

INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS



CERN COURIER

VOLUME 49 NUMBER 8 OCTOBER 2009



AMS gets set to go into space

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2010



THE 12TH VIENNA CONFERENCE ON INSTRUMENTATION FEB 15-20, 2010



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- Astroparticle Physics
- Synchrotron Radiation and Neutron Scattering
- Applications in Biology and Medicine

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Summary Talk

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

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Leon Lederman recalls how he rediscovered his enthusiasm for physics.

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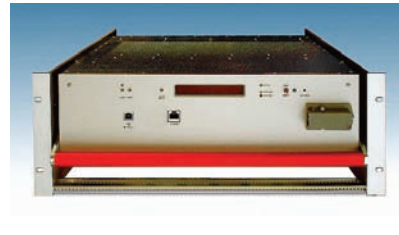


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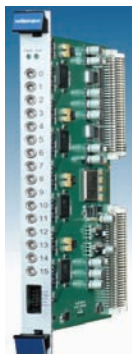
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ACCELERATORS

VECC's superconducting success

A beam of Ne^{+3} has been accelerated by K-500 Superconducting Cyclotron at the Variable Energy Cyclotron Centre (VECC), Kolkata, up to the extraction radius of 650 mm. At 3.00 a.m. on 25 August, the beam probe monitored a beam current of around 40 nA. This measurement was confirmed by a beam viewer that uses a boroscope and through the observation of neutron and gamma radiation by the radiation monitor located outside the superconducting magnet. The energy of the Ne^{+3} beam at a radius of 650 mm is calculated to be 88 MeV. The presence of beam was further confirmed by activation analysis of an aluminium target probe in tests at a radiochemistry laboratory.

VECC's superconducting cyclotron is the most advanced, hi-tech accelerator ever constructed in India. The cyclotron's main structure, a 100-tonne iron-core superconducting magnet, is the largest in the country and has been operating virtually non-stop for more than three years. It produces a magnetic field of around 5 T over an area of about 1.3 m². Its cold mass of about 8 t, consisting of the niobium-titanium superconducting coil and stainless-steel bobbin, has been kept continuously cooled at -269 °C inside a sophisticated cryostat. More than 35 km of superconducting wire was used to construct the coil at VECC. About 300 l of liquid helium is required to keep the coil cooled to its operating temperature, together with hundreds of litres of liquid nitrogen at -195 °C, every day. It is the first large-scale iron-core superconducting system in India.

The "3-Dee" RF system, which provides the acceleration kicks to the beam, has also functioned very satisfactorily. This system delivers more than 100 kW of radiofrequency power per cavity.

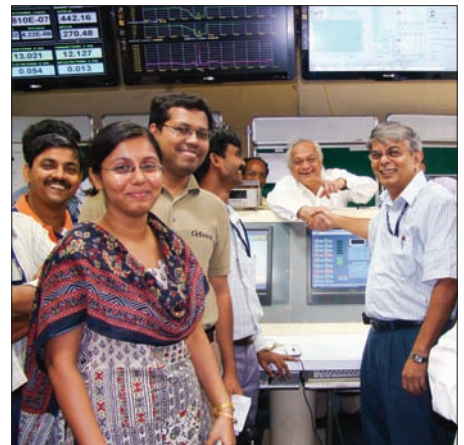
The main control room of the accelerator



Rakesh K Bhandari (dark suit), director of VECC, with his team in the superconducting cyclotron vault.

has been a hive of activity since 11 May when the first beam of low-energy charged particles was injected for acceleration. Since then all of the cyclotron systems have undergone continuous endurance tests. At the same time, the cyclotron team has also carried out all possible critical tests to ensure that the cyclotron is functioning with a circulating internal beam.

With very few such superconducting cyclotrons in the world, VECC has joined an exclusive club. The accelerator's high-energy beams will be used for frontline basic and applied research in nuclear sciences. The facility will soon be dedicated to the nation and will open for research to the international community.



Bikash Sinha, at rear, congratulates members of the cyclotron team. (Photos courtesy VECC.)

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LHC NEWS

Final sector starts cool down

On 2 September the cool down of LHC sector 6-7 got underway, following some minor repair work. As the last sector to be cooled down, this marked a major milestone towards the restart of the collider later this year.

The cool down of sector 6-7 began two weeks earlier but it was interrupted by the detection of a short-circuit on the main dipole circuit. The cause of the short-circuit was later tracked down to poor insulation in a magnet busbar, which had been degraded by friction against a screw as the structure contracted during the cool down. After repair work followed by electrical and vacuum validation, the sector was once again ready to cool down.

In sector 8-1, the flexible hose that caused the helium leak into the insulation vacuum has been replaced and the sector is now being cooled down again. The cool down of sector 3-4, the one affected by the incident on 19 September 2008, also began at the end of August, thus marking the end of a complex phase of repair work.

Meanwhile consolidation work on the LHC has continued. On 26 August, the first two fully tested crates for the new quench-protection system (QPS) were installed in sector 1-2. These are the first of a total of 436 crates to be installed around the ring. The two crates include detectors for both the enhanced busbar protection and the symmetric quench protection.

Training quenches on magnets in sector 5-6 in June 2008 revealed that heat transfer to a



All LHC sectors are now cooling down.

neighbouring magnet can cause a quench that develops identically in two magnet coils. The original detection system compared voltage signals from two coils to detect a resistive build-up in either one, but if the signals develop in the same way, the quench would go unnoticed. The new protection system monitors the voltage across four adjacent dipoles (or two adjacent quadrupoles), allowing a symmetric quench to be detected, as well as providing a back-up detection method for normal, asymmetric quenches.

To test the crates before installation, a dedicated test bed has been created, capable of simulating all of the conditions in the LHC, from a symmetric quench to an increase in busbar resistance. The teams are working two

shifts a day, including weekends, to test the new crates. Two more test benches are also being built to increase the production rate. The whole task is on target for completion in mid-October.

Another important new task for the QPS team is to speed up the energy extraction from the magnets. The quicker the energy can be extracted, the lower the risk of dangerously high temperatures in the event of a quench. The time constant for the dipoles will be halved to about 50 s. The decision to run at 3.5 TeV, and therefore with lower current in the magnets, has made this task relatively straightforward. Switching two of the three “dump” resistors into a series circuit, instead of having all three resistors in parallel, allows the energy to be converted into heat much faster. In the quadrupole circuits, the task is more complex. Reducing the time constant to the desired 10 s, from a previous 35 s, requires adding extra, newly designed resistors.

The new QPS system will also allow accurate resistance measurements to be taken remotely. This will save a huge amount of time and effort for the next rounds of interventions – for example when the energy of the LHC is increased.

● CERN is publishing regular updates on the LHC in its internal *Bulletin*, available at www.cern.ch/bulletin, as well as via twitter and YouTube at www.twitter.com/cern and www.youtube.com/cern.

FUNDING

DOE allocates Fermilab an additional \$60.2 million

In the latest instalment of funding from the US Department of Energy's (DOE) Office of Science under the American Recovery and Reinvestment Act, Fermilab is to receive an additional \$60.2 million to support research towards next-generation particle accelerators and preliminary designs for a future neutrino experiment.

The new funds are part of more than \$327 million announced by Energy Secretary Steven Chu on 4 August from funding allocated

under the Recovery Act to DOE's Office of Science. Of these funds, \$220 million will go towards projects at DOE national laboratories. While many of the physics-related projects are associated with fusion research or light sources, Fermilab and the Brookhaven National Laboratory have both received support for activities in high-energy physics.

Taking the stimulus funds announced earlier this year into account, the Recovery Act is allocating more than \$100 million

to Fermilab. Out of the additional \$60.2 million announced in August, the laboratory will devote \$52.7 million to research on next-generation accelerators using superconducting RF technology. The remaining \$7.5 million will go to fund a preliminary design for a future neutrino experiment, in collaboration with Brookhaven, which has received \$6.5 million for neutrino research in addition to \$3 million for improvements to its light source.

SPACE

AMS gets its slot on a space shuttle in 2010

AMS-02, the experiment that will seek dark matter, missing matter and antimatter in space aboard the International Space Station (ISS), has recently received the green light to be part of the STS-134 NASA mission in 2010.

NASA has announced that the last or last-but-one mission of the space shuttle programme will be the one that is to deliver the Alpha Magnetic Spectrometer (AMS) to the ISS. The space shuttle Discovery is due to lift off in July 2010 and its mission will include the installation of AMS to the exterior of the space station, using arms on both the shuttle and station. Last year both the US House of Representatives and the Senate unanimously approved a bill requesting NASA to install AMS on the ISS, which was signed by



Installation work on the Prévessin site at CERN.

president George W Bush a month later.

AMS is a cosmic-ray detector based on technologies developed at CERN, where

it is currently based. The installation of the detector to the right side of the space station's truss will be a delicate operation. It will be lifted out by the shuttle's robotic arm and handed on to the station's robotic arm, which will then install AMS in its location.

The astronauts selected for this flight include the European astronaut Roberto Vittori, a colonel in the Italian air force with a degree in physics. He will come to CERN in October with the rest of the crew to learn more about the experiment. The data collected by AMS will be transmitted instantly from the ISS to the Marshall Space Flight Center in Huntsville, Alabama, and finally to CERN, where all of the detector controls and physics analyses will be performed.

B PHYSICS

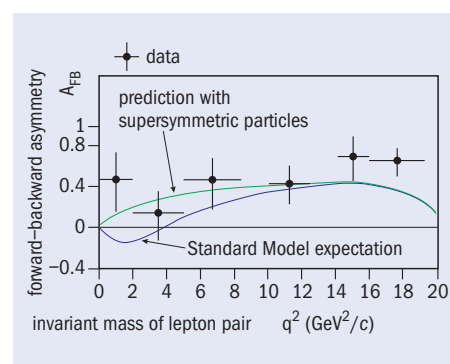
Belle finds a hint of new physics in extremely rare B decays

The Belle collaboration at KEK has recently analysed the angular distribution of leptons in the decays of B mesons into a K^* meson and a lepton anti-lepton pair, where the lepton is an electron or a muon. The team finds that the results, which were presented in August at the Lepton-Photon International Symposium in Hamburg, are larger than expected from the Standard Model.

The figure shows the forward-backward asymmetry of the positively charged lepton with respect to the direction of the K^* in $B \rightarrow K^* l^+ l^-$, based on the analysis of 660 million pairs of B and anti-B mesons. The measured data points are above the Standard Model expectation (solid curve). In the Standard Model this decay mode proceeds via a "Penguin diagram" involving intermediate virtual particles, such as a Z boson or a W boson, which are much heavier than the B meson. New heavy particles beyond those already known in the Standard Model

should also participate in a similar way. The difference between the measurements and the Standard Model expectation (blue curve) might indicate that such new particles are indeed produced in addition to Z and W bosons. Indeed, the data points are closer to the prediction that includes supersymmetric particles (green curve).

This rare decay process was discovered by Belle in 2002. However, the measurement of the lepton forward-backward asymmetry has been quite difficult owing to the small decay rates. It has become possible only with increased data samples that the experiment has gathered, thanks to the improved performance of the KEKB accelerator. The analysis so far has yielded about 250 signal events. To clarify whether the results are indeed hinting at new physics, the Belle collaboration is continuing its measurements with a larger sample of accumulated data.



Lepton angular-distribution measurements for $B \rightarrow K^* l^+ l^-$. The vertical axis shows the forward-backward asymmetry of a positively charged lepton with respect to a K^* meson. The horizontal axis shows the invariant mass of the lepton pair. The points with error bars are data, the blue curve is the Standard Model expectation, and the green curve is from a model where supersymmetric particles are involved in the decay.

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

CERN Courier welcomes contributions from the international particle-physics community. These can be written in English or French, and will be published in the same language. If you have a suggestion for an article, please send your proposal to the editor at cern.courier@cern.ch.

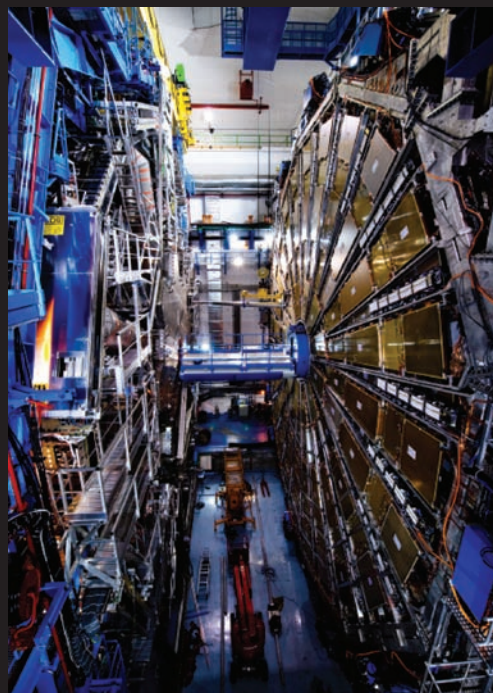
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SRI09 10th International Conference on Synchrotron Radiation Instrumentation
September 25 - October 2 '09 Melbourne, Australia
<http://www.sri09.org/>

2009 IEEE Nuclear Science Symposium (NSS) and MIC
October 25 – 31 '09 Orlando, Florida,
<http://www.nss-mic.org/2009/NSSMain.asp>

Compiled by John Swain, Northeastern University

Sandfish swim through sand by making waves

Granular solids such as sand are like fluids in many ways and yet are also quite different. For example, you can pour both sand and water, but piles of sand do not flatten out as a result of gravity, as water does; there are no analogous “water piles”. So what about swimming in sand?

Daniel Goldman of the Georgia Institute of Technology and colleagues have studied the motion of the desert-dwelling sandfish *Scincus scincus* – a lizard that “swims” as it burrows through sand. High-speed X-ray photography shows that rather than moving its limbs, the creature generates large-amplitude travelling waves on its body to propel it in a truly novel way, which exploits the unique mechanical properties of sand.

There is no theory of granular drag to date that would do for granular materials what viscous-fluid dynamics does for water. The team therefore developed their own empirical model for the motion of the sandfish based on measurements they made of the granular thrust and drag forces on a small cylinder. In addition to helping understand the behaviour of sandfish and other burrowing creatures, the



The Georgia Tech study shows that sandfish place their limbs against their sides and create a wave motion with their bodies like snakes to swim through sand. (Courtesy Georgia Tech Photo/Gary Meek.)

research may help in the design of robots to travel through rubble and other debris.

Further reading

Ryan D Maladen *et al.* 2009 *Science* **325** 314.

New invisibility cloak alters appearance

There has been much recent excitement surrounding the idea that metamaterials with exotic light-bending properties could be used to create an “invisibility cloak” that would bend light around it, rendering anything inside “invisible” – to the obvious glee of Harry Potter fans around the world. One of the pioneers of the field, John Pendry of Imperial College London, has recently drawn attention to the work of Yun Lai and colleagues of the Hong Kong University of Science and Technology. They are pushing things even closer towards the technological realization of what in Celtic magical tales might be called a “glamour” – disappearing not through invisibility but through the illusion of a changed appearance. Moreover, the illusion is created at a distance.

The idea is that it is possible to bend the light rays from any object and rearrange them into the image of anything else. Basically, in this case the structure of the cloaking device contains an “anti-object” that cancels light from the object beyond it, as well as an image of a completely different object. The result is truly amazing – put a fork into the right sort of metamaterial box, stand next to it, and it looks as though you have disappeared and been replaced by a fork. Amusement aside, this research could lead to a variety of optical applications.

Further reading

Yun Lai *et al.* 2009 *Phys. Rev. Lett.* **102** 253902.

John Pendry 2009 *Nature* **460** 579.

A proper swear can keep the mind off painful business

Many people have an intuitive appreciation for the fact that a proper swearword seems to release more frustration than a more politely muted “fudge” or “fiddlesticks”. To study the phenomenon, Richard Stephens and colleagues at Keele University asked students to put one hand in cold water (about 5°C) and found that repeated swearing (as opposed to the use of softer words, say with a different first letter) allowed most of them to keep their hands in for longer and reduced the apparent perceived pain reported later. The researchers suggest that swearing may induce a fight-or-flight response and reduce the link between fear of pain and pain perception.

Further reading

R Stephens *et al.* 2009 *NeuroReport* **20** 1056.

Rethinking bits: qubits to qudits

Current technology has made the idea that digital data can be stored as “bits” almost beyond question, but as progress is made towards quantum computing using qubits there may be good reasons to revisit some traditional assumptions. Matthew Neeley and colleagues of the University of California at Santa Barbara and the University of Georgia have demonstrated a superconducting phase qudit – a system with d quantum levels – with five states ($d=5$) as opposed to the two states ($d=2$) of the more familiar qubit.

A 5-level system is mathematically equivalent to a spin-3/2 system and can be broken down into conceptual spin-1/2 systems with two states. However, it may be that physical realizations of quantum computation in n -level systems will be easier or more robust than can be achieved by restricting attention to qubits.

Further reading

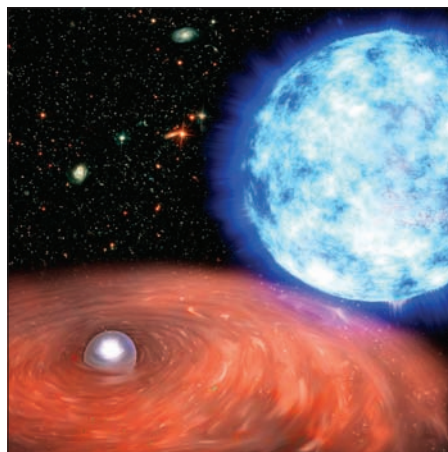
Matthew Neeley *et al.* 2009 *Science* **325** 722.

