

in gas sampling calorimetry. E-594, a new neutrino experiment at Fermilab, is currently preparing inexpensive multiplicity hodoscopes based on their use.

The experiments, carried out by Muzaffer Atac, reveal that when avalanche size reaches a critical value as the electrical field is increased, a discontinuously fast transition occurs from the limited proportional mode (the normal operating regime for proportional and drift chambers) to a self-quenching streamer mode. Measurements show that pulses rise to about 50 mV (fifty times normal proportional chamber pulses) in 5 ns.

Photographs of the self-quenching streamers were recorded using a double image intensifier video camera. The streamers are 200-300 microns thick and are formed orthogonal to the anode wire with a height of several millimetres starting from the anode. The height and width of the streamers shrink as the pressure is increased.

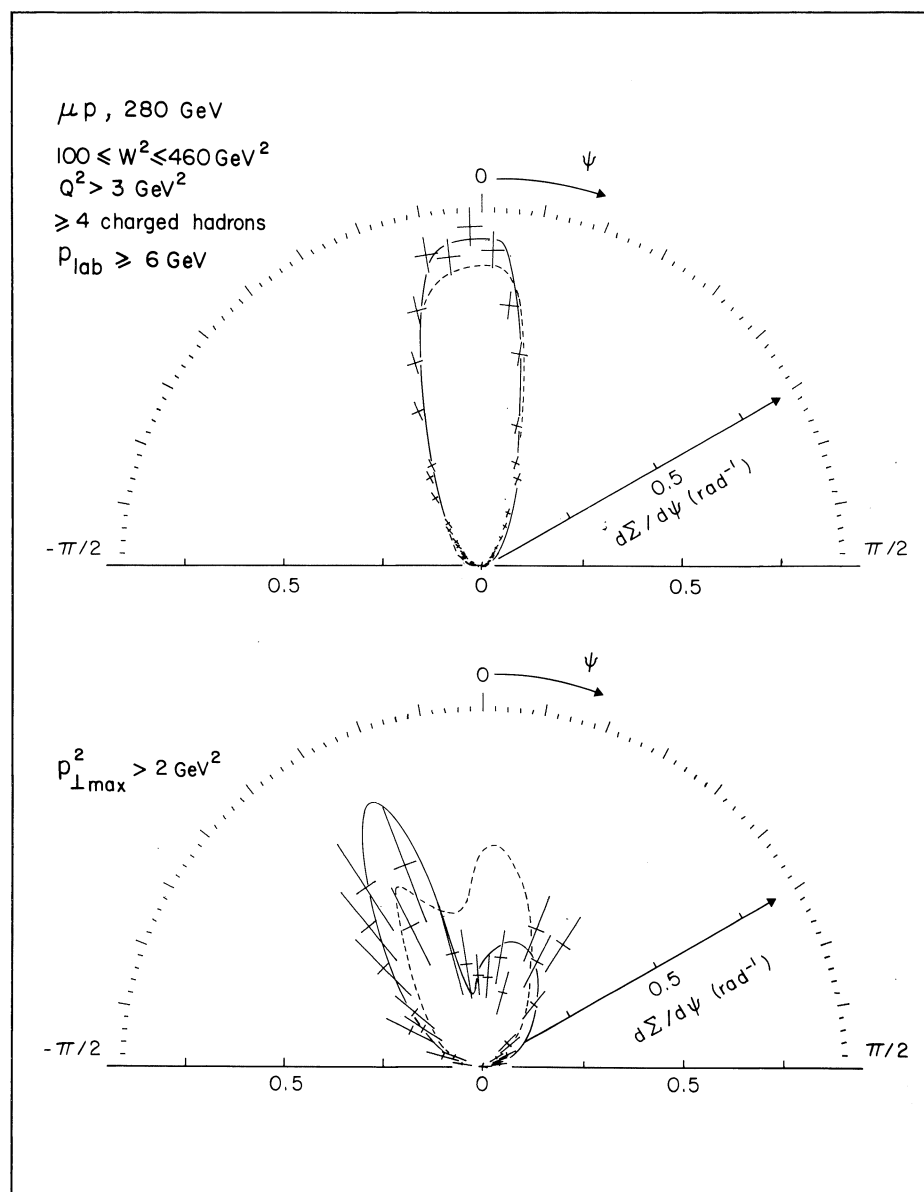
Pulse height distribution is very uniform in this mode, independent of initial ionization (minimum ionizing tracks and X-rays produce the same type of distribution). The Landau tail disappears and the distribution becomes gaussian for minimum ionizing tracks. The typical charge obtained from the anode is larger than 10^8 electrons, thus requiring no amplifier and with practically noise-free readout.

