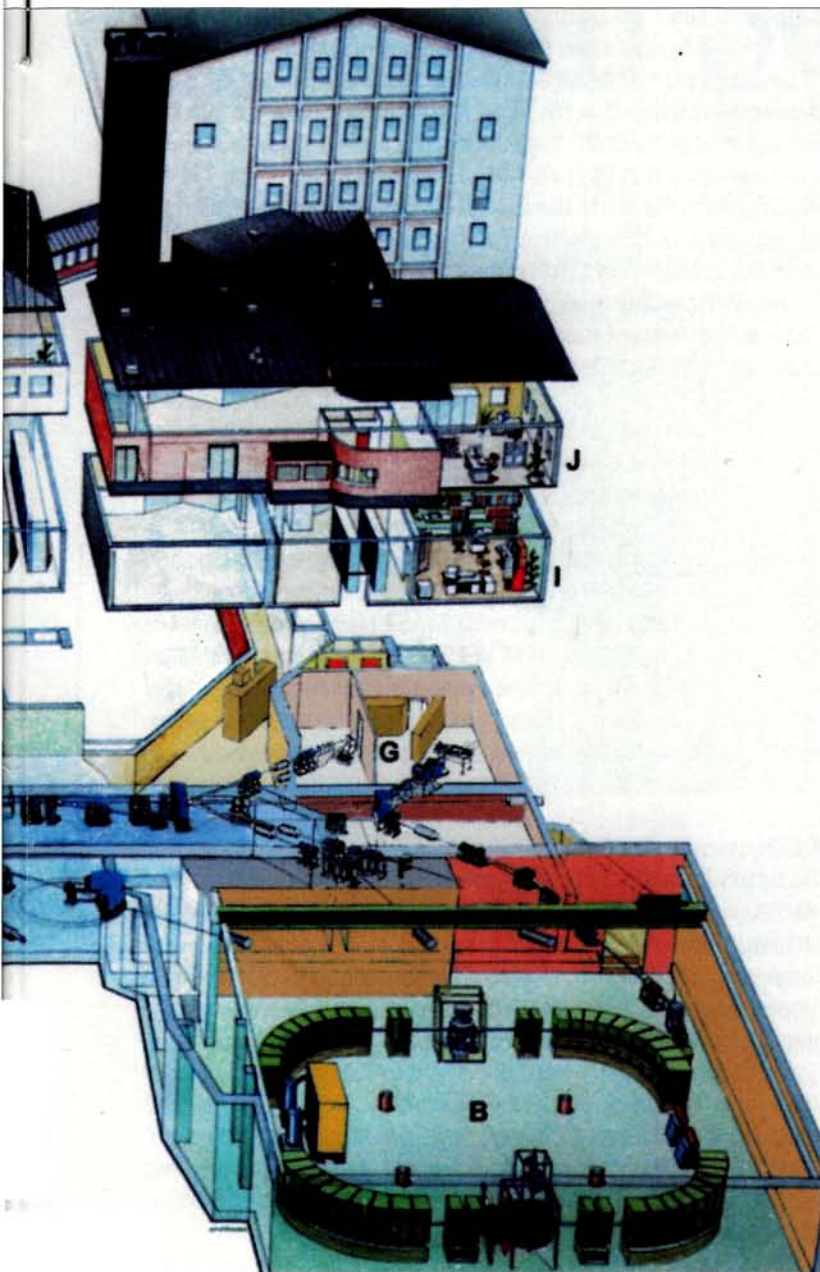


Schematic of today's The Svedberg Laboratory. The two accelerators are

objections. The instrument's energy of 200 MeV was above the threshold energy for the production of the newly discovered pi meson. Protons of this energy also have a sufficiently short wavelength to interact with individual nucleons in the nucleus, and the range in tissue is 25 cm, which is important for proton therapy.

On 8 December 1949, Crown Prince Gustaf Adolf inaugurated the

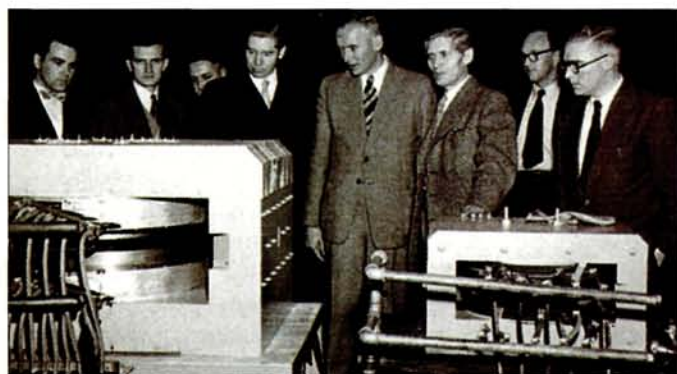
take a look at the past



below ground level.

Gustaf Werner Institute for Nuclear Chemistry (GWI). Exactly two years later, on 9 December 1951, Ernest O Lawrence, the inventor of the cyclotron, pressed the button to initiate the first beam circulating in the new synchrocyclotron.

For a few years, scientists in Uppsala could access protons of the highest energy in Western Europe. Several foreign physicists visited



With its accumulated expertise, the Gustaf Werner Institute (GWI) in Uppsala played a major role in work for CERN's first machine, the synchrocyclotron (SC). Inspecting a model magnet for the CERN SC in 1953 at Uppsala are, left to right, O Fredriksson (GWI), F Bonaudi (CERN), G Hansson (GWI), B Hedin (GWI), C J Bakker (CERN DG), Theodor Svedberg (GWI), H Tyrén (GWI) and T G Pickavance (CERN). In 1955 Bakker became CERN's director-general.

to familiarize themselves with these high-energy projectiles.

Meanwhile, CERN was founded and construction began for its first two accelerators: the synchrocyclotron (SC) and the proton synchrotron (PS). A large percentage of the Uppsala staff were recruited to take part in the build-up of CERN's new European laboratory. The Uppsala group, under Bengt Hedin, was responsible for the construction of the SC magnet.

A spectrum of research

A milestone in the development of the GWI was the extraction of the proton beam in 1955, giving more flexibility to the arrangement of nuclear physics experiments. Nuclear spectroscopy was always an important part of the research, both off line and on line. Among the intermediate-energy physics experiments were the first studies of quasi-free proton-proton reactions, and later studies of pion production on atomic nuclei – so-called sub-threshold reactions.

Biomedical research began under the leadership of Börje Larsson, who was later to become professor of radiobiology. He was one of the pioneers in the history of radiosurgery, as well as in other therapeutic and diagnostic uses of the proton beam at the GWI. On 23 November 1957, in a pioneer proton irradiation of a malignant human cancer, he and physician Stig Stensson irradiated a woman suffering from a large malignant tumour of the uterus. In 1958 Boerje Larsson also participated, together with medical doctors Lars Leksell and Bror Rexed, in the first neurosurgery on patients.

For well over two decades, a large number of physics and biomedical research projects were carried out at the Uppsala



The first doctor to graduate from the GWI was Goesta Rudstam, who defended his thesis in January 1957. Here he is being questioned by the "second" opponent, Goeran Andersson. Both were very active for the first ISOLDE on-line ion source at CERN.

machine. In 1977 it was closed for a major overhaul and also modification into a sector-focusing synchrocyclotron. It was reopened in 1986, with much improved performance. The energy can be varied in the 20–190 MeV range for protons, and a variety of different ions can be accelerated.

From ICE to CELSIUS

As well as providing beams for physics and biomedical research, the cyclotron is an injector for the cooler storage ring CELSIUS

(Cooling with Electrons and Storing of Ions from the Uppsala Synchro-cyclotron). The CELSIUS proton energy can be raised to well over 1 GeV, making a new field of research available to the physicists.

CELSIUS uses the lattice magnets of the Initial Cooling Experiment (ICE), which was built at CERN in the late 1970s. The decision to send the equipment to Sweden was taken by CERN Council in December 1982, and additional funding for the ring was included in the 1983/4 budget of the Swedish Ministry of Education.

Ongoing work to improve the machine and extend laboratory space was accelerated so that the "new" ring could be accommodated. In the summer of 1983, 20 trucks transported the 40 magnets and 4 coils from Geneva to Uppsala. The experience acquired in building the ICE ring was of value to the CELSIUS project, and in particular the contributions by CERN's Heiner Herr and Alfredo Susini should be mentioned. The first CELSIUS proton beam circulated in 1988.

The GWI ceased to exist in 1986, when it, together with the Tandem Accelerator Laboratory, formed a new national laboratory – the The Svedberg Laboratory ("The" is an abbreviation of Theodor), and a new university department, the Department of Radiation Sciences, with units in high-energy physics, nuclear physics, ion physics and physical biology.

Today around 300 physicists and medical researchers, from Sweden and abroad, use the two The Svedberg Laboratory accelerators. The Programme Advisory Committee can only accept a fraction of the proposed experiments. Notable experiments are those performed by two large collaborations – WASA (CERN Courier October 1999 p8) and CHICSi, both at CELSIUS, and operating with light and heavy ions, respectively. The storage ring has two internal target stations – one for a gas jet target and one for pellets of frozen hydrogen or deuterium. Among the SC projects, international teams are using a neutron beam for both fundamental and applied research.

CERN contributions

Scientists from the GWI, and since 1986 from the Department of Radiation Sciences, have been very active in research at CERN. At the end of the 1960s, accelerator physicists contributed to the improvement of the SC, where experiments were initiated by an Uppsala group in 1967. Later SC experiments were carried out on pionic atoms and muon-induced fission.

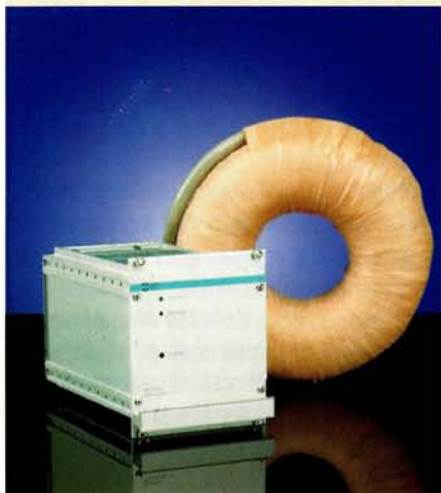
At CERN's LEAR antiproton ring, the production of heavy hyper-nuclei and lambda-antilambda pairs were studied. Pion-helium and proton-helium interactions were studied at the PS between 1967 and 1976. In 1977 the Uppsala group took part in one of the first experiments at the SPS proton synchrotron: hadron-hydrogen elastic scattering in the Coulomb interference region.

