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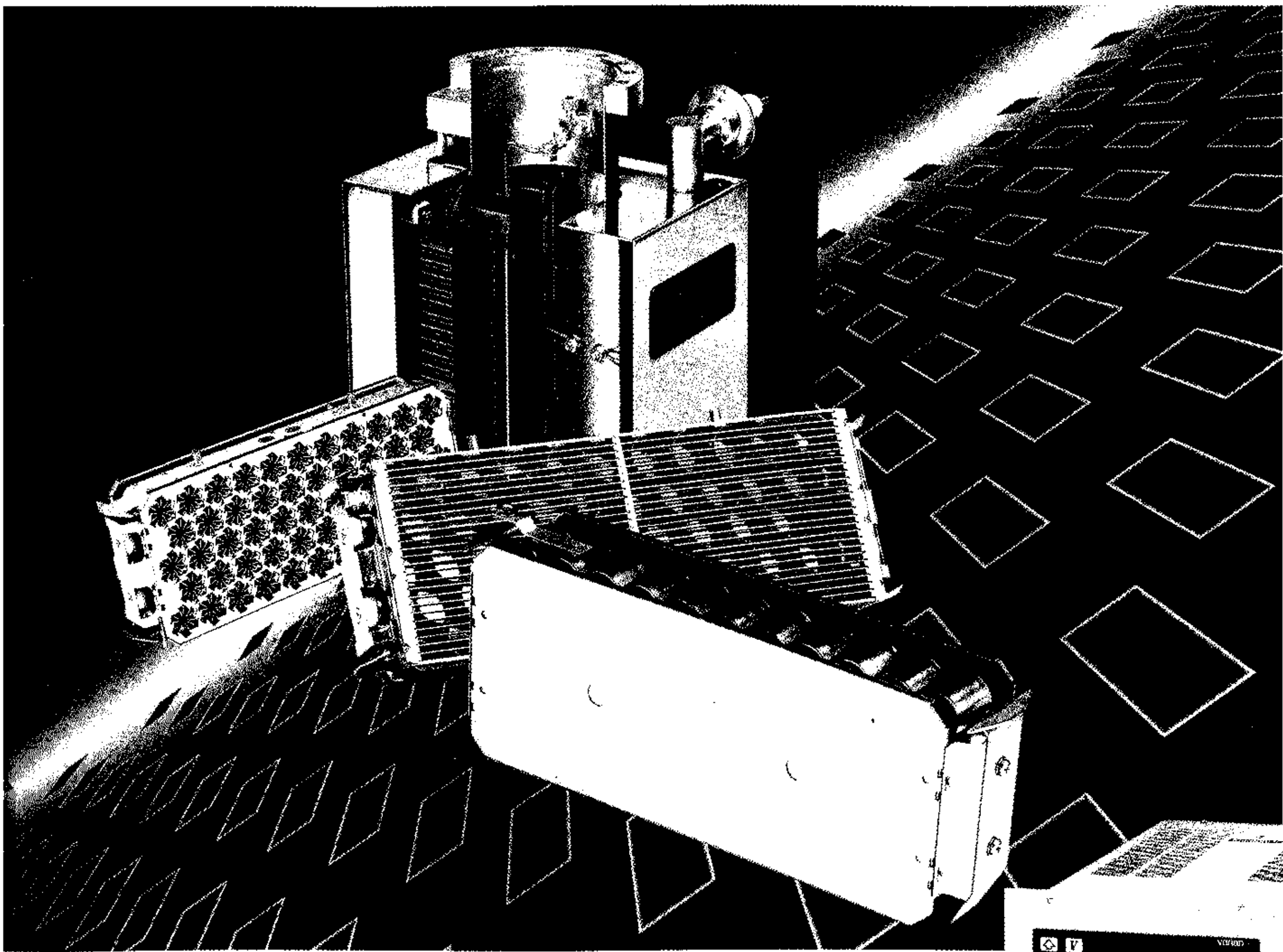

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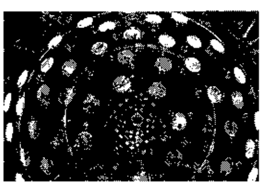

Cover photograph: Infrastructure of the new neutrino experiment at a recently commissioned nuclear power station near the village of Chooz (pronounced 'Shau') in the Ardennes region of France. Its results have been awaited with great interest by physicists trying to explain the apparent deficit of muon neutrinos produced by cosmic ray interactions in the atmosphere (see page 5).

US contributions to the LHC

In a significant international agreement, signed in the 'Indian Treaty Room' of the Old Executive Office Building in Washington, DC, on 8 December, US scientists will contribute a total of $531 million towards the 27-kilometre Large Hadron Collider (LHC) now under construction and its physics experiments. Subsequent protocols were signed at the CERN Council meeting on 19 December.

This is the first time that the US will contribute significantly to an accelerator to be built outside the US, and it is the first agreement between CERN and the US government. About 25 percent of the US experimental high energy physics community are expected to do research at the LHC.

The agreement also underlines the global nature of the physics research at CERN, with the US now joining a participation which includes Japan, Russia and Commonwealth of Independent States, Canada, China, India and Israel as well as CERN's 19 European Member States.

Signing the new agreement in Washington were US Secretary of Energy Federico Peña, US National Science Foundation Director Neal Lane, CERN Director General Chris Llewellyn Smith and President of CERN Council Luciano Maiani. (Shortly afterwards, at the meeting of CERN's governing body, Council, distinguished theorist Maiani, who is also the President of the Italian INFN, was elected CERN's next Director General, to take office on 1 January 1999 - see page 28.)

Under the agreement, the United States will provide goods and services for the LHC, scheduled to come into operation in 2005. Specifically, the Department of Energy will provide components and materials costed at $200 million for use in the accelerator. Three of the department's national laboratories, Brookhaven, Berkeley and Fermilab, will use $110 million to design and produce systems for the accelerator's interaction regions where the detectors are located. The remaining $90 million will be used for procurements from US industrial firms, including niobium and niobium-titanium for European production of superconducting cable, and for some of the superconducting cable supply.

The United States will also provide an in-kind contribution of components costed at $331 million to the massive ATLAS and CMS detectors, with $250 million from the Department of Energy and $81 million from the National Science Foundation. More than 550 US scientists from nearly 60 universities and six national laboratories in 25 states are collaborating on designing and fabricating these components. Some 15 percent of the physicists working on the large LHC experiments are from the US.

Further protocols were signed by Martha Krebs, Director of the Office of Energy Research, US Department of Energy, Bob Eisenstein, Assistant Director of Mathematical and Physical Science of the US National Science Foundation, and CERN Director General Chris Llewellyn Smith during the meetings of CERN's governing body, Council, at CERN at the end of December, when the US joined the growing ranks of CERN Observer States.

Under a major agreement signed in the historic Indian Treaty Room of the Old Executive Office Building in Washington, DC, on 8 December, US scientists will contribute a total of $531 million towards the 27-kilometre Large Hadron Collider (LHC) now under construction at CERN and its physics experiments. Signing the new agreement were (left to right) US National Science Foundation Director Neal Lane, US Secretary of Energy Federico Peña, President of CERN Council Luciano Maiani, and CERN Director General Chris Llewellyn Smith.

LHC preparations gather momentum

Since approval by CERN Council in December 1994, LHC preparations have pushed ahead steadily, and some 800 million Swiss francs of contracts, in line with budget estimates, are signed or in the process of being signed. The total cost of the LHC is 2488 million (1997 prices).

1998 marks a special LHC milestone following the award of three major civil engineering projects worth together 269 million Swiss francs and the commencement of large-scale civil engineering.

This includes 102 million of work for

the accelerator itself, covering some 5 kilometres of transfer tunnels to take particles from the existing SPS ring to the LHC, and modifications to the existing 27-kilometre tunnel, currently housing the LEP electron-positron collider. LEP will continue to operate until the year 2000 before being removed to make way for the new LHC ring.

The other 167 million Swiss francs are for the huge underground caverns to house the experiments. In December, Geneva's 'Grand Conseil' gave the go-ahead for construction of one of the major areas, opposite the Meyrin site. The other, sited in France, should be approved later this year.

The LHC will contain some 8000 superconducting magnets, including 1232 dipoles to steer the beams. Magnet development has been underway for some time en route to perfecting the final design to ensure the 8.4 Tesla design field using superfluid helium at 1.9K. The first 15-metre dipole, assembled in industry under an agreement between CERN and the Italian INFN, arrived in December to undergo stringent measurements.

The magnet string test, using three 10-metre dipoles, has now clocked 9000 hours at 1.9K and forced ramping has simulated ten years of realistic operation. It will soon be dismantled and the magnets replaced with a more current design.

As well as the magnets, the cryogenic system to cool the 40,000 tons of material to 1.9K is also being developed, based on the existing four LEP cryoplants, which will be upgraded and supplemented by four additional plants. The prototype centrifugal cryogenic compressor from IHI (Japan) was delivered late last year.

On the vacuum front, a prototype beam screen (cover photo, September 1997) to reduce the effects of synchrotron radiation has been installed in the string test. This year, a desorption experiment, developed with the Dutch NIKHEF laboratory, to study the 'pollution' of high vacuum will be installed in the EPA ring used to store low energy electrons and positrons at the beginning of the LEP particle production line. Other desorption studies have been carried out at Novosibirsk.

The pace of expenditure and financial commitment across the board for the LHC machine is now increasing, with some 130 million Swiss francs already spent and another 100 million foreseen for this year.

Special contributions

As well as the new US contributions described above, several other special agreements have been drawn up to aid LHC construction.

Canada, through the TRIUMF Laboratory in Vancouver, is supplying Canadian $30 million over five years, primarily to help upgrade CERN's Booster and PS synchrotrons to handle their new role in the LHC injection chain.

Japan is supplying a total of over 9 billion yen (100 million Swiss francs). 40% of this is earmarked for quadrupoles (to squeeze the colliding beams) to be procured via Japan's KEK Laboratory, while a substantial portion of the remainder is expected to be used for superconducting cable for the various LHC magnets.

India is contributing a net $12.5 million for liquid nitrogen tanks, corrector magnets and other services, including support for Indian scientists working on the LHC and its experiments.

Agreements with Russia with a net value of 66 million Swiss francs include transfer line magnets supplied by Novosibirsk, and gas desorption studies carried out at the Siberian laboratory, and a variety of special equipment from the Protvino Institute near Moscow. In addition, the international Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, is supplying an LHC transverse damping system worth several million Swiss francs.

In addition, the CERN 'Host States' - France and Switzerland - are supplying 64.5 and 25 million Swiss Francs respectively in kind, and in addition are according additional indexation beyond that of other contributions. The French contribution in kind covers superconducting quadrupole magnet development and high technology supplied locally. The Swiss contribution involves one of the transfer tunnels to feed the LHC.

Progress for the major LHC experiments, where expenditure is accelerating in the same way as for the machine itself, will be covered in a subsequent issue.

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Technology transfer

At a two-day meeting 'Basic Science and Technology Transfer - means and methods in the CERN environment'. Left to right, Portuguese Minister of Science and Technology José Mariano Gago, a former high energy physicist and longtime CERN user, and CERN's new Technology Transfer Coordinator François Bourgeois.

It is not the mission of publicly funded basic science to benefit industrial shareholders directly. Instead, basic science is culture, extending our knowledge and understanding of the world around us. However this new understanding inevitably opens up whole new technologies - electrical engineering, electronics and communications technology are the legacy of the careful investigation of electromagnetism by 19th century scientists. In this picture, science drives the long term development of technology in a way which is difficult to plan or even foresee in the short term.

However there is another side to the coin. There are many examples of spinoff technological development from science which almost immediately open the door to new applications areas. Röntgen's 1895 discovery of X-rays was made in the context of research into the atomic structure of matter, but within the space of a few years, before even its scientific implications had been digested, X-rays went on to revolutionize medical diagnosis.

Experiments at the cutting edge of science frequently require new conditions which challenge current technology. Satisfying these demands can lead to important spinoff benefits. At CERN, the decision in the mid-1960s to construct the Intersecting Storage Rings (ISR) led to a requirement for new techniques to provide the ultra-high vacuum in which high intensity proton beams could circulate happily.

Today, CERN is an acknowledged centre of expertise in the ultra-high vacuum domain, expertise which has yet to be fully integrated into the European scheme of learning.

Following in the tradition of Röntgen's X-ray discovery, medical applications, particularly of detector technology, are frequently fruitful. Positron emission tomography (PET) and magnetic resonance imaging (MRI) are two major growth areas spawned by basic physics. CERN's 1992 Nobel prizewinner Georges Charpak has striven ceaselessly to promote such detector spinoff.

In another sector, the growing size and complexity of particle physics experiments involving thousands of specialists in hundreds of research institutes spanning several continents led to new requirements for communication. The spectacular outcome, directly sparked by developments at CERN, was the World Wide Web for accessing information via the internet.

Several surveys of economic spinoff from CERN have demonstrated how each Swiss franc spent by CERN on high technology has generated several Swiss francs of subsequent business elsewhere for the suppliers. Working at the high technology frontier can pay dividends.

CERN has amassed an impressive portfolio of rewarding technology transfer. It is clear that a laboratory whose aim is to advance knowledge must also be prepared and equipped to handle such spinoff. With time and despite complex administrative rules in its special international environment, CERN has developed ad hoc strategies to streamline the technology transfer process and make its achievements more visible.

A two-day meeting 'Basic Science and Technology Transfer - means and methods in the CERN environment' highlighted the challenge and set out to help define strategies to further develop CERN's technology transfer policy.

The meeting was organized by CERN's new Technology Transfer Coordinator François Bourgeois, who

recently took over this responsibility from Oscar Barbalat, now formally retired (although as enthusiastic as ever).

Introducing the meeting, CERN Director General Chris Llewellyn Smith pointed to the superfluid helium cryogenics of CERN's new LHC proton collider as an example of how today's basic research continues to bring fresh technological challenges.

A living example of technology transfer was provided by Portuguese Minister of Science and Technology José Mariano Gago, a former high energy physicist and longtime CERN user. In his keynote address, Minister Gago outlined changing attitudes and underlined new trends in science policy, demanding a flexible approach and less complacency.

This requirement for flexibility was also stressed by Jorma Routti, Director General of the European Commission's DGXII for science research and development, who described how technology transfer programmes have to contend nowadays with large multinational concerns who can shift production platforms between continents.

The meeting was divided into three compartments - technology transfer through people, through cooperation agreements, and through purchasing.

The meeting presented an impressive array of case histories, with examples of niche markets, of new developments, of people who themselves have surfed a technological wave and moved from one specialist domain to another, and of the approach in other organizations, generally with missions quite different to that of CERN.

On the people front, several hundred European technical students and fellows now pass through CERN each year. In addition, bilateral agreements covering technology have been established between CERN and various nations, extending even beyond the existing Member State community.

Many skills are acquired in this work - as well as the technology itself, working in large projects to tight deadlines in an international environment means that the students are frequently eagerly sought.

Beginning with the requirement for large magnets for its particle accelerators and extending through to electronics development and materials research for large detector systems, CERN has a long history of industrial collaboration.

