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CERN COURIER

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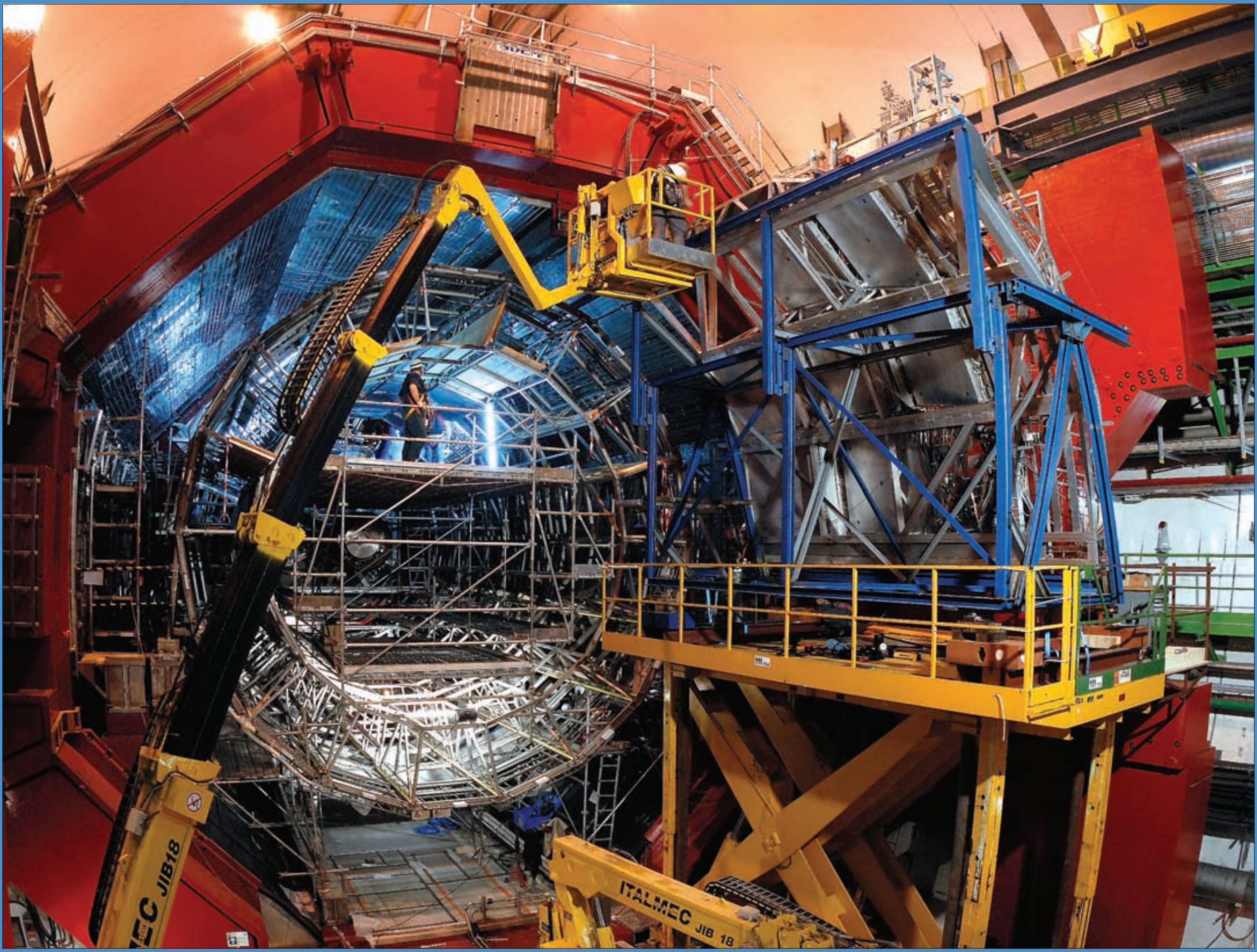

ALICE gets set for heavy ions

NEW PARTICLES
CDF discovers baryons
with b quarks p9

HADRON THERAPY
Accelerators take up
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CONFERENCES
ICHEP'06 brings the
world to Moscow p21


Image courtesy Stanford Linear Accelerator Center)

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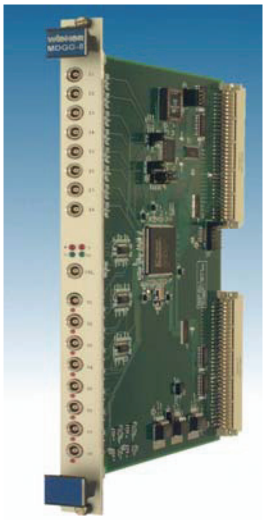

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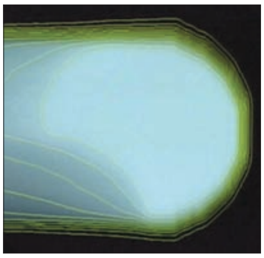
Cancer therapy gets a boost p5

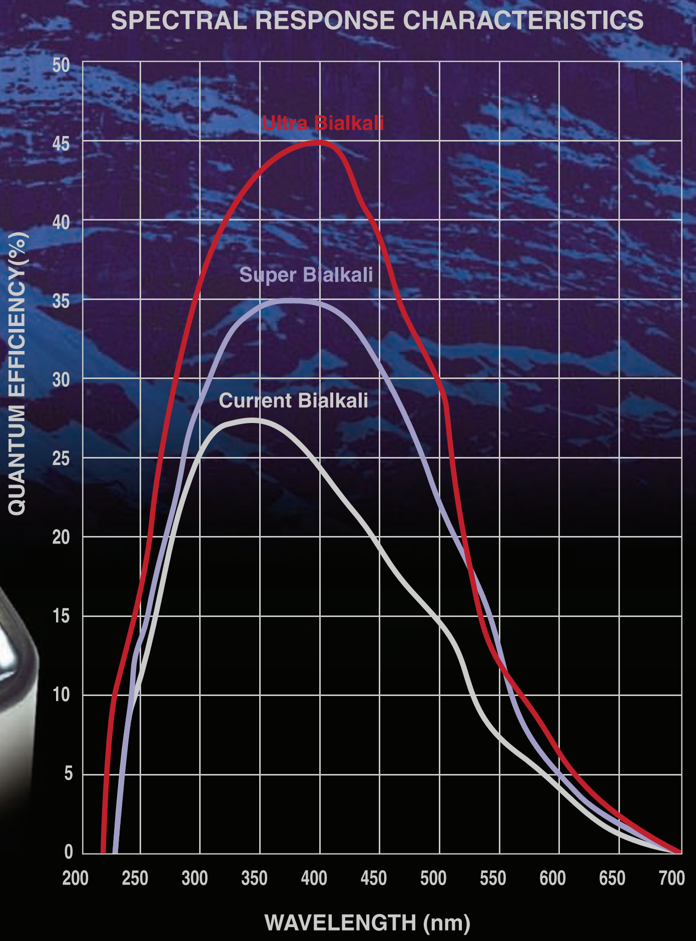
Untidiness could be best p13



PROSCAN is back online p24

Features

Cover: Installation of detectors for the ALICE experiment at CERN's Large Hadron Collider is in full swing (p6). Here seven elements of the High Momentum Particle Identification Detector (right) are set up on a platform before insertion inside the octagonal magnet structure (red).



SPECTRAL RESPONSE CHARACTERISTICS
QUANTUM EFFICIENCY(%)
0
5
10
15
20
25
30
35
40
45
50
Ultra Bialkali
Super Bialkali
Current Bialkali
200
250
300
350
400
450
500
550
600
650
700
WAVELENGTH (nm)

BIOPHYSICS

Antiprotons could help fight against cancer

A pioneering experiment at CERN with potential for cancer therapy has produced its first results. Exploiting the unique capability of CERN's Antiproton Decelerator to produce an antiproton beam at the right energy, the Antiproton Cell Experiment (ACE) has shown that antiprotons are four times more effective than protons for cell irradiation.

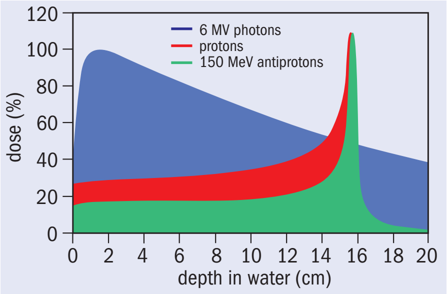
Cancer therapy is about collateral damage: destroying the tumour while avoiding the healthy tissue around it. Unwanted exposure of healthy tissue could cause side effects and result in a reduced quality of life. It is also believed to increase the chances of secondary cancers developing. In radiation therapy there is an ongoing quest to reduce the radiation level to tissue outside the primary tumour volume.

In hadron therapy, which began in 1946 with Robert Wilson's seminal paper, "Radiological Use of Fast Protons", the dose profile of heavy charged particles (hadrons) does not irradiate healthy tissue because most of the energy is deposited at the end of the flight path of the particles – the Bragg peak – with little before and none beyond (see p17). However, the question remains of how to maximize the concentration of energy onto the target.

The first speculations that antiprotons could offer a significant gain in targeting tumours through the extra energy released by annihilation date back more than 20 years (Gray and Kalogeropoulos 1984). Now the ACE collaboration has tested this idea by directly comparing the effectiveness of cell irradiation using protons and antiprotons.

To simulate a cross-section of tissue inside a body, the experiment uses tubes filled with live hamster cells suspended in gelatine. These are irradiated with beams of protons or antiprotons at a variety of intensities with about a 2 cm range in water. After irradiation the gelatine is extruded from the tubes and cut into 1 mm slices. These are then dissolved in growth medium and the cells are placed in Petri dishes in an incubator. After a few days the naked eye can see that some of the cells have produced healthy offspring. This gives a measure of the survival of cells along the beam path for the different dose levels. Cell survival is plotted for the entrance and the Bragg-peak regions as a function of particle fluencies, and the ratio of dose for a 20% survival in these two regions is extracted.

Michael Holzscheiter, ACE spokesperson (left), retrieves an experimental sample after irradiation with antiprotons, while Niels Bassler (centre) and Helge Knudsen from the University of Aarhus look on.



Physical dose deposition by X-rays, protons and antiprotons, as calculated using the Monte Carlo simulation code FLUKA, clearly demonstrates the reduction of dose outside the target area for protons and antiprotons compared with X-rays. Antiprotons are also expected to enhance the biological effective dose in the Bragg peak, rendering the difference between protons and antiprotons even more significant.

Comparing beams of protons and antiprotons that cause identical damage at the entrance to the target, the results of the experiment show that the damage to cells inflicted at the end of the beam is four times higher for antiprotons (Holzscheiter *et al.* 2006.) The method directly samples the total effect of the beams on the cells, combining the enhanced energy deposition in the vicinity of the annihilation point and the higher biological effectiveness of this extra energy (delivered by nuclear fragments). The experiment demonstrates a significant reduction of the damage to the healthy cells along the entrance channel of a beam for antiprotons compared with protons.

While antiprotons may seem unlikely candidates for cancer therapy, the initial results from ACE indicate that these antimatter particles could lead to more effective radiation therapy. There is no doubt, however, that the first clinical application is still at least a decade away.

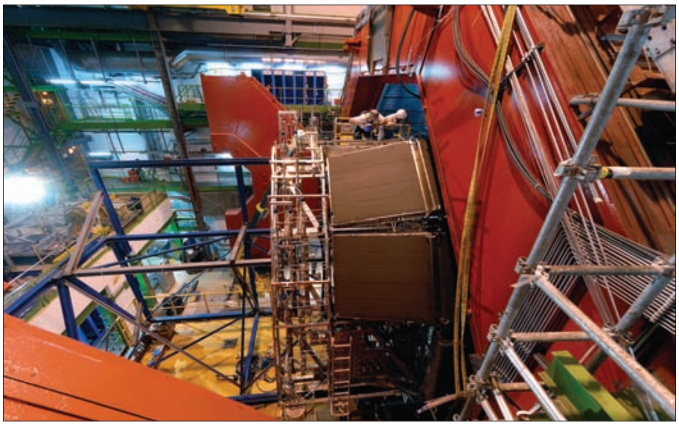
Further reading

L Gray and T E Kalogeropoulos 1984 *Radiation Research* **97** 246.
M H Holzscheiter *et al.* 2006 *Radiother. Oncol.* doi:10.1016/j.radonc.2006.09.012.

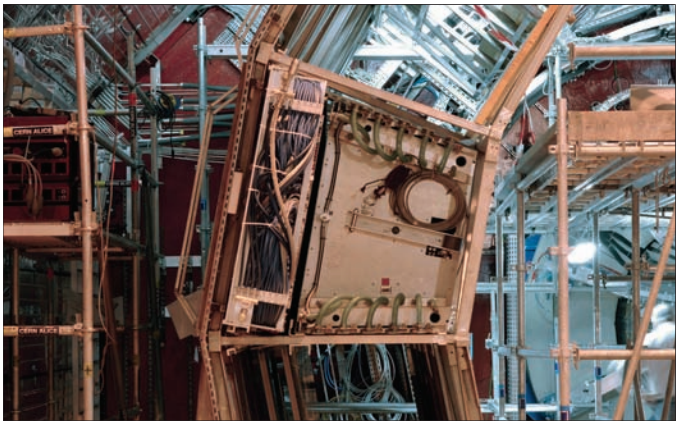
Sommaire

LHC EXPERIMENTS

ALICE forges ahead with detector installation



Two sections of the High Momentum Particle Identification Detector remain visible as it is inserted into the ALICE magnet.



Two installed supermodules of the Time of Flight and the Transition Radiation Detector. (Courtesy Antonio Saba for CERN.)

When it starts up the ALICE experiment will observe collisions of heavy ions in CERN's Large Hadron Collider (LHC), where "fireballs" of extremely hot and dense matter will be fleetingly made. Up to 20 000 tracks will emerge from each fireball, and one of the challenges for ALICE will be to identify different particles among this veritable "haystack" (*CERN Courier* September 2003 p20). Different elements in the armoury of particle identification for ALICE are now arriving in the experiment's underground cavern, beginning with the High Momentum Particle Identification Detector (HMPID), which was installed inside the solenoid magnet on 23 September. This was soon followed by the first elements of the Time of Flight (TOF) system and the Transition Radiation Detector (TRD).

The HMPID will extend hadron identification in ALICE up to 5 GeV/c, complementing the reach of the other particle-identification systems. It is a ring-imaging Cherenkov detector in a proximity-focusing configuration, which uses liquid C_6F_{14} as the radiator medium, while a 300 nm layer of caesium iodide (CsI) on the cathode of a multiwire proportional chamber converts the Cherenkov photons into electrons. This layer is divided into 161 280 pads, each 8 mm square, which are individually read out by two ASIC chips, GASSIPLEX and DILOGIC, developed with the Microelectronics Group at CERN.

The complete HMPID, realized by Bari University and INFN, CERN (PH-DT1, -DT2 and -AIT groups) and the Institute for Nuclear Research, Moscow, is approximately 8 m wide by 8 m tall, and weighs about 5 t. It comprises seven identical modules shaped to fit against two sides of ALICE's octagonal magnet. The modules, fully equipped with electronics, were individually transported to ALICE and mounted on a support structure. The complete HMPID was then lowered into the cavern and inserted inside the magnet. Three months of preparation by CERN (PH-DT1 and AIT) and Bari groups, and the help of the CERN transport service, ensured that transport and installation were accomplished within a few hours.

With an active area of about 11 m^2 covered with CsI, the HMPID is the largest application of this technology. Development began at CERN in the RD26 project, and it took 15 years for the method to reach the current scale and efficiency. The full production of the 42 photocathodes required to equip the detector, from CsI deposition to quality control, was done by the groups at CERN.

The first week of October saw the installation of the first two supermodules for the TOF system, which will be used to identify the thousands of pions, kaons and protons produced in each fireball. Its basic element is a multigap-resistive-plate-chamber (MRPC) strip, with a 120 cm × 7.4 cm active area made of a sandwich of resistive glass sheets (0.4 mm thick) and spacers, with 96 readout pads, each 3.5 cm × 2.5 cm. The full detector, which contains 1638 MRPC strips with a total of 157 248 readout channels, covers a cylindrical surface of about 150 m^2 at 3.7 m from the beamline, and weighs 25 t. It is the responsibility of the INFN sections in Bologna and Salerno, in collaboration with the Institute for Theoretical and Experimental Physics, Moscow, and Kangnung National University, Republic of Korea.

The TRD must identify high-energy electron pairs generated in the fireballs. It comprises 18 supermodules that form a cylinder around the large Time Projection Chamber in the central barrel of the ALICE experiment. Each supermodule is about 7 m long and comprises 30 drift chambers in six layers. The construction of the modules is a collaboration between the Universities of Frankfurt and Heidelberg, GSI Darmstadt, the National Institute of Physics and Nuclear Engineering, Bucharest, and the Joint Institute for Nuclear Research, Dubna, with the radiators produced at the University of Munster.

During the summer the drift chambers for the first supermodule were equipped with readout electronics and inserted into the supermodule hull at the University of Heidelberg. After transportation to CERN on 27 September, the module was tested on the surface using cosmic rays before being lowered into the ALICE cavern on 9 October. The final installation took place a day later.

POSITRONS

Tungsten-crystal target boosts positron intensity at KEKB linac

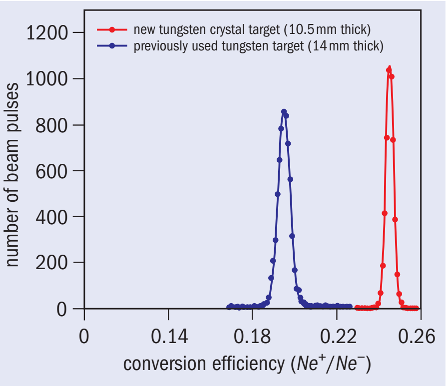


Fig. 1. Electron-to-positron conversion efficiencies measured for each pulse at the positron-capture section of the KEKB injector. The mean conversion efficiency for the new crystal target increased by about 25% compared with the conventional tungsten target previously used.

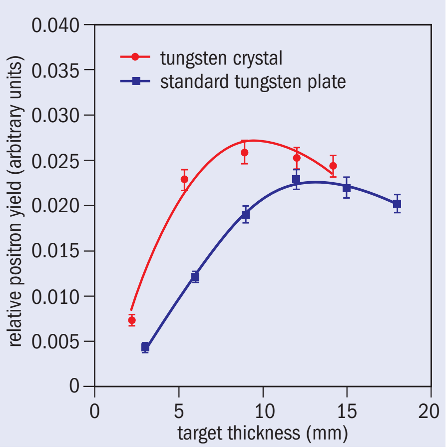
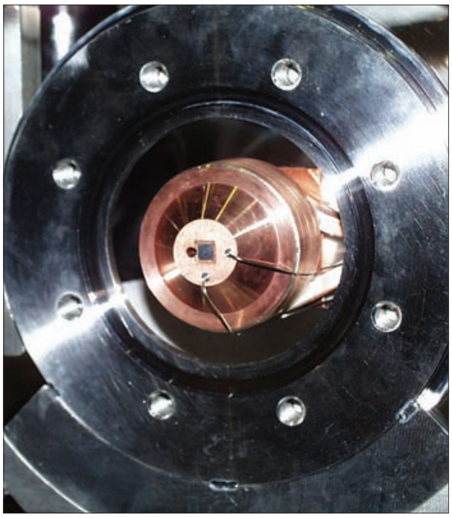


Fig. 2. Variations of the relative positron yield as a function of the target thickness. The incident electron energy and the measured positron momentum were 4 GeV/c and 20 MeV/c, respectively.



The 50 mm diameter copper target assembly, with the tungsten crystal in the centre, installed in a vacuum chamber.

A new tungsten monocrystalline positron target has generated an intense positron beam at the injector linac of the KEK B-factory (KEKB). It has operated stably since its first use in September 2006 and it is helping to increase the integrated luminosity of KEKB. Crystal positron sources of this kind could be important for the next generation of B-factories and electron–positron linear colliders.

The new positron target at KEKB consists of a 5 mm square tungsten monocrystal 10.5 mm thick, which is bombarded with 4 GeV electrons. The positrons created are then collected and accelerated in succeeding sections up to the final energy of 3.5 GeV for injection into the KEKB positron ring. A conventional target of a 14 mm thick tungsten plate has previously been used, giving a conversion efficiency – the ratio of the number of positrons captured in the positron-capture section and the number of the incident electrons (N_{e+}/N_{e-}) – of 0.20 (mean). Replacing the tungsten plate with the tungsten crystal has increased the conversion efficiency to 0.25 (mean) (figure 1), which in turn has boosted the positron intensity to its highest since KEKB began operating in 1999.

In a positron source, electrons radiate photons when they interact in a suitable target, and the photons then create electron–positron pairs. The use of a crystal target as a good alternative positron source was first proposed by Robert Chehab and colleagues at Laboratoire de l'Accélérateur Linéaire (LAL), Orsay, in 1989. The method has the advantage of producing high photon intensities by channelling radiation and coherent bremsstrahlung. Experiments at CERN (WA103) and KEK confirmed that the positron yield from a crystal target is remarkably enhanced at higher electron energies. Studies have since been done at KEK to find the optimum crystal thickness as a function of the incident electron energy (figure 2), and Tomsk Polytechnic University has developed tungsten crystals of various thicknesses.

Technology for mounting the tungsten crystal in the positron production station at KEK has also been studied carefully because the <111> crystal axis must be oriented with respect to the direction of the incident electrons to within 1 mrad. To achieve this precise orientation without alignment devices, the target assembly (figure 3) was carefully fabricated, using X-ray Bragg-reflection measurements to ensure that the crystal axis orientation was correct. The team then installed the crystal target at the operational positron source of the KEKB injector linac, and it has since been operating stably. Continued operation at KEKB will provide useful information about radiation damage and the stability of the crystal target.

● This work has been done through the collaborative efforts of Tokyo Metropolitan University, Kyushu Synchrotron Light Research Center, Tomsk Polytechnic University, LAL and KEK.

ANTIPROTONS

Serendipity at the Antiproton Decelerator opens the way to new antiproton chemistry

Most experiments at the Antiproton Decelerator (AD) at CERN involve laser or microwave studies of atoms such as antiprotonic helium ($\bar{p}\alpha e^-$) and antihydrogen ($\bar{p}e^+$). These may throw light on outstanding questions concerning, for example, the apparent absence of cosmic antimatter and possible limits to the validity of the charge–parity time-reversal (CPT) theorem. In this research, antiprotons are brought to rest in a container – a helium-gas target chamber in the first case, and a high-vacuum electromagnetic trap containing positrons in the second. In either case, interpretation of the results requires a full understanding of how the atoms are created, what their quantum states are and how they subsequently behave. However, it is rather like performing chemistry in a test tube where residues of impurity gases might also be present. Though unwanted these could have important effects and the studies at the AD have indeed led to some unexpected, serendipitous discoveries.

