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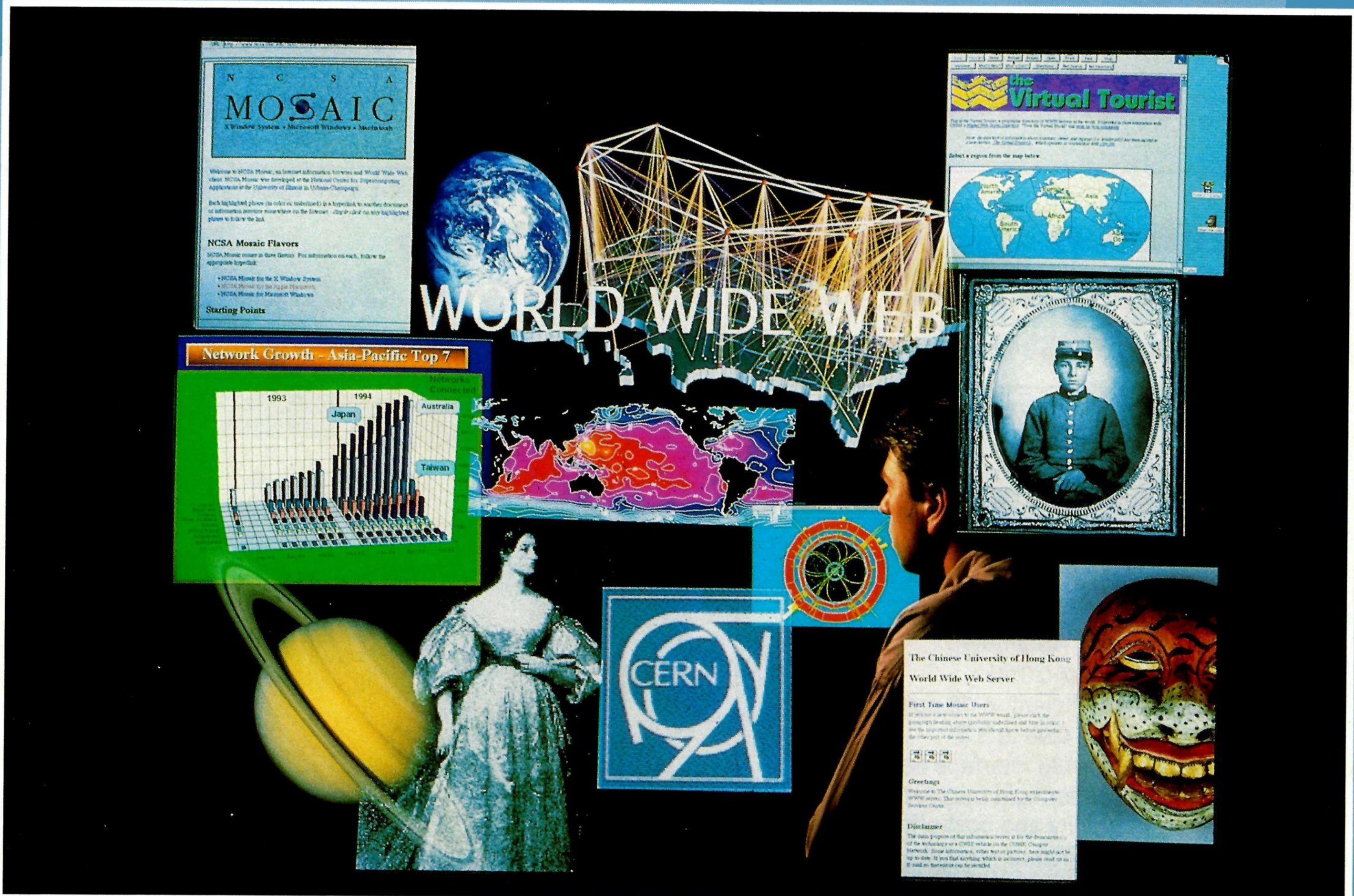

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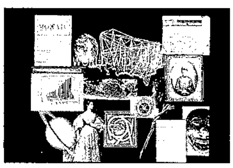
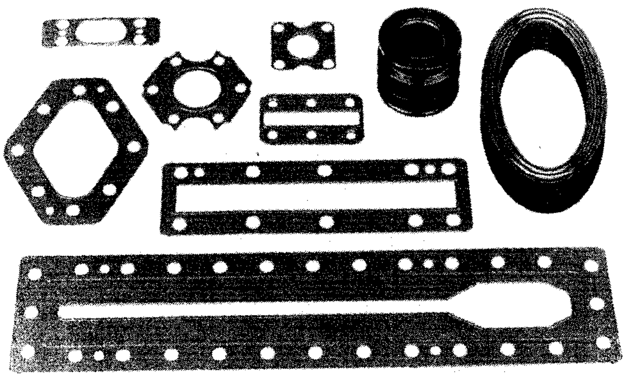
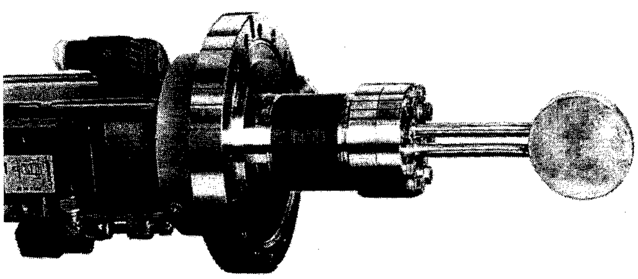
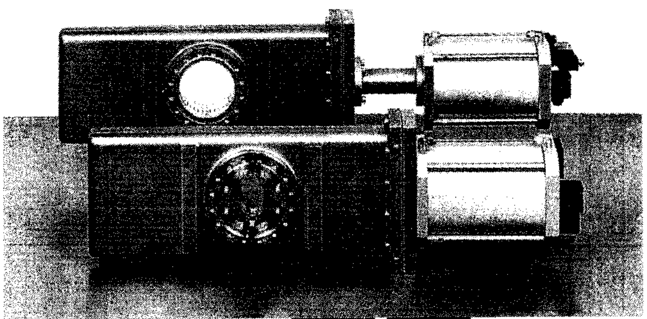
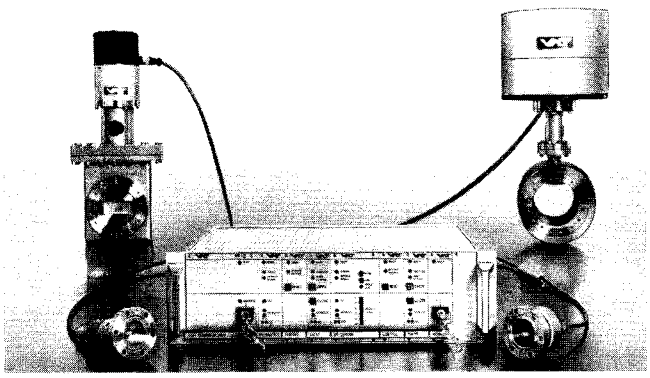


Cover photograph: World-Wide Web - a composition by David Parker. A CERN spinoff from particle physics, the World-Wide Web has gone to take the Internet by storm. Article by James Gillies on page 1.









Caught in the Web

CERN World-Wide Web pioneer Robert Cailliau (standing) explains a point to Geoff Heaford of the UK Engineering and Physical Sciences Research Council as delegates at the CERN World-Wide Web Days take their first hesitant steps in Cyberspace. Hands-on experience was an important element of the event (60 workstations were generously loaned to CERN by Apple, DEC, Hewlett Packard, IBM, Olivetti and Silicon Graphics). (Photo CERN HI 21 3 95/24)

The World-Wide Web may have taken the Internet by storm, but many people would be surprised to learn that it owes its existence to CERN. Around half the world's particle physicists come to CERN for their experiments, and the Web is the result of their need to share information quickly and easily on a global scale.

Six years after Tim Berners-Lee's inspired idea to marry hypertext to the Internet in 1989, CERN is handing over future Web development to the World-Wide Web Consortium, run by the French National Institute for Research in Computer Science and Control, INRIA, and the Laboratory for Computer Science of the Massachusetts Institute of Technology, MIT, leaving itself free to concentrate on physics.

The Laboratory marked this transition with a conference designed to give a taste of what the Web can do, whilst firmly stamping it with the label "Made in CERN".

Over 200 European journalists and educationalists came to CERN on 8 - 9 March for the World-Wide Web Days, resulting in wide media coverage. The conference was opened by UK Science Minister David Hunt who stressed the importance of fundamental research in generating new ideas.

"Who could have guessed 10 years ago", he said, "that particle physics research would lead to a communication system which would allow every school to have the biggest library in the world in a single computer?".

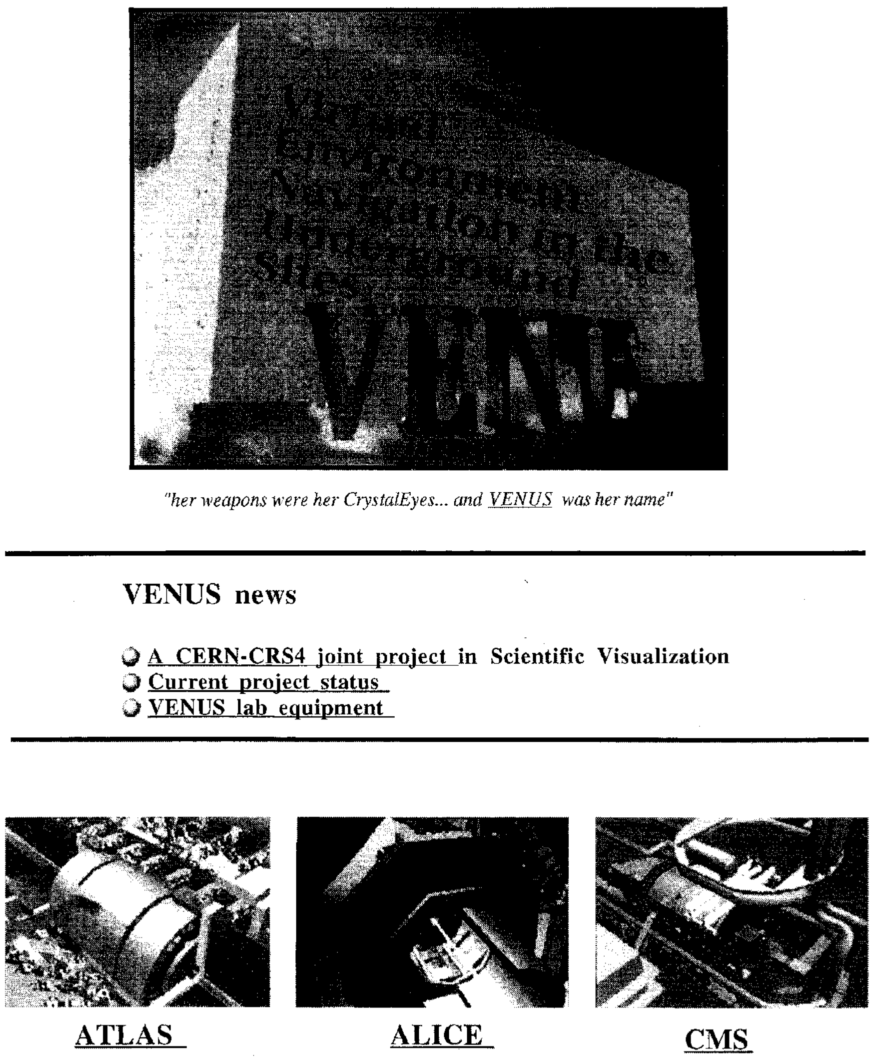
In his introduction, the Minister also pointed out that "CERN and other basic research laboratories help to break new technological ground and sow the seeds of what will become mainstream manufacturing in the future."

Web? Internet? What's the difference?

Learning the jargon is often the hardest part of coming to grips with any new invention, so CERN put it at the top of the agenda. Jacques Altaber, who helped introduce the Internet to CERN in the early 1980s, explained that without the Internet, the Web couldn't exist. The Internet began as a US Defense Department research project in the 1970s and has grown into a global network-of-networks linking some three million computers in over 100 countries. Its strength is that it is user-driven and evolves in a democratic and Darwinistic fashion. Good network products thrive, whilst poor ones wither. The Web, a relative newcomer, is to the Internet what mammals were to the post-Cretaceous Earth, sweeping all else before it.

The Web has replaced complex commands with a simple mouse-click, making Internet access available to everyone. From its 1989 origins as a tool for physicists, it has taken a remarkably short time to develop into today's global phenomenon. The benchmark browser was developed at CERN for the NeXTStep operating system in 1991. At the same time, a line mode browser written at CERN brought the Web to users in particle physics laboratories the world over.

But it was when the US National Center for Supercomputing Applications, NCSA, released the Mosaic browsers in 1993 that things really took off. Web traffic now drives the Internet's expansion, and has grown to the equivalent of the entire works of Shakespeare every second. Significantly, one of the Web's most comprehensive directories lists over twice as many servers in entertain-



The VENUS homepage is just one of the things you will find on a Web visit to CERN. From physics papers to press releases, many of the Laboratory's activities are represented. VENUS offers a virtual reality voyage around the particle detectors of tomorrow. By giving engineers the impression that they are really there, virtual reality helps them to design these huge devices.

ment and business as in science and computing, clear evidence that the Web has outgrown its academic origins.