Since 1980 the group has collaborated in studies using CERN's high-energy muon beam for the determination of polarized and unpolarized structure functions from nucleons and nuclei. A significant contribution to the build-up of the RICH detectors for the Delphi experiment at LEP has been made, as well as the running and analysis of Delphi. For the future LHC collider, the Uppsala group contributes to the semiconductor tracker for the ATLAS collaboration.

Sven Kullander, Uppsala.

The proven performers

Zero-flux™ DC measuring systems



Curacc

The high stability performer

Zero-flux™ system with current output

For currents up to 6.000 A

Linearity error less than 2 ppm

Temperature stability < 0.05 ppm/K

Used as feed-back element or as current reference



Hitec Power Protection by
Division Special Measuring Systems
P.O. Box 4
7550 GA Hengelo, The Netherlands



Phone : +31 74 246 28 53
Fax : +31 74 246 26 78
E-mail : sales@hitecsms.com
Internet: www.hitecsms.com

Scintillations in Seattle

Making invisible physics visible has always called for ingenuity. The techniques can also lead to important applications in other areas. Two meetings in Seattle offered an update on developments. *Paul Lecoq, Dale Bailey and Christian Michel report.*

The regular IEEE Nuclear Science Symposium is a shop window for developments in technology and instrumentation for both nuclear science and spin-off areas. For both of these directions, one of the highlights of the recent Seattle meeting was the parallel sessions on inorganic scintillators.

Scintillators now form a major focus for calorimetry (energy measurement) in several large high-energy physics detector projects – Belle and BaBar are already in operation with CsI(Tl) crystals, and even bigger projects are under construction, such as the lead

tungstate investment for the CMS and ALICE experiments at CERN's future LHC collider. Other future studies, such as BTeV at Fermilab, and some nuclear physics studies also focus on lead tungstate.

These groups have organized profitable collaborations with crystal manufacturers and producers. Here the goals are to optimize the crystals for the requirements of the particular experiment as well as mass-production.

Such scintillators are also being used increasingly in the important spin-off sector of medical imaging for a new generation of cameras for nuclear medicine. With clinical studies and diagnostics supplemented by basic biomedical research and pharmacokinetics evaluations, this camera market is expanding rapidly. In the quest for optimal image precision and contrast for minimal patient radiation dose, the requirement for high spatial and time resolution somehow clashes with the need for high sensitivity.

Basic research into energy transport and scintillation mechanisms, initiated at CERN and in the US some 10 years ago, help to define guidelines for the development of new, dense, high-light-yield, fast materials. After years of hit and miss, an element of predictability has emerged. For example, it is no surprise that lutetium



Lead tungstate crystals for the CMS electromagnetic calorimeter at CERN's LHC collider.

or gadolinium are the main constituents of most of the new host lattices and that cerium is the favourite luminescence activator for fast scintillation.

Several presentations on lithium- and boron-based scintillators confirmed the rapidly growing interest for new neutron-sensitive materials for use in neutron spallation source projects and the monitoring of nuclear waste.

Medical imaging

Seattle also featured the IEEE Medical Imaging Conference (MIC). This meeting evolved from

the traditional Nuclear Science Symposium (NSS) a number of years ago and now runs in parallel under a common organizing umbrella.

This reflects the interest in applying nuclear science techniques in medicine. The identification of the MIC as a mature entity within the same framework as NSS allowed the scope of the NSS/MIC to expand, so that today it is not only the most important meeting in the international calendar for new developments in detectors and acquisition systems for the detection of ionizing and non-ionizing radiation in general, but also the main meeting for presenting new nuclear medicine systems along with algorithms for medical image reconstruction. The number of submitted abstracts was more than 500, shared equally between MIC and NSS.

Chaired by Grant Gullberg and Larry Zeng from Utah, the recent MIC began with a joint session, shared with the NSS, on new detectors for measuring gamma radiation. Solid-state detectors have not yet made great inroads in medical imaging devices, but this session showed that this transition is starting to take place.

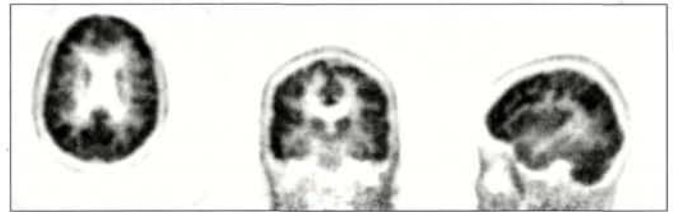
In general, there was great interest in new detectors. The field of positron emission tomography (PET) is moving into the vast arena of clinical diagnostic application with established inorganic



1988 Nobel prizewinner and former Fermilab director Leon Lederman was lunch speaker at the IEEE Nuclear Science Symposium and Medical Imaging Conference in Seattle.

scintillators (NaI(Tl), bismuth germanate - BGO), but at the same time new detector materials are being incorporated into clinical systems.

Lutetium oxyorthosilicate doped with cerium, originally developed by Schlumberger-Doll for geophysical applications, looks certain to be the detector material for annihilation radiation measurements in medicine for the next decade or more. This scintillator has almost the same stopping power as BGO but offers a much faster decay response time.



Nuclear science techniques have traditionally pushed the technology for medical diagnostics – first fluorodeoxyglucose brain images (from left: transverse, coronal and sagittal reconstructed sections) obtained with the High Resolution Research Tomograph. (Dieter Heiss and Klaus Wienhard, Max Planck Institute for Brain Research, Cologne.)

Presentations on this exciting new scintillator included a report on the first full PET system built using this set-up by one of the main companies in the field (CTI PET Systems, Knoxville, Tennessee) and the Max Planck Institute in Cologne.

Other topics included new scanners that combine traditional anatomical devices – X-Ray computer tomography (CT), magnetic resonance imaging (MRI) – with features from PET and its gamma-emitting counterpart, single photon emission computed tomography, new algorithms for finding the solution of “inverse problems” encountered in medical imaging, and applications of simulation in the design and testing of imaging systems.

Model 218

Setting the Standard in Temperature Monitoring

www.lakeshore.com

sales@lakeshore.com

8 Channels!

- All sensors read twice each second
- Individual current excitation
- Eight displays of temperature, volts or ohms
- Platinum RTDs, Silicon Diodes and NTC Resistive sensors

Lake Shore Cryotronics, Inc. • 575 McCorkle Blvd.
Westerville, OH 43082 • Phone: (614) 891-2244 • Fax: (614) 818-1600

Faster responses

A number of papers focused on the problem of measuring the density distribution of the body for use in correcting for the attenuation of photons, and allowing for the unwanted contribution of Compton scattered photons in images. New detectors with faster response times and improved energy resolution may contribute to this area.

While the meeting was dominated by emission tomography (single-photon and positron emitters), there is increasing interest in MRI, spiral X-Ray CT and other medical imaging methods.

Arrangements are well advanced for the IEEE Nuclear Science Symposium and Medical Imaging Conference 2000 in Lyon in October, the first time that this important meeting will come to Europe. In addition to the usual scientific papers, the organizing committee anticipates increased interest from exhibitors of a highly technical nature, and a number of short courses aimed at PhD student/postdoctoral graduate level in topics of current interest in image reconstruction and multimodality imaging. These would also serve as a useful introduction to an experienced scientist or engineer in high-energy physics who might have an interest in applications in medicine. Last year's MIC Web site is at "<http://www.rad.med.utah.edu/mirl/mic99/mic99.html>". This year's NSS/MIC Web site is at "<http://nss2000.in2p3.fr/>".

Paul Lecoq of CERN reported on the IEEE Nuclear Science Symposium. **Dale Bailey** of the Department of Nuclear Medicine, Guy's & St Thomas' Hospital, London, and **Christian Michel** of Université catholique de Louvain, Louvain-la-Neuve, Belgium, reported on the Medical Imaging Conference.

7th International Conference on Synchrotron Radiation Instrumentation

<http://sri2000.tu-berlin.de>

Berlin

SRI

2000

Berlin, Germany
August 21 – 25, 2000

Hosted by Technische Universität Berlin
and



Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung



Scientific Chairmen

W. Gudat, BESSY
P. Zimmermann, TUB

Scientific Program

SR sources and beamline techniques

- Accelerators
- Insertion devices
- SR beam position monitors
- Optics and beamline design
- Mirrors, multilayers, gratings and crystals
- Microbeams

Industrial applications

Next generation SR sources and future science

Experimental techniques

- Spectroscopy
- Microscopy / Spectromicroscopy
- Imaging
- Diffraction and scattering
- Detectors
- Use of coherent and high energy SR beams
- Use of short bunches
- Two colour experiments
- Life sciences

Satellite Conferences

Metrology with Synchrotron Radiation

Application of Lasers in the VUV and soft X-Ray range

Microfabrication with Synchrotron Radiation

Conference Office

Technische Universität Berlin
Wissenstransfer (WTB 3) - SRI 2000 -
Steinplatz 1, D-10623 Berlin
Germany

Tel.: +49 - 30 - 314 21457 or 25686

Fax: +49 - 30 - 314 24098 or 24087

Email: kongresse@wtb.tu-berlin.de

homepage: <http://sri2000.tu-berlin.de>

Deadline

Early Registration: June 1, 2000

Computer control of



The mayor of Trieste, R Illy, welcomes participants at the opening session of the recent International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS).

Control by computer was once the domain of major facilities like particle accelerators. With these methods now being used across the board, a recent international conference on control systems for physics, held in Trieste, drew a large audience.

The changing face of physics and physics research is underlined by the increasing use of and emphasis on sophisticated control systems. Once dominated by systems for big particle accelerators, control systems are now widely used in other major facilities, and increasingly in large experiments.

This was demonstrated at the recent International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS), the scientific and technical programme of which covered controls for, among others, particle accelerators, detectors, telescopes, nuclear fusion devices and nuclear reactors.

ICALEPCS'99 saw an increased number of contributions from the plasma physics and astronomical community and also, although to a lesser extent, from the particle detector community. Philippe Charpentier of CERN presented a memorable talk entitled "The evolution of the DELPHI experiment control system - how to survive 10 years of running".

ICALEPCS looked at all aspects - hardware and software - of experimental physics control systems, but concentrated on how controls can contribute to the success of a major experiment. With



G Baribaud (left) of CERN, current chairman of the EPS Interdivisional Group on Experimental Physics Control Systems, awards the first EPS-EPCS prize to Thijs Wijnands of CERN during the ICALEPCS banquet at the Venetian "Villa Manin".

this objective in mind, different technology and engineering issues were covered. State-of-the-art software and hardware technologies were reviewed in terms of the possibilities that they offer for dealing with systems of increasing complexity and sophistication within restricted budgets and human resources.

