CERN COURIER

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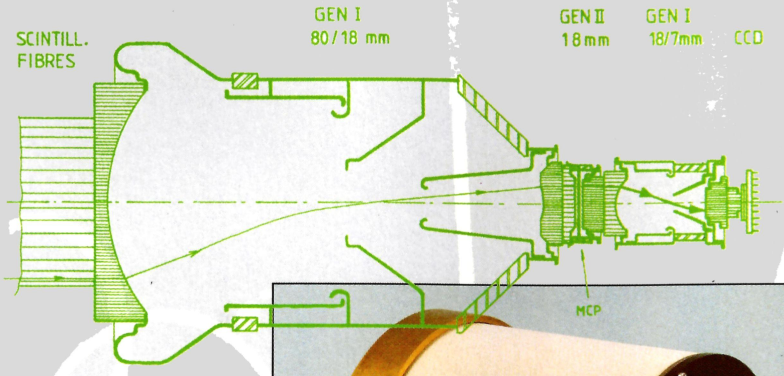
DEP SCIENTIFIC

Photon Detectors for Physics



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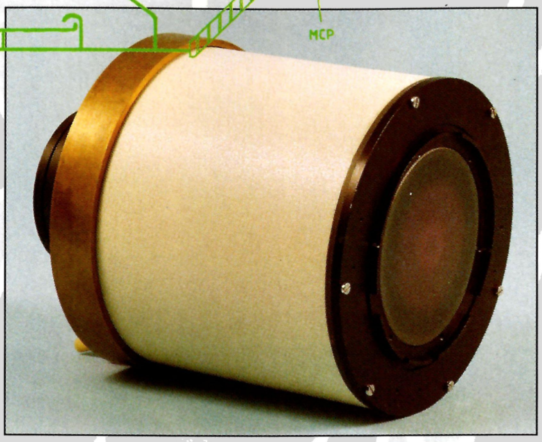

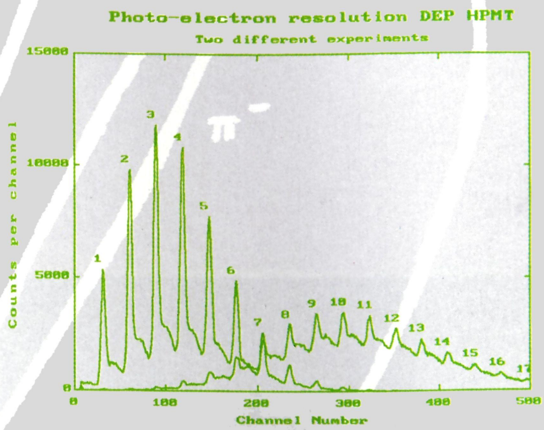

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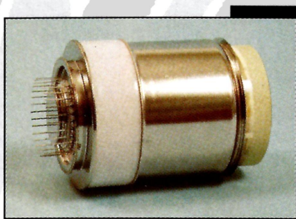

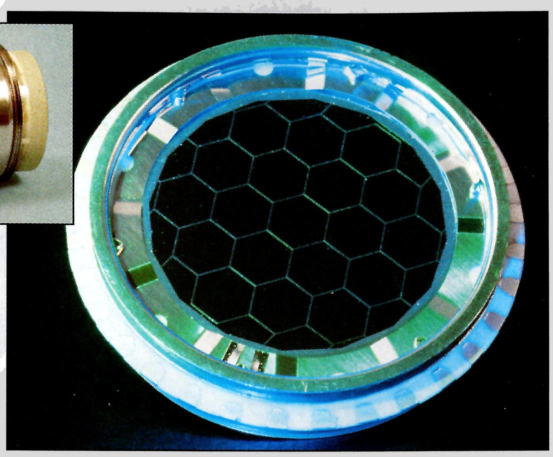

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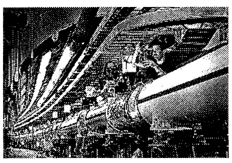
Around the Laboratories

Physics monitor



Cover photograph: The new ring on the block - an arc of Brookhaven's Relativistic Heavy Ion Collider (RHIC), with all of its superconducting magnets installed and interconnected (see page 1).

CES PRESENTS:

The PowerLink Family

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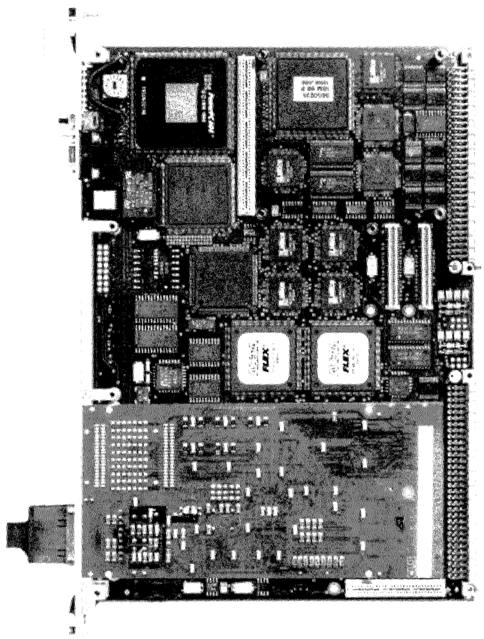

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CES CREATIVE ELECTRONIC SYSTEMS

Around the Laboratories

STAR magnet engineer Ralph Brown and STAR administrative asssistant Elizabeth Mogavero watch one of the 24-foot diameter, steel outer rings for the solenoid magnet of the STAR detector for Brookhaven's Relativistic Heavy Ion Collider (RHIC) is delivered to the experiment's assembly hall.

BROOKHAVEN RHIC update

The Relativistic Heavy Ion Collider (RHIC) Project at Brookhaven has passed a number of significant milestones in recent months.
The superconducting collider has reached the point where most of the components are in place, and the major activity now involves connecting up and testing the electrical and cryogenic systems that comprise the new accelerator. Meanwhile, detector systems are being fabricated in laboratories around the world, and detector installation process has begun in the experimental halls. Overall, the facility is on track to begin its quark matter searches in 1999.

Launched by the US Department of Energy in 1991, the RHIC Project includes the construction of the collider, implementation of an existing complex of Brookhaven accelerators as injectors, and the construction of the initial complement of detectors for a programme of experiments capable of sorting out new phenomena of unprecedented complexity.

RHIC is designed to provide nuclear collisions in the so-called "ultrarelativistic" regime where the density, temperature, and sheer numbers of quarks and gluons produced in the most violent interactions should provide the means by which colour-deconfined hadronic matter - the sought-after quark-gluon plasma - can be produced and observed. RHIC will accelerate heavy ions (gold nuclei) to a top energy of 100 GeV/nucleon in each of the two counter-rotating beams, with six intersection points where collisions take place and experiments can be mounted.

The available collision energy will exceed by factors of 10-100 the energies currently being explored in heavy ion collisions at CERN's SPS and Brookhaven's Alternating Gradient Synchrotron (AGS). As the result of a collaborative agreement with Japan's RIKEN Laboratory, RHIC will also be capable of carrying out a spin research programme with colliding beams of polarized protons at energies up to 250 GeV per beam (March, page 19).

The RHIC injection system underwent its first major test this past fall when gold ions, originating at the Tandem Van de Graaff, were accelerated to the RHIC injection energy of 10.8 GeV/nucleon in the AGS and its Booster, then transported through the newly completed AGS- RHIC transfer line and brought to a beam dump at the entrance to the RHIC rings. During six weeks of beam studies time-shared with the normal AGS heavy ion physics run in November and December of 1996, the transfer line optics, instrumentation, and control system were commissioned and tuned, as were the bunch cycling in the AGS and Booster required for the injection sequence. This test achieved the designed values for the bunch size and emittance for injection to RHIC, and demonstrated that the intensity requirements for collider operation are within reach.

In another major milestone for the construction project, the final dipole magnet fabricated for RHIC by the Northrop Grumman Corporation, the last of the industrially- produced magnets for the project, was delivered at the end of May. This marked the end of a four-year contract between Brookhaven and

Northrop Grumman, during which 373 of the 10-metre superconducting dipole magnets were produced, as well as 420 quadrupole units. The dipole magnets, after acceptance tests, were delivered directly to the RHIC tunnel for installation. The quadrupoles were combined with sextupole and corrector coil units in Brookhaven's shops before final installation in the ring. All of the magnets produced by Northrop Grumman met the machine designers' criteria for electrical and mechanical tolerances (as demonstrated by field quality and quench performance), and none of the magnets delivered to Brookhaven have been rejected. The RHIC Project's Magnet Group, at Brookhaven, is now producing the final magnets to go into the machine - the specialized focussing and bending magnets that bring the beams into collision at the intersection points. This fall sees the first beam from the AGS injected into one of the RHIC rings and transported through the first 1/6th of its circumference. This "sextant test" will be the first operation of the installed superconducting magnets with beam in RHIC, and will touch upon essentially all of the accelerator's systems.

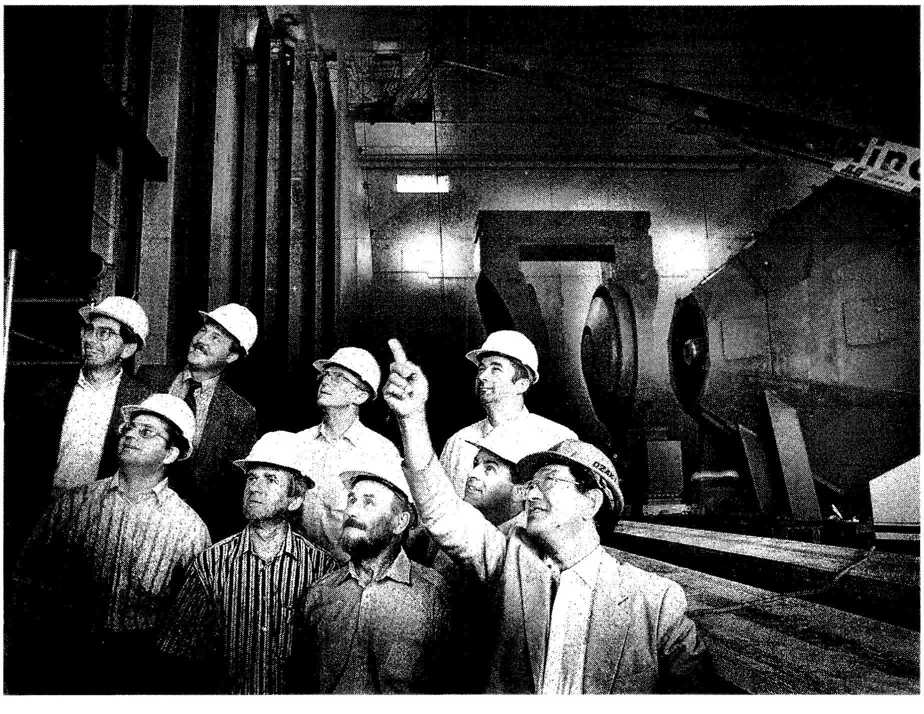
As RHIC machine components near completion and begin to get their first taste of particle beams, the big detectors PHENIX and STAR are starting to take shape in their respective assembly halls. These two detectors, quite different in their respective designs, represent the backbone of the RHIC experimental programme, providing broad general coverage of the expected signals related to the formation and evolution of deconfined states of matter in high energy nuclear collisions (June 1994, page 16). Currently the most visible aspect of these detectors is the massive amount of steel required.

In the case of STAR, the 4-metre diameter, 4-metre long solenoidal field volume for the central Time Projection Chamber calls for a cylindrical iron structure and aluminium coils that weigh in at a total of about 1,200 tons. The PHENIX axial field magnet and its two muon arms require over 2,500 tons of steel forgings and plates. Built in France, Britain, Canada and Russia, the components of these giant magnets have now arrived at Brookhaven and the assembly process is well underway.

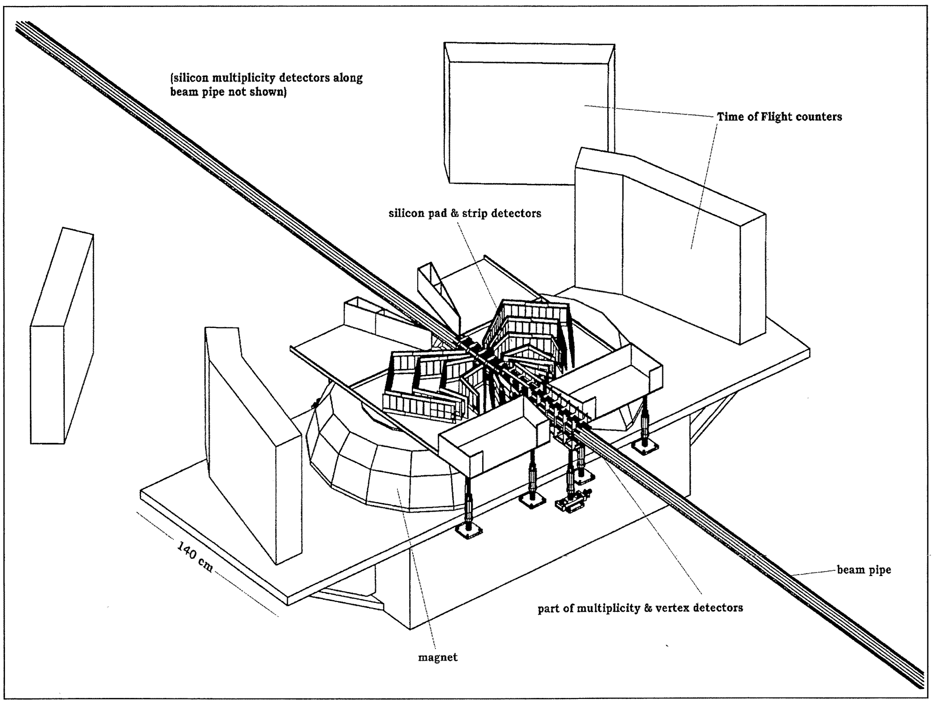
While the detectors they will serve are models of complexity and elegance, these magnets themselves are simply huge. Some of the large components of the STAR magnet, brought by truck from Quebec, Canada to Brookhaven, required temporary closing of New York City's George Washington and Throgs Neck bridges in order to get onto Long Island.

