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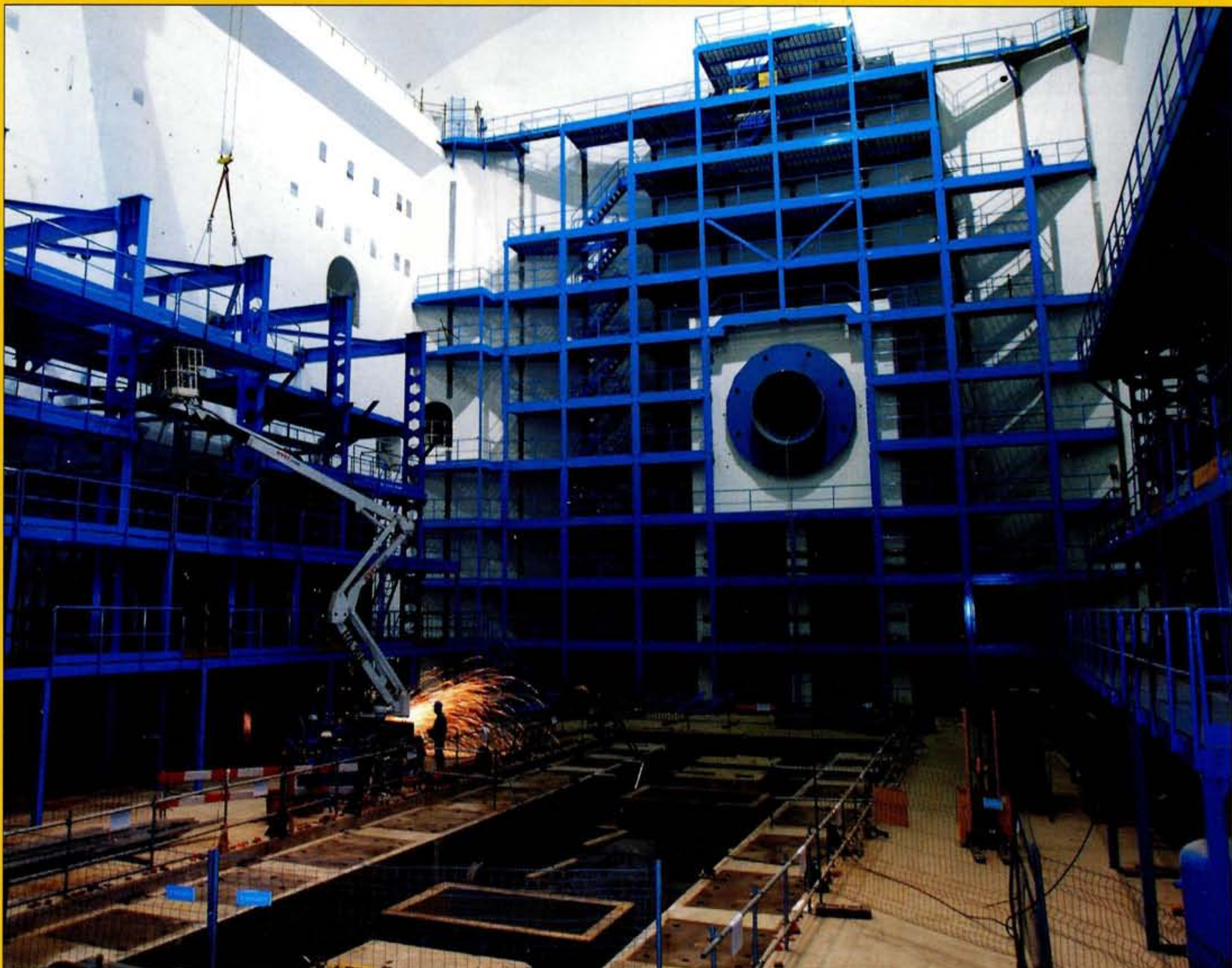

ATLAS begins to fill the cavern

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

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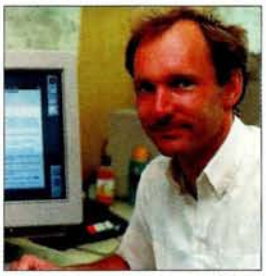

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Cover: Almost every day brings changes in the ATLAS cavern at CERN, as preparations are made for the installation of the detector. This recent image taken in October 2003 shows the progress made since July with installing support structures (p26).

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NEWS

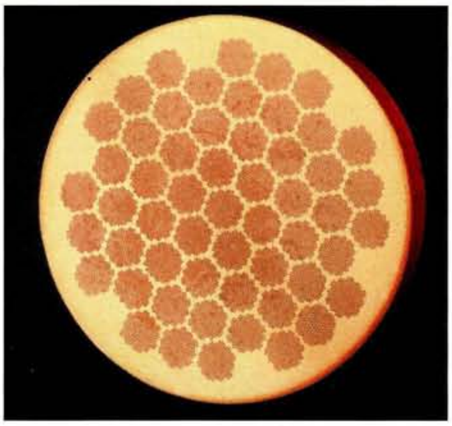
NOBEL PRIZES

Superconductivity links physics and medicine

The 2003 Nobel prizes in physics and physiology or medicine both have connections with the field of particle physics. Alexei Abrikosov, Vitaly Ginzburg and Anthony Leggett have received the physics prize for "pioneering contributions to the theory of superconductors and superfluids", while Paul Lauterbur and Peter Mansfield were rewarded for discoveries in magnetic resonance imaging (MRI), which is in turn a major use for superconducting magnets.

The most important superconducting materials technically have proved to be type-II superconductors, which allow superconductivity and magnetism to exist at the same time. Type-I superconductors expel a magnetic field in what is known as the Meissner effect, and lose their superconductivity at high magnetic fields. However, type-II superconductors – generally alloys of various metals – exhibit only a weak Meissner effect, or none at all, and retain their superconductivity at high magnetic fields. Superconducting magnets are now routinely used in particle accelerators, and the magnets used for CERN's Large Hadron Collider (LHC) are based on coils of niobium-titanium alloy, a type-II superconductor.

Abrikosov, who is now at Argonne National Laboratory, was working at the Kapitsa Institute for Physical Problems in his native Moscow when he succeeded in formulating a new theory to explain the behaviour of type-II superconductors, which cannot be explained by the earlier BCS theory (Nobel prize 1952).



A superconducting strand for the LHC magnets made of around 8000 filaments of niobium-titanium alloy – a type-II superconductor – embedded in copper.

In Abrikosov's theory, the external magnetic field penetrates the type-II material through channels between vortices in the "electron fluid" in the material. This theory was based on work in the 1950s by Ginzburg at the P N Lebedev Physical Institute in Moscow.

Superfluidity is another low-temperature phenomenon that will become large scale with the LHC. Liquid helium, which is used to cool superconducting magnets, becomes superfluid at temperatures below its boiling point and takes on heat transfer properties that allow efficient heat removal over the large distances involved in the LHC. The helium used to cool the LHC magnets is the common isotope, helium-4, which becomes superfluid around 2 K. However, helium also exists as a rarer isotope, helium-3, which is superfluid only at much lower temperatures of mK. While helium-4 is a boson, helium-3 is a fermion, so the two isotopes have quite different quantum properties. The contribution of Leggett, now at the University of Illinois, Urbana, was to develop the decisive theory, while at Sussex in the UK in 1970s, to explain how helium-3 atoms interact and become ordered in the superfluid state.

There is a link between this year's physics prize and the prize in medicine, as one of the major uses for superconducting magnets is in MRI. The nuclear resonance phenomenon used in MRI was first demonstrated, for protons, in 1946 by Felix Bloch and Edward Mills Purcell, who received the Nobel prize in 1952. In a further connection with particle physics, Bloch went on to be the first director-general of CERN until 1955. It was 20 years, however, before Lauterbur, from Urbana, Illinois, discovered in 1973 how to create 2D pictures by introducing gradients in the magnetic field. Peter Mansfield of Nottingham in the UK developed this idea further by showing how the resonance signals could be mathematically analysed to make a useful imaging technique. He also demonstrated how extremely fast imaging could be achieved. Today, MRI is used to examine almost all organs of the body, and is especially valuable in imaging the brain and spinal cord.

SOLAR NEUTRINOS

SNO gets results with a large pinch of salt

New results from the Sudbury Neutrino Observatory (SNO) are beginning to pin down more precisely the parameters for mixing between different types of neutrino.

Unlike other neutrino detectors, SNO can detect neutrinos in three different ways through its use of heavy water. Only electron neutrinos give rise to charged-current reactions with deuterons in the water, while all types of active neutrino can scatter elastically off the deuterons or induce neutral current (NC) reactions. In the NC reactions the neutrino splits the deuteron into a proton and a neutron, and the gamma rays emitted when the neutron is subsequently captured by another nucleus provide the signature for the reaction.

For the earlier analyses based on events detected with pure heavy water, the SNO collaboration assumed an energy-independent survival probability for the neutrinos. While this allowed the team to say that their data show that electron neutrinos must oscillate to another type, it was not sufficient for calculating the constraints on parameters in MSW mixing. For the new measurements, the team added 2 tonnes of high-purity sodium chloride to the 1000 tonnes of heavy water in the detector. This increased the detection efficiency for NC events three-fold, due to neutron capture on chlorine-35 nuclei. The increased sensitivity allowed them to measure the total active boron-8 solar-neutrino flux, which was found to agree with standard solar-model calculations. A global analysis of solar and reactor neutrino results, including the new measurements, yields $\Delta m^2 = 7.1 + 1.2/-0.6 \times 10^5$ eV^2 and $\theta = 32.5 + 2.4/-2.3°$, disfavouring maximal mixing at a confidence level equivalent to 5.4σ.

Further reading

http://arxiv.org/abs/nucl-ex/0309004.

PARTICLE SOURCES

Laser ion source heads for new life

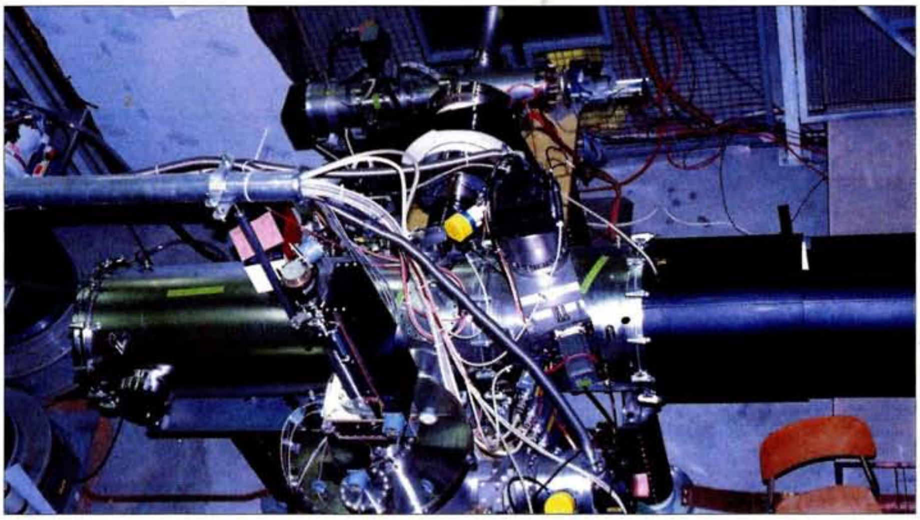
On 22 August the last of three Russian trucks left CERN for Moscow carrying, as a long-term loan, a laser ion source in 93 boxes with a total volume of 150 m^3 and a weight of 42 tonnes. This marked the end of more than 10 years of R&D work on a high current, high charge state, heavy ion source that has the potential to provide beam for the Large Hadron Collider (LHC) and other heavy ion accelerators demanding extremely high beam intensities, such as the Terawatt Accumulator, TWAC, at Moscow (*CERN Courier* May 1998 p6). At the same time, the journey marked the beginning of a new phase in the life of the laser ion source (LIS).

Only three different types of source are thought able to reach the performance needed for high-intensity heavy ion machines: the electron-beam ion source (EBIS); the LIS, which has been studied in close collaboration between CERN and Russia; and the electron cyclotron resonance ion source (ECRIS), which is used in combination with an accumulator ring to fatten the beam.

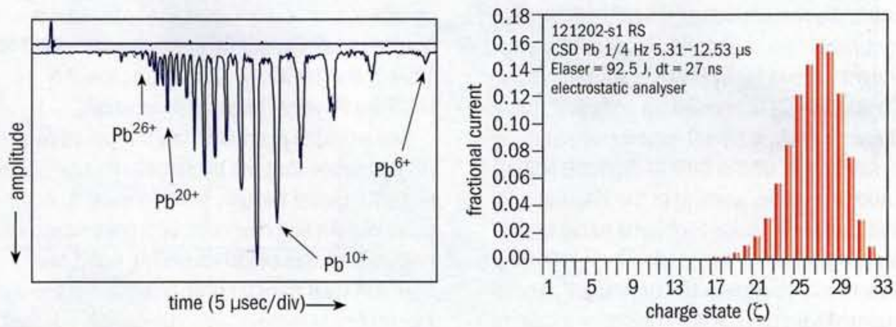
In the LIS developed at CERN, intense laser radiation heats the target surface causing the emission of atoms and a plasma containing low charge-state ions. This plasma is then heated by the laser radiation, such that the ions are ionized 20–30 times. These ions are then extracted by an electrostatic field before acceleration by a radio-frequency quadrupole (RFQ).

For many years studies were done with a commercially available CO_2 laser providing a 30 J pulse every 30 seconds, but its energy, pulse form and pulse repetition rate were far from the parameters required to produce an ion beam for LHC. The present Heavy Ion Linac at CERN, LINAC3, feeding the PS Booster in single-turn injection, would need a 5 µs long pulse with some 10^{10} lead ions in charge state 25+, every second. For this reason the two Russian institutes in the collaboration, ITEP and TRINITI, designed and built a CO_2 laser capable of delivering 100 J pulses in 27 ns with a 1 Hz repetition rate. The project was co-funded by the European Union and CERN.

With the new laser, power densities of 10^{13} W/cm^2 were obtained on the target of the ion source. For 1 Hz pulse trains lasting more than 60–70 minutes, statistical fluctuations in pulse amplitude and pulse width from shot to shot were less than ±15%.



The LIS target area. Laser light enters through the black pipe (right), and a mirror at the end (left) focuses the light, via another mirror, on the target in the chamber at the lower edge of the picture. The extracted ions then travel through the pipe passing up the image.



Measured charge-state distributions from 1992 (left) and December 2002 (right) show the progress made with the laser ion source over a decade.

The two measured charge-state distributions of ions shown in figure 1 demonstrate the progress over the past 10 years. The second distribution was obtained in December 2002, shortly before the source was shut down. Extrapolating current densities from the measuring point (an electrostatic analyser) to real extraction geometries leads to $1-2 \times 10^{10}$ Pb^{27+} in a pulse of 3–4 µs. The fact that with an RFQ and an interdigital-H-type (IH) RF structure, as used in LINAC3, three different charge states can be accelerated simultaneously up to the first stripper, gives confidence that LHC conditions can be fulfilled comfortably. Nevertheless, converting the laser prototype to a device satisfying LHC reliability standards, interfacing this source to LINAC3, and accelerating the ions to the energy needed at the entrance of the IH structure, meant further R&D. CERN, at present under pressure to reduce R&D work for the sake of LHC progress, decided to use LINAC3 (with an ECRIS) and LEIR, the former Low Energy Antiproton Ring, as the first heavy ion source. This freed the LIS for an immediate application at TWAC.

With the new CERN/ITEP Collaboration Agreement, the LIS will be used not only to produce medium-mass ions as required by TWAC for its daily operation, but also for R&D on source performance, which will continue in parallel. *Le roi est mort, vive le roi!*

CERN

A heavy load arrives for ALICE

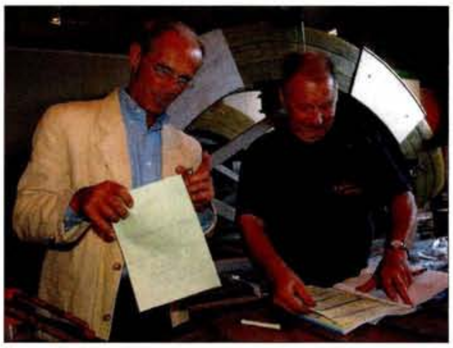
On 25 September the two large coils for the ALICE dipole magnet arrived at Point 2 of the Large Hadron Collider (LHC) after a 1200 km journey from their manufacturer. The two coils, which are 5 m long, 6 m wide, more than 3 m high, and weigh 20 tonnes each, were manufactured by Sigmaphi in Vannes, France. They will form the dipole magnet of the forward muon arm spectrometer of the ALICE detector.

Even loading the huge coils at Sigmaphi was not a simple task. The overhead crane could not be used to lift the coils plus their supports, so the coils had to be jacked up on rollers and pulled outside the hall, where a mobile crane lifted them onto the trucks. Moreover, the big door of the assembly hall was too small and part of the wall had to be cut open to roll out the coils. Once on the road, detours were necessary because of the height of bridges and so on.

The two coils will be installed within a 780 tonne iron yoke, which has been manufactured in Russia and is on its way to CERN. The dipole magnet will be used to identify high-momentum muon pairs and will be one of the biggest dipoles operating at room temperature. The impressive size and gap width between the poles of 3–4 m is necessary to obtain the required acceptance angle of 9°. The electrical power dissipation will be close to 4 MW, and to reach the nominal field of 0.7 T, it will be powered by a DC power converter providing 6000 A.

The convoy approaches CERN through the streets of the French town of Collonges.

The safe arrival of the coils at CERN.



CERN's Detlef Swoboda (left), project leader for the ALICE dipole magnet, takes delivery of the coils.

HADRON PHYSICS

Narrow states abound at HADRON 2003

Aschaffenburg, a medieval town near Frankfurt in Germany, was the attractive setting for the 10th International Conference on Hadron Spectroscopy, held from 31 August to 6 September. The reason the meeting was held in Germany for the first time in its history was the decision of GSI in Darmstadt to include hadronic physics in future research by constructing an antiproton source and a storage ring (HESR/PANDA) for antiprotons, thus extending the programme that was so successfully started with LEAR at CERN.

The conference, jointly organized by GSI and the Institute for Experimental Physics of the Ruhr–Universität Bochum, was attended by around 200 scientists from all over the world. The timing of the conference was very fortunate as many new and surprising results appeared in the months just prior to the meeting.

The highlights of this year's conference were the discussions about the nature of the recently discovered narrow states, the widths of which are compatible with the experimental mass resolutions, of the order of 10 MeV.

In the mesonic sector, new results came from BaBar, Belle, CLEO and BESII. Two narrow states with masses of 2317 and 2460 MeV with open charm and strangeness have been seen, and may be the missing 0^+ and 1^+ states (*CERN Courier* June 2003 ▷

HADRON PHYSICS

p6). Their masses and widths are, however, difficult to explain in standard quark model calculations, and so explanations in terms of D-K "molecules", D-π "atoms" and charmed four-quark states are under intense discussion. The observed pattern fits very well to chiral model predictions, giving additional weight to these ideas.

Belle has found another very narrow ($\Gamma < 3.5$ MeV) state at 3872 MeV decaying into $J/\psi\pi^+\pi^-$. Its properties do not fit the values expected for the still missing $1\,^3D_2\,c\bar{c}$ state well, therefore an explanation in terms of a $D^0\bar{D}^{0*}$ molecule is not excluded. BESII has reported a bump in the $p\bar{p}$ mass distribution, which might belong to a $p\bar{p}$ bound state below the $p\bar{p}$ threshold. However, this state still needs confirmation.

As far as baryons are concerned, there is evidence from four different laboratories for the existence of a narrow state, Θ^+ with a mass of 1540 MeV decaying to nK^+ (*CERN Courier* September 2003 p5). Having positive strangeness, it is a very exotic particle and cannot be constructed in a conventional three-quark picture. All signals have a significance of five standard deviations and their confirmation continues. Such a state was predicted six years ago using a soliton model giving rise to an antidecuplet with $J^P = 1/2^+$. The implications of these findings were discussed in several talks at the conference and in an open panel, resulting in many ideas for future measurements that will clarify the true nature of these states.

Additionally, there were some very interesting contributions concerning the properties of hadrons inside nuclear matter, the discovery of baryons with double charm and its implications, and the role of the sigma/kappa structures in low-energy $\pi\pi$ and πK scattering. Although new results concerning the sigma/kappa problem were presented, it is not yet clear if these structures can be attributed to particles or are effects of dynamical origin.

One outcome of the conference is that it has become very clear that the advent of precision data in the heavy quark sector is of high relevance for future developments in hadron physics, even in the light quark sector. It seems that the quark-antiquark and three-quark descriptions of hadrons have reached their limitations and have to be extended or replaced by new ideas, such as chiral models, soliton pictures, molecular states, and so on, which have to be taken more seriously than in the past.

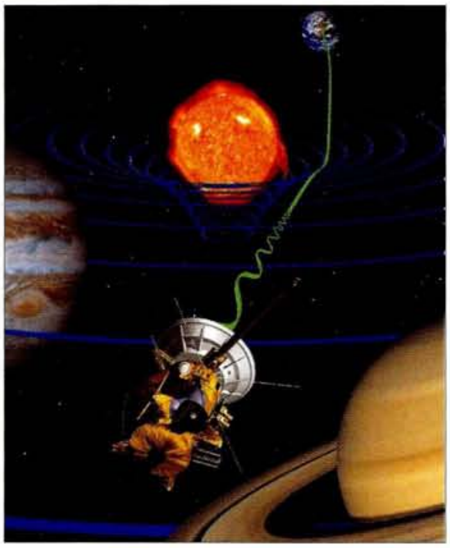
The proceedings of HADRON 2003 will be dedicated to Lucien Montanet from CERN, who died on 19 June this year (*CERN Courier* October 2003 p40). He belonged to the pioneers of hadron physics and his eminent role in this field was highlighted during a special plenary session in his honour. The next conference in the series is scheduled to take place two years from now in Rio de Janeiro, where there should be further exciting results. Undoubtedly, hadron physics has a bright future.

