Determine the Total Number of J/ψ from $J/\psi \to e^+e^-(\gamma)$

Yuekun Heng, IHEP
hengyk@hpws3.ihep.ac.cn
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1 Introduction

BES has acquired much high qualified data at BEPC at the C.M. energy of 3.097 GeV from Nov. 1999 to May 2001. The total number of the J/ψ data has been obtained by the analysis of dimuon channel and 4-prong hadron channel. Here we try to get it by $J/\psi \to e^+e^-(\gamma)$.

The QED process $e^+e^- \to e^+e^-(\gamma)$ has the same final state as $J/\psi \to e^+e^-(\gamma)$ and they have interference. So there are totally three items in the final state of $e^+e^-(\gamma)$.

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_{res}}{d\Omega} + \frac{d\sigma_{qed}}{d\Omega} + \frac{d\sigma_{int}}{d\Omega} \tag{1}$$

where σ_{res} is the cross setion of $J/\psi \to e^+e^-(\gamma)$, the σ_{qed} is of $e^+e^- \to e^+e^-(\gamma)$, the σ_{int} is of their interence. They have diffierent angular distribution. According to F.A. Berends's detailed discution [1], here list the the cross section of three processes:

$$\frac{d\sigma_{res}}{d\Omega} \sim (1 - 2x + 2x^2)/2 \tag{2}$$

$$\frac{d\sigma_{qed}}{d\Omega} \sim (1 - 2x + 3x^2 - 2x^3 + x^4)/x^2 \tag{3}$$

$$\frac{d\sigma_{int}}{d\Omega} \sim (1 - 2x + 2x^2) - (1 - x^2)/x \tag{4}$$

where $x = \frac{1}{2} sin^2\theta$, θ is the polar angle. We try to fit the angular distribution to get the ratio of $J/\psi \to e^+e^-(\gamma)$ to all events, R_{res}, and then the total number of J/ψ can be obtained by the following formular:

$$N_{J/\psi} = \frac{N_{ee} \dot{R}_{res}}{\varepsilon_{trg} \varepsilon_{ee} BR(J/\psi \to e^+e^-(\gamma))} \tag{5}$$

where N_{ee} is the number of the selected e^+e^- events,ε_{trg} is the trigger efficience, ε_{ee} is the efficience of detecting and selecting e^+e^- events. Because the trigger efficience of e^+e^- events should be greater than that of dimuon events, which is 0.9977[2], here we take $\varepsilon_{trg} = 1$.

2 Event Selection

The selection of e^+e^- events is easy. Here are the cuts:

- Exact two oppsitely charged tracks in MDC, Mfit=2,-19
- Vertex: $r < 1.5cm$, $|z| < 15cm$
- Avoid the border and ribbon region: $0.1 < |cos\theta| < 0.7$, $|cos\theta \pm 0.58| > 0.06$
- Momentum: $1.2 < P < 1.8(GeV)$
- Back-to-back:$||\Delta\phi| - 180^o| < 1^o$
- TOF: $|T - T_{exp}| < 1.0(ns)$
- Deposit energy in BSC: $0.7 < E < 3.0(GeV)$

Fig. 1 shows some quatities' distribution and we can see the data and the MC are cosistent. But the simulation of the ribbon region in BSC is not very well(see fig. 2), especially in the middle region. This is why the cuts of $|cost\theta| > 0.1$ and $|cos\theta \pm 0.58| > 0.06$ are used.