The PHENIX magnet and muon identification system includes one-foot thick steel plates that stand 35 feet tall and weigh nearly 100 tons each. These were produced in Russia's Izhora steel plant, near St. Petersburg, one of the few facilities in the world capable of steel manufacture on such a large scale.

With STAR and PHENIX well along



Installation at Brookhaven of the steel components for the central magnet, forward muon magnet and hadron absorber plates of the PHENIX detector for Brookhaven's Relativistic Heavy Ion Collider (RHIC). Representatives of the Russian team that manufactured these components were on hand to view progress, along with members of the RHIC project management team. Top row, left to right, Tom Ludlam (RHIC project), James Yeck (Department of Energy), Peter Kroon (PHENIX), Vladimir Kashikin (Efremov Institute, St. Petersburg). Bottom row, Victor Durynin (Izhora Steel Works, St. Petersburg), Vladimir Alunin (Izhora), Bitaly Shangin (Efremov), Sam Aronson (PHENIX), Satoshi Ozaki (Rhic Project Head).



Layout of the PHOBOS detector for RHIC (with the upper poletips of the two dipole magnets removed for clarity).

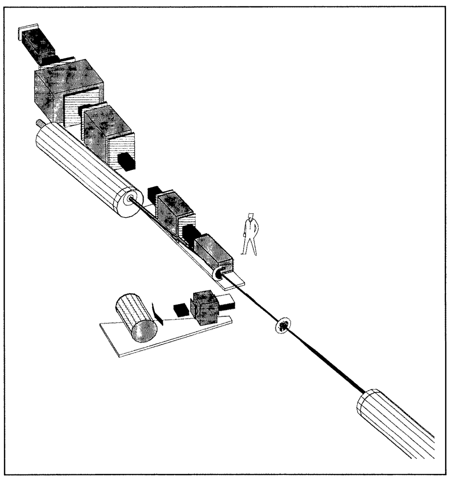
in their design and construction, two smaller detectors, PHOBOS and BRAHMS, are completing final designs and preparing to begin a construction phase that will have them on line as well when RHIC collisions first become available for physics. These detectors, more specialized in their physics focus than the big detectors, are optimized for particular measurements that complement the capabilities of STAR and PHENIX. A feature of the two smaller detectors is their relative simplicity, and ability to quickly answer certain questions that may have important consequences for the long-term research programme at RHIC.

Although small-scale in terms of cost and size, PHOBOS, now just beginning construction, is a high-rate detector utilizing approximately 100,000 channels of silicon pads and microstrips to undertake a sensitive search for events with unusual fluctuations in the global properties of the multiplicity and angular distribution of charged particles.

The capabilities of PHOBOS include fine-grain angular coverage over a large angular coverage, and the ability to reconstruct central particle trajectories at very low transverse momentum. The BRAHMS detector, now in the final stages of design and technical approval, will consist of a double-arm, magnetic focussing charged-particle spectrometer with particle identification capabilities for momenta up to approximately 20 GeV, optimized to measure single particle momenta over a very complete range in polar angle.

The inclusive particle spectra obtained by BRAHMS will help to map out, among other things, the types of processes that can determine the degree of nuclear stopping and the corresponding energy densities reached in the new energy realm to be explored at RHIC. Brookhaven expects to begin commissioning the collider early in 1999, and to start physics operation, with all four detectors in place, later that year.

By Tom Ludlam



Layout of the BRAHMS detector for RHIC. The two spectrometer arms (shown shaded) rotate about the collision point.

INFN/DESY Teraflops

In a good example of spinoff from particle physics, a new agreement between the Italian National Institute for Nuclear Physics (INFN) and the German DESY Laboratory, Hamburg, covers the development of a powerful parallel-processing computer for use in particle physics. This APE (Array Processor Experiment) 1000 machine will be based on the existing successful APE 100 processor (September 1994, page 23) marketed by QSW (Quadrics Supercomputer World Ltd), a subsidiary of Alenia Spazio SA.

APE 1000's processing power will be 100 billion floating point instructions per second (100 Gigaflops/s), a ten-fold improvement over the existing APE 100 and is the outcome of modest investment and operating costs. Development work has been underway for ten years with the help of Italian particle physicists at Rome and Pisa within the framework of the INFN and under the guidance of Nicola Cabibbo and Giorgio Parisi.

As well as particle physics, statistical physics and computer science also require powerful processing power to handle frequent problems with a lot of input data. Other applications will be possible in data-rich areas such as image processing in medicine, weather forecasting, and seismology.

The first APE1000 will go to INFN, while the second is scheduled to be installed in the year 2000 in DESY's Zeuthen (Berlin) premises, where two powerful Quadrics machines have been in use since 1994. The new installation will become part of the German High Performance Computer Centre (HLRZ) based in Jülich and encompassing installations in several research centres, including DESY, and providing powerful simulation capabilities for problem solving over a wide range of applications.

FERMILAB
Large transition radiation detector for rare kaon decays

In Fermilab's new KTeV detector hall, experiment E799 is a rare CP-violating decay search using the long-lived neutral kaon. Seen here are experiments' eight transition radiation detectors with part of the team that built and operated the system - left to right, John Krider, Greg Graham, Lew Morris, Nick Solomey, Y.W. Wah and Breese Quinn. (Photo Fermilab)

In Fermilab's new KTeV detector hall, experiment E799 is a rare CP-violating decay search using the long-lived neutral kaon. The experiment now looks forward to a long fixed target run of almost two years, which will surely provide a wealth of data for the rare CP-violating decay of the long-lived neutral kaon into a neutral pion and an electron-positron pair.

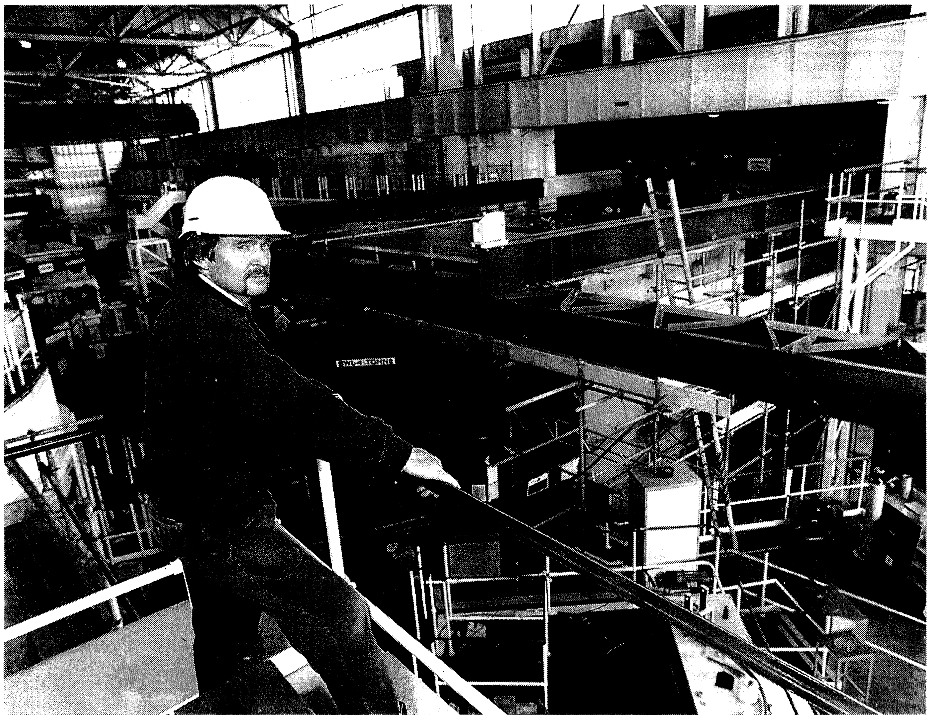
(E799 is a sister experiment to E832, another major CP-violation study in the KTEV - Kaons at the Tevatron - hall. We hope to carry a progress report on both experiments in a forthcoming issue.)

E799's goal is to understand the origin of the mysterious CP violation mechanism, but instead of measuring CP violation by the usual indirect technique of comparing the decays of long- and short-lived neutral kaons, E799 aims at searching for a rare decay mode that comes directly from CP violation itself.

An essential feature of the experiment is its transition radiation detector (TRD), consisting of eight planes of twin multiwire proportional chambers, gaseous X-ray detectors related to the original multiwire proportional chamber and drift chamber invented at CERN by Georges Charpak in 1968. For E799 the detector had to be carefully designed to ensure that the sensitive area is uniform and that the entrance window permitted maximum X-ray transparency between 4 and 25 keV. These detectors are large - 2.5 metres square - and use a mixture of recirculated xenon and CO_2 gas. The whole system has 6000 anode wires, 18,000 cathode wires and is read out by 2000 electronics channels with ten-bit analog/digital converters. Each of the eight detectors has 12 cm of loosely packed polypropylene fibre felt to generate the transition radiation. Detector construction and operation is a joint Fermilab/Chicago effort, with design and building requiring three years of effort and involving more than 15 people. A trigger processor with TRD inputs was built by the University of Virginia.

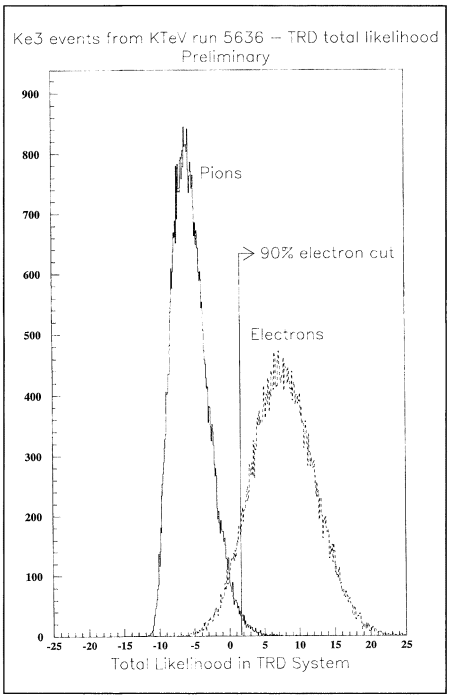
The tracking TRD detector system is better than 100:1 electron-pion discrimination, which, combined with 400:1 discrimination from the cesium iodide calorimeter will give a total discrimination of almost 40,000:1. The tracking TRD system saw transition radiation X-rays along electron tracks when the first beam arrived in August.

Such high rate gaseous detectors are called for at fixed target experiments or future high rate colliders such as CERN's LHC since other detector solutions are more expensive and require more intervening material.



Johnny Kleinfeller admires the upgrade at the KARMEN Karlsruhe-Rutherford Medium Energy Neutrino Experiment at the Rutherford Appleton Laboratory's ISIS spallation source.

Electron-pion discrimination for E799 at Fermilab. The likelihood distributions for pions and for electrons from kaon decays into three electrons with track momenta below 10 GeV. Pion rejection is better than 100:1 at 90% electron efficiency.



KARLSRUHE/ RUTHERFORD-APPLETON KARMEN upgrade

The Karlsruhe-Rutherford Medium Energy Neutrino Experiment KARMEN at the Rutherford Appleton Laboratory's ISIS spallation source is currently installing a new large filter (veto counter) system of plastic scintillators to enhance its sensitivity in its search for oscillations between muon and electron type anti-neutrinos.

The benefit of the extensive detector upgrade will be a substantially reduced cosmic ray background. As a result, future measurements with the upgraded detector will allow a definite test of the positive evidence for neutrino oscillations reported by the LSND experiment at Los Alamos (June 1995, page 13).

The secondary positive pions produced when the 800 MeV proton bunches from ISIS slam into a beam stop constitute a pointlike source of prompt 30 MeV muon neutrinos, while a subsequent pulse of electron neutrinos and muon antineutrinos with well defined energies up to 53 MeV comes from the subsequent muon decays.

These short but intense bursts of ISIS particles are especially suited for a high sensitivity search for oscillations. KARMEN's 60-tonne high resolution liquid scintillator calorimeter looks simultaneously for neutrino oscillations in two appearance modes, and at the same time investigates neutrino-induced excitations of carbon-12 with spectroscopic quality (December 1993, page 23).

The search for neutrino oscillations with KARMEN focuses on detecting transitions between muon antineutrinos and electron antineutrinos. The 'fingerprint' of this oscillation would be the detection of the characteristic inverse beta-decay produced by electron antineutrinos on free protons of the liquid scintillator. These would be identified through a spatially correlated delayed coincidence between a resultant positron with energies up to 50 MeV in the neutrino time window followed by a low-energy neutron capture.

A thorough analysis of the data obtained over five years of continuous data-taking shows no net excess of such a signature. Hence there is no evidence for oscillations of muon antineutrinos to electron antineutrinos, in clear contradiction to the LSND result (October, page 6). However KARMEN's present oscillation sensitivity does not exclude the entire range of oscillations suggested by the LSND experiment .

KARMEN's oscillation sensitivity has been limited by a small (0.2 events per day) of neutral background. Detailed simulations show that this background comes from high energy neutrons produced by cosmic ray muons interacting in the massive iron shielding surrounding the detector.

