CERN COURIER

International journal of high energy physics

VOLUME 38 6 SEPTEMBER 1998

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CERN COURIER is published monthly except January and August in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management.

Printed by: Drukkerij Lannoo nv
8700 Tielt, Belgium

Published by:

European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
tel.: +41 (22) 767 61 11,
telex: 419 000 CERN CH,
telefax: +41 (22) 767 65 55

CERN COURIER only:
tel. +41 (22) 767 41 03,
telefax +41 (22) 782 19 06

USA: Controlled Circulation
Periodicals postage paid at St. Charles, Illinois

ISSN 0304-288X

Volume 38
No. 6
September 1998

Covering current developments in high energy physics and related fields worldwide

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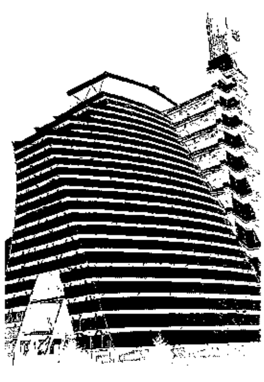
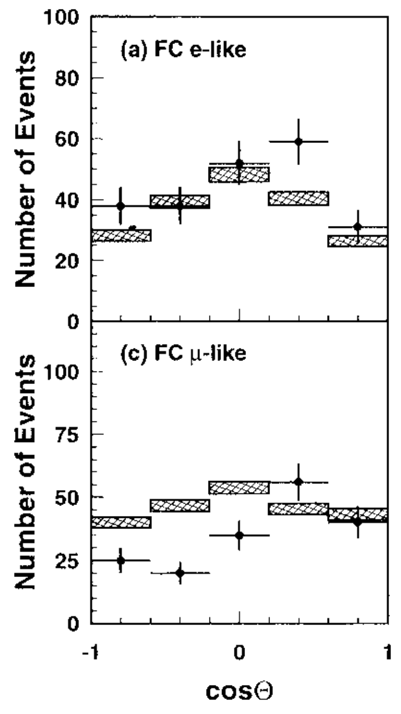


Cover photograph: Among the scientific installations in the central Asian republic of Uzbekistan is the 1000KW solar furnace at Parkent near Tashkent which includes over 5000 square metres of reflecting and focusing mirrors, achieving a temperature of 2500C. Uzbekistan is one of the newer recruits to the club of CERN users (see page 13).

Neutrino monitor

Neutrino data from the Superkamiokande neutrino detector for electrons (top) and muons (below), with the data points (crosses) compared to the prediction (shaded boxes). In the muon case, the number of upward-coming neutrino interactions (cosine -1) is very different to those coming down (cosine 1).



Neutrinos once more hit the headlines when the international Neutrino 98 meeting held in Takayama, Japan, in June was the stage for an announcement of evidence for neutrino mass and neutrino oscillations. Several observers commented that here was the first positive sign of physics beyond the orthodox Standard Model.

Neutrinos with mass: What comes up doesn't come down

The most inactive of all known subatomic particles, neutrinos were thought to come in three immutable types, associated with the trio of weakly interacting particles - electron, muon and tau - and for long were thought to be massless (see page 9). If the new evidence is correct, neutrinos are not immutable and do carry vestigial mass.

Although greeted in the popular press as a new discovery, the latest neutrino evidence is the continuation of a story which began in 1967 when Ray Davis began watching for the arrival of neutrinos from the Sun and soon began to report that he was not seeing as many neutrinos as expected. Some 12 years ago, other underground neutrino experiments began to report other kinds of neutrino deficit. With neutrino effects so difficult to measure, these effects were difficult to confirm, but the whisper of disappearing neutrinos (see page 11) has been echoing in the background ever since.

The latest evidence comes from the big Superkamiokande detector, 1000 metres underground in a Japanese mine, where up to 50,000 tonnes of water provides a target for natural neutrinos. 13,000 large photodetectors pick up the tiny light flashes produced by the interactions. Some of these neutrinos are the by-products of high energy cosmic rays crashing into the Earth's atmosphere, producing pions and kaons. As such there should be twice as many muon-type neutrinos as electron-type.

In the 1980s, big underground experiments, initially built to search for signs of proton decay, began to scan the neutrino sky. The Kamiokande precursor of Superkamiokande and the IMB and Soudan detectors in the United States saw what came to be called the 'atmospheric neutrino anomaly' - the observed ratio of muon- to electron-type neutrinos was less than the expected value of two.

This could have been explained by various background effects, but fresh data reported last year from Superkamiokande (September 1997, page 25) increased the belief that this was due to physics, not background.

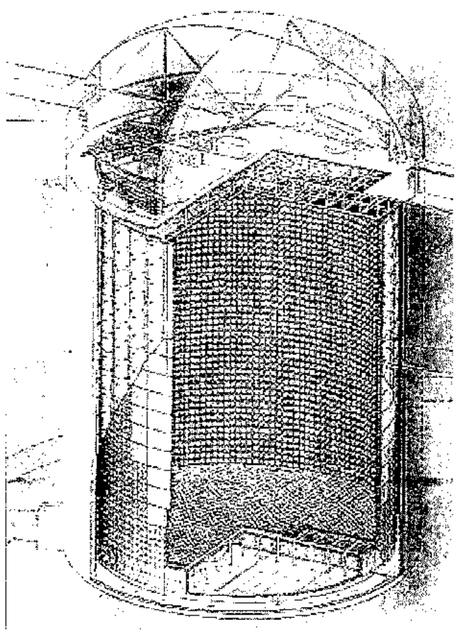
Over 540 days, Superkamiokande has now accumulated some 47000 neutrino interactions. The large detector enables physicists to intercept higher energy muon neutrinos better than before. Muons from muon-neutrino interactions are distinguished from electrons by the Cherenkov light signals picked up by the surrounding photomultipliers.

The muon neutrino deficit is still there, and is most marked for neutrinos arriving in the target from below, which have passed right through the Earth before interacting in the water tank. Similar effects are reported from other experiments (see next story).

With such a clear-cut effect difficult to explain otherwise, the spotlight falls on oscillations - neutrinos begin their life as muon-type high up in the atmosphere but gradually change their composition en route. The upward neutrinos, which have travelled 13,000 km through the Earth, have had most chance to disguise themselves.

With physicists suspecting that neutrinos oscillate, experiments have long been looking for signs of such a phenomenon. Late last year, the international Chooz experiment at a French nuclear reactor (January, page 5) reported a study of electron-neutrino interactions whose results effectively rule out electron-to-muon neutrino oscillations under the conditions explored by Super-K. The atmospheric neutrino anomaly appears to be due to oscillations between muon neutrinos and another type, most probably tau neutrino. The

Schematic of the underground Superkamiokande neutrino detector, 40 metres high and 39 metres in diameter, containing 50,000 tonnes of water and 13,000 large photodetectors to pick up the light produced by neutrino interactions.

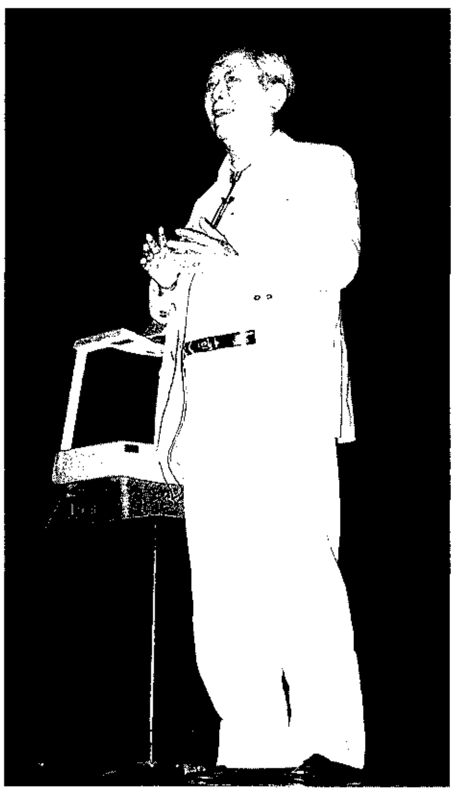


effect depends on the difference in mass squared, corresponding to a mass difference of about a ten millionth of the mass of the electron.

Meanwhile physicists at Super-K and other neutrino telescopes eagerly scan their incoming signals for fresh signs of this and other intriguing phenomena. However with Japan reeling under increased spending cuts in the public sector, running restrictions at scientific experiments, including Super-K are being called for.

The new neutrino effects provide new motivation for 'long baseline' terrestrial neutrino experiments, where beams of high energy neutrinos derived from particle accelerators are aimed at targets hundreds of kilometres away. The Japanese K2K study using the Superkamiokande detector (July, page 7) 250 kilometres from the neutrino source at the KEK laboratory, will begin to take data next year. In the US, a Fermilab neutrino beam will be directed towards a detector in the Soudan mine in Minnesota 730 kilometres away, while in Europe the possibility of firing neutrinos from CERN towards a detector in the Italian Gran Sasso underground laboratory, 732 kilometres distant, has also been extensively studied.

This accumulated neutrino evidence provides a first chink in the solid armour of the Standard Model, which is usually taken to imply that neutrinos are massless. Can neutrino mass be incorporated into the Standard Model, or are these masses the first sign of physics beyond? Whatever the outcome, it will first need more neutrino data.



Masatoshi Koshiba addresses the Neutrino98 meeting in Takayama, Japan. The meeting featured new evidence for neutrino mass and oscillations from the Japanese Superkamiokande underground detector. Koshiba, a pioneer of the original Kamiokande experiment, last year received Japan's prestigious Order of Cultural Merit for his key work in neutrino astronomy, particularly Kamiokande's observation of neutrinos from the 1987A supernova.

CONFERENCE REPORT Neutrino98

'Neutrinos need patience and longevity', remarked Pierre Ramond of Florida in his introductory talk at the Neutrino98 conference in Takayama (Japan) from 4-9 June.

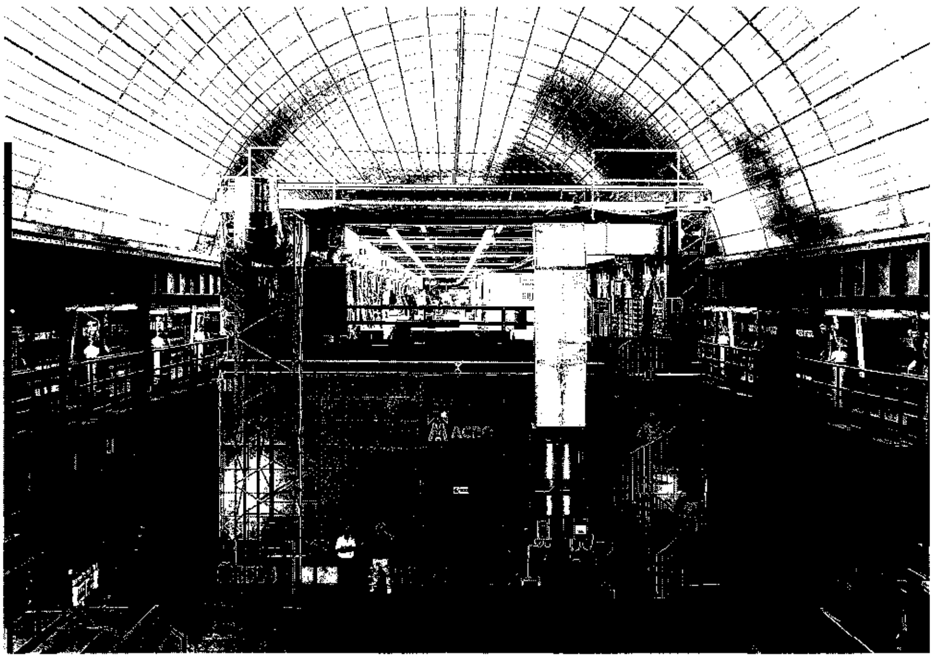
Following Wolfgang Pauli's neutrino hypothesis in 1930, Bruno Pontecorvo's 1945 proposal for a radiochemical detector using chlorine was the first attempt to conceive experimental neutrino physics. Its birth came with the first observation of neutrino interactions by Reines and Cowan in 1956.

Since then, the neutrino has continually fascinated physicists. Throughout its history, the particle has provided regular moments of great excitement to patient scientists confronting the challenge of difficult and delicate experiments.

The discovery of parity violation and the first experimental evidence of the Standard Model, with the discovery of neutral currents, are examples of how the neutrino is also an incisive tool to a better understanding of the physics of elementary particles and fundamental interactions.

Neutrino98 showed clearly that the

The full MACRO detector in the Italian Gran Sasso underground laboratory, with 6 supermodules in an array 77 metres by 12 by 9 has been taking data for some three years and provides supporting evidence for neutrino oscillations. After event selection, the accumulated number of upward muons passing through the detector is significantly less than expected.



focus is again on understanding the intrinsic properties of the neutrino, now enriched by their implications for astrophysics and cosmology. The most fundamental question is whether its mass is zero, as generally assumed in conventional theories, or whether it has a finite though extremely small value.

The Takayama Conference, with the announcement of the Superkamiokande results (see page 1), supported by data from MACRO and Soudan-2, provided a new milestone in neutrino history. Motivated by fresh questions, new ideas and projects are foreseen. Neutrino physics needs this new investment not only to answer the new questions, but also to make its traditional longevity attractive to a new generation of physicists.

Solar neutrinos

In 1968, the pioneer chlorine radiochemical experiment at the Homestake mine saw less solar neutrinos than predicted by solar models. The effect could result from the possible transformation of solar neutrinos of the electron type into neutrinos of another type, not detectable by the experiment. This transformation may occur over long distances according to the quantum-mechanical phenomenon of neutrino oscillation proposed by Pontecorvo and independently by Maki, Nakagawa and Sakata. Homestake provided the first experimental evidence for a neutrino mass.

More precisely, neutrino oscillation experiments measure squared mass differences. The solar neutrino experiments indicate the existence of an oscillation partner of the electron neutrino, with a square mass difference as low as 10^{-5} eV^2.

The first Neutrino98 session was devoted to solar neutrinos and began with a report by K. Lande of Pennsylvania on improvements to the chlorine experiment and on the preparation of the new iodine experiment.

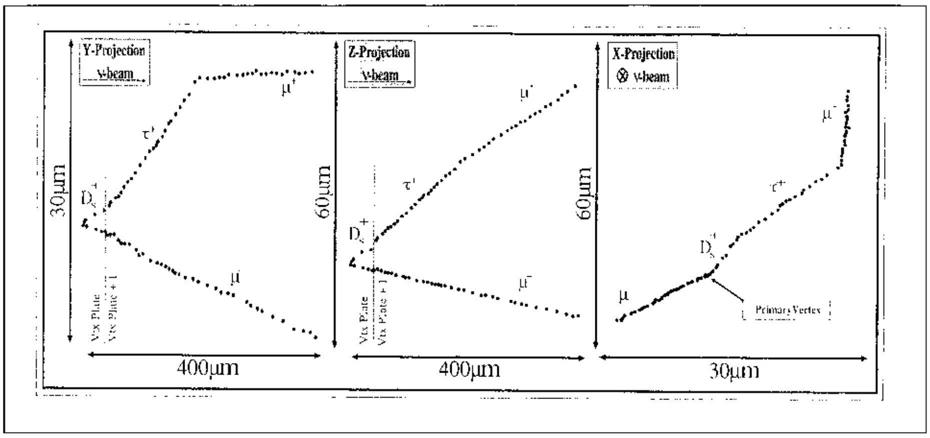
The next generation of radiochemical experiments, GALLEX at Gran Sasso and SAGE in Russia, lowered the energy threshold for neutrino detection and became sensitive to the primary nuclear reaction producing neutrinos in the Sun. Their confirmation of the solar neutrino deficit is thus less dependent on uncertainties in the underlying solar model. SAGE and GALLEX are refining their results with detector calibrations and are evolving towards "solar neutrino observatories".

The new SuperKamiokande underground detector in Japan is continuing the work of its Kamiokande predecessor, with a very impressive rate of solar neutrino interactions observed in 'real time' by its 50 kton water Cherenkov detector. The large number of events allows studies of relative effects (diurnal and seasonal), independent of the prediction of the absolute neutrino flux. Interesting results, presented by Y. Suzuki of Tokyo, are already coming from almost 100,000 events collected in 1996-98.

The Canadian SNO heavy water Cherenkov detector will soon be taking data (July, page 1). Its use of deuterium, hence protons and neutrons, will allow it to distinguish different neutrino types and provide further insight into the puzzle.

The Borexino experiment is under construction at Gran Sasso and new ideas are being tested or proposed, as reported by R.E. Lanou from Brown and R. Raghavan from Bell Labs. Meanwhile, as discussed by John Bahcall from Princeton, the solar neutrino model is being refined, agreeing with helioseismological data.

Meanwhile, theoretical studies are improving the understanding of the observations in terms of neutrino



In this unusual CHORUS event (from a sample of 87,000 events recorded in 1994) the event imaging capability of the emulsion technique clearly reveals, at the micron level and in three dimensions, details of D_s production by neutrinos and the successive decay chain including a tau. At the primary vertex on the left, two tracks emerge from a single emulsion grain without nuclear breakup.

oscillation and neutrino mass, as reported by S.T.Petcov from SISSA and A.Smirnov from ICTP, Trieste.

Atmospheric neutrinos

The major highlight of the Conference were the new Superkamiokande results, reported by T. Kajita of ICRR-Tokyo (see page 1). The anomalous ratio between events induced by muon and electron neutrinos observed earlier gave the first indication of atmospheric neutrino oscillation. The anomaly is observed by Superkamiokande both in the sub-GeV and in the multi-GeV data and is confirmed by the Soudan-2 results, reported by E. Peterson.

The most striking Superkamiokande result, based on fully and partially contained multi-Gev events, comes from the zenith angle dependence of the muons and electrons produced by neutrinos.

Muon neutrinos, unlike electron neutrinos, show a zenith angle dependence. Unless a fourth neutrino exists (necessarily sterile, since LEP tells that there are only three kinds of active neutrinos), this points to mixing between muon and tau neutrinos as the possible source of the observed phenomenon.

Atmospheric neutrinos are produced by cosmic rays interacting in the upper layer of the atmosphere. Hence the zenith angle tells the distance travelled before reaching the detector, neutrinos coming upward having travelled right through the earth. At the energies typical of atmospheric neutrinos, the oscillation length is therefore comparable to the Earth's diameter (13000 km) and allows an estimate of the neutrino mass.