While these agreements cover the needs of their immediate goals, their ongoing potential is less clear, and one requirement could be for a better indicator of the latent worth of new developments, and for better follow-through to seed them effectively. In the US, a small percentage of federal spending has to be allocated to small businesses.

As well as CERN's own requirement for technology, specialist companies looking to extend the range of their activities look to large organizations such as CERN as a 'safe bet' while acquiring these new skills.

The meeting, where more than half of the participants came from industry, underlined the value of a CERN Technology Transfer unit. To increase the appreciation of the benefits to society of basic science spinoff, irrespective of its apparent cost, current policy should be reinforced and take into account the wide range of technologies covered. Special attention should be paid to acquisition and exploitation of know-how in the academic environment of the postgraduate programmes at CERN, and to collaboration and purchase in industry.

Around the Laboratories

CHOOZ
New neutrino results

In March 1997, a new neutrino experiment began operation at a recently commissioned nuclear power station near the village of Chooz (pronounced 'Shau') in the Ardennes region of France. Its initial results were awaited with great interest by physicists trying to explain the apparent deficit of muon neutrinos produced by cosmic ray interactions in the atmosphere (September 1997, page 25).

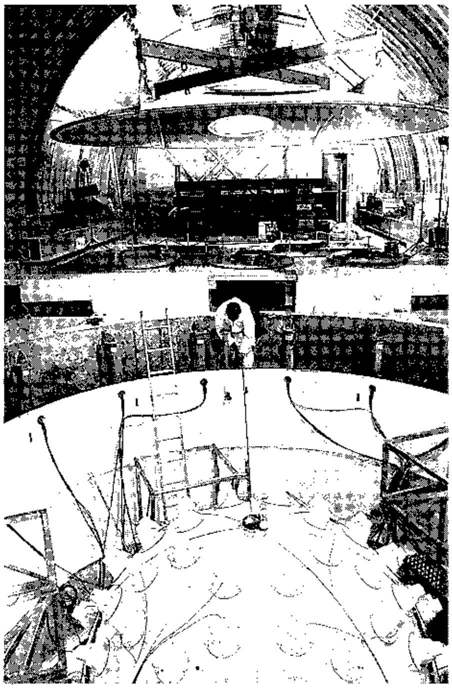
The Chooz experiment is a new recruit in the effort to search for neutrino oscillation. Neutrinos come in three types, each with a different lepton allegiance - electron, muon or tau. Conventionally, these neutrino categories are considered immutable - a free neutrino in flight retains its allegiance for ever.

However unexplained effects seen by experiments studying solar neutrinos, and by experiments looking at neutrinos produced by cosmic ray interactions in the atmosphere, suggest that neutrinos can change their allegiance and oscillate from one kind to another in flight (November 1997, page 12).

Classically, neutrinos are also massless, but any oscillation would imply that they have mass, with different neutrinos having different masses. The results from the solar and cosmic ray neutrino studies impose limits on how neutrinos can oscillate.

Each experiment probes a different oscillation scenario. Typically experiments using neutrinos produced via an accelerator beam test high energies and produce predominantly muon neutrinos, while the high neutrino flux from nuclear reactors use lower energies and use

View of the Chooz experimental hall, showing the photomultiplier screen surrounding the neutrino target regions.



exclusively electron neutrinos.

Chooz has a high electron neutrino flux, known with high accuracy, with an energy centred around 3 MeV. Siting the detector a kilometre from the source, thus giving the neutrinos more room to oscillate than previous neutrino experiments, probes a hitherto unexplored region where oscillations might occur.

The experiment benefited from earlier studies using the Bugey reactor which gave useful oscillation limits. French researchers from Annecy and the College de France (funded by IN2P3-CNRS) were joined for the new study by physicists from New Mexico, Drexel (Philadelphia) and Irvine (California) in the US (funded by the US Department of Energy), from Pisa and Trieste in Italy (funded by INFN), and from the Kurchatov Institute in Russia. Half the costs were underwritten by Electricité de France.

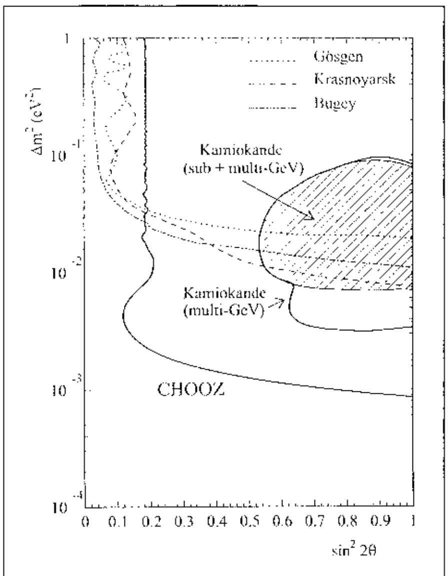
Each Chooz neutrino interaction (inverse beta decay) produces a positron and a neutrino. The neutrinos are detected by correlations (delayed coincidence) between the prompt positron and the subsequent neutron capture (producing gamma rays). These signals are picked up by a 5-tonne target of gadolinium-loaded liquid scintillator in an acrylic vessel surrounded by a 70-cm thick layer (17-tonnes) of unloaded scintillator viewed by 192 8-inch photomultipliers. This in turn is contained in a 90-tonne cosmic ray shield equipped with two rings of 24 photomultipliers.

The detector is under a hillside, the intervening rock cutting the cosmic ray muon signal by a factor of 300. The apparatus is further protected from natural radioactivity in the surrounding rock by an artificial barrier of low radioactivity sand and 14 cm of iron.

Initial running in 1996 was hampered by chemical problems with the gadolinium-loaded scintillator, however this gave the team valuable experience in tuning and calibrating their detector. From March to October 1997, Chooz amassed 1320 neutrino signals. This count is in total accord with the expected reaction rate from such an accurately calibrated source, thus excluding neutrino oscillations in the parameter region accessible.

The range excluded, shown in the figure, completely covers the implied muon-electron neutrino oscillation area in which the Japanese Kamiokande experiment observes a muon neutrino deficit. Taken at face value, this incompatibility suggests that oscillations involving tau neutrinos, to which Chooz is not sensitive, play a role in the atmospheric phenomena.

Chooz continues to take data, and expects to obtain final results at the end of 1998.



The conditions for neutrino oscillation ruled out by the new Chooz reactor experiment (above and to the right of the contour), compared with limits from other experiments and with the allowed area implied by atmospheric neutrino results from the Japanese Kamiokande detector, assuming only electron-muon neutrino oscillations.

CERN ISOLDE astrophysics helps piece together supernova puzzle

Very light elements were made at the Big Bang and everything else is stardust. To a good approximation, this much is well established. But the precise mechanisms of this nucleosynthesis remain to be clarified, particularly in the extreme conditions of heavy supernovae. A new research tool, the laser ion source, at CERN's on-line isotope separator, ISOLDE, is helping

scientists to fill in some of the missing pieces.

The laser ion source has transformed ISOLDE from a very good source of unstable ions into an excellent one. It uses laser light as a key to unlock just the ions needed by a particular experiment.

Ions are created at ISOLDE when a proton beam strikes a uranium carbide target. The resultant fission reactions create a range of short-lived exotic atoms.

These are evaporated from the target and allowed to find their way into a small capillary. The new laser ion source works by firing three precisely tuned laser pulses into this capillary in quick succession. The first has just the right energy to lift a valence electron into an excited orbit, the second lifts it again to a higher orbit, and the third ionizes the atom. The combination of laser energies is unique to the ion required. An electrostatic field pulls the ionized atoms out of the capillary and into ISOLDE's general purpose separator, GPS, which further selects isotopes to be delivered to experiments. The selectivity of the laser ion source coupled with the GPS mass resolution ensures a very pure beam contaminated only with a small number of ions of the same mass as the one required.

One of the first experiments to use the ion source last October studied the properties of highly neutron-rich silver isotopes. For the first time, silver-129, an isotope with 22 more neutrons than the most common stable isotope of silver, was identified and its half-life measured.

Silver-129 plays an important role in the so-called rapid neutron capture, or r-process, of nucleosynthesis. This takes place when the neutron density is so high that an unstable beta-emitting element is very likely to capture a neutron before it decays. This leads to extremely neutron-rich isotopes, most of which later decay through a chain of beta disintegrations until a stable isotope is reached.

The r-process is thought to be responsible for the majority of stable neutron-rich elements heavier than iron, but is notoriously difficult to study. The only place where conditions are right for the r-process is in the explosion of heavy supernovae. There, in a period of just a few seconds, all kinds of elements are formed and sprayed out into the Universe where they eventually end up in new stars and planets.

Laboratory studies of the r-process rely on facilities like ISOLDE where highly neutron-rich isotopes can be made. The half-life of silver-129 is just one of a myriad parameters in nucleosynthesis calculations, but its measurement pins down one piece of the puzzle. In the future, although the laser ion source is under heavy demand from many areas of physics, new experiments will measure more neutron-rich isotopes, slowly building up a coherent picture of Supernova nucleosynthesis.

Members of the IS333 collaboration, which measured the half-life of silver-129, in front of the experiment's neutron detector in the experimental hall of CERN's ISOLDE on-line isotope separator. Left to right: Karl-Ludwig Kratz, Ylva Jading, Peter Möller, Bill Walters, and Slava Mishin.

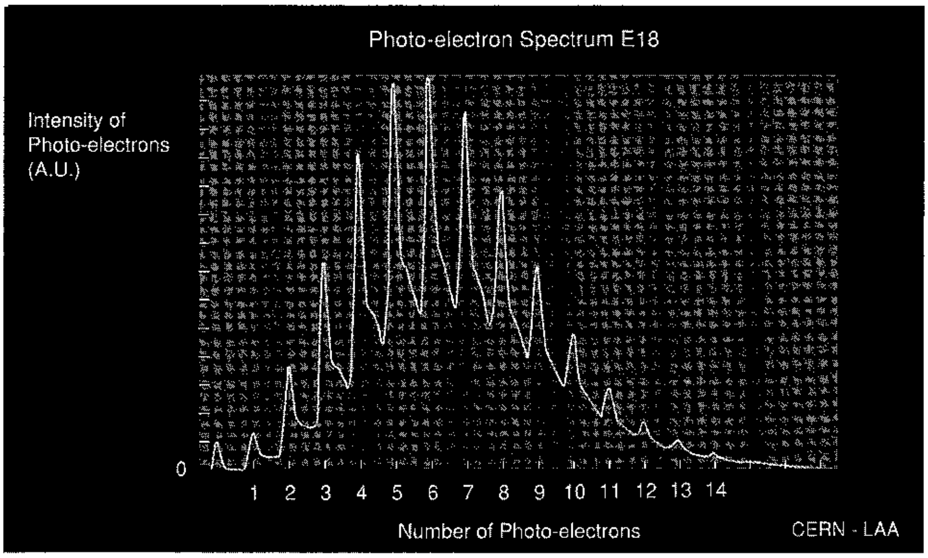
Hybrid photodetectors come of age

A technology which first saw the light of day 30 years ago has come of age with new hybrid photodetectors, HPDs, being prepared for the CMS and LHC-B experiments at CERN's LHC proton collider. The result not only offers a faster, higher resolution photodetector for particle physics applications, but also the possibility of an exciting new tool for medical diagnosis.

The basic idea is to marry a photocathode with a silicon detector combining the advantages of both devices. Although HPDs were successfully produced 30 years ago, they were prone to problems of rapid ageing. Impurities in the silicon resulted in the photocathode, which must be extremely pure, becoming polluted and thus deteriorating. The idea was left to rest, but with the demands of detectors for the LHC to detect small signals rapidly and with good efficiency, a collaboration between CERN, Italy's LAA project and National Institute for Nuclear Research, INFN, began to look at the idea afresh in 1990.

Thanks to advances in image intensifier technology, extremely pure silicon manufacture, and electronics, the old problems were resolved. Right from the start, the collaboration worked with industry. The Dutch company, DEP, which manufactures image intensifiers, had developed the ability to make vacuum tubes with state-of-the-art photocathodes, and the American firm Canberra provided silicon diodes through its Belgian subsidiary. The result is a stable photodetector with extremely high energy resolution. Unlike a traditional photomultiplier, where the intrinsic

The excellent resolution and sensitivity of hybrid photodetectors makes them ideally suited for particle physics and medical applications alike. This curve shows how an HPD can count the precise number of photoelectrons liberated at the cathode. (Image: DEP catalogue)



resolution is limited by fluctuations in the number of electrons produced in the multiplication process, an HPD can actually count the number of photoelectrons produced.

In CMS, single channel devices called hybrid photomultiplier tubes, HPMTs, are being used in the development phase to characterize the response of the lead-tungstate crystals destined for the electromagnetic calorimeter to gamma-ray photons. Later on, multi-channel devices will read out the experiment's hadronic calorimeter in which just 10 photoelectrons per GeV are expected.

Another advantage of HPDs compared to traditional photomultipliers is that they will work in CMS's 4 Tesla magnetic field. As long they are aligned with the field to within 3 degrees, the photoelectrons travel along the field lines from the cathode to the silicon diode.

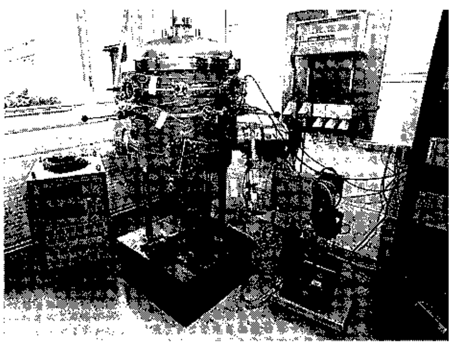
LHC-B is taking the technology a step further, aiming to produce HPDs with up to 2048 channels for their ring-imaging Cerenkov, RICH, detectors. It is the ability of HPD to detect single photoelectrons which makes them attractive to the LHC-B collaboration where signals in the RICH will be individual photons. The aim is to image the rings of Cerenkov light using 2 millimetre squared pixels over as high as possible a fraction of the detector's active area. Multi-anode photomultipliers, which cram 64 conventional photomultipliers into a single compact package, are one option, and are already available off the shelf. But they do have drawbacks. Because the sensitive area is smaller than the overall package, only about 40% coverage would be possible with today's devices.

LHC-B has embarked on a programme of research and development aimed at squeezing up to 2048 channels into a single vacuum tube. Its HPDs will differ from those commercially available in that they will electrostatically focus the photoelectrons onto the silicon detectors. This means that a relatively small silicon detector can be embedded in a large tube, and crucially, that the photocathode will cover the almost full face of the device.

