The Analysis of $J/\psi \to p\overline{p}\pi^+\pi^-$, $p\overline{p}\pi^+\pi^-\pi^0$

The 9th BES Annual Meeting, DaLian

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Abstract

The branching ratios of $J/\psi \to p\overline{p}\pi^+\pi^-$, $p\overline{p}\pi^+\pi^-\pi^0$ have been measured, which are consistent with PDG values. We have got preliminary study on searching N* by ωp final state, and found that some interesting signals may exist in the invariant mass spectrum of $\pi^+\pi^-\pi^0$p.

I. Introduction

The symmetric quark model predicts many baryons with masses above 1.8GeV which have not been observed in $\pi N \to \pi N$ reactions. Many of the "missing" states may couple to channels such as ωN, ρN, or $\pi\Delta$. Electromagnetic production of these channels may be the only way to search for the "missing" states. So, the channel of $J/\psi \to \overline{p}$N*, N* $\to \rho$p, ωp will be an important way of searching the $N*$[1].

The branching ratio of $J/\psi \to p\overline{p}\pi^+\pi^-$, $p\overline{p}\pi^+\pi^-\pi^0$ have not been measured at BES yet, it was measured at MARKII[2] in 1984, but at that time, the total number of J/ψ was 1.32M, about 1/6 of our BESI J/ψ sample, which is the largest in the word, forthermore BESII will obtain new J/ψ sample with 50M events. So it is worth to measure the branching ratio at BES.

According H. HARARI's prediction[3], η' contains approximately 7% mixture of $c\overline{c}$, so the decay ratio of $J/\psi \to p\overline{p}\eta'$ will be larger than the ratio of $J/\psi \to p\overline{p}\omega$ (after the phase space correction). We will test this assumption.

II. The analysis of $J/\psi \to p\overline{p}\pi^+\pi^-$

The basic cuts of $J/\psi \to p\overline{p}\pi^+\pi^-$, $p\overline{p}\pi^+\pi^-\pi^0$ are as follows:

Nchrg=4, Nneu$\leq$6; Ntotchrg=0, MFIT=2 or MFIT=-19.
$|x| \leq$1.5cm, $|y| \leq$1.5cm, $|z| \leq$15cm

1. $J/\psi \to p\overline{p}\pi^+\pi^-$ events further selection

For charged tracks:

1). Particle is identified by the weight information from TOF, We need at least one of the four tracks is identified as p and at most one track is identified as K:

$N_p \geq 1$, $N_K \leq 1$
for p, we need $W_p > W_\pi$, $W_p > W_k$
And if $N_p = 1$ or $N_p = 3$, we need $0.23 < \beta_p < 0.76$
for π, we need $0.67 < \beta_\pi < 1.15$, N_π=2 (see Figure 1)
2). Use 4c-fit to the four tracks (regarded as $p\overline{p}\pi^+\pi^-$): $\chi^2 \leq 50$
For neutral tracks: no good photons: N_γ=0
The cuts for good photons are as follows:
$E_{sc} \geq 70MeV$
Δ: The angular relation between the direction of γ cluster after reconstruction and the direction of line from the collision point to the first fired point in SC:
$\Delta \leq 0.3$, $\theta_{\gamma c} \geq 15^0$, $Nlay_{sc} > 1$

After above selections, we get 2894 events from 7.8M BESI J/ψ events. We use phase space to generate 20000 Monte Carlo events, then get the acceptance is about 7.06%

2. The background study of $J/\psi \to \pi^+\pi^-p\overline{p}$:

$$J/\psi \to \pi^+\pi^-\pi^0p\overline{p},\ p\overline{p}k^+k^-,\ k^+k^-\pi^+\pi^-,\ \pi^+\pi^-p\overline{p}\gamma$$

	$p\overline{p}\pi^+\pi^-\pi^0$	$p\overline{p}k^+k^-$	$k^+k^-\pi^+\pi^-$	$p\overline{p}\pi^+\pi^-\gamma$	$\pi^+\pi^-\pi^+\pi^-$
Evts	18000	30000	56000	6100	32000
Final events	0	0	0	21	0

3. The Branching ratio of $J/\psi \to p\overline{p}\pi^+\pi^-$

	Finial events	Efficiency	Branching ratio(10^{-3})
Result	2894	7.06%	$5.25\pm0.10\pm1.30$

*The Branching ratio in PDG is: $(6\pm0.5) \times 10^{-3}$
The systmetic error contains: MC about10%, events selection about 10%, data about20%.