XMM-Newton sees fast-spinning white dwarf

Using observations by ESA's Newton X-ray multimirror satellite, XMM-Newton, a group of Italian astronomers has derived the characteristics of a peculiar binary system consisting of a white dwarf and an evolved companion star. The mass of the compact object is found to be close to the maximum mass for a white dwarf. Continued accretion in the million years to come could make it explode as a Type Ia supernova.

White dwarfs are the cores that remain of Sun-like stars after they have ejected their gas envelopes, creating beautiful planetary nebulae (*CERN Courier* July/August 2003 p13, April 2007 p10 and September 2009 p11). They are analogous to neutron stars, which are produced in the core-collapse (Type II) supernovae explosions of stars that are more than eight times as massive as the Sun. While neutron stars are only about 20 km across, white dwarfs are typically the size of the Earth and are sustained by the quantum-degeneracy pressure of their electrons, rather than their neutrons.

The shallower gravitational potential well of white dwarfs compared with neutron stars is not able to heat the gas accreted from a companion star up to very high temperatures. X-ray binaries, where the compact object is a white dwarf, are therefore much less luminous and only detectable in the soft X-ray waveband. The feeble X-ray emission from a binary system that was first detected by the ROSAT satellite in the 1990s was re-observed in 2008 by XMM-Newton. The observation of



Artist's rendering of the massive accreting white dwarf orbiting very close to its companion blue star. (Courtesy Francesco Mereghetti, background image: NASA, ESA and TM Brown/STScI.)

RX J0648.0-4418, which was proposed by a group of Italian astronomers led by Sandro Mereghetti from the INAF-IASF institute in Milan, was scheduled to catch a possible X-ray eclipse of the white dwarf as it passed behind the companion star. The aim was also to analyse the X-ray pulsation induced by the spin of the white dwarf with a period of 13.2 s.

The 12-hour observation by XMM-Newton was successful and provided a clear detection of the eclipse as well as allowing the possibility to derive relative time lags in the pulses from one hour to the next. These delays were used by the researchers to gauge the size of the orbit of the white dwarf around

the companion star. With the corresponding information already available for the optical star through spectroscopic analysis, the only remaining unknown related to the mass of both objects is the orbital-plane inclination. However, this is well constrained by the observed eclipse of the X-ray source to be close to edge-on and the study yields values in units of solar masses of 1.28 ± 0.05 for the white dwarf and 1.50 ± 0.05 for the companion star.

For the compact object, this is about twice the usual mass of white dwarfs and is close to the limit of 1.4 solar masses that Subrahmanyan Chandrasekhar derived in the early 1930s. It means that the increased accretion expected in the million years to come could make the white dwarf reach this limit with two possible consequences: either the dwarf star explodes as a supernova of Type Ia or it collapses into a neutron star. Type Ia supernovae are bright events that are used as standard beacons to measure the expansion rate of the universe (*CERN Courier* September 2003 p23, October 2007 p13). If this is going to happen at the derived distance of only about 2800 light-years from Earth, the supernova would appear as bright as the full Moon for several days. However, the fast spin of the dwarf star is likely to increase its stability and should thus delay this celestial show or even prevent it from happening.

Further reading

S Mereghetti *et al.* 2009 *Science* **325** 1222.

Picture of the month



The Trifid Nebula, number 20 in the catalogue of diffuse objects compiled by Charles Messier in 1774, is a firm favourite of amateur astronomers. The dust bands that divide the cosmic cloud into three lobes inspired John Herschel – the son of William Herschel – to call it “Trifid”. This image by the Wide-Field Imager camera attached to the MPG/ESO 2.2-m telescope located at La Silla in Chile reveals in detail this rare combination of three nebula types. The dark lanes are dense star-forming clouds of gas and dust masking the red and the blue nebulae. The red emission comes from the Balmer H_{α} recombination line of ionized hydrogen, whereas the blue hue is from starlight scattered by dust grains. (Courtesy ESO.)

CONFERENCE

Developments in particle theory

More than 100 European physicists attended the 13th International Conference on High-Energy Physics at the Lawrence Radiation Laboratory, Berkeley, California, USA. CERN theoretician A Martin discusses developments in particle-physics theory presented at the conference.

Quantum electrodynamics

In QED, theoreticians were happy that pair-production at high energies, examined by a Columbia–DESY collaboration at DESY, agrees perfectly well with the old Bethe–Heitler formula, but worried by a new measurement of the Lamb shift, which deviates by 0.3 MHz from the theoretical prediction. If the measurement is taken seriously this deviation, only 3 parts in 10 000, becomes too large to be accounted for by strong interaction effects or by readjusting basic physical constants.

Fundamental questions (axiomatic field theory and S-matrix theory)

The main success of axiomatic field theory has been to establish forward-dispersion relations for pion–nucleon scattering and the famous CPT theorem showing that particles and antiparticles have the same mass, spin, lifetime, etc. S-matrix theory differs from field theory in that the structure of the scattering amplitude is somehow postulated and then confronted with the powerful requirement of unitarity, i.e. conservation of probability.

There were two CERN contributions in field theory. J Bros, H Epstein and V Glaser showed that if the proton–proton scattering cross-section is known, the proton–antiproton scattering cross-section can be obtained. The second contribution, which I presented, adds the unitarity requirement. It is then possible to establish that total cross-sections increase with energy at a rate that is at most the square of the logarithm of the energy.

In S-matrix theory, a connection between spin and statistics was obtained by M Froissart, and J C Polkinghorne showed that the predicted structure of reaction amplitudes coincides with that obtained from a series expansion of the reaction amplitude.

COMPILER'S NOTE

The frontiers of theoretical particle physics now deal with strings and other things beyond the Standard Model, but at the time that this conference report was written most of the model's foundations were still to be laid. Now, field theory reigns and quarks are definitely regarded as real. André Martin, who wrote the report, continues his work in theoretical physics and recently celebrated his 80th birthday at CERN (p26).

Current algebra and higher symmetries

Two years ago, after the famous paper on SU6 by F Gürsey and G Radicati, higher symmetries began to flourish, involving not only internal quantum numbers such as strangeness (as in SU3) but also spatial properties such as spin. Serious difficulties have arisen in attempts to make these symmetries consistent with i) Lorentz invariance, ii) locality, iii) unitarity.

M Gell-Mann and B W Lee tried to derive the same results from current algebra without real success. However, the commutation relations of the currents survived and lead to extremely interesting sum rules connecting weak and strong interactions, in good agreement with experiment. Multitudes of sum rules were reported at the conference.

Weak interactions

The situation in weak interactions seems to have improved, if one ignores the decay of long-lived K^0 mesons into two pions, which violates time-reversal invariance. T D Lee's proposal that the origin of the violation is electromagnetic would have been confirmed by an asymmetry in the decay of the η meson into three pions (as appeared to be the case in an experiment of P Franzini *et al.*). However, the CERN experiment by G Finocchiaro *et al.* showed that the asymmetry was less than 1% – and this apparently convinced everybody.

Regge-poles and quarks

The enthusiasm for the Regge-pole description of high-energy scattering that

followed the 1962 conference, at CERN, declined when experiment failed to confirm the prediction that the target nucleon seems to increase in size and become more transparent at high energies.

However, the analysis of pion–nucleon backward scattering by V Barger and D Kline required a background term of Regge character and nucleon excited states lying on Regge trajectories. The L Dick group at CERN measured polarizations in pion–proton scattering and checked that the positive pion–proton and the negative pion–proton polarizations are opposite, a basic Regge prediction. On the theoretical side, if Regge-poles do exist, they are more complicated objects than was first thought.

On the other hand, the quark model, in which nucleons are made of three quarks and mesons of two quarks, makes impressive predictions. All speakers, in particular M Gell-Mann and L Van Hove, stressed that this is not evidence that real quarks exist. As Van Hove remarked, crystals can be described in terms of collective excitation modes called phonons, but if you tear a crystal to pieces you will not find any phonon. The same could happen if you try to split the nucleon into quarks. The search for real quarks goes on but so far with negative results.

General impressions

Firstly, some experimentalists complained that a great deal of time was allocated to theory, but this was one of the few conferences where some aspects of theory (for instance the so-called “fundamental questions”) were discussed. I was extremely happy that such discussions could take place.

The second impression is general agreement on the importance of the European contributions, in particular from CERN. Most of the previous conferences were dominated by American experimentalists and theoreticians, or Russian theoreticians. But the impact of the European physicists at the Berkeley conference was most gratifying and encouraging.

● Compiled from the article pp193–196.

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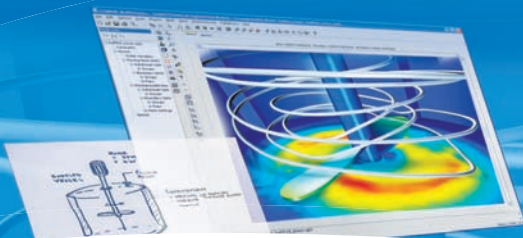
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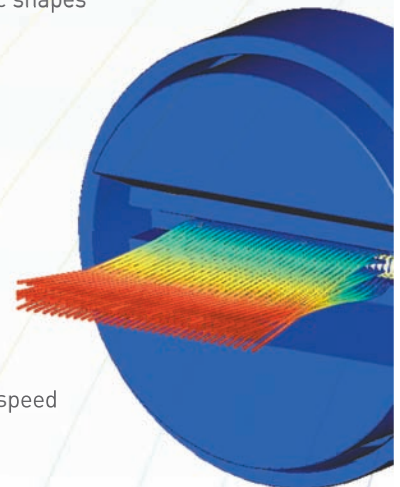
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Krakow welcomes 2009 EPS-HEP conference

More than 600 physicists, eager to be informed about the latest developments in particle and astroparticle physics, converged on Krakow in July for the HEP 2009 conference.

The 13th-century merchants' town of Krakow and former capital is now one of the largest and oldest cities in Poland. The scenic city centre – a UNESCO World Heritage Site – with its fascinating history and pleasant climate, provided the perfect setting for discussing new results and future developments at the biennial European Physical Society (EPS) conference on High Energy Physics (HEP). The event was held on 16–22 July at the new conference centre of the Jagiellonian University – the Auditorium Maximumum.

The conference began with 35 parallel sessions and more than 350 contributions over two and a half days. Then, as is tradition, the EPS and European Committee for Future Accelerators scheduled a joint plenary meeting for Saturday afternoon. This focused on a number of talks concerning the future of the field: with Christian Spiering of DESY on “Astroparticle physics and relations with the LHC”; CERN’s director-general, Rolf Heuer, on “The high-energy frontier”; Alain Blondel of Geneva University on “The future of accelerator-based neutrino physics”; and Tatsuya Nakada of the École Polytechnique Fédérale de Lausanne on “Super-B factories”. Each presentation was followed by a lively discussion.

Sunday provided the opportunity for several sightseeing trips in and around Krakow. Monday saw a fresh start to the week and time for another tradition: the presentation of the EPS awards. For the first time, the High Energy and Particle Physics (EPS HEPP) prize was awarded to an experimental collaboration, Gargamelle, for the observation of the weak neutral current (*CERN Courier* September 2009 p31). After the awards ceremony, Frank Wilczek, the 2004 Nobel laureate, gave a special talk on “some ideas and hopes for fundamental physics”. This provided an excellent start to three days of plenary sessions, with around 35 presentations.

The Standard Model still reigns

The Tevatron proton–antiproton collider continues its smooth operation. With more than 6 fb^{-1} integrated luminosity delivered and peak luminosities exceeding $3.5 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$, the CDF and DØ experiments are steadily increasing their statistics. Both collaborations are pushing forward on the analysis of their latest data in a joint effort to confirm and enlarge the previously reported exclusion region for the Higgs mass of around 160–170 GeV. At the same time, several new ideas are emerging on how to improve the sensitivity of these experiments to more challenging Higgs decay channels. In addition to the direct search for the Higgs boson, both collabora-



The beautiful old city centre of Krakow. (Photos courtesy of Per Osland and the local organizing committee.)



Local organizing committee chair Antoni Szczurek (right) and Marek Jeżabek, of the Institute for Nuclear Physics PAN, fine-tuning the organization of the conference.

tions reported on new mass measurements of the W boson ($M_W = 80.399 \pm 0.023 \text{ GeV}$) and confirmed the combined experimental result for the top quark mass ($m_t = 173.1 \pm 1.3 \text{ GeV}$), pushing the error below the 1% level. These values lead to a further reduction of the preferred mass region for the Standard Model Higgs, as John Conway of the University of California Davis pointed out in his plenary presentation. Moreover, these and other precision measurements of the weak parameters ($\sin^2\theta_W = 0.2326 \pm 0.0018_{\text{stat}} \pm 0.0006_{\text{sys}}$) ▷



A guest with Polish roots: Frank Wilczek gives a special talk.

as compared with the theoretical prediction of $\sin^2\theta_w = 0.23149 \pm 0.00013$ show growing evidence that the Standard Model prefers a light Higgs, which, as Conway concluded, will make life difficult. Even for the large LHC experiments, ATLAS and CMS, this region of the window on the Higgs mass will require high statistics, combining different decay modes and sophisticated analyses.

A number of sophisticated statistical procedures are being developed and becoming available as complete software packages – for example, GFITTER – to simplify or fine-tune multidimensional analyses of experimental data. At the same time, there is impressive progress in calculating amplitudes for multileg processes and loops. A rather complete set of automatically derived “2 → 4 particle” cross-sections (the “Les Houches 2007 wish list”) demonstrates that higher-order corrections to important physics processes at the LHC cannot be ignored.

Increasing statistics at the Tevatron are also consolidating the observation of single top production, but at the same time the parameter space for new physics at or below the 1 TeV scale is becoming smaller, as Volker Büscher of Mainz explained. CDF and DØ have conducted studies that probe mass values for the charginos of supersymmetry up to 176 GeV; they find no evidence for neutralino production in their current data sample. In addition, the studies shift the possibility of quark compositeness or large extra dimensions further towards a higher energy scale.

While the latest updates on analyses of data from RHIC and the SPS were presented in the parallel sessions, Urs Wiedemann of CERN covered theoretical aspects of collective phenomena in his plenary talk. He summarized the motivation for experiments at RHIC ($\sqrt{s_{NN}} = 200$ GeV) and the LHC ($\sqrt{s_{NN}} = 5500$ GeV) to study the QCD properties of dense matter at the 150 MeV scale, which will be accessible at these high collision energies.

A wealth of new data is also emerging from the experimental analysis of B-physics – from both hadron colliders and e^+e^- machines – ranging from analyses of rare exclusive decay modes to spectroscopy and physics related to the Cabibbo–Kobayashi–Maskawa matrix (CKM). The results further confirm oscillations in the neutral D and B_s sectors. This is another area where the Standard Model seems not to be seriously challenged: the CKM triangle appears to remain “closed” (within experimental errors). Nevertheless, as Andrzej Buras of TU Munich pointed out in his talk on “20 goals in flavour physics for the next decade”, there are still many challenges



Antonino Pullia and Jean-Pierre Vialle receive the EPS-HEPP prize from Per Osland, on behalf of the Gargamelle collaboration.

ahead. A breakthrough could come with firm experimental evidence for flavour-changing neutral currents in excess of Standard Model predictions. Buras’s message is clear: stay focused on the many observables that are not yet well measured and the decay modes that are not so far (or poorly) studied; spectacular deviations from the Standard Model remain possible.

With a new series of experiments under construction and several experiments producing new data, neutrino physics remains an experimentally driven enterprise. The neutrino sessions were – not surprisingly – very well attended. Better mass measurements are coming within reach, be it from obtaining upper limits by measuring time shifts in neutrinos from supernovae ($m_\nu < 30$ eV) or from measuring the tritium β -decay spectrum ($m_\nu < 2$ eV) or mass differences from oscillations (all $\Delta m^2 < 1$ eV²). Because neutrinos are abundant in the universe, even a small neutrino mass will have implications in astrophysics. Dave Wark of Imperial College summarized the broad spectrum of neutrino physics experiments and their discovery potential. Anticipating the various experimental approaches and progress, he explained under which terms the Majorana phases, for example, could be determined.

New frontiers – on Earth and in space

While the large LHC experiments are commissioning their triggers, new ideas on the future of the LHC machine are being explored. These include high-luminosity schemes and higher beam energies, which will have different implications for future upgrades of both machine and experiments. R&D on accelerators is focusing not only on higher-energy frontiers and currents, but also on more efficient beam-crossing (“crab”) scenarios.

In a worldwide effort, the International Linear Collider collaboration aims to present a Technical Design Report in 2012 for a high-energy e^+e^- machine. The Compact Linear Collider Study (CLIC) based at CERN, which aims for a Conceptual Design Report at the end of 2010, investigates different approaches and may reach a higher beam energy (3 TeV v 1 TeV). However, the physics simulations and detector designs for the two schemes face equal challenges.

The development of “super factories” is an ongoing effort that is complementary to the high-energy machines. These facilities should provide high-statistics experiments on, for example, the neutrino, charm and bottom sectors, with the necessary infrastructure for high-precision measurements. Caterina Biscari of



Even very young physicists enjoyed the conference dinner.

Frascati presented a comprehensive overview of existing machines and (possible) future accelerators, in which she compared their main parameters.

