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50 years 1959–2009

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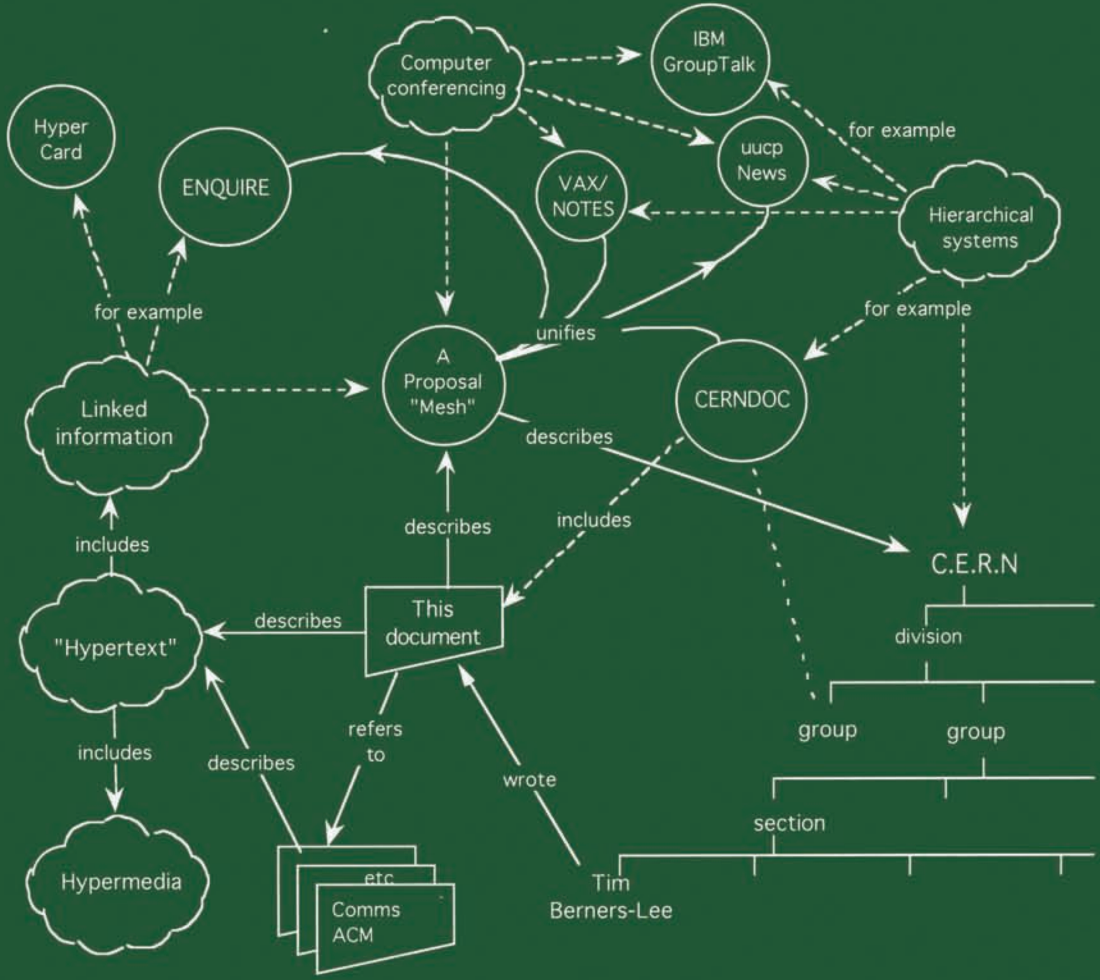

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Covering current developments in high-energy physics and related fields worldwide

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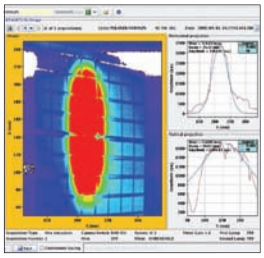

Seeing beam once again p6

Dirac was right about antimatter p15

A new side to Peter Higgs p36

Cover: In March 1989 Tim Berners-Lee, a physicist at CERN, handed a document to his supervisor Mike Sendall, titled "Information Management: a Proposal". "Vague, but exciting", were the words that Sendall wrote on the proposal, allowing Berners-Lee to continue with the project. This low-key beginning to the phenomenon that became the World Wide Web was celebrated at CERN in March (p24).

WIENER Magnet Power Supply Systems

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ACCELERATORS

FFAGs enter the applications era

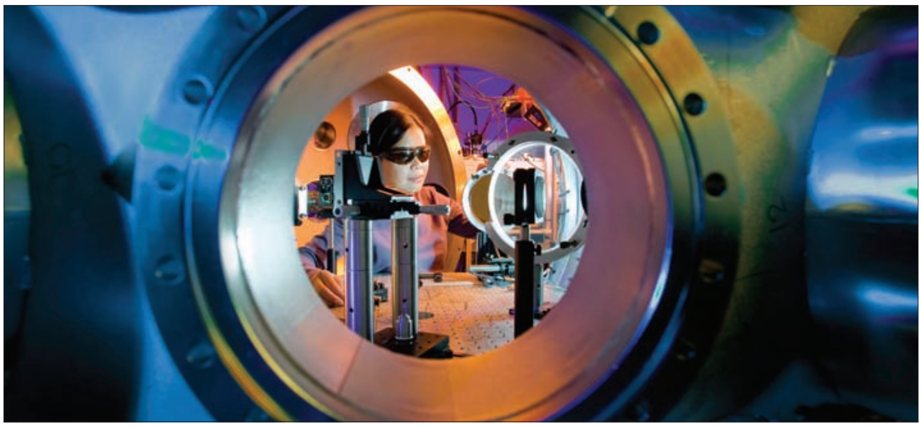
After a series of preliminary tests held on 26–27 February the Research Reactor Institute of Kyoto University (KURRI) received a national licence to conduct experiments for an accelerator-driven subcritical reactor (ADSR) using the Kyoto University Critical Assembly (KUCA). The first ADSR experiment began on 4 March using a newly developed fixed-field alternating-gradient (FFAG) proton accelerator connected to the KUCA. This marks the first use of an FFAG accelerator built for a specific application rather than as a prototype, and it heralds the start of a new era (*CERN Courier* September 2008 p21).

The Development of an Accelerator Driven Subcritical Reactor using an FFAG Proton Accelerator project, which is now reaching its goal, was initiated in 2002 under a contract with the Ministry of Education, Culture, Sports, Science and Technology (MEXT) as part of the Technology Development Project for Innovative Nuclear Energy Systems. In the experiment the FFAG accelerator provides a high-energy proton beam to a heavy-metal target in the KUCA to produce spallation neutrons, which in turn drive fission chain reactions in the KUCA-A Core.

The proton FFAG accelerator. (Courtesy KURRI.)

The aim is to examine the feasibility of an ADSR and to lay the foundations for its development. The fact that the reactor is driven slightly below criticality makes this system intrinsically safe: as soon as the external neutron supply is stopped, fission chain reactions cease. ADSRs may also be useful for the transmutation of long-lived transuranic elements into shorter-lived or stable elements. They therefore have the potential to be used as energy amplifiers, neutron sources and transmutation systems.

Laser-pulse blasts set antiparticle production record



Hui Chen sets up targets for the antimatter experiment at the Jupiter laser facility. (Courtesy LLNL.)

The latest record for antiparticle density created in the laboratory has not come from an accelerator facility but from the Lawrence Livermore National Laboratory's Jupiter laser facility. Hui Chen and colleagues blasted picosecond laser pulses carrying 10^{20} Wcm^{-2} from the Titan laser onto gold targets some 1 mm thick. Part of each laser pulse created a plasma and part drove the plasma's electrons into the gold. The gold nuclei then slowed down the electrons, producing photons that converted into electron–positron pairs. The result was an estimated 10^{16} positrons/cubic centimetre.

In addition to being intrinsically interesting this work could aid better understanding of astrophysical phenomena such as gamma-ray bursts. It could also lead to new ways to produce positron sources, which at present are limited to positron-emitting radioisotopes and pair-creation from high-energy photons at accelerators.

Further reading

Hui Chen *et al.* 2009 *Phys. Rev. Lett.* **102** 105001.

Sommaire

LHC NEWS

First sector is closer to cool down…

Installation of the new helium pressure-release system for the LHC is progressing well. The first sector to be fully completed is 5-6, with all 168 individual pressure-release ports now in place. These ports will allow a greater rate of helium escape in the event of a sudden increase in temperature (*CERN Courier* April 2009 p6).

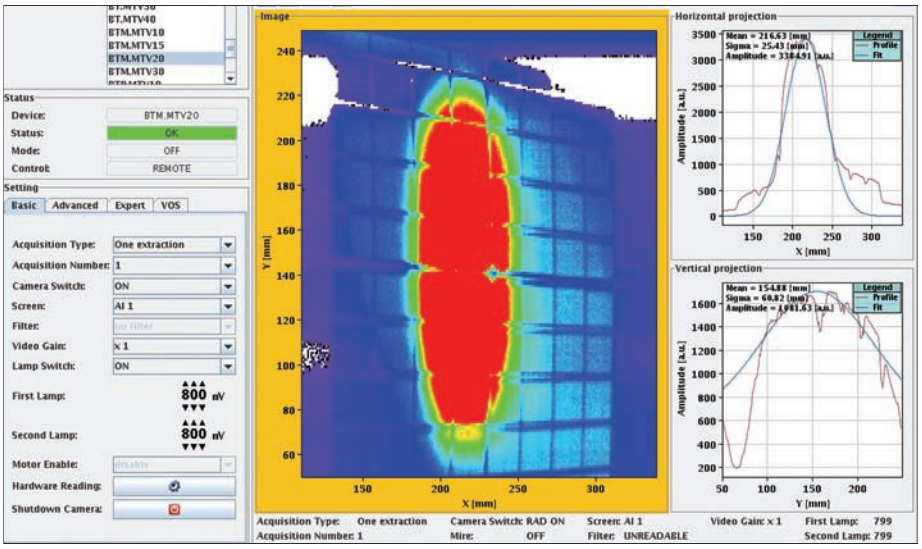
To install the pressure-release ports teams had to cut and open the "bellows" – the large accordion-shaped sleeves that cover the interconnections between two magnets. Once all of the ports were fitted, work on closing the bellows could begin. This marked the end of the consolidation work on this sector and the start of preparations to cool it down. By the end of March the first three vacuum subsectors had been sealed. Each subsector is a 200 m long section of the insulating vacuum chamber that surrounds the magnet cold mass. Once sealed, each subsector is tested for leaks before the air is pumped out.

Meanwhile, teams are working through the night and on weekends to install the replacement magnets in the damaged area of sector 3-4 at a rate of six to seven per week. At the same time, the pace of interconnection work has increased sharply over the past few weeks. For example, within a fortnight, the number of joints being soldered rose from two to eight a week. Elsewhere, a magnet in sector 1-2 that was found to have high internal resistance has now been replaced.

● For up-to-date news, see *The Bulletin* at http:/cdsweb.cern.ch/journal/.

…while the injection chain sees beam again

On 18 March beam commissioning started in Linac 2, the first link in CERN's accelerator complex. This marks the start of what will be the longest period of beam operations in the laboratory's history, with the accelerators remaining operational throughout winter 2009/2010 to supply the LHC. This will limit the opportunities for maintenance, so teams are anticipating what they would normally have done in the winter shutdown and doing as much as possible during the consolidation work on the LHC.



Protons are again circulating in the PS Booster after the winter shut-down, as CERN gears up for re-start.

The injection chain for the LHC also contains more venerable accelerators, which have had considerable refurbishment work done on them over recent years. At 50 years old this year, the PS was starting to show signs of its age back in 2003, when the long period of radiation exposure on electrical insulation caused a fault in two magnets and a busbar connection. Since then there has been a huge campaign to refurbish more than half of the PS magnets, with the 51st and final refurbished magnet being installed in the tunnel on 3 February this year. In addition, the power supplies for the auxiliary magnets have been completely replaced and this year new cables have been laid.

The Magnet Group has also thermally tested almost every part of the machine – the first thorough survey of its kind in the history of the PS. After leaving the magnets to run for several hours the team used a thermal camera to check for poor connections, which would lead to slight heating.

The SPS has also undergone considerable refurbishment on top of the normal shutdown activities over the past few years. The final 90 dipole magnets have been repaired this year, ending the three-year project to refurbish the cooling pipes in 250 of the dipole magnets. Also, most of the cabling to the short straight sections has been replaced.

LHC EXPERIMENTS

ALICE prepares for jet measurements

The ALICE experiment has reached another milestone with the successful installation of the first two supermodules of the electromagnetic calorimeter (EMCal).

ALICE is designed to study matter produced in high-energy nuclear collisions at the LHC, in particular using lead ions. The goal is to investigate thoroughly the characteristics of hot, dense matter as it is thought to have existed in the early universe. Experiments at RHIC at Brookhaven have shown that an important way to probe the matter formed in heavy-ion collisions is to study its effect on high-energy partons (quarks and gluons) produced early in the collision. As the partons propagate through the resulting "fireball" their energy loss depends on the density and interaction strength of the matter they encounter. The high-energy partons become observable as jets of hadrons when they hadronize and the energy loss becomes evident through the decreased energy of the products that emerge from the fragmentation process.

Installation of the EMCal supermodules requires a special insertion device with rails.

Although the ALICE experiment has excellent momentum-measurement and identification capabilities for charged hadrons, it previously lacked a large-acceptance electromagnetic calorimeter to measure the neutral energy component of jets. The EMCal, a lead-scintillator sampling calorimeter with "Shashlik"-style optical-fibre read-out, will provide ALICE with this capability. It consists of identical modules each comprising four independent read-out towers of 6 cm × 6 cm. Twelve modules attached to a back-plate form one strip-module, and 24 strip-modules inserted into a crate comprise one EMCal supermodule with a weight of about 8 t.

The EMCal is a late addition to ALICE, arriving in effect as a first upgrade. Indeed, the full approval (with construction) funds didn't occur until early 2008. The calorimeter covers about one-third of the acceptance of the central part of ALICE, where it must fit within the existing structure by means of a novel independent support structure – between the magnet coil and the layer of time-of-flight counters. Installation of the 8 t supermodules requires a system of rails with a sophisticated insertion device to bridge across to the support structure. The full EMCal will consist of 10 full supermodules and two partial supermodules.

EDITOR'S NOTE

50 years
1959–2009

This year sees the celebration of many anniversaries at CERN, beginning with the 20th anniversary of the World Wide Web, invented in 1989 (p24). Later in the year, the laboratory will celebrate the 20th anniversary of the Large Electron–Positron (LEP) collider, which did much to pin down parameters of the Standard Model of particles and forces. The Standard Model itself will also see some key anniversaries, for the award of Nobel Prizes to major contributors: Sheldon Glashow, Abdus Salam and Steven Weinberg (1979), CERN's Carlo Rubbia and Simon van der Meer (1984) and Gerard 't Hooft and Martin Veltman (1999).

There will also be celebrations for the 50th anniversary of the Proton Synchrotron (PS) – an anniversary that it shares with the *CERN Courier*, which first appeared in August 1959. In black and white, it was eight pages long and intended to be "published monthly for CERN staff members". The magazine, rather like CERN itself, has evolved over the years, growing to serve a worldwide community of physicists and more. Now in full colour and typically some 50 pages long, it nevertheless shares similar content with the original version, as the now-regular archive page reveals each issue (p13).

NUCLEAR PHYSICS

NSCL researchers constrain nuclear symmetry energy at low density

By analysing collisions between several combinations of tin nuclei, researchers at the Michigan State University National Superconducting Cyclotron Laboratory (NSCL) have refined the understanding of nuclear symmetry energy. Their work marks the first successful theoretical explanation of common observables that are related to symmetry energy in heavy-ion experiments. The results should help in discerning the properties of neutron stars, particularly in the crust region.

The nuclear attraction between a neutron and a proton is, on average, stronger than that between two protons or two neutrons. The nuclear contribution to the difference between the binding energy of a system of all neutrons and another with equal numbers of protons and neutrons is known as the symmetry energy. To allow for this difference, formulae to calculate nuclear masses include a symmetry-energy term. This term often takes a form that assumes the symmetry energy to be independent of density, even though its value inside the nucleus, at normal density, should exceed its value at the surface, where the density is lower and the ratio of proton to neutron densities differs from that for the nuclear interior.

The symmetry energy of a stable nucleus reflects typical nuclear densities of about $2–3 \times 10^{14}$ g/cm^3; it contributes modestly to the binding energy but influences significantly the stability of nuclei against beta decay. Despite the sensitivity of nuclear masses to its average value, the precise understanding of the dependence of symmetry energy on density has proved elusive, leading to large uncertainties in theoretical predictions for properties of nuclei that are very rich in neutrons. The effects of symmetry energy loom even larger in environments that have unusual ratios of protons to neutrons and much larger ranges of density, such as in neutron stars. There, the dependence of the symmetry energy upon density is one of the most uncertain parts of the mathematical palette describing the forces at play.

Betty Tsang adjusts a detector that is used to make precise measurements of particles produced in high-speed collisions of nuclei. (Courtesy NSCL.)

Now, Betty Tsang, Bill Lynch, Pawel Danielewicz and colleagues have helped to constrain understanding of the density dependency of symmetry energy by studying how it affects heavy-ion reactions at NSCL's Coupled Cyclotron Facility (Tsang *et al.* 2009). In two experiments, the team directed various beams of tin nuclei at stationary targets of tin. The four combinations included a beam of ^{124}Sn (50 protons and 74 neutrons) on a target of ^{124}Sn, ^{112}Sn (62 neutrons) on ^{112}Sn, ^{124}Sn on ^{112}Sn, and ^{112}Sn on ^{124}Sn. This allowed the researchers to create and study nuclear matter with different neutron-to-proton ratios over a range of density, which could be varied by adjusting the energy of the beam and the centrality of the collisions.

The team collected data on several observables, including isospin diffusion, which probes the neutron-to-proton ratio of neutron-rich projectile nuclei after collisions with neutron-deficient target nuclei. During grazing collisions at relative velocities of 0.3 *c*, a neck region with reduced density can form between projectile and target nuclei through which neutrons and protons can diffuse. The stronger the symmetry energy is in this neck region, the more likely the neutron-to-proton ratios in the projectile and target nuclei will equilibrate and become equal. A second observable involves comparisons of the energy spectra of neutrons and protons in central head-on collisions. In this case the symmetry energy expels neutrons from the central overlap region of the projectile and target nuclei; the ratio of neutron-to-proton emission then provides a probe of the variation in symmetry energy as the system compresses and expands during the collision.

