LIFETIME OF THE ω MESON*

N. Gelfand, D. Miller, M. Nussbaum, J. Ratau, J. Schultz, J. Steinberger, and T.-H. Tan
Columbia University, New York, New York

and

L. Kirsch and R. Plano
Rutgers, The State University, New Brunswick, New Jersey
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Previous experiments[1] have given upper limits to the width of the ω, the width itself having been masked by the experimental resolution. We report here an experiment with greater resolution, sufficient to exhibit the natural width.

The technique employs the capture of antiprotons at rest in the reaction

$$\bar{p}+p\rightarrow K^{+}+K^{-}+\pi^{+}+\pi^{-}+\pi^{0}. \qquad (1)$$

The larger part of this reaction proceeds through the ω channel[2]:

$$\bar{p}+p\rightarrow K^{+}+K^{-}+\omega, \quad \omega\rightarrow\pi^{+}+\pi^{-}+\pi^{0}. \qquad (1A)$$

The special usefulness of the process rests on the fact that the total kinetic energy for the outgoing particles in Reaction (1A) is only about 100 MeV. The K^{+} and K^{-} mesons then have a good chance of stopping in a liquid hydrogen chamber. This permits an accurate determination of their energies, and these combined with the angle between them, yield a measurement of the ω mass.

Approximately 400 000 antiprotons were stopped in the Columbia-BNL 30-inch hydrogen chamber and 119 examples of Reaction (1) were found, with both K's stopping in the chamber. The calculated errors on the three pion masses ranged between 0.6 and 1.2 MeV. This resolution is approximately ten times better than resolutions previously obtained. The range-energy relation, which plays an essential role in the mass determinations, was extensively checked, using pions and protons of known energy. This work will be reported elsewhere. Figure 1 is a mass scatter diagram for these events. An over-all check on the technique is provided by the mass determination of the Λ^{0}, using decays in which both pion and proton stop in the chamber. The mass determination here also uses the ranges of the two tracks and the angle between them. The Λ^{0} direction or known momentum is not used. The observed Λ^{0} mass distribution is shown in Fig. 2 in the form of a Gaussian ideogram, together with the calculated resolution function. The resolution function is obtained by multiplying the individual mass errors by $\sqrt{2}$ and then plotting a Gaussian ideogram about a common value. The observed distribution is perhaps 10% wider than the calculated. The agreement is adequate to support the following discussion on the ω width.

The $\pi^{+}\pi^{-}\pi^{0}$ mass distribution of the examples of Reaction (1) is presented in Figs. 3 and 4.

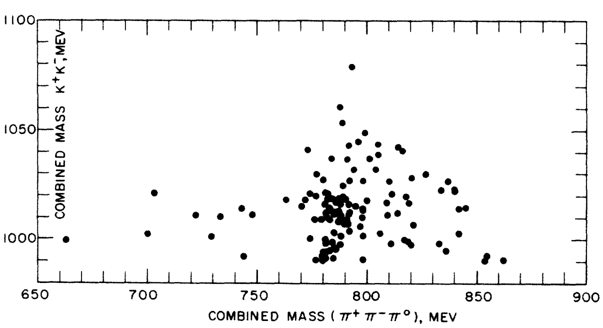

FIG. 1. Mass scatter plot for the reaction $\bar{p}+p\rightarrow K^{+}+K^{-}+\pi^{+}+\pi^{-}+\pi^{0}$.

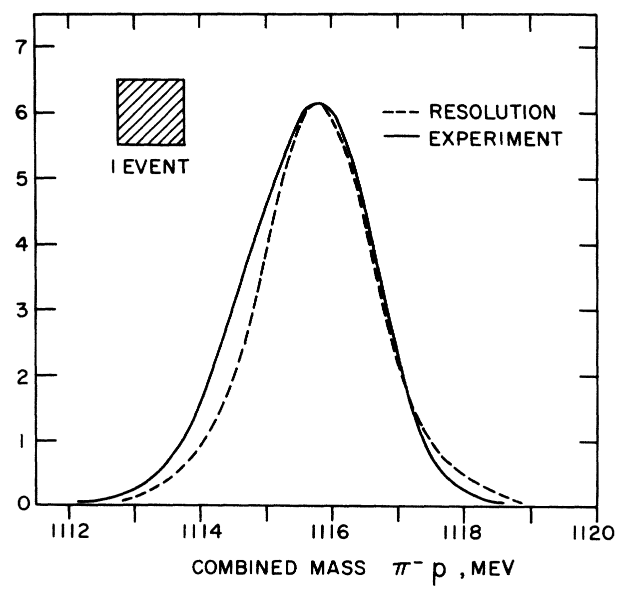

FIG. 2. Check on the mass resolution of the experimental method. Ideogram of the masses of 17 Λ^{0} decays on the basis of the pion and proton ranges and the included angle, together with the calculated resolution.

