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Three-Pion Form Factor from Electron-Positron Experiments.

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A recent work (1) has shown the possibility of a direct measurement of the photon-(n-pion) vertices through processes of the kind $e^+ + e^- \to n\pi$. Such processes will be studied with the storage rings presently under development in Frascati (2).

Particularly the reaction

$$e^+ + e^- \to \pi^+ + \pi^- + \pi^0 , \tag{1}$$

can be used to obtain information on the vertex $\gamma - 3\pi$, which is important in the theory of the isoscalar nucleon structure. Following reference (1) the differential cross-section in the C.M.S. for the process (1) is given by

$$\frac{\mathrm{d}^2\sigma}{\mathrm{d}\omega^{(+)}\,\mathrm{d}\omega^{(-)}} = \frac{\alpha}{(2\pi)^2}\,\frac{|H|^2}{64\,E^2}\,|(\boldsymbol{p}^{(+)}\times\boldsymbol{p}^{(-)})|^2\,\mathrm{sen}^2\,\theta\,\mathrm{d}(\cos\theta) , \tag{2}$$

where $\boldsymbol{p}^{(+)}$, $\omega^{(+)}$, $\boldsymbol{p}^{(-)}$ and $\omega^{(-)}$ are the momenta and the energies of the π^+ and π^-, E is the energy of the electrons, θ is the angle between the normal to the plane in which the three pions are produced and the line of collision, and H is the form factor of the vertex $\gamma \to \pi^+ + \pi^- + \pi^0$. Recently BLANKENBECLER an TARSKI (3) have calculated this vertex essentially in terms of the $T=1$, $J=1$ 2-pion resonance.

From their work we obtain

$$|H|^2 = (2\pi)^9\,|F_0|^2\,|\exp\,[\Delta_{12} + \Delta_{23} + \Delta_{31}|^2\,D^{-2}(t)\,|_{t=4E^2} , \tag{3}$$

where F_0 is a constant that must be determined experimentally; $|\exp\,[\Delta_{ij}]|^2$ are

(1) N. CABIBBO and R. GATTO: *Phys. Rev. Lett.*, **4**, 313 (1960).

(2) See the reports by B. TOUSCHEK and by R. GATTO in the *Procedings of the International Conference on the Theoretical Aspects of very high energy phenomeua* CERN, June 1961 (CERN Report 61-22, pag. 75), and R. GATTO, *Proceedings of the Conference on the elementary particles* Aix-en-Provence, 1961 (to be published).

(3) R. BLANKENBECLER and J. TARSKI: *Phys. Rev.* (to be published).

the pion-pion phase functions; t is the square of the four momentum transfer; and $D(t)$ is the function that sums the connected three pions diagrams (see [3]).

For the total cross-section we have obtained the expression

$$(4)\qquad \sigma(E) = \frac{\alpha}{3}\frac{(2\pi)^7}{(4E)^4}|F_0|^2 D(4E^2)^{-2}\int_{4\mu^2}^{(2E-\mu)^2} dx \int_{y_1}^{y_2} dy \cdot$$

$$\cdot |\exp[\Delta(x) + \Delta(y) + \Delta(4E^2 - x - y + 3\mu^2)]|^2 |\boldsymbol{p}^{(+)} \times \boldsymbol{p}^{(-)}|^2 .$$

Where μ is the pion mass, and

$$(5)\qquad \omega^{(+)} = \frac{1}{4E}(4E^2 + \mu^2 - y) ,$$

$$(6)\qquad \omega^{(-)} = \frac{1}{4E}(4E^2 + \mu^2 - x) ,$$

$$(7)\qquad \cos(\widehat{\boldsymbol{p}^{(+)}\boldsymbol{p}^{(-)}}) = \frac{1}{2|\boldsymbol{p}^{(+)}||\boldsymbol{p}^{(-)}|}\cdot$$

$$\cdot[x - 2\omega^{(+)}(2E - \omega^{(-)})] ,$$

$$(8)\qquad y_{1,2} = 2E\omega\boldsymbol{p}^{(-)} \mp |^{(-)}| \sqrt{\frac{x-4}{x}} .$$

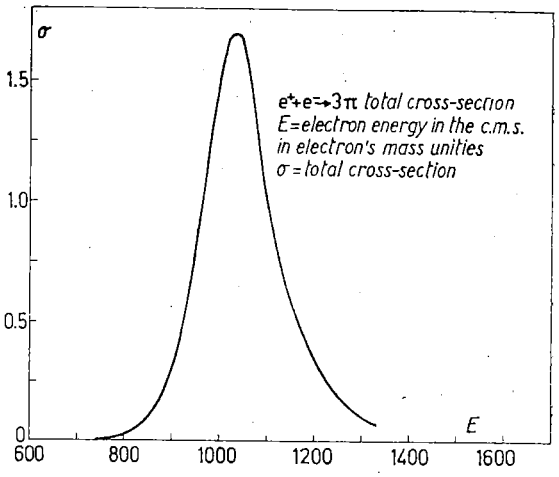

Fig. 1.

We have integrated (4) for the value $t_R = 20\mu^2$ of the π-π resonance, in the approximation $D(t) = 1$.

The results are reported in Fig. 1, that gives $\sigma(E)$ in arbitrary units.

However recently experimental evidence [4] has been found for a narrow three pion resonance around $\sqrt{t} = 787$ MeV, with a half-width less than 15 MeV. The rescattering function $D^{-1}(t)$ should therefore show a strong resonance in this zone, and the cross-section $\sigma(E)$ should have a peak around $E = 395$ MeV.

Our results give another peak at $E = 525$ MeV. It seems difficult at present to evaluate the relative importance of the two resonances.

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[4] B. C. MAGLIC, L. W. ALVAREZ, A. H. ROSENFELD and M. L. STEVENSON: *Phys. Rev. Lett.*, **7**, 178 (1961).