The Analysis of Decay Channels $J/\psi \to \gamma\gamma V(\rho, \phi, \omega)$

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Abstract

The radiative decays of the J/ψ is one of the best ways to search for the glueball,if glueballs really exist. Using BESII J/ψ data from run number 13700 to 16835, Our results on the $J/\psi \to \gamma\gamma\rho$ and $J/\psi \to \gamma\gamma\phi$ are consistent with BESI data. We confirm the signal at 1417MeV in $\gamma\rho$ Invariant Mass Spectrum, and another signal at 1411MeV in the $\gamma\phi$ Invariant Mass Spectrum. Furthermore, we analyse $J/\psi \to \gamma\gamma\omega$ and find there may exist a signal around 1450-1500MeV. These rusult are very meanful to understand the structure of $\iota/\eta(1440)$.

I. Introduction

1. The physical results in the world so far.

Decay Mode	Mass (Mev)	Width (Mev)	$B(J/\psi \to \gamma\eta).B(\eta \to \gamma V)$ (*10^{-4})	Experiment
$\eta(1440) \to \gamma\rho^0$	1390 ± 25	185 ± 110	$1.9 \pm 0.5 \pm 0.4$	Cry.Ball[1]
	1432 ± 8	90 ± 26	$0.64 \pm 0.12 \pm 0.07$	MarkIII[2]
	1401 ± 18	174 ± 44	$0.9 \pm 0.2 \pm 0.14$	DM2[3]
	1431 ± 17	88 ± 28	$1.1 \pm 0.5 \pm 0.3$	BESI
$\eta(1440) \to \gamma\phi$			< 1.6	MarkIII[2]
$\eta(1440) \to \gamma\phi$	1424 ± 15	73 ± 58	$2.0 \pm 1.0 \pm 0.6$	BESI
$\eta(1440) \to \gamma\omega$			< 2.3	MarkIII[2]

2. The $\iota/\eta(1440)$ is the candidate for the 0^{-+} glueball. Up to now, the structure of $\iota/\eta(1440)$ is not very clear. The existence of two overlapping pseudo-scalar mesons has been suggested, one at 1410 MeV which decays into $K\overline{K}$ and $\eta\pi\pi$, and the other at 1470 MeV which decays only to $K\overline{K}$. It is conceivable that the higher mass state is $s\overline{s}$ member of the 2^1S_0[4]. Is the lower mass state a meson, glueball, or hybrid? It should be further investigated in different decay channels.

It[5] points out that the glueball can be distinguished from $q\overline{q}$ and hybrid by analysis of $J/\psi \to \gamma\gamma\rho$ and $J/\psi \to \gamma\gamma\phi$. For a glueball, it should have the same mass value regardless of where it comes from ($\gamma\rho$ or $\gamma\phi$), but for the $q\overline{q}$ and $q\overline{q}g$ states, it has been predicted that the mass peak position from $\gamma\phi$ should higher than that from $\gamma\rho$ about 300 MeV.

Furthormore, although the analysis of $J/\psi \to \gamma\gamma\omega$ has ever been done by MarkIII, they only gave the upper limit. The theory[6] predicts if $\iota/\eta(1440)$ is a $q\overline{q}$ state which decays in a flavour independent way, the width relationship between $\gamma\rho$, $\gamma\phi$, and $\gamma\omega$ is $\Gamma_{\gamma\rho}$:$\Gamma_{\gamma\phi}$: $\Gamma_{\gamma\omega}$=9:2:1. Therefore the analysis is a very meanful supplement of $J/\psi \to \gamma\gamma V$.

II. Check $J/\psi \to \gamma\gamma(\rho, \phi)$ with BESII data

BESII BW Fit results compared with BESI data

Decay Mode	Mass (Mev)	Width (Mev)	Experiment
$\eta(1440) \to \gamma\rho^0$	1431 ± 17	88 ± 28	BESI
	1417 ± 11	60 ± 20	Ours
$\eta(1440) \to \gamma\phi$	1424 ± 15	73 ± 58	BESI
	1411 ± 5	92 ± 19	Ours

III. $J/\psi \to \gamma_1\gamma_2\omega$ Event Selection

1. $N_{chrg} = 2$, $N_{totch} = 0$, $N_{neu} \leq 10$.