The ATHENA collaboration, whose primary is to study antihydrogen spectroscopically, has reported evidence that metastable protonium atoms (i.e. antiprotonic hydrogen, $\bar{p}p$) can be created in binary antiproton reactions with H_2^+ ions. These ions were produced when the positrons in the trap collided with H_2 molecules, inevitably present as "dirt in the test tube". This serendipitous method of making protonium turns out to be interesting because it seems to produce it in states with principal quantum number (n) near 68 and angular momentum quantum number $l < 10$.

Ground-state $n = 1$, $l = 0$ protonium can be produced easily and has been known for many years. However, it annihilates almost instantaneously owing to the marked overlap of the p and $\bar{p}$ wave functions. In high-n protonium, however, there is little overlap, since the Bohr-model orbit radius is proportional to n^2. The p and $\bar{p}$ can then come into contact only by de-exciting radiatively to $l \sim 0$ via a chain of transitions that the ATHENA team estimates to take about 1 ms. This extreme longevity should enable detailed laser-spectroscopy experiments on the protonium atom, leading to values of the antiproton's properties relative to those of the proton, and so to a new class of CPT-invariance tests (N Zurlo *et al.* 2006). Two-body atoms are especially valuable in this respect since their transition frequencies can be calculated analytically

Another experiment at the AD, ASACUSA, has been exploiting longevity against annihilation for some years with the (neutral) antiprotonic helium atom, $\bar{p}He^+$. Although this is a three-body atom, its high-n, high-l, $\bar{p}He$ states have microsecond annihilation lifetimes and are easily produced when antiprotons with electron-volt energies collide with ordinary helium atoms. As in the antihydrogen experiment, H_2 impurities are always present in the "test tube" at some level and have long been known to reduce, or quench, the $\bar{p}He^+$ lifetime, even at very low molecular concentrations, via binary collisions between H_2 and $\bar{p}He^+$.

To understand this fully, the ASACUSA team introduced H_2 and D_2 molecules into the helium target at various temperatures and concentrations and then deduced the quenching cross-section from the annihilation lifetime of the antiproton in the $(n,l) = (37,34)$ and $(n,l) = (39,35)$ states, as a function of these variables (B Juhász *et al.* 2006). Below 30 K the cross-section levelled off in the first case, revealing a tunnelling effect with a small activation barrier, while the (39,35) state had a 1/v "Wigner"-type dependence. Such results can perhaps serendipitously fill some gaps in our understanding of astrophysics, since the measured cross-sections should be similar to those for binary reactions of hydrogen and deuterium, which play an important role in cold interstellar and protostellar clouds, but have not been well studied at low temperatures.

A final unsought discovery has resulted from ASACUSA's quest for ever lower systematic errors in the laser-spectroscopy experiments on antiprotonic helium. This forced the team to go to extremely low helium target pressures. At helium densities less than 3×10^{16} cm^{-3} they noticed a lengthening of the tail of the spectrum of time intervals between the formation of the $\bar{p}He^+$ atom and the subsequent annihilation of the antiproton. This could only be explained by longevity of the $\bar{p}He^{++}$ two-body, doubly charged ion, which in higher-pressure gas is a short-lived intermediate stage between the formation of the neutral $\bar{p}He^+$ atom and the "contact" $p\bar{p}$ annihilation (Hori *et al.* 2005). Once again, a two-body atom promises to become serendipitously available as a test bench for CPT tests. Following up this possibility is an important part of the ASACUSA experimental programme.

Further reading

M Hori *et al.* 2005, *Phys. Rev. Letts.* **94** 063401.
B Juhász *et al.* 2006 *Chem. Phys. Letts.* **427** 246.
N Zurlo *et al.* 2006 *Phys. Rev. Letts.* **97** 153401.

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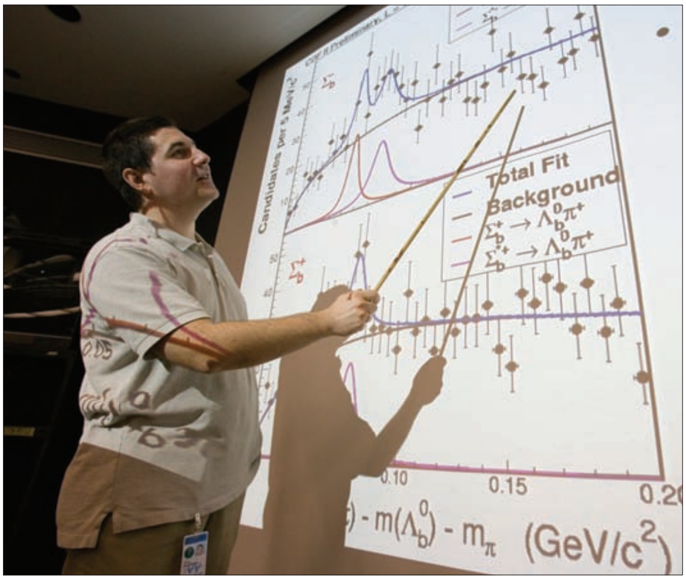
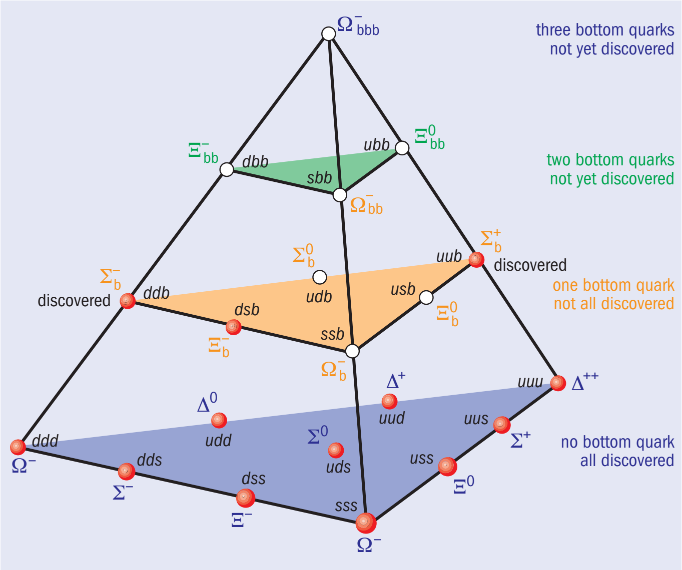
FERMILAB

CDF collaboration finds new baryons that contain b quarks



CDF physicist Petar Maksimovic, professor at Johns Hopkins University, presented the discovery of the Σ_b particles to the particle-physics community at Fermilab in a seminar on 20 October. (Pictures courtesy Fermilab Visual Media Services.)



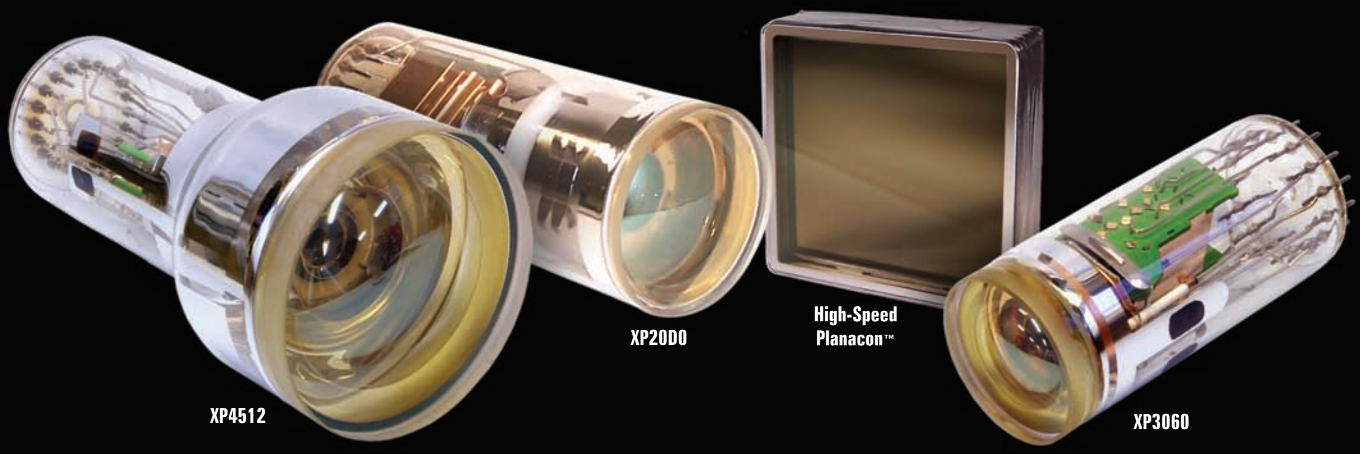
Quark theory predicts six different types of baryons with one bottom quark and spin-parity $J^P = 3/2^+$. The CDF experiment now accounts for two of these baryons. The experiment has also observed the corresponding ground states with $J^P = 1/2^+$.

Researchers at the Tevatron at Fermilab have found two new heavy particles and two of their excited states. The CDF collaboration has observed the first Σ_b particles, made up of quark combinations uub and ddb. Until now the Λ_b^0 (udb) was the only baryon (three quark) state containing a b quark to have been observed.

The quark model predicts the existence of Σ_b particles, in which the spins of the light quarks (u or d) combine with spin-parity, $J^P = 1^+$ to give a ground-state baryon with $J^P = 1/2^+$, and excited state, Σ_b^*, with $J^P = 3/2^+$. CDF is well placed to search for new particles like these, as the collaboration has the world's largest data set of baryons containing the b quark, thanks to the displaced track trigger that the experiment uses and a total of proton–antiproton luminosity around 1 fb^{-1} from the Tevatron, collected between February 2002 and February 2006. As the ground states of Σ_b are expected to decay strongly to Λ_b^0 states by emitting pions, the CDF team searched first for the Λ states via the decay chain, $\Lambda_b^0 \to \Lambda_c^+\pi$, $\Lambda_c^+ \to pK^-\pi^+$. They then looked for narrow resonances in the mass difference $m(\Lambda_b^0\pi) - m(\Lambda_b^0) - m_\pi$, where they found signals corresponding to a hundred or so examples of positively charged states, and rather more with negative charge.

The states with positive charge correspond to uub and are consistent with being either Σ_b^+ or Σ_b^{*-}, while the negative states correspond to ddb, that is Σ_b^- or Σ_b^{*-}, where the Σ_b^* states have slightly higher masses. Working from CDF's measurement of the Λ_b^0, the four new states have masses in the region of 5800 MeV/c^2.

BUILT FOR SPEED



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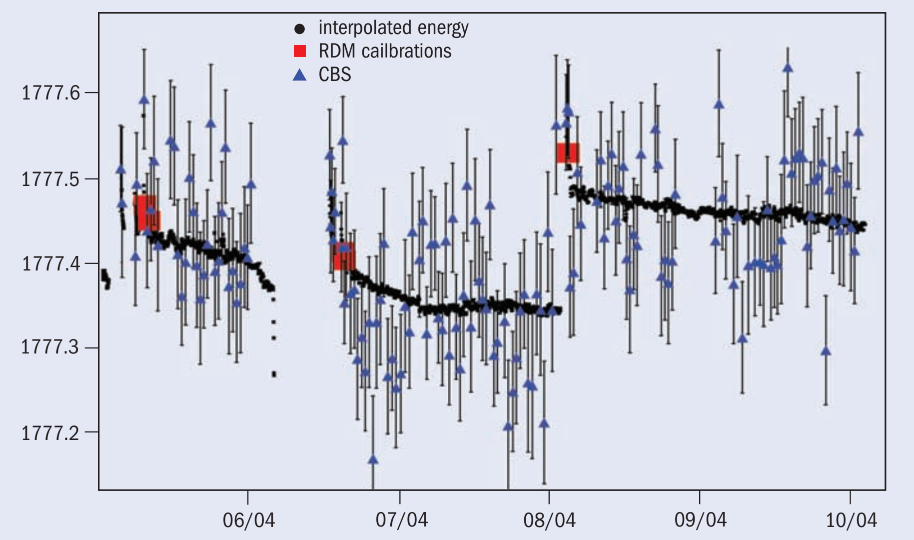
KEDR continues the quest for mass precision



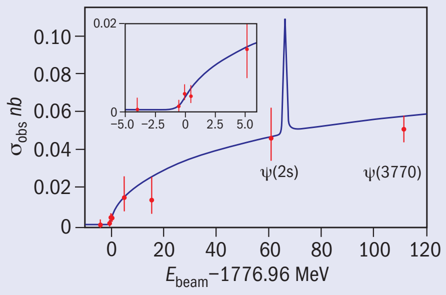


Fig. 1 (above). The $\tau^+\tau^-$ cross-section observed by the KEDR collaboration versus the beam energy at the VEPP-4M electron–positron collider. A key factor in these measurements is the determination of the beam energy.
Fig. 2 (left). An example of the energy behaviour of VEPP-4M in April 2006.

The KEDR collaboration has precisely measured the τ lepton mass. This continues a series of high-precision measurements of masses of particles and resonances at the VEPP-4M collider at the Budker Institute of Nuclear Physics in Novosibirsk (*CERN Courier* November 2005 p9). In 2004 and 2005 masses of the J/ψ and ψ' mesons were measured with a relative accuracy of 4×10^{-6} and 7×10^{-6}, respectively.

The τ lepton mass is a fundamental parameter of the Standard Model. Its value can be used with the τ lifetime and the decay probability to $e\bar{\nu}_e\nu_\tau$ to test the principle of lepton universality, one of the postulates of modern electroweak theory. Up to now the accuracy of the measurement of the Beijing Spectrometer (BES) has dominated the accuracy of the τ mass. Like BES, the KEDR experiment determines the τ mass by measuring the energy dependence of the $\tau^+\tau^-$ cross-section near threshold, and the key factor in such experiments is the accuracy of the beam-energy determination.

While previous experiments relied on the extrapolation based on the J/ψ and ψ' meson masses (measured in Novosibirsk) as reference points, the new KEDR-VEPP experiment uses two independent high-precision methods for the beam-energy measurement. During data-taking the beam energy was monitored through Compton backscattering of infrared laser light with a precision of 5×10^{-5}. The beam energy was absolutely calibrated daily with a precision of 1×10^{-5} using the resonant depolarization method.

The preliminary result, presented at ICHEP'06 (see p21), based on 6.7 pb^{-1} of data, is $m_\tau = 1776.80^{+0.25}_{-0.23} \pm 0.15$ MeV. This value agrees well with the current world average $m_\tau = 1776.99^{+0.29}_{-0.26}$ MeV and has comparable accuracy. It is also in good agreement with the recent preliminary result from the Belle experiment at KEK of $m_\tau = 1776.71 \pm 0.13 \pm 0.32$ MeV, which was also reported in Moscow. Detector-related uncertainties currently dominate in the systematic error presented for KEDR, but they will be reduced with more detailed data analysis. The experiment started a new run of data-taking at the threshold for τ production in October, with the aim of reducing the statistical error.

RECTIFICATIF

Dans l'édition de novembre l'article "Exotic atoms cast light on fundamental questions" (p39) a malencontreusement été publié avec le résumé en français d'un autre article, sur l'expérience OPERA (p24).
Le résumé correct est publié ci-dessous avec toutes nos excuses pour la confusion occasionnée par cette erreur.

Des atomes exotiques pour comprendre des questions fondamentales

Un atelier d'été, tenu à Trente, s'est attaché à étudier l'apport des expériences sur les atomes exotiques, les formes kaoniques fortement liées et l'antihydrogène pour explorer la physique fondamentale à basse énergie. L'atelier a rassemblé des experts dans le domaine des atomes et noyaux exotiques, afin d'examiner l'état actuel des expériences et de la théorie et de déterminer quels sont les sujets les plus prometteurs. Le programme, très fourni, allait des variétés pioniques, kaoniques et antiprotoniques des atomes exotiques à l'antihydrogène, et aux clusters nucléaires exotiques, plus généralement appelés de nos jours noyaux kaoniques fortement liés. Les participants ont pris connaissance des derniers résultats obtenus par de nombreuses expériences sur ces atomes exotiques, et ont discuté de projets futurs fondés sur des techniques d'expérimentation améliorées.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SCIENCEWATCH

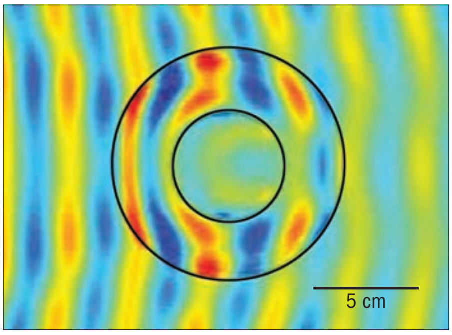
Compiled by Steve Reucroft and John Swain, Northeastern University

Invisibility cloak relies on the magic of metamaterials

The first invisibility cloak has been demonstrated by David Schurig of Duke University and colleagues. This is the first practical realization of a theoretical concept proposed earlier this year by John Pendry from Imperial College London (*CERN Courier* September 2006 p11).

The team created a shield in the form of a "metamaterial" made of 10 concentric fibreglass rings, each printed with a copper pattern. Working in the microwave region, the cloak interacts with electromagnetic waves to give the impression that both the cloak and the object within are nothing more than free space. It reduces both the shadow of the object and the radiation reflected, basically bending the incoming microwaves to make it appear that the shielded object is not there. The effect is rather like when water flows round a smooth rock and no disturbance is visible downstream.

The device tested was some 12 cm across and provided invisibility in two dimensions. Now the team plans to work towards a 3D device. So far the technique works only in a narrow frequency band in the microwave region, but shorter wavelengths could follow.



The invisibility cloak, between the black circles, shields a copper cylinder within.

Further reading

D Schurig *et al.* 2006 *Science* **314** 977.

Untidy packing can have its advantages

The optimal packing of spheres in higher dimensions is an open problem with important implications for computing and error-correcting code in communications. It might seem that the best arrangement should involve some sort of regular lattice – think of stacking oranges in the market – and indeed in three dimensions the face-centre cubic lattice provides the densest packing arrangement. This was conjectured by Johannes Kepler some 400 years ago but proved only recently.

When it comes to higher dimensions the case is less clear, and no-one has yet improved on the lower bound on maximal packing density found 100 years ago by Hermann Minkowski for a d-dimensional space. Now, however, Salvatore Torquato and Frank Stillinger at Princeton University have found that sometimes it may be better to vary the local density of packing – that is, to pack in a disordered way. They argue that for a high number of dimensions lattice packings are unlikely to be the densest, with disordered packing becoming more important as the number of dimensions increases.

In higher dimensions untidy packing may be better than the tidy equivalent. (Image copyright Willem Dijkstra/Dreamstime.com.)

Further reading

S Torquato and F H Stillinger 2006 *Experimental Mathematics* **15** 307.

Transitions reveal new Doppler effect

Everyone is familiar with the Doppler shift that occurs when the observer moves relative to some source of waves, but now a rotational effect has been found.

The idea hinges on the fact that a beam of light can carry orbital angular momentum in addition to the spin angular momentum of the photons. So an oncoming wave with orbital angular momentum could be Doppler-shifted depending on how the observer rotated relative to the beam.

The effects are small, but Sergio Barreiro of the University of Montevideo in Uruguay and colleagues have demonstrated them. They used a sophisticated set-up with an exotic transition in rubidium, a magnetic field, and two light beams with different values of orbital angular momentum.

Further reading

S Barreiro *et al.* 2006 *Phys. Rev. Lett.* **97** 113601.

Dubna discovers heaviest element yet

Researchers at the Joint Institute for Nuclear Research (JINR) in Dubna have created the first atoms of element 118, the heaviest produced so far, by firing calcium-48 ions into californium-249. They were detected by their alpha-decay to element 116 – also a new discovery – followed by two further alpha-decays to element 112, which broke into two fission fragments of approximately equal mass. Element 118 falls into the same column as the noble gases in the Periodic Table.

The collaboration, including members of the Lawrence Livermore Laboratory, has found only three examples of element 118 in some 2×10^{19} events (the first in 2002 and two more in 2005). However, the odds of a fluke are 1 in 100 000. The three examples had an average lifetime of 1 ms and a total atomic mass of 294.

Further reading

Yu Ts Oganessian *et al.* 2006 *Phys. Rev. C* **74** 044602.

ASTROWATCH

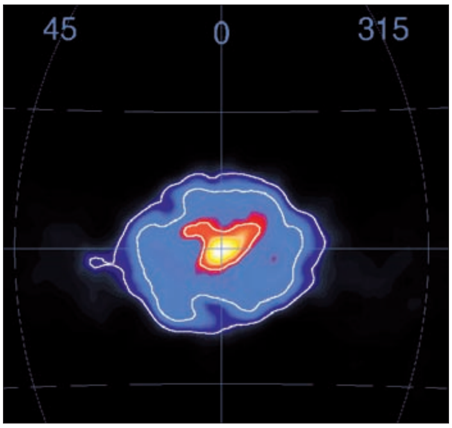
Compiled by Marc Türler, INTEGRAL Science Data Centre and Geneva Observatory

Finding the speed limit for galactic positrons

A new analysis of diffuse galactic gamma-ray data sets constraints on the initial energy of positrons produced in the centre of our galaxy. This limitation to at most a few mega-electron-volts severely restricts their production sites and in particular the range of masses allowed for a possible origin in lightweight dark matter.

A balloon-borne spectrometer first detected the characteristic electron–positron annihilation line at 511 keV in radiation from the galactic centre in the early 1970s. It was only in the 1990s with the Oriented Scintillation Spectrometer Experiment on NASA's Compton Gamma Ray Observatory (CGRO) that the distribution of the 511 keV emission could be mapped. A decade later, the improved capabilities of the Spectrometer on board ESA's INTEGRAL mission revealed a simple circular distribution of emission around the galactic centre with an extension of about 8° in diameter at half-maximum.

The confinement of the positrons to the galactic bulge, with only weak evidence for emission from the galactic disc, triggered new and exotic ideas about their origin. In particular, the idea that annihilation of lightweight dark matter could be behind the positrons ignited much interest (*CERN Courier* November 2004 p13).



INTEGRAL map of the gamma-ray line at 511 keV emitted by positron annihilation at the centre of the galaxy. (Courtesy J Knödlseder/CESR, Toulouse.)

The fact that positron annihilation can result only in gamma-ray emission at energies at or below 511 keV implies that if the positrons are energetic, they have to cool down before annihilating, possibly leaving an imprint at gamma-ray energies above 511 keV. John Beacom and Hasan Yüksel from Ohio State University have now reconsidered this and used gamma-ray data in the mega-electron-volt range to constrain the injection energy of the positrons.

Previous work considered only internal bremsstrahlung radiation associated with positron production as a possible cooling mechanism. However, Beacom and Yüksel also took into account the in-flight annihilation of energetic positrons in the interstellar medium as they lose energy by ionization in matter.

After calculating the expected gamma-ray spectrum through this mechanism for mono-energetic positrons of different energies, Beacom and Yüksel compared it with gamma-ray observations from INTEGRAL and CGRO. They found that the in-flight annihilation signal from positrons injected with energies above about 3 MeV would produce a detectable excess in the gamma-ray emission of the central 5° diameter circle of our galaxy. Such an excess is not detected and this strongly limits the initial energy of the positrons.