By comparing the experimental data to results obtained with theoretical models developed by their Chinese colleagues, YingXun Zhang and Zhuxia Li at the China Institute of Atomic Energy, the team obtained constraints on the density dependence of symmetry energy at densities ranging from normal down to around one third nuclear matter density. The results will help to describe the inner crust of neutron stars, where the density of nuclear matter is in the $1–2 \times 10^{14}$ g/cm^3 range. The role of symmetry energy at the cores of such stars, where the density of nuclear matter reaches 8×10^{14} g/cm^3, is currently associated with the largest uncertainty in descriptions of neutron stars.

Further reading

M B Tsang *et al.* 2009 *Phys. Rev. Lett.* **102** 122701.

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ADVERTISING FEATURE

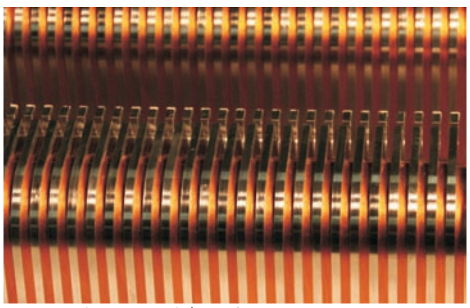
Insertion Devices for highly brilliant synchrotron radiation

The new generation synchrotron radiation sources together with the free-electron laser facilities under construction in US and in Europe aim, in the upcoming years, to drastically increase the peak brilliance of the emitted radiation. This will unleash a number of different experiments in several fields of application including nano technology, biology and nuclear physics.

A significant role in achieving this goal is played by the development of insertion devices such as undulators.

Babcock Noell GmbH (BNG) is strongly involved in the field since 2006 with the design and fabrication for DESY of the first 5m long permanent magnet (PM) planar undulator prototype for XFEL. This 29mm period length unit is capable of moving its 316LN girders with a precision of 1 micron in positioning.

In 2008 BNG successfully fabricated and delivered 11 undulators in 11 months to be installed in PETRA III and FLASH at DESY.


Superconducting Undulator for ANKA

These are 2m long planar undulators with aluminum girders which will allow PETRA III to become one of the most brilliant storage ring-based X-ray radiation sources worldwide.

This result was achieved with a strict quality assurance system and a flexible organization of our project teams.

Additionally in 2007 BNG started the design and fabrication of a conduction cooled 1.5m long superconducting (SC) planar undulator for the ANKA light source at Forschungszentrum Karlsruhe (FZK). This magnet is designed to reach a peak field on the beam axis of 1.5T with a nominal gap of 5mm and will be assembled and tested by the end of 2009.

At the moment BNG just completed the fabrication of a prototype which was successfully tested in liquid helium at FZK. This short magnet reached over 95% of the short sample limit of the superconductor which is 30% above the specification for the full scale magnet.

BNG together with FZK plans to fabricate a prototype of a switching undulator-wiggler and a conduction cooled undulator capable of withstanding the high beam heat load of third generation synchrotron light sources in the next years.

At BNG we are pushing the limit of insertion devices. For both PM and SC undulators our close collaboration with institutes is the key factor for success.

BABCOCK NOELL

SCIENCEWATCH

Compiled by John Swain, Northeastern University

Alfvén waves may solve solar-corona mystery

The outer parts of the solar corona are millions of degrees hotter than the surface of the Sun – a fact that has puzzled astrophysicists for quite some time (*CERN Courier* June 2008 p8). Now David Jess of Queen's University Belfast and colleagues have made major progress in unravelling this mystery. Using the 1 m Swedish Solar Telescope on La Palma in the Canary Islands they observed a tiny conglomeration of highly magnetized bright points on the Sun's surface. Their observations show evidence for Alfvén waves, oscillations of magnetized plasma, moving up from the lower solar atmosphere, which may hold the key to the coronal heating.

Hannes Alfvén predicted such waves in his seminal paper of 1942. Their incompressible nature and ability to penetrate the solar atmosphere have made them likely candidates for heating the solar corona. However, Alfvén waves on the Sun had evaded unambiguous observation until now, owing to difficulties in getting clear-enough images of small parts of the Sun using Earth-based telescopes. The long-wavelength plasma oscillations that Jess and colleagues have observed appear to follow magnetic field lines towards the corona. They seem to be capable of carrying enough heat to the corona to explain its high temperature.

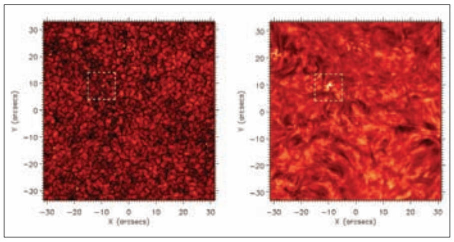


Fig. 1. Simultaneous hydrogen-alpha images in the photosphere (left) and chromosphere (right), obtained with the Swedish Solar Telescope. The square marks the group of bright points investigated. (The scale is in heliocentric coordinates, where 1 arc sec is around 725 km.)

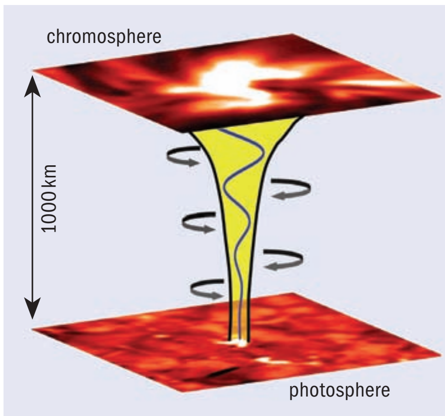


Fig. 2. An expanding magnetic-flux tube between images obtained for the photosphere and chromosphere (not to scale) undergoes a torsional perturbation and generates a wave that propagates longitudinally in the vertical direction.

Further reading

H Alfvén 1942 *Nature* **150** 405.
David B Jess *et al.* 2009 *Science* **323** 1582.

Noise can make itself logically useful

Traditional logic represents "1" and "0" by rather sharp voltage levels – something that noise makes difficult to control in nanoscale circuitry. William Ditto of Arizona State University in Tempe and colleagues have built reliable logic circuits that rely on noise to work.

The idea is to exploit stochastic resonance, whereby noise can boost the detectability of an otherwise low "1" signal, while not driving a "0" signal to look like a "1". The nonlinear circuitry used for the logic gates offers another advantage: suitable control voltages used rapidly to make a single gate act as a NAND or a NOR – enough for any other logic circuit.

Further reading

K Murali *et al.* 2009 *Phys. Rev. Lett.* **102** 104101.

Carbon nanotubes make 'muscles'

Aerogel ribbons drawn from forests of carbon nanotubes can act spectacularly as an artificial muscle of sorts. Ali Aliev and colleagues of the University of Texas at Dallas have created the material that, in response to an applied voltage, rapidly and reversibly triples in width and thickness while contracting in length.

With the strength and stiffness of steel in one direction and more flexibility than rubber in the other two, such ribbons can operate over temperatures ranging from that of liquid nitrogen to the melting point of iron. Perhaps even more remarkable, the ribbons are optically transparent.

Further reading

Ali E Aliev *et al.* 2009 *Science* **323** 1575.

Brain patterns show sleep deprivation

When you lose concentration and "tune out" your brain activates what is called the "default network" – rather like a screen saver of the mind. However, it does so differently if you're sleep deprived compared with if you're not. Ninad Gujar of the University of California, Berkeley, and colleagues used functional magnetic-resonance imaging to observe the workings of the brains of sleep-deprived and well rested people as they pushed a button in response to viewing a picture.

In both cases the "default network" was activated between pictures, but there were significant changes in the activation patterns of sleep-deprived brains. It was possible to gauge with 93% accuracy if a volunteer was sleep deprived or not from the altered activity in only two areas of the brain – both associated with decreased performance on memory tests. Being tired really does appear to have major impacts on the functioning of the brain.

Further reading

Tina Hesman Saey 2009 *Science News* **23** March web edition (http://www.sciencenews.org/view/generic/id/42054/title/Tired_brain_defaults_differently).

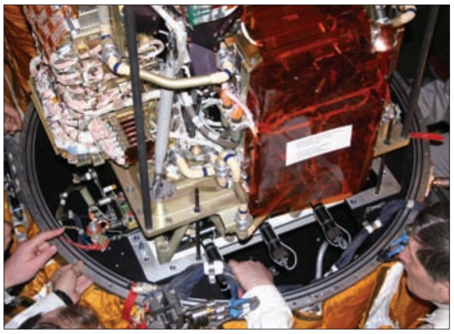
Compiled by Marc Türler, ISDC and Observatory of Geneva University

PAMELA finds an anomalous cosmic positron abundance

The collaboration for the Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics (PAMELA) experiment has published evidence of a cosmic-positron abundance in the 1.5–100 GeV range. This high-energy excess, which they identify with statistics that are better than previous observations, could arise from nearby pulsars or dark-matter annihilation.

PAMELA, which went into space on a Russian satellite launched from the Baikonur cosmodrome in June 2006, uses a spectrometer – based on a permanent magnet coupled to a calorimeter – to determine the energy spectra of cosmic electrons, positrons, antiprotons and light nuclei. The experiment is a collaboration between several Italian institutes with additional participation from Germany, Russia and Sweden.

Preliminary, unofficial results from the PAMELA mission appeared last autumn on preprint servers together with speculation that PAMELA had found the signature of dark-matter annihilation. The paper by Oscar Adriani from the University of Florence and collaborators now published in *Nature* is more cautious with the dark-matter interpretation of the positron excess, identifying pulsars as plausible alternatives. The data presented include more than a thousand million triggers collected between July 2006 and February 2008. Fine tuning of the particle identification allowed the team to reject 99.9% of the protons, while selecting more than 95% of the electrons and positrons. The resulting spectrum of the positron abundance relative to the sum of electrons and positrons represents the highest statistics to date.



The PAMELA instrument on 1 April 2006 being prepared for launch at the Baikonur cosmodrome in Kazakhstan. (Courtesy PAMELA collaboration.)

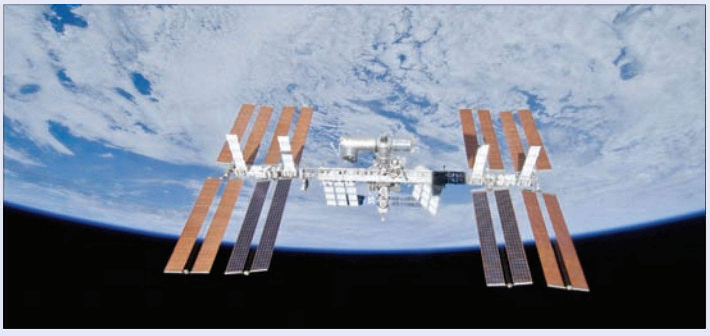
Below 5 GeV, the obtained spectrum is significantly lower than previously measured. This discrepancy is believed to arise from modulation of the cosmic rays induced by the strength of the solar wind, which changes periodically through the solar cycle. At higher energies the new data unambiguously confirm the rising trend of the positron fraction, which was suggested by previous measurements. This appears highly incompatible with the usual scenario in which positrons are produced by cosmic-ray nuclei interacting with atoms in the interstellar medium. The additional source of positrons dominating at the higher energies could be the signature of dark-matter decay or annihilation. In this case, PAMELA has already shown that dark matter would have a preference for leptonic final states. Adriani and colleagues deduce this from the absence of a similar excess of the antiproton-to-proton abundance, a result that they published earlier this year. They suggest that the alternative origin of the positron excess at high energies is particle acceleration in the magnetosphere of nearby pulsars producing electromagnetic cascades.

The authors state that the PAMELA results presented here are insufficient to distinguish between the two possibilities. They seem, however, confident that various positron-production scenarios will soon be testable. This will be possible once additional PAMELA results on electrons, protons and light nuclei are published in the near future, together with the extension of the positron spectrum up to 300 GeV thanks to on-going data acquisition. Complementary information will also come from the survey of the gamma-ray sky by the Fermi satellite (*CERN Courier* November 2008 p13).

Further reading

O Adriani *et al.* 2009 *Nature* **458** 607.

Picture of the month



This majestic view of the International Space Station (ISS) in front of the Earth was taken from the space shuttle *Discovery* after undocking. The crew of the shuttle mission STS-119 successfully delivered and installed on the ISS the last set of solar-array wings before returning home on the 28 March. The ISS is still missing a few modules but it now looks complete. When the solar arrays are in the ideal orientation to reflect sunlight, the ISS becomes the second brightest object in the night sky, after the Moon, but brighter than Venus. The ISS orbits the Earth 15 times a day at an altitude of about 350 km. Its assembly started in 1998 and will be finished by 2011. (Courtesy NASA.)

CERN COURIER ARCHIVE: 1966

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

CERN

The SC prepares for ISOLDE

The 600 MeV synchrocyclotron began a long shutdown on 8 May, which will extend to mid-July. During this time major modifications will be carried out as part of a programme to improve the capacity of the machine and its associated facilities. One of the main items of work planned for the shutdown is the construction of a new underground tunnel to take the external proton beam line to the ISOLDE (Isotope Separator On-line Development) project. This tunnel has to be constructed underground to keep external radiation levels down. It also frees the existing proton room for experiments involving less intense beams.

● Compiled from *CERN News* p90.

Excavation of the hole for the underground laboratory of the ISOLDE project. The project will use extracted proton beams from the 600 MeV synchrocyclotron in the adjacent building (right).

COMPILER'S NOTE

The 1960s were golden years for particle physics, with new machines, ground-breaking experiments and giant leaps in quantum theory all setting the scene for the emergence of the Standard Model of particle physics in the early 1970s.

Ever since the first experiments in October 1967, ISOLDE has played a pioneering role in exploring nuclear structure in terms of masses and β-decay. ISOLDE's observations of nuclear beta-decay, mediated by the weak interaction, form part of on-going tests of the Standard Model, while studies of neutron-saturated nuclei are contributing to a full understanding of rapid neutron capture (the r-process) in core-collapse supernovae, which creates approximately half of the nuclei in the universe that are heavier than iron.

In the US, Weston was chosen as the site for the 200 GeV accelerator and became home to Fermilab, which now runs the Tevatron, the world's highest-energy machine until the LHC comes on air. The lab has several famous firsts to its credit: the bottom quark in 1977, the top quark in 1995, and direct observation of the tau neutrino in 2000. However, "moral fiber" perturbation theory has not been proven!

The Villigen cyclotron, at what is now the Paul Scherrer Institute, had its first extracted proton beam in January 1974. Today PSI boasts a widely diverse research programme, ranging from health to energy, with studies in radiation medicine, reactor physics, nuclear-waste management and condensed matter, to mention but a few.

The nascent Brookhaven experiment went on to give us the "solar neutrino problem" when, during 30 years of operation, it revealed the famous short-fall in the number of electron-neutrinos reaching Earth and inspired a series of follow-on experiments. Finally, in 2002, the Sudbury Neutrino Observatory in Canada provided direct evidence that 2/3 of the Sun's neutrinos "oscillate" to another type before reaching Earth (*CERN Courier* May 2007 p24). While this accounted for the disappearance of electron-neutrinos from the solar-neutrino flux, such oscillations can happen only if neutrinos have mass, however small. In this way the solar-neutrino experiments provided important evidence for massive neutrinos and some of the first physics beyond the realm of the Standard Model.

OTHER LABS

News from abroad

Six sites have emerged from the second stage of the selection process for the American-proposed 200 GeV accelerator. They are: Ann Arbor, Michigan; Brookhaven; Denver, Colorado; Sierra foothills, California; Madison, Wisconsin; and Weston, Chicago. A site at South Barrington, a suburb of Chicago, was also listed as an alternative to the Weston site, but was withdrawn after local pressure. One of the contentions against having the accelerator at South Barrington was that the influx of scientists would "disturb the moral fiber of the community"! Four commissioners of the US Atomic Energy Commission will make the final decision which is expected within a few months.

Villigen

The Swiss Parliament has approved the construction of a 500 MeV isochronous cyclotron at Villigen. The site of the new accelerator Laboratory is across the River Aare from the Federal Institute of Reactor Research at Würenlingen, north-west of Zürich. The project has been under consideration since 1961. It involves a two-stage acceleration process – a 70 MeV cyclotron injecting into the 500 MeV machine, which uses eight spiral ridge magnets and four accelerating cavities. External proton beams of 50 to 100 μA will be available. The total cost of the accelerator is estimated at about 90 million Swiss francs.

Research will cover nucleon–nucleon interactions with emphasis on the use of polarized beams; meson studies with π and μ meson beams; nuclear-structure research; radiation-damage studies, and also research into the biological use of meson beams.

Brookhaven

A large-scale experiment, planned by scientists from the Brookhaven Laboratory, to investigate the solar neutrino flux, is expected to be in operation very soon. The experiment uses as its detector a tank containing 3.8×10^5 litres of perchloroethylene in which neutrino interactions produce the radioisotope argon-37 from chlorine-37. It is located in a mine in South Dakota 1470 m deep. About five solar-neutrino events per day are expected to be recorded in the detector.

● Compiled from *News from Abroad* pp93–94.

Why antihydrogen and antimatter are different

As Paul Dirac realized, the existence of antihydrogen does not in itself prove the existence of antimatter. A look through the history of the subject, and in particular the role played by the CPT theorem, shows that ultimately it came down to experiment to prove the existence of antimatter through the discovery of the antideuteron at CERN in 1965.

"Those who say that antihydrogen is antimatter should realize that we are not made of hydrogen and we drink water, not liquid hydrogen." These are words spoken by Paul Dirac to physicists gathered around him after his lecture "My life as a Physicist" at the Ettore Majorana Foundation and Centre for Scientific Culture in Erice in 1981 – 53 years after he had, with a single equation, opened new horizons to human knowledge. To obtain water, hydrogen is, of course, not sufficient; oxygen with a nucleus of eight protons and eight neutrons is also needed. Hydrogen is the only element in the Periodic Table to consist of two charged particles (the electron and the proton) without any role being played by the nuclear forces. These two particles need only electromagnetic glue (the photon) to form the hydrogen atom. The antihydrogen atom needs two antiparticles (antiproton and antielectron) plus electromagnetic antiglue (antiphoton). Quantum electrodynamics (QED) dictates that the photon and the antiphoton are both eigenstates of the C-operator (see later) and therefore electromagnetic antiglue must exist and act like electromagnetic glue.

