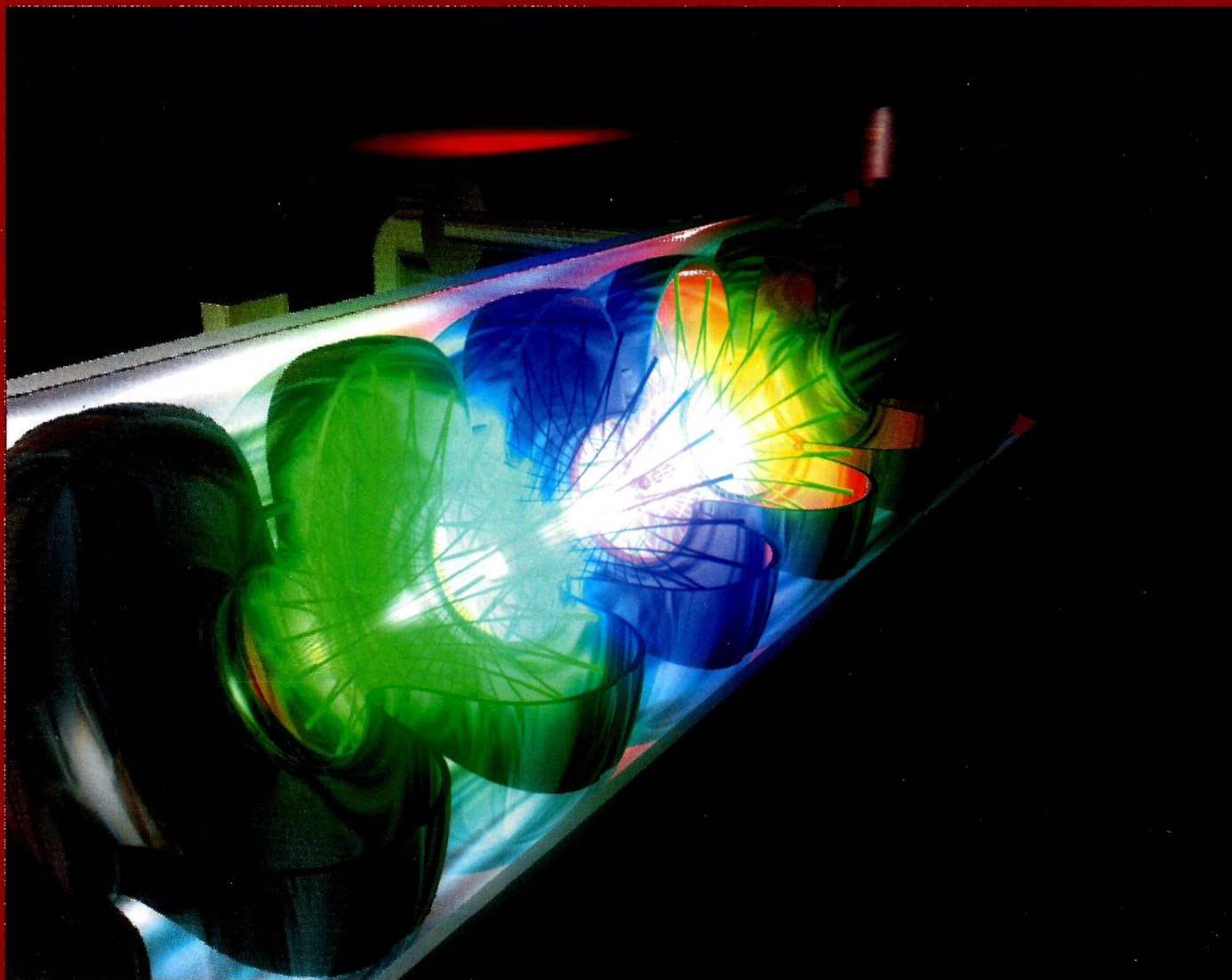


CERN COURIER

VOLUME 39 NUMBER 4 MAY 1999



The Free Electron Laser show

COPENHAGEN INTERPRETATION

Bohr and Heisenberg on stage make for great physics theatre

THE RETURN OF ANTIMATTER

New machine heralds an antiproton renaissance at CERN

OECD MEGAFORUM SURVEY

Nuclear physics scene provides some valuable pointers

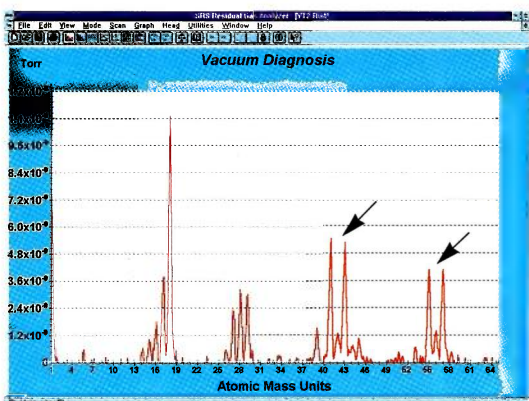
RGA for the Masses

Systems from \$4125 (Int'l list)

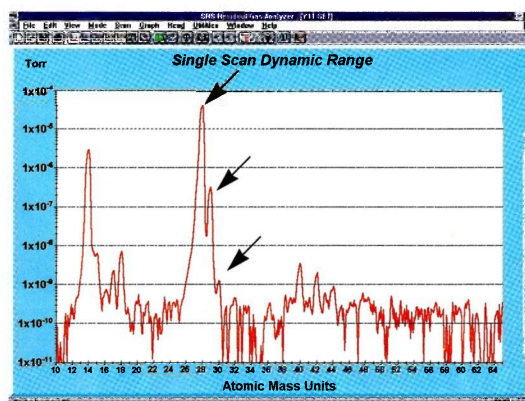


- 100, 200, 300 amu systems
- Partial pressure to 10^{-14} Torr
- 6 orders of magnitude dynamic range in a single scan
- Real-time Windows® software
- Mass spectra, leak detection and pressure vs. time modes
- Multi-head operation
- Optional Electron Multiplier

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>

Circle Reader Service #85

Windows is a registered trademark of Microsoft Corporation

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>

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

Laboratory correspondents

Argonne National Laboratory (USA): D Ayres
Brookhaven, National Laboratory (USA): P Yamin
Cornell University (USA): D G Cassel
DESY Laboratory (Germany): Ilka Flegel, P Waloschek
Fermi National Accelerator Laboratory (USA): Judy Jackson
GSI Darmstadt (Germany): G Siegert
INFN (Italy): A Pascolini
IHEP, Beijing (China): Qi Nading
Jefferson Laboratory (USA): S Corneliussen
JINR Dubna (Russia): B Starchenko
KEK National Laboratory (Japan): A Maki
Lawrence Berkeley Laboratory (USA): B Feinberg
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 mark.wormald@ioppublishing.co.uk
Web <http://www.iop.org>

Publishing director: Mark Ware
Publisher: Mark Wormald
Art director: Andrew Giaquinto
Production controller: Kate Boothby
Technical illustrator: Alison Tovey
Sales manager: Harvey Stockbridge
Advertising sales: Jo Nicholas
Classified sales: Chris Thomas
Advertisement production: Katie Graham
Product manager: So-Mui Cheung

Advertising: Jo Nicholas or Chris Thomas
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 Astrid Nagel, DESY, Notkestr. 85, 22603 Hamburg 52
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
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, Lincs, UK

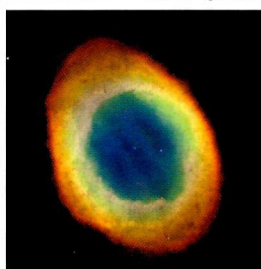
© 1999 CERN

ISSN 0304-288X

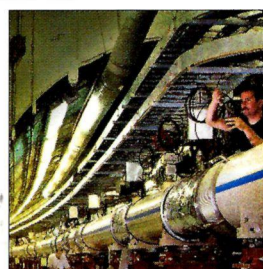


CERN COURIER

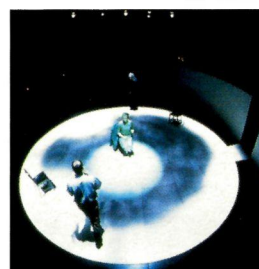
VOLUME 39 NUMBER 4 MAY 1999



More supernovae p10



Nuclear outlook p22



Physics theatre p26

News

The seeds of East-West collaboration. Ending the century on a century. Yerevan synchrotron is back in action. Ready for the Bs. CMS experiment crystal clear. Leader of the PAC. What's the quark matter.

5

Astrowatch

Features

EXPO 2000

Hamburg's Free Electron Laser

9

11

The return of antimatter

Antiprotons set to return to CERN

15

A wide span of physics

Appreciating Carlo Rubbia's contributions to science

19

Echoes of a report

OECD Megaforum nuclear physics recommendations

21

Copenhagen interpretation

Physics theatre is definitely Bose-Einstein statistics

26

The incomprehensible is always fresh

CERN Courier editor Gordon Fraser on communicating physics

29

Don't be afraid of the dark

The invisible component of the universe

31

People

34

Obituaries

35

Recruitment

37

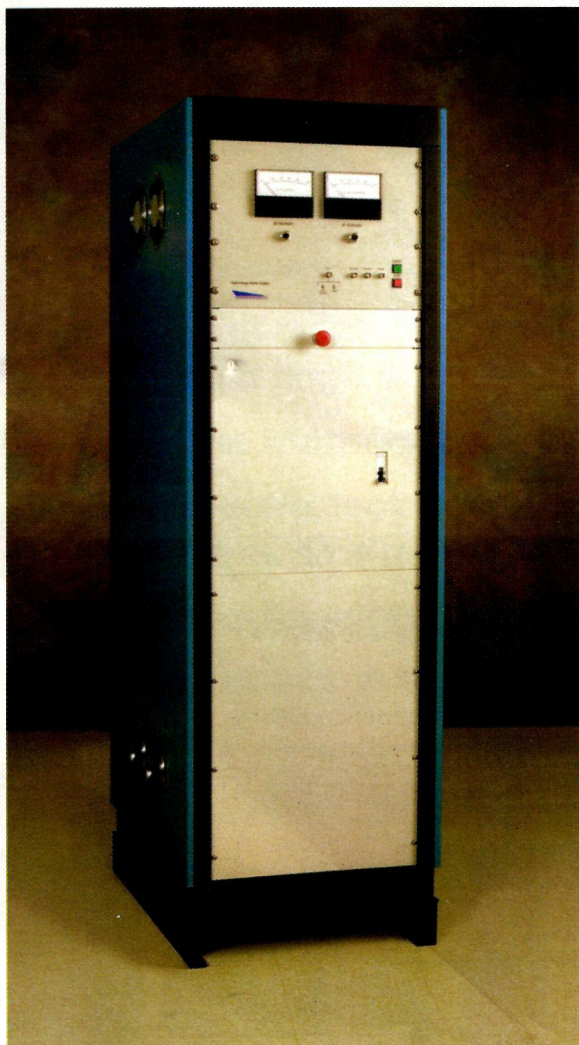
Bookshelf

42

Cover: Simulation of electron acceleration in superconducting niobium cavities. Electron acceleration will be at the heart of a new X-ray laser for the DESY laboratory in Hamburg. Next year, on-site visitors to the EXPO 2000 at DESY will be able to see the new machine being constructed (p24; photo: Plettau, Darmstadt).

The Power You NeedSM

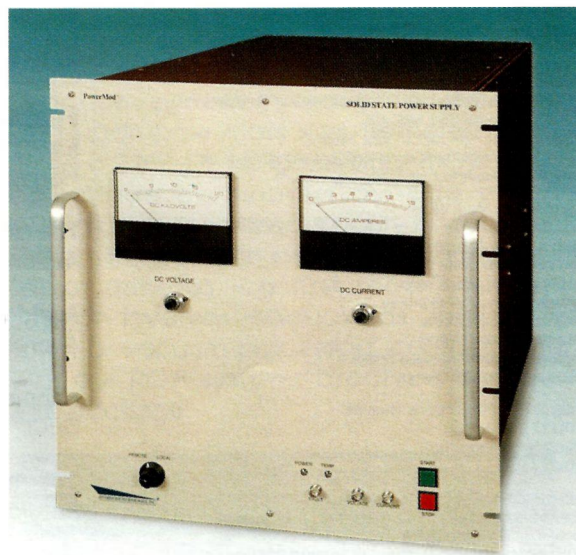
PowerModTM Switching Power Supplies
From DTI - The Experts in High Power Solid-State Technology
DTI is the Complete Source for Solid State High Voltage Systems



*PowerModTM HVPS-100 100 kV, 100 kW,
Free Standing DC Power Supply*

Switching Power Supplies

- 10 - 200 kV
- 10 - 200 kW Average Power
- Custom Power Supplies to 10 MW
- High Reliability
- High Power Without Stacking Multiple Units



*PowerModTM HVPS-30 20 kV, 30 kW Rack
Mount DC Power Supply*

DTI's award-winning, solid-state, high-power systems provide reliable power to leading commercial, research, and government organizations world-wide. Call DTI or visit our web site today for more information.

DIVERSIFIED TECHNOLOGIES, INC

35 Wiggins Avenue Bedford, MA 01730 781-275-9444

www.divtecs.com

The seeds of East-West collaboration

It is no accident that Russia has become a major partner in the CERN programme. In 1967 a historic agreement between CERN and the Institute for High Energy Physics (IHEP) in Protvino, Russia, was signed, under which CERN equipment and expertise was provided for the 70 GeV IHEP machine that was soon to come on line as the world's highest-energy synchrotron. This agreement led to continual

fruitful collaboration between CERN and IHEP in particular, and it opened the door to wider East-West collaboration in general.

In a short ceremony at CERN on 18 March, IHEP director academician A A Logunov bestowed the title of IHEP professor honoris causa on CERN personalities who played important roles in this initial exchange and in its subsequent consolidation.



A A Logunov bestowed the title of professor honoris causa on CERN personalities(*) who played important roles in developing CERN-Russia collaboration. Left to right: CERN director-general 1981-88 Herwig Schopper*, Berend Kuiper*, Academician Logunov, first IHEP vice-director Nicolai Tyurin, CERN director-general Luciano Maiani, F Perriollat, Giuseppe Fidecaro*, K Runge, S Denisov, Jean-Pierre Stroot*, V Mikhailov, Herbert Lengeler* and P G Innocenti.

Ending the century on a century

During the current shutdown, CERN's LEP electron-positron collider is undergoing a major overhaul and is also being fitted with even more superconducting radiofrequency accelerating cavities, in order to boost its energy.

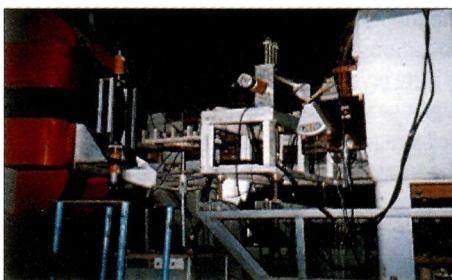
In addition, the 288 superconducting cavities are being tweaked to boost their accelerating gradients from the design value of 6 to 7 MV/m in an attempt to increase LEP's energy to the landmark level of 100 GeV for each beam.

When LEP became operational in 1989, it operated both at and around the Z resonance, which called for some 45 GeV for each beam. As well as the technical challenge that this represents, the goal of increasing the beam energy is also subject to the formal approval of the French authorities.

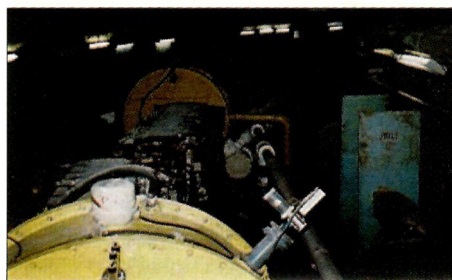
LEP running at 100 GeV per beam (and possibly even beyond) will be the machine's finale. After its run in the year 2000, attention will be switched over to the Herculean task of removing equipment from the 27 km ring and from its ancillary klystron tunnels prior to construction and installation for the LHC proton collider.

With the machine already prospecting physics territory that is deemed to be rich in discovery potential, the LEP stage appears to be set for a dramatic final act.

Yerevan synchrotron is back in action



The Yerevan magnetic spectrometer.



The Yerevan electron synchrotron.

After seven years of inactivity owing to difficult economic conditions, the electron synchrotron in Yerevan, Armenia, is in operational again.

Work resumed last May on the 70 m diameter machine, which was commissioned

in 1967. By the middle of October last year, the various regimes of electron acceleration up to 4.15 GeV had been tested and a beam of linearly polarized photons in the 0.9-1.8 GeV range had been obtained.

The asymmetry of deuteron photodisintegration was measured at photon energies up to 1.8 GeV and at an angle of 90° in the centre-of-mass. This asymmetry suggests problems in understanding the process in terms of constituent quark counting rules.

A magnetic spectrometer (for protons) in coincidence with a neutron hodoscope spectrometer allow the two-body decay of the deuteron to be separated from a multiparticle background. Scientists from the Joint Institute for Nuclear Research in Dubna, near Moscow, took part in the experiment.

Plans for the Yerevan machine include continuing these photodisintegration studies and investigating quasi-deuteron disintegration in light nuclei, such as helium-4 and lithium-6, using the polarized photon beam. The team hopes to expand its collaboration.

Ready for the Bs

In February, physicists at SLAC, Stanford, successfully finished commissioning the PEP-II B factory. A few weeks later, engineers and technicians rolled the 1200 ton BaBar detector into position at the interaction point of this dual-ring electron-positron collider. With the insertion of its vertex detector and final checkout scheduled, everything seems ready for the long-anticipated start of the first physics run.

During this final commissioning phase, a team of physicists led by John Seeman gradually nudged the 3.1 GeV positron beam up to very high intensities – several times exceeding a current of 1 A. To do so they managed to circulate more than 1500 positron bunches simultaneously, countering the deleterious effects of multibunch instabilities using a sophisticated fast-feedback control system.

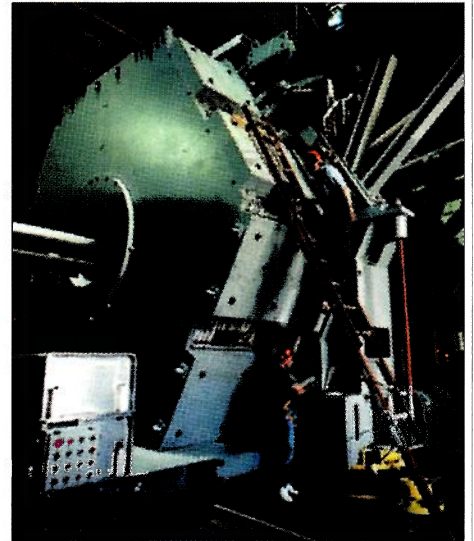
At one point the current reached 1.2 A, which is thought to be the highest current ever achieved with an antimatter beam. Its lifetime is fairly short – typically less than 1 h – but

continued “scrubbing” of the ring’s vacuum chambers by circulating the positron beam should eventually resolve this limitation.

Bringing the positron beam into collision with the 9.0 GeV electron beam, the commissioning team achieved a peak luminosity of 5.2×10^{32} /sq. cm/s in late February. This is more than 17% of the design value – an encouraging feat at this early stage in the life of the new collider.

Design intensities have already been achieved in single-bunch operation. “There are no single-bunch issues remaining on PEP-II,” remarked Seeman. “It is all about multibunch issues now.”

A remaining area of concern is the high background levels encountered during commissioning, which are factors of 5–10 greater than what was anticipated in early simulations. A group of BaBar physicists led by Tom Mattison and Witold Kozanecki has been studying these backgrounds in detail, with an eye to reducing them or coping with them



Final construction work for the 1200 ton BaBar detector at the new PEP-II B Factory at SLAC, Stanford, prior to rolling the detector into the interaction point of this dual-ring electron-positron collider.

during the experimental runs. Better collimation of the beams well upstream on either side of the detector is one likely solution. ▶

CMS experiment crystal clear



Some members of the CMS collaboration, ISTC and Bogoroditsk Techno-Chemical plant with a sample of the first lead tungstate crystals for the electromagnetic calorimeter of their experiment at CERN’s LHC proton collider.

As a result of the technological problems to be solved and the global level of participation in the major experiments at CERN’s LHC proton collider, supply and manufacturing has to explore unusual sources.

From the outset, the design of the major CMS experiment at the LHC foresaw calorimetry – measuring the energy of the particles emerging from the collisions – as of prime

importance. Both the electromagnetic and the hadronic calorimeters are inside the solenoid that supplies the detector’s magnetic field, with the electromagnetic calorimeter (ECAL) immediately outside the inner tracker.

The ECAL will use lead tungstate crystals to pick up the emerging photons, which could provide useful signatures of new particles. With its strong photon absorption, lead

tungstate makes a compact, and so cheaper, detector. Displaying the international flavour of the CMS collaboration, production of the approximately 80 000 lead tungstate crystals will be shared between the Bogoroditsk Techno-Chemical Plant in Russia and the Shanghai Institute of Ceramics in China.

After four years of active R&D, a preproduction phase has just begun in Russia, where 6000 crystals will be grown in mass-production conditions. This continues until the middle of next year. The goal of this preproduction phase is to tune the production conditions for a maximum yield of good-quality crystals. The first three batches, together amounting to 400 crystals, were delivered to CERN on schedule late last year. The quality of the first crystals received is already greater than the most optimistic expectations. The crystals are very clear, colourless, highly transparent and with an exceptionally fast response time (more than 97% of the light appears within 100 ns). The light yield is in excess of eight photoelectrons per mega electron volt.

All LHC detector components will have to contend with a harsh environment owing to the thousands of secondary particles that ▶

Physicists from the BaBar collaboration commissioned their detector – minus its vertex detector and most of its differential Cherenkov detector – on cosmic rays in late 1998 and early 1999. The on-line software package has come along smartly in recent months, enabling the reconstruction of cosmic-ray events. One continuing problem is an unfortunate delay in obtaining enough quartz bars of sufficiently high quality for use in the Cherenkov detector, which begins the first run with only five (out of twelve) bars in place.

Thus an idea proposed more than a decade ago by Lawrence Berkeley Lab's Piermaria Oddone – that an asymmetric electron-positron collider would prove a superb facility for studying CP violation in the B meson system – is about to become reality at SLAC (and across the Pacific at KEKB at the Japanese KEK lab too). It has been a long, twisting and demanding road, deftly navigated by PEP-II project director Jonathan Dorfan, BaBar spokesman David Hitlin and many others. In the months to come, high-energy physics should begin reaping the benefits of all of the diverse efforts that have gone into this imaginative, challenging project.

are produced by each collision. "Radiation hardness" is therefore of prime importance. Initial measurements of the CMS ECAL crystal's radiation hardness is well within the specified range.

