INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 41 NUMBER 6 JULY/AUGUST 2001

Breakthrough for new physics

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

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

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

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 nicola.rylett@iop.org
Web http://www.iop.org

Head of magazines: Richard Roe
Sales manager: Justin Mafham
Marketing manager: Tessa Edgecombe
Art director: Andrew Giaquinto
Production editor: Lucy Farrar
Technical illustrator: Alison Tovey
Advertising manager: Nicola Rylett
Deputy advertising manager: Chris Thomas
Recruitment sales: Debra Wills and Jayne Purdy
Advertisement production: Katie Graham
Product manager: So-Mui Cheung

Advertising: Nicola Rylett, Chris Thomas, Debra Wills or Jayne Purdy
Tel. +44 (0)117 930 1027
E-mail sales@cerncourier.com
Fax +44 (0)117 930 1178

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

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

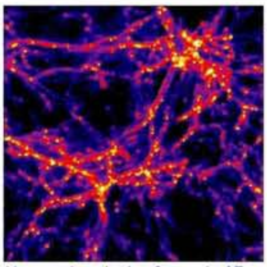
USA: Controlled Circulation Periodicals postage paid at St Charles, Illinois

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

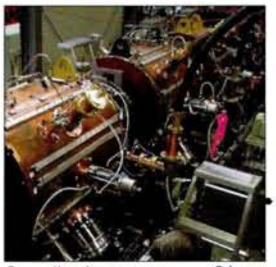
ISSN 0304-288X

CERN COURIER

VOLUME 41 NUMBER 6 JULY/AUGUST 2001



How early galaxies formed p15

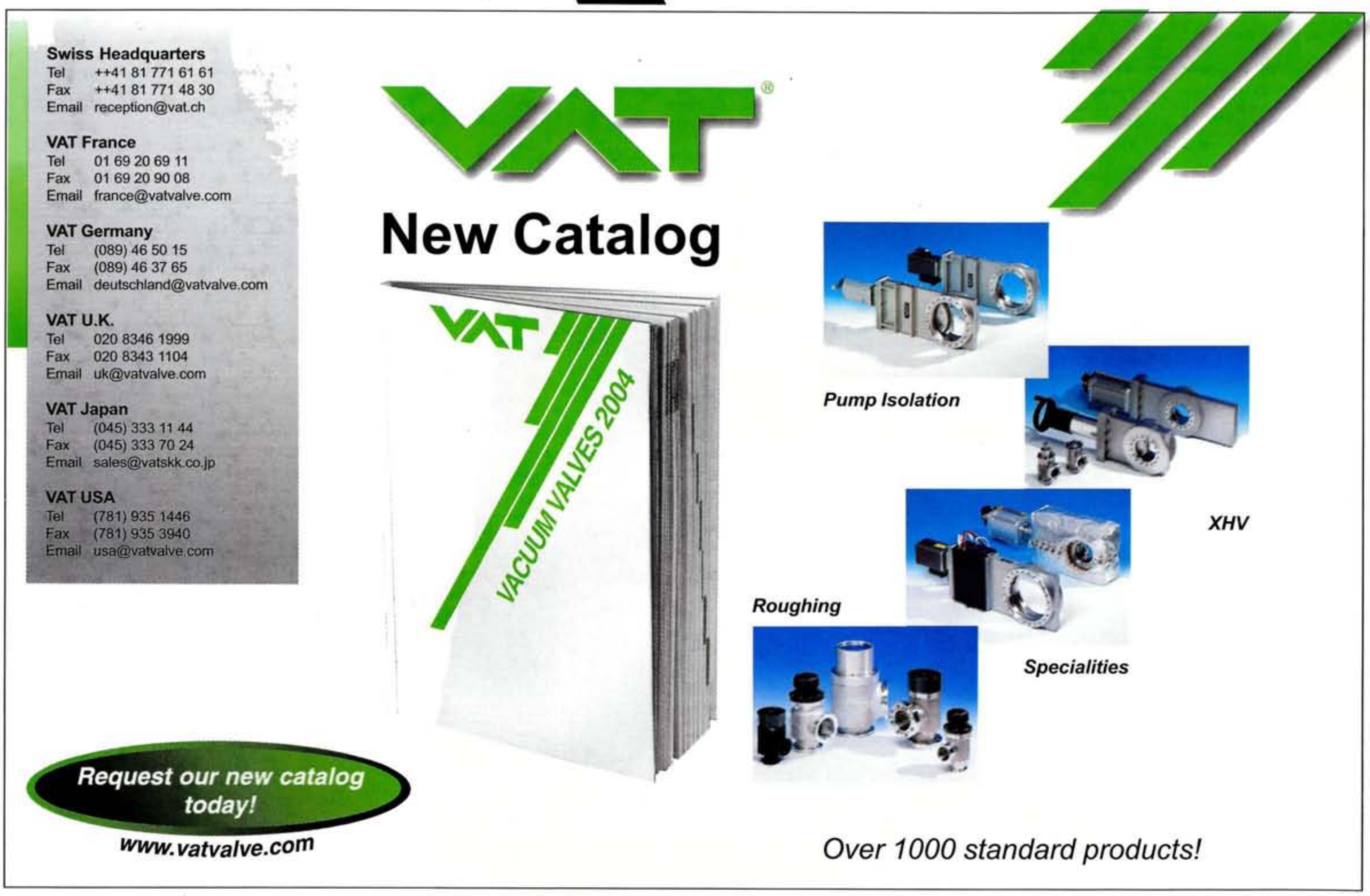


Canadian isotope source p21

SPS anniversary at CERN p24

Cover: Smiling faces on 15 May, as one of the transfer tunnels that will supply protons for CERN's new LHC collider links up with the tunnel in which the LHC ring will be installed. Left to right: LHC project director Lyn Evans and CERN director-general Luciano Maiani. The 27 km main tunnel was built in the 1980s to house CERN's LEP electron–positron collider, which was shut down last year (p24).


LakeShore
thermometry solutions
from 20 mK to 800 K
Model 370 AC Resistance Bridge
Model 340 Temperature Controller
• Sensors
• Instruments
• Accessories
www.lakeshore.com
Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville OH 43082
Phone: (614) 891-2243 • Fax: (614) 818-1600 • e-mail: sales@lakeshore.com


Swiss Headquarters
Tel ++41 81 771 61 61
Fax ++41 81 771 48 30
Email reception@vat.ch
VAT France
Tel 01 69 20 69 11
Fax 01 69 20 90 08
Email france@vatvalve.com
VAT Germany
Tel (089) 46 50 15
Fax (089) 46 37 65
Email deutschland@vatvalve.com
VAT U.K.
Tel 020 8346 1999
Fax 020 8343 1104
Email uk@vatvalve.com
VAT Japan
Tel (045) 333 11 44
Fax (045) 333 70 24
Email sales@vatskk.co.jp
VAT USA
Tel (781) 935 1446
Fax (781) 935 3940
Email usa@vatvalve.com
VAT
New Catalog
VAT
VACUUM VALVES 2004
Pump Isolation
XHV
Roughing
Specialities
Request our new catalog today!
www.vatvalve.com
Over 1000 standard products!

NEWS

CERN

CP violation is measured precisely

The problem of obtaining a precise measurement of one of the most elusive effects in particle physics has finally been overcome. After many years of uphill struggle, with sometimes conflicting results from different experiments, the parameter that measures the tiny matter–antimatter asymmetry of quarks has been found to be non-zero with almost complete certainty (six standard deviations).

From 1997 to 1999, the big NA48 experiment at CERN patiently accumulated data from the decays of neutral kaons. A preliminary analysis using only a portion of the data (May 2000 p6) reported that the vital charge/parity (CP) violation parameter was $14 \pm 4.4 \times 10^{-4}$. This was in line with an earlier NA48 measurement of $18.5 \pm 7.3 \times 10^{-4}$, but the same quantity reported in 1998 by the KTeV experiment at Fermilab was higher at $28 \pm 4.1 \times 10^{-4}$. The difference between the CERN and Fermilab results was difficult to reconcile*. However, the new CERN result, $15 \pm 2.7 \times 10^{-4}$, based on 20 million CP-violating decays of neutral kaons, each producing a pair of pions, has far better statistics than all previous measurements.

With CP symmetry, the physics of right-handed particles is the same as that of left-handed antiparticles (and vice versa). CP symmetry was introduced in the late 1950s, when physicists were stunned to discover that weak interactions (nuclear beta decays) are not left–right symmetric. In 1964 an experiment found that CP too was flawed.

The classic stage for such experiments is the neutral kaon – an enigmatic particle–antiparticle pair distinguished only by the obscure quantum number of strangeness. However, strangeness is only conserved in strong interactions, and in weak decays the neutral kaon particle and antiparticle get mixed up.

This mixing produces two clearly distinguishable kinds of neutral kaon – a variety that decays relatively easily into two pions and is therefore short-lived, and another that cannot slip easily into two pions and instead has to struggle to decay into three pions. The latter is therefore longer lived.

The 1964 experiment by Christenson, Cronin, Fitch and Turlay found that a few long-lived kaons in every thousand disobeyed the rules and instead decayed into two pions. CP was violated.

The support structure of the liquid-krypton calorimeter of the NA48 experiment at CERN. The calorimeter reconstructs the production of neutral pions, which is a key task en route to measuring the delicate CP violation in neutral kaon decays.

But there could be a deeper form of CP violation at work. Instead of arriving via the quantum mechanical mixing of neutral kaons, CP violation could also happen in the underlying quark transitions that are the cause of weak decays. If so, nature would have a way of distinguishing between quarks and antiquarks.

This "direct" CP violation could have occurred immediately after the Big Bang, when subnuclear particles began to freeze out of the primordial quark–gluon soup. Such an effect could help to explain the mystery of how a universe that appears to consist only of matter could have been produced from a Big Bang, which nevertheless produced equal numbers of particles and antiparticles.

To establish whether direct CP violation occurs and to measure it, physicists must carefully compare two ratios. The first is the rate of long-lived kaons decaying into two charged pions, compared with the decay rate into two neutral kaons. The second ratio is the equivalent pion pair comparison for short-lived kaons. If these two ratios were not exactly the same, then direct CP violation would occur.

Measuring this double ratio, which involves very similar particle signatures, is extremely difficult. NA48 uses simultaneous and collinear beams of short-lived and long-lived kaons and all decays are examined inside the same region. A large magnetic spectrometer analyses the charged pions, while a liquid-krypton calorimeter analyses the production of neutral pions.

The number of neutral kaon decays collected and analysed by NA48 is far greater than in any other experiment so far. The parameter used by physicists to measure this CP violation (ε'/ε) is the difference of the double ratio from unity, divided by a numerical factor. The new NA48 result is $15 \pm 2.7 \times 10^{-4}$. Note the small errors, compared with earlier measurements. Combined with previous NA48 data, this gives $15.3 \pm 2.6 \times 10^{-4}$ and contributes to a world average figure of $18 \pm 2 \times 10^{-4}$.

Thus direct CP violation certainly happens. The classic "indirect" CP violation discovered in 1964 happens in a few decays in every thousand, and for every thousand indirect CP violations there are a few direct CP violations. Looking at the decays of the neutral kaon and its antiparticle into two oppositely charged pions, direct CP violation gives an asymmetry of $5 \pm 0.9 \times 10^{-6}$. The universe can discriminate between matter and antimatter, and even the resulting tiny imbalance of a few decays per million is apparently enough to ensure the demise of Big Bang antimatter.

NA48 was brought to a halt by an accident to its high-tech carbon fibre beam pipe in 1999, but this damage has since been repaired and the experiment is set to continue its careful analysis of neutral kaon decays.

**On 8 June, the KTeV experiment at Fermilab announced a reanalysis of their earlier result, giving $(23.2 \pm 3.0 \pm 3.2) \times 10^{-4}$, and a new result of $(19.8 \pm 1.7 \pm 2.3) \times 10^{-4}$.*

CERN

Proposed SPL machine could help provide neutrino beams

The imaginations of physicists all over the world have been fired by the quest for new schemes for making intense beams of neutrinos. Attention is now turning to the proton machines that may be able to provide these synthetic particles. At established laboratories like CERN, developing such proton drivers would offer new possibilities for boosting existing beam networks, as well as benefiting future ones.

Superconducting radiofrequency equipment salvaged from CERN's LEP electron–positron collider could go on to be used in a new Superconducting Proton Linac.

The new idea involves muon storage rings. The first step is to use high-energy protons to produce pions, which decay to give muons. These are then quickly accelerated (their lifetime at rest is only 2 μs) and passed to a storage ring, where they decay (April 2000 p17). The key requirement is for a very intense proton accelerator that can deliver several megawatts of beam power.

At CERN, this has generated increased interest in the idea of a Superconducting Proton Linac (SPL), which had already been proposed as a new injector for the 28 GeV Proton Synchrotron (PS). The PS is CERN's oldest machine, but it remains the heart of the laboratory's unique particle beam system.

To deliver its 2.23 GeV protons, the SPL, operating at 352 MHz, would use radiofrequency equipment salvaged from CERN's LEP electron–positron collider, which was closed at the end of last year. The SPL would in fact handle negative hydrogen ions (two electrons orbiting each proton), the classic medium for eventually supplying high-energy protons.

All 44 of the klystrons that previously powered LEP's accelerating structures would be reused. They would operate in pulsed mode with a 30% duty cycle. Over the 800 m of the proposed linac design, the last 360 m (above a kinetic energy of 1085 MeV) would be equipped with 108 unmodified LEP-2 radiofrequency cavities. Between 390 and 1085 MeV, 12 LEP cryostats would also be employed, refurbished with new five-cell cavities. Suitable resonators would have to be developed for the lowest energy range.

Upstream, room temperature structures would be used, namely radiofrequency quadrupoles to supply the initial energy kick up to 7 MeV, and drift tube linacs up to 120 MeV. The linac would inject into an accumulator ring and then a bunch compressor ring before the tailored beam reaches the pion production target.

Such a high-power machine brings special design considerations. Electrical power increases with the repetition rate of the machine, and a compromise value of 75 Hz has been selected. Short proton bunches are needed to maximize the density of the muons, and the requisite 1 ns levels are difficult to achieve. However, deleterious effects are minimized by limiting the number of protons per bunch to 3.3×10^8, using 140 bunches spaced by 23 ns.

The SPL would supply beams to the PS, and thence to the SPS and the LHC. Higher-performance beams could be delivered by the PS, thanks to the increased injection energy and higher density of the injected beam. This would have knock-on benefits for all of CERN's machines, including the neutron time-of-flight facility and the antiproton decelerator.

Another happy SPL client would be the ISOLDE on-line isotope separator, especially in view of the ambitious plans of this physics community, which is looking for such a proton accelerator to drive the next-generation facility in Europe.

CERN

Neutron Time of Flight facility takes off smoothly at CERN

There was a new arrival among CERN's family of particle beams when the laboratory's first intense beam of neutrons was produced at the new neutron Time Of Flight (nTOF) facility. The nTOF opens the door to many corridors of research, ranging from fundamental science to new forms of energy generation, and it is complementary to CERN's existing ISOLDE radioactive-beam facility.

The goal of the nTOF (November 1999 p6) is to provide unprecedented precision in neutron kinetic energy determination, which will in turn bring much-needed precision in neutron-induced cross-section measurements. Such measurements are vital for a range of studies in fields as diverse as nuclear technology, astrophysics and fundamental nuclear physics. The nTOF will provide neutron rates some three orders of magnitude higher than existing facilities, allowing measurements to be made more precisely and more rapidly than in the past.

Members of CERN's neutron Time Of Flight (nTOF) collaboration in the proton beamline at the entrance to the tunnel housing the 185 m vacuum tube that allows the new facility to achieve unprecedented precision in neutron energy measurement.

The lineage of the nTOF can be traced back to work that was carried out by CERN's 1984 Nobel prizewinner Carlo Rubbia on a new, safe and clean way of extracting energy from the atomic nucleus. Rubbia's Energy Amplifier is an example of an Accelerator Driven System (ADS) in which the thorium cycle would be put to work. Since thorium fission does not release sufficient neutrons to sustain a chain reaction, an accelerator would be used to produce the neutrons that drive the reactions.

In 1994, in a European Union-backed experiment at CERN, Rubbia's team showed that the energy produced by fission is about 30 times that injected by the accelerated particle beam, giving a strong impetus to the Energy Amplifier concept. Then, in 1997, the Transmutation by the Adiabatic Resonance Crossing experiment used lead-moderated neutrons to induce the transmutation of long-lived fission fragments from conventional reactors, and of elements yielding isotopes useful in nuclear medicine.

These early experiments demonstrated the viability of the Energy Amplifier concept and showed that ADS technology could have an impact on society that involved much more than energy generation. Experiments at the nTOF, which is financially supported by the European Union's EURATOM programme, will now turn to the more technological issues of an ADS, measuring neutron cross-sections on structural and coolant materials as well as on fuel and fission products. In line with one of EURATOM's main goals, special emphasis will be placed on the elimination of nuclear waste.

The nTOF collaboration, which consists of almost 150 scientists from 40 institutes, began its scientific programme by precisely calibrating the neutron spectrum. From there, the collaboration moved on to its first approved experiments, both of which are in the domain of astrophysics. One will provide neutron capture data needed for computing stellar reaction rates – data that will help to improve calculations of the age of the universe. The other will measure cross-sections important for understanding nucleosynthesis by slow neutron-capture, or the s-process, which is important for generating elements heavier than iron. For the future, a rich and varied range of proposals has been submitted to CERN's ISOLDE and nTOF committee, promising an intense hive of scientific activity for many years to come.

CERN

ISOLDE tests the Standard Model

Tests of the Standard Model of particle physics are largely the domain of high-energy particle accelerators. However, a research programme recently inaugurated at CERN's ISOLDE on-line isotope facility is demonstrating that low-energy experiments also have something to say – testing the Standard Model today, and looking for physics beyond it tomorrow.

Nuclear beta decay is nature's way of redressing any uncomfortable imbalance between the number of protons and neutrons in a nucleus when either becomes excessive. It is a manifestation of the weak interaction, which acts over distances that are small compared with nuclear dimensions. That means that the nucleus can be used as a micro-laboratory for investigating the weak interaction, thus putting the Standard Model to the test. ISOLDE is an ideal place for such research, because it is an abundant source of many isotopes with an uncomfortable mixture of protons and neutrons.

The nuclide chosen for ISOLDE's Standard Model investigation is rubidium-74, which has equal numbers of protons and neutrons – an uncomfortable mixture in a heavy nucleus due to electrostatic repulsion – and is particularly suitable for the task. It decays with a half-life of around 65 ms to krypton-74 via a so-called super-allowed Fermi beta transition in which only the vector component of the weak interaction is at work.