Energy flow of the hadrons produced by muons in the European Muon Collaboration experiment at the CERN SPS. For events with high energy forward-produced hadrons, the energy is contained in a narrow forward cone (top). However for a subset of the data containing at least one hadron produced with large transverse momentum (bottom), a clear two-jet structure shows up. The data is in good agreement with a quantum chromodynamics calculation (solid line), while the broken line shows the results of a quark jet fragmentation model.

CERN Finding jets

With the interactions of leptons apparently well understood, experiments using high energy lepton beams on fixed targets now tend to look hard at the hadrons which are produced. When the leptons penetrate deep inside the target hadrons and interact with the constituent

quarks, violent collisions occur which are characterized by the release of particles with large momentum transverse to the collision axis. By looking carefully at the results of these collisions, experimenters are finding more and more effects due to quark dynamics and which can be calculated by quantum chromodynamics (QCD), the theory of the 'colour' force acting between quarks.



Big polarized target

The world's largest polarized target, 1 m long and 50 mm in diameter, has been successfully tested at the European Muon Collaboration (EMC) experiment at the CERN SPS. This target will be used in future data-taking to measure the dependence of the muon interaction on quark spin.

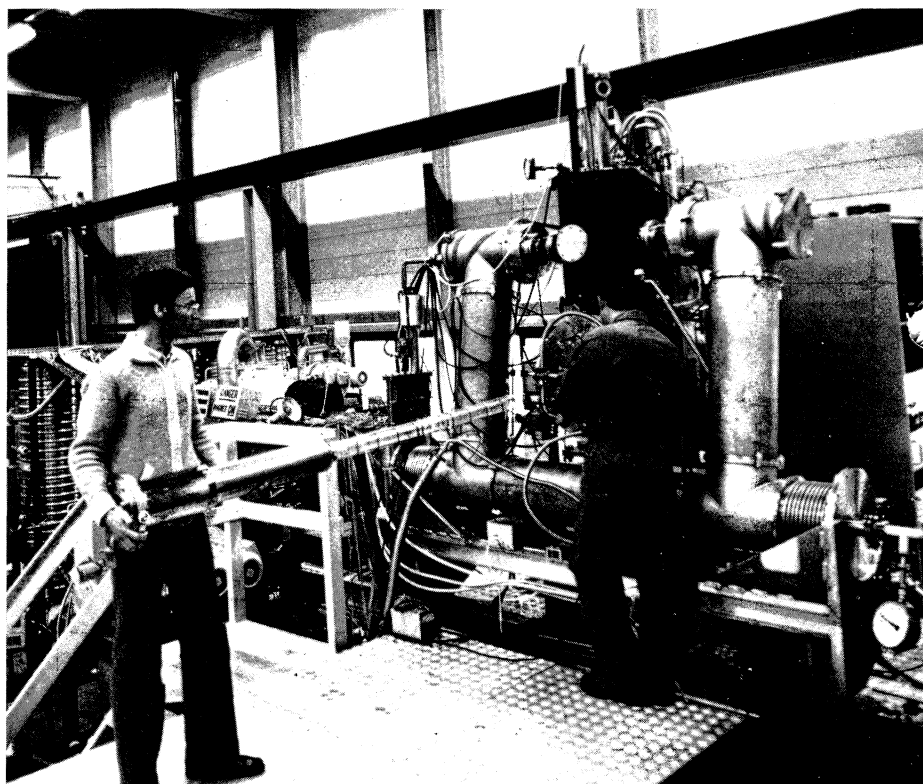
To operate the target requires a very large liquid helium dilution refrigerator, supplying 1.3 W of cooling power at 0.5 K. The polarizing field is provided by a superconducting magnet specially built by the Rutherford Laboratory (see May 1980 issue, page 113), providing a magnetic field of 2.5 T accurate to one part in 10^4 over the target volume. In the first tests, polarization of up to 80 per cent was achieved with good homogeneity.

In addition to the dilution refrigerator and specially constructed superconducting magnet, the EMC polarized target uses an impressive array of state-of-the-art technology, including a multichannel r.f. system, developed by Liverpool University, for polarization measurements using nuclear magnetic resonance.

According to Erwin Gabathuler of the CERN Directorate and a member of the EMC team, this type of close collaboration between home institute, national institute and CERN is foreseen for the development of detectors by the future collaborations to work at the LEP electron-positron ring.

Tapio Niinikoski holds the world's largest polarized target ready for insertion into its cryogenic magnet.

