Analysis of the $f_1(1285)\pi^-$ System Produced in $\pi^- p$ Interactions at 18 GeV/c

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Abstract. The reaction $\pi^- p \to f_1(1285)\pi^- p \to \eta\pi^+\pi^-\pi^- p$ at 18 GeV/c is being studied. The $f_1\pi^-$ system is expected to be an important decay mode for a hybrid meson and a previous experiment (BNL E818) has shown some evidence for such a state with $J^{PC} = 1^{-+}$. The existence of a high quality sample of $f_1(1285)/\eta(1295)\pi^-$ events in the $\eta\pi^+\pi^-\pi^- p$ final state has been established. Twelve thousand events have been selected from the 1994 E852 data run. A partial-wave analysis of this sample is presented. All significant waves are produced via natural parity exchange (i.e. $f_2(1270)$ or $\rho^0(770)$ exchange). The strongest contributions are from the 1^{++}, 1^{-+}, and 2^{-+} waves. Interesting relative phase motion is observed between these waves.

INTRODUCTION

The search for exotic mesons has been an important task of meson spectroscopy for many years. One theoretical model (flux tube model [1,2]) predicts that one of the preferred decay modes of hybrid mesons should be $f_1(1285)\pi$. A primary technique for observation of an exotic meson is to look for a meson with quantum numbers which are not allowed by a $q\bar{q}$ pair (e.g. a J^{PC}=1^{-+}).

Two previous experiments have published studies of the $f_1(1285)\pi$ system. The first is BNL 818 [3] which studied $\pi^- p$ interactions at 18 GeV/c. With limited statistics, a partial-wave analysis indicated a possible 1^{-+} state near 1.7 GeV/c^2. The second experiment is VES [4] at Serpukhov which studied π^- Nucleus interactions at 37 GeV/c. Their partial-wave analysis also shows the presence of a 1^{-+} wave.

Brookhaven Experiment 852 has the capability of studying various states with multiple charged particles and/or multiple neutral particles. It studied $\pi^- p$ interactions at 18 GeV/c using the MultiParticle Spectrometer (MPS)

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with enhanced photon measurement. One of the final states studied was $\eta\pi^+\pi^-\pi^-p$. There were 46 million triggers consistent with this topology taken in 1994. Forty-six thousand survived the reconstruction and selection criteria.

Of these forty-six thousand, twelve thousand were selected as candidate $f_1(1285)\pi^-$ events. This selection was made by requiring that one of the two $\eta\pi^+\pi^-$ combinations lie within the $f_1(1285)$ peak (1.23<M($\eta\pi^+\pi^-$)<1.33 GeV/c^2). These events were then used in a partial-wave analysis to determine the possible states which produced the data sample.

Figure 1 shows some of the characteristics of the data. The open histograms (in fig. 1(a)-(d)) show the distributions before the $f_1(1285)$ selection, while the hatched histograms show them after the $f_1(1285)$ selection.

A clear peak in $\eta\pi^+\pi^-$ (fig. 1(a)) near 1.28 GeV/c^2 can be seen. The $a_0(980)$ (which is a primary decay mode of $f_1(1285)$) can be seen in the $\eta\pi$ spectrum (fig. 1(b)). The possibility of $\rho(770)$ (fig. 1(c)) and $a_2(1320)$ (fig. 1(d)) within the data sample can also be seen. Each of these possible final states will be taken into account in the final analysis. The $\eta\pi^+\pi^-\pi^-$ spectrum (fig. 1(e)) is unremarkable.

ANALYSIS

A complete partial-wave analysis has been performed to determine the states which contribute to this data sample. The following possible in-