A tour of Web highlights by co-developer Robert Cailliau displayed some of the questions that CERN is passing on to INRIA and MIT. The tour demonstrated the Web's multimedia nature, taking in text, pictures, film clips and music. But with a system that makes transferring all this around the world so easy, how can copyright be protected? A visit to the Paris Métro server to find the quickest route from Gaité to Pigalle illustrated the Web's interactive capabilities, but if these are ever to be used for electronic shopping, how can security be ensured? The Web carries news fast. Help lines for the recent Kobe earthquake were available via the City's homepage before they made it into newspapers, but how do you know where to look for the information you need?

Getting connected

Finding sliproads to the information superhighway is easy, but choosing the right one is not so simple. It depends on whether you just want to browse, or whether you wish to publish your own material on the Web. Either way, it helps to live in the US, according to Bruce Elliott of Swiss Internet provider Prolink. America's liberal telecommunications market makes it much cheaper to use the Web there than in Europe.

For those with aspirations to publish on the Web, a rented connection is not enough. A popular server needs permanent connectivity and high bandwidth to cope with demand for the information it holds. Børre Ludvigsen is someone who should know. Since setting up his famous "Home on the Web", Ludvigsen has become something of a Cyberspace celebrity. If we are not careful, he believes, the Web could turn out to be just more TV.

Current commercial networks are already becoming very imbalanced with bandwidth into people's homes often sufficient to download a Hollywood movie in a matter of minutes, whilst allowing the viewer just enough bandwidth out of his home to choose which film to watch. Ludvigsen's message to budding Web publishers, as opposed to those who are content simply to browse, is buy the bandwidth, don't rent it.

Using the Web

Many pioneering Web users came to the conference to explain why they are on the Web, and the benefits it has brought.

Evidence that the Web has achieved its initial goals was provided by the L3 collaboration at CERN's LEP e^+e^- collider. L3 has completely revised its working

Web Words

WWW, W3, the Web: alternative names for the World-Wide Web

Internet: a world-wide communications network

Browser: a programme allowing mouse-click access to the Web

Homepage: The 'gateway' page presented by a browser when it is activated. A signpost to other pages on the Web, possibly including other homepages.

Server: a computer holding accessible information

Hypertext: a way of linking related pieces of information on a computer

HTML: HyperText Mark-up Language, the language in which Web documents are structured

HTTP: HyperText Transfer Protocol, the rules governing communication between browsers and servers

URL: Uniform Resource Locator, an address used by browsers to locate a server, "http://www.cern.ch" is the URL for CERN's Web server

practices, exploiting the Web to the full. The collaboration's Web site provides information about L3 for collaboration members and general enquirers alike. L3 publications and analyses are no longer circulated around the world by mail for approval and discussion, but simply posted on the Web, speeding up the process considerably.

Moving away from academia, the Swiss company Lighting Instrumentation SA installed a server only eight months ago, but it already generates 15% of their export turnover, and was set up for less than the cost of a single advertising campaign.
The Web is fast becoming an indispensable tool for small exporting companies, allowing them to open a cheap and effective shop window to the world. According to Lightning, presentation is the key to success; Web pages have to look good, and they must be listed in appropriate directories.

Policing the net

Internet law is developing into a major field of study. Pierre Trudel of the University of Montreal sees three potential zones of conflict; right of network access, circulation of information, and contractual obligation. But Trotter Hardy from the William and Mary Law School in Virginia, believes that many existing US laws governing these issues apply equally well to the Internet. Both agree that the problems arise from the Internet's disregard for national boundaries, and suggest that self-regulation is the way forward. Hardy predicts that "Cyberspace geography" will replace physical geography in Internet law, and cases will be heard in virtual courts.

CERN says farewell

The conference was brought to a close on a cautionary note by David Williams, head of CERN's computing and networks (CN) division. The Web was invented at CERN because the Laboratory had the need, the expertise, and the necessary bandwidth to make it work. It has taken off on the other side of the Atlantic because ordinary people can afford to use it there. A leased line in Europe costs up to 90 times its equivalent in the US, whilst individuals in America can plug in to the Internet for around half the price of their European counterparts. Food for thought in the run up to European telecommunications deregulation in 1998.

As the Laboratory bids farewell to the Web, Williams underlined the fact that fundamental physics made it happen at CERN: "Let us be grateful for our breakthrough", he said, "and hope that Europe is able to turn a happy, but not fortuitous, discovery at CERN into something that benefits the whole of the economy which supports our fundamental research."

by James Gillies

CMS

LHC experiment milestones

This month we publish the first two in a series of articles which mark the publication of full Technical Proposals for experiments at CERN's LHC proton-proton collider. LHC physics will be covered by two major experiments, ATLAS and CMS, focused primarily on LHC's proton beams. The ATLAS and CMS Technical Proposals were presented to the LHC Committee earlier this year.
A third major detector, ALICE, will study the physics of LHC's heavy ions beams. These are among the largest experiments ever proposed in high energy physics. In addition, LHCB will look at particles containing the fifth 'beauty' quark, and several other studies will look at additional aspects of LHC physics. As well as sheer scale, these LHC experiments have to confront the challenges of very high collision rates, in particular the concomitant problems of radiation resistance and data collection (April/ May, page 3).

The milestone workshops on LHC experiments in Aachen in 1990 and at Evian in 1992 provided the first sketches of how LHC detectors might look. The concept of a compact general-purpose LHC experiment based on a solenoid to provide the magnetic field was first discussed at Aachen, and the formal Expression of Interest was aired at Evian. It was here that the Compact Muon Solenoid (CMS) name first became public.

Optimizing first the muon detection system is a natural starting point for a high luminosity (interaction rate) proton-proton collider experiment. The compact CMS design called for a strong magnetic field, of some 4 Tesla, using a superconducting solenoid, originally about 14 metres long and 6 metres bore. (By LHC standards, this warrants the adjective 'compact'.)

The main design goals of CMS are:

1 - a very good muon system providing many possibilities for momentum measurement (physicists call this a 'highly redundant' system);

2 - the best possible electromagnetic calorimeter consistent with the above;

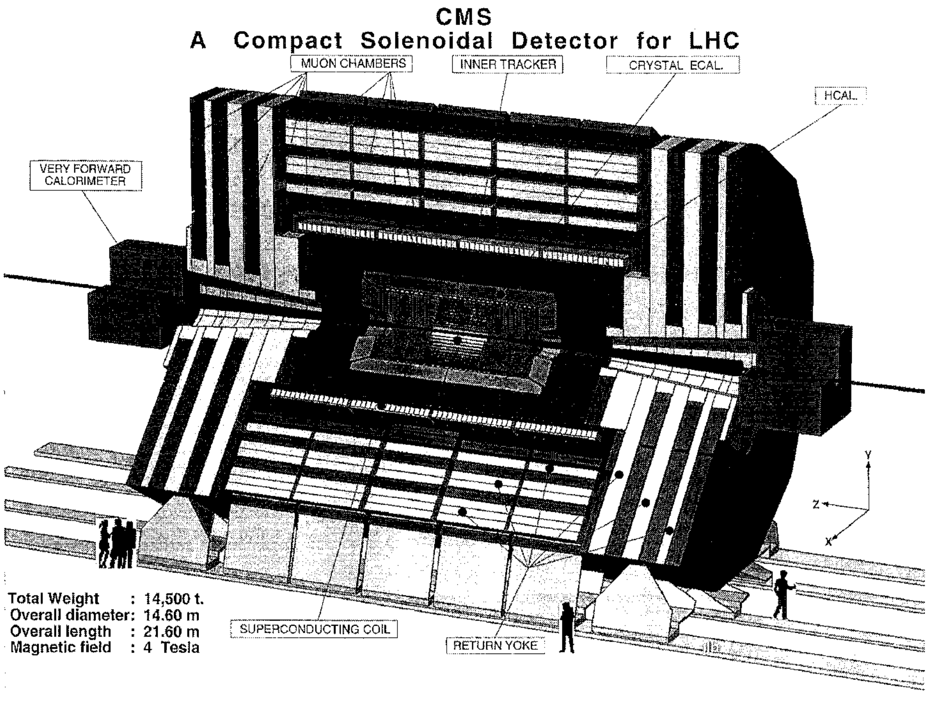
3 - high quality central tracking to achieve both the above; and

4 - an affordable detector.

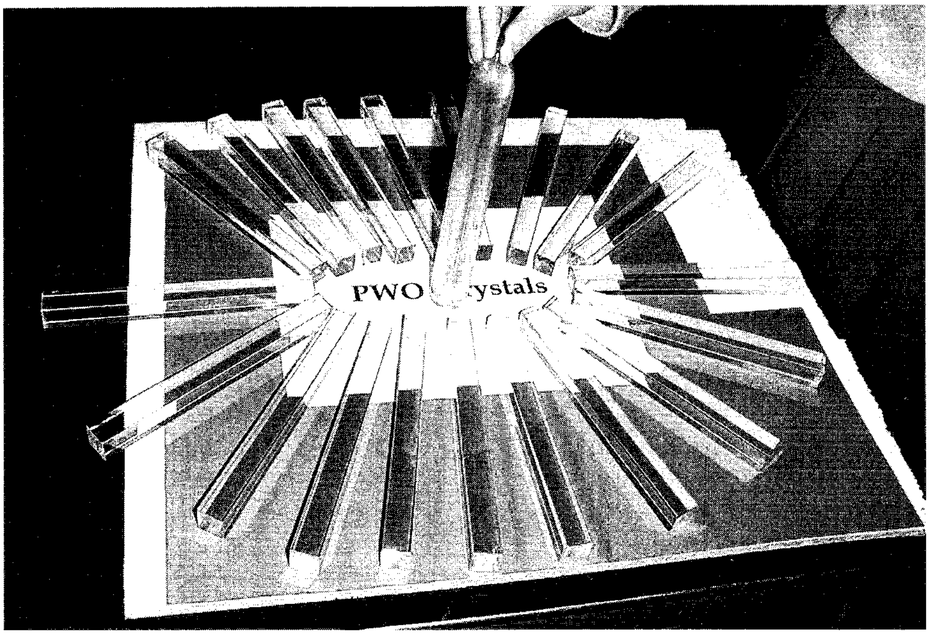
Overall, CMS aims to detect cleanly the diverse signatures of new physics by identifying and precisely measuring muons, electrons and photons over a large energy range at very high collision rates, while also exploiting the lower luminosity initial running. As well as proton-proton collisions, CMS will also be able to look at the muons emerging from LHC heavy ion beam collisions.

History

The Evian CMS conceptual design foresaw the full calorimetry inside the solenoid, with emphasis on precision electromagnetic calorimetry for



Full calorimetry inside a solenoid - schematic of the CMS detector for CERN's LHC proton-proton collider.



Lead tungstate ($PbWO_4$) crystals will be used for electromagnetic calorimetry in the CMS experiment. Its absorption properties are such that required volume (approx. 12.5 m^3) is only half that for other crystals leading to a substantial reduction in cost. In addition lead tungstate is a relatively easy crystal to grow from readily available raw materials and significant production capacity already exists.

picking up photons. (A light Higgs particle will probably be seen via its decay into photon pairs.) The muon system now foresaw four stations. Inner tracking would use silicon microstrips and microstrip gas chambers, with over 10^7 channels offering high track finding efficiency. In the central CMS barrel, the tracking elements are mounted on spirals, providing space for cabling and cooling.

Following Evian, a Letter of Intent signed by 443 scientists from 62 institutes was presented to the then new LHC Experiments Committee. Two electromagnetic calorimetry routes were proposed, a preferred one based on homogeneous media, and the other on a less expensive sampling solution using a lead/ scintillator sandwich read out by wavelength-shifting fibres, named shashlik.

Due to limited resources in the collaboration at the time the shashlik solution was adopted as baseline. However R & D continued on cerium fluoride (CeF_3) and two other candidate media, lead tungstate crystals ($PbWO_4$) and hafnium fluoride glasses. The collaboration had doubled in size by the summer of 1994 and in September of that year lead tungstate was chosen after extensive beam tests of matrices of shashlik, cerium fluoride and tungstate towers. The radiation length of $PbWO_4$ is only 0.9 cm and the required volume (approx. 12.5 m^3) is only half that for CeF_3 leading to a substantial reduction in cost. In addition lead tungstate is a relatively easy crystal to grow from readily available raw materials and significant production capacity already exists.

Following the November 1993 decision to foreclose the SSC project, US physicists were looking for new possibilities and many knocked at the CMS door. A letter of intent submitted to the US Department of Energy in September 1994 covered a 270-strong US contingent in CMS, where the main responsibility would be for the endcap muon system and barrel hadronic calorimeter.

Meanwhile interest continued to grow, so that CMS now involves some 1250 scientists from 132 institutions in 28 countries. Some 600 scientists, from 60 research institutes, are from CERN Member States, the remainder, from 72 institutes, hail from further afield. Some three hundred of these scientists are from 37 institutes in the US, and 250 from 25 research institutes in Russia and Member States of the international Joint Institute for Nuclear Research, Dubna, near Moscow.

