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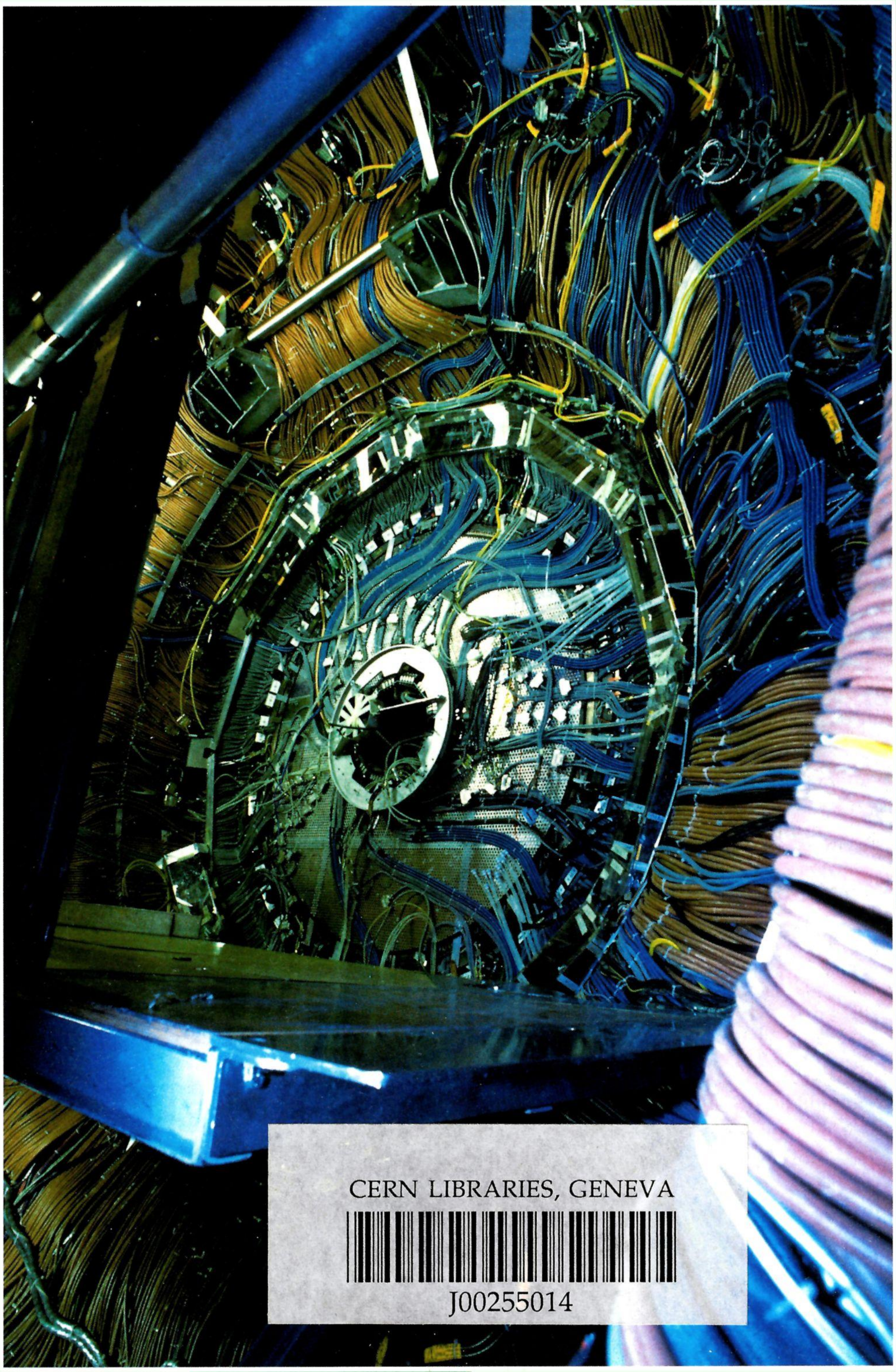

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Around the Laboratories

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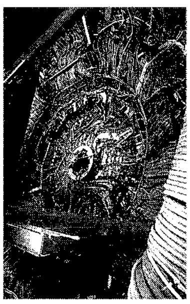

Cover photograph: End-on view of the 10-metre diameter Delphi detector at CERN's LEP electron-positron collider. Its concentric modules, including a pioneer large-scale application of the Ring Imaging Cherenkov technique to differentiate between all the various secondary charged particles, ensure high precision and 'granularity'. Design and construction of the detector took seven years. The collaboration currently consists of about 550 physicists from 56 participating universities and institutes in 22 countries.

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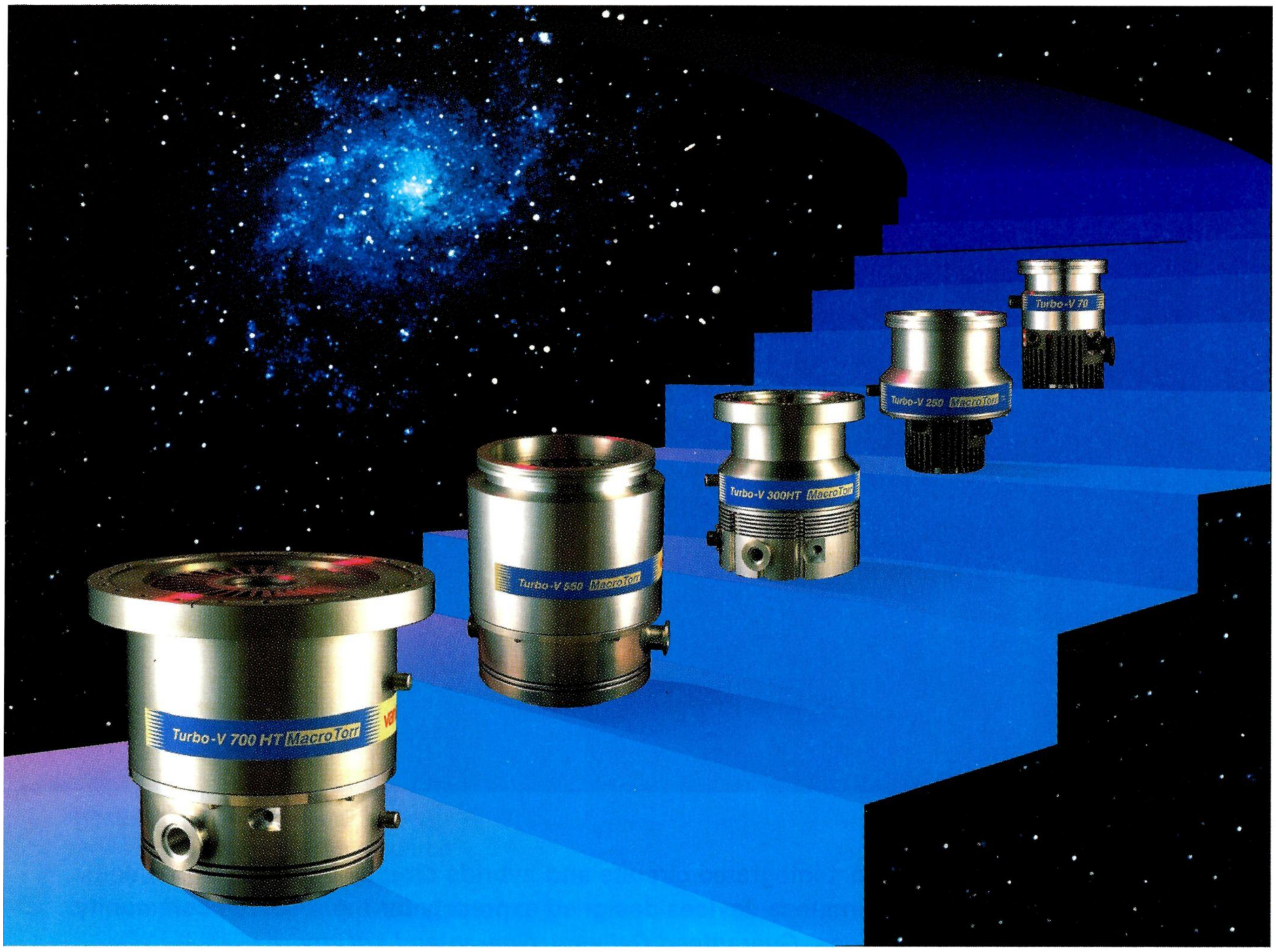

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Around the Laboratories

BROOKHAVEN
New US - Japanese Physics Centre

A recent decision by the Japanese Parliament paves the way for the Japanese Institute of Physical and Chemical Research (RIKEN) to found the RIKEN Research Center at Brookhaven with $2 million in funding in 1997, an amount that is expected to grow in future years.

T.D. Lee, who won the 1957 Nobel Physics Prize for work done while visiting Brookhaven in 1956 and is now a professor of physics at Columbia, has been named the Center's first director.

The Center will host close to 30 scientists each year, including postdoctoral and five-year fellows and visiting scientists. Its research focus will begin with theoretical physics but will eventually expand to include experimental studies.

With Brookhaven the home of the Relativistic Heavy Ion Collider (RHIC), to begin operation in 1999, the new Center's research will relate to the experiments that will be performed at RHIC by scientists from 19 countries.

RHIC's main purpose is to collide heavy nuclei such as gold at high energy to continue the search for the long-awaited quark-gluon plasma, the precursor of conventional nuclear matter as the Universe cooled in the wake of the Big Bang.

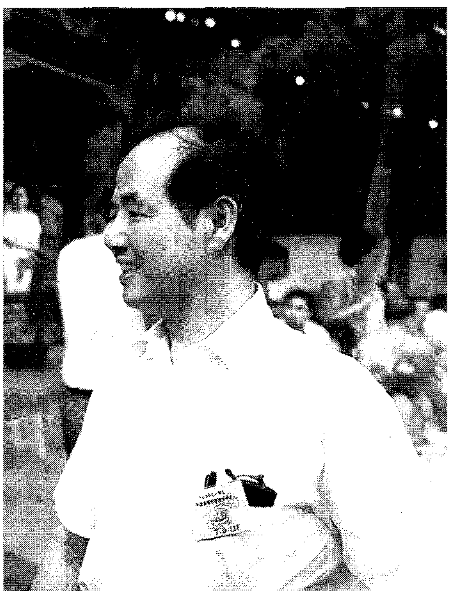
But RHIC took on an additional, complementary mission in 1995, when RIKEN agreed to contribute $20 million to equip RHIC for the study of the world's highest-energy spin-polarized protons (November 1995, page 1). Scientists hope that such studies will help our understanding of subnuclear particles.

Said Lee, "The progress of physics depends on young physicists opening up new frontiers. The RIKEN - Brookhaven Research Center will be dedicated to the nurturing of a new generation of scientists who can meet the challenge that will be created by RHIC."

RIKEN, a multidisciplinary lab like Brookhaven, is located north of Tokyo and is supported by the Japanese Science & Technology Agency.

The new Center's research will relate entirely to RHIC, and does not involve other Brookhaven facilities.

T.D. Lee is first director of the new RIKEN US-Japanese Research Center at Brookhaven.



CERN
Antiproton encore

At the end of 1996, the beam circulating in CERN's LEAR low energy antiproton ring was ceremonially dumped, marking the end of an era which began in 1980 when the first antiprotons circulated in CERN's specially-built Antiproton Accumulator.