Software

In the software domain, several applications that were described are based on Windows NT using the Common Object Request Broker Architecture (CORBA) as a distributed programming model. Examples are A Goetz (ESRF, France) with "Tango - an object oriented control system based on CORBA"; and C Scafuri (Sincrotrone Trieste, Italy) with "The ELETTRA object-oriented framework for high-level software development", as a distributed programming model, using Java as a programming language.

Noteworthy is the growth of Windows 98/NT, followed closely by Linux. Both are competing with the more traditional UNIX platforms. Increased geographical distribution of systems as well as requirements relating to remote observation and monitoring lead naturally to the application of the Web and related technologies (J Farthing, JET, UK - "Technical preparations for remote participation at JET").

The crucial role played by well integrated centralized data repositories was also emphasized by H Shoae (SLAC, Stanford) - "The role of a central database for configuration management". Indeed, controls are no longer stand alone systems but rather part of a unity that ties physics to other areas, both technical and administrative, in a Computer Integrated Manufacturing environment.

Although the Experimental Physics and Industrial Control System

physics is increasing



Posters under control – K Furukawa of KEK, Japan (right) and Chunhong Wang of IHEP, Beijing during one of the three ICALEPCS poster sessions, which brought delegates closer together.



D Bulfone (conference co-chairman, Sincrotrone Trieste), left, and A Daneels (conference co-chairman, CERN), right, after the closure of their ICALEPCS'99 meeting with (centre) M Mouat (TRIUMF, Canada) of the Conference Programme Committee.

(EPICS) is still rather popular as a framework and set of tools for developing control system software, both in the US (K White – “The evolution of Jefferson Lab’s control system”) and in some non-US labs, commercial Supervisory Controls and Data Acquisition (SCADA) systems are now penetrating the experimental physics “market” as well (A Daneels, CERN – “What is SCADA?”).

SCADA systems prove to be effective and efficient in controlling infrastructure systems such as vacuum, cryogenics, cooling, ventilation and personnel access, and in controlling experimental physics processes such as some small to medium-sized particle detectors.

In the wake of SCADA, technologies such as OLE for Process Controls (OPC) and SoftPLC are becoming more popular.

Hardware

The hardware domain makes increasing use of commercial Programmable Logic Controllers (PLC) connected to devices via fieldbuses, and of PCI (Peripheral Component Interconnect) and its related standards.

With restricted resources, and individual in-house development minimized in favour of buying industrial systems, the task of experimental physics control specialists is steadily moving towards the integration of these industrial products into an overall comprehensive and consistent control system.

Networks are being re-engineered using 100 Mbit/s Ethernet with GigaEthernet backbones, while the Asynchronous Transfer Mode (ATM) is also considered to be candidate technology for the long distance communication of time-critical accelerator data.

Of particular importance are timing systems (T Korhonen, PSI, Switzerland – “Review of accelerator timing systems”). Telescopes as

well as tokamaks and accelerators require highly stable, highly precise and highly flexible timing systems, both for event timing and counter-based systems.

The increasing complexity and sophistication of physics processes leads to the introduction of ever-more complex feedback systems, often themselves relying on measurements that need high data rates. Such high-performance measurements may require sampling rates as high as hundreds of megahertz and state-of-the-art Digital Signal Processors (DSP) (J Lister, CRPP-EPFEL, Switzerland – “The control of modern tokamaks”; J Safranek, SLAC – “Orbit control at synchrotron light sources”; and T Shea, Brookhaven – “Bunch-by-bunch instability feedback systems”).

In particular, new developments in the field of accelerator power supplies are taking advantage of the available digital technology by the use of embedded DSP controllers; the digital generation of high-stability, high-precision reference signals; and real-time algorithms for regulation (J Carwardine and F Lenkszus, Argonne – “Trends in the use of digital technology for control and regulation of power supplies”).

Engineering and management

The frequently unappreciated engineering and management aspects of control systems were also highlighted. The weight of maintenance and adaptation costs in software projects were discussed.

In the context of increasingly elaborate systems and reduced resources, and considering the progress demonstrated by industry in keeping proper control of the lifecycle of software development, project management and engineering have shown their worth in today’s physics world as well. Particular attention was paid to

requirements engineering, and emphasis was given to sharing experiences and techniques in these fields. Applications of solutions from the industrial world were also presented and discussed.

News content came from status reports from a variety of control and data acquisition projects of new experimental physics facilities. Among them were the Swiss Light Source (SLS), which is being built at the Paul Scherrer Institute in Villigen, Switzerland (S Hunt, PSI - "Control and data acquisition system of the Swiss Light Source"), and the Spallation Neutron Source (SNS), which is to be built in Oak Ridge, US (D Gurd, Los Alamos - "Plans for a collaboratively developed distributed control system for the Spallation Neutron Source"). Gianni Raffi from the European Southern Observatory summarized the meeting.

Added attractions

As well as the conference, two preconference workshops covered EPICS (Experimental Physics Industrial Control System) and SOSH (Software Sharing), which were organized by M Clausen of DESY and W A Watson of Jefferson Lab, respectively.

During the conference, a round table discussion, "Prospective directions in controls in geographically distributed collaborations", chaired by W Humphrey (SLAC) and involving H Burckhart (CERN), R Claus (SLAC), J Farthing (JET), D Gurd (Los Alamos) and G Raffi (ESO), focused on the management of projects developed by distributed teams and on the experience with the available tech-

nologies for long-distance interaction.

Four tutorials covered special topics: "Cases for requirements capture and tracing" (G Chiozzi, ESO); "Network technology" (G Montessoro, Udine); "Introduction to JAVA" (J P Forestier, OSYX, France); and "Introduction to OPC" (OLE for Process Control) (F Iwanitz, Softing, Germany).

ICALEPCS'99, the seventh biennial conference, was held in Trieste on 4-8 October 1999, hosted by Sincrotrone Trieste. It took place at the "Stazione Marittima", which has recently been restored as the city's congress centre.

The meeting was organized by Sincrotrone Trieste in conjunction with the European Physical Society's (EPS) Interdivisional Group on Experimental Physics Control Systems and the Istituto Nazionale di Fisica Nucleare. The International Scientific Advisory Committee was chaired by D Bulfone of Sincrotrone Trieste and A Daneels of CERN.

The meeting brought together some 400 control specialists from 32 different countries, covering Africa, the US, Asia and Europe, and representing 116 organizations. The proceedings are available at "http://www.elettra.trieste.it/ICALEPCS99". An industrial programme included an exhibition and seminars.

During the conference the EPS Experimental Physics Control Systems prize was awarded for the first time. It went to TWijnands of CERN for an advanced plasma control system for TORE SUPRA.

From D Bulfone, Sincrotrone Trieste.

NEW PRODUCTS

Dantec offers LDA signal processors

Dantec Measurement Technology's two new LDA signal processors - the BSA F70 and the BSA F50 - combined with Dantec's BSA Flow Software package and FiberFlow or FlowLite transmitting/receiving optics, should provide complete solutions for flow and turbulence measurement across the spectrum of scientific and industrial research.

The new processors measure flow using Laser Doppler Anemometry (LDA), a non-intrusive optical technique used to measure velocity and turbulence in gases and liquids.

New features include 160 MHz Doppler frequency for high-velocity measurement; 120 MHz bandwidth for measurement in flows with high turbulence levels; 8-bit sampling; fast Fourier transform signal processing; and an Ethernet interface.

Contact Palle Gjelstrup, Dantec measurement

Technology A/S, Tonsbakken 16-18, DK 2740 Skovlunde, Denmark; tel. +45 44 57 80 00; e-mail "palle.gjelstrup@dantecmt.com".

Further information is available at "http://www.dantecmt.com/About/press/Index.html".

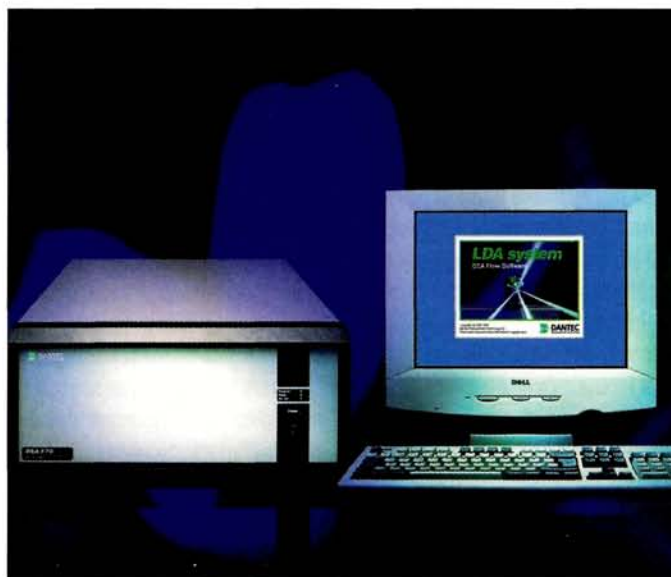
Diffpack Toolbox suits data exchange

Numerical Objects AS of Oslo has announced the release of Diffpack Datafilter Toolbox 1.0. This plug-in module for the Diffpack Multi-Physics Simulation Framework gives easy and safe import facilities for third-party finite

element meshes. In combination with the Diffpack Adaptivity Toolbox, it boosts preprocessing capabilities in Diffpack.

The Datafilter Toolbox can be used as a standalone file-to-file converter or as a linkable library that facilitates direct mesh import into customers' Diffpack applications.

The Diffpack product line is available on Win32 as well as the Linux, DEC, IBM, SGI, HP and Sun Unix platforms. Test versions of the software, documentation and application examples are available on a demonstration CD or for downloading from the Numerical Objects Web server at "http://www.nobjects.com".



Dantec's new LDA signal processors: BSA F70 and BSA F50.

FREE LITERATURE



Janis Research Co Inc

ST-400 Ultra High Vacuum Systems

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

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

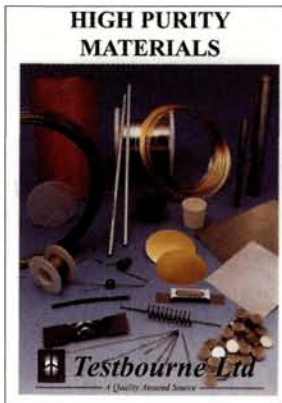


VAT Vacuum Valves 2000 Catalogue

From the World's Largest Supplier of Vacuum Valves

Request your free copy today. It's packed with details of over 1000 products including one of the industry's widest range of angle valves. From Viton-sealed, low-cost, high-cycle lifetime valves, to high-performance all-metal angle valves for extreme applications, VAT have the right angle valve to meet your needs.