Detector overview

The choice of magnet was the starting point for the whole CMS design. Although the solenoid has been cut from 14 to 13 m in length, its radius (2.95m) and magnetic field (4T) remain unaltered. This long and high field solenoid removes the need for additional forward magnets for muon coverage, while accommodating easily the tracking and calorimetry.

The 12-sided structure, designed at CERN, is subdivided along the beam axis into five rings, each some 2.6 metres long, with the central one supporting the inner superconducting coil. End caps complete the magnetic volume. The coil itself, designed at Saclay, is split into four sections, each 6.8 metres in diameter, the maximum girth compatible with transport by road. The conductor is a 40-strand niobium-titanium enclosed in an aluminium stabilizer. With 900W of cooling power at 4.5K and 3400W at 60K, cooldown will take 32 days.

In order to deal with high track multiplicities in the inner tracking cavity, detectors with small cell sizes are needed. Solid-state and gas

microstrip detectors provide the required granularity and precision. Two layers of pixel detectors have been added to improve the measurement of the track impact parameter and secondary vertices. The silicon pixel and microstrip detectors will be kept at 0° to slow down damage by irradiation. High track finding efficiencies are achieved for isolated high transverse momentum tracks. It is also fairly high for such tracks in jets. All high transverse momentum tracks produced in the central region are reconstructed with high momentum precision (5 per mil), a direct consequence of the high magnetic field. The responsibility for the inner tracker extends to institutes in Belgium, Finland, France, Germany, Greece, India, Italy, Switzerland, UK, US and CERN.

Centrally produced muons are identified and measured in four muon stations inserted in the magnet return yoke. The chambers are judiciously arranged to maximize the geometric acceptance. Each muon station consists of twelve planes of aluminium drift tubes designed to give a muon vector in space, with 100 micron precision in position and better than 1 mrad in direction.

The four muon stations also include resistive plate chamber triggering planes that identify the bunch crossing and enable a cut on the muon transverse momentum at the first trigger level. The endcap muon system also consists of four muon stations. Each station consists of six planes of Cathode Strip Chambers. The final muon stations come after a substantial amount of absorber so that only muons can reach them. The large bending power is the key to very good momentum resolution even in the so called "stand alone" mode, especially at high transverse momenta. The muon system team includes scientists from Austria, China, Germany, Hungary, Italy, Poland and Spain with large contingents from the US and Dubna Member States.

As the coil radius is large enough to install essentially all the calorimetry inside, a high precision electromagnetic calorimeter can be envisaged. The lead tungstate (PbWO4) crystal calorimeter leads to a di-photon mass resolution twice as good as that anticipated from the shashlik.

The electromagnetic calorimeter groups scientists with large experience of total absorption calorimeters from China, Dubna Member States, France, Italy, Germany, Switzerland, UK, US and CERN.

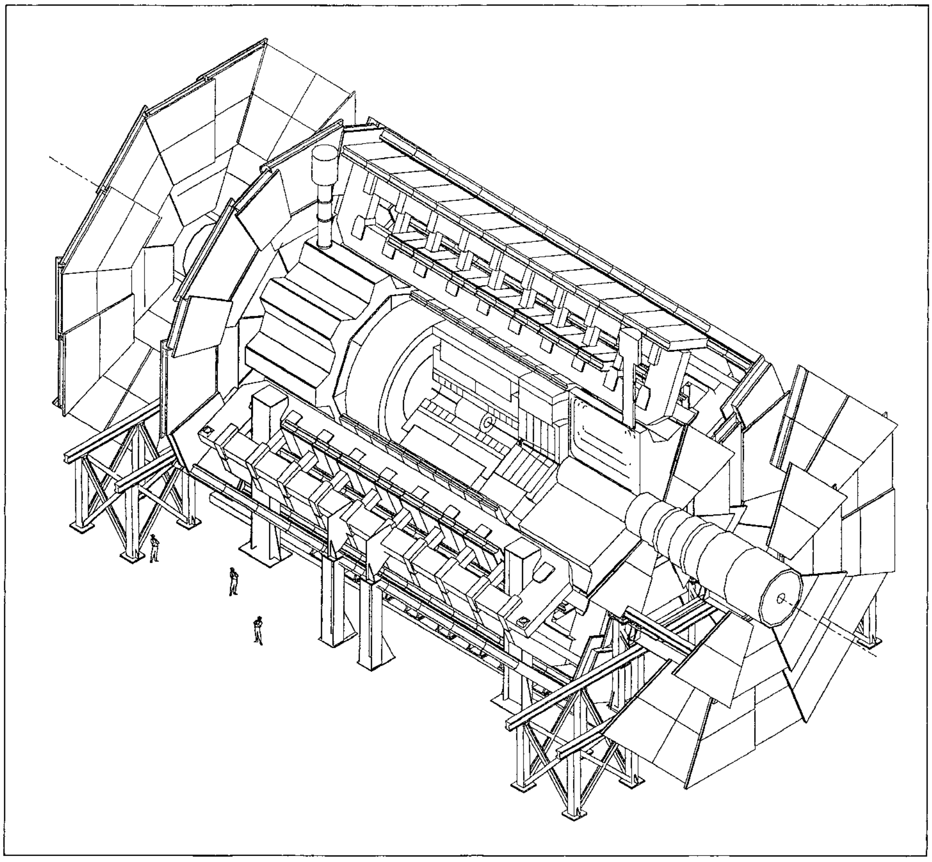
The hadron calorimeter, benefiting from US involvement, will use interleaved copper plates and plastic scintillator tiles read out by wavelength-shifting fibres. As well as the US, the CMS hadron calorimetry squad includes institutes from China, Hungary, India, Spain and Dubna Member States.

For LHC's design luminosity of 10^{34} cm^{-2} s^{-1}, CMS will have to digest 20 highly complex collisions every 25 nanoseconds. This input rate of 10^{9} interactions per second has to be reduced to just 100 for off-line analysis. This will be accomplished by a two-level trigger. The first level trigger uses pipelined information from the muon detectors and the calorimeters to reach a decision after a fixed time period of 3 microseconds. The data from a maximum of 10^{5} interactions per second, from the muon detectors and the calorimeters only, is forwarded to an online processor farm. This "virtual" Level 2 uses the full granularity to reject almost 90% of the events. The entire data from the remaining events is then passed to the farm for further processing. The trigger and data acquisition systems are the responsibility of a team from Austria, Finland, France, Germany, Hungary, Italy, Portugal, Poland, Dubna Member States, Spain, Switzerland, UK, US and CERN. Software and computing, for monitoring and control as well as data handling and analysis, will take on a new dimension at the LHC.

Like its LHC counterparts, CMS defines a new scale in world-wide physics collaboration. The total cost of the detector is 459 million Swiss francs, the magnet being the largest single item (25%). If everything goes according to plan for the LHC machine itself, CMS should be seeing its first collisions in 2004.

ATLAS

Cutaway view of the ATLAS detector for CERN's LHC proton-proton collider. The outer toroidal magnet will extend over 26 metres, with an outer diameter of almost 20 metres. The total weight of the detector is 7,000 tonnes.



In Greek mythology, Atlas was a Titan who had to hold up the heavens with his hands as a punishment for having taken part in a revolt against the Olympians. For LHC, the ATLAS detector will also have an onerous physics burden to bear, but this is seen as a golden opportunity rather than a punishment.

The major physics goal of CERN's LHC proton-proton collider is the quest for the long-awaited 'higgs' mechanism which drives the spontaneous symmetry breaking of the electroweak Standard Model picture. The large ATLAS collaboration proposes a large general-purpose detector to exploit the full discovery potential of LHC's proton collisions.

LHC will provide proton-proton collision luminosities at the awe-inspiring level of 10^{34} cm^{-2} s^{-1}, with initial running in at 10^{33}. The ATLAS philosophy is to handle as many signatures as possible at all luminosity levels, with the initial running providing more complex possibilities.

The ATLAS concept was first presented as a Letter of Intent to the LHC Committee in November 1992. Following initial presentations at the Evian meeting ('Towards the LHC Experimental Programme') in March of that year, two ideas for general-purpose detectors, the ASCOT and EAGLE schemes, merged, with Friedrich Dydak (MPI Munich) and Peter Jenni (CERN) as ATLAS co-spokesmen.

Since the initial Letter of Intent presentation, the ATLAS design has been optimized and developed, guided by physics performance studies and the LHC-oriented detector R&D programme (April/May, page 3).

The overall detector concept is characterized by an inner superconducting solenoid (for inner tracking) and large superconducting air-core toroids outside the calorimetry. This solution avoids constraining the calorimetry while providing a high resolution, large acceptance and robust detector.

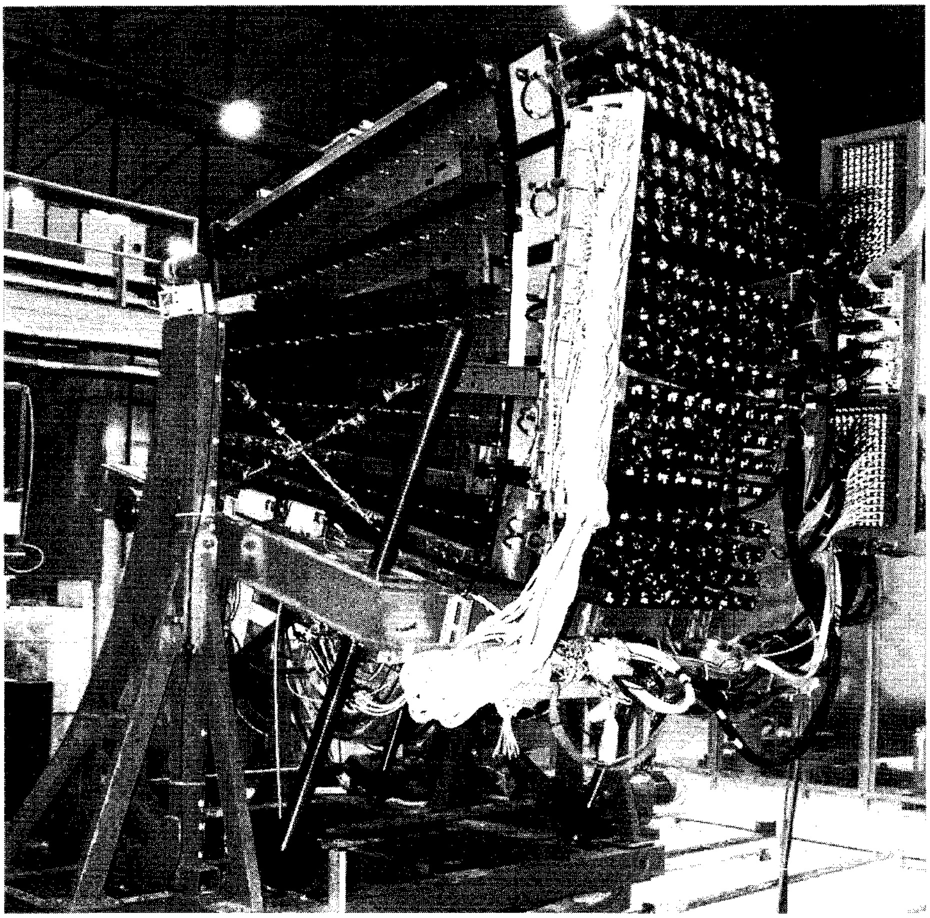
The outer magnet will extend over a length of 26 metres, with an outer diameter of almost 20 metres. The total weight of the detector is 7,000 tonnes. Fitted with its end-cap toroids, the outer magnet alone will weigh 1,400 tonnes. Estimated total cost of the detector is 450 million Swiss francs.

To achieve its basic aims, the ATLAS design has gone for:
very good electromagnetic calorimetry for electron and photon identification and measurements, complemented by complete (hermetic) jet and missing energy calorimetry;
efficient tracking at high luminosity for lepton momentum measurements, for heavy quark tagging, and for good electron and photon identification, as well as heavy flavour vertexing and reconstruction capability;
precision muon momentum measurements up to the highest luminosities and very low transverse momentum triggering at lower luminosities.

Other overall design aims have been large angular coverage together with triggering and particle momentum capabilities at low transverse momenta.

The inner detector is contained in a cylinder 6.8 metres long (with a solenoid of length 5.3 metres) and diameter 2.3 metres, providing a magnetic field of 2 Tesla. Design of the coil is being developed by the Japanese KEK Laboratory. Reflect-

ATLAS hadronic calorimetry under test. The design uses a novel tile scintillator with plastic scintillator plates embedded in iron absorber.



ing LHC's bold physics aims and the pace of detector R&D, this inner detector is packed with innovative tracking technology (compared with existing major detectors) including high-resolution pixel and strip detectors inside and straw-tubes with transition radiation capability further away from the beam pipe. Finest granularity will be provided by semiconductor pixel detectors immediately around the beam pipe, providing about a hundred million pixels. With this technology moving rapidly, the final solution will benefit from ongoing R&D work.

Surrounding the tracking region will be highly granular electromagnetic sampling calorimetry, probably based on liquid argon (however studies on an alternative liquid krypton scheme are still in progress), contained in an 'accordion' absorber structure in a cylinder 7 metres long and 4.5 metres across, plus two endcaps. The inner solenoid coil is integrated into the vacuum vessel of the calorimeter cryogenics, reducing the amount of material that emerging particles have to cross.

