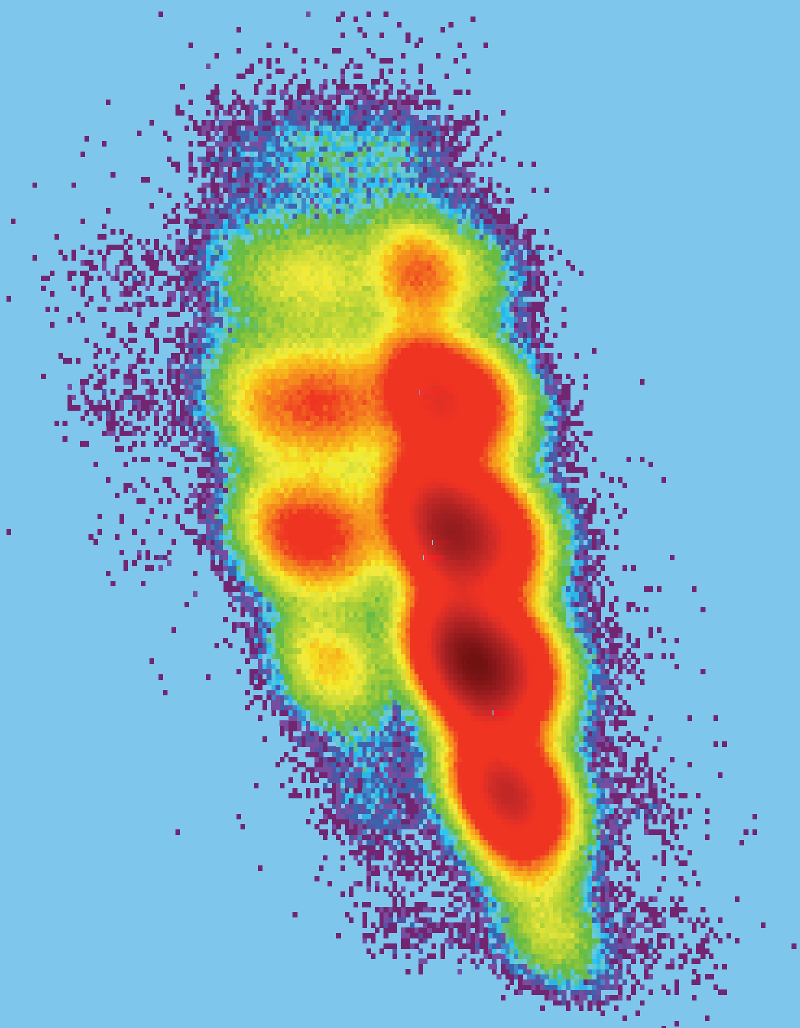
INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 49 NUMBER 1 JANUARY/FEBRUARY 2009



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CERN Courier is distributed to member-state governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly, except for January and August. The views expressed are not necessarily those of the CERN management.

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Produced for CERN by IOP Publishing Ltd
IOP Publishing Ltd, Dirac House, Temple Back,
Bristol BS1 6BE, UK
Tel +44 (0)117 929 7481

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Tel +44 (0)117 930 1026 (for UK/Europe display advertising),
+1 215 627 0880 (for North American display advertising), or
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E-mail: sales@cerncourier.com; fax +44 (0)117 930 1178

General distribution Courrier Adressage, CERN, 1211 Geneva 23, Switzerland. E-mail: courrier-adressage@cern.ch
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UK Mark Wells, Science and Technology Facilities Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1SZ. E-mail: mark.wells@stfc.ac.uk
US/Canada Published by Cern Courier, 6N246 Willow Drive, St Charles, IL 60175, US. Periodical postage paid in St Charles, IL, US. Fax 630 377 1569. E-mail: creative_mailing@att.net
POSTMASTER: send address changes to: Creative Mailing Services, PO Box 1147, St Charles, IL 60174, US

Published by European Organization for Nuclear Research, CERN, 1211 Geneva 23, Switzerland. Tel +41 (0) 22 767 61 11
Telefax +41 (0) 22 767 65 55

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

 ISSN 0304-288X

IOP Publishing

CERN COURIER

VOLUME 49 NUMBER 1 JANUARY/FEBRUARY 2009

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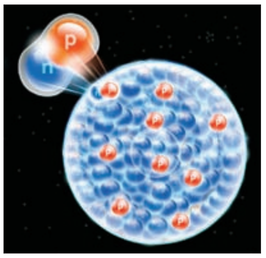

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Cover: Dots to the upper left of this spectrum of heavy nuclei are isotopes that are close to the proton-rich limit of stability. In research at the National Superconducting Cyclotron Laboratory at Michigan State University, these nuclei are casting light on the production of elements in the solar system (p11). (D Bazin *et al.* 2008 subm *Phys. Rev. Lett.* http://arxiv.org/pdf/0810.3597v1 [nucl-ex].)

CERN

CERN Council rings in the changes

At its meeting on 12 December, CERN Council thanked the organization's outgoing management and welcomed in the new. It was an occasion to take stock of the achievements of the past five years and to look forward to the next. Robert Aymar, the departing director-general, looked back on his five years at the helm, while his successor, Rolf Heuer, presented his vision for the future.

At the close of CERN's Council meeting on 12 December, Robert Aymar (right) passed the baton to his successor, Rolf Heuer, who will be director-general for the coming five years.

Aymar's five-year mandate encompassed both CERN's 50th anniversary and the first beams in the LHC. "It has been a privilege to lead this great organization for the last five years," Aymar told Council. "My mandate started on a high note – the celebration of 50 years at the cutting edge of science and innovation – and it is also finishing on a positive. After a year of highs and lows, I am leaving CERN with a clear route to physics at the LHC in 2009."

Council was also informed of the actions taken following the incident that brought LHC commissioning to a halt on 19 September (p6). The scientific policy committee, an advisory body for Council, had an extensive session on this matter and reported its findings, endorsing the robust manner in which CERN is addressing the issue. "We have been impressed by the rapid and professional manner in which this situation has been mastered," said Torsten Åkesson, president of Council, "and look forward to the LHC experiments collecting their first colliding-beam data in 2009." Council's confidence was underlined by its endorsement of the existing LHC project-management team until the machine is handed over for routine operation.

Presenting his ambition for the future, Heuer stressed that physics at the LHC would be the top priority in 2009. Looking farther ahead, he outlined his vision of a key role for CERN in an increasingly global basic-research environment. "CERN is a European lab hosting a global project," he said. "The LHC project has evolved this way. In the future, however, we need to go further, working together with our partners around the world on the basic programme, with national projects, regional projects and global projects all serving a common goal. Now is the time for us to lay the foundations for such future programmes, which will be built on strong national and regional pillars in the Americas, Europe and Asia. In my view, CERN is Europe's pillar."

Following a period of study, Romania was formally accepted as a candidate for accession to membership of CERN. Its membership will be phased in over a five-year period during which the country's contributions will ramp up to normal member-state levels in parallel with Romanian participation in CERN projects.

Setting a marker for the future, Council approved the creation of a study group to examine the geographical and scientific enlargement of CERN. This group will hold its first meetings in early 2009.

In its European strategy session, Council decided on the procedure to recognize and follow projects that are relevant to the European strategy for particle physics, including projects that are not necessarily based at CERN's Geneva laboratory. Council followed these new procedures in recognizing four projects in the EU's Seventh Framework Programme that are related to accelerator R&D and future facilities.

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LHC NEWS

Mobilizing for the LHC

Investigations following the incident in sector 3-4 of the LHC on 19 September have confirmed that the cause was a faulty electrical connection between two magnets. This resulted in mechanical damage and the release of helium from the magnet cold masses. CERN has published two reports on the incident and confirmed that the accelerator will be restarted in summer this year.

An interim report issued on 15 October gave the result of preliminary investigations. A more detailed report followed on 5 December, confirming that a small resistive zone developing in a bus connection in the circuit that conducts current between magnets probably caused the incident. Arising during the ramping-up of current in the main dipole circuit at the nominal rate of 10 A/s, in less than a second the zone led to a resistive voltage of 1 V at 9 kA. The resistance was small – 200 nΩ – dissipating of the order of 10 W at high current intensity. The power supply, unable to maintain the current ramp, tripped off and the energy-discharge switch opened, inserting dump resistors into the circuit to produce a fast decrease in current. In this sequence of events, the quench-detection, power converter and energy-discharge systems behaved as expected. Within a second, an electrical arc developed, puncturing the helium enclosure and leading to a release of helium into the insulation vacuum of the cryostat. After three and four seconds, the beam vacuum also degraded in beam pipes 2 and 1, respectively.

The insulation vacuum then started to degrade in the two neighbouring subsectors. (A vacuum subsector consists of two lattice cells, each with six dipoles and two quadrupoles, with “vacuum barriers” at both ends.) The spring-loaded relief discs on the vacuum enclosure opened when the pressure exceeded atmospheric, thus releasing helium into the tunnel, but they were unable to contain the pressure rise below the nominal 0.15 MPa in the vacuum enclosure of the central subsector. This resulted in large pressure forces acting on the vacuum barriers separating the damaged subsector from its neighbours.

Investigation teams confirmed the location of the electrical arc and, while they found no electrical or mechanical damage in neighbouring interconnections, they discovered contamination by soot-like dust, which propagated over some distance in the beam pipes. They also found damage to the multilayer insulation blankets of the cryostats. In addition, the forces on the vacuum barriers attached to the quadrupoles at the subsector ends were such that the cryostats housing these quadrupoles broke their anchors in the concrete floor of the tunnel and moved, with the electrical and fluid connections pulling the dipole cold-masses in the subsector from cold supports inside their undisplaced cryostats. The displacement of the quadrupole cryostats – short straight sections (SSS) – also damaged jumper connections to the cryogenic-distribution line.

As soon as the gravity of the incident was clear, a campaign for cryostating and testing of spare cold masses – both dipoles and quadrupoles – was immediately launched. After the sector had been warmed up, by the end of October, the repair programme began in earnest with the inspection of all the affected magnets – first underground and then at the surface. The programme also includes the inspection of the beam pipes and screens for contamination by soot-like metal dust and debris from the damaged insulation blankets. All the affected sections will be cleaned.

Virtually all the cold masses of magnets in the affected zone seem to be intact, with the possible exception of the bus bars in the end zone. The damage has been mainly to components located between the cryostat and the cold masses, as a result of the displacement that occurred. In all, from a total of 57 magnets (42 dipoles and 15 SSS) in the affected zone, 53 magnets (39 dipoles and 14 SSS) have been removed from the tunnel for inspection and/or cleaning or repair. Of the magnets to be re-installed, 39 (30 dipoles and 9 SSS) will have new cold masses, almost depleting CERN’s stock of spares. The decision was taken to reuse spare cold masses as much as possible to enhance operational safety. Nine of the dipoles removed are believed to be undamaged and will simply be inspected and retested. Five SSS will be reused after reconditioning of the cryostat (i.e. change of multilayer insulation blankets and the cold supports).

This work is being carried out in building SMI2, where the cryostat facility is based, and also in B904 at the Prévessin site. Meanwhile a temporary line for decryostating dipoles has been installed in B180 (West Hall) to recover quickly cryostat components that will be used for new cryodipoles based on new cold masses.

All magnets will undergo complete warm and cold testing in building SM18, where they were tested before original installation. They are being tested up to 12 850 A, which corresponds to a field of 9 T, compared with the 8.3 T for nominal LHC operation at 7 TeV. It will be possible to test up to five magnets a week, once more cryogenic capacity has been brought on line in February. In addition, the circuits of the main magnets are undergoing power tests to detect any abnormal resistances. As a result, a magnet in Sector 1-2 will also be replaced.

As of mid-January, all 53 magnets had been brought to the surface and the first eight replacement units had been installed in the tunnel. The goal is to have all the magnets in place in the tunnel by the beginning of April. Making the interconnections will start at the beginning of February, with enhanced quality control.

New electronic boards will protect the magnets by constantly measuring the resistance of the busbars and the interconnections. These additional electronics will also measure other parameters. Installation will start at the beginning of April. In addition, a better use of the present quench-protection scheme will help to single out possible bad connections inside cold masses already installed in the tunnel. The final stage will be the testing of the entire sector in June and July.

● For the two reports, see http://press.web.cern.ch/press/PressReleases/Releases2008/PR17.08E.html.

ACCELERATORS

ALICE achieves energy recovery at Daresbury and Cockcroft Institute

At 2.00 a.m. on 13 December 2008, the commissioning team at the ALICE facility of the UK's Daresbury Laboratory and Cockcroft Institute successfully demonstrated "energy recovery" from a relativistic electron beam at 11 MeV back into the microwave source that powers the linear accelerator. Although the FEL facility and the CEBAF at Jefferson Lab in the US recently demonstrated energy recovery, this is a first for a European team.

ALICE is designed to produce ultrabright and ultrashort pulses of electrons, coherent-synchrotron radiation, FEL and tailored Compton-scattered light, which can be used – in conjunction with modern ultrafast lasers – in cutting-edge experiments in physical and life sciences. At the same time, accelerator research at the facility could revolutionize the way that high-energy particle accelerators, colliders and accelerator-based photon- and neutron-research facilities are designed in the future. A major design goal is to achieve efficient energy recovery (i.e. the repeated exchange and recycling of energy between particles and microwaves). This is a critical requirement for both the scientific reach in beam brightness and the economic viability and affordability of future high-power, high-energy particle accelerators. High-energy beams from ALICE will also be used to explore technology for new cancer treatments in a linked demonstration project known as EMMA.

After more than four years of planning and construction, ALICE achieved its first high-energy beam at 12.54 a.m. on 24 October in the 4 MeV booster. This consists of a superconducting accelerator cavity fed by a photoinjector. The photoinjector is a high-brightness electron gun capable of generating extremely short pulses of electrons, which are fired into the booster at a rate of 81 million shots a second.

At 5.00 p.m. on 7 December, after the booster had accelerated the high-quality electron beam from the photoinjector to 4 MeV, the commissioning team took the beam from the booster up to relativistic energies of 11 MeV in a linear superconducting microwave accelerator (figure 1). The stage was then set for the final act, where the beam is threaded through 360° of beam-transport systems back to the start of the same linac. By recirculating in the opposite microwave phase, the beam undergoes deceleration to achieve energy recovery, where the energy used to accelerate the beam can be recovered and reused after each circuit of the machine.

Less than a week later, at 2.00 a.m. on 13 December, the superconducting linac accelerated electrons to a total energy of 11 MeV and the beam was successfully sent round the total circuit, demonstrating energy recovery for the first time outside the US. At 10.50 p.m. on 20 December, energy recovery was achieved at 20.8 MeV (figure 2).

The next stage will be to commission the facility to its full operating energy of 35 MeV.

● ALICE is financed by the UK's Science and Technology Facilities Council with seed funding from the North West Development Agency. It is operated by the ASTeC team within the Cockcroft Institute which is developing its advanced accelerator-research programme.

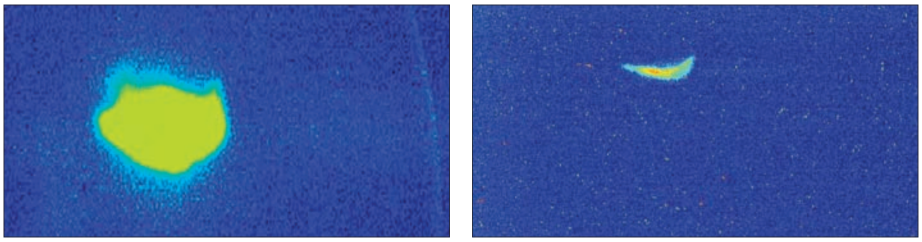

Fig. 1. The 4 MeV booster beam (left) accelerates on to relativistic energies (right) in the linac.