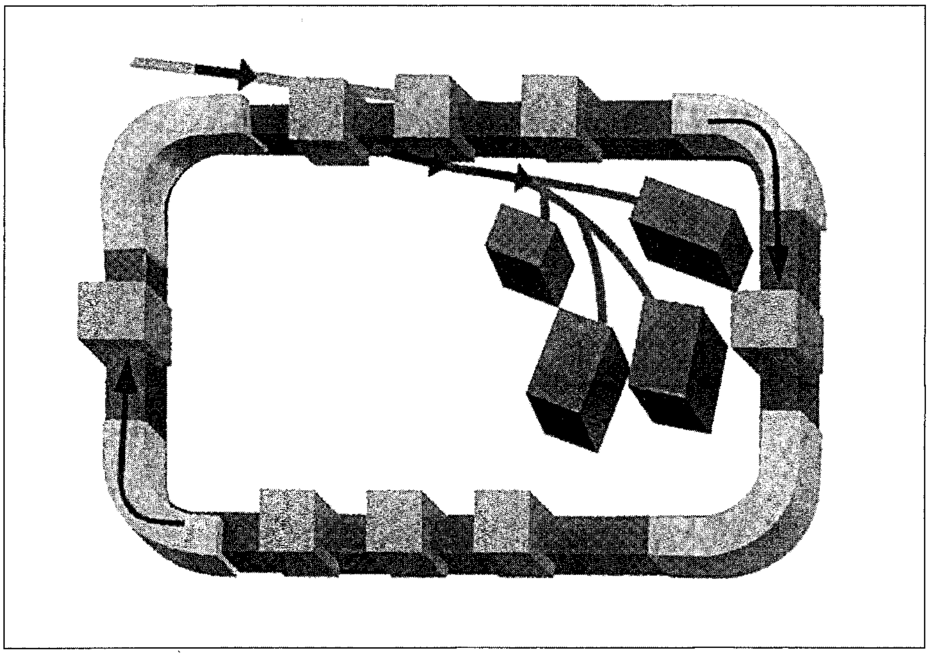
With the accomplishments of these years now part of 20th-century science history, for the future CERN is building a new antiproton source – the antiproton decelerator, AD – to cater for a new range of physics experiments.

The invention of stochastic cooling by Simon van der Meer at CERN made it possible to mass-produce antiprotons. With these beam cooling techniques available, Carlo Rubbia proposed transforming CERN's then new SPS proton synchrotron into a high energy proton-antiproton collider and building big experiments to search for the W and Z carrier particles of the weak nuclear force.

With CERN anxious to spread its research wings, the message fell on fertile ground. In 1983, just three years after CERN accelerated its first antiprotons in the specially built Antiproton Accumulator, the W and Z were in the bag and the following year Rubbia and van der Meer were awarded their Nobel Prize.

While the W and Z were the big prizes, this was not the only new physics that antiprotons could provide, and alongside the big machines the LEAR ring decelerated the particles for another range of physics. LEAR hit the headlines in 1995 when a team working with a special gas jet target at the Jetset

For the future CERN is building a new antiproton source - the antiproton decelerator, AD - to cater for a new range of physics experiments. The AD will be built using the former Antiproton Collector (AC) ring, commissioned in 1987 to supplement the original Antiproton Accumulator and serve a new experimental area inside the ring's four straight sections, two of 28m and two of 15m, linked by densely packed magnet arcs.



experiment saw the world's first atoms of antimatter (January 1996, page 1).

The discovery of atomic antimatter made headlines across the world, but the big scientific question remained unanswered – does antimatter behave in exactly the same way as matter? Subtle differences between the behaviour of matter and antimatter could have significant implications for our understanding of how the Universe as we know it emerged from the Big Bang.

To answer this question, LEAR would no longer be available, its destiny having already been decided. LEAR will now be converted into the LEIR ion ring to prepare beams of lead ions and other heavy nuclei prior to injection into CERN's new LHC collider, to come into operation in 2005.

The new AD antiproton source will be built using the former Antiproton Collector (AC) ring, commissioned in 1987 to supplement the original AA and relieve it of the onerous task of precooling the injected antiproton beam prior to stacking in the AA. In this way CERN's antiproton levels were boosted tenfold.
The AC/AD transformation cost of some 7 million Swiss francs plus some external manpower will be provided by special contributions from several countries, including Denmark, Germany, Italy, Japan, Poland and the US.

The 'ring' has four straight sections, two of 28m and two of 15m, linked by densely packed magnet arcs. The AA and AC were concentric, with the AC on the outside. Dismantling the AA ring liberates space for a new experimental area enclosed by the AD.

For the AD, antiprotons, selected at 3.57 GeV/c in the traditional way, will continue to be produced by 26 GeV protons using a special production target at the PS proton synchrotron, using the latest improvements in beam handling techniques.

Initial stochastic cooling will reduce momentum spreads to just 0.1%, after which the antiprotons will be decelerated to 2 GeV/c momenta and the resultant beam blow-up compensated by further stochastic cooling.

The existing 1.6 MHz radio-frequency system to decelerate the antiprotons will be modified to cover a frequency range of 0.5 - 1.6 MHz, while the system used to rotate the particle bunches has to be moved to free space for the new electron cooling system.

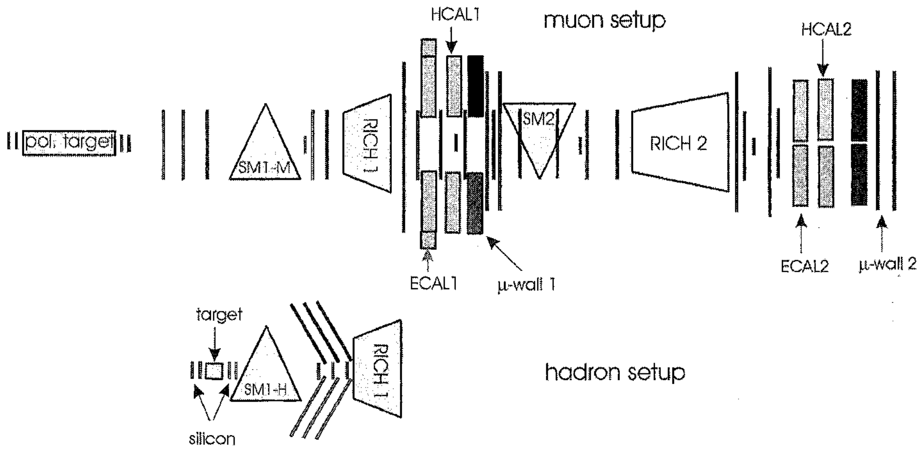
When deceleration has reached 300 MeV/c momenta, electron cooling becomes the order of the day. Using the cooler previously used at LEAR, momenta will finally reach a floor at 100 MeV/c. At these energies, an estimated 25% of the original bunches of 5 x 10^7 antiprotons should survive. At this stage, the antiprotons will be ready for ejection into the waiting beamlines serving the experiments.

With the exploration of antihydrogen or similar anti-atoms high on the agenda, the new ATHENA and ATRAP experiments will use magnetic trapping techniques to create and capture more than 1000 neutral atoms of antihydrogen per hour, and using precision laser techniques for hyper-accurate spectroscopy.

Another experiment will be by a Japanese-European collaboration to continue the exploration of antiprotonic atoms, where a LEAR experiment by a Tokyo/Okazaki/Munich/Budapest/CERN team discovered that antiprotonic helium can be extraordinarily stable (December 1994, page 18). Earlier this year, the Japanese Ministry of Education, Science, Sports and

Culture (Monbusho) announced this project had been selected as an important ongoing project.

The AD construction schedule sees the new ring being commissioned in 1998 and ready to supply its first antiprotons in 1999.



The COMPASS spectrometer at CERN's SPS proton synchrotron will combine a common core with interchangeable elements for proton (hadron) and muon beams. The common equipment consists of ring-imaging Cerenkov counters, RICH, electromagnetic and hadronic calorimeters, ECAL and HCAL, muon filters, and the spectrometer magnet SM2. The main difference between the two configurations will be the target system and upstream spectrometer magnet, SM1-H.

Set a course for the future

With the closure of the Omega spectrometer (March, page 2) still fresh in people's minds, CERN has ensured a future for the multipurpose spectrometer concept with initial approval of the COMPASS programme.

COMPASS, which stands for Common Muon and Proton Apparatus for Structure and Spectroscopy, will physically take the place of the Spin Muon Collaboration, SMC, apparatus in CERN's high intensity muon beam (January, page 2). Its initial physics aims will be to continue the work of SMC into nucleon structure, and to study in detail the hadron spectrum. For this latter task, the muon beamline will be modified to transport hadrons with energies up to 300 GeV as well as muons.

Deep inelastic scattering experiments in which a high energy projectile scatters from a quark inside a nucleon were pioneered at SLAC, Stanford, in the 1960s. These experiments demonstrated that nucleons are made up of small pointlike objects, which subsequent studies using neutrino beams at CERN's Gargamelle bubble chamber showed to be quarks. A later experiment conducted by the European Muon Collaboration, EMC, at CERN in the mid 1980s showed that these quarks carry only a small fraction of the nucleon's spin. The SMC, with its high quality polarized target, took over from the EMC, and has gone as far as it can in quantifying this effect.

Current thinking points to gluons as contributing to the nucleon's spin, and this is one of the ideas COMPASS will put to the test.
By looking for charmed mesons emerging from deep inelastic scattering events, COMPASS will probe the gluonic content of the nucleus. This is because charmed particles are mainly produced when a virtual photon radiated by the incident muon combines with a gluon from the target nucleon.

This method has been used in the past by the EMC to measure the momentum distribution of gluons in the nucleon. COMPASS will use a polarized target to probe the gluon spin. By measuring charm production in deep inelastic scattering, COMPASS aims to provide the definitive answer to a question which has been troubling physicists for over a decade.

Charmed particles play a major role in the COMPASS hadron beam programme too. In what is likely to be experimentally the most challenging part of the programme, charmed hadron decays producing a pair of leptons or a lepton and another hadron will be studied. This will probe the internal structure of charmed mesons, and investigate the transitions from heavy to light quarks in heavy hadron decays. Further ahead, COMPASS plans to search for baryons containing two charmed quarks, extending the currently known baryon spectrum.

In the shorter term, the spectroscopy programme will address another long standing question. It will look for so-called exotic particles made up of quarks and gluons - particles such as glueballs, composed only of gluons, quark-gluon hybrids, and quark-antiquark combinations which do not fit into existing meson multiplets. The COMPASS experiments will complement studies recently completed at CERN's LEAR Low Energy Antiproton Ring, where new evidence for glueballs has been collected by the Crystal Barrel detector (October 1996, page 4).

With its unusual mixture of muon and proton physics, COMPASS has attracted researchers with a diverse range of backgrounds. The core of the SMC collaboration brings two decades of muon physics experience, whilst researchers from facilities as varied as LEAR and the Omega spectrometer, both recently closed, will carry on their studies with COMPASS.

But this disparity in experimental background disguises a great similarity in physics goals. Although their methods were different, COMPASS members hailing from LEAR, Omega, and the SMC have all been involved in studying the structure of hadrons, and COMPASS is a logical place for them to come together.

The programme foreseen for COMPASS is to build a state-of-the-art spectrometer capable of handling up to $2x10^8$ particles per two-second spill from CERN's SPS Super Proton Synchrotron. This will be ready by 1999. An initial five-year period of running is foreseen, after which the progress made will determine any future programme.

With COMPASS and the recently approved AD Antiproton Decelerator (page 1) both set to start physics after the LEP Large Electron Positron collider switches off, CERN's period of waiting for the LHC looks set to be full of new physics.

FERMILAB
Permanent magnets and the Antiproton Recycler Ring

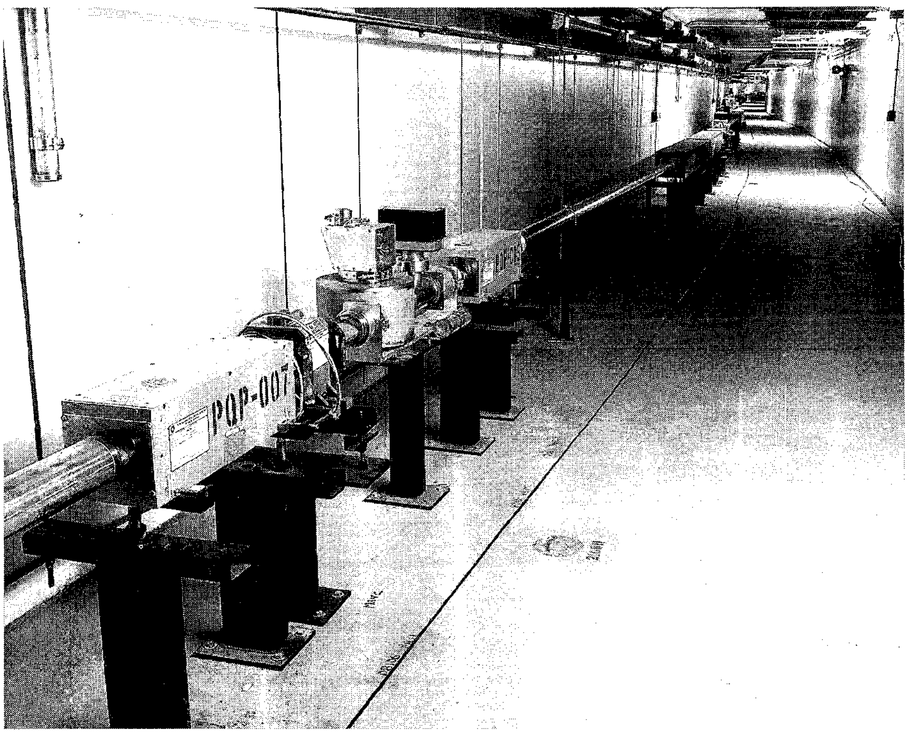
The Fermilab Main Injector project and the Tevatron luminosity upgrades made a major step forward February 20 with the successful first operation of the permanent magnet 8 GeV line. The achievement marks the first large-scale use of permanent magnets for high-energy accelerators*, and helps establish permanent magnets as a cost-saving and effective accelerator technology. The 8 GeV line will connect Fermilab's new Main Injector to the Fermilab Booster, and is the first-commissioned component of the Main Injector project.