Liquid argon is used for both electromagnetic and hadronic calorimetry in the endcaps of the calorimeter, the former arranged in a 'Spanish fan' geometry to cover all azimuthal angles without cracks, the latter in a wheel-like structure using copper absorber. Integrated into the endcaps is the forward calorimetry based on an array of rods and tubes embedded in a tungsten absorber some 5 metres from the interaction point.

The bulk of the hadronic calorimetry is provided by three large barrels of a novel tile scintillator with plastic scintillator plates embedded in iron absorber and read out by wavelength-shifting fibres. The tiles, laid perpendicular to the beam direction, are staggered in depth to simplify construction and fibre routing.

Total weight of the calorimetry system is 4,000 tonnes (the entire UA1 detector which ran at CERN's proton-antiproton collider for a decade and was considered a big detector in its time weighed 2,000 tonnes).

The air-core toroid magnet, with its long barrel and inserted endcaps, generates a substantial field over a large volume but with a light and open structure minimizing troublesome multiple scattering. The toroid route was chosen because this geometry features the magnetic field perpendicular to the particle, and avoids large volumes of iron flux return (see page 12). The French Saclay Laboratory is responsible for the barrel and the UK Rutherford Appleton Laboratory for the endcaps.

Interleaved with the main air toroid magnet will be the muon chambers, the last outposts of ATLAS. These chambers, arranged in projective towers in the barrel region, are diametrically 22 metres apart, with the central muon barrel extending 26 metres and forward muon chambers 42 metres apart along the beam direction. Cathode strip chambers will be used in the highest rate environment close to the beam direction, supplemented further out by 'monitored' drift tubes - pressurized thin-wall tubes arranged in several layers.

Overall, ATLAS involves so far some 1500 scientists and engineers representing 140 institutions in 31 countries (including 17 CERN Member States). The participation of Non-

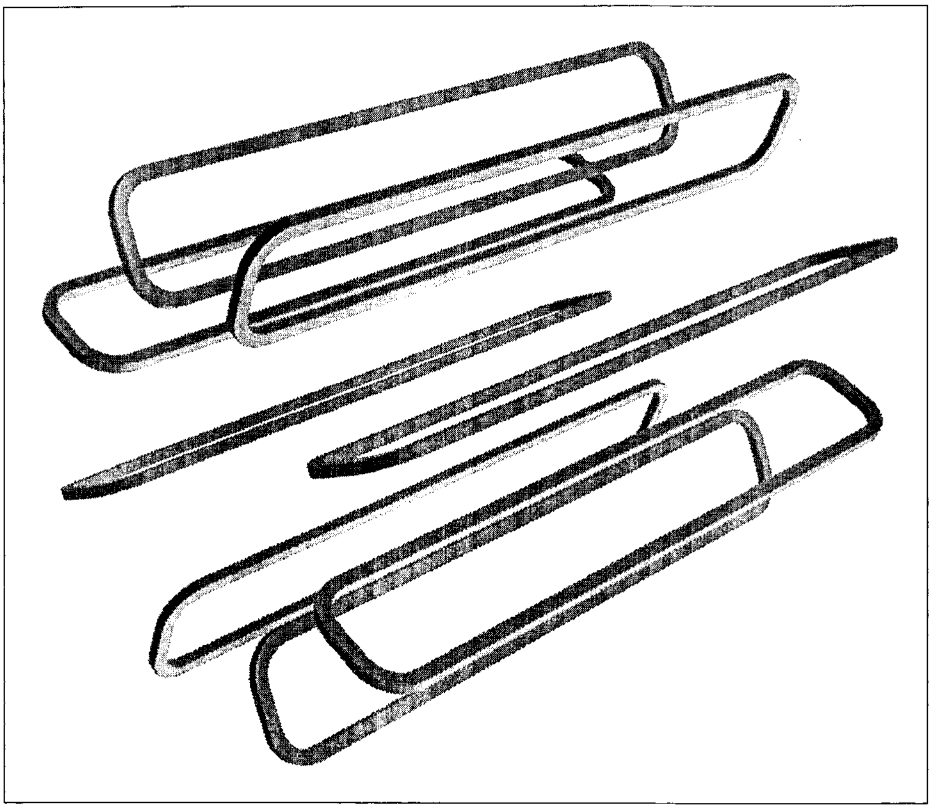
ATLAS uses a toroidal electromagnet. Usually used in tokamaks for fusion research, toroids are rarely encountered in particle physics.

Member State groups is still subject to the satisfactory establishment of bilateral agreements between CERN and the appropriate funding agencies.

However their potential involvement in ATLAS is already woven deeply into the fabric of the collaboration. For example semiconductor strips for the inner detector could involve teams from institutes in Australia, Canada, the Czech Republic, Finland, Germany, Japan, Norway, Poland, Russia, Sweden, Switzerland, the UK and the US, while the scintillator tiles could involve Armenia, Brazil, the Czech Republic, France, Italy, Portugal, Romania, Russia, Spain, Sweden, CERN and the US.

In addition to the 7,000 tonnes of ATLAS hardware, software and data acquisition requires a major effort. To handle ATLAS data, the first level trigger, which identify unambiguously which event crossing is responsible for the event, operates at the full bunch crossing rate of 40 MHz (one bunch every 25 nanoseconds). It takes about 2 microseconds for the first level trigger information to take shape and be distributed. During Level 1 trigger processing time, all data is held in pipelines prior to output at 100 kHz for subsequent processing at Level 2. During this 10 milliseconds, the Level 2 processors look at subsets of detector data before passing it on for final processing (at about 1 kHz) at Level 3, where complete event reconstruction becomes possible. Trigger processors at all three levels will be programmable.

The master plan is to have ATLAS ready for data taking at the end of 2003, when the planet's largest particle physics detector will be ready to begin the job for which it was so carefully designed and planned.



Solenoids and toroids

A solenoid (from the Greek meaning 'pipe-shaped') is the usual way of making an electromagnet from a cylindrical coil of wire. Solenoids have a long tradition in physics, from pioneer experiments on electromagnetic induction by Oersted, Biot, Savart and Faraday in the early 19th century to contemporary particle physics experiments at colliding beam machines.

Large toroidal magnets were first required to confine an isotropic plasma in tokamak machines for experiments on thermonuclear fusion. As well as looking very different, toroidal magnets have distinctive properties.

- A solenoid gives constant resolution in the transverse momentum of particles which emanate from the centre and traverse the coil. However 'forward' particles moving along the solenoid axis encounter progressively less bending as they near the end of the coil and the resolution deteriorates rapidly. In contrast, the toroid gives transverse momentum resolution which improves as the particle moves forward.

- The solenoid permits using the (usually very precise) transverse beam position given by the tracking system to reconstruct the particle trajectory. The toroid can also make use of the longitudinal position.

- The solenoid needs an external flux return but the toroid is self-contained.

Overall, there is no decisive argument in favour of either the solenoid or the toroid - it is the integration into the detector design which is the deciding factor.

Around the Laboratories

Neutrino oscillations

Throughout their 50-year history, neutrinos have been controversial, and 1995 is no exception. On 31 January the New York Times *ran a story that a team at Los Alamos had uncovered intriguing new neutrino results. Taken at face value, this report had far-reaching physics implications.*

Before interpreting any new result, scientists have to assess the reliability of the data it is founded on. Although no Los Alamos scientific paper was available to confirm the newspaper story, its implications and hearsay immediately fuelled some people's thinking. On 1 February the CERN Courier invited the Los Alamos team to issue a statement. Taking a lot of care with their announcement, the team finally issued an authoritative statement on 20 April. Other than minor changes, such as transcribing symbols into words, the statement has not been edited.

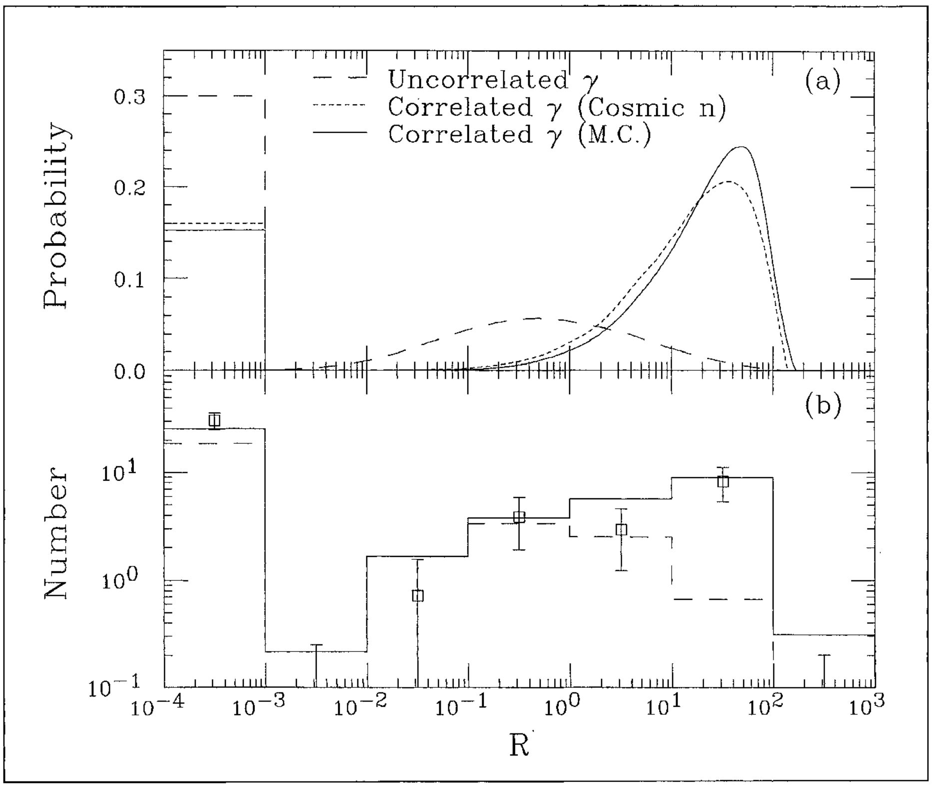
LOS ALAMOS Candidate events in a search for neutrino oscillations

In the past several years, a number of experiments have searched for neutrino oscillations,where a neutrino of one type (say muon-antineutrinos) spontaneously transforms into a neutrino of another type (say electron antineutrinos). For this phenomenon to occur, neutrinos must be massive and the apparent conservation law of lepton families must be violated. At this time, there is no broadly accepted evidence for neutrino oscillations from a terrestrial experiment.

The Liquid Scintillator Neutrino Detector (LSND) experiment (July 1993, page 10) at the Los Alamos Meson Physics facility (LAMPF) is designed to search with high sensitivity for muon-antineutrino electron-antineutrino oscillations from positive muon decay at rest. The collaboration consists of groups from the University of California at Riverside, San Diego and Santa Barbara, the University California Intercampus Institute for Research at Particle Accelerators, Embry Riddle Aeronautical University, Linfield College, Los Alamos National Laboratory, Louisiana State University, Louisiana Tech University, the University of New Mexico, Southern University, and Temple University.

LAMPF is an intense source of low energy neutrinos due to its 1 mA proton intensity and 800 MeV energy. The neutrino source is well understood because almost all neutrinos arise from positive pion or muon decay; negative muons and pions are readily captured in the iron of the

Figure 1. Searching for the gamma rays produced following neutrino interactions in the LSND experiment at Los Alamos. R is the likelihood that the gamma is correlated with an interaction compared to the likelihood that it is accidental. The leftmost bin corresponds to no gamma found within cuts (R=0), properly normalized in area. (a) Accidental photons (averaged over the tank) and correlated photons. (b) Beam-on minus beam-off spectrum for events in the 36 - 60 MeV electron energy range. The dashed histogram is the result of the R likelihood fit for events without a recoil neutron, while the solid histogram is the total fit, including events with a neutron.