Growing large crystals is not straightforward, but the growth yield has also been very high – already very close to the target of 75%. This was made possible through a concerted R&D effort supported by CERN and the ISTC (International Science and Technology Centre) in which several groups of the CMS ECAL community, particularly those from Minsk and CERN, have actively participated. (The ISTC is the international scheme set up in 1991 to diversify and reorient the effort that was formerly channelled into Soviet military applications.)

During this initial period the basic mechanisms underlying the phenomena responsible for the light production and the radiation damage in this crystal have been studied systematically.

This was a vital step towards improving crystal quality, first at a small scale and progressively at the mass-production scale, at a level that meets the very tight specifications imposed by the LHC running conditions.

Leader of the PAC



Fermilab's accelerator control room. Fermilab's new Main Injector will soon be supplying protons for physics.

This year's Particle Accelerator Conference in New York City on 29 March – 2 April included news from several major new machines that are beginning to flex their muscles.

Both of the new B factories, PEP-II (SLAC, Stanford) and KEKB (KEK, Japan), had seen collisions and measured luminosities. They are both rolling in their detectors – BaBar and Belle respectively – and both foresee physics runs from May (p6).

PEP-II has achieved 750 mA of electrons and 1171 mA of positrons, which are believed to represent the highest positron current ever stored, with a peak luminosity of 5×10^{32} /sq. cm/s (design 3×10^{33}) and an average luminosity of 2×10^{32} over substantial periods. PEP-II's goal for its May-August run is a maximum luminosity of 10^{33} and an average of 5×10^{32} . KEKB has achieved 420 mA electrons and 380 mA positrons, with a maximum luminosity of 1.2×10^{31} , on 25 March.

Both KEKB and PEP-II observe dust trapping and reduced lifetime in a range of currents, and evaporation above, as well as pressure runaway as a result of electron multipacting. Both machines need feedback to stabilize the beams. Linear optics in both agree well with models. There are no serious single-bunch instabilities and no multiple-bunch instabilities related to modes in the RF cavities in KEKB.

The new RHIC heavy-ion collider had been hoping to provide headline news at PAC, but unfortunately it suffered a serious mechanical failure. Leak checks are now complete, but power supplies are still being installed. Cooldown has begun, first to 50 K then to 4 K. Beam commissioning is foreseen from 18 May, with shutdown from August to October and a 37 week physics run from November.

Fermilab's new Main Injector was reported as having achieved six of seven milestones. The last is 2×10^{13} protons/pulse resonant extracted. The permanent-magnet recycler was completed in the week of the conference. The initial injection into the Tevatron will be followed by a fixed-target run. Proton-antiproton collider Run II is scheduled from February 2000. Its goals are a maximum luminosity of 5×10^{31} , integrated luminosity of 2 inverse femtobarns by the end of 2002, and 3×10^{13} 120 GeV protons on target every 1.9–2.9 s.

Frascati's DAFNE phi factory had a circulating beam after the KLOE detector had been rolled in. It must make the beams flat by correcting the coupling caused by the detector solenoid. Before the shutdown for rolling in the detector, it achieved a maximum luminosity of 10^{31} with 13 bunches in each beam.

J M Slater, a physician, spoke about the Loma Linda proton therapy machine. Under a fabrication contract between Loma Linda University and Fermilab, which was signed in 1986, the 250 MeV machine was installed in 1989. By now more than 4000 patients have been treated. The rate is 100 patients per day with 20 min per patient, 16 h a day, five days a week and 98% uptime. The cost was \$125 million, but replicas could be built for half of that amount.

Slater gave a list of 17 future installations. His examples were mostly prostate cancer and some eye treatment. The operation needs more physicists and engineers, and about the same number of nurses and medical technicians, as other forms of treatment.

The conference session on linear colliders opened with a tribute to the late Bjoern Wiik and his work.

From Eberhard Keil.

What's the quark matter?

Careful analysis of data collected by the NA50 experiment studying high-energy heavy-ion collisions at CERN shows clear signs of new behaviour, suggesting that under these conditions the colliding nuclear particles briefly fuse together to form a new kind of matter.

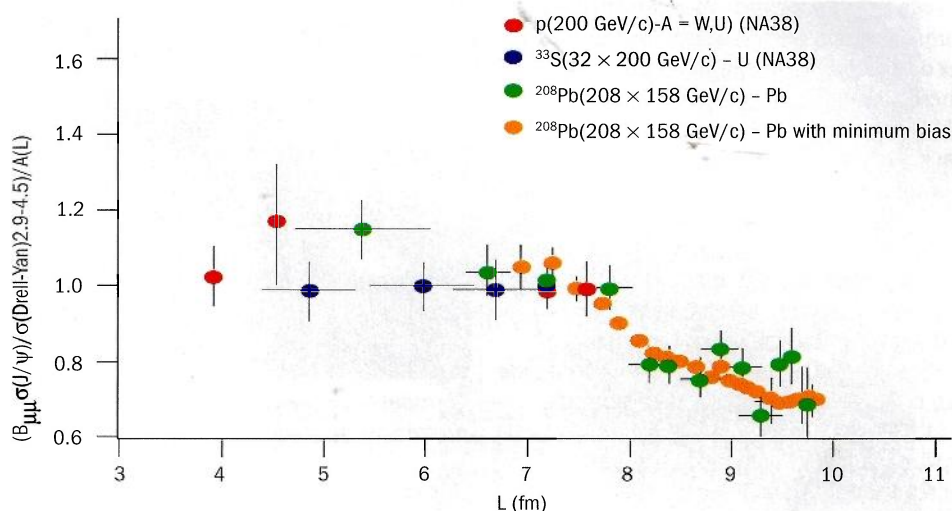
In ordinary matter, quarks and gluons are confined inside nucleons, the component particles of nuclei. However, this has not always been the case. In the first split second after the Big Bang, when the temperature exceeded 10^{13}° , quarks and gluons roamed around in a uniform "soup". When the temperature dipped, the free-ranging quarks and gluons suddenly "froze" into strongly interacting particles (hadrons), where they have remained ever since. The only known way for them to leave this confinement is via high-energy nuclear collisions - "Little Bangs" - when small pockets of hot and dense nuclear matter simulate post-Big Bang conditions.

Over the past 20 years, lab physics experiments have gradually increased the energy of their nuclear beams in the search for this "quark-gluon plasma". As well as providing sufficient input energy to create Little Bangs, another challenge is to recognize clearly the deconfined state once it has been recreated.

One suggestion, which was made in 1986 by Tetsuo Matsui and Helmut Satz, was to look among the emerging particles for states like the J/psi - a meson composed of a charmed quark and antiquark bound together.

Approaching plasma conditions, the attractive force between the quark and the antiquark will be screened by gluons and lighter quarks, and less charmed quark-antiquark pairs will bind into J/psi states.

However, an absorption effect also results from interactions of the produced J/psis with the nucleons while traversing the surrounding nuclear matter. Fortunately, this conventional absorption mechanism can be understood from the study of lighter collision systems, as



J/psi production yield per nucleon-nucleon collision, measured in lead-lead collisions by the NA50 experiment at CERN, relative to the normal nuclear absorption pattern inferred from other collision processes, as a function of L, the total length of nuclear matter traversed by the produced state. The abrupt fall in yield at higher L values shows that, in the violent collisions when the lead nuclei hit each other head-on, the quarks and antiquarks find it more difficult to stick together.

has been done at CERN's SPS synchrotron with proton, oxygen and sulphur beams.

A sudden drop in the rate of J/psi formation, after accounting for the normal nuclear absorption, is considered to be a clear signature of quark-gluon plasma formation.

In 1996, colliding 158 GeV/nucleon lead beams on a solid lead target and using an improved experimental set-up, NA50 saw 190 000 J/psis via their decay into muon pairs, four times the data collected in 1995. For peripheral lead-lead collisions, where the density of nuclear matter is least, NA50 sees the expected nuclear absorption effects, extrapolated from studies with lighter nuclei.

However, for more violent lead-lead collisions, more energy is transferred and there is a maximum density of hot nuclear matter. Under these conditions, quarks and antiquarks find it more difficult to stick together and the J/psi production rate dramatically decreases.

Under these conditions the quarks and gluons in the colliding lead nuclei briefly "forget" about their 15 billion year nuclear heritage and revert to their primeval state.

As well as the clear signs of J/psi suppression seen by NA50, other encouraging signs that collective quark-gluon behaviour is not far away come from other experiments at CERN using heavy-ion beams, notably NA45;

seeing an excess of light electron-positron pairs; the increased yield of multiply strange particles by WA97/NA57; and several intriguing observations from the big NA49 study.

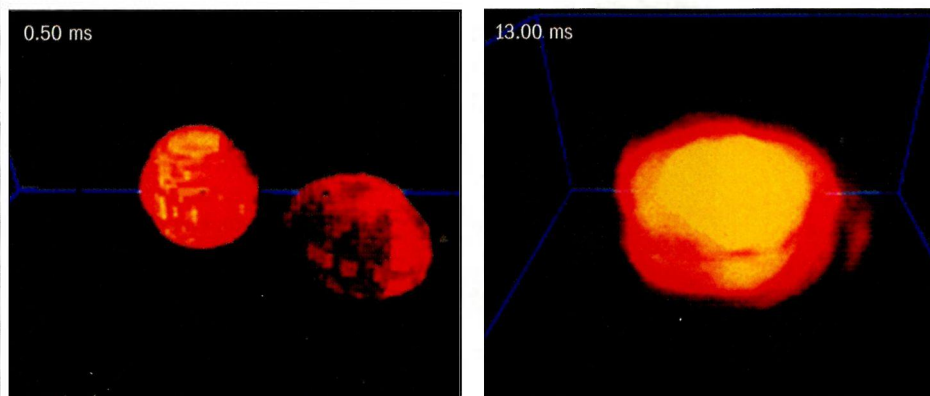
This bodes well for the experiments that are preparing to take their first data at the end of the year at the higher energies of Brookhaven's RHIC heavy ion collider. Their measurements should confirm beyond reasonable doubt the current indications that high-energy nuclear collisions lead to a transition from confined to deconfined matter, where quarks and gluons are no longer bound inside hadrons.

Collective wisdom

Later this year, Brookhaven's RHIC collider will start exploring a higher-energy frontier for heavy-ion physics, with gold nuclei at 200 GeV per nucleon-nucleon collision. Meanwhile, CERN's SPS experiments - NA45, NA49 and NA57 - convinced by the results found at 158 GeV per nucleon, will devote their 1999 beam time to a low-energy run with lead ions at 40 GeV per nucleon. The aim is to study the onset of the anomalous phenomena seen at the full SPS energy and to fill in the energy gap between existing SPS results and lower-energy data from the CERN and Brookhaven synchrotrons.

Edited by Emma Sanders

Supernovae and gamma-ray bursts are the biggest explosions in the universe bar the Big Bang. The former, occasionally visible with the naked eye, have been chronicled for centuries, while gamma-ray bursters had to wait for modern technology before being revealed. The study of these explosions provides valuable information on the evolution of the universe. In this special edition, Astrowatch previews some of the presentations at the Symposium on Supernovae and Gamma Ray Bursts at the Space Telescope Science Institute in Baltimore on 3–6 May.



A computer simulation of two neutron stars coalescing. (Ruffert & Janka 1997.)

Gamma-ray bursts

The most powerful objects in the universe are also the most mysterious. Gamma-ray bursts can emit more energy in a few seconds than all of the 10^{11} stars in our galaxy emit over a few days. This colossal concentration of energy is also thought to produce ultrahigh-energy cosmic rays – protons of more than 10^{19} eV.

Cambridge astronomer Sir Martin Rees has spent a number of years working on the theory of gamma-ray bursts. At the May symposium he speaks about their diversity and how theory is finally catching up with observation. For many years, astronomers did not know how far away these mystery bursts were. However, recent identification of their optical counterparts has shown that they are far outside our galaxy.

Today the popular model is of a spinning black hole with a torus of material swirling around it, which feeds two hyper-relativistic jets (Lorentz factor typically more than 100). The rapid infall into a newly formed black hole releases a burst of energy lasting a few seconds that transforms into gamma rays. The afterglow comes from the subsequent outflow of material slowed down by the interstellar

medium. The complicated time structure of most bursts can be explained by a succession of internal shocks as the jet changes speed.

Most observations to date fall into the category of long bursts, but Sir Martin believes that we may not be seeing the real distribution as the BeppoSAX X-ray satellite is not sensitive to short bursts. Long bursts are thought to be caused by enormous hypernovae explosions collapsing into a spinning black hole. Short bursts are thought to be coalescing binary stars collapsing into a spinning black hole.

There are two main candidates for the mechanism governing the prodigious energy release. First, thermal neutrinos produced in the hot swirling debris are converted into electron-positron pairs. Second, the outflow is caused by an electromagnetic torque, like that in pulsars. A magnetic field of 10^{15} gauss and 1 ms orbit could produce the observed luminosity.

Gamma-ray bursts are of wide interest to physicists. "They are very interesting as probes of great distances," said Sir Martin, "moreover, events that give gamma ray bursts are also likely to emit gravitational waves." Some quantum gravity effects may also be observable.

Accelerating universe

The universe is expanding at an accelerating rate, studies of supernova explosions are now suggesting. This result has revived talk of Einstein's cosmological constant. Saul Perlmutter, who is head of the Supernova Cosmology Project, gives an update on his work in the field.

Some supernova explosions – type Ia – always have essentially the same luminosity. Knowing the luminosity of the explosion means that its distance can be calculated, and observing how the light is red-shifted shows how much the universe has expanded since that point in space-time.

Perlmutter and his team have studied altogether some 80 high red-shift type Ia supernovae. Their results imply that the universe was decelerating for the first half of its existence, and then began accelerating approximately 7 billion years ago. Perlmutter said: "this presumably was due to the universe becoming large enough that the mass became so dilute that its effect was overwhelmed by the accelerating effect of the vacuum energy density – the cosmological constant."

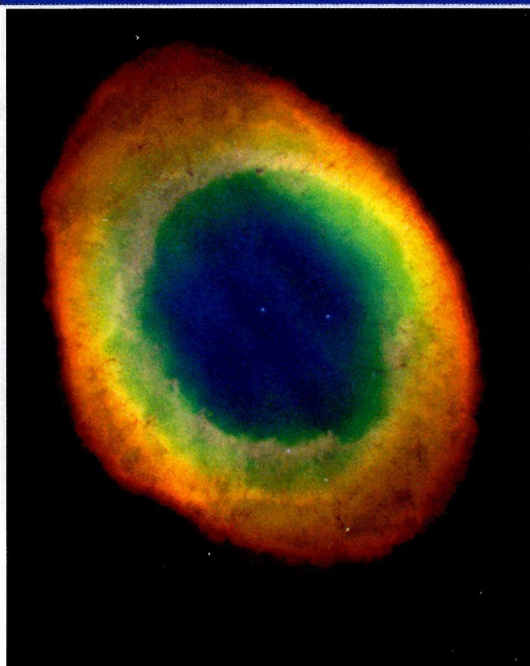
For the Supernova Cosmology Project, most of last year was spent hunting for "loopholes" that might explain away the need for a cosmological constant. The group has observed more supernovae, including the furthest ever detected, but the results have not changed. "We are now in the midst of a new search for nearby type Ia supernovae, so that we can check them more rigorously for even more arcane problems that could distort our high-red-shift results," said Perlmutter. "This time we are nicknaming them after Shakespeare characters, so we have a Petruccio, a Hamlet, a Friar John..."

Great balls of fire

Last month, Astrowatch reported the first direct optical observation of a gamma-ray burst. For a few seconds this emitted more light than the rest of the universe. Theorists can now compare their models from a new perspective. Whatever the mechanism turns out to be, attempts to explain gamma-ray bursts have almost inevitably focused on some generic picture of a highly relativistic fireball.

Tsvi Piran of Jerusalem's Hebrew University shows how this model fits the data. A reverse shock at the moment of the "afterglow" following the gamma-ray burst could give the optical effects. The Hubble Space Telescope has shown a decrease in the afterglow, which Piran suggests could be caused by the jets spreading out. He estimates the angle of the jet to be around 10° , and therefore the actual energy of the burst to be around 10^{52} ergs, which is comparable to that of a supernova.

Picture of the month

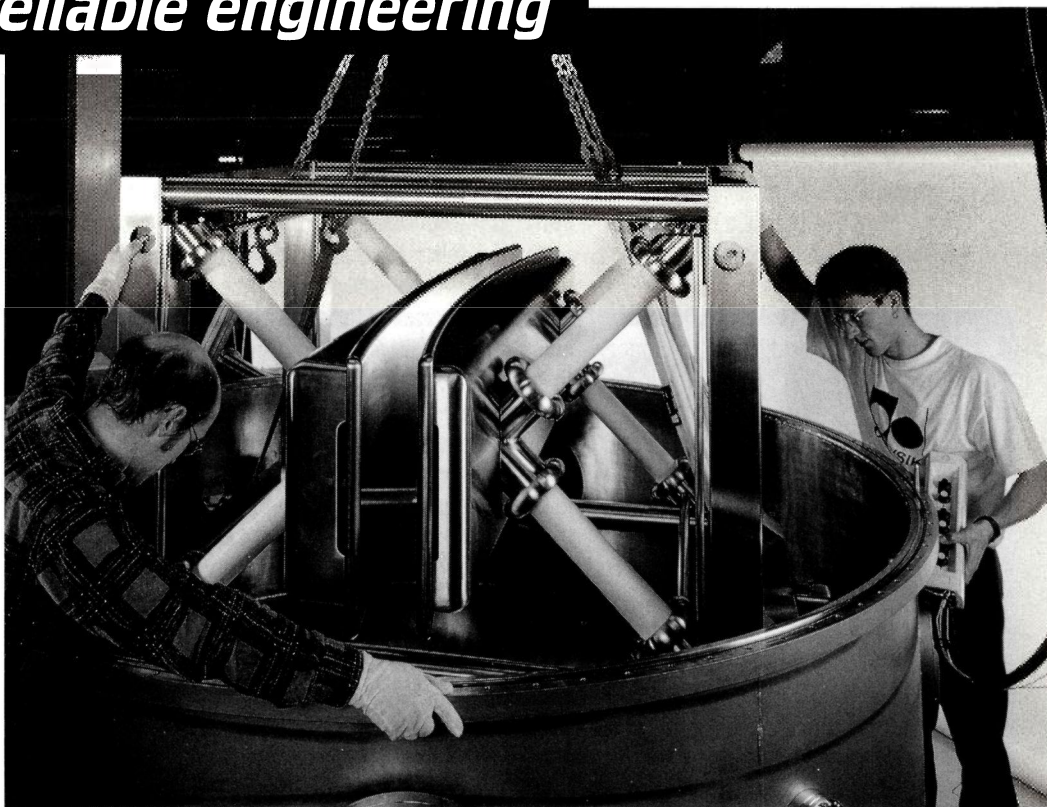


The Ring Nebula, from the Hubble Space Telescope. The hot gas thrown into space by a supernova explosion travels at more than 100 km/s. The telescope has been at the forefront of astronomy for nearly 10 years. In particular, its studies of benchmark stars, such as Cepheids and supernovae, have improved our knowledge of the expanding universe – a fitting memorial to its namesake, who pioneered work in this field. Now, repairs are necessary to the guidance system and a rescue mission is expected this year to mend three of the six gyroscopes on board. In June 2000, a new camera and cooling system will be installed and will update the computers. (NASA/ESA.)

Great and reliable engineering

With years of experience Danfysik offers a wide range of electrostatic products in the highest performance class. We offer you systems from our standard product list or custom designed units matching to your specifications. The products feature:

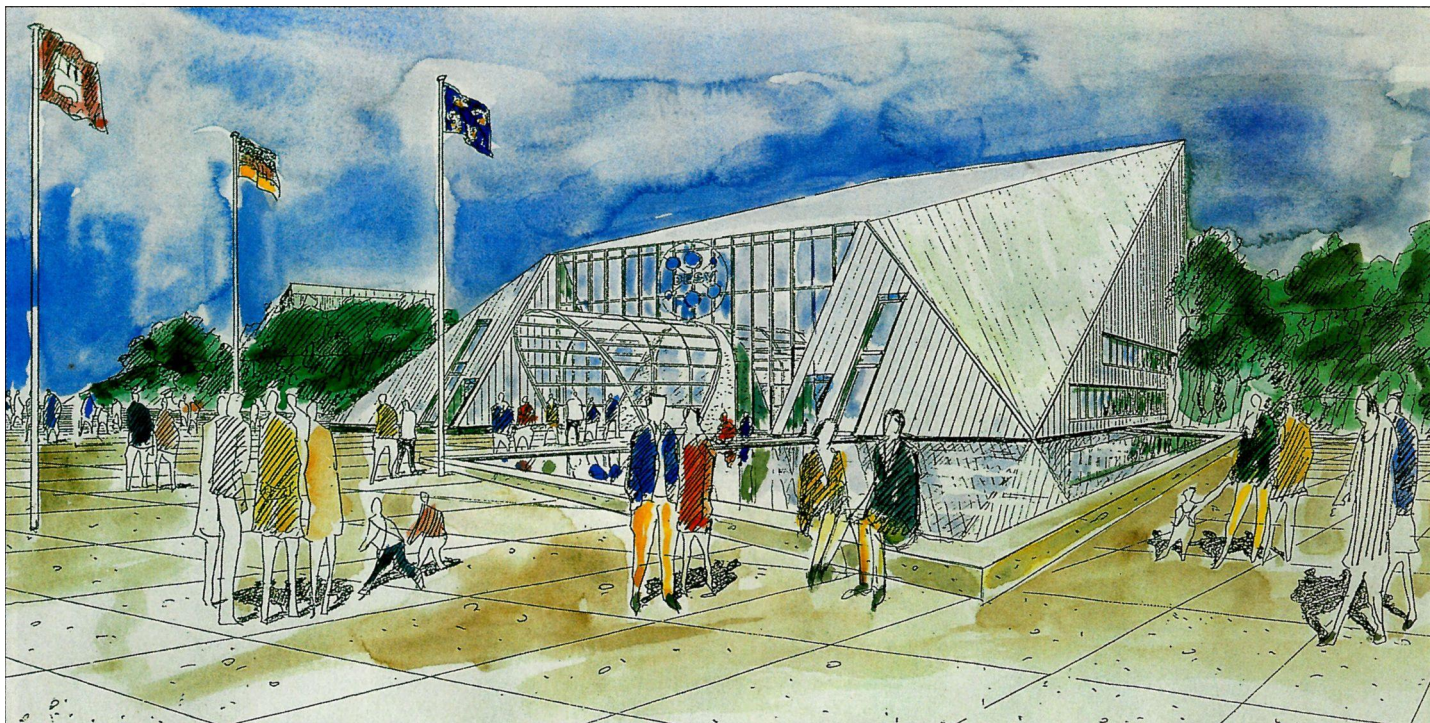
- Large electrostatic dipole analysers for spectrometers
- Electrostatic quadrupole lenses
- Electrostatic beam scanning systems
- Electrostatic extraction and lens systems
- Wien filters



DANFYSIK

DANFYSIK A/S · DK-4040 Jyllinge · Denmark
 Tel. international: +45 46 78 81 50 · Fax: +45 46 73 15 51 · e-mail: sales@danfysik.dk
 In USA: GMW Associates · Tel.: (650) 802-8292 · Fax: (650) 802-8298
 In India: Transact India Corp. · Tel.: (22) 285-5261 · Fax: (22) 285-2326

Probably the best electrostatic analysers you can buy...