These neutrons can penetrate deep into the scintillator without being vetoed by the existing anticounters. They can mimic an oscillation signal through recoil protons or nuclear excitations in the sensitive volume of the detector before finally being captured.

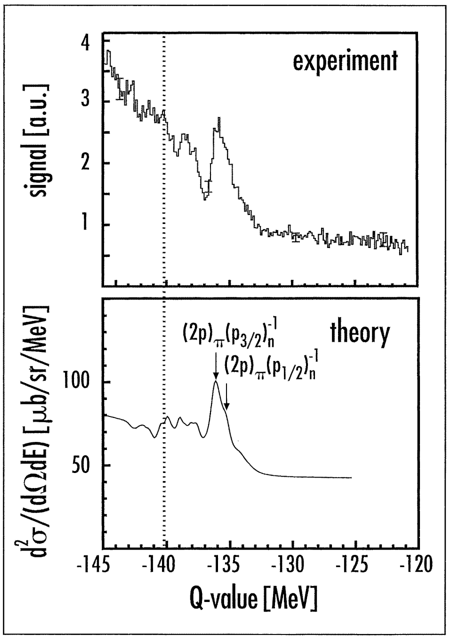
The elimination of this background requires the detection of the primary muon by a layer of plastic scintillator embedded inside the 2 m thick walls and the 3 m thick roof of the massive iron shielding. In January 1996 the KARMEN upgrade began with the almost complete dismantling of the experiment's massive 7000 tonne iron shielding blockhouse. In parallel, production began of 136 scintillator modules with 1100 two-inch phototubes for signal readout. Individual scintillator modules have a width of 0.65 m, a thickness of 50 mm, and a length of 3.15, 3.75 or 4.0 m. Each module is read out by four phototubes on either end.

The detector upgrade was complete by the end of October with the complete reinstallation of the massive iron shielding. The following two years of measurements with significantly reduced background levels (expected factor is 40) will allow KARMEN to probe neutrino oscillation at the 10^{-3} level, covering thoroughly the parameter range favoured by the LSND results.

KARMEN thus becomes the only neutrino experiment with the capability either to verify or exclude in the near future the claim of evidence for oscillations between muon- and electron-type antineutrinos.

GSI DARMSTADT
Deeply bound pions in lead

Pionic atoms, in which the orbital electrons of ordinary atoms are replaced by pions which move close to, and even penetrate, the nucleus provide a window on nuclear forces. Above, experimental spectrum from GSI Darmstadt for the production of helium 3 nuclei by 600 MeV deuterons on lead 208, with the helium nuclei intensities plotted against Q (change in binding energy). The boundary between bound (right) and unbound (left) pionic states is shown by the dotted line, and the structure at -135 MeV comes from the population of a pionic state in lead 207. Below, the theoretically predicted spectrum



Virtual (bound) pions play an important role as a carrier of exchange forces between the nucleons in the atomic nucleus. Until now, however, very little was known about how real pions behave in the immediate vicinity and even in the interior of a nucleus. Do they retain their identity as particles, or are they immediately absorbed into the nucleus so that discrete pionic states are no longer observable? The experimental answers to these questions have long been sought by both particle and nuclear physicists.

These questions can be investigated using pionic atoms, where one or more of the orbital electrons is replaced by a negatively charged pion. A pion captured in the ground state of a lead atom with a nuclear charge of 82 spends up to 5 percent of its time inside the nucleus. The pion thus feels both the attractive electromagnetic force due to the high nuclear charge, and to the strongly repulsive pion-nucleus interaction. Caught between these two forces, the pion forms a halo-like state on the surface of the nucleus.

How could this type of system be prepared experimentally? The standard process for the production of pionic atoms is the capture of slow pions in outlying atomic states. The pion then de-excites to sequential lower-lying states, emitting an X-ray or Auger electron at each step. This method suffers from the difficulty that the characteristic times for the pion's transitions into the low-lying states, or even the ground state, are much longer than it takes for the pion to be absorbed in the nucleus.

In heavy atoms, in which the orbital radius of the pionic ground state and the nuclear radius are of the same order of magnitude, the lowest states are hidden from view. To find low-lying pionic states for such a heavy system, the pions must be brought to the corresponding state as directly as possible via a nuclear reaction.

A German-Japanese collaboration (GSI, TU München, Tokyo) accomplished this for the first time at the Fragment Separator at the GSI Laboratory, Darmstadt, in April. In an experiment suggested by Toshimitsu Yamazaki, a transfer reaction in which a deuteron produced a helium-3 nucleus was utilized to create and detect the low-lying states. To accomplish this, a deuteron beam from GSI's SIS accelerator with an energy of 600 MeV was directed onto a lead foil, and the energy of the helium-3 nuclei emitted in the forward direction measured using the Fragment Separator as a high-resolution magnet spectrometer. The bombarding energy of the deuteron beam was chosen so that the pions would preferentially populate a low-lying atomic (2p) state in lead-207.

But how is it possible to demonstrate the formation of these pionic states? The pionic reaction takes place at a neutron of the lead-208 nucleus, which, however, combines with the deuteron to form helium-3, while the pion created in the reaction remains bound to the lead-207 nucleus. In the case of this two-body reaction, the energy of the helium-3 nucleus supplies an exact picture of the energy of the bound system consisting of lead-207 and a pion. Low-lying states should thus be revealed as lines in the energy spectrum of the helium-3.

Such lines could actually be seen, their position and shape being in remarkably close agreement with the theoretically predicted spectrum[1]. The value for the binding energy of the pionic state obtained from the experimental data is 5.4 ± 0.2 MeV, with an upper limit of 0.8 MeV for the width.

The experiment has led to the first demonstration of discrete pionic states in close proximity to a heavy nucleus. This close proximity leads to a blurring of the distinction between atomic and nuclear state: the state formed can also be considered as an excited halo-type state of thallium-207, which despite the high excitation energy of around 140 MeV is only a few hundred keV wide.

Now that the existence of the low-lying pionic states has been demonstrated, a new field of high-resolution nuclear spectroscopy, with access to numerous questions relating to pion-nucleus interactions, opens up. As the pion is also within the nucleus for some of the time, it can also serve as a probe for studying the outer region of the nuclear density distribution.

Of particular interest is the connection to a completely different area of nuclear physics research - investigating the effects of the nuclear medium on the masses of strongly interacting particles. Extremely precise spectroscopic methods could help to resolve this question, even when the effective density of the medium lies below the normal nuclear density.

Reference
1 T. Yamazaki et al., Z. Physics A355, 219 (1996)

CERN
CMS muons

After several years of generic research and development into experimental techniques needed to exploit CERN's LHC proton collider, LHC experimental collaborations are now focusing their attention on preparing detector elements.

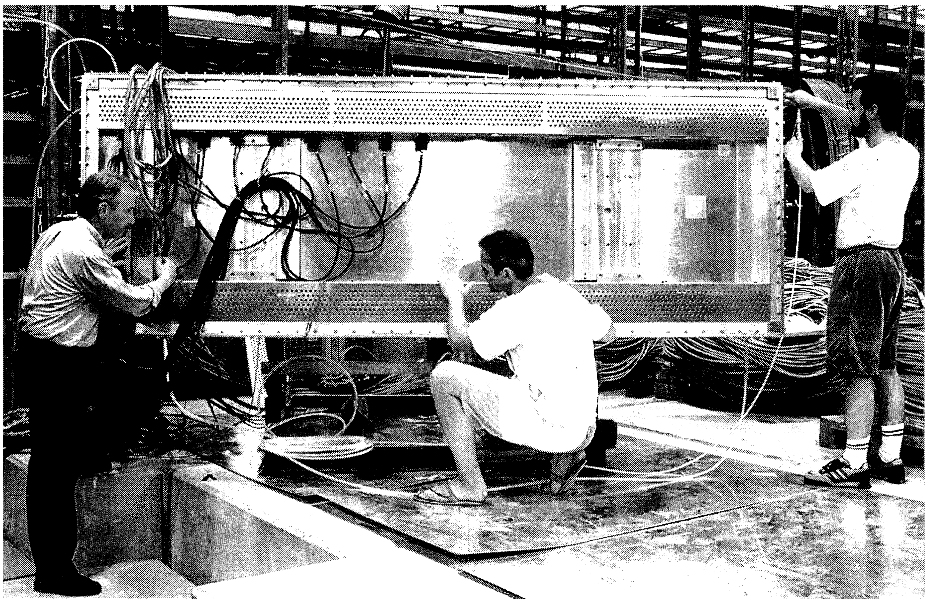
For the CMS detector (June 1995, page 5), optimizing the outermost layers - the muon detection system - was a natural starting point for the design, which has four muon 'stations' interleaved with the return yoke of the 4T superconducting magnet in the central 'barrel' of the detector, together with another four layers in each endcap.

Groups from Aachen, Bologna, Madrid, and Padova are responsible for the drift chambers of the Barrel Muon Detector, and have already tested several drift chamber prototypes of different sizes and arrangements in muon and hadron beams at CERN. So far the largest prototype was 3x1 m^2 and consisted of the full 12 layers of drift cells foreseen for the final detector.

The CMS configuration calls for a total of 240 drift chambers with 200,000 drift cells, complemented by a similar number of resistive plate chambers, to measure emerging muons in the barrel region. Each muon will cross up to four such drift chambers. In order to measure the small magnetic bending of high energy muons, their position will be measured with a precision of around 100 microns in each chamber.

Although extensive studies carried out up to now have produced encouraging results, one essential test remains. At the LHC, the muon chambers will have to cope with a

A prototype of the muon drift chambers for the CMS experiment, built at RWTH Aachen, placed in the H2 muon test beam at CERN last July.



sustained high rate of particles over their entire area. Presently there is no beam at CERN which can simulate this environment, and the installation of a suitable test facility has recently been approved. This "muon test facility" will be available in spring 1997.

COSMIC RAYS
Auger project site

On 13 September, at a meeting in San Rafael, Argentina, scientists of the Pierre Auger Project, whose goal is to discover the source of very high-energy cosmic rays, announced their choice of Millard County, Utah, as the project's northern-hemisphere observatory.

At the Utah site, the 150-member collaboration will build a large detector array to observe the air showers from mysterious high-energy cosmic rays that zoom to earth from an unknown source in space. In November, 1995, the Auger Project chose a site near Mendoza, Argentina, to build a similar southern-hemisphere observatory.

High energy cosmic rays bombard the earth from all directions. These particles, usually protons, strike atmospheric air molecules, creating cascades of secondary particles, called air showers, first observed by the French physicist Pierre Auger in 1938.

Physicists can account for the low- and medium-energy cosmic rays, but the origin of the rare high-energy cosmic rays remains a mystery - one that Auger collaborators hope to solve.

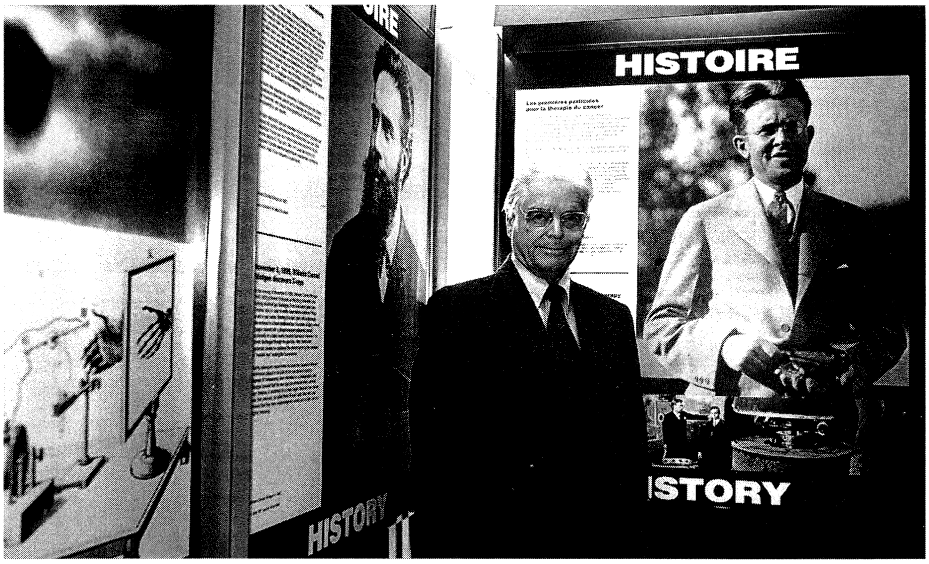
The Auger Project's two observatories will measure the nature, energy and direction of these high-energy cosmic rays - the most energetic particles in nature, with more than 100 million times the energy of particles produced by the most powerful particle accelerators on earth (January 1995, page 18).

Each Auger observatory will contain 1,600 detectors, 12,000 litre water tanks spaced 1.5 kilometres apart. An optical fluorescence or "fly's eye" detector will sit at the centre of each array. The project hopes to begin cosmic ray observations early in the next century.

Collaborators estimate the cost of constructing the observatories at approximately $100 million. Funding for the project comes from UNESCO and science agencies of the participating nations, which include Argentina, Armenia, Australia, Bolivia, Brazil, Chile, China, France, Georgia, Germany, Greece, Japan, Mexico, Russia, Slovenia, Spain, the UK, the US, and Vietnam.

Physics monitor

Protontherapy pioneer and Fermilab founder Robert Wilson was guest of honour at the recent International Symposium on Hadrontherapy at CERN. It was in 1946 - exactly half a century ago, that Wilson wrote his landmark paper pointing out the possibilities of using protons for therapy.



Hadrons for health

A recent conference at CERN refocused attention on the use of particle beams for therapy.

