

Around the Laboratories

CERN Another step for LEP

In mid-August, six weeks after its first electron-positron collisions at 80.5 GeV per beam on 9 July (September, page 15), CERN's energy-boosted LEP2 halted for installation of more superconducting radiofrequency cavities.

After six years studying electron-positron annihilations into Zs, the electrically neutral carrier of the weak nuclear force, these energies gave the four LEP experiments - Aleph, Delphi, L3, and Opal - their first look at pairs of W particles, the electrically charged partners of the Zs, breaking new physics ground.

Initial luminosities, a measure of the electron-positron collision rate, reached a healthy 3×10^{31} per sq cm per s, and integrated luminosity, a measure of the number of collisions achieved, at the new higher energy was 12 inverse picobarns, including a week of machine development work when the physics score stood still. This was slightly up compared to the corresponding operating periods in previous years, promising well for the future. The highest luminosity recorded in one day was an inverse picobarn, equalling earlier record performance.

Equipped with 28 more superconducting cavities, taking its complement from 144 to 172, and pushing its beam energy ceiling to 87 GeV, LEP2 is scheduled for a further five-week run in October-November.

Major item in an extensive upgrade for the H1 detector at DESY's HERA electron-proton collider has been a new 'SPaghetti CALorimeter' (SpaCal), seen here in the centre of the detector.

DESY Upgrading H1

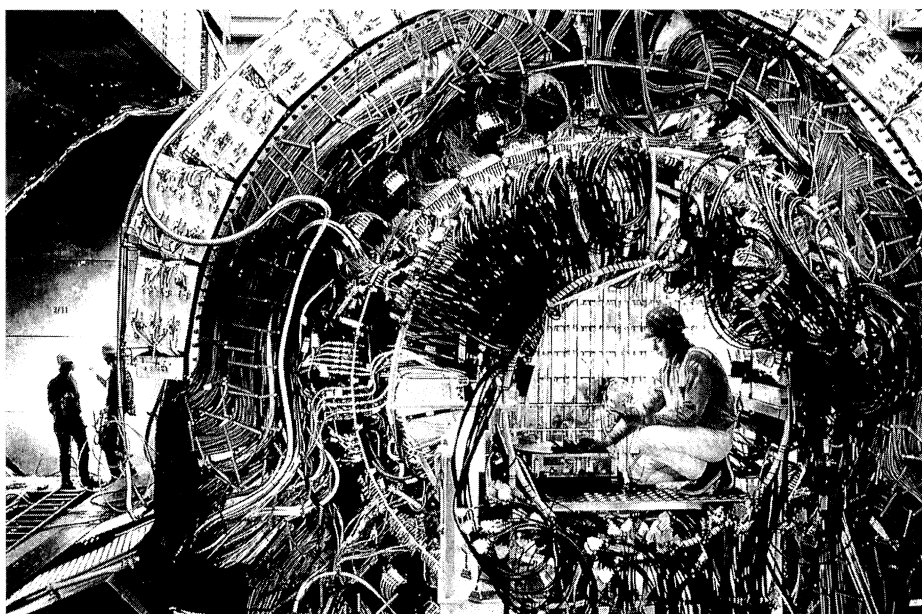
The usual evolution a particle physics experiment is increasing interest in rarer, more violent interactions at high momentum transfer, putting the stress on detection away from the beam direction.

The ever-increasing luminosity delivered by DESY's HERA electron-proton collider is allowing deep inelastic (DIS) probing of the proton to take place at unprecedentedly high momentum transfers (Q^2) up to several tens of thousand GeV^2 . The proton's structure is thus becoming ever better determined and searches for the production of new particles, as well as possible interactions which would reveal quark substructure, are being ever extended.

The HERA experiments are also able to extend the kinematical range over which the proton is probed to very low x, a variable which may be thought of as the struck quark or

gluon's share of the proton momentum. It is in the x region below 0.001 that the intriguing sudden rise in the proton structure function was first seen several years ago. Subsequent precision measurements have attributed this rise to a steep increase in the proton's gluon density. If this trend continues, interesting "hot-spot" clustering properties should eventually be seen.

