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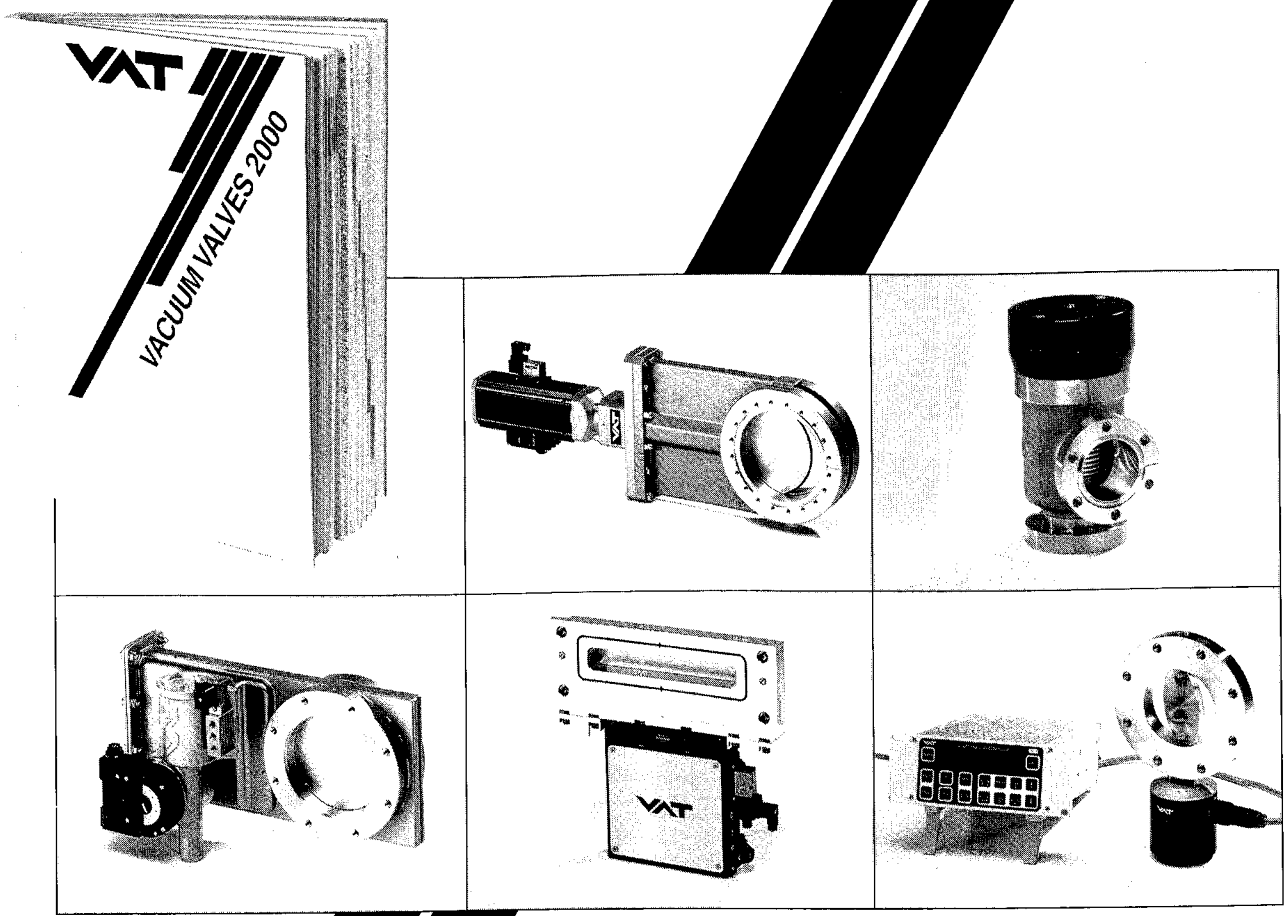

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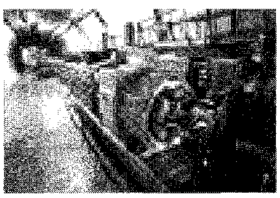
Around the Laboratories

Physics monitor



Cover photograph: A sextupole magnet in CERN's 27 kilometre LEP electron-positron collider, now operating regularly above 90 GeV per beam (180 GeV collision energy). Peak luminosities are over 5 x 10^{31} per sq cm per s, with over 2 inverse picobarns delivered in 24 hours (Photo CERN AC 1.5.97).

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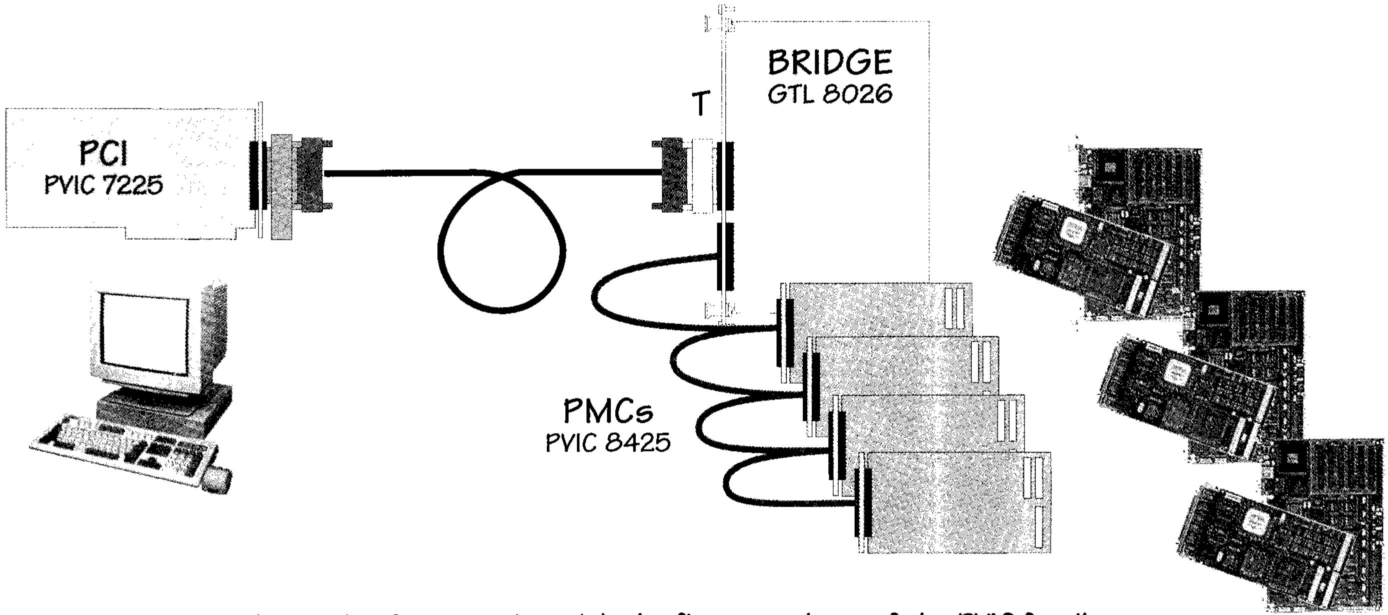

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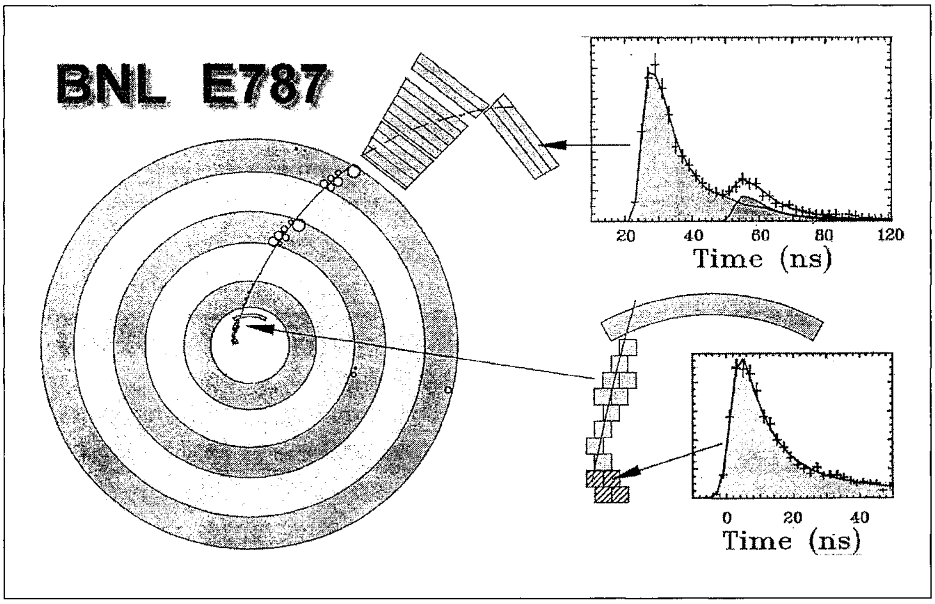
CREATIVE ELECTRONIC SYSTEMS

Around the Laboratories



The rarest event in physics? The signature of a positively-charged kaon decaying into a pion and two neutrinos. Lower right is the signal shape of one of the stopping target elements excited by the incoming kaon. On the left is the end view of the detector, showing the emerging pion traversing the drift chamber and finally stopping after passing through several range-track scintillators. On the upper right is the signal in the pion stopping counter, showing the characteristic double pulse due to the pion's subsequent decay into a muon

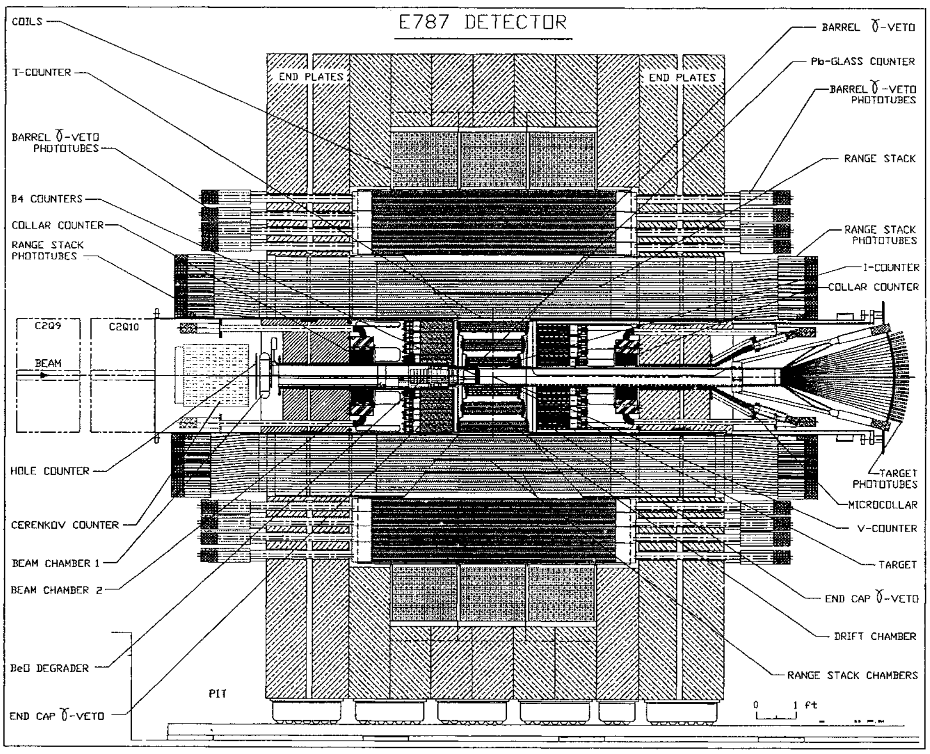
BROOKHAVEN Rarest particle decay

After ten years of searching, an international collaboration at Brookhaven believes it has seen the rarest decay of a subatomic particle ever detected, happening only once or twice in every 10 billion times a kaon self-destructs. Instead of producing the usual kaon breakdown products, the 'rare' kaon decay is thought to have released a positively charged pion together with a neutrino and an antineutrino.

So rare is the process that the scientists found only one such event after sifting through more than a trillion decays using their detector at Brookhaven's Alternating Gradient Synchrotron (AGS) accelerator. The team is made up of 50 researchers from Brookhaven, Canada's TRIUMF laboratory, Japan's KEK laboratory and Osaka University.

This rare kaon decay sheds new light on the extraordinarily successful Standard Model picture of elementary particles and their interactions, and may also suggest new phenomena that cannot be explained by the Standard Model. However to do this will require much more data to find more such decays.

Recent upgrades made the 35-year-old AGS capable of producing



Side view of the E787 detector at Brookhaven. Besides a conventional magnet and plastic scintillator calorimeters, the detector incorporates a scintillating fibre target, two systems of high speed (500 MHz) transient recorders, low-mass tracking and calorimeters with undoped cesium iodide crystals. Together, these elements can suppress background from processes occurring up to a trillion times higher.

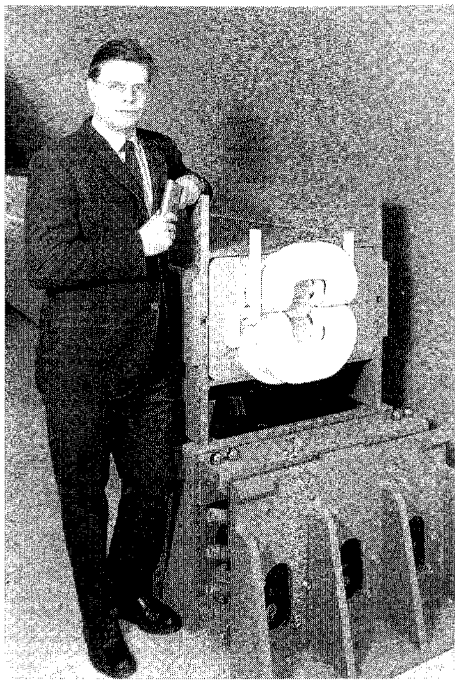
the world's most intense kaon beam. Kaons last only about 12 billionths of a second before decaying in a multitude of different ways, the main decay routes involving the transmission of one massive W or Z boson carriers of the weak force. However according to the Standard Model, the decay of a kaon to a pion and a neutrino pair might sometimes involve the momentary creation of a charged W boson and a neutral Z boson (which itself instantly decays into the two neutrinos).

So, to catch a fleeting pion, the E787 team, led by Doug Bryman of TRIUMF, Laurence Littenberg of Brookhaven and A. J. Stewart Smith of Princeton, built a new detector module, located in a strong magnetic field, using scintillating fibres, a tracking chamber and several other devices used to determine the energy and momentum of the pion and observe its characteristic decay. The detector first started working ten years ago, when the limit on this as yet unseen process was 1.4×10^{-7}. After an initial running period from 1988-91, this limit was improved to 2.4×10^{-9}, after which both the experiment and its beam were upgraded.

Charged kaons enter along the axis of a solenoid and are identified by a Cherenkov counter, beam chambers and scintillators. They are slowed in a beryllium oxide degrader and finally stop in a scintillating fibre target. Charged decay products are picked up in a cylindrical array of scintillation counters and straw chambers.