At lower energies, they noted that there is a hint of an excess in the INTEGRAL data in this region between 0.5 and 1 MeV. If confirmed by observation, this could be the first detection of in-flight positron annihilation.

The finding that positrons annihilating in our galaxy cannot be produced insite with energies above a few mega-electron-volts has been independently confirmed by P Sizun and collaborators from Dapnia, Saclay, using similar arguments. This severely limits the possible energy of any lightweight dark-matter candidate. However, these authors stress that it is premature to exclude this hypothesis, because the main constraints on the continuum gamma-ray emission in the mega-electron-volt range come from measurements by the past CGRO mission rather than INTEGRAL. Further INTEGRAL observations are required, as well as a reassessment of both statistical and systematic uncertainties on fluxes in the CGRO maps.

Further reading

John F Beacom and Hasan Yüksel 2006 *Phys. Rev. Lett.* **97** 071102.
P Sizun *et al.* 2006 *Phys. Rev. D* **74** 063514.

Picture of the month

The Hubble Space Telescope offers a new view of the powerful merger of two spiral galaxies: a preview of what may happen when the Milky Way collides with the neighbouring Andromeda galaxy in several billion years. The Antennae galaxies shown here started to interact a few hundred million years ago, producing long tails of material left behind by tidal disruption and inspiring their naming. While the stars themselves are unlikely to collide during the merger, the violent collision of the gas and dust clouds triggers intense star formation. The brilliant points in the image are star-forming regions surrounded by glowing hydrogen gas appearing pink. Most of the young stellar clusters – visible as faint blue dots – will disperse in the next million years, but it is believed that about 100 of the most massive clusters will survive to form regular globular clusters, like those in the Milky Way (*CERN Courier* July/August 2006 p10). (NASA, ESA and the Hubble Heritage Team [STScI/AURA]-ESA/Hubble Collaboration.)

CERN COURIER ARCHIVE: 1963

A look back to CERN Courier vol. 3, December 1963

EDUCATION

Development of supplementary training

The success achieved last year by the newly organized technical-training programme showed that there was a strong demand for increased knowledge among the technicians as well as the scientific staff of CERN. A great many of them feel a need to extend their training, either by keeping up to date in their own field and increasing their understanding of it, or by acquiring a basic understanding of other techniques currently applied at CERN.

Following this encouraging lead, the directorate last May created the Training and Education Section, whose functions are to organize, coordinate and develop both technical and academic training according to the needs of the laboratory. What follows is a brief outline of the 1963/4 programme.

Academic programme

This year, two series of lectures have been arranged, one theoretical and one experimental, both at post-graduate level. They deal mainly with the recent developments in elementary-particle physics, from the theoretical as well as the experimental and technological points of view, but are not intended to be only for specialists in each of these fields. It is worth mentioning that [the experimental] courses attract 50–100 physicists and engineers, some of whom come from outside CERN.

Technical programme

This year, the technical programme consists of 10 courses (at "elementary" or "specialized" level), each of 15–30 lessons given once or twice a week. Since nearly all of the students prefer the courses to be in French, the lessons are again being given in this language.

About 350 technicians and other staff have registered for this year's courses. Some of them take mathematics as well as their technical course, so that the total number of registrations is about 550.

In addition to the above programme, a course in basic physics is being prepared. This will use the principles of "programmed instruction" and will follow the physics course devised in the United States, by the Physical Science Study Committee. It will be used to try out the new methods of auto-instruction, which seem to offer great advantages in such a complex and "busy" community as ours.

The section is also organizing three series of technical seminars: electronics, mechanics (technology of materials and workshop processes) and accelerator technology. These are intended for the technical and scientific staff.

General lectures

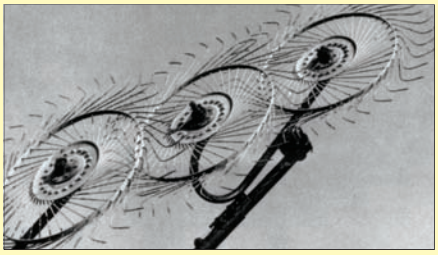
General information lectures on important experiments or big technological projects at CERN are also organized by the training and education section. These lectures, given by some of those closely concerned with the projects, are aimed at a non-scientific audience and are intended for the whole of the staff. They provide a good opportunity for the lecturers to repay the debt that they owe to all those who have helped, in one way or another, by giving their audience an understanding of the general outlines and enabling them to appreciate the importance of the various experiments.

● Extracted from an article on p154.

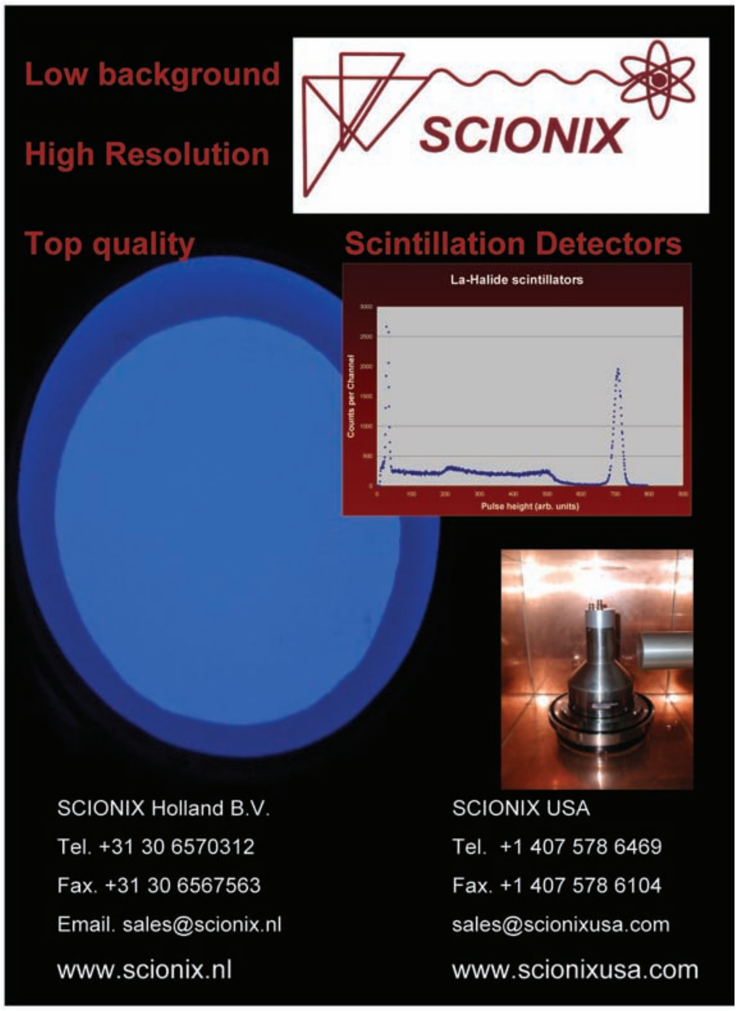
Were you at this Christmas party?

The (cover) photograph shows that the main auditorium at CERN has more than one use, and that a young audience can be even more attentive than the physicists and engineers who more often occupy the seats. The occasion was the performance of a play called *Capucines*, presented by the drama group of the international organizations, Harlequin and Co, during the first of this year's two Christmas parties bringing together the children of CERN staff and some of those from neighbouring communities. Also on the programme were a film and a conjurer, as well as refreshments and the visit of Father Christmas.

PHOTO PUZZLE



How much do you know about CERN's equipment? Here we have two mystery pieces of equipment for you to identify. The answers can be found on p31.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High Resolution
Top quality
SCIONIX
Scintillation Detectors
La-Halide scintillators
Counts per Channel
Pulse height (arb. units)


radiabeam
TECHNOLOGIES

Particle accelerators take up the fight against cancer

Sixty years ago accelerator pioneer Robert Wilson published the paper in which he proposed using protons for cancer therapy. **Ugo Amaldi** and **Gerhard Kraft** describe how the field has since advanced, as an increasing number of accelerators in dedicated clinical centres come online to provide therapy with protons and carbon ions.

In 1945 William Hansen at Stanford University built a disk-loaded linear accelerator that produced 4.5 MeV electrons and was less than a metre long. This first electron linac ran at the previously unimaginable frequency of 3 GHz and was so short because it used pulsed high-power klystrons invented by the Varian brothers and developed during the Second World War. Hansen had aimed to advance research in nuclear physics, but his invention was to have an enormous impact on medicine. By the 1970s the company Varian led the market in producing what is now “conventional” radiotherapy systems based on the same type of linac running at the same frequency.

In developed countries every year some 40 000 per 1 million inhabitants are diagnosed as having cancer, around half of whom are treated with high-energy photons produced by electron linacs. There are almost 10 000 electron linacs worldwide, which run more than one shift a day. They irradiate around 4 million patients a year, each in about 30 sessions over 5–6 weeks. The photon beams have energies of a few million electron volts, but are still called X-rays by medical doctors. They have replaced low-energy X-rays and the gamma radiation from radioactive cobalt because they deposit the dose (the energy per unit mass) at greater depth (see figure 1).

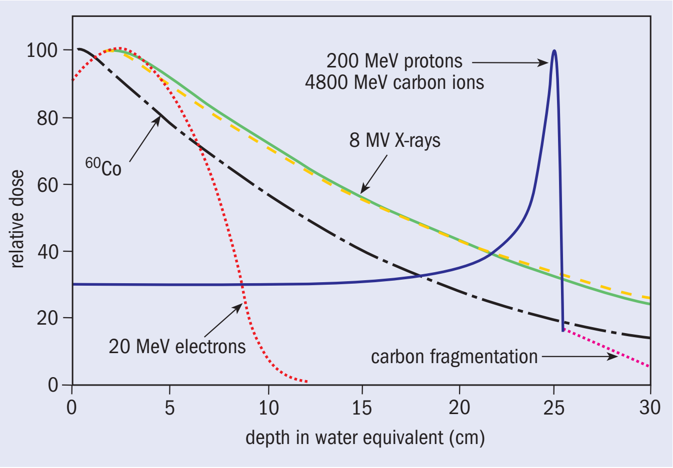

Fig. 1. Qualitative depth dependence of the deposited dose for each radiation type, with the narrow Bragg peak at the end.

In the same year of Hansen’s invention, and not far away, Robert R Wilson – a Harvard associate professor who was working on cyclotrons with his old teacher Ernest Lawrence at the Radiation Laboratory in Berkeley (*CERN Courier* November 2006 p11) – was computing the shielding thickness for a 150 MeV cyclotron to be constructed and installed at Harvard. Fifty years later, opening the Advances in Hadron Therapy conference, held at CERN in 1996, Wilson said, “I found that a few inches of lead would fix everything. But I did not stop. Why? Fifty years later I do not know why I did not stop. I suppose the first reason was just plain simple curiosity. So I went on and I jumped into the most obvious thing I could do next: because one could hurt people with protons, one could probably help them too. So I tried to work out every detail and I was surprised to see that the Bragg curve came up and came down very sharply,” (Wilson 1997). The narrow Bragg peak at the end of the range (figure 1) prompted him to publish in the journal *Radiology* a now-famous paper suggesting the use of protons (and carbon ions) to irradiate tumours while sparing – much better than with X-rays – the healthy tissue traversed, contiguous and located more deeply (Wilson 1946).

However, the resonance within the medical community was almost zero and it was a decade before Berkeley and Harvard treated patients with proton beams from accelerators originally designed for nuclear-physics experiments. It wasn’t until the beginning of the 1990s that radiation oncologists started to recognize this new therapeutic method, because the apparatus was huge by medical standards and the irradiations were done in nuclear-physics laboratories with horizontal particle beams and simple beam-shaping methods. By 1993 about 10 000 patients worldwide had been treated with protons, and by the end of 2006 this has reached 50 000. Today five companies supply turnkey proton-therapy centres.

It is no surprise that from 1961 interesting clinical results for proton therapy were obtained at Harvard where radiotherapists at Massachusetts General Hospital and physicists from Harvard have successfully treated many thousands of head and neck tumours (*CERN Courier* January/February 1999 p22). Eventually in 1993 at the Loma Linda University Medical Center in California, the first

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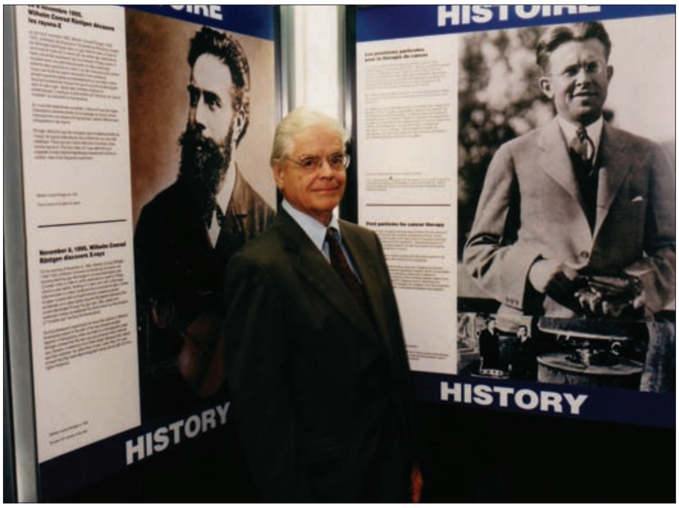

Fig. 2. This photograph of Robert Wilson was taken during the 1996 Second International Symposium on Hadron Therapy, which was held at CERN 50 years after the publication of his well known paper on "Radiological use of fast protons".

proton synchrotron dedicated to proton therapy began irradiating patients in three treatment rooms featuring magnet beamlines on 10 m high gantries, which rotate around the patient. Again, it is no surprise that the Loma Linda synchrotron was built at Fermilab, the particle-physics laboratory that Wilson created and then directed until 1987 (*CERN Courier* March 2000 p13).

Carbon ions join the fight

Heavier ions than protons, such as helium and later argon, first came into use at Berkeley in 1957 and 1975, respectively. At the old 184 inch cyclotron 2800 patients received brain treatment with helium beams: the lateral spread and range straggling are smaller and this leads to much better dose gradients than protons. At the Bevalac, argon beams were tried to increase the effectiveness against hypoxic and otherwise radio-resistant tumours, i.e. tumours that need deposited doses 2–3 times higher if they are to be controlled with either photons or protons. But problems arose owing to non-tolerable side effects in the normal tissues. After a few irradiations, the Bevalac used lighter ions, first silicon ions and then neon, for 433 patients before it shut down in 1993.

The transition from protons to heavier ions adds another order of magnitude to the complexity of patient irradiation. In the beginning at Berkeley the increase in the relative biological effectiveness (RBE) for ions with respect to photons was believed to be related to the physical parameters of the beam, being the same for different tissues. Since 1980 a large programme of systematic studies of RBE has been carried out at various accelerators, such as Unilac (Darmstadt), Ganil (Caen), Bevalac (Berkeley), the Tandem Van de Graff (Heidelberg) and, later, SIS (Darmstadt). This research studied the effects on very different biological objects, from sub-cellular systems, such as DNA and chromosomes, to biological systems that are resistant to extreme environmental conditions and are used in space research.

The experiments used more than 100 000 biological samples and ion beams from very light to very heavy elements. The research identified the systematic dependence of RBE on physical and biological parameters – mainly the capacity of cells to repair DNA damage – as the most important factor, which was then theoretically modelled for use in treatment planning. In particular, the work showed that for beams of carbon ions the section of the particle track with increased RBE coincides with the few centimetres up to the Bragg peak, while for lighter ions it is concentrated in the last few millimetres. For heavier ions, such as the argon, silicon, and neon ions used previously at Berkeley, it causes significant damage in the normal tissues before the tumour.

For these reasons, in 1994 the synchrotron facility led by Yasou Hirao at the Heavy Ion Medical Accelerator in Chiba (HIMAC), of the National Institute for Radiation Sciences in Japan, treated the first patient with carbon ions, although the accelerator complex was originally designed for ions up to argon.

While an energy of 200 MeV is needed to reach deep-seated tumours (about 25 cm of water equivalent) for protons, 4800 MeV is needed for carbon ions, 24 times higher. Protons beams are obtained either from cyclotrons (normal or superconducting) or from synchrotrons with a diameter of 6–8 m. Currently only synchrotrons are used to produce carbon ions up to 400–430 MeV/u. Their magnetic rigidity is about three times larger than for 200 MeV protons, so synchrotrons of 18–25 m diameter are needed.

Since the end of the 1990s, newly built proton-therapy centres feature isocentric gantries to improve treatment conformity. These avoid high doses to healthy tissue by rotating the beam around the patient as in X-ray treatments. These complex hi-tech systems could not be designed and run effectively and continuously – as is necessary in a hospital environment – were it not for decades of colliding particles and understanding the subatomic world.

Until 1997 relatively simple passive spreading systems were used to produce a spread-out Bragg peak in all hadron-therapy centres. A first scatterer widens the pencil beam while the energy is adapted to the further side of the tumour by appropriate absorbers. More recently, GSI and PSI have developed novel active spreading systems (Haberer *et al.* 1993 and Pedroni *et al.* 1995, respectively), which magnetically guide the charged hadrons over the treatment area and modulate the intensity (Intensity Modulated Particle Therapy, or IMPT). All future centres will feature such systems (see p24). In particular the ion-therapy centres currently being built at Darmstadt and Pavia have been equipped with the first active beam-delivery system for carbon ions, which restricts the physically and biologically effective end of the track to the target volume (Rossi 2006).

Treating patients

By the beginning of 2006, around 45 000 patients had been treated with proton beams in 12 subatomic physics laboratories and in more than 10 hospital-based proton-therapy centres. (The Particle Therapy Co-ordination Group updates the number of patients treated at http://ptcog.web.psi.ch.) Another 10 centres are running or are being built. This shows that proton therapy is booming. At the same time around 2200 patients have been treated with carbon ions at HIMAC, and about 300 at the pilot project proposed by Gerhard Kraft and built at GSI in Darmstadt.

In a conventional treatment with photons of a few million electron volts, a total dose of 60–70 Gy (1 Gy = 1 J/kg) is deposited in a tumour in typically 30 fractions over six weeks. This "fractionation" gives time for re-oxygenation of hypoxic – and therefore radio resistant – tumour cells and allows them to change from radio-resistant stages in the cell cycle to more sensitive stages. In addition, unavoidably irradiated healthy cells have a chance to repair themselves. A proton treatment typically needs the same number of fractions, but allows higher doses to the tumour and thus larger control rates. A larger dose is beneficial because even a 10% increase in the deposited dose generally increases the probability of local control of the tumour by 15–20%.

With carbon ions, the clinical results from Japan and Germany on head, lung, liver and prostate tumours confirm the radiobiological predictions that they have a larger RBE than protons, because their ionization is 24 times higher, which produces multiple double-strand breaks of the DNA of the traversed cell. This damage cannot be repaired, so ion beams are most suited for slow-growing tumours, which are precisely those tumours that are resistant to photons and protons. It is important to note that, since there is only little repair to damage by carbon ions, the fractionation of the dose is not needed as far as tumour inactivation is concerned, but for the normal tissue in the entrance channel fractionation helps to repair the less severe damage. In principle a patient can be treated in 5–10 sessions, reducing both psychological and financial cost. A proton treatment costs 2–3 times more than a conventional treatment, averaging in the West around €6000, but the economy of carbon treatment is different because the shortening of the treatment allows for effective use of the infrastructures. If confirmed by the ongoing clinical trials, this will reduce the cost of treatment and may become one of the main reasons behind any rapid expansion of light-ion therapy in the future. In addition, having little or no side effects reinforces the necessity of active beam-delivery systems for carbon ions, to tailor the dose to the tumour.

In summary, research indicates that carbon-ion beams should be used in the treatment of deep-seated tumours, which are radio resistant both to high-energy photons and to protons. These tumours are thus the targets of choice in a carbon-ion facility, while proton therapy is well adapted to the cases in which a tumour is close to critical organs that cannot be irradiated (Amaldi and Kraft 2005). Groups of radiotherapists in Austria, France, Germany and Italy have applied specific criteria for each tumour site to the national data and made detailed analyses of the number of potential patients (Carbon-ion therapy 2004). The results of these different approaches are consistent. They show that about 1% of the patients treated today with X-rays should be irradiated with protons as the outcomes are definitely better than conventional therapy. In addition, about 12% of X-ray patients would benefit from proton treatment but further clinical trials are needed to quantify the clinical advantages site by site. Lastly, about 3% of X-ray patients would benefit from carbon-ion therapy, but more clinical trials and dose-escalation studies are needed.

Overall, 15% of the approximately 20 000 patients per 10 million inhabitants treated with conventional radiation would receive better treatment with hadron beams. Irradiating these patients would require 3–4 proton treatment rooms (i.e. a centre treating about 1500 patients a year) per 5 million people and a carbon-ion centre per 35 million people. A balanced national programme can therefore make good use of dual centres that accelerate carbon ions and protons and feature fixed ion beams (horizontal, vertical and inclined) and rotating gantries for protons.

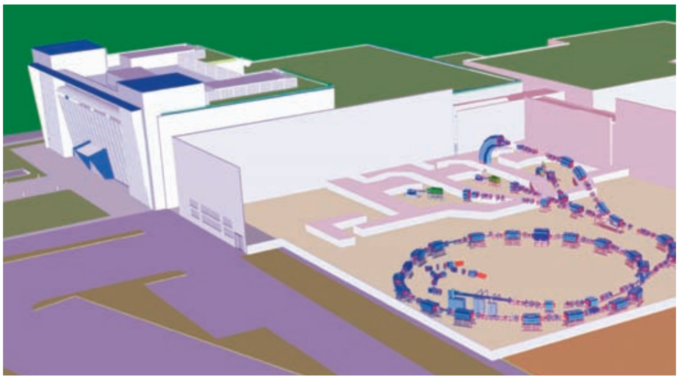

Fig. 3. Phase 1 of the Italian national hadron-therapy centre, CNAO, features three treatment rooms. In the central one patients are irradiated with a horizontal and a vertical beam. Two gantry rooms will be added so that, when completed in Phase 2, the centre will feature five treatment rooms and more than 3000 patients will be treated each year. GSI is building the 7 MeV/u linac, which is installed inside the synchrotron ring to reduce the dimensions of the facility.

Hadron therapy in Europe

In the past five years Europe has made important steps in developing and building hospital-based dual centres for carbon ions and protons. Based on the success of GSI's pilot project, the Heidelberg Ion Therapy Centre (HIT), designed by GSI, was approved in 2001 and civil engineering work began in November 2003. This centre features two horizontal beams and the first carbon-ion rotating gantry, which is 25 m long and weighs 600 tonnes. The first treatment will be at the end of 2007.

