Silicon makes tracks for CMS

CERN
LHC cryogenic line passes first tests p5

COMPUTING NEWS
Combating congestion on the Internet p17

Z BOSON
LEP and SLD publish combined results p23
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Cover: The final screw is adjusted on a module of Layer 4 of one half of the silicon tracker for the CMS experiment, which has been assembled in Pisa using modules constructed by many CMS collaborators in labs throughout Europe and the US (p6). (Courtesy INFN Pisa.)

CONTENTS

News 5
LHC project tunnels ahead p5
Saturn's moon soak up p13
Wormser takes over at LAL p43

Computing News and Features 17
Synergia provides new 3D tool. Tim Berners-Lee receives Quadriga award. W3C specification guidelines assist authors. FZJ's new supercomputer offers extra power. Internet growth requires new transmission protocol.

Features 23
Experiments finally unveil a precise portrait of the Z
Martin Grünewald summarizes combined results from LEP and SLD.

Fifty years of antiprotons 27
Lynn Yarris looks back to the discovery of the antiproton in 1955.

New exhibition unites people and ideas 30
Jean Audouze talks about the 1st European Research and Innovation Exhibition.

Uppsala 2005: leptons, photons and a lot more 33
Francis Halzen reports from the recent Lepton-Photon conference.

Close nucleon encounters 37
Mark Strikman presents new results from Jefferson Lab on short-range nucleon correlations.

Wisdom generation in the Alps: a student's tale 39
Sezen Sekmen on this year's European School for High Energy Physics.

People 43
Recruitment 50
Bookshelf 56
Viewpoint 58
ADVERTISING FEATURE

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Ranked among the eight largest high-energy accelerator centers in the world, the Beijing Electron-Positron Collider – BEPC II (www.ihep.ac.cn) – is being reformed with funds of the Chinese central government: estimated to be completed by the end of 2007, the ambitious project will allow the collider to improve its performance to one hundred times the present level. Following the world’s most advanced collider patterns, the old storage ring will be replaced by a new double ring, with a circumference of 240 meters, which will enable electrons and positrons to move in their own rings and to collide with each other at defined interaction points.

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SAES’ CapacITorr NEG pumps help preserve ultra-high vacuum conditions in high energy machines.
Progress on the construction of the Large Hadron Collider (LHC) at CERN has passed several important milestones in recent weeks. In mid-September the first 600 m of the cryogenic distribution line that will supply superfluid helium to the superconducting magnets passed initial testing at room and cryogenic temperatures. At the same time, the number of magnets installed in the tunnel passed the 100 mark, and several major contracts related to their construction have been successfully completed.

The tests of the cryogenic line, which were the first to be implemented at close to the eventual operating conditions in the LHC tunnel, took place in sector 7-8. This is where technical problems were discovered during the initial installation in summer 2004, so that the system had to be redesigned, repaired and reinstalled (CERN Courier January/February 2005 p5).

After several days of testing and cleaning at room temperature, the cool-down itself took 15 hours. This is a two-stage process using a 4.5 K helium refrigerator and a nitrogen pre-cooler. After the initial 10 hours of cool-down, the system reached the first temperature plateau of 80 K. Then, by the evening of 14 September, the cryogenic line had been brought down to around 5 K, about 3 K above the eventual operating temperature. The complete cold-commissioning process takes about five weeks. Once the thermal design has been validated, the magnets can then be connected to the cryogenic line.

Meanwhile, by the end of September, 102 of the LHC’s 1232 superconducting dipoles had been put in position in the tunnel. At the same time one of the most important contracts for the LHC had successfully concluded, with the supply of all 7000 km of the superconducting cable that forms the heart of the machine’s magnets. This cable weight. This was the first major contract to be concluded for the LHC; worth 60 million Swiss francs, it was signed just after CERN Council approved the LHC project in December 1996.

October saw the completion of the 60 km of vacuum pipes for the LHC beams by a single firm, DMV of Bergamo, Italy. These 16 m long pipes, made from austenitic steel, had to be continuously extruded and had to contain not a single weld in order to ensure perfect leak tightness between the vacuum inside and the superfluid helium outside. In the first week of September, the last coils of austenitic steel for the collars of the dipole magnets arrived at CERN from NSSC (Nippon Steel) in Japan. The collars are designed to contain most of the magnetic forces created in the eight layers of superconducting coil that provide the magnetic field.

The production of the collared coils is also well on track. On 8 August Babcock Noell Nuclear (BNN) delivered their last collared coil, completing their contract for one-third of the dipole magnet coils. The contracts with the two other suppliers will also come to an end during the autumn of 2006.
Silicon trackers begin to take shape for CMS and ATLAS

Over the past few months the silicon microstrip tracker of the CMS experiment has been making steady, and rapid, progress towards meeting its next major target – installation of the complete detector in its site at Intersection point 5 on the Large Hadron Collider in November 2006.

This has been especially encouraging to the CMS collaboration as the past year has seen significant problems with relatively small details in a few key components, delaying the assembly of modules and their subsequent integration into the mechanical superstructure. However, these problems have now been overcome and the subsequent assembly speed of several inner layers of the tracker has demonstrated the readiness of the teams of engineers and physicists, who had used some of the time during the pauses to refine their procedures.

The CMS tracker will be the largest silicon system ever built, with more than 200 m² of silicon microstrips surrounding three layers of pixel detectors in a cylindrical barrel-like layout, with end-caps completing the tracking in the forward and backward regions. The construction involves teams from all over Europe and the US, who have developed components and pioneered automated techniques to manufacture modules that must withstand the stringent conditions at the heart of the CMS.

The inner barrel (see cover picture) is the responsibility of an Italian consortium. The delivery of the first half to CERN is expected this month, followed by the second half in January 2006. While tests begin on the inner barrel in a brand new integration facility, which is currently being erected at CERN, it will be joined by, and later inserted inside, the outer barrel system. This is largely the responsibility of CERN, and consists of modules arranged in rods that are being manufactured in the US by teams who have experience from Fermilab experiments. The two end-caps will complete the assembly in mid-2006; one will be built by a French team of researchers, and the other by a team from France.

One of the CMS silicon tracker end-cap petals under test in a close-to-final environment in Lyon. (Courtesy IN2P3-CNRS Lyon.)

The insertion of a completed barrel of the ATLAS inner detector into its support structure.
team in the facility at CERN, the other by a German team in Aachen.

The remaining off-detector electronics and cooling systems are also beginning to arrive at CERN. These will allow the completed tracker to be studied for several months before it is moved to its final underground location at the centre of the CMS. Once in operation it will provide precise radiation-hard tracking for many years.

Meanwhile, September saw an important milestone for the ATLAS inner detector project with the delivery of the fourth and final Semiconductor Tracker (SCT) barrel to CERN. A few days after delivery, on 20 September, the barrel was integrated into the final configuration of the full barrel assembly.

The SCT has a silicon surface area of 61 m² with about six million channels and is part of the ATLAS inner detector, where charged tracks will be measured with high precision. More than 30 institutes from around the world have contributed to building the component parts and structure of the SCT.

Moving outwards from the interaction region, the ATLAS inner detector comprises the pixel detector (consisting of three pixel layers), the SCT (four silicon strip layers) and the transition radiation tracker, or TRT (consisting of about 52 000 straw tubes).

During 2004 a team of physicists, engineers and technicians from several SCT institutes set up one of the largest silicon quality-assurance systems ever built (corresponding to about 15% of the final ATLAS readout system), which was capable of analysing the performance of one million sensor elements on nearly 10 m² of silicon detectors simultaneously. Using this system to test barrels prior to their integration, the team found that more than 99.6% of the SCT channels were fully functional, an exceptionally good performance that exceeded specifications. The work is taking place in the SRI facility at CERN, which was purpose-built by the ATLAS inner detector collaboration and houses a 700 m² cleanroom.

This month the ATLAS inner detector teams will integrate the silicon tracker with the barrel TRT and test their combined operation in SRI. At the end of this year the SCT end-caps will arrive at CERN, and then be inserted into the TRT end-caps during spring 2006. In March 2006 the inner detector team will then place the barrel inner tracker in a steel frame and transport it to the ATLAS underground cavern. The entire integration process is scheduled to be finished at the end of 2006, when the all-important pixel detector will be inserted in the tracker.

The whole assembly of the inner detector will sit in the 2 T magnetic field of the central superconducting solenoid, which has a diameter of about 2.5 m. This will deflect the tracks of charged particles passing through the inner detector. The much larger air toroid magnet system (cover picture CERN Courier September 2005) is to deflect the tracks of muons, which penetrate to the outer reaches of the huge ATLAS detector.

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Rewards for optics in theory and practice

The 2005 Nobel prize in physics has been awarded to three physicists working in the field of optics, in recognition of past advances in the understanding of light as well as the present-day potential of laser-based precision spectroscopy. Roy Glauber of Harvard University receives half the prize for “his contribution to the quantum theory of optical coherence”, while John Hall of the University of Colorado and Theodor Hänsch of the Max-Planck-Institut für Quantenoptik in Garching share the other half for “their contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique”.

The recognition of Glauber’s work comes appropriately enough in 2005, the centenary of Albert Einstein’s work on the photoelectric effect, in which he described radiation in terms of quanta, later termed photons. Glauber’s aim in his seminal paper of 1963 was to move from a semi-classical description of the photon field in a light beam towards a full quantum theoretical description, in particular to describe correlation effects. In Glauber’s words, “There is ultimately no substitute for the quantum theory in describing quanta.”

Roy Glauber, second from left, at the Quark Matter conference in August. Glauber has received the Nobel prize for his work in the field of optics, but his expertise has for many years extended also to particle physics.

Glauber’s name is also familiar in particle physics, however, where he is widely known for his “Glauber model”, which nowadays has a range of applications in understanding heavy-ion interactions. In August 2005 he gave an opening talk at the Quark Matter 2005 conference in Budapest, 50 years after his original paper using diffraction theory to develop a formalism for calculating cross-sections in nuclear collisions. Glauber himself has regularly spent time as a visiting researcher in CERN’s theory division, from 1967 until the mid-1980s.

The work of Hall and Hänsch is by contrast a tour de force in experimentation. In developing a measurement technique known as the optical frequency comb, they have made it possible to measure light frequencies to within an accuracy of 15 digits. The “comb” exploits the interference of lasers of different frequencies, which produces sharp, femtosecond pulses of light at extremely precise and regular intervals. This allows precise measurements to be made of light of all frequencies and has many applications in both fundamental and applied fields. In particular, in particle physics the technique is allowing precise measurements of asymmetries between matter and antimatter, and possible drifts in the fundamental constants. Hänsch himself is a member of the ATRAP collaboration, which has successfully made antihydrogen at CERN’s Antiproton Decelerator (AD) (CERN Courier December 2001 p5). Moreover, the frequency comb technique is being used in the ASACUSA experiment at the AD, which studies the spectroscopic properties of anti-protonic helium (CERN Courier May 2004 p31).

CERN

Barish presents plans for the ILC

The schedule of the Global Design Effort (GDE) for the future International Linear Collider (ILC) was an important topic at the meeting in September of CERN’s Scientific Policy Committee. Barry Barish, head of the GDE, presented a report on the progress made since the International Technology Review Panel announced the technology choice for the ILC in August 2004 (CERN Courier October 2004 p5).

Since the first ILC workshop, which was held at KEK in November 2004, work has been progressing towards a reference design. This year a second workshop was held in August at Snowmass in the US to refine the ideas. The reference design should be completed by the end of 2006, to be followed by a technical design report two years later. By 2010 the technical design report, together with the scientific results from the Large Hadron Collider and input from the CLIC Test Facility (CTF3) at CERN, will allow a decision on the future of the ILC.
KEDR adds new precision to meson mass measurements

In October 2005 the VEPP-4M collider at the Budker Institute of Nuclear Physics started its latest run with the KEDR detector. This continues a series of experiments that are exploiting the method of resonant depolarization (which was proposed and developed at the Budker Institute) to make precise measurements of masses in the region of the $\Psi$ to $Y$ mesons (Skrinsky and Shatunov 1989).

Progress in understanding the resonant depolarization technique, as well as a new detection system for Touschek electron pairs (intrabeam scattering), has resulted in a significant improvement in the accuracy of the beam energy determination with KEDR. The error in a single measurement of the beam energy has reached a level of 1 keV, corresponding to a relative accuracy of 0.7 ppm. Figure 1, for example, illustrates a very clear jump in the counting rate of Touschek pairs, allowing a precise measurement of the depolarization frequency directly related to the beam energy. In 2002 this led to a measurement of the mass of the $J/\Psi$ with a relative accuracy of 4 ppm: $M_{J/\Psi} = 3096.917 \pm 0.010 \pm 0.007$ MeV (Aulchenko et al. 2003). Compared with the previous experiment in 1980, this represented a sevenfold decrease in the uncertainty in the mass.

In 2004 the masses of the $\Psi'$ and $\Psi(3770)$ were measured in a second run in KEDR. The results, which are shown in figure 2, were presented recently at the HEP2005 conference in Lisbon in July. The preliminary values of the masses of the $\Psi'$ and $\Psi(3770)$ are $3686.117 \pm 0.012 \pm 0.015$ MeV and $3773.5 \pm 0.9 \pm 0.6$ MeV, respectively.

The precise measurement of the masses of the $J/\Psi$ and $\Psi'$ mesons provides a mass scale in the energy region around 3 GeV, which forms the basis for an accurate determination of the mass for all charmed particles and the $\tau$ lepton. Since the width of the $\tau$ is proportional to its mass to the fifth power, high-precision tests of the Standard Model are very sensitive to the accuracy of this mass. At present the accuracy of the $\tau$'s mass is dominated by the accuracy of the measurement by the Beijing Spectrometer (Bai et al. 1996).

KEDR began the measurement of the mass of the $\tau$ in spring 2005. Using the same method as the Beijing Spectrometer, the collaboration plans to determine the mass by measuring the energy dependence of the cross-section near threshold. The aim is also to improve the statistics of $\tau$ decays, benefiting from the precise knowledge of the beam energy. In KEDR the energy is measured by two methods: resonant depolarization for a high-accuracy measurement once a day, and Compton backward scattering for monitoring the beam energy drift during data collection. Data processing is currently in progress.

Further reading
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Electric fields create hot ice

Ice at room temperature? Don't worry - this is not the deadly "ice-nine" of Kurt Vonnegut's novel *Cat's Cradle*, but rather a special state found to exist in the presence of high-electric fields. Heon Kang of Seoul National University, Korea, and colleagues were using an electrochemical scanning tunnelling electron microscope – which has an electrically charged tip – to look at how electrons move through water to a gold surface below. Measurements indicated a solid barrier, which was interpreted as the electric field driving the alignment of water molecules into a solid.

Theorists had predicted that such an effect could occur, but at about a thousand times the field strength in this experiment. Kang and colleagues observed the effect at a mere 1 million V/m, or close to the breakdown voltage for air. Fields of this strength can occur in many places, from cracks in rocks to across cell membranes, so this new type of hot ice may be more common than anyone had imagined.

Bose–Einstein feels the Casimir effect

Two quintessential quantum phenomena are the Casimir effect, whereby two electrically neutral objects exert forces on each other by distorting the zero-point fluctuations in the vacuum, and the Bose–Einstein condensation. Bringing these together, Eric Cornell and his colleagues at the University of Colorado, Boulder, have set up a pancake-shaped Bose–Einstein condensate of rubidium atoms, several micrometres thick, in a magnetic trap just below a silica plate.

Watching the condensate oscillate at various distances 6–10 μm from the plate, the researchers could determine the Casimir force from the way it pulled differently on the near and far sides of the pancake. The results came out in good agreement with expectations from theory, but perhaps the most interesting thing about this measurement is the shift in focus away from the condensate itself and towards interesting things that can actually be done with this novel state of matter.

New nanorods are harder than diamond

Natalia Dubrovinskaia of the University of Bayreuth and her colleagues have made carbon that is harder than diamond. Squeezing together buckyballs, each made of 60 carbon atoms, at 20 GPa and 2200 °C, the group reports the formation of a translucent cylinder made of diamond nanorods that is about 0.2–0.4% denser than natural diamond. This is the densest form of carbon that has been determined experimentally and may find applications in very hard coatings for tools.

Nanotechnology gives new twist to measuring spin

Nanotechnology and spintronics are two technologies that are supposed to revolutionize computing. Now Anatoly Mal'shukov of the Russian Academy of Sciences, Moscow, and colleagues have suggested that merging the fields could lead to interesting new devices. The group proposes that the flow of spin-polarized electrons could be detected as a measurable torsion in a tiny crystalline bridge.

The idea builds on something that is familiar to high-energy physicists: a strained crystal can provide an electric field in its rest frame that looks like a magnetic field to particles travelling through the crystal. A twisting of the bridge in response to the current of tiny magnets (the electrons) could provide a way of measuring the spin associated with that current. So far the work is theoretical, but it could lead to real devices.

Amazon puts the pressure on Earth

This almost sounds like something from the era of CERN's Large Electron–Positron collider when distortions due to solid-earth tides were found to affect the beam energies. It turns out that a Global Positioning System (GPS) station in Manaus, close to the centre of the Amazon basin, has been registering an up-and-down motion of about 50–75 mm a year. A close look by Michael Bevis of Ohio State University, Columbus, tracked this down to the rising and falling levels of the Amazon river pushing the ground up and down over the course of the year. If the interpretation is correct, this is the first measurement of an elastic response of the earth to changes in weight of a river system.
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A team using the Very Large Telescope (VLT) of the European Southern Observatory (ESO) has identified a much larger population of distant galaxies than previously estimated. The new population mainly consists of galaxies forming stars at a very high rate.

The determination of the number of galaxies in the universe at different epochs is crucial for constraining models of the formation and evolution of galaxies. Counting galaxies in deep astronomical images is relatively simple, but measuring their redshift – hence, their distance and the epoch in the history of the universe when we see them – requires taking a spectrum of each galaxy.

Until now, measuring the spectrum of distant and therefore faint galaxies needed a great deal of observing time on the largest telescopes. Astronomers therefore had to select carefully the candidate high-redshift galaxies based on their brightness and colour. However, it now seems that they have been too restrictive in their criteria, thus missing a large population of distant galaxies with strong ultraviolet emission.