The experiment collected some 15 terabytes of data, from which it unearthed one event that was completely unexplainable except by the rare decay. The pion momentum band was from 211 to 230 MeV, and the estimated background is 0.08 ± 0.03 events. The estimated branching ratio, up for ratification as the lowest ever seen, is $4.9 + 9.7 - 3.5 \times 10^{-10}$.

Now that the experiment has shown it can detect and measure such rare processes, the ongoing goal is to ascertain whether the width of this tiny decay slot corresponds to the rare but nevertheless Standard-Model-compatible mechanism or whether another mechanism also contributes. If so, then a chink in the Standard Model will have been found. The search will continue, even after the AGS is thrust into its new role as injector for Brookhaven's RHIC heavy ion collider, scheduled to become operational in 1999.



Fermilab founder Robert Wilson with an early model of a magnet for the laboratory's Main Ring, which became operational in 1972 and was formally closed in September after a quarter of a century of sterling service.

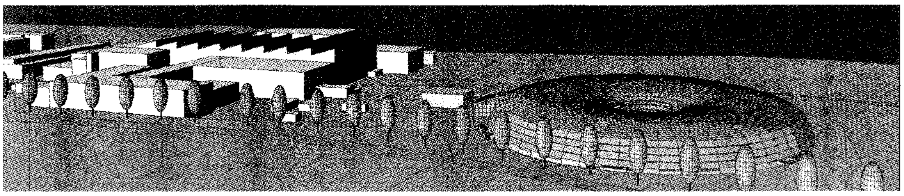
FERMILAB
Farewell Main Ring

On 15 September a flip of a switch turned off forever the beam of protons in Fermilab's Main Ring, the Laboratory's original particle accelerator, after 25 years of faithful service marked by milestone contributions to science.

Fermilab staff have begun dismantling the ring and transplanting its quadrupole focusing magnets for the Laboratory's newest accelerator, the Main Injector. When this Main Injector begins operating in 1999, it should result in a tenfold increase in the rate of high-energy proton-antiproton collisions at Fermilab's Tevatron, the world's highest-energy particle accelerator.

Caught in the act. Main ring closure at Fermilab - left to right: Main Ring veteran Rich Orr, Andy Mravca of the Department of Energy, Fermilab Director John Peoples, and Head of Beams Division Operations Bob Mau.

(Fermilab photo - Reidar Hahn)



Artist's view of the proposed Swiss Light Source (SLS) site at the Paul Scherrer Institute. The new 288 m radius storage ring is on the right of the existing accelerator complex.

Fermilab's founding director Robert Wilson broke ground for the Main Ring on 3 October 1969. The first beam of 200 GeV protons circled its four-mile circumference in 1972, and the Main Ring reached its operating energy of 400 GeV later that year.

In 1977 Leon Lederman used the accelerator's beams in experiments that revealed the bottom (b) quark, the first quark of the third generation of elementary particles.

Since 1983, the Main Ring has served as injector to the Tevatron, where in 1995, physicists discovered the bottom quark's partner, the top quark. As an injector, the Main Ring was a bottleneck for antiprotons, limiting the high-energy particle collision rate and the $229 million Main Injector was designed as a replacement.

Many Fermilab employees who took part in building, commissioning and operating the Main Ring were on hand to bid it a nostalgic farewell, among them Accelerator Operations Chief Bob Mau, who said "I sure hope it will be easier to turn it off than it was to turn it on."

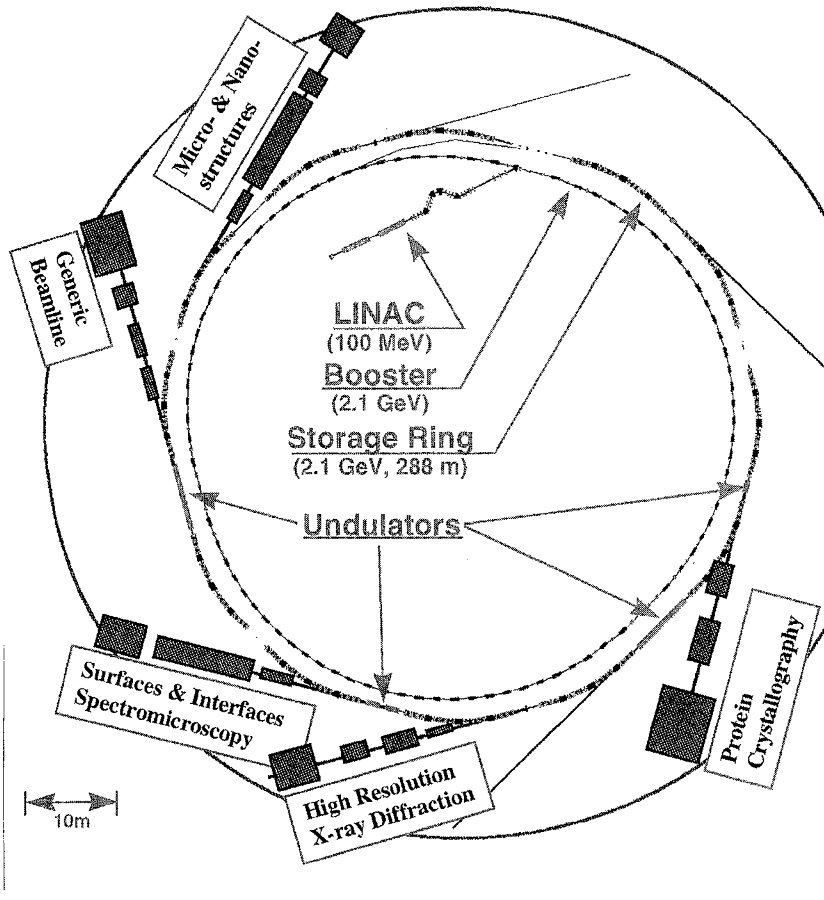
PSI
Green light for Swiss Light Source (SLS)

On the 18 June, the Upper House of the Swiss Parliament voted unanimously in favour of the proposed Synchrotron Radiation Facility (SLS), at the Paul Scherrer Institute. The decision followed an equally positive one by the Lower House, some three months earlier. The project with a total budget of 159 million Swiss francs, is scheduled for operation at the start of 2001.

The original proposal for this national facility dates back to 1993 and in the last few years the project has been thoroughly vetted both within the scientific community and by national science policy bodies. Architectural planning has to a large extent been completed and 'groundbreaking' is expected soon.

Synchrotron radiation, for a long time a troublesome by-product of high-energy accelerators, has developed into a powerful multidisciplinary tool. At modern synchrotron radiation facilities photons have a brightness (flux per solid angle and energy bin) twelve orders of magnitude stronger than conventional laboratory sources.

The energy spectrum of the synchrotron radiation provided extends from a few eV to hundreds of keV and covers a broad range of scientific



Layout of SLS showing the Linac, the Booster and Storage rings together with the proposed initial beamlines.

applications from biology and chemistry to materials science and medicine. There is also strong interest from industry, for example in analytic applications, in crystallography, and in lithography (LIGA).

Nowadays, sources can be subdivided into high-energy rings (e.g. the APS Advanced Photon Source at Argonne, the ESRF European Synchrotron Radiation Facility, Grenoble, and SPRING8 in Japan) with electron energies of 6 - 8 GeV, which are optimized for hard X-rays. Complementary to these are the machines of around 2 GeV which deliver soft X-ray beams and are predominantly regional. They are also centres for the surrounding universities and industry. In the Swiss SLS the electrons, created by a gun and preaccelerated to 100 MeV, will be brought up to their final energy of 2.1 GeV in the booster synchrotron.

The 288 m radius storage ring will contain 12 straight sections. The emittance will be 3 nm rad, leading to a peak brightness from undulators of over 10^{20} for photon energies ranging from 1-3 keV.

Characteristic insertion devices in the straight sections will serve the specific needs of the beamlines. For low-energies (5 - 3000 eV), undulators are planned with period lengths ranging from 38 to 200 mm, to serve the soft-X-ray community, which has a long tradition in Switzerland.

The high-energy part will be covered by mini-gap undulators (photon energies up to 17 keV) and superconducting wavelength shifters (up to 50 keV). In addition, it will eventually be possible to replace the centre magnets of the triple-bend achromats with superconducting dipoles. These hard X-rays emitted from wigglers and bending magnets will be very useful for crystallographic applications.

Interest from future users is already great, as shown by many Letters of Intent and the high attendance at the workshops to fix beamline details.

From Heinz-J. Weyer and P.-R. Kettle PSI

STANFORD (SLAC) Matter from light

A team of 20 physicists has for the first time made matter directly from ordinary light. The experiment was carried out at the Stanford Linear Accelerator Center (SLAC) by scientists and students from Rochester, Princeton, Tennessee, and Stanford and was reported in the September 1 issue of Physical Review Letters.

The production of electron-positron pairs from high energy photons - light quanta, or gamma rays - has long been known. The first examples, from cosmic rays, were recorded by Blackett and Occhialini in 1933, and in high energy laboratory experiments, bubble chamber pictures were traditionally adorned with the characteristic whorls produced by an electron and a positron produced by an itinerant high energy photon.

The possibility that in a sufficiently strong electric field the vacuum would spontaneously break down into electron-positron pairs was first considered in the 1930s (referred to as the "Klein paradox") and discussed more extensively by Julian Schwinger in a classic 1951 paper.

However this latest experiment observed for the first time the creation of particles from real photons in a laboratory. Physicists accomplished the feat by dumping an incredible amount of power - nearly as much as it takes to run the entire US but lasting only for a tiny fraction of a second - into an area less than one billionth of a square centimetre, far smaller than the full stop at the end of this sentence.

They used high energy electrons produced by SLAC's two-mile-long accelerator and photons from a powerful "tabletop terawatt" glass laser developed at Rochester's Laboratory for Laser Energetics, attaining electric fields of order 10^{11} V/cm.

The laser unleashed a tiny but powerful sliver of light lasting about one trillionth of a second (picosecond) and just half a millimetre long. Packed into this sliver were more than two billion billion photons. The team synchronized the two beams and sent the electrons head-on into the photons, using SLAC's Final Focus Test Beam Facility.

When the 46.6 GeV SLAC electrons cross the focus of the 1 picosecond laser pulse, the field seen in their own rest frame is boosted by a relativistic gamma factor of 9×10^4, enough to produce electron-positron pairs. In a series of experiments lasting several months the team studied thousands of collisions, leading to the production of more than 100 positrons.

The process can also be interpreted as light-by-light inelastic scattering. When the electrons enter the laser focus, photons are backscattered, reaching an energy of 30 GeV. These 30 GeV gammas rescatter within the laser focus to produce the pair. To satisfy energy and momentum conservation the high energy gamma must absorb at least

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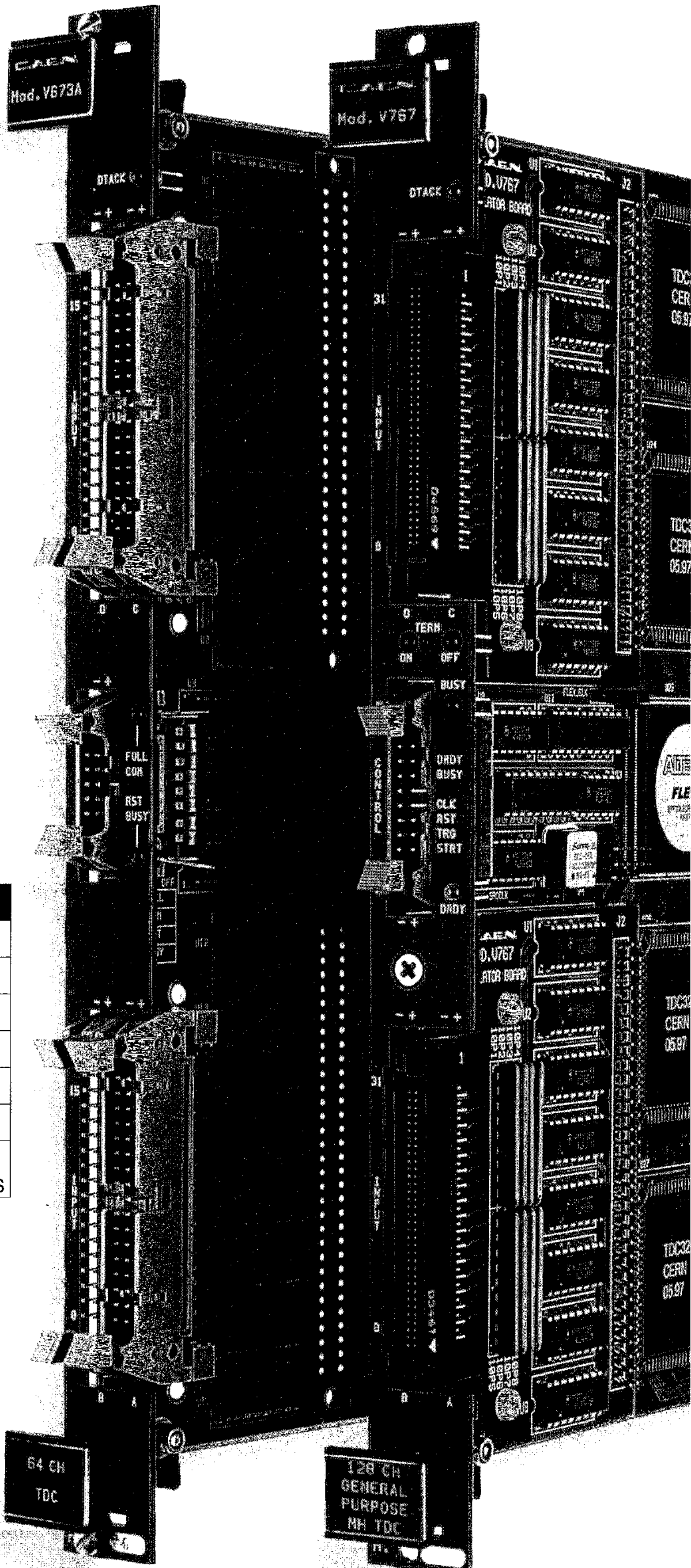

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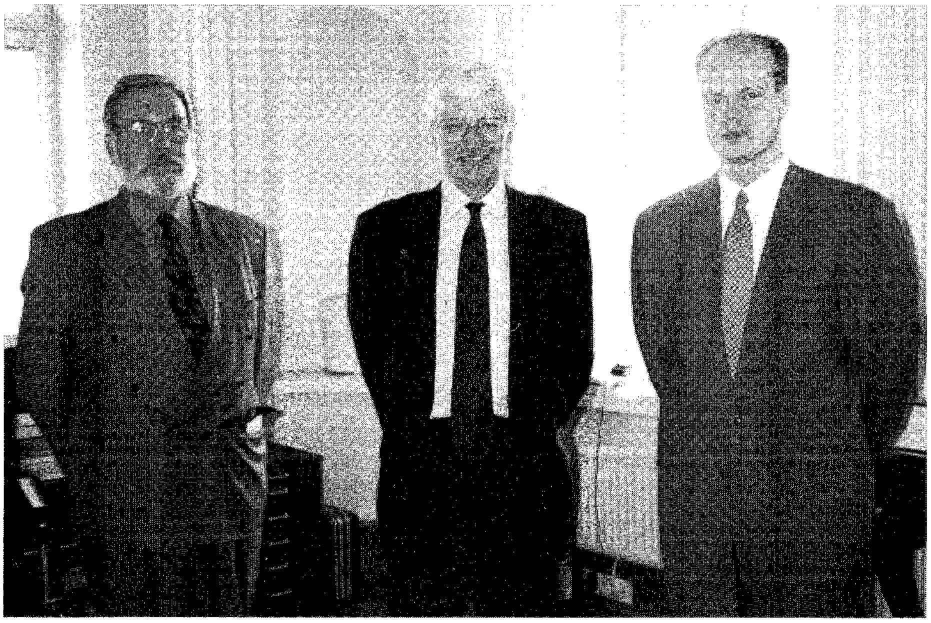
four laser photons, leading to a highly nonlinear process varying as the tenth power of the electric field.

