The 2005 European Physical Society (EPS) Conference on High Energy Physics (HEP) took place in Lisbon on 21–27 July at the Cultural Centre of Belém, beautifully situated on the right bank of the Tagus river, 10 km west of downtown Lisbon. Held in alternate years, the EPS HEP conference starts with three days of parallel talks, followed by a day off, and then three days of plenary sessions. The format thus differs from that of the Lepton–Photon conferences, which are organized in the same year (CERN Courier, November 2005 p33), and allows the participation of more “grass-root” and young speakers.

This year a total of 17 sessions yielded a wealth of detailed results from both experiment and theory, including new results from astroparticle physics. One of the highlights was provided by Barry Barish, newly appointed director of the Global Design Effort for the International Linear Collider (ILC). The EPS and the European Committee for Future Accelerators organized a particularly popular “Lab directors’ session”, which presented status and future plans.

The opening ceremony was honoured by the presence of Mariano Gago, Portuguese Minister for Science, Technology and Universities, who as an experimental high-energy physicist, was also a member of the local organizing committee. As usual, the plenary sessions started with the prize awards. The EPS 2005 High Energy Particle Physics Prize was presented jointly to Heinrich Wahl of CERN and to the NA31 collaboration, with other prizes awarded to Mathieu de Naurois, Matias Zaldarriaga, Dave Barney and Peter Kalmus (CERN Courier, September 2005, p43). The next highlight was the invited talk by David Gross of Santa Barbara/KITP, Nobel Laureate in 2004 and EPS Prize winner in 2003. He checked off the list of predictions he had made in the summary talk of the 1993 Cornell Lepton–Photon conference, the majority of which had been confirmed.

Sijbrand de Jong of Nijmegen/NIKHEF and Tim Greenshaw of Liverpool started the main business of the plenary session with talks on tests of the electroweak and quantum chromodynamic sectors of the Standard Model, respectively. The new (lower) mass for the top quark from Fermilab, of 172.7±2.9 GeV, as presented by Koji Sata of Tsukuba in the parallel sessions, gives an upper Higgs mass of 219 GeV at 95% confidence level. Greenshaw discussed how HERA continues to play a major role in precision studies in quantum chromodynamics (QCD) of the proton, now mapped down to 10^{-18} m, or a thousandth of its radius. Such results will be very valuable for the analysis of data from the Large Hadron Collider (LHC). New results on the spin structure of the proton were also reported.

Riccardo Rattazzi of CERN and Pisa then talked on physics beyond the Standard Model and was followed by Fermilab’s Chris Quigg, who reviewed hadronic physics and exotics. Rattazzi presented an interesting “LEP paradox”: the hierarchy problem, with a presumed light Higgs particle, requires new physics at a low scale, whereas there are no signs of it in the data from CERN’s Large Electron–Positron collider. He also reviewed the anthropic approach to the hierarchy problem: we inhabit one of very many possible universes. This many-vacua hypothesis is also referred to as “the landscape”, and might have implications for supersymmetry. Quigg reviewed several new states discovered by the CLEO collaboration at Cornell and at the B-factories, and reminded us that the pentaquark states are still controversial.

Near- and more-distant-future possibilities were reviewed by Günther Dissertori of ETH Zurich in his talk on “LHC Expectations (Machine, Detectors and Physics)” and by Klaus Desch of Freiburg in “Physics and Experiments – Linear Collider”. Dissertori gave an overview of all the complex instrumentation in the process of being completed for both the LHC and its four major detectors. The first beams are planned for the summer of 2007, with a pilot proton run scheduled for November 2007. All detectors are expected to be
ready to exploit LHC collisions starting on “Day 1”. Desch presented the ILC project and highlights of the precision measurements it will provide in electroweak physics, in particular, in the Higgs sector.

More theoretical considerations were offered by CERN’s Gabriele Veneziano and Yaron Oz of Tel Aviv, who spoke on cosmology (including neutrino mass limits) and string theory, respectively. Veneziano reviewed current understanding, according to which the total energy content of the universe is split into 5% baryons, 25% dark matter and 70% dark energy. The question of what dark energy is was compared with the problem that faced Max Planck when he realized that the total power emitted by a classical black body is infinite. Interesting speculations on alternative interpretations of cosmic acceleration were also discussed. Precision measurements in cosmology have an impact on high-energy physics: they provide an upper bound on neutrino masses, indicate preferred regions in the parameter space of minimal supergravity grand unification, and suggest self-interacting dark matter. Oz reviewed the beauties of strings and their two major challenges: to explain the big bang singularity, and the structure and parameters of the Standard Model. So far, neither is explained, but the consistencies are impressive.