Compiled by Steve Reucroft and John Swain

Cassini gives general relativity a good test...

While most physicists are convinced that Einstein's theory of gravity in terms of a curved space–time geometry is basically correct, it is always good to check. Now researchers in Italy have made a new, more stringent test of general relativity using measurements of the frequency shift of radio signals to and from the Cassini spacecraft as it passed on the opposite side of the Sun from Earth. Bruno Bertotti of the University of Pavia and colleagues measured the parameter γ, which is unity in general relativity and zero in Newton's theory, and therefore indicates the degree to which gravity can be explained purely in terms of geometry without any additional forces.

The team found that $\gamma - 1 = 2.1 \pm 2.3 \times 10^{-5}$, which is a dramatic improvement over previous measurements that gave results at the 0.1% level, and strongly supports the idea that gravity is of purely geometrical origin, at least over distance scales of the order of our solar system. The improved accuracy is due to technological improvements implemented on the spacecraft's communication system and at NASA's ground station at Goldstone, California. Meanwhile, Cassini, a joint NASA/ESA mission, continues its journey towards Saturn, which it will begin orbiting on 1 July 2004.



This artist's impression shows the concept of the general relativity experiment. (Jet Propulsion Laboratory.)

Further reading

B Bertotti *et al.* 2003 *Nature* **425** 374.

...while relativity makes entropy more confused

Entropy is turning out to be more subtle than ever. As a measure of the number of microstates accessible to a system, entropy is clearly Lorentz-invariant, but now Donald Marolf of the University of California in Santa Barbara, Djordje Minic of Virginia Tech, and Simon Ross of Durham University have had a close look at what happens in transformations to non-inertial (accelerated) frames, and have found that things can become very tricky.

As with Hawking radiation, the Unruh effect predicts that the vacuum of an inertial observer will have particles in it as seen by an accelerated observer. It is not immediately obvious then what can be said about the corresponding entropies, and a great deal of careful rethinking about statistical thermodynamics may be in order. With luck, when the dust settles, the results may be comparable to those after it was realized that the second law had to be revised if black holes were to be accounted for properly.

Further reading

http://xxx.lanl.gov/abs/hep-th/0310022.

Single molecule able to store memories

A new approach to memory devices stores ones and zeros on individual molecules. Fraser Stoddart and collaborators at the University of California in Los Angeles have shown that individual organic molecules called catenanes, held between carbon nanotubes and metal electrodes, can be used to store data. Each catenane molecule has two linked rings that can rotate relative to each other depending on an applied voltage. The nanotubes act as incredibly thin wires, and also bond chemically to the catenanes. These memory elements can be very small – a gramme of organic molecules could, in principle, be enough to make all the memories for all the new computers worldwide for several years.

Further reading

A Goho 2003 *Science News* **164** 182.

New display device creates E-paper

Paperless offices, paperless journals – and now paperless paper? Robert Hayes and B J Feenstra of Philips Research Eindhoven in the Netherlands have developed a new display device that acts like a sheet of paper, but can display images fast enough to be used for video. The idea is to use an applied voltage to control the degree to which a droplet of coloured oil mixed with water in a tiny pixel wets a white reflective surface. Contrast and reflectivity are far higher than can be obtained with liquid-crystal displays, so this looks like a technology that might really take off quickly.

Further reading

R A Hayes and B J Feenstra *et al.* 2003 *Nature* **425** 383.

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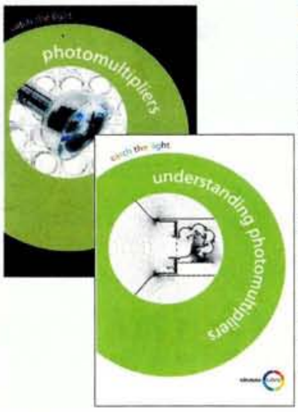

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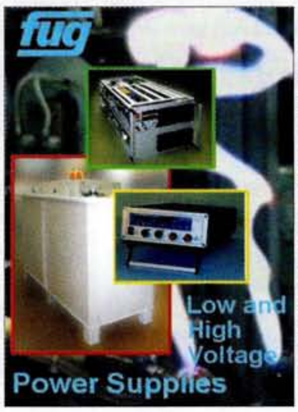

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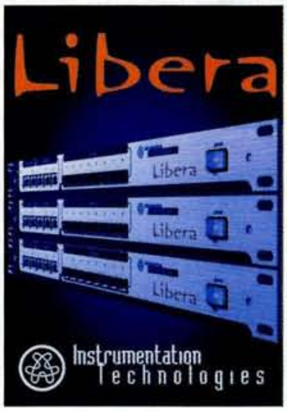

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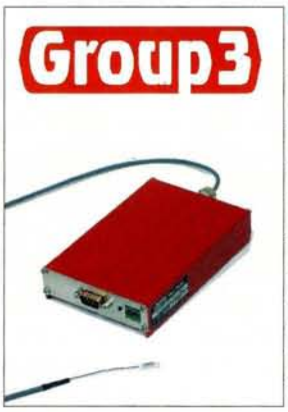

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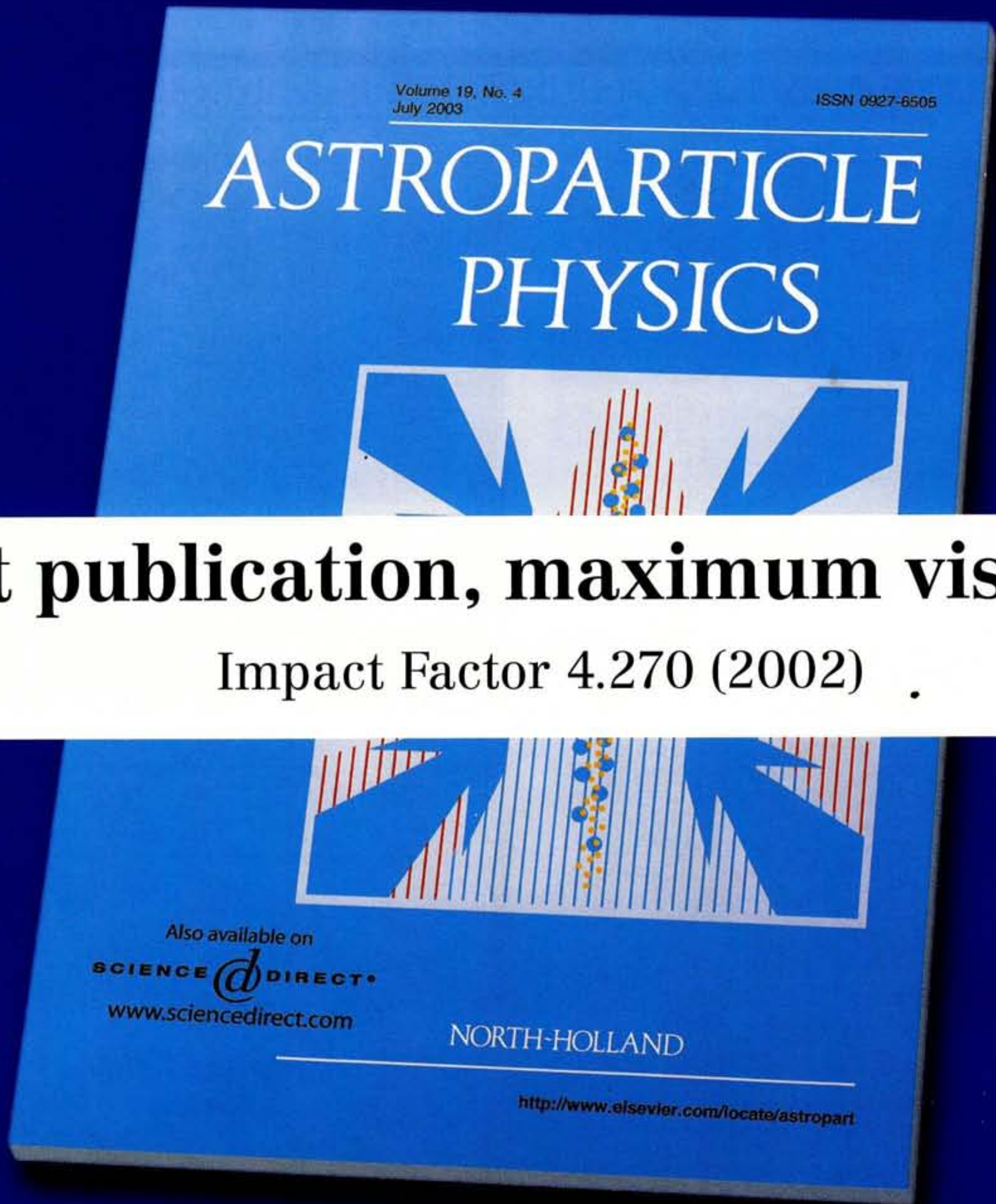
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Compiled by Marc Türler

Evidence for spinning black holes in our galaxy

Do all black holes spin? How fast do they spin? The most detailed studies of stellar black holes to date by NASA's Chandra X-ray Observatory and the European Space Agency's XMM-Newton satellite have found observational evidence that some stellar black holes have high spin rates.

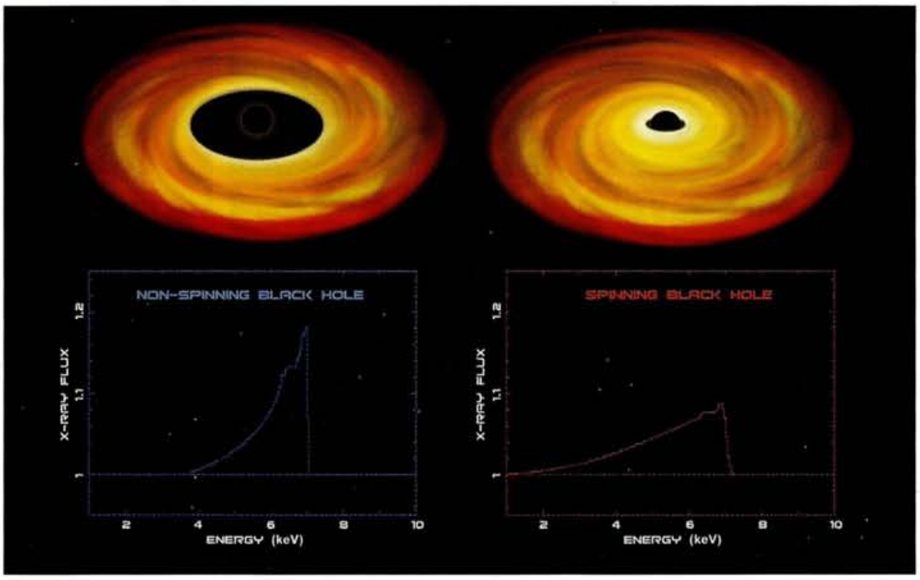
Stellar black holes have masses between five and 20 times that of the Sun. They are probably formed during supernova explosions, when the core of a massive star collapses once its nuclear fuel is exhausted. A gamma-ray burst might be the signature of such an event (*CERN Courier* September 2003 p15).

Black holes remain hidden in our galaxy unless they are close enough to another star to manifest their strong gravitational pull. In tight binary systems composed of a star and a black hole rotating around each other, the black hole strips the star of its outer layers. This material then forms a swirling disc of gas around the compact object. The gas rotates faster the closer it gets to the black hole and is heated, due to friction, to up to tens of millions of degrees. At such temperatures the gas is ionized and emits X-rays.

Iron atoms in the swirling gas around a black hole produce distinctive emission lines. These spectral features can be used to study the orbits of particles around the black hole. For example, the gravity of a black hole can shift the emitted X-rays to lower energies. The orbit of a particle near a black hole depends on the curvature of space induced by the black hole, which also depends on how fast the black hole is spinning. A spinning black hole drags space around with it and allows atoms to orbit closer to the black hole than is possible for a non-spinning black hole.

The latest Chandra data from Cygnus X-1, the first stellar-sized black hole discovered, show that the gravitational effects on the signal from the iron atoms can only be due to relativistic effects around a black hole. However, there is no evidence for a spinning black hole in Cygnus X-1. The XMM-Newton observations of the binary system XTE J1650-500 show a very similar distribution of iron atom X-rays, but with more low-energy X-rays coming from deep in the gravitational well around the black hole, at only about 30 km from the black hole event horizon. An orbit as close to the black hole as this can only be stable if the black hole is spinning rapidly. Evidence for another spinning black hole has been obtained by the Chandra observations of a third binary system, GX 339-4.

To explain why some stellar black holes spin rapidly and others do not, a likely possibility is that the spin rate depends on how long the black hole has been devouring matter from its companion star, a process that makes the black hole spin faster. Black holes with more rapid spin, XTE J1650-500 and GX 339-4, have low-mass companion stars. These relatively long-lived stars may have been feeding the black hole for longer, allowing it to spin up to faster rates. Cygnus X-1, with its short-lived blue giant companion star, may not have had enough time to spin up.



Matter can orbit closer to a black hole if the black hole is spinning rapidly. The spin rate can be derived from the more or less elongated shape of the X-ray emission line emitted by iron atoms swirling around the black hole. (Illustration: NASA/CXC/M Weiss; Spectra: NASA/CXC/SAO/J Miller et al.)

Picture of the month

This beautiful picture of the galaxy NGC 3982 is just one of the images that are being collected of hundreds of galaxies by the NASA/ESA Hubble Space Telescope, in the hope that one of the millions of resolved massive stars will some day explode as a supernova. The European astronomers leading this project will then look back into these images to pinpoint the exact star that has exploded. Up to now, only two such supernova "mother stars" have been identified. (ESA and Stephen Smartt, University of Cambridge.)

Further reading

J Miller *et al.* 2003 www.arxiv.org/astro-ph/0307394 and *ApJ* (in press).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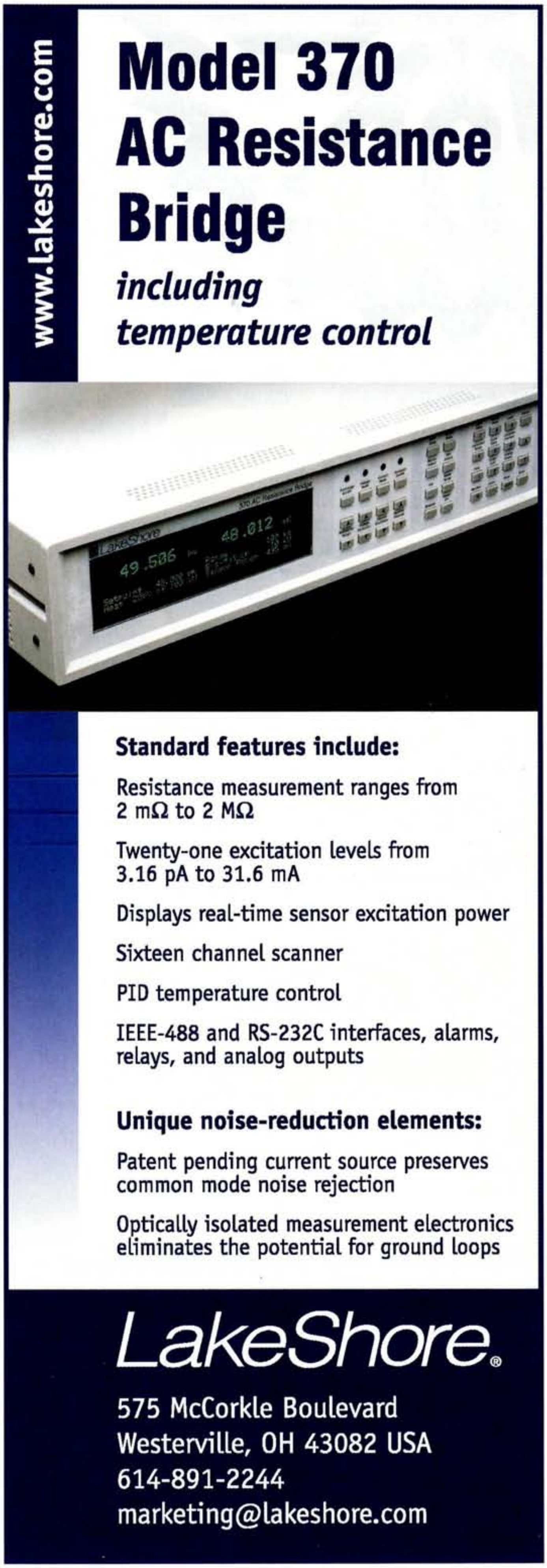
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International interactions at Fermilab

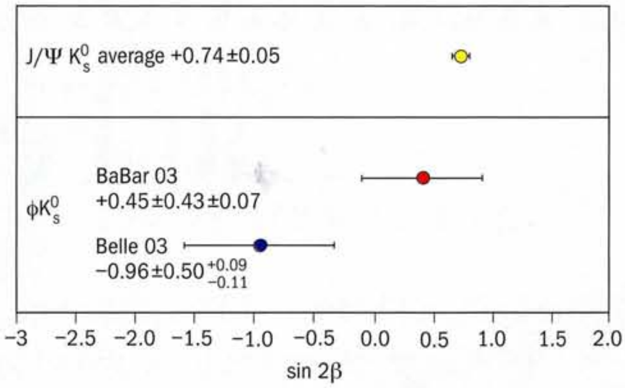
The Lepton Photon 2003 conference, hosted by Fermilab, provided an opportunity to take stock and to look ahead to TeV-scale physics in the coming decade. **John Womersley** and **James Gillies** report.

The directors of seven particle-physics laboratories who met with the press during the conference. From left: Michael Witherell of Fermilab, Albrecht Wagner of DESY, Yoji Totsuka of KEK, Sergio Bertolucci of INFN, Jonathan Dorfan of SLAC, Luciano Maiani, director-general of CERN, Robert Aymar, director-general elect of CERN and Mikhail Danilov of ITEP. (Fermilab.)

The big international summer conferences provide the venue for high-energy physicists to show their newest results in front of a large, influential audience. While delegates always hope for something new and exciting, the pace of research doesn't always oblige. This year, 650 physicists attended the XXI International Symposium on Lepton and Photon Interactions at High Energies (Lepton Photon 2003) at Fermilab. While radical revisions to our view of the universe are probably not required, interesting new results were presented, and a series of excellent review talks covered the broad sweep of particle physics.

As one might expect for a conference at Fermilab, the first day was devoted largely to collider physics and electroweak-scale phenomena. The experimental state of play with results from LEP, the Tevatron and HERA was covered by a series of speakers: Patrizia Azzi of Padova on top physics, Terry Wyatt of Manchester on electroweak, Michael Schmitt of Northwestern and Emmanuelle Perez of Saclay on Higgs/SUSY and other searches, respectively, and Bob Hirosky of Virginia on QCD. The overall picture remains one of consistency with the Standard Model, but the good news is that with roughly 200 pb^{-1} of data now recorded at CDF and DØ, the Tevatron's Run II has entered previously unexplored territory. The experiments are opening up new areas of parameter space and potential discovery reach for new physics, both with their direct searches and through precise measurements of the properties of the top quark and the W and Z bosons. On the theory front, CERN's Paolo Gambino talked about the status of electroweak ▷

Fermilab's director Mike Witherell talks to journalist Charles Seife from Science *during the conference. (Fermilab.)*



The most talked about results at the conference came from BaBar and Belle, with a measurement of sin2β that is apparently at odds with the Standard Model.

measurements and global fits, including the muon (g-2) measurement and NuTeV's anomalous value of $\sin^2\theta_W$, and this led to a spirited discussion in the question and answer session after the talk. Gian Giudice, also from CERN, described theoretical predictions for new physics at colliders, and Thomas Gehrmann of Zurich covered developments in QCD. Cornell University's Peter Lepage described recent notable progress in lattice QCD calculations, and the last two speakers, Augusto Ceccucci of CERN and Yuval Grossman of Technion, described rare K and B decays. There are recent results from experiments at Fermilab, CERN and Brookhaven, and new initiatives that will significantly extend our sensitivity to new TeV-scale physics through such windows are underway or planned. A reception and poster session wound up the day, with music by the Chicago Hot Six, led by trombonist Roy Rubinstein – otherwise known as Fermilab's assistant director.

The second day was devoted to heavy-flavour physics and the CKM matrix. Probably the most talked about new result of the conference was presented by Tom Browder of Hawaii, who reported on Belle's determination of sin $2\phi_1$ (sin 2β) from $B\rightarrow\phi K_S$ decays. In the Standard Model, this should be the same as the value extracted from the familiar $B\rightarrow J/\Psi K_S$ process, namely 0.74 ±0.05. In 2002, both BaBar and Belle had found negative values, but the errors were large. With more data, Belle reported a new value at the meeting of −0.96 ±0.50 (+0.09/−0.11). By itself this measurement is 3.5σ from the Standard Model, but the situation was confused by a new measurement from BaBar of the same quantity, which has moved much closer to the Standard Model and is +0.45 ±0.43 ±0.07. This puzzle will take either more data or more study before it is resolved.

The Fermilab organizers introduced a number of innovations to the 2003 edition of the conference, one of which was designed to attract the media. Shortly after the new Belle and BaBar results were reported, the first of a series of informal media briefings brought physicists and journalists together over a sandwich lunch to discuss the physics of the previous session.

Hassan Jawahery of Maryland described progress from the B-factories towards constraining the other two angles of the unitarity triangle, and Kevin Pitts of Illinois outlined the complementary capabilities of hadron colliders, which allow access to the B_s and to b-baryons. Dresden's Klaus Schubert reported on significant progress in determining the magnitudes (as opposed to the phases) of the CKM matrix elements, using results from a broad array of experiments. The CKM matrix appears unitary at the 1.8σ level, but some important inputs are still awaited. Gerhard Buchalla of Munich explored tools to understand the QCD aspects of heavy hadron decays. Liverpool's John Fry covered measurements of rare hadronic decays, while Mikihiko Nakao of KEK did the same for electroweak and radiative rare decays.