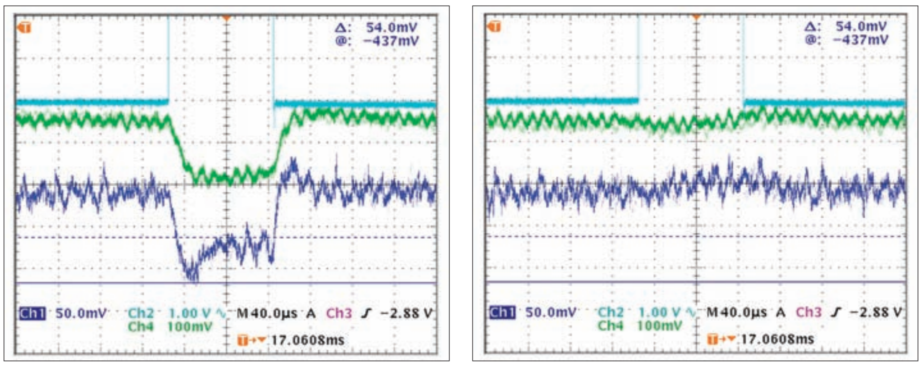

Fig. 2. The RF-gradient demand in the linac at 10.50 p.m. on 20 December, showing the effect of energy recovery (right) compared with no energy recovery (left). (All figures courtesy STFC Daresbury.)

Susan Smith of the Cockcroft Institute and group leader for accelerator physics in its ASTeC/STFC partnership at Daresbury celebrates with the ALICE commissioning team.

LHC EXPERIMENTS

CMS does a full cosmic-data run

On 11 November 2008 the conclusion of a month-long, major data-taking run by the CMS collaboration brought a two-year commissioning phase to a successful close. The aim of the Cosmic Run At Four Tesla (CRAFT) was to run CMS continuously as a complete experiment, 24 hours a day, to gain further operational experience even without LHC beams. Data from 300 million cosmic muons were recorded with the solenoid at its operating point of 3.8 T for detailed detector studies. By the end of the exercise more than 7 million tracks in the strip tracker and around 75 000 tracks in the pixel tracker were available for alignment and other studies. The data volume totalled an impressive 400 TB. Runs were reconstructed at the Tier-0 centre with a typical latency of six hours before shipping to several Tier-1 and Tier-2 centres.

The CMS data flow was stressed during CRAFT in a way similar to what is foreseen for LHC operations, with calibration and/or alignment sequences performed for the electromagnetic calorimeter, the tracker and the muon systems during the run. Random triggers added on top of the cosmic-muon triggers emulated the trigger rates that will be experienced at the LHC. The high-level trigger ran a menu similar to the one used for the LHC start-up, with the installed complement of nearly 4500 filter processors for the CMS filter farm (around 40% of the final number) being deployed for the first time at the end of the run. Along with the main cosmic data, special raw-data streams created for specific calibration and alignment purposes were shipped to the Tier-0 centre. Teams residing at the CMS analysis facility in Meyrin and at remote centres including DESY and Fermilab checked the data quality offline and validated the online quality-assignments of the data-quality monitoring system.

The precision of tracker alignment previously obtained with data recorded without a magnetic field is now improving significantly with the data collected during CRAFT because the momentum measurement enables better control of the uncertainty that arises from multiple scattering. The run also allowed an initial alignment of the modules comprising the barrel pixel detector. The collaboration completed a first reprocessing of the CRAFT data, incorporating these newly determined calibration and alignment constants, in early December 2008. Several analysis teams will use these data to perform some basic physics measurements, including measurements of the charge ratio and momentum distribution of cosmic muons.

The success of the continuous operation of CMS in "LHC-like" conditions marks the end of a commissioning phase that started two years ago: in November 2006 both the underground experimental cavern and the adjoining service cavern (which is now buzzing with all of the off-detector readout electronics) were empty. The CMS teams are looking back with understandable pride at what has been achieved since then and are looking forward to the challenges of operation with colliding LHC beams in 2009. The commissioning programme to improve the readiness for LHC physics will resume after the annual cooling maintenance, which is expected to take place in late January 2009.

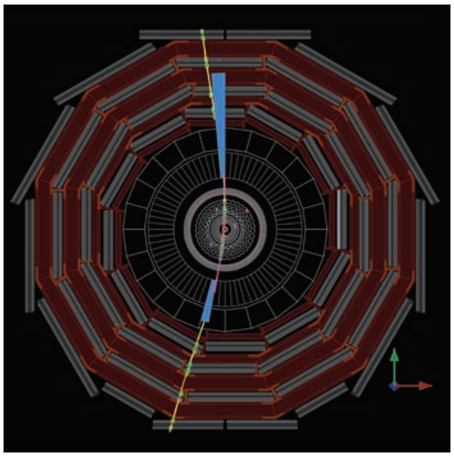

Fig. 1. Event display of a cosmic muon going through the pixel and silicon strip trackers (green and magenta), the electromagnetic and hadron calorimeters (magenta and blue, respectively), and the barrel muon chambers (green).

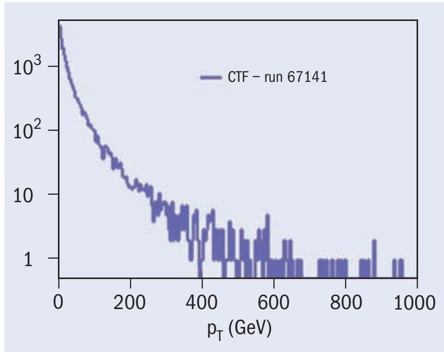

Fig. 2. The reconstructed transverse-momentum distribution for cosmic tracks during the run.

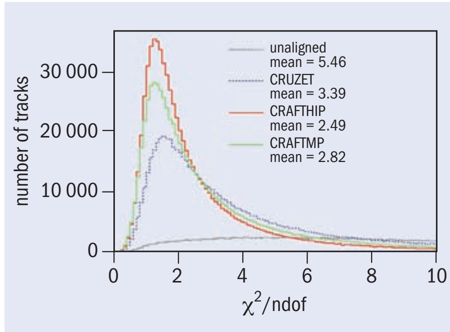

Fig. 3. Distribution of the means of the residuals for the inner-barrel compartment of the silicon strip tracker. Red and green lines show the improvement of the alignment using tracks in the CRAFT data samples (comparing two alignment algorithms, Millepede (MP) and HIP) with respect to the earlier alignment constants: black shows the result with the initial geometry, blue with data from cosmics collected without a magnetic field.

Les physiciens des particules du monde entier sont invités à apporter leurs contributions aux *CERN Courier*, en français ou en anglais. Les articles retenus seront publiés dans la langue d'origine. Si vous souhaitez proposer un article, faites part de vos suggestions à la rédaction à l'adresse cern.courier@cern.ch.

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TRIUMF

MW linacs could supply medical isotopes

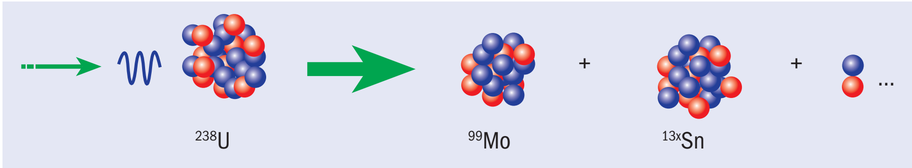
In late 2007, owing to an extended shutdown of Canada's National Research Universal (NRU) reactor at Chalk River, North America experienced a critical shortage of the medical isotope molybdenum-99 (^{99}Mo). Currently some 80–85% of the 40 million nuclear-medicine procedures worldwide each year use ^{99}Mo. The NRU reactor, which has been operating since 1957, produces about half of the world's supply. A second reactor in the Netherlands produces the balance. It too has suffered from age-related shutdowns.

The ^{99}Mo isotope has traditionally been manufactured using nuclear reactors to irradiate highly enriched uranium targets because high neutron fluxes are available. Now, in the light of advances in accelerators – particularly in superconducting RF (SRF) cavities that enable high beam power (p42) – TRIUMF, Canada's national laboratory for particle and nuclear physics, has led a study of alternative techniques for producing ^{99}Mo. The North American study group that was convened by TRIUMF included physics and chemistry experts, as well as clinical professionals representing industry.

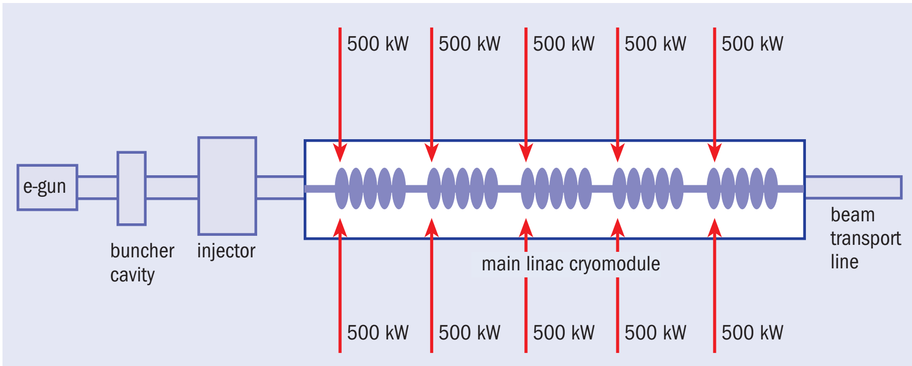
The most favoured approach uses photons from a high-power electron linear accelerator to produce ^{99}Mo from natural uranium. The researchers concluded that significant quantities of ^{99}Mo can be produced using this method, although several laboratory experiments will be needed to establish efficiencies, equivalency of products, reliability of operation and capacity. A single multimegawatt machine could supply the entire Canadian market or 5–7% of the total North American market. The radiochemistry needed to recover and refine the ^{99}Mo generated through photofission from natural uranium targets is likely to resemble that which is currently in use for reactors using highly enriched uranium targets. The similarity of the initial ^{99}Mo-recovery step will depend on the volume of the target for photofission, which relies in detail on the optimization of design and performance parameters. The study group recommended the formation of a steering group, which would oversee laboratory demonstrations of the entire process, ultimately leading to a full-scale design process.

The study has attracted widespread interest in Europe, Asia and North America, with each region investigating options for securing a reliable supply of ^{99}Mo. In many cases, however, these are highly dependent on the future plans for nuclear power, because manufacturers of power plants are likely to construct and operate their own research reactors. Canada's five-year plan for TRIUMF (2010–2015) already includes the construction and operation of a high-power electron linear accelerator using SRF. This machine could be an important testbed for the proposed ^{99}Mo technology because it will operate at similar power densities.

● For more about the Canadian task force on alternatives for medical isotope production, see http://admin.triumf.ca/facility/5yp/comm/isotope-task-force.php.



The photofission process proposed for the production of the isotope ^{99}Mo from natural uranium.



A schematic layout of the kind of accelerator that could supply the Canadian demand for ^{99}Mo for nuclear medicine: a 5 MW electron linac based on 704 MHz superconducting RF technology.

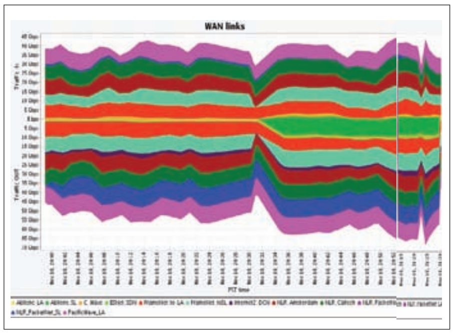
COMPUTING

High-energy physics team sets data-transfer world records

An international team led by the California Institute of Technology (Caltech), with partners from Michigan, Florida, Tennessee, Fermilab, Brookhaven, CERN, Brazil, Estonia, Korea and Pakistan, set new world records for sustained data transfer among storage systems during the successful SuperComputing 2008 (SC08) conference held in Austin, Texas, in November.

Caltech's exhibit at SC08 by the High-Energy Physics (HEP) group and the Center for Advanced Computing Research (CACR) demonstrated new applications and systems for globally distributed data analysis for the LHC at CERN, together with Caltech's global monitoring system, MonALISA, and its collaboration system, Enabling Virtual Organizations. A highlight of the exhibit was the HEP team's record-breaking demonstration of storage-to-storage data transfers. This achieved a bidirectional peak throughput of 114 Gbit/s and a sustained data flow of more than 110 Gbit/s among clusters of servers on the show floor and at Caltech, Michigan, CERN, Fermilab, Brazil (Rio de Janiero, São Paulo), Korea, Estonia and locations in the US LHCNet network in Chicago, New York, Geneva and Amsterdam.

The team used a small fraction of the global LHC Grid to transfer data between the Tier-1, Tier-2 and Tier-3 facilities at the partners' sites and between a Tier-2-scale computing and storage facility that the HEP and CACR team had constructed on the exhibit floor in fewer than two days. Rates of more than 40 Gbit/s were sustained in both directions for several hours (and up to 71 Gbit/s in one direction). One of the key elements in this demonstration was Fast Data Transfer (FDT), an open-source Java application based on TCP developed by the Caltech team in close collaboration with colleagues at Politechnica Bucharest. FDT works dynamically with Caltech's MonALISA system to monitor the capability of the storage systems, as well as the network path, in real time. It also sends data out to the network at a rate that is matched to the capacity of long-range network paths.



A sample of the rates flowing in and out of servers at SC08, monitored by MonaLISA. The general smoothness results from using FDT.

A second major milestone was achieved by the HEP team working together with Ciena Corporation, which had just completed its first OTU4-standard optical link carrying a 100 Gbit/s payload over a single wavelength with forward-error correction. The teams used a fibre-optic cable with 10 fibre-pairs to link their neighbouring booths together; Ciena's system to multiplex and demultiplex ten 10 Gbit/s links onto the single OTU4 wavelength running on an 80 km fibre loop; and some of the Caltech nodes used in setting the wide-area network records, together with FDT. Thanks to the system's high throughput capabilities and the error-free links between the booths, the teams managed to achieve a maximum of 199.90 Gbit/s bidirectionally (memory-to-memory) within minutes, and an average of 191 Gbit/s during a 12 hour period that logged the transmission of 1.02 PB overnight.

FACILITIES

Pierre Auger Collaboration inaugurates observatory

More than 200 guests and 100 collaboration members celebrated the inauguration of the Pierre Auger Observatory at its southern site in Malargüe, Argentina, on 14 November. The event marked the completion of the first phase of the observatory construction and the beginning of the project's second phase, which includes plans for a northern-hemisphere site in Colorado, US. Also planned are several enhancements to the southern-hemisphere site.

The Pierre Auger Collaboration began construction of its Southern Observatory in 2000. This consists of an array of 1600 detectors spread over 3000 km^2 in Argentina's Mendoza Province. Surrounding the array is a set of 24 fluorescence telescopes that view the faint ultraviolet light emitted by the cosmic-ray shower particles as they cascade through the atmosphere (*CERN Courier* July/August 2006 p12). More than 40 funding agencies are contributing to the observatory, which cost approximately $53 million to construct.

Guests at the inauguration ceremony included Julio Cobos, the vice-president of Argentina, Celso Jaque, the governor of Mendoza, several ambassadors, many high-level officials from funding agencies, the directors of CERN and Fermilab, and research officers from universities associated with the project. In addition to a symposium, guests enjoyed a dusty two-hour ride across the Pampa Amarilla to inspect some of the 1600 particle detectors.

The Pierre Auger Observatory's original protagonists, Alan Watson (left) and James Cronin (centre), with project manager Paul Mantsch. (Courtesy Pierre Auger Observatory.)

DESY awards two building contracts for European XFEL

DESY has commissioned two consortia of renowned building contractors to construct the underground buildings (tunnels, shafts and halls) for the 3.4 km long X-ray laser facility, European XFEL.

The contracts for the sites at Schenefeld, in the Pinneberg district (Schleswig-Holstein), and Osdorfer Born, in Hamburg – which add up to nearly €206 million – were awarded to the consortium Hochtief/Bilfinger Berger. The commission for the civil-engineering works at the Hamburg site of DESY-Bahrenfeld amounts to €36 million and goes to the consortium Züblin/Aug. Prien. The contracts were awarded on 12 December and construction started officially on 8 January. DESY is at present acting for the future not-for-profit company European XFEL GmbH, which is to be founded in spring 2009 and will be in charge of the construction and operation of the new research facility.

The 3.4 km long research facility will be located between the DESY site at Bahrenfeld and the neighbouring town of Schenefeld. It will begin at DESY, where the central supply stations will be situated. In the last kilometre, the tunnel will fan out into several separate tunnels in which the X-ray laser flashes will be generated and transferred to the experiment stations. The site at Osdorfer Born, which will comprise another access and supply building, will be established at the beginning of this tunnel fan. The underground experiment hall at the end of the facility will be located on the future 15 ha research campus in Schenefeld and provide space for 10 experiment stations. It will be 14 m deep, with a surface area of 4500 m^2. The contracts that were awarded in December cover all civil-engineering works. These comprise eight shafts leading into underground halls, the experiment hall and all of the tunnels. The total length of tunnel system will be 5.8 km and will be constructed using tunnel-boring machines.