The conference saw substantial contributions from astroparticle physics. The Auger experiment probing the highest energy cosmic rays (10^{20} eV) shows growing evidence for the Greisen–Zatsepin–Kuzmin cut-off. The energy spectrum agrees well (within the 25% calibration uncertainty on the energy scale) with results from the HiRes collaboration. Active galactic nuclei are now also observed by the High Energy Stereoscopic System (HESS) and the Large Area Telescope on the Fermi Gamma-ray Space Telescope. In particular, the core of Centaurus A appears to be extremely interesting owing to the bright radio source in its centre. High-energy cosmic rays are predominantly produced by “nearby” (< 100 Mpc) sources, while there is a slight indication that the composition changes with increasing energy, towards more heavy nuclei.

PAMELA (launched in 2006), the Advanced Thin Ionization Calorimeter balloon experiment (2008), Fermi (launched in 2008) and HESS show some excesses in the e^\pm spectrum. The interpretation of these signals remains uncertain (*CERN Courier* September 2009 p9). Is it related to the nature of non-baryonic, that is, dark matter, or can the spectra be explained by astrophysics phenomena such as pulsars or supernova remnants? The PAMELA data have generated huge theoretical interest resulting in a multitude of dark-matter models. However, much more data are needed from both space-based experiments and ground-based searches for decaying weakly interacting massive particles. The Alpha Magnetic Spectrometer, finally scheduled to be launched in 2010 (p6), should at least provide much improved limits on the antiproton flux.

The next international Europhysics conference on high-energy physics will take place in Grenoble on 21–27 July 2011. After last years’ successful injection of proton beams into the LHC, followed by the unfortunate incident and subsequent repairs and consolidation, the starting date for high-energy collisions at the LHC is now rapidly approaching. At the meeting in Grenoble there will be lively discussions on Tevatron data – perhaps with surprises – and extensive reports, among others, on dark-matter searches. Of course, we all look forward to reports on first data analyses by the LHC experiments.

● The local organization of EPS–HEP 2009 by the Institute of Nuclear Physics PAN, Jagiellonian University, the AGH University of Science and Technology and the Polish Physical Society is acknowledged.



Wilfried Buchmuller summarizes the conference.

Celebrating 10 years of outreach

Ten years ago Polish physicists and CERN introduced an outreach/training programme aimed at high-school teachers. Now celebrating its 10th anniversary, the programme is widely recognized for its success and impact. During EPS-HEP 2009, and in the presence of the Polish minister for education, Mick Storr and Andrzej Siemko of CERN were awarded the Medal of the Commission of Polish National Education, in recognition of their outstanding contributions to the organization of the programme for Polish teachers. Nowadays many countries send high-school teachers to CERN’s training courses on particle physics. As Storr pointed out in a special session at the conference attended by 140 Polish teachers, “reaching teachers implies a large multiplication factor in reaching young high-school students”.

Further reading

The transparencies of presentations of plenary and parallel sessions are available at the conference website: www.ifj.edu.pl/hep2009/. The proceedings of the conference will be published in the online journal *Proceedings of Science*.

Résumé

La conférence EPS-HEP 2009 s’est tenue à Cracovie

Les physiciens ont afflué à Cracovie pour la conférence 2009 de la Société européenne de physique sur la physique des hautes énergies, où ont été présentées les dernières évolutions en physique et astrophysique des particules. Les expériences menées auprès d’accélérateurs ne donnent encore que peu de signes d’une physique au-delà du Modèle standard, malgré la foison de données du Tévatron et des usines à B. Tandis que tous attendent le redémarrage du Grand collisionneur de hadrons, on travaille à la planification d’un collisionneur linéaire e^+e^- de haute énergie et d’anneaux de stockage e^+e^- haute intensité. L’astrophysique des particules apporte aussi d’importantes contributions, grâce aux nouveaux résultats des expériences avec rayons cosmiques, sur Terre ou en orbite.

Bob van Eijk, Nikhef.

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Working for the world: UNOSAT and CERN

UNOSAT provides international development organizations with satellite-derived analysis data that help mitigate the effects of natural disasters and conflicts. Hosted at CERN, this programme benefits from the laboratory's IT infrastructure and network connectivity.

Much of the interesting work that happens at CERN is underground – but not all. Since 2002, the team that runs UNOSAT, the Operational Satellite Applications Programme of the United Nations Institute for Training and Research (UNITAR), has been based at the laboratory's Meyrin site. This hosting arrangement, which has support from the Swiss government, resulted from a pioneering institutional agreement between CERN and the UN. The programme demonstrates the potential for collaboration between these two international bodies in areas of mutual interest.

The mission of UNITAR, established by the UN General Assembly, is to deliver innovative training and to conduct research on knowledge systems and methodologies. Through adult professional training and technical support, the institute contributes towards developing the capacities of tens of thousands of professionals around the world using face-to-face and distance learning.

UNOSAT is a technology-based initiative supported by a team of specialists in remote-sensing and geographic-information systems. It is part of UNITAR's Department of Research, mainly because of its groundbreaking innovations in the use of satellite-derived solutions in the context of the UN work. As a result of its research and applications, UNOSAT offers very high-resolution imagery to enhance humanitarian actions; monitors piracy using geospatial information; connects the world of the UN to Grid technology; and it has introduced objective satellite images into the assessment of human-rights violations.

A vital source of information

Initially created to explore the potential of satellite Earth observation for the international community, this programme has developed specific mapping and analysis services that are used by various UN agencies and by national experts worldwide. UNOSAT's mission is to deliver integrated satellite-based solutions for human security, peace and socioeconomic development. Its most important goal, however, is to make satellite data and geographic information easily accessible to an increasing number of UN and national experts who work with geographic information systems (GIS).

The UNOSAT team combines the experience of satellite imagery analysts, database programmers and geographic-information experts with that of fieldworkers and development experts. This



UNOSAT experts participate in UN mission to the field to contribute their geographic-information skills. Here, UNOSAT staff plots GPS points during an emergency in Côte d'Ivoire. (Courtesy United Nations.)

unique set of skills gives the UNOSAT team the ability to understand the needs of a variety of international and national users and to provide them with suitable information anywhere and anytime. Anywhere, because – thanks to CERN's IT support – UNOSAT can handle and store large amounts of data and transfer maps as needed directly via the web; anytime, because UNOSAT is available 24 hours a day, every day of the year.

In simple terms, UNOSAT acquires and processes satellite data to produce and deliver information, analysis and observations, which are used by the UN and national entities for emergency response and to assess the impact of a disaster or conflict, or to plan sustainable development. The main difference between this programme and other UN undertakings is that UNOSAT uses high-end technology to develop innovative solutions. It does this in partnership with the main space agencies and commercial satellite-data providers.

One such innovation was the creation in 2003 of a new humanitarian rapid-mapping service. Now fully developed, the service has been used in more than 100 major disasters and conflict situations, and has produced more than 900 satellite-derived analyses and maps. The work requires the rapid acquisition and processing of satellite imagery and data for the creation of map and GIS layers. These ▷

are then used by the headquarters of UN agencies to make decisions and in the field during an emergency response to co-ordinate rescue teams and assess the impact of a given emergency. This type of map was of great use in the aftermath of the Asian Tsunami of 2004 (CERN Courier April 2005 p6) and in response to the 2005 earthquake in Pakistan. Similar maps have been used to monitor the impact of the conflict between Israel and the Hezbollah in Southern Lebanon and during the Middle East crisis in Gaza. They have also been valuable in monitoring the flux of displaced populations, most recently, during the conflict this year in Sri Lanka (figure 1).

There are tens of less publicized crises every year in which the UN is involved because of their humanitarian consequences on thousands of innocent civilians in developing countries. UNOSAT supports the work of relief workers and NGO volunteers with timely and accurate analysis of a situation on the ground, and responds to requests from the field for particular geographic information.

The work of UNOSAT is not solely related with emergencies, although the maps available on the website all refer to humanitarian assistance. This publication policy is linked to enabling humanitarian workers in various field locations to download maps prepared by UNOSAT at CERN via internet or satellite telecommunications. In addition, there are a large number of maps and analyses that are not publicly available on the UNOSAT website because they are part of project activities requested by UN agencies, such as the UN Development Programme, the International Organization for Migration and the World Health Organization.

Once an emergency is over, the work of the UN continues with assistance to governments in rehabilitation and reconstruction. UNOSAT remains engaged beyond the emergency phase by supporting early recovery activities that are undertaken to help local populations get back to normality following a disaster or conflict. Satellites are helpful in these circumstances: think of the work required to reconstruct an entire cadastre, for example, without appropriate geographic information; or to plan the re-establishment of road and rail networks without accurate information on the extent of damage suffered.

UNOSAT's experience in mapping and analysis – and its innovative methodologies – are regularly transferred to the world beyond, thanks to training modules and information events that are organized by the UN or directly by UNITAR. At CERN, for example, UNOSAT hosts and trains national experts from Indonesia, Nicaragua and Nigeria, to mention a few recent cases. These experts receive intensive two-week training sessions, during which they stay at CERN. In other cases, UNOSAT sends its trainers abroad to train and provide technical support to fieldworkers in developing countries. All of the experts trained by UNOSAT then become part of a global network of skilled staff who can be connected to work together when needed.

The technical work of UNOSAT is made possible by the agreement between UNITAR and CERN, so CERN's support is of fundamental importance. The recognition – and even the awards that UNOSAT enjoys in return for its relentless work – go in part also to all those at CERN who help and support UNOSAT work.

Conscious of the potential held by this success story, CERN and UNITAR took the opportunity of the renewal of their agreement in December 2008 to begin a series of consultations to strengthen their collaboration in areas of mutual interest. The realm of scientific applications to advance international agendas that guide the

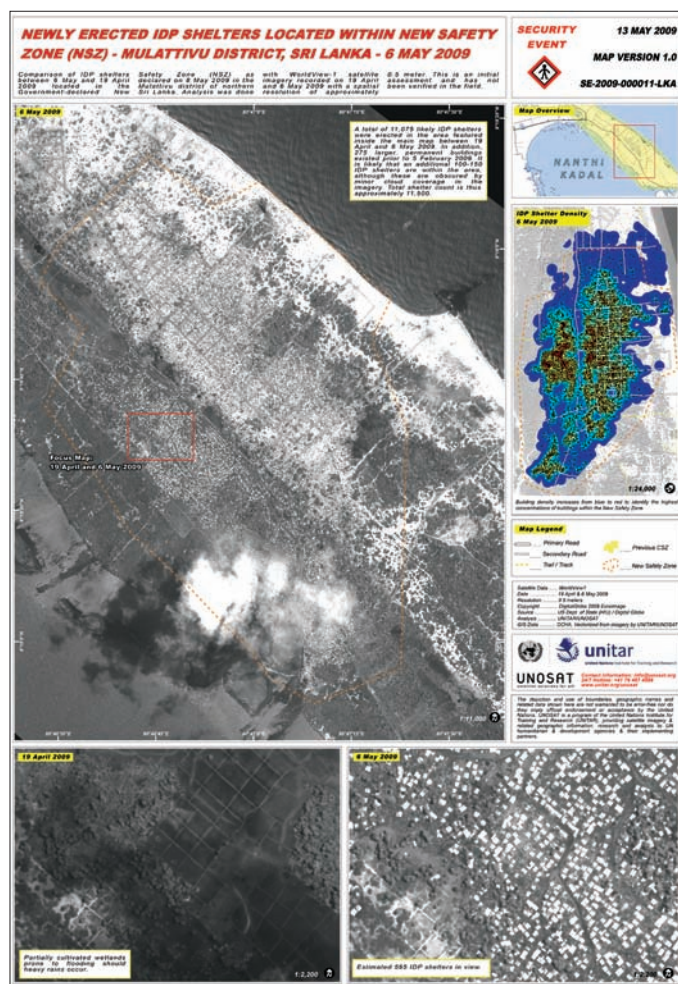


Fig. 1. An example of using satellite geographic information to analyse and monitor the humanitarian situation on the ground in Sri Lanka.

work of the UN is being discussed at senior level and ideas for joint undertakings are currently being considered.

- For more information, visit www.unitar.org and www.unitar.org/unosat.

Résumé

Au service de la planète : UNOSAT et le CERN

Grâce à UNOSAT, la communauté internationale peut accéder à des images satellite pour mieux faire face aux catastrophes naturelles et aux conséquences des conflits. Ce programme, implanté au CERN depuis 2002, met à profit l'infrastructure informatique du Laboratoire et la connectivité de ses réseaux. L'équipe d'UNOSAT réunit des analystes de l'imagerie satellite, des programmeurs de bases de données et des experts en information géographique avec des travailleurs du terrain et des spécialistes du développement. Grâce à l'appui informatique du CERN, UNOSAT peut gérer et stocker d'importantes quantités de données et transférer en tout temps des cartes par le web au lieu précis où elles sont nécessaires.

Francesco Pisano, manager of the UNOSAT programme, United Nations.

The future is together

As R&D makes progress on ideas for a future e^+e^- collider to explore particle physics at the terascale, recent events at CERN are paving the way towards a common, worldwide linear-collider community in the areas of accelerators and detectors.

There are two major efforts underway to develop a linear electron–positron collider to complement CERN’s LHC in the exploration of physics in the region of the “terascale” – energies of around 1 tera-electron-volt (TeV) and higher. The concept pursued by the International Linear Collider (ILC) Global Design Effort (GDE) is based on superconducting RF technology for collisions up to 1 TeV in energy (*CERN Courier* December 2005 p24). The Compact Linear Collider Study (CLIC) on the other hand, is developing a novel technological approach based on two-beam acceleration, which is potentially capable of achieving collisions at energies of multi-tera-electron-volts (*CERN Courier* September 2008 p15). Now these

two efforts are coming closer together with the aim of combining resources on areas of common interest.

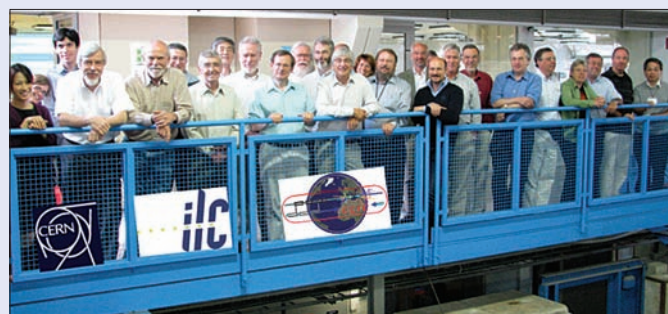
On 12 June the first joint meeting of the ILC GDE executive committee, the CLIC steering committee and the CERN directorate took place at CERN. The GDE’s executive committee consists of the GDE’s director, Barry Barish, together with three regional directors (for the Americas, Asia and Europe), three project managers and three accelerator experts, who include the chairman of the CLIC steering committee (Jean-Pierre Delahaye). The CLIC steering committee comprises accelerator, detector and particle-physics experts as well as the chairman of the CLIC/CTF3 collaboration board ▸

One step at a time

This meeting at CERN [on 12 June] represented another step in bringing the CLIC and ILC efforts closer together. CERN’s director-general, Rolf Heuer, the CERN research director, Sergio Bertolucci, and the secretary of the CERN Council strategy group, Steiner Stapnes, attended part of the meeting and expressed their support. The meeting itself was constructive and productive in that we agreed on several important new initiatives, including plans to combine future workshops and to begin discussions on developing and articulating a joint strategy towards a linear collider.

In one sense, these efforts are in competition with each other. Each one has dedicated proponents and teams, and works hard to develop the competing technologies. But, in a more overriding sense, we are all working towards the same goal: to prepare for the next-energy-frontier machine for our field. Independent physics studies in Asia, the Americas and Europe have each given the highest priority for the future of the field to develop a lepton collider that complements the LHC while exploiting fully the terascale. These parallel R&D programmes are all needed to determine the technical capabilities, readiness, risks and costs of these options, while the LHC discoveries will determine the desired technical requirements and energy range.

Although the CLIC technology for the main linac is totally different from the superconducting RF technology of the ILC, other aspects of the design – including the sources, damping rings, beam delivery and detectors, as well as civil engineering and conventional facilities, and cost and schedule – have large overlaps. For that reason, last year we initiated a set of seven joint working groups in those areas where we can pool our resources and work together for the benefit of both teams.



Members of the CERN management, ILC Executive Committee and CLIC Steering Committee at the joint meeting at CERN on 12 June. (Courtesy Perrine Royole-Degieux.)

During the meeting we reviewed the progress of the joint working groups and discussed future plans and ideas for specific work and deliverables for these groups. In addition to the obvious benefits of combining resources for joint problems, we have agreed on some other new longer-term goals. In particular, we have agreed to take a step towards bringing our managements closer together by adding a CERN/CLIC representative as a member of the GDE executive committee, and vice versa for the equivalent CLIC steering committee. Another step we have agreed on is to investigate the integration of our major CLIC and ILC workshops into common Linear Collider Workshops, from which the first one is foreseen tentatively at CERN on 20–24 September 2010.

Barry Barish, director of the ILC GDE.

● Extracted with permission from Director’s Corner, www.linearcollider.org/cms/?pid=1000644.

(Ken Peach) and the ILC representative (Brian Foster).

The meeting proved to be a successful start to bringing the ILC and CLIC efforts closer together, particularly in areas linked to the construction and implementation of a future collider (see box, p19). Following the meeting, a statement of common CLIC/ILC intent is under discussion. The aim is to promote and develop scientific and technical preparations for a linear collider as well as exploit possible synergies that enable the design concepts for the ILC and CLIC to be prepared efficiently in the best interest of linear colliders and more generally of high-energy physics.