2. For Charged Tracks:
(1) $|x| \leq 0.015m$, $|y| \leq 0.015m$, $|z| \leq 0.15m$

(2) MFIT=2 or -19 for every event

(3) $|cos\theta|$ $\leq$0.8,

(4) P_{xy} $\geq$0.06GeV

(5) $P_{miss} \leq 1.0GeV$

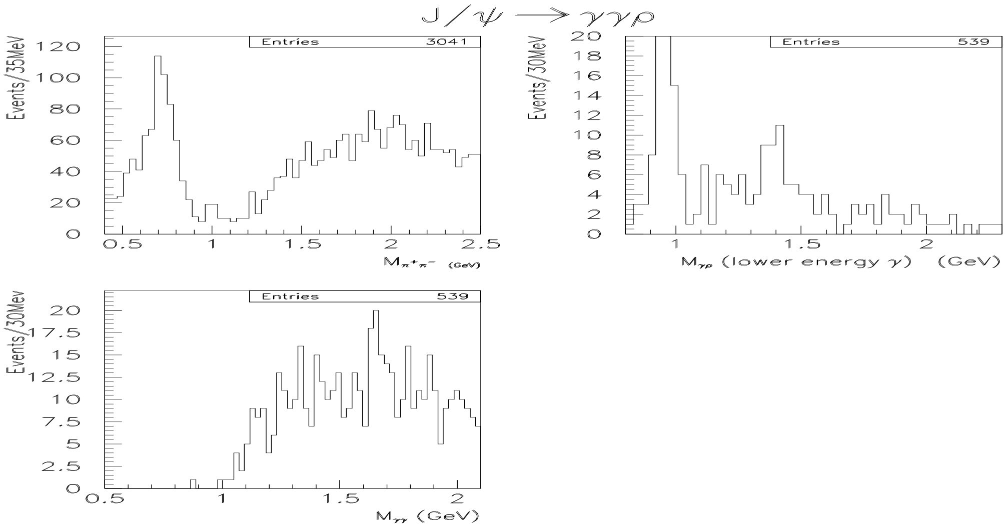

Figure 1: The Invariant Mass Spectrum with BESI data

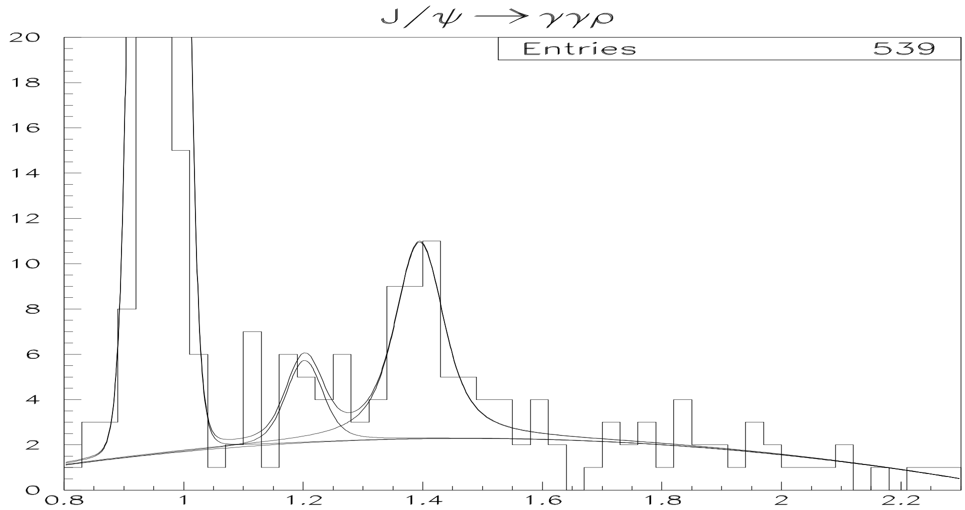

Figure 2: The BW Fit of $\gamma\rho$ Invariant Mass Spectrum with BESI data

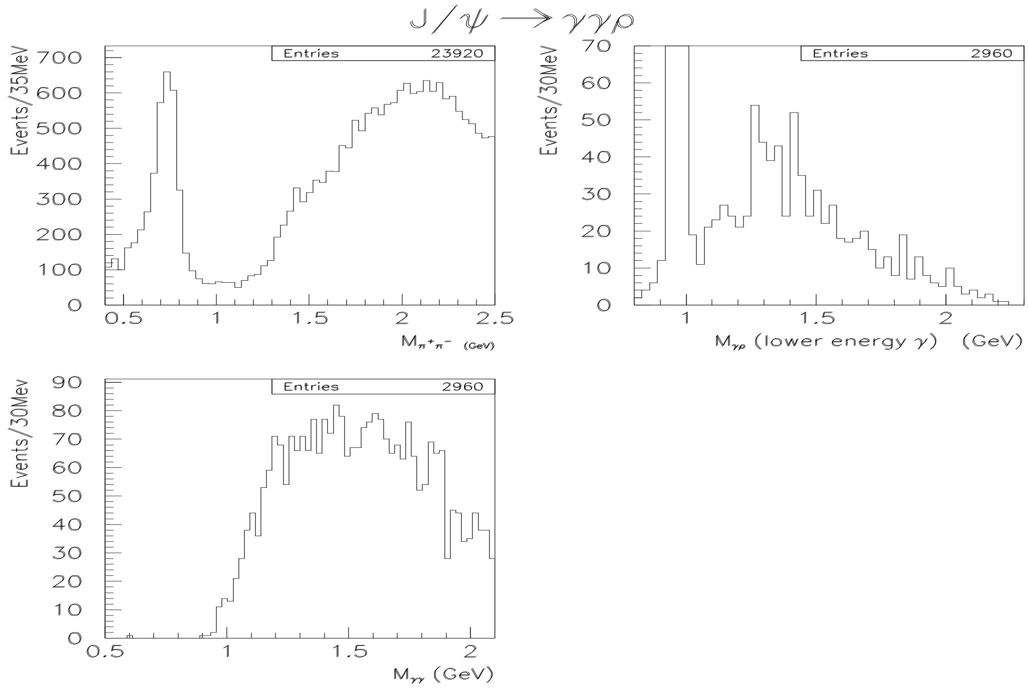

Figure 3: The Invariant Mass Spectrum with BESII data

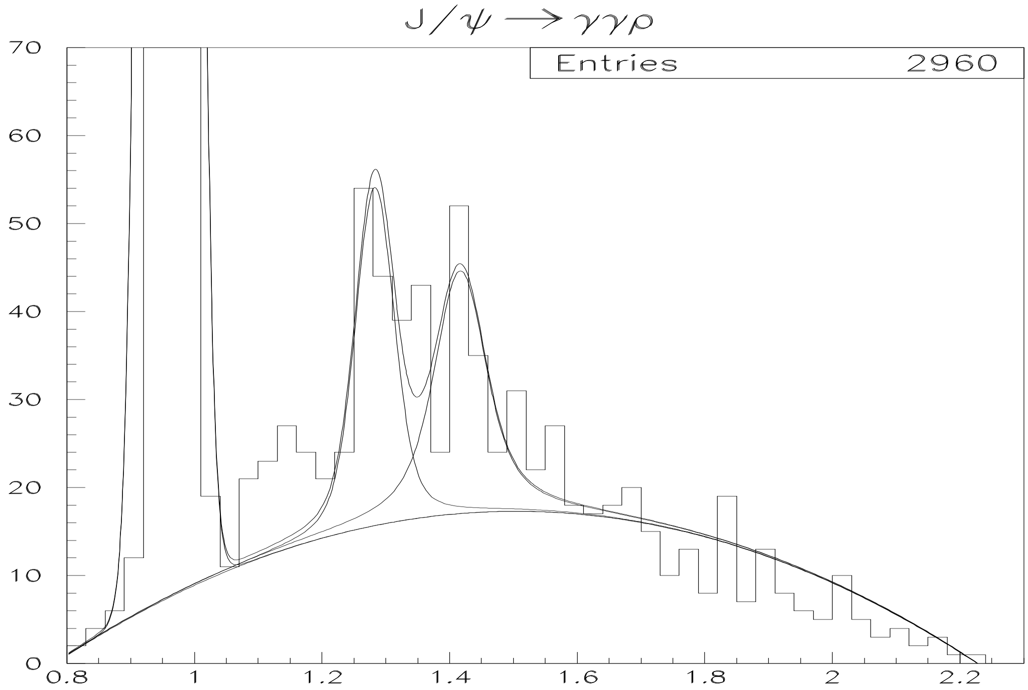

Figure 4: The BW Fit of $\gamma\rho$ Invariant Mass Spectrum with BESII data

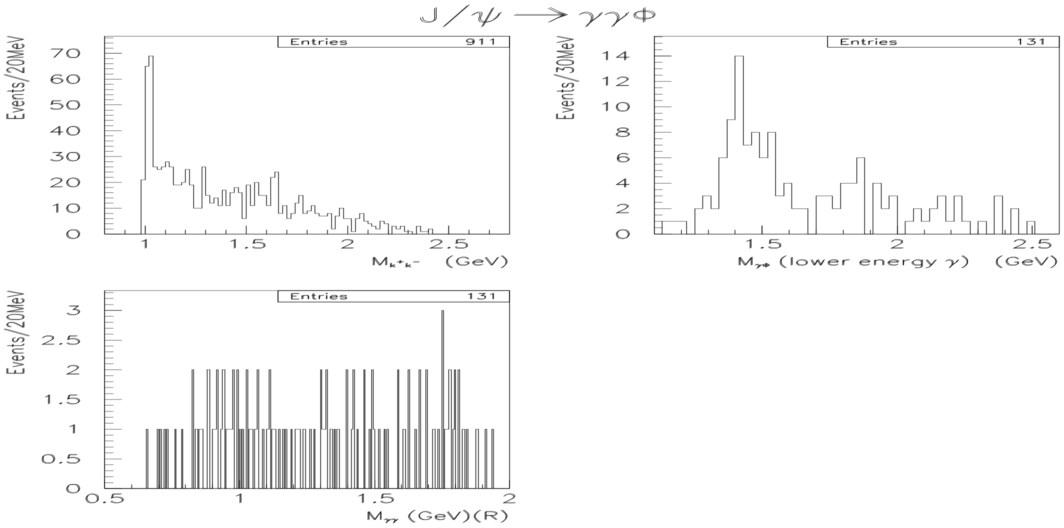

