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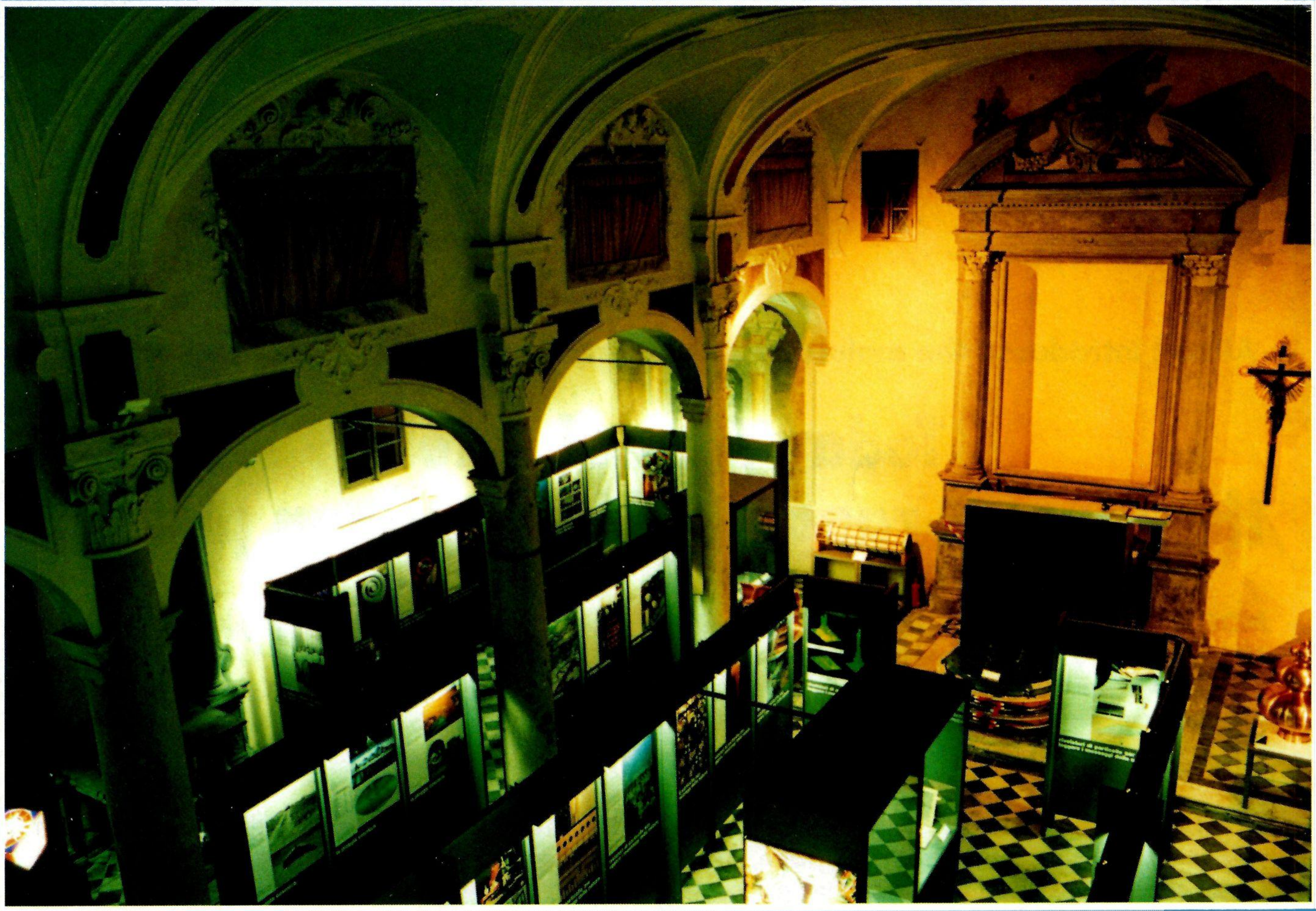

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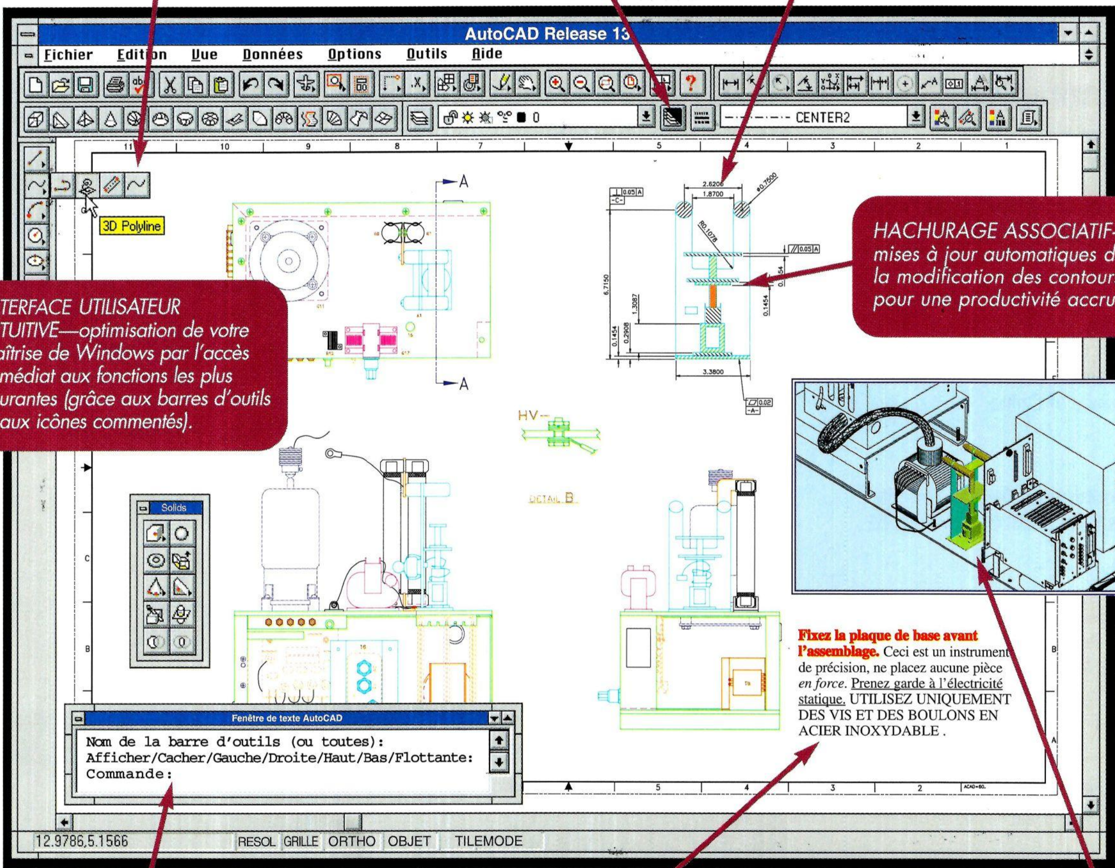

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Covering current developments in high energy physics and related fields worldwide

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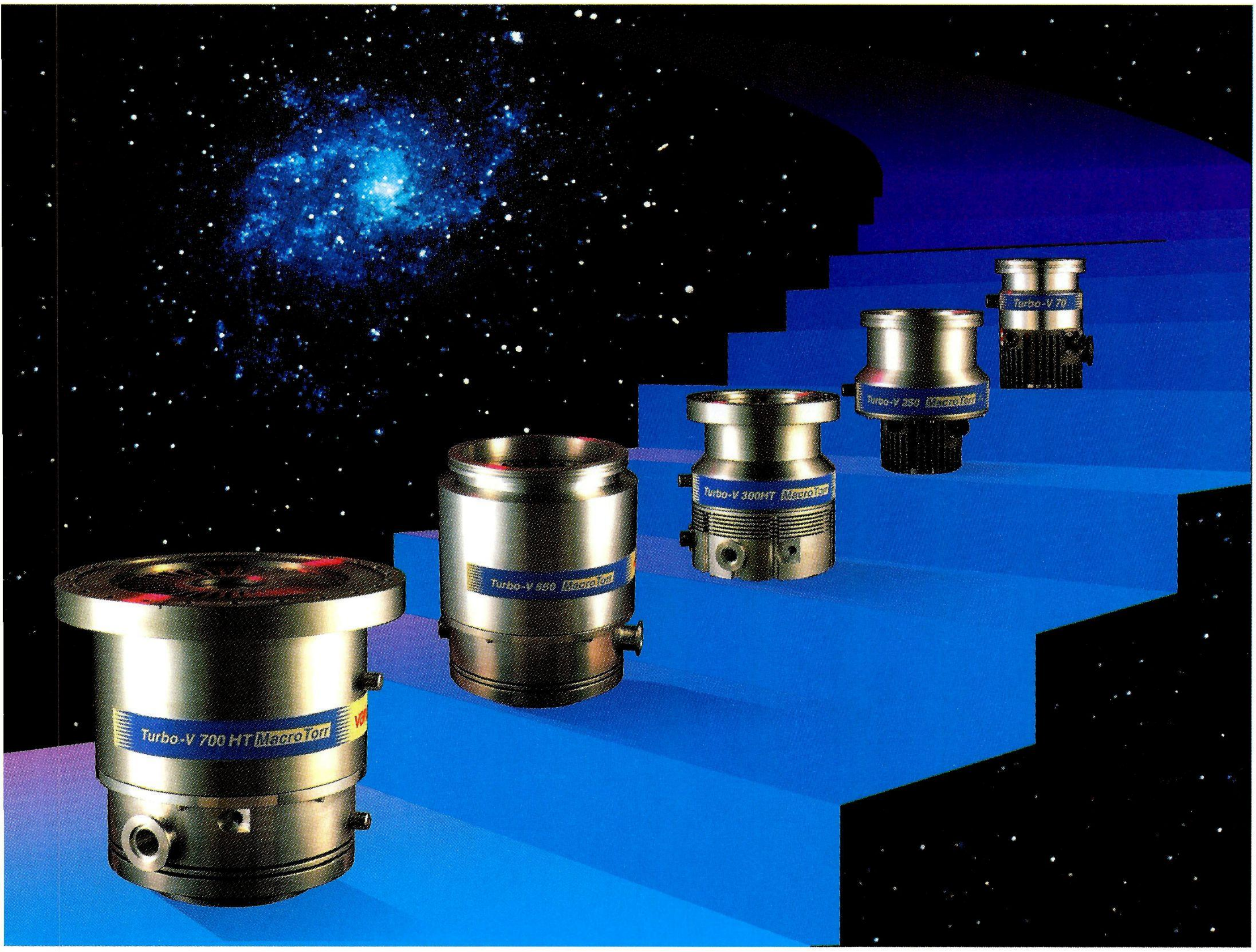
Around the Laboratories

Physics monitor

On 2 March, the CDF and DO experiments at Fermilab announced their discovery of the sixth 'top' quark. More news in the next issue.

Cover photograph: View of the science exhibition "inside quarks, beyond galaxies" produced by the Istituto Nazionale di Fisica Nucleare and shown at the end of last year in Pisa, in the former church of S. Paola all'Orto (see page 22).