The data are in excellent agreement with the calculations for multiphoton processes and are the first observation of the production of matter in light-by-light collisions involving only real photons.

The experiment is the forerunner of a wide range of photon studies which could be opened up using high power lasers in conjunction with the next generation of high energy linear electron-positron colliders.



At the European Committee for Future Accelerators (ECFA) meeting in Finland: Finnish Minister of Education Olli-Pekka Heinonen (left) with CERN Director General Chris Llewellyn Smith (centre) and Matti Lähdeoja, responsible for CERN matters.

FINLAND
ECFA survey

At the beginning of September, Finland was the venue for the latest national survey by the European Committee for Future Accelerators (ECFA) in its continual round of CERN Member States.

While Finland has a long research tradition in theoretical physics, experimental high energy physics only began in the mid-sixties with bubble chamber work initiated by K.V. Laurikainen, followed by a contribution to Carlo Rubbia's historic UA1 experiment at CERN's proton-antiproton collider. It was with the participation in Delphi at the LEP electron-positron collider in the 80s and later the creation of SEFT (the Research Institute for High Energy Physics) that Finnish particle physics reached cruising altitude.

Some 20 Finnish experimentalists have some sort of particle physics career. There are relatively many fixed-term researchers and graduate students (about 55) but two-thirds of them work on technical developments. However nobody in experimental particle physics has a fully tenured position (positions have to be renewed periodically) and there is no University professor in experimental high energy physics.

Until the summer of 1996, CERN-related activities were organized by SEFT, which coordinated particle physics research in 7 universities. Under Director R. Orava, SEFT employed 30 people on a permanent basis (mainly physicists) together with about 30 people on programmes supported by project funds from outside high-energy physics. SEFT also ran a training programme at CERN for students from technical universities, involving about 60 persons/year. This programme continues in the framework of the Helsinki Institute of Physics, with some special support from the Ministry of Education. SEFT has now merged with other institutes into the Helsinki Institute of Physics (HIP - Director E. Byckling) which covers all activities in particle physics.

Research activities at CERN are mainly centred on Delphi, with some participation in L3 at LEP. There is also detector research and development at HIP, which began for Delphi, on silicon detectors, gas ageing, magnet yoke design, cryogenics and data links, etc. But this is not yet focused on the LHC, work for which consists mostly of software and analysis for Atlas and CMS. Participation in heavy ion research (NA52) is likely to develop into a participation in ALICE, associating nuclear physicists to CERN. There was participation in SMC (cryostat) and there is R&D work on TESLA at DESY. The group using the ISOLDE on-line isotope source includes five Finnish physicists.

Finland joined CERN in 1991. As well as physics research, there is much emphasis on benefiting from CERN's technical developments and industrial spinoff, on which SEFT put a strong emphasis. Finland quickly obtained the highest industrial return index (return in relation to contributions paid) for non-Host Member States who pay in full. SEFT also catalysed the emergence of companies with the help of VTT (the State Research Centre). Finland's support for CERN and interest in the LHC is strongly linked to CERN's potential for technical developments and training. There is also a strong interest and support for CERN's student training programme.

Now incorporating SEFT and the Particle Physics Technology Institute at the Helsinki University of Technology (HTI) as well as the theory group (TFT) of the University of Helsinki, the streamlined Helsinki Institute of Physics (HIP) covers all CERN-related activities.

HIP should provide a stronger link between high-energy experimental physics and the universities. A recent visiting Committee (chaired by CERN Director Horst Wenninger) recommended that HIP offer permanent positions, especially for experimentalists, given the present very long timescale of present experiments. Half the recent PhDs went to industry or to research positions abroad.

HIP activities follow four lines: theoretical physics (S. Stenholm); experimental physics and detector developments (R. Orava); technology (E. Hameri); and another to prepare for the scientific exploitation of the LHC (J. Tuominiemi).

There is a long and strong tradition in theoretical physics, where Finnish theorists have had a fruitful association with CERN. Two CERN-JINR (Dubna) schools have been organized in Finland.

For historical reasons, there were until recently two main research groups, both in Helsinki. One was under the Physics Department of the University of Helsinki, the other at the Research Institute for Theoretical Physics, TFT, close to SEFT (Head V. Ruuskanen, with A. Niemi and L. Faddeev as frequent visitors). All theoretical activities are now regrouped within the Helsinki Institute of Physics. At present there are 45 theorists (15 with stable positions) and 20 graduate students. There are 7 full professorships in theoretical physics.

The Finnish contribution to CERN (currently 11.4 million Swiss francs per year) is paid through the Academy funded for that purpose by the Ministry of Education, which independently channels funds to the Universities (including HIP) and to the Finnish Academy. Overall support for particle physics is of the order of 7 million Swiss francs annually.

The budget of SEFT was constant from 1990 to 1995 although an increase had been foreseen and it could sustain its increasing operations only through important funding associated with technical R&D projects.

The Ministry of Trade and Industry channels research funds through the Technical Research Centre (VTT - which takes part in detector developments) and mainly through the Technology Development Centre (TEKES). Finland is increasing its R&D funding and by 2000 should have reached 2.9% of GNP (more than Japan) from a typical West European value of 2.4%. There is also some funding from Brussels, so that total additional 1997 funding for HIP, in addition to the money from the Ministry of Education, is 2.5 million Swiss francs.

The specialist company Cerntech (with former directors J. Teräs and then P. Pellinen) has been very successful in promoting contacts between European science and Finnish industry, which has strong traditions in superconducting materials and in electronics. CERNtech is now part of the Finntech technology transfer company.

Finland is a model for the development of fruitful industrial links with CERN and other international scientific organizations. On the basis of this success, Cerntech has been successfully assisting other Member States to boost their return from CERN. Some other Member States are setting up industrial liaison schemes along the CERNtech pattern.

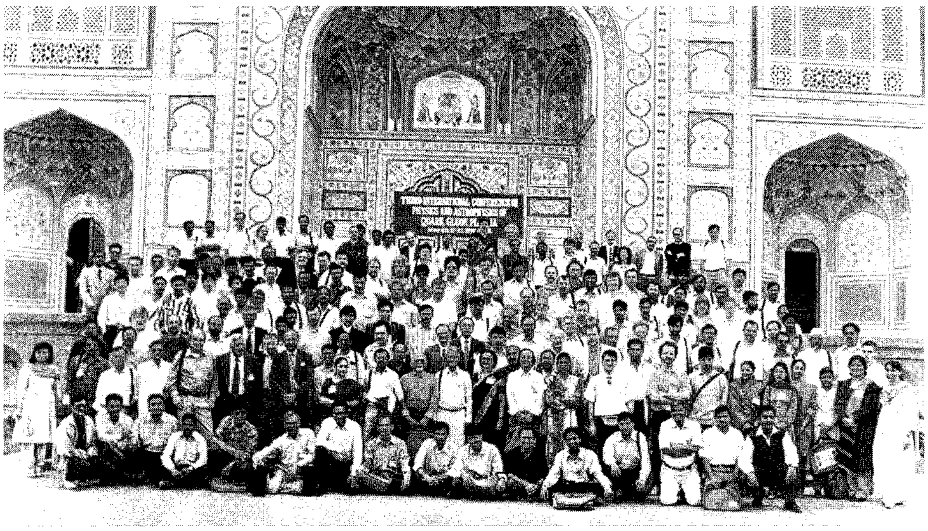
As well as the ECFA meeting itself, there were top level contacts between CERN and Finnish representatives.

SEFT has greatly helped the group in Tallinn in nearby Estonia, which, under the leadership of E. Lippmaa, has joined CMS. Estonia has signed a co-operation agreement with CERN.

Finnish Academy Director of Research and CERN Council delegate Jorma Hattula (right) with Finland's ECFA representative Paula Eerola.

Quark-gluon plasma on the horizon?

Participants at the Third International Conference on Physics and Astrophysics of Quark Gluon Plasma (ICPA-QGP'97) held at Jaipur, Rajasthan, from 17-21 March, with the massive gate of the Birla Science and Technology Centre in the background.



"Have you not heard his silent steps? He comes, comes, ever comes." So sang Tagore, the immortal Indian poet in Geetanjali - "The Song Offerings". And the Third International Conference on Physics and Astrophysics of Quark Gluon Plasma (ICPA-QGP'97) held at Jaipur, Rajasthan, from 17-21 March will be remembered for providing gentle hints of the likely formation of the long-awaited Quark Gluon Plasma in experiments underway at the CERN SPS synchrotron.

Ever since quantum chromo-dynamics (QCD), the theory of quark interactions, predicted the liberation of quarks and gluons from the rigid confines of hadrons at high temperatures or at high densities, nuclear physicists have looked for terrestrial and celestial signatures of the matter thus produced - the quark gluon plasma.

This has led to extensive experimentation at Brookhaven's Alternating Gradient Synchrotron (AGS) and CERN's SPS synchrotron, has pushed the building of the RHIC relativistic heavy ion collider at Brookhaven, and extended the research scenario at CERN's LHC collider to accelerate heavy ions as well as protons.

The well known signatures of the possible quark-hadron phase transition in heavy ion collisions include the suppression of J/psi production, the enhancement of strangeness production, the excess production of dileptons and single photons, etc. The heavens are also expected to hold some unique signatures of the quark hadron phase transition; well known examples being the expected effects on the Big Bang nucleosynthesis and MACHOs (massive astronomical compact halo objects) and black holes which would also offer an explanation for the dark matter. The cores of some neutron stars may also contain quark matter.

A group at Calcutta's Variable Energy Cyclotron Centre (VECC) led by Bikash Sinha, having realized the unique challenges of this fast emerging field, started organizing a series of International Conferences on Physics and Astrophysics of Quark Gluon Plasma in 1988. The first meeting was held at Bombay and the second at Calcutta in 1993. The third meeting in this series held at Jaipur earlier this year marked a long and fruitful journey for most of the Indian participants from the first hesitant steps at Bombay throughthe second meeting at Calcutta, (unfortunately coinciding with a brief period of social unrest).

These meetings, held at a convenient interval of four to five years and positioned between the more frequent Quark Matter series, have traditionally provided the reviewer with ample opportunity to obtain a panoramic view of a field whose distinctive features emerge only slowly.

The first contacts of the large number of young, competent, and aspiring Indian nuclear physicists with the international community have now culminated into collaborations such as the Indian participation in WA93 and WA98 experiments at the CERN SPS, STAR and PHENIX experiments at Brookhaven's RHIC, and the ALICE and CMS experiments at the CERN LHC. India is also contributing substantially to the construction of the LHC at CERN. A vibrant theoretical physics group has also evolved during this period, working exclusively on problems related to quark gluon plasma and astrophysics of the early universe. The Indian meetings have thus been able to reflect the emergence of much talent and a considerable channeling of intellectual effort.

The latest conference attracted about 200 participants from over 15 countries who met just before the spring festival of Holi in the modern B.M. Birla Science and Technology Centre tastefully set in a medieval town which has retained the splendour of its colourful heritage. Participants also got a taste of the culture of India during their stay at Jaipur. Many used this opportunity to explore exotic Rajputana - the land of

Jürgen Schukraft reviews experimental developments in the search for quark-gluon plasma during the opening session at Jaipur.

Rajputs; said to have originated not from quark gluon plasma but from a fire-pit on Mount Abu.

An excellent theoretical overview was provided by Jean Paul Blaizot (Saclay). The experimental overview of the heavy ion experiments at AGS and SPS energies was given by Jürgen Schukraft (CERN). His message could be simply summarized: the advent of a new generation of detectors and, most important, the availability of really heavy ion beams clearly indicate that the answer to the most crucial question 'Do we see signs for deconfinement, signs that the original vacuum symmetry is restored, signs for equilibrated hadronic matter? ' is very clearly 'Yes'. He also explained the exciting possibilities offered by RHIC and the LHC, where much larger volumes of much hotter and longer-lived plasma is expected to be produced.

An important guiding factor in this field has been the results from simulations of the QCD on an artificial lattice, discussed by Frithjof Karsch (Bielefeld) and Kazuyuki Kanaya (Tsukuba). The critical temperature for the pure gluonic theory is now quite precisely known to be about 264 ± 2 MeV. With dynamical quarks the temperature is more uncertain, and the transition temperature is now estimated to be between 150 - 200 MeV. It is also known now that the approach to free gas limit is rather slow. The order of the phase transition, except for the case of pure SU(3) gauge theory where it is first order, has remained somewhat uncertain.

David Schramm (Chicago) commented that even though a first order quark hadron phase transition in the early universe could not have drastically affected the big bang nucleosynthesis, it could lead to

formation of MACHOs, and also black holes having a mass of about half a solar mass. Among other things, this could offer an interesting explanation for dark matter.

The fascinating consequences of the premise that three-flavour quark matter can be metastable or even stable was discussed by Jes Madsen (Aarhus). He pointed out that one may even have a shell structure and "magic numbers" for the strange nuclear matter. It is now clear that an entirely new branch of 'strange' nuclear physics is fast emerging where almost the entire development of the traditional nuclear structure will be revisited in the 'company' of strange quarks. The future, thus, does seem to promise interesting surprises.

Fridolin Weber (Munich) explored yet another dimension of strange matter by discussing the fascinating structure of strange stars and pointed out that, contrary to the earlier claims, 'neutron' stars may very well contain quark matter in their cores surrounded by a region of a mixed phase of quarks and hadronic matter. He christened these objects 'hybrid stars' and claimed that up to 10 out of the presently known 700 pulsars may be carrying the signature of the phase transition.

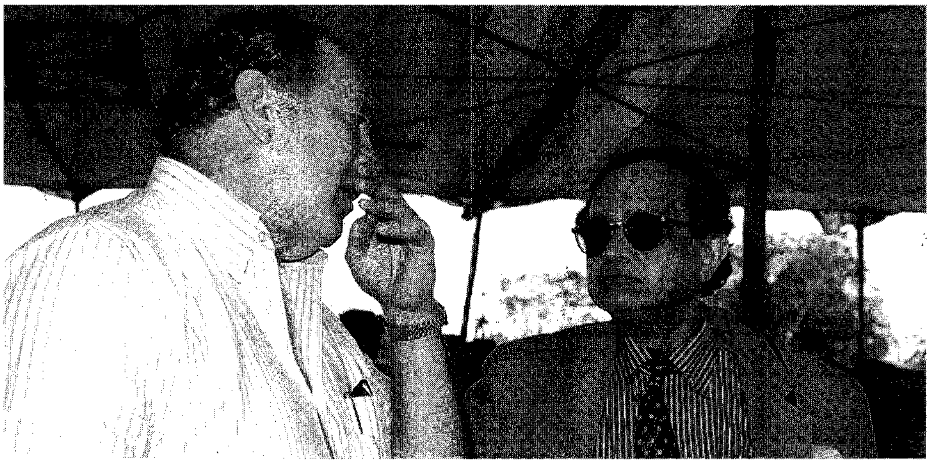
Bhaskar Datta (Bangalore) described the features of compact stars and their relevance for quark gluon plasma studies. Sibaji Raha (Calcutta) described the interesting possibility where relics of phase transitions in the early universe could have survived to present day as cosmological nuggets. He also discussed ongoing work to build a detector to identify their fragments in cosmic ray showers.