Figure 5: The Invariant Mass Spectrum with BESI data

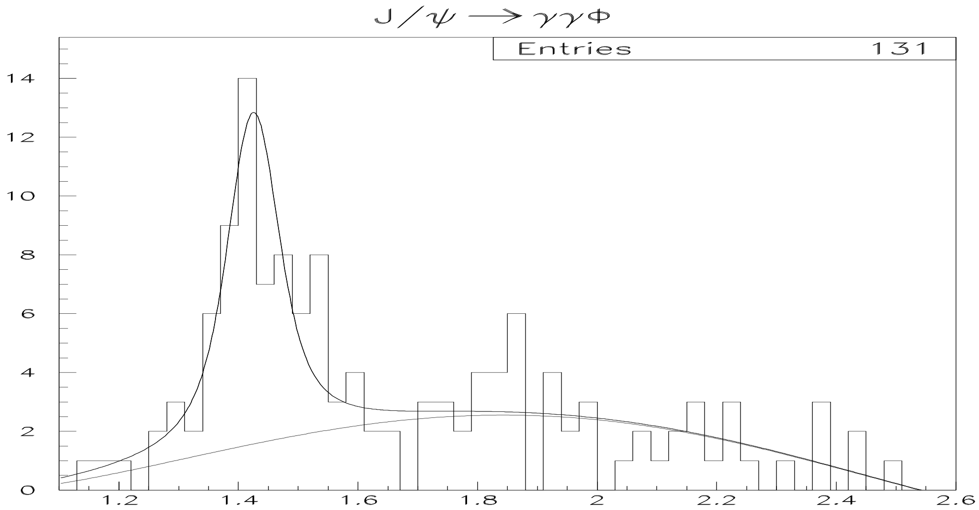

Figure 6: The BW Fit of $\gamma\phi$ Invariant Mass Spectrum with BESI data

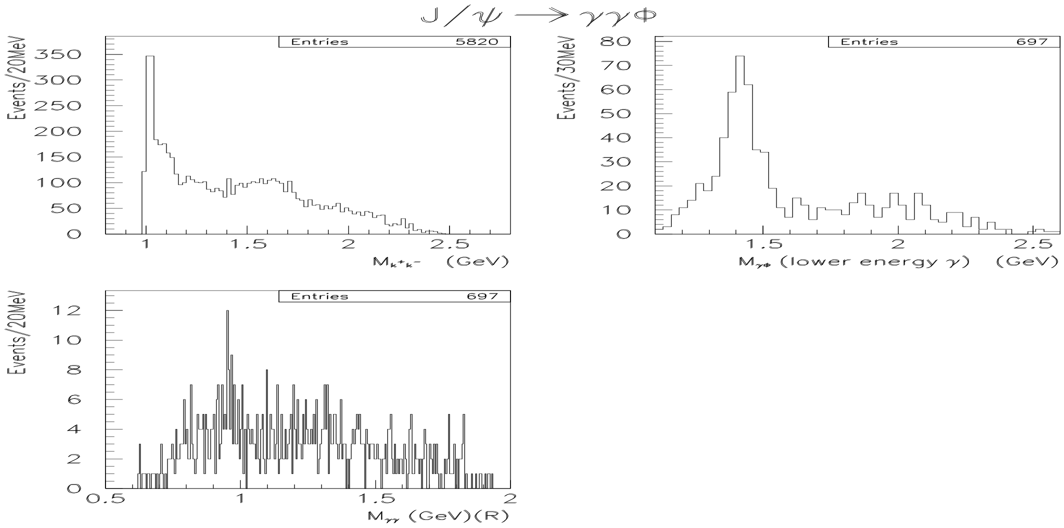

Figure 7: The Invariant Mass Spectrum with BESII data

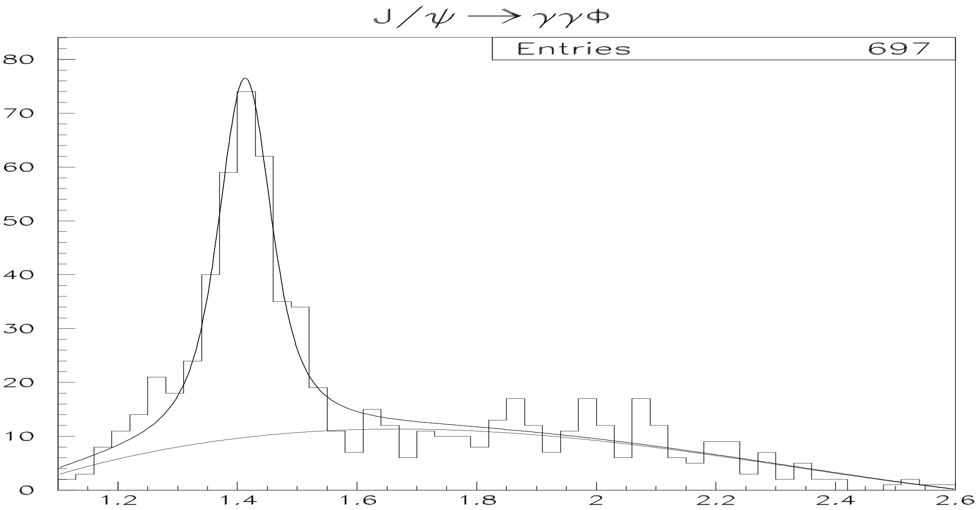

Figure 8: The BW Fit of $\gamma\phi$ nvariant Mass Spectrum with BESII data

(6) Particle identification by the weight information in TOF, we need at least one π track in one event

$W_\pi > W_k$ and $W_\pi > W_p$

(7) Use 4c-fit to fit the four tracks (regarded 2 as π and 2 as γ). We need

$\chi^2 \leq 10$

$\chi^2 < \chi^2_{\gamma\gamma\gamma\gamma k^+k^-}$

$\chi^2 < \chi^2_{\gamma\gamma\gamma\omega}$

