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CERN COURIER

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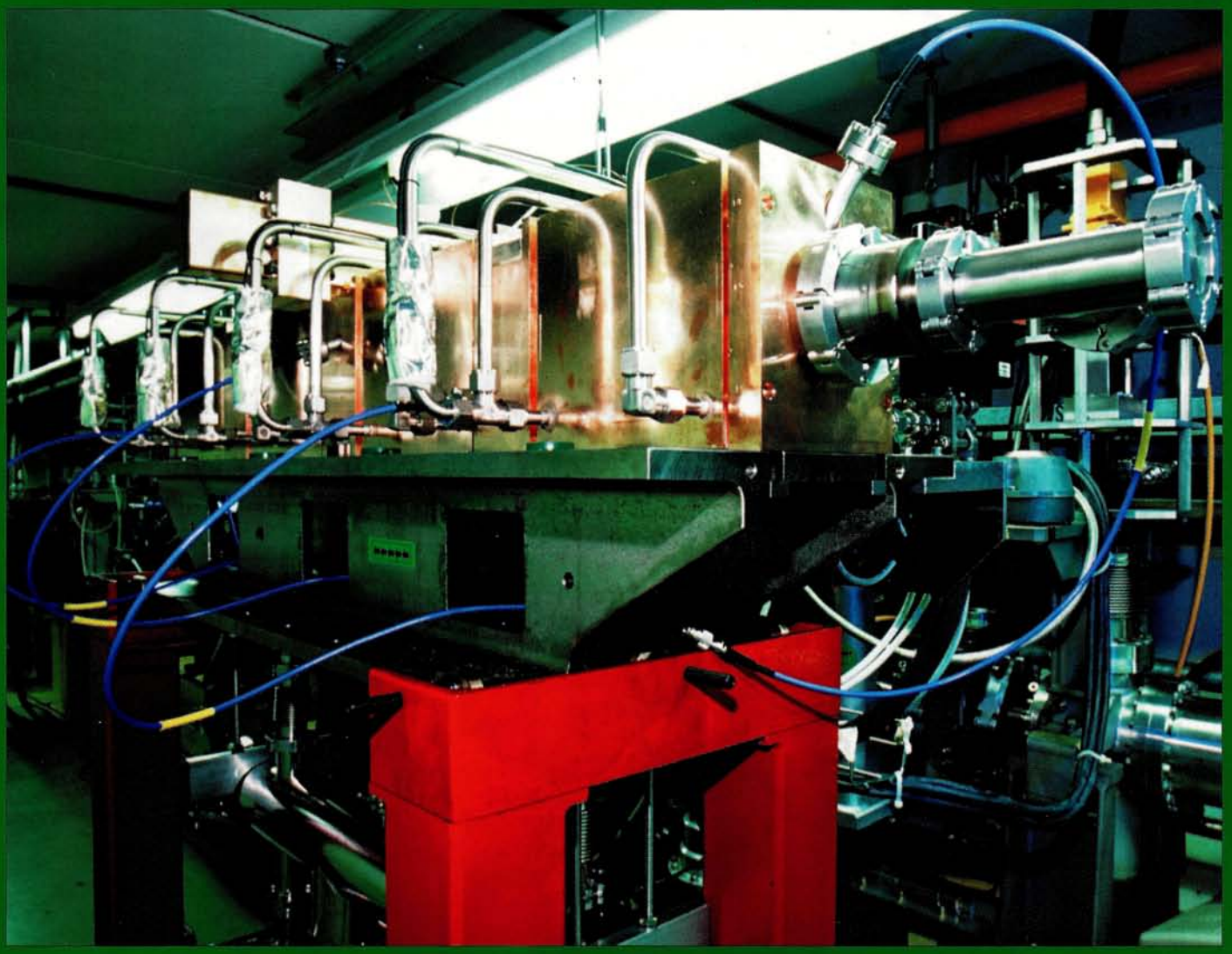

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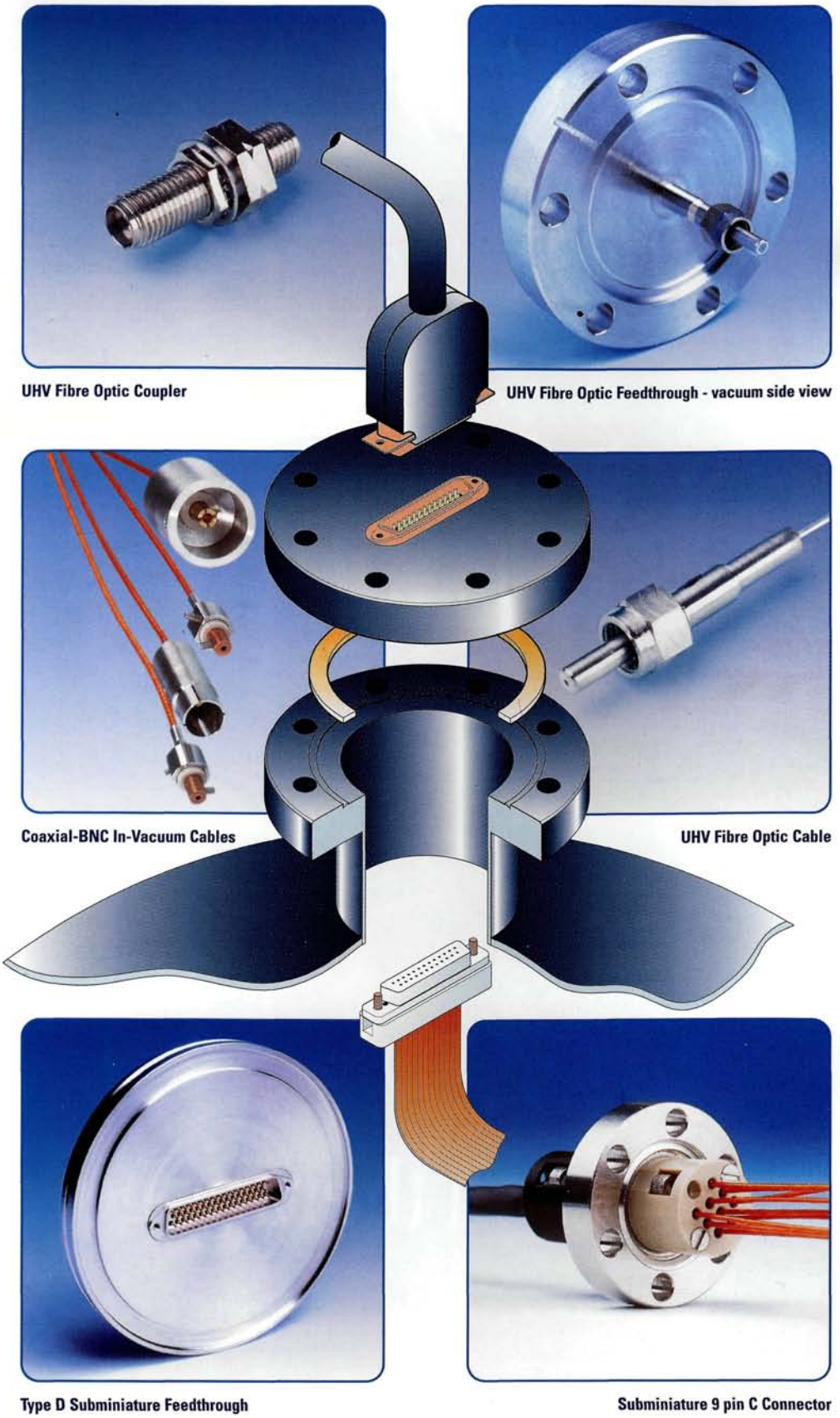

UHV Fibre Optic Coupler

UHV Fibre Optic Feedthrough - vacuum side view

Coaxial-BNC In-Vacuum Cables

UHV Fibre Optic Cable

Type D Subminiature Feedthrough

Subminiature 9 pin C Connector

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

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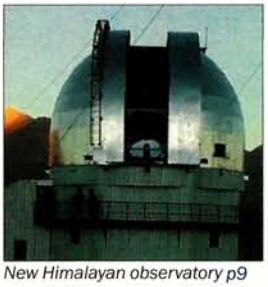
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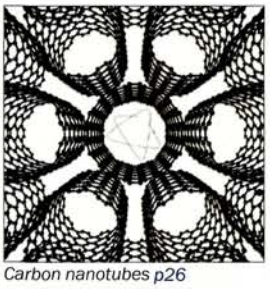
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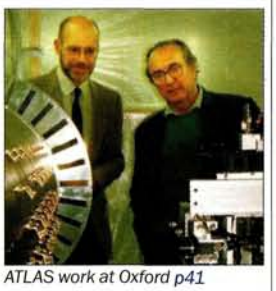

ATLAS work at Oxford p41

Cover: The first module of the "LIBO" proton linac booster has been tested at full power at CERN, promising more scope for proton tumour therapy in hospitals (p5).

CERN

Medical accelerator is on course

A new linear accelerator is on course to bring about important advances in cancer therapy following successful tests at CERN last year. The LIBO Linac Booster was conceived in 1993 by Ugo Amaldi (then a member of CERN staff), who instigated the Terapia con Radiazion Adroniche (TERA) Foundation to promote the development of cancer therapy using hadron beams.

The LIBO project, led by TERA's Mario Weiss (also formerly of CERN), aims to build a proton linear accelerator to boost the energy of beams extracted from existing 50–70 MeV cyclotrons to 200 MeV. Many such cyclotrons are already used in nuclear research for isotope production, and for the proton therapy of superficial eye melanomas. The addition of a linac booster would allow the treatment of deep-seated tumours where higher energies are needed.

The main challenge for the LIBO team was to make the linac sufficiently compact. This requires high-frequency operation to achieve a large accelerating gradient. A frequency of 3 GHz was chosen for a gradient of around 15 MV/m in the accelerating tanks. LIBO is the first proton linac of its kind to be designed with such a high frequency and low injection energy.

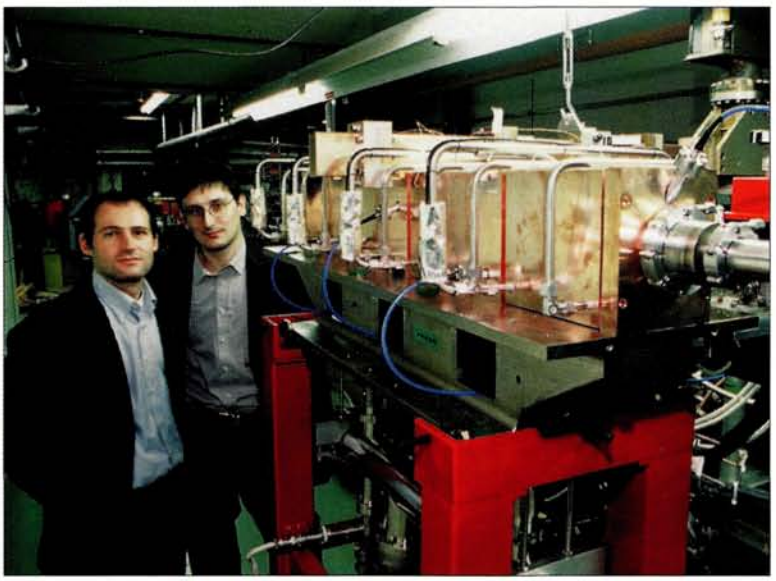
A complete LIBO accelerator will comprise nine modules, each consisting of four accelerating tanks, the lengths of which increase to match the increasing velocity of the accelerated protons. The length will be just 15 m and the average gradient 10 MV/m for a modest power consumption of around 80 kW.

LIBO's beam aperture is only 8 mm, which leads to an additional challenge for beam transfer. This is overcome by focusing the beam with 36 identical permanent quadrupole magnets – four per module. Cyclotrons are direct-current machines, whereas LIBO is pulsed with a 0.2% duty cycle. In DC operation it would capture only 10% of the beam, but, as proton therapy does not require high currents, this is sufficient.

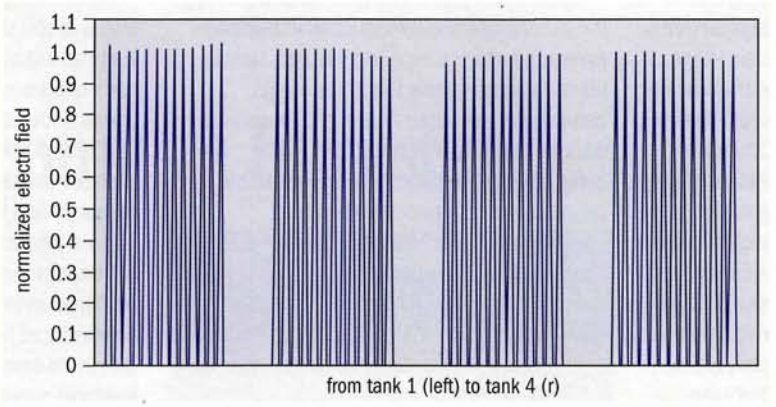
Excessive irradiation of LIBO will be avoided by pulsing the cyclotron source. LIBO's resulting beam structure, with 2.5 ms between pulses, is well adapted to the active scanning techniques currently used in proton therapy to deliver precisely measured doses to each three-dimensional pixel of a tumour.

The first stage in the LIBO project was to build and test the first module of the accelerator, which will accelerate protons from 62 to 74 MeV. A decisive step was taken in 1998 when a collaboration was established between TERA, CERN (Ettore Rosso *et al.*) and the universities and INFN sections of Milan (Carlo De Martinis *et al.*) and Naples (Vittorio Vaccaro *et al.*). With help from CERN, LIBO's copper accelerating structure was designed and the module was built in CERN's workshops. It was installed at CERN last November and power-tested using a spare 3 GHz klystron from the LEP electron linac. After a period of conditioning, an average gradient of nearly 30 MV/m – well in excess of the design requirement – was achieved in each tank of the module.

The next step is to move the module to the INFN laboratories in Catania, where it will be coupled to a superconducting cyclotron to provide it with a proton beam of 62 MeV. The LIBO collaboration has teamed up with Belgian company IBA – the world's foremost supplier of medical cyclotrons – and its Swedish subsidiary, Scanditronix Wellhöfer, to use one of their 3 GHz modulators in Catania. This collaboration may lead to the creation of a consortium to oversee the longer-term development of the accelerator technology. The LIBO collaboration is also looking for another industrial partner to develop the diagnostic instrumentation that would be needed at a LIBO-based proton therapy centre.



Riccardo Zennaro and Paolo Berra of the LIBO Linac Booster collaboration with the first LIBO module installed and awaiting power tests at CERN.



The accelerating field of the first LIBO module, plotted along the axis of the module, shows uniformity of around ±3%.

CERN

The final curtain falls on LEP

Valuable research real estate – French President François Mitterrand speaks at the LEP groundbreaking ceremony in 1983.

Pulling out – on 2 November 2000, CERN SPS/LEP division head Steve Myers ceremonially switched off LEP for the last time.

After a concerted push by physicists to extend the running of CERN's LEP 27 km electron–positron collider into 2001, the decision has been taken to close the machine for good.

The original masterplan foresaw closure in September after 11 years of running, but unprecedented collision energies above 200 GeV enabled several of the experiments to glimpse signs of the long-awaited Higgs particle, which endows all other particles with mass. LEP was thus given a six-week "stay of Higgs execution" (November 2000 p5).

Extra evidence seen during the extension shows the tentative LEP Higgs signal to have a a mass of around 115 GeV. These candidate events are dominated by the production in LEP's electron–positron collisions of a Higgs particle and a Z boson, although evidence for other Higgs production mechanisms is also seen. However, the combined effect falls slightly short of what is required to claim an outright Higgs discovery.

Physicists continued to push for additional LEP running, but on 17 November the committee of CERN's governing body, Council, gave its verdict. Council expressed its "recognition and gratitude for the outstanding work done by the LEP accelerator and experimental teams. It has taken note of the request by many members of the CERN scientific community to continue LEP running into 2001 and also noted the divided views expressed in the scientific committees consulted on this subject. On the basis of these considerations and in the absence of a consensus to change the existing programme, Council supports the director-general in pursuing the existing CERN programme."

The "existing programme" meant the plan to close LEP in 2000 and focus resources on the LHC proton collider, to be installed in the LEP tunnel and scheduled to start running in 2005.

While the Higgs evidence was compelling, the mechanisms involved were also at the extreme end of LEP's energy reach, so the physicists could only touch the Higgs candidates with their fingertips. There were doubts that additional running would substantially consolidate the signal. This, coupled with the need to keep LHC construction on schedule, led to the final controversial decision.

It is rare that major particle accelerator machines close at CERN. The usual pattern is that new machines stand on the shoulders of their predecessors. The electrons and positrons for LEP came via a chain of more mature machines, including the 28 GeV PS synchrotron, which, when it first came into operation in 1959, was briefly the world's highest-energy accelerator, and the 450 GeV SPS synchrotron, commissioned in 1976.

One CERN machine that closed was the laboratory's first accelerator, the 600 MeV synchrocyclotron (SC), commissioned in 1957 and turned off in 1990. The SC was a stand-alone accelerator and did not serve as an injector for any later machine, but it did spawn the ISOLDE on-line isotope separator, subsequently transferred to the PS Booster.

Another past CERN machine was the Intersecting Storage Rings – the world's first proton collider. It was commissioned in 1971 but was switched off early in 1984 to release resources for LEP construction.

The LEAR low-energy antiproton ring, commissioned in 1983, was terminated in 1996 to free resources for the LHC.

The 1983 groundbreaking ceremony for LEP was a major milestone in CERN's history. LEP was the initial reason for the 27 km tunnel excavated under the Swiss-French frontier, but it was understood almost from the outset of LEP preparations in the mid-1970s that the tunnel would be a valuable piece of physics research real estate that would one day house a more powerful machine – LHC.

In a final proud gesture before the curtain came down on its part in the play, LEP, operating at high energies unforeseen until late in its career, revealed its intriguing hints of the long-awaited Higgs particle. This physics now has to await confirmation and consolidation at Fermilab's Tevatron proton–antiproton collider and/or LHC.

The step from LEP to LHC is a natural progression. LEP's disappearance is not an abrupt closure of a thriving machine – it gave all that was expected of it, and more.

LHC will take its particles from the Booster–PS–SPS chain of synchrotrons. As well as this physical supporting infrastructure, LHC will stand on metaphorical shoulders – the extinct ISR – for it was here that CERN first acquired collider expertise; the additional skills acquired at the SPS, which operated as the world's first proton–antiproton collider (1981–1990); and, of course, LEP.

SPAIN

CMS calorimeter begins to take shape

Research institutes all over the world are busy providing components for the experiments at CERN's Large Hadron Collider.

The hadronic calorimeter for the Compact Muon Solenoid (CMS) experiment reached an important milestone on 27 October 2000 when the first half of its barrel structure was test assembled at the Felguera Construcciones Mecánica SA plant in the Asturias region of Spain. The structure has since been dismantled and transported to CERN, where the sensitive elements – scintillator tiles with optical-fibre read-out – will be installed over the coming year.

CMS has adopted a conventional scintillator/absorber sandwich architecture for its hadronic calorimeter. However, because the device will be installed inside the experiment's powerful solenoid magnet, it is subject to unconventional constraints. The absorber material – brass – has been chosen because it is non-magnetic, cheap, easy to machine and sufficiently dense for the job. The brass has been supplied by companies in both Bulgaria and the UK.

Representatives of CERN, Fermilab and Felguera Construcciones Mecánicas SA with the first half barrel of the CMS hadronic calorimeter at the Felguera factory in Spain.

Read-out is via optical fibres that are coupled to hybrid photodiodes that are capable of functioning within the CMS magnet. Design and construction of the CMS barrel hadronic calorimeter are the responsibility of Fermilab in the US, which awarded the contract for the building the structure to Felguera.