Step up to the MacroTorr advantage



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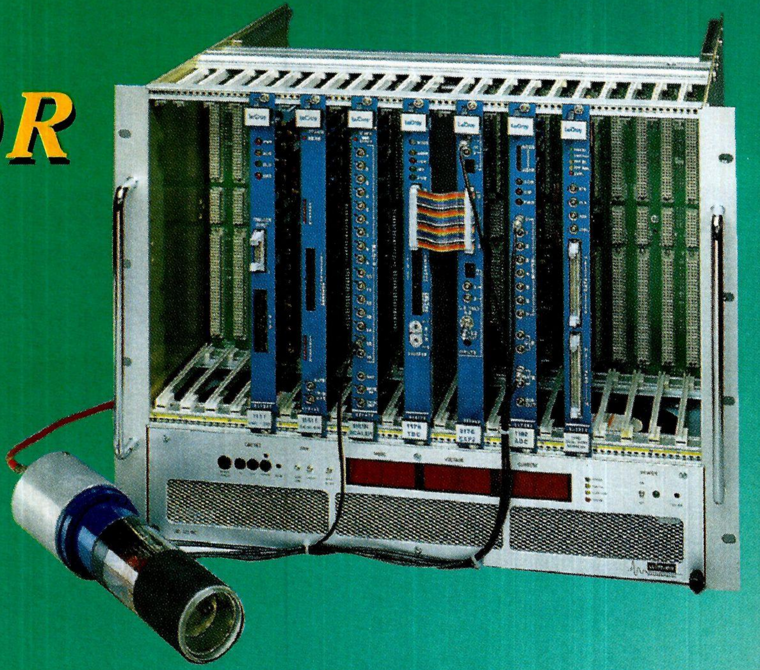
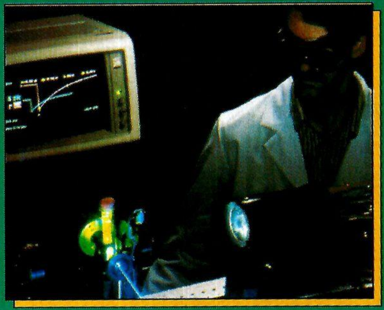
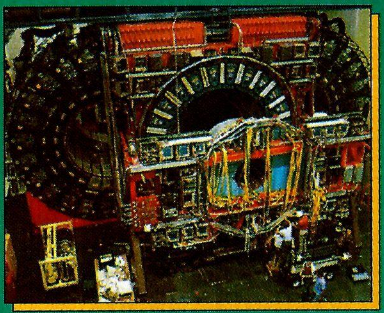
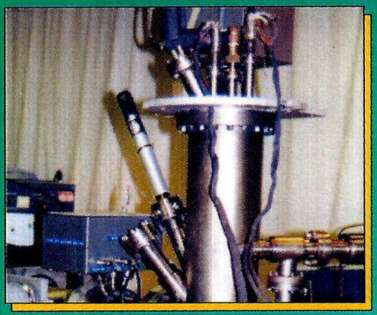




Laser Chemistry



High Energy Physics
courtesy of Fermi National Laboratory.



Time-of-Flight Spectroscopy,
courtesy of Northwestern University.

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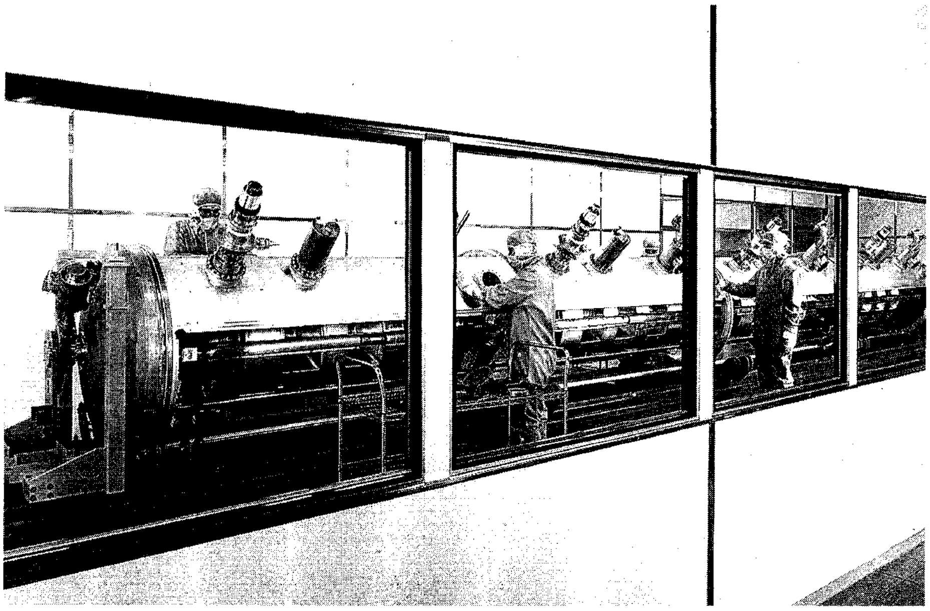
Innovators in Instrumentation

Around the Laboratories

Clean room processing of superconducting radiofrequency accelerating cavities prior to installation in CERN's LEP electron-positron collider. Equipped with these cavities, LEP will soon be operating at higher energies. (Photo CERCA)

CERN
Higher energies at LEP



This year will be the last that CERN's 27-kilometre LEP electron-positron collider will run routinely at around 45 GeV per beam. In the run, scheduled to begin in May, the four big experiments will top up their harvest so far of over 12 million Z particles for a final polishing of precision Z data.

Behind the scenes, LEP is being prepared for higher energy running and a new phase of physics. After a brief technical stop in October, the aim is for a test run of up to 70 GeV per beam before the end of the year.

Higher energy demands more radiofrequency power, which will be supplied by superconducting cavities. With this goal in mind, a programme of development work began at CERN over ten years ago, when LEP was still on the drawing board. Initially this effort focused on cavities made from sheet niobium, but later switched to copper covered by a sputtered niobium film, which gives better thermal and r.f. performance (September 1990, page 24).

The first industrially-manufactured four-cavity niobium coated module, complete with its cryostat and r.f plumbing, was installed in LEP in 1993. Although it quickly achieved its nominal accelerating gradient of 6 MV/m, its reliability was affected by unforeseen problems in the associated power couplers.

This delayed the installation schedule, but after a crash programme of design and modification of the power couplers, together with improvements in actual cavity design and manufacture, module supply and testing has now attained a satisfactory rhythm.

Two modules installed in LEP amassed between them over 50 days of continuous running in 1994, and confidence is now high that the emphasis can shift towards integrating the cavities into LEP, rather than running the cavities themselves.

During LEP's 1994-5 winter shutdown, modules are being installed at Points 2 and 6. Later, additional cavities will be installed in Points 2, 6 and 8 prior to embarking on the higher energy test run at the end of the year.

After installation of the remaining equipment and commissioning in 1996, the machine, relabelled LEP2, will reach for its new goal of at least 83 GeV per beam. For the first time, this will allow pairs of W particles to be mass-produced in electron-positron collisions.

So far, LEP has been focused on the Z resonance. Z particles, the carriers of the electrically neutral part of the weak interaction, are produced one at a time in electron-positron annihilations, and Z data have been steadily accumulating in the detectors since LEP was commissioned in 1989.

However the Z's electrically charged counterpart, the W, the carrier of beta decay, can only be produced in pairs in electron-positron collisions, each W pair - a positive and negatively-charged W - carrying zero net charge. Providing this amount of rest mass means almost doubling LEP's energy (the W and Z masses are some 80 and 91 GeV respectively).

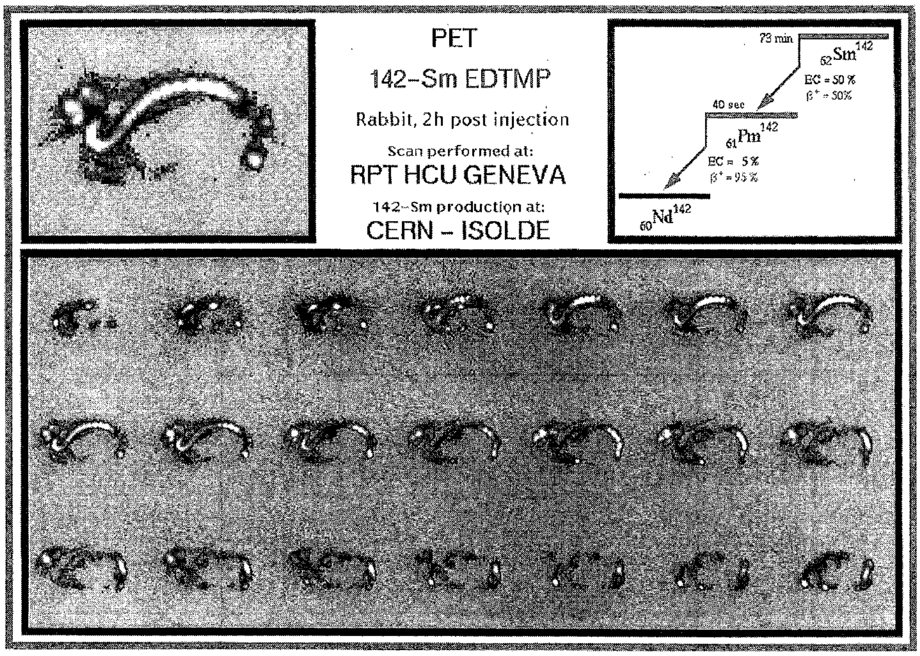
To perfect the precision picture of the Standard Model, the mass of the W has to be measured with a precision approaching that of the Z, and the behaviour of the W has to be probed in depth.

Because of the higher energy involved, producing pairs of Ws is more difficult than producing single Zs. For precision W physics, LEP has to supply 500 inverse picobarns of integrated luminosity over three years. At first sight this figure looks intimidating, but plans to boost LEP performance are well in hand (January/February, page 6).

As well as studying W physics, LEP2 could also dig out clues on the long-awaited higgs mechanism which drives the symmetry breaking at the heart of the electroweak picture. Here it is important that LEP2 reaches out as far in energy as it can reasonably go, and there is strong physics motivation for installing more radiofrequency power.

1 and 2 February at CERN saw the first of a series of major meetings to study the physics possibilities at LEP2 (December 1993, page 14) and further meetings are scheduled for later this year en route to publication of a final report at the end of 1995. Meanwhile CERN management has requested an interim report on physics possibilities at energies beyond the W pair threshold.

But first things first....



The positron emission tomography (PET) image (recorded using the rotating PET scanner of the Division of Nuclear Medicine at Geneva Cantonal Hospital) shows slices around the spinal column of a rabbit. High density regions of electron-positron annihilation appear in white, showing the high metabolic activity of bone tissue.

Radioactive beams for cancer research

Positron emission tomography (PET) is one of the big spinoff successes of basic physics for medicine, in the tradition of X-rays and nuclear magnetic resonance.

In PET, specially prepared compounds (radiopharmaceuticals) labelled with positron-emitting isotopes are used as tracers. The annihilation of a positron with an electron gives a characteristic back-to-back pair of 511 keV photons, and detecting these coincident photons shows where the tracer has gone. As well as providing the technique itself, physics technology has also led to the development of cheap but effective PET detectors using multiwire proportional chambers.