(*However permanent magnets are in widespread use as insertion devices – wigglers and undulators – in synchrotron radiation sources and free electron lasers: several facilities use ten or more, each up to 4.5 m in length.)

Fermilab is also building permanent magnets for the newly approved Antiproton Recycler Ring, an important addition to the Fermilab accelerator complex and a key factor in the rising luminosity of the Tevatron.

Fermilab's permanent magnets use strontium ferrite, an inexpensive commercially available material used mainly for automotive and consumer applications. (The average new automobile uses about 10 kg of the stuff.)

A steel pole tip shapes the magnetic field, in a "hybrid" configuration pioneered by Klaus Halbach. This scheme allows an extremely precise magnetic field



Fermilab recently operated a new 8 GeV beamline using permanent magnets. The line will connect Fermilab's new Main Injector to the Fermilab Booster, and is the first-commissioned component of the Main Injector project. The achievement marks the first large-scale use of permanent magnets for high-energy accelerators.

A view of Fermilab's permanent magnet factory, with the ferrite brick magnetizing station in the foreground and several magnets under assembly on the central floor.

determined by the accurately machined pole tip, while using inexpensive permanent magnet material to drive the magnetic field.

"What we will be doing with the Recycler is making a low-cost antimatter bottle out of refrigerator magnets," according to magnet designer and 8 GeV Line Project Manager Bill Foster.

Use of permanent magnets for the 8 GeV line was a key factor in the recent advance in the Main Injector schedule. For example, the milestone of delivering first beam to the "833" location halfway down the 8 GeV line, originally scheduled for 1998, was rescheduled for June 1997, and actually achieved on February 20.

Dipole magnet production for the Main Injector is ahead of schedule and under budget. As a result, Fermilab recently advanced the overall schedule for the final construction phase of the Main Injector by several months. (The final construction phase requires decommissioning and salvaging components from the venerable Fermilab Main Ring.)

Initial commissioning of the 8 GeV line took less than two hours. After some initial troubles convincing the controls system to fire the extraction magnets to send the beam out of the Booster and towards the Main Injector 8 GeV transport line (rather than to its habitual destination, the Main Ring), and some delicate beam steering through a string of electromagnets used to snake the beam out of the 25-year old Booster, the crew launched the beam into the long string of 84 permanent magnets. After this point the control room crew had almost no ability to control the beam transport. If even a single magnet had been misaligned, installed with the wrong polarity, or constructed slightly off strength, the beam would have been hopelessly lost, leaving the crew without the usual fallback options of reversing leads or changing power supply settings on conventional electromagnets.

However, almost immediately instrumentation began to detect signs of beam activity at the far end of the line. Main Injector Project Manager Steve Holmes, waiting anxiously in the back of the control room, went out into the driving rain to a remote service building to watch the camera that had been set up to view a fluorescent flag, a small sheet of fluorescent material that lights up when the beam passes through. When the phone call came back to the control room and Main Injector Department Head Phil Martin announced that Holmes could see a clear signal of beam on the flag, thoughts quickly turned to the champagne locked away in a nearby refrigerator.

In a related development, the Fermilab Antiproton Recycler Ring received formal approval from the US Department of Energy for inclusion as part of the Main Injector construction project. The Recycler's mission is to recover and reuse the antiprotons that remain from previous collider stores, and to store the enormous quantities of antiprotons required for ongoing luminosity upgrades to the Tevatron.

Permanent magnets are ideal for this because of their inherent reliability, the fixed energy of the ring, and the low field strength required. (The reliability issue is familiar to experimenters accustomed to the anguish of seeing a day's worth of painstakingly collected antiprotons evaporate in a power-supply trip or other magnet failure...) The permanent magnets will save approximately $100,000 in annual power costs for the 8 GeV line and Recycler.

The hybrid permanent magnets demonstrate the excellent field quality that can be obtained in iron magnets. Prototype Recycler magnets show total field defects of a few parts in 100,000 across the aperture of the magnet. Costs are low and well understood, on the

basis of the successful production of magnets for the 8 GeV line. Permanent magnets also have advantages because of the fast time scale required. Only two years elapsed between the first 10 cm prototype magnet and the first beam through the 8 GeV line. Magnet production and commissioning of the Recycler will proceed in parallel with the Main Injector in 1998-9. The low-tech aspect of the production of the permanent magnets made the setup and tooling of a new magnet factory (in an unused experimental hall) a quick and straightforward operation.

When complete, the Recycler will be the eighth largest accelerator in the world, built for a total of only $12.5M. Although the direct benefit of the Recycler is about a factor of two, Fermilab expects it will serve as a platform for eventually raising the Tevatron's luminosity (a measure of the proton-antiproton collision rate) by a factor of 10 to 10^{33} per sq cm per sec or above. "The history of the Tevatron luminosity is exponential, with a doubling time of about 1.5 years. The Recycler Ring keeps us on that curve," said Recycler Project Manager Gerry Jackson.

Meanwhile, the detector collaborations are scrambling to keep up with luminosity improvements. Both DZero and CDF have undergone recent successful Department of Energy reviews and established their baseline funding. Both collaborations are actively seeking help in taking and analysing the data that will come pouring in beginning in 1999 when the Main Injector and the first of a series of luminosity upgrades kick in. Luminosity increases in the years following 1999 will require new and advanced hardware upgrades.

The potential physics payoff from the luminosity upgrades to the Tevatron is handsome. When the luminosity upgrades are completed, the Tevatron will have the data either to discover or exclude minimal supersymmetry, to discover the light higgs (slipping out of reach at LEP at CERN), and to perform precision measurements of the top quark recently discovered at Fermilab.

The low cost and high reliability of permanent magnets make them certain to find other uses. Foster cites their possible use in injection accumulators (where they could increase the average intensity of circular accelerators), the bending arcs of recirculating linacs, low-cost high stability synchrotron light sources, and inexpensive and reliable beam transport lines for energy upgrades at Fermilab.

A step in the right direction

To its credit, the 450-member DZero collider detector collaboration at Fermilab's Tevatron proton-antiproton collider has begun publishing brief "plain English" summaries of the physics research papers that the collaboration submits for publication.

As an integral part of the publication process, collaborators explain the results and make clear how they fit into the picture of current particle physics research in language understandable to nonphysicists. The DZero collaboration has made the summaries available on the World Wide Web (http://www- d0.fnal.gov/ public/pubs/ d0_physics_summaries.html) and is considering other methods of getting out the word.

DZero spokesperson Harry Weerts said the group began the practice of writing brief summaries of research results for nonphysicists in response to the collaboration's perception of "a general need for high-energy physicists to communicate what we do."

It is only natural that any specialized community develops its own jargon, and physics-speak is no exception. However the CERN Courier, with its circulation of 27,500, has always been very aware of the need to explain the significance of particle physics discoveries to a wider audience, unscrambling the arcane information routinely disseminated in physics papers and seminars. The people out there want to understand the significance of the latest particle physics discoveries, but the quantum mechanical message is not always easy to get across. Retrenching behind a wall of impenetrable jargon is not the way to do it.

An example of DZero's Plain-English summaries is their 'Search for Diphoton Events with Large Missing Transverse Energy'.

"Once again, extending the Standard Model will take longer than recently had been hoped. This theory provides an excellent description of the observed interactions of the most fundamental constituents of matter (the quarks and leptons). However there are good theoretical reasons to assume that it is just an approximation to, or part of, a larger and more general theory.

One of the most popular suggestions for this larger theory is Supersymmetry (SUSY), which introduces a new symmetry between fundamental particles and predicts that there should be a supersymmetric partner for each of the presently observed particles. None of the superpartners has yet been observed, but over the past year

The 450-member DZero collider detector collaboration, some of whom are seen here, at Fermilab's Tevatron proton-antiproton collider has begun publishing brief "plain English" summaries of the physics research papers that the collaboration submits for publication.

there has been considerable theoretical speculation that a single event observed by the CDF detector at Fermilab, and reported at conferences this last summer, might be indicative of SUSY. This event contained two electrons, two photons and unbalanced (missing) transverse energy. Missing transverse energy is often used as a pointer to possible SUSY signals because it could indicate the escape of a non-interacting SUSY particle (like the lightest superpartner) from the detector.

Physicists in the D0 ("DZero") Collaboration have recently submitted a paper to Physical Review Letters describing a similar search for SUSY particles. They used the D0 detector at the Fermilab Tevatron Collider, where protons and antiprotons are made to collide in the world's highest energy particle accelerator. The D0 detector uses a calorimeter consisting of uranium and liquid argon to measure the energy of all the interacting particles produced in the proton-antiproton collisions. This detector technique affords an excellent measurement of missing transverse energy.

The D0 physicists searched for events with two photons and missing transverse energy, which could signal pair production of SUSY particles. From over 100 million interactions recorded in the 1992-95 data-taking run, 842 events contained two good-quality photons. However, none of these events is found to have unexpectedly large missing transverse energy. They therefore fail to confirm the kind of SUSY model inspired by the CDF event, and in fact rule out a significant fraction of them.

There are still good reasons to believe that SUSY may exist; it could well be that the superpartners are produced too rarely to be seen in the current data sample. For this reason, the Fermilab accelerator and detectors are in the midst of a major upgrade that will increase the collision rate by a factor of twenty in the next data-taking run, scheduled for 1999."

Other experiments, please take note.

BOULDER/ NOVOSIBIRSK New nuclear moment

After a long search by several teams, Carl Wieman's group from the Joint Institute of Laboratory Astrophysics, Boulder, Colorado, (already famous for their recent discovery of Bose Einstein condensation - November 1995, page 12) has experimentally discovered an unusual 'anapole' moment of the nucleus cesium 133.

Forty years ago, V. Vaks and Ya. Zel'dovich pointed out that a system which does not reflect under space inversion (has no definite parity) generates a special distribution of magnetic fields which looks like the magnetic field created by a current in toroidal winding, and differs from the fields due to common electromagnetic multipoles, such as e.g. dipole or quadrupole moments. This electromagnetic field was called an anapole.

For many years the anapole remained a theoretical curiosity, but the situation changed with the investigation of parity non-conservation in atoms. Since these small effects increase with the nuclear charge, Z, all the experiments are carried out with heavy atoms. The main contribution to the effect is independent of nuclear spin and caused by the parity-odd weak interaction of electron and nucleon neutral currents. This interaction is proportional to the so-called weak nuclear charge Q, numerically close (apart from its sign) to the neutron number N. Thus in heavy atoms the nuclear-spin-independent (NSD) weak interaction is additionally enhanced about a hundredfold.

NSD effects due to neutral currents not only lack the mentioned coherent enhancement but are also strongly suppressed in the electroweak theory. Therefore the observation of parity-odd NSD effects in atoms looked absolutely unrealistic.

However, in 1980 V. Flambaum and I. Khriplovich from the Budker Institute of Nuclear Physics, Novosibirsk, demonstrated that these effects in atoms are mainly caused not by the weak interaction of neutral currents, but by the electromagnetic interaction of atomic electrons with the nuclear anapole moment.

The magnetic field of an anapole is completely contained, in the same way as the magnetic field of a toroid is completely confined by the winding. It means that the electromagnetic interaction of an electron with the nuclear anapole occurs only as long as the electron wave function penetrates the nucleus. In other words, this electromagnetic interaction is as local as the weak interaction, making it difficult to distinguish between them.

The nuclear anapole arises due to parity-odd nuclear forces and is therefore proportional to the magnitude of the weak interactions in general and that of neutral currents in particular. The electron interaction with the anapole, due to its electromagnetic nature, introduces an additional small factor, the fine-structure constant 1/137. How does this effect become dominant?