$\chi^2 < \chi^2_{\gamma\gamma\gamma\gamma\omega}$

3. For neutral tracks, we need at least four neutral tracks are good photons

$N_\gamma \geq 4$

(1) The selective conditions for good photons are as below:

a. $E_{sc} \geq 70MeV$

b. 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

$\Delta \leq 0.4$

c. $cos\theta_{\gamma q} \leq 0.98$

d. The number of hitted layers by photons in SC should be greater than two

(2) To search for two of four photons which are decayed from π^0, We define:

$\Delta M = \sqrt{[(M_{\gamma\gamma} - 0.135)/0.017]^2 + [(M_{\pi^+\pi^-\pi^0} - 0.782)/0.027]^2}$

4. The Invariant Mass Restriction

$|M_{\pi^+\pi^-\pi^0} - 0.782| \leq 0.04$

$|M_{\gamma\gamma} - 0.135| \leq 0.03$

In order to reject the backgroud $J/\psi \to \omega\eta$ and $J/\psi \to \omega\pi^0$, we need:

$|M_{\gamma_1\gamma_2} - 0.135| \geq 0.04,$

$|M_{\gamma_1\gamma_2} - 0.547| \geq 0.04$

The acceptance is determined from Monte Carlo simulation. The results are about 2.1% for $J/\psi \to \gamma_1\gamma_2\omega$ channel

IV.Discussion

1. The BESII results of $J/\psi \to \gamma\gamma\rho$ and $J/\psi \to \gamma\gamma\phi$ are consistent with BESI's.

2. In the analysis of radiative decay $J/\psi \to \gamma\gamma\omega$, the η' signal has been found in $\gamma\omega$ Invariant Mass Spectrum, which comes from $J/\psi \to \gamma\eta'(\eta' \to \gamma\omega)$, therefore our study is