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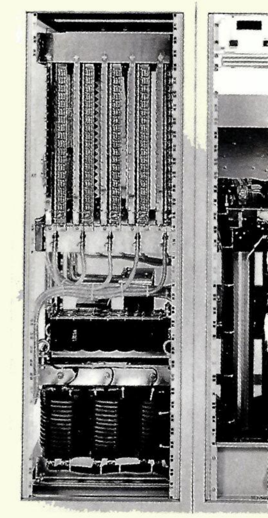

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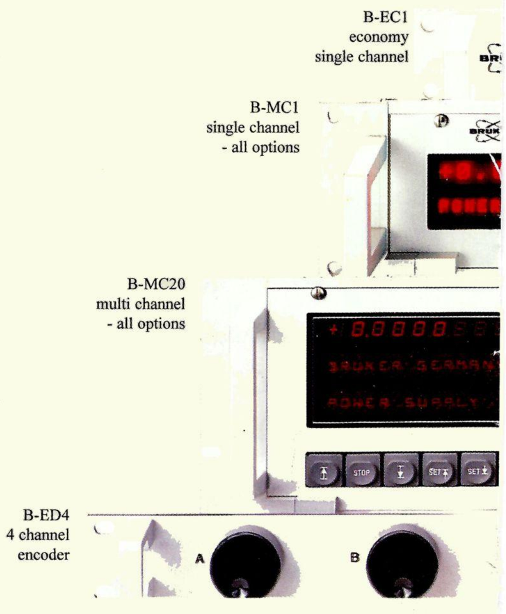

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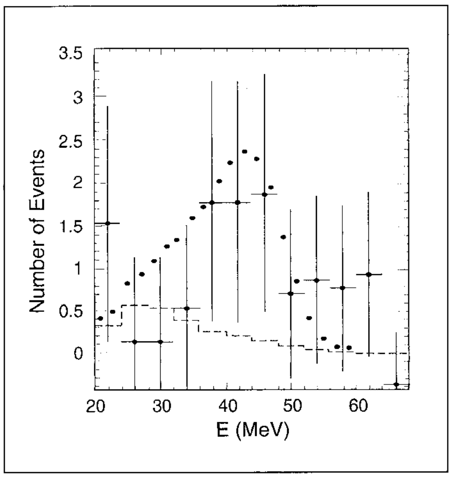
Figure 2. Oscillation evidence. The electron energy distribution, beam-on minus beam-off, for events with an associated 2.2 MeV gamma with R >30. The dashed histogram shows the expected background from known neutrino interactions. The dotted curve is the expected distribution for neutrino oscillations in the limit of large mass squared , normalized to the excess between 36 and 60 MeV. There are 9 events beam-on in the 36 - 60 MeV energy range and a total estimated background (beam-off plus neutrino-induced background) of 2.1 ± 0.3 events. The probability that this excess is due to a statistical fluctuation is less than 10^{-3}.



shielding and copper of the beam stop.

The production of kaons and heavier mesons is negligible at these energies. The electron-antineutrino rate is calculated to be only 4 x 10^{-4} that of muon-antineutrinos in the neutrino energy range between 36 and 52.8 MeV, so that the observation of a significant electron-antineutrino rate would be evidence for muon-antineutrino electron-antineutrino oscillations.

The LSND detector consists of an approximately cylindrical tank 8.3 m long by 5.7 m in diameter. The centre of the detector is 30 m from the neutrino source. On the inside surface of the tank 1220 8-inch Hamamatsu phototubes provide 25% photocathode coverage (cover photo, July 1993). The tank is filled with 167 metric tons of liquid scintillator (mineral oil) and 0.031 g/l of b-PBD. This low scintillator concentration allows detection of both Cerenkov light and scintillation light and yields a relatively long attenuation length of more than 20 m for wavelengths greater than 400 nm.

A typical 45 MeV electron created in the detector produces some 1500 photoelectrons, of which some 280 are in the Cerenkov cone.

The phototube time and pulse height signals are used to reconstruct the track with an average position resolution of some 30 cm, an angular resolution of some 12 degrees, and an energy resolution of around 7%.

The Cerenkov cone for relativistic particles and the time distribution of the light, broader for non-relativistic particles, give excellent particle identification.

The signature for an electron-antineutrino interaction in the detector is its conversion of a proton to a neutron and a positron, followed by a neutron and a proton giving a deuteron and a 2.2 MeV gamma ray. A likelihood ratio, R, is employed to determine whether an observed gamma is a 2.2 MeV photon correlated with a positron or is from an accidental coincidence. R is the likelihood that the gamma is correlated compared to the likelihood that it is accidental, and depends on the number of hit phototubes for the gamma, the reconstructed distance between the positron and the gamma, and the relative time between the gamma and positron.

Figure 1a shows the expected R distribution for accidental photons and correlated photons. Figure 1b shows the R distribution, beam-on minus beam-off, for events with positrons in the 36 - 60 MeV energy range. The dashed histogram is the result of the R likelihood fit for events without a recoil neutron, and the solid histogram is the total fit, including events with a neutron. After subtracting the neutrino background with a recoil neutron there is a net excess of 16.4 +9.7-8.9 ± 3.3 events, which if due to neutrino oscillations corresponds to an oscillation probability of (0.34 +0.20-0.18 ± 0.07)%.

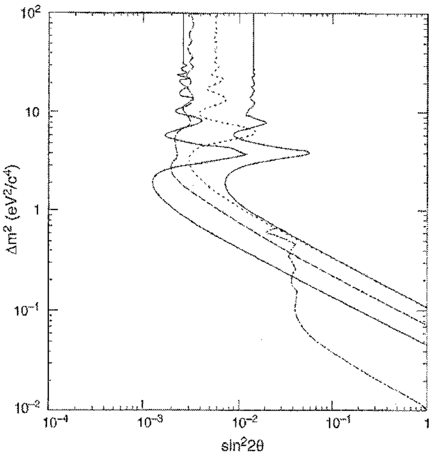
Figure 2 shows the electron energy distribution, beam-on minus beam-off excess, for events with an associated 2.2 MeV with R more than 30. For this , the total 2.2 MeV gamma detection efficiency is 23% and the probability that an event has an accidental gamma in coincidence is 0.6%. The dashed histogram shows the background from expected neutrino interactions. There are 9 events beam-on in the 36 - 60 MeV energy range and a total estimated background (beam-off plus neutrino-induced background) of 2.1 ± 0.3 events. The probability that this excess is due to a statistical fluctuation is less than 10^{-3}.

If the observed excess is due to neutrino oscillations, Figure 3 shows the allowed region of mixing parameter vs mass squared from a maximum likelihood fit to the L/E (the neutrino distance to energy ratio) distribution of the 9 beam-on events. Some of this allowed region is excluded by the ongoing KARMEN experiment at the UK Rutherford Laboratory's ISIS machine (April/May, page 14), the E776 experiment at Brookhaven, and the Bugey reactor experiment.

In summary, the LSND experiment observes an excess of events with positrons in the 36 - 60 MeV energy range that are correlated in time and space with a low energy gamma. If the observed excess is interpreted as muon-antineutrino electron-antineutrino oscillations, it corresponds to an oscillation probability of (0.34 +0.20-0.18 ± 0.07)% for the allowed regions shown in Figure 3. More data taking is planned, and the detector performance is under continuous study.

Both of these efforts are expected to improve the understanding of these phenomena. If neutrino oscillations have been observed, then the minimal standard model would need to be modified and neutrinos would have mass sufficient to influence

Figure 3. Neutrino oscillation probabilities. Mixing parameter against mass squared from a maximum likelihood fit to the L/E distribution of the 9 events which satisfy the R >30 requirement, where L/E is the neutrino distance to energy ratio, normalized to the oscillation probability extracted from the photon likelihood fit. The shaded area is the allowed region (95% C.L.) from LSND. Not shown is the 20% systematic uncertainty in the LSND normalization. Also shown are 90% C.L. limits from KARMEN (dotted histogram), the Brookhaven E776 experiment (dashed histogram), and the Bugey reactor experiment (dot-dashed histogram), where the excluded region is to the right of each of these lines.



cosmology and the evolution of the universe.

CERN
Antiprotons probe the nuclear stratosphere

The outer periphery of heavy stable nuclei is notoriously difficult to study experimentally. While the well understood electromagnetic interaction between electrons (or muons) and protons has given the nuclear charge (or proton) distribution with high precision for almost all stable nuclei, neutron distribution studies are much less precise.

This is especially true for large nuclear distances, where the nuclear density is small. A few previous experiments probing the nuclear "stratosphere" suggested that far from the centre of the nucleus (of the order of 2 nuclear radii) this stratosphere may be composed predominantly of neutrons.

At the end of the sixties the term "neutron halo" was introduced to describe this phenomenon, but experimental evidence was scarce or even controversial, and remained so for almost a quarter of a century. Recently, the Warsaw/Munich/Berlin collaboration working within the PS203 experiment at CERN's LEAR low energy antiproton ring, proposed a new method to study the nuclear periphery using stopped antiprotons. The halo now looks firmer.

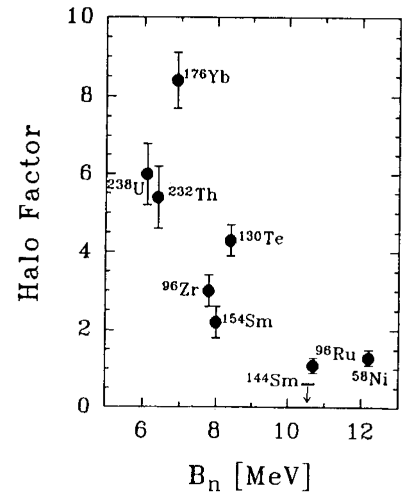
A 200 MeV/c beam of antiprotons was slowed down by interactions with atomic electrons. When antiproton kinetic energy drops well below 1 keV, the particles are captured in the outermost orbits of "exotic atoms", where the antiprotons take the place of the usual orbital electrons.

With the lower orbits in this antiprotonic atom empty, the antiproton drops toward the nuclear surface, first emitting Auger electrons and later predominantly antiprotonic X-rays. Due to the strong interaction between antiprotons and nucleons, the antiproton succumbs to annihilation with a nucleon in the rarified nuclear stratosphere, far above the innermost Bohr orbit of the atom. The annihilation probability in heavy nuclei is maximal where the nuclear density is about 3% of its central value and extends to densities many orders of magnitude smaller.

Antiproton annihilation on a proton or on a neutron at the nuclear periphery produces on average five pions. Some of these enter the nuclear volume and "heat" the nucleus, which "cools" by first emitting fast nucleons and later evaporating neutrons or charged particles, or by fission.

After all these processes, the residual nucleus is often substantially lighter. However, in 10-20% of cases a quite different scenario evolves. Distant annihilations have a large probability that all produced pions "miss" the inner nucleus, giving a "cold" reaction product. If the antiproton annihilated with a neutron, the resulting reaction product is a one mass unit lighter isotope of the target element. If a proton participated in the annihilation, the reaction product is a target isotone, with one charge number less.

Recent data from the Warsaw/Munich/Berlin collaboration (PS203 experiment) at CERN's LEAR low energy antiproton ring showing how the 'neutron halo' depends on target neutron separation energy. The halo factor is the ratio (suitably corrected) of antiproton annihilations on neutrons to those on protons.



Among naturally occurring isotopes some have both such products radioactive. For these, the absolute yield and the yield ratio of their production can be determined by nuclear spectroscopy. The yield ratio - proportional to the number of antiproton encounters with neutrons to the number of encounters with protons - reflects the neutron/proton ratio, or "concentration", where annihilation occurred.

The new method probes the nuclear periphery at distances roughly equal to 2 nuclear radii. The data indicate that a neutron halo - a nuclear stratosphere in which there are much more neutrons than would be expected from the target neutron/proton ratio - appears for nuclei with neutron binding energies lower than about 9 MeV.

Webbed archives

Proving that the World Wide Web (see page 1) can span time as well as space, the archivists at CERN have developed their own home page supplying general information on archives and more specific information on their holdings and how to access them. As well as providing instant access to information anywhere on the planet, in years to come the Web will be able to reach back and trace historical documents on archive information pages and database catalogues - as long as imaginative archivists first had the foresight to use the Web. Perhaps in future times material could be scanned to assist historians who normally have to rummage in cellars and blow the dust off discarded files. Instead, using the World Wide Web, they may be able to instantly resurrect pristine copies of long-forgotten papers and other valuable relics.

To prepare the way, CERN's archivists, Roswitha Rahmy and Tanya Peel, are liaising with their opposite numbers at the European University Institute in Florence to establish Web links on items of mutual interest. If this proves to be successful, links with other international archives and high energy physics centres could be developed.

Roswitha and Tanya would like to receive URLs from other HEP Archives. If you are thinking about creating an Archive Home Page please contact them - they would be willing to share experiences and advice.

With new CERN Archive pages planned and underway, the current pages can be accessed from the CERN Home Page under 'Scientific Information Service' or directly on the following URL:

http://wwwas.cern.ch/ASinfo/AS-SI/archives/Welcome.html

Given the recent consolidation of CERN's international role, links between CERN's Archives and other communities become more important, and the Web provides the necessary communication.

However despite the advent of this new medium, archive material still has to be collected, and the CERN archivists appeal once more to existing and former CERN staff and users. If you are leaving, retiring, already retired or are working in another institute and have some files or documents which could be of value, please contact the Archives. A CERN archivist is always at hand should you need any assistance with record management or archiving, or if you find any 'orphaned' material.

Roswitha Rahmy
(Roswitha_Rahmy@macmail.cern.ch or Rahmy@cernvm.cern.ch)
Tanya Peel
(Tanya_Peel@macmail.cern.ch)

Roswitha Rahmy (left) and Tanya Peel are equally at home with traditional and modern archives.

DESY
HERA-B approved

Following the recommendations of the DESY Physics Research Committee, on 9 February the DESY directorate concluded that the conditions outlined in the conditional approval of the ambitious HERA-B experiment (October 1994, page 10) have now been met by the collaboration and therefore gave its approval.

The HERA-B collaboration presently has 192 members from 29 institutions in 18 countries. HERA-B is a fixed target experiment to study CP violation (the subtle disregard of physics for invariance under simultaneous particle-antiparticle and left-right reversal). This phenomenon is best known in the behaviour of neutral kaons, but the neutral B system will provide a new window, and hopefully new understanding.

The B mesons will be copiously produced using the HERA proton ring by positioning an internal wire target into the beam halo, providing a well localized and high intensity source. Prototype halo target tests over the past two years have demonstrated that the required rates can be safely reached.