The answer follows from the same analogy with a toroidal winding. The interaction is proportional to the magnetic flux through such a winding, in this case to the cross-section of the nucleus, i.e. to 2/3A where A is the atomic number. In heavy nuclei this enhancement factor is close to 30 and essentially compensates for the smallness of the fine-structure constant.

As a result, the dimensionless effective constant which characterizes the anapole interaction in standard weak interaction units is not so small in heavy atoms, numerically close to 0.3. Nevertheless, the interaction discussed constitutes only about one percent of the main atomic parity-odd effect independent of the nuclear spin, which is caused by the weak charge Q and is enhanced therefore as N.

To single out the anapole interaction requires comparing parity-odd effects at different hyperfine components of an optical transition. The main effect, independent of the nuclear spin, will be obviously the same at all components. But the anapole interaction depends on the mutual orientation of the nuclear spin and the electron total angular momentum and changes therefore from one hyperfine component to another.

The observation of this tiny effect is extremely difficult and it is no accident that its discovery required many years of hard work by several groups. The result obtained at Boulder for the total effective constant of the parity-odd NSD interaction is 0.44(6), derived from the experimental data using the results of atomic calculations done in Novosibirsk by P. Frantsuzov and I. Khriplovich, and by A. Kraftmakher.

If one excludes from the above number the neutral current NSD contribution, as well as the result of combined action of the weak charge Q and the usual hyperfine interaction, the anapole constant becomes 0.37(6).

Thus a new physics phenomenon, an unusual electromagnetic multipole, has been discovered. Seventy years ago studies of atomic hyperfine structure gave the first clue to nuclear magnetic moments. Since then atomic and molecular spectroscopy has served as a source of valuable information on nuclear properties, such as multipole moments and nuclear radii. Now a chapter in the story begins as optical spectroscopy reveals parity-odd effects in nuclear forces.

Physics monitor

Half a century of synchrotron radiation

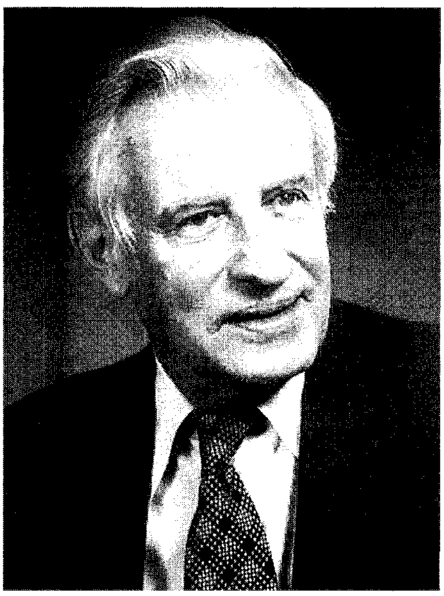
Hard on the heels of the 50th anniversary of the synchrotron (September 1996, page 10) comes the 50th anniversary of synchrotron radiation. On 24 April 1947, Herb Pollock, Robert Langmuir, Frank Elder and Anatole Gurewitsch saw a gleam of bluish-white light emerging from the transparent vacuum tube of their new 70 MeV electron synchrotron at General Electric's Research Laboratory, Schenectady, New York. Synchrotron radiation had been seen.

However the synchrotron radiation story goes back a long way. The General Electric machine was the second synchrotron to operate, the first having been a small 8 MeV machine at the UK Telecommunications Establishment, Malvern. Unfortunately the UK machine did not have a transparent vacuum tube.

Nor is synchrotron radiation restricted to synchrotrons. Electromagnetic radiation is produced whenever a beam of charged particles loses energy when it is bent in a field, a sort of electromagnetic centrifugal effect. Thus it could equally well be called 'betatron radiation', in honour of the first circular accelerators built to handle electrons. The betatron was first demonstrated by Donald Kerst and Robert Serber at Illinois in 1941, and development work was taken up by General Electric. However these early betatrons, like the UK synchrotron (which in fact was an imported GE betatron), did not have transparent vacuum tubes.

Although it was invisible, 'synchrotron' radiation was nevertheless there and was sapping the energy of the betatron beam. In 1945 John Blewett, then at General Electric, calculated that synchrotron radiation resulted in an energy loss of about 10 electronvolts per revolution, and predicted a resultant tiny orbit shrinkage. The measurement of this shrinkage was the first indirect observation of synchrotron radiation effects.

But the idea of synchrotron radiation goes back much further. Maxwell's grand formulation of electromagnetism in 1864 was a watershed in understanding and new insights proliferated in the ensuing years. Widely credited as the 'inventor' of synchrotron radiation is the French physicist Alfred Lienard of the Ecole des Mines in Paris, who in a 1898 paper in the journal "L'Eclairage Electrique" (Electric Lighting) described the concept of retarded potentials in the calculation of the effects due to the motion of charged particles, and worked out a basic theory of what is now known as synchrotron radiation and which is still followed in modern textbooks. This work was supplemented by Emil Wiechert at Göttingen, so that the formalism is generally known as the Lienard-Wiechert potentials.



Synchrotron pioneer John Blewett, who in 1945 at General Electric calculated that synchrotron radiation resulted in an energy loss of about 10 electronvolts per revolution, and predicted a resultant tiny orbit shrinkage. Its measurement was the first indirect observation of synchrotron radiation.

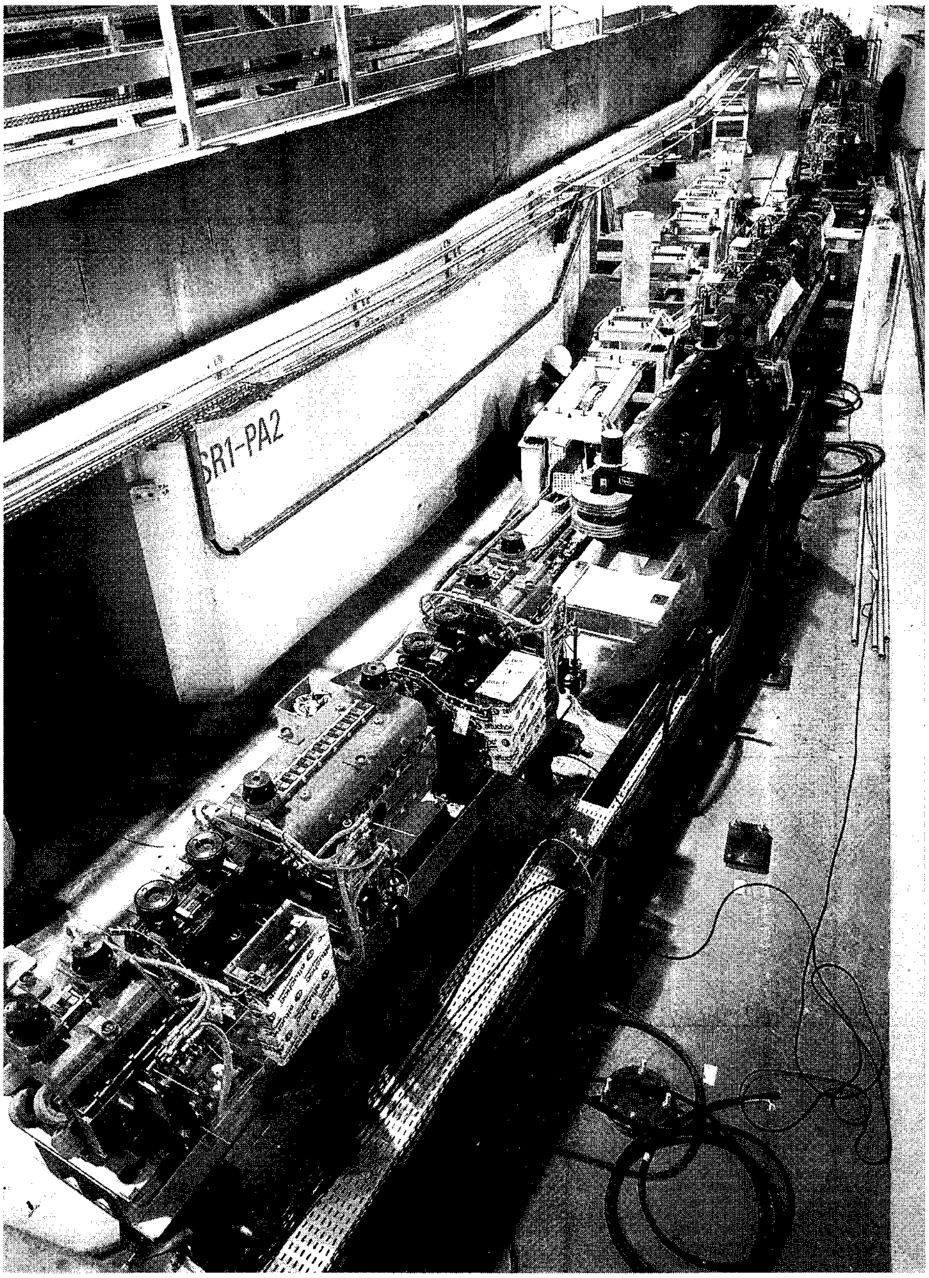
Lienard's paper appeared just after the discovery of the electron by J.J. Thomson exactly one hundred years ago at Cambridge. (The electron concept and the elucidation of cathode rays had been in the air for some time, but Thomson's measurement of the ratio of the electron's charge/mass ratio is generally accepted as the official discovery.) However, according to synchrotron radiation pioneer John Blewett, an embryonic idea of synchrotron radiation can be traced as far back as 1867, to Ludwig Lorenz.

The next major development in the formulation of synchrotron radiation theory came in1908 from G.A. Schott, first as a student at Cambridge, then at Aberystwyth, Wales, in a prizewinning paper on the mechanical reactions of electromagnetic radiation.

The idea lay dormant for several decades before being picked up by Isaak Pomeranchuk in Russia in 1940, at about the same time that Kerst and Serber were getting their betatron to work. Betatrons were also being developed in Russia, where Pomeranchuk and D. Iwanenko in 1944 looked at the problem of radiation losses in higher energy machines.

Perhaps the crowning achievement in this theoretical understanding came from an unexpected source - Julian Schwinger. Unexpected, in the sense that Schwinger's name is eternally linked with the development

Synchrotron radiation is now a flourishing branch of science, with dedicated major facilities such as the European Synchrotron Radiation Facility at Grenoble.



of relativistic quantum electrodynamics in the immediate post-war period, rather than with classical problems.

However Schwinger had mastered the trade of classical electrodynamics in his wartime efforts on microwave propagation at the MIT Radiation Laboratory, work which had a direct bearing on highly effective new radar techniques.

Schwinger continued to follow this up, and showed that synchrotron radiation contains many higher harmonics, extending into the visible range. In 1949, shortly after his monumental papers on relativistic electrodynamics for which he went on to receive the 1965 Nobel Prize, he published another elegant masterpiece - 'On The Classical Radiation of Accelerated Electrons', which definitively updated earlier work.

Synchrotron radiation was initially a nuisance, sapping energy from circulating electron beams and upsetting calculations. Gradually physicists learned that the tangential fan of synchrotron radiation 'waste' from high energy electron rings could be used to probe the structure of a wide range of samples, and parasitic synchrotron radiation studies began to be carried out at machines built to supply electrons for particle physics studies.

In the 70s, as more applied researchers clamoured for time at these synchrotron radiation sources, a new generation of purpose-built machines appeared. As well as basic research, synchrotron radiation studies went on to be used in the chemical, materials, biotechnology and pharmaceutical industries. A new research community had come of age.

On the occasion of the 50th anniversary of synchrotron radiation, the European Synchrotron Radiation Facility (ESRF), Grenoble, is organizing a conference 'Highlights in X-ray synchrotron radiation research' from 17-20 November, covering magnetism, high pressure, soft condensed matter, imaging/ topography and biology. Information from the Conference Secretariat, ESRF, BP220, 38043 Grenoble cedex, France, fax +33 4 76 88 21 60, e-mail SR50@esrf.fr

WORKSHOP
Strange structure in the nucleon

Physicists from widely different fields came together recently at CERN for a workshop focusing on one of the oldest problems of quark-gluon physics - "The Strange Structure of the Nucleon." Rolf Landua of CERN was in the chair for the opening session.

Over 150 frequent and infrequent CERN visitors from widely different fields came together from March 11-15 for an international workshop focusing on one of the oldest but still very controversial problems of quark-gluon physics - "The Strange Structure of the Nucleon."