(Photo CERN 396.3.81)



However so far these lepton scattering experiments, which have been mainly confined to neutrino beams, have not revealed signs of the 'jet' structure seen in colliding beam experiments. These jets are understood to be due to the fragmentation of quarks and gluons produced in the initial collisions with quarks (see following story).

Now some new results from the European Muon Collaboration (EMC) at CERN show definite signs of jet production in high energy muon-hadron collisions, and the results agree with the predictions of the QCD theory.

EMC is a major collaboration of twelve research centres involving some eighty physicists, and is one of the largest installations in the North Experimental Area of the SPS 400 GeV proton synchrotron. The muons have a mean energy of 280 GeV and are scattered from a hydrogen tar-

get six metres long. The produced hadrons are measured in the forward spectrometer, a comprehensive piece of experimental apparatus incorporating a large aperture bending magnet and a magnetized iron muon filter.

Earlier analysis of the data showed how the transverse momentum of the produced hadrons increases with their energy. This is interpreted as being due to the emission of gluons as well as quarks in the primary collisions, and has also been seen in high energy neutrino scattering experiments.

A subsequent analysis of the EMC data looked at 2700 muon scattering events with large momentum transfer and containing high energy forward-produced hadron showers with at least four charged hadrons. For each of these events, an event plane was calculated which contained the event's virtual photon

Preliminary results from the NA5 experiment at CERN on particle production in high energy hadron-hadron collisions using a wide angle calorimeter to intercept as many of the produced particles as possible. Data was taken in three ways: using the full calorimeter, using two opposite arms making up half the calorimeter, and using just one arm (one quarter of the calorimeter). The measured cross-sections as presented are difficult to reconcile with a jet model.

(responsible for the interaction between the muon and the struck hadron), and which contained a maximum amount of the transverse momentum of the produced hadrons. The results were corrected for systematic errors by a simulation of the whole experiment.

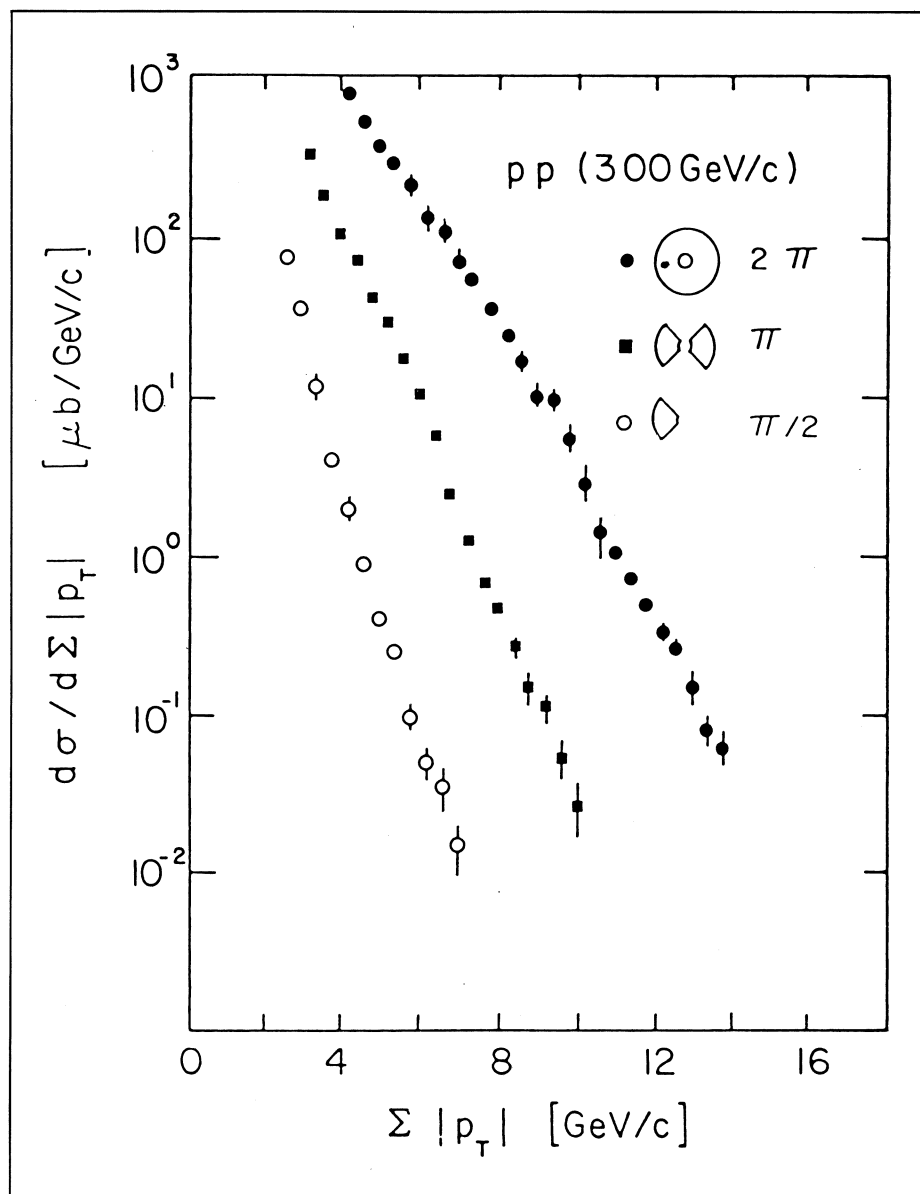
The analysis showed a significant number of events where the calculated event planes contained very high transverse momenta, strongly suggesting that the events themselves were basically planar.