At CERN's ISOLDE on-line isotope separator and using the rotating PET scanner at Geneva Cantonal Hospital (April 1993, page 1), compounds labelled with exotic positron-emitting isotopes of rare earth elements are being investigated for use in cancer diagnosis. As well as CERN and the Geneva hospital, the collaboration involves the medical faculties of Basle and Geneva.

Because of their very high purity (being carrier-free and isotopically separated) rare earth isotopes available at ISOLDE are very suitable for 'fine tuning' in biomedical cancer research.The radioactive metal ions are bound either to tumour-specific antibodies or in compounds with special affinities (low molecular chelators). The aim of the study is to learn more about the biological behaviour and the uptake mechanisms of such tracers in diagnosis and therapy.

As an example, the positron-emitting samarium-142 (73 minutes half-life) provides a quantitative measurement of radioactivity uptake, allowing the applied dose using samarium-153 to be precisely monitored to optimize the therapy for bone metastases.

Electronics for LHC experiments

The first workshop on electronics for LHC experiments will be held in Lisbon, from 11-15 September, organized by Lisbon's Particle Physics Instrumentation Laboratory (LIP), on

behalf of CERN's LHC Electronics Review Board (LERB), one of the advisory boards to CERN's LHC Experiments Committee - LHCC.

The role of the LERB is to review the electronics and photonics component of Technical Proposals for LHC experiments, and to monitor the current and future R&D programme in particle physics. As such it is one of the successors of CERN's successful Detector Research and Development Committee (DRCD), established in 1990 to help prepare the ground for LHC experiments. With the formal approval of LHC in December 1994, DRDC was discontinued. A review of DRDC achievements will appear in a forthcoming issue.

LERB will identify areas and encourage efforts for rationalization and common development within and between the different experiment collaborations to help ensure the reliability and long-term maintainability of installed equipment. Members of the Board are drawn from laboratories participating in the LHC programme and are recognized specialists with positions of authority in their home institutes.

The workshop will promote cross fertilization within the engineering and physics communities involved in the design of electronics for LHC experiments. The main topics will be - Electronics for trackers; Readout electronics for calorimeters; Readout electronics for muon detectors; Optoelectronic signal and data transfer; Trigger and event building systems; and Test and quality assurance systems.

Authors are invited to submit papers applicable to future particle physics experiments describing developments in the fields of system design, switching fabrics, data acquisition standards, triggering, signal processing and radiation hard electronics. Manufacturers are welcome to submit abstracts on state-of-the-art products.

Review or tutorial talks by invited speakers will introduce each topic session, and the invited speaker will chair a round-table discussion at the end of each session.

Abstracts and summaries will be made available at the time of the workshop and will include papers which cannot be granted an oral presentation because of time constraints but which, in the view of the programme committee, are of interest to the community. Workshop records will be made available.

Abstracts (100 words) and summaries (500 words) should be submitted by e-mail, preferably in PostScript format with Times 12pt font for the body of the text. The summary should be complete and describe the work, its relevance to experiments at LHC and important conclusions. The deadline for submission is 1 May. An acknowledgement will be sent by electronic mail.

To be registered, receive the detailed programme, or the workshop poster, contact: Catherine DECOSSE, ECP Division, CERN, CH 1211 Geneva 23; e-mail decosse@cernvm.cern.ch fax (+41.22).767.90.95

ECOLE POLYTECHNIQUE
Acceleration by plasma beat waves

An experiment by a multi-disciplinary team including laser, plasma, accelerator and particle detector specialists at the Ecole Polytechnique, Palaiseau, France, has confirmed the principle of particle acceleration by the 'beating' of laser waves. The first accelerated electrons were detected in May 1994, just after the apparatus had been completely assembled, during the subsequent set of experiments in July, and again in January.

In the continual quest for new acceleration methods, such ideas had been proposed for several decades, but it was only about ten years ago that experimental verification of these effects began.

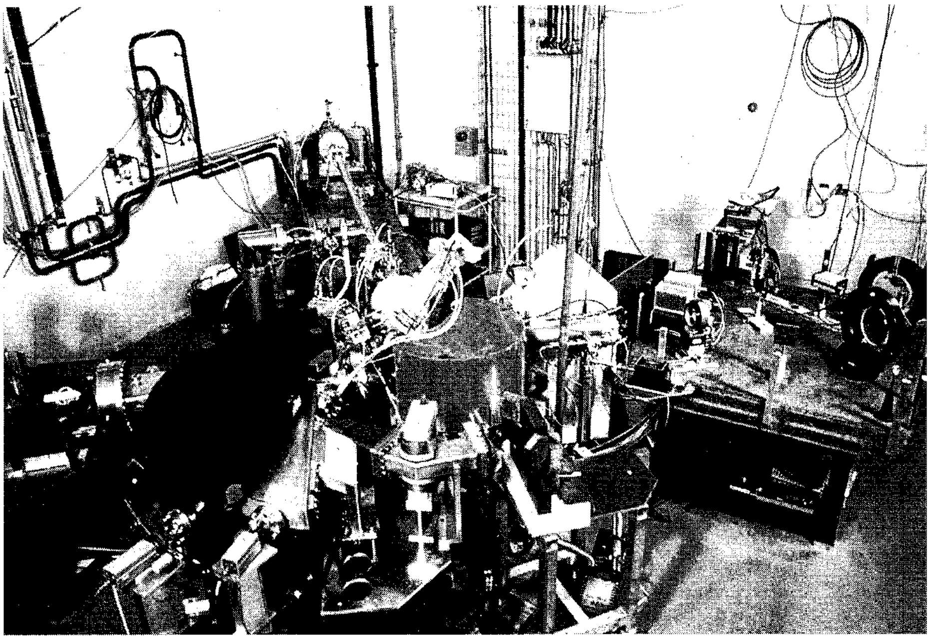
In existing accelerators using radiofrequency cavities the electric field is limited to some hundred megavolts per metre, beyond which breakdowns occur.

The joint use of power lasers and plasmas, however, should make it possible to generate fields very much greater than a GV/m. The light wave fulfils the same purpose as radiofrequency and the material medium required to couple the electromagnetic energy to the particle beam is provided by the plasma which - already fully ionized - is not destroyed by a breakdown.

In the wave-beating method, proposed in 1979 by Dawson and Tajima, two laser waves of adjacent frequencies are transmitted and produce 'beats'. If the frequency of these is equal to the natural oscillation frequency of the plasma electrons, there is resonant energy transfer. The resultant longitudinal electric field is propagated at slightly below the speed of light and may be used to accelerate particles injected into the plasma in the right phase.

The French team comprises the high energy nuclear physics laboratory, the intense laser laboratory, the irradiated solids study section, and the centre for theoretical physics (all at the Ecole Polytechnique), together

Overall view of the experimental hall at the Ecole Polytechnique, Palaiseau, France, where the principle of particle acceleration by the 'beating' of laser waves has been confirmed. Centre, the magnet for handling injection into the plasma, left the spectrometer magnet and the scintillator detector. In the background is the beamline and on the right (on the bench) is the laser focussing lens. (Photo Philippe Lavialle/Ecole Polytechnique)



with Orsay's gas and plasma physics laboratory and the Orleans research group on the energy of ionized media.

A 3 MeV van de Graaff with a current of 300 microamps injects electrons into deuterium at 2.2 millibars, a pressure which must be controlled with a precision of 0.5% since the electronic density of the plasma determines its natural frequency. A dual-frequency laser supplies pulses with an energy of 10 J and a duration of 100 ps.

During the initial picoseconds it ionizes the gas, forming a plasma volume about 0.1 mm in diameter over a distance of 1 cm. It is therefore vitally important to align the light and electron beams. This is done using an optical transition radiation monitor with a spatial resolution of 10 microns. The accelerated electrons are collected in a magnetic spectrometer and detected by a bank of scintillators and photomultipliers over 5 ns.

The acceleration effect - several hundred electrons per laser shot - was highly reproducible. The energy gain, of the order of 1.5 MeV, is somewhat modest at present as the laser pulse does not ensure optimal energy transfer between the laser and the plasma. This is in line with theoretical predictions which also state that a shorter light pulse and a higher electron injection energy would increase this amplification.

Acceleration by plasma beat waves has already been observed by American (UCLA), Japanese (Osaka) and Canadian teams (Chalk River and Varennes), who obtained energy gains of up to 30 MeV with a CO_2 laser. The French team's experiment - a European first - used a more convenient solid laser (neodymium). This could open up a more promising route.

It is also intended to test a second acceleration principle based on the laser excitation of a plasma, the wake-field method, following the rapid development of femtosecond power lasers generating ultra-short pulses.

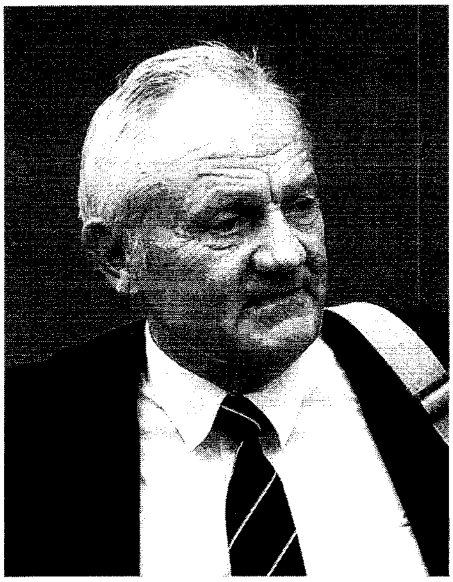
DESY
Gus Voss retires

As mentioned briefly in the previous issue (page 28), last year Gus Voss reached the age of 65 and therefore was released from official duties at DESY from the beginning of this year. However, as a senior scientist, he keeps an office at DESY and will continue his work in all the international committees of which he is a member, as well as giving colleagues and friends around the world the benefit of his advice - "if requested", as he likes to phrase it.

Gus Voss was leader of DESY's Accelerator Division and as such a Laboratory Director for exactly 22 years. He contributed to planning the first electron synchrotron at DESY back in 1958-9. Then he went to CEA (Cambridge, Massachusetts), where he directed with Ken Robinson the famous bypass electron-positron collider project. He is also well known for his important contributions to accelerator technology, like low beta insertion for storage rings, which he made (again with Ken Robinson) in 1966.

In January 1973 he returned to DESY, called by Wolfgang Paul, then chairman of the Board of Directors. He arrived in time to commission and inaugurate the DORIS electron-positron storage ring in 1974 and then directed the design and construction of the bigger PETRA ring, which began operation in 1978. Together with Bjorn Wiik he directed construction of the HERA electron-proton collider, in operation since 1992. During the last few years he took strong interest in linear colliders, together with Norbert Holtkamp building a 400 MeV test section to develop new linear collider technology.

Gus Voss (top-photo Kai Desler) has formally retired from the DESY Laboratory, Hamburg. Dieter Trines, below (photo Nowakowski) is the new leader of DESY's Accelerator Division.



