PWA with modified Decay Amplitudes in $\eta\pi^0$ system

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1 Model DATD

Let's insert the modifications of decay amplitudes suggested in Note [1]. Call this modifications of Decay Amplitudes with t' Dependence as DATD model.

The decay amplitudes have an additional factor $Q_m(t')$ depending on the square momentum transfer t' in the reaction

$$Q_m(t') = exp(1-v), \quad m=0, \; so \;\; for \; S_0, \; P_0, \; D_0 \; waves; \tag{1}$$
$$Q_m(t') = v \; exp(1-v), \quad m \neq 0, \; so \;\; for \; D_\pm, \; P_\pm \; waves. \tag{2}$$

where v is equal to

$$v = \frac{t'}{t'_0}, \; NPE \; waves; \tag{3}$$
$$v = \frac{t'}{t''_0}, \; UNPE \; waves. \tag{4}$$

The factor $exp(1-v) = e * exp(-\frac{t'}{t'_0}) = e * exp(-b_0 * t')$.

2 Decay amplitudes with t' dependence. MDPWA.

We performed the mass dependent partial wave analysis (MDPWA) in the DATD model. Let's take the same values of parameter $t'_0 = t''_0 =$

Table 1: Fitted BW Resonance Parameters (MDF) in $\eta\pi^0$ system, $t'_0 = 0.333(GeV/c)^2$.

Partial Wave	Mass, MeV/c^2	Width, MeV/c^2	Intensity
$D_+, (MDPWA)$	1314 *fixed*	112 *fixed*	28.2 *fixed*
$P_+, (MDPWA)$	1767 ± 12	600 ± 9	19 ± 0.3
$D_+, (MDPWA)$	1299 ± 1	191 ± 2	22.6 ± 0.2
$P_+, (MDPWA)$	1599 ± 69	1159 ± 101	8.0 ± 0.3
$UNPW$	*free*	*free*	free

Table 2: Fitted BW Resonance Parameters (MDF) in $\eta\pi^0$ system, $t'_0 = 0.1(GeV/c)^2$.

Partial Wave	Mass, MeV/c^2	Width, MeV/c^2	Intensity
$D_+, (MDPWA)$	1314 *fixed*	112 *fixed*	28.2 *fixed*
$P_+, (MDPWA)$	2196 ± 491	1153 ± 716	20 ± 13
$D_+, (MDPWA)$	1294 ± 2	100 ± 2	30 ± 1
$P_+, (MDPWA)$	1327 ± 26	1095 ± 101	16 ± 1
$UNPW$	*free*	*free*	free

$0.1(GeV/c)^2$ and $t'_0 = t''_0 = 0.333(GeV/c)^2$, which corresponds to $b_0 = 10.0(GeV/c)^{-2}$ and $b_0 = 3.0(GeV/c)^{-2}$. It seems the interval $b_0 = (3.0 - 10.0)$ $(GeV/c)^{-2}$ covers values, which corresponds to parameter of nucleon formfactor.

The results are in Table 1 with $t'_0 = 0.333(GeV/c)^2$ and in Table 2 with $t'_0 = 0.1(GeV/c)^2$. Comparison the fitted curves with the points from standart PWA in each mass bin (without DATD) is in Fig. 1-3. Remind that in MDPWA the distributions in figures are not fitted to points. They are fitted to the angular distributions and mass dependence simultaneously (see Draft 5.2 of $\eta\pi^0$ paper). The points are little different from Draft 5.2, but it doesn't matter in this analysis. A dotted line in figures with the relative phase is the resonant D_+ phase with parameters from Draft 5.2.

You see the fit is not satisfied data. If the parameters of a_2 are fixed then the experimental relative phase isn't described by fitted lines (left panels of Fig.1 and 3). The UNP waves are also not described by DATD model (Fig.2).

If we make all parameters free then the mass dependent form of a_2 is distorted and the experimental relative phase is not descibed by DATD model (rigth panels of Fig.1 and 3, Table 1, 2). P_+ wave is fitted badly in every fits.

So the DATD model is not adequate to experimental data.