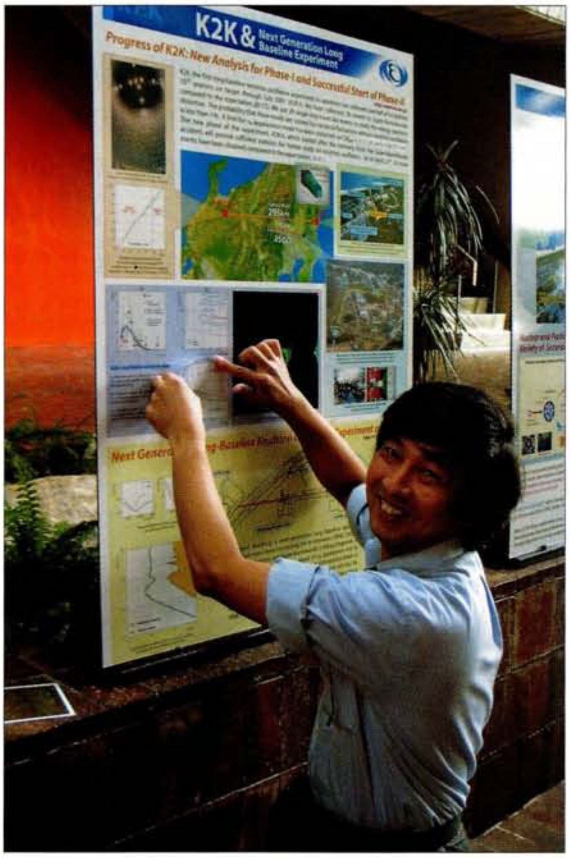
In the session on charm and quarkonium physics, Bruce Yabsley of Virginia Tech discussed the limits on new physics from charm decay, concluding that the results from CLEO-c (*CERN Courier* January/February 2002 p13) are eagerly awaited. Tomasz Skwarnicki of Syracuse described a revitalized scene in heavy-quarkonium physics, thanks in part to large data samples at BES-II in Beijing, CLEO-III at Cornell and Fermilab's E835 experiment. He pointed to solid theoretical progress and to new experimental opportunities at BaBar and Belle, as well as CLEO-c. Jussara de Miranda of the Brazilian Centre for Research in Physics asked the question: "why is charm so charming?", concluding that it provides a powerful bridge to the parton world.

Rounding off the second day was another innovation, a special open session on the Grid, to which the public was invited. Ian Foster of Argonne and Chicago introduced the concept of Grid computing, and CERN's Ian Bird described its application to the LHC. Bob Aiken from Cisco, Stephen Perrenod from Sun and David Martin of IBM explained the industry's perspective, while Dan Reed from the National Center for Supercomputing Applications provided the view from an academic computer centre.

Day three began with a session on astroparticle physics, with Pennsylvania's Licia Verde reporting the exciting results from the Wilkinson Microwave Anisotropy Probe (WMAP). The detailed cosmic microwave background images provided by WMAP bring new insights into the early universe and into the amount of baryonic matter in the universe. Polarization measurements with WMAP also give a handle on the formation of the first stars. The results point to a flat universe consisting of just 4% baryonic matter, with the first stars forming earlier than previously thought at around 200 million years.

Harvard's Bob Kirshner focused on the universe's invisible 95%. Supernovae observations indicate an accelerating universe, consisting of about a third matter and two-thirds dark energy. Concluding that there is a bright future for dark energy, he looked forward to a resolution of the questions surrounding the cosmological constant through forthcoming supernovae studies.

Esteban Roulet of Bariloche gave an update on very-high-energy cosmic rays, whose spectrum is described by a "knee" at around 10^{15} eV and an "ankle" at 10^{19} eV. Recent work has shown that the chemical composition becomes heavier above the knee, and that above the ankle the extragalactic component dominates. Roulet also raised the question of doing astronomy with ultra-high-energy cosmic rays, saying that although it would be like trying to do optical astronomy with a telescope at the bottom of a swimming pool, the field has promise.



Youhei Morita from the KEK laboratory making changes to KEK's poster display to reflect the new results announced by the Belle collaboration. (Fermilab.)

Lyon's Maryvonne de Jesus gave a comprehensive overview of the status of dark-matter experiments. So far, only the DAMA experiment at Italy's Gran Sasso underground laboratory has reported a positive signal for WIMPS. A new detector, DAMA/LIBRA, is expected to report its first result towards the end of 2003. A range of experiments planned or in preparation in Europe and the US can exclude much, but not all of the area allowed by the DAMA measurement. Giorgio Gratta of Stanford discussed tritium and double beta decay experiments. The tritium experiments study the endpoint of the decay spectrum from tritium decays to helium, an electron and a neutrino, which is sensitive to neutrino mass. Results from spectrometer-based experiments at Mainz (< 2.2 eV) and Troitsk (< 2.05 eV) are the most sensitive so far. In the future, KATRIN at Karlsruhe should achieve a sensitivity of around 0.25 eV.

In his review of accelerator neutrino experiments, Koichiro Nishikawa of Kyoto focused on the controversial LSND result, which suggests an oscillation scenario incompatible with the accepted picture. Final results from CERN's NOMAD experiment do not entirely exclude the LSND region, and attention has now passed to MiniBOONE at Fermilab, which has so far recorded some 125 000 events. The first results are expected this autumn. Further ahead are the long-baseline projects NUMI/MINOS at Fermilab–Soudan, and the ICARUS and OPERA detectors, which will observe a neutrino beam from CERN at the Gran Sasso laboratory in Italy.

Reactor-neutrino experiments were covered by Kunio Inoue of Tohoku, who pointed out that all modern experiments are extrapolations of the 1956 Reines and Cowan original, but with vast improvements in scale and flux, along with a better understanding of reactor neutrinos. The fact that Japan's Kamioka mine has 70 GW of reactor power at distances of 130–240 km and an existing cavern, led to the KamLAND experiment, whose first results provide evidence for neutrino disappearance from a reactor source. Reactor experiments also probe θ_{13}, the last remaining mixing angle in the neutrino sector. The current best measurement of θ_{13} less than 10 degrees comes from the French CHOOZ experiment. Turning to solar neutrinos, Carleton's Alain Bellerive gave a comprehensive historical overview from Homestake to Sudbury, but kept the audience waiting for new results from SNO (see p5).

In his wide-ranging theoretical review, Alexei Smirnov pointed out that the Lepton Photon conference devoted a full day and a half to discussion of the unitarity triangle for quarks, but no time to the equivalent for leptons. To redress the balance he constructed a leptonic unitarity triangle, which he used to discuss the possibility of measuring CP violation in the leptonic sector. He also pointed out that the only chance of reconciling LSND's oscillation result with other experiments is by invoking extra, sterile, neutrinos. Deborah Harris of Fermilab then took the podium to give a detailed analysis of the beamline strategies and detector options for facilities ranging from the near-term, such as the Japanese J-PARC to Kamioka beam, to long-term projects such as the neutrino factory.

Day four was devoted to hadron structure and detector research and development. It began with a review of structure functions from deep-inelastic scattering at HERA given by Paul Newman of Birmingham. HERA shut down in 2000 for an upgrade that was designed to boost the luminosity five fold. Now running again as HERA-II, a few tens of inverse picobarns of data are expected this year, and this is sufficient to begin studies of polarization dependence. The theoretical perspective was given by Robert Thorne of Cambridge, who discussed the parton distributions that are essential for analyses at high-energy hadron colliders such as Fermilab's Tevatron and CERN's LHC. Toki-Aki Shibata of the Tokyo Institute of Technology discussed measurements with polarized hadrons, both in deep-inelastic scattering and proton–proton collisions, as a probe of the spin structure of hadrons and a tool to develop QCD. After ▷

Interactions for all

Lepton Photon 2003 saw the launch of *interactions.org*, a new website designed to serve as a central resource for communicators of particle physics, whether they be physicists, professional communicators or members of the media. The site is updated daily with news, information, images and links from the world of particle physics. It provides links to current particle-physics news from the world's press; high-resolution photographs and graphics from the particle-physics laboratories of the world; links to education and outreach programmes; information about science policy and funding; links to universities; a glossary; and a conference calendar.

the break, Yuji Yamazaki of KEK continued the QCD theme in his discussion of diffractive processes and vector meson production. Diffractive processes have historically been described in terms of pseudo-particle exchange within Regge theory. Today they can be described at least in part by perturbative QCD, though there remains work to be done.

In his review of heavy-ion collisions, David Hardtke of Berkeley asked the question: "have we seen the quark–gluon plasma at RHIC?" He concluded that although the density and the temperature produced in RHIC gold–gold collisions is at or above the predicted phase transition, no direct evidence has been seen for excess entropy production.

Ties Behnke of DESY and SLAC had the honour of presenting the only detector R&D talk of the conference, and he focused on detectors for a future linear electron–positron collider, for which the requirements are rather different from those for hadron machines.

The final day's programme looked forward. Veronique Boisvert of CERN reported on a meeting held during the conference by the Young Particle Physicists' organization, and complimented the conference organizers on the visible role that young physicists had played at Lepton Photon 2003. CERN's director-general, Luciano Maiani, reported on the status of the LHC and the steps that have been taken over the past couple of years to firm up its financial situation. Dipole magnet production remains the main item that is setting the pace, and first beam is still foreseen for 2007. Vera Luth of SLAC reported on IUPAP's Commission on Particles and Fields, the umbrella under which the Lepton Photon and ICHEP conferences are held. She observed that the current difficulties experienced by scientists trying to obtain visas to enter the US were of great concern and had a negative impact on the attendance at the conference (p50).

> Experimenters in the audience enjoyed hearing such a prominent theoretican argue that we need new results that put experiments ahead of theory again.

Looking further ahead, Francois Richard of Orsay described the physics motivation for a TeV-scale linear collider, including the constraints that can now be placed on SUSY models from WMAP's cosmic microwave background measurements, assuming that cosmic dark matter actually consists of neutralinos. SLAC's Jonathan Dorfan reported for ICFA, and Maury Tigner of Cornell for the International Linear Collider Steering Committee. An international report on the desired parameters of a linear collider is expected this autumn, and this will be followed by the setting up of a committee of "wise persons" from the Americas, Asia and Europe to make a technology recommendation by the end of 2004. In parallel, a task force will recommend how to set up an internationally federated "pre-global design group" intended to evolve into a design group for the accelerator as the project gains approval. Intergovernmental contacts have started with a pre-meeting that was held in London in June.

Ed Witten of Princeton's Institute for Advanced Study described supersymmetry and other scenarios for new physics. Witten admitted that an anthropic principle could account for the fine tuning and hierarchies that plague the Standard Model, but he hoped that this would not turn out to be the case. The experimenters in the audience enjoyed hearing such a prominent theoretician argue that we need new results that put experiments ahead of theory again – "as is customary in science". The closing talk, an outlook for the next 20 years, was given by Hitoshi Murayama of Berkeley. He argued that there is a convergence, at the TeV scale, of questions to do with flavours and generations (neutrino masses and mixings, CP violation, B physics), questions to do with unification and hierarchies of forces, and questions to do with the cosmos (dark matter and dark energy). The TeV scale offers the answers to many of these questions, but also forms a cloud that blocks our vision. The next decade holds the exciting promise of dispersing this cloud and giving us the first clear view of what lies ahead.

Further reading

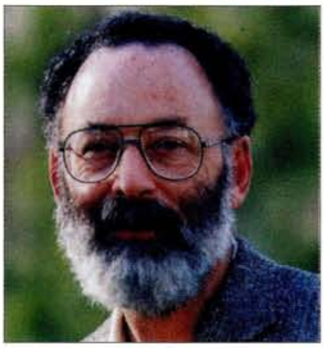
All the presentations are available from the conference website at http://conferences.fnal.gov/lp2003.
The proceedings are to be published by World Scientific.

John Womersley, *Fermilab, and* **James Gillies**, *CERN.*

CEBAF celebrates seven years of physics

Douglas Higinbotham reports from the Jefferson Lab symposium on results that span the boundary between nuclear–meson models and quark–gluon physics.

An aerial photograph of the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. The dashed line indicates the location of the accelerator, and the circles indicate the location of the three experimental halls.



Jefferson Lab's director Christoph Leemann, shown above speaking at the opening of the symposium on "The first seven years of physics with CEBAF", which was dedicated to the memory of Nathan Isgur (left), the laboratory's first chief scientist who passed away in 2001.

Jefferson Lab in Newport News, Virginia, recently celebrated the first seven years of physics with the Continuous Electron Beam Accelerator Facility, CEBAF. The unique design of this electron accelerator allows three experimental halls to be operated simultaneously, with a total beam current of 200 μA and a beam polarization of up to 80%. With this facility, a user community of more than 1000 scientists from 187 institutions in 20 countries has completed 81 nuclear-physics experiments, with substantial data taken on 23 more. From the data obtained in these experiments, more than 250 refereed journal articles have been published and 146 doctoral degrees have been awarded. In the near future more than 60 experiments are planned, and there are currently 128 PhD theses in progress.

To celebrate and review these accomplishments, while also looking toward the future, the Jefferson Lab user group board of directors organized a symposium, which was held on 11–13 June and dedicated to the memory of Nathan Isgur, Jefferson Lab's first chief scientist. The meeting was divided into eight physics topics: nucleon form factors, few-body physics, reactions involving nuclei, strangeness production, structure functions, parity violation, deep exclusive reactions and hadron spectroscopy. Each topic was presented by one experimentalist and one theorist.

The symposium began with presentations by Donal Day of Virginia and John Ralston of Kansas on nucleon form factors, which probe the electromagnetic structure of the proton and neutron. The pre- ▷

sentations included a discussion of the most referenced and surprising result from Jefferson Lab, that the proton's form factors do not follow an expected simple relation. While theorists have proposed different models to explain this result, the basic ingredient in almost all new models is the addition of relativistic effects.

The talks continued with presentations focusing on few-body systems, such as the deuteron and ^{3}He, by Paul Ulmer of Old Dominion University and Franz Gross from the College of William and Mary. In these experiments, the Jefferson Lab electron beam is used to knock out a proton from the few-body system or to probe it with elastic scattering. The expected yield can be calculated exactly, assuming nucleons and mesons are the underlying particles. The presentations showed that even with beam energies of up to 5.7 GeV, the electron scattering results are surprisingly well explained by the nucleon–meson models to distance scales of the order of 0.5 fm. In contrast, experiments on deuteron photodisintegration, which probe even smaller distance scales, have revealed clear evidence of the limitations of the nucleon–meson models and of the onset of quark–gluon degrees of freedom.

For reactions involving nuclei, i.e. many-body systems such as oxygen and carbon, statistical methods in the context of the nucleon–meson picture are used to calculate the expected yields of the quasi-elastic reaction. Larry Weinstein of Old Dominion University presented a talk entitled "So where are the quarks?", in which he showed that the nucleon–meson model describes even the highest momentum transfer Jefferson Lab data, while Misak Sargsian of Florida International presented a talk looking mostly to the future, when the quark–gluon nature of matter should become evident from experiments with a 12 GeV electron beam.

Reinhard Schumacher of Carnegie Mellon and Steve Cotanch of North Carolina State presented reactions involving strangeness production, which includes the production of particles such as kaons. They showed new Jefferson Lab data confirming the Θ^+ particle as discovered by SPring-8 in Japan (*CERN Courier* September 2003 p5). This new particle is comprised of five quarks and has been dubbed the pentaquark. This had been described as the first observed nucleon resonance comprised of more than three valence quarks and has sparked international excitement. A new Jefferson Lab experiment to further study this new particle has already been approved.

Structure-function experiments, which provide information on the quark and gluon structure of the nucleon, were presented by Keith Griffioen of the College of William and Mary, and Wally Melnitchouk of Jefferson Lab. While Jefferson Lab's beam energy is relatively low for this type of experiment, the high luminosity available has allowed many high-precision structure-function results to be produced. An interesting feature of the Jefferson Lab data is that if one scales the smooth deep-inelastic cross-section results from high-energy physics to the laboratory's kinematics, the scaled results will pass through the average of the resonant peaks of the laboratory's data. This effect, known as duality, may lead to a better understanding of how the underlying quarks and gluons link to the nucleon–meson models.

Krishna Kumar of Massachusetts and Michael Ramsey-Musolf from the California Institute of Technology presented the parity-violation experiments, where the strange quark distributions in the proton can be extracted by measuring the extremely small asymmetry in the elastic scattering of polarized electrons from an unpolarized proton target. One series of these experiments has already been completed at Jefferson Lab and several more are planned, including the G0 and HAPPEX-II experiments scheduled for next year.

During the symposium, user-group president Paul Stoler, right, of Rensselaer Polytechnic Institute, presented the 2003 Jefferson Lab thesis prize to Xiaochao Zheng, who recently received a PhD at Massachusetts Institute of Technology and is now at Argonne National Laboratory.

Deep exclusive reactions – experiments done in deep-inelastic kinematics but where the detection of multiple particles allows the final state of the system to be determined – were presented by Michel Garcon of SPhN/Saclay and Andrei Belitsky of Maryland. Generalized parton distribution models, which should enable a complete description of the nucleon's quark and gluon distributions to be extracted from this type of data, were presented along with the results of the deeply virtual Compton scattering experiments at HERMES, DESY, and at Jefferson Lab. The results indicate that generalized parton distributions can indeed be extracted from this type of data. Several high-precision experiments are also planned for the coming years.

Steve Dytman of Pittsburgh and Simon Capstick of Florida State presented the wealth of hadron spectroscopy data that is coming from Jefferson Lab. The analysis of the vast set of data produced by the laboratory on the nucleon resonances has been only partially completed, but hints of new states are already emerging and work on a full partial-wave analysis of the data is now getting underway.

Following the physics presentations, Larry Cardman, the Jefferson Lab associate director for physics, presented the long-term outlook for the laboratory. This talk focused primarily on upgrading the CEBAF to a 12 GeV electron machine and building a fourth experimental hall. The higher energy will allow Jefferson Lab to continue its mission of mapping out the transition from the low-energy region where matter can be thought of as made of nucleons and mesons, to the high-energy region that reveals the fundamental quark and gluon nature of matter.

Further reading

Copies of these presentations can be found at www.jlab.org/div_dept/physics_division/talks/Users_meeting_2003.html.

Douglas Higinbotham, *Jefferson Laboratory.*

DESY looks to the future

The DESY laboratory in the western part of Hamburg, with the river Elbe shown in the background. (DESY Hamburg.)

Earlier this year the German Federal Ministry of Education and Research reached a policy decision on the TESLA project that determines the way ahead for DESY. **Albrecht Wagner**, chairman of the DESY Directorate, assesses the impact of the decision for the laboratory in Hamburg.

In February 2003 Edelgard Bulmahn, the German federal minister of education and research, decided to support several large-scale facilities for basic scientific research. These included the 4 km long X-ray free-electron laser (XFEL), which was originally conceived as part of the project proposed by the international TESLA collaboration for a 33 km electron–positron linear collider to be built near DESY, Hamburg, together with an integrated X-ray laser laboratory (*CERN Courier* June 2001 p20). At the same time, the German government decided not to proceed nationally with the linear collider part of the TESLA project and not to propose a German site for such a machine at this moment, but to wait for international developments. These decisions will have important implications for DESY in the coming years.

The German government is thus proposing Hamburg as the site for a European XFEL facility, and is prepared to carry half of the investment costs of €673 million. A decision on construction should be possible within two years, and would be followed by a construction period of about six years. Since the announcement in February, the German government has entered into bilateral discussions with other European governments. The first goal is to set up two European working groups, one on scientific and technical issues, and one on organizational and administrative matters. In parallel, the European Strategy Forum on Research Infrastructure (ESFRI) recently organized a workshop at DESY, on 30–31 October, on the technological challenges of X-ray lasers. So far discussions have led to the conclusion that only one major facility for research with hard X-ray radiation should be developed in Europe. The XFEL is the only project proposal in Europe in this field.

In addition, the ministry foresees €120 million for the conversion of the PETRA storage ring – which currently serves as a pre-accelerator for HERA – into a high-performance third-generation synchrotron radiation source. This upgrade is scheduled to start in 2007, after the conclusion of the HERA physics programme, and is intended to strengthen further the research with synchrotron radiation.

Regarding the linear collider part of TESLA, the German government decided that DESY will continue work on the project as part of the international research and development effort. At the EPS conference on High Energy Physics held in Aachen in July, Hermann Schunck, director-general of the Federal Ministry of Education and Research, said: "We have to wait for international developments. But we will continue our efforts so that we can participate in a global linear collider project. Let me underline this – my government is the first one to have announced that it is in principle committed to participating in this project."

Testing acceleration structures

For the past 10 years the TESLA collaboration has made decisive progress with the superconducting accelerator technology that forms the basis of the TESLA linear collider and the XFEL. A test accelerator of 250 MeV – the TESLA Test Facility (TTF) – has been built and has operated at DESY since 1997. The international partners in the project provided about 35% of the investment and personnel funding. At the TTF the collaboration successfully tested the superconducting acceleration structures and made groundbreaking progress on the SASE (Self-Amplified Spontaneous Emission) principle for a free-electron laser at short wavelengths around 100 nm. The first experiments with this new type of laser provided an impressive demonstration of the high scientific potential of free-electron lasers in the UV and X-ray region. The TTF is currently being extended to reach an energy of 1 GeV, that is, a length of 260 m. Starting in 2004, it will be available as a user facility for experiments with ▷

soft X-ray laser radiation above 6 nm wavelength. As such it will allow researchers to gain important experience in experimentation with free-electron lasers in the X-ray region, and it will provide valuable operating experience for the linear collider.

In co-operation with European partners, DESY is actively preparing for the construction of the 20 GeV superconducting linear accelerator for the XFEL laboratory, and is focusing on issues related to the industrialization, mass production, quality assurance and reliability of all the linear accelerator components. A first step in the concrete planning of the XFEL will be the commissioning of the free-electron laser for soft X-ray radiation at the expanded TTF. Since the XFEL is to be realized as a European project, discussions are being held with scientists and politicians in countries that are interested in participating in the effort. In these discussions a number of issues must be examined and clarified, such as the exact operational parameters of the laser and the organizational models for the laser laboratory. The inclusion of international partners from a very early stage in the planning and development of the superconducting accelerator within the TESLA project has proved very helpful in this respect.

