Photoproduction of an isovector $\rho\pi$ state at 1775 MeV

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(Received 19 June 1990)

Evidence is presented for the charge-exchange photoproduction, in two distinct reactions, of an isovector $\rho\pi$ state of mass ~ 1775 MeV. Results of an analysis of the decay-angular distributions are also presented, from which it is concluded that $J^P = 1^-$, 2^-, or 3^+.

About fifteen years ago Deutschmann *et al.*[1] presented evidence for an isovector 3π state at a mass of ~ 1.8 GeV/c^2. Their analysis, utilizing data from a 16-Gev/$c\,\pi^+ p$ experiment, employed the thesis that the decay pions from higher-mass states would exhibit larger values of the transverse momentum than pions from competing processes. Somewhat later the Amsterdam-Briston-CERN-Cracow-Munich-Rutherford (ACCMOR) Collaboration,[2] in a massive study of the reaction $\pi^- p \to \pi^- \pi^- \pi^+ p$, confirmed the existence of the $\pi_2(1670)$ (formerly denoted as A_3) as a ($J^P = 2^-$) state with dominant $f_2(1270)\pi$ decay, but also with a substantial $\rho\pi$ decay mode. They also observed a second isovector $J^P = 2^-$ state at a mass of ~ 1.85 GeV/c^2 which, when combined with a multichannel analysis, indicated a resonant mass of ~ 2.1 GeV/c^2. Subsequently, Chanowitz and Sharpe[3] observed that, since this heavier state was unlikely to be a radial excitation of the $\pi_2(1670)$, because of the proximity of their masses, this second 3π state was a strong candidate for a hybrid ($q\bar{q}g$) state[3] (even if its mass was as great as 2.1 GeV/c^2). Another strong indication of the existence of an isovector 3π state in this mass region has been presented by Aston *et al.*,[4] who observed such a state, with substantial $\rho\pi$ decay, at a mass of ~ 1760 MeV/c^2, as a 6.6σ enhancement in the photoproduction reaction $\gamma p \to (p\pi^\pm)(\pi^+\pi^-\pi^\mp)$. A similarly positioned peak can also be seen in the $\rho^0\pi^+$ spectrum, presented by Eisenberg *et al.*,[5] from the reaction $\gamma p \to n\pi^+\pi^+\pi^-$, where the charge-exchange photoproduction of the $a_2(1320)$ was first reported. In a related matter, we have recently presented evidence[6] that peripheral Δ^{++} production, in the reaction $\gamma p \to \Delta^{++}\pi^+\pi^-\pi^-$, was consistent with production via the absorptive one-pion-exchange model.

The purpose of this article is to confirm the existence of an isovector 3π state at a mass of ~ 1775 MeV. We shall also show that a possible value of J^P for this state is 1^- which would mandate the state to be $(q\bar{q})$ exotic.

Our data come from a large triggered hydrogen-bubble-chamber experiment which was performed at the Stanford Linear Accelerator Center, utilizing incident photons of average energy 19.3 GeV with a full width at half maximum of 1.7 GeV. The photon beam was generated by backscattering laser photons from the SLAC 30-GeV electron beam. The experimental details have been presented in prior publications.[7] In the present work, we employ two classes of events:

$$\gamma p \to p\pi^+\pi^+\pi^-\pi^- \text{ (5441 events)} , \quad (1)$$

$$\gamma p \to n\pi^+\pi^+\pi^- \text{ (3872 events)} . \quad (2)$$

The events comprising the sample of reaction (1) are those five-prong events which have a kinematic fit to this three-constraint interaction with a derived photon energy between 16.5 and 21.0 GeV and for which the fit probability exceeds $10^{-2}\%$. The event sample for reaction (2) was obtained as follows. Any three-prong event which has a three-constraint fit to any of the hypotheses ($\gamma p \to p\pi^+\pi^-$, pK^+K^-, $\bar{p}pp$) with a fit probability in excess of $10^{-2}\%$ was summarily rejected. Further, any event for which either of the positive tracks was identifiable as a proton on the basis of ionization, curvature, and/or Cherenkov information was rejected. Finally, any event for which the downstream lead-glass wall registered one or more photons was excluded. Throughout this article we treat the $n\pi^+\pi^+\pi^-$ final state in this conservative fashion, excluding events where any evidence for ambiguity exists. The events accepted for this zero-constraint channel were those which survived these cuts and for which energy and momentum balance provided a photon energy between 16.5 and 21.0 GeV. For both of these reactions the trigger efficiency is a rather smoothly varying function of mass and varies by no more than 0.05 for 3π masses between 0.95 and 2.4 GeV. Therefore, our mass plots will remain ungarnished by this correction.