Full assembly of the first half of the barrel structure allowed the experiment to verify that the exacting tolerances that are required between the 25 tonne wedges to eliminate gaps had been achieved. This ensures that the calorimeter has full azimuthal coverage without any cracks.

The next step is the installation of the scintillator elements at CERN. Production of these elements is more than 50% complete, and delivery from Fermilab to CERN is well advanced. Installation of the scintillator into the first half barrel should be completed by the autumn, with the second half following by the end of 2002. The ontegration and testing of the detector will take place in 2003.

CERN

ATLAS becomes a film star

An 18 minute video entitled *The ATLAS Experiment* has been declared overall winner of the 2000 MIF-Sciences Scientific Film Box Office contest.

The award-winning film explains how more than 1800 physicists from 35 countries are working on the ATLAS detector for CERN's Large Hadron Collider. It gives a glimpse behind the scenes of building a technological edifice that measures 45 m long and 22 m high, and is made up of millions of components with a precision of one-hundredth of a millimetre.

Will all of the physicists who teamed up to construct this apparatus eventually be able to answer such fundamental questions as: Where does mass come from? Why does the universe have so little antimatter? Is there an underlying theory?

Members of the ATLAS experiment's Education/Outreach Committee developed the concept of a film for both the general public and students that would describe the physics motivations, the process by which 1800 people from all over the world go about building such a complex detector, and the accelerator that would both deliver and collide beams of protons.

Excavation of the roof of the vast cavern to house the ATLAS experiment for CERN's LHC collider. An video on the mighty ATLAS project has just won a major award.

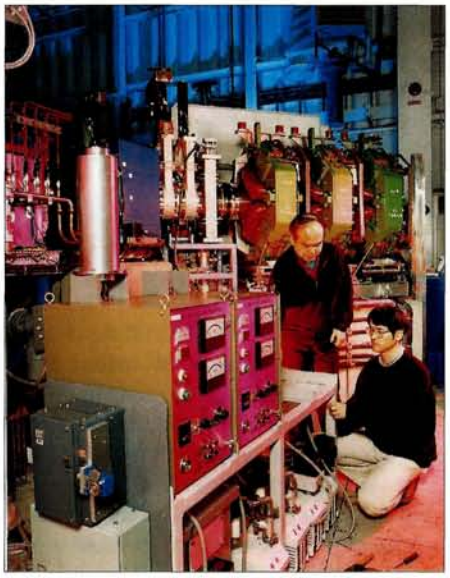
Committee members prepared a detailed outline for the film and hired a professional director from the Netherlands. At various stages the participating members and ATLAS management evaluated progress and provided input. Funding came from nine countries: the Czech Republic, France, Germany, Italy, the Netherlands, Spain, Sweden, the UK and the US.

The film, which combines live footage and animation, was designed to be translated into many languages, so there are two sound tracks – one with ambient sounds and the other for the narration (provided by each country). The various language versions will be linked from the ATLAS site in the near future and eventually collected onto a DVD. The film is currently available as a videotape, as a CD-ROM and on the Web ("http://webcast.cern.ch/Archive/2000/misc/atlas-experiment-2000.rm"). See also "http://atlasinfo.cern.ch:80/Atlas/Welcome.html".

The Scientific Film Box Office Award is organized by MIF-Sciences (see "http://www.mif-sciences.net/").

UK

Riken–RAL notch up another decade



Isao Watanabe (standing) and Katsu Ishida from RIKEN, Japan, adjusting the muon beamline at the joint RIKEN/RAL facility.

The 10 year collaboration between RIKEN, the Japanese Institute of Physical and Chemical Research, and the UK Rutherford Appleton Laboratory (RAL) to create an intense muon source has been renewed for another 10 years. There are also plans to continue development and expansion of the joint facility.

The first large-scale scientific partnership between the UK and Japan, it develops and exploits a world-class muon facility at the RAL Isis pulsed neutron and muon source.

Isis is the world's most intense source of pulsed muons. Muons can be used to explore matter at the microscopic scale, acting as implanted "spies" to help to understand better the internal workings of materials. Such information can help to develop new materials for specific applications. Muons are also used for fundamental physics studies and possible energy production via muon catalysed fusion.

A further £2 million investment will see expansion of the muon source for the development of new methods to increase the effectiveness of muons for analysing matter.

For more details about Isis and Riken see "http://www.isis.rl.ac.uk/" and "http://nectar.nd.rl.ac.uk/~rikenral/index.html".

ASTROWATCH

Edited by Emma Sanders

VLT investigates cosmic shear

Astronomers have mapped the universe's dark matter in 50 independent directions using the European Southern Observatories' Very Large Telescope (VLT). Their results, announced in December, show that it is unlikely that mass alone would stop the current expansion of the universe, and they support the existence of a non-zero cosmological constant.

Dark matter is, by definition, invisible and non-radiating. To map it, astronomers observed more than 70 000 normal galaxies and studied how their shape was deformed. This deformation, which is known as cosmic shear, is caused when the light from distant galaxies is deflected by large clumps of dark matter along the line of sight. The larger the mass of dark matter, the greater the distortion of the image and the more galaxies appear to be aligned. The phenomenon provided a new focus of astronomical interest last year (June 2000 p12).

The analysis of such a large sample of galaxies means that limits can be set on the overall mass density of the universe. These observations are a big step forward for astronomers. It is the first time that calculations of cosmic shear have been made in enough different directions from the Earth to give an accurate estimate of overall mass density. The results are in excellent agreement with other methods and suggest that the total matter in the universe is less than half of that needed to stop Big Bang expansion.

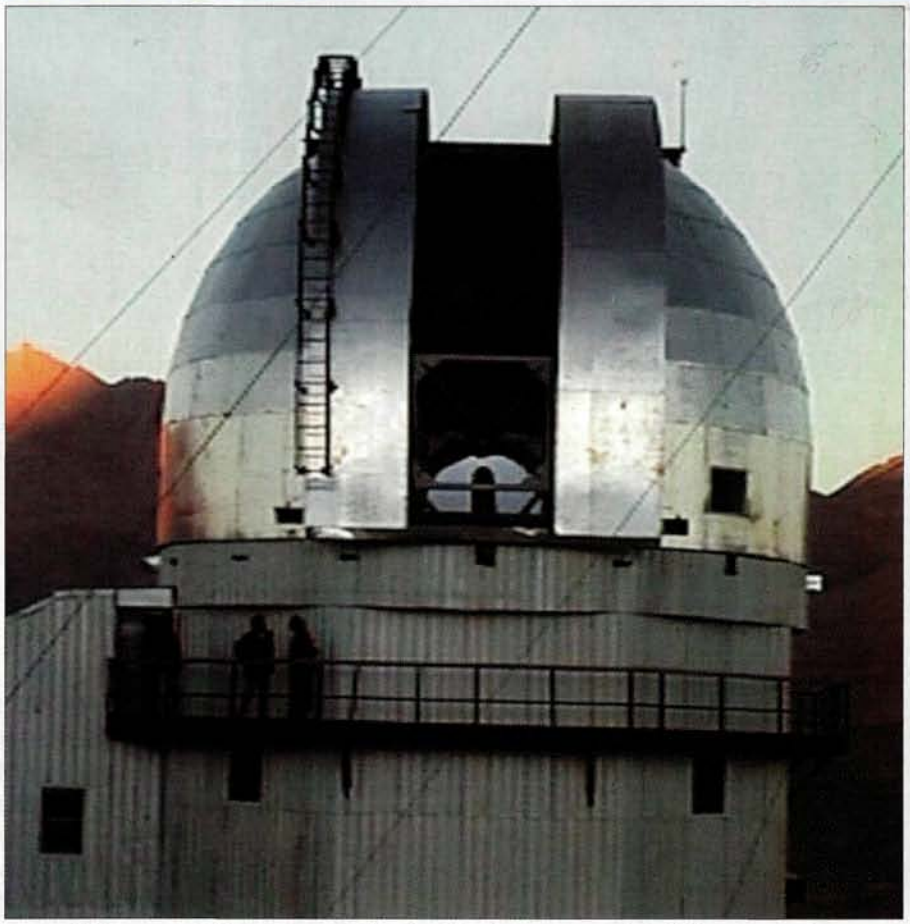
ESA supports physics missions

Last autumn the European Space Agency's Science Programme Committee met to define the priorities for 2008–2013. Its announced package included funding for two missions to study fundamental physics in space – the gravitational wave detector LISA and the Microscope mission, which aims to investigate the equivalence principle. Gravitational waves are predicted by Einstein's theory of general relativity.

The acceleration of massive bodies, such as orbiting neutron stars or newly forming black holes, disturbs the fabric of space-time, sending out gravitational waves like ripples on a pond. The theory has been tested indirectly, but gravitational waves have never been detected. LISA will be the first gravitational wave space observatory. Three spacecraft will orbit the Sun 5 million kilometres apart in a gigantic triangle. The separation of the spacecraft will be measured using lasers and, as gravitational waves pass, this distance will oscillate. LISA is a joint project with NASA, which is due for launch in 2010.

ESA will also contribute to the Microscope mission, which is currently being built by the French space agency, CNES. The Microscope mission will test the equivalence principle by measuring the acceleration of masses in free fall about the Earth. The experiment consists of two electrostatic differential accelerometers, the first containing two different materials and the second (a control) containing two identical materials.

Picture of the month



Some 4500 m up on Mount Saraswati in the Himalayas, the world's highest optical observatory has commenced operations. A 10 hour drive through the mountains from the nearest town, the site was chosen for its observing conditions – the environment is extremely cold and dry, which is ideal for optical and infrared observations. The observatory is equipped with a 2 m reflecting telescope and is one of several new facilities being built by the Indian Institute of Astrophysics. (Indian Institute of Astrophysics.)

Pulling the trigger on LHC electronics

The conditions at CERN's Large Hadron Collider pose severe challenges for the designers and builders of front-end, trigger and data acquisition electronics. A recent workshop reviewed the encouraging progress so far and discussed what remains to be done.

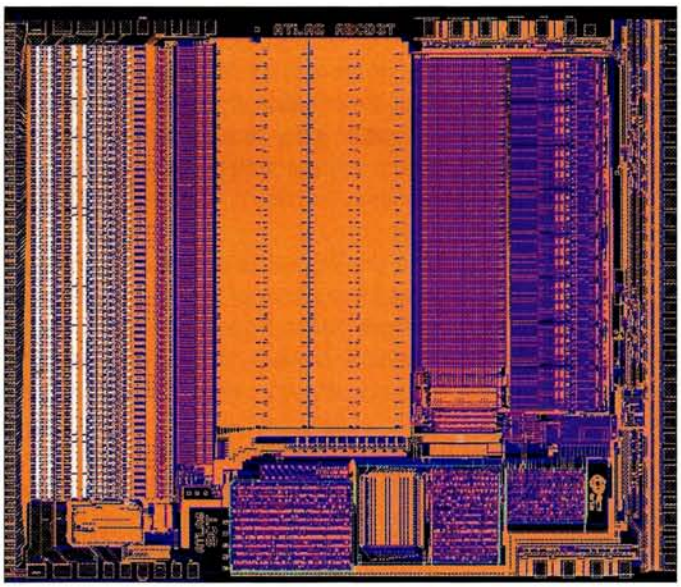


Fig. 1. The ABCD chip for the ATLAS detector. Each chip reads out 128 channels of the silicon central tracker. Each channel contains a bipolar preamplifier, a discriminator, a digital pipeline and read-out interface logic.

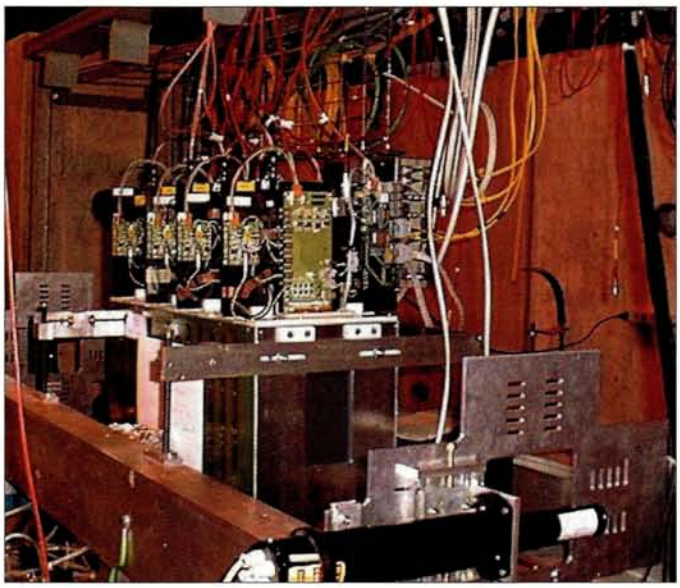


Fig. 2. A small-scale prototype set-up of the CMS experiment's tracker analogue read-out, timing distribution and on-detector slow-controls system under evaluation in CERN's 25 ns structured test beam.

A decade ago, many aspects of the preparations for the major physics experiments for CERN's Large Hadron Collider (LHC; scheduled to come into operation in 2005) appeared to be problematic. Particularly so were the front-end data acqusition electronics, which needed to be resistant to continual bombardment by high-energy collision products, and the trigger, which has to sift through the collisions for interesting results and reduce the original collision rate by a factor of about 10 million.

Fully aware that these preparations had to anticipate and take optimum advantage of rapid developments in modern microelectronics, a systematic research and development programme led by CERN's Detector Research and Development Committee started to address these challenges and pave the road towards the LHC experiment proposals. However, the real work started once the projects had been approved. Progress has been marked by successive workshops of the Electronics Board of the LHC Experiments Committee. The most recent of these – the sixth in the series – was held in Cracow, Poland, in September 2000. The previous workshop was held in Snowmass, Colorado, and the workshop for 2001 is scheduled to take place in Stockholm, Sweden.

New challenges

At the time of the first of such workshops (1995–1997), designers were concentrating on individual designs, studying the basics of radiation effects and learning how to work with industry. Custom integrated circuit technology offered them the possibility of placing data buffering and first-level trigger filtering functions directly onto the detectors. ▷

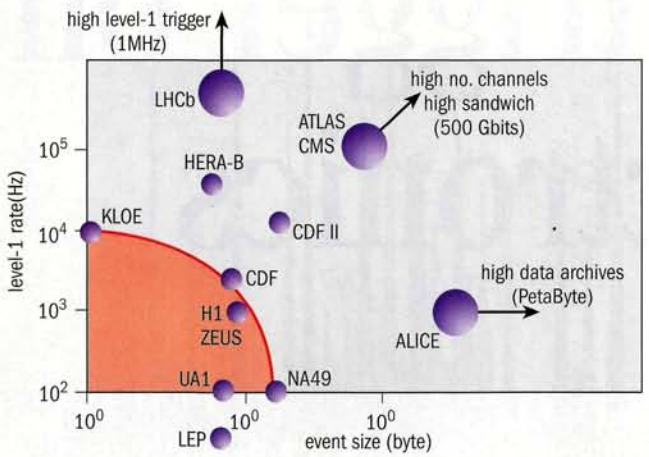


Fig. 3. The LHC experiments introduce new challenges in trigger rates, data acquisition bandwidth and data archival.

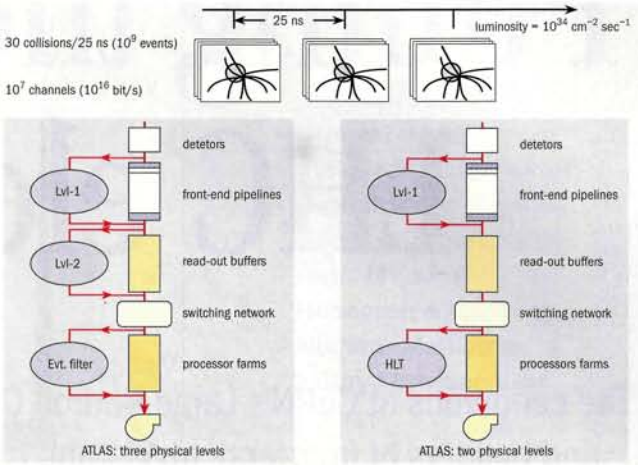


Fig. 4. Trigger and data acquisition architectures for the ATLAS and CMS experiments.

However, the process of developing mature integrated circuits turned out to be more time-consuming than had been anticipated. Testing was a bottleneck (one full design cycle takes about a year to complete), and using the special industrial technologies required to resist the LHC radiation environment involved a number of unexpected complications.

Meanwhile, the LHC community had realized that the experimental caverns would also present risks for the electronics, which needed to be, at the very least, "radiation tolerant". Making sure that the many commercial off-the-shelf components that were envisaged for the caverns were sufficiently radiation tolerant was a complex and difficult task.

All of these challenges led the electronics development teams to search for new solutions, working hand-in-hand with other research labs and with industry. Today we have several designs ready, or almost ready, for production. A good example is the ABCD3T silicon tracker front-end chip for the giant ATLAS detector (figure 1).

This implements a binary read-out architecture in a 0.8 μm BiCMOS silicon-on-insulator technology, specially developed to meet the challenges of the LHC environment. Its equivalent for the big Compact Muon Solenoid (CMS) experiment – APV25 (May 2000 p5) – reads out the data in analogue form and is implemented in a commercial 0.25 μm CMOS technology using a radiation-tolerant design technique developed for LHC. Both function according to the target design specifications.

Viable solutions

In addition, complex radiation-hard chips for the read-out of pixel detectors of all LHC experiments have now started to appear, a good example being the pixel read-out chip developed for the ALICE and LHCb experiments. This contains more than 13 million transistors and can be configured for tracking applications in ALICE or for particle identification in LHCb's hybrid Ring Imaging Cerenkov detectors.

Prototype read-out boards for calorimeters and muon chambers have been shown to meet the functionality and performance specifications needed. However, not all of the components are sufficiently resistant to radiation yet, and further work is needed to optimize this aspect of the designs before launching production.

New problems, which are known as "single event upsets", appeared as side-effects of the evolution of microelectronics technologies towards smaller feature sizes. Smaller charges are more easily perturbed, which often requires modifications to the design (e.g. selecting a more robust component, or using error detection/correction techniques).

For the optical read-out links, 1310 nm edge-emitting lasers have been selected for the analogue read-out of the CMS tracker, while 850 nm vertical cavity surface-emitting lasers appear to be a good choice for digital read-out links. Altogether it appears that viable solutions for the front-end detector electronics and optical read-out links have been found.

However, it will not be easy to integrate all of these components into the compact LHC detectors. Recent LHC Electronics Board (LEB) workshops tried to underline the system aspects of the LHC electronic designs: power supplies and distribution; grounding and shielding; cooling; timing and synchronization; and controls. The development groups are gradually attacking these issues and presenting solutions.

Figure 2 shows a small test set-up using prototypes of almost all of the elements foreseen for the read-out of the CMS tracker. To study issues such as timing and synchronization, it is being operated in a CERN test beam with a 25 ns structure, mimicking the 40 MHz LHC bunch-crossing frequency.

Nevertheless, large prototype system tests still have to be built and operated to prove that everything is understood and under control. This will require the mastery of complex test and assembly processes using state-of-the-art technologies, for which available staffing is not always sufficient.

Close partnerships with industry and the adoption of common solutions (for crates, power supplies, cables, controls, etc) wherever possible will help to alleviate this problem. Other difficult issues include the maintenance and obsolesence of technologies over the relatively long timescale of the LHC project – already the very rapid pace of microelectronics advances has forced redesigns of several developments using new technology.