With money hard to come by in the economic depression of the 1930s, Ernest Lawrence at Berkeley had to cast his net wide to obtain backing for his new invention - the cyclotron. It was medical applications which provided a driving force for the development of these early particle accelerators.

The use of naturally radioactivity substances such as radium for cancer therapy had long been realized. In 1934, following the discovery of artificial radioactivity by Irène and Frédéric Joliot, Lawrence saw how these unstable nuclei could be used as synthetic radiation sources in medicine or as tracers in biological research, a technique invented by the Hungarian physicist George de Hevesy at Rutherford's laboratory in Cambridge. Lawrence's proposal brought in welcome money from the Rockefeller and Macy Foundations.

The following year, with the help of his brother John, a physician, Lawrence looked at the possibility of using high energy radiation - particle beams from the cyclotrons - rather than the artificial isotopes. While this brought more powerful beams and better therapy, the radiation source could no longer come to the patient - instead the patient had to go to the source.

With Harvard offering Lawrence a job, the University of California was able to obtain fresh funds for a new medical accelerator, and induce Lawrence to stay on the West Coast. In 1938 Lawrence's mother was the first cancer patient to be successfully treated with neutrons, derived from a cyclotron beam.

In Europe, Enrico Fermi in Rome, after discovering the high yield of radioactive substances produced by slow neutrons, had also seen the potential of particle beams for therapy, and a new Istituto Superiore di Sanità, set up to provide the necessary support, built the first MeV Cockcroft-Walton accelerator and has remained a traditional centre of particle and nuclear physics expertise in Italy.

The discovery of nuclear fission and the Second World War diverted physicists' attention. As researchers picked up the threads of their peacetime activities, at Harvard in 1946 Robert Wilson wrote a landmark paper pointing out the possibilities of using protons for therapy. Rather than 'wandering' around, like neutrons, protons penetrate tissue and eventually deposit a high energy density in a small region, the famous 'Bragg peak'. If this peak can be made to coincide with the tumour, then the beams provide a precision scalpel.

Before leaving for a new career at Cornell, Wilson began a programme of protontherapy at Harvard in collaboration with Massachusetts General hospital. In Europe, proton beams of 185 MeV from the synchrocyclotron at Uppsala's Gustaf Werner Institute were used to combat cancer in the 1960s.

From Cornell, protontherapy pioneer Wilson went on to found the new Fermi National Accelerator Laboratory, which has its own therapy unit. Fermilab collaborated with Loma Linda Hospital in California for the construction of a successful dedicated protontherapy unit.

As well as protons, other heavy particle beams too can be useful, and programmes using beams of pion have been carried out at Los Alamos in the US, at the Canadian TRIUMF Laboratory in Vancouver and at the Swiss Paul Scherrer Institute in Villigen.

However beams of heavier nuclei pack a stronger punch and are more effective than protons in sheer cell-destroying power. With the availability of such beams at Berkeley from the late 1950s, California scientists began a new therapy programme, work which came to an end when Berkeley's accelerator was decommissioned in 1993.

In 1995, the purpose-built Heavy Ion Medical ACcelerator (HIMAC) began providing beams for therapy at Japan's National Institute of Radiological Sciences (NIRS), in Chiba, near Tokyo. More recently this has been joined by a new venture based at Darmstadt's GSI Laboratory (January, page 16).

In Italy and for Europe, a Hadrontherapy Collaboration masterminded by Ugo Amaldi of CERN, initiated in 1991, aims to refoster interest in these schemes and revive the illustrious tradition of Enrico Fermi. The TERA Foundation provides the administrative infrastructure and pushes for funds.

Design work began in 1992 and a first study published in 1994 for a new therapy centre to be built in Milan using a synchrotron to take protons to at least 250 MeV and carbon ions to 375 MeV per nucleon.

Another design study caters for the needs of TOP (Terapia Oncologica con Protoni) for Rome's Istituto Superiore di Sanità, which now has funds to build a novel high frequency (3 GHz) proton linac as a prototype for future hospital-based centres.

The design of such machines demands accelerator expertise under project leader Philip Bryant, and specialists from CERN, from GSI, from the Austrian AUSTRON project and from TERA collaborate in ongoing design work, paralleling Fermilab's 'godfather' role for the Loma Linda centre.

These projects and the specialized design work for them, as well as medical research in general, are highlighted at a new series of International Symposia on Hadrontherapy, the first of which was organized by the TERA Foundation and held in Como, Italy, in October 1993. The second, held at CERN from 12-13 September, coincided with the 50th anniversary of Wilson's milestone paper which first proposed the idea of using protons to treat cancer. Because high energy proton beams were a dream in those days, guest of honour Wilson said the idea went down initially 'like a lead balloon'.

As well as particle beams, many other aspects of modern physics benefit medical and biological research. The genealogy of detectors opened by Georges Charpak's development of the multiwire chamber provide the imaging complement to new methods of scanning. Thanks to the World Wide Web, pioneered at CERN, the internet is now the medium of choice to disseminate research findings, assisted by powerful computers, as new genomes are mapped in detail.

But with 50 years separating the Wilson paper and developments which are still blazing an initial trail, delegates at the CERN meeting rued the slow rate of progress and spoke of half a century as a 'Wilson unit'. For his part, the hadrontherapy pioneer urged his successors to 'make the idea work'.

A European travelling 'Hadrons for Health' exhibition produced by CERN in collaboration with GSI Darmstadt and the TERA Foundation and organized by Werner Kienzle and Alessandro Pascolini is also passing the message.

LEAP LEAR

In physics, LEAP (conference on Low Energy Antiproton Physics) is a biennial event, so that a LEAP year is not necessarily a leap year.

The 1996 LEAP was made this summer in Dinkelsbühl, a small medieval town in the heart of Germany, and was attended by scientists whose research focuses mainly on CERN's LEAR low energy antiproton ring. The meeting was especially significant in that it was the last such meeting to be held while LEAR was still in operation. With the decision to close the facility, the research community looks forward to the proposed AD antiproton project (November 1995, page 6) and subsequent developments.

One highlight was high precision spectroscopy using high power lasers on antiprotonic atoms (December 1994, page 16). This experiment at LEAR investigated highly excited atomic levels of antiprotons bound to helium-4 nuclei. These live as long as several microseconds and can be regarded as short-term storage for antimatter. Hyperfine splitting provides a test of quantum electrodynamics at the part per million level (if any further assurance is still required) and exhibits the sophistication of three-body calculations. Further experiments at the AD would provide a precision measurement of the magnetic moment, and possibly the quadrupole moment, of the antiproton.

Light meson spectroscopy has benefited considerably from the Crystal Barrel, Obelix and Jetset studies at LEAR. This is particularly evident in the mass range 1400 - 2200 MeV and for zero spin, positive

High precision spectroscopy using high power lasers on antiprotonic atoms has been a highlight of the experimental programme at CERN's LEAR low energy antiproton ring. These atoms live as long as several microseconds and can be regarded as short-term storage for antimatter.

parity states. New candidates have been found for members of this meson nonet, replacing the insecure f_0(975) and a_0(980).

In addition, Crystal Barrel has found a state at 1520 MeV which cannot be accommodated in this nonet. With six different decay modes known, this is the leading candidate for the long awaited lightest 'glueball' - a particle made of gluons but no quarks. However it probably mixes with nearby quark-antiquark states.

Spin zero, negative parity, and spin two, positive parity glueball states could also show up at LEAR. Preliminary signals have been seen, but the analysis is incomplete. For hybrids (states containing quarks and gluons) signals have been seen at Brookhaven (1320 MeV) and LEAR (1900 MeV) but need further analysis. Other multi-quark states might also be there, and final analysis of the LEAR data should clarify the picture.

The CPLEAR experiment (whose contributions will be described in more detail in a forthcoming issue) measures additional parameters of the mysterious CP-violation process seen with neutral kaons. Measurements on neutral kaon masses provided new precision, adding to the knowledge of CP-violation and the accompanying violation of time symmetry (in the neutral kaon sector, future and past are not interchangeable as in other branches of physics).

LEAR experiments on exact symmetry tests using 'trapped' antiprotons were very successful, comparing the proton and antiproton mass to one part in a billion. Following the discovery of anti-hydrogen at LEAR (March, page 1), a goal is look at the spectroscopy of antihydrogen and its behaviour under gravity.

The LEAP community regretted the disappearance of LEAR at the summit of its achievement and hoped this will not be the end of antiprotons at CERN.

Norway

Continuing its survey of particle physics activities in its member states, the European Committee for Future Accelerators (ECFA) met in Norway in September at the University of Oslo. Introducing the meeting, E. Osnes of Oslo reviewed the Norwegian university system, while L. Hambro described how the new Norwegian Research Council (NFR) funds research.

The main examples of current Norwegian involvement are the Delphi experiment at the LEP electron-positron collider and the heavy ion programme using the Omega detector: work at the LEAR low energy antiproton ring and the ISOLDE on-line isotope separator is being wound down. The future spearhead will be effort for the Atlas and Alice detectors at CERN's future LHC proton collider. During the meeting there was also discussion about possible participation in the BaBar experiment at SLAC, Stanford (September 1995, page 16) and HERA-B at DESY (June 1995, page 20), which could provide a useful research focus during the leadup to the LHC.

Norwegian participation in Delphi has centred on the SAT Small Angle Tagger and the microvertex detector. On the analysis side, work covers mainly luminosity monitoring, line shape analysis and the physics of heavy flavours (B-mesons and taus). For Atlas, the main effort is on silicon sensors and the related electronics (inner detector and microstrips) in collaboration with high technology specialists such as the national SINTEF/SI research organization, and IDE, founded by a former CERN fellow and whose present staff of 13

At its September meeting at the University of Oslo, the European Committee for Future Accelerators (ECFA) L. Hambro (left) explained how the new Norwegian Research Council (NFR) funds research. On his left is ECFA Chairman Enrique Fernandez of Barcelona.

includes 4 former CERN fellows.

PhD students who favour analysis are steered towards Delphi, while those with hardware ambitions are oriented towards Atlas. Despite keen awareness of what is needed, there is not enough funding for graduate students and far too few postdoc positions. More of the latter would be useful in opening Norwegian research to the outside world, allowing visitors from overseas to work alongside their Norwegian colleagues. After a period of serious questioning in 1995, LHC detector funding from the NFR has yet to be resolved.

Norway was one of the founding CERN member states, and with meagre national particle physics resources, has always relied on CERN, participating fully in all aspects of the Laboratory's programme - experiment, theory, and significantly, technology. A Norwegian, Odd Dahl, played a vital role in shaping the plans for CERN's first synchrotron, ensuring its future success, while one of his colleagues, Kjell Johnsen, went on to lead the Intersecting Storage Rings (ISR) project.

There are currently 100 Norwegian experimentalists whose research relies on data from CERN. However the research technical support is only seven strong. Oslo and Bergen are the main research centres, while Trondheim, formerly only a theory centre, is now working in cryogenics for the Atlas detector at CERN's future LHC proton collider.

Work continues on several detector research and development projects, in particular the SCI (Scalable Coherent Interface) data acquisition collaboration including the Oslo/Dolphin group.

Some 15 theorists in Bergen, Olso and Trondheim are active in CERN-related work. On the theoretical side, Norway also benefits from the long-standing collaboration at the Nordita Nordic theoretical centre in Copenhagen.

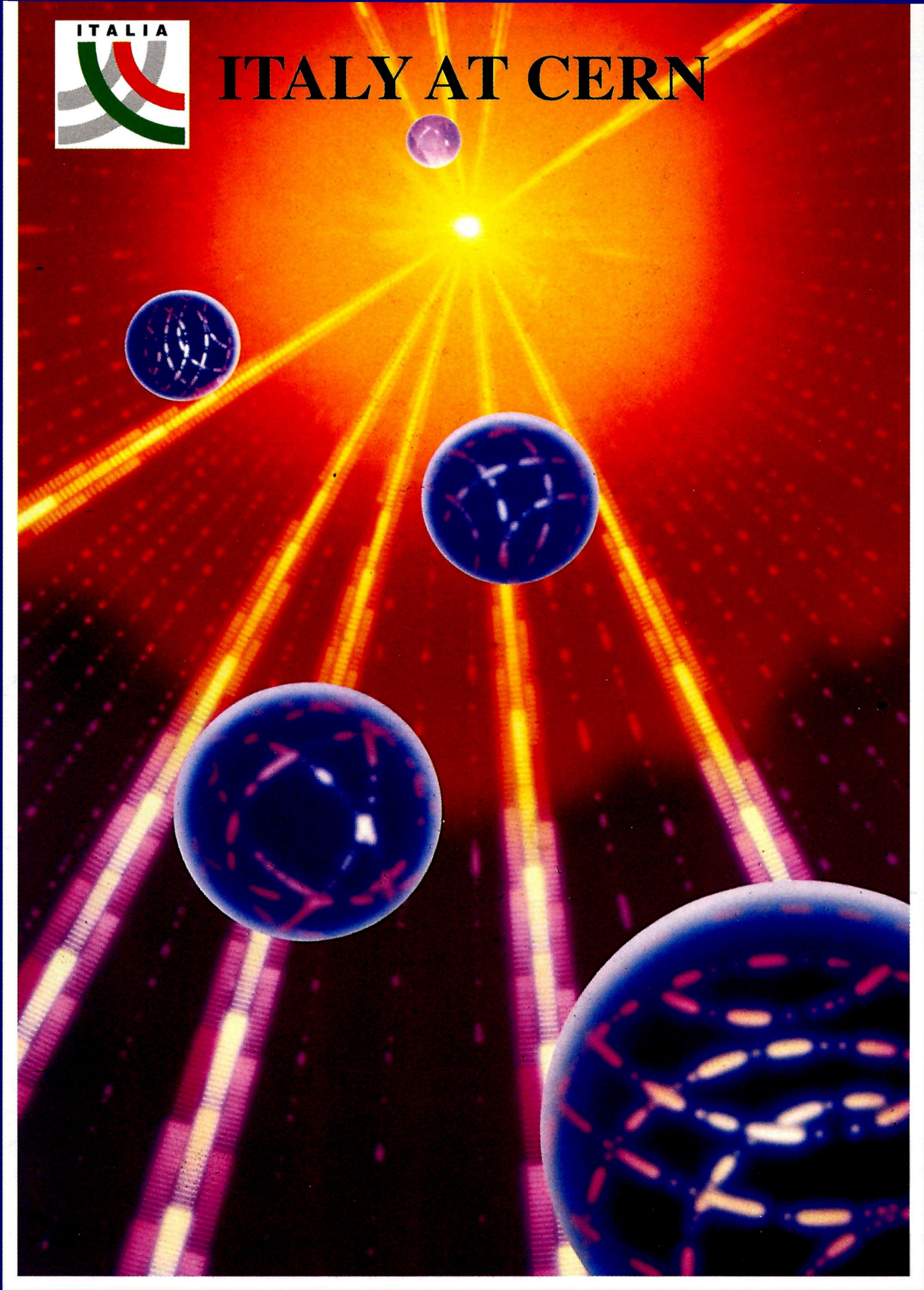
Funding for particle physics research, previously channeled through one of the Research Council for Science and the Humanities (NAVF) and managed through the CERN-Norway committee, now depends on the NFR. This national executive and advisory body for research policy follows guidelines set up by the Government and the National Assembly. Particle physics falls under the Science and Technology Board. The Programme Board for Nuclear and Particle Physics, which reports to the NFR, is chaired by Egil Lillestøl of CERN and Bergen.