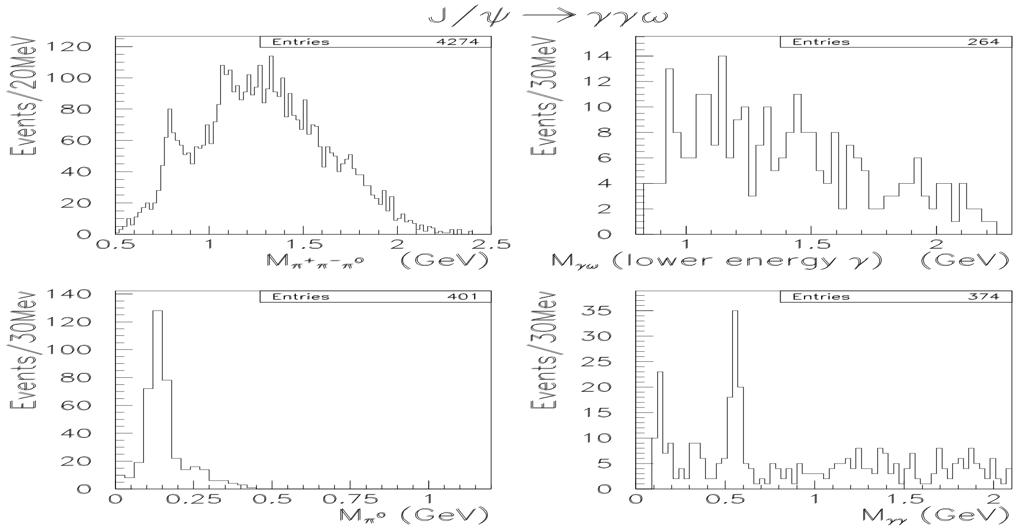

Figure 9: The Invariant Mass Spectrum with BESI data

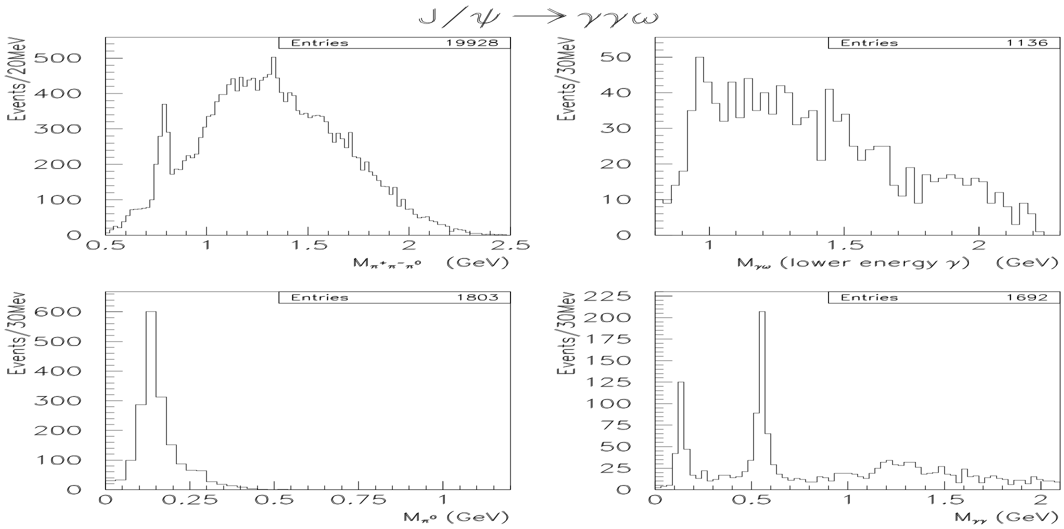

Figure 10: The Invariant Mass Spectrum with BESII data

reliable. In the meanwhile, We find that there may exist a signal near 1450-1500MeV in $\gamma\omega$ Invariant Mass Spectrum. With the increasing BESII data, We will continue this study and check existence of the "signal" with high statistics.

3. We clearly see the π^0 and η signals in $M_{\gamma_1\gamma_2}$. They come from $J/\psi \to \omega\pi^0$ and $J/\psi \to \omega\eta$. We can do further study in $J/\psi \to VP$ decay channels, which are very meanful to study "$\rho\pi$ puzzle"

V.Reference

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