If matter were made with hydrogen, the existence of antimatter would be assured by the existence of the two antiparticles (antiproton and antielectron), the existence of the antiphoton being assured by QED. As Dirac emphasized, to have matter it is necessary to have another particle (the neutron) and another glue (the nuclear glue) to allow protons and neutrons to stay together in a nucleus. This problem first comes into play in heavy hydrogen, which has a nucleus – the deuteron – made of one proton and one neutron. For these two particles to remain together there needs to be some sort of "nuclear glue". We have no fundamental theory (like QED) to prove that the nuclear antiglue must exist and act like the nuclear glue. It can be experimentally established, however, by looking at the existence of the first example of nuclear antimatter: the antideuteron, made with an antiproton, an antineutron and nuclear antiglue. If the antideuteron exists, all other antielements beyond heavy antihydrogen must exist. Their nuclei must contain antiprotons, antineutrons and nuclear antiglue. But if the antideuteron did not exist, nothing but light antihydrogen could exist: farewell anti-water and farewell all forms of antimatter.

Dirac's statement takes into consideration half a century of theoretical and experimental discoveries, which have ultimately concluded that the existence of antimatter is supported exclusively by experiment. The CPT theorem implies that if matter exists then so should antimatter, but T D Lee has shown that the theorem is invalid at the Planck scale (around 10^{19} GeV) where all of nature's fundamental forces converge (Lee 1995). Because this grand unification is the source of everything, if CPT collapses at the energy scale where it occurs, then we can bid farewell to all that derives from CPT.

Dirac surrounded by young physicists in Erice after his lecture "My Life as a Physicist". It was on this occasion that he made the statement quoted at the beginning of the article. (Photos courtesy EMFCSC.)

CPT and the existence of antimatter

The CPT theorem states that physical laws are invariant under simultaneous transformations that involve inversions of charge (C), parity (P) and time (T). The first of these invariance operators to be discovered was C, by Hermann Weyl in 1931. This says that physical reality remains invariable if we replace the charges that are additively conserved by their corresponding anticharges – the first known example being that of the electron and the antielectron. ▷

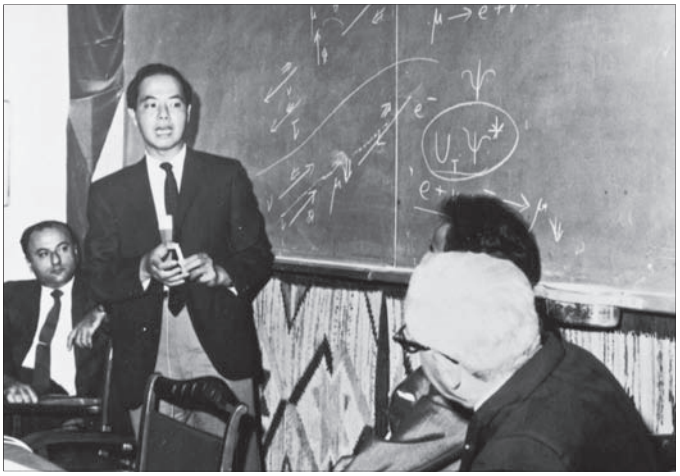
The P operator, discovered by Eugene Wigner, Gian-Carlo Wick and Arthur Wightman, tells us that in replacing right-handed systems with left-handed ones, the results of any fundamental experiment will not change. The T operator, discovered by Wigner, Julian Schwinger and John Bell, established that inverting the time axis will also not alter physical reality.

The mathematical formulation of relativistic quantum-field theory (RQFT), which is supposed to be the basic description of nature's fundamental forces, possesses the property of CPT invariance whereby inverting all does not change the physical results. In other words, if we invert all charges using C, the three space reference axes (x, y, z) using P, and the time axis using T, all will remain as before. However, matter is made of masses coupled to quantum numbers that are additively conserved: electric charges, lepton numbers, baryon numbers, "flavour" charges etc. If we were to apply the three CPT operators to matter in a certain state we would obtain an antimatter state. This means that if the CPT theorem is valid then the existence of matter implies the existence of antimatter and that the mass of a piece of matter must be identical to that of the corresponding piece of antimatter.

Suppose that nature obeys the C invariance law; in this case, the existence of matter implies the existence of antimatter. If C invariance is broken, the existence of antimatter is guaranteed by CPT. Now, suppose that CP is valid; again, the existence of matter dictates the existence of antimatter. If CP is not valid, then the existence of antimatter is still guaranteed by CPT. If CPT collapses, however, only experimental physics can guarantee the existence of antimatter. This summarizes what effectively happened during the decades after Dirac's famous equation of 1928 – until we finally understood that CPT is not an impervious bulwark governing all of the fundamental forces of nature.

Three years after Dirac came up with his equation, Weyl discovered C and it was thought at the time that the existence of the antielectron and the production of electron–antielectron pairs were the consequences of C invariance. The equality of the mean life of positive and negative muons was also thought to be an unavoidable consequence of the validity of C. These ideas continued with the discoveries of the antiproton, the antineutron and, finally, of the neutral strange meson called θ_2. This apparent triumph of the invariance operators came in parallel with the success in identifying a "point-like" mathematical formulation that was capable of describing the fundamental forces of nature. Building on the four Maxwell equations the marvellous construction of RQFT was finally achieved. This theory should have been able to describe not only the electromagnetic force (from which it was derived) but also the weak force and the nuclear force. Two great achievements reinforced these convictions: Enrico Fermi's mathematical formulation of the weak force and Hideki Yukawa's triumphant discovery of the "nuclear glue" – the famous π meson – thanks to Cesare Lattes, Hugh Muirhead, Giuseppe Occhialini and Cecil Powell (*CERN Courier* September 2007 p43).

These initial extraordinary successes were, however, later confronted with enormous difficulties. In QED, there were the so-called "Landau poles" and the conclusion that the fundamental "bare" electric charge had to be zero; for the weak forces, unitarity fell apart at an energy of 300 GeV; and in the realm of the nuclear force, the enormous proliferation of baryons and mesons was totally beyond understanding in terms of RQFT. This is when a different mathematical



T D Lee explaining why the CPT theorem collapses at the Planck scale, with Melvin Schwartz (left) and Isidor Rabi (far right).

formulation, the "scattering matrix" or S-matrix, was brought in, and with it the total negation of the "field" concept. It required three conditions: analyticity, unitarity and crossing. So, why bother with RQFT if the S-matrix is enough? On the other hand, if RQFT does not exist, how do we cope with the existence of CPT invariance? This opened the field related to the breaking of the invariance laws, C, P, T.

The shock of CP violation

In 1953 Dick Dalitz discovered the famous θ–τ puzzle: two mesons, with identical properties, had to be of opposite parity. Intrigued by this "puzzle", T D Lee and C N Yang analysed experimental results in 1956 and found that there was no proof confirming the validity of C and P in weak interactions. Within one year of their findings, Chien-Sung Wu and her collaborators discovered that the invariance laws of C and P are violated in weak interactions. So how could we cope with the existence of antimatter? This is why Lev Landau proposed in 1957 that if both the C and P operators are violated then their product, CP, may be conserved; the existence of antimatter is then guaranteed by the validity of CP (Landau 1957).

There is one small detail that was always overlooked. In 1957, in a paper that not many had read (or understood), Lee, Reinhard Oehme and Yang demonstrated that, contrary to what had been said and repeated, the existence of the two neutral strange mesons, θ_1 and θ_2, was not a proof of the validity of C or P, or of their product CP (Lee, Oehme and Yang 1957).

I was in Dubna in 1964 when Jim Cronin presented the results on CP violation that he had obtained together with Val Fitch, James Christenson and René Turley. On my right I had Bruno Touschek and on my left Bruno Pontecorvo. Both said to me of Cronin and his colleagues, "they have ruined their reputation". The validity of Landau's proposal of CP invariance, with antimatter as the mirror image of matter, was highly attractive; to put it in doubt found very few supporters. Dirac, however, was one of the latter and he fell into a spell of deep "scientific depression". He, who was well known for his caution, had total belief in C invariance, which had led him to predict the existence of antiparticles, antimatter, antistars and antigalaxies. Now even CP was breaking.

If the CPT product is to remain conserved, the breaking of CP involves that of T. For some of the founding fathers of modern physics, however, invariance relative to time inversion at the level of the fundamental laws had to remain untouched. So, if CP breaks and T does not, then CPT must break. After all, why not? In fact, the bulwark of CPT was RQFT, but it already seemed as if this mathematical formulation had to be replaced by the S-matrix. The breaking of the invariance operators (C, P, CP) and the apparent triumph of the S-matrix were coupled at the time to experimental results that indicated no trace of antideuterons, even among the production of 10 million pions in proton collisions.

To obtain the first example of antimatter it seemed that CPT had to be proved right, which meant proving the violation of T. No one back in 1964 could imagine that physics would open the new horizons that we know today. The only actions left to us then were of a technological–experimental nature. It turned out that the discovery of true antimatter required the realization of the most powerful beam of negative particles at CERN's PS, as well as the invention of a new technology capable of measuring, with a precision never achieved before, the time-of-flight of charged particles. This is how we came to discover an antideuteron produced, not after 10 million pions, but only after a 100 million (Massam *et al.* 1965).

The crucial experiment

The search for the existence of the first example of nuclear antimatter needed a high-intensity beam of negative particles produced in high-energy interactions. This negative beam was dominated by pions, with a fraction of K mesons and a few antiprotons. It was necessary to separate particles with different masses, starting with pions and then going up with mass to K mesons, antiprotons and (it was hoped) antideuterons. To accomplish this the first step was a combined system of bending magnets coupled with magnetic quadrupoles – for focusing purposes – and a strong electrostatic separator. This high-intensity beam of negative "partially separated" particles was the result of a special project made and carried out with two friends of mine, Mario Morpurgo and Guido Petrucci. The second vital step was a sophisticated time-of-flight system capable of achieving the time resolution needed to detect one negative particle (the antideuteron) in a background of a 100 million other negative particles (essentially, π mesons). The results, which showed the existence of a negative particle with mass equal to that of the deuteron, were obtained on 11 March 1965, the same day as the 41st birthday of the PS director, Peter Standley.

Dirac came out of his depression when he received a phone call from his friend Abdus Salam, saying: "Relax Paul, my friend Nino Zichichi has discovered the antideuteron". Dirac called me and invited me for lunch at his place, and this started a friendship that led us to the realization of the Erice Seminars on Nuclear Wars.

To understand the importance of this discovery we need to have a clear idea of what is meant by "matter". Particles are not sufficient to constitute matter; we also need "glues". With electromagnetic glue we can make atoms and molecules; to make the nucleus, we need protons, neutrons and nuclear glue. To make antimatter requires antiprotons, antineutrons and nuclear "antiglue"; but we also need to know that nuclear antiglue allows these constituents of antimatter to stick together just as protons and neutrons do to form matter. A fundamental law is needed that establishes the existence of nuclear antiglue that is exactly identical to the nuclear glue in matter. This fundamental law is missing.

In fact, we know today that the strengths of all of the fundamental forces converge at the Planck energy, where CPT invariance breaks down. Moreover, if we replace the "points" with "strings", nothing changes. CPT results from the "point-like" mathematical formulation of RQFT but it collapses at the energy scale at which the fundamental forces originate, i.e. at the Planck energy. If we replace "points" with "strings" then relativistic quantum string theory results; but it cannot validate CPT. This implies that no theory exists that can guarantee that if we have matter then antimatter must exist. This is why the fact that all anti-atoms with their antinuclei must exist with certitude resulted from the experiment at CERN in March 1965.

In 1995, during his opening lecture for the symposium celebrating the 30th Anniversary of the Discovery of Antimatter in Bologna, T D Lee said: "Werner Heisenberg discovered quantum mechanics in 1925 and by 1972 he had witnessed almost all of the big jumps in modern physics. Yet he ranked the discovery of antimatter as the biggest jump of all. In fact in his book *The Physicist's Conception of Nature* (1972), Heisenberg writes, 'I think that this discovery of antimatter was perhaps the biggest jump of all big jumps in physics in our century.'."

● This article is based on the opening talk given at the event to celebrate the 50th anniversary of the Karlsruhe Nuclide Chart, held in Karlsruhe on 9 December 2008 (see www.nucleonica.net:81/wiki/index.php/Help:Karlsruhe_Nuclide_Chart). For the full article with complete references, see http://www.nucleonica.net:81/wiki/images/a/aa/05_Zichichi_Karlsruhe.pdf.

Further reading

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Résumé

Antihydrogène et antimatière : deux choses différentes

Pour fabriquer de la matière autre que l'hydrogène « léger », il faut plus que des particules. Une « colle nucléaire » est également nécessaire pour lier les protons et les neutrons, même dans les noyaux légers tels que le deutéron, noyau de l' hydrogène « lourd » appelé deutérium. C'est la même chose pour l'antimatière, si bien que, comme le pensait d'ailleurs Paul Dirac, l'existence d'antihydrogène ne prouve pas en elle-même l'existence de l'antimatière. Dans l'article, Antonino Zichichi passe en revue l'histoire de l'antimatière et en particulier le rôle joué par le théorème CPT, en montrant qu'il revenait à l'expérimentation de prouver l'existence de l'antimatière par la découverte de l'antideutéron au CERN en 1965.

Antonino Zichichi, *CERN, Geneva, Enrico Fermi Centre, Rome, INFN and the University of Bologna.*

New Zealand meeting looks at dark matter

Participants from around the world gathered in Christchurch, New Zealand, for the Dark 2009 conference in January. **Hans Volker Klapdor-Kleingrothaus** reports.

The 7th Heidelberg International Conference on Dark Matter in Astrophysics and Particle Physics – Dark 2009 – was held at Canterbury University in Christchurch on 18–24 January. The event saw 56 invited talks and contributions, which provided an exciting and up-to-date view of the development of research in the field. The participants represented well the distribution of dark-matter activities around the world: 25 from Europe, 11 from the US, 5 from Japan and Korea, 14 from Australia and New Zealand, and 1 from Iran. The programme covered the traditionally wide range of topics, so this report looks at the main highlights.

The conference started with an overview of searches for supersymmetry at the LHC and dark matter by Elisabetta Barberio of the University of Melbourne. To date, the only evidence for cold dark matter from underground detectors is from the DAMA/LIBRA experiment in the Gran Sasso National Laboratory, as Pierluigi Belli from the collaboration explained. This experiment, which looks for an expected seasonal modulation of the signal for weakly interacting massive particles (WIMPs), now has a significance of 8.4 σ. Unfortunately, all other direct searches for dark matter do not currently have the statistics to look for this signal. Nevertheless, Jason Kumar from Hawaii described how testing the DAMA/LIBRA result at the Super-Kamiokande detector might prove interesting.

Later sessions covered other searches for dark matter. Tarek Saab from Florida gave an overview of ongoing direct searches in underground laboratories, including recent results from the Cryogenic Dark Matter Search experiment in the Soudan mine, and Nigel Smith of the UK's Rutherford Appleton Laboratory presented results from the ZEPLIN III experiment in the Boulby mine. Irina Krivosheina of Heidelberg and Nishnij Novgorod discussed the potential offered by using bare germanium detectors in liquid nitrogen or argon for dark-matter searches, on the basis of the results from the GENIUS-Test-Facility in the Gran Sasso National Laboratory. Chung-Lin Shan of Seoul National University reported on how precisely WIMPs can be identified in experimental searches in a model-independent way.

Searching for signals from dark-matter annihilation in X-rays and weighing supermassive black holes with X-ray emitting gas were subjects for Tesla Jeltema of the University of California Observatories/Lick Observatory and David Buote of the University of California, Irvine. Stefano Profumo of the University of California, Santa Cruz, provided an overview of fundamental physics with giga-electron-volt gamma rays. Iris Gebauer of Karlsruhe addressed the excess of cosmic positrons indicated by the Energetic Gamma Ray Experiment Telescope, which are still under discussion, as well as the new anomalies observed by the Payload for Antimatter Matter Exploration and Light-Nuclei Astrophysics (PAMELA, p12) satellite experiment and the Advanced Thin Ionization Calorimeter (ATIC) balloon experiment. These results and the limits that they set on some annihilating dark matter (neutralino or gravitino) models were also discussed by Kazunori Nakayama of Tokyo and Koji Ishiwata of Tohoku.

Participants of DARK 2009 at the monument for Robert Falcon Scott, who started his Antarctic expedition from Christchurch in 1910.

Other presentations outlined results and prospects for the AMANDA, IceCube and ANTARES experiments, which study cosmic neutrinos – though there is still a long way to go before they have conclusive results. Emmanuel Moulin of the Commissariat à l'Énergie Atomique/Saclay presented results from imaging atmospheric Cherenkov telescopes, in particular the recent measurements from HESS, which exploited the fact that dwarf spheroidal ▷

galaxies, such as Canis Major, are highly enriched in dark matter and are therefore good candidates for its detection. Unfortunately, the results do not yet have the sensitivity of the Wilkinson Microwave Anisotropy Probe in restricting either the minimal supersymmetric Standard Model or Kaluza–Klein scenarios.

Leszek Roszkowski of Sheffield gave an overview of supersymmetric particles (neutralinos) as cold dark matter, while scenarios of gravitino dark matter and their cosmological and particle-physics implications were presented by Gilbert Moultaka of the University of Montpellier and Yudi Santoso of the Institute for Particle Physics Phenomenology, Durham. Dharam Vir Ahluwalia of the University of Canterbury put the case for the existence of a local fermionic dark-matter candidate with mass-dimension one, on the basis of non-standard Wigner classes. However, as the proposed fields, as outlined in detail by Ben Martin of Canterbury, do not fit into Steven Weinberg's formalism of quantum-field theory, this suggestion led to dispute between other experts. An interesting candidate for dark matter was presented by Norma Susanna Mankoc-Borstnik of the University of Ljubljana, who proposed a fifth family as candidates for forming dark matter.

Dark energy and the cosmos

Dark energy was a major topic at the conference. Chris Blake of Swinburn University of Technology in Melbourne presented the prospects for the WiggleZ survey at the Anglo-Australian Telescope, the most sensitive experiment of this kind, and Matt Visser of Victoria University in Wellington gave a cosmographic analysis of dark energy. On the theoretical side there are diverging approaches to dark energy, including attempts to explain it in a "radically conservative way without dark energy", as David Wiltshire of Canterbury University, Christchurch, explained.