Three main processes contribute to reaction (1).

(a) Diffractive $\rho(1700)$ production: $\gamma p \to \rho(1700)p$.

(b) Inelastic ρN^* production: $\gamma p \to \rho^0 N^{*+} \to (\pi^+\pi^-)(p\pi^+\pi^-)$.

(c) Charge-exchange photoproduction: $\gamma p \to \Delta^{++}X^- \to (p\pi^+)(\pi^+\pi^-\pi^-)$.

We shall concentrate, in this article, on process (c). The requirement of a peripheral Δ^{++} for this reaction essentially eliminates any background events due to processes (a). Figure 1 of Ref. 6 illustrates the strong peripheral Δ^{++} signal obtained from reaction (1). However, processes (b) and (c) do have some common regions of phase space. To minimize this interference we physically remove from consideration any event consistent with peripheral ρN^* production at $|t'_{\gamma,\rho^0}| < 0.2$ GeV^2. We define the Δ^{++} mass as $M(p\pi^+) < 1.4$ GeV$/c^2$, the N^* mass as $M(p\pi^+\pi^-) < 2.1$ GeV$/c^2$, and generally take the ρ^0 mass region as 0.6–0.9 GeV$/c^2$. (However, to define ρN^* events, because of the skewed nature of the ρ^0 mass spectrum in diffractive photoproduction,[8,9] the ρ^0 mass region is expanded to 0.55–0.90 GeV$/c^2$.) With these definitions we present in Fig. 1(a) the dipion spectrum (both combinations) for process (c) above at $|t'_{\gamma,3\pi}| < 0.2$ GeV^2 after removal of peripheral $\rho^0 N^{*+}$. The smooth curve represents a fit to a Breit-Wigner resonance for the ρ superimposed over a third-order polynomial background. Of principal interest is the fact that the ρ^0 is well represented by a Breit-Wigner form for which we find $M_\rho = 768 \pm 5$ MeV$/c^2$, $\Gamma_\rho = 187 \pm 18$ MeV. These values are quite consistent with those given by the Particle Data Group[10] (PDG) and stand in stark contrast to the situation encountered in both elastic[8] and inelastic[9] ρ^0 photoproduction where the ρ^0 peak occurs at ~ 725 MeV and the fit to a simple Breit-Wigner form is always of poor quality. This spectrum also suggests the presence of some $f_2(1270)$ production, which, because of charge-conjugation invariance, cannot be due to diffractive production. Since this behavior of the ρ^0 and the presence of the $f_2(1270)$ are not observed in diffractive photoproduction, another process must be present. In Fig. 1(b) we present the $\rho^0\pi^-$ mass spectrum for the reaction $\gamma p \to \Delta^{++}\pi^+\pi^-\pi^-$ at $|t'_{\gamma,3\pi}| < 0.2$ GeV^2 (after removal of peripheral $\rho^0 N^{*+}$ events). This spectrum is dominated[6] by the $a_2(1320)$ but there appears to be a state at ~ 1750 MeV$/c^2$ as well as, perhaps, another at ~ 2150 MeV$/c^2$. The smooth curve represents our fit to these data. The mass and width obtained for the state near the $\pi_2(1670)$ region are 1763 ± 20 MeV$/c^2$ and 192 ± 60 MeV, respectively. If this state is to be identified with the $\pi_2(1670)$, even though its mass exceeds that given by the PDG (Ref. 10) by $\sim 5\sigma$, its decay should be dominated by $f_2(1270)\pi$. In Fig. 1(c) we present the dipion spectrum (both combinations) for the 3π mass region (1.65–1.95 GeV$/c^2$). The fit shown corresponds to a relative decay rate, averaged over resonance and background, $x^- \to \rho^0\pi^- / x^- \to f_2\pi^- = 1.3 \pm 0.3$. This is to be compared with the PDG listings for the $\pi_2(1670)$ where

$$\frac{\pi_2(1670) \to \rho^0\pi^- \to \pi^+\pi^-\pi^-}{\pi_2(1670) \to f_2\pi^- \to \pi^+\pi^-\pi^-} = 0.48 \pm 0.09 .$$

