

Tokyo Conference

In the opening address at the International Conference on High Energy Physics, held in Tokyo from 24-30 August, KEK Director T. Nishikawa pointed out that this — the 19th conference in the so-called 'Rochester' series — was the first time the traditional biennial international meeting had been held outside venues in Europe, the USA and the USSR.

The conference was truly an international affair, with some 1000 participants from nearly 50 countries. Despite its size and complexity, with the first three days being given over to parallel sessions, the mammoth meeting was managed with impressive efficiency and precision, thanks to the Organizing Committee led by G. Takeda. But then almost everything in the seething Japanese metropolis seems to run this way.

No single big discovery or new development emerged as the highlight of the conference. Nevertheless, there was much progress to report over a wide range of investigations and the general picture which emerged was of firming-up of our understanding of particle interactions.

In particular, the techniques of quantum chromodynamics, which describe the interactions of constituents deep inside hadrons, appear to have progressed to a level where there is now widespread agreement with experiment. However, the effects due to these deep interactions of quarks and gluons are difficult to detect and even harder to measure, and Leon Lederman urged his fellow experimentalists to strive hard to pin down these delicate effects.

Quantum chromodynamics calculations can encounter problems and the theoreticians have to find ways of avoiding them. With calculations difficult to carry out and experimental effects hard to measure, the path towards a quantitative understanding of the inner workings of hadrons is a

rocky one, but the mood at Tokyo was optimistic.

One particular new result was the observation of the second ψ resonance near 10 GeV by two teams working at the DORIS electron-positron storage ring at DESY (see also page 298). Until this precision measurement on the ψ prime, the Fermilab data was always a bit ambiguous, allowing the broad enhancement between 9.5 and 10.5 GeV to be fitted by either two or three resonances, so the number of ψ 's remained open to question. However the accurate result from DESY has now ruled out a two resonance fit, showing that there are at least three ψ 's and that this new particle family indeed consists of narrow resonances. This consolidates the picture of the ψ 's as the bound states of a new type of quark and antiquark.

As the mass of the ψ prime from the latest DESY experiments is slightly lower than first indicated from Fermilab, this increases the relative importance of the third and heaviest ψ . Latest predictions for its mass give 10.38 GeV and the DORIS experimenters were urged to push to this mass region. DESY Director, Herwig Schopper, indicated however that the electricity bill during recent months with DORIS cranked up to its record energies has caused severe pain to the Laboratory's wallet. Maybe the third ψ is for PETRA.

As well as the DESY results and accumulated data from Fermilab, ψ sightings were also reported by three teams working at the CERN ISR — the CERN/Columbia/Oxford/Rockefeller, Athens/Brookhaven/CERN/Syracuse/Yale and CERN/DESY/Frascati/MIT/Naples/Pisa collaborations. These high energy results confirm the ψ as a way of life and show how production levels increase with energy.

Experiments on dilepton production by hadrons now reach out as far as 19 GeV in the dilepton mass spectrum

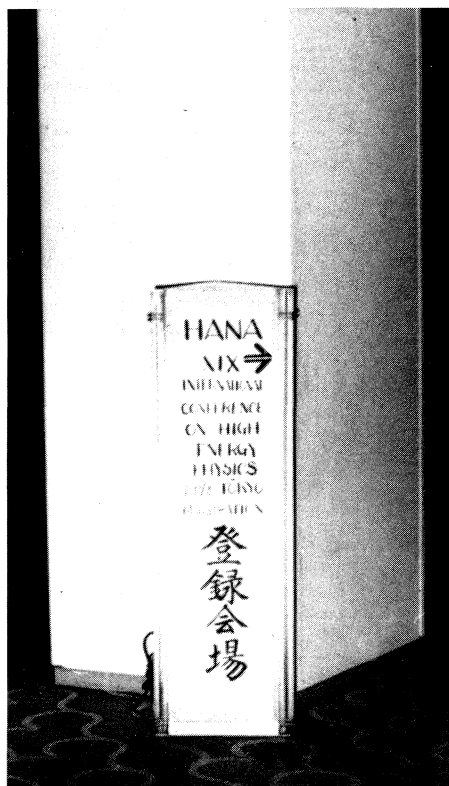
but no heavier states are evident. Lederman added wistfully that some sets of data seem to show small enhancements at the extreme end of their mass spectra, providing a tantalizing glimpse of things to come.