A particular highlight was the presentation by Terry Goldman of Los Alamos, which discussed a possible connection between sterile fermion mass and dark energy. His conclusion was that a neutrino with mass of 0.3 eV could solve the problem of dark energy. This possibility was qualitatively supported by results of non-extensive statistics in astroparticle physics that Manfred Leubner of the University of Innsbruck presented, in the sense that dark energy is expected to behave like an ordinary gas. Goldman's suggestion is also of interest with respect to the final result of the Heidelberg–Moscow double-beta-decay experiment, reported by Hans Klapdor-Kleingrothaus, which predicts a Majorana neutrino mass of 0.2–0.3 eV.

Danny Marfatia of the University of Kansas discussed mass-varying neutrinos in his presentation about phase transition in the fine structure constant. He proposed that the coupling of neutrinos to a light scalar field might explain why $\Omega_{\text{dark energy}}$ is of the same order as Ω_{matter}. Possible connections between dark matter and dark energy with models of warped extra dimensions and the hierarchy problem were outlined by Ishwaree Neupane of the University of Canterbury and Yong Min Cho of Seoul National University.

Dark mass and the centre of the galaxy was the topic of a special session in which Andreas Eckart of the University of Cologne presented recent results on the luminous accretion onto the dark mass at the centre of the Milky Way. Patrick Scott of Stockholm University discussed dark stars at the galactic centre, while Benoit Famaey of the Université Libre de Bruxelles and Felix Stoehr of the Space Telescope European Coordinating Facility/ESO in Garching discussed the distribution of dark and baryonic matter in galaxies. Primordial molecules and the first structures in the universe were the topics addressed by Denis Puy of the Univesité Montpellier II. Youssef Sobouti of the Institute of Advanced Studies on Basic Science in Zanjan, Iran, presented a theorem on a "natural" connection between baryonic dark matter and its dark companion, while Matthias Buckley of the California Institute of Technology put forward ideas about dark matter and "dark radiation".

Gravity also came under scrutiny. David Rapetti of SLAC explored the potential of constraining gravity with the growth of structure in X-ray galaxy clusters, while Agnieszka Jacholkowska of IN2P3/Centre National de la Recherche Scientifique gave an experimental view of probing quantum-gravity effects with astrophysical sources. In a special session on general relativity, Roy Patrick Kerr of Canterbury University gave an interesting historical lecture entitled "Cracking the Einstein Code".

To conclude, the lively and highly stimulating atmosphere of Dark 2009 reflected a splendid future for research in the field of dark matter in the universe and for particle physics beyond the Standard Model. The proceedings will be published by World Scientific.

Further reading

For the presentations at Dark 2009, see www.klapdor-k.de/Conferences/Program09.htm.

Résumé

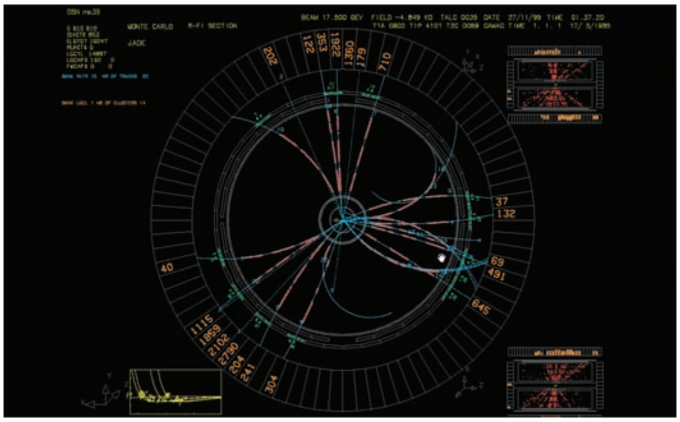
La Nouvelle-Zélande se penche sur la matière noire

Des spécialistes du monde entier se sont réunis en janvier 2009 à Christchurch (Nouvelle-Zélande) pour la 7^{e} Conférence internationale d'astrophysique et de physique des particules sur la matière noire. Quelque 56 communications et contributions passionnantes ont permis de faire un tour d'horizon des derniers développements de la recherche dans le domaine de la matière noire. Cette conférence, généralement biennale, rassemble des chercheurs travaillant dans les domaines de la cosmologie, l'astrophysique, la physique des particules et la physique nucléaire. Cette année, les thèmes comprenaient la recherche (directe ou indirecte) de la matière noire, divers aspects de l'énergie sombre, la structure à grande échelle et la gravité quantique.

Hans Volker Klapdor-Kleingrothaus, *Heidelberg.*

Study group considers how to preserve data

For experimentalists in high-energy physics, the data are like treasure, but how can they be saved for the future? A study group is investigating data-preservation options.



A simulated event in the JADE detector, generated using a refined Monte Carlo program and reconstructed using revitalized software more than 10 years after the end of the experiment. (Courtesy Siggi Bethke.)

High-energy-physics experiments collect data over long time periods, while the associated collaborations of experimentalists exploit these data to produce their physics publications. The scientific potential of an experiment is in principle defined and exhausted within the lifetime of such collaborations. However, the continuous improvement in areas of theory, experiment and simulation – as well as the advent of new ideas or unexpected discoveries – may reveal the need to re-analyse old data. Examples of such analyses already exist and they are likely to become more frequent in the future. As experimental complexity and the associated costs continue to increase, many present-day experiments, especially those based at colliders, will provide unique data sets that are unlikely to be improved upon in the short term. The close of the current decade will see the end of data-taking at several large experiments and scientists are now confronted with the question of how to preserve the scientific heritage of this valuable pool of acquired data.

To address this specific issue in a systematic way, the Study Group on Data Preservation and Long Term Analysis in High Energy Physics formed at the end of 2008. Its aim is to clarify the objectives and the means of preserving data in high-energy physics. The collider experiments BaBar, Belle, BES-III, CLEO, CDF, D0, H1 and ZEUS, as well as the associated computing centres at SLAC, KEK, the Institute of High Energy Physics in Beijing, Fermilab and DESY, are all represented, together with CERN, in the group's steering committee.

Digital gold mine

The group's inaugural workshop took place on 26–28 January at DESY, Hamburg. To form a quantitative view of the data landscape in high-energy physics, each of the participating experimental collaborations presented their computing models to the workshop, including the applicability and adaptability of the models to long-term analysis. Not surprisingly, the data models are similar – reflecting the nature of colliding-beam experiments.

The data are organized by events, with increasing levels of abstraction from raw detector-level quantities to N-tuple-like data for physics analysis. They are supported by large samples of simulated Monte Carlo events. The software is organized in a similar manner, with a more conservative part for reconstruction to reflect the complexity of the hardware and a more dynamic part closer to the analysis level. Data analysis is in most cases done in C++ using the ROOT analysis environment and is mainly performed on local computing farms. Monte Carlo simulation also uses a farm-based approach but it is striking to see how popular the Grid is for the mass-production of simulated events. The amount of data that should be preserved for analysis varies between 0.5 PB and 10 PB for each experiment, which is not huge by today's standards but nonetheless a large amount. The degree of preparation for long-term data varies between experiments but it is obvious that no preparation was foreseen at an early stage of the programs; any conservation initiatives will take place in parallel with the end of the data analysis.

From a long-term perspective, digital data are widely recognized as fragile objects. Speakers from a few notable computing centres – including Fabio Hernandez of the Centre de Calcul de l'Institut, National de Physique Nucléaire et de Physique des Particules, Stephen Wolbers of Fermilab, Martin Gasthuber of DESY and Erik Mattias Wadenstein of the Nordic DataGrid Facility – showed that storage technology should not pose problems with respect to the amount of data under discussion. Instead, the main issue will be the communication between the experimental collaborations and the computing centres after final analyses and/or the collaborations where roles have not been clearly defined in the past. The current preservation model, where the data are simply saved on tapes, runs the risk that the data will disappear into cupboards while the read-out hardware may be lost, become impractical or obsolete. It is important to define a clear protocol for data preservation, the items of which should be transparent enough to ensure that the digital ▷

content of an experiment (data and software) remains accessible.

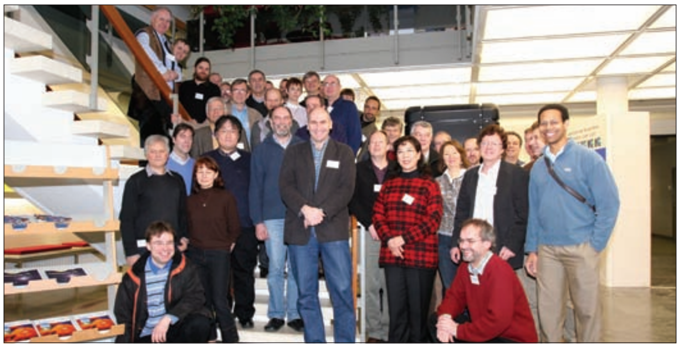
On the software side, the most popular analysis framework is ROOT, the object-oriented software and library that was originally developed at CERN. This offers many possibilities for storing and documenting high-energy-physics data and has the advantage of a large existing user community and a long-term commitment for support, as CERN's René Brun explained at the workshop. One example of software dependence is the use of inherited libraries (e.g. CERNLIB or GEANT3), and of commercial software and/or packages that are no longer officially maintained but remain crucial to most running experiments. It would be an advantageous first step towards long-term stability of any analysis framework if such vulnerabilities could be removed from the software model of the experiments. Modern techniques of software emulation, such as virtualization, may also offer promising features, as Yves Kemp of DESY explained. Exploring such solutions should be part of future investigations.

Examples of previous experience with data from old experiments show clearly that a complete re-analysis has only been possible when all of the ingredients could be accounted for. Siggi Bethke of the Max Planck Institute of Physics in Munich showed how a re-analysis of data from the JADE experiment (1979–1986), using refined theoretical input and a better simulation, led to a significant improvement in the determination of the strong coupling-constant as a function of energy. While the usual statement is that higher-energy experiments replace older, low-energy ones, this example shows that measurements at lower energies can play a unique role in a global physical picture.

The experience at the Large Electron-Positron (LEP) collider, which Peter Igo-Kemenes, André Holzner and Matthias Schroeder of CERN described, suggested once more that the definition of the preserved data should definitely include all of the tools necessary to retrieve and understand the information so as to be able to use it for new future analyses. The general status of the LEP data is of concern, and the recovery of the information – to cross-check a signal of new physics, for example – may become impossible within a few years if no effort is made to define a consistent and clear stewardship of the data. This demonstrates that both early preparation and sufficient resources are vital in maintaining the capability to reinvestigate older data samples.

The *modus operandi* in high-energy physics can also profit from the rich experience accumulated in other fields. Fabio Pasian of Trieste told the workshop how the European Virtual Observatory project has developed a framework for common data storage of astrophysical measurements. More general initiatives to investigate the persistency of digital data also exist and provide useful hints as to the critical points in the organization of such projects.

There is also an increasing awareness in funding agencies regarding the preservation of scientific data, as David Corney of the UK's Science and Technology Facilities Council, Salvatore Mele of CERN and Amber Boehnlein of the US Department of Energy described. In particular, the Alliance for Permanent Access and the EU-funded project in Framework Programme 7 on the Permanent Access to the Records of Science in Europe recently conducted a survey of the high-energy-physics community, which found that the majority of scientists strongly support the preservation of high-energy-physics data. One important aspect that was also positively appreciated in the survey answers was the question of open access to the data in conjunction with the organizational and technical matters, an issue that deserves careful consideration. The next-generation publications database, INSPIRE, offers extended data-storage capabilities that could be used immediately to enhance public or private information related to scientific articles, including tables, macros, explanatory notes and potentially even analysis software and data, as Travis Brooks of SLAC explained.



Participants of the first workshop on data preservation and long-term analysis in high-energy physics at DESY, Hamburg. (Courtesy DESY.)

While this first workshop compiled a great deal of information, the work to synthesize it remains to be completed and further input in many areas is still needed. In addition, the *raison d'être* for data preservation should be clearly and convincingly formulated, together with a viable economic model. All high-energy-physics experiments have the capability of taking some concrete action now to propose models for data preservation. A survey of technology is also important, because one of the crucial factors may indeed be the evolution of hardware. Moreover, the whole process must be supervised by well defined structures and steered by clear specifications that are endorsed by the major laboratories and computing centres. A second workshop is planned to take place at SLAC in summer 2009 with the aim of producing a preliminary report for further reference, so that the "future of the past" will become clearer in high-energy physics.

Further reading

For more information about the Study Group for Data Preservation and Long Term Analysis in HEP, see www.dphep.org.

Résumé

Les données à l'épreuve du temps

En physique des hautes énergies, l'amélioration continue de la théorie, des expériences et des simulations, l'éclosion de nouvelles idées ainsi que des découvertes inattendues peuvent faire naître le besoin de réanalyser d'anciennes données. Cela s'est déjà fait et pourrait devenir plus fréquent à l'avenir. Afin de faire le tour de la question, un groupe d'étude sur la préservation et l'analyse à long terme des données de physique des hautes énergies a été constitué à la fin 2008, composé de représentants des grandes collaborations travaillant sur des collisionneurs de particules et des centres informatiques associés. Le but est de définir les objectifs, ainsi que les moyens de préserver les données de physique des hautes énergies.

Cristinel Diaconu, *CPP Marseille and DESY Hamburg, and* **David South**, *Technische Universität Dortmund.*

Happy 20th birthda

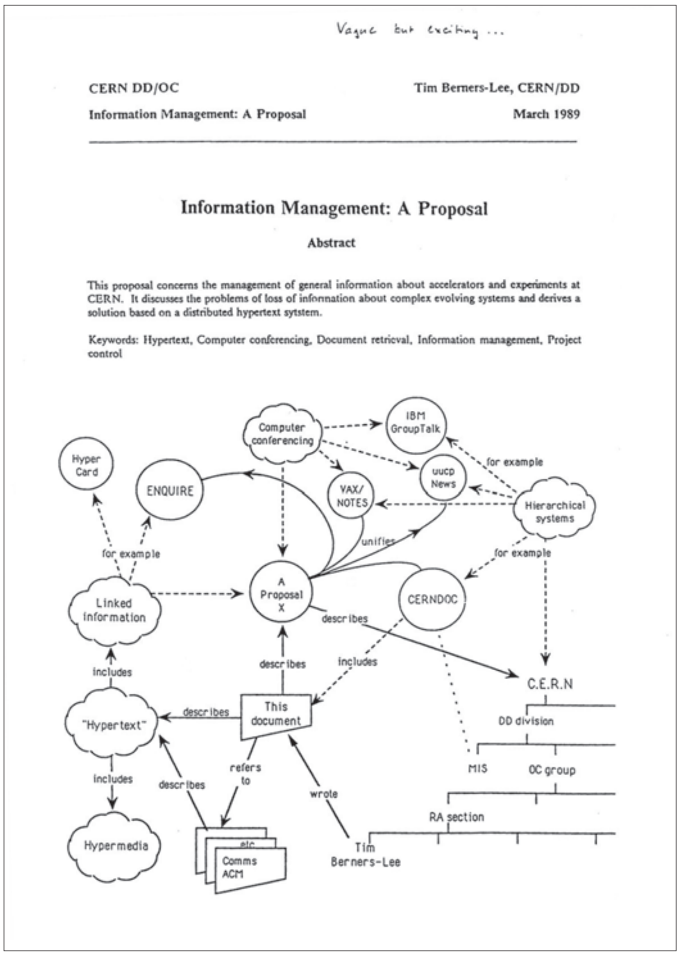
Twenty years ago something happened at CERN that changed the world forever.

In March 1989 Tim Berners-Lee, a physicist at CERN, handed a document entitled "Information management: a proposal" to his supervisor Mike Sendall. "Vague, but exciting", were the words that Sendall wrote on the proposal, allowing Berners-Lee to continue with the project. Both were unaware that it would evolve into one of the most important communication tools ever created.

Berners-Lee returned to CERN on 13 March this year to celebrate the 20th anniversary of the birth of the World Wide Web. He was joined by several web pioneers, including Robert Cailliau and Jean-François Groff, who worked with Berners-Lee in the early days of the project, and Ben Segal, the person who brought the internet to CERN. In between reminiscing about life at CERN and the early years of the web, the four gave a demonstration of the first ever web browser running on the very same NeXT computer on which Berners-Lee wrote the original browser and server software.

The event was not only about the history of the web; it also included a short keynote speech from Berners-Lee, which was followed by a panel discussion on the future of the web. The panel members were contemporary experts who Berners-Lee believes are currently working with the web in an exciting way.

Berners-Lee's original 1989 proposal showed how information could easily be transferred over the internet by using hypertext, the now familiar point-and-click system of navigating through information pages. The following year, Cailliau, a systems engineer, joined the project and soon became its number-one advocate.


Vague but exciting ...

CERN DD/OC — Tim Berners-Lee, CERN/DD

Information Management: A Proposal — March 1989

Information Management: A Proposal

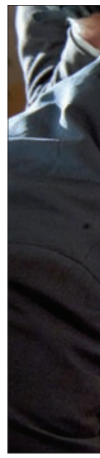
Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext sytstem.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control

The first page of Berners-Lee's 1989 proposal for the World Wide Web.

The panel … right: Chri… Brickley a…



Tim Berne… and run th…

The birth of the web

Berners-Lee's idea was to bring together hypertext with the internet and personal computers, thereby having a single information network to help CERN physicists to share all of the computer-stored information not only at the laboratory but around the world. Hypertext would enable users to browse easily between documents on web pages that use links. Berners-Lee went on to produce a browser-editor with the goal of developing a tool to make a creative space to share and edit information and build a common hypertext. What should they call this new browser? "The Mine of Information"? "The Information Mesh"? When they settled on a name in May 1990 – before even the first piece of code had been written – it was Tim who suggested "the World Wide Web", or "WWW".

Development work began in earnest using NeXT computers delivered to CERN in September 1990. Info.cern.ch was the address of the world's first web site and web server, which was running on one NeXT computer by Christmas of 1990. The first web-page address was http://info.cern.ch/hypertext/WWW/TheProject.html, which gave information about the WWW project. Visitors to the pages could learn more about hypertext, technical details for creating their own web page and an explanation on how to search the web for information.

To allow the web to extend, Berners-Lee's team needed to distribute server and browser software. The NeXT systems, however, were far more advanced than the computers that many other people had at their disposal, so they set to work on a far less sophisticated piece of software for distribution. By the spring of 1991, testing was under way on a universal line-mode browser, created by Nicola Pellow, a technical student. The browser was designed to run on any computer or terminal and worked using a simple menu with numbers to provide the links. There was no mouse and no graphics, just plain text, but it allowed anyone with an internet connection to access the information on the web.

