Analysis of $\eta\pi^0$ system with the decay of η meson $\eta \to \pi^+\pi^-\pi^0$

Outline

Version 1.0

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Abstract

The exclusive reaction $\pi^- p \to \eta\pi^0 n$, $\eta \to \pi^+\pi^-\pi^0$, $\pi^0 \to 2\gamma$ at 18 GeV/c has been studied in E852 experiment. A partial wave analysis has been performed on a sample of 23492 $\eta\pi^0 n$ events. A mass dependent fit with the average ambiguous solutions and a mass dependent partial wave analysis give the coincident resonant parameters of the P_+ wave. We have an evidence of neutral exotic $J^{PC} = 1^{-+}$ meson state $\pi_1^0(1400)$.

Introduction

A. Short discussion of special characteristics of the 1^{-+} state

B. Summarize recent observations: E852 $\eta\pi^-$, E852 $\eta'\pi^-$, Crystal Barrel $\eta\pi^-$ and $\eta\pi^0$, GAMS and E852 $\eta\pi^0$ data with $\eta \to 2\gamma$.

C. Discussion of IU conclusions on $P+$ wave in E852 $\eta\pi^0$ data with $\eta \to 2\gamma$.

D. Summarize predictions of various models regarding masses and branching ratios of he 1^{-+} states.

1 Data Selection

(a) The data was acquires during the 1995 E852 data run and stems from a total of 108 million triggers which required:

i. Interaction beam

ii. Two downstream tracks

iii. No recoil track

iv. LGD trigger processor mass $> M(\pi^0)$

(b) Off-line selection required:

i. Reconstruction beam

ii. No recoil

iii. $CSI < 160MeV$

v. Vertex in target

vi. Exactly 4 photons

vii. Kinematical fit selection events consistent with $n\pi^+\pi^-\pi^0\pi^0$ hypothesis (74549 events)

viii. Kinematical fit selection events consistent with $n\eta\pi^0$ hypothesis (23492 events at $cl > 0.01$)

(c) Main features of the data:

A. The $\eta(539.2 \pm 0.3MeV)$ with a width of $23.7 \pm 0.22MeV$ is clearly observed (Fig.1).

B. The selection of side bands in the $\pi^0\pi^+\pi^-$ distribution is shown in Fig.1. A ratio η signal to background is 6 to 1.

C. Invariant mass $\eta\pi^0$ system distribution are in Fig.2.

D. Fig.3 is a comparison the total data $\eta\pi^0$ mass distribution and the background from the side bands in Fig.1 (mass bin = 40 MeV). A ratio of background to data events for different interval of $\eta\pi^0$ mass is $15\% - 25\%$ for $m(\eta\pi^0) > 0.85GeV/c^2$.

E. Fit of t' dependence of the acceptance corrected data is in Fig. 4. The parameters of fitted function $N(t') = n_1|t'|e^{-b_1|t'|} + n_2 e^{-b_2|t'|}$ are $b_1 = (7.41 \pm 0.08)(\mathrm{GeV/c})^2$, $b_2 = (2.68 \pm 0.07)(\mathrm{GeV/c})^2$, $n_2/n_1 = 0.71 \pm 0.03$

2 PWA

Here and below we use the same assumptions as in our $\eta\pi^-$ system study and the standart E852 software.

(a) The fit was performed in 40 MeV mass bin from 0.78 GeV to 1.74 GeV (23492 events) and from 1.1 GeV to 1.74 GeV (14188 events).

(b) The fit included a non-interfering, isotropic background of fixed magnitude determined from side bands.

(c) The fit contained 7 wave as in our previous publication on $\eta\pi^-$ analysis.

(d) The quality of the fit is shown in a comparison of the moments and angular distributions for the data and predicted Monte Carlo (see Fig.5 and Fig. 6.

(e) For control aims we made PWA in two t' interval: $t' < 0.225(GeV/c)^2$ and $t' > 0.225(GeV/c)^2$, but with 100 MeV mass bin in the mass interval 0.78 - 1.74 GeV..

3 Mass Dependent Fit

Mass dependent fit of two waves $D+$ and $P+$ and their relative phase was performed with average ambiguous solutions (see Fig.7). Here we used a resonant hypothesis for $D+$ and $P+$ waves and mass independent production phase and got $\chi^2/DoF = 1.22$. Non resonant hypothesis for $P+$ wave gives $\chi^2/DoF = 3.02$.