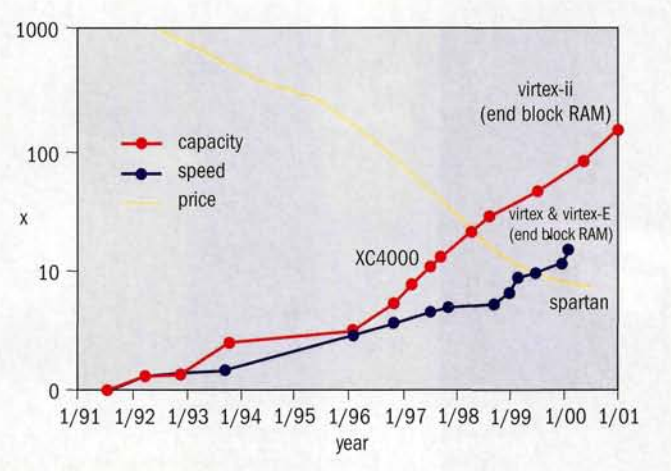


Fig. 5. The remarkable improvement in field programmable gate array capacity from specialist supplier Xilinx.

Triggering and data acquisition make up one of the extraordinary challenges facing detector designers at the high-luminosity LHC (figure 3). The LHCb trigger and data acquisition system must be able to handle trigger rates approaching 1 MHz, while the ALICE experiment operating in ion–ion collision mode must be able to handle large event sizes.

In the case of ATLAS and CMS, when LHC operates in proton collision mode at its nominal design luminosity of 10^{34} $cm^{-2}s^{-1}$, an average of 25 events are expected to occur at each bunch crossing, while bunch crossings will occur at a rate of 40 MHz. This input rate of 10^9 interactions every second must be reduced by a factor of at least 10^7 to about 100 Hz – the maximum rate that can be archived by the on-line computer farm.

Capturing the data

As shown in figure 4, CMS has chosen to reduce this rate in two steps. At the first level, all data are stored for 3 μs, after which no more than 75 kHz of the stored events are forwarded to the high-level trigger (HLT) system. This must be done for all channels without dead time.

Figure 4 also shows the ATLAS pipelined, deadtimeless, level one trigger system with a latency of 2.5 μs. However, after a level one accept, regions of interest in the data are further analysed by a second level of dedicated hardware processors – which include tracking data – before a rate of events reduced by an order of magnitude are transmitted to the processor farm.

In the case of both CMS and ATLAS, the level one system uses only coarsely segmented data from calorimeter and muon detectors, while holding all of the high-resolution data in pipeline memories in the front-end electronics. During the level one trigger processing time, decisions must be developed that discard the larger portion of the data while retaining the small fraction that relates to interactions of potential significance. The large size of the detector and the short decision time present a series of technical and system challenges.

The ATLAS event filter and the CMS HLT are implemented as processing farms that are designed to achieve a rejection factor of 10^3 and about 100 events per second to mass storage. The last stage of HLT processing involves reconstruction and event filtering with the primary goal of making datasets of different signatures on easily accessed media for further analysis by the worldwide physics community. A global "grid" network of information systems (June 2000 p17) is already being prepared to absorb this tidal wave of data.

Hardware solutions

The LHC experiments have addressed level one trigger systems with a variety of high-speed hardware. The CMS Calorimeter Level One Regional Trigger uses 160 MHz logic boards plugged into the front and back of a custom backplane, which provides point-to-point links between the cards. Much of the processing in this system is performed by five types of 160 MHz digital applications-specific integrated circuits designed using Vitesse submicron high-integration gallium arsenide gate array technology.

The LHC experiments make extensive use of field programmable gate arrays (FPGAs). These offer programmable reconfigurable logic, which has the flexibility that trigger designers need to be able to alter algorithms so that they can follow the physics and detector performance more closely as luminosity and beam conditions change. As shown in figure 5, during the past decade there has been a remarkable improvement in FPGA speed and capacity, while the price has dropped. The enhanced performance of these devices is resulting in improved level one trigger designs.

Another important industrial development is the advent of high-bandwidth telecoms switches. These devices allow hundreds of buffers of LHC front-end read-out electronics to be connected to the hundreds of computer processing nodes that must analyse the data. The greater the bandwidth of these switches, the more data can be brought directly to the processing nodes for detailed analysis.

The option to have an increasing proportion of commodity hardware in the read-out network and data processing enables more easily scalable and supportable designs, which can be augmented with additional straightforward purchases as more processing power is needed.

Overall, the LEB workshop in Cracow provided an excellent opportunity for the international community of physicists and engineers from the four LHC experiments to review their work in preparing the electronics for constructing working detectors in 2005.

The past six years have seen spectacular progress in developing advanced electronics systems suitable for the challenges of LHC experiments. This has been achieved via collaborative partnerships between industry and the research community.

However, there are many problems that have still to be solved. Obtaining the demanding performance required of these massive and complex electronics systems will require creativity, excellent engineering and the optimal utilization of the very limited resources available. The LEB workshop planned for Stockholm in September 2001 will show the results obtained by that stage.

The workshop held in Cracow was organized by the LHC Electronics Board with the help of CERN, the UK Rutherford Appleton Laboratory and, locally, the Faculty of Physics and Nuclear Techniques of the University of Mining and Metallurgy, and the Institute of Nuclear Physics. □

Mapping chaos in particle revolutions

Over the past decade the technique of frequency map analysis, developed to study astronomical systems, has shown its value in an increasing number of areas, including the analysis of particle orbits in accelerators.

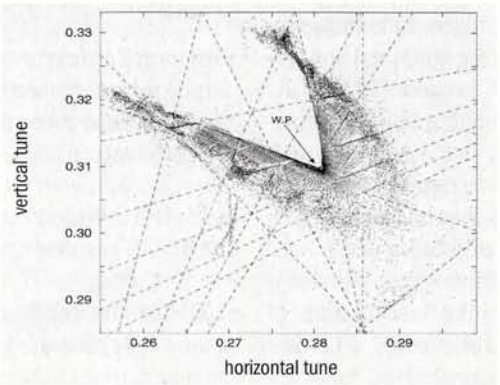
At first glance, any close association between the planets of the solar system – huge masses of rock, liquid and gas gently guided by gravity through the vast emptiness of space – and the mad traffic of tightly bunched particles in a circular accelerator, crushed together by fierce radiofrequency and magnetic fields, could hardly seem less likely.

Nonetheless, the dynamics of planets moving through our solar system and particles moving in accelerators do share many similar features. Both demand an analysis of the evolution of a dynamic system over a very long time – up to 1 billion revolutions for both the solar system and the Large Hadron Collider (LHC) at CERN. In addition, these systems can be studied to a first approximation as though they were non-dissipative (although radiation damping is not negligible when synchrotron radiation becomes significant, as in electron storage rings).

Over the last 10 years the relatively new technique of frequency map analysis has turned out to be very effective when applied to the analysis of numerical simulations in physical systems – particularly those with three or more degrees of freedom – which may be as large as the solar system or even an entire galaxy, or as small as the particles in an accelerator.

The frequency mapping technique was recently applied for the first time to measured rather than simulated electron trajectories in a storage ring, at the Advanced Light Source (ALS) at the Lawrence Berkeley National Laboratory. The aim was to reveal the dynamics of an actual particle beam.

Part of the ALS storage ring at the Lawrence Berkeley National Laboratory. Frequency mapping was first applied to measured rather than simulated electron trajectories at the ALS.



Frequency map showing the stability of particle motion in the LHC storage rings. Regions with stable orbits are marked by points with orderly spacings in frequency space, while chaotic regions show up as randomly spaced points. The dashed lines represent the network of resonances, which appear as distortions of the frequency map. (Y Papaphilippou.)

Chaotic motion

The story of frequency map analysis began in 1989 when Jacques Laskar (Bureau des Longitudes, Paris) demonstrated that the motion of the solar system is chaotic (Laskar 1989). He showed that the separation between two orbits with similar initial conditions will diverge exponentially over time (e.g. the distance between the orbits will increase by a factor of 10 every 10 million years).

In practice, this means that, although it is possible to make a useful prediction for the evolution of the solar system over 10 million years, it is essentially impossible to ascertain what the planetary positions will be after 100 million years have passed.

So will the Earth collide with Venus or Mars within the next few billion years? Thankfully, this possibility seems to have been ruled out (Laskar 1990), but it is difficult to understand more precisely the behaviour of this chaotic system with a large number of degrees of freedom. For this reason, Laskar began developing the frequency map analysis technique.

Frequency map analysis involves looking at the dynamics in frequency rather than configuration space. Any regular and quasi-periodic motion appears as ▷

a fixed point in frequency space, where it will be characterized by the values of its fundamental frequencies (one per degree of freedom).

By contrast, irregular trajectories will be subject to some diffusion in frequency space (the frequencies will change with time). The map from initial conditions to points in frequency space is regular in regions where the trajectories are regular, and irregular where the trajectories are chaotic.

The full dynamics of the system can thus be analysed by varying the initial conditions (in position or momentum) of the system and computing the fundamental frequencies for each set of initial conditions. To accomplish this, a numerical integration of the equations of motion and a fast-converging modified Fourier technique can be used to obtain a quasi-periodic approximation of the calculated trajectories.

Adapting to the accelerator

Frequency map analysis was applied to particle accelerators for the first time in 1992, when Scott Dumas, a mathematician from Cincinatti, visited the Bureau des Longitudes to discuss some of the difficulties that arise in accelerator dynamics. Laskar realized that his new technique could very well be adapted to accelerators, and the following year Laskar and Dumas published a letter in *Physical Review Letters* applying the technique to a simple accelerator model that had previously been studied extensively by other means (Dumas and Laskar 1993).

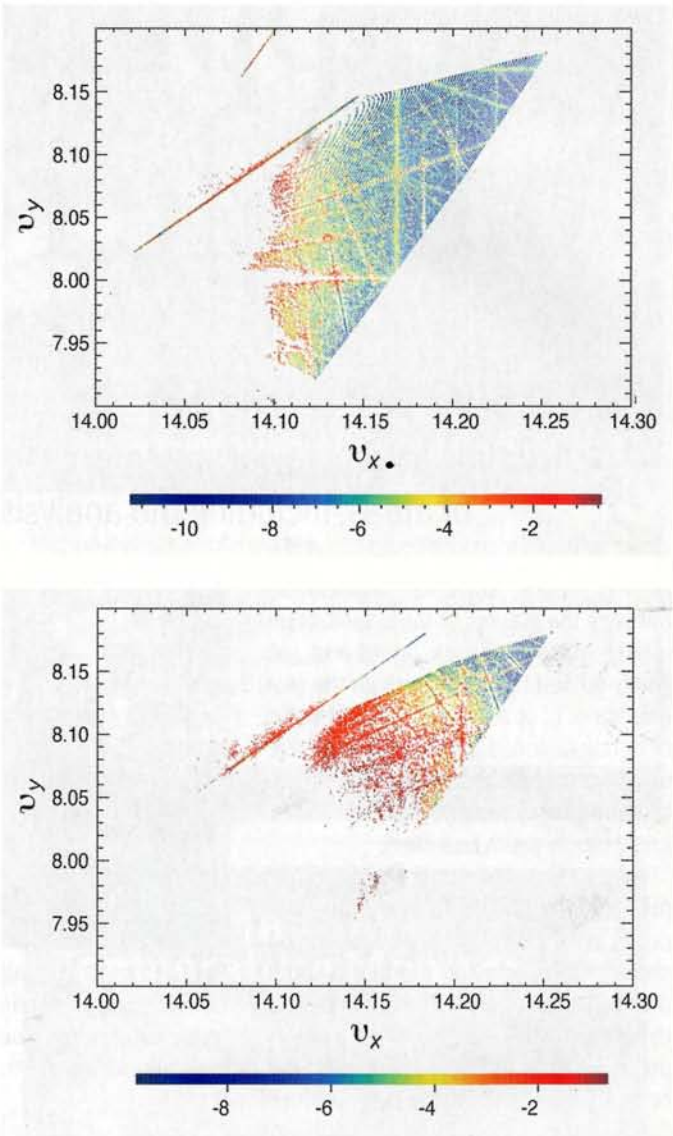
In a circular accelerator, focusing magnetic fields cause particles to oscillate transversely about the closed, central trajectory. The number of oscillations in one turn around the ring is called the betatron tune and can be different in the horizontal and vertical directions. Additionally, the oscillations are nonlinear and the oscillation frequencies change with the transverse amplitude of the particles.

In this context the fundamental frequencies extracted from the frequency map analysis correspond to the tunes for each trajectory. The amplitude of the transverse particle motion is mapped into frequency space by associating a pair of fundamental frequencies with the horizontal and vertical transverse amplitudes. This frequency map is displayed in a coordinate system with the horizontal and vertical tunes as the axes.

From the nominal working point corresponding to small transverse amplitude oscillations, the frequencies shift over a wide area as the amplitudes of the betatron oscillations increase. The motion of electrons with large transverse amplitudes may be influenced by resonances. Damaging resonances show as distortions in the map.

This publication led Laskar to a 1994 conference on Nonlinear Dynamics in Particle Accelerators held in the Tuscan town of Arcidosso, where he presented a model of Berkeley's ALS, a 1.9 GeV electron storage ring designed to generate synchrotron radiation with the highest brightness in the soft X-ray region.

David Robin, now ALS Accelerator Physics Group leader, was in the audience and immediately invited Laskar to a working-group meeting later in the conference. This resulted in an ongoing collaboration between the Astronomie et Systèmes Dynamiques group at the Bureau des Longitudes and ALS accelerator physicists, with the goal of investigating this new application of frequency map analysis to the study of ALS dynamics.

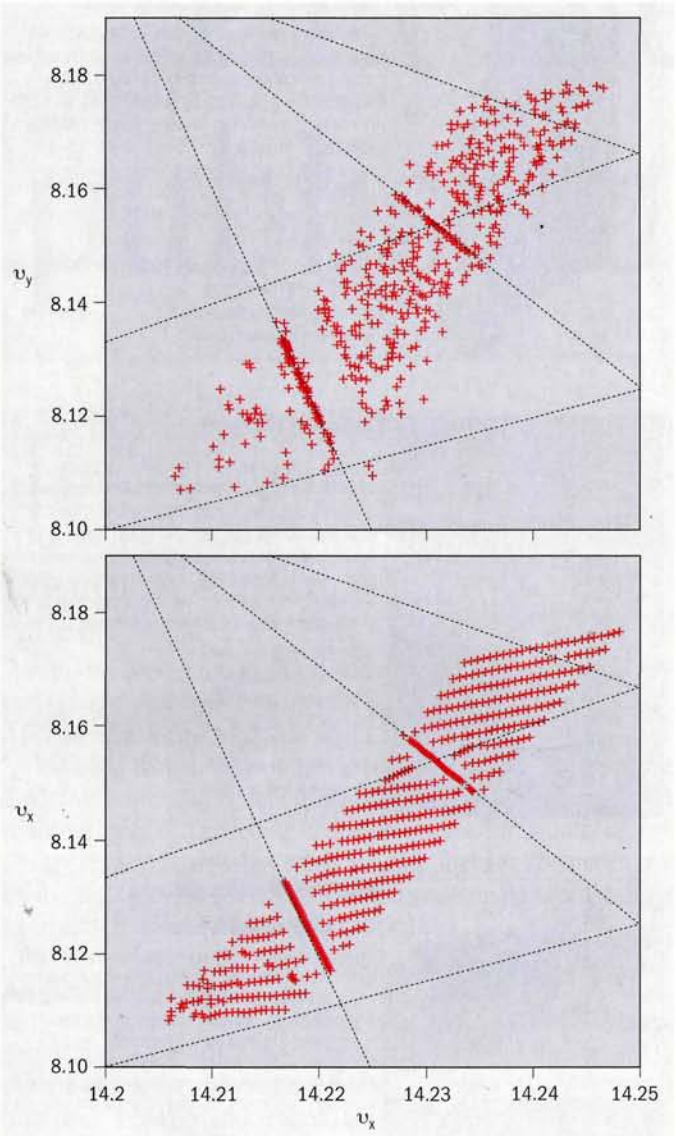


Frequency maps for the ideal lattice of the ALS (top) and for a lattice including measured gradient and coupling errors (bottom). Blue areas represent electron trajectories with no diffusion (no change in betatron tune); red areas represent particles with high rates of diffusion. In the logarithmic colour scale the diffusion rate for electrons in the red regions is about 1 billion times that of electrons in the blue regions.

At first the collaborators applied frequency map analysis to numerically generated data from a model. In these simulations the frequency maps turned out to be very sensitive to the distribution of magnetic-field errors in the model.

Even for a machine with very small field errors, there was a striking difference in the frequency map compared with the frequency map of an ideal machine. Smaller stable areas and larger chaotic regions resulting from the errors emphasized the importance of accurate machine models.

During this period, accelerator physicists were also applying the frequency map analysis technique to several other synchrotron radi-



Comparison of a measured frequency map of the ALS (top) with a portion of the simulated map based on gradient and measured coupling errors (bottom). Resonances of the order of ≤5 are shown as dashed lines.

ation storage rings, including those at the Stanford Synchrotron Radiation Laboratory (Stanford Linear Accelerator Center), the European Synchrotron Radiation Facility (Grenoble) and the Laboratoire pour l'Utilisation du Rayonnement Electromagnétique (Orsay), as well as the recently approved French synchrotron source, SOLEIL (November 2000 p7).

In the high-energy physics field, the frequency map analysis technique is finding a role in the evolution of the design of the LHC (Papaphilippou 1999). To take one example, when making changes in the magnet lattice, accelerator physicists want to know with considerable confidence that it will be possible to accumulate particles in the storage ring during the rather lengthy injection process (10 million turns round the ring). Frequency map analysis provides a global view of the resonance structure and other features of the phase space, thereby enabling accelerator physicists to avoid areas which might be dangerous.

Constructing experimental frequency maps based on measured beam oscillations and using them to optimize performance takes frequency map analysis beyond simulations to operating accelerators. A step in this direction has now been taken at the ALS (Robin *et al.* 2000), using two tools to provide the required data.

In practice

First, a set of two "pinger" magnets, the fields of which rise and fall in less time than it takes the electrons to travel round the ring, can deliver horizontal and vertical kicks respectively to the beam, displacing it with independently adjustable horizontal and vertical amplitudes. Second, beam-position monitors synchronized with the pinger magnets can measure the transverse centre of charge of the electron beam for each turn round the storage ring.

In one experiment, David Robin and Christoph Steier from the ALS and Jacques Laskar and Laurent Nadolski from the Bureau des Longitudes collected data for a set of 25 initial transverse momenta. They set the small-amplitude betatron tunes close to the setting for user operation and adjusted magnet parameters so that the storage ring was as close as possible to the ideal 12-fold symmetry.

Under these conditions they found that the frequency map contained two strongly excited resonances that are "unallowed". These do not appear in the frequency map for the numerical model of the ideal storage ring but do show up in the frequency map calculated using a machine model with realistic errors. It appears that small coupling errors in the storage-ring lattice broke the 12-fold periodicity sufficiently to excite the unallowed resonances.

The excellent agreement between the map that was based on experimental data and that which was obtained with calibrated numerical models leads the collaborators to propose the use of frequency map analysis as a tool to improve both numerical models and the behaviour of actual storage rings, including parameters that are important to synchrotron radiation users, such as lifetime and injection efficiency.