The squared mass difference given by Superkamiokande is 2.2 x 10^{-3} eV^2. This is lower than the value previously given by Kamiokande but partially overlaps with it, accounted for by the rather large uncertainties of both experiments.

For the MACRO experiment at Gran Sasso, F. Ronga from Frascati reported a zenith angle dependence of upward muons passing through the detector, produced by neutrinos interacting in the earth or in the detector. This observation supports the Superkamiokande data.

Baselines

The oscillation probability of neutrinos that mix depends on the quantity Δm^2 L/E, where Δm^2 is the squared mass difference, L is the 'baseline' between neutrino production and observation, and E is the neutrino energy. Hence sensitivity to low masses requires a long baseline between neutrino production and observation.

The large L between the sun and the earth, or of the Earth's diameter, explains the successes of the solar and atmospheric neutrino experiments in being sensitive to low neutrino masses.

The next objective is long baseline experiments using the controlled conditions of man-made neutrinos. The first successes come from nuclear reactors, providing relatively low energy neutrinos, attaining high L/E values with only moderate baselines.

C. Bemporad from Pisa reported the ongoing refinements in the long baseline (about 1 km) CHOOZ reactor experiment (January, page 5) looking for the disappearance of electron antineutrinos. The experiment almost covers the atmospheric neutrino mass range. No disappearance of electron neutrinos provided the first indication that for atmospheric neutrinos the major oscillation partner of the muon neutrino is the tau (or a sterile) neutrino.

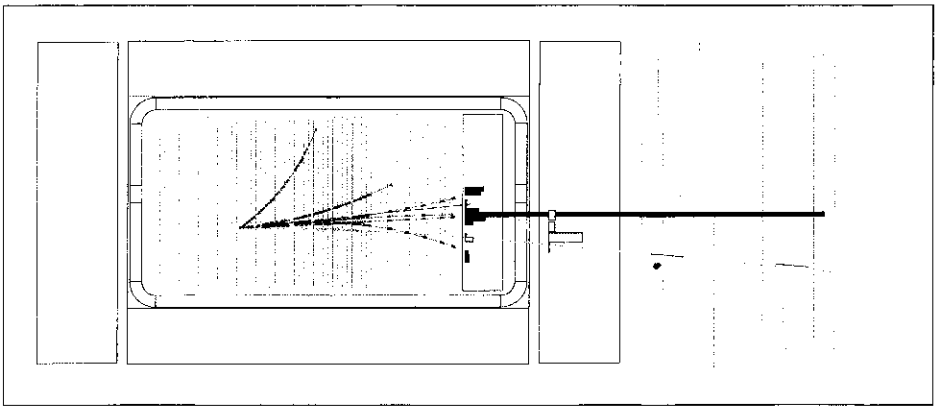
A similar experiment is in preparation at Palo Verde in the US.

The very ambitious Japanese KAMLAND proposal aims at Δm^2 values orders of magnitude lower, indicated by the solar electron neutrino oscillation signal. The KAMLAND large liquid scintillator detector should see, from Kamioka, a sizeable signal from neutrinos produced by reactors hundreds of kilometres away.

Atmospheric neutrinos give evidence for neutrino oscillation with a large neutrino mixing and with a squared mass difference of 10^{-3} -10^{-2}

A muon neutrino charged current interaction in the NOMAD neutrino experiment at CERN. The long track is a muon, the black histogram describes the energy deposition in the electromagnetic calorimeter: the very large bin is due to a lead glass block struck by a photon or an electron. The grey histogram refers to the energy deposition in the hadronic calorimeter.

The experiment uses a 2.7 ton fiducial mass target consisting of 44 drift chambers followed by transition radiation detectors and a lead glass electromagnetic calorimeter all located inside the old magnet from the historic UA1 experiment at CERN's proton-antiproton collider and complemented downstream by a hadronic calorimeter and muon chambers.



eV^2, presumably between the muon and the tau neutrino. The low energy of the atmospheric neutrinos is below threshold for the tau neutrino to become visible through production of the heavy tau lepton. Is the above mass range accessible with muon neutrino long baseline experiments? Since the electron neutrino now seems to be excluded as oscillation partner, the exciting challenge is to observe tau neutrino appearance in high energy accelerator experiments. Tau neutrino appearance would crown the present observations by positively identifying their origin. S.Wojcicki from Stanford and F. Pietropaolo from Padova presented the Fermilab-Soudan and CERN-Gran Sasso neutrino beam projects, with 730 km baseline and comparable beam performance.

The various experimental scenarios foresee the conventional but very massive detector MINOS at Soudan and the liquid argon ICARUS time projection chamber at Gran Sasso. The success of the emulsion target technique with CHORUS at CERN and DONUT at Fermilab (see later), as well as its unique feature for low background tau neutrino detection, have prompted the OPERA proposal for a massive lead-emulsion detector at Gran Sasso. MINOS now also envisages the use of emulsion.

Other ideas pursued at Gran Sasso range from experiments based on a calorimeter (NICE and NOE) to a focused ring Cherenkov detector (AQUARICH). Also presented at Takayama was the K2K project for a pioneer long baseline disappearance experiment, pioneer at energy below the tau production threshold, using a beam from the Japanese KEK laboratory to Superkamiokande. First muon neutrino data are expected next year.

Living with neutrinos

With three neutrinos and therefore two neutrino mass differences, the signal for a third neutrino mass difference from the LSND experiment at Los Alamos is creating some problems, leading to the invention of a fourth (sterile) neutrino. Using data collected in 1993-97, LSND confirmed its earlier claim to see oscillation of muon to electron neutrinos. However the results from the improved KARMEN experiment at Rutherford Appleton, presented by B.Zeitniz from Karlsruhe, see no evidence for the LSND signal.

The question whether the neutrino is one of the constituents of the Dark Matter in the universe and its implications for the expansion of the Universe following the Big Bang needs an answer from particle physicists. This means searching for tau neutrino masses in the 10 eV range and with very small neutrino mixings, hence short baseline experiments.

Experiments at CERN are making a major effort to see if tau neutrinos with 'cosmological' masses appear from muon neutrino beams. As reported by O. Sato from Nagoya, the "hybrid" (emulsion and electronic detectors) experiment CHORUS at CERN is gradually approaching its design sensitivity, corresponding to an oscillation probability in the 10^{-4} range. The renaissance of the emulsion technique stems largely from the development of automatic emulsion scanning in Nagoya.

Results were also presented by J.J.Gomez-Cadenas from CERN/ Valencia for the CERN NOMAD experiment, using an entirely electronic detector and relying on high quality event reconstruction and background rejection by kinematical cuts. Future projects for short baseline oscillation searches were presented by L. Camilleri from CERN.

A tau neutrino signal in CHORUS and NOMAD would at the same time 'discover' it (as Reines and Cowan did in 1956 with the electron neutrino) and give evidence for its mass. With the tau neutrino so far having escaped direct observation, the DONUT beamdump experiment at Fermilab aims at its discovery. M. Nakamura from Nagoya presented preliminary results, with a tau neutrino candidate. The experience gained in DONUT with a lead-emulsion sandwich introduces the technique as a candidate for long baseline tau neutrino searches.

In the same physics session, the NUTEV experiment at Fermilab presented a measurement of electroweak mixing which comple-

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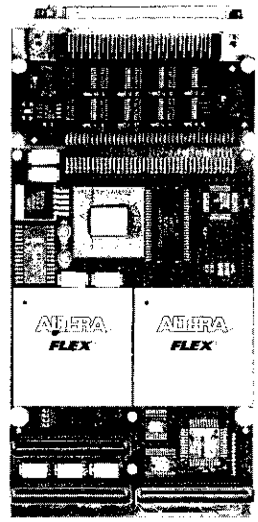

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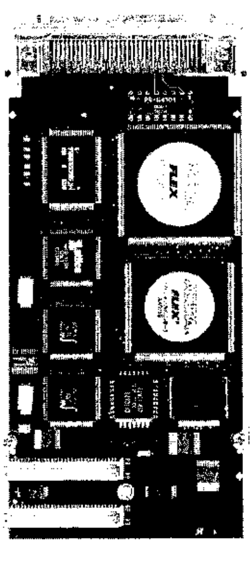

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ments, in the neutrino sector and with remarkably comparable precision, the high energy measurements at LEP at CERN and provides a further stringent test of the Standard Model.

At the Bugey reactor the MUNU experiment is taking data for the measurement of the very low neutrino magnetic moment favoured by energies below 1 MeV.

One new perspective for the future is intense neutrino beams at muon colliders.

Non-accelerator experiments

Although with lower sensitivity than with oscillation experiments, a signal for massive neutrinos could come from the kinematics of beta-decay, the process which originally revealed the need for neutrinos. C.Weinheimer and V.M.Lobashev from the Mainz and Troitsk experiments respectively (with innovative experimental techniques) presented new limits on the electron neutrino mass, at the 3 eV level.

The Troitsk experiment observes an intriguing anomaly in the energy spectrum, consistent with the less statistically significant Mainz data. The anomaly consists of a monochromatic energy line superimposed to the normal beta-decay spectrum. The time dependence of the anomaly shows a sinusoidal behaviour with a half-year period. Could it be explained by the capture of relic neutrinos trapped along the earth's orbit?

The only possible way to learn about the neutrino mass and its possible Majorana nature (see next story) is to search for double-beta decay without neutrinos in the final state. A Majorana neutrino would give important constraints on new physics. New results by several experiments, leading to a 0.2-0.5 eV limit for the effective electron neutrino mass, were reviewed by A.Morales from Zaragoza. Ideas have been presented for new searches, aiming at sensitivity of the order of 0.01 eV.

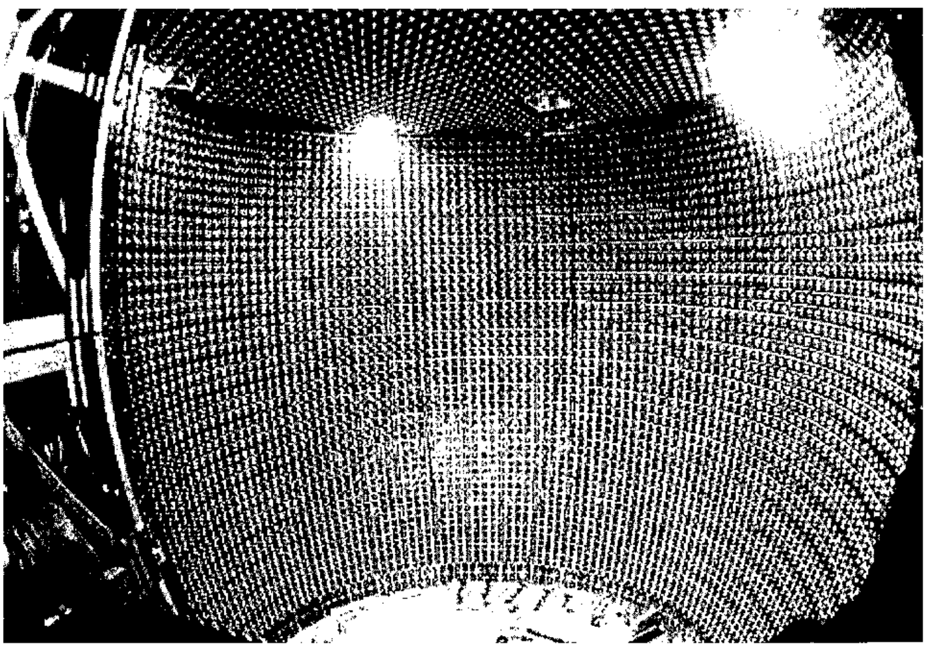
Recent direct and indirect searches for dark-matter, reported at Takayama, do not exclude a massive neutrino as a possible component of the dark matter. It has been also shown that the detailed implications of a massive neutrino could help explain the baryon asymmetry of the Universe.

As reviewed by R.J. Protheroe from Adelaide, high-energy neutrinos are a unique tool for studying regions of the Universe shielded by large amounts of matter. Experiments based on the detection of the Cerenkov light from muons or showers produced by neutrinos interacting in deep water or ice are taking data (at Lake Baikal in Siberia and the Antarctic AMANDA experiment) or under study (NESTOR and Antares in Europe).

J. W. Cronin closed the session with a review of the field of extremely high energy cosmic rays and neutrinos, and presented the large Pierre Auger project, based on shower detection on the ground.

Theory

Such impressive experimental activity is reflected in theory. Studies beyond the Standard Model, in the field of Grand Unification Theories (GUT), are very active. T. Yanagida from Tokyo, J. Pati from Maryland and C. H. Albright from Illinois/ Fermilab presented several models based on Grand Unified Theories



A wall of the Superkamiokande neutrino detector containing about 9000 photodetectors.

and able to reproduce the SuperKamiokande results.

In a very stimulating talk Sheldon Glashow discussed departures from perfect Lorentz symmetry and presented a compelling test using solar, atmospheric and accelerator neutrino experiments.

With so many ideas proposed and new neutrino projects under way, neutrino enthusiasts look forward to new excitement at Neutrino2000, to be held in at the new Sudbury Neutrino Observatory in Canada.

From Pasquale Migliozzi and Paolo Strolin

So what if neutrinos are massive?

Neutrinos left over from the Big Bang are so common that on average every cubic centimetre of the Universe contains about three hundred of them. That means that if they have even the tiniest mass, they could still be major players in determining the gravitational fate of the Universe. Coupled with the hints from solar and atmospheric neutrino oscillations that neutrinos may be massive, this argument gives a compelling reason for weighing these elusive particles.

Ettore Majorana - Neutrino alternatives

Neutrinos were discovered by Fred Reines and Clyde Cowan at the Savannah river nuclear reactor in the 1950s. Soon after, C.S. Wu's landmark beta-decay experiments showed that parity is violated when a nucleus decays emitting an electron and an antineutrino. This presented a problem for the description of the neutrino as a conventional Dirac fermion since in the Dirac equation parity is conserved. The Dirac equation describes fermions as four-component objects. For example, the electron exists in negatively charged and positively charged versions each of which has two possible helicity states. They can be right-handed, spinning along their direction of motion, or left-handed, spinning against their direction of motion.

However this parity problem was soon resolved when physicists realised that if the neutrino's mass were zero, then the standard Dirac description would reduce to a two-component system which does not conserve parity. The two components were interpreted as being a left-handed neutrino and its right-handed antiparticle, just what C.S. Wu had observed.

But if the neutrino has a mass, as now seems likely, then the Dirac formalism does not reduce to a two-component object and right-handed neutrinos ought to exist. Since no-one has ever seen such an object, a different solution must be found. One idea is that there is a conservation law at work, the conservation of lepton number. In this picture, antineutrinos (lepton number -1) are always produced along with electrons (lepton number +1) – as observed in beta-decay. One possible worry with this interpretation, however, is that it does not easily explain why the neutrino mass is so much smaller than the masses of all the other matter particles.

Another possibility was proposed by the Italian physicist Ettore Majorana in the 1930s who suggested that neutrinos might be their own antiparticles. In this picture, the left- and right-handed helicity states are just manifestations of the same particle. Moreover, such neutrinos must be massive. If they were not, they would travel at the speed of light and, whatever frame of reference they were seen from, would always appear to have the same helicity. If they were massive, however, they could be 'overtaken' by an observer in some frame of reference so that their direction would appear reversed whilst their spin remained the same – they would appear to have the opposite helicity.

The ultimate test of whether neutrinos dance to the tune of Dirac or that of Majorana will come from experiments testing lepton number conservation. If lepton number is indeed conserved, as required in the Dirac formalism for heavy neutrinos, then the process of neutrinoless double beta-decay would be impossible.

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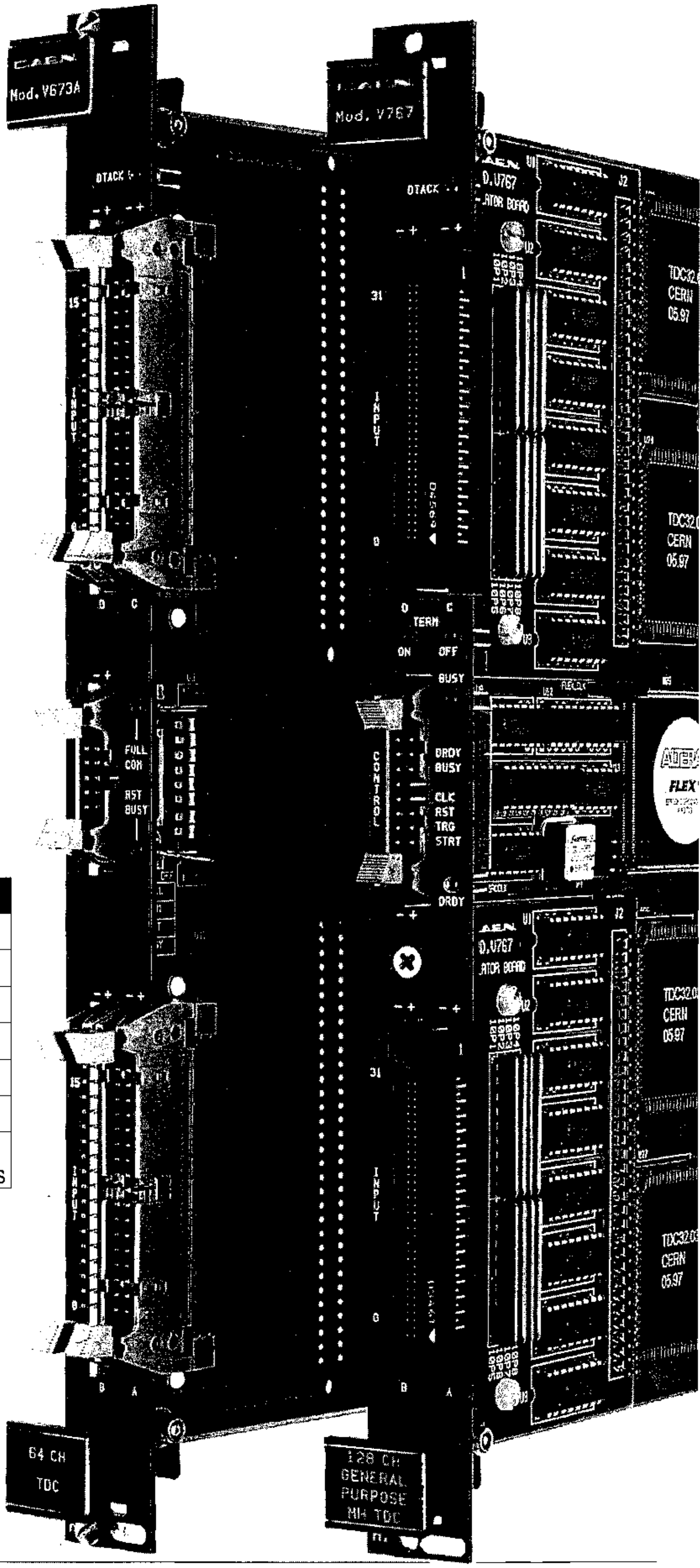

Type*	V667	V673A	V767	V693
Width	1 slot	1 slot	1 slot	1 slot
Channels	64	64	128	128
Bits	21	16	20	16
LSB	780 psec**	1 nsec	780 psec**	1 nsec
DPR	10 nsec	5 nsec	10 nsec	5 nsec
Conv. Time	Nil	Nil	Nil	Nil
Output Buffer	2KWords	4 events 6KWords	32KWords	4 events 12KWords

*VME 6U Units ** 520 psec with speed graded ICs and 60 MHz Clock

The V667 and V767 are based on an IC developed at CERN by the ECP-MIC Group
The V673A and V693 are based on an IC developed for the KLOE experiment by INFN-Roma

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In this process, a neutron undergoes beta decay turning into a proton with the release of an electron and an antineutrino. If the neutrino is its own antiparticle, then this antineutrino can be immediately absorbed by another neutron producing a proton and an electron. Two electrons are seen to escape the nucleus, and no neutrinos emerge.