This reinforces the difficulty of identifying the observed state with the $\pi_2(1670)$. In fact the only direct observation of the $\pi_2(1670)$ as a "bump" in a $\rho\pi$ mass spectrum has been by Antipov et al.,[11] who detected the ρ^0 by means of its $\mu^+\mu^-$ decay. It has never been reported as a $\rho\pi$ mass enhancement in a 3π mass spectrum.

We now note that, if one-pion exchange is the operative production mechanism for reaction [1(c)], we should see similar production in the mesonic spectrum of reaction (2). As mentioned above, Eisenberg et al.[5] employed reaction (2) to observe the charge-exchange photoproduction of the $a_2(1320)$. In Fig. 2(a) we present the full 3π spectrum for reaction (2), albeit under the somewhat more restrictive peripherality condition $|t'_{\gamma,3\pi}| < 0.1$ GeV^2. For this channel, both the $a_2(1320)$ and the higher-mass state of interest in this article, are clearly visible with only this peripherality cut. The shaded part of this spectrum represents the restriction to

$\rho^0\pi^+$ events. The fit to the full spectrum (smooth curve) shown on this figure yields a resonance mass of 1787 ± 18 MeV/c^2 with a width of 118 ± 60 MeV. In Fig. 2(b) we present the dipion mass spectrum for 3π events in the range 1.7–1.9 Gev/c^2. After correcting for direct ρ^0 production, which we estimate by the excess of forward-going ρ^0 to be $\sim$20% of the ρ^0 signal we find the $\rho^0\pi^+/f_2\pi^+$ branching ratio to be 1.8 ± 0.5.

Thus we have observed, in two distinct channels, evidence for an isovector, predominantly $\rho\pi$, state at a mass of $\sim$1775 MeV/c^2 with a width of $\sim$100–200 MeV. This is apparently the state first observed by Aston *et al.*[4] Because of the relatively large mass and branching-ratio differences between the photoproduced state and the $\pi_2(1670)$ it would not seem to be identifiable as the latter. It should be pointed out that all previous observations of the $\pi_2(1670)$ have been made in experiments employing pion beams where diffractive Deck processes can be important ($\pi^\pm\rightarrow\pi^\pm\rho^0$, $\pi^\pm f^0,\ldots$). The current experiment uses a photon beam which because of charge-conjugation