The discovery of this population of bright and distant galaxies was made possible by the Visible Multi-Object Spectrograph (VIMOS) on Melipal, one of the four 8.2 m telescopes of the VLT. Instead of measuring the spectrum of one galaxy at a time, VIMOS can measure simultaneously the spectra of about 1000 galaxies in a single field.

The unique capabilities of VIMOS allowed a team of French and Italian astronomers to determine systematically the redshift of all the galaxies in a given sky area and a given range of brightness. From a total of about 8000 galaxies, almost 1000 were measured at a redshift between 1.4 and 5, corresponding to looking back 9–12 billion years.

The results published by O Le Fèvre and collaborators show that the number density of galaxies at a redshift of around 3 exceeds previous estimates by a factor of 1.6 for the faintest galaxies and of 6.2 for the brightest ones. Around a redshift of 4 the number of galaxies was underestimated by a factor of 2–3.5. It seems therefore that a large population of bright galaxies at high-redshift was completely overlooked.

The newly identified population escaped previous studies mainly because of relatively high ultraviolet emission, which is emitted by massive young stars. The ultraviolet luminosity of these galaxies allows the estimate that their star-formation rate is in the region of 10–100 solar masses per year; currently in the Milky Way only a few solar masses of gas and dust are converted into stars every year. This discovery has profound implications for the history of star formation in the universe and for current theories of the formation and evolution of galaxies.

Further reading

Picture of the month

This surprising view of Saturn’s moon Hyperion was taken on 26 September when the Cassini spacecraft flew by at a distance of only 500 km. This small moon has a surface dotted with craters and modified by some unknown process creating a strange “spongy” appearance, unlike any other moon pictured so far. Hyperion is 266 km across, about the size of the moon Gabrielle found to be orbiting the newly discovered 10th planet, which has been dubbed Xena by its discoverers (CERN Courier September 2005 p12). (Courtesy NASA/JPL/SSI.)
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TRIBUTE

Niels Bohr 1885–1962

While this issue was in preparation news came of the death in Copenhagen on 18 November of Prof. Niels Bohr. World-renowned as a physicist and as a man, he is remembered here at CERN especially for the leading role he played in our foundation, and as the leader of the Theoretical Study Group, in his own Institute of Theoretical Physics, in the early days before the laboratory at Meyrin was ready, as well as for his guidance as a member of the Scientific Policy Committee.

On the day the news was received, Prof. Weisskopf, himself a former student and collaborator of Bohr’s, wrote the following appreciation:

“The flags at CERN are flying at half mast. CERN has lost the greatest of its founders. The world has lost a great man.

Niels Bohr died yesterday after a life full of achievements. He discovered in 1913 the fundamental role of the quantum in the structure of the atom and since then he was the intellectual leader of the greatest scientific breakthrough in the history of human search into the nature of things.

Before Bohr, nobody knew about the structure of matter; after Bohr the material phenomena with which we are surrounded are well understood. Because of Bohr, we know how light is radiated and absorbed, how atoms join into molecules and how electricity produces its effects, and our knowledge even penetrates into the secrets of the atomic nucleus. Never before was so much explained by so few in such a short period of time as it was under Niels Bohr’s leadership.

It was his way of looking at the atom which gave science a tool of comprehension, so all embracing, that it was possible for the first time to consider all natural phenomena from the hottest star to the living cell, as the effect of one fundamental principle.

His influence is felt wherever science is pursued all over the world. CERN would not exist if it had not been for the untiring efforts of Niels Bohr to bring about in the heart of Europe an international laboratory devoted to the innermost structure of matter. He always looked at science as an endeavour which goes beyond national boundaries, not only as a means for research but also as a bond between men.

The significance of Niels Bohr for humanity cannot yet be estimated. We are too near to his work and to the developments which his work has created. Future generations will recognize how his work stands out as a tower of achievement in the culture of our days.”

EDITOR’S NOTE

With the death of Niels Bohr in November 1962, the world, and CERN, lost a great man. The CERN Courier published not only the appreciation, reprinted here, from the director-general at the time, Victor Bannier, but also the full text of the tribute that Weisskopf gave before the CERN staff. Up until his death, Bohr had been a member of the Scientific Policy Committee, so he would have contributed to the report presented to Council at the meeting also described here – a meeting that approved the Bannier committee’s recommendations on an increasing budget.

Niels Bohr. (Photo courtesy of H and H Jacobsen, Copenhagen.)

CERN COUNCIL

Council session discusses growth of our organization

On 12 October, delegates from the 13 Member States, together with observers from Turkey and Yugoslavia, gathered at CERN for a special session of Council, under the presidency of Mr J Willems (Belgium).

Their main purpose was to discuss the report on the programme and budget, drawn up earlier this year by a working party headed by Mr J H Bannier, director of the Netherlands Organization for the Development of Pure Research (ZWO). The report, which was briefly discussed at the Council meeting last June, was approved in its broad lines. Among its proposals are recognition of the need for CERN to continue growing, with expenditure increasing by between 10 and 14 per cent per year for the next few years, and a procedure for long-term planning and budgeting. In future, planning will be on a continuing 4-year basis: each year a budget for the next year will be fixed, together with a firm estimate for the following one, and broad indications must also be given for the two years after that.

The members of the Council heard a statement by Prof. C F Powell (UK) who, as chairman of the Scientific Policy Committee, reported the assessment of CERN made by this body. "The judgement and aspiration of those who founded CERN have been most brilliantly vindicated," he said. "Every month brings important discoveries... and there can be hardly any doubt that in the next decade this process will continue... bringing radical changes in our understanding of matter and in our basic conception of it. Through the development of CERN, Europe has to make very valuable contributions to these great developments. In all the Member States, physicists see CERN as their chief place of experiment... and sometimes forgo equipment and resources in order that CERN can be better supported. The Scientific Policy Committee concludes that CERN plays an indispensable part in the development of European physics and this institution can have a brilliant future."

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Synergia provides new 3D tool

The Synergia project has reached a major milestone with the release of Synergia version 1.0. Developed by the Advanced Accelerator Modelling team at the Fermilab Computing Division, the software simulates the behaviour of particles in an accelerator, emphasizing three-dimensional models of collective beam effects. The physics model, algorithmic implementation, interface and benchmarks are described in detail in the paper “Synergia: an accelerator modelling tool with 3-D space charge”, currently in press at the Journal of Computational Physics.

Panagiotis Spenzouris and James Amundson lead the Synergia project to develop advanced accelerator-modelling tools. Accelerator modelling studies the passage of individual particles through the components of an accelerator, which act as lenses guiding the particles. Tracking individual particles requires elaborate modelling, but is not very computationally intensive. This changes dramatically when the forces created by the beam itself are taken into account. An example is the repulsive force generated when a large number of particles of the same charge are confined to a small region of space. Since modern accelerator beams contain tens of billions of particles, modelling such collective effects is very important to optimize particle throughput and minimize particle loss. Synergia combines state-of-the-art single-particle tracking with self-consistent modelling of collective beam effects.

Synergia version 1.0 reuses and extends existing accelerator-physics codes together with new physics, integration and interface modules. The implementation is optimized for massively parallel computers because simulating collective beam effects is computationally intensive. Typical large-scale Synergia applications run on 32–512 processors on Linux clusters and the IBM SP3 at the National Energy Research Scientific Computing Center in the US. The user interface uses Python to control the simulation and specify the accelerator parameters. The accelerator components can be described using the Methodical Accelerator Design (MAD) language. Synergia provides facilities for automatically generating location-specific job description, as well as tools for job tracking and job submission.

Development of the next major version of Synergia is already underway. The new framework will be fully Python-driven, allowing much greater flexibility and easier addition of new physics modules.

Successful Synergia applications include the reproduction of the theoretical predictions for simple configurations, comparisons with other accelerator codes, and detailed simulations of real accelerators. Most prominent in this latter category is the study of space-charge effects during the injection phase at the Fermilab Booster accelerator. These studies included comparisons between the simulation and the results of controlled-beam experiments and provided useful insight into machine operations.

The Synergia project is partially funded by the US Department of Energy’s Scientific Development through Advanced Computing (SciDAC) programme. The team works in close collaboration with Fermilab Accelerator Division personnel and SciDAC colleagues from Lawrence Berkeley National Laboratory and the TechX Corporation.

Further reading
For more information see http://cepa.fnal.gov/psm/aas/Advanced_Accelerator_Simulation.html.
Tim Berners-Lee receives Quadriga award

Tim Berners-Lee, W3C director and inventor of the World Wide Web, is one of the laureates of Germany's Quadriga award, a prize bestowed every year in four categories: political, economic, social and cultural.

The organizers of the award named Berners-Lee one of the most important scientists of the 20th century, second only to Albert Einstein. Berners-Lee, who was named Greatest Briton in 2004, invented the World Wide Web while he was working at CERN and made the protocols freely available.

Berners-Lee was awarded the prize in Berlin on 3 October, the date when Germany celebrates its unification in 1990. The award is named after the famous sculpture on top of the Brandenburg Gate, with the goddess of peace driving a four-horse chariot (the quadriga) representing the interplay of harmony, friendship, valour and state wisdom for the welfare of all. It reflects the Brandenburg quadriga's change from symbolizing partition to being an emblem of unification.

The other winners of the €25 000 prize this year include former German chancellor Helmut Kohl for his achievements in reuniting Germany in 1990; the Aga Khan, for his charitable institution, the Aga Khan Development Network; and six Northern Irish women who challenged the Irish Republican Army over the murder of a Catholic man, Robert McCartney, in Belfast in January 2005.

W3C specification guidelines assist authors

The Quality Assurance (QA) Working Group of the World Wide Web Consortium (W3C) has concluded its work with the completion of Specification Guidelines, issued as a W3C Recommendation. This document provides clear instructions to writers and editors on how to create technical specifications that are precise and clear.

W3C launched the QA Activity in 2001, following a successful workshop, with the following goal: to improve W3C specifications by offering guidelines to W3C groups, by reviewing draft specifications for adherence to these guidelines, and by helping W3C groups develop test suites and other tools to promote interoperable implementations.

Since that time, the QA Working Group has produced six documents, including the new recommendation — Specification Guidelines. By identifying requirements and “good practices”, these guidelines help both W3C and other specification authors create and describe technologies in ways that make it easier for developers to implement them as intended. The QA Working Group has also put together templates for writing conformance clauses as well as full specifications.

In addition the group has published the QA Framework Primer, QA Test FAQ, the Variability in Specifications Working Draft and the QA Handbook. One of the group’s most famous and useful documents is the W3C Quality Assurance Matrix, a list of more than a hundred W3C specifications, which includes links to conformance clauses, test suites and validators.
SUPERCOMPUTERS

FZJ’s new supercomputer offers extra power

A new supercomputer, Jülicher Blue Gene/L (JUBL), has been installed at the Forschungszentrum Jülich (FZJ), offering far higher performance of up to 5.6 teraflops. Stefan Krieg, of the Central Institute for Applied Mathematics (ZAM), was the first scientist to use the machine, in his studies of the forces between nature’s smallest building blocks, the quarks. "Thanks to JUBL we now have the possibility to simulate the world of quarks with unprecedented accuracy," said Krieg.

JUBL, an IBM computer, currently occupies 60th place in the supercomputer ranking list, which is headed by the bigger and 30 times more powerful machine at the Lawrence Livermore Laboratory. However, JUBL’s 2048 processors are connected by a variety of networks, which gives it flexibility to operate in varied areas. Not only particle physicists, but also biologists, chemists, astrophysicists and mathematicians will use JUBL to simulate their models.

Currently, about 150 groups from Germany and the rest of Europe use the supercomputer resources (now at 14.5 teraflops) at Jülich. Apart from the hardware, the FZJ also has many years of know-how and modern software tools to optimize the use of supercomputers in many fields. If the architecture of JUBL proves successful for the complex applications at Jülich, a successor 50 times more powerful could soon arrive at the ZAM.

PRODUCT INFORMATION

Chemical Abstracts Service and FIZ Karlsruhe have officially launched their new STN AnaVist software for patent and competitive intelligence analysis. STN AnaVist includes an intellectually based standardization of fielded data from patent and non-patent literature, coupled with an interactive approach for viewing data relationships. TN AnaVist was developed to meet the need to assimilate and present information more effectively to derive greater value from search results, and to support management in making business-critical decisions. Details and pricing information can be found at www.stn-international.de/stninterfaces/stnanavist/stn_anavist.html.

Toradex of Switzerland has cut the price of the 520 MHz version of its popular Colibri XScale PXA270 SODIMM-sized module. Colibri features 64 MB of SDRAM (32 Bit), 32 MB of Flash (32 Bit), 16 Bit Stereo Audio in/out, 100MBit Ethernet, 32 Bit external bus, CompactFlash/PCMCIA, LCD and touch screen control, CMOS/CCD image sensor interface, MSL (up to 416 Mbps), I2C, SPI, SDCard, Memory Stick, USB Host/Device, PWM and many digital inputs/outputs. Windows CE or Linux is included with every Colibri module. For more information see www.toradex.com/e/products.html.

Calendar of events

November
12–18 Supercomputing – High Performance Networking and Computing
Seattle, Washington, US,
http://sc05.supercomputing.org

30 – 2 December IFIP International Conference on Network and Parallel Computing (NPC 2005)
Beijing, China,
http://grid.ia.cn/npc05

December
5–8 IEEE International Conference on e-Science and Grid Technologies
Melbourne, Australia,
www.gridbus.org/eScience

7–9 International Symposium on Parallel Architectures, Algorithms, and Networks (I-SPAN)
Las Vegas, Nevada, US,
http://sigact.acm.org/isp05/

February 2006
13–17 15th International Conference on Computing in High Energy and Nuclear Physics
Mumbai, India,
www.tifr.res.in/chep06/

March 2006
1–3 TridentCom 2006
Barcelona, Spain,
www.tridentcom.org
Since the birth of the Internet, the Transmission Control Protocol (TCP) has been phenomenally successful. Today TCP controls the transmission of most traffic on the Internet—everything from downloading web pages to peer-to-peer file sharing. TCP's development began in 1974, it was overhauled in 1988, and since then its design has served well with barely any changes, even though data rates have rocketed from 30 kbit/s to 40 Gbit/s. There is now, however, a growing feeling in the network-research community that it is time for another major overhaul. We understand better the mathematics of how data networks work, and hope that we might be able to overhaul TCP so that it is fit for a long time to come.

To understand why TCP has been so successful, and to explain why an overhaul is needed, it is useful to know more about what TCP does. TCP code sits on every computer and device connected to the Internet. It is built into Windows, Linux, mobile phones, etc. When one computer has to transmit data to another, the data are split into packets. TCP decides when to send packets and how many to send. It has two duties: to resend any packets that may have been lost on the way (for example, because of congestion, or signal interference on a wireless link), and to limit the sending rate so that the network does not become congested.

The second duty was not part of TCP's original specification. It was added in 1988 by Van Jacobson at the Lawrence Berkeley National Laboratory (LBNL). In October 1986, the data rate between the University of California at Berkeley and LBNL—400 m apart—collapsed from 32 kbit/s to just 40 bit/s. Jacobson and colleagues realized the problem: the network was congested, which caused packets to become lost in transit; TCP sent those packets again, and made the congestion worse. Jacobson's grand idea was that TCP could control congestion (Jacobson 1988). He proposed an extension to TCP: it should steadily increase its transmission rate when the network seems uncongested, and reduce the rate whenever it detects a lost packet (figure 1, p21).

Arguably, Jacobson's congestion control is what has made the Internet succeed. In 1988, "proper" networks like national telephone networks were very different from the Internet. Someone sitting in the network control centre monitored traffic; when links came close to overload, traffic was rerouted—and when this was not enough your telephone call was simply blocked. In the Internet there is no central control, yet Jacobson's TCP achieves a similar effect, using the collected decentralized intelligence of all the computers connected to the Internet.

Congestion is a fundamentally difficult problem, and the Internet was the first large-scale demonstration that it could be solved without central control. This allowed the Internet to grow to become a global network. Nevertheless, network control centres are not out of business yet; Jacobson's TCP does not attempt to balance traffic across different parts of a network, nor to provide the speedy delivery that real-time voice and video need. These are still problems for which we need central control.

However, Jacobson's TCP is beginning to show its age. A driving
problem is the difficulty of getting high data rates, even when capacity is available. Consider a physicist in CERN trying to send data to SLAC in California. The round-trip time (RTT), i.e. the time it takes to send a packet from CERN to SLAC and to receive an acknowledgement that the packet arrived, is a little over 200 ms. When the network is working smoothly and no packets are lost, TCP increases its data rate by one packet per RTT, every RTT — to achieve a data rate of 100 Mbit/s therefore takes 333 s. On the other hand, every time a packet is lost in transit, TCP cuts its data rate by half. That means that it takes 167 s to recover from a single packet loss. To achieve a sustained average data rate of 100 Mbit/s, no more than 1 in 1.9 million packets can be lost. But cosmic rays and imperfections in the optical fibre links are likely to corrupt at least one packet in every 1 million! TCP needs to change if it is to support such high data rates — but injudicious changes could bring about another congestion collapse.

The scientific approach is to devise mathematical models for congestion control, and to test them experimentally. The approach that physicists have developed for studying complex systems seems to work well for the Internet: first explore the detailed rules of interaction between atomic entities (like TCP connections), then formulate high-level laws about the behaviour of large collections of these entities (e.g. with differential equations), then investigate the consequences of these laws.

Indeed, Richard Feynman himself studied communications systems in this spirit. Daniel Hillis describes Feynman’s work at the Thinking Machines Corporation (Hillis 1989): “By the end of that summer of 1983, Richard had completed his analysis of the behaviour of the router, and much to our surprise and amusement, he presented his answer in the form of a set of partial differential equations. To a physicist this may seem natural, but to a computer designer, treating a set of Boolean circuits as a continuous, differentiable system is a bit strange. Feynman’s router equations were in terms of variables representing continuous quantities such as “the average number of 1 bits in a message address.””