3 Short theoretical comment

Let's take a simple example of $\pi + p \to \pi + N^*(1440)$. A spin density matrix of $N^*(1440)$ is

$$\hat{\rho} = \frac{1}{2}\,(1 + \vec{P}\hat{\vec{\sigma}}). \tag{5}$$

where $\vec{P}$ is a polarisarity of $N^*(1440)$. An amplitude of $N^*(1440)$ production is

$$f(t') = f_0(t') + f_1(t')\hat{\vec{\sigma}}\vec{n}. \tag{6}$$

and $\vec{n} = [\vec{k}_0 \times \vec{k'}_0]$ is a normal to production plane.

Angular distribution $N^*(1440) \to p + \pi$ in the rest system is determined by the spin density matrix $\hat{\rho}$, so on the polarisarity $\vec{P}$

$$\vec{P} = P(t')\vec{n}. \tag{7}$$

When $\vec{k}_0 \parallel \vec{k'}_0$ then we have only one direction $z = \vec{k}_0$. In this case spin density matrix is diagonal upon spin projection

$$\hat{\rho} = \frac{1}{2}\begin{pmatrix} 1 + P_z & 0 \\ 0 & 1 - P_z \end{pmatrix}$$

But it is known that when a spin density matrix is diagonal then the angular distribution $\frac{dI}{d\omega}(\theta, \varphi)$ doesn't depend on an asimuthal angle φ. So it is not necessary to introduce any t' -dependence in decay amplitude in order to suppress amplitudes with $m \neq 0$.

References

[1] S. U. Chung "Decay amplitudes with t' dependence", (2006)

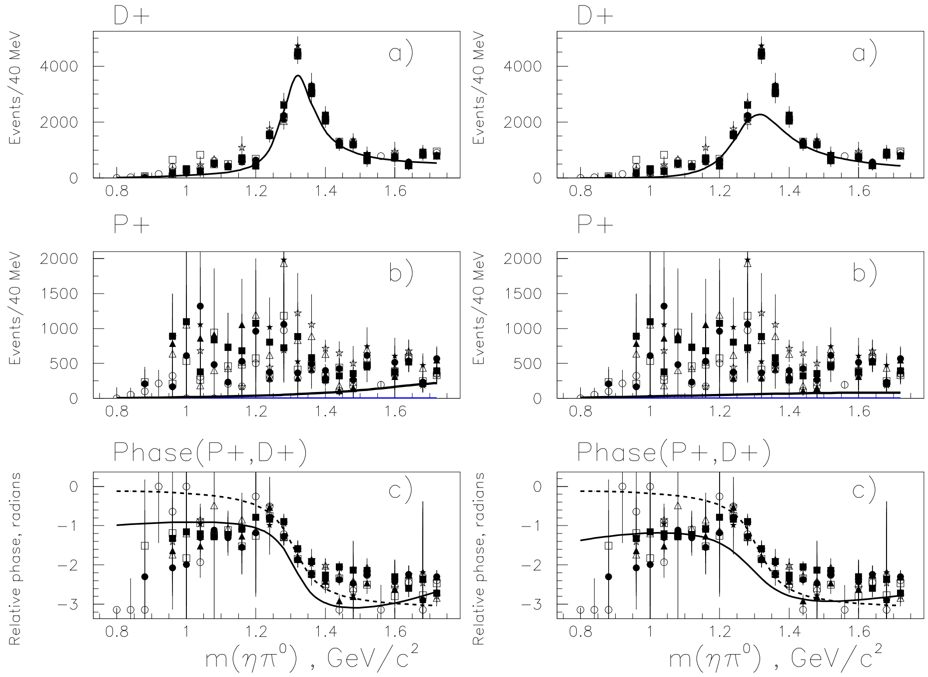

Figure 1: The results of MDPWA for NPWs $D+$ and $P+$ waves and phase difference between them. a) D_+ wave intensity, b) P_+ wave intensity, c) the relative phase $(P_+ - D_+)$ and the resonant D_+ phase (dotted line). Left panel for fixed a_2, rigth panel with free a_2. Parameters are in Table 1.