Norway's CERN contribution (14 million Swiss francs in 1996) is paid by the Ministry of Education, Research and Church Affairs, which also supports the universities. Annual particle physics funding through the NFR runs to 1.4 million Swiss francs.

Always very conscious of its commitment to CERN, Norway established a committee to promote and monitor CERN's activities. This CERN Norway Committee initially continued to exist within the NFR, but was replaced in 1994 by the new KjernPar - the Committee for Nuclear and Particle Physics - to distribute NFR funds and to promote Norwegian industrial exploitation of CERN.

Norwegian industry has benefited considerably from work for CERN,

Norwegian discussions. Left to right, Bergen theorist Per Osland, Oslo theorist Hallstein Høgassen and DESY Director Bjorn Wiik (who is Norwegian).



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Bookshelf

and, discounting the host states of France and Switzerland, for a long time has been one of the leading CERN Member States in terms of industrial return (expressed as a fraction of the nation's CERN contribution), although this return factor has dropped in recent years. However Norwegian industry understands well that the technology transfer value of CERN business far exceeds its face value.

Paradoxically, Norway's industrial liaison with CERN began in Sweden, where in 1967 Norwegian engineer Carl Rønnevig was invited by the Swedish authorities develop industrial contacts with CERN. After some success Mr. Rønnevig returned to Norway to start his own successful business but since 1980 has managed to combine this with the responsibility of being Norway's Industrial Liaison Officer for CERN.

In the 1980s, computer manufacturer Norsk Data had valuable CERN contracts. Significant contracts were also obtained for telecommunications and cabling. More recently semiconductor detector work has involved the University of Oslo, the national SINTEF/SI research organization, Dolphin and AME.

Norway's share of CERN business has dropped, but this has not gone unnoticed. A recent report 'Industry Liaison Models between International Laboratories and Norwegian Industry and R&D - Case study: CERN' by Tom. Ø. Kleppestø of the Norwegian Foundation for Research in Economics and Business Administration looks into the history of Norway's industrial links with CERN and explores some future possibilities.

Stars as Laboratories for Fundamental Physics, by Georg G. Raffelt, published by University of Chicago Press, ISBN 0 226 70271 5 (hbk price $77) 0 226 70273 3 (pbk)

Ever since Roemer, in 1675, analysed the timing of the occultations of the satellites of Jupiter to conclude that the speed of light is not infinite, fundamental physics has found in astronomy, astrophysics and cosmology not only inspiration, but also concrete answers to fundamental questions. As the title of this book reflects, the trend continues to this day.

This thick volume of some 650 pages is authored by a leading expert on the field. It thoroughly covers what stars have to tell us about some particles that do exist (neutrinos) and others whose existence is quite defensible (axions). It contains a mercifully brief chapter on "Miscellaneous Exotica", but no more than one paragraph on the emission of gravitational waves by the binary pulsar PS 1913 + 16.

Some subjects, such as the clash between observed and expected solar neutrino fluxes, do not have clear-cut resolutions at the moment; their presentation requires a pinch of opinion. In this, the author shows very good taste, in the usual sense (that is, more often than not, his judgements agree with those of the reviewer).

The list of references is quite exhaustive, often reflecting more of a collector's spirit than a potentially more useful thorough sifting. The style is clear, making the book an easy consulting tool, and a must for any scientific library or serious practitioner of the field.

Alvaro De Rùjula

History of Original Ideas and Basic Discoveries in Particle Physics, Harvey B. Newman and Thomas Ypsilantis (eds), NATO Advanced Study Institute Series, Plenum Press, ISBN 0 306 45217 0 ($195)

Now available are the proceedings of the International Conference on the History of Original Ideas and Basic Discoveries in Particle Physics, held at the Ettore Majorana Centre for Scientific Culture, Erice, Sicily from 27 July - 4 August 1994. (Christine Sutton of Oxford reported on the meeting for the CERN Courier - December 1994, page 11.) This is a fascinating collection of personal recollections of milestone physics discoveries, particularly for some of the more recent developments which have yet to make science history books: Murray Gell-Mann on how to be innovative; Steven Weinberg on electroweak unification; Gerard 't Hooft on Gauge Theory and Renormalization; David Gross on Asymptotic Freedom, Confinement and QCD; Martin Perl on the Tau Lepton; and Sheldon Glashow on Quark Families and Flavour, to name but a few of the book's 49 chapters. A mine of useful information.

The SSC Low Energy Booster, edited by H.-Ulrich Wienands, IEEE Press, Piscataway, NJ, ISBN 0 7803 1164 7 ($149.95)

When the US Superconducting Supercollider, SSC, being built at Ellis County, Texas, was abruptly cancelled in October 1993, design and prototyping of the Low Energy

People and things

Booster (LEB) were well advanced. This 570-metre circumference synchrotron would have taken 600 MeV protons from the injector linac to 11.1 GeV for injection into the next machine in the chain, the Medium Energy Booster. The design and prototyping work achieved is fully documented, and could be useful. (Two injector synchrotrons were originally planned for the SSC, but the large acceleration steps in this sequence subsequently led the design to be modified to include three booster synchrotrons - the 540 m-circumference Low Energy Booster taking 600 MeV protons from the injector linac to 11 GeV to feed a 3.96 kilometre-circumference Medium Energy Booster and take the particles to 200 GeV for a 10.69 kilometre High Energy Booster to inject into the 87-kilometre main ring at 2000 GeV.)

Books received

Spectrométrie de masse, Principes et Applications, (2 édition), Emilia Constantin, Lavoisier Tec & Doc, Paris (In French) ISBN 2 7430 0084 8

CERN Council President

From 1 January 1997, Luciano Maiani of Rome becomes President of CERN's governing body, Council, succeeding Hubert Curien. A distinguished theoretician (the 1970 Glashow-Iliopoulos-Maiani model showed how electroweak synthesis could be extended to a world of four quarks), he has also been President of the Istituto Nazionale di Fisica Nucleare since 1993.

Joël Feltesse becomes director of DAPNIA, Saclay

Joël Feltesse, formerly spokesman of the H1 experiment at DESY, Hamburg, is now director of DAPNIA (department of astrophysics, particle physics, and associated instrumentation) at Saclay (French Atomic Energy Commission). He succeeds Jacques Haïssinski, who created a new synergy between the diverse DAPNIA components.

Joël Feltesse has dedicated the major part of his career to the exploration of nucleon constituents. After initial research on baryonic resonances at Saturne (Saclay), for many years he has been a prominent member of the NA4 team studying nucleon structure at CERN. In 1985, together with his colleagues at DESY, he laid the foundations of the large H1 experiment at HERA dedicated to the exploration of the proton.

He now manages a huge department comprising not only particle physics (in particular experiments at CERN) but also space experiments (satellites), ground astrophysics experiments, nuclear physics (GANIL and CEBAF/Jefferson in particular). As part of the experiments at CERN under his management, the departments of particle physics and associated instrumentation are considerably involved in the magnets for CERN's LHC, the big toroid and solenoid

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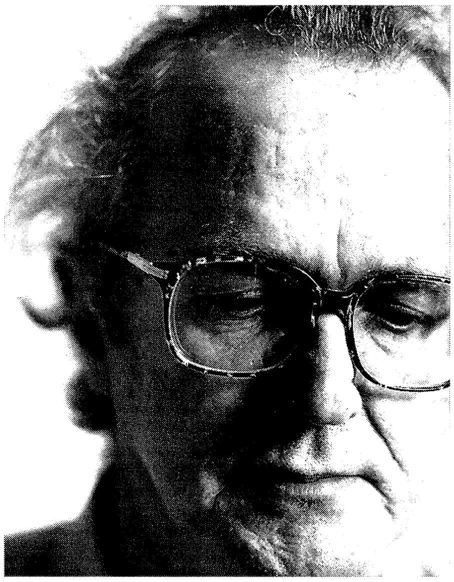


Joël Feltesse, the new director of DAPNIA, Saclay (Photo Luc Perenom) magnets of the ATLAS and CMS experiments, to the construction and maintenance of the detectors, and to data analysis.

On people

Hans Hofer of ETH Zurich, a prominent member of the L3 experiment at CERN's LEP electron-positron collider, has been awarded the prestigious and rarely awarded 'Friendship Award' of the State Council of the People's Republic of China for his contributions to promote science in China. The award is in recognition of his many years of work in promoting scientific exchange, technology transfer and student exchanges.

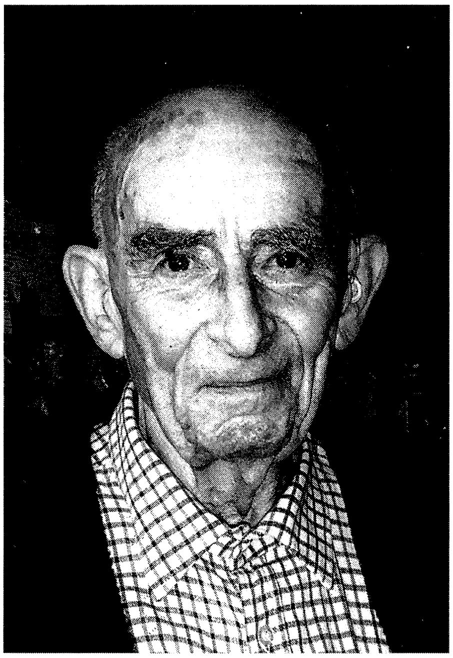
Jan Madsen retires

Retiring from CERN after 34 years, Jan Madsen has had a major influence on the operation and control of the Laboratory's accelerators. Arriving in December 1962 with considerable experience in the operation of high-flux reactors in the Netherlands, he was one of the very first engineers in charge of PS operation. As early as 1965 he undertook responsibility for the "Controls" group, covering not only control and operation but also beam instrumentation, radiation safety, communications, experiment targets and the electronic workshops. PS operation developed considerably under his management to embrace beam extraction to external targets and injection into the ISR. From 1974 he took a leading part in the "cultural revolution" involving computerized accelerator control necessitated by both technological developments and the additional performance needed to turn the PS into an injector for the SPS. At the beginning of the 80s he accepted a fresh challenge by undertaking responsibility for the LEP Pre-Injector (LPI), which he ran successfully from the design stage until the first beam injections into LEP and in close collaboration with the Linear Accelerator Laboratory (LAL) near Paris. In 1988 he turned to technological developments for future accelerators, becoming co-ordinator of the Compact Linear lepton Collider (CLIC) test facility, achieving record levels in r.f. power generation and high accelerating fields.

Rolf Wideröe 1902-96

Accelerator pioneer Rolf Wideröe died in October at the age of 94. Born in Oslo, he initially studied electrical engineering in Karlsruhe, Germany, where he became fascinated by the idea of accelerating electrons. Moving to Aachen, his initial idea for a 'beam transformer', in which a circulating beam of electrons acted as a secondary winding, could at first not be made to work, and he turned instead to linear accelerators, in 1927 successfully demonstrating an idea proposed in 1924 by Gustaf Ising in Sweden. This device, with a potential of 25 kV, accelerated ions to 50 keV in what came to be known as a drift tube, or Wideröe tank, and earned Wideröe his doctorate. Ernest Lawrence acknowledged that Wideröe's written report of these developments influenced Lawrence's invention of the cyclotron, while after attention from Donald Kerst and Robert Serber the earlier beam transformer idea emerged as the betatron.

Accelerator pioneer Rolf Wideröe 1902-96 (Photo P. Waloschek)



Wideröe subsequently moved into industry, where he became involved in the construction of power supply and radiofrequency equipment as well as betatrons, and in 1943 submitted a patent for a 'Kernmühle', now better known as a storage ring collider. One of his collaborators during this time was Bruno Touschek, who went on to pioneer electron-positron colliders. After the war Wideröe joined the Swiss Brown Boveri concern, becoming Head of their Radiation Laboratory and working on betatrons. From 1953-72 he was also a professor at ETH Zurich. As one of the world authorities on accelerators, in the early 1950s he was a consultant during the design of CERN's first proton synchrotron, and participated in the famous August 1952 meeting at Brookhaven which led to the development of strong focusing. Subsequently he acted as a consultant for the DESY electron synchrotron and supervised a 100 MeV electron synchrotron for Turin.

