A SUGGESTION CONCERNING INCLUSIVE STUDIES IN e^+e^- REACTIONS

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Abstract : Inclusive reactions with e^+e^- colliding beams are studied.

Résumé : On étudie les réactions inclusives avec les anneaux de collision e^+e^-.

1. - One-particle inclusive cross sections have been one of the most important results in deep inelastic e-p scattering, in particular, the scaling property observed over a certain range of variables in the 2-dimensional kinematic plane (q^2, ν) [(1)] has suggested quite new interpretations of the structure of hadrons (parton model, light cone dominance).

Since most of the existing data refer to the structure of the nucleons and to the deep inelastic scattering part of the q^2, ν plane, it is natural to ask for data concerning both different kinematical regions and particles.

This task could actually be achieved by the study of annihilation reaction of the type

$$e^+e^- \rightarrow h + \text{anything} \qquad (1)$$

where h is any known hadron.

2. - In principle, the way to perform experiments of the type (1) consists in single particle detection with mass and momentum measurement. This means that the experimental apparatus must accept single particle triggers, a procedure providing an unbiased definition of the "anything" in (1).

However, the single rates in colliding beam experiments are usually dominated by backgrounds : therefore, experiments on process (1) in which h is a stable hadron (π , K, nucleon) look very difficult.

We propose here to pass to a slightly different category of reactions, namely

$$e^+e^- \rightarrow h_1 + h_2 + \text{anything} \qquad (2)$$

in which $h_1 + h_2$ is a hadron pair of given square mass M^2. It is obvious that when $M^2 = M_R^2$, the mass of a resonance R decaying into $h_1 + h_2$, reaction (2) will have a complete similarity to reaction (1). At the same time, the study of non-resonating masses M^2 can provide some further information on structure functions if the rates are high enough to allow good statistics.

Since the background problem in two particle triggers is much less severe, an unbiased definition of the "anything" in (2) is now conceivable.

3. - By following the usual procedure to construct the cross section for (2) we introduce as variables

$$q^2 \equiv s \qquad \nu = q \cdot P \quad , \qquad M^2 = P^2$$

q being the 4-momentum of e^+e^- and P the total 4-momentum of $h_1 + h_2$. Also, we call θ the angle that $\vec{P}$ makes with $\vec{p}_+$, the e^+ 3-momentum. Then the relevant cross section is

$$\frac{d^3\sigma}{dM^2\, d\nu\, d\Omega} = \frac{2\,\alpha^2}{S^2}\,\frac{M}{\nu}\left(\frac{\nu^2}{M^2 S} - 1\right)^{\frac{1}{2}} \cdot \left\{ 2\,\bar{W}_1 + \left(\frac{\nu^2}{M^2 S} - 1\right)\bar{W}_2 \sin^2\theta \right\} \qquad (3)$$

where $\bar{W}_i$ are structure functions of the variables q^2, ν, M^2.

When M^2 corresponds to a sharp resonance (narrow width approximation) we expect

$$\bar{W}_i = \delta\,(M^2 - M_R^2)\,\bar{W}_i^{(R)}\,(q^2, \nu)$$

where $\bar{W}_i^{(R)}$ are the usual structure functions for the "particle" R ($R \to h_1 + h_2$ is implied).

The analysis in terms of q^2, ν, M^2 is different from that presented by Drell and Yan[(2)] in that here full advantage is is taken of the possible enhancement occurring in resonance production. Also, we notice that the present proposal concerns a parametrization in 3 rather than 4 variables allowing a grouping of the data to the benefit of statistical significance. Still, the extra variable M^2 has a simple meaning.

4. - For a given experimental apparatus in which particle detection is subject to known energy and angle restrictions, the range of accessible M^2, ν values at fixed q^2 must be reconstructed. In practice, M^2 and ν range as determined by the requirement that no event of a given mass is lost, otherwise the integration over phase space leading to (3) would be incomplete.

The ν value fixes the total energy of the produced mass M^2, therefore its velocity in the lab system. Given the masses of the decay products h_1, h_2 it is a simple matter to decide whether for that M^2 the ν value allows the minimum momentum for both particles to be larger than the threshold for detection. Similar considerations (on the minimum aperture angle of the pair h_1, h_2) will determine the useful solid angle in the apparatus.

In general, two classes of events will be simultaneously compatible with actual experimental conditions :

a) M^2 large, ν small, such that h_1, h_2 fly nearly opposite directions with large energies (a mass M^2 nearly at rest in the lab decaying into two light particles).

b) M^2 small, ν large, such that h_1, h_2 fly in the same emisphere at small relative angles and with large energies (a mass M^2 very fast in the lab decaying into two not much lighter particles).

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REFERENCES

(1) q^2 is the mass of the virtual photon, ν is the product p.q of the photon 4-momentum and the 4-momentum p of the "un-integrated hadron".

(2) S.D. Drell, Tung Mow Yan, Phys. Rev. Lett. 24, 855 (1970).