4 Mass Dependent Partial Wave Analysis

Mass dependent partial wave analysis (MDPWA) is a fit, in which PWA of the angular $\eta\pi^0$ distribution is carried for each mass $\eta\pi^0$. The fitted functions are the Breit-Wigner amplitudes for the D_+, P_+ and some simple functions of mass for other waves. The results of MDPWA don't depend on the ambiguous solutions. The results of MDF with average solutions in each mass bin and the results of MDPWA are shown in Fig.7 and Fig.8.

The curves in Fig.8 are the results of MDPWA and the points with errors are the ambiguous solutions from PWA, which don't used in MDPWA.

The fitted parameters of $\pi_1(1400)$ meson for two fits are in the table 1.

Table 1: Fitted Resonance Parameters of P_+ wave

	PWA + MDF	MDPWA
$Mass, MeV/c^2$	$1270 \pm 14^{+80}_{-70}$	1283 ± 7
$Width, MeV/c^2$	$334 \pm 42^{+116}_{-184}$	382 ± 24

5 Systematic studies

For estimation of the systematical errors due to ambiguous solutions the following procedure was applied:

1. In each mass bin one solution was chosen randomly.
2. The simultaneous fit of intensities of D+ and P+ waves and phase difference was done for each combination of solutions in mass interval $1.1 < M(\eta\pi^0) < 1.74$ GeV/c^2. The parameters of the a_2^0 were chosen from E852 $\eta\pi^-$ analysis and fixed.
3. We also include the leakage of D^+ wave to P^+ wave. A form of mass dependence of leakage was the same as D^+ intensity, but the normalization of leakage was free in the fit. The leakage contribution in our different fits is less then 18% comparing with P^+ wave.

6 Results

The parameters of the fitted BW amplitudes for a_2^0 meson and for π_1^0 are in Table 2. The resonant parameters are stable in two different t' intervals. The values of resonant mass coincide with the basic analysis with 40 MeV mass bin.

The ratio of P_+ and D_+ wave intensities in the range of $1.24 < M(\eta\pi^0) < 1.34 GeV$ is equal to

$$|P_+|^2/|D_+|^2 = 0.35 \pm 0.10$$

Table 2: Fitted Resonance Parameters of D_+ and P_+ waves from MDPWA

	a_2^0	π_1^0
$Mass, MeV/c^2$	1326 ± 3	1283 ± 7
$Width, MeV/c^2$	112 ± 5	382 ± 24

7 Acknowledgments

Thank you ...

Supporting materials are in web site
$http://lav01.sinp.msu.ru/\ vlk/E852-EtaPiz/$
Previous materials of 2000 year are in web site
$http://home/lemond/e852/WWW/secure/analysis/1995/korotkih$

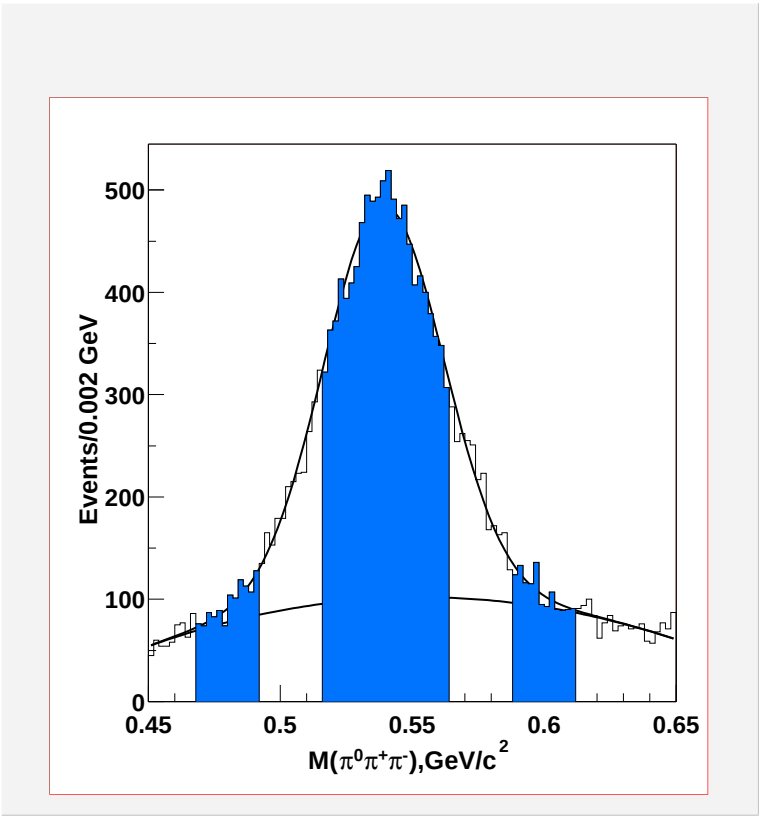

Figure 1: The η signal and the selection of side bands in the $\pi^0\pi^+\pi^-$ distribution (two entries).