Nuclear beta decay, in which a neutron changes into a proton, is described in quark terms as the transition of a "down" quark to an "up" quark. The Cabibbo–Kobayashi– Maskawa matrix has three rows and three columns, which describe all possible quark transitions. Super-allowed beta decays give access to the up–down quark element, V_{ud}, of the matrix. Combining V_{ud} with the other elements, V_{us} and V_{ub}, allows an important test (unitarity) of a Standard Model containing six quarks arranged pairwise in three generations.

Several experiments on relatively light isotopes have already given a very precise measurement. Curiously, these experiments are proving to be consistently at odds with the Standard Model, differing by more than two standard deviations.

The ISOLTRAP spectrometer at CERN's ISOLDE on-line isotope facility – already exceeding expectations.

The most precisely known of the three elements, V_{ud}, also carries the most weight and, as such, is still the greatest source of uncertainty. This is due to the fact that the beta decay takes place in the nuclear medium, requiring theoretical corrections that must be constrained.

The precision expected from the latest ISOLDE experiments will allow the discrepancy observed in lighter nuclei, if confirmed, to be measured with greater significance and could therefore expose a small chink in the much-vaunted Standard Model's armour. The choice of rubidium-74 will also allow some important nuclear model distinctions to be made, because the heavier the nucleus, the more significant model-dependent Coulomb corrections become.

The ISOLDE experiments will explore three quantities involved in the decay of rubidium-74: the half-life and branching ratio of its super-allowed beta decay, and the mass difference between the parent and daughter nuclei – the Q-value of the decay. Experiments began in November 2000 using three different experimental facilities: the low-energy electron spectrometer ELLI, and the mass spectrometers ISOLTRAP and MISTRAL.

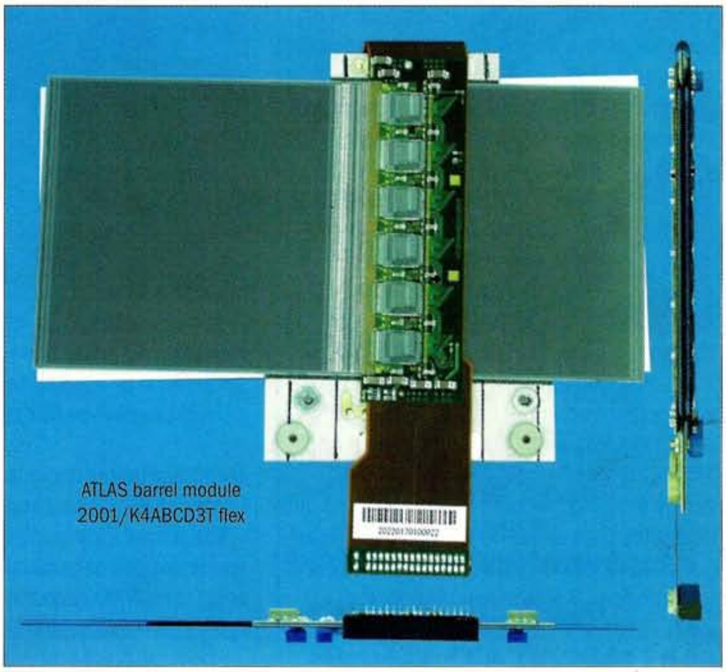
While MISTRAL was conceived specially for short-lived nuclei, the 65 ms half-life of rubidium-74 would normally have been far too short to be successfully measured by the tandem Penning trap spectrometer ISOLTRAP. However, recently developed ion-cooling techniques have allowed ISOLTRAP to extend its lower reach, thereby giving two independent measurements. In the game of high-precision mass determination, measurements by different instruments in the same regime of precision are important for cross-checking any hint of systematic error. ISOLTRAP has also succeeded in improving the measurement of mass of krypton-74, which further constrains the Q-value.

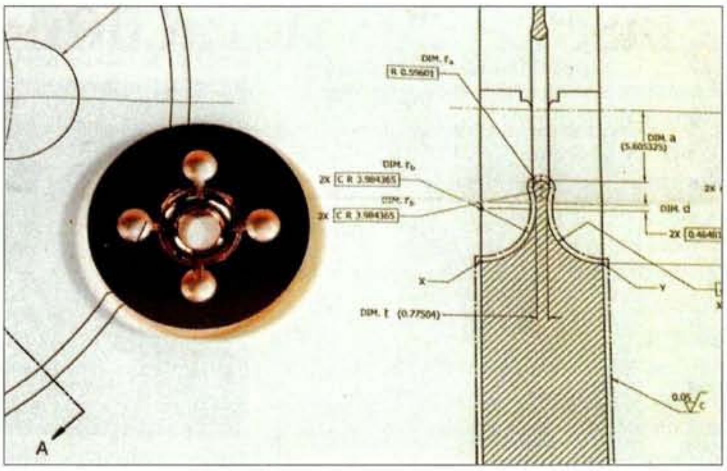
The new ISOLDE data are currently being analysed, with early indications suggesting small but significant deviations from previous mass values. The half-life of rubidium-74 is also the subject of similar studies at the Canadian TRIUMF laboratory's new ISAC facility (March 2001 p10), the initial results of which have recently been published. The new ISOLDE spectroscopy results are in agreement with those of the ISAC facility, adding the equally important branching ratio measurement.

For the future, the ISOLDE programme aims to go one step further. Whereas ISOLDE today tests the Standard Model with rubidium-74, one of the first experiments scheduled for the REX-TRAP facility will use the nuclear micro-laboratory to look for physics beyond the Standard Model. The WITCH experiment (Weak Interaction Studies Using an Electromagnetic Ion Trap), which is scheduled to run in 2002, will look for scalar and tensor components of the weak interaction – physics "forbidden" by the Standard Model.

NEW TECHNOLOGY

KEK prize encourages innovation





Above: the superconducting focusing magnets that are being developed at KEK for CERN's LHC collider need a ready supply of liquid helium. Top right: special electronics for the silicon tracking modules for the ATLAS detector at CERN's LHC. Bottom right: precision machining – a component for the proposed X-band linear accelerator plan being developed in Japan.

The KEK high-energy physics laboratory in Japan has established a new prize – the KEK Technology prize – to encourage its engineers to tackle technical challenges.

The first winners were five KEK engineers who contributed to outstanding advancements in technology related to KEK's research activities.

Takashi Koriki developed a high-density read-out PC board made of a copper polyimid hybrid film and carbon radiator fins for the ATLAS silicon strip module.

Takashi Kosuge received his award for his invention of an intelligent interlock system for the beamline area in the synchrotron radiation facility.

Hirokatsu Ohata and Masahisa Iida's team were also among the winners for their innovative refrigerator system – using two existing small refrigerators – that provided liquid helium to the team developing focusing magnets for CERN's LHC machine.

The fourth prize, which went to Toshikazu Takatomi, was for the ultraprecision machining for the proposed X-band linear accelerator. The unprecedented precision made it possible to build the accelerating structure by a unique method – the diffusion bonding of discs.

With the increasing importance of technical breakthroughs to the future of high-energy physics, the management at KEK is keen to encourage its engineers to exercise their creativity, and hopes to continue to award the prize in the coming years.

SOUTH-EAST EUROPE

Promoting science in south-east Europe

On 13–14 May, CERN hosted a meeting for a taskforce aiming to develop a set of recommendations for the reconstruction of scientific collaboration with the countries of south-east Europe.*

In the past, CERN's involvement in particle physics has provided a valuable catalyst in overcoming political obstacles. During the Cold War, scientific exchange between CERN and the former Soviet Union helped to prepare the ground for the establishment of today's cordial relations. It is hoped that scientific collaboration in and with south-east Europe will be similarly fruitful.

The meeting at CERN followed a conference, organized in the framework of UNESCO's Regional Office for Science and Technology for Europe, that was held in Venice on 24–27 March. It was attended by delegates from south-east Europe and international experts including representatives of the European Science Foundation, the European Union and the Academia Europaea, as well as observers from CERN.

Members of the Task Force on the Reconstruction of Scientific Co-operation in South-East Europe meet CERN's director-general, Luciano Maiani, left.

The aim of the conference was to seek resources and assess the prospects for integrating R&D in south-east Europe into the infrastructure of other European countries. With these goals in mind, the taskforce that met at CERN drew up a number of recommendations that will be forwarded to UNESCO and submitted at its General Conference in Paris on 6–7 November.

Among other things, the taskforce recommends the promotion of educational exchanges between the countries of south-east Europe, with the assistance of scientists in neighbouring countries (Hungary, Italy and Greece) and observer countries (France, Poland, Germany and the UK). The taskforce is also recommending the development of high-capacity electronic networks to offer the same opportunities for access to information to all scientists in the countries of south-east Europe.

**The countries of south-east Europe are: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, the former Yugoslav Republic of Macedonia, Greece, Romania, Slovenia, Turkey and Yugoslavia.*

PARTICLE BEAMS

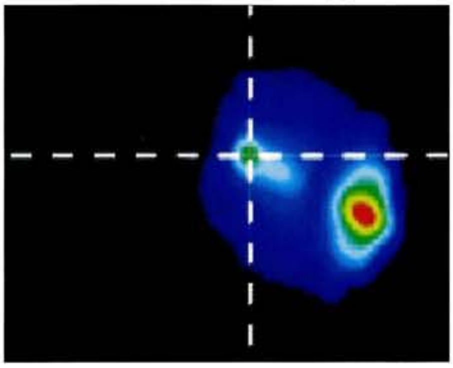
Plasma–gas refraction improves on crystals

Experiments using a high-energy electron beam at the Stanford Linear Accelerator Center (SLAC) have shown the way in which such a beam can be bent as it crosses the boundary between a plasma and a gas.

Electrons in the gas are expelled by the electrostatic pressure at the head of the high-energy electron beam, leaving a positively charged channel that steers the remainder of the beam. This force is asymmetric at the plasma boundary, there deflecting the beam in the same way that light is refracted.

These results confirm earlier simulations. According to the authors of the report, the results together show that "it is possible to refract and even reflect a particle beam from a dilute plasma gas. Remarkably, for a 28.5 GeV beam that can bore through several millimetres of steel, the collective effects of a plasma are strong enough to 'bounce' the beam off an interface that is one million times less dense than air."

According to the SLAC-Southern California–UCLA team, the effects also suggest that beam refraction could lead to the replacement of bulky magnetic kickers in particle accelerators by fast optical kickers, or even the use of plasma fibre optics to make storage rings without magnets.



Head-on view of the bending of a 28.5 GeV electron beam by a plasma–gas boundary. The crosshairs show the undeflected particles.

Particles can also be channelled by the arrangement of atoms in crystals, and specially bent crystals are already used in accelerator laboratories to steer high-energy beams. For example, a bent crystal is used at CERN's SPS synchrotron to split off a small fraction of protons to generate neutral kaons for the NA48 CP violation experiment. The small crystal, which is only a few centimetres long, bends 450 GeV protons through 7.2 mrad, which would otherwise require a magnet 5 m long.

The deflection angles achieved by gas refraction are comparable to those provided by channelling in crystals. Unlike in crystal channelling, however, there are no losses from surface transmission. In addition the plasma, being much more dilute than a crystal, does not suffer from the same degree of loss due to scattering. Channelling expert Soeren Pape Moeller of Aarhus, Denmark, said: "The only serious difficulty is that it is without doubt a complicated device, 1.4 m long. Whether it can be turned into more modest and practical device, only time can show. But I think both the idea and the demonstration deserve attention."

Reference

P Muggli *et al.* 2001, *Nature* **411** 43.

FUTURE PHYSICS

Linear collider study is extended for two years

A strong physics case has been made for building an electron-positron linear collider with an energy range from 90 GeV up to about 1 TeV.

It was presented on 23–24 March at the TESLA Colloquium at DESY (May p6) and is documented – along with a detector design – in the third volume of the TESLA Technical Design Report (the "TDR"; see DESY report 2001-011, ECFA report 2001-209 and "http://tesla.desy.de/tdr").

That volume, along with the detailed supporting notes that go with it, was produced by members of the Second ECFA/DESY Study of Physics and Detectors for a Future Electron-Positron Collider, drawing on contributions from physicists from throughout Europe and around the world. Now the mandate to the study from the European Committee for Future Accelerators (ECFA) has been extended for another two years, until spring 2003.

The goals of the extended study are:

- to continue to build up the active community of experimenters, theorists and machine physicists who prepared the TDR, in order to be ready to make firm proposals by 2003 for a funded programme of linear electron-positron physics up to about 1 TeV, if it is agreed to go ahead;
- to complete and extend feasibility studies on important physics channels;
- to review the detector's design in the light of results from the R&D programmes that are now under way;
- to interact with the accelerator's designers on questions relating to the machine-detector interface, including backgrounds, shielding, radiation levels, beam position monitoring, luminosity measurement and energy measurement;
- to look at the physics potential and technical possibilities for extensions of the programme to produce real photon-photon, electron-photon and electron-electron collisions;
- to extend the work of the "LoopVerein", developing new tools and techniques for calculating precise rates for Standard Model and supersymmetric processes that match the expected experimental precision;
- to continue to make and extend contacts with physicists in the US, Asia and the rest of the world.

Wherever the collider is built, the collaborations carrying out the experiments are likely to be composed of groups from all over the world – as they were at LEP, and are at HERA, the Tevatron and the LHC.

The first workshop of the extended study will be held in Cracow, Poland, on 15–18 September 2001. Details of registration, the programme and the working groups can be found on the study's Web page at "http://www.desy.de/conferences/ecfa-desy-lcext.html". Some of the working groups on physics and detector topics are already holding their own specialized meetings.

There will be a worldwide workshop in Korea in summer 2002 – the fifth of the LCWS series, following Saariselkä, Finland 1991; Waikoloa, Hawaii 1993; Morioka, Japan 1995; Sitges, Spain 1999; and Fermilab, US 2000. An open invitation is offered to interested physicists from anywhere in the world to participate in all of these activities.

Membership of the ECFA/DESY study is likely to overlap strongly with the studies currently being carried out at CERN on the higher-energy CLIC collider (for more information see "http://clicphysics.web.cern.ch/CLICphysics/"). The two studies will also share tools and ideas.

The organizing committee for the extended ECFA/DESY study comprises Mikhail Danilov (ITEP, Moscow), Enrique Fernandez (Barcelona), Rolf Heuer (Hamburg), Leif Jönsson (Lund), Paolo Laurelli (Frascati), Martin Leenen (DESY), David Miller (UCL, London, chair), Walter Majerotto (Vienna), Francois Richard (Orsay), Albert de Roeck (CERN), Ron Settles (MPI, Munich), Janusz Zakrzewski (Warsaw) and Peter Zerwas (DESY).

The European Physical Journal

http://www.eurphysj.org

LINK Online First
Immediately Online
http://link.springer.de
link.springer-ny.com
Faster publication!

The European Physical Journal A

Hadrons and Nuclei

http://link.springer.de/journals/epja/

Editors-in-Chief

R.A. Ricci
raricci@lnl.infn.it

Th. Walcher
walcher@kph.uni-mainz.de

The scope of *EPJ A* is to cover all physics related to Hadrons and Nuclei. Its aim centers around the common theme: many body systems and the shape and interactions of their constituents.

The structure of hadrons at low energies and its connection to QCD is one of the unsolved problems of the standard model of particle physics. The transition from quark-gluon to hadron scales require the search for the right degrees of freedom in order to describe the experiments. These degrees of freedom have to be related to QCD and may provide its understanding at low energies.

This relation between composite systems and their constituents is familiar with the nucleus. The many facets of this many body system are only understood by the realization of the right degrees of freedom: single particle, particle-hole, collective, etc. Though an empirical description of the nucleon-nucleon interaction exists many aspects of its relation to the hadron structure are still unclear.

The European Physical Journal C

Particles and Fields

http://link.springer.de/journals/epjc/

Editors-in-Chief

J. Bartels
bartels@x4u2.desy.de

D. Haidt
dieter.haidt@desy.de

Zichichi
Fax: +41 22 767 7755

The physics of elementary particles lies at the frontier of our understanding of nature. The journal *EPJ C* publishes most recent experimental and theoretical results obtained in this field. Experimental results come from the high energy physics laboratories, such as CERN (Switzerland), DESY (Germany), SLAC and Fermilab (both USA), and KEK (Japan), with their accelerators and experimental facilities, and also from nonaccelerator laboratories, such as Kamioka (Japan), Gran-Sasso (Italy) and others. Theoretical topics include studies and tests of the Standard Model, computer simulations of Quantum Chromodynamics, search for the Higgs particle and supersymmetry, and the investigation of new ideas beyond the standard model.

Order your free sample copy at
http://link.springer.de/orders.htm

The Electronic Only Alternative...

EPJdirect C

http://link.springer.de/journals/epjc/

EPJdirect C is both an alternative and complementary way to publish in *The European Physical Journal C.*

Free of charge for the user in 2001 and 2002
and no charges are billed to the author

Convincing Features:

Free access
Access to the full texts of *EPJdirect C* is free of charge for all users worldwide.

No page charges
Authors may submit their papers to *EPJdirect C* at no cost - there are no page charges whatsoever.

No pages limits
There is no limitation with respect to the length of papers submitted to *EPJdirect C.*

Peer reviewed
Every paper submitted to *EPJdirect C* will be reviewed to the same standards and by the same editorial board as for the corresponding journal *EPJ C.*

Rapid, online-only publication
Papers are submitted in electronic form and handled this way until publication.
EPJdirect C is an online-only journal and papers are published normally within 5 days or less after submission and acceptance of the final manuscript.

Multimedia Material
It is possible to include multimedia material, color figures or Java applications into the papers submitted or to submit material which is otherwise not suitable for the print medium, such as very large tables or figures.

Fully citable
Every paper published in *EPJdirect C* is fully citable through an internationally recognised and consistent identification code (DOI, Digital Object Identifier).

Contact ► epjdirect@springer.de

Please order from
Springer · Customer Service
Haberstr. 7 · 69126 Heidelberg, Germany
Tel.: +49 (0) 6221 - 345 - 239 · Fax: +49 (0) 6221 - 345 - 229
e-mail: subscriptions@springer.de
or through your bookseller

Springer

Plus carriage charges. Price subject to change without notice. In EU countries the local VAT is effective. d&p · 7734/SF

Edited by Archana Sharma

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

Cubic boron nitride could supplant diamond

A new material – cubic boron nitride (cBN) – could soon rival the status of diamond. As well as being the hardest material known so far, diamond shows the highest thermal conductivity. Combined with these important properties, diamond also shows very low thermal expansion and high electrical resistance.

Owing to its hardness, diamond is far more effective and efficient than competing materials used in abrasive, cutting, shaping or finishing tools. Its high thermal conductivity makes it ideal for spreading and conducting the heat out of compact, high-power, fast electronics.

The polycrystalline growth of cubic boron nitride, which could replace diamond as the ultimate hard material.