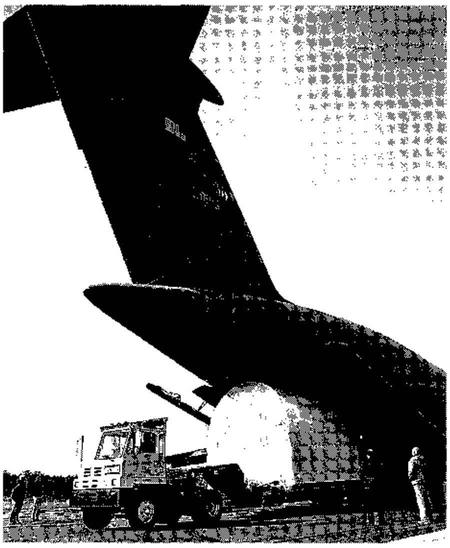
Two approaches are under consideration. The first, being pursued with DEP, envisages bonding silicon pixel detectors recently developed at CERN directly onto readout chips so that all the electronics can be sealed inside the vacuum tube. This builds on the work of the LAA project whose 1024-pixel imaging silicon pixel array, ISPA, tube has been available for testing since 1994. The second is a purely in-house effort. A facility for assembling phototubes is being commissioned at CERN. It will be used to install silicon pad detectors, also developed at CERN, into vacuum tubes. The pads are read out using traces on the silicon surface to separate electronics chips.

As is so often the case with advances in particle physics detector technology, medical applications are not far behind. Work is already underway to produce an ISPA tube for medical imaging. Since these gamma or beta-ray cameras are extremely sensitive to small numbers of photons and have good spatial and energy resolution, smaller quantities of radioactive tracer are

This new CERN facility for fabricating hybrid photodetectors will be used to produce photocathodes and to install silicon pad detectors into vacuum tubes. (Photo CERN EX 97.11.026)



required. In addition, image contrast and resolution will be improved. This makes the technique particularly attractive for diagnosis for children, and it is there that trials are scheduled to begin next year. For the longer term, larger devices might open up new approaches to mammography, whilst small, hand-held devices could be used for rapid preliminary scanning for cancers, for example, of the thyroid.



On November 6, the STAR Time Projection Chamber (TPC) was moved from Lawrence Berkeley National Laboratory, where it was designed and constructed, to Brookhaven for installation at one of the Intersection Regions at RHIC. The photograph shows the TPC being unloaded on Long Island from a US Air Force C-5C cargo plane. The STAR TPC, which had undergone a period of highly successful tests with cosmic rays at Berkeley immediately prior to the move, is the largest such tracking detector in the world.

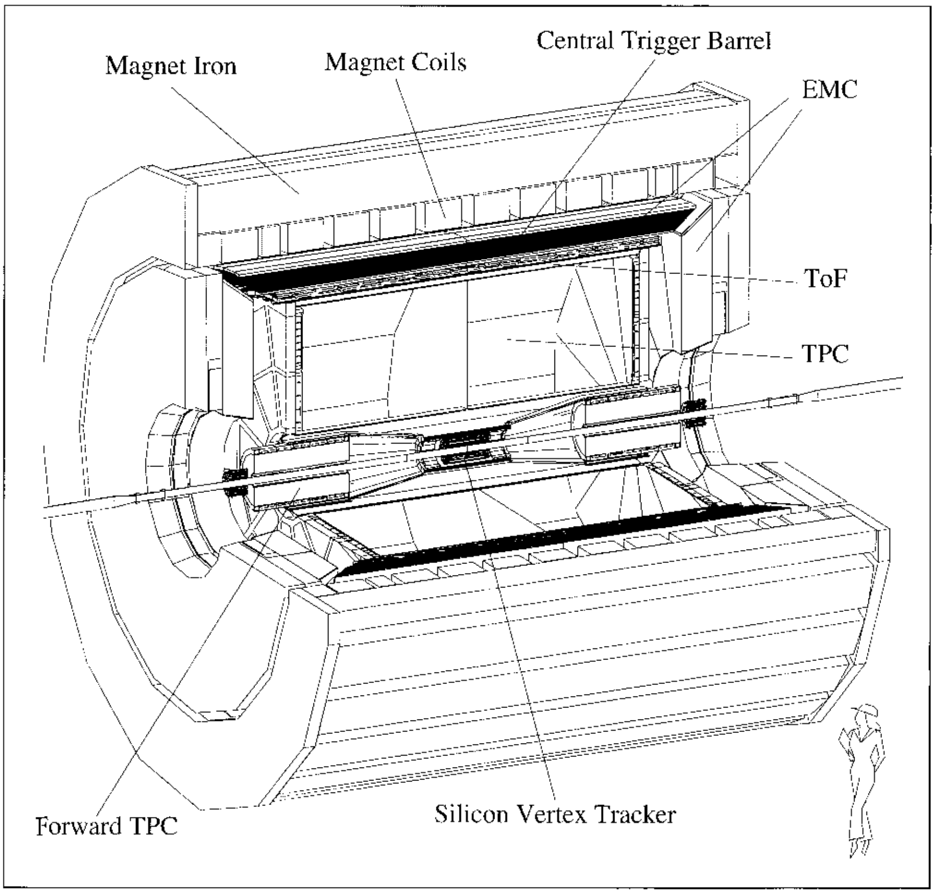
RHIC
More STAR physics

It's not often that physicists can treat ultrarelativistic heavy ions as single particles. But that's an appropriate picture for a new physics programme in the STAR (Solenoidal Tracker at RHIC) collaboration. In July, the collaboration formally added studies of photon and pomeron* interactions to the planned physics at the RHIC heavy ion collider now under construction at Brookhaven. (*The pomeron is the aggregate mechanism responsible for elastic scattering.)

This programme considers interactions at relatively large distances, where the nuclei do not physically collide, but interact via collisions of coherent photon or Pomeron fields. Two-photon interactions, such as those studied at LEP, are the best known example of this.

At RHIC, the large nuclear charge produces intense electromagnetic fields, with a two-photon luminosity proportional to the fourth power of the nuclear charge. These interactions study a variety of physics, from strong field quantum electrodynamics to meson spectroscopy.

One facet, unique to RHIC, is that because the product of the nuclear charge and the electromagnetic coupling constant is large, about 0.6, two-photon interactions probe strong field quantum electrodynamics. The large two-photon luminosity also leads to large production rates for many scalar and tensor mesons, and thence to high statistics hadron spectroscopy; the coupling of mesons to two-photons is a measure of their internal quark content.



Drawing of the STAR detector for the RHIC heavy ion collider at Brookhaven. A silicon vertex tracker and main TPC are surrounded by a scintillator trigger, electromagnetic calorimeter and solenoidal magnet. An endcap calorimeter and forward TPCs increase the solid angle coverage.

Rates are also large for photon-pomeron interactions, where part of the photon wave function is absorbed by the other nucleus, producing a vector meson. In addition to light vector mesons, J/psis will also be produced copiously. These interactions test how the vector mesons interact with the other nucleus; by changing nuclear beams and hence the nuclear radius, different thickness targets can be probed.

Double-pomeron interactions are also expected, as is interference between two-photon and photon-pomeron effects. These interactions are characterized by final states consisting of a few particles, with nothing else visible in the detector.

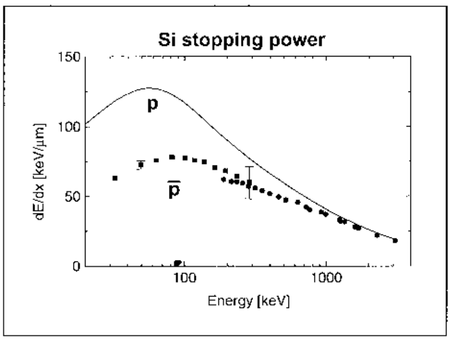
The STAR Peripheral Collisions Working Group, led by Spencer Klein (Lawrence Berkeley) has performed detailed simulations studying background processes that can mimic these interactions, and concluded that good signal to noise ratios can be obtained for a variety of signals.

The STAR detector is well suited to detect these interactions. The 4 metre-long, 4 metre-diameter main TPC tracks charged particles with good solid angle and momentum measurement in a 5 kG solenoidal magnetic field. A three-layer silicon vertex tracker will help detect strange particles by finding separated vertices, while an electromagnetic calorimeter will detect photons with good efficiency. Forward TPCs will detect charged particles in the forward rapidity regions, checking for the rapidity gaps that are characteristic of 'uncoloured' photon and pomeron interactions. Finally, a zero degree calorimeter will detect neutrons from nuclear breakup, providing an indication of nuclear impact parameter.

One of the most difficult parts of this programme is triggering on coherent events, while rejecting incoherent background from grazing nuclear interactions, beam gas, photonuclear interactions and cosmic rays. Initially, a set of scintillator and wire chamber trigger detectors will measure charged particle multiplicity and topology on an event by event basis. Later triggering decisions will be made using tracking, vertex position and perpendicular momentum balance. These criteria provide a good efficiency for coherent events, while maintaining a low deadtime.

Besides the excellent physics, the STAR program will provide a good lead-in for the two-photon physics at CERN's LHC.

CERN
Barkas effect revisited



Stopping power for protons and antiprotons in silicon, showing the reduced effect for antiprotons at lower energies due to the repulsion of atomic electrons by the negatively charged antiprotons.

In the mid-fifties, Walter Barkas and co-workers at Berkeley discovered that the range in matter of negative pions was longer than that of positive pions of equal momentum by about 0.3 %.

Initially, this was thought to be due to a difference in mass between the two types of pions, but soon it was realized that the origin of the effect was to be found in the slowing-down process itself.

The energy loss of fast charged particles in matter arises mainly from inelastic collisions with atomic electrons. Charged particles penetrating a target polarize the atomic electrons, and since the negative pions have the same charge as the electrons, these pions will repel the electrons and experience a lower stopping power of the target material than their positive antiparticles, leading to a longer range.

The Barkas effect was later also studied with sigma-hyperons and muons, but the measurements suffered from the low quality of these beams at low energy. The effect implies deviations from the Bethe formula for the stopping power, applicable to faster-moving particles and which scales as the square of the projectile charge. Hence, the effect also shows up in comparisons between equi-velocity protons and alpha-particles: the stopping power for alpha-particles is more than 4 times the stopping power for protons.

One of the objectives of the PS194 experiment at CERN's LEAR Low Energy Antiproton Ring by an Aarhus/PSI (Villigen) collaboration was to study the Barkas effect using high quality beams of antiprotons. The antiproton stopping power of different materials was measured at energies between 20 keV and 5 MeV using time-of-flight and calorimetric techniques.

The antiproton stopping power was found to be reduced by 30 % around the stopping power maximum as compared to protons. The two stopping powers are seen to merge at high energy, above a few MeV.

Such measurements are important not only for stopping negative particles, but also for a better understanding of the slowing-down process itself. Accurately-known stopping powers are important in many fields, ranging from radiation therapy and materials science to high energy physics.

Valuable information about antiproton stopping powers in hydrogen and helium gases and extending to even lower energies has also been obtained by the PS201 experiment (OBELIX) at LEAR.

WORKSHOP
Beam dynamics issues

From 5-7 November, CERN hosted the 4th Beam Dynamics Mini-Workshop on Transverse Emittance Preservation and Measurements, under the auspices of ICFA (International Committee for Future Accelerators). 43 experts in beam dynamics and instrumentation, from 7 different labs (Brookhaven, CERN, DESY, Fermilab, KEK, Rutherford Appleton and Svedberg) debated the transverse emittance issues facing the accelerator physics community in the coming century to ensure reliable production of the high intensity, high brightness beams for future large hadron colliders.

This type of beam has to be achieved in veteran machines such as the PS proton synchrotron at CERN and the AGS Alternating Gradient Synchrotron at Brookhaven, as well as Fermilab's new Main Injector and the 50 GeV synchrotron under study at KEK, Japan.

Among the topics covered were: emittance measurement devices; precision and consistency of emittance measurements; emittance blow-up vs injection oscillations; emittance blow-up vs mismatch, performance of injection dampers; non-linear field effects at ejection and in transfer lines; scraping of tails; and exotic measurements.

The programme thus catered for both machine physicists and beam diagnostics specialists. As usual in these workshops, less than 50% of the time was devoted to formal presentations, allowing maximum time for discussions.

After an opening address by D.J. Simon, head of CERN PS division, on the first half day the representatives of the organizing labs - Brookhaven, CERN, DESY, Fermilab and KEK described details of their respective projects. The ensuing programme covered many topics, from the basic definitions and expected precision of measurements, to exotic methods such as bunched beam Schottky spectrum.

W. Chou, H. Koziol, L. Vos, and K. Wittenburg summarized the instrumentation and machine physics contributions before the workshop was closed by K.H. Kissler, head of CERN's SL (SPS and LEP) division. Local organization was in the hands of CERN's PS Performance Committee.

DESY
Theory workshop

Although Quantum Chromodynamics (QCD), the quark-gluon (parton) field theory of strong interactions, has been with us for 25 years, it is still a challenge to fully explore its rich and complex structure. Recent methodical developments in QCD and theoretical and experimental progress in understanding hadronic phenomena were discussed and reviewed at the latest annual Theory Workshop at the DESY Laboratory in Hamburg.

DESY Chairman Bjørn Wiik introduces the laboratory's Theory Workshop.

Reviewing current knowledge of the internal structure of the nucleon, Allen Caldwell (DESY/Columbia) presented experimental results on the quark/gluon structure of nuclei (structure functions). DESY's HERA electron-proton collider now gives precise results over four orders of magnitude in Bjorken x (momentum fraction carried by the struck parton) at fixed squared momentum transfer Q^2, and almost four orders of magnitude in Q^2 at fixed x. The data are well reproduced over most of the kinematic range from the conventional (DGLAP) equations using input parton densities.

Although the structure function data is generally well fitted by perturbative QCD at higher Q^2, a complete theoretical description of the low Q^2 region is lacking. The transition from a region well-understood with perturbative QCD to a region dominated by 'soft QCD interactions' takes place around $x = 0.0001$ and $Q^2 = 4\ GeV^2$, dramatically exhibited by the data.

The HERA data show a rise in the parton distributions at small x in the whole Q^2 range, with a slope which

Recent developments in Quantum Chromodynamics (QCD) and progress in understanding hadronic phenomena were reviewed at the latest annual Theory Workshop at the DESY Laboratory in Hamburg. Left to right, Matthias Neubert, Guido Martinelli and Ahmed Ali.

steadily increases with Q^2. Marcello Ciafaloni (Florence) discussed whether this behaviour, successfully ascribed to large scaling violations (gluon radiative corrections which modify the naive parton model), can also be quantitatively understood with the 'hard Pomeron' picture, that views the nucleon at large Q^2 but small x as being composed mainly of 'hot spots' of feebly interacting gluons. This picture is derived from the evolution of the parton densities using the BFKL equation. While this evolution is at variance with the data at leading level, higher order scaling violations (the calculations of which are almost complete) lead to a drastic change. The preliminary estimate of these corrections is now compatible with the small-x behaviour of parton distributions in the few GeV region. Ciafaloni made the point that the hard Pomeron picture and QCD corrections may be two sides of the same picture, and that the transition to 'soft physics' is perhaps much smoother than previously thought.

Michael Düren (Erlangen) summarized recent experiments using polarized electrons and muons at CERN (SMC), DESY (HERMES) and SLAC (E154, E155). The nucleon spin structure functions of all experiments agree with each other and with the Q^2 evolution predicted by next-to-leading order QCD. The new data confirm that the 'spin puzzle' - fixing the relative contributions from valence quarks, virtual 'sea' quarks, gluons, and orbital angular momentum to the nucleon spin - is still with us. New data from HERMES will separate spin contributions from various quark flavours. In the long term, the COMPASS experiment at CERN (May 1997, page 4) and possibly a polarized HERA collider will shed light on the spin contribution of the gluon.