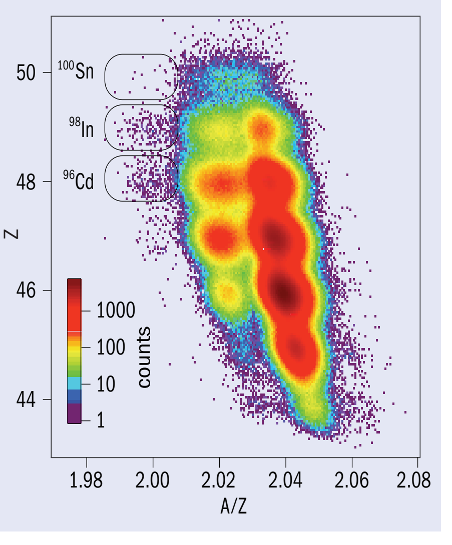
The investment costs for the European X-ray laser facility amount to €986 million (at 2005 price levels). As the host country, Germany will cover as much as 60% of the investment costs and at least 40% will be borne by the international partner countries. Alongside the German federal ministry of education and research, the City of Hamburg and the German federal state of Schleswig-Holstein, 13 countries are participating: China, Denmark, France, Greece, Hungary, Italy, Poland, Russia, Slovakia, Spain, Sweden, Switzerland and the UK.

NUCLEAR PHYSICS

Proton-rich nuclei shed light on heavy-element synthesis in cosmos

Researchers at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) have measured the half-lives of ^{100}Sn and ^{96}Cd, two nuclei with equal numbers of protons and neutrons that are close to the proton drip line – the proton-rich limit of stability. The result for ^{100}Sn narrows the error range of previous half-life measurements, while the half-life of ^{96}Cd, measured here for the first time, casts a light on the role of the isotope in the rapid proton-capture (rp) process – a key part of heavy-element synthesis in the cosmos. The result for ^{96}Cd also implies a new, as-yet-unknown origin for ^{96}Ru in the solar system, where its abundance has long remained unexplained.

Daniel Bazin and colleagues at MSU used the same fast-beam fragmentation scheme to create both species. Using the facility's coupled cyclotrons, the team generated a primary beam of 120 MeV/nucleon ^{112}Sn and fragmented it on a beryllium target. The resulting radioactive beam was filtered through the A1900 Fragment Separator and newly commissioned RF Fragment Selector. Finally, the filtered secondary beam implanted itself in NSCL's Beta Counting System, a series of silicon beta-particle detectors flanked by detectors of the laboratory's segmented germanium array. To track the beta-decay of implanted nuclei, Bazin's team monitored decay events at the impact site and neighbouring pixels in the detector for 10 s after implantation.



Particle identification spectrum of the heavy nuclei transmitted through the Radio-Frequency Fragment Selector. The most intense contaminants normally present at larger A/Z are rejected. The low-Z contaminants are not shown on this figure. The gates indicated on the spectrum were used to select the N = Z nuclei, to reduce cross contamination. (Bazin et al. *2008.)*

For ^{100}Sn, the team observed a half-life of $0.55^{+0.70}_{-0.31}$ s. This result is similar to previous measurements made at GSI and yields an average of $0.86^{+0.37}_{-0.20}$ s when combined. The increased precision may bolster understanding of this isotope, which is one of the few "doubly magic" nuclei close to the proton drip line. Its protons and neutrons both form a closed-shell configuration, which affords extra stability to the nucleus.

The measured half-life of ^{96}Cd, which was previously unknown, was $1.03^{+0.24}_{-0.21}$. This is within the range of several theoretical predictions but it is too short to make ^{96}Cd a critical "waiting point" in the rp process. This process, along with slow neutron capture and rapid neutron capture, probably accounts for many of the universe's heavy elements. It occurs in supernovae, X-ray bursts and perhaps other astrophysical environments where seed nuclei join with free protons to form nuclei of increasing atomic number. Build-up stalls at specific stages when the binding of another proton is energetically unfavourable. Nuclei accumulate at these so-called waiting points, generating a spike in the observed isotope abundance. Such a spike exists at ^{96}Ru, the product of beta-decay from ^{96}Cd, which suggests a waiting point at ^{96}Cd.

With the result for ^{96}Cd, the half-lives of all expected waiting points along the proton drip line, up to the rp-process's predicted endpoint, are now known experimentally. However, the half-life that Bazin and collaborators have measured is approximately a tenth of the value required to account for the observed abundance of ^{96}Ru. There must be a different explanation – perhaps an unexplored astrophysical process.

Further reading

D Bazin *et al.* submitted *Phys. Rev. Lett.* http://arxiv.org/pdf/0810.3597v1 [nucl-ex].

SCIENCEWATCH

Compiled by John Swain, Northeastern University

Bacteria give taste its flavour

Not many research papers can legitimately begin by quoting a book on wine, but Christian Starkenmann and colleagues of Firmenich SA in Geneva have good cause when they describe how "the golden Sauvignon grape releases an aromatic fruity odour 20–30 seconds after being swallowed". The team has made the remarkable discovery that mouth bacteria help to produce this "retro-aromatic effect" and so create the overall taste of wine and grapes, as well as other fruit and vegetables.

Other researchers had earlier shown that volatile sulphur compounds are important in giving Sauvignon blanc its flavour and that these arise from naturally occurring precursor compounds called cysteine-S-conjugates.

To study the retro-aromatic effect in more detail, Starkenmann and colleagues looked at cysteine-S-conjugates in Sauvignon grapes, onions and capsicum peppers. They performed a number of tests with both a panel of tasters and samples of sterile and "crude" saliva.

The tests showed that the initial sulphur compounds are undetectable by human taste and smell until the oral bacteria transform them into the volatile – and thus smellable – thiols. The process takes about 30 seconds and the volatiles remain for a few minutes. However, saliva also plays another role; it traps free thiols and so influences the flavour. As the researchers explain: "The mouth acts as a reactor, adding another dimension to flavour perception."

Bacteria in the mouth give Sauvignon grapes their "finish". (Courtesy John Kroetch/Dreamstime.)

Further reading

C Starkenmann *et al.* 2008 *Journal of Agricultural and Food Chemistry* **56** 9575.

Membranes mimic Schrödinger's cat

Putting a whole cat into a quantum mechanical superposition of two states, as in Erwin Schrödinger's original thought experiment, might not be realistically possible, but researchers have found a macroscopic system that could come close to it.

Mishkat Bhattacharya and Pierre Meystre of the University of Arizona have demonstrated that it should be possible to get pairs of membranes to interact by reflecting light into vibrational states that are analogous to the excitations of single molecules.

Michael Hartmann and Martin Plenio at Imperial College in London have also argued that such optically coupled membranes could be put into entangled states. It will take challenging experimental work using laser cooling to get these effects to occur, but the membranes could be 1 mm^2, which is closer to feline scales than to the scale of atoms.

Further reading

M Bhattacharya and P Meystre 2008 *Phys. Rev. A* **78** 041801.

M J Hartmann and M B Plenio 2008 *Phys. Rev. Lett.* **101** 200503.

Back from the dead

Sayaka Wakayama of the RIKEN Center for Developmental Biology and colleagues in Japan have published a paper on "Production of healthy cloned mice from bodies frozen at –20 °C for 16 years". While cloning from frozen pretreated tissue samples has been done before, this is a first because it uses untreated frozen mouse brain. Clones have never been made from live brain cells, and while brain tissue could be expected to be relatively fragile, it appears that sugars in the brain protect DNA against freezing damage.

Further reading

S Wakayama *et al.* 2008 *Proc. Nat. Acad. Sci.* **105** 17318.

Bioanalysis by CD

It may soon be possible to convert a CD player into a cheap biosensor, thanks to some clever lateral thinking by Yunchao Li and colleagues at Simon Fraser University in British Columbia. They took treated-gold nanoparticles that could bind to specific molecular targets and put them onto a normal CD. By exposing the CD to a test sample, this would then reveal the presence of specific targets through their binding to the gold nanoparticles, triggering the formation of a larger clump of silver particles via a nucleation process.

They used a standard CD player to detect the resulting clump via the error signal it produced – like a scratched CD. Such software is normally used as part of the digital error-correction system for reading damaged CDs, but in this case the error was actually interpreted as a signal.

Further reading

Y Li, L M L Ou and H-Z Yu 2008 *Analytical Chemistry* **80** 8216.

Carbon nanotubes make loudspeakers

One novel application of carbon nanotubes could be to make flexible loudspeakers, according to Kali Jiang of Tsinghua University and colleagues in Beijing. They discovered that thin carbon-nanotube films produce loud sounds when driven by varying electrical currents. This appears to arise from a thermoacoustic effect whereby the alternating current periodically heats the films and produces changes in temperature, which in turn cause pressure changes in the air – hence sound.

The researchers state that they can produce transparent, nanometre-thick loudspeakers that can be made in virtually any shape or size without the need for magnets. The discovery could open up new applications for loudspeakers and other acoustic devices, as well as new manufacturing possibilities.

Further reading

L Xiao *et al.* 2008 *Nano Letters* **8** 4539.

Compiled by Marc Türler, ISDC and Observatory of Geneva University

Chandra improves dark-energy constraints

Evidence that the nature of dark energy is a cosmological constant is gathering strength. By adding independent constraints on dark energy from X-ray observations of clusters of galaxies by the Chandra spacecraft, it seems unlikely that the universe will end in a Big Rip.

Dark energy manifests itself by accelerating the expansion of the universe, an effect that was first noticed in 1998 by studying distant supernovae of type Ia (*CERN Courier* September 2003 p23). Additional evidence that dark energy currently constitutes more than 70% of the matter-energy content of the universe came from the Wilkinson Microwave Anisotropy Probe (WMAP) spacecraft through the analysis of the cosmic microwave background fluctuations (*CERN Courier* April 2003 p11, May 2006 p12, May 2008 p8).

A first step in the characterization of dark energy is the determination of its equation of state, which describes the relation between pressure, P, and energy density, u, through the parameter w: $P=wu$. Unlike matter, dark energy is characterized by a negative value of w leading to a negative pressure acting as anti-gravity in the equations of general relativity. An acceleration of the expansion rate of the universe is possible if w is less than $-1/3$. If w is exactly -1, dark energy has the properties of the cosmological constant, with an acceleration going on forever at the same rate. For lower values of w, the acceleration would continue increasing until a dramatic Big Rip occurred, which would tear everything apart, from galaxies down to atoms and nuclei (*CERN Courier* May 2003 p13).

The study of clusters of galaxies provides an independent characterization of dark energy. The approach is based on measurements by the Chandra satellite of X-ray emission from hot gas in the clusters. The first results appeared four years ago (*CERN Courier* July/August 2004 p12). By increasing the sample to 37 distant clusters, with an average redshift of $z=0.55$, and comparing them with a sample of 49 nearby ones, the team led by A Vikhlinin from the Harvard-Smithsonian Center for Astrophysics has now significantly improved the constraints on dark energy. They find an evolution of the cluster-mass function implying the existence of dark energy with an equation-of-state parameter of $w=-1.14\pm0.21$, assuming it to be constant and the universe to be flat. In combination with the latest constraints from type-Ia supernovae, baryonic acoustic oscillations and WMAP, the team obtains $w=-0.991$ with statistical and systematic uncertainties each of only about 0.04. This combined analysis also puts an upper limit of 0.33 eV on the masses of light neutrinos.

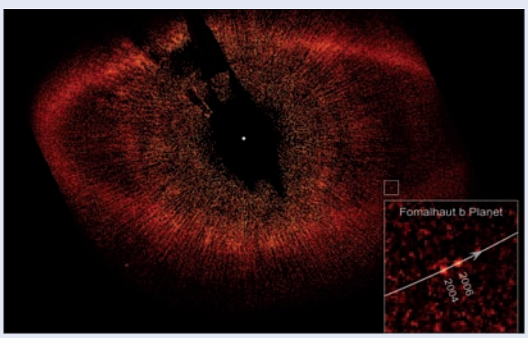
Composite image of the galaxy cluster Abell 85, with the optical image from the Sloan Digital Sky Survey combined with the Chandra image of the hot X-ray glowing gas (purple). (Courtesy X-ray NASA/CXC/SAO/A Vikhlinin et al.*; optical SDSS.)*

Only 10 years after identifying the effect of dark energy, astronomers can now combine different measurements that are consistent with each other if dark energy has the properties of the cosmological constant introduced by Einstein to counteract self-gravity in a static universe. There is still some freedom within the uncertainties for a more exotic dark energy, but the alternatives are clearly disfavoured by simplicity arguments (Occam's razor). This means that dark energy is most likely vacuum energy, but the mystery of its low but none-zero energy density remains: why is it 120 orders of magnitude below the quantum expectation?

Further reading

A Vikhlinin *et al.* 2009 *ApJ*, in press. http://arxiv.org/abs/0812.2720.

Picture of the month



This is the first direct image in visible light of an extrasolar planet. The Hubble Space Telescope found the exoplanet to orbit the Fomalhaut star, the brightest star in the constellation Piscis Austrinus, the southern fish. The light from the star, 25 light-years away, was masked by a coronagraph to detect the dim planet. The presence of the planet was predicted from the sharp inner edge of the dust belt that still surrounds this young star. The Jupiter-sized planet has cleared the area just inside this dust ring. The inset at bottom right corresponds to the white box at the planet's location and shows the motion of the planet between observations in 2004 and 2006 along its orbit around the star (central white dot), which is about four times the size of Neptune's orbit around the Sun. (Courtesy NASA, ESA and P Kalas/University of California, Berkeley.)

A look back to *CERN Courier* vol. 6, January/February 1966, compiled by Peggie Rimmer

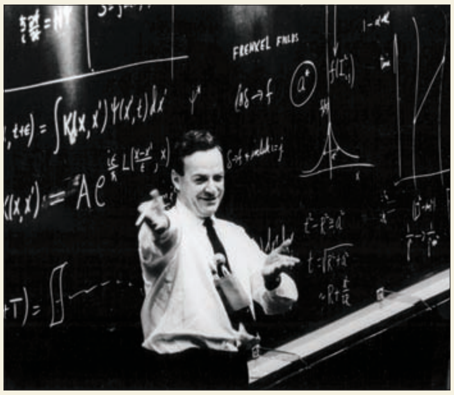
TRIBUTE

Farewell to Professor Weisskopf

At the end of 1965, after five years as Director General of CERN, Professor Weisskopf returned to the Massachusetts Institute of Technology, Cambridge, USA. Several ceremonies were held to show the appreciation of CERN for Professor Weisskopf's services to the Organization.

The photograph on the right was taken at a reception on 8 December, organized by CERN's theoretical physicists in honour of the departing Director General and his wife. Professor Weisskopf was presented with the first copy of a new book, dedicated to him, called Preludes in Theoretical Physics, *containing 42 essays by 50 theoretical physicists who have worked at CERN. Professor Weisskopf (left) is taking his first look at the book together with his successor as Director General, Professor Gregory (right), and Professor Van Hove, the new Directorate Member for Research. The photograph far right shows Professor Fierz at the Council Dinner, declaiming the poem to Professor Weisskopf which he had composed during the evening. Markus Fierz was Head of CERN's Theory Division in 1959. In the foreground is Charles Peyrou (left), then Head of CERN's Track Chambers Division, and John Adams, Acting CERN Director General 1960–61 and Co-Director General with Willibald Jentscke 1971–75 and with Léon Van Hove 1976–80.*

● Compiled from photos and texts on pp2–4.



The 1965 Nobel Prize in Physics was awarded to Schwinger, Tomanaga and Feynman for their fundamental work in quantum mechanics on the theory of the interaction of charged particles with the electro-magnetic field. Richard Feynman, from the California Institute of Technology, visited CERN while in Europe to receive the Nobel prize. He fascinated a packed auditorium, on 17 December 1965, with a brilliant and entertaining lecture on his Nobel prize work.