Compressing carbon-rich materials such as graphite produces vast quantities of synthetic diamond grit, which is used for making cutting tools and drill bits, and as an abrasive. However, synthetic diamond is not the ideal all-purpose hard material. When it is heated up by friction in the presence of air, diamond tends to decompose into carbon dioxide. Also, hot diamond dissolves in iron and so cannot be used to cut steel.

Boron and nitrogen, cBN's constituents, straddle carbon in the periodic table. All three elements tend to form strong, short chemical bonds, which accounts for the hardness of their materials. When united, the three form materials analogous to graphite, the soft form of pure carbon, rather than diamond. However, just as graphite can be converted into diamond by squeezing, so these soft "boron carbonitrides" (BC2N and BC4N) can be compressed into a harder form.

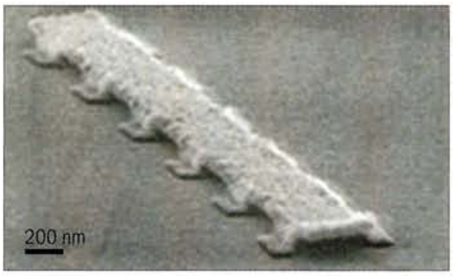
Diamond and cBN are of great interest for a multitude of applications. They combine a number of extreme properties, such as great hardness and rigidity; optical transparency over a large wavelength range; chemical resistance; and high thermal conductivity. Methods and processes that have been developed in recent years for the low-pressure, gas-phase deposition of polycrystalline diamond coatings have led to considerably improved availability and more widespread applications for diamond.

A group in the Ukraine squeezed BC2N and BC4N in a diamond anvil cell, in which small samples are placed between diamond "teeth" and crushed hard. At more than about 1.8 million times atmospheric pressure (about 10 times the pressure that is needed to make synthetic diamond), they found that the graphite-like boron carbonitride changes into a cubic form of the same material (cBC2N), in which the atoms are arranged in the same manner as in diamond.

3-D printing is applied on a nanometre scale

New "soft lithographic" techniques, developed for fabricating structures at nanometre scales, could revolutionize this technology.

In nano-imprint lithography, a mould made by electron beam lithography and reactive ion etching is used to imprint structures onto a thin polymer film. The polymer templates are then used to make metal structures by means of vapour deposition, and this is followed by the lift-off of the polymer film in acetone.



The small-scale future – a nanobridge, as used in integrated circuits to change the intrinsic granularity.

Researchers in Princeton have been able to make silicon dioxide moulds patterned in three dimensions by using a bilayer of electron-sensitive resists with different exposure sensitivities. Imprinting, metal deposition and lift-off can be used to make three-dimensional metal structures, such as T-gates, with footprints as small as 40 nm. This is useful for fabricating field-effect transistors, which operate at high frequency with low noise.

Another application of the technology could be for making the bridges that are widely used in monolithic integrated circuits and nanoelectromechanical systems. Photonic transistors are currently switching in about 30 fs, whereas electronic transistors are switching in the nanosecond range.

The researchers envisage that their technique will be used for mass-producing three-dimensional nanostructures. The imprinting step is much faster than conventional nanofabrication techniques, and the moulds can be reused many times, repaying the time investment that is needed to make them. Detectors for large particle physics experiments could also benefit from this technology.

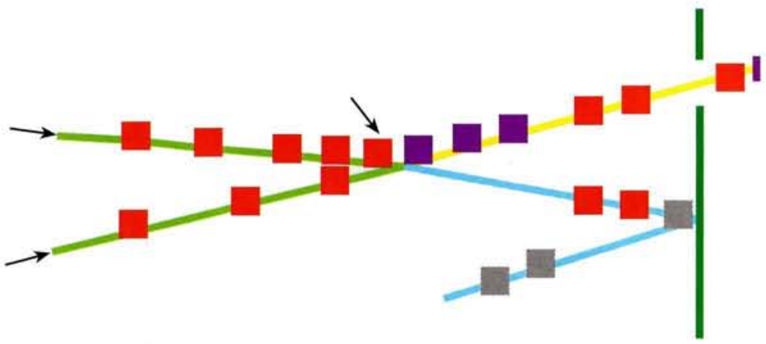
Further reading

Mingtao Li 2001 Direct 3-D patterning using nanoimprint technology *Applied Physics Letters* **78** 3322–3324.

Transistors shed light on data transmission

Researchers at the National Institute of Advanced Industrial Science and Technology in Tsukuba, Japan, have developed a photonic transistor that uses a laser to control the amplification of signals in another laser beam.

In contemporary optical devices, signals that are encoded in light must be converted into electrical signals so that they can be manipulated and subsequently converted back into light for transmission. This leads to complex hybrids of optical and electrical components, in which high-speed optical data transmission is interrupted by sluggish electronics.



Data transmission light – a schematic of a photonic transistor showing logical output separation from digital inputs.

The novel optical transistor involves two lasers – one red and one blue – which are focused at the same spot on a thin film composed of metal and plastic layers. The lasers form energy-storing plasmons – local groups of collectively moving electrons – on the surface of the film. One of the lasers, usually the red one, also generates a light-scattering particle of silver in a layer of silver oxide that comprises a portion of the film. The silver particle couples energy from the plasmons into the other laser beam, enhancing the signal in the blue beam by up to 60 times.

The power of the red beam determines the size of the scattering silver particle and therefore regulates the magnitude of the energy coupled from the plasmons and the resulting amplification. If the new device can be sufficiently perfected, photonic transistors may become building blocks in all-optical circuits analogous to, but much faster than, modern electrical circuitry.

Edited by Emma Sanders

Observations of cosmic ripples reveal more hints of the blueprint for the early universe

April and May were exciting months for cosmologists, as new results brought them one step closer to unravelling the mysteries of the early universe. Observations of fluctuations in the microwave background placed important new constraints on the fundamental cosmological parameters; and for the first time, optical observations showed hints of analogous structure in matter distribution.

Cosmic microwave background radiation (CMB) dates from 300 000 years after the Big Bang, when radiation decoupled from matter. Fluctuations in the CMB are evidence for the first clumping of matter particles – the seeds of the galaxies that we see today. Plotting the observed power as a function of the angular size of regions contributing to the CMB provides a constraint on cosmological parameters.

It is predicted that this power spectrum will show a number of peaks. The first, corresponding to the largest clumps of matter in the early universe, can be used to give a constraint on Ω – the ratio of matter in the universe to the critical level needed to halt its expansion. Subsequent peaks give an indication of the amount of ordinary matter and dark matter in the universe.

Last year's results from the Boomerang and Maxima balloon experiments (March 2000 p12) provided a map of the first peak, and suggest that Ω is equal to one, which is equivalent to a flat universe. Now a new analysis of the Boomerang data has revealed other peaks that show that the amount of baryonic, or ordinary, matter is about 5%. Results from the Degree Angular Scale Interferometer, which is based at the South Pole, agree with Boomerang, lending strong support to the inflationary model of the early universe.

The two experiments also suggest that the amount of dark matter present in the universe is between 30% (Boomerang) and 65% (Maxima). These results were announced at the American Physical Society meeting in late April.

Meanwhile, astronomers using the Anglo Australian Telescope (AAT) announced observations of ripples in the matter distribution of the universe, in a structure analogous to the fluctuations in the radiation background. The discovery resulted from a survey of 170 000 galaxies carried out using the AAT's two degree field instrument.

"What we showed was not just that there are ripples in the matter distribution, but that the strength of these ripples is enhanced at certain wavelengths related to the preference for certain angular scales in the CMB," said John Peacock of Edinburgh. He added: "These are consistent with the effects of acoustic oscillations and allow us to rule out the higher end of the CMB range for dark matter. We prefer 5% baryons and about 30% dark matter."

Further information

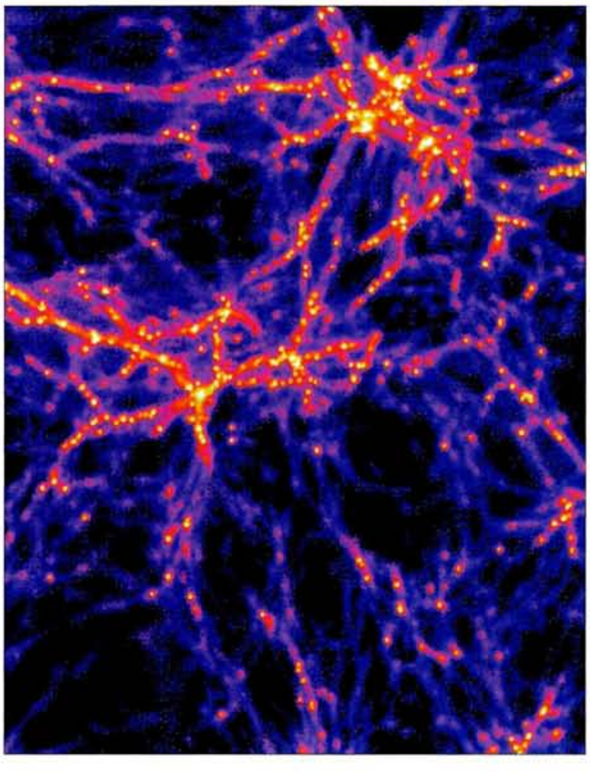
Visit "http://xxx.soton.ac.uk/abs/astro-ph/0105252" for more details.

European network for astro-particle physics is formed

Five European countries have pledged to collaborate on research into astroparticle physics. The Astro-Particle Physics European Coordination (APPEC) network was formed on 2 May in Paris. Its goals include promoting European collaboration in research areas such as high-energy cosmic rays, neutrino physics and dark matter; and improving links between international organizations such as CERN, the European Southern Observatory and the European Space Agency. APPEC's partners include research councils and organizations in Germany, France, Italy, Holland and the UK.

On the same theme, a major meeting on Astronomy, Cosmology and Fundamental Physics will be held in Garching, Germany, on 4–7 March 2002. An initial announcement will appear in the September issue.

Picture of the month



This computer simulation shows what the first large-scale structures in the early universe might have looked like, around 2 billion years after the Big Bang. The yellow areas indicate where gas density is highest, and hence where galaxies will eventually form. This structure of long filaments connected by nodes, which is predicted by models of the early universe, is supported by new observations using the European Southern Observatory's Very Large Telescope in Chile. Astronomers determined the distances to some very faint distant galaxies and plotted their positions in a three-dimensional map, which showed that they were located along a narrow filament. (Max-Planck-Institute for Astrophysics.)

Fermilab launches Run II of Tevatron

After detecting hints of the long-awaited Higgs particle, CERN's LEP electron-positron collider closed at the end of 2000 and is now being dismantled. The search for the Higgs – the missing link in today's picture of particle physics – is now taken up by Fermilab's Tevatron proton-antiproton collider, which has just begun a major new phase of operations. In this article, first published in *Ferminews,** *Mike Perricone* sounds out the prospects.




Left, top: the Fermilab Main Injector Tunnel showing the Main Injector ring (large magnets on the floor) and the Antiproton Recycler ring (smaller green magnets above). The Recycler ring in the 2-mile tunnel is the world's most extensive collection of large permanent magnets. Right, top: theorist Chris Hill. Left, bottom: Chris Tully of Princeton University. Right, bottom: part of the 4-mile tunnel housing Fermilab's superconducting Tevatron proton-antiproton collider. The tunnel was originally built for Fermilab's Main Ring, which has now been removed.

Chris Tully made his first visit to Fermilab in 1988 as a high school student, representing the state of Virginia in the US Department of Energy's national high school honours programme. He learned to string wires for the muon chambers at the D0 detector.

He returned 12 years later, on 13 December 2000, as a Fermilab Colloquium presenter, Princeton University physicist and CERN experimenter. This time he was reporting on the "tantalizing hints" for the Higgs mechanism that had shown up at CERN's Large Electron-Positron (LEP) collider before the 8 November shutdown (March p25).

Tully's presentation echoed the global state of anticipation over the beginning of Collider Run II of the Tevatron – and the search for the origin of mass. "For eager Higgs hunters," said Tully, "the immediate focus will be on the Run II results from Fermilab as the next possible source for direct evidence for the Higgs mechanism. Now that evidence suggests a low-mass Higgs, it might mean that Fermilab is in exactly the right place to observe a wealth of new physics."

The whole world is watching, and the Higgs is far from being the only attraction as Fermilab opens Collider Run II of the Tevatron. In fact, Higgs candidates might not make an appearance for quite some time. CDF experiment co-spokesperson Franco Bedeschi estimates that five years of Run II would produce about 3000 Higgs candidates (out of 5×10^{14} proton-antiproton collisions) in the mass range of 115 GeV that is suggested by LEP results and other data.

So what else is new? Almost everything: new particles; new dimensions; new top quark measurements and production channels; and new CP violation results in B physics. "There is the possibility of finding something definitive early on," said theorist Chris Hill. "For example, it's possible that we will uncover a new layer of physics with new strong dynamics. That could show up in the first inverse femtobarn."

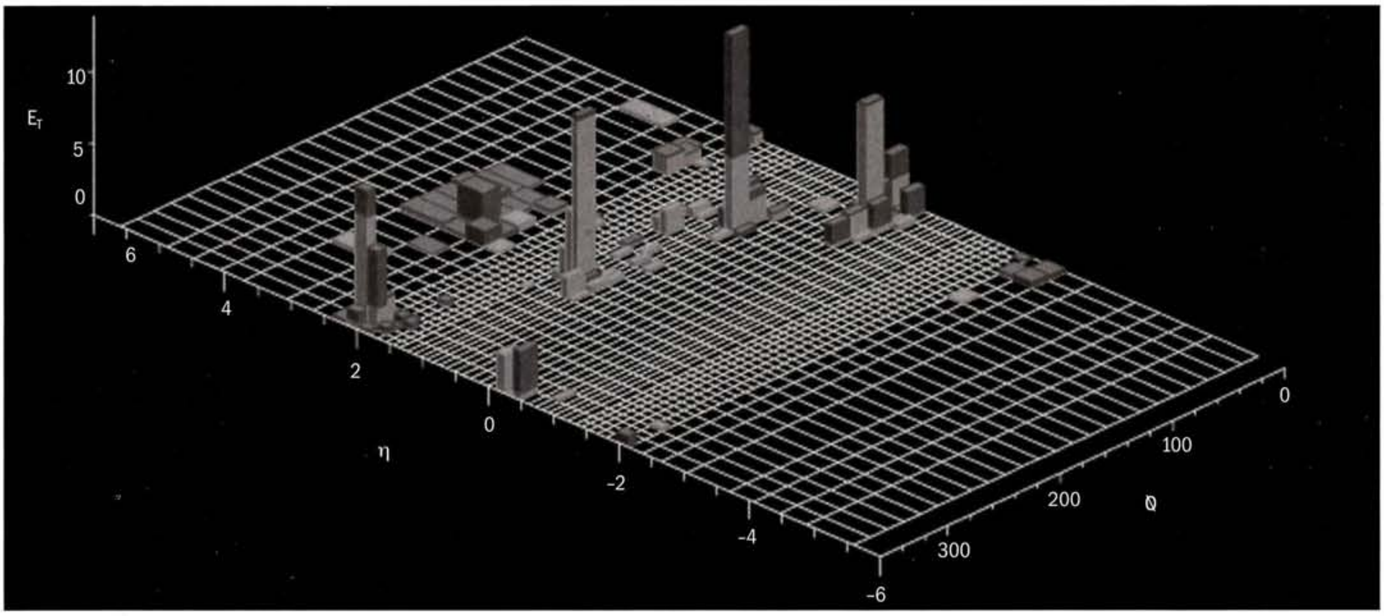
Near the top of the Run II wish list is the top quark. Discovered at the Tevatron in 1995, the top is due for a step up in precision and a new production mode. Called single top production, the process starts with an up quark annihilating against a down quark (within the

Sixteen years of Tevatron

On 1 March 2001, Fermilab's superconducting Tevatron proton–antiproton collider, operating at up to 980 GeV per beam, began Run II. Operations will continue, with a mid-course interruption for further upgrades and improvements to the accelerators and detectors, until 2007 – more like a marathon than a run. At about that time, first results should also begin to emerge from CERN's LHC proton collider, which, with seven times the Tevatron's collision energy, will overtake it at the high-energy frontier.

Although the Tevatron produced its first proton–antiproton collision in 1985, and for its first phase of operations (pre-Run I, until 1989) ran with a single detector, CDF, the period that was officially known as Run I began in 1992, when the newly commissioned D0 detector joined CDF in the Tevatron ring. By the completion of the run in 1996, the two big Tevatron collider detectors had discovered the sixth – and by far the heaviest – quark: the top.

Between Run I and Run II, Fermilab commissioned its new 150 GeV Main Injector, which replaced the original Fermilab Main Ring synchrotron as the laboratory's workhorse machine.



Computer simulation of a Higgs particle produced in Fermilab's CDF detector. The plot shows the way in which different particles deposit their energy.

Tevatron's proton-antiproton collisions). Out pops a "virtual" W boson, which quickly decays into a top and an antibottom.

"Single top production has never been observed before," said Hill. He described it as a "new window into the top", offering a view of how the top couples to the W boson. It also provides tests of the Standard Model and background for Higgs production.

Precision measurements of the masses of the top quark and the W also serve as constraints on the Higgs mass. "These precision electroweak tests use the top mass and the W mass in combination with other measurements to predict the Higgs mass," Hill continued. "You then have the potential to define precisely where the Higgs ought to be, and check it with a discovery."

In Run I, Fermilab produced a grand total of 150 top quarks. Run II, however, will yield thousands. The top is also a route into supersymmetry – the theory that all Standard Model particles have "superpartners." But it's a route with a twist.

"It seems to work in reverse," Hill explained. "Because the top is heavy, many people expect its superpartner – the 'stop' – to be light. The production of a 'top' and an 'antistop' are possibilities, although the decay modes are very model-dependent: you have to determine what they're decaying into. There are many possible channels, but 'stop' production is something people might expect in Run II."

Fermilab discovered the fifth – "bottom" – quark in 1977. The field of B physics measures the behaviour of particles containing bottom quarks, known as B mesons. The decays of B mesons and their anti-matter counterparts produce subtle differences that could go a long way towards explaining the universe's preferential treatment of matter over antimatter, leading to life as we know it.

Here, the key quantity differentiating the decays is sinß, and the goal is to measure that quantity as accurately as possible. Fermilab's Collider Detector Facility (CDF) collaboration set a new standard in sin2ß measurement with data from Collider Run I, establishing a value of 0.79 ± 0.4, which is consistent with Standard Model predictions of a large positive CP-violating asymmetry in this decay mode – in other words, a big gap between the behaviour of matter and antimatter.