Artist's view of the new experimentation hall for DESY's Free Electron Laser pilot facility. From June to October 2000, the hall will house the 1200 square-metre *Light for the New Millennium* exhibition, DESY's contribution to the EXPO 2000 World Exhibition.

EXPO 2000



Licht der Zukunft
Light for the New Millennium

At the Germany DESY laboratory in Hamburg, an ambitious X-ray laser is scheduled to come into regular operation in the year 2003.

Next year, on-site EXPO 2000 visitors will be able to see the new machine being constructed.

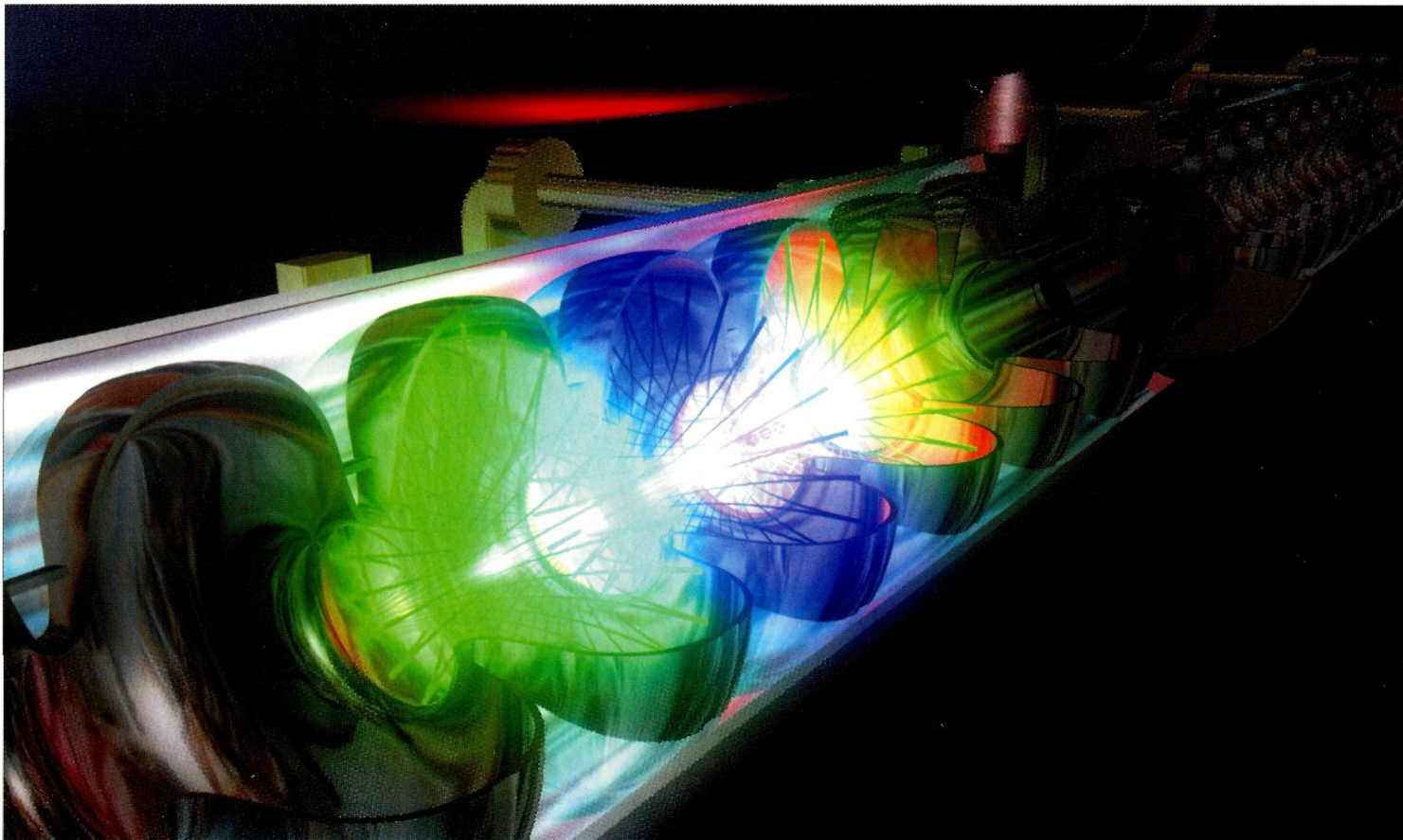
'To see something new, you must make something new.' This quotation from 18th-century German scientist and philosopher Lichtenberg was a favourite of the late Bjoern Wiik, chairman of the DESY Directorate, and chief promoter of DESY's TESLA electron-positron linear collider and X-ray laser project.

While for particle physicists this credo seems natural, the general public and many politicians usually find it harder to digest, especially when facing the finance of basic research.

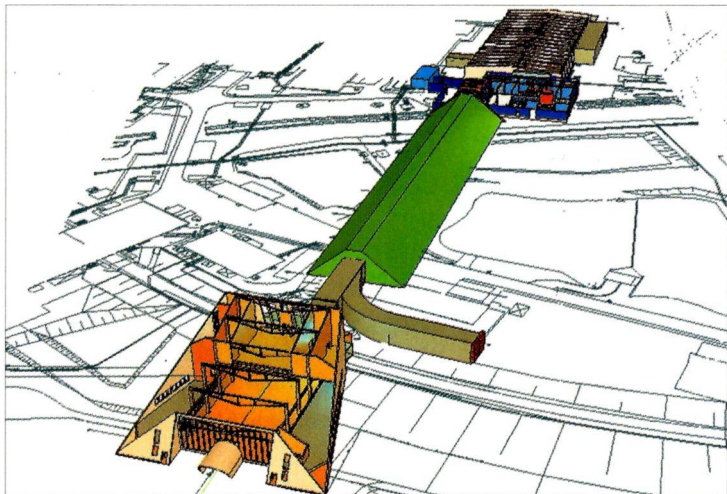
Conveying the purpose of basic research and introducing the public to the thrill and fascination of frontier science and discovery are the main goals of a new DESY exhibition, which is planned to take

place in Hamburg from June to October 2000, as one of the Worldwide Projects of the EXPO 2000 World Exhibition.

The *Light for the New Millennium* will be delivered by the new type of Free Electron Laser (FEL) into which DESY's TESLA Test Facility (TTF) will eventually be converted. What had started mainly as a test-bed for TESLA's superconducting acceleration principle will be extended as a 300 m FEL delivering laser light of wavelengths in the soft-X-ray range down to 6 nm. Radiation generation via the SASE (self-amplified spontaneous emission) principle is a completely novel technique allowing high-intensity laser pulses to be produced at these short wavelengths for the first time. SASE-FEL proof of prin-



Simulation of electron acceleration in superconducting niobium cavities. (Plettau, Darmstadt.)



Starting from the existing TTF hall in the background, a new tunnel will house the superconducting accelerator and undulator of DESY's Free Electron Laser. The experimental hall in the foreground lies just beyond the tunnel of the PETRA ring on the DESY perimeter and will be used for the DESY exhibition during EXPO 2000.

ception is foreseen later this year.

The facility, which is due to go into test operation in 2002 and be available to users from all over the world a year later, will be under construction during the exhibition. Visitors will witness the machine

being built and inspect it much more closely than would ever again be possible during operation.

However, accelerator and FEL components in the facility's tunnel will be only one facet of the DESY-EXPO: a 1200 square-metre exhibition in the future experimental hall will show the technology and research opportunities of the new device, general DESY research - in both synchrotron radiation and particle physics - and the laboratory's plans for the future.

Laser insights

Multimedia and virtual reality shows as well as hands-on experiments will introduce the fascination of science and the emotion and thrill of discovery. Subjects will include "From light to microscopes to the X-ray laser", "Laser technology in science and everyday life", New insights opened up by the FEL in fields such as biology and materials sciences, and a presentation of DESY, its research programme and its planned TESLA project.

With 50 000 visitors expected, exhibition staff will be supported by DESY's own undergraduate and graduate students, plus - a new idea - undergraduates from other German universities, who will be offered a research trainee period at DESY in return.

Exhibition languages will be German and English. Admission, which is free, will be from 1 June to 31 October 2000, from 10.00 a.m. to 7.00 p.m. daily but until midnight on Thursdays. In the meantime, the Web site at "<http://www.desy.de/expo2000/>" is well worth a visit.

CHARGE

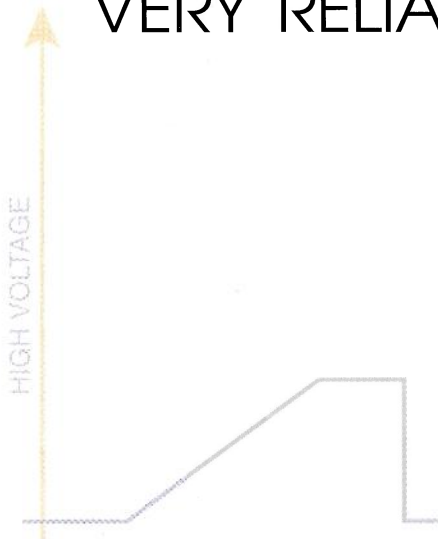
CAPACITORS

UP TO 65 kV AND 20 kJ/s...
VERY RELIABLE.

The Maxwell CCS Series is the ultimate HV Power Supply performer and only choice for low, medium and high repetition rate Pulse Discharge Systems.

With voltages to as high as 65 kV and output power to 20 kJ/s, when it comes to reliability, performance and price, we've rewritten the specifications for High Voltage Capacitor Charging.

Maxwell has successfully applied the CCS to every conceivable Pulsed Power Application. Whether you are developing the latest Pulsed Modulator, Solid State Laser, High Energy Storage Bank or Ultra Fast Excimer, call for the specialist "San Diego Chargers."



SERIES CCS

Capacitor Charging Power Supplies

- Output Power 2, 4, 6, 8, 10, 12 kJ/s (20 kJ/s available as custom).
- Output Voltages 1, 2, 3, 5, 10, 20, 30, 40, 50, 60, 65 kV.
- 208, 400, 480 VAC 3 phase all standard.
- 22/240 VAC single phase to 6 kW available.
- 2 year warranty.

Maxwell[™]
TECHNOLOGIES
Energy Products



For information on the CCS, visit:

<http://www.hvpower.com>

Or for our extensive range of HV Components and Systems, go to:

<http://www.maxwell.com/energy>

4949 Greencraig Lane, San Diego, CA 92123 • (619) 576-7545 • FAX (619) 576-7672

The return of antimatter

After a three-year pause, antiproton physics gets under way later this year at CERN using the new Antiproton Decelerator ring. These articles look at the AD and its physics programme.

This year should see the start of physics with CERN's new Antiproton Decelerator ring, marking the return of antiparticle physics to the CERN research stage three years after the closure of the LEAR low-energy antiproton ring in 1996.

The Antiproton Decelerator (AD) was built from CERN's former Antiproton Collector ring, which was commissioned in 1987 to supplement the original Antiproton Accumulator (AA; meanwhile, elements of the AA have been sent to the Japanese KEK laboratory).

The task of the AD will be to take the antiprotons, which are produced by 26 GeV/c momentum protons hitting a target and selected at the optimum 3.57 GeV/c momentum level, and, as its name implies, decelerate them to much lower energies, using electron and stochastic cooling to control the beams.

Late last year the AD had a foretaste of particles - the much more readily available protons, in this case. The antiproton debut is scheduled to take place soon after the restart of the CERN machines this spring, with the physics programme following in September.

On the menu are the ATHENA and ATRAP experiments, which will use magnetic trapping to manufacture atoms of antihydrogen (see



CERN Antiproton Decelerator project leader Stephan Maury at the AD during a live antimatter "Webcast" from CERN.

p17). Following the first synthesis of chemical antimatter at LEAR in 1995, physicists have been eagerly awaiting a chance to revisit atomic antimatter country to see whether there is any difference between the behaviour of matter and antimatter.

Also on the menu is the ASACUSA experiment (see this page) by a Japanese-European collaboration, which aims to continue the exploration of antiprotonic atoms - atoms in which an orbital electron has been replaced by an antiproton.

Telegrams from the antiworld

Physics with antiparticles is difficult, but one trick is to replace atomic electrons by antiprotons. The resulting compact atoms are useful antiparticle laboratories.

Antiprotonic atoms, in which an antiparticle is bound to an ordinary nucleus, carry important messages about the antiworld and are much easier to make than anti-atoms. Among antiprotonic atoms, protonium (a "nuclear" proton and an "orbital" antiproton) is particularly interesting because it is the simplest two-body system consisting of a strongly interacting particle-antiparticle pair.

An isolated protonium atom will not be destroyed by collisions

with atoms of the medium in which it was produced and can only de-excite by giving off radiation. The lifetime can then easily exceed microseconds. The difficulty will be to produce the atoms in isolation (see next article).

Antiprotonic helium is a special case. An experiment at CERN (April 1998 p8) discovered that this exotic atom can survive a very large number of collisions and survive long enough to be studied by

laser spectroscopy.

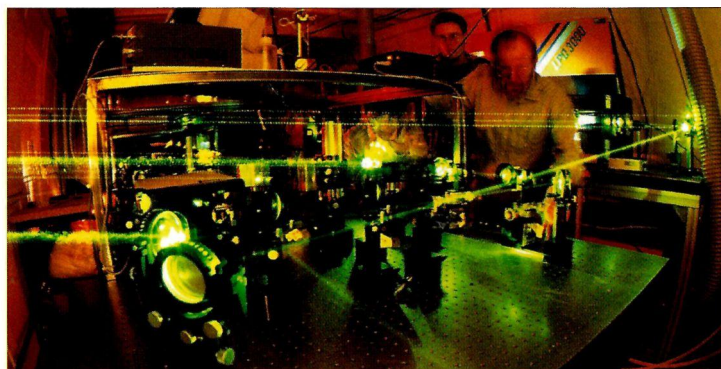
Isolated antiprotonic lithium would also be of great interest because its antiproton orbit should be far outside the residual pair of electrons. It should then be able to descend a ladder of these slow electromagnetic transitions, which ends only when it approaches the electrons.

In studying the interactions of antiprotons with matter, it is important to understand their ionization effects – how antiprotons strip electrons from ordinary atoms.

An experiment at LEAR by a collaboration involving Aarhus, PSI Villigen, University College London and St Patrick's Maynooth measured the ionization of hydrogen by antiprotons within the 30–1000 keV energy range, where the antiprotons can be considered to be “fast and heavy” (see next article). The experimentally observed effects concur with theoretical calculations.

However, at lower energies, where there are as yet no data, theoretical analysis becomes more difficult and different calculations dis-

Some “atoms” with orbital antiprotons live long enough to be examined by laser spectroscopy. (This “trick” image is a superposition of two images: one with the people and one with the laser.)



agree, although they suggest an at the most weak energy dependence.

The study of the ionization of helium by antiprotons, with removal of one or both electrons, was pioneered at LEAR and is also ripe for further investigation.

These additional physics objectives form an integral part of the ASACUSA experimental programme, which involves some 50 researchers from 19 research institutes and in which Japanese physicists play a prominent role.

Per Ardua ad ASACUSA

A major antiproton experiment at CERN's Antiproton Decelerator is currently lining up an impressive array of techniques to investigate the interaction of antiprotons with atoms.

At CERN's AD Antiproton Decelerator, the ASACUSA collaboration is already preparing to greet the first AD antiprotons with a barrage of laser and microwave beams. ASACUSA (April 1998 p8) stands for Atomic Spectroscopy And Collisions Using Slow Antiprotons, and, as this name implies, the experimenters' joblist will include studies of the interaction of antiprotons with atoms at super-low energies, both as a means of understanding the formation of antiprotonic atoms, and as a subject in its own right.

Most physicists learn early in their career that it is impossible to find exact solutions for problems with more than two interacting bodies. Unfortunately, nature's arrangements do not include making life easy for physicists – most of the phenomena that they find interesting (including those mentioned above) turn out to involve three bodies or more. Often physicists can avoid this handicap, sometimes by taking advantage of the fact that the masses and/or ener-

gies of some bodies may be much larger or smaller than those of other bodies; sometimes by using approximation methods; and sometimes by employing both approaches.

The many-body problem of the interaction of charged particle projectiles, such as protons and antiprotons, with atoms has repeatedly engaged many of the most agile minds of 20th-century physics. If, in such collisions, the incident particle is much heavier than the electrons in the target atom and its encounter with the atom is short-lived enough to be treated as a small perturbation, it will follow a straight, charge-independent, constant-velocity path through the atom and will not be deflected by electric fields.

This approximation, together with a few additional assumptions (for example, that the nucleus is too small a target to play a significant role), leads to the familiar Bethe–Bloch formula for the cumulative energy loss from multiple atomic encounters of charged particles passing through matter – of everyday importance in every particle physics experiment.

The “fast and heavy” approximation can at best hold down to projectile velocities about equal to that of the target atom's electrons: about 25 keV for nucleons approaching hydrogen atoms. At lower energies the charge-independence assumption will also be lost, because the projectile stays in the atom long enough to feel the nucleus. Among the more dramatic ultralow-energy effects is that of projectile protons repeatedly capturing and losing electrons.

Antiprotons cannot do this, but when their energy drops still further (below a few tens of electron volts) they will readily be captured by the nucleus (see previous article) and form antiprotonic atoms.

These effects showed up clearly in the very-low-energy domain of antiproton physics opened up at CERN's LEAR low-energy antiproton ring, and groups from Aarhus and Tokyo carried out many atomic interaction experiments as a guide to a better theoretical understanding of these many-body collisions (see previous article).

In the LEAR era, such experiments injected high-energy antiprotons into metallic foils or high-density gases, which degraded the antiprotons to electron volt energies and (in some experiments) provided the target atoms in which they were finally captured.

If the target density or thickness could be made so small that only one collision occurred, much more precise and better-controlled experiments on the atomic interactions of antiprotons would be possible, and the dynamics of antiprotonic atom formation could be studied in detail. At such low target densities the absence of collisions after the capture process should also ensure that all antiprotonic atoms are stable enough to be brought under the penetrating eye of laser spectroscopy (see previous article).

The thin-target condition, where a beam particle enters a target and makes a single interaction, is, in a sense, "business as usual" for high-energy particle experiments, yet it constitutes one of ASACUSA's more difficult longer-term goals. The solution is to separate the deceleration of the antiprotons from the atomic interaction (or antiprotonic atom formation) to be studied.

However, the electron volt antiprotons required for these experiments have a millionth of the energy that even the AD can provide. This energy gap will be crossed in two stages. First, the AD will be supplemented by a decelerating Radio Frequency Quadrupole (under construction in CERN PS division) to reduce the energy to tens of kilo electron volts. The antiprotons will then be confined in a Penning trap that is being constructed at Tokyo University, cooled to cryogenic temperatures, and reaccelerated to a given electron volt-scale energy.

Finally, the reaccelerated antiprotons will be introduced into low pressure gas targets or jets or ultrathin foils. These experiments should start in 2000, after the first round of experiments (on antiprotonic helium) is complete.

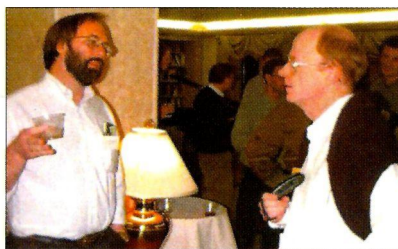
John Eades, CERN.

Is spacetime symmetric?

Do particles and their antiparticles behave in the same way? Even tiny differences could be amplified over astronomical distances to produce very large effects.

The synthesis of antihydrogen (a lone positron orbiting a nuclear antiproton) at CERN in 1995 showed that antimatter is not merely a theoretical dream. Later this year, experiments at CERN's new Antiproton Decelerator (AD) will begin investigating the properties of antihydrogen, their objective being to search for tiny differences in behaviour between matter and antimatter. Any such disparity would have deep implications for our understanding of space and time, as was highlighted at a recent meeting on spacetime symmetries held at Indiana University, Bloomington.

At the microscopic level the universe seems invariant both under CPT (the combination of charge conjugation, C, parity inversion, P and time reversal, T) and relativistic Lorentz transformations (rotations and boosts). However, these symmetries could be violated by effects at the Planck scale, at distances so small (10^{-33} cm) and energies so high (10^{19} GeV) that the gravitational force between two particles becomes comparable to the other forces of physics. Although such effects would be very small, they might be detected in sensitive experiments.



Ace particle trapper Gerald Gabrielse of Harvard (left) with Alan Kostelecky, organizer of the recent meeting on spacetime symmetries at Indiana, Bloomington.

If nature is CPT invariant, the masses of a particle and its antiparticle should be exactly equal. Recent experiments at Fermilab and CERN have established mass equality for the neutral kaon and antikaon to about one part in 10^{19} . This astonishing precision can be compared to measuring the distance between the Earth and

the nearest stars (a few light years) to an accuracy of about 1 cm.

Opening the meeting, Bruce Winstein, spokesman for Fermilab's KTeV experiment, summarized the status of these experiments and the KLOE experiment at Frascati's DAPHNE collider. An ambitious proposal to improve the current bound by more than an order of magnitude in a dedicated CPT kaon experiment was presented by Gordon Thomson of Rutgers. Measurements constraining CPT violation in the B-meson system to about one part in 10^{16} , recently performed by the OPAL and DELPHI collaborations at CERN using data from LEP, were reviewed by Martin Jimack of CERN.

A general extension of the standard model and quantum electro-

dynamics that includes CPT and Lorentz violation was presented by meeting organizer Alan Kostelecky of Indiana. This can be employed to identify promising observable signals that arise from a broad class of theories with CPT and Lorentz violation, including those in which Lorentz symmetry is spontaneously broken in an underlying unified theory at the Planck scale. Malcolm Perry of the University of Cambridge reviewed the status of string and M (membrane) theory and described a new mechanism for CPT violation that involves the dilaton field.