While the change of parton distributions with Q^2 from moderate to large values of Q^2 is well understood, the computation of the parton distributions is a truly non-perturbative problem and thus remains a serious challenge. Dmitri Diakonov (NORDITA) outlined how a chiral quark-soliton model leads to parton distributions that are in reasonable agreement with parametrization at moderate Q^2.

Roger Horsley (Berlin) presented results obtained from QCD in the lattice approximation. The x-moments of a structure function can be related to the hadronic consequences of certain quark-gluon operators which can, in principle, be directly evaluated by methods of lattice QCD. Using the Quadrics high-speed parallel computer of DESY-IfH Zeuthen, researchers were able to numerically compute them and low moments of the valence quark distribution at two different lattice spacings allowing a glimpse of the continuum limit (that is, the extrapolation to zero lattice spacing). The calculations are in fair agreement with the data.

Another theme of the workshop was diffraction phenomena in high energy collisions, especially in lepton-nucleon scattering. Recent experimental findings were presented by John Dainton (Liverpool/DESY). Diffraction (elastic-like scattering) has a pedigree stretching back to the 1960s, but hadronic diffraction has gone through a renaissance with the advent of HERA in the 1990s. Just as the first high Q^2 interactions of electrons with protons in the early 1970s revealed and established the picture of the proton as a bound state of quarks and gluons, so the new results at HERA have established the partonic nature of diffractive interactions to be described in terms of QCD. Before the HERA results, diffraction was understood entirely in terms of 'soft' hadronic interactions as the exchange of a 'Pomeron' (a colour-neutral collective partonic excitation) between the two interacting hadrons. The new measurements have probed the Pomeron, revealed that its sub-structure is dominated by gluons, and even quantified the basic partonic dynamics involved, albeit within a theoretical framework not stringently derived from QCD.

Alfred Mueller (Columbia) discussed a number of current theoretical issues in understanding and interpreting diffraction scattering. He compared hadron-hadron and lepton-proton collisions, especially diffractive dissociation at Fermilab and at HERA, where significant differences between hadronic- and virtual photon-initiated processes have become apparent. In contrast to the very weak growth with the collision energy of the single diffraction reaction rate in hadronic collisions (where only one nucleon dissociates and the other stays intact) the energy dependence of analogous HERA events (where a 'heavy' virtual photon hitting the target proton dissociates into hadrons) appears to be significantly stronger. He made the point that this may be evidence for nonlinear QCD effects (due to the unitarity of the scattering matrix) that are extending from the region of 'soft' to the regime of 'semihard' strong interactions.

Gregory Korchemsky (Orsay) showed that QCD gives intriguing mathematical structure when considering hadron scattering amplitudes for large collision energy but fixed momentum transfer - the so-called Regge limit. It has been argued that the QCD dynamics is then described by an effective field theory which can be reduced to a 1-dimensional spin-chain model, the 'XXX' Heisenberg magnet. This model can be solved exactly. The Regge regime remains, however, to be fully understood in QCD.

Another topic to stimulate recent theoretical activity is high transverse momentum charmonium production at the Tevatron and HERA. A CDF (Tevatron) measurement can be accounted for by the idea that the main production mechanism is the fragmentation of a gluon into a coloured charm quark-antiquark pair which evolves into charmonium and light hadrons. However, HERA measurements show no evidence for this mechanism. Michael Krämer (Rutherford Laboratory) reviewed current attempts to understand the CDF and HERA data in a coherent fashion.

Accurate calculations are available for a number of hard scattering processes using perturbation expansions. Erwin Mikes (Karlsruhe) reported recent advances in computing multiple parton scattering and jet production rates at high energy colliders, while Kostja Chetyrkin (Moscow/Karlsruhe) reviewed recent results on multi-loop QCD calculations, incorporating the total electron-positron annihilation process into a heavy quark-antiquark pair, the hadronic decay of the yet to be discovered Higgs particle, and the variation of the strong coupling with energy. Recent progress in this field became possible only by elaborate combinations of analytic, computer-algebraic, and - in the case of jet physics - numerical methods.

With measurements of QCD observables for hard processes becoming ever more precise, the experimental and theoretical analysis of nonperturbative 'power' corrections (proportional to some inverse power of the large energy scale characterizing the reaction) has become a rapidly developing field. Martin Beneke (CERN) outlined how power corrections are related to the divergence of the QCD perturbation series and summarized the present status of theoretical investigations. He then proceeded to a comparison of theoretical results with data on hadronic event shape observables in electron-positron collisions and deep-inelastic scattering. Critically reappraising the theoretical assumptions made, he concluded that the success of the predictions is both encouraging and puzzling.

The B mesons and their weak decays provide a good 'laboratory' for exploring QCD. On the other hand precise calculations of B meson decays are, in general, necessary prerequisites for analysing future precision experiments aiming to clarify the origin of CP violation. Matthias Neubert (CERN) outlined the concepts of 'Heavy Quark Symmetry' and 'Heavy Quark Effective Theory' and confronted theoretical results on semileptonic and nonleptonic B meson decays with recent experimental data. Guido Martinelli (Rome) reviewed the current status and results of numerical QCD calculations in the lattice approximation of weak matrix elements, including those of (semi)leptonic B meson decays and of neutral meson oscillations.

An issue not yet settled is the precise calculation of the mass parameters of the light (up, down, strange) quarks from the measured light meson mass spectrum. Heinrich Leutwyler (Bern) discussed how the concept of chiral symmetry breaking in QCD and the now classic method of chiral perturbation theory lead to a reliable determination of the ratios of light quark masses. Martin Lüscher (DESY) reviewed the techniques used in present lattice QCD calculations of the light quark masses. He outlined also a computational strategy that should eventually lead to reduced systematic errors.

Investigating strong interactions at high temperature has been (and still is) of major interest among theorists because of its importance in understanding the deconfinement phase transition from hadrons to a gas of liberated quarks and gluons. Eric Braaten (Ohio) reviewed theoretical tools and problems of QCD at high temperatures and applications to static and dynamic phenomena. Helmut Satz (Bielefeld) discussed the suppression of J/psi

production in nuclear collisions, the prominent and long-sought signature of quark-gluon plasma formation that should occur at high temperatures or high nuclear densities. He compared theoretical expectations with the data from the NA50 collaboration at CERN on 'anomalous' J/psi suppression in lead-lead collisions which seem to show, for the first time, the onset of deconfinement.

The DESY workshop attracted in particular many young theorists. More than 50 short talks were given in the parallel sessions — certainly a sign that the compelling problems of QCD continue to fascinate the new generation of physicists.

From Werner Bernreuther (RWTH Aachen)

George Kalmus (left) steps down as Director of Particle Physics for the UK Council for the Central Laboratory for the Research Councils. His place is taken by Ken Peach (right).

RUTHERFORD APPLETON
Kalmusfest

At a packed meeting at the UK Rutherford Appleton Laboratory (RAL) on 3 October, an audience of particle physicists from the UK and overseas gathered to honour George Kalmus a few weeks before he stepped down as Director of Particle Physics for the UK Council for the Central Laboratory for the Research Councils.

The occasion, organized by Erwin Gabathuler and Bob Brown, consisted of four main presentations in which people who had been associated with George at different times in his career reviewed various aspects of particle physics in depth, while at the same time providing light-hearted reminiscences.

Peter Smith, in a talk entitled "Four Particles and a Symphony", returned to the days when he and George were students at University College, London, and then went on to review searches for exotic particles and dark matter. (The 'symphony' referred to a rare performance of the Toy Symphony by Bernard Romberg, conducted by Peter Smith, in which George had displayed unsuspected talents.) Bob Ely then recalled the golden days of bubble chamber physics at Berkeley in the early 60s which shaped George's career for many years to come, and went on to describe the exciting physics currently coming from CDF at Fermilab's Tevatron.

In 1972 George joined RAL as leader of the Bubble Chamber group; this period was covered by Ken Peach, who also gave a comprehensive review of the physics of CP violation. Ugo Amaldi recalled George's key role in the early and sometimes turbulent days of Delphi, and showed some of the results flowing from this now fully mature LEP detector.

In short contributions preceding and following these talks, Erwin Gabathuler and Paul Williams - CLRC Chairman and Chief Executive - expressed the warmly felt appreciation of the particle physics community for George's activities over the last years, both as Director at RAL and in managing the UK particle physics programme.

George is stepping down to spend the next few years once again in active participation in a particle physics experiment; he will continue to work at RAL.

George's place as Director was taken on 1 January by Ken Peach, formerly Deputy Division Head of CERN's PPE Division.

KYOTO
Polarized protons at high temperature

A Kyoto group has realized a long-cherished dream of spin physicists, the polarization of proton in a solid target at high temperature.

Usually protons in organic materials and ammonia are polarized dynamically for the purpose of the target of high energy physics, since the polarization in thermal equilibrium is very low. In this method, high polarization of electrons of paramagnetic impurities is transferred to the protons by microwave irradiation in a high magnetic field (25-50kG) at very low temperature(1-0.1K). This is called the solid effect.

In the last decade I. Schmidt and his collaborators in Leiden proposed polarizing protons in organic crystals by means of microwave-induced polarization involving the photoexcited triplet state of the guest molecules [1] .

Electrons in a pentacene molecule are diamagnetic in the ground state because these electrons are in a singlet state. Electrons are excited to higher singlet states with the laser beam. The spin-orbit interaction causes the transition from singlet excited states to intermediate triplet states.

The populations of the Zeeman sublevels of the lowest triplet state with Z-component of the total electron spin +1, 0 and -1 are 12, 76 and 12% respectively. During the lifetime of the triplet state (some 20 microsec) microwave irradiation occurs and the external field is swept simultaneously to transfer the population difference of electrons between two Zeeman sublevels to the proton polarization by means of the integrated solid effect.

Electrons on the triplet state decay to the ground state, where the proton spin remains polarized for a long time since the spin-spin interaction between electrons and protons on the ground state is negligible.

Using this method, the Leiden group obtained 0.5% polarization of protons in naphthalene in room temperature. Recently a Kyoto group tried to polarize protons in naphthalene doped with pentacene and got about 34% polarization by means of a similar method with a high-power pulsed dye-laser at liquid nitrogen temperature [2].

The enhancement factor corresponding to this value is 8 x 10^4. The relaxation times of protons are about 1,000 and 160 minutes in fields of 3kG and 7G respectively, surprisingly long compared to those in other target materials.

It is expected that a proton polarization up to 70% can be obtained if the laser power and the concentration of pentacene are optimized. Although the proton polarization is less than 1% at room temperature, it was found to be improved significantly at a temperature slightly lower than 0C, since the coupling between slow molecular motion and proton spin is quite small in this temperature region.

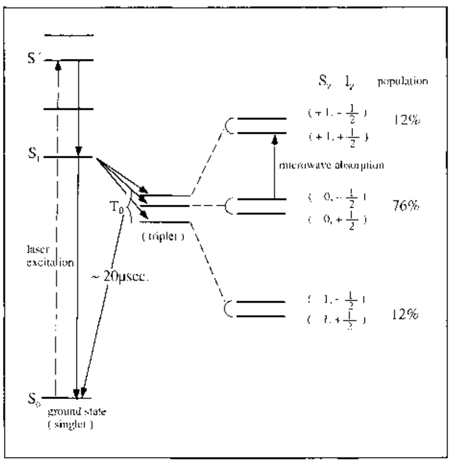
The method is applicable to the wide field of spin physics. Even though the ordinary polarized targets of ammonia and organic materials have higher hydrogen contents and higher polarization (more than 90%) than the naphthalene target, the newly developed target has many advantages over the ordinary target for some kinds of experiments.

Since the target has no heating problem and possibly no serious problem of radiation damage, it can be used for high-intensity primary beams of hadrons and electrons, important for the investigation of rare phenomena.

Secondly, the target is useful for experiments with very low-momentum charged particles, since the necessary magnetic field to keep the polarization is extremely low. Furthermore, the target system is not so expensive and does not require a great deal of expertise. Future developments aim at further improvements of the polarization and proton concentration.

References
1) A. Henstra et al., Chemical Physics Letters, 165 (1990) 6
2) M. Iinuma, PhD thesis Kyoto Univ. 1997 M. Iinuma et al., in preparation for publication

Energy levels of the polarization-useful pentacene molecule



Physics monitor

Photodetection

Since the earliest days of particle physics research, photodetectors have been an essential item in the experimenter's tool kit. The principal techniques for detection of charged particles are based either on sensitivity to ionization produced by a particle's passage or on sensitivity to photons produced by scintillation, fluorescence, Cerenkov or synchrotron radiation, or annihilation.

The first photodetector, the human eye, even today is among the most sophisticated of photon imaging devices. No system ever developed can compare with the sensitivity, spectral resolution, pixelization, data acquisition and data analysis capabilities of the eye.

The discovery of X-rays in 1895 by Wilhelm Roentgen was made through observations of a fluorescent screen exposed to a cathode ray tube. Sixteen years later, Ernest Rutherford and his students discovered the atomic nucleus via observations of light flashes in fluorescent screens produced by particle impacts.

Photographic plates, either coupled to cloud chambers, (and, later bubble chambers) or used directly as emulsions, first provided the means to record particle interactions with matter. However, the general tendency that developed in experimental particle physics towards real-time detection and digital representations has greatly diminished the role of photographic films.

The invention of the vacuum photomultiplier tube in 1936 also opened up an entirely new aspect of experimentation, allowing precise timing of events in units of a trillionth of a second.

Participants at the First International Conference on New Developments in Photodetection held in Beaune, France.

The discovery of the antiproton in 1955 by O. Chamberlain, E. Segre, C. Wiegand and T. Ypsilantis was accomplished through precise measurements of particle velocities. Both Cerenkov and time-of-flight techniques were needed to distinguish the heavier, slower antiprotons from the much more numerous lighter, faster mesons. Signals from a pair of widely separated plastic scintillators, each viewed by a photomultiplier tube, were processed electronically to record the time-of-flight for particles traversing the space between them.

Following the advent of photosensitive solid state devices in the 1950s, technological progress in the field of photodetectors slowed. New devices tended to be improvements on and variations of existing devices optimized for specific sets of requirements. However, during the past decade, this situation has changed dramatically.

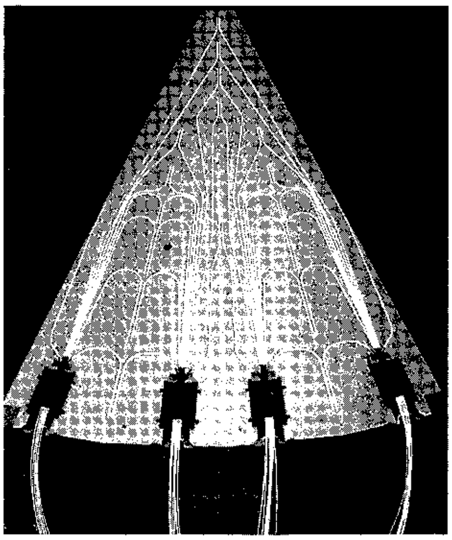
A rapid expansion in basic knowledge and technology in the field of photon detection and imaging has occurred through research in private companies and in public laboratories, resulting in the introduction of completely new solid state, gaseous and vacuum devices.