The recently discovered connection between string theory and QCD was described by SLAC’s Lance Dixon. An important problem being solved is how to optimize the calculation of multiparticle processes (which might be backgrounds to new physics processes). By ingeniously exploiting the symmetries of the theory, one is able to go beyond the method of Feynman diagrams in terms of efficiency. Roughly speaking, this amounts to first representing four-vectors by spinors, and then Fourier-transforming the left-handed but not the right-handed spinors.

Getting results

Christine Davies of Glasgow presented new results on non-perturbative field theory, in particular in lattice QCD (LQCD). She reported on the very impressive recent advances in LQCD, where high-precision unquenched results are now available to confront the physics of the Cabibbo–Kobayashi–Maskawa (CKM) matrix with only 10% errors on the decay matrix elements. This has been made possible by breakthroughs in the theoretical understanding of the approximations, together with faster computers.

Josh Klein of Austin and Federico Sanchez of Barcelona reviewed neutrino physics results and prospects, respectively. Neutrino physics has become precision physics, and now oscillations, rather than just flux reductions, are beginning to emerge in data from the KamLAND and Super-Kamiokande II experiments in Japan. Sanchez discussed rich plans for the future, with two main questions to tackle. Is the neutrino mass of Majorana or Dirac origin? How can the small angle $\theta_{13}$ and the CP-violating phase $\delta$ be constrained, or preferably, measured? The plans include the Karlsruhe Tritium Neutrino experiment to study tritium decay, and the GERDA experiment in the Gran Sasso National Laboratory (LNGS), the Neutrino Mediterranean Observatory and the Enriched Xenon Observatory, all of which will look for neutrinoless double beta decay. The Main Injector Neutrino Oscillation Search, the Oscillation Project with Emulsion Tracking Apparatus (OPERA) in the LNGS, and the Tokai to Kamioka (T2K) long-baseline neutrino experiments will all study the phenomena of “atmospheric” neutrino oscillations under controlled conditions, and the Double CHOOZ experiment will further bound the small values of $\theta_{13}$. A new idea is to exploit beams of unstable nuclei, which would provide monochromatic neutrinos. Meanwhile, the CERN Neutrinos to Gran Sasso project will start taking data in 2006, with a neutrino beam from CERN to the OPERA detector.

Flavour physics was the topic for both Gustavo Branco of Centro de Física Teórica das Partículas in Lisbon, in “Flavour Physics –
Theory (Leptons and Quarks)*, and Marie-Hélène Schune of LAL/Orsay, who talked about CP violation and heavy flavours. At the B-factories, the Belle detector is collecting a lot of luminosity, and after a long shutdown, BaBar is back in operation. Many detailed results on CP violation in B-decays were presented at the meeting. The BaBar and Belle results on $\beta$ or $\phi_1$ are now in agreement, and the CKM mechanism works very well, leaving little room for new physics, although the precision is also steadily improving.

Looking to the skies
Astrophysics was covered by three speakers, with Thomas Lohse of Berlin talking about cosmic rays (gammas, hadrons, neutrinos), Alessandro Bettini of Padova presenting dark matter searches, and Yanbei Chen from the Max-Planck Institute for Gravitational Physics reviewing work on gravitational waves. What and where are the sources of high-energy cosmic rays? How do they work? Are the particles accelerated or due to new physics (decay products) at large mass scales? The Pierre Auger Observatory is beginning to collect data in the region of the Greissen–Zatsepin–Kuzmin cut-off, while neutrino detectors search for “coincidences” (repeated events from the same direction).

The HESS telescopes and other detectors have discovered tera-electron-volt gamma rays from the sky! The origin is unknown, but they are correlated with X-ray intensities. The galactic centre is one such tera-electron-volt gamma-ray point source. It has also been discovered that supernova shells accelerate particles (electrons or hadrons?) up to at least 100 TeV. The searches for weakly interacting massive particles, on the other hand, remain inconclusive. Other experiments are still unable to confirm or refute the observation of an annular modulation seen by the DAMA project at the LNGS.

A major instrument in the search for gravity waves is the Laser Interferometer Gravitational-Wave Observatory, a ground-based laser interferometer that is sensitive in the region from 10 Hz to 10 kHz. The sources include pulsars, and one hopes to detect a signal after the planned upgrade. The Laser Interferometer Space Antenna will be launched in 2015, and will be sensitive to lower frequencies, in the range 0.01 mHz to 0.1 Hz, as might come from super-massive black-hole binaries.