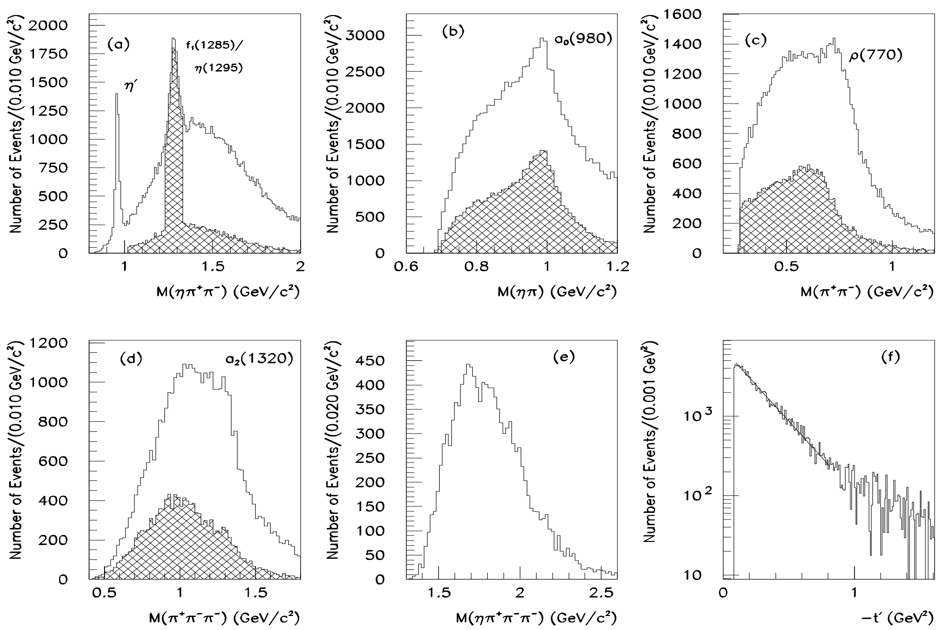

FIGURE 1. Various spectra for the $\eta\pi^+\pi^-\pi^-p$ data. The figures are: (a) M($\eta\pi^+\pi^-$); (b) M($\eta\pi$); (c) M($\pi^+\pi^-$); (d) M($\pi^+\pi^-\pi^-$); (e) M($\eta\pi^+\pi^-\pi^-$); (f) acceptance corrected t$'$.

termediate states were included in the analysis ($f_1(1285)\pi^-$, $\eta(1295)\pi^-$, $a_0^-(980)\rho^0(770)$, $a_2^-(1320)\eta$, $a_1^-(1260)\eta$, $a_0^-(980)(\pi\pi)_s$). Because of the selection on the $\eta\pi^+\pi^-$ spectrum no significant conclusions can be drawn about the non-$f_1(1285)\pi^-$ states. The final set of waves included the following $f_1(1285)\pi^-$ waves: ($J^{PC}m^\epsilon\ell$=$1^{++}0^+P$, $1^{-+}1^+S$, $1^{-+}1^+D$, $2^{++}1^+P$, $2^{-+}0^+D$, $2^{-+}1^+D$, and $3^{++}0^+F$). All of the waves in the final fit were produced via natural parity exchange.

Figure 2 shows the intensity distributions and relative phase motion for the three strongest $f_1(1285)\pi^-$ waves ($1^{++}0^+P$, $1^{-+}1^+S$, and $2^{-+}0^+D$). There is significant intensity in all three waves. The final PWA fit requires the $1^{-+}1^+S$ $f_1(1285)\pi^-$ wave at greater than the 99.99% confidence level. The $1^{++}0^+P$ $f_1(1285)\pi^-$ intensity can be well described by a Breit-Wigner distribution. The mass and width of this distribution are found to be (1.74 ± 0.02) GeV/c^2 and (0.40 ± 0.05) GeV/c^2, respectively.

There is also interesting phase motion between the strongest $f_1(1285)\pi^-$ waves. Analysis of this phase motion in conjunction with the intensity distribution leads to two primary interpretations. The small phase motion between the $1^{++}0^+P$ and $1^{-+}1^+S$ waves indicates the two waves are either resonant or non-resonant together. The strong phase motion of the $2^{-+}0^+D$ wave relative to the other two waves indicates one more resonance in the $2^{-+}0^+D$ wave than

