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CERN COURIER

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Hubble celebrates 20th birthday

CERN

LHC takes steps to
higher intensities p5

JAPAN

New facilities for
carbon-ion radiotherapy p22

ARTS

Does CERN need a
cultural revolution? p42



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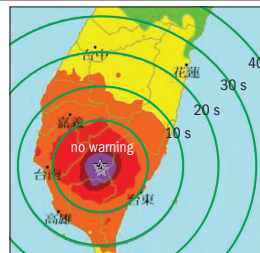
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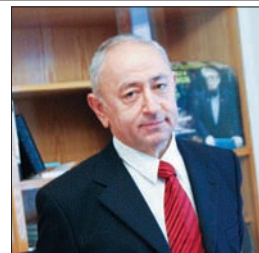
VOLUME 50 NUMBER 5 JUNE 2010



Reinventing the Roman shield p6



GRIDs go South-East Asia p13



Sissakian passes away p32

News

5

The LHC takes first steps to higher intensities. Roman lead will shield CUORE experiment. ALICE reveals first results at 7 TeV. Strategy meeting looks forward to high-power laser acceleration. EuCARD: mixing neutrinos, crab cavities, magnets and more.

Sciencewatch

9

Astrowatch

10

CERN Courier Archive

11

Features

EUAsiaGrid discovers opportunity in diversity

13

A look at the unique aspects of a project to promote awareness of Grid computing.

A brilliant light source rises in South-East Asia

16

The challenging aspects of a project to build a new 3 GeV light source.

Gran Sasso becomes a workshop WONDERland

19

A report from a workshop to discuss directions in dark-matter research.

Carbon-ion radiotherapy flourishes in Japan

22

New facilities are coming on line to play a key role in the treatment of cancer.

Faces and Places

26

Recruitment

34

Bookshelf

39

Viewpoint

42

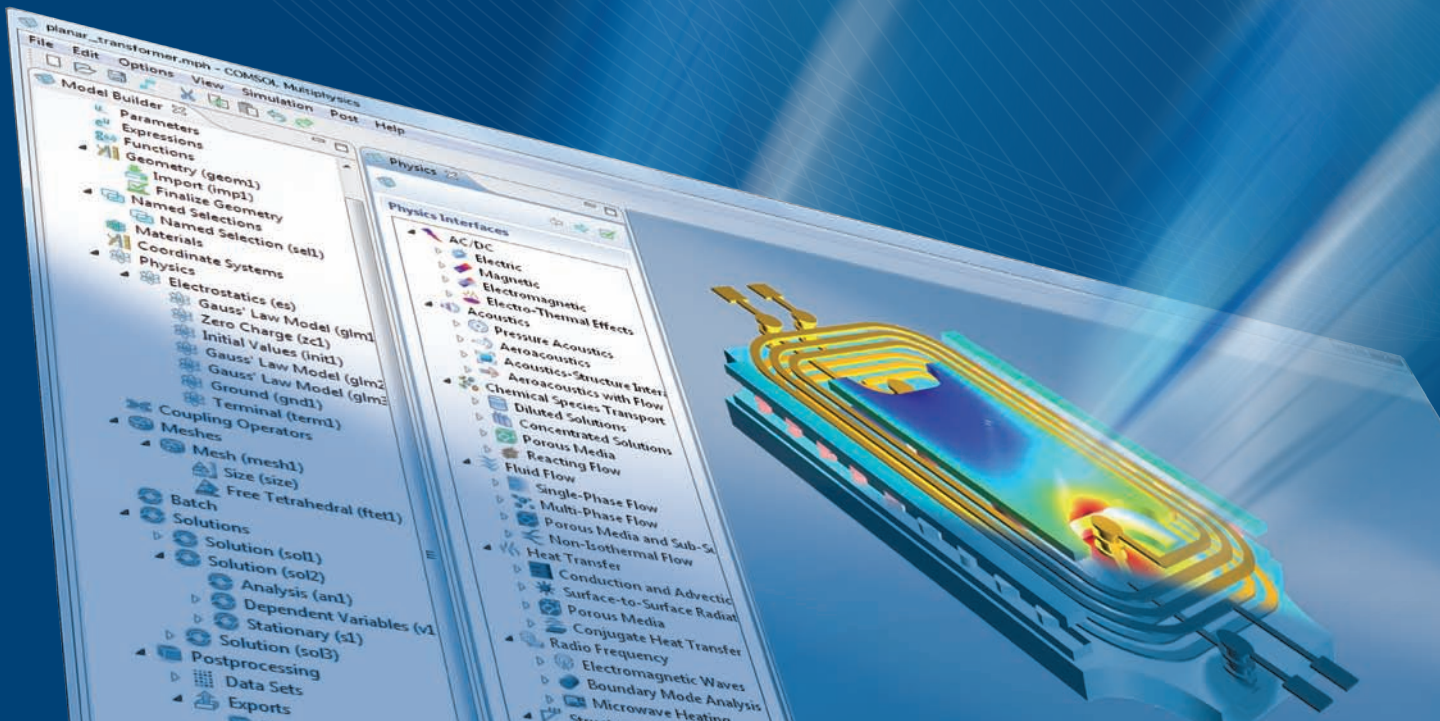
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Cover: Hubble celebrates the 20th anniversary of its launch with the release of a spectacular cosmic image (p10). (Courtesy NASA/ESA/M Livio & Hubble 20th Anniversary Team (STScl).)



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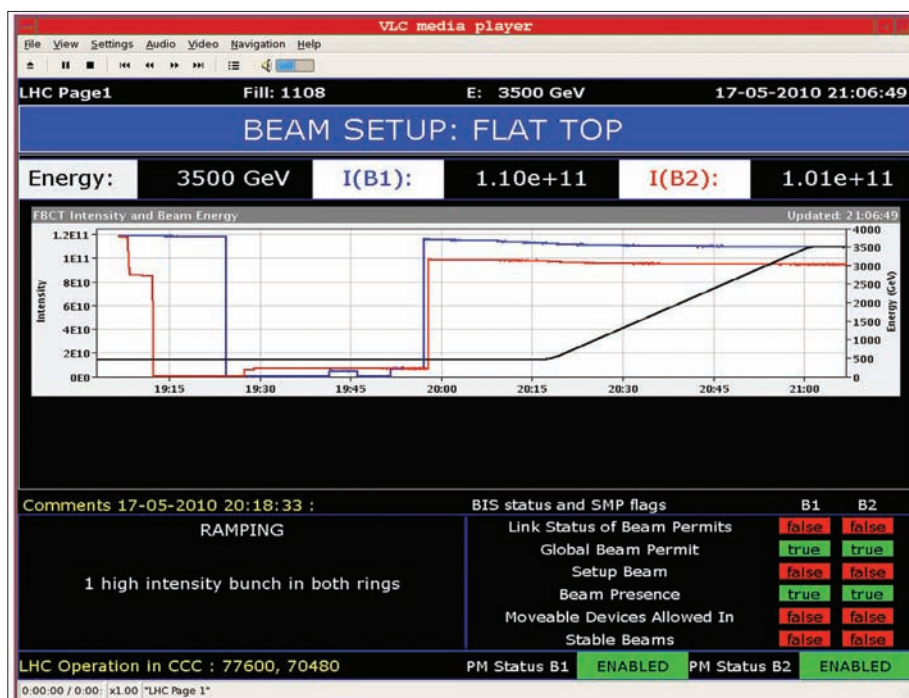
CERN

The LHC takes first steps to higher intensities

The weeks following the first collisions at 7 TeV in the centre of mass have seen the LHC pass important milestones in delivering higher instantaneous luminosity to the experiments. With days dedicated mainly to beam-commissioning studies and nights given over to the preparation and delivery of collisions for experiments, the progress is clear to see.

The weekend of 23–24 April saw not only a tenfold increase in instantaneous luminosity to above $1.1 \times 10^{28} \text{ cm}^{-2} \text{ s}^{-1}$ in all four experiments but also a record physics fill, with the machine in “stable-beam” mode for 30 hours. This allowed the experiments to more than double the total number of events recorded at 7 TeV. The successful weekend had been preceded by work to commission the “squeeze” on the beams at an energy of 3.5 TeV per beam at all four interaction points. This process, one of the most complex stages in the operation of the accelerator, was followed by a number of collimation and beam-dump tests to ensure sufficient protection of the experiments. The first physics fill with squeezed-beam optics led to a factor of five improvement in luminosity. A new bunch scheme with three bunches per beam then provided a further improvement by another factor of two.

Sunday 2 May saw another major step towards higher intensities with the first fill with two bunches per beam at the nominal (design) intensity of 1×10^{11} protons per bunch, at the injection energy of 450 GeV per beam. Within an hour of injection the team had removed the “separation bumps”, which keep the beams separated during the ramp, at all four interaction points simultaneously, thus providing collisions. After some further adjustments the operators were ready to prepare a second fill, this time with collisions



The screen shows the successful ramp to 3.5 TeV with one high-intensity bunch in each ring on 17 May.

in stable beam conditions, for the first time with bunches at nominal intensity.

The following two weeks saw further steps in a two-pronged approach to deliver higher luminosity to the experiments, either with more bunches or more protons per bunch. With two bunches per beam providing a total of up to 4×10^{10} protons per beam, the LHC was already delivering an instantaneous luminosity of $2 \times 10^{28} \text{ cm}^{-2} \text{ s}^{-1}$ in some long periods of stable running at 3.5 TeV per beam on the weekend of 8–9 May.

After further tests, on the beam-dump system and aspects of machine protection, for example, on 14 May, a physics fill began with squeezed beams and four bunches per beam, giving a total of 8×10^{10} protons per beam.

The next day, the first test took place to ramp a beam at nominal intensity at 3.5 TeV, with 60% of the beam surviving the ramp. This was followed by a long fill of stable beams for nearly 24 hours, now with six bunches per beam. It was then time to try ramping again with one bunch at nominal intensity and this eventually succeeded for beam 2, with 1.2×10^{11} protons, in fact, 10% above nominal and without losses.

By the end of the long weekend of 14–16 May, the LHC had doubled the integrated luminosity previously delivered since the restart in March. Then, on the evening of 17 May, both beams were successfully ramped at nominal intensity, marking the passage of another milestone in the progress towards the final targets for the year.

Sommaire

Le LHC franchit une étape sur la voie des hautes intensités
 Du plomb romain pour le blindage de l'expérience CUORE
 ALICE révèle ses premiers résultats à 7 TeV
 Une réunion stratégique sur la technologie laser des accélérateurs du futur

5 Projet EuCARD : neutrinos, cavités en crabe, aimants à champ élevé
 6 et ce n'est pas tout ! 8
 6 Des équations jettent un nouvel éclairage sur la lumière
 Fermi met une limite au champ magnétique intergalactique 10
 7

NEUTRINOS

Roman lead will shield CUORE experiment

Twenty years ago, an amateur scuba diver swimming off the coast of Oristano in Sardinia found a *navis oneraria magna* – a 36-m Roman ship dating back more than 2000 years, to between 80 and 50 BC – whose cargo consisted of a 1000 lead forms. These were recovered with help from Italy's National Institute of Nuclear Physics (INFN), which at the time received 150 of the lead bricks. Now, INFN is to receive a further 120 bricks to complete the shielding for the Cryogenic Underground Observatory for Rare Events (CUORE), in INFN's Gran Sasso National Laboratory (LNGS).

INFN has received the lead bricks from the National Archaeological Museum of Cagliari in Sardinia. The bricks, together with the ship that transported them, had remained in the sea for two millennia, during which time the albeit low original radioactivity of one of the radionuclides, Pb^{210} , decreased by approximately 100 000 times. The Pb^{210} , which has a half-life of 22 years, has by now practically disappeared from the ancient Roman lead.

The parts of the bricks that contain inscriptions will be removed and conserved, whereas the remainder will be cleaned of incrustations and melted to construct a shield for the international CUORE experiment. Moreover, researchers from INFN will perform precise measurements on the lead (and possibly on the copper that was also found



These lead bricks come from a Roman ship that sank some 2000 years ago. (Courtesy Il Nuovo Saggiatore/Società Italiana di Fisica di Bologna and INFN.)

on the ship) to study the materials used in the Bronze Age.

The lead bricks were made available as the result of a collaboration involving INFN, its facilities in Cagliari and the Archaeological Superintendency of Cagliari, as well as with the support of the General Directorate of Antiquity. As part of this joint operation 20 years ago the INFN contributed 300 million lira for the excavation of the ship and the recovery of its cargo.

The bricks, which weigh about 33 kg each

and are 46 cm long and 9 cm wide, will be used to shield the CUORE experiment. This collaboration is seeking to discover the extremely rare process of neutrinoless double-beta decay, which would allow researchers not only to measure directly the mass of neutrinos but also to determine whether or not they are Majorana particles (i.e. particles and antiparticles are one and the same). The detector will be based on an array of nearly 1000 tellurium-dioxide bolometers, cooled to about 10 mK.

LHC EXPERIMENTS

ALICE reveals first results at 7 TeV

The ALICE collaboration has submitted its first paper with results from LHC proton collisions at a centre-of-mass energy of 7 TeV. The results confirm that the charged-particle multiplicity appears to be rising with energy faster than expected.

The results are based on the analysis of a sample of 300 000 proton-proton collisions the ALICE experiment collected during the first runs of the LHC with stable beams at a centre-of-mass energy, \sqrt{s} , of

7 TeV, following the first collisions at this energy on 30 March (*CERN Courier* May 2010 p27). The collaboration compares them with data collected earlier at $\sqrt{s}=0.9$ TeV and $\sqrt{s}=2.36$ TeV, which they have re-analysed since their earlier publication, with the same normalization as for the new data.

The events used in the analysis have at least one charged particle in the central pseudorapidity region, $|\eta| < 1$. The selection leaves 47 000, 35 000, and 240 000 events for analysis at 0.9 TeV, 2.36 TeV, and 7 TeV, respectively. At 7 TeV, the collaboration measures a pseudorapidity density of primary charged particles, $dN_{ch}/d\eta = 6.01 \pm 0.01(\text{stat.}) + 0.20/-0.12(\text{syst.})$. This

corresponds to an increase of $57.6\% \pm 0.4\%(\text{stat.}) + 3.6/-1.8\%(\text{syst.})$ relative to collisions at 0.9 TeV.

This increase is significantly higher than expected from calculations with the commonly used models, so confirming the observations made earlier at 2.36 TeV (*CERN Courier* May 2010 p5). In addition, the ALICE Collaboration find that the shape of the multiplicity distribution is not reproduced well by the standard simulations. These results have already triggered interest in the cosmic-ray community (see p 29).

Further reading

ALICE collaboration 2010 arxiv:1004.3514.

ACCELERATORS

Strategy meeting looks forward to high-power laser acceleration

A meeting at GSI Darmstadt on 8–10 April provided a first opportunity to formulate a strategy on the laser technology needed to meet the challenge of future accelerators that will use or rely on lasers with very high average power. Hartmut Eickhoff, technical director of GSI, and Wim Leemans of Lawrence Berkeley National Laboratory opened the event. Leemans is chairman of the newly established Joint Task Force on Future Applications of Laser Acceleration, which operates under the umbrella of the International Committee for Future Accelerators (ICFA) and the International Committee on Ultra-High Intensity Lasers (ICUIL). The task force had invited experts on high-power laser technology and accelerator technology and their applications to this first meeting. Altogether, there were 47 participants from countries around the world, including China (1), France (4), Germany (18), Japan (4), Switzerland (2), the UK (4) and the US (14).

The main topics of discussion were the laser performance needed for accelerator technology to support the most challenging present and future needs, as well as questions of laser architecture, laser material and optical components. Representatives from accelerators and light sources outlined the top-level laser requirements for potential laser-based accelerator applications – that is, for colliders, light sources and medical applications.

The biggest challenge for laser technology is a laser-plasma e^+e^- collider with the goal of a top energy of 10 TeV. The consensus in the global high-energy physics community is that the next large collider after the LHC should be a tera-electron-volt-scale lepton collider. Options currently under study include an International Linear Collider (ILC) at 0.5–1 TeV, a Compact Linear Collider (CLIC) at up to 3 TeV and a muon collider at up to 4 TeV, all using RF technology. On the other hand, the very high gradients of around 10 GeV/m that are possible with laser acceleration, offer



Meeting participants in front of GSI's PHELIX high-power laser facility. (Courtesy A Zschau, GSI.)

new avenues to reach even higher energy and more compact machines.

The workshop investigated the beam and laser parameters of a 1–10 TeV e^+e^- collider, with a luminosity of $10^{36} \text{ cm}^{-2}\text{s}^{-1}$, based on two different technologies – laser plasma acceleration and direct laser acceleration. The main challenges to the practical achievement of laser acceleration are high average power (around 100 MW), high repetition rate (kilohertz to megahertz), and high efficiency (around 40–60%) at a cost that ideally would be an order of magnitude lower than using technology based on RF. The workshop also studied the laser requirements for a 200 GeV $\gamma\gamma$ collider, proposed as the first stage of a full-scale ILC or CLIC. The laser systems required for such a collider may be within reach of today's technology.

For light sources, lasers already play a significant role in existing facilities but they face new challenges with future projects that aim at much higher repetition frequencies. Ultrafast (femtosecond) lasers reaching levels of 1–10 kW will be required for use as “seed lasers” and for user-driven experiments. The

third area of application is the use in medicine of laser acceleration of protons or ions and its potential to replace technology currently used in tumour therapy. Such lasers typically have very high peak-power (petawatt class) and require special pulse shapes with very high temporal contrast. Again, compact multi-kilowatt lasers will be needed.

Laser requirements for these applications are often many orders of magnitude beyond the capabilities of the lasers that are used in today's scientific work, i.e. they require megawatts instead of tens of watts. Representatives from laser science at the meeting discussed and outlined how, with appropriate R&D, emerging 100-kW-class industrial lasers, 10-MW-class laser technologies for fusion energy and megawatt-class laser systems for defence work might be adapted to meet these challenging requirements.

Results from the workshop, including tables of the parameters required for laser technology and the goals, will be compiled in a report and submitted to ICFA and ICUIL for their approval, prior to public release.