If neutrinos and antineutrinos are different, the re-absorption by a neutron could not happen. In this case, the only way that double beta decay could occur would be by the simultaneous decay of two neutrons, with the emission of antineutrinos. Neutrinoless double beta decay has not been observed, although the search continues, and experiments to date prefer the Dirac description of the neutrino with lepton number conservation.

This still leaves the question of why neutrinos are so light, and many models are on the table. One idea is that the neutrino is indeed a Dirac four-component object, but that it has decoupled into two two-component objects. One is extremely heavy, which is why it has never been observed, the other is the familiar light neutrino.

The questions raised by the evidence for neutrino masses are set to occupy the minds of physicists for many years. On top of the purely theoretical question of describing neutrino masses, the neutrino-oscillation data from Superkamiokande, Los Alamos, and reactor experiments seem to be inconsistent if only Standard Model neutrinos are involved.

If neutrino oscillations are indeed the reason for the atmospheric and solar neutrino anomalies, and if all the data are correct, then perhaps a new kind of neutrino exists. This has been dubbed a 'sterile-neutrino' because its interactions would be so rare as to make even the more familiar neutrinos seem gregarious.

If sterile neutrinos are real, then it could be time for the Standard Model to welcome a new particle to its family. But many physicists are reluctant to buy sterile neutrinos, preferring to wait for more data. With the neutrino data traditionally difficult to accumulate, however, this could still take some time.

Appearing and disappearing

If neutrinos oscillate - changing their allegiance between electron, muons and taus as they move along - some neutrinos of a particular type disappear, while those of another type appear. Thus experiments searching for such oscillations are either classed as 'appearance' or 'disappearance' experiments - now you see them, or now you don't.

Disappearing neutrinos

To see whether neutrinos disappear, the flux of a given neutrino type is measured at a certain distance from the neutrino source. If there are oscillations, the flux is smaller than expected.

The sensitivity of such experiments is limited by the uncertainty of the knowledge of the composition of the initial neutrino flux. To reduce this uncertainty, a second detector is often mounted close to the source.

Disappearance experiments are the only way to detect neutrino oscillations when the neutrino energy is insufficient to produce all three charged leptons (the electron's mass is 0.5 MeV, that of the muon just over a 100 MeV, and the tau almost 1800 MeV).

For example, the core of a nuclear reactor is an intense source of electron (anti)neutrinos with an average energy of about 3 MeV, which can be detected when they interact with a proton to produce a neutron and a positron. If an electron neutrino turns into its muon or tau counterpart, it becomes invisible because it does not have enough energy to produce muons or taus. Similarly, solar neutrino experiments are disappearance experiments, seeing whether electron neutrinos from the Sun survive by the time they reach the Earth.

Appearing neutrinos

Neutrino appearance experiments use beams containing predominantly one neutrino type and search for neutrinos of different types.

Their sensitivity is often limited by the uncertainty of the knowledge of beam contamination at the source. For example, in a typical muon neutrino beam from a high energy accelerator, the electron neutrino contamination at the source is of the order of 1%, and any uncertainty in this value limits the sensitivity of muon to electron neutrino searches.

On the other hand, the tau neutrino contamination at the source is less than 10^{-5}, too small to give a measurable tau signal. Thus the sensitivity of muon to tau neutrino appearance experiments is limited by statistics or by the ability to identify taus.

EPAC with impact

Report from the European Particle Accelerator Conference, Stockholm

New synchrotron light - emitted light at the diagnostic beamline measured with a pinhole array camera at BESSY II, a new, low emittance, high brilliance third generation synchrotron light source at Berlin-Adlershof, which began commissioning with beam in April.

The biennial European Particle Accelerator Conference (EPAC), established in 1988 and alternating with the American Particle Accelerator Conferences, is a showcase for world as well as European developments.

As well as the traditional high energy physics arena for which particle accelerators were originally invented, these machines are increasingly being used in other areas of research and for other applications. Major accelerator meetings reflect this new diversity. This report from EPAC98, held in Stockholm in June, pulls together impressions from observers in different walks of accelerator life.

Synchrotron Radiation Sources and Free Electron Lasers

Synchrotron radiation, a major spinoff from particle accelerators, now has its own applications community, but retains strong links with its parent machine physics sector.

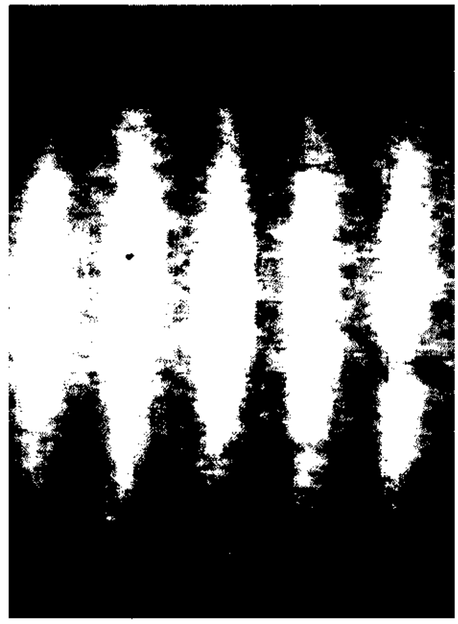
This use of accelerators as intense "light" sources (electromagnetic radiation ranging from the infra-red to X-ray wavelengths) covered a diverse range at the conference, nowhere more clearly illustrated than in the invited paper "Overview of Synchrotron Radiation and Free Electron Laser Projects". With this ambitious title, and with only 30 minutes available, Richard Walker (Sincrotrone Trieste) succeeded in presenting a comprehensive review of the major features, developments and achievements of existing installations, and of the objectives and status of the installations presently under construction or being planned.

The pace of progress in the field was graphically illustrated by the talk "Start of Commissioning for the High Brilliance Synchrotron Light Source BESSY II", where Dieter Krämer (BESSY) notified the conference of a new machine on the block - a new, low emittance, high brilliance 3rd generation synchrotron light source at Berlin-Adlershof, which began commissioning with beam on April 21, some three months ahead of schedule.

Circulating beam was rapidly established, followed by storage and accumulation over the following shifts, and only 30 hours later, on April 22, up to 10 mA were accumulated at injection rates of 1 mA/s. In a second test run the orbit correction was tested successfully, the optics measured and the first light obtained at the diagnostic beamlines.

To maintain the record of four orders of magnitude increase in light output (brightness) every 10 years, a new "4th generation" type of light source will be needed. For example, in a Self-Amplified Spontaneous Emission Free Electron Laser (SASE-FEL) a high energy electron beam traverses a long series of magnets with alternating field direction (undulator), giving rise to the emission of intense coherent electromagnetic radiation. Claudio Pellegrini (UCLA), in his invited paper, asked the question "Is the X-Ray FEL the 4th Generation Light Source?" The answer was an emphatic "Yes".

Experiments at accelerator laboratories worldwide are now underway to test the physics of FELs, in particular at shorter wavelengths and at high powers. A new record of lasing at 226 nm wavelength was announced for the OK-4/Duke Storage Ring XUV FEL, while the Jefferson/CEBAF FEL has just started lasing, with a first report of



155 W of a record cw power at 4.9 micron wavelength (see page 24).

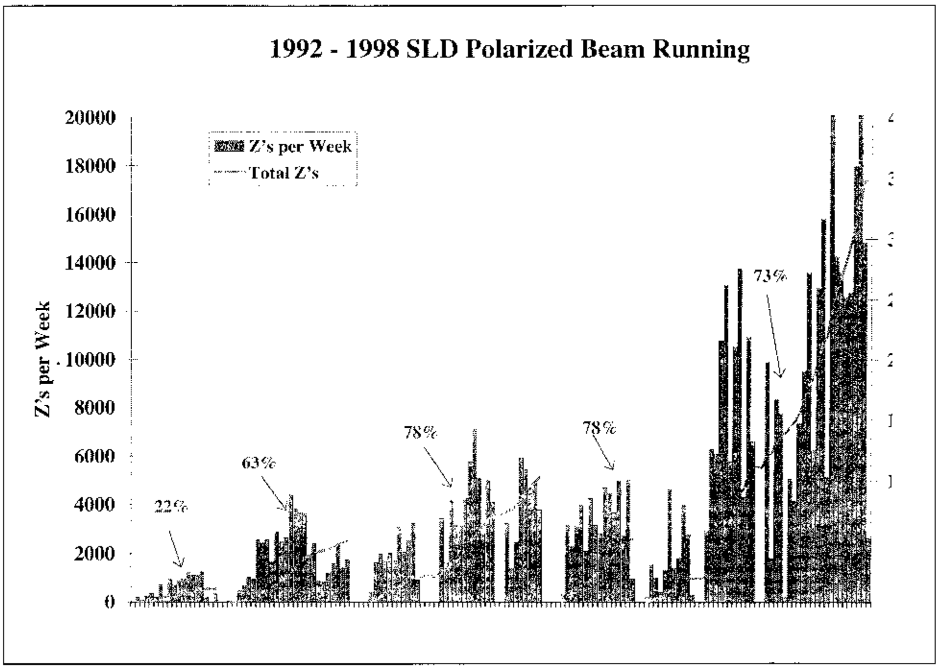
For the future, a SLAC/Livermore/ Los Alamos/UCLA collaboration has now proposed the construction of the Linear Coherent Light Source (LCLS), based on the SLAC linac. LCLS would use a beam of 14.3 GeV electrons, traversing a 100 m long undulator, to produce X-ray photons with a brightness some ten orders of magnitude higher than that of existing 3rd generation synchrotron radiation sources.

Electron machines

For the electron high energy frontier, the future is acknowledged as belonging to linacs.

Among the topics related to existing machines, the recent luminosity increases at the SLC Stanford Linear Collider were presented by Nanette Phinney (SLAC); where work on alignment, automated emittance tuning and the final focus lattice has enabled the luminosity to be increased by a factor of around three

Zs delivered to the SLD detector by the SLC Stanford Linear Collider from 1992 to 1998.



during the 1997-1998 run.

A significant fraction of this improvement comes about from "disruption", which occurs when two small, intense beams collide. The mutual focussing of the beams actually results in an increase in luminosity (up to 100% measured so far at SLC), a rare "free lunch" for accelerator physicists.

The detailed accelerator issues facing the next generation of TeV electron linacs were addressed by several invited, and many contributed, papers. Such a machine would be an eventual companion to CERN's LHC proton collider, and at the lower energy range could function as a Higgs factory.

Exploration of the available "design space" continues, with three leading contenders emerging. These are based on very different RF technologies; a superconducting structure operating at about 1.3 GHz and 25 MV/m (TESLA), a room-temperature structure operating at 11 GHz and 35-65 MV/m (NLC), and a drive-beam structure operating at 30 GHz and 100-200 MV/m (CLIC - see page 18).

For particle physics projects at lower energies, where the emphasis is on interaction rate (luminosity), electron storage rings are still very much in contention. The most interesting and advanced projects are those concerning the beauty factories. Two presentations by Jonathan Dorfan (SLAC) and Shin-ichi Kurokawa (KEK) presented the status of PEP-II and KEKB respectively.

Both projects share a number of common features: - two colliding rings - asymmetric energies (about 3 GeV in one ring and 8-9 GeV the other) - high luminosities (10^{34} per sq cm per s). In PEP-II the two rings are stacked vertically, while in KEKB they are stacked horizontally.

A peculiarity of the KEKB machine is the scheme adopted at the interaction point. To avoid the harmful effects due to the (unavoidable) finite crossing angle at the interaction point, a "crab crossing" scheme has been implemented via a dedicated RF cavity.

A single experiment is foreseen for each machine: BaBar (PEP-II) and Belle (KEKB). The construction of both machines is well advanced. The PEP-II high energy ring has been built and was commissioned in the period June 97- January 98. The low energy ring commissioning is imminent. BaBar data taking should start in January.

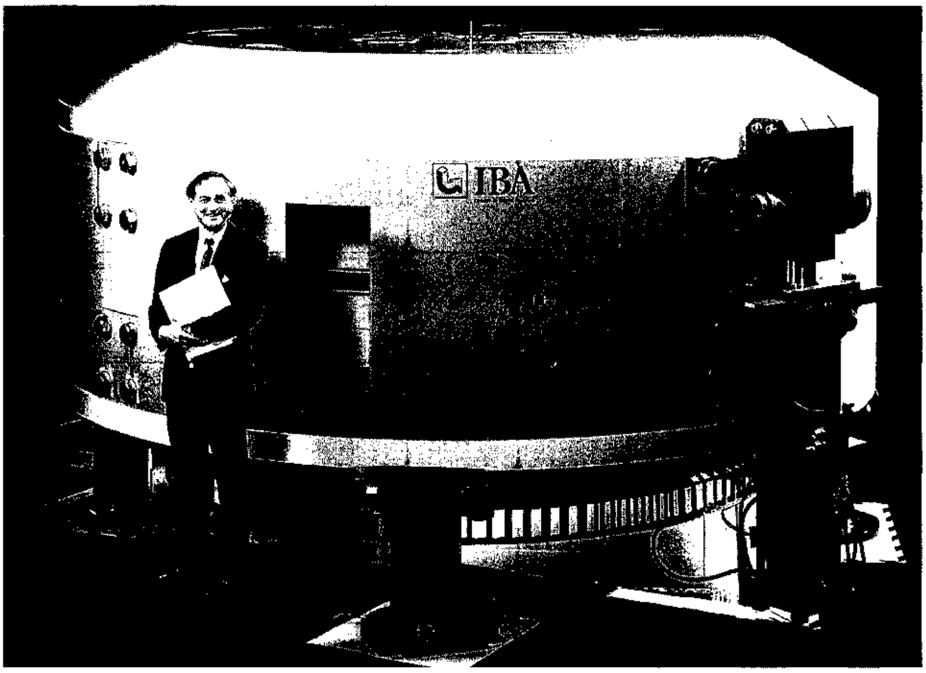
For KEKB too, commissioning of the two rings is imminent. In January the detector Belle should be complete, with physics following in February.

Hadron machines

For the traditional highway of pure particle physics research using proton and ion machines, CERN's LHC collider is the flagship project. Project director Lyn Evans presented the main technological challenges: superconducting magnets, cryogenic systems, and vacuum issues.

Two EPAC presentations were devoted to ion machines. Steve Peggs described the status of Brookhaven's RHIC superconducting heavy ion collider. One of its main characteristics is flexibility, as it should bring into collision a wide range of ions over a broad range of energies, including also the possibility of collision between protons and ions orbetween ions of different energies. Construction is well under way: a part of the machine is already completed, and some tests with beam have been carried out. RHIC commissioning should take place next year, the culmination of a seven-year construction period.

Michel Chanel of CERN discussed the result of the lead ion experiments



The 235 MeV Cyclone proton machine from specialist company IBA of Louvain-la-Neuve, Belgium, is one of the new workhorse machines for proton therapy. (Photo IBA)

carried out in the LEAR machine. CERN's LHC is planned to collide ions as well as protons. To achieve high luminosity it is necessary to prepare very dense bunches and this can be obtained by storing the heavy ions in an accumulation ring and by cooling them by means of an electron beam (April, page 8).

Dag Reistad of Sweden's Svedberg Laboratory gave an overview of the three methods used to cool beams - stochastic cooling, electron cooling and, the most recent, laser cooling.

Finally, to conclude with particle beams, a possible new direction is signalled by the growing interest in muon colliders. Robert Noble from Fermilab presented the progress made in recent years. A collaboration gathering more than thirty institutions has focussed the efforts on 'low energy' colliders, between 100-500 GeV in the centre of mass. This covers the main characteristics of the whole complex, from the proton source to the final collider. Starting from this proposal, a number of experiments have been proposed in order to test the feasibility of this design.

Applications

The application of accelerator technologies and particle beams has become a well established segment of particle accelerator conferences, and EPAC'98 continued this tradition. The conference was accompanied by an industrial exhibition involving 32 companies, fostering lively interest in cutting edge technologies.

Another point of contact between the accelerator and the industrial worlds was a special session devoted to the present and future involvement of industry in accelerator projects. Issues such as commercial supply of components for CERN's LHC, and possible impact of future linac projects on industry were reviewed. In the domain of novel industrial applications, potentials of FEL-based systems in materials treatment were reported, with examples of processes, like making nylon less shiny and more water vapour absorbent, which are becoming technically feasible and economically attractive.

Radiotherapy with light and heavy ions has developed into a major applications field, with significant commitment from both accelerator and medical communities, and the final EPAC'98 session was devoted to this particular topic.

An overview of the medical machine sector was given by Philip Bryant of CERN. Protons have the nice property of releasing almost all of their kinetic energy at the end of their path through matter. This makes them extremely efficient in destroying tumour cells while sparing the neighbouring tissues (in contrast to standard X-ray therapy). This effect can become even more marked with ions, provided that the nuclear particles are not large enough to break up en route and produce fragments.

Typically a compact proton machine (either a linac, a cyclotron or a synchrotron) delivers a proton beam to a treatment room. The extraction process has to be ultra stable to provide a smooth spill so that the delivered dose can be exactly controlled and, possibly, also synchronized with the patient's breath!