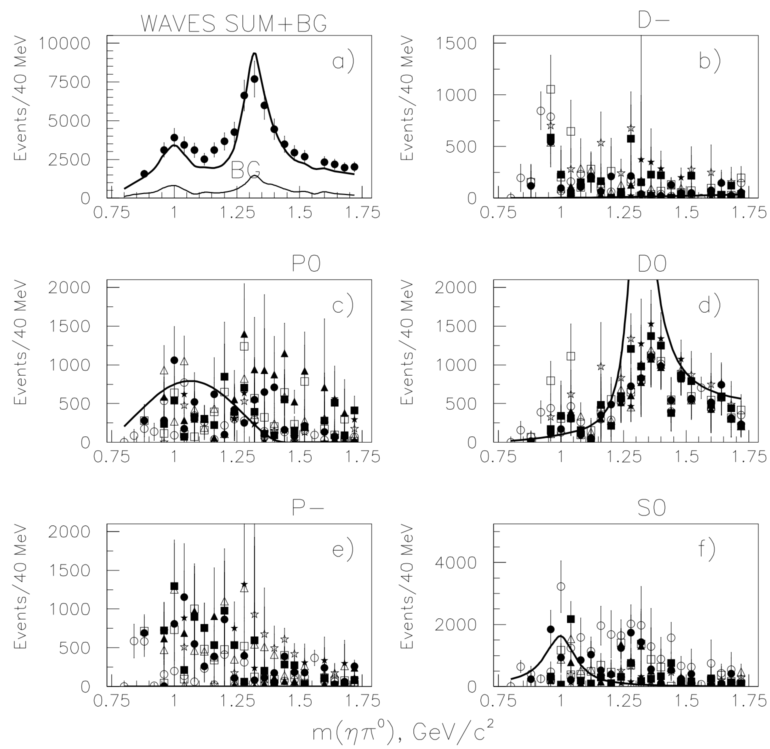

Figure 2: The results of MDPWA for UNPWs. a) A sum of waves and background BG, b)D_- wave intensity, c)P_0 wave intensity, d)D_0 wave intensity, which was fitted with fixed BW resonant parameters as for D_+ wave, e)P_- wave intensity, f)S_0 wave intensity. The waves P_0, P_-, D_- were fitted as polynomial background with constant phase. Parameters are in Table 1 with fixed a_2 with $t'_0 = 0.333(GeV/c)^2$.

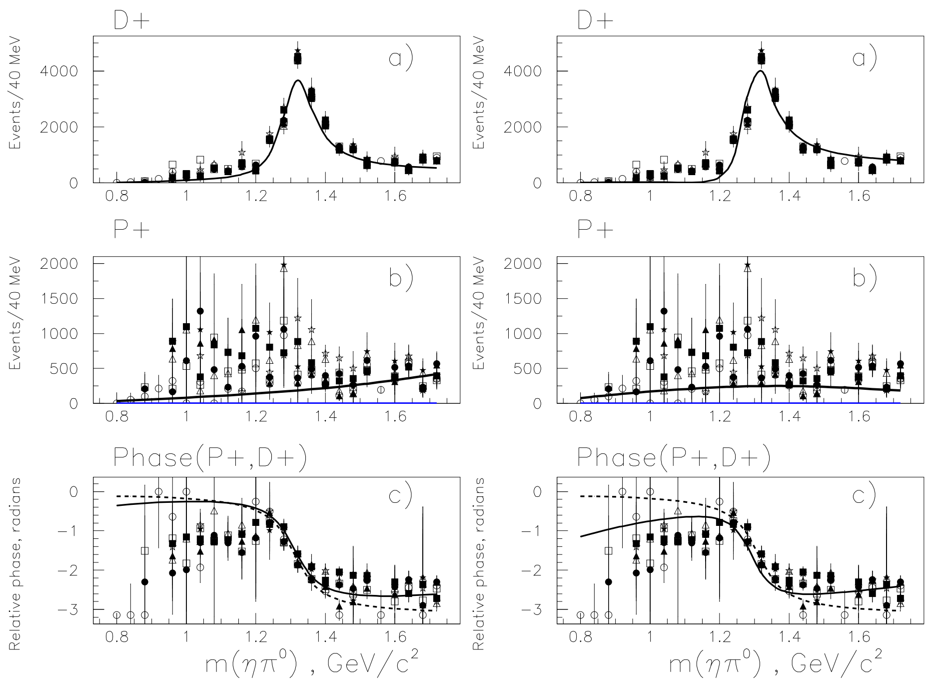

Figure 3: The results of MDPWA for NPWs $D+$ and $P+$ waves and phase difference between them. a) D_+ wave intensity, b) P_+ wave intensity, c) the relative phase $(P_+ - D_+)$ and the resonant D_+ phase (dotted line). Left panel for fixed a_2, rigth panel with free a_2. Parameters are in Table 2 with $t'_0 = 0.1(GeV/c)^2$.