EuCARD: mixing neutrinos, crab cavities, magnets and more

Under a cloud of volcanic ash, the first annual meeting of the European Co-ordination for Accelerator Research & Development (EuCARD) project took place at the Rutherford Appleton Laboratory of the UK's Science and Technology Facilities Council (STFC). From 13–16 April, this melting pot of ideas saw neutrino physicists mix with collimator designers, RF experts and magnet specialists to discuss progress with the EuCARD project as well as cutting-edge topics in accelerator sciences. EuCARD is a four-year project co-funded by the EU's Framework Programme 7 (FP7), which involves 37 partners from 45 European accelerator laboratories, universities, research centres and industries (*CERN Courier* November 2009 p16).

The attendees, more than 100 in number, heard how the EuCARD networks (neutrino facilities, accelerator performance and RF technologies) had successfully oriented themselves towards efficient topical meetings, including the successful mini-workshop on LHC crab cavities that took place in October 2009. Two of these networks are currently considering increasing their scope to include plasma-wave acceleration and medical accelerators.

The collaborative R&D studies, whether on magnets, collimation, linear-collider technologies or advanced concepts, have demonstrated effective collaborations with promising progress. Out of many examples, the highlights presented at the meeting included an implementation strategy for crab-crossing at the LHC described by Rama Calaga of Brookhaven and progress in the design of a new compact crab cavity presented by Graeme Burt of Lancaster

University. Many success stories provided food for thought, including impressive results on crab-waist luminosity at Frascati reported by Catia Milardi of INFN and prototyping of cryogenic collimators at the Facility for Antiproton and Ion Research, as Peter Spiller of GSI described. Whetting everyone's appetite for a new type of acceleration was the talk by Allen Caldwell, of the Max Planck Institute for Physics, on proton-driven plasma-wave acceleration, following on from a recent EuCARD workshop (*CERN Courier* March 2010 p7). Future facilities for neutrinos were also part of the event with animated discussions about superbeams, beta beams and neutrino factories.

The EU strongly promotes access to European facilities, and within EuCARD opportunities are now open to external researchers. Four teams have already received EU support for access to the MICE facility at the Rutherford Appleton Laboratory, while the HiRadMat facility is at a design stage at CERN.

Enlarging the vision beyond EuCARD, guest speakers from related projects included Roland Garoby from CERN on the preparatory phase for an LHC upgrade (SLHC-PP); Eckhard Elsen from DESY on high-gradient superconducting RF cavities for an International Linear Collider (ILC-HiGrade); and Brigitte Cros of the French National Center for Scientific Research (CNRS) on the EuroLEAP project on laser-driven plasma-wave acceleration. Eric Prebys of Fermilab and the US LHC Accelerator Research Program showcased the strong R&D collaborations between the US and Europe, as well as exceptional advances

in magnet design (*CERN Courier* January/February 2010 p6). Tord Ekelöf of Uppsala University and Roy Aleksan of the French Atomic Energy Commission (CEA) and the European Steering Group on Accelerator R&D (ESGARD) put EuCARD's contribution towards the global accelerator R&D effort into perspective. A natural outcome was a discussion, under the auspices of ESGARD, of ways and means to tighten European and global collaborations.

Holding the meeting at the Rutherford Appleton Laboratory allowed attendees to visit the ISIS neutron source and the Diamond Light Source facility. In addition, staff from STFC presented aspects of the UK programme, notably Susan Smith with a summary of the ALICE and EMMA facilities at Daresbury and Mike Poole with an overview of STFC's programme of accelerator R&D.

In his concluding remarks, CERN's Jean-Pierre Koutchouk, the EuCARD project co-ordinator, acknowledged the quality and interest of the presentations, and the promising first results of this 4-year project. He thanked the 37 European partners for their dedication and dynamism and the STFC for the outstanding organization of the meeting at the Rutherford Appleton Laboratory.

● For application details for EuCARD opportunities, see <http://cern.ch/EuCARD/activities/access/>.

Further reading

For the full agenda of the first annual EuCARD meetings and presentations, as well as useful links and resources, see <http://indico.cern.ch/conferenceTimeTable.py?confId=73614#all.detailed>.

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.

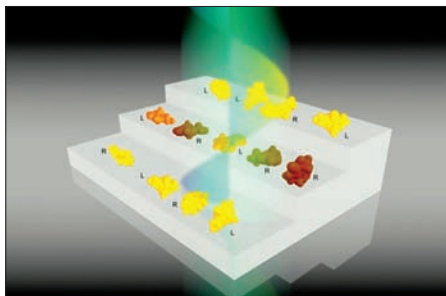
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Compiled by John Swain, Northeastern University

Equations reveal a new twist on light

Despite the fact that Maxwell's equations have been around since 1865, it looks as though there is still interesting physics that can be pulled out, even at a classical level. Yiqiao Tang and Adam Cohen of Harvard University have shown that a long-ignored combination of electric field dotted with its curl, plus the corresponding magnetic quantity, can represent the degree to which a non-planar, and in a sense, highly twisted electromagnetic field can interact differently with chiral molecules of different handednesses. Waves for which this quantity is non-vanishing have complex spatial profiles and could find useful applications in chiral photochemistry and for complex interactions with nanomaterials.

Tang and Cohen have found what they call “superchiral” light with chiral asymmetries much larger than those of circularly polarized light and they have proposed an experiment that could probe such light. The idea would be to confine molecules in thin films at a range of heights above a reflective surface



An experiment designed to probe superchiral light. (Courtesy A Cohen and Y Tang/Harvard University; figure by Lu Men.)

and illuminate them with circularly polarized light to set up a superchiral standing wave (see figure). The researchers predict that molecules at the nodal planes of the standing wave will show enhanced chiral asymmetry.

Further reading

Yiqiao Tang and Adam E Cohen 2010 *Phys. Rev. Letts.* **164** 163901.

Entropy opens door to Pictish language

Physicists are not the only researchers to look for patterns in data in an effort to find underlying structure – linguists also need to find patterns, and they have had a recent hand from the concept of entropy. Rob Lee of the University of Exeter and colleagues compared symbols inscribed by the Picts – a Scottish Iron Age culture dating back to about the 4th to 9th centuries AD – with texts known to be in a written language (though not Pictish).

Measures of repetitiveness as quantified by entropy showed the inscriptions to be much closer to a modern language, with a small vocabulary, than to simple pictorial (no pun intended!) scripts. The work is particularly interesting because it could be used even when samples of whatever symbols are written are small, as is the case for known examples of Pictish. This method could also be extended to see how much linguistic content animal communications, such as those of dolphins, contain.

Further reading

Rob Lee et al. 2010 *Proceedings of the Royal Society A*. doi:10.1098/rspa.2010.0041.



Symbols from the Pictish stone ‘Alberlemno 2’ of the kind that Lee and colleagues have analysed.

Molecular chain makes the smallest superconductor

How few atoms or molecules does it take to make a superconductor? Amazingly, the experimental answer so far is that as few as four pairs of molecules of a rather exotic substance called (BETS)₂GaCl₄ will do the job, where BETS is bis(ethylenedithio)tetraselenafulvalene. The substance was already known to be superconducting in bulk at about 8 K, but now Saw-Wai Hla of Ohio University in Athens and colleagues have made super-thin layers of the material by depositing molecular chains of it on a silver substrate.

They used scanning tunnelling electron microscopy to show the superconductivity down to the minute scales involved. The work is remarkable because it allows researchers to track down the mechanisms at work down to the level of only a few molecules. It could show the way to novel superconducting nanocircuits.

Further reading

K Clark et al. 2010 *Nature Nanotechnology* **5** 265.

Photonic crystals provide 3D invisibility cloak

Attempts to make Harry Potter's invisibility cloak by using metamaterials to bend light round objects have generally been restricted to two dimensions and microwave frequencies. Now, Tolga Ergin of the Karlsruhe Institute of Technology and colleagues have manufactured photonic crystals in the shape of a sort of “woodpile” that can cloak a bump in a gold reflector within a viewing angle of 60°. The cloaking works with unpolarized light from 1.4 to 2.7 μm. This is fast approaching wavelengths that would be suitable for human vision.

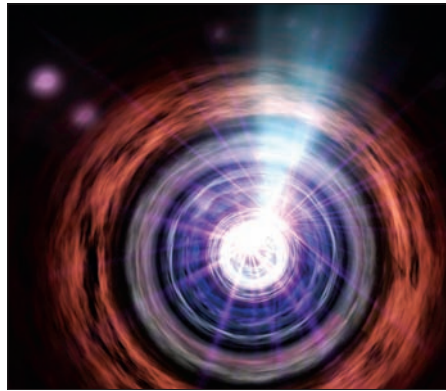
Further reading

T Ergin et al. 2010 *Science* **328** 337.

Fermi limits the intergalactic magnetic field

Astronomers have found evidence that the magnetic field between galaxies cannot be negligible. Otherwise, a blazar observed by the High Energy Stereoscopic System (HESS, *CERN Courier* January/February 2005 p30) at tera-electron-volt (TeV) energies should also have been detected by the Fermi Gamma-Ray Space Telescope in the giga-electron-volt (GeV) range (*CERN Courier* November 2008 p13). The non-detection by Fermi sets a lower limit of the order of 10^{-19} T on the magnetic field strength in intergalactic space, which is consistent with a cosmological origin of the field.

In the universe, the bigger the object, the weaker its magnetic field. The strongest fields are found around magnetars, neutron stars with a field of up to 10^{11} T (*CERN Courier* June 2005 p12). The Earth, being almost 1000 times larger than a neutron star has a modest field of 10^{-4} T, and the Milky Way's field is again about 20 000 times less, even at its centre. Measuring the extremely low magnetic field of intergalactic space – away from any galaxy – is very challenging. Until now, only upper-limits could be set, but thanks to Fermi's observations, the situation is changing. Two recent, independent papers give a lower-limit of the magnetic field based on very high-energy observations of the blazar 1ES 0229+200. Andrii Neronov and Ievgen Vovk from the ISDC data centre of the University of Geneva constrain the field to be higher than 3×10^{-20} T, while Fabrizio Tavecchio and colleagues from the Observatory of Brera, Italy, derive a lower



An artist's rendering of a blazar, a type of active galaxy where the powerful jet of plasma beams directly towards Earth. (Courtesy NASA/Goddard Space Flight Center Conceptual Image Lab.)

limit of 5×10^{-19} T. The difference comes from differing analyses and assumptions, but both studies are based on the same dataset and the same argument.

The blazar – a powerful jet source in a distant galaxy – emits gamma-rays at TeV energies in a narrow cone that happens to be pointing towards the Earth. Along their journey, some of the gamma-rays interact with the optical-infrared background light to produce electron-positron pairs (*CERN Courier* June 2006 p14). These pairs will then rapidly cool on photons of the cosmic microwave background and Compton scatter them to GeV energies. The strength of the intergalactic magnetic field can have an influence on the intensity of the GeV photons observed by Fermi. A weak

field will not significantly deflect electrons and positrons and hence the GeV photons will be predominantly emitted in the same direction as the primary TeV photons, whereas a strong field will result in an isotropically distributed GeV emission, which will then be undetectable by Fermi. The measurement of the TeV spectrum of the blazar by HESS, together with the upper limit on the GeV emission from the source direction set by Fermi, thus results in the determination of a lower limit on the magnetic field.

This very indirect determination is subject to many uncertainties, in particular on the opening angle of the jet emission, the intrinsic spectrum of the blazar and the intensity of the optical-infrared background light. Nevertheless, the estimated magnetic field is strong enough to favour a “top-down” scenario for its origin. The idea is that the accretion of matter within stars and galaxies amplifies a preexisting magnetic field that permeates the universe and would have been produced soon after the Big Bang. The alternative “bottom-up” scenario, where the magnetic fields are first produced in stars and then propagate outwards to galaxies and eventually intergalactic space, is disfavoured. This is good news for cosmologists because the field might help to identify and constrain processes at work in the very early universe.

Further reading:

A Neronov & I Vovk 2010 *Science* **328** 73.
F Tavecchio *et al.* 2010 *MNRAS* submitted
<http://arxiv.org/abs/1004.1329>.

Picture of the month



“Mystic mountains” is the name given to this spectacular cosmic landscape released to celebrate the 20th anniversary of Hubble's launch and deployment into orbit around Earth. The scene might look familiar to you because it was already shown in this column (*CERN Courier* June 2007 p12), but it looks even more dramatic with the new colour rendering. The pillar of gas and dust, three light-years tall, is eroded from outside by the brilliant light from nearby bright stars, as in the famous “pillars of creation” in the Eagle Nebula (*CERN Courier* June 2005 p12 and March 2007 p11). But here, the assault comes also from inside with infant stars firing off jets of gas that can be seen streaming from towering peaks. The turbulent cosmic pinnacle lies within the Carina Nebula, a stellar nursery some 7500 light-years away, where the giant star Eta Carinae came to birth (*CERN Courier* July/August 2008 p12). (Courtesy NASA/ESA/M Livio & Hubble 20th Anniversary Team (STScI).)

CERN COURIER ARCHIVE: 1967

A look back to *CERN Courier* vol. 7, June 1967, compiled by Peggie Rimmer

CERN

News from the 34th Session of Council

The 34th Session of the CERN Council was held on 14 and 15 June under the Chairmanship of Dr G Funke. Representatives from the 13 Member States discussed the proposed 300 GeV accelerator and took important decisions on collaboration with the Serpukhov Laboratory in the Soviet Union, and on the construction of a very large hydrogen bubble chamber.

The 300 GeV project

About 8000 cubic centimetres of printed information concerning the proposed European 300 GeV accelerator confronted CERN Council delegates. The documents included the 1967 Report of the European Committee for Future Accelerators (ECFA) (119 pages); three volumes of "Utilization Studies for a 300 GeV Proton Synchrotron" put together by the various sub-groups of ECFA (1036 pages); two volumes of further

information on "Sites for the Proposed CERN 300 GeV Proton Synchrotron", one by the CERN Study Group on sites and the other by experts of those Member States offering sites (328 pages); an "Addendum to the Report on the Design Study of a 300 GeV Proton Synchrotron" prepared by the machine study group at CERN (110 pages); and various documents concerned with the revision of the CERN Convention to accommodate the proposed Laboratory.

The ECFA Report in particular is of great significance for the future of sub-nuclear physics in Europe. It was introduced by Professor Amaldi, who again underlined that work on the Report had involved scientists from throughout Europe whose hard work and enthusiasm had been most impressive. The construction of a 300 GeV synchrotron is the unanimous decision of the European sub-nuclear physics community as the next step forward.

In the discussion that followed, Professor Puppi, on behalf of the Scientific Policy Committee, said that Europe could go ahead with reinforced confidence in the project. Technically, scientifically and psychologically there were now no barriers to setting up the 300 GeV laboratory.

The ultimate decision rests, of course, with the Governments of the Member States who have to balance it against all the other demands on their resources. It is hoped that many of the Member States will be in a position by the Council Meeting next December to present a "letter of intent" with regard to the 300 GeV project.

In reply to a question on the future of ECFA, Professor Amaldi said that many people had expressed the view that ECFA should continue to exist in some form. It would be important to have the utilization studies for the 300 GeV machine under continual revision to keep pace with developments in physics and technology. Other work, such as examining more data on national programmes could be useful.

Serpukhov collaboration

The Council authorized the Director General to sign an agreement with the USSR State



The CERN Council in session on 14 June.

Committee for the Utilization of Atomic Energy along the lines of a draft Convention which has been prepared by representatives of CERN and the Soviet Union. Some points of detail have still to be cleared with the Soviet authorities but it is hoped that the agreement can be signed in the very near future. The agreement concerns collaboration at the 70 GeV proton synchrotron which is nearing completion at the Serpukhov Laboratory. It will give European scientists access to what will be for several years the highest energy accelerator in the world.

Large hydrogen chamber

An agreement concerning the construction of a very large hydrogen bubble chamber was authorized by the Council. The chamber, which has a diameter of 3.5 metres, will be built as a joint project by CERN, France and the Federal Republic of Germany. It is scheduled to cost 84 million Swiss Francs, provided equally by the three partners. A steering committee with one representative from each party will supervise the project. This new chamber is one of the major elements of the improvements programme at the CERN proton synchrotron. The Council expressed its gratitude to France and Germany for their willingness to make this extra, important contribution to the future of European physics at CERN.

● From the article on pp102–119.

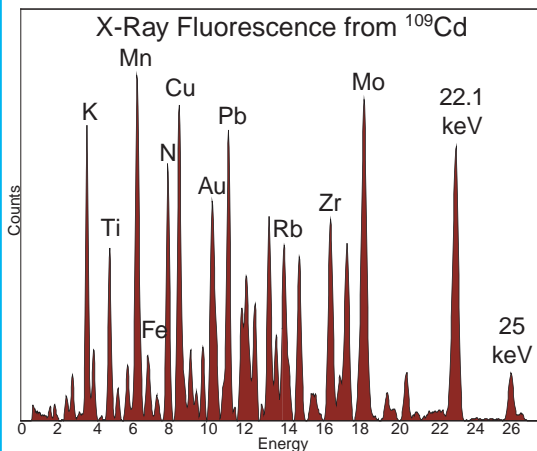
COMPILER'S NOTE

I was more than usually struck by the absence of females in the photo of Council in session, possibly sensitized by events organized at CERN and Fermilab for International Women's Day in March this year (*CERN Courier* May 2009 p38). I don't know whether there were any women on Council in 1967 but nowadays of the 40 delegates (two per Member State) 6 are female. This fraction of women is similar to that found for research physicists and engineers among CERN staff (almost 13%) and CERN users (around 16%). As for the trend, while the total percentage of women on the CERN staff increased from 13.5% to 21% over the past 25 years, their presence in the scientific categories increased from 3% to the current 13%.

In operation, the very large hydrogen bubble chamber became known as the Big European Bubble Chamber, BEBC, an acronym easier to pronounce; in retirement, it can be seen in the garden next to the Microcosm exhibition at CERN.

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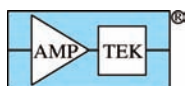


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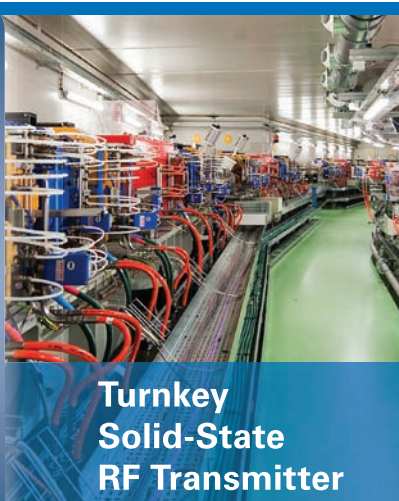
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EUAsiaGrid discovers opportunity in diversity

A two-year project to promote awareness of Grid computing in South-East Asia is entering its final phase. **François Grey** takes stock of some unique aspects of running this geographically and culturally diverse project and its influence on scientific collaboration.