In his welcome, CERN Director General Chris Llewellyn Smith mentioned that CERN had contributed much to this field with its diverse research. Unfortunately much of this research has had to be sacrificed in view of budget restrictions and the clearly defined aim to have the LHC proton collider running by the year 2005. Nevertheless, CERN supports the upcoming COMPASS experiment (see page 4) and the heavy ion programme using lead beams.

Experiments have long shown that a constituent quark model with just three quarks in the nucleon is much too naive. For example, when CERN's European Muon Collaboration (EMC) revealed that less than half the spin of the nucleon is carried by these valence quarks, it triggered a "spin crisis" of the proton.

These "strange" findings by EMC were supported by the completely different field of low energy pion-nucleon scattering. So-called 'sigma terms' are much higher than expected on the basis of just up and down quarks, opening the door to a strange quark content of the nucleon.

This evidence was reviewed in the experimental introduction to the workshop by Erwin Gabathuler (Liverpool), who encouraged experimentalists to follow the example of his fellow EMC collaborators and continue "looking for the unexpected."

As a consequence of these results, the idea of strange quarks in the nucleon took root. In the theoretical introduction to the workshop, Robert Jaffe (MIT) pointed out that such results were not so surprising in that they challenged only the convenient assumptions of the naive quark model as first proposed by Murray Gell-Mann. Jaffe summarized the theoretical situation with two questions: not only "Why strangeness?" but also "Why so little strangeness?"

With substantial experimental progress, one aim for theorists should be to understand the transition from isolated quarks to those actually seen, developing a less naive quark model to eventually provide a unified theoretical description.

But then maybe physicists will have to get used not only to a "strange" nucleon but also to a "charmed" one. Stan Brodsky (SLAC) emphasized that intrinsic charm should also be taken into account, and can be tested for experimentally. He further noted the need to distinguish between 'intrinsic' and 'extrinsic' flavour, the latter being generated by the evolution of a wave function. The distinction between intrinsic versus extrinsic is often difficult and was a matter of some discussion during the workshop.

The experimental progress of the past decade is evident. For example, Greg Smith (TRIUMF) reported on several experiments at meson factories that are aiming at a more precise determination of the pion-nucleon sigma term. The interpretation of such measurements requires a complicated theoretical framework, but the newest results hint that the experimental sigma term value – and thus the strangeness content of the nucleon – may even increase.

The pioneer EMC results initiated a series of successor experiments, *Erwin Gabathuler of Liverpool – "looking for the unexpected."*

introduced at the meeting by Vernon Hughes (Yale) and Emlyn Hughes (Caltech). Father and son, talking at the same conference for the first time, showed that the Spin Muon Collaboration at CERN (SMC) and the SLAC experiments agree in the kinematical region in which they overlap. The SLAC E142/143 data have much smaller statistical errors, but SMC covers a much wider kinematical range.

While the newest SLAC experiment, E155, continues taking data, the SMC has just stopped (January, page 3).

Alain Magnon (Saclay) presented preliminary data from SMC's 1996 run, showing a downward shift of the lowest-x (quark momentum fraction) point compared to earlier measurements. An ideal place to study this kinematic region would be DESY's HERA ring using polarized protons, as has been under discussion for some time.

For the past two years, the HERMES experiment at HERA has also been seeking insights into the spin structure of the nucleon. Using a polarized internal target, its aim is to measure the strange sea quark contribution and determine the relative contributions of valence and sea quarks.

Arthur Mateos (MIT) presented the first HERMES data for the neutron, and these results are in good agreement with the SLAC E142/154 results. First data on the proton should be coming soon.

What has theory to say about spin? Generally, the nucleon spin can be written as a sum of the spin of the three light quark flavours, a contribution from gluons, and contributions from the angular momenta between quarks and gluons.

In the polarized gluon interpretation of the results, presented by Stefano Forte (Torino), a large component of polarized gluons in the nucleon reduces the quark contribution to the nucleon spin.

Marek Karliner (Tel Aviv) advocated another model, in which negatively polarized intrinsic strange quarks play a role. According to Xiangdong Ji (Maryland), orbital angular momentum may be important and should be better explored. His proposed measurement: deeply virtual Compton scattering.

But not only spin physics holds some surprising results with consequences for the nucleon structure. In antiproton-proton annihilations at CERN's LEAR low energy antiproton ring, huge violations of a quark selection rule – the quark line (OZI) rule – have been observed (December 1994, page 19). This rule forbids the production of quarks which were not there originally, and one theoretical side-step is to invoke the presence of strange quarks in the nucleon.

The newest results from the Crystal Barrel and OBELIX collaborations at LEAR also show that the angular momentum of the initial system plays an important role, predicted by models with polarized intrinsic strangeness. If so, the results from deep inelastic scattering and from antiproton-proton annihilation would then have a natural common explanation.

An alternative explanation for the LEAR results was given by Valeri Markushin (PSI), who could explain some of the OZI violations using rescattering without assuming intrinsic strangeness. Although LEAR has been stopped at CERN, ongoing proton experiments at Saturne (Saclay) and COSY (Jülich) should produce results on strangeness production in low energy hadron processes. COSY in particular has a whole programme surveying strangeness production at threshold.

In yet another field, Orlando Villalobos-Baillie (Birmingham) reviewed strangeness production in relativistic heavy ion collisions, which may have both intrinsic and extrinsic sources. Maybe the strange structure of the nucleon plays a role here too.

Some of the cleanest evidence for intrinsic strangeness comes from charm production in deep-inelastic neutrino scattering. Panagoitis Spentzouris (Columbia) presented the data from the CCFR collaboration at Fermilab. There is no sign of disappearing (anti)strange quarks at low momentum transfer – a clear pointer to intrinsic strangeness.

Another way to study polarized strangeness in the nucleon is to look for lambda (hyperon) polarization. The PS185 experiment at LEAR, presented by Tord Johansson (Uppsala), tries to determine the spin transfer from a polarized proton target to lambdas produced in antiproton-proton annihilation. The direction of the lambda spin relative to the one of the polarized protons in the target should show whether the strange quark in the lambda results from intrinsic strangeness or from polarized gluons. PS185 took data in the last weeks of LEAR's life and results can be expected in the near future.

According to Stephan Paul (Heidelberg), the wealth of data on hyperon polarization in high energy proton collisions is not very well understood by theorists. Lambdas can also be produced by virtual polarized photons in muon beams and this may be another tool to investigate polarized intrinsic strangeness. Fermilab experiment E665 will soon have results on the longitudinal polarization of lambdas, which may be traced to virtual photon absorption by valence quarks.

A different approach to studying strangeness in the nucleon is taken by experiments at MIT-Bates and future experiments at the Jefferson Laboratory (formerly CEBAF) and MAMI (Mainz). They plan to measure the strange magnetic moments and the strange quark charge radii from parity-violating electron-proton scattering. This programme and the first preliminary results from the SAMPLE experiment at Bates were presented by Robert McKeown (Caltech).

Theorists have their work cut out to explain these phenomena. Approaches that can explain certain low energy effects include 'chiral perturbation' techniques, in which light quark masses are initially set to zero and subsequently gently introduced, reviewed by Ulf Meissner (Jülich), and the assumption that the number of quark/gluon colours is very large, a model presented by Aneesh Manohar (San Diego). How theory can match experimental progress was demonstrated by Sergei Larin, who showed how an extremely detailed calculation with 10,000 contributing diagrams could modify sum rules derived from more basic quark ideas.

What can be done to explore the structure of the nucleon in the future? Gerd Mallot (Mainz) described how the COMPASS experiment at CERN will play an important role in this field at the beginning of the next century.

By looking at open charm production from the photon-gluon fusion process, a determination of the polarized gluon component is possible. These data will be supplemented by lambda polarization results to explore quark polarization. John Collins (Penn State) reported that complementary measurements are planned with RHIC at Brookhaven with polarized protons, whose detectors, which are primarily aimed at heavy ion physics, will be upgraded.

The difficult task of summarizing all the week's varied discussions in one hour was left to John Ellis (CERN), who illustrated how diverse and widespread the problem of nucleon structure can be, and how much more work has to be done before we may someday understand what a nucleon really is.

Ulrich Wiedner (Local Organizing Committee Chairman)

ECFA Spain

In its continual tour of CERN Member States, on 28 February and 1 March the European Committee for Future Accelerators (ECFA) met at Madrid, under its chairman, Enrique Fernandez of Barcelona, for an insight into the present state of Spanish particle physics. Unlike other major Western European nations, particle physics has no great tradition in Spain. CERN has played a major role in getting this science off the ground, but even this recent history is somewhat chequered.

Currently there are about 140 Spanish experimentalists, some 55 on permanent positions, the others less so, 50 being graduate students. The long-term goal of a national institute for high energy physics now formally exists on paper and in the years to come may go on to consolidate the national effort and offer some permanent research positions.

At present there is a group at CIEMAT, Madrid, (which depends on the Ministry of Industry and Energy) and seven university groups which depend on the Ministry of Education and Culture. Santiago, Zaragoza, Madrid-Autónoma, Madrid-Complutense and Cantabria are complemented by a group in Valencia, integrated in the IFIC in a group which combines university staff and personnel from the CSIC (Consejo Superior de Investigaciones Cientificas, which also depends on the Ministry of Education and Culture), and a group in Barcelona, integrated in IFAE, an Institute created by the Autonomous University of Barcelona and the Autono-

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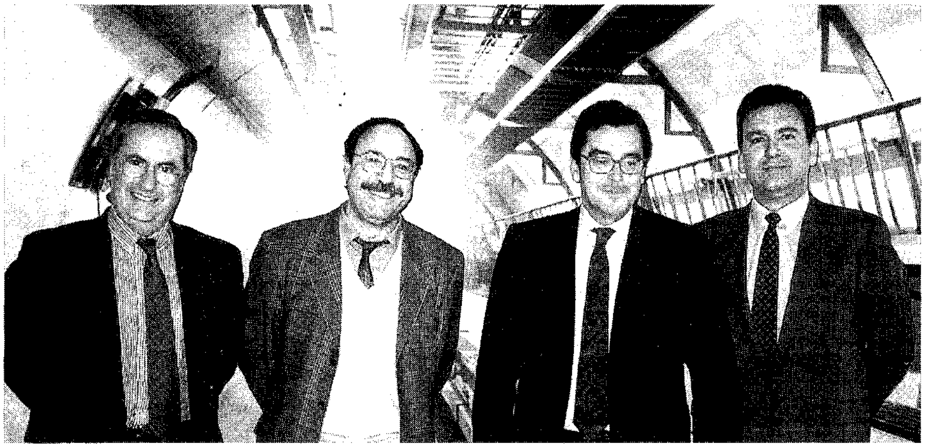
mous region of Catalonia, which combines its own personnel with personnel from the two universities in Barcelona.

The main scientific activities focus on research at CERN, principally at the LEP electron-positron collider. CIEMAT-Madrid has 13 physicists in the L3 experiment, Barcelona has 17 in Aleph and Valencia has 17 in Delphi. There are groups at the two Madrid universities, at Madrid-Autónoma (ZEUS at HERA, DESY, with 9 physicists) and at Madrid-Complutense (astroparticle physics). There are also groups in Zaragoza (double beta-decay), in Santander (8 physicists in Delphi) and in Santiago (12 physicists in the SMC muon experiment at CERN).

For the future, there is a strong Spanish interest in work at CERN's LHC proton collider. Four groups are involved in the ATLAS and CMS experiments: Barcelona (21 persons); Madrid-Autónoma (4); and Valencia (13 persons) in ATLAS; and CIEMAT (15 persons), Madrid-Autónoma (2) and Cantabria (6) in CMS. The lack of permanent positions deters aspiring young physicists and after more than tripling in the eighties, the size of the community has recently increased only slowly, although the number of senior scientists in most groups has grown.

There is some hope that a national institute for high energy physics could be created, with structure similar to that of other European countries.

The national research budget has remained at about 5 million Swiss francs/year (not including personnel costs) over the past four years, even though the CIEMAT material budget dropped considerably. In the 70s, research activities were concentrated at CIEMAT (then called Junta of Nuclear Energy), operated by the Ministry of Industry and Energy, with about 30 people, including 10 senior physicists and 10 students. At CERN they participated in bubble chamber work and later in the European Hybrid Spectrometer with work on charmed particles. J.A. Rubio, then a member of the CIEMAT directorate, played an important role in convincing Spain to return to CERN in the early eighties, as did P. Pascual, the first head of the 'Plan Movilizador' (mobilization plan) for high energy physics.