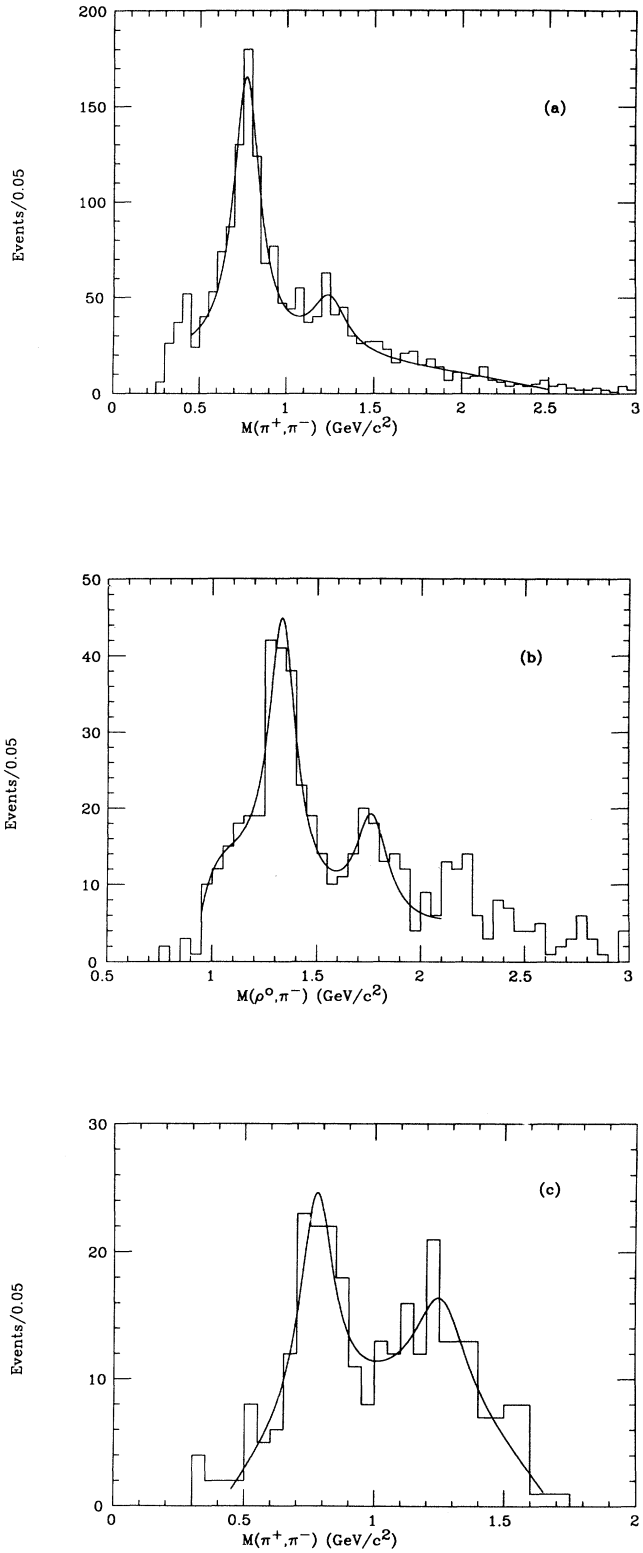

FIG. 1. For the reaction $\gamma p\rightarrow\Delta^{++}\pi^+\pi^-\pi^-$ at $|t'_{\gamma,3\pi}|<0.2$ GeV^2 (no peripheral ρ^0N^{*+}): (a) The neutral-dipion spectrum; (b) the $\rho^0\pi^-$ spectrum; (c) the $\pi^+\pi^-$ spectrum for events with $1.65\leq M(3\pi)\leq1.95$ GeV/c^2.

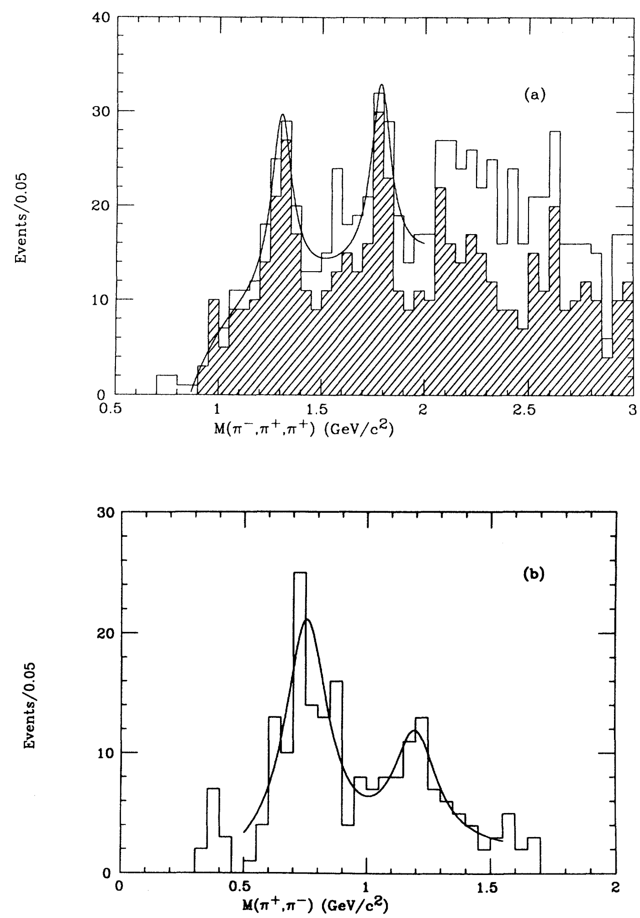

FIG. 2. For the reaction $\gamma p\rightarrow n\pi^+\pi^+\pi^-$: (a) The full 3π mass spectrum at $|t'_{\gamma,3\pi}|<0.1$ GeV^2. The shaded area indicates the results of requiring at least one $\pi^+\pi^-$ combination to be a ρ^0; (b) the $\pi^+\pi^-$ spectrum for events with $1.7\leq M(3\pi)\leq1.9$ GeV/c^2.

