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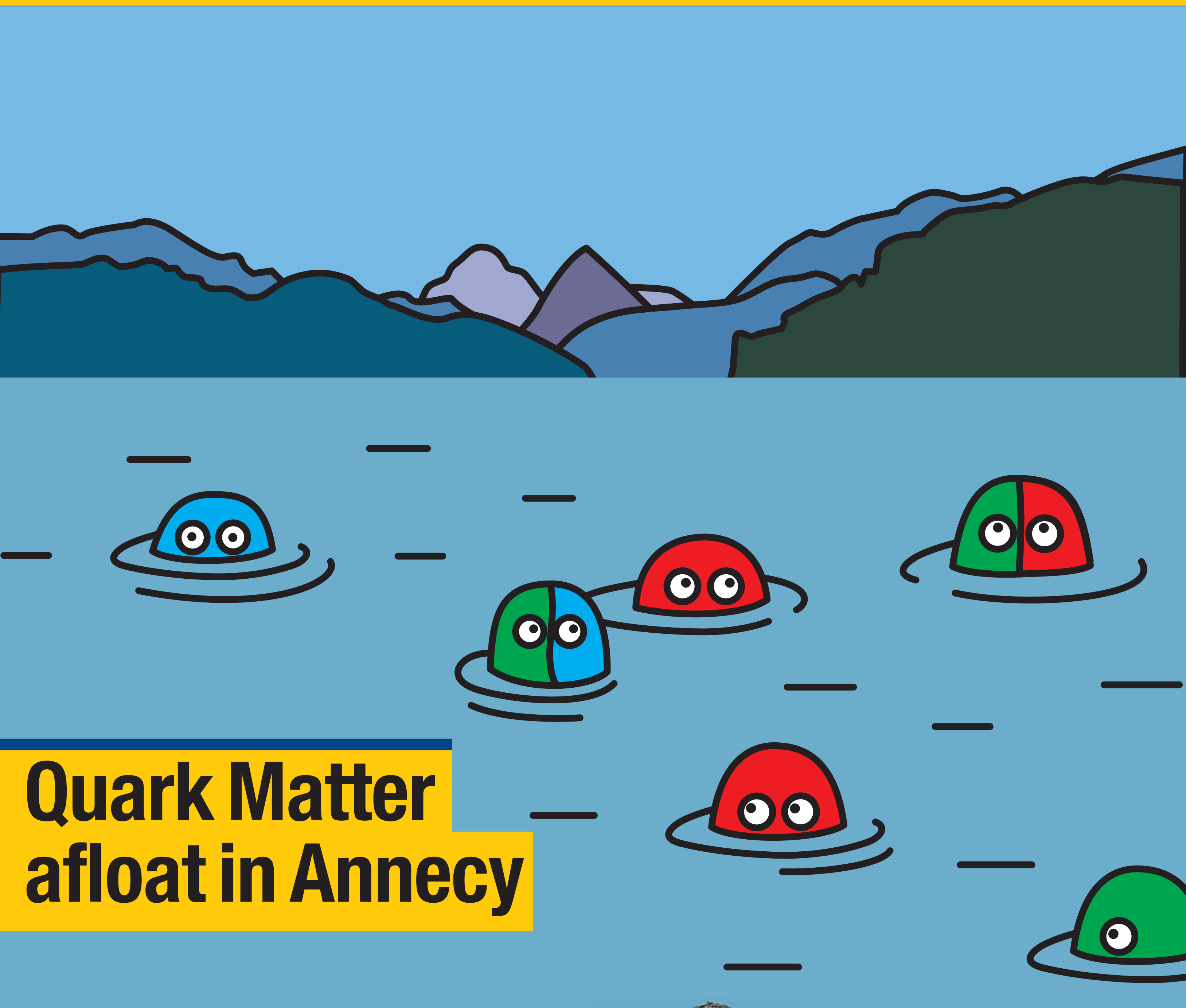

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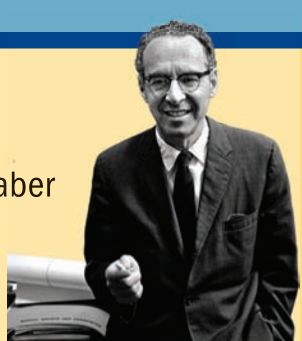

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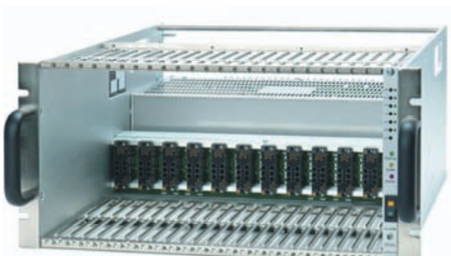

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Covering current developments in high-energy physics and related fields worldwide

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CERN

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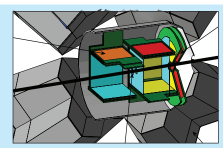
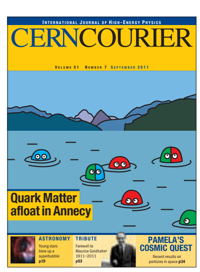




On the cover: While first results from the LHC were the star attraction at Quark Matter 2011 in Annecy, these quarks took pride of place on the posters. (Image credit: Roxane Arleo.)

News

CONFERENCE

EPS-HEP 2011: the harvest begins

Impressive results, and so much more to come: this is the general feeling that more than 800 participants took home from the International Europhysics Conference on High-Energy Physics, EPS-HEP 2011, which was held in Grenoble on 21–27 July. After only a year of data-taking, the spectacular performance of the LHC and the amazingly fast data analysis by the experiments have raised current knowledge by a huge notch in searches for new physics.

Those who had hoped that the LHC would reveal supersymmetry early on may have been slightly disappointed, although each extended limit contributes to the correct picture and new physics is guaranteed, as many speakers reminded the audience. CERN's director-general, Rolf Heuer reinforced this point, stating that for the Higgs boson in particular, either finding it or excluding it will be a great discovery.

On the search for the Higgs boson, both the CMS and ATLAS experiments at the LHC have observed small excesses of events in the WW and ZZ channels. Each one is statistically weak but taken together, they become interesting, as each team independently sees a small excess in the low range for the Higgs mass. While this is exactly how a Standard Model Higgs would manifest itself, it is still far too early to tell (p11).

Another big topic of conversation was the report by the CDF collaboration at Fermilab of the first measurement of the rare decay $B_s \to \mu\mu$, appearing possibly stronger than predicted. On the other hand, the CMS and LHCb collaborations at the LHC showed preliminary results, which when combined provide a limit in contradiction with the CDF result (p11). More data will soon clarify what is happening here.

At the press conference, from left to right: Fabio Zwirner, chair of the High Energy Physics Division of EPS; Rolf Heuer, CERN's director-general; Stavros Katsanevas, the deputy director of IN2P3; and Michel Spiro, president of CERN Council. (Image credit: LPSC/Tomas Jezo.)

The session on QCD showed great progress in the field, with updates on parton-distribution functions from the experiments at HERA, DESY, as well as several results from the LHC experiments. These measurements are now challenging the precision of theoretical predictions, and will contribute towards refining the Monte Carlo simulations further. The experiments at Fermilab's Tevatron and at the B-factories also presented improved and impressive limits in all directions in flavour physics, contributing to a clearer theoretical picture.

In neutrino physics, new results came from the T2K and MINOS experiments, giving the first indications of a sizeable mixing angle between the first and third neutrino generations (p6). It was particularly moving to see how Japanese colleagues are recovering after the devastating earthquake and tsunami. Atsuko Suzuki, head of the KEK laboratory, thanked the particle-physics community for its extended support.

An important highlight of the conference was the award of the European Physical Society (EPS) High Energy and Particle Physics Prize to Sheldon Lee Glashow, John Iliopoulos and Luciano Maiani. They received this for their crucial contribution to the theory of flavour, currently embedded in the Standard Model of strong and electroweak interactions, which is still of utmost importance today.

With the first results from significant amounts of data at the LHC, the conference attracted a great deal of interest from the world's press. A press conference was held on 25 July to announce the EPS 2011 high-energy physics prizes, with contributions on the latest results from the LHC, the European strategy for particle physics, and the latest advances in astroparticle physics in Europe.

● A more detailed report will appear in the October issue of the *CERN Courier*.

CERN

LHC passes 2 fb^{-1}

The LHC is enjoying a confluence of twos. On 5 August the total integrated luminosity delivered in 2011 passed 2 fb^{-1}; the peak luminosity has risen to over 2×10^{33} $cm^{-2}s^{-1}$; and fill number 2006 lasted for 26 hours, delivering an integrated luminosity of 100 pb^{-1}.

Following the period of machine development that started at the end of June, the decision was taken to continue running with 50 ns bunch spacing and the maximum of 1380 bunches (*CERN Courier* July/August 2011 p5). Increases in luminosity must come from increasing the number of protons per bunch, or decreasing the transverse beam size at the interaction point. The size of the beams coming from the injectors has now been reduced to the minimum possible, bringing an increase in the peak luminosity of about 50%.

Sommaire en français

NEUTRINOS

MINOS and T2K glimpse electron-neutrinos

The T2K and MINOS experiments, which are both designed to study neutrino oscillations over long baselines, have reported results from their searches for the appearance of electron-neutrinos in beams of muon-neutrinos produced at distant locations. On 15 June the T2K collaboration announced that it had observed an indication that muon-neutrinos are able to transform into electron-neutrinos over the 295 km baseline of their experiment in Japan. Ten days later, the MINOS collaboration announced its latest results on the same effect. Both experiments find a non-zero value for the neutrino mixing angle θ_{13}. This would be zero if electron- and muon-neutrinos could not transform into each other.

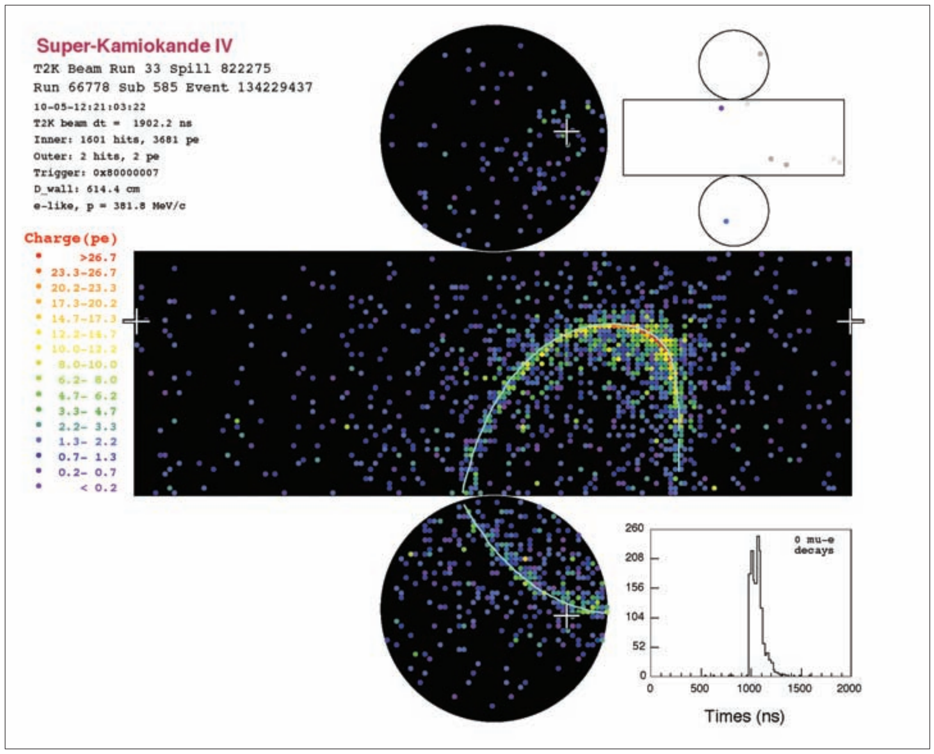
Oscillations between the three known flavours of neutrino – electron, muon and tau – are described by a mixing matrix, which can be parameterized in terms of three angles, θ_{12}, θ_{23}, θ_{13}, and a CP-violating phase. Observations of oscillations in solar neutrinos and atmospheric neutrinos have determined θ_{12} and θ_{23}, respectively, leaving θ_{13} still unknown. The new results provide the first indications that this angle is not zero, via values of $\sin^2 2\theta_{13}$.

T2K (Tokai to Kamioka) uses the Super-Kamiokande detector in Kamioka to detect neutrinos produced at the Japan Proton Accelerator Research Complex (J-PARC) situated 295 km away (*CERN Courier* July/August 2008 p19). The new results are from an analysis based on all of the data collected between January 2010 – when the experiment began full operation – and 11 March 2011, when it was interrupted by the enormous earthquake in East Japan. This corresponds to a total of 1.43×10^{20} protons on the neutrino-production target. The collaboration found 88 neutrino events registered in the Super-Kamiokande detector, six of which are clearly identifiable as candidate electron-neutrino events. The expectation would be for 1.5 such events in this data sample if neutrino oscillations do not take place. The observation implies the appearance of electron-neutrinos in the experiment, with a probability of 99.3%. At 90% confidence level (CL), the data are consistent with $0.03 < \sin^2 2\theta_{13} < 0.28$.

The MINOS (Main Injector Neutrino Oscillation Search) in the US sends a muon-neutrino beam 735 km through the Earth from the Main Injector accelerator at Fermilab to a 5000-tonne detector in the Soudan Underground Laboratory in northern Minnesota. In the recently announced analysis, based on 8×10^{20} protons on target, the collaboration found a total of 62 electron neutrino-like events. Only 48 events would be expected if muon-neutrinos do not transform into electron neutrinos.

Compared with T2K, MINOS uses a different method and a different analysis technique to search for electron-neutrino appearance. The MINOS collaboration extracts $2\sin^2\theta_{23}\sin^2 2\theta_{13}$, and finds that it is less than 0.12 at 90% CL, with a best fit of $2\sin^2\theta_{23}\sin^2 2\theta_{13} = 0.04$. This improves on results that the collaboration obtained with smaller data sets in 2009 and 2010. The latest results disfavour $\theta_{13} = 0$ at 89% CL, with a range that is consistent with that measured by T2K.

More work and more data are needed to confirm both these measurements. The T2K experiment collected about 2% of the proposed number of events before the massive earthquake hit in March. Once J-PARC resumes producing muon-neutrinos, which is planned to happen by the end of 2011, the experiment will continue accumulating events. MINOS will continue to collect data until February 2012. In addition, three nuclear-reactor-based neutrino experiments, which use different techniques to measure $\sin^2 2\theta_{13}$, are in the process of starting up.



An event display of one of the six electron-neutrino candidate events recorded by the Super-Kamiokande detector. The coloured circles indicate photomultiplier tubes that were struck by Cherenkov light. (Image credit: T2K.)

The MINOS far detector at the Soudan mine. (Image credit: Fermilab Visual Media Services.)

Further reading

K Abe *et al.* T2K collaboration 2011 *Phys. Rev. Lett.* **107** 041801.
P Adamson *et al.* MINOS collaboration 2011 arXiv:1108.0015v1 [hep-ex].

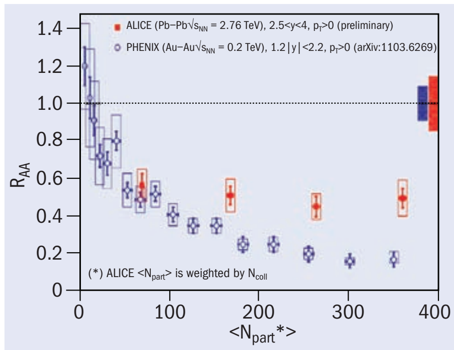
HEAVY IONS

ALICE goes in search of charmonium in the quark–gluon plasma

The ALICE collaboration has measured the nuclear modification (R_{AA}) factor of J/Ψ mesons down to a transverse momentum (p_T) equal to zero, in lead–lead (Pb–Pb) collisions at $\sqrt{s_{NN}}$=2.76 TeV, delivered by the LHC in November 2010. The results, presented at the Quark Matter 2011 conference (p23), hint at the recombination of charm and anticharm quarks in the quark–gluon plasma (QGP) formed in heavy-ion collisions at LHC energies.

The ALICE detector was conceived especially for measurements in heavy-ion collisions and is able to study QGP via comprehensive measurements of hadron abundances and correlations as well as of thermal photons (*CERN Courier* June 2011 p17). At LHC energies, new mechanisms of charmonium production in the QGP could occur. QCD calculations have predicted that a large number of charm quarks, around 50 c-$\bar{c}$ pairs, should be produced per central lead–lead collision at $\sqrt{s_{NN}}$=2.76 TeV. These charm quarks would then coexist with the QGP during its dynamical evolution, like Brownian particles. A number of dynamical transport models predict that c and $\bar{c}$ quarks could then combine in later stages, leading to an enhancement of charmonium production in the most central Pb–Pb collisions.

ALICE detects charmonium down to p_T=0 in two different rapidity domains: |y|<0.9 in the dielectron channel and 2.5<y<4 in the dimuon channel. The detection at low transverse momentum is crucial because the recombination of the charm and anticharm quarks is expected to be the main production mechanism for charmonium at low p_T (p_T<3 GeV/*c*). The different rapidity domains allow for the study of QGP with different charm densities.



Nuclear modification factor for the J/ψ in Pb–Pb collisions at 2.76 TeV as measured by the ALICE collaboration.

In particular, ALICE has studied the nuclear modification factor, R_{AA}, as a function of collision centrality for J/Ψ mesons. R_{AA} is defined as the ratio of the yield measured in nucleus–nucleus (AA) collisions to that expected on the basis of the proton–proton yield scaled by the number of binary nucleon–nucleon collisions in the nucleus–nucleus reaction. The results from ALICE indicate that the J/Ψ R_{AA} factor appears to show little dependence on centrality (see figure), a trend that is different from that observed at lower energies. The factor for central and mid-central collisions is larger at the LHC than was measured at lower centre-of-mass energy in gold–gold collisions in the PHENIX experiment at the Relativistic Heavy Ion Collider, Brookhaven. In complementary studies, the ATLAS and CMS collaborations at the LHC have measured a smaller J/ΨR_{AA} factor at high p_T (p_T>6.5 GeV/*c*).

These observations contrast with expectations from the dissociation of charmonium through the mechanism of colour-screening in the QGP. They hint instead at the recombination of charm and anticharm quarks in the QGP as the main mechanism for J/Ψ production in central Pb–Pb collisions at LHC energies. ALICE's analysis of J/Ψ production as a function of the p_T and rapidity continues and should shed light on the topic soon.

● Further reading

G Martínez García ALICE collaboration QM2011 Proceedings, arXiv:1106.5889v1.

ANTIMATTER

ASACUSA measures antiproton mass with unprecedented accuracy

The Japanese-European ASACUSA experiment at CERN's Antiproton Decelerator (AD) has reported a new measurement of the antiproton's mass, accurate to about one part in a thousand million. This means that the measurement of the antiproton's mass relative to the electron is now almost as accurate as that of the proton.

To make these measurements, the ASACUSA team first traps antiprotons inside antiprotonic helium, in which the negatively charged antiproton takes the place of an electron and occupies a Rydberg state, keeping it relatively far from the nucleus. The antiprotonic helium atoms thus live long enough to allow the frequencies of atomic transitions to be measured by laser spectroscopy. The frequencies depend on the ratio of the antiproton mass to the electron mass and ASACUSA has already used this technique to achieve record precision (*CERN Courier* July/August 2006 p8).

However, an important source of imprecision comes from Doppler broadening of the resonance observed when the laser is tuned to the transition frequency. The atoms move around, so that those moving towards and away from the laser beam experience slightly different frequencies. In the previous measurement in 2006, the ASACUSA team used just one laser beam, and the achievable accuracy was dominated by this effect. This time they have used two beams moving in opposite directions, with the result that the broadening for the two beams partly cancels out.

The resulting narrow spectral lines allowed the team to measure three transition frequencies with fractional precisions of 2.3–5 parts in 10^9. By comparing the results with three-body QED calculations, they find an antiproton-to-electron mass ratio of 1836.1526736(23), where the error (23) represents one standard deviation. This agrees with the proton-to-electron value, which is known to a similar precision.

● Further reading

Hori *et al.* 2011 *Nature* **475** 484.

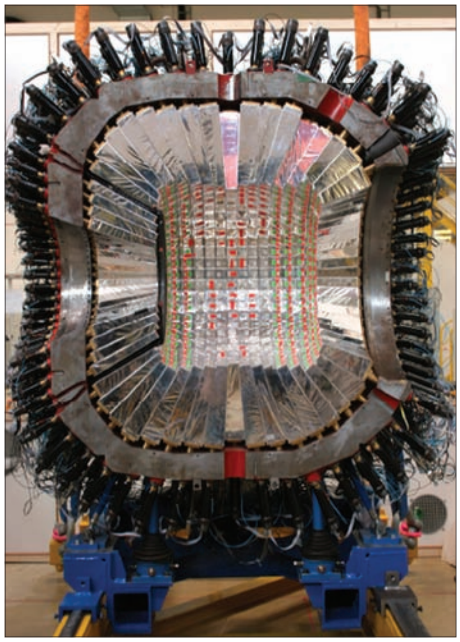
News

New particles

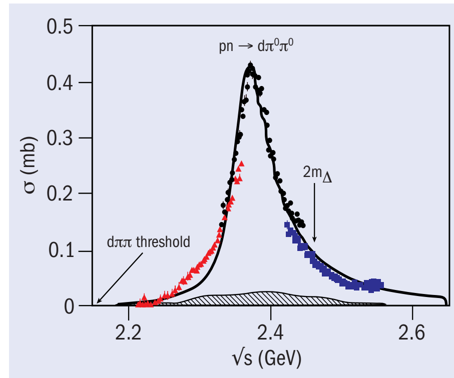
COSY finds evidence for an exotic particle…

Experiments at the Jülich Cooler Synchrotron, COSY, have found evidence for a new complex state in the two-baryon system, with mass 2.37 GeV and width 70 MeV. The structure, containing six valence quarks, could constitute either an exotic compact particle or a hadronic molecule. The result could cast light on the long-standing question of whether there are eigenstates in the two-baryon system other than the deuteron ground-state. This has awaited an answer since Robert Jaffe first envisaged the possible existence of non-trivial six-quark configurations in QCD in 1977.

The new structure has been observed in high-precision measurements carried out by the WASA-at-COSY collaboration, using the Wide-Angle Shower Apparatus (WASA). The data exhibit a narrow isoscalar resonance-like structure in neutron–proton collisions for events where a deuteron is produced together with a pair of neutral pions. From the differential distributions, the spin-parity of the new system is deduced to be $J^P = 3^+$ and its main decay mode is via formation of a ΔΔ system below the nominal threshold of $2m_\Delta$. The collaboration will further test the resonance hypothesis in elastic proton–neutron collisions with a polarized beam; the $J^P = 3^+$ partial waves should be dominated by the new structure, while its contribution to the elastic cross-section should be small.



View into the open central part of the WASA detector. This consists of 1012 CsI(Na) crystals, which surround the superconducting solenoid that contains the mini drift-chamber. The vertical cut-out is for the pellet target system. (Image credit: WASA-at-COSY collaboration, IKP-FZJ.)



Measurement of the energy dependence of the total cross-section for the basic double-pionic fusion reaction to deuterium. The data exhibit a clear resonance-like structure. The solid line shows a fit by a Lorentzian with m = 2.37 GeV and Γ = 68 MeV. The hatched area indicates systematic uncertainties in the measurements.

The resonance structure also turns out to be intimately connected to the so-called ABC effect, in which the two pions produced in a nuclear fusion process are emitted preferentially in parallel. This 50-year-old puzzle, which is named after the initial letters of the surnames of its first observers A Abashian, N E Booth and K M Crowe, could now find its explanation in the way that such a resonance decays.

Further reading

P Adlarson *et al.* 2011 *Phys. Rev. Lett.* **106** 242302.

…while CDF discovers a heavy relative of the neutron

The CDF collaboration at Fermilab has announced the observation of the Ξ_b^0, the latest entry in the periodic table of baryons. Although Fermilab's Tevatron is not a dedicated bottom-quark factory, the sophisticated particle detectors employed there and large integrated luminosity of proton–antiproton collisions delivered to the experiments have made it a haven for discovering and studying almost all of the known bottom baryons. Experiments there discovered the Σ_b baryons in 2006, observed the Ξ_b^- baryon in 2007 and found the Ω_b in 2009. The lightest bottom baryon, the Λ_b, was discovered at CERN.

The complex decay pattern of the neutral Ξ_b^0 has made the observation of this particle significantly more challenging than that of its charged sibling. Combing through an integrated luminosity of 4.2 fb^{-1} of proton–antiproton collisions produced at a centre-of-mass energy of 1.96 TeV, the CDF collaboration isolated 25 examples in which the particles emerging from a collision revealed the distinctive signature of the Ξ_b^0, through its decay to $\Xi_c^+\pi^-$ and the subsequent decay chain. The analysis established the discovery at a level of 6.8 σ and measured the mass of the Ξ_b^0 as 5787.8 ± 5.0(stat) ± 1.3(syst) MeV/c^2.

CDF also observed a similar number of events for the charged Ξ_b, in the decay $\Xi_b^- \to \Xi_c^0\pi^-$, never previously observed; this served as an independent cross-check of the analysis.

Further reading

T Aaltonen *et al.* CDF collaboration 2011 arXiv:1107.4015v1 [hep-ex]. Submitted to *Phys. Rev. Lett.*

Facilities

ELENA prepares a bright future for antimatter research

At its recent session in June, the CERN Council approved the construction of the Extra Low ENergy Antiproton ring (ELENA) – an upgrade of the existing Antiproton Decelerator (AD). ELENA will allow the further deceleration of antiprotons, resulting in an increased number of particles trapped downstream in the experiments. This will give an important boost to antimatter research in the years to come.

The recent successes of the AD experiments are just the latest in a long list of important scientific results with low-energy antiprotons at CERN that started in the 1990s with the Low Energy Antiproton Ring. Over the years, the scientific demand for antiprotons at the AD has continued to grow. There are now four experiments running there (ATRAP, ALPHA, ASACUSA and ACE). A fifth, AEGIS, has been approved and will take beam for the first time at the end of the year; further proposals are also under consideration. The AD is approaching the stage where it can no longer provide the number of antiprotons needed. As antihydrogen studies evolve into antihydrogen spectroscopy and gravitational measurements, the shortage will become even more acute.

The solution is a small ring of magnets that will fit inside the current AD hall – in other words, ELENA, the recently approved upgrade. ELENA will be a 30 m-circumference decelerator that will slow down the 5.3 MeV antiprotons from the AD to an energy of only 100 keV. Receiving slower antiprotons will help the experiments to improve their efficiency in creating antimatter atoms.

Currently, around 99.9% of the antiprotons produced by the AD are lost because of the experiments' use of degrader foils, which are needed to decelerate the particles from the AD ejection energy down to around 5 keV – the energy needed for trapping. ELENA will increase the experiments' efficiency by a factor of 10–100 as well as offer the possibility to accommodate an extra experimental area.

The new ring will be located such that its assembly and commissioning will have a minimal impact on operation of the AD. Indeed, the commissioning of the ELENA ring will take place in parallel with the current research programme, with short periods dedicated to commissioning during the physics run. The layout of the experimental area at the AD will not be significantly modified, but the much lower beam energies involved require the design and construction of completely new electrostatic transfer lines.

The construction of ELENA should begin in 2013 and the first physics injection should follow about three years later. The initial phase of the work will include the installation and commissioning of the ELENA ring while using the existing AD beam lines. The old ejection lines in all of the experimental areas will then be replaced with new electrostatic beam lines that will deliver antiprotons at the design energy of 100 keV. In its final configuration, ELENA will be able to deliver beams almost simultaneously to four experiments, resulting in a vital gain in total beam time.