Although Wideröe was for most of his life outside the mainstream of particle accelerators, his prolific ideas were a strong influence on the field. As a Norwegian, he contributed to that nation's illustrious tradition in particle accelerators. As well as US figures of Norwegian extraction (Lawrence, Tuve and Hafstad), in Europe Odd Dahl, Rolf Wideröe, Kjell Johnsen, and in more recent years, Björn Wiik have been prominent in the field.

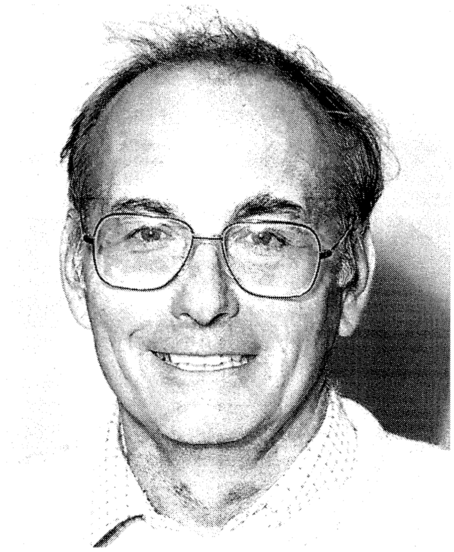
John Storrow 1943-1996

John Storrow, a well-known and much loved figure in British particle physics and beyond, died on 5 September. Ill for some time, he appeared to be successfully recovering from an operation to remove a tumour when he died of a pulmonary embolism.

His significant contributions to particle phenomenology began with his 1968 Cambridge thesis on Photons in S-matrix theory, followed by two years in CERN's Theory Division working mainly on applications of duality and the Veneziano model to strange particles. Subsequently he moved to Daresbury and in 1974 to Manchester, where he spent the rest of his career.

His irrepressible sense of humour and generosity of spirit made him a very effective teacher at all levels and he was justly proud of his fifteen graduate students. His contributions to the understanding of pion photoproduction and baryon exchange processes were particularly important. More recently, he played a leading part in the revival of interest in the structure of the photon and its role in interpreting HERA data. He was an enthusiastic and effective advocate of two-photon physics at LEP, and was eagerly anticipating the realization of his hopes at LEP2.

John Storrow 1943-1996



Belgrade international scientific centre

This summer in Belgrade, Yugoslavia, seven Yugoslav and one Bulgarian scientific and medical institutions founded the TESLA Scientific Centre (TSC) - a regional centre for fundamental and applied research in physics, chemistry, biology, materials science, nuclear medicine, and radiology.

The principal facility of TSC is the TESLA Accelerator Installation - an ion accelerator facility consisting of a compact isochronous cyclotron, an electron cyclotron resonance heavy ion source, a volume light ion source, and a number of experimental channels. The construction of this facility has been going on in the VINCA Institute of NUclear Sciences, in Belgrade. The first experiments with the ion beams generated within the facility are planned for 1997.

TSC is organized as an association of institutions from the southeastern region of Europe interested in the use and development of the TESLA Accelerator Installation. Its task is also to provide the additional education for talented young scientists, engineers, and physicians in a number of new and modern disciplines within the above mentioned fields. More on the TESLA Scientific Center can be found under: http://VINCY.BG.AC.YU

Contact P.R. Adzic VINCA Institute of Nuclear Sciences, Laboratory of Physics (010), P.O. Box 522, 11001 Belgrade, Yugoslavia. Phone: (381)(11) 446-2227, Fax: (381)(11) 446-2226 E-mail: adzic@vxcern.cern.ch

Physics in Collision

The 17th International Conference on Physics in Collision will be held from 25 - June 27 at Bristol University, UK. These annual international meetings consist of three days of exclusively review talks, given by invited speakers, and provide an overview of the main topics of high energy physics. The web page for the conference, which includes an e-mail facility, is at http://gaia.phy.bris.ac.uk/pic97/ e-mail may also be sent to: PIC-97@mail.phy.bris.ac.uk

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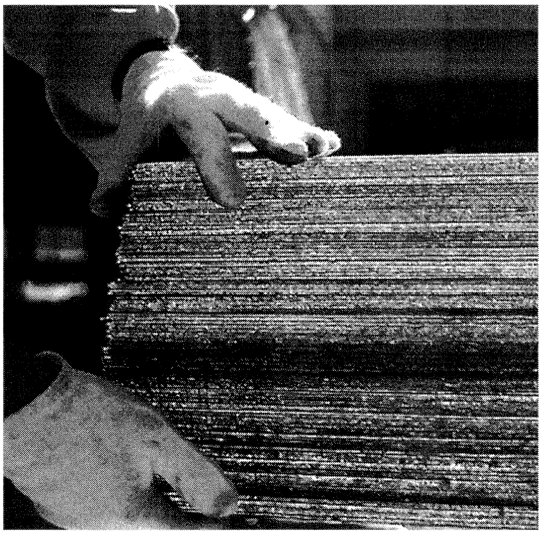

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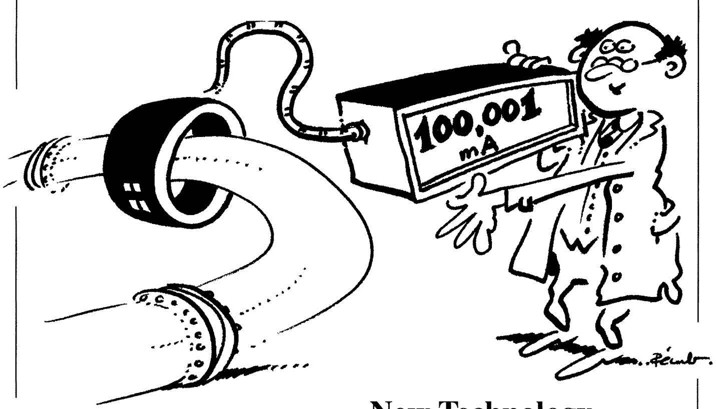

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Late News: On 19 October, CERN's LEP electron-positron collider attained a new high energy of 86 GeV per beam.

Distinguished company. Former members of CERN's Scientific Policy Committee were invited to the Laboratory on 23 September. Left to right, standing: G. Stafford, H. Schopper, G. Salvini, R. Dalitz, V. Telegdi, C. Jarlskog, D. Perkins, L. Leprince-Ringuet, M. Veltman, I. Mannelli, A. Skrinsky, G. Morpurgo, I. Bergström, G. Ekspong; seated: P.G. Hansen, M. Davier. G Kalmus, L. Foà, G. Flügge.

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Helium-3

The 1996 Physics Nobel is attributed to David Lee of Cornell, Douglas Osheroff of Stanford and Robert Richardson of Cornell for demonstrating that helium-3 can act as a superfluid. As described in the official Nobel announcement, this superfluidity has been exploited in experiments to simulate phase transitions which could have occurred in the wake of the Big Bang, and in which defects could have been the seeds for subsequent galaxy formation. The ideas behind this work were described in the June 1994 issue of the CERN Courier (p. 28).

Award for Jentschke

The John T. Tate Award of the American Institute of Physics recognizes distinguished service to physics by a foreign national and is awarded every few years. Willibald Jentschke, former Director General of the DESY Laboratory, Hamburg, and of CERN, is the eighth recipient, following Paul Rosebaud (1961), Harold W. Thompson (1966), Gilberto Bernardini (1972), Abdus Salam (1978), Pierre Aigrain (1981), Edoardo Amaldi (1989) and Roald Z. Sagdeev (1992). The award cites Jentschke's 'leadership in constructing DESY, building it into a truly international center, and integrating Germany into the world community of high energy and synchrotron radiation physics'. He also served as Director General of CERN from 1971-75. The award is being made by Hans Frauenfelder from Los Alamos on November 21 during a ceremony at DESY.

Siberian magnets for LHC

At CERN on 24 September, CERN Director General Chris Llewellyn Smith and Alexander Skrinsky, Director of the Budker Institute of Nuclear Physics, Novosibirsk, signed an undertaking under which Novosibirsk will supply magnets for some five kilometres of beamlines to link CERN's existing 7 kilometre SPS proton synchrotron and the new LHC proton collider to be built in CERN's 27-kilometre LEP tunnel. Through these beamlines, protons and eventually heavy ions from the SPS will be fed into the LHC.

The first detailed document to be signed in the framework of the recently signed CERN-Russia protocol (September, page 32), it covers some 360 6.3-metre dipole and 180 1.25-metre quadrupole magnets, together worth some 24 million Swiss francs.

This new mutual undertaking between CERN and Novosibirsk in such generally cost-conscious times displays well the spirit of partnership required to maintain a commitment to international scientific collaboration. The new agreement extends the tradition of CERN-Russian cooperation which dates back to 1960 and was one of the few contacts able to flourish in the depths of the Cold War.

As well as supplying these beamlines for the LHC machine itself, Novosibirsk is also a partner in the Atlas, CMS and Alice detectors.

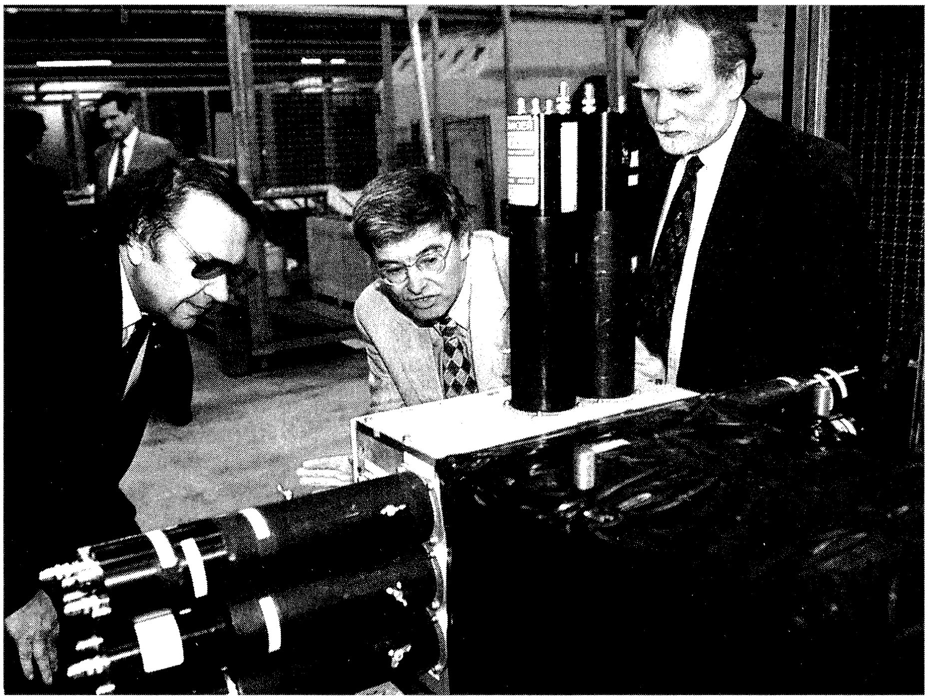
Siberia and global warming

Displayed on a map of the world, the Budker Institute of Nuclear Physics in Novosibirsk provides a convenient link in the network of high energy physics sites spanning the globe, bridging the wide geographical gap between the famous large institutes in West Russia and the research centres of Eastern Asia in Japan and Beijing.

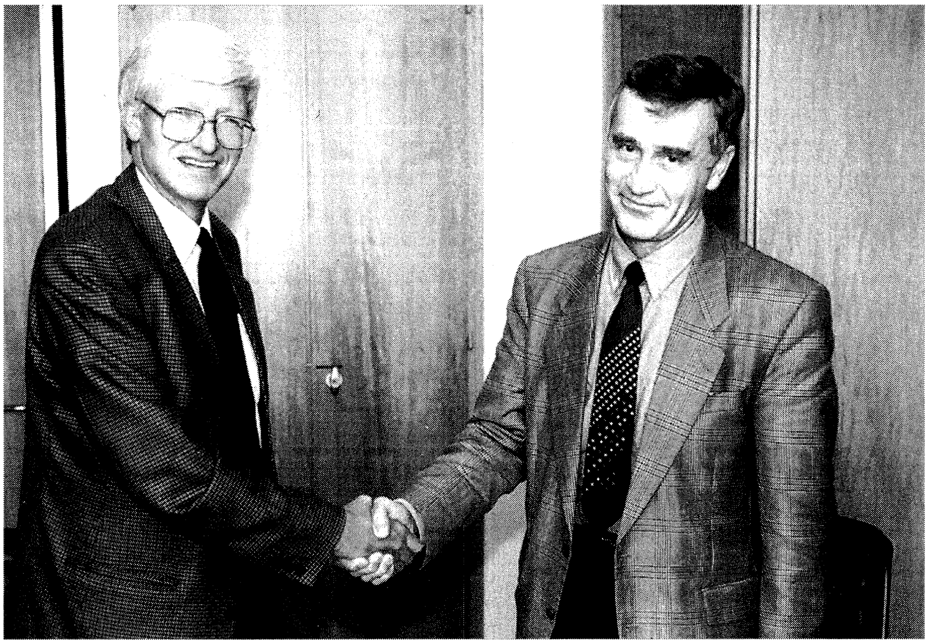
But the Budker Institute is now more than a remote stopover. With a tradition of supplying sophisticated instrumentation and specialized know-how all over the world, the Laboratory is now emerging as a major player on the world stage. Its wide-ranging in-house research programme is complemented by substantial involvement in new projects at CERN and at the Japanese KEK Laboratory, as well as several ongoing collaborations in the US and in Europe.