At the end of 1995 Ugo Amaldi, with Meinhard Regler of the Med-Austron project, attracted CERN management's attention to the design of an optimized synchrotron for light-ion therapy. This was the starting point of a five-year Proton and Ion Medical Machine Study (PIMMS) (Badano *et al.* 1999 and 2000). As a development of this initiative, in 2002 the Italian health minister financed a second European centre, based on the PIMMS design modified by the TERA Foundation (Fondazione per Adroterapia Oncologica). This is now being built in Pave by the Centro Nazionale di Adroterapia Oncologica Foundation (CNAO) with strong support from INFN (figure 3). It will be ready by the end of 2007.

At the end of 2004 the Austrian authorities approved the Med-Austron project, granting a substantial part of the required funding for the construction of a dual centre in Wiener Neustadt. The tendering procedure to acquire a turnkey carbon-ion facility is now almost complete. Similarly, in May 2005 the French government approved the ETOILE project to be built in Lyon.

In 2002 the initiatives at Heidelberg, Lyon, Pave, Stockholm (where the Karolinska Institute has proposed a similar facility) and Wiener Neustadt all teamed up with the European Society for Radiotherapy, CERN and GSI to form the European Network for Light Ion Therapy, which the European Union financed for three years. The work by this network, and the existence of its potential successor, guarantees that carbon-ion therapy in Europe is on ▷

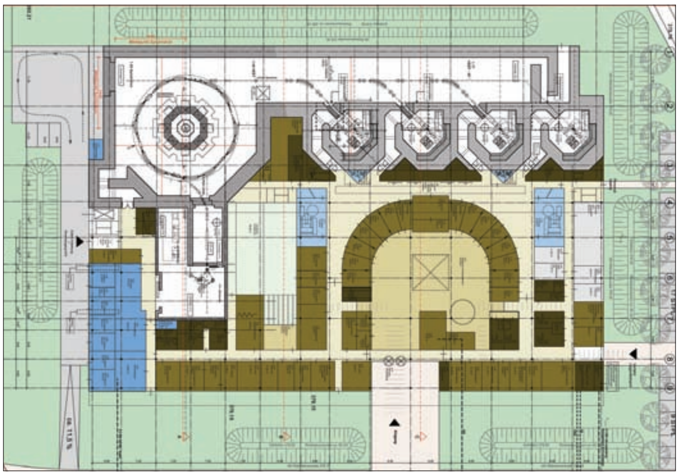

Fig. 4. The Marburg heavy-ion therapy facility is based on an extended study of the clinical workflow. Three treatment areas with a horizontal beamline and one with a 45° oblique beam will be optimized to shorten the treatment. (Courtesy Rhön–Klinikum–AG and architects Brenner and partners).

the right track and that the foreseen facilities will be run for the benefit of all European patients. During 2006 a larger group of institutes and hospitals from 15 countries has come together to prepare a new proposal for the EU Framework Programme FP7 under the name ENLIGHT++ (*CERN Courier* June 2006 p27).

In addition, in January 2006 contracts for a privately financed carbon/proton centre were signed by Rhön–Klinikum–AG, which owns more than 40 German hospitals, including the Giessen-Marburg University clinics, and Siemens Particle Therapy. When it starts up in 2010, the new heavy-ion therapy facility in Marburg (figure 4) will show that hadron therapy with ion and proton beams has left research and arrived in the clinical environment.

Future developments

The unique physical and biological properties of hadron beams are better for patients than the most recent photon image guided radiotherapy (IGRT) techniques if the position of the tumour target can be accurately determined and an active irradiation system can follow the movements of the treated organ. To achieve this, two approaches have been considered. One uses feedback systems that redirect the moving beam during scanning, while the other uses the multiple "repainting" of the target to avoid the local delivery of larger or smaller doses than predicted. In the former, the online motion correction can be done in 3D, using the scanning system for the lateral correction and a fast passive absorber for the depth correction. Experiments at GSI with a phantom showed that the homogeneity and the steep gradients can be preserved to 95% compared with static target irradiation. PSI will pursue the latter approach with proton beams at the PROSCAN project (see p24).

Scientists at KEK and TERA have proposed two types of fast cycling accelerators, better suited than cyclotrons and synchrotrons to treating moving organs. They are, respectively, the fixed field alternating gradient accelerator (a mixture of a cyclotron and a synchrotron) and the cyclinac (the combination of a low-energy high-current cyclotron and a high-frequency linac), both of them suitable for proton and carbon-ion therapies. It will take a few years to see what the best solution is both economically and technically.

Without waiting for these developments, industry has shown interest in the upcoming market of hadron therapy, proposing solutions based on synchrotrons and cyclotrons. Five companies already sell proton-therapy units. In the heavy-ion market Mitsubishi has designed a micro-HIMAC, a synchrotron for combined proton and carbon therapy, while Siemens Particle Therapy offers a combined proton/carbon facility on the basis of exclusive licences of the GSI patents and know-how. At present a commercial company is discussing the licensing of the PIMMS/CNAO synchrotron design with the CNAO Foundation. Moreover scientists at the INFN Laboratori Nazionali del Sud in Catania have designed a 300 MeV/u superconducting cyclotron that accelerates hydrogen molecules and carbon ions, allowing treatment with protons of all tumours as well as treatment with carbon ions of tumours located at a water depth of about 15 cm. The Ion Beam Application company in Belgium has transformed this design into a commercial product. The recent interest of industrial companies in ion therapy indicates its large potential, which has its roots in the instruments developed for fundamental research in subatomic physics.

Further reading

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Résumé

Les accélérateurs de particules contre le cancer

En 1946, le pionnier des accélérateurs Robert Wilson publia un article dans lequel il proposait d'utiliser des protons pour traiter le cancer. Soixante ans plus tard, la technique est parvenue à maturité: on trouve de plus en plus d'accélérateurs dans les centres spécialisés dans le traitement par faisceau de protons ou d'ions carbone, des particules qui s'avèrent plus efficaces que les rayons X dans certains cas. De nombreux centres sont équipés d'instruments industriels, mais ces systèmes complexes haute technologie n'auraient pas pu être conçus ni exploités efficacement en milieu hospitalier sans l'expérience acquise pendant des décennies par les chercheurs en physique subatomique.

Ugo Amaldi, *University of Milano Bicocca and TERA Foundation, and* **Gerhard Kraft**, *GSI and Technical University, Darmstadt.*

Rochester conference goes back to Russia

Moscow hosted this year's major summer conference, which presented the latest news across a broad range of topics. **Gennady Kozlov** and **Simon Eidelman** report.

In summer 1976, the International Conference on High Energy Physics (ICHEP), known traditionally as the Rochester conference, was held in Tbilisi, the last time it would take place within the USSR. Thirty years later, the Rochester conference returned to Russia, when around a thousand physicists from 53 countries attended ICHEP'06, held on 26 July – 2 August in the Russian Academy of Sciences in Moscow. The extensive scientific programme contained the customary mixture of plenary reports, parallel sessions and poster presentations. For six days, participants discussed key issues in high-energy physics, ranging from astrophysics and cosmology, through the physics of heavy-ions, rare decays and hadron spectroscopy, to theoretical scenarios and experimental searches beyond the Standard Model. Topics also included Grid technology for data processing, new accelerators and particle detectors, and mathematical aspects of quantum field theory and string theory.

In his opening speech, the co-chair of the conference, Victor Matveev, emphasized that the entire community of Russian high-energy physicists was honoured to host the major international conference of 2006. The participants were also greeted by the director of the Budker Institute of Nuclear Physics (BINP) and co-chair of the conference, Alexander Skrinsky, and deputy rector of the Lomonosov Moscow State University, Vladimir Belokurov. The vice-chair of the organizing committee, and director of the Joint Institute for Nuclear Research (JINR), Alexei Sissakian then spoke about the structure of ICHEP'06 and its scientific programme.

Duality, QCD and heavy-ions

On the theory side, the progress in so-called "practical theory" is evident, primarily in the sophisticated calculations in quantum chromodynamics (QCD) presented by Giuseppe Marchesini of Milano-Bicocca University and Zvi Bern of the University of California, Los Angeles. Gerritt Schierholz from DESY, Adriano Di Giacomo of Pisa University and Valentin Zakharov of the Institute for Theoretical and Experimental Physics (ITEP), Moscow, explained the remarkable achievement of the splendid harmony between analytical calculations and the results obtained on the lattice using dynamical quarks.

The theoretical discussions emphasized the concept and use of gravity-gauge duality in a framework generalizing the anti-de Sitter space/conformal field theory correspondence. This duality is a conjectured relationship between confining gauge theories in four dimensions on the one hand, and gravity and string theory in five and more dimensions on the other. DESY's Volker Schomerus described how, when applied to QCD, this approach reproduces numerous non-perturbative features of strong interactions, from the low-energy hadron spectrum through Regge trajectories and radial excitations to quark counting rules. On the experimental side, Pavel Pakhlov of ITEP Moscow, Antonio Vairo of Milano University and Alexandre Zaitsev of the Institute for High Energy Physics (IHEP) Protvino, reported on the numerous candidates ▷


The parallel session on Heavy ion collisions & quark matter.


During a coffee break Jonathan Dorfan, director of SLAC, left, talks with Albrecht Wagner, chair of the DESY directorate.

Conference participants at the Russian Academy of Sciences.

for exotic hadronic states, both with light quarks only and with heavy quarks and/or gluons, that have been confirmed or newly reported by teams from the VES experiment in Protvino, BES II in Beijing, E852 at Brookhaven, CLEOc at Cornell, Belle at KEK, and BaBar at SLAC. These exotic states have still to be interpreted theoretically, within either gravity/gauge duality or more traditional approaches.

The Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory is intensively studying a relatively new area of QCD – the properties of matter at high temperatures and high particle densities. Timothy Hallman from Brookhaven, Larisa Bravina of the Skobeltsyn Institute of Nuclear Physics (SINP) Moscow University, Nu Xu of Lawrence Berkeley National Laboratory (LBNL), and Oleg Rogachevsky of JINR, among others, presented numerous experimental results, some of which were reported for the first time. These results suggest, quite surprisingly, as Xin-Nian Wang of LBNL explained, that collisions of highly energetic ions at RHIC result in the formation of strongly coupled quark–gluon matter, rather than weakly interacting quark–gluon "gas". Here, too, gravity/gauge duality can reflect the most remarkable properties such as the low viscosity of quark–gluon "fluid", jet quenching and so on.

Karel Safarik from CERN and Lyudmila Sarycheva of SINP described how QCD will be probed at even higher temperatures at the Large Hadron Collider (LHC) at CERN. Sissakian and Alexander Sorin of JINR reported on plans at the JINR Nuclotron for complementary studies of matter at lower temperatures but high baryon number densities; there are also plans at GSI, Darmstadt. Most likely, matter at these extreme conditions will exhibit new surprising properties in addition to those observed at RHIC.

Quarks and leptons

With the B-factories and Tevatron operating, this conference witnessed impressive progress in flavour physics, including B-meson decays, processes with CP violation, $b \to s$ and $b \to d$ transitions and so on, which featured in the review talks by KEK's Yasuhiro Okada and Masashi Hazumi and Robert Kowalewski from Victoria University. The discovery of B_s oscillations at the Tevatron was one of the highlights of the year. Doug Glenzinski of Fermilab reported on these results from the CDF collaboration, which reveal a mass difference between the mass eigenstates equal to 17.31 ps^{-1} (central value) (*CERN Courier* June 2006 p8). All data on flavour physics, including CP violation and B_s oscillations, are now well described by the Standard Model and Cabibbo–Kobayashi–Maskawa theory. Thus, the Standard Model once again has passed a series of highly non-trivial tests, this time in the heavy-quark sector.

Dugan O'Neil of Simon Fraser University and Florencia Canelli from Fermilab were among those presenting precision measurements of the masses of the heaviest known particles, which are still an important aspect of experimental high-energy physics. New results presented at the conference were based mainly on data from the CDF and D0 collaborations at the Tevatron. The top quark became lighter than it had been at the Beijing Conference in 2004 (*CERN Courier* January/February 2005 p37): now its mass is 171.4±2.1 GeV. Measurements of the W-boson mass are also more accurate. Making use of these data, the Electroweak Working Group has produced a new fit for the mass of the Standard Model Higgs boson, $m_h = 85^{+39}_{-28}$ GeV, which is somewhat lower than before. According to this fit, the upper limit on the Higgs boson mass is 166 GeV, as Darien Wood of Northeastern University explained. Yuri Tikhonov from BINP presented recent high-precision measurements of the mass of the τ lepton at Belle and at the KEDR detector at BINP, which have confirmed lepton universality in the Standard Model.

Beyond the Standard Model

The conference paid considerable attention to the search for new physics. Numerous possible properties beyond the Standard Model are even more strongly constrained than before, including supersymmetry; extra space–time dimensions; effective contact interactions in the quark and lepton sectors; additional heavy-gauge bosons; excited states of quarks and leptons; and leptoquarks. This was emphasized in various talks by Elisabetta Gallo of INFN Florence, Roger Barlow of Manchester University, Herbert Greenlee of Fermilab, Stephane Willocq of Massachusetts University and others. Yet most of the community is confident that new physics is within the reach of the LHC. Indeed, more theoretical scenarios for tera-electron-volt-scale physics beyond the Standard Model were presented at the conference, in talks for example by Rohini Godbole of the Indian Institute of Science, Alexander Belyaev of Michigan University, Pierre Savard of Toronto University and TRIUMF, Sergei Shmatov and Dmitri Kazakov of JINR, and Satya Nandi of Oklahoma University. Notable exceptions were Holger Bech Nielsen of the Niels Bohr Institute, who argued that even the Higgs boson might never be discovered (for a not necessarily scientific reason), and Mikhail Shaposhnikov of Lausanne University and the Institute for Nuclear Research (INR) Moscow, who defended his "nuMSM" model, which accounts for all existing data in particle physics and cosmology at the expense of extreme fine-tuning.

CERN's Fabiola Gianotti raised much interest by discussing the tactics for early running at the LHC, reflecting the community's thirst for new physics and the high expectations for the LHC. More generally, there was a sense of expectation as this was the last Rochester meeting before the start-up of the LHC.

The properties of neutrinos continue to be among the top issues in high-energy physics. Geoff Pearce of the Rutherford Appleton Laboratory presented the first data from a new player, the MINOS collaboration, which support the pattern of the oscillations of muon neutrinos observed by the Super-Kamiokande and KEK-to-Kamioka (K2K) experiments. Other collaborations presented refined analyses of their data in talks by Kiyoshi Nakamura of KamLAND and Tohoku University, Yasuo Takeuchi of Super-Kamiokande and Tokyo University, Kevin Graham of the Sudbury Neutrino Observatory and Carleton University, Valery Gorbachev of the Russian American Gallium Experiment and INR Moscow, and Yuri Kudenko of K2K and INR. These agree overall on oscillations of both electron and muon neutrinos, with evidence for oscillations of muon neutrinos into tau neutrinos confirmed by the Super-Kamiokande experiment. Also, the KamLand experiment has confirmed and enhanced the case for geo-neutrinos. The dominating oscillation parameters are now measured with the precision of 10–20%, except for the smallest mixing angle θ_{13} and a possible CP-violating phase, as Regina Rameika of Fermilab, Ferruccio Feruglio of Padova University and Kunio Inoue of Tohoku University explained. Interestingly, the range of neutrino masses $0.01\ \text{eV} < m_\nu < 0.3\ \text{eV}$, suggested by neutrino oscillation experiments, as well as by cosmology and direct searches, is in the right ballpark for leptogenesis – a mechanism for the generation of the matter–antimatter asymmetry in the universe.

Astroparticle physics is another area of continuing interest. Anatoli Serebrov of Petersburg Nuclear Physics Institute presented a new measurement of the neutron lifetime, which makes a significant contribution to the calculation of the abundance of primordial helium-4 in the universe. Techniques for the direct and indirect detection of dark-matter particles are rapidly developing, with indications for positive signals from DAMA and EGRET still persisting, as described by Alessandro Bettini of INFN Padova and by Kazakov. In cosmic-ray physics, the Greisen–Zatsepin–Kuzmin cut-off in the spectrum of ultra-high-energy cosmic rays is still an issue. Giorgio Matthiae of Rome University "Tor Vergata" presented the first data from the Pierre Auger Observatory. Masahiro Teshima of the Max Planck Institute, Munich, and Gordon Thomson of Rutgers University presented the new analyses by the AGASA and HiRes collaborations, respectively. As a result, as Yoshiyuki Takahashi of Alabama University explained, the discrepancy between different experiments is now reduced.

Traditionally, the Rochester conferences discuss future accelerators for high-energy physics and new developments in particle detection, and receive reports from the International Committee for Future Accelerators (ICFA) and the Commission on Particles and Fields (C11) of the International Union of Pure and Applied Physics (IUPAP). This was particularly timely in Moscow in view of the upcoming start-up of the LHC. At present, the scientific community is discussing a new megaproject – the large linear electron–positron collider with an energy of 0.5–1.0 TeV, known as the International Linear Collider (ILC). Together with the LHC, the ILC will be a unique tool for studying fundamental properties of matter and the universe. The talks by Skrinsky, DESY's Albrecht Wagner and Rolf Heuer, and CERN's Lyn Evans discussed the prospects for the project, including the contribution from Russia. Gregor Herten of Freiburg University, who heads the IUPAP Commission (C11), said that fundamental science is very important in Russia, and that the research conducted by Russian scientists is highly esteemed around the world.

Valery Rubakov summarizes in the final talk of ICHEP'06.

Valery Rubakov of INR Moscow closed the conference with a summary talk emphasizing both the current confusion of some theorists regarding new physics and the impact of the LHC on the entire field and beyond. The hope is that, with results from the LHC, at least some of the numerous questions raised in Moscow will be answered at the next Rochester conference, to be held in summer 2008 in Philadelphia.

The ICHEP'06 conference was jointly organized by the Russian Academy of Sciences, the Russian Federation (RF) Ministry of Education and Science, the RF Federal Agency on Science and Innovation, the RF Federal Agency on Atomic Energy, the Lomonosov Moscow State University and JINR, the main coordinator of the meeting. It was financially supported by IUPAP, the Russian Foundation for Basic Research, RAS, JINR and the RF Federal Agency on Science and Innovation.

● The authors are indebted to Valery Rubakov for his help in preparing this article.

Résumé

La Conférence de Rochester de retour en Russie

La Conférence internationale sur la physique des hautes énergies (ICHEP), connue aussi sous le nom de Conférence de Rochester, s'est à nouveau tenue en Russie à la fin juillet, cette fois à Moscou, où elle a rassemblé un millier de physiciens de 53 pays. Comme à l'accoutumée, séances plénières et sessions parallèles se sont combinées avec des présentations sur panneau. Les thèmes clés allaient de l'astrophysique aux scénarios théoriques et recherches expérimentales au-delà du modèle standard, en passant par la cosmologie, la physique des ions lourds, les modes rares de désintégration et la spectroscopie hadronique. Parmi les sujets traités figuraient aussi la technologie des grilles, les nouveaux accélérateurs et détecteurs de particules, et certains aspects de la théorie des champs quantiques comme de la théorie des cordes.

Gennady Kozlov, *JINR, and* **Simon Eidelman**, *BINP.*

New COMET brings a promis

PROSCAN, the proton-therapy facility at PSI in Switzerland is about to resum
proton accelerator, COMET. This will take the project into a new tec

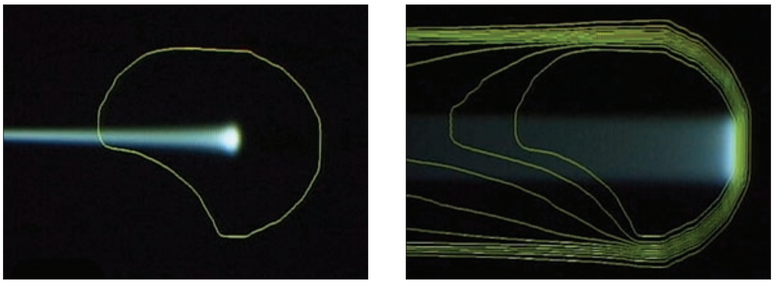


Fig. 1. The principle of dose delivery through active spot scanning, from le sweeping or superposition of multiple pencil beams; range-shifting with m

Fig. 2. The current PSI PROSCAN compact Gantry 1, which uses the active spot-scanning method. The rotating beamline gantry weighs more than 100 tonnes and is controlled to sub-millimetre precision.

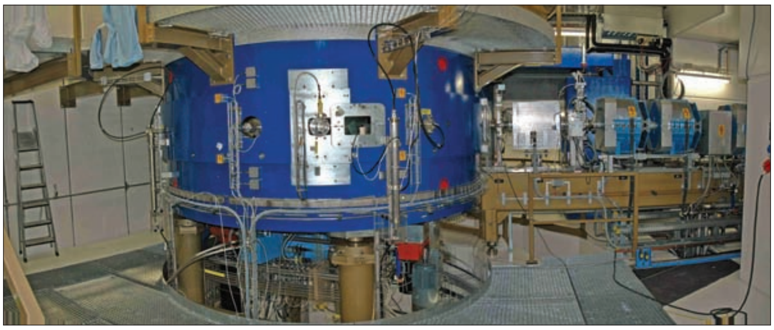


Fig. 4. The heart of the new PROSCAN Facility at PSI's Medical complex – the newly commissioned 3.25 m diameter, 250 MeV superconducting cyclotron, COMET, built by ACCEL Instruments in Germany, and based on a design by Henry Blosser of Michigan State University. Part of the extraction beamline is visible to the right of the picture.

In Europe, one in three people is expected to confront some form of cancer during his or her lifetime. In Switzerland alone, this amounts to about 28 000 patients a year – 70% of whom undergo radiotherapy, now the second most successful form of treatment after surgery. While the majority of tumours are treated with photons, the use of proton beams, first proposed 60 years ago, is becoming increasingly important for deep-seated tumours, as the technique moves from accelerator centres to dedicated clinical facilities (see p17). The Paul Scherrer Institute (PSI) is one of Europe's leading centres for proton-therapy research and has recently begun work with a new superconducting proton cyclotron, COMET, and beamline to serve its proton-therapy project, PROSCAN.

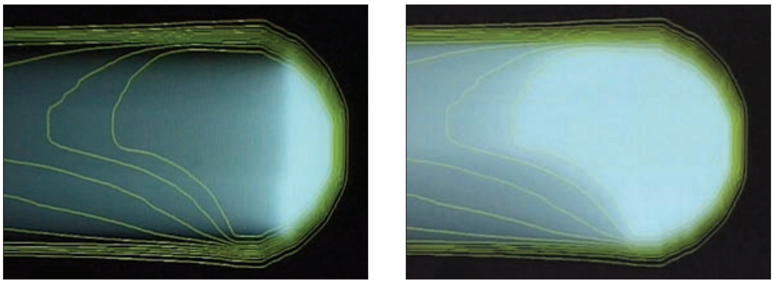
PROSCAN grew from PSI's decision in 2000 to expand its radiotherapy activities by developing a new compact gantry system to enable the laboratory's successful spot-scanning technology to be used in a hospital environment. The project also aims at optimizing treatment methods and expanding the spectrum of treatable forms of cancers, as well as transferring the technology and know-how to industry and other radiotherapy centres, including the education and training of specialist personnel.

