

Gluons

With PETRA running at total energies around 30 GeV, latest results on the jet analysis of hadron production in high energy electron-positron annihilations were eagerly awaited at the Fermilab Lepton/Photon Symposium (see page 308).

The big question was the existence of the sixth quark, but none of the four groups taking data at PETRA produced any evidence for a new quark production threshold, either from the hadronic production rate or from the topology of the observed events.

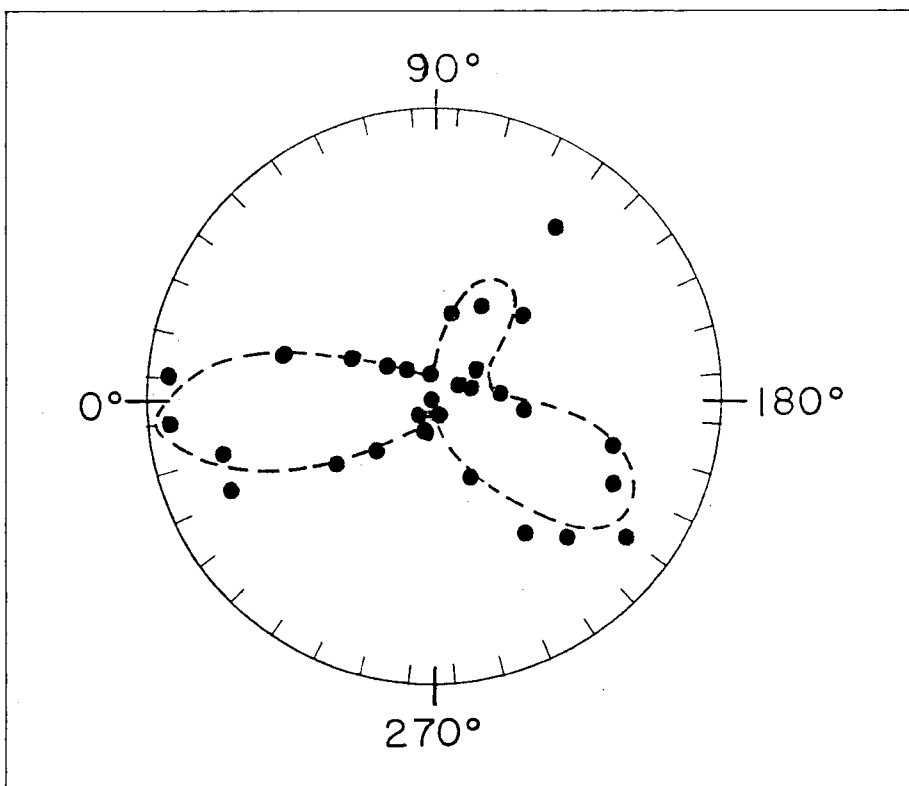
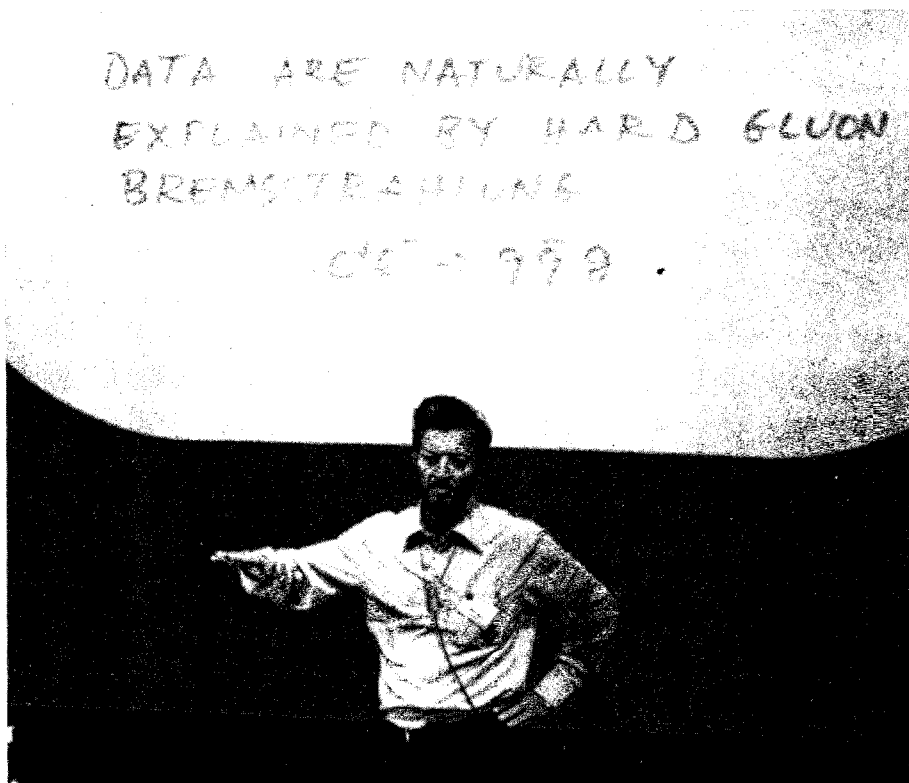
However jet analysis by the JADE, Mark-J, TASSO and PLUTO teams now confirms preliminary evidence first presented at the Geneva conference in June (see September issue, page 246).