The impetus for detector improvement in basic research came from astronomers' desire to scan the sky over a very wide energy range and from the extremely difficult experimental conditions created in modern colliding beam accelerators. On the private side, the desire to look deeper into the body and, the need for improved medical diagnostic techniques appears to be the stimulus.

Because of this considerable progress, the idea of an international conference on new developments in photon detection was conceived and proposed by Pierre Besson of CEA, Direction des Sciences de la Matiere, DAPNIA. Subsequently, the First International Conference on New Developments in Photodetection was organized by Pierre and a local committee of physicists from IN2P3 (the Institut de Physique Nucleaire et de Physique des Particules) and DSM (Direction des Sciences de la Matiere.)

Held in Beaune, France, the Conference was sponsored by the Direction des Sciences de la Matiere, the Institut de Physique Nucleaire et de Physique des Particules, the Ministere de la Recherche, and the European Commission. About 180 participants from 16 countries took part. Among them were physicists and engineers working in diverse fields: high energy physics, nuclear

An example of scintillator techniques which benefit from the development of photodetectors with many pixels in one package (such as the hybrid photodetector - see page 8) is the end plug calorimeter upgrade for the CDF detector at Fermilab's Tevatron. Light from a mosaic of independent scintillator tiles is collected by embedded wavelength-shifting fibres spliced to clear fibres which pipe the signal to accessible photodetectors.



science, astrophysics, and medical instrumentation.

The programme was organized around plenary sessions on major categories, supplemented with poster sessions, with more than 90 contributions spread over five days. An exhibition of related products by companies triggered interesting discussions. Companies also reported on their most recent developments. The proceedings of the conference can be found in NIM A 387 (1997).

Nobel prize-winning physicist Georges Charpak of CERN chaired the initial session. In his opening remarks, he reminded participants of the human benefit of photon imaging and of scientists' ethical obligations regarding rapid transfer of new ideas and new technologies to the field of medical imaging.

Amos Breskin of the Weizmann Institute gave the initial talk, an excellent review of photon detection entitled "Photon Detectors for the 21st Century," that set the stage for the conference by providing an overview of where the field stands now, describing ongoing research, and analysing future directions for the next decade.

The situation in astronomy was reviewed by L. Vigroux (CEA/DSM/DAPNIA) where an entirely new generation of detectors has been developed. In both fields, the present state of flux and development is unprecedented; new devices and new techniques are almost an annual occurrence.

Because of their differing sensitivities and characteristics, photodetectors are frequently classified into three groups: vacuum devices, gaseous photodetectors, and solid-state devices. The conference encompassed significant new developments in all three categories with substantial contributions in both the applied domain and in basic research.

For vacuum devices, the contributions showed a trend toward position-sensitive detectors. These devices are used in medical and scientific imaging applications and for readout of detectors producing light in fibres or fibre bundles. Most promising has been the development of hybrid devices (see page 8) in which the entrance window and photocathode are as in a normal phototube, but the dynode multiplier stages are replaced by a silicon diode detector. Direct photoelectron bombardment produces the electronic signal. The most significant advantages of the hybrid approach are gain stability, potential for pixelization, insensitivity to magnetic fields, response uniformity, and photon counting capability.

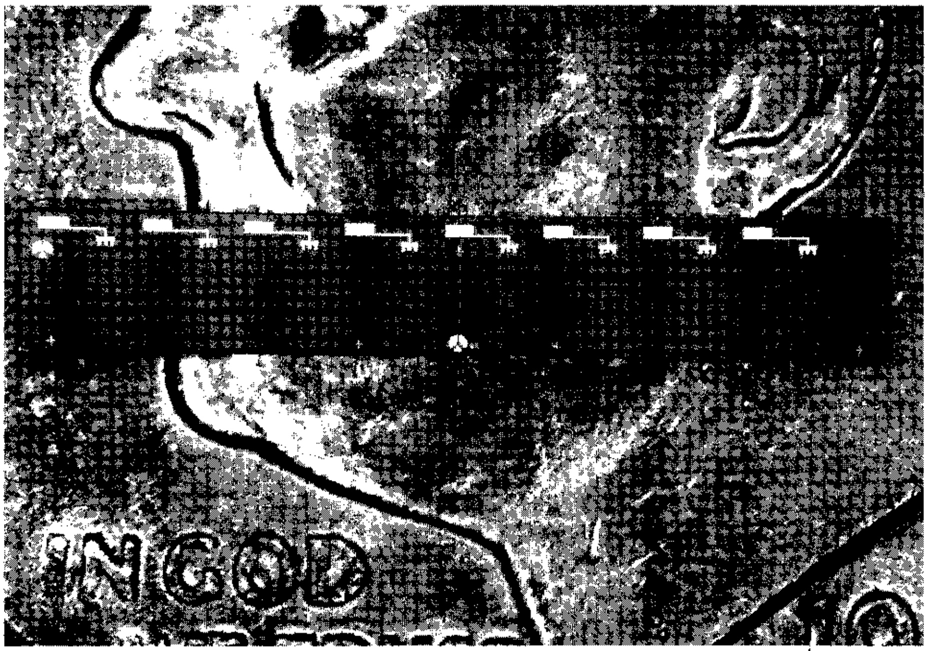
Also reported were significant advances in mesh dynode photomultiplier tubes for use in magnetic fields or position-sensitive applications. Born only about 10 years ago, mesh dynode devices have seen very rapid implementation by the high energy physics community. The advancements presented at the conference concerned significant decreases in crosstalk, or the amount of signal from one optical pixel that inadvertently shows up on adjacent electronic pixels.

Overall, six groups reported use or planned use of position-sensitive phototubes or hybrid photodiodes: CDF Calorimeter Upgrade (M. Lindgren, UCLA), H1 Forward Spectrometer (K. Hiller, DESY), DELPHI Shashlik Calorimeter (M. Bonesini, INFN Milan), CMS Hadron Calorimeter (J. E. Elias, Fermilab, and P. Cushman, Minnesota), LHC-B ring-imaging cherenkov detector (D. Websdale, Imperial College, and J. Seguinot, College de France), medical gamma-cameras (D. Puertolas, INFN Rome).

Gaseous detectors are based on photoconversion and subsequent charge multiplication in a gas. Frequently, large-area applications are involved, as no other technique is cost competitive for square metres of coverage. Physics applications for cherenkov ring imaging and medical applications for gamma ray imaging have a basic requirement in common – both need good efficiency for photons in the blue and ultraviolet region. Since most photocathode materials can only function in vacuum, the "holy grail" for gaseous detectors has been a room-temperature photosensitive vapour or an air-stable photocathode that can be applied like paint or wallpaper.

Recently, cesium iodide has been identified as the leading candidate in the latter category. Progress in photodetectors with gaseous amplification (J. Va'vra, SLAC) and contributions by very careful and skilled groups (J. Friese for HADES, M. Staric for HERA-B, and C.

Superimposed on a coin is this 8-element linear 1 mm diameter photodetector array for a Visible Light Photon Counter (VLPC) for the upgrade of the D0 experiment at Fermilab's Tevatron with scintillating fibre tracker readout and one VLPC pixel per fibre in the tracker. With high quantum efficiency and low noise, this enables single fibre readout at very low light levels.



Coluzza for RD26 at CERN) indicate that subtle issues regarding interactions between surface quality, microcrystal structure and quantum efficiency are in need of further investigation. Given that cesium iodide technology is also an innovation of the last decade, the indications are favourable for development of large-area photocathodes.

The search for new organic UV-sensitive vapours was reviewed by P. Mine of LPNHE, with the most promising results coming from a class of ferrocene derivatives. Progress in solid state photodetectors has been even more dramatic. Avalanche photodiodes (APDs) have come of age, two entirely new structures have been invented, and first results on compound semiconductor detectors have emerged. Nine contributions addressed different aspects of the modern APD, with the impetus coming from the readout requirements for the CERN LHC environment. An excellent review of the use of avalanche photodiodes for particle detection (J. P. Pansart, CEA Saclay) served as the introduction to the APD session.

Visible light photon counters (VLPCs) are a new solid state photodetector concept based on gain developed in band-gap impurity conduction structures. Originally developed for night vision applications, this new variant enables the use of large scale scintillating fibre detectors for particle tracking. The combination of high quantum efficiency and very high single photoelectron detection efficiency fits the requirements exactly. Very successful results from a fibre tracking prototype readout with 3000 VLPCs over many months of operation for the DZero upgrade at Fermilab were presented (M. Wayne, Notre Dame).

The other new solid state photodetection structure is based on self-quenching avalanches in a region of high electric field. Called MRS, for the metal-resistive layer-silicon nature of the structure, the principle is to convert incident photons to electron-hole pairs, allow the electrons to drift to the high field region, and quench the subsequent avalanche by means of a resistive layer that prevents formation of a spark. Again, these ideas are born of the last decade in response to the needs of particle accelerator colliders and medical imaging diagnostics.

Advances reported at the conference included extensions into short-wavelength sensitivity and robustness against ageing under high illumination conditions. This technology is in its infancy with much promise for the future.

The Beaune meeting, the first modern conference on advances in photodetectors, found itself deluged by recent technological progress. The past decade has seen far-reaching innovations in photon detection and photon imaging. Sessions at the meeting effectively combined review presentations with talks on cutting-edge research.

Frontier topics are always challenging for their own sake, but an appreciation of the synergy with applications in medicine is also emerged. Participants agreed that the next Conference, Beaune99, would see the development of even more significant advances and the possibility of yet another radically new technique.

by John Elias, Fermilab

Stephen Hawking with schoolchildren during the COSMO-97 international workshop on particle physics in Ambleside in the English Lake District. His public lecture 'The Theory of Everything' attracted a large audience.

Particle physics and the early Universe

The spectacular progress of cosmology in recent years means that scientists have to face a dilemma. The comfort of an increased understanding of the formation of a complex Universe in the Big Bang has to be reconciled with an uncomfortable awareness that the Universe we actually see is only a small fraction of all there is. The search for this missing 'dark matter' is the major goals of contemporary physics.

Theoretical and experimental aspects of dark matter searches and particle cosmology were the main focus of the COSMO-97 international workshop on particle physics and the early Universe. Held from 15 - 19 September 1997 in Ambleside in the beautiful English Lake District, the meeting (organized by Lancaster University) gathered some 110 participants from around the world. Deciphering the script for the Big Bang was the main theme.

Inflation remains the only attractive scenario for explaining the puzzle of why the gross features of the cosmic microwave background radiation look the same in all directions. Inflation occurred as a brief period of extremely rapid expansion a tiny fraction of a second after the Big Bang. During this time the Universe stretched by over 40 orders of magnitude and became nearly Euclidean in the process. This beautiful idea introduced 15 years ago by Alan Guth still lacks a fully satisfactory particle physics scenario.

Understandably, this domain of research remains almost solely a theoretical playground. However this will change in the years to come with experimentalists now seriously involved in mapping the sky up to the largest distances.

Much progress is expected in sharpening fine details of irregularities in the cosmic microwave background radiation and in deep sky galaxy surveys. The emerging picture of mass distribution around the Universe will have direct implications for predictions from inflationary models and will be used as a model discriminator, as reviewed by J. Frieman (Fermilab), E. Kolb (Fermilab) and D. Lyth (Lancaster).

Even present data can constrain some cosmological scenarios. A. Albrecht reported that approaches in which large structures in the Universe have grown around topological defects, like cosmic strings, are already inconsistent with observations. At the end of inflation the Universe was very empty, cold, and dominated by an 'inflaton' which subsequently decayed to give the particles we know today. As a result the temperature jumped up again and the Universe "reheated".

While the general idea is easy to sketch, the detailed theory is still model dependent and often difficult to analyse. Comprehensive reviews by A. Linde (Stanford) and L. Kofman (Hawaii) summarized the present status.

Some theorists boldly try to imagine what happened in the very first moments of the Universe's history at the 'Planck scale' where the known laws of physics crumble.

Stephen Hawking (with his Cambridge student R. Bousso) explored the consequences of his no-boundary approach, in particular the production and subsequent possible evaporation of primordial black holes. (A. Liddle of Sussex analysed how such objects would affect the subsequent evolution of the Universe.)

Others advocate using superstring ideas to glimpse the evolution of the Universe during the Planck era. R. Brustein (Ben Gurion) presented work with G. Veneziano (CERN) which addresses the issue of the initial singularity in a so-called pre-Big-Bang approach.

Superstrings are often claimed to be the theory of everything, but they still lack understanding of their fundamental structure. H.-P. Nilles

(Munich) reviewed the presently much debated M(atrix)-theory which is supposed to shed a new light on the theory of superstrings. He argued that robust cosmological parameters, like the age of the Universe, can constrain certain otherwise allowed predictions from strings. R. Gregory (Durham) considered topological defects resulting from superstrings. R. Kallosh (Stanford) reviewed a possible connection between black holes and superstrings.

Among the other topics discussed relating to the particle physics of the early Universe, J. Cline (McGill) argued that if the observed asymmetry between baryons and antibaryons is to be explained by purely (supersymmetric) electroweak effects, the mass of the Higgs particle responsible for electroweak symmetry breaking must be below 100 GeV, making it accessible at CERN's LEP electron-positron collider.

The origin and subsequent evolution of primordial magnetic fields, still poorly understood, were discussed by K. Enqvist (Helsinki) and M. Shaposhnikov (CERN).

G. Senjanovic (ICTP Trieste) showed how the normally expected restoration of symmetries at high temperatures can be evaded in the presence of non-zero charge densities. This could automatically solve the domain and monopole problems in cosmology.

Another important theme of the workshop was cosmological relics of the Big Bang, where the subject is more experimental. Neutrino oscillations would imply that neutrinos have mass and hence may contribute to dark matter.

The first possible accelerator observation of neutrino oscillations from the Los Alamos LSND experiment, presented by R. Imlay

Graham Ross of Oxford suggests a scenario with several periods of inflation of the early Universe.

(Louisiana State), will soon be challenged (or confirmed) by the KARMEN experiment at the UK Rutherford Appleton Laboratory, according to J. Kleinfeller (RAL), while Chorus and Nomad at CERN, represented by J. Herin (Louvain), are not sensitive to the LSND signal. K. Zuber (Dortmund) reviewed the prospects for neutrino oscillation searches. Evidence for such mixing of neutrino species from atmospheric neutrino and solar neutrinos observations is underlined by the Japanese Super-Kamiokande detector (September 1997, page 25).

The present picture remains unclear, with the LSND, solar and atmospheric data implying different oscillations, as reviewed by D. Caldwell (Santa Barbara). He argued that introducing a fourth, sterile neutrino would help solve the confusion. R. Mohapatra (Maryland) reviewed theoretical scenarios for neutrinos and conjectured that physics beyond conventional Grand Unified Theories may be needed to explain the data.