One crucial test of spacetime symmetries is to compare the properties of stable particles with those of their antiparticles. This is possible with high-precision measurements made in electromagnetic traps. New results were presented by experimentalist Richard Mittleman from Hans Dehmelt's group at Washington. An analysis of several months of data from an experiment with single trapped electrons placed a bound of six parts in 10^{21} on a combination of Lorentz- and CPT-violating quantities. Another new bound was reported by Gerald Gabrielse of Harvard, who constrained certain Lorentz-violating quantities to four parts in 10^{26} by comparing the cyclotron frequencies of an antiproton and a hydrogen ion in an electromagnetic trap. A bold plan for testing spacetime symmetries is to perform spectroscopic measurements on antihydrogen and compare them with those of hydrogen. This requires the production of trapped antihydrogen, soon to begin, employing CERN's Antipro-

One crucial test of spacetime symmetries is to compare the properties of stable particles with those of their antiparticles

ton Decelerator (AD). Talks at the meeting outlined the goals of the AD's two key trapped antihydrogen collaborations, ATRAP and ATHENA.

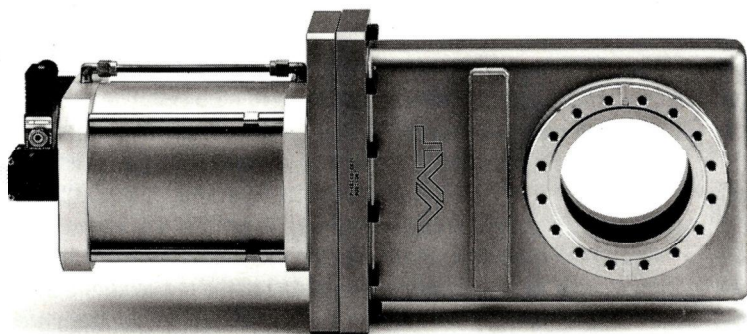
Comparisons between specialized atomic clocks can provide sharp tests of spacetime symmetries. These experiments are, in principle, capable of discerning Lorentz violation at the remarkable level of about one part in 10^{31} . Astrophysical observations are interesting too, because small effects could be amplified as light travels over astronomical distances. One possibility is to look for radiowave birefringence on cosmological scales. Roman Jackiw of MIT presented a theoretical study of such effects, while other talks described possible experiments along these lines.

Organized by particle theorist Alan Kostelecky and attended by about 70 physicists from about half a dozen countries, the meeting was the first conference specifically focusing on this topic. More information can be found on the meeting Web site at "<http://www.indiana.edu/~cpt98/>".

Neil Russell, Indiana.

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 6920 6911
Fax 01 6920 9008
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 0990 134872
Fax 0990 133335
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

A wide span of physics

Nobel prizewinner in 1984, architect and mason of CERN's biggest ever physics discovery and director-general of CERN from 1989 to 1993, Carlo Rubbia remains a continual fountainhead of new ideas. A recent seminar at CERN highlighted the extent of his work.



Speakers at Carlo Rubbia's 65th birthday event (left to right) Gerard 't Hooft, Georges Charpak, Alan Astbury, CERN director-general Luciano Maiani, Klaus Winter, Carlo Rubbia, Arthur Kerman and Val Fitch.

CERN owes a tremendous debt to Carlo Rubbia. His vision foresaw a gleaming new SPS proton synchrotron transformed into a proton-antiproton collider, the springboard for discovering the W and Z particles, the carriers of the weak force. With this discovery, CERN moved to the centre of the world physics stage. At a special seminar at CERN on 16 March, director-general Luciano Maiani pointed out that Rubbia's vision brought the W and Z particles into the reach of physics much earlier than would otherwise have been possible.

The birthday seminar focused on science, but CERN's debt to Rubbia extends much wider. When he took over from Herwig Schopper as CERN director-general on 1 January 1989, the LEP electron-positron collider had not yet come into operation, research and development work on superconducting magnets for the proposed LHC proton collider was just beginning, and CERN had 14 Member States: Austria, Belgium, Denmark, France, the German Federal Republic, Greece, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the UK.

The LHC road had already been chosen in 1986 as the main thrust of CERN's scientific advance by the CERN Long Range Planning Committee, chaired by Rubbia. The route to higher electron-positron collision energies through a purpose-built linear collider (CLIC; CERN Linear Collider) was also acknowledged at that time.

Under Rubbia, the LHC moved from a proposal to a plan, with orchestrated research and development in CERN, other laboratories and industry. In parallel, the LHC's proposed research programme emerged from a vigorous and carefully managed series of presentations throughout the world.

To safeguard CERN's future and reflect the growing internationalism of high-energy physics, Rubbia sought to extend CERN's traditional role as a Western European venture by attracting new member states in Central and Eastern Europe, and by negotiating valuable new working agreements with scientific partners further afield.

Finland, Poland, Hungary, the Czech Republic and Slovakia became CERN member states, while Germany grew to include the former German Democratic Republic, and CERN's relations with other traditional close-collaborating nations, notably Russia and Israel, were put on a new footing.

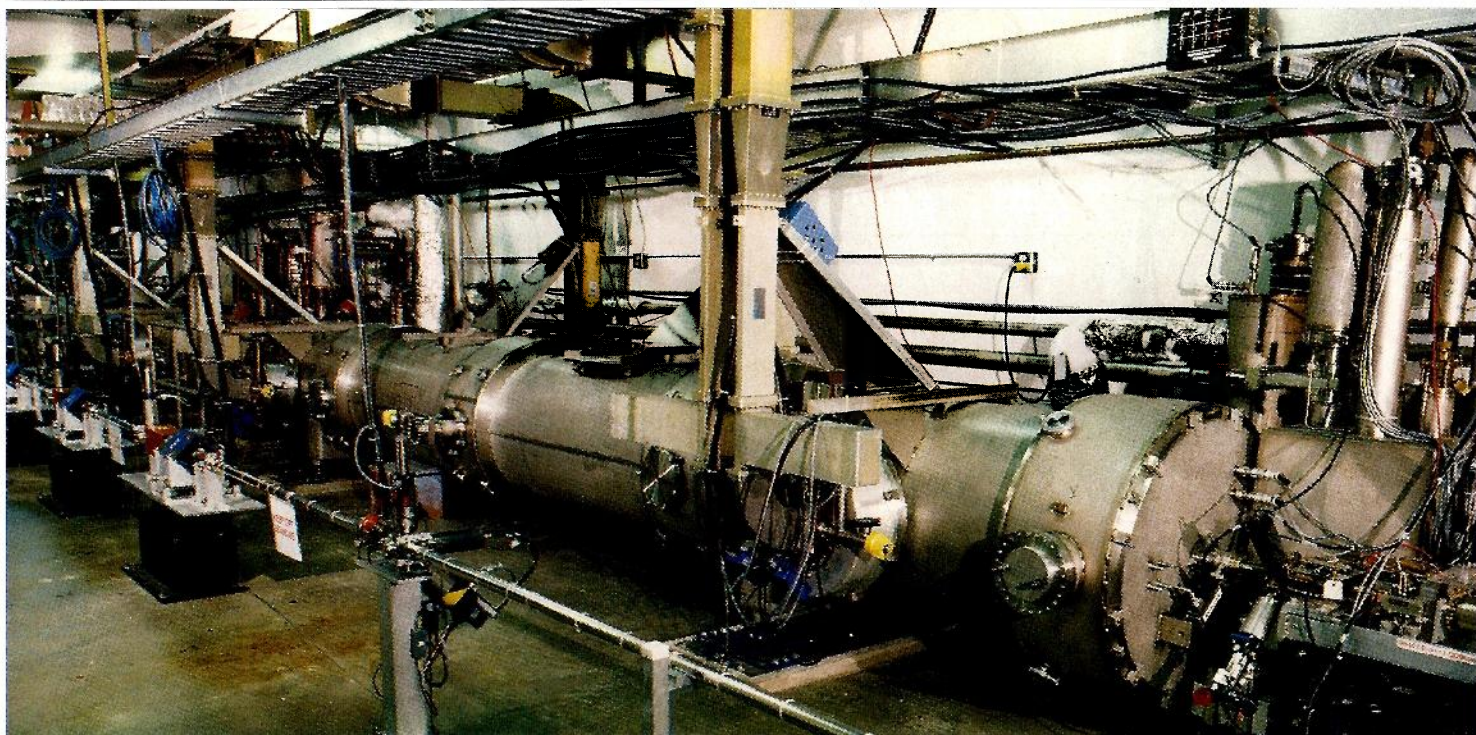
Rubbia worked tirelessly to ensure that LHC plans moved steadily forward during a global recession, when money was extremely tight and governments were not looking at pure science as an investment for the future.

A life in science

Scientific research has dominated Rubbia's life, and the seminar emphasized this side of his achievement, which was for a long time concentrated around weak interactions. Rubbia was also a transatlantic physicist, carrying out research at major US research centres as well as at every CERN machine (prior to LEP).

The seminar proceedings were introduced by 1992 Nobel prizewinner Georges Charpak, who pointed to Rubbia's latest research interests around emerging energy technology as an example of his continual quest for innovation and his flair for new ideas. Innovative instrumentation has been a theme throughout Rubbia's career.

Val Fitch of Princeton, who shared the 1980 Nobel Prize with Jim



Upgrade in sight? One of the linacs of the Continuous Electron Beam Accelerator Facility (CEBAF) at the Jefferson Laboratory, Newport News, Virginia.

Echoes of a report

A major report by a working group of the influential OECD Megascience forum provides a valuable snapshot of nuclear physics and makes far-reaching recommendations for its future direction.

The Organization for Economic Cooperation and Development (OECD), through its Megascience Forum, is making its wisdom felt in scientific circles, acting as a valuable catalyst for future developments and as a focus for international collaboration in sectors where this is not yet centrally organized.

Founded in 1960, the OECD is a grouping of nations with advanced economies, its aim being to improve economic and social conditions in its own sector, stimulating relations with developing countries and generally boosting world trade.

Megascience Forum

Its initial concerns were economic and financial, but the roles of science and technology have been identified as being of major importance, hence the creation of the Megascience Forum. Its latest exercise is a report by a special working group that was set up in 1996 under Bernard Frois of Saclay to look into nuclear physics and its worldwide implications.

Nuclear physics is pursued in all OECD member countries (and

many others) with a global annual investment of about \$1 billion. Nuclear physics has a major impact on technology and society: energy production, biological research, medical imaging, cancer treatment, semiconductor manufacturing, materials science, food processing, environmental monitoring and protection, preservation of art works, archaeology and anthropology.

As scientists probe ever deeper into the structure of nuclear matter, they require larger and increasingly complex facilities and equipment. In most cases these are unique, dedicated facilities, distinct from those of particle physics. The long lead times and considerable resources needed call for strategic decision-making and long-range planning, with a careful consideration of the scientific, technological, economic and social benefits of nuclear research. These requirements are especially critical now, when research budgets are under pressure.

The goals of the Megascience Working Group were to provide an international forum for the exchange of information on priorities, programmes and plans, and to explore opportunities for inter-

Carlo Rubbia

Cronin for their discovery of CP violation, described Rubbia's contributions in this area of physics in the period 1966 to 1973. Fitch displayed a list of 20 physics papers and 4 instrumentation papers with Rubbia as an author, and which had helped to pin down vital parameters in these difficult measurements.

Klaus Winter of CERN looked at the neutrino sector. Rubbia was convinced that neutrino beams were the route to the discovery of the neutral currents - the key to electroweak unification. In the early 1970s, he and his colleagues convinced the new Fermilab to make a major commitment to this physics. The experiment's all-electronic detectors bore the unmistakable stamp of Rubbia ingenuity.

After a long period away from the neutrino stage, the excitement around neutrino oscillations tempted Rubbia back, this time with the ICARUS neutrino detector at the Italian Gran Sasso underground laboratory. The innovative liquid argon time-projection chamber again bears the trademark of Rubbia innovation.

Continual innovation

Turning away from the experimental side, Gerard 't Hooft of Utrecht sketched the development of the theoretical infrastructure that led to electroweak unification and the Standard Model, which Rubbia's 1983 discovery dramatically confirmed. 't Hooft remarked that new theoretical ideas in and around superstrings have predictions that are very difficult to verify by conventional experiments.

Alan Astbury of TRIUMF, Vancouver, a close collaborator of Carlo Rubbia for the UA1 experiment at CERN's proton-antiproton col-

lider, covered the historic period from the late 1970s that led to the 1983 discovery of the W and the Z particles. This physics was a continual close race between the UA1 and UA2 experiments. Astbury pointed out how UA1 had been galvanized into action in late 1982 by having lost the race to discover the tightly confined "jets" of particles, which signal quark-gluon interactions deep inside the proton-antiproton collisions.

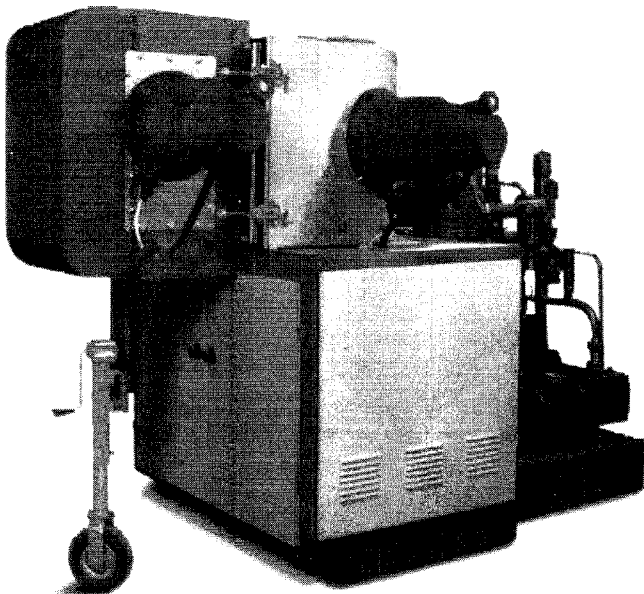
After his mandate as CERN director-general, Rubbia made a dramatic return to the physics stage, this time through his ideas for harnessing accelerators for energy production via nuclear fission with a minimum of nuclear waste and for the destruction of existing waste by transmutation.

Arthur Kerman was billed as covering this phase of Rubbia's career, but began by pointing out the initial role Rubbia had played in recommending the US Superconducting Supercollider. Kerman described the neutron behaviour that opens up the possibility of controlled fission reactions, whether by orthodox absorbers or via an accelerator in tandem with the reactor. The latter possibility had long been recognized, but only recently has accelerator performance begun to approach the necessary levels.

Carlo Rubbia characteristically used the occasion to look forward rather than back, underlining how little we know about the universe. With much of the world around us composed of invisible but all-pervading "dark matter", innovative instrumentation is still called for.

Finally director-general Luciano Maiani underlined the breadth of Carlo Rubbia's contributions, both to CERN and to physics.

Plasma - Immersed Surface Engineering of Advanced Materials



Surface Engineering Equipment

- Filtered cathodic arc PVD equipment
- Custom sources for direct or filtered cathodic arc deposition
- Custom design of modular PVD surface engineering equipment
- Custom upgrade of existing PVD equipment

Surface Engineering Services

- Ion implantation service: 0.4 KeV to 6.0 MeV range
- Reactive magnetron sputtering of hard coatings
- E-beam and ion-assisted deposition of materials
- Continuous PVD coating of ceramic fibers for composites
- Solid lubricant coating by PVD methods
- High-rate sputter deposition of metals and alloys

R&D and Consulting Services

- Advanced aerospace materials technology development
- Defect structure simulations in thin films and interfaces
- Modeling of thermal management in avionics, electronics, industrial machinery and processes
- Deformation processing of advanced structural alloys
- Fracture mechanics, fatigue, failure analysis
- Structural ceramics and ceramic-metal composites development

UES ARCOMAC

UES ARCOMAC, INC

For further information, please contact: Dr. Deepak G. Bhat, *President*
Tel: 937-426-6900 • Fax: 937-429-5413 • E-mail: dbhat@ues.com
UES ARCOMAC Inc. 4403 Dayton-Xenia Road, Dayton, OH 45432



The RHIC heavy ion collider at Brookhaven. The Megascience nuclear physics working group recommends more co-ordination and collaboration to strengthen the worldwide effort in heavy ion collision physics.

national collaboration during the next 10 to 20 years.

Particular attention was given to the role of large facilities and programmes that would benefit from international co-operation:

- to examine the policies and practices that govern access to large facilities, and to assess the impact of current and future trends on the users and providers of international facilities;
- to explore specific opportunities for collaboration in research and development related to nuclear physics facilities, detectors and associated technologies.

Scientific objectives and applications

The fundamental challenges of nuclear physics are not the same as those of particle physics.

What are the constituents of matter, how do they interact and how do they form nuclei?

For nuclear physics, the aim is to understand the properties of nuclear particles from those of quarks and gluons, to solve the nuclear many-body problem and to predict the properties of large nuclei from the known interaction of protons and neutrons. These formidable theoretical problems may become tractable using high-power computers and results from new generations of electron and

hadron beam facilities.

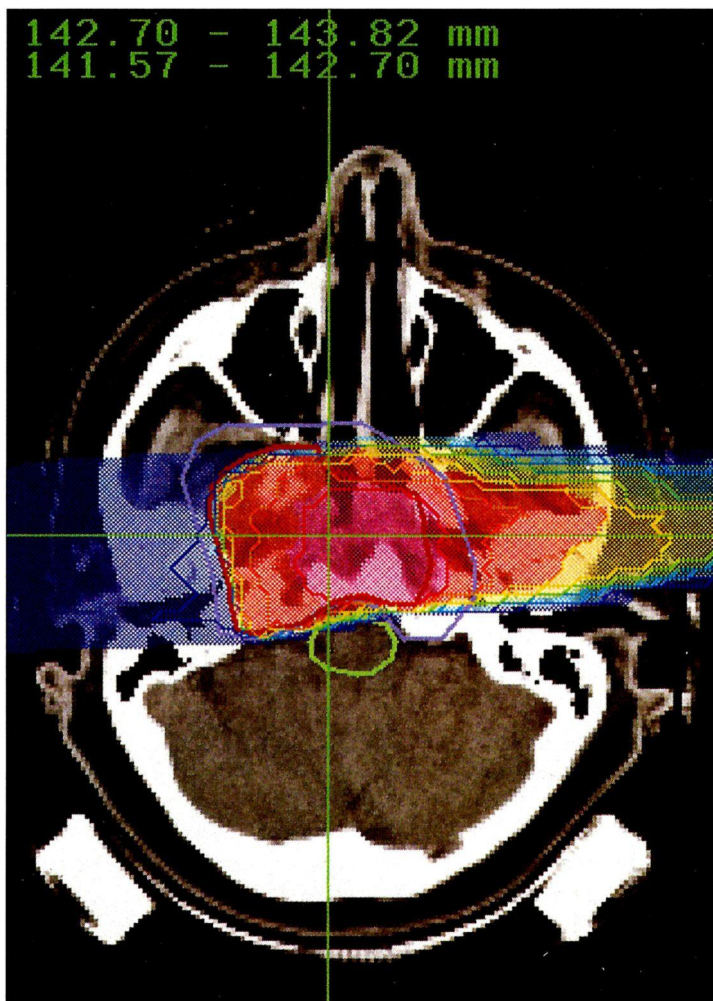
What are the limits of nuclear stability?

The early evolution of the universe was determined by the aggregation of quarks and gluons to form hadrons and nuclei, and the synthesis of heavier elements through nuclear reactions. The stability of nuclei arises from a delicate balance between the nuclear, electromagnetic and weak forces in the nuclear medium.

Some very neutron-rich nuclei have recently been found to have extended distributions of dilute, nearly pure neutron matter that are of much theoretical interest and thus a subject of intense investigation. The direct investigation of nuclear structure far from stability will be made possible through the production of intense beams of rare and short-lived isotopes (radioactive beams).

What happens to nuclear matter at extreme pressures and temperatures?

Nuclei can be compared to liquid drops of nuclear matter. In the collision between two nuclei at high energy, the pressure and temperature of nuclear matter are increased. Is there a transition in the nature of nuclear matter? Is there formation of a plasma of elementary constituents in ultrahigh-energy collisions of heavy nuclei? The search for these phase transitions via heavy-ion collision experi-



Cancer therapy using light ion beams at GSI, Darmstadt. New techniques permit the treatment of tumours in critical locations. In the wide-ranging applications sector, cancer therapy was one of the areas selected by the Megascience nuclear physics working group as worthy of special attention.

ments will be a subject of intense experimental and theoretical work during the next decade.

The liquid-gas phase transition is studied at existing energies. The "deconfinement" transition to a quark-gluon plasma will be investigated in new regimes at Brookhaven's RHIC and CERN's LHC colliders. The early universe presumably underwent this phase transition within the first few millionths of a second following the Big Bang. Such phenomena might have a bearing on important aspects of cosmology, such as nucleosynthesis, dark matter and the large-scale structure of the universe. In astrophysics, the dynamics of supernova explosions and the stability of neutron stars depend on the compressibility and thus the equation of state of nuclear matter.

What is the origin of the chemical elements in the cosmos?

Many elements are formed in stellar explosions via very neutron-rich or, under different circumstances, very proton-rich nuclei. The properties of both routes are largely unknown. While element formation inside stars can be sketched by extrapolating model calculations, there is a critical need for experimental data to provide benchmark

tests for these predictions or input to numerical simulations. Nuclear methods are widely used in materials research and manufacturing. Some examples are non-destructive testing via computerized tomography or neutron radiography, the production of densely packed microchips by ion implantation and the sterilization of heat-sensitive materials by ionizing radiation.

Materials analysis using nuclear reactions and Rutherford scattering is a major research tool for surface analysis, catalysis, semiconductor manufacturing, archaeology, etc.

Particle beams from research accelerators are used to analyse the damage to microelectronic circuits that is caused by cosmic radiation or natural radioactivity – an issue of increasing importance for the further miniaturization of electronics.

Ultrasensitive accelerator mass spectrometry plays an increasing role in environmental research – the study of climatic change, global air and water circulation patterns, stratospheric ozone depletion, and the monitoring of air and water quality. Nuclear technology is indispensable in the monitoring of existing radioactive waste repositories.

For energy production, nuclear fission reactors currently provide about 17% of the world's electricity. Nuclear techniques have an impact on other forms of energy production, including the exploration and utilization of oil reserves. Neutron techniques are routinely used to monitor the chemical composition of coal, coal preparation plants and the determination of the sulphur, water, ash and energy content of coal. For the long term, thermonuclear fusion still holds the promise of a virtually inexhaustible supply of clean energy and is an area of active research and development.