III. The analysis of $J/\psi \to p\overline{p}\pi^+\pi^-\pi^0$.

1. Events selection

1). Charged tracks cuts are the same as $J/\psi \to p\overline{p}\pi^+\pi^-$

2). For neutral tracks: at least two good photons: $N_\gamma \geq 2$

The cuts for good photons are as fellows:

$E_{sc} \geq 50MeV$, $\Delta \leq 0.5$, $\theta_{\gamma c} \geq 15^0$, $Nlay_{sc} > 1$

3). Use 4c-fit to the events (regarded as $p\overline{p}\pi^+\pi^-\pi^0$): $\chi^2 \leq 50$

4). The invariant mass of the two γ selected after 4-c fit can match the mass of π^0

$0.05 < M_{\gamma\gamma} < 0.25$ (GeV) (see Figure 3)

After above selections, we get 191 events from 7.8M BES I events. We use phase space to generate 30000 Monte Carlo events, then get the acceptance is about 1.58%

2. **The background study of $J/\psi \to \pi^+\pi^-\pi^0 p\overline{p}$** :

$$J/\psi \to \pi^+\pi^- p\overline{p},\ p\overline{p}k^+k^-\pi^0,\ k^+k^-\pi^+\pi^-\pi^0,\ \pi^+\pi^- p\overline{p}\gamma$$

	$p\overline{p}\pi^+\pi^-$	$p\overline{p}k^+k^-\pi^0$	$k^+k^-\pi^+\pi^-\pi^0$	$p\overline{p}\pi^+\pi^-\gamma$	$\pi^+\pi^-\pi^+\pi^-\pi^0$
Evts	47000	30000	98000	6100	265000
Final events	0	0	0	8	0

3. The Branching ratio of $J/\psi \to p\overline{p}\pi^+\pi^-\pi^0$

	Finial events	Efficiency	Branching ratio(10^{-3})
Result	191	1.58%	$1.55 \pm 0.11 \pm 0.55$

*The branching ratio in PDG is: $(2.3 \pm 0.9) \times 10^{-3}$

The systematic error contains: MC about 20%, events selection about 25%, data bout20%.

IV. Preliminary results

The branching ratios of $J/\psi \to p\overline{p}\pi^+\pi^-$, $p\overline{p}\pi^+\pi^-\pi^0$ are consistent with PDG values. The further study will be continued, especially in systematic error analysis.

We haven't found the signal of $p\overline{p}\eta'$ so far, after BESII collects the 50M J/ψ events, we will check the signal further.

In our analysis, it seems that there is something around 1.7-1.9GeV in the invariant mass spectrum of $\omega p(\pi^+\pi^-\pi^0 p)$. Due to data statistics, we are not sure they are signals or a statistical fluctuations. We need more data to comfirm them. We will check them further with the 50M J/ψ events.

References

[1]. D. Burkert, The CEBAF N* Program, Nuclear Physics A623 (1997) 59c-70c

[2]. EATON, PR D29 804(1984)

[3]. H.HARARI, Phys.Rev. Lett.60B, 172(1976).