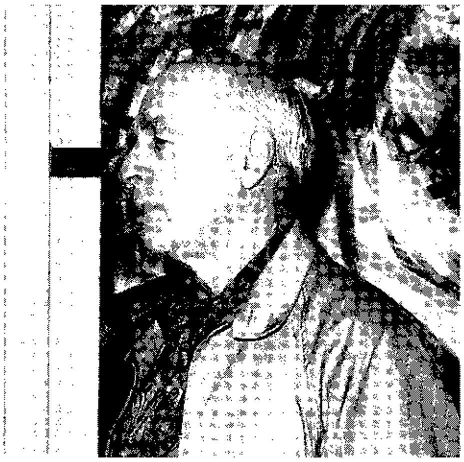
Inflation in Big Bang cosmology says that the Universe's mass density is equal to the critical density, just enough to make the Universe's expansion slow to zero at infinite time. While "direct" observations currently give the ratio to be about one-third of the critical density, large-scale flows and cluster evolution tend to give higher values, closer to what theorists' favour, as reviewed by J. Primack (Santa Cruz).

Measurements of the concentrations of light nuclei such as deuterium and helium in the Universe from the theory of nucleosynthesis constrain the density of conventional matter (protons and neutrons) to be about 5% of the critical density. However, visible baryons in stars and galaxies account for less than 1%. K. Freese (Michigan) argued that the "missing" baryons hide in very old stars - white dwarves. S. Raby (Ohio State) presented another exotic possibility of coloured dark matter following currently hotly debated gauge-mediated SUSY-breaking models.

The other 95% of the total mass in the Universe is probably non-baryonic and locked in some yet undiscovered particles which only interact weakly. Such particles, known as WIMPs (Weakly Interacting Massive Particles) should be abundant in the Galactic halo surrounding us. One favourite bet is that these will be the lightest supersymmetric particles (LSP).

Many limits on the existence of supersymmetric particles have come from LEP at CERN and the Tevatron at Fermilab. Better limits, or a discovery, should come from the LHC, as reviewed by S. Katsanevas (Lyon) and V. Barger (Wisconsin). J. Ellis (CERN) combined experimental data from LEP with cosmology to sharpen the limits on the LSP. R. Arnowitt (Texas A&M) and P. Nath (Northeastern) considered the WIMP in the context of supersymmetric

The chairman of COSMO-97, L. Roszkowski (left) with D. Caldwell who will be organizing the next COSMO meeting (COSMO-98) at Asilomar, California.



unification. The masses of superpartners can be squeezed by collider searches from below, and increasingly accurate cosmological constraints from above.

Recent years have witnessed the growth of an impressive experimental programme to hunt for WIMPs. An indirect way of searching for WIMP signals is to look for energetic neutrinos from the Sun (or the core of the Earth) from annihilation of WIMPs gravitationally trapped there. F. Halzen (Wisconsin) reviewed such detection techniques and described the AMANDA project, a 1 km-cube neutrino telescope built into the ice at the South Pole.

Direct searches look for a very faint energy deposit (a few kiloelectronovolts) from WIMP scattering. Due to the extremely low event rate expected, extreme sensitivity is required, along with careful shielding to reduce the background. Several detector materials are used and experimental techniques are improving, as reviewed by N. Spooner (Sheffield).

More recently, extremely low temperature methods have been introduced to reduce heat noise. They were reviewed by D. Bauer (Santa Barbara) from the CDMS experiment at Stanford using an innovative cryogenic technique.

An intriguing signal was claimed by D. Belli (INFN Rome) from the DAMA experiment with a heavily shielded sodium iodide crystal in the Italian Gran Sasso Laboratory. This experiment sees a small annual change in the putative WIMP count rate, corresponding to what would be expected due to the earth's rotation around the Sun and the Sun's motion through the Milky Way. If this is real, it will be confirmed soon by the UK Dark Matter collaboration running in the Boulby Mine in North-Eastern England, described by T. Ali (Imperial, London), and by CDMS.

One bold proposal was presented by H.-V. Klapdor-Kleingrothaus whose Heidelberg group is designing the 1 tonne GENIUS germanium detector (December, page 19).

COSMO-97 has initiated a series of "Lancaster workshops" which will be held yearly: California will host COSMO-98, COSMO-99 will return to Europe and in 2000 the workshop will be held in Korea.

From Leszek Roszkowski and Terry Sloan (Lancaster)

Faculty Position
Institute for Theoretical Physics
State University of New York
Stony Brook, N.Y. 11794-3840

The Institute for Theoretical Physics at the State University of New York at Stony Brook will have an opening for a Full or Associate Professor beginning January, 1999.

The Institute does comprehensive research in various fields of theoretical physics including, but not limited to, gauge field theory, the standard model of elementary particles, perturbative quantum chromodynamics, lattice field theory, supersymmetry, superstrings and statistical mechanics, condensed matter physics. It is also looking forward to expansion into mathematical biophysics.

Review of applications will begin on June 15, 1998 and continue until the position is filled.

Applicants should submit a curriculum vitae, a summary of current and proposed research and arrange to have three letters of recommendation sent to:

email address: jobs@max.physics.sunysb.edu

Professor Chen Ning Yang, Director or
Professor Peter van Nieuwenhuizen, Deputy Director,
SUNY - Institute for Theoretical Physics,
Box A,
Stony Brook, N.Y. 11794-3840.

The State University is an Equal Opportunity/Affirmative Action employer.
Qualified women and minorities are encouraged to apply.

DEUTSCHES ELEKTRONEN SYNCHROTRON DESY

DESY is one of the leading laboratories in particle physics and synchrotron radiation research. For its location in Zeuthen near Berlin DESY is offering a

POSTDOCTORAL RESEARCH POSITION

to young scientists to participate in the HERA-B experiment at HERA. The main goal of HERA-B is to study CP violation in decays of neutral B-mesons, one of the most interesting fields in modern elementary particle physics.
To reduce the huge amount of data and to perform a pre-selection of events a multi-processor system (farm) with more than 100 nodes is currently under construction.
The accepted candidate is expected to work on concept, installation, and administration of a multi-processor farm for the date acquisition and trigger system of the HERA-B experiment and on design and implementation of software for a distributed system. Furthermore, participation in the development of filter algorithms is possible. The position requires a high amount of motivation and reponsibility.

A doctoral degree in physics or computer science is required.

Applicants should be:
- able to administrate Unix-Systems on AIX-workstations and especially Linux-PCs,
- able to plan and install a network system based on standards, like Fast-Ethernet,
- familiar with C, C++, and Fortran.
- Knowledge of IP-programming is desirable.

Experiences with high energy physics experiments is of advantage.
The position is limited to a duration of 3 years. The salary will be according to the German civil services BAT-O IIa.
Handicaped applicants will be given preferences to other applicants with the same qualification.
DESY encourages especially women to apply.

Interested young scientists should send their letter of application and three names of referees and their addresses by February, 27th, 1998 to:

DESY Zeuthen, Personalabteilung
Platanenallee 6, 15738 Zeuthen, Tel.: 0049/33762/77210

The ISTITUTO NAZIONALE DI FISICA NUCLEARE - Sezione di Pisa (Italy) is seeking an:

On-Site Computer and Software System Manager

VIRGO *is an Italian-French project of a large interferometer intended to detect gravitational waves.* This interferometer is being built at Cascina near Pisa and involves about 150 researchers among 11 Italian and French laboratories. The first part is planned to be integrated early 1998 and full operation is foreseen in 2002.

Job Description: on-site computer and software system manager.

Functions: responsible for the on-site operation of the whole computer and software system of VIRGO.
The selected candidate will actively participate to the initial on-site integration of the computer and software system and is expected to play a key-role in its subsequent and future development.

Experience and education: the candidate will possess a University Degree in computer sciences or engineering or physics and a substantial experience in the operation of large and complex computer systems in a scientific environment.
He/She will be well aware and will possess experience in modern software development methodologies.
He/She will be fluent in English. Good knowledge of Italian and French will be an advantage.

Working place: Cascina near Pisa (Italy).

Contract: a 2 years contract will be offered with possibility of extension. The career path will be determined according to the experience and to the level of the functions performed.

Candidates are invited to send a curriculum vitae in which is pointed out the respondence to the above requirements. Please send C.V. preferably within February 20, 1998 to the following address: **Istituto Nazionale di Fisica Nucleare, Via Livornese n. 1291 - 56010 S. Piero a Grado (Pisa) Italy. Attn. Ms. Claudia Tofani.**
I.N.F.N. will get in touch with all screened candidates for an interview.

I.N.F.N. is now announcing that within a few months a notice of competition will be issued in order to seek the following position, for which advertisements will be published on Italian local and national newspapers.

Job Description: electronics technician.
Functions: assistant to the system manager for the operation and maintenance of the computer networks. He/She will also provide assistance for the computer system and electronics integration.
Experience and education: the candidate will possess a technician degree in electronics or computer techniques and will have a few years of professional experience.
He/She will have a good knowledge of English. Knowledge of French will be an advantage.
Working place: Cascina near Pisa (Italy).
Contract: a 2 years contract will be offered with possibility of extension. The career path will be determined according to the experience and to the level of the functions performed.

For any information: tel. (39) 50 880352 - fax (39) 50 880350 - e-mail: claudia@galileo.pi.infn.it

People and things

Bookshelf

Weak Neutral Currents - The Discovery of the Electro-Weak Force, edited by David B. Cline, Addison Wesley (Frontiers of Physics Series), ISBN 0-201-93347-0

Addison Wesley's Frontiers of Physics Series began in 1961, and David Cline's anthology on weak neutral currents is the 97th volume in the series. 'Frontiers' books usually make extensive use of lecture notes or reprints, and Cline's volume takes the latter route. It is divided into 9 chapters: The Weak Interaction Uncovered; Forty Years of Weak Interactions; The Search for Other Forms of Weak Interaction; The Electroweak Interaction Picture Emerges; The Discovery of Weak Neutral Currents; Other Weak-Neutral Current Processes, Parity Violation in Weak Neutral Currents, and $\sin^2 q_w$; On to the W and Z Particles; High Precision Studies of the Electroweak Force; Back to the Future with the Higgs Boson.

Apart from the first, which is an introduction, each chapter has a useful introduction by neutral current enthusiast Cline (see November 1997, page 18) and includes several reprints. As well as predictable classic papers, the collection includes some gems, notably the historic but rarely seen March 1976 proposal by Carlo Rubbia, Peter McIntyre and Cline to build a proton-antiproton collider to search for the W and Z particles, and a Peter Higgs paper given at a 1993 Santa Monica meeting which takes the lid off the eponymous mechanism.

I found it very useful.

GF

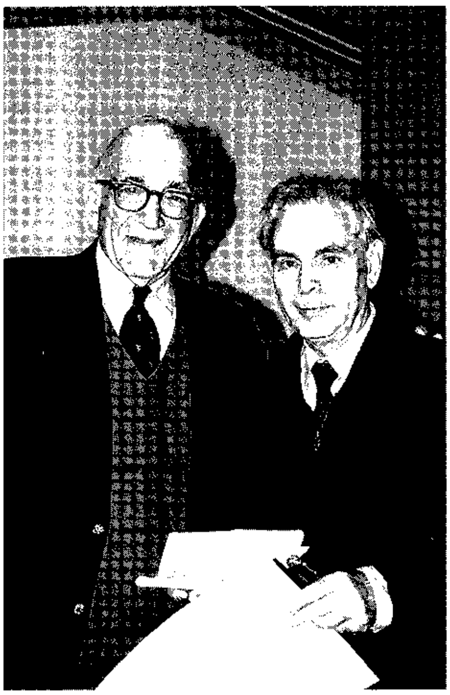
Books received

Future High Energy Colliders, Editor Zohreh Parsa, AIP Conference Proceedings 397, ISBN 1-56396-729-4

Proceedings of a meeting held in Santa Barbara in October 1996 (see March 1997 issue of the CERN Courier, page 16).

The Interpretation of Quantum Mechanics and the Measurement Process, by Peter Mittelstaedt, Cambridge University Press 0 521 55445 4 £30/$44.95

A volume of interest to the more philosophically minded on how to live with the measurement dilemmas introduced by the orthodox interpretation of quantum theory.



CERN Council

At the meeting of CERN's governing body, Council, in December, Luciano Maiani was elected the next Director General of the Organization, to take office on 1 January 1999, when the current Director General, Chris Llewellyn Smith, will have completed his five year mandate. A distinguished theorist, Luciano Maiani is currently President of the Italian INFN and has been President of CERN Council since January 1997.

At the same meeting, leading German science administrator and head of Germany's CERN delegation Hans C. Eschelbacher was elected President of CERN Council for an initial period of one year from 1 January 1998, replacing Luciano Maiani. Fernando Aldana of Spain was elected Vice-President of Council for one year, while Fernando Bello of Portugal was appointed Chairman of the Finance Committee and Leif Westgaard of Norway was elected Vice-Chairman of the Finance Committee, for the same one-year period.

Lev Okun honoured

A foundation set up by philanthropist George Soros honoured Russian theorist Lev Okun of Moscow's Institute of Theoretical and Experimental Physics with a special humanitarian award at a ceremony at SLAC, Stanford, on December 11.

Russian theorist Lev Okun (right) of Moscow's Institute of Theoretical and Experimental Physics was honoured with a special humanitarian award from a foundation set up by George Soros at a ceremony at SLAC, Stanford, on December 11. SLAC Associate Director Sidney Drell (left) presented the award on behalf of George Soros.

Moscow's Institute of theoretical and Experimental Physics (ITEP) recently celebrated the 75th birthday of eminent nuclear and particle theorist Karen Ter-Martirosyan.

With the award is a cash prize of $25,000. The award from The Open Society, created by Soros in 1992 to help the most talented scientists of the Former Soviet Union through their economic and political transition without having to leave their work or their country, recognizes Okun's "dedication and selfless devotion to the cause of Russian scientists". SLAC Associate Director Sidney Drell presented the award on behalf of George Soros. "The battle to save Russian science goes on and I can tell you no one has worked harder than Lev Okun," he said. The CERN Courier, which has long benefited from Okun's wisdom, adds its congratulations for a particularly merited award.

Austron OK?

The Austron high flux pulsed neutron source has been recommended as fundamentally suitable as a major scientific facility by a European Science Foundation panel.

Sited in Austria, the Austron would cover experiments in materials science, physics, chemistry, and biology. Accelerating light ions as well as protons, it would also support cancer therapy and research work.

Based on a proton machine producing neutrons by spallation, the 3000 million schilling (270 million Swiss francs) facility would be funded 2:1 by the European Commission and Austria. The home country, eager to have an international centre, has indicated its willingness to support the project.

It remains now to clarify Austron's complementarity to a planned German research reactor and to the new SINQ continuous neutron source at the Swiss PSI laboratory (March 1997, page 2).

Development work for the Austron has been centred at CERN on the machine side and in Vienna for the targets and experiments.

On people

A recent seminar at Moscow's Institute of theoretical and Experimental Physics (ITEP) marked the 75th birthday of eminent nuclear and particle theorist Karen Ter-Martirosyan. From his teachers Yakov Frenkel and Lev Landau he inherited wide interests and a brilliant intuition. His accomplishments range from the theory of Coulomb excitation of nuclei, to the integral equation for the three-body problem (subsequently generalized by Faddeev), to field theory renormalization, to high energy strong interaction theory. He created a famous school, the first student being Vladimir Gribov. His list of disciples also includes A. Ansel'm, Yu. Simonov, A Kaidalov, A. Polyakov, A. Migdal, A. Zamolodchikov, ... Their greetings from all over the world joined the warmest wishes of ITEP colleagues and students from Moscow's Institute of Physics and Technology, where Ter-Martirosyan founded and headed for 35 years the Chair of Elementary Particle Physics.