Radiotherapy with 250 MeV proton beams is becoming a major therapy tool, with a highly reliable cyclotron system now commercially available and contracted to several radiotherapy centres in the USA.

New ideas for improving the precision of synchrotron beams which offer a new quality in treatment planning are being developed within the framework of the PIMMS (Proton

Ion Medical Machine Study) collaboration, piloted by CERN, with indications that a new generation of medical machines is ready to take over. Other centres are also very active in the field, for example HIMAC (Heavy Ion Medical Accelerator) at the Research Center for Heavy Ion Therapy, National Institute of Radiological Science, Chiba, Japan.

In the two-ring HIMAC, the upper ring can be operated as a synchrotron and the lower one as a storage ring. Fast-extracted primary beam from the upper ring can produce isotopes by projectile fragmentation in a target. The resulting nuclei are stacked and electron cooled in the lower ring. In this way positron-emitting carbon-11 can be used for radiation therapy (instead of carbon-12), and the result directly monitored by positron emission tomography (PET).

Gerhard Kraft presented the new facility using carbon ions at GSI (Darmstadt) where recent developments have been already implemented. The first patient was successfully treated at the end of last year, following important technical improvements of the ESR storage ring and lengthy administrative preparations.

The conference closed with a memorable talk by Carlo Rubbia of CERN on accelerator-based transmutation of nuclear waste. With an accelerator delivering a 1 GeV proton beam onto a target, the produced neutrons then induce nuclear reactions in a sample of long-lived radioactive material, thus generating a short-lived harmless chemical element. One of the strong points of this approach is that the whole system is subcritical. The technique illustrates the responsibility and involvement of the accelerator community in solving one of today's major environmental problems.

From Massimo Giovannozzi, Brennan Goddard and Ranko Ostojic.

Around the Laboratories

Beams collide at SLAC Asymmetric B Factory

During the final week of its July commissioning run, the PEP-II Asymmetric B Factory at SLAC, Stanford, achieved its first collisions. Electron and positron beams first clashed with one another on Thursday 23 July. Over the following weekend, they were maintained in collision in stable orbits through the interaction region, with disruption of one beam by the other clearly observed.

CERN
First full-scale prototype LHC magnet achieves nominal field

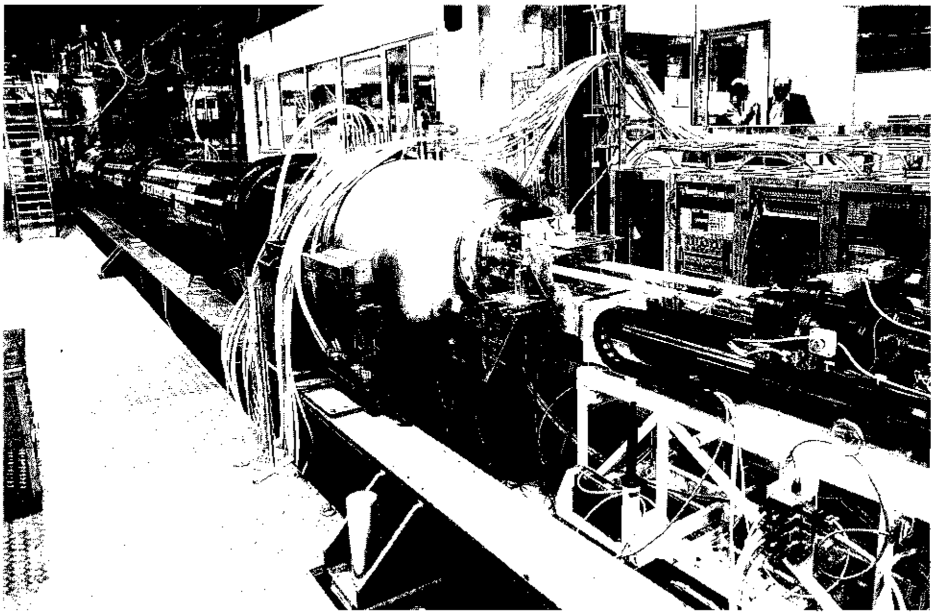
The first full-size prototype dipole for CERN's future LHC collider was successfully demonstrated at CERN on 16 June to representatives of the Italian Istituto Nazionale di Fisica Nucleare (INFN) and Ansaldo Energia. INFN developed the magnet in collaboration with CERN whilst Ansaldo Energia was one of the main contractors.

The magnet, installed on the LHC magnet test stand and cooled to 1.8 K since the beginning of June, was ramped up to the nominal LHC operating field of 8.3 tesla. After this successful demonstration, the field was further raised until the magnet naturally quenched at 8.6 tesla.

Weighing in at about 26 tons, 15.16 metres long with a magnetic length at 1.9 K of 14.2 metres, the magnet has a radius of curvature of 2700 metres. Its twin apertures each have an inner diameter of 56 millimetres.

The magnet is closer to the LHC final design than most previous large-scale prototypes, but it differs in one important way from the dipoles which will steer the LHC's proton beams: its coils are arranged in a five-block structure whereas the final configuration, recently realized in a 1-metre model magnet (May 1998, page 1), reverts to the six-block

Developed by the Italian Istituto Nazionale di Fisica Nucleare (INFN) in collaboration with CERN, and with Ansaldo Energia as one of the main contractors, this first full-size prototype dipole for CERN's LHC collider was successfully demonstrated at CERN on 16 June.



structure used in earlier prototypes. The six-block structure is more robust against component and assembly tolerances than the five-block design.

The June demonstration came as part of a series of tests continuing into the summer in which the magnet will be thermally cycled, its field quality investigated, and the systems which protect it against quenches will be put through their paces.

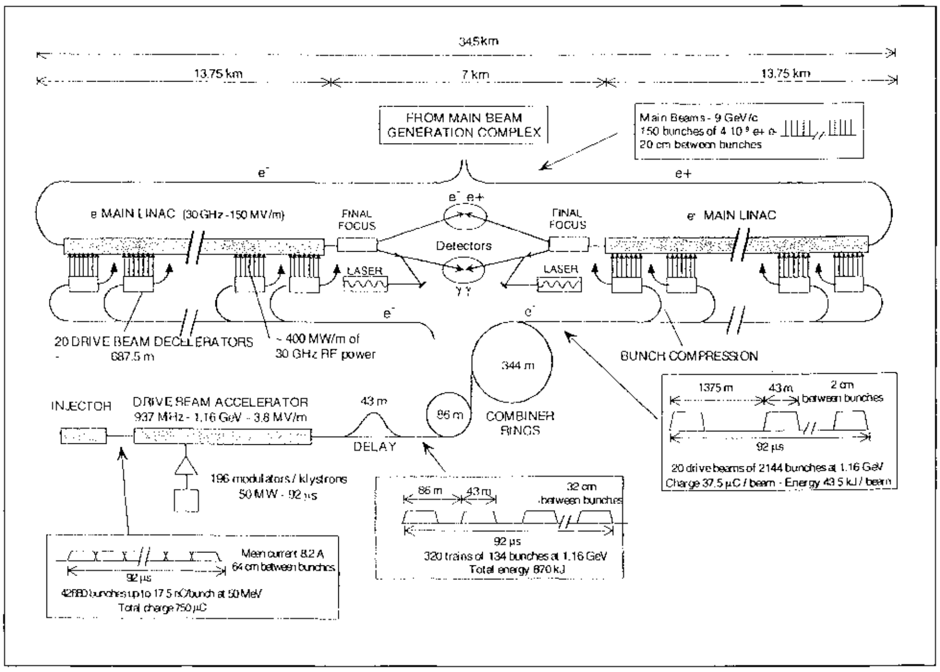
CLIC, a 0.5 to 5 TeV electron-positron compact linear collider

The next advance across the energy frontier will be provided by CERN's LHC proton collider, but the alternative electron-positron route will eventually provide complementary physics conditions to round out the picture.

With CERN's 27-kilometre LEP ring probably going into the history books as the largest electron synchrotron ever to be built, laboratories all over the world are busy with research and development work for a new generation of electron-positron colliders. Abandoning synchrotrons, these aim for collision energies in the TeV (1000 GeV) range with luminosities above 10^{34} per sq cm per s by firing beams from a high energy electron linac and a positron linac at each other.

This development work covers a wide range of different technologies (April 1997, page 16), but the scheme being developed at CERN in this direction is really quite novel. Instead of more or less conventional klystrons to supply the radiofrequency accelerating power, CLIC (Compact Linear Collider) extracts its power from low-energy high-intensity drive beams which run parallel to the main linac.

In addition, CLIC plans to operate at a high frequency (30 GHz) in order to achieve high accelerating fields (100 - 200 MV/m), minimizing the length of the linac and reducing its cost. (Even so, a 1 TeV collider would require a total length of 14 kilometres.) With



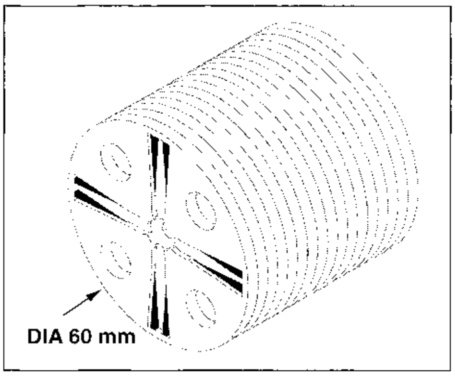
Schematic of CERN's CLIC - Compact Linear Collider - design for producing 3 TeV electron-positron collisions.

Precision engineering for a large-scale project - radial waveguides for CLIC

the tunnels unencumbered by klystrons, construction becomes more cost-effective and the facility can relatively easily be extended to higher energies. CLIC is optimized for a collision energy of 3 TeV and a luminosity of 10^{35} but could be built in stages to cover the range 0.5-5 TeV.

The original CLIC plan was to have parallel drive and main beams, with the length of the drive beam equal to the length of the required RF pulse. This solution however requires many electrons to be squeezed into a short time interval. To overcome this bottleneck, a new approach is proposed where the energy for RF production is initially stored in a long pulse electron beam which is efficiently accelerated to about 1.2 GeV by a fully-loaded, conventional, low-frequency linac. The beam pulse length is twice the length of the high gradient linac, and is compressed using combiner rings to create a sequence of higher peak power drive beams with gaps in between. These drive beams are distributed from the end of the linac against the main beam direction down a common transport line where each drive beam powers a section of the main linac. After a turnaround each high-current, relativistic drive beam is decelerated in low-impedance decelerator structures which feed power across to the low-current, high-energy main beam at the required instant and location. The method which acts as a transformer for both accelerator gradient and frequency, is very flexible, and can be used to accelerate beams for linear colliders over the entire frequency and energy range.

A 3 TeV collision energy linac would have 40 1.16 GeV drive beams (20 for the electron linac and 20 for the positrons) made up of 2144 bunches. These 20 drive beams, spaced at



1.375 km intervals, emanate from one 90 microsec pulse supplied by a 937 MHz drive beam generator operating at 3.8 MV/m. Each drive beam would power a 687.5m section of the main linac. Each 80 cm long power-extracting structure would provide 462 MW of 30 GHz RF power - enough to power two 50 cm long accelerating structures.

Harmful wakefield effects in the 30 GHz main linac are minimized by a judicial choice of bunch charge, bunch length and focusing strength. The resulting beam quality after applying beam-based correction schemes is as good as that obtained by lower frequency colliders.

The accelerating sections are precision manufactured to tolerances of a few microns. These units must also be aligned in the transverse plane to a precision of about 10 microns over distances of several kilometres, achieved by automatic compensation of micro-movement in real time using a sophisticated active-alignment system and beam-based monitoring.

The feasibility of the two-beam approach was initially demonstrated in the first CLIC Test Facility (CTF1) which operated from 1990-95. With a drive beam generated by a laser-driven photoinjector, 76 MW of 30 GHz RF power was produced with a peak field gradient of 125 MV/m being measured in the power extracting structure.

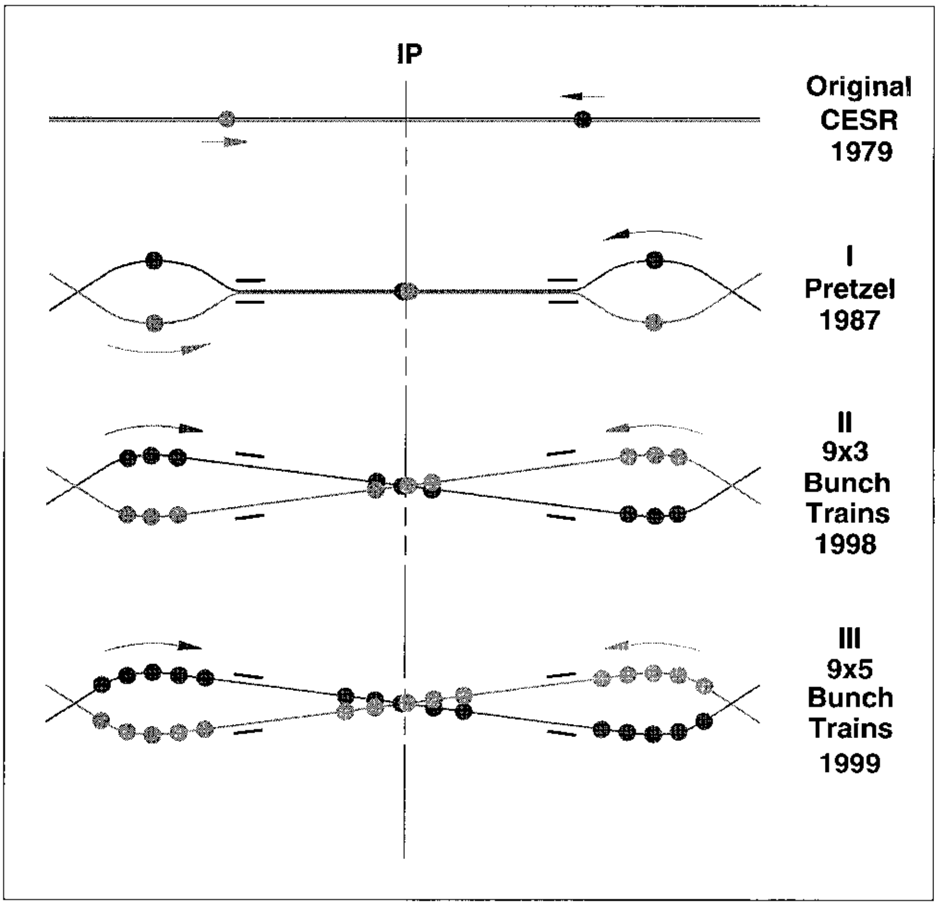
A new test facility (CTF2), equipped with the micron-precision active-alignment system and prototype components developed during the course of the CLIC study, has been constructed and is presently being used to further explore two-beam behaviour. Although CTF2 is still in the commissioning phase, it has already achieved one of its primary objectives by accelerating an electron beam for the first time by a Two-Beam Acceleration (TBA) scheme. Accelerating gradients of 52 MV/m have already been achieved and beams accelerated by 24 MeV.

A new CTF3 facility is under study which would test all major parts of the CLIC power generation and acceleration scheme. To reduce costs it uses RF equipment which would be taken over from the LEP injection system after LEP is decommissioned in the year 2001.

CORNELL CESR luminosity milestone

In the search for rare physics in a colliding beam machine, energy is not the only frontier - event rate is also important, and pushing the rate as high as possible helps compensate for the rarity of the physics being sought.

This physics potential of a colliding beam machine is characterized by the luminosity, defined as the collision rate per unit collision cross section. With a collision energy of 10.58 GeV, the Cornell Electron Storage Ring (CESR) is far from the



Schematic diagram of positron and electron beam orbits near the interaction point (IP) in the various stages of CESR history. The sketch labeled II is the present scheme in which the beams circulate in 'pretzel' orbits and cross at angles of 2.3 milliradians, with three bunches in each of 9 trains per beam. Future plans foresee extended trains with more bunches.

energy of CERN's LEP or Fermilab's Tevatron, but for over a decade has valiantly extended the luminosity frontier. Even so, opening up unexplored physics territory at CESR demands yet more improvements.

So over the years Cornell's resourceful accelerator physicists have continually pioneered new ways of eking out more luminosity. On April 27, CESR reached a peak luminosity of 6×10^{32} per sq cm per s, the stated goal of the Phase II luminosity project installed in 1995. Phase III continues with the installation of more equipment with the goal of at least 1.7×10^{33}.

The strategy behind the recent gains in CESR performance has been to increase the number of beam bunches circulating in the ring, with only modest improvements in the parameters characterizing each bunch.

The original design, brought into operation in 1979, had one bunch per beam, colliding at two opposite points in the ring where the CLEO and CUSB experiments were set up. Following a development by Raphael Littauer, operation with 'pretzel' orbits began in 1987. In this scheme the two beams were oppositely deflected by electrostatic fields into separate orbits that zigzagged horizontally about the original circular orbit. This allowed three (later seven) equally spaced bunches in each beam to avoid each other while circulating in the same beam chamber, colliding only at the two experiments. With the completion of the CUSB experiment in 1990, one of the two interaction points was eliminated by separating the beams vertically there.

The ingenious pretzel scheme has also been used to increase the luminosity at LEP and the Tevatron. In 1994, at Robert Meller's suggestion, CESR began running with the pretzel orbits reconfigured so that the two beams collide at a 2.3 milliradian angle rather than head on (September 1995, page 11). This permitted replacing each of the (by then) nine bunches in each beam by a train of up to five closely spaced bunches.