Nuclear techniques are important in medicine and biology. Radioactive isotopes produced by accelerators and nuclear reactors are widely used for treatment and diagnosis, and also in biomedical research.

In the wide-ranging applications sector, the working group focused on three potentially promising topics: the accelerator-driven transmutation of nuclear wastes, medical imaging and cancer therapy.

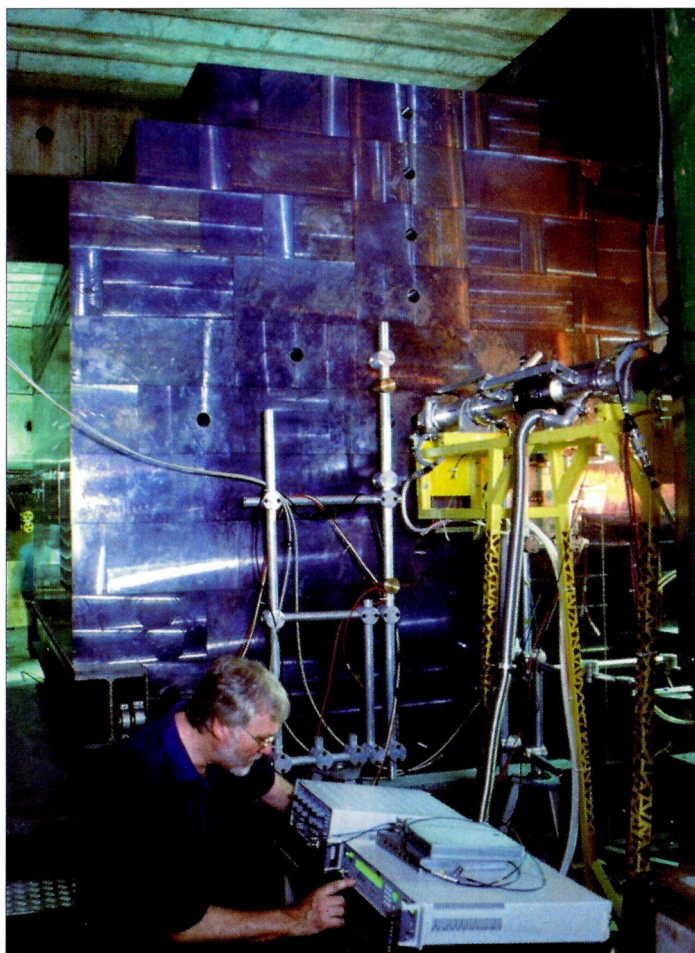
The recommendations

The working group believes that nuclear physics will continue to provide new and important direct benefits for society in the next century. It recognizes the need for

- high-intensity radioactive nuclear beam facilities;
- intense high-energy continuous electron beam facilities;
- multipurpose hadron facilities with a variety of secondary particle beams;
- facilities for heavy ion collisions at very high energies.

Radioactive nuclear beam facilities

Radioactive nuclear beam (RNB) facilities are seen as being important for a broad programme of research in fundamental nuclear physics and astrophysics, as well as in applications of nuclear science. A new generation of high-intensity RNB facilities of each of the two basic types – on-line and in-flight – should be built on a regional basis. Interested governments are encouraged to undertake the necessary decisions within the next few years, and the facilities should become operational in 5 to 10 years.



Carlo Rubbia's TARC (*Transmutation by Adiabatic Resonance Crossing*) experiment at CERN. Accelerator-driven transmutation has emerged as a potentially complementary technology for radioactive waste handling by transmuting the longest-lived radioactive isotopes into short-lived or stable ones.

A contact group should be established that consists of government-appointed programme managers and other scientific and technical experts from countries that are actively involved in planning and implementing new (or upgraded) RNB facilities. It should provide a venue for the accurate and timely exchange of information regarding decisions, priorities, schedules and progress being made in the three major regions of the world.

Electron facilities

High-energy continuous electron beams are important probes of nuclear and hadronic structures at the quark-gluon level.

The proposed upgrade of CEBAF at the Jefferson Laboratory to 12 GeV by 2005 would enter the high-intensity, high-energy domain at a reasonable cost and at the right time.

In Europe, attention has focused on the Electron Laboratory For Europe (ELFE). At the DESY laboratory in Hamburg, the 27 GeV pulsed injector of the proposed TESLA linear collider could be used with the existing HERA electron ring (operating in a "pulse stretcher" mode) to obtain an extracted continuous beam with a maximum intensity of 30 A.

The superconducting radiofrequency cavities from CERN's LEP collider (which will be removed to make way for the Large Hadron Collider) could be utilized for a new 3.5 GeV linac, which could provide a continuous 150 μ A beam at 25 GeV via the recirculation of the electrons.

The employment of heavy ions in the HERA electron-proton collider could be used to study electron-nucleus collisions at even smaller distances, where the gluon density is expected to increase strongly, leading to a completely new physics regime.

For a 25–30 GeV electron facility, the working group encourages international coordination and collaboration.

Hadron facilities

The Japan Hadron Facility (JHF) proposed by the KEK laboratory will attract a worldwide community. Interested parties are encouraged to form partnerships to develop instrumentation and detectors to take advantage of the facility. They should take note of the initiative to open the JHF to an international community.

Heavy-ion collisions

Given the challenges and the pre-eminent importance of heavy-ion collisions for quark matter physics, significant benefits would be realized from increased international collaboration.

Scientific and technical groups, in co-operation with the relevant funding agencies, should maintain the fruitful contacts initiated by the working group. Enhanced co-ordination and collaboration will strengthen the worldwide effort in this field, and, in particular, between the RHIC (Brookhaven) and ALICE (CERN) communities.

Applications

Accelerator-driven transmutation has emerged as a potentially complementary technology for radioactive waste handling by transmuting the longest-lived radioactive isotopes into short-lived or stable ones. This technology could have a significant synergy with other projects, like neutron sources and high-intensity accelerators.

To make optimum use of the available intellectual and financial resources, it may be necessary to strengthen existing co-operative mechanisms or to create new ones. The existing OECD Nuclear Energy Agency could be adapted to play a wider role. While recognizing the diversity of national policies, the working group nevertheless encourages coordination.

For cancer therapy, optimized medical synchrotrons for light-ion therapy have recently been designed by CERN and GSI Darmstadt. New techniques of more accurate beam delivery and precise control permit the treatment of tumours in critical locations, such as the brain or near the spinal cord.

For medical imaging, significant progress can be expected in terms of spatial resolution and sensitivity. Novel techniques will considerably improve the early detection of tumours.

For such a wide-ranging subject, the report is very compact and easy to digest, and it was well received by its parent Megascience Forum. It provides useful indications for scientists and their funding agencies. Even without its recommendations, it is a good summary of nuclear physics today. The full report is available at "http://www.oecd.org/dsti/sti/s_t/ms/prod/NUCLEAR2.pdf".

UNE HAUTE IDÉE DE L'ENTREPRISE

À 10 minutes de l'aéroport international de Genève, au carrefour des réseaux autoroutiers F / CH / D / I, près de deux gares TGV, à proximité du prestigieux CERN.

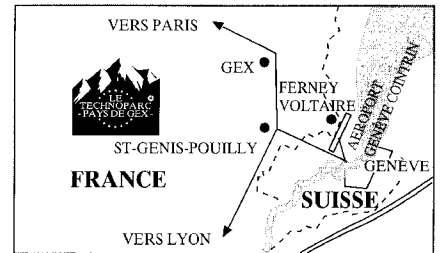
LE TECHNOPARC - PAYS DE GEX -

A Ten minutes' drive to Geneva International Airport, at the crossroads of the F/CH/D/I motorways, close to two TGV railway stations, right next to the prestigious CERN.

propose sur 40 hectares :
des parcelles de terrains viabilisées (achat ou location)
des bureaux et des bâtiments mixtes
une pépinière d'entreprises
des services spécifiques d'assistance aux entreprises pour une implantation régionale et pour des relations avec le CERN
un Bureau de Rapprochement des Entreprises agréé par l'UE.

proposes 100 acres (40 ha) of equipped site with :
pieces of land (purchasing or renting)
offices spaces
activity buildings
incubator
Business Corporation Center agreed by EU.

CONTACT :
**COMMUNAUTÉ DE COMMUNES
DU PAYS DE GEX**
Technoparc - Pays de Gex -
F-01630 Saint-Genis-Pouilly
Tél. 04 50 42 65 00 - Fax 04 50 42 65 01
E-mail : bregex @leman.com
internet : <http://www.leman.com/~bregex>



FAST CURRENT TRANSFORMER

BERGOZ Instrumentation makes Faster Current Transformers to monitor particle beams or currents at high voltage levels. Faster transformers are made by BERGOZ Instrumentation using specially annealed cobalt alloys. Standard models inner diameter from 16 up to 178 mm, risetime falltime down to 175ps. Up to 5 V/A sensitivity. Special models can be as large as 300mm, or very small. Other models integrate picosecond risetime pulses with less than 1% ratio error.

www.bergoz.com

Espace Allondon Ouest
156 rue du Mont-Rond
01630 Saint Genis-Pouilly, France
info@bergoz.com

bergoz
Instrumentation

BIMETALLIC TRANSITION JUNCTIONS

THE T+C / CEA KNOW-HOW :

for the assembly of different metals under stringent reliability

VARIOUS APPLICATIONS

Class 1	• Normal Cryogenics
Class 2	• Advanced Cryogenics
Class 3	• Space, nuclear, chemicals

STANDARD TRANSITION ON STOCK
QUALITY ASSURANCE

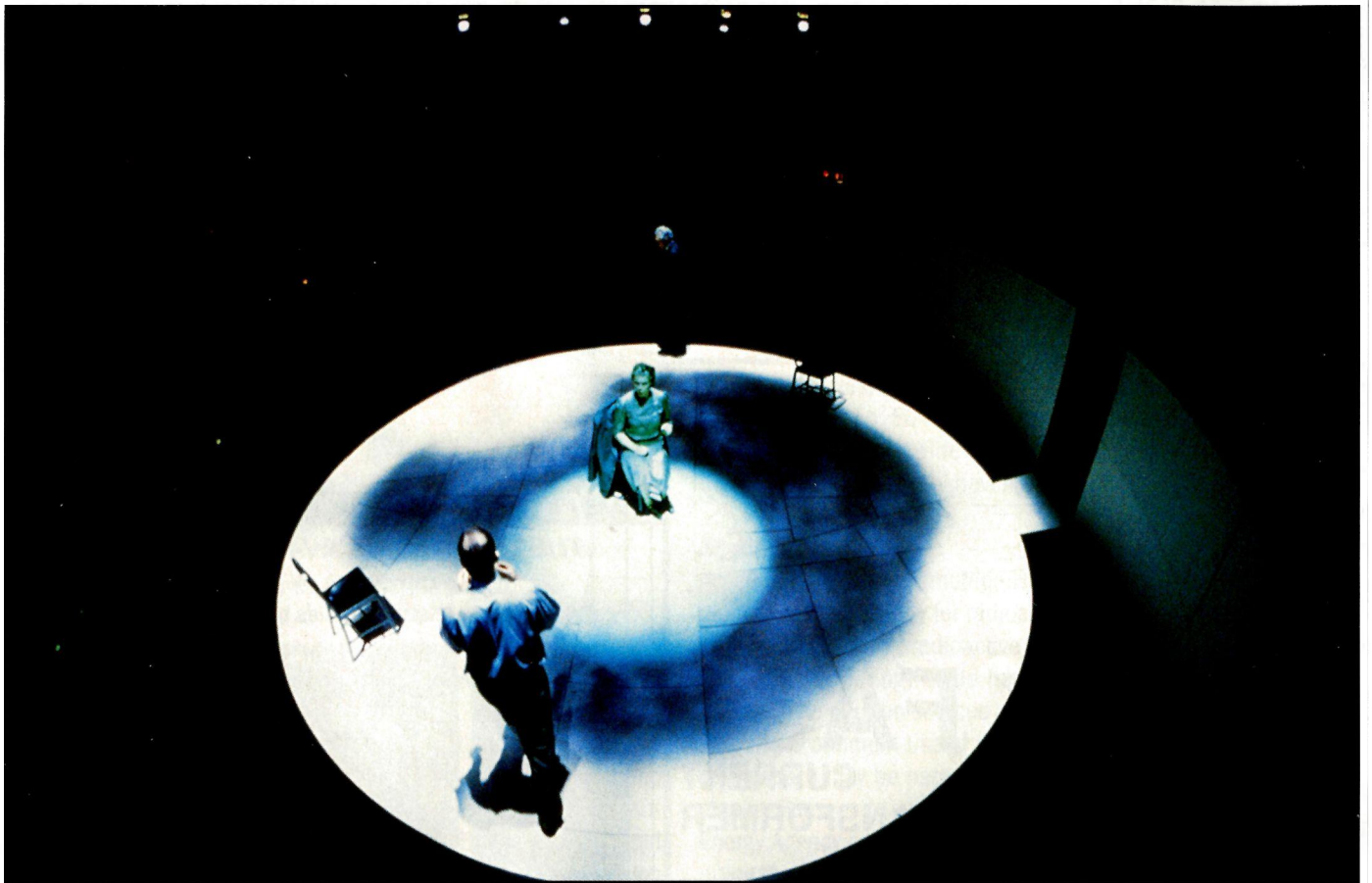
CALL FOR DETAILS
V. MOULIN
Phone: (33) 472.02.68.00
Fax (33) 472.02.68.01
E.Mail Info @Thevenet.Clerjounie.Fr

T+C

THEVENET + CLERJOUNIE
22, avenue Franklin Roosevelt - 69517 VAULX-EN-VELIN (France)

Copenhagen interpretation

Now playing to full houses in London's theatreland is *Copenhagen*, a fascinating new play that imagines a dialogue between the ghosts of quantum pioneers Niels Bohr and Werner Heisenberg.



Copenhagen in London - physics theatre with Matthew Marsh as Werner Heisenberg (foreground), Sara Kestelman as Margrethe Bohr (seated) and David Burke as Niels Bohr (photo Conrad Blakemore).

The play *Copenhagen* shows that physics, in the hands of talented British playwright and author Michael Frayn, can be entertainment.

However, few theatregoers are pulled to the box office by the promise of an evening about physics: it is Frayn's name that packs them in. With an International Emmy Award in 1990, several Best Comedy Awards and Play of the Year, audiences know that he delivers the goods.

In the 1998 harvest of theatre awards, *Copenhagen* was judged Best Play by the *London Evening Standard* and Best New Play by the Critics' Circle, and was nominated for a 1999 Olivier Award.

It is stark theatre - no scenery, three chairs as the only props and a cast of three: Niels Bohr, his wife Margrethe and Werner

Heisenberg on stage for the entire performance.

The focus of the "action" is a recreation of what happened in 1941 when Heisenberg went to Copenhagen to meet Bohr. Shortly afterwards, Bohr fled to Sweden and then the UK, eventually turning up in Los Alamos, where he became a father-figure for the Manhattan project.

Heisenberg played an influential role in the much more modest German wartime effort. Did they exchange physics information in Copenhagen? Did they try to influence each other in any other way? Suspecting that Bohr was in contact with the Allies, did Heisenberg try to dupe them by giving Bohr bad information? Did Bohr try to dupe the Germans by fooling Heisenberg? Who knows? Nobody, but

Wonderful Copenhagen

In Michael Frayn's play about the uncertainty surrounding Werner Heisenberg's wartime visit to Niels Bohr, one thing is absolutely sure: it's great theatre. He has taken the excitement of discovery, the horror of war and the controversy of Heisenberg's motives on that fateful day in 1941 and skilfully wrapped them all in a cloak of uncertainty.

The action takes place long after the characters are dead and gone. Niels and Margarethe Bohr return from the afterlife for one last try to work out what really happened with Heisenberg. Up to a point, the facts are clear. Heisenberg visits Nazi-occupied Copenhagen to give a talk at the German Cultural Centre. While there, he drops in on his old friend and mentor, and the two of them go for a walk under the trees, just as they did when Heisenberg was Bohr's collaborator. In those days they would walk and talk for hours. This time they are back after minutes and Bohr is highly agitated. Heisenberg had asked Bohr whether it was right to work on atomic energy. So much is certain. All that follows is not, as the characters run through three possible interpretations of the evening's events.

Despite having only three characters, the play mentions all of the great physicists of the era and 30 members of the audience sit in apparent judgement behind the stage. It is as if the characters – the Bohrs as well as Heisenberg – are on trial. Why didn't Bohr hear his old friend out? Why didn't he help him to come to terms with the awful knowledge that he thought he had? And why was Margarethe so willing to condemn?

The Bohr's house is bugged, so conversation over dinner is guarded. Heisenberg advises the Bohrs to visit the German Cultural Centre. Is he trying to tell them something important? We don't know, but a hint comes later when Bohr escapes arrest by fleeing across the water to Sweden. He had been tipped off by an anti-Nazi German

Frayn tries to guess.

Rather than a scientific "whodunit?", the play is more of a "who did what?", with accusations and counter-accusations coming from all three sides. As well as the wartime nuclear fission developments, in the second half of the play the "plot" overflows into basic physics for good measure.

Margrethe (admirably depicted by Sara Kestelman) is portrayed as omniscient. Why did Frayn not depict instead Carl von Weizsäcker, who accompanied Heisenberg to Copenhagen and whose pronouncements on physics would have been more authoritative than those of Mrs Bohr? Probably because the idea is to recreate what happened when Heisenberg went to talk with Bohr at his house, not in his physics institute. Whatever else was on his mind in 1941, Heisenberg cared deeply about Bohr.

David Burke's Bohr is visually evocative. In the Bohr-Heisenberg stage duel, both characters are portrayed as strong and assertive in their dialogue, but in real life their assertiveness and obstinacy lay deeper than their oral skills.

For such a stark presentation, director Michael Blakemore and

working at that same centre. Was Heisenberg behind this? Uncertainty again. Once in Sweden, Bohr helps to organize the successful evacuation of almost 6000 of Denmark's 7000 Jews. Was Heisenberg somehow involved in that too?

The physics is deftly woven into the plot and Frayn's treatment of the Copenhagen interpretation is a master class for any would-be science communicator. The research must have been prodigious.

The matinee was performed by the play's second cast. David Barron's Bohr was gruff but likeable, and William Brand's Heisenberg was brilliant, naïv, and confused. Heisenberg's love of his country was a thing to be admired, even though Germany was in thrall to a despotic regime. Margarethe, played by Corinna Marlowe, was balm to soothe the men's fraying tempers and reins to pull their straying conversation back on course. If the first cast does half as well, their performance will be well worth seeing.

Frayn adds nothing to the controversy of Heisenberg's visit, the motives of which remain just as unclear at the end of the play as at the beginning. However, he seems prepared to give Heisenberg the benefit of the doubt. When conversation turns to why Heisenberg had never calculated how much uranium-235 would be needed to build a bomb, Heisenberg demands of Bohr:

"Why didn't you calculate it?"

"Why didn't I calculate it?"

"Tell us why you didn't calculate it and we'll know why I didn't!"

"It's obvious why I didn't!"

"Go on."

But it's left to the initially sceptical Margarethe to save Heisenberg: "Because he wasn't trying to build a bomb!"

You could almost feel the relief in the auditorium.

James Gillies, CERN.

lighting designer Mark Henderson have pulled out all of the stops.

Frayn says that his interest was whetted by reading Thomas Powers' book *Heisenberg's War* and David Cassidy's biography of Heisenberg, *Uncertainty*.

Science communication is still in its infancy (p29), but full marks should be awarded to Frayn for making compelling theatre out of physics. He deserves special recognition for such a heroic undertaking. The result is certainly riveting and accurate, although scientific nit-pickers will occasionally wince. In places the physics is painted too thickly, blinding the audience with science. But that is by the way.

Gordon Fraser, CERN.

● *Copenhagen* is playing at the Duchess Theatre in London until 7 August. For additional information and tickets, you should telephone the theatre box office on +44 171 494 5075 or you can visit the London Theatre Guide Web site at <http://www.londontheatre.co.uk/>.



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.

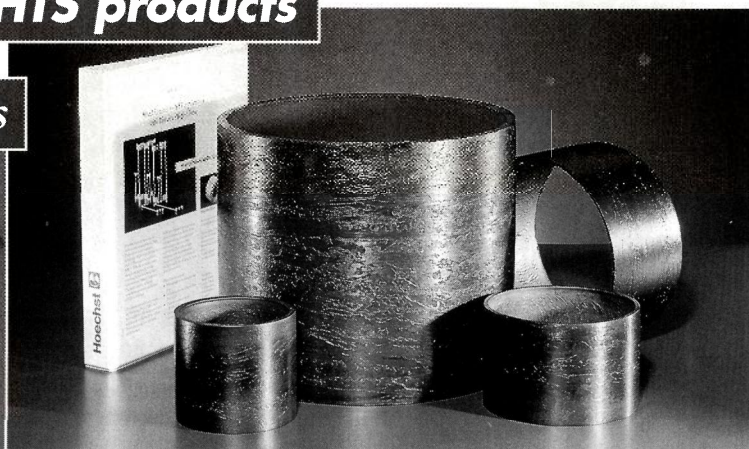
Whilst we can't guarantee to make fairy tales come true, we can help with your unusual requests for materials. Contact us now for a copy of our new product guide and find out what we can do for you.

Goodfellow

Goodfellow Cambridge Limited
 Cambridge Science Park, Cambridge, CB4 4 DJ
 Freephone: 0800 7314653 Telephone: 01223 568 068
 Facsimile: 01223 420 639
 Email: info@goodfellow.com
 Web: www.goodfellow.com

Everything changes: **Aventis HTS products**

for superconductor applications



You have known us as Hoechst Corporate Research & Technology. As a result of the changes in the Hoechst group, we have a new name and new appearance: our new, own identity: Aventis

HTS current leads based on MCP BSCCO rods and tubes from Aventis are the first application of ceramic superconductors in electrical power engineering with currents up to 10.000 A.

A reduction of the heat load to the 4K level by more than a factor of 10 was achieved. This results in a significant reduction of the refrigeration costs and allows new innovative cooling concepts.

Parts of up to 400 mm in length or diameter can also be used in applications in the field of magnetic shielding, current limiters or others.

If you are interested in further information, please contact:

Aventis Research & Technologies GmbH & Co KG

Dr. Joachim Bock
 High Temperature Superconductors
 Chemiepark Knapsack
 D-50351 Huerth Germany
 Tel: (+49) 2233 486658
 Fax: (+49) 2233 486847
 Email: bock@msmiuk.hoechst.com

Aventis

Research & Technologies

A member of the
 Hoechst Group

The incomprehensible is always fresh

Communicating the unfamiliar ideas of basic physics is already a challenge. With theories for the 21st century already on the drawing board and looking even more bizarre, *CERN Courier* editor Gordon Fraser wonders how to get the message across.