ILC Global Design Effort publishes milestone report

The International Linear Collider (ILC) Global Design Effort (GDE) has released a major milestone report, *The International Linear Collider: A Technical Progress Report*. As its title suggests, the 162-page report represents the current status of the global R&D that is currently coordinated by the GDE. Coming roughly half way through the ILC Technical Design Phase, it documents the considerable progress that has been made worldwide towards a robust and technically mature design of a 500–1000 GeV electron–positron linear collider. With a stated five-year programme for the technical design phase, the GDE felt it necessary to have a significant mid-term publication milestone that would bridge the gap between the publication of the Reference Design Report (RDR) in 2007 and that of the foreseen Technical Design Report (TDR) in 2012. Because much of the R&D referred to in the report is still ongoing, it necessarily represents a snapshot of the current situation.

The focus of the progress report is on the co-ordinated worldwide "risk-mitigating" R&D that was originally identified at the time of the RDR publication. Although the report is comprehensive in covering nearly all areas of R&D, it has a strong focus on the development of the 1.3 GHz superconducting RF accelerating technology – the heart of the linear collider design. A large fraction of the total resource available has been used to develop the necessary worldwide infrastructure and expert-base in this technology, which includes research into high-gradient superconducting cavities as well as a focus on industrialization and mass-production models for this state-of-the-art technology. A further focus is on the three beam-test facilities: TTF/FLASH at DESY Hamburg, for the superconducting RF linac; the CesrTA facility at Cornell, for damping-ring electron cloud R&D; and ATF/ATF2 at KEK, for final focus optics, instrumentation and beam stabilization. Finally, the report also indicates work towards the ILC TDR baseline design and, in particular, the conventional facilities and siting activities.

The technical progress report will serve as a solid base for the production of the final report on the technical design phase R&D, which will be part of the TDR. Some 350 authors from more than 40 institutes around the globe have contributed to its successful publication. Now attention is already turning to producing the TDR – work that will formally start at the joint ILC-CLIC workshop being held in Granada in September.

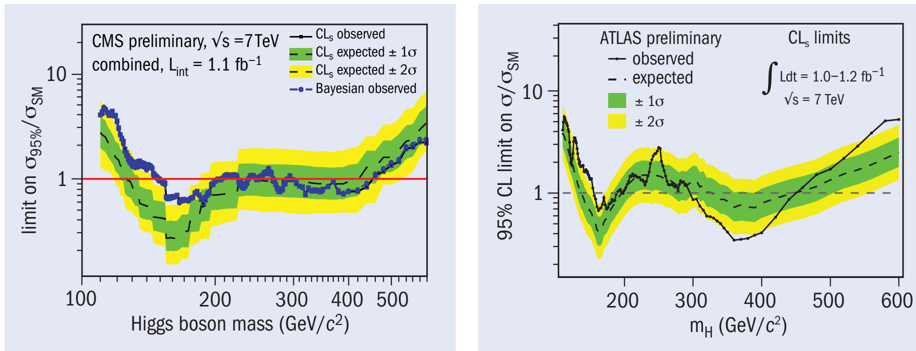
● The report, which is available online at www.linearcollider.org/interim-report, is the first of two volumes; a second volume, to be released soon by the ILC Research Directorate, will focus on the ILC scientific case and on the design of the detectors associated with the collider.

LHC EXPERIMENTS

The LHC homes in on the Higgs

EPS-HEP 2011

In this issue, news from the LHC experiments focuses on a few highlights at the first big summer conference.



Experimental limits from the LHC on Standard Model Higgs production in the mass range 100–600 GeV. The solid curves (labelled CL_s observed) reflect the observed experimental limits, parameterized in units of the theoretically predicted cross-section (vertical axis) for the production of Higgs of each possible mass value (horizontal axis). All mass ranges for which the solid curve dips below the horizontal line at the value of $\sigma_{95\%}/\sigma_{SM} = 1$ are excluded. The dashed curve shows the expected sensitivity to the Higgs boson, based on simulations. The green and yellow bands correspond to the 68% and 95% excursions, respectively, of the expected limits.

The outstanding performance of the LHC enabled the ATLAS and CMS collaborations to report remarkable progress in the hunt for the Higgs boson at EPS-HEP 2011. With an integrated luminosity of more than 1 fb^{-1} each – the original luminosity goal for all of 2011 – the experiments have been able to extend significantly the exclusion region for the Standard Model Higgs boson and to achieve impressive advances in extending sensitivity in other mass ranges.

In the Standard Model, the Higgs boson endows other particles and itself with mass. At the same time, the dominant decay mode of the Higgs depends on the value of its mass. Consequently, a comprehensive search for the Higgs must look in numerous decay modes.

At the conference, each collaboration reported results on several possible Higgs decay modes. These results were based on the full sample of data recorded by the end of June; the ability to search for so many decay modes so promptly reflected the efficiency of the experiments and the dedication of the collaborations. The most generally promising decay modes, such as $H\rightarrow\gamma\gamma$, $H\rightarrow W^+W^-$, and $H\rightarrow Z^0Z^0$, were well covered by both experiments, while early results on $H\rightarrow\tau^+\tau^-$ from CMS and on $H\rightarrow b\bar{b}$ from ATLAS were also produced. In each experiment the results of these searches can be combined to optimize sensitivity across the range of possible Higgs boson masses.

The CMS and ATLAS Higgs limits presented at the conference are summarized by the solid curves in the two figures. These plots show the result of combining the limits from all of the analysed decay modes in each experiment in terms of the range of possible Standard Model Higgs mass that can be excluded with 95% confidence.

The two experiments presented similar exclusion ranges. They have now excluded mass ranges for the Higgs boson from 150 to 200 GeV and 300 to 450 GeV; they have also established expected limits within 50% of the Standard Model prediction for the region in between. Moreover, they are homing in on both the low mass region (around 115–150 GeV), which is preferred by electroweak measurements, and the high mass region above about 450 GeV. Throughout these regions, the experiments have already achieved sensitivities, reflected by the dashed curves, within a factor of 2–3 of the Standard Model cross-section.

While it is still early in the hunt for the Higgs, but the ATLAS and CMS data also show some excesses that participants at the conference found tantalizing. For instance, both experiments currently see a small excess of candidate events at a mass of roughly 140 GeV. However, given the large range of masses and modes investigated by the two experiments and the as yet limited statistics, the limits observed do sometimes fluctuate from the limits that are expected. In addition, although the two detectors are independent, the results can be somewhat correlated because their background estimates make use of the same theoretical predictions.

Even as the LHC provides the experiments with more data, the painstaking process of combining the limits of the two experiments is currently underway. A combination with the experiments at Fermilab's Tevatron, whose searches are particularly complementary in the low mass region, will also eventually be done.

Will the Higgs boson be discovered soon, or will the Standard Model Higgs boson be excluded as more data are accumulated? The answer at present is "watch this space".

● Further reading

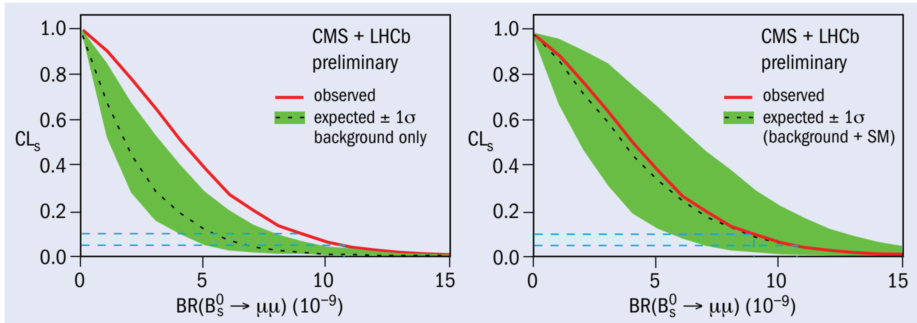
CMS collaboration 2011 CMS-HIG-11-011.
ATLAS collaboration 2011 ATLAS-CONF-2011-112.

CMS and LHCb pull together in search for rare decay

The first major conference since the LHC started to deliver significant luminosities provided the opportunity for the experiments to begin to work together on certain results. CMS and LHCb joined forces in just this way in their search for the decay $B_s\rightarrow\mu^+\mu^-$. This rare decay mode is suppressed in the Standard Model, which predicts a branching ratio of $(3.2\pm0.2)\times10^{-9}$. It has recently gained much attention, with a preliminary measurement from the CDF experiment at Fermilab indicating a possible excess of events over the Standard Model expectation.

Now LHCb and CMS have combined

their results based on 0.34 fb^{-1} and 1.14 fb^{-1} of proton–proton collisions, respectively, at a centre-of-mass energy of 7 TeV. The observed candidates in both experiments are consistent with the expectation from the sum of backgrounds and Standard Model signal. The combination results in an upper limit on the branching ratio for $B_s \to \mu^+\mu^-$ of less than 1.1×10^{-8} at 95% confidence level (CL), which improves on the limits obtained by the separate experiments and represents the best existing limit on this decay. Enhancement of the branching ratio by more than 3.4 times the Standard Model prediction is excluded at 95% CL. However, there remains room for a contribution from new physics, so the experiments will press ahead with this search, as the data flood in from the LHC.

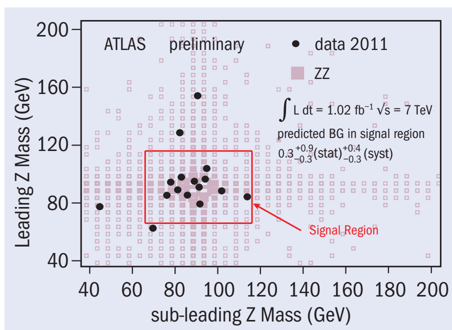


Left: the observed (solid curve) and expected for background-only (dotted curve) CL_s values as a function of the branching ratio for ($B_s^0 \to \mu^+\mu^-$). The green shaded area contains the ±1σ interval of possible results compatible with the expected value, when only background is observed; the 90% and 95% CL observed limits are illustrated by the dashed lines. Right: the same, but adding the Standard Model signal to the background for the calculation of the expected value.

ATLAS takes a closer look at dibosons

A wealth of physics results from ATLAS emerged at EPS-HEP 2011, ranging from detailed measurements of strong and electroweak processes to a spectrum of searches for new physical processes using the full 2011 dataset collected up until the end of June, and comprising up to 1.2 fb^{-1} of analysed data. As with the Higgs searches, constraints on other new processes now probe mass ranges that have substantially increased with respect to 2010 data alone, but no evidence has yet appeared for physics beyond the Standard Model. Several measurements also benefited by including the 2011 data, such as measurements of the cross-section for the production of pairs of top quarks with a precision of 8%, and a more than 7σ observation of electroweak production of single top quarks.

The collected integrated luminosity has now brought processes involving the dibosons WW, WZ and ZZ under the microscope at ATLAS. Diboson production at the LHC is of great interest because it tests the fundamental gauge structure of the Standard Model. The production of the pairs involves boson self-couplings that are precisely predicted by the Standard Model, so any deviation from the expected values would be an indication of new physics.



The masses of the leading (higher transverse momentum) Z candidate versus the mass of the sub-leading Z candidate in events with two oppositely-charged same-flavour lepton pairs. The solid circles show events observed in ATLAS data, while the prediction from simulation is shown as pink boxes.

Of the three dibosons, the production of ZZ pairs is particularly rare. The Z bosons were observed in ATLAS via their decays to electrons or muons, giving a very clean signature of four isolated leptons with high transverse momentum. Electrons were identified from a cluster in the fine-granularity ATLAS electromagnetic calorimeter, muons from a track in the muon spectrometer, in each case matched to a track measured in the high-precision inner detector. In events with four leptons, pairs of oppositely-charged electrons or muons were combined to form Z candidates.

The figure shows a plot of the mass of one electron or muon pair against the mass of the second pair. The ZZ signal is clearly seen as a cluster of events around the Z boson mass, 91 GeV, for both pairs. ATLAS thus sees 12 events that are consistent with ZZ production, with an expected background of 0.3 events, and measures a cross-section of 8.4^{+27}_{-24} pb compared with the Standard Model prediction of 6.5 pb.

ATLAS has also measured cross-sections for WW and WZ production, again using leptonic final states. All values are in agreement with Standard Model expectations, and the WZ and ZZ measurements have been used to constrain gauge boson self-couplings. These constraints are comparable with, and in some cases tighter than, those from measurements at the Large Electron–Positron collider at CERN and at Fermilab's Tevatron.

● Further reading

ATLAS collaboration 2011 ATLAS-CONF-2011-099 (WZ).
ATLAS collaboration 2011 ATLAS-CONF-2011-107 (ZZ).
ATLAS collaboration 2011 ATLAS-CONF-2011-110 (WW).

CMS in search of new physics

The CMS collaboration contributed more than 30 new or updated physics analyses at EPS-HEP 2011. The most eagerly awaited results probably concerned searches for the Higgs boson as well as for new physics beyond the Standard Model. A highly anticipated search is the one for supersymmetry (SUSY), and the corresponding search for the production of new heavy supersymmetry particles. If SUSY exists in nature at the tera-electron-volt scale, it could solve many of the outstanding issues in particle physics, such as the gauge hierarchy problem. It could also deliver a natural candidate particle to explain the high density of dark matter in the universe.

The CMS collaboration released several new analyses at EPS-HEP 2011 on the search for SUSY, based on the full data sample of about 1 fb^{-1} at 7 TeV in the centre-of-mass, collected by the end of June 2011 and analysed in time for the conference. These analyses search for a variety of characteristic event final-state topologies: e.g. events with a large missing transverse momentum plus either only jets, or leptons and jets. Techniques already used to analyse the 2010 data sample, based on 30 times less data, were further refined and used with the 2011 data.

The results are remarkable, testing regions in the parameter space of SUSY theory where the squarks and gluinos (the supersymmetric partners of quarks and gluons) can be as heavy as 1 TeV. Unfortunately there is no sign so far of the production of SUSY particles. With these latest results, CMS has substantially reduced the phase space where SUSY can hide, particularly in the so-called constrained models such as the Constrained Minimal Supersymmetric extension of the Standard Model (CMSSM). Figure 1 illustrates the impressive reach of the CMS analyses with respect to other experiments in the plane of the universal scalar and gaugino masses at the GUT scale (m_0 and $m_{1/2}$, respectively) of the CMSSM.

The collaboration has also released its first paper based on the 2011 dataset of 1 fb^{-1}, namely on the search for very high mass resonances in events that have at least two jets with a large transverse momentum in the final state. Jets are observed in the detectors as sprays of particles ejected from the interaction point in a given direction – that is, the direction of the original parton produced in the hard scattering of the collision, or in the decay of a heavy new particle. Examples of possible heavy new particles that can be

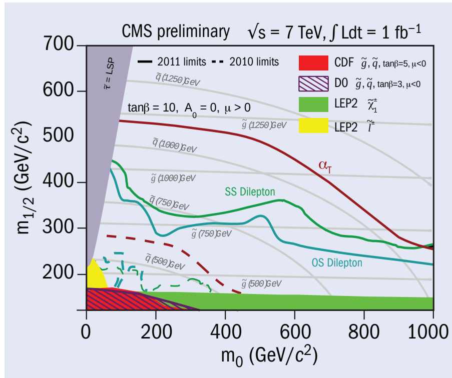


Fig. 1. Results of the search for supersymmetry by CMS: the area below the curves is excluded by the measurements. Results are shown for different analyses. Exclusion limits obtained from previous experiments are presented as filled areas in the plot. Grey lines indicate constant squark and gluino masses.

studied in such di-jet invariant mass analyses are new gauge bosons, graviton resonances, string resonances, and more exotic objects that couple via the strong force, such as axigluons or colour octet states. Each one of these particles is predicted in one or more models for new physics beyond the Standard Model.

CMS has now examined the di-jet mass for mass values up to 4 TeV. No significant sign of di-jet resonances has been found and, as figure 2 shows, various other new particles have now been excluded in the range of 1–4 TeV, depending on the model and particle species.

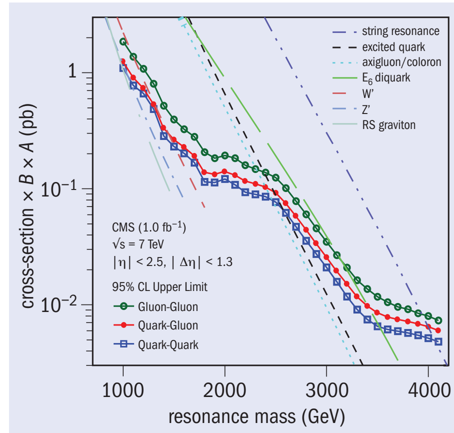


Fig. 2. Results of the search for di-jet resonances by CMS are shown for 95% CL upper limits on the cross-section times acceptance for di-jet resonances produced in gluon–gluon, gluon–quark and quark–quark scattering, compared to predictions of the production for various new particles.

The search for SUSY and other new physics signatures at the LHC is in a very early stage – an important increase in luminosity is expected before the end of 2012. These first data are beginning to disfavour the simplest and more constrained models, but the range of possibilities that need to be explored further is vast. As David Gross said in the concluding remarks at the conference: "Nobody promised it would be easy."

Further reading

CMS-SUS-11-003 and arXiv:1107.4771.

LHCb brings precision to bear on B physics

The LHCb experiment has been designed to focus on B physics, which offers a rich hunting ground for new physics as the large numbers of B hadrons produced at the LHC allow the detailed study of rare processes. Two results presented at EPS-HEP 2011 show how quickly the experiment has been able to access this kind of physics. In one case, LHCb has made the first 5σ observation of a CP asymmetry at the LHC, in the mode $B^0 \to K\pi$; in the other, the collaboration has made the most precise measurement to date of the forward-backward asymmetry of the rare

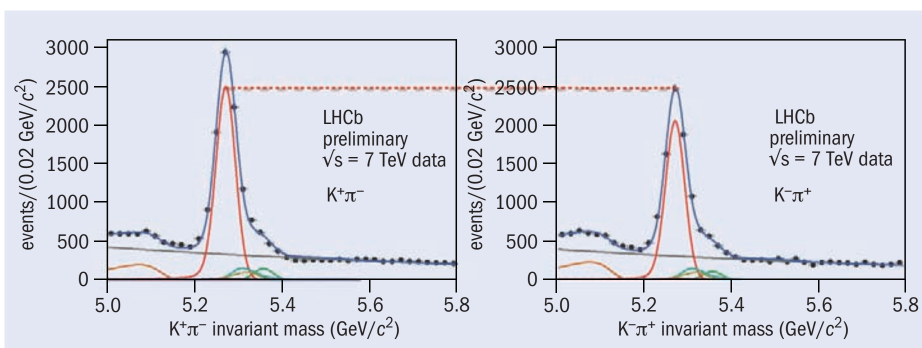


Fig. 1. Invariant mass plots showing signals for $B^0 \to K^+\pi^-$ (left) and $B^0 \to K^-\pi^+$ (right) illustrating the clear asymmetry in the raw rates, corresponding to 5σ CP asymmetry .

decay $B^0 \to K^{*0}\mu^+\mu^-$, which is very sensitive to new physics.

The CP asymmetry for the $B^0 \to K\pi$ decay is defined as $A_{CP}(B^0 \to K\pi) = [\Gamma(\overline{B}^0 \to K^-\pi^+) - \Gamma(B^0 \to K^+\pi^-)] / [\Gamma(\overline{B}^0 \to K^-\pi^+) + \Gamma(B^0 \to K^+\pi^-)]$. As figure 1 shows, the asymmetry is clearly visible in the raw invariant mass distribution measured by LHCb for a data sample corresponding to 320 pb^{-1} of integrated luminosity – i.e. most of the data taken up to the LHC's technical stop in June, just a month prior to the conference. However, to correct for any asymmetry in the production of the B^0 and $\overline{B}^0$ and in the detection of the different final states, the collaboration uses control channels, such as $B^0 \to J/\Psi\, K^{*0}$ and

News: LHC at EPS-HEP 2011

$D^{*+} \rightarrow D^0\pi^+$; they also compare results taken with opposite polarities of the detector's magnetic field. The corrections are typically at the percent level and yield a corrected asymmetry of $A_{CP} = -0.088 \pm 0.011 \pm 0.008$.

This result is a world best, with a significance of more than 5σ, and is in good agreement with the existing world average of $A_{CP}(B^0 \rightarrow K\pi) = -0.098 +0.012-0.011$. It is an important landmark for LHCb. The many CP asymmetries in B decays can be sensitive to physics beyond the Standard Model and form an important part of the physics programme for the experiment.

In a second study, LHCb has observed the decay $B^0 \rightarrow K^{*0}\mu^+\mu^-$. This is a rare mode involving a flavour-changing neutral current; it proceeds via a $b \rightarrow s$ transition through a loop diagram, with a branching ratio of order 10^{-6}. New physics processes can therefore enter at the same level as the Standard Model processes, making the decay a sensitive probe of contributions from new physics. The partial rate as a function of the di-muon invariant mass squared (q^2) and the di-muon forward-backward asymmetry (A_{FB}) can both be affected in many new physics scenarios. Existing measurements of A_{FB} vs q^2, which are shown on the left side of figure 2, have all tended to be rather higher than the expectation from the Standard Model, hinting at possible new physics, although the individual statistical significance is small.

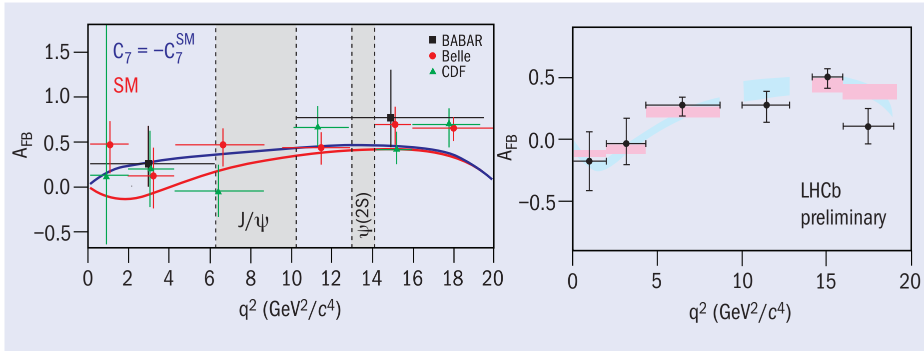


Fig. 2. A_{FB} vs q^2 for the muons from $B^0 \rightarrow K^{*0}\mu^+\mu^-$ decays. Left: for all previous measurements compared to Standard Model (SM) and beyond SM. Right: new result from LHCb, giving the most precise results, consistent with SM prediction (shaded bands).

LHCb has already collected over 300 events for $B^0 \rightarrow K^{*0}\mu^+\mu^-$, with a signal-to-background ratio above three. This is the largest sample of such decays in the world, and is even cleaner than the samples used by the B factories. The right side of figure 2 shows the distribution of A_{FB} vs q^2 for these events, which is in good agreement with the Standard Model expectation (shown by the shaded bands). The collaboration plans to continue to study this channel in finer detail, with measurements that include more angular variables, and expects to achieve high sensitivity to any small deviation from the Standard Model.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Sciencewatch

Compiled by John Swain, Northeastern University

Isotopes reveal dinosaur temperatures

In the debate over whether dinosaurs were cold- or warm-blooded (more correctly, took their temperature from the environment or not) it would be nice if there were some way of finding out what their body temperatures were. Amazingly, it turns out that there is. Robert A Eagle of Caltech and colleagues were able to make use of the fact that ^{13}C and ^{18}O isotopes preferentially bind to each other by an amount that depends on temperature. In particular, the precise amount of such binding in the carbonate in bones depends on the temperature at which they were formed: the higher the temperature, the less this isotopic combination is present.

The researchers find that body temperatures of large Jurassic sauropods must have been 36–38°C – similar to that of modern mammals and some 4–7°C lower than predicted by models based on the scaling of temperature with mass for "cold"-blooded creatures. (They are in fact expected to be rather warm because of their large size and the associated difficulty in getting rid of heat.)

Further reading

Robert A Eagle *et al.* 2011 *Science* **333** 443.

Jurassic sauropods such as Diplodocus *could have had temperatures similar to modern mammals. (Image credit: Mr1805/ Dreamstime.)*

Towards a fountain of youth?

Everyone is gradually getting older, and yet the cells that go into reproduction somehow have to be set to a youthful state to make offspring – no matter how old the parents are. Now, Angelika Amon of Massachusetts Institute of Technology and colleagues have made a remarkable discovery in spores from young and old yeast cells: they both turn out to be free of the protein clumps and DNA fragments that characterize older cells.

A gene, NDT80, is activated during sporulation and, remarkably, if it is turned on in ageing cells then their lifespan doubles. It is early days but the discovery gives food for thought that, one day, researchers may not just slow down ageing but even manage to turn back the clock.

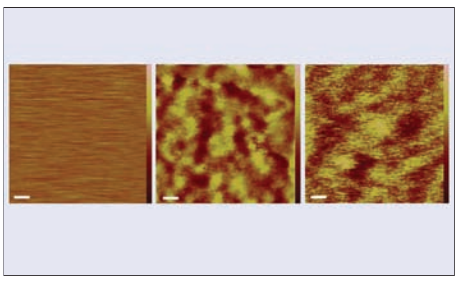
Further reading

E Ünal *et al.* 2011 *Science* vol **332** 1554.

How things charge up

Put two different dielectrics in contact and then pull them apart, and they become oppositely charged, as in the classic example when an ebonite rod is rubbed with cat fur. Despite this being something done in the most elementary of electromagnetism lectures, there is actually very little known about what exactly goes on. Now, H T Baytekin and colleagues of Northwestern University in Illinois have shown that it is much more complicated than one might have thought.

Far from there being nearly uniform charge distributions, each piece of material comes away with a random mosaic of positively and negatively charged nanoscale areas. Although there is a net charge difference, there is far more net charge per unit area than anyone had ever imagined. Exactly what is going on is, at present, far from clear, so there is still much to be learnt – even in this seemingly simple phenomenon.



These potential maps show the mosaic result of contact electrification. The map at the left corresponds to a 4.5 μm square of dielectric material before contact electrification. The others show surfaces after contact-charging in two different ways; both feature a mosaic of + (light) and – (dark) regions.

Further reading

H T Baytekin *et al.* 2011 *Science* **333** 308.

Metamaterials for wireless power

Metamaterials have found many kinds of low-power applications for exotic devices, such as superlenses and invisibility cloaks, but it seems that they might be of help at the scale of many watts in removing the last cable from the ubiquitous laptop. Bingnan Wang of Mitsubishi Electric Research Laboratories in Cambridge, Massachusetts, and colleagues have shown that a panel constructed of metamaterial can vastly improve the coupling between resonators for wireless power transfer.

Powering a 40 W bulb from half a metre away, while putting a metamaterial grid of copper spirals between the source and receiver, boosted the efficiency of power transfer from 17% to 47%. This could represent a big step in finally having truly wireless (even for the power) consumer electronics.

Further reading

Bingnan Wang *et al.* 2011 Appl. *Phys. Lett.* **98** 254101.

Making a new genetic code

The use of genetically engineered organisms to produce proteins has so far been limited by the need to work within the standard genetic code (based on triples of letters C, T, A and G) found in nature. However, Farren Isaacs of Yale University and colleagues have found a way to rewrite it as they please.

Each three-letter combination of TAG or TAA represents "stop", with the others coding for amino acids. By replacing all of the TAG stop codons in *E. coli* bacteria with TAA, they effectively freed up the TAG combination to be able to code for another amino acid. This opens up the possibility of engineering organisms that make proteins never before seen. These new organisms would act like alien life forms – immune to existing viruses and unable to mix their DNA with other organisms.

Further reading

Farren J Isaacs *et al.* 2011 *Science* **333** 348.