PSI's pioneering development of the spot-scanning technique for deep-seated tumours dates back to its former times as the Swiss Institute for Nuclear Research (SIN), when the laboratory established a therapy programme using pions. This used a dynamic beam-delivery system of 60 converging pion beams where the patient's target area could be moved 3-dimensionally within a body (bolus) of water. Some 500 patients were treated with this system between 1981 and 1992. Protons for both the pion work and the subsequent proton-therapy programme at the Gantry 1 system described below were produced by the main 590 MeV Ring Cyclotron and a beam-splitter system, which at the same time served the main users in particle physics and materials science. In 1984, in collaboration with the Lausanne University Eye Clinic, the very successful OPTIS Proton Therapy Programme began. A first in Europe, this facility has treated more than 4400 patients with differing forms of eye tumours, using a 70 MeV horizontal proton beam from PSI's Injector 1 cyclotron. With a success rate of better than 98%, it continues to treat the highest number of eye patients worldwide each year, and has led in turn to the establishment and operation of six new European facilities in England, France, Germany, Italy and Sweden.

Modern ways to achieve a conformal dose distribution tailored 3-dimensionally to a target tumour volume, while sparing healthy tissue, use active scanning rather than conventional passive scattering (Goitein *et al.* 2002). The latter, which has fewer degrees of freedom, uses a set of scattering foils to produce a laterally spread-out proton beam of constant range. A set of individually

sing future to proton therapy

me patient treatment after commissioning a new dedicated superconducting
chnological and clinical phase, as **Peter-Raymond Kettle** explains.



eft to right: dose profile from a single proton pencil beam; lateral
material or beam energy change; and final conformal dose profile.

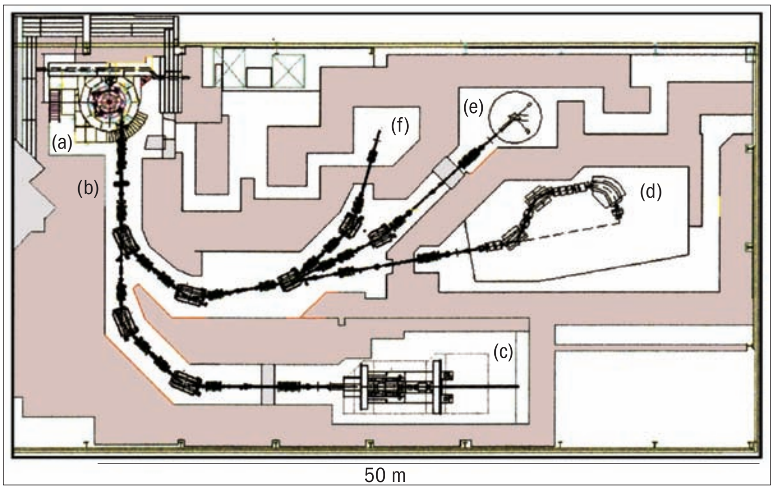


Fig. 3. The layout of the PROSCAN facility showing the ongoing expansion to the dedicated proton-therapy project: a) the superconducting cyclotron, COMET; b) the degrader station; c) Gantry 1; d) Gantry 2; e) OPTIS 2 eye-treatment area; and f) the experimental area.

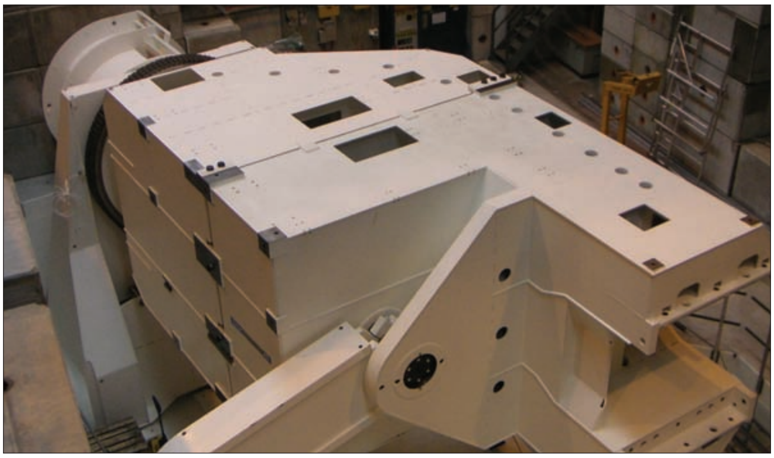


Fig. 5. The PROSCAN facility's new fast-scanning, compact Gantry 2.

manufactured collimators and compensators then contours the beam to match each target volume. The range of the protons is subsequently modulated by, for example, a rotating range-shifter wheel, which alters the proton depth profile.

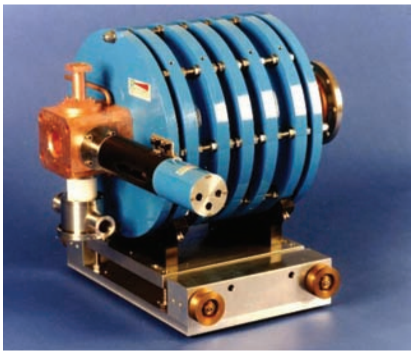
Figure 1 illustrates the principle of active scanning. Here the dose delivery to the patient is achieved through the sequential superposition of single pencil beams of protons, each of which produces a hot spot at the Bragg peak, where the protons deposit most of their energy (see p17). The hot spot is about 1 cm^3 for a Gaussian beam profile of 7–8 mm FWHM. Lateral scanning is possible either using sweeper magnets or by moving the patient table, or by a combination of both. Depth modulation, on the other hand, is achieved either by a fast active degrader or by changing the beam energy. Combining these options with both a beam-delivery system that can rotate and an eccentrically mounted counter-rotating patient table yields the very compact (4 m diameter) PSI Gantry 1 system (figure 2).

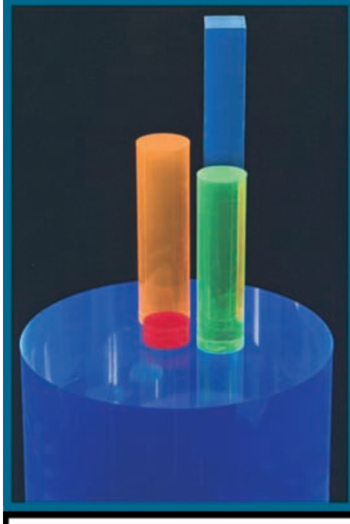
This system allows a dose application of almost 10 000 spots/litre to be applied in a few minutes with an individual spot-dose precision of 1%. It is the only facility in the world to use a dynamic beam-delivery technique based on active spot scanning with protons. A similar scanning system using a horizontal beamline has been developed for carbon ions at Germany's national laboratory for heavy-ion physics, GSI in Darmstadt.

Gantry 1 was designed to treat deep-seated tumours and since it started up in 1996 has handled around 260 patients, some 69 of whom were treated with a new therapy plan using intensity-modulated proton therapy (IMPT), which further reduces the dose to healthy tissue. One of the main disadvantages of the present spot-scanning technique as applied in Gantry 1 is the modulation speed, which is currently too slow to apply IMPT to moving target volumes. This will soon be addressed with the new features being incorporated into Gantry 2, within the PROSCAN project.

The PROSCAN project

When PROSCAN is complete it will consist of six main features (figure 3), with the newly commissioned 250 MeV superconducting cyclotron, COMET, as the heart of the facility (figure 4). ACCEL Instruments, Germany, built this machine in close co-operation with accelerator specialists at PSI, and based it on a design by Henry Blosser of Michigan State University. It will allow year-round therapy operation. The decision in favour of a cyclotron was based on the benefits of the 100% duty cycle and the need to control the beam intensity precisely and dynamically prior to acceleration. The restriction of the fixed energy from a cyclotron in turn requires a degrader system that acts rapidly, allowing fast, small energy steps to be implemented. This, together with a beam-diagnostics sys- ▷





tem after the degrader, means that the rapid modulation of both energy and intensity can be fully exploited, allowing the possibility of fast volumetric rescanning and the study of IMPT for moving tumours. The new machine also achieved the stringent requirement of an 80% extraction efficiency and an availability of 98%.

Gantry 1 will remain unchanged and will continue as the workhorse for treating patients in PROSCAN. The development work will concentrate on implementing IMPT methods into clinical practice, including treatment planning, dosimetry and quality-assurance. The present OPTIS eye-treatment facility at the Injector 1 cyclotron will continue its successful operation until mid-2007 when it will be transferred to the new 70 MeV area at PROSCAN. This will involve a complete re-design of the control system and treatment procedures. The second of the two horizontal beamlines will do biological and dosimetry experiments.

Finally, to meet the challenge to proton therapy of producing a beam-scanning method that can overcome the sensitivity to organ motion, a new compact gantry system, Gantry 2, is being built to be implemented in 2007, with the first treatments of patients expected in 2008 (figure 5 p25). This will allow faster beam scanning by 2D magnetic deflection, to achieve multiple target rescannings of the same volume within a single sitting (Pedroni *et al.* 2004).

Once the PROSCAN facility is fully operational it is expected that the number of patient treatments for deep-seated tumours will increase by a factor of 3–4 (150–250 patients a year) with a further 200–300 patients a year benefiting from the OPTIS eye-treatment station. It has taken some 50 years from the basic idea for protons to come of age as a clinical tool, enabling more than 40 000 patients so far to benefit from this therapy developed in a multi-disciplinary fashion. Although the future is clearly aimed at providing dedicated commercial facilities for hospitals and clinics, the present role played by accelerator laboratories such as PSI, in developing new methods and the technology to implement them, is an essential ingredient in achieving this goal.

Further reading

For further information about proton therapy at PSI see http://p-therapie.web.psi.ch/e/.

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Résumé

Le nouveau cyclotron COMET au service de la protonthérapie

Fort d'une expérience de plus de 20 ans en protonthérapie, en particulier pour le traitement des tumeurs oculaires, l'Institut Paul Scherrer (PSI) compte parmi les grands centres européens de recherche dans le domaine. Il a récemment commencé à travailler avec un nouveau cyclotron supraconducteur à protons commercial, COMET, et une nouvelle ligne de faisceau aux fins de son projet de protonthérapie, PROSCAN, qui entrera ainsi dans une nouvelle phase technologique et clinique. Le projet vise à la fois à adapter à un environnement clinique la méthode efficace du «balayage actif» du PSI, et à optimiser les méthodes de traitement pour un plus grand nombre de cancers.

Peter-Raymond Kettle, *PSI.*

Hard Probes conference focuses on jet quenching

The latest jet-quenching results were a major topic of discussion at the second conference dedicated to the use of hard probes for investigating the hot and dense quark–gluon matter that is produced during high-energy heavy-ion collisions.

The beautiful Asilomar resort, on the Pacific coast of the Monterey Peninsula in northern California, attracted 130 participants to the Second International Conference on Hard Probes of High Energy Nuclear Collisions, on 11–19 June 2006. The Hard Probes series brings together experimentalists and theorists to discuss perturbative quantum chromodynamics (pQCD) in the context of relativistic heavy-ion physics. Penetrating, hard probes provide essential tools for understanding the properties of the hot and dense QCD matter that is produced in nuclear collisions at the Super Proton Synchrotron (SPS), the Relativistic Heavy Ion Collider (RHIC) and, in the near future, at the Large Hadron Collider (LHC). The programme was divided into three areas: jets and high transverse-momentum (high p_T) hadrons, heavy flavour and quarkonia, and photons and dileptons.

Monterey provided the conference setting. (Courtesy S A Bass.)

Jet quenching

Producing jets by the hard scattering of quarks and gluons from incoming projectile particles is the hard probe par excellence. One of the most striking early results at RHIC was the discovery that jets are quenched in hot QCD matter, providing a direct measurement of the parton number density and transport properties of the system that is produced. Since that initial discovery, RHIC experiments have extended their studies of jet quenching in many directions. The Pioneering High Energy Nuclear Interaction eXperiment (PHENIX) now measures strong suppression of pion production up to a p_T of 20 GeV, while observing that direct photons (which do not carry colour charge, in contrast to the jets generating the pions) are not suppressed, as Gabor David of Brookhaven National Laboratory (BNL) explained.

One of the highlights of the conference was the discussion of the unexpectedly large suppression of high-p_T D and B mesons, measured by PHENIX and by the Solenoidal Tracker At RHIC (STAR). These results challenge the robust QCD prediction that heavy quarks experience smaller radiative energy loss in matter than light quarks or gluons, as Carlos Salgado from the University of Rome “La Sapienza”, Magdalena Djordevic of Ohio State University, Che-Ming Ko of Texas A&M University and others described. Matteo Cacciari from the Université Pierre et Marie Curie reviewed the pQCD calculations of charm and bottom production at colliders and the implications for RHIC. In addition, in two exciting ad hoc night sessions, theorists debated vigorously the merits of various approaches to calculating radiative energy loss in QCD, while the experimentalists kept score.

New insights into jet quenching featured in the talk by Krishna Rajagopal of Massachusetts Institute of Technology (MIT). He presented a recent calculation of the jet quenching parameter $\hat{q}$ in string theory using the intriguing anti-de Sitter space/conformal field theory correspondence between strongly coupled QCD and weakly coupled gravity. Other non-static parameters of QCD-like hot matter can also be calculated in this approach, in particular the viscosity and heavy-quark diffusion coefficient, as discussed by Ed Shuryak of Stony Brook University (SUNY), Pavel Kovtun of the Kavli Institute for Theoretical Physics, and Urs Wiedemann from CERN. These new theoretical developments provide insight into dynamical properties of non-perturbative QCD that cannot be directly treated by either perturbative or lattice methods.

Another important focus of discussion was the modification of dijet azimuthal correlations in the medium. Thomas Peitzmann, of Utrecht University/NIKHEF, showed how STAR has put the back-to-back nature of dijets to good use, most recently reporting the measurement of the high-momentum “punch through” products of the recoiling jet. Given the large jet-energy loss, it is natural to ask where the lost energy goes and how the medium responds to it. Theorists have proposed that Mach cones or Cherenkov radiation might be produced in the process, as Abhijit Majumder of ▷

Participants at the 2006 Conference on Hard Probes of High Energy Nuclear Collisions, held in Asilomar in California.

Duke University and Thorsten Renk of Jyvaskyla University discussed. Two-particle correlation measurements have shown previously that the recoiling jet is both softened and broadened in matter, but insight into the specific mechanisms at play requires higher-order correlations. Marco van Leeuwen of Lawrence Berkeley National Laboratory (LBNL) reviewed three-particle correlation techniques and their subtleties, and Jason Ulery of Purdue University and Nuggehalli Ajitanand of SUNY presented new, high-statistics three-particle correlation measurements from STAR and PHENIX, respectively. The data suggest the formation of a cone structure from shock waves or Cherenkov radiation. With improved statistical and systematic uncertainties in the near future, such a measurement could provide important information on the speed of sound or the dielectric constant in the strongly interacting quark–gluon plasma.

The STAR collaboration also reported "near side" correlations in which the jet structure is elongated owing to coupling with the longitudinally flowing medium, a theoretical prediction that Nestor Armesto of Santiago de Compostela reviewed. The jet-quenching results from RHIC have stimulated the reanalysis of high p_T heavy-ion data from the SPS, described by Christoph Blume and Mateusz Ploskon of Frankfurt University, which show surprisingly similar (albeit less spectacular) effects. Jet measurements will undoubtedly play an important role in the heavy-ion programme at the LHC, as CERN's Andreas Morsch, MIT's Gunther Roland, and BNL's Helio Takai from the ALICE, CMS and ATLAS experiments, respectively, explained.

Heavy quarkonium and dimuouns

In 1986, Helmut Satz of Bielefeld University, together with Tetsuo Matsui, suggested that deconfinement would be signalled by the melting of heavy quarkonium states, and quarkonium suppression was well represented at the conference. Masayuki Asakawa of Osaka University, Takashi Umeda from BNL and Agnes Mocsy from RIKEN-BNL presented the latest lattice gauge calculations on heavy quarkonium at finite temperature which show that, in contrast to early calculations, the ground states (J/ψ, Υ) survive at least up to twice the critical QCD temperature, whereas excited states such as the ψ' and χ_c melt around T_{crit}. At the conference Satz interpreted the similar J/ψ suppression pattern at RHIC and SPS, reported by Abigail Bickley of Colorado University/PHENIX and Roberta Arnaldi of INFN Torino/NA60, respectively, as resulting from the dissociation of ψ' and χ_c, which contribute via feed-down decay to 40% of the J/ψ yield. Robert Thews of Arizona University argued alternatively that direct J/ψ suppression is partially counterbalanced by heavy-quark recombination in the dense medium.

The venerable heavy-ion programme at the SPS continues to provide surprising and interesting results. Sanja Damjanovic from CERN presented the NA60 experiment's new, high-statistics low-mass dimuon measurements, which address the important question of the restoration of chiral symmetry. The spectral shape of the ρ meson in hot matter broadens but is not shifted in mass, in contrast to a long-standing prediction by Gerry Brown of SUNY and Mannque Rho of Saclay. Theorists were excited by these new data, which may provide a new window into the mechanisms underlying the breaking of chiral symmetry in the strong interaction.

All in all, the conference showed once again that hard processes are excellent probes of matter under extreme conditions of temperature and density. The large attendance, lively discussions, and marked experimental and theoretical progresses reported during the conference guarantee a strong future for the Hard Probes conference series. To maintain the now-traditional venue beside the sea, the next in the series will be held in 2008 at the spectacular thermal resort of A Toxa, on the Galician coast of the Iberian Peninsula.

Résumé

La Californie accueille la conférence Hard Probes

La deuxième conférence internationale sur les sondes dures des collisions nucléaires de haute énergie a attiré 130 participants à Asilomar, sur la côte pacifique de la Californie du Nord. Ce cycle de conférence rassemble expérimentateurs et théoriciens pour débattre de l'utilisation des sondes «dures» pénétrantes pour étudier la matière chaude et dense produite dans les collisions d'ions lourds. Le programme comprenait trois thèmes: les jets et les hadrons d'impulsion transversale élevée; les quarks lourds et les quarkoniums; et les photons et dileptons. Cette année, un moment fort a été la discussion sur les derniers résultats des «jet quenching».

David d'Enterria, *CERN*, **Peter Jacobs**, *LBNL*, **Dmitri Kharzeev**, *BNL, and* **Xin-Nian Wang**, *LBNL.*

Cracow meeting looks forward to the LHC

As preparations for the start-up of the LHC continue to gather pace, a meeting in Cracow gave physicists the opportunity to take time to look to the exciting physics in store.

About 200 physicists were in Cracow on 3–8 July to attend Physics at LHC 2006, organized by the Henryk Niewodniczański Institute of Nuclear Physics of the Polish Academy of Sciences and the University of Science and Technology, and hosted by the Polish Academy of Arts and Sciences. The third conference in the series, it should be the last to review only plans, expectations, hopes and nightmares related to the Large Hadron Collider (LHC). The next conference, in 2008, should summarize some first results.

Jos Engelen, CERN's chief scientific officer, opened the 2006 conference with a review of the status of the LHC project: apart from small delays, it should run on schedule. The rest of the first day focused on the Higgs problem. Robert Harlander of the Bergische Universität Wuppertal presented a theoretical overview of Higgs particles in the Standard Model (SM) and its various extensions. Vanina Ruhlmann-Kleider from Dapnia and Guillaume Unal from CERN then reviewed LHC plans, and Oscar Gonzalez Lopez of the Centro de Investigaciones Energéticas, Medioambientales y Technológicas, Madrid, reviewed results from Fermilab's Tevatron. Several further talks by experimentalists and theorists considered specific "Higgs discovery potentials" for LHC experiments in various decay channels.

The second day focused on supersymmetry (SUSY). CERN's Peter Jenni and Ludwik Dobrzyński of the Laboratoire Leprince-Ringuet presented the plans that the ATLAS and CMS collaborations have, respectively, for searching for SUSY particles. Jan Kalinowski of Warsaw University gave a theoretical overview of the subject both within and beyond the minimal supersymmetric SM (MSSM). He stressed that new physics at the tera-electon-volt scale is almost unavoidable, and that SUSY seems to be the best candidate. Elemer Nagy of the Centre de Physique des Particules de Marseille presented a summary of Tevatron results on SUSY, and CERN's Maria Spiropulu gave a general review of the LHC's potential in this field. Further talks followed on specific problems of SUSY particles and searches at the LHC, including astrophysical aspects.

A short session on the morning of the third day covered diffractive physics, and included a report on the HERA for LHC workshop by Albert de Roeck of CERN and a theoretical review by Joachim Bartels of the University of Hamburg. Valentina Avati from CERN described the TOTEM experiment, which will investigate diffractive physics at the LHC.

During a coffee break the organizers mix with some of the participants. From left: Michal Turala, Andrzej Bialas, Karolis Tamosiunas, Guenakh Mitselmakher and Daniel Denegri.

Fermilab's Joseph Lykken began the fourth day with an overview of theoretical physics, Standard Model and Beyond. He appealed for so-called "negative results" of searches for SM violations to be treated as exciting discoveries that may bring new understanding in particle physics. Marek Zieliński of Rochester University and Chris Hays of Oxford University reported on Tevatron results of SM tests, and Maarten Boonekamp of CEA/Saclay described the possibilities at the LHC. Stefan Pokorski of Warsaw University presented various theoretical routes beyond the SM (other than the MSSM). Sung-Won Lee of Texas Tech University reported on related searches at the Tevatron, and Reyes Alemany-Fernandez of the Laboratório de Instrumentação e Física Experimental de Partículas in Lisbon looked forward to the LHC. There were also more specific short talks.

Heavy flavours and heavy ions shared the fifth day. Ikaros Bigi of Notre Dame University gave an inspired theoretical review of heavy-flavour physics, and Jianming Qian of Michigan University and Rainer Bartoldus of SLAC reported on results from the Tevatron and B-factories, respectively. CERN's Tatsuya Nakada presented the future LHCb experiment. In heavy-ion physics, Carlos Salgado of the University of Rome "La Sapienza" and Gunther Roland of MIT presented theoretical and experimental reports, respectively. In this session, Eugenio Nappi of INFN reported on the ALICE experiment and other perspectives of heavy-ion research at the LHC. In the afternoon, parallel sessions covered more specific ▷

problems in both subjects.

The last day looked further into the future. Brian Foster of Oxford University presented the status of the International Linear Collider study, and Masa Yamauchi of KEK described the plans for super B-factories. Peter Saulson of Syracuse University looked at present and future searches for gravitational waves, and Pierre Binetruy of APC-Collége de France discussed the plans that astroparticle physicists have for the LHC and elsewhere, in particular the Laser Interferometer Space Antenna project.