In the past few years our theoretical understanding of Internet congestion control has blossomed. We now have a variety of mathematical models that help us evaluate how the network behaves, and what the consequences will be of rapidly growing communications capacity. Frank Kelly from the Statistical Laboratory in Cambridge has made a major contribution, which won him the IEEE Koji Kobayashi prize (Kelly 2000). Research groups in computer science, engineering and mathematics are pushing the boundary at Berkeley, Caltech, Stanford, Cambridge, Turin, Paris, the University of Massachusetts, University College London, MIT and elsewhere.

Theoretical models now exist for alternatives to TCP that can be mathematically proved not to cause congestion collapse, and work is ongoing to test these models experimentally. Some of these alternatives promise to balance traffic across the Internet, and to deliver high data rates and much better quality of service for services like voice-over-Internet-Protocol (VoIP) and live video — all at the same time. It seems likely that these theories will find their way into the mainstream Linux and Windows kernels within the next five years or so, and we hope that they will serve for many years to come.

Further reading
For further information see Sally Floyd’s High Speed TCP website at www.icir.org/floyd/longpaths.html.

W Daniel Hillis 1989 Physics Today 42 (2) 78.

Résumé
Pas de bouchons sur l'Internet de la prochaine génération

Le protocole TCP de contrôle de la transmission, qui commande la manière dont les données sont lancées dans le réseau, a connu un succès phénoménal et il régit aujourd'hui l'essentiel de la circulation sur l'Internet. Cependant, on pense de plus en plus qu'une révision complète s'impose pour faire face à un trafic toujours croissant. On dispose maintenant des modèles théoriques et des preuves mathématiques montrant que des solutions alternatives existent et qu'elles n'entraînent pas de blocage total. Des travaux sont en cours pour en faire la démonstration expérimentale.

Damon Wischik, University College London.
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Experiments finally unveil a precise portrait of the Z

After six years of preparation, a 300 page article combining thousands of measurements from five different experiments presents a precision study of the properties of the Z boson.

From 1989 to 1995, the Large Electron–Positron collider (LEP) at CERN provided collisions at centre-of-mass energies, 88–94 GeV. This range includes the mass of the Z boson, which is thus produced as a resonance, the Z pole (figure 1). In this first phase of LEP running (LEP-1), the four large state-of-the-art detectors ALEPH, DELPHI, L3 and OPAL recorded 17 million Z decays. Over a similar period, from 1992 to 1998, the SLD experiment at SLAC in the US collected 600,000 Z events at the world’s first high-energy linear collider, the SLAC Linear Collider (SLC), with the added advantage of a longitudinally polarized electron beam.

Now, the five big experimental collaborations have submitted a joint paper for publication in *Physics Reports*. Signed by 2500 authors, “Precision electroweak measurements on the Z resonance” summarizes and combines thousands of cross-section and asymmetry measurements. The data sample consists of the world set of electron–positron interactions at the Z pole. The Z boson decays to all kinematically accessible fermion–antifermion pairs, i.e. all leptons and quarks, except the top quark. Hence the collected data allow very detailed investigations of the properties of the Z-boson and Z-to-fermion couplings.

Combining the wealth of measurements has been a long and painstaking task. The large data sample has demanded advanced analysis techniques to reduce systematic measurement uncertainties in the sophisticated detectors to below the statistical precision. This is one of the main reasons for the long delay between the end of data-taking at Z-pole energies and the publication of this report. Any measurement used in the combined review had to have been published in a journal beforehand. Furthermore, to exploit the power of the combined data sets of the experiments, it was necessary to investigate how each measurement could be meaningfully and properly combined with other measurements, while accounting for correlated systematic effects.

Early in the LEP programme, the high-precision measurements resulting from complex analyses made it clear that a dedicated effort by experts was required to tackle such inter-collaborational aspects of the scientific work. This led to the formation of the LEP Electroweak Working Group (LEP-EWWG), the first of several LEP-wide working groups. The LEP-EWWG consists of members from the experimental collaborations and is responsible for properly combining both published and preliminary results of the LEP experiments. It makes use of the expertise of its members in scrutinizing the measurements for combination purposes, in particular in evaluating correlations between measurements. The group also maintains close contact with many theorists, who are advancing calculations of the many observables and their radiative corrections, thus reducing the theoretical uncertainties to the level required by the precision of the data. The great success of the LEP-EWWG has spawned similar efforts at other accelerators, for example, between experiments at B-factories and between experiments at Fermilab’s Tevatron.

One of the first and foremost combined measurements of the Z resonance at LEP concerns the mass and total decay width of the Z boson and the number of light neutrino species (figure 1). The determination of these quantities is based on total cross-sections measured accurately at precisely known centre-of-mass energies; here the LEP beam-energy calibration is crucial. In 1986, during the preparation of the LEP physics programme, it was estimated that the Z-boson mass and width could possibly be measured to an accuracy of about 50 MeV. Today, the Z-pole report shows that an accuracy nearly 25 times better has been finally achieved. The
Fig. 2. Left: the neutrino scattering and low-energy $e^+e^-$ annihilation data available in 1987 constrained the values of the effective vector and axial-vector coupling constants, $g_V$ and $g_A$, to lie within broad bands. Their intersections helped establish the validity of the Standard Model and were consistent with the hypothesis of lepton universality. Right: the results of the LEP/SLD measurements at a much expanded scale. The flavour-specific measurements demonstrate the universal nature of the lepton couplings unambiguously on a scale of approximately 0.001.

Fig. 3. Comparison of the effective electroweak mixing angle $\sin^2 \theta_{\text{eff}}$ derived from measurements depending on lepton couplings only (top) and on quark couplings as well (bottom). Also shown is the Standard Model prediction for $\sin^2 \theta_{\text{eff}}$ as a function of the Higgs mass, $m_H$. The additional uncertainty of the prediction is parametric and dominated by the uncertainties in hadronic vacuum polarization, $\Delta \alpha^{(S)}_{\text{had}}$, and the mass of the top quark, $m_t$, shown as bands. The total width of the two bands is the linear sum of these effects.
These analyses predict the Higgs boson to weigh at most a few hundred gigaelectronvolts, as shown in the paper (CERN-EP/2005-041 and SLAC-R-774) can be found at www.arXiv.org/abs/hep-ex/0509008. For more about the LEP-EWWG see www.cern.ch/LEPEWWG.

Résumé
Le boson Z vu sous haute résolution

Au terme de six ans de préparation, les collaborations ALEPH, DELPHI, L3 et OPAL au CERN et la collaboration SLD au SLAC ont soumis pour publication dans Physics Reports un article coordonnant des milliers de mesures. Cet article de 300 pages, signé par 2500 auteurs, résume et combine les mesures de sections efficaces et d’asymétries du Grand collisionneur électron–positon LEP du CERN et du collisionneur linéaire du SLAC dans une méta-analyse qui offre un portrait à haute résolution du boson Z.

Martin Grünewald, University College Dublin.
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Fifty years of antiprotons

It is 50 years since Emilio Segrè, Owen Chamberlain and their group first created an antiproton. Lynn Yarris describes their achievement at Berkeley’s Bevatron in 1955.

On 1 November 1955, Physical Review Letters published the paper “Observation of antiprotons” by Owen Chamberlain, Emilio Segrè, Clyde Wiegand and Tom Ypsilantis, at what was then known as the Radiation Laboratory of the University of California at Berkeley. This paper, which announced the discovery of the antiproton (for which Chamberlain and Segrè would share the 1959 Nobel Prize for Physics), had been received only eight days earlier. However, the story of the discovery of the antiproton really begins in 1928, when the eccentric and brilliant British physicist, Paul Dirac, formulated a theory to describe the behaviour of relativistic electrons in electric and magnetic fields.

Dirac’s equation was unique for its time because it took into consideration both Albert Einstein’s special theory of relativity and the effects of quantum physics proposed by Edwin Schrödinger and...
ANNIVERSARY

Werner Heisenberg. While it worked well on paper, Dirac’s rather straightforward equation carried with it a most provocative implication: it permitted negative as well as positive values for the energy E. Initially few physicists seriously considered Dirac’s idea because no-one had ever observed particles of negative energy. From the standpoint of both physics and common sense, the energy of a particle could only be positive.

Attitudes towards Dirac’s equation changed dramatically in 1932, when Carl David Anderson reported the observation of a negatively charged electron in a project at the California Institute of Technology that originated with his mentor, Robert Millikan. Anderson named the new particle the “positron”. Both Dirac and Anderson would win Nobel Prizes for Physics for their discoveries. Dirac shared the 1933 Nobel prize with Schrödinger, and Anderson shared the 1936 Nobel prize with Victor Hess. However, the existence of the positron, the antimatter counterpart of the electron, raised the question of an antimatter counterpart to the proton.

As Dirac’s theory continued to explain successfully phenomena associated with electrons and positrons, it followed – from the revised standpoints of both physics and common sense – that it should also successfully explain protons. This would then demand the existence of an antimatter counterpart. The search for the antiproton was under way, but it would get off to a very slow start, as it would be another two decades before a machine capable of producing such a particle became available.

Enter the Bevatron

Anderson discovered the positron with a cloud chamber during investigations of cosmic rays, but it was extremely difficult, if not impossible, to use the same approach for finding the antiproton. If physicists were going to find the antiproton, they were first going to have to make one.

However, even with the invention of the cyclotron in 1931 by Ernest Lawrence, earthbound accelerators were not up to the task. Physicists knew that creating an antiproton would require the simultaneous creation of a proton or a neutron. Since the energy required to produce a particle is proportional to its mass, creating a proton–antiproton pair would require twice the proton rest energy, or about 2 billion eV. Given the fixed-target collision technology of the times, the best approach for making 2 billion eV available would be to strike a stationary target of neutrons with a beam of protons accelerated to an energy of about 6 billion eV.

In 1954, Lawrence commissioned the Bevatron accelerator to reach energies of several billion electron-volts – then designated as BeV (now universally known as GeV) – to be built at his Radiation Laboratory in Berkeley. (Upon Lawrence’s death in 1958, the laboratory was renamed the Lawrence Berkeley National Laboratory.) This weak-focusing proton synchrotron was designed to accelerate protons up to 6.5 GeV. Though never its officially stated purpose, the Bevatron was built to go after the antiproton. As Chamberlain noted in his Nobel laureate lecture, Lawrence and his close colleague, Edwin McMillan, who co-discovered the principle behind synchronized acceleration and coined the term “synchrotron”, were well aware of the 6 GeV needed to produce antiprotons and made certain the Bevatron would be able to get there.

Armed with a machine that had the energetic muscle to make antiprotons, Lawrence and McMillan put together two teams to go after the elusive particle. One team was led by Edward Lofgren, who managed operations of the Bevatron. The other was led by Segre and Chamberlain. Segre had been the first student to earn his physics degree at the University of Rome under Enrico Fermi. He had, with the aid of one of Lawrence’s cyclotrons, discovered technetium, the first artificially produced chemical element. He was also one of the scientists who determined that a plutonium-based bomb was feasible, and his experiments on the scattering of neutrons and protons and proton polarization broke new ground in understanding nuclear forces. Chamberlain had also studied under Fermi, and under Segre as well. He was Segre’s assistant on the Manhattan Project at Los Alamos while still a graduate student, and later joined Segre at Berkeley to collaborate on the nuclear-forces studies.

Making an antiproton was only half the task; no less formidable a challenge was to devise a means of identifying the beast once it had been spawned. For every antiproton created, 40 000 other particles would be created. The time to pull the antiproton from the surrounding herd would be brief: within about 10⁻¹⁰ s after it...
appears, an antiproton comes into contact with a proton and both particles are annihilated.

According to Chamberlain, again from his Nobel lecture, it was understood from the start that at least two independent quantities would have to be measured for the same particle to identify it as an antiproton. After considering several possibilities, it was decided that they should be momentum and velocity.

Measuring momentum
To measure momentum, the research team used a system of magnetic quadrupole lenses, which was suggested to them by Oreste Piccioni, an expert on quadrupole magnets and beam extraction, who was then at Brookhaven National Laboratory. The idea was to set up the system so that only particles of a certain momentum interval could pass through. As the Bevatron's proton beam struck a target in the form of a copper block, fragments of nuclear collisions would emerge in all directions. While most of these fragments were lost, some would pass through the system. For specifically defined values of momentum, the negative particles among the captured fragments would be deflected by the magnetic lenses into and through collimator apertures.

To measure velocity, which was used to separate antiprotons from negative pions, the researchers deployed a combination of scintillation counters and a pair of Cherenkov detectors. The scintillation counters were used to time the flight of particles between two sheets of scintillator, 12 m apart. Under the specific momentum defined by Segrè, Chamberlain and their collaborators, relativistic pions traversed this distance 11 ns faster than the 51 ns it took for the more ponderous antiprotons. Signals from the two scintillators were set up to coincide only if they came from an antiproton. However, because it is possible for two pions to have exactly the right spacing to imitate the signal from an antiproton, the researchers also used the Cherenkov detectors.

One Cherenkov detector was somewhat conventional in that it used a liquid fluorocarbon medium. It was dubbed the "guard counter" because it could measure the velocity of particles moving faster than an antiproton. The second detector, which was designed by Chamberlain and Wiegand, used a quartz medium, and only particles moving at the speed predicted for antiprotons set it off.

In conjunction with the momentum and velocity experiments, Berkeley physicist Gerson Goldhaber and Edoardo Amaldi from Rome led a related experiment using photographic-emulsion stacks. If a suspect particle was truly an antiproton, the Berkeley researchers expected to see the signature star image of an annihilation event. Here the antiproton and a proton or neutron from an ordinary nucleus, presumably that of a silver or bromine atom in the photographic emulsion, would die simultaneously.

Success!
The antiproton experiments of Segrè and Chamberlain and their collaborators began in the first week of August, 1955. Their first run on the Bevatron lasted five consecutive days. Lofgren and his collaborators ran their experiments for the following two weeks. The Segrè and Chamberlain group returned on 29 August and ran experiments until the Bevatron broke down on 5 September. On 21 September, a week after operating crews had revived the Bevatron, Lofgren's group was to begin a four-day run, but instead it ceded its time to Segrè and Chamberlain. That day, the future Nobel laureates and their team found their first evidence of the antiproton based on momentum and velocity. Subsequent analysis of the emulsion-stack images revealed the signature annihilation star that confirmed the discovery. In all, Segrè, Chamberlain and their group counted a total of 60 antiprotons produced during a run that lasted approximately 7 h.

The public announcement of the antiproton's discovery received a mixed response. The New York Times enthusiastically proclaimed "New Atom Particle Found; Termed a Negative Proton", while the particle's hometown newspaper, the Berkeley Gazette, somberly announced "Grim new find at UC". The Berkeley reporter had been told that should an antiproton come in contact with a person, that person would blow up. Today, 50 years on, antiprotons have become a staple of high-energy physics experiments, with trillions being produced at CERN and Fermilab, and no known human fatalities.

Résumé
Les 50 ans de l’antiproton


Lynn Yarris, Lawrence Berkeley National Laboratory.
New exhibition unites
The 1st European Research and Innovation Exhibition, held in Paris, attracted 24,000 visitors. Astrophysicist Jean Audouze, chairman of the exhibition’s Scientific Committee, talked to Beatrice Bressan about the event’s objectives and its impact.

The 1st European Research and Innovation Exhibition – the Salon Européen de la Recherche et de l’Innovation – took place in Paris on 3–5 June 2005 under the patronage of Jacques Chirac, president of France. The aim of the exhibition, which is to become an annual event, is to provide a place for players from a broad sector of activities to come together, creating a crossroads where people and ideas from both the public sector and the corporate world can meet. This year, the 130 exhibitors included CERN, the Institut National de Physique Nucléaire et de Physique des Particules (IN2P3) of the Centre National de la Recherche Scientifique (CNRS), and the Dapnia laboratory of the Commissariat à l’Énergie Atomique, who together presented a stand showing examples of technology transfer.

Jean Audouze, senior CNRS researcher, is the founder and chairman of the exhibition’s Scientific Committee. Consisting of scientific leaders in the world of research and innovation, this committee is responsible for the programme of events, in particular conferences and round-table discussions. Audouze himself has had a great deal of experience in communicating physics on the highest and broadest levels, as scientific adviser to the president of France (1989–1993) and as director of Paris’s well known science museum, the Palais de la Découverte (1998–2004).

How would you describe the role of research today, in the World Year of Physics?
Research is the driving force behind economic, cultural and social progress. The French government, much as the other European political leaders, has set a goal of devoting 3% of gross domestic product to research and development by 2010. Together, France and Europe are actively preparing for the future to meet the dynamic momentum of countries like the US, China and Japan, with whom competition is already very fierce. According to the OECD [Organization for Economic Co-operation and Development], gross domestic expenditure on research and development by member countries amounted to over $650 billion in 2001. The countries of the European Union contributed about $185 billion of this amount. France spent about $31 billion on research and development, which places it in second position in Europe and fourth worldwide, behind the US, Japan and Germany. Many researchers have started their own companies since 1999. Business incubators are playing a crucial role in the development of new companies, assisted by organizations that provide financing specifically for the creation of innovative companies. The biotechnology and nanotechnology sectors are at present leading in terms of the creation of new businesses.

Can you explain the event’s objectives?
The exhibition combined information from fundamental research with its applications. It provided an opportunity for researchers, public and private institutions, universities and the top engineering and business schools in France (les grandes écoles), industrial and commercial companies, R&D departments, incubators, financing organizations, laboratory suppliers, local governments, technology parks
Innovation to Transfer of CERN, IN2P3 and Dapnia at the 1st European Research and Innovation Exhibition, held in Paris on 3–5 June 2005.

(technopoles), research associations and foundations to meet. They could present their activities, develop contacts to encourage professional development, discuss the establishment of new projects, start new partnerships, and negotiate financing for new businesses or research programmes.

**What was the outcome of the three days?**
The final balance is very positive. A total of around 24,000 people attended the event. In addition, the presence of many visitors at the conferences, at the round tables concerning the European research programme and the diffusion of scientific culture in Europe, and at events with the participation of the Nobel laureates in physics has shown the strong interest the public has in scientific topics.