Higher energies

One area of common ground is the development of suitable detectors for the particular environment of a terascale e^+e^- linear collider. CERN joined this worldwide detector-development effort through its newly established Linear Collider Detector (LCD) project, which targets physics and detectors at a future collider, be it ILC or CLIC.

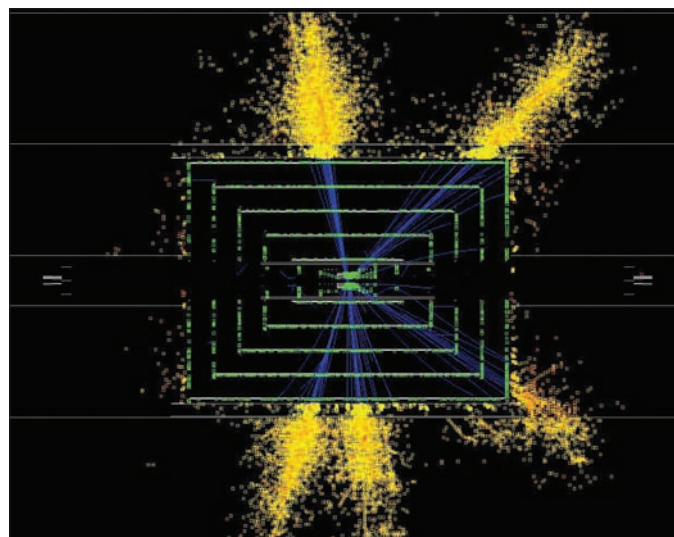
Currently most of the effort at CERN is going into the preparation of the conceptual design report for CLIC, which will be delivered by the end of 2010. Earlier studies have shown that the layout of an experiment exploiting the physics potential of a 3 TeV CLIC machine is in many ways similar to an experiment designed for sub-tera-electron-volt energies. Therefore, the ILC detector concepts (named ILD and SiD) form an excellent starting point for the CLIC study. Adaptations concentrate on a few essential differences: the higher CLIC energy, the increased beam-induced background rates and the ultra-fast 0.5 ns bunch spacing.

Compared with the ILC, outgoing particles will generally have higher energies at CLIC and will often group closely together in highly boosted jets. To preserve a good performance level this normally calls for an increase in lever-arm of the tracking system and more depth for the calorimeters. In practice this increase in size can be limited by optimizing the choice of detector materials and granularity, thereby restricting the corresponding increase in the inner radius of the detector's solenoid coil.

The electron- and positron-beam bunches in CLIC are extremely small, with sizes of just 40 nm wide and 1 nm high. Their close encounter gives rise to strong electric fields, leading to the emission of numerous beamstrahlung photons, most of which will leave the detector through the outgoing beam pipe. Some subsequent secondary-beamstrahlung products will nonetheless enter the main detector volume. Because bunch crossings take place every 0.5 ns, the resulting background hits in the detector will overlay quickly while genuine high-energy e^+e^- -physics interactions will take place at a much smaller rate. This means that to preserve the capability to recognize the physics signatures with good precision, the electronic-signal readout of most detectors at CLIC will require time stamping. Current studies indicate that a time-stamping resolution in the 20 ns range will be sufficient.

Low power consumption will be a "must" for all future linear-collider detectors because this allows for low-mass detectors and, therefore, excellent track and vertex precision. Turning the power of the detectors on and off at the pace of the incoming bunch-trains can potentially reduce the on-detector power dissipation by nearly two orders of magnitude. The corresponding power-pulsing rate will be 5 Hz for the ILC and 50 Hz for CLIC.

Given the similarity between the ILC and CLIC detectors, the new



Simulation of a multi-tera-electron-volt e^+e^- event, in which a 1.1 TeV supersymmetric heavy Higgs is created.

LCD-physics and detector project is an important cornerstone of the ILC-CLIC collaboration. It integrates fully into the worldwide detector and physics studies – and profits from the tremendous developments made for the ILC and its predecessors. It uses the ILC-experiment concepts and detector technologies as a basis and makes use of the same simulation tools. As of 2010, hardware R&D will start in a number of critical areas for a CLIC detector, such as very dense hadron calorimetry, time stamping of tracking and calorimeter signals, power pulsing of detector electronics and reinforced conductors for a large solenoid.

Motivated by the case of an e^+e^- collider as the next machine to explore particle physics at the terascale, work towards a common linear-collider-physics community is underway. The LHC results will tell us whether this will be a sub-tera-electron-volt machine (ILC) or whether an energy reach to multi-tera-electron-volts is needed (CLIC).

● For further information about ILC, see www.linearcollider.org/. For details about CLIC, see <http://cllc-study.web.cern.ch/>; and for more about LCD, see <http://lcd.web.cern.ch/LCD/>.

Résumé

L'avenir se fera ensemble

Tandis que progresse la R&D sur les options de collisionneur e^+e^- pour explorer la physique des particules à des énergies de quelque 1 TeV ou plus, de récentes réunions tenues au CERN semblent indiquer qu'une seule communauté travaillera sur le collisionneur linéaire mondial pour les accélérateurs et pour les détecteurs. Au CERN, le 12 juin, le Comité exécutif du Projet mondial de conception du collisionneur linéaire international, le Comité de pilotage de l'Étude du collisionneur linéaire compact et le Directoire du CERN ont tenu leur première réunion conjointe. Récemment, le CERN s'est également joint aux travaux de développement de détecteurs à l'échelle mondiale dans le cadre du récent Projet de détecteurs pour collisionneur linéaire.

Jean-Pierre Delahaye, CLIC study leader, and **Lucie Linssen**, LCD project leader, CERN.



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think forward

Life in physics and the o

Leon Lederman recalls how Gilberto Bernardini helped him to rediscover his enthusiasm for experimental physics, setting him on the road that would eventually lead to Stockholm and a Nobel prize in physics.

As a grad student at Columbia around 1950, I had the rare opportunity of meeting Albert Einstein. We were instructed to sit on a bench that would intersect Einstein's path to lunch at his Princeton home. A fellow student and I sprang up when Einstein came by, accompanied by his assistant who asked if he would like to meet some students.

"Yah," the professor said and addressed my colleague, "Vot are you studying?"

"I'm doing a thesis on quantum theory."

"Ach!" said Einstein, "A vaste of time!" He turned to me: "And vot are you doing?"

I was more confident: "I'm studying experimentally the properties of pions."

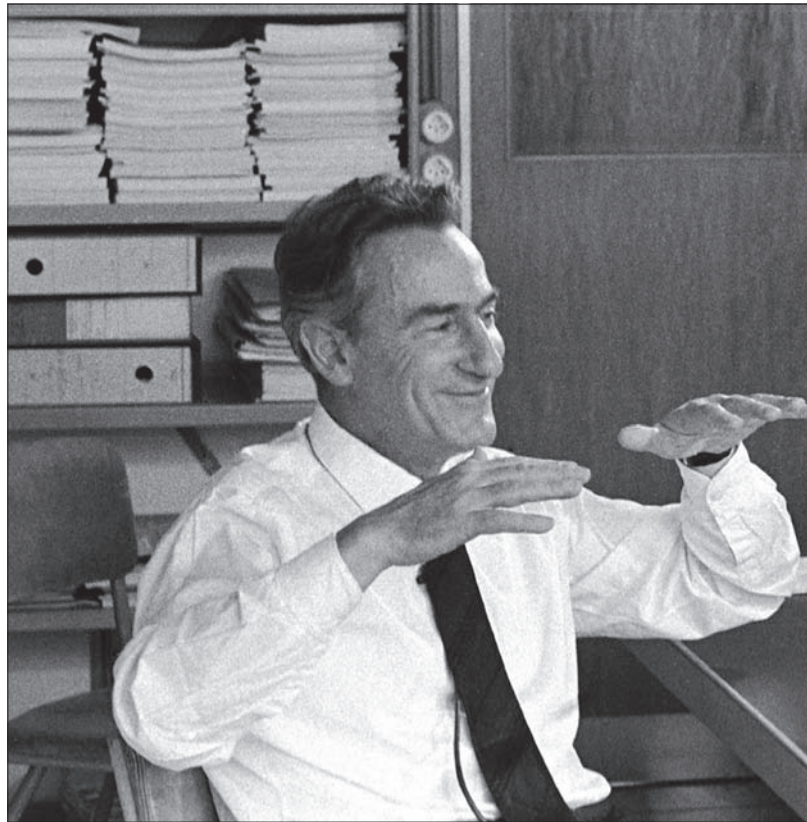
"Pions, pions! Ach, vee don't understand de electron! Vy bother mit pions? Vell, good luck boys!"

So, in less than 30 seconds, the Great Physicist had demolished two of the brightest – and best-looking – young physics students. But we were on cloud nine. We had met the greatest scientist who ever lived!

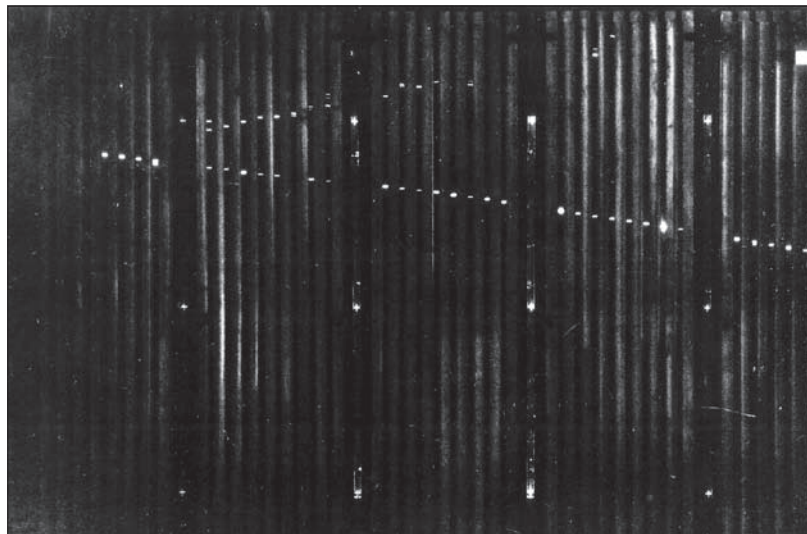
Some years before this memorable event, I had recently been discharged from the US army, having been drafted three years earlier to help General Eisenhower with a problem he had in Europe. It was called World War II. Our troop ship docked at the Battery and, having had a successful poker-driven ocean crossing, I taxied to Columbia University and registered as a physics grad student for the fall semester.

I was filled with enthusiasm to resume my study of physics but also exhausted by three years of mostly mindless military service. Things quickly degenerated towards disaster. I had indeed forgotten simple equations, how to study and, most crucially, forgotten the joy that I had found in my college physics classes. Full-time, intense study did not seem to help. I failed the crucial qualifying exam, twice. I was ready to quit.

I had been assigned a lab on the 10th floor of the Pupin Physics Building where I had been given the job of making a cloud chamber work. This was a 12-inch cylinder of glass and plastic filled with N_2 alcohol vapour. This device can render the path of a nuclear particle visible since the "wake" of the intruder particle produces a trail of disturbed atoms. This encourages alcohol



Inspiration: Gilberto Bernardini, expressive and enthusiastic as ever.



Fantastico! Lederman received the 1988 Nobel prize in physics, together with Jack Steinberger and Melvin Schwartz, for the experiment at Brookhaven that demonstrated the existence of two different neutrinos, associated with the electron and the muon. The track here reveals a muon created by an incident neutrino. (Courtesy BNL.)

crucial sense of wonder

vapour to coalesce from vapour to drops of liquid. A flash photograph then captures a record of the nuclear particle – much like the vapour trail of a jet airliner. But as much as I tried, my cloud chamber produced no tracks, only a cloud of white smoke. This failure, added to the failed tests and joyless lectures, brought me misery and to the point of quitting. I decided to take the PhD qualifying test once more and took two weeks to study.

After the test (I felt only slightly better), I returned to the lab to find a janitor mopping the wire-strewn floor and singing an Italian operatic tune. As I entered, the guy shouted something in Italian and offered a handshake.

I said, “Okay, but be careful. The wires are carrying a high current and your wet mop may produce a short circuit.” He stared cluelessly and, in total disgust, I walked out in the hall to wait for the guy to leave.

In the hall, there was the department chairman. “We have a new, dumb janitor, huh?” I said.

“New? No, wait! You mean the guy in your lab?”

“Yeah.”

“That’s no janitor, dummy, that’s Professor Gilberto Bernardini, a world-famous Italian cosmic-ray expert whom I invited to spend a year here to help you in your research.”

“Oh, my God!” I gasped and rushed in to repair my damage.

Over time, Bernardini and I learnt how to communicate and I began to watch Gilberto. There was his habit of entering a dark room, pushing the light switch: light. Pushing it again: off. On, off five or six times. Each time there would be a loud “fantastico!” Why? He seemed to have this remarkable sense of wonder about simple things.

Then the cloud chamber.

Gilberto: “Wat’s dat wire in de middle?”

Leon: “That’s carrying the radioactive source.”

Gilberto: “Tayk id oud.”

Leon: “It makes tracks.”

Gilberto: “Tayk id oud.”

After a few minutes, tracks appeared. My source had been far too radioactive for the chamber! Now we had a success.

But this was only the beginning of my learning from Bernardini. Next, we constructed a kind of Geiger counter. We machined, soldered, polished, flushed with clean argon gas and watched the oscilloscope. Soon we had tracks.

Bernardini went nuts. “Izza counting!” he screamed. Half of my height and weight, he lifted me and danced me round the lab to the music of Bernardini’s sense of wonder. He explained: “Dese particles, cosmic ray, come from billions of miles away to say buonjourno to us on de tenth floor of Pupin Physics Building. Izza beautiful! So little particle, so long da trip.”

So, through Bernardini, I began to recover my love of physics, of searching for simplicity and elegance of how the world

works. I recovered academically and eventually graduated to a professorship.

Gilberto warned me about what happened next. Some years into my Columbia career, I was on the night shift of an experiment. It was 3 a.m.; I had checked that all the apparatus was working when one computer began to beep out of tune. I tuned it to scan the data and – there it was, the most spectacularly beautiful track I had ever seen. What I was seeing was a muon entering from a thin metal plate and passing through 10 more plates. A muon! The only explanation was that a neutrino had generated this track – a muon neutrino! Its implications dawned on me – two neutrinos – this would change how we taught physics; this would make headlines from Scotland to Argentina... My palms were wet, my breathing became difficult. I tested everything, but only confirmed the discovery. At 4 a.m. I telephoned Gilberto, who was then visiting in Illinois. His wonderful “fantastico!” had been Americanized and when I told him what we had found, out came “Holy shit!”

Gilberto knew everybody. Fermi, Amaldi, Bohr, Schrödinger, ... Einstein. At a meeting (after receiving my PhD), we heard Einstein describe relativity: “scarcely anyone who truly understands this theory can escape its magic.”

As Keats said: “Truth is Beauty and Beauty Truth. That is all ye know of Earth.” And Plato: “The soul is awestruck and shudders at the sight of the beautiful.”

Some years later, Gilberto and my wife, Ellen, were in Sweden to help me receive the Nobel prize. Gilberto’s “fantastico!” was ubiquitous. And I said to Ellen, “Did you ever in your wildest dreams imagine that we would be in Sweden dining with the king and queen?” Ellen, as ever sceptical, said, “You were never in my wildest dreams!”

Science has always been and will continue to be a mixture of 96% frustration and (if lucky) 4% elation. But having a Bernardini to restore that crucial sense of wonder sure helps.

Résumé

La physique et l'importance de l'émerveillement

Après la Deuxième Guerre mondiale, lorsque Leon Lederman était jeune étudiant en doctorat, une rencontre avec Gilberto Bernardini a ravivé son enthousiasme pour la physique expérimentale. C'est ainsi qu'il a pris le chemin qui allait le mener à Stockholm et au prix Nobel de physique – pour avoir découvert qu'il existe plus d'un type de neutrinos. Dans cet article, Lederman évoque ses débuts en tant que chercheur. Il en conclut que la recherche scientifique est parfois très frustrante et qu'avoir un « Bernardini » pour raviver son émerveillement peut être décisif.

Leon Lederman, Fermilab.

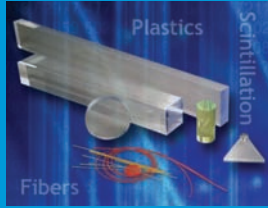
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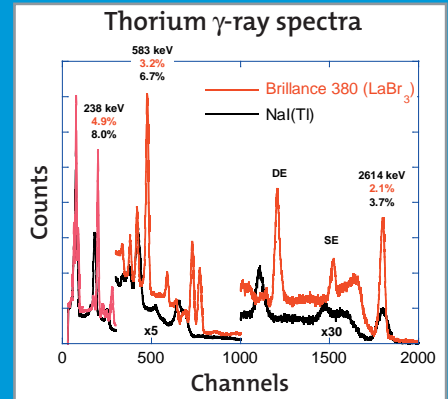
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FACES AND PLACES

ANNIVERSARY

TRIUMF celebrates its first four decades

A little more than 40 years after TRIUMF was formally introduced to the world with the planting of an apple tree from Sir Isaac Newton's family estate, the laboratory threw open its doors to the community to show off the fruit borne by four decades of basic and applied research. On 8 August TRIUMF celebrated its 40th anniversary with a festive open house, where for only the second time, the lab was open to the public for self-guided tours, physics demonstrations, games, fun for kids and free food. More than 1300 people came to this milestone event and they were not disappointed – some 100 TRIUMF employees volunteered on a pleasantly warm Saturday afternoon to talk to visitors along the tour route, answer questions, give demonstrations and explain the experiments and apparatus currently in operation.