Astrowatch

COMPILED BY MARC TÜRLER, ISDC AND OBSERVATORY OF THE UNIVERSITY OF GENEVA

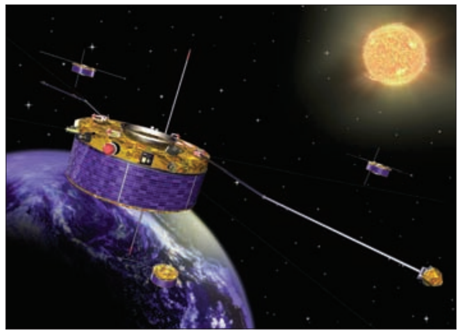
Cluster satellites observe plasma jets *in situ*

While astrophysical jets are often powered by black holes, high-speed plasma flows are also ejected by solar flares and can even arise in the Earth's magnetosphere. The four Cluster spacecraft have been lucky to observe one of the latter events from inside the plasma flow and witness jet-braking and plasma-heating processes.

The story of the Cluster mission to study the Earth's magnetosphere and its environment in three dimensions is long and tumultuous. First proposed to the European Space Agency (ESA) in November 1982, the four identical satellites, to be flown in a tetrahedral configuration, should have benefited from a "free" launch on the first test flight of the Ariane-5 rocket. Unfortunately, this flight lasted just 37 s and ended abruptly by breaking up during launch on 4 June 1996. To recover at least part of the 10-year development effort, ESA decided to build one additional Cluster satellite named Phoenix, named after the mythical bird reborn out of its ashes. It soon became apparent that the scientific objectives would not be met by Phoenix alone and that a second Ariane-5 launch would be too expensive. Eventually, in the summer of 2000, all of the obstacles had been overcome and four new Cluster satellites were successfully carried into space, two at a time by Russian Soyuz rockets.

Eleven years after the launch, the Cluster mission is still operating, providing insights into the physical processes involved in the interaction between the solar wind and the magnetosphere of the Earth. These interactions often send electrons and ions to the Earth's magnetic poles, where they hit neutral gas in the atmosphere and produce aurorae. This occurs either by direct entry of solar-wind particles through the polar cusps or by plasma acceleration in the magnetotail during substorms. The magnetotail is located on the night side of the Earth, where the planet's magnetic field is drawn out into a long tail by the solar wind. It hosts in its centre the plasma sheet, a large reservoir of particles with ion temperatures of about 50 million degrees. When magnetic reconnection occurs in the magnetotail, the plasma sheet is energized and jets are created.

On 3 September 2006, the four Cluster satellites happened to fly through the magnetotail at an altitude of roughly a quarter of the Earth–Moon distance, just in time to witness the sudden rearrangement of the magnetic field leading to the explosive release into the plasma of much of the stored magnetic energy. The instruments aboard the four Cluster satellites monitored the flux of energetic particles focused along the magnetic field lines into a jet pointing towards the Earth. These observations and their implications are now published in *Physical Review Letters* by a team from the Swedish Institute of Space Physics, Uppsala, and the Mullard Space Science Laboratory, University College London.



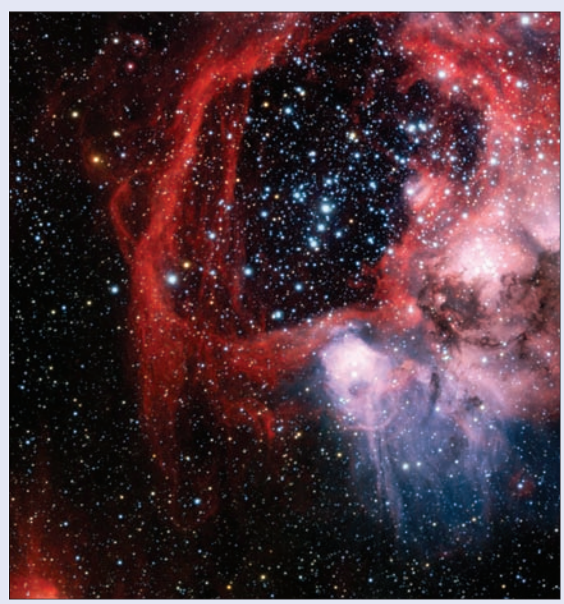
Artist's impression of the Cluster mission consisting of four identical spacecraft flying in formation to study the interaction between the solar wind and Earth's magnetosphere. (Image credit: ESA.)

The data indicate that the original, fairly "cold" jet was subsequently heated by a separate mechanism similar to friction. At first, the flow's interaction with other particles and the enhanced magnetic field closer to Earth caused the front of the jet to slow down. This led to a pile up of the magnetic field in the plasma and to further heating and acceleration of the electrons. The process is called betatron acceleration in reference to the particle accelerators developed in the early 1940s, which used a variable electromagnetic field to accelerate electrons circling in a toroidal vacuum chamber. As Yuri Khotyaintsev, the lead author of the study, points out, this process is likely to occur in other types of astrophysical jets whenever they are interacting with the local environment and braking. So, not only shocks but also the pile-up of the magnetic field at the jet front can result in particle acceleration and heating.

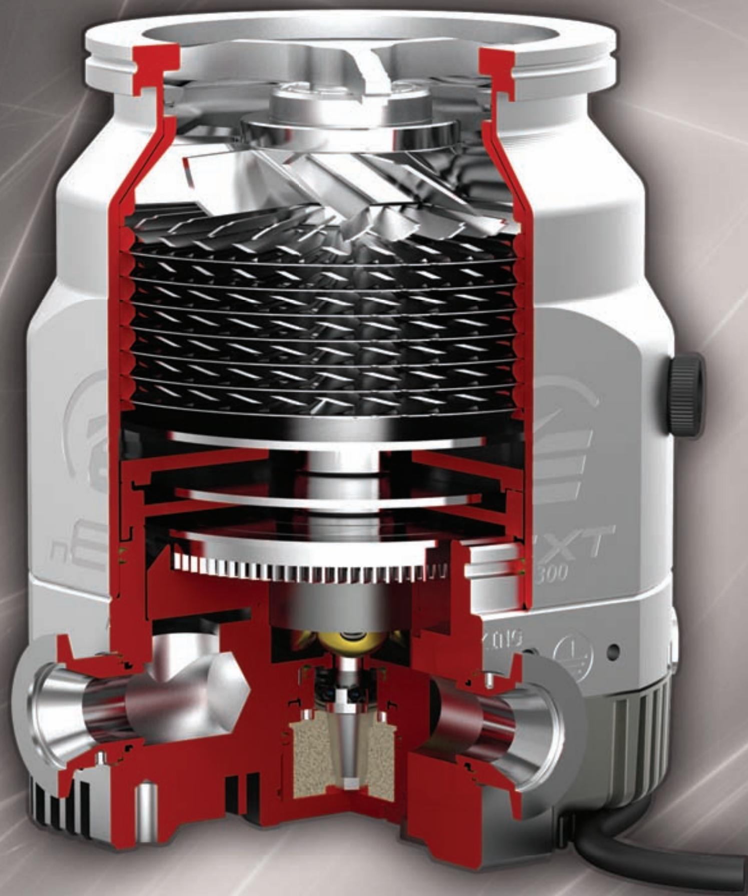
Further reading

Yu V Khotyaintsev *et al.* 2011 *Phys. Rev. Letters* **106** 165001.

Picture of the month



This image by the Very Large Telescope of the European Southern Observatory (ESO) shows a nebula surrounding the star cluster NGC 1929 located in the Large Magellanic Cloud, a satellite galaxy of the Milky Way (*CERN Courier* January/February 2007 p11). The nebula is a colossal superbubble of gas inflated by the combined effect of stellar wind and supernova explosions from the cluster of young stars at its heart. Spanning around 325 by 250 light-years across, it will continue to expand and glow red – a characteristic of ionized hydrogen. The beauty of the nebula was recognized by the amateur astronomer Manu Mejias, from Argentina, who proposed a similar picture for ESO's Hidden Treasures 2010 astrophotography competition (*CERN Courier* March 2011 p10). (Image credit: ESO/Manu Mejias.)



CERN Courier Archive: 1968

A look back to CERN Courier vol. 8, September 1968, compiled by Peggie Rimmer

CERN

The Central Library and its ‘satellites’

The CERN Library is part of the Scientific Information Service, under Dr. A Günther, which is part of the Data Handling Division. The most intensive use of the service is, of course, made in high-energy physics and accelerator technology. Here, the Library aim is clear: to collect everything available. In more marginal fields (for example medium- and low-energy physics, electronics, computers, etc.), the proportion of literature collected is smaller, depending on the subject, and in some areas the emphasis is more on bibliographies, abstract bulletins and the like. In administrative and similar “support” fields, hardly anything is collected without a request from the person interested.

Overall Library policy, and particularly subscriptions to periodicals, is in the hands of a Library Committee, appointed by the Director General, on which all departments of CERN, as well as the library, are represented. The present chairman is Dr. L Kowarski.

The major part of the library collection is housed in the Central Library, close to the Main Auditorium, Council Chamber, etc.; a subsidiary collection, containing many documents on accelerator design and use, is housed in the Proton Synchrotron library. Both reading rooms are open permanently and books and reports are thus available at any time of day or night, weekends included. Since 1965, a small reference collection of important periodicals, conference proceedings and handbooks has been housed in the Track Chambers Division.

Of particular historical interest is the Salle Pauli, near the Council Chamber. This houses the private library of the late Professor Wolfgang Pauli, presented to CERN in 1960. It contains over 700 books and a few periodicals, but the major part of the collection is made up of some 10 500 reprints of papers on physics and mathematics, particularly quantum theory, published during the period 1920–1959.

Part of the collection in the Central Library.

The present library catalogue exists in the form of two identical collections of cards (one kept in the Central Library, the other in the PS Library), each composed of two separate files: the Alphabetic Catalogue and the Subject Catalogue.

Although much of the work in cataloguing is routine copying and sorting, the necessity for strict accuracy means that it has to be checked by people with full library training. With the continued growth in the number of documents to be handled, the prospect of a third card catalogue in some future satellite library is daunting indeed.

Copying and sorting, however, are ideal tasks for a computer. A logical answer to the problem was thus seen to be the use of CERN’s administrative computer (IBM 360/30). Briefly, the idea is to put the basic bibliographical information for all documents into a standard, computer-readable form. Once the error-free main entries are stored, lists, indexes, etc., can be produced in various formats automatically, with little or no further checking.

One of the most attractive and challenging aspects of a computerized cataloguing system is the opportunity for future development, not only within CERN but also in a wider field, as easier methods of “communicating” with computers are being developed. The exchange of catalogue files on magnetic tape is already quite common between libraries. The printing of many scientific periodicals by computer could lead to the automatic provision of standardized catalogue entries on magnetic tape.

● Compiled from texts on pp215–219.

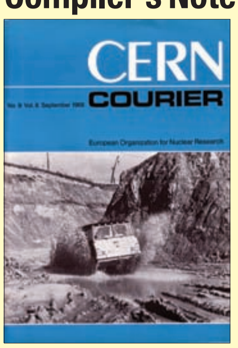
Quadrupole success

On 22 August, first tests were carried out on a completed pole of the superconducting quadrupole being built for CERN at the Oxford Instrument Company, UK, using niobium-titanium composite superconductor produced by Imperial Metal Industries. A full-scale copper-wound pole produced at CERN had been sent to Oxford to be used as a model in the winding of the first pole, and a current of 1000 A was passed through the completed coil without difficulty and without any quenching, indicating that the design specifications of 825 A for the quadrupole will be easily exceeded.

● Compiled from texts on pp204–205.

A full-scale copper-wound model of a pole produced at CERN to develop the coil-winding technique.

Compiler’s Note



Apart from the archival Salle Pauli, CERN’s popular satellite libraries are no more; the “LHC library” in Building 30 was the last to close in 2010. Thanks to electronic publishing and “World Wide Webbing”, the only papers accumulated by the library these days are glossy browsables, such as *Science*, *Nature* and, of course, the *CERN Courier*.

As for computerized cataloguing, the latest, state-of-the-art digital-library system, INSPIRE, was released in October 2010. Produced jointly by specialists from DESY, Fermilab, CERN and SLAC, it provides “readers” with advanced tools to find and assess the most relevant literature in high-energy physics (*CERN Courier* April 2010 p19). And so the venerable CERN card collection has been laid to rest, in an impressive oak and brass filing cabinet; to paraphrase Hamlet, we shall not look upon its like again.

Heavy ions in Annecy

The first results in a new energy region at the LHC were the undoubted star attractions at Quark Matter 2011. Yves Schutz and Urs Wiedemann report on just a few of the highlights from the 22nd International Conference on Ultra-Relativisitic Heavy-Ion Collisions.

Since the early 1980s, the Quark Matter conferences have been the most important venue for showing new results in the field of high-energy heavy-ion collisions. The 22nd in the series, Quark Matter 2011, took place in Annecy on 22–29 May and attracted a record 800 participants. Scheduled originally for 2010, it had been postponed to take place six months after the start of the LHC heavy-ion programme. It was hence – after Nordkirchen in 1987 and Stony Brook in 2001 – the third Quark Matter conference to feature results from a new accelerator.

The natural focus of the conference was on the first results from the approximately 10^8 lead–lead (Pb+Pb) collisions that each of the three experiments – ALICE, ATLAS and CMS –participating in the LHC heavy-ion programme have recorded at the current maximum centre-of-mass energy of 2.76 TeV per equivalent nucleon-nucleon collision. In addition, the latest results from the PHENIX and STAR experiments at Brookhaven's Relativistic Heavy Ion Collider (RHIC) and its recent beam energy-scan programme featured prominently, as well as data from the Super Proton Synchrotron (SPS) experiments. The conference aimed at a synthesis in the understanding of heavy-ion data over two orders of magnitude in centre-of-mass energy.

The meeting also covered a range of theoretical highlights in heavy-ion phenomenology and field theory at finite temperature and/or density. And although, as one speaker put it, the wealth of first LHC data contributed much to the spirit that "the future is now", there were sessions on future projects, including the programme of the approved experiment NA61/SHINE at the SPS, plans for upgrades to RHIC, experiments at the Facility for Antiproton and Ion Research under construction in Darmstadt, a plan for a heavy-ion programme at the Nuclotron-based Ion Collider facility in Dubna, as well as detailed studies for an electron–ion programme at a future electron–proton/electron–ion collider, e-RHIC, at Brookhaven, or LHeC at CERN.

Following a long-standing tradition, the conference was preceded by a "student day" featuring a set of introductory lectures catering for the particular needs of graduate students and young postdocs, who represented a third of the conference participants. The official conference inauguration was held on the morning of 22 May in the theatre at Annecy, the Centre Bonlieu, with welcome speeches from CERN's director-general, Rolf Heuer, the director of the Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Jacques Martino, and the president of the French National Assembly, Bernard Accoyer. The same morning session featured an LHC status report by Steve Myers of CERN and a theoretical overview by Krishna Rajagopal of Massachusetts Institute of Technology.

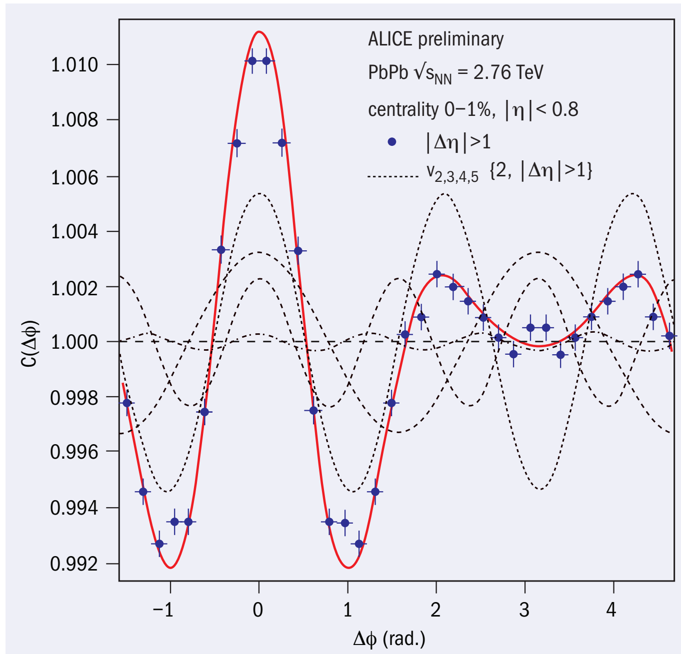


Fig.1. The Annecy spectrum of harmonic flow coefficients. The azimuthal distribution of particles in Pb–Pb collisions at the LHC expanded in terms of flow harmonics v_n.

The conference aimed at a synthesis in the understanding of heavy-ion data over two orders of magnitude in centre-of-mass energy.

Quark Matter 2011 also continued the tradition of scheduling summary talks of all of the major experiments in the introductory session. When the 800 participants walked in for a late lunch on the first day from the Centre Bonlieu along the Lake of Annecy ▷

Quark Matter 2011

to the Imperial Palace business centre, the site of the parallel sessions in the afternoon, they had listened to experimental summaries by Jurgen Schukraft for ALICE, Bolek Wyslouch for CMS, Peter Steinberg for ATLAS, Hiroshi Masui for STAR and Stefan Bathe for PHENIX. These 25-minute previews set the scene for the detailed discussions of the entire week.

This short report cannot summarize all of the interesting experimental and theoretical developments but it illustrates the breadth of the discussion with a few of the many highlights. Examples from three particular areas must therefore suffice to illustrate the richness of the new results and their implications.

The importance of flow

Heavy-ion collisions at all centre-of-mass energies have long been known to display remarkable features of collectivity. In particular, in semicentral heavy-ion collisions at ultra-relativistic energies, approximately twice as many hadrons above $p_T = 2$ GeV are produced parallel to the reaction plane rather than orthogonal to it, giving rise to a characteristic second harmonic v_2 in the azimuthal distribution of particle production. Only a month after the end of the first LHC heavy-ion run, the ALICE collaboration announced in December 2010 that this elliptic flow, v_2, persists unattenuated from RHIC to LHC energies (*CERN Courier* April 2011 p7) The bulk of the up to 1600 charged hadrons produced per unit rapidity in a central Pb–Pb collision at the LHC seems to emerge from the same flow field (*CERN Courier* June 2011 p17). Moreover, the strength of this flow field at RHIC and at the LHC is consistent with predictions from fluid-dynamic simulations, in which it emerges from a partonic state of matter with negligible dissipative properties. Indeed, one of the main motivations for a detailed flow phenomenology at RHIC and at the LHC is that flow measurements constrain dissipative QCD transport coefficients that are accessible to first-principle calculations in quantum field theory, thus providing one of the most robust links between fundamental properties of hot QCD matter and heavy-ion phenomenology.

Quark Matter 2011 marks a revolution in the dynamical understanding of flow phenomena in heavy-ion collisions. Until recently, flow phenomenology was based on a simplified event-averaged picture according to which a finite impact parameter collision defines an almond-shaped nuclear overlap region; the collective dynamics then translates the initial spatial asymmetries of this event-averaged overlap into the azimuthal asymmetries of the measured particle-momentum spectra. As a consequence, the symmetries of measured momentum distributions were assumed to reflect the symmetries of event-averaged initial conditions. However, over the past year it has become clear – in an intense interplay of theory and experiment – that there are significant fluctuations in the sampling of the almond-shaped nuclear overlap region on an event-by-event basis. The eventwise propagation of these fluctuations to the final hadron spectra results in characteristic odd flow harmonics, v_1, v_3, v_5, which would be forbidden by the symmetries of an event-averaged spatial distribution at mid-rapidity.

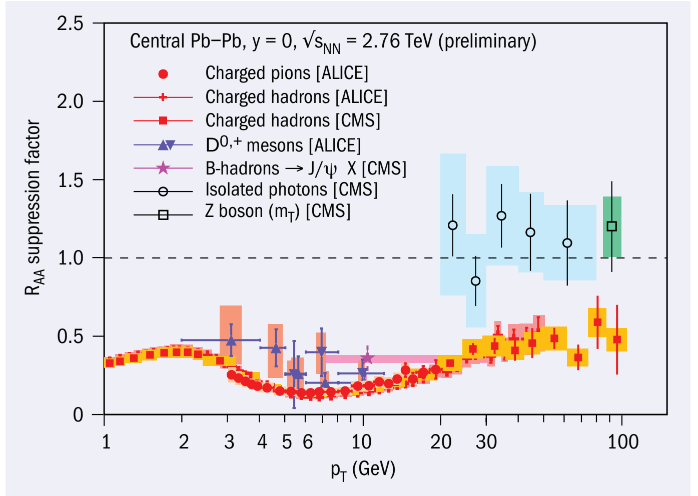


Fig. 2. Nuclear modification factor for various particle species showing the medium-induced suppression of hadrons and the absence of suppression for particles (photons and Z boson) that do not interact with the medium through the strong force. (Figure prepared by David d'Enterria.)

In Annecy, the three LHC experiments and the two at RHIC all showed for the first time flow analyses at mid-rapidity that were not limited to the even flow harmonics v_2 and v_4; in addition, they indicated sizeable values for the odd harmonics that unambiguously characterize initial-state fluctuations (figure 1, p23). This "Annecy spectrum" of flow harmonics was the subject of two lively plenary debates. The discussion showed that there is already an understanding – both qualitatively and on the basis of first model simulations – of how the characteristic dependence on centrality of the relative size of the measured flow coefficients reflects the interplay between event-by-event initial-state fluctuations and event-averaged collective dynamics.

Several participants remarked on the similarity of this picture with modern cosmology, where the mode distribution of fluctuations of the cosmic microwave background also gives access to the material properties of the physical system under study. The counterpart in heavy-ion collisions may be dubbed "$v_n$iscometry". Indeed, since uncertainties in the initial conditions of heavy-ion collisions were the main bottleneck in using data so far for precise determinations of QCD transport coefficients such as viscosity, the measurement of flow coefficients that are linked unambiguously to fluctuations in the initial state has a strong potential to constrain further the understanding of flow phenomena and the properties of hot strongly interacting matter to which they are sensitive.

Quark Matter 2011 also featured major qualitative advances in the understanding of high-momentum transfer processes embedded in hot QCD matter. One of the most important early discoveries of the RHIC heavy-ion programme was that hadronic spectra are generically suppressed at high transverse momentum by up to a factor of 5 in the most central collisions. With the much higher rate of hard processes at the tera-electron-volt scale, the first data from ALICE and CMS have already extended knowledge of this nuclear modification of single inclusive hadron spectra up to p_T = 100 GeV/*c*. In the range below 20 GeV/*c*, these data show a suppression that is slightly stronger but qualitatively consistent with the suppression observed at RHIC. Moreover, the increased accuracy of LHC data allows, for the first time, the identification of a non-vanishing dependence on transverse momentum of the suppression pattern from a factor of around 7 at p_T = 6–7 GeV/*c* to a factor of about 2 at p_T = 100 GeV/*c*, thus adding significant new information.

Another important constraint on understanding high-p_T hadron production in dense QCD matter was established by the CMS collaboration with the first preliminary data on Z-boson production in heavy-ion collisions and on isolated photon production at p_T up to 100 GeV/*c*. In contrast to all of the measured hadron spectra, the rate of these electroweakly interacting probes is unmodified in heavy-ion collisions (figure 2). The combination of these data gives strong support to models of parton energy loss in which the rate of hard partonic processes is equivalent to that in proton–proton collisions but the produced partons lose energy in the surrounding dense medium.

The next challenge in understanding high-momentum transfer processes in heavy-ion collisions is to develop a common dynamical framework for understanding the suppression patterns of single inclusive hadron spectra and the medium-induced modifications of reconstructed jets. Already in November 2010, the ATLAS and CMS collaborations reported that di-jet events in heavy-ion collisions show a strong energy asymmetry, consistent with the picture that one of the recoiling jets contains a much lower energy fraction in its jet conical catchment area as a result of medium-induced out-of-cone radiation (*CERN Courier* January/February 2011 p6 and March 2011 p10). At Quark Matter 2011, CMS followed up on these first jet-quenching measurements by showing the first characteristics of the jet fragmentation pattern. Remarkably, these first findings are consistent with a certain self-similarity, according to which jets whose energy was degraded by the medium go on to fragment in the vacuum in a similar fashion to jets of lower energy.

This was the first Quark Matter conference in which data on the nuclear modification factor were discussed in the same session as data on reconstructed jets. All of the speakers agreed in the plenary debate that there will be much more to come. On the experimental side, advances are expected from the increased statistics of future runs, complementary analyses of the intra-jet structure and spectra for identified particles, as well as from a proton–nucleus run at the LHC, which would allow the dominant jet-quenching effect to be disentangled from possibly confounding phenomena. On the theoretical side, speakers emphasized the need to improve the existing Monte-Carlo tools for jet quenching with the aim of constraining quantitatively how properties of the hot and dense QCD matter produced in heavy-ion collisions are reflected in the modifications of hard processes.

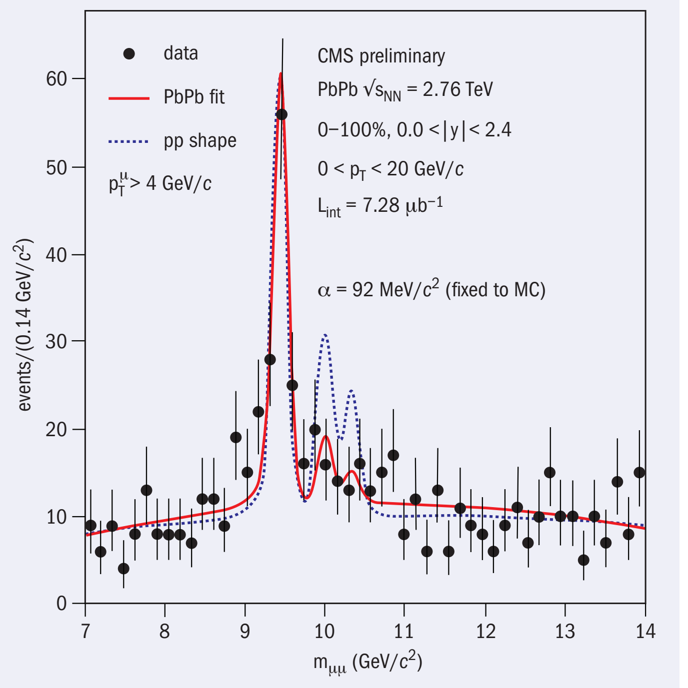


Fig.3. The dimuon invariant mass spectrum in Pb–Pb collisions at the LHC. The preliminary data of the CMS collaboration display a clear signal for the Υ 1s ground state whereas excited states of the Υ family appear to be strongly suppressed compared to the expected yields measured in proton–proton collisions.

Quark Matter 2011 marks a revolution in the dynamical understanding of flow phenomena in heavy-ion collisions.

Another highlight of the conference was provided by the first measurements of bottomonium in heavy-ion collisions, reported by the STAR collaboration for gold–gold (Au–Au) collisions at RHIC and the CMS collaboration for Pb–Pb collisions at the LHC. The charmonium and bottomonium families represent a well defined set of Bohr radii that are commensurate with the typical thermal length scales expected in dense QCD matter. On general grounds, it has long been conjectured that, depending on the temperature of the produced matter, the higher excited states of the quarkonium families should melt while the deeper-bound ground states may survive in the dense medium.

While the theoretical formulation of this picture is complicated by confounding factors related to limited understanding of the quarkonium formation process in the vacuum and possible new medium-specific formation mechanisms via coalescence, the CMS collaboration presented preliminary data of the Υ family that are in qualitative support of this idea (figure 3). In particular, CMS has established within statistical uncertainties the absence of higher excited states of the Υ family in the di-muon invariant mass spectrum, while the Υ 1s ground state is clearly observed. The rate of ▷

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this ground state is reduced by around 40% (suppression factor, R_{AA} = 0.6) in comparison with the yield in proton–proton collisions, consistent with the picture that the feed-down from excited states into this 1s state is stopped in dense QCD matter. STAR also reported a comparable yield. Clearly, this field is now eagerly awaiting LHC operations at higher luminosity to gain a clearer view of the conjectured hierarchy of quarkonium suppression in heavy-ion collisions.

