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EVIDENCE FOR A $\Lambda\pi^+$ RESONANCE AT 1480 MeV*

Yu-Li Pan and Fred L. Forman†
University of Pennsylvania, Philadelphia, Pennsylvania 19104
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An enhancement in the $\Lambda\pi^+$ mass spectrum has been observed at 1480 MeV in the reaction $\pi^+p \rightarrow K^+\pi^+\Lambda$ at 1.7 GeV/c. In addition, the Λ polarization undergoes a sharp oscillation in the same $\Lambda\pi$ mass region. The best fit values for this resonance are $M = 1480 \pm 15$ MeV and $\Gamma = 35 \pm 20$ MeV.

We have examined the reaction

$$\pi^+p \rightarrow K^+\pi^+\Lambda \qquad (1)$$

produced by 1.7-GeV/c π^+ mesons in the Princeton-Pennsylvania Accelerator 15-in. hydrogen bubble chamber. The data presented represent approximately 90% of the sample found in our 1.4×10^6 pictures. Each picture contained, on the average, about seven beam tracks.

The distribution of the mass squared for the $\Lambda\pi^+$ system is shown in Fig. 1. The mass resolution is approximately ±5 MeV. $Y_1^*(1385)$ production dominates the reaction. The analysis of the two-step process $\pi^+p \rightarrow K^+Y_1^*(1385)$, $Y_1^*(1385) \rightarrow \pi^+\Lambda$ will be presented elsewhere. The existence of a $\Lambda\pi$ resonance as reported by Cline, Laumann, and Mapp[1] at 1440 MeV is not needed to explain our data. Upon examination of the Dalitz plot we do not find statistically significant evidence for resonances in the ΛK^+ or $K^+\pi^+$ channels.

We have tried to fit Reaction (1) with a $Y_1^*(1385)$ resonance and nonresonant background (i.e., making the interaction matrix element a constant) assuming a Breit-Wigner form for the resonance.[2] We found that the confidence level of the best fit for this hypothesis is less than 0.5%. The major reason for this unsatisfactory fit is the $\Lambda\pi$ enhancement around 2.19 GeV^2. Cline, Laumann, and Mapp,[1] in addition to the 1440-MeV peak, also observed an enhancement in the $\Lambda\pi$ system in this mass region. However, their peak can be explained by the kinematics of the K^-d interaction and do not require the introduction of another resonance.

We have also fitted Reaction (1) in terms of two $\Lambda\pi$ resonances with the same type of nonresonant background assuming Breit-Wigner forms for both resonances.[2] The best fit found for this hypothesis gives a confidence level of 50% for these data.

If an anomaly in the mass distribution is due to a resonance, one may expect that the angular distributions will show a related anomaly. Such an anomaly is shown, in the present case, by the Λ polarization. We show the $\alpha\overline{P}$ distribution of the Λ as a function of mass$^2(\Lambda\pi^+)$ in Fig. 2. The maximum-likelihood technique was used to

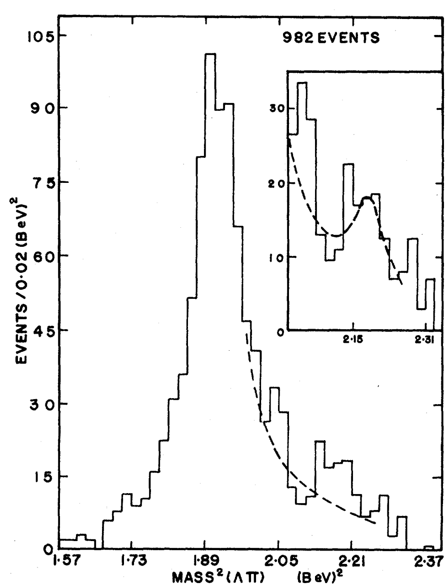

FIG. 1. Distribution of the $\Lambda\pi^+$ mass for all $\pi^+p \rightarrow K^+\pi^+\Lambda$ events. The dashed line represents the best fit obtained for $Y_1^*(1385)$ plus nonresonant background. The insert is an enlargement of the same mass distribution in the 2.17-GeV^2 region. The dashed line in the insert represents the two-resonance fit.