invariance cannot dissociate into $\pi^0 f_2(1270)$. Furthermore, in the vector-dominance model, only the isoscalar (ω) part of the photon can dissociate into $\rho\pi$ and this process appears to be too weak to produce any Deck-type enhancements in the reaction $\gamma p \to p\pi^+\pi^-\pi^0$. Although the hadronic experiments, upon which the PDG entries for the $\pi_2(1670)$ are based, do not appear flawed, the difficulties encountered regarding the notorious $a_1(1260)$ are a cause for caution. Notwithstanding this, our conclusion is that, unless the hadronic production data for $\pi_2(1670)$ have been grossly misinterpreted, the state observed by Aston *et al.*[4] and confirmed here cannot be the $\pi_2(1670)$.

It is then of some interest to investigate the degree to which J^P for this state can be deduced from the various angular distributions. We assume, throughout this analysis, that one-pion exchange is the reaction mechanism[6] with its concomitant corollary of t-channel helicity conservation. In Figs. 3(a) and 3(b) we present the angular distribution of the decay plane normal in the 3π rest frame with the Z axis defined by the direction of the incoming photon (Gottfried-Jackson frame). Both distributions are reasonably well fitted by a $\sin^2\theta_N$ distribution, for which the χ^2 per nine degrees of freedom is 0.76 and 1.3 for Figs. 3(a) and 3(b), respectively. From Table I, the J^P assignments consistent with these data are $1^-, 2^-, 3^+$. (The distributions given for 2^- and 3^+ have had their decay amplitudes adjusted to minimize any $\cos^2\theta_N$ component in their decay.) This amplitude selection is then employed to yield the parameter-free Ψ distributions given in this table. The angle Ψ is the corresponding azimuth (ϕ_N) of the decay plane normal relative to the angle (Φ) between the polarization vector of the photon and the production plane ($\Psi = \phi_N - \Phi$). The experimental distributions, reflected about $\Psi = \pi$, are given in Figs. 3(c) and 3(d). Both of these distributions are representative of one whose form is $(a + b\cos 2\Psi)$ with $b < 0$ which favors $J^P = 1^-$ as opposed to $J^P = 2^-$ or 3^+. We continue in Figs. 3(e) and 3(f) with the ρ helicity angular distributions. This angle θ_H is defined as the angle the π^+ from ρ^0 decay makes in the ρ rest frame with a Z axis given by the direction of the ρ^0 (in the $\rho^0\pi^\pm$ rest frame). Among its virtues is the fact that the ρ helicity angular distribution is independent of the state of the parent's polarization. The θ_H distributions clearly contain substantial 1^- components. Although both the Ψ and θ_H distributions exhibit 1^- characteristics it is not possible to exclude the hypothesis that this results from background events.

Our principal conclusions are the following.

(1) We have confirmed the existence of an isovector $\rho\pi$ state at a mass of 1775 MeV/c^2 with a width of $\sim$100–200 MeV.

(2) Under the assumption of t-channel helicity conservation,the polar distribution of the decay plane normal in the Gottfried-Jackson frame is only consistent with $J^P = 1^-, 2^-, 3^+$.

(3) Our data could be consistent with $\pi_2(1670)$ formation if its mass were about 100 MeV/c^2 larger than the Particle Data Group's average, if its dominant decay mode were to $\rho\pi$ rather than $f_2\pi$, and if our angular dis-