David Schramm 1945 - 97

Prominent astrophysicist David Schramm died on 19 December while piloting his airplane. A gentle giant, he came very near to representing the US in wrestling in the 1968 Olympics, but was soft spoken, using intellectual power, rather than physical, to advance his scientific arguments.

A product of William Fowler's school at Caltech, he was naturally drawn towards nucleosynthesis and became a leading proponent of the astrophysical implications of Big Bang ideas. He stressed the cosmic distributions of light nuclei in general as tracers of the early Universe, and in particular the significance of deuterium as a 'baryometer' of cosmic processes, implying the existence of exotic dark matter. With Jim Gunn and Gary Steigman in 1977, he used astrophysical helium measurements to provide a limit to the number of lightweight neutrino species, work refined in the late 1980s in time for LEP's 1989 demonstration that there are only three such particles.

Schramm was a personification of the symbiosis between particle physics and cosmology and was a frequent visitor to accelerator laboratories, where his objective seminars were widely appreciated.

In 1974 he moved to Chicago, and his influence helped introduce cosmology and astrophysics research at nearby Fermilab.

His physical and intellectual stature

Kalervo Laurikainen 1916 - 97

made him a natural centre of attraction at major meetings. A gifted communicator as well as a scientist, his talks and papers enabled many particle physicists to learn about cosmology and astrophysics. He wrote several popular books - 'The Shadows of Creation', with Michael Riordan, and 'From Quarks to the Cosmos' with Leon Lederman.

Kalervo Laurikainen 1916 - 97

Distinguished Finnish physicist Kalervo Laurikainen died on 13 July after a long illness. Laurikainen was a founding father of theoretical physics, nuclear physics, high energy physics and history and philosophy of physics in Finland. In recent years he became a central figure in promoting the cultural and spiritual significance of science rather than the technical or commercial aspects of fundamental research.

After his military duty was extended by the Second World War, Laurikainen worked at Helsinki and Turku in Finland, and Zurich, Lund and Copenhagen. In 1960 he became the chair professor of nuclear physics at the University of Helsinki (later known as the Department of High Energy Physics). It was Laurikainen who built contacts to the Joint Institute of Nuclear Research (JINR) in Dubna and to CERN and it was due to his efforts that the Research Institute of Theoretical Physics, the Computing Bureau for Physics and experimental high energy physics were established in Finland.

Until his death, Laurikainen actively pursued a fresh career in philosophy, organized conferences and published books on the Copenhagen interpretation of quantum mechanics and on the correspondence of Wolfgang Pauli with Markus Fierz.

From Risto Orava

Joseph Ballam 1917-97

Joseph Ballam, Emeritus Professor and long-time Associate Director for the Research Division at the Stanford Linear Accelerator Center (SLAC) died on December 14 of emphysema-related complications. He was 80 years old.

He worked for the US Navy's Bureau of Ships during World War II and subsequently earned his PhD at Berkeley in 1951 for studies on cosmic rays. After working at Princeton and Michigan State, he joined SLAC at its inception in 1961, becoming its first Research Director two years later. During his lengthy tenure at SLAC, Ballam oversaw the efforts of some 300 physicists, engineers and technicians involved in the construction of major scientific instruments and analysis of the experimental data. He also led an experimental programme that built a rapid-cycling bubble chamber and matched it to the SLAC electron beam. This configuration extended by an order of magnitude the data flow available to physicists at many participating institutions. Ballam received a Guggenheim Fellowship, was a visiting scholar at Imperial College, London, the Ecole Polytechnique, Paris, and Columbia. He served on many committees for the US Department of Energy.

Throughout his long and productive life, Joe, as he was known to one and all, was esteemed for his acute intellect, kindness, and wisdom, as well as his steady and considered judgement. Although he often had to disappoint researchers who were vying for limited access to the SLAC accelerator, they always trusted that his decisions were wise and fair. He was a friend to all, and was always ready to provide whatever help and counsel that he could, both on a personal and a professional basis. He will be truly missed.

Wolfgang K. H. Panofsky

Hajime Ishimaru 1940 - 97

World renowned ultra-high vacuum expert Hajime Ishimaru died on 6 October 1997.

He pioneered the development of all the aluminium ultra-high vacuum materials for the successful TRISTAN electron-positron collider at the Japanese KEK laboratory. He studied nuclear physics and plasma physics at Hokkaido, Tohoku and Nagoya, and received one doctorate from Nagoya for his research on plasma physics and another from Tokyo for work on vacuum feedthrough in ultra-high vacuum and cryogenic environments.

After working on plasma and molecular beams for several years as

Hajime Ishimaru 1940 - 97

a Tokyo research associate, he joined KEK in 1972 and went on to make distinguished contributions to all the KEK accelerators, particularly their vacuum systems.

His monumental contribution to the all-aluminium TRISTAN vacuum system was the result of his expertise and passion for invention. During the past 25 years at KEK, he made many inventions in the field of ultra-high vacuum, with about 40 registered patents and over 100 pending.

He was also a technical consultant to numerous accelerator projects worldwide such as the Korean POSTECH 2 GeV synchrotron radiation source, DAFNE at the Italian Frascati laboratory, the Taiwanese 1.5 GeV synchrotron (SRRC), Spring-8 in Japan, and the terminated American SSC main ring vacuum tube. He also served as a member of the editorial board for the British Journal "Vacuum". Dr. Ishimaru received numerous awards and honours, including recognition from the American Vacuum Society, the Vacuum Society of Japan, and the British Vacuum Society.

His sudden death is an immeasurable loss not only to KEK but also to the world high energy community. His enchanting smile and generous heart are greatly missed.

CERN retirements

The end of 1997 marked the formal retirement of several prominent CERN staff members.

Research physicist Alan Wetherell joined CERN in June 1959, and went on to participate in a series of early experiments by a group working at the then new Proton Synchrotron. After studies at the Serpukhov accelerator in Protvino in the late 1960s and at the start-up of CERN's Intersecting Storage Rings in the early 1970s, Alan Wetherell became head of this group when Giuseppe Cocconi became a Director of CERN. The group became interested in weak interactions and joined with Klaus Winter to form the CHARM neutrino collaboration (CERN-Hamburg-Amsterdam-Rome-Moscow). Alan was appointed CERN's Experimental Physics Division Leader in 1981 and served for three and a half years. Subsequently he joined Ugo Amaldi and Jim Allaby in the Delphi collaboration at LEP, eventually taking responsibility for the hadron calorimeter which was mainly constructed under his guidance by a Russian team. His election as a Fellow of the UK Royal Society (FRS) signifies distinguished contributions to physics.

Fritz Ferger - retiring after 39 years at CERN

Having joined the laboratory in February 1959, Fritz Ferger's career at CERN lasted exactly 39 years. After studies in Stuttgart and Grenoble, he began at CERN in the Proton Synchrotron Accelerator Research Group under Arnold Schoch, where he soon became involved in development work for future storage rings. With the establishment of the Intersecting Storage Rings (ISR) Division in 1964, he was in charge of development and construction of power for the radiofrequency acceleration system. With the ISR operational in 1971, he became head of the ISR General Engineering Group, and in 1974 Head of ISR Division, where he remained until 1982. In 1983 he became Head of CERN's new Technical Inspection and Safety Commission, and in 1986 Head of the new Technical Support Division. When he stepped down from this post in 1997, he had spent 23 years as a CERN Division Leader.

At his retirement, he said 'If I wish to retain one single lesson, I would like to underline the importance and value of the existence of a dedicated group of inspired and enthusiastic physicists and engineers who explore what future accelerators and detectors should look like, what mechanisms and tools could be

During the visit of Hungarian President Arpad Goncz to CERN on 11 November, Michel Della Negra explains the workings of the CMS experiment for CERN's LHC proton collider.

Former SLAC Director Wolfgang ('Pief') Panofsky gave several seminars at CERN in November.

invented, readied and employed to unlock the secrets of Nature'.

Massimiliano Ferro-Luzzi took his Laurea *at La Sapienza in Rome in Edoardo Amaldi's nuclear emulsion group, carrying out pioneer work on antiproton reactions using emulsions exposed to beams from the Bevatron at Berkeley. Moving to Berkeley, he spent three years in Alvarez' legendary group before joining CERN's Track Chamber division in 1963.*

Prominent among many his bubble chamber experiments was the study of baryon resonances. At Berkeley Max played an important role in the discovery and elucidation of hyperon resonances, providing valuable input to the quark model. Max continued this research at CERN for over a decade, organizing several European collaborations studying kaon-nucleon collisions. These impressive results helped prepare the way for unitary symmetries. His career then turned from bubble chambers to electronic detectors, with tests on the first ICARUS prototype, the JETSET experiment at LEAR and the guidance of the first steps of the DIRAC experiment at the PS. Max served as secretary of CERN's Research Board from 1984 to 1997.

Intellectually strict, tempered by a degree of pragmatism in interpreting experiments, Max is a keen advocate of linguistic precision, has a highly individual view of the world and cultivates a scathing sense of humour.

Meetings

The 14th International HADRONS Conference, organized by the Bogolyubov Institute for Theoretical Physics, Ukraine Academy of Sciences, and dedicated to strong interaction at high energies (theory and experiment), will be held on the southern coast of the Crimea (Ukraine) from June 21-26. The coverage includes: large rapidity gap physics, polarization, spectoscopy and heavy flavours, collective properties of nuclear matter - with emphasis on future collider experiments - as well as advances in quantum field theory. Invited speakers include: V.Fadin, B.Gerasimov, W.Greiner, A.Kaidalov, B.Kopeliovich, L.Lipatov, U.Maor, N.Nikolaev, A.Slavnov, H.Stoecker. More information from: HADRONS, ITP, Kiev-143, Ukraine; fax: ++38 44 2665998; phone: ++ 38 44 2669123; E-mail: jenk@gluk.apc.org; http://www.gluk.apc.org/hadrons

The 8th European Symposium on Semiconductor Detector, to be held at Schloß Elmau, Germany from June 14 - 17, will cover new developments in the field of radiation detectors. The conference programme covers particular detector concepts, readout electronics, device physics, detector technology, defects in base materials and devices and new applications for semiconductor detectors. Further information from the conference secretary: Irmgard Helfrich (Ms), MPI Halbleiterlabor, Paul-Gerhardt-Allee 42, 81245 München, Fax: 089/839400-11, e-mail: sds@mpe-garching.mpg.de, WWW: http://www.hll.mpe-garching.mpg.de/sds98

The Xth International Symposium on Very High Energy Cosmic Ray Interactions will be held from July 12-17 at the Laboratori Nazionali Del Gran Sasso, Assergi (Italy). Secretariat: E.Fantozzi, Laboratori Nazionali del Gran Sasso, INFN, 67010 Assergi (AQ) - Italy Phone: +39-862-437236; Fax: +39-862-437570; E-mail: FANTOZZI@LNGS.INFN.IT WWW HTTP://WWW.LNGS.INFN.IT/ choosing "Meetings and Seminars" and "ISVHECRI 98".

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)
München, Germany

We invite applications from recent Ph.D. graduates for two post-doctoral positions in

Experimental High Energy Physics

The initial appointments are made for two years with the possibility of renewal for up to a total period of five years. The positions are available now.

Our group has been engaged in the design and construction of the H1-detector at HERA and is actively participating in the data taking and the analysis of the data with focus on testing QCD at low and high Q^2. We are also engaged in the upgrading of the detector (liquid argon calorimeter and trigger, second level neural network trigger).

We expect that the persons appointed will participate in exploiting the physics potential of the H1 detector as well as in its maintenance, operation, and upgrade program.

Candidates should submit a curriculum vitae and arrange to have three letters of recommendations sent directly via normal or electronic mail and as soon as possible to:

Prof. G. Buschhorn
Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)
Föhringer Ring 6
D-80805 München
(email: gwb@mppmu.mpg.de)

STAFF PHYSICIST

The **Ernest Orlando Lawrence Berkeley National Laboratory** has an excellent opportunity for an innovative theoretical physicist. Under the direction of the Head, Center for Beam Physics, you will organize analysis and computation in laser-plasma-beam physics, free electron lasers, radiation sources and optics. The selected candidate will support the CBP program, ensuring adherence to environmental, health and safety regulations, and publish/present research results. Responsibilities will include collaborating with physicists, engineers and technical support teams and providing direction and guidance to related personnel.

Requires a Ph.D. in Physics or equivalent and extensive, broad experience in laser-beam-plasma physics and radiation sources/FELs. You must have a thorough knowledge of particle beams, lasers, plasmas, electromagnetic radiation and radiation sources/interactions. A self-directed professional with excellent analytical, computational and communication skills is essential.

Please e-mail resume with cover letter and **Job# AFR5627/JCERN** to: **employment@LBL.gov** or fax to: **(510) 486-5870** or mail to: **Ernest Orlando Lawrence Berkeley National Laboratory, Staffing Office, Job# AFR5627/JCERN, One Cyclotron Road, MS 938A, Berkeley, CA 94720**. Visit our web site at **www.lbl.gov**. Berkeley Lab is an equal opportunity employer committed to the development of a diverse workforce.

BERKELEY LAB

Michel Besse, centre, French Préfet de Région Rhône-Alpes (which includes the CERN site on French territory) hears an explanation from senior CERN physicist and at the time spokesman for the Delphi experiment, Daniel Treille (left). With them is Manfred Buhler-Broglin, administrator of CERN's LHC project.

Visiting Thessaloniki, Greece, from 25 September to 30 November, CERN's new Travelling Exhibition was a major success.

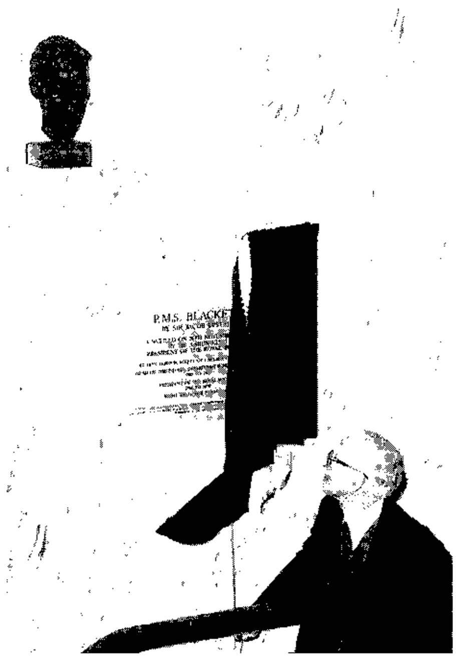
INPC98

The 1998 International Nuclear Physics Conference (INPC) will be held from August 24 - 28 at UNESCO, Paris.