Then along came the BaBar experiment at PEP-II, the electron-positron collider at the Stanford Linear Accelerator Center ▷

(SLAC) and the Belle experiment at the KEKB collider in Japan, which have recently reported more accurate results (April p5). "CDF will be very competitive," said Hill. "When CDF is back up to speed, they'll be able to address CP violation in the B system."

Fermilab has a long history of offering up something extra, and this may be a bonus for Run II. Hope springs from luminosity, a measure of the number of collisions that the Tevatron can produce to light up the field with new discoveries, Higgs and otherwise.

"The big question is: can we get the integrated luminosity?" said veteran CDF experimenter Henry Frisch of Chicago. "If we make enough Higgs candidates, the newly upgraded detectors will definitely be capable of seeing them."

The issue of making enough candidates applies to the entire range of Run II science. That puts the focus on Fermilab's Beams Division, which performs the intricate task of creating antiprotons, "cooling" them into intense beams and colliding them with proton beams.

The Beams Division has a long and distinguished history of exceeding its goals. For example, the original design goal for the Tevatron collider luminosity was $10^{30}/cm^2/s$, which corresponds to about 50 000 proton-antiproton collisions per second witnessed at each detector.

The Beams Division took that goal and exceeded it by a factor of about 16. It got to 1.6×10^{31}, which corresponds to a collision rate of about 800 000/s. "Now we're talking about something in the order of 10 to 20 times that number – as many as 10 to 15 million collisions per second," Frisch stressed.

Luminosity holds the key to discoveries – specifically, integrated luminosity, or the number of total collisions over the course of the run. Frisch explained that the Higgs has an extremely small cross-section – physics-speak for the probability that a proton would actually produce a Higgs particle, or any specific particle under investigation. The equation in question is simple: (luminosity) × (cross-section) = collision rate, or number of events per second. Thus a small cross-section requires lots of luminosity to produce a significant number of observable events.

"The people in the Beams Division have always had wonderful ideas to get the luminosity up," Frisch said. "We're not yet running up against a 'brick-wall' limit set by physical law. Clever ideas, new techniques and a lot of hard work may well get us what we need."

All this is happening against a background of pushing forward with the MINOS and MiniBooNE neutrino experiments; and of the lab's continuing support for CERN's LHC and its Compact Muon Solenoid detector.

"Looking from the outside," said Chris Tully, perhaps wistfully, "the prospects for Run II at Fermilab are very promising if new physics is sitting just beyond what LEP was able to explore."

Mike Perricone, *Fermilab.*

*FermiNews *is a biweekly magazine published by Fermilab's Office of Public Affairs.*

A major SHIFT in outlook

The big experiments in high-energy physics are fertile ground for new developments in computers and communications – witness the World Wide Web, which was developed at CERN. Computer specialist *Ben Segal* recalls how distributed UNIX boxes took over from CERN's all-powerful IBM and Cray mainframe workhorses.

The changing landscape at CERN's Computer Centre: 1988, with the Cray supercomputer (in blue and yellow) in the background.

Ten years on: CERN's Computer Centre in 1998, with banks of SHIFT-distributed computing arrays for major experiments.

I don't remember exactly who first proposed running physics batch jobs on a UNIX workstation, rather than on the big IBM or Cray mainframes that were doing that kind of production work in 1989 at CERN. The workstation in question was to be an Apollo DN10000, the hottest thing in town with reduced instruction set (RISC) CPUs of a formidable five CERN Units (a CERN Unit was defined as one IBM 370/168, equivalent to four VAX 11-780s) each and costing around SwFr 150 000 for a 4-CPU box.

It must have been the combined idea of Les Robertson, Eric McIntosh, Frederic Hemmer, Jean-Philippe Baud, myself and perhaps some others who were working at that time around the biggest UNIX machine that had ever crossed the threshold of the Computer Centre - a Cray XMP-48, running UNICOS.

At any rate, when we spoke to the Apollo salespeople about our idea, they liked it so much that they lent us the biggest box they had, a DN10040 with four CPUs plus a staggering 64 Mb of memory and 4 Gb of disk space. Then, to round it off, they offered to hire a person of our choice for three years to work on the project at CERN.

In January 1990 the machine was installed and our new "hireling", Erik Jagel, an Apollo expert after his time managing the Apollo farm for the L3 experiment, coined the name "HOPE" for the new project. (Hewlett-Packard had bought Apollo and OPAL had expressed interest, so it was to be the "HP OPAL Physics Environment").

We asked where we could find the space to install HOPE in the Computer Centre. We just needed a table with the DN10040 underneath and an Ethernet connection to the Cray, to give us access to the tape data. The reply was: "Oh, there's room in the middle" – where the recently obsolete round tape units had been – so that was where HOPE went, looking quite lost in the huge computer room, with the IBM complex on one side and the Cray supercomputer on the other.

Soon the HOPE cycles were starting to flow. The machine was surprisingly reliable, and porting the big physics FORTRAN programs was easier than we had expected. After around six months, the system was generating 25 per cent of all CPU cycles in the centre. Management began to notice the results when we included HOPE's accounting files in the weekly report we made that plotted such things in easy-to-read histograms.

We were encouraged by this success and went to work on a proposal to extend HOPE. The idea was to build a scalable version from interchangeable components: CPU servers, disk servers and tape servers, all connected by a fast network and software to create a distributed mainframe. "Commodity" became the keyword – we would use the cheapest building-blocks available from the manufacturers that gave the best price performance for each function.

On how large a scale could we build such a system and what would it cost? We asked around, and received help from some colleagues who treated it as a design study. A simulation was done of the workflow through such a system, bandwidth requirements were estimated for the fast network "backplane" that was needed to connect everything, prices were calculated, essential software was sketched out and the manpower required for development and operation was predicted.

Software development would be a challenge. Fortunately, ▷

some of us had been working with Cray at CERN, adding some facilities to UNIX that were vital for mainframe computing: a proper batch scheduler and a tape-drive reservation system, for example. These could be reused quite easily.

Other new functions would include a distributed "stager" and a "disk-pool manager". These would allow the pre-assembly of each job's tape data (read from drives on tape servers) into efficiently-managed disk pools that would be located on disk servers, ready to be accessed by the jobs in the CPU servers. Also new would be the "RFIO", a remote file input-output package that would offer a unified and optimized data-transfer service between all of the servers via the backplane. It looked like Sun's networking filing system, but was much more efficient.

PC power: CERN's Computer Centre in 2001 has wall-to-wall PCs.

SHIFT in focus

Finally, a suitable name was coined, again by Erik Jagel: "SHIFT", for "Scalable Heterogeneous Integrated FaciliTy", suggesting the paradigm shift that was taking place in large-scale computing: away from mainframes and towards a distributed low-cost approach.

The "SHIFT" proposal report was finished in July 1990. It had 10 names on it, including the colleagues from several groups that had offered their ideas and worked on the document.

"Were 10 people working on this?" and "How many Cray resources were being used and/or counted?" came the stern reply. In response, we pointed out that most of the 10 people had contributed small fractions of their time, and that the Cray had been used simply as a convenient tape server. It was the only UNIX machine in the Computer Centre with access to the standard tape drives, all of which were physically connected to the IBM mainframe at that time.

Closer to home, the idea fell on more fertile ground, and we were told that if we could persuade at least one of the four LEP experiments to invest in our idea, we could have matching support from the Division. The search began. We spoke to ALEPH, but they replied, "No, thank you, we're quite happy with our all-VAX VMS approach." L3 replied, "No thanks, we have all the computing power we need." DELPHI replied, "Sorry, we've no time to look at this as we're trying to get our basic system running."

Only OPAL took a serious look. They had already been our partner in HOPE and also had a new collaborator from Indiana with some cash to invest and some small computer system interface (SCSI) disks for a planned storage enhancement to their existing VMS-based system. They would give us these contributions until March 1991, the next LEP start-up – on the condition that everything was working by then, or we'd have to return their money and disks. It was September 1990, and there was a lot of work to do.

Our modular approach and use of the UNIX, C language, TCP/IP and SCSI standards were the keys to the very short timescale we achieved. The design studies had included technical evaluations of various workstation and networking products.

By September, code development could begin and orders for hardware went out. The first tests on site with SGI Power Series servers connected via UltraNet took place at the end of December 1990. A full production environment was in place by March 1991, the date set by OPAL.

And then we hit a problem. The disk server system began crashing repeatedly with unexplained errors. Our design evaluations had led us to choose a "high-tech" approach: the use of symmetric multiprocessor machines from Silicon Graphics for both CPU and disk servers, connected by the sophisticated "UltraNet" Gigabit network backplane. One supporting argument had been that if the UltraNet failed or could not be made to work in time, then we could put all the CPUs and disks together in one cabinet and ride out the OPAL storm. We hadn't expected any problems in the more conventional area of the SCSI disk system.

Our disks were mounted in trays inside the disk server, connected via high-performance SCSI channels. It looked standard, but we had the latest models of everything. Like a performance car, it was a marvel of precision but impossible to keep in tune. We tried everything, but still it went on crashing and we finally had to ask SGI to send an engineer. He found the problem: inside our disk trays was an extra metre of flat cable which had not been taken into account in our system configuration. We had exceeded the strict limit of 6 m for single-ended SCSI, and in fact it was our own fault. Rather than charging us penalties and putting the blame where it belonged, SGI lent us two extra CPUs to help us to make up the lost computing time for OPAL and ensure the success of the test period!

At the end of November 1991, a satisfied OPAL doubled its investment in CPU and disk capacity for SHIFT. At the same time, 16 of the latest HP 9000/720 machines, each worth 10 CERN Units of CPU, arrived to form the first Central Simulation Facility or "Snake Farm".

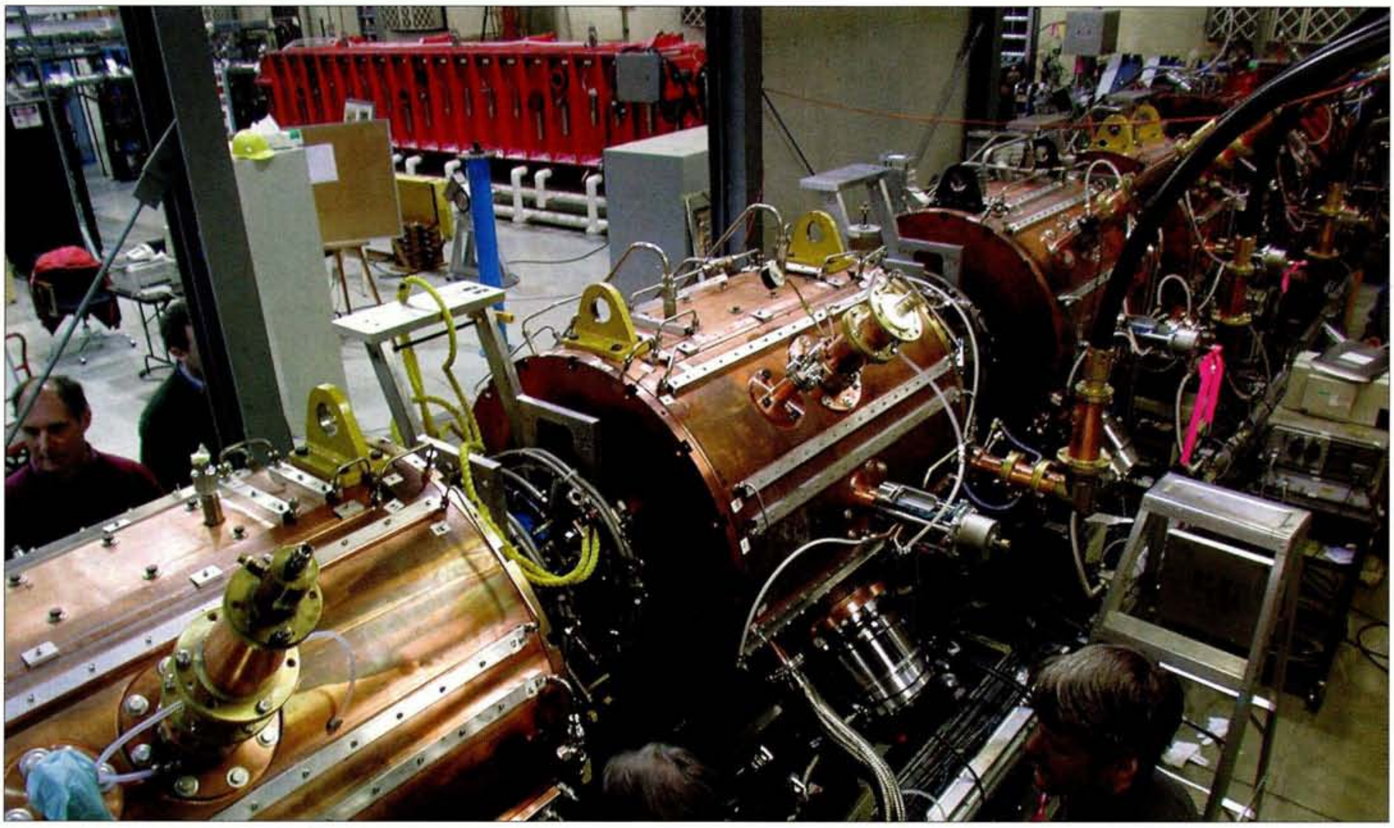
The stage was set for the exit of the big tidy mainframes at CERN, and the beginning of the much less elegant but evolving scene we see today on the floor of the CERN Computer Centre. SHIFT became the basis of LEP-era computing and its successor systems are set to perform even more demanding tasks for the LHC, scaled this time to the size of a worldwide grid.

Ben Segal, *CERN.*

• On 4 June in Washington, Les Robertson, deputy leader of CERN's Information Technology division, accepted a 21st Century Achievement award from the Computerworld Honors Program on behalf of the laboratory. The award came in recognition of the laboratory's developments in high throughput computing, which were pioneered by SHIFT.

Isotope source hits target

The ISAC on-line isotope source at the Canadian TRIUMF laboratory recently achieved its full design energy. *Paul Schmor* and *Jean-Michel Poutissou* describe the experiments scheduled for the source.



Final adjustments to the ISAC drift-tube linac, with the RFQ tank (red) in the background.

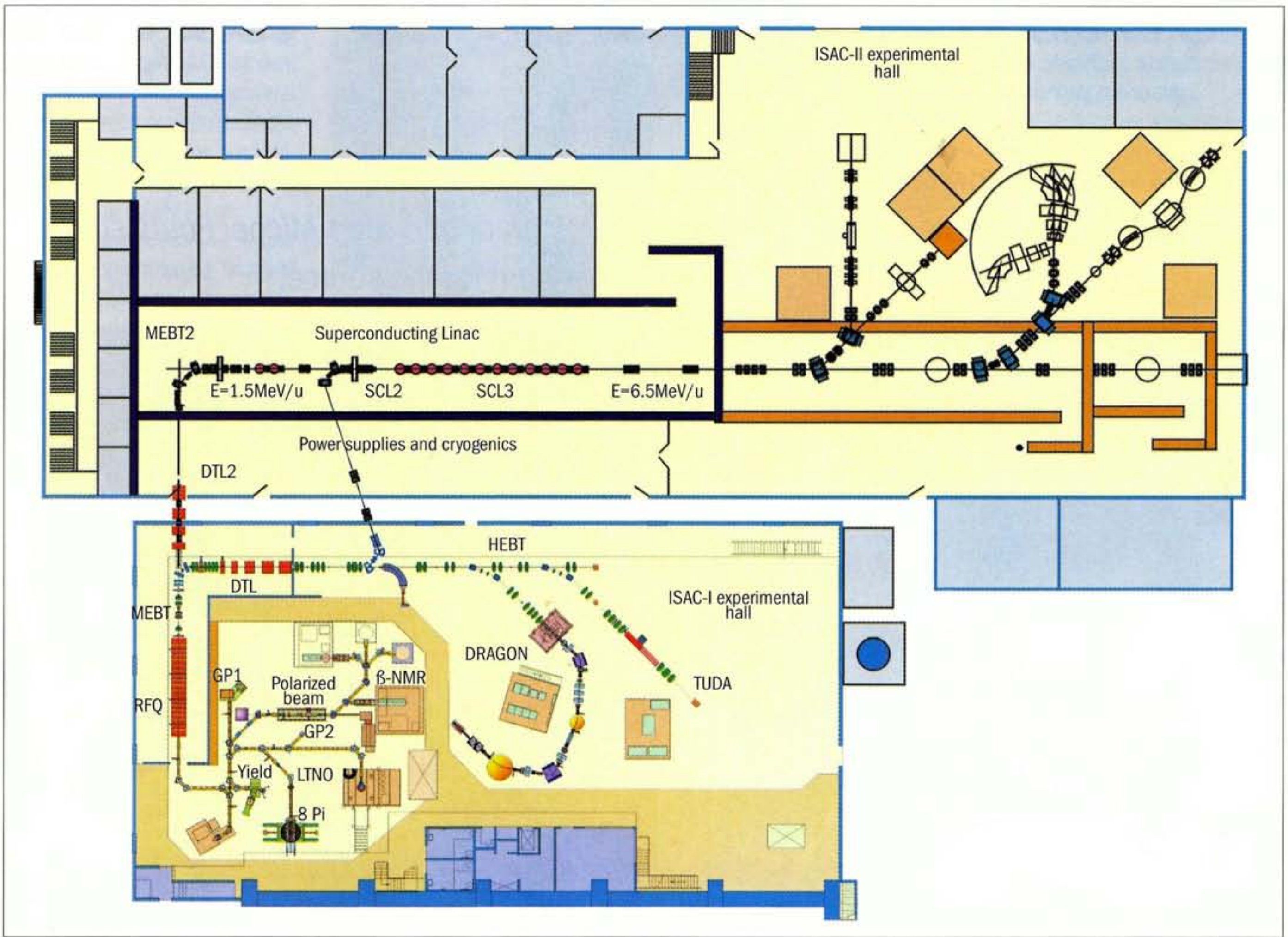
The Isotope Separator and Accelerator (ISAC) at TRIUMF uses the on-line isotope separation technique that was developed at CERN to produce relatively intense beams of short-lived exotic nuclei for experiments in nuclear astrophysics and nuclear and condensed-matter physics.

A 500 MeV beam of protons from the TRIUMF cyclotron is used to create the rare isotopes in a thick heated target, from which they effuse and are then ionized, extracted as a beam, separated by mass and accelerated. The first stage, ISAC-I, passed a major milestone on schedule last December when a $^4He^+$ beam was accelerated through the continuous-wave radiofrequency quadrupole (RFQ) and drift-tube linacs to the design energy of 1.5 MeV nucleon.

Users have been running experiments with radioactive ion beams with an atomic mass of less than 30 at up to 60 keV since November 1998, and they have now begun taking data at full energy. The 20 μA proton beams used until now make this the highest-power ISOL source. The current is being raised to 40 μA, and a target has been tested to the full 100 μA design capability.