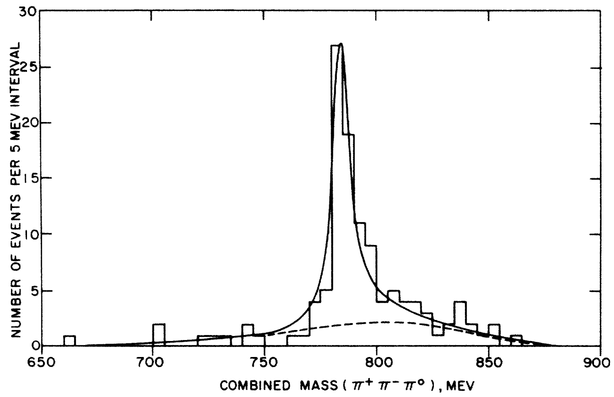

FIG. 3. Histogram of the combined pion mass for 119 examples of the reaction $p+\bar{p}\to K^+ + K^- + \pi^+ + \pi^- + \pi^0$. The solid line represents the best fit to Eq. (2), and the dashed line is the best fit for product of phase space and efficiency.

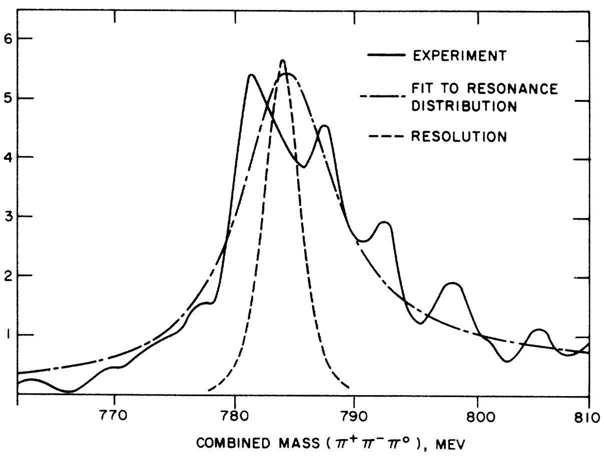

FIG. 4. Ideogram of the events of Fig. 2, with resolution function and best-fit resonance curve.

Both figures include appropriate resolution functions. Figure 4 shows, in addition, an analysis in which a function of the following form has been fitted to the data:

$$F(m) = \{\Gamma^2/[(m-m_0)^2 + (\tfrac{1}{2}\Gamma)^2] + \text{const}\}(\text{phase-space function of } m) \times (\text{detection efficiency function of } m). \quad (2)$$

Here m_0 is the central ω_0 mass, Γ its width, and the detection efficiency is the probability that both kaons will stop in the chamber. The geometrical problem presented by the latter was handled by the "Monte Carlo" technique. For comparison with experiment, the experimental resolution function obtained from the measurement errors for the individual events is folded into $F(m)$.

We obtain

$$m_0 = 784.0 \pm 0.9 \text{ MeV},$$

$$\Gamma = 9.5 \pm 2.1 \text{ MeV}.$$

The corresponding ω lifetime is $(0.69 \pm 0.15) \times 10^{-22}$ sec. Using the charged-neutral branching ratios,[1,3] the partial decay rates are

$$\omega \to \pi^+ + \pi^- + \pi^0, \quad P_t = (1.30 \pm 0.3) \times 10^{+22} \text{ sec}^{-1};$$

and

$$\omega \to \text{neutrals}, \quad P_t = (0.15 \pm 0.07) \times 10^{+22} \text{ sec}^{-1}.$$

Theoretical estimates for these rates have been put forward by several authors.[4]