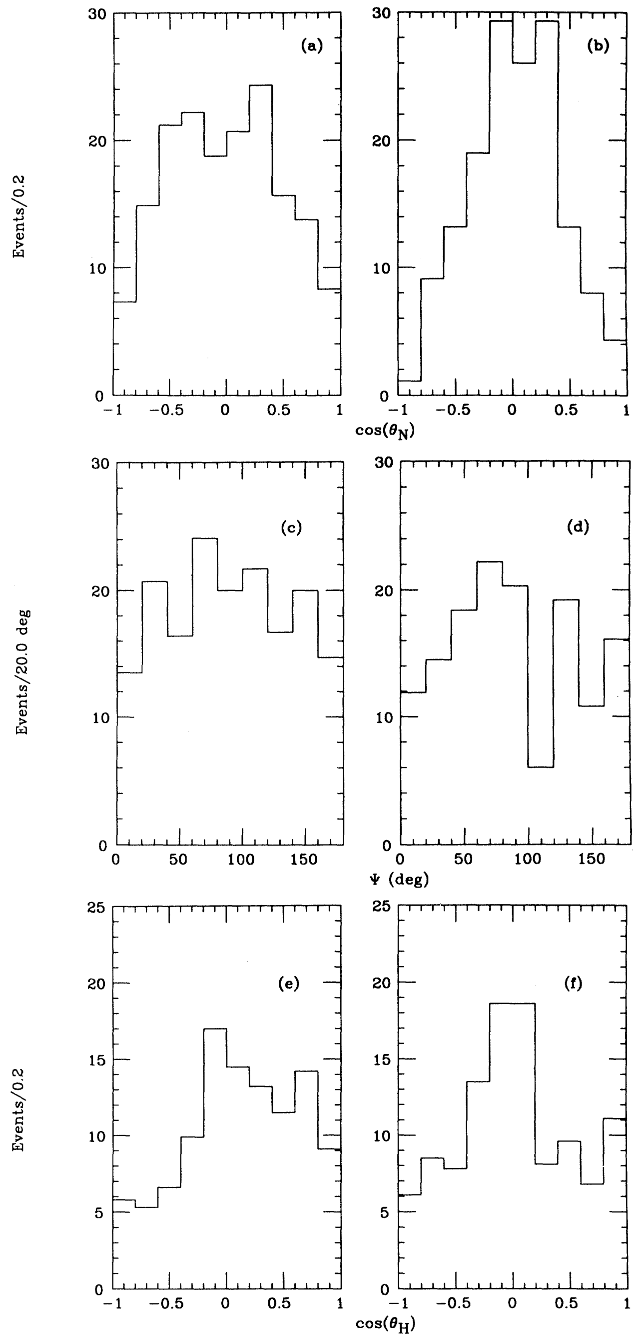

FIG. 3. Angular distributions for the resonant mass regions for the reactions $\gamma p \to \Delta^{2+} x^- (a,c,e)$ and $\gamma p \to n x^+ (b,d,f)$. (a) and (b) are the distributions of the decay plane normal in the Gottfried-Jackson frame (θ_N). (c) and (d) are the distributions of the corresponding azimuth relative to the difference between the photon polarization direction and the normal to the production plane (Ψ). (e) and (f) are the ρ^0 helicity angular distributions (θ_H). All of the angular distributions have been corrected for experimental acceptances. The distributions for the negative meson include a small correction for $\rho^0 N^*$ removal as described in Ref. 6. The distributions for the positive meson, which include all events, are relatively unaffected by any $\rho^0 N^*$ contamination. None of these corrections has a material effect on the shape of any of the angular distributions presented in this paper.

TABLE I. Unnormalized angular distributions.

J^P	θ_N	Ψ[a]	θ_H[b]
0^+	Does not exist		
0^-	Isotropic		
1^+	$1+\cos^2\theta_N$		
1^-	$\sin^2\theta_N$	$1-P_\gamma \cos 2\Psi$	$\sin^2\theta_H$
2^+	$4\cos^4\theta_N - 3\cos^2\theta_N + 1$	$6-P_\gamma \cos 2\Psi$	$\sin^2\theta_H$
2^-	$1-\cos^4\theta_N$	$3+2P_\gamma \cos 2\Psi$	$3+\cos^2\theta_H$
3^+	$(1-\cos^4\theta_N)(1-\cos^2\theta_N)$	$4+5P_\gamma \cos 2\Psi$	$2+\cos^2\theta_H$