CERN's John Ellis concluded the day and reflected on events beyond the conference by presenting past, recent and future events around the LHC as a World Cup football match: from the training camps, team selections and preparation, through the first and second half including injury time, and the extra time and penalty shooting. This corresponded to the early planning of the accelerator and experiments, forming the collaborations, detailed planning and construction, future early measurements, planned upgrades of detectors, possible necessary unexpected changes and plans for future accelerators. He stressed very strongly the role of the first LHC results in further planning. For example, it is quite possible that these results may prove that the energy range of a future electron linear collider must be far beyond present plans.

The conference was a success and showed the broad scope of problems to be dealt with at the LHC. It led to many new ties between existing members of the LHC community and others present, who may soon become involved in this great particle-physics adventure. The speakers, representing both the LHC management level and enthusiastic young physicists, allowed a better understanding of the unique role that this project will play in developing particle physics. The organizing committee assured the smooth running of the conference and a pleasant atmosphere. All the participants are looking forward to the next conference in the series, in which the first LHC results should be presented.

Further reading

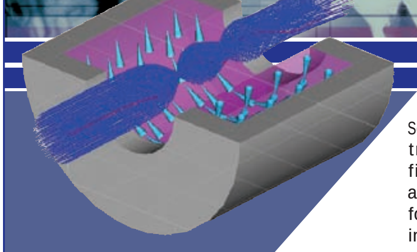
All talks and posters are available at http://newton.ftj.agh.edu.pl/physLHC/. In February 2007, *Acta Physica Polonica B will publish* the conference proceedings, which will soon afterwards be freely accessible at http://th-www.if.uj.edu.pl/acta/.

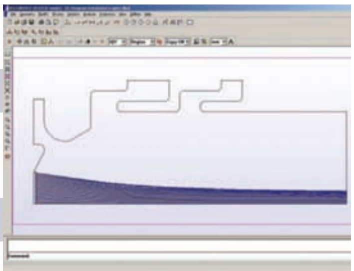
Résumé

Une réunion à Cracovie anticipe le LHC

Les préparatifs de la mise en service du Grand collisionneur de hadrons (LHC) s'accélérant, une réunion, tenue à Cracovie, a permis aux physiciens de prendre le temps d'anticiper les stimulants résultats que promet le LHC. Quelque 200 physiciens ont assisté à la conférence Physics at LHC 2006, organisée par l'Institut de physique nucléaire Henryk Niewodniczanski de l'Académie polonaise des sciences et l'Université des sciences et technologies, au sein de l'Académie polonaise des arts et des sciences. Troisième édition de la série, cette conférence devrait être la dernière à ne porter que sur des prévisions et des attentes liées au LHC; la prochaine édition, en 2008, devrait pouvoir faire une synthèse des premiers résultats.

Krzysztof Fialkowski, *Jagellonian University.*





LABORATORIES

NSF funds NSCL with $100 million

The US National Science Foundation has awarded the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University more than $100 million to fund operations through 2011. Established in 1963, the NSCL is the largest nuclear-science facility on a university campus in the US and educates about 10% of US nuclear-science doctoral students.

Much of the new funding will support the ongoing operation of the NSCL as a user facility and the work of NSCL nuclear scientists, which includes developing specialized methods of production and in-flight separation of nuclei with unusual proton-to-neutron ratios.

The NSCL's Coupled Cyclotron Facility is one of the leading user facilities for rare-isotope research, serving more than 700 users from 100 institutions in 35 countries. Fast beam techniques developed there have already advanced efforts to determine the basic properties of rare isotopes. In addition, researchers at the NSCL have implemented ion-trap techniques for precision experiments after slowing isotopes from more than 100 MeV per nucleon to thermal energies. Associate director Thomas Glasmacher received the 2006 Sackler Prize in the Physical Sciences for developing new, sensitive techniques to study the structure of exotic nuclei.

The National Superconducting Cyclotron Laboratory at Michigan State University.

Currently, the NSCL is implementing the capability to re-accelerate stopped rare isotopes for studies at energies near the Coulomb barrier. In collaboration with its user community, it is developing plans for a significant upgrade to its MSU-based laboratory, with the Isotope Science Facility as its working name.

Further reading

For more information about the NSCL see www.nscl.msu.edu.

COLLABORATION

East meets West at Rencontres in Hanoi

Two Rencontres du Vietnam held in Hanoi in August allowed physicists from Vietnam and neighbouring countries to meet with those from more distant places, including Europe and the US. Organized by Jean Tran Thanh Van, the parallel meetings on Challenges in Particle Astrophysics, and Nanophysics: from Fundamentals to Applications attracted more than 400 participants, including two Nobel laureates, James Cronin and Klaus von Klitzing. Highlights included a tour of the experimental facilities of VATLY, the cosmic-ray research group at the Institute of Nuclear Science and Technology, Hanoi, which is working with the Auger Collaboration under the leadership of Vo Van Thuan, former director of the Institute, and Pierre Darriulat, former research director of CERN.

The meetings also allowed Vietnamese physicists to express their interest in collaborating with CERN, particularly on the Large Hadron Collider (LHC) and on theoretical physics. A group led by Nguyen Mong Giao from Ho Chi Minh City is already participating in the D0 experiment at Fermilab, and is now exploring contacts with the ATLAS collaboration at the LHC, while a group led by Nguyen Mau Chung from Hanoi is working with the LHCb collaboration. The Institut national de physique nucléaire et de physique des particules and the Ecole Polytechnique Fédérale de Lausanne are already supporting these initiatives, as is the president of the Vietnam Academy of Science and Technology, Dang Vu Minh.

Vietnamese President Nguyen Minh Triet, sixth from right, receives a delegation from the Rencontres at his palace.

Participants in the 2006 Rencontres du Vietnam saw the rapid economic strides now being made by Vietnam. The omens are good for a growing Vietnamese presence at CERN, where several Vietnamese physicists are already active.

ANSWERS FROM P15

Top: This is not used for physics; it is a "Remy" rake known as the "Sun". Attached to a tractor, its task is to rake up the cuttings from those areas of the site given over to grassland. Robust and easy to handle, it enables the work to be carried out in difficult, even acrobatic, positions (such as on "Mount Citron" and the mounds of the Proton Synchrotron ring).

Bottom: No connection with the [other] photo, this many-legged octopus, tended by Mario Grossi, is actually a pile of three "pancakes" destined for a DC electromagnet under construction in NPA Division. The magnet will produce a field of 100 000 gauss and will be used for testing the properties of superconducting samples. Each pancake is made of a rectangular-section hollow conductor, 8.5 mm × 5.5 mm, spirally wound and cast in epoxy resin; it is so arranged that there are 11 parallel water circuits for cooling, but one continuous electrical circuit as in a simple coil. The complete magnet contains eleven pancakes mounted in an iron yoke.
● Taken from *CERN Courier* December 1963 pp156–157, with captions on p158.

AWARDS

APS announces the prizewinners for 2007

Clockwise from top left: Heinrich Wahl who retired from CERN in 2003, joint winner of the W K H Panofsky Prize; Stanley Brodsky, who won the J J Sakurai Prize; Lisa Randall, who won the Julius Edgar Lilienfield Prize; and Lee C Teng, winner of the Robert R Wilson Prize.

The American Physical Society (APS) has announced its awards for 2007, naming many recipients who work in particle physics and related fields.

The 2007 W K H Panofsky Prize in experimental particle physics, which aims to recognize and encourage outstanding achievements in the field, goes to Italo Mannelli of the University of Pisa/INFN, Heinrich Wahl, of the University of Ferrara and CERN, and Bruce Winstein of the University of Chicago. The award cites their "leadership in the series of experiments that resulted in a multitude of precision measurements of properties of neutral K-mesons, most notably the discovery of direct CP violation".

The Tom W Bonner Prize for outstanding experimental research in nuclear physics is awarded to Stuart J Freedman of the University of California, Berkeley. He won the prize for "contributions to neutrino physics and the study of weak interactions, in particular for his leading role in the KamLAND experiment, as well as for his work on precision measurements of the beta decay of the neutron".

In theoretical physics, the J J Sakurai Prize for outstanding achievement in particle physics is awarded to SLAC's Stanley Brodsky for "applications of perturbative quantum field theory to critical questions of elementary-particle physics, in particular, to the analysis of hard exclusive strong interaction processes". The Dannie Heineman Prize for mathematical physics goes to Juan Maldacena of the Institute for Advanced Study, Princeton, and Joseph Polchinski of the University of California, Santa Barbara. They receive this award for "profound developments in mathematical physics that have illuminated interconnections and launched major research areas in quantum field theory, string theory, and gravity".

The Hans A Bethe prize recognizes outstanding work in astrophysics, nuclear physics, nuclear astrophysics or closely related fields. The 2007 award goes to James R Wilson of the Lawrence Livermore National Laboratory for "work in nuclear astrophysics and numerical work on supernovae core collapse, neutrino transport and shock propagation". The citation adds that "his codes re-energized supernovae shocks, launched numerical relativity and magnetically driven jets".

In another area of particle astrophysics, the Einstein prize for accomplishments in gravitational physics goes to Ronald Drever of the California Institute of Technology and Rainer Weiss of Massachusetts Institute of Technology for "fundamental contributions to the development of gravitational-wave detectors based on optical interferometry, leading to the successful operation of the Laser Interferometer Gravitational-Wave Observatory". Gravitational-wave research also features in the Edward A Bouchet award, which recognizes a distinguished minority physicist. This goes to Gabriela Gonzalez of Louisiana State University for "her significant impact on the field of gravitation-wave physics through her many important technical and scientific contributions to the Laser Interferometer Gravitational-Wave Observatory and for communicating the excitement of this field to the scientific community and the public".

In observational cosmology Amy Barger of the University of Wisconsin-Madison receives the Maria Goeppert-Meyer award for outstanding achievement by a woman physicist in the early years of her career. She receives the award for “her pioneering efforts in using observational cosmology to provide new insight into the evolution of black holes, star formation rates and galaxies”. Lisa Randall of Harvard University receives the Julius Edgar Lilienfeld Prize for a most outstanding contribution to physics for “her pioneering work on particle physics and cosmology, and her tireless efforts to inspire and engage both specialist and non-specialist, by allegory and fact through publications and presentations”.

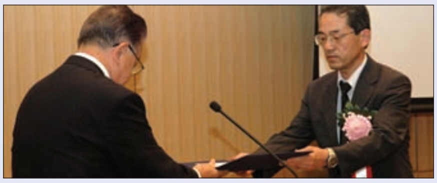
The Robert R Wilson Prize is awarded for achievement in the physics of particle accelerators. For 2007 this goes to Lee C Teng of Argonne National Laboratory for the “invention of resonant extraction and transition crossing techniques critical to hadron synchrotrons and storage rings, for early and continued development of linear matrix theory of particle beams, and for leadership in the realization of a facility for radiation therapy with protons”. Wilson was the first to propose proton therapy 60 years ago (see p24).

In August, the APS awarded the 2006 James Clerk Maxwell prize for plasma physics to Chandrasekhar Joshi, of the University of California Los Angeles (UCLA) for “insight and leadership in applying plasma concepts to high-energy electron and positron acceleration, and for his creative exploration of related aspects of plasma physics”. Now the Nicholas Metropolis Award for outstanding doctoral-thesis work in computational physics goes to Chengkun Huang, also of UCLA. He is rewarded for “his innovative work in plasma physics that led to the development of the QuickPIC code that has revolutionized the simulation of plasma-based accelerator research”. Meanwhile, the award for outstanding doctoral-thesis work in plasma physics, the Marshall N Rosenbluth award, goes to Cameron Geddes of the Lawrence Berkeley National Laboratory for “experimental and computational studies of channel-guided laser-wakefield accelerators” (*CERN Courier* November 2006 p5).

Dissertation awards also recognise work in several areas of particle physics. The dissertation award of the APS Division of Atomic, Molecular and Optical Physics goes to Brian C Odom of the University of Chicago, for the “measurement of the electron *g*-factor in a sub-Kelvin cylindrical cavity” (*CERN Courier* October 2006 p35). The Dissertation Award in Nuclear Physics goes to Kathryn K S Miknaitis of the University of Washington, for her work on salt-phase data from the Sudbury Neutrino Observatory to identify day–night variations in the rate of neutrino interactions, and to Magdalena Djordjevic of Columbia University for her work on a theoretical treatment of heavy-quark energy loss in a strongly interacting quark–gluon plasma in which the gluon radiative energy loss was solved to all orders in opacity.

AWARDS

Rafael Ballabriga, right, a PhD student working in the Microelectronics Group at CERN on the Medipix3 project has won the IEEE Nuclear and Plasma Sciences Society Student Paper Award. Medipix3 is the latest stage in adapting hybrid pixel detectors, developed for particle tracking at the Large Hadron Collider, for single photon counting in applications such as medical X-ray imaging. Ballabriga's prototype chip uses the latest CMOS technology to allow neighbouring pixels to pool information event-by-event, providing precise simultaneous measurements of position and energy. The award was presented at the recent IEEE Nuclear Science Symposium. (Courtesy Bo Yu.)



Tom Haruyama of KEK, right, has won the Commendation of the Research and Education Promotion Fund from the Alumni Association of Keio University Faculty of Science and Technology. It recognizes his development of a pulse-tube cryocooler for liquid-xenon particle detectors. This technology is used at CERN and is being studied for further applications in detectors.

VISITS

Karlsruhe keeps strong links with CERN

On 6–8 October 40 people from the University of Karlsruhe visited CERN. Headed by the rector, Horst Hippler, they included members of the university president's office, senate and administration. After a welcome by Sigurd Lettow, chief financial officer designate at CERN, Maximillian Metzger, secretary general, and Herwig Schopper, former director-general of CERN, the group toured the Tier0 Computing Centre, the tunnel of the Large Hadron Collider, and the CMS detector. Scientists and graduate students from Karlsruhe who work at CERN concluded the visit with a presentation of the CMS Tracker Integration Facility. The close relationship between CERN and Karlsruhe, initiated by Schopper more than 40 years ago, is now continued by Thomas Müller, Schopper's successor at the Institut für Experimentelle Kernphysik at Karlsruhe, and by Lettow, former co-head of the Forschungszentrum Karlsruhe.

Visitors from the University of Karlsruhe in front of the CMS detector, together with Sigurd Lettow and Austin Ball from CERN.

MEETINGS

IDTB07, the ILC Detector Test Beam Workshop, will be held at Fermilab on 17–19 January 2007. The workshop will discuss the detector R&D programme for the International Linear Collider (ILC) in view of the need for test beams, with the opportunity to evaluate the capabilities of existing facilities. Facility managers will describe the current and future test-beam facilities and their availability. For further information see https://conferences.fnal.gov/idtb07/.

INPC2007, the 23rd International Nuclear Physics Conference, will be on 3–8 June 2007 in Tokyo. The conference will comprise plenary talks and parallel sessions and will include a special session commemorating the centennial of Heidiki Yukawa's birth, and will be open to the public. Online submission of papers for the conference will be available until 22 January. For further information about submission and registration visit www.inpc2007.jp.

The **13th Lomonosov Conference on Elementary Particle Physics** will be at the Moscow State University on 23–29 August 2007. These biennial conferences bring together about 300 theorists and experimentalists from different countries to review the current status and future prospects in elementary-particle physics. The programme of the 13th conference will include neutrino physics, astroparticle physics, gravitation and cosmology, and electroweak theory. For registration (deadline 1 March 2007) see the conferences section at www.icas.ru/english/index.htm. For further information contact Alexander Studenikin, chair, e-mail studenik@srd.sinp.msu.ru or Alexander Grigoriev, conference scientific secretary, e-mail ane@srd.sinp.msu.ru.

NEW PRODUCTS

SAES Getters and **SUSS MicroTec** have announced technologies that extend the lifetime of wafer-level packaging for micro-electro-mechanical systems (MEMS) applications. SUSS MictoTec's M-Lock system provides an ultra-clean, low moisture and low-organics environment for vacuum and inert-gas wafer bonding. SAES Getters has engineered PaGeWafer to guarantee long-term stability for vacuum or inert-gas atmosphere in wafer–wafer hermetically bonded MEMS devices by maximizing absorption of active gases such as H_2O, O_2, CO, CO_2, N_2 and H_2. For further information see www.saesgetters.com or www.suss.com.

ANNIVERSARY

Yuriy Zaitsev celebrates his 70th birthday

Yuriy Zaitsev from the Institute of Theoretical and Experimental Physics (ITEP), Moscow, celebrates his 70th birthday on 5 December. He now looks forward to having spent 50 years at ITEP, where he is a head of the laboratory of heavy quarks and leptons. In honour of his birthday, ITEP is hosting an international colloquium on the most interesting aspects of modern high-energy physics on 7–8 December.

In the 1960s Zaitsev participated in the pioneering measurements of pion–pion interactions at low momentum-transfer at the Joint Institute for Nuclear Research and at ITEP. He then took part in experiments on high-energy particle interactions with nuclei at ITEP and Fermilab during the 1970s.

In 1979 Zaitsev joined the ARGUS collaboration at DESY as a group leader on the design, construction and operation of the muon detector. In 1997 he received the W K H Panofsky Prize in Experimental Particle Physics of the American Physical Society, together with Henning Schroeder from DESY, for "their leading role in the first demonstration of mixing in the B_0–$\bar{B}_0$ system". For the past decade he has coordinated the construction and operation of the muon detector in the HERA-B experiment at DESY, and the construction of the precision muon spectrometer for the OPERA detector in the Gran Sasso underground laboratory.

During the 1990s Zaitsev lectured at the Moscow Engineering Physics Institute and at the High Energy Physics department of the Moscow Institute of Physics and Technology, while also chairing the department in 1997/98. Many young and already mature scientists have received care, attention and advice under his leadership. Zaitsev also applied his professional approach in sport, helping him to become handball champion of the USSR in 1966. At 70 he still competes at the students' football friendlies.

OBITUARIES

Wolfgang Schnell 1929–2006

Left: Wolfgang Schnell in 2004, displaying a piece of equipment for the CLIC test facility. Above: Wolfgang with John Adams, PS project leader, in the famous picture that marked the start-up of the PS accelerator in 1959. From left to right: John Adams, Hans Geibel, Hildred Blewett, Chris Schmelzer, Lloyd Smith, Wolfgang Schnell and Pierre Germain (with his back to the camera).

Wolfgang Schnell died on 2 October after an illness that he endured with great courage and lucidity. He was one of CERN's pioneers. After gaining a physics degree from the University of Heidelberg he worked at the Max-Planck Institute there, before joining the Proton Synchrotron (PS) construction team in 1954. He made numerous and significant contributions to accelerator physics and technology throughout his career.

Working in the group led by Chris Schmelzer, Wolfgang achieved a breakthrough in 1959 during the running-in of the PS, which was suffering from substantial beam loss during acceleration with the radio-frequency (RF) programming based on the magnetic field. With his phase-lock feedback system the beam went immediately to 24 GeV with hardly any losses. He later proudly showed his younger colleagues that the electronics of his system was built inside a coffee tin.

Wolfgang then became a member of the design team that studied the next generation of CERN accelerators after the PS – namely the Super Proton Synchrotron (SPS) and the Intersecting Storage Rings (ISR). He contributed significantly to both.

He proposed a travelling-wave structure for the 300 GeV SPS to accelerate the particles, which are already nearly relativistic at injection energy. A system of four such structures is still used in the SPS, faithfully accelerating protons since 1976 and ions since 1990.

The ISR was the first proton–proton collider. It was constructed in the late 1960s and operated from 1973 to 1983. Wolfgang led the design and construction of the RF system, including the many improvements implemented during the lifetime of the ISR. Examples of the novel ideas that he introduced are the missing-bucket scheme, based on a suggestion of Arnold Schoch, which increased the stacked beam current by a factor of 1.5, and equipping the vacuum chamber with clearing electrodes. He was responsible for the running-in and performance improvements of this tricky accelerator, which eventually stored up to 40 A of protons for each coasting beam in colliding mode and reached beam lifetimes exceeding many months. The final luminosity was 35 times the design value.

During this period Wolfgang discovered the transverse Schottky signal, a type of noise generated by the random transverse motion of the particles. This was immediately used to obtain some indication of the betatron frequencies of the DC beam, which previously could not be measured. The discovery of this signal led to another of Wolfgang's unique accomplishments: the resurrection and first experimental proof of the stochastic cooling of beams, based on the concept invented by Simon van der Meer in 1968 but considered to be without a practical application. It opened the door to antiproton cooling and, consequently, to proton–antiproton collisions, a technique that was highly successful in the SPS and remains so in the Tevatron at Fermilab.

In 1983 the ISR was shut down in favour of the Large Electron–Positron (LEP) collider and Wolfgang was a leader of the initial study group for this unique facility. He went on to be the driving spirit of the LEP RF group, which constructed the world's largest and most complex RF system. This was based on copper cavities coupled to spherical storage cavities that lowered the power consumption by a factor of 1.4, another of Wolfgang's original ideas. Also in 1983 he and Steve Myers presented the first paper on the parameters of a future proton–proton collider in the LEP tunnel – now the Large Hadron Collider – and participated in the brainstorming about CERN's future in 1985 chaired by Carlo Rubbia. It was then that he proposed an attractive, more practical variant of a two-beam scheme for a linear electron–positron collider, which is considered to be of strong potential for reaching the highest energies and is being studied at CERN as the Compact Linear Collider (CLIC). Wolfgang led the CLIC study with great enthusiasm for almost 10 years and contributed with various novel ideas even after his retirement.

His accomplishments were internationally recognized, as reflected in his membership of high-level international committees, and by the award of the Prize for Achievements in Accelerator Physics and Technology in the US and the *Doctor honoris causa* by the University of Heidelberg. He also played a leading role in the management of CERN as director of the ISR department after Kjell Johnsen, and as a prominent member of committees and project teams, and he was renowned for his implementation of a lean management while keeping a keen eye on the essentials.

Wolfgang will be remembered as a friend and a colleague who could create a team spirit, not as a boss but by being a natural leader with contagious enthusiasm. His ability to solve the most complex RF and beam-dynamics problems by the simplest means based on his deep insight was proverbial. He was always approachable to the young people to whom he was a patient tutor and mentor. He kept in close contact with his technicians and workshop staff to follow the latest developments and to keep his feet on the ground.

Many will be proud to have been part of one of his teams and to have had the honour to work with him. He will be sorely missed.
His colleagues and friends.

Vitali Kaftanov 1931–2006

Vitali Kaftanov died on 14 September at the age of 74. He was an outstanding Russian physicist, professor and former deputy-director of the Institute of Theoretical and Experimental Physics (ITEP) in Moscow. He was born on 3 December 1931 in Moscow to the family of well known Soviet scientist, Sergey Kaftanov. In 1954 he graduated with honours from Moscow State University, where he specialized in nuclear physics.

In the mid-1950s international contacts began to develop between Soviet scientists and their foreign colleagues. Fluent in English, the young physicist Kaftanov was included in a Soviet government delegation, which participated in international conferences on the peaceful use of atomic energy taking place in Geneva under the auspices of the UN. It was here that Kaftanov met colleagues from the recently founded CERN. He had by then become a scientific researcher at ITEP, where he was working on similar issues to his CERN colleagues.