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WIDTH OF THE φ MESON*

N. Gelfand, D. Miller, M. Nussbaum, J. Ratau, J. Schultz, J. Steinberger, and T. H. Tan
Columbia University, New York, New York

and

L. Kirsch and R. Plano
Rutgers, The State University, New Brunswick, New Jersey
(Received 16 September 1963)

In several recent Letters[1] it has been shown that there exists a $K\bar{K}$ resonance, named the φ meson, with mass $M_\varphi = 1019 \pm 1$ MeV and a width not exceeding 3 to 5 MeV. This resonance was produced in the reaction

$$K^- + p \rightarrow K^{-,0} + K^{+,0} + \Lambda$$

and was shown to have $I = 0$ and $J = 1$. We have observed the φ in the reaction

$$\bar{p} + p \rightarrow K^+ + K^- + \pi^+ + \pi^- \quad (1)$$

for antiprotons at rest in the hydrogen bubble chamber. The technique and exposure have been reported briefly.[2] In particular, we have found examples of Reaction (1) in which both K^+ and K^- stop in the chamber. The mass scatter diagram for these events is presented in Fig. 1.

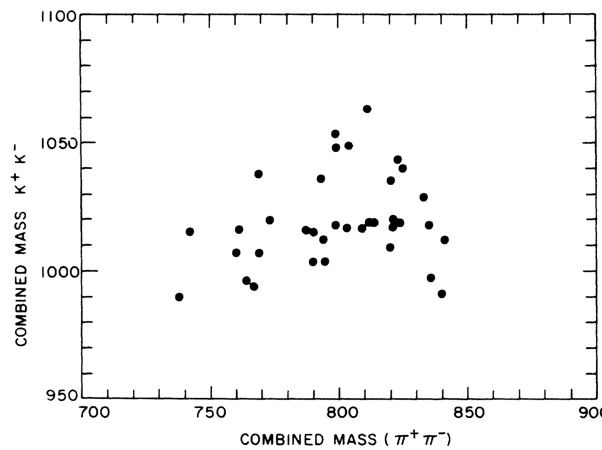

FIG. 1. Mass scatter diagram for the events $\bar{p}+p \rightarrow K^+ + K^- + \pi^+ + \pi^-$ with both K^+ and K^- stopping in the chamber.

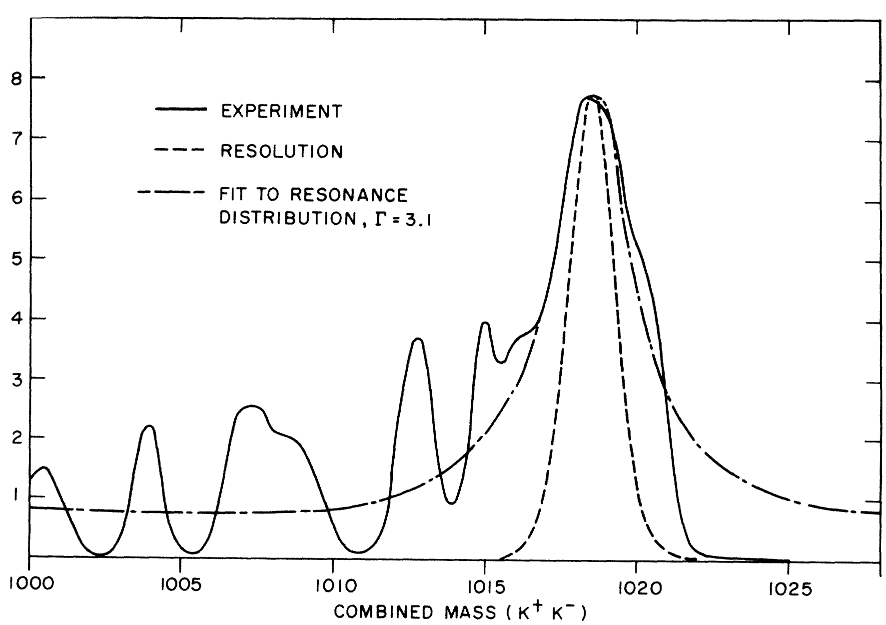

FIG. 2. Gaussian ideogram for the K^+K^- mass in the reaction $\bar{p}+p \rightarrow K^+ + K^- + \pi^+\pi^-$.