"A fifth of the lab gave up their Saturday to show TRIUMF off to the community," explains Colin Morton, ISAC beam physicist and key member of the open-house planning committee, "and it was their enthusiasm that really made the event a success". His sentiments were echoed by many of the visitors who enjoyed talking to the scientists and were inspired by the passion and enthusiasm that they expressed for their work. The physics demonstrations were also a big hit, from the superconducting levitating train to the physics magic show, the cosmic-ray shower detectors and the liquid-nitrogen demonstration.

One highlight was the ceremony commemorating the 40th Anniversary of TRIUMF's dedication and the original planting of Newton's apple trees. During the ceremony, Mark Halpern of the nearby University of British Columbia (UBC) talked on the physics of apples, gravity and Newton, while TRIUMF co-founder and director emeritus Erich Vogt put TRIUMF into context as an evolving initiative in science, excellence and innovation for Canada. Invited dignitaries gave their observations on the lab's achievements and contributions to the advancement of Canadian health and science. They included local federal member of parliament, Joyce Murray; local provincial member of the legislative assembly



TRIUMF's 40th Anniversary commemoration ceremony. Invited guests and scientists who attended the original tree-planting ceremony 40 years ago, pose for a photograph in front of descendants of "Newton's apple trees". From left to right: Joop Burgerjon, Ed Auld (kneeling), Terry Creaney, Alan Otter, provincial government MLA Richard Lee, Lyle Robertson, federal government MP Joyce Murray, TRIUMF co-founder Erich Vogt, David Walker, Lorna Warren, Ralph Korteling, TRIUMF director Nigel Lockyer, Mark Halpern, John Hepburn, George MacKenzie, Jan Fialkowski, Jack Beveridge, Michael Craddock (kneeling), George Griffiths, Richard Helmer, Karl Erdman and Don Heywood.

(and formerly of TRIUMF), Richard T Lee; the executive director of the University Neighbourhood Association, Jan Fialkowski; the vice president of research at UBC, John Hepburn; and the federal minister of state for science and technology, Gary Goodyear (via prepared video).

At the end of the ceremony, Lorna Warren, wife of the late John Warren, a TRIUMF co-founder and its first director, unveiled a plaque commemorating the 40th anniversary. Many of TRIUMF's scientists present at the 1969 ceremony were in attendance and were moved by the significance of the event. A special display of photographs helped to honour their contribution to the lab's four decades of success. "It was great to see so many of the pioneers who helped to make TRIUMF a reality 40 years ago return from retirement to celebrate the anniversary and see what had become of their creation," says Michael Craddock, himself a TRIUMF pioneer (and longtime lab correspondent for *CERN Courier*). "...Lorna Warren's description of

the genesis of subatomic physics at UBC after the Second World War was particularly interesting. A worthy commemoration of TRIUMF's roots and a credit to the present staff responsible for the many and various arrangements!"

From the archives

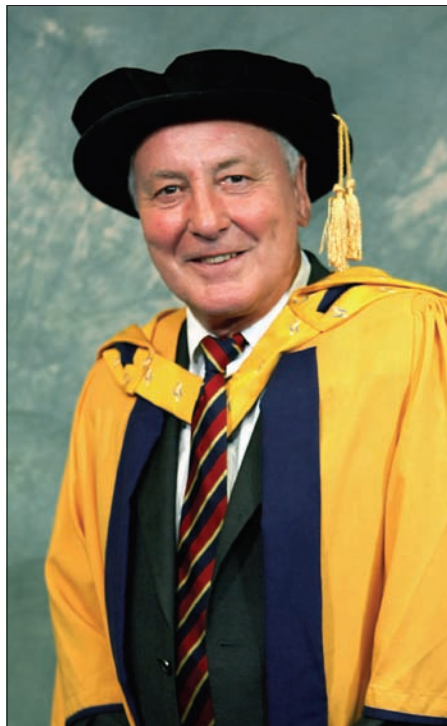
On 5 May a symbolic tree-planting ceremony was held. The Honourable Jean Luc Pepin, Canadian Minister of Energy, Mines and Resources, planted an apple tree on which had been grafted some scions of a direct descendent of the famous apple tree at Woolsthorpe Manor in Lincolnshire, England, under which Newton received inspiration for his laws of gravity. From March 1973, when the first beam is scheduled to be extracted from TRIUMF, scientists may well be seen grouped under this tree hoping for similar messages from above.

● *CERN Courier* June 1969 p172 (extract).

AWARD

Glamorgan honours Lyn Evans with doctorate

CERN's Lyn Evans has received an honorary doctorate from the University of Glamorgan, in his homeland of Wales. Evans, who led the LHC project from its inception in 1994 until the start-up in September 2008, was born in Aberdare in Mid Glamorgan and attended the local grammar school there. The University of Glamorgan, which began as the South Wales and Monmouthshire School of Mines, is now the second-largest university in Wales with more than 22 000 students. Evans was awarded the honorary doctorate in a ceremony at the university on 14 July.



Lyn Evans. (Courtesy University of Glamorgan.)

VISIT



Israel's minister of science and technology, **Daniel Hershkovitz**, right, visited CERN on 26 August. He toured the ATLAS experimental cavern accompanied by former ATLAS muon project leader, **George Mikenberg**, left, and ATLAS spokesperson, Fabiola Gianotti. He also met with members of the Israeli community at CERN and toured the ATLAS visitor centre.

CELEBRATION

CERN celebrates as André Martin turns 80

On 27 August CERN's main auditorium was the venue for a celebration in honour of André Martin's 80th birthday. Regarded as one of the most important theoretical particle physicists of his generation, Martin is one of CERN's most distinguished figures. The celebration began with a symposium, with contributions from: Jean-Marc Richard, of the Laboratoire de Physique Subatomique et Cosmologie (LPSC), at Grenoble University; Harald Grosse of the University of Vienna; Shansaka Roy of Jawaharlal Nehru University; and Tai Tsun Wu of Harvard.

Martin joined CERN in 1959 as a Fellow in the Theory Division and became a permanent staff member in 1964. He



André Martin at the 80th birthday symposium.

was awarded the Gian Carlo Wick Gold Medal in 2007 in recognition of his work on the rigorous analyticity and symmetry properties of scattering amplitudes, including the Froissart-Martin bound on total cross-sections and his contributions to the understanding of heavy quark-antiquark systems. He retired in 1994 but continues his work as a theoretician at CERN.

After the symposium, Martin made a speech in which he looked back over his 50-year career and paid tribute to all of those who had made important contributions during his time at CERN. This was followed by a concert of piano and cello music, as well as a reception.

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PARTICLE ASTROPHYSICS

Neutralino makes an appearance in space

Late on 28 August, ESA astronaut Christer Fuglesang, took off on board the space shuttle Discovery for his second journey into space, this time as a specialist on the STS-128 mission. During the space flight to the International Space Station (ISS), the Swedish astronaut completed two space walks to make repairs and modifications, bringing his total number of space walks to five. However, there was also something slightly different about this mission: accompanying him in his flight kit was a neutralino – a particle predicted by supersymmetry that could also explain the dark matter in space.

Fuglesang was selected for the ESA astronaut corps in 1992, but prior to that he embarked on a career in particle physics as a fellow at CERN (*CERN Courier* January/February 2003 p58). Now a highly trained and experienced astronaut, he wanted to take something special into space that represented CERN. Enter the custom-made neutralino designed by the “Particle Zookeeper” Julie Peasely (*CERN Courier* July/August p66), branded with both the CERN and ESA logos and chosen because, as a candidate for dark matter, it neatly links the research of the two organizations in astrophysics and particle physics.



Swedish ESA astronaut Christer Fuglesang during flight-day two of the STS-128 mission with space shuttle Discovery. (Courtesy ESA/NASA.)



The handmade plush neutralino that accompanied Christer Fuglesang on his latest space mission.

COLLABORATION

Fellowships for Koreans at CERN

The funding agency of the Ministry of Education, Science and Technology of the Republic of Korea, the National Research Foundation, has launched a new programme for collaboration between the Republic of Korea and CERN in theoretical particle physics. As a part of the programme, CERN’s Theory Unit has this year awarded fellowships to two young Koreans, Chul Kim from Duke University in the US and Hyun Min Lee from McMaster University in Canada. They will come to CERN to work for one and two years, respectively, as CERN fellows with the Theory Unit.

Korea is the third non-member country, after Japan and Israel, to establish such a collaboration in theory. The programme’s Korean team leader, Deog-Ki Hong of Pusan National University, says that the Korean government is trying to expand the programme to include scholarships for graduate students in high-energy theory and establish a short-term visit programme for postdocs.

The aim is that the new collaboration between CERN and the Republic of Korea will benefit the high-energy community in Korea as well as CERN, especially in the exciting era of the Large Hadron Collider.



The 50th anniversary of the first publication of the *CERN Courier* provided the opportunity for a modest celebration on 2 September 2009. All six of the principal editors that the magazine has had over its 50 years met together for the first time. After getting acquainted and re-acquainted over lunch, they gathered in the library at CERN to answer questions about producing the magazine over the years. From right to left, from the first editor to the present incumbent: **Roger Anthoine, Alec Hester, Brian Southworth, Gordon Fraser, James Gillies and Christine Sutton.**

MEETINGS

A Workshop on Applications of High Intensity Proton Accelerators will be held on 19–21 October 2009 at Fermilab. Fermilab's future accelerator R&D programme is focused on an SRF linac for Project-X, the ILC, or any future machine. The workshop will cover topics related to challenges in the design of high-power CW and pulsed linear accelerators, targetry and the design of systems to collect pions to achieve muon beams leading to a neutrino factory.

It will focus on SRF linac approaches and how they can be used for future accelerator applications. For further information, please contact Cynthia M Sazama, e-mail: sazama@fnal.gov; or visit <http://conferences.fnal.gov/App-Proton-Accelerator/index.html>.

The Indian Institute of Astrophysics, Bangalore and the Institute of Mathematical Sciences, Chennai, are conducting a **Winter School on High Energy Astrophysics** in

Kodiakanal, on 1–11 December 2009. With good foundation courses in particle physics and astrophysics, the emphasis will be on neutrino astrophysics and gamma-ray astronomy. Second-year master's students and young researchers in related fields are encouraged to apply. There are no registration charges and the selected candidates will be given local hospitality. The deadline for applications is 20 October. For further information, see www.iap.res.in/kodai_he09.

LETTERS

Discovering antimatter

I would like to comment on the article by Antonino Zichichi in the *CERN Courier* (May 2009 p5). This was on the “discovery of the antideuteron” at CERN by Zichichi and colleagues, submitted on 13 March 1965 to *Nuovo Cimento* and published on 1 September (T Massam *et al.* 1965 *Nuovo Cimento* **39** 10). Since we had published our data from an experiment carried out at Brookhaven in *Physics Review Letters* on 14 June 1965 in the paper “Observation of Antideuterons” (DE Dorfan *et al.* **14** 1003; submitted 4 May), we surely would like to be included in the amazing statement attributed to Heisenberg: “I think that this discovery of antimatter was perhaps the biggest jump of all big jumps in physics in our century.”

The Brookhaven data show the advantage of a higher energy and intensity beam of protons. The antideuteron peaks are statistically much stronger and with far smaller background than that of CERN. In addition, the d^- peak falls solidly on the d^+ peak when we changed to a positive beam, so that calibrations were unnecessary. The d^- peak allowed us to check that the antideuterons showed the correct change in momentum with a change in beam energy.

As emphasized by Zichichi *et al.*, the establishment of d^- in both papers establishes the proof for the existence of antimatter, via the observation of bound states, that Dirac insisted was essential. *Leon M Lederman, Fermilab.*

I read with great interest Antonino Zichichi's article in the edition of May 2009. One argument that I could not quite understand

was why a bound multi-antinucleon state was required to prove the existence of antimatter. After all, the positron was discovered in 1933 by Anderson, and the antineutron, the antiproton, and the antiparticle of the Λ baryon were observed before 1960 at Berkeley. Many other antihyperons and the antiparticle of the Fermi pion–nucleon Δ resonance were found at Brookhaven and CERN in the early 1960s (the $\bar{\Delta}$, in particular, in four strong isotopic-spin states). Some of these states are long-lived and others short lived, and they involve coupling of both electromagnetic as well as nuclear “glue” as prescribed in the article. That is surely sufficient for defining antimatter? As an aside, having lived through that period as a graduate student and a postdoc, and having done a thesis on antiproton–proton collisions at 3–4 GeV/c, I do not recall any questioning of the existence of antimatter at that time. *T Ferbel, Rochester.*

• Antonino Zichichi replies:

Priority in a discovery is the date when the paper is submitted. The CERN paper was submitted to *Nuovo Cimento* on 13 March 1965. Fifty-two days later our result was confirmed by Lederman *et al.* working at BNL. The fact that the d^- and d^+ fall on the same peak when you switch from negative to positive beams does not justify the lack of calibrations since systematic effects could destroy the result. In fact the best limit on the equal (d^-/d^+) masses comes from the CERN experiment.

The existence of any number of antiparticles does not imply the existence of antimatter. The crisis of relativistic quantum field theory (RQFT) and the apparent triumph

of the S-matrix theory, which is the negation of RQFT, was a focal point of physics in the 1960s. In his preface to the proceedings, *The Discovery of Nuclear Antimatter*, of the symposium held in 1995 to celebrate the 30th anniversary of the antideuteron experiment at CERN, Luciano Maiani writes: “The prevalent view of the strong nuclear forces was based, at that time, on S-matrix theory, Regge poles and, later on, dual models, a framework which abandoned the foundations of RQFT and in which the CPT symmetry was not fundamental anymore. To this picture, one should add in 1964 the discovery of CP violation in K decays, which prompted doubts on all symmetries thus far considered as granted, to conclude that it was not at all obvious that the nuclear binding forces had to be CPT invariant” (Maiani 1995). From the Dirac antielectron to the existence of antimatter the road is long and full of unexpected troubles (Zichichi 2001). The relevance of the antideuteron experiment is strongly correlated with the breakdown of the symmetry operators and to the problem of RQFT versus S-matrix theory. In his opening lecture at the symposium in 1995 TD Lee said: “The symmetry between matter and antimatter rests on purely experimental grounds” – the reason being that CPT breaks down at the Planck energy and there is “no theory able to guarantee that if we have matter then antimatter must exist”. L Maiani 1995 “Symposium to celebrate the 30th anniversary of the Discovery of Nuclear Antimatter”, Italian Physical Society *Conference Proceedings* **53**. A Zichichi 2001 “Antimatter. Past, Present and Future”, Italian Physical Society, *Rivista del Nuovo Cimento* **24** 1.

Those were the days

The personal account by John Ellis "Those were the days: discovering the gluon" in the July/August 2009 issue of CERN Courier attracted a large response. The varied points of view indicate the continuing interest in events surrounding the discovery of the gluon. Here we reproduce edited versions of several letters in order of receipt, together with further comments from John Ellis. (Full versions are published online in this month's Letters section at www.cerncourier.com.) Correspondence on this issue is now closed.

I'd like to comment on John Ellis's article, which gave undue emphasis to the work of the TASSO group. I presented our work in Mark-J, on the discovery of gluon jets, at the opening talk of the session at the Lepton/Photon Symposium at Fermilab in July 1979 (*Proceedings of the 1979 International Symposium on Lepton and Photon Interactions at High Energies* p3). As I stated right after the talk (recorded in the proceedings), the keys to discovery were (a) comparison of our data to QCD predictions for gluon bremsstrahlung, and (b) rejecting alternative models including quark-antiquark fragmentation and heavy quark decays, which were not well understood at the time. These key points, covered in my presentation, were entirely missing from TASSO's. As Ellis himself points out, showing individual events by members of TASSO was intriguing, but had nothing to do with the establishment of a gluon signal. In fact the TASSO events shown had only half the energy and a large energy imbalance, as TASSO only measured the charged tracks in the event.

The work I presented at Fermilab, which compared both the flatness distribution and the 3-jet pattern quantitatively with QCD, as opposed to quark-antiquark models with heavy-quark decays, and which established the gluon signal in Mark-J, was published in August 1979 (D P Barber *et al. Phys. Rev. Lett.* **43** 830). TASSO showed no comparison of their data with a QCD model at Fermilab at

all; in fact no TASSO paper that tested QCD against their data appeared until a year later (R Brandelik *et al. 1980 Phys. Lett.* **B94** 437). Harvey Newman, Caltech.

In his account John Ellis wrote: "He (Bjørn Wiik) told me that Sau Lan Wu had joined the TASSO experiment and that he had proposed that she prepare a 3-jet analysis for the collaboration." This is not correct since Bjørn Wiik never mentioned to me to look for 3-jet events in TASSO. This was my initiative as is evident from the write-up of the acceptance speech for the 1995 EPS High Energy and Particle Physics prize, written by Paul Söding, Bjørn Wiik, Gunther Wolf and me (*Proceedings of the International Europhysics Conference on High Energy Physics EPS HEP 95* p3): "At the time of PETRA's turn-on in 1978-79, it was widely believed that the initial energies of the first year at PETRA would not be high enough to see 3-jet events clearly. Therefore, one looked for jet broadening and high p_T phenomena¹⁷. ... By this time Sau Lan Wu had developed and tested a 3-jet analysis method and had convinced herself that three-jet events, if they were produced, could be detected once the PETRA energy went above three times the SPEAR energy i.e. $3 \times 7.4 \sim 22$ GeV." (Ref. 17 refers to the following sentences in the paper of John Ellis *et al.* [1976 *Nucl. Phys.* **B111** 253]: "The first observable effect should be a tendency for the 2-jet cigars to be unexpectedly oblate, with a high large p_T cross section. Eventually, events with large p_T would have a 3-jet structure, without local compensation of p_T .")