More than half of the world's people live in Asia. Even putting aside the two titans India and China, there are some 600 million inhabitants – 100 million more than in the entire EU – in the region that is commonly referred to as South-East Asia. From Myanmar in the west to Indonesia's Papua province in the east, the territory is nearly twice the width of the continental US. Most of the Asian partners in EUAsiaGrid hail from this region, which has more than its fair share of natural disasters in the form of earthquakes, volcano eruptions, typhoons and tsunamis, not to mention enduring political tensions.

Despite these challenging circumstances, EUAsiaGrid has managed to make a significant impact in a relatively short time. This has been driven by increased sharing of data storage and processing power between participating institutions in the region. It was achieved through a concerted effort by the project leaders to encourage the adoption across the region of the gLite middleware of Enabling Grids for E-sciencE (EGEE), which is the same middleware used by the Worldwide LHC Computing Grid (WLCG).

As the head of EUAsiaGrid, Marco Paganoni, who is based at INFN and the University of Milan-Bicocca, points out: "This technological push has enabled researchers in some of the participating countries to become involved in international science initiatives that they otherwise might not be able to afford to participate in."

Like many other international Grid projects, EUAsiaGrid owes its origins to the pioneering efforts of the global high-energy physics community to promote Grid technology for science, and to the nurturing role of the European Commission in spreading Grid technical know-how throughout the world through joint projects. In addition, a key catalyst for EUAsiaGrid has been Simon Lin, project director of Academia Sinica Grid Computing (ASGC). His efforts established ASGC as the Asian Tier-1 data centre for WLCG. He and his team have been bringing Asian researchers together for nine years at the annual International Symposium on Grid Computing (ISGC) held each spring in Taipei.

The EUAsiaGrid project, launched as a "support action" by the European Commission within Framework Programme 7 in April 2008, focuses on discovering regional research benefits for Grid computing. "We realized that identifying and addressing local needs was the key to success in this region," says Paganoni. From the

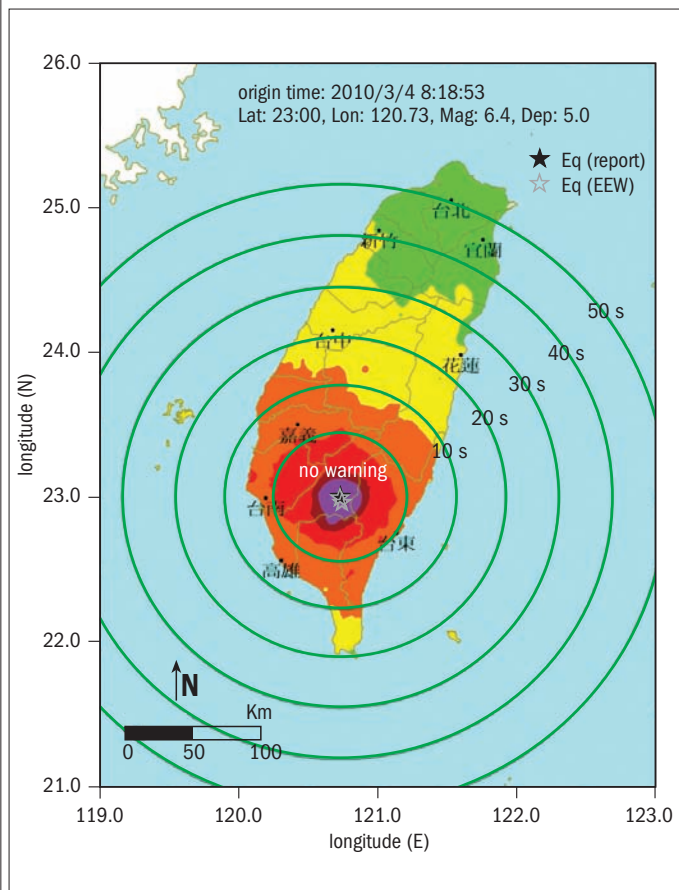


Distribution of the EUAsiaGrid institutional partners across South-East Asia and Australia. The partners in Europe are INFN in Italy, CESNET in the Czech Republic, NCeSS in the UK and HealthGrid in France.

outset, capturing local e-science requirements was an important component of the project's objectives. Moreover, comparing those requirements revealed a great deal of common ground amid all of the regional diversity.

Earth-shaking experience

One common theme was the region's propensity for natural disasters and the ability of Grid technology and related information technology solutions to help mitigate the consequences of such events. For example, EUAsiaGrid researchers have helped build links between different national sensor-networks, such as those ▷



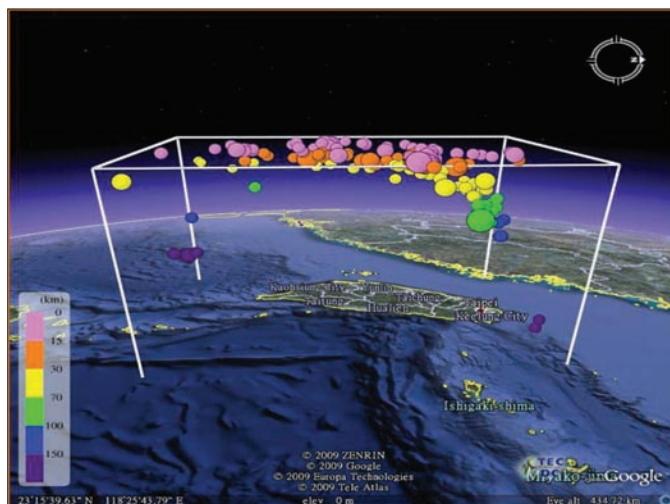
Circles indicate warning times for the earthquake that struck the island of Taiwan on 4 March 2010. Taipei is the northernmost city indicated on the map, on the 50-s circle. (Courtesy Nai-Chi Hsiao, Central Weather Bureau, Taipei.)

of Vietnam and Indonesia. Researchers in the Philippines are now benefiting from the Grid-based seismic modelling experience of their Taiwanese partners. Sharing data and Grid know-how in this manner means that the scientists involved can better tune local models of earthquake and tsunami propagation.

At the most recent ISGC, which was held in March, a special EUAsiaGrid Disaster Mitigation Workshop devoted a day to the latest technological progress in monitoring and simulating both earthquakes and tsunamis. Nai-Chi Hsiao of the Central Weather Bureau in Taipei explained in a talk about the early-warning system for Taiwan that it takes just 60 s for an earthquake to travel from the south to the north of the island, leaving precious little time to make a decision about shutting down nuclear reactors or bringing high-speed trains to a grinding halt and so avoid the worst consequences that a large earthquake might cause.

Where could Grid technology fit into this picture? The island is rocked by earthquakes, both large and small, all of the time. It is simply not viable to shut down power plants and stop trains every time that a tremor is detected. What is needed is a quick prediction of the impact that a particular earthquake may have on key infrastructure across the island. However, the level of shaking that an earthquake produces 100 km away can depend strongly on, for example, the depth at which it occurs.

There is certainly no time to do a full simulation once an earthquake



Perspective of earthquake depth for major earthquakes in and around the island of Taiwan. (Courtesy Wen-Tzong Liang, Institute of Earth Sciences Academia Sinica.)



Map of prevalence of dengue fever around the world. (Courtesy WHO.)

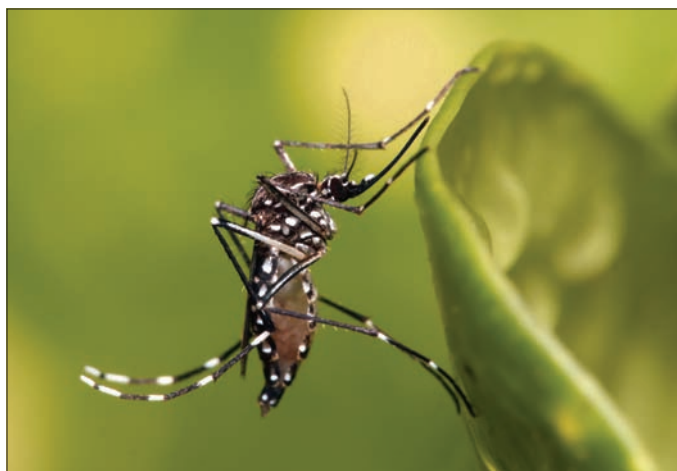
is detected. According to Li Zhao of the Institute of Earth Sciences at Academia Sinica, it might instead be possible to pull out a pre-processed simulation from a database and make a quick decision based on what it predicts. This would require processing and storing the results of simulations for a huge number of possible earthquake epicentres – a task that is well suited to Grid computing.

Neglected diseases

Another common thread of the research sponsored by EUAsiaGrid has been searching for cures to diseases that plague the region but which have been largely neglected by pharmaceuticals companies because they do not affect more lucrative markets in the industrialized world.

Consider dengue fever, for example. For most sufferers, the fever and pain produced by the disease pass after a very unpleasant week, but for some it leads to dengue haemorrhagic fever, which is often fatal. Like malaria, dengue is borne by mosquitoes. But unlike malaria, it affects people as much in the cities as it does in the countryside. As a result, it has a particularly high incidence in heavily populated parts of South-East Asia and it is a significant source of infant mortality in several countries.

As yet there are no drugs designed to specifically target the dengue virus. So EUAsiaGrid partners launched an initiative last July called Dengue Fever Drug Discovery, which will start a systematic



The *Aedes aegypti* mosquito is the principal carrier of dengue fever. (Courtesy Muhammad Mahdi Karim.)

search for such drugs by harnessing Grid computing to model how huge databases of chemical compounds would interact with key sites on the dengue virus, potentially disabling it.

This is not the first time that Grid technology has been used to amplify the computing power that can be harnessed for such ambitious challenges. Malaria and avian influenza have been targets of previous massive search efforts, dubbed by experts “in-silico high-throughput screening”.

Leading the effort on dengue at Academia Sinica in Taipei is researcher Ying-Ta Wu of the Genomics Research Centre. He and colleagues prepared some 300 000 virtual compounds to be tested in a couple of months, using the equivalent of more than 12 years of the processing power of a single PC. The goal of this exercise was not just to get the processing done quickly but also to encourage partners in Asia to collaborate on sharing the necessary hardware, including institutes in Malaysia, Vietnam and Thailand.

It is not just hard sciences such as geology and biology that benefit from Grid know-how. Indeed, as Paganoni notes: “Modelling the social and economic impacts of major disasters and diseases is a Grid-computing challenge in itself, and is often top of the agenda when EUAsiaGrid researchers have discussions with government representatives in the region.”

Even the humanities have benefited from these efforts. Capturing culture in a digital form can lead to impressive demands for storage and processing. Grid technology has a role to play in providing those resources. For instance, it can take more than a week using a single desktop computer to render a 10-minute recording of the movements of a Malay dancer performing the classical Mak Yong dance into a virtual 3D image of the dancer, using motion-capture equipment attached to the dancer’s body. Once this is done, though, every detail of the dance movement is permanently digitized, and hence preserved for posterity, as well as being available for “edutainment” applications.

The problem, however, is that a complete Mak Yong dance carried out for ceremonial purposes could last a whole night, not just 10 minutes. Rendering and storing all of the data necessary for this calls for Grid computing.

Faridah Noor, an associate professor at the University of Malaya, became involved in the EUAsiaGrid project because she saw great



A Mak Yong dancer with motion sensors attached for recording movements during the dance. (Courtesy Info Com Development Centre of Universiti Putra Malaysia.)

potential for Grid-enabled digital preservation of traditional dances and artefacts for posterity. She and her colleagues are working on several projects to capture and preserve digitally even the most ephemeral cultural relics, such as masks carved by shamans of the Mah Meri tribe used to help cure people of their ailments or to ward off evil. The particular challenge here is that the shamans deliberately throw the masks into the sea as part of the ritual, to cast away bad spirits.

As Noor, who works in the area of sociolinguistics and ethnolinguistics, points out: “We have to capture the story behind the mask.” Each mask is made for an individual and his or her illness, so capturing the inspiration that guides the shaman while preparing the mask is as important as recording the way in which he carves the wood, and rendering 3D images of the resulting mask.

An important legacy of the EUAsiaGrid project, Paganoni says, will be the links that it has helped to establish between researchers in the natural sciences, the social sciences and the humanities, both within South-East Asia and with European institutions. These links trace their origin to a common interest in exploiting Grid technology.

● Based on articles previously published in *International Science Grid This Week*, with permission.

Résumé

Le projet EUAsiaGrid explore la voie de la diversité

Le projet EUAsiaGrid, une « action de soutien » lancée par la Commission européenne en avril 2008, a pour objectif de découvrir comment les grilles de calcul peuvent être utilisées en Asie du Sud-Est pour venir en aide à la recherche. Le projet, qui entre à présent dans sa phase finale, a déjà donné d'importants résultats en un temps relativement court, autant sur le plan technologique qu'en rassemblant des chercheurs en sciences naturelles, sociales et humaines. Le projet s'intéresse à diverses thématiques, telles que la réduction de l'impact des catastrophes naturelles, la recherche de traitements des maladies négligées telles que la dengue, ainsi qu'à de possibles applications dans le domaine de l'art et de l'histoire sociale.

François Grey on behalf of EUAsiaGrid.

A brilliant light source rises in South-East Asia

The use of local expertise and a challenging construction site represent just two of the interesting characteristics of a project to build a new 3 GeV light source in South-East Asia.

The National Synchrotron Radiation Research Center (NSRRC), situated about one hour's drive from Taipei, has begun the construction of its second synchrotron-light source, the Taiwan Photon Source (TPS), with a ground-breaking ceremony that took place on 7 February. Like any other large-scale project, reaching this milestone involved years of preparation and intense decision-making. The project requirements left little room for even small deviations from delivery timetables or for cost increases. To meet its mandate on time, the NSRRC has relied on its experienced staff members, many of whom had previously participated in the construction of the Taiwan Light Source (TLS) in 1983 – the first accelerator at NSRRC. This is allowing the project to meet challenging deadlines and to transfer expertise to younger engineers.

The TPS is a \$210 million project involving, at various times, more than 150 staff in charge of design, construction, administration and management of day-to-day operations. The official proposal for the TPS was submitted in 2006 and primary funding was provided by the National Science Council over a seven-year period, with \$54 million for civil construction backed by the Council for Economic Planning and Development. Conceptual designs of the major systems were completed in 2009 and key systems are currently under construction. These include the linac, the cryogenic system, the magnets and the RF transmitters.

The TPS will be equipped with a 3 GeV electron accelerator and a low-emittance synchrotron-storage ring 518.4 m in circumference (see table). This will be housed in a doughnut-shaped building, 659.7 m in outer circumference, next to the smaller circular building that houses the existing 1.5 GeV accelerator, the TLS. The dual rings will serve scientists from South-East Asia and beyond who require an advanced research facility for conducting experiments with both soft and hard X-rays.

The storage ring

The TPS storage ring comprises 24 bending sections, 6 long straight sections and 18 short ones. A mock-up of a unit cell representing 1/24 of the storage ring has been constructed to test all systems before mass production, including the 14-m long vacuum pipe, prototype magnets and girders. This mock-up will be useful for evaluating and correcting – if necessary – specific design decisions. It has also served as a case study for the Machine Advisory Committee

Design parameters of the TPS

Energy: 3 GeV
Brilliance: $\sim 10^{21}$ photons/s/mm²/mrad²/0.1% $(\Delta\lambda/\lambda)$
Maximum beam current: 500 mA
Horizontal emittance: 1.6 nm-rad
Storage-ring circumference: 518.4 m
Straight sections: 6 × 12 m + 18 × 7 m
Unit cells: 24 double-bend achromats
Beam lifetime: >10 hours
Operation mode: Top-up
Insertion devices: 6 (phase I)

that reviewed the status of the TPS from technical and scheduling standpoints. One significant benefit gained from such a mock-up is that it allows for the spatial study of components that fit closely together, as well as of the cables and piping.

The vacuum chambers are made of aluminium alloy, based on the merits of lower impedance, lower heat resistance and its outgassing rate. There are two bending chambers per unit cell, each 4 m in length with, in some places, a 1 mm gap to the adjoining sextupole magnet in a bending section. In total there are 48 such units in the storage ring, with walls typically 4 mm thick in the straight sections. The beam pipes are made from aluminium extrusions with two cooling channels on each side. There are also several long vacuum chambers to cope with undulators installed between the magnet poles.

From vacuum to RF

A 14-m long vacuum pipe was produced as part of the 1/24 mock-up. Foreseeable production challenges include the development of machining and cleaning, of welding and cooling systems for the bending-chambers, and of a means to transport the finished product from the assembly site to the TPS storage ring. To minimize the mechanical distortion caused by thermal irradiation of the vacuum chambers, cooling-water channels are attached on both sides of the pipe and where the beam-position monitors (BPMs) are located. To transport the 14-m long vacuum pipe, a “hanger” of equivalent size was built to carry the assembled unit. A successful rehearsal, mov-



A model showing the location of the TPS (the big ring) adjacent to the existing, smaller TLS (north is to the left). (Photos courtesy NSRRC.)

ing the transportation gear along 8 km of busy streets took place in March. The next step will be to ensure that no damage occurs to the vacuum pipe during the process.

To achieve optimal performance, the TPS accelerator will be mounted on metal girders placed on pedestals that can be adjusted via remote-control. The mock-up has demonstrated the sophistication reached in the design of these girders. Metal girders often suffer from rather low eigenfrequencies compared with concrete girders, especially when heavy magnets are placed on them. The TPS girders, however, are very stiff, which pushes up the eigenfrequencies. Measurements so far are in close agreement with predicted performance.

The TPS is designed for “top-up” operation, which is the standard operation mode in the TLS. The TPS injector complex will consist of a 150 MeV linear accelerator and a full-energy booster that will share the tunnel with the storage ring. Because this is a new facility with a low-emittance injector, the opportunity exists for using pulsed multipole injection, which may have significant benefits for quiet top-up. To allow acceptance tests of the linac before the storage-ring tunnel becomes available, construction work is under way on a bunker that will see future use for a Free-Electron-Laser (FEL) injector test facility.