Electromagnetic radiation has long been believed to signal the presence of hot and dense matter. The results of the CERES experiment (CERN SPS) looking for the resultant dilepton production were presented by Axel Drees (Heidelberg). The data for sulphur- and lead-induced collisions show a clear enhancement of dilepton production above the hadronic background. The data perhaps also show one of the first signs of symmetry restoration, where the rho meson mass decreases substantially.

Charles Gale (McGill) reviewed the attempts to understand this behaviour and pointed that at SPS energies the dilepton yield is dominated by hadronic reactions and it is necessary to understand all the reactions leading to dileptons clearly and quantitatively.

The status of experiments awaiting the 'whisper' of single photons from the lead beam experiments were discussed by Terry Awes (Oak Ridge). Dinesh Srivastava (VECC) used the upper limit of single photon production reported by the WA80 collaboration in a sulphur beam on

Chicago astrophysicist David Schramm of Chicago (left) with Bikash Sinha, Director of Calcutta's Variable Energy Cyclotron Centre and the Saha Institute of Nuclear Physics, a leading figure in Indian involvement in heavy ion physics.



gold target experiment to argue that the data seem to rule out a hadronic description of the initial state of the collision, unless we can accept a situation where three to five hadrons reside within a volume normally occupied by a single hadron!

The subject of so-called Disoriented Chiral Condensates (what Bjorken refers to as a quark-gluon inverse 'baked Alaska' with the inside still hot but the outside condensed) received special attention with theoretical developments summarized by Ajit Srivastava and experimental efforts of MINIMAX (Fermilab) and WA98 (CERN SPS) collaborations by Tapan Nayak (VECC). WA98 is the only experiment which has measured both neutral and charged particle distributions over a large and common part of phase space.

Particle spectra from CERN's NA44 and NA49 experiments described by Peter Jacobs (Berkeley) suggested that stopping is enhanced in heavier systems compared to lighter ones.

Progress in model-independent analysis of each event using measures based on a system of scaled topological entropies and renormalization group theory was elegantly illustrated by Tom Trainor (Seattle). This event-by-event physics will be specially useful at future collider experiments with large particle multiplicities in each event.

Discussing the current status of the results two-particle correlation studies, Jeremy Dodd (Columbia) observed that the size of the freezout region is large, significantly larger than the transverse extent of the incoming nuclei both at the AGS and the SPS.

Federico Antinori (Padua/CERN) described in detail how the WA97 group has seen very clear excess production of strange (anti-)baryons; which seems to indicate the enhancement of strangeness production, long believed to be a signature of quark hadron phase transition.

The WA93/WA98 groups used the conference to announce the first observation of flow (the phenomenon discovered in pioneer heavy ion experiments at Berkeley in 1984) in experiments at the SPS. Peter Braun-Munzinger (GSI Darmstadt) eloquently summarized the AGS experiments which have led to confirmation of such directed flow. The discovery of flow in these collisions clearly confirms the collective behaviour of the system. Jean Cleymans (Cape Town) demonstrated on very general arguments that particle ratios in such experiments remain unaffected by flow and a variety of theoretical uncertainties, which may be present in the so-called thermal models. He also showed that the data measured by AGS and SPS experiments can be used to constrain and fix the temperature, the transverse velocity, and the chemical potential of the system at the time of freeze-out.

Larry McLerran (Minnesota) described progress in determining the initial conditions in relativistic heavy ion collisions which seem to reliably indicate the possibility of forming hot plasma. Joe Kapusta (Minnesota) showed that the gross behaviour of the bulk of heavy ion collision data could be explained surprisingly well as a straightforward linear extrapolation of proton-proton data. This will be of importance as deviations from this would confirm a collective behaviour.

The greatest excitement was generated by the final data for the J/psi suppression observed by the NA50 group, covered by Michel Gonin (Ecole polytechnique). Dima Kharzeev (Bielefeld) summarized the studies aimed at understanding the latest data and pointed out that it is very likely that the suppression seen in lead beam experiments is most probably due to quark-hadron phase transition while all the other data with sulphur or lighter projectiles could be explained without invoking any phase transition. He also pointed out that the different threshold behaviour seen in the lead beam experiment compared to the sulphur beam experiment might be originating from the fact that the (energy) densities likely to be reached in these experiments are much larger. In a special session devoted to future experimental efforts at the colliders,

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Govinda Mishra explaining flow results to Klaus Werner, Peter Jacobs and Basant Nandi during the poster session.

John Harris (Yale), Melynda Brooks (Los Alamos) and Guy Paic (CERN) described the tremendous efforts at RHIC and the LHC in designing experiments to meet the new challenges of increased particle density and the increased hopes of being able to collect many signatures of the phase transition in one experiment.

Summarizing the experimental talks, Hans Gutbrod (Nantes) complimented the Indian groups for the successful design, fabrication, testing, and operation of the Photon Multiplicity Detector at CERN which is fast emerging as an indispensable tool. (The first results from this detector had been earlier presented by Subhashis Chattopadhyay of VECC.)

In his theoretical summary, Helmut Satz (Bielefeld) described with satisfaction the progress of J/psi suppression studies, which have reached a very high degree of sophistication on both experimental and theoretical fronts and which seem to show the onset of colour deconfinement in the data obtained using lead beams. In a passionate reference to thermal models he pointed out that particle production even in such light systems as formed in proton-proton collisions have been shown to be consistent with thermal models. This perhaps indicates that we should try to understand all data in terms of quark-gluon scattering rather than using a hadron picture.

All these hints of the formation of the quark gluon plasma from so many different experiments somehow bring the words of the immortal poet, Tagore again to mind: "Many a song have I sung in many a mood of mine, but all their notes have always proclaimed. "He comes, comes, ever comes."

It is quite clear that the time is not far off when we would be producing the 'notorious' quark gluon plasma at will. Even with such hopes for the future, many participants will nevertheless always remember the beat of the drums, the enchantment of centuries-old music, and the explosion of folk dances experienced at the Jaipur meeting. With such an international effort underway, such a unique blend of science and culture makes this field so very exciting.

Oscillations underground

With potentially interesting phenomena increasingly out of reach of accelerators, or extremely rare, the complementarity between the accelerator approach to particle physics, using high energy beams, and the non-accelerator approach is becoming ever more apparent. This is highlighted in this issue by several conference reports.

In 1989, the first workshop on Theoretical and phenomenological Aspects of Underground Physics took place at Italy's Gran Sasso laboratory. In 1997, the series changed its name. Now known as Topics in Astroparticle and Underground Physics, the workshop recognizes the growing importance of the experimental side of the field and the link with traditional particle physics. TAUP'97, fifth in the series, was held at Gran Sasso from 7 - 11 September. This report by James Gillies covers the neutrino physics aspects of the workshop. Cosmology and cosmic ray physics will follow in the next issue of the CERN Courier.

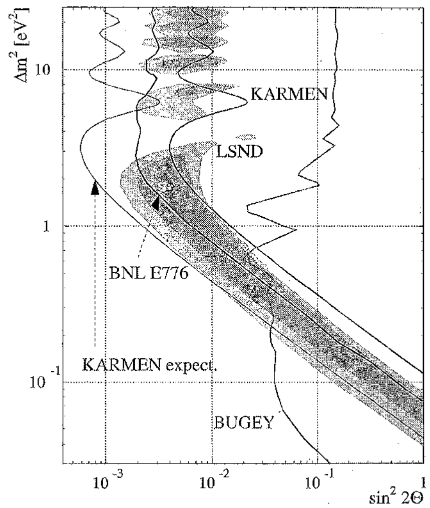
Neutrino oscillation, the proposed phenomenon whereby a neutrino of one kind (electron, muon or tau) can change into a neutrino of another kind, is one of the most pressing issues in physics today, since if neutrinos oscillate then according to quantum mechanics, they must have mass.

Attempts to detect oscillations, or measure neutrino mass directly, were accordingly high on the TAUP'97 agenda. CERN's Luigi Di Lella summarised the accelerator-based experiments: LSND at Los Alamos, Karmen at the Rutherford Appleton Laboratory, and Chorus and Nomad at CERN. In 1995, LSND famously announced evidence for oscillations, but the other experiments have yet to agree. Since the CERN experiments are less sensitive to low neutrino masses, they are unable to test the LSND result. However, according to Klaus Eitel of Karlsruhe, recent upgrades to Karmen will allow this Anglo-German collaboration to confirm or contradict LSND within two years.

Neutrino experiments quote their sensitivity in terms of the mass difference squared between the oscillating neutrino types. Current accelerator experiments are sensitive to a mass difference squared down to about an electronvolt squared. Future long baseline experiments in which a detector is placed far from the accelerator source will extend this sensitivity to 10^{-3} eV^2. Three projects are on the cards, with the first to take data likely to be in Japan where a beam from the KEK laboratory will be sent to the Super Kamiokande detector 250 kilometres away.

An American long baseline project was presented by Barry Barish of Caltech who described the Minos experiment at the Soudan mine. Starting in 2001 Minos will look for oscillations in a beam from Fermilab 730 kilometres away. In Europe, a proposal to send a CERN beam to Gran Sasso is awaiting final approval but has already aroused much interest.

Three experimental proposals were presented. Donatella Campana of Naples, speaking for the NOE collaboration, suggested a scintillating fibre detector. Tom Ypsilantis of CERN proposed a water



Limits on neutrino oscillations have yet to settle down. The vertical axis is the mass squared difference between neutrino types while the horizontal axis is the mixing angle between them. The area to the right of the lines is excluded, and the region allowed by Los Alamos' LSND experiment is shown by the shaded area. Some of the LSND-allowed area is excluded by the KARMEN experiment at the UK Rutherford Appleton Laboratory and by the Brookhaven (BNL) E776 experiment. The expected sensitivity of the upgraded Karmen detector ('KARMEN expect.') will test the LSND result.

Cerenkov detector, and the Icarus project was presented by Claudio Montanari of Pavia. Prototyping work is well underway, said Montanari, and if the CERN-Gran Sasso long baseline project gets the go-ahead, Icarus could be taking data by 2001.

Reactor experiments were summarized by Yves Declais of Annecy. Two new experiments, at Chooz in France and Palo Verde in the US, will have similar sensitivity to the long baseline accelerator experiments. Both place a detector about 1 kilometre from the reactor source.

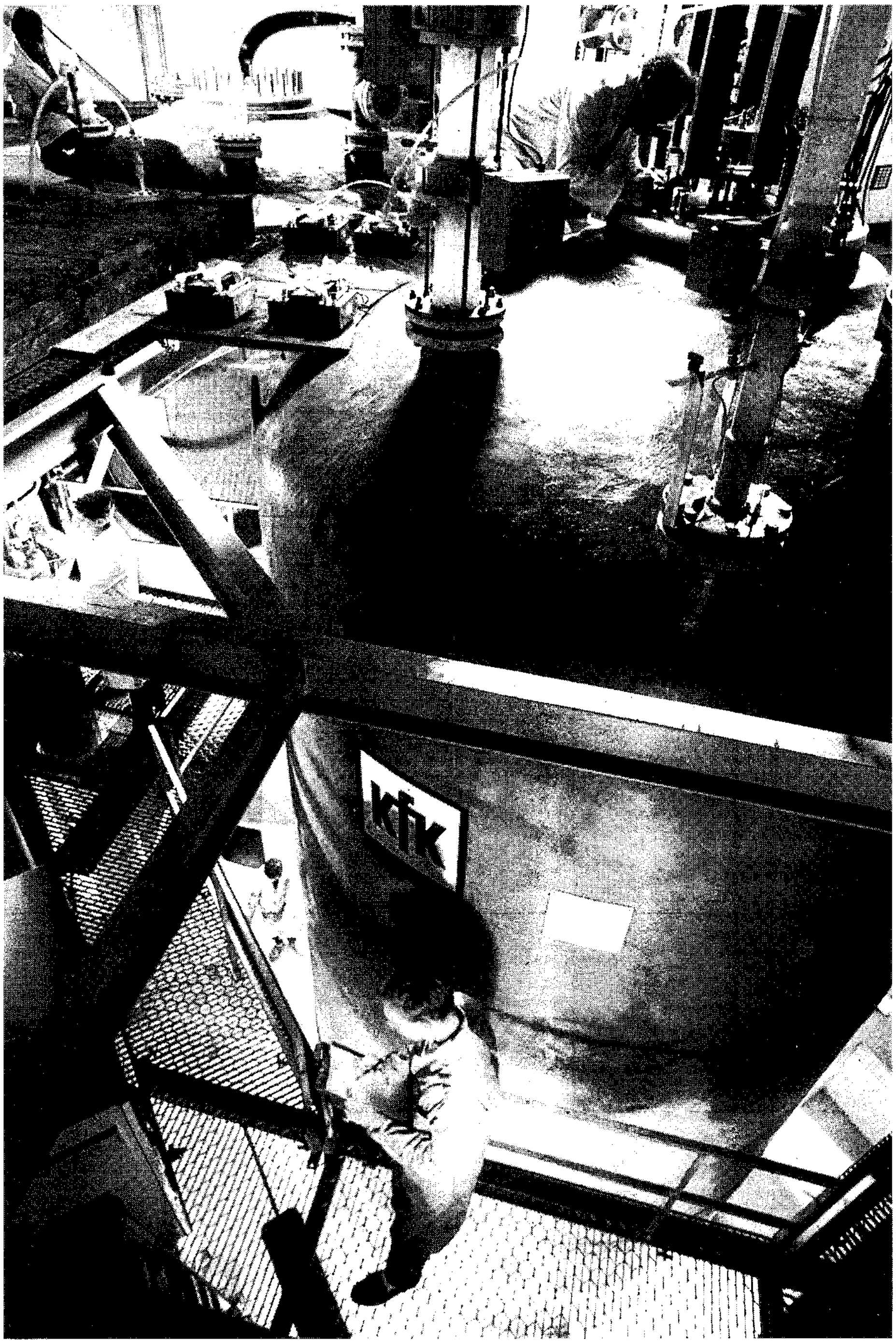
Looking further ahead, Declais discussed two experiments which will look at neutrinos from reactors extremely far away, with a sensitivity to mass differences squared of 10^{-5} to 10^{-6} eV^2. KamLAND in Japan is a 1000 ton liquid scintillator detector to be installed in 2000 at Kamioka and will detect neutrinos from reactors between 150 and 200 kilometres distant. The Borexino experiment at Gran Sasso, designed for solar neutrino physics, will also look at neutrinos from reactors. As explained by Stefan Schoenert of Munich Technical University, Italy's non-nuclear energy policy means that the nearest reactor to Gran Sasso is 400 kilometres away in Slovenia and most of the reactor neutrino flux at Gran Sasso comes from French reactors.