Inside the proton

It was perhaps indicative of the introspective mood of the Conference that as much attention was paid to the non-resonant background production of dileptons as to the new resonant states. This background provides a valuable window on the interactions of quarks/partons deep within the hadrons and provides a testing ground for quantum chromodynamics. Theory and experiment now agree in many respects and determinations of the distribution of virtual quarks in the 'sea' surrounding the nucleon, using data from dilepton production, now agree with other determinations, for example from the CERN/Dortmund/Heidelberg/Saclay neutrino experiment.

In another example of the use of very recent results to search for inner hadronic effects, Gideon Alexander of Tel-Aviv presented an analysis of ψ decays measured in PLUTO before the detector was resited at PETRA. Theorists predict that decays of the heavy quarkonium state should show signs of the production of three gluons, in much the same way that positronium decays into three photons.

The observation of two jets in hadron production from electron-positron collisions at SLAC, now nearly ten years ago, was one of the first pieces of evidence for the existence of constituents within hadrons. The idea now is that, across a heavy resonance such as the ψ , this two-jet behaviour should be replaced by a triple jet pattern. Such an effect would be a valuable proving ground for quantum chromodynamics predictions, which



Nearly there! For many travel-weary participants at the Tokyo Conference, this welcome sign showed that at last the end of their journey was in sight.

are otherwise largely restricted to small scaling violations and the like.

G. Flügge of DESY pointed out that jet behaviour does indeed seem to change across the ϵ region, although in some cases the deviations from a statistical 'phase space' decay are not very marked. Confirmation of this gluon effect could come from the first experiments at PETRA.

More evidence for the interactions of hadron constituents in hadron-hadron collisions was summarized by R. Sosnowski of Warsaw, using data from experiments at the ISR by the CERN / Columbia / Oxford / Rockefeller, British / French / Scandinavian, CERN / Collège de France / Heidelberg / Karlsruhe, CERN / Saclay and Brookhaven / CERN / Syracuse / Yale collaborations. These results show good indications of jet production, both on the trigger and away sides of the interaction and with the 'spectator' particles. This goes a long way towards substantiating the hypothesis that these phenomena are due to interactions between constituent particles inside the hadrons and are similar to the jets seen in electron-positron annihilation.

Additional evidence for jet production in hadron collisions was described in a parallel session by W. Selove of Pennsylvania, reporting results from a Fermilab / Lehigh / Pennsylvania / Wisconsin group which investigated high transverse momentum reactions

in both proton-proton and pion-proton collisions. Jet-type signals are seen in both types of processes and allow the different quark behaviour in pions and protons to be compared. According to Selove, this work could go on to measure the angular distribution of constituent quark-quark scattering.

Charm searches

Results from charm searches came from a variety of directions in the parallel sessions — cosmic rays, neutrino beam dump experiments, high energy photoproduction studies, etc. In summarizing these attempts to pin down the production levels and lifetimes of free charmed particles, Bob Diebold of Argonne said that the present situation seemed 'confused' and hoped that it would resolve itself over the next few years.

According to Diebold, specific assumptions, such as the assumed atomic number dependence and the type and/or number of charmed particles being looked for, were often not made clear in individual papers, and this did not help in the comparison of data. Experimental results also did not tie in with theoretical predictions. In a parallel session, F. Halzen remarked that calculations of the production of heavy quarks should be straightforward and very reliable, adding that perhaps additional mechanisms could be introduced to provide the necessary corrections. Other theoreticians were openly sceptical about the value of the experimental results.

Wong-Yong Lee of Columbia presented evidence for the production of a charmed antibaryon by a team using the tagged photon beam at Fermilab. A peak is seen in the antilambda plus three pion mass spectrum at 2.27 GeV, close to the value reported at Fermilab a few years ago using a different set-up. The antibaryon, rather than baryon, signal seemed puzzling to some. There was also a report of a

charmed baryon signal from an experiment at Serpukhov.

G. Flügge reported work at DESY which has consolidated the spectrum of the F mesons displaying both charm and strangeness. There appears to be as yet no reliable sighting of F mesons at SLAC, although the existence of the particles now cannot be doubted.