With this conviction, I developed a 3-jet analysis with Georg (not Gus) Zobernig. The first event observed by this analysis was presented by Wiik in June 1979 at Bergen. A few days later, more such events were found by our 3-jet analysis and they were presented by Söding at the EPS conference in Geneva. This presentation by Söding was the second public announcement by TASSO of $e^+e^- \rightarrow q\bar{q}g$. At the time of his talk, the other three collaborations at DESY – JADE, Mark-J

and PLUTO – had not presented anything on 3-jet events publicly. Sau Lan Wu, University of Wisconsin-Madison.

Concerning John Ellis's article, we would like to say that "those were NOT the days" and that was not the process nor the accelerator, but the laboratory was correct: DESY. Half a year earlier, in 1978 (1979 *Phys. Lett.* **82B** 449), our PLUTO experiment at DORIS discovered the $Y \rightarrow 3$ gluons decay, as hypothesized by Th Appelquist and D H Politzer (1975 *Phys. Rev. Lett.* **34** 43) by analogy with orthopositronium and proposed by K Koller and TF Walsh (1977 *Phys. Lett.* **72B** 227). The Y decays were studied by PLUTO as 3-jet topologies, using information from both charged and neutral particles.

The same experimental information was used later by PLUTO at PETRA when searching for $q\bar{q}g$ jets for the discovery of gluon bremsstrahlung (as suggested by J Ellis, MK Gaillard and G G Ross and by a few more theoreticians and phenomenologists), a confirmation of the existence of gluons (see eg Ch Berger (PLUTO) 1979 *Proceedings of the EPS International Conference on High-Energy Physics Geneva* p19). Some other experiment, at the same time and supported by our $Y \rightarrow 3$ gluons discovery, used nevertheless only charged particles.

A fuller recollection of the PLUTO experiments and the gluon discovery can be found at <http://www.roma3.infn.it/~stella/PLUTO.gluon>.

Hans-Juergen Meyer, (at the time, Siegen University), and Bruno Stella, (at the time, DESY), Roma Tre and INFN.

In e^+e^- collisions both the total energy and the total momentum of events must be conserved. However, the five events presented by TASSO at the 1979 EPS Conference only measured charged flux and showed about half of the total energy. The momenta were also not conserved. Thus, one cannot conclude the discovery of the gluon based on such events. In fact, the TASSO



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speaker at the conference did not make any claim of the gluon discovery at all.

I believe that the true story of the discovery of the gluon jet at PETRA was described by Herwig Schopper, the director-general of DESY during the period, in his article in *Physics Today* (February 1980), which concluded that the first statistically significant confirmation of QCD with 3-jet events had come from the work in MARK-J. The group of physicists from the Chinese Academy of Sciences made very important contributions to the gluon discovery, which were completely ignored in John Ellis's article.

Hesheng Chen, Director, Institute of High Energy Physics, Beijing.

The strength of TASSO was to measure the energy and momentum of charged particles. The TASSO detector was built as a major joint effort by my institute, I Physikalisches Institut der Rheinisch-Westfälischen Technischen Hochschule Aachen (RWTH I) and the DESY group headed by G Wolf, P Söding and B Wiik. The most important parts of the TASSO detector, the magnet, the time-of-flight system and the forward-backward argon calorimeter were built partly under my leadership, in RWTH I Aachen.

In the article by John Ellis there were detailed descriptions of the excitement of the first five charged-track events. These events were scanned simultaneously at Aachen by me and my colleagues as well as at DESY, with daily exchange of information between the two groups. In particular, the visual scanning of the hadronic final-state events and the interactive reconstruction were done entirely in parallel at both laboratories, sending data tapes each night to Aachen and comparing results the same day by telephone conversation.

These five events of charged particles, which do not conserve energy and momenta due to the large missing neutrals, do not by themselves show the existence of the gluon as pointed out by Paul Söding in his EPS conference talk (1979 *EPS International Conference on High-Energy Physics* p280).

Three-jet events can have many origins such as heavy quark decays and gluon emission. To ascertain that part of these events are indeed from gluon emission predicted by QCD, one must compare the properties of the events with QCD. The QCD Monte Carlo simulation and data analysis leading to the distributions for narrow and wide jets were developed and carried out in Aachen.

Klaus Lübelmeyer, emeritus director, RWTH I.

● John Ellis replies:

At the outset of my article, I made it clear that it was a personal reminiscence, mainly based on the early theoretical developments following the paper on large-angle gluon bremsstrahlung that I wrote in 1976 with Mary Gaillard and Graham Ross. It was my intention not to take sides in the experimental priority dispute, and I took pains in my article to avoid doing so. For example, I repeated a remark I made at the time of the Bergen conference that one could not believe in 8 gluons on the basis of the single first 3-jet event shown there by Bjørn Wiik, and I wrote only that gluons "looked good" after the EPS conference in Geneva where more 3-jet events were shown by other members of the TASSO collaboration. I did not write that the gluon had been discovered at that stage; I assigned credit for the gluon discovery to the presentations by the four PETRA collaborations (JADE, Mark-J, PLUTO and TASSO) at the subsequent

Fermilab conference.

I take this opportunity to recall some more theoretical contributions, in addition to those mentioned in my article. One was the sum rule derived in 1969 by Chris Llewellyn-Smith for the contributions of quarks to the total momentum of the proton: experimental data on electron and neutrino scattering substituted into this sum rule demonstrated that about half was missing, presumably carried by gluons. During the 1970s, scaling violations in deep-inelastic scattering came to provide strong quantitative evidence for collinear gluon bremsstrahlung as calculated in asymptotically free QCD. I would also like to recall that, following our suggestion that large-angle gluon bremsstrahlung might lead to 3-jet events in the e^+e^- continuum in 1976 and the discovery of the Y bottomonium resonances in 1977, various groups of theorists suggested that the 3-gluon decays of Y states might lead to 3-jet final states. This possibility was pursued by the PLUTO collaboration, which demonstrated in 1978 that there was indeed a significant difference between final states on- and off-resonance, as predicted by the 3-gluon theory. These developments were impressive pieces of circumstantial evidence for the gluon, but were not as spectacular as the 3-jet events seen in higher-energy running at PETRA, at least in my view. Finally, in the years from 1977 onwards, many younger theorists at DESY and the University of Hamburg were very active in the study of possible 3- and 4-jet final states, and were very valuable consultants for their experimental colleagues working at PETRA.

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

OBITUARIES

Guy von Dardel 1919–2009

Guy von Dardel, a well known figure at CERN and in the international particle-physics community, passed away on 28 August.

Born on 26 August 1919 in Stockholm, Guy von Dardel went on to study at the Royal Institute of Technology, obtaining his doctorate in 1953 with a thesis titled "The Interaction of Neutrons with Matter studied with a Pulsed Neutron Source". During his

studies he was employed by SAAB, the National Defence Research Institute, and Atomic Energy Ltd.

He came to CERN at its beginning in 1954 and was a full-time staff member until 1964, performing several experiments and working on technical developments. In particular, he carried out the first measurement of the neutral pion's lifetime, an experiment

known to all who study particle physics at university level.

Called to Lund University in 1964, he became professor there in 1965 and director of the 1.2 GeV electron accelerator. This machine marked the start of the accelerator competence at Lund University that later developed into the MAX-lab for photon science.

In the late 1960s, he performed an experiment at CERN's PS that measured the decays of the Λ . Then, in the early 1970s, he involved the Lund group in a series of experiments at the Intersecting Storage Rings (ISR), which at the time provided the world's highest-energy particle collisions. There, he measured the production of various types of particles, and in particular participated in a series of experiments that observed the production of a high abundance of particles with large transverse momenta, which required an explanation in terms a substructure in the colliding protons.

Guy von Dardel initiated the Scandinavian ISR Collaboration, which included the Niels Bohr Institute in Denmark and Bergen University in Norway. He also initiated the participation of some of the Lund group in an experiment at DESY. Further experiments followed there, but he did not himself participate in these.

He was chair of the European Committee for Future Accelerators (ECFA) from 1976–1977. During this period he was instrumental in



Guy von Dardel. (Courtesy Len Sirman Press.)

starting CERN's preparations for the Large Electron Positron (LEP) collider. He was later involved in the L3 experiment at LEP.

In the mid-1980s, together with James Cronin, he conducted a new version of the experiment that measured the lifetime of the

neutral pion. The result was consistent with the first measurement, but with an order of magnitude better precision.

As a scientist, Guy von Dardel was characterized by his large flow of ideas; ideas for physics experiments and ideas about instrumentation. He was also strong in providing rapid and rough estimates, an important ability when discussing new ideas. He was an inspiration for all of those he worked with.

His half-brother Raol Wallenberg disappeared at the end of the Second World War after having saved tens of thousands of Jewish lives. Guy von Dardel was dedicated to finding out his brother's fate. He made countless journeys to the Soviet Union and Russia for discussions and to examine records, taking the initiative for many actions, and he compiled an extensive archive regarding his brother's fate.

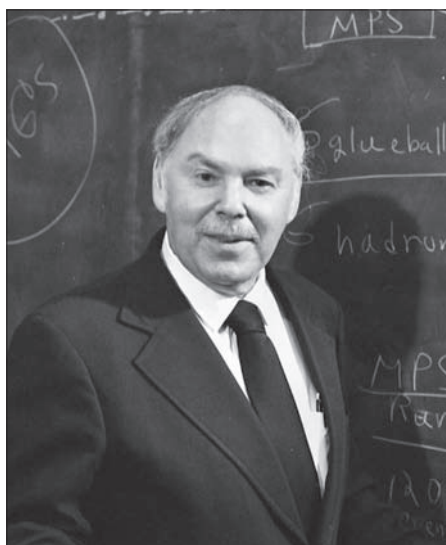
We share our sorrow with his family and convey our deepest condolences to his wife Matilda and the rest of his family. *His colleagues and friends.*

Sam Lindenbaum 1925–2009

Sam Lindenbaum, whose distinguished career at the Brookhaven National Laboratory (BNL) spanned 45 years, died on 17 August 2009.

Born in New York City, Lindenbaum earned a bachelor's degree in physics from Princeton University in 1945, followed by a master's degree and PhD from Columbia University in 1949 and 1951, respectively. He joined BNL in 1951 and he soon began experimental research at the Cosmotron, where he developed the first differential gas Cherenkov counters at this machine and proposed a theory known as the nucleon "isobar model" to explain the dominant features of high-energy pion production. He also designed the radiation protection shielding for the Cosmotron, proposed the basic parameters of the Alternating Gradient Synchrotron (AGS) shielding and was a consultant on many other high-energy shielding projects.

In 1959, Lindenbaum formed a new group to develop a novel approach to study basic high-energy interactions, which required handling the high data rate made possible with



Sam Lindenbaum. (Courtesy BNL.)

electronic detector arrays and rapid automatic processing of complex particle interactions. The team developed an online computing technique that fulfilled these requirements and, in 1962, it performed the first online computer experiments at the AGS, using

scintillation counter hodoscopes. This work led to the founding of the On-Line Data Facility, which was used both by universities and by BNL groups, with Lindenbaum as group leader.

During the 1960s Lindenbaum and his group exploited online techniques further in experiments at the AGS. Their research included investigations of pion–nucleon forward dispersion relations that proved the validity of a basic axiom of modern relativistic field theory. They also found that the A_2 meson was not "split", thus helping to confirm the validity of the quark model.

In 1970, Lindenbaum became co-group leader of the Particle Spectrometer Group with his long-term collaborator, Satoshi Ozaki. With help from university user groups, the group designed and constructed the Multiparticle Spectrometer (MPS) at the AGS, a 700-tonne large-acceptance particle detector with high-speed electronic sub-detector systems that enabled detection of rare events. A more powerful successor, MPS II, followed in the late 1970s. Using MPS II, the team discovered direct evidence for glueballs.

Following the cancellation in 1983

of the proposed high-energy collider, ISABELLE, at BNL, Lindenbaum worked on a time-projection chamber, for a new relativistic heavy-ion programme at the AGS and he began to focus his attention on magnet design and detector technology for the Relativistic Heavy Ion Collider (RHIC). As a member of the STAR collaboration at RHIC, Lindenbaum, along with Ron Longacre at BNL, was interested in a theoretical interpretation of particle interactions at RHIC. Together they studied the fluctuations and correlations

in relativistic heavy-ion collisions to search for indications of “bubbles” of quark–gluon plasma that might be created prior to the formation of hadrons. They published a paper on their theory, and another paper was pending at the time of Lindenbaum’s death.

In 1970, Lindenbaum became a faculty member at the City College of New York (CCNY), while retaining a joint appointment at Brookhaven. He retired from CCNY in 1995, but held the title of professor emeritus at the college from 1998. He retired from BNL

in 1996, returning in 1998 as a guest senior physicist to continue his research as part of the STAR collaboration.

Lindenbaum was highly appreciated by his colleagues as a great scientific thinker and a source of new and innovative ideas. He was also a fierce defender of scientific freedom and enjoyed spirited scientific and philosophical debates. His brother, Stanley Lindenbaum, a niece, Karen Koevary, and a nephew, Michael Kimmel, survive him. *Diane Greenberg, BNL.*

Jan Nassalski 1944–2009

Jan Nassalski, a prominent figure in the deep inelastic scattering community, an ingenious physicist and a dedicated teacher, passed away on 5 August.

Jan graduated from the physics department of Warsaw University in 1966. He started his scientific career at Warsaw University of Technology and in 1971 he joined the Institute of Nuclear Research (now the Soltan Institute for Nuclear Studies), where he later became scientific director. His research work centred on the physics of elementary particles of matter and their interactions and he collaborated with the Laboratory of High Energy Physics at JINR, the Rutherford Laboratory in the UK, and Fermilab. From the late 1970s, however, his research was concentrated at CERN.

His continuous participation in one of CERN’s longest running experimental facilities started when he joined the European Muon Collaboration and in the early 1980s he set up a group in Warsaw to study the nucleon structure in deep inelastic muon scattering. He participated in the ground-breaking discovery in 1988 that the quark spins contribute little to the nucleon spin and he was a key contributor to the structure-function studies in the New Muon Collaboration, leading to the measurement that showed violation of the Gottfried sum rule.

In the 1990s Jan focused on high-precision experiments of the polarized structure of the nucleon. Under his leadership the Warsaw group contributed to the first test of the Bjorken sum rule by the Spin Muon Collaboration and he was essential in studies of gluon polarization in the nucleon by the COMPASS experiment – an important step



Jan Nassalski, prominent Polish physicist.

in understanding the quark/gluon structure of matter. For his colleagues Jan was the reference point for all aspects of physics in the domain of deep inelastic scattering.

Jan’s group from the Soltan Institute made successful contributions to the NA48 experiment at CERN, with read-out electronics for the liquid krypton calorimeter. The group was also active in physics analysis, leading some studies of rare kaon decays and precise measurements of fundamental properties of neutral mesons. In particular, Jan was one of the main authors of the precision measurement of the mass of the η .

In addition to his research, Jan was chair

of the Programme Advisory Commission for High Energy Physics of the Scientific Council of JINR and he was a member of the Scientific Council at DESY. He also chaired the High Energy Physics Commission at the Polish Atomic Energy Council.

In his home country, Jan was tireless in his outreach activities, publishing widely in the Polish media. Whenever CERN launched a new outreach initiative, the uptake in Poland was phenomenal, and Jan’s hand could be seen behind the success. For example, a CERN educational CD was distributed free with a popular science magazine, and more recently, Jan played a vital role in making CERN’s high-school teacher programme a great success in Poland. He was particularly proud of this work and justifiably so.

Jan was a delegate to CERN Council from December 2004, representing his country’s interests powerfully and with great conviction. Although softly spoken, he knew how to carry an argument. Yet even in the most heated of debates, he was a model of politeness and courtesy.

Thanks to his natural kindness and sense of humour, his infinite patience and above all his extreme rigour and great integrity, exchanges with Jan were of a high standard and rewarding. The quality and accuracy of his judgments always made them an irreplaceable reference. Particle physics has lost not only an excellent physicist, but also a true gentleman.

Jan was to all of us more than a colleague. We will greatly miss his perceptiveness and sensitivity as well as his advice, and remember him as a precious friend. *His colleagues and friends.*

NEW PRODUCTS

Elma Electronic Inc has announced a new conduction-cooled ATR 6U VPX platform that provides the highest level of environmental protection while also allowing for optimal cooling. The operating temperature ranges from -40°C to $+70^{\circ}\text{C}$. Additional backplane options for the seven-slot, conduction-cooled ATR platform include VME/64X, cPCI, VXS and custom backplanes. For more information, contact Valerie Andrew tel +1 800 445 6194; e-mail valeriea@acttechnico.com; or visit www.elma.com.

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goodfellow.com; or see www.goodfellow.com.