Voss' position at DESY is taken over by Dieter Trines (52) who contributed to the construction and commissioning of PETRA from 1975. Dieter Trines spent two years in the TASSO Group at PETRA and in 1983 joined the HERA effort as head of the Proton Ring Vacuum Group. From 1992 he was leader of DESY's newly created Cryogenic and Vacuum Group and was increasingly involved with the new superconducting linear collider project in the framework of the TESLA collaboration. Dieter Trines obtained his physics degree in Bonn in 1972 on pion photoproduction and then spent nearly two years in Richard Taylor's group at SLAC studying deep inelastic scattering. On May 26 at 14h a scientific colloquium in the DESY main auditorium will honour Gus Voss.

NORTH CAROLINA
Big free-electron laser

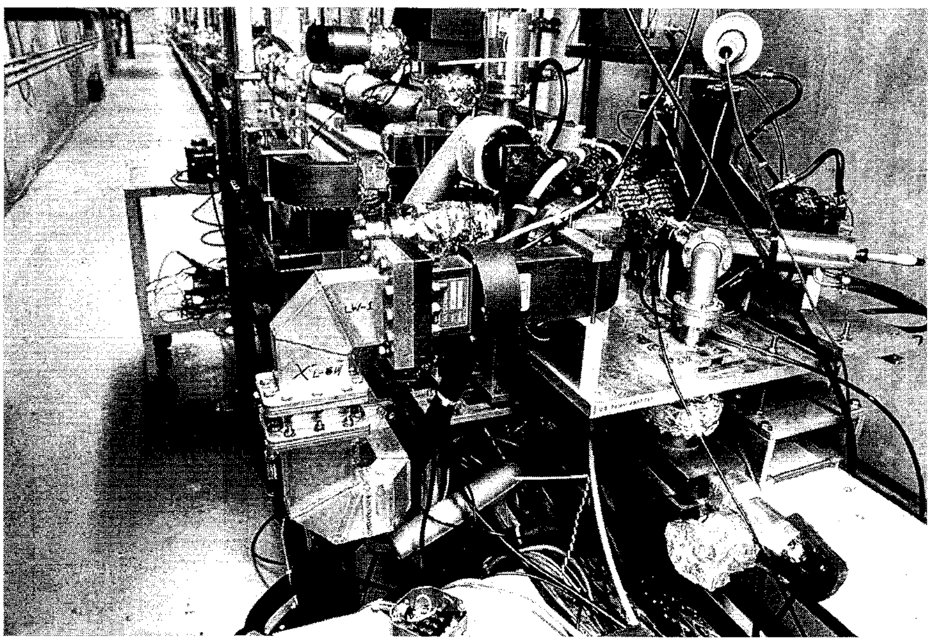
Now in operation at Duke University, Durham, North Carolina, is a major new free-electron laser (FEL) - a 100-metre electron storage ring designed to operate at 1.3 GeV and already achieving 1 GeV.

The ring will provide very bright beams of ultraviolet, X- and gamma radiation for a wide range of experiments and applications, including molecular engineering and micromachinery as well as providing a high resolution tool to study the structure of matter.

The new FEL complements the Mark III infrared source at Duke's FEL Laboratory, directed by FEL pioneer John Madey. Later this year the new ring should deliver electrons to the OK-4 optical klystron, an ultraviolet FEL being moved to Duke from the Budker Institute in Novosibirsk. Later the new ring will be equipped with an undulator to extend the range of wavelengths.

Injector for the new FEL is a 120-foot linac providing 250 MeV electrons, claimed to be the second highest energy linear accelerator in the US, outgunned only by the two-mile giant machine at SLAC, Stanford. Radiofrequency power for the new ring is provided by a cavity supplied by the Budker Institute.

This 120-foot linac supplies 250 MeV electrons to the new 1.3 GeV storage ring for a free-electron laser at Duke University, Durham, North Carolina. (Photo Jim Wallace)

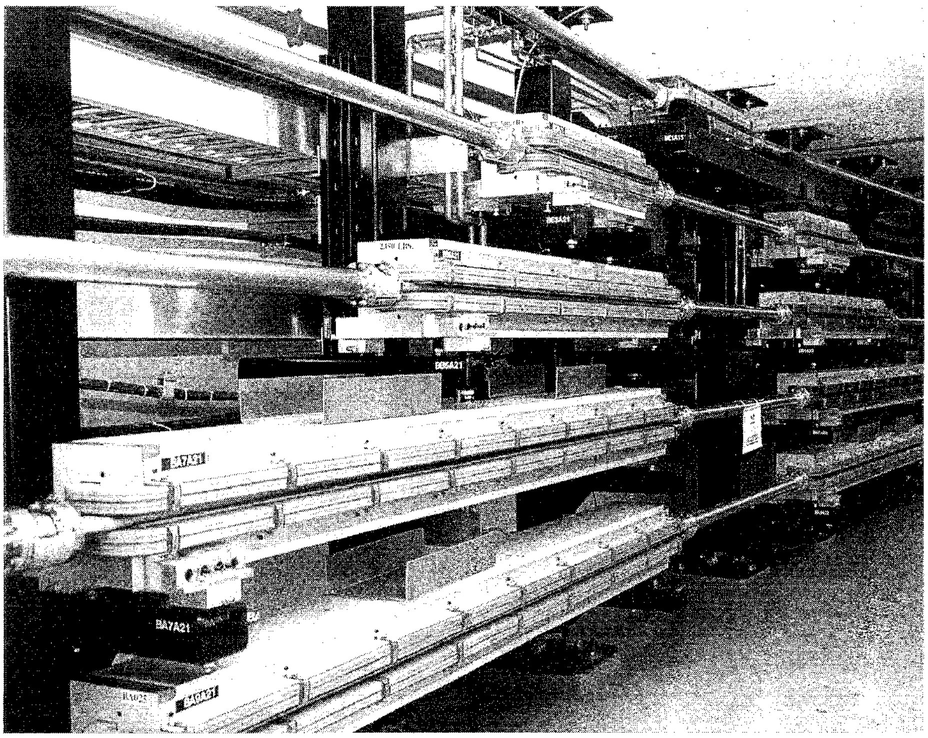


CEBAF
Three-pass beam and first physics

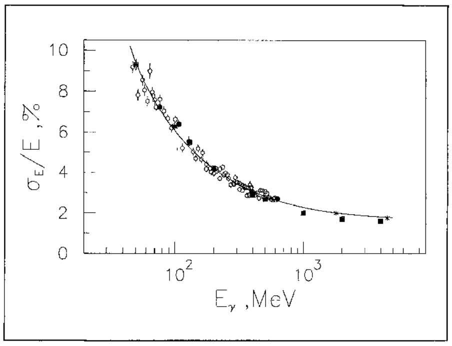
During December, third-pass commissioning took place as scheduled at the Continuous Electron Beam Accelerator Facility, Newport News, Virginia. In the process, CEBAF's 4 GeV recirculating machine for the first time delivered beam for a physics measurement.

Measurements began within hours of the continuous beam arriving on target, both at 750 MeV and 2.1 GeV. A sieve collimator was used to check the optics and the data acquisition system of the Hall C High Momentum Spectrometer (HMS), which had been receiving beam for checkout and debugging during earlier commissioning phases. Data were reproduced at the same kinematics as, and in agreement with, previous high energy electron scattering data, but - due to the CEBAF beam's continuous nature and the HMS's large acceptance - with better statistics in less running time.

On December 17, starting from "dead stop" after having completed two passes previously, accelerator operators were able to use nominal settings to attain the third pass; within six hours, two passes were re-established and beam was sent through the previously untransited third. CEBAF will eventually be a five-pass machine.


Five layers of recirculating arcs at the Continuous Electron Beam Accelerator Facility (CEBAF), Newport News, Virginia. In December, the third of these arcs came into action.

Energy resolution of a full scale prototype of the liquid krypton calorimeter for the KEDR detector at Novosibirsk's VEPP-4M electron-positron storage ring. (Black points are from a simulation.)



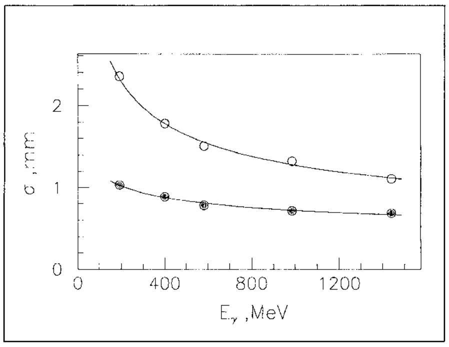
NOVOSIBIRSK
Prototype liquid krypton detector

Now under construction at the Budker Institute of Nuclear Physics in Novosibirsk is the KEDR detector for experiments at the VEPP-4M electron-positron storage ring operating in upsilon energy region. One of the key components of the detector is an electromagnetic calorimeter based on liquid krypton (somewhat similar to that planned for the NA48 CP violation experiment at CERN).

In Novosibirsk's pioneer major liquid krypton project, last spring a full scale prototype liquid krypton calorimeter was successfully tested at the VEPP-4M tagged photon station. Tagged photons are obtained by backward (Compton) scattering of laser photons by the electron beam. The recoil electrons are detected by the tagging system of scattered electrons, developed for KEDR studies of two-photon physics.

The energy of the scattered electron is measured with an accuracy better than 10^{-3}, providing energy resolution for photons better than 1.5% from 40 to 600 MeV. Data at higher photon energies are obtained by correlating the final parts of the

KEDR prototype liquid krypton calorimeter space resolution data in the energy range 150 to 1300 MeV. Black circles present the resolution in the layer of liquid krypton where conversion occurred, open circles in the next layer. The space resolution for photons, of the order of 1mm, sets a new standard for total absorption calorimeters.



Compton and single bremsstrahlung spectra at different beam energies. In this way the tagged photon station allows high intensity photon beam experiments in a wide energy range, from 40 up to 4500 MeV.

The prototype liquid krypton calorimeter contains 400 kilograms of krypton and consists of flat ionization chambers (made of foiled G10 - fibreglass with copper foil covering) with an electrode gap of 2cm. The electrode structure is close to that of the actual KEDR liquid krypton calorimeter and has towers and strips for measuring photon energy and coordinates. The 96-channel readout electronics consists of a low noise charge sensitive preamplifier, simple shaper optimizing signal-to-noise ratio, and a 12-bit ADC.

Since all the calorimeter is practically active material and therefore homogeneous, the energy resolution is comparable to the best calorimeters based on heavy crystals. Space resolution is considerably improved because of the possibility of seeing the photon conversion vertex.

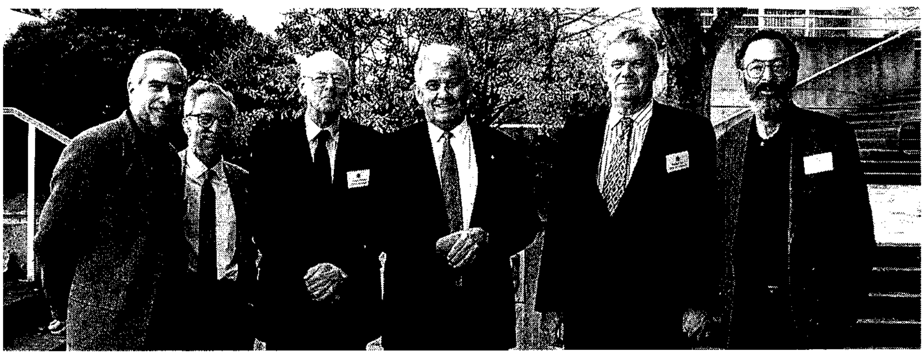
The experimental technique - photon tagging and the measurement of photon energy and coordinates with high resolution - is important not only as a test of the calorimeter, but also as an independent study for experiments with high energy photons. For example it makes possible an experiment on photon splitting (through vacuum polarization - a transient electron-positron pair - in the field of nucleus) scheduled for this spring.