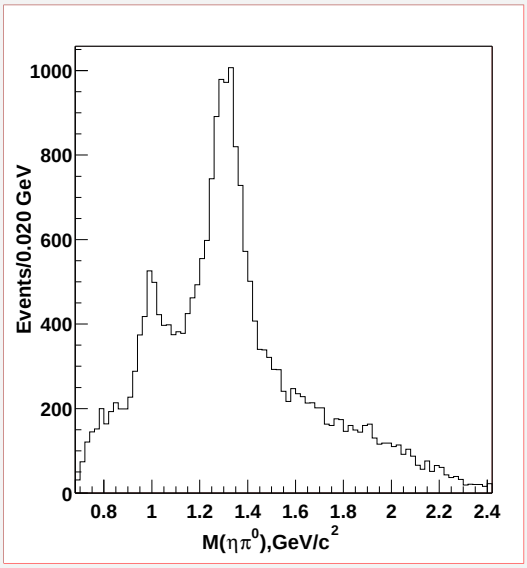

Figure 2: Mass $M(\eta\pi^0)$ distribution.

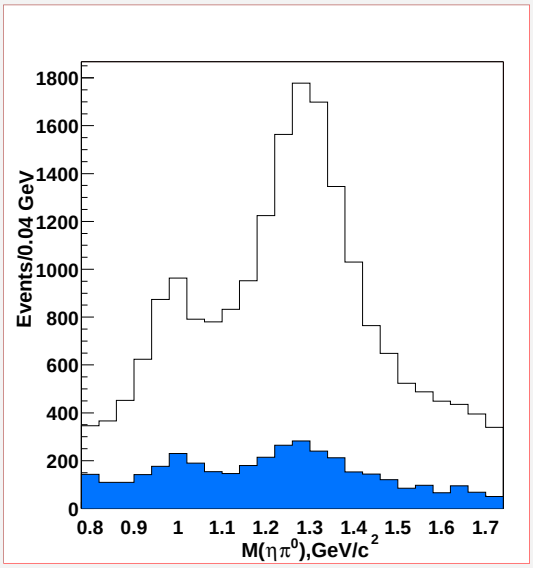

Figure 3: Data and background in the $\eta\pi^0$ mass distribution

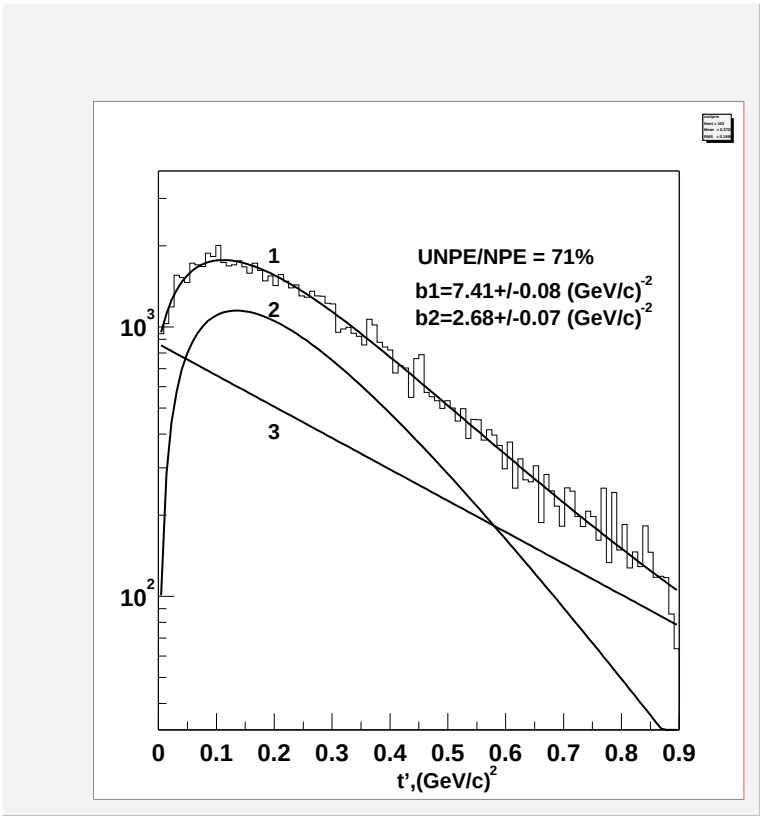

Figure 4: The acceptance corrected t' - distribution and the results of fit. 1) $N(t') = NPE + UNPE$, 