Reviewing the directly measured limits on neutrino mass was Lothar Oberauer of Munich Technical University who described the tritium beta decay experiments at Troitsk, Mainz, and Lawrence Livermore. All produced negative mass squared differences in their early days but now an improved Troitsk set-up gives a positive value and an upper bound on the electron-neutrino mass of 3.9 eV. Similar improvements have also been made at Mainz, and a result is expected soon. Muon-neutrino mass limits are obtained from positive pion decay at rest. The best is from Switzerland's Paul Scherrer Institute at 160 keV. The best tau-neutrino limit of 22.3 MeV comes from the ALEPH experiment at CERN.

Extraterrestrial neutrinos

Georg Raffelt of the Max Planck Institute in Munich considered what can be learned from supernova neutrinos. A supernova happens when a star has burnt most of its fuel to produce an iron core. As the star collapses, a shock wave blows off the surrounding material in a spectacular explosion. Supernovae release colossal amounts of energy, equivalent to nearly 17% the mass of our sun, and 99% of it is carried by neutrinos.

One puzzle dogging our understanding of supernovae is how the shock wave escapes the iron core. Neutrino oscillations could play a role, but at the same time, they



Preparing to extract germanium chloride from the Gallex detector for analysis. Gallex, at the Italian Gran Sasso underground laboratory, included 12 tons of gallium-71 in the form of gallium chloride solution. Solar neutrino interactions with the gallium-71 atoms produced germanium-71 which could then be counted. The low energy threshold of 233 keV for this reaction allows Gallex to be sensitive to neutrinos from solar proton-proton interactions, the principal source of the Sun's neutrinos.

could hinder heavy element production, so the issue is far from settled. Another enigma is how pulsars, the dense spinning neutron stars left behind after supernovae, attain their high velocities. Neutrinos emitted asymmetrically from the collapsing star could provide the necessary impulse.

The solar neutrino enigma, which began in the 1960s with Ray Davis' pioneering experiment in the Homestake gold mine, is best explained by neutrino oscillations. The mammoth Super Kamiokande water Cerenkov detector, presented by Kunio Inoue of Tokyo, continues to see a solar neutrino deficit as does the Gallex experiment at Gran Sasso, presented by Michel Cribier of Saclay. If neutrino oscillation is the answer, then a summer-winter flux variation would point to oscillations in vacuum since the Earth's distance from the Sun varies with season. Day-night variation would point to matter-enhanced oscillation since solar neutrinos reaching the detector at night have passed through the Earth. Super Kamiokande has so far not seen evidence for either.

Guy Jonkmans of the Laurentian University presented the Sudbury Neutrino Observatory, a 1000 tonne heavy-water Cerenkov detector sensitive to neutrinos from the decay of boron atoms in the Sun. SNO will detect flavour-independent neutral current neutrino interactions allowing the total neutrino flux to be measured, regardless of whether neutrinos oscillate or not. SNO is currently being installed in Sudbury's Creighton mine and will switch on in March.

Another neutrino anomaly, described by Boston's Ed Kearns, is the ratio of muon-neutrino flux to electron-neutrino flux at the Earth's surface arising from cosmic ray interactions in the atmosphere. As pions and kaons decay, a single electron-neutrino is produced and two muon-neutrinos, yet the detected ratio appears far lower than two-to-one.

This anomaly was first observed in water Cerenkov detectors and has recently been underlined by Super Kamiokande, but early measurements in iron detectors had failed to confirm it. Tomas Kafka from Tufts University presented recent results from the Soudan 2 detector which agree with the water Cerenkovs giving valuable evidence that the effect is real.

Francis Halzen of Wisconsin showed where high energy neutrino astronomy might lead. He argued for 1 kilometre cubed Cerenkov telescopes which would see one event per day at 10^{15} eV.

Two smaller telescopes are already taking data. The first, deep in Lake Baikal, Siberia, was presented by Moscow's Grigory Domogatsky. It consists of strings of photomultipliers built into pressure-resistant glass spheres suspended in the lake. In 1994, the detector started up with 36 photomultipliers, and the full

complement of 192 is scheduled to be installed by winter 1998.

Per Olof Hulth of Stockholm presented the status of the Amanda detector, embedded in the 2800 metre thick South Pole glacier. Among the advantages of working at the South Pole, said Hulth, are the lack of radioactivity in the surrounding medium, and the lack of fish. Preliminary results show that tracks can be reconstructed and associated with events in the surface detectors Spase 1 and Spase 2. Hulth concluded with a possible time scale for building a kilometre cubed detector, Icecube, at the South Pole by 2004 or 2005.

Hot on the heels of Baikal and Amanda are Nestor and Antares. Presented by Frascati's Luciano Trasatti, Nestor will be situated on an underwater shelf in the Ionian sea. Antares, presented by Fabrice Feinstein of Saclay, aims to prove the feasibility of a detector off the coast of Toulon with the goal of building a kilometre cubed detector by 2007.

To round off the neutrino discussions, a mischievous cat was set among the neutrino pigeons by Sheldon Glashow who speculated on what might happen if Einstein was wrong and Lorentz invariance does not hold. Among other things, neutrino oscillations would be possible for massless neutrinos. Oscillations could be velocity driven, claimed Glashow gleefully.

With the initial prediction by Wolfgang Pauli of the existence of neutrinos being a surprise to everyone else, and their subsequent discovery being a surprise to Pauli, neutrinos have a reputation for being unpredictable.

Physics monitor

Participants at the "Beyond the Desert '97 - Accelerator and Non-accelerator Approaches", conference held in Castle Ringberg, Germany, this summer.

Signals from beyond the desert ?

With physics looking so conventional, when and where will new effects be seen? From 8 -14 June a 'Beyond the Desert 97' conference at Castle Ringberg, Germany, on future aspects and perspectives of particle physics attempted to provide an answer.

The meeting, organized by the Max Planck Institute for Nuclear Physics, Heidelberg, and chaired by H.V. Klapdor-Kleingrothaus set out to analyse the future potential and trends in particle physics in both the accelerator and non-accelerator sectors. It was attended by theorists as well as experimentalists and with both accelerator and non-accelerator fields well represented.

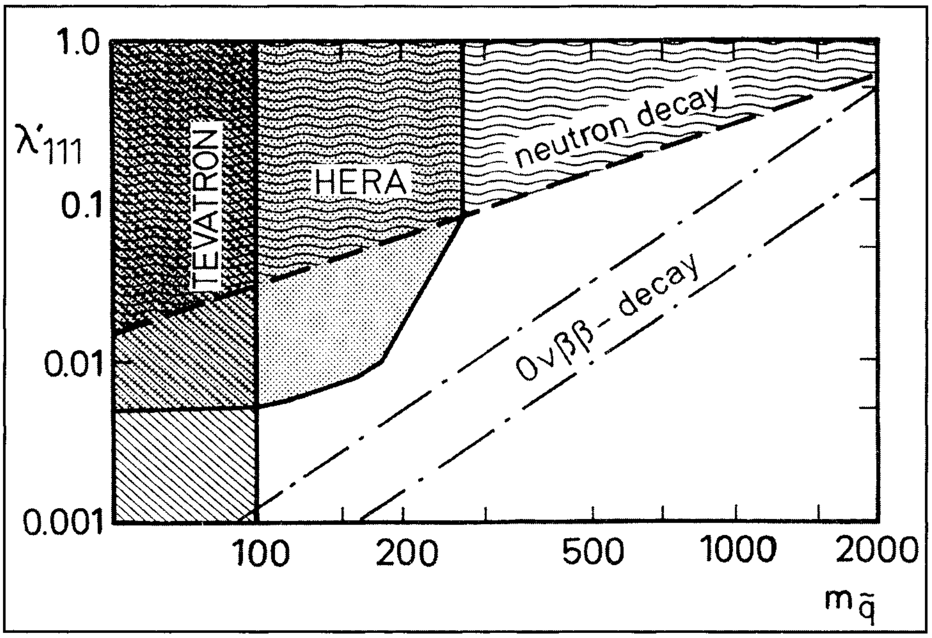
Particle physics is making extreme demands on future accelerators. This route has provided most of the physics discoveries of the past 45 years. On the other hand, non-accelerator physics looking at transient effects (propagator physics) has the advantage of having no energy restrictions. The meeting assessed present physics objectives and current thinking.

Strategies for detection of supersymmetry and new possibilities for CERN's LHC collider and other accelerators were discussed by Daniel Denegri (CERN), Helmut Baer (Tallahassee) and Gordon Kane (Michigan). The potential of future linear electron-positron colliders (e.g. NLC at DESY) was outlined by M. Nojiri (KEK, Japan) and J. Kalinowski (DESY/Warsaw). R. Brinkmann (DESY) presented the already rather advanced project studies for NLC, while D. Cline (Los Angeles) discussed a future muon collider.

Superstring ideas now encapsulated in an "M-theory" seem to be to some extent testable by their "low energy" predictions like extended (R) parity violation, accessible in accelerator and non-accelerator experiments (double beta decay). This was covered by Alain Faraggi (Gainesville), D. Nanopoulos (Texas) and G.Volkov (Moscow). D. Nanopoulos outlined further aspirations of such theories in a special evening lecture 'Superstrings, Quantum Mechanics and Brain Function'.

A possible substructure of quarks and leptons (compositeness) and the search for it at accelerators and in double beta decay was treated by J. Virey (Marseille), E. Takasugi

Limits from double beta decay (the Heidelberg-Moscow experiment) for R-parity violation in supersymmetric models as a function of the squark mass, under two assumptions for the gluino mass (1 TeV and 0.1 TeV). Also given are the limits obtained by the Tevatron and HERA, as well as from neutron decay. Excluded are the areas beyond (or on the left of) the curves.



(Osaka) and O. Panella (Perugia), the latter pointing out the large potential of double beta decay in this respect.

The use of neutrinos to test for new theories was stressed by Yu. Smirnov (Trieste/Moscow), Rabi Mohapatra (Maryland) and J. Valle (Valencia). As well as the neutrino mass, M.Hirsch from the Heidelberg double beta group also showed how to obtain information about the supersymmetric neutrino mass. He showed that for first generation sneutrinos, double beta decay is more than competitive with future accelerators - and discussed together with Y. Grossman (SLAC) and S. Kolb (Double Beta, Heidelberg) new phenomenological consequences for future collider experiments at the NLC Next Linear Collider.

In the neutrino sector, the results paralleled those of the recent TAUP Gran Sasso meeting (see page 12).

Status and perspectives of proton decay, neutron-antineutron oscillations and the search for magnetic monopoles were presented by F. Mauri (Pavia) for ICARUS, who announced operation of the first component in Gran Sasso for 1998, Y. Kamyshkov (Oak Ridge), who presented plans for the new neutron-antineutron project in Oak Ridge, and Barry Barish (Caltech), who announced shutdown of MACRO for the year 2001. Bernard Schutz (Potsdam) and F. Fidecaro (Pisa) reported future gravitational wave searches, including experiments in space.

The origin of CP violation was the main topic of a session on fundamental symmetries, and was discussed by Boris Kayser (Arlington), N. Mavromatos (Oxford), and P.Pavlopoulos (CERN). The new analysis by B. Kayser showed that the new experiments aiming at solving the question of the origin of CP violation will have a hard time to really determine all three angles of the unitarity triangle, vital for deciding whether CP violations are inside or beyond Standard Model.

Turning to particle physics and cosmology, E. Kolb (Fermilab), discussed inflation, M. Schmidt (Heidelberg) the electroweak phase transition and Leszek Roszkowski (Lancaster) superparticle mass restrictions from inflation.

Vadim Kuzmin (Moscow) gave a new interpretation of highest-energy cosmic radiation - as decay products of new superheavy dark matter particles. Glennys Farrar presented new results about light supersymmetric gauge particles (gauginos) and their consequences for particle and astrophysics. Rainer Dick (Munich) presented new dark matter candidates from superstring theories. G. Boerner (Garching) presented the cosmological evidence for dark matter and R. Gaitskell (Berkeley) and Yorck Ramachers (Heidelberg) reported on the status of the CDMD and HDMS dark matter searches under construction. These will enter the supersymmetric domain with possible neutralino dark matter, and will go beyond a test phase within the next two years.

One of the highlights of the conference was of course the new HERA high momentum transfer events in positron-proton collisions (April, page 1). Such events could occur in the production of leptoquarks or of squarks - or they could indicate a substructure of quarks and leptons. Here again an interplay between accelerator and non-accelerator experiments opens up.

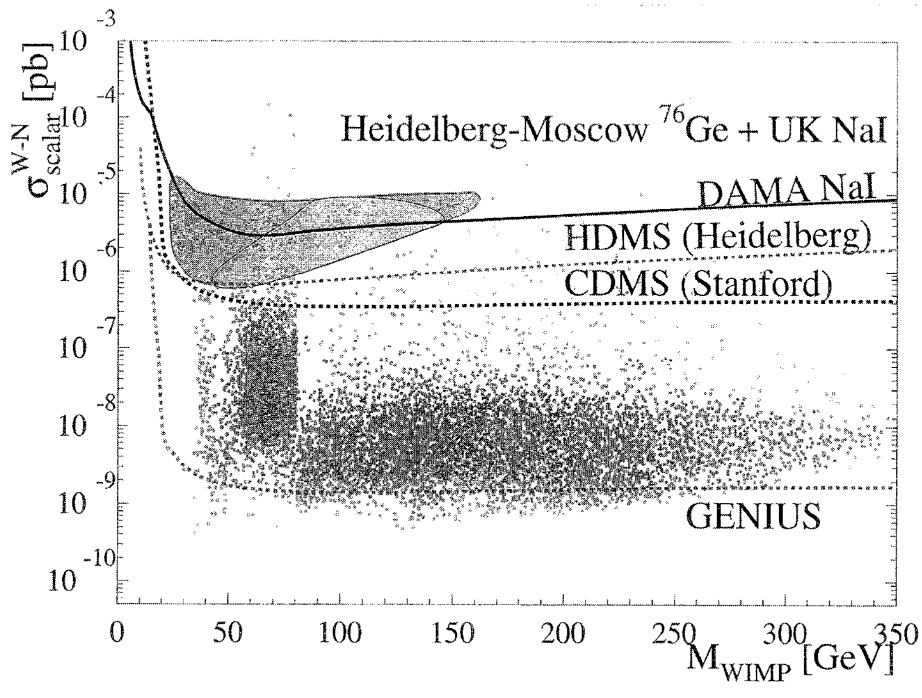
The recent results of the sensitive Heidelberg-Moscow double beta experiment - reported by the author of this report and speaker of the experiment - contribute directly to the interpretation of the HERA events: The limits for R-parity violation in supersymmetric models deduced from the experiment - considerably more stringent than those obtained from Tevatron and HERA - exclude the formation of first generation squarks.