TRIUMF Vogtfest

A symposium on "Subatomic Physics in the '90s" was held at the University of British Columbia on 4 December to honour Erich Vogt on his official retirement from the university and, earlier in the year, from the Directorship of the Canadian TRIUMF Laboratory in Vancouver. (He is succeeded by Alan Astbury.) Distinguished speakers included E.M. Henley (QCD Sum Rules and the Weak Interaction), N. Isgur (Heavy Quark Symmetry and the Quark Model: A Curious Coincidence), T.D. Lee (The Importance of Condensates in high temperature Superconductivity and Relativistic Heavy Ion Collisions), and Sir Denys Wilkinson (The Universe and I). The event concluded with an entertaining evening 'Vogtroast' directed by Richard Taylor, the leading contributor of highly appreciative and mostly respectful remarks being Karl Erdman.

Erich Vogt was one of the founders of TRIUMF and served as Associate Director (1968-71, 1972-3), Chairman of the Board of Management (1974-80) and Director (1981-94). He was also Vice-president of the University of British Columbia (1975-81) but has been best known recently as "Dr. KAON" for his long-term championship of the project to build a major particle beam factory at TRIUMF. Retirement has not yet caused any visible diminution in his activity level, and, among other things, he continues to edit "Advances in Nuclear Physics" and to serve as Vice-chairman of the IUPAP Commission on Nuclear Physics.

Vogtfest celebrants at TRIUMF, Vancouver: (left to right) Douglas Bryman, Ernest Henley, Sir Denys Wilkinson, Erich Vogt, Richard Taylor and Nathan Isgur. (Photo: David Axen)



CATANIA First beam from superconducting cyclotron

The CS superconducting (K=800) cyclotron built at the Laboratorio Nazionale del Sud (LNS) of INFN, Catania, in a collaboration between the LNS and INFN Milan gave its first beam on 22 December when nickel-

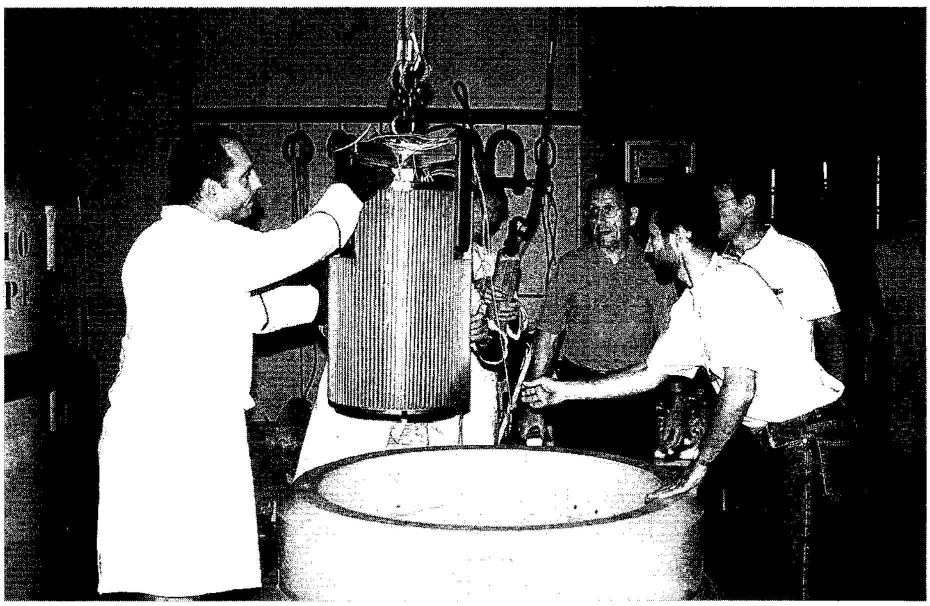
Physics monitor

58 (16+) ions were extracted. The beam energy was 30 MeV/nucleon and currents of 3 and 5 nA were measured before and after the extraction deflectors.

The CS, presently with an SMP15 Tandem injector, can accelerate lighter ions up to 100 MeV/nucleon and heavier nuclei to 20 MeV/nucleon. Research with heavy ions will now be extended to the intermediate energy domain at the LNS, one the four INFN national laboratories and a major nuclear physics facility in Italy.

E.Migneco and D.Vinciguerra

Placing the chromium-51 neutrino source in its shielding, prior to use as a benchmark in the Gallex solar neutrino experiment.
(Photo D. Vignaud, CEA Saclay)



GRAN SASSO/ GRENOBLE Artificial neutrino source confirms solar neutrino result

In 1992, the Gallex experiment announced the first observation of the neutrinos produced in the primary proton-proton fusion reaction in the core of the Sun, reaction at the origin of the energy production by our star (September 1992, page 1).

The Gallex team stressed that the observed neutrino flux was only about two-thirds of the predicted level, confirming the deficit observed by the two pioneering experiments, Ray Davis' chlorine-based detector in the USA and the Kamiokande study in Japan (which are only sensitive to neutrinos from subsidiary solar fusion processes).

This deficit demands explanation, and could considerably modify our understanding of how stars shine and/or of neutrino physics. But before drawing conclusions, the Gallex result had to be checked.

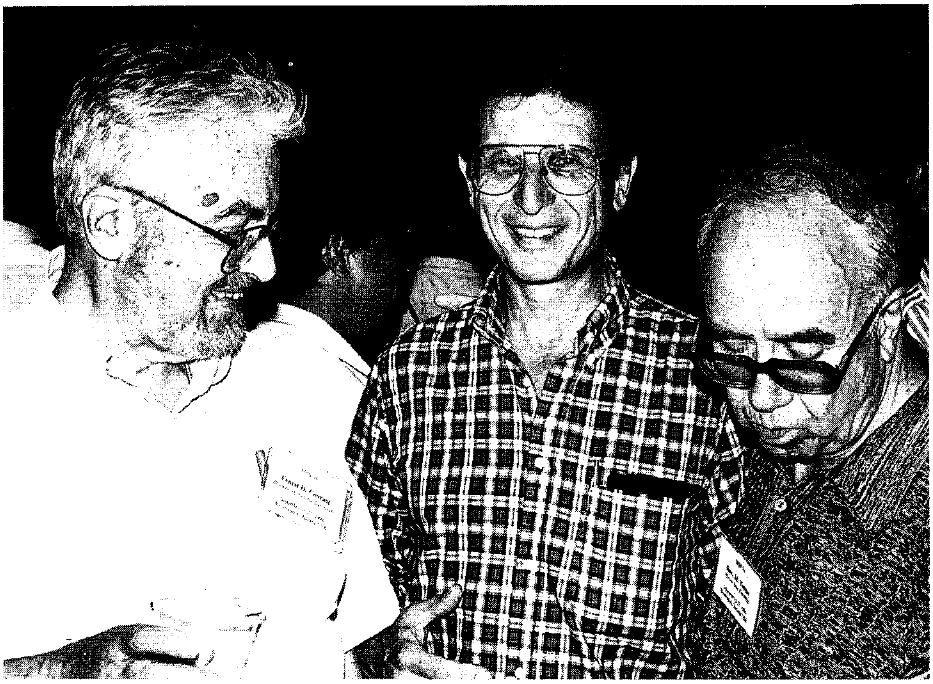
Gallex, installed in the Italian Gran Sasso underground Laboratory, is a radiochemical experiment using neutrino interactions to transform gallium-71 into germanium-71. The latter is radioactive and decays with a half-life of 11.4 days. Counting the germanium-71 atoms extracted from the target tank measures the neutrino flux to which the detector is exposed.

Neutrinos are famous for their reluctance to interact. 65 billion per square centimetre per second on the surface of the Earth produce only one germanium-71 atom in the Gallex target containing 30 tons of gallium. This is at the limit of homeopathy (extracting few atoms of germanium-71 from a solution containing 10^{30} atoms) and needs careful checking. Since it is not possible to switch off the Sun, the only recourse was to build an artificial neutrino source more powerful than the Sun as a benchmark. This was done last summer.

Last May, 36 kilograms of chromium grains were placed in the Siloe reactor of the French Commissariat à l'énergie atomique, Grenoble. The chromium had been previously enriched to 40% chromium-50 by the Kurchatov Institute in Moscow (natural chromium contains only 4.5% chromium-50).

A dedicated core was built for the reactor, whose neutrons transform chromium-50 into chromium-51, which decays by emitting 750 keV neutrinos (very close of the mean energy of the solar neutrinos interacting with the gallium target). After 23 days of irradiation, the chromium was removed from the reactor and placed in a special tungsten shielding. It was the most powerful artificial neutrino source ever made, giving 60 x 10^{15}

Polarized beam experts Ernest Courant (Brookhaven/Michigan, left), Massimo Placidi (CERN, centre), and Igor Ternov (Moscow) discuss how to polarize more accelerators.



per second (60 petabecquerels).

Immediately transported to the Italian Gran Sasso underground Laboratory, it was installed in a special thimble in the core of the detector. Over more than three months, the source produced a relative abundance of neutrino interactions, ten times more than the Sun. The ratio between the number of germanium atoms produced by the artificial neutrino source and the number expected from its measured activity is 1.04 ± 0.12, showing that the detector works perfectly well and confirming the original solar neutrino deficit observed by Gallex.

Because the Gallex, chlorine and Kamiokande experiments use different techniques, they have different sensitivities to the various sources of solar neutrinos. While Gallex sees an overall deficit, the current thinking is that the detector sees all the predicted neutrinos produced by the basic solar proton-proton fusion process, but not those from subsidiary fusions involving beryllium-7 and boron-8. The chlorine and Kamiokande experiments are only sensitive to these latter processes, and it is here that the deficit arises.

The leading contender explanation for the dearth of beryllium-7 and boron-8 particles is resonant neutrino oscillations inside the Sun (the so-called MSW effect). If the Sun produces electron-type neutrinos and the detectors are sensitive only to these, if some of them have been transformed en route into muon- or tau-types then the observed deficits can be accounted for.

To confirm this interpretation means waiting for the next generation of detectors (SNO in Canada, Superkamiokande in Japan and Borexino in Gran Sasso) and the neutrino experiments at CERN (Chorus and Nomad) which will look hard for possible neutrino oscillations.

The Russian-American experiment SAGE, using a target containing 57 tons of metallic gallium in the Baksan Laboratory (Caucasus), is carrying out a similar check.