Spanish notables at CERN: left to right - L. de Segovia, F. Castro, Ambassador R. Perez-Hernandez, E. Roman.

Theoretical physics in Spain is relatively very strong and has developed since the late sixties. There are close to 140 theorists (90 with tenure and 50 postdocs), together with 40 graduate students. The preponderance of theorists over experimentalists is particularly marked when considering physicists with permanent positions. While only seven experimentalists have full professorships, there are close to thirty full professors in theoretical physics.

Spanish theoretical physics benefited considerably from the GIFT Inter-University Group for theoretical physics and from initial CERN membership (see below), becoming strong when experimental physics was still very weak. This work has always had very good relations with CERN's Theory Division and many Spanish theorists had CERN fellowships at an early stage in their careers. Alvaro de Rùjula, the new leader of CERN's Theory Division is Spanish. The main theory centres are in Madrid (Autónoma, Complutense and CSIC), Barcelona (Autónoma and Central), Santiago Valencia and Zaragoza. There are also groups in Bilbao and Granada.

This emerging pattern has been influenced by the national history of involvement with CERN. Spain was a CERN Member State from 1961 to 1968 but withdrew for financial reasons as at the time the domestic science base was not strong enough to benefit. With mounting new pressures, Spain rejoined in 1983 with an initial contribution of 30% of the calculated value, subsequently increased to attain its full value in 1989.

Rejoining CERN also catalysed a national development programme - the "Plan Movilizador" - supposedly worth 15 million Swiss francs/year. Although this level of funding was never attained, there was nevertheless important investment throughout

Juan-Antonio Rubio (left) played a major role in Spain's decision to rejoin CERN in 1983. He is seen here with F. Aldana, Secretary General of the National Plan for Research and Development.

the 80s. This developed sizeable university groups with a strong participation in LEP. The CIEMAT material funding has since decreased considerably, but the funding of university groups has remained constant since 1990.

As shown by the drop in support for CIEMAT, the interest of the Ministry of Industry, on whose budget the Spanish contribution to CERN depended, has lagged. There was a lack of support for CERN in some key areas, and some believed that an "à la carte" solution could be reached. In addition, three other factors contributed to the development of a crisis in Spanish support.

Two CERN-linked schemes which should have been of direct interest to Spanish industry were included in the mobilization plan - the establishment of an industrial connection and a technical student training programme. The latter should have benefited from a million Swiss francs per year with a programme involving 30 students/year, each coming to CERN for a few months. However this was not implemented, while the Technical Committee, set up to monitor the industrial scheme, lapsed.

The national GNP increased considerably during the eighties, driving the Spanish CERN contribution to heights not initially anticipated. By the end of 1993, several years of Spanish contributions to CERN were overdue. This was exacerbated when it was realized that CERN membership was no longer even a budget line for 1994. After a concerted effort, the crisis was defused and Spain has strongly reaffirmed its commitment to CERN. Debts have been paid and Spain benefits from a temporary reduction of its contribution over the five years from 1994 which acknowledges its present difficulties.

The national contribution to CERN, which amounts to 61 million Swiss francs before any reduction, is now the responsibility of the Ministry of Foreign Affairs. Most of the funding for research is in the hands of the Interministerial Commission for Science and Technology (CICYT), which administers the National Plan for Research and Development, where F. Aldana is Secretary General. The funding for its Particle Physics Programme (head Manuel Aguilar-Benitez) has been stable over the past few years. Residual research funding still comes through the Ministry of Industry, and more specifically through the Secretary of State for Industry and Energy supporting CIEMAT (Director F. Yndurain).

The goal is to contribute 15 million Swiss francs to the LHC detectors. 30% of CICYT funding goes towards running particle physics research and 45% to preparations for LHC experiments. There is some astroparticle activity, at the level of 5%. While recent crises are no more, the situation has to be carefully monitored. There is a need to better promote experimental particle physics, and the experimental community has to be accorded more stable positions and funding. There is also a need for more technical personnel. More senior positions at CERN are another goal.

Relations with Spanish industry started well with some significant LEP contracts. However this conventional construction work was soon completed and Spain was left with an extremely low industrial return coefficient. Some technical cooperation agreements developed on quadrupole development, cryogenics, power supplies and vacuum techniques.

CERN could help boost Spanish engineering: CDTI (the Spanish Centre for the Development of Industrial Technology) and CERN have signed an agreement to send about 10 technical graduates to CERN with Spanish support, each staying for two years. The first arrived last year (January, page 34). A concerted effort in which liaison officer S. Romo and F. Castro was CDTI play special roles, looks to assure Spanish industry of involvement in LHC construction, although safeguards should still be taken.

Spain has made the largest effort of any Member State to introduce its industry to CERN, and this effort is ongoing. Encouragingly, industrial return (the ratio of national contributions to CERN to contracts received) recently rose from 0.14 to 0.63, and Spanish high technology is set to make further use of CERN expertise and know-how.

A national showcase was the European Particle Accelerator Conference, EPAC, held in Sitges (Barcelona) in June 1996 (September, page 2).

SPACE
Unparalleled parallax

New precision information from the European Space Agency's Hipparcos satellite gives a fresh focus on astronomical measurements and reopens the old controversy on the size and age of the Universe.

One of the major astronomical discoveries of the century was Edwin's Hubble's realization that the Universe is expanding. The further away a celestial object is, the more the intervening space has expanded since the Big Bang and the faster the distant object appears to recede.

This is embodied in the Hubble relation which links distance and apparent velocity. The so-called 'Hubble constant' governs the age of the Universe – the faster the expansion appears to be, the less time has passed since the Big Bang for the Universe to attain its present size.

Measuring the Hubble constant has always been difficult, but paradoxically the implications for the age of the Universe can be very evident. Hence the latest controversy a few years ago when measurements by the Hubble Space Telescope suggested a value for the Hubble constant which embarrassingly said that the Universe was younger than some of its oldest component stars! Any upwards correction of this estimated age of the Universe is therefore welcome.

The Hipparcos satellite was launched by Ariane in August 1989 and over the next four years fixed the position of 120,000 stars to within 1 milliseconds of arc (the accuracy needed to hit a coin-sized target at a distance of about 100 kilometres).

Using this data, astronomers have been able to obtain a better fix on certain stars, called Cepheids. These objects, discovered by Henrietta Leavitt in 1912, are like stellar steam engines, continually puffing up and deflating, and their regular period-luminosity cycles are traditionally used by astronomers as a distance yardstick.

The distances of galaxies can be fixed by looking for Cepheids in them – the Hubble Space Telescope has given some particularly useful results.

The Hipparcos observations looked at Cepheids from different points in the Earth's orbit and from these stereo views were able to obtain parallax measurements – comparing the position of a distant object at two different points gives a measure of how far away it is. In the same way, our binocular vision, comparing the images in each eye, enables us to estimate short distances, but is useless for objects as far away as stars. On the other hand, the Hipparcos views were separated by some 250 million kilometres, enough to detect tiny parallax differences.

Concentrating on 26 Cepheids, these distances measured by Hipparcos turn out to be about 10 per cent larger than had been previously assumed, so that estimates of the Hubble constant based on Cepheid measurements need to be revised downwards by about 10 per cent, implying that the Universe is larger, and therefore older (about 11×10^9 years), still younger than some of its oldest component stars - 14×10^9 years - but still a step in the right direction.

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Bookshelf

Feynman Lectures on Gravitation, R.P. Feynman et al, Edited by B. Hatfield, Addison Wesley, ISBN 0 201 62734 5,1995, 232pp.

This edited version of the first half of Feynman lectures on gravitation at Caltech in the early sixties, previously only available as photocopies at the Caltech bookstore, is a welcome addition to the existing book on Einstein's General Relativity. The point of view taken is that of a field theorist who tries to derive Einstein's theory by studying the properties and interactions of spin-two particles.
It also presents the geometrical approach to the theory. There are beautiful discussions of many topics including the Equivalence Principle, the post-newtonian predictions, the Schwarzschild singularity, wormholes, superstars, cosmology and the generation of gravitational radiation. Although more than thirty years have elapsed since these lectures were first delivered, and some of the topics are outdated, or we have now better formulations, it is refreshing to read how Feynman's deep physical intuition goes from an elementary discussion of the conceptual foundations of the theory to topical subjects of the time, and occasionally he is far ahead of his time, as in a preferred critical density in cosmology (omega equal one) which would almost twenty years later become one of the basic predictions of inflationary theory (although this prediction is currently being revised).

All those who have grown up in physics learning a good fraction of the subject in Feynman's books will be delighted to read another where again he is a master of exposition depth and clarity. The excellent foreword by J. Preskill and K. Thorne places the book in the context of gravity research in the 60s, and gives more details about Feynman's positions on many issues. There is also a brief update of subsequent work by B. Hatfield.

Luis Alvarez-Gaume

The Collected Works of Eugene Paul Wigner

When Eugene Paul Wigner died on 1 January 1995, he left a fund of papers and correspondence. But it had already become clear that the astounding breadth and impact of his life's work merited a serious compilation. This was undertaken by a team of dedicated specialists and the outcome published by Springer.
The master plan divided the material into Part A, five volumes of scientific papers edited by Arthur Wightman, and Part B, three volumes of historical, philosophical, and socio-political papers, edited by Jagdish Mehra.
Already published in Part A are Volume I (Part I - Eugene Paul Wigner, A Biographical Sketch; Part II, Applied Group Theory 1926-35; and Part III, The Mathematical Papers); Volume II on Nuclear Physics and Volume V on Nuclear Energy (Part I - Eugene Wigner and Nuclear Energy, Part II - Memoir of the Uranium Project; Part III - Articles, Reports and Memoranda on Nuclear Energy; and Part IV - The Wigner Patents). Already published in Part B is Volume VI - Philosophical Reflections and Syntheses.

Now published in Part A are Volume III (Part I - Particles and Fields, annotated by Arthur Wightman, and Part II - Foundations of Quantum Mechanics, annotated by Abner Shimony) and Volume IV, (Part I - Physical Chemistry, annotated by Nandor Balazs, and Part II Solid State Physics, annotated by Walter Kohn).

In preparation for Part B are Volume VII on Historical and Biographical Reflections and Syntheses, and Volume VIII on Socio-Political Reflections and Civil Defense.

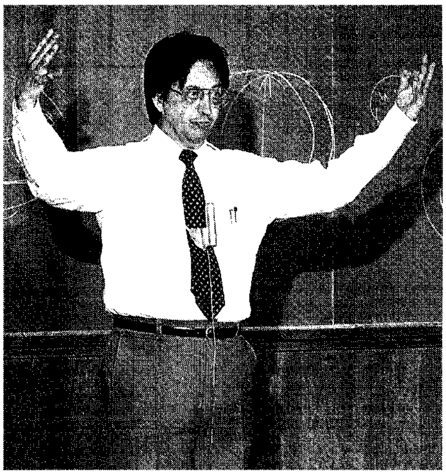
Books received

Quantum Fields on a Lattice, by Istvan Montvay and Gernot Münster, Cambridge Monographs on Mathematical Physics, paperback version, ISBN 0 521 59917 2, £35/$44.95

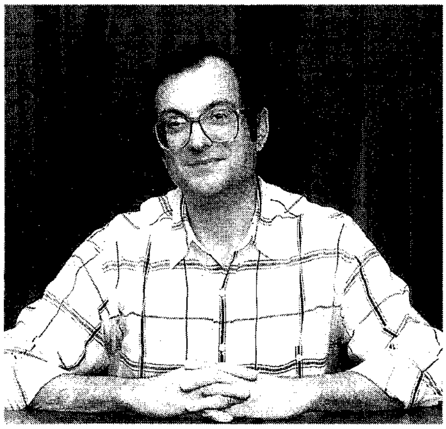
This useful book ('a must for every student taking up the subject') was reviewed by U. Wolff in the CERN Courier (September 1994, page 36) when it originally appeared in hardback.

People and things

Nicholas Samios - 15 years as Director of Brookhaven National Laboratory.



Lawrence S. Cardman becomes associate director at the Thomas Jefferson National Accelerator Facility (formerly CEBAF), Newport News, Virginia.