The importance of studying the properties of exotic nuclear isotopes has been increasingly recognized by physicists and astronomers in recent years (see OECD Megascience Forum report; *CERN Courier* May 1999 p21), and almost a dozen radioactive ion beam projects are now under way around the world. Research at ISAC-I focuses on the nuclear processes occurring in stars – where the high densities and huge numbers involved can lend importance to even short-lived isotopes – and on precision tests of the Standard Model of particle physics.

The ISAC ion source and target system is suspended at the bottom of a 2 m long iron shield block that can be lifted out of its vacuum enclosure and transported, as a unit for servicing, to a hot cell by a remotely operated crane. This system was designed to increase the useful target lifetime and decrease the exposure of personnel to radiation ▷



Schematic layout of the ISAC-I (above, bottom) and ISAC-II (above, top) facilities. The production target, mass separator and TRINAT atom trap are on lower levels.

during servicing. In fact, the shielding permits the operation of thick uranium targets with up to 50 kW of proton beam.

Although the initial range of isotopes is limited by the use of a surface ion source to provide isotopes that can easily be thermally ionized, the list of available nuclei will expand considerably in 2002, when a 2.45 GHz electron-cyclotron resonance ion source (ECRIS) is scheduled to begin operation. Any isotope with an atomic mass of less than 240 and an energy of up to 60 keV can be transported, with the aid of electrostatic optics, through a magnetic mass analyser (mass resolution one part in 10 000), either to one of several low-energy experimental stations, or to the low-frequency (35 MHz) continuous-wave RFQ linac.

The 8 m long RFQ, which has a four-rod split-ring design, accelerates ions with a mass:charge ratio of less than 30 from 2–150 keV per nucleon. An 11.7 MHz pseudo-sawtooth prebuncher in the injection line is used to fill every third radiofrequency bucket in the RFQ, forming beam bunches at 87 ns intervals. The accelerated beam is then bunched again, stripped by a carbon foil to a higher charge state, rebunched and accelerated in a five-tank drift-tube linac (DTL) operating continuous wave at 105 MHz.

The DTL has a completely separated-function design, with the interdigital H-mode accelerating cavities separated by magnetic quadrupole triplets for transverse and three-gap split-ring bunchers for longitudinal focusing (the latter having been developed for ISAC by INR Moscow). The final beam energy, for selected ions with a mass:charge ratio of less than 6, is continuously variable at 0.15–1.5 MeV/nucleon.

The higher-energy experimental facilities reflect the emphasis on nuclear astrophysics. A large-acceptance recoil spectrometer system (DRAGON) is being commissioned to study the radiative capture reactions involved in explosive events like novae, supernovae and X- and gamma-ray bursts. To complement it, a large-acceptance scattering facility (TUDA) has been developed to locate resonances of interest in the corresponding compound nuclei.

The programme will focus on proton and alpha radiative-capture reactions in the low-mass (A<30) region. The first scheduled experiment will try to establish the rate for the $^{21}Na(p,\gamma)\,^{22}Mg$ reaction, which determines the production of sodium-22 in nova explosions of O-Ne-Mg-rich white dwarfs. With a 2.6 year half-life and a 1.275 MeV decay gamma ray, sodium-22 is the prime candidate for nova sight-

The ISAC 35-MHz radiofrequency quadrupole linac and its builders.

ings in the next round of satellite-based gamma-ray searches, such as the ESA INTEGRAL mission.

The low-energy beams (up to 60 keV) are used in a broad programme covering fundamental symmetry tests, nuclear structure studies in exotic nuclei and condensed matter studies using light-polarized ions. Precision measurements of pure-Fermi beta-decay lifetimes, branching ratios and Q values (currently under way on rubidium-74) will improve the testing of the weak interaction theory and the determination of up-down quark mixing, while correlation studies in beta decay with trapped atoms (the TRINAT programme with metastable potassium-38 and polarized potassium-37) are placing constraints on extensions of the Standard Model.

A low-temperature nuclear orientation refrigerator (LTNO) for on-line nuclear magnetic resonance and perturbed angular correlation studies, and a large germanium gamma-ray detector array (the former Chalk River 8π spectrometer) are to be used in studies of nuclear deformation in transitional regions (mass band 80–100 and near 180).

Novel facility

A novel facility for beta-NMR (nuclear magnetic resonance) studies of condensed (especially superconducting) materials is being commissioned. Light polarized ions (currently lithium-8) are produced via collinear polarized laser beam excitation, while the spectrometer sits at an adjustable high voltage. The range of the ions can be adjusted so that they stop on the surface of the sample or at a prescribed depth, allowing studies of magnetism on surfaces, in thin layered materials and at interfaces.

With ISAC-I coming into full operation, TRIUMF is now turning to the construction of ISAC-II, funding for which was approved by the Canadian government last year (June 2000 p5) for completion in 2005. This will involve adding a 6.5 MeV/nucleon superconducting linac and a new experimental hall, and will not only increase the ion energies but also allow the mass range to be extended to atomic masses of around 150. This will enable the electrostatic barrier to be overcome for all target nuclei, opening up a range of nuclear structure physics with proton- or neutron-rich projectiles – particularly studies of nuclei near the limits of stability, although a strong focus on nuclear astrophysics will remain.

Paul Schmor *and* **Jean-Michel Poutissou**, *TRIUMF.*

Super Proton Synchrotro

A quarter of a century ago, CERN's gleaming new Super Proton Synchrotron supplied its first proton beams. Although no longer the spearhead of CERN's research programme, the machine has become a vital part of CERN's unique interconnected accelerator network and continues to meet new challenges.

Fig. 1. Satisfaction for project leader John Adams (centre, with tie) and his team in the control room at CERN's Super Proton Synchrotron in June 1976 as the beam reaches its design energy.

Fig. 2. 15 May – one of the new transfer tunnels to s into the tunnel in which the LHC ring will be installec Luciano Maiani, CERN accelerator director Kurt Hül

On the afternoon of 17 June 1976, CERN executive director-general John Adams addressed the CERN governing body, Council. After he had reported on the operation status of CERN's various accelerators, he turned to its newest addition, the Super Proton Synchrotron (SPS), and announced that the machine had just accelerated protons to 300 GeV – the energy specified in the programme previously approved by Council.

With the dignified aplomb that characterizes the making of CERN's major decisions, Adams then politely consulted Council about increasing the energy of the machine to 400 GeV, a possibility that had been formally discussed three years earlier. The motion was duly approved at 1530 h. Five minutes later, as Council continued its formal business, Adams was able to inform the meeting that the SPS had duly delivered 400 GeV protons.

Adams had always had a fine sense of occasion when announcing the successful operation of his new machines. Some 17 years earlier, in November 1959, he had displayed an empty bottle of vodka during his announcement to CERN staff that the Proton Synchrotron (PS) had reached its design energy of 25 GeV. He had been given the full bottle several months earlier on a trip to Dubna in the Soviet Union, with strict instructions that it should be drunk immediately after the PS had surpassed the world record energy of 10 GeV, then held by Dubna's synchrophasotron.

However, the 400 GeV achieved by the SPS on 17 June 1976 was not a world record. In the US, Fermilab's Main Ring, the 6.4 km circumference of which was comparable to that of the SPS, had already been in operation for several years. On 14 May 1976, a matter of days after the SPS had achieved an initial circulating proton beam (with no accelerating radiofrequency power) on 3 May, Fermilab took its protons all the way to 500 GeV. This achievement provided the opportunity to introduce a new energy scale, the teraelectronvolt (TeV), equal to 1000 GeV. The Fermilab Main Ring had become a 0.5 TeV machine.

A proud moment for Europe in June 1976 had, therefore, already been upstaged by Fermilab. CERN had lost the multihundred gigaelectronvolt synchrotron race, and the European community gritted its teeth and prepared for the next round.

On the table this time was Carlo Rubbia's proposal to convert a multihundred GeV synchrotron like Fermilab's Main Ring or CERN's SPS into a proton–antiproton collider. Fermilab left this imaginative proposal where it was, having initially preferred to build a second ring, this time superconducting, to merit the title of Tevatron. In this way Fermilab pioneered a cryogenic route to large proton synchrotrons.

CERN, though, picked up the proton–antiproton collider challenge

n marks its 25th birthday

upply protons from the SPS for CERN's new LHC collider breaks through Left to right – LHC project director Lyn Evans, CERN director-general ner, CERN site engineer Johanna Rammer-Wutte. See cover photo.

Fig. 3. The SPS ring and tunnel.

and resolutely sprinted with it all the way to the finish line. The new CERN proton–antiproton complex provided its first collisions in 1981, and two years later it was the scene of the epic discovery of the W and Z boson carriers of the weak interactions.

Since it was commissioned in 1976, the SPS has learned how to accelerate antiprotons (for the SPS proton–antiproton collider), electrons and positrons (the SPS was the injector for CERN's LEP electron–positron collider) and heavy ions (for a new research programme that began in the mid-1980s). The proton–antiproton collider is no more, and nor is LEP, but the veteran SPS is still having to learn many more new tricks to supply high-intensity proton beams to CERN's LHC collider, which is scheduled to begin operations in 2006. The SPS will also be supplying the particles that will generate the neutrinos to be sent to the Italian Gran Sasso laboratory 730 km away (December 2000 p7). This year, to celebrate its 25th birthday, the SPS is supplying proton beams for a major physics run.

It is a tribute to John Adams and the team that designed and built the SPS that their machine has met all of the challenges of the past 25 years, and will surely continue to do so in the future. The precision of the SPS survey and construction work, the sheer perfection of its magnets, its computer-driven control system and its robust power supplies have all contributed to this success. Foresight has been the key.

In addition, the SPS was CERN's first machine to straddle an international frontier, breaking new ground in diplomacy and administration as well as in science and technology. The SPS supplied (and continues to supply) beams to two distinct experimental areas – one on the main CERN Meyrin site and the other on the Prévessin site, several kilometres away.

A second CERN

The initial proposal had been that the SPS would be built on an entirely new "greenfield" site somewhere else in Europe: a second CERN. Countries vied with one another to host the new machine, and political wrangling delayed a final decision. It took the Solomonic wisdom of John Adams to convince everybody of the advantages of building a new machine next to CERN's existing site and using the Proton Synchrotron as the injector.

The idea was accepted, but the second CERN still went ahead. While the SPS was being constructed in the early 1970s, these two sites were known as CERN I (the original site based on Swiss territory) and CERN II (in France), and each site was run by its own director-general. Despite the obvious advantages of inherited proton infrastructure, grafting a CERN site in France onto one based in Switzerland had called for some imaginative administration. The two sites also looked very different, with the CERN II buildings harmonizing with their verdant surroundings in stark contrast ▷

Champagne and no sandwiches for the SPS

As the midsummer Sun rose over the Alps on 17 June 1976, the team commissioning CERN's new Super Proton Synchrotron began to assemble in the control room. We were going to try, yet again, to push the beam to its design energy.

We had spent several days setting up the extracted 10 GeV beam from the PS synchrotron, guiding it along Bas de Raad's TT10 transport line and through his injection kickers into the ring. In the SPS control room, those responsible for the construction of the SPS hardware systems, Roy Billinge for magnets, Clemens Zettler for radiofrequency and Simon van der Meer for power supplies, would start their components pulsing to follow the heartbeat of injection.

A new kind of control system – a network of Norsk Data minicomputers that was the brainchild of Michael Crowley Milling – would set the tempo, while I, helped by the American Ray Stiening (as I was when we had coaxed Fermilab's Main Ring into life several years before), went through the many tuning processes needed – setting the injection field, correcting the orbit and measuring chromaticity and resonance Q factor – to bring the beam in.

Just before lunch the beam was circulating at full strength, but dying as the radiofrequency captured it and the power supplies for dipoles and quadrupoles were tuned to keep in step and guide the beam through its acceleration cycle. Clearly something was wrong, and project director John Adams began to wonder if some obstruction – even someone's sandwiches – had been left in Bo Angerth's vacuum system. Could it be that Jean Gervaise's impeccable survey had made a millimetric error in the 7 km circumference of this huge monster, crafted out of steel and copper by Hans Horisberger's engineers and installed in the tunnel built by Robert Levy-Mandel?

We had heard another lab director in another place invoke vacuum chamber obstructions to explain beam loss, but we remained convinced that careful measurement of orbit and resonance Q would unlock the secret.

This it did. Just before lunch, a close examination of the behaviour and Q in the first few parabolic giga-electronvolts of the power supply cycle showed that it took a dive to an integer stop band. The "obstacle" was in the software, which matched the quadrupoles to the dipoles. A rapid debate revealed that an obsolete conversion factor for the bus bar shunts had been used. With this corrected, the beam winged its way through transition to 200 and then 300 GeV.

Council was in session as Adams announced that his baby had been delivered. Permission was duly given to increase the machine's energy to 400 GeV, and up it went – a fat trace on the oscilloscope up to and beyond the plateau in the magnet cycle.

Celebrations took place and – typical of the planning that had brought this machine to life on time and on budget – the champagne was found to have been well chilled in advance.

Ted Wilson, CERN.

with the postwar utility concrete of the original CERN site.

In 1975, CERN Council voted to merge the two laboratories, but a vestigial duality was to remain for another five years, with two director-generals heading the laboratory: John Adams as executive director-general of the united laboratory and Leon Van Hove as its research director-general. It was not until 1981 that the larger CERN came under a single director-general, Herwig Schopper.

Preparing for the future

The SPS will be the final pre-injector for the LHC, accelerating 26 GeV protons from the PS to 450 GeV before extraction via two specially built links connecting the SPS and the LHC ring tunnels (figure 2). Many changes to the existing SPS will be necessary before it can deliver the high-brightness proton beams required by the LHC.

To accomplish this, the main hardware modifications and additions will include an upgrade to the existing 200 MHz travelling wave radiofrequency system; the construction of a new extraction channel and modification to the existing ones; upgrades to the beam instrumentation, the transverse damper, the transfer lines, and the injection and extraction kickers; the development of a fast beam scraper; and an upgrade to the internal beam dump. Measures to reduce the impedance will also be taken.

This programme is already well under way, and work last year had to be conducted in such a way that LEP operations were not disturbed. During the past seven-month shutdown, the SPS has received a major facelift. In addition to the work already mentioned, the civil engineering required to connect the new transfer tunnels to the LHC ring tunnel has been carried out and major changes to the infrastructure and services for the machine have been made.

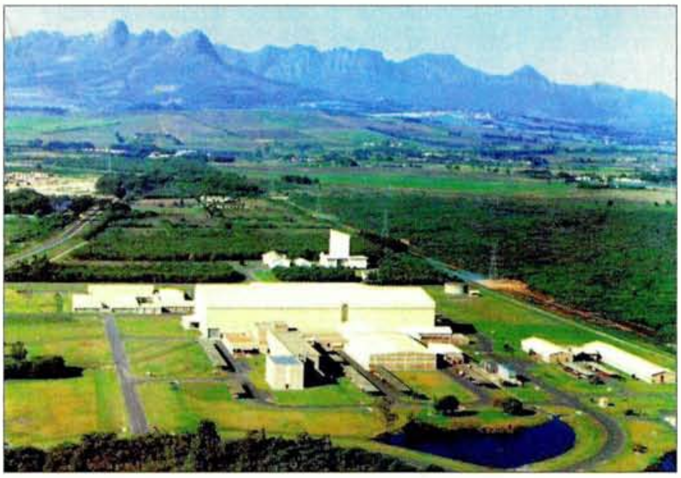
Reducing the impedance of the machine has involved clearing out all of the equipment previously used to provide beams to the LEP and the installation of shields to smooth the transitions in the vacuum chambers around the machine. This last activity alone involved removing and reinstalling half of the main magnets of the machine (some 400 in total) and most of the auxiliary magnets, requiring the displacement of around 8000 tonnes of material.

Work on upgrading the SPS will continue during the next two annual shutdowns, by which time all of the elements will be in place to allow commissioning of the new extraction channel in time for the first LHC injection tests, planned for 2004. One year later, the same extraction channel will be used to send a high-intensity proton beam towards a target for the CERN–Gran Sasso project for long-distance neutrino experiments. From 2006, the SPS will have to deliver a 450 GeV proton beam to the LHC on demand, as well as beams for Gran Sasso neutrinos and for the current experimental areas. During 2007, high-brightness heavy-ion (initially lead) beams for the LHC at 177 GeV per nucleon will be added to its repertoire. Plans for intermediate ions for LHC in later years are already under way.

The future of the SPS is assured for a long time to come. □

First African school for instrumentation

A recent instrumentation school held near Cape Town, South Africa, reflected the increasing worldwide appeal of fundamental physics. The first such school to be held on the African continent, it generated both positive feedback and pointers for new directions.



Left: African setting – the National Accelerator Centre, Faure, near Cape Town, South Africa. The centre's three cyclotrons are in the large building in the centre of the picture. The photograph was taken facing due east, showing the Helderberg peak against the backdrop of the Hottentots-Holland range. Right: learning instrumentation in Africa.

Every two years since 1987 the ICFA Instrumentation Panel, as an activity of the International Committee for Future Accelerators, has organized an international school of instrumentation. The main aim of the school is to promote interest in nuclear instrumentation among graduate students and young researchers from developing countries. ICFA2001, which was held from 25 March to 8 April, was hosted by the National Accelerator Centre in Faure, near Cape Town, South Africa. It was the first such school to be held on the African continent.

ICFA2001 was devoted to the physics and technologies of instrumentation in elementary particle physics, with a slant towards devices and applications that generate and process image-like information from radiation detectors on a quantum-by-quantum basis. The basic research and spin-offs from the application of such instrumentation to high-energy physics, medicine, microbiology and nuclear sciences, as well as research and development for non-destructive testing in industry, attest to the importance of this vital and continuously growing field.

Instrumentation is usually developed in university laboratories with relatively low investment costs, but access to the latest technology is possible by means of co-operative ventures with other institutes, and in particular with large international research centres and industry. Access to instrumentation technology is a key tenet for the ICFA Instrumentation Panel. At ICFA2001, the organizers, speakers and instructors joined with Kobus Lawrie, Naomi Haasbroek and the rest of the National Accelerator Centre staff in an effort not only to provide access to instrumentation technology and stimulate development in experimental particle physics instrumentation, but also to reinforce the "Science for Africa" motto of South Africa's National Accelerator Centre.

As far as content and structure were concerned, the main feature of this school – unique to high-energy physics – was its direct, hands-on approach. Students attended morning lectures, after which there were afternoon laboratory sessions lasting four to six hours. Lecture topics this year were wide-ranging, including introductory courses on the physics of particle detection, gaseous detectors, particle identification, calorimetry, silicon detectors, signal ▷

Geoff Hall (back, of Imperial College, London) with students trying hard to make analogue and digital electronic circuits work.