The double beta experiment also yields a new restriction for the production of leptoquarks. The Heidelberg double beta group shows that the production of leptoquarks with a mass of around 200 GeV at HERA would imply a leptoquark-Higgs coupling in the 10^{-6} region. This would be unexpectedly small and would support the opinion of Harald Fritzsch (Munich - who predicted leptoquarks in the early seventies and named them) that for leptoquarks much larger masses would be expected than are presently accessible at HERA.

More far-reaching connections between non-accelerator experiments and present questions of particle physics could be implied by the planned new Heidelberg Double Beta and Dark Matter project GENIUS (GErmanium in NItrogen Underground Setup) proposed by the author of this report and first presented at this meeting. It aims to probe the neutrino mass down to 0.01 eV or less, and at the same time being extremely sensitive to neutrino oscillations. A description of this project will be published in a forthcoming issue of the CERN Courier.

The stimulating atmosphere of the meeting, which survived even when Prince Luitpold of Bavaria arrived with several barrels of beer, demonstrated that it reflected well the aims and requirements of the scientific community. The unanimous opinion was that the meeting should be repeated.

By H.V. Klapdor-Kleingrothaus



Best present experimental limits for neutralinos as cold dark matter (WIMPs) and perspectives of future experiments. Masses and cross sections beyond the contour lines are excluded. The present best limits are from the Heidelberg-Moscow experiment and later from the DAMA experiment.
The CDMS (Berkeley), CRESST (Munich), and HDMS (Heidelberg) experiments now under construction will probe for the first time the range of supersymmetric expectations for neutralinos. The proposed GENIUS experiment (Heidelberg) will be able to cover the full parameter space of the supersymmetric model predictions for neutralinos.

The test is in the flavour

The weak nuclear interactions of beta decay and analogous processes are now understood in terms of quark transitions. For example in the beta decay of a neutron into a proton, one 'down' quark (electric charge -1/3) in the neutron changes its 'flavour', becoming an 'up' quark (charge 2/3), and the overall quark configuration becomes that of a proton. Such quark transitions permute electric charges - beta decay and analogous weak interactions are 'charged currents'.

As theoretical ideas advanced and the parallels between the weak and electromagnetic interactions became clearer, theorists began to speculate about a new form of the weak interaction, a 'weak neutral current' (WNC) in which quarks could interact but their electric charges would remain the same.

While this neutral current preserved electric charges, it might still switch other quark flavours, for example changing a strange quark into a down quark. In the 1960s, a crucial search was mounted for weak neutral current processes that change flavour (FCNCs) in kaon decays (such as the decay of a kaon into a pion and weakly interacting particles).

At the same time, which was before

Muon tracks from an early Brookhaven neutrino experiment. In the early 70s, neutrino experiments at Brookhaven and at CERN were recording a few unusual events which did look like a neutral current. However Leon Lederman and Mel Schwartz dismissed them as 'little crappers'.

the discovery of the weak neutral current at CERN in 1973, neutrino experiments at Brookhaven and at CERN were recording a few unusual events which did look like a neutral current. However Leon Lederman and Mel Schwartz dismissed them as 'little crappers'.

The search for FCNC in kaon decays had reached a branching ratio of 10^{-6} by 1970, while even before that one CERN experiment published an upper limit on neutral currents on weak neutral currents of 3% (which was later pushed even higher). A natural conclusion was that neutral currents are absent in Nature, a conclusion overturned by the epic 1973 discovery of the neutral current at CERN and the subsequent 1983 finding of its carrier particle, the Z.

However to explain the parallel existence of the weak neutral current and the relative absence of FCNC came two crucial theoretical developments that have framed and defined the Standard Model of physics ever since:

1 - The GIM (Glashow-Iliopoulos-Maiani) mechanism, proposed in 1970, showed how quark mixing could almost entirely suppress FCNC. Different contributions to FCNC contrived to cancel each other out.

2 - The concept of natural flavour conservation (NFC) was put forward by S. Glashow and W. Weinberg in 1977 to show why the scalar or Higgs (symmetry breaking) sector should also give FCNC. It also showed that quarks must come in doublets, opening the door to the sixth 'top' quark following the discovery of the fifth, 'beauty' or 'b' quark in 1977.

Since the 1970s, many new models have come onto the market, including technicolour and supersymmetry. These must contend with the absence of FCNC, at least for the well explored light quark sector, which places powerful constraints on the parameters and even the fundamental nature of the models. As well as being crucial for the Standard Model, FCNCs are also important for finding physics beyond the Standard Model.

Away from the quark sector, the changing of leptonic flavour, such as neutrino oscillations, where neutrinos of one type can transform into another en route, without interacting, looks to be on firmer ground. Results from several experiments seem to indicate that neutrinos have to oscillate.

To address all these issues, a special symposium 'Flavour Changing Neutral Currents - Present and Future Studies' was held recently in Santa Monica, California. Both theory and experiment were well covered. (The proceedings, published by World Scientific and dedicated to C.S. Wu, who died in February, contains a memorial tribute by P. Franzini.)

Some of the important conclusions emerging from the meeting were:

- NFC must be tested once the Higgs particle is found.
- S. Pakvasa emphasized the role of charm-changing neutral currents, particularly the mixing of neutral D mesons.
- The first search for FCNC in the top sector was presented. This will clearly be of major interest in the future.
- Supersymmetry provides a natural mechanism to ensure FCNC, and such effects should be looked for, especially a b quark decaying into a strange quark and a photon.
- A search for muon-electron transitions at a future muon collider, as well as the decay of a tau into three muons at the LHC, could bear fruit.
- The solar neutrino effect, and possibly the atmospheric muon-to-electron neutrino deficit, also reported, provides the best evidence for neutrino oscillations and possibly for leptonic FCNC.
- Tests of fundamental symmetries (CPT) should be tested in FCNC.

With these conclusions, the meeting reflected key physics objectives. The old concept of NFC assumes a single neutral Higgs particle. This now seems unnatural, and supersymmetry has a set of both neutral and charged Higgs. Thus FCNC may be a crucial test for supersymmetry.

As soon as the Higgs is/are found at the LHC, it will be crucial to test for FCNC in their decay, and a muon collider Higgs factory, as was first suggested by the author in 1992,

could be of major importance. FCNC tests at a Higgs factory would be the ultimate test of the NFC concept.

According to the Standard Model, the mixing of neutral D mesons is expected to be extremely small. In contrast, mixing in the neutral kaon and B meson sectors is large and deviations could be difficult to see. Neutral D mixing could therefore be a physics treasure trove, probing energies inaccessible even at the LHC.

The next such FCNC meeting will be held in 2001, a fitting start to the physics of the next millennium.

By David Cline, UCLA

James Bjorken (left) and Bo Andersson during the Conference Dinner for the XXVII International Symposium on Multiparticle Dynamics, held at INFN Frascati.

(Photo S. Kittel-Haböck, Nijmegen)

Multiparticle dynamics

Multiparticle dynamics now ranges from particle correlations and multiplicity distributions to colour coherence effects, from heavy ions to cosmic rays, from jet dynamics to total cross-sections. Thus the XXVII International Symposium on Multiparticle Dynamics had a lot of ground to cover. The meeting took place at INFN Frascati, Italy, from 8 - 12 September, attended by approximately 100 physicists. Frans Verbeure, secretary of the Multiparticle Dynamics Conferences, following into the recent retirement of Douglas Morrison, chaired the first session.

Recent results on high energy, large momentum transfer processes at Fermilab's Tevatron (proton-antiproton collisions), CERN's LEP (electron-positron) and DESY's HERA (electron-proton), were followed by presentations on the interplay between soft and hard processes. After Bo Andersson discussed quark-gluon cascades, the sessions concentrated on soft interactions.

Discussion of Bose-Einstein correlations, factorial moments and scaling behaviour in hadron-hadron collisions were followed by heavy ion sessions.

During the last two days, attention shifted to diffractive and total cross-sections and the possibility of measuring them at CERN's LHC. Karsten Eggert from CERN presented the project FELIX (October, page 9), which sets out to measure physics processes of interest to this community.

On the last day, two different fields, charmonium production in hadronic interactions and the structure of the Pomeron were discussed, with a unifying point of view by Francis Halzen, who sees the evaporation model at the heart of both of them, thus leading the way to a discussion of the octet model for quarkonium production.

J. Bjorken's summary talk was preceded by a short presentation of Frascati's KLOE detector at the DAPHNE phi-factory (July, page 8).

The next Multiparticle Dynamics Symposium will be organized by Nikos Antoniou from Athens and will be held in Delphi, Greece, in September 1998.

The Conference opened by remembering Valodia Gribov and Peter Carruthers, recently passed away, but whose participation in the symposia has contributed much to this field.

Most of the talks of this Conference are available at http://www.lnf.infn.it/conference/ismd97.html.

Euroconference QCD 97

Quantum chromodynamics (QCD), the field theory of quarks and gluons, has a traditional summer venue in Montpellier, France. QCD 97 was the 5th High Energy Physics Quantum Chromodynamics Conference organized by Stephan Narison there since 1985, and was second of the new Montpellier Euroconference Series in QCD sponsored by Brussels.

This year, the conference coincided with the much publicized centenary of the discovery of the electron and the somewhat more under-exposed 25th anniversary of QCD (although the 'asymptotic freedom' property which enables perturbative approximation calculations to be performed at high energies was not proved until one year later).

Traditionally involving equal numbers of experimental and theoretical talks and participants, the QCD meeting also gives an opportunity for young physicists to contribute (often for the first time) at an international level, together with more familiar names. It is thus a compromise between a large scale international high energy physics conference and a small specialized meeting.

The programme covered various approaches of QCD, including perturbative series expansions - increasingly limited when the coupling becomes strong - and non-perturbative approaches. Results from experiments at electron-positron colliders covering the wide energy range from 14 to 172 GeV include measurements of the QCD coupling alpha-s.

Probing the collisions of quarks and gluons deep inside nucleons, data from quark and gluon jet production and event shapes from the LEP electron-positron collider at CERN and from the SLC linear electron-positron collider at Stanford (SLAC), Fermilab's Tevatron (proton-antiproton collider and fixed target studies) and DESY's HERA electron-proton collider show a general good agreement with QCD predictions, and provide estimates of some non-perturbative power corrections and improved measurements of alpha-s.

The SMC Spin Muon Collaboration at CERN and the E154 SLAC experiments presented results on the polarized (spin-dependent) quark structure of the proton and deuteron, where the total spin does not reflect the component quark spins. Theoretical talks emphasized that this "spin crisis" is not only valid for the proton but is a universal property of QCD (the 'U(1) anomaly'), and should occur for any targets. Some tests of this idea have been proposed.

The continued exploration by HERA and by CERN's NMC muon collaboration of the low momentum transfer (Q^2) and momentum fraction (x) regions gives new impetus to perturbative QCD in these low-energy regimes. The enigmatic new excess of HERA events at large Q^2 (April, page 1 and September, page 1) which need, however, to be confirmed by more statistics was also presented.

For light quarks, an interesting session was devoted to the determinations of variable ('running') masses from different QCD non-perturbative methods, while the running of the b-quark mass has been seen for the first time from quark-gluon jet data at LEP, and compared with theoretical estimates, such as QCD spectral sum rules.

For heavy quarks, experimental results of the spectroscopy, decay and production of the B- (containing the fifth 'beauty' quark) and D-mesons (containing the fourth 'charm' quark) came from the CLEO detector at Cornell's CESR electron-positron colliders and from LEP , SLC and HERA. The sixth ('top') quark production and decays presented by the CDF collaboration at Fermilab's Tevatron collider show good agreement with QCD predictions, while yielding improved measurements of the top quark mass and other properties.

A review of different determinations of the QCD coupling has shown the

This year, the traditional summer Quantum chromodynamics (QCD) conference in Montpellier, France, coincided with the 25th anniversary of QCD.

continued progress in measuring this important quantity and shows further evidence for how the coupling varies as predicted with the inverse of a logarithm of the energy, from around the tau lepton mass of 1.8 GeV up to the LEP energy of 172 GeV. It also shows the increasing number of processes from which the coupling can be extracted. Previous results from deep inelastic scattering and heavy quarkonia decays have been improved and agree better with some other determinations.

The Crystal Barrel and Obelix groups at CERN's LEAR low energy antiproton ring have consolidated evidence for gluonia (bound states of gluons), which are fundamental QCD particles. However, the mixing of these states with conventional quark-antiquark states needs to be better understood.

With no spectacular recent discovery, the presentations at the 5th QCD-Montpellier conference reflected continuous progress and improved results both from theory and experiment.

The meeting underlined the conviction that QCD is the unique candidate gauge theory of strong interactions, while ongoing results also show that non-perturbative approaches (such as effective theories, lattice calculations and QCD spectral sum rules) used for the understanding of the complex properties of hadrons satisfy most experimental tests.

In many respects the theory is simple, with quarks behaving more and more like free particles at high momenta. However the permanent confinement of quarks is not yet quantitatively explained, making QCD an enigmatic (and interesting) part of the otherwise so successful Standard Model, which is still waiting for the (eventual) discovery of the Higgs particle.

The next QCD Montpellier meeting will be from 2-8 July 1998. More information from http: // www.lpm.univ-montp2.fr/~qcd

From Stephan Narison (Conference Chairman)

Fractional charges, but no quarks

Quasiparticles carrying fractional electric charges have been detected for the first time. While they appear to carry one-third of the standard electronic charge, they are nothing to do with quarks, the constituents of protons and neutrons, which also carry such fractional electric charges.

Charge carriers come in a variety of forms, such as electrons in copper wires, pairs of electrons in superconductors, and even holes (the absence of an electron) in certain semiconductors and high-temperature superconductors.

Such a hole is a "quasiparticle," which belongs to an aggregate physical system, such as a chunk of silicon. Such quasiparticles arise from the collective behaviour of many electrons and cannot exist independently of the lattice through which they move.

Such collective behaviour is at the heart of the quantum Hall effect, discovered by Klaus von Klitzing and which brought him the 1985 Nobel Prize. At low temperature and high magnetic field, the electrons at the boundary between two semiconductors form a two-dimensional electron liquid with discrete energy states and a quantized electrical resistance.

More than a decade ago, theorists predicted that excitations in some of the collective electron states could have a charge equal to a fraction of the basic electron charge, e. In a powerful magnetic field, a two-dimensional system of electrons behaves like a classical electron gas on the surface of liquid helium, which can crystallize into a (Wigner) solid if the conditions are right. The resistivity (tensor) of this material would make quasiparticles behave as though they had fractional electric charge.

Using the latest techniques for making very small electrical contacts (100-300 nm) and for detecting minuscule currents, condensed matter researchers at Saclay and specialists in microstructures and microelectronics in Bagneux, France, have studied the "shot noise" from a tiny gallium arsenide sample. This noise represents the random quantum current fluctuations when carriers tunnel from one side of an electrical junction to the other, and gives quasiparticle charges of e/3.

(The CERN Courier acknowledges the American Institute of Physics Bulletin of Physics News Number 335, by Phillip F. Schewe and Ben Stein)

Bookshelf

"Crystal Channeling and Its Applications at High Energy Accelerators", V. M. Biryukov, Y. A. Chesnokov, and V. I. Kotov, Springer-Verlag Berlin Heidelberg New York, 1997 (DM 138) ISBN 3-540-60769-2.