On people

After 15 years, Nicholas Samios steps down as Director of Brookhaven National Laboratory on 30 April, returning to full-time research as Distinguished Scientist. Among the many highlights of this tenure is his success in initiating and guiding the development of Brookhaven's RHIC Relativistic Heavy Ion Collider, scheduled to begin operation in 1999.

John J. Domingo has stepped down after a decade as associate director and head of Physics Division at the Thomas Jefferson National Accelerator Facility (formerly CEBAF), Newport News, Virginia, during which time he has helped plan and launch the new Laboratory's research programme. Lawrence S. Cardman, formerly at the University of Illinois, and Domingo's recent deputy, becomes the new associate director.

Theorist Dimitri Nanopoulos of Texas A&M and Head of the Center for Astroparticle Physics at the Houston Advanced Research Centre has been elected a Permanent Member of the Academy of Athens.

Bruno Pontecorvo Prize

The 1996 Bruno Pontecorvo Prize of the Joint Institute for Nuclear Research (Dubna) has been awarded to two well-known Russian theorists - Lev Okun for theoretical elementary particle physics and to Semen Gerstein for the theoretical research in the field of electroweak interactions (Photo page 29).

The Bruno Pontecorvo Prize is awarded to a single scientist, or exceptionally to a group of up to three scientists, for outstanding research in particle physics. Brief abstracts of the research, if possible enclosing copies of major papers, should be received not later than 1 August by: Prof. S.Bunyatov, Joint Institute for Nuclear Research, Laboratory of Nuclear Problems, 141 980 Dubna, Moscow Region, Russia. Phone: (709621) 65880, Fax: (709621) 66666 E-mail: bunyatov@nusun.jinr.dubna.su

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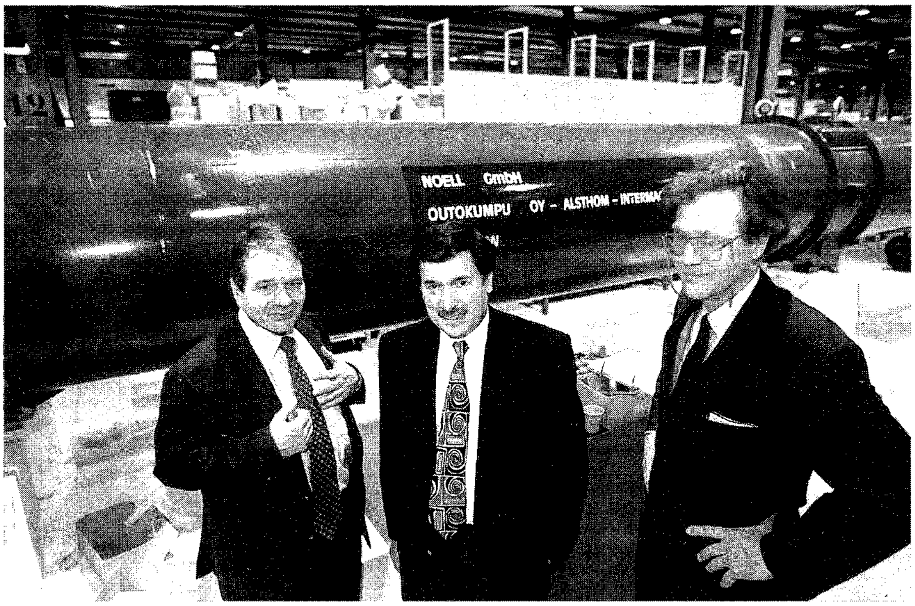
Yuri D. Prokoshkin 1929-97

Reinhold Leitterstorf (centre) of the German Federal Ministry for Education, Science, Research and Technology inspects testing of superconducting magnets for CERN's LHC proton collider with (left) CERN's Technical and Research Director Horst Wenninger, and Peter Sievers of the magnet test group.

(CERN HI 32.2.97)



Yuri D. Prokoshkin 1929-97

Yuri Prokoshkin died on 1 March after four months of illness.

A member of the Russian Academy of Sciences, he began his career at the international Dubna laboratory, leaving in 1965 to organize an experimental research division at the new Institute of High Energy Physics (IHEP) at Protvino. Here he welcomed members of the first joint IHEP-CERN experiment in 1968 at the then world's highest energy proton synchrotron, 70 GeV. From 1978, he was spokesman for the GAMS project, two parallel experiments (one at IHEP, the other - NA12 - at CERN) which went on to be particularly fruitful in the search for glueballs and exotic particles. Both were based on the development of a cellular electromagnetic calorimeter, a principle which went on to be widely used. In 1993, GAMS moved to Omega and opened new horizons in non-perturbative QCD. Yuri played an important role in the new COMPASS experiment, one of the most recent to be approved at CERN, and was also involved in calorimeter development for the CMS experiment at the LHC.

For his family, collaborators, colleagues and friends, it was difficult to believe that his vitality, intelligence, creativity and enthusiasm for research, his devotion to the continuation of top level Russian science, his presence and friendship were no more. It was left to acknowledge the loss of a colleague who dedicated his life to particle physics and in particular to international collaboration, especially with CERN, for the humanitarian goal of peaceful cooperation as well as for scientific progress.

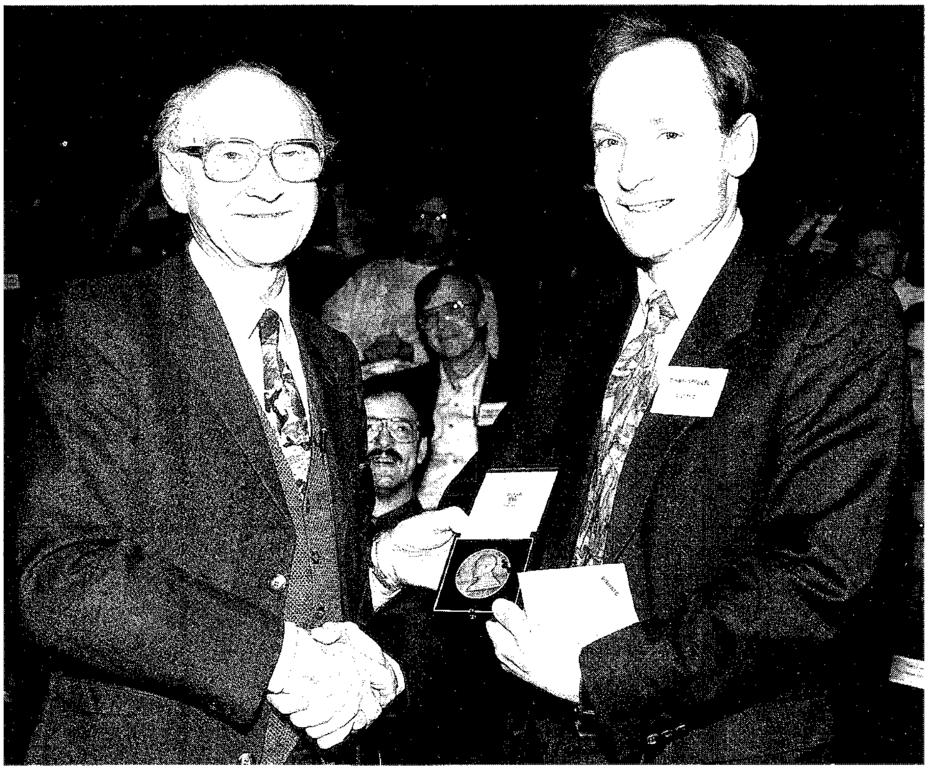
J.-P. Stroot

Edward Purcell 1912-97

Edward Purcell of Harvard, who shared the 1952 Nobel Prize with Felix Bloch for work on nuclear magnetism, died in March. At the MIT wartime Radiation Laboratory he became Head of Fundamental Developments Group, working with a distinguished band on radar techniques. As researchers returned to basic physics, this new expertise led to precision measurements of magnetic fields and particle magnetism and led to important new spinoff discoveries. He also carried out pioneer work in radio astronomy and later turned to biophysics.

Meetings

Following the first meeting, held in Frascati in 1994, the second Edoardo Amaldi Conference on Gravitational Waves will be held at CERN from 1-4 July. Further information from http://www.cern.ch/Physics/Conferences/C1997/GravitationalWave



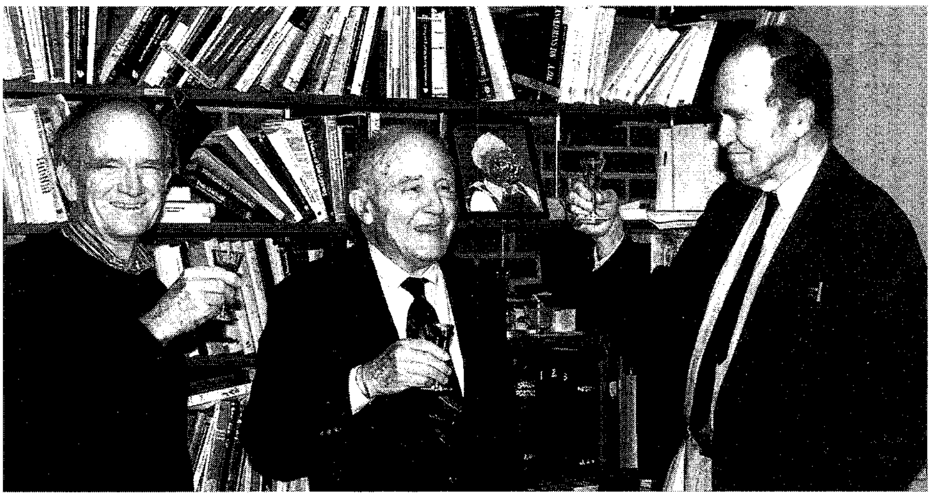
At a meeting of the World Wide Web Consortium at the UK Rutherford Appleton Laboratory, the inventor of the World Wide Web, Tim Berners-Lee (right) of MIT and formerly of CERN, receives the Duddell Prize of the UK Institute of Physics from former Laboratory Director and Institute of Physics President Godfrey Stafford.

(Photo RAL)

▲ Françoise Praderie of the Paris Observatory, formerly secretary of the OECD Megascience Forum, is the prime mover of the new 'Euroscience' initiative to promote science in Europe. The fledgling organization recently held a constituent assembly of founder members in Strasbourg.

◀ Swedish Minister of Education and Science Carl Tham (seated) with CERN Director General Chris Llewellyn Smith during his official visit on 24-25 March.

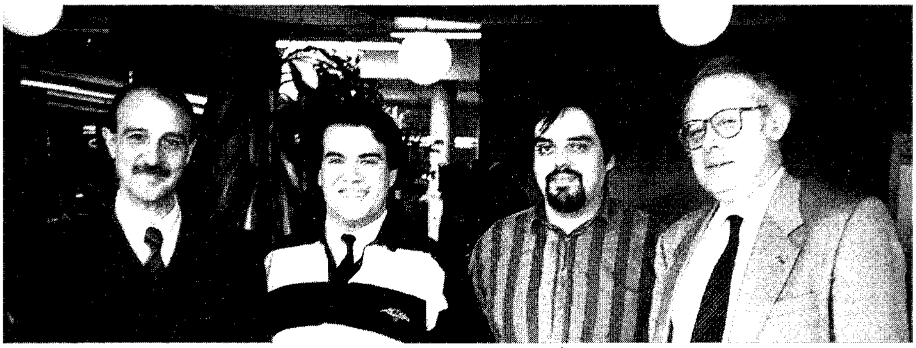
(Photo CERN HI 20.3.97)



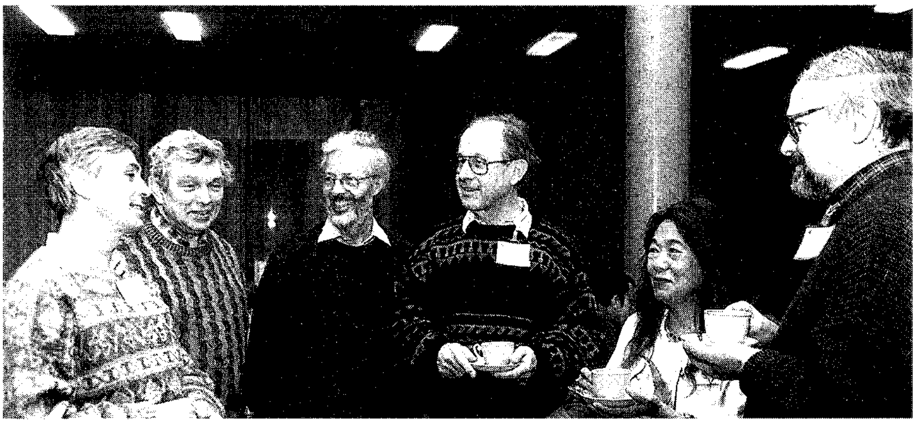
A toast for John Wheeler (centre) from his Princeton colleagues Val Fitch and Art Wightman on the news he had won the 1997 Wolf Prize in Physics (March, page 22).