**How have politicians reacted to the measures required to maximize the value of scientific research?**
The politicians have responded well to the scientists' needs, indeed a few programmes have received specific financing allocations. They appreciated the creative way the technological developments were presented to the public, and the debates on social impact to arouse awareness of the importance of science for everyday life.

**What is the outlook for continuing the dialogue in research, education and industrial promotion?**
The perspective for the future is to make this event an annual rendezvous with the participation of other European institutions and national stands.

The World Year of Physics 2005 is an international celebration of physics. Events throughout the year have been highlighting the vitality of physics and its importance in the coming millennium, and have commemorated Einstein's pioneering contributions in 1905. How can the World Year of Physics bring the excitement and impact of physics, science and research to the public?

I am convinced that the World Year of Physics has been a success in terms of popularizing physics and in conveying enthusiasm for the subject among a large public. In each country, and especially in France, many very exciting events were set up with that goal and have attracted quite big audiences. We astrophysicists have a project to make 2009, the 400th anniversary of the use of the astronomical lens by Galileo, the World Year of Astronomy and Astrophysics.

How can worldwide collaborations and fundamental research laboratories such as CERN, CNRS and Dapnia inspire future generations of scientists?

This inspiration is induced by at least two factors: first, CERN, CNRS and Dapnia are involved in the most exciting aspects of fundamental research, e.g. the very nature of matter and the universe; second, their research programmes are planned for the coming decades: the forthcoming operation of the Large Hadron Collider at CERN and projects like VIRGO (which aims to detect gravitational waves) for CNRS and Dapnia should be very enticing for European newcomers to science.

- The CERN, IN2P3 and Dapnia stand showed examples of technology transfer and was prepared by CERN's Technology Transfer and Communication groups. In addition, CERN's Daniel Treille gave a talk "Miroirs brisés, antimatière disparue, matière cachée: le CERN mène l'enquête".

Further reading
For more information see www.salon-de-la-recherche.com.

Résumé
Recherche, innovation et affaires: un nouveau carrefour


Beatrice Bressan, CERN.
The biennial Lepton-Photon conference was held in Uppsala on 30 June – 5 July. The talks erected the impressive edifice known as the Standard Model and showed that experimental ingenuity has not yet shaken its foundations. Francis Halzen summarizes.

Twenty-five years ago at the Rochester meeting held in Madison, Leon Lederman said, “The experimentalists do not have enough money and the theorists are overconfident.” Nobody could have anticipated then that experiments would establish the Standard Model as a gauge theory with a precision of one in 1000, pushing any interference from possible new physics to energy scales beyond 10 TeV. The theorists can modestly claim that they have taken revenge for Lederman’s remark. However, as the Lepton-Photon 2005 meeting underlined, there is no feeling that we are now dotting the i’s and crossing the t’s of a mature theory. All the big questions remain unanswered; worse still, the theory has its own demise built into its radiative corrections.

**The electroweak challenge**

The most evident of unanswered questions is why are the weak interactions weak? In 1934 Enrico Fermi provided an answer with a theory that prescribed a quantitative relation between the fine-structure constant, $\alpha$, and the weak coupling, $G \sim \alpha/M_W^2$, where $M_W$ can be found from the rate of muon decay to be around 100 GeV (once parity violation and neutral currents, which Fermi did not know about, are taken into account). Fermi could certainly not have anticipated that his early phenomenology would develop into a renormalizable gauge theory that allows us to calculate the radiative corrections to his formula. Besides regular higher-order diagrams, loops associated with the top quark and the Higgs boson also contribute, and are consistent with observations.

One of my favourite physicists once referred to the Higgs as the “ugly” particle. Indeed, if one calculates the radiative corrections to the mass appearing in the Higgs potential, the same gauge theory that withstood the onslaught of precision experiments at CERN’s Large Electron-Positron collider, the SLAC linear collider and Fermilab’s Tevatron grows quadratically. Some new physics is needed to tame the divergent behaviour, at an energy scale, $\Lambda$, of less than a few tera-electron-volts by the most conservative of estimates. There is an optimistic interpretation, just as Fermi anticipated particle physics at 100 GeV in 1934, that the electroweak gauge theory requires new physics at 2~3 TeV, to be revealed by the Large Hadron Collider (LHC) at CERN and, possibly, the Tevatron.

Dark clouds have built up on this sunny horizon, however, because some electroweak precision measurements match the Standard...
CP violation and neutrino mass

Another grand unresolved question concerns baryogenesis: why are we here? At some early time in the evolution of the universe quarks and antiquarks annihilated into light, except for just one quark in $10^{10}$ that failed to find a partner and became us. We are here because baryogenesis managed to accommodate Andrei Sakharov’s three conditions, one of which dictates CP violation. Precision data on CP violation in neutral kaons have been accumulated over 40 years, and the measurements can, without exception, be accommodated by the Standard Model with three families of quarks. History has repeated itself for $B$-mesons, but in only three years, owing to the magnificent performance of the experiments at the B-factories – Belle at KEK and BaBar at SLAC. Direct CP violation has been established in the decay $B_s \rightarrow \bar{K} \pi$ with a significance in excess of $5\sigma$.

Unfortunately, this result and a wealth of data contributed by the CLEO collaboration at Cornell, DAFNE at Frascati and the Beijing Spectrometer (BES) fail to reveal evidence for new physics. Given the rapid progress and the better theoretical understanding of the expectations in the Standard Model relative to the kaon system, the hope is that improved data will pierce the Standard Model’s resistant armour. Where theory is concerned, it is worth noting that the lattice now does calculations that are confirmed by experiment (CERN Courier July/August 2005 p13).

A third important question concerns neutrino mass. A string of fundamental experimental measurements has led progress in neutrino physics. Supporting evidence from reactor and accelerator experiments, including first data from the reborn Super-Kamiokande detector, has confirmed discovery of oscillations in solar and atmospheric neutrinos. High-precision data from the pioneering experiments now trickle in more slowly, although evidence for the oscillatory behaviour in $L/E$ of the muon neutrinos in the atmospheric-neutrino beam has become very convincing.

Nevertheless, the future of neutrino physics is undoubtedly bright. Construction at Karlsruhe of the KATRIN spectrometer, which by studying the kinematics of tritium decay will be sensitive to an electron-neutrino mass as low as 0.02 eV, is in progress, and a wealth of ideas on double beta decay and long-baseline experiments is approaching reality. These experiments will have to answer the great “known unknowns” of neutrino physics: their absolute mass and hierarchy, the value of the third small mixing angle and its associated CP-violating phase, and whether neutrinos are really Majorana particles. Discovering neutrinoless double beta decay would settle the last question, yield critical information on the absolute-mass scale and, possibly, resolve the hierarchy problem. In the meantime we will keep wondering whether small neutrino masses are our first glimpse of grand unified theories via the seesaw mechanism, or represent a new Yukawa scale tantalizingly connected to lepton conservation and, possibly, the cosmological constant.

Information on neutrino mass has also emerged from an unexpected direction – cosmology. The structure of the universe is dictated by the physics of cold dark matter and the galaxies we see today are the remnants of relatively small overdensities in its nearly uniform distribution in the very early universe. Overdensity means overpressure that drives an acoustic wave into the other components that make up the universe, i.e. the hot gas of nuclei and photons and the neutrinos. These acoustic waves are seen today in the temperature fluctuations of the microwave background, as well as in the distribu-

Model predictions with too high a precision, pushing $\Lambda$ to around 10 TeV. Some theorists have panicked and proposed that the factor multiplying the unruly quadratic correction, $2M_w^2 + M_h^2 - 4M_\tau^2$, must vanish exactly. This has been dubbed the Veltman condition. It “solves” the problem because the observations can accommodate scales as large as 10 TeV, possibly even higher, once the dominant contribution is eliminated.

If the Veltman condition does happen to be satisfied, it would leave particle physics with an ugly fine-tuning problem reminiscent of the cosmological constant; but this is very unlikely. The LHC must reveal the “Higgs” physics already observed via radiative corrections, or at least discover the physics that implements the Veltman condition, which must still appear at $2-3$ TeV although higher scales can be rationalized for other tests of the theory. Supersymmetry is a textbook example. Even though it elegantly controls the quadratic divergence by the cancellation of boson and fermion contributions, it is already fine-tuned at a scale of $2-3$ TeV. There has been an explosion of creativity to resolve the challenge in other ways; the good news is that all involve new physics in the form of scalars, new gauge bosons, non-standard interactions, and so on.

Alternatively, we may be guessing the future while holding too small a deck of cards, and the LHC will open a new world that we did not anticipate. The hope then is that particle physics will return to its early traditions where experiment leads theory, as it should, and where innovative techniques introduce new accelerators and detection methods that allow us to observe with an open mind and without a plan.

Analysis from the UTfit collaboration, using no angles (left) and angles only (right), illustrates the precision – and redundancy – now achieved with the new measurements from the B-factories, Belle at KEK and BaBar at SLAC.
The physics of partons

Physics at the high-energy frontier is the physics of partons, probing the question of what the proton really is. At the LHC, it will be gluons that produce the Higgs boson, and in the highest-energy experiments, neutrinos interact with sea-quarks in the detector. We can master this physics with unforeseen precision because of a decade of steadily improving measurements of the nucleon’s structure at HERA, DESY’s electron–proton collider. These now include experiments using targets of polarized protons and neutrons.

HERA is our nucleon microscope, tunable by the wavelength and the fluctuation time of the virtual photon exchanged in the electron–proton collision. With the wavelengths achievable, the proton has now been probed with a resolution of one thousandth of its 1 fm size. In these interactions, the fluctuations of the virtual photons survive over distances ct = 1/x, where x is the relative momentum of the parton. In this way, HERA now studies the production of chains of gluons as long as 10 fm, an order of magnitude larger than, and probably totally insensitive to, the proton target. These are novel structures, the understanding of which has been challenging for quantum chromodynamics (QCD).

Theorists analyse HERA data with calculations performed to next-to-next-to-leading order in the strong coupling, and at this level of precision must include the photon as a parton inside the proton. The resulting electromagnetic structure functions violate isospin and differentiate a u quark in a proton from a d quark in a neutron because of the different electric charge of the quark. Interestingly, the inclusion of these effects modifies the extraction of the Weinberg angle from data from the NuTeV experiment at Fermilab, bridging roughly half of the discrepancy between NuTeV’s result and the value in the Particle Data Book. Added to already anticipated intrinsic isospin violations associated with sea-quarks, the NuTeV anomaly may be on its way out.

While history has proven that theorists had the right to be confident in 1980 at the time of Lederman’s remark, they have not faded into the background. Despite the dominance of experimental results at the conference, they provided some highlights of their own. Developing QCD calculations to the level at which the photon structure of the proton becomes a factor is a tour de force, and there were other such highlights at this meeting. Progress in higher-order QCD computations of hard processes is mind-boggling and valuable, sometimes essential, for interpreting LHC experiments. Discussions at the conference of strings, supersymmetry and additional dimensions were very much focused on the capability of experiments to confirm or debunk these concepts.

Towards the highest energies

Theory and experiment joined forces in the ongoing attempts to read the information supplied by the rapidly accumulating data from the Relativistic Heavy Ion Collider (RHIC) at Brookhaven. Rather than the anticipated quark–gluon plasma, the data suggest the formation of a strongly interacting fluid with very low viscosity for its entropy. Similar fluids of cold 6Li atoms have been created in atomic traps. Interestingly, theorists are exploiting Juan Maldacena’s connection between four-dimensional gauge theory and 10-dimensional string theory to model just such a thermodynamic system. The model is of a 10D rotating black hole with Hawking–Beckenstein entropy, which accommodates the low viscosities observed. This should give notice that very-high-energy collisions of nuclei may prove more interesting than anticipated from “QCD-inspired” logarithmic extrapolations of accelerator data. Such physics is relevant to analysing cosmic-ray experiments.

A century has passed since cosmic rays were discovered, yet we do not know how and where they are accelerated. Solving this mystery is very challenging, as can be seen by simple dimensional analysis. A magnetic field B of size R can accelerate a particle with electric charge q to an energy \( E \leq \frac{1}{2} q v_B R \), with velocity \( v \approx c \), and
no higher (where $I$ is a possible boost factor between the frame of the accelerator and ourselves). This is the Hillas formula. Note that it applies to our man-made accelerators, where kilogauss fields over several kilometres yield 1 TeV, because the accelerators reach efficiencies that can come close to the dimensional limit.

Opportunity for particle acceleration to the highest energies in the cosmos is limited to dense regions where exceptional gravitational forces create relativistic particle flows, such as the dense cores of exploding stars, inflows on supernovas black holes at the centres of active galaxies, and so on. Given the weak magnetic field (microgauss) of our galaxy, no structures seem large or massive enough to yield the energies of the highest-energy cosmic rays, implying instead extragalactic objects. Common speculations include nearby active galactic nuclei powered by black holes of 1 billion solar masses, or the gamma-ray-burst-producing collapse of a supermassive star into a black hole.

The problem for astrophysics is that in order to reach the highest energies observed, the natural accelerators must have efficiencies approaching 10% to operate close to the dimensional limit. This is so daunting a concept that many believe that cosmic rays are not the beams of cosmic accelerators but the decay products of remnants from the early universe, for instance topological defects associated with a grand unified theory phase transition near $10^{24}$ eV.

There is a realistic hope that this long-standing puzzle will be resolved soon by ambitious experiments: air-shower arrays of 10,000 km$^2$, arrays of air Chernikov detectors, and kilometre-scale neutrino observatories. While no definitive breakthroughs were reported at the conference, preliminary data forecast rapid progress and imminent results in all three areas.

The air-shower array of the Pierre Auger Observatory is confronting the problem of low statistics at the highest energies by instrumenting a huge collection area covering 3000 km$^2$ on an elevated plane in western Argentina (CERN Courier March 2002 p6). The completed detector will observe several thousand events a year above 10 EeV and tens above 100 EeV, with the exact numbers depending on the detailed shape of the observed spectrum.

The end of the cosmic-ray spectrum is a matter of speculation given the somewhat conflicting results from existing experiments. Above a threshold of 50 EeV cosmic rays interact with cosmic microwave photons and lose energy to pions before reaching our detectors. This is the origin of the Greissen-Zatsepin-Kuzmin cutoff that limits the sources to our supercluster of galaxies. This feature in the spectrum is seen by the High Resolution Fly's Eye (HiRes) in the US at the 5σ level but is totally absent from the data from the Akeno Giant Air Shower Array (AGASA) in Japan. At this meeting the Auger collaboration presented the first results from the partially deployed array, with an exposure similar to that of the final AGASA data. The data confirm the existence of events above 100 EeV, but there is no evidence for the anisotropy in arrival directions claimed by the AGASA collaboration. Importantly, the Auger data reveal a systematic discrepancy between the energy measurements made using the independent fluorescent and Chernikov detector components. Reconciling the measurements requires that very-high-energy showers develop deeper in the atmosphere than anticipated by the particle-physics simulations used to analyse previous experiments. The performance of the detector foreshadows a qualitative improvement of the observations in the near future.

Cosmic accelerators are also cosmic-beam dumps producing secondary beams of photons and neutrinos. The AMANDA neutrino telescope at the South Pole, now in its fifth year of operation, has steadily improved its performance and has increased its sensitivity by more than an order of magnitude since reporting its first results in 2000. It has reached a sensitivity roughly equal to the flux anticipated to accompany the highest-energy cosmic rays, dubbed the Waxman–Bahcall bound. Expansion into the IceCube kilometre-scale neutrino observatory is in progress (CERN Courier May 2005 p17). Companion experiments in the deep Mediterranean are moving from R&D to construction with the goal of eventually building a detector the size of IceCube.

However, it is the HESS array of four air Chernikov gamma-ray telescopes deployed under the southern skies of Namibia that delivered the particle-astrophysics highlights at the conference. This is the first instrument capable of imaging astronomical sources in gamma rays at tera-electron-volt energies, and it has detected sources with no counterparts in other wavelengths (CERN Courier January/February 2005 p30). Its images of young galactic supernova remnants show filament structures of high magnetic fields that are capable of accelerating protons to the energies, and with the energy balance, required to explain the galactic cosmic rays. Although the smoking gun for cosmic-ray acceleration is still missing, the evidence is tantalizingly close.

The next Lepton-Photon conference will take place in Daegu, Korea, in 2007.

Résumé

La conférence lepton-photon bisannuelle s’est tenue à Uppsala du 30 juin au 5 juillet. Les exposés ont engagé l’impressionnant qu’édifice du modèle standard et montré que, malgré toute leur ingéniosité, les expérimentateurs ne parviennent toujours pas à ébranler cette forteresse. Cependant, comme l’a souligné la réunion, le sentiment ne prévaut nullement que nous portons les grandes questions du moment restent sans réponse.

Francis Halzen, University of Wisconsin.
Close nucleon encounters

Jefferson Lab may have directly observed short-range nucleon correlations, with densities similar to those at the heart of a neutron star. Mark Strikman explains.

Scientists believe that the crushing forces in the core of neutron stars squeeze nucleons so tightly that they may blur together. Recently, an experiment by Kim Egiyan and colleagues in Hall B at the US Department of Energy's Jefferson Lab (JLab) caught a glimpse of this extreme environment in ordinary matter here on Earth. Using the CEBAF Large Acceptance Spectrometer (CLAS), the team measured ratios of the cross-sections for electrons scattering with large momentum transfer off medium and light nuclei in the kinematic region that is forbidden for scattering off low momentum nucleons. Steps in the value of this ratio appear to be the first direct observation of the short-range correlations (SRCs) of two and three nucleons in nuclei, with local densities comparable to those in the cores of neutron stars.

SRCs are intimately connected to the fundamental issue of why nuclei are dilute bound systems of nucleons. The long-range attraction between nucleons would lead to a collapse of a heavy nucleus into an object the size of a hadron if there were no short-range repulsion. Including a repulsive interaction at distances where nucleons come close together, \( <0.7 \text{ fm} \), leads to a reasonable prediction of the present description of the low-energy properties of nuclei, such as binding energy and saturation of nuclear densities. The price is the prediction of significant SRCs in nuclei.

