The 1977 International Symposium on Lepton and Photon Interactions at High Energies was held from 25 - 31 August in the Congress Centre at Hamburg. The symposium was sponsored by IUPAP, the German Research Ministry BMFT, the city of Hamburg, and DESY, and attracted 500 physicists from more than thirty countries. It was excellently organized by DESY and in particular by G. Weber and G. Flügge.

The Conference opened with the latest results from electron-positron colliding beam physics which consolidate the amazing series of discoveries made in the past couple of years. Particularly important for the charm model was the discovery of the long awaited F meson by the DASP group on DORIS at DESY some weeks before the Conference (see August issue, page 235). Another important discovery was that of the psi resonance at 3.772 GeV by the DELCO and SLAC / LBL (Leadglass) groups on SPEAR at SLAC. Because this resonance is just above threshold for charm production it nearly always decays into D\overline{D} and so provides an almost background free source of D mesons — a happy circumstance which has already been exploited by the SLAC/LBL group who reported on many properties of the D mesons.

Direct electron production continues to provide a key to the new physics in electron-positron annihilations. This was demonstrated beautifully by the results on inclusive electron production of the DELCO group. By looking at the production of an electron plus multiprong they have been able to draw the most detailed map yet of charm production.

Any mention of direct lepton production leads quickly to the other outstanding result of the past few years — the discovery of the heavy lepton, tau. All the evidence for the existence of the tau comes from such observations. Martin Perl gave an inspiring review of the experimental situation showing that all experiments that should see a tau signal, do see one and with more or less the properties expected of a sequential heavy lepton. He emphasized, however, that while it is possible with existing data to exclude certain types of lepton, it is going to be very difficult to pin down the parameters of the tau precisely.

In the past year particularly important evidence came from the electron-muon events of the PLUTO group on DORIS and more recently from the SLAC/LBL (Leadglass) group. The events are very clean with only a small contamination from charm particle sources. Further important evidence was the electron momentum spectrum of the two prong events from the DASP group.

The Conference heard about a number of tentative measurements of some tau decay branching ratios. Among these was the possible identification by the PLUTO group of the decay into the A_1 meson and neutrino, with the A_1 decaying into a rho and a pion, which was supported by preliminary results from SLAC/LBL. It is amusing to note that these data are also among the first observations of the A_1, and show that Sakurai was right when he suggested looking, long before the discovery of the tau, for the A_1 in heavy lepton decays.

The only cloud in the picture at the moment is a discrepancy in the pion decay rate as measured by the DASP group but the statistics are small and it is obviously of the utmost importance to repeat this experiment since the validity of standard weak interaction theory is at stake.

Attention in the field of neutrino interactions was, of course, focused on the question of the existence or non-existence of the so-called high y anomaly (see August issue, page 244). The evidence that the HPWF group...
gathering in 1974 and 1975 at Fermilab of an excess of events in antineutrino charged current interactions at large lepton energy transfers (high $y$) and high energies had caused a major stir. The simplest explanation required the existence of a fifth quark with a right handed coupling to the weak current which does not fit easily into the otherwise successful theory of weak interactions.

The first results published earlier this year by the CDHS experiment at CERN showed no high $y$ anomaly and results from other experiments at Fermilab (CITF) and CERN (BEBC) were therefore of particular interest. Neither group can exclude the possibility of a slight energy dependence in the ratio of the neutrino to antineutrino charged current total cross sections and in the sea quark fraction ($B$) but neither group sees an effect anything like as large as that seen in the HPWF experiment.

All groups summarized the interpretation of their results as being compatible with the standard weak interaction four quark scheme with perhaps some evidence for breaking of scale invariance with a magnitude comparable to that seen in deep inelastic electron and muon scattering.

Still with neutrinos — in addition to the original observation by the HPWF group, dilepton events have now been seen in the CERN counter experiment (CDHS) and the BEBC bubble chamber experiments and in the other neutrino experiments at Fermilab. The rates of dilepton production are compatible with each other and with the expectations of models based on charm production and decay.

The status of trimuon production is unchanged. HPWF have now collected twelve events, other experiments have a few examples but are not yet in a position to confirm the observation. What was rather surprising was the absence of any further trimuon results from the CDHS experiment at CERN — the group could report that trimuon candidates have been seen and that data taking and analysis continue.

The discussion session on neutrino physics was dominated by the confrontation between the HPWF and CDHS experiments — high $y$ seems to incite high blood pressure. Despite sometimes heated exchanges, the understanding of the high $y$ discrepancy was not much advanced. Obvious questions were whether the discrepancy exists in the measured data, as far as it can be compared, and if so how much and whether the analysis procedures employed can enhance or suppress a possible effect.

