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Pour toute information, merci de contacter :

. au CFME (Comité Français des Manifestations Economiques à l'Etranger)

Monsieur Serge SAUNIER — Tél. : (33) 1 40 73 32 24

Madame Evelyne DALISSON — Tél. : (33) 1 40 73 37 20

Fax : (33) 1 40 73 39 69

. au CERN

Monsieur Laszlo ABEL — Tél. : (41) 22 767 63 60

Fax : (41) 22 767 75 30

Advertising enquiries

Europe

Micheline Falciola
Advertising Manager
CERN
CH-1211 Geneva 23, Switzerland
Tel.: +41 (22) 767 4103
Fax: +41 (22) 782 1906

Rest of the world

Guy Griffiths
Advertising Manager, USA
International Publishers Distributor
820 Town Center Drive
LANGHORNE PA 19047
Tel.: (215) 750-2642
Fax: (215) 750-6343

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Jacques Dallemagne
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In certain countries, to request copies or to make address changes contact :

China

Dr. Qian Ke-Qin
Institute of High Energy Physics
P.O. Box 918, Beijing,
People's Republic of China

Germany

Gabriela Heessel or Monika Stuckenberg
DESY, Notkestr. 85, 22603 Hamburg 52

Italy

Mrs. Pieri or Mrs. Montanari
INFN, Casella Postale 56
00044 Frascati, Roma

United Kingdom

Su Lockley
Rutherford Appleton Laboratory,
Chilton, Didcot, Oxfordshire OX11 0QX

USA/Canada

Janice Voss
Creative Mailing Services
P.O. Box 1147
St. Charles, Illinois 60174
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telex: 419 000 CERN CH,
telefax: +41 (22) 767 65 55

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Editor: Gordon Fraser CERN.COURIER@ CERN.CH
Production and Advertisements:
Micheline Falciola
Micheline_Falciola@macmail.cern.ch
Advisory Board: E.J.N. Wilson (Chairman), E. Lillestol, M. Neubert, D. Treille; with L. Foà, E.M. Rimmer
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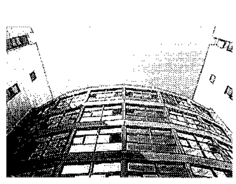
Around the Laboratories

Physics monitor



Cover photograph: Recently opened at CERN is this striking building for physicists, constructed with the help of the Swiss 'Fondation des Immeubles pour les Organisations Internationales', which has over the years added several major edifices to the Geneva landscape (see also page 25 - Photo CERN SI 2.8.96)

Around the Laboratories

In the main control room of Brookhaven's Alternating Gradient Synchrotron (AGS) where a beam of gold ions was guided from the AGS to the end of the first sextant of the RHIC Relativistic Heavy Ion Collider ring on Sunday 26 January - clockwise from far left, James Rose, Robert Frankel, Peter Wanderer, Waldo McKay, Michael Brennan, Michael Harrison, Ted Robinson, Michael Anerella, Tom Shea; centre, from left, Thomas Roser and Steve Peggs.

BROOKHAVEN
RHIC goes for gold

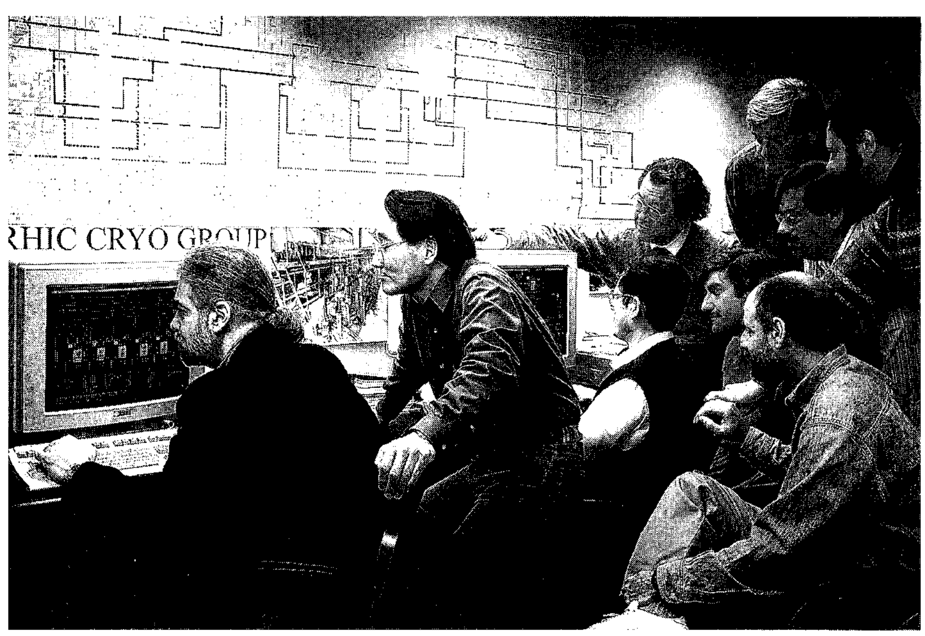
A gold beam of 11.3 GeV per nucleon from Brookhaven's AGS Alternating Gradient Synchrotron was successfully transported through the 4/5 o'clock sextant of the RHIC Relativistic Heavy Ion Collider ring on Sunday 26 January. Reaching this important milestone on schedule was a goal set over two years ago.

Cooldown of the sextant began on Monday, January 20. By Wednesday, January 22, the temperature of the sextant had been brought down to the operating level of 4.6 K. Thursday and Friday were devoted to checking power supplies and the quench detection system, completing tests of the personnel access safety system, and a related safety review. By 4 p.m. on Friday, permission to operate was received from the Department of Energy's Brookhaven Area Group.

At about 5 a.m. on Saturday, January 25, beam was brought through the AGS-to-RHIC transfer line to the beginning of the injection arcs into the collider. Beam reached the downstream end of the "Y-line" arc (which feeds the counter-clockwise RHIC ring) by mid-day Saturday, the area of the injection kicker by Sunday morning, and was transported through an entire sextant to a temporary beam dump at 2 p.m. Sunday. The size of the beam at the end of the sextant was as predicted.

This important test allows relatively early testing of most of the RHIC accelerator subsystems. In addition to the cryogenics, power supply, and vacuum systems, the radiofrequency and controls system, and most beam instrumentation were fully functional.

The injection and transfer process was precisely as it is designed to be in final collider operation, with the correct number of bunches being extracted from the AGS phase and locked to the RHIC radiofrequency system. Mechanically, all the magnets were present (including the large aperture quadrupoles designed to achieve low beta crossing point



Overseeing the cryogenics for RHIC superconducting magnets - front, from left, Michael Iarocci, Dick Hseuh, K.C. Wu, George Ganetis, Steve Musolino; back, from left, Satoshi Ozaki, Jack Sondericker, Bob Lambiase and Gary McIntyre.

insertions) with the exception of the "DX" magnet, a large aperture dipole closest to the intersection region. Highlights of the test include the stable performance of the cryogenics and vacuum systems, and valuable feedback on mechanical assembly.

A new record of 4 x 10^8 gold ions per bunch has been achieved. Following the beam test, a few weeks of systems testing without beam is scheduled. This includes repeated ramping of the magnets to full field, deliberate (heater induced) magnet quenching, and exercising the "sequencer," the highest level machine control software which, among other things, tunes intersection regions. If time permits, a thermal cycle will be performed.

Physics with colliding beams at RHIC is scheduled to begin in 1999.

From Alan Stevens

PSI
Swiss spallation neutrons

Director of the Swiss Paul Scherrer Institute Meinrad K. Eberle presents Swiss Federal Minister for Internal Affairs Ruth Dreifuss with a memento of the inauguration of the Swiss Spallation Neutron Source SINQ, in the form of a section of a "Supermirror". This glass-based neutron-guide is coated with up to 900 alternating layers of nickel and titanium. Both the development and the production were undertaken at PSI. First SINQ neutron fluxes were beyond expectation.

January 17 saw the official inauguration of the Swiss Spallation Neutron Source SINQ at the Paul Scherrer Institute (PSI) in Villigen. This event was celebrated by a host of prominent guests from the realms of politics, science and industry, headed by Swiss Federal Minister for Internal Affairs Ruth Dreifuss.

SINQ is the culmination of approximately 700 person-years of effort and an estimated investment of 85MSFr, reflecting Swiss interest in the field of neutron scattering, making it the country with the largest number of neutron scatters per head of population!

SINQ is based on PSI's existing 590 MeV proton Ring Cyclotron, commissioned in 1974, and the new high current 72 MeV Injector Cyclotron, commissioned in 1985. Proton beam intensity was steadily increased as part of a continuous upgrading programme and reached a world record 0.9 MW of beam power for a cyclotron (April 1996, page 5).

The 1.5mA proton beam is not only a rich source for the pion, muon and nucleon beams, used in nuclear, solid-state and particle physics but also was mandatory for SINQ, which became the highest power spallation neutron source when it was brought into operation on the 3 December.

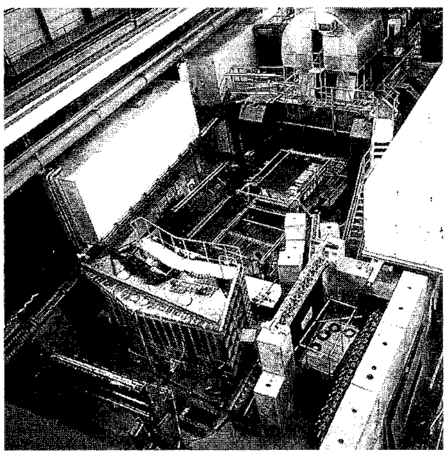
The commissioning was a success story in itself with a beam intensity of 900 microamps on the SINQ target being reached some three and a half hours after the initial injection into the beamline on 4 December. Furthermore, measurements of the neutron flux were also beyond expectation. First operational experience with SINQ will be reported on in a forthcoming issue.

CERN
Minus omega

With omega the 24th and final letter of the Greek alphabet, it was appropriate that in its 25th year of faithful service, CERN's Omega spectrometer bowed out at the end of 1996, as part of CERN's gradual rundown of fixed target work in the West Experimental Area (see accompanying story).

Coming to bury and/or praise in time-honoured fashion, former SPS Experiments Committee Chairman Sandy Donnachie underlined the

CERN's Omega spectrometer was decommissioned at the end of 1996 as part of CERN's gradual rundown of fixed target work in the West Experimental Area. The spectrometer is seen here in its youth, when still equipped with optical spark chambers, and with its magnet hidden under an 'igloo' (top). (Photo CERN X535.6.76)



long and varied career of a spectrometer that began fitted with optical spark chambers for work at the 28 GeV proton synchrotron and finished with state-of-the-art electronic detectors for work with the 450 GeV SPS synchrotron.

Omega provided a fruitful proving ground for pioneer applications of new techniques, such as Ring-Imaging Cherenkov detectors, lead-liquid scintillator calorimetry, and microstrip arrays for short-lived particles. In addition to covering a wide range of detector technology, Omega has also worked with a wide range of SPS primary and secondary beams, extending from photons to heavy ions.

On the physics side, the exploration of the inner mechanisms of strong interactions and detailed particle spectroscopy were key threads which ran throughout the Omega tapestry. In the early 1970s, strong interactions were delineated by a framework of Regge poles, while in the late 80s and the 90s quantum chromodynamics became the preferred orthodoxy.

Spectroscopy steadily mounted the quark ladder: from the initial picture involving just three quarks, Omega's sights moved to charm and then to beauty, and finishing on a gluon note.

To continue this physics, CERN plans the versatile COMPASS spectrometer in the North Experimental Area of the SPS. An article will appear in a future issue.

Coming to bury and/or praise in time-honoured fashion, former SPS Experiments Committee Chairman Sandy Donnachie (right) underlined long and varied career of the Omega spectrometer. With him is Omega pioneer and stalwart Emanuele Quercigh.