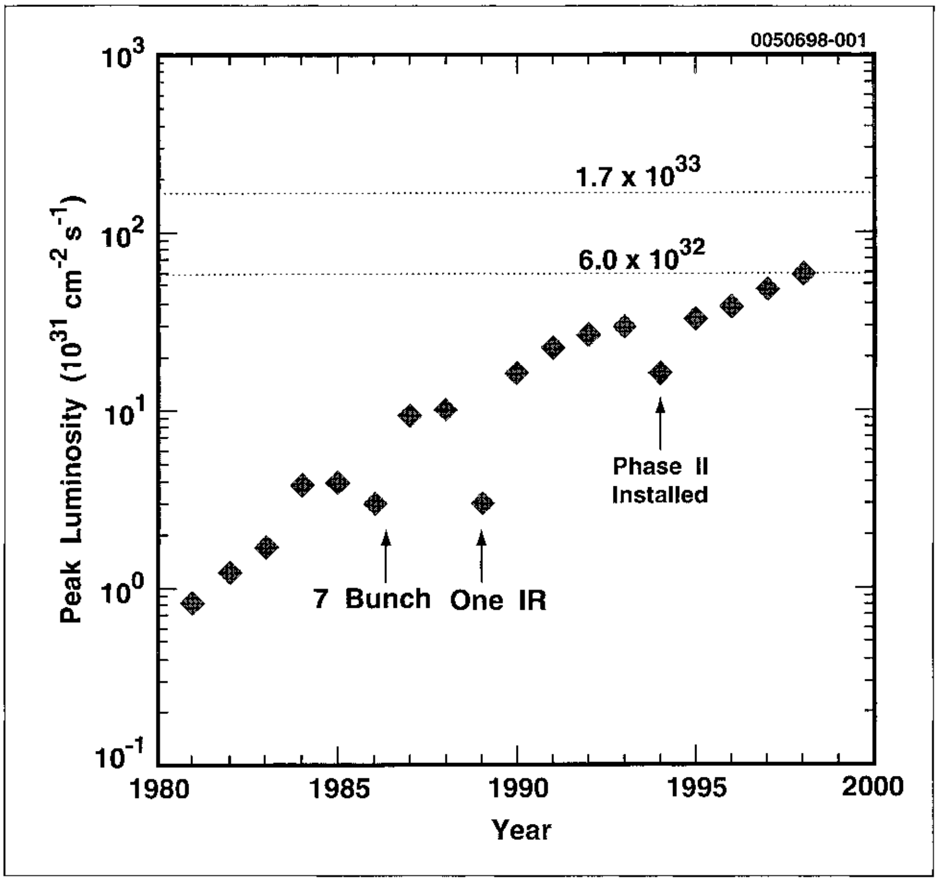
The minimum spacing between the bunches depends on the crossing angle allowed by the beam pipe aperture and on the beta function (a measure of focusing strength and consequent beam compression) where the beams pass each other near the collision point.

In the 1995 Phase II installation the aperture was increased, the first vertically focusing magnet was lengthened, and the first horizontally focusing magnet was pushed closer to the collision point. This allowed collisions with three bunches per train - a total of 27 bunches in each beam - which made the latest luminosity record possible.

Since 1995, a series of problems has had to be solved to reach the luminosity goal, all related to the greatly increased total circulating beam current, now more than 400 mA for the two beams. The efficiency of the injection system had to be improved - positron production, linac and synchrotron operation, and transport into the ring.

Synchrotron radiation heating of the CESR vacuum system components was alleviated by new temperature monitoring and cooling systems. Major improvements were made to the vacuum system near the collision point. Wakefields left by the bunches in the radiofrequency accelerating cavities and at other beam chamber discontinuities can destabilize the other bunches. Fast multibunch feedback systems were devised to damp the wakefield- and photoelectron-induced horizontal, vertical, and longitudinal bunch motions.

Most of the harmful wakefield effects will be eliminated when Phase III is completed by the replacement of the present 20-cell copper RF cavities with four single-cell superconducting RF cavities. Each superconducting cell has a much reduced higher-order-mode impedance than a copper cell, and there will be only one-fifth as many. The first of the four new cavities has been operating successfully in CESR since September 1997, and has delivered a record 180 kW of RF



Luminous watch. Peak colliding beam luminosity in Cornell's CESR electron-positron storage ring from its beginnings in 1980 to the present year has improved by a factor of 100 and still climbing. The horizontal dotted lines show the goals of the Phase II upgrade (installed in 1995) and the Phase III upgrade (to be installed in 1999).

power to the beam. The rest of the cavities are in production.

Phase III also includes the installation of superconducting quadrupole doublets for the interaction region. These will produce yet more beam compression near the collision point, allowing CESR to operate with five bunches per train.

Monitoring CESR physics is the CLEO experiment. CLEO's speciality is the study of decays of b quarks produced at the upsilon(4S) resonance just above the threshold for pair production of B mesons. If enough B mesons can be produced, there are exciting opportunities for the understanding of CP violation and for seeing new physics beyond the Standard Model.

Although this has provided the motivation for the CESR luminosity effort, the increasing collision rate has challenged the CLEO experimenters. As a part of the 1999 Phase III installation, CLEO will undergo significant improvements.

The data acquisition and trigger systems will have to be upgraded to cope with higher event rates. A ring-imaging Cherenkov detector is under construction at Syracuse to provide improved selectivity so that the rarer decays accessed in larger data samples can be positively identified against relatively larger backgrounds.

The big cylindrical tracking drift chamber will be replaced with a new design that makes space for the Cherenkov detector and for the more intrusive superconducting interaction region focusing magnets. A new, radiation-hard silicon vertex tracker surrounding the beam pipe will complement the drift chamber tracking.

Once the Phase III hardware is installed, CESR will be able to collide efficiently with five bunches per train (45 bunches per beam), and the completed superconducting RF cavity system should make it possible to reach peak luminosities of at least 1.7 x 10^{33}. By that time, CESR will be joined by the new asymmetric B Factories, PEP-II at SLAC, Stanford, and KEK-B in Japan.

Just as CLEO benefited in the past from the rivalry with the ARGUS experiment at DESY, experimenters now look forward to friendly competition with the BaBar and Belle collaborations at PEP-II and KEK-B respectively.

Cornell's accelerator physicists, however, are already looking further into the future. Convinced by their CLEO colleagues that settling open questions in b physics will require luminosities at or above 3 x 10^{34}, they are working on ideas to achieve such performance in a future upgrade of CESR.

Building on the capabilities of the Phase III superconducting RF cavities and the superconducting interaction region magnets, new techniques ranging from the "Moebius" round-beam accelerator lattice to compact two-in-one superconducting quadrupole magnets for dual beam chambers show excellent potential for a further push across the luminosity frontier.

DESY
Superconducting cavity performance

In an interesting milestone in the development work for future linear electron-positron colliders, one of the superconducting resonators at DESY's TESLA Test Facility (TTF) has achieved an impressive performance for multicell cavities. The higher the accelerating gradient achievable, the shorter these multi-kilometre linear machines need to be.

The new result was achieved in a horizontal test cryostat during a final test for which the resonator was placed inside its helium tank, fully equipped with a high power input coupler, higher order mode coupler and the frequency tuning system.

The nine-cell cavity of pure niobium produced by the French company CERCA reached an accelerating gradient of 30.6 MV/m at a quality factor of 7 x 10^9. This is far in excess of the design values of 15 MV/m at a quality factor of 3 x 10^9 specified for the TESLA Test facility, and exceeds the 25 MV/m at a quality factor of 5 x

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

We invite applications from recent Ph.D. graduates for a post-doctoral position in

Experimental High Energy Physics

The initial appointment is made for two years with the possibility of renewal for up to a total period of five years. The position is available now.

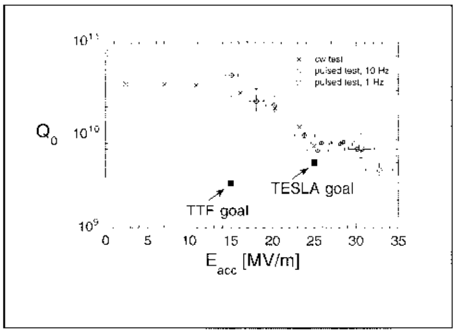
Our group has been engaged in the design and construction of the H1-detector at HERA and is actively participating in the data taking and the analysis of the data with focus on testing QCD at low and high Q^2. We are also engaged in the upgrading of the detector (liquid argon calorimeter and trigger,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

We expect that the person appointed will participate in exploiting the physics potential of the H1 detector as well as in the maintenance, application and the upgrade program of the neural network trigger.

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)

A superconducting resonator at DESY's TESLA Test Facility (TTF) has achieved an impressive performance for multicell cavities. This shows performance of a nine-cell superconducting cavity under continuous wave (vertical test with high Q input coupler) and pulsed condition (horizontal test, completely equipped for use in the accelerating module). The maximum gradient was limited by available rf power (cw test) and by arcing of the warm rf window (pulsed test) but the results are far beyond what is needed for a new generation electron-positron linear colliders.



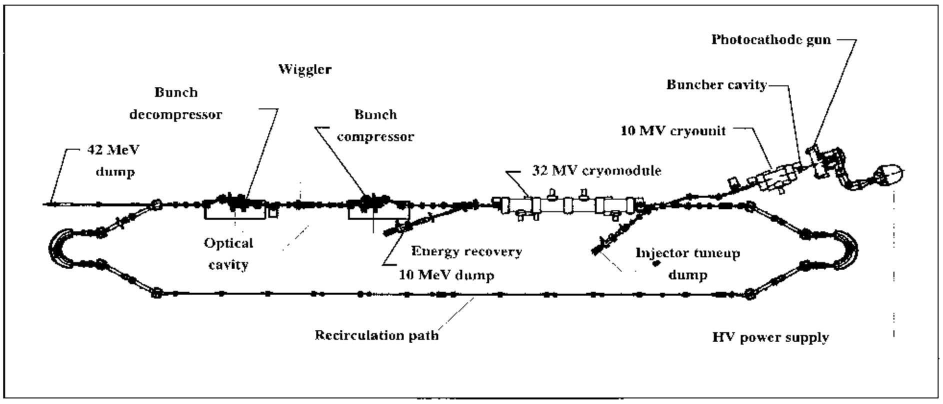
10^9 required for the projected TESLA electron-positron linear collider (October 1997, page 12).

The cavities tested at the TTF are operated at a frequency of 1.3 GHz under pulsed conditions (5 Hz) , with a 800 microsecond flat top at high gradient. Last year, eight were installed into a first cryomodule and operated with beam at an average gradient of 16.7 MV/m (July/August 1997, page 1). Cavities for two more modules are now under production. Eight of the cavities for module II have undergone an acceptance test in a vertical cryostat at an average gradient of 24 MV/m and at a quality factor exceeding the TTF specification.

JEFFERSON
First light from new Free Electron Laser

Researchers at the Jefferson Laboratory, Newport News, Virginia, have delivered first light from their Free-Electron Laser (FEL). Only 2 years after ground was broken for the new facility, on June 17, Jefferson's FEL produced 155 W of continuous-wave (cw) power at 4.9 micron wavelength. No previous FEL had exceeded 11 W.

Layout of the Jefferson Laboratory's new Free Electron Laser whose first light achieved 155 W of continuous-wave (cw) power at 4.9 micron wavelength.



FEL development is a spinoff from the lab's main mission of basic studies of the quark structure of hadrons and nuclei, and the superconducting radio-frequency (SRF) electron accelerator that drives the FEL derives from the technology of Jefferson Lab's 4 GeV, 200 microampere, cw main machine.

For the FEL, electrons are accelerated in a cryomodule before transiting a wiggler, where they supply energy for the production of light in an optical cavity. While a conventional laser typically produces a fixed wavelength, FEL light can be tuned by varying the electron energy or the magnetic field of the wiggler.

Jefferson's superconducting electron-accelerating technology offers two commanding cost advantages for FELs: the laser can stay on 100% of the time instead of only 1% or 2%, and 99% of the energy that is not converted to useful light in a single pass can be recycled back into radiofrequency power.

The device is the first in a series of high-average-power, wavelength-tunable FELs being developed at Jefferson Lab for basic science, for industrial applications, and for applied defence research. The laser is planned to reach 1 kW. Envisioned upgrades would lead ultimately to an FEL reaching 20 kW in the infrared and 1 kW in the deep ultraviolet down to 0.2 microns.

The FEL accelerator, designed for 5 milliampere average current, is laid out in a racetrack configuration to recover energy from the spent electron beam. The electrons are produced in a 350 kV DC photocathode gun and accelerated to 10 MeV in a superconducting radio-frequency accelerating unit of 1 m active length - a pair of five-cell cavities like those in the main machine. The electrons are then accelerated to 57 MeV in a four-cavity-pair cryomodule.

After the FEL, the beam can be recirculated for energy recovery and dumped at the injection energy of 10 MeV. The recirculation loop is based on the isochronous achromat used in the MIT Bates accelerator but designed with an energy acceptance of 6%. With energy recirculation, estimated power output at 3 microns is 980 W with a small signal gain of 46%. The wiggler covers the wavelength range 3.0 to 6.6 microns using 40 periods of 2.7 cm.

Design values for the electron beam parameters are:
Kinetic energy - 42 MeV (nominal)
Average current - 5 mA
Repetition rate - 37.425 MHz
Charge per bunch - 135 pC
Normalized transverse emittance -

13 mm-mrad
Longitudinal emittance - 50 keV-degrees
Beta function at wiggler centre - 50 cm
Energy spread - 0.20%
Peak current - 50 A
Bunch length (rms) 1 psec

To minimize emittance-growth effects and speed the commissioning process, the wiggler and optical cavity were initially placed at the exit of the accelerator. Commissioning of the recirculation loop is the next objective, followed by the start of user experiments.

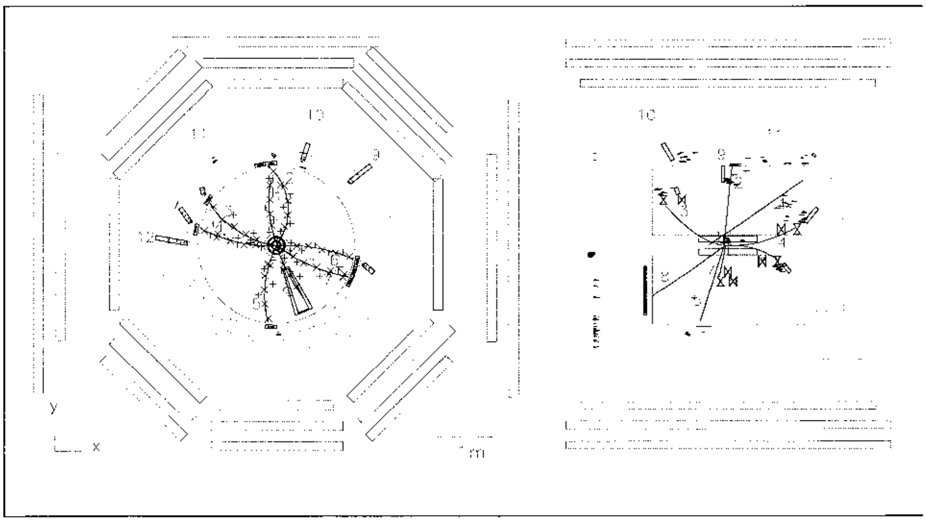
Envisioned applications include:

- Basic science: materials science and molecular and optical physics.
- Polymer surface processing: amorphization to enhance adhesion, fabric surface texturing, enhanced food packaging, and induced surface conductivity.
- Micromachining: ultrahigh-density CD-ROM technology, surface texturing, micro-optical components, and Micro-Electrical Mechanical Systems (MEMS).
- Metal surface processing: laser glazing for corrosion resistance and adhesion pre-treatments.
- Electronic materials processing: large-area processing (flat-panel displays) and a laser-based "cluster tool" for combined deposition, etching, and in situ diagnostics.

The industrial applications exploit the potential of SRF-driven FELs to overcome conventional lasers' cost, capacity, wavelength, and pulse-length constraints. Of additional interest for basic science is the potential for short pulses of x-rays from the IR FEL, which arise from Thomson scattering of the recirculating optical pulse against the drive electron beam.

As well as providing a unique tool for basic research in materials science and atomic and molecular physics, because of its efficiency it also offers the potential to produce light at a cost useful for industrial processing. Initial users include DuPont (polymer processing) and Armco/Northrop-Grumman/Virginia Power (metals processing). In addition, Old Dominion University, the College of William and Mary, Christopher Newport University, and Norfolk State University are partnering with industries in the recently dedicated Applied Research Center built by the City of Newport News adjacent to the Jefferson Lab to take advantage of the new FEL.

User labs at the FEL facility have been equipped via substantial donations by universities and industries for use with the first experiments scheduled for this summer. The Free-Electron Laser project was funded by the Department of Energy, the Commonwealth of Virginia, and the Department of the Navy, and supported by industries, universities and the City of Newport News.



A hadronic event with 8 charged tracks observed by the upgraded BES II spectrometer at the BEPC Beijing electron-positron collider.

BEIJING
Upgraded BES II spectrometer at work

After sterling work, particularly in precision measurements of the heavy tau lepton, the Beijing Spectrometer (BES) collaboration at the Beijing electron-positron collider BEPC has now turned its attention to comparing hadron and muon production in the 2-5 GeV region. This is the most poorly measured region for the hadron/muon production ratio, R, with typical errors of the order of 15-20 %. BES aims to improve these measurements by a factor of about three.

An R measurement in this region is absolutely essential for a precise value of the quantum electrodynamics coupling at the energy of the Z particle. At present, its uncertainty seriously limits further progress in determining the Higgs mass in the Standard Model. Measurements of R, particularly below the J/psi, are also required for interpreting the new muon magnetic moment measurement at Brookhaven.

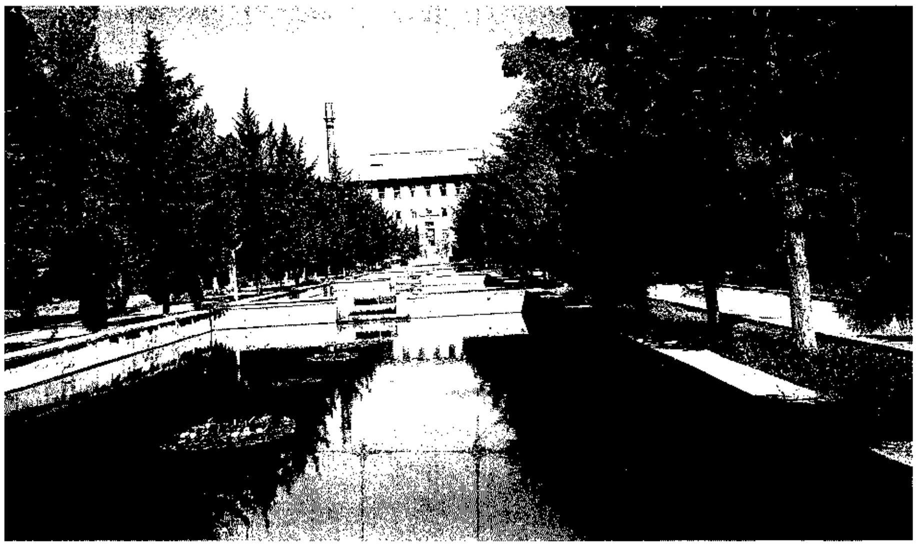
The measurements have been carried out with an upgraded BES detector. The upgrades included replacement of the central drift chamber with a vertex chamber composed of 12 tracking layers. The vertex chamber was rebuilt from the endplates and beryllium beam pipe of the Mark III detector (used at the SPEAR electron-positron collider at SLAC, Stanford) and provides a spatial resolution of about 90 microns. A new barrel time-of-flight counter with shortened light pipes improves on the BES I design and provides 180 ps resolution. A new main drift chamber replaces the aging original, providing similar momentum and energy loss resolution as the old one.