This interesting book brings together two decades of developments in the area of high energy channeling. Prior to the seventies, channeling, the behaviour of particles moving near the planes and axes of a crystal, had been studied in the MeV regime. Outside of the intriguing process itself, physics interest was driven by solid state and nuclear physics investigations. Because the critical angle for channeling is small and shrinks with energy, there was little interest in high energy channeling. Then in the seventies pioneering experiments at CERN, Fermilab, Dubna, and Serpukhov demonstrated that channeling, and particularly channeling in bent crystals, could be applied at high energy. Channeling is now routinely used at CERN and Serpukhov. A recent Fermilab demonstration has shown that TeV-scale extraction can be handled easily.

The authors have had a key role in this development. With Tsyganov, Samsonov, and others they were winners of a 1996 Russian Federation state prize for their work. An important feature of the book is a coherent treatment of the transmission of bent channeling crystals, needed to reliably apply channeling in different high energy physics and accelerator applications. The book reexamines dechanneling data and gives useful formulations of dechanneling lengths that fit the data. Anyone setting out to apply channeling at high energy should have a copy of the book in hand.

Reviewed by Richard Carrigan, Fermilab.

Books received

Symmetries, Lie Algebras and Representations: A Graduate Course for Physicists, by Jürgen Fuchs and Christoph Schweigert, Cambridge University Press.

In the prestigious series of Cambridge Monographs on Mathematical Physics, this book carefully presents Lie algebras with a view to their application for physics. It is rather detailed and contains exercises, but the typography makes it easy to select material for a first reading.

Mathematica in the Laboratory, by Samuel Dick, Alfred Riddle and Douglas Stein, Cambridge University Press: hardback £55/$74.95, paperback £19.95/$29.95

A hands-on guide on how to use Mathematica in the gathering and analysis of experimental data, with many examples.

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People and things

Royal visit: Prince Philippe of Belgium (right) at CERN on 29 September accompanied by Belgian deputy Prime Minister and Minister for Commerce and Communications Elio Di Rupo, with explanations by Kathy Huet of Mons. (CERN HI 27.9.97)

Peter A. Carruthers

Peter A. Carruthers died at the age of 61 in his home in Tucson, Arizona on 3 August. His career as a theoretical physicist spanned a remarkably broad spectrum ranging from elementary particles and field theory to condensed matter physics, astrophysics and nonlinear dynamics. In the past few years he had become an acknowledged leader in the area of multiparticle production.

After a PhD in theoretical physics from Cornell in 1961 under Hans Bethe, he joined Cornell and rapidly climbed to full professor. He supervised many outstanding PhD students and post-doctoral fellows, many of whom have had distinguished careers. In 1973 he became Leader of Los Alamos Theoretical Division, where he had a major impact on its growth, reputation, and scientific excellence. He attracted many outstanding scientists and established a highly visible broadly-based basic research programme of international repute.

In 1980, he stepped down from the Division Leadership to return to research. He was named a Senior Fellow of the Laboratory and became the Leader of the Elementary Particle and Field Theory Group. In 1986 Pete moved to Arizona as Professor and Head of the Physics Department and, later, as Director of the Center for the Study of Complex Systems. Together with Murray Gell-Mann and others he was instrumental in creating the much-heralded Santa Fe Institute. Peter was an eloquent spokesman for the Supercollider, and for the importance of basic research across all of science. He was a man of ideas, an accomplished musician and a bon vivant. His presence will be sorely missed.

Mladen Paic 1905-97

Mladen Paic, regarded as the founder of modern experimental physics in Zagreb and for 30 years the head of experimental physics at the university, passed away on 8 July. In the 50s he was one of the founders of the Institute Rudjer Boskovic, the leading institute for natural sciences in Croatia, and in the 60s founded Zagreb's Institute of Physics, devoted to condensed matter, where until recently he relentlessly investigated the optical properties of ionic superconductors.

One notable student was the distinguished theoretician Vladimir Jurko Glaser (1924-84). The building, with collaborators, of a neutron generator led to the emergence of a whole generation of talented nuclear and particle physicists who, despite scarce funding, have pursued successful careers.

The long-standing international involvement of Croatian physicists was formalized by the 1991 CERN-Croatia agreement. Today about 20 Croatian researchers collaborate in ongoing experiments, including Alice and CMS for the LHC. This continuing involvement will continue to be an enduring tribute to his memory.

From Daniel Denegri

Heavy elements

After lengthy discussion, a special committee of the International Union of Pure and Applied Chemistry has recommended definitive names for elements 101-109, where some nuclei previously had been known under different titles, according to taste.

The ruling is: element 101 is Mendelevium (Md), 102 Nobelium (No), 103 Lawrencium (Lr), 104 Rutherfordium (Rf), 105 Dubnium (Db), 106 Seaborgium (Sg), 107 Bohrium (Bh), 108 Hassium (Hs) and 109 Meitnerium (Mt).

As well as honouring important scientists, the significant roles played by the Joint Institute for Nuclear Research (JINR) Dubna and the German GSI (Darmstadt, in Hesse, Hassia in Latin) Laboratory are also commemorated.

However with GSI also having discovered elements 110,111 and

112 (April 1996, page 1), the committee still has some decisions to make. The tradition is that the discoverer of an element has first option on choosing its title.

Feynman video

The final touches have been completed and the video of Richard P. Feynman delivering the first Dirac Memorial Lecture on 'The Reason for Antiparticles' is now available. Recorded in 1986, this video has never before been available to the public. By special arrangement with Cambridge University (where the lecture was delivered), this video has been produced complete with copies of Feynman's lecture notes in his own handwriting. Included are new material written by Ralph Leighton, Lawrence Krauss, and John Gribbin.

The video is available in NTSC and PAL formats for $45 US (NTSC) and $57 (PAL) postage included. The video may be ordered from Friends of Tuva (fot@sprintmail.com) or from the address below. All proceeds from the sale of this video are being donated to charity, half to Marie Curie Cancer Care in the UK and half to the John Wayne Cancer Clinic in the US. This price includes public performance rights provided no fee is charged for admittance. Transparencies may be duplicated for educational use.

(The text of the lecture, with that of Steven Weinberg, is available as 'Elementary Particles and the Laws of Physics' by Richard P. Feynman and Steven Weinberg, published by Cambridge University Press, ISBN 0 521 340004.)

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Meetings

The 10th biennial Advanced Study Institute on Techniques and Concepts of High Energy Physics, directed by Tom Ferbel of Rochester, will be held June 18-29, 1998, in St. Croix, US Virgin Islands. Advanced graduate students or recent PhDs in experimental high energy physics should submit a letter of application, with a vita, a list of publications and a supporting letter. The cost of local accommodations is estimated to be about $1100, including a copy of the proceedings. There will be limited funds for partial support of needy students. The letter of inquiry should make it clear what financial support will be required. The deadline for application is February 1, 1998, but it is advisable to apply early.

Further information from Ms. C. Jones, Dept of Physics/ASI-1998, University of Rochester, River Campus, B&L Bldg, Rochester, NY 14627-0171 USA WWW http://server-mac.pas.rochester.edu/Asiinfo.html e-mail: CONNIE@PAS.ROCHESTER.EDU phone: (716) 275-5306 fax: (716) 275-8527

CERN Courier index

The names and subject indexes for the 1996 issues of the CERN Courier can be accessed via http://www.cern.ch/CERN/Courier/1996/ListE.html

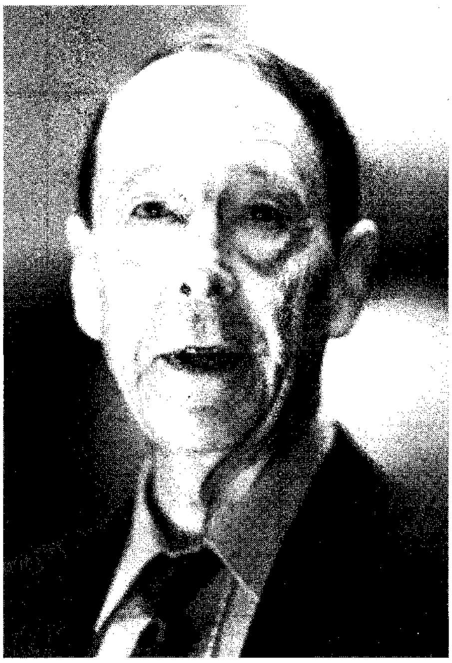
At CERN on 17 September was Professor Dagmar Schipanski (second from left), President of the German Scientific Council, with, left, the Council's General Secretary W. Benz, and Professor Wegener of Dortmund. Among the CERN researchers they met were Doris Forkel-Wirth (far right), physics coordinator at CERN's ISOLDE on-line isotope separator and Georg Bollen, ISOLDE physics group leader.
(Photo CERN HI 16.9.97)

At a colloquium in memory of distinguished theorist Abdus Salam (1926 - 96) at CERN on 23 September (Photos CERN HI24.9.97):

1 - Tom Kibble of London's Imperial College recalled Salam's spectacular career.

2 - Carlo Rubbia (centre), 1984 Nobel prizewinner and Director General of CERN from 1989 - 93, stressed the importance of Salam's work in CERN's experimental research programme past, present and future. CERN Director Chris Llewellyn Smith (right) underlined the importance of Salam's main creation, the International Centre for Theoretical Physics in Trieste, for the world theoretical physics community. On the left is Louise Johnson (Mrs. Salam).

3 - Sheldon Glashow, who shared the 1979 Nobel Physics Prize with Salam and Steven Weinberg, recalled Salam as 'one of the warmest, gentlest and most gracious people I have ever known'.



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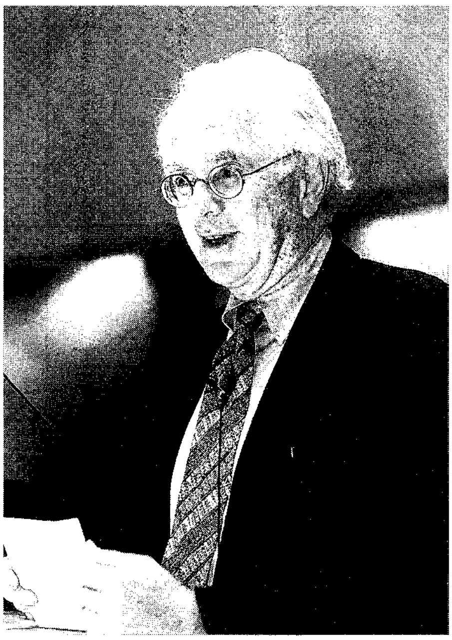

3

CERN PS intensity record

Just one month after a previous record of 3.02 x 10^{13} protons accelerated up to transition energy in CERN's veteran PS Proton Synchrotron, a new step was reached on 26 September with more than 3.1 x 10^{13} protons.

The proton Linac was again working near its top performance with a current of 163 mA delivered to the PS Booster which accelerated more than 3.45 x 10^{13} protons and extracted 3.32 x 10^{13} protons towards the PS.

The main improvements were at the Booster (acceleration, bunch shape and synchronization). PS losses were minimized by optimizing injection, low energy working points and the acceleration process. Proton intensity finally reached a new peak of 3.115 x 10^{13} protons with the vital intensity at extraction at 14 GeV as 3.05 x 10^{13}.

Vanna Cocconi-Tongiorgi (1917 - 1997)

Vanna Cocconi, who passed away peacefully on the first of October, was a wonderful colleague and great friend. She was the heart of the European High Energy bubble chamber collaboration for 18 years so when she retired in 1982, we gave her a many-tiered cake with 65 candles. As each candle was lit, we retraced her life. First she studied the interactions of cosmic rays. Her first paper in 1939 was written with a young physicist, Giuseppe Cocconi who later became her husband. Moving to Cornell, her next 15 years were spent bringing up her daughter and son, and interacting with the many exceptional physicists there. She continued her cosmic ray work begun in Italy, and was the first to observe that when cosmic rays hit a heavy element target, an unexpectedly large number of neutrons are

C++/Object Oriented Software Engineer

At Fermi National Accelerator Laboratory, our high energy physics program is dedicated to unlocking the secrets of the universe as we explore the fundamental nature of matter using the highest energy particle accelerator in the world — the Tevatron.

To support this mission, we are embarking on a major upgrade of our software from FORTRAN and C to C++ (with some FORTRAN and C legacy remaining). This endeavor, which is scheduled for completion by late 1999, has created an excellent professional opportunity for an experienced software programming expert with proven experience in C++/Object Oriented project design and implementation, as well as exposure to large-scale systems projects (e.g., equivalent to 100+ FTE years of effort). The selected individual will provide coding and design assistance to large collaborations of physicists and other computing professionals.

Qualified candidates will be seasoned professionals who possess a minimum of 3 years experience with C++ coding, OO design and STL (or earlier implementations of templates and specialized container classes), and a Master's degree in computer science (or equivalent). Also necessary is thorough knowledge of object oriented design techniques that includes the ability to implement systems using such techniques. Experience working with large scientific/technical groups to design and implement project standards (e.g., interface, templates, data models, documentation, etc.) is preferred. An understanding of other programming and modern scripting languages, and a familiarity with scientific/technical computing enterprises are desirable.

Located 40 miles west of downtown Chicago, we offer a competitive salary and an excellent benefits package. For consideration, please send a resume to: **Employment Department/970110, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510-0500, U.S.A.** To access Employment Opportunities at Fermilab, our URL is **[http://fnalpubs.fnal.gov/employ/jobs.html]**. EOE M/F/D/V.

Fermilab

VACUUM SCIENTIST
(Research Associate II)

Vacuum Scientist at the Laboratory of Nuclear Studies, Cornell University, to join the Vacuum Group responsible for maintaining and improving the vacuum systems of the high energy particle accelerators, consisting of the CESR electron-positron storage ring and its injectors (a Synchrotron and a Linac), [Webpage:http://www.lns.cornell.edu/]. The ultra high vacuum system of CESR is being upgraded, presenting a considerable challenge and an opportunity to participate in the design and fabrication of a system using innovative UHV concepts. The Laboratory maintains a well-equipped Vacuum Laboratory with a staff of trained vacuum technicians. The responsibilities of the position include: research into materials, processes and equipment for improving the vacuum systems for high beam current operation; design and assembly of laboratory apparatus and evaluation of new design concepts, surface preparation, etc.; and generally assisting in improving accelerator performance, including further training of technicians. A Ph.D. or Master's degree with equivalent experience in vacuum science is required. Experience with accelerator or other large vacuum systems is highly desirable. Complete job description provided on request. Contact Dr. N. B. Mistry, **search@lns62.lns.cornell.edu**, FAX: 607-254-4552, Tel: 607-255-4951. Mailing address: Newman Laboratory, Cornell University, Ithaca, NY 14853-5001, Attn: Vacuum Scientist Search.

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UNIVERSITY OF TORONTO
TENURE TRACK FACULTY POSITION
DEPARTMENT OF PHYSICS

The Department of Physics plans to make a tenure track appointment in High Energy Physics at the rank of Assistant Professor, subject to budgetary approval, with a starting date of July 1, 1998.

We seek candidates with a Ph.D. in Physics, proven or potential excellence in both research and teaching, whose research interests are in Theoretical Particle Physics. Salary will be commensurate with qualifications and experience.