Sun sets on the West

At the end of 1996, the principal hall in CERN's West Experimental Area saw its last beams for physics. Many experiments are simply shutting up shop, while others move to the North Area as the hall's experimental programme closes prematurely; one of the sacrifices CERN is making to pave the way for the Large Hadron Collider, LHC. Over the coming years, as experiments gear up for physics at the LHC, the West Area will instead become CERN's proving ground.

As the West Area's main hall draws the curtain on 20 years of physics with beams from the Super Proton Synchrotron, SPS, it is hard to imagine that it was never foreseen as an SPS experimental zone at all. When the hall was built, the SPS was still at the design stage, and could have been located in any of a number of sites around Europe. The hall was built to assemble magnets for the World's first proton-proton collider, the Intersecting Storage Rings, ISR. When that was complete, it housed fixed target experiments for the Proton Synchrotron, PS.

Even when the SPS, or the 300 GeV project as it was then known, had been approved, original plans called for one experimental area, and for anticlockwise rotating beams. Then in 1970, two young physicists, Carlo Rubbia and Jim Allaby, pointed out that with clockwise beams and a slight shifting of the machine, the West Area could be used for SPS physics as well, allowing experiments to begin two years earlier than originally planned.

The layout of beams to the West

Aerial winter view of CERN's Meyrin site with the city of Geneva in the background and against the magnificent backdrop of the Alps. The large circular site marks CERN's Intersecting Storage Rings (ISR) closed in 1984. Closer to the camera is the series of halls in the West Experimental Area. In the immediate foreground are the downstream halls housing neutrino experiments.

Area meant that although the full SPS energy could go into making neutrino beams, hadron beams used protons of just 200 GeV. Over the years, SPS beams have provided a plethora of secondary beams ranging from neutrinos, one of the mainstays of West Area physics, to pions, photons, hyperons, kaons, and more recently, heavy ions.

The first experiment in the West Area to use neutrino beams was the Big European Bubble Chamber, BEBC. BEBC was installed in the early 1970s in a specially constructed building behind the main hall. Installation was complete by 1972, and the bubble chamber was cooled down for the first time. In 1973, BEBC made good use of the first PS experimental beams to be delivered to the West Area, photographing some 25 000 events.

In 1975, with SPS beams just one year away, preparations for more neutrino experiments gathered pace. The CERN-Dortmund-Heidelberg-Saclay, CDHS, collaboration installed its counter detector in a hall behind BEBC and became the first designated SPS West Area experiment, WA1. Electronic technology was catching up with the older, optical, methods. WA1 was soon joined by another counter experiment built by the CERN-Hamburg-Amsterdam-Rome-Moscow, CHARM, collaboration.

Work also started in 1975 on new buildings to house the Gargamelle bubble chamber. This French-built chamber had its finest hour in 1973 at its original site in the PS South-East Hall, with the discovery of neutral weak currents. Subsequently it was transferred to the West Area in 1976 and 1977. Soon after, however, Gargamelle was forced to retire, leaving behind a proud record of achievement.

Towards the end of 1976, the SPS delivered its first neutrino beams to the West Area, and BEBC was there to record them. The chamber went on to run for eight years in SPS beams, before reverting to the PS in 1984 for an experiment searching for neutrino oscillations, a quest still occupying West Area physicists today. At the end of the 1984 run, the BEBC programme reached an end, and the chamber was dismantled to free up space for the construction of experiments for the forthcoming Large Electron Positron collider, LEP.

Like BEBC, WA1 and CHARM also had long and illustrious careers. Graffiti left behind on West Area buildings still bear witness to their achievements, and their original aspirations. WA1 shut up shop along with BEBC in 1984, while CHARM became CHARMII, and ran until 1991. Today, the neutrino tradition continues with the Chorus and Nomad experiments still looking for the elusive neutrino oscillations in a neutrino beam revamped for the purpose in 1992 and 1993.

Another mainstay of West Area physics was the mammoth Omega spectrometer (see page 2). Also built originally with PS physics in mind, Omega started to take shape in

1971. When PS beams arrived on schedule in 1972, Omega recorded over a million events in its first year. With the end of physics in the West Area's main hall, Omega now takes a well earned rest.

The West Area saw its first major revision in 1982 and 1983 to prepare test beams needed for LEP experiments. The modified beam lines allowed the full 450 GeV of the SPS to be used. In 1984, part of the West Area was set aside for assembly, conditioning, and testing of LEP's original copper accelerating cavities. More recently, the superconducting cavities which will increase LEP's energy to 96 GeV per beam by 1998 have been tested and conditioned there.

In 1986, a newcomer was seen among the West Area's impressive array of beams. WA80 was the first of the West Area's heavy ion experiments, which took data originally with beams of oxygen, then sulphur in 1987, and most recently lead for the last three years. Heavy ion physics will continue at CERN in the North Area, with one West Area experiment packing its bags to join its North Area contemporaries in 1997.

But the closure of the main hall does not leave the West Area completely devoid of physics. The two neutrino experiments will continue their search for neutrino oscillations, and the main hall will be adapted for test beams for LHC experiments. Test beams for LHC are every bit as important as they were for LEP, and because of the size of the detectors, more of them are needed than ever. With the availability of such comprehensive test facilities, the sacrifice of physics experiments in the main West hall will not entirely have been in vain.

Two speakers at the Rutherford Laboratory's traditional pre-Christmas theory meeting - Zoltan Kunszt (right, ETH Zurich) with Vittorio de Duca (Edinburgh). This event always attracts a large number of theorists from the UK community, and the programme this year proved as interesting as ever.

RUTHERFORD APPLETON
Annual theory meeting

The Rutherford Laboratory's traditional pre-Christmas theory meeting always attracts a large number of theorists from the UK community, and the programme this year proved as interesting as ever.

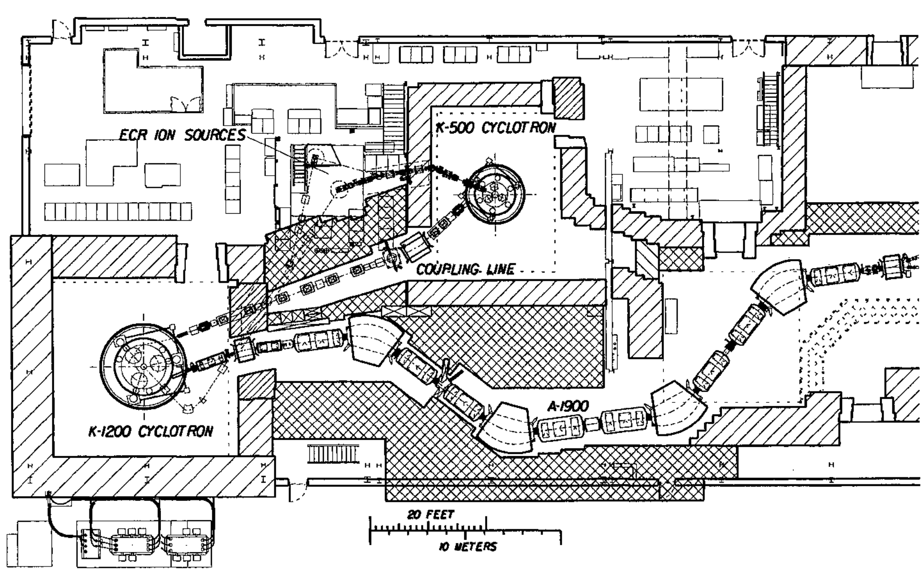
On the phenomenological side, there were review talks by Howie Haber (Santa Cruz) on the prospects for higgs physics, by Steve Abel (Brussels) on supersymmetry and the various expectations for CP violation in future experiments, by Zoltan Kunszt (ETH Zurich) on recent impressive progress in perturbative QCD. On the more formal side, Jeff Harvey (Chicago) reviewed the exciting progress in the theory of strings, 'branes' and duality and Alain Connes (Paris) enthusiastically proposed an approach based on non-commutative geometry. Lattice technology continues to improve and Christine Davies (Glasgow) showed how the hadron spectrum begins to emerge with realistic numbers while Jan Smit (NIKHEF, Amsterdam) applied new techniques to extract information on quantum gravity in four dimensions.

Experimental achievements in 1996 from heavy ion collisions were reviewed by Carlos Lourenco (CERN) while tantalizing new features in LEP2 data from Aleph, where unexplained enhancements are still seen in the mass spectra of jet pairs, were discussed by John Thompson (Rutherford Lab).

The meeting closed with a forward view to the next century by Paul Steinhardt (Pennsylvania) on the various scenarios for cosmology which encouraged the audience to return in a hundred years to get the answers to the fundamental questions of the Universe!

The upgraded configuration of the accelerator area of the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University. The upgraded NSCL will provide a unique resource to the world-wide nuclear science community by filling a need for both stable and radioactive ion beams in an interesting and nearly unique energy domain.

The high intensity and low emittance primary beams of lighter ions are an excellent match to the growing needs for intense beams of rare isotopes. The dramatic performance increases will permit a wide variety of experimental programs to be undertaken which are presently not feasible.



MICHIGAN Superconducting upgrade

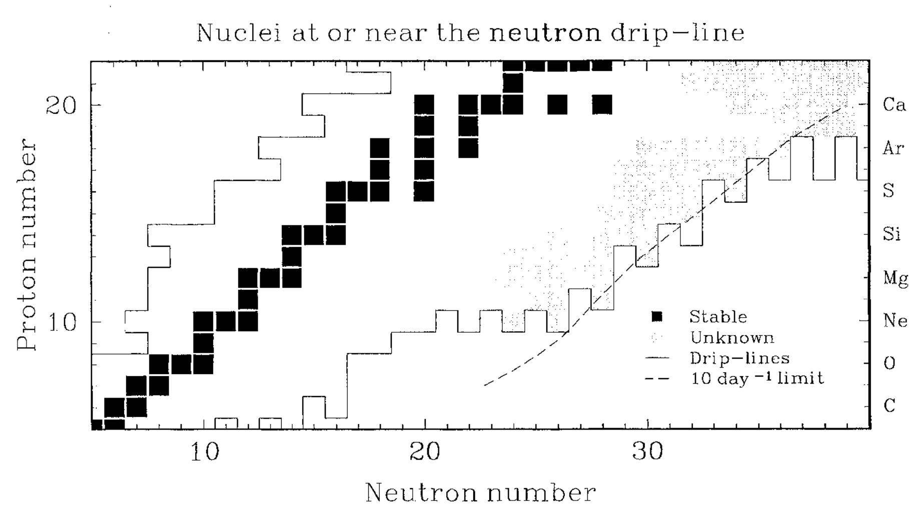
The National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) has recently received funding authorization from the National Science Foundation (NSF) for an upgrade. The modifications will increase the intensities of primary beams by factors of 10 to 1000, the intensities of secondary beams of rare isotopes (radioactive beams) by factors of 100 to 10,000, and the energy range of the heavier ions (e.g. uranium) by a factor of four.

The NSCL upgrade received a high-priority recommendation in the 1996 long range plan for nuclear science prepared by the Nuclear Science Advisory Committee of the US Department of Energy (DOE) and the NSF. The upgrade cost, funded jointly by NSF and MSU, is approximately $20 million with completion scheduled for 2001.

The NSCL is jointly funded by the NSF and MSU to operate the major intermediate-energy heavy-ion user facility in North America. The Laboratory has made major contributions in the fields of nuclear structure, nuclear astrophysics, heavy-ion reaction mechanisms, and accelerator physics.