For many decades, directly observing SRCs was considered an important, though elusive, task of nuclear physics; the advent of high-energy electron–nucleus scattering appears to have changed all this. The reason is similar to the situation encountered in particle physics: though the quark structure of hadrons was conjectured in the mid-1960s, it took deep inelastic scattering experiments at SLAC and elsewhere in the mid-1970s to prove directly the presence of quarks. Similarly, to resolve SRCs, one needs to transfer to the nucleus energy and momentum \( >1 \text{ GeV} \), which is much larger than the characteristic energies/momenta involved in the short-distance nucleon–nucleon interaction. At these higher momentum transfers, one can test two fundamental features of SRCs: first, that the shape of the high-momentum component \( (>300 \text{ MeV}/c) \) of the wave function is independent of the nuclear environment, and second, the balancing of a high-momentum nucleon by, predominantly, just one nucleon and not by the nucleus as a whole.

An extra trick required is to select kinematics where scattering off low momentum nucleons is strongly suppressed. This is pretty straightforward at high energies. First, one needs to select kinematics sufficiently far from the regions allowed for scattering off a free nucleon, i.e. \( Q^2/2q_0m_n <1 \), and for the scattering off two nucleons with overall small momentum in the nucleus, \( x<2 \). (Here \( Q^2 \) is the square of the four momenta transferred to the nucleus, and \( q_0 \) is the energy transferred to the nucleus.) In addition, one needs to restrict \( Q^2 \) to values of less than a few \( \text{giga-electron-volts squared} \); in this case, nucleons can be treated as partons with structure, since the nucleus remains intact in the final state due to final phase-volume restrictions.

If the virtual photon scatters off a two-nucleon SRC at \( x>1 \), the process goes as follows in the target rest frame. First, the photon is absorbed by a nucleon in the SRC with momentum opposite to that of the photon; this nucleon is turned around and two nucleons then fly out of the nucleus in the forward direction (figure 1). The inclusive nature of the process ensures that the final-state interaction does not modify the ratios of the cross-sections. Accordingly, in the region where scattering off two-nucleon SRCs dominates (which for \( Q^2 \geq 1.4 \text{ GeV}^2 \) corresponds to \( x>1.5 \)), one predicts that the ratio of the cross-section for scattering off a nucleus to that off a deuteron should exhibit scaling, namely it should be constant independent of \( x \) and \( Q^2 \) (Frankfurt and Strikman 1981). In the 1980s, data were collected at SLAC for \( x>1 \). However, they were in somewhat different kinematic regions for the lightest and heavier nuclei. Only in 1993 did the sustained efforts of Donal Day and collaborators to interpolate these data to the same kinematics lead to the first evidence for scaling, but the accuracy was not very high.

An experiment with the CLAS detector at JLab was the first to take data on \(^3\)He and several heavier nuclei, up to iron, with identical kinematics, and the collaboration reported their first findings in 2003 (Egiyan et al. 2003). Using the \( 4.5 \text{ GeV} \) continuous electron beam available at the lab's Continuous Electron Beam Accelerator Facility (CEBAF), they found the expected scaling behaviour for the cross-section ratios at \( 1.5 \leq x \leq 2 \) with high precision.

The next step was to look for the even more elusive SRC of three nucleons. It is practically impossible to observe such correlations in intermediate energy processes. However, at high \( Q^2 \), it is straightforward to suppress scattering off both slow nucleons and two-nucleon SRCs. One needs only to reach the \( x>2 \) region where scattering off a deuteron is kinematically forbidden. Here, the experiment typically...
probes scattering off a fast nucleon with momentum opposite to the virtual photon, with two nucleons balancing the fast nucleon’s momentum (figure 2, p37).

Again, a scaling of the ratios was expected. In this case, however, the ratios of the cross-sections for a pair of nuclei of masses $A_1$ and $A_2$ and with $A_1 > A_2$ was predicted to be higher for $2 < x < 3$ than for $1.5 < x < 2$. This is because there is a high probability for a nucleon to have two nearby nucleons in a heavier, denser nucleus. Hence, one expected to find two steps. This is exactly what the CLAS experiment observed in data recently reported for these kinematics and shown in figure 3 (Egiyan et al. 2005). Moreover, the iron-carbon ratios for $x \sim 1.7$ and 2.5 are consistent with the expectation that the probability of two- and three-nucleon SRCs should increase with $A$ as the square and cube, respectively, of the nuclear density. For iron, the probability of two-nucleon SRCs reaches about 25%.

More data for exploring SRCs have already been taken at JLab, and several more efforts are already planned to study this interesting region of nuclear physics, which has important implications for the dynamics of the cores of neutron stars.

Fig. 3. Cross-section ratios of $^4$He, $^{12}$C and $^{56}$Fe to $^3$He, normalized to mass A, as a function of $x$ for $Q^2 > 1.4$ GeV$^2$. The horizontal lines indicate two scaling levels of the cross-section ratios. Solid parts of the lines show the scaling regions used to calculate the per-nucleon probabilities for two- and three-nucleon correlations in helium-4, carbon and iron.

Further reading

Résumé
Rencontres étroites de nucléons

Une équipe du Laboratoire Jefferson a réalisé ce qui pourrait bien être la première observation directe de corrélations à courte portée dans des noyaux présentant des densités comparables à celles du cœur des étoiles à neutrons. Utilisant le spectromètre CLAS de grand’ acceptance du CEBAF, cette équipe a mesuré les rapports des sections efficaces de diffusion des électrons à grande impulsion transversale par des noyaux légers et moyens. La variation par paliers de ce rapport semble indiquer des corrélations à courte portée de deux et trois nucléons dans les noyaux.

Mark Strikman, Penn State University.
Wisdom generation in the Alps: a student's tale

Sezen Sekmen describes her experience as a student at the European School for High Energy Physics, which was hosted this year by Austria in the scenic town of Kitzbühel.

“Seventy per cent of today's successful particle physicists have attended this school – which means you have a high chance to be one of them in the future,” says a joyful Egil Lilseth as he welcomes us to the 2005 European School for High Energy Physics. Instantly more than 100 glasses rise, accompanied by a cheerful applause. We all feel lucky to be here.

We are in Kitzbühel, a peaceful town with green and beautiful surroundings in south-west Austria, to witness a curious learning experience and to contribute to its spirit as much as we can. The first evening’s dinner sweeps away any clouds of anxiety we might have, and observations of the first encounters have provided more than 50 evidence of a great event.

On the first morning, just as rain is refreshing the beauty of the mountains outside, the overhead projector starts to light up the first fields and interactions on the screen. Wilfried Buchmüller from DESY provides us with the most fundamental piece of knowledge we will ever need – the Standard Model itself. The school’s academic programme is like a perfect PhD Student’s Guide to High-Energy Physics, as if to advise “don’t panic” in the wide and diverse realm of this exciting subject, “we will show you the route”.

Our appetite for learning grows as cosmology slowly makes peace with precision in the lectures by Rocky Kolb from Fermilab. He calmly strides through the whole universe, from its brilliant but furious past to its settled and gloomy present, from its simply overwhelming dark side to its modest but comforting light side.

Then enters Larry McLerran from Brookhaven, who introduces us to the colour glass condensate and the quark–gluon plasma, which happen to be two rather unusual forms of strongly interacting matter. He tells us the ancient tales of the good old days when quarks and gluons used to enjoy their freedom, and how the Relativistic Heavy Ion Collider came along at Brookhaven with the aim of capturing a few memories of such eras. On the other hand, Gerhard Ecker from Vienna draws a somewhat more familiar portrait of strong interactions as he systematically goes through quantum chromodynamics, explaining the usual quarks and gluons, and showing the remarkable detail hidden behind even the simplest approaches in this theory.

The school’s participants, including Sezen Sekmen, who is seated on the left, enjoy a day out in Salzburg.

The students study each other’s work during the poster session.

The evenings call for our creativity in the discussion sessions (which might also be considered as gentle warnings for us to stay awake during the lectures). Having received our daily lecture notes we are divided into six discussion groups, where we are supposed to make an account of the day’s learning and remove any obscurities in the lectures. Encouraged by the friendly attitudes of our discussion leaders, who are all young and willing theorists, and of the visiting lecturers, any shyness disappears and the first hints of inspiration begin to appear as ideas, questions and comments bravely...
The European School of High Energy Physics comes to Austria

For the first time in its 40 year history, the European School of High Energy Physics was hosted by Austria in 2005. Organized jointly by CERN and the Joint Institute for Nuclear Research (JINR) in Dubna, the school took place from 21 August to 2 September in the town of Kitzbühel.

Beginning as the CERN School of Physics in 1962, when it was aimed at those using emulsion techniques at CERN, the school quickly evolved to place its emphasis on teaching theoretical particle physics to young experimentalists, and to rotating among the member states. From 1970 the school was organized every two years, jointly with JINR, and in 1991 it became the European School of High Energy Physics, organized each year by CERN and JINR. Every year the school assembles around 100 young experimentalists for a unique opportunity to improve their understanding of physics. Outstanding theorists lecture the students on the various aspects of high-energy particle physics. A special feature is the discussion sessions moderated by young theorists, which allow open questions to be clarified in smaller groups.

On a typical day of this year’s school, there were two lectures make their way into the discussions.

It is now Thursday night and the poster session begins, transforming modest students into proud physicists who share the outcomes of their current research with great skill and enthusiasm. As well as discovering new ideas, we also see some different approaches to familiar subjects. For example, as someone who wrote an MSc thesis on the analysis of miniature black holes in the CMS experiment at CERN, I am delighted to come across a poster on a similar study for ATLAS. I discover that our friends from Oxford suffered the same problems we did, and so over discussions we decide to support each other in any future studies of these ruthless objects. Best of all though, is to have the vision that through all of these diverse contributions the goals of physics today can indeed be fulfilled.

The sound of music
But it’s not all work. We also have enough time to answer the irresistible call of the great Alps or to relax in the pleasant atmosphere of the historic town of Kitzbühel. On Saturday we visit Salzburg, the town enchanted by the graceful hand of Mozart.

The second week brings new lectures and new lecturers. After convincing us that Buchmüller’s Standard Model is fine but definitely insufficient, John Ellis from CERN goes on to reveal the vast worlds beyond, which are ruled by brilliant scientific imagination, with of course some rightful emphasis placed on the unavoidable elegance of supersymmetry. His presence is an invaluable gift, especially for me, as my current research happens to be on supersymmetric dark matter. Inspired by his lectures, as devoted experimentalists, we even go on a dangerous quest for dark matter on the nearby Schwarzsee at night.

Later, Robert Fleischer, also from CERN, explains how a nasty complex phase destroyed the beautiful CP symmetry and introduced some excitement into our universe, which would otherwise be less interesting; and how it also caused a few headaches among the physicists trying to explore the rich phenomenology of the Cabibbo–Kobayashi–Maskawa matrix and its unitarity triangles. We then discover some “CP violating terms” in the local organizing committee as two of its members from Vienna, Manfred Jeitler and Laurenz Widhalm, in addition to their efforts to offer us an outstanding experience, present lectures on experimental aspects of B- and K-physics, respectively. Then Manfred Lindner from Munich describes the ghostly neutrinos and the many consequences of their mischievous behaviour, and gives a long list of the global endeavours to discover their nature experimentally.

There are even some lectures not on particle physics. Wolfram

Rocky Kolb, from Fermilab, talks on spontaneous symmetry breaking during his lecture on astrophysics and cosmology.
Müller from Graz gives instructions on the physics of ski jumping, which seems quite appropriate in Kitzbühel, and Herbert Pietschmann from Vienna shows us our fate on the way to knowledge in his delightful lecture on physics and philosophy.

Meanwhile, the interactions increase, just as predicted by the famous "Summer Student Group Theory". Although we have grown up under the strict hands of scientific work, the children within us still seek fun and adventure. We make the most of a colourful international community formed without prejudices and borders. The coffee breaks, which seemed a little long in the beginning, now fly swiftly by with cheerful conversations. I feel a significant improvement in my debating skills, especially after all the "SUSY and beyond" discussions with several expert theorist friends.

**Grand finale**

However, the inescapable end is close. In order to avoid becoming too melancholy and to create a glorious finale, we amalgamate all our creativity in preparing an unforgettable farewell night. This time we are on stage, giving so-called lectures on "serious subjects" (that cannot be mentioned here!), singing, acting and doing all sorts of things to entertain our audience. But finally we have to say difficult goodbyes to all of our friends (yes, we are friends now), and leave the cosy Hotel Kitzhof, where our hosts, through their patience and goodness, have somehow managed to survive our two-week occupation.

I know that all of us share the same feeling of gratitude towards everyone who made this school possible. I am especially indebted, as a student coming from an observer state who had the privilege of being supported through the generosity of CERN. We are greatly thankful for the endless support and kindness we received from Egil Lillesøl (CERN schools director), Danielle Méral (CERN schools secretary), Tatjana Doronskova (JINR schools secretary), all the local organizers plus all the other representatives of CERN and JINR who were with us during the school. We have been thoroughly enriched as a result of their sincere efforts. This worthy tradition must continue, as long as physics has new puzzles to offer us and as long as we can respond through willing fresh minds.

**Résumé**

Une génération de sages dans les Alpes: une étudiante raconte

Chaque année, l'Ecole européenne de physique des hautes énergies rassemble une centaine de jeunes expérimentateurs en leur offrant une occasion unique d'améliorer leur compréhension de la physique des particules grâce aux cours d'éminents théoriciens. L'Ecole se distingue par ses séances de discussion en petits groupes pour clarifier divers sujets. Organisée cette année par le CERN et l'Institut unifié de recherche nucléaire (IURN) de Dubna, elle se tenait à Kitzbühel, Autriche. Sezen Sekmen décrit son expérience d'étudiante.

Sezen Sekmen. Middle East Technical University, Ankara, Turkey.
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Wormser takes the reigns at LAL

Guy Wormser has been named director of the Laboratoire de l'Accélérateur Linéaire (LAL) at Orsay, with effect from 1 September 2005. He succeeds Bernard D'Almagne.

Wormser joined LAL in 1977, when he was newly graduated from the Paris Ecole Normale Supérieure. During his time at the laboratory he has worked at CERN and has also forged extensive ties in the US, in particular at SLAC. At the end of the first phase of the Large Electron Positron (LEP) collider project, where he worked on the DELPHI experiment, Wormser participated in the PEP-II project at SLAC and persuaded French researchers to join the nascent BaBar collaboration, thus contributing to the new era of international collaboration at SLAC.

Since then, Wormser’s leadership has extended to other areas, including computing with the DataGRID and Enabling Grids for E-science projects. A member and chairman of numerous international committees, he was named deputy director of IN2P3 from 1999 to 2003. He recently created and chairs a new panel of the International Committee for Future Accelerators, which is devoted to the international coordination of computing in high-energy physics, and he co-chairs the French Global Design Effort for the International Linear Collider (ILC).

With more than 300 people, including 100 physicists, LAL is the largest laboratory of CNRS/IN2P3 devoted to particle physics and enjoys strong links with Paris XI University. It plays a major role, both at the construction stage and in data analysis, in many particle-physics experiments at CERN, DESY and in the US. It is also involved in neutrino physics and is making major contributions to astroparticle and cosmology projects. In addition, the laboratory is a key participant in long-term machine projects, such as the German XFEL, the ILC and the Compact Linear Collider at CERN, where the LAL accelerator group is a major partner for R&D and construction, as it was for LEP.

Under Wormser’s influence, LAL will undoubtedly retain its impact on present and future research in particle physics, and remain one of the main European centres for particle physics and cosmology, committed to excellence and international partnerships.

Italian Physical Society honours theorists of gravity

Sergio Ferrara and Gabriel Veneziano of CERN, and Bruno Zumino of the University of California, Berkeley, have been awarded the 2005 Enrico Fermi prize of the Italian Physical Society. The trio of Italians were said to have "honoured Italian physics with their discoveries, which have contributed in substantial ways to the development of the modern theories of gravity."

In particular, Ferrara receives the award for his contribution to the discovery of supergravity theory; Veneziano for the discovery of dual models, which were recognized subsequently as the theoretical base of the string theory version of quantum gravity; and Zumino for his contributions to the theory of supersymmetry and supergravity.

CERN theorists Sergio Ferrara (left) and Gabriel Veneziano after the award ceremony on 26 September at the annual meeting of the Italian Physical Society in Catania.
IEEE dedicates Milestone plaque at CERN...

At a ceremony on 26 September at CERN, W Cleon Anderson, president of the Institute of Electrical and Electronics Engineers (IEEE), formally dedicated a “Milestone” plaque in recognition of the invention of electronic particle detectors at CERN. The plaque was unveiled by Anderson and Georges Charpak, the Nobel-prize winning inventor of wire-chamber technology at CERN.

With the attribution of this IEEE Milestone, CERN finds itself in good company. There are currently more than 60 Milestones around the world, awarded for such momentous achievements as the landing of the first transatlantic cable, code breaking at Bletchley Park during the Second World War, and the development of the Japanese bullet train, the Tokaido Shinkansen.

Particle-physics research was revolutionized in 1968 when Charpak published a paper describing the multi-wire proportional chamber, a forerunner to many of the particle detectors in use today. This invention, which paved the way for new discoveries in particle physics, also made it possible to increase the rate of data collection by a factor of one thousand.

Charpak, who received the Nobel Prize for Physics in 1992 for his invention, has also actively contributed to the use of this type of detector in various applications in medicine and biology. The value of fundamental research institutes such as CERN in fostering innovation of this kind was a recurring theme of the ceremony. Charpak himself stressed the importance of intellectual freedom, saying of his time at the laboratory, “CERN was a fantastic place because of the freedom I had, which permitted me to do a lot of things that were unexpected.”

...and honours Romeo Perin with superconductivity award

CERN engineer Romeo Perin has been awarded the IEEE Council on Superconductivity Award for Significant and Continuing Contributions to Applied Superconductivity. He has been recognized for his work in the field of large-scale applications of superconductivity, in particular for his many contributions in both the design and construction of magnets for particle accelerators.