● Picture and caption from p13.

NEWS FROM ABROAD

Orsay

On the 25 October 1965, the first attempt was made to inject electrons into the storage ring (ACO, Anneau de Collisions d'Orsay). The storage ring is designed for electron-positron collisions with each particle beam having an energy up to 500 MeV. Several hundreds of particles were stored at the first attempts.

Rutherford Laboratory

A 1.4 metre heavy-liquid bubble chamber operated for the first time on 29 October. The bubble chamber was designed by engineers and physicists from University College, London, and the Laboratory. The capacity of the chamber is 450 litres; the magnetic field strength is 21.5 kg. The first experiments using the chamber will begin early in 1966.

Stanford

In November 1965, successful acceleration of a beam of electrons in a superconducting cavity was achieved at Stanford. The cavity was a copper cylinder 4 inches long coated inside with lead, which becomes superconducting near absolute zero, cooled by liquid helium to 1.80 K. Acceleration equivalent to 4 MeV/ft was obtained.

● Compiled from texts on pp14–15.

COMPILER'S NOTE

Robert Aymar completed his five-year term of office as CERN's director-general at the end of 2008, having seen the first circulating beams in the laboratory's latest big accelerator, the LHC. It is interesting to recall similar events that happened at CERN and elsewhere forty-odd years ago and, as Rolf Heuer begins his mandate as director-general (p5), to wonder what the next decades hold for CERN and for particle physics.
Happy New Year.

Accelerators shine as experts gather in Genoa

EPAC returned to Italy for the last meeting in this European series, which is to merge into an annual international event. It revealed the increasing strength and breadth of research in particle accelerators, which seems destined for a bright future.

EPAC '08 took place in the Magazzini del Cotone conference centre in the old port city of Genoa, close to the iconic "Il Bigo" constructed for the city's 500th anniversary. Il Bigo includes a covered public area and a lift for viewing the city. (Photos courtesy Claudio Federici from LNF/INFN.)

The European Particle Accelerator Conference (EPAC) has been a regular feature on the conference calendar since the first meeting in Rome 20 years ago. It brings together accelerator specialists working in areas ranging from fundamental physics through applications in material science, biology and medicine to commercialization in industry. EPAC '08, the 11th in the series, took place in Genoa, the Italian port city with links to Christopher Columbus and Marco Polo – explorers who established some of the first routes from Europe to the Americas and the Far East. It was a fitting location, because this was the final conference in the series. EPAC will merge with the related American and Asian conferences into the International Particle Accelerator Conference (IPAC), which will roam between America, Asia and Europe on a three-yearly basis.

High energies and high intensities continue to be the major goals in the field, with a common thread of superconducting technology. The drive for high energies comes principally from high-energy particle physics, where CERN's LHC is poised to lead the field. The machine was entering the final stages of hardware commissioning at the time of the conference. It is often pointed out that the LHC is its own prototype, breaking new ground in many ways in terms of scale and complexity – from the world's largest vacuum system to the quench-protection systems and interlocks. Problems have been inevitable; the latest (p6) will surely be overcome as previous ones were. One lesson that can be learned for future projects of this scale is not to forget the infrastructure while focusing on the more challenging aspects.

High aspirations

For now, the Tevatron at Fermilab and RHIC at Brookhaven continue to provide the high-energy frontier in hadron collisions. Thanks to a number of improvements, the Tevatron reached a peak luminosity of 3.15×10^{32} cm^{-2}s^{-1} in 2008, exceeding the goals of the upgrade for Run II. Beam–beam interactions remain a major limitation, but work on compensation using two electron lenses installed in the ring is providing promising results in increasing the lifetime of the proton beam. Similarly RHIC has exceeded its design parameters, not only with gold–gold collisions but also in operating as a high-luminosity polarized-proton collider. Runs have reached a peak luminosity of about 35×10^{30} cm^{-2}s^{-1} and a polarization of around 60% for a 100 GeV proton beam. To reach higher luminosities, electron cooling of the heavy-ion beams is being investigated, and a 20 MeV energy-recovery linac (ERL) is under construction for tests. This could also be used to study the new idea of coherent electron cooling in which density variations induced in the electron beam by the hadron beam are amplified by a free-electron laser (FEL) and fed back to correct the hadron beam – a variation on stochastic cooling. In addition, the ERL can test design ideas for the proposed electron–ion collider, e-RHIC.

For some years the international particle-physics community has been pursuing options for a future linear electron–positron collider to complement the high-energy hadron collisions at the LHC. In 2004 the International Technology Recommendation Panel decided that a future International Linear Collider operating in the 0.5 TeV centre-of-mass region should be based on 1.3 GHz superconducting RF technology. The *Reference Design Report* released ▷

Members of the local organizing committee pose for a photograph, including from left to right, Renzo Parodi from Genova, Paolo Pierini of INFN, Caterina Biscari of INFN and Christine Petit-Jean-Genaz of CERN.

In the opening session, CERN's Frederick Bordry (right) presented the status of the ongoing LHC commissioning to the large audience.

in 2007 specified two 11 km linacs with an accelerating gradient of 31.5 MV/m and a peak luminosity of 2×10^{34} cm^{-2}s^{-1}.

A major goal of the first stage of the technical-design phase is to demonstrate by mid-2010 the feasibility of an accelerating gradient of 35 MV/m in 9-cell cavities, thereby allowing an operating margin of 10%. Global R&D on cavity shapes, fabrication and surface preparation is under way to meet this challenge. While tests have achieved field gradients as high as 41 MV/m, average results worldwide are still 15–20% short of reliably meeting the design requirement. A further challenge is the beam-delivery system, and particularly the issue of chromaticity, which is being investigated by a large international collaboration, with dedicated test facilities existing and under construction at SLAC and at KEK. The positron source is another challenging area because the design luminosity demands a source that delivers 1000 times as many particles per pulse than previous sources, together with the added complication of a possible upgrade to high (60%) polarization. Tests at SLAC have shown that a superconducting-undulator solution is feasible and development work is now in progress in the UK.

In parallel, an increasing international effort in the Compact Linear Collider (CLIC) study is investigating an innovative two-beam accelerator concept, which aims at a centre-of-mass energy of 3 TeV and a luminosity of 2×10^{34} cm^{-2}s^{-1}. Tests are under way at CERN in the CLIC Test Facility with a view to the production of a conceptual design report by 2010 (*CERN Courier* September 2008 p15). Accelerating structures have already been tested to the required field gradient of 100 MV/m.

More futuristic is the attempt to harness electric fields in plasmas to accelerate particles (e.g. in the plasma-wakefield approach). Studies at the Accelerator Test Facility at Brookhaven are using multiple electron bunches only 5.5 ps long to generate the wakefields in a potentially more efficient manner. New results demonstrate a maximum wakefield of around 22 MV/m near the tail of the bunched beam. At Lawrence Berkeley National Laboratory, tests with laser wakefields reached 1 GeV in a distance of only 3 m in 2006 (*CERN Courier* November 2006 p5). The goal now is to develop this principle into a laser accelerator to drive a short-wavelength FEL.

Current plans for the LHC foresee a series of luminosity upgrades by 2017, with a new injection system that could easily be upgraded to provide a multimegawatt beam. Another future option, which is still in the embryonic stage, would be to build an electron ring in the LHC tunnel to allow electron–proton collisions. The aim is for a luminosity of 1.1×10^{33} cm^{-2}s^{-1}, some 10 times as high as at DESY's HERA collider, which ceased operations in 2007. Another option would be for a 140 GeV linac to supply the electrons. In either case, ERL technology should prove useful.

Intense and brilliant

In other areas of particle physics, the emphasis is on high intensities, because physics beyond the Standard Model may well lie in processes that are rare and/or difficult to observe. By the time it ceased operations in April 2008, the PEP-II B factory at SLAC had surpassed its design luminosity by a factor of four, reaching 1.2×10^{34} cm^{-2}s^{-1}, thanks to successive improvements, including continuous injection. The machine also provided valuable lessons to be learned for the design of future machines, such as in feedback. Elsewhere, commissioning is in full swing on the upgrade of the Beijing Electron–Positron Collider, BEPCII, to increase the collision rate by a factor of 100 (*CERN Courier* September 2008 p7). At the Budker Institute of Nuclear Physics in Novosibirsk the aim is to achieve higher luminosity in the VEPP-2000 collider by means of innovative ideas, using existing injectors in a restricted area.

KEKB, the asymmetric e^+e^- collider for the study of B mesons at KEK, has operated with crab cavities for more than a year, the first installation to do so, following 13 years of R&D (*CERN Courier* September 2007 p8). The scheme using a single cavity per ring gives somewhat lower luminosity than without, but also at a lower beam current. The system needs further study to understand the effects limiting the luminosity at higher currents. A similar R&D programme at the DAΦNE e^+e^- collider at Frascati is investigating the use of a "crab waist" scheme, with sextupoles that give a factor of three shrinkage in the vertical plane as well as a narrower crossing. Put into operation in early 2008, they reached a peak luminosity 50% higher than the previous record, but at lower currents and two-thirds power.

Elsewhere, high-intensity facilities offer the possibility of a range of research. At the Japan Proton Accelerator Complex (J-PARC), the main ring is a 50 GeV synchrotron designed to deliver a 0.75 MW beam. This will serve kaon-rare decay studies, for example, and provide the first-ever megawatt-class fast-extracted beam to create neutrinos for the Tokai to Kamioka experiment (*CERN Courier* July/August 2008 p19). It will be fed by a 3 GeV 1 MW rapid-cycling

EPAC '08: a hard act to follow

EPAC '08 was a resounding success: the fruit of 20 years of experience in organizing these events with exciting scientific programmes reflecting the state of the art. More than 1000 delegates from 38 countries converged on EPAC '08, the last in the biennial series as the conference joins Asia and North America to propose an International Particle Accelerator Conference on a three-year cycle.

As is customary for EPAC, the four-and-a-half-day programme consisted of plenary sessions at the opening, closing and prize sessions (with no more than two oral sessions in parallel), followed each afternoon by plenary poster sessions, allowing delegates to derive maximum benefit from the scientific programme. The meeting was augmented by the regular industrial exhibition, which for EPAC '08 was the largest ever, with 90 companies participating. Many conference delegates also attended the traditional session for industry.

The 2008 prizes for the European Physical Society Accelerator Group were awarded during the prize ceremony, with the Rolf Wideröe prize going to Alex Chao of SLAC; the Gersh Budker prize to Norbert Holtkamp now at ITER and formerly of the Oak Ridge National Laboratory (ORNL) and Spallation Neutron Source (SNS); and the Frank Sacherer prize to Viatcheslav Danilov, also of ORNL/SNS (*CERN Courier* April 2008 p32).

With the continuing financial support of European laboratories, 66 students from around the world attended the conference. They had an extra opportunity to present their work in a special student-poster session. A prize was awarded in two categories: for a young physicist or engineer for quality of work and promise for the future; and for best posters. The prize for the best student poster went to Rocco Paparella of INFN–LASA.

Thanks to the team effort of the Joint Accelerator Conferences website (JACoW) collaboration editors, the proceedings were published "prepress" on the last day of the conference, and in record time at the JACoW open-access site three weeks later.

synchrotron (RCS), which will also serve muon and neutron production targets in the Materials and Life Science Facility. The RCS already operates at design energy in conditions corresponding to a beam power of about 130 kW.

The Facility for Antiproton and Ion Research (FAIR), which is planned for Darmstadt, is set to be the largest science project funded in Europe in the next decade. It will provide beams of antiprotons and heavy ions at intensities 100 times as great as present, with additional capabilities for fragment-separation and plasma physics using ion bunches and petawatt lasers. Technical challenges surround the high-current beams, control of the dynamic-vacuum pressure and the design of rapid-cycling superconducting magnets. With two linacs and eight rings (including four storage rings), the FAIR complex will involve interesting beam manipulations with implications for RF synchronization. Experiments are expected in 2013.

The techniques of in-flight separation and isotope separation online (ISOL) are currently providing a turning point for research using radioactive beams. Superconducting linacs are the key in providing beams of heavy ions, while cyclotrons and synchrotrons are needed to reach high energies at in-flight facilities such as FAIR and the Radioisotope Beam Factory at the RIKEN institute in Japan. Studies in Europe, meanwhile, are leading towards the European ISOL facility, EURISOL, with a planned beam power of 5 MW. In the US both the National Superconducting Cyclotron Laboratory at Michigan State University and the Argonne National Laboratory have proposals for facilities that include the possibility of reaccelerating rare isotopes. TRIUMF has a slightly different proposal to use a megawatt-class electron linac for the photofission of a uranium target to produce neutron-rich rare isotopes (p9).

Neutron sources also demand high-incident beam intensities for neutron production. The Spallation Neutron Source at Oak Ridge National Laboratory has a design-beam power of 1.4 MW, which is to be achieved after three years of operation. Since start-up in October 2006 the facility has reached 0.52 MW, making it the world's most powerful spallation neutron source. There have been problems, however, with the low-energy beam transport and the superconducting 1 GeV proton linac. An intense neutron source is also a key element of the International Fusion Materials Irradiation Facility, which will study the responses of materials to the high flux of neutrons (10^{18} n/m^{2}s) that would be emitted in a future fusion reactor. Design ideas for the necessary low-energy deuteron accelerator are already being pursued in the context of an international agreement between Euratom and Japan.

For facilities using FELs to provide short-wavelength photon beams for a variety of science, the key word is "brilliance". While synchrotron sources can provide high energies (and hence short wavelengths), FELs offer the route to increased brilliance. The Free-electron Laser in Hamburg (FLASH) at DESY has been operating successfully for more than a year, delivering pulses at 6.5 nm. For the future, there is ongoing accelerator R&D for an X-ray FEL (XFEL) based on a 17.5 GeV electron linac, compared with the 1 GeV linac in FLASH. At SLAC, meanwhile, the Linac Coherent Light Source is under construction to operate at X-ray wavelengths (0.15–1.5 nm). This will use a new 135 MeV injector and the downstream third of the famous 3 km linac to reach a final energy of 14 GeV. It is on course to provide X-rays for the first experiments in summer 2009.

Beyond the laboratory

The main use of particle accelerators is outside research, particularly in X-ray machines in medicine. Now an increasing number of machines are being designed and built explicitly for hadron therapy using protons and carbon ions (*CERN Courier* December 2006 p17). In April 2007, PSI started the treatment of patients with a proton-scanning system based on a commercially supplied 250 MeV superconducting cyclotron. The Heidelberg Ion Therapy Facility is set to be Europe's first dedicated proton- and carbon-therapy facility, with a synchrotron to provide the particles. Commissioning for three fixed beams was finished in April 2008, and commissioning of the gantry for scanning has begun. In Italy, the Centro Nazionale di Adroterapia Oncologica in Pavia is under construction, and commissioning the sources and the low-energy beam transfer is also under way. ▷

EPAC '08

As hadron therapy moves out of research laboratories and into hospitals, there is a growing market that industry can serve by providing not only the basic accelerators but also other items and services related to the treatment of patients. In this area, as well as in others, collaborations between industry and researchers provide an important means of transferring from a project to a product.

Indeed, working closely with industry is an increasingly important part of the accelerator scene. The LHC has led the way for "mega projects", with industrialization of the magnet construction. One problem, however, is that the duration of such big projects can be longer than the lifetime of some companies. Nevertheless, co-operation with industry is essential from an early stage. The European XFEL project has already begun to work with industry in the production of the 100 cryomodules – each with eight 9-cell superconducting RF cavities and superconducting magnets. At the same time, research institutes that require linacs can benefit from being able to acquire customized systems direct from industry, particularly from the company ACCEL Instruments. There are many other specialized areas where partnerships between research and industry have proved mutually beneficial.

The accelerator scene continues to evolve and grow, not only in underlying technology, but also in its relations with other areas of science and industry. It is therefore fitting that the conference scene should reflect this evolution. The last EPAC provided a worthy ending to a successful series and the community now looks forward to the first IPAC, in 2010 in Kyoto, following the last in the Particle Accelerator Conference series, in Vancouver in May this year.

● The organizing committee for EPAC '08, chaired by Caterina Biscari of INFN, and the scientific programme committee, chaired by Oliver Bruning of CERN, were formed by the board elected by the European Physical Society Accelerator Group, plus representatives of APAC and PAC, while the local organizing committee, chaired by Paolo Pierini of INFN, included a dozen members from INFN (Genoa, LASA, LNF), SINCROTRONE Trieste and CERN.

