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An Experiment to Determine the Decay Width of $\rho \longrightarrow \pi\gamma$ ($\Gamma_\rho \longrightarrow \pi\gamma$)

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I. There are three different types of experiments to consider to measure the width of the electromagnetic decay mode $\rho \longrightarrow \pi + \gamma$.

1) With incident photons one can measure the width by looking at the reaction $\gamma + p \longrightarrow \rho^0 + p \longrightarrow \pi^+ + \pi^- + p$. The appropriate Feynmann diagram is shown in figure 1a. Berman and Drell[1] have estimated the width of the $\rho \longrightarrow \pi\gamma$ from an experiment of this type.[2] They obtain a width of 0.5 MeV which gives a branching ratio of $\approx 0.5 \times 10^{-2}$ for $\rho \longrightarrow \pi\gamma / \rho \longrightarrow 2\pi$.

2) The branching ratio of $\rho \longrightarrow \pi\gamma / \rho \longrightarrow 2\pi$ may be measured directly. Fidecaro[3] is working on such an experiment now at CERN with counter techniques (see figure 1b). This type of experiment would also be possible in a heavy liquid chamber, however a very large number of photographs would be required (the order of 10 times the number of photos in the T 16 experiment).

3) An experiment is proposed here to measure the channel $\pi^- + A_Z \longrightarrow \rho^- + A_Z$ with $\rho^- \longrightarrow \pi^- \pi^0$. (See figure 1c). This experiment is discussed in the following pages. These three different experiments measure $\Gamma_\rho \longrightarrow \pi\gamma$ in very different ways. Thus they would permit three independent measurements of $\Gamma_\rho \longrightarrow \pi\gamma$ plus a very good check on calculational procedures of quantum electrodynamics (see references 1, 4, 5, 6 for theoretical considerations). Figure 2 illustrates the three different vertices considered.

II. Feasibility of Experiment

The momentum transfer to the target is characteristic of an inverse interaction radius[6] $t \sim m_\pi / A_Z^{1/3} \sim 25$ MeV/c for large Z. The threshold incident momentum is $P_{th} \gg m_\rho^2/2t \sim 10$ GeV/c. The cross section is given by Berman and Drell.[1]

$$\left(\frac{d\sigma}{d\Omega}\right)_{lab} = \frac{F(t) Z^2 \alpha}{m_\rho^2} \left(\frac{24\,\Gamma_\rho \longrightarrow \pi\gamma}{m_\rho}\right) \frac{\sin^2\theta \; E_\pi^2 \; P_\rho^2}{\left[m_\rho^2 - 2 E_\pi E_\rho (1 - \beta_\rho \cos\theta)\right]^2}$$

integrating

$$\sigma \cong Z^2 \alpha \pi \left(\frac{24\,\Gamma_\rho \longrightarrow \pi\gamma}{m_\rho}\right) \frac{1}{m_\rho^2} \ln \frac{4 E_\pi^4}{m_\rho^4}$$

A reasonable beam would be 16 GeV/c π^- (similar to O_3 beam at CERN). This would give

$$\sigma \cong 0.6\ Z^2\ \alpha\ \Gamma\rho \longrightarrow \pi\gamma$$

Consider the following method for measuring $\Gamma\rho \longrightarrow \pi\gamma$ in a heavy liquid chamber.

Freon Mixture with Gold Target in Chamber
(see figure 3)
X_o = 25 cm

For 50 cm fiducial volume	
Prob. inter. freon/B.T.	.4
Prob. inter. gold/B.T.	.2
	.6
Prob. π^-+Au $\longrightarrow$ ρ^-+Au/B.T.	.0017
Therefore ~2.5 B.T./photo =	50.000
photos = 210 π^- + Au $\longrightarrow$ ρ^- + Au	
~1/2 of these events would be measurable	
(see appendix A)	

From the measured events the total and differential cross sections can be found and thus $\Gamma\rho \longrightarrow \pi\gamma$.

An experiment of this type has been performed by V.V. Barmin et al[7] with 2.8 GeV/c π^- in a Xenon chamber. They obtained a value of 4.4 $\pm$ 1.6 mb. for the total cross section of coulomb production of a π^- and π^o on Xenon. They were not able to determine the mass of the $\pi^-\ \pi^o$ since their chamber did not have a magnetic field.

The background for the experiment with the gold target would consist of about 400 events with a final $\pi^-\ \pi^o$. All but 10 o/o of these events can be eliminated on the scanning table since the maximum angle of the π^- from coulomb production is ~ 4^o (see figure 4). The remaining background events can be separated after fitting the events in a program such as "Grind". This is done by rejecting those events with a momentum transfer to the target of more than 150 MeV/c. This has been done successfully with diffraction dissociation events[8] which have similar characteristics (see figure 5).

To obtain the photos quoted on page 2 would require 12 shifts of PS time for the following conditions. The PS is run at 24 GeV/c with a 3 second repetition rate.

