The Total Number of ψ' Events

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1 Introduction

At BES, there are two sets of running for ψ' data acquisition, one is collected in period of December in 1993 to January in 1994 and the other is January to April in 1995, namely the old and the new ψ' data. All ψ' physics analyses including been, being and to be done are based on these data sets. Therefore, it is important to determine the total number of ψ' events of these data. Partly, the work depending on the 93/94 data have been carried out by Yuan Changzheng and some results have been obtained[1]. My work is the succeeding and some deepening .

In this paper, the determination of the total number of ψ' events in both the old and the new ψ' data will be described. Additionally, the Monte Carlo program will be checked by comparing data and Monte Carlo events for $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$.

2 Method

The basic idea is dividing the number of the inclusive events $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to anything$(in the following text, *the inclusive events* just refers to the type of events), which can be calculated from the event selection and Monte Carlo analysis, by the inclusive-channel decay ratio, which is considered to be known. Steps are as following:

1. To get J/ψ line shape. Firstly, the lepton sub-decay events $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$ should be selected and their recoiling mass spectrum against $\pi^+\pi^-$ which is a J/ψ peak can be plotted. After fitting the spectrum, the parameters of the J/ψ peak are able to be obtained. These parameters naturally stand for nearly pure J/ψ peak, namely, J/ψ line shape.

2. To fit out observed number of the inclusive events. The inclusive events are selected and the recoiling mass spectrum against $\pi^+\pi^-$, in which a J/ψ peak piles up on some background, can be plotted. Using the preceding J/ψ line shape and some kind of background , this spectrum can be fitted and the number of J/ψ under the J/ψ peak can be gotten. This number, indicated as $N^{obs}_{J/\psi}$, just stands for the inclusive events being observed after the event selection program.

3. To determine the efficiency ε. This can be achieved from appropriate Monte Carlo simulation . Of course, the efficiency ε includes the detection efficiency and the event selection efficiency.

4. To result the total number of ψ' events. From the Table of Particle Physics of PDG-94, the inclusive events branching ratio can be gotten:

$Br(\psi' \to \pi^+\pi^- J/\psi) = (32.4 \pm 2.6)\%$. So the produced number of ψ' events included in the BES ψ' data sets can be calculated as:

$$N_{\psi'}^{prod} = \frac{N_{J/\psi}^{obs}/\varepsilon}{Br(\psi' \to \pi^+\pi^- J/\psi)}.$$

3 IHEP ψ' Data

The data analyses in this paper are all done in HP-UNIX system. However, the old and the new ψ' data of IHEP are all reconstructed in VAX-VMS system. Therefore, it is necessary to transfer data from VAX machine to HP machine first.

So far as the new data, there is only one reconstruction version V86; as for the old, there are several versions and I used the newest, just V86 as well. Table 1 shows the data sets I used.

Table 1: IHEP ψ' Data Sets

Collect Year	Date	RecVer	Rec Date
Dec 1993-Jan 1994	Run5738-6059.dst	V85	Dec. 1994
Jan-Apr 1995	Run7430-8100.0pn Run7430-8100.2pn Run7430-8100.4pn Run7430-8100.6pn Run7430-8100.btrk	V86	May. 1995

Additionally, because the trigger situation and the environment condition are not the same during data collection, the quality of data runs are also not the same and they are marked by one number named KJI, details seen in **Appendix A**:

- KJI=0 means bad runs and can't be used,
- KJI=1 means runs with some problems and should not be used normally,
- KJI=2 means runs may be used normally but can't be used when pure neutral channels are analyzed,
- KJI=3 means good runs.

According to the convention, I will calculate the $N_{\psi'}^{prod}$ corresponding to two situation: $KJI > 0$ and $KJI > 1$ respectively.

4 Getting J/ψ Line Shape

4.1 Selection of $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$ Events

In order to fit out $N^{obs}_{J/\psi}$, the J/ψ line shape which is characterized by two parameters Γ and Σ, Where Γ is the width of Breit-Wigner function and Σ is the resolution of Gaussian function, should be known. Furthermore, in order to use $\chi^{dE/dx}_{\pi^\pm}$ to separate $\pi^\pm$ from other charged tracks, correcting $\chi^{dE/dx}_{\pi^\pm}$ to a standard Gaussian distribution is to be done first. Therefore, it is necessary to select the channel $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$, of which the advantage is that the events may be identified very clearly. The following cuts are made in the event selection:

- Skip bad run: $KJI > 1$ or 0
- Four charged tracks with net charge zero: $N_{chrg} = 4$, $\Sigma charge = 0$
- Select $\pi^\pm$:
  - $M_{fit} = 2, -9, -19$
  - $p_{xy} > 0.10 GeV/c$
  - $p < 0.45 GeV/c$
  - $|\cos\theta_{MDC}| < 0.75$
  - $\Sigma Hit_{dE/dx} > 13$
  - $|\chi^{cor}_{dE/dx}| < 3$ *
- $m_{\pi^+\pi^-} > 0.36 GeV/c^2$
- $3.0 < m_{recoil} < 3.2 GeV/c^2$
- Select $\mu^\pm$
  - $0.45 < p < 2.0 GeV/c^2$
  - $p_{\mu^+} > 1.4 GeV/c$ or $p_{\mu^-} > 1.4 GeV/c$ or $p_{\mu^+} + p_{\mu^-} > 2.6 GeV/c$
  - $|cos\theta^{MDC}| < 0.6$
  - $ID_{\mu^+} + ID_{\mu^-} \geq 4$[2]

*Where $|\chi^{cor}_{dE/dx}|$ is corrected as in the following subsection.

4.2 Monte Carlo-Data Comparison

In order to calculate the number of ψ' events, appropriate Monte Carlo simulation will be used to determine the efficiency. Therefore, it is very important whether the Monte Carlo programs being used are correct. A very good check of the Monte Carlo is given by the comparison of data and Monte Carlo events for $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$[3].

The Monte Carlo generator used is PPGEN[4]. It assumes:

1. Sequential 2-body decays: $\psi' \to X + J/\psi$, followed by $X \to \pi^+\pi^-$, and $J/\psi \to \mu^+\mu^-$.
2. The orbital angular momentum between $\pi^+\pi^-$ system and J/ψ and between π's in $\pi^+\pi^-$ system are 0.
3. The mass of the $\pi^+\pi^-$ system is weighted towards high mass:

$$\frac{d\sigma}{dm_{pp}} \propto phase\ space \times (m^2_{\pi^+\pi^-} - 4m^2_{\pi^\pm})^2$$

4. X and J/ψ are uniformly distributed in space.
5. π's are uniformly distributed in X rest frame.
6. Leptons have $1 + cos^2\theta$ distribution in J/ψ rest frame.
7. J/ψ decay has α^3 order final state radiative correction in CMS of J/ψ.

Figure 1–3, in every which points with error bars are data of 1995 and the histogram corresponds to Monte Carlo events, show the comparison situation. From the distributions of these figures, it can be seen that data and Monte Carlo events are agreeable well.

4.3 Correction of $\chi_{dE/dx}$

Before doing it, the above criterion $|\chi^{cor}_{dE/dx}| < 3$ is not used. Then the $\pi^\pm$'s $\chi_{dE/dx}$ distribution can be plotted. They are asymmetric Gaussian distributions. Fitting them, the correction results can be gotten. Figure 4 shows the case of 95's data and Monte Carlo , the case of 93-94 is similar, and Table 2 shows the results.

4.4 J/ψ Line Shape

Plotting the mass spectrum recoiling against $\pi^+\pi^-$ and fitting it, seeing Figure 5, Γ and Σ can be gotten. The results corresponding the old and new data and two version Monte Carlo are shown in the Table 3.