The charmonium spectrum now begins to look crowded, and results on ψ prime decays from the new sodium iodide/lead glass detector at DORIS point to a new hidden charm state near 3.6 GeV. The exact quantum numbers of this state have yet to be fixed.

The other newcomer to the list of particles was covered when G. Feldman of SLAC drew a clear picture of the tau heavy lepton. Quantum chromodynamics calculations give good results for the decay of this particle into a muon (or an electron) plus two neutrinos but the description of the decay into a pion and a neutrino is not in such good shape. The mass of the tau's neutrino is consistent with zero.

Dibaryons and baryonium

A number of speakers covered the dibaryon discoveries at Argonne (see October 1977 issue, page 330). A. Yokosawa of Argonne said he had 'tons of data' on a string of dibaryon states above 2 GeV. Baryonium too got its share of attention at the Conference, although the narrow 2.95 GeV state reported last year by a team working at the Omega spectrometer at CERN has been submerged by new data. However, the existence of both broad and narrow mesonic states with strong coupling to the baryon-antibaryon channel now looks good.

According to some theoreticians, these new effects could be just the tip of a big iceberg of new hadron physics with multiquark states and there was talk of seeing this in electron-positron annihilation.

In one of the early parallel sessions at the Tokyo Conference, G. Alexander of Tel-Aviv described how the DORIS data on upsilon decays had been analysed to search for signs of triple gluon production. Quark/gluon interactions were one of the main talking points at Tokyo.

As well as the dibaryon results, the work with polarized protons at Argonne has also produced possible evidence for new effects, described as 'dramatic' by V. Tsarev of Lebedev in his rapporteur talk. Experiments using polarized beams and polarized targets were first covered in a parallel session by A. Krisch of Michigan who pointed out that the comparison of high momentum transfer results from collisions with similarly and oppositely polarized protons at 11.75 GeV seemed to point to some coherent effects between the proton constituents, possibly due to gluons. It seems bizarre that the Argonne ZGS, soon to cease operation, is still such a fruitful source of significant new results.

Neutrino experiments

In the neutrino area, there was little new to report, as charged current experiments, according to rapporteur K. Tittel of Heidelberg, seem to be in step with each other. Scaling violations agree with those seen in electron experiments and provide yet another example of agreement with quantum chromodynamics predictions. Determinations of the 'sea' content of virtual quarks inside nucleons from these experiments show 11-14 per cent level for non-strange quarks but a 2-4 per cent level for strange quarks, indicating that this virtual quark sea surrounding the three valence quarks is not SU(3) symmetric.

With everything behaving so nicely in neutrino experiments, physicists can afford to look at finer details of the reactions in their quest for new or unexpected results. Some effort has gone into looking for signs of gluon jets in the hadronic components but more work is required before any pronouncement can be made. Other studies have concentrated on like sign muon pairs and different experiments give the ratio of like to unlike sign muon pairs from zero to about 12 per

cent. Again it seems too early to say anything definite.

In the neutral current area, the Weinberg-Salam theory seems to reign supreme. With the storm of events initially observed for high energy neutrino-electron scattering in Gargamelle now subsiding, C. Baltay of Columbia indicated that the world average neutral current data for this type of reaction points to a value of the mixing angle, θ , giving $\sin^2 \theta = 0.23$.

In the parallel sessions, Dick Taylor from SLAC presented his epic result on polarized electron scattering (see August issue, page 245), which had firmly established the Weinberg-Salam model as the premier theory. Additional fuel for this theory came from L. Barkov who presented the Novosibirsk results on the behaviour of polarized light in bismuth vapour (see June issue, page 200).

However D. Boulware in a subsequent unscheduled parallel talk said that bismuth experiments at Seattle

had still to detect any positive effect, despite using new apparatus. But last-minute news from the Oxford group indicated that a parity violating effect had at last been seen, though its magnitude was not in agreement with the standard theory. This lack of agreement between the different groups searching for parity violation in atomic physics did not seem to worry Steve Weinberg, who was convinced that everything would come out right in the end.

In theory

The last morning of the conference was given over to theory. Weinberg painted a rosy picture of the understanding of weak interactions, pointing out that the existence of six flavours and six leptons would provide a handy framework for describing CP violation. In his customary style, Weinberg was able to cover new theoretical ideas while at the same time dealing