Present research interests include studies of nuclei under extreme conditions, the dynamics and thermodynamics of colliding nuclei (including the liquid-gas phase transition and the equation of state of nuclear matter), fundamental modes of nuclear excitation (giant resonances, multiphonon states, spin and isospin transfer strengths), properties of nuclei far from stability (limits of nuclear stability, disappearance of shell structure, extended "halo"-distributions of nearly pure neutron matter), and benchmark measurements needed for a reliable understanding of nucleosynthesis in the cosmos (primordial nucleosynthesis of light elements in Big Bang, hot CNO cycle, rapid proton capture processes, and supernovae physics). About 10% of the beam time is devoted to applied and interdisciplinary research.

Over the last few years, demand for intense beams of rare and short-lived isotopes (radioactive beams) has



The range of nuclei close to the neutron dripline which is expected to become accessible at the upgraded NSCL. The high energies (more than 100 MeV/nucleon for uranium) will be an excellent match to the needs of studies of heated, compressed nuclear matter.

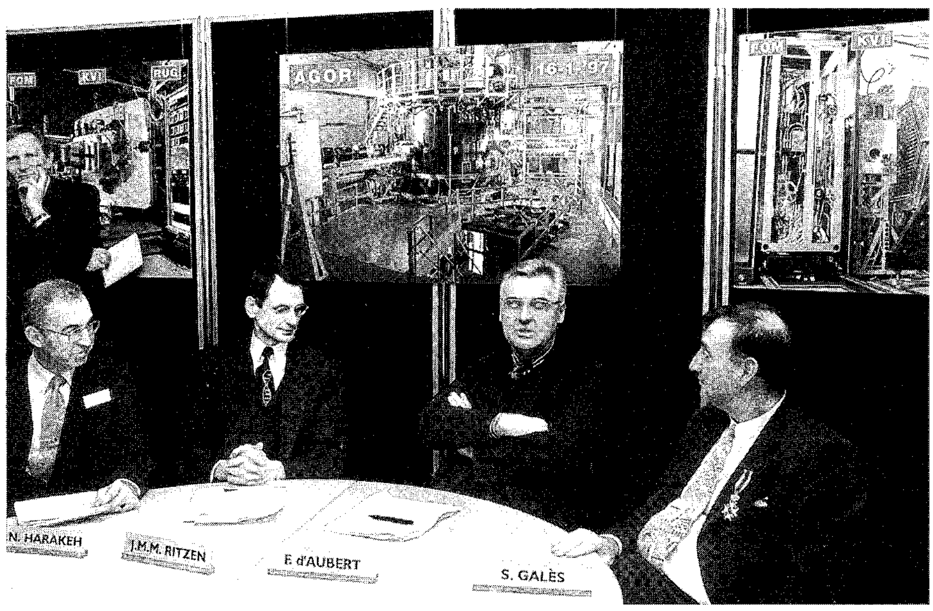
increased dramatically. Nuclear structure research with these beams now makes up more than two-thirds of the NSCL experimental programme.

NSCL beams of rare isotopes are produced by the technique of projectile fragmentation where the primary beam hits a thin target to produce a broad spectrum of isotopes with near-beam velocity. The desired isotopic beam is then selected by a downstream fragment separator. This technique is also used by GSI Darmstadt, GANIL Caen, France, and RIKEN Japan.

The present NSCL experimental programme is supported by the K1200 superconducting cyclotron injected by an electron cyclotron resonance (ECR) ion source. The upgrade will provide large performance gains by refurbishing and coupling two existing superconducting cyclotrons (the K500 and the K1200) and replacing the existing fragment separator with one of increased acceptance and rigidity (the A1900 - see figure).

Large gains in primary beam intensity are achieved by producing a high-intensity beam of low-charge ions with an ECR ion source. This beam will be axially injected into the K500 central region and accelerated to a few tens of MeV/nucleon. The ions will then be re-bunched and transported by a new injection line to the K1200 and injected through an existing horizontal port. At approximately one third of the K1200 extraction radius, they will be stripped to a higher charge state and then accelerated to their final energy.

The maximum energy is determined by the characteristics of the K1200 cyclotron. The performance gains result from the low charge states required from the ECR ion source in the coupled-cyclotron mode which can be produced with much higher intensity than the high charge states needed for present K1200 stand-alone operation. The secondary beam performance is further enhanced by the improved A1900 fragment separator.



Official start of the scientific programme at the Franco/Dutch AGOR project at KVI Groningen. Left to right: KVI Groningen director M.N. Harakeh; Dutch Minister of Education, Research and Culture J.M.M. Ritzen; French State Secretary of Research F. d'Aubert; and director IPN Orsay and chairman of NuPECC S. Galès.

GRONINGEN/ORSAY AGOR programme launched

In January Dutch Minister of Education, Research and Culture J.M.M.Ritzen and his French colleague, State Secretary of Research F. d'Aubert, gave the official go-ahead to the research programme at the AGOR cyclotron at KVI Groningen.

The "Accelerateur Groningen ORsay" is the largest-ever scientific collaboration between France and the Netherlands. Following the initial 1985 agreement, in the following years AGOR was designed, built and tested at the Institut de Physique Nucleaire (IPN) in Orsay, in close cooperation with KVI (Kernfysisch Versneller Instituut) in Groningen.

In 1994 the machine was dismantled and then shipped to Groningen where it was re-installed (September 1994, page 18). AGOR distinguishes itself by its flexibility: it can accelerate the whole range of nuclei from protons (up to 200 MeV) to nuclei of the heaviest elements such as lead. The use of superconducting magnetic coils has made the machine compact, with a diameter of 4.4 metres and a height of 3.6 metres.

The first nuclear physics experiments began last July. As well as nuclear research, AGOR also offers the possibility to investigate the use of protons in the treatment of tumours.

Guest of honour at the 50th anniversary celebrations of the Swedish Natural Science Research Council, NFR, which has responsibility for high energy groups at CERN, was Princess Lilian, seen here with NFR Chairman Arne Wittlöv.

(Photo Reportagephoto)

SWEDEN
50th anniversary

The Swedish Natural Science Research Council, NFR, which has responsibility for high energy groups at CERN, recently celebrated its 50th anniversary. "Fifty Years of Joy and Curiosity" was the motto for celebration at Stockholm's Concert Hall in November.

After guest of honour Princess Lilian was escorted to her seat by NFR Chairman Arne Wittlöv, the programme opened with a song of tribute to NFR, with lyrics and music by NFR staff members Lina Berglöf and Jan Destner.

After welcoming the audience, Dr. Wittlöv explained that "NFR is and has been a keen advocate of renewal and internationalization of Swedish Natural Science and Mathematics" and that "internationalization and renewal walk hand in hand".

NFR's Secretary General Gunnar Öquist said '"Fifty years of joy and curiosity" accentuates two central driving forces for successful research, namely the researcher's expectations when testing a hypothesis and the feeling of excitement when making a discovery.'

'There are many examples of how curiosity-driven basic research has given unexpected results,' he continued. 'This has created new possibilities, but also highlighted the question of responsibility regarding the appropriate use of knowledge.'

A far-sighted research policy, he said makes it 'possible to safeguard long-term research in an impatient world that demands rapid exploitable results.'

He also mentioned three important Council decisions which he believes have played a vital role in the positive development of Swedish natural science and mathematics: Evaluation of research; promotion of young researchers; and international cooperation.

The Agni Kundu - 'reservoir of fire' - hot spring in West Bengal, India, with, right, a liquid helium plant donated by CERN which will feed the new K500 Superconducting Cyclotron now under construction at Calcutta's Variable Energy Cyclotron Centre.

INDIA
Spring into action

Some 40 kilometres from the ancient university town of Shantinekatan in West Bengal, India, is the village of Bakreswar, where hot spring water emerging at 72° earns the name Agni Kundu - 'reservoir of fire'. As well as being a health spa, the spring is also a prolific source of natural gases, including some 2% of helium.

With a liquid helium plant donated by CERN, scientists from Calcutta's Variable Energy Cyclotron Centre (VECC) have harnessed the natural gas for VECC's new K500 Superconducting Cyclotron now under construction.

Scientists report that the Agni Kundu helium production rate mysteriously appears to reflect distant earthquake activity - before the 1995 Osaka/Kobe tremblor the helium rate fell, rising to more than double its usual level after the earthquake.

Physics monitor

CONFERENCE
Linacs

In these days of tight budgets and sharp curtailment of many government-funded research programmes, it would be reasonable to assume that there could be little in the way of new developments in accelerator technology. However, a brief perusal of the Proceedings of Linac 96, the 1996 International Linac Conference (produced very rapidly - CERN 96-07, Nov. 1996) should quickly dispel that notion.

The 18th meeting in an illustrious series, Linac 96, in an intense week late last August at the Penta Hotel in Geneva, covered the status, progress and future plans for specific facilities and the general field of scientific and medical/industrial linear accelerators.

Wolfgang Panofsky (SLAC) led off the opening plenary session with a paper chronicling the 30-year history of SLAC, from first beam in 1966, through several Nobel prizes, to development of the B-factory, an electron-positron collider with a planned luminosity of $3x10^{33}$ cm^{-2} sec^{-1} which will provide a new tool for physicists of the next century.

Major projects for high power linacs, primarily proton linacs, were reviewed by Michel Promé (CEA). The subject of many studies and proposals for over 30 years, projects have now been started in Europe, Japan and the US that may soon eclipse by many times the 1.5 MW beam-power record established by the MTA accelerator that operated briefly at Livermore in the 1950s.

Accelerator technology developments for the largest of these, a 130 to 170 MW proton linac being

Linac96 speaker "Pief" Panofsky of SLAC admires the poster session.

developed to produce tritium from helium-3 by a team headed by Los Alamos National Laboratory, were described in presentations by David Schneider and Dominic Chan (both of Los Alamos), and Yoshishige Yamazaki (KEK) addressed design issues for such high-power proton linacs.

Control of beam loss is of primary concern for such linacs, where losses must typically be less than one part in 10^{-7} or 10^{-8} per metre in order to allow hands-on maintenance. To this end, as was reported by Michael Pabst (KFA Jülich) and James Billen (Los Alamos), significant progress is being made in understanding beam halo formation and the importance of smooth transitions in transverse and longitudinal focusing.

Operational and commissioning details of new or upgraded facilities were the subject of several invited papers. Experimental programmes have started at 4 GeV, 200 microamp continuous wave electron accelerator at the Jefferson Lab (formerly CEBAF) and on the Wakefield Accelerator at Argonne as reported by Bruce Dunham (Jefferson) and Wei Gai (Argonne) respectively. Other electron facilities reported on include the recently commissioned 200 MeV electron, 450 MeV positron linac for the APS (Marion White/ Argonne) and the in-progress 8 GeV linac upgrade for the KEK B-factory (Atsushi Enomoto/ KEK).

Design and development for the next generation of electron-positron linear colliders are high on the agenda at several laboratories. Gregory Loew (SLAC) reviewed the work of the International Linear Collider Technical Review Committee and some of the changes since that committee's report in 1995.

More details of current collider work at their respective laboratories were presented by Tor Raubenheimer (SLAC), Ian Wilson (CERN), and Hitoshi Hayano (KEK) respectively. Rainer Wanzenberg (DESY) reviewed several topics with respect to the preservation of the longitudinal and transverse beam quality that will be necessary to reach luminosities above 10^{33} as required for such machines.