Further reading

The proceedings are available through open access from the JACoW website at www.jacow.org.

Résumé

Toujours plus brillant : réunion de l'EPAC à Gênes

La Conférence européenne sur les accélérateurs de particules (EPAC) est devenu un rendez-vous régulier depuis sa première édition il y a 20 ans. Elle rassemble des spécialistes des accélérateurs travaillant dans des domaines très divers, allant de la physique fondamentale aux applications en science des matériaux, à la biologie et à la médecine, ainsi que la commercialisation dans l'industrie. L'édition 2008 était la onzième et dernière, car l'EPAC va désormais être intégrée à une manifestation mondiale. La conférence a révélé la force et la richesse croissante de la recherche concernant les accélérateurs de particules, promise à un brillant avenir. Les énergies élevées et les intensités élevées continuent à être des objectifs importants, et les technologies supraconductrices restent la base commune des projets.

Christine Sutton, *CERN.*

Protons and neutrons cosy up

Douglas Higinbotham, **Eli Piasetzky** and **Mark Strikman** investigate recent measurements that have probed the cold, dense nuclear systems of nucleons comparable to those of neutron stars.

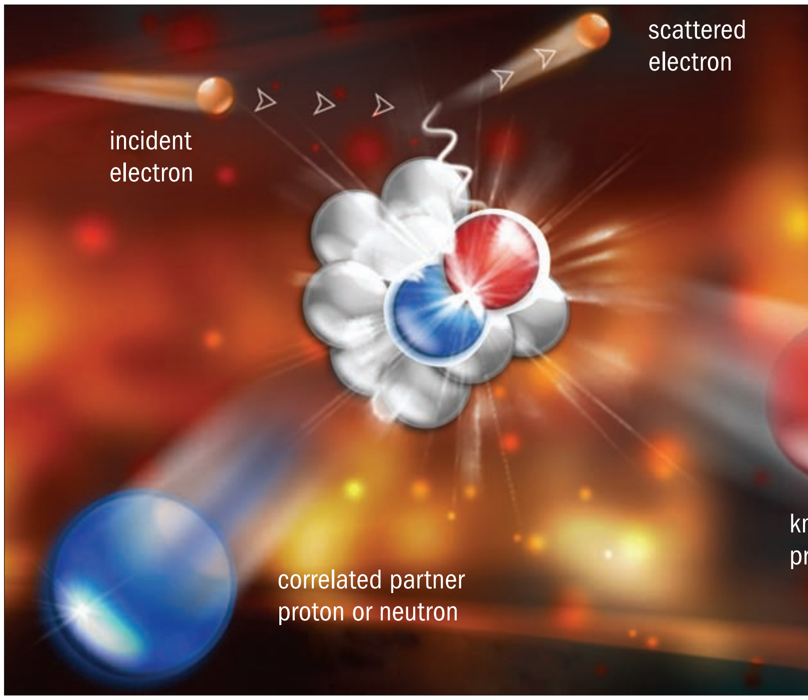


Fig. 1. An illustration of a short-range correlation reaction. By selecting kinematics beyo
momentum of nucleons in the nucleus, knocking out a proton causes a high-momentum
nucleon to be emitted from the nucleus, leaving the rest of the system relatively unaffe

The structure of nuclei is determined by the nature of the strong force: strong repulsion at short distances and strong attraction at moderate distances. This force, which binds the nucleons together while also keeping the structure from collapsing, makes the nucleus a fairly dilute system. This has allowed for calculations that treat the nucleus as a collection of hard objects in an average or mean field to describe many of the properties of nuclear matter. Of course, this simple picture of the nucleus is inaccurate – the nucleons should really be thought of as waves that can strongly overlap for short periods of time. Indeed, recent experiments have shown that about 20% of all nucleons in carbon are in such a state at any given time.

These states of strongly overlapping wave functions are commonly referred to as nucleon–nucleon short-range correlations (SRC). Calculations indicate that, for short periods, these correlations lead to local densities in the nucleus that are several times as high as the average nuclear density of 0.17 GeV/fm^3. Such densities are comparable to those predicted in the core of neutron stars. Isolating the signal of short-range correlated nucleons may therefore lead to a deeper understanding of cold, dense nuclear systems – whether extremely small (such as helium nuclei) or extremely large (such as neutron stars).

The distinctive experimental features of two-nucleon SRCs are the large back-to-back relative momentum and small centre-of-mass momentum of the correlated pair, where large and small are relative to the Fermi-sea level of about 250 MeV/*c*. This is shown in figure 1, where a virtual photon is absorbed by one nucleon in a correlated pair, causing both nucleons to be emitted from the nucleus. The large strength of the nucleon–nucleon interaction at short distances means that the relative motion in the pair should be the same in all nuclei, although the absolute probability of a correlation grows with density – with the probability of a nucleon to be part of a pair reaching 25% for iron and heavier nuclei.

Scaling effects

Isolating the signal of the SRC initial state has been difficult at low and medium energies because other processes (such as final-state interactions and meson-exchange currents) mimic this effect. Nevertheless, there has recently been progress using modern accelerators with high-luminosity and high-momentum transfer – as well as with kinematics, where competing mechanisms are suppressed. For electron scattering, this corresponds to luminosities of 10^{-37} cm^{-2}s^{-1}; a four-momentum transfer, Q^2, greater than 1.4 (GeV/c)^2; and focusing on kinematics where Bjorken-x, $Q^2/2m\nu$, is greater than 1, where ν is the beam energy minus the energy of the scattered electron. For elastic scattering from a free proton, Bjorken-x is exactly 1. At least two nucleons must be involved to have $x > 1$; $x > 2$ requires a system with at least three nucleons.

One of the new results has come from inclusive data at high momentum-transfer, $Q^2 > 1.4$ (GeV/c)^2, and $x > 1$ from the Hall B CEBAF Large Acceptance Spectrometer at the US Department of Energy's Jefferson Laboratory (K S Egiyan *et al.* 2006). The measurement was made to check the predicted universality of SRCs by measuring the ratio of the inclusive cross-sections off heavy nuclei to those of light nuclei at sufficiently large Q^2 and x, where the scattering off slow nucleons in the nucleus does not contribute. The signal predicted to indicate dominance of such correlations is the scaling of the ratios – a weak dependence on x and Q^2 for $1 < x < 2$ – which is clearly observed in the data. Continuing this line of reasoning would suggest that a second scaling region arising from three-nucleon correlations should be observed for $x > 2$. Indeed, a second scaling region does seem to be present, although the statistics are limited (figure 2). These results reflect the dominance of few-nucleon correlations in the high-momentum component of the nucleus (*CERN Courier* November 2005 p37).

While the inclusive data clearly suggest strong local correlations, it has taken exclusive data to confirm that the inclusive scaling arises from SRCs, as well as to measure directly what fraction of

p in nuclei and neutron stars

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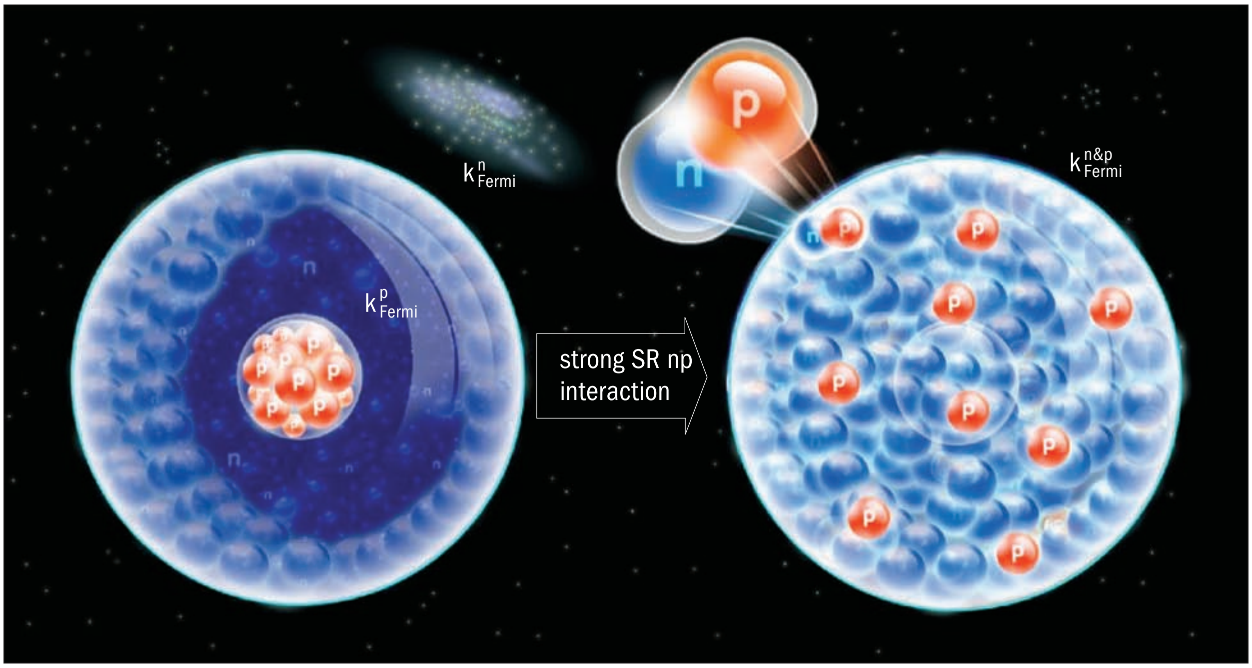

Fig. 4. Illustration in momentum space of the momentum distribution, k_{Fermi}, of protons and neutrons in neutron stars. The left side shows the case where the protons and neutrons weakly interact and can be approximated as separate Fermi spheres, with the neutron momentum much greater than the proton momentum. The figure on the right shows how strong neutron–proton SRCs cause protons to escape their Fermi sphere and have higher momentum then would otherwise be allowed.

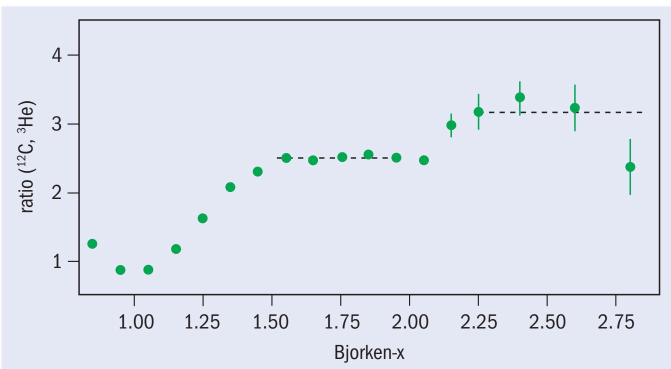

Fig. 2. The cross section ratio ^{12}C to ^{3}He as a function of Bjorken-x for Q^2 >1.4 (GeV/c)^2. The horizontal solid and dashed lines indicate scaling regions, which have been interpreted as being due to two- and three-nucleon SRCs, respectively. As the cross-sections fall rapidly with Bjorken-x, the absolute strength of the three-nucleon correlation is an order of magnitude smaller than the two-nucleon correlation.

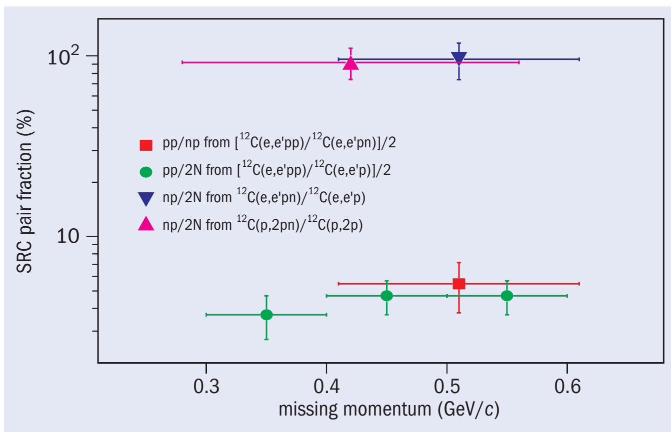

Fig. 3. The fractions of SRC pair combinations in ^{12}C as obtained from the Jefferson Lab (e,e'pp) and (e,e'pn) reactions, as well as from Brookhaven (p,2pn) data. The results agree with the interpretation of the inclusive data, and show the dominance of proton–neutron pairs.

nucleon-pair types are involved. In exclusive experiments, using a high-momentum probe to remove one fast nucleon from the nucleus effectively breaks a pair and releases the second nucleon of the correlation. Brookhaven National Laboratory and Jefferson Lab have conducted such tests on the carbon nucleus with a hadronic and electromagnetic probe, respectively. They measured momentum transfers of greater than 1.5 GeV/*c* and a missing momentum greater than the Fermi momentum of 250 MeV/*c*.

Both experiments have shown that recoiling nucleons, with a momentum above the Fermi-sea level in the nucleus, are part of a correlated pair and both observed the same strength of proton–neutron correlations (Piasetzky *et al.* 2006; Subedi ▷

et al. 2008). This confirms that the process is accessing a universal property of nuclei unrelated to the probe. The Jefferson Lab's experiment also observed the proton–proton pairs and used matched-acceptance detectors to determine the ratio of neutron–proton to proton–proton pairs as nearly 20, as figure 3 shows. Calculations explain the magnitude of this neutron–proton to proton–proton ratio as arising from the short-range tensor part, or nucleon–nucleon spin-dependent part, of the nucleon–nucleon force (Sargsian *et al.* 2005; Schiavilla *et al.* 2007; Alvioli *et al.* 2008).

Isolating the signatures of SRCs opens new avenues for the exploration of nucleon–nucleon interactions at short distances, particularly in addressing the long-standing question of how close nucleons have to approach before the nucleons' quarks reveal themselves. Nucleon degrees of freedom can no longer be used to describe the system.

These studies can also influence calculations of the extremely massive. Without SRCs, a large object, such as a neutron star, could be well approximated as a Fermi gas predominantly of neutrons with a small fraction of protons acting as a separate Fermi gas. With SRCs the protons and neutrons interact, strongly enhancing the high-momentum component of the proton momentum distribution, leading to changes in the physical properties of the system.

In the future, inclusive short-range-correlation experiments will improve the statistics of the $x > 2$ data to show definitively whether or not there is indeed a second scaling. These will use targets such as ^{40}Ca and ^{48}Ca to measure the dependence on the initial-state proton–neutron ratio. The future exclusive experiments will focus on ^{4}He (a nucleus where both full and mean-field calculations can come together) and push the limits of the recoil momentum to extend our understanding of the repulsive part of the nucleon–nucleon potential.

Further reading

M Alvioli *et al.* 2008 *Phys. Rev. Lett.* **100** 162503.
K S Egiyan *et al.* 2006 *Phys. Rev. Lett.* **96** 082501.
E Piasetzky *et al.* 2006 *Phys. Rev. Lett.* **97** 162504.
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Résumé

Rapprochement entre protons et neutrons dans les noyaux et les étoiles à neutrons

L'image simplifiée du noyau est celle d'un ensemble d'objets durs (nucléons) agissant dans un champ moyen. C'est bien sûr inexact ; les nucléons doivent en réalité être conçus comme des ondes qui peuvent se recouvrir pendant des temps brefs. Des expériences récentes ont montré qu'à tout moment 20% environ des nucléons d'un atome de carbone sont dans un tel état. Ces nucléons peuvent être impliqués dans des corrélations de courte portée, ce qui produit brièvement des densités locales comparables à celles des étoiles à neutrons. Certaines mesures, effectuées en particulier dans des expériences sur les électrons au Laboratoire Jefferson, permettent d'étudier ces systèmes nucléaires froids et denses.

Douglas Higinbotham, *Jefferson Laboratory*, **Eli Piasetzky**, *Tel Aviv University and* **Mark Strikman**, *Penn State University.*

The Pauli principle faces testing times

A workshop on the spin-statistics connection was enlivened by discussions on the nature of space–time. **Catalina Curceanu** and **Edoardo Milotti** report from SpinStat 2008.