Each of the 24 achromatic bending sections (unit cells) in the TPS contains 2 dipoles, 10 quadrupoles and 7 sextupoles. A further 168 skew quadrupoles, 1 injection septum-magnet and 4 kicker magnets, bring the total number of magnets to be installed to 629. All of the magnetic cores are made of silicon-steel sheet. The shaping of the iron laminations are made by wire cutting with computer numerical control machines to within 10 μm accuracy and are shuffled to ensure uniform magnetic properties. Accuracy in the magnet assembly is to be controlled to within 15 μm . The upper half of the magnet can be removed to install the vacuum chamber and the whole magnet can be detached without removing the vacuum chamber. The entire design for the magnet was performed in house with prototypes produced during phase I for thorough testing and measurement.



A complete mock-up of 1/24 of the storage ring was built for tests.

The TPS adopts the KEK approach to superconducting RF (SRF) to cope with future operational modes. Collaboration and technology transfer on the 500 MHz SRF module, as used at KEK for KEKB, is a de facto requirement to ensure the timely development of the SRF modules (including the 1.8 K cryostat for the harmonic SRF modules) and of technology-transfer for a higher-order-mode damped superconducting cavity suited to high-intensity storage rings. Conventional PETRA-type cavities will be considered as an alternative for commissioning in case the SRF cavities are not available in time.

Construction challenges

The complexity and cost of constructing a new accelerator facility adjoined to an existing one is much higher than for one built on undeveloped land. However, to optimize resources and personnel, and the use of common equipment, as well as to allow a versatile research facility for users of both accelerators, the decision was taken to build the TPS at the NSRRC home base.

The site slopes down from south to north and abruptly descends 5 to 10 m at the northern edge, where the TPS will be built. The geology around the site is simple with gravel as the main formation. Ideally, the platform for the storage ring would be created above ground or by digging underground. The first approach is expensive and risks instability in an area known for frequent earthquakes; the latter will magnify the humidity problems in land soaked with rain and may cause a partial, if not total, subsidence of the existing TLS. To keep the civil construction cost within budget, the solution has been to meet both alternatives half way. The TPS storage-ring building will have its floor at the beamline area 12.5 m underground near the south side, and 4 m above ground at the north side. A beamline for medical imaging will be located on the west side next to the busiest traffic of the Hsinchu Science Park, while beamlines demanding nanoscale resolution will be located away from the possible sources of vibration.

Building a new accelerator next to an existing one involves continual challenges. Because the TPS building cuts into the edge of the TLS, the prevention of instability and vibration in the TLS caused \triangleright



A 14-m long "hanger", equivalent in size to the vacuum chamber, was built to carry the assembled unit.

by the construction work is a critical issue. To prepare for this daunting task, the NSRRC held workshops on ambient ground motion and civil engineering for the TPS in 2005 and 2008, so as to study the methods and strategic solutions used at other synchrotron facilities. These resulted in mechanical approaches to eliminate or reduce amplification of the floor motion by the girder system for the TPS, while also adding steel piles to prevent the adjacent TLS foundations from gradually crumbling.

Various methods to protect the TLS foundations and building centre on supporting the ground soil with *in situ* reinforcing and shoring-up the longitudinal sections that are exposed by excavation work. Taking advantage of the fact that the site is mainly of gravel formation, the TLS beam columns were reinforced with additional frames. In addition, seven H-beam, Type-L steel piles, 17.5 m long, were inserted in places where parts of walls of the TLS storage ring previously stood. Each pile was also equipped with a 200 cm × 120 cm × 60 cm concrete beam laid horizontally against the TLS foundations. These piles provide pressure to prevent the TLS from rising through elastic deformation occurring when the suppression disappears as a result of the 10 m-deep excavation.

To meet the target milestone of commissioning by the end of 2013, civil construction and accelerator installation will proceed concurrently. Partial occupancy of the linac building and ring tunnel needs to occur by the beginning of 2012 to meet the installation timetable for ring components. Power and other utilities will be brought in once pedestal paving and the installation of piping and cable trays begins. This will allow the setting up of the booster ring and subsystems in the storage ring. The SRF cavity will be the final



Walls of the TLS building were torn down for the new interface with the TPS storage ring and piles were inserted to stabilize the TLS foundations.

component to move in and tests for TPS commissioning will follow accordingly.

With the accumulated expertise from the past, the design of the TPS has been achieved by the NSRRC's own members. With their capability in developing insertion devices for the TLS and systems to cope with their operation established since 1993, the photon energy of the TPS should reach 30 keV. With a maximum brightness of 10^{21} photons/s/0.1%BW/mm²/mrad² at 10 keV it will be among the brightest light-sources available.

Résumé

Et la lumière fut en Asie du Sud-Est

Le NSRRC, le centre national taiwanais de recherche sur le rayonnement synchrotron, a commencé la construction de sa seconde source de lumière synchrotron, nommée Taiwan Photon Source (TPS). À l'instar d'autres programmes de grande envergure, des années de préparation et de processus décisionnels ont été nécessaires pour atteindre cette étape cruciale. Pour respecter les échéances, il a fallu considérablement solliciter du personnel expérimenté qui avait déjà participé à la construction du premier accélérateur du NSRRC, Taiwan Light Source (TLS), en 1983. Ainsi, le projet a su tenir des délais ambitieux et a permis le transfert de connaissances à de jeunes ingénieurs.

Diana Lin and Gwo-huei Luo, National Synchrotron Radiation Research Center.

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Gran Sasso becomes a workshop WONDERland

Dark-matter practitioners congregated at Gran Sasso in March to discuss the future of their particular field of astroparticle physics.

The INFN's Gran Sasso National Laboratory provides the world's largest underground infrastructure for astroparticle physics. It currently hosts four operational dark-matter experiments – CRESST, DAMA-LIBRA, WArP and XENON – and was therefore a fitting venue for WONDER, the Workshop On Next Dark-matter Experimental Research. Designed to generate fruitful discussions about the future of the exciting field of dark-matter physics, the workshop was held on 22–23 March and attracted around 100 participants.

As is well known, “dark matter” is the name given to 23% of the “inventory” of the universe, the existence of which is indicated by several experimental facts, the first and most famous being the anomalous behaviour of the radial velocity of galaxies. Although some alternative models still survive to explain these unexpected effects, the most fascinating explanation – at least for particle physicists – is the existence of stable, massive particles that interact only weakly with ordinary matter and permeate all galaxies, including ours. Supersymmetry provides a nice theoretical framework for such an explanation, and the lightest supersymmetric particle, the neutralino, could be a viable candidate for dark matter. First, however, someone has to observe some experimental evidence to pin down the characteristics of the “dark” particles, which are often referred to as “WIMPs” – weakly interacting massive particles. The question is: how to identify the particles?

One way is to look for the production of WIMPs in collisions at the LHC at CERN. Other “indirect” techniques look for likely signatures of annihilations of WIMPs occurring in the Sun, Earth or galactic halo; these could appear, for example, as anomalous neutrino or gamma-ray fluxes. A third method is to observe the direct interactions of WIMPs with ordinary matter. Underground laboratories are the ideal place to carry out this quest. Anywhere else on the surface of the Earth, the overwhelming cosmic radiation would drown out the tiny signal (if it exists), making the search as hopeless as trying to spot a distant star in daylight.

Even amid the “cosmic silence” at the heart of a mountain (as at Gran Sasso), dark-matter experiments struggle to attain the best sensitivity with elaborate techniques and, above all, by trying to reduce the residual gamma and neutron backgrounds to unprecedentedly low levels.

DAMA-LIBRA, one of the first experiments at Gran Sasso, does in



Installing the DAMA-LIBRA detectors in high-purity nitrogen atmosphere.



Above: The XENON100 detector uses more than 100 kg of xenon.

Left: The CRESST detector modules are arranged in a support structure that can hold up to 33 crystals, corresponding to 10 kg of detector material.

(All photos courtesy LNGS-INFN.)



fact observe a significant modulation signal in its scintillators of high-purity sodium iodide, which is identical to the one that the motion of the Earth through the dark-matter halo is supposed to cause. The DAMA collaboration presents this signal as evidence for the discovery of dark matter and the scientific community waits for a confirmation, possibly with new, different techniques. The ▷



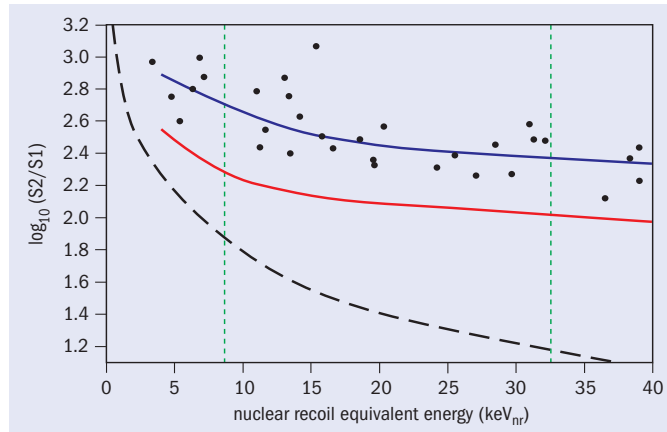
The whole WArP system is contained in a stainless steel, vacuum-tight cylindrical container, which is completely immersed in a liquid-argon bath to provide the co-existence of liquid and gaseous phase argon in the inner detector.

problem is that, until to now, the other experiments seem to rule out DAMA-LIBRA's result, although the comparison between different techniques is far from straightforward. Theoretical models still survive that reconcile all current experimental results with a positive discovery by DAMA-LIBRA.

Among today's technologies, detectors employing cryogenic noble liquids occupy a pre-eminent position. These seem to allow for excellent signal-to-background discrimination, coupled with the possibility to build massive detectors. The Gran Sasso National Laboratory provided a natural location to discuss the future of these searches because it hosts three experiments, other than DAMA-LIBRA, that are competing for the discovery of dark matter, namely CRESST, WArP and XENON. The race is particularly interesting between the latter two of these because they use the same "double-phase" technique, but with different targets. XENON employs 160 kg of its homonymous noble element in liquid form, while WArP has a similar amount of liquid argon, a medium with which research groups at INFN have considerable expertise.

Carlo Rubbia, the spokesperson of the WIMP Argon Programme (WArP), opened the workshop with an excellent and comprehensive overview of the experimental landscape. This was followed by theoretical talks that helped to set up the general framework of the field. With regard to experimental activities, preliminary results from the XENON100 detector provided a highlight of the workshop. About 11 days of data have been analysed and were presented by the XENON spokesperson Elena Aprile, from Columbia University. The data show an extremely low background – the lowest ever reached – and raise even stronger expectations for future results.

Claudio Montanari of INFN presented the status of WArP, which has just started data-taking, while Wolfgang Seidel of the Max Planck Institute talked about interesting results from CRESST, a detector made from scintillating calcium-tungstate crystals. Activities beyond Gran Sasso were also discussed. Masaki Yamashita of Kamioka/Tokyo presented Xmass, a particularly promising detector based on liquid xenon, which is close to its commissioning phase in the Kamioka mine in Japan. Newer techniques also seem to be interesting and promising. These include the directional detectors that Neil Spooner of Sheffield University described and, in particular, the bubble chambers



Analysis from 11 days of data-taking with XENON100 shows how the log of the ratio of primary scintillation (S1) and ionization (S2) signals for the 22 events match single-scatter electronic recoils (blue) rather than nuclear recoils (red). (The dashed line is a software threshold.)

COUPP and PICASSO, which Nigel Smith of SNOLAB discussed in his extensive overview of dark-matter activities around the world.

Two stimulating talks were dedicated to the problem of backgrounds, especially from neutrons. Frank Calaprice of Princeton University and Vitaly Kudryavtsev of Sheffield University described these issues. The final session covered, in depth and in a critical manner, the issues of backgrounds, sensitivity and stability for each group of techniques.

Overall, the workshop revealed an extremely lively field, with existing detectors producing new results, others about to enter their commissioning phase, advanced projects being proposed for new underground facilities and intense theoretical activity. We all "wonder" if a discovery is just round the corner.

Further reading

All talks are available at the WONDER website. See <http://wonder.lngs.infn.it>.

Résumé

Le Gran Sasso accueille l'atelier WONDER

Quatre expériences sur la matière noire sont actuellement menées au laboratoire italien du Gran Sasso de l'Istituto Nazionale di Fisica Nucleare (INFN). Le lieu était donc idéal pour organiser l'atelier WONDER (Workshop on Next Dark Matter Experimental Research) sur les prochaines recherches expérimentales sur la matière noire. Ayant pour objectif de susciter des débats constructifs sur l'avenir du domaine passionnant qu'est la physique de la matière noire, cet atelier s'est déroulé du 22 au 23 mars et a attiré une centaine de participants. Dans l'ensemble, l'événement a démontré que la recherche sur la matière noire était un domaine extrêmement dynamique. Les détecteurs en fonctionnement donnent de nouveaux résultats et d'autres vont entrer dans leur phase de mise en service. D'autres projets en phase avancée de développement sont également proposés pour de nouvelles installations souterraines.

Francesco Arneodo, INFN.

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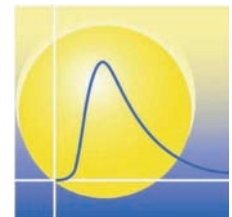
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Carbon-ion radiotherapy

Japan has pioneered the use of carbon ions in the treatment of tumours, treating the first patient in

The first prostate cancer patient was successfully treated with a 380 MeV/u carbon-ion beam at a new facility of the Gunma University Heavy Ion Medical Center (GHMC) on 16 March, three years after construction began in February 2007. This facility, which is a pilot project to boost carbon-ion radiotherapy in Japan, has been developed in collaboration with the National Institute of Radiological Sciences (NIRS).

The GHMC facility, shown schematically in figure 2, can deliver carbon-ion beams with energies ranging from 140 to 400 MeV/u. It consists of a compact injector, a synchrotron ring, three treatment rooms and an irradiation room for the development of new beam-delivery technology. The first beam was obtained from the accelerator system on 30 August 2009. Beam commissioning was followed by three months of pre-clinical research before the first treatment began. Each week since has seen two patients added to the schedule. The facility is a pilot based on a smaller version of the Heavy-Ion Medical Accelerator in Chiba (HIMAC). This means that clinical instrumentation, as well as the accelerator system, has been better tailored for clinical use and has a much lower cost – about a third less than the HIMAC facility.

Clinical trials

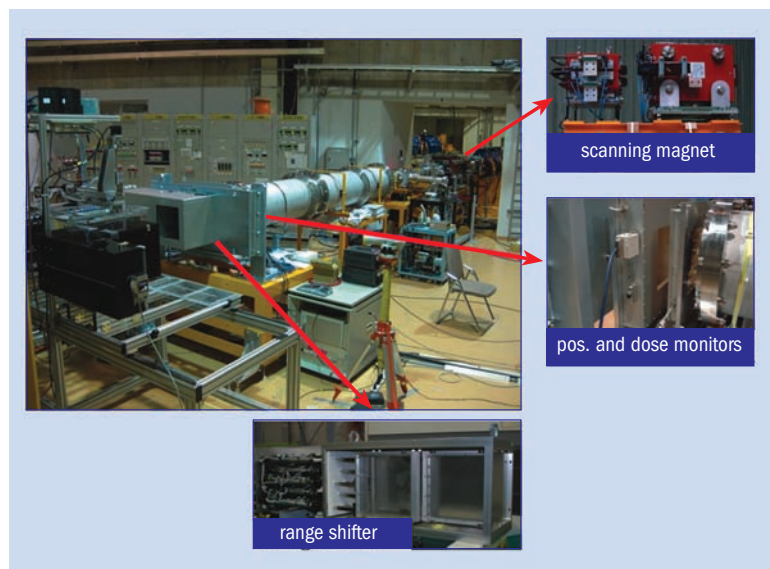
Heavy-ion beams are particularly suitable for deeply seated cancer treatment not only because of their high dose-localization at the Bragg peak but also as a result of the high biological effect around the peak (*CERN Courier* December 2006 p5). NIRS decided to construct the HIMAC facility in 1984, encouraged by the promising results from the pioneering work at the Lawrence Berkeley National Laboratory in the 1970s. Completed in October 1993, HIMAC was the world's first heavy-ion accelerator facility dedicated to medical use. A carbon-ion beam was chosen for HIMAC, based on the fast-neutron radiotherapy experience at NIRS. It uses the single beam-wobbling method – a passive beam-delivery method – because it is robust with respect to beam errors and offers easy dose management.

Since the first clinical trial in June 1994, the total number of treatments with HIMAC had reached more than 5500 by February 2010, including about 750 treatments in 2009 alone, with single-shift operation on an average of 180 days a year. The treatment has been applied to various types of malignant tumour. As a result of the accumulated numbers of protocols, in 2003 the Japanese government approved carbon-ion radiotherapy with HIMAC as a highly advanced medical technology.

The development of beam-delivery and accelerator technologies has significantly contributed to improved treatments at HIMAC. For example, NIRS developed methods for treating tumours that move



Fig. 1. Rehearsal just before the first patient treatment at the GHMC facility.



with a patient's breathing and for reducing the undesired extra dose on healthy tissue around tumours that occurs in the single beam-wobbling method, routinely used at HIMAC.

The carbon-ion radiotherapy with HIMAC has so far proved to be significantly effective not only against many kinds of tumour that have been treated by low-linear energy transfer (LET) radiotherapy but also against radio-resistant tumours, while keeping the quality of life high without any serious side effects. It has also reduced the number of treatment fractions, which leads to a short course of treatment compared with low-LET radiotherapy. For exam-

Radiotherapy flourishes in Japan

in 1994. A new facility has come on line and others are under construction, as **Koji Noda** explains.

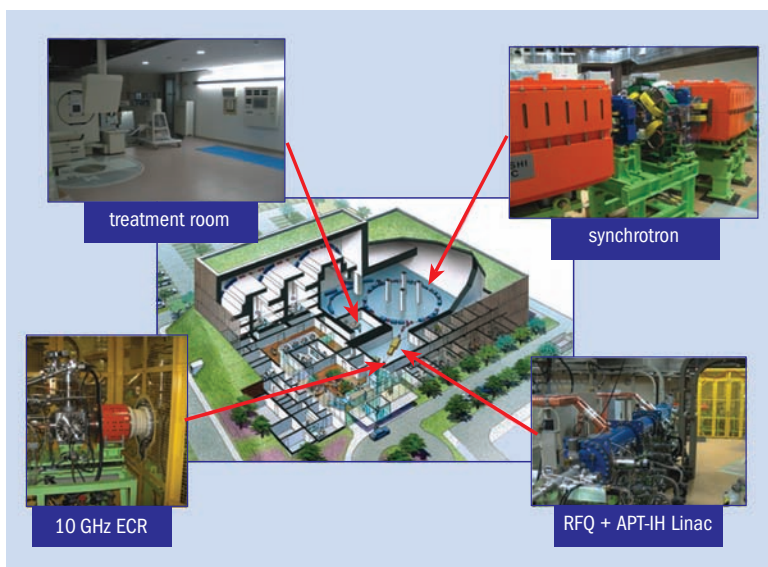


Fig. 2 Schematic of the Gunma University Heavy Ion Medical Center (GHMC) facility, which opened in March. The insets show the facility's various components.