In addition to the scientific programme, Quark Matter 2011 was accompanied by an effort to reach out to the general public. The week before the conference, the well known French science columnist Marie-Odile Monchicourt chaired a public debate between Michel Spiro, president of CERN Council, and Etienne Klein, director of the Laboratoire de Recherches sur les Sciences de la Matière at Saclay and professor of philosophy of science at the Ecole Central de Paris, attracting an audience of around 400 from the Annecy area. During the Quark Matter conference, physicists and the general public attended a performance by actor Alain Carré and the world-famous Annecy-based pianist Francois-René Duchable that merged classical music, literature and artistically transformed pictures from CERN. On another evening, the company Les Salons de Genève performed the play *The Physicists*, by Swiss writer Friedrich Dürrenmatt, in Annecy's theatre. While the conference reached out successfully to the general public, participants encountered some problems in reaching out because the wireless in the conference centre turned out to be dysfunctional. However, the highlights were sufficiently numerous to reduce this to a footnote. As one senior member of the community put it during the conference dinner: "It was definitively the best conference since the invention of the internet."

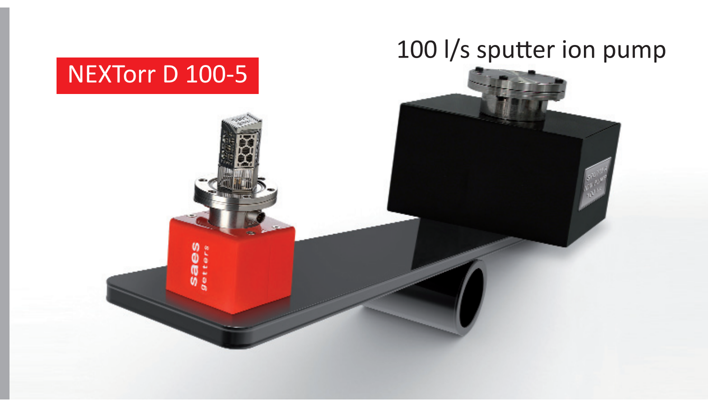
● For the full programme and videos of Quark Matter 2011, see http://qm2011.in2p3.fr.

Résumé

Ions lourds à Annecy

Les premiers résultats des collisions d'ions lourds au LHC ont tenu la vedette à Quark Matter 2011, la 22e édition de la conférence internationale sur les collisions d'ions lourds ultra-relativistes. Les expériences du collisionneur d'ions lourds relativistes (RHIC) de Brookhaven ainsi que les expériences du Supersynchrotron à protons (SPS) y ont également présenté leurs résultats. Le but de la conférence était de faire la synthèse des résultats expérimentaux sur la matière de quarks à haute température et densité obtenus dans les collisions d'ions lourds à des énergies couvrant plus de deux ordres de grandeur. Une large place a également été faite à la discussion des modèles phénoménologiques décrivant ces collisions ainsi qu'à la théorie des champs à température et/ou densité finies.

Yves Schutz, IN2P3/CERN and **Urs Wiedemann**, CERN.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ISOLDE explores the Island of Inversion

A recent experiment at ISOLDE, CERN's radioactive-beam facility, has discovered a long sought-after missing part in understanding a region of exotic nuclei where the traditional shell model fails.

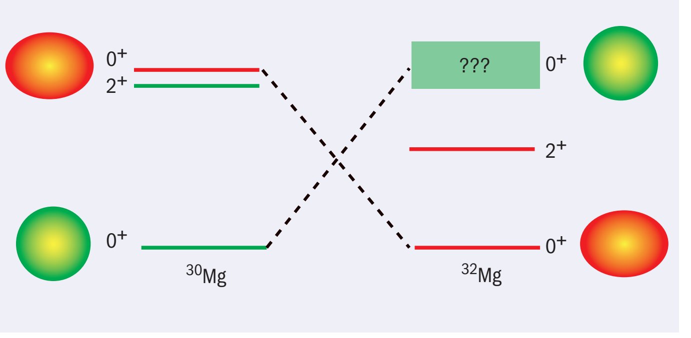

Fig. 1. Partial level scheme of ^{30,32}Mg illustrating the shape coexistence that occurs at the border of the "Island of Inversion" and the new state predicted for ^{32}Mg.

The nuclear shell model, one of the cornerstones in describing nuclear structure, was invented independently by Maria Goeppert-Mayer and Hans Jensen in 1949, who both received the Nobel prize in 1963. In the model, nuclei with "magic" numbers of protons or neutrons exhibit highly symmetric spherical configurations similar to the electron cloud in noble gases or the carbon atoms in C_{60} molecules ("buckyballs"). The traditional "magic" numbers in nuclear physics – 2, 8, 20, 28, 50, 82 (and 126 for neutrons) – are well established for stable nuclei. These emerged from a purely phenomenological approach, but modern nuclear theory can trace the magic numbers down to nucleon–nucleon forces derived from low-energy QCD.

Many current studies of nuclear structure with exotic radioactive nuclei focus on the question of whether these magic numbers persist or are altered in going away from the "valley of stability", where the numbers of protons (Z) and neutrons (N) combine to give the most stable nuclides. Challenging the predictive power of nuclear theory, the aim is to lead the way towards a universal description of nuclear structure. Predictions for nuclei that lie beyond the reach of experiments are also important, for example, for the understanding of nucleosynthesis in exploding stars, at the origin of the chemical elements in the universe.

Such changes have already been observed experimentally in exotic nuclei. For example, the stable isotope ^{16}O (Z=N=8) is an exemplary doubly magic nucleus. However, far from stability, ^{24}O (the oxygen isotope that has the most neutrons while still being bound) behaves in a similar fashion, indicating that locally a new magic number, N=16, appears (*CERN Courier* July/August 2009 px). Other examples are the disappearance of the magic number N=8 in ^{12}Be and evidence for a new magic number, N=34, in ^{54}Ca.

Anomalies in nuclear structure in the region around N=20 have been known of experimentally since 1975, when mass measurements of exotic sodium isotopes at CERN's Proton Synchrotron revealed a tighter binding than expected. This was followed by the discovery in studies of magnesium isotopes that the energy of the first excited state, populated by the decay of sodium, drops from 1482.8 keV in ^{30}Mg to 885.3 keV in ^{32}Mg (N=20) – the opposite of what is expected on approaching a magic number. These features were then attributed to an unexpected onset of deformation, with the nuclei having most likely the shape of a rugby ball rather than being spherical.

Further evidence for this interpretation came from studies of electromagnetic transition strengths and ground-state properties, some of them performed at CERN's world-leading ISotope OnLine separation (ISOL) facility, ISOLDE (*CERN Courier* December 2004 px). In terms of the nuclear shell model, the nucleon–nucleon forces are believed to change the ordering of some single-particle orbitals, sometimes so drastically that orbitals are lowered even across a closed shell (in this case N=20). The neutron-rich nuclei in the N=20 region, whose ground-state configuration includes valence neutrons that occupy such "intruder" orbitals, form what is known as the "Island of Inversion".

Shape coexistence

In ^{30}Mg (N=18), all of the experimental and theoretical work points to the coexistence of a spherical ground state with spin (J) and parity (P), $J^P = 0^+$, together with a deformed excited 0^+ state at 1788.2 keV, which has a wave function with a strong intruder contribution. The latter has been identified at ISOLDE by measuring the conversion electrons of the characteristic electric monopole (E0) transition between the two 0^+ states, as in this particular case the emission of a gamma ray is forbidden because of angular momentum conservation. In ^{32}Mg – in agreement with theory ▷

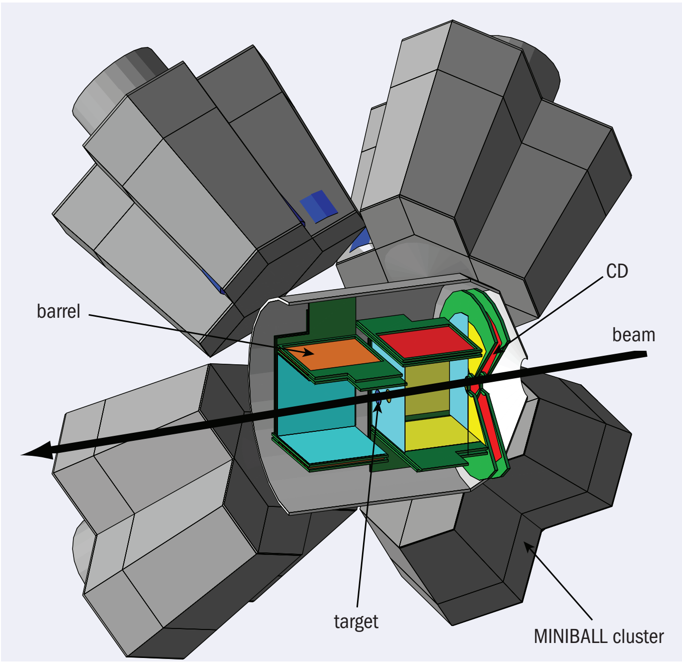

Fig. 2a. Schematic of half of the MINIBALL high-purity germanium spectrometer with T-REX (CD and barrel) inside. (Image credit: K Wimmer.)

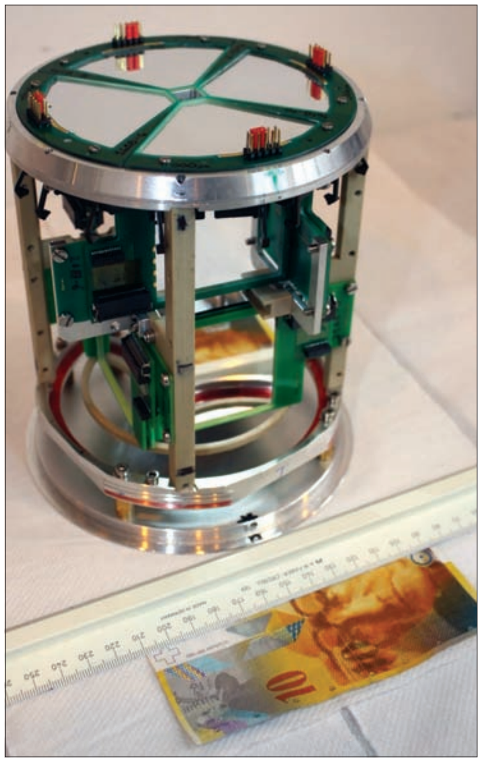

Fig. 2b. The T-REX silicon detector set-up, which fits inside MINIBALL as shown in figure 2a . (Image credit: Janne Pakarinen/ ISOLDE.)

– all of the data indicate that inversion has taken place so that the energetically favoured intruder configuration dominates the deformed ground state. Consequently, a near-spherical excited 0^+ state, the analogue of the ground state in ^{30}Mg, is expected, as illustrated in figure 1 (p29). Despite numerous attempts, however, this state has never been observed experimentally – until now.

An experiment led by the Technische Universität München and the Katholieke Universiteit Leuven and involving 39 experimenters from 14 institutes in 9 countries has at last discovered the excited 0^+ state in ^{32}Mg (Wimmer *et al*. 2010). The experiment was performed in October 2008 at ISOLDE, where fundamental and applied research with radioactive ions is performed at CERN. Operating since 1967, ISOLDE has produced more than 700 isotopes of almost 70 elements as low-energy beams (60 keV). Starting in 2001, nearly 80 isotopes of elements from lithium to radium have been post-accelerated by the Radioactive Beam Experiment (REX) to energies up to 3 MeV/*u*, enabling the study of nuclear-reactions (*CERN Courier* December 2005 p31) .

The key idea was that the addition of two neutrons to the spherical ground state of ^{30}Mg should populate either the deformed ground state of ^{32}Mg or the spherical excited 0^+ state, depending on which orbital the additional neutrons occupy. Experimentally, this was achieved by a two-neutron transfer reaction in inverse kinematics. A beam of ^{30}Mg impinged on a tritium (t) target from which the two neutrons were transferred to form a ^{32}Mg nucleus in a (t,p) reaction.

The radioactive ^{30}Mg ($T_{1/2}$ = 335 ms) was produced by the 1.4 GeV proton beam from the PS Booster impinging on a thick, uranium carbide production target. The magnesium atoms were selectively ionized by the Resonant Ionisation Laser Ion Source and the singly charged ions were mass-separated to obtain a pure ^{30}Mg beam. The energy of the ions was then boosted by the REX-ISOLDE facility to 1.83 MeV/*u*, with a final intensity of around 10^4 particles a second.

The experimental set-up consisted of MINIBALL – a high-resolution gamma-ray spectrometer with 24 segmented high-purity germanium detectors – in combination with the newly built Transfer reactions at REX (T-REX) array, which is the key detector for this experiment. T-REX is a 4π array with 58% coverage in solid angle. It consists of a box-like "barrel" of quadratic silicon-strip detectors together with an annular double-sided segmented silicon-strip detector, the "CD"; in both cases there are two layers of silicon detectors (figure 2). Energy and position are measured for charged, target-like particles – protons, deuterons and tritons; these are identified by measuring the energy loss in a thin detector, which is characteristic for a species at a given energy, and the remaining kinetic energy in a thick detector that stops the particles (the ΔE–E method). The compact set-up was housed in a cylindrical vacuum chamber with a diameter of 12 cm to fit inside MINIBALL.

One challenge was to make a thin tritium target, small enough to fit in the centre of T-REX.

One of the experimental challenges was to make a thin radioactive tritium target, small enough to fit in the centre of T-REX. The technical solution was found in the form of a tritium-loaded titanium foil. The measured energies and angles of the protons emitted from the (t,p) reaction enabled the reconstruction of the excitation energy of the ^{32}Mg nucleus. The angular distributions of

Nuclear physics

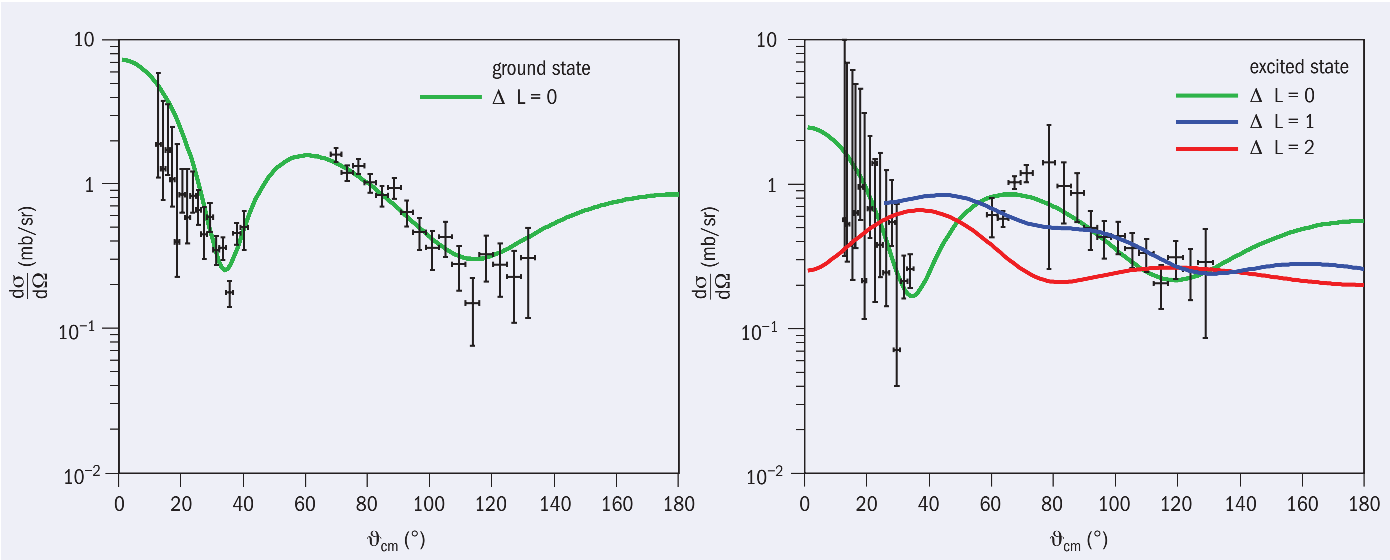

Fig. 3. Angular distributions of the protons emitted from the (t, p) reaction populating the ground state (left) or an excited state at 1058 keV (right) in ^{32}Mg. The experimental data are compared with distorted-wave Born-approximation (DWBA) calculations assuming different values of orbital angular momentum transfer, ΔL (coloured lines).

the protons allowed for the determination of the transferred orbital angular momentum ΔL, from which the spins and parities of the populated states could be deduced (figure 3).

The shape of the measured angular distribution is characteristic for ΔL=0 and firmly establishes the 0^+ assignment for the excited state, just as for the ground state (figure 3). An excitation energy of 1058 keV and a lower limit for its lifetime of 10 ns have been deduced. The population cross-sections for both states and results from recent knockout reactions contribute to a consistent picture of a deformed ground state and a spherical excited 0^+ state.

Such a low-lying – lower than predicted by any calculation – and long-lived 0^+ state poses a challenge to modern theory. An experimental challenge also remains: to determine the lifetime of the excited state as well as the strength of the E0 transition between the two 0^+ states. However, bringing all of the existing pieces of the puzzle together is already enabling a deeper insight into the physics relevant for the formation of the Island of Inversion.

The fascinating phenomenon of different nuclear shapes coexisting at similar energies – the difference is less than 1 per cent of the total binding energy – is also present in other regions of the nuclear chart, the most prominent example being the triple shape coexistence in the neutron-deficient ^{186}Pb isotope. Transfer reactions at REX-ISOLDE are currently limited by the available beam energy to nuclei with mass number A lower than 80, but the upgrade of the facility to HIE-ISOLDE is already on the horizon. This includes an incremental increase of beam energy to 10 MeV/u and will become available in 2015. In particular, at these energies one- and two-nucleon-transfer reactions with heavy radioactive-ion beams will become feasible, opening up a whole new field for studies of single-particle aspects, shape coexistence and the role of pairing interactions. The future of nuclear structure studies with radioactive ion beams at CERN looks bright.

● Further reading

K Wimmer *et al.* 2010 *Phys. Rev. Lett.* **105** 252501.

Résumé

ISOLDE explore "l'île de l'inversion"

Dans le modèle des niveaux du noyau, certains nombres dits "magiques" de protons ou de neutrons correspondent à des états sphériques hautement symétriques. Plusieurs études actuelles impliquant des noyaux exotiques radioactifs cherchent à savoir si ces nombres magiques changent quand les noyaux quittent ces configurations stables. Une expérience sur l'installation de faisceaux radioactifs du CERN, ISOLDE, vient de réaliser une étude sur les noyaux de magnésium riches en neutrons et proches du nombre magique de 20. Les scientifiques ont trouvé une pièce manquante du puzzle, connue sous le nom de "l'île de l'inversion".

Thorsten Kröll, Technische Universität Darmstadt, and **Kathrin Wimmer**, Technische Universität München (now at NSCL, Michigan State University).


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Astroparticle physics

PAMELA's quest for answ

Data from the PAMELA detector, which has orbited Earth for five years, are casting new light on the origin of cosmic rays and other puzzles in modern physics.

PAMELA – the Payload for Antimatter Matter Exploration and Light nuclei Astrophysics – was launched into space on 15 June 2006 aboard a Soyuz rocket from Bajkonur in Kazakhstan. Since then, it has been orbiting the Earth, installed on the upward side of the Resurs-DK1 satellite at a distance that varies between 350 km and 610 km. On board are different types of detector (figure 1) comprising: a magnetic spectrometer, based on a neodymium-iron-boron permanent magnet and a precision tracking system; a sampling imaging calorimeter, in which pairs of orthogonal millistrip silicon sensor planes are interleaved with tungsten absorber plates; a precise time-of-flight system, using plastic scintillation detectors; an anticoincidence system; and a neutron detector (*CERN Courier* October 2002 p24).

The experimental apparatus was designed to provide precise measurements of the particle and nuclei fluxes in the cosmic radiation over a wide energy range. It is sensitive to antiprotons between 80 MeV and 190 GeV, positrons between 50 MeV and 270 GeV, electrons up to 600 GeV, protons up to 1 TeV and nuclei up to a few hundred giga-electron-volts. In addition, in the search for antinuclei PAMELA has a sensitivity of about 10^{-7} in the ratio $\overline{\mathrm{He}}/\mathrm{He}$.

The experiment's scientific objectives are ambitious and aim to clarify some of the trickiest questions of modern physics: the origin of cosmic rays, their energy spectrum, their antimatter components and particles possibly originating in the annihilation of dark matter particles. With data accumulated over several years, the mission, which is scheduled to finish at the end of the year, is now providing new insights into some of these questions and more.

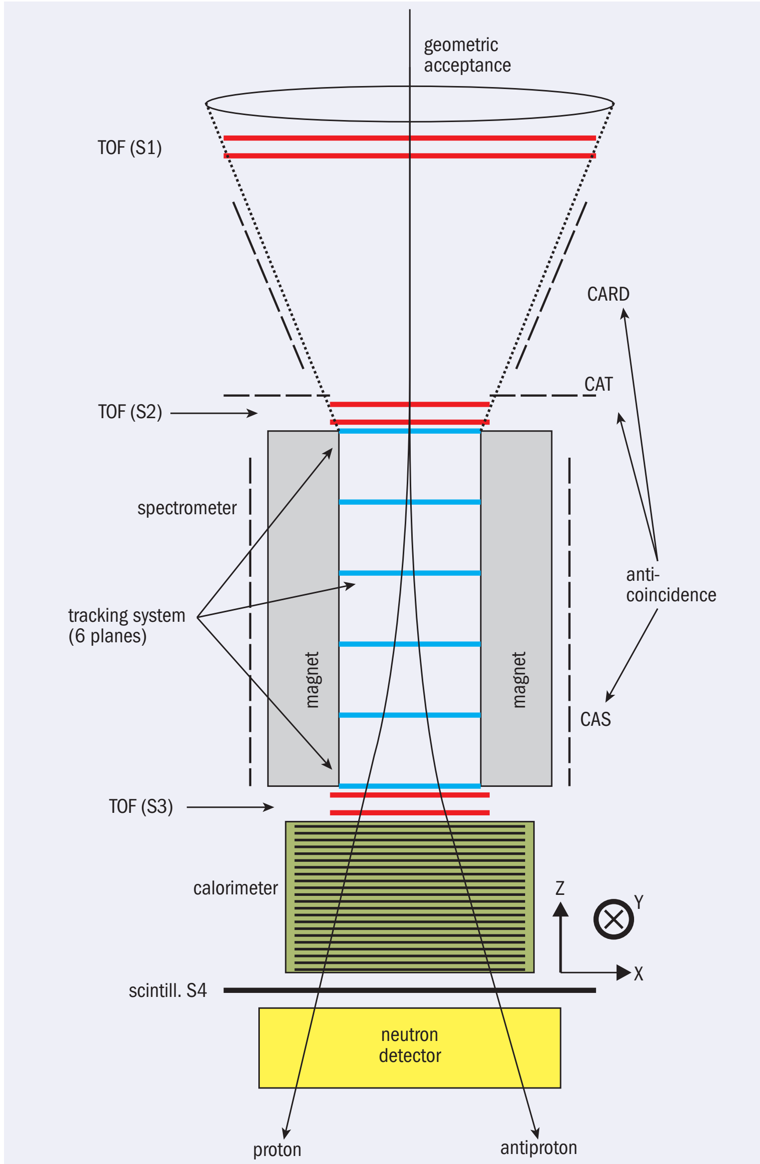


Fig. 1. The PAMELA detector, which is approximately 1.2 m tall. The magnetic spectrometer is complemented with time-of-flight (TOF) and anti-coincidence (CA) counters.

Cosmic revelations

In 2009, the PAMELA collaboration published an anomalous positron abundance in cosmic rays with energies between 1.5 and 100 GeV (*CERN Courier* May 2009 p12). By contrast, as figure 2 shows, the antiproton flux they observe agrees with standard secondary antiproton production in the Galaxy (Adriani *et al.* 2010). These results were followed more recently with the publication of precision measurements of the proton and helium spectra in the rigidity range 1 GV to 1.2 TV (*CERN Courier* April 2011 p6). The proton and helium spectra show different shapes and moreover cannot be described by a single power law, as would be expected from previous observations and from the theoretical models adopted so far. Also, while the spectra of protons and helium gradually soften in the rigidity range 30–230 GV, they both show a hardening at 230–240 GV. Previous experiments did not have the statistical and systematic precision to show this behaviour, although an indirect indication was derived by comparing the results from a range of balloon-borne experiments (JACEE, CREAM and BESS) as well as from the first trial flight of the Alpha Magnetic Spectrometer in 1998.

So far, supernovae have been considered to be the sites of cosmic-ray acceleration. However, the discrepancies found by PAMELA

wers to cosmic questions

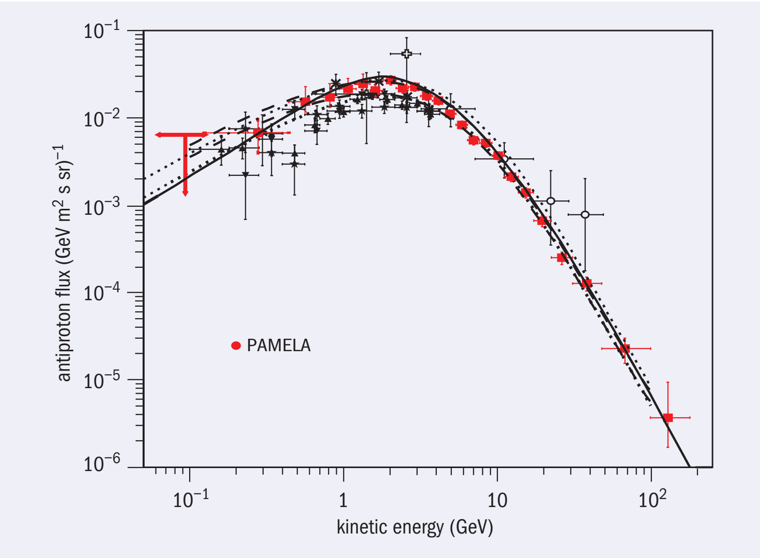


Fig. 2. The antiproton flux observed by PAMELA

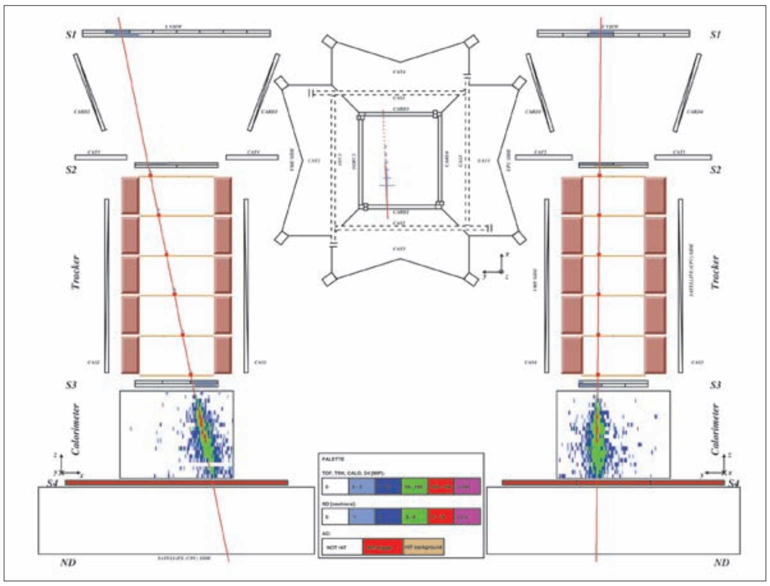


Fig.3. A 57 GeV electron passing through the PAMELA detector, in x and y projections.

in the proton and helium spectra have prompted a re-evaluation of the processes that underlie the acceleration, as well as the propagation of cosmic rays. Similar conclusions were drawn from PAMELA's results on the positron abundance. Theoretical explanations of these data invoke more complex processes of acceleration and propagation, as well as possible contributions from new astrophysical sources, such as pulsars or more exotic ones, such as dark matter.