The design and construction of the spectrometer magnet and various detector components has begun, and the present schedule calls for installation of the magnet and first detector prototypes in the HERA West Hall during the 1995-6 winter shutdown. To make room for the experiment, the HERA electron and proton machine lattice had to be substantially redesigned over the past months. The HERA-B detector should be available for physics for the 1998 run.

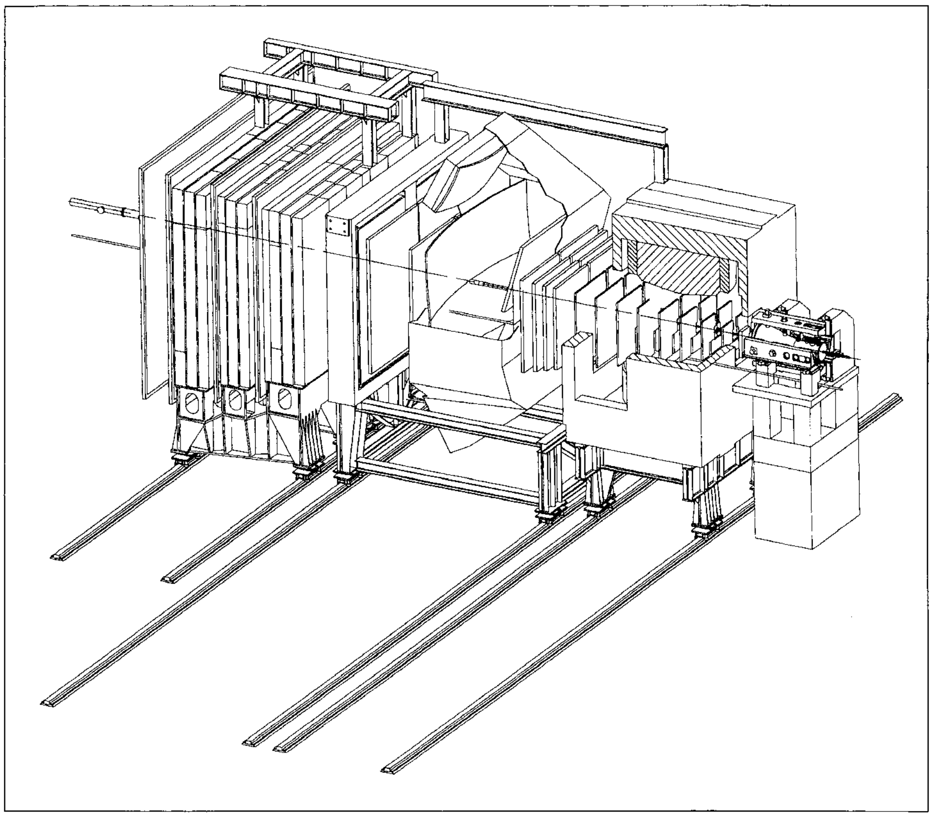
Approval is given under the assumption that the collaboration will follow the time schedule and budget outlined in the recent Technical Design Report (DESY-PRC-95/01).

CEBAF reaches design energy

CEBAF, the Continuous Electron Beam Accelerator Facility in Newport News, Virginia, reached its design energy of 4 GeV on 9 May, using the full five circuits of the accelerator.

LHC magnet string

At CERN the string of prototype superconducting magnets for the future LHC proton-proton collider (January/February, page 2) was powered up again, attaining 9 tesla, a higher magnetic field than that normally envisaged for the LHC.



Schematic of the HERA-B detector. This uses an internal target in the HERA proton ring at the DESY Laboratory. Hamburg. Protons enter from the right.

Physics monitor

Megascience for all

Increased global cooperation in particle physics, with scientists from all countries having access to this science, is the message emerging from a new report from the 'Megascience Forum' organized by the influential Organization for Economic Cooperation and Development (OECD).

International involvement in particle physics is not new. CERN, the European Centre for Particle Physics, celebrated its 40th anniversary last year and currently hosts thousands of users from all over the planet. Other major projects in the US, Europe, Japan, China and Russia also attract researchers from many countries.

But there is a growing awareness that the world-wide interest in high energy physics needs world-wide planning and discussion. Hence its inclusion in the OECD Megascience programme (May 1994, page 12).

The Megascience Forum, chaired by P. Tindemans, Director of the Division of Higher Education and Science of the Netherlands Ministry of Education, forms special 'expert panels' to study and make recommendations on special research areas. Megascience reports have been prepared on deep drilling, astronomy, global change, oceanography, and neutron beams and synchrotron radiation, and now these are joined by a new volume 'Particle Physics'*.

Part 1 of this volume presents the main conclusions of the expert meeting which took place at the Paul Scherrer Institute, Villigen, Switzerland, from 16-18 May 1994, at the invitation of the Swiss government. This was attended by 51 participants from 17 OECD Member States together with observers from Hungary, India, Mexico and the Russian Federation (Mexico has subsequently joined the ranks of OECD Member States).

The much more substantial Part 2 of the new volume was prepared by a subgroup and served as the basis for the discussion at Villigen. It presents the development of the science, its existing facilities, the socio-economic benefits of particle physics, existing mechanisms for international cooperation, new projects and long-term developments and scenarios. While most of this background material has been published elsewhere, it is a useful and concise collection. The final chapters present an accurate picture of ongoing projects and ways in which they could be better integrated into the world scene.

The Megascience Forum had begun to look at particle physics some time ago when construction of the 87-kilometre ring of the Superconducting Supercollider (SSC) project was getting underway. The SSC was to have been the ultimate in megascience, the largest scientific machine in the world. Then came the shock decision by US Congress in October 1993 to cancel the SSC.

Although the Villigen meeting was post-SSC, the OECD book makes little reference to the SSC episode. It is implicitly acknowledged ('in the light of some recent examples...'), but the uninformed reader would have to study the report quite hard to even discover that the SSC project had been proposed and prematurely abandoned.

However the message emerging from the OECD report is clear. 'It is important that maximum international collaboration should be sought at a sufficiently early stage of project development'.

The International Committee for Future Accelerators (ICFA) is the current world forum for international consultation and cooperation in this science, and the OECD recommends that ICFA might modify its composition and mode of operation, in particular to include representatives from more countries than its traditional base.

According to the OECD definition, Megascience means projects costing more than $1 billion, and for which CERN's LHC machine, a proton-proton collider in the 27-kilometre LEP tunnel, is the only immediate example. The report strongly endorsed early approval of the LHC. In the event, the project was approved (January, page 1) before the report was published!

The next megascience particle physics step after LHC would be a large electron-positron linear collider, where coordinated research and development work is pushing ahead at several centres. Here, the report advocates continuing with full global cooperation.

Turning to sub-megascience, the report underlines the importance of global and inter-regional collaboration. This global cooperation, says the report, means involving all countries, not just first-world ones. Scientists from developing countries need access to megascience. As well as ICFA, UNESCO's Physics Action Council could play a role here through its Large Physics Facilities Working Group.

After the Villigen meeting, the Megascience Forum discussed the conclusions from the expert meeting. While agreeing with most of what was said, the Forum signalled that in some areas the perspective of governments is beginning to diverge from that of scientists. The Forum points out 'with some insistence' that

Surveying the Swiss particle physics scene - European Committee for Future Accelerators (ECFA) chairman Günter Flügge at the recent ECFA meeting in Bern.
(Photo M. Jacob)

similar machines and scientific programmes should not be duplicated in different countries, even at the sub-megascience level.

**Megascience: The OECD Forum. Particle Physics, published by OECD, Paris, ISBN 92-64-14396-3. Also available in French.*

EUROPE
Swiss role

On its continual round of CERN Member States, the European Committee for Future Accelerators (ECFA) met in Bern, Switzerland, in March. With CERN based in Geneva, and with a national research centre at the Paul Scherrer Institute (PSI), Villigen, Switzerland figures prominently in European particle physics.

The Bern ECFA meeting provided a full picture of Swiss particle physics activities, project by project, and was prefaced by an overview by Claude Joseph of Lausanne.

The number of experimental particle physicists in the country is about 200, with an academic staff of about 170. These are distributed among seven universities - Basel, Bern, Fribourg, Geneva, Lausanne, Neuchâtel and Zürich. In addition there are substantial research groups at ETH-Zurich and at PSI. Probably reflecting the proximity of CERN, the size of the national research community, when scaled to the population, is above the CERN Member State average.

At CERN, there is a strong Swiss participation in research at the LEP electron-positron collider (concentrated on L3), with 44 physicists. There are also 33 physicists working at the LEAR low energy antiproton ring, in particular the Crystal Barrel and CP-LEAR studies.

In addition there is interest in heavy ion research and in neutrino physics (NOMAD) as well as substantial participation in research and development work for experiments at the LHC.

Away from CERN, there are 6 Swiss physicists working at the HERA electron-proton collider at DESY, Hamburg, with the national PSI programme involving about 40 physicists. (The PSI programme was covered at the Bern ECFA meeting by H.C. Walter.) Following the illustrious tradition of Fritz Zwicky, Switzerland also counts many astrophysicists.

Theoretical physics, with a community of some 80 researchers, has a great tradition. Throughout the 20th century, leading Swiss research centres have been beacons of brilliance. Zürich, in particular, played a leading role, with Einstein, Schrödinger and Pauli among its distinguished professors.

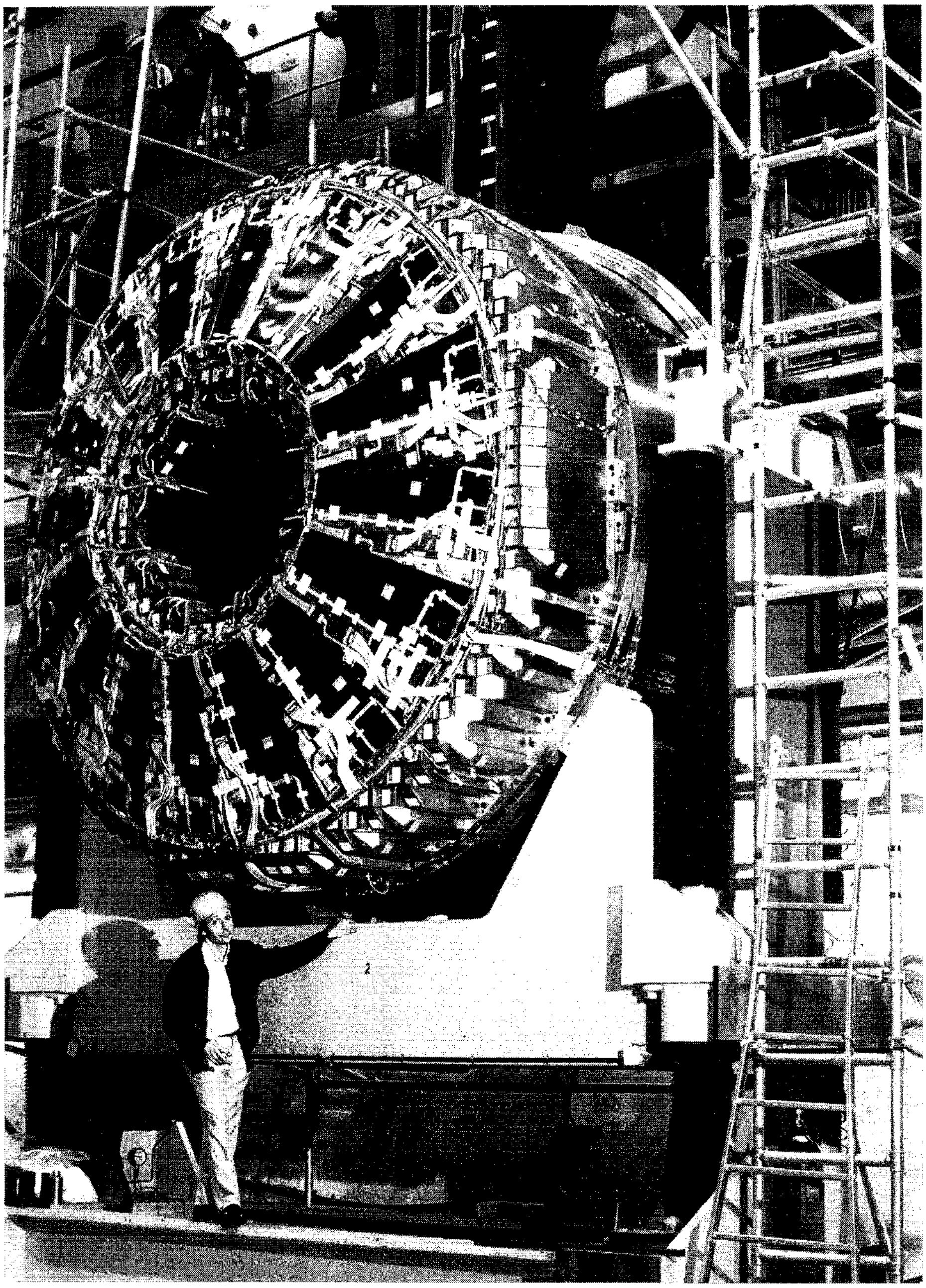
Modern Swiss theoretical research groups cultivate numerous international links and collaborations. Many projects are now in part funded by the European Commission's programmes. The main groups are in Bern, Geneva and ETH-Zurich. Permanent positions are almost restricted to full professors (only about one fourth of the theorists).There are hardly any permanent positions at an intermediate level.