Servers began to appear in other institutions across Europe throughout 1991 and by December the first server outside the continent was installed in the US at the Stanford Linear Accelerator Center (SLAC). By November 1992 there were 26 servers in the world and by October 1993 the number had increased to more than 200 known web servers. In February 1993 the National Center for

ay, World Wide Web

anel discussion, "The Future of the Web", with left to Chris Bizer, Tom Scott, Tim Berners-Lee, Dan ey and Stephane Boyera.

Robert Cailliau talks of the early days of the web at CERN and the key role played by the late Mike Sendall.

erners-Lee reunited with the historic NeXT computer that he used in 1990 to develop n the first web server, multimedia browser and web editor.

Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign released the first version of Mosaic, which made the web easily available to ordinary PC and Macintosh computers.

The rest, as they say, is history. Although the web began as a tool to aid particle physicists, today it is used in countless ways by the global community. Today the primary purpose of household computers is not to compute but "to go on the web".

Berners-Lee left CERN in 1994 to run the World Wide Web Consortium (W3C) at the Massachusetts Institute of Technology and help to develop guidelines to ensure long-term growth of the web. So what predictions do Berners-Lee and the W3C have for the future of the web? What might it look like at the age of 30?

In his talk at the WWW@20 celebrations Berners-Lee outlined his hopes and expectations for the future: "There are currently roughly the same number of web pages as there are neurons in the human brain". The difference, he went on to say, is that the number of web pages increases as the web grows older.

One important future development is the "Semantic Web" – a place where machines can do all of the tedious work. The concept is to create a web where machines can interpret pages like humans. It will be a "move from using a search engine to an answer engine," explains Christian Bizer of the web-based system groups at Freie Universität Berlin. "When I search the web I don't want to find documents, I want to find answers to my questions!" he says. If a search engine can understand a web page then it can pick out the exact answer to a question, rather than simply presenting you with a list of web pages.

As Berners-Lee put it: "The Semantic Web is a web of data. There is a lot of data that we all use every day, and it's not part of the web. For example, I can see my bank statements on the web, and my photographs, and I can see my appointments in a calendar, but can I see my photos in a calendar to see what I was doing when I took them? Can I see bank-statement lines in a calendar? Why not? Because we don't have a web of data. Because data is controlled by applications, and each application keeps it to itself."

"Device independence" is a move towards a greater variety of equipment that can connect to the web. Only a few years ago, virtually the only way to access the web was through a PC or workstation. Now, mobile handsets, smart phones, PDAs, interactive television systems, voice-response systems, kiosks and even some domestic appliances can access the web.

The mobile web is one of the fastest-developing areas of web use. Already, more global web browsing is done on hand-held devices, like mobile phones, than on laptops. It is especially important in developing countries, where landlines and broadband are still rare. For example, African fishermen are using the web on old mobile phones to check the market price of fish to make sure that they arrive at the best port to sell their daily catch. The W3C is trying to create standards for browsing the web on phones and to encourage people to make the web more accessible to everyone in the world.

● The full-length webcast of the WWW@20 event is available at http://cdsweb.cern.ch/record/1167328?ln=en.

Résumé

Le web fête ses 20 ans

En mars 1989, Tim Berners-Lee, physicien au CERN, remettait à son superviseur Mike Sendall une proposition concernant la gestion de l'information. « Vague, mais prometteur », tel était le commentaire écrit par Sendall sur ce document. C'est ainsi que Berners-Lee a pu poursuivre la mise au point de ce projet. Il était bien loin à l'époque de penser qu'il était en train de créer un outil de communication révolutionnaire. Berners-Lee est revenu au CERN le 13 mars dernier, pour célébrer les 20 ans du web. Après le discours de Tim Berners-Lee, les participants ont pu voir une démonstration du tout premier navigateur web et participer à une table ronde sur l'avenir du web.

Christine Sutton, *CERN.*

SAES® Getters' advanced getter technology is adopted for the Karlsruhe Tritium Neutrino experiment (KATRIN)

The KATRIN experiment, resulting from the joint work of several European and US Institutions, is a next generation beta-decay experiment designed to measure the electron neutrino mass with a sensitivity of 0.2 eV [1]. This ambitious project is located at the Forschungszentrum Karlsruhe (FZK) Institution and improves on the size and precision of previous experiments by an order of magnitude. The KATRIN project is extremely demanding regarding the vacuum requirement, with the largest vessel being the 200 Ton main Spectrometer with a volume of $1250 m^3$ that has to be maintained at pressures below $\approx 10^{-11}$ mbar [2]. Figure 1 shows arrival of the main Spectrometer at FZK – photo courtesy of KATRIN [3].

Fig. 1. KATRIN main Spectrometer in transit to Karlsruhe

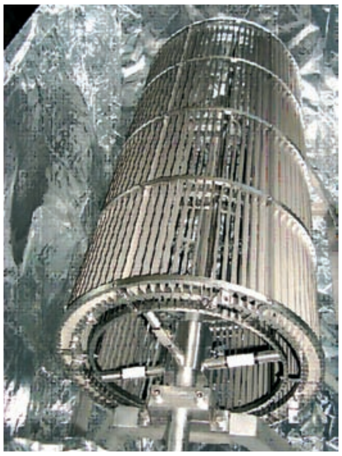


Fig. 2. "SAES NEG Pumps tailor-made for the pre-spectrometer"

To help meet this challenging pressure target SAES Getters has worked closely with KATRIN FZK scientists to provide several kilometers of non-evaporable Zr- V-Fe alloy getter strips (a specifically modified version of the St707 type) which were integrated into cylindrical cartridges (Figure 2 – courtesy of KATRIN [2]).

These cartridges have been designed and optimized for sticking probability and interference effects using Monte Carlo simulation techniques, and have resulted in a pump utilizing 1km of St707 strip that provides a pumping speed of ~300 m^3s^{-1} for H_2 at 15°C [1].

Non Evaporable Getter (NEG) materials are well known in vacuum technology to be an effective means of removing molecules through the process of chemisorption on the getters' active surface, and also for providing high sorption capacity through thermally driven diffusion of the sorbed gas into the getter bulk. The getter material is carefully prepared by SAES in the form of sintered bodies or, as in the case of the KATRIN experiment, laminated getter strip.

SAES® Getters Group, the worldwide market leader in getter components for sealed-off devices and vacuum tubes, provides a wide range of Non Evaporable Getter (NEG) pumps and tailor-made NEG pump devices for supporting UHV-XHV applications.

Further details on SAES Getters products are available via the SAES Getters website and through local SAES Getters Group Sales Offices.

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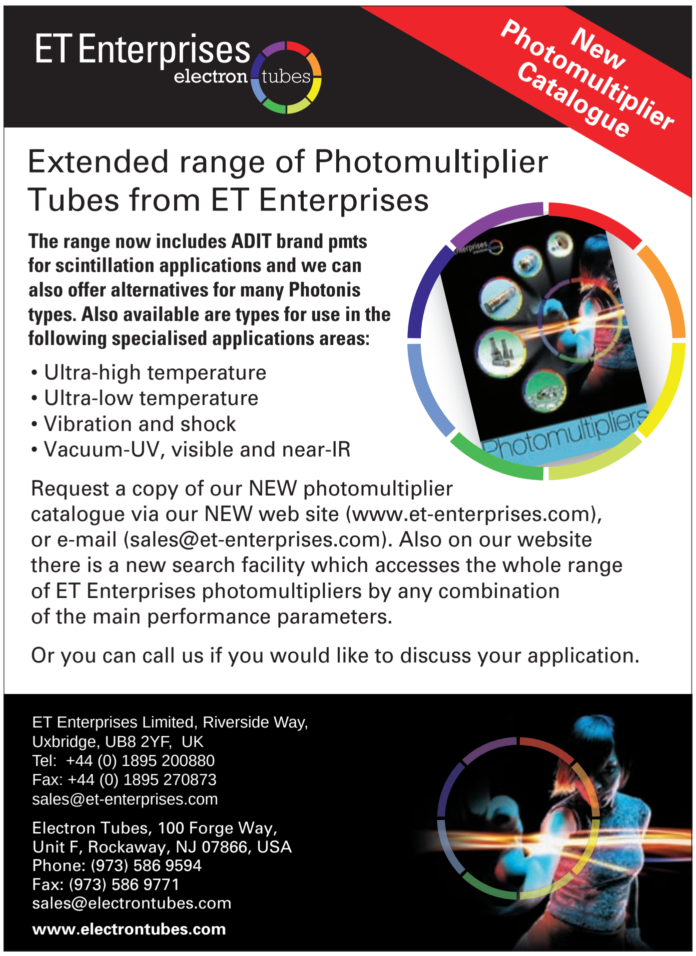


Nara workshop looks at heavy quarkonia

Physicists from many universities and research centres met in the ancient Japanese imperial city of Nara to discuss the latest progress in understanding the physics of heavy quarkonia.

The 6th International Workshop on Heavy Quarkonia took place in Nara in December 2008, attracting some 100 participants. It was the latest in a series organized by the Quarkonium Working Group (QWG), a collaboration of theorists and experimentalists particularly interested in research related to the physics of quarkonia – bound states of heavy quark–antiquark pairs (*CERN Courier* January/February 2008 p7; Brambilla *et al.* 2004). The talks and discussions in three round tables emphasized the latest advances in the understanding of quarkonium production, the discovery of the η_b, the properties of the X, Y and Z narrow resonances, as well as the use of quarkonium states as probes of the QCD matter formed in high-energy nuclear collisions. The meeting ended with a series of talks about how the Antiproton Annihilations at Darmstadt ($\overline{\text{P}}$ANDA) experiment and the LHC experiments should improve and complement present knowledge.

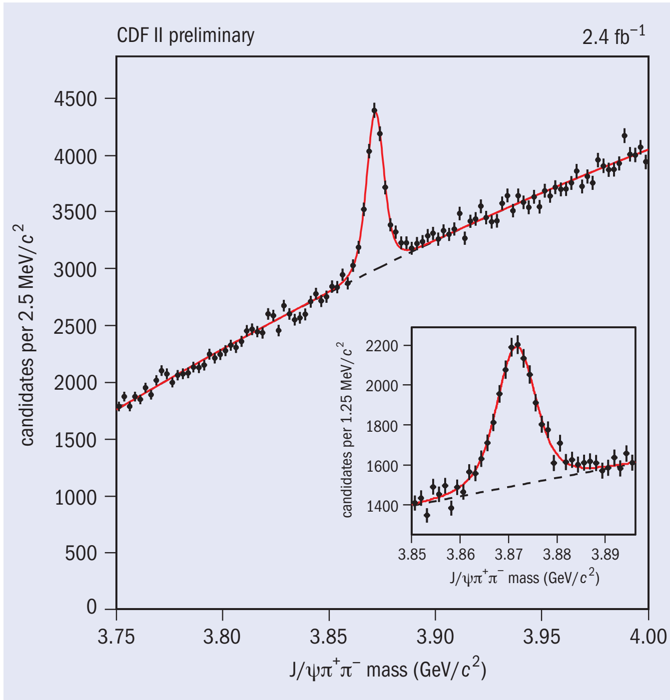


Fig. 1. CDF's $J/\psi\pi^+\pi^-$ invariant mass distribution, showing the very prominent X(3872) resonance.

New states

The nature and properties of the X, Y and Z narrow resonances, recently discovered in B-factories (and thought to be quarkonium states), were extensively discussed at the workshop. Presentations from the Belle, BaBar and CDF collaborations provided new information on the masses, branching ratios, quantum numbers and production properties of these particles. Using approximately 6000 signal events in $J/\psi \to \pi^+\pi^-$ decays, CDF obtained the most precise determination of the X(3872) mass: 3871.61±0.16(stat.) ±0.19(syst.) MeV/c^2, a value extremely close to the $D^0\bar{D}^{*0}$ mass threshold, 3871.8±0.36 MeV/c^2 (figure 1). Given present uncertainties, the interpretation of the X(3872) as a "molecular" $D^0\bar{D}^{*0}$ bound state remains possible but not compulsory. In addition the CDF collaboration reported a very accurate mass measurement for the $B_c^\pm$ of 6275.6±2.9(stat.) ±2.5(syst.) MeV/c^2, obtained by studying the mass spectrum of $B_c^+ \to J/\psi\pi^+$ decays (and the charge conjugates). The CDF and D0 experiments also measured the B_c lifetime, through the study of semileptonic decays. The measurements are of comparable precision, leading to a world average lifetime of 0.459±0.037 ps for the only observed charged quarkonium.

Another hot topic was the BaBar experiment's discovery of the long-sought-after bottomonium ground state, the η_b. On the basis of a record amount of event samples collected early in 2008 (more than two hundred million Υ(2S) and Υ(3S) events), the BaBar collaboration announced in July the observation of the η_b in the rare magnetic-dipole transition $\Upsilon(3S) \to \gamma\eta_b$ (*CERN Courier* September 2008 p6). At the Nara workshop, BaBar showed preliminary evidence for the $\Upsilon(2S) \to \gamma\eta_b$ decay, which confirms the earlier observation (figure 2). The measured mass for the η_b is $71.4^{+2.3}_{-3.1}$(stat.) ±2.7(syst.) MeV smaller than the Υ(1S) mass. This mass difference is almost twice the value calculated in perturbative QCD, 39±11(theor.)$^{+9}_{-8}(\delta\alpha_s)$ MeV, hence challenging the expectation that non-perturbative corrections should be only a few million electron-volts.

The Belle collaboration reported an improved measurement of the inclusive cross-section for the production of a J/ψ meson plus additional charmed particles. The new result is around 15% lower ▷

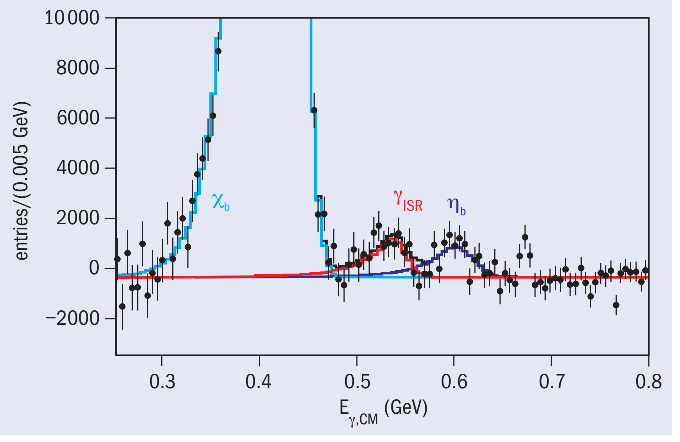


Fig. 2. BaBar's inclusive photon spectrum from Υ(2S) decays, showing evidence of η_b production in Υ(2S) → $\gamma\eta_b$ decays.

QWG participants gather in the sunshine to pose for the traditional group photo during the meeting in Nara. (Courtesy Kenkichi Miyabayashi.)

than their previous value and, in combination with a new calculation of next-to-leading-order (NLO) corrections, brings theory and experiment into reasonable agreement – albeit with large uncertainties – potentially solving a long-standing quarkonium-production puzzle.

The workshop also heard about new calculations of NLO corrections to the colour-singlet quarkonium-production mechanism, which confirm that the ratio between the colour-singlet and colour-octet production rates is larger than previously thought. The same calculations predict that J/ψs produced via the colour-singlet mechanism should exhibit a stronger longitudinal polarization in the helicity frame than is observed in the data from CDF. In the case of J/ψ photoproduction, new NLO calculations of the colour-singlet contribution fail to reproduce the polarization measurements made at HERA. If it turns out that feed-down effects do not modify the observed polarizations significantly then these discrepancies might indicate that a colour-octet contribution is required to bring the polarization predictions and experiment into agreement. There was also a discussion on the consistency of the measurements of the J/ψ polarization by the E866, HERA-B and CDF experiments. The seemingly contradictory data sets are surprisingly well reproduced if one models the polarization along the direction of relative motion of the colliding partons by assuming that, for directly produced J/ψs, it changes continuously from fully longitudinal at low total momentum to fully transverse at asymptotically high total momentum.

Heavy ions

Another interesting line of research in the QWG's activities has to do with the use of heavy-quarkonium states as particularly informative probes of the properties of the high-density QCD matter produced in high-energy heavy-ion collisions. Contrary to early expectations, however, currently available J/ψ suppression measurements cannot be seen as "smoking-gun signatures" that would show beyond reasonable doubt the creation of a deconfined state of quarks and gluons. Indeed, the present experimental picture is blurred by several "cold nuclear matter" effects, including shadowing of the parton densities, final-state nuclear absorption of fully formed charmonium states (or of pre-resonances) and initial-state parton-energy loss. Furthermore, there needs to be a careful evaluation of feed-down contributions to the production yields of the J/ψs (and their own "melting" patterns). Presentations in Nara showed recent progress in the understanding of these topics and there were detailed discussions concerning the quarkonium properties in finite-temperature QCD. Future measurements of the Υ family at the LHC should open a better window into this interesting landscape.

The next International Workshop on Heavy Quarkonia will take place at Fermilab in May 2010. Meanwhile, quarkonium aficionados are eagerly awaiting the first results from the LHC. More than 30 years after the serving of the charmonium and bottomonium families as revolutionary entrées, quarkonium physics remains high in the menus of many physicists, providing a *table d'hôte* where to test the properties of perturbative and non-perturbative QCD and validate the continually improving computational tools. Sprinkled with enough puzzles to spice up the meal, quarkonium physics will continue to please the most discerning appetites for years to come.

Further reading

For more about the Nara workshop, see http://www-conf.kek.jp/qwg08/.

N Brambilla *et al.* 2004, http://arxiv.org/abs/hep-ph/0412158.

Résumé

Atelier sur la physique des quarkoniums lourds à Nara

Le 6e séminaire international sur les quarkoniums lourds, qui a eu lieu à Nara en décembre 2008, a rassemblé quelque 100 participants. Ces séminaires sont organisés par le groupe de travail sur les quarkoniums (QWG), une collaboration de théoriciens et d'expérimentateurs qui s'intéressent particulièrement à la recherche dans le domaine de la physique des quarkoniums – les états liés des paires quarks anti-quarks lourds. Il a été question lors de ce séminaire des dernières avancées concernant le mécanisme de production des quarkoniums, de la découverte du η_b, des propriétés des résonances étroites X, Y et Z et de l'utilisation des états quarkoniums pour sonder la matière CDQ formée dans les collisions de noyaux de haute énergie.