In addition, the energy flow and particle flow in this topology were calculated, and not surprisingly most of the hadrons and the energy were found to be contained in a narrow forward cone in front of the calculated direction of the events' virtual photons. However when a subset of 124 events was taken which contained at least one produced hadron with transverse momentum greater than 2 GeV^2 , then a clear two-jet structure showed up. Moreover these energy and particle flow patterns are in agreement with the predictions of QCD.

Looking for jets

The study of 'jets' – more or less well defined sprays of particles emerging from high energy particle collisions – is now a well established part of high energy physics. However preliminary results from an experiment at CERN by a Bari/Cracow/Liverpool/MPI Munich/Nijmegen (NA5) collaboration show that the study of jets in hadron-hadron collisions might pose some difficulties.

Jets are understood to arise from the liberation and subsequent fragmentation of quarks and gluons. They are seen in violent collisions which probe the inner structure of hadrons, and in electron-positron annihilation.



In jet studies, experimenters monitor the particles emerging with large momentum transverse to the collision axis. In colliding beam experiments, for example with proton-proton collisions at the CERN Intersecting Storage Rings, jet-like events are sought by triggering the apparatus on single particles with large transverse momentum. However this may mean that jets with high transverse momentum leading particles

are being selected in preference to jets whose large transverse momentum is smeared over many particles. This is known in the trade as 'trigger bias'.

To remedy this, experiments have been carried out at CERN and Fermilab using large angle calorimeters to catch the products of fixed target collisions and where the events are triggered by a threshold transverse energy in the calorimeter.

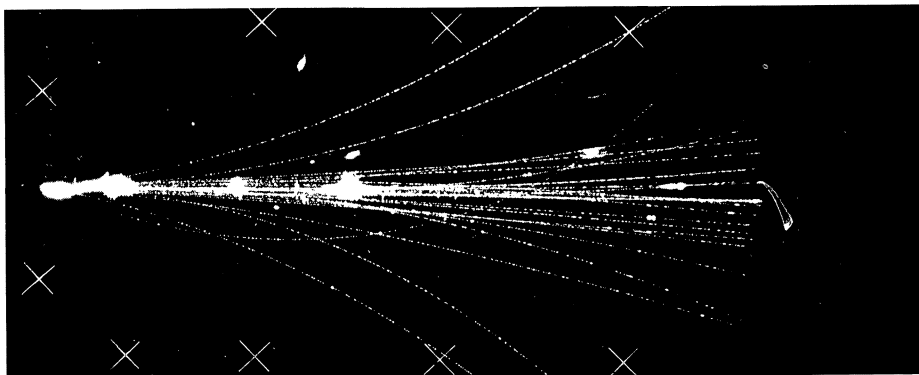
Streamer chamber picture from the NA5 experiment, showing the large secondary multiplicities seen in high energy hadron-hadron collisions.

At CERN, preliminary results from the NA5 collaboration, using a large acceptance calorimeter, do not show conclusive strong evidence for jets in collisions using SPS beams. First results were announced at the Madison Physics Conference last year (see September 1980 issue, page 240), but the latest results are nevertheless still described as preliminary.

The aim of the experiment is to investigate violent hadron collisions producing large numbers of secondary particles. A streamer chamber, mounted in a magnetic field, is used to capture the interaction vertex. Downstream, a series of magnetostriuctive wire chambers gives improved momentum resolution, while photon detectors and hadron calorimeters cover a maximal angle and trigger the streamer chamber. In this way the experiment is able to select highly inelastic events independent of the nature of the final state, and to reconstruct the event using the streamer chamber. A novel feature of the apparatus is the use of plastic scintillators with fluorescent converters to colour the light and so enable hadron and photon signals to be readily distinguished (see January/February 1980 issue, page 447).