VAT Vacuum Products Ltd
235 Regents Park Road, Finchley, London N3 3LG, UK
Tel. +44 (0)208 3461999
Fax +44 (0)208 3431104
E-mail uk@vatvalve.com



HIGH PURITY MATERIALS

Testbourne

Testbourne supplies a comprehensive range of high purity materials for both research and development and production.

the product range includes: crucibles, foils, lumps, pellets, powders, wires, thin film evaporation sources and sputtering targets.

Testbourne Limited
Unit 12
Hassocks Wood Estate
Stroudley Road
Basingstoke
Hampshire RG24 8UQ, UK
Tel. +44(0)1256 467055
Fax +44(0)1256 842929
E-mail testbourne@compuserve.com



Goodfellow

Metals and Materials in small quantities for R&D and prgtotype 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



November 27 - December 1
Boston, Massachusetts

Exhibit:

November 28-30

Materials Development
Characterization Methods
Process Technology

For additional meeting information, visit the MRS Web site at www.mrs.org or contact:



Member Services
Materials Research Society
506 Keystone Drive
Warrendale, PA 15086-7573
Tel 724-779-3003
Fax 724-779-8313
E-mail: info@mrs.org

Abstract Deadlines — In fairness to all potential authors, late abstracts will not be accepted.

June 5, 2000: for abstracts sent via fax or mail • June 19, 2000: for abstracts sent via the MRS Web site

2000 MRS FALL MEETING SYMPOSIA

Cluster 1: Nano-/Microstructured Materials

- A: Nanotubes and Related Materials
- B: Structure and Mechanical Properties of Nanophase Materials—Theory and Computer Simulations vs Experiment
- C: Anisotropic Nanoparticles—Synthesis, Characterization, and Applications
- D: Nanolithographic and Lithographic Methods for Nanofabrication—From Ultralarge-Scale Integration to Photonics to Molecular Electronics
- E: Microphotonics—Materials, Physics, and Applications
- F: Nano- and Microcrystalline Semiconductor Materials and Structures

Cluster 2: Semiconductors

- G: GaN and Related Alloys
- H: Silicon Carbide—Materials, Processing, and Devices
- I: Semiconductor Spintronics—Physics, Materials, and Applications
- J: Semiconductor Quantum Dots

Cluster 3: Metals

- K: Quasikrystals
- L: Supercooled Liquid, Bulk Glassy, and Nanocrystalline States of Alloys
- M: Thermal Barrier Coatings
- N: High-Temperature Ordered Intermetallic Alloys IX

Cluster 4: Materials Processing and Analysis

- O: Ion Beam Synthesis and Processing of Advanced Materials
- P: Growth, Evolution, and Properties of Surfaces, Thin Films, and Self-Organized Structures
- Q: Fundamentals of Nanoindentation and Nanotribology II
- R: Microstructural Processes in Irradiated Materials
- S: Applied Magnetic Field Effects on Materials Behavior
- T: Dynamics in Small Confining Systems VI
- U: Ultrafast Nonlinear Optical Phenomena
- V: Low-Vacuum SEM/ESEM in Materials Science: Wet SEM—The Liquid Frontier of Microscopy

Cluster 5: Defects, Mechanics, and Length Scales

- W: The Limits of Strength in Theory and Practice
- Y: Influences of Interface and Dislocation Behavior on Microstructure Evolution
- Z: Multiscale Materials Modeling
- AA: Structure-Property Relationships of Oxide Surfaces and Interfaces

Cluster 6: Device and Functional Materials

- BB: Characterization and Modeling of Domain Microstructures in Materials
- CC: Ferroelectric Thin Films IX
- DD: Materials Issues for Tunable RF and Microwave Devices II
- EE: Materials Science of Microelectromechanical System (MEMS) Devices III

Cluster 7: Inorganic Materials

- FF: Materials Science of High-Performance Concrete
- GG: Solid-State Chemistry of Inorganic Materials
- HH: Advanced Catalytic Materials - 2000
- II: High-Temperature Superconductors—Crystal Chemistry, Processing, and Properties

Cluster 8: Organic and Biomaterials

- JJ: Organic Electronic and Photonic Materials and Devices
- KK: Filled and Nanocomposite Polymer Materials
- LL: Orthopaedic/Dental Biomaterials
- MM: Cardiovascular Biomaterials
- NN: Biomaterials for Drug Delivery
- OO: Neurologic Biomaterials

Cluster 9: General

- X: Frontiers of Materials Research

2000 MRS FALL MEETING ACTIVITIES

SYMPOSIUM TUTORIAL PROGRAM

Available only to meeting registrants, the tutorials will concentrate on new, rapidly breaking areas of research.

EXHIBIT

Over 225 international exhibitors will display a full spectrum of equipment, instrumentation, products, software, publications, and services.

PUBLICATIONS DESK

A full display of over 630 books, plus videotapes and electronic databases, will be available at the MRS Publications Desk.

SYMPOSIUM ASSISTANT OPPORTUNITIES

Graduate students planning to attend the 2000 MRS Fall Meeting may apply for a Symposium Assistant (audio-visual aide) position.

EMPLOYMENT CENTER

An Employment Center for MRS members and meeting attendees will be open Tuesday through Thursday.

The 2000 MRS Fall Meeting will serve as a key forum for discussion of interdisciplinary leading-edge materials research from around the world. Various meeting formats—oral, poster, round-table, forum and workshop sessions—are offered to maximize participation.

PEOPLE

MEETINGS

Photon2000 – a conference on “the nature and interactions of the photon”

will take place in Ambleside, UK, on 26–31 August 2000. It will cover two-photon physics data from the LEP experiments and photoproduction results from HERA. E-mail “A.Finch@lancaster.ac.uk” or see “<http://www.photon2000.lancs.ac.uk/photon2000/>”.

The International Workshop on High Energy Photon Colliders, covering physics in high-energy gamma-gamma and gamma-electron collisions, laser and optical systems for photon colliders, processes in the conversion region, the production of polarized electrons with very low emittance, and the optimization of gamma-gamma and gamma-electron luminosities, will be held at DESY, Hamburg, on 14–17 June. E-mail “gg2000@mail.desy.de” or visit “<http://www.desy.de/~gg2000/>”.

The Fourth Rencontres du Vietnam, devoted to physics at extreme energies and to physics and astrophysics, will be held in Hanoi on 19–25 July and will focus on fundamental and current topics in particle physics and astrophysics from the experimental and theoretical points of view. More information is available at “<http://www-lpnhep.in2p3.fr/vietnam2000/>”.

Computing Marathon: the 2000 CERN School of Computing, organized by CERN in collaboration with the Institute of Nuclear Physics NCSR “Demokritos” of Athens, will be held on 17–30 September in Marathon, Greece. It is aimed at postgraduate students and research workers with a few years experience in particle physics, computing or related fields. Special themes this year are distributed computing, object-oriented design and implementation, and storage and software systems for data analysis. More information is available at “<http://www.cern.ch/CSC>”.

Correction

The Louis Michel obituary (March p42) should have read: “His corollary work on lepton polarization was soon brought to the fore with the discovery of parity violation in lepton decays. In the same period, he established for strong interaction physics the conservation of isotopic parity (later known as G-parity).” We regret the error.



Walter Oelert of Jülich receives the Merentibus Medal of Crakow's Jagellonian University for his efforts in promoting collaboration between physicists at the university and at the Jülich research centre, in the implementation of the research programme for meson production at threshold at Jülich's COSY accelerator, and for his key role in the first observation of antihydrogen atoms at CERN in 1995.

European Commissioner **Philippe Busquin** (centre) hears about cryogenics for CERN's LHC from CERN director-general **Luciano Maiani** (right) and LHC division leader **Philippe Lebrun**



Famous physicist and former Israeli Minister **Yuval Ne'eman** (right) explains a particle physics landmark to Israel's Science Minister **Matan Vilnai** during a visit to CERN on 20 March. In 1961 Ne'eman was one of the architects of what became known as the “Eightfold Way” – the SU(3) symmetry classification of particle multiplets.

Accelerator prizes

The European Physical Society Interdivisional Group on Accelerators (EPS-IGA) prize selection committee, under the chairmanship of V Suller of Daresbury, met in Geneva on 18 February to decide the award of the EPS-IGA prizes for 2000.

The EPS-IGA prize, awarded to a person early on in their career for a recent significant, original contribution to the accelerator field is awarded to **Pantaleo Raimondi** of SLAC, who has made a significant contribution to understanding the effects that, in a practical real-life situation, can be optimized at the interaction point of an electron-positron collider to improve the luminosity.

Through a deep appreciation of beam diagnostics and error analysis, he applied

numerous inventive techniques in beam-based alignment and beam optics to the Stanford Linear Collider, which resulted in a three-fold increase in its luminosity. An important breakthrough has been his analysis of the beam-beam deflection scan data in the flat beam situation. With proper allowance for beam disruption effects and from measuring the energy loss profile during the scan, Raimondi was able to estimate the individual transverse and longitudinal beam sizes at the interaction point.

Raimondi was also able to apply similar



Raimondi – improving collider performance.



The recent School of Instrumentation in Elementary Particle Physics organized by the International Committee for Future Accelerators at the University of Istanbul attracted 100 participants from all over the world. As well as formal lectures and laboratory work, the school included presentations on future experiments, in collaboration with industry, and instrumentation for medical imaging and particle astrophysics. The main organizers were M N Erduran and S Kartal from Istanbul and M Atac from Fermilab, with funding from CERN, the US Department of Energy/Fermilab, the US National Science Foundation, DESY, the Abdus Salam International Centre for Theoretical Physics in Trieste, and Istanbul and Bogazici universities.

techniques to CERN's LEP electron-positron collider during a visit to CERN in 1998-9. He introduced a new algorithm to allow the simultaneous correction of the measured momentum dispersion as well as the closed orbit position. This resulted in smaller beam sizes at collision with a corresponding increase in luminosity. He also suggested a way of using the LEP correctors to allow the energy to be increased by 0.2 GeV.

The prize is merited for the significant improvement that this innovative work has had on the performance of existing colliders, and the expectation that future colliders can be designed with increased confidence that the required performance can be attained through the application of his techniques.