At the same time, the TESLA collaboration continues to pursue the high-gradient programme to demonstrate the accelerating field of 35 MV/m that is required to reach 800 GeV for a 33 km TESLA collider. Substantial progress has been made in this area. In a test at low RF power, four nine-cell cavities have shown the required performance of 35 MV/m after electro-polishing. Two of these cavities were then fully assembled with all their ancillaries and have reached gradients above 35 MV/m in long-term testing under typical collider operating conditions (at $Q > 5 \times 10^9$ with an RF loading as required for linear collider operation), but without beam. Each of these cavities corresponds to one-eighth of a TESLA cryo-module. This represents a significant step towards the milestones set by the International Linear Collider Technical Review Committee for "Phase II" of TESLA. A full test of one module – eight cavities – at 35 MV/m with beam will, however, take more time due to constraints on the resources available at DESY.

Towards a linear collider

The next major step towards a global collider project concerns the choice of technology. The International Linear Collider Steering Committee is currently setting up an advisory group ("wise persons"), which will be charged with performing an analysis of the status of the two competing technologies ("warm" and "cold") and with making a technology recommendation before the end of 2004.

If the chosen linear collider technology is "cold", a major synergy will exist between the work on the XFEL and the linear collider. In this case the contribution of DESY and the partners in the TESLA collaboration will most likely be in the area of the main accelerator of the collider. A recent analysis of the work needed to be done on the basic accelerator unit for the XFEL, the cryo-module, has shown that more than 90% of the issues to be tackled are the same for the XFEL and the linear collider. The synergy is therefore achieved by the fact that the work done now for the XFEL will be largely of direct use for the linear collider. In addition, the R&D funds now spent on the XFEL will not need to be spent again for a collider built using the cold technology.

In 2004 the TESLA test facility, which has been extended to reach an energy of 1 GeV, will become available as a user facility for soft X-ray experiments. (DESY Hamburg.)

If the chosen technology is "warm", a major reassessment of the contributions will be necessary. In this case DESY will probably participate in other subsystems and its contribution will probably be less pronounced than for a "cold" machine due to the commitment to the XFEL.

DESY will continue to participate in the linear collider working groups of ICFA and ECFA and once the technology choice has been made, the laboratory will be a partner in a European team within an international linear collider design team. DESY will also play a major role in the design, construction and future operation of the collider detector(s).

The international efforts for the coming years aim at reaching an agreement, in principle, to start the construction of a linear collider in time for commissioning in 2014/15, in accordance with the recommendations of ACFA, ECFA, HEPAP and the OECD Global Science Forum. Taking into account a construction time of seven to eight years, this requires a decision to go ahead to be made in 2007. Such a schedule also requires the first funds to become available in 2007, although the major investment spending for the linear collider will typically begin three years after the project starts, i.e. around 2010, as has been the case for other major accelerators.

The future for DESY

The strength of DESY is the result of an in-house synergy in three key areas: accelerator development, particle physics and research with synchrotron radiation. Particle physics has been the driving force behind accelerator development, and this also applies to the TESLA project. The decisions of the research ministry have secured DESY's long-term future as one of the world's leading centres for research at accelerators.

In particle physics DESY's research and its contributions to both the linear collider itself and the detector, will ensure that the laboratory remains a major contributor to the realization of the project, regardless of whether or not the facility is built in Germany.

Albrecht Wagner, *DESY.*

Light in the darkness

Alan Ball and **Apostolos Tsirigotis** show the first results from NESTOR, the underwater neutrino detector in Greece, and describe just how well the chosen techniques are working.

In pitch-black darkness, four kilometres below the surface of the sea, a cone of blue Cerenkov light suddenly illuminates an array of photomultiplier tubes situated some 80 m above the sea floor – the signature of a relativistic muon passing through the detector. Did it come from a "common" cosmic-ray event in the Earth's atmosphere, or was it generated by a neutrino emitted in some high-energy process in a distant galaxy that has interacted in the water near the detector or in the rock below? Neutrino astronomy is a relatively new and exciting domain that for the first time uses telescopes that do not rely on photons for primary signal transmission.

One such telescope under construction is NESTOR – the Neutrino Extended Submarine Telescope with Oceanographic Research – which will ultimately consist of a "tower" of Cerenkov detectors anchored a few nautical miles off the south-west tip of the Peloponnese in mainland Greece. Figure 1 gives an artist's impression of part of the tower, showing several hexagonal "floors" or "stars" made of 15 m long rigid titanium arms. The arms are equipped at their extremities with upward and downward-looking 38 cm diameter photomultiplier tubes (PMTs) in glass pressure housings, which help to differentiate between upward and downward-travelling muons. The full tower, with 12 stars of 32 m diameter, will have a total height of 410 m from the sea floor and an effective area of 20 000 m^2 for neutrinos with energies of 10 TeV.

The NESTOR collaboration successfully deployed the first floor of the detector tower to a depth of 4000 m (see figure 2) at the end of March 2003 (*CERN Courier* May 2003 p5). Since then, more than five million events, selected by a fast fourfold coincidence trigger, have been accumulated in an initial "physics" run. Clearly the physics or astronomy possible with a single-floor detector is limited, but it has provided invaluable experience in the operation of the detector, in data handling and in the techniques for signal processing and track reconstruction.

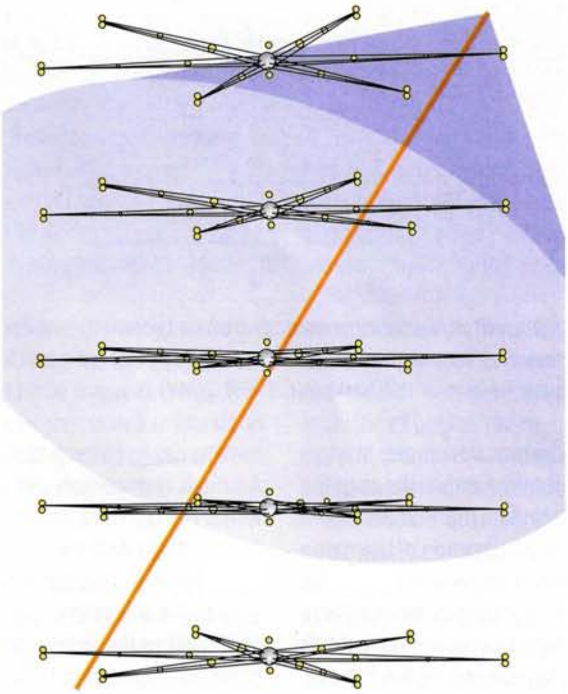


Fig. 1. Artist's impression of several floors of a NESTOR tower, illuminated by the cone of Cerenkov light from an incident muon (orange). The PMTs are mounted in glass pressure spheres at the end of the titanium arms, with the electronics in the central enclosures.

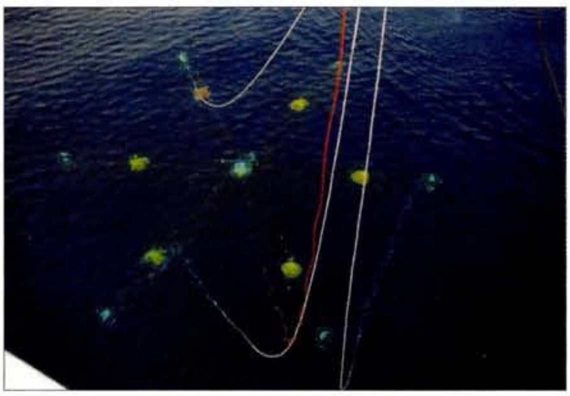


Fig. 2. The first floor floating in the water below the bow chute of France Telecom's cable ship Raymond Croze, *a few moments before it was lowered to 4000 m on 30 March 2003.*

The techniques for deployment and payload exchange at a depth of 4000 m are well tested. Recovery of the cable termination and junction box to the surface enables the use of simpler, dry-mating connectors and avoids expensive operations with manned or autonomous submarine vehicles. To appreciate the scale of the challenge, imagine sitting at the top of Mont Blanc with a fishing line in Lake Geneva, positioning a package at the end of the line on the lake bottom to within a few metres, and then months later going back to retrieve the package in good order. These achievements were recently highlighted in the cover article in the July issue of *Sea Technology*, a leading marine industry journal (Anassontzis and Koske 2003).

Tracking the muons

The electrical pulses from the PMTs are digitized in a central titanium sphere on each floor and transmitted over a 30 km electro-optical cable to the shore station, where the raw data are recorded. At the heart of the system are novel ASICs, analog transient waveform digitizers (ATWDs), devel- ▷

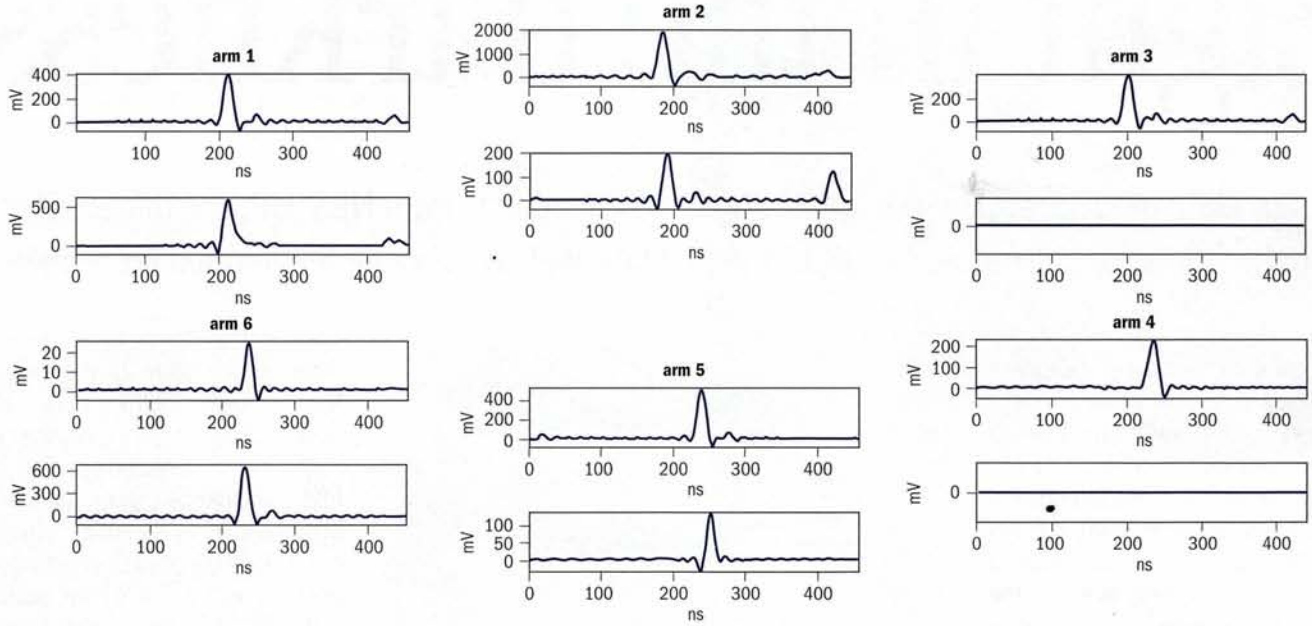


Fig. 3. Digitized photomultiplier waveforms, after signal processing, from a typical event selected with a four-fold majority trigger. The upper and lower traces for each of the six detector arms are from the up and down-looking photomultipliers. A single photoelectron gives a mean pulse height of 120 mV. (NESTOR 2003 Event 1785-Run 81-BFile 3.)

oped at Lawrence Berkeley National Laboratory, which can sample the PMT signals from 200 MHz to 3 GHz. From the arrival times of the signals and their intensity, the cone of Cerenkov light created by a muon has to be reconstructed to determine the direction of the muon and eventually infer the physical parameters of the incident neutrino.

In the control room the parameters of the detector are continuously monitored. These include the floor orientation (compass and tilt meters), the temperatures, humidity and hygrometry within the titanium sphere, and the external water-current velocity, temperature and pressure, as well as data from other environmental instruments mounted on the sea-bottom station (pyramid). In addition, the electrical power-distribution network and the high voltages applied to the PMTs are controlled and monitored. A run-time monitor carries out fast, on-line data processing, in parallel to the data taking, so as to check continuously the detector performance – this consists of monitoring the stability of such crucial parameters as the PMT rates, pulse height distributions, trigger timing, majority logic rates and the overall data acquisition (DAQ) performance (dead time).

A fraction of the data is fully analysed on-line to check the quality and ensure that the trigger is unbiased. Trigger rates, as a function of the signal thresholds and coincidence level settings, as well as the total photoelectron charge inside the trigger window, agree very well with Monte Carlo predictions based on Atsushi Okada's atmospheric muon flux model (Okada 1994), the natural ^{40}K radioactivity in the sea water and PMT dark currents. Calibration in the sea uses LED "flasher" modules mounted above and below the detector floor. These provide a rigorous, independent check of the trigger and pulse intensity of all PMTs and the full DAQ system.

In the off-line analysis, the raw data from each PMT are first passed through a signal-processing stage, which performs a baseline subtraction and corrects for attenuation. This is based on calibration parameters determined in the laboratory before deployment. As most parameters are frequency dependent, fast Fourier transforms are used. At the end of the processing stage multiple pulses are resolved and the arrival time, pulse height and total charge of each pulse (hit) is determined with precision.

In order to reconstruct tracks, events with more than five active PMTs within the trigger window are selected. The estimation of the track parameters is based on a χ^2 minimization using the arrival times of the PMT pulses. In most cases the procedure converges to two or occasionally several minima, often due to an inherent geometrical degeneracy known as a "mirror solution". To resolve this ambiguity, a second level algorithm is used that takes account of the measured number of photoelectrons at each PMT and the number expected from the candidate track, and performs a likelihood hypothesis comparison.

Figure 3 shows the digitized PMT waveforms, after signal processing of a selected event, whilst figure 4 shows a pictorial representation of the reconstructed track that corresponds to this event. Several tests of the track reconstruction procedures have been carried out using both data and Monte Carlo generated events. The results demonstrate that the estimation of the track parameters is unbiased.

Figure 5 shows the measured zenith angular distribution (solid points) of reconstructed events using a fraction (~30%) of the collected data. The reconstructed tracks used in this measurement have been selected by means of the minimum χ^2 fit (χ^2 probability > 0.1), the track quality based on the number of photoelectrons per PMT and on the total accumulated photoelectrons per hit per track (> 4.5). The histogram shows the predicted angular distribution of atmospheric muon tracks (for the NESTOR floor geometry and reconstruction efficiency) derived from Monte Carlo calculations using Okada's phenomenological model.

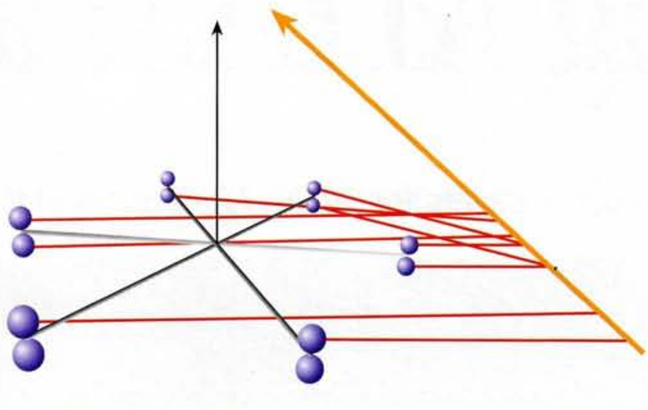


Fig. 4. *A pictorial representation of the reconstructed muon track (orange), which corresponds to the PMT pulses shown in figure 3. The red lines represent the Cerenkov light paths to the photomultipliers. The zenith angle of this track has been estimated to be 123° ± 21°. At the depth of 4000 m, upcoming or horizontal reconstructed tracks are good neutrino candidates.*

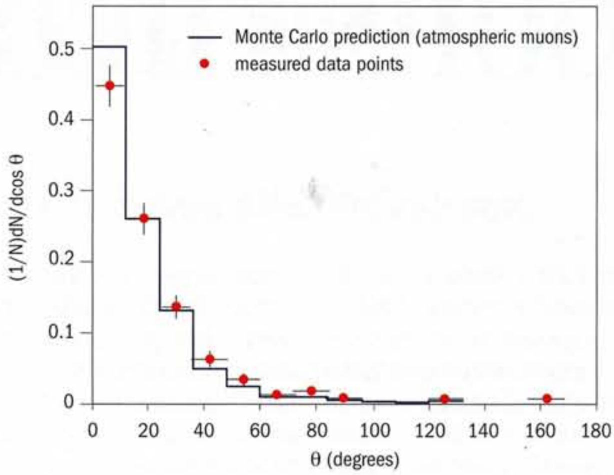


Fig. 5. *A comparison between the measured zenith angular distribution of reconstructed tracks and the Monte Carlo prediction, based on the phenomenological model of atmospheric muons of Okada.*

Further improvements in the reconstruction efficiency are to be expected, but effective neutrino detection will require the deployment of at least four floors, which we hope to achieve in the coming year. However, we already know we have a detector that is well understood and that the data quality is excellent, supporting many of the choices made regarding, for example, the site and detector layout.

Improving signal to noise

As with any experiment, a good signal-to-noise ratio is the key to success. Cosmic-ray muons represent the principal background for a neutrino telescope and this depends on the depth of the water "shielding" – the attenuation between 1000 and 4000 m is more than two orders of magnitude. With NESTOR, further improvement is possible as the deepest point in the Mediterranean, 5200 m, is nearby. Limiting the cosmic-ray background also removes many of the uncertainties in track reconstruction, such as wrongly assigning a downward-going muon as an upward-going track. The NESTOR collaboration's decision to have upward, as well as downward-looking phototubes seems to be well justified. At 4000 m an unambiguous upward-coming or horizontal muon track must have been generated by a neutrino.

Another source of background is bioluminescence (light emitted by micro-organisms in the water), which reduces exponentially with water depth. The signal bursts, of the order of 1 to 10 seconds duration, are easily distinguishable from those of muon tracks, but they contribute to dead time and ultimately reduce the detector efficiency. At the NESTOR site the average dead time measured at 4000 m is around 1%; values of up to 40% have been reported at other sites. A third background source, independent of depth, comes from the natural radioactive β-decay of ^{40}K. Together with the thermionic noise from the PMTs, this represents a low-intensity uncorrelated baseline signal level of 50 kHz, which is easily subtracted by the tracking algorithm.

The use of a rigid structure to mount groups of PMTs removes uncertainties in their relative positions and aids reconstruction at the "floor level". This approach seems preferable to having individual or small clusters of phototubes on independent strings. The orientation of the whole star is monitored so that only relative horizontal displacements between complete stars require external telemetry using acoustic or optical references. Experience of track reconstruction with several floors is needed to demonstrate that these advantages compensate for the additional constraints in deployment operations.

The choice of the NESTOR site for its depth, water clarity, low sedimentation and very low underwater currents is already paying dividends. The proximity to shore is an important safety consideration in case of bad weather at sea and facilitates the staging of deployment and recovery operations. Crews can be exchanged during lengthy procedures, and additional equipment or specialist help can be brought in when required. The NESTOR site is only 7.5 nautical miles from land and 11 nautical miles from the shore station in Methoni – 20 minutes by fast launch.

Deploying this first stage of the detector in 4000 m of water and making it work has required an enormous effort from the small team most directly involved and has only been possible due to the unfailing support of many authorities, organizations, companies and individuals too numerous to mention.

The European astroparticle physics community's aim is to build a very large volume neutrino telescope (km cube) in the northern hemisphere. It is to be hoped that this "feasibility demonstration" will encourage better co-ordination between the various groups working in the field and will help to attract the necessary funding and manpower for this large project. Such a detector would complement the already approved ICECUBE project at the South Pole.

Further reading

For further information about NESTOR, see www.nestor.org.gr.

E G Anassontzis and P Koske 2003 *Sea Technology* **44** 10.
A Okada 1994 *Astroparticle Physics* **2** 393.

Alan E Ball, *CERN, and* **Apostolos Tsirigotis**, *Hellenic Open University, for the NESTOR collaboration.*

Constructing ATLAS: a

Now that the civil engineering is complete, the cavern for the ATLAS detector at the l

In April 2007, one of the largest and most complex sets of scientific instruments ever constructed – the Large Hadron Collider (LHC) and its four companion detectors – is scheduled to begin its odyssey into the uncharted waters beyond the Standard Model of particle physics. The discoveries that are likely to be made there could fundamentally change our ideas about the basic constituents of matter, and therefore our concepts of the universe itself. It is this hope that has led the 20 member states of CERN, and a number of non-member state partners as well, to promote, develop, fund and build the LHC project. In addition, several thousand physicists have bet a substantial part of their careers on the success of the LHC.

From the initial concept in the mid-1980s, the LHC project has followed a winding road on its way to completion. Challenging the frontiers of technology on many fronts simultaneously is one of its biggest risks, as in many cases the appropriate solutions to technological issues – and their costs – had to be presumed well in advance of construction. The sheer size of the LHC itself, and of the two biggest detectors ATLAS and CMS, presented major challenges in civil and mechanical engineering, as physicists and engineers struggled to optimize the physics return for minimal size and cost. The project has also written new standards for international co-operation in science, as much of the apparatus is being constructed in laboratories all over the world and then brought to CERN for final assembly. These tasks have often been accomplished by international teams of technicians working across a variety of languages and cultures, but with a common goal in mind. For the most part this process has worked very well indeed, and at the time of writing the ATLAS collaboration consists of about 1700 physicists from more than 150 institutions.

A significant milestone was achieved on 4 June this year when the ATLAS detector cavern, UX15, and its associated buildings and underground structures at Point 1 on the LHC ring were accepted on schedule by CERN. The day was marked by a ceremony and commemorated by many dignitaries, including Pascal Couchepin, president of the Swiss Confederation, Carlo Lamprecht, Geneva state councillor, and CERN's director-general Luciano Maiani (*CERN Courier* July/August 2003 p5). With this dedication, Winston Churchill's famous phrase from a very different era comes to mind: "We have reached the end of the beginning" of ATLAS construction. Now the difficult work of assembling ATLAS underground can start.