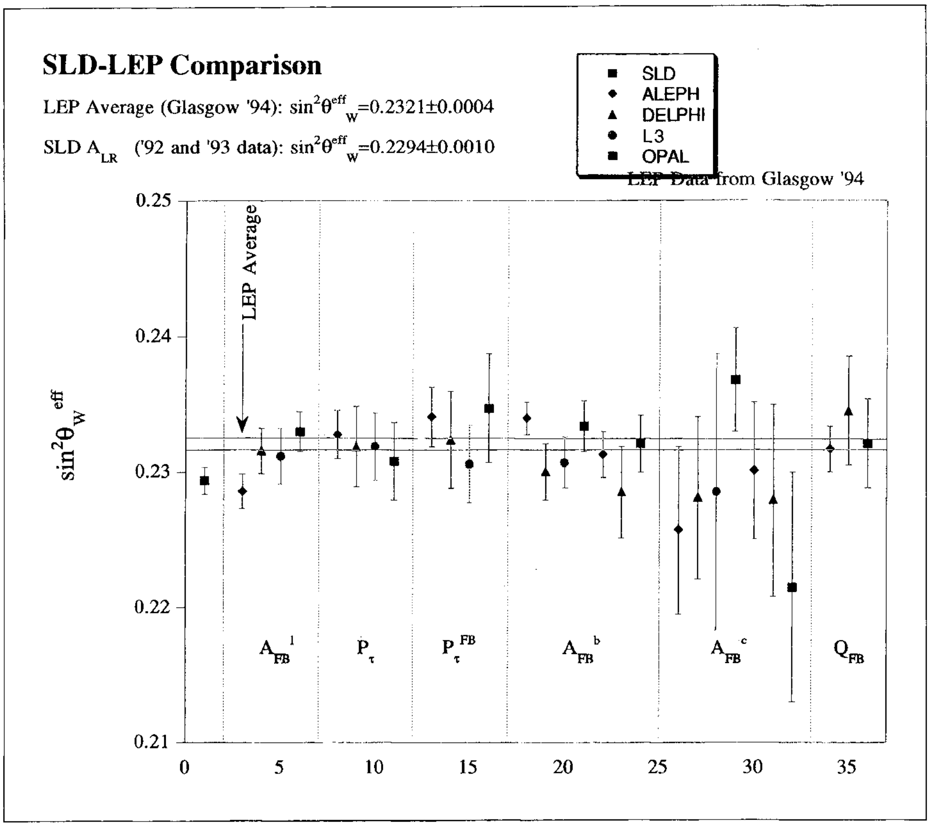
Spin jamboree

About 340 spin enthusiasts gathered in Bloomington, Indiana, this Fall for the "trial partial merger" of the 11th International Symposium on High Energy Spin Physics and the 8th International Symposium on Polarization Phenomena in Nuclear Physics. Although there were five separate organizing committees, the Spin '94 Meeting was a great success, reflecting the fact that most of the world's nuclear and high energy laboratories are now actively using or seriously considering spin-polarized beams and spin-polarized targets.

One major highlight was the recent blossoming of polarization at the world's large electron facilities: SLC (Stanford/SLAC), HERA (DESY) and LEP (CERN). Massimo Placidi (CERN) described the high transverse polarization obtained in LEP (January, page 6), which has allowed a very precise and important calibration of the Z mass.

HERA has recently made great progress with its polarized electron beam. Gus Voss and Desmond Barber (DESY) reported a transverse electron polarization of about 70%; HERA also successfully used spin rotators to produce the first longitudinally polarized electron beam with about 55% polarization (September 1994, page 24). This exceeded the 50% "Soergel limit" and thus led to the approval of the HERMES experi-

The comparison of the electroweak mixing (Weinberg) angle measured at the SLC electron-positron collider at Stanford (SLAC), using the left-right polarization asymmetry, and at LEP at CERN using various asymmetries and the tau polarization.



ment. Hal Jackson (Argonne) discussed the clever HERMES "storage cell" internal polarized proton target which should soon allow precise measurements of the nucleon form factors' spin structure.

Igor Ternov (Moscow) gave a historical account of the 1963 calculations of the (Sokolov-Ternov) self-polarization effect. Because of their different synchrotron radiation rates, spin-up and spin-down electrons or positrons become polarized along an accelerator ring magnets' vertical direction. In 31 years, this clever theoretical abstraction has become the most important polarization tool at HERA and LEP.

In the 1990s, SLAC has become an almost "dedicated" polarized beam facility. The sterling work of their polarization team was described by Mike Woods (SLAC) and Herb Steiner (Berkeley). In 1994, their gallium-arsenide source gave an electron beam polarization of 85% for SLAC fixed-target running and 80% for SLC collider running. This high polarization allowed electroweak measurements almost as precise as all the combined LEP data. The two measurements disagree by about 2.5 standard deviations; while this disagreement is not yet a "crisis", it certainly seems interesting.

The "Spin Crisis" (where does the proton spin come from? - July 1994, page 19) was extensively discussed by many theorists and experimenters from both the high energy and nuclear communities. Opening speaker Tony Thomas (Adelaide) suggested that perhaps, with the new data and some new theoretical understanding, the crisis has somewhat evaporated. Summarizer Alan Krisch (Michigan) suggested that physicists should use the word "crisis" more sparingly; noting that the SSC's cancellation in 1993 gave direct experience with a real crisis.

The recent SMC data using a CERN polarized muon beam on a polarized proton target agrees rather well with the SLAC polarized electron data experiments. Moreover, the theoretical extrapolations to other kinematic regions and the validity of some sum rules have been reevaluated. With this latest theoretical input and the new polarized lepton-nucleon data, it now appears that perhaps one-third of the proton's spin is probably carried by the quarks and antiquarks.

At low energies, the weak interaction between nucleons was studied by searching for parity (left-right symmetry) violations at the level of one part in ten million. Using epithermal neutrons, these violations were found to be strongly enhanced by the mixing between different levels in compound nuclei. Early measurements at LANCE for thorium 232 showed effects as large as 10%; new LANCE results, reported by Yi-Fen Yen (Los Alamos), show even larger effects, with the expected mean of zero. These large parity violations should permit previously impossible studies of the weak interaction between nucleons.

Another highlight was the proliferation of 'Siberian snakes' to control spin-oriented beams. The Michigan-Indiana Siberian snake at the IUCF Cooler Ring (May 1993, page 21) has been joined by the Brookhaven AGS Siberian snake reported by Thomas Rose (Brookhaven). Both teams of "herpetologists" are enthusiastically testing the snakes' abilities to overcome all sorts of depolarization problems.

The Michigan-Indiana team and the AGS team both reported using a partial Siberian snake to accelerate

High energy spin symposium organizers Ken Heller (Minnesota, left) and Alan Krisch (Michigan) looking organized but tired.

through depolarizing resonances (September 1994, page 27). Rick Phelps (Michigan) also reported the first spin-flipping of a stored polarized proton beam by using an r.f.-solenoid-induced depolarizing resonance at IUCF; the polarization loss per flip was less than 0.05%. These technological innovations, together with the recent success of polarized experiments with pure internal targets and stored beams, have led to a plan for a Light Ion Spin Synchrotron (LISS) reported by Steve Vigdor (Indiana); LISS would exploit this technology to explore nucleon spin physics in the 1-20 GeV range.

Several other proton laboratories are now seriously considering installing Siberian snakes to accelerate polarized protons. Yusef Makdisi (Brookhaven) described a plan to inject polarized protons from the AGS into the RHIC machine, now under construction. By installing two Siberian snakes in each RHIC ring, it would be possible to accelerate polarized protons to 200 GeV and then collide them. Spin rotators on either side of the STAR and PHENIX detectors would allow studying spin-spin effects in 400 GeV proton-proton collisions in either longitudinal or transverse spin states.

Fermilab has commissioned the SPIN@Fermilab Collaboration (Michigan/Indiana/Fermilab/Protvino/Dubna/Moscow/INR/KEK/TRIUMF) to design polarized beam capability for the new 120-150 GeV Main Injector and the Tevatron Collider. Dave Caussyn (Michigan) noted that, if the project were approved, there would be one Siberian snake in the 8 GeV Booster, two in the Main Injector, and six in the Tevatron.

Spin rotators near CDF and D0 would allow studies of one-spin antiproton-proton collisions at 2 TeV with either longitudinal or transverse polarization. There could also be proton-proton two-spin experiments near 1 TeV using a Tevatron polarized internal gas jet target. Moreover, the new Main Injector would allow simultaneous fixed-target two-spin experiments in the 120 GeV extracted polarized proton beam.

Summarizer Alan Krisch also described the plans for the NEPTUN and NEPTUN-A polarization experiments at UNK in IHEP-Protvino, near Moscow. When UNK-1 begins 400-600 GeV operation around 1997, it will be the world's largest circumference (21 km) proton accelerator until LHC starts up. Due to financial problems, the 3 TeV UNK-2 superconducting ring has been delayed to focus on the earliest possible operation of UNK-1. The first experiments planned for UNK-1 are NEPTUN and NEPTUN-A, which will both use the Michigan Ultra-cold polarized proton internal jet target. Thus, prior to UNK-2 operation, the huge UNK facility may be dedicated to these polarization experiments on the one-spin asymmetry in 400 GeV elastic and inelastic proton-proton collisions.

Since the 1992 Spin Symposium in Nagoya, spin has bloomed. The nuclear and high energy polarization community spun out of Bloomington wondering what dramatic advances would occur before the next major meeting in NIKHEF-Amsterdam in September 1996.

Peter Schlein (left) and Dino Goulianos at the Fermilab Workshop on Small-x and Diffractive Physics at the Tevatron.

Hard diffraction and small-x

In the United States, phrases such as "small-x evolution", "the BFKL Pomeron" , "deep-inelastic rapidity-gap events" and "hard-diffraction" do not generate the same intensity of discussion amongst high-energy physicists that they do in Europe. However, for three days in the fall such discussion filled the air at Fermilab. The "2nd Workshop on Small-x and Diffractive Physics at the Tevatron" was a review of the rapid theoretical and experimental progress taking place in this field.

Although Quantum Chromo-dynamics (QCD) has been established as the theory of strong interactions for twenty years, as yet neither perturbative high-energy calculations nor low-energy non-perturbative techniques have been successfully extended to the mixture of high energy and low transverse momenta which characterize traditional "soft" diffractive processes.

The simplest soft diffractive process is elastic scattering. In this case it is easiest to accept that there is an exchanged "pomeron", which can be pictured as a virtual entity with no electric charge or strong charge (colour), perhaps like an excitation of the vacuum. The same pomeron is expected to appear in all diffractive processes. Understanding the pomeron in QCD is a fundamental theoretical and experimental challenge. In the last two or three years the "frontier" in this challenging area of QCD has been pushed back significantly in both theory and experiment.

Progress has been achieved by studying the evolution of hard collisions to relatively smaller constituent momenta (small x) and by studying "hard" diffractive collisions containing simultaneous signatures of diffraction and hard perturbative processes. The hard processes have included high transverse momentum jet production, deep inelastic lepton scattering, and (most recently) W-production. The pioneer experiment was UA8 at CERN, which found events with a "nearly elastic" antiproton in which the proton was excited to a massive state containing jets (March 1992, page 4). Interpreted as evidence for quark or gluon constituents in the pomeron (as suggested by Gunnar Ingelman and Peter Schlein), a "hard" pomeron structure was favoured, one in which nearly all the pomeron momentum is often carried by a single gluon or quark.