Arthur L Robinson, *Advanced Light Source, Lawrence Berkeley National Laboratory.*

Further reading

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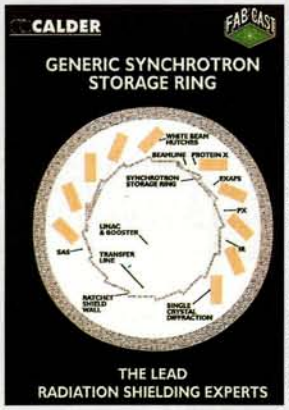

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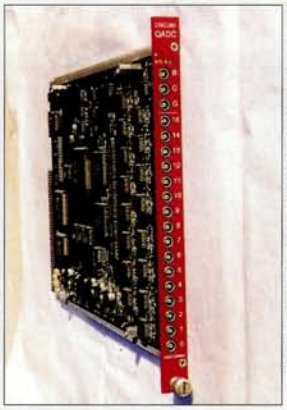

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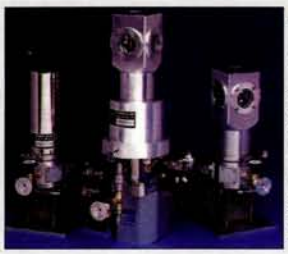

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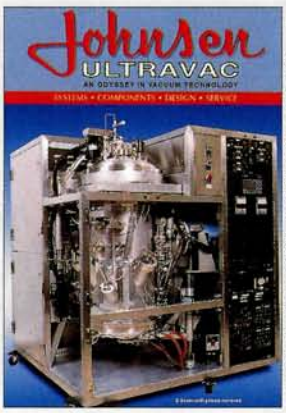

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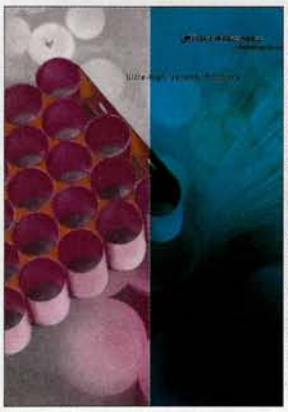

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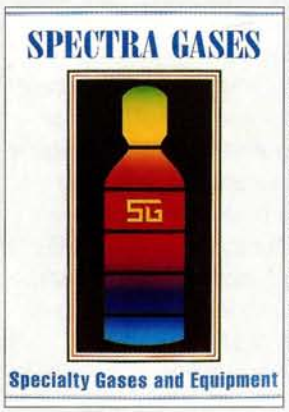

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HEP electronic publishing takes off

Scientific communication is now virtually instantaneous, with scientists able to download book-quality versions of papers. High-energy physics has been in the eye of this publishing storm – witness the Word Wide Web developed at CERN. Now a new electronic journal developed for high-energy physics could be a role model for other new ventures.

The *Journal of High Energy Physics* is a scientific journal that is written, run and distributed electronically. First published in July 1997, it is now established as one of the leading journals in the field.

On-line publication is made possible through the complete automation of editorial work by means of a software robot, thereby reducing costs and speeding up the procedure. The *Journal of High Energy Physics* is available via eight nodes that are updated in real time using innovative software. Special multimedia facilities have been added to enhance the Web possibilities.

An electronic journal

With the extensive use of the World Wide Web by the international community of physicists, the *Journal of High Energy Physics* (JHEP) aims to exploit the new media and take advantage of their innovative qualities – rapid communication, broad diffusion and low cost.

The journal's initial focus was on theoretical high-energy physics and has now been extended to encompass experimental high-energy physics as well. However, the same model (and the same software robot) will be used to create similar journals in the same field, such as a review journal, as well as in other fields.

As far as research and development are concerned, a new project, begun in February 2000, is now devoted to the development of new-generation software that will be applied to new journals and services. It is directed by Loriano Bonora and Marco Fabbrichesi, JHEP's creator, and it is financed by the European Union.

The journal has grown enormously, now publishing 12 000 pages a year and still growing. As a consequence of the complexity of operating JHEP and other publications, it is now time to give JHEP a more professional structure. To do so, Hector Rubinstein joins Loriano Bonora and Daniele Amati in the JHEP directorate, thus adding his wide professional experience in academic publishing and emphasizing the international character of the enterprise already witnessed in the editorial and advisory boards.

As a consequence of the complexity of operating JHEP and others, it is now time to give JHEP a more professional structure.

Moreover, it seems necessary to spread the costs to all users. A typical week sees the journal consulted by 10 000 users from all over the world. At present the costs are paid by the International School for Advanced Studies (SISSA) in Trieste and the INFN, and sponsorship is being requested from major research centres. CERN has already accepted the financial and moral commitment.

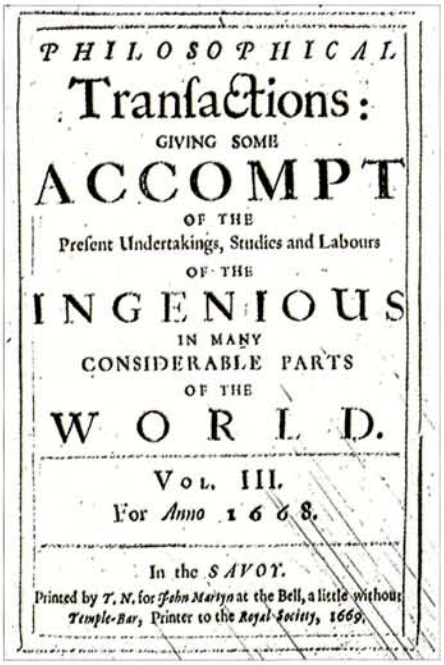
In parallel with the directorate, JHEP's distinguished advisory board lays down the scientific policy of the journal. An editorial board of leading scientists in a large number of fields acts as mediator between authors and referees. Selected by an electronic robot, they either referee or assign referees. Unless unforeseen problems develop, they are the final arbiters. If problems arise, they consult the higher boards via the Executive Office.

The running of the journal is assigned to the executive office at SISSA, which is in charge of supervising the functioning of the journal in collaboration with the editorial board. The executive office monitors the journal daily and intervenes in the event of any problems that may arise. Local system support is provided at each one of the journal nodes.

The software robot

The JHEP software performs all of the steps in the editorial procedure: submission of papers; assignment to appropriate editors; review by referees; management of the contacts between editors, referees and the executive office; revision, proofreading and publication of papers; and administration of the journal.

Accepted papers are made available on the JHEP Web sites to all interested readers. Editors, referees and authors have their personal Web pages, where they run the editorial procedure or check the ▷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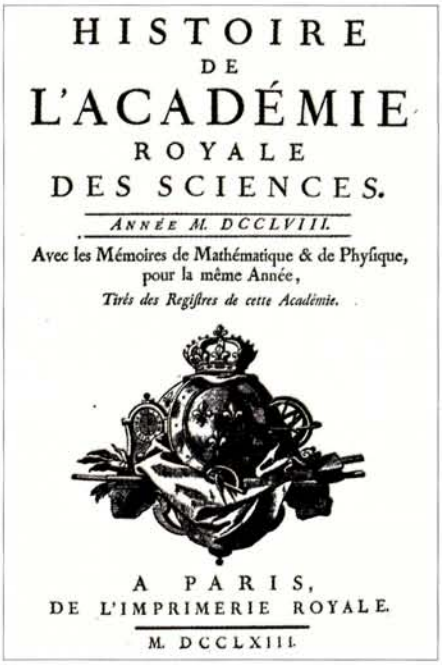
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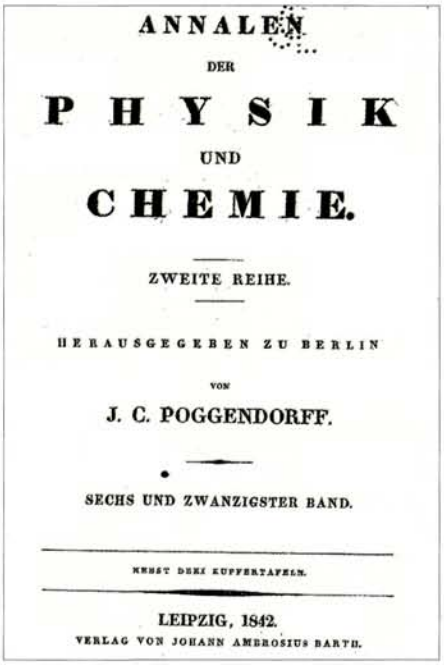
ANNALEN
DER
PHYSIK
UND
CHEMIE.
ZWEITE REIHE.
HERAUSGEGEBEN ZU BERLIN
VON
J. C. POGGENDORFF.
SECHS UND ZWANZIGSTER BAND.
MEBST DREI KUPFERTAFELN.
LEIPZIG, 1842.
VERLAG VON JOHANN AMBROSIUS BARTH.

Standing on the shoulders of giants – scientific literature has come a long way in 350 years.

status of the papers. The software comprises three major families of scripts. All interfaces with the robot are via e-mail or accessible from a browser (optimized for Netscape Navigator 3.0 or later).

The first family of scripts allows the interaction between JHEP and the scientific community and deals with the publication of papers. The submission procedure is also part of this family of programs. The second script family runs the interface among editors, between editors and referees, and between editors and authors. The third family is in charge of the administration of the journal.

In addition to these scripts, there is a program called Harold that is dedicated to updating in real time the journal's network of nodes throughout the world (see below). The robot carries out many of the menial tasks that make the running of a scientific journal expensive and slow. This program has been implemented in successive steps and is now fully working. Further upgrades will follow as new possibilities are explored and realized.

Multimedia facilities have been added to enhance the possibilities offered by the Web: powerful search engines replace the table of contents and indexes used by paper journals; and papers, published in three different formats (PDF, PS, DVI), are in hypertext, with links within the articles themselves and to the papers quoted in the references.

To ensure reliability and fast connections, JHEP exists as a network of nodes throughout the world. Currently active sites are:

- http://jhep.sissa.it
- http://jhep.cern.ch
- http://jhep.yukawa.kyoto-u.ac.jp
- http://jhep.jinr.ru
- http://jhep.tifr.res.in
- http://jhep.mse.jhu.edu
- http://jhep.ift.unesp.br
- http://jhep.weizmann.ac.il

All nodes are equivalent. The program Harold has been developed to keep them synchronized. All events taking place at any of the nodes are notified to the other nodes within a matter of minutes. On notification, the nodes execute the corresponding action and are updated accordingly. All transactions are encrypted in order to protect the data.

Editorial procedure

The entire editorial procedure for a paper – from submission to publication – is automatic and carried out electronically. Hence the time required to process a paper is significantly reduced compared with the equivalent time in traditional journal publishing. Typically the time from submission to the editor's first decision is about a month.

Authors, editors and referees run their stages of the editorial procedure through personal Web pages, which are updated in real time as soon as new events occur. Authors can access their preprint page, which is set up at the time of the submission of a paper, where they can check the status of their papers throughout the editorial procedure and communicate with the executive office.

Referees also operate from a personal Web page, where they can read and download the papers that are to be reviewed, upload their reports and communicate with the executive office.

From their personal pages, editors can read and download papers, select referees, communicate with the executive office and make decisions about papers. Other tools, such as personal address books, search engines, bulletin board systems and statistics, are also available to assist users in running and using the journal.

Authors submit their manuscripts via the Internet using the appropriate form, which is available at any JHEP node. They can upload the necessary files or simply enter the corresponding Los Alamos archive number. Submission of material via e-mail is also possible but is not encouraged because it is insecure and not interactive.

In the present version of JHEP, authors are asked to send their manuscripts as TeX files, or one of its dialects, including figures in PostScript format. After submission, the robot automatically assigns the paper to the appropriate editor according to the keywords chosen by the authors to characterize their work. This is a dynamic process in which both the possible key words and their association with the editors are constantly updated.

Libraries have been squeezed economically, and archival space has become a nightmare.

On receiving the paper, the robot starts by processing the submitted work. It creates the PostScript file, runs routine checks that filter submissions and sends an e-mail acknowledgement back to the submitter via e-mail. It puts the PostScript file of the paper on the editor's Web page and it creates a Web page accessible by the authors (via a password chosen by the authors at the time of submission) where the status of the submitted paper will be constantly updated for perusal.

The refereeing procedure

JHEP refereeing is based on the traditional peer-review system in which an editor receives the submitted paper, examines it, asks one or more referees for an opinion and then acts accordingly. The confidentiality of both the submission and the identity of the referee are guaranteed.

The JHEP editorial board applies a strict filter in selecting the submitted papers. Thus there is a very high selection rate, and referees and editors have to comply with the strict standards recommended by the advisory board.

The advisory board comprises distinguished physicists who monitor the journal and review the editorial work. The scientific policy of JHEP (including the level of accepted papers) is jointly established by the advisory and the editorial boards and the board of directors.

Editors are ultimately responsible for decisions on papers, although their decision is generally supported by one or more referees. As a rule, papers are processed as quickly as possible, in proportion to the time required to evaluate their scientific quality.

Publishing procedure

The accepted papers are processed by the robot and reformatted into JHEP style. The JHEP TeX style replaces that of the authors to format the papers in a uniform manner. It contains many shortcuts and facilities to help the authors in both writing and proofreading.

The paper is initially posted on the author's Web page for checking and proofreading. Subsequently it is posted on its own Web page, which features the title, the names of the authors and the institution, and the abstract. On this page, readers will have access to DVI, PostScript and PDF versions of the paper.

If the editor requires a revision, authors must follow the modifications requested and provide a new version within a reasonable timespan. Revisions submitted later than the deadline are treated as new papers: the original paper is withdrawn and a new procedure begins. Revised versions are submitted by the authors directly from their personal page. They are then reviewed again before a final decision or a further round of revision.

Papers are selected, processed and reviewed as fairly as possible. In case of rejection, authors can appeal without discrimination and reply to the editor and referee(s). However, such appeals should be scientifically justified and not polemic.

Market impact

Scientific communication has become instantaneous, with authors in many fields creating their personal library on their computers. Retrieval and printing with book quality is possible at low cost. Obtaining papers tailored exactly to the individual requirements of any researcher is simple and avoids sifting through thousands of unnecessary pages.

At the same time, libraries have been squeezed economically, and archival space has become a nightmare, demanding yearly additions of shelf space. In the last 15 years, most libraries have had to cut subscriptions painfully, and they have now reached the point where collections are seriously impaired.

The US Association of Research Libraries calculates that its 114 member libraries spent 142% more on journals in 1997 than 10 years before, but ordered 6% fewer titles. Meanwhile, journal publishers continue to reap profits.

Commercial publishers and learned societies have introduced electronic versions of their journals. Unfortunately, they have consistently linked their use to subscriptions to paper versions or are planning to reintroduce page charges. The net effect is high costs.

JHEP has proved to be a timely answer to the need for a new avenue for scientific communication. It is an efficient and cheap alternative to conventional publishing that maintains the essential features of quality control, easy retrieval, and archival responsibility.

Interested readers can gather the most recent statistics from the JHEP pages at http://jhep.sissa.it.

● Material for this article came from issue 1 of the *High Energy Physics Libraries Webzine*, published at CERN. See http://library.cern.ch/HEPLW/.

Further reading

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High energies and high altitudes

The Mount Chacaltaya laboratory near La Paz, Bolivia.

The Utah Fly's Eye detector (1981–1993) provided milestone cosmic ray measurements.

A recent meeting in Bolivia looked at the possibilities of mounting new physics instrumentation at the highest-altitude laboratory in the world. *Larry Jones* reports.

Before the advent of particle accelerators, cosmic rays were the source of many major physics discoveries. As physicists realize that the energies attainable using terrestrial accelerators represent only a tiny slit of nature's wide window, cosmic ray physics is becoming fashionable once more.

A recent meeting of cosmic ray physicists in La Paz, Bolivia, examined the research programme of the Chacaltaya Laboratory, one motivation being the recent declaration of support for the laboratory by the Centro Latinoamericano de Fisica (November 2000 p9).

At 5220 m (540 g/cm^2 barometric pressure), Chacaltaya is the highest continuously operating cosmic ray research laboratory in the world and barely an hour's drive from the outskirts of La Paz.

Several speakers recalled the early history of the laboratory, including the discovery of the pion in nuclear emulsions by Lattes, Occhialini and Powell (seen also in emulsions exposed on the Pic du Midi in the Pyrenees). Other unusual emulsion chamber observations include the still mysterious Centauro events.

Local experiments

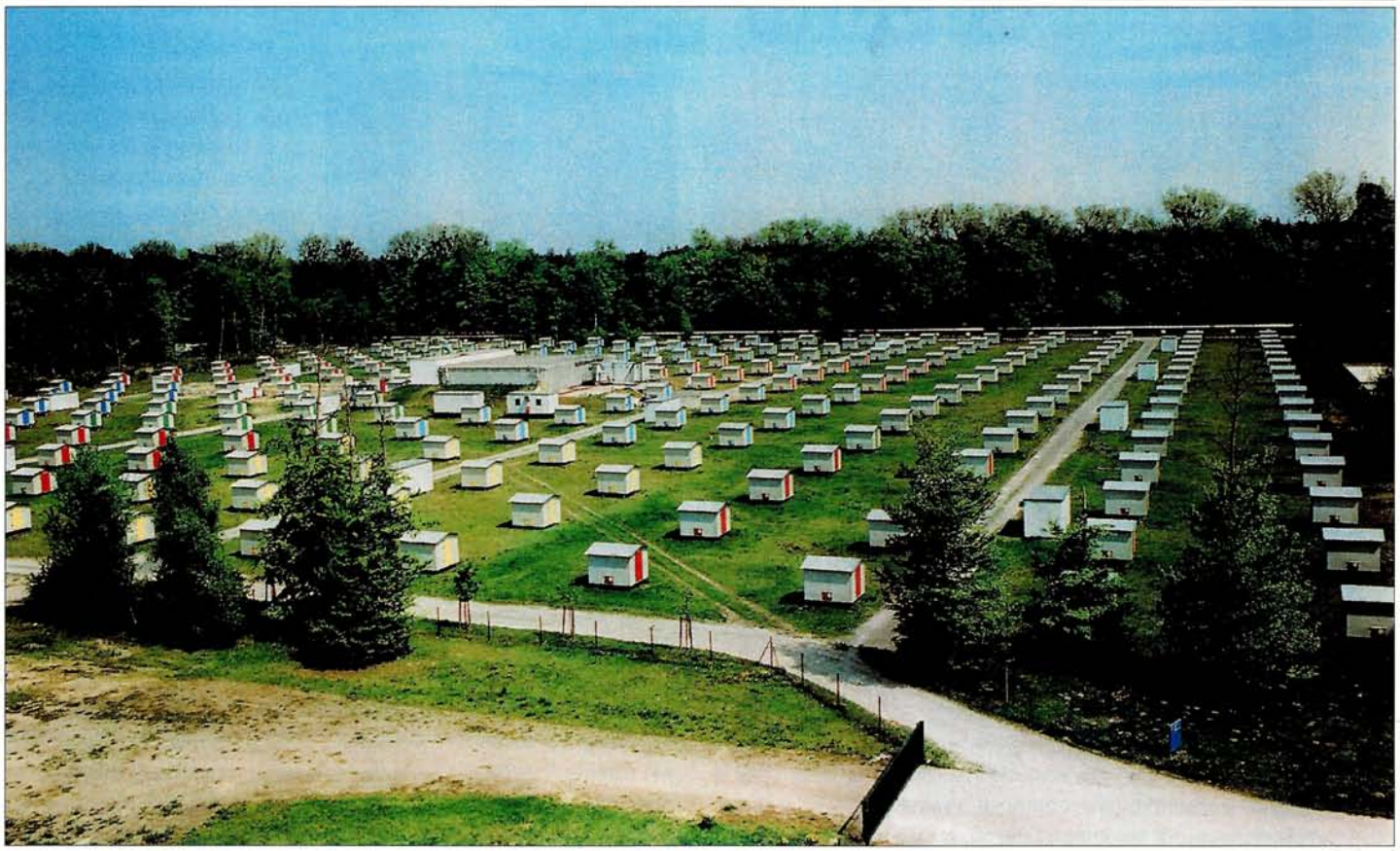
Several reports came from experimental collaborations currently working at Chacaltaya. The Bolivian Airshower Joint Experiment (BASJE) group's work was discussed by H Yoshii (Ehime) and others. This collaboration, operating since 1962, currently utilizes an array of about 80 scintillation detectors in a 60 × 60 m array.

An interesting result is the observation of a galactic anisotropy in arrival directions, an enhancement of the primary cosmic ray flux between 270° and 300° galactic longitude. As the events showing this anisotropy have a normal muon content, the conclusion is that the effect is due to primary cosmic ray nuclei and not gamma rays.