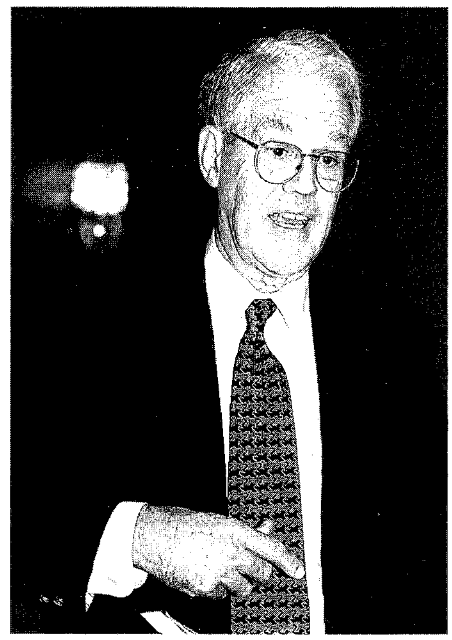
Some of the alignment issues and diagnostics issues for these machines were addressed by Andrey Sery (CEA Saclay) and Mark Ross (SLAC) respectively, while Martin Dohlus (DESY) looked at damping of higher-order modes in linear collider structures and Hiroshi Matsumoto (KEK) addressed electrical breakdown in cavities.

From information presented by André Wambersie (UCL), France alone has more radiation-therapy electron linacs (greater than 200) than the world-wide number of scientific linacs. His report on medical applications of electron linacs, and a presentation by Ugo Amaldi (Milan) on medical applications of protons and ions, provided excellent overviews of this very important applications field.

Free electron lasers are another

Linac96 chairman Helmut Haseroth (left, CERN), with Yanglai Cho (Argonne), chairman of the next conference, the 19th in the series, to be held in Chicago in 1998, after handing over the chairman's gavel, made of an original Linac drift tube, and its support, on which all Linear Accelerator conferences are commemorated.

In a special Linac96 evening session Ed Knapp explained the activities of the Santa Fe Institute.



important application for electron linacs. Joerg Rossbach (DESY) reviewed work underway at several laboratories to extend the wavelength range of FELs to very far below the visible, possibly down to the angstrom level. FEL work at SLAC and the Jefferson Laboratory were the subjects of presentations by James Clendenin and D.X. Wang respectively.

Significant developments were also reported in the ion linac field. Helmut Haseroth (CERN) reported on the new heavy ion accelerator at CERN that began operation with lead-208 with 25-27 charges in 1994 and Hartmut Kugler (CERN) described progress being made on a laser ion source to produce such highly-charged ions. The new heavy-ion injector at GSI Darmstadt was reported on by Ulrich Ratzinger (GSI) and Akira Ueno (KEK) described initial operation of a new 3 MeV H-injector for the Japanese Hadron Project at KEK.

A lot of interest is being generated in heavy-ion accelerators specifically designed to accelerate radioactive beams. Work in this area, going on at nearly 20 laboratories around the world, was reviewed by Jerry Nolen (Argonne), while Shigeaki Arai (INS, Tokyo) described beam test results obtained at one such facility, INS.

The control system software toolkit called EPICS (Experimental Physics and Industrial Control System) has grown from modest roots at Los Alamos and Argonne National Laboratories to current use at 58 projects. A review by Michael Thuot (Los Alamos) describes this interesting system, and operational experience with EPICS at one of the largest installations was the subject of a presentation by Curt Hovater (Jefferson).

Induction technology has unique capability for high current and high peak power, and Simon Yu (Berkeley) reviewed some of the recent development in induction accelerators with emphasis on applications in fusion energy, high energy physics and defence.

Robert Palmer (Brookhaven) outlined the challenges posed for accelerator physicists by the requirements for a 4 TeV muon collider. Perry Wilson (SLAC) reviewed radiofrequency power sources for colliders (frequency range of approximately 3 to 35 GHz) and Swapan Chattopadhyay (LBNL) gave an overview of the role of lasers in linear accelerators.

The closing plenary session included two talks on superconducting structures. Graziano Fortuna (INFN Legnaro) described work at LNL on quarter-wave resonator development for their superconducting heavy-ion linac, and Günther Geschonke (CERN) reviewed superconducting structures for high-intensity proton, deuteron and electron linacs. As a counterpoint, the conference closed with CERN Director General Christopher Llewellyn Smith covering "Physics at the LHC".

Away from the mainstream sessions, in a special evening session Edward Knapp discussed work going on at the Santa Fe Institute in introducing simulation techniques from the physical sciences into the realm of cultural and economic problems.

The three poster sessions, with a total of about 230 contributed papers, were each preceded by short plenary sessions with brief oral summaries of selected papers. All poster papers can be found in the two-volume Proceedings. In addition, an electronic version of the proceedings has been available on http://www.cern.ch/Linac96/ and a higher-quality version on CD-ROM is being distributed.

Another commendable achievement of the conference organizers is the

Wilhelm Röntgen - one hundred years after his discovery of X-rays, this radiation remains the main weapon of medical diagnosis, while the even older techniques of photographic film remain the avenue of choice for recording the X-ray images.

production of a Compendium of Scientific Linacs which gives pertinent details for 176 "scientific linacs" distributed over 3 continents that are in operation, under construction, or proposed.

Linac 96 was superbly organized by a team under Conference Chairman Helmut Haseroth. The meeting brought together over 300 scientists from 16 countries for 40 invited papers and 230 poster presentations. From the initial welcome, through sessions and dinners in castles, to an interesting tour of CERN, the organizers ensured that everyone enjoyed a memorable mix of science and Swiss hospitality.

From Gerald McMichael (Argonne)

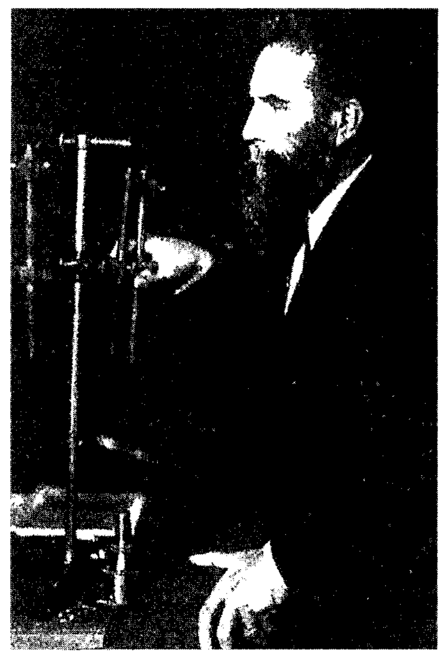
Minidose X-rays

One hundred years after their discovery, X-rays remain the main weapon of medical diagnosis, while photographic film, invented more than a century ago, remains the medium of choice for recording the X-ray images. But if X-rays are administered indiscriminately, the accumulated dose can become dangerous. Now electronic detection techniques enable X-ray information to be recorded digitally and offer important advantages. The radiation dose needed can be as little as one per cent of that of conventional film radiography - such doses becoming comparable to natural background sources, so that X-rays can be taken for effectively 'zero dose'. Such digital information can also be processed to obtain different views, say of the chest and the spine, from the same recorded data without the need for separate exposures. Despite these advantages, an ingenious system of digital readout for X-ray radiography developed by specialists in Novosibirsk, Russia, and used at several hospitals has yet to make an impact on the market. Entrenched in outdated technology and with relatively high X-ray doses nevertheless legal, major industrial suppliers are dragging their heels.

On 8 November 1895, Wilhelm Conrad Röntgen embarked on a physics experiment which was to change the course of science. Investigating invisible radiation such as ultra-violet rays, he covered a cathode-ray tube with black paper and darkened his tiny laboratory. With the glow from the cathode ray-tube masked, Röntgen was startled to see a fluorescent screen across the room light up. He had discovered X-rays.

In January 1896, newspapers across the world were carrying the story of Röntgen's dramatic new discovery, illustrated with skeletal photographs of people's hands. That same year, dentists began taking X-ray pictures of teeth, while doctors quickly realized how the new radiation enabled them to examine broken bones. It was a breakthrough in medical diagnosis - for the first time doctors were able to see inside the body without any need for invasive surgery.

But there were backlash effects. Ignorant of the dangers of radiation, research workers burned or otherwise injured themselves. As well as the operators, patients too ran risks, although these took longer to identify. A 1994 report by the United Nations Scientific Committee on the Effects of Atomic Radiation pointed out that high X-ray doses led to an



increase in primary cancers, particularly of the thyroid. X-rays are dangerous and have to be treated with respect.

What are the alternatives? Some half a century after Röntgen's discovery, other radiography techniques emerged. Radioactive substances can be administered and their distribution through the body or a particular organ followed by monitoring the emitted radiation. Rather than using film, the 'camera' for recording these images is usually an array of scintillating material, such as sodium iodide crystals, with photomultipliers amplifying the tiny light signals. However this technique, like X-rays, gives only a two-dimensional projection of a three-dimensional image, with no direct depth information, and the accuracy of about 0.5 cm is inadequate for many radiological needs.

In 1972, Godfrey Hounsfield at EMI made a new breakthrough which solved the problem of depth. In his

Georges Charpak - radiography with less radiation.

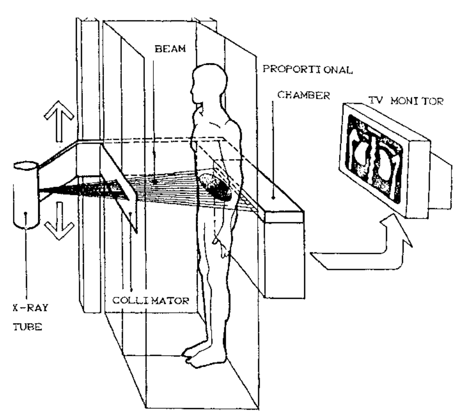
computer-assisted tomography (CT) scanner, a narrow fan of X-rays rotates around the patient's body, with the image recorded by an arc of high pressure gas detectors in which the X-rays produce tiny sparks. From this information, a two dimensional picture is reconstructed of each 'slice' of the patient's body. While CT scans now provide an important diagnostic tool, CT is relatively heavy diagnostic artillery. Conventional X-ray pictures, using photographic film, remain the front-line of medical diagnosis.

For medical work, alternative routes have opened up using digital imaging, however in many cases film has remained the initial recording medium, the film image being subsequently digitized by laser scanners or TV cameras. However film can be dispensed with by using photodiodes or photoluminescent screens. Such techniques are promising but have yet to make a major impact.

Röntgen's discovery was a classic example of 'spinoff' from pure science. The Würzburg physicist had not been intending to find a new tool for medical diagnosis. Instead, his primary goal had been fundamental physics, and here he also succeeded, being awarded in 1901 the first-ever Nobel Prize for Physics. Röntgen's discovery was a major turning point in physics. On hearing the news, J.J. Thomson at the Cavendish Laboratory in Cambridge mobilized his research forces, a young New Zealand student called Ernest Rutherford being ordered to drop his investigations in radio telegraphy and turn to X-rays instead.

In the early 20th century, Rutherford became the Moses of subatomic physics. His epic 1911 discovery of the atomic nucleus led in turn to the study of subnuclear physics and the world of elementary particles, the smallest possible constituents of matter. To watch the behaviour of these tiny fragments, physicists used ingenious cloud or bubble chambers in which particle interactions showed up as a network of tracks, like aeroplane vapour trails in the sky.

Millions of these tracks were photographed. Physics laboratories employed teams of scanners to patiently scrutinize these films for signs of anything unusual. It was a very labour-intensive way of doing research. In the mid-1960s the Polish-born French physicist Georges Charpak set himself the task of finding a way of revealing particle tracks without always having to photograph them. When a high energy particle passes through a gas, it leaves behind it a trail of broken atoms, or 'ionization'. If a high voltage is applied, this ionization literally causes sparks to fly, and such 'spark chambers' were first developed in the early 1960s as another way of seeing particle tracks.