Recently the discovery in deep-inelastic scattering at the HERA electron-proton collider at DESY, Hamburg, of both the fast structure function rise at small-x and the significant production of 'rapidity gap' events (September 1993, page 6) has attracted most attention. The Fermilab Tevatron collaborations, CDF and D0, are exploiting their high energy to provide definitive studies of rapidity gap events with various jet configurations, thus extending the breadth and vitality of the subject.

The realization that perturbative calculations, originally aimed at small momentum transfer processes, can be applied to the small-x evolution of parton distributions has (together with the experimental developments) also produced a burst of theoretical activity. The Balitsky-Fadin-Kuraev-Lipatov (BFKL) pomeron can produce the observed rise in small-x structure and may also appear in hard diffractive processes.

Questions of how perturbative processes can consistently produce hard diffraction, when the BFKL pomeron will appear, and what the higher-order corrections will be, have been the major issues. The current status and directions for future progress were reviewed in a stimulating overview presented in the opening talk by Al Mueller. Issues relevant to HERA were covered by Jochen Bartels.

At the time of the first Small-x and Diffractive workshop in 1992, HERA was just beginning operation. In contrast the latest workshop opened with a succession of talks describing the impressive range of HERA results already obtained. Experiments ZEUS and H1 are investigating the remarkably frequent deep-inelastic events with a "rapidity gap", - an angular region completely devoid of particles. This is a signature of pomeron exchange, as the pomeron carries no colour. The standard interpretation is that, just as the electron radiates a photon, the proton radiates a pomeron, and the photon-pomeron collision sometimes gives rise to jets of hadrons. This gives the possibility of directly probing the pomeron's structure with the photon (a technique which has taught us much of what we know about the structure of the proton).

With the closure of the CERN Collider in 1990, hadron collider studies could only be continued at the Fermilab Tevatron. Since neither the CDF nor D0 experiments have very forward detectors, attention also turned to rapidity-gap diffractive events. At the workshop, Anwar Bhatti for CDF and Tracy Taylor for D0 reported events with two high transverse momentum jets separated by a large rapidity gap. This gap implies a colourless exchange and the large transverse momentum exchange (typically 50 GeV) implies a perturbative process. The simplest possibility is two gluons, but the full BFLK pomeron could be responsible. If it is pomeron exchange, its squared momentum transfer is about a thousand times greater than classic pomeron instances.

Changlyong Kim reported on a D0 search for BFKL correlation effects but do not find a definitive result. CDF has also searched for two further classes of rapidity gap events, as reported by Dino Goulianos. These are events with two jets on the same side of the gap (corresponding to events seen by UA8), and events containing a W. In neither case are gaps observed at the present level of sensitivity. While diffractive W production represents an exciting possibility for future studies, the absence of a signal at the present level appears in conflict with models where the pomeron contains mainly hard quarks and antiquarks.

Both HERA experiments have added detectors for quasi-elastically scattered protons, which will give a direct tag of the pomeron momentum. Ideas to add similar detectors at the Tevatron (CDF) are being formulated. The HERA and Tevatron experiments complement each other nicely and together should allow a mapping of the quark and gluon structure of the pomeron.

An interesting range of small-x and diffractive results in muon-nucleus scattering was reported by E-665. As Karsten Eggert explained, CERN's LHC proton collider should also provide a rich field for studying the pomeron and using diffraction as a tool for heavy quark studies.

After some years in the wilderness, pomeron physics has gained momentum, perhaps leading on to new understanding. As the long-distance carrier of the strong interaction at high energy, the pomeron is in some ways analogous to the electromagnetic photon. At the same time, it must also be an extremely complex collective phenomena at the level of gluons - the carriers of the strong force.

Until we understand the pomeron, we cannot claim to understand strong interactions.

From Mike Albrow

Bookshelf

An Equation That Changed the World, by Harald Fritzsch, University of Chicago Press ($29.95, ISBN 0-226-26557-9)

Distinguished theorist Harald Fritzsch is already well known through his popular books 'The Creation of Matter, The Universe from Beginning to End', and 'Quarks: The Stuff of Matter'. (Written and first published in German.)

The Equation That Changed the World, is of course $E=mc^2$. However the book ranges wider, describing the impact of Newton's and Einstein's work on our present understanding, imaginatively acted out through the Alice-in-Wonderland adventures of a fictitious Professor of Theoretical Physics at the University of Bern called Adrian Haller.

After a brief introduction on Newton's life and work, the book is the narration by Haller of a dream in which he meets Newton in Cambridge. Still fast asleep, Haller and Newton then depart for Bern, where they encounter Einstein. Finally the trio depart for Geneva and CERN.

Newton, who has much to assimilate from both his companions, shows himself an apt pupil. Einstein too is put to the test. As well as having the benefit of scientific hind-

sight, know-all narrator Haller is also familiar with 20th century technology, acting as tourist guide as well as mentor.

While the interplay of the characters makes for a compelling explanation of physics ideas, Haller shows little humility towards the two behemoths of science. The action in the final chapters of the book takes place at CERN, but it is a book about theory, so theorist lifestyle predominates.

With its insight and offbeat slant, the book is a good scientific read and will surely add to Professor Fritzsch's already solid reputation as a popular science writer.

Science exhibition in Pisa

The Istituto Nazionale di Fisica Nucleare produced a science exhibition " inside quarks, beyond galaxies", shown at the end of last year in Pisa, in the former church of S. Paolo all'Orto in the town centre.

The exhibition illustrated our present understanding of nature, from the innermost structure of matter to the far galaxies; presenting the research tools from cyclotrons to LHC and detectors from Geiger counters to the latest blend of microgap chambers and apparatus for studying cosmic rays and gravitational waves. A section was given over to particle detectors for medical applications and the technological spin-off of subnuclear research.

Special attention was given to the research carried out by Pisa groups, from their activities at the CERN ISR to the CDF experiment at Fermilab, and plans at new accelerators.

The exhibition included interactive multimedia. It attracted some 20,000 visitors, including many high school students.

A view of the science exhibition " Inside quarks, beyond galaxies" produced by the Istituto Nazionale di Fisica Nucleare and shown in Pisa at the end of last year (see also front cover).

People and things

On people

Khosrow Chadan, former director of Orsay's Laboratoire de Physique théorique et particules élémentaires has been nominated Chevalier of the Legion of Honour.

R. Vinh Mau, main author of the 'Paris' nucleon-nucleon potential, has been nominated and promoted Officer of the French Ordre du Mérite.

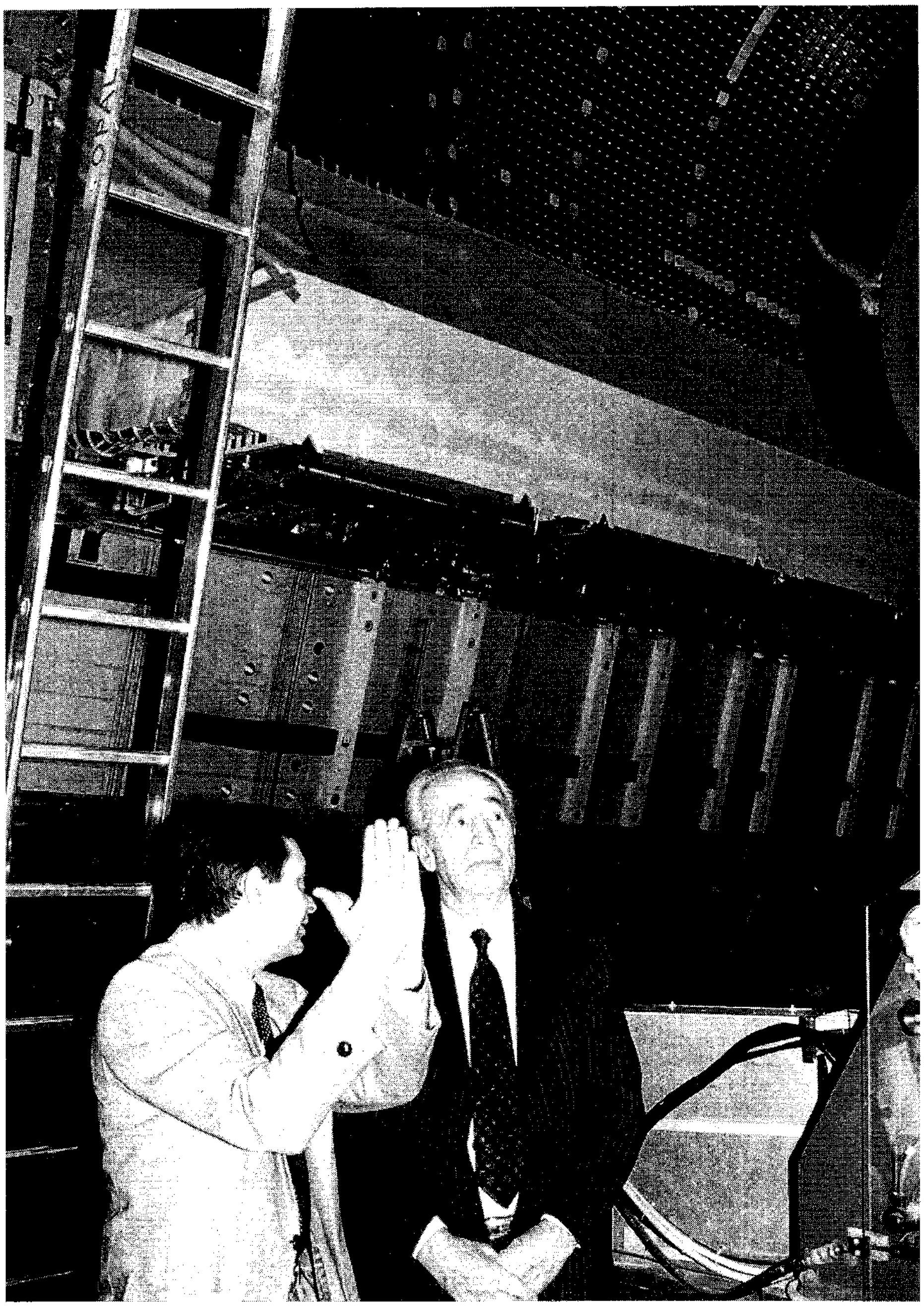
Tom Roser is Head of the Accelerator Division in the Alternating Gradient Synchrotron Department at Brookhaven, succeeding Bill Weng. We apologize for the unfortunate misprint in the December issue, page 27.

Moisei Markov 1908-1994

Academician Moisei Alexandrovich Markov died on 1 October. Although basically a theorist, he made major contributions to the development and infrastructure of Russian experimental physics.

After graduating from Moscow in 1930, he went on to join the new Lebedev Institute. His initial interests were in the problem of infinities in quantum field theory, carrying out pioneer work on the idea of non-locality, a regular theme during his career. In the 1960s he turned to fundamental questions at the interface between particle physics and cosmology.