Paula Bordalo of the Laboratório de Instrumentação e Física Experimental de Partículas in Lisbon presented an experimental overview of ultra-relativistic heavy-ion physics. Photon probes are important for the study of the new state of matter observed, as they do not interact strongly and carry information about the early stage of the collision. There is also a related virtual photon or dilepton signal that shows some interesting features. The new state being explored is possibly a colour glass condensate, which is behaving more like a low-viscosity liquid rather than a gas (see p25).

Alexander Skinisky of the Budker Institute of Nuclear Physics reviewed the status and prospects of accelerators for high-energy physics, covering machines in operation as well as new facilities under construction or planned. Superconductivity is widely used and is being further developed for accelerating structures and for magnets. One important line of development is oriented towards higher luminosity and higher quality beams, including longitudinal polarization and monochromization techniques. There are studies aiming at shorter and more intense bunches, suppression of instabilities involving fast digital bunch-to-bunch feedbacks and minimization of electron-cloud effects. Rapid progress is being made on energy-recovery linacs, recyclers and free-electron lasers, which are being studied for future synchrotron light sources. Higher power proton beams and megawatt targets are being developed and several promising options for neutrino factories are under study. Plasma wake-field acceleration appears to be still in an early stage of development, although it has the potential to achieve very high acceleration gradients.

Grid references
Turning to computing, DESY’s Mathias Kasemann described the status of the Grid projects in high-energy physics. The big experiments running today – CDF, D0, BaBar and ZEUS – are already using distributed computing resources and are migrating their software and production systems to the existing Grid tools. The LHC experiments are building a vast hierarchical computing system with well defined computing models. The LHC Computing Grid (LCG) collaboration has been set up to provide the resources for this huge and complex project. The LCG system is being developed with connections to the Enabling Grids for E-science (EGEE) project and the Nordic Data...
Grid Facility in Europe and to the Open Science Grid in the US. Basic Grid services have been defined and first implementations are already available and tested. Kasemann’s personal prediction was that the data analysis of the LHC experiments will not be late because of problems in Grid computing.

On the detector front, CERN’s Fabio Sauli reported on new developments presented at the conference. Interesting progress has been achieved in fabricating the radiation-hard solid-state detectors needed for the LHC and other high-radiation-level applications. One way is through material engineering: choosing materials that are radiation resistant, such as oxygenated silicon, silicon processed with the Czochralski method, or using thin epitaxial detectors. Other solutions have been developed by device engineering, and these include pixel detectors, monolithic active pixels or three-dimensional silicon structures. For high-rate tracking and triggering, gas micro-pattern detectors, such as the gas-electron multipliers, have found versatile solutions in several experiments. For calorimetry, new materials like lead tungstate crystals have been adopted in LHC experiments. Also new scintillation materials with large light yield, fast decay time and with high density have been tested.

Boris Kayser from Fermilab closed the conference with an eloquent summary. On the day off, various excursions to charming medieval villages and ancient monasteries all converged on the city of Mafra, where the conference participants met Portuguese students and teachers in a baroque palace dating from 1717. There was also a visit to a precious library created by Franciscan friars, with 36 000 prize volumes (the “arXiv” of its time!) and where bats control the insect numbers (visitors were told). Gaspar Barreira and his colleagues jangled the local organization masterfully, and the many excellent fish restaurants nearby provided a relaxed setting for informal discussions.

● The next EPS-HEP conference, in July 2007, will take place in Manchester, UK.

Résumé
La physique des particules au Portugal

La plus prestigieuse conférence européenne de physique des particules de 2005 s’est tenue à Lisbonne. 17 sessions parallèles ont permis de communiquer une mine de résultats détaillés, notamment en Astrophysique des particules. Parmi les moments forts : un exposé de Barry Barish, directeur du Projet mondial de conception du Collisionneur linéaire international, et une “Session des directeurs de laboratoire” sur le présent et l’avenir. On y a présenté divers résultats expérimentaux sur des tests du modèle standard, l’observation des rayons cosmiques de haute énergie et la quête des ondes gravitationnelles, de même que les dernières nouvelles de la théorie des cordes et de l’énergie sombre de l’univers.

Per Osland, University of Bergen, and Jorma Tuominiemi, Helsinki Institute of Physics.