Members of the silicon microstrip detector laboratory course and some hard-working students. Back, left to right: Paolo Giubellino; Alan Rudge; an ICFA2001 student; Shaun Roe. Front: Alick Macpherson (left) with a group of ICFA2001 students.

processing and data acquisition, as well as several review talks devoted to new technologies, applications in medical physics, molecular biology, astrophysics and data acquisition.

The laboratory classes were state-of-the-art instrumentation sessions, led by researchers in the fields in question from universities and research labs all over the world. In some cases they had simply packed up their current research project and shipped it to South Africa, so that students could get a true taste of what is currently of interest.

Students worked in small groups to carry out selected experimental techniques, using multiwire proportional chambers; drift chambers; silicon detectors; microstrip gas chambers; analogue and digital circuits; and data acquisition. They also worked with specific applications in medical imaging, cosmic rays and protein crystallography.

Satisfied students

A measure of its success is that the anonymous student evaluations that were collected at the end of the school overwhelmingly reflected the enthusiasm and satisfaction of the students. As was the case in previous schools, the students placed a strong emphasis on the importance of the laboratory sessions. The labs provided many students with their first hands-on experience of nuclear instrumentation, and offered those students who were well versed in issues of instrumentation a varied and challenging "playground".

The school also provided a stimulating human experience for its students, some of whom had never attended a scientific meeting abroad, and for whom it was their first excursion outside their home country.

Those involved in running the school also found it rewarding, owing to the energy and enthusiasm that was generated by all who took part. One student even asked if she could skip lunch in order to return to the lab to finish a measurement from the day before. In another instance, Michel Spiro was bombarded with more than 20 questions during his evening public lecture on astrophysics and cosmology. A number of lecturers and instructors are continuing the discussions that they began with students at the school, with a view to potential scientific collaboration.

The decision to hold the school in Africa was made in an attempt to make an impact on young African researchers and postgraduate students who were interested in nuclear instrumentation. Previous workshops had attracted, on average, only one or two African students.

ICFA2001 achieved this goal and was a resounding success. Of the 96 students in the school, 45 were African, and they represented 12 different countries. Not only was the students' level of preparation high, but all brought with them a remarkable enthusiasm for the subject. Many had a clear understanding of the instrumentation needs faced by their home countries, which were, in general, related to applications such as nuclear medicine and ambient protection (as in the case of a student from Sierra Leone who was working on radioactive waste management). Yet it was clear that such pragmatism is balanced by a common sentiment that involvement in basic research might be a way to slow down the "brain drain" from their home countries.

Follow-up programme

To promote "Science for Africa" further, ICFA has launched a new programme this year that provides a follow-up to the school, by means of a number of summer student placements offered by CERN and DESY (and Fermilab is expected to participate next year). Suitable candidates were easily identified among the students of the school, and all studentships have been accepted.

It was also clear that South Africa might be able to act as a catalyst for science, and, in particular, nuclear physics, at a regional level, providing higher education to students from countries such as Kenya, Zambia and Mozambique. African students who distinguished themselves came not only from South Africa (primarily from the National

Accelerator Centre) but also from Kenya, Nigeria and Tanzania.

With "Science for Africa" as its motto, the National Accelerator Centre has made its objectives clear. Indeed, the centre's leading role in African science was apparent throughout the school, as was the significant support given by local scientific authorities.

Small but active

The facilities at the National Accelerator Centre are good, despite the cashflow crisis in the past couple of years that has resulted in a downsizing of its workforce. The centre has overcome that hurdle and has a stable workforce of about 200 staff. Its experimental physics group is small but active and includes several young postgraduates who are working on MScs and PhDs. Significant effort is being made to bridge the age gap and remedy racial disparity.

With these resources the centre carries out several programmes. Its radiation therapy programme includes impressive facilities for neutron and proton therapy with which hundreds of patients have been treated, while its production of isotopes for medical applications brings in additional income for the centre through their sale on both the national and the international markets. The centre also runs a nuclear physics programme, including the use of a spectrometer to study nuclear reactions, and a new state-of-the-art "gamma ball" (Afrodite), which has attracted foreign experimentalists from such laboratories as INFN-Milano, Italy; and another on material science, using a nuclear microprobe on a 6 MV Van de Graaff accelerator.

Activities are based on a large separated sector cyclotron that accelerates protons to energies of 200 MeV, and heavier particles to much higher energies. Two smaller cyclotrons are also used to provide intense beams of light ions, polarized light ions or heavy ions for injection into the large cyclotron. The beam time from the cyclotron is shared equally among the three main programmes, with some beam allocated specifically to the experimental physics community at weekends, when users come in from several South African universities and from abroad.

ICFA2001 was the eighth edition of the school. Previous editions took place at ICTP Trieste, Italy, in 1987, 1989 and 1991; in Rio de Janeiro, Brazil, in 1990; in Bombay, India, in 1993; in Ljubljana, Slovenia, in 1995; in Léon, Guanajuato, Mexico, in 1997; and in Istanbul, Turkey, in 1999.

The ICFA2001 instrumentation school was jointly supported by the National Research Foundation, DACST, ESCAM and NESCA of South Africa, and by CERN, DESY, INFN, ICTP, IN2P3, RAL, DOE and NSF.

More information on the activities of the ICFA Instrumentation Panel, led by A H Walenta, can be found at "http://www.uni-siegen.de/~ag_walen/icfa/". Information on ICFA can be found at "http://www.fnal.gov/directorate/icfa/icfa_home.html".

Paolo Giubellino, *INFN Turin/CERN, and* **Alick Macpherson**, *CERN/Alberta.*

Lasers make light work

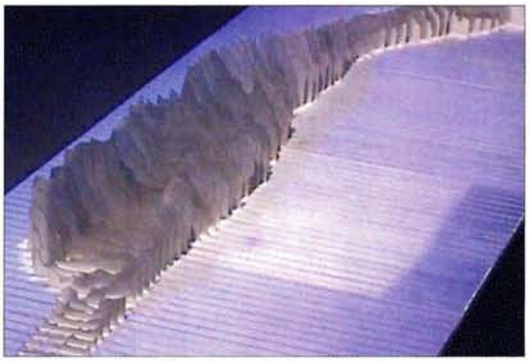
In May *CERN Courier* covered the Signatures of the Invisible art exhibition, which opened in London earlier this year and showcased the results of a collaboration between physicists from CERN and artists from around Europe. In this article, CERN technician *Ian Sexton* describes his encounter with an artist.

When CERN started working in collaboration with the London Institute on the Signatures of the Invisible project, I was nominated to work with UK artist Ken McMullen, who needed me to fabricate a scaled metallic model of his paper creation "Crumpled Theory".

At CERN I make items according to detailed specifications from physicists and engineers. Although the project with Ken was very different, I was surprised to find quite a few parallels between it and my normal work. In both cases time was a constraint, and the goal was the transformation of a requirement or idea into hard reality. However, whereas the pieces I make for CERN have to meet criteria dictated by their functionality, the success of this work was measured by aesthetics and non-functionality.

Light was going to play an important part in the finished work. Ken was going to present the result in the gallery using different lighting effects, which would ultimately determine how it would be perceived. Taking this into consideration, I decided to use lasers during the manufacturing process wherever possible. Lasers are the ultimate sources of light, and their concentrated beams generate intense heat.

Heavy metal – the work on show in London.



Laser art – "Crumpled Theory".

I had some initial discussions with Ken to see whether building this scaled piece of art would actually be feasible. Following this early exploration, I proposed how we could make the piece and, after some fine-tuning, we finalized the fabrication method.

The idea was to represent Ken's "Crumpled Theory" using five baseplates, each mechanically machined with 20 grooves, along with 100 profiled segments, each of which would be fixed into a groove in the appropriate lateral (*x*) position.

The first stage was to scan the crumpled piece of paper. This was done in CERN's metrology department using a helium-neon laser. The surface scans were represented by *x* and *z* co-ordinates. A total of 100 scans were made for every 3 mm of the paper, covering its whole length. These co-ordinates were then manipulated and scaled up by a factor of four in both the *x* and *z* directions, using a specially written computer program.

After we had written the required numerical control programs, the 100 stainless steel segments were laser cut. A high-power Nd:YAG laser burned through the stainless steel using oxygen as an assist gas to increase cutting efficiency. The resulting 100 profiled segments would be laser welded to the five baseplates produced in CERN's mechanical workshops by conventional machining methods.

Once the baseplates had been made, the assembly process could get under way. We made calculations to ensure that each segment was correctly positioned before it was attached. All 100 segments were subjected to the trauma of laser-welding, a violent procedure in which the materials are heated up in a fraction of a second, fuse together and then cool quickly, which causes some localized internal stresses. A series of spot welds gave the effect of the segments being stitched to the baseplate.

The finished piece was simply presented on the workshop floor, with sunlight streaming through the blinds. Ken was at CERN just at the right time to get a glimpse of it before it was shipped to England, and he was delighted. His enthusiasm was a most unusual experience for me. Normally on completion of a job at CERN a perfunctory "thank you" is the only response.

I found the whole project, as well as Ken's reaction on its completion, very rewarding and motivating. Ken's interest in and passion for the project meant that I thoroughly enjoyed the experience of working with him, and our thought-provoking conversations.

Ian Sexton, *CERN*.

CERN is to host the Magnet Technology Conference 2001

The 17th International Conference on Magnet Technology (MT-17) will take place in Geneva, Switzerland, on 24–28 September, and will be hosted by CERN. It will bring together approximately 500 scientists, engineers and experts from all over the world.

The conference will cover major projects and new developments in all aspects of the science, technology and use of magnets, as well as materials and supporting techniques. The programme will focus on topics including magnets for particle accelerators and detectors; fusion; and the generation of high fields, including superconducting, resistive, pulse and permanent magnets. There will be a strong emphasis on magnets for life science and industrial applications, such as magnetic resonance imaging and nuclear magnetic resonance, energy storage, levitation and separation. Sessions will be dedicated to new developments in high- and low-temperature superconductors and other magnet materials for reinforcement, impregnation and insulation.

An industrial and scientific exhibition, displaying products related to magnet technology as well as the achievements and services offered by industries, academia and research laboratories, will be held in conjunction with the conference.

The venue will be the International Conference Centre of Geneva, which is located in the international quarter of the city.

The opportunity to visit CERN and see the superconducting magnets of the Large Hadron Collider and other large experiments now under construction and test will make this conference a privileged meeting forum for all those with an interest in magnets and related technologies.

MT-17 promises to be very successful – about 600 contribution abstracts have been received and all space available for the industrial exhibition has already been booked.

Further information and registration are available at "http://www.cern.ch/MT-17/".

Every March, experimentalists and theorists meet at the Electroweak and QCD Rencontres de Moriond to discuss their latest results. These meetings provide good opportunities for interdisciplinary discussions. The Electroweak meeting takes place in parallel with the astrophysics conference, while the QCD (quantum chromodynamics) meeting runs in tandem with the biology conference. This year, results from the LEP electron–positron collider, together with an exciting visit to extra dimensions, were presented to biologists by Egil Lillestol of CERN and Bergen. Left to right: Jean Tran Thanh Van, director of Rencontres de Moriond; Pierre Sonigo, director of the Biology Rencontres; speaker Egil Lillestol; and Bolek Pietrzyk, member of the QCD Program Committee.

Dikansky celebrates his 60th birthday

From student to rector – distinguished Russian physicist Nikolai Dikansky celebrates his 60th birthday in July.

On 30 July, Nikolai Dikansky, distinguished Russian physicist, corresponding member of the Russian Academy of Sciences and rector of the Novosibirsk State University, celebrates his 60th birthday. He has contributed significantly to the development of the physics of particle colliders and storage rings. His achievements in the general theory of coherent oscillations, nonlinear dynamics, beam–beam instability and beam cooling are well known. In particular, he discovered that the abilities of a system to damp coherent and incoherent oscillations in a bunch are deeply related.

For more than 30 years, Dikansky has been one of the leaders in the study of the electron cooling of heavy particles, which has opened up a new field for particle colliders and storage rings. Results have shown that the physical phenomena responsible for electron cooling are much richer than had initially been expected. Other developments include the theory of coherent fluctuations in the cooled (intense) beams and the physics of supercold beams in storage rings. His great erudition, numerous scientific achievements and openness have always attracted young scientists. He has spent a lot of time teaching physics in Novosibirsk State University, where he has progressed from student to rector.

On 9 May CERN director-general Luciano Maiani was awarded the honorary degree of doctor of science by the Slovak Academy. Receiving the award in Bratislava, the director-general said that Slovak scientists were an active and valuable component of the international high-energy particle physics community. The Slovak Republic is one of the 20 member states of CERN.

Is it art? In the eyes of the judges for the title of Meilleur Ouvrier (best craftsman) de France, it certainly is. For this piece of work, **Didier Lombard** of CERN's manufacturing facilities group was crowned France's top metalworker in a ceremony at the Sorbonne in March. This triennial contest rewards skilled craftsmen in 200 trades, from pastry chefs and painters to lacemakers and goldsmiths. Covering the period from 1997 to 2000, Lombard's award comes hot on the heels of that of Michel Caccioppoli, another CERN metalworker who carried off the prize in 1997, making it two in a row for the laboratory.

MEETINGS

On 9–14 September 2001 the **International Autumn School on the Digital Library and E-publishing for Physics, Astronomy and Mathematics**, a course on digital libraries and e-publishing, will be held at CERN. It has been specially developed for librarians in the fields of physics, astronomy and mathematics. It is being organized by Tilburg University and Ticer B V – renowned for their International Summer School on the Digital Library – in co-operation with the CERN Scientific Information Service and the Los Alamos National Laboratory Research Library. The course director is Rick Luce, research library director at Los Alamos.

The course aims to provide knowledge support to academic libraries, research libraries and publishers in the current transitional phase, and to identify new roles and opportunities. Group discussions and workshops will be included.

Among those taking part will be Martin Blume (American Physical Society), David Dallman (CERN), Hans Geleijnse (European University Institute, Italy), Emanuella Giavarra (Chambers of Mark Watson-Gandy, UK), Gertraud Griepke (Springer-Verlag), André Heck (Strasbourg Astronomical Observatory), Carol Ann Hughes (Questia Media, US), Rick Johnson (The Scholarly Publishing & Academic Resources Coalition, US), Michael Jost (FIZ Karlsruhe), David Kohl (Cincinnati), Rick Luce (Los Alamos), Teun Nijssen and Thomas W Place (Tilburg, NL), Marten Stavenga (Elsevier Science, NL), Herbert Van de Sompel (Cornell) and Jens Vigen (CERN).

A detailed programme, biographies of the lecturers and administrative details are available at "http://cwis.kub.nl/~ticer/autumn01/".

A course brochure can be requested by filling out the form at "http://cwis.kub.nl/~ticer/autumn01/form.htm" or by contacting Mrs Jola Prinsen, Ticer B V, PO Box 4191, 5004 JD Tilburg, The Netherlands; tel. +31 13 4668310; fax +31 13 4668383; e-mail "ticer@kub.nl"; Web "http://www.ticer.nl".

The **International Workshop on Ageing Phenomena in Gaseous Detectors** will be held at DESY, Hamburg, on 2–5 October. Further information is available at "www.desy.de/agingworkshop".

Lattice 2001 – the XIX International Symposium on Lattice Field Theory will be held on 19–24 August at Berlin's Humboldt University. Conference topics include: QCD spectrum and quark masses; hadronic matrix elements; non-zero temperature and density; heavy quark physics; topology and confinement; chiral symmetry; spin and Higgs models, quantum gravity and random surfaces; and algorithms and machines. Further information is available at "www.desy.de/ lattice2001".

Electromagnetic Interactions with Nucleons and Nuclei, a EuroConference on Hadron Production with Electromagnetic Probes, will take place on 2–7 October in Santori, Greece. Part of this year's European

CERN physicist and world-renowned expert on gas jet target techniques, **Louis Dick**, recently celebrated his 80th birthday, and he is still active at CERN. He is seen (centre) in this 1964 photograph with **Charles Peyrou** (left), escorting **Francis Perrin** (right) around the laboratory.

Israel's Health Minister, **Nissim Dahan**, visited CERN on 16 May. At the ATLAS experiment's headquarters are (left to right): CERN coordinator for non-member state affairs **Jim Allaby**; ATLAS spokesman **Peter Jenni** (hidden); chief scientist for Israel's Ministry of Health **Bracha Regev**; Minister Dahan; director-general for Israel's Ministry of Health **Boaz Levy**; CERN director for technology transfer and scientific computing **Hans Hoffmann**; and senior ATLAS physicist **Giora Mikenberg**.

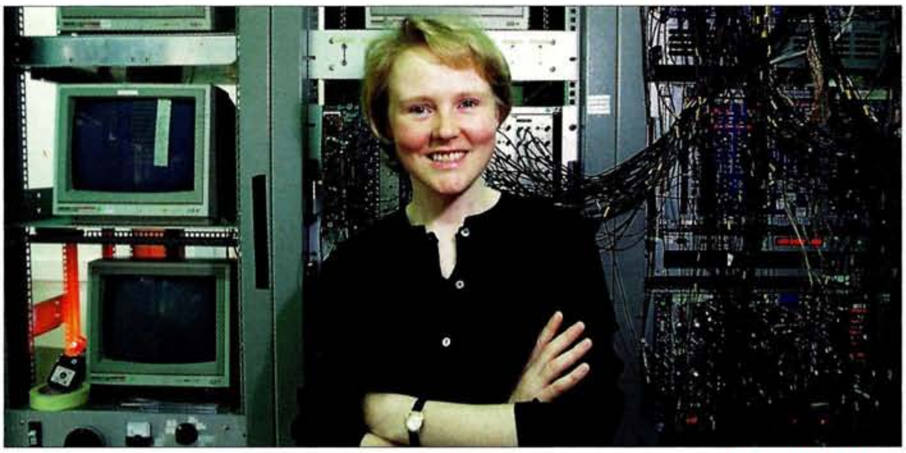
Science Foundation Euresco Conference Programme, it is supported by the European Commission's research director-general.

The ultimate goal of today's hadronic physics with electromagnetic probes (photons, electrons and muons) is to understand the strong interaction between quarks and gluons as described by underlying field theory – quantum chromodynamics – in the transition region where quarks and gluons become "confined" into the observed subnuclear particles. The conference is chaired by Klaus Rith (Erlangen).

Further information is available at "http://www.esf.org/euresco/01/pc01117a.htm".

HEP-MAD'01 is the first of a proposed series of biennial high-energy physics conferences in Madagascar. The main motivation is to promote high-energy physics and, more generally, theoretical physics in this remote part of the world, and to help the establishment of a future Theoretical Physics Institute.