Perin’s contributions include the realization of magnets for the Large Hadron Collider, from the design of the first models and prototypes through the critical phase of industrialization; the design and construction of quadrupoles for the Intersecting Storage Rings; and the leadership of the magnet group, which is responsible for developing magnets and superconductors at CERN.

Perin received the award on 19 September at the International Conference on Magnet Technology in Genoa, when René Flükiger of the University of Geneva was also rewarded for his work in applied superconductivity. Flükiger was recognized for his contribution to the development of useful superconductor cables, with both low and high critical temperature.
RFQ pioneer celebrates 80th birthday

Vladimir Teplyakov, one of the leading scientists at the Institute for High Energy Physics (IHEP) in Protvino, celebrates his 80th birthday on 6 November. A distinguished expert in accelerator and beam physics and engineering, he is well known for his invention in the late 1960s, together with Ilia Kapchinsky of ITEP-Moscow, of the radio-frequency quadrupole (RFQ) linear accelerator. This versatile device, which bunches, focuses and accelerates lower energy protons and ions using only RF fields, has been put into operation in many labs throughout the world.

After being drafted into the Red Army and serving in the Second World War, Teplyakov graduated from the Polytechnic Institute, and in the 1950s began his career in the Moscow-based Institute for Chemical Physics of the National Academy of Sciences. While there, he was involved in feasibility studies for a high-current proton linear accelerator. In 1966 Teplyakov moved with his team to IHEP in Protvino, where he was charged with commissioning and running a 100 MeV Alvarez drift-tube linac, the I-100. This machine has served for 20 years as an injector to the 70 GeV proton synchrotron, the U-70, which was the world’s largest when it started up.

In 1969 Teplyakov and Kapchinsky put forward the concept of the RFQ, for which they received the Lenin prize, the top award of the former USSR, in 1988. The American Physical Society has also honoured the achievement. Since then, Teplyakov has contributed greatly to extending RFQ focusing to higher beam energies by developing various RFQ drift-tube structures and RF cavities to drive them. In 1985 the world’s only all-RFQ 30 MeV linear accelerator, the URAL-30, was put into operation and is still being employed as an injector to the fast-cycling 1.5 GeV booster synchrotron in the upgraded injector chain of the U-70. Now, a modified successor, named URAL-30M, is being assembled and subjected to pre-commissioning bench testing.

Teplyakov has authored more than 100 scientific papers and many patented inventions, and is co-author of the fundamental book *Linear Accelerators of Ions*, used by several generations of accelerator scientists in Russia. He is still active in science and full of new ideas. His friends and colleagues wish him good health and many more years of creative research.

ISAPP 2005

Third school for astroparticle physicists of the future

At the beginning of July, more than 60 European doctoral students gathered in Belgirate, on Lake Maggiore in Italy, to attend the third International School on Astroparticle Physics (ISAPP 2005). The school is part of the activities of the ISAPP network, which includes 23 universities, institutes and laboratories from France, Germany, Israel, Italy, Russia and Spain. It is different from other schools in that it is dedicated to European doctoral students from two fields – nuclear and particle physics, and cosmology and astrophysics – whose students do not traditionally mix, and so aims to create new astroparticle physicists.

The format of the school begins with two days dedicated to parallel introductory lessons on topics that some of the students are less familiar with, while the “core” lessons, common to all the students, provide an in-depth look at specific areas of astroparticle physics. This year the main topic concerned high-energy cosmic rays, while previously there were in-depth lectures on neutrinos in physics and astrophysics, dark matter and dark energy, and gravitational waves.

Time is also set aside during the school for formal and informal discussions and short seminars by the students. Care is taken to have the speakers stay for the full length of the school and at the same location as the students, so as to encourage the exchange of experiences and ideas.

This year’s school was attended by students from 11 countries, with a majority of non-Italians, and there was also a large number of women, who constituted half the participants. Next year the school is planned to take place in Germany.

For more information on the ISAPP network, together with complete lists of the school’s programme, organizers, teachers and lessons, see www.mi.infn.it/ISAPP.
China and CERN look to strengthen co-operation in high-energy physics

Over the past 30 years, the Chinese high-energy particle-physics community has become an important participant in CERN's experimental physics programme, with formal co-operation agreements signed in the 1990s between CERN and the Chinese government, the Chinese Academy of Sciences (CAS), and the National Natural Science Foundation of China (NSFC). Since the signature of a renewed co-operation agreement between the Chinese government and CERN early in 2004, contacts have intensified at the highest level, for example with the visit of the president of CAS, Yongxiang Lu, to CERN, and a meeting between China's premier, Jiabao Wen, and CERN’s director general Robert Aymar.

To establish closer ties in high-energy physics, as well as in the associated computing and accelerator technologies, it was agreed to organize a China–CERN workshop in China. Its aim was that all Chinese scientific institutions with a potential interest in either high-energy physics or accelerator technology could meet with representatives from CERN to review the scope of the CERN–China collaboration and explore opportunities to strengthen further, and possibly also enlarge, the partnership on a longer term.

Organized by the Institute for High-Energy Physics (IHEP), at the request of China’s Ministry of Science and Technology (MOST), the China–CERN workshop took place in Beijing on 14–15 May 2005. It was attended by more than 70 scientists from 16 different scientific institutions in China, as well as high-level representatives of MOST, the Ministry of Education (MOE), the NSFC and CAS. The CERN delegation, led by Robert Aymar, included CERN’s chief scientific officer Jos Engelen, the advisor on relations with non-member states, the spokespersons of the Large Hadron Collider (LHC) experiments (ALICE, ATLAS, CMS and LHCb), a representative for LHC Grid Computing, and the leaders of the Compact Linear Collider (CLIC) and Superconducting Proton Linac (SPL) studies.

Following the opening by Jie Zhang, the director of CAS’s Bureau of Basic Sciences, the vice-minister of science and technology, Jinpei Cheng, reviewed co-operation between CERN and China since its beginnings in the early 1970s. He acknowledged the mutual benefits arising from a strengthened co-operation to both China and the scientific community working at CERN, and pledged a sustained effort by the Chinese government to support this endeavour. Aymar responded by acknowledging the participation of Chinese scientists in activities at CERN and invited China to deepen and extend this co-operation.

The director of IHEP, Hesheng Chen, then presented an outline of particle-physics research in China, and summarized China’s participation in international research programmes, recognizing CERN as one of China’s most significant partners. Aymar and Engelen followed with an overview of the ongoing and future research programmes at CERN, pointing out where Chinese physicists already participate, and presented the opportunities to extend or deepen China’s participation.

The workshop heard more detailed reports on the status and future plans for the LHC experiments and for LHC Grid Computing from the spokespersons and leaders of the teams participating from China. The first part of the workshop then concluded with presentations on accelerator projects and studies, including the SPL study at CERN, China’s Spallation Neutron Source project, the Beijing Electron-Positon Collider (BEPC), studies on CLIC at CERN, and China’s involvement in the International Linear Collider.

Further discussions took place in six parallel sessions dedicated to the four LHC experiments, to LHC Grid Computing, and to accelerator studies and projects. The conclusions were finally presented in a plenary session. The workshop ended with a closed session between CERN’s management and representatives of Chinese funding agencies (MOST, MOE, CAS and NSFC).

The China–CERN workshop was useful for providing CERN and its Chinese colleagues, as well as the Chinese government and funding agencies, with a comprehensive overview of the current status of co-operation between CERN and China, and it helped to identify areas where this co-operation could grow. It was an opportunity for CERN’s management to meet with the relevant Chinese officials, but it was also an opportunity for scientists to establish new contacts and exchange new ideas, as the necessary condition for the future growth of scientific co-operation between China, CERN and the international science community, collaborating through CERN.

Diether Blechschmidt, CERN, and Sijin Qian, Peking University.
COMMUNICATION

Global Design Effort for the ILC launches new website and online publication

The Global Design Effort (GDE) for the International Linear Collider (ILC) has launched a new website, www.linearcollider.org, together with ILC NewsLine, a weekly electronic newsletter reporting news and information about the next-generation particle accelerator from around the world.

ILC NewsLine is written for the global particle-physics community and non-scientists, and is available online and e-mailed free to subscribers. It includes news about the latest ILC developments, reports from conferences and workshops worldwide, statements from the GDE director and regional directors, and profiles about the international scientists and engineers that are collaborating to design a future particle accelerator. The website includes ILC news, a calendar of upcoming events, announcements and technical and scientific documents.

ILC NewsLine is jointly written and produced on behalf of the global ILC community by the GDE communicators in the Americas, Europe and Asia, who welcome submissions and ideas for newsletter content. To subscribe to ILC NewsLine, see www.linearcollider.org/newsline.

LETTERS

CERN Courier welcomes letters from readers. Please e-mail cern.courier@cern.ch. We reserve the right to edit letters.

Sponsoring open access: more than just wry amusement

I am delighted to witness the high interest in open access that exists and has been demonstrated by the series of letters on the topic recently published in these pages. In addition, a well-attended debate on “The changing publishing model” held at CERN in September shows that physicists are concerned with this issue.

Following the endorsement of the new CERN publishing policy in March, the library has taken certain steps to support open access where it can. It is therefore my pleasure to announce that CERN will be, as of 2006, the first European financial sponsor of mega-sciences.

For the future, I would like to propose that we do not mix peer-review and long-term archiving into the debate. Both are of obvious importance, but neither is relevant to the difference between open-access publishing and the traditional model. The open-access model can of course incorporate peer-review, and with regards to archiving, even traditional subscription journals will most likely be electronic-only in a few years. The real debate is how to finance publishing activities and at the same time ensure equal access for everyone to results from publicly funded research.

A change to full open-access publishing cannot be made by one of the actors in the publishing chain alone. CERN is therefore hosting, in December, a tripartite meeting, which will include funding agencies, research organizations and publishers who already implement some form of open-access publishing. At the workshop we will hope to use our years of open-access experience to work out a common strategy for the transition to the new publishing paradigm.

Corrado Pettenati, CERN Library.

George Placzek revisited

The physics community will welcome Jan Fischer’s article “George Placzek – an unsung hero of physics” (CERN Courier Sept 2005 p25) on the life and work of Jewish physicist George Placzek, who was born in Brno in 1905.

As an addendum to the article, I would like to tell readers of Placzek’s brief appointment in the physics department of the newly established Hebrew University in Jerusalem (opened in 1925). Placzek worked there for just six months during the academic year 1934–1935. Before arriving, he had received an unusual request from the university. In August 1934 Leonard Ornstein informed him that the language of teaching in Jerusalem is Hebrew, but the use of another language is permitted for one year (I Unna 2000 Phys. Perspect. 2 336).

Placzek’s difficulty in using Hebrew to teach physics was also mentioned by Otto Frisch (O R Frisch 1979 What Little I Remember Cambridge University Press). Frisch wrote: “We had numerous communications from [Placzek in] Israel; how at first he had to fend off the persistent requests from the university authorities that he should give his lectures in Hebrew, which he had not yet learned. They gave him a year to learn Hebrew. (He learned Arabic as well.) When at the end of that year he still wouldn’t give lectures in Hebrew – he felt the language couldn’t cope with modern physics – and they insisted on it, there was a telegram “Through with Jews for ever”, and he came back to Denmark.”

Min-Liang Wong, College of Veterinary Medicine, National Chung-Hsing University, Taichung, Taiwan.
Cesare Mansueto Giulio Lattes, the last pioneer of the pion discovery, died on 8 March 2005 at Campinas, São Paulo State, Brazil.

Born in Curitiba, Brazil, Lattes studied at São Paulo University, where he was a student of Giuseppe Occhialini, graduating in 1943. In 1946 he joined Occhialini in Cecil Powell's group at the University of Bristol, where together with Hugh Muirhead they made the historic discovery of the pion in studies of cosmic rays (CERN Courier October 1987 p11). At the end of 1947 Lattes moved to Berkeley to work with Eugene Gardner at the 184 inch cyclotron, where, in Lattes' own words: "The beam of α-particles was only 380 MeV (95 MeV/nucleon), an energy insufficient for producing pions. I took my chance on the 'favourable' collisions in which the internal momentum of a nucleon in the α and the momentum of the beam provided sufficient energy in the centre-of-mass system." The method proved successful and produced both positive and negative pions. Later, around February 1949, just before leaving the US, Lattes was asked by Edwin McMillan to look at some plates exposed to gamma-rays from the 300 MeV electron synchrotron, and found a dozen pions of both charges, surely the first artificial photoproduced pions ever detected.

Despite many invitations to join research institutions in other countries, Lattes returned to Brazil in 1949 to take part in the establishment of a Brazilian Center for Research in Physics (CBPF). His international prestige attracted many well known researchers to the institution, which also benefited from the contributions of other prominent scientists such as Gert Molière, Léon Rosenfeld and Richard Feynmann. Lattes was scientific director from the centre's foundation until 1955, after which, from 1955 to 1957, he served as a research associate at the universities of Chicago and Minnesota. He was also a visiting professor from 1964 to 1965 in Pisa, where he became interested in geochronology research.

Meanwhile, in 1947, Lattes had found out at Bristol's Department of Geography that there was a meteorological station 5500 m above sea level on Mount Chacaltaya in Bolivia, which was easily reachable by car. There he exposed borax-loaded emulsion plates to cosmic rays and obtained a mass for the pion. Lattes always said the observation of the pion was facilitated by both the borax-loaded emulsion plates and Mount Chacaltaya, the true discoveries concerned. In the 1950s he constructed an observatory at Chacaltaya, with a budget obtained with some difficulty from the National Council of Technological and Scientific Development (CNPq).

In 1958 Hideki Yukawa wrote to Lattes to propose unifying the efforts of Japanese and Brazilian cosmic-ray groups in order to study multiple meson production at the Mount Chacaltaya Observatory. The Brazil–Japan Collaboration on Cosmic Rays in Chacaltaya Emulsion Chamber Experiments (the B–J Collaboration) began in 1962. The work of the B–J Collaboration was appreciated by the international community, particularly at CERN where the proposal for the UA1 experiment by Carlo Rubbia mentions the collaboration's observation of "fire-balls". The so-called Centauro events, also observed by the collaboration, are still under study in both cosmic-ray and accelerator experiments.

In 1967 Lattes joined the State University of Campinas (UNICAMP) in São Paulo State, where he started the Institute of Physics, with its first research laboratory dedicated to studies of geochronology and cosmic rays through inexpensive experiments. This was one of Lattes' characteristics: he had a profound faith that the real facts of nature are observable even with inexpensive experiments, a lesson he learned early as a student at São Paulo University. Today UNICAMP is one of the most important institutions in Brazil.

Lattes received many awards from South American countries, as well as the 1987 Physics Award from the Third World Academy of Sciences. Probably the most important reward to him, however, was the recognition of the Brazilian scientific community of his enthusiasm for modern science in Brazil, which nowadays accounts for 1% of the world's scientific research, despite the still small number of Brazilian scientists and some modest budgets. The discovery of the pion brought attention to the role of science in Brazil, where the scientific community's debt to Lattes has been recognized by the CNPq through its database of researchers' curricula in all areas of knowledge, the "Plataforma Lattes". 

E H Shibuya, State University of Campinas, Brazil.
OBITUARIES

P Gregers Hansen 1933–2005

Gregers Hansen, who died on 20 July 2005, spent a large part of his scientific life connected to CERN and its ISOLDE programme. Since 1995 he was the John A Hannah distinguished professor of physics at Michigan State University (MSU).

Gregers was born in Svendborg, Denmark, and studied at the Technical University of Denmark before being employed for a decade at the Niels Bohr Institute and Risø National Lab. His work there earned him the degree of doctor of science from the University of Copenhagen in 1965. He then became professor of experimental physics at the University of Aarhus in Denmark in 1966, a chair that he held until 1995. At Aarhus he almost immediately became involved in the experimental programme at the newly constructed ISOLDE facility at CERN, coming to CERN as senior physicist in 1969. He became ISOLDE group leader in 1970 and stayed in this position until the end of 1978. During 1974–1977 he also acted as deputy division leader in CERN's Experimental Physics Division. Gregers' first-hand experience of nuclear structure physics at CERN formed the basis of his account of this period in History of CERN, III.

Gregers had a very broad interest in several fields of physics. The main themes of his work were the nuclear structure and beta decay of exotic nuclei, but he also wrote papers in atomic physics about inner-shell processes and the beta-decay effects of X-rays, and in particle physics and general physics. Besides experiments at CERN, he also conducted experiments at the LISE3 Facility at GANIL and at the ALAIN-LAND setup at GSI. At MSU Gregers worked on physics with radioactive beams and studied in particular one- and two-knockout reactions from exotic projectiles. He wrote several seminal papers about the structure of exotic nuclei.

Gregers' work received widespread recognition. He was a member of the Royal Danish Academy of Sciences and Letters and served in many advisory functions, including CERN's Scientific Policy Committee. He was also president of the Danish Physical Society (1984–1986) and chaired the Proton Synchrotron and Synchrocyclotron Committee at CERN (1981–1985). He was an inspiration for many scientists working with exotic nuclei, and his ability to express penetrating insight in elegant but clear language was admired, as well as feared.

Even though Gregers' life was devoted to science, he possessed an intellect of wide scope and also enjoyed the outdoors. His life ended much too early, but he had the privilege to work with physics every day until he died.

Björn Jonson, Chalmers University of Technology, and Karsten Riisager, CERN.

NEW PRODUCTS

Burle Electro-Optics Inc has announced a patent award for its high-performance, high-speed BiPolar Time-of-Flight detectors for mass spectrometry applications. Providing up to 10 kV of post acceleration, the detector is enclosed in a low-profile assembly combining a highly sensitive microchannel plate and electro-optically isolated output signal. For further details, tel. +1 800 648 1800, +1 508 347 4000, or e-mail sales@burle-eo.com.

Narda Safety Test Solutions has equipped its Selective Radiation Meter SRM-3000 with an innovative time analysis mode. This allows frequency-selective, uninterrupted measurements of pulsed electromagnetic radiation and makes the instrument ideal for recording all pulsed radiation at up to 3 GHz, enabling evaluation for compliance with emission safety standards. For more details, tel. +49 7121 9732 777, e-mail support@narda-sts.de or see www.narda-sts.de.