A Ohsawa (Institute for Cosmic Ray Research, Tokyo) and N Ohmori (Koshi) discussed results from the Saytama–Yamanashi–San Andres (SYS) collaboration detector – an array of 32 emulsion chambers, each 0.25 m^2 and each containing 15 cm of lead plates, mounted on a thick scintillator. This array opens up the study of the hadron component of an air shower core in correlation with the electromagnetic component.

Among the conclusions based on their observations are a confirmation of a breakdown of Feynman (kinematic) scaling at energies of 1 PeV (10^{15} eV) and above; a scarcity of hadrons compared with the predictions from simulations; and a decrease in inelasticity with increasing energy (inelasticity is the average value of 1–K, where K is the fraction of the incident energy retained by the most energetic hadron in the final state of a nuclear interaction).

M de Petris (Rome) described the Millimetre Observations from a high-altitude 2.6 m ground-based telescope (MITO) infrared telescope programme at 3500 m on Testa Grigia, Italy, for infrared astronomy over the 30–0.6 mm wavelength range. One stated goal is "the multifrequency observation of rich large clusters of galaxies to estimate, together with X-ray information, the Hubble constant". As these wavelengths are strongly absorbed by atmospheric water vapour, which falls off more rapidly than barometric pressure with



The KASCADE experiment in Karlsruhe is one of the most densely instrumented arrays for detecting cosmic ray air showers.

altitude, such observations profit particularly from high-altitude locations, and the advantages of locating such a facility at Chacaltaya were pointed out.

Nuclear content

The SYS group also reported that the (logarithmic) average nuclear composition of the primary cosmic rays at an energy of 10 PeV was about that of oxygen. This is somewhat lower than the BASJE data had suggested; BASJE (and others) argue that the composition at this energy is heavier, with iron nuclei dominant. On the other hand, studies of the atmospheric Cherenkov radiation accompanying air showers have suggested a lighter nuclear spectrum at this energy.

J Stamenov (Bulgarian Academy of Sciences) and J Procureur (Bordeaux) presented a proposal to select showers generated by primaries with different masses but the same energy to a possible future extended air shower array at Chacaltaya.

Other activities on Mount Chacaltaya that were discussed included a Search for Light Magnetic Monopoles (SLIM) with a 100 m^2 (expandable to 400 m^2 in the future) passive nuclear track detector consisting of three sheets of CR-39 track etch detector sheets, three Makrofol sheets and an aluminium absorber, as reported by S Cecchini (Bologna). SLIM could also be sensitive to "strangelets", as discussed by G Wilk (Warsaw). A strangelet (strange quark matter or "nuclearite") would be a nuclear object containing approximately equal numbers of up, down and strange quarks.

Searches for high-energy gamma-ray point sources with the SYS array were presented by R Bustos (La Paz) and searches for gamma-ray "bursters" with the INCA experiment (Investigation on Cosmic Anomalies) by S Vernetto (Turin). Results of both searches were negative. However, Vernetto showed that the INCA experiment at Chacaltaya has provided the lowest upper limits on gamma-ray bursters from a GeV–TeV ground-based experiment. Also reported were high-altitude studies of background ionizing radiation at Chacaltaya by S Cecchini, and a neutron monitor installation by E Cordaro (Santiago).

Bending the knee

The cosmic ray spectrum changes behaviour at a "knee" (between 1 and 10 PeV). Studying this effect, the flux is too low for direct observation using small balloon- or satellite-borne detectors, and earth-based observations must interpret indirect observables such as air-shower (electron and gamma ray) components, muons and hadrons in terms of primary interaction and the mass composition.

The simulations for the primary interaction are based on long extrapolations from sub-TeV accelerator data and are hence uncertain. The primary cosmic rays range from protons to iron nuclei. The problem is that the observable consequences of the composition and characteristics of the primary interaction are interrelated.

The KASCADE array at Karlsruhe is probably the most densely instrumented air shower array in operation. A Haungs (Karlsruhe) reported on recent work. Analysis of the hadron and electromagnetic components shows that the spectrum of light primaries shows a clear break (the knee), while the heavy primary spectrum is relatively smooth. This results in an increase in average nuclear mass with energy through the knee region. The Karlsruhe group has found no existing Monte Carlo model to be totally satisfactory at energies of 10 PeV and above and is tuning a promising new candidate.

An analogue of the KASCADE array at the elevation of ▷

Far left: the first engineering array surface detector of the international Pierre Auger project, installed at the Pampa Amarilla, near Malargüe, Argentina. Left: Cecil Powell was awarded the 1950 Nobel Physics Prize for his discovery of the pion in nuclear emulsions exposed on Mount Chacaltaya. Other key members of the team were Cesare Lattes and Giuseppe Occhialini.

Chacaltaya was presented by O Saavedra (Turin). A central hadron calorimeter/muon detector of perhaps 100 m^2 with finely instrumented upper layers would be surrounded by a dense air shower array, including additional muon detectors. Although an ambitious project, this could go a long way towards resolving the confusion and contradictions surrounding the composition, the primary spectrum and the physics around the knee of the cosmic ray spectrum.

The Japanese and the Russians have exploited an emulsion chamber array in the Pamirs. Aspects of this research were presented by M Tamada (Kinki, Osaka), T Yuldashbaev (Tashkent), and S Slavatinsky and A Borisov (Lebedev Institute, Moscow). They compared their data with a quark–gluon string model, concluding that inelasticity increases with energy, contrary to the SYS conclusions.

Slavatinsky also emphasized unusual phenomena seen in their emulsion chambers – "aligned events", "halo events" and the "long-flying component". The latter was interpreted by Z Wlodarczyk (Kielce) as possible evidence for strangelets, which, he noted, might also be the source of the mysterious Centauros. J N Capdevielle (Paris) and S Nikolsky (Moscow) presented possible evidence for quark–gluon plasma in emulsion chambers.

Gamma-ray astronomy

A lively topic was gamma-ray astronomy, primarily via ground-based detectors. P Lipari (Rome) summarized the observations of gamma sources and of gamma bursts, noting that 62% of the 170 highest-energy sources are not identified with optical counterparts. There are, however, 17 different TeV sources, which are identified with pulsars, active galactic nuclei and supernova remnants.

Satellite observations extend to tens of GeV, but for higher energies the detector sizes and exposure times of ground-based techniques are required. V G Sinitsyna (Lebedev) presented results from the SHALON air Cherenkov telescopes with an energy threshold of about 0.8 TeV. They have studied Markarian (Mkn) 421, Mkn 501 and the Seyfert AGN, NGC 1275, as well as Cygnus X-3 and the Crab.

Results from the CLUE Cherenkov telescope array in the Canary Islands were reported by M T Ciocci and A Menzione (Pisa), and from the CELESTE solar farm Cherenkov array by J Procureur (Bordeaux). Procureur discussed studies of the polarization of the Cherenkov light as detected by CELESTE, where he noted that the Cherenkov light from gamma-initiated showers was significantly more polarized than that from proton-initiated showers.

A new air shower detector, ARGO, at Yang ba Jing, Tibet (4300 m), will overlap the Cherenkov telescope energy coverage. This resistive plate chamber array was described by P Vallania (Turin).

Data from the MILAGRO water Cherenkov detector system at Los Alamos and its prototype MILAGRITO were presented by G Yodh (Irvine). MILAGRITO has detected Mkn 501 as well as a possible signal from a gamma-ray burster in the TeV range. The relevance of these techniques to future Chacaltaya installations was noted.

To observe from the Earth's surface, an air shower produced by a gamma of less than 10 TeV requires both a high elevation (to sample the shower before total absorption in the atmosphere) and a detector providing a continuously sensitive surface area rather than a sampling array. Such arrays are sensitive over the entire vertical solid angle and, unlike air Cherenkov telescopes, need not be "aimed" at a suspected source. Both ARGO and MILAGRO meet these criteria and would achieve an even lower energy threshold by operating at the increased altitude of Chacaltaya.

Ultrahigh energies

Of perennial interest are the highest-energy cosmic rays – above 10^{19} eV. These have been detected with air shower arrays (the Japanese AGASA) and atmospheric fluorescence detectors (the Utah Fly's Eye).

Owing to photonuclear interactions with the 2.7 K cosmic microwave background radiation, protons or nuclei at such extreme energies would have a limited mean free path within the universe. If they were produced "locally" (within about 100 Mpc), they would be so weakly deflected by the intergalactic magnetic field that they would "point back" to their source. However, the few dozen events observed so far have no apparent source(s). It is hard to understand how protons or nuclei could be accelerated to such phenomenal energies. The most energetic cosmic ray ever detected had an energy of about 3×10^{20} eV (50 J) – equivalent to the kinetic energy of 1 kg being dropped from a height of 5 m.

One idea is that these extreme energy cosmic rays are not the

result of the acceleration of protons, but of the decay of unstable primordial objects. Wlodarczyk and Wilk pointed out that their strangelets may be highly energetic primordial remnants of the Big Bang. L Masperi (Rio de Janeiro) discussed sources of such cosmic rays from topological defects produced in the early stages of the universe. One concept is a "necklace" of magnetic monopoles connected by cosmic strings. Another is "vortons" – closed cosmic loops containing a superconducting circulating current.

J Ellis (CERN) introduced "cryptons" – relic massive metastable particles born during the inflationary epoch. Given that the decay lifetime of a relic metastable particle of mass m would be expected to vary as m^{-4}, particles of rest masses as high as 10^{12} GeV may have survived.

Major projects

The Extreme Universe Space Observatory concept was described by L Scarsi and J Linsley (Palermo), and by P Spillantini (Florence). The programme, earlier called Air Watch or OWL, is based on an imaging telescope to be carried on the International Space Station that will observe atmospheric fluorescent light from the most energetic air showers with a net sensitivity more than an order of magnitude greater than the current Pierre Auger project (see below).

The telescope would be deployed above 400 km and would employ an optical system of double fresnel lenses with an aperture of 2.6 m and a field of view of 60°, using an array of multianode photomultipliers to achieve a 57 600 pixel image. With the time structure of an observed air shower providing the third dimension, only a single eye would be needed.

The coverage of this "fly's eye in the sky" would exceed 0.25 million square kilometres and, even accepting a dark-sky duty factor of only 5 or 10%, would represent a truly impressive sensitivity. A matrix of such detector systems could cover millions of square kilometres, and scaled-up versions would even be sensitive to interactions of ultra-high energy neutrinos of more than 10^{18} eV.

The international Pierre Auger project, which aims to detect and improve understanding of these highest-energy cosmic rays, was discussed at the Very High Energy Cosmic Ray Interactions Symposium in Campinas, Brazil, preceding the Chacaltaya meeting.

Other presentations included the AMS project by M Steuer (CERN) and the L3-Cosmics programme at CERN by B Petersen (Nimegen). P Lipari summarized the formal conference proceedings.

After the technical presentations, delegates visited Mount Chacaltaya (profiting from several days acclimatization at the 3700 m elevation of La Paz). Once at the laboratory, many braved the additional 160 m climb to the summit.

The meeting was attended by 110 physicists, including 65 from outside Bolivia, representing 16 countries, and 28 Bolivian college students (graduate and undergraduate). The meeting was opened with a welcoming speech by the president of Bolivia, Gral Hugo Banzer Suarez, and with addresses by the rector of the Universidad de San Andres (La Paz) Dr G Taboada, the Minister of Education Dr T Hoz de Vila, and the president of Academia Nacional de Ciencias de Bolivia Prof. Carlos Aguirre.

Larry Jones, *Michigan.*

Can carbon nanotubes handle high-energy particles?

New types of materials suggest new ways of handling high-energy particle beams, but can carbon nanotubes handle high-energy particles? Specialists from Yerevan outline the possibilities.

Nanoparticles are small pieces of matter that, at least in one dimension, consist of tens to thousands of atoms and have widths of the order of a few nanometres. Nanotechnology – the production, study and application of nanoparticles – could be set to play a major role in technological development.

Carbon nanotubes are typical nanoparticles, which were first produced in 1991 after the 1985 discovery of large football-like "fullerene" molecules of pure carbon-60 atoms that are found in the sediments from the laser irradiation of graphite.

Nanotubes can be imagined as rolled-up graphite crystallographic planes with carbon atoms separated by 1.3 nm at the vertices of honeycomb hexagons. Nanotubes are either concentric multiwalled (MWNT) or single-walled (SWNT) structures. The latter are characterized by two numbers, n and m, which determine not only the diameter and geometry, but also many physical parameters, such as the metallic or semiconductor nature.

In 1996 it was shown that the metallic SWNTs with $n = m = 10$ are produced with 75% efficiency in the sediment of graphite after laser irradiation. SWNTs have a length of up to 200 μm and a diameter of 1.38 nm, and a few hundred of them form compact ropes with 17 nm between the axes.

The unique properties of MWNTs and SWMTs promise wide application in various fields of industry and science. Owing to their smaller size, nanotube chips could replace transistors in electronic devices, providing higher densities of logic units. With their more effective field emission of electrons, they could be better than liquid crystals in advertisement, electronic and television displays.

Channelling

In addition to other possible developments, during 1996–1997 V V Klimov, V S Lethokhov, L A Gevorgian and we considered the theory of the channelling of high-energy particles in SWNTs. (In conventional channelling, charged particles are steered by the electromagnetic forces in crystals.)

The fact that the diameter of SWNTs is larger than the distances between the crystallographic planes, and the possibility that, in the near future, nanotubes will be available in lengths greater than single crystals, underline the potential advantage of nanotubes.

Indeed, the much lower SWNT electron density results in a sharp decrease in multiple scattering. As a result, the channelling protons and positrons moving near the SWNT axis suffer less dechannelling.

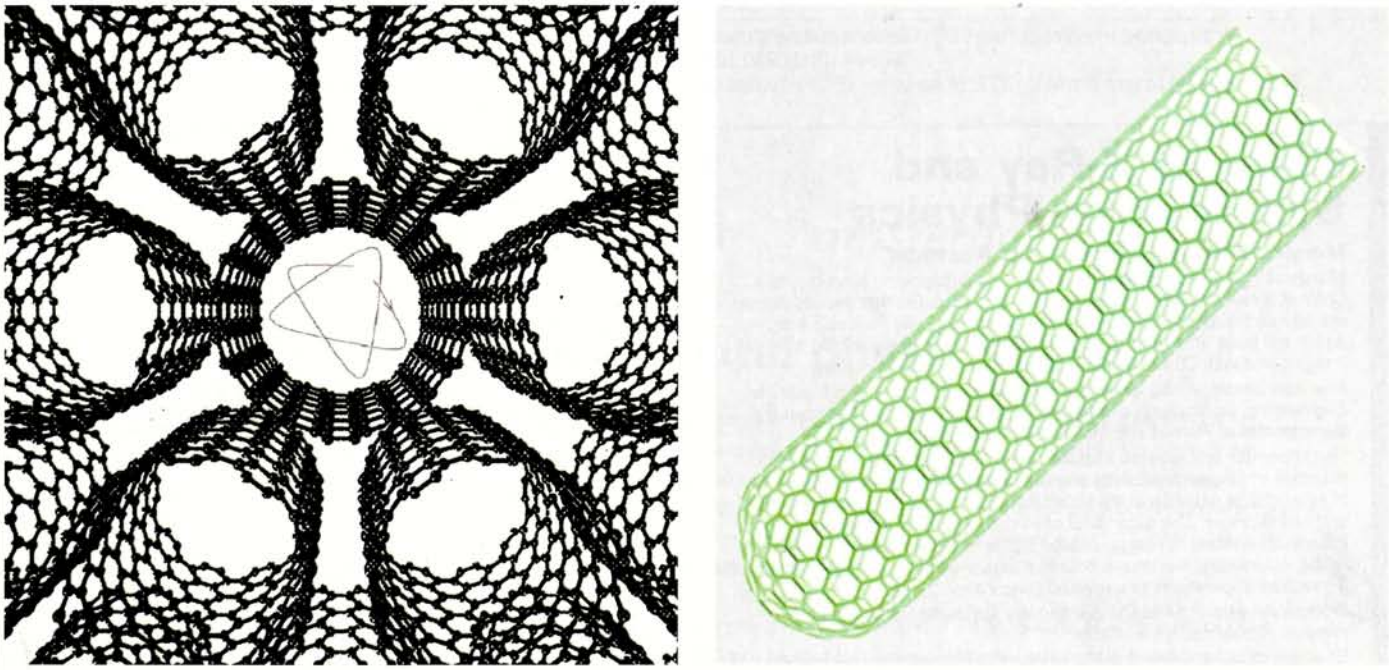
The classical and quantum theories of the radiation of particles channelled in SWNT, which are valid for energies both above and below about 100 MeV respectively, demonstrate that, taking into account medium polarization, X-ray production has specific threshold and spectral properties, and it can also serve as a source of intense quasimonochromatic photon beams. Periodically deformed nanotubes as microundulators can provide intense linearly and circularly polarized spontaneous and stimulated radiation in the X-ray region.

Dispensing with magnets?

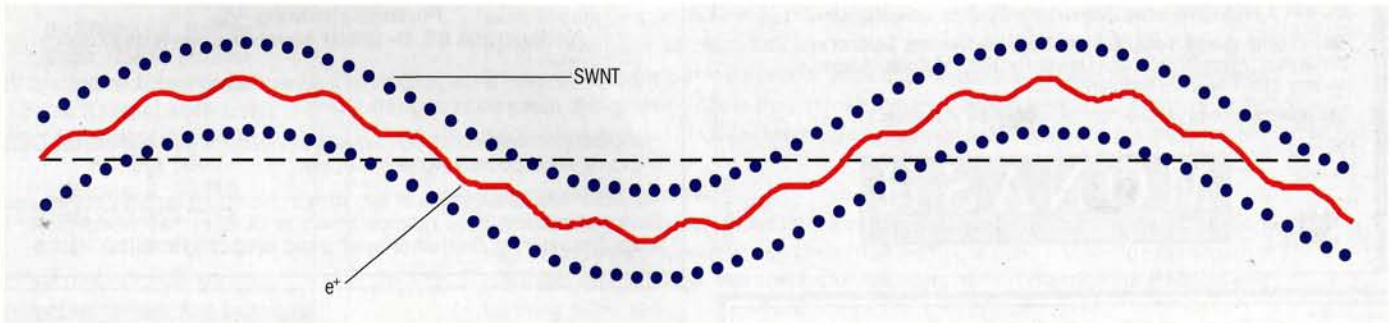
Just as with single crystals, SWNTs open up the possibility of bending, focusing and accelerating high-energy particle beams without the use of large electromagnets. The relatively small dechannelling effects in SWNTs could even lead to revolutionary designs for high-luminosity colliders at energies greater than 0.1–1 TeV.

Unfortunately, current nanotechnology cannot produce nanotubes oriented with angular deviations less than the critical Lindhard angles that are necessary to provide the particle channelling. No methods for producing regularly deformed nanotubes have been developed, so these dreams cannot yet be realized. ▷

No methods for producing regularly deformed nanotubes have been developed



Left: six single-wall carbon nanotubes with n = m = *10 geometry in a rope, showing the honeycomb hexagons and the projection of the trajectory of a channelled particle. Right: An* n = m = *10 SWNT with tip closed with half a carbon-60 fullerene molecule.*



Trajectory of a channelled particle in a periodically deformed SWNT.

However, other nanotube applications do appear to be realistic. Experiments carried out from 1995 until 2000 with static electric fields show that nanotubes have intriguing electron field emission properties. MWNTs with hemispherical fullerene tips provide more intense and stable beams. No experimental data exist for pulsed electric fields.

On the other hand, experiments on self-amplified spontaneous emission on advanced methods of particle acceleration and the production of higher-brightness photon beams require low emittance intense electron femtosecond beams.