This conference belongs to the series sponsored by the International Union of Pure and Applied Physics (IUPAP) held every three years. The last conferences were held in Beijing (1995), Wiesbaden (1992) and Sao-Paulo (1989). It will cover all areas of nuclear physics research and its applications with special emphasis on new directions and new opportunities. It will also celebrate the Centennial of the discovery of radioactivity by Henri Becquerel, and of the first radioactive elements by Pierre and Marie Curie. Special emphasis will be placed on the impact of nuclear science on society.

The Conference, with plenary, parallel and poster sessions, should give participants a broad vision of nuclear physics at the turn of the century. Speakers will emphasize concepts, recent developments, future progress and perspectives at the world level. Plenary talks should be understandable by physicists who are not specialists in a specific research domain. Specialized presentations will be held in parallel and poster sessions. Chairman is B. Frois (Saclay).

Further information: Frederique Dykstra, Institut de Physique Nucleaire, 91406 Orsay Cedex (France), Tel: +33 (0) 1 69 15 73 18 Fax: +33 (0) 1 69 15 44 75 or 64 70, e-mail: inpc98@in2p3.fr http://www-dapnia.cea.fr/Inpc98



President of the UK Royal Society Sir Aaron Klug unveils a bust of P.M.S Blackett by Jacob Epstein in the Blackett Laboratory of London's Imperial College to mark the centenary of Blackett's birth.

(Photo Nick Jackson, Blackett Publications)

Expo travelogue

With the Greek city of Thessaloniki acting as Europe's 1997 Cultural Capital, the Laboratory of Nuclear and Particle Physics of the Physics Department of the Aristotle University of Thessaloniki hosted CERN's new Travelling Exhibition.

From 25 September to 30 November the exhibition proved a major success, attracting some 12,000 enthusiastic visitors, including some 8,000 from over 100 schools in Northern and Central Greece.

After a spell at CERN in December, the exhibition packs its bags this year for a comprehensive tour of Scandinavia. Already booked are Heureka in Vantaa, Finland, from 12 February to 22 March, Stockholm's Teknorama from 2 April to 31 May, Copenhagen's Experimentarium from 24 September to 8 November and Oslo's Teknoteket from 19 November to January 1999. The summer schedule has yet to be concluded.

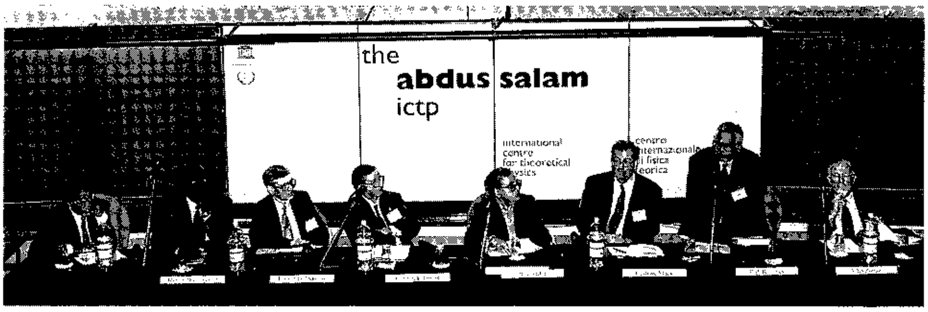
Who needs Quarks and Higgs?

This was the title of an exhibition in Vienna from 6 - 27 November 1997 to mark the 150th anniversary of the Austrian Academy of Science, the

At the inauguration of the 'Who needs Quarks and Higgs?' expo in Vienna to mark the 150th anniversary of the Austrian Academy of Science. Left to right, exhibition organizer Meinhard Regler (Vienna), CERN Accelerator Director Kurt Hübner, and expo coordinators Ray Lewis (CERN) and Christian Gottfried (Vienna).

main sponsor of particle physics research in Austria. Its aim was to publicize recent results and underline the relevance and achievements of this science, with the accent on Austria.

An online connection to the WIRED system enabled presentation of actual electron-positron annihilations as seen by the Delphi experiment at CERN's LEP machine, and 'Schafft Wissen', a pioneer virtual reality scientific universe. CERN supported the exhibition by providing accelerator and detector modules, and a spark chamber showing the flux of cosmic rays.



Above: At a special memorial meeting to mark the first anniversary of the death of the Pakistani theorist and Nobel Prizewinner Abdus Salam, the International Centre for Theoretical Physics, Trieste, which he founded in 1964, was renamed in his honour. The Centre is a major focus for the world theoretical physics community.

Below: One of the guests of honour at the special Abdus Salam memorial meeting at the Abdus Salam International Centre for Theoretical Physics, Trieste, was Albanian President and theoretical physicist Rexhep Meidani (right), seen here with the centre's Director Miguel Virasoro.

A recent symposium on particle physics and neural computation at Tel Aviv University marked the 60th birthday of distinguished theorist David Horn (left); with (centre) particle symmetry pioneer Yuval Ne'eman, past president of Tel Aviv University and founder of the School of Physics and Astronomy; and Gabriele Veneziano of CERN, whose 1968 fruitful formulation of duality opened the way to new insights. Veneziano's talk at the symposium covered the evolution of duality in particle physics from the landmark 1967 Dolen-Horn-Schmid paper to today's compelling multi-dimensional string and 'brane' physics.

A special symposium at Kaiserslautern recently marked the 60th birthday of theorist Werner Rühl, who has also been a frequent visitor to CERN.

CERN Courier contributions

The Editor welcomes contributions. These should be sent via electronic mail to cern.courier@cern.ch

Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland).

Contributors, particularly conference organizers, contemplating lengthy efforts (more than about 500 words) should contact the Editor (by e-mail, or fax +41 22 782 1906) beforehand.

At an unscheduled stop on the way from Oslo to the recent CERN Accelerator School (CAS) at Gjørik in Norway, Joel Le Duff of Orsay demonstrates how to change a bus fan belt under the watchful eye of CAS Leader Ted Wilson. As well as fixing fan belts, Joel is also the longitudinal dynamics mainstay of the school's team of lecturers.

POSTDOCTORAL RESEARCH ASSOCIATES
JUNIOR STAFF

The Nuclear Theory Group in the Physics Department at Brookhaven National Laboratory expects to have positions available at the Postdoctoral Research Associate and/or Junior Staff levels. The initial appointments would begin September 1, 1998. The Nuclear Theory Group has active programs in the theory of heavy ion collisions at ultrarelativistic energies and in the structure of nuclear physics. Applicants should send a *curriculum vitae* including names and addresses of three references to Dr. Robert D. Pisarski, Group Leader, Department of Physics, Bldg. 510A, Brookhaven National Laboratory, Upton, Long Island, New York 11973. BNL is an equal opportunity employer committed to workforce diversity.

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Postdoctoral Positions in Accelerator Physics

Applicants are invited to take part in one of the fields below

- design and measurement of magnets for accelerators and experiments including development of field sensors and their electronics for field controlled power supplies **(Ref. 61120-98.1)**
- development of the heavy ion synchrotron SIS for higher beam intensities and design studies for a new high current synchrotron/storage ring facility **(Ref. 64600-98.2)**
- development of ECR ion sources for highly charged heavy ions **(Ref. 64300-98.3).**

Applicants should have experience in the corresponding field.

The appointments will be limited to 3 years with a possible extension to a maximum of 5 years. Applicants should not be older than 32 years.

Women are especially encouraged to apply for these positions. Handicapped applicants will be given preference to other applicants with the same qualification.

Applications should be submitted not later than February 20, 1998, to

GESELLSCHAFT FÜR SCHWERIONENFORSCHUNG MBH
PERSONALABTEILUNG
PLANCKSTR. 1
64291 DARMSTADT

SUPERCONDUCTING MAGNET TECHNOLOGY
ACCELERATOR PHYSICS
TEXAS A&M UNIVERSITY
POSTDOCTORAL RESEARCH POSITION

Applications are invited for a post-doctoral position in superconducting magnet technology and accelerator physics. The accelerator research group at Texas A&M University is developing a 16 Tesla dual dipole for future hadron colliders, a superconducting magnet for oil well logging, and a stabilized cable using high temperature superconductor.

Applicants should have a Ph.D. in physics or allied subject, and good knowledge of superconducting technology and/or accelerator physics.

Interested persons should send a resume and arrange for three letters of reference to be sent to:

Prof. Peter M. McIntyre
Department of Physics
Texas A&M University
College Station, TX 77843

Applications should be received by March 15, 1998. Texas A&M University is an Affirmative Action/Equal Opportunity employer, committed to diversity.

DESY announces several

"DESY-Fellowships"

for young scientists in experimental particle physics to participate in the research mainly with the HERA collider experiments H1 and ZEUS or with the fixed target experiments HERA-B and HERMES. New fellows are selected twice a year in April and October.

DESY Fellowships in experimental particle physics are awarded for a duration of two years with the possibility for prolongation by one additional year.

The salary for the fellowship is determined according to tarifs applicable for public service work (IIa MTV Ang.).

Interested persons, who have recently completed their Ph.D. and who should be younger than 32 years are invited to send their application including a résumé and the usual documents (curriculum vitae, list of publications, copies of university degrees) until 31 of March 1998 to **DESY, Personalabteilung - V2 -, Notkestraße 85, D-22607 Hamburg**. They should also arrange for three letters of reference to be sent until the same date to the address given above.

Handicapped applicants with equal qualifications will be preferred.

DESY encourages especially women to apply.

As DESY has laboratories at two sites, in Hamburg and Zeuthen near Berlin, applicants may indicate at which location they would prefer to work. The salary in Zeuthen is determined according to II a, BAT-O.

Head Laboratory Services

Fermi National Accelerator Laboratory (Fermilab), a renowned national laboratory dedicated to high energy physics research, has an exceptional professional opportunity available to lead one of its four major administrative service sections.

The seasoned professional we seek will support the operational needs of the Laboratory through the management of our Accommodations, Employment and Travel, Equal Opportunity, Human Resources, Medical, and Visual Media service functions. Additional responsibilities will include conducting management studies; developing and assessing quality assurance procedures; evaluating project development efforts for the modification of new administrative service features; and serving as the corporate pension plan administrator.

As a member of the Laboratory's management team and senior HR administrator, the qualified candidate will possess at least 10 years of relevant experience and the ability to interface with all levels of employees, U.S. Department of Energy (DOE) representatives, and stakeholders on a wide range of issues. Facility with modern management techniques, including team building, is also necessary. Some travel will be required.

Operated by Universities Research Association, Inc. for the U.S. DOE, Fermilab is located 40 miles west of downtown Chicago and offers an attractive compensation package. For consideration, please send a resume to: **Employment Department/970157, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510-0500, U.S.A.** *Principals only. No phone calls, please.* To access Employment Opportunities at Fermilab and a complete description of this position, our URL is **[http://fnalpubs.fnal.gov/employ/jobs.html]**. EOE M/F/D/V.

Fermilab

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Lecturer in Experimental Particle Physics

As part of a programme of expansion in particle physics, a permanent lecturer post will be available from September 1998.

You would join a highly successful group, currently 25 members, including four academic staff, working on a research programme based on the ALEPH experiment at LEP, the BaBar experiment at SLAC and ATLAS at the LHC. We are also contributing to studies for a possible linear collider. You will be expected to participate in one of these projects and to contribute to the undergraduate and postgraduate teaching programmes of the Physics Department. Further expansion of the group is anticipated in the future and you will help in attracting support. Salary on Lecturer A Scale: £18,179 - £23,150 (including London Allowance).

Further details about the group and its research programme can be found on the World Wide Web (http://www.hep.ph.rhbnc.ac.uk). Informal enquiries may be made to Professor M G Green, Physics Department, Royal Holloway, University of London, Egham, Surrey TW20 0EX; telephone +44 (0)1784 443454, fax +44 (0)1784 472794, email m.green@rhbnc.ac.uk

Application forms and further particulars are available from the Personnel Office, Royal Holloway, University of London, Egham, Surrey TW20 0EX; telephone +44 (0)1784 443030, fax +44 (0)1784 473527, email s.watson@rhbnc.ac.uk Please quote reference MHA/1353.

Closing date for receipt of applications is 6th March 1998.

We positively welcome applications from all sections of the community.

Universität Zürich

The Faculty of Sciences (Philosophische Fakultät II) of the University of Zürich invites applications for a faculty position in

Experimental Physics
Physics of Fundamental Systems

at the Physics Institute. The appointment will be made at the associate (Extraordinarius) professor level. There is a preference for candidates working in a field of Fundamental Systems like Astroparticle Physics, Atomic Physics, Gravitation, Neutrino Physics or at the medium energy facilities of the Paul Scherrer Institute (PSI). Candidates should have demonstrated their ability to carry out independent research. The research topic should complement the activities of the existing particle physics groups working at DESY, CERN and PSI.

The successful applicant is expected to participate in the teaching of basic courses in general physics and of particle and nuclear physics. The requirements are pedagogical experience, thesis and Habilitation or an equivalent qualification. Applicants should send their curriculum vitae (publication list indicating the five most important publications, a short statement of research interests, research plan, and teaching experience) before March 20, 1998 to the

Dekan der Philosophischen Fakultät II der Universität Zürich, Prof. Dr. H. Haefner, Winterthurerstr. 190, CH-8057 Zürich.

For further information please contact Prof. Dr. R. Engfer, phone +41 1 635 5720, fax + 41 1 635 5704. Suggestions for suitable candidates are welcome.

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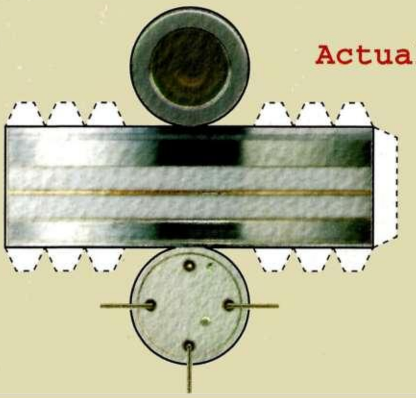

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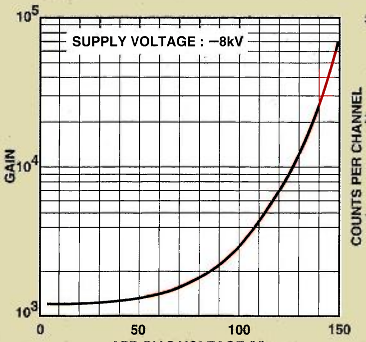

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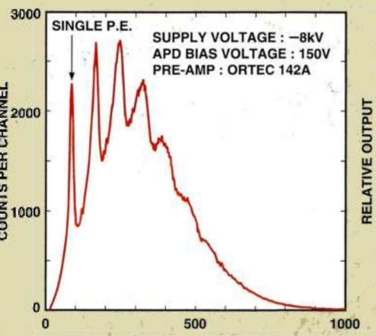

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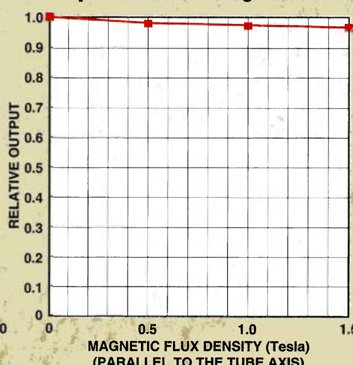

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