Conventional diffusive propagation models can, on the other hand, be used to interpret recently published PAMELA data on the electron component of the cosmic radiation (Adriani *et al*. 2011a). Precision measurements of the electron flux provide information regarding the origin and propagation of cosmic rays in the Galaxy that are not accessible through the study of the cosmic-ray nuclear components because of their differing energy-loss processes. PAMELA collected data between July 2006 and January 2010 by selecting electrons in the energy interval 1–625 GeV. This is the largest energy range covered by any cosmic-ray experiment so far, and the first time that electrons above 50 GeV have been identified in cosmic rays.

The collaboration derived the electron spectrum in two independent ways – using either the calorimeter or the tracking information – and the two sets of measurements show good agreement within the statistical errors. Figure 3 shows a typical electron event with a track and energy deposited in the calorimeter. The electron spectrum, although in substantial agreement with the results of other recent experiments, in particular the balloon-bourn Advanced Thin Ionization Calorimeter (ATIC) and the Fermi Gamma-Ray Space Telescope, appears softer than the e^-+e^+ spectra they measure. This difference is within the systematic uncertainties between the various measurements, but it is also consistent with a positron component that increases with energy.

Solar events

PAMELA has also measured solar-particle events and their temporal evolution during the major solar emissions of 13–14 December 2006 (figure 4, p36). This was the first direct measurement by a single instrument of proton and helium nuclei of solar origin in a large energy range between 100 MeV/n and 3 GeV/n (Adriani *et al*. 2011b). The data show a spectral behaviour that is different from those derived from the neutron monitor network, with no satisfactory analytical description fitting the measured spectra. This implies the presence of complex, concurrent acceleration and propagation processes at the Sun and in interplanetary space. Modelling the solar-particle events is also relevant for future manned missions to the Moon and Mars.

Over the past five years, PAMELA has continuously monitored solar activity during an unusually long-lasting solar minimum, followed by – as of the end of December 2009 – a slow increase of activity, probably marking the beginning of the new solar cycle. This particularly favourable situation is providing the collaboration with an excellent opportunity to study heliospheric effects and underlines the major role that the experiment has in providing unique information about the nature of the cosmic rays at the scale of giga-electron-volts in the heliosphere. By combining data from PAMELA and the ULYSSES space mission, the PAMELA collaboration has also performed a new evaluation of the spatial dependence of cosmic-ray intensities in the heliosphere, with an accurate measurement of the radial and longitudinal gradients (De Simone *et al*. 2011).

Many new results from PAMELA were presented recently at ▷

Astroparticle physics

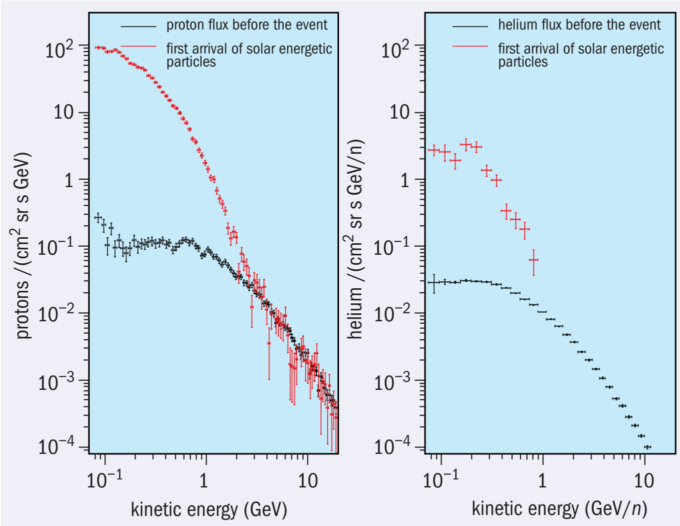


Fig. 4. Proton and helium spectra for a solar flare.

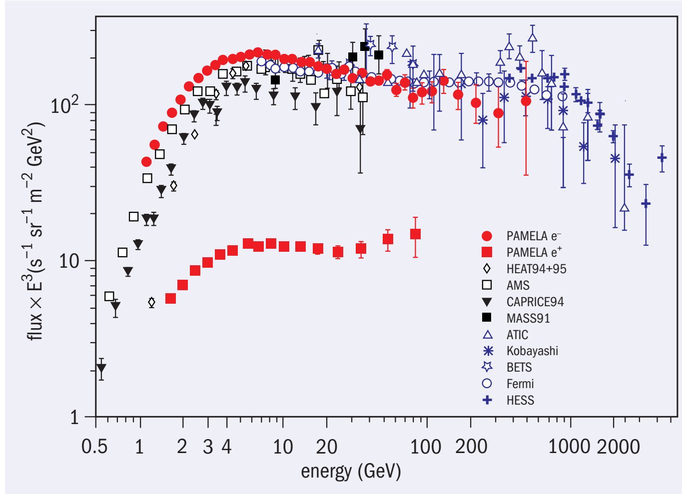


Fig. 5. PAMELA's measurement of the positron spectrum, with the earlier electron spectrum and data from other experiments.

the 2011 European Physical Society Conference on High-Energy Physics in Grenoble on 21–27 July and at the International Cosmic Ray Conference in Beijing on 11–18 August, as well as at other conferences. These results concern mainly new data on the electron/positron ratio, the absolute flux of positrons up to 100 GeV, fluxes and ratios of light nuclei, the abundance of hydrogen and helium isotopes, as well as new limits of the anti-helium to helium ratio. The new results confirm earlier findings and also extend the energy range and precision of the data. One interesting feature concerns the change in slope of the positron flux above 20 GeV, as shown in figure 5, which also includes the electron spectrum. Exclusion limits on the existence of new sorts of matter, such as strangelets, are also in the pipeline The latest interesting PAMELA result concerns the discovery of a radiation belt around the Earth containing trapped antiprotons (Adriani *et al.* 2011c).

The new results confirm earlier findings and also extend the energy range and precision of the data.

Although all the instrumentation aboard PAMELA is working well, the mission is expected to finish at the end of this year. The collaboration will then continue to work for another two years to analyse all of the data collected and improve the statistics.

● PAMELA was constructed by the WiZard collaboration, which was originally formed around Robert Golden, who first observed antiprotons in space. There are now 14 institutions involved. Italian INFN groups in Bari, Florence, Frascati, Naples, Rome Tor Vergata and Trieste, and groups from CNR, Florence and the Moscow Engineering and Physics Institute form the core. They are joined by groups from The Royal Institute of Technology (KTH) in Sweden, Siegen University in Germany and Russian groups from the Lebedev Institute, Moscow, and the Ioffe Institute, St Petersburg.

● Further reading

N De Simone *et al.* 2011 *ASTRA* in press.
O Adriani *et al.* 2010 *Phys. Rev. Lett.* **105** 121101.
O Adriani *et al.* 2011a *Phys. Rev. Lett.* **106** 201101.
O Adriani *et al.* 2011b accepted for publication, *Ap. J.*, arxiv:1107.4519v1 [astro-ph.sr].
O Adriani *et al.* 2011c *Ap. J.* **737** L29.

Résumé

PAMELA en quête de réponses à des questions cosmiques

Le détecteur PAMELA a été mis en orbite en 2006. Il vise à clarifier des questions sur l'origine des rayons cosmiques, leur spectre énergétique et leur composition en antimatière. Les données accumulées jusqu'à présent par la mission, qui s'achèvera fin 2011, apportent un nouvel éclairage sur ces interrogations et d'autres encore. PAMELA a par exemple mesuré des électrons à des niveaux d'énergie très élevés, jamais mesurés auparavant dans le rayonnement cosmique, et étudié les spectres des protons et des noyaux d'hélium d'origine solaire.

Antonella Del Rosso, CERN.

LEAP 2011 casts light on antiproton physics

Physicists gathered at TRIUMF for the recent conference on low-energy antiproton physics to hear the latest news on topics ranging from atoms of antihydrogen to antimatter in the universe.

LEAP 2011 participants gather on TRIUMF's front lawn in Vancouver. (Image credit: Mindy Hapke/TRIUMF.)

Low-energy antiproton physics is an interdisciplinary field that spans particle, nuclear, atomic and applied physics, as well as astrophysics. It confronts directly the relationship between matter and antimatter, in particular CPT symmetry, one of the foundations of the theory of particle physics. CPT is so fundamental that its violation would require a complete rewriting of particle-physics textbooks. Precision studies with antiprotons may also shed light on the question of why the universe is made almost exclusively of matter but not antimatter. Recent months have witnessed dramatic breakthroughs in the field at CERN's Antiproton Decelerator (AD), including the trapping of antihydrogen atoms and developments towards an antihydrogen beam. Satellite and balloon experiments are searching for cosmic antimatter, the results of which could have profound implications on cosmology. Antiprotons are also being used to study the properties and structures of atoms, nuclei and hadrons, for which the start of the Facility for Antiproton and Ion Research (FAIR) in Darmstadt will usher in a new era.

Dialogue across disciplines

It was against this stimulating backdrop that LEAP 2011 – the 10th International Conference on Low Energy Antiproton Physics – took place at TRIUMF in Vancouver on 27 April – 1 May. The conference was organized and supported by the Canadian institutions involved in the ALPHA experiment at the AD (the universities of British Columbia, Calgary, Simon Fraser, York and TRIUMF), with additional support from the Canadian Institute of Nuclear Physics, and was chaired by Makoto Fujiwara of TRIUMF/Calgary, with Mary Alberg of Seattle as co-chair. LEAP 2011 was the first of the series in North America; the conferences have traditionally been held in Europe, with the exception of Yokohama in 2003. It attracted nearly 100 participants and featured more than 60 invited plenary speakers, with an emphasis on promoting young researchers. Several review talks by senior physicists facilitated dialogue across the disciplines. In addition, a dozen posters were presented and presenters were allowed a two-minute talk to advertise their work at a plenary, a format that worked quite effectively. This report presents some of the highlights of a packed programme.

The conference began with a session on antihydrogen physics, with reports on the recent trapping of antihydrogen by the ALPHA experiment and the ASACUSA collaboration's developments towards an antihydrogen beam, both at the AD. The two results were together voted the number one physics breakthrough for 2010 by *Physics World* (*CERN Courier* January/February 2011 p7). Key techniques that enabled ALPHA's trapping of antihydrogen are evaporative cooling and autoresonant excitation of antiproton plasmas. The conference heard how the collaboration's work has led to the successful confinement of antihydrogen for 1000 s (*CERN Courier* July/August 2011 p6). The next major goal for ALPHA is to perform microwave spectroscopy on trapped antihydrogen. ASACUSA also has plans to use microwave spectroscopy to measure ground-state hyperfine splitting with an antihydrogen beam.

The ATRAP collaboration, again at the AD, presented new results on adiabatic cooling of antiprotons, with up to 3×10^6 antiprotons cooled to 3.5 K, and described the first demonstration of centrifugal separation of antiprotons and electrons, suggesting a new method for isolating low-energy antiprotons. The team also has a scheme for improved antihydrogen production via interactions with positronium atoms, created in the interactions of excited caesium atoms with positrons. Other talks described new possibilities for antimatter gravity experiments with antihydrogen at the ▷

Antiprotons

AD: AEGIS, already under preparation, and the proposed Gbar.

Ion traps with single-particle sensitivity are another powerful tool. A team from Heidelberg and Mainz has recently observed a single proton spin-flip, a result that paves the path for the comparison of the magnetic moments of protons and antiprotons. At TRIUMF, an ion trap system, TITAN, is being used at the ISAC facility for precision studies of radioactive nuclei.

Talks on applications and new techniques with antiprotons included the ACE experiment at the AD, which is studying the possible use of antiprotons for cancer therapy, and developments towards spin-polarized antiprotons. The session on atomic physics also covered some novel techniques that have possible applications to antihydrogen. One proposal concerns a new pulsed Sisyphus scheme for (anti)hydrogen laser cooling. Another involves using an atomic coil-gun, which can stop beams of paramagnetic species, to trap hydrogen isotopes, followed by single-photon cooling techniques. A Lyman-α laser for antihydrogen cooling is being developed at Mainz.

The positron, or anti-electron, is the other ingredient in antihydrogen atoms. A review on positron accumulation techniques was given by Clifford Surko of the University of California, San Diego – the inventor of the Surko trap now used by many of the antihydrogen experiments. Studies were reported using variations of the Surko trap by ATRAP and the University of Swansea groups. Measurement of hyperfine splitting in positronium could provide precision tests of QED. One experiment on positronium atoms at the University of Tokyo has made the first direct measurement of this splitting, employing a novel sub-THz source, while another aims at precise measurements via the Zeeman effect.

This year marks the 20th anniversary of the discovery of long-lived antiprotonic helium at KEK. Studies of such exotic atoms and fundamental symmetries are an important part of antiproton physics. ASACUSA has made recent progress on precision studies on antiprotonic helium and on microwave measurements of antiprotonic ^{3}He atoms. Recent but still controversial results on muonic hydrogen spectroscopy at the Paul Scherrer Institute indicate a much smaller size for the proton radius than is generally accepted. Hadronic and radioactive atoms were featured in review talks at the conference, focusing on pionic and kaonic atoms, as well as on the fundamental symmetries programme at TRIUMF. The final results of the TWIST experiment at TRIUMF, a precision measurement of muon decay parameters, have greatly reduced systematic uncertainties, providing improved limits for constraining extensions to the Standard Model.

An important pillar of antiproton physics is hadron and QCD physics at “low energy”, ranging from stopped antiprotons to a beam of 15 GeV. At the lower energy end, ASACUSA is studying antiproton in-flight annihilation on nuclei. Following hints from an experiment at KEK, an experiment in a low-momentum antiproton beam at the Japan Proton Accelerator Research Complex (J-PARC) will search for a ϕ-meson–nucleus bound state using antiproton annihilation on nuclei. Also at J-PARC, a study of double antikaonic nuclear clusters in antiproton–^{3}He annihilation has been proposed. Further into the future, the research programme for the major PANDA detector at FAIR, which is expected to start running in 2018, encompasses a breadth of physics that includes searches

John Ellis, right, a featured speaker, and Makoto Fujiwara, LEAP 2011 chair, discussing the dark side of the universe (Image credit: Mindy Hapke/TRIUMF.)

for exotic states and studies of double Λ hypernuclei. Back to the present, hot news from the Brookhaven National Laboratory concerned the discovery of the anti-alpha nucleus, the heaviest antinucleus observed (*CERN Courier* June 2011 p8).

The theory talks at the conference covered topics ranging from atomic collisions to cosmology. There were reviews on atomic collision physics with antiprotons and on interactions of antihydrogen with ordinary matter atoms. Calculations of gravitational effects on the interaction between antihydrogen and a solid surface suggest that the antiatoms would settle in long-lived quantum states, the study of which could provide a new way to measure the gravitational force on antihydrogen. Theoretical ideas based on the so-called Standard Model Extension, an effective theory that incorporates CPT and Lorentz violation, could offer the opportunity for probing Planck-scale physics as well as antimatter gravity in antihydrogen experiments. On the hadron physics side, antiproton–proton and antiproton–nucleus collisions provide ways to test theories of strangeness production, the latter offering a window onto the behaviour of strange particles in the nuclear medium that complements heavy-ion studies. In cosmology, baryon asymmetry – or the dominance of matter over antimatter – is a long-standing puzzle, as is the nature of dark matter. Could hidden antibaryons be the dark matter? Such a possibility could explain the two mysteries in one go.

Studies of exotic atoms and fundamental symmetries are an important part of antiproton physics.

LEAP 2011 featured two dedicated sessions on the universe. In the first, CERN’s John Ellis discussed the nature of dark matter and its connection to low-energy hadron physics and William Unruh, from the University of British Columbia, reported on fascinating experimental work that confirms aspects of Hawking radiation in an analogue system, confirming his own theoretical prediction from some 30 years ago. The second of the sessions focused on experimental searches for antimatter in the universe – a hot topic as the conference was held not long before the launch into space of the Alpha Magnetic Spectrometer (*CERN Courier* July/August p18). The latest results from the PAMELA detector, which has been in space since 2006, continue to show an anomaly in the positron flux at high energies (p34). BESS-Polar II, the second flight of the Balloon-borne Experiment with a Superconducting Spectrometer (BESS) over Antarctica, has a new measurement of the antiproton spectrum based on 24.5 days in which 4.7×10^9 cosmic-ray events were collected, yielding a sensitivity complementary to satellite experiments. The proposed General Antiparticle Spectrometer (GAPS) would be a balloon experiment to search for anti-deuterons from dark-matter annihilations using exotic atom techniques.

Looking to the future, the construction of FAIR at Darmstadt will allow for a dedicated Facility for Low-energy Antiproton and Ion Research (FLAIR), while Fermilab has a proposal to use its Antiproton Source – the world's most intense – for low-energy experiments once the Tevatron programme comes to an end later this year. Finally the conference returned to the AD, when the proposal for the Extra Low ENergy Antiproton ring (ELENA) was described by Walter Oelert, from the Jülich Research Centre, whose experiment at CERN observed the first antihydrogen atoms in 1996. The conference ended with his remarks on the prospects for antiproton physics. Just a few weeks after the conference, CERN Council approved the construction of ELENA, which will provide significantly enhanced opportunities for antiproton physics at CERN in the coming decade (p9).

This successful conference was capped off by a social programme that included a dinner cruise in Vancouver's spectacular English bay, and a well-attended public lecture by John Ellis at the University of British Columbia. The future of low-energy antiproton physics appears bright. The next LEAP meeting is planned for Uppsala in 2013, chaired by Tord Johansson.

● For full details of the speakers and many of the presentations, see http://leap2011.triumf.ca. The proceedings will be published in *Hyperfine Interactions*.

Résumé

LEAP 2011 illumine la physique des antiprotons

La physique des antiprotons de basses énergies est un domaine interdisciplinaire qui marrie physique des particules, nucléaire et appliquée, ainsi qu'astrophysique. La 10e conférence internationale de cette discipline s'est tenue à TRIUMF du 27 avril au 1er mai, rassemblant chercheuses et chercheurs de tous ces domaines. Les sujets couverts allaient de l'usage des antiprotons pour l'étude de la chromodynamique quantique à la recherche d'antiprotons dans l'espace. Points marquants de la conférence : les résultats des expériences du décélérateur d'antiprotons du CERN, les nouvelles techniques d'étude de l'antihydrogène et les aspects théoriques des symétries fondamentales.

Makoto C Fujiwara, TRIUMF/University of Calgary, chair of LEAP 2011.

Computing

Citizen cyberscience: the new age of the amateur

Thanks to internet-based participative projects, the distinctions between amateur and professional scientists are beginning to blur. **François Grey**, co-ordinator of the Citizen Cyberscience Centre, explains more.

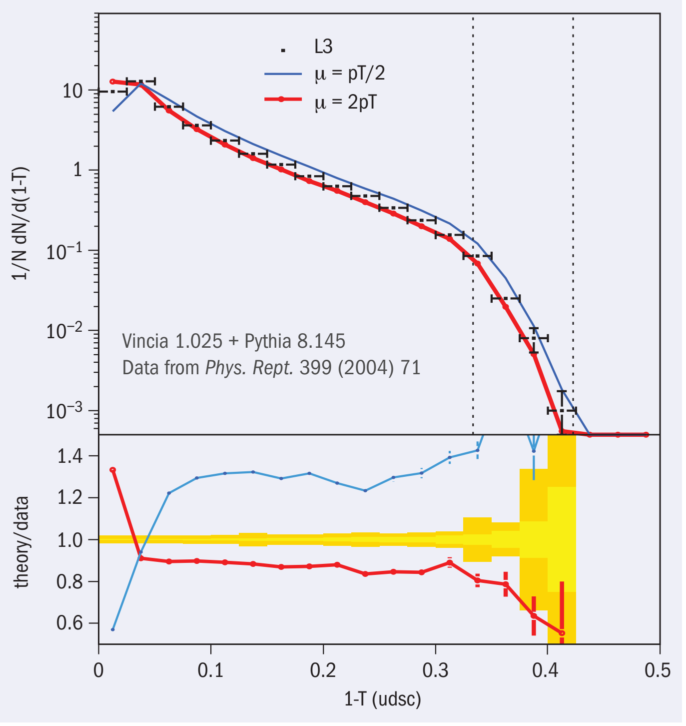
The world of journalism has been turned upside-down in recent years by social media technologies that allow a wider range of people to take part in gathering, filtering and distributing news. Although some professional journalists resisted this trend at first, most now appreciate the likes of Facebook, Twitter and blogs in expanding the sources of news and opinion and accelerating dissemination: the audience has become part of the show.

Could the internet one day wreak the same sort of social change on the world of science, breaking down the distinction between amateur and professional? In the world of high-energy physics, that might seem unlikely. What amateur can really contribute something substantial to, say the analysis of LHC data? Yet in many fields of science, the scope for amateur contributions is growing fast.

Modern astronomy, for example, has a long tradition of inspired amateur contributions, such as spotting comets or supernovae. Now, the internet has broadened the range of tasks that amateurs can tackle. For example, the project GalaxyZoo, led by researchers at the University of Oxford, invites volunteers to participate in web-based classification of galaxy images. Such pattern recognition is a task where the human mind still tends to outperform computer algorithms.

Not only can astronomers attract hundreds of thousands of free and eager assistants this way, but occasionally those helpers can themselves make interesting discoveries. This was the case for a Dutch school teacher, Hanny van Arkel, who spotted a strange object in one of the GalaxyZoo images that had stumped even the professional astronomers. It now bears the name "Hanny's Voorwerp", the second word meaning "object" in Dutch.

GalaxyZoo is just one of many volunteer-based projects making waves in astronomy. Projects such as Stardust@home, Planet Hunters, Solar Watch and MilkyWay@home all contribute to cutting-edge research. The Einstein@home project uses volunteer computing power to search for – among other things – pulsar signals in radio-astronomy data. Run by researchers at the Max-Planck Institute for Gravitational Research, the project published its first discoveries in *Science* last year, acknowledging the names of the volunteers whose computers had made each discovery.



An example of fitting theory to experimental particle physics data (black points) gives clearly different results from different parameter values (red and blue curves). Somewhere in between, a theory curve should be possible that "best" describes the data, a task a volunteer could do by altering parameter values. (W T Geile, D A Kosower and P Z Skands 2011 arxiv: 1102.2126v [hep-ph], accepted by Phys. Rev. D.*)*

Crowdsourcing research

However, it is in fields outside those traditionally accessible to amateurs where some of the most impressive results of citizen-powered science are beginning to be felt. Consider the computer game *FoldIt*, where players compete to fold protein molecules into their lowest energy configuration. Humans routinely outperform computers at this task, because the human mind is uniquely apt at such spatial puzzles; and teenagers typically out-compete trained biochemists. What the scientists behind the *FoldIt* project, ▷

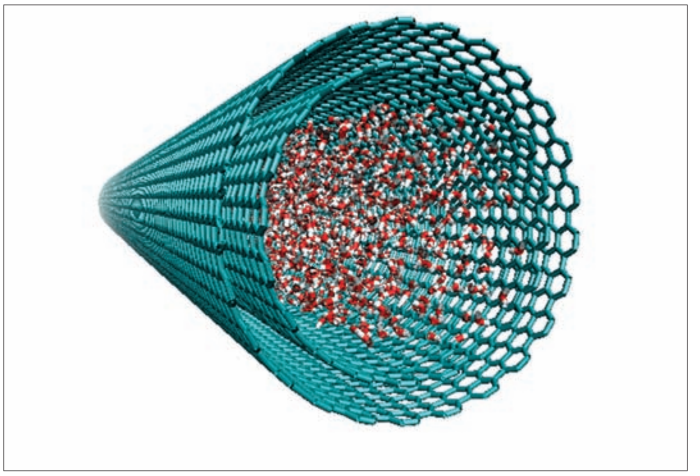
Computing

based at the University of Washington, have also discovered is that the players were spontaneously collaborating to explore new folding strategies – a possibility the researchers had not anticipated. In other words, the amateur protein folders were initiating their own research programme.

Could high-energy physics also benefit from this type of approach? Peter Skands, a theorist at CERN, thinks so. He has been working with colleagues on a project about fitting models to LHC data, where delicate tuning of the model parameters by eye can help the physicists achieve the best overall fit. Experience with a high-school intern convinced Skands that even people not versed in the gory details of LHC physics could solve this highly visual problem efficiently.

Volunteers can already contribute their processor time to another project that Skands is involved in – simulating collisions in the LHC for the recently launched LHC@Home 2.0 project, where 200 volunteers have already simulated more than 5 billion collision events. Such volunteer computing projects, like Einstein@Home, are not as passive as they might appear. Many of the volunteers have spent countless hours helping developers in the early alpha-test stages of the project by providing detailed bug reports. Message boards and a credit system for the amount of processing completed – features provided by an open-source platform called BOINC – add elements of social networking and gaming to the project.

The LHC@Home 2.0 project also relies on CernVM, a virtual machine technology developed at CERN that enables complex simulation code to run easily on the diverse platforms provided by volunteers. Running fully fledged physics simulations for the LHC on home computers – a prospect that seemed technically impossible when the first LHC@home project was introduced in 2004 to simulate proton-beam stability in the LHC ring – now has the potential to expand significantly the computing resources for the LHC experiments. Projects like LHC@home typically draw tens of thousands of volunteers and their computers, a significant fraction of the estimated 250 000 processor cores currently supporting the four LHC experiments.



Volunteers can run simulations on their own PCs and laptops to help explore how water molecules flow through carbon nanotubes, as part of an effort to design low-cost, efficient water filtration systems. (Image credit: Centre for Micro and Nano Mechanics, Tsinghua University.)

Damage assessment using satellite images, like this assessment produced after the Haiti earthquake, is an area where the Citizen Cyberscience Centre is exploring the benefits of public participation for humanitarian response to natural disasters and conflict situations. (Image credit: UNOSAT.)

A humanitarian angle

LHC@home 2.0 is an example of a project that has benefited from the support of the Citizen Cyberscience Centre (CCC), which was set up in 2009 in partnership between CERN, the UN Institute of Training and Research and the University of Geneva. A major objective of the CCC is to promote volunteer computing and volunteer thinking for researchers in developing regions, because this approach effectively provides huge resources to scientists at next to no cost. Such resources can also be used to tackle pressing humanitarian and development challenges.

One example is the project Computing for Clean Water, led by researchers at Tsinghua University in Beijing. The project was initiated by the CCC with the sponsorship of a philanthropic programme run by IBM, called World Community Grid. The goal is to simulate how water flows through carbon nanotubes and explore the use of arrays of nanotubes for low-cost water filtration and desalination. The simulations would require thousands of years on a typical university computing cluster but can be done in just months using volunteer-computing resources aggregated through World Community Grid.

Another example is volunteer mapping for UNOSAT, the operational satellite-applications programme for UNITAR, which is based at CERN (*CERN Courier* October 2009 p17). Although a range of crowd-based mapping techniques are available these days, the use of satellite images to assess accurately the extent of damage in regions devastated by war or natural disasters is not trivial, even for experts. However, rapid and accurate assessment is vital for humanitarian purposes in estimating reconstruction costs and rapid mobilization of the international community and NGOs.

With the help of researchers at the University of Geneva and HP Labs in Palo Alto, UNOSAT is testing new approaches in crowdsourcing damage assessment by volunteers. These involve using statistical approaches to improve accuracy, as well as models inspired by economics where volunteers can vote on the quality of others' results.

There are hundreds of citizen-cyberscience projects engaging millions of volunteers but the vast majority supports researchers in industrialized countries. A large part of the CCC activities involve raising awareness in developing regions. With the support of the Shuttleworth Foundation in South Africa, the CCC has been organizing a series of "hackfests": two-day events where scientists, software developers and citizen enthusiasts meet to build prototypes of new citizen-based projects, which the scientists can then go on to refine. Hackfests have already taken place in Beijing, Taipei, Rio de Janeiro and Berlin, with more planned this year in South Africa and India.