The Pauli exclusion principle (PEP), and more generally the spin-statistics connection, plays a pivotal role in our understanding of countless physical and chemical phenomena, ranging from the periodic table of the elements to the dynamics of white dwarfs and neutron stars. It has defied all attempts to produce a simple and intuitive proof, despite being spectacularly confirmed by the number and accuracy of its predictions, because its foundation lies deep in the structure of quantum theory. Wolfgang Pauli remarked in his Nobel Prize lecture (13 December 1946): "Already in my original paper I stressed the circumstance that I was unable to give a logical reason for the exclusion principle or to deduce it from more general assumptions. I had the feeling, and I still have it today, that this is a deficiency...The impression that the shadow of some incompleteness fell here on the bright light of success of the new quantum mechanics seems, to me, unavoidable." Pauli's conclusion remains basically true today.

The PEP was a major theme of the workshop "Theoretical and experimental aspects of the spin-statistics connection and related symmetries" at SpinStat 2008, held in Trieste on 21–25 October at the Stazione Marittima conference centre. Some 60 theoretical and experimental physicists attended, as well as a number of philosophers of science. The aim was to survey recent work that challenges traditional views and to put forward possible new experimental tests, including new theoretical frameworks.

Participants of SpinStat 2008 filled the entrance stairs of the Stazione Marittima conference centre in Trieste. (Courtesy Erica Novacco.)

A single framework for discussion

On the theoretical side, several researchers are currently exploring theories that may allow a tiny violation of PEP, such as quon theory, the existence of hidden dimensions, geometric quantization and a new spin-statistics connection in the framework of quantum gravity. Others have done several experiments over the past few years to search for possible small violations of the spin-statistics connection, for both fermions and photons. Thus scientists have recently obtained new limits for the validity of PEP for nuclei, nucleons and electrons, as well as for the validity of Bose–Einstein statistics for photons. These results were presented during the workshop and discussed for the first time in a single framework together with theoretical implications and future perspectives. The aim was to accomplish a "constructive interference" between theorists and experimentalists that could lead towards possible new ideas for nuclear and particle-physics tests of the PEP's validity, including the interpretation of existing results.

The workshop benefited from the presence of researchers who have devoted a life's work to the thorough examination of the structure of the spin-statistics connection in the context of quantum mechanics and field theory. In addition, young scientists put forward suggestions and experimental results that may pave the way to interesting future developments.

Oscar W Greenberg of the University of Maryland opened the workshop with a review talk on theoretical developments, with special emphasis on quon theory – which characterizes particles by a parameter q, where q spans the range from −1 to +1 and thus interpolates between fermion and boson – in an effort to develop more general statistics. Greenberg is the originator of this concept and he continues to be a major contributor to its ▷

Some of the workshop participants gathered for a group photograph on a terrace overlooking the city centre. (Courtesy Catalina Curceanu.)

The public event – a reading of selected parts of the book by George Gamow and Russell Stannard, The New World of Mr Tompkins *– was a great success. The cartoon seen here, illustrating the twin paradox of special relativity, is by Javad Alizadeh. (Photo courtesy Erica Novacco.)*

theoretical development, maintaining a high degree of interest in the field. Robert Hilborn of the University of Texas reviewed the past experimental attempts to find a violation. Other theoretical speakers included distinguished scientists such as Stephen Adler, Michael Berry, Aiyalam P Balachandran, Sergio Doplicher, Giancarlo Ghirardi, Nikolaos Mavromatos and Allan Solomon.

The experimental reports included presentations on spectroscopic tests of Bose–Einstein statistics of photons by Dmitry Budker's group at the University of California and the Lawrence Berkeley National Laboratory, and studies of spin-statistics effects in nuclear decays by Paul Kienle's group at the Stefan Mayer Institute for Subatomic Physics in Vienna. Other talks included results from the Borexino neutrino experiment and the DAMA/LIBRA dark-matter detector in the Gran Sasso laboratory, the KLOE experiment at Frascati, the NEMO-2 detector in the Fréjus underground laboratory and the dedicated Violation of the Pauli exclusion principle experiment in the Gran Sasso laboratory. Each talk was followed by lively discussions concerning the interpretation of the results. Michela Massimi of University College London closed the workshop with an excellent talk on historical and philosophical issues.

Another highlight was the event held for the general public: a reading of selected parts of the book by George Gamow and Russell Stannard, *The New World of Mr Tompkins*, where the professor depicted in Gamow's book was played by a witty Michael Berry from the University of Bristol. This event was a success, especially among the young students who participated so enthusiastically.

Overall, the workshop showed that the field is full of new and interesting ideas. Although nobody expects gross violations of the spin-statistics connection, there could be subtle effects that may point to new physics in a context quite different from that of the LHC.

The workshop was sponsored jointly by the INFN and the University of Trieste. It received generous contributions from the Consorzio per la Fisica, the Hadron Physics initiative (Sixth Framework Programme of the EU) and Regione Friuli–Venezia Giulia.

Further reading

The full programme and the complete list of speakers are available at www.ts.infn.it/eventi/spinstat2008/index.php.

Résumé

Le principe de Pauli à l'épreuve du temps

Le principe d'exclusion de Pauli, et, plus généralement, la relation spin-statistiques, joue un rôle central dans notre compréhension d'innombrables phénomènes physiques et chimiques allant du tableau périodique des éléments à la dynamique des étoiles à neutrons. Néanmoins, il reste à trouver une démonstration simple et intuitive de ses fondements. C'était là un thème important lors d'un atelier sur la relation spin-statistiques tenu à Trieste en octobre 2008. L'atelier a réuni environ 60 physiciens, théoriciens et expérimentateurs, ainsi que des philosophes des sciences, qui ont examiné des travaux récents et proposé de nouvelles vérifications expérimentales et de nouveaux cadres théoriques.

Catalina Curceanu, *Laboratori Nazionali di Frascati dell'INFN*, **Edoardo Milotti**, *Dipartimento di Fisica, Università di Trieste and INFN–Sezione di Trieste.*

APPOINTMENTS

LBNL head moves to Washington

US president-elect Barack Obama has nominated Steve Chu, the Lawrence Berkeley National Laboratory (LBNL) director, to be the next secretary of energy. Chu will be among the few active scientists to head the Department of Energy (DOE), and the first winner of a Nobel prize in science in the US cabinet.

In this role Chu will manage the $24 billion budget of the DOE, covering a range of basic research, energy technology (including for nuclear energy), nuclear weapons and environmental remediation. The DOE also supports research in high-energy and nuclear physics at DOE laboratories (Fermilab, SLAC, LBNL, BNL, etc) and in many university groups.

Chu is a strong advocate for research in alternative energy, particularly in solar energy and biofuels, as well as for science in general. He has been director of LBNL since 2004. During his tenure he initiated significant new multidisciplinary efforts in biofuels and solar energy using both public funding and private donations. One high-profile step was a $500 million grant from BP to create the Energy Biosciences Institute. Chu has spoken widely on the dangers of global warming and the need for energy efficiency. He has also pushed several initiatives to modernize LBNL, including a new energy-efficient computer centre, an on-site guesthouse and the demolition of the old Bevatron building.

Chu (right), seen here with the governor of California, Arnold Schwarzenegger, is a strong supporter of research into alternative energies and the need for energy efficiency. (Courtesy LBNL.)

Chu received his PhD in 1976 from the University of California, Berkeley. He spent 17 years as a professor of physics at Stanford University and served as chair of the physics department before coming to LBNL. Prior to Stanford he had been a member of the technical staff at Bell labs. He received the Nobel Prize in Physics in 1997 for his work on laser cooling and trapping, but his research spans from atomic physics through biophysics to polymer physics. For example, he used laser "tweezers" to grab the two ends of a DNA molecule and measure the force required to separate the ends.

Engelen takes on role as NWO chair in the Netherlands

Jos Engelen is the new chair of the Netherlands Organisation for Scientific Research (NWO). After five years as scientific director and deputy director-general of CERN, Engelen took up his new post on 1 January, succeeding Peter Nijkamp, who has stepped down. Engelen is no stranger to NWO, previously being chair of ASTRON (the NWO institute for radio astronomy) – a post he relinquished after becoming the NWO chair.

After working at CERN from 1979 to 1985, Engelen joined Nikhef, the Netherlands' national institute for subatomic physics. He became a professor at the University of Amsterdam in 1987 and was subsequently director of Nikhef from 2001 to 2003, before returning to CERN as scientific director and deputy director-general in 2004.

Jos Engelen took up his NWO role on 1 January.

CONFERENCE

STORI '08: storage rings come to China

STORI '08 in Lanzhou attracted some 90 participants from around the world. (Courtesy IMP, Lanzhou.)

STORI '08, the 7th International Conference on Nuclear Physics at Storage Rings, took place on 14–18 September 2008 in Lanzhou. Organized by the Institute of Modern Physics of the Chinese Academy of Sciences, the meeting was chaired by Guoqing Xiao from the nearby Heavy Ion Research Facility, and attracted 90 scientists from around the world.

A wealth of new scientific results from the operating hadron and electron rings, as well as new plans, were presented among the 25 invited talks and 20 contributions. There were presentations on the first nuclear-mass measurements from the newly commissioned pair of cooler-storage rings (CSR) for ions at Lanzhou – the main ring, CSRm, and the experimental ring, CSRe. A visit during the meeting revealed the progress in setting up and commissioning these storage rings.

Participants discussed not only physics-related issues but also the technological challenges related to storage rings, such as electron and stochastic cooling, polarized beams (of antiprotons), the targets (liquid and cluster jets, pellets and polarized) as well as the internal and external detectors. Several talks were devoted to the transition from existing detectors and rings to future facilities: e.g. from the Wide-Angle Shower Apparatus at the Cooler Synchrotron in Jülich to the PANDA experiment at the High-Energy Storage Ring at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt; and from the Experimental Storage Ring (ESR) at GSI to the ESR at FAIR.

The next STORI conference will be in 2011 in Frascati, with Stefano Bianco of the Frascati National Laboratory and INFN as chair. By then the construction of new facilities, particularly FAIR, should have begun.

AWARDS

IUPAP recognizes CERN's research

Award winners Georg Bollen, second from left, Heinz-Jürgen Kluge, centre, and Frank Herfurth, second from right, with the C2 representatives Jens Dilling (Canada), far left, and Juha Äystö (Finland), far right, during the special award session at the ENAM 2008 conference in Poland. (Courtesy of M Zielińska.)

An afternoon session of the Exotic Nuclei and Atomic Masses (ENAM) 2008 conference held in September in Ryz, Poland, was dedicated to awards from the International Union of Pure and Applied Physics (IUPAP) and highlighted pioneering work at CERN's ISOLDE facility.

Heinz-Jürgen Kluge from GSI, Georg Bollen from Michigan State University and David Pritchard from MIT received the Senior Scientist medal for 2008, awarded by the International Commission (C2) on Symbols, Units, Nomenclature, Atomic Masses and Fundamental Constants. In addition, the IUPAP C2 Young Scientist Prize in Fundamental Metrology was awarded to Sébastian Bize of the Laboratoire National d'Essais: Système de Références Temps-Espace and Frank Herfurth of GSI.

Kluge, Bollen and Herfurth carried out their award-winning work at CERN. All three were involved in the development and utilization of ion-trap techniques for precision mass-spectrometry on short-lived isotopes, particularly with the on-line spectrometer ISOLTRAP at ISOLDE. Their combined efforts there, as well as further developments individually, have ultimately led to the highest precision in on-line mass measurements.

Today, Penning traps are well established as the most precise devices for atomic-mass determinations. This has not always been so. They were limited to stable ions for a long time, but a technological breakthrough occurred when Kluge and Bollen, while both at the University of Mainz, introduced the first Penning-trap installation for high-accuracy mass measurements on radionuclides – ISOLTRAP – at ISOLDE.

Ramond receives the Lise Meitner Prize

The Göteborg Physics Centre, Gothenburg, has awarded the Lise Meitner Prize for 2007 to Pierre Ramond of the University of Florida, Gainesville, and the Institute for Advanced Study, Princeton. The prize is given to a scientist who has made a pioneering contribution to physics under difficult or different circumstances, in memory of the difficulties that Meitner herself encountered.

Ramond receives the prize for his pioneering contributions that led to superstring theory. In 1969–1971 he worked as a new post-doc in what later became Fermilab. The laboratory had just started and had collected a few young theoreticians to help the experimentalists, with no senior theoretician to guide them. In this milieu Ramond worked single-handedly on what became the base for superstring theory. In studying Paul Dirac's work on the Dirac equation, Ramond made an analysis of how a string with spin behaves quantum mechanically. This led to the insight that such theories have to fulfil a new fermionic symmetry: supersymmetry.

Pierre Ramond, left, receives the 2007 Lise Meitner Prize from Bengt Nilsson. (Courtesy Chalmers University of Technology.)

ALICE announces its first thesis awards

The ALICE collaboration has for the first time given awards to two of its doctoral students for their outstanding theses, in a ceremony at CERN on 29 October. Zaida Conesa del Valle, of the Laboratoire de physique subatomique et des technologies associées, received the award for her physics thesis *Performance of the ALICE Muon Spectrometer. Weak Boson Production and Measurement in Heavy Ion Collisions at the LHC*. Christian Holm Christensen, of the Niels Bohr Institute, received the award for his technical thesis *The ALICE Forward Multiplicity Detector. From Design to Installation*.

There are more than 300 doctoral students working for ALICE, which each year receives around 20 theses. The collaboration asked supervisors earlier in the year to nominate exceptional candidates for the award, of which eight were nominated and two winners were chosen. This is the first time that the awards have been handed out.

Christian Holm Christensen (left) and Zaida Conesa del Valle receive the ALICE thesis awards.

Toshi Yamazaki (right), spokesman of the PS205 collaboration and president of the Nishina Memorial Foundation, presents the award to Hayano. (Courtesy Nishina Memorial Foundation.)

Nishina Foundation honours Hayano

On 5 December Ryugo Hayano of Tokyo University received the Nishina Foundation prize – the most prestigious scientific accolade in Japan – in a ceremony at Tokyo Kaikan, near the Imperial Palace.

Hayano receives the prize for his work on high-resolution spectroscopy of antiprotonic helium carried out at CERN's Antiproton Decelerator (AD). This work has led, among other things, to a measurement of the antiproton–electron mass ratio to two parts in a billion. As spokesperson of the ASACUSA experiment at the AD, Hayano has been a familiar figure at CERN for many years.

The Nishina Foundation was established in 1955 to commemorate Yoshio Nishina (1890–1951), the father of Japanese atomic and subatomic physics. Previous winners include 2008 Nobel laureates Makoto Kobayashi and Toshihide Maskawa.

Finland recognizes Robert Aymar with the prestigious Order of the Lion

On 9 December, CERN's director-general, Robert Aymar, was awarded the decoration of Commander, first class, of the Order of the Lion of Finland by the President of the Republic of Finland.

This decoration, one of the highest in Finland, was presented in a ceremony by Ambassador Hannu Himanen, Permanent Representative of Finland to the UN and other international organizations in Geneva. Aymar was honoured for his service to CERN, the LHC, his role in the co-operation between Finland and CERN, as well as for his contribution to science in general.

Aymar, right, accepts the medal from Himanen.

SCHOOLS

CAS introduction course goes to Italy

Students at the CAS Introduction to Accelerator Physics course in Frascati. (Courtesy INFN Frascati.)

With 115 participants from more than 23 countries, the CERN Accelerator School's 2008 "Introduction to Accelerator Physics" course proved another resounding success. Organized in collaboration with the University of Rome "La Sapienza" and the INFN Frascati National Laboratory, the school was held on 2–14 November in Frascati and included a visit to the INFN Frascati Laboratory as well as a day excursion to Rome.

The programme featured 38 lectures, three seminars, four tutorials, a poster session where students could present their own work and six hours of private as well as guided tuition. Feedback from the students praised the expertise of the lecturers, the high standard of the lectures and the excellent programme organization.

The introductory-level course is uniquely important because, for the majority of participants, it is their first opportunity to discover the various aspects of accelerator physics. The programme was significantly revised in 2008 to take into account the latest trends emerging in the field, thus putting more emphasis on linacs, synchrotron light sources and free-electron lasers.

The next CAS course will be a specialized course on magnets and will take place in Bruges from 16–25 June 2009. Information will soon be available on the CAS website, www.cern.ch/schools/CAS.