Carlos Lourenço, *CERN*, **Claudia Patrignani**, *Genova*, **Geoff Bodwin**, *Argonne National Laboratory*, **Roberto Mussa**, *INFN-Torino and* **Vaia Papadimitriou**, *Fermilab, for the QWG.*

Peter Jenni (right) in the ATLAS cavern together with, from left to right, Fabiola Gianotti, Markus Nordberg, Marzio Nessi and Steinar Stapnes.

ATLAS makes a smooth changeover at the top

The ATLAS collaboration is experiencing the first major change of spokesperson since it began. As Fabiola Gianotti takes over from Peter Jenni, they spoke to **Antonella Del Rosso** about being at the helm of one of the world's largest particle-physics collaborations.

If you think that it might be time to retire after more than 15 years of leading a constantly growing international collaboration and of constructing the world's largest-volume particle detector, then Peter Jenni would disagree. Nicknamed the "father of ATLAS" by his colleagues, Jenni was there in 1992 when the ATLAS collaboration was born out of two early proto-collaborations (*CERN Courier* October 2008 p42). Initially co-spokesperson, he was spokesperson from 1995 until March 2009, when he handed over to Fabiola Gianotti. Now he looks forward to getting back to the main purpose of ATLAS: the physics.

"I am very proud to have helped the collaboration to construct ATLAS. Twenty years ago we could only imagine the experiment in our dreams and now it exists," says Jenni. "I could lead the collaboration for so long because I was supported by very good ATLAS management teams where the right people, such as Fabiola Gianotti, Steinar Stapnes, Marzio Nessi and Markus Nordberg over the past five years, were in the right places."

As with most particle-physics experiments, the management of one of the two largest detectors at the LHC is a challenge that changes during the lifetime of the collaboration: it starts with the design phase, continues with the R&D and the construction and ends up with the data-taking and analysis. "Over the years I tried to balance the emphasis given by the collaboration to the different aspects, that is, the hardware part (initially very strong), the data preparation, computing and software," confirms Jenni.

Originally "only" about 800-strong, the ATLAS collaboration today has almost 3000 members from all over the world. "Keeping the groups united, inviting new groups to join the collaboration, negotiating to find the funds necessary for the construction... these have been among my key tasks during the past 15 years," he explains. "My efforts also went into keeping groups whose technologies were not retained in the collaboration. Most of the time we managed to have everyone accept the best arguments, but unfortunately there were a few exceptions."

With such a vast amount of experience, what does Jenni regard ▷

as the key element for managing a successful collaboration? "Talking with as many people as possible is a key factor," he says. "ATLAS members, even the youngest ones, knew that I was available to discuss all problems or issues at any time. With the exception of the Christmas period, I have tried to reply to all e-mails within 24 hours. By the way, that is why my son thinks physics is crazy and decided to study microtechnologies instead!"

While Jenni's functions have changed, his engagement with ATLAS definitely has not. "A significant part of my work remains the same, particularly in the relationships of ATLAS with the outside world. My main duty is to help obtain a smooth transition, which is facilitated by the fact that Fabiola was one of my two deputies – and I have enjoyed working with her before." Indeed, having more freedom now, he can think of doing more than just sharing some management duties. "In the medium term I have the ambition to study physics with ATLAS," he says. "I am already 'selling' LHC physics in many public talks but I would like to contribute some real physics myself."

The ATLAS collaboration is clearly appreciative of its father's dedication over the years. At the party organized in Jenni's honour on 19 February, the Collaboration Board (CB) chairs directed by Katie McAlpine – the author and singer of the LHC rap (*CERN Courier* December 2008 p25) – sang: *"We've been CB chairs/and we're here to affirm /Peter's time was more an era/ than just a few terms/ leading ATLAS to completion/ like no one else can/ Of course he did it/ Jenni is the man."*

The changeover

Now with the construction complete, it's Gianotti's turn to fill the spokesperson's many shoes, after Jenni passed her the leadership baton in March. At the very beginning she joined LHC R&D activities and then the proto-ATLAS collaboration in 1990. "Heading such an ambitious scientific project, and a large and geographically distributed collaboration, is certainly a big honour, responsibility and challenge," she says. "However, I have inherited a very healthy situation from Peter: the experiment has already shown that it performs well, the collaboration is united and strong, and we can continue to prepare for the first collisions without any major worry."

Indeed, activity on ATLAS hasn't stopped since the LHC incident on 19 September 2008 (*CERN Courier* November 2008 p5). "The first single beams that circulated in the machine before the incident were very useful for studying several aspects of the experiment, such as the timing of the trigger system. After the LHC stopped, we decided to focus on some repairs to the detector and on the optimization of the software and computing infrastructure, of the data distribution chain, and of the event simulation and reconstruction," confirms Gianotti.

An effective distribution of data to the worldwide community is a key point for the new ATLAS spokesperson because she thinks that this is the prime requisite for a motivated and successful collaboration. "The crucial challenge for me is to make sure that each single member of ATLAS can participate effectively and successfully in the adventure that this experiment represents. ATLAS has a very exciting future ahead, with many possible discoveries that will change the landscape of high-energy physics. I consider it very important that each individual in this experiment can actively participate in the data analysis, regardless of whether he or she can physically be at CERN or not. In particular, we have to make sure the younger generations are nurtured in a stimulating environment, share the excitement for the wonderful physics opportunities and are given visibility and recognition," she explains.

While the sharing of data relies mostly on the performance of the Grid and the software and computing infrastructure put in place by the collaboration, it cannot occur without the other side of the coin – effective and open communication in real-time with all members of the collaboration. "The solution we have envisaged is a web space where ATLAS people will be able to find updated 'on-line' news about the machine, the experiment, the physics results, anything that is relevant to ATLAS' life," explains Gianotti.

Asked about the potential "competition" among many people working on the same analysis, she says: "I think it is healthy that people from different groups work on the same topic with a collaborative and constructive spirit. This will allow us to produce solid, verified and fully understood results." Regarding the relationship with CMS, the other general-purpose LHC experiment, she says, "There is a healthy competition, but also collaboration. For instance, ATLAS and CMS have set up a common group that works on statistics tools and how to combine the information coming from both experiments."

The excitement about the restart of the LHC is growing again at CERN and around the world, and the experiments all have their own plans and strategies. "Before undertaking the path towards discoveries, we will need to understand the performance of our detector in all details and 'rediscover' the Standard Model," says Gianotti. "I believe that we will be ready to start investigating new territories when we have observed top-quark production. Indeed, final states arising from the production of top quark–antiquark pairs contain most of the interesting physics objects, from leptons to missing energy and light- and heavy-flavour jets. In addition, this process is the main background to many searches for new physics. Being able to reconstruct these events successfully, and perform our first measurements of the top production cross-section and mass, will give us a clear indication that we are ready for discoveries."

When does Gianotti expect ATLAS to release the first results? "It all depends on the performance of the machine – and its luminosity and energy profile. If everything goes well we expect to have first results, mainly addressing the detector performance, for the winter physics conferences early in 2010; then we hope to present the first interesting physics results at the summer conferences of the same year."

Résumé

Transition en douceur à la tête d'ATLAS

Pour la première fois depuis sa naissance par fusion de deux proto-collaborations, en 1992, ATLAS a changé de porte-parole. Peter Jenni a assumé cette fonction jusqu'en mars 2009 et Fabiola Gianotti a maintenant pris sa succession. La collaboration est passée de 800 à près de 3000 membres. Si Peter Jenni a suivi la conception et la construction du détecteur ATLAS jusqu'au démarrage du LHC, Fabiola Gianotti conduira la collaboration à ses premières acquisitions de données et analyses de physique. Ils s'entretiennent ici avec Antonella Del Rosso de leur rôle à la tête de la plus grande collaboration de physique des particules du monde.

Antonella del Rosso, *CERN.*

LABORATORIES

Wagner hands Dosch the baton at DESY

At a ceremony on 2 March, the outgoing DESY director Albrecht Wagner passed a symbolic baton to his successor, Helmut Dosch (*CERN Courier* December 2008 p33). The event took place in the facility's oldest experimental hall, attended by some 900 members of staff, and doubled as the opening in a series of celebrations marking the laboratory's 50th anniversary this year.

The ceremony began with speeches by representatives of the German research ministry, Bärbel Brumme-Bothe, the City of Hamburg, Rolf Greve, and the German federal state of Brandenburg, Josef Glombik, as well as chair of DESY's Extended Scientific Council, Metin Tolan, and scientific director at GSI in Darmstadt, Horst Stöcker. Wagner then spoke reflectively about the 50 successful years of DESY's history before handing a baton over to Dosch as a symbolic gesture. Dosch then presented his vision for the future of the laboratory.

To mark the start of the 50th anniversary year celebration all of the DESY directors lent a hand in officially unveiling the newly designed "DESY 50" logo. Finally, Dosch and Wagner tapped a beer keg and officially opened the night's celebration party.

Dosch, right, takes the baton from Wagner at the ceremony at DESY. (Courtesy DESY Hamburg.)

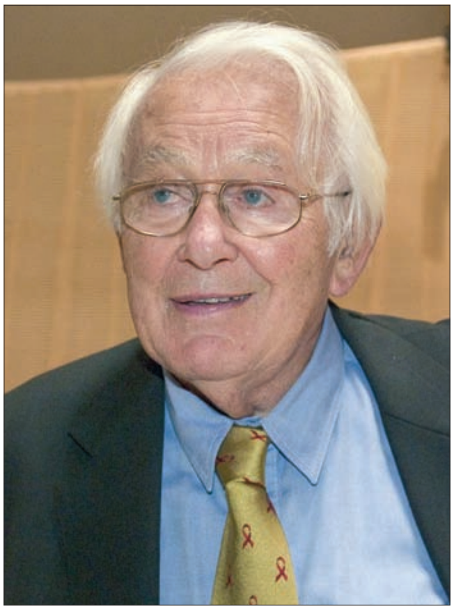
A list of the official events that are planned to celebrate DESY's 50th anniversary can be found at http://zms.desy.de/news/e39081/index_eng.html.

CELEBRATION

CERN honours Charpak's 85th birthday

On 9 March CERN's main auditorium was the venue for a fascinating and moving celebration that marked the 85th birthday of Georges Charpak, who was awarded the Nobel Prize in Physics in 1992 for his invention and development of particle detectors, in particular the multiwire proportional chamber.

Introducing the colloquium CERN's director-general, Rolf Heuer, paid an emphatic tribute to Charpak's work in education. Charpak then gave a 20 minute speech via video conference from his home in Paris. "Dear friends," he began. "Thank you for this unusual celebration. This is the first time that my birthday has been officially celebrated on the correct day". Although his date of birth was recorded as 1 August 1924, Charpak was actually born on 8 March. He went on to speak about his life, including his birth in a village in what is now the Ukraine, his emigration to France at the age of seven, his service in the resistance, his imprisonment in a concentration camp, his enthusiastic discovery of physics and his arrival at CERN. "CERN was a wonderful place. I was able to conduct science in total liberty over several decades," he said.



Georges Charpak, now 85, at CERN in 2005.

Charpak also spoke about his contribution to developments in the field of detectors for medical imaging and his involvement in education initiatives, the most well known of which is "La Main à la Pâte", a programme that helps schoolchildren to learn about science through simple experiments (*CERN Courier* March 2009 p24). Charpak's speech was followed at CERN by a presentation of his work by former colleague Ioanis Giomataris of CEA-Saclay.

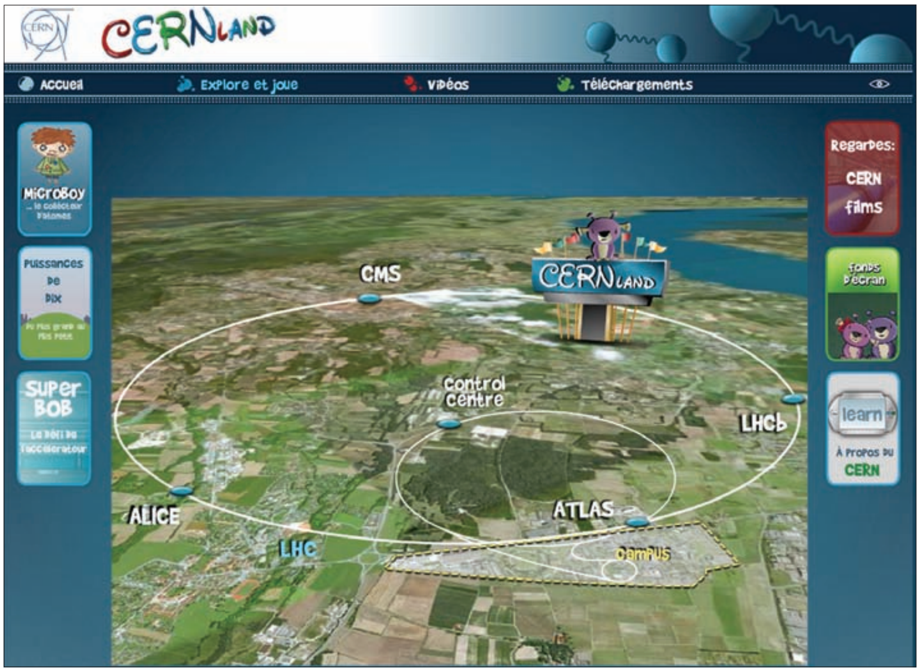
● For the webcast of the entire colloquium, see http://cdsweb.cern.ch/record/1165736/.

OUTREACH

CERNland: a new virtual theme park

The celebrations for the 20th anniversary of the World Wide Web (p24) saw the public release of a new website for young people: *CERNland* has been developed to bring the excitement of CERN's research to a young audience aged between 7 and 12 with a range of films, games and multimedia applications.

CERNland is designed to teach children about CERN's research in an interactive way. It contains information about CERN, several videos and nine different games on themes as varied as the LHC, the CERN Control Centre, antimatter and even the restaurant. The main goal is to get children playing so that they will get to know about the research being done at CERN through the games and interactive activities. Users do not require any particle-physics expertise but those who click on the information links will be better placed to answer the questions and improve their scores. As with many real theme parks there is no real age limit to enjoying CERNland: anyone can follow SuperBob round the LHC or try building atoms by collecting electrons, protons and neutrons.



The CERNland website has plenty to attract the young and not-so young to the physics at CERN.

Young people are an important audience for CERN because there is an increasing demand for a physics-literate graduate population, which is being compounded with falling enrolment in physics courses at university level. CERNland aims to attract youngsters before they begin to make decisions that will influence their future career paths. The site has been developed with the help of professional educators and assisted by some of the young people in the age group that it has been designed to reach. Their input has been incorporated into the site's design.

"Society needs more physicists across a range of industries," said CERN's director-general Rolf Heuer at the launch, "and the way to attract young people into physics is to engage them early with the kind of discovery-science that we do here at CERN, addressing some of the most fundamental questions about our universe."

● To visit *CERNland*, see www.cern.ch/cernland.

NEW PRODUCTS

AMS Technologies has released new Cynergy3 stainless-steel float switches with two liquid-level switching positions or continuous output of 4–20 mA. The devices come in lengths from 10 cm to 3.5 m. The continuous-output devices span from 50 cm to 5 m and the output varies with the level in 10 steps within the span. For more details, tel +49 89 89 5770; e-mail salesinfo@ams.de; or see www.ams.de.

Berkeley Nucleonics Corporation has announced the 1035 areaSam for remote monitoring of radiation levels with isotopic identification of radionuclides. It provides simple identification data backed up by spectroscopic data and isotope-specific dose rates in real time. Firmware upgrades allow users to set up multiple e-mail addresses to receive ANSI N42.42-compliant reports. For more details contact Robert Coresetti, tel +1 800 234 7858 ext. 250; e-mail robert.corsetti@berkeleynucleonics.com; or see www.berkeleynucleonics.com.

Donaldson Advanced Filtration offers Tetratex ePTFE membrane to protect crystals in a wide range of scintillator applications. The membrane can play a significant role in the reflectance of crystals by decreasing voids as it is pushed on to the surface. It acts as a functional barrier and protective layer for sodium iodide, caesium iodide, alkali-halide and other hygroscopic crystal materials. For more details, tel +44 1942 711711; fax +44 1942 711571; e-mail advanced-filtration@donaldson.com or see www.donaldson.com.

Heason Technology has launched its new open frame X–Y table range with high-resolution ceramic motors from Nanomotion and super-compact optical encoders from Renishaw. The result is a large working aperture with positioning at better than 1 μm repeatability and 200 mm/s scanning. The first phase covers new models with X and Y travel of 50 mm, 100 mm and 200 mm. For more details contact Jon Howard, tel +44

ART AND SCIENCE

Peter Higgs, left, with John Ellis in front of Higgs' portrait. (Courtesy C Bennetts/Maverick Photo Agency.)

Higgs meets his likeness in Edinburgh

At a special event at the Informatics Forum of the University of Edinburgh on 2 March the principal, Tim O'Shea, unveiled a new portrait of Peter Higgs by the artist Ken Currier. Higgs is professor emeritus at Edinburgh, where he has been since he was appointed lecturer in 1960.

The event celebrated the work of Higgs, of "Higgs boson" fame, and the work of Ken Currie, one of Scotland's most influential artists. The portrait depicts the physicist in a contemplative mood, as scientists around the world are preparing to resume the search for the eponymous particle at the LHC.

There were also two talks at the event, one by Tom Normand, senior lecturer at the University of St Andrews on "Ken Currie – themes, subjects, and portraits 1985–2008". For the second talk, Richard Kenway, head of the School of Physics and Astronomy at Edinburgh, invited John Ellis of CERN to give the 2009 Robin Schlapp Lecture on "To Higgs or not to Higgs".

The night was made all the more special for Higgs by the presence of many of his friends and colleagues from the days of the Tait Institute of Mathematical Physics, where he did his pivotal work, as well as the current members of the particle-physics theory group.

LETTERS

The high-energy horizon

Further considerations suggest that we revise and expand the third paragraph of our article "The light-pulse horizon", where we addressed the particle-acceleration schemes using lasers (*CERN Courier* March 2009 p22).

Enrico Fermi contemplated a 1 PeV (10^9 MeV) accelerator girdling the Earth. While an energy of peta-electron-volts is in general held to be too ambitious for currently available technology, we see it on the horizon. Laser acceleration may allow us to reach this energy in a device with a size of the order of 1 km employing a sub-picosecond 15 MJ laser. On the way towards this goal, we can test the ultrahigh-gradient acceleration theory at 10 TeV, which we hope can be achieved with a laser of 15 kJ and a 50 fs pulse. Such an intense laser pulse is not yet available, but the proposed Extreme Light Infrastructure (ELI) should offer an opportunity to explore this physics. The peak power of ELI will be in the exawatt (10^{18} W) region– that is 100 000 times the power of the global electricity grid, albeit only over several femtoseconds.