Fig. 3 A test bench (left) at HIMAC has successfully verified a new 3D-rescanning method for treating both fixed and moving tumours. This image of Hirohiko Tsujii (right), one of the world's leading figures in radiotherapy with carbon ions, was produced using the fast 3D-rescanning method.

(All images courtesy Koji Noda.)



ple, a single fractionated irradiation with four directions has been used in treating lung cancer, which means only one day of treatment. NIRS therefore proposed a new facility to boost the application of carbon-ion radiotherapy, with the emphasis on a downsized system to reduce costs.

The design of the proposed facility was based on more than 10 years of experience with treatments at HIMAC. The key technologies for the accelerator and beam-delivery systems that needed to be downsized for the new facility were developed from April 2004 to March 2006, and their performances were verified by beam tests

with HIMAC. In particular, the prototype injector system consisted of a compact 10 GHz electron-cyclotron resonance ion-source consisting of permanent magnets together with radio-frequency quadrupole (RFQ) and alternating-phase-focused interdigital H-mode (APF-IH) linear accelerators. This was constructed and tested at HIMAC because an APF-IH linear accelerator had never been constructed for practical use anywhere else. Tests verified that the injector system could deliver 4 MeV/u C^{4+} with an intensity of more than 400 eμA and transmission efficiency of around 80% from the RFQ to the APF-IH. This R&D work bore fruit in the recently opened GHMC facility.

NIRS, on the other hand, has been engaged in research on new treatments since April 2006 with a view to further development of the treatments at HIMAC. One of the most important aims of this project is to realize an "adaptive cancer radiotherapy" that can treat tumours accurately according to their changing size and shape during a treatment period. A beam-scanning method with a pencil beam, which is an active beam-delivery method, is recognized as being suitable for adaptive cancer radiotherapy.

NIRS, which treats both fixed and moving tumours, has proposed a fast 3D rescanning method with gated irradiation as a move towards the goal of adaptive cancer radiotherapy for treating both kinds of tumour. There are three essential technologies used in this method: new treatment planning that takes account of the extra dose when an irradiation spot moves; an extended flattop-operation of the HIMAC synchrotron, which reduces dead-time in synchrotron operation; and high-speed scanning magnets. These allow for 3D scanning that is about 100 times faster than conventional systems. Experiments using a test bench at the HIMAC facility (figure 3) have verified that the desired physical dose distribution is successfully obtained for both fixed and moving targets, with the expected result for the survival of human salivary-gland cells.

Using this technology, a new treatment research facility is being constructed at HIMAC (figure 4, p24). The facility, which is connected to the HIMAC accelerator system, will have three treatment rooms: two rooms equipped with both horizontal and vertical beam-delivery systems and one room with a rotating gantry. The facility building was completed in March and one treatment room will be finished in September. Following beam commissioning and pre-clinical research, the first treatment should take place in March 2011.

Future outlook

Following on from the pilot facility at GHMC, two additional projects for carbon-ion radiotherapy have been initiated in Japan: the Saga Heavy Ion Medical Accelerator in Tosu (Saga-HIMAT) and the Kanagawa Prefectural project. The Saga-HIMAT project started ▷



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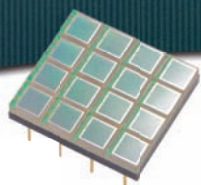
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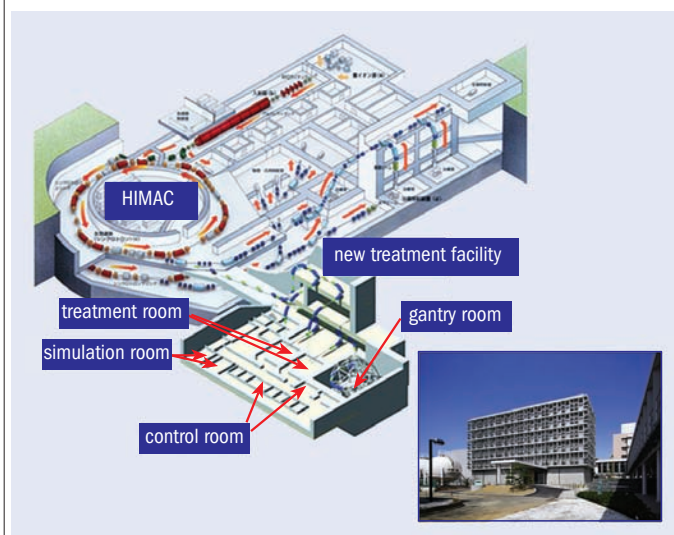


Fig. 4. Schematic of the new treatment facility at HIMAC (inset).

construction of a carbon-ion radiotherapy facility in February 2010. This is based on the design of the GHMC facility and will be opened in 2013. Although this facility has three treatment rooms, two will be opened initially and use the spiral beam-wobbling method. Of these, one will be equipped with horizontal and vertical beam-delivery systems and the other with horizontal and 45° beam-delivery systems. In the next stage, the third room will be opened and use horizontal and vertical beam-delivery systems with the fast 3D rescanning method developed by NIRS. The Kanagawa Prefectural Government has decided to construct a carbon-ion radiotherapy facility in the Kanagawa Prefectural Cancer Center. This will also be based on the design of the GHMC-facility. Design work on the facility building began in April 2010 and it is expected to open in 2014.

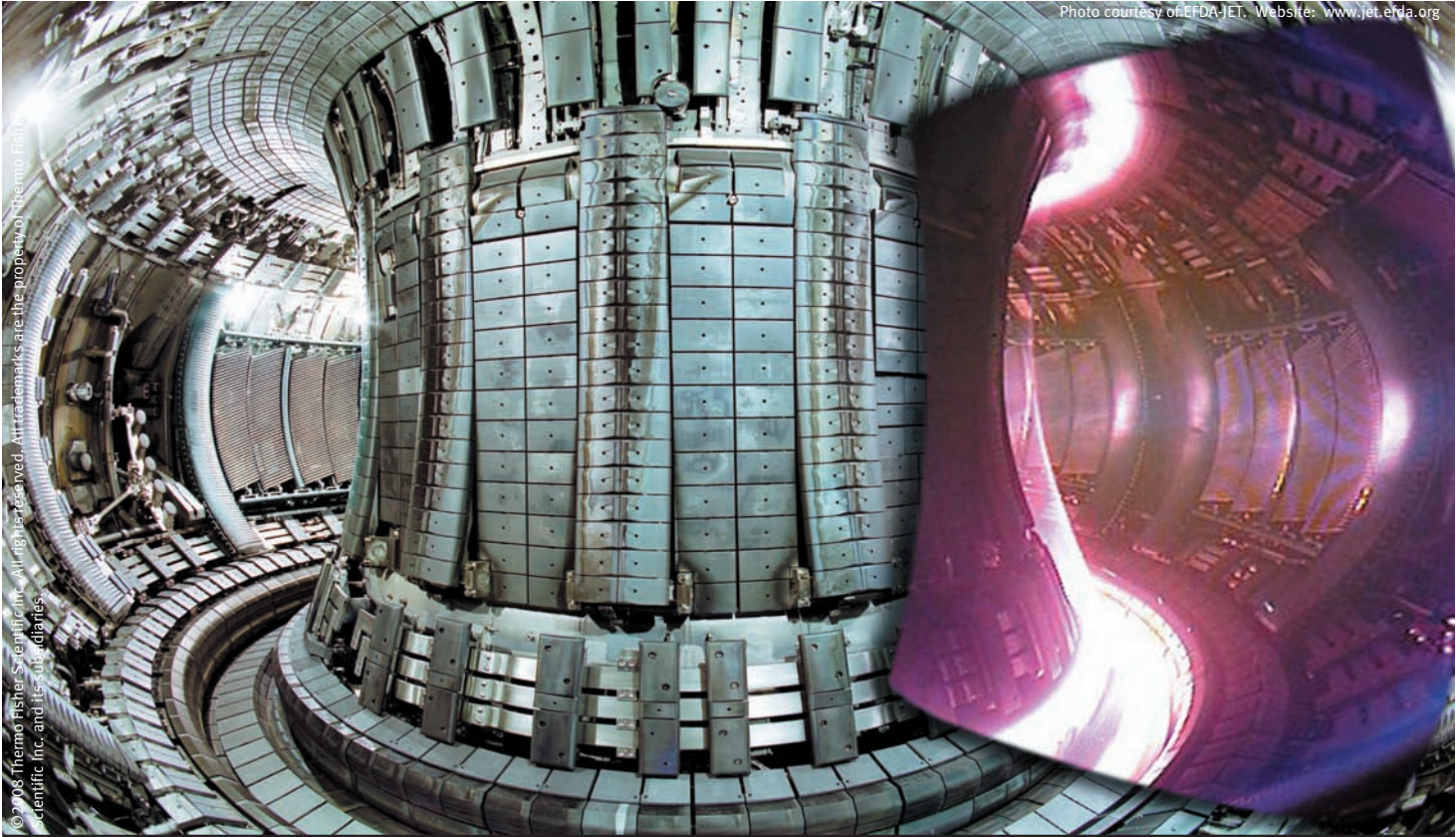
More than 500 000 people in Japan are diagnosed with cancer every year and it is forecast that this number will continue to rise. In such a situation, the newly opened GHMC facility – following those at HIMAC and the Hyogo Ion Beam Medical Center – is expected to boost applications of carbon-ion radiotherapy in Japan. By 2014, five carbon-ion facilities and eight proton facilities will be operating. These are sure to play a key role in cancer radiotherapy treatment.

Résumé

L'hadronthérapie par ions carbone en pleine expansion au Japon

Avec un premier patient traité en 1994, le Japon s'est imposé comme précurseur dans l'utilisation des ions carbone pour le traitement des tumeurs. Le 16 mars dernier, un patient souffrant d'un cancer de la prostate a été traité pour la première fois à l'aide d'un faisceau d'ions carbone dans un nouvel établissement du GHMC, le centre de soin et de recherche dédié au traitement par ions lourds de l'université de Gunma, trois ans après le début de sa construction, en février 2007. Il s'agit d'un modèle réduit de l'HIMAC, le premier accélérateur d'ions lourds utilisé à des fins thérapeutiques situé à Chiba. D'ici 2014, le Japon comptera cinq centres de traitement par ions carbone et huit par protons.

Koji Noda, director, Department of Accelerator and Medical Physics, National Institute of Radiological Sciences.



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FACES AND PLACES

COLLABORATION

CERN and GSI sign new agreement

CERN and GSI have a long and successful history of collaboration, which started even before CERN launched its programme for fixed-target physics with heavy ions at the Super Proton Synchrotron in the 1980s, culminating with the prospect of collisions between beams of lead ions at the LHC. GSI has made major contributions to the LHC – in particular to the ALICE experiment, which is designed principally for the study of lead-lead collisions.

Now, GSI is to become the host laboratory and major partner for the Facility for Antiproton and Ion Research, which is scheduled to start construction at Darmstadt next year.

CERN and GSI have decided to continue as well as strengthen their co-operation in the fields of heavy-ion and hadron physics, accelerator physics and technologies, educational programmes and high-performance computing.

On 14 April GSI's director, Horst Stoecker,



Left to right: Hartmut Eickhoff, Horst Stoecker and Rolf Heuer shake hands on the new agreement.

and CERN's director-general, Rolf Heuer, signed a newly enlarged agreement to enhance the co-operation between the two

laboratories. The agreement was also signed by the two accelerator directors, Hartmut Eickhoff for GSI and Steve Myers for CERN.

ITU and CERN strengthen their relationship

On 10 May CERN and the International Telecommunication Union (ITU) signed a framework agreement that is intended to strengthen the collaboration between the two organizations on scientific and technological issues. The ITU is the leading UN agency for information and communication technology issues. For nearly 145 years it has co-ordinated and promoted international co-operation in telecommunications, from the shared global use of the radio spectrum to efforts to improve telecommunications infrastructure in the developing world and to strengthen cybersecurity.

The agreement will facilitate the setting up and implementation of joint initiatives that are of mutual interest. These are expected to concern the following fields in the near future: citizen cyberscience; the extension of broadband-communication systems to developing countries; training in the use of "digital library" methods in these countries; and cybersecurity.



Hamadou Touré, secretary-general of the ITU and Rolf Heuer, CERN's director-general, have signed a co-operation agreement on scientific and technological matters. (Courtesy ITU.)

LEARNED SOCIETIES



Andrzej Buras. (Courtesy facesbyfrank.)

Buras elected to the Bavarian Academy of Sciences

Andrzej Buras, professor of theoretical elementary particle physics at the Technische Universität München (TUM), has been elected to the Bavarian Academy of Sciences. A leading researcher in applied quantum-field theory, in particular in flavour physics, he is head of the Fundamental Physics Group at the Institute for Advanced Study at TUM and leader of a research area in the Excellence Cluster “Origin and Structure of the Universe”.

Buras is elected on the basis of his studies of strong-interaction (QCD) effects in deep-inelastic processes (the modified minimal subtraction, or MS-bar, scheme, with William Bardeen, Dennis Duke and Taizo Muta); calculations of higher-order QCD effects in weak and rare meson decays; and numerous studies of rare decays and CP violation within the Standard Model and several of its extensions.

The Bavarian Academy of Sciences and Humanities was founded in 1759 and counts Johann Wolfgang von Goethe, Werner Heisenberg and Albert Einstein among its past members. It has two sections, or “classes” – one for philosophy and history and one for mathematics and the natural sciences. The number of ordinary members in each class is limited to 45. Julius Wess was the only particle physicist to be a member, until his death in 2007.

APPOINTMENT

Arturo Menchaca becomes president of the Mexican Academy of Sciences

Arturo Menchaca, of the Instituto de Física de the Universidad Nacional Autónoma de México and a member of the ALICE collaboration at the LHC, is the newly appointed president of the Mexican Academy of Sciences (AMC).

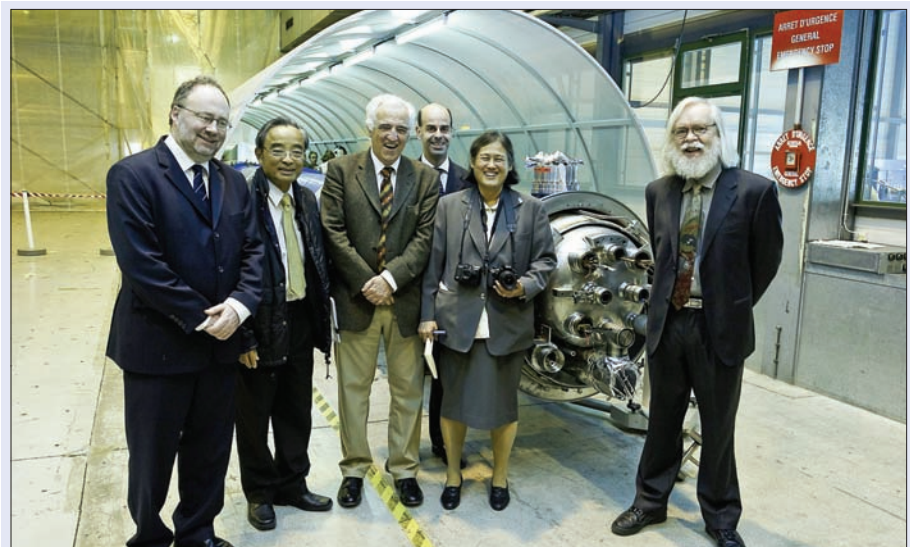
The AMC promotes communication between the national and international scientific communities, advises the Mexican state on issues in science and technology and promotes the development of research in these fields in Mexico. The AMC membership numbers about 2000 and consists of leading Mexican scientists, as well as some 80 scientists from other countries, including nine Nobel laureates.

During his mandate Menchaca aims at strengthening international relations and build up the AMC’s participation in the scientific academies of the G8+5 countries, as well as in other organizations.



Arturo Menchaca. (Courtesy Enrique Siqués.)

VISITS



Her Royal Highness Princess **Maha Chakri Sirindhorn** of the Kingdom of Thailand, second from right, came to CERN on 13 April. During her visit she toured the LHC superconducting magnet test hall accompanied by, from left to right, Albert de Roeck, CMS deputy spokesperson, **Pairash Thajchayapong**, attached to the office of His Majesty’s principal private secretary, Frédéric Bordry, head of CERN’s technology department, Emmanuel Tsemelis, adviser for South-East Asia, Oceania, Cyprus, Malta and Iceland, and John Ellis, adviser for non-member states.

CELEBRATION

Jiří Niederle: a voice for science and CERN

Jiří Niederle, CERN Council member for the Czech Republic, celebrated his 70th birthday in 2009. As well as being a respected theoretical particle physicist, he has been instrumental in building the scientific reputation of Czechoslovakia and, subsequently, the Czech Republic.

A native of Prague, Niederle studied in the Faculty of Technical and Nuclear Physics of the Czech Technical University in his home city. After graduating, he joined the Institute of Physics of the Czechoslovak Academy of Sciences, also in Prague, and followed his PhD studies both there and at the International Centre for Theoretical Physics (ICTP), in Trieste. In 1967 he became a research scientist at the institute and, after defending his thesis on “Generalized Symmetries of Space–Time and their Application to Elementary Particle Physics”, he became associate professor.

Over the years Niederle has made important contributions both to particle physics and mathematical physics. In particle physics he has concentrated on theories that unify fundamental particle interactions, conformal quantum field theory, gauge formulations of gravitation, and the symmetry of elementary particles. In mathematical physics he has solved problems related to the representation theory of Lie algebras and superalgebras and their corresponding groups and special functions, integrable non-linear systems, and the theory of contractions and deformations.