The words "ATLAS installation" do not nearly do justice to the magnitude of this task. During a three and a half year period from April 2003 until December 2006, more than 7000 tonnes of large, delicate apparatus will be lowered into UX15, itself located 100 m underground. The many heavy objects must be aligned with very high precision so ATLAS is able to measure particle trajectories and energies with the accuracy required to extract the fundamental secrets of nature for which it is searching. Then, from the end of December 2006

June 2001: the 35 m span for the ATLAS detector hall, UX15, is on the longest underground spans ever constructed. The ceiling of th 1380 m² cavern "hangs" from a system of ground anchors installe from galleries excavated laterally from the access shafts.

July 2003: a 12 storey metallic structure is one of the first items in in the completed cavern. Such structures, which will be used for a and for racks of electronics, will surround the detector on all four s

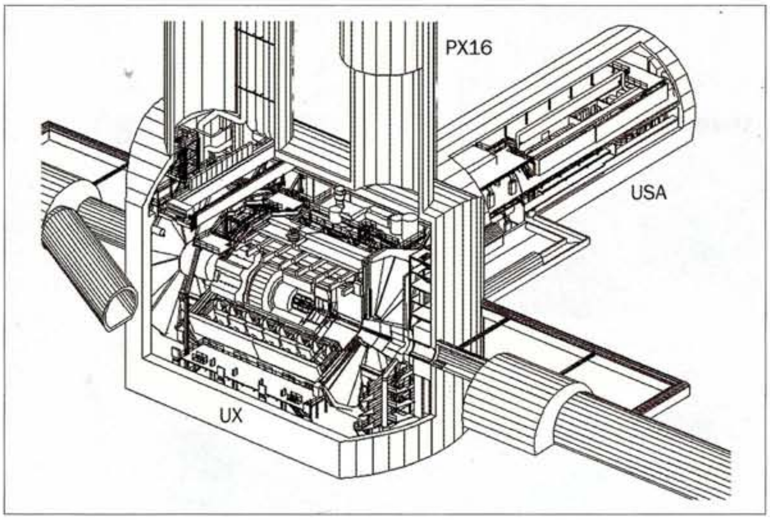
until the beam is turned on in April 2007, the early commissioning of ATLAS will occur. When ATLAS is "ready for physics", more than 100 million sensors will be alive inside the detector. It will produce petabytes of information per year when the LHC achieves full luminosity.

ATLAS will be the largest-volume detector ever constructed for high-energy physics at 46 m long, 25 m wide and 25 m high. However, at 7000 metric tonnes it is not the heaviest detector – that honour belongs to another of the LHC detectors, CMS, which

nodern 'ship in a bottle'

ready for the complex business of installing the detector, as **Robert Eisenstein** explains.

July 2002: the extent of the cavern is clear as the reinforcement of the concrete base is installed.



Drawing of the ATLAS detector installed in UX15. Note the size of ATLAS compared with the diameters of the access shafts.

weighs 12 500 metric tonnes. The relatively light weight of ATLAS is due to the design of its superconducting magnet system, which is based on air-core barrel and endcap toroid magnets and a central solenoid that will provide a field of 2 Tesla.

Not surprisingly, costs have played a major role in determining the final design and configuration of ATLAS. In particular, cost considerations limited the size both of the ATLAS experimental hall and its access shafts, and the detector was in turn designed to make optimal use of the available space – but with sufficient modularity that individual pieces would fit within access-shaft allowances. It was determined early on that two smaller access shafts were significantly cheaper than one shaft large enough to accommodate the entire detector or a major sub-assembly. In another cost-cutting move, the dimensions of the barrel toroid coils were minimized, as were the access shafts. However, the final design for the ATLAS cavern UX15 is not much different in size from the original concept: its dimensions are an enormous 53 m long, 30 m wide and 35 m high.

Given the large volume of UX15, there were important geologic considerations to take into account in determining its location on the LHC ring. Of the available sites, Point 7 was best in terms of stability and absence of water leakage, but ruled out due to the proximity of civil constructions in neighbouring Ferney-Voltaire. Of the remaining locations, Point 5 was ruled out because the rock formations there are not robust enough to support a cavern the size of UX15. In the end, Point 1 was chosen as the least expensive alternative – other sites would have required costly remediation. But there are issues even at Point 1; since ATLAS is light compared with the rock formerly in place, there is expected to be significant upward floor movement that must be estimated and taken into account in the ATLAS installation.

The ATLAS civil construction was also interesting from another point of view – the desire to execute as much of it as possible without interfering with the operations and infrastructure of LEP. To do this the UX15 cavern was built "from the top down" using a novel suspended roof that was later "lowered" into place when the cavern walls were completed. This ingenious solution to a complex problem is typical of the outstanding creativity of CERN's Civil Engineering Group and its consultants in their approach to the construction of the LHC project.

Another cost-saving measure was the decision to minimize strictly the construction of new buildings for the pre-assembly of major components of ATLAS above ground. Because there is no staging area, some of the large subcomponents of ATLAS – for example the barrel toroid magnet – will be completely assembled for the first time only when underground in UX15. As much pre-assembly and testing as possible will be done on the surface, but there is a limit to how much can be done. And since there is no large staging space available at Point 1, detector components, having been assembled at various locations at CERN, must be transported to Point 1 for installation. As some of these items are enormous, this is a task requiring great care. All this implies the need for a very carefully sequenced and choreographed installation procedure. For all these reasons ATLAS is sometimes referred to as a modern day "ship in a bottle".

These considerations also determine the installation strategy to be used. The installation process is organized into six sequential phases: (1) surface and underground infrastructure, (2) barrel toroid and barrel calorimeters, (3) barrel muon chambers and endcap calori- ▷

meters, (4) inner detectors and muon "big wheels", (5) endcap toroids and muon "small wheels" and (6) vacuum pipe, shielding and closing. Of course, considerable testing will be done *en route* to ensure that components are working properly and once installation is complete it will be extremely difficult, almost impossible, to work backward to remove any of the large sub-detectors for major servicing. The barrel toroid is perhaps the most dramatic case in point.

Safety is a paramount concern for everyone in ATLAS, and all the installation activities have been designed with this in mind. Elaborate but practical procedures control the access of people into Point 1, especially the underground areas. Entry of tools and materials will also be carefully monitored so that, for example, when the large magnets are finally energized there will be no metal flying about. The future presence of large amounts of liquid argon in UX15 is also an important safety concern.

The ATLAS Technical Coordination Team has organized the installation strategy using modern project-management ideas and tools. Resource needs (people, cash, special tools, cranes, etc) and schedules are evaluated and monitored using resource-loaded scheduling based on work package, deliverable and milestone concepts. The installation schedule is very much viewed as a living document. It currently contains over 1800 individually scheduled tasks.

The installation of each of these enormous detectors is a rewarding but formidable challenge. Stay tuned to *CERN Courier* for the latest updates!

One of the 11 m high vacuum vessels for the two ATLAS endcap toroids – typical of the large pieces that will be lowered into the cavern during the installation process.

Further reading

More information about the ATLAS installation process is publicly available at the ATLAS website (www.cern.ch/atlas), in the technical coordination section.

Robert Eisenstein, *Sante Fe Institute, for the ATLAS collaboration. Eisenstein spent the past year on sabbatical leave at CERN working with the ATLAS Technical Coordination Team.*

Physics helps medicine gain a sharper view

The ITBS meeting in Greece showed significant progress in the collaboration between physicists and physicians, as **Paul Lecoq** and **Patrick Le Du** describe.

The second International Conference on Imaging Technologies in Biomedical Sciences (ITBS) was held on 26–30 May in Athens and on the island of Milos, Greece. The conference was organized by the Greek Institute of Accelerating Systems and Applications (IASA) and the University of Athens, and was supported by CERN, CEA/DAPNIA and IN2P3 in France. It focused on the recent advances in detectors and techniques for clinical and experimental nuclear imaging.

The main aim of this particular conference is to attract medical doctors, medical physicists and physics detector experts, as well as industrial partners, to the same location to discuss needs and improvements in areas of clinical nuclear medical imaging such as single-photon computed tomography (SPECT) and positron emission tomography (PET). As an illustration of the multidisciplinary spirit of the meeting, it was co-chaired by a particle physicist, Paul Lecoq from CERN, and a medical doctor, Jean Maublant from the Jean Perrin anti-cancer centre in Clermont-Ferrand, France. This year there were nearly 80 participants, from Canada, Japan and the US, as well as from Europe.

A small, head-mounted PET tomograph for imaging the brain of a rat while awake. (Courtesy of Craig Woody, BNL.)

During the first day, which was held at the University of Athens, various tutorials were given with the aim of mutually educating the medical and physics communities. After an introductory talk on "Medicine and economy", the first tutorial session on "Medicine for the physicist" was devoted to various medical topics, including oncology, neurotransmitters, the development of radio pharmaceuticals and a review of the technical requirements and clinical impact of PET. The second tutorial session, "Physics for the physician", was oriented towards experimental physics with didactical reviews of detectors and techniques for medical imaging, including scintillation mechanisms and new crystals, semiconductor sensors, photodetectors, electronics and data acquisition.

The remainder of the conference was held at the George Eliopoulos Conference Centre on the scenic island of Milos in the Cyclades Islands. Here, several sessions reported new hardware developments, revealing, for example, the advance in real-time and high-resolution beta imaging for applications in molecular imaging and dosimetry. Results on new crystals such as LuAP (lutetium aluminate perovskite), novel techniques to optimize light collection on tiny crystals, and experience with flat-panel photomultiplier tubes for PET, provided convincing evidence that progress is underway in this field. A specific session on "Small animal PET imaging" reported on the latest technical developments and challenges in this very active domain, particularly in the area of new drug developments and animal modelling of human diseases. The "RatCAP" developed at the Brookhaven National Laboratory offered the most memorable image of the conference. This portable PET scanner allows *in vivo* neurophysiological studies of rat brain functions without anaesthesia.

Several reports on breast-cancer detection, diagnostics and treatment follow-up aroused much interest in instrumentation for functional breast imaging using positron emission mammography techniques (PEM). The low sensitivity of X-ray mammography in dense breast tissue leads to a very large number of unnecessary biopsies, which have a high cost implication for health services, not to mention their psychological impact. Figure 1 clearly illustrates the much higher sensitivity of PEM. New developments in PEM, ▷

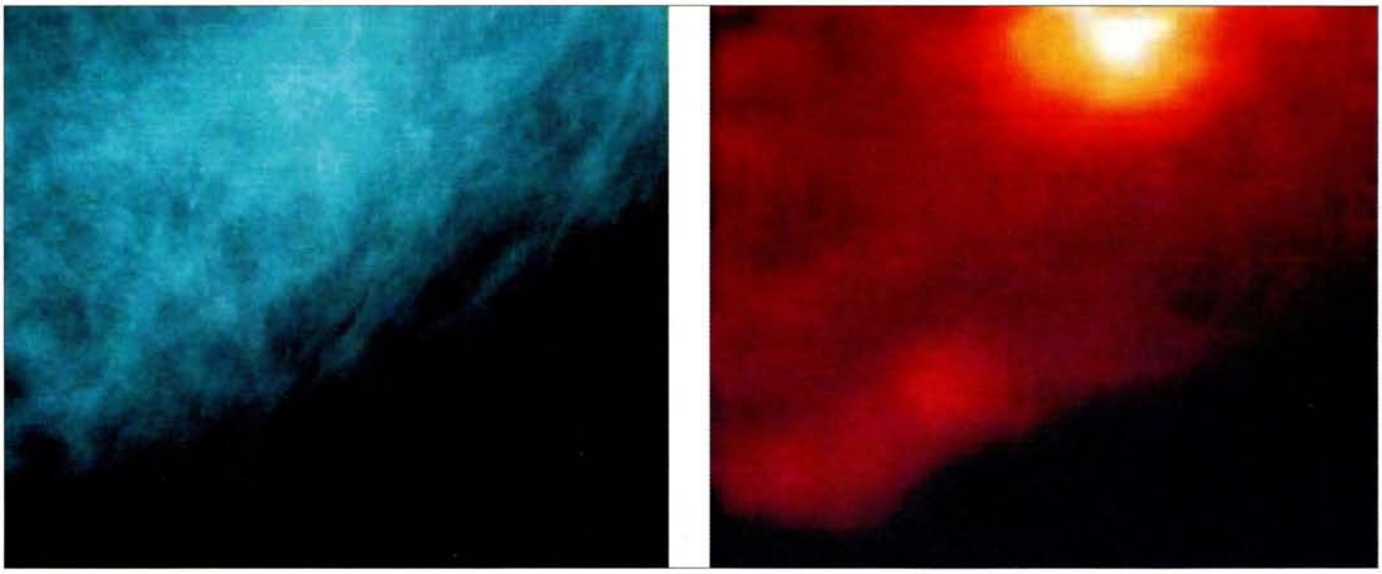


Fig. 1. Comparison of a digital X-ray mammogram (left) with a positron emission mammography image (right) of an infiltrating carcinoma visualized in a dense breast. (Courtesy of Lee P Adler, Fox Chase Cancer Center, Philadelphia.)

SPECT and a dedicated camera show that this field is now moving towards clinical applications.

The conference also heard about new developments in per-operative probes. This very active field involves dedicated, state-of-the-art "small" detectors, which are used in many different applications for diagnostics, staging and surgery of cancer (for example in prostate cancer or the procedure of sentinel lymph node staging for breast cancer), as well as for genomics and proteomics studies. The possible uses of new devices such as micropattern chambers (MICROMEGAS) and silicon strip detectors were also presented.

The conference included a round-table discussion session on the theme of "Multimodality". Since the remarkable demonstration a few years ago by Dave Townsend, a former physicist at CERN, that merging PET and computer tomography (CT) could greatly enhance the diagnostic power of each of these imaging modalities, there is a growing trend to study different combinations of scanners, in particular to combine morphologic and functional imaging techniques. Beside the combination of PET and CT, which is now becoming commercially available, PET and nuclear magnetic resonance imaging can offer considerable improvements, specifically in studies of the brain. More generally, multimodality could be the way to address the very challenging problem of the molecular signature of cancers. The co-registration of different metabolic functions in which tumour cells are involved could provide a non-invasive way to identify precisely the type of cancer under investigation, so as to guide the medical team to the best treatment strategy, in particular when determining the type of chemotherapy to be applied.

Reports on breast-cancer detection, diagnostics and treatment follow-up aroused much interest in instrumentation for functional breast imaging using PEM.

The final session of the conference was devoted to Monte Carlo simulations. Many groups are using GEANT4 libraries to simulate and optimize imaging detectors. The success of GATE (GEANT4 Application for Tomographic Emission) and its first results has clearly demonstrated that the transfer of high-energy physics techniques to the field of medical imaging is now real.

After the success of this conference, all the participants have agreed to reconvene in May 2005, again on the island of Milos, to measure the progress of this fruitful collaboration between physicists and medical doctors.

Further reading

More information can be found on the conference website at http://itbs2003.web.cern.ch/itbs2003. The proceedings will be published in *Nuclear Instruments and Methods A*.

Paul Lecoq, *CERN, and* **Patrick Le Du**, *CEA/DAPNIA.*

Forty years of high-energy physics in Protvino

The Institute for High Energy Physics as it is today, with a clear view of U-70, the 70 GeV proton accelerator.

The Institute for High Energy Physics near Serpukhov in Russia is celebrating four decades of research and international collaboration in particle physics.

In March 1958 the government of the USSR took the decision to create a new scientific centre for high-energy physics, which included the construction of an accelerator and experimental facilities. The design and geological search for a site were soon started, and after considering some 40 places, a site on the left bank of the Protva river 15 km from Serpukhov in Moscow Region, Russia, was chosen. The project concept was developed under the leadership of Vassily Vladimirsky, and in 1960 the construction of the 70 GeV proton synchrotron (U-70) began. At the time, it was the biggest proton accelerator under construction.

On 15 November 1963 the Institute for High Energy Physics (IHEP) received separate institute status, with Anatoli Logunov appointed its director a month earlier. The creation of an efficient team of scientists and specialists from Dubna, Moscow and Kharkov became a decisive factor in pushing forward the construction of the machine, the experimental area and the infrastructure of the new centre.

The research programme was determined by the Scientific Coordinating Committee that was created at IHEP in 1964. It was composed of leading scientists from IHEP and other institutes in the USSR: the Institute for Theoretical and Experimental Physics (ITEP), the Joint Institute for Nuclear Research (JINR), the Institute for Nuclear Research (INR), the Lebedev Physical Institute (LPI), Moscow State University (MSU), Moscow Engineering Physics Institute (MEPhI), the Kurchatov Institute (KIAE) and the Budker Institute for Nuclear Physics (BINP). The timely formation of the first priority research programme and the construction of the experimental facilities allowed experiments to begin at U-70 immediately after the machine's commissioning, and new results in particle physics were soon obtained.

Another mission to be accomplished was the establishment of wide-ranging international collaboration. The construction of the biggest proton accelerator in the world opened up new possibilities in studying the microcosm, and many foreign physicists expressed an interest in taking part in the future research programme. However, it was not a simple task to organize international collaboration under the conditions of the time. Physicists from IHEP held talks with scientists from CERN and Saclay in France, and CERN director-generals Victor Weisskopf and Bernard Gregory played a significant role in helping to establish IHEP's international collaboration with CERN.

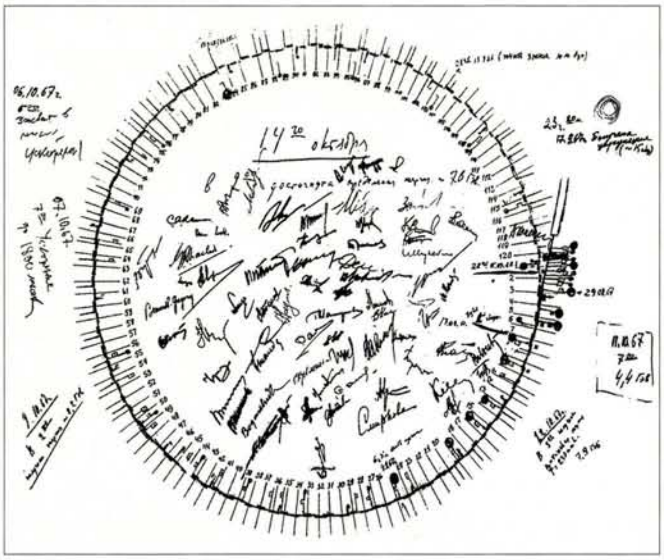
IHEP signed the following agreements as early as 1966/7:

- The agreement concerning scientific and technical co-operation between CERN and the State Committee of the USSR on the Utilization of Atomic Energy (4 July 1967).
- The agreement between the State Committee of the USSR on the Utilization of Atomic Energy and the Commissariat on Atomic Energy of France concerning joint scientific research in high-energy physics at the 70 GeV accelerator (11 October 1966).
- The agreement concerning scientific collaboration between IHEP, Serpukhov and JINR, Dubna (16 April 1966).

The agreement with CERN assumed the fulfilment of a joint programme, which included the design and construction of a fast extraction system and RF separator, as well as the preparation and execution of joint experiments. The CERN–USSR Joint Scientific Committee was formed to coordinate and review this programme.

Commissioning and first experiments

The injector – a 100 MeV linac (L-100) – was put into operation in July 1967, and tuning the proton beam in U-70 began on 29 August. A circulating beam was achieved on 17 September and on 12 October a proton beam was accelerated up to the critical energy (8 GeV). The CERN delegation at IHEP, headed by Bernard Gregory, congratulated IHEP on this success, but expressed the opinion that more work and more time would be needed to ▷



These milestones and signatures of the people who took part in tuning the accelerator, or who were in the control room at the time, were left on a schematic layout of the machine. Among them are the signatures of Bernard Gregory and Anatoli Logunov.

Bernard Gregory opens the champagne in the "Orbita" cafe in Protvino at 4.00 a.m., just after commissioning U-70 in 1967.

French president Georges Pompidou visiting Protvino in 1967.

The official opening of the Mirabelle bubble chamber in 1971.

pass the critical energy and reach the design energy of 70 GeV. However, on the night of 14 October, a record proton energy of 76 GeV was achieved in U-70.

One of the first experiments on the U-70 accelerator, which was carried out by a joint IHEP–CERN team of physicists, was the measurement of the yield of secondary particles produced by 70 GeV protons on internal targets. This work involved high-resolution gas-differential Cerenkov counters with very low background ($\sim 10^{-6}$), and it allowed the study of pion, kaon and anti-proton yields up to momenta of 65 GeV/c. As a result, the new phenomenon of scale invariance was discovered in hadronic interactions at IHEP.

Immediately after the measurements of secondary particle yields, the IHEP–CERN team began to study the energy dependence of total cross-sections in hadron interactions. The results of studies of total cross-sections in the energy range below 30 GeV confirmed the well known data obtained at the Brookhaven National Laboratory in the US and at CERN. However, at energies higher than 30 GeV, while the total cross-sections for $\pi^+/^-$, K^- mesons and protons remained constant, cross-sections for K^+ mesons began to rise. The rise of the total cross-sections for K^+p interactions in the range 15–55 GeV/c was equal to a few per cent. A number of international conferences in high-energy physics focused on this new phenomenon and the discovery became known as the "Serpukhov effect". The measurements of total cross-sections at higher energies at CERN and at Fermilab confirmed the results

> The rise of the total cross-sections for K^+p interactions in the range 15–55 GeV/c was equal to a few per cent...the discovery became known as the "Serpukhov effect".

that the IHEP–CERN team had obtained at U-70, and the rise in total cross-section was found to be a universal phenomenon for all hadrons.

The agreement with France assumed the production and delivery to IHEP of a large hydrogen bubble chamber for experiments with separated hadron beams. Installed at the 70 GeV accelerator in 1970/1, the chamber, which was called Mirabelle, took more than three million pictures and produced a number of excellent physics results.

Continuing collaboration

The joint research programme at U-70 with physicists from JINR, CERN, the US and Japan has continued to the present day. The most well known physics results concern high spin mesons, glueballs and hybrids, while in detector and accelerator techniques important work has been done on polarization effects at high energies, GAMS-type spectrometers, liquid-argon spectrometers, lead-tungstate crystals for electromagnetic calorimetry and beam extraction by bent crystals. Of particular note are the invention of RFQ focusing and the construction of the first RFQ linac, URAL-30, at IHEP.