- The 4th CERN–Fermilab Hadron Collider Physics Summer School will be held at CERN on 8–17 June 2009. This school is targeted particularly at young post-docs and senior PhD students. The deadline for applications is 21 February. For more information, visit http://hcpss.web.cern.ch/hcpss/.

WORKSHOP

Critical stability under scrutiny at Erice

Organizers of the fifth workshop on critical stability, in the Paul Dirac lecture hall; from left to right, Aksel Jensen, Jean-Marc Richard, André Martin and Alejandro Kievsky. (Courtesy J-M Richard.)

The fifth workshop on the "Critical Stability of Quantum Few-Body Systems" took place at the Ettore Majorana Centre in Erice, Sicily, on 10–18 October 2008 in the context of the recently created School of Critical Stability. The workshop is devoted to quantum systems on the cusp of stability and instability. Of particular interest are the critically bound systems in which all or some subsystems are unbound – often referred to by the evocative name of "Borromean" states.

The interdisciplinary character of the workshop is an essential feature. Attending participants represented the following fields: theoretical chemistry; atomic, nuclear and particle physics; and mathematical physics. They share the same tools and questions for systems of different scales in length and energy. For this fifth workshop in the series, nuclear physics was particularly dominant, with discussions about spin effects in few-nucleons systems, three- and four-body forces among nucleons and nuclei with neutron halo.

In particle physics, a session was devoted to exotic hadrons, with a critical historical survey by Kamal Seth of Northwestern University and contributions by Vladimir Belyaev from JINR, Slawomir Wycech of Warsaw and Javier Vijande of Valencia. Eberhard Widmann of the Stefan Meyer Institute in Vienna also reviewed recent results from experiments at CERN using low-energy antiprotons and Edward Armour of Nottingham discussed the theoretical interpretation.

In his opening address, the director of the school, CERN's André Martin, evoked Ettore Majorana and Paul Dirac, whose equation is engraved in the auditorium. He also spoke of the important milestones in Antonino Zichichi's foundation of the Erice Centre, which most of the participants were visiting for the first time. The visit to Sicily was made complete with visits to the nearby Greek temples and beaches, as well as sampling local food and wines.

The workshop was organized by Jean-Marc Richard of Grenoble, with the help of Aksel Jensen of Aarhus, Alejandro Kievsky of Pisa and Laurent Wiesenfeld of Grenoble as conveners. The proceedings will appear as a special issue of *Few-Body Systems*.

ANNOUNCEMENT

EPS HEPP calls for 2009 nominations

The European Physical Society High Energy Particle Physics (HEPP) board is calling for nominations for the following prizes: Young Physicist Prize, the Gribov Medal and the Outreach Prize. HEPP will award the prizes this year in a ceremony at the international Europhysics Conference on high-energy physics on 16–22 July in Krakow.

Information on these prizes can be found on the HEPP board website (http://eps-hepp.web.cern.ch/eps-hepp/prizes.php), along with the list of the former prize winners. Nominations for the Young Physicist Prize and the Gribov Medal should be sent to Per Osland (per.osland@ift.uib.no) and nominations for the Outreach Prize to Daniel Wyler (wyler@physik.uzh.ch). All nominations must be received by 15 April 2009.

OBITUARIES

Oliver Overseth 1928–2008

Oliver Overseth passed away on 17 July 2008 at his home in Key West, Florida.

Overseth received his BS from the University of Chicago in 1952 and his PhD from Brown University in 1958. Following a period as an instructor and research associate at Princeton University he joined the University of Michigan faculty in 1961.

An experimental high-energy physicist, he initially studied proton polarization and other strong-interaction processes at the Cosmotron at Brookhaven National Laboratory. His primary research interest then turned to hyperons, and with Jim Cronin he performed a classic spark-chamber experiment to measure the decay parameters of $\Lambda \rightarrow p\pi^-$. Overseth continued to study the properties of hyperons at the Princeton–Penn Accelerator and in 1969 wrote a *Scientific American* article on *Experiments in time reversal*. He then joined Tom Devlin and Lee Pondrom to initiate a celebrated series of experiments at Fermilab, the first of which, E8, discovered the sizable polarization of inclusively produced hyperons at 300 GeV/c. This was used to make precise measurements of the magnetic moments of all hyperons from the Λ to the Ω^-. He continued his research on hyperons with the UA6 experiment at CERN as well as on the WA96 (NOMAD) experiment.

Oliver Overseth. (Courtesy Tenley LeSann.)

At Michigan, the highly regarded lecturer chaired the doctoral thesis committees of 12 students and served on many college and university committees. Being one of the first to recognize such a need, Overseth pioneered a special physics class teaching future elementary-school teachers in 1973. He was interested in teaching at all levels, an arena where he demonstrated a natural ability, especially in the large lecture courses. He was a great friend to his students, taking an interest in their personal and professional lives.

After his retirement in 1992 he lived in Geneva before moving to Key West. He is survived by two daughters, Alison Overseth and Tenley LeSann, five grandchildren and his second wife, Ludy van Bruggen Overseth.

Lawrence W Jones, Michigan.

Ludwig Tauscher 1939–2008

Ludwig Tauscher passed away on 23 November 2008 after a heart attack.

He studied physics at the University of Heidelberg where he obtained his PhD in 1966. Ludwig arrived at CERN in the early 1970s and performed several experiments at the Synchrocyclotron and the PS. In the early 1980s he searched for the production of nucleon–antinucleon bound states at the PS, a subject that was the main motivation for the construction of the Low Energy Antiproton Ring (LEAR). At LEAR he studied neutral-meson production and spectroscopy with the PS182 experiment, for which he was also the spokesperson.

In 1985 he became professor of physics at the University of Basel and devoted his professional life to teaching and experimental physics. Between 1988 and 1996 he led the Forum of Swiss High Energy Physicists (the predecessor of the current Swiss Institute of Particle Physics, CHIPP).

Ludwig was among the founders of the CPLEAR experiment (PS195), to which he made a significantly strong contribution from the time of the proposal in 1985 to the last publications in 2003. He participated in the construction of the trigger and the electromagnetic calorimeter, and helped to finalize many of the analyses on fundamental symmetries published by the CPLEAR collaboration.

In 1994 Ludwig brought the Basel Institute into the CMS collaboration. He was closely involved in the CMS pixel detector and together with his team contributed to vital parts of this detector as it stands today. He also represented Switzerland for many years on the CMS management and collaboration boards.

In parallel, Ludwig's interest in LEP physics led him to join the L3 experiment. Under his leadership, the Basel group made important contributions to all aspects of the L3 scientific programme. His ideas were implemented as a first-level trigger in the L3, which led to a considerable increase in the acceptance of the experiment. He later focused on two-photon physics. In the late-1990s up until his untimely death, he was involved in the DIRAC experiment (PS212), which is currently studying ππ-atoms. He was the project leader in the design and implementation of a high-level trigger and was a leading scientist throughout the experiment, making essential contributions to the data analysis. He enthusiastically supported the project of an upgrade for the improved measurement of the lifetime of ππ-atoms and the observation and future lifetime measurement of πK-atoms.

Ludwig Tauscher. (Courtesy Daniel Drijard.)

After his retirement in 2004, Ludwig continued his commitment to particle physics and related fields as an academic guest of the Laboratory for High-Energy Physics at ETH Zurich. He also continued his duty as a distinguished member of the particle-physics advisory committee for PSI.

With Ludwig's passing, the Swiss particle-physics community has lost a highly distinguished and dedicated physicist, researcher and teacher who committed himself sincerely to the education of young physicists. His warm and open character will be missed by all of us.

His friends and collaborators.

Antonio Vitale 1943–2008

Antonio Vitale, full professor of physics at the University of Bologna, passed away on 8 October 2008 after a painful struggle with an incurable illness.

Antonio was born in Pesaro in 1943 and graduated in physics in 1967. His scientific work developed mainly at CERN, where he started immediately after his diploma to participate in experiments using negative muons to study weak and electromagnetic interactions at the 600 MeV Synchrocyclotron under the leadership of Emilio Zavattini. As head of a Bologna–INFN group he went on to play an important role in the OBELIX collaboration at the Low Energy Antiproton Ring, and most recently he was a member of the ATLAS experiment.

Antonio also fostered experimental work in other laboratories. His initiative was particularly essential with colleagues from Bologna in the Saclay–CERN–Bologna precision determination (to 10^{-5} accuracy) of the muon lifetime, from which the value of the Fermi constant is obtained. Together with the measurement made simultaneously at TRIUMF, this achievement remains unsurpassed. At DESY he initiated and actively drove Bologna's participation in the HERA-B experiment. His range of scientific interests also led him to perform research at the INFN national laboratories at Legnaro and Gran Sasso, at the EURATOM research centre at Ispra and at the Rutherford Appleton Laboratory in the UK; he also collaborated with colleagues at JINR and Los Alamos.

Antonio Vitale. (Courtesy Antonio Bertin/Bologna.)

Colleagues and students were fascinated by his curiosity, eagerness and enthusiasm for research. He was extremely faithful to experiment – placing results before any theoretical prediction or belief – and was particularly keen on data analysis and phenomenology. He had a special intuition for improvements and possible upgrades of experiments and had a great tenacity during data analysis to leave no stone unturned. Once embarked on a project, he would pursue it passionately, with no fear of updating programmes and schedules as required. This attitude was essential when, soon after the discovery of the $W^{\pm}$ and Z^0 particles at CERN, he proposed to the president of the Italian Physical Society, Renato Ricci, the 1984 Bologna Conference on *Fifty Years of Weak Interaction Physics*; this took place a few months later and remains exceptional in that the volume of printed contributions was available on the opening day.

A tenured full professor at Bologna since 1984, Antonio was co-author of a valuable collection of textbooks for university students and was also passionate about more general scientific dissemination. His latest achievement in this respect was the Giuseppe "Beppo" Occhialini Foundation, which he established in Beppo's birthplace, Fossombrone, under the auspices of INFN and Bologna University, with the primary aim of educating high-school students in the relevance of scientific culture. Most significant are the accurately written books published by the foundation, which are freely distributed with national daily newspapers to familiarize readers with research in nuclear and particle physics. He was working until the end on the latest of these, *La fabbrica delle particelle* (*The particle factory*). Co-authored with Vincenzo Vagnoni, it was released on the day of the LHC inauguration and Antonio just had chance to see the first printed copy.

Antonio was endowed with an outstanding potential for communication and human sympathy, which enriched his personality and made his acquaintance special. His exuberant behaviour, matched with brilliant intelligence, and his generous nature were familiar to all who worked with him, or just talked to him over coffee at CERN. His deeply democratic attitude made him interact in the same way with anyone he met, from summer student to CERN director-general or state minister. His presence will be missed by colleagues and students in personal life as well as in research work.
Alfredo Placci, Geneva.

LETTERS

Progress in superconducting RF

We read with great interest the Viewpoint article by Ganapati Rao Myneni (*CERN Courier* November 2008 p50). Most unfortunately, it seems to paint a distorted picture of decades of progress in superconducting R&D by omitting its major successes and by giving misleading reports on some of the ancillary outcomes. The past four decades have seen steady progress in understanding the science behind superconducting cavity gradient limitations, and in developing countermeasures, with ensuing successes in a variety of accelerator applications. (For the benefit of the CERN Courier readership we have provided a brief review (see p42).)

Sadly, Myneni chooses to ignore these phenomena, which globally linked R&D has addressed and transcended. Instead he gives misleading accounts. He refers several times to hydrogen as the source of major performance impediments, claiming cures at Stanford by 1800 °C annealing and growing large grains in intimate contact to prevent hydrogen from entering the cracks. The body of superconducting RF R&D to date has identified (and addressed) several generic performance-limiting phenomena; hydrogen has not been among them. Hydrogen can become a special problem (called the Q-disease) in the case of excess hydrogen absorption during chemical treatment. On cool-down the hydrogen precipitates as lossy Nb-H islands. A complete cure for this problem is also well established: heating to 600–800 °C for a few hours, which substantially reduces the interstitial hydrogen concentration. We await evidence to support the hypothesis that hydrogen yet limits performance.

In the meantime, SRF enthusiasts will continue to explore new techniques and even new materials to produce ever more powerful and compact accelerators for research.
Hasan Padamsee, Cornell University, Charles E Reece, Thomas Jefferson National Accelerator Facility, and Maury Tigner, Cornell University.

Good company revisited

André Martin is correct in noting that the tensor nuclear force, and its critical effect in binding the n–p system, has been known since the early 1950s (*CERN Courier* November 2008 p36). However, it has also been known that the tensor nuclear force is generally much weaker than the central nuclear force. Thus the factor of nearly 20 in the ratio of n–p to p–p correlated pairs reported in *CERN Courier* July/August 2008 (p7) reflects the momentum dependence of the nucleon–nucleon interaction. This result showed that in the missing momentum region, around 500 MeV/*c*, probed by the experiment, the central nuclear force is much weaker relative to the tensor nuclear force than in the deuteron case.
John Watson, Kent State University.

NEW PRODUCTS

HamaTech Advanced Process Equipment GmbH & Co. KG has announced the release of the HMxSquare, a versatile photomask processing system suitable for processing special substrates in institutional environments with the latest environmental and safety requirements. It has a state-of-the-art electronic control system, redesigned software and sophisticated cleaning techniques that provide a low-risk back-up option for advanced processing. For more information, tel +49 7045 41 8; or fax +49 7045 41239.

Southern Scientific has introduced the Model 725, a new multi-trigger, digital delay generator that addresses requirements for extremely complex timing sequences, ranging from controls and diagnostics to signal-quality monitoring and data acquisition. The Model 725 features eight timing channels with programmable logic, unique timing modes and 10 ns edge resolution. It can be programmed and controlled easily using LabVIEW or Windows, and is supplied with timerPRO software. For further details, see www.ssl.gb.com.

Yokogawa Europe has introduced a high-speed, high-accuracy real-time V/I curve tracer ideally suited to carrying out DC parametric testing on semiconductor and opto-electronic devices. The new compact, lightweight unit consists of the Yokogawa GS820 multi-channel source measuring unit and the 765670 curve tracer software, which runs on a PC connected to the GS820 via a USB link. For more information, contact Terry Marrinan, tel +31 88 464 1811; fax +31 88 464 1111; e-mail terry.marrinan@nl.yokogawa.com; or see www.yokogawa.com.

CORRECTIONS

An error occurred in figure 2 in the article on "The Higgs and the LHC" (*CERN Courier* November 2008 p28). The central value of the x-axis should be 100 (GeV).

For the full article by Cecilia Jarlskog on Ernest Rutherford, on which her article on pp19–22 of the December issue was based, see: *The XXIII Conference on Neutrino Physics and Astrophysics* 2008 *J. Phys.: Conf. Ser.* **136** 012001. doi: 10.1088/1742-6596/136/1/012001.

VISITS

The honourable **Pakalitha Mosisili**, prime minister of Lesotho, second from right, visited CERN with his wife **Matatho Mosisili**, far left, on 10 June. They were welcomed by **John Ellis**, far right, before touring the ATLAS experimental cavern and control room with ATLAS spokesperson **Peter Jenni**. Mosisili also signed the CERN guest book before departing.

On 4 July **Andreas Dimitriou**, left, minister of education in Cyprus, left, was welcomed to CERN by **Maximilian Metzger**, CERN's secretary-general. Dimitriou was given a tour of the LHC Computing Centre by Ian Bird, head of the LHC Computing Grid project, followed by a visit to the CMS experiment with CMS spokesperson Tejinder Virdee.

Turkish prime minister, **Recep Tayyip Erdoğan**, right, visited CERN on 17 November. He was greeted by CERN's director-general, **Robert Aymar**, who accompanied him on a visit to the LHC tunnel and the ATLAS experimental cavern. Erdoğan also spoke with some of the 90 Turkish scientists who are collaborating on the experiments, including members from ATLAS, CMS, CAST and CLIC.

John Denham, the British secretary of state for innovation, universities and skills, left, was welcomed to CERN on 5 August by **Robert Aymar**, CERN's director-general. During his visit Denham toured the CMS and LHCb experiments, the ATLAS experimental control room and the LHC computing grid project. He also participated in a lively discussion with various scientists from the UK, ranging from technical and summer students to staff members with many years of experience at CERN.