Novosibirsk is synonymous with accelerator innovation. Key Novosibirsk ideas - colliding beam machines, electron cooling, and polarized beams and their exploitation: 'Siberian Snakes' to control beam polarization, and the resonant depolarization technique for measuring beam energy to name but a few - have gone on to become standard laboratory practice throughout the world. This vigorous development programme continues, and there will certainly be more such inventions to come.

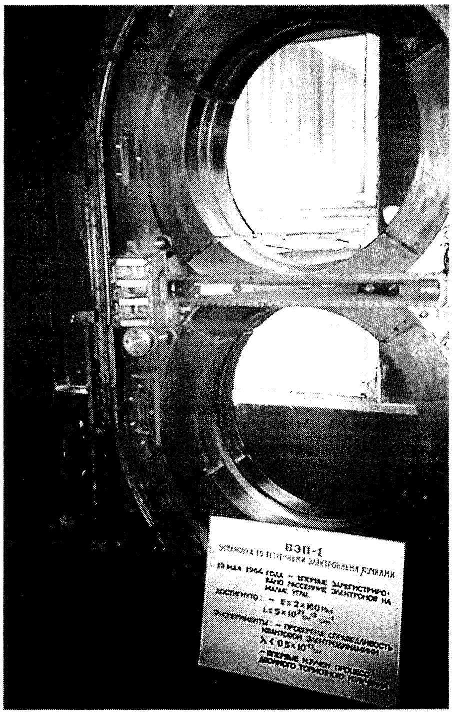
With the establishment of new research centres in Siberia during the Krushchev era, Andrei Mikhailovich Budker moved his Laboratory of New Accelerator Methods from Moscow's Kurchatov Institute to Novosibirsk, there to become a temple of machine development. Although Budker died in 1977, still in his fifties, his traditions and spirit are still alive at Novosibirsk under Budker's erstwhile pupil, Alexander Skrinsky, who has grown in stature through the years and now also serves as Head of the Nuclear Physics Department of the



Russian research centres are major partners in the effort for CERN's LHC proton-proton collider. Visiting CERN on 4-5 October was Russian Deputy Prime Minister and Chairman of the State Committee of Science and Technology Academician V. Fortov, seen here (left) with LHC CMS experiment spokesman Michel Della Negra (centre) and Vladimir Kadishevsky, Director General of the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, admiring radiation-resistant quartz fibre calorimetry for the CMS Very Forward Calorimeter.



CERN Director General Chris Llewellyn Smith (left) and Alexander Skrinsky, Director of the Budker Institute of Nuclear Physics, Novosibirsk, shake hands after signing an undertaking under which Novosibirsk will supply magnets for some five kilometres of beamlines to feed the new LHC proton collider to be built in CERN's 27-kilometre LEP tunnel.



One of Andrei Mikhailovitch Budker's first major projects at his new laboratory in Novosibirsk was the development of the two-ring VEP-1 electron-electron collider, which operated with 160 MeV beams from 1965-7, paralleling the Stanford-Princeton experiment.

Russian Academy of Sciences. However the influence of Budker at Novosibirsk is still almost palpable.

As well as Novosibirsk's substantial contribution of beamline magnets for CERN's LHC proton collider (see box), the Laboratory is also providing 9000 cesium iodide crystals for the electromagnetic calorimeter of the BELLE detector at the B-factory being built at the Japanese KEK Laboratory.

Colliding beams

The history of Novosibirsk is almost that of colliding beams. One of Budker's first major projects at the then new laboratory was the development of the two-ring VEP-1 electron-electron collider, which operated with 160 MeV beams from 1965-7, paralleling the Stanford-Princeton experiment. These two machines were the first in the world to collide beams of subatomic particles.

However the realization that contrarotating beams of electrons and positrons could give collisions in a single ring and provide more fruitful physics immediately led Budker to develop the VEPP-2 collider, which with energies of up to 700 GeV per beam made pioneer measurements of the rho meson in 1967.

VEPP-2 was succeeded by VEPP-2M, which began operations in 1975 in the same energy range. VEPP-2M initially used VEPP-2 as its booster, but now has its own 900 MeV booster synchrotron. The compact VEPP-2M ring is now equipped with two major detectors, CMD with its superconducting magnet, a scale model of the more familiar major detectors at larger colliders, and the SND Spherical Neutral Detector. VEPP-2M experimenters come from Boston, Pittsburgh, Yale and Minnesota as well as Novosibirsk.

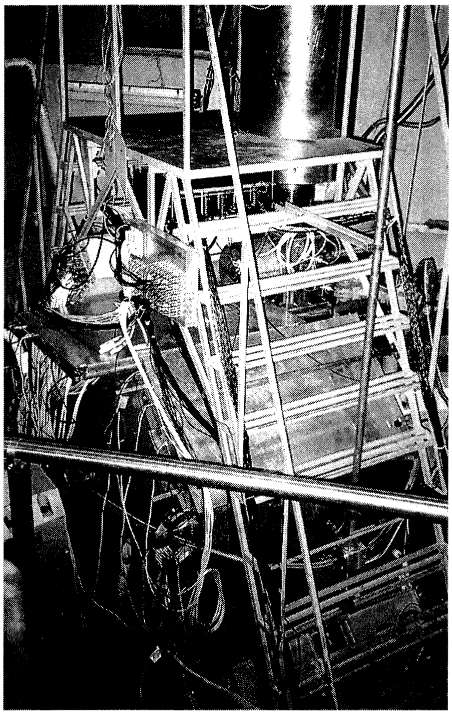
Physics goals centre on precision measurement of the production of light mesons, which still provide useful input for detailed calculations to probe the consistency of the Standard Model.

The installation of an 8 tesla superconducting wiggler magnet in 1985 increased VEPP-2M's luminosity, while also providing increased provision for synchrotron radiation studies using vacuum ultraviolet and soft X-rays. For its size, with a diameter of just a few metres, VEPP-2M, equipped with two major detectors and a full complement of synchrotron radiation experiments, must be one of the world's most prolific physics installations.

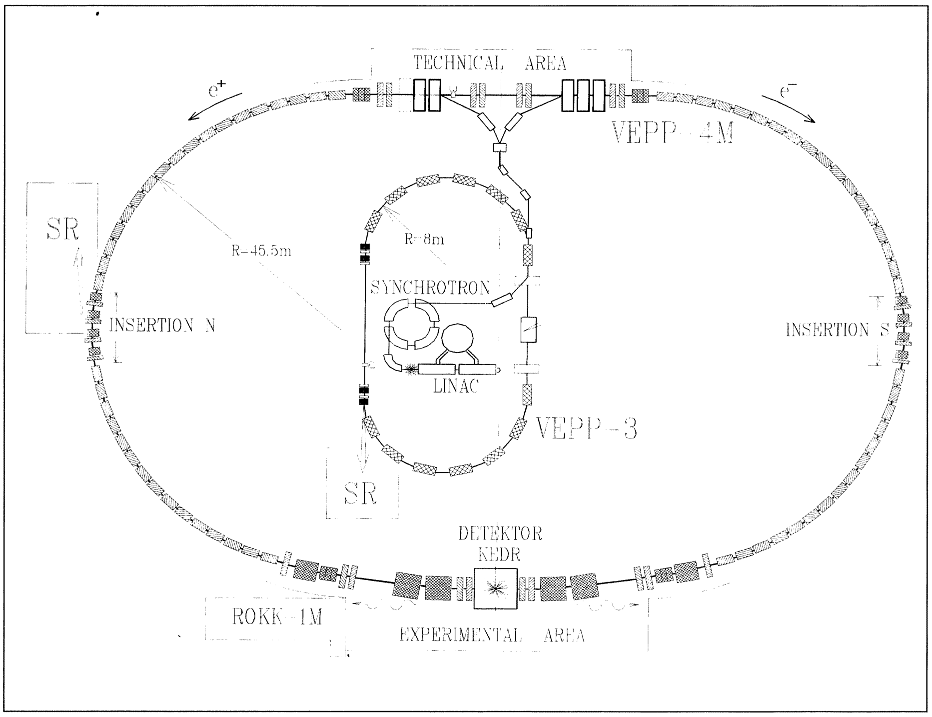
After successfully blazing a trail for electron-positron collision physics, Budker turned his attention to investigating a route for proton collisions. With lightweight electrons, synchrotron radiation losses provide a natural source of damping to make a beam well behaved, but for heavier particles such as protons, this is not the case at low energies. For a compact collider of the type that Budker had in mind, an alternative means of beam control was needed.

In 1965 Budker proposed his electron cooling idea, in which a

The compact CMD detector, equipped with a superconducting magnet, at the VEPP-2M ring is a miniature version of a major collider detector.



Schematic of the VEPP-3/VEPP-4M electron-positron complex at Novosibirsk.



beam of high energy protons passes through a tunnel of well behaved electrons. The unruly protons lose unwanted sideways energy to the surrounding electrons and emerge from the tunnel in a well-ordered beam. This scheme was demonstrated by a Budker team in 1974 in a historic experiment at the specially-built NAP-M proton ring.

Budker's initial objective was for a proton-proton collider, but at the suggestion of Alexander Skrinsky attention turned to proton-antiproton collisions, mirroring fully the developments which had taken place for electrons. Construction work got underway for the 46 GeV collision energy VAPP-NAP scheme, which would have been the world's first proton-antiproton collider. But with insufficient support the project foundered, and the VAPP installation subsequently emerged as the VEPP-4 electron-positron collider.

Despite the demise of VAPP-NAP, antiproton expertise and electron cooling have nevertheless remained one of Novosibirsk's specialities. Several major laboratories have benefited - both CERN and Fermilab's antiproton schemes have used Novosibirsk lithium lenses to improve the antiproton supply, while GSI Darmstadt is the latest laboratory to be equipped with electron cooling equipment made in Novosibirsk.

VEPP-3, VEPP-4, VEPP-5 and VLEPP

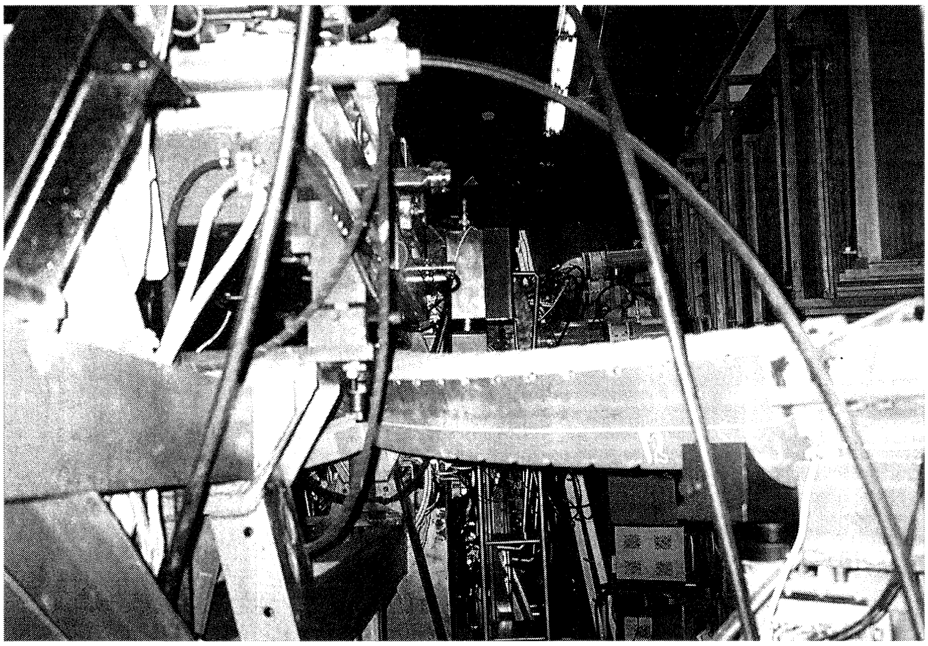
The VEPP-4 electron-positron collider began operation in 1980. With a beam energy of 5.5 GeV and maximum luminosity of 5 x 10^{30}, its major physics result has been a precision measurement of the upsilon particle using polarized beams. VEPP-4 is fed by VEPP-3, which takes electrons and positrons at 350 MeV and accelerates them to 1.8 GeV per beam for injection into the larger ring.

Some ten years ago, a major fire ravaged the VEPP-4 installations. However the ring has been substantially rebuilt, and the new KEDR liquid krypton detector (March 1995, page 9) will eventually have pride of place at the beam intersection region.

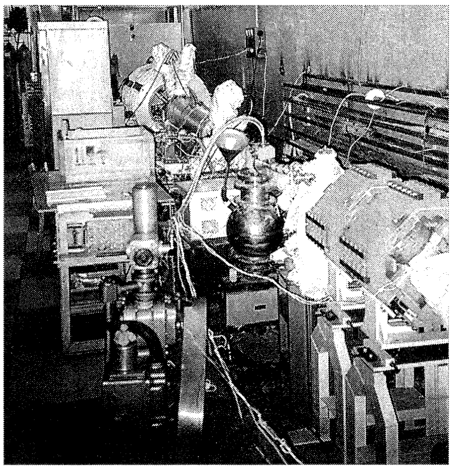
Built in 1993, ROKK-M, using backward scattered laser light on VEPP-4 electrons, provides photon beams for detector calibration (for example cesium iodide crystals for the BELLE electromagnetic calorimeter) and for a specialized range of physics experiments.

In addition, VEPP-4 is being fitted with a new experimental area for synchrotron radiation studies, while the VEPP-3 injector has its own dedicated synchrotron radiation programme, as well as doing physics with a polarized deuteron jet.