2) $NPE = n_1|t'|e^{-b_1|t'|}$, 3) $UNPE = n_2 e^{-b_2|t'|}$.

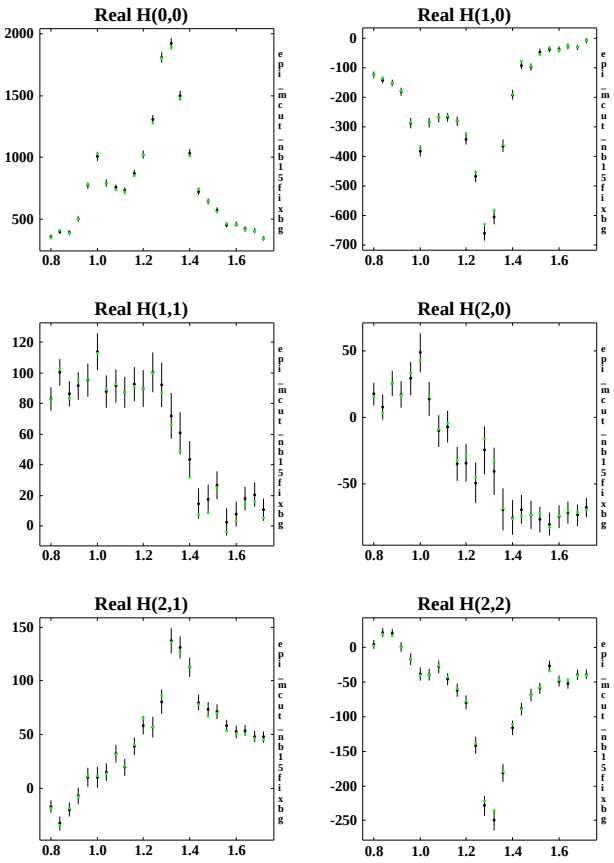

Figure 5: Experimental (points with errors) and the predicted moments H(LM).

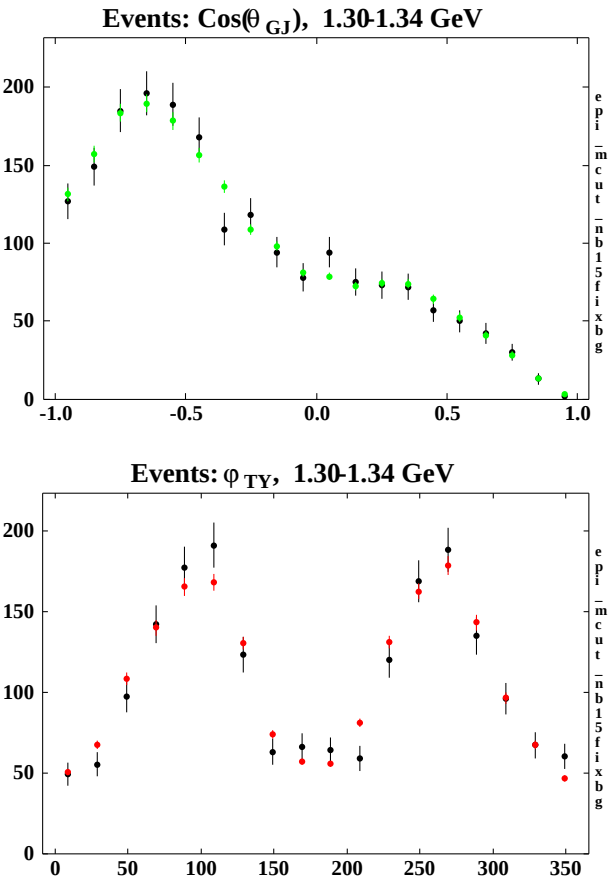

Figure 6: Experimental and the predicted $cos(\theta_{GJ})$ and φ_{TY} for $1.30 < M(\eta\pi^0 < 1.34 GeV/c^2)$