O_3 beam is used with 5 o/o of the PS beam. Two shifts would be used to set up a 16 GeV/c π^- beam (which has been set up previously for experiment T 16). The remaining 10 shifts would be used to take photos. This experiment could be done in the same 10 day period with the experiment to measure the neutrino flux (N_6). The support of the target for this experiment would be the target for N_6. This saves the time necessary to change targets.

Appendix A - Measurability of Events with Lead Target

Consider a π^o of 8 GeV/c. The angle of the gamma in the lab. with respect to the π^o is

$$tg\ \theta_{lab} \cong \frac{1}{57} \quad \frac{\sin \theta\ \pi^o}{\cos \theta_{\pi^o} + (1 - \frac{.01}{64})}$$

Figure 6 gives θ_{lab} as a function of θ_{π^o}. Note the 2 gammas must have an angle of 180^o between them in the π^o center of mass ($\theta\ \pi^o$).

Ten per cent of the events will have both gammas materialize in the gold target in which they are produced. These events will not be measurable. Forty five per cent of the events will have one gamma materialize in the gold target in which it was produced. At least one half of these events will be measurable. Note: even if the momentum of one of the gammas is not measurable, it is yet possible to have a one constraint fit on the events. The remaining forty five per cent of the events will not have a gamma produced in the gold target of production and thus nearly all will be measurable. Thus at least one half of the events will be measurable.

REFERENCES

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7. V.V. Barmin, et al., Soviet Physics JETP, 16, 866, 1963.
8. R. Huson and W.B. Fretter, to be published in Il Nuovo Cimento.

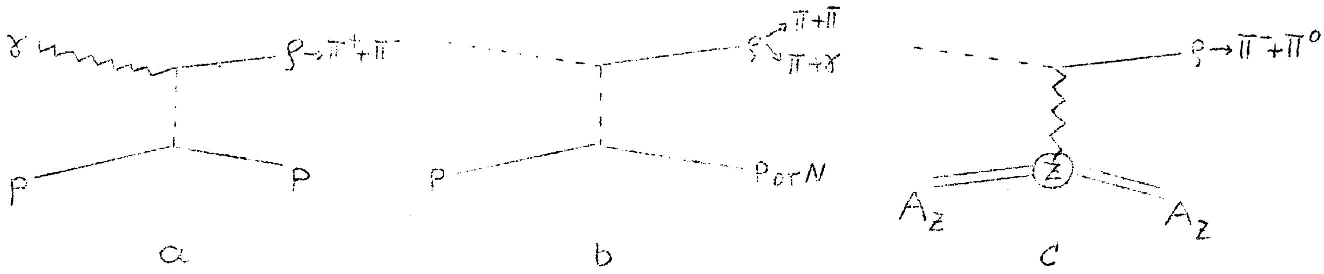

Figure 1 : Feynman diagrams representing the three different types of experiments to measure $\Gamma_{\rho} \longrightarrow \pi\,\gamma$.

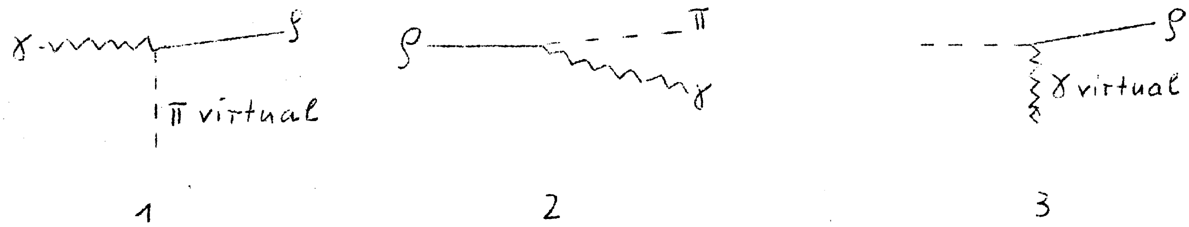

Figure 2 : The three different vertices considered.