As we worry about how we will mark the passage of the millennium and whether its technology will survive that incremental year, fundamental physics has already embarked on its assault on the 21st century. Caught up in the jostle, it is hard to perceive this acceleration. But look back 100 years and it is clear how the prospect of the 20th century provided incentive right across the cultural spectrum.

The work of poverty-stricken artists who were humiliated by the drudgery of unrecognized creativity now trades for fortunes. Fresh influences that were to fire the popular music of the 20th century blazed only in the confines of the ghetto.

Physics too was poised on a launchpad. The decade spanning the 19th and 20th centuries brought a chain reaction of discovery: X-rays, radioactivity, the electron, quantum theory, special relativity... Before the century was much older, a full theory of relativity and the interpretation of empirical quantum theory in terms of quantum mechanics had revolutionized our understanding of the universe.

Rather than having been assimilated into the collective consciousness, these two monuments of human intellect – quantum

mechanics and relativity – still remain obstacles to the public understanding of science. In his introduction to the first edition of his masterpiece *The Principles of Quantum Mechanics*, Paul Dirac said: "The methods of progress of theoretical physics have undergone a vast change during the present century [he wrote in 1930!]. The classical tradition has been to consider the world to be an association of observable objects (particles, fluids, etc) moving about according to definite laws of force, so that one could form a mental picture in space and time of the whole scheme... It has become increasingly evident... that nature works on a different plan. Her fundamental laws do not govern the world as it appears in our mental picture in any very direct way, but instead they control a substratum of which we cannot form a mental picture without introducing irrelevancies."

Dirac was trying to encourage students who were about to embark on a difficult but rewarding book, warning them that they should loosen the straps on their 19th-century imagery of springs and gearwheels and prepare to accept an unfamiliar "impressionist" physics.

Some 70 years later, many generations of physicists have learned

to handle relativity and quantum mechanics in their sleep, but these concepts remain a foreign language for the uninitiated.

"The new theories," wrote Dirac; "if one looks apart from their mathematical setting, are built up from physical concepts which cannot be explained in terms of things previously known...which cannot even be explained adequately in words at all. Like the fundamental concepts which everyone must learn on their arrival into the world, the newer concepts of physics can be mastered only by long familiarity with their properties and uses."

For the 21st century, physicists are venturing into even deeper conceptual water, painting ambitious new pictures that even Dirac would have shunned. Abandoning the "classical" concept of point particles in favour of two-dimensional strings in many-dimensional spaces, new developments suggest that some of the mysteries of quarks and gluons could be inferred from quantum theories of gravity cast in many more dimensions than once was ever thought necessary. The microworld could be a hologram of an otherwise invisible structure of a larger universe.

Superstrings

Recent *CERN Courier* articles on superstrings by Gabriele Veneziano (March p19) and Yaron Oz (April p13) have pointed out how we could have been blindfolded by living in a four-dimensional space-time lesion embedded in a much larger, but ironically indiscernible, scheme. Our limited experience might not be that of most of the

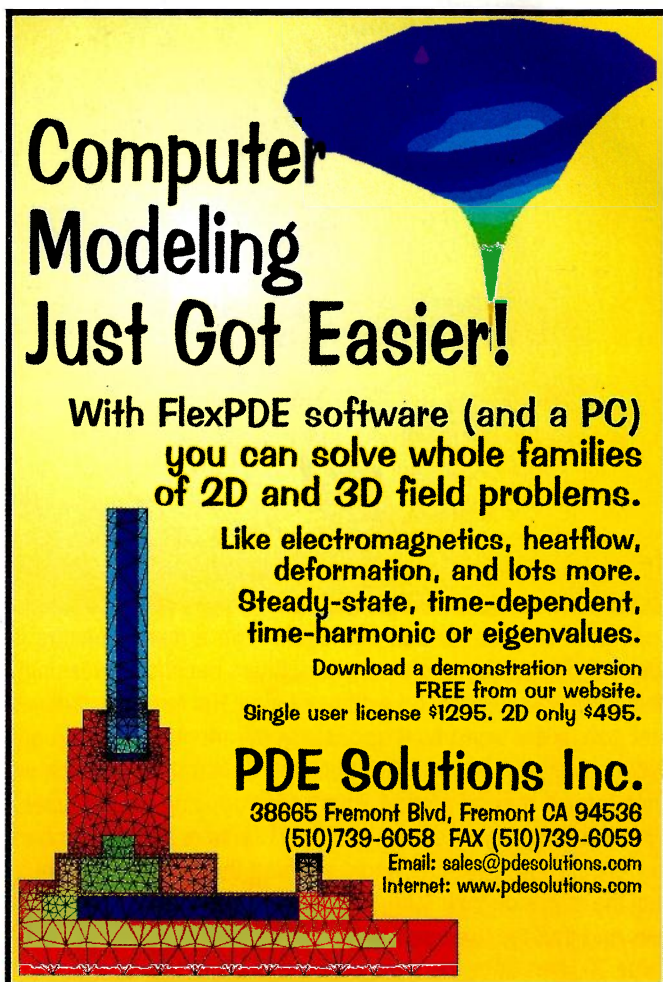
rest of the universe, and another Copernican revolution might be round the corner.

These ambitious theories are not yet ready for any textbooks, but something will surely emerge from all of this intellectual industry. Such a reappraisal of our understanding could go on to parallel Planck's introduction of the quantum concept 100 years ago.

If these new theories do bear fruit, then the problems underlined by Dirac 70 years ago will have been amplified. The preface to the ultimate 21st-century textbook *The Principles of Superstrings* will have to encourage students even more than Dirac did, and the public, blinkered by living in three dimensions, let alone four, could be even more in the dark and seek easier intellectual comfort.

The 21st-century public could find physics not to its taste unless a major effort goes into making the subject palatable. For physics, a key problem is to accomplish this while retaining the confidence and credibility of the scientists. Paraphrasing what can ultimately only be expressed with mathematical precision can attract heavy dogmatic firepower. Researchers accustomed to peer review frequently get hold of the wrong end of the stick when confronted with a popular market.

A successful play now running in London (p26) has shown that physics, given the right treatment, can have popular appeal. However, science communication ultimately has to come from scientists. Where Carl Sagan and Stephen Hawking whetted the public appetite for the incomprehensible, others have followed. With the prospect of fresh conceptual horizons, a new door is open.



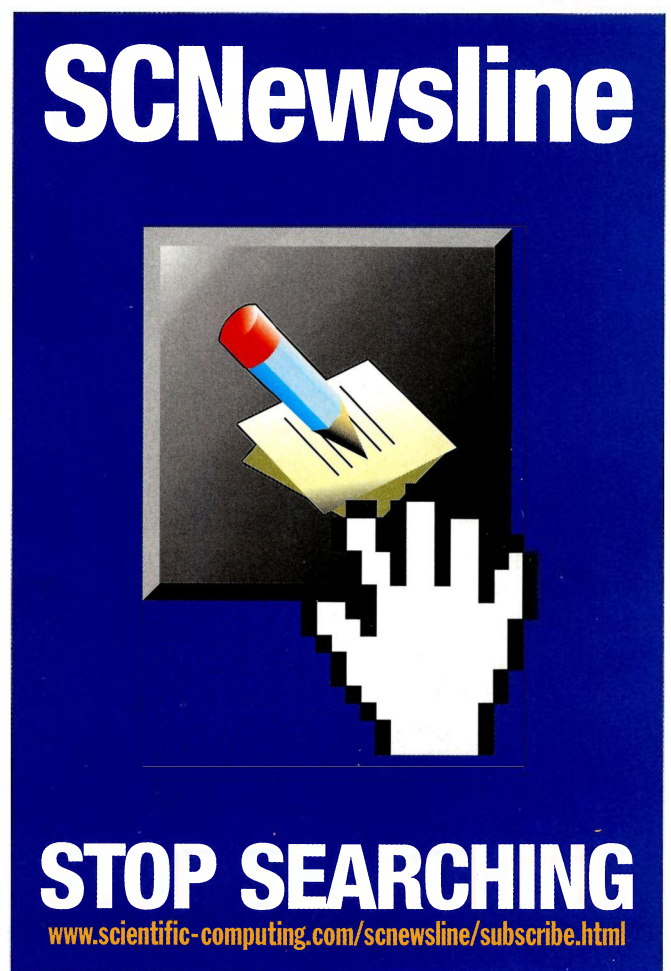
Computer Modeling Just Got Easier!

With FlexPDE software (and a PC) you can solve whole families of 2D and 3D field problems.

Like electromagnetics, heatflow, deformation, and lots more. Steady-state, time-dependent, time-harmonic or eigenvalues.

Download a demonstration version FREE from our website. Single user license \$1295. 2D only \$495.

PDE Solutions Inc.
38665 Fremont Blvd, Fremont CA 94536
(510)739-6058 FAX (510)739-6059
Email: sales@pdesolutions.com
Internet: www.pdesolutions.com

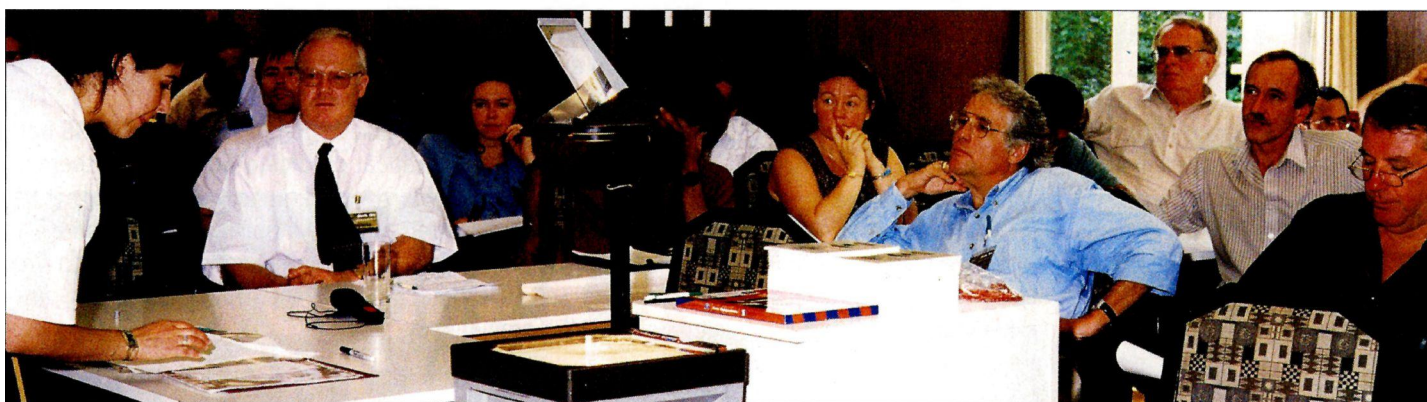


SCNewsline

STOP SEARCHING
www.scientific-computing.com/scnewsline/subscribe.html

Don't be afraid of the dark

Unveiling the nature of dark matter – matter revealing itself only via its gravitational interaction – is a continuous challenge in contemporary cosmology. The job of particle physics experiments is to search for the material of this vital but invisible matter. A recent meeting in Heidelberg surveyed the dark matter scene.



Dark room – a session of the Second International Conference on Dark Matter in Astro- and Particle Physics in Heidelberg.

The invisible dark matter of the universe weighs heavily on cosmology. However, whatever and wherever this invisible material is, it must be made of something, and the most plausible candidates are relic particles from the early phase of the universe (March p25). The search for dark matter, mostly using non-accelerator experiments, has become an established part of particle physics.

These questions were examined when physicists from all over the world met in Heidelberg for the Second International Conference on Dark Matter in Astro- and Particle Physics (DARK98). The goal was to shed light on theoretical backgrounds from particle physics and cosmology, to discuss the results of dark matter detection experiments and to examine future projects.

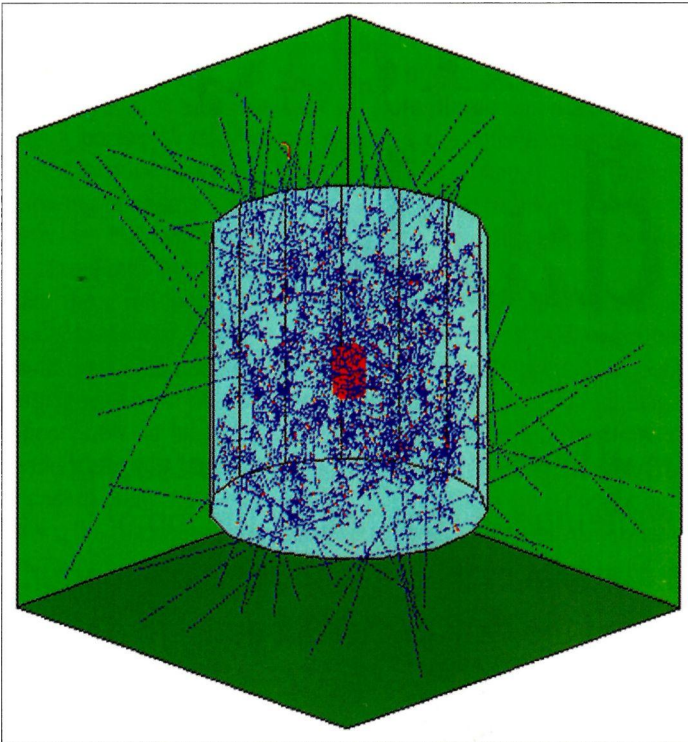
The most compelling evidence for both baryonic (nuclear) and non-baryonic dark matter comes from observations of the rotation curves of galaxies. In particular, the rotation curves of dwarf spirals are completely dark matter dominated, pointed out Andreas Burkert (Heidelberg). The rotation curve of one of the best-measured dwarf spirals can only be fitted to theoretical predictions if both an outer cold dark matter halo and an inner spherical distribution of massive compact baryonic objects (MACHOs) is assumed.

The search for MACHOs in the halo of our own galaxy – in the form of planets, white and brown dwarfs or primordial black holes – exploits the gravitational microlensing effect – the temporary brightening of a background star as an unseen object passes close to the line of sight. For several years a number of groups have been monitoring the brightness of millions of stars in the Magellanic clouds, as Kim Griest (San Diego) and Marc Moniez (Orsay) explained.

MACHOs or WIMPs?

Several candidates have already been detected and if interpreted as dark matter would make up half of the amount needed in the galactic halo. However, no stellar candidate seems to be able to explain the observations. MACHOs could be an exotic form of baryonic matter, like primordial black holes, or they could be located outside the halo of our galaxy.

The leading non-baryonic dark matter candidates are the so-called weakly interacting massive particles (WIMPs). If WIMPs populate the halo of our galaxy, they could be detected directly in laboratory experiments, or indirectly through their annihilation products in the halo – the centre of the Sun or Earth.



Simulation of the GERmanium in Nitrogen Underground Setup (GENIUS) double beta decay and dark matter search using 1 ton more of enriched germanium-76 in liquid nitrogen.

Blas Cabrera (Stanford) gave an overview of the direct detection experiments. The goal is to look for the elastic scattering of WIMPs off nuclei in a low-background target detector. The Stanford Cold Dark Matter Search (CDMS) experiment, he explained, uses detectors of ultrapure germanium and silicon operated at a temperature of 20 mK. The simultaneous measurement of both ionization and phonon signals allows nuclear recoil events to be differentiated from electron interactions – a very effective background suppression method. For the moment, the experiment is located at the Stanford Underground Facility, 10.6 m below ground, but the goal is to operate the detector in the deep Soudan mine in Minnesota.

The DAMA experiment, presented by Rita Bernabei (Rome), is running 115.5 kg of sodium iodide detectors in the Gran Sasso underground laboratory near Rome. Its high statistics open the possibility of looking for WIMPs via a variation in the event rate owing to the movement of the Sun in the galactic halo and the Earth's rotation around the Sun. The analysis of about 13 kg/yr reveals a positive WIMP annual modulation signal, which meanwhile has been confirmed with higher statistics from 54 kg/yr. However, a further confirmation by DAMA and by other experiments must be awaited.

The Heidelberg group reported on the two most sensitive germanium experiments – the Heidelberg-Moscow experiment and Heidelberg Dark Matter Search (HDMS) – both of which are located in the Gran Sasso Laboratory. The Heidelberg-Moscow experiment, which also searches for neutrinoless double beta decay in enriched germanium-76, currently gives the most stringent limits on WIMP-nucleon scattering for raw data.

HDMS, a dedicated dark matter experiment, aims to improve this

limit by one order of magnitude. Like the Heidelberg-Moscow experiment, it looks for a small ionization signal inside a high-purity germanium crystal.

With the expected sensitivity, HDMS will be able to test, like CDMS, the complete DAMA evidence region. The new project of the Heidelberg group, GENIUS, presented by Laura Baudis, aims for a sensitivity that is a thousand times as good as that of present experiments. GENIUS will operate in its dark matter version 40 “naked” germanium crystals (100 kg) in a 12 × 12 m tank of liquid nitrogen. Reaching the target sensitivity, it could test almost the complete parameter space predicted for certain supersymmetric particles, thus deciding whether WIMPs make up the dominant part of our galactic halo.

Terrestrial indirect detection experiments search for high-energetic neutrinos as annihilation products of WIMPs in the centre of the Earth or the Sun. The MACRO experiment in Gran Sasso looks for an excess of neutrino-induced upward-going muons, explained Teresa Montaruli (Bari). No WIMP annihilation signal has been found, but the sensitivity of the experiment sets stringent upper limits on the flux of upward-going muons and thus excludes significant portions of the parameter space predicted for the supersymmetric particles.

An alternative indirect signature for dark matter particles would be a distorted spectrum of secondary antiprotons owing to the pair annihilation of neutralinos in the halo. Pierre Salati (Annecy) compared the measured low-energetic antiproton flux by the BESS balloon experiment with theoretical predicted fluxes. While there is some room left for a possible signal of exotic origin, this cannot be seen as evidence for a supersymmetry-induced signal, he claimed. To disentangle such a signal from the secondary antiproton flux much more sensitive detectors, like the Alpha Magnetic Spectrometer (AMS), are needed.

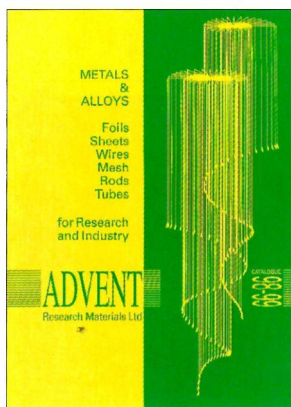
Superheavy dark matter

Recently a new class of dark matter candidates – superheavy dark matter – have emerged. If one gives up the assumption that the particle was in thermal equilibrium in the early universe, explained Edward Kolb (Chicago), then its present abundance is no longer determined by annihilation and much heavier particles – the formidable sounding WIMPZILLAs – are allowed. There are two necessary conditions for WIMPZILLAs: they must be stable, or at least have a lifetime much greater than the age of the universe; and their interaction rate must be sufficiently weak that thermal equilibrium with the primordial plasma was never obtained. Kolb presented a number of ways in which such a particle could have been created, like gravitational production during the transition between an inflationary and a matter- or radiation-dominated universe, and during the defrosting phase after inflation.

Like the new millennium, dark matter could be just around the corner. The next meeting – DARK2000 – will take place in Heidelberg. DARK98 was organized by H V Klapdor-Kleingrothaus (with Laura Baudis as scientific secretary) from the Max Planck Institut für Kernphysik, Heidelberg.

H V Klapdor-Kleingrothaus and L Baudis, Max Planck Institut für Kernphysik, Heidelberg.

FREE LITERATURE



Advent Research Materials

Metals and Alloys for Industry and R&D

30 Metals and Alloys, 650 stock lines, 3500 standard packs. Foil, Sheet, Wire, Insulated Wire, Mesh, Rod, Tube. Small quantities, fast shipment and **very competitive prices**. Visit our Web site for more information. If what you need is not listed in our free 98-99 Catalogue, please ask for a "special order" quotation.

Advent Research Materials Ltd

Oakfield Industrial Estate
Eynsham, Oxfordshire OX8 1JA, England
Tel. +44 (0)1865 884 440
Fax +44 (0)1865 884 460
E-mail info@advent-rm.com
Internet www.advent-rm.com



Goodfellow

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

70 Pure Metals, 200 Alloys, 57 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, Cambridge Science Park, Cambridge CB4 4DJ, England
Freephone 0800 731 4653
Tel. +44 (0)1223 568068
Fax +44 (0)1223 420639
E-mail info@goodfellow.com
Internet <http://www.goodfellow.com>

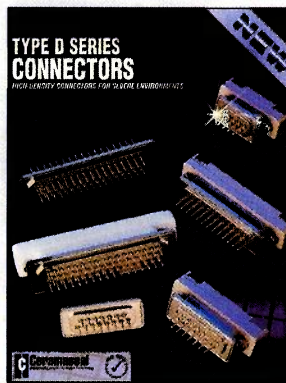


Vacuum Generators

Catalogue 33, the latest catalogue from Vacuum Generators, covers our established range of quality UHV and HV components as well as many new products and services.

For your copy, contact your local agent or Vacuum Generators directly.

Vacuum Generators
Maunsell Road
Castleham Industrial Estate
Hastings
East Sussex
TN38 9NN, UK
Tel. +44 (0)1424 851291
Fax +44 (0)1424 851489
E-mail Sales@vacgen.com



Ceramaseal

Type D Series Connectors

The Ceramaseal D Series connectors are designed for ultra-high vacuum (minimum leak rate of 1×10^{-9} standard cc He/sec, cryogenic (liquid nitrogen) and high temperatures of 350 °C. Options include 9, 15, 25 and 50-pin designs. Materials used in the connector series include 304 stainless-steel shell, gold plated pins and glass-ceramic insulation. Choice of plug materials are available depending on temperature and environmental conditions.

Call for free technical flyer
Ceramaseal/Meili Kryotech, Switzerland
Tel. +41 (0)56/245 41 45
Fax +41 (0)56/245 49 51
Headquarters USA
Tel. +1 518 794 7800. Fax +1 518 794 8080
E-mail info@ceramaseal.com
<http://www.ceramaseal.com>

CERN COURIER'S FULLY INTERACTIVE WEB SITE IS LIVE...

Explore the latest hot topics in particle physics

Link to physics sites worldwide

Digest news and features from the latest *CERN Courier*

Browse through previous issues

Search current quality job opportunities

Bookmark cerncourier.com today

**CERN
COURIER**
www.cerncourier.com

IoP

The complete

IRIS

development environment

IRIS Explorer is the state-of-the-art, interactive 3D application development system for all your visualisation needs.

