Electron Positron Annihilations Above 9 GeV

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Summary of the Session by E. Lohrmann
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The new electron-positron storage ring PETRA has now been working for experimental physics at CM energies up to 31.6 GeV and with luminosities of more than $3.10^{30} cm^{-2} s^{-1}$. Four collaborations (MARK-J, PLUTO, TASSO, JADE) presented data at the following CM energies: 13 GeV, 17 GeV, 22 GeV, 27.4 GeV, 30 GeV, 31.6 GeV. Typical integrated luminosities for experiments were 1000-1500 nb^{-1} summed over all energies.

A check on the validity of QED at large momentum transfers was made, using the reactions $e^+e^- \to e^+e^-$, $e^+e^- \to \mu^+\mu^-$, $e^+e^- \to \gamma\gamma$, up to 31.6 GeV CM energy. Good agreement was found between the measurements and theory for all three reactions. This establishes a new very sensitive test of QED, which can be characterized by new limits on the cut-off parameters Λ ($\Lambda \approx 70$-90 GeV).

In addition the cross section for $e^+e^- \to \tau^+\tau^-$ was measured. It agrees also with QED. This measurement provides new evidence for the pointlike nature of the τ.

The total cross section for annihilation into hadrons σ_h was measured over the entire energy range. It is expressed in terms of the ratio $R = \sigma_h/\sigma_{\mu\mu}$, where $\sigma_{\mu\mu}$ is the point cross section for pair production

$$\sigma_{\mu\mu} = 4\pi\, r_e^2 m_e^2/3\, s$$

s = square of the CM energy.

The measurements do not show a significant variation of R over the PETRA energy range. At the highest energies R is found to be ≈ 4. There is no evidence for a step-like increase of R by 4/3 units as expected if one would cross a new flavor threshold for a quark charge 2/3. The data are not accurate enough to exclude the existence of a step increase $\Delta R = 1/3$ corresponding to a new quark charge of 1/3.

Together with previous measurements of R below the Υ at DORIS, which also gives $R \approx 4$, the PETRA measurements yield new indirect evidence for the charge $|Q| = 1/3$ of the b-quark, because the small increase of R expected for $|Q| = 1/3$ is compatible with the data, but the data exclude a step corresponding to $Q = 2/3$, as one goes beyond the Υ.

The average multiplicity of charged particles is $\langle n_s \rangle \approx 12$ at 30 GeV. Comparison with data taken at lower energies with DORIS and SPEAR show, that $\langle n_s \rangle$ above 10 GeV increases faster than the ln s law found at lower energies. The inclusive momentum spectra of charged secondaries show scaling in the variable $x_p = 2p/\sqrt{s}$ (p = momentum of secondary), for $x_p > 0.2$, in the PETRA energy range. Marked deviations exist for $x_p < 0.2$ between the PETRA data and data at lower energy.

The hadronic data are then analysed in terms of a two-jet model. The bulk of the data exhibits a very clear two jet structure. The mean opening angle of the jets decreases slowly with increasing CM energy. The angular distribution of the jet axis supports a distribution of the form $1 + \cos^2\theta$, expected from the production and subsequent fragmentation of a $q\bar{q}$ state.

Analysis of the jet parameters as a function of CM energy shows a smooth continuous behavior. There are no discontinuities in the jet parameters, which would indicate crossing a new flavor threshold. An effect arising from a quark with charge 2/3 is excluded by the data. A threshold due to a quark charge 1/3, which would give a much smaller effect,

cannot be excluded.

The jet parameters show, however, important changes as the CM energy is increased over the PETRA energy range from 13 GeV to 31.6 GeV. The mean transverse momentum of secondaries with respect to the jet axis increases with CM energy.

This effect is even more pronounced if one restricts oneself to particles with large fractional longitudinal momentum $2p/\sqrt{s} > 0.1$. The relative broadening of jets due to this effect seems to be correlated with an asymmetry between the two jets of an event, resulting in a distinction between "narrow" and "wide" jets outside the fluctuations expected from statistics. Maybe most significantly, the jets begin to show a deviation from the expected rotational symmetry around the jet axis at the highest PETRA energies. The high energy particles have a tendency to lie in a plane. The effects are outside the fluctuations expected from statistics. These effects are very hard to understand with a conventional two-jet picture. The planar nature of the events indicates a three-jet structure. A three-jet structure is indeed expected from gluon bremsstrahlung by one of the quarks of the jet. The data provide therefore evidence for this mechanism.

First investigations of two photon exchange processes have been carried out. The cross section for the QED process $e^+e^- \rightarrow \mu^+\mu^-e^+e^-$ agrees with theory. Also the hadronic process $e^+e^- \rightarrow e^+e^-$ + hadrons has been observed, and first information on the total cross section $\sigma(\gamma\gamma \rightarrow \text{hadrons})$ at high energy is obtained.

A first search for particles with fractional charge 1/3 and 2/3 has been undertaken and upper limits on the existence of such particles were presented.

There is some preliminary evidence that the e^+ and e^- beams are transversely polarized at the highest PETRA energies.

B. McDaniel gave a report on the e^+e^- storage ring CESR at CORNELL University. The machine, designed for a luminosity of $10^{32}cm^{-2}s^{-1}$ at its top energy of 8 GeV/beam has achieved luminosity for the first time on August 18, 1979 with a beam lifetime of three hours. Work on a large general purpose detector is nearing completion.