The topics covered to date include: using mobile-phone Bluetooth signals as a proxy for bacteria, tracking how air-borne bacterial diseases such as tuberculosis spread in buildings, monitoring earthquakes using the motion sensors built in to laptop computers and digitizing tables of economics data from government archives. Because the "end-users" – the citizen volunteers themselves – participate in the events, there is a healthy focus on making projects as accessible and attractive as possible, so that even more volunteers sign up and stay active.

At such events, when asked what sort of rewards the most engaged volunteers might appreciate for their online efforts, one striking response – echoed on several occasions – is the opportunity to make a suggestion to the scientists for the course of their future research. In other words, there is a desire on behalf of volunteers to be involved more actively in the process that defines what science gets done. The volunteers who propose this are quite humble in their expectations – they understand that not every idea they have will be useful or feasible. Whether scientists will reject this sort of offer of advice as unwanted interference, or embrace the potentially much larger brainpower that informed amateurs could provide, remains to be seen. But the sentiment is clear: in science, as in journalism, the audience wants to be part of the show.

Résumé

Cyberscience citoyenne : une nouvelle ère pour les amateurs

L'univers du journalisme a été bouleversé ces dernières années par l'apparition des réseaux sociaux qui permettent à un nombre accru de personnes de participer au partage des informations. La toile conduira-t-elle un jour à une révolution semblable du monde scientifique, effaçant la frontière entre amateurs et professionnels ? Grâce à des projets interactifs en ligne dans plusieurs disciplines scientifiques, les contributions des amateurs prennent de l'ampleur. François Grey, coordinateur du projet "Citizen Cyberscience Centre" explique comment.

François Grey, co-ordinator, Citizen Cyberscience Centre.

Hadrons in Munich: from light mesons to heavy ions

During the week of 13–17 June, more than 230 physicists gathered in the Künstlerhaus, in the heart of Munich, to attend the biennial international hadron-physics conference.

A history of hadron conferences. Right to left: A Zaitsev (Protvino 2001), S U Chung (Brookhaven 1999), A Reis (Rio de Janeiro 2005), S Bianco (Frascati 2007), S Paul (Munich 2011) and P Eugenio (Tallahasse 2009). (Image credit: TUM/Physics.)

Hadron 2011, the 14th International Conference on Hadron Spectroscopy, was the latest in a long series that started in 1985 in Maryland. Originally conceived as a conference on light meson spectroscopy, it now covers all aspects of hadron physics, although spectroscopy and hadron production are still the topics that characterize the meeting. This year, 37 plenary talks, 128 presentations in parallel sessions and 37 posters offered ample possibilities to find out about the latest developments and results, from hypernuclear physics to meson and quarkonium spectroscopy, and from nucleon structure and the meson-baryon interaction to heavy-ion physics.

The conference began by looking at issues related to light mesons, with a summary of recent theoretical progress and experimental tests in chiral dynamics and low-energy $\pi\pi$-scattering phenomena. There were new results on light meson spectroscopy from the BESIII experiment in Beijing and COMPASS at CERN. While COMPASS impressively confirmed previous findings on $\pi_1(1600)$, an exotic meson seen in high-energy diffraction, new structures have been observed in radiative J/ψ decays that point towards new and narrow meson states between 1.8 and 2.5 GeV/c^2, the details and nature of which have still to be unravelled.

Size and structure

Even after many years of precision experiments, the size of the proton is still a hot topic. New findings in laser spectroscopy of muonic hydrogen, which give the proton radius as more than 5σ smaller than previously determined, have opened the hunt for new explanations, although theory cannot offer effects large enough to solve the puzzle.

Research into nucleon structure has for years shifted to spin degrees of freedom. After precision measurements on the helicity contribution of quarks in polarized nucleons, COMPASS has also set new limits on spin effects resulting from polarized gluons. These findings are confirmed by spin experiments at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven. With this, the focus now turns towards transverse-spin degrees of freedom (transversity). Noncollinear treatment of partons inside the nucleon offers a large number of new observables, which can link to quark angular momenta. Both COMPASS and RHIC have new physics programmes on transverse polarization effects, and measurements of Drell-Yan processes using polarized targets are also on the way. Hopes are high that the unexpected single-spin asymmetries that have been observed in pion production at RHIC may finally be understood.

Research into nucleon structure has for years shifted to spin degrees of freedom.

On the low-Q^2 side, big efforts at various laboratories – such as Bonn, Mainz, Jefferson Lab etc – are offering real or virtual photon beams. These allow a coherent set of (double-) polarized scattering and production experiments, also with many-body final states. Using the complete set of polarized measurements, the puzzle ▷

Conference participants take time out from the poster session for a group photo in the courtyard. (Image credit: TUM/Physics.)

Harry Lipkin, left, of the Weizmann Institute, who turned 90 on 16 June, receives a birthday gift from the conference chair. (Image credit: TUM/Physics.)

of baryon resonances, their identification and quantum numbers seem now to be within reach via new and sophisticated partial-wave analyses.

Quarkonium spectroscopy and the hunt for further quarkonium-like states that seem not to fit the $q\bar{q}$ picture of the meson have been and still are highlights in hadron physics. Precision experiments finally allowed the BELLE and BaBar experiments at KEK and SLAC, respectively, to observe missing quarkonium states such as $h_b(1P)$, $h_b(2P)$, as well as η_c (1S) and $\eta_c(2S)$. More precise determination of the mass and width, as well as unexpected decay patterns were revealed also by BESIII, which has observed about 10^9 J/ψ decays. The puzzle of the mass and width of the D(D_s) meson states is on the way to being settled with their spin assignments being resolved. The conference also heard about the remarkable progress in achieving a comprehensive and unified theory description of quarkonium properties at zero and finite temperature in an effective field-theory framework.

The biggest puzzle currently in hadron physics concerns the large number of exotic quarkonium-like states with narrow widths and high excitation energies, as compared with the open-flavour meson channel. New work was reported on the X(3872) and other, partly new states. Theoretical investigations offer a rich choice of possibilities. The X(3872) has a good chance of just being the radial excitation of the χ_c state, but there is also a beautiful effective field-theory description in the molecular-interpretation case. However, further stunning observations were reported from the beauty sector. Two charged quarkonium-like states found by BELLE lie close in mass to the open b-threshold and have been dubbed Z_b, in analogy to the charm sector.

Lattice calculations have shown huge progress with new algorithms, allowing the extraction of excited baryon and meson-state energies. A report from the Flavianet Lattice Averaging Group presented lattice results for kaon and pion physics with the aim of making them accessible to the community. There are also new calculations of hadron structure, the baryon and meson form-factors and the g-2 factor.

First and impressive results were reported from all of the LHC experiments. In particular, CMS and LHCb – offering the best mass resolutions – have confirmed the potential of hadron machines in this field. In addition to the usual quarkonium states, exotic states have also been observed and the elusive B_c mesons have already been seen. At this stage, the focus is on the production cross-section of heavy quarkonia, which can now be understood at LHC energies, assuming colour octet contributions and next-to-leading order (NLO) processes to be relevant. The descriptions follow data up to transverse momenta as high as 20 GeV/*c*. One of the uncertainties comes from unknown polarization effects that influence acceptance calculations. On the theoretical side, huge progress has been achieved with the full NLO calculation of the J/ψ cross-section in non-relativistic QCD (NRQCD) and a combined global data analysis of all existing experiments that hints at the universality of the long-distance NRQCD matrix elements.

Hadron machines are unique in the production of b-baryons and Fermilab's Tevatron has so far been leading this field. The CDF collaboration reported on recent progress with the observation of excited Σ_b states and a radially excited Λ_c. CDF and DØ also presented new precision measurements of the mass and width of other charmed baryons.

The biggest puzzle currently in hadron physics concerns the large number of exotic quarkonium-like states.

A thermal medium, of the type generated in heavy-ion collisions at the LHC, can modify hadron properties, especially in the case of quarkonia. The theory of such modifications was reviewed and first results of lead–lead collisions at the LHC presented. Results from ATLAS and CMS show the striking effects of jet-quenching and also the melting of the excited Υ-states as compared with the ground-state partner. At lower energies, mass shifts and absorption cross-sections of vector mesons have been studied in the medium.

Hadron 2011

Mass shifts – a long-standing issue, where many predictions have stimulated experimental efforts – have not been observed but small effects have been reported by the HADES experiment at GSI, Darmstadt, on the width of ω mesons in nuclei.

Recent and impressive progress in light meson and quarkonium spectroscopy is in good part a result of recent high-luminosity experiments, which offer 10–100 times the statistical sample of their predecessors. Heavy-meson physics, for long the domain of lepton colliders, is now seeing LHC experiments starting to compete in an impressive way and using their low luminosity data from 2010 to catch up with the Tevatron experiments. An interesting future lies ahead with even further increases in luminosity and precision being offered by future experiments such as BELLE II, the SuperB facility and the PANDA experiment at the Facility for Antiproton and Ion Research.

Two impressive summary talks concluded the conference. Stefano Bianco of Frascati/INFN reviewed the experimental situation, a challenging task in view of the large number of new results presented. On the theoretical side, Chris Quigg of Fermilab gave an inspiring outlook on hadron physics. He recognized the enormous diversity and reach of experimental programmes, which offer insights from unexpected quarters, while remarkable progress has been achieved in theory with the emergence of lattice QCD. However, many puzzles remain, leaving ample opportunities and much work to do, as there are still "simple" questions that the field cannot answer.

Participants enjoyed the coffee breaks in the sunny and secluded courtyard of the Künstlerhaus, a building erected more than 100 years ago for artists to meet and enjoy social events. Long and intense discussions also offered vital scientific exchange around the poster session, making this event a pleasant ending to the day. Long hours of sitting were compensated on Wednesday afternoon with a bicycle tour through the old town of Munich and the English garden, with refreshing drinks in the beer garden. Last but not least, the conference enjoyed a guest talk on neutrino physics by Thierry Lasserre of Saclay, who discussed the mass determination from flavour oscillation and reported fresh results from T2K on hints of $\nu_\mu \rightarrow \nu_e$ oscillation.

● For details about all of the speakers and their contributions, see the conference website www.hadron2011.de.

Résumé

Hadrons à Munich : des mésons légers aux ions lourds

Du 13 au 17 juillet, plus de 230 physiciens et physiciennes se sont retrouvés au cœur de Munich, au Künstlerhaus, pour la conférence internationale biennale de la physique des hadrons. Les sessions ont porté sur les développements les plus récents, allant de la physique hypernucléaire à la spectroscopie des mésons et quarkonium, en passant par la structure des nucléons et les interactions entre mésons et baryons dans les collisions d'ions lourds. Les résultats provenaient d'expériences également très diverses, avec BESIII à Pékin et COMPASS et les expériences du LHC au CERN.

Stephan Paul and **Nora Brambilla**, TU-München.

Faces & Places

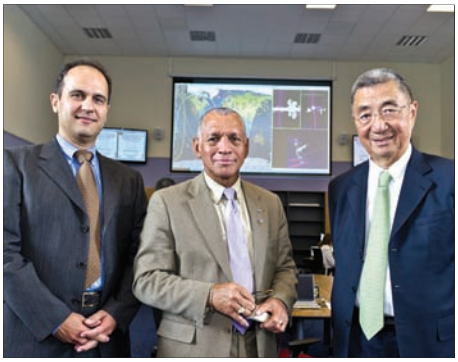
FACILITIES

CERN AMS-02 control centre begins operations

A month after the successful installation of the Alpha Magnetic Spectrometer (AMS-02) on the International Space Station (ISS), the AMS Payload Operation and Control Centre (POCC) began operation from a specially constructed building on CERN's Prévessin site on 24 June. The POCC will control AMS-02 for its entire lifetime.

Data-taking started soon after AMS-02 was installed on the ISS on 19 May, when the spectrometer began detecting cosmic rays at a rate of about 50 million a day. With the detector operational, the AMS team was able to transfer the POCC successfully from the Johnson Space Center in Houston to the new building at CERN.

The experiment is controlled from the POCC round the clock. Each subsystem has a dedicated monitor desk and each is devoted to data flow and to the command function – the only position that can issue commands to be uploaded to AMS-02 from NASA's Marshall Space Flight Center in Alabama. The spectrometer provides a continuous flow of data at a rate of about 10 Mbps, which requires on-line storage, monitoring and processing. While one team takes shifts for monitoring the operation of the experiment in space, another ensures that data are properly processed by a cluster of computers at CERN, before distribution to regional centres for specific, detector-related analysis and calibration.



Charles Bolden, centre, with Sam Ting, right, and Saul Gonzalez, at the AMS POCC.

Bolden together with Claude Nicollier, left, Switzerland's first astronaut.

The POCC started operation at CERN a day after a visit by Charles Bolden, a former shuttle astronaut and current NASA administrator, and Saul Gonzalez of the US Department of Energy. Bolden had been invited to visit the centre by Sam Ting, principal investigator for AMS-02, which had made its journey to the ISS aboard the last flight of the NASA space shuttle *Endeavour* (*CERN Courier* July/August 2011 p23). While at CERN, Bolden, who had piloted the space shuttle *Discovery* into orbit with the Hubble telescope in the payload bay, had a chance encounter with an old acquaintance, Claude Nicollier, Switzerland's first astronaut. Nicollier took part in several shuttle flights, including *Endeavour*'s mission to correct Hubble's faulty optics. He was at CERN to give a colloquium on "Hubble, the astronomer, the telescope, the results".

India sets up first ALICE Centre

A dedicated centre for data monitoring and analysis for the ALICE experiment at the LHC was inaugurated at the Variable Energy Cyclotron Centre (VECC), Kolkata, on 16 June. The new ALICE Centre will allow experts to attend to detector components remotely and extend the capability of Tier-II and Tier-III computing with direct connection to CERN.

The facility at VECC will also provide an excellent environment for training new students and postdocs, preparing them for shift duty in the ALICE Control Room at CERN – mandatory for all collaboration members. The new centre currently contains two workstations for control-system and data-acquisition monitoring; two screens with wireless internet for displaying the ALICE run status

The ALICE Centre at VECC was inaugurated by Srikumar Banerjee, the Chairman of the Atomic Energy Commission and Secretary of the Department of Atomic Energy (DAE). Front row: Subimal Saha, Subhasis Chattopadhyay, Tapan Nayak, Bikash Sinha (Homi Bhabha Professor, DAE), Srikumar Banerjee, Yogendra Viyogi, Dinesh Srivastava, Rakesh K Bhandari (Director, VECC); back row: Baldev Raj (Former Director, Indira Gandhi Centre for Atomic Research, Kalpakkam), Jogender Saini and Susanta Pal. (Image credit: VECC.)

and the LHC status; and several computers for use with monitoring and analysis programs. The centre will also provide a dedicated conference facility, so attending the daily ALICE co-ordination meetings, for example, will now become easier.

The inauguration took place on the anniversary of the foundation day of VECC, with several dignitaries from the Indian physics community in attendance. Paolo Giubellino and Jurgen Schukraft – the current and former spokespeople of the ALICE collaboration – joined via Skype from the ALICE Control Room, together with Indian colleagues at CERN.

CERN

Intel ISEF Special Award winners visit CERN

In June, 12 pre-college students visited CERN as winners of the CERN Special Award at the Intel International Science and Engineering Fair (ISEF) 2011. The Intel ISEF is the world's largest international pre-college science competition, offering a yearly forum for more than 1500 high-school students from 65 countries to showcase their independent research tackling challenging scientific questions. The organizer, Society for Science & the Public, is in partnership with Intel and dozens of other corporate, academic, government and science-focused sponsors, to reward the best students, who are all winners of national competitions.

The CERN Special Award was established in 2009, when Craig Barrett, Intel's chair of the board at the time, visited the laboratory as part of Intel's partnership in CERN openlab. Barrett and Wolfgang von Rüden, former head of the Information Technology Department, defined the award as a five-day trip to CERN for 12 students, co-funded by CERN and Intel. The award, which has proved immensely popular, is now in its third year.

The winners this year are: Arjun Aggarwal, David Alexandre Joseph Campeau, Brian Ronal Graham, Emil Timergalievich Khabiboulline, Jayanth Krishnan, Pratheek Nagaraj, Nicholas James Nothom, Sahir Raoof, Kamal Shah, Andrey Sushko, Aishwarya Ananda Vardhana and Nicole Yeechi Tsai. Each applicant underwent a thorough selection process and had to excel in an online test before being reviewed at the fair in Los Angeles by von Rüden and Albert Pace from CERN. The final selection was based on their evaluation of the students' projects and on individual interviews.

At CERN the students visited the LHC and enjoyed presentations from various prominent physicists and engineers. They particularly appreciated a few hours of individual coaching by a scientist on a topic of their choice. Visits to Geneva, the Ecole Polytechnique Fédérale in Lausanne and the region were also part of their programme.

Intel and CERN have built a strong partnership since the start of CERN openlab in 2001 (*CERN Courier* October 2003 p31). Intel not only collaborates on computing projects but also supports the CERN openlab Summer Student Programme. Indeed, after just one year at university, one of the 2010 ISEF award winners qualified to join this programme.

The 2011 Intel-ISEF CERN Special Award winners, with judges Alberto Pace (left) and Wolfgang von Rüden (right). (Image credit: Society for Science & the Public.)

A small ceremony took place at CERN on 23 June to mark, in effect, the end of the original LHC main magnet group at CERN. It was organized by Lucio Rossi, second from left, who joined CERN in 2001 to become the leader of the construction team. He stepped down as leader of the Magnet Group on 1 July, handing over to Luca Bottura, and now leads the project for future high-luminosity at the LHC (HL-LHC). Those joining in the ceremony included, left to right: Frédérick Bordry, now head of CERN's technology department; Romeo Perin, former head of the Magnet Group; Lyn Evans, former LHC project leader; and Jean-Pierre Koutchouk, now project co-ordinator of the FP7-EuCARD project.

Brian Cox talks about The Infinite Monkey Cage *at the Cheltenham Science Festival in 2010. (Image credit: Jesse Karjalainen.)*

COMMUNICATION

Bulldogs and monkey business: how to present science

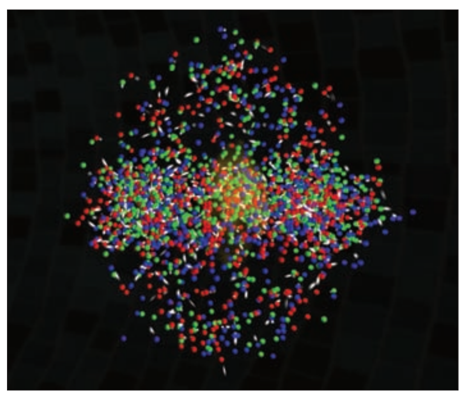
Different ways of taking science to the public have picked up awards on both sides of the Atlantic. In the UK, an unusual partnership between a comedian and a physicist has won a Sony Radio Academy Award, while in a more traditional approach, the Brookhaven National Laboratory (BNL) has received two Bulldog Awards for Excellence in Media and Public Relations for a publicity initiative that brought worldwide media attention in 2010 to results from the Relativistic Heavy Ion Collider (RHIC).

BBC Radio 4's *The Infinite Monkey Cage* took the gold award for Best Speech Programme at the 2011 Sony Radio Academy Awards. Hosted by comedian Robin Ince and particle physicist Brian Cox, *The Infinite Monkey Cage*, which has been running since 2009, is a "witty, irreverent look at the world according to science". Each programme centres on a topic – such as, is philosophy dead?, is cosmology really a science? – which Ince and Cox discuss with guests, typically a couple of scientists and another comedian.

Brookhaven's award-winning campaign was developed to announce two major results from RHIC in 2010. The campaign – which included a press briefing at a national meeting of the American Physical Society and media tours of RHIC – was planned and executed by members of the Media and Communications Office, with the assistance of PR consultants from Tartaglia Communications. It won a gold Bulldog award in the "Best Campaign Under $25 000" category and a bronze award in the "Best Not-for-Profit/Association/Government Campaign" category. The awards are given by the publisher Bulldog Reporter.

● To download podcasts of *The Infinite Monkey Cage*, go to www.bbc.co.uk/podcasts/series/timc.

For more about the results from RHIC, see www.bnl.gov/bnlweb/pubaf/pr/PR_display.asp?prID=1282.



Gold collisions bring gold award for Brookhaven. (Image credit: BNL.)

ASTROPARTICLE PHYSICS

CAST reaches milestone but keeps on searching

The CERN Axion Solar Telescope (CAST) has fulfilled its original physics programme after eight years of searching for the emission of a dark-matter candidate particle, the axion, from the Sun.

CAST, the world's most sensitive axion helioscope, points a recycled prototype LHC dipole magnet at the Sun at dawn and dusk, looking for the conversion of axions to X-rays. It incorporates four state-of-the-art X-ray detectors: three Micromegas detectors and a pn-CCD imaging camera attached to a focusing X-ray telescope that was recovered from the German space programme (*CERN Courier* April 2010 px).

Over the years, CAST has operated with the magnet bores – the location of the axion conversion – in different conditions: first in vacuum, covering axion masses up to 20 meV/c^2; and then with a buffer gas (^{4}He and later ^{3}He) at various densities, finally reaching the goal of 1.17 eV/c^2 on 22 July. While a direct solar-axion signal remains elusive, the experiment has set the most restrictive experimental limit on the axion-photon coupling strength for rest masses, which includes the theoretically and cosmologically motivated range from μeV/c^2 to eV/c^2. At the same time, the collaboration has gained valuable experience in low-background detectors (<10 keV) and ultracold (around 1.8 K) gas systems.

After a scheduled maintenance, CAST will resume data-taking in 2012 with improved sensitivity for solar axions (hot dark matter). The experiment will also expand its physics horizon, searching for paraphotons (the "hidden sector") and chameleons (dark energy), while exploring the possibility of searching for relic axions (cold dark matter) in an, as yet, inaccessible rest mass range of around 0.1–1 meV/c^2.

Members of the CAST collaboration with the dipole-based helioscope in July.

Faces & Places

COLLABORATION

NUFO strengthens the voice of 'users'

The National User Facility Organization (NUFO) represents the interests of 30 000 users who conduct research at 39 national scientific user facilities in the US, as well as scientists from US universities, laboratories and industry who use facilities in other countries. This includes SLAC, Jefferson Lab, Fermilab, the Oak Ridge, Argonne, Brookhaven, Lawrence Berkeley and Los Alamos national laboratories, as well as astrophysics facilities, their user organizations and the organization for US users of the LHC at CERN.

NUFO aims to enable communication between users, user organizations, facility administrators and other stakeholders. It seeks to provide a unified message at the national level about issues of resources for science, economic competitiveness and education for the next generation of the scientific workforce. It is organized into two major branches: user organizations' representatives focus primarily on outreach activities, while user administrators focus on streamlining processes to facilitate access. Both branches work together closely to fulfil the overall mission. An elected steering committee – consisting of three user organization representatives, three user administrators, three additional elected members and three appointed members – conducts the organization's business between annual meetings.

The organization recently played a fundamental role in the 2010 revisions of the Department of Energy (DOE) Order on Foreign Visits & Assignments, widening access to DOE-supported facilities by non-US citizens. This year its most important outreach activity has been the User Science Exhibition, which was held at the US House of Representatives on 7 April with the aim of highlighting the important role that scientific user facilities play in science education, economic competitiveness, fundamental knowledge and scientific achievements.

Visitors to this public exhibit were able to talk to facility users, examine posters, watch videos and learn more about the accomplishments and achievements of facility users. Attendees included congressional leaders (both senators and representatives and their staff members), management from the DOE Office of Science, four national laboratory directors, a representative from the National Science Foundation and representatives from a number of scientific agencies or societies, including the American Physical Society and the American Institute of Physics.

Congressional visitors at the User Science Exhibition. (Image credit: NUFO.)

Speaking briefly during the exhibition, Rene Bellwied of Wayne State University, and NUFO chair, identified the key role that national user facilities play in fostering science by providing the capabilities for key discoveries that advance new technologies and stimulate economic growth. Stephen Wasserman, of Eli Lilly and Company, addressed the importance to his company's drug-development efforts of the research conducted regularly at a number of facilities represented at the exhibition. Thom Mason, director of Oak Ridge National Laboratory, reinforced Bellwied's comments and stressed the research benefits of co-located user facilities at national laboratories. Charles Fleishmann, congressional representative from Tennessee, expressed his support for science and its role in the economic future of the US and thanked NUFO for arranging the exhibition.

NUFO also participated in the inaugural US Science & Engineering Festival in Washington DC in October 2010. An estimated 500 000 people of all ages participated in this two-day event. The NUFO booth, which featured popular science demonstrations and information on the research conducted at user facilities attracted an estimated 5000 children, parents, high-school students and teachers.

● Additional information about NUFO can be found at www.nufo.org.

Ahmad Tajuddin Ali, centre, president of the Academy of Science of Malaysia, came to CERN on 22 June to sign an "expression of interest" in the participation of scientists and students from universities and research institutes in Malaysia in the CMS experiment at the CERN LHC accelerator. Present at the signing were, from right to left: Emmanuel Tsesmelis, CERN contact person for Malaysia, Guido Tonelli, spokesperson of CMS, Albert de Roeck, deputy spokesperson CMS, and Sue Ann Koay, a Malaysian graduate student at the University of California, Santa Barbara. (Image credit: Immanuel Gfall.)

Obituaries

Maurice Goldhaber 1911–2011

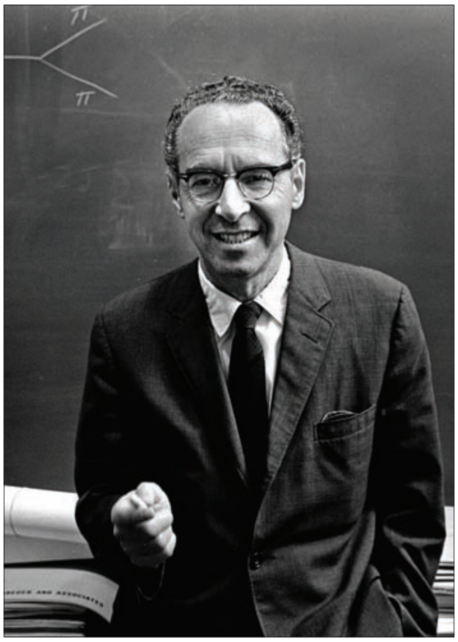
Maurice Goldhaber, a well known physicist and a former director of Brookhaven National Laboratory (BNL), died at the age of 100 on 11 May after a short illness. During his career he contributed in many ways to modern physics and also interacted with many of the physics greats of the 20th century.

Goldhaber was born in Austria and studied as an undergraduate in Berlin. There he experienced the stimulating atmosphere in colloquia attended by many of the great physicists of the time. Then in March 1933, while he was still a student, Nazi students rioted and classes were stopped.

"So I went to the library to read, and there was a German journal, something like the *Scientific American*, that had a little paragraph saying that G N Lewis had made a cc or a gram of heavy water. So I jotted down, 'What can you do with heavy water?' I had five or six ideas but one of them was, 'The photon could disintegrate the deuteron'. It shows you the speed with which things moved in those days. I left Germany in about May 1933, and I had applied to various places and I was accepted in Cambridge at the Cavendish. Laue and Schroedinger wrote me recommendations and Rutherford wrote me that I could come as a student."

Goldhaber earned his PhD in physics at the University of Cambridge in 1936, working mainly with James Chadwick. In 1934 he and Chadwick were the first to measure accurately the mass of the neutron via his idea of photo-disintegration of the deuteron. Goldhaber moved to the US in 1938 as a faculty member of the University of Illinois. He joined BNL in 1950, along with his wife, the nuclear-physicist Gertrude Scharff-Goldhaber. At Brookhaven he served as chair of the Physics Department from 1960 to 1961, and as laboratory director from 1961 to 1973.