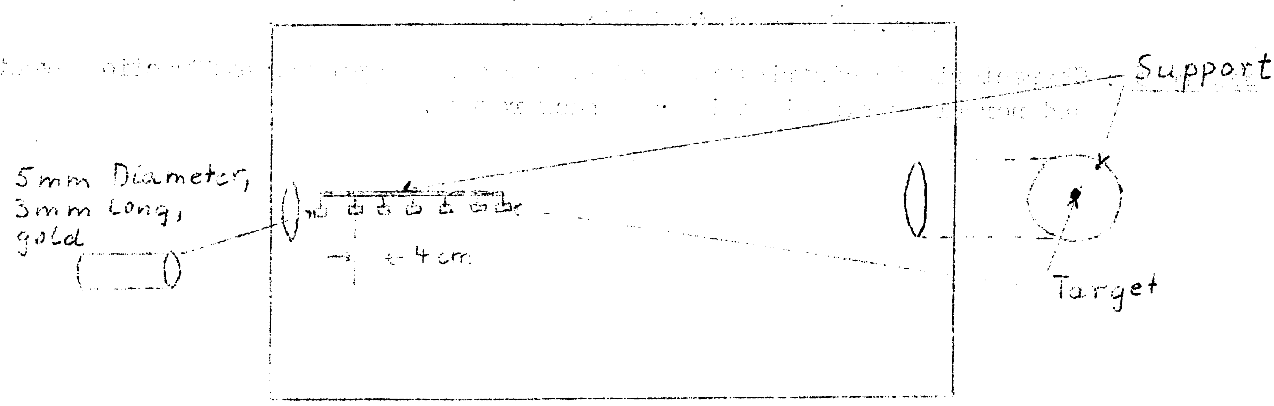

Figure 3 : Arrangement of gold target in heavy liquid chamber. A 5 mm diameter is used, since this would contain about 90 o/o of a 16 GeV/c beam similar to the O_3 beam at CERN.

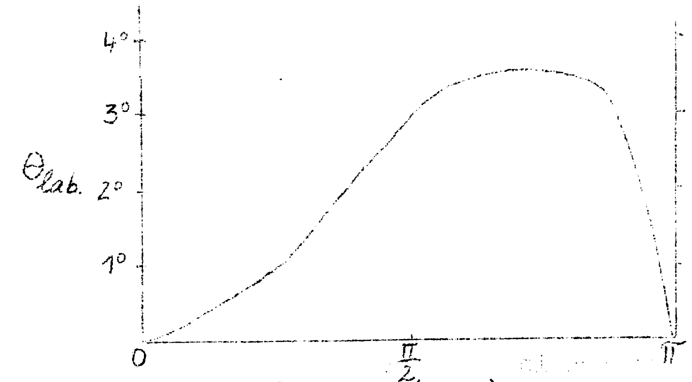

Figure 4 : Angle of π^- or π^0 in lab (θ_{lab}) as a function of the angle of the π^- or π^0 in ρ center of mass (θ ρ). Note the ρ decay distribution is $\sim \sin^2 \theta\rho$ (1), therefore $\theta_{lab} \sim 3^0$ is most likely.

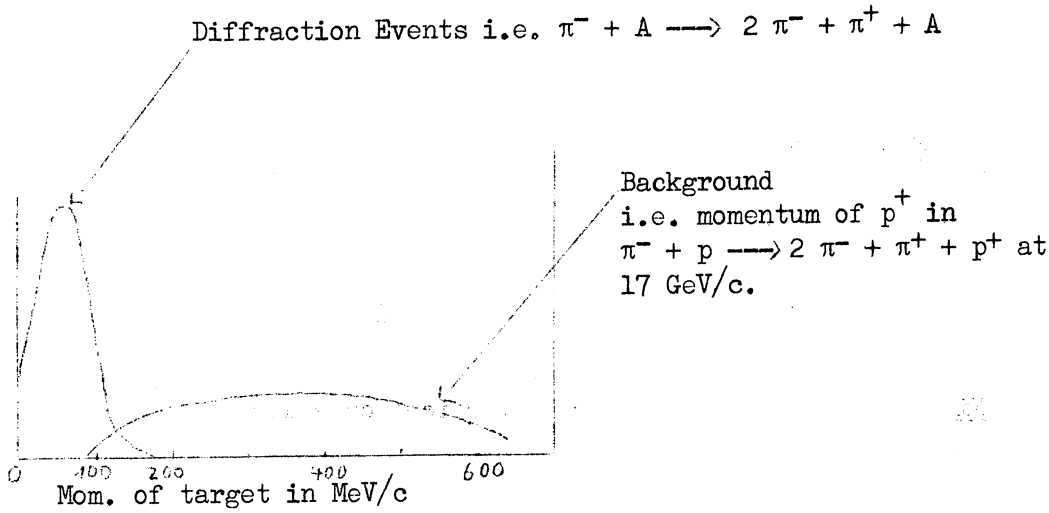

Figure 5 : Characteristic distributions of momentum of target for diffraction events and normal events (in this case background).

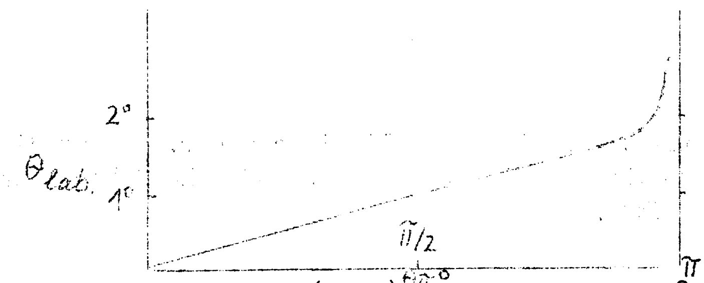

Figure 6 : Angle of γ in lab (θ_{lab}) with respect to π^0 as a function of the angle of the γ in the π^0 center of mass (θ_{π^0}) for an 8 GeV/c π^0.