The EPS-IGA prize to an individual for outstanding work in the accelerator field (with no age limit) is awarded to **Eberhard Keil** of

CERN for his profound knowledge and great experience in all aspects of accelerator physics. Keil is widely known and highly respected throughout the accelerator world. He has made seminal contributions in many fields, including instabilities, beam-beam effects, beam optics, nonlinear resonances and beam environment impedance. His work is evidenced by hundreds of reports and publications that he has authored during his career. A number of these are so fundamental that they are referenced in every major machine design study. Consequently he has contributed actively to almost every major accelerator that has been constructed in the past 35 years. He was one of the leaders of the 1977 LEP study group at CERN.

In addition to this, an outstanding characteristic of Keil, acknowledged by many who have worked with him, is his ability to act as a



At a ceremony at the French National Assembly, president of the French Foreign Affairs Commission **Jack Lang** (right) welcomed **Jean Tran Thanh Van** to the Legion of Honour. Jean Tran Thanh Van is the initiator of several physics meetings that have gone on to become regular features of the international science calendar – the Moriond (Rencontres de Moriond) meetings in the French Alps, the "Blois" elastic scattering conference and most recently in Vietnam.



Slovak Foreign Affairs Minister **Eduard Kukan** (right) with CERN director-general **Luciano Maiani** during a visit to CERN on 10 March.

bridge between theory and the ultimate realization of an accelerator. By translating theory in a comprehensible way, he has convinced others that the desired goals can be reached. In this way he has played an important role in the management of major scientific decisions relating to accelerator-based facilities. The accelerator community is greatly indebted to Keil's endeavours.

The two winners will make oral presentations at a special session during the European Particle Physics Conference in Vienna in June.



Keil – profound knowledge.

Karl Strauch 1922–2000

Karl Strauch, experimental high-energy physicist and Professor Emeritus at Harvard, died in Boston on 3 January at the age of 77 years. His death ended a 15 year struggle with Parkinson's disease.

Strauch's early research at Harvard's Cyclotron was on proton-nucleus scattering. Later, at Brookhaven's Cosmotron, he discovered the decay of the eta into two photons. In the early 1970s, as director of the Cambridge Electron Accelerator, he led experiments that produced tantalizing evidence for an additional degree of freedom, suggesting the existence of heavier quarks. His most recent research was carried out in major colliding beam experiments at CERN (L3), SLAC (Crystal Ball) and DESY (Crystal Ball).

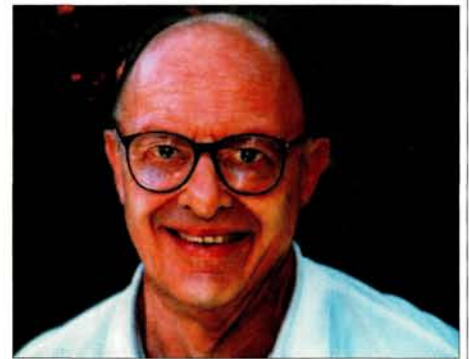
Strauch wrote more than 145 scientific papers and served on various national and international committees and commissions, including the Commission on Particles and Fields of the International Union of Pure and Applied Physics, and the US-USSR Joint Coordinating Committee on Fundamental

Properties of Matter. The latter was the chief conduit between the US and Soviet scientific communities during the height of the Cold War.

Strauch was born on 4 October 1922 in Giessen, Germany. His family was exiled in the mid-1930s for advocating democratic principles, and took up residence in Paris, where Strauch earned his Baccalaureate. In 1939 the family moved to California, where Strauch studied chemistry at Berkeley. After serving in the US Navy, he earned a PhD in Physics at Berkeley in 1950.

In 1950 Strauch was elected to Harvard's Society of Fellows, and he was appointed assistant professor three years later. He rose to become the George Vasmer Leverett Professor of Physics in 1975. He was director of the Cambridge Electron Accelerator, a joint Harvard-MIT facility, from 1967 to 1974, and he served as chairman of the Harvard physics department from 1978 to 1982.

His warm and friendly teaching style endeared him to his college students, and he



Karl Strauch 1922–2000.

firmly guided more than 20 graduate students as they began their physics careers.

Strauch also chaired two committees that significantly influenced the policies and culture of Harvard – the first recommended the merger of Harvard and Radcliffe's admissions offices and the institution of an admissions policy of equal access for women; and the second established the Science Center – the first multi-disciplinary sciences building in the college.

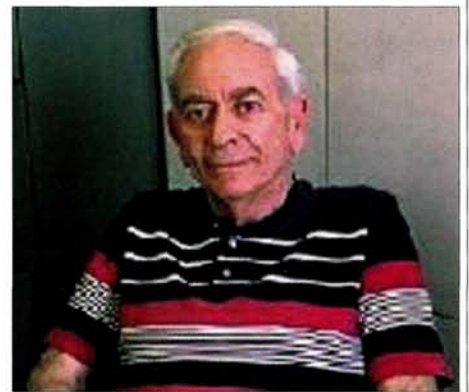
Strauch's enthusiasm for physics, deep insights and friendly smile will be missed by his former colleagues and students.

Dennis Sciama 1926–1999

Gifted and influential cosmologist Dennis Sciama was aware of the crucial role played by elementary particle interactions in the universe at large. His talks at frontier cosmology/particle physics meetings were informative and stimulating for all parties, and his schools at Cambridge and Oxford produced a generation of key cosmology figures.

From 1983, Sciama directed the astrophysics section of the International School for Advanced Studies in Trieste. He had a

strong flair for synthesis – introducing the First Symposium on the Large-Scale Structure of the Universe, Cosmology and Particle Physics, held in 1983 and organized by CERN and the European Southern Observatory, he said: "The convening of this symposium...makes it clear how widespread is the realization that particle physics on one hand, and astrophysics and cosmology on the other, are inextricably linked. This realization is of quite recent origin."



Dennis Sciama 1926–1999.

LETTERS

CERN Courier welcomes feedback but reserves the right to edit letters. Please e-mail "cerncourier@cern.ch".

Physics on stage

As one of the many delighted spectators at Miméscope's mesmerizing presentation *The Delphic Oracle*, I take issue with your assertion (*CERN Courier* March 2000 p21) that the existence of two plays on the theme of physics "all goes to show that physics makes good

theatre". In the humble opinion of a non-physicist, it would be more accurate to state that talented artists can make good theatre out of absolutely anything, even physics.
John Pym, CERN.

A new project, Physics on Stage, to increase public awareness of the subject, has just been launched by CERN, the ESA and the ESO, with support from the EU. Other partners are the European Physical Society and the European Association for Astronomy Education. This forms part of the European

Week for Science and Technology 2000 and will culminate in a festival meeting at CERN on 6–11 November.

Gordon Fraser, Editor, CERN Courier.

Sheer poetry

Tachyon

And Sisyphus knows
through the looking-glass gaze
of a quantum eye
that the harder he pushes
the slower it goes.

Susan Tilley, Ashby de la Zouch, UK.

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.

Five Year Fellowship in Experimental High Energy Nuclear Physics

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

The RNC group has a leading role in the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. The group currently has a strong physics program in nucleus-nucleus collisions at RHIC. Candidates having an interest in all aspects of RHIC physics, including spin, are encouraged to apply.

Applicants are requested to e-mail (our preferred method) a CV, list of publications, statement of research interests, and the names of at least four references to: employment@lbl.gov (no attachments, please), no later than May 31, 2000. Reference job number NS011700/JCERN in your cover letter. Or mail to: Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 937-0600, Berkeley, CA 94720. Or fax: (510) 486-5870. Visit our website at: www.lbl.gov. Berkeley Lab is an AA/EEO employer.



RESEARCH ASSOCIATE POSITION EXPERIMENTAL PARTICLE PHYSICS

University of Virginia

The Particle Physics group at the University of Virginia (UVa) has a new research associate position to work on experiments investigating CP violation. We are presently engaged in two Fermilab experiments: HyperCP, which finished data taking in January, and CKM, which is in the planning stages. HyperCP is searching for CP violation in the decays of Lambda and Xi hyperons. One of us (Dukes) is spokesperson of the experiment. The UVa group fabricated the upstream wire chambers, the hadronic calorimeter, and the trigger, and is playing a leading role in the physics analysis. The goal of CKM is to measure the CKM parameter $V(td)$ to a precision about about 10%. The research associate is expected to spend roughly two-thirds of his time on HyperCP analysis and one-third on CKM. Most of the work would be done at UVa.

The position is immediately available and will be filled as soon as a suitable candidate is found. Applications including curriculum vitae and three letters of reference should be sent to Prof. Craig Dukes, High Energy Physics Laboratory, University of Virginia, P.O. Box 400401, Charlottesville, VA 22904-4401, or via e-mail to dukes@uvahep.phys.virginia.edu.

RESEARCH SCIENTISTS

UKAEA FUSION

UKAEA carries out fusion research on behalf of the UK government and the European Union into magnetically confined plasma at the Culham Science Centre near Abingdon, Oxfordshire. Three magnetic fusion experiments are located on the Culham site: the world's largest toroidal confinement device, JET, where research is carried on as part of a major European venture; MAST, an exciting new experiment building on a successful innovative approach pioneered by the UKAEA; COMPASS-D, smaller than JET, but of similar geometry and used for scaling experiments and testing new ideas. In addition to undertaking this strong experimental programme, UKAEA plays a leading role in the theory of fusion plasma, including the physics of alpha particles in plasmas and links to related fields of science. UKAEA fusion scientists collaborate extensively with other international fusion programmes.

THE POSITIONS:

Successful applicants will be expected to contribute to a broad programme of research into magnetically confined plasmas. The theoretically or computationally based work is expected to be carried out in close collaboration with experimental teams. The experimental work will be in one or more of the following areas: the physics of the edge plasma and its interaction with materials; plasma instabilities and control; microwave heating and current drive.

REQUIREMENTS:

Applicants are likely to have postgraduate research experience in experimental, theoretical or computational physics, although applications from high calibre final year undergraduates are also encouraged. Applicants will be expected to be self-motivated and function effectively as part of multi-disciplinary teams.

CONTACT:

Please send your CV to
Rob Akers, Culham Science Centre, Abingdon, OX14 3DB, UK
or email to robert.akers@ukaea.org.uk

quoting reference CC/PW/RS01

UKAEA



The University of Texas at Austin

The experimental high energy physics group at
The University of Texas
invites applications for a
postdoctoral fellow
available immediately.

The opening is for the MINOS experiment - a long baseline search for neutrino oscillations at Fermilab. MINOS will start taking data in 2003. The University of Texas group provides ample opportunities to participate in the detector construction, commissioning, and future data analysis. Applications, including CV, publication list, and at least three letters of recommendation, should be sent to:

Professor Karol Lang lang@hep.utexas.edu Department of Physics, RLM 5.208 The University of Texas Austin, Texas 78712-1081, USA

The initial appointment is renewable annually for a period of three years, subject to mutual agreements.