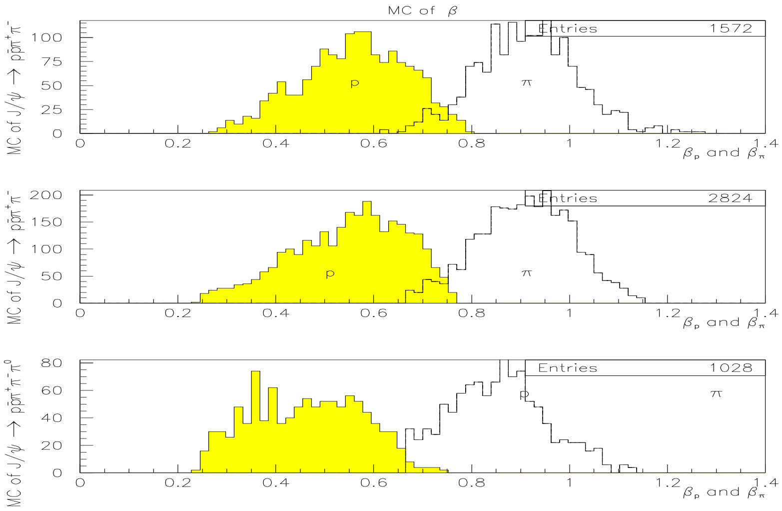

Figure 1: The Invariant Mass Spectrum with BESI data

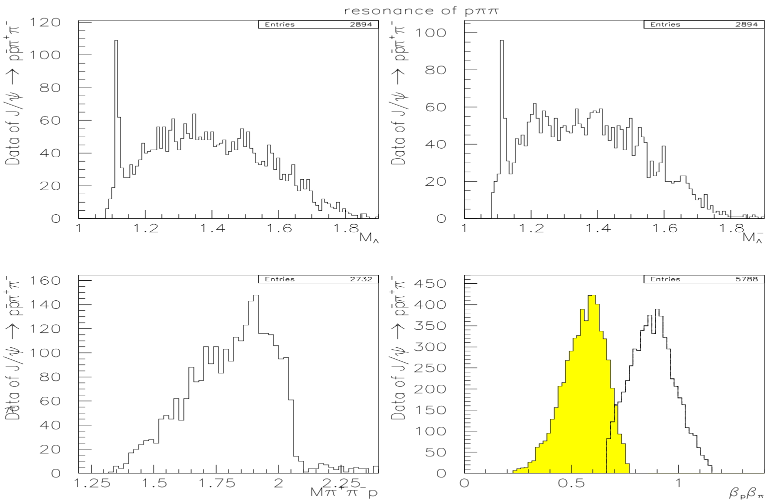

Figure 2: The Invariant Mass Spectrum with BESI data

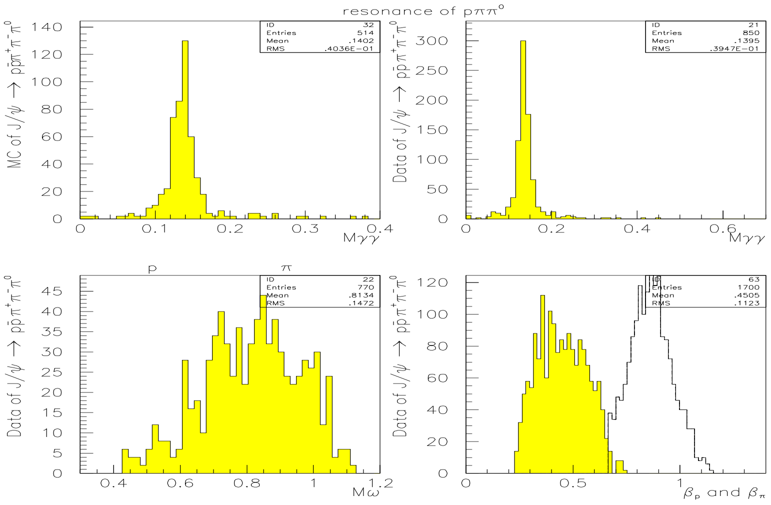

Figure 3: The Invariant Mass Spectrum with BESI data