Goldhaber's research in the fields of nuclear physics and fundamental particles included experiments, systematic evaluations, development of techniques and theory. He made numerous significant contributions to nuclear physics and helped establish parts of the theory of subatomic particles, now known as the Standard Model. In addition to measuring the mass of the neutron, he contributed to the discovery of the nuclear photo-effect, the role of spin in nuclear reactions and a variety of additional physics research, including the Goldhaber-Teller model for the giant dipole resonance. In 1968 the US Atomic Energy Commission was granted a patent for Goldhaber's invention of the Ne-H mixture that made bubble chambers suitable for the study of neutrino interactions.



Maurice Goldhaber photographed in 1967. (Image credit: BNL.)

His best-known experiment was the elegant, table-top determination of the neutrino's helicity, undertaken at BNL with Lee Grodzins and Andrew Sunyar in 1958. Goldhaber's vital contribution arose from his knowledge of the unique combination of spins of the parent and daughter states in the $^{152m}Eu \rightarrow {}^{152}Sm$ decay process, which together with the special kinematics of the decay allowed a straightforward interpretation of the result. Writing about the helicity experiment in 1987, Robert Adair commented: "Without Maurice Goldhaber – who knew everything and understood everything – I am not sure that the helicity of the neutrino would have ever been measured."

As the laboratory's director, Goldhaber initiated and presided over an extraordinary period of scientific productivity at Brookhaven. Research during his tenure resulted in major discoveries in physics, three of which eventually garnered physics Nobel prizes. Medical research that indicated the role of sodium in the development of hypertension and the value of the drug L-dopa to treat Parkinson's disease was also conducted at the laboratory during that time.

He retired in 1985 but continued his research at the laboratory until he was well into his nineties. He told those who saw him working long hours in his later years, "I don't have time to age", and continued to generate new ideas. To acknowledge his significant contributions to physics and BNL, he was named Distinguished Scientist Emeritus at the laboratory after his retirement.

Goldhaber's productive career won him numerous awards, including the Tom W Bonner Prize in Nuclear Physics in 1971, the J Robert Oppenheimer Memorial Prize in 1982, the National Medal of Science in 1983, the Wolf Prize in Physics in 1991 and the Enrico Fermi Award in 1999. He was a member of the National Academy of Sciences and was a fellow of the American Academy of Arts & Sciences, the American Association for the Advancement of Science and the American Physical Society, of which he was president in 1982.

He loved aphorisms and was an avid punster, even into his last days. He often said, "Physics teaches old things to new people" and in talking about an experiment he was involved with on proton decay, he pointed out that you could get an estimate of the lifetime, because if it were too short "you could feel it in your bones". His son, Alfred, recalled that when being taken out of the hospital for the last time, a nurse ran up to his wheelchair and said that they needed one more blood sample. After many failed attempts by a sequence of "experts" to draw anything from a vein, Goldhaber commented, "Well, that was in vain".

Perhaps as valued as any other contribution was the fact that Goldhaber could and would contribute to any discussion in physics at lunch or in the halls, or by asking a telling question at a seminar. He spoke to anyone and everyone, democratically, helpfully – and very much to the point.

BNL's director Sam Aronson said: "Maurice Goldhaber was a valued friend to the lab community. His insight, intellectual curiosity and wit will be sorely missed, but the influence he had on the lab remains."

● For an interview with Maurice Goldhaber about his history, see www.aip.org/history/ohilist/4632.html.

● *Friends and colleagues at BNL.*

Graham Ross Macleod 1929–2010

Ross Macleod, who died on 17 April 2010, was head of CERN's Data Handling Division (DD) for 10 years from 1965, during a period that saw dramatic changes in computing at CERN.

Born in Manchester in 1929, Ross joined CERN in 1955 as a physicist in the Scientific and Technical Services (STS) Division, with a PhD from the University of Cambridge. At that time STS was still located at the airport, with Lew Kowarski as division leader.

By 1965, when he became the head of DD, Ross had gained considerable experience in computing and data handling. After participating in the installation of CERN's first computer in 1958, a Ferranti Mercury, he took part in various early bubble-chamber experiments, using manual measurements made with the prototype Instrument for the Evaluation of Photographs (IEP) and he also developed the Digitised Protractor (or Baby IEP) for the more rapid measurement of simple events. In particular, he wrote the three Mercury programs for the first bubble-chamber experiment performed at CERN, in which the Padua propane chamber was exposed to a beam from the Synchrocyclotron.

When more versatile geometry and kinematics programs were developed, Ross contributed his input program to the production chain for data analysis. In 1963 he was involved in the development of programs for the automatic analysis of spark-chamber photographs using the Hough-Powell Device (HPD) online to the IBM 7090 computer. This was the first use of the HPD and some 200 000 photographs were measured automatically. In the same year, Ross organized a four-week lecture course on these bubble-chamber and spark-chamber programs, which was attended by people from CERN and all around the world.

Ross Macleod in 1965.

As division leader, Ross made a prolonged effort to recruit experienced computer scientists, thus acquiring the resources necessary for the years to come. The division was responsible for the CERN Library, and the Print Shop, both of which Ross completely reorganized, later adding a Computer Science Library.

The CDC 6600, delivered in 1965, had severe running-in problems but when these had been overcome CERN had the most powerful computer centre in all of Europe. Users were fortunate in having someone of the calibre of Ross, with the authority and leadership to develop the facilities, unique at that time, for operating the computer centre as an "open shop". The main facility developed for users was the Focus system for remote file-handling and job-submission from CDC 3100s to the CDC 6600. A major extension came in 1972, when a CDC 7600 – four times as powerful as the 6600 – was installed with similar user facilities.

In 1964 Ross was already encouraging physicists to use small computers directly online to experiments, without film. The networking needed for this was provided in an *ad hoc* manner by the division, until the CERNET facility was developed. CERNET was an initiative by Ross, for which he continued to act as project leader after he left office at the end of 1975. It came into operation in 1977, replacing Focus and allowing users to submit computer jobs from their desks and to transfer data files within the site. Predating the internet, CERNET lasted more than 10 years.

In 1970 Ross founded the CERN School of Computing for young physicists, which is held every year. In 1972, in his capacity as first chair of the European Physical Society Computational Physics Group, he convened a conference at CERN on the "Impact of Computing on Physics".

Ross suffered from a recurrent health problem that finally led to his retirement in 1986, but this did not appear to diminish the energy with which he built up and managed the Data Handling Division in those pioneering years of computing.

● *Gerry Moorhead on behalf of former colleagues.*

New products

Aerotech has introduced the VTS300 vertical translation stages that provide long travel precision positioning in a compact upright design for individual Z-axis payloads up to 450 kg. They may also be arranged as multiple synchronized units that support heavy loads, with kinematic three-point mounting with the added potential for angled tip/tilt load manipulation. It is available in four vertical travel ranges from 50 mm to 200 mm with a nominal positioning resolution of 0.064. For details, contact Simon Smith, tel +44 118 940 9400, e-mail ssmith@aerotech.com, or visit www.aerotech.com.

FLIR Advanced Thermal Solutions has announced two high-performance macro lenses for use with its FLIR SC 645 and FLIR SC 655 thermal imaging cameras. Available with 2.9× and 5.8× magnification, they enable accurate temperature readings of small objects, as well as analysis of small components and processes. The 2.9× (5.8×) lens can resolve elements as small as 50 (100) μm within a field-of-view of 32 × 24 (64 × 48) mm. For details, tel +33 160 370 100, e-mail research@flir.com, or see www.flir.com.

Schroff has introduced a compact new MicroTCA system to meet the requirements of the proposed MTCA.4 subspecifications for high-energy physics and other advanced test-and-measurement applications. It is ideal for development purposes and consists of 5U-high, 42HP-wide chassis complete with backplane, power supply and fan. The front has six AdvancedMC slots in double mid-size format, one MicroTCA carrier hub slot and one slot for a plug-in 300 W PSU, while the rear provides six RTMslots. For details, tel +44 1442 218 726, e-mail schroff.uk@pentair.com, or see www.schroff.co.uk.

UltraVolt has announced enhanced interface options, the –I5 Option and the –I10 Option, for its AA series and high-power C series of high-voltage power supply (HVPS) products. The new interfaces are optimized for connecting the HVPS to computers and programmable logic controllers in process systems and equipment typically standardized on 0 to +5 VDC and +10 VDC signals and controls. For details, call +1 631 471 4444, e-mail ae@ultravolt.com or see www.ultravolt.com.

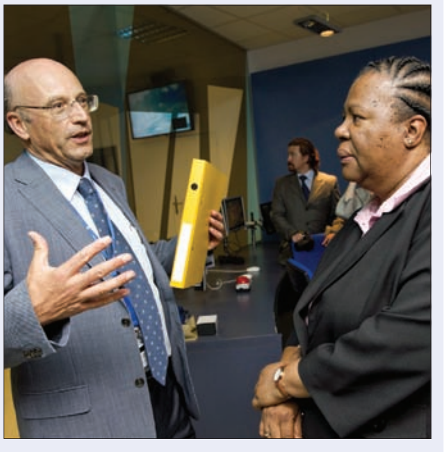
Faces & Places

Visits

Amr Ezzat Salama, right, minister for scientific research, science and technology of the Arab Republic of Egypt, right, came to CERN on 25 May. He visited the CMS control room on the Meyrin site with, from left, CMS spokesperson, **Guido Tonelli**, **Alaa Awad**, Fayum University, **Hisham Badr**, ambassador at the UN Geneva, and **Maged Elsherbiny**, president of the Scientific Research Academy.

A large delegation of representatives of Chinese Ministries and Officials from the People's Republic of China were welcomed to CERN on 1 June. They split into two groups to visit the *Universe of Particles* exhibition in the Globe of Science and Innovation and the ATLAS visitor centre. One group is seen here, with **Steve Goldfarb**, ATLAS outreach co-coordinator (centre).

Members of the Swiss Federal Council, including **Micheline Calmy-Rey**, president of the Swiss Federal Council, front row fourth from right, came to CERN on 7 July. The group visited the *Universe of Particles* exhibition in the Globe of Science and Innovation and toured the ATLAS visitor centre and control room. Here they are outside the Globe with senior members of CERN staff, including the director-general, **Rolf Heuer**.



During a visit to CERN on 22 June, **Naledi G Pandor**, right, minister of science and technology for the Republic of South Africa, looked round the ATLAS visitor centre with **Peter Jenni**, former spokesperson for the ATLAS experiment. She also toured the LHC superconducting magnet test hall and the ALICE visitor centre.

Bruno Zumino, second from left, one of the fathers of supersymmetry, was at CERN on 7 July, to participate in the LAPP-Annecy/CERN celebration for the 80th birthday of Raymond Stora, held at LAPP. Zumino, a former senior staff member of CERN, wrote important papers on the theory of anomalies with Stora, a theoretical physicist at Annecy who is still a frequent visitor to CERN. Another participant was Mary K Gaillard, centre; both she and Zumino gave interesting talks at the special seminar held in Stora's honour. Here they are seen with Sergio Ferrara, left, and on the right, John Ellis and Ignatios Antoniadis of the current Theoretical Group at CERN.

Corrections

In Sciencewatch, *CERN Courier* July/August p13, an error crept into the world's best limit on the electron's electric dipole moment (edm). This should have said that the limit is now less than 10.5×10^{-28} e cm.

Also, the date of the launch of AMS-02 was wrongly given as 25 May on p19 and p21. The launch took place on 16 May.

Apologies to all concerned.

Faces & Places

UK AWARDS

IOP medals for experimental and theoretical physics

Particle physics, cosmic radiation and quantum theory are among the areas of physics recognized by the 2011 awards of the UK's Institute of Physics.

Terry Wyatt, University of Manchester, receives the Chadwick Medal and Prize, which is given specifically for distinguished research in particle physics. Wyatt, who is rewarded for "outstanding contributions to hadron-collider physics", has played a prominent role in the field for the past 25 years, starting with his work on proton–antiproton physics at CERN's Super Proton Synchrotron collider in the 1980s. Since then he has played a prominent role in the DØ collaboration at Fermilab's Tevatron, becoming co-spokesperson (2004–2007), and has also been chair of CERN's LHC Committee (2007–2010).

Of the gold medals awarded, the Faraday Medal for outstanding contributions to experimental physics goes to Alan Andrew Watson, University of Leeds, for his "leadership within the Pierre Auger Observatory, and the insights he has provided to the origin and nature of ultra-high-energy cosmic rays". The Dirac Medal for outstanding contributions to theoretical physics goes to Christopher Isham, Imperial College London, for his "major contributions to the search for a consistent quantum theory of gravity and to the foundations of quantum mechanics". Theory at Imperial College is also honoured with the Rayleigh Medal and Prize for distinguished research in theoretical, mathematical or computational physics. Arkady Tseytlin, receives this award for "his contributions to the understanding of string theory and of its relation to conventional quantum field theories, and in particular to non-abelian gauge theories that form the basis for our current theoretical description of elementary particle interactions".

Remaining with theory, the Maxwell Medal and Prize is an early-career award for outstanding contributions to theoretical physics. The 2011 recipient is Andrei Starinets, University of Oxford, for "his work on the transport properties of systems of strongly coupled quantum fields". His research has been at the forefront of major developments that make use of the gauge/gravity correspondence that arises in string theory. By contrast, the Isaac

Left: Terry Wyatt receives the Chadwick Medal and Prize for his work on hadron-collider physics. (Image credit: T Wyatt.)

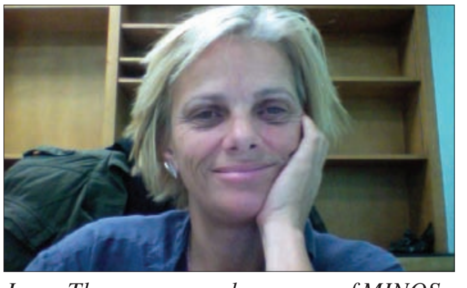
Newton Medal, an international prize for outstanding contributions to physics, regardless of subject area or nationality, this year honours a physicist with a long and highly successful career. Leo P Kadanoff, University of Chicago, receives this medal "for inventing conceptual tools that reveal the deep implications of scale invariance on the behaviour of phase transitions and dynamical systems".

In fields related to particle physics, the Payne-Gaposchkin Medal and Prize for distinguished research in plasma, solar or space physics is awarded to Yvonne Elsworth, University of Birmingham, for "the development of helioseismology into a unique quantitative tool probing the deep interior of the Sun, illuminating stellar structure and evolution and the solar neutrino problem". The Kelvin Medal and Prize for outstanding contributions to the public understanding of physics goes to nuclear physicist Jim Al-Khalili, University of Surrey.

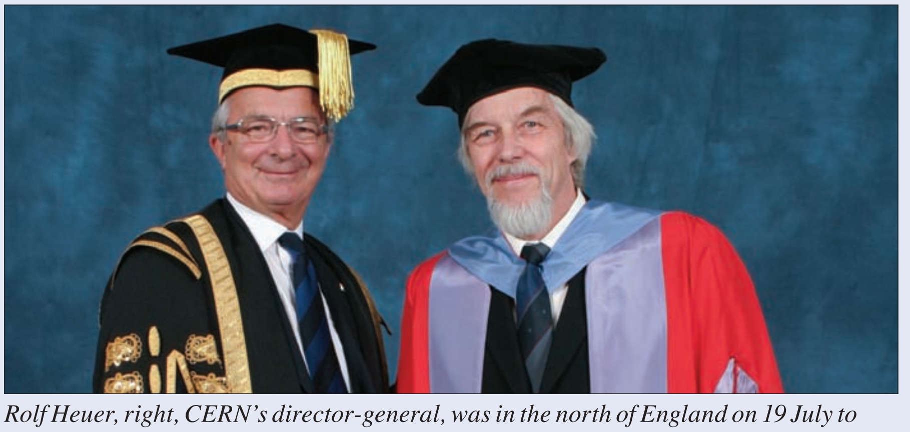
The Queen honours services to science

Jenny Thomas, of University College London, is to become a Commander of the Order of the British Empire (CBE) for services to science, announced in the Queen's Birthday Honours list for 2011. Her career has included participation in particle physics experiments at Fermilab, the Max-Planck Institute in Munich, and CERN. Currently focussing on the physics of neutrinos, she is the co-spokesperson for the MINOS experiment and is a member of the NEMO-III and SuperNEMO experiments.

Also honoured this year are Richard Davis, Professor of Astrophysics at Jodrell Bank, University of Manchester, who becomes an officer of the Order of the British Empire (OBE). Sheila Rowan, director of the Institute for Gravitational Research, and Robin Clegg, Head of Science in Society at the Science and Technology Facilities Council, both become members of the order of the British Empire (MBE).



Jenny Thomas, co-spokesperson of MINOS, becomes CBE. (Image credit: J Thomas.)



Rolf Heuer, right, CERN's director-general, was in the north of England on 19 July to receive an honorary degree from the University of Liverpool. Here is seen here together with the university's vice-chancellor, Sir Howard Newby. The university has long-standing connections with particle physics and CERN in particular. The award was made during a week of ceremonies that saw the graduation of more than 4000 students.

Recruitment

The EU-funded 7th Framework Programme has two main strategic objectives: to strengthen the scientific and technological base of European industry and to encourage its international competitiveness, while promoting research that supports EU policies.

As part of this Programme, initial training of researchers is being offered through Marie Curie Networks which will improve their research skills and help them join established research teams. In parallel, complementary training will enhance their career prospects in both public and private sectors.

We are looking for four Experienced Researchers to participate in a Marie Curie Initial Training Network (ITN) offering research training in the application of advanced accelerator technology, beam instrumentation, radiation protection and advanced material technologies in one of Europe's leading Radioactive Ion Beam facilities (ISOLDE) at CERN, and its future upgrade (HIE-ISOLDE).

Job titles :

ER1: Low level RF
ER2: Beam Instrumentation Developments
ER3: Radioactive Ion Beams Quality Improvements
ER4: General Safety and Radiation Protection Implications Studies

For detailed job descriptions and eligibility conditions please see the project website: https://hr-recruit.web.cern.ch/hr-recruit/special/CATHI.asp

Being present in 50 countries with a staff of 68,000 employees, THALES is the world leader in critical information systems for Aerospace, Defense and Security. The Microwave & Imaging Sub-Systems Business Line (420 M€ sales, 2,700 employees) provides to the market state of the art RF power and imaging solutions. For our research and manufacturing centre in Velizy (France), we are offering a position of **High Power Microwave Source Designer**.

Your missions will be to take in charge the development of new high power RF sources to be used in the large science laboratories worldwide. These powerful RF sources enable to accelerate the particle beams in major accelerator facilities (at CERN, DESY…) and also to heat the plasma in advanced fusion reactors (W7X, ITER…).

In the frame of these development projects, you are leading technical proposals and exchanges with the customers. You have the technical responsibility of product development. Your activities include detailed simulations, supervision of technical validations, drawing file elaboration and prototype manufacturing as well as high power testing of prototypes in the factory and on customer site.

The skills required are: Master degree in Physics or Microwaves in a European University or Engineering School; PhD or 3 years minimum experience in Research and Development with good practice of RF measurements, basic knowledge in vacuum techniques and/or materials science. Fluent English and French languages (or good bases to learn quickly)

Contact : Mathilde PELLEING (Human Resources Manager) – mathilde.pelleing@thalesgroup.com -
2 rue Marcel DASSAULT –
78140 VELIZY VILLACOUBLAY - France

ELEKTA

Elekta is a human care company pioneering significant innovations and clinical solutions for treating cancer and brain disorders. The company develops sophisticated state of the art tools and treatment planning systems for radiation therapy and radiosurgery, as well as workflow enhancing software systems across the spectrum of cancer care.

We have a number of vacancies for Physicists to join our R&D Physics group in Crawley. The Physics group is responsible for providing support to the business and contribute with designs and measurements in the following areas: Physics of Radiotherapy Systems, including beam generation and dosimetry (electron beams, MV and kV photon beams), general Radiation Physics, Monte Carlo simulations and other computational modelling methods, Control Systems for experiments, Microwave components and theory, Waveguide testing and tuning, Optics, Physics of Detectors and Imaging Systems.

Successful applicants will take a leading role in supporting the development of new products and will be involved on a number of projects including both computational and experimental activities. Ideally candidates will have experience of medical accelerator systems and the ability to contribute in several of the areas that the Physics group is responsible for. Projects will often offer interaction with Research Hospitals and other Institutions, therefore exceptional written and spoken communication skills will be required. Our preference is for candidates to be educated to MSc or PhD level. The ability to work to tight deadlines and within a successful team is also essential for these roles.

Current vacancies include (but are not limited to):

- **Radiotherapy System Physicist**: You will take a leading role in designing, planning, implementing and managing test programmes in order to produce performance data for Elekta Linac systems. You will be involved in a variety of R&D projects. You will ideally have an MSc or a PhD degree in Medical Physics, Radiation Physics or closely related discipline and a minimum of 3 years experience working within the Medical Devices industry or a Radiotherapy Hospital department (although experience as a Radiation Physicist in another area will be considered). Experience with international compliance standards and/or Physics QA programmes will be an advantage.
- **Accelerator Physicist**: You will provide the business with technical support of Elekta RF electron linear accelerators and associated developments, with particular focus on beam generation, transport, control and monitoring. This role will require an understanding of periodic accelerating structures, electron sources, RF sources and electron beam dynamics. Ideal candidates will have a PhD degree in Physics, Accelerator Physics, Particle Beam Physics or closely related discipline. Candidates will have ideally a minimum of 5 years experience as an accelerator physicist, involved with modelling aspects of accelerating structures as well as beam experiments, either in a research or industrial environment. However applicants with less experience yet exceptional skills will also be considered.
- **Imaging Physicist**: We also have an upcoming requirement for an Imaging Physicist.

Elekta offer competitive salary packages and a range of benefits including 25 days holiday, Private Medical Insurance and an excellent Pension scheme.
For further details please apply today by sending your CV to recruitment.uk@elekta.com and quote which position you are interested in.

Accelerator | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

DESY

ACCELERATOR RESEARCH.

DESY, Hamburg location, is seeking:

Leading Scientist (m/f) DESY
Salary group W3

DESY

DESY is one of the world's leading accelerator centres for the investigation of matter. Within its mission DESY develops, runs and scientifically exploits accelerators and detectors for the research with photons and for particle physics. Accelerator physics and technology are part of DESY's key competences. DESY wishes to strengthen its programme in accelerator research and development in the context of the newly established Accelerator Research & Development (ARD) initiative of the Helmholtz Association, including the following topics: generation, dynamics and diagnostics of femtosecond beams, electron-photon interactions and advanced acceleration concepts.

The position

DESY is seeking a leading senior scientist in the accelerator division with the following responsibilities:

- Conduct a strong, world-class research program on these topics and assume the respective leadership in the accelerator division
- Coordination of the ARD activities with other accelerator centres in the Helmholtz Association and with German universities
- Collaboration in accelerator R&D with European and international partners

Requirements

- PhD in physics or engineering
- Several years of experience in at least one of the above mentioned research topics
- Significant experience in planning and organizing complex, large scale projects
- Excellent communication and leadership skills

The successful candidate is expected to participate in shaping the strategic development of DESY's accelerator activities, in close collaboration with the division management.

For further information, please contact Prof. Dr. Helmut Dosch (desy-director@desy.de, Phone +49 40 8998 3000) or Dr. Reinhard Brinkmann (reinhard.brinkmann@desy.de, Phone +49 40 8998 3197).

Salary and benefits are commensurate with those of public service organisations in Germany. DESY operates flexible work schemes. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. There is a bilingual German-English Kindergarten on the DESY site.

Please send your application quoting the reference code, also by Email to:
Deutsches Elektronen-Synchrotron DESY
Human Resources Department, Code: 118/2011
Notkestraße 85, 22607 Hamburg, Germany
Phone: +49 40 8998 3392, Email: personal.abteilung@desy.de
Deadline for applications: 30th September 2011
www.desy.de

The Helmholtz Association is Germany's largest scientific organisation.
www.helmholtz.de

HELMHOLTZ | GEMEINSCHAFT

Accelerator | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

DESY

EXPERIMENTAL PARTICLE PHYSICS.

DESY, Hamburg location, is seeking:

Leading Scientist (m/f) DESY
Salary group W3

DESY

DESY is one of the world's leading centres for the investigation of matter. Within its mission DESY develops, runs and scientifically exploits accelerators and detectors for photon science and particle physics. The particle physics programme of DESY consists of strong contributions to the LHC experiments ATLAS and CMS and to the preparation of a future linear collider, as well as to the completion of the analyses of the HERA experiments. The experimental programme is enhanced by collaboration with a strong theory group. DESY collaborates closely with German groups in the framework of the Helmholtz Alliance "Physics at the Terascale" and internationally with major laboratories and institutes in particle physics.

To strengthen its present and future particle physics programme, DESY seeks a leading scientist in experimental particle physics at the Hamburg site. The position is equivalent to a full professor (W3) at a German university.

The position

- Assume a leadership position in the experimental particle physics programme
- Assume a leading role in DESY's CMS activities
- Contribute to shaping the future DESY particle physics programme

Requirements

- Internationally recognized scientist in the field of particle physics at colliders
- Demonstrated leadership abilities in high energy physics projects
- Outstanding qualifications in particle physics analyses and instrumentation

For further information, please contact Prof. Dr. Helmut Dosch (desy-director@desy.de, Phone +49 40 8998 3000) or Prof. Dr. Joachim Mnich (joachim.mnich@desy.de, Phone +49 40 8998 1921).

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www.desy.de

The Helmholtz Association is Germany's largest scientific organisation.
www.helmholtz.de

HELMHOLTZ | GEMEINSCHAFT

UPPSALA UNIVERSITET

Uppsala University is an international research university that targets development in research and education. Uppsala University has 40 000 students, 5 500 employees and a turnover of 5 000 MSEK.

Uppsala University intends to employ

Four Researchers
Four Post-doctoral Researchers
Four Research Engineers
Two Doctoral Students in Physics

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The accelerator physics group at the Department of Physics and Astronomy performs research towards future particle accelerators. The group will construct a superconducting RF test facility in Uppsala.

Complete information about the position is available at http://www.uu.se/jobb

You are welcome to submit your application no later than the 31st August 2011.

www.uu.se

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Tessella delivers software engineering and consulting services to scientists and engineers in leading companies across the globe. We are currently looking to recruit Project Managers who will help drive our business forward.

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You should have a scientific or numerate degree (BSc, MSc, or PhD), experience of hands-on software development and a track record of Project Management including the successful delivery of fixed price projects.

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THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2011 u^b

b UNIVERSITÄT BERN

In the framework of the newly established *Albert Einstein Center for Fundamental Physics* (AEC), the Faculty of Sciences of the University of Bern invites applications for a position of:

Tenure-track Assistant Professor of Experimental Astroparticle Physics

opening on *August 1*, 2012 at the *Laboratory for High Energy Physics* (LHEP), University of Bern, Switzerland.

The successful candidate should have an outstanding experimental research record. Competences are required in one or more of the following fields: dark matter search, cosmic-ray physics, low-energy neutrino physics, neutrino astronomy, matter stability experiments. Experience with particle detectors and advanced experimental methods is a requisite. The new professor is expected to contribute to the research activities on astroparticle physics at LHEP and AEC, to promote future leading projects, to actively participate in the teaching of physics at both the undergraduate and graduate level, and to attract external funding.

In addition to astroparticle physics, the current scientific research of LHEP is in the fields of high-energy proton–proton collisions, neutrino oscillation physics, development of novel particle detectors and medical applications of particle physics; the successful candidate will be encouraged in proposing and establishing synergic research programs with those activities.

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

Applications (in English) should include curriculum vitae, list of publications, copies of the five most relevant publications and an outline of current and planned scientific activities.