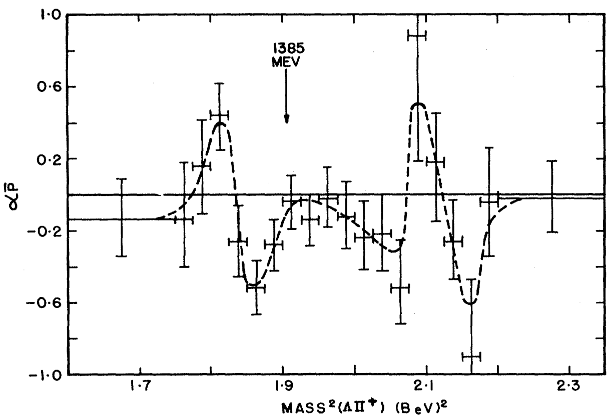

FIG. 2. The Λ polarization as a function of the $\Lambda\pi^+$ mass squared for all $\pi^+p \to K^+\pi^+\Lambda$ events. The dashed line is a free-hand curve drawn through the experimental data.

calculate the polarization and its error. The oscillation near 1.9 GeV^2 in the Λ polarization distribution is undoubtedly the result of the formation of the $Y_1^*(1385)$. We see, in addition, a similar distortion on the same plot near 2.19 GeV^2. We do not know of any kinematic effect present in our reaction which would produce this oscillation. This lends further support to the resonance interpretation for the mass enhancements observed.

We note that in Fig. 2 the center of the polarization oscillations occur 20-30 MeV below the central values of both resonances, and that the displacement, as well as the shape of the oscillation, is similar for the two resonances. We do not know of any theoretical calculation bearing on this displacement.

Reaction (1) can be contaminated by the reaction $\pi^+p \to K^+\pi^+\Sigma^0$. To check if this mass peak and the large oscillation in the polarization data near 2.19 GeV^2 can be due to this contamination, we have removed all $\Lambda K^+\pi^+$ events which also fitted the hypothesis $\Sigma^0K^+\pi^+$ with two fewer constraints and found no differences in results. The number of events removed in this contamination search amounted to approximately 10% of the data in the interval 2.12 to 2.23 GeV^2. We have also checked that the effects observed are not generated by other biases.

To see if the published data are consistent with a $\Lambda\pi$ resonance in the 2.19-GeV^2 region, we have done a careful search of the literature and found no significant evidence against this interpretation. It is of interest to mention the following experiments:

(1) In two missing-mass experiments by a CERN group using π^- mesons or protons and detecting a K^+, Dowell et al.[3] and Blackall et al.[4] found peaks corresponding to the production of Y^{*-} at 1550 and 1450 MeV, respectively. Each of these peaks was seen only in its respective experiment. The result of the second experiment is consistent with ours.

(2) In missing-mass experiments using photons on protons and detecting a K^+, the production of Λ, Σ, and Y^*'s are reflected as a "step" in the K^+ cross section. Mistry et al.[5] have performed a photoproduction experiment using photon energies up to 1800 MeV. Their data are consistent with the existence of a "step" at a mass of 1480 MeV.

Some general conclusions can be drawn from our literature search as to why this resonance has not been observed before. The major source of data on the $\Lambda\pi$ channel comes from the reaction $K^-p \to \Lambda\pi^+\pi^-$ for K^- momenta in the 1-GeV/c region. In this momentum region the reaction above suffers large interferences due to the formation of both $Y_1^{*+}(1385)$ and $Y_1^{*-}(1385)$. The associated production experiments using $\pi^\pm$, p, and $\bar{p}$ are all hindered in observing this resonance by low statistics due to the small production cross section involved and competition from the formation of other resonances, for example $K^*(890)$.

As a result of this investigation we conclude that there is a $T=1$, $\Lambda\pi$ resonance with a mass of 1480 ± 15 MeV and a width of 35 ± 20 MeV.

Preliminary analysis of the production and decay angular distribution of the $Y_1^*(1480)$ indicates that the determination of spin and parity is extremely difficult due to the small number of events. We are not able to make a definite determination of spin and parity from our data.