To carry out the measurement, the China/US team overcame a flaw in the plastic of their main drift chamber feedthroughs by DC shift of the chamber potential. BEPC was also upgraded. Improvements included moving the insertion quadrupoles closer to the interaction point and increasing the total radiofrequency voltage. Bunch length was shortened and the colliding beams further compressed. Performance of the upgraded BEPC, including the injection linac, is substantially improved, especially at the lower energies scanned. The resourceful BEPC crew optimally tuned beam energy over the wide region and repeatedly broke their own beam current and luminosity records during the scan. So far a factor of 1.5 luminosity improvement , to 2 x 10^{30} per sq cm per s at the J/psi peak, has been achieved.

During a short preliminary scan this spring, about 1000 hadronic events were collected at 2.6, 3.2, 3.4, 3.55, 4.6 and 5.0 GeV. Results will soon appear, however the main goal was a careful understanding of the trigger and hadronic event acceptances, as well as hadronic event selection and background, vital for a total cross-section measurement. This fall, BES-II will carry out a finer scan of this important energy region.

From Zhao Zhengguo

TASHKENT
Uzbek physics



The Institute of Nuclear Physics in the Uzbek capital of Tashkent is the largest research centre in Central Asia.

The economically robust central Asian Republic of Uzbekistan, one of the largest fragments to emerge from the Soviet Union, is looking to establish links with other countries.

The Institute of Nuclear Physics in the capital, Tashkent, is the largest research centre in Central Asia, with 350 scientists and a staff of 1500. The institute has two cyclotrons and is active in radioisotope production.

There is already contact with CERN through the study of emulsion targets exposed to high energy beams of heavy ions, which could lead on to involvement in the ALICE detector at CERN's LHC proton collider.

Also for the future is an initial proposal to provide in-kind contributions to CERN experiments. Seven physicists are involved in CMS. Possible areas of technical expertise include activation analysis, radiation hardness studies using secondary neutron beams and radiation damage studies.

CERN COURIER
What do you think?

A recent readership survey amongst the CERN Courier's 1100 readers in the United Kingdom reflects a largely satisfied readership, but also reveals areas for improvement. The survey, sent out with the September 1997

Physics monitor

Out with the old, in with the new

This is the final edition of the outworn old-style CERN Courier before a relaunch of the magazine under a new arrangement with Institute of Physics Publishing, Bristol, UK, who will be publishing the magazine on CERN's behalf. CERN remains the editorial base. Watch out for major changes in design and presentation in the October issue.
We also say farewell to our friends at Lannoo Printers, Tielt, Belgium, who have been printing the magazine under the existing arrangement with CERN since 1992. As well as showing their continual understanding of the limited means at our disposal, the enthusiastic professionals at Lannoo have kept us abreast of new technological developments, with page makeup transmission progressing from telephone modem to full electronic mail, and proofing from simple fax to PDF files.

issue, had questions divided into two categories; appreciation of the magazine, and the nature of the readership.

Results from such a small sample must be treated with caution, but it appears that some 90% of respondents read at least half of the magazine and spend at least half an hour doing so. Around half keep the CERN Courier for two years or more, and three-quarters find the level of writing to be appropriate.

However, the news is not all good. Although the magazine is kept by many readers, it is rarely used as a source of reference. Many respondents asked for more references to further reading to be included. Advertising needs follow-up. Some people get their issues very late. Such deficiencies confirm what we already suspected and will be addressed through the new arrangement with Institute of Physics Publishing who will soon assume responsibility for publishing the CERN Courier later this year.

The UK readership of the CERN Courier is divided evenly between the particle physics community and the scientific community in general. The magazine appears to be particularly appreciated by people working in fields related to but not directly involved with particle physics, as a way of keeping in touch. The UK readership appears from the survey to be largely male and over 50, although the comment of one young reader, a particle physics post-doc, may point to a bias in the sample of questionnaires returned, "Where do I find the time?", he complained, "to complete questionnaires like this".

Physics space mission

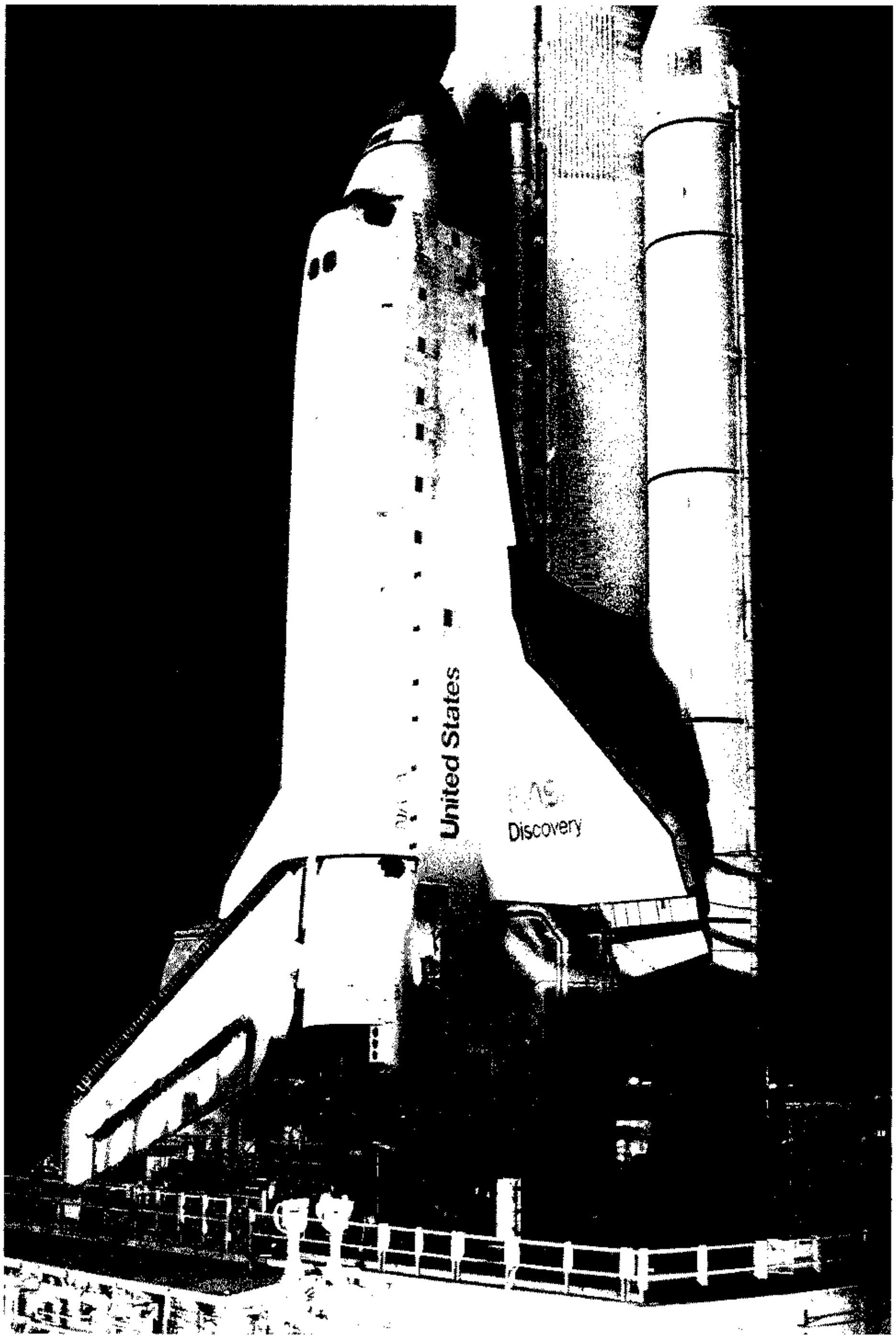
On 2 June at 18h00 local time, the earth shook at NASA's Kennedy Space Center as Space Shuttle Discovery thundered skywards from launchpad 39A. Primary payload aboard was the three-tonne AMS Alpha Magnetic Spectrometer, the first major particle physics detector to go into space.

Equipped with a powerful magnet, tracking and particle identification, AMS is designed to monitor cosmic particles, in particular looking for signs of antinuclei. The ten-day flight, at an altitude of 395 km, was a shakedown cruise for the AMS main mission aboard the International Space Station.

Antiparticles, such as positrons (anti-electrons), are plentiful in the cosmic radiation bombarding the Earth from outer space, but no sign has ever been seen of antinuclei, even light ones such as helium or carbon. Although the Big Bang which created the Universe some 12 billion years ago presumably created matter and antimatter in equal amounts, no sign of nuclear antimatter has been found - everywhere we look, we find only matter.

Negatively-charged electrons always curl the same way in a magnetic field. In 1932, Carl Anderson was surprised to find electron-like cosmic ray tracks curling the 'wrong' way in his magnetic cloud chamber. He was seeing the positrons, predicted only the previous year by Paul Dirac using his new relativistic theory of the electron. Antimatter became a reality and Anderson went on to receive the 1936 Nobel Prize.

AMS is a latter-day rerun of Anderson's experiment, with sophisti-



The Space Shuttle Discovery rolls out prior to liftoff from Launch Pad 39A at NASA's Kennedy Space Center on June 2. As well as the ninth and final docking with the Russian space station Mir, the nearly 10-day mission was the first flight of the Alpha Magnetic Spectrometer (AMS), the first major particle physics detector for space.
Photo Georg Schwering

cated electronics taking the place of the cloud chamber. Masterminded by 1976 Nobel prizewinner Sam Ting, AMS uses silicon microstrip 'ladder' particle tracking technology developed and perfected for the LEP experiments at CERN. Its magnet uses a specially-developed neodymium-iron-boron alloy to optimize the field-to-weight ratio. The full configuration will only be deployed on the Space Station, the initial Shuttle flight using a slightly descoped version.

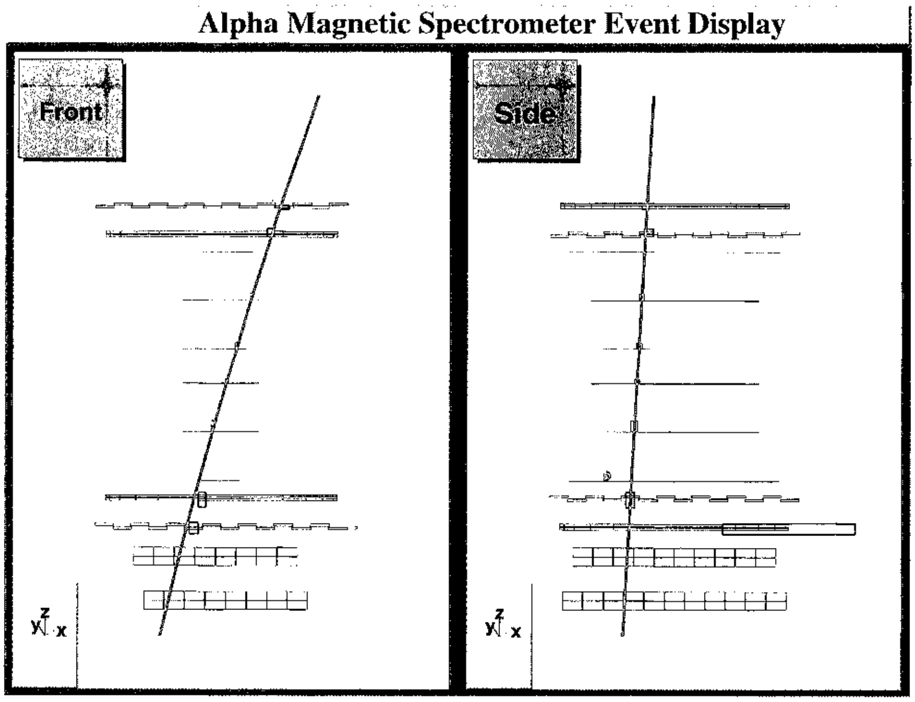
The AMS team includes members from the US, Western Europe, Russia, China and Taiwan. The experiment, with major contributions from Germany, Italy and Switzerland and from the US Department of Energy, a traditional paymaster of US particle physics, is a symbiosis of space-borne and particle physics research.

The detector's time-of-flight counters trigger on charged particles, initializing readout of the silicon microstrip tracker, eventually containing 1921 sensors arranged in six layers totalling six sq m (three sq m in six layers were used in the initial Shuttle flight). Particle identification is through the silicon microstrip sensors and an aerogel Cerenkov counter viewed by 168 phototubes.

As well as ensuring that cosmic ray tracks can be pinpointed down to ten microns, AMS instrumentation had to be able to withstand the huge forces when the Space Shuttle blasts off and lands, noise vibration levels attain 150 decibels. The stringent testing schedule demands that the equipment can withstand accelerations up to 17G. This was new territory for particle physicists used to the relative calm of their terrestrial laboratories. Space qualification tests on the state-of-the-art magnet were carried out in China. Space qualification tests on the detectors were carried out elsewhere. Before being shipped to the US for final installation aboard the Orbiter, final assembly was at the Swiss Federal Technical Polytechnic (ETH) in Zurich under a team led by Hans Hofer.

During the launch, physicists were

A candidate cosmic antiproton recorded by the AMS tracker.



particularly concerned for their delicate detector, and during the flight carefully monitored variations in operating temperature which might have upset their instrumentation.

As well as searching for antinuclei, AMS picks up antiprotons, whose spectra could reveal more information about the mysterious 'dark matter' which dominates the gravitational behaviour of the Universe but is otherwise invisible.

Discovery's flight crew brought the Space Shuttle into land on schedule on 12 June. Although the NASA high speed data transmission link to Earth failed during the flight, this did not affect actual AMS data taking. Resourceful NASA communications specialists were able to patch through some data via a link normally reserved for video pictures, and this 10% sample verified that the detector was functioning correctly. The valuable AMS trawl of physics from outer space will be carefully analysed over the coming months.

LEAR not here

A special symposium at CERN on 15 May highlighted the accomplishments of CERN's LEAR low energy antiproton ring. With effort and resources at CERN at a premium for its LHC collider, LEAR's experimental programme was prematurely terminated at the end of 1996, recalling how CERN's ISR Intersecting Storage Rings had been sacrificed in 1984 to liberate resources for the LEP electron-positron collider.

In the late 1970s, exciting new developments in beam cooling brought tightly controlled beams of antiprotons within reach, opening the door to high energy collider projects which only a few years before had been but a dream.

While the high energy proton-antiproton collider route offered glittering prizes, the same techniques also pointed to the less prominently signposted route of low energy proton-antiproton collision physics. This would open up new physics domains - spectroscopy, atomic and nuclear studies, and fundamental symmetries. Profits were expected in spectroscopy, hitherto explored using limited secondary beams or via electron-positron colliders whose selection rules offer only a limited menu.

As the big push for CERN's high energy proton-antiproton collider got underway, a more modest effort also began for what became CERN's LEAR low energy antiproton ring.

Grafted onto existing infrastructure, LEAR was constructed in the existing South Hall of CERN's PS synchrotron in just 16 months, and commissioned within the following year. Using only a small fraction of CERN's precious antiprotons, it began work for physics in July 1983. Taking secondary antiprotons decelerated from 3.5 GeV to 600 MeV by the PS, it was initially equipped with stochastic cooling systems to further shape the antiproton beams, and an internal gas-jet target.

In the machine sector, LEAR became a showcase for accelerator skill and expertise. Different appetites require very different catering, and the LEAR kitchen could handle anything from fast extraction, stripping out a good fraction of the stored antiprotons, to its impressive ultra-slow extraction. In this latter development, extended (multi-minute) spills could delicately peel off just a single antiproton per turn - equivalent to having a controlled antiproton beam stretching over interplanetary dimensions. The antiproton momentum could also be changed at a few hours' notice, providing additional physics flexibility.

In 1987, LEAR entered a new

phase, with the availability of CERN's Antiproton Collector to refine the antiparticle stacking procedures, while LEAR itself was equipped with its own electron cooling to complement its original stochastic cooling.

For the future, LEAR becomes the LEIR low energy ion ring to provide nuclear particles to CERN's LHC collider now under construction (April, page 10). Also testifying to LEAR's success is its progeny of 'daughter' cooling rings - Astrid (Aarhus), IUCF-cooler (Bloomington, Indiana), ERS (Darmstadt), TSR (Heidelberg), COSY (Jülich), Cryring (Stockholm), TARN II (Tokyo), Celsius (Uppsala), ... - which provide regional centres with world class physics capability for a relatively modest investment.

Physics highlights

For the world at large, the most memorable moment of LEAR's career was undoubtedly the headline announcement in January 1996 that physicists had succeeded in making the world's first atoms of antihydrogen - chemical antimatter.

LEAR had in fact been designed with the possibility of antihydrogen production in mind. Windows had been incorporated so that such neutral atoms, which escape the magnetic clutch of the antiproton orbit, could fly through the surrounding hardware and be detected. However these windows had initially been blocked by other instrumentation, while it also took time to perfect the gas jet techniques necessary to produce antihydrogen in flight.

Antimatter might be seen as the jewel in LEAR's physics crown, but many physicists would say that this 'discovery' merely confirmed what they already believed, and the real physics contributions came in other areas.

The LEAR acronym could have referred to low energy annihilation ring, for proton-antiproton annihilation was at the heart of most of its physics.

Using the Crystal Barrel, Obelix and Jetset detectors, light particle spectroscopy (mass range 1400 - 2200 MeV) became a major industry at LEAR. Notable highlights were clarification of scalar (spin zero, positive parity) meson states, with high statistics studies of many different decay channels, and the sighting of the lightest glueball (composed of gluons, rather than quarks) and exotic particles with unusual quark and gluon assignments.

LEAR also provided a new arena for CP violation, with valuable new parameters including the first evidence (from the CPLEAR experiment) for the concomitant but nevertheless previously unobserved violation of time reversal symmetry. For the neutral kaons, past and future are not interchangeable.

Another LEAR speciality was synthetic 'exotic' atoms containing orbital antiprotons, providing a valuable new laboratory for making precision antiproton measurements.