After the commissioning of the larger accelerators at Fermilab and at CERN, the physicists at IHEP began to take an active part in the experiments at higher energies. These included the neutrino experiments with the 15 ft bubble chamber; polarization experiments and experiments with D0 at Fermilab; experiments with GAMS-4000, EHS and BEBC at CERN's Super Proton Synchrotron; and experiments with DELPHI at LEP and with PHENIX at RHIC, Brookhaven.

Nowadays, physicists from IHEP, together with those from JINR, CERN, INR, ITEP, MSU, MEPhI, LPI, KEK and the University of Michigan, are continuing their research programmes at U-70 in the fields of meson spectroscopy, K-meson rare decays, polarization effects and neutrino interactions. A unique channel of separated K-mesons is under construction at IHEP, the basic elements of which are two superconducting deflectors received from CERN. Among the latest results that have been obtained at U-70 are high-precision measurements of charged kaon decays, spin asymmetries in inclusive reactions and new data on the search for exotic mesons.

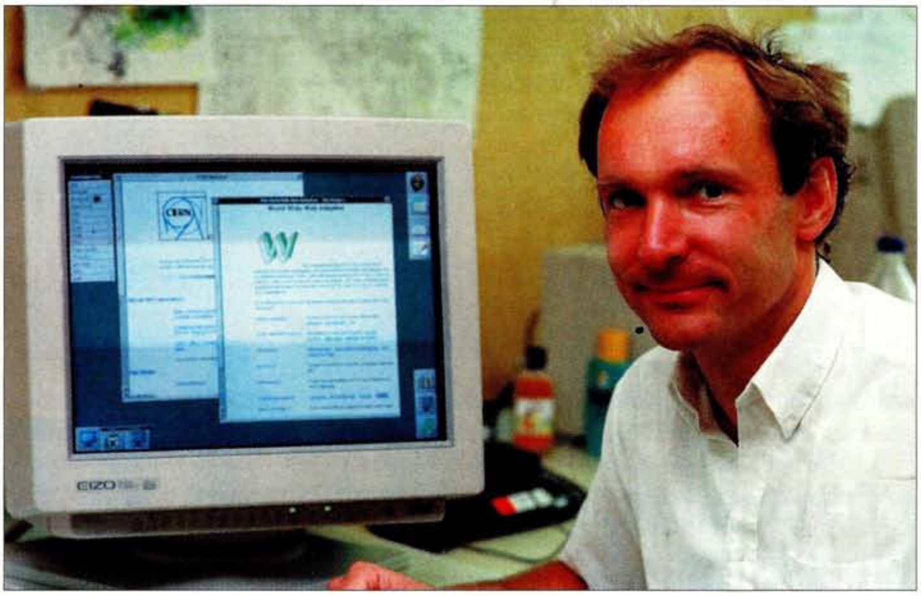
Collaboration between IHEP and CERN remains strong to this day, with physicists from IHEP participating in the ALICE, ATLAS, CMS and LHC-B experiments at the Large Hadron Collider (LHC), as well as in the design and production of equipment for the LHC. The most notable contributions made by the physicists from IHEP are septum magnets for beam injection and extraction systems, DC circuit breakers, dump resistors and components for the CMS forward hadron calorimeter and the ATLAS muon system.

Nikolai Tyurin, *IHEP*.

AWARDS

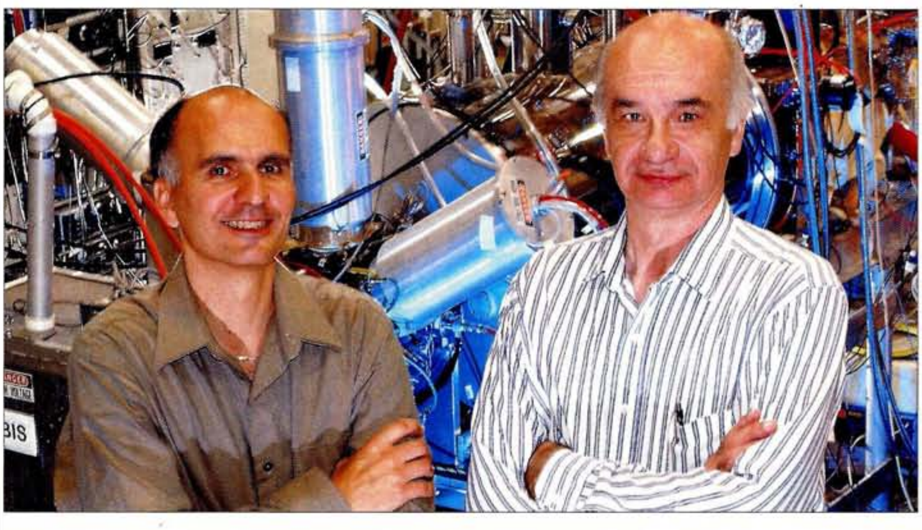
The Economist salutes invention of the Web

The well-respected weekly newspaper *The Economist* has presented its 2nd Annual Innovation Award for Computing to Tim Berners Lee, director of the W3C World Wide Web Consortium. With its innovation awards, *The Economist* recognizes those individuals who are responsible for industry-altering breakthroughs in the areas of computing, biosciences, energy and the environment, telecommunications, and a fifth "no boundaries" category. Berners Lee received the computing award for the global hypertext project he developed at CERN, which became known as the World Wide Web, and in the words of the citation: "forever altered the way information is shared". Candidates for the awards are recommended by readers and writers of *The Economist*, and the winners are selected by a panel of judges.



Tim Berners Lee in 1994 with a screen displaying an early version of a Web browser.

Brookhaven physicists win Brightness Award



Edward Beebe (left) and Alexander Pikin from the Brookhaven National Laboratory have been awarded the Ion Source Prize, also known as the "Brightness Award", which recognizes and encourages innovative and significant recent achievements in the fields of ion-source physics and technology. The two physicists received the award at the Tenth International Conference on Ion Sources, held in Dubna, Russia. Donated by Bergoz Instrumentation of Saint Genis Pouilly, France, the award consists of $6000 (€5111), to be shared by the two winners. Beebe and Pikin have both worked on the development of a new high-intensity electron-beam ion source, which would generate 20 times the intensity of previous designs. Brookhaven plans eventually to use a version of this source for ion injection into the Relativistic Heavy Ion Collider. *Image courtesy of Brookhaven National Laboratory.*

Call for nominations for the 2004 Lise Meitner Prize

The Nuclear Physics Board of the European Physical Society (EPS) is now inviting nominations for the 2004 Lise Meitner Prize. The award will be made to one or several individuals for outstanding work in the fields of experimental, theoretical or applied nuclear science. The board will welcome nominations that represent the breadth and strength of European nuclear sciences.

Nominations should be accompanied by a completed nomination form, a brief curriculum vitae of the nominee(s) and a list of any major publications. Letters of support from authorities in the field, which outline the importance of the work, would also be helpful. The deadline for the submission of the proposals is 10 January 2004.

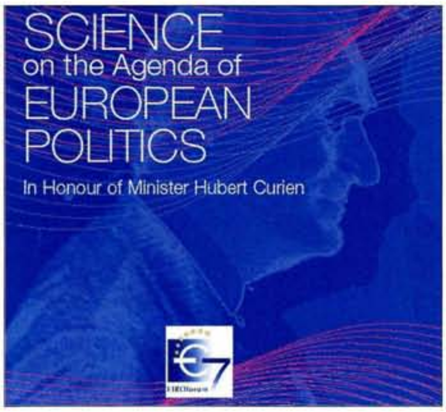
To download the nomination form and for more detailed information about the prize, see the website of the Nuclear Physics Board at www.kvi.nl/~eps_np, or the EPS website at www.eps.org (click on "Prizes", "Lise Meitner Prize").

MEETINGS

Forum Engelberg to honour Hubert Curien

For its 15th annual conference on 1–4 March 2004, the Forum Engelberg will honour its president, Hubert Curien. Curien, a physicist, was minister responsible for research in France from 1984 to 1986 and 1988 to 1993. Curien is also well known at CERN through frequent visits and as former president of the CERN Council.

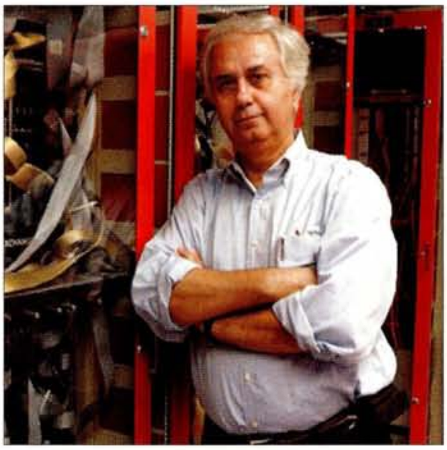
Established in 1989, Forum Engelberg provides an international platform for debate and for the exchange of views on key issues affecting scientific research, technology, economics and philosophy. A different theme is chosen each year, and for 2004 this will be "Science on the agenda of European politics". With this theme, the forum is supporting the EU's strategic goal of making Europe the most competitive and dynamic knowledge-based economy in the world by 2010.



Highlights of the conference programme will include an interdisciplinary scientific programme on 2 and 3 March, chaired by CERN's Luciano Maiani, a session on E-science and the Grid on 4 March, and a young scientists programme. For further information and registration details, see www.forum-engelberg.org.

FERMILAB

CDF collaboration elects spokesman



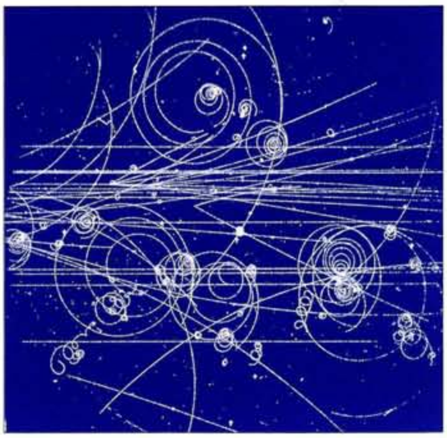
Luciano Ristori, who was at CERN from 1971 to 1980, has been elected co-spokesperson for the Collider Detector at Fermilab (CDF). He will serve for two years as the top scientific authority for the 500-strong collaboration. Ristori received his degree from Pisa in 1971 and joined CERN's NA1 experiment, measuring the photoproduction of vector and scalar bosons. In 1980 he moved to Fermilab, home of the world's highest energy particle accelerator. In 1991 he proposed the Silicon Vertex Tracker, a daring project aimed at using custom silicon chips to identify important events in the CDF detector and activate the trigger. The device proved successful and Ristori now focuses on the data it produces.

ARTS AND SCIENCE

A novel approach to physics

Birmingham University in the UK has been awarded £36 168 (€51 289) to support an Arts and Science Research Fellowship enabling a novelist and a particle physicist to work together on a book that will explore from a literary perspective the largest and smallest objects analysed by modern physics. The project, which links physicist Gron Jones and novelist Alan Wall, is entitled "The Extremes of Experience: Imagery, Beauty and Understanding in Cosmo-Quark Physics". Striking photographs will provide the basis for the study, ranging from pictures of the cosmos produced by the Hubble Space Telescope to images of the paths of subatomic particles produced in a bubble chamber. The book will examine how these extremities of size can be related to each other, and will consider what should be regarded as beautiful in scientific imagery.

Gron Jones, who is based at Birmingham University's Centre for Lifelong Learning, has been involved in CERN's High School Teachers' (HST) programme since its inception (*CERN Courier* October 2003 p28), and the concept of the inspirational images arose from his involvement in this project. Alan Wall's novels include *The Lightning Cage* (1999) and *China* (2003). He is known for his ability to draw accurately upon documentary resources and employ them in an original and striking fashion.



Beauty in the eye of a bubble chamber?

CORRECTIONS

On page 42 of the September issue, in the ALICE awards story, STMicroelectronics is described as a French company. It is in fact a French–Italian company that was formed in 1987 from a merger between SGS Microelettronica of Italy and Thomson Semiconducteurs of France.

On page 11 of the October issue, in the laser alchemy story, the Rutherford Appleton Laboratory is assigned to the US. It is of course located in Oxfordshire in the UK.

CERN AND INDUSTRY

French industry shows its wares

On 23–25 September, French industry exhibited at CERN, showing products and technologies related to research in particle physics. Twenty-five French companies presented their latest developments in the fields of electrical engineering, information technology, vacuum and low-temperature technologies, and civil engineering.

Bernard Frois (shown here second from the right), director of the Energy, Transport and Environment Department of the French Ministry for Research and New Technologies, inaugurated the exhibition on 23 September. To make the most of his time at CERN, he also visited the assembly halls of CMS and ATLAS, and the hall where the superconducting magnets for the LHC are tested.

From left: Jean-Claude Brisson, DAPNIA; Florence Cousquer, CFME/ACTIM; HE Philippe Petit, Ambassador and permanent representative of France to the UN in Geneva; Claude Détraz, CERN's research director for fixed target and future programmes; Alexandre Defay, technical adviser to the French minister for research; Bernard Frois; and Jean-Jacques Aubert, IN2P3.

Head of BTI Group visits CERN

In the ATLAS cavern, left to right: Eleanor Baha, British vice-consul (trade development); Corin Wilson, Trade Partners UK; David Roberts, director of trade and investment, British Embassy, Berne; Sir Stephen Brown; Pippa Wells, CERN, and Mike Cairns, Trade Partners UK.

Sir Stephen Brown, the chief executive of the BTI (British Trade International) Group, visited CERN on 2 October. The BTI Group is the British government's lead organization for enhancing the international competitiveness of companies in the UK. During the visit, Sir Stephen toured the LHC magnet test hall, the assembly area for the CMS detector and the underground cavern for the ATLAS detector.

NEW PRODUCTS

ATLAS Technologies has announced a non-magnetic model of its aluminium flange with a stainless-steel knife-edge – the ATLAS Flange. The new model uses a 316LN stainless alloy to ensure minimal magnetic permeability while providing an aluminium base that is not magnetized during welding to an aluminium chamber. For more details call +1 360 385 3123, e-mail sales@atlasbimetal.com or see www.atlasbimetal.com.

Precision Measurements has developed metal-jacketed microwave cables using high-purity silicon dioxide, which resists temperatures above 900 °C. The cable has a low dielectric constant, can be operated in excess of 20 GHz and provides low insertion loss. The cable assemblies are completely hermetic and useful in hostile environments. For further information see www.measure-tech.com.

Integrated Engineering Software (IES) has released Lorentz 2Dv6.1, the latest version of its software for the design and analysis of charged particle beams in electromagnetic fields. It incorporates a new multi-method solver, which helps reduce model generation time and improve speed and accuracy. For a full review see www.integratedsoft.com/products/updates.asp. For more details tel +1 204 632 5636 or e-mail info@integratedsoft.com.

OBITUARY

Maxim Kotsky 1968–2003

On 30 August a tragic event ended the life of a brilliant young physicist, Maxim Kotsky, who was killed in a car accident.

Maxim graduated from the Novosibirsk State University in 1993. Soon afterwards he joined the Theoretical Division of the Budker Institute for Nuclear Physics, where he received the degree of Candidate of Sciences (the Russian PhD) in 1997.

The main field of Maxim's scientific research was the theory of semi-hard QCD processes, where he made a remarkable contribution to calculations for the derivation of the BFKL equation in the next-to-leading approximation. He also performed important and interesting analyses of heavy-quark pair production near threshold and the double logarithmic asymptotics of QCD.

Maxim was a very warm and engaging person who was endlessly enthusiastic in his scientific work. He could easily establish contact and interact with people. He will remain in the memory of those who knew him for a very long time.

Victor Kim, St Petersburg Nuclear Physics Institute.

LETTERS

Please e-mail cern.courier@cern.ch. We reserve the right to edit letters.

Edward Teller and Rolf Hagedorn

Edward Teller died in September 2003, the month *CERN Courier* published several papers on quark–gluon plasma and the pioneering work of the late Rolf Hagedorn, who was first to predict under which conditions this new state of hadronic matter could be reached. While forthcoming obituaries may recall the many contributions of Teller, it may nevertheless be appropriate to stress that Teller and three colleagues were first to propose that collisions of very energetic heavy ions would be ideal to create hot, dense nuclear matter (*Phys. Rev.* 1973 **D8** 4302). They predicted that experiments with heavy-ion colliders would probably result in the "production of matter in a new regime of temperature and density", and gave credit to Hagedorn for stressing the importance of dense hot nuclear matter "for understanding popular models of the early universe".

André Gsponer, Geneva, Switzerland.

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FOM - founded in 1946 - is a foundation recognized by NWO.

FOM

NIKHEF is the National Institute for Nuclear Physics and High Energy Physics in the Netherlands, in which the Foundation for Fundamental Research of Matter (FOM), the Universiteit van Amsterdam (UvA), the Vrije Universiteit Amsterdam (VUA), the Katholieke Universiteit Nijmegen (KUN) and the Universiteit Utrecht (UU) collaborate. NIKHEF co-ordinates and supports all activities in experimental subatomic (high energy) physics in the Netherlands.

NIKHEF is actively involved in experiments in Switzerland/France at CERN (Delphi and L3), in the USA (D0 at FNAL, BaBar at SLAC and STAR at RHIC) and in Germany at DESY (Zeus and Hermes). NIKHEF participates in the preparation of the Atlas, LHCb and Alice experiments at the Large Hadron Collider at CERN. The Antares project, a detector to be built in the Mediterranean, represents NIKHEF's involvement in astroparticle physics. Detector R&D, design and construction of detectors and the data-analysis take place at the laboratory located in Sciencepark Amsterdam and at the participating universities. NIKHEF has a theory group with both its own research programme and close contacts with the experimental groups.

The academic staff consists of about 120 physicists of whom more than half are Ph.D. students and postdoctoral fellows. The well equipped mechanical, electronic and IT departments have a total staff of about 100. General services are provided by a support staff of about 20.

NIKHEF is searching for an outstanding

Experimental Physicist

with a strong record of accomplishments in experimental research in high energy physics.

Requirements
Candidates - with equal opportunity for women and men - will be considered for a permanent position when they have at least several years of postdoctoral experience. They should have a broad and deep knowledge of physics. Further qualifications include: creativity, competence in detection techniques, knowledge of modern information technology. The successful candidate should have excellent communication skills, ability for team-work and leadership capability. It is assumed that the successful applicant will join one of the present experimental programmes.

Information
General information and information about the scientific and educational activities at NIKHEF can be found at: http://www.nikhef.nl/. Further information can be obtained from the director, prof. dr. J.J. Engelen (telephone: +31 205925001/e-mail: engelen@nikhef.nl) or the chairman of the search committee, prof. dr. ing. J. van den Brand (telephone: +31 205922015/e-mail: jo@nikhef.nl).

Applications
Letters of application, including curriculum vitae, list of publications and the names of at least three references are to be sent before 22 November to Mr. T. van Egdom, P.O. Box 41882, 1009 DB Amsterdam, the Netherlands (or by e-mail: teusve@nikhef.nl).

NIKHEF

Center for Cosmological Physics at the University of Chicago

CfCP Postdoctoral Research Fellowship

The CfCP invites applications for up to two NSF Funded Research Fellowships from young scientists of exceptional ability and promise who will have received a PhD. in Physics, Astrophysics or related fields by September 2004. The appointees are expected to conduct original research in experimental or theoretical cosmology in an interdisciplinary environment. Initial appointments are for one year, renewal annually, for up to three years. Positions have competitive salaries and carry faculty level benefits. Center Postdocs have the freedom to work on any of the efforts in our Center.

Research at the Center for Cosmological Physics (CfCP), based at the University of Chicago, is focused on interdisciplinary topics in cosmological physics: characterizing the Dark Energy, studying the inflationary era, and understanding the highest energy cosmic rays. Studies of the CMB (polarization anisotropies and the Sunyaev-Zel'dovic effect) and Cosmic Infrared Background; analysis of Sloan Digital Survey and other large-scale structure data; high energy astrophysics with photons and cosmic rays, direct detection of Dark Matter particles and numerous topics in theoretical cosmology constitute the current slate of activities. The CfCP also has active visitors, symposia, and education/outreach programs. Information about the CfCP can be found at ***http://cfcp.uchicago.edu/***

An application consisting of a Curriculum Vitae, a statement of research interests, and at least three letters of recommendation should be sent to *centerfellow@cfcp.uchicago.edu* or to Bruce Winstein, Director, Center for Cosmological Physics, Enrico Fermi Institute, 5640 S. Ellis Avenue, Chicago, IL 60637. All qualified applications received for this position will be considered automatically for the DOE Funded Postdoctoral position in theoretical cosmology at the Enrico Fermi Institute unless applicant declines consideration. (For details see: *http://background.uchicago.edu/~whu/postdoc.html*)

The application deadline is December 1, 2003 for positions that will begin in the Summer or Fall of 2004.

The University of Chicago is an Affirmative Action/Equal Opportunity Employer

FACULTY POSITION IN EXPERIMENTAL NUCLEAR PHYSICS

INDIANA UNIVERSITY

The Physics Department at Indiana University seeks outstanding candidates for a tenure-track assistant professor position in experimental nuclear physics to start in Fall 2004. We are searching for strong applicants with the potential to become intellectual leaders in any subfield of nuclear physics or its intersections with astrophysics and/or particle physics. An ability to teach physics effectively in the classroom and through supervision of research at both the undergraduate and graduate levels is essential. IU physicists play leadership roles in high energy spin physics at BNL, neutrino physics at FNAL, fundamental neutron physics at NIST/LANL/ORNL, and hadron spectroscopy at TJNAF. The collective technical resources, infrastructure, and support staff in the Physics Department and at the associated Indiana University Cyclotron Facility (IUCF) allow IU physicists to develop experimental apparatus on a scale normally possible only at national labs. Detailed information on current projects can be found at http://www.physics.indiana.edu and http://www.iucf.indiana.edu. We especially welcome applications from women and minority candidates. Please mail a CV, publication list, and research plan and arrange for a minimum of three letters of recommendation to be sent to:

Faculty Search Committee, c/o Prof. W. M. Snow, Dept. of Physics, Indiana University, Swain Hall West 117, Bloomington IN, 47405-7105

Applications received by December 1, 2003, will receive priority.