Applications, including a curriculum vitae and three letters of reference should be sent to:

Professor Pekka Sinervo
Chair
Department of Physics
University of Toronto
60 St. George Street
Toronto, Ontario ... M5S 1A7
Canada

The deadline for the receipt of applications and letters of recommendation is December 31, 1997.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. The University of Toronto is committed to employment equity and encourages applications from all qualified individuals including women, members of visible minorities, aboriginal persons, and persons with disabilities.

Vanna Cocconi-Tongiorgi (1917 - 1997)

produced - now called spallation! Later she carried out experiments in a diffusion chamber in Cornell and working with Ralph Shutt at Brookhaven, producing many important results with photon and proton beams. Vanna first worked at the SC and PS of CERN in 1959-60 before returning to become a staff member in 1963. She helped set up the high energy bubble chamber collaboration. As well as working hard and being an excellent physicist, she had a unique maturity and infallible judgement which she expressed with kindness. Every collaboration paper, over 100 of them, had to pass the ultimate test, being read and checked by Vanna. She re-organized each paper and brought out the logic and the physics more clearly - even improving the English. All this without ever leaving anyone unhappy; she never had an argument - it was always a friendly and fair discussion.

She was truly international - wherever she travelled, people would stop her in the street and ask directions - they thought she was one of them, and was a person they instantly judged was sympathetic and reliable.

She loved art and the mountains; every Saturday morning she and Giuseppe would visit the art galleries in Geneva's old town. Her gentle guidance was always appreciated, whether advising other physicists or, with her husband, introducing their colleagues to their first descent of the Vallee Blanche.

Following the poet Robert Burns,
A thought ungentle cannot be,
The thought of Vanna Cocconi.

Friends of Vanna.

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.

Physicists and mathematicians from all over the world came to Marseille-Luminy for a conference on the diversified contributions of Alex Grossmann (on the right in the photo - including the invention of wavelets) on the occasion of his becoming emeritus. With him are Raymond Stora (left) of LAPP, Annecy, and Mohamed Mekbout, honorary president of Luminy campus. Grossman recently received a French Physical Society prize.

(Photo A. Martin)

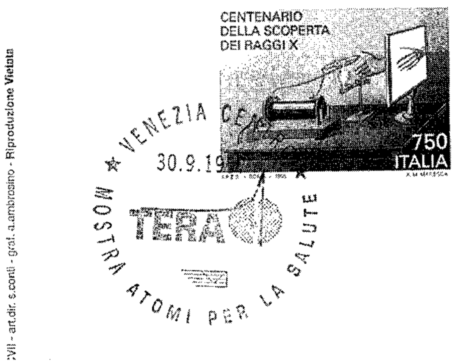
Life in Venice

At the opening of the 'Hadrons for Health' exhibition in Venice sponsored by the TERA Foundation and the Italian PTT - front row, left to right: TERA Foundation President Ugo Amaldi, Italian President Oscar Luigi Scalfaro, Marianna Scalfaro, and Vito Marchese of the Italian PTT.

The latest venue for the travelling exhibition - 'Hadrons for Health', covering a hundred years from X-rays to quarks in the service of health - was Venice. It shows how the application of knowledge from subatomic physics now extends from the introduction of X-ray radiography at the end of the 19th century to the use of hadron beams for cancer therapy. The latter is poised to become a major new medical tool for the 21st.

Under the title 'Atomi per la Salute', the exhibition, put together by Werner Kienzle of CERN and Alessandro Pascolini of Padua, was formally inaugurated on 30 September by Italian President Oscar Luigi Scalfaro and the Minister for Public Health Rosamaria Bindi. The event was staged in the historic 'Fondaco dei Tedeschi' palace close to the Rialto Bridge on Canal Grande, chosen by the Italian PTT, which for the occasion had launched a fund-raising campaign for the TERA Foundation.

Before the President's address, TERA Foundation President Ugo Amaldi and CERN Council and INFN President Luciano Maiani underlined the importance of fundamental research and its value for spinoff in the medical sector. Among other notables were CERN Research Director Lorenzo Foà, Italian Physical Society President Renato Angelo Ricci, and former CERN Director General Herwig Schopper.



The Hadrons for Health exhibition in Venice warranted a special postmark.

Left to right, Italian Minister of Public Health Rosamaria Bindi, CERN Council and INFN President Luciano Maiani, CERN Research Director Lorenzo Foà, and (back to camera) exhibition co-organizer Alessandro Pascolini of Padua.

The CERN-Asia Fellows and Associates Programme

Within the framework of the CERN-Asia Fellows and Associates Programme, CERN offers 3 grants every year to young East, Southeast and South Asia* postgraduates, below 33 years of age, to participate in its Scientific Programme in the areas of Experimental and Theoretical Physics and of Accelerator Technologies.

Applications will be considered by the CERN Fellowship Selection Committee at its meeting on the 27th of Januari 1998.

An application consists of a 'completed application form' where it should be stated 'CERN-Asia Programme', three separated reference letters, a curriculum vitae including the list of scientific publications and any other information in favour of the quality of the candidate.

Application, reference letters and any other information should be provided only in the English language.

Application forms ca be obtained from:
Recruitment Service-CERN-Personnel Division
CH-1211 Geneva 23 - Switzerland
E-mail: Recruitment.Service@cern.ch
Telefax: +41-22-767 2750

Applications should reach the Recruitment Service at CERN before the deadline on the 12th of November 1997.

The duration of the appointment will be for one year, which might, exceptionally, be renewed up to a maximum length of two years.

Applications for a short term Associate position will also be considered for Scientists of less than 40 years of age, who wish to spend a fraction of the year at CERN or a Japanese laboratory and who are 'on leave' from their institute.

Applications are accepted from Scientists who are nationals of the East, Southeast and South Asian countries and from Members of the CERN personnel (Member State nationals only).

* Candidates are accepted from Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, China, India, Indonesia, Japan, Korea, the Lao Republic, Malaysia, the Maladives, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, Singapore, Sri Lanca, Taiwan, Thailand and Vietnam.

RESEARCH ASSOCIATE POSITION
Experimental High Energy Physics
Carnegie Mellon University

The Department of Physics at Carnegie Mellon University invites applications for a postdoctoral Research Associate position in experimental high energy physics. The individual who fills this position will work on detector development for the future CMS experiment at the LHC, in particular, the front-end anode electronics for the CMS endcap muon system. Participation in data analysis for the on-going L3 experiment at LEP will also be encouraged. The successful candidate will work both at Fermilab and at CERN. Applicants should submit a curriculum vitae and arrange to have three letters of recommendation sent directly and as soon as possible to:

Professor Thomas Ferguson
Department of Physics
Carnegie Mellon University
Pittsburgh, PA 15213, USA
(e-mail: ferguson@cmphys.phys.cmu.edu)

The vitae and recommendations can be sent either by normal or electronic mail. We will begin to consider applications on Nov. 15, 1997.

Carnegie Mellon is an equal opportunity / affirmative action employer

EPFL
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

invites applications for a position of

PROFESSOR IN COMPUTER LANGUAGES AND METHODS

The new professor will develop teaching and research activities in the area computer languages, in particular programming languages, and development methods based on them. S/he will give courses, and supervise student diploma and doctoral projects. The teaching activities will be in the computer science and communication systems divisions as well as in other divisions of EPFL.
Candidates should have a proven track record in leading and managing research projects of the highest quality. Industrial experience would be an advantage. Ability and interest in teaching at all levels is indispensable. The new professor will start collaborations, especially with industry. Female candidatures are particularly welcome.

Deadline for applications: January 12, 1998.
Start date: as mutually convenient.

For further information, please ask for the documentation and the application form by writing to:
Présidence de l'Ecole polytechnique fédérale de Lausanne, CE-Ecublens, CH 1015 Lausanne, Suisse

Research Associate Posts in Particle Physics Department

Fixed Term - 3 Years
Rutherford Appleton Laboratory (RAL)

There are vacancies for researchers to work in the Particle Physics Department, at the Rutherford Appleton Laboratory. RAL is involved in a number of experiments at CERN, DESY, SLAC and elsewhere. There are also vacancies in the Particle Physics Theory Group. The successful applicants will be based at RAL but experimentalists are likely to spend time at the experiment, depending on the requirements of the work. All experiments include UK university personnel, with whom a particularly close collaboration is maintained.

Applicants should have a PhD in Particle Physics or be close to finishing their thesis.

The appointments are for a fixed term of up to 3 years but with the possibility of extensions of up to two years. The salary levels are between £15,180 & £24,820, depending upon the amount of experience. A non-contributory pension scheme, flexible working hours and a generous leave allowance are also offered.

For an informal discussion about the experimental posts, please contact Prof. C J S Damerell, phone (+44) 1235 446298, e-mail C.J.S.Damerell@rl.ac.uk. For the theory posts please contact Prof. R G Roberts, phone (+44) 1235 445259, e-mail R.G.Roberts@rl.ac.uk. Application forms and a more detailed job description can be obtained from: Recruitment Office, Personnel Division, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX. Telephone (+44) 1235 445435 (answerphone) quoting reference VN1513/97. More information about CLRC is available from CCLRC's World Wide Web pages at (http://www.cclrc.ac.uk).

All experimental applications must be returned by **1 December 1997.**
All theory applications must be returned by the **31 December 1997.**
The CCLRC is committed to Equal Opportunities and has a no-smoking policy.

CLRC

COUNCIL FOR THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS

DESY, one of the leading laboratories in particle physics and synchrotron radiation research is offering a position for a

Post-Doctoral Researcher in Cryogenics

in the cryogenics group MKS. The position is limited to a duration of three years and the salary will be according to the German civil services II a MTV Angestellte.

The successful applicant will contribute to a collaborative program between Deutsches Elektronen-Synchrotron DESY in Hamburg, Germany and the National High Magnetic Field Laboratory (NHMFL) at Florida State University. This program is primarily involved in the development of He II coolingsystems for future accelerators.

The Researcher will spend 50% of his/her time working at DESY and 50% at the NHMFL. He or she will be involved in a variety of tasks including: experiment design, low temperature measurements, distribution of cryogenic fluids and numerical modeling of fluid dynamics.

Applicants should have experience with cryogenic techniques. Specifically, this includes: handling of cryogenic systems, measurement and understanding of experimental data, numerical analysis and presentation of results. A familiarity with large scale cryogenic systems is desirable.

Preference will be given to applicants with experimental experience; however, strong analytical skills are also desirable. Excellence with written and oral communication is required as is an ability to work independently and as a member of a group. A doctoral degree in Engeneering, Physics or closely related field or an equivalent combination of education and experience is required.

Interested applicants with these qualifications should send their letter of application and three names of referees before 15 December, 1997 to **Deutsches Elektronen-Synchrotron DESY, Personalabteilung, Notkestr. 85, 22607 Hamburg, Tel.-Nr. 49-40 8998 3239 or Fax 49-40 8998 2858** **Code Nr. 61/97**

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

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, 1998. 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 25, 1997. 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.

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

For its Department of microengineering, the Swiss Federal Institute of Technology Lausanne (EPFL) invites applications for a full professor position:

PROFESSOR IN BIOMEDICAL OPTICS

Applicants should have a university education in science or engineering, several years of recent research and development experience in the field of biomedical photonics, and well established collaborations with medical research groups. Priority will be given to candidates who can give evidence of original and creative activity in the industrial or academic sphere and who are ready to develop and maintain collaboration with industries. The candidate should possess a good leadership as well as a marked interest and talent for teaching at the undergraduate and graduate level. In particular, he/she should have a personal vision in his/her field and enjoy to be a mentor to students and young researchers.

Deadline for applications: February 15, 1998.
Start date: as mutually convenient.

Applications from women are particularly welcome. For further information, please write to:
Présidence de l'Ecole polytechnique fédérale de Lausanne, CE-Ecublens, CH 1015 Lausanne, Suisse

POSTDOCTORAL RESEARCH POSITION
RELATIVISTIC HEAVY ION COLLISIONS

The Ohio State University

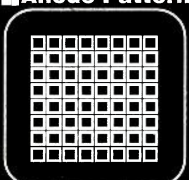
The Relativistic Heavy Ion Group at The Ohio State University invites applications for a postdoctoral research position available immediately. The successful candidate will spend most of his/her time on the LHC ALICE experiment carrying out software development for physics simulations for the Inner Tracker System (ITS). The ALICE ITS consists of two layers each of pixels, silicon drift detectors and silicon strip detectors. The OSU group is also involved in the RHIC STAR Silicon Vertex Tracker (SVT), so some overlap with that project is also possible. The candidate should have strong programming skills. The OSU Relativistic Heavy Ion Group currently consists of three faculty members, three postdoctoral researchers, six graduate students, three undergraduate students and an electrical engineer. Interested candidates should send an application consisting of a curriculum vitae, a description of research experience and interest and the names of three references to Thomas J. Humanic, Department of Physics, Smith Laboratory, The Ohio State University, Columbus, OH 43210 or via E-mail to humanic@mps.ohio-state.edu. The Ohio State University is an equal opportunity and affirmative action employer and encourages all qualified candidates to apply.

64 Anodes New Standard

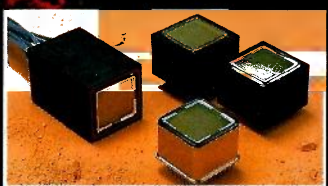
■SPECIFICATION DATA

TYPE	ANODE SIZE	APPLICATIONS
R5900	□18mm	Calorimeter, Trigger counter, TOF etc.
R5900-M4	□8.9mm(×4 Channels)	γ-ray Telescope
R5900-M16	□4.0mm(×16 Channels)	SCIFI Read Out, RICH
R5900-L16	0.8mm×16mm(×16 Channels)	SCIFI Read Out, DIRC
R5900-C8	Cross Wire X4 +Y4	PET, γ-ray Imaging
R5900-M64	□2.0mm(×64 Channels)	SCIFI Read Out, RICH

■Anode Pattern



8×8 MATRIX



MULTI ANODE PMT

28mm×28mm Square
20mm Height
22.5g Weight(Approx)

Front:R5900 Left:H6568(4×4 Multi Anode) Back:R5900U-00-M4(2×2 Multi Anode)
Right:R5900U-L16(16 Linear Anode)

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HAMAMATSU PHOTONICS K.K., Electron Tube Center http: //www.hamamatsu.com
314-5 Shimokanzo, Toyooka-village, Iwata-gun, Shizuoka-ken, 438-01 Japan. TEL:81-539-62-5248 FAX:81-539-62-2205 TLX:4289-625

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Italy: Hamamatsu Photonics Italia S.R.L. TEL:(39) 2-935 81 733 FAX:(39) 2-935 81 741
U.S.A.: Hamamatsu Corporation. TEL:(1)908-231-0960 FAX:(1)908-231-1218
Germany: Hamamatsu Photonics Deutschland GmbH. TEL:(49)8152-3750 FAX:(49)8152-2658
France: Hamamatsu Photonics France S.A.R.L. TEL:(33) 1 69 53 71 00 FAX:(33) 1 69 53 71 10
Switzerland: CERN Liaison Office TEL:(41)31/879 13 33 FAX:(41)31/879 18 74