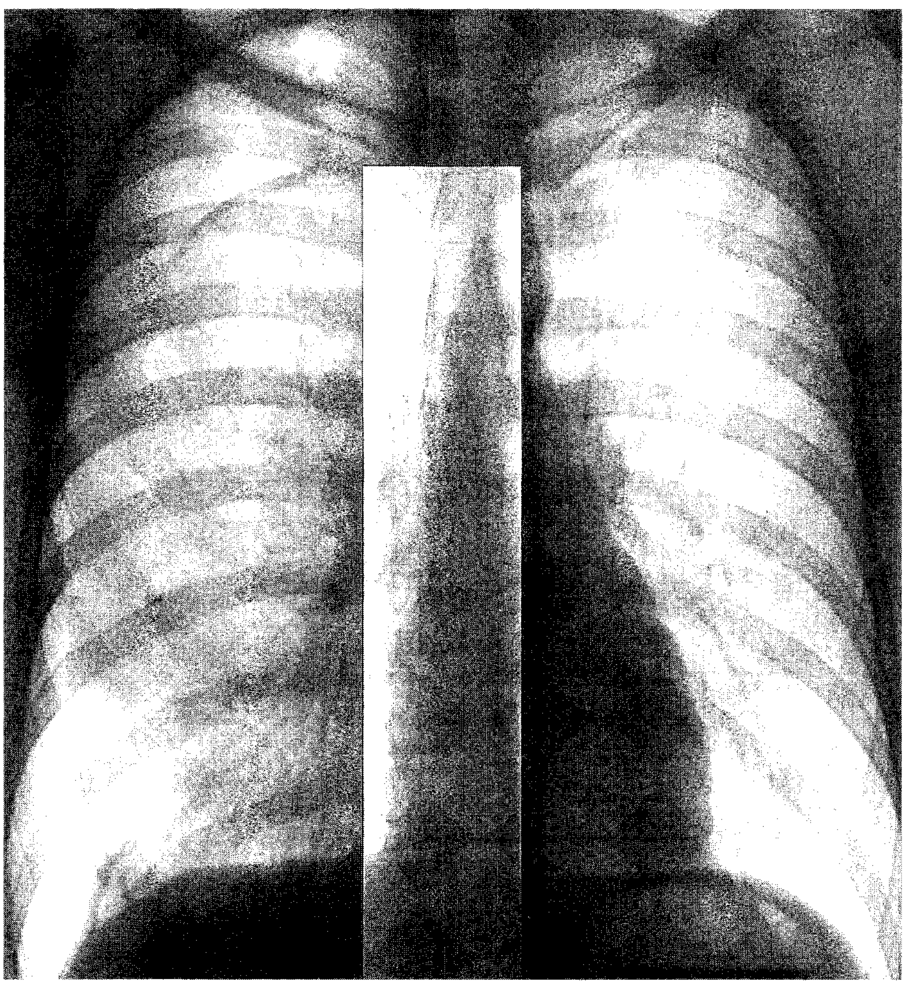
The Novosibirsk X-ray camera consists of a single fan-like array of wires pointing towards the X-ray source, delineated by a narrow horizontal slit. The source, slit and camera then move vertically, building up a matrix exposure. This mechanical scan takes about 8 seconds.

But Charpak was convinced that ionization could be exploited in a more subtle way.

In 1908, Ernest Rutherford and Hans Geiger had developed a high tension device called a 'proportional tube', a long metallic cylinder which acts as a cathode, surrounding a central anode wire. When a particle passes through such a tube, it rips electrons from the atoms of gas in the tube. These electrons are pulled towards the wire anode, producing still more electrons in their wake. This electron 'avalanche' produces a signal, showing that a particle has passed through. In principle an array of such tubes could be used as a particle detector, but with the tube diameter of a few centimetres, little precision was possible, while arrays of such tubes would quickly become unmanageable.

Charpak's brilliant 1968 idea was to use instead an array of parallel anode wires a few millimetres apart sandwiched between two cathode planes - the multiwire proportional chamber, or MWPC. Ionization electrons are produced as high energy particles pass through the chamber, but in this case the geometry of the wires and the stronger electric fields make the ionization electrons react faster and

An X-ray digital readout system developed at Novosibirsk can provide different views from the same exposure data. Here an image of the chest and lungs are separated from a view of the spinal column.



move more uniformly, giving reliable and rapid readout. Charpak's chambers soon became the workhorse detector for particle physics, eventually replacing the bubble chamber. But Charpak was convinced that his new detector could be put to other uses. Here was another development in fundamental physics which was ripe for spinoff.

An ionization 'hit' on the nearest MWPC wire shows where a particle has passed. But such a signal from a single wire only gives one-dimensional information. To build up a full picture, physicists also have to know how far along the wire the hit has occurred.

For high energy particles, this is done by mounting the MWPCs in layers, successive layers having their sense wires running in alternate directions, giving the x- and y-coordinates of the 'hit' signal. However low energy particles, such as those produced from X-rays, find it difficult to penetrate more than one chamber and another method is needed to build up a full picture.

Ripping electrons from atoms leaves behind large positive ions built around the atomic nuclei. These too move in an electric field, but in the opposite direction to the electrons. The work at CERN showed that the signals from these positive ions can help pinpoint where the ionizing particles have passed. Readout methods pioneered by Victor Perez-Mendez at Berkeley opened up new avenues for X-ray work, but did not attain the sensitivity needed for medical diagnostics.

Instrumentation specialists at the Budker Institute for Nuclear Research in Novosibirsk, Russia, have successfully twinned the MWPC with a classic Röntgen source, finally dispensing with the need for photographic film. The Novosibirsk X-ray camera consists of a single fan-like array of wires pointing towards the X-ray source, delineated by a 0.5 mm horizontal slit. To reduce parallax errors, individual anode wires in the camera point towards the focus of the X-ray tube. The source, slit and camera then move vertically, building up a matrix exposure. The mechanical scan takes about 8 seconds, but as the exposure time for each horizontal slice is only 12 milliseconds, slight movements of the patient do not seriously disturb the quality of the image.

The first installation at Moscow's Centre for Maternity and Child Health Protection was initially used to examine 1500 pregnant women, with an individual dose of 40 millirem compared to 1700 with a conventional X-ray - just 2.35% of the dose! From measurements of pelvis and infant head size, specialists were able to develop a quantitative way of evaluating the potential success of the birth and ascertain at an early stage if recourse to Caesarean section would be called for.

Several years ago, a team from London's University College made a quantitative examination of the performance of the Novosibirsk system, concluding that the digital method provided substantially better results in all cases except for high-contrast objects smaller than 1 millimetre across, where the electronic system was limited by the spacing of its anode wires.

With film, the wide range of transmitted X-ray intensities means that an image may contain information which is not visually perceptible. A chest X-ray 'sees' the spine as well as the lungs, but the different X-ray intensities are not matched to the performance of the film, and lung and spine images normally require separate exposures. However with digital readout, different X-ray intensities can be 'windowed' to reveal different kinds of image from the same data. A single X-ray scan using the Novosibirsk technique can reveal separate images of the lungs and the spine without the need for separate exposures.

Cost is no handicap although the installations are still relatively unsophisticated. The Novosibirsk facility costs $100,000 without X-ray tube and power supply, while a commercially-available X-ray unit with three separate radiation stations costs some $250,000. Systems have been supplied to several Russian hospitals. Charpak has taken a paternal interest in the idea and has introduced it to a Paris hospital.

Despite the obvious advantages of the system, major suppliers of X-ray equipment, protected by current dose legislation, see no need to discard the technology they currently use. But as Charpak points out 'We are still petrified by the radiation from the 1986 Chernobyl disaster, but in a Parisian hospital, children with problems of the spine or dislocations receive much more radiation from a hundred X-ray examinations over a two-year period than did the children of Chernobyl. This is tolerated because it is for the good of the patient. But in more than half the cases, the Siberian system could have done the job for ten times less dose.'

Collision crossroads

The remarkable consistency of the current 'Standard Model' picture of particle physics requires that whatever the mechanism responsible for mass generation is, it has to occur at an energy scale of less than about 1 TeV - within the range of the next generation of accelerators.

In addition to this underlying puzzle of the origin of mass, there are other compelling questions. For example, the observed matter-antimatter asymmetry of the universe is not understood. Also, astrophysical observations suggest that between 90 and 99% of the matter that makes up the universe is invisible. There are a number of possible candidates for this "dark matter", but none have been proven experimentally to exist.

Avenues for attacking these problems were explored in the "Future High Energy Colliders" Symposium held in October at the Institute for Theoretical Physics (ITP) in Santa Barbara, one of three symposia hosted by the ITP and supported by its sponsor, the National Science Foundation, as part of a five-month programme on "New Ideas for Particle Accelerators". The programme and symposia were organized and coordinated by Zohreh Parsa of Brookhaven.

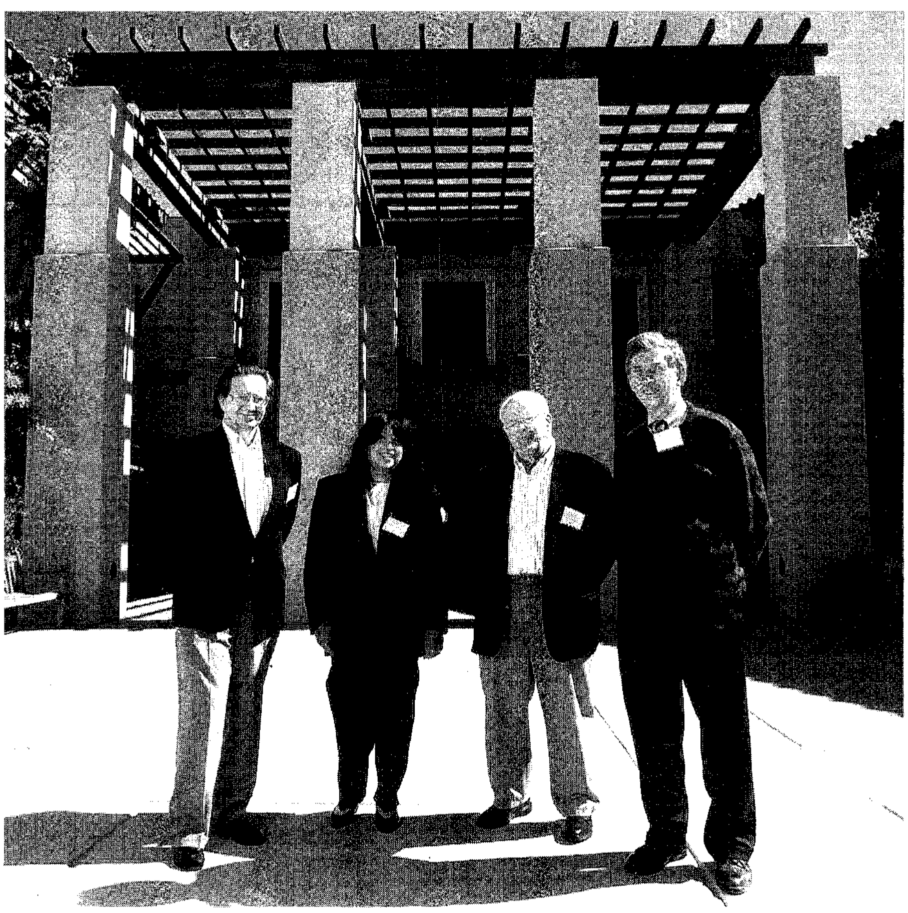
The primary tools for high energy physics research are particle beam colliders, and their design and construction are motivated and constrained by: forefront physics questions; the available technology needed to build and operate these machines and the capabilities to detect and analyse the collisions; and, last but not least, the cost and the availability of funding.

US high energy physics is at a crossroads where its future depends on participation in foreign projects, upgrading and utilizing existing facilities, and new construction initiatives. While some of the underlying physics motivations and technical issues had been addressed at earlier workshops, the Santa Barbara symposium's specific aim was to begin the process of reaching a consensus on how to attain a vision of the future.