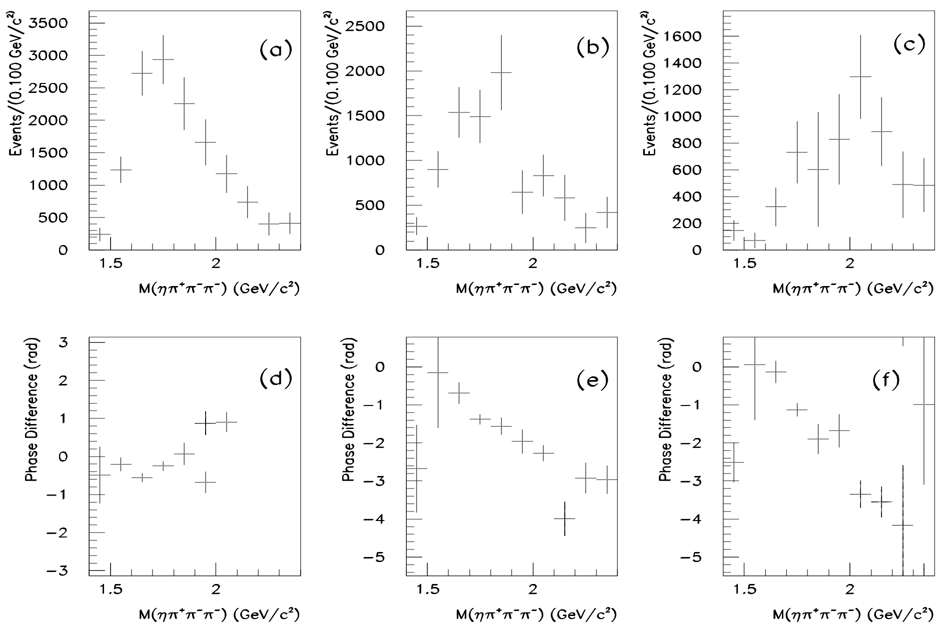

FIGURE 2. Selected results of final $\eta\pi^+\pi^-\pi^-p$ PWA fit. The figures are: (a) $1^{++}0^+P$ $f_1(1285)\pi^-$ intensity; (b) $1^{-+}1^+S$ $f_1(1285)\pi^-$ intensity; (c) $2^{-+}0^+D$ $f_1(1285)\pi^-$ intensity; (d) $[\phi_{1^{++}0^+P\ f_1(1285)\pi^-} - \phi_{1^{-+}1^+S\ f_1(1285)\pi^-}]$; (e) $[\phi_{1^{++}0^+P\ f_1(1285)\pi^-} - \phi_{2^{-+}0^+D\ f_1(1285)\pi^-}]$; (f) $[\phi_{1^{-+}1^+S\ f_1(1285)\pi^-} - \phi_{2^{-+}0^+D\ f_1(1285)\pi^-}]$.

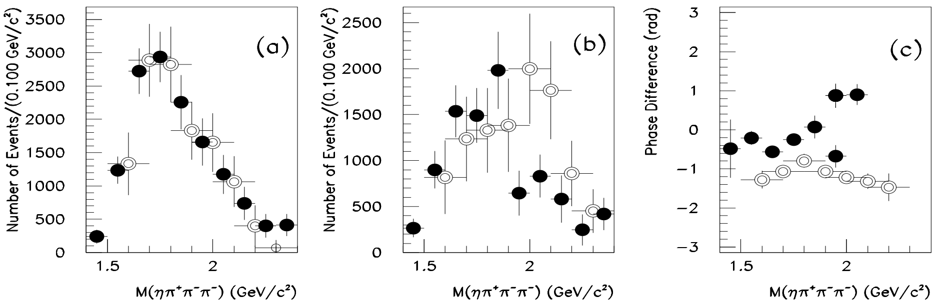

FIGURE 3. Comparison of E852 results with BNL 818 results. The figures are: (a) $1^{++}0^{+}P$ $f_1(1285)\pi^-$ intensity; (b) $1^{-+}1^{+}S$ $f_1(1285)\pi^-$ intensity; (c) $[\phi_{1^{++}0^{+}P\ f_1(1285)\pi^-} - \phi_{1^{-+}1^{+}S\ f_1(1285)\pi^-}]$.

in the $1^{++}0^{+}P$ and $1^{-+}1^{+}S$ waves. Therefore, this analysis suggests either a single resonance ($2^{-+}0^{+}D$) or four resonance (one $1^{++}0^{+}P$, one $1^{-+}1^{+}S$ and two $2^{-+}0^{+}D$) interpretation.

Figure 3 shows a comparison between the results of this analysis and BNL E818 [3] for two of the $f_1(1285)\pi^-$ waves. There is excellent agreement in the $1^{++}0^{+}P$ wave. There is fair agreement (except for the 1.90-2.00 GeV/c^2 region) in the $1^{-+}1^{+}S$ wave. While there are some differences in the relative phase difference, overall the results are fairly consistent.

CONCLUSIONS

Brookhaven Experiment 852 has high quality data which include the intermediate state $f_1(1285)\pi^-$. A partial-wave analysis of these data has been performed. All of the waves in the final fit were produced via natural parity exchange. It shows strong intensity and interesting phase motion in the $1^{++}0^{+}P$, $1^{-+}1^{+}S$ and $2^{-+}0^{+}D$ $f_1(1285)\pi^-$ waves. The $1^{-+}1^{+}S$ $f_1(1285)\pi^-$ wave is strongly needed by the final fit. The $1^{++}0^{+}P$ $f_1(1285)\pi^-$ intensity distribution can be well described by a Breit-Wigner form. The $2^{-+}0^{+}D$ $f_1(1285)\pi^-$ wave shows strong phase motion versus the other waves.

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