Low x inevitably implies low momentum transfer at high collision energy, requiring accurate detection of scattered electrons closer to the beam pipe. This is also the area where decay products from a "nearly-real" photon will be intercepted, so studies of the hadronic structure of photons will also benefit. These and other requirements were described last month (September, page 21) in a general review of plans for the ongoing HERA research programme. Current analyses are already dominated by systematic errors, so the major item in an extensive upgrade for the major HERA H1 detector became the construction of



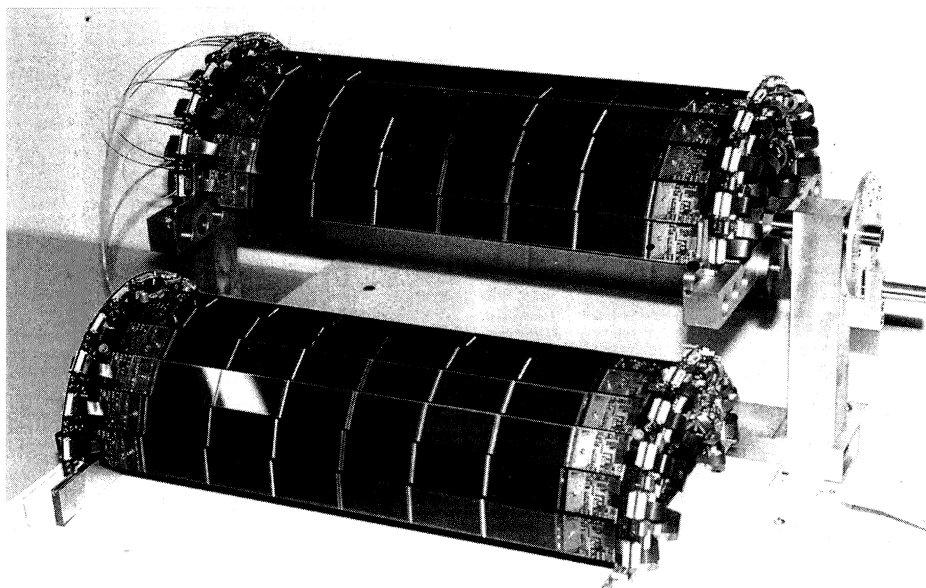
Two half shells of the H1 Central Silicon Tracker, which should reduce the uncertainty of a charged track angle measurement to below 0.5 mrad.

a new 'SPAggetti CALorimeter' (SpaCal). 0.5mm and 1mm diameter scintillating fibres embedded in separate lead matrices for the electromagnetic and hadronic sections are read out by 1400 mesh dynode photomultipliers capable of operating in the ambient 1T magnetic field. With this compact arrangement, 1995 data demonstrated the expected energy resolution for electrons, with millimetre precision.

The SpaCal has a time resolution of less than 1ns, important for differentiating the physics signal from large beam-induced backgrounds arriving some 9ns earlier. The calorimeter covers an angular range from 30° to within 3° of the electron beam direction (corresponding to Q^2 measurements well below 1 GeV² when "vertex shifting" techniques are used). This gives a smooth bridge to the coverage provided by the recently upgraded 44m electron tagger and a new device at 8m downstream.

SpaCal is fronted by a new 8-layer backward drift chamber (BDC) giving pre-shower detection for photon/electron separation, and reducing necessary showering corrections for energy measurements. However its main advantage is the considerable improvement of tracking in the backward (electron) direction.

Tracking has also been extended and improved by the addition of two silicon wafer detectors in the interaction point area. These combined devices can reduce the uncertainty of a charged track angle measurement to below 0.5 mrad. The central silicon tracker (CST) consists of two concentric cylinders, one side of which was already installed and tested in 1995. The backward silicon tracker (BST) will have eight disc planes, four of which should be fully operational this year. Eventually the silicon



detectors will surround a new light-weight carbon fibre beampipe which will further increase tracking capabilities and allow sophisticated vertex detection in heavy flavour production.

Another revelation at HERA has been the contribution from a class of events bearing all the hallmarks of 'colourless' exchange, with the proton essentially remaining intact. These are the so-called large rapidity-gap, or diffractive, events. Although the diffractive final state is clearly seen in the central barrel, the global kinematic properties are best determined by accurate detection close to the beam, this time in the forward direction. Interest in energy deposition in the forward direction has also been fuelled by new ideas for alternative formulations of the quark-gluon field theory equations. Since 1995, H1 has operated 'Roman Pot' stations at 81 and 90m downstream of the interaction point in the proton direction. Scintillating fibre hodoscopes may be lowered to within millimetres of the beam to measure proton

momenta to better than 0.5%. Two additional stations at 63m and 80m are planned for next year and two planes of silicon pixel devices are being prepared to supplement the 90m downstream detectors. This will increase the proton energy acceptance and extend measurements of the diffractive mechanism. This year will also see the first operation of a forward neutron calorimeter (FNC) 107m downstream, a lead/scintillating fibre calorimeter providing equal response for hadronic and electromagnetic showers.

So many additions to the H1 detector inevitably puts a strain on both data acquisition and the trigger. Presently the microprocessor equivalent of several hundred IBM 3090 units take events of 4-5 Mbytes of raw information at a level-1 trigger rate of typically 50 Hz and reduce them to about 50 Kbytes at 10 Hz for writing to tape. The flexible architecture is enabling a 1996 upgrade totalling the addition of some 28 PowerPC 604 cards which

Curt Ekström at the frozen hydrogen pellet target system at Uppsala's CELSIUS ring.

should significantly reduce overall dead-time.