Applications should be sent as a single PDF file or as a hard copy by 15 October 2011 to: **Prof. S. Decurtins, Dean of the Faculty of Science University of Bern, Sidlerstrasse 5, CH-3012 Bern Switzerland**
(e-mail: **dekan@natdek.unibe.ch**).

Further information about the *Laboratory for High Energy Physics* can be found at: **http://www.lhep.unibe.ch**. Enquiries about the position should be addressed to: **Prof. A. Ereditato, Director of LHEP, Sidlerstrasse 5, CH-3012 Bern, Switzerland. Phone: +41 31 631 8566**, e-mail: **antonio.ereditato@lhep.unibe.ch**.

UNIVERSITY OF OXFORD

www.ox.ac.uk/jobs

Professorship of Experimental Physics

In association with St Catherine's College

Start date: 1 October 2012 or earlier if possible.

BRONZE
Athena SWAN
Charter for Women in Science

The Professorship of Experimental Physics is one of two attached to the sub-department of Particle Physics, one of the six sub-departments which constitute the Department of Physics. This is a key senior role at the sub-department of Particle Physics and you will be expected to strengthen the department's international research profile and to provide strategic scientific leadership and excellent teaching in experimental particle physics.

A world-leading portfolio in experimental particle physics activity has been developed at Oxford. Main research areas of expertise include the ATLAS and LHCb experiments at LHC and preparations for their upgrade; neutrino physics including MINOS, T2K and SNO+; and astroparticle physics, including dark matter detection in the EDELWEISS experiment and the proposal for EURECA. As particle physics is currently at an exciting stage of development with critical experiments underway and about to yield results, we are seeking to appoint a leading experimental particle physicist who would be well placed to consolidate and enhance Oxford's position as a major player in the field.

Please see the further particulars at **http://www.ox.ac.uk/about_the_university/jobs/fp/** for more details about the post and for full instructions before making an application. Applications, including a covering letter and full CV, and naming three referees should be received no later than Monday 26 September 2011 by Dr Gwen Booth, Personnel Officer, Senior Appointments at professorships@admin.ox.ac.uk If you have a query about how to apply, please contact Mrs Elaine Eastgate at professorships@admin.ox.ac.uk or telephone: +44 (0) 1865 280189.

Applications are particularly welcome from women and black and minority ethnic candidates, who are under-represented in academic posts in Oxford.

Committed to equality and valuing diversity

Florida Institute of Technology
High Tech with a Human Touch™

FACULTY POSITION IN EXPERIMENTAL PARTICLE PHYSICS

The Department of Physics and Space Sciences at Florida Institute of Technology invites applications for a full-time faculty position to begin in spring or fall 2012 contingent upon the availability of funds. Appointments at all academic ranks will be considered. Applications are welcome from candidates with a Ph.D. degree in physics and working in experimental high-energy particle physics.

The current Florida Tech HEP research program is centered on multi-TeV proton-proton collider physics with the CMS experiment at CERN, as well as detector development with the RD51 collaboration and grid computing. The department is seeking an outstanding candidate to strengthen our CMS research program. For more information on HEP at Florida Tech see www.fit.edu/pss or contact Professors Marc Baarmand (baarmand@fit.edu) and Marcus Hohlmann (hohlmann@fit.edu).

The successful candidate will be expected to conduct a vigorous, externally funded research program and must be committed to excellence in graduate and undergraduate education. To apply, please email in a single pdf file your CV, list of publications, description of current research and future plans, teaching philosophy, and contact information for five references to Professor Terry Oswalt, Department Head (email: HEPsearch@fit.edu). Applications will be reviewed beginning October 3, 2011 and will be accepted until the position is filled. Florida Institute of Technology is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

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

Sr. Research Associate I

The Head of the CLASSE RF group will be responsible for the RF systems of the four CLASSE accelerators and for the R&D program in RF associated with future ventures. Currently the primary research program centers on the Energy Recovery Linac design and development.

The operating accelerator RF systems comprise both normal conducting and superconducting systems and encompass S, L and UHF bands.

The successful candidate will supervise engineers and technicians and be involved in establishing RF R&D activities as needed to support current and future accelerator projects.

The successful candidate will have experience in RF design, construction and operation. Knowledge of the beam-cavity interaction and its impact on the corresponding RF system design is desirable.

A PhD in Electrical Engineering or Physics and at least seven years experience in high power RF systems and the low level RF systems that regulate them is required. Must be a leader in the field with significant publication list.

Please send a cover letter, including curriculum vitae and a publications list to Professor Georg Hoffstaetter, Newman Laboratory, Cornell University, Ithaca, NY 14853, and arrange for three letters of recommendation to be sent. Correspondence may be directed to search-classe@cornell.edu.

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Universität Hamburg

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Unterstützt von / Supported by

Alexander von Humboldt
Stiftung / Foundation

The School of **Mathematics, Informatics and Natural Sciences**, invites applications for a

W1 JUNIOR PROFESSORSHIP IN EXPERIMENTAL PHYSICS FOCUS ON ACCELERATORS OF HIGHEST ENERGIES

Starting as soon as possible **(ref. no. JP173)**

Applicants are expected to demonstrate research experience on an international level as well as a successful track record in procuring external project funding. The University places particular value on the quality of teaching. We therefore request applicants provide details of both their teaching experience and their future teaching objectives.

The University aims to increase the number of women in research and teaching and explicitly encourages women to apply. Equally qualified female applicants will receive preference in accordance with the Hamburg Higher Education Law.

Tasks and responsibilities:
The Department of Physics conducts cutting-edge research in particle physics (LHC, HERA, neutrino physics), astroparticle physics, astronomy, detector and accelerator development, nano-science and photon science in a very international environment.

We are searching for an outstanding scientist with experience in areas related to novel acceleration techniques aimed at application in energy-frontier machines for particle physics to play a leading role in a major new initiative associated with a Humboldt Professorship. In particular we are interested in aspects of laser-plasma acceleration and plan a comprehensive programme on investigations in this area over the next decade. This programme will utilise unique facilities and integration expertise available at Deutsches Elektronen Synchrotron (DESY). We seek persons with experience in some or all of the following areas: plasma wake-field acceleration; modelling and properties of plasmas; high-power laser techniques; accelerator physics.

Duties include holding lectures, exercise-classes and seminars as well as thesis supervision in courses offered by the Department of Physics.

Junior professors are obliged to teach four academic hours per week in the first four years of their professorship, rising to six academic hours per week in the final two years.

Requirements:
Conditions of employment are in accordance with § 18 of the Hamburg Higher Education Law.

Severely disabled applicants will receive preference over equally qualified non-disabled applicants.

Further information can be obtained from Prof. Dr. Brian Foster (Phone +49 40 8998 3201, email brian.foster@desy.de)

Applications should include a curriculum vitae, a list of publications, details of teaching experience and proposals for future courses. The deadline for applications is **31st October 2011**. Please send applications, accompanied by the **reference number JP173**, to: Präsident der Universität Hamburg, Referat Organisation & Personalentwicklung, Ausschreibungsstelle, Moorweidenstraße 18, 20148 Hamburg, Germany or via email to: UniHHAusschreibungsstelle@verw.uni-hamburg.de.

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Accelerator | Photon Science | Particle Physics

DESY

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

Unterstützt von / Supported by

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ACCELERATOR & PARTICLE PHYSICS RESEARCH.

DESY, Hamburg location, is seeking to fill several positions:

Postdocs and Postgraduate Students (m/f)

DESY
DESY is one of the world's leading accelerator centres for the investigation of matter. Within its mission DESY develops, runs and scientifically exploits accelerators and detectors for the research with photons and for particle physics.

The award of an Alexander von Humboldt Professorship to Professor Brian Foster will result in a number of vacancies in the fields of accelerator research aimed at reaching the highest possible energies, in particular in fields relating to superconducting radio-frequency acceleration techniques, plasma wakefield acceleration and in particle physics research.

DESY is seeking two postdocs in the following areas:

- Analysis of ZEUS data and combination with H1 data to form final HERA physics results, to be combined with work in another area of the DESY particle physics research programme
- Accelerator physics related to the areas referred to above, including knowledge of beam optics and the design and operation of accelerators; the successful candidate will be expected to work closely with the accelerator department at DESY in the conception and operation of facilities at for example FLASH to carry out the research programme described above

Requirements
- PhD in physics or engineering
- experience in at least one of the above mentioned research topics
- good communication and leadership skills

In addition DESY is seeking two students in each of the above areas, with the possibility of working in both areas if desired:

Requirements
- Masters degree or equivalent in physics or engineering
- enthusiasm for at least one of the above mentioned research topics
- good communication skills

For further information, please contact Prof. Dr. Brian Foster (email brian.foster@desy.de, Phone +49 40 8998 3201).

The postdoc positions are limited initially to a period of 3 years. Salary and benefits are commensurate with those of public service organisations in Germany and will be at the E13 or E14 levels, depending on experience and qualification. DESY operates flexible work schemes. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. There is a bilingual German-English Kindergarten on the DESY site.

Please send your application quoting the reference code, also by email, to:
Deutsches Elektronen-Synchrotron DESY
Human Resources Department, Code: 134/2011
Notkestraße 85, 22607 Hamburg, Germany
Phone: +49 40 8998 3392, email: personal.abteilung@desy.de
Deadline for applications: 31st October 2011
www.desy.de

The Helmholtz Association is Germany's largest scientific organisation.
www.helmholtz.de

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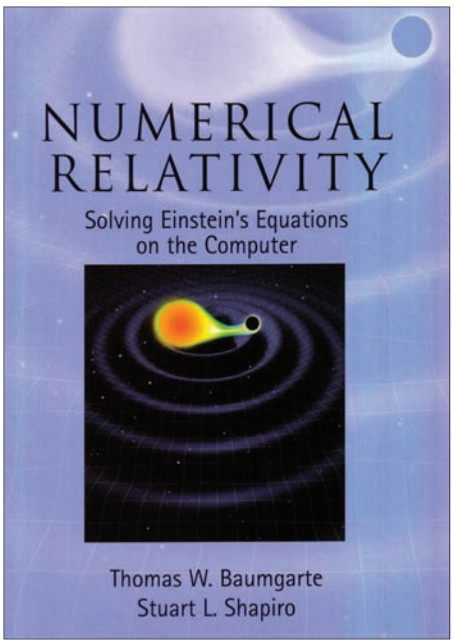
Bookshelf

Numerical Relativity. Solving Einstein's Equations on the Computer

By Thomas W Baumgarte and Stuart L Shapiro
Cambridge University Press
Hardback: £55 $90
E-book: $72

Symmetries are a powerful tool for solving specific problems in all areas of physics. However, there are situations where both exact and approximate symmetries are lacking and, therefore, it is necessary to employ numerical methods. This, in essence, is the main motivation invoked for the use of large-scale simulations in relativistic systems where gravity plays a key role, such as black-hole formation, rotating stars, binary neutron-star evolution and even binary black-hole evolution.

Numerical Relativity by Thomas Baumgarte and Stuart Shapiro is an interesting and valuable contribution to the literature on this subject. Both authors are well known in the field. Shapiro, together with Saul Teukolsky, wrote a monograph on a related subject – *Black Holes, White Dwarfs and Neutron Stars* (John Wiley & Sons 1983) – that is familiar to students and researchers. The careful reader will recognize various similarities in the overall style of the presentation, with systematic attention to the details of the mathematical apparatus. In *Numerical Relativity*, 18 chapters are supplemented by a rich appendix. The first part could be used by students and practitioners for tutorials on the so-called Adler-Deser-Misner formalism and, ultimately, on the correct formulation of the Cauchy problem in general relativity.



It seems that the authors implicitly suggest that the future of numerical relativity is closely linked to our experimental ability to observe directly general relativistic effects at work. While astrophysics and gravitational waves have so far provided a rich arena for the applications, the intrinsic difficulties in detecting high-frequency gravitational waves with wide-band interferometers, such as LIGO and VIRGO, might suggest new cosmological applications of numerical techniques in the years to come. This book will take you into an exciting world populated by binary neutron stars and binary black holes.

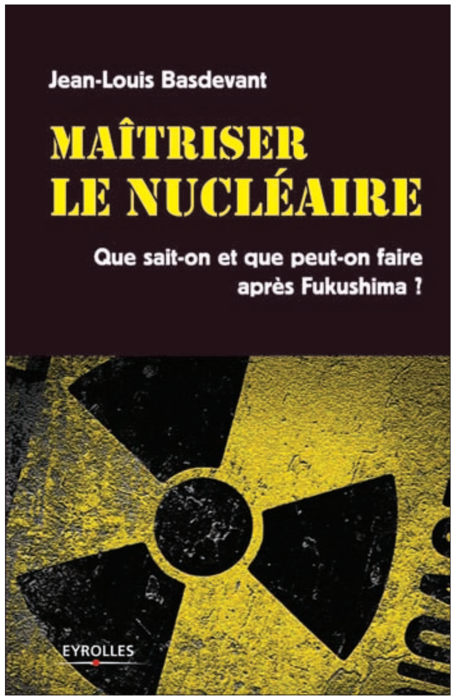
Still, the achievements of numerical relativity (as well as those of all of the other areas of physics where large-scale computer simulations are extensively used) cannot be reduced simply to the quest for the most efficient algorithm. At the end of nearly 700 pages, the reader is led to reflect: is it wise to commit the research programme of young students and post-docs solely to the development of a complex code? After all, the lack of symmetry in a problem might just reflect the inability of physicists to see the right symmetries for the problem. A balanced perspective for potential readers can be summarized in the words of Vicky Weisskopf, when talking about the proliferation of numerical methods in all areas of physics: "[...] We should not be content with computer data. It is important to find more direct insights into what a theory says, even if such insights are insufficient to yield the numerical results obtained by computers" (*Joy of Insight: Passions of a Physicist*, Basic Books, 1991).

● *Massimo Giovannini, CERN and INFN Milan-Bicocca.*

Maîtriser le nucléaire : Que sait-on et que peut-on faire après Fukushima ?

par Jean Louis Basdevant
Editions Eyrolles
Broché: €17,50

Jean Louis Basdevant, ancien professeur à l'Ecole Polytechnique où il donna d'excellents cours, et auteur de nombreux livres pédagogiques, vient de réussir un tour de force en écrivant un livre sur les problèmes du nucléaire en moins d'un mois à la suite de la catastrophe de Fukushima. C'est un livre très pédagogique qui commence par un historique de la radioactivité, puis un exposé du b-a ba de la physique nucléaire, suivi d'une description des avantages et des dangers de



la radioactivité dont il quantifie les effets. Suit une description de la fission, puis de la production d'énergie nucléaire présente et future (si les hommes le veulent!), y compris la proposition de fission induite par accélérateur tel que celui proposé par Carlo Rubbia. Vient alors la description de accidents : Lucens (négligeable) , Three Mile Island, Tchernobyl (y compris une mise au point sur les doses reçues en France, en fait faibles), et Fukushima, avec une analyse des erreurs et même des fautes qui ont conduit à ces catastrophes.

On passe alors à la fusion, par confinement magnétique et aussi inertielle. Le diagnostic n'est pas très optimiste. Le calendrier d'ITER est sans cesse repoussé et ITER ne produira pas d'énergie électrique. Tout ceci suivi de quelques données sur l'énergie.

On passe aux armes nucléaires et thermonucléaires et leur fonctionnement ou encore les affreuses bombes à neutrons, la lutte contre la prolifération, les dangers du terrorisme, avec la facilité de construire des bombes artisanales, et aussi les bombes classiques contenant des matériaux radioactifs.

Finalement le dernier chapitre est intitulé : « que penser et que faire après Fukushima ». L'auteur se contente de donner des éléments de réponse, sans prendre explicitement parti. Les décideurs devraient certainement lire ce livre pour se faire une opinion sérieuse au lieu de se laisser aller à des réactions

Bookshelf

émotionnelles incontrôlées. Je recommande vivement la lecture de ce livre.

Bien qu'il soit en Français, je recommande également ce livre aux anglophones : le Français est simple et compréhensible.

● *André Martin, CERN.*

Books received

Perspectives on Supersymmetry II

By Gordon L Kane (ed.)

World Scientific

Hardback: £97 $141

Paperback: £45 $65

Being an update of *Perspectives on Supersymmetry* published in 1998, which was also edited by Gordon Kane, this volume begins with an excellent pedagogical introduction to the physics and methods and formalism of supersymmetry. It is accessible to anyone with a basic knowledge of the Standard Model of particle physics. Next comes an overview of open questions, followed by chapters such as how to detect superpartners and tools for studying them, the current limits of superpartner masses on entering the LHC era, the lightest superpartner as a dark-matter candidate in thermal and non-thermal cosmological histories, and associated Z' physics. Most chapters have been extended and updated from the earlier edition, while some are new.

Nuclear Collective Motion: Models and Theory

By David J Rowe

World Scientific

Hardback: £55 $89

Paperback: £28 $42

E-book: $116

Two of the most important developments in nuclear physics have been the shell model and the collective model. A third, based on variational and mean-field methods, brings these two approaches together in the so-called unified models. These three approaches provide the foundations on which nuclear physics is based. They need to be understood by everyone practicing or teaching nuclear physics. This book provides a simple presentation of the models and the theory of nuclear collective structure, with an emphasis on the physical content and the ways they are used to interpret data.

Electromagnetic Analysis Using Transmission Line Variables (2nd edition)

By Maurice Weiner

World Scientific

Hardback: £89 $130

E-book: $169

In this book, the author employs a relatively new method for solving electromagnetic problems, making use of a transmission line matrix. Mathematically, the procedures are identical to traditional numerical methods; however, the matrix becomes a launch pad for many improvements in the analysis, using more modern notions of electromagnetic waves. In this second edition, major revisions occur in chapters IV and VII, which now present an up-to-date treatment of plane-wave correlations and decorrelations, as well as provide a revised formulation of simulation to solve transient electromagnetic problems.

Introduction to the Theory of Critical Phenomena: Mean Field, Fluctuations and Renormalization (2nd edition)

By Dimo I Uzunov

World Scientific

Hardback: £88 $142

Paperback: £48 $78

This introduction to the theory of phase transitions and critical phenomena covers a period of more than 100 years of theoretical research, providing a clear interrelationship with experimental problems. Starting from a basic university-level knowledge of thermodynamics, statistical physics and quantum mechanics, it explains various types of phase transition and (multi)critical points. The classic aspects of the theory are naturally related with modern developments. This new edition contains a more detailed presentation of the renormalization group method and its applications to particular systems.

The Light Fantastic: A Modern Introduction to Classical and Quantum Optics (2nd edition)

By Ian R Kenyon

Oxford University Press

Hardback: £70 $126

Paperback: £35 $62.95

Kenyon's thorough introduction to modern classical and quantum optics is appropriate for advanced undergraduates or beginning graduates. Digital cameras, LCD screens, laser welding and the optical fibre-based internet illustrate the penetration of optics in 21st century life, many such applications being presented from first principles. This thoroughly revised and updated edition includes new coverage of photonic crystals and Bloch waves, as well as quantum dots and microcavities.

Elements of Phase Transitions and Critical Phenomena

By Hidetoshi Nishimori and Gerardo Ortiz

Oxford University Press

Hardback: £49.95 $89.95

This introductory account of the theory of phase transitions and critical phenomena reflects lectures given by the authors to graduate students and is thus classroom-tested to help beginners enter the field. Most parts are written as self-contained units and every new concept or calculation is explained in detail without assuming prior knowledge of the subject. The book enhances and revises one that is a bestseller in the Japanese market and considered a standard textbook in the field. It contains new pedagogical presentations of field theory methods, including a chapter on conformal field theory.

Muon Spin Rotation, Relaxation and Resonance: Applications to Condensed Matter

By Alain Yaouanc and Pierre Dalmas de Réotier

Oxford University Press

Hardback: £75 $135

Primarily intended for postgraduate students and researchers of condensed-matter science, chemical physics and material science, who plan to use the muon-spin rotation, relaxation and resonance (μSR) techniques, this book combines for the first time a detailed discussion of the physical information contained in the measured polarization functions with real examples. The first part presents typical results of the application of μSR and explains the basic principles involved. The second part, the core of the book, provides a comprehensive discussion of the measured polarization functions. In the third part, the authors analyse examples from the following fields: diffusion properties of muon and muonium, magnetism, superconductivity and muonium centres in materials.

Elementary Scattering Theory: For X-ray and Neutron Users

By D S Sivia

Oxford University Press

Hardback: £39.95 $71.95

Paperback: £19.95 $35.95

The opportunities for doing scattering experiments at synchrotron and neutron facilities have grown rapidly in recent years and are set to continue to do so. This text provides a basic understanding of how these techniques enable the structure and dynamics of materials to be studied at the atomic and molecular level. Although mathematics cannot be avoided in a theoretical discussion, the aim has been to write a book that most scientists will still find approachable. To this end, the first two chapters are devoted to providing a tutorial background in the mathematics and physics that are implicitly assumed in other texts.

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  Bandwidth: 100 MHz
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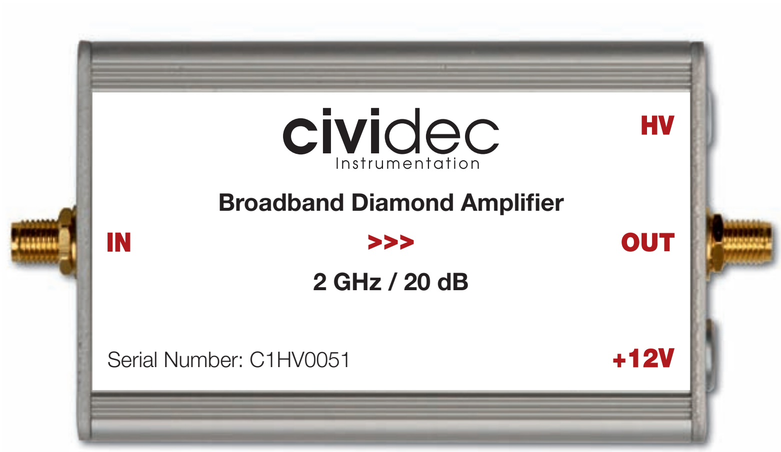
  Peaking time: 4 ns

APPLICATION EXAMPLE:

CERN LHC – **Diamond Beam Loss Monitor**
DBLM are installed complementary to the ionization chambers of the base machine | **radiation-hard pre-amplifier** | <1 ns time resolution | single MIP resolution | high dynamic range



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Bookshelf

Emission Detectors

By Alexander I Bolozdynya

World Scientific

Hardback: £37 $60

E-book: $78

After decades of research and development, emission detectors have recently become the most successful instrumentation used in modern fundamental experiments searching for cold dark matter, and are also considered for neutrino coherent scattering. This book is the first monograph exclusively dedicated to emission detectors. It reviews the properties of two-phase working media based on noble gases, saturated hydrocarbon, ion crystals and semiconductors. It should interest detector physicists and experimentalists, nuclear engineers, materials scientists, and advanced graduate students in physics and medical imaging.

Six Quantum Pieces: A First Course in Quantum Physics

By Valerio Scarani with Chua Lynn and Liu Shi Yang

World Scientific

Hardback: £30 $48

Paperback: £15 $24

This original approach to quantum physics combines the competence of a well known researcher in quantum information science and the freshness in style of two high-school students. Quantum physics is challenging because it describes counter-intuitive phenomena and employs rather advanced mathematics. The description of "traditional" quantum phenomena (such as the structure of atoms and molecules) does indeed involve the whole formalism. However, other striking phenomena – the most "typically quantum" ones – can be described using only high-school mathematics. This course exploits this fact, making it possible for a beginner to tackle mind-boggling experiments such as teleportation and the violation of Bell's inequalities.

Introductory Quantum Physics and Relativity

By Jacob Dunningham and Vlatko Vedral

Imperial College Press

Hardback: £50 $80

Paperback: £26 $42

The authors have based this introduction to the two pillars of modern physics on the lecture courses that they taught at the University of Leeds. It contains all of the necessary material for quantum physics and relativity in the first two years of a typical physics degree course. The choice of topics complies fully with the Institute of Physics guidelines but the coverage also includes more interesting and up-to-date applications, such as Bose condensation and quantum teleportation.

Modern Aspects of Superconductivity: Theory of Superconductivity

By Sergei Kruchinin, Hidemi Nagao and Shigeyuki Aono

World Scientific

Hardback: £62 $90

E-book: $117

Written for students and researchers of superconductivity, this book discusses aspects of the experiment and theory surrounding superconductivity. New experimental investigations of magnetic and thermodynamic superconducting properties of mesoscopic samples are explored, and the results are predicted based on theoretical models in nanoscale superconducting systems. Topics include high-T_c superconductivity, two-gap superconductivity in magnesium diborades, room-temperature superconductivity and the mechanism of superconductivity.

Supersymmetric Quantum Mechanics : An Introduction

By Asim Gangopadhyaya, Jeffry V Mallow and Constantin Rasinariu

World Scientific

Hardback: £50 $80

Paperback: £25 $40

The aim of this book is to provide a single compact source for those who want to understand the essentials of supersymmetric quantum mechanics (SUSYQM). The text contains a large selection of examples, problems and solutions that illustrate the fundamentals and its applications. It is richly illustrated and contains an attractive and relevant list of topics.

Fundamentals of Quantum Information

By Hiroyuki Sagawa and Nobuaki Yoshida

World Scientific

Hardback: £36 $58

This introduction to the basic concepts of quantum computation and information seeks to provide intuitive and transparent ideas of the subjects, in a way that is not strictly mathematical. Aimed at undergraduate and graduate students, it is self-contained and unified in its description of the cross-disciplinary nature of this field. It starts with the quantum bits and the entangled states, which turn out to bring revolutionary ideas in information theory. Quantum mechanics and mathematical tools are explained with many examples and illustrations. There are exercises at the end of each chapter, with detailed solutions provided at the end of the book.

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x724	VME	8	100	14	0.5 / 2.25 / 10	SE / D	40	0.5 / 4	PHA
	Desktop/NIM	4 / 2				SE			
x720	VME	8	250	12	2	SE / D	125	1.25 / 10	CI, PSD
	Desktop/NIM	4 / 2				SE			
x721	VME	8	500	8	1	SE / D	250	2	no
x731	VME	8 - 4	500 - 1000	8	1	SE / D	250 / 500	2 / 4	no
x730 COMING SOON	VME	8	500	12	2	SE / D	250	1.25 / 10	PSD
	Desktop/NIM	4 / 2				SE			
x751	VME	8 - 4	1000 - 2000	10	1	SE / D	500	1.8 / 14.4 - 3.6 / 28.8	PSD
	Desktop/NIM	4 - 2				SE			
x761	VME	2	4000	10	1	SE / D	TBD	7.2 / 57.6	no
	Desktop/NIM	1				SE			
x740	VME	64	62.5	12	2 / 10	SE	30	0.19 / 1.5	no
	Desktop/NIM	32							
x742	VME	32+2	5000 (2)	12	1	SE	600	0.128 / 1 (3)	no
	Desktop/NIM	16+1							

(1) The x in the model name is V1 for VME, VX1 for VME64X, DT5 for Desktop and N6 for NIM
(2) Sampling frequency of the analog memory (switched capacitor array); A/D conversion takes place at lower speed (dead-time)
(3) The memory size for the x742 is 128/1024 events of 1024 samples each
(4) The indication *"size 1/ size 2"* denotes different options
(5) Digital Pulse Processing (DPP) firmware:
DPP-PHA: Pulse Height Analysis (Trapezoidal Filters), DPP-CI: Charge Integration (digital QDC), DPP-PSD: Pulse Shape Discrimination

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September 05 - 09, 2011

FUNFI *- Fusion for Neutrons and Sub-critical Nuclear Fission*
September 12 - 15, 2011

XCVII Congresso Nazionale Società Italiana di Fisica
September 19 - 23, 2011

TWEPP-11 *Topical Workshop on Electronics for Particle Physics 2011*
September 26 - 30, 2011