Indiana University is an Affirmative Action/Equal OpportunityEmployer.

Position in LIGO Gravitational Wave Data Analysis and Grid Computing

The Penn State Center for Gravitational Wave Physics (CGWP) has funding for positions at the postdoctoral scholar level or higher to take part in the analysis and interpretation of observations from the Laser Interferometer Gravitational Wave Observatory (LIGO). At least three years of funding is available for each position.

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

The Penn State LIGO Scientific Collaboration (LSC) group is part of the LIGO Global Grid Virtual Organization, contributing local resources of 312 processors and 34 TB storage (approximately 1/4 of the total aggregate resources). The LIGO VO is part of the larger International Virtual Data Grid Laboratory (iVDGL), which is pioneering the application of Grid-paradigm computing for large, forefront experiments in physics and astronomy. The iVDGL includes computing, storage and network resources in the U.S., Europe, Asia and South America.

The Penn State LIGO Scientific Collaboration (LSC) group is among the largest and most active in the Collaboration with two faculty, five postdocs and technical staff members, five graduate students, and five undergraduate students. It plays a leading role in the analysis and interpretation of LIGO data, including analysis in collaboration with other gravitational wave detector experiments worldwide. It is part of the larger Penn State relativity group, which is among the largest and most active in the country with six faculty, sixteen postdocs, eighteen graduate students, and twelve undergraduate students engaged in research in all areas of gravity.

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

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

LIGO Staff Search
Center for Gravitational Wave Physics
104 Davey Laboratory, PMB 89
University Park, PA 16802.
USA

Applications will be considered beginning immediately and will continue until the available position is filled. For more information see our websites at:

http://gravity.psu.edu
and
http://ligo.aset.psu.edu

Penn State is committed to affirmative action, equal opportunity and the diversity of its workforce.

The Fermi National Accelerator Laboratory (Fermilab) invites applications for:

LEDERMAN FELLOWSHIP
EXPERIMENTAL PARTICLE PHYSICS

Applicants should have demonstrated outstanding ability in research and, in recognition of Leon Lederman's commitment to the teaching of physics at all levels, experience and interest in physics outreach. The successful candidate will have a choice among experiments, which include Tevatron collider experiments, neutrino experiments, other fixed target experiments and non-accelerator projects (dark matter search, cosmic ray observatory), or research on accelerators. See http://www.fnal.gov/ for more information.

Candidates should have obtained a Ph.D. in particle or accelerator physics since Jan 1st 2002. The appointment is normally for three years with an extension possible. Applicants should send a letter including their research and outreach experience and interests, a curriculum vita, publication list and the names of at least four references. One reference should specifically address the outreach experience. ***The deadline for applications is December 6th 2003.*** To apply write to **Dr. Michael Albrow – Experimental Physics Projects Department Head, Fermi National Accelerator Laboratory, MS 122, P. O. Box 500, Batavia, IL 60510-0500. (albrow@fnal.gov)** EOE M/F/D/V

Fermilab

APPLIED PHYSICIST
FOR X-RAY DETECTOR DEVELOPMENT

Praesepe is a Netherlands-based company which specialises in data analysis and instrumentation for X-ray and gamma-ray astronomy (see www.praesepe.com). We currently have a vacancy for an Applied Physicist to provide support to the laboratory research programme of the Advanced Concepts and Science Payloads Office of the European Space Agency (ESA). The work will be based in the ESTEC laboratory of ESA in Noordwijk, The Netherlands.

The ideal candidate would offer experience in the areas of solid state detector development and operation, together with a knowledge of general techniques in X-ray and gamma-ray radiation analysis. The candidate should be able to plan and execute measurement campaigns with a minimum of supervision. The ability to analyse data in support of device physics interpretation is important. Familiarity with cryogenic equipment, computer interfaces to experiments, radioactive source handling and measurement campaigns and national accelerator facilities would be valuable. Some experience in the analysis of data from either ground or satellite-based astronomical observations would be an advantage.

Applications with CV to
Praesepe B.V., Lorentzplein 7, 2012 HG Haarlem, The Netherlands.

Preferably by email (info@praesepe.com) or by FAX +31-23-5510910.

GRID COORDINATOR/ TECHNOLOGY ARCHITECT

Brookhaven National Laboratory (BNL) has an exceptional opportunity for a computer scientist with hands-on GRID experience. Requirements include an advanced degree in information technology, physics, or closely related field and ten years' experience addressing large-scale scientific computing problems. Experience must include work with large geographically distributed collaborations and computing resources, petabyte scale data sets, and hands-on experience with Globus-based computing Grid technology. Excellent communication skills and evidence of management and leadership skills are also required. Familiarity and experience with ongoing DOE and NSF Grid projects would be of great value. BNL is actively participating in Grid projects involving ATLAS and the RHIC experiments. The successful candidate will participate in existing Grid projects, coordinate Grid efforts at BNL and actively pursue new Grid initiatives.

For consideration, please forward your resume, referring to Position #NS3169, and three letters of recommendation to: Nancy L. Sobrito, Brookhaven National Laboratory, Bldg. 185-HR, Upton, NY 11973, USA; email Sobrito@bnl.gov; fax 631-344-7170.

BNL is an equal opportunity employer committed to workforce diversity.

BROOKHAVEN
NATIONAL LABORATORY
A passion for discovery.

www.bnl.gov

Uni Bonn

Rheinische Friedrich-Wilhelms-Universität Bonn

The faculty of mathematics and natural sciences of Bonn University invites applications for a

Chair in Experimental Physics (C 4) (succession E. Klempt)

at the Helmholtz-Institut für Strahlen- und Kernphysik. We look for a renowned scientist with experience in experiments to investigate the structure and dynamics of hadrons as strongly interacting many-body systems. Active participation in the presently applied for Transregio/SFG „Subnuclear sturcture of matter" and in teaching as well as administration is expected.

Appointments follow the rules and regulations of the Universities in Northrine-Westfalia. The University of Bonn aims at increasing the fraction of female staff and encourages women to apply. Disabled candidates will, with equal qualifications, be appointed preferentially.

Applications are to be sent by 31. Dec. 2003 (arrival) to the

Chairman of the Dept. of Physics/Astronomy
Endenicher Allee 11-13
D-53115 Bonn, Germany

ADVERTISING OPENINGS IN A RESEARCH TRAINING NETWORK SPONSORED BY THE EUROPEAN COMMUNITY:

Probe for New Physics , a four-year Research Training Network (RTN), sponsored by the European Community, started on September 1st 2002. The RTN is offering several two-year postdoctoral positions and a few pre-doctoral positions. Six positions are currently opened.

The main focus of this network is on: "The Third Generation as a Probe for New Physics: Experimental and Technological Approach" . Its scope covers the legacy from LEP experiments, the run II of CDF at the Tevatron, the ongoing preparation of ATLAS and CMS experiments at the LHC, the studies for a future Linear Collider detector. It involves related phenomenological, experimental and technological studies.

The following Institutes are participating to the network, also indicated are the scientists in charge :

LPNHE-Université Pierre et Marie Curie/IN2P3-CNRS [A.Savoy-Navarro, network coordinator, F], LAL-Orsay/IN2P3-CNRS [P. Roudeau, F], Karlsruhe University/IEKP [T. Muller, D], University of Athens/IASA and Demokritos NCSR [N. Giokaris, G], University of Padova [G. Busetto, I], University of Pisa/INFN, Pisa Scuola Normale Superiore and University of Cassino [A. Menzione, I], University of Roma "La Sapienza" [L. Zanello, I], Barcelona Autonoma University/IFAE [M. Cavalli-Sforza, E], IFIC-Valencia:University of Valencia/CSIC and CNM-IMB/CSIC [J. Fuster, E], IFCA-University of Cantabria and CSIC [A. Ruiz,E], University of Helsinki [R. Orava, Fin], Comenius University in Bratislava [S. Tokar, SK], Charles University of Prague[M. Suk, CZ], Weizmann Institute of Science in Rehovot and Technion Institute in Haifa[Y. Nir, Il].

The applicant should comply with the following EC rules:
1) Age: Be under 36
2) Nationality: Be nationals of an EU Member State or Associated State or have resided in a EU Member State for at least five years immediately prior to the appointment by a participant in the frame of the network contract.
3) International Mobility: Not be a national of the state in which the institution to be applied to is located and not to have carried out their normal activities in that state for more than 12 months prior to their appointment.

For further information please contact:
aurore@lpnhep.in2p3.fr or **aurore.savoy@cern.ch** or **aurore@fnal.gov**
and visit the network Web site: **http://lpnhe-lc.in2p3.fr/rtn**

The open positions are at: Helsinki U., Karlsruhe IEKP, Charles U./Prague, Paris-LPNHE, Pisa/INFN & Scuola Normale, Santander/Cantabria U., for postdoc positions and a few pre-doctoral positions.
These positions typically provide high visibility, both in large international collaborations and within the network.

UNIVERSITY COLLEGE LONDON

UCL ***Department of Physics and Astronomy***

Physicist/Software Engineer

The High Energy Physics group of the UCL Department of Physics & Astronomy has a challenging opportunity in physics software development for the ATLAS experiment, which is scheduled to start taking data at the CERN Large Hadron Collider in 2007. UCL is a major contributor to the software programme of ATLAS. Our activities include the development of both physics applications (jet clustering, LVL2 tracking) and core software (Quality Control, Simulation, Graphics).

The successful candidate will have (or expect soon) a Ph.D. in Particle Physics, or a B.Sc. (or equivalent) in Computer Science with experience in large scale software development. Good understanding of OO programming techniques is desirable, as is knowledge of one or more of C++, Java, Python and web tools. (S)he will join a small, active group of software and physics experts, which itself is imbedded in a large physics research environment, and will participate in all phases of new projects as well as in upgrades of the existing software for which UCL is responsible. A physicist will also be expected to lead physics studies as part of preparations for data taking.

The starting salary, depending on qualifications and experience, will be in the range £20,311 - £25,451 (pay award pending) plus £2,134 pa London Allowance. The appointment will be for up to three years.

Applications (including a CV, statement of interests and the names of two referees) should be sent to Ms. C. Johnston, Department of Physics & Astronomy, UCL, Gower Street, London WC1E 6BT, UK. Further information about the UCL HEP group can be found on http://www.hep.ucl.ac.uk/. Informal enquiries can be made to Dr. Nikos Konstantinidis (n.konstantinidis@ucl.ac.uk).

We particularly welcome women and black and minority applicants as they are under represented at this level within University College London (Section 48 of the Sex Discrimination Act 1975/Section 38 of the Race Relations Act 1976 apply).

The closing date for applications is **Monday, 1st December 2003.**

UCIrvine

University of California, Irvine

Postdoctoral Position

Neutrino and Neutrino-Oscillation Physics

The University of California, Irvine invites applications for one or more Postdoctoral Scholar positions in neutrino and neutrino-oscillation physics. Our group is heavily involved in the continuing Super-Kamiokande and K2K experiments in Japan. We are also participating in the JPARCnu long-baseline oscillation experiment to search for θ_{13} and leptonic CP violation and a proposed high-statistics measurement of exclusive neutrino cross-sections with the MINERvA experiment at Fermilab. The successful candidate(s) will join in analysis of our on-going experiments and take a major role in the design and realization of the new ones. Positions could begin as early as January 1, 2004, if a suitable candidate is identified, at a starting salary of $35,304 - $46,056. A Ph.D. (or equivalent degree) in high-energy particle physics is required. Candidates with experience in neutrino detection/data analysis or neutrino interaction/oscillation phenomenology, and meeting the highest standards of character and professional integrity, are particularly encouraged to apply.
Interested candidates should provide a curriculum vita and arrange to have three letters of recommendation sent by January 31, 2004 to

Professor D. Casper, Department of Physics and Astronomy,
4129 Frederick Reines Hall, University of California,
Irvine CA 92697-4575,
dcasper@uci.edu (949) 824-6946.

The University of California, Irvine is an equal opportunity employer committed to excellence through diversity.

FACULTY POSITION IN ACCELERATOR PHYSICS

The Department of Physics at the University of California, Riverside, invites highly qualified applicants to apply for a new faculty position in accelerator physics. This position may be filled at either the assistant professor or tenured associate professor level. The appointment will be effective July 1, 2004.

The Department is seeking outstanding candidates with exceptional research records and demonstrated excellence in teaching. The successful candidate is expected to establish a leading edge research program involving graduate students in what will be a new area in the Department and contribute to Department teaching at all levels. The Department currently carries out research in experimental and theoretical condensed matter physics, astrophysics, and high-energy physics.

Candidates for this position are required to have a Ph.D. or equivalent degree in physics. Salary will be competitive and commensurate with qualifications and level of appointment. Candidates should submit a letter of application, curriculum vitae, list of publications, evidence of teaching skills, and evidence of an outstanding research program. Candidates should also provide evidence of leadership and initiative since accelerator physics will be a new area in the Department. They should arrange to have three letters of reference sent to the Department and be willing to submit additional references on request. Letters should be sent to:

Chair, Accelerator Physics Search Committee
Department of Physics
University of California, Riverside
Riverside, CA 92521-0413
U.S.A.

Full review of applications will begin January 1, 2004.
The position will remain open until filled.

UCR
UNIVERSITY OF CALIFORNIA, RIVERSIDE

The University of California is an Equal Opportunity/Affirmative Action Employer

Director of the Indiana University Cyclotron Facility

Applications are invited for the directorship of the Indiana University Cyclotron Facility (IUCF). We seek a distinguished scientist with experience in accelerator-based research to provide scientific leadership for the laboratory and its programs, to manage its diverse mission, and to guide its future development. IUCF's local accelerators provide beams for cancer treatment at the Midwest Proton Radiotherapy Institute, for science and instrumentation development at the Low-Energy Neutron Source presently under construction, and for studies of radiation effects on materials. Its infrastructure supports a vigorous, nationally ranked program of basic nuclear and accelerator science research carried out at other laboratories, often involving major hardware construction. Current emphases of the nuclear science program are: high-energy spin physics, fundamental neutron physics, neutrino oscillations and interactions, and nuclear reaction studies.

More details on the lab activities can be found at **http://www.iucf.indiana.edu**.

The director will serve a five-year term starting in the summer of 2004 and will receive a tenured full professorship in the College of Arts and Sciences. Salary will be commensurate with experience and qualifications. Applications with a complete resume, including the names of four references and nominations should be sent as soon as possible, but no later than Jan 1, 2004, to

Professor J.A. Musser,
Chairman, Search and Screen Committee,
Office of the Vice President for Research,
Bryan Hall 104,
Indiana University, Bloomington, Indiana, 47405.

Indiana University is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minority candidates.

PENNSTATE

Postdoctoral Positions in Gravitational Wave Phenomenology

The Penn State Center for Gravitational Wave Physics expects to make several postdoctoral appointments with a start date of September 2004.

Research at the Center focuses on interdisciplinary problems at the interface of astrophysics, gravitational waves, and general relativity. The core members of the Center include Abhay Ashtekar, Bernd Bruegman, Sam Finn, Pablo Laguna, Peter Meszaros, Ben Owen, Deirdre Shoemaker, Steinn Sigurdsson and Alex Wolszczan, all of whom lead strong research programs in the critical areas from which gravitational wave phenomenology is emerging. The Center for Gravitational Wave Physics has an international visitor program and hosts frequent workshops focused on critical gravitational wave phenomenology problems.

Other leading research areas in the gravitational physics program at Penn State include quantum gravity, mathematical general relativity, relativistic astrophysics and radio astronomy. The Penn State Physics and Astronomy and Astrophysics departments have world-class expertise in several relatedareas: astro-particle physics (Pierre Auger Observatory), gamma raybursts (SWIFT), X-ray astronomy (Chandra observatory) and theoretical and observational cosmology. The Penn State LIGO Scientific Collaboration (LSC) group is among the largest and most active in the Collaboration and plays a leading role in the analysis and interpretation of LIGO data, including analysis in collaboration with other gravitational wave detector experiments worldwide. It hosts a regional center for grid computing, whose primary focus is data analysis for LIGO. The Penn State relativity group, which is among the largest and most active in the country, includes six faculty, sixteen postdocs, eighteen graduate students, and twelve undergraduate students engaged in research in all areas of gravity.

Applicants with Ph.D. in hand should send a CV, statement of research interests and relevant experience, and arrange for three letters of recommendation to be sent to:

Gravitational Wave Phenomenology Postdoc Search
Center for Gravitational Wave Physics
104 Davey Laboratory, PMB 89
University Park, PA 16802.
USA

Applications will be considered beginning 1 December 2003 and will continue until all available positions are filled. For more information see our websites at:

http://gravity.psu.edu and
http://ligo.aset.psu.edu

Penn State is committed to affirmative action, equal opportunity and the diversity of its workforce.

Experimental Research Associates

The Stanford Linear Accelerator Center (SLAC) is one of the world's leading laboratories supporting research in high energy physics. The laboratory's program includes the physics of high energy electron-positron collisions, high luminosity storage rings, high energy linear colliders and particle astrophysics.

Post-doctoral Research Associate positions are currently available at the PEP II Asymmetric B Factory with research opportunities in the BaBar Physics program. Interested candidates should have a strong interest in exploring B Physics with the BaBar detector utilizing 100 fb^{-1} + data set and preparations for improvements to the detector.

These positions are highly competitive and require a background of research in high energy physics and a recent PhD or equivalent. The term for these positions is two years and may be extended.

Applicants should send a letter stating their physics research interests along with a CV and three references to Jan Louisell, via email at janl@slac.stanford.edu or by mail to: SLAC Research Division, 2575 Sand Hill Road, M/S 75, Menlo Park, CA 94025.

Equal opportunity through affirmative action.

Yale University

Faculty Position in Astrophysics

The Department of Physics invites applications for a *faculty position in experimental/observational cosmology or extragalactic astrophysics*. The successful candidate's research program should enhance current research at Yale, which includes high-energy astrophysics, cosmology, gravitational lensing, nuclear astrophysics, and the interface of particle physics and astrophysics. This position is intended at the assistant professor level, although a more senior appointment may be possible in exceptional circumstances. Yale offers a lively scientific environment; a pleasant location convenient to New York City and Boston; competitive salary, benefits, and research funds; and access to front-line astronomical facilities, including the WIYN telescope, the SMARTS telescopes, major telescopes in Chile (through collaboration with the Univ. de Chile), and the Palomar-QUEST survey. Candidates should have an aptitude for teaching as well as research.

Applicants should send their curriculum vitae, bibliography, and brief description of future research program to

Prof. Charles Baltay,
Chair of the Search Committee,
Department of Physics, Yale University,
New Haven, CT 06520-8121,

and should arrange for at least 3 letters of recommendation.

Applications that are complete by Dec 1, 2003, will be assured of full consideration.

Yale is an Affirmative Action/Equal Opportunity Employer, and applications from women and minorities are strongly encouraged.

LUX ET VERITAS

UNIVERSITY OF FLORIDA

EXPERIMENTAL PARTICLE ASTROPHYSICS FACULTY POSITION

The Department of Physics, University of Florida, invites applications for a tenure-track Assistant or Associate Professor in the field of Experimental Particle Astrophysics.

The successful candidate will play a leadership role in a new experimental research effort, joining an active faculty housed in a new physics building with extensive laboratory space and computer facilities. Specific examples of research programs of interest include high-energy cosmic rays, cosmic microwave background observations, non-accelerator based neutrino studies, gamma ray astronomy, dark matter searches, and gravitational wave detection. Further faculty hires in the field are anticipated. Candidates are expected to have a PhD degree, or equivalent, and postdoctoral experience, and to be able to teach physics effectively at all levels. Applicants should submit a CV, publication list, and a statement of research interests and plans, and should arrange to have at least three letters of recommendation sent. All correspondence should be sent to:

Chair, EPA Search Committee, c/o Mrs. Y. Dixon,
Department of Physics, PO Box 118440,
University of Florida,
Gainesville, FL 32611-8440.

To ensure full consideration, all application materials must be received by January 1, 2004.

Women and underrepresented minorities are strongly encouraged to apply. The University of Florida is an Affirmative Action/Equal Opportunity Employer.

For further details on this position, please see:
http://www.phys.ufl.edu/department/jobs/epasearch.html

NUS National University of Singapore

ACCELERATOR PHYSICIST, BEAMLINE SCIENTIST, RESEARCH ASSOCIATE and CONTROL SYSTEMS ENGINEER

Singapore Synchrotron Light Source

The Singapore Synchrotron Light Source (SSLS), National University of Singapore (NUS), invites applications for various positions of **Accelerator Physicist, Beamline Scientist, Research Associate and Control Systems Engineer.**

For full details, please refer to the SSLS website at
http://ssls.nus.edu.sg

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From the Preshower to the New Technologies for Supercolliders edited by Björn H Wiik, Albrecht Wagner and Horst Wenninger, World Scientific. Hardback ISBN 9812381996, £53 ($78).

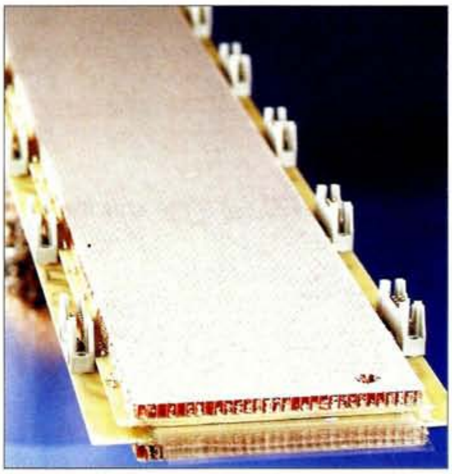
In 2000, the city of Bologna was the European Capital for Culture. To mark the occasion the University of Bologna and its Academy of Sciences published the achievements of their most distinguished members in the field of science and technology. This collection acknowledges the contributions of Antonino Zichichi and his colleagues in the development of experimental techniques that have contributed to the discovery of new particles and phenomena in the field of high-energy physics.