Optical Surfaces Ltd supply high-quality custom toroidal mirrors for spectrophotometry, X-ray crystallography, mass spectrometry and synchrotron applications. Toroidal mirrors are focusing devices utilized where a beam must be focused and folded, making use of one optical element rather than two. For further information, tel. +44 208 668 6126, e-mail sales@opticalsurf.com or see www.opticalsurf.com.

Oxford Instruments and Quantum Design have launched a jointly developed innovative compact dilution refrigerator, model P850. The novel continuously circulating 4He/3He refrigerator is fully automated and valveless and installs easily into Quantum Design's Physical Property Measurement System (PPMS), extending the minimum temperature to 50 mK. For further information, tel. +44 1865 393 200, e-mail superconductivity@oxinst.co.uk or visit www.oxford-instruments.com.

PI (Physik Instrumente) is offering a variety of piezo-driven, high-speed steering mirrors for use in a variety of applications, ranging from lithography to bio-medical instrumentation. The company can also provide miniature nanopositioning stages for applications where space is at a premium, providing resolutions to better than 0.1 nm. For further information, call +1 508 832 3456, e-mail info@pi-usa.us or visit the website at www.pi.ws.

CORRECTION

The article about the award of the 2005 Einstein Medal to Murray Gell-Mann, on p40 of the October issue, incorrectly stated that the president of the Swiss Confederation, Samuel Schmid, had presented the award to Gell-Mann. The presentation was in fact made by Peter Minkowski, president of the Albert Einstein Society. Many apologies to all concerned.
We invite applications for the position of

**Head of the Scientific and Technical Infrastructure Division**

*(Director, Member of the Scientific Directorate)*

The Scientific and Technical Infrastructure division consists of the following units:

- Information technology, electronics for experiments, detector development unit, laboratory for targets, central technical services including design office, construction and workshops, buildings and facility management, library and scientific documentation services.

The scientific and technical infrastructure division is of high importance for the operation of GSI facilities as well as for the GSI scientific programme. Additionally the division will have to contribute substantially to the future FAIR project (Facility for Anti-proton and Ion Research). This will include related R+D as well as close cooperation with other GSI divisions.

For this outstanding position we are looking for a candidate with an academic degree either in engineering or technology oriented natural sciences. The applicant should possess sound knowledge of and some years experience in the management of complex large-scale scientific-technical infrastructure projects as well as relevant leadership experience. He/She must be well experienced in working with teams of different disciplines and competencies. Furthermore, a sound understanding of financial and budgetary requirements in the management of technical and scientific infrastructure is also needed. Proficiency in the German and English languages is required; knowledge of further languages is desired as well as experience in the management of public founded institutions.

The employment contract can be concluded on an indefinite basis, whilst the function is limited to a renewable period of 5 years.

GSI is an equal opportunity employer and encourages women especially to apply. Persons with disabilities will be given preference over other applicants with comparable qualifications.

Applications should be submitted by postal mail until **November 30, 2005** to:

**The National Laboratory for Heavy-Ion Research**, a member institute of the Helmholtz-Society of German Research Centers

**Gesellschaft für Schwerionenforschung mbH**

**Director of Administration**

**Planckstr. 1**

**64291 Darmstadt**

**Germany**

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**SCIENTIST WITH PHD OR HIGH LEVEL ENGINEERING DIPLOMA**

The "Centre de Physique des Particules" (CPPM) of IN2P3/CNRS is considering a high level experimental physics position (fixed Term contract) in 2005/2006 for the period of up to two years.

Candidates must have a PhD or a high level engineering diploma.

We welcome motivated candidates with an excellent scientific level, experienced in hardware, oriented towards team work for the production and system tests of the ATLAS pixel detectors.

Candidates with good experience in programming and running the real-time data acquisition systems are welcome.

Applications require:
- Curriculum Vitae
- Personal motivation letter
- List of publications and internal notes demonstrating personal contributions, with a copy of the most significant ones (3 maximum)
- List of talks at conferences and workshops + 2 or 3 names of persons to be contacted as references

Applications should be sent by E-mail to:

Helene Boyer <boyer@cppm.in2p3.fr>
EMBL, European Molecular Biology Laboratory, an international research organisation is planning to build an integrated facility in structural biology at the future PETRA-3 ring at DESY, Hamburg, Germany. The expected optical properties of PETRA-3 will allow the operation of world-class synchrotron radiation beamlines. The initial phase of the project includes the construction of two beamlines in macromolecular X-ray crystallography and one beamline in Small Angle X-ray Scattering of biological material. These facilities will be complemented by an integrated area for biological sample preparation and characterisation, including high-throughput crystallisation. In the initial phase of the project, EMBL is searching for applications for the following leading positions:

- **PROJECT COORDINATOR FOR STRUCTURAL BIOLOGY BEAMLINES @PETRA-3 (05/119)**
- **PROJECT LEADER FOR A SMALL ANGLE X-RAY SCATTERING BEAMLINE @PETRA-3 (05/118)**
- **PROJECT LEADER FOR PROTEIN CRYSTALLOGRAPHY BEAMLINE-1 @PETRA-3 (05/117)**

Complete job descriptions can be found at:

www.embl.org and www.embl-hamburg.de/jobs.html

Closing date: 31.01.2006. Further information can be obtained from Dr. Matthias Wilmanns, info@embl-hamburg.de, +49 40 89902 110.

To apply, please email a curriculum vitae, cover letter, a detailed description of current & planned research activities, and the names and addresses of three referees, quoting the corresponding ref. no in the subject line to: application@embl.de .

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**Positions in Grid Computing and LIGO Gravitational Wave Data Analysis**

The Penn State Center for Gravitational Wave Physics (CGWP) has funding for several positions at the postdoctoral scholar level or higher to take part in the development and support of the LIGO Virtual Organization, a charter member of the Open Science Grid, and in the use of the VO’s resources for the analysis and interpretation of observations from the Laser Interferometer Gravitational Wave Observatory (LIGO).

LIGO has critical production requirements to process 300 TBytes of data per year of fundamental and pressing scientific importance. This is one of the earliest and most intensive tests to date of grid computing concepts using real-world geographically dispersed, heterogeneous, high performance data processing resources with different local management and technical histories. Working in this environment will provide invaluable experience in the realities of grid computing, extraordinary opportunity to influence the future of grids and computing in general, and participation at the birth of the exciting new field of observational gravitational wave physics.

The Penn State LIGO Scientific Collaboration (LSC) group is part of the LIGO Global Grid Virtual Organization, contributing local resources of 312 processors and 34 TB storage (approximately 1/5 of the aggregate resources of the VO). The Penn State gravitational wave group is the largest and most active in the country with seven faculty, eleven postdocs and technical staff members, and eight graduate students. It plays a leading role in the analysis and interpretation of LIGO data, including analysis in collaboration with other gravitational wave detector experiments worldwide. It is part of the larger Penn State Institute for Gravitational Physics and Geometry, which is the largest and most active relativity group in the country with over twenty faculty, sixteen postdocs, twenty graduate students, and seven undergraduate students engaged in research in all areas of gravity.

Penn State is also home to the Center for Gravitational Wave Physics (CGWP), funded by the National Science Foundation as part of its Physics Frontier Centers program. The mission of the CGWP is to foster research of a truly interdisciplinary character linking the highest caliber astrophysics, gravitational wave physics and experimental gravitational wave detection in the pursuit of the scientific understanding of gravity and the development of gravitational wave observations as a tool of observational astronomy.

Each year the CGWP hosts at Penn State several major workshops and conferences addressing all areas of gravitational wave physics and astrophysics.

Academic background in physics with Ph.D. in hand and a strong interest in computing will be preferred for these positions. Applicants with a computer science background and demonstrated experience in computing for large scale experimental physics will also be favorably considered and do not require a Ph.D. Applicants should send a CV, statement of research interests and relevant experience, and arrange for three letters of recommendation to be sent to:

Grid Computing/LIGO VO Search
Center for Gravitational Wave Physics
104 Davey Laboratory, PMB 89
University Park, PA 16802
USA

Applications will be considered beginning 15 January 2006 and will continue until the available positions are filled. For more information contact lsfinn+grid@psu.edu or see our websites at http://gravity.psu.edu and http://ligo.aset.psu.edu.

Penn State is committed to affirmative action, equal opportunity and the diversity of its workforce.
Applications are invited from electronic engineers or detector physicists for a research position that will provide expertise and leadership in the design, development, and implementation of state-of-the-art electronics and particle detectors for the experimental programme of the Cambridge particle physics group. This currently encompasses the ATLAS and LHCB experiments at the CERN Large Hadron Collider, and their future upgrades, RD5 and for the International Linear Collider through the CALICE and LC-ABD collaborations, and the MINOS experiment at Fermilab.

The successful candidate will have a degree or higher qualification either in electronic engineering, with experience in designing and building fast electronics, or in physics, with a track record in instrumentation. In either case, previous experience in particle physics instrumentation would be advantageous. The post is permanent or on a fixed-term basis, subject to satisfactory completion of a probationary period. The stipend will be at least £22,000 per annum.

Applications, consisting of a supporting statement, a full CV, the names and contact details of three referees, and a completed form PD18 obtainable from www.admin.cam.ac.uk/offices/personnel/forms/pd18, should be sent by mail to The Registrar, Cantab, Cavendish Laboratory, Madingley Road, Cambridge, CB3 0HE, UK, (email: registrar@cam.ac.uk) from whom further details can be obtained. Inquiries may be submitted in writing to Professor Janet Carter by email, jc11@hep.phy.cam.ac.uk. The closing date for the receipt of applications is 18th November 2005.

The University is committed to equality of opportunity.

University of Cambridge
Department of Physics (Cavendish Laboratory)

Research Engineer or Physicist for Instrumentation in
Experimental Particle Physics (Senior Technical Officer/Technical Officer)

The Peoples Fellowships program targets entry-level accelerator physicists, specialists in accelerator technologies, and high energy physics post-doctoral researchers who wish to embark on a new career in accelerator physics or technology. The Fellows Program attracts outstanding accelerator scientists who are early in their careers, both to enhance Fermilab's capabilities in accelerator science and related technologies, and to train and develop the accelerator scientists and technologists who will carry our field forward in the future.

Fermilab seeks Peoples Fellows candidates with outstanding credentials who have the potential to be leaders of the field.

Term of Appointment

The initial term of the fellowship is three years. Peoples Fellows are eligible to be considered for a second three-year term. The Peoples Fellowship is a tenure-track position, which may lead to an appointment to a regular position on the Fermilab scientific staff.

Applications

Application deadlines are February 1st and August 1st. A decision on the applications will be made within a few months of the deadline. Exceptional candidates in extraordinary circumstances may request early consideration of their applications.

Additional information may be found on the web site http://www.fnal.gov/pub/forphysicists/fellowships/peoples.html.

Communications may be sent to: Peoples Fellows Committee, Fermi National Accelerator Laboratory, 53A41, Attn: Eva Clark, PO Box 500, Batavia, IL 60510-0500, peoples_fellowship@fnal.gov.

Fermilab is an Equal Opportunity Employer. M/F/D/V
THE UNIVERSITY OF CHICAGO
ENRICO FERMI INSTITUTE
ENRICO FERMI POSTDOCTORAL RESEARCH
FELLOWSHIP AND THE ROBERT R. MCCORMICK
POSTDOCTORAL RESEARCH FELLOWSHIP

These postdoctoral research fellowships are intended to attract outstanding young scientists to the University of Chicago at an early stage in their career. We expect to award two fellowships each year at the rank of Research Associate from a pool of international candidates. To date, there have been 93 such fellows, many of whom have gone on to careers as influential scientists.

The initial appointment is for one year, renewable annually, for up to three years. The appointment carries a salary of $52,500 per annum with an additional allocation of up to $6,000 per annum for independent research support. Appointees are given the freedom of either working independently or associating with EFI faculty in a research area of common interest.

The Enrico Fermi Institute is an interdisciplinary research unit within the Division of Physical Sciences of the University of Chicago. The Institute's activities include the following: string theory and theoretical high energy physics, experimental high energy physics, theoretical astrophysics and cosmology, experimental astrophysics and space physics, infrared and optical astronomy, cosmic microwave background observations, general relativity, cosmochimistry, scanning electron & ion microscopy, secondary ion mass spectrometry.

Applying for the Enrico Fermi and/or the Robert R. McCormick Postdoctoral Research Fellowship at the rank of Research Associate:

One application is sufficient to be considered for both research fellowships.

Candidates should apply on line at https://jobopportunities.uchicago.edu, using requisition number: 070992.

They will be asked to supply the following documents:

a. Curriculum Vitae
b. Bibliography of publications and preprints
c. Description of research interests to be pursued at the University

In addition, candidates should ensure that three letters of recommendation are sent to: Director, Enrico Fermi Institute, 5640 S. Ellis Avenue, Room 183, Chicago, Illinois 60637 or by fax to: (773) 702-8038. Letters should be from faculty members or senior research scientists who are active in the field of study in question.

Material provided on line need not be sent to the Fermi Institute, however, it is the candidate's responsibility to ensure that these letters are sent to the Enrico Fermi Institute no later than November 11, 2005. Review of applications will begin at that time. Candidates will be notified of the results by late December. Contact Nanci Carrothers at: n-carrothers@uchicago.edu in case of questions.

The University of Chicago is an Affirmative Action/Equal Opportunity employer. It also participates in the Exchange Visitor Program and will facilitate the granting of visas to foreign applicants.

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CERN Courier November 2005

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McGill

Postdoctoral Research Position in Ground-based Gamma-ray Astronomy with VERITAS

The high energy astrophysics group at McGill University is seeking applications for a research associate position in ground-based gamma-ray astronomy. We are members of the VERITAS collaboration, which is constructing an array of four 12-metre air-Cherenkov telescopes near Tucson, Arizona. This will be used to carry out observations of astrophysical sources in the energy range above 100 GeV.

The McGll team comprises two faculty members, a post-doctoral research associate and several graduate students.

We seek individuals with a recent PhD in particle astrophysics, experimental particle physics, or a related discipline. The position is initially for two years with an opportunity for extension. The successful candidate will be based in Montreal and will be expected to travel to Arizona periodically. Salary will be commensurate with experience.

Please send a CV and arrange to have three letters of reference sent to: Professor D. Hanna, Physics Department, McGill University, 3600 University Street, Montreal, QC H3A 2T8, Canada d.hanna@physics.mcgill.ca

Applications will be considered until the position is filled.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada. However, all qualified individuals are encouraged to apply.

McGill University is committed to equity in employment.

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Post Doctoral Fellow

Experimental Cosmology

The Physics Division of the Lawrence Berkeley National Laboratory has an opening for a postdoctoral fellow in experimental cosmology. This is a two-year position with the possibility of renewal. Our program includes high red-shift supernova studies using ground-based telescopes and the Hubble Space telescope, simulation and optimization of a next generation satellite experiment to study dark energy using supernovae and weak lensing, and R&D on advanced instrumentation for next generation telescopes.

This position requires a PhD or equivalent experience in Astronomy or Physics. Experience in astronomical data analysis, simulation techniques, solid-state detectors or electronics is highly desirable. More information is available at http://supernova.lbl.gov and http://snap.lbl.gov. Contact Natalie Roe, nroe@lbl.gov, for more information. Please send all applications, including CV, list of publications, description of research interests and skills, and three letters of recommendation to Natalie Roe at supernova_postdoc@lbl.gov and apply on line at http://jobs.lbl.gov. Please reference Job # 018377 in the subject line. LBNL is an equal opportunity employer committed to developing a diverse workforce.
Research Fellow(s)

Ref: DCL0221-1

Brunel University has an established record of excellent research achievement with '5' ratings in both General Engineering and in Applied Mathematics in the most recent UK Research Assessment Exercise. The SIRE Group is heavily involved in the preparation of parts of the CMS detector, which will operate at the Large Hadron Collider from 2007 onwards. One post is to support our commitment to the electromagnetic endcap calorimeter and to prepare for analysis of the first data.

Jobs

One post is to support our commitment to the electromagnetic endcap calorimeter and to prepare for analysis of the first data. Applicants should be prepared to make a significant contribution to the analysis of early data from the CMS detector in an area in which the UK has a strong involvement (Higgs physics, triple gauge couplings and the gluon structure of the proton).

Applicants should be experienced in using Object Oriented programming in C++ or Java languages, and be familiar with large-scale computing for data analysis and Monte Carlo simulation.

A further post to work on novel data analysis techniques may be funded when candidates are interviewed. In this case, a further appointment may be made.

Applicants will have, or be about to receive, a PhD in particle physics or a closely related subject. Previous experience of data analysis or Monte Carlo simulation is desirable.

The salary will be within the RA1A (£19,640 to £29,128) scale for a minimum of one and maximum of three years. The salary and initial contract period will be dependent on qualifications and experience.

For a downloadable application form and further details of the post, please visit Brunei University’s website. Alternatively for an application form email to recruitdea@brunel.ac.uk

RecruitDEA, Human Resources, Brunei University, Uxbridge, Middlesex UB8 3PH, UK. Tel: +44 (0)1895 274009. Email: peter.hobson@brunel.ac.uk,

Stephen.Watts@brunel.ac.uk

http://www.brunel.ac.uk/about/job/

Faculty Position in Experimental Particle Physics

Drexel University

The Department of Physics at Drexel University invites applications for a tenure-track faculty position in Experimental Particle Physics starting in the Fall of 2006. We seek a candidate who will establish an active research program while participating in our ongoing neutrino physics program in KamLAND or Double Chooz. The successful candidate must also be committed to excellence in education at both undergraduate and graduate levels. The appointment is expected to be made at the level of Assistant Professor, but an appointment at a more senior level may be considered.

Applicants should send a Curriculum Vitae, a Plan of Research, a Statement of Teaching Philosophy, and arrange for three letters of reference to be sent to:

Particle Physics Search Committee, Department of Physics, Drexel University, 3141 Chestnut St., Philadelphia PA 19104, USA

Applications received by January 15, 2006 will receive full consideration.