In 1960 the directorate of CERN made a proposal to the Soviet Academy of Sciences that Soviet scientists could participate in international experiments, and Kaftanov became the first candidate for this role. From then on he had close relations with CERN, spending most of his life in Geneva. He was also involved in developing scientific technology and cultural collaboration between Russia and Switzerland. For a long time he was head of the neutrino research programme of ITEP, which involved accelerators at CERN, the Institute for High Energy Physics at Protvino and Fermilab.

For the past 15 years Kaftanov was a member of the CMS project at CERN and was one of the founders of the Russia and Dubna Member States (RDMS) CMS Collaboration. As a founding member of the magnet technical board, he was involved in designing and building the CMS magnet. He was also the RDMS technical coordinator for a long time and was key in assembling and commissioning the CMS detector.

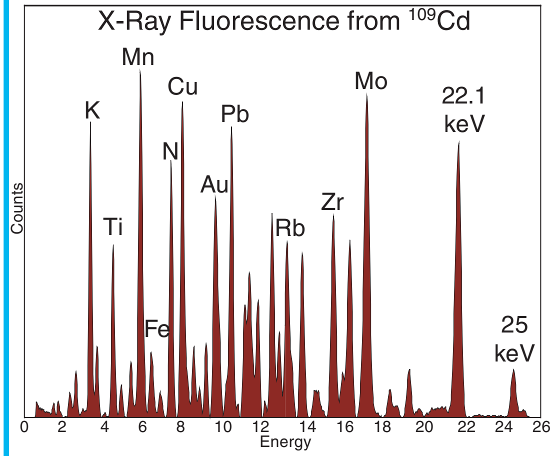
Kaftanov's collaborative attitude and devotion to his work won him high regard and the admiration of all who know him. He will be sorely missed.
His colleagues and friends at the CMS collaboration.

Pedro Pascual 1934–2006

Pedro Pascual died on 29 October, aged 72. He made a difference to Spanish particle physics and was the first scientist to bring theoretical high-energy physics to Spain in the early 1960s from his period of learning with Yoichiro Nambu in Chicago. He educated the first highly competitive generation of theoretical particle physicists and led the development of experimental high-energy-physics groups across Spain.

Pascual established the present Spanish system for evaluating researchers by the quality of their work. He also founded the Benasque Center for Science, which will now carry his name.

We remember his unlimited capacity for work and his uncompromising enthusiasm for excellence. His spirit will remain with us.
J I Latorre, Physics Department, University of Barcelona.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Center for Advanced Microstructures and Devices (CAMD)
Baton Rouge, Louisiana 70803

RESEARCH ASSOCIATE 4 AND/OR RESEARCH ASSOCIATE 5

The J. Bennett Johnston, Sr., Center for Advanced Microstructures and Devices (CAMD) is a Synchrotron Light Source research facility operated by Louisiana State University located in Baton Rouge. At the heart of the facility is a 1.3 GeV second generation electron storage ring which provides radiation extending from infra red through VUV up to X-rays for use in a diverse scientific research program. The facility operates on a continuous 24/7 schedule. The accelerator group, which is responsible for operating and developing the storage ring and its associated injection accelerator, currently has one or more vacancies for Accelerator Physicists. **Responsibilities:** participates in the beam studies program at CAMD which aims to improve and extend the understanding of the Light Source to maintain and improve the level of performance as required by the science research activities; contributes to computational and theoretical studies aimed at increasing the beam brightness of the storage ring through the elimination of beam instabilities driven by cavity higher order modes and by reducing the vertical beam size through emittance coupling control; contributes to computational and theoretical studies needed to develop plans for installing a second Insertion Device in CAMD and to upgrade the existing 7.5 T superconducting wiggler magnet; participates in the development of designs for a high brightness 3rd generation Light Source which is proposed as a South eastern regional facility.

Required Qualifications: (RA 4) Ph.D. in Physics, Engineering or a related field; **(RA 5)** Ph.D. in Engineering or a related field; one year of accelerator research experience; familiarity with the major accelerator software design codes. **Special Requirements: (Both levels)** ability and willingness to work during evenings and weekends occasionally as required in general support of the storage ring. Salary and level will be commensurate with qualifications and experience. See our website at www.camd.lsu.edu for further details about CAMD. Review of applications for the position will begin immediately. Deadline is December 15, 2006, or until filled. Please submit letter of application, C.V. (including e-mail address), and three references with contact information to: Craig P. Stevens, CAMD, 6980 Jefferson Highway, Louisiana State University, Ref: Log #0794, Baton Rouge, LA 70806. Phone: (225) 578-4603; Fax: (225) 578-6954; Email: evstev@lsu.edu. For further technical information you may contact Victor Suller at the above address, e-mail at vsuller@lsu.edu or via telephone at (225) 578-9366

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Survey and Alignment Engineer

Lawrence Berkeley National Laboratory (LBNL) is seeking a talented Survey and Alignment Engineer to lead the survey and alignment section at the Advanced Light Source (ALS). This is a two-year term position with the possibility for renewal, reporting to the Mechanical Engineering Group Leader for the ALS.

The Survey and Alignment Engineer plays a critical role in providing multifunctional technical support, and applying engineering and technical principles, concepts, and practices in the area of survey and alignment to the ALS accelerators and beamlines. We're seeking an experienced professional with 6-8 years of technical and alignment experience to lead our ALS Survey & Alignment section.

For complete job description and information on how to apply, please visit **http://jobs.lbl.gov** and refer to job number 19493.
LBNL is AA/EOE committed to the development of a diverse workforce.

Tenure-Track Faculty Position in Accelerator Physics

Cornell University

We are seeking an outstanding individual for a tenure-track, Assistant Professor position in accelerator physics. For individuals with exceptional qualifications and experience, a more senior appointment can be considered. In addition to teaching undergraduate and graduate courses, responsibilities include supervision of undergraduate and graduate students and participation in the research program of the Cornell Laboratory for Accelerator-based Sciences and Education. Current accelerator research focus is on the completion of and research with an ultra-high brightness electron source for an Energy Recovery Linac, the design and development of an anticipated 5 GeV x-radiation source based on an Energy Recovery Linac. Study of damping rings for the International Linear Collider using the Cornell Electron Storage Ring, CESR, and other aspects of the International Linear Collider are also in train. A PhD in physics is required. Experience with accelerators and either elementary particle physics or x-ray science is highly advantageous as is broad interest in physics as a whole.

The position will be available from July 1, 2007, or earlier by negotiation, with an initial appointment of three years.

Please send an application and at least three letters of reference to

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

Applications should include a curriculum vitae, a publication list, a statement of research interests, and a short summary of teaching and research experience.

Electronic mail inquiries may be addressed to **Search@LEPP.Cornell.edu**

Cornell is an equal opportunity/affirmative action employer.

Five Year Fellowship in Experimental High Energy Nuclear Physics

The Lawrence Berkeley National Laboratory (LBNL) Nuclear Science Division is seeking a Scientist with outstanding promise and creative ability in the field of experimental high energy nuclear physics. The appointment will be as Divisional Fellow for a term of five years with the expectation of promotion to Senior Scientist following successful review. Candidates with appropriate qualifications and experience may be considered for appointment at the Senior Scientist level. The successful candidate will have several years of experience beyond the PhD in nuclear or particle physics and will be expected to assume a lead role in the Relativistic Nuclear Collisions (RNC) Program at LBNL, with special emphasis on developing new directions for the program.

Members of the RNC program play a key role in the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, and participate actively in both the nucleus-nucleus and spin physics programs. RNC Scientists are also responsible for the development of a silicon pixel detector for STAR. In addition, a group within the RNC is participating in the nucleus-nucleus collision program at the LHC as members of the ALICE experiment.

Applicants are requested to submit in a single attachment a curriculum vitae, publication list, statement of research interest, and the names of at least four references on line at **http://jobs.lbl.gov** and by e-mail to **hgritter@lbl.gov**. Applicants also should arrange for four letters of reference to be sent to:

Hans Georg Ritter
Mail Stop 70AR0319,
Lawrence Berkeley National Laboratory
One Cyclotron Road, Berkeley, CA 94720

This position will be open until filled. We will begin considering candidates January 15, 2007. Please reference Job #019542.

LBNL is an equal opportunity employer committed to the development of a diverse workforce.

BERKELEY LAB

LEDERMAN FELLOWSHIP in EXPERIMENTAL PARTICLE PHYSICS or ACCELERATOR PHYSICS

The Fermi National Accelerator Laboratory (Fermilab) has an opening for a postdoctoral Lederman Fellow in experimental particle physics or accelerator physics. We are looking for candidates who have demonstrated outstanding ability in research. In recognition of Leon Lederman's commitment to the teaching of physics at all levels, the successful candidate will be also expected to participate, for a fraction of his/her time, in physics outreach. The Lederman Fellow will have a choice of opportunity within the broad program of experimental research at Fermilab which includes experiments at the energy frontier, neutrino physics, particle astrophysics and accelerators. See http://www.fnal.gov/ for more information.

Candidates should have obtained a Ph.D. in experimental particle or accelerator physics after November 15, 2005. The appointment is normally for three years with an extension possible. To apply, write to: Dr. Vaia Papadimitriou (Chair of Lederman Fellowship Committee), Fermi National Accelerator Laboratory, MS 306, P.O.Box 500, Batavia, IL 60510-0500 or vaia@fnal.gov. Applicants should send a letter including their research experience and noting any experience or interest in teaching and outreach, curriculum vitae, publication list and the names of at least four references. Applications will be accepted through January 5, 2007.

Fermilab

Fermilab is an Equal Opportunity Employer- M/F/D/V

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ARTEMIS Research Training Network (2006-2010)

7 Postdoc and 6 PhD positions in Particle Physics

ARTEMIS is a Research Training Network of seven institutes with world leading expertise in experimental particle physics and phenomenology. The network is aiming to exploit the physics potential of the **ATLAS** detector at CERN's **Large Hadron Collider** in order to explore one of the most fundamental topics in modern science, the electroweak symmetry breaking and the origin of mass of elementary particles using the early ATLAS data. In addition, it has an ambitious training programme of exchanges, schools, tutorials and workshops, to foster closer interaction and transfer of knowledge between experts and young researchers.

The ARTEMIS partner institutes are: (1) **Commissariat à l'Energie Atomique** (DAPNIA, Saclay), France; (2) **University College London**, UK; (3) **Aristotle University of Thessaloniki**, Greece; (4) **University of Sheffield**, UK; (5) **University of Pisa**, Italy; (6) **Max Planck Institute for Physics** (Munich), Germany; and (7) **University of Durham** (IPPP), UK.

More details about the network's research and training programmes, the interests and expertise of the participating institutes, and the posts (including specific job descriptions, starting dates and general eligibility criteria) can be found on http://cern.ch/artemis/.

The postdoctoral positions are normally of 24 months duration and salaries range from €38,980 to 50,050 per annum. The PhD studentships are of 36 months duration, with salaries in the range €25,400 – 32,620 per annum.

Applications comprising a CV and a personal statement, explaining your interest in the ARTEMIS research programme and indicating which institute(s) you would like to join, should be sent to the Network Coordinator, **Dr. Rosy Nikolaidou (rosy.nikolaidou@cern.ch)** by **January 15th 2007.** Candidates should also arrange for two letters of recommendation to be e-mailed to the above address by the deadline. Late applications may be considered until the positions are filled.

University of Heidelberg

The Faculty of Physics of the Ruprecht-Karls-Universität at Heidelberg, Germany, invites applications for a

W3-Professorship in Experimental Physics

(Succession Prof. F. Eisele)

We are looking for an outstanding physicist active in the field of experimental particle physics. The infrastructure available for this professorship is that of a chair of experimental physics.

The new professor is expected to demonstrate a commitment to teaching excellence in physics at both the undergraduate and postgraduate levels and to participate in the self-administration of the University.

Applicants are expected to have a Ph.D. in physics and an excellent research record.

Normally, first-time contracts for professors at universities in Baden-Württemberg are temporary for 3 years at first and turn permanent after a review. Exceptions to this rule can be granted, especially, if suitable candidates from abroad or outside the university cannot be recruited otherwise.

The Ruprecht-Karls-Universität Heidelberg wishes to increase the proportion of female faculty and, for this reason, especially welcomes applications from women. Handicapped persons with the same qualifications will be given preference.

Qualified candidates are invited to submit their application until 15.12.2006, including C.V., publication list, and list of teaching and research activities to **Prof. Dr. M. Bartelmann, Dekan der Fakultät für Physik und Astronomie der Universität Heidelberg, Albert-Ueberle-Str. 3-5, D-69120 Heidelberg**

The ATLAS Group at the Kirchhoff-Institut für Physik at the Ruprecht-Karls-Universität Heidelberg has an immediate opening for a

Post-Doctoral Position in Experimental Particle Physics

The successful candidate is expected to contribute to the physics analysis currently being prepared for the ATLAS Experiment at the LHC collider. Initially a special emphasis will be on the commissioning and calibration of the calorimeter trigger built in part by the Heidelberg ATLAS group.

The position requires a very good doctoral degree in experimental particle physics. Employment will initially be limited to 3 years. The salary will be according to the salary scheme for employees of the country Baden-Württemberg (TV-L).

Heidelberg University is an equal opportunity employer and encourages especially women to apply.

Interested candidates should send their application including a CV, a list of publications and copies of their university degrees to: **Prof. K. Meier, Kirchhoff-Institut für Physik, Ref. ATLAS-PD, Im Neuenheimer Feld 227, D-69120 Heidelberg**

Deutsches Elektronen-Synchrotron
Detector Development

DESY

DESY is world-wide one of the leading accelerator centres exploring the structure of matter. The main research areas range from elementary particle physics over various applications of synchrotron radiation to the construction and use of X-ray lasers.

With the construction of two Free-Electron Lasers (FLASH and the European-XFEL) and a 6 GeV storage ring (PETRA III), DESY will become a world leading center for photon science. In order to profit maximally from these unique light sources, an equally ambitious detector development program is initiated, and a strong photon science detector group is being set up at DESY. For our DESY site in Hamburg we are looking for a

Physicist for detector developments (Ph.D.)

A central part of the detector developments will be the design of state of the art micro-electronic components. You will be responsible for developing the micro-electronics expertise in the photon science detector group. You will be working in close collaboration with other detector physicists and (micro-) electronic designers at DESY, as well as in international collaborations.
Candidates should hold a Ph.D. in Physics. A background in either photon science or particle physics, and a large experience in micro-electronic design, using state of the art technologies are required. Experience in designing ASIC's for photon or particle detection is highly recommended. Further you should have a good team spirit, good communication skills and good command of English. If you are interested in this position, please send your complete application by indication the reference number to our personnel department. Further information may be obtained by Dr. Graafsma on +49 40/8998-1678.

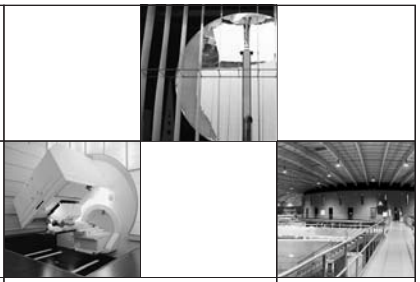
Salary and benefits are commensurate with public service organisations. DESY is an equal opportunity, affirmative action employer and encourages applications from women. DESY has a Kindergarten on site.

Deutsches Elektronen-Synchrotron DESY
member of the Helmholtz Association
code: 132/2006 · Notkestraße 85 · D-22607 Hamburg · Germany
Phone: 040/8998-3392 · www.desy.de
email: personal.abteilung@desy.de

Deadline for applications: 03.01.2007

PAUL SCHERRER INSTITUT

PSI



The Paul Scherrer Institute is a centre for multi-disciplinary research and one of the world's leading user laboratories. With about 1200 employees it belongs as an autonomous institution to the Swiss ETH domain and concentrates its activities on solid-state research and materials sciences, elementary particle physics, energy and environmental research as well as biology and medicine.

As user laboratory PSI operates a system of cyclotrons with the highest average proton beam power worldwide. This complex is the backbone of a multidisciplinary research centre making use of intense secondary beams from the Pion production targets and from the spallation neutron source SINQ.

To contribute to the further development of the proton facilities, an upgrade aimed to substantially increase the beam power, we are looking for an

Accelerator Physicist

Your tasks

As a first project you will work on beam quality measurements and further development of a new ECR proton source which is presently operated in a testing environment. Later you will be engaged in a more general context with the development and the operation of the high intensity proton accelerator complex consisting of the Cockroft-Walton pre-accelerator, the 72 MeV Injector Cyclotron and the 590 MeV Ring Cyclotron.

Your profile

You hold a PhD degree in Physics or equivalent, with preferably good knowledge of the physical, technical and operational aspects of accelerators. Experiences in the fields ion sources, high intensity beam dynamics and operational procedures of accelerators are to your advantage. The successful candidate also has excellent communication skills in German and/or English and exhibits extraordinary team spirit.

We offer an exciting environment where leading edge accelerator science and technology is performed in various areas. As a world-class institute, we expect corresponding performance from you. The responsibility given to you will be in accordance with your experience.

We are looking forward to your application.

For further information please contact Dr. Joachim Grillenberger,
leader of the Proton Accelerator Section, Ph. +41 56 310 4623,
e-mail: joachim.grillenberger@psi.ch or Dr. Mike Seidel, head of the
Accelerator Division ABE, Ph. +41 56 310 3378, e-mail: mike.seidel@psi.ch.

Please send your application to: Paul Scherrer Institut, Human Resources,
Mr. Thomas Erb, ref. code 8530-01, 5232 Villigen PSI, Switzerland.

Further job opportunities: www.psi.ch

UNIVERSITY OF FLORIDA

ASSISTANT PROFESSOR IN EXPERIMENTAL PARTICLE PHYSICS

DEPARTMENT OF PHYSICS – UNIVERSITY OF FLORIDA

The Department of Physics at the University of Florida invites applications for a faculty position in experimental particle physics at the tenure-track Assistant Professor level starting August 2007. Our present projects include major contributions to the CMS, CDF and CLEO experiments. In the future more of our efforts will focus on the CMS experiment where the University of Florida group has taken leading roles in the preparation of the physics program, the design and construction of the muon detectors and the trigger, software, and computing components.

Applicants should have a PhD in physics and an outstanding record of research accomplishments. The appointee is expected to establish a strong research program and play a leadership role in the CMS experiment, particularly in the data analysis effort. The appointee is also expected to teach effectively at both the undergraduate and graduate levels and to participate in the educational programs and other activities of the Department.

The High Energy Experiment group is part of the University of Florida Institute of High Energy Physics and Astrophysics (IHEPA). IHEPA has excellent facilities with modern and powerful computing resources, including a Tier-2 center for LHC data analysis. Further information about the department and IHEPA may be found on our website at http://www.phys.ufl.edu/ihepa/.

An application consisting of a curriculum vitae, list of publications, and a statement of research interests and plans should be sent to: **Experimental Particle Physics Faculty Search, c/o Professor Darin Acosta, Department of Physics, P.O. Box 118440, University of Florida, Gainesville, FL 32611-8440, USA**. The application material may also be sent in electronic form to search06@phys.ufl.edu.

Candidates should arrange for at least three letters of reference to be sent to the above address. To ensure full consideration, applications, including letters of reference, should be received by February 1, 2007. The University of Florida is an equal opportunity institution.

TECHNISCHE
UNIVERSITÄT
DRESDEN

The **Institute for Nuclear and Particle Physics** at the **Department of Physics** in the **Faculty of Science** has the following immediate openings:

Professorship (W3) in Nuclear Physics (non-accelerator Particle Physics)

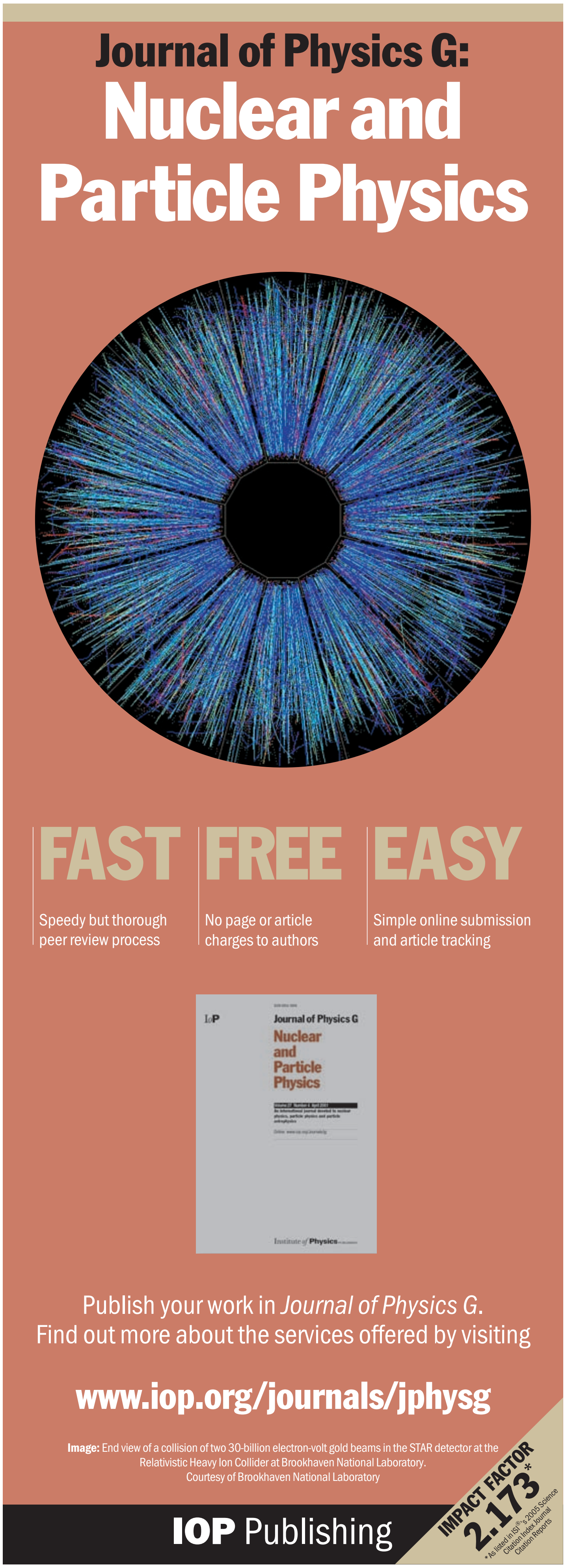
The successful applicant should investigate current problems of particle physics using experimental methods of nuclear physics (e.g. the neutrinoless double beta decay or the direct search for Dark Matter). Under the responsibility of the research group a 14 MeV neutron source is operated at the Forschungszentrum Rossendorf near Dresden, a photo-neutron source is being built. The candidate is expected to participate in teaching of the advanced level specialisation branch "Nuclear and Particle Physics" and in general teaching duties of the Department of Physics.