HERA's 96 ns bunch crossing time is only a factor of four away from that planned for CERN's LHC proton collider. The level-1 pipelined trigger has some 2.2 microseconds for its decision, and was previously fed directly into an on-line software trigger. The central trigger system has been supplemented with an intermediate level-2 trigger which presently has two parts, one exploiting preselected topological aspects of the events, and the other consisting of several parallel neural networks, each optimized for a specific class of reactions.

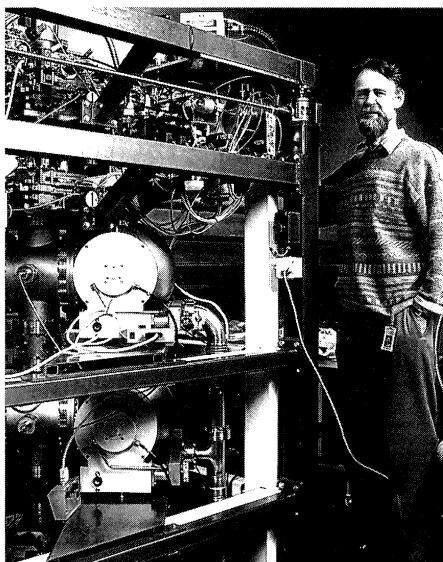
The upgraded detector will be in a good position to exploit the improved and extended physics possibilities provided by HERA.

From Graham Thompson, Queen Mary Westfield College, London

UPPSALA Pelting pellets

A collaboration between Sweden's Uppsala University and the Japanese KEK laboratory came to fruition in August when a thin walled superconducting solenoid magnet was delivered to Uppsala's The Svedberg Laboratory.

The solenoid is a vital part of the Wide Angle Shower Apparatus, WASA, which will make precision measurements of unstable mesons (neutral pions and etas). It was developed with support from the Japanese Ministry of Education, Monbusho, and the Nippon Kokan Company.



The WASA detector is being assembled at the The Svedberg Laboratory's CELSIUS (Cooling with ELectrons and Storing of Ions from the Uppsala Synchrocyclotron) storage ring. About 70 researchers from Germany, Japan, Poland, Russia and Sweden are involved.

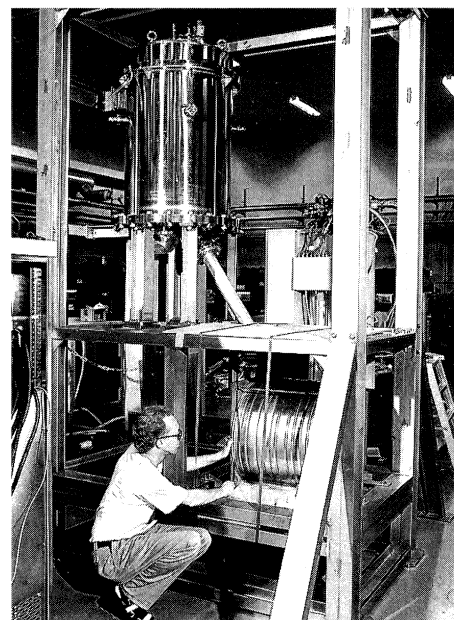
The magnets of the CELSIUS ring have an illustrious history, starting life in the classic muon anomalous magnetic moment experiment at CERN in the 1970s before being used in pioneering cooling studies and finally being shipped to Uppsala in 1983.

WASA will use a novel target system developed at Uppsala with support from the Wallenberg Foundation. The new target achieves high luminosity by replacing a traditional gas jet with a stream of solid pellets - 0.03 mm-diameter micro-spheres of frozen hydrogen, injected vertically into the proton

beam at a rate of about 7 thousand pellets per second travelling at 60 metres per second.

The pellets are formed by breaking up a liquid hydrogen jet into droplets at the temperature and pressure where solid, liquid, and vapour coexist in equilibrium and injecting these droplets into a vacuum. Mesons are produced when the 1360 MeV CELSIUS proton beam collides with the frozen pellets.

The new solenoid provides the magnetic field for momentum measurements of the emerging charged particles. It is made in a split coil configuration with 40 mm separation between the two windings allowing the stream of frozen hydrogen pellets to pass. Each winding consists of four layers of superconducting wire wound on the inside of an aluminium bobbin. The total coil thickness is 9 mm, or 0.18 radiation lengths, with a length and diameter about 50 cm and cold mass of 20 kg. The central magnetic flux density is 1.3 Tesla at a current of



The new superconducting solenoid for the The Svedberg Laboratory's WASA detector shortly after its arrival in Uppsala in August.