At present, such beams are produced using field-, thermo- or photo-emission from various cathodes in radiofrequency guns, the very high accelerating fields of which protect the pulses from being blurred by strong space–charge repulsion.

Experiments using other materials suggest that higher breakdown voltages and current brightness can be achieved using shorter pulses, so it is reasonable to begin the study of the field- and photo-emission from nanotubes in pulsed regimes and in radiofrequency guns, although the corresponding theory of the field emission from the tips of nanotubes with a very small curvature radius has not yet been developed.

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The Board of Governors of the U.S. Particle Accelerator School seeks a new school Director to serve a four year term starting in January 2002. The Director of the USPAS is responsible for establishing the school program and executing two academic sessions per year. He/she is assisted in this task by a standing Program Committee and the USPAS Office. The Director holds responsibility for management of the USPAS Office, situated at Fermilab. While the Director is appointed by the Board of Governors, he/she institutionally reports to the Fermilab Director. To ensure the candidate's career continuity, flexible institutional arrangements are available. Salary will be commensurate with the candidate's experience and qualifications.

Interested parties should please contact:

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e-mail: holmes@fnal.gov

EOE/AA Employer M/F/D/V

vrije Universiteit *amsterdam*

Experimental physicists f/m

The Subatomic Physics Group of the Faculty of Sciences at the Vrije Universiteit participates in the LHCb experiment at CERN (Geneva) and the HERMES experiment at DESY (Hamburg). These experiments are conducted in close collaboration with groups at the NIKHEF institute in Amsterdam. The design and construction of detectors and the analysis of data largely take place on campus. There are close interactions with the local theory group.

The academic staff of the group consists of about 20 physicists of whom more than half are PhD students and postdoctoral fellows. Technical support is provided by well equipped mechanical, electronic and information-technology departments.

The Subatomic Physics Group at the Vrije Universiteit is searching for outstanding experimental physicists with a strong record of accomplishments in experimental particle physics research. Candidates will be considered for a permanent position and are expected to have at least several years of post-doctoral experience. The successful applicant will join one of the present experimental programmes. Furthermore, they are expected to participate in teaching and managerial activities in the department.

General requirements
Candidates should have a broad and deep knowledge of physics. Further qualifications include: creativity, competence in detection techniques and knowledge of modern information technology. The successful candidate has excellent communication and teaching skills, ability for teamwork and leadership capability.

Information
Information about the scientific and educational activities of the Subatomic Physics Group can be found at: http://www.nat.vu.nl/vakgroepen/saf/english/. Further information can be obtained from the director, Prof. Dr Ing. J.F.J. van den Brand (telephone: +31 20 4447892 / E-mail: jo@nat.vu.nl).

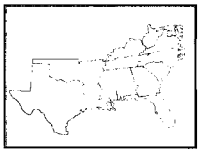
Salary
According to Dutch code of scientific personnel. The gross monthly salary will depend on experience and qualifications.

Duration
The appointment will be for one year with an option for a permanent position after this period.

Applications
Letter of application with job reference number 2865.2000418, including curriculum vitae, list of publications and the names of at least three references are to be sent within three weeks after publication of the advertisement to, Vrije Universiteit, Mrs drs. R. Pereira, Head of Personnel Department, Faculty of Sciences, De Boelelaan 1083a, 1081 HV Amsterdam, the Netherlands (or by E-mail: betsy@nat.vu.nl).

All qualified individuals are encouraged to apply.

SURA



Southeastern Universities Research Association

Jefferson Lab

Director for the Thomas Jefferson National Accelerator Facility (Jefferson Lab)

The Southeastern Universities Research Association (SURA) invites nominations and applications for the position of Director for the Department of Energy's Thomas Jefferson National Accelerator Facility (Jefferson Lab) in Newport News, Virginia. SURA seeks a strong and visionary scientific leader with effective management skills and who enjoys stature among peers in the scientific and lab communities.

The successful candidate will be responsible for leading and managing all Lab initiatives and activities in support of a world-class research facility including its strategic and long-range planning and its building of a comprehensive external relations program to serve and promote the interests of the Lab and its users. Reporting to the SURA President, the Jefferson Lab Director is the Chief Executive Officer of the Lab, responsible for the Lab's 600-plus staff and total annual budget of nearly $100 million.

SURA (www.sura.org), is a consortium of 53 research universities in 15 Southern states and the District of Columbia. In addition to serving as the U.S. Department of Energy's management and operating contractor of the Jefferson Lab, SURA has ongoing research initiatives in information technology and networking applications, coastal research, and materials science.

Jefferson Lab (www.jlab.org) is a national laboratory for nuclear physics research. As a user facility for scientists worldwide, its primary mission is to conduct basic research to advance the understanding of the fundamental constituents of the atomic nucleus and their interactions. The tools for probing the structure of the nucleus are the Lab's Continuous Electron Beam Accelerator Facility (CEBAF) and the advanced particle-detection and ultra-high-speed data-acquisition equipment in three experimental halls. Currently operating at 6 GeV, plans have been developed for a major upgrade of the electron accelerator to 12 GeV. The international user community includes over 1,600 scientists over half of whom are actively involved in the Lab's experimental program. The Lab is also responsible for building the super-conducting linear accelerator for the Spallation Neutron Source under construction in Oak Ridge, Tennessee.

Jefferson Lab has also leveraged its core competencies in electron-source and super-conducting radio-frequency electron-accelerating technology by partnering with industry, government and universities to develop a powerful, versatile Free Electron Laser, thereby giving the Lab and its user communities an opportunity to diversify into other scientific arenas, including biology.

Nominations, applications, and inquiries should be directed to: Director Search Committee; 1200 New York Avenue, NW; Suite 710; Washington, DC 20005 or surahq@sura.org. For timely consideration, submit an outline of qualifications and accomplishments and a curriculum vita by March 1, 2001. The Jefferson Lab is under interim leadership and the selected candidate will be expected to take office as soon as possible. Dr. Steven Koonin, Caltech, and Dr. Stephen Wallace, University of Maryland, co-chair the committee assisting SURA in this search. SURA is an Equal Opportunity, Affirmative Action Employer.

University of Bristol

Postdoctoral Researcher in Experimental Particle Physics

This position has been awarded and funded by PPARC explicitly to work with Professor B Foster, the Spokesman of the ZEUS experiment. You will work on the commissioning of the new ZEUS silicon microvertex detector as well as in the physics analysis of ZEUS data. There will also be an opportunity to work on studies for the TESLA linear collider project. You should have, or be about to receive, a PhD in particle physics. This position is available immediately and will be for two years in the first instance. You will be based in DESY, Hamburg, Germany. Salary from £16,775 per annum plus London weighting and overseas supplementation.

Informal enquiries can be made to Professor B. Foster, telephone +49-40 89983201.

For further details telephone (0117) 954 6947, minicom (0117) 928 8894 or E-Mail Recruitment@bris.ac.uk (stating postal address ONLY) quoting reference 7042. Electronic applications must include an "APPLICATION FORM FOR AN ACADEMIC VACANCY", found at http://www.bris.ac.uk/Depts/Personnel/recruit.htm

The closing date for applications is 9.00am, 1st March 2001.

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SENIOR ELECTRONICS ENGINEER

Electronics Design Facility

This position in the Electronics Design Facility (EDF) provides engineering support to high energy physics research projects at Fermilab, CERN, Brookhaven and other international sites. The EDF is staffed by six engineers and technicians. It utilizes CAD tools from Mentor, Innoveda and OrCAD, Xilinx, Altera and others.

The successful candidate will demonstrate considerable expertise, creativity and independence in state-of-the-art electronics, including high-speed analog and digital circuit design. Substantial experience with experimental physics research or R&D in industry, and experience with VHDL or Verilog and system-on-a-chip FPGA design required. Full-custom CMOS IC design experience a plus, as is experience with the VME64xP standard.

Requires an M.S. in Electrical Engineering or Physics and 5 years of experience in physics research and electrical engineering.

Please send cover letter and resume to Virginia Gregory, Office of Personnel, 25 Buick Street, Boston MA 02215. edf@ohm.bu.edu,www.bu.edu/personnel.

BOSTON UNIVERSITY

An affirmative action equal opportunity employer

Project Leader, Linear Collider R&D at Fermilab

Fermilab seeks an experienced scientist to lead the linear collider R&D program at Fermilab. This expanding program is currently pursuing R&D on room temperature structures and support systems for a second generation electron-positron linear collider. Responsibilities will include providing management and technical direction for a program aimed at developing cost effective approaches to an electron-positron linear collider over the next several years, and for coordinating the Fermilab effort both within the U.S. NLC Collaboration and within the larger world effort. The Project Leader will report to the Associate Director for Accelerators. This position requires previous experience with linear accelerators or high power rf systems, and demonstrated organizational/leadership abilities.

Applicants or interested parties requiring more information should contact:

Steve Holmes, Associate Director for Accelerators
Fermilab, MS105
P.O. Box 500 • Batavia, IL 60510, USA
holmes@fnal.gov
630-840-3211

Applications should include a curriculum vitae, publication list, and the names of at least three references.

Fermilab

A U.S. Department of Energy laboratory.
EEO/AA Employer M/F/D/V

EMBL

The European Molecular Biology Laboratory (EMBL) is an international research organisation with its Headquarters Laboratory in Heidelberg (Germany), Outstations situated in Grenoble (France), Hamburg (Germany) and Hinxton (UK), and a Research Programme at Monterotondo (Italy). It has approx.1000 members of personnel from over 40 different nations. EMBL invites applications for the following vacancy **in Heidelberg, Germany:**

APPLICATIONS DEVELOPER / ANALYST (ref. 00/110)

The successful candidate will be responsible for analysing, adapting, and developing the financial database applications for the Laboratory's administration. The position is assigned to the Computer and Networking Group. This environment provides a stimulating wealth of modern computational machinery, networking, and programming tools. The Applications Developer will closely co-operate with the Administration on improving the tools used to serve the requirements of a dynamic research community. Opportunities exist for continued training and development of skills.

Applicants must have experience with modern programming languages, with relational databases and with Internet protocols. Knowledge of standard financial accounting practice would be an additional asset. Applicants should have excellent interpersonal skills to serve in a challenging position in a demanding environment. Excellent working knowledge of both English and German is required to succeed in this job.

Further Information can be obtained from
Hans.Doebbeling@EMBL-Heidelberg.de, tel: +49 6221 387 247.

EMBL Web site: http://www.embl-heidelberg.de/

EMBL is an inclusive, equal opportunity organisation.

To apply for this post please send your CV, quoting ref. no. 00/110, to:

The Personnel Section, EMBL, Postfach 10.2209, D-69012 Heidelberg, Germany.
Fax: +49 6221 387555. email: jobs@embl-heidelberg.de

UNIVERSITÄT SIEGEN

Im Fachbereich 7 – Physik – der Universität – Gesamthochschule Siegen ist eine

Universitätsprofessur
(Bes,-Gr. C 4)

für **Experimentalphysik**
(Nachfolge Professor Dr. S. Brandt)
zu besetzen

Die/der Bewerber/in muss in einem der Fachgebiete Elementarteilchenphysik/Astro-teilchenphysik wissenschaftlich ausgewiesen sein. Von den Bewerberinnen/Bewerbern wird erwartet, dass sie führend an der wissenschaftlichen Planung und Durchführung netler wissenschaftlicher Experimente auf dem Gebiet der Hochenergiephysik und/oder der Astroteilchenphysik mitwirken. Der Fachbereich Physik verfügt über ein internationales Graduiertenkolleg Methoden und Geräte in der Teilchenphysik und deren Anwendungen. Dieses Kolleg und ein neu eingerichteter Campus für den Physik-Fachbereich stellen ein ideales Umfeld für die/den zu berufende/n Bewerberin/Bewerber dar. Der Schwerpunkt der Tätigkeit der Bewerberin/des Bewerbers sollte in Siegen liegen. Die Mitwirkung an internationalen Kooperationen z.B im Rahmen von CERN und DESY wird erwartet. In der Lehre muss die Bewerberin/der Bewerber das Gebiet der Experimentalphysik vertreten.

Vorausgesetzt wird die Habilitation oder eine gleichwertige wissenschaftliche Qualifikation. Ferner wird die Bereitschaft zur aktiven und konstruktiven Mitarbeit in Selbstverwaltungsgremien der Universität vorausgesetzt.

Die Universität – Gesamthochschule Siegen strebt eine Erhöhung des Anteils von Frauen in Forschung und Lehre an. Entsprechend qualifizierte Wissenschaftlerinnen werden um ihre Bewerbung gebeten.

Die Bewerbung geeigneter Schwerbehinderter ist erwünscht.

Bewerbungen mit den üblichen Unterlagen (Lebenslauf, Lichtbild, Zeugniskopien, Schriftenverzeichnis) richten Sie bitte **innerhalb von acht Wochen** nach Erscheinen dieser Anzeige an den **Dekan des Fachbereichs 7 – Physik** – der Universität – Gesamthochschule Siegen, Walter-Flex-Straße 3, D-57068 Siegen.

NEW OPPORTUNITIES IN ELECTRONICS AND INSTRUMENTATION ENGINEERING AND CAE

Join a world class team in developing innovative instrumentation systems

CLRC offers unique and unrivalled opportunities to work on a broad spectrum of advanced electronic and instrumentation engineering projects. You will have access to the latest design tools and will work in a close knit team on a wide range of technologies and applications for leading scientific and engineering research. Staff are empowered and challenged to their full potential, and encouraged to develop and advance their careers. An IEE approved training scheme is offered to new graduates.

We have vacancies for newly qualified and experienced professional engineers in the following areas:

- Analogue and digital ASIC design including System On Chip
- System, circuit board and MCM design
- Embedded systems and real time software
- Detector Systems
- Support and development of leading design tools and flows for ASIC, MCM and microsystem design.

Posts are available at Rutherford Appleton Laboratory and Daresbury Laboratory. CLRC provide world class facilities and engineering support for the UK scientific and engineering research programmes. Applications include data acquisition and high performance processors for particle physics, instrumentation for neutron and synchrotron radiation studies, spacecraft systems and medical imaging systems.

The appointment will be made at CCLRC Band 5 or 4 level with a salary that is in the range £18,620 to £33,200 (pay award pending). A non-contributory pension scheme and a generous leave allowance are offered.

Further information on this post is available from Mr Steve Quinton, telephone (01235) 445534 or email S.P.H.Quinton@rl.ac.uk

Application forms can be obtained from: HR Operations Group, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX. Telephone (01235) 445435 (answerphone) quoting reference VN1996, or email recruit@rl.ac.uk More information about CCLRC and application forms are available from CCLRC's World Wide Web pages at http://www.cclrc.ac.uk

All applications must be returned by 19 February 2001. Interviews will be held on 7 March 2001.

The CCLRC is committed to Equal Opportunities and to achieving the Investors In People standard.

A no smoking policy is in operation.

CLRC

COUNCIL FOR THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS

Postdoctoral Research Associate/Scholar Position in CMS

The Department of Physics and Astronomy at the University of Iowa invites applications for a postdoctoral position in experimental particle physics. We are looking for an outstanding candidate who can strengthen the existing Iowa activity on the CMS Forward Calorimetry (HF). The appointee will be expected to play a leadership role in the CMS-HF detector construction. A Ph.D. is required by the time of appointment. The physics analysis activities of our group are currently focused on charmed baryon physics (E781).

Salary will be commensurate with experience. Please send a C.V. and the names of three references by email to yasar-onel@uiowa.edu or by post to:

Professor Yasar Onel, Department of Physics and Astronomy, 203 Van Allen Hall, University of Iowa, Iowa City, IA 52242.

The UI is an Equal Opportunity/Affirmative Action employer.

UNIVERSITY OF VICTORIA

DEPARTMENT OF PHYSICS AND ASTRONOMY
and
TRIUMF
BRITISH COLUMBIA, CANADA

R.M. PEARCE CHAIR

Applications are invited by the Department of Physics and Astronomy at the University of Victoria for the R.M. Pearce Chair. The position is funded jointly with TRIUMF, Canada's national laboratory for particle and nuclear physics.

We are seeking a physicist with an outstanding record of achievement in Experimental Subatomic Particle Physics who will actively participate and provide leadership and direction for the subatomic physics programme at Victoria and TRIUMF. The successful candidate will be eligible for tenure in one of the senior professorial ranks at the University, will have reduced teaching responsibilities and will be expected to supervise graduate students.

The Department of Physics and Astronomy consists of approximately 17 faculty members working primarily in the research areas of particle physics, astronomy/ astrophysics and ocean physics. In addition to a very successful and productive association with the near-by TRIUMF laboratory, the department's particle physics group has an ongoing participation in the OPAL and ATLAS experiments at CERN and the BaBar experiment at SLAC.

The University of Victoria is an equity employer and encourages applications from women, persons with disabilities, visible minorities, and aboriginal peoples. We strongly encourage all qualified persons to apply, regardless of citizenship or residence status. In accordance with Canadian immigration requirements, Canadian Citizens and permanent residents will be given first consideration.

Applications, including a curriculum vitae, publication list, statement of present and future research interests, and the names and addresses of at least three referees, should be sent to: **Charles Picciotto, Chair, Department of Physics and Astronomy, University of Victoria, P.O. Box 3055 Stn CSC, Victoria, BC V8W 3P6, Canada.**

For further information, contact Dr. Picciotto at pic@uvic.ca, FAX (250) 721-7715, Phone (250)721-7698. Our web page is www.phys.uvic.ca.

Applications will be accepted until the position is filled, and will be assured of full consideration if received by 31 May 2001.

Research Associate 5

Center for Advanced Microstructures and Devices (CAMD)

Louisiana State University

The J. Bennett Johnston, Sr. Center for Advanced Microstructures and Devices (CAMD) at Louisiana State University has an opening for a Research Associate 5 (Ring Manager).

The position requires a Ph.D. in Physics or Electrical Engineering, preferably with post-doctoral experience. Must have two years experience as an experimentalist in a field related to the design and operation of accelerator systems. Will be responsible for performing optics calculations, in a Unix environment, relating to the linac, transport line, and storage ring. Responsible for day to day operations of the accelerator facilities. This position will involve participation in operations, maintenance and development activities. Specific duties include monitoring and controlling the beam size, orbit position and stability. Will require some evening and weekend work.

The salary will be commensurate with qualifications and experience.

Application Deadline is until a candidate is selected. Submit letter of application, three references with telephone numbers, e-mail addresses and fax numbers along with a resume to: CAMD, Attn: Craig Stevens, Louisiana State University' Ref: #016819 ' RA- Accelerator' 6980 Jefferson Highway' Baton Rouge, LA 70806' E-mail address : evstev@lsu.edu' Phone number: 225/388-4603' Fax number: 225/388-6954

LSU is an equal opportunity/equal access employer

Please visit our web site for other job opportunity listings:
http://www.camd.lsu.edu

The University of Alabama

Research Associate Position in Neutrino Physics

We invite applications for a Postdoctoral Research Associate position to participate in the MiniBooNE neutrino oscillations experiment at FNAL (http//www-boone.fnal.gov/).

A Ph.D degree in physics is required and preference will be given to candidates with experience in experimental particle or nuclear physics. The appointment is initially for one year but may be extended for up to three years. The succesful candidate will be based full-time at FNAL.

The salary is competitive and commensurate with the candidate's experience and qualifications.

Applicants should submit a curriculum vitae, a list of publications, and arrange for at least three professional references to be sent to: Prof. Ion Stancu, Dept. of Physics & Astronomy, Box 870324, The University of Alabama, Tuscaloosa, AL 35487-0324. Inquiries and applications by e-mail should be sent to ion.stancu@ua.edu.

Applications should be received by March 31, 2001, to ensure full consideration, but the search will continue until the position is filled.

The University of Alabama is an equal opportunity/affirmative action employer.