The University of Texas is an Equal Opportunity / Affirmative Action employer.

—Peoples Fellowships at Fermilab—

Fermilab is pleased to announce the creation of a new fellowship program in the name of our most recent director, John Peoples, Jr. This fellowship is being created to facilitate the entry of scientists into the realm of accelerator science and technology at Fermilab. Approximately one award will be made annually.

Position

Peoples Fellows will normally be assigned to either the Beams or Technical Divisions at Fermilab. These organizations retain responsibility for operating the existing accelerator complex, featuring the highest energy particle accelerator in the world, while simultaneously engaging in accelerator R&D aimed at developing the forefront accelerator facilities of the future. The successful Peoples Fellow candidate will be provided with support to execute a research project directed toward assisting Fermilab in achieving success in either of these directions. Current representative areas of research include stochastic and electron cooling, muon storage rings, superconducting magnet R&D, superconducting RF R&D, linear colliders, large hadron colliders, accelerator controls and feedback, and computational physics and modeling. Peoples Fellows will be classified as Associate Scientists – a scientific tenure track position.

Term of Appointment

The initial term of the fellowship is three years, extendible for an additional term if justified.

Eligibility

The Peoples Fellows program targets entry level accelerator physicists and accelerator-related technology specialists, and high energy post-docs approximately three years from their degree who wish to embark on a new career in accelerator physics or accelerator-related technology. As such, eligibility for the program is restricted to persons meeting either of the following criteria:

1. Recipient within the prior three years of a PhD in accelerator physics or accelerator-related technology. Post-doctoral experience not necessarily required.
2. Recipient within the prior five years of a PhD, and normally with subsequent post-doctoral experience of at least three years, in high energy physics or a related field.

Applications

Fermilab invites candidates for Peoples Fellowships to forward applications to:

Dr. James Strait, Chair, Peoples Fellows Committee
Fermilab, MS 343
P.O. Box 500
Batavia, IL 60510

Applications should include a current curriculum vita, four references, and an indication of potential areas of research interest. Applications for year 2000 awards will be accepted through July 31, 2000.

For further information, contact: strait@fnal.gov or holmes@fnal.gov

Located 40 miles west of downtown Chicago on a campus like setting, Fermilab provides its employees with opportunities for personal and professional growth, competitive salaries, and an attractive benefits package.



Fermilab Minds Over Matter 

Fermilab is an Equal Opportunity/
Affirmative Action Employer. M/F/D/V

SINTEF Electronics and Cybernetics Department of Microsystems

Research Scientist in Silicon Radiation Detectors

SINTEF Electronics and Cybernetics has 110 employees and is divided into eight departments situated in Oslo and Trondheim. The institute performs contract research and development for both Norwegian and international customers.

The activities within the Department of Microsystems are focused on three fields; silicon radiation detectors, micro electro-mechanical systems (MEMS), and micro opto-mechanical systems (MOEMS). The department will within a few years establish a National Microtechnology Centre co-located with the University of Oslo.

The department has for several decades been a supplier of advanced silicon radiation detectors for physics experiments at leading international research centres. During the last years there has been an increasing interest in applying silicon radiation detectors in new exciting fields as medical and dental imaging, material characterisation and inspection systems. SINTEF offers design, manufacturing, and testing of silicon detectors adapted to the customer's specification for these applications.

We are looking for a person with experience from testing and use of silicon radiation detectors in high-energy physics experiments. Knowledge within one or more of the following fields

- Physical electronics - Semiconductor process technology - Solid-state physics - Sensor technology - Electronics

is an advantage. For more information please contact Research Director Ralph W. Bernstein (Ralph.W.Bernstein@ecy.sintef.no) or Senior Scientist Berit Sundby Avset (Berit.Sundby.Avset@ecy.sintef.no).

Applications, comprising curriculum vitae, list of publications, and names and addresses of two referees, should be sent to:

SINTEF Electronics and Cybernetics, Attn.: Personnel Consultant Sølvi M. Kristiansen, P.O.Box 124, Blindern, 0314 Oslo, NORWAY.

The deadline for applications is 15 June 2000.



Computing Coordinator — BABAR Collaboration Stanford Linear Accelerator Center

The Stanford Linear Accelerator Center invites applications for the position of Computing Coordinator for the BABAR Collaboration. The physics program of the BABAR Experiment presents significant computing challenges arising from very large data sets, delicate analyses, and a widely distributed international collaboration. The BABAR Computing Coordinator will provide overall leadership and coordination of computing activities throughout the BABAR Collaboration as a full participant in the BABAR research program. In this capacity, he/she will be responsible for the operation and ongoing development activities, which include online and offline software and hardware. He/she will also be responsible for leadership of new developments required by luminosity improvements and detector upgrades. The Computing Coordinator will ensure that BABAR Computing satisfies the continuously growing needs of the BABAR physics program, while maximizing computing and analysis capability at SLAC and off site at regional centers and collaborating institutions. As a member of the BABAR Management, he/she will identify the resources, both material and human, required to accomplish the goals of BABAR computing activities, and, with BABAR and SLAC management, will ensure that necessary resources are available.

A Ph.D. in particle physics and substantial experience with physics analysis and computing for particle physics experiments are required. Excellent communication and presentation skills are essential. A successful record of leadership in the international collaborative environment typical of large present-day particle physics experiments is also desirable.

Applicants should send a letter describing related experience (referring to requisition #22158), a curriculum vita, a publication list, and a list of at least three references to: Human Resources Department, Stanford Linear Accelerator Center, 2575 Sand Hill Rd., Menlo Park, CA 94025.

For full consideration, completed applications should be received before June 19, 2000. Interested candidates may contact Dr. Charles C. Young (young@slac.stanford.edu) or Dr. Richard Mount (rmount@slac.stanford.edu) with questions concerning the responsibilities and challenges of this position. SLAC is an equal opportunity employer committed to excellence through diversity.

Research Associates in Experimental Particle Physics

The Stanford Linear Accelerator Center (SLAC) is one of the world's leading laboratories supporting research in high-energy physics. The laboratory's program includes the physics of high-energy electron-positron collisions, high-luminosity storage rings, high-energy linear colliders, and particle astrophysics.

Postdoctoral Research Associate positions are currently available with opportunities to participate in the laboratory's research program, with particular emphasis on:

- Comprehensive studies of beauty and charm mesons and tau leptons with large data samples from the BABAR Detector operating at the Asymmetric B Factory. The principal goal is the investigation of CP violation in neutral B mesons.
- Participating in a Particle Astrophysics program studying time dependent x-ray sources with the USA, and helping to build the Gamma Ray Large Area Space Telescope (GLAST).
- Small, non-accelerator experiments searching for fractional charge elementary particles and very massive elementary particles. Develop proposal for extending some of these searches into space-based experiments.

These positions are highly competitive and require a background of research in high-energy physics and a recent Ph.D. or equivalent. The term for these positions is two years and may be renewed. Applicants should send a letter stating their physics research interests along with a CV, publications list, and the names of three references to Tanya Boysen, tkb@slac.stanford.edu, SLAC Research Division, M/S 75, 2575 Sand Hill Road, Menlo Park, CA 94025, fax: (650) 926-4439. Equal opportunity through affirmative action.

Stanford Linear
Accelerator Center
SLAC

Postdoctoral Position in Experimental Particle Physics

The BaBar Group of the Physics Division at the E.O. Lawrence Berkeley National Laboratory has an opening for a postdoctoral physicist. The BaBar detector is fully operational at PEP-II and has been actively taking data since Summer 1999. The Berkeley group has major commitments in the following areas: Silicon Vertex Tracker (SVT), DIRC particle ID system, trigger, online and offline computing. Physics analysis of the rapidly accumulating data set is a high priority. Ph.D in particle physics and demonstrated strong potential for outstanding achievement as an independent researcher. The primary responsibility of this position will be physics analysis as well as some hardware development.

This is a two-year term appointment with the possibility of renewal. The salary range is \$3,640-\$4,295/month. Applications, including CV, list of publications, description of research interest/skills, and three letters of recommendation should be sent via e-mail (our preferred method) to employment@lbl.gov (no attachments) or mail to Lawrence Berkeley National Laboratory, One Cyclotron Road MS 937-0600, Berkeley, CA 94720. Please reference Job# PH011898/JCERN. E-mail inquiries to KRPrintup@lbl.gov. For more information, please visit our web site www.lbl.gov/CJO Berkeley Lab is an AA/EEO employer.



LANCASTER
UNIVERSITY

Department of Physics

University Lectureship in Experimental Particle Physics

Lancaster University invites applications for the above post which is available from 1st January 2001, although an earlier starting date may be possible.

Lancaster University has a diverse research programme in experimental particle physics and a growing involvement in particle theory and cosmology. The experimental particle physics group is currently involved in data taking experiments at LEP, HERA and the Tevatron; we participate in the ALEPH, H1 and DØ collaborations. We are strongly committed to preparations for research at the LHC with the ATLAS collaboration. A large high performance computing facility for the DØ collaboration is under construction in Lancaster using JREI funding. We are also active in the development of radiation hard semiconductor particle detectors.

We are seeking a highly qualified candidate with a strong record of achievement in experimental particle physics research. We expect the appointee to be innovative and active in the future evolution of our programme. The Physics Department has a long standing commitment to excellence in education and was recently awarded 23/24 points in the Subject Review by the QAA. The successful applicant will be required to teach at undergraduate and graduate level and supervise research students.

The salary is according to age and experience on the University Lecturer scale. Further particulars of the duties associated with this post and application forms may be obtained from Personnel Services, Lancaster University, Lancaster LA1 4YW, UK (email personnel@lancaster.ac.uk), quoting reference A335. The head of the group, Dr Peter Ratoff, welcomes informal enquiries from potential applicants by telephone (+44 1524 593649) or email (p.ratoff@lancaster.ac.uk).

Applications including a statement of research interests, any teaching experience, curriculum vitae, list of publications and the names (including email addresses) of three referees should be posted to Personnel Services at the above address by July 15 2000. The referees should be asked to send letters of reference directly to Dr Peter Ratoff at the Department of Physics, Lancaster University, Lancaster LA1 4YB, UK to arrive by the closing date. It is expected that shortlisted candidates will be interviewed in Lancaster early in September 2000. Applicants are asked to provide an email address, fax or telephone number where they can be contacted in July and August.

The University is an Equal Opportunities Employer.