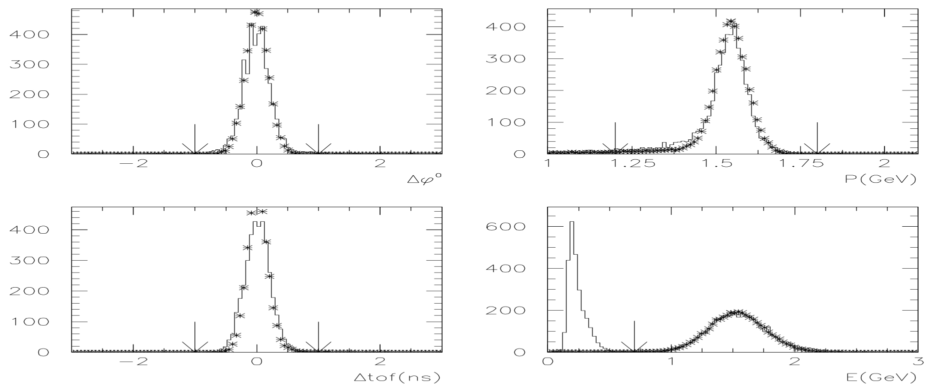

Figure 1: The comparison between data of all e^+e^- events(line) and MC of $J/\psi \rightarrow e^+e^-(\gamma)$(star). The arrow is the position of the cuts.

3 Fitting the angular distribution

To fit the angular distribution the variation of the detection and selection efficience with the $cos\theta$ must be considerated(See fig. 2), which is expressed by $\varepsilon(cos\theta)$. So the fitting formular should be

$$f(cos\theta) = \frac{d\sigma}{d\Omega} \times \varepsilon(cos\theta) = (C_1\frac{d\sigma_{res}}{d\Omega} + C_2\frac{d\sigma_{qed}}{d\Omega} + C_3\frac{d\sigma_{int}}{d\Omega}) \times \varepsilon(cos\theta) \quad (6)$$

where the C_1, C_2 and C_3 are the parameters to be fitted. From these parameters we can get the areas of each distribution and the ratio of $J/\psi \to e^+e^-(\gamma)$ to all events, R_{res}.

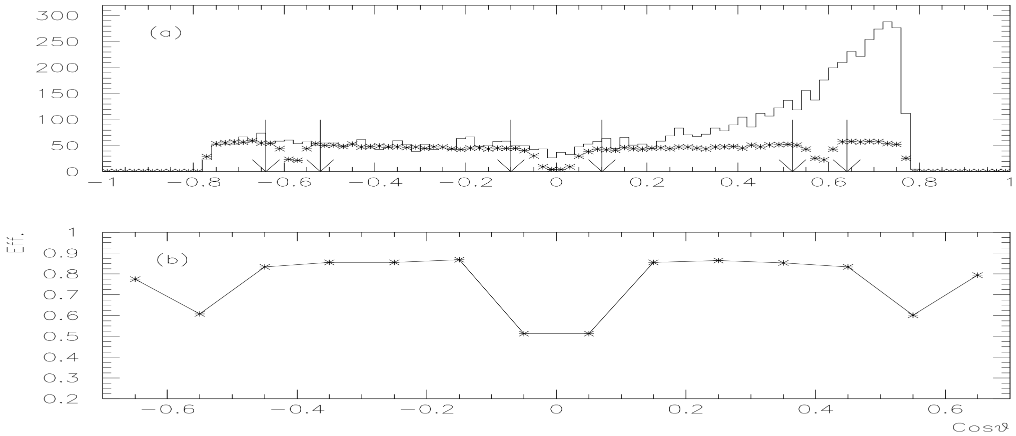

Figure 2: (a)The $cost\theta$ distribution. Line is for the e^+e^- events from data, star is for the MC data of $J/\psi \to e^+e^-(\gamma)$. (b) The detection and selection efficience VS $cos\theta$ from the MC data of $J/\psi \to e^+e^-(\gamma)$.

Fig. 3 and table 1 shows the fitted results:

4 Result and error

The systematic errors come from several aspects. The first is the selection criteria. We vary them and observe the variation of the total number. Thus we can get the error. The second error is from the parameter of the R_{res} which is dependent to the fit process and can be obtained from the fit error of C_1, C_2 and C_3 and the angulur formular error of 1% . The last is the MC simulation and the efficience from it. We compare the typical distribution (see fig. 1), like that of deposit energy and cosθ, then get the difference and use it as a error. Table 2 lists these errors.