CERN Director General Chris Llewellyn Smith signs a Cooperation Agreement between Georgia and CERN. The document had been signed on behalf of Georgia by President Eduard Shevardnadze and brought to CERN by Academician Albert Tavkhelidze (left), President of the Georgian Academy of Sciences, and Academician Nodar Amaglobeli, Head of the Scientific Commission of the Georgian Parliament.

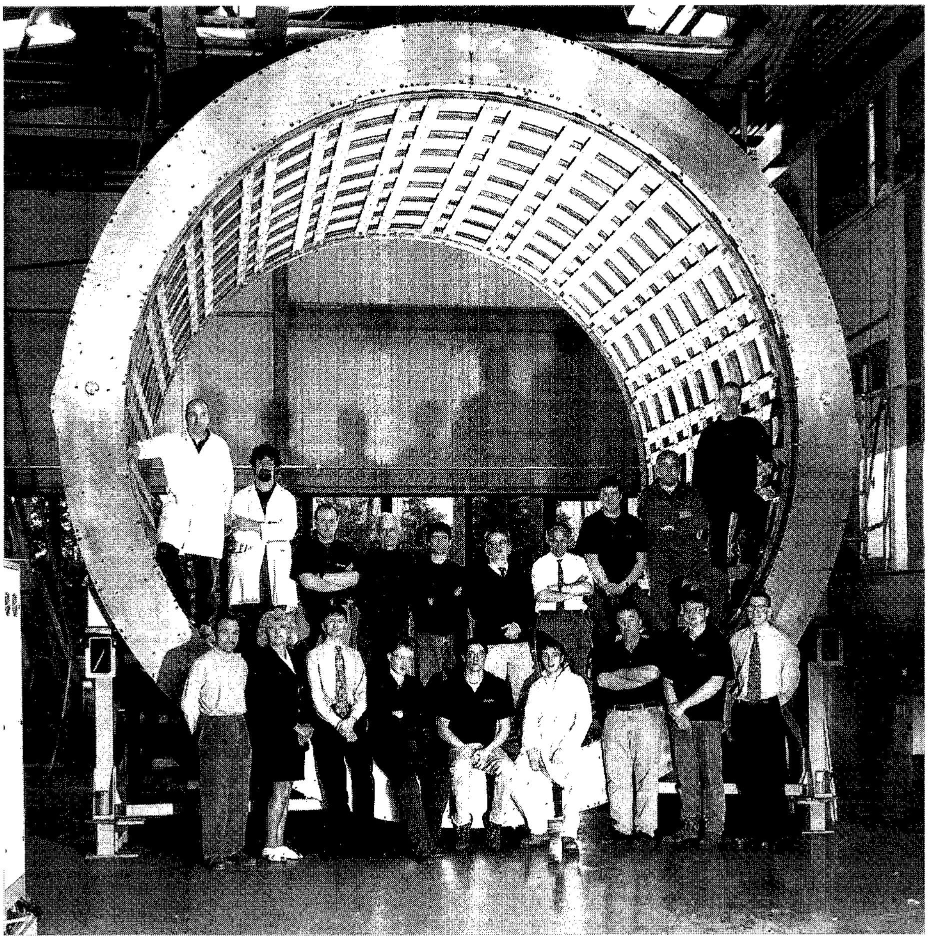
(Photo CERN HI 6.3.97)



More young engineers at CERN. Following an agreement with the Portuguese Agência de Inovação, young engineers from that country will come to CERN for period of two years, with Portuguese support. This parallels a programme already set up with Spain (January, page 34). Here, Artur Da Silva Rocha (second left) and Rui Paulo Da Silva Leite, who both work on Word Wide Web developments, stand between Jose Salicio Diez (left) of CERN's Fellows and Associates Programme and Fernando Bello, one of Portugal's delegates to CERN and President of the Agência de Inovação.



At the XXV ITEP Winter School of Physics, which took place from 17-27 February at Snegiri not far from Moscow, left to right, Michael Danilov and Yuri Zaitsev of ITEP, Günter Wolf of DESY, Stan Wojcicki of SLAC, Stanford, Juliet Lee-Franzini of Frascati, and Peter Zerwas of DESY.



Members of the Oxford Instruments team pictured with the superconducting magnet for the KLOE detector prior to shipment to the DAFNE ring at Frascati. The Oxford magnet, 6 metres in diameter and 4.5 metres long, weighs 40 tonnes and will deliver a field of 0.6 tesla. Oxford claims this to be the world's largest commercially-manufactured superconducting detector magnet. Traditionally, the superconducting magnet coils for major particle physics detector have been fabricated at major national laboratories.

CERN Courier contributions

The Editor welcomes contributions. These should be sent via electronic mail to cern.courier@cern.ch

Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland).

Contributors, particularly conference organizers, contemplating lengthy efforts (more than about 500 words) should contact the Editor (by e-mail, or fax +41 22 782 1906) beforehand.

Lev Okun of ITEP Moscow, left, and Semen Gerstein of IHEP, Protvino, received the 1996 Bruno Pontecorvo Prize of the Joint Institute for Nuclear Research (Dubna). See page 23.

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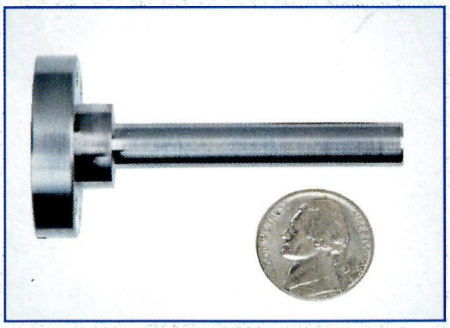

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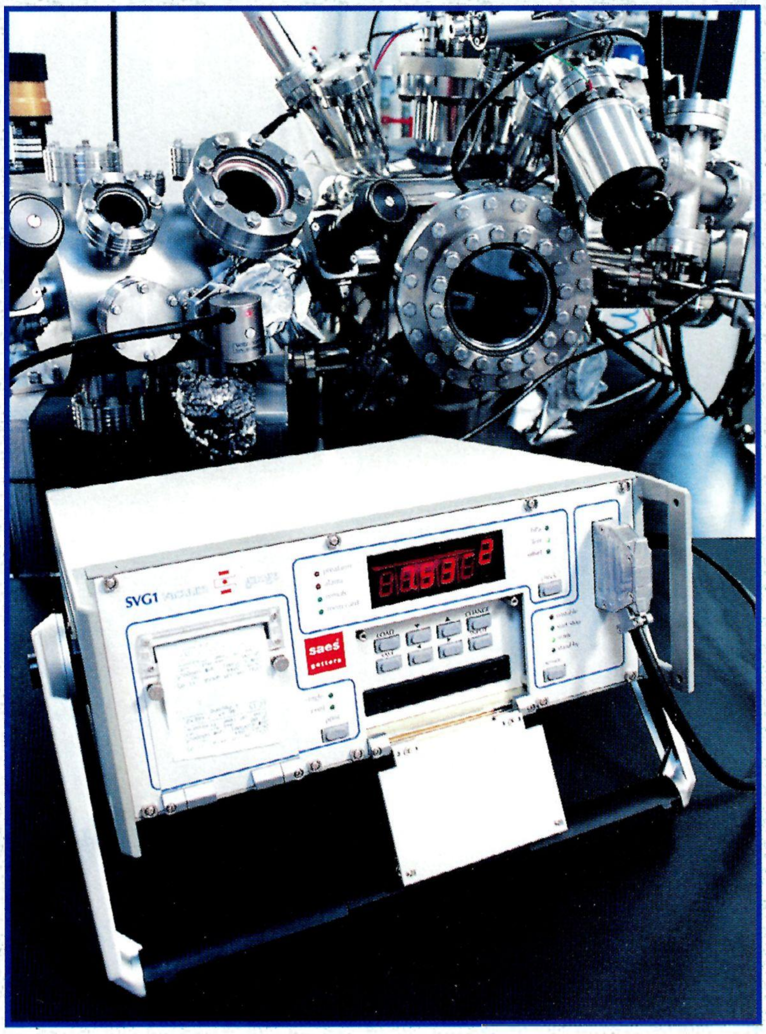

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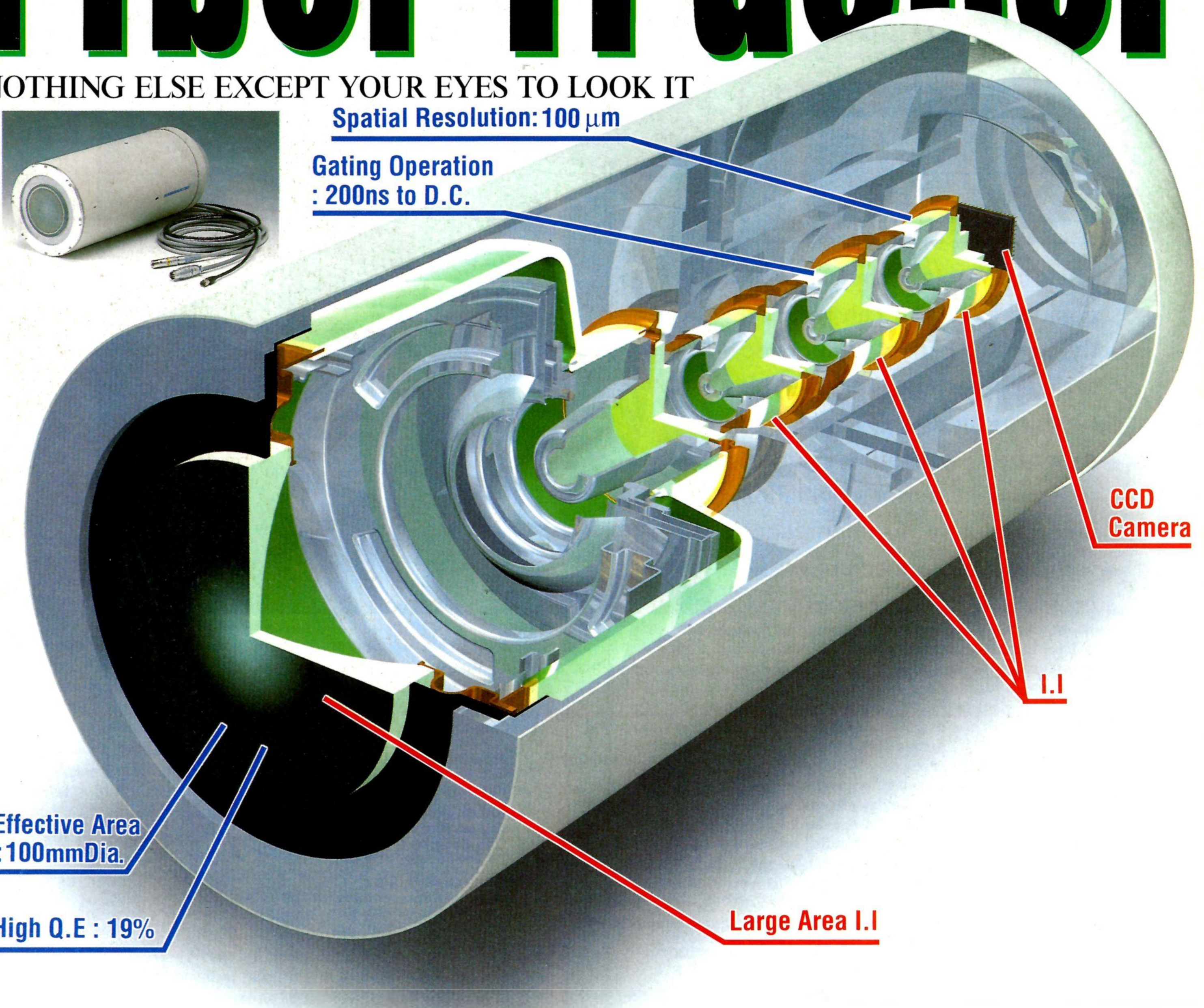

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