Enabling simple and complex, multi-dimensional datasets to be easily accessed, manipulated, visualised and animated, IRIS Explorer gives you greater insight into your data, delivering intelligent decisions faster.

Using this powerful, intuitive software is easy. By simply selecting building blocks and connecting them together using IRIS Explorer's point-and-click interface, you can rapidly design and customise visualisation applications without writing a single line of code.



All trademarks are acknowledged.

To find out how IRIS Explorer can increase your analysis capabilities, or to arrange a demo copy, contact NAG today:
<http://www.nag.co.uk/iriscc>

IRIS Explorer™
From data to understanding using visualisation.



email: sales@nag.co.uk
Tel: +44 (0)1865 511245

People



On 26 March, President of the People's Republic of China **Jiang Zemin** (second from right) and Swiss President **Ruth Dreifuss** (third from right) visited the L3 experiment at CERN. With them were CERN director-general Luciano Maiani (second from left), L3 spokesman and 1976 Nobel prizewinner Sam Ting (right) and L3 physicist and Geneva University rector Maurice Bourquin (left). In 1985, Jiang Zemin, as Mayor of Shanghai, played a key role in organizing the production of BGO crystals at the Shanghai Institute of Ceramics. The crystals are a major part of the L3 experiment.



Indian Atomic Energy Commission Chairman **R Chidambaram** (second from right) visited CERN on 17 March, accompanied by (left to right) **Atul Gurtu** and **Vemuri Narasimham** of Bombay's Tata Institute for Fundamental Research. He saw the progress of Indian contributions for the LHC machine and for the CMS experiment, where his host was CMS co-spokesman **Jim Virdee** (right).

G N Flerov prize

In October, the Joint Institute for Nuclear Research will award the G N Flerov prize to the winner of the contest for outstanding research in nuclear physics. The contest is for individual participants only. The winner will also receive \$1000. Participants should send an abstract of their research, enclosing copies of major contributions, to be received by 1 October, to Dr Andrew G Popeko, Joint Institute for Nuclear Research, Flerov Laboratory for Nuclear Reactions, Dubna, Moscow Region, 141980, Russia. Tel. (7 096) 21 65958. Fax (7 096) 21 65083. E-mail "popeko@sunvas.jinr.ru".

Enrico Fermi award

Maurice Goldhaber wins a prestigious US Enrico Fermi award "for his lifetime of distinguished research". This began in Rutherford's lab in Cambridge in 1934, when Goldhaber and Chadwick measured the mass of the newly discovered neutron. Another physics milestone was his widely admired 1958 experiment at Brookhaven, with Grodzins and Sunyar, measuring the helicity of the neutrino, only two years after the elusive particle had first been observed. Goldhaber served as Brookhaven's director from 1961 to 1973.

Meetings

- Photon 99, the international conference on the structure and interactions of the photon, will be held in Freiburg, Germany, on 23–27 May. The programme will cover photon structure, diffraction, resonance production and photon physics at a linear collider. Further information is available at "<http://ruhph8.physik.uni-freiburg.de/p99/>".
- Tel Aviv University is organizing an international workshop that will address subject areas that are at the frontiers of QCD. Challenges in QCD will take place at Kfar Giladi, a kibbutz in northern Galilee, Israel, on 20–23 June. Further information is available at "<http://www-nuclear.tau.ac.il/~qcd99/>".
- The International Workshop on Polarized Sources and Targets, PST99, will be held on 29 September – 2 October in Erlangen, Germany. The programme will cover polarized ion sources and gas targets, polarized electron sources and polarized solid targets. For further information, contact E Steffens, Physikalisches Institut, Universität Erlangen-Nürnberg Erwin-Rommel-Str. 1, D-91058 Erlangen, Germany. Tel. +49-9131 852 7093. Fax +49 9131 15249. E-mail "pst99@physik.uni-erlangen.de". Internet "www.physik.uni-erlangen.de/pst99/".

Glenn Seaborg 1912–99



US Atomic Energy Commission chairman Glenn Seaborg (right) and Fermilab founding director Bob Wilson brandish a shovel at formal groundbreaking for Fermilab in 1968.

Glenn Seaborg, who shared the 1951 Nobel Prize for Chemistry with Edwin McMillan for their initial discoveries of the transuranic elements, died in February.

After an initial degree in chemistry from UCLA, Seaborg moved to Berkeley for his graduate studies, earning his PhD in 1934 under Ernest Lawrence for neutron research using the new cyclotron.

Using a Berkeley cyclotron to bombard uranium with neutrons, McMillan and Philip Abelson discovered the first transuranic element, neptunium, and soon afterwards Seaborg and his colleagues supplied the first nuclei of the next element, plutonium. Seaborg also discovered its fissionable 239 isotope and went on to play a major role in the wartime effort to manufacture plutonium for a bomb. With the weapon ready, Seaborg was in favour of a test demonstration rather than actually dropping the weapon. For the remainder of his life, he remained a staunch advocate of nuclear arms control and limitation.

From 1961 to 1971 Seaborg was chairman of the US Atomic Energy Commission, then the main overseer of the national particle physics programme. During this time US particle physics boomed, with the construction of major new laboratories around big machines.



Some 36 students between the ages of 17 and 18 from schools in London and Stockholm recently visited CERN as part of their science studies. The idea was the brainchild of Erik Johansson of Stockholm and the Delphi experiment, and the highly successful visit was organized by Johansson and Christine Sutton of Oxford in their roles as Swedish and UK representatives of the European Particle Physics Outreach Group.

Harry Lehmann 1924–98

Harry Lehmann, who died of cancer in November, was the founder of theoretical particle physics in Hamburg, and over a period of 30 years he moulded the character of the II Institute of Theoretical Physics. He also contributed much to the shaping of DESY.

One of the founding fathers of modern quantum field theory, much of Lehmann's pioneer work in the 1950s was in collaboration with Kurt Symanzik and Wolfhart Zimmermann – the shorthand LSZ is still familiar to all elementary particle physicists. This formalism and the Lehmann representation are among the most important basic tools of elementary particle theory.

Born in Güstrow in 1924, Lehmann went to school in Rostock before being conscripted and shipped to North Africa, where he was taken prisoner in 1943 and taken to a camp in the US. Released in Stuttgart, he returned to his parents in Rostock, where he became a student of physics, later moving to the Humboldt University in Berlin.

After doctoral work with Hund in Jena, East Germany, he moved in 1952 to the Max Planck Institute in Göttingen, West Germany, which was presided over by Heisenberg. He

never returned to the German Democratic Republic – his formal application for prolongation of leave was never answered. In 1956, after a year in Copenhagen, he accepted a prestigious professorship in Hamburg as a successor to Lenz.

The destiny of high-energy physics in Hamburg was then being charted, with Willibald Jentschke pushing for the establishment of DESY. Lehmann was a long-time member of DESY's scientific council, doing much to create and promote the Theory Division. He persuaded Kurt Symanzik and many other leading scientists to come to DESY. In the early 1960s he resisted a tempting offer from Institute des Hautes Etudes Scientifiques (IHES), Bures-sur-Yvette.

The development and scientific attraction of his institute was his personal ambition and he was extremely proud of its success. The institute's Tuesday afternoon theoretical seminars have become legendary. Lehmann's criticism at these meetings could be quite aggressive, but towards young scientists he was benevolent and helpful. Junior scientists became fascinated by Lehmann's personality and behaviour, not to mention the unerring accu-



Harry Lehmann 1924–98.

acy of his judgement. He was much appreciated as a teacher and examiner.

Lehmann received many honours, including the Max Planck medal of the German Physical Society in 1967, the Dannie Heinemann prize of the American Physical Society in 1997 and the order Pour le mérite.

We remember him with gratitude.
Gerhard Mack.

Venedict P Dzhelepov 1913–99

Renowned Russian scientist Venedict Petrovich Dzhelepov died suddenly on 12 March. He was one of the founders of the Institute of Nuclear Problems (1948) and later of the Joint Institute for Nuclear Research in Dubna, where he was director (1956–88). From 1988 he was honorary director of the Laboratory of Nuclear Problems.

His long career in science has many landmarks. In 1949 he constructed what was then the world's largest proton synchrocyclotron, reaching 680 MeV. This was later (1984) converted into a high-current phasotron with a shaped magnetic field. He obtained pioneer data in nucleon–nucleon and pion–nucleon interactions, in the capture of negative muons by protons, and in the electron decay of negative pions.

New results were achieved in the multiple production of strange and neutral particles and in hypercharge exchange reactions. Dzhelepov was the first to obtain the funda-

mental, now classical, experimental results on muonic molecules and the muon-catalysed nuclear fusion of heavy hydrogen isotopes. The USSR Academy of Sciences awarded him the IV Kurchatov gold medal and prize for these investigations.

Dzhelepov was also well known for his work on high-current accelerator complexes in the 0.8–1.5 GeV range based on isochronous cyclotrons. He initiated and supervised the construction of Russia's first medical physics complex, based on the synchrocyclotron of the Laboratory of Nuclear Problems, for the proton treatment of cancer and for space medicine.

He was a corresponding member of the Russian Academy of Sciences, for many decades one of the leaders of the Nuclear Physics Division of the Russian Academy of Sciences, and a winner of Russian State prizes. As a member of IUPAP commissions, and ICFA and editorial boards of highly



Venedict P Dzhelepov 1913–99.

authoritative scientific journals, he made a substantial contribution to the development of the international scientific co-operation. Many eminent scientists in Russia and other countries learned much from working with him.

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 £30, Single colour £34, Full colour £36. Please contact us for more information on publication dates and deadlines.

TENURE TRACK FACULTY POSITION Experimental High Energy Physics Carnegie Mellon University

The Department of Physics at Carnegie Mellon University invites applications for a junior tenure track faculty position in the area of experimental particle physics. The present program consists of experiment 781 at Fermilab, R&D for the BTeV detector at Fermilab, the L3 experiment at CERN, and the CLEO III experiment at Cornell. We are also engaged in work in the CMS collaboration for the LHC.

Applicants for the position should have postdoctoral experience and demonstrated ability in both instrumentation and analysis. The successful candidate is expected to assume a leadership role in his/her experimental involvement during the coming decade. Applicants should also be committed to excellence in graduate and undergraduate education.

The position is nominally available for September, 2000, but an earlier starting time might be arranged. Applications and three (3) letters of recommendation should be sent before October 15, 1999, to:

High Energy Search Committee
ATTN: Prof. James Russ
Department of Physics
Carnegie Mellon University
Pittsburgh, PA 15213, USA
(e-mail: russ@cmphys.phys.cmu.edu)

Reply may be by email, followed by paper copy.

Carnegie Mellon is an equal opportunity/affirmative action employer

The NESTOR Institute for Deep Sea Research Technology and Neutrino Astroparticle Physics

is seeking applications for **three TENURE TRACK** positions.

Qualifications for the positions include :

1. Ph.D. in Experimental Physics (Elementary Particles or Nuclear Physics or Astrophysics). 2. An Application in English or Greek. 3. Official copies of diplomas. 4. A detailed CV. 5. An official copy of the military service status (Greek male citizens only). 6. Citizenship of a European Union Country is required.

The NESTOR Institute for Deep Sea Research Technology and Neutrino Astroparticle Physics

is an Independent Research Center under the supervision of the General Secretariat for Research and Technology of the Ministry of Development of Greece. It invites candidates for three entry level TENURE Track Researcher positions. After an initial 3 year appointment, successful candidates will be promoted and extended for an additional 3 years following which they can apply for tenure.

Greek and English are the working languages of the Institute. E.U. citizens are encouraged to apply.

The deadline for receipt of the applications in May 31, 1999. For more information please contact :

<http://solon.cc.uoa.gr/~nestor/> or NESTOR Institute
GR - 24001 - Pylos, GREECE

Tel. (30 723) 23300, (30 1) 3646451, 3633413

Fax. (30 723) 23300, (30 1) 3633413

email : L.Resvanis@cern.ch or secretar@digital.ipn.uoa.gr

Tenure-Track Faculty Position Experimental Heavy-Ion Physics University of Illinois at Chicago

The Physics Department at the University of Illinois at Chicago invites applications for a tenure-track faculty position in Experimental Relativistic Heavy-Ion Physics. The candidate should have a Ph.D. and demonstrated outstanding research ability as well as a strong interest in teaching.

The successful candidate will be expected to carry out experimental research in the general area of relativistic heavy-ion collisions. Current efforts in this area include experimental work on experiment E917 at the BNL-AGS and the PHOBOS experiment at the RHIC (<http://rudipc.phy.uic.edu/hehigroup/>).

Applicants should submit a résumé and arrange for three letters of recommendation to be sent to Professor Inder P. Batra, Head, Physics Department M/C 273, University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL 60607-7059.

For full consideration, applications should be received by June 1st, 1999. UIC is an AA/EOE.

TEXAS A&M UNIVERSITY

POST DOCTORAL POSITION IN EXPERIMENTAL HIGH ENERGY PHYSICS

The Experimental High Energy Physics group in the Physics Department at Texas A&M University has an opening for an assistant research scientist to work on the new long baseline neutrino experiment, MINOS (Main Injector Neutrino Oscillation Search), being planned for Fermilab.

Construction of MINOS is just beginning with the anticipation that first beam to this experiment will be available in calendar 2002. The appointee to this position will participate in our group's R&D and construction activities on the scintillator strip tracking calorimeter system. Applicants must have a Ph.D. in physics with a background in experimental high energy physics, with experience in detector design/construction, data acquisition and data analysis. Interested applicants should submit a curriculum vitae and current bibliography, along with at least three professional references to:

Professor Robert C. Webb, Physics Department, Texas A&M University, College Station, Texas 77843-4242 or by e-mail webb@heprb.physics.tamu.edu
Further information about this position and our group's activities may be found at <http://hepr5.physics.tamu.edu/home1.htm>.

Texas A&M is an affirmative action/equal opportunity employer. Committed to excellence through diversity, Texas A&M University particularly invites applications from minorities, women, veteran and persons with disabilities.

COLLEGE DE FRANCE

Post - Doc Position

Applications are invited for a postdoctoral position in the area of experimental R&D of the solar neutrino experiment HELLAZ, starting September or October 1999 at the Collège de France, located in the heart of Paris.

The mystery of the missing solar neutrinos can only be solved by measuring their spectrum with a low threshold and a high energy resolution in a reaction with an accurately known cross-section.

HELLAZ fulfils these goals by detecting the solar neutrinos in a 2000 m³ TPC filled with Helium at 10 bar and 150°K by neutrino-electron elastic scattering. The high resolution is obtained by detecting each ionisation electron of the scattered electron track, hence, the chamber at the end of the TPC must be extremely fast and work with a high gain. Low radioactivity materials are also studied.

The successful candidate will play a major role in a 15 people team. He should be familiar with neutrino physics, gaseous detectors and data acquisition.

Interested candidates should submit an application consisting of a curriculum vitae, copies of university degrees and a publication list. They should arrange to have three letters of recommendation sent directly to:

**Philippe Gorodetzky, PCC-Collège de France,
11 place Marcelin Berthelot, 75005 Paris, France.
<gorodetzky@cdf.in2p3.fr>**

PAUL SCHERRER INSTITUT



The Paul Scherrer Institute (PSI) is a national, multi-disciplinary research center engaged in a diverse program of basic and applied sciences. As part of the Division Particles and Matter our Instrumentation Group has a position for an

Engineer

to participate in design and construction of particle detectors and associated hardware. Responsibilities include development and design (electro-) mechanical components used in particle physics experiments and evaluation of novel materials and techniques in detector construction. The applicant will also be expected to assist in setup and running of experiments at the accelerator.

We are looking for an engineer (B.Sc.) or a very experienced technician (technical school) with a strong interest in mechanics as well as in electronics, who thrives on working in a small and efficient team.

For any further information please contact Dr. J. Egger (Tel. +41 56 310 36 71, e-mail Johny.Egger@psi.ch) or Dr. W.-D. Herold (Tel. +41 56 310 42 40, e-mail Herold@psi.ch).

Please send your detailed application to:

**PAUL SCHERRER INSTITUTE, Personnel Division,
ref. code 1413-01, CH-5232 Villigen PSI, Switzerland**

POST-DOCTORAL

Resumes are invited for a post-doctoral position in Radiation Safety and Radiation Measurements at Argonne National Laboratory's Advanced Photon Source. The program consists of developing new experimental techniques to characterize the photon and neutron radiation environment, especially the high energy photoneutron environment, on the experiment floor. The appointee will participate in the data collection and analysis, and compare the results with the existing model predictions. Experience with UNIX operating systems and programming experience in C is necessary. Candidates must have a Ph.D. in Physics/Health Physics, received not more than 3 years prior to the start date of the appointment with experience in similar work proven by publications. A CV with publication list and contact information of three references should be sent to Susan Walker, Box XFDPDPK-60, Employment and Placement, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439. Fax: 630-252-9388. TDD: 630-252-7722, or for additional technical information, e-mail to: pkj@aps.anl.gov

Argonne is an affirmative action/equal opportunity employer.



RESEARCH ASSOCIATE POSITIONS

Experimental High Energy Physics Carnegie Mellon University

The Department of Physics at Carnegie Mellon University invites applications for two postdoctoral Research Associate positions in experimental high energy particle physics. The two individuals who fill these positions will work on our CLEO program at CESR, beginning in September 1999. The successful candidates will be based at the Cornell Synchrotron, in Ithaca NY, and will be expected to play a major role in the successful commissioning of the physics program for the CLEOIII detector. They will also be involved in the analysis of the existing CLEOII data, consisting of 10 million B pairs and extensive samples of charm and tau events. Interested candidates should submit a letter of application, curriculum vitae, and list of publications, and arrange to have three letters of recommendation sent to:

Professor Roy Briere
Department of Physics
Carnegie Mellon University
Pittsburgh, PA 15213, USA
(e-mail: briere@mail.lns.cornell.edu)

The application and recommendations can be sent either by normal or electronic mail. Review of applications will begin on July 1, 1999 and continue until the positions are filled.

Carnegie Mellon is an equal opportunity / affirmative action employer

University of Bielefeld

Professorship (C-4) in Theoretical Physics

The Department of Physics invites applications for a professorship in Theoretical Physics (chair of D. Schildknecht), with specialisation Elementary Particle Theory. The appointment will be made for August 1, 2000.

Candidates should have a record of successful research on the important physical questions of the field. They should be willing to participate in the research group on statistical aspects of elementary particle physics maintained at the University of Bielefeld by the German National Research Foundation (DFG).

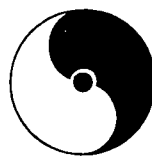
The successful applicant will participate in the general teaching duties of the department, in particular in theoretical physics. It is therefore expected that candidates have the necessary interest and pedagogic skill for this.

Prerequisites are a doctorate in physics and 'Habilitation' or sufficient proof of scientific achievements.

The University of Bielefeld aims to increase the fraction of women on its staff and therefore invites in particular applications from qualified women; in case of equal qualifications, they will be given preference.

Applications should be sent until June 30, 1999, to

Dekan der Fakultät für Physik
Universität Bielefeld
Postfach 10 01 31
D-33501 Bielefeld
Germany



RIKEN BNL
Research Center
Brookhaven National
Laboratory

SCIENTIFIC STAFF POSITIONS

Experimental Particle and Nuclear 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, including theory and experiment, has been established by the Institute of Physical and Chemical Research, Japan (RIKEN) at the Laboratory. RHIC will be the first polarized proton collider, beginning in 2000, and the center will play a major role in developing the RHIC spin program. RIKEN-BNL Fellow (up to five-year appointment) and Postdoctoral Research Associate (two-year appointment) positions will be offered for the fall of 1999. Members of the experimental division of the Center will have the opportunity to participate in the detector program at RHIC.

Scientists with appropriate background who are interested in applying should send a curriculum vitae and three letters of reference to Dr. T.D. Lee, Bldg. 510A, Brookhaven National Laboratory, P.O. Box 5000, Upton, NY 11973-5000 before June 30, 1999. Brookhaven is an equal opportunity employer committed to workforce diversity.

BROOKHAVEN NATIONAL LABORATORY

Visit our website at: www.bnl.gov

POSTDOCTORAL RESEARCH ASSOCIATE Boston University Muon (g-2) Experiment

The Boston University Intermediate Energy Physics Group is seeking a postdoctoral physicist in particle or nuclear physics to work on the muon (g-2) experiment at the Brookhaven AGS.

The muon (g-2) experiment recently finished its first production data run and will run again in 2000 and 2001.

The successful candidate will have the opportunity to lead in one or more of: Monte Carlo simulations, data analysis, detectors, electronics, beam dynamics and the muon kicker, as well as in the development of future experiments.

The position is open immediately. The initial appointment will be for one year, renewable for two additional years, subject to mutual agreement and the availability of funding.

Curriculum vitae and three letters of reference should be sent to Prof. J. Miller and L. Roberts, Department of Physics, Boston, MA 02215, or email roberts@bu.edu.

Boston University is an affirmative action/equal opportunity employer.

POSITIONS IN HADRON PHYSICS at Forschungszentrum Rossendorf

The FZR at Dresden has openings (for 2 years, renewable) in a research program on properties of hadron and dense hadronic matter, using GeV protons and heavy ions at the synchrotrons SIS and COSY.

From strange mesons and di-leptons as probes results are obtained with interesting consequences for the understanding of neutron stars and supernovae.

Successful applicants will participate in detector development in data taking and analysis and in the interpretation of the results; if wanted these may be used for a Ph.D.-thesis at TU Dresden.

Interested scientists should send a CV to:
Prof. B. Kaempfer, FZR, PF-510119, D-01314 Dresden;
information at www.fz-rossendorf.de/FWK/.

Are you looking for . . .

- Bio/Medical Physicists • Radiologists • Electrical Engineers • Software Developers
- Technical Editors • Cosmologists • Subatomic, Nuclear, Particle, Astro, High, Medium and Low Energy Physicists.

For further information and professional recruitment advice contact Chris Thomas

Tel: +44 (0)117 9301031 Fax: +44 (0)117 9301178

E-mail: chris.thomas@iopublishing.co.uk

Experimental Research Associates

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:

- Preparing for B physics with the BABAR detector at the PEP II Asymmetric B Factory, helping to tune up the BABAR Detector hardware and software for operations and to get ready for physics analysis
- Participating in a Particle Astrophysics program studying time-dependent x-ray sources with the USA, and R&D for a high-energy gamma-ray astronomy experiment in space (GLAST)

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 and three references, to: Tanya Boysen, tkb@slac.stanford.edu, Research Division, M/S 80, SLAC, P.O. Box 4349, Stanford, CA 94309. Equal opportunity through affirmative action. Visit our Web site at: www.slac.stanford.edu.