European Graduate School Basel-Tübingen

The European Graduate School "Hadrons in Vacuum, in Nuclei and Stars", a joint organization of the Physics Department of the University of Basel and the Institute for Theoretical Physics and the Physics Institute of the University of Tübingen, is seeking candidates for

Graduate Fellowships in Experimental and Theoretical Hadron Physics

for its Tübingen branch, starting January 1, 2001.

Research of this Graduate School centers on hadron physics, both with elementary probes and with heavy ions, and on nuclear astrophysics.

Applicants should hold a Masters's or Diploma degree from a recognized university, preferably in nuclear or hadron physics. Accepted candidates will receive a stipend to pursue graduate work in collaboration and exchange with the Basel groups, leading to a doctoral degree in physics. The stipends range between about DM 2000 and DM 2300 per month (including supplements for spouses and children) and are taxfree. There are no tuition fees.

Applications, including a curriculum vitae, copies of academic records, information on previous research experience and letters of reference, should be mailed to Prof. A. Faessler, Universität Tübingen, Institut für Theoretische Physik, Auf der Morgenstelle 14, D-72076 Tübingen, Germany.
e-mail: Faessler@uni-tuebingen.de
home page: http://eurograd.physik.uni-tuebingen.de

Eberhard Karls
Universität
Tübingen

University of Wisconsin-Madison

Postdoctoral Position in Experimental Particle Physics

A University of Wisconsin-Madison research group on the BaBar experiment at SLAC seeks outstanding applicants for one or more positions of postdoctoral Research Associate. Applicants should have a Ph.D. in high energy physics with significant research experience in the area of analysis, preferably on a colliding beam experiment.

The successful candidate will be based at SLAC and participate in the measurement of the CP asymmetry in B decays.

Please send a full CV and three letters of recommendation to the following address (preferably by e-mail or by fax):

**Prof. Sau Lan Wu, CERN, PPE Division, Bldg. 32,
R-A05, CH-1217 Geneva 23
Switzerland**

**wu@wisconsin.cern.ch
Tel: (4122) 767-7171 Fax: (4122) 782-8395**

University of Wisconsin is an Affirmative Action/Equal Opportunity Employer.

POST-DOC POSITIONS FOR A NORDIC GRID TEST-BED

An inter-Nordic GRID test-bed facility is presently being planned that will provide infrastructure for inter-disciplinary feasibility studies of high throughput GRID-like computer structures and metacomputing. The project is divided into 6 Work Packages which are: 1.Test bed hardware, 2.Computer farm software, 3.GRID monitoring services, 4.GRID data management, 5.User applications and benchmark tests and 6.Dissemination of information on GRID.

Two post-doc positions are open for this project. The applicant should have experience of work with computers and programming in natural-science research. The two nominees are expected to take a key role in the execution of the Work Packages. In the first phase the aim will be to get the infrastructure of Work Packages 1-4 into an operational state. In addition to installing and maintaining already available software packages there will be need for software development, in particular for Work Packages 3 and 4. The posts are announced for 1+1 years, starting spring 2001, with the second year pending confirmation. A yearly grant, exempt from taxation, of about 250 000 DKK will be paid for each position. One post will be based at Lund University, covering the activities in Copenhagen, Lund, Oslo and Bergen, and the other at Uppsala University, covering the activities in Stockholm, Uppsala and Helsinki. The application should state which of the two posts it refers to and be accompanied by a CV, a list of publications and two letters of recommendation. It should be submitted in five copies before 25 February 2001 to: Lector John Renner Hansen, Dept of Experimental High Energy Physics, Niels Bohr Institute, Blegdamsvej 17, DK-2100 Copenhagen Ø (renner@nbi.dk, tel. +45 35325327, fax 45 35 325016). Further information can be obtained at **http://www.quark.lu.se/grid/** as well as from Docent Paula Eerola at Lund University (paula.eerola@quark.lu.se, tel. +46 46 2227695) and from Professor Tord Ekelöf at Uppsala University (Tord.Ekelof@tsl.uu.se, tel. +46 70 4250210).

UNIVERSITY OF HAWAII POSTDOCTORAL FELLOW POSITION

The experimental high energy physics group at the University of Hawaii invites outstanding applicants for a position of POSTDOCTORAL FELLOW. The successful candidate will participate in the Belle experiment at the KEKB asymmetric e+e collider at the KEK laboratory in Japan. The primary goals of the experiment are to investigate CP violation in the decays of B mesons and make precision tests of the standard model. The Hawaii Belle group participates in the analysis of Belle data, the operation of the sub 100ps resolution time-of-flight detection system, and the development of a second generation semiconductor vertex detection system.

Minimum Qualifications: PhD in experimental high energy physics is required; experience with modern electronics, semiconductor detectors and data analysis techniques is desirable. Stipend: in the range of $36,000-$52,000 depending on qualifications and experience.

To Apply: submit curriculum vita and arrange for three letters of recommendation to be sent to Prof. Hitoshi Yamamoto, c/o Ms. Janet Bruce, Department of Physics and Astronomy, University of Hawaii at Manoa, 2505 Correa Road, Honolulu, HI 96822. Closing Date: March 15, 2001. The University of Hawaii is an affirmative-action equal-opportunity employer.

The Niels Bohr Institute for Astronomy, Physics and Geophysics

University of Copenhagen

Faculty Renewal Program

Associate Professor in Theoretical Subatomic Physics

As part of its program of faculty renewal, the Niels Bohr Institute for Astronomy, Physics, and Geophysics (NBIfAFG) announces the availability of a position as associate professor in theoretical particle physics or theoretical nuclear physics. The position will be open from January 1, 2002. The NBIfAFG, which constitutes the physics department of the University of Copenhagen, with a faculty of 70, has a strong position in theoretical particle physics and nuclear physics with connections to astrophysics and to the physics of complex systems. An extensive guest program, run in close co-operation with NORDITA, supports these theoretical activities. The Institute has experimental programs, which include relativistic heavy-ion physics and participation in the ATLAS-project at CERN.

Applicants must have an independent research profile, which can support and complement the Institute's current activities in the above-mentioned theoretical areas. This position involves participation in all facets of university teaching, and the successful candidate must be able to teach undergraduate physics courses in Danish within two years of appointment.

In accordance with the Ministerial Circular on Job Structure, appointment to the position of associate professor requires documented scientific production at an international level. In the event that the applicant lacks sufficient teaching experience through an appointment as assistant professor or acquired corresponding teaching experience, the appointment will be probationary for a period of up to 1 year.

Terms of appointment and salary are set by agreement between the Ministry of Finance and AC (The Danish Confederation of Professional Associations on Academics in the State). In addition to salary based on seniority, the successful applicant will receive an annual pensionable supplement of DKK 65,951.63.

Applicants will be considered for appointment without regard to race, sex, national origin, or religion.

The deadline for applications is noon April 30, 2001. This announcement is an extract of the full legal announcement. The latter must be followed and can be found on the Institute homepage: http://ntserv.fys.ku.dk/afg/ or obtained from the Personnel Office (Phone +45 3532 2645)

EXPERIMENTAL PARTICLE or ACCELERATOR PHYSICS Argonne National Laboratory

The High Energy Physics Division of Argonne National Laboratory invites resumes for two or more postdoctoral positions. One position is in accelerator physics and involves research in advanced acceleration methods for future generations of accelerators - Accelerator Research at Argonne emphasizes the dielectric wakefield accelerator technique, which Argonne pioneered, and related applications of the unique high-charge electron gun developed at Argonne. The position requires a fundamental understanding of classical electrodynamics, wakefield calculations and electron beam optics. Familiarity with electron beam diagnostics and beam line instrumentation is a plus. Interested candidates should have obtained a Ph.D. degree in a related physics field.

The second position is with the CDF (Collider Detector at Fermilab) Group. The CDF experiment has been extensively upgraded in order to take advantage of the high luminosities expected at the Fermilab Tevatron Collider. The experiment will study a broad range of topics, including heavy quark production, top and B physics, exotic searches, electroweak physics including the Higgs search, and QCD studies. The Argonne group has been responsible for building and maintaining the central electromagnetic calorimeter system. The group has been heavily involved in a variety of analysis projects, including B physics, the W mass, the Higgs search, and QCD prompt photon production. The primary responsibility of this position will be analysis of the CDF data, both physics results and associated calibration topics.

For both positions, well-qualified candidates will also be considered for higher level appointments.

Postdoctoral appointments are one-year appointments with the possibility of renewal for up to three years. For consideration, please send a detailed resume, publication list, and the names/addresses of three references to: **Susan Walker, Box HEP-300887-60 Employment and Placement, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439. Fax: 630-252-9388. TDD: 630-252-7722.**

Argonne is an Equal Opportunity/Affirmative Action Employer.

Research Associate Positions Elementary Particles Experiment Princeton University

The Elementary Particles group at Princeton University anticipates one or more postdoctoral research associate openings in the coming months. The group is active in the following areas: B Physics at BaBar and Belle, Collider Physics at CMS, Muon Collider R&D, and Neutrino Physics at MiniBooNE. The CMS group is particularly interested in applicants who wish to participate in the development of the calorimeter trigger hardware and software. Interested persons should send an application to:

Prof. Daniel Marlow, Physics Dept.
P.O. Box 708, Princeton University,
Princeton NJ 08544

The application should include a curriculum vitae, a statement or research interests and the names of three referees. Applicants should arrange to have referees' letters sent directly to the address above. Review of the applications will begin **March 30, 2001** and will continue until the position(s) are filled.

Princeton University is an Affirmative Action/Equal Opportunity Employer

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• Software Developers • Technical Editors
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• Subatomic, Nuclear, Particle, Astro, High, Medium and Low Energy Physicists.

For further information and professional recruitment advice contact

Andrew Hardie
Tel: +44 (0)117 930 1090
Fax: +44 (0)117 930 1178
E-mail: andrew.hardie@iop.org

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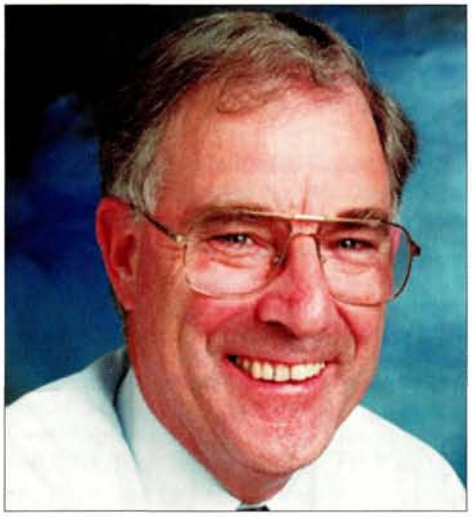
PEOPLE

APPOINTMENTS & AWARDS



Alan Shotter – the next director of TRIUMF.

Sidney Drell of the Stanford Linear Accelerator Center is one of the three recipients of the prestigious Enrico Fermi Award, administered by the US Department of Energy for the White House. The award recognizes "his contributions to arms control and national security and to particle physics".

Drell served as SLAC's deputy director until 1998 and has since been a senior fellow at the Hoover Institution. He has been an advisor to the federal government on national security and defence technical issues, and he is a founding member of the high-level JASON US national advisory group.

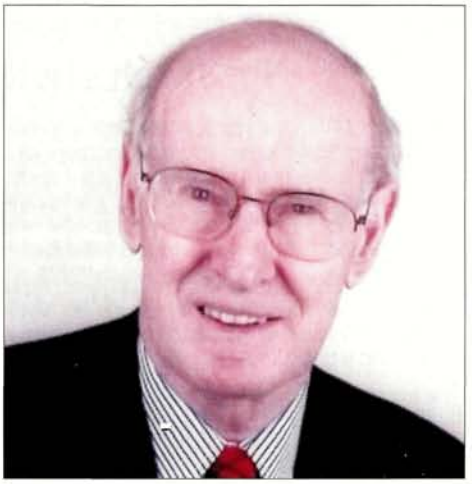
The other two recipients of the award are **Sheldon Datz** of Oak Ridge and **Herbert York** of the University of California's Institute on Global Conflict and Cooperation.

TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics, has announced that its next director, following Alan Astbury's retirement in September, will be **Alan Shotter**, professor of experimental physics at Edinburgh and former head of the Department of Physics and Astronomy there.

Shotter has played a pioneering role in the use of radioactive ion beams for nuclear physics and astrophysics in Europe, and he will be leading the Canadian effort to exploit the new ISAC facility, which began operating at TRIUMF in late 1998 (June 2000 p5).

CERN physicist **Luigi "Gigi" Rolandi** has been nominated chairman of DESY's Physics Research Committee for a period of two years.

The Henryk Niewodniczanski Institute of Nuclear Physics in Cracow has bestowed the title of honorary professor on **Douglas Morrison** from CERN "in recognition of his outstanding achievements in experimental particle physics, his versatile and deep analysis of the most important problems of modern physics and other disciplines, and his major contribution to the development of the scientific collaboration between CERN and Polish research centres, in particular, the Institute of Nuclear Physics in Cracow".



Douglas Morrison –10pm meetings.

At the ceremony on 16 October, Tomir Coghen, who worked with Morrison for many years, recalled a publication list contains more than 120 papers published with Cracow co-authors. The mention of 10.00 pm group meetings surprised many young attendees.

ICTP Trieste Dirac medallists get together

Dirac medallists at the Abdus Salam International Centre for Theoretical Physics, Trieste. Left to right: Ludwig Fadeev, St Petersburg (1990 award); David Olive, Swansea (1997); Roman Jackiw, MIT (1998); seated, Bryce DeWitt, Austin (1987); Mike Green, Cambridge (1989); John Schwarz, Caltech (1989); Helen Quinn, SLAC (2000); Sergio Ferrara, CERN (1993); Peter van Nieuwenhuizen, Stony Brook (1993); seated, Jogesh Pati, Maryland (2000); Daniel Freedman, MIT (1993); seated, Giorgio Parisi, Rome (1999), ICTP director Miguel Virasoro. (Massimosilvano.)

The end of last year marked the 15th anniversary of the institution of the award of the Dirac Medal of the Abdus Salam International Centre for Theoretical Physics. During its short life, the Dirac Medal has become an extremely prestigious award and has it has managed to generate an impressive list of recipients.

Many of the medal winners attended the special anniversary meeting in Trieste and signed a statement of support, which read:

"On the occasion of the celebration marking the 15th anniversary of the Dirac Medal, during which the Abdus Salam ICTP has renewed its fruitful collaboration with the distinguished scientists awardees of the Dirac Medal, a Support Group of Dirac Medallists was constituted to sustain ICTP's mission to promote basic sciences in the developing countries and north-south collaboration.

In particular, the group members will:
1) provide advice when requested to the ICTP, help to increase the visibility of its activities, act as goodwill ambassadors and make a special effort to participate in programmes such as the Visiting Scholar programme;
2) propose nominations for the Dirac Medal Award reinforcing the well-established tradition of high scientific excellence and innovative impact."

The Pomeranchuk Prize, established by Moscow's Institute of Theoretical and Experimental Physics, has been awarded to **James Bjorken** of SLAC (right) and **Evgenii Feinberg** of Moscow's Lebedev Institute on 27 November (September 2000 p36).

Portugal is often used as an example of the rapid and successful growth of scientific vitality which can follow from membership of CERN. Over the past 15 years, the CERN–Portugal Committee has played an important role in this work. Minister of Science and Technology **Jose Gago**, a physicist himself (front row, centre), joined some former and present members of that committee at CERN on the occasion of the retirement of one of them, **Peter Sonderegger** (front row, far right).

UK honours to CERN

Former CERN director-general Chris Llewellyn Smith receives knighthood.

In the traditional UK New Year's Honour List, former CERN director-general Chris Llewellyn Smith receives a knighthood and henceforth becomes "Sir Chris". LHC project director Lyn Evans received a CBE "for services to accelerator physics" and Erwin Gabathuler of Liverpool and former CERN research director receives an OBE "for services to physics".

A special colloquium at Berlin's Humboldt University on 15 December marked the 70th birthday of distinguished CERN physicist **Klaus Winter**, who has made notable contributions to physics, both at CERN and in Germany. Konrad Kleinknecht of Mainz spoke on these scientific achievements. Other speakers included Jerome Friedman of MIT and Hans Blümer of Karlsruhe.

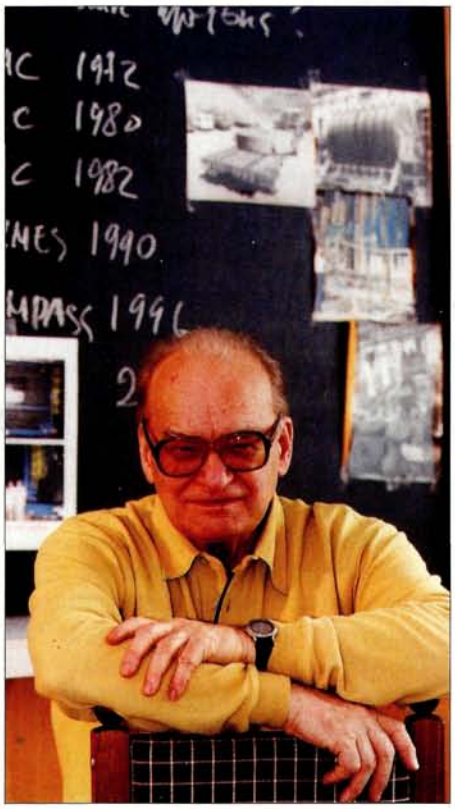
CERN elections and appointments

At the December meeting of CERN's governing Council, Maurice Bourquin of Geneva was elected president of Council for one year from January. Ryszard Sosnowski of Warsaw was elected vice-president for the same period. Birgitte Sode-Mogensen of Denmark was appointed chairperson of the finance committee for one year, with Janet Seed from the UK as vice-chairperson.

Within CERN, Jan van der Boon was nominated director of administration, and Vincent Hatton becomes leader of the laboratory's Human Resources Division, both for a period of three years.

Maurice Bourquin – CERN Council chairman.

Savin celebrates 70th birthday



Igor Savin at 70.

The 70th birthday of Igor Savin, outstanding Russian experimentalist and honorary director of the Particle Physics Laboratory of the Joint Institute for Nuclear Research at Dubna, near Moscow, was on 7 December.

In the 1950s and early 1960s, Savin took part in pioneer research in measuring total cross-sections of pion and kaon interactions, and inelastic pion scattering, conducted at the JINR Synchrophasotron at 10 GeV.

Later, at CERN's Proton Synchrotron, he studied the properties of neutral kaons, and in the following years he carried out one of the first experiments to study neutral kaon regeneration at the Serpukhov accelerator – at the time the world's largest accelerator.

He played a leading role in the major NA4 experiment collaboration using the SPS muon beam for a detailed study of nucleon quark structure, and he continued these studies in the SMC (CERN) and HERMES (DESY) projects. Currently he leads a large JINR group in the COMPASS project at CERN.

MEETINGS

HEP2001

The **European Physical Society's International Europhysics Conference on High Energy Physics** (HEP2001) will take place on 12-18 July in Budapest (see "http://www.hep2001.elte.hu"). Participation is normally restricted to those nominated by their national contact persons, but nominations can also be made via the Web site. The conference will follow the traditional pattern of three days of parallel talks, followed by an excursion day (15 July) and three days of plenary presentations. It will include the plenary meeting of the European Committee for Future Accelerators (ECFA) to allow young physicists to learn first hand about future projects for European high-energy physics.

At the meeting the 2001 High Energy Particle Physics Prize of the European Physical Society will be bestowed, as will three new awards: the Prize for Young Particle Physicists, the Gribov Medal honouring a young theorist and the Outreach Prize for the best popular explanation of particle physics discoveries.

The Young Physicist Prize is intended for outstanding work by one or more (up to three) young physicists (less than 35 years of age) in the field of particle physics and/or particle astrophysics. The prize, to be given every two years at the EPS-HEP conference, will consist of a diploma specifying the contribution of the recipient of the prize, and 2000 Swiss francs in cash. Nominations for this year's award should be sent to the chairman of the EPS High Energy Particle Physics Board ("Giora.Mikenberg@cern.ch") before 15 March.