The most urgent open physics question is to understand where the masses of Standard Model particles come from. The simplest possibility, the "higgs mechanism" predicts a fundamental particle called the higgs scalar. Finding it or whatever new physics is actually responsible for mass generation originally motivated the US Superconducting Super-collider (SSC) and remains the primary goal of the next generation of colliders, led by the LHC at CERN.

The current energy frontier is delimited by Fermilab's Tevatron proton-antiproton collider, CERN's LEP electron-positron collider, and the SLC electron-positron collider at the Stanford Linear Accelerator Center (SLAC). The proton-antiproton and electron-positron collision routes complementary information. LEP's 1996 energy upgrade almost doubled the energy ceiling in electron-positron collisions.

Avenues for attacking outstanding physics problems were explored in a "Future High Energy Colliders" Symposium held at the Institute for Theoretical Physics (ITP) in Santa Barbara, one of three symposia hosted by the ITP and supported by its sponsor, the National Science Foundation, as part of a five-month programme on "New Ideas for Particle Accelerators", organized and coordinated by Zohreh Parsa of Brookhaven (second from left). Key presentations were given by major US Laboratory Directors (left to right) Nick Samios (Brookhaven), Burt Richter (Stanford Linear Accelerator Center - SLAC) and John Peoples (Fermilab),



For the next step, in 2005 the LHC will operate with a beam energy about seven times that of the Fermilab Tevatron. Although the LHC should uncover the origin of mass, it probably will not be able to answer all outstanding questions. Thus a major international collaboration has been developing a design for a high energy electron-positron collider, the Next Linear Collider (NLC). This would have a somewhat lower energy reach than the LHC, at least initially, but it would be able to make many interesting unique measurements that would complement those at the LHC.

Together the LHC and NLC should clarify the origin of mass and address many other interesting questions. They might also find the explanation for the dark matter of the universe and open new frontiers such as the much anticipated heavy particles predicted by supersymmetry, an elegant and attractive extension of the underlying structure of spacetime. If supersymmetry is found, it will become the focus of high energy physics. Studying its spectrum of particles and their properties will be a major experimental enterprise.

Also under discussion at Brookhaven, Fermilab, Berkeley and many universities is the idea of a muon collider. Since muons at rest decay in about two millionths of a second, building such a collider would be a major technological achievement, and would open additional physics frontiers. This physics overlaps that of electron-positron colliders but also includes novelties such as the possibility for fusing the colliding beams to produce higgs particles, permitting, for example, the precise direct measurement of the mass and lifetime of the higgs particle as well as its decay properties.

However, the main enthusiasm for the muon collider stems from its potential to reach very high energies and the possibility that it could be constructed at an existing laboratory.

An explanation of the matter-antimatter asymmetry in our universe requires first an understanding of the origin of mass. In addition, important additional information would come by studying rare interactions of known particles, including B mesons, kaons, and muons. Such experiments are ongoing at several laboratories, and with the advent of B factories and intensity upgrades of proton synchrotrons at Brookhaven and Fermilab, more will be carried out in the future.

The Santa Barbara symposium brought together many physicists who will have a major impact on the future direction of the field. Especially significant were the presentations by Department of Energy Director of Energy Research M. Krebs, by B. Kayser of the National Science Foundation, and by the directors of the three major US High Energy Physics laboratories, J. Peoples (Fermilab), B. Richter (Stanford Linear Accelerator Center - SLAC) and N. Samios (Brookhaven).

The difficulties and far-reaching consequences of the decisions that must be made were further clarified

Bookshelf

during a panel discussion. While a unanimous opinion has not yet been reached in all matters, the consensus is that an NLC should be built somewhere and vigorous research and development should pursue promising new areas such as the muon collider and new modes of particle acceleration.

Given the long lead times necessary for the design of new particle accelerators, it is important for the high energy physics community to decide soon what types and energy ranges of colliders are necessary to address the additional questions which current machines and the LHC may not be able to answer.

From Zohreh Parsa (Brookhaven)

HISTORY Carnegie reunion

A recent Pittsburgh reunion of 80 people who had worked at the Carnegie 450MeV synchrocyclotron relived the heady physics of the 1950s.

The Carnegie accelerator was similar to contemporary university machines at Berkeley, Chicago, Columbia, Harvard, Liverpool, McGill, Rochester and Uppsala as well as those at Harwell, CERN and Dubna Laboratories.

The Carnegie machine was designed and built by the faculty and students of the Carnegie Institute of Technology, now Carnegie-Mellon University, from 1949-53 with initial support from the Buhl Foundation and the US Office of Naval Research, and later from the US Atomic Energy Commission.

The 1947 discovery of the pion in cosmic rays pointed to the need to increase the energy from the 300MeV initially planned. A combination of an efficient magnet design by Martin Foss and a bold decision by Ed Creutz, then Chairman of Physics, to plan for increased energy even though funds were not in hand, resulted in a machine of 450MeV, built on land donated by the Westinghouse Corporation in the village of Saxonburg, 50km north of Pittsburgh.

The site and buildings had been used earlier for the transmitter of the first US commercial radio station - KDKA. The village was also the site of John Roebling's first factory to manufacture steel wire rope, used in the construction of a number of suspension bridges - including the Brooklyn bridge.

One notable early synchrocyclotron result came from the measurements of pion-proton reaction rates by Julius Ashkin and his collaborators - the observation of the first pion resonance, the delta, also discovered by Fermi's group at Chicago.

After the meeting, a visit to the Saxonburg site revealed that the cyclotron buildings are now occupied by a high-tech company making high purity crystals and other optical components for laser systems. Those who attended the reunion looked back with nostalgia to when milestone high energy physics experiments could be completed within months by a few people.

Introduction to Quantum Field Theory, by Michael Peskin and Daniel Schroeder, Addison Wesley, ISBN 0 201 50397 2

I remember having been told as a student that in order to understand Quantum Field Theory (QFT), one should know it already. However paradoxical, few can deny that there is some truth in this statement: it is hard to reach a deep comprehension of the subtleties and surprises of QFT by just starting from a list of axioms, rules and theorems. Better to learn just enough to start doing some interesting calculation, and then go back to the fundamentals for a deeper perspective. The authors of this book, authorities in the field, must have felt the same way. Their technique is to anticipate and start using, in concrete examples, results that require the development more formalism before being rigorously proved.

Formal discussions alternate with well selected practical examples, elegantly worked out. All physical aspects of a given problem are explored with insight and presented with a style that makes reading a real pleasure (I did most of my reading in bed, before going to sleep, and, as with the best thrillers, could not put the book down).

A few examples: the elementary derivation of differential distributions in the production of muon pairs from electron-positron pairs, without the use of Feynman rules; the parallel treatment of soft radiation in classical electrodynamics and the low-energy limit of QED; and the discussion on asymptotic freedom.

This over-800-page book is divided into three main parts. The first contains an introduction to Feynman diagrams, QED, and radiative corrections. Here even the canonical sections on the quantization of the free field or the optical theorem have a special zest! Several examples of higher-order calculations are worked out in detail, including all standard examples such as the anomalous magnetic moment, as well as less standard subjects such as the resumation of soft divergences and Sudakov form factors.

The second part deals with renormalization, presented within the Wilson approach. The functional integral is introduced, as well as the connection between the physics of phase transitions and QFT and the interplay between symmetries and renormalization. The third part, which with 300 pages is almost a book in itself, discusses non-Abelian gauge theories, and the Standard Model in particular. A lot of the material cannot be found in standard QFT textbooks: operator product expansions, parton evolution, Drell-Yan and dijet production in hadronic collisions, the equivalence theorem, electroweak radiative corrections, are just some examples; all of them are worked out with a care that is uncommon even in books on the specific subjects.

Ample sets of problems, with helpful hints for their solution, complete each chapter, while more demanding research projects are proposed at the end of each part. Most problems are taken from current advanced research topics and provide good self-contained introductions. This excellent book will enable all students, whether theorist or experimentalist, to attain a deep understanding of QFT and to learn how to make profitable use of it.

Michelangelo Mangano

The Origin of the Concept of Nuclear Forces, by L.M. Brown and H. Rechenberg, Institute of Physics Publishing, ISBN 0 7503 0373 5, hbk £49/$79.50

In our present understanding, the forces at work deep inside the nucleus involve fractionally charged quarks and are mediated by 'coloured' gluons. In this picture, the interactions between atomic nuclei, although strong, are secondary, analogous to the chemical interactions between atoms. This perspective took a long time to develop, and from 1932 until the arrival of quark physics in the 1960s, physicists tried to understand nuclear interactions as a basic force using whatever limited means they had at their disposal.

This book candidly traces the frustration of trying to understand nuclear forces from 1932 (the discovery of the neutron) to 1950 (the discovery of the neutral pion).

At a time when once again a unified field theory is a major goal of mainstream physics, the authors point out 'Our story can be read as a cautionary tale: all of the earlier proposed fundamental theories of nuclear forces aspired to be 'unified field theories' which unified at least the strong and weak nuclear forces - but during the two decades in question, Nature's response was always "no", or at least, "not yet".'

A valuable insight into the history and confusion of an earlier epoch, full of historical anecdotes, providing a useful reminder that physics is human.

In Search of the Ultimate Building Blocks, by Gerard 't Hooft, published by Cambridge University Press, ISBN 0 521 57883 3 (pbk £9.95, $14.95), 0 521 55083 1 (hbk £27.95, $39.95)

A neat little book on particle physics by a distinguished author which emphasizes progress in theoretical understanding and looks forward to further such advances, with chapters on recent developments in technicolour, grand unification, supergravity, superstrings, and black hole physics. Required reading for those wishing to understand better the role of spontaneous symmetry breaking. In general experimental details take a background seat (the glossary runs to 'sigma model', but not to synchrotron), but a good read for all those who want to know about elementary particles and prefer a theoretical approach.

Books received

Constitutions of Matter: Mathematically Modelling the Most Everyday of Physical Phenomena, by Martin H. Krieger, University of Chicago Press, ISBN 0 226 45304 9 (hbk $65, £51.95), also pbk.

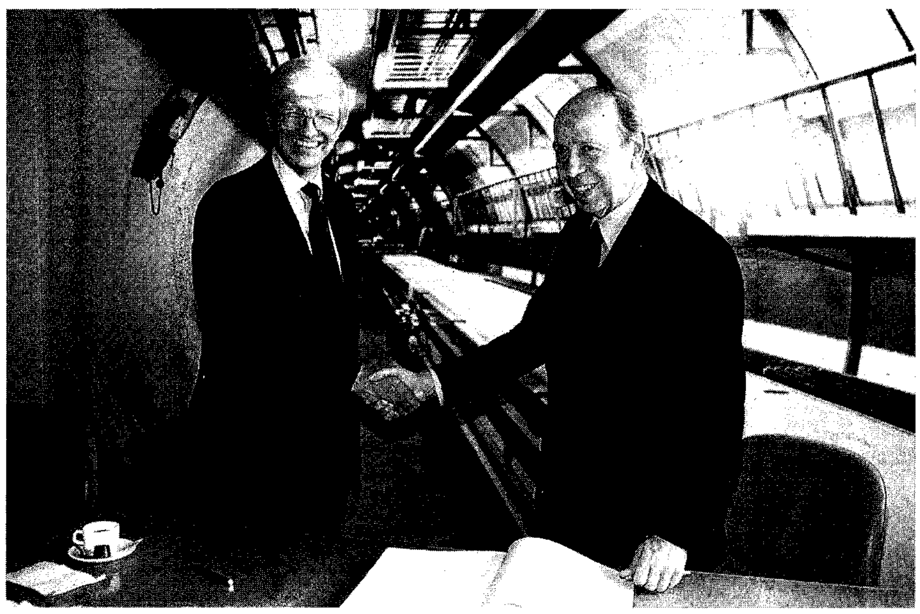
The mathematics behind physics, particular in the domain of thermodynamics and phase changes.