With the advent of major accelerators in the post-war period, he was a staunch promoter of experiments at these machines, first for the Lebedev electron machine, and subsequently for the Dubna proton synchrotron. After milestone contributions to the



On a visit to CERN on 26 January, Israel's Foreign Minister Shimon Peres (right) hears about the Opal detector at the LEP electron-positron collider from George Mikenberg of the Weizmann Institute. The Opal collaboration includes some 25 Israeli physicists from Haifa, Tel Aviv and the Weizmann Institute. (Photo CERN HI 17.1.95)

study of weak interactions, he stressed the importance of underground or underwater detectors for cosmic rays and neutrinos, leading to the establishment of the Baksan neutrino observatory.

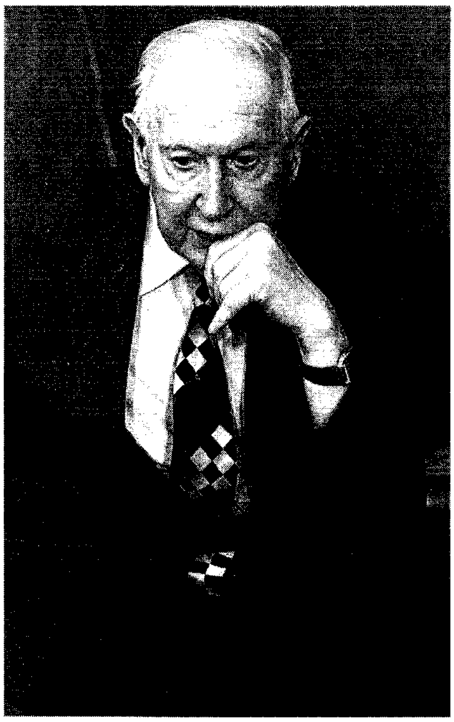
From 1967-88, as head of the Nuclear Physics Department of the Academy of Sciences, he oversaw the establishment of major new projects, including the Moscow meson factory as well as Baksan, while continually providing new stimulation for the research community. For many years he was the USSR representative in the Pugwash movement which provided a useful international forum during a difficult period.

Meetings

The XXIII SLAC Summer Institute on Particle Physics, entitled The Top Quark and the Electroweak Interaction, will be held from 10-21 at The Stanford Linear Accelerator Center, Stanford. Information from Lilian DePortel, Conference Coordinator, SLAC MS 62, PO Box 4349, Stanford CA 94309, fax +1 415 926-3587, e-mail ssi@slac.stanford.edu

The Fourth International Workshop on Vertex Detectors - Vertex'95 will be held at the Ein Gedi Resort, Dead Sea, Israel, from 11-16 June. Topics include: vertex detectors at colliding beam and fixed target experiments; research and development for future vertex detectors; advances in semiconductor and other detectors; and radiation hardness of readout electronics and detectors. Attendance is by invitation only. Further information vertex95@weizmann.weizmann.ac.il Local organizing committee: Eilam Gross and Ronen Mir. Sponsored by: The Weizmann Institute of Science, The Israel Academy of Sciences and Humanities, and The Goldschleger Foundation. Secretary: Mrs. Ana Weksler Department of Particle Physics, Weizmann Institute of Science, Rehovot 76100, Israel. Fax: 972-8-344106 Phone: 972-8-343836) Previous meetings in this series were held in Basto Island, Finland (1992) Lake Bohinj, Slovenia (1993) Lake Monroe, USA (1994)

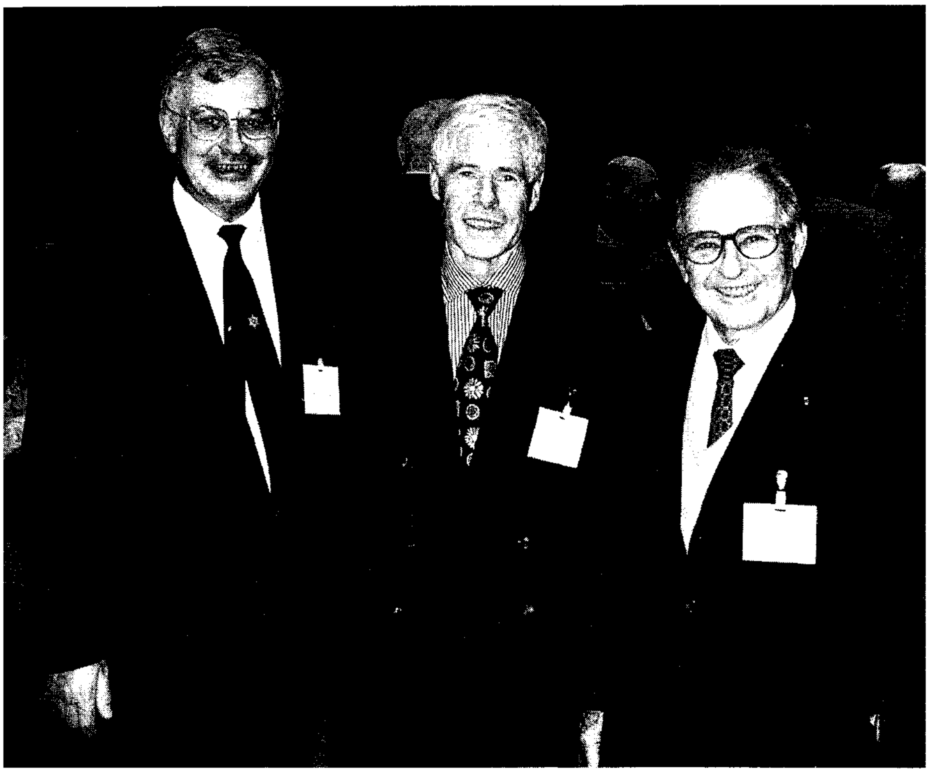
Moisei Markov 1908-1994

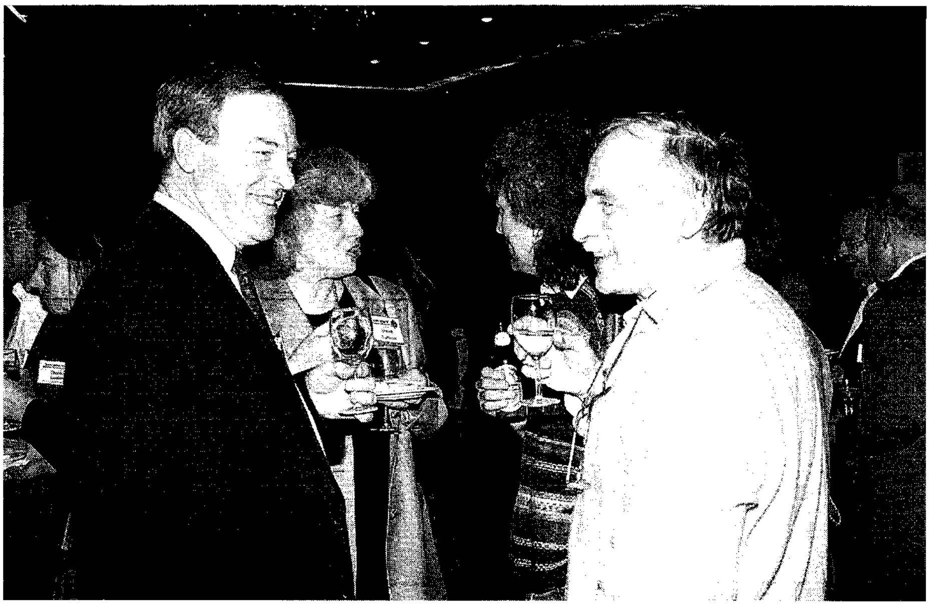


Top, on 15 December a one-day meeting at UNESCO headquarters in Paris featured a tribute to Pierre Auger, one of the founding fathers of CERN, who died in December 1993, aged 94. Auger's impressive career (January 1994, page 34) was covered by J.C. Pecker of the Collège de France (right), European Space Agency Scientific Director R. Bonnet (centre) and M. Jacob, who spoke on Pierre Auger and CERN.

Below, heavy ion heavyweights Hans Gutbrod (left) of GSI Darmstadt and Reinhard Stock of Frankfurt in jovial mood at the recent Quark Matter 95 meeting in Monterey, California. The next issue will feature a report from this meeting, which included the first major public presentation of preliminary results from the lead beam run at CERN at the end of 1994.

(Photo LBL)





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Lawrence Berkeley Laboratory, (USA)
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Competition #688-025

Research Associate Nuclear/Particle Physics

The Simon Fraser University group at TRIUMF invites applications for a Research Associate position with the HERMES experiment at DESY. Responsibilities will include: data taking and further developments of the HERA Compton polarimeter; development of analysis software for semi-inclusive events; and participation in future upgrades of software and hardware.

Applicants are required to have a recent Ph.D. in experimental subatomic physics. Experience in analyzing data from large intermediate/high-energy experiments with UNIX operating systems and a solid background in lepton-nucleus physics are essential.

The successful candidate is expected to reside in Hamburg, Germany. The appointment will be made initially for one year and is renewable. Salary is competitive and depends on experience.

Applicants should send curriculum vitae and the names of three referees **before May 15, 1995 quoting Competition #688-025** to: **TRIUMF Personnel, 4004 Wesbrook Mall, Vancouver, B.C., Canada V6T 2A3**

For further information contact O. Hausser (hausser@triumf.ca). We offer equal employment opportunities to qualified male and female applicants.

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Applications are invited for postdoctoral research associate positions to participate in the D0 experiment at the Tevatron at Fermilab. The positions offer opportunities for hardware, software and physics analysis activities and could start immediately. The Stony Brook High Energy Group has been involved with the D0 experiment since its conception. The experiment studies proton-antiproton collisions at a center-of-mass energy of 1.8 TeV, and is currently collecting large data samples. The group is actively involved in several analyses: top-quark search, W and Z physics, searches for new phenomena, QCD and B physics. We are also working on the design and construction of detector elements and electronics for the D0 upgrade. We are seeking candidates holding a Ph.D. or an equivalent degree in physics, with diverse experience in experimental particle physics. We strongly encourage applications from women and minorities. Interested applicants should send a curriculum vitae, a brief summary of research interests, and arrange to have at least three letters of recommendation sent to:

Professor M. Mohammadi
Dept. of Physics, SUNY at Stony Brook
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UCL

UNIVERSITY COLLEGE LONDON

Department of Physics and Astronomy

Lecturer in Experimental High Energy Particle Physics

Applications are invited for the above position, to commence in October 1995.

The HEPP group is a collaborator in the OPAL experiment at CERN and the ZEUS experiment at DESY. It is also actively pursuing a programme of physics studies and detector R&D work for the ATLAS collaboration at the LHC project at CERN and is developing proposals for future linear colliders. Some preference exists for candidates working in the area of HERA physics and with an interest in working on the ATLAS project.

The successful applicant will be young, with an established record of research and the potential to become a leading researcher in the field. He/she will also be expected to show evidence of competence in teaching at undergraduate and postgraduate level.

Applications, accompanied by a full CV including a statement of research interests, and the names and addresses of three referees, should be sent to Professor B.R. Martin, Head of Department of Physics and Astronomy, University College London, London WCIE 6BT, to arrive not later than 12 April 1995.

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LA FRANCE AU CERN

4 - 6 AVRIL 1995

Pour toute information ou inscription,
Merci de contacter :

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- Mme Cléro : Tél. : (33.1) 40 73 36 01
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- Mr Diraison : Tél. : (41.22) 767 45 85
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