However, Niederle’s influence on science extends beyond his contributions to theoretical physics. Science has always been one of the first fields to penetrate the artificial political barriers that separate individual countries and prevent free scientific contacts and circulation of scientists. After the collapse of the communist regime in Czechoslovakia in November 1989, a radical reconstruction of the organization of international contacts and co-operation in science was unavoidable, both in the Academy of Sciences and in the country’s universities. The enormous challenge that such a reorganization entailed fell to Niederle, who was president of the Council for International Co-operation of



Hoisting the flag when Czechoslovakia became a full member of CERN in 1992. From left, Jiří Niederle, Carlo Rubbia, CERN director-general, Zdenko Pírek, Foreign Affairs Deputy Minister of Czechoslovakia, and William Mitchell, president of the CERN Council.



Jiří celebrating his 70th anniversary in 2009. (Courtesy J Niederle.)

the Academy of Sciences. While in this position in 1990–1997 and in 2001–2005 he was able to help the academy to become a top scientific institution and to find its place in the community of world scientific organizations, despite the previous 40 years of communist isolation.

Niederle also contributed in a decisive way to his country’s membership in CERN, initially as Czechoslovakia (in 1992) and later as the Czech Republic (1993). As president of the Czech Committee for Co-operation

with CERN, a position he has held since 1992, he has rendered outstanding service in support of the collaboration of the Czech Academy and Czech universities with CERN. He has been a member of the CERN Council since 1992, and was its vice-president in 1996–1998. He was also the first Czech delegate to the NATO Science Committee, in 1994–1995.

An experienced lecturer, Niederle gave lectures at ICTP and at the International School for Advanced Studies in Trieste from

1964 until 1979, and wrote the three-volume work *Group Theory* aimed at students. He has also been visiting professor and presented many invited lectures at institutes in both Europe and the US. His communication skills are not limited to academic circles – he successfully writes and gives interviews in popular science, covering topics from special relativity and quantum mechanics to the construction and work on the Large Electron Positron collider and its successor, the LHC. He is very active in broadcast popular science programmes, such as *Keys to knowledge*, a

five-part TV programme that won a prize for popularization. He has also made successful TV programmes about CERN and the activities of Czech experts at CERN.

Niederle has been a member of several scientific societies and associations. For example, he was a founding member of the International Association of Mathematical Physics and for many years was an elected member of the council of the European Physical Society. He has been a member of the Czech branch of the Club of Rome since 1991 and was a founding member of the

Euroscience Association. He was a member of the Subcommittee for Research and Education of the Parliament of the Czech Republic in 1995–1998 and now sits on the scientific councils of a number of Czech universities and on the editorial boards of seven scientific journals.

In 1995 Niederle was appointed professor of theoretical physics at Charles University, Prague, and in 1999 he became head of the Department of the Theory of Elementary Particles of the Institute of Physics at the Academy of Sciences of the Czech Republic.

MEETINGS

The **5th International Accelerator School for Linear Colliders** will take place at Villars-sur-Ollon, Switzerland, on 25 October – 5 November 2010. Organized by the International Linear Collider Global Design Effort, the Compact Linear Collider study and the International Committee for Future Accelerators Beam Dynamics Panel, the school is hosted by CERN and sponsored by a number of funding agencies and institutions. The first two days of the 10-day programme will be an introductory course with an overview of TeV-scale lepton colliders. This will be followed by two elective courses,

one on accelerator physics and the other on RF technology. The school will accept a maximum of 70 students from around the world. Students will receive financial aid covering their expenses for attending the school including travel (full or partial). There will be no registration fee. The application deadline is 15 June. For more details, see www.linearcollider.org/school/2010.

The **6th International Workshop on the CKM Unitarity Triangle** will take place at the University of Warwick, UK, on 6–10 September. The CKM workshop

provides the opportunity for theorists and experimentalists in quark-flavour physics to discuss results and develop new ideas. The meeting will feature results from the Tevatron, B factories and charm and kaon experiments, the status of preparations for next generation experiments, and first results from the LHC. There will be reports on the latest progress in lattice QCD calculations and on the development of techniques that enable ever more precise determinations of the elements of the CKM matrix. For more details about CKM2010, and on-line registration, see <http://ckm2010.warwick.ac.uk>.

LETTERS

The LHC and cosmic rays

Very recent measurements at the LHC show that the charged-particle density in the central rapidity region is following a simple power law in energy all the way from as low as 10 GeV up to 2.6×10^7 GeV laboratory energy (ALICE collaboration 2010, see also page 6). Specifically the power law exponent, $\alpha = 0.11$, is the same as that found for laboratory energies $1.5 \times 10^3 - 1.5 \times 10^5$ GeV (Erlykin 1983) and close to $\alpha = 0.13$ found at even lower energies $10 - 1.5 \times 10^3$ GeV (Wdowczyk and Wolfendale 1979).

There is immediate relevance to the nature of the famous “knee” in the primary cosmic-ray energy spectrum around 3×10^6 GeV, because it is the first time that measurements cover interactions at these and even higher energies. The preservation of that rate of rise for the charged-particle density means that drastic changes in the “nuclear-physics model” of the knee cannot be invoked. Conventional astrophysical models – with no change in

interaction mechanism – suggest light nuclei (protons and helium) from a local single supernova as being responsible.

ALICE collaboration 2010 arxiv:1004.3514.
A D Erlykin 1983 *Proc. Int. Cosm. Ray Conf. Bangalore* **5** 1.

J Wdowczyk and A W Wolfendale 1979 *Nuovo Cim.* **54A** 433.

A D Erlykin and A W Wolfendale.

Krisch and cross-sections

I am a great admirer of Alan Krisch and I was delighted to see the article about him in the *CERN Courier* of April 2010. I think that all of those like Krisch, or, at CERN, Louis Dick, who had the courage to investigate polarization phenomena without the support of most of the theoretical community have great merits. Their surprising results remain largely unexplained, and many theoreticians say that these results are not really interesting. Indeed perturbative QCD is unable to say anything about these because the transition

from quarks and gluons to hadrons is poorly understood. For this reason, at CERN, several proposals of experiments with polarized particles have been rejected. I am not sure that this is a very scientific attitude.

I would like to make a historical correction to the statement, that it is in Krisch’s papers of 1967 and 1968 that the notion of “inclusive cross-section” was introduced. As early as 1961 it was realized that with electron linacs one could only get inclusive cross-sections. For electron and neutrino inclusive cross-sections, Fubini, Gourdin and I, and, independently, Bjorken found that these processes could be described by respectively two and three functions later called “structure functions”. Also, in the purely hadronic case, Ascoli and Minguzzi, in 1960, defined the cross-section for production of a particle at a given angle, i.e. the inclusive cross-section integrated over the energy of this particle.
André Martin, CERN.

AWARD

Dolgov and Sobel receive the 2009 Pontecorvo Prize

The Pontecorvo Prize for 2009 goes to Alexander Dolgov of the Institute for Theoretical and Experimental Physics, Moscow, and Henry Sobel of the University of California, Irvine. Dolgov receives the prize for his fundamental work on neutrino oscillations and kinetics in cosmology, while Sobel is honoured for his significant contributions to experiments in neutrino oscillations.

The awards ceremony was held on 19 February at the 107th session of the JINR Scientific Council. Alexei Sissakian, director of JINR, presented the prize certificates and



From left to right: Prizewinners Henry Sobel, Alexander Dolgov with JINR director Alexei Sissakian.

badges of honour. (Sissakian very sadly passed away on 1 May, see p32.)

Dolgov and Sobel presented the experimental results based on the ideas

postulated by Bruno Pontecorvo. Both of them noted that it was a great honour to be awarded with a prize named after one of the 20th century's most outstanding physicists.

NEW PRODUCTS

Agilent Technologies has introduced the U1084A PCIe high-speed digitizer with an on-board field-programmable gate array for real-time data processing. This platform provides higher sampling rates, faster measurement throughput and more flexibility, while maintaining precision and cost-effectiveness. The product's PCIe form factor and flexible architecture are ideal for use in scientific instrumentation. The digitizer's performance is also suited to advanced research in high-energy physics, nuclear physics and astrophysics. For further details, e-mail digitizers@agilent.com; or visit www.agilent.com/find/advanced-research.

Elma Electronic Systems Division has announced the 6211 cPCI RAIDStor with up to 1.2 TB in a single cPCI slot or 2.4 TB with two slots. The new 6U CompactPCI blade network attached storage board provides automatic and transparent cross-network or intra-blade data replication and re-sync for enhanced data security and preservation. Standard with dual 2.5-inch SATA hard-disk drives, the new RAIDStor also comes in lower capacity configurations. For more information, contact Valerie Andrew, tel +1 215 956 1200; fax +1 215 956 1201; e-mail sales@elma.com; or visit their website at www.elma.com.

Lake Shore Cryotronics Inc has introduced

the Model 425 gaussmeter. Designed to meet the needs of the permanent magnet industry, the Model 425 provides high-end functionality and performance in a desktop instrument. Additional features, which include DC to 10 kHz AC frequency response, maximum hold and relative measurement, make the Model 425 useful for manufacturing, quality control and R&D flux density measurement applications. For further details, tel +1 614 891 2244; fax +1 614 818 1600; e-mail info@lakeshore.com; or visit www.lakeshore.com/mag/ga/gm425po.html.

Maxon Motor Ag has announced the EPOS2 70/10, a positioning system developed specifically for commanding and controlling in the CANopen network. USB and RS232 are also available as further communication interfaces. The EPOS2 70/10 matches with DC brush motors with encoder, or with brushless EC motors with Hall sensors and an encoder with up to 700 W of power. It features high-precision motion control functionalities and offers a dual-loop position and speed controller. For more information, tel +41 666 1500; fax +41 666 1650; e-mail info@maxonmotor.com; or visit their website at www.maxonmotor.com.

UltraVolt Inc has introduced a new line of benchtop high-voltage power systems, the

BT series. Standard features include a clear output-voltage display, power grid input, positive or negative polarity, tight line/load regulation, low ripple, high stability, overload protection and optional shielded HV output cable. The BT series systems are single channelled and have output voltages from 0–100 V up to 0–6 kV. UltraVolt has also announced that the V series and M series of microsize, micropower products have been enhanced with power levels increased by up to 50%. These modules are now offered at 500 mW with 12 V input, 800 mW with 15 V input, or 1 W with 24 V input for all output voltage ranges. For more information, tel +1 631 471 4444; or visit www.ultravolt.com.

Unitemp has introduced a new range of easy-access temperature and humidity chambers, designed for the testing and monitoring of electronics and semiconductors, for example. The control panel incorporated in the door allows easy access to the specimen under test through cable ports located on both sides of the equipment. The series has a temperature range of –40°C to +150°C and 20–98% RH. The control panel allows 20 program patterns to be stored in memory. For further details, contact Paul Brown, tel +44 162 885 0611; e-mail paul@unitemp.co.uk; or visit their website at www.unitemp.co.uk.

OBITUARIES

W Owen Lock 1927–2010

Following a long and cruel illness, which he and his family bore with great fortitude, Owen Lock died on 19 March 2010.

Owen was born on 8 August 1927 and grew up in Cirencester, England. In 1945 he won a state scholarship to study physics at the University of Bristol, where he graduated in 1948 with a first-class honours BSc. He joined the international group of Cecil Powell and colleagues, immediately after their Nobel prize-winning discovery of the π meson, and worked with the newly developed technique of photographic nuclear emulsions, which were exposed to cosmic rays in high-altitude balloon flights. Owen's numerous papers from that time include observations of the production and decays of μ , π and K mesons and their interactions with nuclei. He wrote a review article in *Progress in Cosmic Ray Physics* in 1951 and obtained his PhD in 1952. By then he had been, successively, secretary and chair of the Bristol branch of the Association of Scientific Workers and had joined the World Federation of Scientific Workers and the British Pugwash Movement.

Owen met his wife, Eleanor, in Bristol. They were married in 1952 and moved to Manchester, where Owen took up a research fellowship, working with Patrick Blackett on further investigations of K mesons. After five months he became a lecturer at the University of Birmingham in 1953. In addition to lecturing in the physics and extra-mural departments, he formed a group to expose nuclear emulsions to beams at the university's newly constructed 1 GeV proton cyclotron. There followed a rich series of papers on proton interactions with matter and the nuclear disintegrations they provoke. While in Birmingham he wrote a book, *High Energy Nuclear Physics*, which was subsequently translated into Russian, French and Polish.

Having savoured the rich, international atmosphere of Powell's group in Bristol, Owen was attracted by CERN. He was awarded a research associateship in 1959, which led to a staff appointment in 1960, when he took over the joint leadership of the Nuclear Emulsion Group in the nuclear physics division. He was responsible for organizing the exposure of emulsions to beams from



W Owen Lock – a rare organizational talent.

the Proton Synchrotron (PS), in conjunction with groups from all over Europe and beyond. He became, in turn, PS physics co-ordinator, secretary of the Emulsion Experiments Committee and secretary of the Nuclear Physics Research Committee. He initiated and organized the first Easter School for emulsion physicists, held in St Cergue in 1962 and repeated in 1963. This became the CERN School of Physics, held each year in a different CERN member state. Owen was subsequently responsible for the school's becoming a joint venture with JINR, Dubna, which was then in the USSR. Starting in 1970, the school was hosted alternately in eastern and western Europe.

The breadth of his human contacts and his rare organizational talent led Owen to transfer to the personnel division in 1965 to become head of the Fellows and Visitors Service. Already in 1962 he had started organizing conferences and in 1966 he became head of the Scientific Conference Secretariat and secretary to a working group, chaired by the director-general Bernard Gregory, on the European Space Research Organization (a forerunner of ESA). In 1970 he was appointed head of Education Services and deputy to

the PE division leader until 1977, when he became personal assistant to John Adams, who was then executive director-general (at the time when Léon Van Hove was research director-general). He also became secretary of the board of directors and of the management board. He guaranteed continuity in this respect because he also fulfilled these roles under two subsequent directors-general, Herwig Schopper and Carlo Rubbia.

As early as 1965, Owen had accompanied Bernard Gregory to Moscow to negotiate an agreement with the State Committee for Atomic Energy on collaboration between the new Institute for High Energy Physics, in Protvino, and CERN. First contacts with China followed under Willibald Jentschke in 1971, which resulted in a visit by a Chinese delegation to CERN in 1973 and return visits in 1975 and 1977. These contacts led to co-operation agreements with China, signed by John Adams in 1979 and by Herwig Schopper in 1981 and 1985, during visits where Owen was the link-person. In 1976, the International Council of Scientific Unions founded what, in 1978, became the International Committee for Future Accelerators with John Adams as chairman and Owen as secretary. Under Carlo Rubbia, Owen became responsible for relations with central and eastern Europe, in addition to his ongoing contacts with China and India, which continued until his retirement in 1992. He was largely responsible for five countries acceding to full membership of CERN: Finland, Poland, Hungary, the Czech Republic and Slovakia.

Owen was highly educated and widely read, yet a modest person. Complementing his outstanding contributions to physics and scientific co-operation, he possessed deep convictions that led him to weld human contacts and friendships, encompassing people throughout the world. To his family and to those of us who experienced his generosity and had the privilege of being guided by him, an era has ended and we feel the loss. Our sympathy goes to his wife, Eleanor, and his four sons, Nicholas, Adrian, Evan and Eric. *His close friends.*

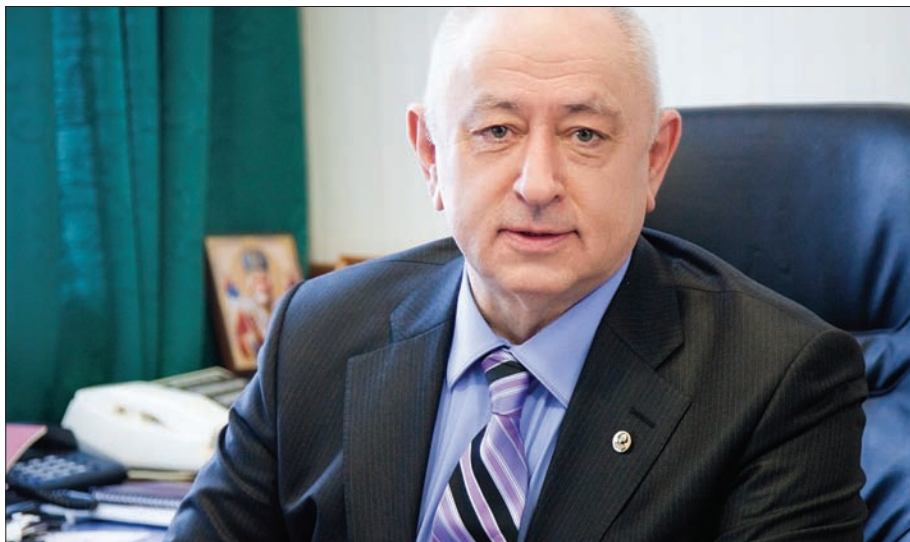
Alexei Norairovich Sissakian 1944–2010

Alexei Norairovich Sissakian, the director of JINR, a member of the Presidium of the Russian Academy of Sciences, a distinguished theoretical physicist and an organizer of scientific research based on broad international co-operation, passed away on 1 May aged 65. He had been elected for his second term as director of JINR in March.

Alexei Sissakian was born on 14 October 1944 in Moscow. In 1968 he graduated from the physics faculty of the M Lomonosov Moscow State University and started work at the JINR Laboratory of Theoretical Physics in Dubna under the guidance of Nikolay Nikolaevich Bogoliubov. Sissakian's main scientific work concerned elementary particle physics, approximation methods and equations of quantum field theory, the quantization problem of systems with nontrivial geometry, symmetry and topology, and the physics of strong interactions at high temperatures and densities.

In quantum field theory, Sissakian and colleagues offered a new description of processes with large momentum-transfers within the 3D approach to quantum field theory and developed a multicomponent approach in the theory of multiple particle production. Under his guidance seminal investigations in the field of mathematical physics were carried out on classical and quantum superintegrable systems in constant curvature space, as well as on the generation of topologically nontrivial objects. In recent years Sissakian and co-workers dealt with the further development of the method of contraction of Lie algebras applicable for theoretical physics problems.

Studies by Sissakian's research group were widely recognized in one of the most topical problems of particle physics – the development and application of nonperturbative methods in quantum field theory and the development of new approaches to very high multiplicity processes. Under Sissakian's leadership, novel and promising investigations took place to search for processes in the formation of a mixed quark-hadron phase of nuclear matter in heavy-ion collisions. He initiated and led JINR's largest project for the construction of a heavy-ion collider – the Nuclotron-based



Alexei Sissakian, who had just begun his second term as director of JINR. (Courtesy JINR.)