For more information, see http://www.physics.drexel.edu/hiring

Drexel University is an Affirmative Action/Equal Opportunity Employer.

Faculty Position in Experimental Particle Physics

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Drexel University is an Affirmative Action/Equal Opportunity Employer.
The Cockcroft Institute
An International Centre for Research in Accelerator Science and Technology

Two Faculty Positions and Two Research Positions

The Cockcroft Institute (http://www.lancs.ac.uk/cockcroft-institute/) is a newly created centre for Accelerator Science and Technology in the UK. It is a joint venture of Lancaster, Liverpool and Manchester Universities, the Daresbury and Rutherford Appleton Laboratories (CCLRC), the Particle Physics and Astronomy Research Council (PPARC), and the North West Development Agency (NWD). It will soon be situated in a purpose-built building on the Daresbury Laboratory campus. The Institute’s aim is to provide the intellectual focus, the educational infrastructure, and the essential scientific and technological facilities for scientists and engineers to take a leading role in global projects concerned with accelerator design, construction and operation for the foreseeable future. New, research-led, positions are now available. They all provide an exciting and unique opportunity to take a major role in the realisation of the Institute’s vision.

Lecturer in Accelerator Physics
Quote ref: E550
Closing date: 5th December 2005

The University of Lancaster intends to make an appointment to a position of Lecturer in the Physics Department. The successful candidate will join the new multi-disciplinary Accelerator Science and Technology (AST) group in the Department of Physics (http://www.physics.lancs.ac.uk/home/index.asp) and of Engineering (http://www.engineering.lancs.ac.uk/home/index.asp), and will initiate and pursue R&D concerned with particle acceleration and beam handling as part of the programme of the Cockcroft Institute and of the High Energy Physics and Mathematical Physics groups of the Department of Physics.

The position is available immediately from appointment. Applications are invited from internationally experienced and respected experimentalists with a relevant research background and with the desire to contribute to a programme of research and teaching on particle acceleration. The position is intended for a fixed period of two years with a possible extension of 1 year, and the successful candidate will be eligible to join the USS pension scheme. An appointment at this level will represent an opportunity for a scientist or engineer to achieve a long-term career in this expanding field, and to pursue his career in a very innovative and exciting environment.

Informal enquiries can be made to Prof. John Dainton (jbd@hep.ph.liv.ac.uk) or Drs Roger Barlow (roger.barlow@manchester.ac.uk) and Rebecca Seviour (seviour@nx1.ac.uk).

Lecturer in Accelerator Physics
Quote ref: B577
Closing date: 5th December 2005

An appointment is to be made to a position in the Department of Physics (http://www.ph.lancs.ac.uk/). The successful candidate will initiate and lead innovative R&D in the science and technology of particle acceleration and beam handling as part of the programme of the Cockcroft Institute. The successful applicant will also be a member of the new Accelerator Science and Technology (AST) group in the Physics Department, consisting of five academic staff members, including the Director of the Institute.

Applications are invited from internationally experienced and respected experimentalists with a relevant research background and with the desire to contribute to a programme of research and teaching on particle acceleration. The position is intended for a fixed period of two years with a possible extension of 1 year, and the successful candidate will be eligible to join the USS pension scheme. An appointment at this level will represent an opportunity for a scientist or engineer to achieve a long-term career in this expanding field, and to pursue his career in a very innovative and exciting environment.

Informal enquiries can be made to Prof. John Dainton (jbd@hep.ph.liv.ac.uk) or Prof. Roger Barlow (roger.barlow@manchester.ac.uk). An application form is available at:
http://www.liv.ac.uk/university/jobs.html

Research Position in Accelerator Engineering
Quote ref: A538
Starting salary up to £29,128 p.a.
Closing date: 5th December 2005

Applications are invited from highly motivated scientists and engineers for a new position in the Accelerator Science & Research programme of the Institute. The successful candidate will work at the Institute with the Microwave Research Group in the Department of Engineering (http://www.comp.lancs.ac.uk/engineering/) of Lancaster University.

The successful candidate will focus on the continuation of the development of techniques for the suppression of multipactor discharge in accelerator components. The work addresses this phenomenon using theoretical, numerical and experimental methods to develop generic techniques for suppressing multipactor discharge in situations where traditional techniques fail or are prohibited by cost or operation. The successful candidate will be expected to devote a portion of her/his time contributing to related work in the growing research programme of the Cockcroft Institute.

The position is available immediately from appointment for an initial period of 2 years with a possible extension of 1 year, and the successful candidate will be eligible to join the USS pension scheme.

Informal enquires can be made to Dr Rebecca Seviour (seviour@nx1.ac.uk, tel: +44 1524 593086) and to Prof. John Dainton (jbd@hep.ph.liv.ac.uk, tel: +44 151 794 7769, fax: +44 151 794 3444), and to the Head of Department Prof. Paul Nolan (pjn@ns.ph.liv.ac.uk, tel: +44 151 794 3377, fax: +44 151 794 3362); Oliver Lodge Laboratory, University of Liverpool, Liverpool L69 7ZE, GB.

Further particulars and details of the application procedure for both positions are available from the Director of Personnel, Lancaster University, Lancaster LA1 4YW.

Research Position In Accelerator Electronics
Quote ref: EPS/257/05
Starting salary to £29,128 p.a.
Closing date: 5th December 2005

Applications from highly motivated scientists and engineers are invited for a new position in the Accelerator Science & Research programme of the Cockcroft Institute. The successful applicant will work at the Institute on the production, transport and disposal of disrupted beams (ref: EPS/257/05). The work is centred in the research interests of the Manchester University group working in the Institute on the beam delivery system for the ILC and EuroTeV initiatives. The successful applicants will have, or will be able to obtain, a PhD in physics, electrical engineering or computational science. A demonstrated ability to program in either Fortran, C++ or C# is essential.

Familiarity with Python and Mathematica will be considered an asset. The successful applicants will be expected to devote a portion of their time contributing to related work in the growing research programme of the Institute. The position is available immediately following appointment and for a fixed term of initially 2 years with a possible extension of 1 year, and the successful candidate will be eligible to join the USS pension scheme.

Informal enquiries may be made to Prof. John Dainton (jbd@hep.ph.liv.ac.uk, tel: +44 151 794 7769, fax: +44 151 794 3444), and to the Head of Department Prof. Paul Nolan (pjn@ns.ph.liv.ac.uk, tel: +44 151 794 3377, fax: +44 151 794 3362); Oliver Lodge Laboratory, University of Liverpool, Liverpool L69 7ZE, GB.

Anniversary volumes usually mark a significant birthday of an individual, or perhaps an institution. But this fascinating compilation celebrates the golden jubilee of a theory – namely, the type of non-Abelian quantum gauge field theory first published by Chen Ning Yang and Robert L Mills in 1954, and now established as a central concept in the Standard Model of particle physics. It was a brilliant idea (by the editor, Gerardus 't Hooft, I assume) to signal the 50th birthday of Yang–Mills theory by gathering together a wide range of articles by leading experts on many aspects of the subject. The result is a most handsome tribute of both historical and current interest, and a substantial addition to the existing literature.

There are 19 contributions, only two of which have been published elsewhere. They are grouped into 16 sections ("Quantizing Gauge Fields", "Ghosts for Physicists", "Renormalization" and so on), each accompanied by brief but illuminating comments from the editor. The style of the contributions ranges from an equation-free essay by Frank Wilczek, to a paper by Raymond Stora on gauge-fixing and Koszul complexes. Somewhere in between lie, for example, François Englert's review of "Breaking the Symmetry", and Stephen Adler's exemplary account of "Anomalies to All Orders".

One recurrent theme is how unfashionable quantum field theory was in the 1950s and 1960s. As 't Hooft puts it: "In 1954, most of those investigators who did still adhere to quantum field theory were either stubborn, or ignorant, or both. In 1967 Faddeev and Popov not only had difficulties getting their work published in Western journals; they found it equally difficult to get their work published in the USSR, because of Landau's ban on quantized field theories in the leading Soviet journals." One of the most interesting papers in the book is the 1972 English translation of their 1967 "Kiev Report", produced via an initiative of Martinus Veltman and Benjamin Lee. It is more detailed than their famous 1967 paper in Physics Letters, and includes a discussion of the gravitational field.

Alvaro De Rújula inimitably brings to life the strong interactions between theorists and experimentalists in the heady days of 1973–1978. He includes a candid snap of Howard Georgi and Sheldon Glashow, circa 1975, which made me wish there were more such shots of the leading players from that era. De Rújula's is the only contribution to address the experimental situation, despite the editor's admission that the lasting impact of Yang–Mills theory depended on "numerous meticulous experimental tests and searches". But, after all, this is a volume celebrating the birthday of a theory.

Many contributors look to the future, as well as the past. These include Alexander Polyakov on "Confinement and Liberation", Peter Hasenfratz on "Chiral Symmetry and the Lattice", and Edward Witten on "Gauge/String Duality for Weak Coupling". I have only had space enough to (I hope) whet the reader's appetite. This unusual and elegant festchrift is a treat for theorists— and, as a bonus, you get a full-colour representation on the cover of a 17-instanton solution of the Yang–Mills field equations (designed by the editor).

High p_T Physics at Hadron Colliders by Dan Green, Cambridge University Press. Hardback ISBN 0521835097, £70 ($110). Over the past several years, Fermilab physicist Dan Green has developed an excellent course on "High p_T Hadron Collider Physics". This is now published as a Cambridge monograph that successfully traces the important past and future roles of hadron colliders in testing and probing the limits of the Standard Model for electroweak and strong interactions. In so doing, it provides an accessible and pedagogical introduction to key features of parton–parton collisions in pp or pp interactions. It is not, however, an up-to-date survey of the field. Rather, the centrepiece of Green's book concerns the motivation and experimental strategy for detecting, and subsequently studying, the Higgs scalar particle (the last undetected element of the minimal Standard Model).

Written by an experimentalist, the book is qualitative in nature and can even be enjoyed by final-year undergraduates, although to profit from it formal introductions to particle-physics phenomenology and quantum field theory are essential. (Such courses are fortunately part of most relevant Master's programmes, and the reader is directed to excellent texts on the subject.) A key feature is the use of dimensional (heuristic) arguments to estimate key production and decay processes in hadron collisions. In addition, and uniquely, the COMPILE freeware program has been extensively used to back up the dimensional arguments with lowest order computations. Despite some incompatibilities of nomenclature, this innovation is (to the reviewer) extremely successful.

The first chapter presents a concise summary of the Standard Model particles and their couplings, as well as a description of the Higgs mechanism for mass generation of the W and Z bosons. It lays out the key properties of the Higgs boson, and concludes with a list of issues that are not answered by the Standard Model. These issues are (rather superficially) discussed in chapter six, with chapters two to five directed towards experimental and phenomenological issues relevant to the Higgs search.

Chapter two describes, in an extremely accessible way, the detector requirements for identifying key high-p_T parton–parton collision processes and the associated instrumental or irreducible physics-related backgrounds. The treatment of jet energy reconstruction and dijet mass reconstruction is excellent. Inevitably, given the author's background in the DO and CMS experiments at Fermilab, the book leans towards examples of these experiments. In a few cases, some important
instrumental innovations are not given adequate space (e.g. the real-time selection of heavy quarks as in the CDF experiment). Students could also have benefited from a description of the relative merits of the CDF and D0 experiments, and of course of the future ATLAS and CMS detectors at CERN’s Large Hadron Collider (LHC). The third chapter is good reading for any new graduate student. Green introduces key features of collider physics: the central rapidity plateau and its energy dependence; the basic parton–parton collision processes and their kinematics; the main gauge boson and gauge-boson pair production processes; and jet fragmentation. In all cases experimental data (usually not the latest) are used to justify heuristic arguments and COMPARE calculations. A series of exercises complements the chapter.

Chapters four and five concentrate respectively on the more important results from Fermilab’s Tevatron and on the Higgs search strategy at the LHC experiments (for which chapter four’s material is invaluable as a guide to the experimental backgrounds to be expected from any Higgs signal at the LHC). As a reviewer, I enjoyed the experimental approach of these two chapters and their highly readable nature. However, the extremely important sections on heavy-quark (b and t quark) production were rather incomplete, given the unique measurements at the Tevatron and the important implications for the LHC. While the somewhat arbitrary choice of figures in chapter four (taken in most cases from the experiments) is adequate for lecture notes, it detracts from the book’s quality that an effort was not made to include the latest available data, and to combine data from the CDF and D0 experiments. Chapter five concerns the experimental strategy for detecting and studying the Standard Model Higgs particle at the LHC, and relies heavily on relevant preparatory studies from the ATLAS and CMS experiments.

Finally, the concluding sixth chapter discusses extensions to the Standard Model such as supersymmetry, as well as some of the open questions alluded to in chapter one. While extensions relevant to the LHC physics programme must be discussed, it felt as if this was a hurried addition. Judy Garland’s quotation, from The Wizard of Oz: “Toto, I’ve a feeling we’re not in Kansas anymore,” is rather appropriate.

Published at a time when the CDF and D0 experiments are increasing their data samples by more than an order of magnitude, and in advance of the LHC, Green’s book has limited shelf life in its present edition. However, despite some shortcomings, its core is an excellent introduction for any graduate student starting out in experimental hadron-collider physics and can be strongly recommended. Dan Green should be congratulated on the overall quality of his text. Presumably, any new edition beyond 2007 will provide some interesting updates.

Allan Clark, University of Geneva

From Fields to Strings: Circumnavigating Theoretical Physics (Ian Kogan Memorial Collection) by Misha Shifman, Arkady Vainshtein and John Wheater (eds), World Scientific. Hardback ISBN 9812369555 (three volume set), £146 ($240).

On the morning of 6 June 2003, Ian Kogan’s heart stopped beating. It was the untimely departure of an outstanding physicist and a warm human being. Ian had an eclectic knowledge of theoretical physics, as one can easily appraise by perusing the list of his publications at the end of the third volume of this memorial collection.

The editors of these three volumes had an excellent idea: the best tribute that could be offered to Ian’s memory was a snapshot of what physicists thought of their subject at the turn of the 21st century. There is much to learn and profit from this trilogy.

Circumnavigating theoretical physics is indeed fun. It is unfortunate, however, that it had to be gathered in such sad circumstances.

Luis Alvarez-Gaume, CERN.
The dark side of computing power

Urs Hölzle from Google points out that while the performance of commodity computer clusters continues to increase, so does their electrical power consumption.

On a recent visit to CERN, I had the chance to see how the high-energy physics (HEP) community was struggling with many of the same sorts of computing problems that we have to deal with at Google. So here are some thoughts on where commodity computing may be going, and how organizations like CERN and Google could influence things in the right direction.

First a few words about what we do at Google. The Web consists of more than 10 billion pages of information. With an average of 10 kByte of textual information per page, this adds up to around 100 TB. This is our data-set at Google. It is big, but tractable - it is apparently just a few days' worth of data production from the Large Hadron Collider. So just like particle physicists have already found out, we need a lot of computers, disks, networking and software. And we need them to be cheap.

The switch to commodity computing began many years ago. The rationale is that single machine performance is not that interesting any more, since price goes up non-linearly with performance. As long as your problem can be easily partitioned - which is the case for processing Web pages or particle events - then you might as well use cheaper, simpler machines.

But even with cheap commodity computers, keeping costs down is a challenge. And increasingly, the challenge is not just hardware costs, but also reducing energy consumption. In the early days at Google - just five years ago - you would have been amazed to see cheap household fans around our data centres, being used just to keep things cool. Saving power is still the name of the game in our data centres today, even to the extent that we shut off the lights in them when no-one is there.

Let’s look more closely at the hidden electrical power costs of a data centre. Although chip performance keeps going up, and performance per dollar, too, performance per watt is stagnant. In other words, the total power consumed in data centres is rising. Worse, the operational costs of commercial data centres are almost directly proportional to how much power is consumed by the PCs. And unfortunately, a lot of that is wasted.

For example, while the system power of a dual-processor PC is around 265 W, cooling overhead adds another 135 W. Over four years, the power costs of running a PC can add up to half of the hardware cost. Yet this is a gross underestimate of real energy costs. It ignores issues such as inefficiencies of power distribution within the data centre. Globally, even ignoring cooling costs, you lose a factor of two in power from the point where electricity is fed into a data centre to the motherboard in the server.

Since I’m from a dotcom, an obvious business model has occurred to me: an electricity company could give PCs away - provided users agreed to run the PCs continuously for several years on the power from that company. Such companies could make a handsome profit!

A major inefficiency in the data centre is DC power supplies, which are typically about 70% efficient. At Google ours are 90% efficient, and the extra cost of this higher efficiency is easily compensated for by the reduced power consumption over the lifetime of the power supply.

Part of Google’s strategy has been to work with our component vendors to get more energy-efficient equipment to market earlier. For example, most motherboards have three DC voltage inputs, for historical reasons. Since the processor actually works at a voltage different from all three of these, this is very inefficient. Reducing this to one DC voltage produces savings, even if there are initial costs involved in getting the vendor to make the necessary changes to their production. The HEP community ought to be in a similar position to squeeze extra mileage out of equipment from established vendors.

Tackling power-distribution losses and cooling inefficiencies in conventional data centres also means improving the physical design of the centre. We employ mechanical engineers at Google to help with this, and yes, the improvements they make in reducing energy costs amply justify their wages.

While I’ve focused on some negative trends in power consumption, there are also positive ones. The recent switch to multicore processors was a successful attempt to reduce processors’ runaway energy consumption. But Moore’s law keeps growing away at any ingenious improvement of this kind. Ultimately, power consumption is likely to become the most critical cost factor for data-centre budgets, as energy prices continue to rise worldwide and concerns about global warming put increasing pressure on organizations to use electrical power more efficiently.

Of course, there are other areas where the cost of running data centres can be greatly optimized. For example, networking equipment lacks commodity solutions, at least at the data-centre scale. And better software to turn unreliable PCs into efficient computing platforms can surely be devised.

In general, Google’s needs and those of the HEP community are similar. So I hope we can continue to exchange experiences and learn from each other.

Urs Hölzle, vice-president of operations, Google.
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