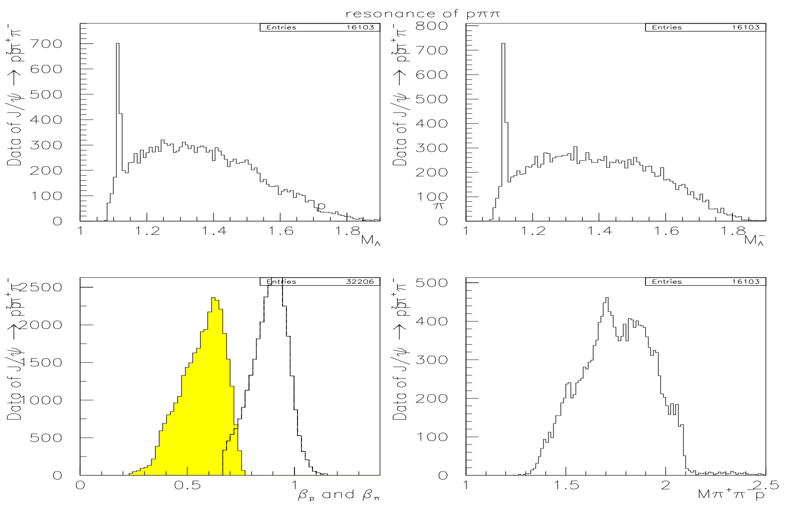

Figure 4: The Invariant Mass Spectrum with BESII data

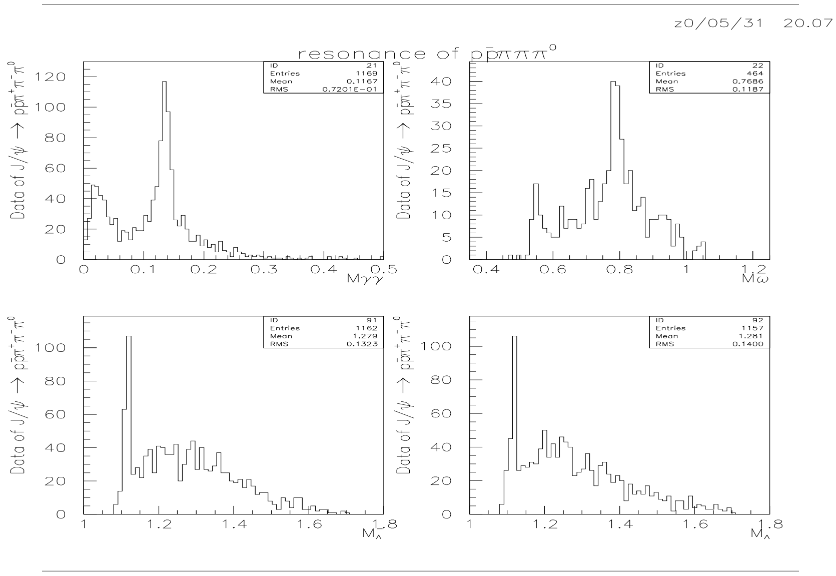

Figure 5: The Invariant Mass Spectrum with BESII data

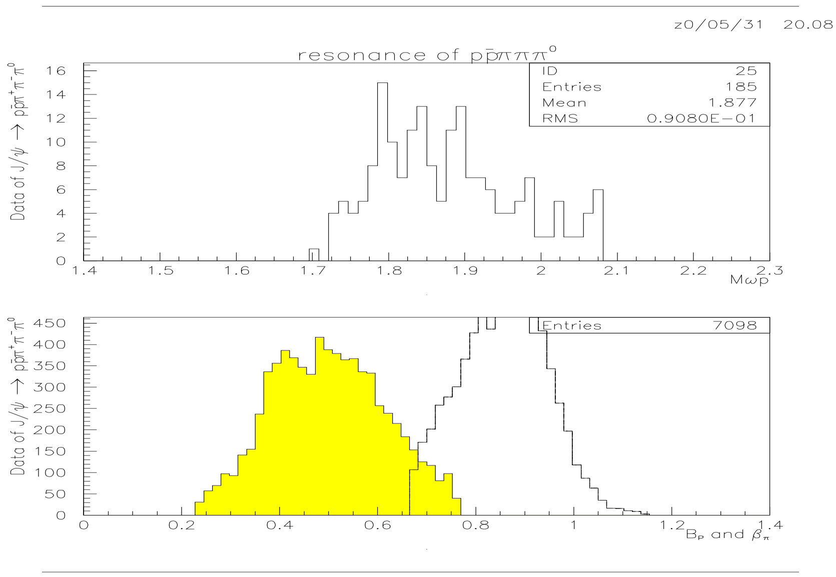

Figure 6: The Invariant Mass Spectrum with BESII data