As well as stopping antiprotons by capturing them in atoms, antiprotons were also captured by electromagnetic traps, enabling the proton and antiproton masses to be compared to one part in a billion.

For the future, the AD antiproton decelerator, a simpler machine providing less antiprotons and with only fast extraction (May 1997, page 1), will continue CERN's low energy antiproton tradition. The physics programme already includes trapping to 'mass produce' antihydrogen at the rate of about 1000 atoms per hour, and new precision studies of antiprotonic helium. The AD is scheduled to supply its first antiprotons next year. LEAR may be dead, but its physics tradition is still very much alive.

A special symposium at CERN on 15 May highlighted the accomplishments of CERN's LEAR low energy antiproton ring. Among those present were LEAR pioneers Dieter Möhl (left) and Ugo Gastaldi.

Bookshelf

Data Analysis BriefBook, by R.K. Bock and W. Krischner, published by Springer, 3-540-64119-X; Particle Detector BriefBook, by R.K. Bock and A. Vasilescu, published by Springer, 3-540-64120-3

These 'Briefbooks' are brief handbooks, extended glossaries, in concise alphabetical encyclopedia style. The Data Analysis Briefbook, by Rudolf Bock of CERN and Werner Krischner, covers statistics, computing, analysis, signal and image processing and related fields, while the Particle Detector Briefbook, by Bock and Angela Vasilescu of Bucharest, deals with detector techniques and principles, the underlying physics and the analysis of data. It does not cover specific detectors.

Author Rudy Bock explains that after having accumulated useful collections of formulae, these were put together and published initially through the European Physical Society. This was sold out after a few years, but people still asked for a reprints, and this led to the opening with Springer.

Complementary information, will many links, is also available via http://www.cern.ch/Physics/ParticleDetector/BriefBook/ and http://www.cern.ch/Physics/DataAnalysis/BriefBook/

Conceptual Developments of 20th Century Field Theories, by Tian Yu Cao, Cambridge University Press, ISBN 0 521 43178 6 hardback, 0 521 63420 2 paperback

This masterpiece, first published last year in hardback (Bookshelf - April 1997, page 20), is now available in paperback.

Quantum Gravity in 2+1 Dimensions, by Steven Carlip, Cambridge University Press, ISBN 0 521 56408 5

An addition to the series of Cambridge Monographs on Mathematical Physics

The riddle of Majorana

Those who were intrigued by the July (page 28) article on the mysterious disappearance of the Italian theorist Ettore Majorana in 1938 and can read Italian would profit from the paperback 'Il Caso Majorana' by Erasmo Recami, Bestsellers Saggi, published by Mondadori, ISBN 88-04-35344-9

People and things

At CERN, Geoff Taylor of Melbourne explains the ATLAS experiment at CERN's LHC proton collider to Australian senator Jacinta Collins. Both Melbourne and Sydney are members of the ATLAS collaboration.

LEP 2000

At its June meeting, CERN's governing body, Council, decided that CERN's flagship machine, the LEP electron-positron collider, should continue physics in the year 2000 before finally being shut down. Running at a collision energy of 189 GeV, LEP is exploring the region where, according to consistency checks on today's Standard Model of particle physics, the famous Higgs particle is most likely to be found. The Higgs, responsible for electroweak symmetry breaking, is the missing link in the Standard Model picture. Other new physics could come into view as the LEP energy is cranked higher. With upgrades of the cryoplants servicing the superconducting accelerating cavities which provide energy to the circulating beams, and with careful preparation of the cavities themselves, the goal is for LEP to attain an ultimate collision energy of 200 GeV (100 GeV per beam), more than double the energy of the machine when it was commissioned in 1989.

CERN Council

Also at the June meeting of CERN Council, Walter Majerotto of Austria was nominated Vice-President of Council for one year from 1 July.

Council decided CERN's new management structure to begin in January 1999 when Luciano Maiani starts his five year mandate as Director-General. Roger Cashmore (currently at Oxford) was appointed Director for Collider Programmes until December 2001; Claude Détraz (currently Director of the French IN2P3 institute of nuclear and particle physics) was appointed Director for Fixed Target and Future Programmes until December 2001; Lyndon Evans will continue as LHC Project Leader for three years; Horst Wenninger was appointed Director for Technology Transfer and Scientific Computing until May 1999 with Hans F. Hoffmann taking over from June 1999 to December 2001; Kurt Hübner will continue as Director for Accelerators for two years; Jürgen May was appointed Technical Director until 31 December 2001; and Maurice Robin will continue as Director of Administration for three years.

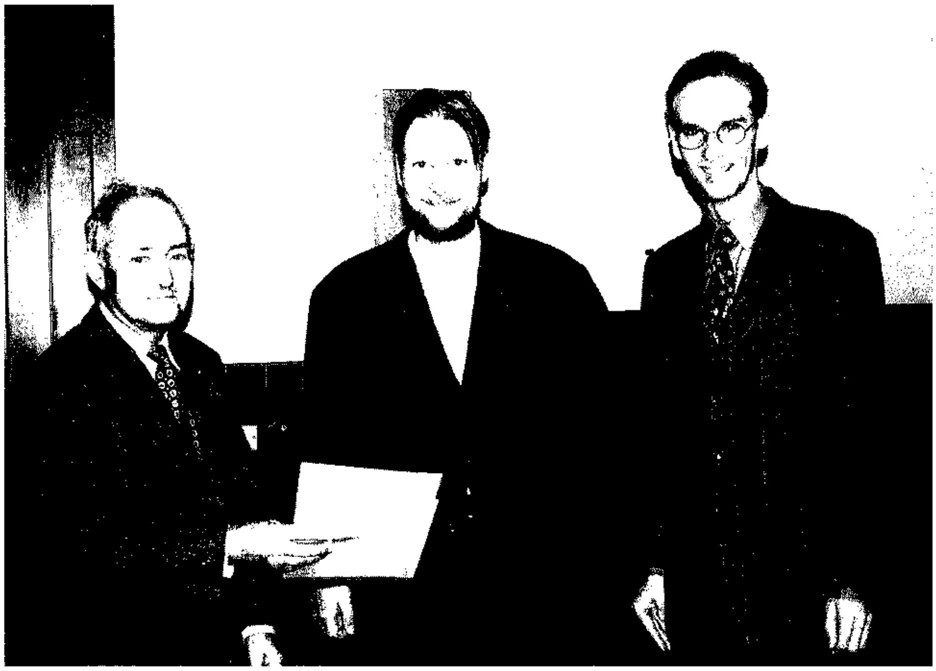
Manuel Delfino (currently at Barcelona's Universidad Autónoma) was appointed Leader of CERN's Information Technology (IT) Division from 1 January 1999 to 31 December 2001. Dietrich Güsewell was re-appointed Leader of Engineering Support and Technologies (EST) Division from 1 January 1999 to 31 December 1999, and Philippe Lebrun (currently Leader of the Cryogenics for Accelerators Group in CERN's LHC Division) was appointed as Leader of LHC Division from 1 January 1999 to 31 December 2001.

On people

Prominent cosmologist Martin Rees of Cambridge has been awarded the prestigious Bower Science Prize of Philadelphia's Franklin Institute 'for his significant contributions and research on cosmic evolution, black holes and galaxies'.

New members of the US National Academy of Sciences include Roman Jackiw of MIT and Michael Witherell of Santa Barbara.

Hans von der Schmitt takes over DESY's Technical Infrastructure and Central Computing department



The head of the Friends and Sponsors of DESY Association, Erich Lohrmann (left), Research Director at CERN from 1976 to 1978, former member of the DESY Directorate and leading DESY scientist for many years, presents the Association's annual PhD thesis prize to Alexandre Alimovich Glazov (32) from the Humboldt University in Berlin (centre) and Arnulf Quadt (29) from Oxford (right) for their measurements of the proton structure functions with respectively the H1 and ZEUS detectors.
(Photo Ilka Flegel)

DESY Directorate

On July 1, Hans von der Schmitt (49) took over the direction of the DESY's "Technical Infrastructure and Central Computing" (called "Z" for short) department from Ulrich Gensch, in charge of it since 1995, and who is now head of the DESY branch institute in Zeuthen (Brandenburg).

Hans von der Schmitt studied physics at Mainz. His main activities have included the realization of the "microtron" electron accelerator in Mainz and the development and optimization of the data acquisition systems for the OPAL and UA1 detectors at CERN as well as for the JADE detector at DESY. He habilitated (worked for a professorial degree) at Heidelberg in 1991 on microprocessor systems in data acquisition for high energy physics experiments. Two years later, he joined a software company in Bern, where he headed several major projects for the Swiss Telecom PTT (now Swisscom).

Honour for DESY's "Founding Father"

On June 18 Willibald Jentschke (86) was awarded a honorary doctorate by the Institute for High Energy Physics in Protvino near Moscow. The "founding father" of DESY was honoured "for his great contribution to the World Science, Humanism and Progress".

When Jentschke received a call from Hamburg University in the mid-fifties, he coupled his acceptance of a new responsibility with a demand for a modern particle accelerator - a German facility where internationally-recognized particle physics research could be performed and which would also provide students with up-to-date training. The result, DESY, was founded in 1959. The scientific use of synchrotron radiation, now DESY's second research area, also goes back to Jentschke's times. Willibald Jentschke was Head of the DESY Directorate from 1959 to 1970, and from 1971-75 served as Director General of CERN I.

SLAC archive

The Stanford Linear Accelerator Center (SLAC) has been honoured for its commitment to archival programmes by the California Society for Archivists, the first award given by the Society. SLAC, authorized by Congress in 1961, began its archival programme in 1986, when hundreds of linear feet of research records were inventoried as part of a history project. SLAC Archives officially began in 1989. Since then, the archival "dungeon" has been transformed into a state-of the-art storage area with temperature and humidity controls, light and air filtering, and mobile shelving. In addition, SLAC has continued and expanded its support of staff and equipment. Two of SLAC's oldest collections of photographs are being preserved on microfilm.

UNIVERSITY OF VICTORIA
POSTDOCTORAL
RESEARCH ASSOCIATE POSITIONS IN
EXPERIMENTAL HIGH ENERGY PHYSICS

The University of Victoria invites applicants for Research Associate positions in Experimental High Energy Physics. The positions will be based at CERN and at the University of Victoria, working on the OPAL experiment. The positions have terms of two years with a possible one year extension. Positions are available immediately.

The University of Victoria group is currently pursuing research at LEP II with the OPAL collaboration. We expect successful candidates to take an active role in the analyses of OPAL data. The group already has a significant role in searches for new phenomena, triple gauge coupling measurements and several aspects of physics with tau leptons.

The University of Victoria also is responsible for operating the OPAL online data reconstruction facility. The successful candidates would be expected to assume a major role in the operation and support of this system. Candidates should have a recent Ph.D. in particle physics and experience with UNIX operating systems. Familiarity with the C programming language and experience with operating system installation and management would be an asset. Interested candidates should, prior to 30 October 1998, send a curriculum vitae and arrange for two letters of recommendation to be sent to:

R. Sobie
Department of Physics and Astronomy
University of Victoria
Box 3055 Stn CSC
Victoria, British Columbia
V8W 3P6
E-mail: rsobie@uvic.ca
FAX: (250) 721-7752

In accordance with Canadian immigration regulations, priority will be given to Canadian citizens and permanent residents. All qualified individuals are encouraged to apply.

Princeton University
Electrical Engineering Staff Position in the Physics Department

Princeton University invites applications from qualified electrical engineers for a position in the Professional Technical Staff of the Physics Department. The position will be based at CERN for work on the CMS Electromagnetic Calorimeter, and the successful candidate will be expected to assume a major role in the ECAL readout. Candidates are expected to have knowledge in the design and layout of full-custom mixed-mode circuits, and they should have experience in electronics for high energy physics experiments, especially calorimeter readout at high-luminosity colliders. Interested candidates should send curriculum vitae and the names of three references or letters of recommendation to:

Dr. Peter Denes
CERN / EP
CH-1211 Geneva 23
Switzerland
(peter.denes@cern.ch)

Princeton University is an Equal Opportunity/Affirmative Action Employer

Experimental Research Associates

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

A limited number of postdoctoral Research Associate positions will be available in the coming year to participate in the laboratory's research program, with particular emphasis on:

- Preparing for B physics with the BABAR detector at the PEP II Asymmetric B Factory, helping design and build the detector subsystems and get ready for physics
- Participating in a Particle Astrophysics program studying time-dependent x-ray sources with the USA and R&D for a high-energy gamma ray astronomy experiment in space (GLAST)

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

Applicants should send a letter stating their physics research interests, along with a CV, list of publications, and the names and addresses of three references to: Tanya Boysen, TKB@slac.stanford.edu, Research Division, M/S 80, SLAC, P.O. Box 4349, Stanford, CA 94309. Equal opportunity through affirmative action.

Stanford Linear Accelerator Center
SLAC

EXPERIMENTAL MEDICAL PHYSICS/BIOPHYSICS
University of Utah

The Physics Department at the University of Utah is seeking highly qualified candidates for a tenure track faculty position at the assistant, associate, or full professor levels in experimental medical physics or biophysics. Research specialties of interest include but are not limited to magnetic resonance imaging (MRI), functional imaging, diagnostic angiography, microcapillary perfusion imaging, NMR microscopy, optical imaging, membranes, neurobiophysics, cell biophysics, motor molecules, protein structure/function. We seek candidates with strong commitments to both teaching and research. Successful candidates will be expected to teach undergraduate and graduate courses in physics as well as medical physics or biophysics, depending on the candidate's speciality.

Candidates should submit their curriculum vitae, list of publications, and at least three letters of recommendation by February 15, 1999 to:

MEDICAL PHYSICS/BIOPHYSICS SEARCH COMMITTEE
Department of Physics
115 South 1400 East, Room 201
University of Utah
Salt Lake City, UT 84112-0830

University of Utah is an Affirmative Action Equal Opportunity Employer. It encourages applications from women and minorities and provides reasonable accommodations to the known disabilities of applicants and employees.

23 May marked the 70th birthday of eminent particle theorist Samoil Bilenky of Dubna's Bogoliubov Laboratory of Theoretical Physics. His researches into spin effects and neutrino oscillations have made a substantial contribution to particle physics.

Association of the Friends and Sponsors of DESY PhD Thesis Prize 1997

On June 4 the Association of the Friends and Sponsors of DESY awarded its fourth annual PhD thesis prize. Consisting of a certificate and 6000 DM, it honours the best PhD theses on a DESY subject in high energy physics and synchrotron radiation research, including biology, chemistry etc., completed during the year. This year Alexandre Alimovich Glazov (32) from the Humboldt University in Berlin and Arnulf Quadt (29) from Oxford receive the prize for their measurements of the proton structure functions with respectively the H1 and ZEUS detectors - reflecting the fact that HERA is now looking deeper than ever before into the structure of the proton. The Association of the Friends and Sponsors of DESY is an organization of firms and private individuals which aims to make DESY more than just a scientific base, for instance by supporting social and cultural activities.

JINR Dubna

This summer Joint Institute for Nuclear Research (JINR) Director V. Kadyshevsky and Vice-Director A. Sissakian paid a working visit to Armenia, a JINR Member State. They were received by Armenian President R. Kocharyan, with whom they discussed the development of collaboration between JINR and Armenian scientists. Special attention was given to the participation of Armenian research centres, together with JINR, in large international programmes, including those for CERN's LHC.

Despite economic difficulties, science in Armenia continues. On 29 June in Yerevan, the JINR leaders took part in the opening of the International Workshop on Classical and Quantum Integrated Systems, co-organized by JINR and Yerevan State University.

At the Yerevan Physics Institute (YePI), 30 June was marked by a special scientific event for the 90th anniversary of the birth of Academician A. Alikhanian, the founder and first director of YePI. At this Institute's accelerator, joint experiments with JINR are planned to study deuteron photodisintegration by polarized photons at 2 GeV.

Boris Sergeevich Dzhelepov

Boris Sergeevich Dzhelepov

Boris Sergeevich Dzhelepov, renowned Russian scientist, corresponding member of the Russian Academy of Sciences, Professor of St.Petersburg, head of the nuclear spectroscopy laboratory at the Khlopin Radium Institute, suddenly died on 22 April.

Among the founders of atomic science and industry in Russia, his name is closely associated with development of fundamental research on spectroscopy of atomic nuclei. He began investigating artificial radioactivity and beta decay as early as the mid-1930s, was one of the first to estimate the neutrino mass, and predicted proton radioactivity. He participated in the Soviet uranium project under I.V.Kurchatov.

His precise magnetic spectrometers allowed extensive investigations of nuclear decays. From 1950 he headed a major programme for studying the properties of nuclei far from beta stability. Decay of neutron-deficient nuclei produced in spallation reactions at the 680-MeV synchrocyclotron in Dubna was investigated at JINR (Dubna) and many other research centres in the

World Wide Web pioneer Tim Berners-Lee was the main speaker at the recent meeting 'Internet, Web, What's Next?' at CERN on 26 June, recalling how his 'dream' of a seamless information space using global hypertext became a reality at CERN in 1989. The special requirements of world collaboration in high energy physics catalysed the sudden appearance of the World Wide Web as an internet phenomenon. 'The Web could have been invented anywhere,' remarked Berners-Lee, 'but there was nowhere better than CERN.'

At the end of March CERN's Travelling Exhibition moved to Sweden after receiving over 31,000 visitors during five busy weeks in Helsinki. Gunnar Öquist, General Secretary of the Swedish Research Council NFR, and Luciano Maiani, CERN's Director-General designate, officiated at the opening ceremony in Teknorama at the Tekniska Museet, Stockholm, Cultural Capital of Europe '98. Next stop Luleå!

At a symposium dedicated to the memory of Los Alamos theorist Richard Slansky, who died on 16 January - left to right: Geoffrey West of Los Alamos, Slansky's daughter Jill, who spoke on cancer research at Johns Hopkins, and Sydney Meshkov of Caltech.

USSR and other JINR Member States. Over a hundred new radioactive nuclei were found. He summarized much new information in several monographs and handbooks.

For almost half a century B.S.Dzhelepov was the leading figure in planning and organizing annual all-Russian confrences on nuclear spectroscopy and nuclear structure. Many eminent scientists in Russia and other countries learnt much by working with him.