Playing an important national role is the "Forum of Swiss High Energy Physicists" (Chairman, Ludwig Tauscher), which reports to the Federal Office for Education and Science. Support for LHC emerged at an early stage, and about 60

academic staff have signed LHC proposals. With such a strong community, Swiss groups do not concentrate on a single LHC detector. However financing of the LHC detectors and the related R&D work might call for some additional funding.

The 1992 Beck research report, commissioned by the Swiss Science Council, pointed out that about a quarter of physics professors are high energy experimentalists and that about one-third of these institutes have strong high energy groups. Particle physics is therefore a strong theme in the Swiss physics community. There are about 10 new PhDs in experimental particle physics per year. Many of these find employment in industry.

The Beck report also stressed that, at the university level, high energy experimentalists are on the average no more costly per head than physicists working in other domains. This is because most of the funding for large scale research comes from sources outside the universities and is allocated according to specific projects. This contrasts with the situation in some CERN Member States, where universities are reluctant to open professorships in experi-



Israel supplied innovative Thin-Gap Chambers for the endcap presampler and pole tip calorimeter of the Opal experiment at CERN's LEP electron-positron collider. Preparations in the early 1980s for the experimental programme at LEP was the signal for Israeli researchers to mount a concerted effort and contribute to one of the LEP experiments - Opal - at a level comparable to that of major nations.

mental particle physics and avoid what they perceive as concomitant heavy spending.

The report recommended that national experimental particle physics should maintain its current pattern, with active research all over the country reinforced by a skeleton of larger groups in major research centres. However for graduate teaching the report concluded there should be more coordination between the universities and the polytechnic schools.

The report also recommended a more central approach to the construction of heavy equipment. pointing to a special role which could be played by PSI (in the same way that the Rutherford Appleton Laboratory in the UK acts as a staging post for the UK CERN effort).

Relations between Switzerland and CERN are excellent and clearly benefit from proximity. Switzerland has a strong industrial basis in several areas of key interest to CERN, including mechanical and electrical engineering, electronics and microtechnics. Several small Swiss companies have benefited from fruitful technological transfers, and CERN has been an important influence behind the establishment in Geneva of European centres for several international concerns.

Switzerland's annual CERN contribution is 39.1 million Swiss francs, representing 4.17% of the Organization's budget. In return, Swiss industry receives CERN contracts worth 6.46 times this amount, not counting industrial support services and energy. This high return on investment on one hand reflects the wisdom of those Swiss founding fathers who first proposed Geneva as a home for the Laboratory. On the other hand this return has in recent years come under scrutiny by more distant Member States vying for CERN contracts.

In addition to the Swiss CERN subscription, there is annual funding of 20 MCHF for specific experiments and projects. As a Host State, Switzerland has also made repeated generous special contributions, especially for CERN buildings and infrastructure, and under the terms of the motion approved by Council in December (January/February, page 1) will make a special contribution towards the construction of CERN's new LHC proton-proton collider.

CERN and Israel

Israel (along with the US, Japan, Canada, the Russian Federation and India) is one of the CERN non-Member State nations targeted for substantial future participation in CERN's experimental programme, in particular for the LHC proton collider to be built in the 27-kilometre LEP tunnel and which was formally approved by CERN Council in December (January/February, page 1).

In keeping with their illustrious scientific traditions, Israeli experimental physicists have collaborated in experiments at many of the world's major high energy Laboratories - Brookhaven, Fermilab and SLAC in the US, and in Europe, DESY, Hamburg, as well as CERN. However CERN, as the geographically closest major Laboratory (as well as the largest), plays a special role for Israeli scientists.

At CERN, the advent of preparations in the early 1980s for the experimental programme at the LEP electron-positron collider was the signal for Israeli researchers to mount a concerted effort and contribute to one of the experiments - Opal - at a level comparable to that of major nations. This allowed Israeli teams to participate fully in the planning and construction phase of this branch of Big Science.

Underlining this commitment, and to coordinate the various national agencies involved in this aspect of Big Science, in 1983 the Israel Commission for High Energy Physics (ICHEP) was formed. It is currently chaired by David Horn of Tel Aviv.

The initial ICHEP/CERN contract established the official CERN/Israel link under which, in the short-term, teams from three major research centres - the Weizmann Institute, Tel-Aviv University, and Haifa's Technion - contributed to Opal, as the flagship experiment, while providing a framework for longer-term collaboration. (At CERN, Israeli physicists also participate in the NA45 heavy ion experiment and the NA47 Spin Muon Collaboration - SMC.)

Opal groups some 320 scientists from 32 research centres in eight countries, and includes a 21-strong Israeli contingent. Their 'national' contribution was to construct pole-tips for the hadron calorimeters and end-cap presamplers, at an estimated cost of 1.6 million Swiss francs, including the cost of technical support at and for home institutes. The Israeli teams are led by Jacques Goldberg from the Technion, Gideon Alexander from Tel Aviv and Giora Mikenberg from the Weizmann Institute.

This work involved the development of the 'thin-gap' chamber technique (TGC - very thin wire chambers operating in a saturated mode) which will go on to play an important role in ongoing projects, including the LHC programme.

In 1990, CERN/Israel links were consolidated with the signing of a new collaboration agreement following which the country was granted Observer status at CERN Council. This led less than a year later to a financial protocol under which Israel contributed 17% of the current full membership contribution. This protocol, renewed in 1993, stipulates that 15% of this contribution to CERN is in cash (from the Ministry of Science, mainly earmarked for a programme of Fellowships) and the remaining 85% in kind (supplied by the Ministry of Trade and Industry).

With the door opened, Israeli industry went on to supply equipment worth more than 2.7 million Swiss francs to CERN (mostly covered by the financial protocol arrangement) and including high technology areas like transmission equipment (optical and electronic), beryllium pipes, aqueous cleaning systems, electronics, semiconductors, power supplies, voice mail,..... A useful visiting card for the European market, this work is highly valued in Israel.

For LHC, experiments will be bigger than Opal, and the nation's contributions (to the proposal for the ATLAS detector) will need to be rescaled. This will be negotiated during the year. As well as applying Thin-Gap chamber technology to LHC detectors, Israel could also become involved in cryogenics for the LHC superconducting magnet infrastructure.

As well as at CERN, Israel is also very visible at the DESY Laboratory, Hamburg, where Weizmann and Tel Aviv scientists work on the Zeus detector at the HERA electron-proton collider. It is envisaged that this effort will gradually be phased into the LHC effort at CERN.

At the dedication of the Weizmann Institute Physics Building, May 1958 - left to right Meyer Weisgal (who subsequently became Institute President), Niels Bohr and J. Robert Oppenheimer.
(Photo Ben-Zvi, Rehovot, Israel)

Israel and modern science

Science has always been an important part of Jewish culture, and this has already become woven into the traditions of the State of Israel. Chemist Chaim Weizmann became the first President of Israel when the state was created in 1948. During the First World War, Weizmann had risen to fame in the UK after his discovery of a vital process for synthesizing acetone needed in explosives manufacture. He was also the first president of the internationally-renowned research institute in Rehovot, south of Tel Aviv, which bears his name. At this institute, Amos de Shalit and Igal Talmi are among the names which have made significant contributions to fundamental physics. On Weizmann's death in 1952, Albert Einstein turned down the invitation to succeed him as the young nation's President.

The Hebrew University in Jerusalem and the Technion in Haifa were both founded in the 1920s. It was at the Hebrew University that G. Racah, an immigrant from Italy, made pioneer contributions to the mathematics of the symmetries underlying nuclear interactions. In more recent years, another pioneer symmetry theorist, Yuval Ne'eman, has led a burgeoning physics centre in Tel Aviv.

Israel was among the founding members of the European Molecular Biology Laboratory in 1964, as well as having made significant contributions to the experimental programme at CERN. Israel is also a member of the European Physical Society.

Scientist and statesman - Chaim Weizmann, first President of Israel and of its Weizmann Institute.

External correspondents

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Yu. Ryabov

Stanford Linear Accelerator Center, (USA)
M. Riordan

TRIUMF Laboratory, (Canada)
M. K. Craddock

People and things

Bookshelf

Einstein lived here by Abraham Pais - Oxford University Press, ISBN 0-19-853994-0

Einstein enthusiasts will be pleased with Abraham Pais' new book 'Einstein lived here', advertised as a companion volume to Pais' classic Einstein biography 'Subtle is the Lord'. (Some of the material also appears in 'Subtle'.) As such the new volume is packed with anecdotes, quotes and other details to delight Einstein admirers and entertain the scientifically literate, but falls short of being a biography. Especially interesting is the background to his Nobel Prize, awarded for his explanation of the photoelectric effect and not for his monumental work on relativity, and the account of his first marriage, to Mileva Maric.

Books received

Ideas and Methods of Supersymmetry and Supergravity Or a Walk through Superspace By I.L. Buchbinder, Tomsk State Pedagogical Institute, and S.M. Kuzenko, Tomsk State University

Provides a detailed and self-contained account of four-dimensional simple supersymmetry and supergravity

UK Institute of Physics Publishing hardback, ISBN 0 7503 0330 1, £57

Giorgio Brianti retires

After a 40-year career spanning the whole of CERN's history, Giorgio Brianti retired from the Laboratory at the end of April. As well as having overseen many major projects, Brianti's dedicated work for CERN's next major machine, the LHC, scheduled to become operational in 2004, means his contributions will continue to be evident.

Joining the infant Laboratory in 1954, Brianti was initially involved in industrial liaison, a theme to which he subsequently returned. After work on the magnets and then controls and instrumentation for the new PS proton synchrotron, he moved on to operations. In 1964 he became leader of Synchro-Cyclotron (SC) Division, at a time when the SC, CERN's first machine, was being substantially upgraded and its role extended for the ISOLDE on-line isotope separator.

In 1967 he took charge of the team building the Booster, a new synchrotron to inject beams into the PS. As well as fulfilling its immediate objective of improving PS performance, the innovative design of the Booster and its astonishing adaptability are still paying dividends. Built to operate at 800 MeV, it has shown its ability to attain 1.4 GeV and has impressively demonstrated how it can handle the gymnastics needed for future LHC beams.

When John Adams was forming his team to build CERN's next major proton synchrotron, the SPS, Brianti's skills were eagerly sought, but with continuing responsibilities for the Booster, he transferred to the SPS later, to take charge of the complex preparations for its experimental areas, initially for fixed target work. In 1976 he became Deputy Leader of SPS Division, moving on to lead the Division the following year. During this time he supervised the imaginative work required to convert the SPS for historic role as a proton-antiproton collider.

Giorgio Brianti - 40 years at CERN.

In 1981 he became Technical Director at a time when the challenge of developing the technology for CERN's future requirements demanded increasing cooperation with industry. With the LHC emerging as the Laboratory's major long-term objective, in addition to his Directorship duties he put in much dedicated effort to prepare the way for this technically demanding machine. Superconducting magnets, long one of Brianti's pet ideas, were brought to the fore and the stamp of his expertise is written all over the present LHC design, both for the machine infrastructure and the main dipole magnets themselves. In recognition of his deep involvement in plans for the LHC, in 1990 he became Associate Director for Future Accelerators.

POSTDOCTORAL POSITIONS AT UC BERKELEY THEORETICAL BEAM PHYSICS

One or two post-doctoral positions in theoretical beam physics will be open in July, 1995 to candidates who have recently received a Ph.D. Current research topics include two-beam accelerators, intense laser propagation in plasmas, collider physics, photocathodes, and free-electron lasers.

Experience in one of these areas is desirable. The research will involve collaborations with Dr. Andrew Sessler and other scientists at the Lawrence Berkeley Laboratory Center for Beam Physics. The positions are for one year with the possibility of extending to two. Competitive Postdoctoral Research Physicist salary level dependent on experience and capability. Such salary is based on current University of California pay scales.

Interested candidates should send a curriculum vitae, including the names of three references, no later than July 10, 1995 to:

Prof. Jonathan Wurtele, University of California Berkeley, Department of Physics, 366 LeConte Hall, Berkeley, CA 94720 USA. email: Wurtele@physics.berkeley.edu

The University of California is an affirmative action/equal opportunity employer.

Katholieke Universiteit Nijmegen

Faculty of Science

The Department of Physics at the University of Nijmegen, The Netherlands, invites applicants for the position of

professor (m/f) of theoretical physics (high energy)

Candidates should have proven record of success in theoretical high energy physics. The chosen candidate is expected to have a profound knowledge of field theory, where also numerical simulation may play a role, and to have an important impact on future developments in this field. Familiarity with recent progress in experimental high energy physics and experience with outside financial support are desirable.

High quality teaching of undergraduate and graduate physics courses is an important aspect of this position. Foreign candidates are expected to teach in Dutch within two years.

The Faculty is making an effort to increase the number of women in academic positions. Women are encouraged to apply.

Suggestions for suitable candidates are welcome. Further information can be provided by Prof.Dr. E.W. Kittel, tel. ++31 80 653343 or e-mail: Erna@hef.kun.nl. An application with a curriculum vitae, a list of publications, and names of three references should be addressed within three weeks to the Faculty of Science, Personnel Department, Toernooiveld 1, 6525 ED Nijmegen, The Netherlands, under reference number 57-95.