The Gribov Medal is intended for outstanding work by a young physicist (less than 35 years of age) in theoretical particle physics and/or field theory. The medal, to be given every two years at the EPS-HEP conference, will consist of the Gribov Medal and a diploma specifying the contribution of the recipient of the prize. Nominations for this year's award should be send to the chairman of the EPS HEPP-Board ("Giora.Mikenberg@cern.ch") before 15 March.

The Outreach Prize is intended for outstanding outreach achievement connected with high-energy physics and/or particle astrophysics. The prize can be given to a scientist or to a non-scientist. It is to be given every year, alternating between the EPS-HEPP conference and the general EPS conference. and consist of a diploma specifying the work of the recipients, as well as 2000 Swiss francs in cash. Nominations for this year's award should be send to the secretary of the HEPP-Board, Michel Spiro ("Michel.Spiro@cern.ch") before 15 March.

Left to right, UK Ambassador to Switzerland Christopher Hulse, CERN director-general Luciano Maiani, chief executive of British Trade International Sir David Wright and CERN director Roger Cashmore at the opening of the Britain at CERN exhibition in November 2000. The UK is a major service provider for CERN.

TESLA meeting to take place at DESY

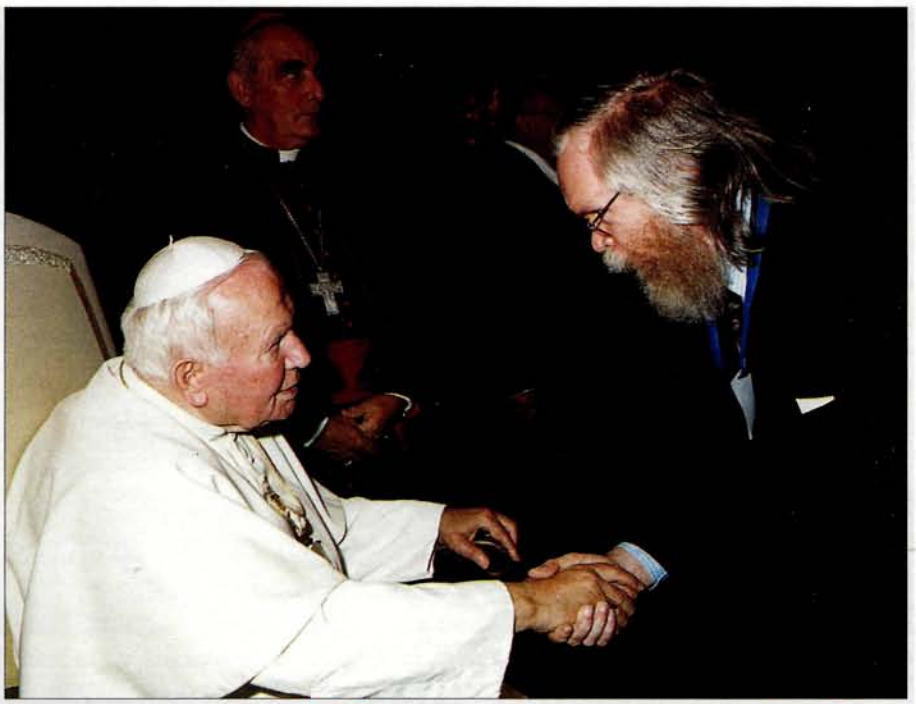
A **Colloquium on the Scientific Perspectives and Realisation of TESLA**, the superconducting 500-800 GeV Electron-Positron Linear Collider with an X-Ray Free Electron Laser Laboratory, will be held on 23–24 March at DESY, Hamburg.

The institutes that have contributed to an international effort to the Technical Design Report will present the prospects of TESLA for particle physics and science with X-ray free electron lasers as well as its technical realization.

On Friday 23 March the programme will start with plenary talks on the status and perspectives of particle physics and of research with photons, followed by presentations of the technical aspects of TESLA.

On Saturday morning the multiple aspects of the X-Ray FEL and TESLA's potential for particle physics will be presented.

Further information is available at "http://www.desy.de/tesla_colloquium".



Distinguished CERN theorist **John Ellis** was one of the scientists presented to **Pope John Paul II** during the recent Physics for the 21st Century conference held at Rome's Tor Vergata University. The conference reviewed highly significant recent results from various fields of physics, and it identified ongoing trends and developments.

Call for proposals to INFN–LNL

The Laboratori Nazionali di Legnaro (LNL) of Istituto Nazionale di Fisica Nucleare (INFN), Italy, has been recognized by the European Commission as a major Research Infrastructure for the period 1 November 2000 to 31 October 2003 (Contract. HPRI-1999-CT-00083). The contract offers the opportunity for European research groups performing experiments at LNL facilities to have their subsistence and travel expenses refunded. Eligible research teams include groups from all European countries and the associated states.

Further information and application forms can be obtained from INFN-LNL Laboratori Nazionali di Legnaro, Via Romea, 4- 35020 Legnaro (Padova) Italy (tel. +39 049 8068. 442, fax +39 049 8068 514, e-mail "lsf_secr @lnl.infn.it", "http://www.lnl.infn.it/~lsf_ secr/LSF_home.html", secretariat e-mail "lsf_secr@lnl.infn.it").

More than 100 000 visitors, many of whom were school pupils, came to DESY's 1000 square-metre Light for the New Millennium multimedia exhibition, which ran from 1 June to 31 October last year.. The central theme of the exhibition was the superconducting X-ray laser being built at the laboratory (July 2000 p26).

Louis Leprince-Ringuet 1901–2000

Renowned French physicist, author, artist, sportsman and personality, Louis Leprince-Ringuet died on 23 December 2000. He would have had his 100th birthday on 27 March this year. A tribute will appear in the next issue.

His work strongly influenced the course of subnuclear physics in France and the rest of the world. As vice-chairman of CERN's Scientific Policy Committee from its inception in 1954, and from 1964–1966 as its chairman, he played an important role in shaping CERN. He is seen (right) in 1961 with CERN director-general John Adams.

Louis Leprince-Ringuet (right) 1901–2000

Shuji Orito 1941–2000

Shuji Orito, who was an extremely energetic and outstanding physicist in the international high-energy physics arena, passed away on 14 November at the age of 59.

Orito was a leading figure in electron–positron collider physics, but his quest for a deeper understanding of the universe also led him to a successful venture in particle astrophysics.

After studying physics at Waseda University in Tokyo, he became a graduate student of Masatoshi Koshiba at Tokyo, where he received his doctorate in 1969. His long association with Europe began in 1971, when he came to CERN to work with Carlo Rubbia.

With his early recognition that high-energy electron–positron collisions are of fundamental importance, he joined the pioneering experiment at Frascati's ADONE collider. Here he devised a powerful method for searching for heavy leptons, but unfortunately ADONE just did not have enough energy to produce them, and they were eventually discovered two years later at SLAC by Martin Perl. Orito also pioneered the study of two-photon collisions – now routine physics at electron–positron colliders. In 1973 he moved to the German Max Planck Institute and joined the DASP experiment at DESY's DORIS collider, where he discovered a new charmonium state.

Shuji Orito 1941–2000.

After returning to Tokyo as a faculty member in 1975, he continued to work at European electron–positron colliders. He was a founding member of the JADE collaboration at PETRA at DESY and of the OPAL collaboration at LEP at CERN. He contributed to the success of these experiments both in the important physics analyses and in the actual detectors. It is impressive to see how reliably his electromagnetic calorimeters of thousands of lead-glass counters operated.

At the 1979 Lepton–Photon Conference in Fermilab, Orito was one of the four physicists who announced the discovery of gluons. He also played a leading role in vital electroweak measurements leading to the determination of the number of neutrino types and the prediction of the top quark mass.

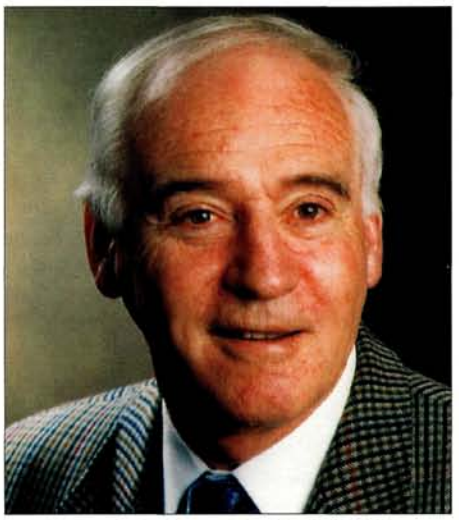
Back in Japan, he led the Japanese community in a revolutionary proposal for the JLC-I electron–positron linear collider in 1992. Starting at an energy as low as 300 Gev and with high-precision detectors, it covered all of the essential issues for a linear collider project. With the community's great expectations for this project, he was elected ▷

Lochlainn O'Raifeartaigh 1933–2000

Prominent Irish field theorist Lochlainn O'Raifeartaigh died on 18 November aged 67. From 1960 to his death he was a professor at the School of Theoretical Physics in the Dublin Institute for Advanced Studies (DIAS).

Born and educated in Dublin, as a student he attended lectures by Erwin Schrödinger, the first director of the DIAS School of Theoretical Physics. When Schrödinger returned to Vienna in 1956, O'Raifeartaigh worked with John L Synge on relativity. He entered DIAS in 1956 and a year later was awarded a studentship to study under Walter Heitler at Zurich, where he was awarded his doctorate in 1960. He returned to DIAS in 1961 as assistant professor and was elected to the Royal Irish Academy at the age of 29, and later to the Academia Europaea.

He specialized in the application of group theory to physics, and this research on the symmetries of physical theories attracted much attention worldwide. He spent the winter of 1963/4 at the Madras Institute for Mathematical Sciences, and in the autumn of 1964 he went on extended leave to Syracuse, New York, where he discovered what became known as the O'Raifeartaigh Theorem, which shows the impossibility of combining relativistic symmetry with other symmetries in a non-trivial way.



Lochlainn O'Raifeartaigh 1933–2000.

Despite the fame that this brought, he chose to return to DIAS in 1968 as a senior professor, after spending one year at the Institute for Advanced Study at Princeton. He attracted a succession of postdoctoral students from around the world and made significant contributions to new theoretical developments. One such major advance was what became known as the O'Raifeartaigh mechanism for the spontaneous breaking of supersymmetry. In the early 1980s he made a fundamental contribution to the theory of monopoles in gauge theories.

O'Raifeartaigh's work on gauge theories was consolidated in his book entitled *Group Structure of Gauge Theories* (1991, Cambridge University Press). Recently he had been applying the expertise that he had gained from his work on two-dimensional conformal field theories to string theories. ▷

chairman of the Japanese High Energy Physics committee in 1999.

Orito's talents as an experimenter were also demonstrated in his recent balloon-borne experiment, BESS. He designed and flew a 1 tesla superconducting spectrometer to an altitude of 36 km to measure primary antiprotons, which could provide important information on the early universe. With more than a thousand antiprotons precisely measured, he was awarded the prestigious Nishina prize just two weeks after his death.

His originality was most recently evident in the design of a newly approved experiment at the Swiss PSI Laboratory to search for evidence of supersymmetry by looking for muon decays that violate conventional conservation rules.

A leading figure in the electron–positron collider world who had a clear vision of the future direction of high-energy physics, Shuji Orito had remarkable energy and enthusiasm to pursue important scientific issues. We lost him at the dawn of a new century and a new physics era, when his talents would have been absolutely vital.

Ramón Marimón (right), Secretary of State of Spain's Ministry of Science and Technology, greets CERN director-general **Luciano Maiani** at CERN on 26 October.

He received much international recognition, including the von Humbolt Research Award in 1998 and the prestigious Wigner Medal in August 2000 for his "pioneering contributions to particle physics'.

However, O'Raifeartaigh is also remembered by his colleagues for his humility, patience, kindness and humour. He was fluent in Irish, French and German, an enthusiastic theatre-goer and a keen hillwalker. He put his interest in international politics to good use in the cause of nuclear disarmament; and, along with the Irish Nobel Laureate Ernest Walton, he helped Michael Fry to found the Irish Pugwash group, bringing together physicists and experts on international affairs. His book *The Dawning of Gauge Theory* (Princeton University Press, 1997) also showed him to be an accomplished science historian.

Just a month before his death he was one of the key participants at the symposium celebrating 30 years of supersymmetry, which was held at Minnesota.

CERN director-general **Luciano Maiani** (right) and **Richard Nickerson** discuss work at Oxford on precision tracking for the ATLAS detector for CERN's LHC collider.

BOOKSHELF

BOOK OF THE MONTH

Against the Donning of the Gown by Galileo Galilei in 1590, translated into English by Giovanni Bignami, Moon Books Limited 2000, Information and orders via http://www.galileounaluna.com/

It is with pity and anguish that I see
Students and seekers of the Greatest Good
Fail yet again to strike where it may be

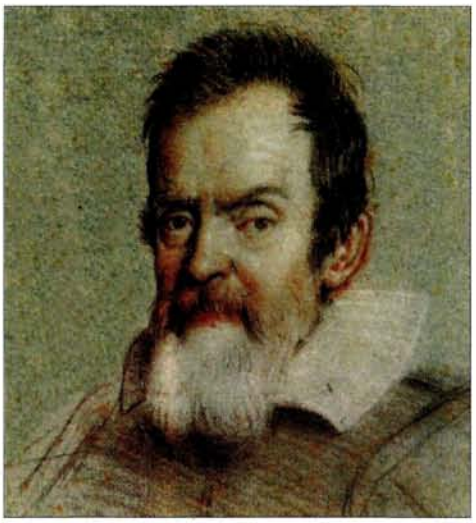
So begins an epic verse penned in 1590 in Pisa, not by poet Francesco Berni, who defined the rhythmic style of the poem, nor by Pisa's Cardinal Antonio Pozzi, but by his contemporary, Galileo Galilei. To those familiar only with Galileo's scientific work, the fact that he also composed poetry might come as something of a revelation. That he should begin by talking of the greatest good even more so. Yet the subject-matter of this work was close to the young scientist's heart, as soon becomes apparent in Giovanni Bignami's wonderful English translation.

Bignami, head of science at the Italian Space Agency, is a master of modern English. With this work he has gone one step further by translating the poem into the English of Shakespeare, and Berni's rhythmic form into iambic pentameter. Moreover, as Bignami himself points out, the challenge of translating poetry from a language with 7 vowel sounds to one with 52 was daunting in its own right. But Bignami has succeeded spectacularly. The translation reads with fluid clarity, and the humour is as intact as can be expected after its journey through time and language.

It is a few pages in that we begin to learn what stirred Galileo to put pen to paper:

I now conclude, and turn to you, signor,
And force you to confess, against your will,
The Greatest Good will be all clothes to abhor

As a young lecturer in Pisa, Galileo railed against a system in which he was obliged to wear his academic gown at all times, on pain of heavy fines, and this poem is his response. His technique is to take the very idea of wearing – or rather not wearing – clothes to its logical conclusion and to propose, tongue firmly planted in cheek, that we do as the beasts do and go naked.



Galileo Galilei – scientist and poet.

Hilarious and profoundly irreverent consequences rapidly ensue as Galileo examines, for example, the potential repercussions for matchmaking and marriage.

Moon Books of Milan has given the translation a fitting treatment by producing a volume using the materials and techniques of the time. It is rare to find a book of such beauty as the company's calf-bound limited edition printed on hand-made paper and lavishly illustrated with original drawings by Donata Almici. It is even rarer to find such a treat in store on opening the cover, and it would be a great shame if Prof. Bignami's efforts, and indeed those of Galileo, were limited to the 2000 copies produced by Moon Books. Prof. Bignami is seeking a mainstream publisher to produce a more affordable edition. Here's hoping that he succeeds.

James Gillies /CERN

A Alikhanian: Essays, Recollections, Documents (mainly in Russian) edited by G Merzon, Moscow, 335pp, pbk.

This book surveys the career of Armenian physicist academician Artem Alikhanian (1908–1978, see http://www.yerphi.am/found/found0.htm), including his initial work at the Leningrad Physical and Technical Institute; the first expedition to Mount Aragats in Armenia to establish a centre for cosmic-ray studies; the foundation of the Yerevan Physics Institute and the years of his directorship (1943–1973); the construction of one of the world's largest electron ring accelerators at the time, the 6 GeV Yerevan machine; his pioneering use of X-ray transition radiation as an important tool in particle detection; and the application of crystals for the formation of polarized beams of electrons and photons. Despite this illustrious history, the institute is unfortunately suffering serious difficulties owing to inadequate funding and the uncertainty of its civic status.

Contributors to the book are close friends, colleagues and former colleagues of Alikhanian, including A Amatuni, L Artsimovich, T Asatiani, M Daion, B Dolgoshein, V Dzhelepov, V Goldansky, A Migdal, L Okun, W Panofsky and R Wilson.

Alikhanian's notable scientific achievements, his versatile intellect and wide culture brought him recognition among the international physics community. In their reminiscences, Panofsky and Wilson wrote: "We wish he was still with us during this time when Armenians, Russians, Americans and other people of the world are collaborating in many activities in high energy physics."

The publication was supported in part by the Lebedev Institute of Physics, Moscow, Russia; the Open Society Institute Assistance Foundation, Armenia; and the Yerevan Physics Institute.

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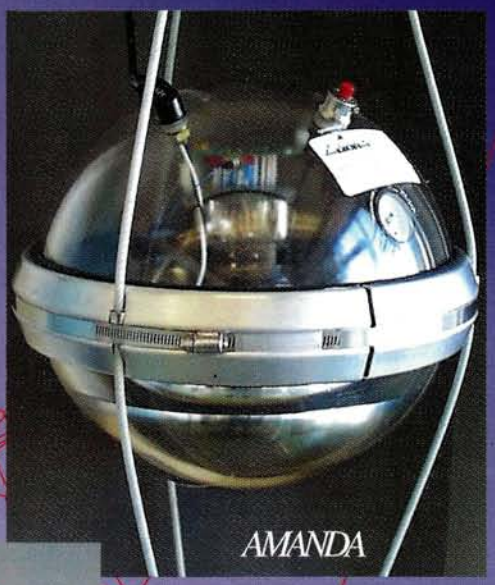
Books received

Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics selected and edited by StanleyJeffers, Bo Lehnert, Nils Abramson and Lev Chebotarev, Apeiron, ISBN 0 9683689 5 6.

This is a *festschrift* for the 80th birthday of a physicist whose non-conformist political and scientific views have made his long life a continual uphill struggle. Vigier's close collaborators have included Louis de Broglie and David Bohm. The book is a collection of Vigier's papers with a short biographical introduction by Jeffers and a scientific overview by Chebotarev.



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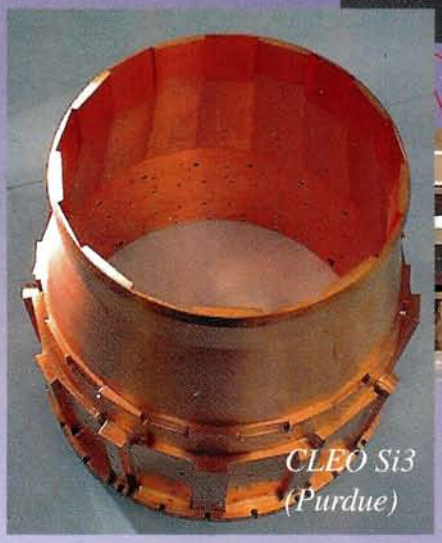

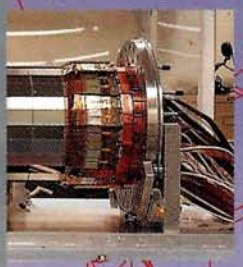

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