Fermilab meetings

October 10-12, International Conference on Heavy Quarks at Fixed Target (HQ98): Joel Butler, Fermilab, Chairman; Sponsored by Fermi National Accelerator Laboratory. http://www.fnal.gov/projects/hq98/

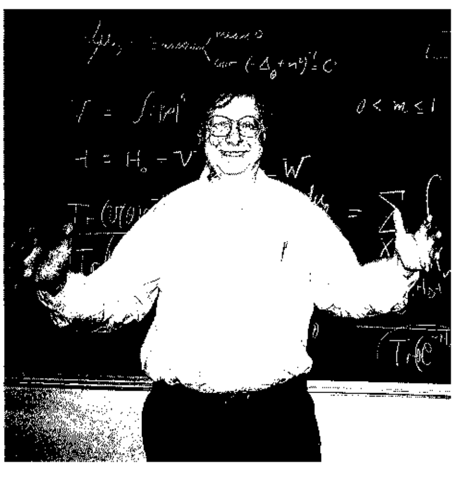
On April 3, a special symposium at Argonne marked the 65th birthday of former Argonne CERN Courier correspondent Malcolm Derrick and his contribution to the study of elementary particles. Speakers included John Dowell (Birmingham), Gale Pewitt (Fermilab), Gordon Charlton (DOE), Don Perkins (Oxford), David Miller (Purdue), Bo Andersson (Lund), Paul Kooijman (NIKHEF), Frank Sciulli (Columbia), Ned Goldwasser (Illinois) and Matthew Derrick (California, San Francisco). The symposium began with absorbing reminiscences by John Dowell of the early days at the Birmingham 1 GeV proton synchrotron. All the areas to which Malcolm made significant contributions were covered: bubble chamber construction, neutrino physics, electron-positron collisions, and electron-proton physics at HERA. The photo shows (left to right) Gaurang Yodh (California, Irvine), Larry Price (Argonne), Malcolm, and K.C. Wali (Syracuse).

October 16-18, RUN II Workshop (Top): Chris Quigg, Fermilab, Chairman; Sponsored by Fermi National Accelerator Laboratory.

November 19-21, RUN II Workshop (SUSY): Joe Lykken, Fermilab, Chairman; Sponsored by Fermi National Accelerator Laboratory. http://fnth37.fnal.gov/nov_meeting.html

June 14-19, SUSY 99 - 7th International Conference on Supersymmetries in Physics : Keith Ellis, Fermilab, Chairman; Sponsored by Fermi National Accelerator Laboratory. http://fnphyx-www.fnal.gov/conferences/susy99/susy99.html

Nov 19-21, 1998 "Physics at Run II" - Workshop on Supersymmetry/Higgs: Summary Meeting, M. Carena and J. Lykken, Co-Chairs; http://fnth37.fnal.gov/nov_meeting.html



A recent symposium marked the 60th birthday of axiomatic field theorist Arthur Jaffe of Harvard, currently President of the American Mathematical Society.

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.

The **Physics Department** of the **Johannes Gutenberg-Universität in Mainz** wants to fill the tenure faculty position of a

Professor for Experimental Physics (Besoldungsgruppe C3) at its Institute for Nuclear Physics

The activities of the Institute for Nuclear Physics are centered around the Mainz Microtron MAMI, a 100% duty cycle electron accelerator with an energy of 855 MeV (MAMI B), and related fields of physics. An increase of the energy to 1500 MeV (MAMI C) is applied for and will be decided by end of 1998. Physicists qualified in the fields of nuclear or particle physics are invited to apply. It is expected that the successful candidate will use this accelerator on the basis of the common equipment, budgets and personnel and that he/she promotes the fields of physics pursued at the institute.

For additional support of the work at MAMI a special research project (Sonderforschungsbereich) 'Many-Body Structure of Strongly Interacting Particles' has been applied for at the Deutsche Forschungsgemeinschaft DFG. A participation in this special research project is desired. It is expected that the successful candidate takes on teaching and administrative duties to the usual extent.

Applications from qualified women are particularly encouraged.

Applications should be sent with a curriculum vitae including research, teaching, and administrative experience and a list of publications to arrive not later than September 30, 1998 at the: Dekan des FB Physik der Johannes Gutenberg-Universität Mainz, Postfach 3980, D-55 099 Mainz, Germany.

EPFL

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

The Swiss Federal Institute of Technology Lausanne (EPFL) invites applications for a position of

Professor in processor architecture

for the Department of Computer Science

Candidates should be high competent in the fields of hardware architecture of processors and systems, and in one or several areas mentioned below: **reconfigurable systems, RISC and VLIW processors, Low power processors, micro-controllers for industrial applications, architecture for parallel pre-processing (intelligent sensors), specialized coprocessors.**

The applicant must have pedagogical skills at all teaching levels as well as strong aptitudes in guidance and management of research projects. He/she will be open to research collaborations, especially with companies. A few years of industrial experience is an advantage.

Deadline for registration: 15 November 1998. Starting date upon mutual agreement. Interested applicants can ask for the applications forms by writing or faxing to: **Présidence de l'Ecole polytechnique fédérale de Lausanne, CE-Ecublens, CH-1015 Lausanne, Switzerland, fax nr. +41 21 693 70 84.** For further information, please consult also URL: *http://www.epfl.ch, http://diwww.epfl.ch/* or *http://admwww.epfl.ch/pres/profs.html*

University of Helsinki
Finland

Professor in Experimental Particle Physics

The Faculty of Science at the University of Helsinki, Finland, invites applications for a full professorship in Experimental Particle Physics. The professorship is a joint permanent position of the Department of Physics and the Helsinki Institute of Physics. The candidate should direct research projects related to the CMS experiment at CERN. He (she) will be responsible for the Finnish participation in this project which is the main national particle physics experiment of Finland. The candidate is expected to work for a large part of the year at CERN. We are looking for a candidate with both significant accomplishments and promise for important achievements, who will lead innovative and high-impact research efforts. Teaching experience at undergraduate and graduate levels is expected. Candidates who do not have Finnish as their mother tongue should teach in English. Salary conditions will be based on those applied at CERN and Finnish universities.

For further information please contact: **Prof. J. Keinonen**, Head of the Department of Physics, tel. +358 9 191 8437, e-mail: Juhani.Keinonen@helsinki.fi, or **Prof. E. Byckling**, Director of the Helsinki Institute of Physics, tel. +358 9 191 8506, e-mail: Eero.Byckling@hip.fi.

An overview of the Department of Physics can be obtained from http://www.physics.helsinki.fi and of the Helsinki Institute of Physics from http://www.hip.fi.

Applications should include curriculum vitae with a brief account of the applicant's qualifications and academic activity relevant to the vacancy, a short report of the applicant's teaching merits, a numbered complete list of publications, one copy of all the listed publications, and four copies of up to 25 most important publications. The application should be addressed to the **Faculty of Science, University of Helsinki** and mailed to the **Registrar of the University, P.O. Box 33 (Yliopistonkatu 4), FIN-00014 UNIVERSITY OF HELSINKI, Finland**. Deadline for the application is November 3, 1998.

See also page 37
Victoria UNIV.!!!

FACULTY POSITIONS IN PHYSICS

UNIVERSITY OF CALIFORNIA, BERKELEY

The Physics Department of the University of California, Berkeley intends to make one or more faculty appointments effective July 1, 1999, pending budget approval. Candidates from all fields of physics are encouraged to apply. Appointments at both tenure-track assistant professor and tenured levels will be considered.

Please send a curriculum vitae, bibliography, statement of research interests, and a list of references to **Professor Roger W. Falcone, Chairman, Department of Physics, 366 LeConte Hall #7300, University of California, Berkeley, CA 94720-7300**, by Tuesday, November 24, 1998. E-mail applications will not be accepted. Applications submitted after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

TENURE TRACK FACULTY POSITION
Experimental High Energy Physics
Carnegie Mellon University

The Department of Physics at Carnegie Mellon University invites applications for a junior tenure track faculty position in the area of experimental particle physics. The present program consists of experiment 781 at FNAL and the L3 experiment at CERN. Future activity is planned at the LHC, as members of the CMS detector and in the development of a BTEV facility at FNAL.

Applicants for the position should have postdoctoral experience and demonstrated ability in both instrumentation and analysis. The successful candidate is expected to assume a leadership role in future experiments. Applicants should be committed to excellence in undergraduate and graduate education.

The position will become available starting September 1999. Applications and three letters of recommendation can be sent via e-mail followed by a paper copy, to:

High Energy Search Committee
ATTN: Prof. A. Engler
Department of Physics
Carnegie Mellon University
Pittsburgh, PA 15213, USA
(e-mail: engler@cmphys.phys.cmu.edu)

Applications arriving until October 15, 1998 will be considered.

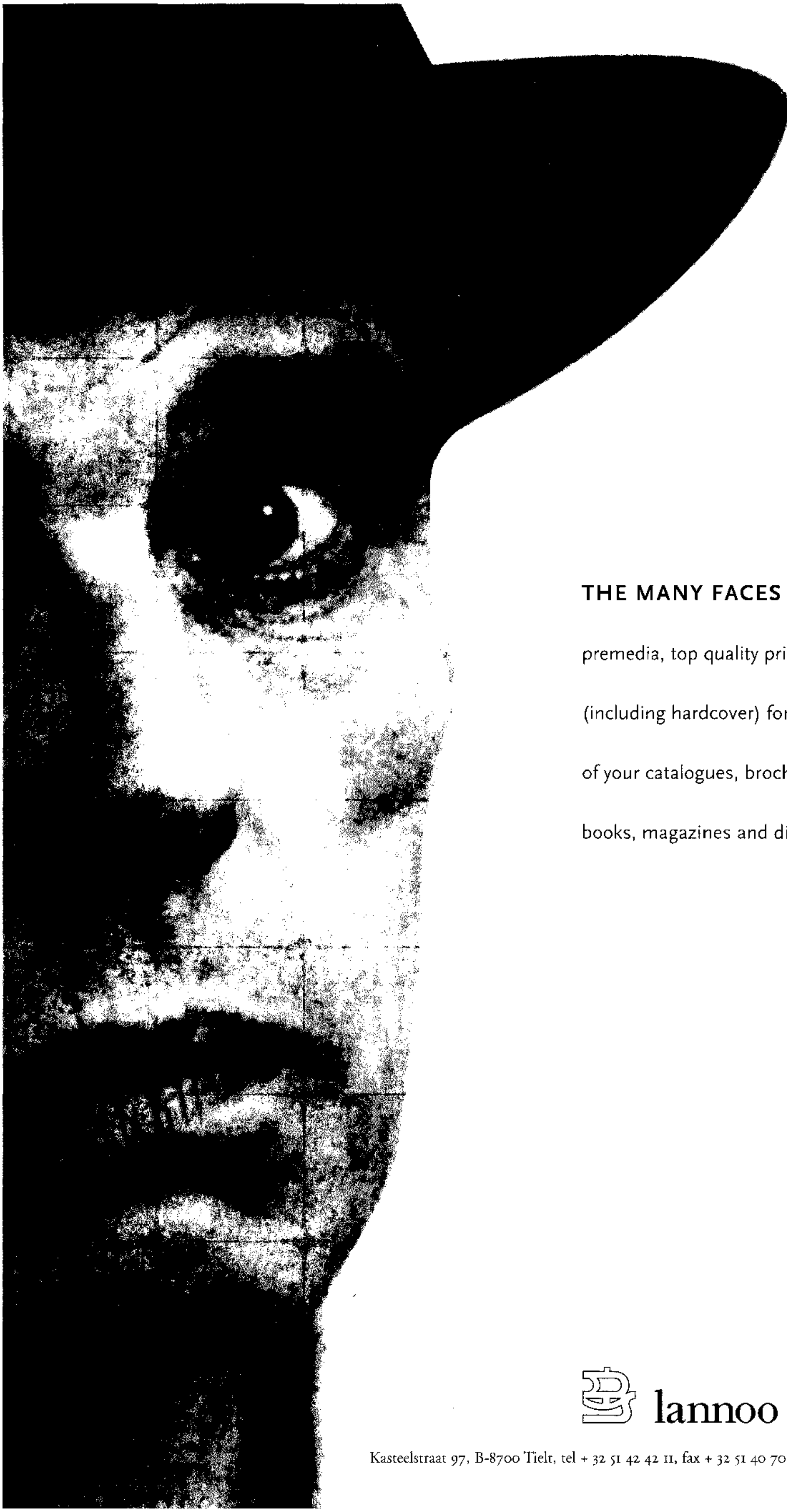
Carnegie Mellon is an equal opportunity / affirmative action employer

POSTDOCTORAL RESEARCH POSITIONS
EXPERIMENTAL ELEMENTARY PARTICLE PHYSICS
UNIVERSITY OF CALIFORNIA AT SAN DIEGO

The Department of Physics at the University of California, San Diego invites applications from outstanding candidates for one to two postdoctoral research positions in experimental Elementary Particle Physics (subject to budget approval). The primary purpose of these postdoctoral positions is to develop and build components of the CMS Data Acquisition and Higher Level Trigger system. The CMS DAQ is a project which strains modern electronics and computing technology. The Level-2 and Level-3 triggers, both performed on the same large CPU farm, will make a factor of about 1000 reduction in the trigger rate and pick the events that are kept for physics analysis. UCSD is involved in experimental research in BaBar, CLEO, LEP, and the LHC. We expect to plan a program including both hardware R&D and physics analysis with the successful candidate(s). Information on the UCSD group and its activities can be accessed at http://hephp1.ucsd.edu/. A Ph.D. in experimental Particle Physics and experience in both hardware and software development is required. Applicants should send a copy of their curriculum vitae, including a statement of physics interests, and arrange for three letters of recommendation to be sent to:

Prof. James G. Branson
Department of Physics, 0319
University of California at San Diego
9500 Gilman Drive
La Jolla, CA 92093-0319
email: pdsearch@hephp1.ucsd.edu or phone: (619) 534-2978)

The nominal deadline for the receipt of the application is October 20, 1998, but the search will continue until the position(s) are filled.



Universität Heidelberg

The Institute for High Energy Physics (IHEP) at Heidelberg University has two immediate openings for a

Scientific Staff Position in Technical Computer Science

(Wissenschaftlicher Angestellter) at the *Lehrstuhl für Hardware Informatik*, a newly formed research group. Immediate activities of this group include the design of high-performance trigger processors for LHC experiments, which includes as the implementation of trigger algorithms in both hard- and software. Heidelberg is one of the most beautiful German cities, located at the Neckar, in an area with a particularly mild micro climate.

The successful applicant is to participate in both the scientific and educational activities of a German *Lehrstuhl*. Besides collaboration with industry, the scientific projects include long term activities such as the design and implementation of a fast trigger processor for LHC experiments at CERN. Those projects include hardware and software design using the latest state of the art tools and equipment. The research group has access to an in-house ASIC laboratory.

Candidates should have experience with hard- and software. Experience with modern digital design methodology (VHDL, Verilog synthesis) is very favorable. The candidate should be familiar with common operating systems such as Windows NT and Unix and should have experience with C and C++.

The position requires a Ph.D and includes a substantial benefits package. The appointment will be initially for two years with a possible extension up to 5 years. Provided superior performance the position offers the possibility to confer qualification as a university lecturer (*Habilitation*). Disabled applicants with equal qualifications will be preferred. The Heidelberg University encourages especially women to apply. Interested applicants are invited to send their application before 31.10.1998 to:

Ruprecht-Karls-Universität Heidelberg
Institute for High Energy Physics
Ref: VOLI_2A
Schröderstrasse 90 – D-69120 Heidelberg, Germany

For additional information, please contact Prof. Volker Lindenstruth, e-mail: voli@ihep.uni-heidelberg.de, phone: + 62 21 / 54 - 43 03.

RESEARCH POSITION EXPERIMENTAL HIGH ENERGY PHYSICS

INDIANA UNIVERSITY

The Department of Physics at Indiana University invites applicants for a research position to work with the high energy physics group on the OPAL and ATLAS experiments at CERN and possible other future activities. The position will be available beginning September 1998. Appointments can be made at either the research associate or research scientist level, depending upon qualifications.

In OPAL the Indiana University Group played a leading role in the development of the silicon microvertex detectors and radiation monitor and now have responsibilities for their continued operation. We also developed and maintain for OPAL the offline analysis facility, SHIFT. We are now heavily involved in searches for new particles at LEP2, particularly the Higgs boson and supersymmetric particles, as well as other physics. In ATLAS we are constructing part of the Transition Radiation Tracker and play a major role in computer simulation of tracking in the Inner Detector. We have also begun a new effort on muon collider research and development.

Applicants should have experience in physics analysis and tracking detectors. Candidates must have a Ph.D. degree. Applications, including vitae, list of publications, and three reference letters, should be sent to:

High Energy Physics Secretary
Department of Physics
Indiana University
Bloomington, IN 47405

by **September 30, 1998.** Indiana University is an Equal Opportunity/Affirmative Action Employer.

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

We invite applications from recent Ph.D. graduates for a post-doctoral position in

Experimental High Energy Physics

The initial appointment is made for two years with the possibility of renewal for up to a total period of five years. The position is 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 person appointed will participate in exploiting the physics potential of the H1 detector as well as in the maintenance, application and the upgrade program of the neural network trigger.

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)

EPFL

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

L'Ecole polytechnique fédérale de Lausanne met au concours un poste de

Professeur/e en architecture de processeurs au Département d'informatique

Le/la candidat/e possédera des compétences du plus haut niveau dans le domaine de l'architecture matérielle des processeurs et systèmes informatiques, ainsi que dans un ou plusieurs des domaines suivants: **systèmes reconfigurables, processeurs RISC et VLIW, processeurs à faible consommation, micro-contrôleurs pour applications industrielles et horlogères, architecture de pré-traitements parallèles (capteurs intelligents), coprocesseurs spécialisés.**

Ce poste demande des aptitudes et un goût pour la formation des ingénieurs à tous les niveaux, ainsi que de solides capacités dans la conduite et la gestion de projets. Le/la titulaire de ce poste lancera de nombreuses collaborations de recherche, en particulier avec des entreprises. Une expérience de quelques années dans une entreprise serait un avantage.

Délai d'inscription: 15 novembre 1998. Entrée en fonction: à convenir. Les candidatures féminines sont vivement sollicitées. Les personnes intéressées voudront bien demander, par écrit, le dossier auprès de: **Présidence de l'Ecole polytechnique fédérale de Lausanne, CE-Ecublens, CH-1015 Lausanne, Suisse**, ou par **téléfax au n° +41 21 693 70 84.** Des informations supplémentaires peuvent être obtenues sur le web:
http://www.epfl.ch, http://diwww.epfl.ch/ or
http://admwww.epfl.ch/pres/profs.html