AT last the total number of J/ψ acquired by BES in 99-00 is

$$N_{J/\psi} = (24.07 \pm 1.30) \times 10^6$$

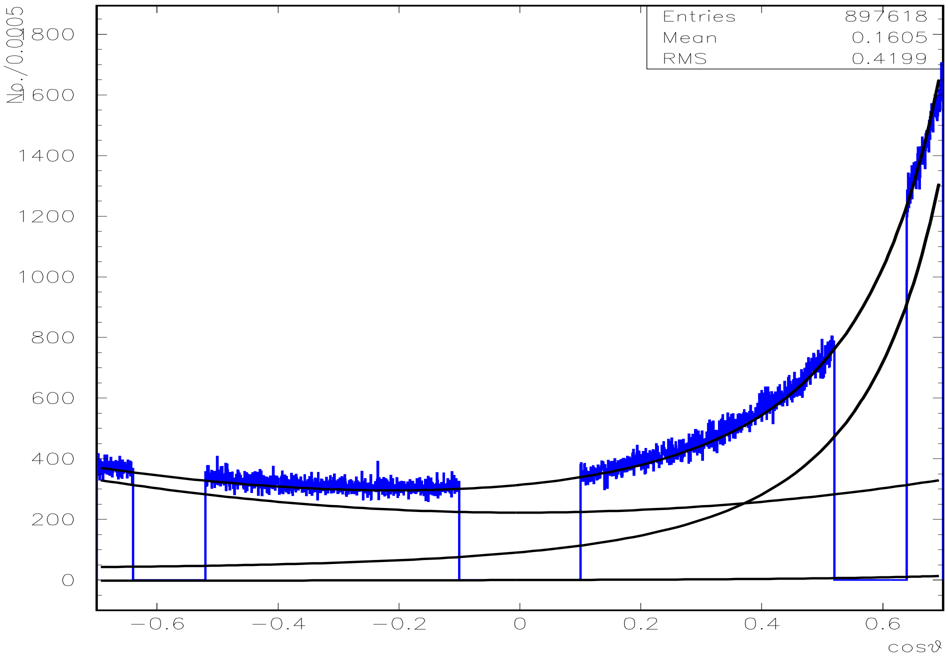

Figure 3: The fitting the angular distribution of the e^+e^- events. At the left end, the first line is for total; the second is for resonant process; the third is for the QED process; the last is for the interaction.

Table 1: Results

Data Set	$N_{ee}(\times 10^6)$	R_{res}	ε_{ee}	$N_{J/\psi}(\times 10^6)$
run13691-run15797	0.5838 ± 0.0216	0.5556 ± 0.0047	0.3501 ± 0.0109	15.63 ± 0.84
run15798-run16242	0.1340 ± 0.0050	0.5564 ± 0.0123	0.3521 ± 0.0109	3.60 ± 0.20
run16243-run16835	0.1798 ± 0.0067	0.5655 ± 0.0104	0.3540 ± 0.0110	4.84 ± 0.26
Total	0.8976 ± 0.0333			24.07 ± 1.30

Table 2: Error Analysis

Items	Relative Error(Result)
$\cos\theta$	2.8%
deposit energy	0.5%
P	2.2%
$\Delta\phi$	0.9%
ε	3.2%(0.3493 ± 0.0111)
R_{res}	1.6%(0.538 ± 0.006)
$BR(J/\psi \to e^+e^-(\gamma))$	1.7%(0.0593 ± 0.010)
Total	5.4%

References

[1] Electromagnetic Interaction of Hadron Collisions,F.A. Berends, "Radiative Correction in e^+e^- Collisions".

[2] BES Memo, "Determine the Total Number of J/ψ from $J/\psi \to \mu^+\mu^-$", Yuekun Heng.