Mathematica 3.0: Standard Add-On Packages, Wolfram Research/ Cambridge University Press, ISBN 0 521 58585 6 (pbk, £19.95, $29.95) 0 521 58586 4 (hbk £40, $59.95)

Useful goodies for algebra, calculus, graphics, discrete and numerical mathematics, number theory, statistics, etc.

People and things

On 21 January CERN Director General Chris Llewellyn Smith welcomed Italian Foreign Affairs Minister Lamberto Dini (right) to the Laboratory.



Internet performance - a concern for physicists

Internet performance and future communications networks were major topics at the International Committee for Future Accelerators (ICFA) semi-annual meeting at the Stanford Linear Accelerator Center on January 31. In addition to connectivity, the group also explored other topics related to particle accelerators, technology and design.

Internet reliability, bandwidth and speed were suffering due to the increased use of the public Internet lines, according to specialist David Williams, formerly head of CERN's Computers and Networks Division. "Intranets and Extranets are now necessary for private traffic," said Williams. "The American car industry is already investigating such possibilities. So physics must do the same."

"The problem in setting up a private Internet for physics is not technology, but it is the organization, financing, and politics of such a venture," continued Williams. "The United States is the only country so far where deregulation has worked and service is related to costs." Deregulation of the telecom industry hits Europe in January of 1998. Individual nations may operate more efficiently internally after European deregulation, but "there is yet no clear indication of how the pricing of international lines to the United States and Japan will be affected," according to Williams.

According to Burton Richter, Director of SLAC and host of the ICFA meeting, "Physics was vital to the implementation of the first Internet. Now we need to look the next level in order to maintain our science proficiency," said Richter. The ICFA meeting was attended by 25 leaders of physics facilities from around the world, including Russia, China, Japan, Europe and the United States. *(See also page 25.)*

1997 American Physical Society Awards

Among the prestigious awards made by the American Physical Society for 1997 are: the Tom W. Bonner Prize to R.G. Hamish Hamilton of Washington 'for his intellectual and experimental leadership in seminal experiments' testing and determining fundamental properties of nuclear reactions and establishing stringent limits on the mass of the electron antineutrino (at Los Alamos); the Dannie Heineman Prize to Harry Lehmann of Hamburg for developing powerful new mathematical relations; the Lilienfeld Prize to Michael Turner of Chicago for his work in particle cosmology and 'his ability to communicate the excitement of the field'; the W.K.H. Panofsky Award to Henning Schröder of DESY and Yuri Zaitzev of ITEP, Moscow, for 'their leading role in the first demonstration of mixing in the neutral B system' (with the ARGUS experiment); the I.I. Rabi Prize to Eric Cornell of the US National Institute of Standards and Technology and Wolfgang Ketterle of MIT for their achievement of Bose-Einstein condensation in a gas; the J.J. Sakurai Prize to Thomas Appelquist of Yale for pioneering work on charmonium and on the decoupling of heavy particles; the Robert R. Wilson Award to Andrew Sessler of Berkeley for his many contributions to beam dynamics and accelerator science; the Edward A. Bouchet Award to Larry Gladney of Pennsylvania for work on B meson physics and for his efforts in physics education; and The Dissertation in Beam Physics Prize to Linda Spentzouris of Northwestern for her pioneering measurements of nonlinear coherent phenomena in high energy hadron beams. The Herbert P. Broida Prize goes to William Happer of Princeton for contributions to atomic and chemical physics (Happer preceded Martha Krebs as Director of the Office of Energy Research at the US Department of Energy). The Nicholson Medal goes to Fang Lizhi of Arizona for his 'courageous struggle for democracy and human rights in China'.

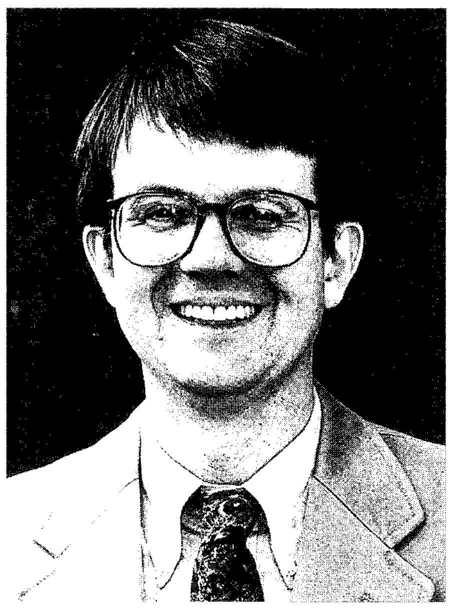
On people

This year's prestigious Wolf Prize for physics goes to John Wheeler, professor emeritus at Princeton and Texas, Austin. He is cited for his work on black holes, quantum gravity and contributions to nuclear scattering and fission, work which goes back to milestone papers with Niels Bohr.

Herwig Schopper, Director General of CERN 1981-88, and Ugo Amaldi of CERN were among those awarded the Order of Friendship of the Russian Federation in recognition of their contributions to the development of international collaboration in nuclear research. The awards were made during a recent meeting of the Scientific Council of the Joint Institute for Nuclear Research, Dubna.

Larry Cardman, former deputy associate director of physics at the Jefferson Laboratory (formerly CEBAF), Newport News, Virginia, becomes the Laboratory's Associate Director of Physics, replacing John Domingo, who steps down following the completion and equipping of the Laboratory's three large experimental halls.

Eric Cornell of the US National Institute of Standards and Technology, who shares with Wolfgang Ketterle of MIT the American Physical Society's I.I. Rabi Prize. and with Carl Wieman of Colorado shares the prestigious 1997 King Faisal International Prize for Science, for their 1995 synthesis of a Bose-Einstein condensate.



Bose-Einstein condensate prizes

The synthesis of a Bose-Einstein condensate (November 1995, page 12) is one of the major physics achievements of recent years.

Eric Cornell of the US National Institute of Standards and Technology and Carl Wieman of Colorado share the prestigious 1997 King Faisal International Prize for Science for this work. In addition (see above), the American Physical Society's I.I. Rabi Prize goes to Eric Cornell of NIST and Wolfgang Ketterle of MIT.

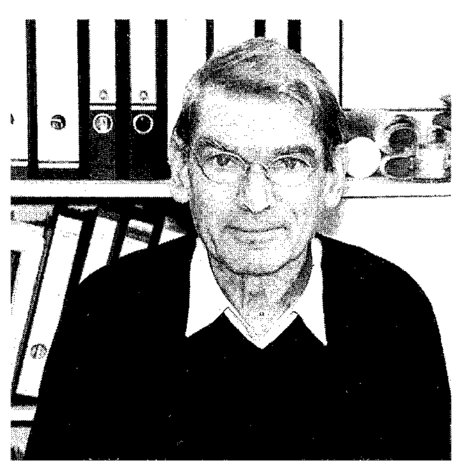
The King Faisal Science Prize was awarded for the first observation of BEC in a dilute bose gas. Cornell and Wieman were the leaders of that experiment. The APS Rabi prize is a specialized prize specifically for "young" physicists, hence the selection of Wolfgang Ketterle, who has also realized a BEC in his labs, and has done some very nice work with condensates.

Gerhard Horlitz 1926-97

Gerhard Horlitz, worldwide authority on low-temperature installations for high energy physics and the father of most such devices built and operated at DESY, died in January at the age of 70. After finishing his PhD in Bonn, in 1957 he joined Willibald Jentschke's team at Hamburg to construct the first DESY electron synchrotron, devising ingenious methods for measuring magnetic fields. In 1961 he moved for three years to Saclay, where the 85 cm hydrogen bubble chamber was being built for DESY. Back at DESY he organized the smooth operation and a series of impressive improvements of this chamber, including runs with deuterium, with neon-hydrogen mixtures and some using internal targets. This chamber operated up to 1972, providing some 8 million pictures, mainly with GeV photons.

The bubble chamber was finally replaced by a streamer chamber (using the same magnet) with hydrogen targets provided by Horlitz' group. At that time his team had already started experimenting with

Gerhard Horlitz 1926-97



LABORATORI NAZIONALI DI FRASCATI DELL'INFN

EU Postdoctoral Fellowships (TMR Programme)

We invite applications for postdoctoral fellowships (one to two years) in theoretical, experimental physics (high energy physics, astroparticle physics, nuclear physics, synchrotron radiation and gravitational wave detection), and accelerator physics at the Laboratori Nazionali di Frascati of INFN (Istituto Nazionale di Fisica Nucleare).

The Laboratory is situated on a pleasant hill about 20km south of the centre of Rome. Some 150 researchers work here on the different activities. The 1 GeV e^+e^- machine DAΦNE (Phi factory), to study CP violation and hypernuclear physics, is currently under commissioning. Information on the Laboratory activities can be obtained from:
A. Antonelli, tel. 39-6-94032787, e-mail antonelli@lnf.infn.it and at the URL: http://www.lnf.infn.it/.

Applicants must be nationals of an EU member state (excluding Italy), or an associated state, age under 35 and have a PhD degree (or equivalent level of education) or 4 years' full-time research activities at post-graduate level. They should not have carried out research activities in Italy for more than 18 months in the last two years.

Fellows will be employed under the EU's general conditions governing research training fellowships (TMR Programme) and will receive an allowance in ECUs per month to cover subsistence and mobility expenses, tax and social security contributions and cost of attending conferences, travel expenses, etc. Global monthly allowance will be of about 3000 ECUs. More information on the TMR Programme are given at the URL: http://www.cordis.lu/tmr/home.html.

Candidates should send a letter of application (where the activity of interest must be specified), a C. V. and two letters of recommendation by 15 April 1997 to:

EU Fellowships Programme, Mrs. M. Cristina D'Amato, LNF-INFN
Via E. Fermi, 40 - 00044 Frascati (Italy)
tel.: +39 6 94032373, fax: +39 6 94032475, e-mail: damato@lnf.infn.it

The selected candidates will apply to the next round of EU selection which has the closing date of 16 June 1997.

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUOPEAN ORGANIZATION FOR NUCLEAR RESEARCH
Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

CERN
GENEVE SUISSE
GENEVA SWITZERLAND

The CERN-Asia Fellows and Associates Programme

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

Applications will be considered by the CERN Fellowship Selection Committee at its meeting of June.

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

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

Application forms can be obtained from:

Recruitment Service-CERN-Personnel Division
CH-1211 Geneva 23 - Switzerland
E-mail: recruit@afsmail.cern.ch
Telefax: +41-22-767 2750

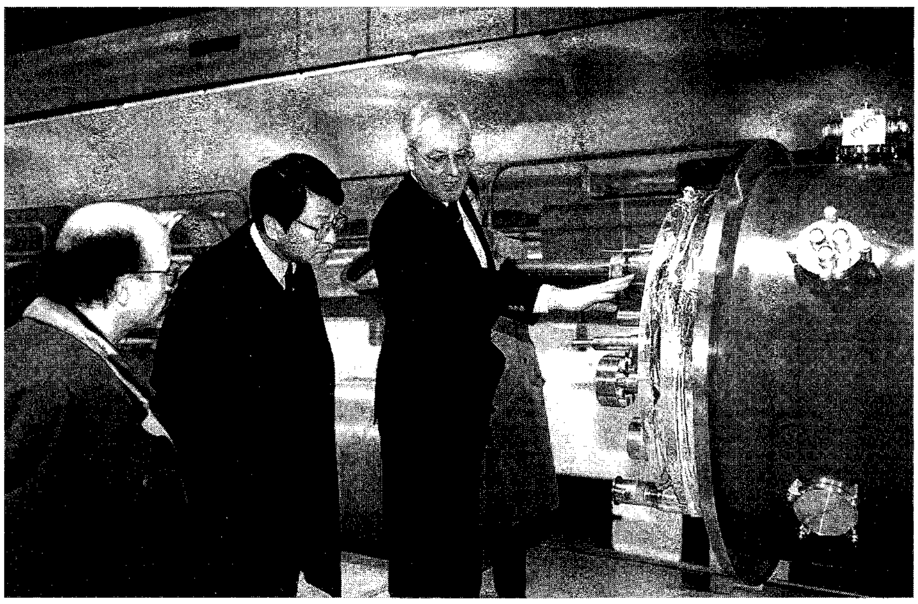
Applications should reach the Recruitment Service at CERN before the 7th of April 1997.