Oxford Instruments has announced the world's first integrated Cryofree dilution refrigerator with a 12 T superconducting magnet. This system operates without liquid helium and only uses a single pulse tube refrigerator. It offers the ability to control temperatures from below 10 mK to 30 mK and magnetic fields up to 12 T on the same instrument. For more information, contact Sophie Walker tel +44 1865 393 349; fax +44 1865 393 3333; e-mail sophie.walker@oxinst.com; or visit www.oxford-instruments.com.

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high-voltage testing, micro-channel plates, photomultiplier tubes etc. Output voltages range from 0 to 6 kV at up to 6 W of output power, with output current from $166\ \mu\text{A}$ to 6 mA. For further details, tel +1 631 471 4444; or see www.ultravolt.com.

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DIRECTOR OF COMPUTATION-BASED SCIENCE AND TECHNOLOGY RESEARCH CENTER (CaSToRC)

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- Collaborating closely with the Cyl Vice President for Research and the President of the Institute to develop the CaSToRC within the overall Cyl structure.
- Developing organisational structures for the appropriate functioning of

the CaSToRC.

- Raising financial and other resources to support the research programs of the CaSToRC

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The candidate must have excellent interpersonal skills, with strong capacities for managing human resources, and for generating and maintaining contacts in the academic, business and governmental circles, as well as obtaining support from them for the Center. Proficiency in spoken and written English is indispensable, while knowledge of the Greek language would be an advantage but is not a requirement.

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For further information please contact Dr Michalis Yiangou (m.s.yiangou@cyi.ac.cy). To be assured full consideration, applications should be received by 15th of November 2009 via e-mail to HR@cyi.ac.cy. Please show the following reference in the subject heading: **CaSToRC-09-01**. Recruitment will continue until the position is filled.

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This position may be filled as a Staff Scientist or Career-Track Staff Scientist depending on qualifications and years of relevant scientific experience. The career-track position is a one-year, term appointment that may be renewed to a maximum of five years with the expectation of being converted to a career position based upon satisfactory job performance, continuing availability of funds, and ongoing operational needs.

Apply on line at <http://cjo.lbl.gov/LBNLCareers/details.asp?jid=23303&p=1SID=2033>, and follow the on-line instructions to complete the application process. In addition, please submit the names of at least five references by email to Dr. Ernst Sichtermann, EPSichtermann@lbl.gov.

The position will be open until filled. We will be considering candidates starting October 15, 2009. Please reference Job 23303. LBNL is an Equal Opportunity/Affirmative Action Employer.



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Universität Hamburg



At the Faculty of Mathematics, Informatics and Natural Science in the Department of Physics at the University of Hamburg, and jointly with DESY, the position of a

FULL PROFESSOR W₃ (DESY-PROFESSORSHIP)

for Experimental Physics with main focus
Experimental Particle Physics at Colliders

is offered/reference number 2051/W₃

The University of Hamburg and DESY are equal opportunity employers and welcome participation from all qualified individuals. They aim at increasing the representation of women among their staff and, therefore, explicitly encourage applications from female scientists.

Background:

Candidates should have an established international reputation in the field of experimental particle physics at colliders at the highest energies. Expertise in the preparation, accomplishment and analyses of experiments in large international collaborations is expected. The successful candidate should assume a leading scientific role at DESY and in one of the LHC collaborations as well as in the preparatory work for a Linear Collider. He or she is expected to further develop particle physics at Hamburg and to strengthen the close collaboration between DESY and the University of Hamburg. Adequate participation in teaching is expected.

Requirements:

According to § 15 Hamburgisches Hochschulgesetz.

The University of Hamburg attaches particular importance to the quality of teaching. Therefore, experience and ideas on teaching should be presented.

Disabled persons are given priority over applicants of equal suitability, qualification and degree of specialized knowledge.

For full consideration applications (including a CV), a complete list of publications, and a summary of current and future research interests and objectives should be sent by **October 30th, 2009** to the President of the University of Hamburg, Referat Organisation & Personalentwicklung - 631.6-, Moorweidenstraße 18, 20148 Hamburg, Germany.

TOR ZUR WELT DER WISSENSCHAFT

Department of Physics

Applications are invited for a Senior Lecturer/Reader position within the experimental particle physics group at Royal Holloway. The experimental group is part of the Centre for Particle Physics, which also includes the John Adams Institute for Accelerator Science and a new phenomenology group.

Senior Lecturer/ X0809/1724

Reader in Experimental Particle Physics

Salary £47,064 to £54,220 per annum inclusive of London Allowance

We would particularly welcome applications from someone with hardware expertise who will drive a new initiative in detector development; in this context we are also open to establishing a new direction in our physics programme. Significant new laboratory space is being planned to support this initiative.

For an informal discussion about the post contact Professor Grahame Blair (G.Blair@rhul.ac.uk).

Further details and an application form are available from our website <http://rhul.ac.uk/personnel/jobvacancies.htm> or contact Human Resources on 01784 414241 email: recruitment@rhul.ac.uk Please quote the reference number.

Closing date: Midday, 16th November 2009. Interviews: Early December 2009.

We positively welcome applications from all sections of the community.





Postdoctoral Research Positions LIGO Laboratory

**California Institute of Technology (Caltech)
Massachusetts Institute of Technology (MIT)**

The Laser Interferometer Gravitational-Wave Observatory (LIGO) has as its goal the development of gravitational wave astronomy. The LIGO Laboratory is managed by Caltech and MIT, and is sponsored by the National Science Foundation. It operates observatory sites equipped with laser interferometric detectors at Hanford, Washington and Livingston, Louisiana. The initial detectors have achieved design sensitivity and a data set spanning more than a year of coincidence operation has been collected. Analysis is ongoing, with extensive participation by the LIGO Scientific Collaboration (LSC). Further observation is now underway, with incrementally improved instruments. A major upgrade (Advanced LIGO) is underway in parallel. In addition, a vigorous R&D program supports the development of enhancements to the detectors as well as future capabilities.

The LIGO Laboratory expects to have several postdoctoral research positions at Caltech, MIT and at the two LIGO observatory sites. Successful applicants will be involved in the operation of LIGO itself, analysis of data, both for diagnostic purposes and astrophysics searches, as well as the R&D program for future detector improvements. Expertise related to astrophysics, modeling, data analysis, electronics, laser optics, vibration isolation and control systems is desirable. Most importantly, candidates should be broadly trained physicists, willing to learn new experimental and analytical techniques, and ready to share in the excitement of building, operating and observing with a gravitational-wave observatory. Appointments at the post-doctoral level will initially be for one-year with the possibility of renewal for up to two subsequent years.

Applications for post-doctoral research positions with LIGO Laboratory should indicate which LIGO site (Caltech, MIT, Hanford, or Livingston) is preferred by the applicant. Applications should be sent to HR@ligo.caltech.edu (Electronic Portable Document Format (PDF) submittals are preferred).

Applications should include curriculum vitae, list of publications and the names, addresses, email addresses and telephone numbers of three or more references. Applicants should request that three or more letters of recommendations be sent directly to HR@ligo.caltech.edu (Electronic Portable Document Format (PDF) submittals are preferred). Consideration of applications will begin December 1, 2009 and will continue until all positions have been filled.

*Caltech and MIT are Affirmative Action/Equal Opportunity Employers
Women, Minorities, Veterans and Disabled Persons are encouraged to apply
More information about LIGO available at www.ligo.caltech.edu*



www.ippp.dur.ac.uk

Durham University invites applications for the post of

Professor of Particle Physics Phenomenology

tenable within the Department of Physics, in association with the Institute for Particle Physics Phenomenology (IPPP).

We are looking for an outstanding physicist in the field of particle physics phenomenology. The successful applicant will have expertise in one or more of the following areas: beyond the standard model physics; electroweak and Higgs boson physics; flavour physics; model building; Monte Carlo simulations; neutrino physics; particle astrophysics and strong interactions. He or she will be expected to play a substantial role in the management of the IPPP and have the potential to be a future Director of the Institute. Applications from candidates with a strong record of engagement with experimental groups are encouraged.

An outline of the current research programme and activities of the IPPP can be found at <http://www.ippp.dur.ac.uk>.

Further details of the post are available on the university website (<https://jobs.dur.ac.uk>) or telephone +44 (0) 191 334 6499; fax +44 (0) 191 334 6495.

Closing date: **30th October 2009**. Please quote reference number: **3301**

Informal enquiries, expressions of interest, or names of potentially interested parties should be sent as soon as possible, and in confidence, to: **Professor Nigel Glover, E.W.N.Glover@durham.ac.uk**.

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opening February 1, 2012, at the Albert Einstein Center for Fundamental Physics, Institute for Theoretical Physics, University of Bern, Switzerland. The position can be filled either at the Full Professor or at the tenure track Assistant Professor level. Candidates should have a strong research record in quantum field theory applied to particle physics, aiming at a detailed understanding of the strong interaction, the standard model, or its extensions, in particular using non-perturbative methods. The current research activities at the institute include effective field theories, non-perturbative quantum field theory, the standard model, flavor physics, supersymmetry, gravity, and string theory. The successful candidate is expected to build up a strong research group, to be experienced in acquiring external funding, and to actively participate in the teaching and supervision of Bachelor and Master students, as well as of Ph.D. students in the graduate school.

The University of Bern particularly encourages women to apply for this position.

Applications including a curriculum vitae, a publication list, copies of the most important publications, a brief outline of past and future research, and a summary of obtained external funding should be sent to **Prof. U. Feller, Dean of the Faculty of Science, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland, by November 15, 2009.**

For further information you may contact **Prof. U.-J. Wiese, Institute for Theoretical Physics, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland, e-mail: wiese@itp.unibe.ch, www.itp.unibe.ch**

Associate Scientist – Fermi National Accelerator Lab

As a member of the Superconducting Radio-Frequency Development (SRFD) Department, the successful candidate will conduct R&D in support of Fermilab's SRF program, which is aimed at developing the facilities, technologies and expertise needed to utilize SRF cavities and cryomodules in accelerator projects such as Project X and the High-Intensity Neutrino Source (HINS). The candidate will also support the ongoing International Linear Collider (ILC) R&D program. This position is an extendable three-year term appointment with the expectation of a subsequent performance-based promotion to a Scientist I position.

The successful candidate will be expected to fulfill the following responsibilities:

- Conduct R&D in support of the Fermilab SRF program under the guidance of experienced scientists and engineers
- Develop research interests that are aligned with the Fermilab SRF program
- Propose and execute R&D activities in the areas of accelerator physics and accelerator technology
- Participate in relevant conferences, workshops and meetings
- Publish research results in refereed journals

Qualified candidates must have demonstrated ability to carry out independent research; Ph.D. in Physics or relevant subject; 2+ years of post-doctorate experience; experience with SRF cavities and related technologies, in accelerator technology R&D, and in the application of accelerator technology and/or accelerator operations; knowledge of materials, vacuum systems, and cryogenics.

Applicants should include a curriculum vitae and a publication list. Applications and requests for information should be sent to Victor Yarba at yarba@fnal.gov.



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The European XFEL will make available X-rays of unique quality for studies in physics, chemistry, life sciences, materials research and others. Located in the vicinity of Hamburg, Germany, it will comprise scientific instruments for a wide range of experimental techniques. Construction of the European XFEL is underway, its commissioning is scheduled for 2014. The European XFEL is an international project with the participation of 14 countries. In 2009, the project will assume its legal form as a not-for-profit company with limited liability: the European XFEL GmbH. We are looking for a

Technical coordinator of the experimental hall (f/m)

The position

Organization and coordination of technical installations in the experimental hall, adjacent tunnel sections and laboratories/mechanical/electronics workshop, in collaboration with the global technical coordination group of the European XFEL. This task includes

- planning and installation of photon beam components (mechanics and vacuum)
- planning and installation of general infrastructure (all media including electricity, cooling water, gases, networks)
- integration of the scientific instruments into the overall technical infrastructure

This coordination will transfer in the operation phase into a service group providing technical assistance to internal and external scientific users groups, with a mechanical and an electronics workshop.

Requirements

- academic degree in physics or engineering
- practical experience with coordination of large scientific and technical installations
- documented communication and organizational skills
- fluency in spoken and written English
- knowledge of German may be an advantage

For additional information contact serguei.molodtsov@xfel.eu

Reference number: E-011(C)

Please apply via e-mail: recruitment@xfel.eu

This position is initially limited to 3 years but will be made permanent upon performance.

Salary and benefits are similar to those of public service organisations in Germany. Handicapped persons will be given preference to other equally qualified applicants. The European XFEL company will be an equal opportunity and affirmative action employer. – English is working language, some knowledge of a further language represented among the participating countries would be welcome. – The European XFEL project intends to achieve a widely international staff. Non-German candidates hired from abroad receive an international allowance.

■ ■ ■ **Deadline for application:** 31 October 2009

European XFEL Project Team
c/o DESY, 22603 Hamburg, Germany

www.xfel.eu



EUROMAGNET CALL FOR PROPOSALS FOR MAGNET TIME

The next deadline for applications for magnet time at the **LABORATOIRE NATIONAL DES CHAMPS MAGNETIQUES INTENSES** (ex GHMFL&LNCMP / <http://lncmi.cnrs.fr>), the **HIGH FIELD MAGNET LABORATORY** (www.hfml.science.ru.nl) and the **HOCHFELD LABOR DRESDEN** (www.fzd.de/hld) is November 15th, 2009

Applications can be done through an on-line application form on the web site: <http://www.euromagnet.org>.

Scientists of EU countries and Associated States* are entitled to apply under FP7 for financial support according to the rules defined by the EC.

*Listed on [ftp://ftp.cordis.europa.eu/pub/ftp7/docs/third_country_agreements_en.pdf](http://ftp.cordis.europa.eu/pub/ftp7/docs/third_country_agreements_en.pdf)

For further information concerning feasibility and planning, please contact the facility of your choice.





POST-DOCTORAL FELLOWSHIPS FOR NON ITALIAN CITIZENS IN THE FOLLOWING RESEARCH AREAS

**THEORETICAL PHYSICS (N. 15)
EXPERIMENTAL PHYSICS (N. 20)**

The INFN Fellowship Programme 2009/2010 offers 35 (thirty five) positions for non Italian citizens for research activity in theoretical (n. 15) or experimental physics (n. 20).

Fellowships are intended for young post-graduates who are under 35 years of age by **November 15, 2009**.

Each fellowship, initially, is granted for one year and then, may be extended for a second year.

The annual gross salary is EURO 28.000,00.

Round trip travel expenses from home country to the INFN Section or Laboratory will be reimbursed, also lunch tickets will be provided for working days.

Candidates should choose at least two of the following INFN sites, indicating their order of preference.

- **INFN Laboratories:** Laboratori Nazionali di Frascati (Roma), Laboratori Nazionali del Gran Sasso (L'Aquila), Laboratori Nazionali di Legnaro (Padova), Laboratori Nazionali del Sud (Catania);

- **INFN Sections in the universities of:** Bari, Bologna, Cagliari, Catania, Ferrara, Firenze, Genova, Lecce, Milano, Milano Bicocca, Napoli, Padova, Pavia, Perugia, Pisa, Roma La Sapienza, Roma Tor Vergata, Roma Tre, Torino, Trieste.

The research programs, must be focused on the research fields of the Section or Laboratory selected (<http://www.infn.it>).

Applications, in electronic form, must be sent to INFN no later than **November 15, 2009**.

To register, candidates must use the website <http://www.ac.infn.it/personale/fellowships/>

The application form requires:

- statement of research interests;
- curriculum vitae;
- three reference letters (specifying name, surname and e-mail of each referee).

Theoretical fellowships must start from September to December 2010.

Requests for starting earlier accepted.

Experimental fellowships must start no later than April 2010. Requests to participate accepted.

ISTITUTO NAZIONALE DI FISICA NUCLEARE
IL PRESIDENTE
(Prof. Roberto Petronzio)

LEON M. LEDERMAN Postdoctoral FELLOWSHIP

The Fermi National Accelerator Laboratory (Fermilab) invites applications for the Lederman Postdoctoral Fellowship in experimental particle physics. The Lederman Fellow will have a choice of opportunity within the broad program of experimental research at Fermilab which includes research at the Tevatron and the LHC, neutrino physics, particle astrophysics, and experiments at the Intensity Frontier. In recognition of Leon Lederman's outstanding career in research and his commitment to the teaching of physics, we are looking for candidates who have demonstrated exceptional ability in research and who also wish to participate in physics outreach for a fraction of their time.

The Lederman Fellowship appointment is normally for three years with a possible extension. Candidates should either have obtained a Ph.D. in experimental particle physics, astrophysics, or a closely related field, after November 1, 2008, or should expect to obtain a Ph.D. in the same fields by June 2010.

Applications including a curriculum vitae, a description of prior research and research interests, and details of experience and interest in outreach, should be sent to LMLFAPP@fnal.gov. Applicants should also arrange for three or four references to be sent to the same address. Applications and their references should be received by November 23, 2009.



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Wilson Fellowship in Experimental Physics

The Wilson Fellowship program at Fermilab seeks applications from Ph.D. physicists of exceptional talent with at least two years of post-doctoral work. The fellowships are awarded on a competitive basis and support physicists early in their careers by providing unique opportunities for self-directed research in experimental physics. Fellows will work on the Fermilab particle physics experiment of their choice. The Fermilab experimental program includes collider physics at both the Tevatron and the LHC, studies of neutrino and astroparticle physics, as well as R&D and planning for experiments at future colliders and high intensity beams.

The Wilson Fellowships are tenure track positions with an annual salary fully competitive with university assistant professorships. The appointment is for an initial term of three years and can be renewed for an additional two years upon the completion of a successful review after the first two years.