At 13 and 17 GeV collision energies, the two-jet structure seen at lower energies is reproduced, indicating a quark and an antiquark emitted in opposite directions, producing back-to-back hadron fragments. At 30 GeV, another process becomes visible as one or other of the emitted quarks probably radiates a gluon (bremsstrahlung) which also fragments into hadrons.

Since jets are not labelled to indicate their origin, some sort of phenomenological analysis is required to see what is going on. Away from resonances, the bulk of hadron production in electron-positron colli-

Günter Wolf of the TASSO collaboration at DESY presents his evidence at the Fermilab Lepton/Photon Symposium on gluon emission in high energy electron-positron annihilations.

(Photo Fermilab)



Three-jet event energy distribution from the Mark-J detector at PETRA looking at high energy electron-positron annihilations. It suggests two large jet streams of energy due to fragmentation of quark-antiquark pairs, and a smaller flow of energy from gluon fragmentation. The radial distance is a measure of particle energy. The plot comes from 40 events in the kinematical region where hard gluon effects dominate and displays the consequences of gluon emission. According to Sam Ting, at this high energy a phase space distribution is inconsistent with this shape and with the results from jet analysis.

sions produces two mutually opposite jets, giving typical cigar-shaped events.

As the energy is increased, one of these jets is seen to grow wider, but in a very special way. Rather than simply getting fatter with a cylindrical profile, it becomes planar, and at higher energies the jet clearly splits into two, giving an overall event with three coplanar jet components.

The observed frequency of these events agrees with quantum chromodynamics (QCD) calculations on the emission of hard gluons. The events are incompatible with pure quark-antiquark formation and can-

not be reconciled by a simple 'phase space' model which assumes a purely statistical decay pattern.

Both theoreticians and experimentalists have shown vivid imagination in inventing procedures and names to describe this jet analysis, but the underlying structure is clear by simple visual inspection. Quantitative analysis is less clear-cut, but the results of all the PETRA groups are in line with QCD.

Another scene of QCD predictions is still the decay of the Υ into hadrons, as measured by PLUTO at DORIS before its move to PETRA. While the neighbouring off-reson-

ance behaviour is in good agreement with a simple quark-antiquark model, the resonance decays show a totally different behaviour.

Collinear back-to-back jets are ruled out as the dominant effect, but the data is in good agreement with a three-gluon decay model in which the gluon fragmentation is assumed to be similar to that of a quark. This three-gluon process is the lowest order QCD contribution to the decay of Υ into hadrons, and is now clearly distinguishable from a simple statistical phase space description.

Lepton/Photon highlights

The Lepton/Photon Symposium held at Fermilab at the end of August was dominated by the results of jet analysis in PETRA electron-positron annihilations (see above). However many other important results emerged which were highlighted by Leon Lederman in his summary talk.

PETRA, as well as giving the new evidence for gluon production, has also shown that quantum electrodynamics is as good as ever, even at high energies.

The continued non-appearance of the sixth quark flavour at PETRA is not yet a problem, but it is unfortunate that no firm indications of this quark mass are available from theory, unlike the intermediate bosons of weak interactions where confident predictions can be made. Other new data from PETRA comes from two photon exchange mechanisms, while at SPEAR, the two photon process has been used to measure the η' lifetime.

The candidate beauty signal seen

at CERN (see September issue, page 249) qualified for inclusion in the Symposium because the experiment triggers on lepton pairs, and although no new information was available, it was still a feature.

New results on neutrino-electron scattering came from the fine-grained calorimeter of a Virginia / Maryland / Oxford / Pekin collaboration. This is the first time that data on this reaction has been available from a large counter experiment, and the results underline yet again the success of the Weinberg-Salam model. Preliminary results on anti-neutrino-electron scattering were also presented from the fine-grained calorimeter of the CERN / Hamburg / Amsterdam / Rome / Moscow ('CHARM') collaboration.

Charmed baryons have been reported before, but now they have been pinpointed in electron-positron collisions at SPEAR. These precision measurements could open up the field of charmed baryon spectroscopy, where information so far has

been scanty. Also from SPEAR came news of a candidate pseudoscalar (spin zero, negative parity) charmonium state at 2980 MeV. A previous pseudoscalar charmonium candidate at 2820 MeV from DESY had not been confirmed at SPEAR and a new level is therefore welcome (see September issue, page 246).

An unexpected contribution was the new signal seen by the CHARM detector in a neutrino beam dump experiment at CERN (see page 313). While others preferred to adopt a cautious wait and see attitude, Lederman was in more optimistic mood, pointing out that here might be the first signs of the tau neutrino.

These Lepton/Photon Symposia started in a modest way at MIT in 1963 to cover a specialized area of particle physics research, but have now grown to cover the most exciting developments, as was demonstrated by the Fermilab meeting.