Ion Collider Facility (NICA) – to study phase transitions and critical phenomena in nuclear matter (*CERN Courier* January/February 2010 p13).

Under Sissakian's leadership a very fruitful collaboration developed between JINR and CERN in preparing many experiments at the Large Electron Positron collider and the LHC. As a member of the ATLAS collaboration, he did much to strengthen the collaboration between JINR and CERN team members.

Sissakian always combined his active research work with pedagogical and organizational activities in science. He supervised 15 theses, was head of the chairs at Moscow Institute of Physics and Technology and Moscow Engineering Physics Institute, was a professor at the M Lomonosov Moscow State University, the vice-president of the International University "Dubna" and had the chair in theoretical physics. In addition he led the scientific seminar "Symmetries and Integrable Systems" at JINR.

Sissakian was the editor-in-chief of *Physics of Particles and Nuclei Letters*, a deputy editor-in-chief of *Physics Particles and Nuclei* and a member of the editorial boards of several scientific publications. He was also a member of specialized scientific councils and programme committees of international conferences and symposia, and the organizer of major international conferences and

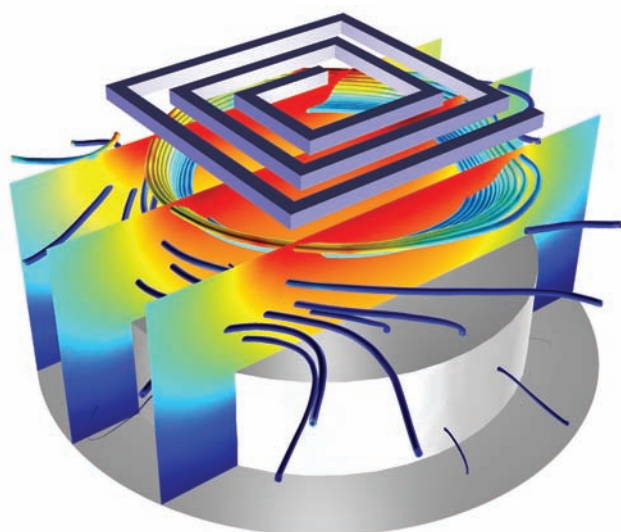
schools on particle physics.

As vice-director of 1989–2005 and director of JINR since 2006, Sissakian made invaluable contributions towards maintaining and enhancing the potential of the institute, determining its future scientific prospects, improving its research and production capacity, renovating the institute as an open international nuclear physics laboratory, promoting broad co-operation with national and international research and educational centres, and training qualified scientific personnel.

Sissakian was elected a corresponding member of the Russian Academy of Sciences in 2006 and a full member of the academy and a member of its presidium in 2008. As president of the Union of Russian Science Cities, he actively participated in the establishment of science cities. He was also first deputy chairman of the Russian Pugwash Committee under the Presidium of the Russian Academy of Sciences.

Since school age his favourite hobby was poetry. He was the author of several collections of fine poems.

Alexei Norairovich was always distinguished by his dedication to science, by a wonderful combination of great will power with kindness and sympathy to his relatives, friends, colleagues, indeed to all people. *JINR Directorate, his colleagues and friends.*



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Max-Planck-Institut für Physik

(Werner-Heisenberg-Institut)



2 ATLAS Postdoctoral Positions

The Max Planck Institute for Physics is engaged in fundamental research in particle and astroparticle physics from both experimental and theoretical perspectives. One main research activity is the participation in the ATLAS experiment at the Large Hadron Collider (LHC) at CERN. The institute has contributed to the design, construction and commissioning of the Semiconductor Tracker, the Hadronic Endcap Calorimeter, the Muon Spectrometer, and maintains a 50% share in the federated Munich Tier-2/3 computing centre for ATLAS.

We invite applications for 2 postdoctoral positions in experimental particle physics within our ATLAS Group. Successful candidates are expected to participate in the group's efforts to operate and maintain the ATLAS detector and, in particular, the hardware components contributed by our institute. One candidate is expected to play a significant role in the research and development efforts for the upgrade of the ATLAS hadronic endcap calorimeter. The second candidate is expected to take over responsibility for the smooth operation and further development of our ATLAS Tier-2/3 computing centre at Munich. Both candidates should also contribute to the ATLAS data analysis focusing – among other topics – on detector performance studies and on measurements of standard model processes with first data.

Salary and benefits are according to the German public service pay scale (TVöD Bund). The contracts are initially limited to three years with the possibility of extension within the frame of the German Wissenschaftszeitvertragsgesetz. The Max Planck Society is an equal opportunity employer.

For questions concerning the positions please contact Dr. Sven Menke (menke@mpp.mpg.de, for the calorimeter group) or PD Stefan Kluth, PhD (skluth@mpp.mpg.de). Interested applicants should send an application letter including curriculum vitae, list of publications and a statement of research interests and arrange for three letters of recommendation to arrive no later than June 14, 2010 at the following address:

Max Planck Institute for Physics
(Werner-Heisenberg-Institut)
Frau A. Schielke
Föhringer Ring 6, D-80805 München, Germany
E-mail: schielke@mpp.mpg.de



MAX-PLANCK-GESELLSCHAFT

Academic position in theoretical high-energy physics

A full-time tenured academic position is available at the Department of Physics and Astronomy of the University of Leuven, Belgium starting October 1, 2011 in the field of theoretical high-energy physics.

More information can be found on the web:

<http://www.kuleuven.be/personeel/jobsite/vacatures/science.html>

Closing date: September 30, 2010

The full-time position can be offered in one of the academic levels (full professor, professor, associate professor, assistant professor), depending on the qualifications of the candidate. The level of assistant professor will be offered for a period of five years. A positive evaluation at the end of the five-year appointment will result in a tenured appointment as associate professor.

The K.U.Leuven is an equal opportunity employer. Non-Dutch speaking candidates should be able to teach in Dutch within three years.



Department of Physics and Astronomy
K.U.Leuven, Belgium
http://fys.kuleuven.be/index_en.php

PAUL SCHERRER INSTITUT



The Paul Scherrer Institute is with 1300 employees the largest research centre for the natural and engineering sciences in Switzerland and a worldwide leading user laboratory. Its research activities are concentrated on the three main topics of solid-state physics, energy and environmental research as well as human health.

For use at the future X-ray free electron lasers (XFEL) - the most advanced radiation sources worldwide - the Detector Group of the Swiss Light Source (SLS) develops one- and two dimensional high speed solid state detectors. In collaboration with DESY (Hamburg), the Universities of Hamburg and Bonn, PSI is working on AGIPD, an adaptive gain integrating pixel detector system for applications at XFELs and synchrotrons.

In this respect, the SLS Detector Group is seeking a

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- Perform experiments at XFELs and synchrotrons

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For further information please contact: Dr Bernd Schmitt, phone +41 56 310 23 14, bernd.schmitt@psi.ch
Please submit your application including 2 references to: Paul Scherrer Institut, Human Resources, Ref. code 6114-01, Elke Baumann, 5232 Villigen PSI, Switzerland or to: elke.baumann@psi.ch
www.psi.ch

Post-doctoral Research Position in Experimental Particle Physics – CMS experiment

The experimental high energy physics group of the Université catholique de Louvain (UCLouvain) in Louvain-la-Neuve (Belgium) invites applications for one position at the post-doctoral level to join its efforts in data analysis and running of the CMS experiment at the Large Hadron Collider (LHC).

UCLouvain has contributed significantly to the design and construction of the CMS silicon strip tracker and has been deeply involved in its commissioning, start-up in 2009 and exploitation of first data since then. The UCLouvain group is currently active in software development and CMS data analysis within the exotica, forward and top quark physics groups. UCLouvain hosts one of the Tier-2 LHC GRID computing centers that allow CMS data to be processed and analyzed. The activity of the group develops within the Center for Particle Physics and Phenomenology (CP3) of UCLouvain (<http://cp3.phys.ucl.ac.be/>) in close collaboration with theoreticians and phenomenologists. A strong Monte Carlo generator (MadGraph/MadEvent) team has resulted from this collaboration. The group is also involved in the NA62 experiment as well as in research and development programs related to possible extensions of the CMS experiment and to the Super-LHC.

The position is dedicated to the analysis of the first CMS physics data at high energy, in synergy with the other members of the CP3 CMS group. The selected candidate is expected to be based at CERN to also contribute to the CMS tracker detector performance activities. **Additional information concerning this position can be obtained from Prof. Christophe Delaere**

(christophe.delaere@uclouvain.be; tel: +41 76 487 5667).

Applicants must have (or expect to receive soon) a Ph.D. in particle physics. The appointment will start in fall 2010 and is initially intended for one year at CERN, with the possibility of future extensions in Belgium depending on the funding opportunities. The position is funded by the UCL-FSR program and is open to candidates of any nationality. Applications, including curriculum vitae, a list of publications and at least three letters of recommendation, should be submitted before September 1st 2010 at the following address: <http://cp3.phys.ucl.ac.be/Jobs/Details/CP3-10-CMS-Postdoc>

That position will remain open until a suitable candidate is found.



The Cockcroft Institute
of Accelerator Science and Technology

Chair and Lectureship in Particle Accelerator Engineering



The Department of Engineering at Lancaster University is one of the founding members of the Cockcroft Institute, specifically responsible for engineering aspects of this important, internationally-leading activity in the UK. As part of this and due to recent investment, applications are invited from Engineers and Physical Scientists at the top of their profession seeking an academic career specialising in *Particle Accelerator Engineering*. These represent exciting and challenging opportunities for someone wishing to excel and lead a significant contribution to world-wide development of tomorrow's particle accelerator systems.

Particle accelerators serve a wide variety of purposes spanning their use as tools for scientific research at many of

the most prestigious national and international institutes and laboratories, through to applications in energy, environment, security, health and medicine. This Chair appointment will act as a focus for research, teaching, scholarship, public engagement and debate on issues of particle accelerator science and engineering, and the pursuance of novel applications of these systems. The Lectureship appointment will provide a prestigious start to an academic career with a demonstrable international research dimension.

The successful candidates will already have an extensive track record in internationally-leading research in, for example: r.f. engineering, power engineering, waveguide modelling & design, materials science and beam

diagnostics. They will have a high-impact publication record commensurate with such experience. They will also demonstrate proven ability to lecture at postgraduate and undergraduate level at the highest levels of quality. An understanding of current global priorities for particle accelerator science and related applications will be important, together with the ability to contribute to and develop existing taught provision in related areas of curricula with an international dimension.

Active involvement and collaboration with the existing specialist research areas within the Engineering Department, along with relevant activities in the Department of Physics at Lancaster and particularly with the partners in the Cockcroft Institute will be encouraged.

Informal enquiries should be directed to Professor Malcolm Joyce (m.joyce@lancaster.ac.uk)
For further information about the Cockcroft Institute, visit <http://www.cockcroft.ac.uk>
or contact Prof. Swapan Chattopadhyay (swapan@cockcroft.ac.uk)

The closing date for applications is: 30th June 2010



Senior Accelerator Physics Faculty Position

The SLAC National Accelerator Laboratory is seeking an accelerator scientist with a combination of outstanding scientific vision, accomplishment and leadership to direct programs in advanced accelerator research. The successful candidate will assume a tenured position at the associate or full professor level as a Stanford Faculty member with a joint appointment in the Particle Physics & Astrophysics Department and the Photon Science Department. He/she is expected to conduct a vigorous research program, to participate in the University's education mission and, in collaboration with other faculty members and scientific staff, to articulate the vision for advanced accelerator research at SLAC. In doing so, he/she will bring together accelerator physicists, graduate students and post docs focused on advancing the state of the art in accelerator science aimed at probing the fundamental underpinnings of acceleration methods and particle beam physics using the unique experimental facilities at SLAC and other facilities worldwide. The current research emphasis includes innovative particle acceleration methods and techniques utilizing ultra-high-power microwaves, lasers, and plasmas. It also includes research on RF technologies, plasma physics, formal control theory for accelerator systems, and ultrafast feedback and control technology. These research programs are aimed primarily towards future applications and facilities for high energy physics and photon science. Applicants should submit a summary of their educational and professional background, a current list of published work, and the names of at least three references who may be consulted by the Search Committee. A brief summary of how the candidate's experience matches the position described above should also be submitted with the application. Applicants are also encouraged to submit a brief description of their plans and ambitions for the future and how those plans might be realized at SLAC. Applications should be submitted by **July 31** to:

Accelerator Physics Search Committee
SLAC National Accelerator Laboratory
2575 Sand Hill Road, MS 75
Menlo Park, CA 94025, USA
e-mail address: jonathan@SLAC.Stanford.edu

Stanford University is an equal opportunity employer and is committed to increasing the diversity of its faculty. It welcomes nominations of and applications from women and members of minority groups, as well as others who would bring additional dimensions to the university's research and teaching missions.



Superconducting RF Scientist

The Accelerator Systems Division at Argonne National Laboratory is seeking a candidate with a strong background in superconducting radio-frequency (SRF) systems to fill a full-time position at the Advanced Photon Source (APS). The successful candidate will be responsible for a design, implementation, and operation of a superconducting rf deflecting system to be used for the generation of picosecond x-ray pulses at the APS at Argonne. The successful candidate may also work on future R&D programs including SRF CW accelerator for an x-ray free electron laser oscillator (XFEL-O).

Requirements

- Ph.D. degree in Physics or Electrical Engineering and 10 years of experience with rf systems.
- Experience in designing, testing, and troubleshooting SRF cavities, cryomodules, and associated auxiliary systems.
- Some experience with electromagnetic, thermal, and structural numerical modeling.
- Good understanding of electron beam/cavity interaction.
- Good verbal and written communication skills.

Candidates should submit a resume through the Argonne job website at <http://www.anl.gov/jobs> for Requisition 315849.

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As CERN's Large Hadron Collider opens up a new high energy frontier, the Organization is pursuing advanced research and development for an electron-positron linear collider to exploit the anticipated discoveries and further the understanding of the underlying physics.

In order to lead, coordinate, and liaise the studies of both accelerator and detectors, the linear collider community at CERN is looking for a

Linear Collider Studies Leader

Your main responsibility will be to lead the linear collider work at CERN in a new project phase. You will also have a strategic international role to participate in shaping the linear collider and detector landscape beyond the host Organization. Reporting directly to the CERN Directorate and the CLIC/CTF3 collaboration board, you will engage with other laboratories to strengthen the current collaboration. Within this framework you will drive the R&D and prototyping work with a view to the production of a Technical Design Report.

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Please apply to job ID# 15268.



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BOOKSHELF

The Standard Model and Beyond by Paul Langacker, CRC Press. Hardback ISBN 9781420079067, £49.99 (\$79.95).

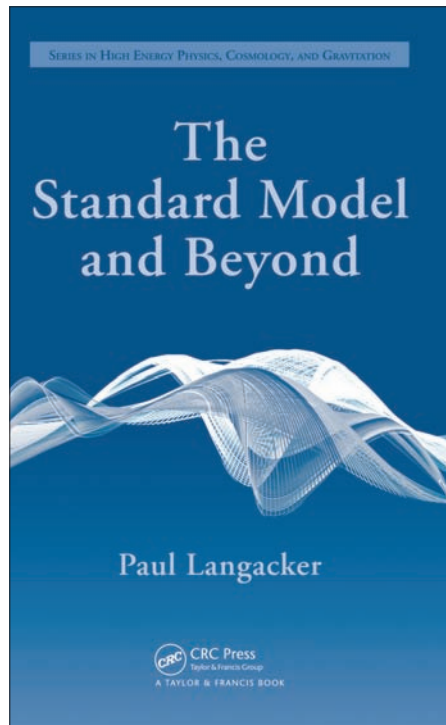
The Standard Model of elementary particles and their interactions via the electromagnetic, weak and strong interactions is a fabulously successful theory. Tests of quantum electrodynamics have been made to a precision at the level of better than one part in one billion; electroweak tests approach the one part in one hundred thousand level; and even tests of quantum chromodynamics, which are intrinsically more challenging, are being made at the per cent level.

Yet, despite this, we are still sure that the Standard Model cannot be the “ultimate” theory. We have yet to account theoretically for the exciting observations of the recent decades, namely, massive neutrinos, dark matter and dark energy, which provide direct evidence for new physics processes. We cannot account for the observed patterns of the masses of the fermion building blocks of matter, their manifestation in three generations or “families”, the “mixing” between the generations, or why the universe seems to contain almost no antimatter. And we don’t yet understand how to incorporate gravity in terms of a quantum-field theory.

Theoreticians have not been idle in developing models of the new physics that could underlie the Standard Model and that ought to manifest itself at the tera-electron-volt energy scale, such as alternative spontaneous electroweak symmetry-breaking mechanisms, supersymmetry and string theories, for example. However, within the framework of the Standard Model itself, we have yet to observe the Higgs boson, the presence of which is required to account for the generation of the masses of the W and Z particles.

This substantial book – at more than 600 pages – gives a detailed and lucid summary of the theoretical foundations of the Standard Model, and possible extensions beyond it.

Chapter 1 sets up the required notations and conventions needed for the ensuing theoretical survey. Chapter 2 reviews the basics of perturbative field theory and leads, via an introduction to discrete symmetry principles, to quantum electrodynamics. Group theory, global symmetries and symmetry breaking are reviewed in Chapter 3, which forms the foundation for



the presentation of local symmetries and gauge theories in Chapter 4, where the Higgs mechanism is first introduced.

The heart of the book lies in Chapters 5 (strong interactions), 6 (weak interactions) and 7 (the electroweak theory), which at more than 170 pages is the most substantial. These chapters present a clear theoretical discussion of key physical processes, along with the phenomenology required for a comparison with data, and a brief summary of the relevant experimental results. Precision tests of the Standard Model are summarized, and the framework is introduced for parametrizing the head-room for new physics effects that go beyond it.

The final chapter summarises the known deficiencies of the Standard Model and introduces the well developed extensions: supersymmetry, extended gauge groups and grand unified theories. Fortunately, now that the LHC is up and running, we should expect to start to address experimentally at least some of these theoretical speculations. LHC results will provide the sieve for filtering the profound and accurate, versus the merely beautiful and mathematically seductive, models of nature.

The book ranges over huge swathes of theoretical territory and is self-consciously broad, rather than deep, in terms of coverage.