Darmstadt

Positions for Postdocs and Doctoral Students in Heavy-Ion Research

At the Atomic Physics Division of the heavy-ion research institute GSI in Darmstadt, Germany, we offer fellowships for experiments at the Experimental Storage Ring (ESR), the ion trap facility SHIPTRAP and the planned HITRAP facility. For these fellowships all postdocs and graduate students can apply who are from the European Union and their associated countries*. Applicants should send their CV to:

Prof. H.-J. Kluge Planckstr.1, D-64291 Darmstadt, Germany
j.kluge@gsi.de <http://www.gsi.de/ap/>

* associated countries: Bulgaria, Republic of Cyprus, Czech Republic, Estonia, Hungary, Iceland, Israel, Latvia, Lithuania, Malta, Norway, Poland, Romania, Slovakia, Slovenia, Switzerland and Turkey.

CERN COURIER RECRUITMENT BOOKING DEADLINES

June issue: 12 May July issue: 16 June September issue: 4 August

Contact Andrew Hardie

Telephone +44 (0)117 930 1090 Fax +44 (0)117 930 1178
E-mail andrew.hardie@iopublishing.co.uk



**RIKEN BNL
Research Center**
Brookhaven National
Laboratory

Scientific Staff Position Experimental Spin Physics

A research center focusing on the physics program of the Relativistic Heavy Ion Collider (RHIC), hard QCD/spin physics, lattice QCD and relativistic heavy ion physics has been established by the Institute of Physical and Chemical Research, Japan (RIKEN) at Brookhaven National Laboratory. An experimental division on spin physics was established in 1998. The RHIC will be the first polarized proton collider, beginning in 2000, and the Center is playing a major role in developing the RHIC spin program.

A Research Associate (two-year appointment) position will be offered for the fall of 2000. We will also consider applications for RIKEN BNL Fellow positions, which are for 5 years, entering at the equivalent of Assistant Professor Level. The group has 5 members at this time, 4 fellow and 1 RA. Members of the experimental division of the Center will have the opportunity to participate in the detector program at RHIC.

Scientists with appropriate backgrounds who are interested in applying should send a *curriculum vitae* and three letters of reference to be sent to: Dr T.D. Lee, Building 510A, Brookhaven National Laboratory, P.O. Box 5000, Upton, Long Island, NY 11973-5000 before, June 30, 2000. BNL is an equal opportunity employer committed to workforce diversity.

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery
www.bnl.gov

CERN Courier's recruitment advertisements are on the Web within 24 hours of booking and are then sent to e-mail subscribers. Call +44 (0)117 930 1090 for more details



The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for the position of an

Assistant Professor in Physics (Experimental Particle Physics)

at the Institute of Particle Physics (IPP). The long-term focus area of research of the IPP is on the construction and operation of the CMS experiment at the CERN Large Hadron Collider (LHC). The IPP is involved in the various aspects of the experiment, such as in the electromagnetic calorimeter (ECAL), the magnet, the inner tracking detector, and the data acquisition system. The new professor is expected to strengthen the participation of the IPP in the ECAL project during the construction phase and startup of the data taking of the CMS experiment. A participation in the data analysis of presently running experiments is encouraged.

The new professor is expected to participate in teaching physics in all departments of ETHZ, including propaedeutic physics and specialized particle physics courses up to the level of the ETH diploma.

This assistant professorship appointment will be made on a three years basis with a possibility of renewal for three additional years.

Applicants are asked to send their curriculum vitae, list of publications, names of at least three references, and a short overview of their research interests to the **President of ETH Zurich, Prof. Dr. O. Kübler, ETH Zentrum, CH-8092 Zurich, no later than June 30, 2000.** The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.

General information on ETH Zurich and its Department of Physics is available on "<http://www.phys.ethz.ch>". Questions referring to this position should be mailed to Prof. Felicitas Pauss, CH-8093 Zurich (E-mail: pauss@particle.phys.ethz.ch).



Max-Planck-Institut für Kernphysik Heidelberg

The physics program of the newly founded research group "**Next Generation Solar Neutrino Experiments**" at the Max-Planck-Institut für Kernphysik in Heidelberg focuses on the real-time spectroscopy of solar neutrinos at low energies. Our group is involved in the complementary solar neutrino experiments LENS and BOREXINO. The research topics comprise detector design, development of loaded scintillators, MC simulations, as well as trace analysis and ultra purification of radioactive contaminants.

Within this project we have an opening for a fixed term appointment at the **post-doctoral level** (BAT IIa) for 2 years, extendable up to maximal 5 years according to the rules of the Max-Planck-Gesellschaft.

It is expected that the candidate holds a PhD in experimental physics and has experience in neutrino physics or related topics.

Furthermore, we have an opening for a **Phd-student** (BAT IIa/2) in our research group. The project is dedicated to the development of a prototype detector for the LENS experiment.

More detailed information can be obtained via email from **Dr. Stefan Schöenert** (Stefan.Schoenert@lngs.infn.it).

Letters of application including a curriculum vitae, list of publications and references should be sent to **Personalverwaltung, Max-Planck-Institut für Kernphysik Heidelberg, Postfach 10 39 80, D-69029 Heidelberg.**

The Max-Planck-Gesellschaft especially encourages women to apply.

POST-DOCTORAL RESEARCH POSITION EXPERIMENTAL PARTICLE PHYSICS TUFTS UNIVERSITY

The Department of Physics and Astronomy at Tufts University invites applications for a Post-Doctoral Research Associate position in experimental particle physics to work on the CDF experiment at FNAL and the ATLAS experiment at CERN. The Tufts Group is involved in studies of the top quark, precise measurements of the parameters of the Standard Model and searches for Higgs boson and Supersymmetry. On the technical side, the Tufts Group is leading the efforts to simulate various aspects of world-wide distributed computing systems for the LHC era experiments (MONARC project at CERN), and is responsible for CDF Run-II Trigger Simulation. As both projects use modern, Object-Oriented computing methods and languages, candidates should know Java and/or C++. Applicants should submit a curriculum vitae, resume, and the names of three references to

Professor Krzysztof Sliwa, Department of Physics and Astronomy, Tufts University, Medford, Massachusetts 02155, USA.
(e-mail: ksliwa@tufts.edu, krzysztof.sliwa@cern.ch).

Tufts University is an equal opportunity/affirmative action employer.

Are you looking for . . .

- Biophysicists and medical physicists
 - Rocket scientists
 - Electrical engineers
 - Software developers
 - Technical editors
 - Technical Sales engineers
 - Laser engineers
- Subatomic, nuclear, particle and astrophysicists
 - High-, medium- and low-energy physicists
 - Cosmologists

For further information and professional recruitment advice on how to promote your position contact Andrew Hardie

Telephone +44 (0)117 930 1090

Fax +44 (0)117 930 1178

E-mail andrew.hardie@iopublishing.co.uk

BOOKSHELF

The Quantum Theory of Fields III: Supersymmetry

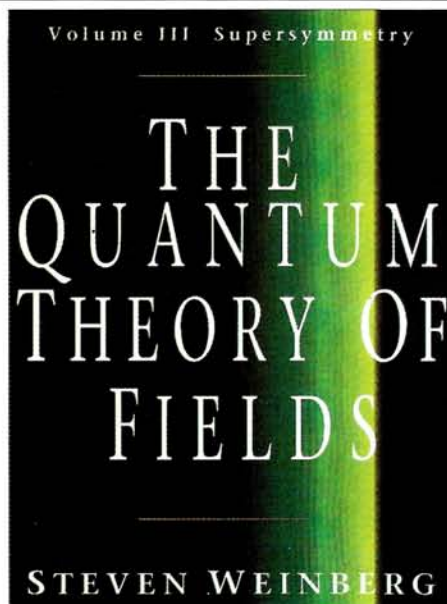
by Steven Weinberg, Cambridge University Press, ISBN 0 521 66000 9 (hbk £32.50/\$49.95).

The third volume in Steven Weinberg's very successful collection on "The Quantum Theory of Fields" covers the topical area of supersymmetry and appears three years after the celebrated opening ones on "Foundations" (1995) and "Modern applications" (1996). If these two volumes were considered masterpieces in a modern and original presentation of the basics of quantum field theory and its penetration in the recent development of particle physics, with the machinery of spontaneously broken gauge theories, the new volume embraces the wide subject of supersymmetry in Weinberg's typical style, which always means a self-contained treatment of the subject, from its foundations and motivations, to its most recent application as a possible scenario for new physics beyond the Standard Model (SM).

Weinberg's main motivation for "Supersymmetry" as a quest for a unified theory relies on the possible solution of the so-called hierarchy problem, that is, the explanation of the "mystery" of the enormous ratio between the electroweak scale (around 300 GeV) and the Planck scale (10^{19} GeV). It is worth noticing that such a fine-tuning problem, which calls for new physics at the TeV scale and is one of the main reasons for future searches at the LHC under construction at CERN, was raised by Weinberg himself in a famous paper with Eldad Gildener (1976 *Phys. Rev. D* 13, 3333), and by two more of the main contributors to the modern theory of electroweak and strong interactions, Martinus Veltman (1981 *Acta Phys. Polon.* B12 437) and Luciano Maiani (1979 *Proc. Summer School of Gif-sur-Yvette* IN2P3 1).

Supersymmetry is the only known example of the enlargement of the space-time symmetry of physical laws (the so-called Poincaré symmetry based on Einstein's special relativity), which is consistent with all axioms of relativistic quantum field theory. In so doing it unites particles of different spin, thus predicting a variety of new species when applied to the SM of the electroweak and strong interactions.

Weinberg's exposition (in chapters 24–32) starts with a synthetic but complete presentation of the mathematical foundations of supersymmetry, called "graded Lie algebras", which is a generalization of the concept, more



familiar to physicists, of Lie algebras and continuous Lie groups (chapter 25).

As a preliminary to the above, he recalls in chapter 24, with an original presentation, the "no-go" theorems, which are the basis of the (failed) attempts, prior to supersymmetry, to unite space-time with internal symmetries (such as isospin or SU(3) eightfold-way symmetries). He then undertakes, in chapter 26, supersymmetric field theories, using superfields, that is fields living in superspace, an abstract space that unifies space-time points with anticommuting coordinates, able to encompass multiplets of particles with different statistics and spin. In chapter 27, he develops the subject of supersymmetric gauge theories, which realize the remarkable marriage between the principle of local Yang-Mills symmetry with supersymmetry.