A free-electron laser based on an optical klystron previously used in a special VEPP-3 by-pass is now in service at the machine at Duke



Electron injection line from VEPP-3 to VEPP-4M.



Pre-injection equipment for Novosibirsk's new VEPP-5 electron-positron complex is already in place.

University, North Carolina (March 1995, page 8). A further sophisticated optical klystron is under development for photochemistry and other applications.

For the future, Novosibirsk is planning a new VEPP-5 electron-positron complex. Some of the underground tunnel already exists and equipment is being installed. Upstream, a series of linacs and a damping ring would also feed a figure-of-eight shaped phi factory aiming for luminosities of 10^{33}. Initial equipment being prepared includes a damping ring, linear accelerator radiofrequency equipment. Downstream, these injectors would feed a new tau-charm factory as well as VEPP-4M.

While synchrotron radiation is a boon for low energy electron rings, high energy rings quickly become too large. For the high energy frontier, electron-positron colliders have instead to be linear machines, long electromagnetic cannons to fire proton and antiproton beams at each other.

The idea of such a linear machine was first considered at Novosibirsk in the 1960s and presented at an international meeting in Morges, Switzerland, in 1971. By 1978, the VLEPP linear collider idea was taking shape, but activities for this particular project were subsequently transferred to a new branch of Novosibirsk at the Institute of High Energy Physics at Serpukhov, near Moscow, where the 21-kilometre UNK proton ring was under construction. The idea was that having the proton ring and a multi-kilometre electron linac next to each other would open up the possibility of electron-proton collisions. However linear collider research and development work remain at Novosibirsk, and Novosibirsk specialists continue to play a major role in the wide international collaboration for the development of high energy electron-positron colliders.

Industrial accelerators

Budker saw himself as a prophet for particle accelerators. As well as continually pushing to develop new laboratory techniques, he strived to use particle accelerators for the common good, developing new machines for applications in industry and in medicine.

To help further this aim, he ensured that his new laboratory was well endowed with manufacturing capabilities. By being highly autonomous on the manufacturing side, the laboratory would be able to react more quickly to emerging new requirements.

From the outset, his institute was equipped with well-equipped workshops to provide a range of specialist equipment for both the institute's own needs and for 'export', an imaginative goal in the Soviet era.

Initially some 25% of the institute's considerable manufacturing capacity was earmarked for applications, but with severe reductions in state support Novosibirsk began an export drive, with some 40% of this output going outside Russia. Novosibirsk's own factory continues to be well equipped with numerically-controlled tools, technology for high vacuum equipment, precision machining, ultrasonics, electron beam welding, clean room, etc. However the em-

DESY announces a

Post-Doc position

Applications are invited for a Post Doc position in the experimental support electronics groups.

The candidate is expected to contribute to a project to design and implement multi-platform client-server applications for the monitoring and control of complex high energy physics systems, such as detectors and accelerators. The integration of standardised object oriented software-interfaces such as CORBA or OLE for the communication between various platforms will feature prominently in the project.

Applicants should have a Ph.D. in either physics or computer science. The applicants should also have good knowledge of object-oriented methodologies and programming languages (e.g. C++ or JAVA) and experience with multitasking and/or object-oriented operating systems (UNIX, WindowsNT). Experiences with client-server technologies would be desirable.

The Post-Doc position is awarded for a duration of three years. The salary for the Post-Doc position is determined according to tariffs applicable for public service work.

Interested persons, who should be younger than 32 years are invited to send their application including a résumé and the usual documents (curriculum vitae, list of publications, copies of university degrees) until 16th of December 1996 to **DESY, Personalabteilung -V2-, Notkestraße 85, D-22607 Hamburg .** They should also arrange for three letters of reference to be sent until the same date to the adress given above.

Handicapped applicants with equal qualifications will be prefered.

DESY encourages especially women to apply.

Research Associate Position
University of Virginia
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The University of Virginia Experimental High Energy Physics group is seeking qualified applicants for a Research Associate position to work on the physics of CP violation. On the short term, this work will focus on the KTEV experiment at Fermi National Accelerator Laboratory, and on a longer time scale, on the LHC-B beauty physics experiment at CERN. This position is now open. The successful candidate is expected to play an important role in the KTEV experiment in the operation of an e+e- trigger based on a transition radiation detector and in the development of lepton detectors and triggers for the LHC-B experiment. Applications including curriculum vitae, a list of publications, and three letters of reference should be sent to:

Prof. B. Cox
Physics Department, McCormick Rd.
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Prof. Michael E. Peskin
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We encourage applications from qualified women and minority candidates.

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Programme Director for the Finnish LHC Programme at CERN

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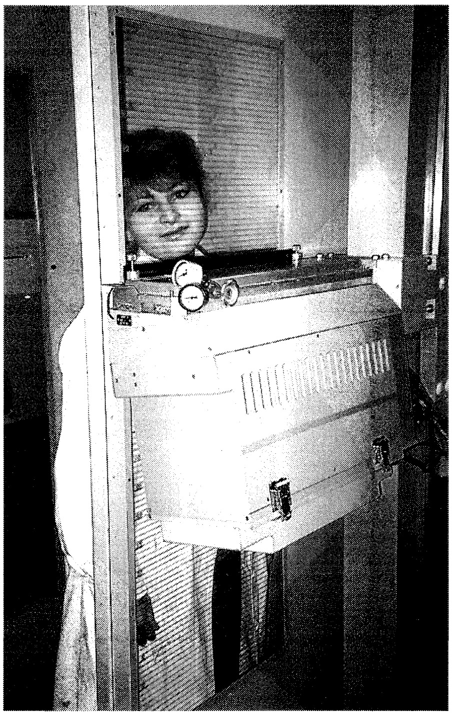
The person will be based at CERN, *with obligations to keep close contact with the research groups in Helsinki. The position will be filled for a period of three years. Salary conditions will be similar to those provided by CERN.*

The candidate must have a Ph.D. in experimental particle physics, an outstanding research record, and experience in leading a research group. The applicant is expected to show potential for major accomplishments.

Helsinki Institute of Physics is a new institute which combines three earlier institutes (SEFT, TFT, HTI) in Helsinki. It is jointly governed by Helsinki University and Helsinki University of Technology. It was established in September 1996.

Applicants should send a curriculum vitae, a publications list, and names of three references by December 31, 1996 to:

Professor Eero Byckling, Director, Helsinki Institute of Physics,
CERN Office, Building 32, 1-B-20,
CH-1211 Geneva 23, Switzerland



Novosibirsk has developed an X-ray radiography system with complete electronic readout, using specially-designed multi-wire proportional chambers. With this technique, the dose is only a tiny fraction of that normally used for X-ray radiography. (Photos G. Fraser)

phasis is on heavy electromechanical work rather than microelectronics or other microengineering.

A range of standard Novosibirsk accelerators are available more or less off the shelf to provide electron beams for such applications as the sterilization of medical equipment, and the irradiation of plastic cables and thermoshrinkable sheathing to improve handling qualities. Several million dollars-worth of such equipment has recently been shipped to China.

Novosibirsk also built the 'Siberia 1' and 'Siberia 2' rings of 450 MeV and 2.5 GeV respectively used for synchrotron radiation research at Moscow's Kurchatov Institute.

As well as complete accelerators, Novosibirsk supplies machine components such as power sources, beam monitoring equipment, magnets for synchrotrons, and wiggler and undulator magnets for synchrotron radiation sources.

Despite achieving considerable earnings, Novosibirsk has no 'sales force'. All contacts are made through scientific channels such as personal meetings or attendance at major international conferences.

The cancellation of the US Superconducting Supercollider (SSC) project in 1993 was an especially bitter disappointment for Novosibirsk as the laboratory had been manufacturing magnets for the SSC Low Energy Booster synchrotron. This 570-metre circumference machine would have taken 600 MeV protons from the injector linac to 11.1 GeV for injection into the next machine in the chain, the Medium Energy Booster. Magnets are still sitting in Novosibirsk.

In laboratories like CERN with large semi-nomadic user communities, these days detectors are built by collaborations, with components provided by different research centres. For in-house experiments, Novosibirsk is more self-centred, with detectors being built mainly on site.

While Novosibirsk machine expertise has long been acknowledged and exported, the laboratory's detector expertise is now also being shared with other research centres. Besides the substantial cesium iodide commitment for KEK, there is also aerogel research and development and some BGO for KEK, and cesium iodide for the WASA experiment at the CELSIUS ring at Uppsala, Sweden (October, page 20). Novosibirsk is also a partner in the Atlas, CMS and Alice detectors for CERN's future LHC proton collider.

Medical applications

Novosibirsk staff are well cared for medically. Among the facilities available is one of the few examples of X-ray radiography with complete electronic readout, using specially-designed multi-wire proportional chambers, made in Novosibirsk.

The main advantage of this technique is that the dose is only a fraction, as small as one-hundredth, of that normally used for X-ray radiography. This is particularly useful for pre-natal care, and means that the radiation dose is comparable with ordinary background levels - the patient undergoes a radiograph at effectively 'zero dose'.

The image captured in digital form produces a screen image only ten seconds after scanning, and data processing provides different views from the same set of data, for example separating an image of the chest and lungs from that of the spinal column without the need for two exposures. The data can also be transmitted electronically to a physician at a distant site.

Georges Charpak, inventor of the multiwire proportional chamber on which the Novosibirsk unit is based, takes a lively interest in the development and has introduced one unit to a Paris hospital.

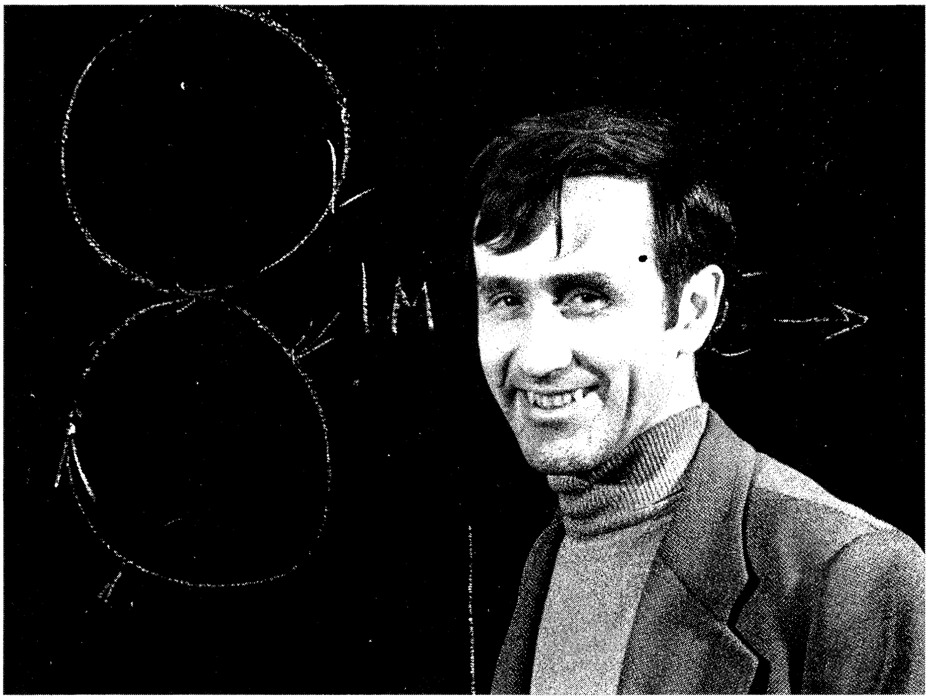
It seems bizarre that the X-ray tube invented by Röntgen one hundred years ago still has to rely on photographic film and that a unit which can operate with only small doses of those currently used in standard X-rays has not elicited more response from major suppliers.

Other significant Novosibirsk activities include a comprehensive programme on controlled thermonuclear fusion, using the mirror trap introduced by Budker and other subsequent Novosibirsk ideas to complement the conventional tokamak approach.

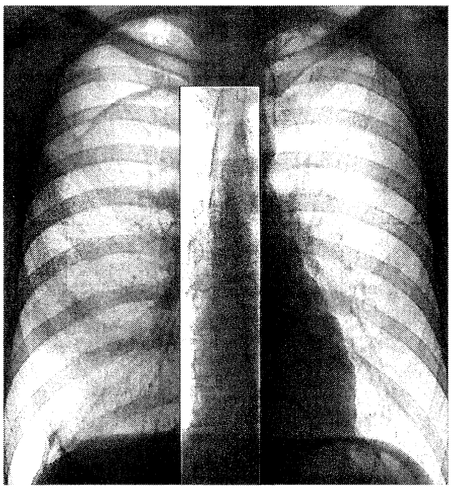
Novosibirsk affairs revolve around the famous open 'Round Table' forum, another tradition dating back to the Budker era. On Mondays, the forum discusses general and administrative issues; on Tuesdays the topic is accelerators; on Wednesdays physics; on Thursdays plasma and fusion; and on Fridays electronics and computation. Each daily topic has its own chairman, but Director Skrinsky is there as frequently as his busy schedule permits.

Remote from Moscow and faithful to its innovative traditions, the Budker Institute always seems to be going against the grain. In the pre-perestroika days it was considered an island of capitalism in a socialist ocean. Post-perestroika the analogy sometimes seems reversed. While the climate on the vast Siberian plain is harsh and notoriously unpredictable, the Budker Institute knows how to survive and even thrive there.

By Gordon Fraser



As well as being Director of Novosibirsk's Institute of Nuclear Physics, the talented Alexander Skrinsky is also Head of the Nuclear Physics Department of the Russian Academy of Sciences



Novosibirsk's digital X-ray image can provide different views from the same set of data, for example separating an image of the chest and lungs from that of the spinal column without the need for separate exposures.

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