I heartily recommend it to particle physicists as a great single-volume reference, especially useful to experimentalists. It also provides a firm, graduate-level foundation for theoretical physicists who plan to pursue concepts beyond the Standard Model to a greater depth.
Philip Burrows, John Adams Institute, Oxford University.

At the Leading Edge: The ATLAS and CMS LHC Experiments by Dan Green (ed.), World Scientific. Hardback ISBN 9789814277617, £79 (\$120). Paperback ISBN 9789814304672, £38 (\$58).

At the Leading Edge is the latest book edited by Dan Green, who is already well known as the editor of earlier books, such as *High p_T Physics at Hadron Colliders* (CERN Courier November 2005 p56). His new book is addressed to physicists and graduates in particle physics and it appears just in time for the first physics runs at LHC. With it he adds a new angle to the descriptions and information that are already available about the detectors and physics of the LHC. Green, from Fermilab, is currently chair of the CMS collaboration board.

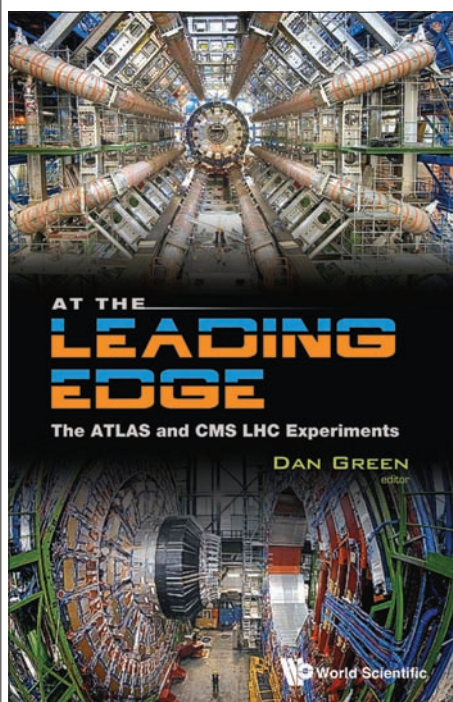
In contrast to conference proceedings, where one might find detailed reports about the LHC-detector hardware and read-out chains, this book follows a new concept, which makes it unique and interesting to read. In Green’s own words the book aims at explaining why the LHC detectors are – almost necessarily – conceived the way that they are, given the experimental environment of the LHC and the physics questions to be answered. It is also instructive to have two detectors, ATLAS and CMS, treated side by side in the same book because this emphasizes the complementary approach of the different technological choices for the various subdetectors.

Following the concept and logic of the book, the introduction, which was written by Green himself, describes “how physics defines the LHC environment and detectors”. He has also written two chapters, which cover global detector properties and generic detector subsystems. The actual technological choices made by the collaborations to address the physics at the LHC are outlined by subsequent well written and illustrated contributions from 22 prominent scientists, engineers, experts and leaders responsible for the detector subsystems of ATLAS and CMS. The book

contributes in an impressive way towards understanding the motivation behind specific choices, and towards learning about the risks and the courage required to tackle necessary technological developments. Several authors evaluate the challenges and the mistakes made during 15 years of R&D and construction at the end of their contributions in a paragraph on “Conclusions and lessons learnt”.

Despite the historical background of the formation of LHC collaborations, the influence of committees and panels and of the leading physicists – or, as one of the authors puts it, “the cultural bias of the physicists involved” – on some of the technological choices and, last but not least, the constraints of cost and competences, the contributors nevertheless convince the reader that the technological choices at the leading edge all followed the same concept. This was to build a detector that is best matched to the experimental environment at the LHC and that allows all of the data to be extracted from collisions at the tera-electron-volt scale, so as to reach the physics goals of the collaborations.

In summary, and repeating what I wrote in reviewing *The Large Hadron Collider: a Marvel of Technology*, edited by Lyn Evans (*CERN Courier* October 2009 p39), both that book and this one edited by Dan Green should be on the shelf of all friends of the LHC. Each



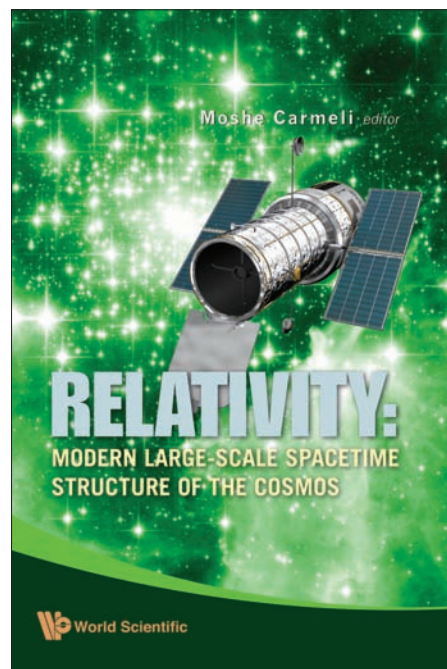
book represents a nicely balanced record of the historical developments, technical challenges and scientific background, and both are packed with photos of the LHC machine and its two major general-purpose detectors, ATLAS and CMS, taken during construction and assembly.
Horst Wenninger, CERN.

Relativity. Modern Large-Scale Space-time Structure of the Cosmos by Moshe Carmeli (ed.), World Scientific. Hardback ISBN 9789812813756 £61 (\$110).

Before speaking about the content of this book edited by Moshe Carmeli, I would like to say some words about its form. Many chapters are at the level of some advanced draft, the reason being that Carmeli passed away before the final version was ready for the press. Much of the material is repeated several times almost with the same wording, which is really both annoying and unfortunate, because the book is worth reading from the beginning to the end. I hope many people will be patient enough to do so.

The text covers in detail an extended version of Einstein’s relativity theory, developed by Moshe Carmeli and refined by the authors of the different chapters, in which space–time is extended by adding a fifth dimension, connected with the evolution of the cosmos. Because the theoretical construction of such a theory proceeds by analogy with Einstein’s special and general relativity, the book happens also to be an excellent text on these latter theories. Though this may sound paradoxical, it actually makes sense: the authors need to reproduce the successful predictions of Einstein’s theories, while at the same time they want to emphasize the differences. From this point of view, chapters 8–10 and 13–14 have most importance because they highlight what can be done on the experimental side to distinguish between cosmologies based on Einstein’s or Carmeli’s theories.

Though I found a few points that are not very convincing – although I admit that I might have misinterpreted some explanation, which would have become clearer in a more refined version of the text – I would still like to recommend the book, at least for the following reasons (in order of my personal taste). First, Carmeli’s theory adds as a fifth dimension the velocity of the cosmic expansion, postulating that the Big Bang



time is a universal constant for all observers (in particular, at any time). Second, the cosmology based on Carmeli’s theory automatically produces a flat 3D space with Euclidean metric (which is indeed what we observe) though the global 5D space may have different curvatures. Third, galaxy rotation curves are reproduced assuming that Newton’s gravitation holds whenever the effect of cosmic expansion can be neglected (i.e. at the core of the galaxy) while a correction takes over when the latter cannot be neglected (far enough from the core), inducing a slower decrease of the gravitational attraction with increasing distance. In particular, this means that no dark matter needs to be assumed to explain the Tully-Fisher law on the rotation velocity of the stars inside a galaxy. Fourth, no dark matter (or cosmological constant) is needed at cosmic distances because the redshift of the supernovae of Type Ia can be made to fit very well in the context of Carmeli’s cosmology if the fraction of the total energy density from matter is 0.04, which is compatible with the constraints set on the baryonic matter. Finally, the propagation of gravitational waves is different from Einstein’s general relativity: when the cosmic expansion cannot be neglected, the intensity of the waves is dumped. This means that the detection of gravitational waves emitted by galactic sources (e.g.

rotating binary pulsars) should be possible whereas extragalactic sources should be hardly visible.

Diego Casadei, New York University and CERN.

Introduction to Relativistic Heavy Ion

Physics by J Bartke, World Scientific. Hardback ISBN 9789810212315, £36 (\$65).

This book sets out to cover several facets of what is commonly known as “heavy-ion physics”, mainly from an experimentalist’s point of view. It is based on lectures given by the author in Krakow, over many years. The text is written in an informal and qualitative style, complemented by figures that, as the preface indicates, aim to capture “the main features of experimental data”. This is often by means of preliminary versions of the results, as presented in conference proceedings rather than by citations from the final publications.

The book starts with a few introductory chapters that remind the reader, among other things, of some basic properties of atomic nuclei. For instance, we are told that, contrary to what happens in heavy nuclei, the spatial distribution of neutrons in light nuclei is narrower than that of protons, because of the repelling Coulomb forces between the latter. The absence of a reference for further reading is presumably intentional, given

the introductory character of the text, which targets a young audience. These first chapters are of a generic nature, as they present typical experimental apparatus and basic concepts about cross-sections, charged-particle multiplicities and spectra.

The later chapters are devoted to a few more specific physics topics. Naturally, considerable emphasis is given to the studies made by the experiments with which the author has worked: NA35 and NA49 at CERN’s Super Proton Synchrotron. Many pages focus, in particular, on the topics of strangeness enhancement, pion interferometry and collective flow, where these two experiments made seminal contributions. The final chapter looks forward to heavy-ion collisions at the LHC and presents some predictions for what may be expected in the new energy regime. *Carlos Lourenço, CERN.*

Books received

Introduction to Nanoscience by S M Lindsay, Oxford University Press. Hardback ISBN 9780199544202, £69.95 (\$99). Paperback ISBN 9780199544219, £35 (\$59.95).

Nanoscience is not physics, chemistry, engineering or biology. This text, aimed at advanced undergraduates and beginning graduate students, sets out to integrate the disciplines. The book is divided into three parts. Part I (The Basics) is a self-contained introduction to quantum mechanics, statistical mechanics and chemical kinetics, and calls for no more than basic calculus. The conceptual approach and an array of examples and problems will allow even those without the mathematical tools to grasp much of what is important. Part II (The Tools) covers microscopy, single-molecule manipulation and measurement, nanofabrication and self-assembly. Part III (Applications) covers electrons in nanostructures, molecular electronics, nano-materials and nanobiology.

Relativity, Gravitation and Cosmology: A Basic Introduction, 2nd edition, by Ta-Pei Cheng, Oxford University Press. Hardback ISBN 9780198529569, £64 (\$99). Paperback ISBN 9780198529576, £27 (\$49.95).

Einstein’s general theory of relativity is introduced in this textbook aimed at advanced undergraduates and beginning graduate students. The author presents the subject initially with an emphasis on

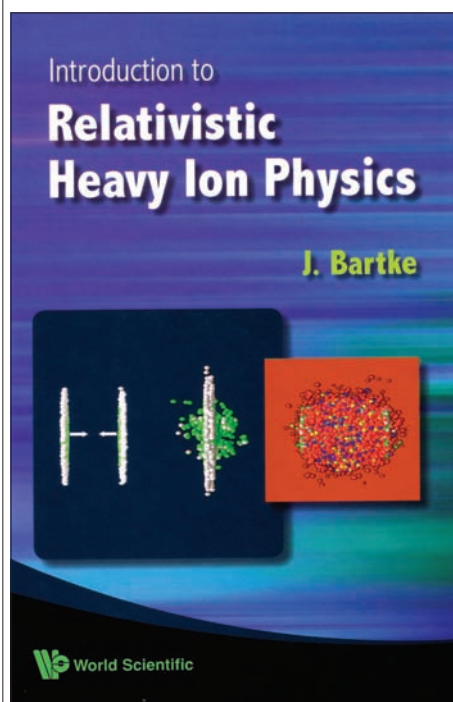
physical examples and simple applications, saving the full tensor approach for later. The reader learns first how to describe curved space–time, and at this mathematically more accessible level can already study interesting phenomena such as gravitational lensing, precession of Mercury’s perihelion, and black holes, as well as cosmology. The full tensor formulation is presented later, when the Einstein equation is solved for a few symmetric cases. Many modern topics in cosmology are also discussed, from inflation and cosmic microwave anisotropy to the “dark energy” that propels an accelerating universe.

Computing with Cells: Advances in Membrane Computing by Pierluigi Frisco, Oxford University Press. Hardback ISBN 9780199542864, £50 (\$99).

Membrane systems are a new class of distributed and parallel models of computation inspired by the subdivision of living cells into compartments delimited by membranes. Membrane computing – the study of membrane systems – is a fast-growing area of research. The main streams of current investigations concern theoretical computer science and the modelling of complex systems. In this monograph the author considers the former trend and presents an in-depth study of the formal language and computational complexity of the most widely investigated models of membrane systems. The text provides a comprehensive understanding of the computational power of the models considered, which cover a range of features.

The Origin of Discrete Particles by T Bastin and C W Kilmister, World Scientific. Hardback ISBN 9789814261678, £51 (\$68). Online version ISBN 9789814261685, \$88.

Volume 42 in the Series on Knots and Everything, this book is a summary of the results of a long research project undertaken by the authors on discreteness in modern physics. In contrast to the usual expectation that discreteness is the result of mathematical tools for insertion into a continuous theory, this more basic treatment builds up the world from the discrimination of discrete entities. This gives an algebraic structure in which certain fixed numbers arise. As such, one agrees with the measured value of the fine-structure constant to one part in 107.



Collide: a cultural revolution

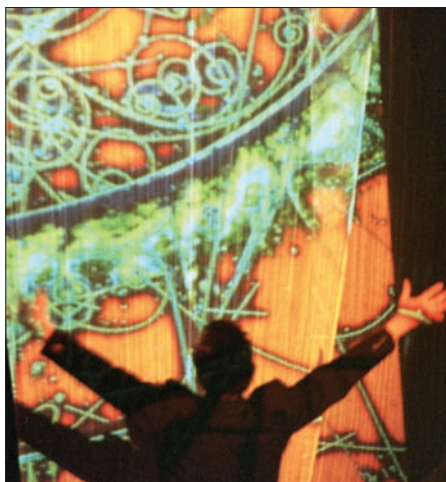
Ariane Koek makes the case for an arts residency programme soon to be established at CERN.

Would you employ me to run the LHC? Or perhaps to run an experiment at CERN with antimatter? After all, I have an abiding interest in physics – ever since an inspiring science teacher sparked my imagination with the Van de Graff generator and the laws of gravity. I have no expertise and little experience in physics – just a school girl’s love of equations combined with joyful enthusiasm and a wish to understand and engage with what it is that makes the world work.

Now turn this question round: would you ask a physicist to devise an arts programme or CERN’s first cultural policy for engaging with the arts? What would your answer be? All right, I admit it. This is deliberate provocation. So let me explain.

Much has been written about the two cultures – art and science. It is a false distinction, which was imposed in the Age of Enlightenment and which in the 21st century we are finally beginning to shake off. Leonardo da Vinci made no such distinction between art and science. Aristotle most definitely did not. As the physicist-turned-poet Mario Petrucci says: “I have found that the rigour and precision of the scientist is not foreign to the poet, just as the faith-leaps of poetry are not excluded from the drawing boards of science.” The arts and science are kissing cousins. Their practitioners love knowledge and discovering how and why we exist in the world. They just express it in different ways.

Where there is a distinction between art and science – which has contributed to the this misunderstanding of how intimately related they really are – is in the ways in which people’s work is judged and evaluated. Cultural knowledge and expertise in the arts can seem totally mystifying. Why is one artist judged as great, and another not? There are no equations to evaluate and therefore no



A scene from The Oracle at Delphi, an interaction between CERN and the arts in a production by the Miméscope company a decade ago.

absolutes. The arts seems to be a muddy water of individual will, taste and whimsical patronage. But this is a simplistic distortion of a more complex and nuanced picture.

Arts specialism is all about knowledge and understanding. It is about knowing inside-out the history of art forms – whether dance, music, literature, the visual arts or film – and possessing the expertise to evaluate contemporary work; to spot the innovative and the boundary-bursting, as well as the great and exceptional. History lies at its heart – arts knowledge exists on a space-time continuum of reflection and understanding of the creative processes. Moreover, at the heart of this is what every scientist understands: peer review. Experts who are used to working with artists, who know what they are realistically capable of, as well as understanding the past and therefore the present and the future, choose and select projects and individuals for everything from exhibitions and showings, to competitions and grants, for example.

Which takes us to a new bold and brave experiment at CERN and my presence there. Don’t worry. I am not tinkering with the LHC. The collisions and interactions that I will be working with are all of the cultural kind. My expertise, knowledge and experience is in

the field of arts and culture – 25 years of working in that arena, working with science too. The director-general, Rolf Heuer, has the vision and the wish to express the crucial inter-relationship of arts and science that makes culture. To do this, I am raising the partnerships and funds for “Collide” – an international arts residency programme at CERN – in which artists will come every year from different art forms to engage with scientists in a mutual exchange of knowledge and understanding through workshops, lectures and informal talks, and to begin to make new work. Who knows what the artists will create? Or the scientists for that matter? A spark chamber of poetry? A dance that defies gravity? Light sculptures that tunnel into the sky? Who knows? That depends on the serendipity of who applies and how they interact with whom and what is at CERN.

Crucially, the artists in residence will be selected by a panel of leading scientists working alongside leading arts specialists – directors, producers, curators, artists – so that mutual understanding and appreciation of how cultural knowledge works, and how expert judgements are made, can develop and be exchanged. This is one of the key strategies of a new cultural policy for engaging with the arts that I have devised for CERN. After all, great science deserves great art. Nothing less will do for the place that pushes knowledge to beyond known limits.

Nevertheless, at the heart of the arts at CERN is the critical connection between the lateral and logical minds that artists and scientists both have. “Collide” will be a way of showing this, of encouraging scientists and artists to work together in a structured programme of interplay and exchange. It will also be a way of creating an all-encompassing vision of CERN to the outside world and on different platforms – from stage and screen to canvas and the orchestra – showing CERN’s status as a major force in culture, as befits the home of the LHC and what some consider is possibly the biggest, most significant experiment on Earth.

Ariane Koek, CERN. Follow her blog at <http://www.beautyquark-beautyquark.blogspot.com>.



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V6521 P/N/M	6 kV (0.2 V)	300 μ A	5 nA (0.5 nA zoom)	500 V/s	5 mVpp (10 mVpp)
 V6524 P/N/M	2 kV (0.2 V)	4 mA	50 nA (5 nA zoom) ⁽³⁾	500 V/s	10 mVpp (20 mVpp)
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INPC2010 - 24th International Nuclear Physics Conference

July 4 - 9, 2010

NIC XI - 11th Symposium on Nuclei in the Cosmos

July 19 - 23, 2010