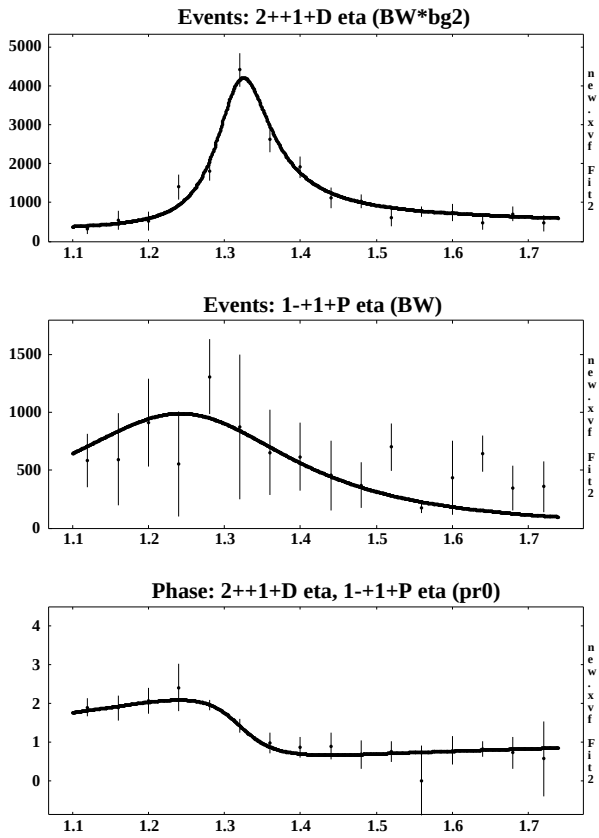

Figure 7: Mass dependent Brei-Wigner fit of the intensities of D+ and P+ waves and phase difference between them. The points and errors are the average solutions.

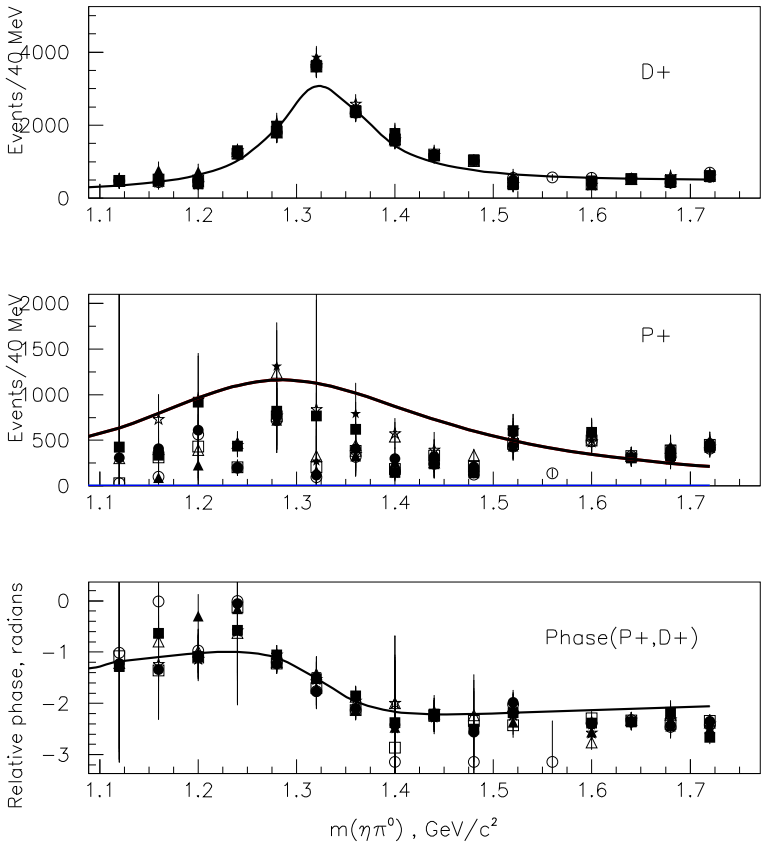

Figure 8: The results of MDPWA for D+ and P+ waves and phase difference between them. The curves are the results of MDPWA with Brei-Wigner free parameters. The points and errors are from PWA in each mass bin for comparison with MDPWA curves.