Controlling a beam of even relatively few electrons at such energies may allow us to calibrate high-energy cosmic-ray detectors, study large Lorentz-contraction phenomena such as the Landau–Pomeranchuk–Migdal effect, and test fundamental laws in this new domain, including an exploration of the validity and limits of relativity itself.

Gérard Mourou, Johann Rafelski and Toshiki Tajima.

1403 755800; fax +44 1403 755810; e-mail jhoward@heason.com; or see heason.com.

HiTek Power has introduced the OLS10K family of 10 kW high-voltage power supplies for use in a range of ion and electron beam systems and other applications. The series has 40% lower volume than previous supplies, leading to lower weight and cost. Housed within a single 6U 19 inch rack-mounted chassis, the units are mains powered and provide a range of output voltages from 1 kV to 8 kV. Full remote control and monitoring is available. For more information contact Michelle Quiggan, tel +44 1903 712400; e-mail sales@hitekpower.com; or see www.hitekpower.com.

LG Motion Ltd has announced a new range of manual and motorized rotary stages with accuracy up to 0.1° and for loads up to 500 kg. The LGR range covers five models with outside diameter of 82–250 mm. The smaller stages include fine handwheel-driven adjustment with a vernier scale for positioning to within 6 arc-min and loads of up to 5 kg. For more details contact Gary Livingstone, tel +44 126 365600; fax +44 1256 365645; e-mail g.livingstone@lg-motion.co.uk; or see www.lg-motion.co.uk.

Maxon Motor AG has launched the EPOS2 Module 36/2, an OEM addition to the EPOS family of digital positioning controllers. The miniaturized plug-in module can operate in various modes within a CANopen network with USB or RS232 interfaces. The company has also unveiled the MILE encoder with a diameter of 6 mm. It delivers 64 pulses at up to 120 000 rpm and is suited to harsh environments. For more details tel +41 41 666 1500; fax +41 41 666 1650; or see www.maxonmotor.com.

Southern Scientific has introduced the FM 6150K, a new floor monitor for radioactive contamination, which is compact and easily manoeuvred. With a sealed proportional counting tube, it provides high efficiency for ^{90}Sr/^{90}Y and other alpha and beta emitters such as ^{241}Am, ^{60}Co and ^{137}Cs. A new decontamination gel is also available. DeconGel 1101 is a water-based, peelable hydrogel that can be applied to many surfaces. For more information see www.ssl.gb.com.

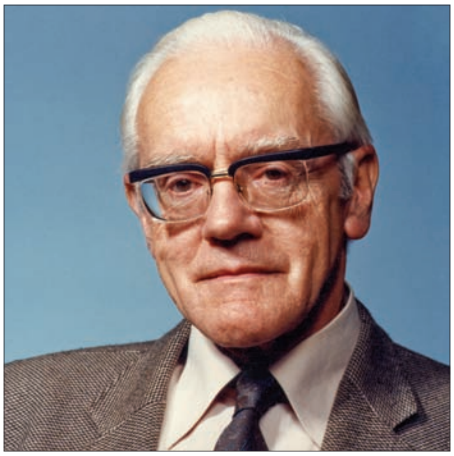
OBITUARIES

John Riley Holt 1918–2009

John Holt was an experimental physicist whose career started with small-scale bench-top experiments just after the discovery of nuclear fission and progressed to the large-scale experiments of today.

Holt came to Liverpool University's physics department in 1934 as a student aged 16; he graduated in 1938 and won the Oliver Lodge Prize for the best undergraduate student in his year. The department was propelled onto the world stage of physics with the arrival of James Chadwick in 1935, the year in which he won the Nobel Prize for his discovery of the neutron. Holt joined Chadwick as a graduate student and started work on studies of artificial radioactive isotopes. The studies changed direction abruptly at the beginning of the Second World War, when Otto Frisch and Rudolf Peierls surmised that a nuclear weapon could be created with a few kilograms of ^{235}U – rather than the tons referred to in Albert Einstein's famous letter to President Roosevelt in 1939. To verify the Frisch–Peierls calculations the rudimentary information available had to be improved. Liverpool, with its newly built cyclotron, became the centre for the necessary measurements and Holt became Frisch's assistant. The culmination of this work was the proof of the feasibility of the production of a nuclear weapon, paving the way for the Manhattan Project.

Holt made several significant discoveries during his career. He was the first to discover that the angular distributions of particles emitted in deuteron-stripping reactions could be used to deduce the orbital angular momentum of the higher energy levels of the final-state nucleus. The agreement of



John Holt. (Courtesy Liverpool University.)

these values with the predictions of the newly proposed shell model of the nucleus helped gain credence for the model. He also measured the helicity of the decay electrons and positrons from muon decay, firmly establishing the weak interaction as a vector and axial-vector interaction rather than as pseudoscalar-tensor, as thought at the time. Furthermore, his demonstration that the helicity of electrons from μ^- decay was opposite to that of positrons from μ^+ decay proved the violation of charge-conjugation invariance in weak decays. These facts are now taken for granted in the Standard Model.

High precision became bywords for Holt's later experiments, such as πp scattering at the 156 inch synchrocyclotron in Liverpool and a series of studies of π^0 and η photoproduction at the electron synchrotron NINA at the Daresbury Laboratory. In the *NINA scrapbook*, published to celebrate the synchrotron's 10th anniversary of the electron synchrotron, Sandy Donnachie wrote: "Holt's name has become synonymous with precision and accuracy". Holt had earlier been responsible for the design of the magnet system for NINA, which enabled the first direct extraction of a beam from such a machine.

Holt's final experiment was on deep-inelastic muon scattering in the European Muon Collaboration at CERN in the mid-1980s. His group developed a very large polarized target for experiments to study the spin of the proton in terms of the constituent quarks. The results obtained from these experiments showed that the proton's spin was not simply distributed among its quarks, overturning all of the preconceived ideas of the time. This led to an avalanche of theoretical papers and spawned a whole new series of experiments around the world.

Holt was elected to a Fellowship of the Royal Society in 1964. His deep understanding of the experimental method meant that his opinions were highly valued when important decisions were needed. He was keen to communicate his great enthusiasm for physics to people within and outside the academic world. He was kindly, unassuming and led by example, never seeking the limelight, preferring to work with colleagues young and old. In meetings he was a man of few words but every one counted. His main form of relaxation was gardening and he enjoyed collecting exotic shrubs and trees.

His wife Joan died in 2001 and he is survived by his sons David and Eric and grandsons Christopher and Timothy.

T Sloan, Lancaster University.

Daniel Morellet 1925–2009

Daniel Morellet nous a quittés le 4 mars dernier, dans sa quatre-vingt quatrième année. Il était entré en 1947 dans le Laboratoire du Professeur Louis Leprince-Ringuet à l'Ecole Polytechnique pour étudier les particules élémentaires. Les rayons cosmiques étaient alors l'unique source de particules de haute énergie et leurs propriétés devaient être observées avant que leur énergie ne soit dégradée par leur interaction avec les noyaux de l'atmosphère terrestre. Daniel Morellet fit partie du groupe qui utilisait des émulsions photographiques à la fois comme cible et comme détecteur et les exposait dans la stratosphère au moyen de ballons-sondes. Il était chargé de l'organisation du vol de ces ballons, ainsi que du développement, très délicat, des émulsions qui étaient ensuite observées au microscope pour détecter et mesurer les trajectoires des particules. Tout le groupe étudiait les mésons π, puis des mésons plus lourds – appelés 'étranges' à l'époque – et les hypérons après leur découverte.

Dès l'apparition des premiers accélérateurs, les émulsions comme les chambres de Wilson furent rapidement délaissées au profit de moyens de détection mieux adaptés et le laboratoire construisit des chambres à bulles pour ses premières expériences au PS du CERN. Daniel Morellet rejoignit alors le groupe des Chambres à Bulles à liquides lourds, dirigé par André Lagarrigue. Il étudia les problèmes de statistique liés aux mesures dans ces chambres et à la détermination des quantités physiques objet des expériences ; il s'attacha à définir les méthodes correctes et à les enseigner.

Quand, en 1964, André Lagarrigue fut nommé professeur à Orsay, Daniel Morellet le suivit avec la moitié du groupe et le seconda jusqu'à sa disparition. Il prit en charge l'installation au Laboratoire de l'Accélérateur Linéaire (LAL) puis la préparation des moyens d'analyse pour la grande chambre à bulles Gargamelle construite au CEA sous la direction d'André Lagarrigue. Il contribua à la grande et difficile aventure de l'étude des interactions des neutrinos qui déboucha sur la découverte des courants neutres, l'une des plus importantes découvertes de la physique des particules au siècle dernier.

Daniel Morellet. (Courtesy LAL.)

Au décès d'André Lagarrigue, il devint responsable du groupe 'Chambre à Bulles' puis sous-directeur du LAL et accompagna la réorientation de ses physiciens vers des expériences d'électronique sur les machines du CERN et de DESY. Sa charge principale fut alors de faire fonctionner les services du laboratoire pour assurer un soutien technique et administratif aux expériences. Il encouragea en particulier le développement de l'informatique au laboratoire et l'utilisation de la conception assistée par ordinateur pour l'électronique. Il s'acquitta de cette tâche souvent difficile avec beaucoup de dévouement, trouvant un dérivatif dans les cours de physique atomique et nucléaire qu'il donnait à l'Ecole Supérieure d'Electricité et surtout dans la poursuite de ses travaux sur le développement des gerbes électromagnétiques qui ont permis d'améliorer la qualité de la mesure des électrons dans tous les types de détecteurs

Ceux qui l'ont connu garderont le souvenir de la qualité de son accueil, de son humour, de son ouverture d'esprit et de son tempérament toujours égal. Il était attentif à tous les problèmes, petits ou grands, qui apparaissaient dans le laboratoire et il fit en sorte que chacun, chercheur ou technicien, trouve la place qui lui convenait et les moyens dont il avait besoin. Il fit beaucoup, souvent dans l'ombre, pour la réussite des expériences.
Ses collègues et amis.

Janusz Zakrzewski 1932–2008

Janusz Zakrzewski passed away on 26 October 2008 in Warsaw, Poland, after a long illness.

Zakrzewski studied physics at the University of Warsaw and obtained a PhD in physics at Bristol University in 1961. He was employed at the University of Warsaw from 1956 until his retirement in 2002. In the early stage of his career he was involved in emulsion studies of hypernuclei and participated in the discovery of heavy hypernuclei, as well as the first observation of a double hypernucleus in 1963. In the following years he was involved in K meson physics at the Rutherford High Energy Laboratory in the UK and in studies of interactions of high-energy hadrons with nuclei at Dubna and Serpukhov. In 1983/1984 he took part in the UA2 Collaboration at CERN.

He was an active member of the Polish physics community and a renowned academic. Always interested in teaching, he devoted much effort to the education of young physicists, which he regarded as important as scientific research. He had a natural ability for the clear expression of thoughts and his public appearances were always perfectly prepared. He is also a co-author (with A K Wróblewski) of a popular Polish student textbook on basic physics.

Janusz Zakrzewski. (Courtesy A Jagielska.)

Zakrzewski was an energetic proponent of co-operation between Polish and German universities and scientific institutions in the 1970s and 1980s, when Polish–German political relations were uneasy. His efforts resulted in a collaboration with DESY, which started with small-scale participation in the TASSO group and soon transformed into the full involvement of the Polish high-energy-physics community in the HERA project and the ZEUS and H1 experiments.

He was vice-rector of the University of Warsaw (1981–1982) and held functions at the Faculty of Physics. He was dean of the Faculty (1972–1975); and head of the High-Energy Physics Department (1971–1994). In 1976 he was elected member of the Polish Academy of Sciences. He was a member of the European Physical Society and received the society's Cecil Powell Medal in 1990. He was also president of the Polish Physical Society (1987–1991) and was honoured by the Marian Smoluchowski–Emil Warburg Medal of the Polish Physical Society–Deutsche Physikalische Gesellschaft in 2001.

Zakrzewski had many cultural interests including music, history and literature. He will be missed as a good friend, a passionate physicist, a person with a lively sense of humour and impeccable manners.
Jacek Ciborowski.

Anatoly Moskalev 1936–2009

Anatoly Nikolaevich Moskalev died on 18 January at the age of 73. He had suffered following a severe stroke five years ago.

For almost 50 years Moskalev contributed to various parts of physics including high-energy physics and physics of nuclei, but he is best known as one of the pioneers of the development of a specific branch of atomic physics: the investigation of parity-violating processes in atoms. This where the Standard Model of electroweak interactions, which was invented to describe what happens at energies of about 10^{11} eV, manifests itself in radiation from atoms that involves energies of about 10 eV. Work on this subject is still ongoing and several people who started their studies together with Moskalev at the Petersburg Nuclear Physics Institute continue their investigations in universities in the US, the UK and Australia.

In 1975, together with D A Varshalovich and V K Khersonsky, Moskalev published the monograph *Quantum theory of angular momentum*. It was translated into many languages and became widely known, providing the most complete coverage of the subject. It is remarkable that to this day only two misprints have been found in the book, which is mainly a reference book, containing many formulas and tables.

For many years Moskalev gave lectures on classical electrodynamics and later on relativistic quantum theory at the St Petersburg Polytechnical University. His students remember him as one of the most popular professors, whose lectures were clear and full of physics meaning. These lectures formed the book *Relativistic field theory*, published in Russian several years ago.

Anatoly Moskalev. (Courtesy PNPI Theory Dept.)

In the 1990s Moskalev held high positions in the administration of the Petersburg Nuclear Physics Institute – at the time of a deep crisis in the Russian economy, caused by the disintegration of the Soviet Union. Moskalev did his best to lessen the consequence of this crisis for the institute employees.

We shall remember him as a bright physicist, an excellent professor, a skilful administrator and simply a kind and friendly person.

His colleagues and friends.

MEETINGS

The **International Neutrino Summer School** (INSS09) will take place at Fermilab on 6–17 July at Fermilab. The summer school aims to cover the full breadth of neutrino physics and will present an opportunity for participants to concentrate on the many aspects of the field that the community will be addressing over the next few decades. It is aimed at advanced graduate students and recent post-docs. Young researchers, either currently engaged in neutrino physics, or those considering it, are encouraged to attend. The final deadline for registration is 30 April. For more information about the summer school and details of how to register, visit http://projects.fnal.gov/nuss/.

The **Fourth International Accelerator School for Linear Colliders** (2009 LC School) will be held on 7–18 September at Hotel Jixian, Huairou, near Beijing, under the auspices of the GDE, ILCSC and ICFA Beam Dynamics Panel and hosted by the Institute of High Energy Physics in Beijing. Topics will include an overview of TeV-scale future lepton colliders; accelerator physics for sources, damping rings, linacs and beam delivery systems; and superconducting and warm RF technology, LLRF and high-power RF.

The school will take a maximum of 70 students from around the world. Students will receive financial aid to cover airfare, lodging, meals and local transportation, full or partial. The deadline for registration is 1 June; only online applications will be accepted. For more information, visit www.linearcollider.org/school/2009/.

CLARIFICATION

Commenting on the small resistive zone in an LHC bus connection that led to the incident on 19 September 2008, a recent article (*CERN Courier* January/February p6) stated that "in less than a second the zone led to a resistive voltage of 1 V at 9 kA. The resistance was small – 200 nΩ – dissipating of the order of 10 W at high current intensity."

A quick application of Ohm's law suggests that these two statements are incompatible. What happened is that the resistance evolved with time as the current was ramped up. In tests on 15 September at 7 kA the resistance was indeed around 200 nΩ and had it stayed so small there would have been no incident.

However as the current was ramped up to 8.7 kA, localized heating increased the resistance, leading to thermal runaway. Dissipation was nearly 9 kW by the time that the detection threshold of 1 V was reached.

RECRUITMENT

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Max Planck Institute for Physics
(Werner Heisenberg Institute)

Tenure Track Position and Postdoctoral Position

Gamma-Ray Astrophysics (MAGIC and CTA)

The Max Planck Institute for Physics does fundamental research in particle and astroparticle physics from both an experimental and a theoretical perspective. Our research activities in astroparticle physics comprise participation in the gamma ray telescope MAGIC at the Roque de Los Muchachos Observatory at La Palma (Spain), the future space mission EUSO, and the CRESST dark matter search at Gran Sasso (Italy).

We invite applications for a postdoctoral position in high energy gamma ray astrophysics to strengthen our experimental astroparticle physics group. MAGIC is the world's largest single dish ground based Imaging Atmospheric Cherenkov telescope studying the deep universe with high energy gamma rays above 50 GeV. The scientific objectives are the study of high energy astronomical objects, e.g. AGNs, GRBs, Pulsars, and SNRs, and the investigation of fundamental physics. The first telescope has been in scientific operation since summer 2004. The second telescope is in its commissioning phase and will soon start full operation. Please see the MAGIC web site (http://www.magic.mppmu.mpg.de/). In parallel, the institute's experimental astroparticle physics group is heavily involved in the next generation project CTA (Cherenkov Telescope Array), which aims at a 10 times better sensitivity than that of currently working IACTs, and covers a wider energy range between a few 10s GeV and 100 TeV.

We are looking for a researcher for the tenure track position and a postdoctoral researcher who can contribute to the MAGIC experiment and also to the development of the next generation project CTA. Candidates with an experimental background in cosmic-ray physics, gamma-ray physics, or neighbouring fields, such as elementary particle physics and astrophysics, are invited to apply.

The tenure track position will become permanent after an evaluation period of three years, if the researcher successfully demonstrates his or her qualification and ability. The postdoctoral position is limited to a period of initially two years, with the possibility of an extension by up to four years. Salary and benefits are in accordance with the German public service pay scale (TVöD Bund). The Max Planck Society wishes to increase the participation of women wherever they are underrepresented; therefore, applications from women are particularly welcome. Following its commitment to an equal opportunities employment policy, the Max Planck Society also especially encourages handicapped persons to submit their applications.