The way in which Weinberg exposes the subject, with all of its subtleties and technical details, is spectacular. He covers non-renormalization theorems, supersymmetry breaking and extended supersymmetry with an original, clear and self-contained presentation. He then develops, in chapter 28, supersymmetric versions of the SM, covering most of the problems at the core of today's search for supersymmetry in particle physics, namely the scale of supersymmetry breaking, the minimal supersymmetric SM, possible baryon- and lepton-number violation and gauge-mediated supersymmetry breaking.

In the last four chapters, Weinberg develops more theoretical aspects of supersymmetric

field theories, which are, however, tremendously important to the theoretical motivation of supersymmetry and its role in the formulation of quantum theories of gravity.

General aspects of supersymmetry beyond perturbation theory are touched on in chapter 29, with the modern developments of electric-magnetic duality. The latter allows us to give "exact results" for the low-energy action of certain supersymmetric field theories that exhibit a Coulomb phase for the Higgs field (the Seiberg-Witten solutions).

The following chapters are devoted to Feynman rules for supersymmetric field theories (chapter 30), an elegant presentation of supergravity theory (chapter 31) and its essential aspects, from the weak-field limit to local supersymmetry to all orders and the basic role of the gauge field predicted by supergravity, the spin-3/2 gravitino, in gravity-mediated supersymmetry-breaking scenarios.

The final chapter is devoted to supersymmetry in high space-time dimensions and the merging role of extended objects, called p-branes, in the description of modern gauge theories as coming from more general schemes such as higher-dimensional supergravities, M-theory and string theory.

The book also contains, at the end of each chapter, "problems" for the reader to exercise in the subject, even giving alternative proofs of derived results. In this respect the book, like the two preceding volumes, is well suited to graduate students in physics and applied mathematics as well as researchers who want to get acquainted with the fascinating subject of supersymmetry.

The author has achieved in a superb way the important task of producing a volume on supersymmetry, building a bridge between a formal development and its most important applications in particle physics, through a self-contained and very original sequence of subjects and topics.

To conclude this review, let us recall some indirect experimental signals, alluded to also in different parts of Weinberg's book, indicating that supersymmetry is a plausible scenario for new physics beyond the SM:

- the non-observation of proton decay via a neutral pion and a positron, excluding a minimal Grand Unified Theory (GUT);
- the LEP precision measurements, incompatible with gauge-coupling unification for conventional minimal GUTs, but in reasonable agreement with minimal supersymmetric

GUTs, with supersymmetry broken at the TeV scale;

- the large top Yukawa coupling, unusually large compared with all other quark and lepton couplings;
- the possible solution of the dark-matter problem with some of the natural supersymmetric particles (the neutralinos) as natural dark-matter candidates (WIMPs).

Although none of these facts is *per se* a compelling reason for supersymmetry and alternative explanations may be found, it is fair to say that they can all be interpreted in the context of a supersymmetric extension of the SM. Whatever the final theory for quantum gravity may be, supersymmetry remains a deep and non-trivial extension of our concept of space-time symmetries.

Sergio Ferrara, CERN.

Lucifer's Legacy: the Meaning of

Asymmetry by Frank Close, Oxford University Press, ISBN 0 19 850380 6.

Communicating science is difficult. In contrast with other fields, it needs long experience before being able to contribute. While creativity in science or the arts is often left to younger people with open minds, when it comes to explaining new developments to a wide audience, the science communicator first has to master the science itself, its teaching and its popular dissemination.

Frank Close, who has already provided several popular science standards, has all it requires. Here he takes us on a tour of modern science, following a theme, the study of which started early in 19th century: the fascination and appeal of the underlying symmetry of nature, and its attendant asymmetry.

The tour begins and ends in Paris, in a French garden where almost perfect symmetry appears slightly broken, that day, by a damaged statue of Lucifer. With this metaphor of our entire world, accidentally asymmetric but governed by apparently symmetric laws, Close embarks on a journey through the history of the quest to understand where the asymmetry of the universe comes from.

This governs even our own existence: matter overcoming antimatter was a necessary step for there to be anything at all. Moreover, life on Earth, seen through the basic structure of organic molecules, is asymmetric. The mystery of life cannot be understood by physics alone, yet asymmetry is a property of life itself, and this thread continues throughout the book.

First the author reviews symmetry at large, with examples taken from everyday life, featuring common notions and clichés. One of the enigmas dealt with is my own favourite, Martin Gardner's puzzle: why does a mirror invert left and right, but not top and bottom? Here the author adds much of his own insight and wit ("the muscles which close a mouth are stronger than those which open it – as is well known to all who have sat in committees"). The result is a fascinating panorama, down to the molecular level, of the asymmetries around us, which have first to be discovered before being explained.

The remainder of the book covers the history of the tools needed to explore matter and to reveal its hidden asymmetries. Following the pioneer work of Biot (polarization of light) and Pasteur (study of racemic acid), the end of the 19th century brought major discoveries by scientists investigating the true nature of electricity, continuing the route taken by Faraday and Maxwell.

First came the discovery of X-rays by Roentgen, a key tool for decoding DNA structure half a century later. Immediately after X-rays came the discovery of the electron by Thomson, and then of radioactivity (Becquerel and the Curies) and the nucleus (Rutherford). The major cornerstones of modern physics were revealed during those few "magic" years, and they are narrated by Close in a way that reveals the hesitations and inspirations of the actors, the banal errors of those who "could have found" (Lenard, Crookes) but were not quite ready, and the genius of those who made sure that they were in the right place at the right time with the right ideas. What better plea could there be for fundamental research?

All of this leads to modern physics, exploiting the concept of symmetry in a profound way, revealing hitherto unsuspected laws through delicate symmetry breaking. We are introduced to unification schemes based on symmetries broken at our energy scale, but revealed in high-energy experiments. Close explains this in detail and with amusing anecdotes, and how it guided physicists during their major discoveries of the secrets of the matter, right up to the next foreseen step – the quest to find the Higgs boson.

The instrumentation and apparatus required for this quest are impressive. The incredible effort of a worldwide community at CERN for the LHC and its giant experiments

help the reader to become familiar with this ultimate search for the origin of mass.

On the way, the chapter on antimatter deserves admiration: antimatter is one of the most difficult notions scientists have to explain. I remember a colleague beginning a public talk by unapologetically defining antimatter as "the negative energy solution to Dirac's equations". What is exact is not always clear, and Frank Close takes the time to introduce antimatter, to draw its human side through Dirac's character and by noting the time it took, from Dirac's work in 1928 to Anderson's discovery of the positron in 1932.

The violation of "mirror" P symmetry by the weak force, how this was discovered, the violation of CP symmetry and recent evidence for the violation of time symmetry are all clearly explained, illustrated by analogies with Escher prints to help the mind see patterns in abstract spaces.

We then understand that the universe, once fully symmetric, exhibited asymmetries when freezing, which enabled life to be. Life, intrinsically related to asymmetries, is the theme of this book, and Close revisits what has already been written on this theme, offering us an absorbing and scientifically correct account of symmetry and its deep implications.

Yves Sacquin, Saclay.

Cosmology: the Science of the Universe

by Edward Harrison, Cambridge University Press, ISBN 0 521 66148 X (£32.50/\$54.95).

A great deal has happened to our understanding of the universe in the almost 20 years since the first edition of "Cosmology" became a bestseller. Now Prof. Harrison has produced this updated and extended second edition. It has many new sections and revisions and it is wonderfully informative and authoritative on an amazingly wide range of topics.

My own particular favourites are his treatment of Special Relativity – just the way particle physicists like it – and his explanation of Olbers' paradox – the clearest I've ever seen. The entire book is quirky and entertaining, peppered with historical facts, extremely perceptive questions, and provocative and challenging issues for discussion. All of this comes with essentially no mathematics in a very satisfactory and readable introductory overview of modern cosmology.

Steve Reucroft, Northeastern University.

EPAC

Vienna

2000

7th European Particle Accelerator Conference A Europhysics Conference



Austria Center Vienna
26 - 30 June 2000

The 7th European Particle Accelerator Conference will take place at the Austria Center, Vienna, from 26 to 30 June 2000. Previous conferences took place in Rome, Nice, Berlin, London, Sitges and Stockholm, with approximately 800 delegates participating each time. Lively poster sessions, an important industrial exhibition and a session organized with representatives of the industry in mind, complete the overall programme of the conference.

EPAC 2000 is a Europhysics Conference, organized by the Elected Board of the EPS Interdivisional Group on Accelerators. The Organizing Committee is chaired by Dr. S. Myers, CERN, Geneva. The Scientific Programme Committee is chaired by Dr. J.-L. Laclare, CEA, Paris. The Local Organizing Committee is chaired by Professor M. Regler, Institute of High Energy Physics of the Austrian Academy of Sciences, Vienna.

All information concerning the conference is published at the conference website at

<http://www.cern.ch/epac/Vienna/General.html>

Registration is possible via mail, fax, e-mail, and the WWW.



Revealing Unknown Phenomena With Hamamatsu Large Diameter PMT Series

A 332 mm (13-inch) diameter has now been added to our large diameter PMT (photomultiplier tube) series.

Thousands of Hamamatsu large diameter PMTs are awaiting their chance to exhibit the unequalled abilities for capturing messages from unknown phenomena or matter.

There are still many hidden truths of the science that can only be revealed with our large diameter PMTs.

332

mm dia.

LARGE DIAMETER
PMT



508 mm (20-inch) dia.
332 mm (13-inch) dia.
252 mm (10-inch) dia.
202 mm (8-inch) dia.

HAMAMATSU PHOTONICS K.K., Electron Tube Center <http://www.hamamatsu.com>
314-5 Shimokanzo, Toyooka-village, Iwata-gun, Shizuoka-ken, 438-0193 Japan. TEL:81-539-62-5248 FAX:81-539-62-2205

United Kingdom: Hamamatsu Photonics UK Limited. TEL:(44)208-367-3560 FAX:(44)208-367-6384
North Europe: Hamamatsu Photonics Norden AB. TEL:(46)8-509-031-00 FAX:(46)8-509-031-01
Italy: Hamamatsu Photonics Italia S.R.L. TEL:(39) 02-935 81 733 FAX:(39) 02-935 81 741

U.S.A.: Hamamatsu Corporation. TEL:(1)908-231-0960 FAX:(1)908-231-1218
Germany: Hamamatsu Photonics Deutschland GmbH. TEL:(49)8152-3750 FAX:(49)8152-2658
France: Hamamatsu Photonics France S.A.R.L. TEL:(33) 1 69 53 71 00 FAX:(33) 1 69 53 71 10
Switzerland: CERN Liaison Office TEL:(41)31/879 7070 FAX:(41)31/879 18 74

HAMAMATSU