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

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

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

Soon after the announcement that Japan is extending an additional generous tranche of support for CERN's future LHC proton collider (January, page 1), Wataru Iwamoto, centre, Director of International Science Affairs of the Japanese Ministry of Science, Sports and Culture (Monbusho) hears about LHC superconducting magnets from LHC Project Director Lyn Evans. Looking on is Peter Jenni, spokesman of the LHC ATLAS experiment. (Photo CERN HI18.1.97)



superconducting magnets and getting acquainted with liquid helium technology. Several superconducting coils were built, including one used later for medical purposes, and at the same time the first bigger solenoid, intended for the PLUTO detector, was built by industry under the direction of Horlitz. His group constructed at DESY a very thin superconducting shielding coil and the PLUTO compensation coils. The successful running of PLUTO at the electron-positron storage-rings DORIS and PETRA was to a great extent due to the Horlitz group. After PLUTO was replaced by the bigger CELLO, reliable superconducting operation was again his responsibility.

The most challenging of his activities came with the construction of the HERA proton superconducting storage ring, able to reach energies of more than 800 GeV. Already in 1978 the first studies for dipole magnets were undertaken, culminating with the construction of more than 400 nine-metre magnets by German and Italian industry. In collaboration with Saclay, Gerhard Horlitz organized the development of HERA superconducting quadrupoles, also built by industry.

HERA required the biggest refrigeration plant ever built in Europe up to that time - and he was responsible for that project too. Its successful operation has contributed greatly to the smooth running of HERA and to experiments requiring low temperatures.

After his 'retirement' in 1991, Gerhard Horlitz continued his activities at DESY and developed a useful concept for the refrigeration of a superconducting linac (within the TESLA project).

As well as being a gifted scientist, Gerhard Horlitz had tremendous energy and was an excellent organizer, able to assume major responsibilities. He was also an admirable team leader, discussing personal or human problems as well as physics and technology with his collaborators and colleagues.

25 years of hadron colliders

In the article on 25 years of proton colliders (October 1996, page 9), we contrived to say 'Following the invention of beam stacking by the US Mid-Western Universities Research Association (MURA), led by Gerald O'Neill, in the mid-1950s, CERN built a ... model machine'. MURA was, of course, led by Donald Kerst. We regret the error.

Meetings

The third European Workshop on Beam Instrumentation and Diagnostics for Particle Accelerators will be held from 12-14 October at Laboratori Nazionali di Frascati dell'INFN, Frascati Italy, http://www.lnf.infn.it/conference/dipac97.html Further information from the Workshop Secretariat: Manuela Giabbai, LNF-INFN Accelerators Div., 00044 Frascati - Italy, fax +39 6 94032256 e-mail dipac@lnf.infn.it

The Advanced ICFA Workshop on Beam Dynamics Issues for electron-positron Factories will be held from 20-25 October at Laboratori Nazionali di Frascati dell'INFN, Frascati Italy, http://www.lnf.infn.it/conference/icfa97.html Further information from the Workshop Secretariat: Mariarita Ferrazza, LNF-INFN, 00044 Frascati - Italy, fax +39 6 94032582 e-mail icfa97@axlnf1.lnf.infn.it

Beauty 97, the 5th International Workshop on B Physics at Hadron Machines, will be held at UCLA from 13 - 17 October. Information from beauty97@physics.ucla.edu and

Swiss Ambassador to the United Nations and International Organizations in Geneva Walter Gyger at the opening of CERN's striking new building for physicists (see cover photograph), constructed with the help of the Swiss 'Fondation des Immeubles pour les Organisations Internationales', which has over the years added several major edifices to the Geneva landscape.
(Photo M. Jacob)

http: //www.physics.ucla.edu/ ~beauty97

The 6th Conference on Electronics for Particle Physics will be held at LeCroy corporate headquarters at Chestnut Ridge, New York, on 28-29 May, Information from Linda Nelson at LeCroy, fax +1 914 578 5984, e-mail linda.nelson@lecroy.com

The 13th International Symposium on High Energy Spin Physics will be held from 8 - 12 September 1998 at the Institute for High Energy Physics, Protvino, Russia. There will be morning sessions of plenary talks, afternoons of contributed talks, poster sessions and round table discussions. The conference web page is http://www.ihep.su/~spin98 e-mail spin98@mx.ihep.su.

ICFA Statement on the Large Hadron Collider

The International Committee for Future Accelerators (ICFA) met at the Stanford Linear Accelerator Center on 31 January, together with Directors of the world's major high energy physics laboratories. ICFA noted with great satisfaction that in December 1996 the CERN Council approved construction of the Large Hadron Collider (LHC) in a single stage, with commissioning planned for 2005.

The LHC will open a new energy domain and address today's key questions in particle physics, and is essential for further progress in this field. Its importance is indicated by the commitment of the nineteen CERN Member States and of non-Member States to support both the facility and the experiments.

The LHC will be a true world facility: some twenty-five non-Member States will contribute to and participate in the experiments, and contributions to the accelerator itself from Canada, India, Israel, Japan, Russia and the USA have been agreed or proposed. This development fulfills the primary purpose of ICFA which is "to promote international collaboration in all phases of the construction and exploitation of very high energy accelerators". It is a very important step forward in interregional collaboration, which ICFA regards as an excellent precedent.

External correspondents

Argonne National Laboratory, (USA)
D. Ayres

Brookhaven, National Laboratory, (USA)
P. Yamin

CEBAF Laboratory, (USA)
S. Corneliussen

Cornell University, (USA)
D. G. Cassel

DESY Laboratory, (Germany)
P. Waloschek

Fermi National Accelerator Laboratory, (USA)
Judy Jackson

GSI Darmstadt, (Germany)
G. Siegert

INFN, (Italy)
A. Pascolini

IHEP, Beijing, (China)
Qi Nading

JINR Dubna, (Russia)
B. Starchenko

KEK National Laboratory, (Japan)
S. Iwata

Lawrence Berkeley Laboratory, (USA)
B. Feinberg

Los Alamos National Laboratory, (USA)
C. Hoffmann

NIKHEF Laboratory, (Netherlands)
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Novosibirsk Institute, (Russia)
S. Eidelman

Orsay Laboratory, (France)
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IHEP, Serpukhov, (Russia)
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Stanford Linear Accelerator Center, (USA)
M. Riordan

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M. K. Craddock

MIT

PRINCIPAL RESEARCH SCIENTIST/ RESEARCH SCIENTIST

The Laboratory for Nuclear Science is seeking applicants for a research staff position with the Medium Energy Physics Group. This position is associated with the construction and operation of the Bates Large Acceptance Spectrometer Toroid (BLAST), a detector which has recently been approved for construction at the Bates Linear Accelerator Center (operated by MIT for the Department of Energy). BLAST will be the critical detector for internal target experiments using the new Stretcher/Storage Ring at Bates. An important responsibility of the MIT Medium Energy Physics Group in the BLAST project is the construction of the multi-wire drift chambers for particle tracking. The person we are seeking will play a leadership role in the construction, testing, and installation of these chambers.

Requirements: a Ph.D. in nuclear or high energy physics, significant experience beyond the graduate level, and experience in the construction of large multi-wire chambers. The level of this position (Principal Research Scientist or Research Scientist) will depend on the qualifications of the candidate.

*Applications should include a curriculum vitae, a list of publications, and the names of at least three scientists who could be asked to write letters of recommendation. Applications should be sent before **April 15, 1997** to: **Prof. June L. Matthews, Room 26-433, MIT, 77 Massachusetts Avenue, Cambridge, MA 02139.** Qualified women and minorities are encouraged to apply.*

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Niels Bohr Institute for Astronomy, Physics and Geophysics

Professorship in Theoretical High Energy Physics

A professorship in theoretical high energy physics will become available as of October 1, 1997, at the Niels Bohr Institute for Astronomy, Physics and Geophysics. The high energy theory group at the Institute consists of 5 staff members and 10-15 guests, postdocs and graduate students. The group works in field theory, cosmology, quantum gravitation, string theory and related subjects. The areas of particular interest for the present professorship are the physics at the interface between particle physics and astrophysics, condensed matter physics and non-linear physics.

The high energy theory group works in close contact with the NORDITA high energy group and with the theoretical groups in complex systems and astrophysics at the Institute and NORDITA.

The successful candidate must have documented original theoretical research at the highest level within theoretical high energy physics and will be expected to contribute to the Institute's teaching programme at both graduate and undergraduate levels.

The application must include a *curriculum vitae* and a complete list of publications with a special indication of which publications are considered most relevant for this position. Information about teaching experience must also be enclosed.

The applications will from the Faculty of Science receive a list of applicants for the position. A specially appointed committee will evaluate the applicants' qualifications and also the entire report of the committee will be sent to all applicants. The list of applicants and the evaluation of fellow applicants must be treated confidentially by all applicants. The evaluation committee may ask for supplementary material, which the applicant then must provide in the requested number of copies.

Information about research plans, facilities and staff may be obtained from the Director, Professor Ole Hansen, Niels Bohr Institute for Astronomy, Physics and Geophysics, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark; telephone: +45 35325292, fax: +45 35431087, E-mail: oleh@nbi.dk. Homepage: htt://www.nbi.dk/NBIfAFG/.

The appointment is made according to a continuing contract as agreed between the Ministry of Finance and the Danish Confederation of Professional Associations. The annaul salary is approx. DKK 430,500 after contribution to the pensions scheme.

The application, *marked "5207-P/1-97"* and written in English, must formally be made to the Rector of the University of Copenhagen and mailed to the Faculty of Science, Øster Voldgade 3.DK-1350 Copenhagen N, Denmark. *Applications, in order to be considered, must be received by the Faculty of Science not later than May 1, 1997, at noon.*

Three copies of the application, as well as three copies of a brief outline of proposed research and three copies of the most relevant publications, should be mailed to the Director of the Niels Bohr Institute for Astronomy, Physics and Geophysics. No further material should be forwarded until requested.

POSTDOCTORAL POSITION IN EXPERIMENTAL HIGH ENERGY PHYSICS

The ATLAS Group at the **Lawrence Berkeley National Laboratory** has an immediate opening for a postdoctoral candidate in experimental High Energy Physics. The LBNL group is part of the ATLAS collaboration, building one of the two large experiments at the CERN Large Hadron Collider. The LBNL group is engaged in the design and construction of the ATLAS silicon strip and pixel trackers. We are currently working on the electronics and detector module design for the silicon strip tracker. And we are also engaged in the design of the ATLAS pixel system, including the mechanics and cooling, the electronics, detectors and preparations for detector module construction.

The successful candidate will participate in the design and fabrication of the ATLAS silicon strip and/or pixel systems. The candidate is expected to take a major role in the analysis of laboratory and test beam data for silicon strip and pixel systems. Experience in the area of silicon systems is preferred. This position is a two-year term appointment.

Please send a Curriculum Vitae and three letters of reference by April 1, 1997, to: **Betty Moura, 50E-124, Lawrence Berkeley National Laboratory, Job #PHY/4858, 1 Cyclotron Road, Berkeley, CA 94720.** LBNL is an Equal Opportunity Employer committed to the development of a diverse workforce.

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Telefax: 022/782 19 06

Inquiries for the rest of the world:

please see page III