The conference will be held this year on 27 September – 5 October in Antananarivo (the capital) and will alternate with the traditional QCD conference in Montpellier. However, the range of subjects discussed will be wider, touching on all aspects of high-energy physics (theoretical and experimental) and including astrophysics. The conference will include plenary and/or review talks by experts as well as short contributions and/or posters from young physicists. For more information visit "http: //www.lpm.univ-montp2.fr:7082/~qcd/".



Former CERN physicist and editor of *CERN Courier*'s Physicswatch section Alison Wright has moved to *Nature*, where she has an internship working with the News And Views, News and Features teams, handling physical sciences.

Britain's Princess Anne, the Princess Royal, chats with art director Andrew Giaquinto (centre) during a visit to Institute of Physics Publishing, Bristol, where *CERN Courier* is published. Left is IOPP managing director Jerry Cowhig. (Bristol Evening Post.)

After 36 years of sterling service, Helga Schmal left CERN in May. As head of the director-general's office during the tenureship of Willibald Jentschke, Léon Van Hove, Herwig Schopper and, most recently, Luciano Maiani, and in her role as head of the CERN Council secretariat, Helga has played a key role in the organization for many years. Trying to find the words to describe her departure, CERN's legal counsel Jean-Marie Dufour said: "At CERN we are used to seeing things come and go, the arrival and closure of big machines, even the closing of LEP. But not the departure of Helga..." Here Helga is toasted by former CERN director-general Herwig Schopper.

Participants at the recent Workshop on Ion–Aerosol–Cloud Interactions at CERN. The workshop was sponsored by the European Geophysical Society, the European Physical Society and the European Science Foundation, and aimed to review current knowledge of ion–aerosol–cloud interactions and their possible role in solar-climate variability, along with related particle beam studies.

CERN's **Robert Cailliau** (centre) receives the Genève Reconnaissante medal from town mayor and physicist **Alain Vaissade** (left) at a ceremony held on 15 May. On the right is the secretary-general of Geneva's Administrative Council, **Jean Erhardt**.

Geneva has been honouring those who have contributed to the reputation of the city in this way since 1932. This year it selected Tim Berners-Lee and Robert Cailliau for their work on the World Wide Web. Berners-Lee, who was unable to be present, invented the Web at CERN just over a decade ago, and Cailliau was his first collaborator.

This was the first time that the Genève Reconnaissante medal had been presented for a technological development.

Alexander Baldin 1926–2001

The Directorate of the Joint Institute for Nuclear Research (JINR, Dubna, Russian Federation) deeply regrets to announce the death on 29 April, at the age of 75, of the outstanding scientist Alexander Mikhailovich Baldin.

Academician Baldin's many roles within the world of physics included that of scientific leader of the JINR Laboratory of High Energies, member of the Russian Academy of Sciences, professor and laureate of the USSR State and Lenin prizes in the field of science and technology.

He made pioneering and fundamental contributions to the development of the physics of particle electromagnetic interactions and relativistic nuclear physics, as well as to the creation of a new type of accelerator for charged particles and high-energy nuclei based on superconducting technology. His work is internationally recognized and is widely cited by the physics community.

Baldin greatly influenced the activity of the international research centre in Dubna and was an active initiator of scientific activities in JINR member states and in many leading research centres of the world. His demise is an irreplaceable loss for world science.

Alexander Baldin 1926–2001.

Fritz Schmeissner 1915–2001

Fritz Schmeissner died on 12 April, aged 86. He may be considered the father of cryogenic engineering at CERN.

Born on 4 January 1915 in northern Bavaria, he studied physics at Munich, and shortly before the Second World War became assistant to Walther Meissner, one of the pioneers of the phenomenological study of superconductivity. Meissner's authority and the importance of his research work largely protected Schmeissner from military obligations.

After the war he became the head of the newly created Low Temperature Research Centre at Garching/Herrsching near Munich. He was well on the way to a brilliant research career when, in the late 1950s, two physicists from CERN arrived, urging him to join the team that was engaged in the design of a liquid hydrogen bubble chamber for research with the Proton Synchrotron, which was nearing completion. With some hesitation, Schmeissner committed himself for three years, but his leave of absence from his German laboratory doubled, then tripled, and eventually ended with his retirement in 1980 at the age of 65.

Schmeissner's essential achievement, as it concerns CERN, was the integration of cryogenics into both the technical and the physics aspects of the organization's particle physics research programme. This meant on the one hand tempering the ambition of particle physicists by introducing some respect for the thermodynamic and technical constraints of cryogenics, and, on the other, motivating industry to invest in the major research and development projects required by physics. Above all, it meant passing the modest wisdom of first-generation experts – the "old hands" – to young physicists, engineers and technicians who were fascinated by the possibilities and challenges of new, "big" science.


Fritz Schmeissner 1915–2001.

Milestones for Schmeissner were huge bubble chambers and superconducting magnets, gigantic liquid-deuterium beam targets, and a superconducting radiofrequency beam separator cooled by superfluid helium, in many respects technically a precursor of LEP2 and LHC technologies.

The number of cryoplants, cryolaboratories, cryogenic detectors and cryogenic research facilities built at CERN under Schmeissner's authority is impressive, particularly when we consider the state of the art when Schmeissner's career began. We should see the multi-cubic-metre liquid-helium installations of the LHC and its detectors against the backdrop of the days when the Meissner laboratory in Munich was proud of owning a few hundred cubic centimetres of liquid helium.

The initial spirit and outlook of CERN was determined by some strong personalities, and Fritz Schmeissner was certainly one of them. His sharp and critical mind was much appreciated and guaranteed the technical success of every project that he was involved with.

During his long career at CERN he made many friends – among research physicists and engineers, inside and outside CERN, and in industry. Some of them stayed in close contact with him during his years of serious illness and suffering, which were made bearable by his wife Anneliese and his children.

We have all lost a good friend.

Herwig Schopper.

René Morand 1940–2001

Our friend René Morand, a remarkable French physicist and a dynamic personality in particle physics, died on 20 April at the age of 61.

He began his career in 1968 with Pierre Lehmann at the Orsay linear accelerator laboratory, where he studied the photoproduction of π^0 and the elastic scattering of $\pi^\pm$, $K^\pm$ and p. From 1971 he worked with Michel Croissiaux at the Nuclear Research Centre, Strasbourg, and took part in the creation of a high-energy experimental physics group that collaborated in the search for new particles at CERN's ISR.

From 1973 to 1983, Morand concentrated on the physics of hyperons, first at the CERN PS and then at the SPS, before going on to the study of high-mass muon pairs from intense pion beams.


René Morand 1940–2001.

At the beginning of the 1980s, he switched to physics at electron–positron colliders, and in 1983 joined the Annecy-le-Vieux laboratory of particle physics, led by Michel Vivargent, where he made important contributions to the construction of an electromagnetic calorimeter for the L3 experiment. A tireless builder, his quest for a deeper understanding of the universe led him to the study of gravitational waves in 1993. He played a major role in the planning and development of the towers housing the optics for the interferometer of the Virgo experiment. From 1997 to 2000 he also served as technical director of LAPP. He left us before the commissioning of Virgo, where his experience and talents would have been of invaluable service. In losing René, his colleagues have also lost a friend.

Jean-Jacques Blaising, LAPP, Annecy.

Laser equipment: Raptelle optical spectrum analysers are optimized for DWDM control

Shoebox-sized- the Raptelle optical spectrum analyser from Multichannel Instruments of Stockholm.

Multichannel Instruments of Stockholm has announced a new line of products that have been optimized for the control of dense wavelength division multiplex (DWDM) components, especially tunable lasers. The heart of the product – the Raptelle – is a new type of optical spectrum analyser based on a patent pending optical design. So far, two models are available: the Raptelle 10000, which covers the 1000–1650 nm range, and the Raptelle 20000, which covers the 1500–1650 nm range at higher resolution.

Inside each Raptelle, division into segments is provided inherently by the optics in such a way that its more than 30 segments appear to be underneath one another on a two-dimensional InGaAs sensor. The camera, measuring 320 × 256 pixels, records all of the segments in parallel. Each segment represents a subspectrum of the spectral range. The software joins the segments together, resulting in more than 5000 simultaneously recorded channels covering the full spectral range. Consequently, there are no moving parts in the system.

The camera can operate at a frame rate of more that 100 per second. At a rate of 50 per second the system acquires, to a high level of precision, all of the data that is necessary for DWDM component calibration. This provides the manufacturer with the means to make an immediate increase in the rate of production of tunable lasers and other DWDM components, with assured quality control.

More information is available from Multichannel Instruments AB, Pilotgatan 2, S-12832 Skarpnäck (Stockholm), Sweden; tel. +46 8 605 70 90; fax +46 8 605 71 01; e-mail "info@multichannel.se"; Web "http://www.multichannel.se/".

Compact photomultipliers: a faster and more reliable photomultiplier designed for large experiments

Major particle physics experiments, as well as gamma-ray telescopes, need fast photomultipliers that can operate for years and withstand considerable doses of radiation. Electron Tubes offers a new range of compact 25 and 30 mm photomultipliers that have a long lifetime and stable gain characteristics designed specifically for this environment.

The new photomultipliers have a gain capability that ranges from 10^4 to 10^7, to cover a variety of applications from those involving high light levels down to photon counting.

All are available with quartz- or ultraviolet-transmitting glass windows that can withstand high dose rates.

More information is available from Electron Tubes Ltd, Bury Street, Ruislip, Middlesex HA4 7TA; tel. 44 (0)1895 630771; fax 44 (0)1895 635953; Web "http://www.electrontubes.com".

Correction

In the photograph of CERN's 1961 "g-2" experiment (April p4), the person seen on the far right is Théo Muller, not Francis Müller as the caption stated.

Apparently, when the picture was originally published 40 years ago the same error was made, which we regret.

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 centimetre: mono £36, single colour £38, full colour £40. Please contact us for more information on publication dates and deadlines.

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

LABORATOIRE EUROPÉEN POUR LA PHYSIQUE DES PARTICULES
EUROPEAN LABORATORY FOR PARTICLE PHYSICS

The Theoretical Physics Division invites applications for an indefinite appointment as

THEORETICAL PHYSICIST

The appointment would be in theoretical particle physics or in a related area of field theory, cosmology or astroparticle physics.

Candidates are expected to have an excellent record of successful work in these areas with demonstrated scientific originality, good leadership qualities and the potential to contribute significantly to the scientific profile of the Division in the years to come.

Expressions of interest from highly qualified theoretical physicists are welcome, and should be addressed to the Division Leader, Guido Altarelli, (guido.altarelli@cern.ch), before Sept. 1st, 2001.

For additional information see http://wwwth.cern.ch/

CERN is an equal opportunity employer and encourages both men and women with the relevant qualifications to apply.

Preference will be given to nationals of CERN Member States: AT, BE, BG, CH, CZ, DE, DK, ES, FI, FR, GR, HU, IT, NL, NO, PL, PT, SE, SK, UK

DESY

DESY announces several

"DESY Fellowships"

for young scientists in experimental particle physics to participate in the research mainly with the HERA collider experiments H1 and ZEUS or with the fixed target experiments HERA-B and HERMES. New fellows are selected twice a year in April and October.

DESY fellowships in experimental particle physics are awarded for a duration of two years with the possibility for prolongation by one additional year.

The salary for the fellowship is determined according to tariffs applicable for public service work (BAT IIa).

Interested persons, who have recently completed their Ph. D. and who should be younger than 32 years are invited to send their application including a resume and the usual documents (curriculum vitae, list of publications, copies of university degrees) until September 30, 2001 to

DESY
Personalabteilung -V2-
Notkestraße 85, D- 22607 Hamburg, www.desy.de

They should also arrange for three letters of reference to be sent until the same date to the address given above.

Handicapped applicants with equal qualifications will be prefered. DESY encourages especially women to apply.

As DESY has laboratories at two sites in Hamburg and in Zeuthen near Berlin, applicants may indicate at which location they would prefer to work. The salary in Zeuthen is determined according to IIa, BAT-O.

LIP

LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS

RESEARCH ASSOCIATE IN EXPERIMENTAL PARTICLE PHYSICS

Applications are invited for a Research Associate position at LIP-Lisbon to work in the CMS experiment at CERN.

The successful applicant will participate in the LIP activities in the CMS Electromagnetic Calorimeter Trigger and Data Acquisition. The work will involve the development of control software, the test of hardware prototypes and the development of electron and photon reconstruction algorithms.

The successful applicant will be based in the Geneva area integrating a LIP team of physicists and engineers on the CERN site.

Applicants should have a PhD in particle physics and expertise in modern software techniques. The position is for a duration of three years, with a possible extension of three years, and is available from July 2001. A later starting date is possible.

Applications, comprising a curriculum vitae, a list of publications and three letters of reference, should be sent to Joao Varela, CERN/EP, 1211 Geneva 23.

Further information can be requested from joao.varela@cern.ch or obtained at the LIP web site http://www.lip.pt

---

UNIVERSITY OF CAMBRIDGE
Department of Physics

Research Associate in Experimental Particle Physics

Applications are invited from experimental particle physicists (post-doctoral, or about to complete a PhD) for a research associate position in the Cambridge group to work on ATLAS; the construction of the Semiconductor Tracker and physics preparation.The post is available from 1st September 2001 and is funded by PPARC for three years initially, with starting salary in the range £16,775-£25,213 pa (under review).

Further information can be obtained from Dr Janet Carter (jrc1@hep.phy.cam.ac.uk), Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE, UK, to whom applications, including a CV and the names and addresses of three referees, should be sent by 3rd August 2001.

The University is committed to equality of opportunity

DATAGRID - THE NEXT STEP

Particle Physics Grid Team Located In Oxfordshire - Fixed Term Posts

PPARC and the Particle Physics Department at CLRC are jointly seeking people to work in the next major development of Internet technology. The Grid is an emerging fast growing area of distributed computing which aims to provide transparent access to world wide computing and data resources. UK Particle Physics is involved in national, European and US Grid initiatives to provide the computing infrastructure for its next generation of experiments. A small number of vacancies exist which will be based at Rutherford Appleton Laboratory, Chilton Oxfordshire (RAL), to participate in technical Grid developments as part of the recently approved EU DataGrid project. The posts are fixed-term, being funded to the end of the 3 - year project.

The posts are in a number of areas:-

- development of services for monitoring the Grid environment and for assessing application performance;
- integration of various mass storage sub-systems into the Grid;
- integration of existing and new particle physics applications into the Grid environment (requiring previous particle physics computing experience, a PhD is also desirable).

The successful candidates will be part of the particle physics grid team and will be fully involved in the technical aspects of building the Grid for particle physics in collaboration with the UK and international communities.

Applicants for these posts should be in possession of a science or mathematics degree and have C programming expertise in a Unix environment. Previous experience in some of the following: Linux/C++/Java/Databases/LDAP/TCP-IP/ Network Protocols/Client Server would be an advantage.

The salary range is between £18,000 & £31,250. Salary on appointment is dependent upon relevant experience. There is an on site nursery at RAL. For further details about the posts, please contact Dr. R.Middleton, telephone +44 (0)1235 446348, Fax +44 (0)1235 44 6733 or e-mail R.P.Middleton@rl.ac.uk

Application forms can be obtained from: Operations Group, HR Division, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX. Telephone (01235) 445435 (answerphone) or email recruit@rl.ac.uk quoting reference VN2041R/01. More information about PPARC is available at http://www.pparc.ac.uk/ and about CLRC at http://www.cclrc.ac.uk

All applications must be returned by 16th July 2001.

PPARC and CCLRC are committed to Equal Opportunities and are a recognised Investors In People. A no smoking policy is in operation.

INVESTOR IN PEOPLE

CLRC

COUNCIL FOR THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS

PSI PAUL SCHERRER INSTITUT

research for the future

Experimental Physicist
Proton Therapy

Since 1997, PSI is operating a novel proton therapy facility for cancer treatments, using a dynamic beam delivery technique applied on a very compact proton gantry. The positive experience with the present system at PSI is now bringing a further expansion of the facility, with the installation of a dedicated medical accelerator and of a new, second generation, proton gantry.

Your tasks

You assist the project leader on developments for the 2nd gantry, i.e. computational work during the conceptual design, followed by the preparation and the experimental work with the beam during commissioning.

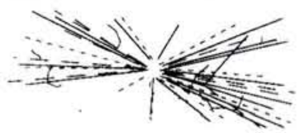
Your profile

You have recently graduated (PhD) in physics and have some practical experience in working with particle beams in an accelerator environment. The requirements include programming skills for the simulation work of the new advanced beam scanning methods and for the analysis of the experimental results. Furthermore, you are a good team player and have a good knowledge in English and German.

For more information please contact Dr. E. Pedroni, tel. +41 56 310 35 18, email eros.pedroni@psi.ch.

Please send your application to: PAUL SCHERRER INSTITUT, Human Resources, ref.code 2100-03, CH-5232 Villigen PSI, Switzerland.

Further job opportunities: www.psi.ch



Inter-University Institute for High Energies

Brussels-Belgium

ESEARCH ASSOCIATE IN EXPERIMENTAL PARTICLE PHYSICS

Applications are invited for a Research Associate position at the Inter-University Institute for High Energy Physics to work in the CMS experiment.

The successful applicant will play a pivotal role in the construction of the silicon tracker and the development of the trigger for the CMS experiment at LHC. He or she will be based in Brussels and will make frequent trips to CERN.

Applicants should have a PhD in particle physics. The position is for renewable periods of one year starting from 1st of September 2001.

Applications, comprising a curriculum vitae with a list of publications should be sent to:

Prof. S. Tavernier, Vrije Universiteit Brussel,
Faculteit Wetenschappen, Pleinlaan, 2 – 1050 Brussels.

Further information can be requested from

Prof. S. Tavernier (tavernier@hep.iihe.ac.be,
Tel. +32 2 629 3218) or
Prof. W. Van Doninck (walter.vandoninck@cern.ch,
Tel. in CERN : +41 22 7671539).

Visiting Faculty Position - Theoretical Astrophysics/Astroparticle Physics

NTNU, Trondheim, Norway

We are accepting immediate applications for a position at the level of a professorship or assistant professorship for the 2001/2002 Academic Year beginning in August 2001, with a possible prolongation for at least one year. The person to be hired is expected to take part in the teaching of astrophysics at both graduate and undergraduate levels.

Interested applicants should contact either
the Head of the Department, **Prof. S. Raaen** (email: **steinar.raaen@phys.ntnu.no**) or
the leader of the Section for Theoretical Physics, **Prof. B.-S. Skagerstam** (email:**boskag@phys.ntnu.no**).

(http://www.phys.ntnu.no/index-e.html)

NEED TO RECRUIT?

Call Debra Wills on +44 (0)117 930 1196

POSTDOCTORAL POSITIONS IN EXPERIMENTAL PARTICLE PHYSICS

Stanford University

The Stanford University experimental particle physics groups on the BaBar and MINOS experiments invite applications for two Postdoctoral Research Associate positions.