For further information please contact Prof. Masahiro Teshima, e-mail: mteshima@mppmu.mpg.de Interested scientists should send their applications (referring to either tenure track or postdoctoral position) and including a CV, a list of publications and statement of research interest until May 31 2009, and arrange for two recommendation letters to be received by the same date at

Max Planck Institute for Physics
(Werner-Heisenberg-Institut)
Ms. Sybille Rodriguez
Föhringer Ring 6
80805 München, Germany
e-mail: rodi@mppmu.mpg.de

MAX-PLANCK-GESELLSCHAFT

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Professor of Experimental Particle Physics

The Department of Physics (www.phys.ethz.ch) at ETH Zurich invites applications for a professorship of Experimental Particle Physics. The candidate should have a strong research program in the field of experimental particle physics, with a focus on collider physics.

The Department offers a stimulating environment both in experimental and theoretical particle physics, with activities at the high energy frontier with the LHC at CERN, in accelerator-based neutrino physics, in Astro-Particle Physics with dark matter searches and gamma-ray astronomy, as well as in R & D for future detector technologies. These activities are complemented and supported by the presence of a strong theory group at the Department and of experimental and theoretical groups at the close-by Paul Scherrer Institute, PSI (www.psi.ch), which also hosts the CMS Tier-3 compu-ting centre for the CMS groups in the Zurich area.

The future professor will make leading contributions to the LHC physics exploitation, to the operation of the CMS detector and to its eventual upgrades. Teaching duties involve the physics curriculum at the undergraduate level and advanced courses in particle physics in the Master's program. He or she will be expected to teach undergraduate level courses (German and English) and graduate level courses (English).

The appointment will be at the Associate or Full Professor level.

Please submit your application together with a curriculum vitae, a list of publications, and a brief statement of present and future research interests **to the President of ETH Zurich, Prof. Dr. Ralph Eichler, Raemistrasse 101, 8092 Zurich, Switzerland, no later than June 30, 2009.** With a view toward increasing the number of female professors, ETH Zurich specifically encourages female candidates to apply.

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

Research Associate

The Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE) has an opening for a Research Associate to work on research and development for a broad range of topics involving RF superconductivity for particle accelerators.

Please provide an application and arrange to have at least three letters of reference sent to: Dr. Hasan Padamsee, Chair, Search Committee, Laboratory for Elementary-Particle Physics, Newman Laboratory, Cornell University, Ithaca, NY 14853 USA.

Applications should include a curriculum vita, publication list, summary of research experience and interests. Electronic to search@lepp.cornell.edu. For a complete description of the ad, please visit www.lepp.cornell.edu and click on Jobs.

Cornell is an equal-opportunity/affirmative action employer.

ADVERTISER'S INDEX

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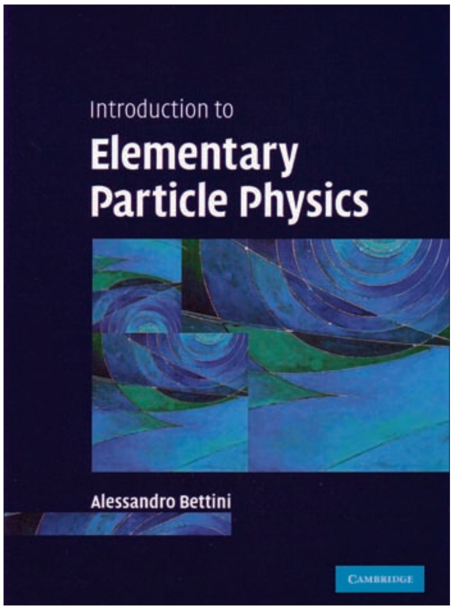
BOOKSHELF

Introduction to Elementary Particle Physics by Alessandro Bettini, Cambridge University Press. Hardback ISBN 9780521880213, £35 ($70). Also available in e-book format.



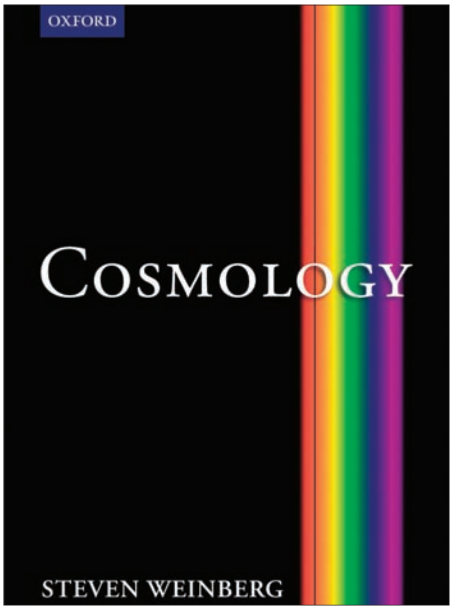
I was a graduate student when the first version of *Introduction to High Energy Physics* by Donald H Perkins appeared; the slim one with the plain grey cover, written before the discovery of charm. This book was a welcome sight to many of us "youngsters" because it contained a wealth of concentrated information so valuable to the budding experimentalist. The book began with a nice discussion of the passage of radiation through matter in a form that was not as dated or cumbersome as the two must-read classics by Bruno Rossi and Emilio Segrè. It was also sufficiently detailed to call upon as a ready reference for an upcoming oral exam. Since then, perhaps in part because I have lived through all subsequent discoveries in particle physics, I have not been impressed with any of the rather few particle-physics texts that have appeared; not, at least, until the publication of Alessandro Bettini's *Introduction to Elementary Particle Physics*. Like Perkins before him, Bettini's expertise as a careful, methodical and experienced experimentalist shines brightly throughout the text. The reader is never left in any doubt that physics is an experimental science.

The choice of topics and the level of detail are excellent and the explanations are clear. The book is rich in physics content, especially its emphasis of important concepts, including relativistic kinematics, the wave nature of particles and quantization of fields. Some of my favourite examples are determination of the spin and parity of the pion and why this is important, the Lamb shift in quantum electrodynamics and the discussion of α_s and the proton mass. The author is an expert in neutrino physics and this comes through in the material clearly. He does a good job of emphasizing the physics at an appropriate level without getting absorbed in the mathematics of Feynman diagrams, which belongs in a course on field theory. The text is sprinkled with a few historic gems, such as the story of Marty Block asking Dick Feynman who asked C-N Yang at the 1956 Rochester conference: "Is it possible to think that parity is not conserved?" The book is extremely well written, topically informative and easy to read – but best of all it is full of physics.

Bettini's text is suited for a one-semester introductory course in particle physics; the one I have taught at Boston University is attended by a mixture of beginning graduate students and advanced undergraduates. The text (431 pages) is organized into 10 chapters, which can be easily covered in 16 weeks. Each chapter contains a number of accessible and readable references, as well as a generous number of end-of-chapter problems. A complete instructors' solution manual is also available in electronic form.

After this well deserved praise, do I have any complaints? Sure, but they are relatively minor: the use of dashed lines instead of wavy lines for W and Z propagators; time not going "up" in Feynman diagrams; and Λ_{QCD} written unconventionally as λ_{QCD}. I would personally have introduced several aspects of the weak interaction much earlier, such as parity violation in beta decay, helicity in pion decay, and the discovery of the τ. I would also have covered deep-inelastic scattering before QCD and included more details on hadron jets, but these are largely personal choices. I was somewhat disappointed that a large number of complete solutions to end-of-chapter problems are available in the text, limiting what I could assign from the book as homework. The bottom line, however, is that as a particle physicist I enjoyed Bettini's book three times – not unlike a fine wine: the first time when admiring its contents; the second when reading it; and a third time when teaching from it. Bravo, Sandro!

James W Rohlf, Boston University.

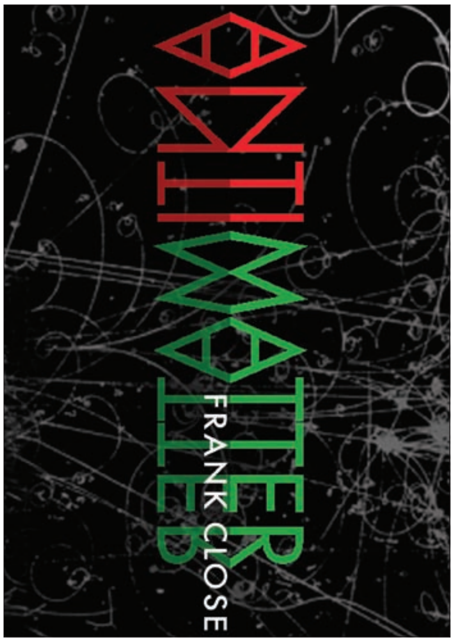


Cosmology by Steven Weinberg, Oxford University Press. Hardback ISBN 9780198526827, £45 ($90).

Those who think that a book on cosmology and gravitation overlaps with science fiction should probably not even try to flick through the latest treatise by Nobel laureate Steven Weinberg. Conversely, those who believe that gravitation, astrophysics and cosmology could offer fertile playgrounds for the analytical methods of theoretical physics will find in *Cosmology* a stimulating source of intellectual excitement. Finally, those who think that the physics of the early universe is a mere mathematical game with no observational relevance will also be disappointed, because observations play a central role in the book's nearly 600 pages.

On the 30th anniversary of the discovery of neutral currents by Gargamelle, a round-table discussion took place in the main auditorium of CERN (*CERN Courier* December 2003 p25). Various Nobel laureates, including Weinberg, were present. Some of the questions from the audience addressed the worries of the particle-physics community, always anxious about novelty and excitement; some of Weinberg's replies in that discussion reverberate in the preface of this book: "Today cosmology offers the excitement that particle physicists had experienced in the 1960s and 1970s".

The treatise consists of 10 chapters organized around the three observational pillars of the standard cosmological



paradigm, i.e. the physics of the cosmic microwave background (CMB), the analysis of supernova light-curves and the observations of large-scale structures. The first four chapters, following a didactical trail, cover the basic aspects of the standard paradigm, often dubbed the Λ_{CDM} scenario, where Λ stands for the dark-energy component and CDM refers to the cold dark-matter component. The remaining six chapters cover, with more theoretical emphasis, the description (chapter 5), the evolution (chapter 6), the effects (chapters 7, 8 and 9) and the normalization (chapter 10) of inhomogeneities in Friedmann–Robertson–Walker universes.

Readers will not find the usual pretty pictures and maps that often decorate cosmology books. Instead the author adapts the style of theoretical particle physics to cosmology and gravitation: solid, analytical calculations and semi-analytical estimates are preferred over fully numerical results. Analytical methods are implicitly viewed as a mandatory step for an effective comprehension of natural phenomena. The latter aspect is evident in the discussion of the anisotropies in the CMB, where the author exploits some of his own results that have appeared over the past five years in *Physical Review*. The book contains eight assorted appendices, which are useful for both newcomers and experienced readers. The notations used by the author are unusual at times but may quickly become a standard.

While the relevant technical aspects of the presentation can only be fully appreciated after a careful reading, a clear message emerges with vigour after the first reading: atomic physics, nuclear physics, field theory, high-energy physics and general relativity all come together in the description of our universe. In other words, *Cosmology* provides a vivid example of the basic unity of physics, which is something to bear in mind during the decades to come.
Massimo Giovannini, CERN.

Antimatter by Frank Close, Oxford University Press. Hardback ISBN 9780199550166, £9.99 ($19.95).
Is antimatter the stuff of angels and demons? Yes, and we learn in this marvellous little book that the angels are called Paul Dirac and Ernst Stueckelberg, but I will not name the demons. Though the author on occasion waxes a little over-lyrical, I thoroughly enjoyed the story. It reads like a murder-mystery plot – but it's not the butler who did it.

While at CERN I myself had to answer questions about antimatter from the lay public, so I fully appreciate how difficult it is to debunk myths and expose reality instead. Explaining why there is "something" rather than "nothing" – i.e. why matter exceeded antimatter when the naive assumption is that after the Big Bang there were exactly equal amounts of each – is a difficult task, but I think that I have understood it now.

Frank Close does an excellent job of pulling all of the known pieces together into a coherent story; a story that shows how much antimatter has been present in the study of physics throughout the history of quantum mechanics. Fortunately, he does not shy away from including a little maths and a few diagrams, both of which are necessary because these physics concepts cannot be expressed by language alone.

The book is concise, clear and its small format is easy to handle. The artwork is exemplary, which is quite unusual for works in this category. In all, this is a good read for anyone who would like to know more than the *Star Trek* platitudes.
Robert Cailliau, Prévessin.

Books received

The Self-Evolving Cosmos: A Phenomenological Approach to Nature's Unity-in-Diversity, Series of Knots and Everything, Vol. 18 by Steven M Rosen, World Scientific. Hardback ISBN 9789812771735, £48 ($88). Paperback ISBN 979812835819, £26 ($48).
This book offers an original way of thinking about two of the most significant problems confronting modern theoretical physicists: the unification of the forces of nature and the evolution of the universe. In bringing out the inadequacies of the prevailing approach to these questions, the author demonstrates the need for more than just a new theory. The meanings of space and time must themselves be radically rethought, which requires a whole new philosophical foundation. To this end, the book turns to the phenomenological writings of Maurice Merleau-Ponty and Martin Heidegger. Their insights into space and time bring the natural world to life in a manner well suited to the dynamic phenomena of contemporary physics. The author's pioneering work in topological phenomenology is applied to such topics as quantum gravity, cosmogony, symmetry, spin, vorticity, dimension theory, Kaluza-Klein and string theories, fermion–boson interrelatedness, hypernumbers and the mind–matter interface.

Topological Foundations of Electromagnetism by Terence W Barrett, World Scientific Series in Contemporary Chemical Physics – Vol. 26. Hardback ISBN 9789812779960, £36 ($69).
This book seeks a fundamental understanding of the dynamics of electromagnetism. It marshals the evidence that in certain precisely defined topological conditions, electromagnetic theory (Maxwell's theory), must be extended or generalized in order to provide an explanation and understanding of, until now, unusual electromagnetic phenomena. The key to this generalization is an understanding of the circumstances under which the so-called "A potential" fields have physical effects. Basic to the approach taken is that the topological composition of electromagnetic fields is the fundamental conditioner of the dynamics of these fields. A major thread is the treatment of electromagnetism from, first, a topological perspective, continuing through group theory and gauge theory, to a differential calculus description. Suggestions for potential new technologies based on this understanding and approach to conditional electromagnetism are also given.

VIEWPOINT

The age of citizen cyberscience

François Grey argues that the internet is enabling a new era of citizen science.

I first met Rytis Slatkevicius in 2006, when he was 18. At the time, he had assembled the world's largest database of prime numbers. He had done this by harnessing the spare processing power of computers belonging to thousands of prime-number enthusiasts, using the internet.

Today, Rytis is a mild-mannered MBA student by day and an avid prime-number sleuth by night. His project, called PrimeGrid, is tackling a host of numerical challenges, such as finding the longest arithmetic progression of prime numbers (the current record is 25). Professional mathematicians now eagerly collaborate with Rytis, to analyse the gems that his volunteers dig up. Yet he funds his project by selling PrimeGrid mugs and t-shirts. In short, Rytis and his online volunteers are a web-enabled version of a venerable tradition: they are citizen scientists.

There are nearly 100 science projects using such volunteer computing. Like PrimeGrid, most are based on an open-source software platform called BOINC (*CERN Courier* September 2004 p62). Many address topical themes, such as modelling climate change (ClimatePrediction.net), developing drugs for AIDS (FightAids@home), or simulating the spread of malaria (MalariaControl.net) (*CERN Courier* September 2006 p62).

Fundamental science projects are also well represented. Einstein@Home analyses data from gravitational wave detectors, MilkyWay@Home simulates galactic evolution, and LHC@home studies accelerator beam dynamics. Each of these projects has easily attracted tens of thousands of volunteers.

Just what motivates people to participate in projects like these? One reason is community. BOINC provides enthusiastic volunteers with message boards to chat with each other, and share information about the science behind the project. This is strikingly similar to the sort of social networking that happens on websites such as *Facebook*, but with a scientific twist.

Another incentive is BOINC's credit system, which measures how much processing each volunteer has done – turning the project into an online game where they can compete as individuals or in teams. Again, there are obvious analogies with popular online games such as *Second Life*.

Distribution of some of the volunteers contributing to the project MalariaControl.net, which simulates the spread of malaria in Africa. More than 25 000 have so far contributed computing power to the project. (Courtesy Swiss Tropical Institute)

Brains vs processors

A new wave of online science projects, which can be described as volunteer thinking, takes the idea of participative science to a higher level. A popular example is the project GalaxyZoo, where volunteers can classify images of galaxies from the Sloan Digital Sky Survey as either elliptical or spiral, via a simple web interface. In a matter of months, some 100 000 volunteers classified more than 1 million galaxies. People do this sort of pattern recognition more accurately than any computer algorithm. And by asking many volunteers to classify the same image, their statistical average proves to be more accurate than even a professional astronomer.

When I mentioned this project to a seasoned high-energy physicist, he remarked wistfully, "Ah, yes, reminds me of the scanning girls". High-energy physics data analysis used to involve teams of young women manually analysing particle tracks. But these were salaried workers who required office space. Volunteer thinking expands this kind of assistance to millions of enthusiasts on the web at no cost.

Going one step farther in interactivity, the project Foldit is an online game that scores a player's ability to fold a protein molecule into a minimal-energy structure. Through a nifty web interface, players can shake, wiggle and stretch different parts of the molecule. Again, people are often much faster at this task than computers, because of their aptitude to reason in three dimensions. And the best protein folders are usually teenage gaming enthusiasts rather than trained biochemists.

Who can benefit from this web-based boom in citizen science? In my view, scientists in the developing world stand to gain most by effectively plugging in to philanthropic resources: the computers and brains of supportive citizens, primarily those in industrialized countries with the necessary equipment and leisure time. A project called Africa@home, which I've been involved in, has trained dozens of African scientists to use BOINC. Some are already developing new volunteer-thinking projects, and a first African BOINC server is running at the University of Cape Town.

A new initiative called Asia@home was launched last month with a workshop at Academia Sinica in Taipei and a seminar at the Institute of High Energy Physics in Beijing, to drum up interest in that region. Asia represents an enormous potential, in terms of both the numbers of people with internet access (more Chinese are now online than Americans) and the high levels of education and interest in science.

To encourage such initiatives further, CERN, the United Nations Institute for Training and Research and the University of Geneva are planning to establish a Citizen Cyberscience Centre. This will help disseminate volunteer computing in the developing world and encourage new technical approaches. For example, as mobile phones become more powerful they, too, can surely be harnessed. There are about one billion internet connections on the planet and three billion mobile phones. That represents a huge opportunity for citizen science.

François Grey is a visiting professor at Tsinghua University