Using proton and pion beams, the experiment took data in three ways: using the full calorimeter, using two diametrically — opposed segments (half the calorimeter), and using just one calorimeter arm (one quarter of the calorimeter). With the full calorimeter being used, typical events are found to have many (about 25) secondary charged particles spread evenly around the collision axis, rather than being confined to narrow jets. This high multiplicity makes analysis of the streamer chamber output difficult.

Cross-sections have been mea-



sured using the three different trigger modes described above, and the results do not resemble what would be expected in terms of a jet model. Instead, the behaviour looks more like an extrapolation of what is seen in 'soft' collisions producing particles with low transverse momentum. Analysis of the data to find the planarity and thrust ('jettiness') of the events also fails to reveal any strongly jet-like behaviour.

These preliminary results suggest that jets, as they have been understood so far from colliding beam experiments, look difficult to study in hadron-hadron experiments under fixed target conditions. However analysis of the data continues with a view to obtaining final results.

Silica aerogel detector

Even in high energy collisions, a large fraction of the produced particles have relatively low momenta. At the SPS 400 GeV proton synchrotron, about 40 per cent of the secondary particles have momenta below 5 GeV, a momentum range in which particle identification usually has been difficult. In bubble chambers, the ionization information can be used for particle identification up to about 1 GeV. Particle identification in the range 1-5 GeV is possible with very high pressure gas Cherenkov

detectors, but they tend to become rather complex and very bulky. With the development of silica aerogel, a very light and fragile material, particle identification in this range is possible, and some very neat and simple Cherenkov detectors can be constructed.

Silica aerogel can be produced with refractive index ranging from 1.01 to 1.10. However the fragility increases rapidly with decreasing refractive index, making it very difficult both to produce and handle samples with refractive index around the lower limit.

The SAD detector has been built by a Brussels/Mons/Stockholm collaboration. Brussels and Mons took care of the mechanical structure and magnetic shield, while Stockholm designed the light collection system and supplied the aerogel, manufactured at Lund. Composed of 18 identical modules, it will be used for particle identification in the momentum range 1-5 GeV in the EHS (European Hybrid Spectrometer) in the North Experimental Area at CERN, where it is installed a few metres downstream of the rapid cycling bubble chamber (see March issue, page 64). The photomultipliers are situated in a region where the magnetic field is around 0.1 T, which constrains both their position and orientation.

Because aerogel is a new material

A futuristic-looking module of the silica aerogel detector built by a Brussels/Mons/Stockholm collaboration for use in the European Hybrid Spectrometer at CERN.



with relatively unknown optical properties, the optimization of the individual Cherenkov modules was not entirely straightforward. A large number of measurements were done with different types of light collection systems, using both diffusely reflecting walls of millipore and mirrors made of aluminized mylar. In the optimization process a 'Cherenkov detector kit' (composed of a roll of aluminized mylar, card-

board, scissors, tape and a measure) was found to be extremely useful to complement computer simulations. An optimized light collection system made of aluminized mylar was found to be clearly superior to the diffusing light collection system. On the other hand the detector response was rather sensitive to the mirror orientations, and as a result the module was more difficult to optimize.

In each module, the detector sur-

face is $23 \times 55 \text{ cm}^2$ and the aerogel thickness is typically 15 cm. The aerogel volume is made up of blocks with dimensions $18 \times 18 \times 3 \text{ cm}^3$. The refractive index is 1.03, giving momentum thresholds of 0.6, 2 and 3.8 GeV for pions, kaons and protons respectively. The light collection system is composed of cylindrical and plane mirrors made of aluminized mylar 75 microns thick. The light is collected by two RCA 8854 photomultipliers with 11 cm diameter photocathode. The complete detector surface measures 2.3 m^2 .

The response of all 18 modules has been determined in a particle beam at the CERN PS. The light yield averaged over the whole detector surface is close to 11 photoelectrons for particles travelling at the speed of light.

DESY HASLAB opens

Recent highlight at DESY was the inauguration ceremony for the new Hamburg synchrotron radiation laboratory (HASLAB) at the DORIS electron-positron storage ring. The presence of many distinguished guests and speakers and other representatives of user groups from both Germany and abroad gave an international flair to the ceremony.

The inauguration was followed by a two-day seminar for present and potential users of HASLAB and the smaller (800 MeV) BESSY storage ring presently under construction in Berlin. The large audience of approximately 300 scientists and the 60 entries registered for the poster session reflected the high level of current interest in the use of synchrotron radiation.

HASLAB, short for Hamburger Synchrotronstrahlungslabor, was built in less than two and a half years and its costs remained well within