The BaBar experiment is currently recording data at the PEP-II B Factory at the Stanford Linear Accelerator Center (SLAC) for the study of CP violation in the B meson system, as well as precision measurements and searches for rare decays of bottom, charm and tau particles. The Stanford University group has made contributions to the Silicon Vertex Tracker, including data acquisition, detector. monitoring and control, and the radiation monitoring and protection system. The successful candidate will have opportunities to contribute in these areas, including possible upgrades, and in the analysis of the large and growing data set. The Stanford University group on BaBar enjoys a position of close geographical proximity to SLAC yet is housed in an academic environment.

The MINOS experiment is a long-baseline neutrino oscillation experiment that will utilize a neutrino beam produced by protons extracted from the Fermilab Main Injector, a recently constructed 120 GeV proton synchrotron. The MINOS detector will be a multi-kiloton magnetic iron/scintillator spectrometer in the Soudan mine in Minnesota, 730 km away. The installation of the detector in the newly excavated cavern in the Soudan mine will start in the summer of 2001 and data will be recorded starting in 2004. The majority of the successful applicant's time will be spent in residence at Stanford, working on simulations and design of the MINOS detectors and neutrino beam elements and later, on physics analysis. It is expected that the successful applicant will spend some time at Soudan and/or Fermilab during the installation and commissioning phase of the experiment. The initial appointment will be for three years with the possibility of an extension.

Candidates must have a Ph.D. in experimental particle physics. The positions are available starting September 1, 2001. Applications are being considered now and until the positions are filled.

Interested applicants should send a curriculum vitae, list of publications, and a description of research interests and skills, and arrange for three letters of recommendation to be sent to the following address:

Professor Patricia Burchat (for the BaBar experiment) or
Professor Stanley Wojcicki (for the MINOS experiment),
Department of Physics, Stanford University, Stanford CA 94305-4060.

Stanford University is an equal opportunity employer.
We especially encourage applications from women and minority scientists.

DEPARTMENT OF PHYSICS AND ASTRONOMY

Lecturer in Experimental Particle Physics

UNIVERSITY of GLASGOW

£18,731 - £30,967

You will work in the Experimental Particle Physics Group on the LHCb experiment, and should have relevant postdoctoral experience. An interest in detector development is an advantage. You will participate fully in the research, teaching and administration of the Department.

Informal enquiries to Prof. D H Saxon (d.saxon@physics.gla.ac.uk).

For an application pack please see our website at www.gla.ac.uk or write quoting Ref 257/01AV/CC to the Recruitment Section, Human Resources Department, University of Glasgow, Glasgow G12 8QQ. Closing date: 25 July 2001.

The University is committed to equality of opportunity in employment.

University of Basel

Professorship in Computational Physics

The Department of Physics and Astronomy announces an opening for a tenure-track assistant professorship or associate professorship (in exceptional cases an appointment on a higher level is possible). The Department focuses on two fields of research: astro-particle physics (astronomy/cosmology, computational astrophysics, nuclear and particle physics) and condensed matter (nanosciences, mesoscopic physics, quantum computing, biophysics). More information can be found at www.physik.unibas.ch.

We look for qualified Computational Physicists with broad research activities related to either or both of these fields, who are also interested to participate in the program computational sciences (jointly organized with biology, chemistry, computer sciences, mathematics). Qualified women are especially invited to apply.

Applicants should provide evidence for significant research accomplishments and potential and are expected to take part in teaching activities of the Department of Physics and Astronomy and of the joint Computational Sciences Program. Please submit a curriculum vitae, list of publications, research plan and names of three references until 20 August to: Prof. Andreas Zuberbühler, Dekan der Phil.-Naturw. Fakultät, Klingelbergstrasse 50, CH-4056 Basel, Switzerland.

UNI BASEL

MIT

POSTDOCTORAL ASSOCIATE

The Relativistic Heavy-Ion Group at the MIT Laboratory of Nuclear Science invites applications for a postdoctoral research position. Our group is heavily involved in the operation and analysis of the PHOBOS experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. Our future plans also include studies of heavy-ion collisions at the CERN Large Hadron Collider currently under construction.

PHOBOS had its first successful physics run in 2000 and will continue systematic studies of strongly interacting matter under extreme conditions in the upcoming RHIC run periods. The successful candidate is expected to play a major role in the physics analysis of the experiment, the design and implementation of possible PHOBOS upgrades, and the preparation for future experiments. In particular, we are developing innovative analysis and computing techniques to deal with the very high statistics datasets that will be collected by PHOBOS and future heavy-ion experiments.

Applicants should have a Ph.D. and a strong experimental background in Nuclear Physics or High Energy Physics. Experience with object-oriented software or the operation and analysis of Si-based detectors would be helpful.

Interested candidates should submit a curriculum vitae and arrange for three letters of reference to be sent to: **Prof. Gunther Roland, Laboratory of Nuclear Science, Massachusetts Institute of Technology, Room 24-504, Cambridge, MA 02139, USA; E-mail: Gunther.Roland@cern.ch.**

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

UNIVERSITY OF TORONTO

Department of Physics

TENURE TRACK FACULTY POSITION in EXPERIMENTAL PARTICLE PHYSICS

VELUT ARBOR ÆVO

The Department of Physics at the University of Toronto plans to make a tenure stream appointment in experimental particle physics at the rank of Assistant or Associate Professor, with starting date of 1 July 2002.

The University has a strong experimental particle physics program, playing leading roles in the ATLAS experiment at CERN, the ZEUS experiment at DESY and the CDF II experiment at Fermilab. This is reinforced by a strong effort in theoretical particle physics and astrophysics. We invite prospective candidates to visit our home page at www.physics.utoronto.ca. Through the joint support of the TRIUMF laboratory and the University of Toronto, this appointment will allow the successful candidate to focus on developing a successful research program.

For this position, we seek candidates with a Ph.D. in physics and strong proven or potential excellence in both research and teaching. The salary will be commensurate with qualifications and experience. Applicants should submit a curriculum vitae, list of publications, research plan, and arrange for at least three letters of reference, to be sent to:

Professor Henry M. van Driel, Chair
Department of Physics
University of Toronto
Toronto, Ontario, Canada M5S 1A7

Applications will be reviewed beginning October 1, 2001 until the position is filled.

The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, and others who may contribute to further diversification of ideas.

CERN COURIER RECRUITMENT BOOKING DEADLINE

September issue: 10 August

Reach a global audience with *CERN Courier* Internet options. Recruitment advertisements are on the Web within 24 hours of booking and then also sent to e-mail subscribers.

Contact Debra Wills:

Tel. +44 (0)117 930 1196
Fax +44 (0)117 930 1178
E-mail debra.wills@iop.org

cerncourier.com

INTERNATIONAL UNIVERSITY IN GENEVA — IU

Undergraduate, Adult Accelerated and Graduate Programs in:

- **Business Administration** (BBA, MBA, EMBA)
- **Communication and Media** (BA, MA)
- **Telecommunication** (MBAT)

INTERNATIONAL UNIVERSITY IN GENEVA

ICC, Rte de Pré-Bois 20 • 1215 GENEVA 15, Switzerland
Tel.: (+41+22) 710 71 10/12 • Fax: (+41+22) 710 71 11
Email: info@iun.ch • Website: www.iun.ch

Accredited by IACBE, USA

success starts with a good education

Spallation Neutron Source Project

The Spallation Neutron Source Project (SNS) at Oak Ridge National Laboratory invites applications for various positions in the Accelerator Systems Division. The US Department of Energy's (DOE) Office of Science has funded the design and construction of the SNS, which will provide the world's most powerful pulsed spallation source for neutron scattering research. The SNS is a partnership between six DOE laboratories: Argonne, Brookhaven, Lawrence Berkeley, Thomas Jefferson, Los Alamos and Oak Ridge. The SNS will be based on a high-intensity front end, providing a chopped H^- beam, a 1-GeV pulsed normal conducting followed by super-conducting RF linac, a 248-m-circumference accumulator ring, a liquid mercury target and a suite of best-in-class scientific instruments. Design and construction is underway and the project is scheduled for completion in 2006.

Staff positions are available for:

Physicists
Senior Ring Team Leader, Senior Linac Team Leader

Operations
Operations Deputy Manager, Operations Coordinator, Chief Operators

Software and Programming
Beam Physics Applications, EPICS Controls System

Mechanical Engineers
Front End, Warm Linac, Cold Linac, Cryogenics, Vacuum, Diagnostics

Electrical Engineers
Low-Level RF, High-Power RF, Power Supply, Pulsed Power, Diagnostics, Controls System

Technicians
Low-Level RF, High-Power RF, Mechanical, Vacuum, Power Supply, Pulsed Power, Ion Source, Diagnostics, Controls System

For more complete descriptions, visit our Web site at: www.sns.gov

Qualified and interested candidates should send a resume, with a list of three references, to: M.J. Fultz, Spallation Neutron Source Project, 701 Scarboro Road, MS-6477, Oak Ridge, TN 37830; e-mail: fultzmj@sns.gov. Please reference the job title when applying. Applications will be accepted until the positions are filled.

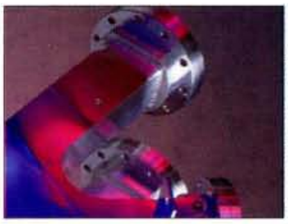
ORNL, a multiprogram research facility managed by UT-Battelle, LLC, for the US Department of Energy, is an equal opportunity employer committed to building and maintaining a diverse workforce.

SNS SPALLATION NEUTRON SOURCE

INDEX TO DISPLAY ADVERTISERS

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

FREE LITERATURE



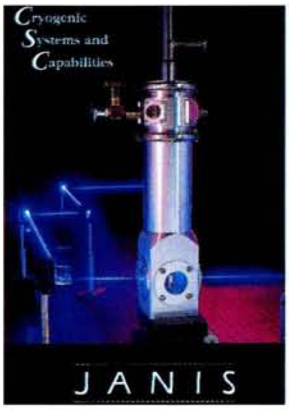
Atlas Technologies

Aluminum UHV Chamber & Components... Metal Sealed

Aluminum vacuum chambers can now be metal sealed with standard CF copper gaskets and hardware. The Atlas flange is an aluminum flange body with a 6-8mm thick stainless sealing face for robust and reliable knife-edge sealing. When you need to build UHV aluminum vacuum chambers, use the Atlas flange.

Proven at major accelerators and synchrotron facilities worldwide, Atlas Technologies supply flanges and components and fabricate custom aluminum chambers for accelerators and beam lines.

Atlas Technologies
305-B Glen Cove Road, Port Townsend, WA 98368 USA
Tel. +1 360 385 3123
Fax +1 360 379 5220
Email atlas@olympus.net
Web www.atlasbimetal.com

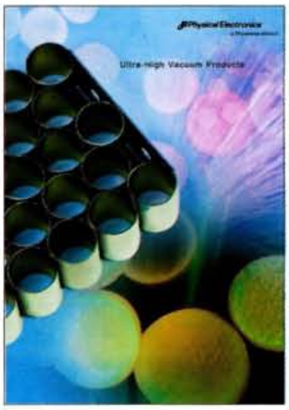


Janis Research Co Inc

Laboratory Cryogenics

The Janis Research family of laboratory cryogenic products includes variable temperature liquid nitrogen and liquid helium cryostats, continuous flow systems, and closed cycle refrigerator systems. When standard systems and existing designs do not meet your requirements, Janis Research can design and build a customized system to your exact specifications.

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



Physical Electronics

The Ultra High Vacuum Technologies Group offers ion pumps and other ultrahigh vacuum (UHV) pumping products. We design and manufacture our own UHV products based on the special considerations UHV applications require. Our applications need stable and reliable UHV; so do yours. Ion pumping technologies continue to be the most dependable and economical methods for creating UHV environments in high-energy physics, instrumentation and processing applications. Entrust your UHV system to the UHV experts.

Physical Electronics, UHV Technologies Group
6509 Flying Cloud Drive, Eden Prairie, MN 55344
Toll free: 800 237 3603
Tel. +1 952 828 6100; Fax: +1 952 828 6322
Email vacuum@phi.com
Web www.phi.com

SARL SMO-MET

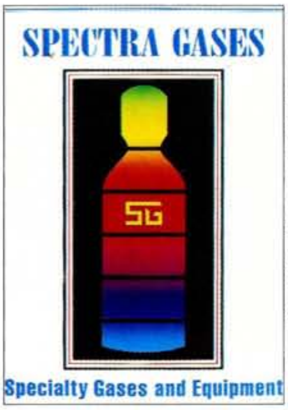
Expertise: the manufacture of made-to-measure coaxial, electrical and mixed connections

All of our connections are delivered with a certificate of conformity to standards.

We will fulfill all of your orders, even orders for a single item.

Please do not hesitate to get in touch – we will reply promptly.

SARL SMO-MET
ZA Porte des Chambaran 38980
Viriville France (Isére)
Tel. +33 474 541 305
Fax +33 474 541 437
Email smo-met@wanadoo.fr



Stable Isotopic and Rare Gases

Helium-3, Xenon-129, Oxygen-18, Xenon, Krypton, Neon, Deuterium, Excimer Laser Gases, VOC Gas Standards, EPA Protocol Gas Standards and other speciality gases and gas mixtures are manufactured and distributed daily by Spectra Gases around the world.

Please contact us at:
Spectra Gases GmbH @ Germany
Tel. +49 (0) 6073 620021
Spectra Gases @ United Kingdom
Tel. +44 (01480) 436 961
Spectra Gases @ USA
Tel. +1 (800) 932 0624
Fax +1 (908) 252 0811
Internet www.spectra-gases.com

VAT Vacuum Valves 2000 Catalogue

From the World's Largest Supplier of Vacuum Valves

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

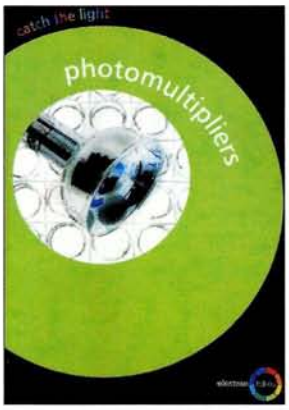
VAT Vacuum Products Ltd
235 Regents Park Road, Finchley, London N3 3LG, UK
Tel. +44 (0)208 3461999
Fax +44 (0)208 3431104
Email uk@vatvalve.com

Goodfellow

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

70 pure metals, 200 alloys, 57 polymers, 31 ceramics as well as many composites and compounds in 28 forms including foil, rod, tube, wire, powder, etc. The new product guide is now available, detailing standard ex-stock and custom-made items.

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



Electron Tubes

A new photomultiplier brochure. At last, a clear, easy to use brochure to help you choose the right photomultiplier.

With a step-by-step selection guide plus a colour-coded data section, choosing your photomultiplier has never been more straightforward!

Electron Tubes Ltd. UK
Tel. +44 (0)1895 630771
Email info@electron-tubes.co.uk

Electron Tubes Inc. USA
Tel. (973) 586 9594
Toll free (800) 521 8382
Email sales@electrontubes.com
Web www.electrontubes.com

FREE LITERATURE

Cheesecote Mountain CAMAC

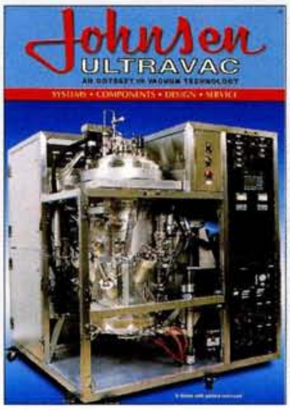
Using FERA? Worried?

CMCAMAC is developing a new FERA compatible driver/memory/histogrammer module. First deliveries are expected this autumn. This module can replace the 4301, 4301/4302, and 4301/histogrammer combinations. The memory readout is FASTCAMAC, of course.

Our CAMAC product line is growing. From left to right, the charge ADC, a delay box (2 channels, 31.5 ns in 0.5 ns steps), an ECL fanout (36 high-speed ECL outputs) and a TDC/scaler (16 channels of deadtimeless TDC and 32 scalers). Several more are in the planning stage.

Details are available on the Internet. Call or write for printed data sheets.

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



Johnsen Ultravac

Johnsen Ultravac specializes in the design and manufacture of ultrahigh vacuum products including 6-axis instruments with heating/cooling stages, 1500 K to 10 K range, UHV chambers, ultralong translators, surface analysis systems, multi-technique deposition systems and a complete range of beamline components for synchrotrons such as photon/safety shutters, collimators and mask assemblies.

3470 Mainway, Burlington
Ontario, Canada L7M 1A8
Toll free: 800 268 4980
Tel. 905 335 7022
Fax 905 335 3506
Email juvinfo@ultrahivac.com
Web www.ultrahivac.com

Physics World

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

For further details, please contact our marketing department at:

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

Kimball Physics Inc

ELECTRON AND ION OPTICS, UHV COMPONENTS

UHV electron and ion sources/systems: beam energies 5eV to 100keV.
System options: energy sweeping, rastering, fast pulsing, emission current control.
UHV components: multi-CF fittings, vacuum chambers, Faraday cups, eV parts.
Applications: surface physics, vacuum physics, charge neutralization, cathodoluminescence, phosphor testing, RHEED, ESD semiconductor processing, custom designs.
See the catalogue online at www.kimphys.com

Kimball Physics Inc
311 Kimball Hill Road, Wilton, NH 03086, USA
Tel. +1 603 878 1616
Fax +1 603 878 700
Email info@kimphys.com
Web www.kimphys.com


FLAT PANEL
PMT
GET A PEAK
AT THE 21ST CENTURY!
The future of optical sensing starts here!
The Flat Panel PMT from Hamamatsu.
HAMAMATSU PHOTONICS K.K., Electron Tube Center http: //www.hamamatsu. com
314-5 Shimokanzo, Toyooka-village, Iwata-gun, Shizuoka-ken, 438-0193 Japan. TEL:81-539-62-5248 FAX:81-539-62-2205
HAMAMATSU
United Kingdom:Hamamatsu Photonics UK Limited. TEL:(44)208-367-3560 FAX:(44)208-367-6384
North Europe: Hamamatsu Photonics Norden AB. TEL:(46)8-509-031-00 FAX:(46)8-509-031-01
Italy: Hamamatsu Photonics Italia S.R.L. TEL:(39) 02-935 81 733 FAX:(39) 02-935 81 741
U.S.A.: Hamamatsu Corporation. TEL:(1)908-231-0960 FAX:(1)908-231-1218
Germany: Hamamatsu Photonics Deutschland GmbH. TEL:(49)8152-3750 FAX:(49)8152-2658
France: Hamamatsu Photonics France S.A.R.L. TEL:(33) 1 69 53 71 00 FAX:(33) 1 69 53 71 10
Switzerland: CERN Liaison Office TEL:(41)31/879 70 70 FAX:(41)31/879 18 74