Professorship (W2) in Phenomenology of Elementary Particles

The successful applicant should be a theoretical physicist working in the field of elementary particles. His/Her topics of research should match optimally with the future research spectrum of the experimental groups of the institute in the field of elementary particle physics with and without accelerators. Participation in teaching theoretical physics (undergraduates, graduates and student teachers) and advanced level particle physics within the specialisation branch "Nuclear and Particle Physics" is expected.

The applicants have to fulfil the employment conditions of §40 Sächsisches Hochschulgesetz of 11.06.1999, the skeleton law of university affairs. The TU Dresden is an equal opportunity employer and encourages especially the application of women and handicapped persons.

Please submit your application together with your CV, your scientific employment record, list of publications and copies of the certificate of your highest academic degree as well as of 5 publications before **January 10, 2007** to: **TU Dresden, Dekan der Fakultät Mathematik und Naturwissenschaften, Herrn Prof. Dr. M. Ruck, D-01062 Dresden, Germany.**



ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

The Faculty of Mathematics and Physics invites applications for a

Professorship in Experimental Physics (W3)

in the field of experimental particle physics, with focus on data analysis and computing in high energy physics experiments.

A prerequisite is the "Habilitation" or an equivalent scientific qualification. The successful applicant is expected to participate in the general teaching and administrative duties of the department. The university is seeking to increase the number of female faculty members and therefore especially encourages suitably qualified women to apply. Applicants with a physical handicap will be given preference over other candidates provided they are equally qualified.

The professorship is available as a permanent position. In case of a first time appointment to professorship, the appointment is, as a rule, temporary, with possible exceptions. The subsequent appointment to a permanent professorship does not require a renewed, full application procedure.

Applications (with a curriculum vitae, copies of degree certificates, list of publications and teaching records) should be sent by January 15th 2007, to the Dekan der Fakultät für Mathematik und Physik, Eckerstr. 1, D-79104 Freiburg, Germany.

Dublin Institute for Advanced Studies
Schrödinger Fellowship
School of Theoretical Physics

A Post-doctoral Research Fellowship position in Theoretical Physics is currently available in the Dublin Institute for Advanced Studies. This is a dedicated research position and does not involve any teaching or administrative duties. Candidates must have a proven record as independent researchers in one of the following fields of study – Quantum Field Theory, Conformal Field Theory, String Theory and Statistical Mechanics.

Further details on the positions together with the application procedures are available on the School's website at **www.stp.dias.ie**. Enquiries should be directed to the School Director, **Prof. T. C. Dorlas** at **dorlas@stp.dias.ie**

Appointments will be on the basis of a fixed-term contract up to five years. The attaching salary is €49,035 increasing by annual increments up to €54,701.

Applicants should submit a CV, a list of publications together with a research proposal and arrange for three letters of recommendation to be sent to: **The Registrar's office, DIAS, 10 Burlington Road, Dublin 4** to arrive **before 15 December 2006** Electronic applications should be sent to **registrarsoffice@admin.dias.ie**. The search for a suitable candidate may be widened beyond the applications received.

DIAS is an Equal Opportunities employer

GSI Darmstadt, the National Laboratory for Heavy-Ion Research, a member institute of the Helmholtz-Society of German Research Centres, is looking for a

Physicist (Ph.D.)

Ref. No.: 3410-06.74

as Beam Diagnostic Group Leader.

The group leader will take responsibility for the beam diagnostic systems of all GSI accelerator sections with a team of 25 technical staff members (physicists, engineers, and technicians). He/she has a background of several years in accelerator physics, beam diagnostic instrumentation, analog and digital electric system design, and central system computers.

The group leader takes the responsibility for efficient operation of the running technical systems, improvement of operation, and development of new systems for the existing accelerators. In addition, it is also expected that the group leader takes the responsibility for the design and construction of future beam diagnostic systems for the FAIR accelerator facilities at GSI.

Very good knowledge is expected on the fields accelerator-physics, beam diagnostic systems, digital and analog electronics, rf-technique and data-acquisition.

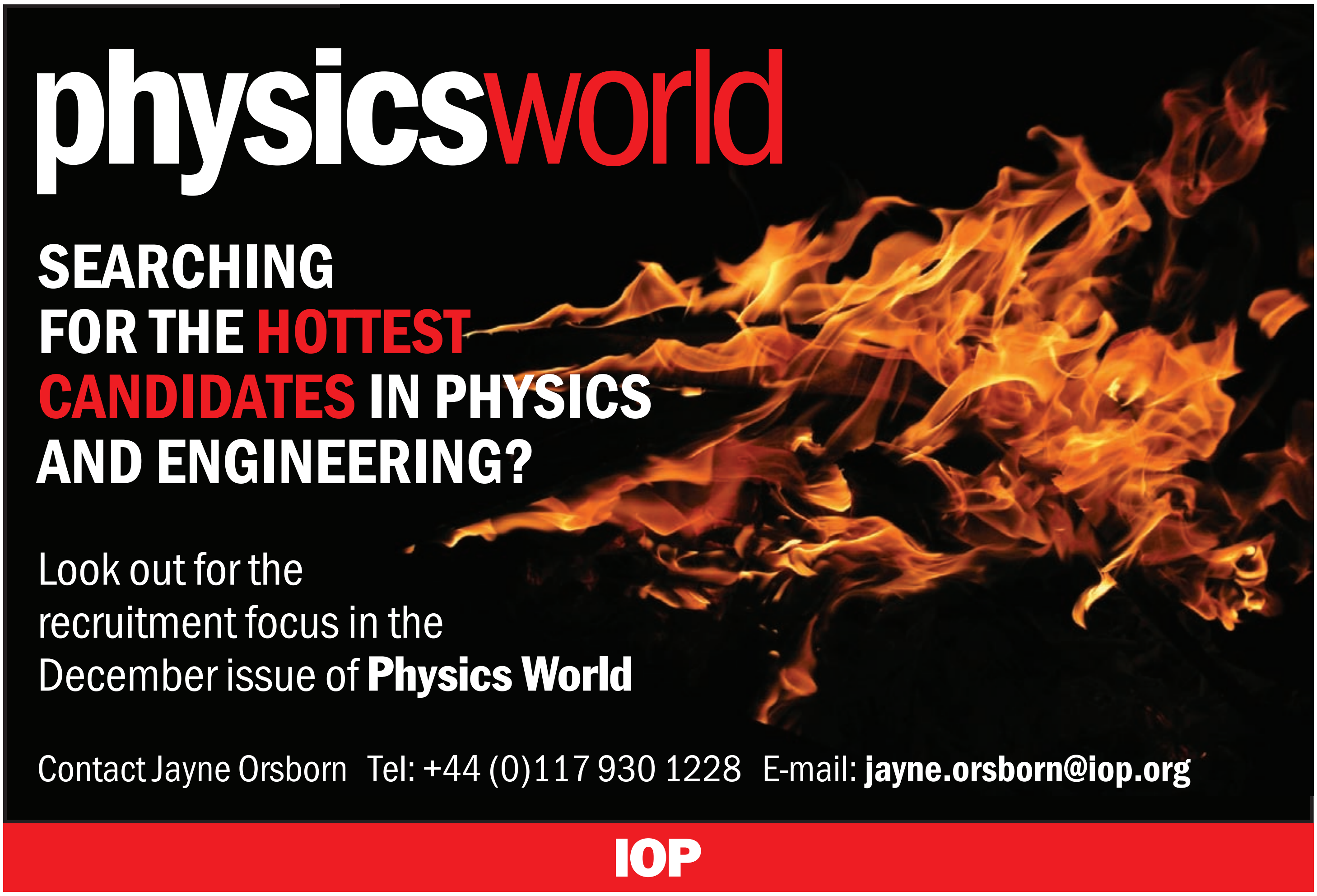
Remuneration according to pay scale grouping TVöD for federal employees in Germany.

Women are especially encouraged to apply for the position. Handicapped applicants will be given preference to other applicants with the same qualification.

Candidates are invited to send their application including a curriculum vitae, list of publications as well as three letters of reference not later than **December 15, 2006** to:

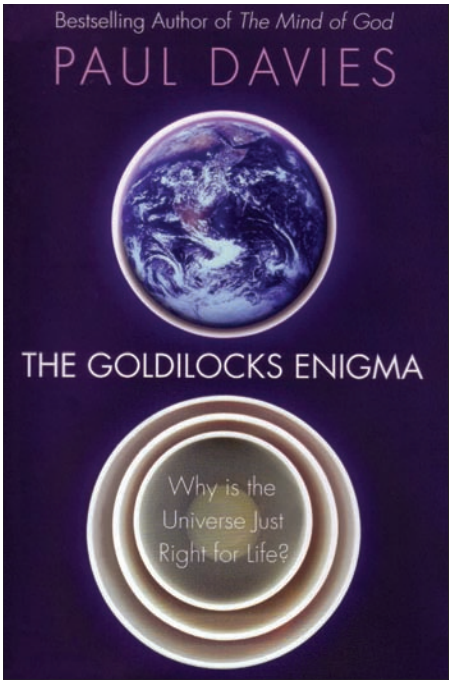
GSI
Darmstadt

Gesellschaft für
Schwerionenforschung mbH
Personalabteilung
Ref. No.: 3410-06.74
Planckstraße 1
64291 Darmstadt
GERMANY



BOOKSHELF

The Goldilocks Enigma: Why is the Universe Just Right for Life? by Paul Davies, Penguin – Allen Lane. Hardback ISBN 9780713998832, £22.00.



The Goldilocks Enigma is the latest in a series of books from the past 20-plus years by physicist, cosmologist and internationally acclaimed outreach expert Paul Davies, covering the often vexed issue of the boundary between science and theology. The central theme of this book is the baffling truism, the so-called anthropic principle, that the universe is surprisingly bio-friendly, consistent with the evolution of life, at least on Earth and possibly elsewhere. Like Goldilocks's third porridge, the universe seems to be just right for "us", but why?

Davies guides the reader comprehensively and comprehensibly through the properties and interactions of the components of the universe, small and large, observable and imagined. He presents an equation-free exposé of particle physics and cosmology, from strings to multiverses, and in so doing reveals the wonder of the physical universe. He then augments the "facts" with an impressive sequence of analyses of how and why they came about. But is "our" universe the only one that exists? Is it the only one that can exist? If so, why? If not, what, where and when could other universes be? And does it all point to an Intelligent Designer?

Getting rid of God, numinous, eternal and responsible for all universes at all times, is a popular pursuit for some science communicators these days – Richard Dawkins springs to mind. However Davies is not relentlessly driven to deicide: "You can't use science to disprove the existence of a supernatural God, and you can't use religion to disprove the existence of self-supporting physical laws." This attitude ought to leave many an agnostic armchair physicist patiently waiting for Davies's next book.

Goldilocks is not always easy to read, but each chapter ends with a helpful shortlist of the important facts and ideas to be retained. A couple of typos and the erroneous statement, appearing twice, that the Large Hadron Collider will collide protons with antiprotons, blemish a text that otherwise bears all the hallmarks of intelligent design.

Peggie Rimmer, Satigny/Oxford.

Books received

Relativity: Special, General and Cosmological (Second edition) by Wolfgang Rindler, Oxford University Press. Hardback ISBN 9780198567318, £55 ($99.50). Paperback ISBN 9780198567325, £27.50 ($49.50).

Relativistic cosmology has recently become an active and exciting branch of research. Consequently, this second edition mostly affects the section on cosmology, and the purpose remains the same: to make relativity come alive conceptually. The emphasis is on the foundations and on presenting the necessary mathematics, including differential geometry and tensors. With more than 300 exercises, it promotes an in-depth understanding and the confidence to tackle basic problems in this field. Advanced undergraduates and beginning graduate students in physics and astronomy will be interested in this book.

Quantum Mechanics: Classical Results, Modern Systems, and Visualized Examples (Second edition) by Richard W Robinett, Oxford University Press. Hardback ISBN 9780198530978, £39.95 ($74.50)

This second edition is a comprehensive introduction to non-relativistic quantum mechanics for advanced undergraduate students in physics and related fields. It provides a strong conceptual background in the most important theoretical aspects of quantum mechanics, and extensive experience of the mathematical tools required to solve problems. It also gives the opportunity to use quantum ideas to confront modern experimental realizations of quantum systems, and numerous visualizations of quantum concepts and phenomena. This edition includes many new discussions of modern quantum systems, such as Bose–Einstein condensates, the quantum Hall effect and wave-packet revivals.

Data Analysis: A Bayesian Tutorial (Second edition) by D S Sivia and J Skilling, Oxford University Press. Hardback ISBN 9780198568315 £39.95 ($74.50). Paperback ISBN 9780198568322 £22.50 ($39.50).

Statistics lectures can be bewildering and frustrating for students. This book tries to remedy the situation by expounding a logical and unified approach to data analysis. It is intended as a tutorial guide for senior undergraduates and research students in science and engineering. After explaining the basic principles of Bayesian probability theory, their use is illustrated with a variety of examples ranging from elementary parameter estimation to image processing. Other topics covered include reliability analysis, multivariate optimization, hypothesis testing and experimental design. This second edition contains a new chapter on extensions to the ubiquitous least-squares procedure.

Field Theory: A Path Integral Approach (Second edition) by Ashok Das, World Scientific. Hardback ISBN 9812568476 £45 ($78). Paperback ISBN 9812568484 £28 ($48).

This book describes quantum-field theory within the context of path integrals. With its utility in a variety of fields in physics, the subject matter is primarily developed within the context of quantum mechanics before going into specialized areas. Adding new material keenly requested by readers, this second edition is an important expansion of the popular first edition. Two extra chapters cover path integral quantization of gauge theories and anomalies, and a new section extends the supersymmetry chapter, describing the singular potentials in supersymmetric systems.

Nuclear science hits new frontiers

C Konrad Gelbke argues that nuclear science has a bright future thanks to the possibilities being opened in particular by the exploration of rare isotopes.

Nuclear science is undergoing a renaissance as it confronts new and previously unapproachable research opportunities. One such opportunity, the study of short-lived nuclei far from stability, is emerging as a major frontier in nuclear science. Rare-isotope research is tied to astrophysics and mesoscopic science, fields in which voracious demand for new data is generating worldwide interest in high-power, next-generation accelerators.

New facilities will probe the limits of nuclear stability and determine nuclear properties in uncharted regions of nuclei with unusual proton-to-neutron ratios. The new data will challenge descriptions of nuclei that are based on data limited to nuclei near the valley of nuclear stability. These improved models of nuclei – two-component, open mesoscopic systems – will increase our understanding of mesoscopic systems in fields such as chemistry, biology, nanoscience and quantum information. More directly, the models will greatly boost our understanding of the cosmos.

Today, our descriptions of stellar evolution, and especially of explosive events, such as X-ray bursts, core-collapse supernovae, gamma-ray bursts, thermonuclear (Type Ia) supernovae and novae, are limited by inadequate knowledge of important nuclear properties. We need new data for nuclei far from stability and better nuclear theories to develop accurate models of these astrophysical phenomena. Improved models, in turn, will help astrophysicists make better use of data from ground- and space-based observatories, understand the nuclear processes that produce the elements observed in the cosmos and learn about the environments in which they were formed.

We already have the first concrete evidence that nuclear structure, well established for nuclei near the line of stability, can change dramatically as we move away from the line of stability. The effective interactions far from stability – pairing, proton–neutron, spin-orbit and tensor – are different, but largely unknown. We need quantitative experimental information to refine theoretical treatments that describe these exotic isotopes.

There are several particularly promising research directions. For example, nuclei with unusual density distributions have been discovered for the lighter elements, but little is known about the properties of heavier, very neutron-rich nuclei. These heavier nuclei may have multi-neutron halo distributions with unusual cluster or molecular structures, which otherwise only occur at the surface of neutron stars. Such nuclei provide a unique opportunity to study the nucleon–nucleon interaction in early pure neutron matter.

Intense beams of neutron-rich isotopes will be used to synthesize transactinide nuclei that are more neutron-rich than is possible with stable beams. These nuclei are predicted to be sufficiently strongly bound and long-lived for detailed chemical study.

Energetic nucleus–nucleus collision experiments with beams of very neutron-rich and very neutron-poor isotopes will explore the asymmetry energy term in the equation of state of neutron-rich nuclear matter. This term is important in understanding the properties of neutron stars.

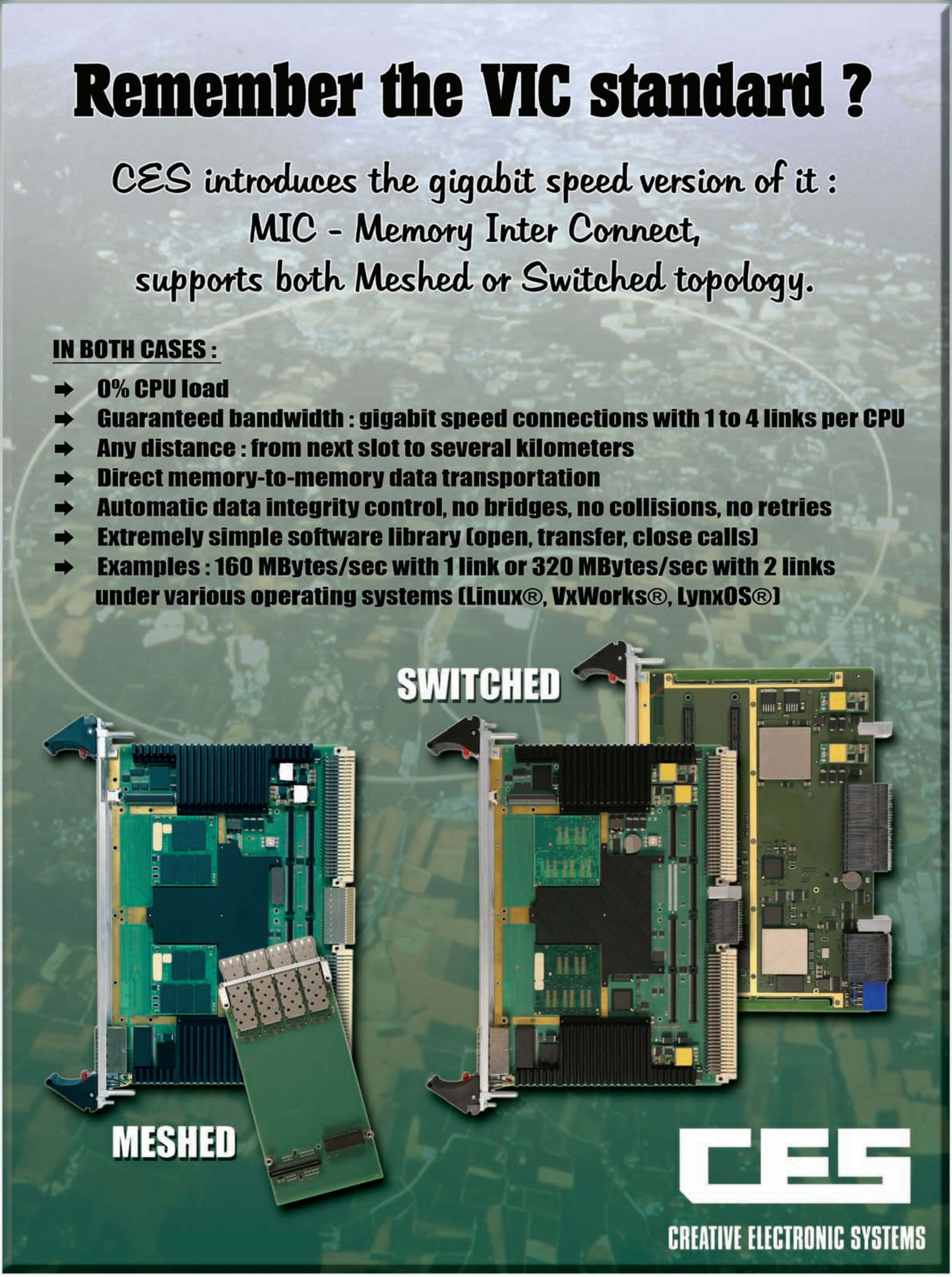
Nuclei are self-sustaining finite droplets of a two-component – neutron and proton – Fermi-liquid. Selectively prepared nuclei will allow us to study, on a femtoscopic scale, typical mesoscopic phenomena: self-organization and complexity arising from elementary interactions, symmetry and phase transformations, coexistence of quantum chaos and collective dynamics. The openness of loosely bound nuclei owing to strong coupling to the continuum allows us to probe general mesoscopic concepts, such as information processing and decoherence, which are key ideas in quantum computing.

The interplay of strong, electromagnetic and weak interactions determine detailed nuclear properties. Selecting nuclear systems that isolate or amplify the specific physics of interest will allow better tests of fundamental symmetries and fuel the search for new physics beyond the Standard Model.

Beyond advancing basic research questions, new accelerators should yield practical benefits for science and society. In fact, nuclear science has a long record of such applications. Technologies rooted in nuclear science – such as positron-emission tomography, the use of radioactive isotopes for treating or diagnosing disease, and more recently, the use of dedicated accelerators for treating cancer patients (see p17) – have transformed medicine. Sterilization of fresh produce or surgical instruments with ionizing radiation is growing in importance. Ultra-sensitive nuclear detection, such as Rutherford backscattering, proton-induced X- and gamma-ray emission and accelerator mass spectrometry, has provided diagnostic tools for archaeology and material science.

Next-generation rare-isotope research and this tradition of applied work promise new opportunities for cross-disciplinary collaboration on national and international security, biomedicine, materials research and nuclear energy. Nuclear science is well positioned to deliver new benefits to physics and society in the coming decades.

C Konrad Gelbke, director of the National Superconducting Cyclotron Laboratory and University Distinguished Professor of Physics at Michigan State University.



Tools for Discovery

CAEN

Overview

VME8002 and VME8010 Crates

VME8002 is a 9 slot portable VME mini-crate, perfect for small and flexible set-up.

VME8010 offers the best Quality/Price ratio you can demand in a full 21 slot VME crate.

Thanks to the low noise Power Supply they are suitable both to analogue and digital electronics, for all types of measurements.

Highlights

- Low cost
- VME64 compliant J1/J2 monolithic backplane
- 350W Pluggable / 470W Power Supply
- Short circuit protection
- Over / Undervoltage protection
- Over temperature protection
- Fan Unit
- 19" rack mountable
- Remote control via CANBUS (VME8002)

VME Crates & VME Bridges

VME setup has never been so simple and inexpensive!

Overview

V1718 - V2718/A2818 USB and PCI bridges

V1718 offers a very simple and low cost solution for VME bus control. What you need to do is just to plug the unit in the VME crate and to connect it to an USB port on your PC.

V2718 + A2818 exploit the high speed of PCI and optical link technologies and permit simultaneous control of up to eight crates. Just add one more V2718 for each additional crate and connect them in daisy chain via optical fibres.

Highlights

- Low Cost
- USB 2.0
- Optical Link
- Daisy Chainable
- Dataway Display
- Driver for Windows 98/2000/XP, Linux
- Software and Libraries in C++, Visual Basic and LabView

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information, call us at
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