[a]For this experiment, $P_\gamma = 0.52$ was the expected and measured value (Refs. 8 and 9) of the photon polarization. The distributions for $J^P = 2^-$ and 3^+ result from setting to zero those amplitudes which yield $\cos\theta_N$ distributions incompatible with the experimental θ_N data.
[b]The θ_H distributions are independent of the decaying mesons' polarization.

tributions (Ψ, θ_H) were characteristic of background rather than resonance formation. If the state we observe is not the $\pi_2(1670)$, we could exclude the $J^P = 2^-$ assignment (unless it is a 2^- hybrid) on the basis of its proximity to the $\pi_2(1670)$. Similarly if the 1^- characteristics of the (Ψ, θ_H) angular distributions are due to background the choice of $J^P = 3^+$ cannot be excluded.

(4) An alternative hypothesis which is consistent with the angular distributions is that $J^P = 1^-$. An isovector $\rho\pi$ state with $J^P = 1^-$ must have even charge parity so that this assignment requires the exotic combination, $J^{PC} = 1^{-+}$. Using a QCD sum-rule approach de Viron and Govaerts[12] find that an isovector state, with $J^{PC} = 1^{-+}$, at a mass of ~ 1.3 GeV/c^2, would decay predominantly to $\rho\pi$ with a width of 10–100 MeV. The state observed here is considerably more massive than this prediction although the widths are in tolerable agreement. At the recent SLAC Tau-Charm Factory Workshop, Close[13] has pointed out that the preponderance of experimental data for $q\bar{q}$ states may be related to the preponderance of studies effected with hadron beams. The current work utilized a photon beam where there is overwhelming evidence that meson production is concentrated in the states with $J^P = 1^-$. In a certain sense photoproduction provides at least a rough approximation of the J^{PC} "filter" which Isgur[14] has suggested may be required for further progress in meson spectroscopy.

We are grateful to J. Weinstein and T. Barnes for useful discussions and suggestions.

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[1]M. Deutschmann *et al.*, Nucl. Phys. **B114**, 237 (1976).
[2]ACCMOR Collaboration, C. Daum *et al.*, Phys. Lett. **89B**, 285 (1980); Nucl. Phys. **B182**, 269 (1981).
[3]M. Chanowitz and S. Sharpe, Nucl. Phys. **B222**, 211 (1983); T. Barnes and F. Close, Phys. Lett. **116B**, 365 (1982); T. Barnes, F. Close, and F. de Viron, Nucl. Phys. **B224**, 241 (1983).
[4]D. Aston *et al.*, Nucl. Phys. **B189**, 15 (1981).
[5]Y. Eisenberg *et al.*, Phys. Rev. Lett. **23**, 1322 (1969).
[6]G. T. Condo *et al.*, Phys. Rev. D **41**, 3317 (1990).
[7]K. Abe *et al.*, Phys. Rev. D **30**, 1 (1984); R. C. Field *et al.*, Nucl. Instrum. Methods **200**, 237 (1982); A. Bevan *et al.*, *ibid.* **203**, 159 (1982); J. E. Brau *et al.*, *ibid.* **196**, 403 (1983).
[8]J. Ballam *et al.*, Phys. Rev. Lett. **24**, 960 (1970); Y. Eisenberg *et al.*, Phys. Rev. D **5**, 15 (1972); K. Abe *et al.*, Phys. Rev. Lett. **53**, 751 (1984).
[9]K. Abe *et al.*, Phys. Rev. D **32**, 2288 (1985).
[10]Particle Data Group (PDG), G. P. Yost *et al.*, Phys. Lett. B **204**, 1 (1988).
[11]Yu. M. Antipov *et al.*, Yad Fiz. **45**, 1041 (1987) [Sov. J. Nucl. Phys. **45**, 645 (1987)].
[12]F. de Viron and J. Govaerts, Phys. Rev. Lett. **53**, 2207 (1984).
[13]F. Close, in *Proceedings of the Tau-Charm Factory Workshop*, Stanford, California, 1989, edited by Lydia V. Beers (SLAC Report No. 343, Stanford, 1989).
[14]N. Isgur, in *Glueballs, Hybrids and Exotic Hadrons*, proceedings of the Workshop, Upton, New York, 1988, edited by Suh-Urk Chung, AIP Conf. Proc. No. 185 (AIP, New York, 1989), p. 3.