These points were taken up by Barry Barish in his summary talk on neutrino results. He emphasized how difficult neutrino experiments are and in particular how errors can multiply due to the inherent poor resolution of the apparatus. He showed that although the $y$ distributions from the CDHS and HPWF experiments agree qualitatively, fits to determine the antiquark $B$ parameter differ by factors of 2 or 3. Drawing together the results of all relevant experiments he declared that there is no high $y$ anomaly.

The remaining experimental results on the once dominant themes of electron production and photoproduction were dealt with in a single morning. New information was presented on the magnitude of scale breaking from the experiments at Fermilab and further interesting work remains to be done in this field. Another thorny question, of perhaps less fundamental importance, is that of the precise $q^2$ dependence of the nuclear shadowing effect.

The evidence for the new vector meson at about 1100 MeV found in the Bethe-Heitler interference experiment at DESY has improved. There are also indications of more states at higher energies and it will be interesting to see how these results tie in with the many possible new states found below 3 GeV in the electron-positron colliding beam experiments reported to the Conference from the groups at Adone in Frascati and DCI in Orsay.

A week-end break was devoted to lighter pursuits, allowing time for a proper digestion of the experimental results before the theoretical papers of the second half of the Conference. A tour of DESY stimulated a good appetite for a very pleasant buffet and an excursion by special train to Lübeck and the Baltic coast provided a most relaxing day.

Business started again with the most exciting and important result of all. Leon Lederman, in a characteristic talk, presented the results of the experiment at Fermilab showing a clear enhancement at 9.5 GeV (see August issue, page 223). This has now been resolved into two narrow peaks and rough estimates give the mass of Upsilon as 9.4 GeV and Upsilon prime
as 10 GeV. With the demise of the high anomaly in antineutrino charged current scattering, the Upsilon are now providing the most provocative indication that there are more than four types of quark in nature. The results from the first electron-positron machine to reach the 9.5 GeV energy region will be eagerly awaited!

An interesting change from the usual fare at high energy meetings was an elegant report by Patrick Sandars on the experiments looking for weak interference effects in atomic transitions. The experiments are miniatures by high energy physics standards but extremely sensitive; to quote Sandars, 'A fingerprint in the wrong place can produce a bigger optical rotation than Weinberg and Salam combined'.

The only experimental groups sufficiently advanced to be able to present results were from Washington (Seattle) and Oxford looking for optical rotation in bismuth vapour. Both find a null result which is of the order of six standard deviations from the expected rotation assuming the standard Weinberg-Salam theory. However, Sandars emphasized that the calculation involves a non-trivial atomic physics part which, although very carefully done, may ignore certain many-body effects.

Attempts to understand these are in progress and preliminary results indicate that the expected rotation may be reduced by up to a factor of two. This is still not enough to remove the disagreement with theory and the failure to observe parity violation in these atomic physics measurements remains the biggest cloud in particle physics at present. Further experiments looking for weak interference effects in hydrogen are in progress.

The theoretical sessions were dominated by gauge theories, quantum chromodynamics (QCD) and quark models. Among many excellent talks, Steve Weinberg gave a breathtaking overview of the status of gauge theories in weak interactions. He showed how the requirements of generalized gauge invariance and renormalizability already restrict the possible theories very considerably and how many critical experiments already in progress in atomic, nuclear and particle physics will be able to define the structure of the correct theory very closely. He ended with a tantalising glimpse of how a superunified theory might look and how we may be able to see a shadow of its structure at accelerator energies.

Most other speakers concerned themselves with comparisons of the data with the expectations of various quark models and the corrections to be expected on the basis of QCD calculations. The basic agreement was impressive but a few problems remain — the pseudo-scalar states in charmonium, a theory to accommodate all results bearing on the structure of the weak interactions, the compatibility of the various attempts to determine the running coupling constant in QCD, to say nothing of where to fit the tau lepton in!

The Conference closed with some looks into the future. Pief Panofsky and Herwig Schopper were concerned with the immediate future in the form of the PEP and PETRA storage rings respectively. The construction of PETRA is well up to schedule and colliding beams are expected before the end of 1978. Despite rumours to the contrary, even SLAC cannot build accelerators overnight and PEP is expected to be available for physics at the earliest in October 1979. John DeWire and Leon Van Hove then looked a little further into the future at the plans for CESR storage rings at Cornell and the ECFA recommended very high energy electron-positron facility for Europe.

The final talk was by J.D. Bjorken who took a bold leap into the dark and speculated about how things might look in ten or twenty years' time. He pointed out that there is ample evidence from cosmic ray physics in the multi-TeV region of interesting effects and events which cannot be explained by extrapolations from existing accelerator data (see page 289). Otherwise his dominant theme was the understanding of the weak interactions. Something interesting must happen in the region of 100 GeV where the weak and the electromagnetic interactions become equal in strength. In particular, if the $Z^0$ exists and can be produced as a free state in electron-positron annihilations, it will provide an unrivalled source of information on all the interesting effects that one expects in gauge theories.