Each candidate should submit a research statement describing a proposed research program, a curriculum vitae, and should arrange to have four letters of reference sent to the address below. Application materials and letters of reference should be received by October 30, 2009.

Materials, letters, and requests for information should be sent to:
Wilson Fellows Committee
Fermi National Accelerator Laboratory
MS 122, Attention: Ms. Cathryn Laue
P.O. Box 500, Batavia, IL 60510-0500
Email: wilson_fellowship@fnal.gov

Additional information is available at:
http://www.fnal.gov/pub/forphysicists/fellowships/robert_wilson/

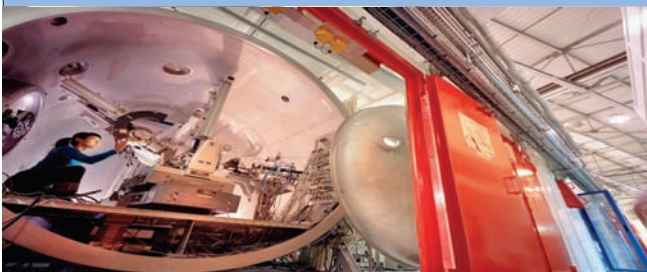


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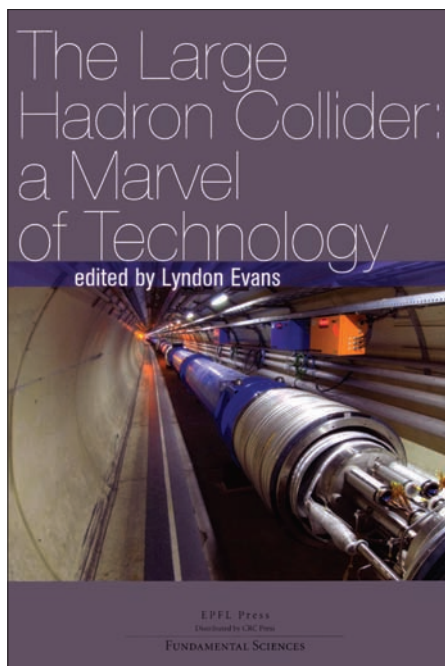
The Large Hadron Collider: a Marvel of Technology by Lyndon Evans (ed), EPFL Press. Paperback ISBN 97829400222346, €45 (SFr69).

Edited by Lyn Evans, the LHC project leader, this book outlines in a well balanced manner the history, physics and technologies behind the most gigantic scientific experiment at CERN: the LHC accelerator and its detectors. The book describes the highlights of the LHC's construction and the technologies developed and used for both the accelerator and the experiments. The 16 chapters are all written by leaders of activities within the LHC project. The timing is perfect because the book is on the shelf just in time for the anticipated start of LHC-physics data-taking.

There are thousands of people at CERN – from universities and collaborating institutions around the globe – who have accompanied the LHC project over the past two decades or joined during the construction phase. In this book they will find a superb record and detailed account of their own activities and the many aspects and challenges that their colleagues involved in the LHC construction had to face and solve. It features excellent photos that illustrate many of the ingenious technological inventions and show the detailed LHC infrastructure, components and experimental equipment installed both in the tunnel and above ground.

The interested readers will learn about the scientific questions and theory behind the LHC. The book presents in detail the scale, complexity and challenges inherent in the realization of this wonder of technology. Readers will gain an insight into the managerial and organizational aspects of long-term planning in present-day, large-scale science projects. They will learn much about superconductivity and superconducting magnets; industrial-scale cryogenic plants and cryogenics; ultra-high vacuum techniques; beam physics, injection, acceleration and dumping; as well as environmental protection and security aspects around the LHC. They will also read about the complex political processes behind the approval, funding, purchasing and construction of these enormous scientific experiments.

Colleagues involved in new, large-scale scientific projects in Europe – e.g. ITER, XFEL, FAIR, ESS – are well advised to benefit for their respective projects by reading this



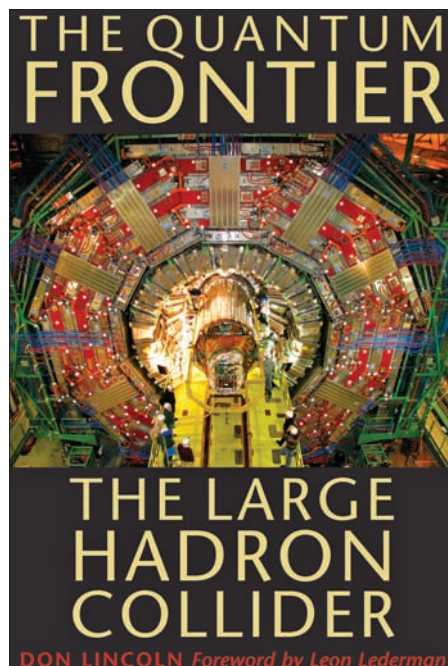
book. Many unforeseen problems faced during project execution, which required unconventional flexible measures to be adopted, are openly presented and discussed, with mention of the lessons to be learnt.

A significant part of the book is devoted to the description of the four major LHC experiments by their respective spokespersons and to the LHC data analysis and the Grid. The introduction is written by TS Virdee and provides a good overview of particle-detection basics, detector developments and challenges at the LHC. This section of the book is dedicated not only to the thousands of scientists, engineers and technicians involved in preparing LHC detectors worldwide but also – an interesting idea – to the agencies that funded the LHC detectors to a large extent.

In summary, this book comes at the right time and should be on the shelf of all friends of the LHC because it represents a nicely balanced record of the historical developments, technical challenges and scientific background. It is packed with many, many photos of the LHC taken during construction and assembly.

Horst Wenninger, CERN.

The Quantum Frontier: The Large Hadron Collider by Don Lincoln, foreword by Leon Lederman, Johns Hopkins University Press. Hardback ISBN 9780801891441, \$25.



As I write this review, in less than one week's time I will be starting the second year of my physics-undergraduate degree at McGill University, Montreal. During the past summer I was granted the chance to spend time at CERN, an aspiration for every young physicist. Working as a student journalist for the *CERN Bulletin*, I was able to get away with asking enough questions to drive everyone mad and learnt a great deal about the various experiments currently (and previously) being conducted at CERN, in particular at the LHC. However, even after two months of constant probing, the LHC still held many more secrets and fantastic intricacies that I sought to understand.

It was only during my final weeks that the answers to these questions were found, by reading *The Quantum Frontier*. Don Lincoln's playful, energetic style took me from the fundamentals of contemporary physics through to the extremely complex and sophisticated guts of the LHC experiments, touching on everything from the Earth's "inevitable" destruction by black holes to speculated future physics experiments in a post-LHC era.

Cracking it open for the first time, I was worried that a book taking under 200 pages to cover such an ambitious topic would be riddled with sterile facts listed one after the other. But the contrary is what I found. Lincoln starts by addressing the obvious

misconception that is in the watching world's mind: will the LHC destroy the planet and all of us with it? Tackling this issue first with an overview of basic material often covered in high-school science classes (the components of the atom, etc.), Lincoln goes on to peer deeper and deeper into the world of particle physics, laying out the basic building blocks of matter and what the LHC hopes to discover.

As a student of the subject, I found that some of the material was familiar, while a great deal of the new ideas and theories were elegantly explained. Lincoln kept me happily engaged with poignant and often funny analogies that facilitated the explanations and catered for a concise understanding. Like any scientifically relevant book, it uses diagrams and graphs to elaborate ideas, but their inclusion is not daunting.

Being a particle physicist himself, Lincoln gives us a chance to see the world from such a perspective and conveys the excitement and awe that is experienced working in this field. *Jordan Juras, McGill University.*

Der kosmische Detektiv: Auf der Suche nach den Geheimnissen des Universums by Mani Bhaumik, Seifert Verlag. Paperback ISBN 9783902406651, €14.90.



This little book – a translation from the English edition (*The Cosmic Detective. Exploring the Mysteries of Our Universe*, Penguin Books India, 2008), which has been officially endorsed by the

International Year of Astronomy 2009 – is aimed mainly at young people. The author, an eminent physicist, tries to ignite in them the same enthusiasm for the mysteries of the cosmos that he, born in a small Indian village, experienced when looking at the star-spangled sky. He succeeds in describing in simple, sometimes poetic, words all of the phenomena that populate the universe.

Galaxies, nebulae, stars and planets – their formation and properties are all discussed. The book also gives a brief description of the development of the universe from the Big Bang to present times and addresses many burning questions, such as: is there life somewhere else in the universe? In addition, the beautiful colour images, which the author collected from NASA and other sources, show galaxies, planets and their moons, and form a major attraction of the book.



Of course, to produce a popular description of modern astronomy and cosmology is not easy but thanks to his competence Bhaumik manages to achieve it without mistakes, despite the unavoidable simplifications. Terms such as dark energy and dark matter come up and their links to particle physics are mentioned. A third of the book is devoted to planets and their moons, including questions of whether there is water on some of them. Here, the author's optimism concerning future space travel and the possible habitation of the Moon and Mars appears somewhat exaggerated.

Bhaumik mainly focuses on the description of phenomena; for an understanding of the cosmological events, more ambitious and challenging literature would have to be consulted. In addition, as in many other popular books, there is an emphasis on theoretical developments, giving the impression that observation consists more or less of looking through telescopes and taking pictures. The sophisticated modern technologies of measurements and their evaluation are hardly mentioned. On the other hand the author insists, rightly, that the progress of science is a combination of theoretical ideas and experiments.

Unfortunately some ambiguities or imprecision have crept into the translation. Even the subtitle, *Exploring the mysteries*

of our universe, would have been better translated as "*die Erforschung der Geheimnisse des Universums*" (instead of "*auf der Suche*") because we are not looking for the well presented mysteries in the book, but rather are trying to understand them. *Herwig Schopper, CERN.*

Books received

Particle Detection with Drift Chambers, 2nd edition, by Walter Blum, Werner Riegler and Luigi Rolandi, Springer. Hardback ISBN 9783540766834, €105.45 (£89.99, \$139). Online version ISBN 9783540766841.

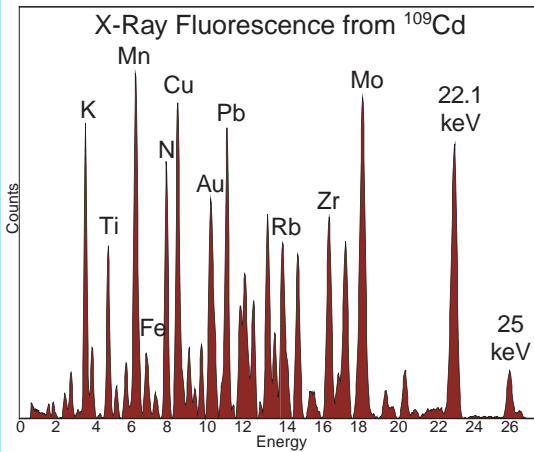
The second edition is a revised, updated and expanded version of this classic text. It provides a thorough introduction to the theory and operation of drift chambers, and surveys all types of drift chambers and drift-chamber gases in use. Topics include the basics of gas ionization by particles and lasers; the drift of electrons and ions in gases and signal creation; the fundamental limits of accuracy; and particle identification. The new edition also contains further material on electronic signal creation, amplification and shaping. The calculation of the device parameters and physical processes are presented in some detail, as is all necessary background material, with many illustrations. The text is well suited to graduate physics students and others seeking a thorough and pedagogical introduction to the field.

Electromagnetic Scattering from Random Media by Timothy R Field, OUP. Hardback ISBN 9780198570776, £55 (\$110).

This book develops from first principles the dynamical theory of scattering from random media. Its key findings are to characterize the time evolution of the scattered field in terms of stochastic differential equations, and to illustrate this framework in simulation and experimental data-analysis. The physical models contain all correlation information and higher-order statistics, which enables radar- and laser-scattering experiments to be interpreted. An emphasis is placed on the statistical character of the instantaneous fluctuations, as opposed to ensemble average properties. The book illustrates how ideas in mathematical finance can be applied to physics problems in which non-Gaussian noise processes play an essential role. It is aimed at mathematicians, physicists and engineers at the postgraduate level or higher.

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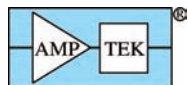


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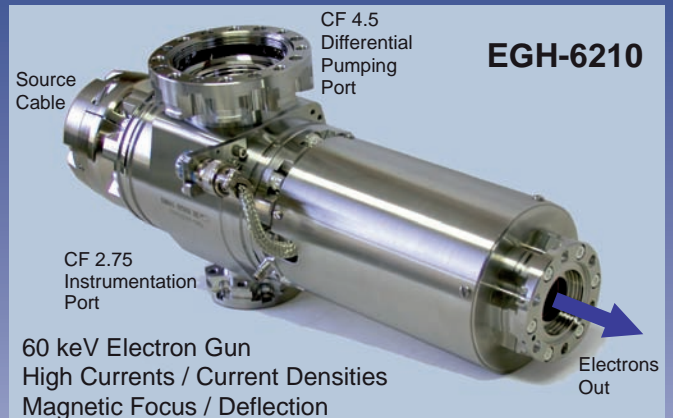
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The queen of all sciences and Intelligent Design

Antonino Zichichi says that physicists should not ignore the debate on Intelligent Design.

In the mid-1930s, physics was heavily attacked by the most famous Italian philosopher of the time, who called physicists “vile mechanics”. It was on this occasion that Enrico Fermi told his young fellows: “Don’t worry. Physics is the queen of all sciences.”

We physicists cannot remain silent and keep ignoring the cultural debate on “Intelligent Design”. Other scientists discuss what their observations allow them to say about Intelligent Design: practically all fields of science are present in the debate. Physics, however, is absent. But it is the only science that studies the fundamental logic of nature. Therefore we are the most involved in the hypothesis of Intelligent Design. The purpose of this note is to review, briefly, the scientific basis for this hypothesis, which I describe more fully elsewhere (Zichichi 2008).

Mankind has always been concerned with this extremely important problem but it is only in the past four centuries that, following Galileo Galilei, an impressive series of experimental discoveries has allowed us to reach the conclusion that a fundamental logic of nature exists. The point I would like to make clear is that all other fields of scientific research are not in a position to study this logic for the very simple reason that, no matter what the field may be, the root of our existence has to be investigated in order to overcome the basic difficulty in dealing with the foundations of this logic.

For example, whether we study the evolution of inert matter or the evolution of matter endowed with the property of life, at the very end we discover that all forms of matter – with or without life – have to obey the same fundamental logic. No matter what form of evolution we attempt to study, the key issue is that if a fundamental logic exists, then nature – including its evolution – has to obey this logic.

The field of research where this logic is studied is physics. For the universe to be as it

is now, endowed with the properties of life and reason, three basic transitions are needed and each must obey the logic of nature.

The first of these transitions is the Big Bang, which describes how the universe – consisting of inert matter – came into being from a vacuum and subsequently evolved. I call this Big Bang 1. There are many problems to be studied for Big Bang 1 to be rigorously described on the basis of first-level “Galilean Science”; that is, through experimentally reproducible results that can be described with the rigour of mathematical formalism. Although Big Bang 1 and the subsequent cosmic evolution are a one-off event, every step must obey the fundamental logic discovered with first-level Galilean science; this logic is based on three fundamental forces (electroweak, strong and gravitational) and three families of elementary particles.

The second transition in the universe, Big Bang 2, deals with the problem of how to describe the transition from inert matter to living matter. So far no one has been able to solve this problem but once it is solved, the evolution of all different forms of living matter must be studied and referred to the fundamental logic of nature before the evolution of the living matter can be classified as Galilean science.

Then, Big Bang 3 – the transition from living matter without reason to living matter endowed with reason – must be described. It is thanks to Big Bang 3 that we are able to discuss Big Bang 2 and Big Bang 1. The fact that out of the innumerable number of different forms of living matter, there is only one endowed with the property called reason, needs to be examined in detail.

Once all of these problems have been solved we will be able to say that we have a scientific description of the theory of evolution. The present status of our culture takes for granted that the Darwinistic approach to the theory of evolution is

scientifically founded. As I have outlined above, this is not the case.

The basic message coming from science is that a fundamental logic exists that governs all forms of inert and living matter. If a fundamental logic exists then the author of this logic must exist too. The atheistic culture claims that the author is not there, but no one is able to prove, using either theoretical logic (mathematics) or experimental logic (science), that this is the case. Those who claim that this logic does not exist are in conflict with science and its most advanced achievements.

Four centuries ago Galilei discovered why it is not enough to be “smart” in order to understand the logic of nature. He pointed out that experiments need to be implemented if we want to know the correct answers to our questions. To express a question in a rigorous way – as is the case, for example, for a supersymmetric world, using a relativistic quantum string-like theory – is not enough; experimental proof of its existence is needed. The reason is that the fellow who created the world is smarter than all of us, no one excluded.

This is at present all that physics can say on the author of Intelligent Design. The hypothesis of which, to the extent that it is based on the argument that this fundamental logic exists, proposes nothing other than that there is an intelligence that designed such logic. And this is in perfect agreement with the most advanced frontier of our field of activity which was defined by Fermi as “the queen of all sciences”.

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● A Zichichi 2008 *Rigorous Logic in the Theory of Evolution*, presented at the Plenary Session on “Scientific Insights into the Evolution of the Universe and of Life”. Proceedings of the Pontifical Academy of Sciences (Vatican, 31 October – 4 November 2008), to be published.



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