Stanford Linear
Accelerator Center
SLAC

SOUTHERN METHODIST UNIVERSITY FACULTY POSITION

The Department of Physics at Southern Methodist University in Dallas invites applications for a tenure track assistant professorship in the area of experimental high energy physics beginning August, 2000.

Applicants should have had postdoctoral experience in one or more frontier experiments and should have high potential for playing a leadership role in future experiments. The successful candidate will be expected to teach at the undergraduate and graduate levels and to conduct an active research program.

Currently, the SMU group is involved in the CLEO and ATLAS experiments. Applicants should submit a detailed curriculum vitae, list of publications, statement describing their research and teaching interests and should arrange for at least three letters of reference to be sent to:

Faculty Search, c/o Ms. Carol Carroll, Department of Physics,
Southern Methodist University, Dallas TX 75275-0175

The committee will begin its review of the applications on or about September 1, 1999. To ensure full consideration, applications should be postmarked by September 1, 1999, but the committee will continue to accept applications until the position is filled.

SMU will not discriminate on the basis of race, color, religion, national origin, sex, age, disability, or veteran status.

RESEARCH ASSOCIATE POSITION HIGH ENERGY PHYSICS THE OHIO STATE UNIVERSITY

The experimental high energy physics group at The Ohio State University invites application for a postdoctoral research associate position with our CLEO/ATLAS program. In the CLEO program, we are involved in both the ongoing data analysis effort in heavy flavor physics and the CLEO III upgrade program where we have major responsibilities for the design and implementation of the silicon vertex detector and the data acquisition system. For the ATLAS program, we are involved in the design and prototyping of the optical electronics and packaging for the pixel detector. Interested candidates should send a letter of application, vitae, list of publications, and three letters of recommendation to **Professor. K. K. Gan, The Ohio State University, Department of Physics, 174 West 18th Avenue, Columbus, Ohio 43210-1106, or email: GAN@ohstpy.mps.ohio-state.edu.**

The Ohio State University is an equal opportunity employer and we actively encourage applications from women and minority candidates.

UNIVERSITY OF PITTSBURGH

The High Energy Group invites applications for a postdoctoral research position. The position offers opportunities for participation in three experiments; ATLAS, MINOS, and NuTeV.

For more information see <http://ariel.phyast.pitt.edu/naples/job.html>
Curriculum vitae and three letters of recommendation should be sent to:

Professor W. E. Cleland, Department of Physics, University of Pittsburgh,
Pittsburgh, PA 15260. email:cleland@vms.cis.pitt.edu
Phone: 412-624-9059 Fax: 412-624-9163

Review of applications will begin on May 1, 1999 and continue until the position is filled. University of Pittsburgh is an affirmative action/equal opportunity institution.

NORTHWESTERN UNIVERSITY

POST-DOCTORAL POSITION

We have an opening for a postdoctoral research associate to participate in the D0 experiment at Fermilab.

We have recently completed a run (Run I) of over 100 pb⁻¹ of proton-antiproton collisions at a center-of-mass energy of 1.8 TeV. Both the Tevatron and the D0 detector are currently being upgraded for a run (Run II) to start in 2000.

Northwestern University is located just north of Chicago, 45 miles from Fermilab. It is possible to enjoy the advantages of living in a college town (or Chicago) and still participate fully in the activities at Fermilab.

Candidates should send a CV and arrange for three letters of reference to be sent to either David Buchholz or Heidi Schellman at Northwestern University, Department of Physics and Astronomy, 2145 Sheridan Road, Evanston, IL 60208-3112 or via e-mail to: dbuchholz@nwu.edu or to: schellman@fnal.gov

Applications should be sent by June 1, 1999.

Northwestern University is an equal opportunity employer.

Don't Lose Your Technical Edge ...

Attend the premier annual symposium on materials, surfaces, interfaces, and processes!

American Vacuum Society 46th International Symposium October 25-29, 1999, Seattle, WA

Eight technical division programs will be held on issues related to films, microelectronics, nanostructures, processing, surfaces, and vacuum, including:

- ◆ Applied Surface Science.
- ◆ Electronic Materials and Processing.
- ◆ Nanometer-Scale Science and Technology.
- ◆ Plasma Science and Technology.
- ◆ Surface Science.
- ◆ Thin Films.
- ◆ Vacuum Metallurgy.
- ◆ Vacuum Technology.

In addition, the week-long annual symposium will feature:

Three Technical Group Programs

- ◆ Biomaterial Interfaces.
- ◆ Magnetic Interfaces and Nanostructures.
- ◆ Manufacturing Science and Technology.

Four Topical Conferences

- ◆ Emerging Opportunities and Issues in Nanotubes and Nanoelectronics.
- ◆ Flat Panel Display.
- ◆ Science of Micro-electromechanical Systems.
- ◆ Organic Electronic Materials.

50 Short Courses

- ◆ Applied Vacuum Technology.
- ◆ Surface Analysis and Materials Characterization.
- ◆ Materials, Thin Films, and Coatings: Processing and Properties.

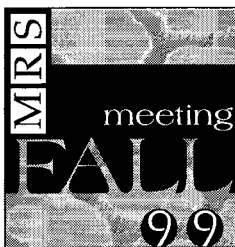
150+ Exhibitors

- ◆ Vacuum and Deposition Equipment.
- ◆ Analysis Systems.
- ◆ Vacuum-Related Services.

For more information on the symposium, visit the AVS Web site at <http://www.vacuum.org> or contact the AVS, 212-248-0200, fax 212-248-0245, e-mail avsny@vacuum.org.



New Developments ■ New Characterization Methods ■ New Process Technology



**NOVEMBER 29-
DECEMBER 3**
BOSTON
MASSACHUSETTS

**HYNES CONVENTION
CENTER
and
BOSTON MARRIOTT
COPLEY PLACE**

Exhibit:
November 30-
December 2

The MRS 1999 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.

1999 MRS FALL MEETING SYMPOSIA

- | | |
|---|--|
| A: Multiscale Phenomena in Materials—Experiments and Modeling | T: Structure and Electronic Properties of Ultrathin Dielectric Films on Silicon and Related Structures |
| B: Computational Approaches to Predicting the Optical Properties of Materials | U: Amorphous and Nanostructured Carbon |
| C: Microstructural Modeling for Industrial Metals Processing | V: Thin Films—Stresses and Mechanical Properties VIII |
| D: New Advances in Materials Prediction | W: GaN and Related Alloys |
| E: Nucleation and Growth Processes in Materials | X: Frontiers of Materials Research |
| F: Nanophase and Nanocomposite Materials III | Y: Ferroelectric Thin Films VIII |
| G: Nanolithographic Approaches to Micro- and Nanoscale Organization | Z: Thin Films for Optical Waveguide Devices |
| H: Molecular Electronics | AA: Materials Science of Food—Processing/Structure-Property Relationships |
| I: Self-Organized Processes in Semiconductor Alloys—Spontaneous Ordering, Composition Modulation, and 3-D Islanding | BB: Electrical, Optical, and Magnetic Properties of Organic Solid-State Materials V |
| J: Advanced Materials and Techniques for Nanolithography | CC: Complex Fluids and Polymers |
| K: Thermal Spray—Materials Synthesis by Thermal Spraying | DD: Mineralization in Natural and Synthetic Biomaterials |
| L: Fundamental Mechanisms of Low-Energy-Beam-Modified Surface Growth and Processing | EE: Materials Science of Phospholipid Assemblies |
| M: Interfacial Engineering for Optimized Properties II | FF: Electroactive Polymers |
| N: Atomic Scale Measurements and Atomistic Models of Epitaxial Growth and Lithography | GG: Transport Properties and Microstructure of Cement-Based Systems |
| O: Substrate Engineering—Paving the Way to Epitaxy | HH: Superplasticity—Current Status and Future Potential |
| P: Optical Microstructural Characterization of Semiconductors | II: Superconducting Materials—Properties, Crystal Chemistry, and Processing |
| Q: Advances in Materials Problem Solving with the Electron Microscope | JJ: Magnetostrictive Oxides and Related Materials |
| R: Applications of Synchrotron Radiation Techniques to Materials Science | KK: Materials Issues for Tunable RF and Microwave Devices |
| S: Nondestructive Methods for Materials Characterization | LL: Smart Materials |
| | MM: Materials Science of Microelectromechanical System (MEMS) Devices II |
| | NN: Chemical Processing of Dielectrics, Insulators, and Electronic Ceramics |
| | OO: Infrared Applications of Semiconductors III |
| | PP: Materials for Optical Limiting III |
| | QQ: Scientific Basis for Nuclear Waste Management XXIII |

1999 MRS FALL MEETING ACTIVITIES

SYMPOSIUM TUTORIAL PROGRAM

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

EXHIBIT

Over 275 international exhibitors will display a full spectrum of equipment, instrumentation, products, software, publications, and services.

PUBLICATIONS DESKS

A full display of over 600 books, plus videotapes and electronic databases, will be available at the MRS Publications Desks.

SYMPOSIUM ASSISTANT OPPORTUNITIES

Graduate students planning to attend the 1999 MRS Fall Meeting may apply for a Symposium Assistant (audio-visual aide) position.

JOB CENTER

A Job Center for MRS members and meeting attendees will be open Tuesday through Thursday.

For additional meeting information...

...or to request a detailed 1999 MRS Fall Meeting Program, contact:



Materials Research Society Member Services

506 Keystone Drive, Warrendale, PA 15086-7573
Tel: 724-779-3003 • Fax: 724-779-8313
E-mail: info@mrs.org • Web site: www.mrs.org

Bookshelf

● *Conceptual Foundations of Quantum Field Theory*, edited by Tian Yu Cao, Cambridge University Press 0 521 63152 1 (hbk £60/\$100).

Tian Yu Cao's book *Conceptual Developments of 20th Century Field Theories*, published in 1997, was hailed in many quarters as a masterpiece. The same careful thinking is evident in this book, the result of a conference held at Boston University in 1996.

Boston (particularly Harvard) has long been a cradle of field theory, even during the dark years when the subject was not fashionable, and many key figures attended the event. The idea was for leading field theorists, philosophers and historians to present their insights and views. Participants included Sidney Coleman, David Gross, Sheldon Glashow, Steven Weinberg and Arthur Wightman.

All of these figures also participated in a lively concluding round-table discussion that was moderated by Stanley Deser. The following extract from this discussion underlines the scholarship and entertainment that the meeting provided.

Gross: Actually, I wanted to answer [the] question about what question I would ask God...There are two answers...The first is a kind of joke. I'd paraphrase Gertrude Stein and ask "What's the question?", because in some sense that's really the hardest thing in physics: to ask the right question. In explaining to me the question, He would have to explain all the answers I would like to know.
Deser: He's subtle. We don't know what He would say.

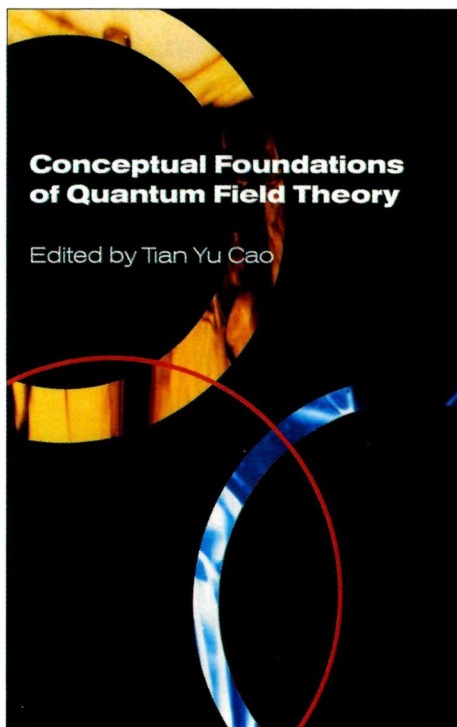
Gross: The other question is one that from the point of view of particle physics seems to be the most mysterious...that is, "Why is the cosmological constant zero or so small?"

Weinberg: I think we all always keep raising the same question, which is why things are the way they are.

Deser: Sure, but there are some things which are more "the way they are" than others. And it's not clear to me why the cosmological constant is picked on specifically as being -
Weinberg: It's a lot of orders of magnitude.

Deser: No, I understand that.

Coleman: 120 orders of magnitude between the rough order of magnitude and the experimental observation.



Deser: That should tell you that it can't be the fundamental problem. But anyway, that would take longer to discuss. Shelly, what would you like to ask God, or do you know all the answers?

Glashow: I'm working at that...One question: "Why is the top quark so heavy?"

Deser: That's a good question. You don't care about the tau lepton?

Weinberg: Yeah, I would have said, you know, that's the easy one, because that's the mass you would expect.

Coleman: Why are the others so light?

Gross: Why is the neutrino so light?

Glashow: Yeah, well, you start off with the easy questions, see.

Weinberg: Why is the electron so light? That's really hard. I mean, the electron is the mysterious particle, not the top quark.

Deser: Anyway, why is this difference of emphasis important?

Weinberg: Well, it does direct the way you think. I mean, some people think you have to give the top quark new kinds of interactions which are different from the other particles. And other people think you have to invent new symmetries that keep the light quarks light. I'm not sure, obviously, which is right, but there is a difference.

Glashow: Steve, we're asking the same question: "Why is there this little, curious factor of 10^5 between the mass of the lightest particle

and the mass of the heavier particle?"

Weinberg: Yeah, that's the right one to ask. And it really is an amazing thing.

Deser: And you have no leptonic questions?

Weinberg: Same question.

● *Detectors for Particle Radiation* by Konrad Kleinknecht, Cambridge University Press 0521 64854 8 (pbk \$19.95/\$34.95), 0 521 64032 6 (hbk £52.50/\$80).

The second edition of this popular text has been updated with the inclusion of recent detector developments and a presentation of modern experimental facilities.

The excellent introduction provides a thorough discussion of the physics principles of detectors, including, for example, such modern treatments as the Photoabsorption Model for the energy loss. This recommendable approach provides the reader with a basis for understanding and evaluating detector behaviour.

The subsequent chapters focus in turn on different types of measurement (position, time, particle identification, momentum, energy). Within each broad topic the full range of the relevant detectors is analysed. The text is complete, yet compact and authoritative. A wealth of equations guides the reader to an analytical understanding of detectors.

One important subject - energy measurement - would merit a more extensive discussion. A more systematic analysis of the various contributions to the energy resolution would demonstrate that these detectors too can be understood from first principles.

One of the big successes of particle physics detectors is their increasing range of applications in other areas. The description of these applications, although short and less complete than this success merits, should be applauded.

The book is illustrated throughout with instructive diagrams of fine quality. Only the - admittedly difficult - illustration of large detector facilities will probably leave the novice unsatisfied. A complete list of references covering approximately 30 years of research and development provides ready access to the source literature.

This volume will serve the apprentice experimentalist as an attractive introduction and the seasoned physicist as a fine reference. The publishers should be congratulated for issuing this text in paperback.

CW Fabjan, CERN.

BELGIUM AT CERN

17th and 18th of May 1999

Participants:

ADVANCED COATING S.A.

Phone : +32.4/254.50.11 – Fax :+32.4/254.50.90
E-mail : info@advanced.coating.com

ALSTOM EIB S.A.

Phone :+32.87/32.03.99 – Fax :+32.87/32.04.05
E-mail : frederic.magerat@tde.alstom.com

AMOS S.A.

Phone :+32.4/361.40.40 – Fax :+32.4/367.20.07
E-mail : info@amos.be

BELGIAN ADVANCED TECHNOLOGY SYSTEMS S.A.

Phone : 04/367.08.88 – Fax 04/367.13.14
E-mail : bats@cci.be

CAPPAUL S.A.

Phone : +32.87/59.55.60 – Fax :+32.87/74.04.68
E-mail : info@capaul.be

CE+T S.A.

Phone :+32.4/345.67.00 – Fax :+32.4/345.67.01
E-mail : cet@skynet.be

CEGELEC ACEC S.A.

Phone :+32.71/44.67.13 – Fax :+32.71/44.68.54
E-mail : maret@cegelec.be

CENTRE SPATIAL DE LIÈGE

Phone: 04/367.66.68 – Fax : 04/367.56.13
E-mail : jp.collette@ulg.ac.be

EREM S.A.

Phone :+32.71/36.62.54 – Fax :+32.71/43.94.62
E-mail : erem@charline.be

INDUSTRIAL AND TELECOMMUNICATION SYSTEMS

Phone :+32.10/43.84.14 – Fax :+32.10/43.84.20
E-mail : edouard.vandenplas@mas.its.be

K.S. TECHNIQUES S.A.

Phone :+32.4/247.01.67 – Fax :+32.4/247.02.54
E-mail : kst.op@skynet.be

METAL FORMING

Phone :+32.4/337.79.62 – Fax :+32.4/338.10.03

RESARM ENGINEERING PLASTICS S.A.

Phone :+32.4/387.44.10 – Fax :+32.4/387.44.11
E-mail: resarm@skynet.be

SIMONIS PLASTICS S.A.

Phone :+32.4/239.88.33 – Fax :+32.4/239.88.31
E-mail: ov.sip@infonie.be

SOUDOBEAM S.A.

Phone :+32.4/382.14.65 – Fax :+32.4/382.16.96
E-mail: soudobeam@euronet.be

TECHSPACE AERO S.A.

Phone :+32.4/278.81.11 – Fax :+32.4/278.80.24
E-mail: mgruslin@techspace-aero.be

FABRIMETAL WALLONIE

Phone :+32.2/706.79.39 – Fax :+32.2/706.79.43
E-mail : elvira.solowianiuk@fabrimetal.be

CHAMBRE DE COMMERCE ET D'INDUSTRIE DE WALLONIE

Phone :+32.4/343.92.92 – Fax :+32.4/343.92.67
E-mail : bpiette@ccilg.be

DIRECTION GENERALE DES TECHNOLOGIES, DE LA RECHERCHE ET DE L'ENERGIE DU MINISTERE DE LA REGION WALLONNE

Mr J.P. GERARD

Phone :+32.81/32.12.11 – Fax :+32.81/30.66.00
E-mail : jp.gerard@mrw.wallonie.be

For any further information,

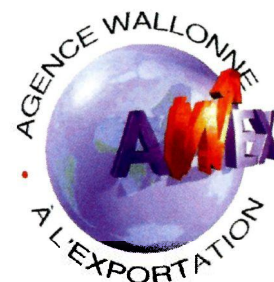
Please contact the office of the Walloon Region in Geneva :

Mr. Jean-Marie WAREGNE

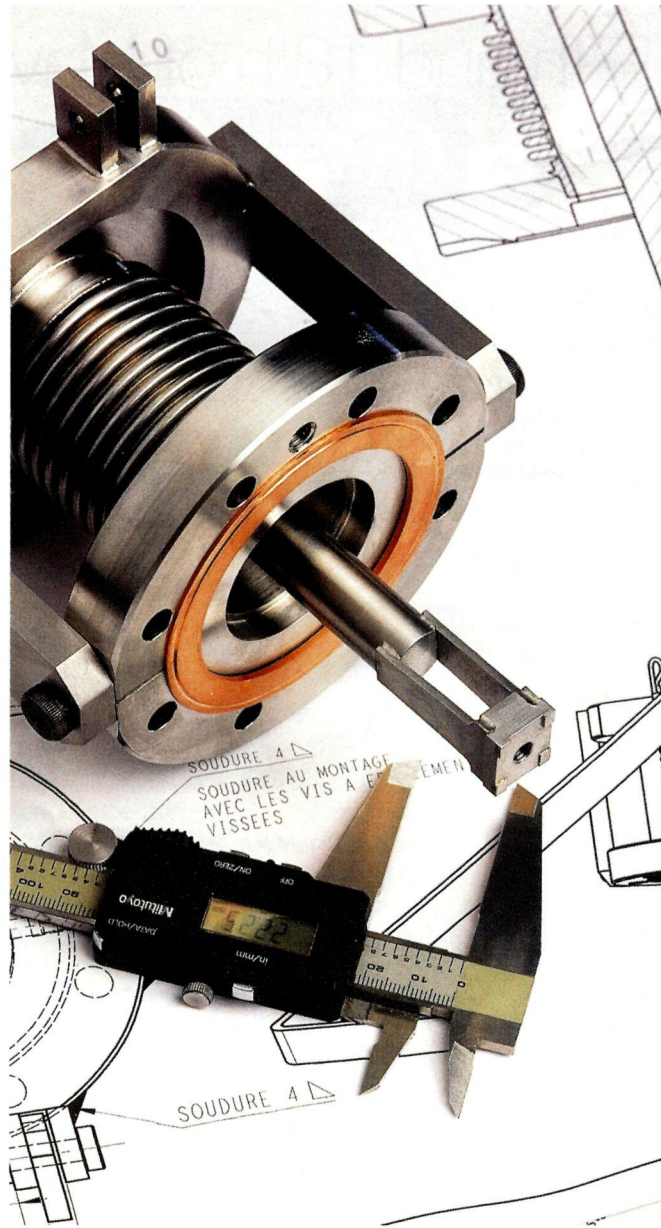
Phone (41) 22 788.48.60

Fax (41) 22 788.87.37

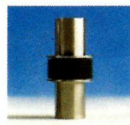
E.mail: jean-marie.waregne@ties.itu.ch



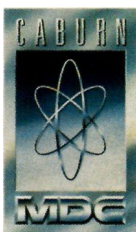
CUSTOM FABRICATION



Ultra-High Vacuum (UHV) Precision Engineering



CABURN-MDC LIMITED THE VACUUM COMPONENTS COMPANY™



GLYNDE

Caburn-MDC Limited
The Old Dairy, Glynde
East Sussex BN8 6SJ
United Kingdom

Tel: +44 (0)1273 858585
Fax: +44 (0)1273 858561

www.caburn-mdc.co.uk

BERLIN

Caburn-MDC GMBH
Hauptstrasse 117
D-10827 Berlin-Schöneberg
Germany

Tel: +49 (0)1802-22 66 52
Fax: +49 (0)1803-22 38 38

caburngmbh@compuserve.com

LYON

Caburn-MDC S.A.R.L.
Novacité-Alpha, B.P. 2131
F-69603 Villeurbanne Cedex
France

Tel: +33 (0)478 94 56 30
Fax: +33 (0)472 44 34 85

caburn@easynet.fr

TORINO

Caburn-MDC S.R.L.
Via Donizetti 60
10093 Collegno (TO)
Italy

Tel: +39 (0)11 41 54 175
Fax: +39 (0)11 41 54 896

caburn@inrete.it