RESEARCH ASSOCIATE POSITION EXPERIMENTAL HIGH ENERGY PHYSICS INDIANA UNIVERSITY

The Department of Physics at Indiana University invites applicants for a research associate position to work with the high energy physics group on the D0 experiment at Fermilab. The position will be available beginning September 1995.

In D0 the Indiana University Group has been playing a leading role in beauty-quark physics, and has taken major responsibilities for the design and construction of the upgraded muon detector. A large fraction of the new muon chambers will be built at Indiana.

Applicants should have an interest and experience in physics analysis and computing. Candidates must have a Ph.D. degree. Applications, including vitae, list of publications, and three reference letters, should be sent to:

Professor Andrzej Zieminski, Department of Physics, Indiana University, Bloomington, IN 47405 USA. Applications must be received by July 15, 1995. Indiana University is an Equal Opportunity/ Affirmative Action Employer.

Against a backdrop of the string of prototype magnets for CERN's future LHC proton-proton collider, Italian President Oscar Luigi Scalfaro (centre) addressed Italian CERN staff members in the large SM18 hall during his visit to CERN on 20 April. With him on the podium are (left) Romeo Perin of CERN and Italian INFN President Luciano Maiani.

APS Awards 1995

This year's crop of American Physical Society Prizes and Awards includes:
The Tom W. Bonner Prize to Felix Boehm of Caltech for his pivotal contributions to our understanding of the weak interaction and fundamental symmetries in the nucleus;
The Dannie Heineman Prize for Mathematical Physics to Roman Jackiw of MIT for his quantum field theory work, including the existence and role of anomalies in particle physics (Jackiw's famous 1969 anomaly paper with the late John Bell was written while Jackiw was a visitor in CERN's Theory Division.);
The Julius Lilienfield Prize to Val Telegdi of Chicago, ETH Zurich, Caltech and CERN for ingenious experiments, including the capture and decay of muons, and for his ability to inspire and delight audiences (At CERN, Telegdi was leader, with R.L. Garwin, of the first experiment to measure the anomalous magnetic moment of the muon.);
The W.K.H. Panofsky Prize to Frank Sciulli of Columbia for his contributions to seminal neutrino experiments at Fermilab;
The J.J. Sakurai Prize to Howard Georgi of Harvard for his pioneering contributions to the unification of strong and electroweak interactions and his applications of quantum chromodynamics;
The Maria Göppert-Meyer Award to Jacqueline Hewitt of MIT for her contributions to radio astronomy and pioneering work in detecting gravitational lenses;
The Leo Szilard Award to Roald Sagdeev and Evgenii Velikov for their contributions to Soviet glasnost;
The John Wheatley Award to Galileo Violini for founding and directing the Centro Internacional de Fisica, Bogota.

Roumanian Science and Technology Minister Doru Dumitru Palade (left) with CERN Research and Technical Director Horst Wenninger during the Minister's visit to CERN on 3 April.

(Photo CERN HI.9.4.95/27)

On people

Distinguished theorist Gerard 't Hooft of Utrecht, best-known for his 1971 demonstration of the renormalizability of what was to become the electroweak theory, and former Director of the LEP Project at CERN Emilio Picasso, presently Director of the Scuola Normale Superiore, Pisa, have been elected Foreign members of the French Academy of Sciences.

Discussing research collaboration. The action committees 'Physics and Society' and 'Applied Physics and Physics in Industry' of the European Physical Society (EPS) recently organized a meeting, hosted by the German Physical Society in Bad Honnef, on the topical theme of research collaboration between universities, major laboratories and industry. Left to right, W. Hebel of the European Commission's Directorate General for Science Research and Development, EPS President-elect and former CERN Director General Herwig Schopper, and German Physical Society President H.G. Danielmeyer.

Roger Hess 1937-1995

Roger Hess 1937-1995

It was with much sadness that we learnt of the death of Roger Hess of Geneva.

Following his doctorate from ETH Zurich and a postdoctoral period at Columbia, he joined the University of Geneva in 1969. He then embarked on a series of key experiments which compared data with models of the nucleon-nucleon interaction. With the Medium Energy Group, he investigated nucleon-nucleon scattering using beams of polarized neutrons and a polarized nucleon target. These experiments at the Swiss SIN/PSI Laboratory provided the first data for a full reconstruction of nucleon-nucleon scattering amplitudes. Similar measurements were made at SATURNE energies in a collaboration with Saclay. In a LEAR collaboration, the Geneva group went on to study antiproton scattering using a polarized nucleon target. These experiments are key reference points for the nucleon-nucleon interaction.

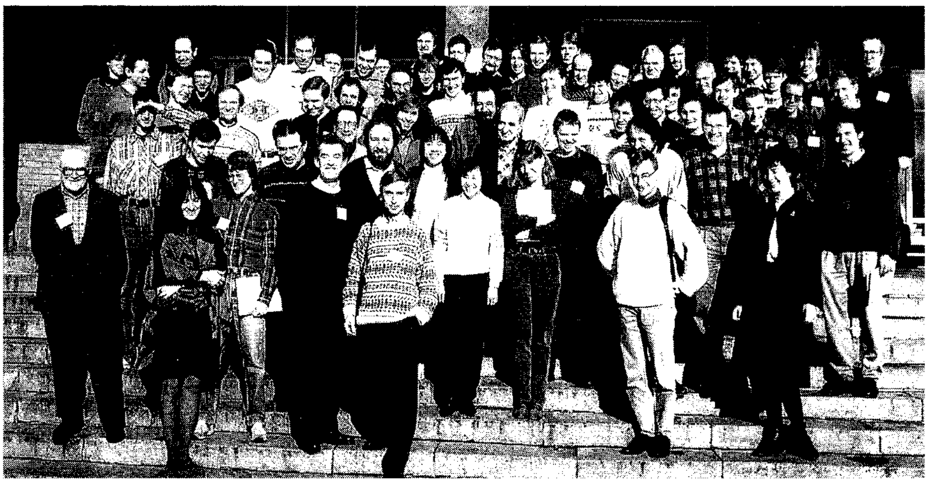
Roger Hess placed great importance on the teaching of physics and computing. Dedicated to the life of the university, he creditably carried out many university and departmental responsibilities.

As expressed in numerous messages of sympathy, we have lost a dedicated colleague and the scientific community an outstanding personality.

Catherine Leluc and Pierre Extermann, University of Geneva

Meetings

An International Symposium on LHC Physics and Detectors will be held at the Joint Institute for Nuclear Research, Dubna, Russia from 19-21 July. Information from A. Korol, e-mail Korol@cv.jinr.dubna.su Fax: (7-09621) 65 891 or (7-095) 975 23 81



Participants at the XXIII ITEP School of Physics (the second year of its new international flavour) which took place near the old town of Zvenigorod, near Moscow, from February 21 to March 1. The school was mostly devoted to different aspects of strong interactions, and about 100 students and teachers from eleven countries participated. As well as the main lecture courses, there were short presentations by students. Cross-country skiing filled free time.

*Enjoying a joke at the 'France at CERN' industry exhibition in April - (left to right) President of CERN Council Hubert Curien, CERN Research and Technical Director Horst Wenninger, and CERN Head of Administration Maurice Robin.
(Photo CERN EM 2.4.95/10)*

Paul Williams becomes Chairman and Chief Executive of the Council of the Central Laboratory of the UK Research Councils, now responsible for the Daresbury and Rutherford Appleton Laboratories, previously under the ownership of the Engineering and Physical Sciences Research Council.

The first ELFE Summer School and Workshop on Confinement Physics will be held from July 22-28, 1995 at Christ's College, Cambridge, UK. This meeting is being organized following the positive recommendation of NuPECC to proceed with the Electron Laboratory for Europe (ELFE) project. The meeting will consist of a joint School - Workshop on the physics and technical aspects of the ELFE project and is aimed at both experimentalists and theorists. Participation is by invitation. The number of participants will be limited to 100. Contact Steven Bass at QCD@hep.phy.cam.ac.uk for further information.

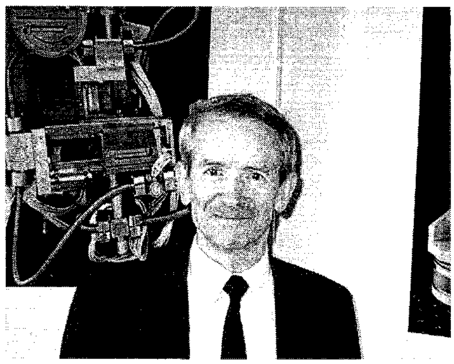
The Zeeman Effect Centenary International Conference on Atomic Physics XV (ZICAP) will be held at the University of Amsterdam from 5-9 August 1996. Further information: fax +31 20 525 5102, e-mail zicap@phys.uva.nl

CERN Courier Index 1994

The Index for the 1994 issues of the CERN Courier (English edition) is now available from Micheline Falciola, CERN Courier, 1211 Geneva 23, Switzerland, fax +41 22 782 1906, e-mail fal@cernvm.cern.ch

Applying the accelerator

The June issue of the CERN Courier will be a special edition covering the widespread application of particle accelerators. Guest Editor is Dewi M. Lewis of Amersham International, UK. Particle accelerators, providing tailor-made particle beams for specific applications, are a direct offshoot from physics research. According to a recent survey, there are some 10,000 particle accelerators in the world: only a small proportion are used for basic physics research; most are used for radiotherapy and ion implantation.



*The 'France at CERN' industry exhibition in April was one of the last such events organized by Mathieu Diraison, who retires from CERN later this year. He has meticulously organized this very successful series of trade shows since 1971, providing a valuable shop window for CERN Member State products and services.
(Photo M. Jacob)*

FACULTY POSITION
High/Intermediate Energy Physics
Indiana University

The Department of Physics at Indiana University-Bloomington invites applications for a tenure-track faculty position at the assistant or associate professor level for an appointment to begin in Spring, 1996 or later. The Department has an established graduate program and is inviting applications from Ph. D. physicists to work with our group involved in light-quark meson spectroscopy studies and fundamental symmetry tests. Currently the group, consisting of senior faculty and scientists, engineers, technicians and graduate students, is using the Multiparticle Spectrometer at Brookhaven to search for non-$q\bar{q}$ mesons. The Indiana group was responsible for the design and construction of a 3000-element lead-glass detector, including the read-out, calibration, monitoring and triggering system for this experiment (E852). The group has also succesfully proposed an experiment at CEBAF to study the rare radiative decays of the Ø meson. This experiment will explore issues in light-quark meson structure and fundamental symmetry tests. There is also the possibility of extending this program to complement the physics of a Ø-factory and/or to use photoproduction to search for exotic or hybrid mesons. Our group also places emphasis on the strong involvement of undergraduate students in our research program. Responsibilities include teaching, supervising graduate and undergraduate students in research, participation in current experiments and planning for future experiments. To apply please send a complete vitae (including a description of research interests, accomplishments and a list of publications) to **Professor Alex R. Dzierba, Chair, Search Committee, Department of Physics, Indiana University, Bloomington, IN 47405 USA**. Applications must be received by the closing date of August 31, 1995. For more information please contact Alex Dzierba at (812)855-9421 or by e-mail (dzierba@indiana.edu), or consult our home page on the World Wide Web (http://anthrax.physics.indiana.edu/). *Indiana University is an Equal Opportunity/Affirmative Action Employer.*

EC Human Capital and Mobility: NONLINEAR PROBLEMS IN BEAM DYNAMICS AND TRANSPORT

Research Assistantships

The European Commission has provided funding to support research in nonlinear effects in beam dynamics. The EC network consists of the following institutions: laboratories of CERN, DESY, GSI, LNL, LNF, and the universities of Bologna, Madrid and Patras. Three fellowships are available.

- 1 fellowship to be spent part at CERN and part in the University of Bologna; reserved to EC citizens, excluding Italians; research topic: diffusion induced by the ripple power supplies.
- 1 fellowship to be spent at DESY; reserved to EC citizens, excluding Germans; research topicis: effect of noise on the beam.
- 1 fellowship to be spent at GSI; reserved to EC citizens, excluding Germans; research topics: nonlinearities of a magnetic lattice and collective phenomena.

The appointment is for one year starting not later than 1st october 1995. Gross salary will be 2000 ECU per month. Applicants should have a PhD in Physics, preferably concerning nonlinear dynamics and its applications to particle accelerators. Candidates not having yet obtained the PhD will be considered with lower priority; exceptionally the fellowship could be attributed, but with a lower salary to be negotiated.

The applications with a full C.V. and letters by two referees should be addressed to

Prof. G. Turchetti
Dipartimento di Fisica, Università di Bologna
Via Irnerio 46, 40126 Bologna, ITALY
(Fax 39.51.247244; E-Mail Turchetti@bo.infn.it).

Closing date for applications is 30th of august 1995.

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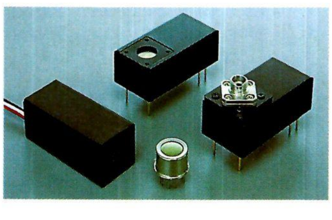

Left: H5783 (cable output type) Center: H5773 (on-board type which allows to mount directly on a printed circuit board) Right: H5773 with fiber connector

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