During a visit to CERN on 25 November, the state councillor, deputy vice-prime minister in charge of science, technology and education for the People's Republic of China, **Liu Yandong**, far right, toured the AMS experimental clean room with **Yupu Yang**, centre, head of the CGSE Control System of AMS. Yandong also met with Felicitas Pauss to discuss Swiss research, education and innovation.

KIT – The cooperation of Forschungszentrum Karlsruhe GmbH and Universität Karlsruhe (TH)

Karlsruhe Institute of Technology

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

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Forschungszentrum Karlsruhe, a member of the Helmholtz Association of German Research Centres, is one of the largest science and engineering research institutions in Europe. Forschungszentrum Karlsruhe and Universität Karlsruhe (TH) are currently joining forces under the roof of the **Karlsruhe Institute of Technology, KIT,** which represents a new kind of interaction between research, education and innovation.

Within KIT, the University Computing Centre and the Institute for Scientific Computing of the Forschungszentrum were merged to form the new Steinbuch Centre for Computing, SCC **(www.kit.edu/scc)**, which is one of the first joint institutes of KIT.

SCC is one of the leading German computing centres in the fields of High Performance Computing and Grid Computing.

KIT invites applications for the position of

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as a member of the SCC Board of Directors

who will be in charge of all SCC operational matters. A large and motivated team will assist her/him.

SCC provides high quality IT Services for 8,000 employees as well as for 18,500 students of KIT. Highest bandwidth networks, high performance computing based on various architectures, large-volume compute and storage resources, high-level desktop services etc. are permanently required by all KIT users as well as by our partners in national and international SCC and KIT projects. Modern methods of Service Management are applied for the continuous optimisation of the services.

Candidates are expected to possess proven management skills and the ability to lead a large scientific research and service institute. The position also requires economic and business thinking.

If applicants are equivalently qualified, handicapped candidates will be selected preferentially.

Applications including CV, references and publication list should be sent to

Prof. Dr.-Ing. Detlef Löhe, Member of the Executive Board
Forschungszentrum Karlsruhe GmbH, P.O. Box 3640, 76021 Karlsruhe, Germany

and also by email to **detlef.loehe@vorstand.fzk.de,** by **February 06, 2009.**

POSTDOCTORAL POSITIONS IN PARTICLE ASTROPHYSICS GAMMA-RAY ASTRONOMY AND DARK MATTER DETECTION

University of California, Los Angeles

We invite applications for postdoctoral research positions at the University of California Los Angeles (UCLA) in the areas of gamma-ray astronomy and dark matter detection.

We are seeking a talented individual to carry out research with VERITAS - a major ground-based gamma-ray observatory located in southern Arizona and sensitive to photons with energies between 50 GeV and 50 TeV. See **http://www.astro.ucla.edu/~veritas**/ for more details. There is also the possibility to analyze data from the Large Area Telescope (LAT) of the recently launched Fermi Gamma-ray Space Telescope. We encourage candidates with an instrumental/observational background in astronomy or an experimental background in particle/nuclear physics to apply.

We also seek a talented researcher to participate in the development of the GAPS experiment - a novel balloon-borne instrument sensitive to low-energy anti-deuterons that could signal the annihilation of neutralino dark matter. See **http://gamma1.astro.ucla.edu/gaps/index.html** for more details. We encourage candidates with experimental backgrounds in particle/nuclear physics or astrophysics to apply.

A Ph.D., or equivalent degree, in physics or astronomy is required. Applicants should send a CV, a statement of research interests and arrange for at least three letters of recommendation to be sent to:

Professor Rene Ong
Department of Physics and Astronomy
University of California
Los Angeles, CA 90095-1547

Deadline for receipt of applications is March 1, 2009. Applications will be accepted until the positions are filled.

www.helmholtz-berlin.de

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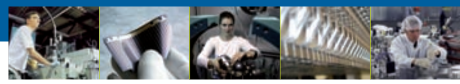

Research with Photons and Neutrons

Established in January 2009, the Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB) merged two of Berlin's largest research institutes, the Hahn-Meitner-Institut and BESSY into one centre.

The two large scale facilities of the Helmholtz-Zentrum Berlin, the neutron source BER II and the synchrotron radiation source BESSY II, serve more than 2,000 scientists from universities, research institutes and industry. The complementary research with photons and neutrons places the HZB in a unique position to address the needs of the international scientific community in physics, chemistry, and materials and life sciences. The HZB intends to further the combined research with photons and neutrons.

The centres' own research activities are largely concentrated in materials research with a focus on:

- Solar Energy
- Magnetic Materials
- Micro- und nanostructured Materials
- Functional Materials

Applying outstanding highly sophisticated analytical tools for investigating materials, solar cells and solar modules, the HZB offers great competences in the field of Solar Energy. A joint initiative, PVcomB, aims to accelerate industrial application of thin-film photovoltaics by efficient technology transfer, based on a comprehensive network of fundamental know-how partners from science, industry and education.

Join us

The new Helmholtz-Zentrum Berlin offers outstanding opportunities for scientists, post-docs and Ph.D. students to tackle scientific problems at the forefront of research in an inspiring environment.

The centre has approximately 1,100 employees. Its two sites are integrated in the unique scientific infrastructure that the Berlin area has to offer, including four universities and numerous research institutes and research driven enterprises.

Two partners became one: The former Hahn-Meitner-Institut (left) and BESSY (right) are now the Helmholtz-Zentrum Berlin für Materialien und Energie.

Divisional Fellow in Experimental High Energy Nuclear Physics

The Nuclear Science Division at Lawrence Berkeley National Laboratory 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.

The successful candidate will have several years of experience beyond the PhD in nuclear or particle physics and will assume a leading role in the Relativistic Nuclear Collisions (RNC) Program at LBNL, with special emphasis on developing new directions. LBNL is a partner of the Helmholtz Alliance "Cosmic Matter in the Laboratory." The position will be associated with and the research will be carried out in the framework of the Extreme Matter Institute of this Helmholtz Alliance.

The RNC Program has major roles in both the STAR experiment at RHIC and the ALICE experiment at the LHC. RNC Scientists are responsible for the development of a silicon pixel detector for STAR and have major responsibilities for a large solid angle electromagnetic calorimeter for ALICE. The Nuclear Science Division also has activities in nuclear structure, nuclear astrophysics, and neutrino physics. LBNL pursues research in a wide range of scientific fields, and has major strengths in computing and engineering.

Applicants are requested to submit in a single attachment a curriculum vitae, publication list, statement of research interest, and the names of at least five references, on-line at **http://cjo.lbl.gov/LBNLCareers/details.asp?jid=22550&p=1** and by e-mail to Dr. Hans-Georg Ritter at **hgritter@lbl.gov**.

This position will be open until filled. We will begin considering candidates **April 1, 2009**. Please reference **Job# 22550**.

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Berkeley Lab

Career Track Staff Scientist in Experimental High Energy Nuclear Physics

The Nuclear Science Division at Lawrence Berkeley National Laboratory is seeking a Scientist with outstanding promise and creative ability in the field of experimental high energy nuclear physics. The appointment will be as Staff Scientist for a term of five years with the expectation of promotion to Career Staff Scientist following successful review.

The successful candidate will have several years of experience beyond the PhD in nuclear or particle physics and will assume a leading role in the ALICE group of the Relativistic Nuclear Collisions (RNC) program at LBNL. The ALICE group has major responsibilities for a large Electromagnetic Calorimeter being built for the ALICE experiment, at the Large Hadron Collider at CERN. The successful candidate will initially be based at CERN, with responsibilities for both technical and scientific aspects of the Calorimeter project.

The RNC Program has major roles in both the STAR experiment at RHIC and the ALICE experiment at the LHC. The Nuclear Science Division also has activities in nuclear structure, nuclear astrophysics, and neutrino physics. LBNL pursues research in a wide range of scientific fields, and has major strengths in computing and engineering.

Applicants are requested to submit in a single attachment a curriculum vitae, publication list, statement of research interest, and the names of at least five references, on-line at **http://cjo.lbl.gov/LBNLCareers/details.asp?jid=22551&p=1** and by e-mail to Dr. Peter Jacobs at **pmjacobs@lbl.gov**.

This position will be open until filled. We will begin considering candidates **April 1, 2009**. Please reference **Job# 22551**.

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Thomas Jefferson National Accelerator Facility (Jefferson Lab) in Newport News, Virginia, USA, is an internationally recognized laboratory engaged in fundamental scientific research in nuclear and particle physics based on the Continuous Electron Beam Accelerator Facility (CEBAF), currently operating at 6 GeV. CEBAF has an approved, funded upgrade to 12 GeV, which is now in the construction phase with completion expected in 2014. In addition to operating CEBAF, the laboratory also operates a Free Electron Laser (FEL) facility. As a result of its core strength and competency in RF superconductivity, the laboratory is a major partner in many national and international projects such as the SNS, FRIB, ILC and Project X. The laboratory is operated for the US Department of Energy by Jefferson Science Associates (JSA).

In order to further enhance its core competencies in the physics and technology of accelerators, lasers, particle beams, and synchrotron radiation, Jefferson Lab is currently seeking qualified candidates for the position of Deputy Associate Director, Accelerator Division. The Deputy Associate Director is responsible for a significant fraction of the Division and reports to the Associate Director, Accelerator Division. The position could lead to a senior laboratory management role at Jefferson Lab as part of the laboratory's succession planning.

The Accelerator Division is responsible for the day-to-day operation of the CEBAF accelerator, and provides technical supervision and guidance of all technical personnel from Operations and other departments in the Accelerator and Engineering Divisions engaged in the performance and operations of the accelerator systems. The Accelerator Division responsibilities also include preparations for the commissioning and operation of the 12 GeV Upgrade. Design work has started on an electron-ion collider which could be the next nuclear physics facility at Jefferson Lab, and this is expected to continue. In addition, the Accelerator Division has a vibrant R&D portfolio based on its core competencies of SRF, cryogenics, electron guns and accelerator physics. The principal focus of the R&D is on high current, CW, multi-pass superconducting linacs, making Jefferson Lab a collaborator of choice for DOE Office of Science projects based on SRF technology. In collaboration with the FEL Division, this expertise is expected to be directed towards the development of a fourth-generation light source based on a superconducting CW electron linac.

The successful candidate will have a PhD and 15 years relevant experience or the equivalent of education and experience in Accelerator Physics or related field, and a demonstrated track record of technical management of significant projects in accelerator design, construction, commissioning and/or operation. The candidate should possess excellent communication and leadership skills and demonstrate good judgment. The candidates should have a functional knowledge of beam dynamics in accelerators and of all the accelerator systems, including RF, magnets and power supplies, beam diagnostics, control systems, etc. Knowledge of superconducting cavities or cryogenics would be a plus, but is not a requirement.

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Superconducting RF success

Hasan Padamsee, **Charles Reece** and **Maury Tigner** highlight past successes in the evolution of superconducting RF technology and look to future developments.

The past four decades have seen many successes in using superconducting RF (SRF) technology in a variety of accelerator applications. These are the result of steady progress in understanding the science behind the gradient limitations in SRF cavities and developing effective countermeasures.

In the 1970s research groups at Stanford, Siemens and Cornell demonstrated spectacular results with available niobium, with surface fields corresponding to accelerating gradients of 25–35 MV/m in single-cell cavities at X-band frequencies (8–10 GHz). However, these performance levels fell apart at the frequencies used in accelerator applications, i.e. below 3 GHz. The primary roadblock was multipacting (the spontaneous resonant production of electrons) limiting the performance of 1.3 GHz cavities to 2–4 MV/m. The physics of multipacting clearly shows that the limiting field levels scale with the RF frequency, so that the X-band cavities of the 1970s had been fortuitously exempt.

Steady progress

The next three decades saw several layers of gradient problems uncovered, the underlying physics understood and solutions developed. Performance then ratcheted up at a steady pace, as did applications. The development of the anti-multipacting spherical (and elliptical) cavities in the 1980s was a breakthrough moment. With multipacting overcome, thermal breakdown of superconductivity became the next limiting mechanism, at 4–6 MV/m. Local heating at surface imperfections led to thermal runaway and a quench of superconductivity. The cure was to switch to high-purity – high residual resistance ratio (RRR) – niobium. With the co-operation of industry, the RRR improved by an order of magnitude and cavity gradients rose on average by a factor of three. Another cure for thermal breakdown was to sputter a film of niobium only a few microns thick onto a copper cavity substrate of high thermal conductivity, which also had the benefit of reduced material costs – especially for low-frequency (0.35 GHz) cavities.

Major applications of RF superconductivity then took off and pushed the energy frontier in storage rings, with TRISTAN at KEK, HERA at DESY and LEP-II at CERN. At the cutting edge of nuclear physics, Jefferson Lab installed the recirculating linac, CEBAF, while at the luminosity frontier CESR at Cornell and KEK B applied niobium cavities to store ampere-sized beams. Superconducting linacs powered FELs at Jefferson Lab and at JAERI in Japan. Thus, 1 km of SRF cavities provided a total 5 GV of acceleration.

With the corresponding rise in surface electric fields, electron emission became the next significant limit to gradients, at 10–15 MV/m. Global R&D revealed microparticle contamination to be the dominant source of field emission, which demanded better preparation techniques such as powerful surface scrubbing with high-pressure water and assembly in Class 100 clean rooms. With these breakthroughs cavity gradients in accelerator assemblies climbed to 20 MV/m. For any given preparation protocol, the probability of encountering field emitters and quench-producing defects grows with cavity area, providing favourable conditions for the X-band cavities of the 1970s, with areas of square centimetres compared to multicell gigahertz-accelerator cavities with surface areas in the order of square metres.

These advances spurred new applications of accelerators for materials science, with the FLASH light source in Hamburg and the Spallation Neutron Source in Oak Ridge adding another 2 GV of acceleration.

The quest for higher gradients continued into the new millennium. At levels above 20 MV/m, RF losses rise exponentially with electric field. The physics of increased losses is still under active investigation worldwide, but pragmatic countermeasures are already in place. Electro-polishing has replaced standard chemical etching to obtain a smoother surface with reduced microscopic field enhancements, followed by mild baking at 120 °C for two days. Research continues to understand the physics of these cures. One alternative may be to use large-grain niobium, cut directly from the ingot to avoid defects, combined with standard chemical etching to produce a smooth surface – again followed by baking at 120 °C, but for 12 hours. Niobium cavities with surface areas of square metres now reach 30–40 MV/m with tolerable losses.

The next frontier

These successes demonstrate how R&D in SRF science and technology has pushed towards ever higher gradients. New applications continue to benefit from the steady progress. Nearly 20 GV of SRF cavities are foreseen for the European XFEL at DESY. The worldwide SRF community has expanded with re-invigorated efforts, encouraged by the successes in unravelling the physics of gradient limitations and the invention of effective countermeasures.

The next frontiers with bulk niobium lie in achieving consistent high-Q performance above 35 MV/m and pushing towards 50 MV/m – already achieved in 1-cell cavities operating at gigahertz frequencies. High-Q values are vital for continuous-wave applications. To accomplish this and push beyond it, materials scientists and process engineers are eager to join SRF enthusiasts in exploring new techniques and new materials to produce more powerful and compact accelerators for physical research.

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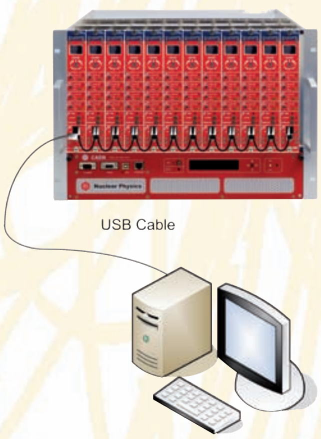

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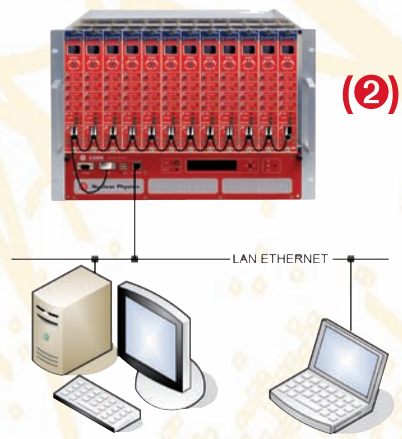

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