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[2]The programs THRESH and GRIND were used for the geometrical reconstruction and kinematic fitting of each event. The events which fit Reaction (1) were used as input to two different programs to find best estimates of reaction parameters: (a) MURTLEBURT [University of California Lawrence Radiation Laboratory Internal Report No. P-156, 1966 (unpublished)], using maximum-likelihood techniques, and (b) a program developed at the University of Pennsylvania using χ^2 minimization. In the former we assumed a P-wave Breit-Wigner form for the resonance; in the latter we used a constant-width Breit-Wigner form.

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OBSERVATION OF THE $Y_1^*(1480)$ IN THE $(\Sigma\pi)^+$ AND $(p\bar{K}^0)$ SYSTEMS: COMMENTS ON SPIN AND SU(3) MULTIPLET ASSIGNMENT*

Yu-Li Pan and Fred L. Forman†
University of Pennsylvania, Philadelphia, Pennsylvania

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We have recently reported the observation of a resonance in the $\Lambda\pi^+$ system at 1480 MeV. We have observed this same resonance decaying into the $(\Sigma\pi)^+$ and $(p\bar{K}^0)$ channels. The mass, width, and branching ratios for this resonance are presented. We comment on the spin of the $Y_1^*(1480)$ and its possible SU(3) multiplet assignment.

We recently reported the observation of a Y_1^* resonance in the $\Lambda\pi$ system in the reaction[1]

$$\pi^+p \to K^+\Lambda\pi^+ \qquad (1)$$

at an incident π^+ momentum of 1.7 GeV/c. This paper reports the observation of the same resonance in the channels

$$\pi^+p \to K^+\Sigma^0\pi^+, \qquad (2)$$

$$\pi^+p \to K^+\Sigma^+\pi^0, \qquad (3)$$

and

$$\pi^+p \to K^+p\bar{K}^0 \qquad (4)$$

in the same experiment.

We have searched our data from Reactions (2)-(4) for evidence of resonance production. We report here 153 events of the type (2), 169 events of the type (3), and 37 events of the type (4). At this energy, we are below the $K^*(890)$ threshold and we do not know of any ΣK, K^+p, or $K^+\bar{K}^0$ resonances in the available mass ranges. Our data are consistent with no resonance production in these systems.

Figure 1 shows the distribution of the square of the $(\Sigma\pi)^+$ invariant mass for Reactions (2) and (3). The data from both channels have been added together. The mass resolution is about ±10 MeV. The dashed histogram represents the total data. There is a substantial amount of background. However, we see indications of $Y_1^*(1385)$ production near 1.9 GeV^2 and $Y_1^*(1480)$ production in the 2.14-GeV^2 region. We note that the central values of square of the invariant mass for the resonances in Reaction (2) are approximately 0.04 GeV^2 lower than those found in Reaction (3). This shift, however, is not statistically significant. For the remainder of this paper we refer to the resonance as the $Y_1^*(1475)$ in accordance with the weighted average mass presented below of 1475 ± 15 MeV.

In Reaction (1) we[2] found that the production

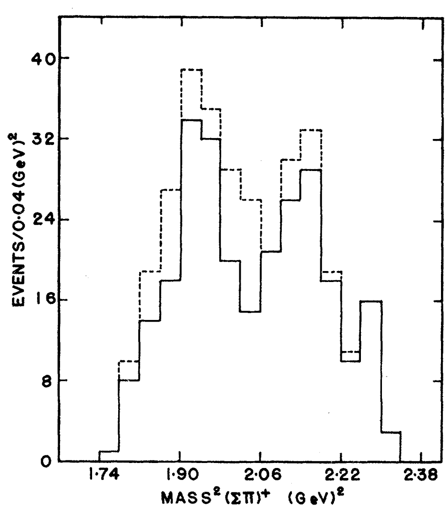

FIG. 1. The distribution of the square of the $(\Sigma\pi)^+$ invariant mass for Reactions (2) and (3). The dashed-line histogram is the total data and the solid-line histogram is the data with the cut $\Delta^2(\pi \to K) < -0.4$ GeV^2.