The collection was originally prepared by Björn Wiik, who at the time was director of DESY. After Wiik's untimely death in 1999, Albrecht Wagner, Wiik's successor, continued and completed his work, with the help of Horst Wenninger of CERN.

In his introduction Wiik recalls how in the early 1960s, when the dominant detector was the bubble chamber and the dominating field of interest was the physics of hadrons and neutrinos, Zichichi started to study the unfashionable topic of lepton-pair production in hadronic interactions. During the 1960s and early 1970s, Zichichi and colleagues, mainly working at CERN, developed a number of techniques to help in the problem of particle identification. This foresight was vindicated with the discovery in 1974 of the J/Ψ particle. The "pre shower" technology was essential to this discovery. In fact, this early emphasis on the development of innovative detection techniques continued to be one of Zichichi's main scientific motivations.

The first section of this collection contains the major contributions from Zichichi and his co-workers on the development of three techniques that have come to be widely used in high-energy physics experiments: the "early shower development" method (universally used and now called the "pre shower" method), the study of range curves for high-energy muons in order to discriminate against pion penetration ("muon punch-through method"), and the "lead scintillator sandwich telescope" – the precursor of today's calorimeters.

In the second section there are original papers by Zichichi and colleagues on high-precision time-of-flight (TOF) counters and the neutron missing-mass spectrometer technique.



The ALICE experiment at the LHC will use multigap resistive plate chambers (MRPCs) like this in its time-of-flight (TOF) system. The MRPC is a stack of resistive plates that define a number of independent gas gaps (10 in the case of the ALICE TOF), allowing full detection efficiency and excellent time resolution (< 50 ps). This device was developed by Crispin Williams et al. *within the framework of the LAA project detector R&D initiated by Antonino Zichichi.*

This section also includes an extract of a paper by Federico Palmonari on the AMS experiment. This experiment uses a TOF system that relies heavily on the early work of Zichichi and his colleagues at Bologna and CERN.

The third part of the collection describes the achievements of the LAA project. This was initiated by Zichichi, funded by the Italian government and implemented at CERN in 1986. The goal of the project was to prove the feasibility of a series of detector technologies that could be used in a future multi-TeV hadron collider. Zichichi had long promoted the construction in his native Sicily of a very high-energy hadron collider, the "Eloisatron", with a collision energy of 200–1000 TeV and luminosities of up to $10^{36}\,cm^{-2}\,s^{-1}$. The machine parameters that served as a basis of the LAA project were those of a 10% model of the Eloisatron, surprisingly close to those of the LHC. The book reproduces the CERN report by Zichichi on the main achievements of the LAA project. All aspects of detector layout were considered in the project and, in view of the demands of the machine, special attention was paid to radiation hardness, rate capability, hermeticity and momentum resolution of the detector assemblies.

From 1990 to 1996 the LAA was transformed into the CERN Detector R&D. The fourth section is a review by Wenninger of the impact of the results from these two programmes on the design of the LHC detectors. Although the solutions adopted for the LHC may differ from those studied at the LAA, Wenninger argues convincingly that the initial work had a great influence and measurable impact on the design of the present LHC detectors.

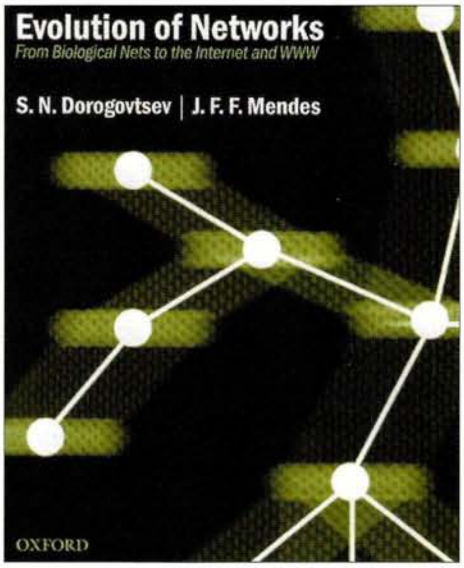
Through this collection of papers, which touch only on one aspect of his work, Zichichi emerges as a person highly motivated by the development of experimental techniques to meet the challenges of future high-energy particle-physics experiments. The early work carried out directly by Zichichi and colleagues and the later LAA work that he inspired have certainly had a significant and continuing influence on particle detector design.
Mike Price, CERN.

Evolution of Networks: From Biological Nets to the Internet and WWW by S N Dorogovstsev and J F F Mendes, Oxford University Press. Hardback ISBN 0198515901, £49.95 ($95).

Imagine some collections of diverse objects: autonomous systems on the Internet, pages on the World Wide Web, neurons, genes, proteins, citations of scientific publications, the words in a human language, etc. Is it not fascinating that the graph-based abstractions of these different systems reveal that certain qualitative relationships among the objects remain invariant from one system to another? For instance, it was found that in a graph of the protein interactions of the yeast *S.cerevisiae*, the number of nearest neighbours follows a power-law distribution just as in a graph of the pages on the World Wide Web.

This book is an introduction to the exciting area of networks modelled as random graphs. The authors describe some fundamental structural properties of these graphs, and give a tour through a variety of real-world examples. They explain the underlying mechanisms that drive the evolution of graphs over time, and discuss the impact that a structural property of a graph may have on performance issues such as virus spreading and network connectivity.

As Dorogovstev and Mendes put it, this book was written by physicists but is aimed at a broader audience. The technical developments are kept at a low level, so no particular prerequisites are needed to follow them, and the authors present timely examples that ▷



cover the broad scope of the book.

The first chapter gives definitions of basic metrics that characterize a graph. The next chapter is devoted to exposing the preferential linking, a principle that, for instance, explains the emergence of the power-law distribution of the number of nearest neighbours of a vertex in a graph. The book proceeds with a discussion of a broad set of network examples, including scientific literature, communication systems and biological systems. In the subsequent two chapters, the authors separately cover equilibrium and non-equilibrium networks. The chapter on equilibrium networks analyses the stochastic recursive evolutions that drive a random graph to its steady state (equilibrium). A standard example in this context is the construction of a random graph by Erdos and Renyi. The chapter on non-equilibrium networks focuses on temporal aspects, especially the evolution of some probability measures of a graph over time. The book continues with a chapter on the global properties of graphs and their effect on performance. The authors end with appendices including some mathematical content and a detailed bibliography on the graph literature.

The exposition of the book is very pedagogical. Instead of rushing to examples, the authors first introduce readers to important elementary notions. After motivating the problems through well-chosen examples, they delve into specific subjects in detail, and the fundamental principles are unveiled in a suitable manner. There is, however, a certain imbalance in the lengths of different chapters.

This book should benefit readers who seek to gain an insight into the fundamental principles that underlie the random graphs found in diverse scientific disciplines.
Milan Vojnovic, EPFL.

Weep for ISABELLE – a rhapsody in a minor key by Mel Month, Avant Garde Press. ISBN 1410732533, $28.95.

This book attempts to unravel a complicated politico-scientific tapestry, but in trying to unpick some tricky knots it creates a few new tangles of its own. In 1982 the US high-energy physics community organized a meeting at Snowmass to look at the future of national high-energy physics. After riding the crest of a wave for 30 years, the community felt in danger of falling into deep water. Across the Atlantic, CERN's proton–antiproton collider had not yet discovered the W and Z carriers of the weak nuclear force, but the writing on the wall was clear (the crucial discovery came in 1983).

The US community was pushing for an ultra-high-energy proton collider to probe a distant energy frontier and search for the "Higgs mechanism" – which drives the subtle electroweak symmetry breaking and ensures that the weak W and Z carriers are much heavier than the massless photon that mediates electromagnetism. Thus Snowmass helped paint the wagon for the US Superconducting Supercollider (SSC), which was to emerge as the nation's bid to regain particle-physics superiority. But by 1993 the global financial climate had cooled and the SSC was sacrificed, leaving the field clear for CERN's LHC to become the world focus for high-energy physics.

Among those at Snowmass in 1982 was Mel Month of the Brookhaven National Laboratory and founder of the US Particle Accelerator School. One lunchtime, Month blurted out his views on the current US physics scene. These innocent remarks were not meant for general consumption, but bosses have long ears and there was an abrasive run-in. Month's career then became slow-tracked. A heavy chip on the shoulder can be difficult to offload. To help, Month compiled this 600-page book, in which he portrays himself as "Mickey", a highly motivated but politically naive young Brookhaven researcher.

The first half of the book depicts the evolution of particle physics in the second half of the 20th century as seen through Brookhaven eyes. Brookhaven was the site of major post-war US high-energy machines, which from 1960 to 1975 made many discoveries and reaped an impressive Nobel harvest. But as the US continued to disperse its high-energy physics effort, Brookhaven began to lag behind in this research sector. Its contender, the ISABELLE proton collider, was overshadowed by other US plans and hampered by difficult technology for superconducting magnets to guide its high-energy protons. Eventually ISABELLE had to make way for the new SSC, and Brookhaven looked to have missed the boat. (Ironically, when the SSC was finally cancelled, ISABELLE was reincarnated as the RHIC high-energy nuclear collider now in full swing at Brookhaven.) The laboratory's stock tumbled further in the 1990s with unwarranted scaremongering of a tritium leak from its nuclear reactor.

The evolution of particle physics as seen from Brookhaven is a little like the British view of Europeanism – interesting but distorted because of evolved isolation. Month attributes blame, while his skewed overview brings some fresh insight and provides some vivid quotes: "Always the bridesmaid and never the bride", referring to CERN's early history; and for the SSC, "Like Lady ISABELLE a decade earlier, this dressed-to-kill damsel turned out to be a flash in the pan".

The survey would be more valuable with a detailed index to help track through the intricate history. However, as the book calls itself a "historical novel", none is supplied. The "novel" content is mainly confined to the second half of the book, where Month imagines Mickey interviewing the "Players", the major characters in the book, most of whom are ex-Brookhaven management.

The book is difficult to read without an insider's knowledge of particle physics. In the very first paragraph, BNL (for Brookhaven National Laboratory) appears without explanation, the first of much in-your-face shorthand, not all of which gets sorted out in the glossary. There are also some inaccuracies, such as: "1993 – Rubbia forced to resign as CERN director-general".

In the push and shove of ruthless competition, most people experience at some time the bitterness of career injustice. These unpleasant episodes can be sublimated into fresh motivation, or simply filed. This book looks to have been a catharsis for Month, but does so much subjective detail need to be displayed?
Gordon Fraser, Divonne-les-Bains.

World crises cast a long shadow on science

Restrictions on travel to the US are having a damaging impact on international scientific collaboration, as **Vera Lüth** explains.

The free circulation of scientists, the freedom to pursue science, to communicate among scientists and to disseminate scientific information, are generally taken for granted in the regions we commonly refer to as the free world. The guarantee of those freedoms is the most important goal of IUPAP, the International Union of Physics and Applied Physics. Unfortunately, the events of the past few years have led to the curtailment of those freedoms. Visa problems have restricted travel to the US and have had a severe impact on the ability of scientists from many countries to continue their collaboration with scientists in the US.

While there have been difficulties in obtaining US visas in the past, these problems have become much more severe due to new rules and procedures. These procedures were introduced as part of the security measures to prevent illegal immigration, the infiltration of terrorists and the transfer of information that might lead to the design of weapons or their illegal import. Consular officers now have to interview all applicants and are held responsible for the consequences of their decisions. This has led to long delays in approvals and some denials of visas to bona fide scientists from many countries, primarily Russia and China. For them the visa application process has been drawn out from a few days to many months. On average, applicants wait for more than four months without any indication of when a decision may be made. Also, while the application is pending, the applicant's passport is held at the consulate, thus preventing him or her from travelling to any other country.

A recent consequence has been that the attendance at the IUPAP-sponsored International Lepton Photon Symposium held at Fermilab (see p15) was significantly affected. Realizing that the chances of obtaining approval in time were slim, many of the invitees withdrew their application; others did not want to subject themselves to the application process. This was apparently true not only for scientists from countries that have visa restrictions, but also from some Western European countries. While four years ago 46% of the invitees from countries with visa restrictions attended the Lepton Photon Symposium at Stanford, this was down to 27% at this year's meeting. Almost all the Russian scientists travelled on multi-entry visas or were already in the US. The Chinese delegation was reduced to a single scientist, compared with 12 at Stanford in 1999. Their invited speaker, Lioyuan Dong, was denied a visa. Hesheng Chen, the director of IHEP in Beijing and a member of ICFA, received approval for a visa, but too late to allow him to travel. He wrote a letter of protest to the chair of IUPAP's Commission on Particles and Fields, pointing out that he and his senior colleagues had repeatedly been prevented from travelling to the US. Indeed, IUPAP will discuss the overall situation at a forthcoming meeting.

Probably a wider impact than restricted attendance at an annual conference is the irrevocable harm caused to the US science community's international collaborative efforts. For many decades particle physicists have been working at large laboratories, travelling frequently from country to country and sharing equipment and funds. An example is the D0 experiment at the Tevatron. To a very large degree, the D0 muon tracking system was designed and built by Russian groups. The visa denials and delays are threatening the full realization of the enormous investments by these scientists and their home institutions, and as a result the funds committed by the Russian government to support this project are likely to be redirected. The fact that this and many other activities involving our Russian and Chinese colleagues are performed under the auspices of government-to-government agreements stresses the irony and seriousness of the current situation.

The American Physical Society, the organizers of the Lepton Photon Symposium, several prominent scientists, and I as chair of the Commission of Particles and Fields of IUPAP, have tried through the US National Academy of Sciences (NAS) to intervene at the State Department, at the Department of Energy and at other government agencies. The NAS, which is recognized by the US government as the adhering body for international science unions, has increased its efforts to report on these impediments to the Bureau for Consular Affairs, to develop procedures to account for reported delays and refusals, and to coordinate the reporting with other professional societies. But despite recent pronouncements by the State Department, the situation has worsened.

While I understand the need for tighter security and controls of the borders in these troubling times, I am convinced that the visa restrictions for scientists do not serve that purpose. To the contrary, collaborations among scientists have in the past been highly beneficial in times of crisis – they have helped to reduce international tensions rather than impeded security. I personally fear that unless there is clear evidence that the imposed measures have a truly damaging impact on the US, it will be difficult to attract the attention of the US Congress or government. Thus, it is my hope that the international community in Europe and Asia may be able to raise these issues at the highest levels and delineate the current procedures as deleterious not just to science, but to international relations in general.

Vera Lüth, chair of the Commission on Particles and Fields of IUPAP.

CES Physics News

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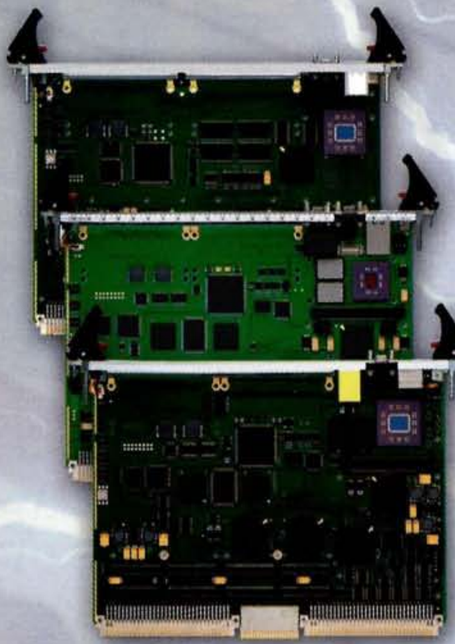

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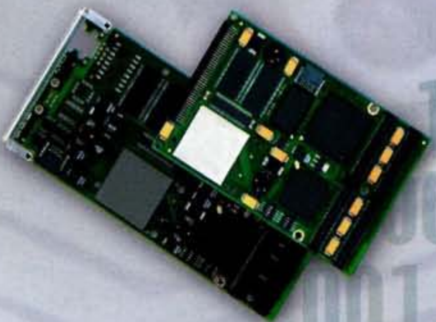

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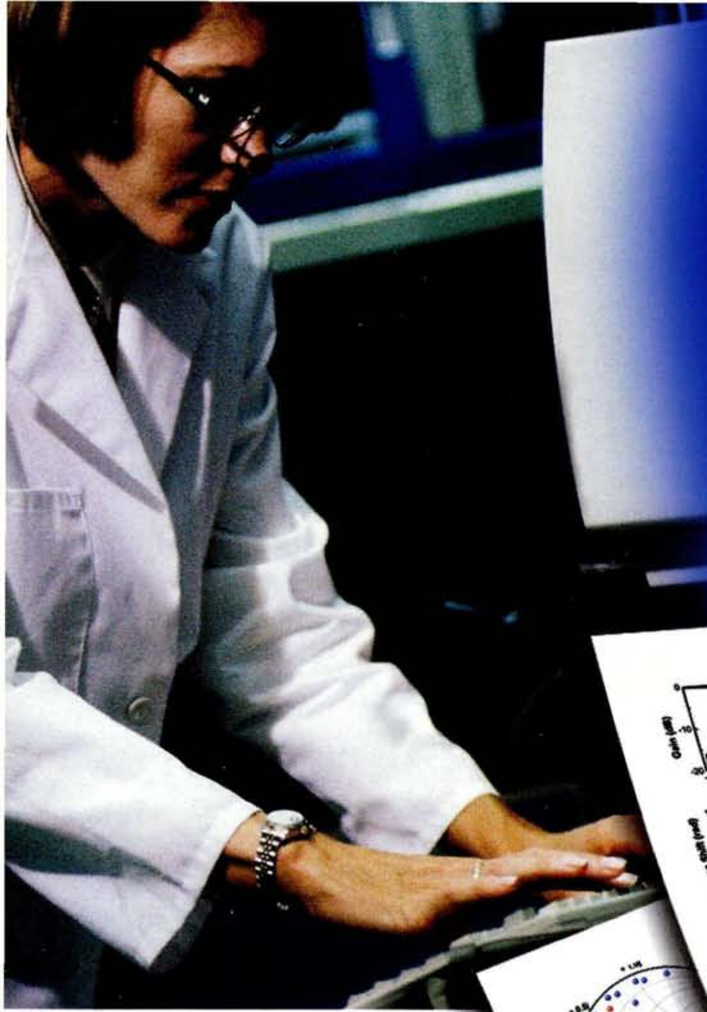

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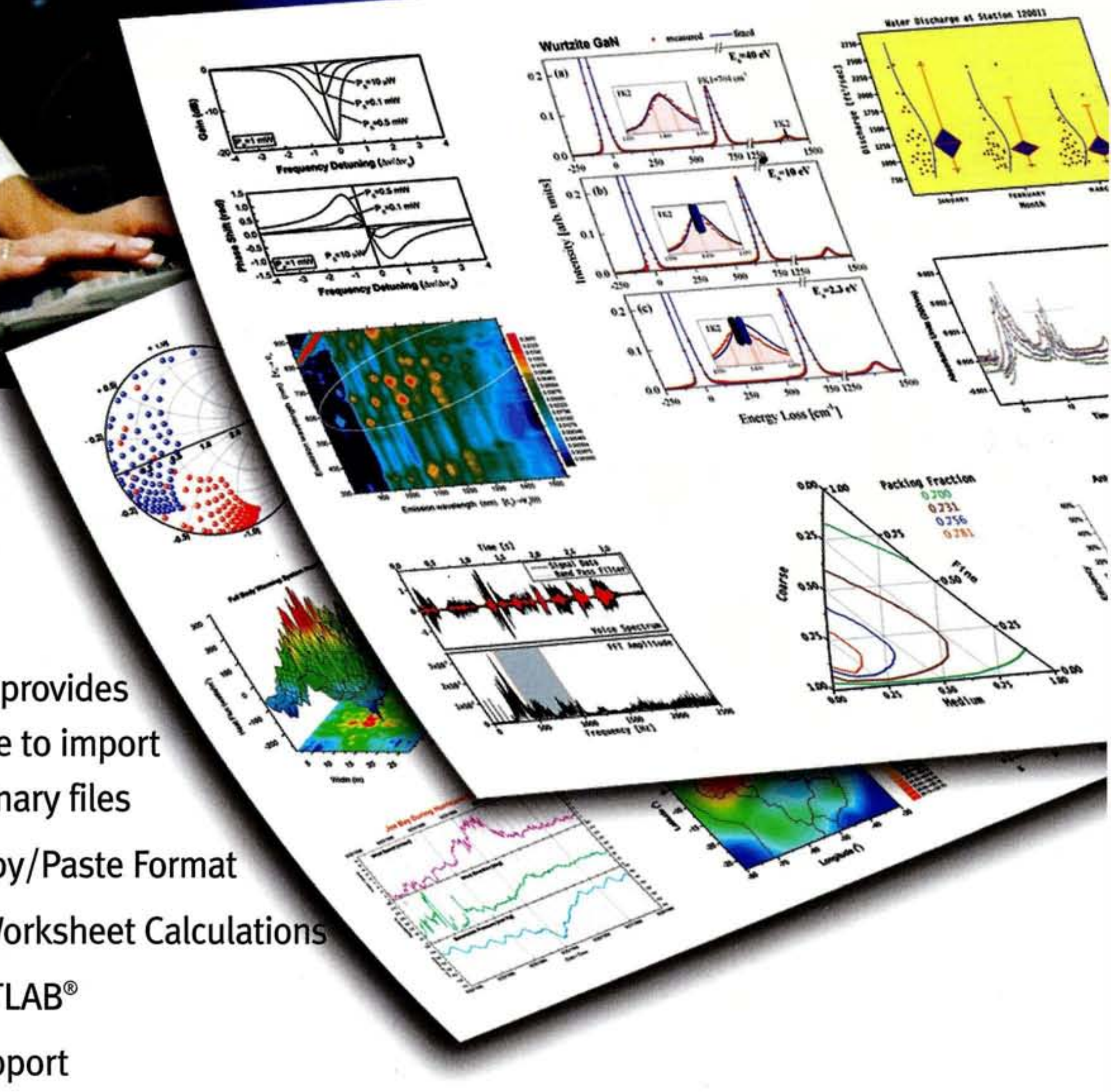

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