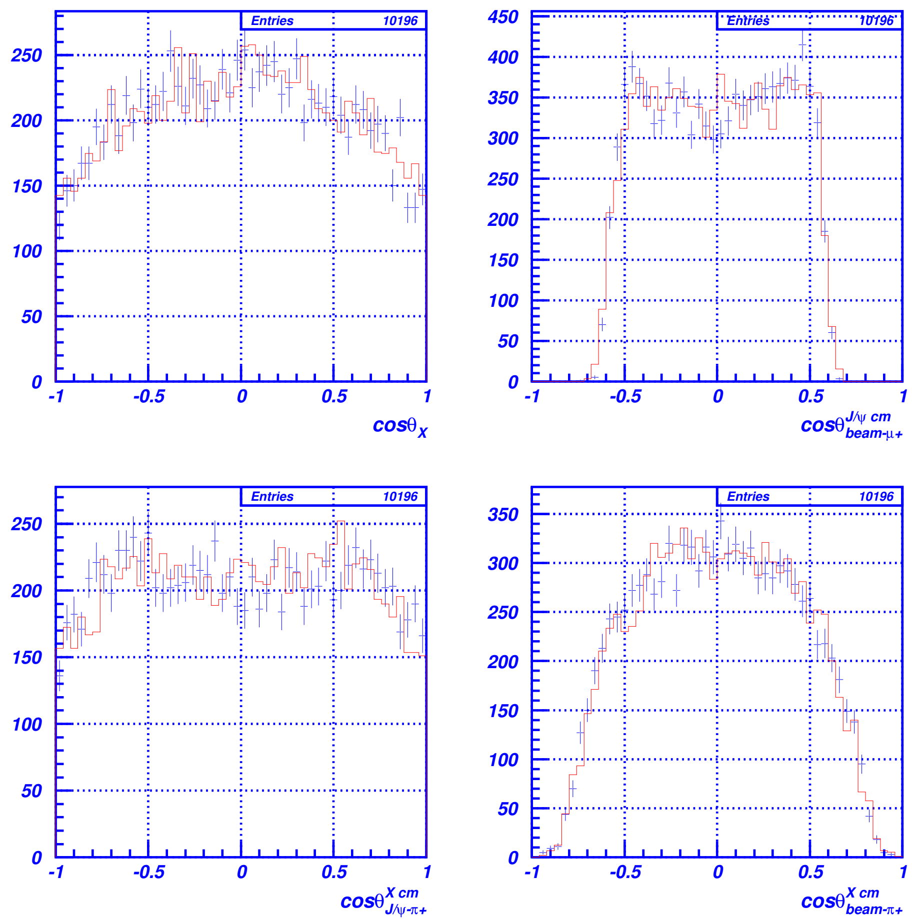


Figure 1: Various angle distributions for $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$. θ_X is the angle of the dipion system with respect to the beam direction in lab. $\theta^{J/\psi cm}_{beam-\mu^+}$ is the angle between the beam direction and the μ^+ in the J/ψ rest frame. $\theta^{X cm}_{J/\psi-\mu^+}$ is the angle between the J/ψ and π^+ in the dipion rest frame. $\theta^{X cm}_{beam-\pi^+}$ is the angle between the beam and the π^+ in the dipion rest frame.

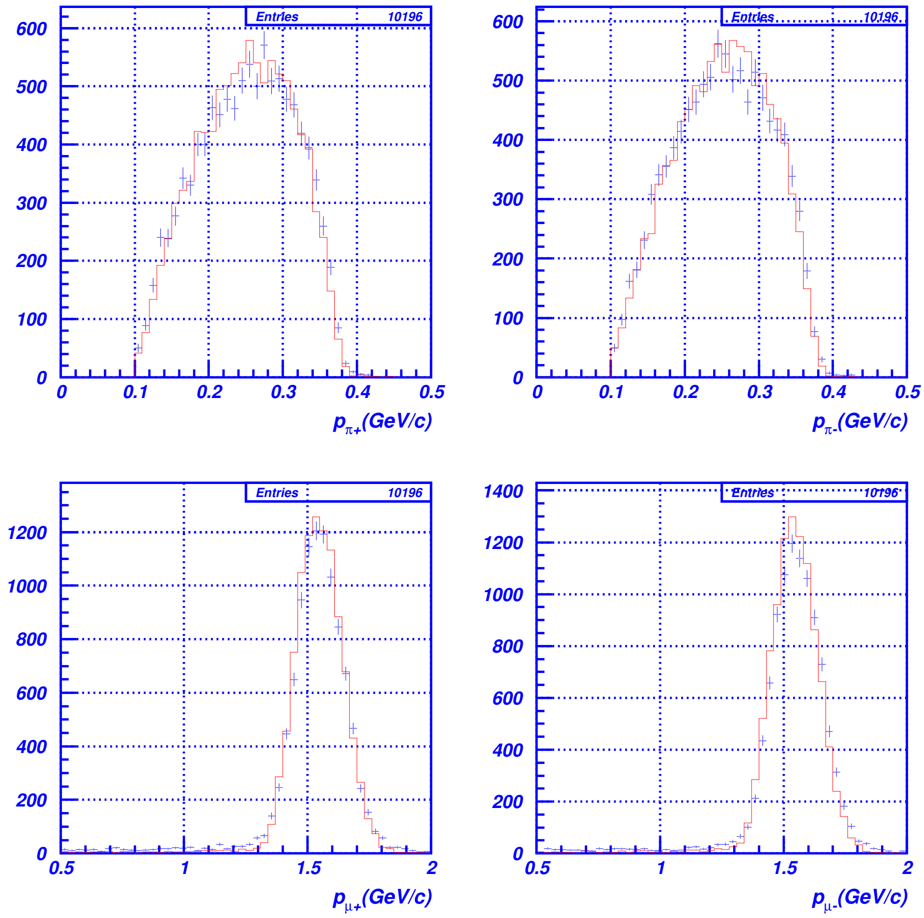


Figure 2: Momentum distributions of $\pi^\pm$ and $\mu^\pm$ for $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$.

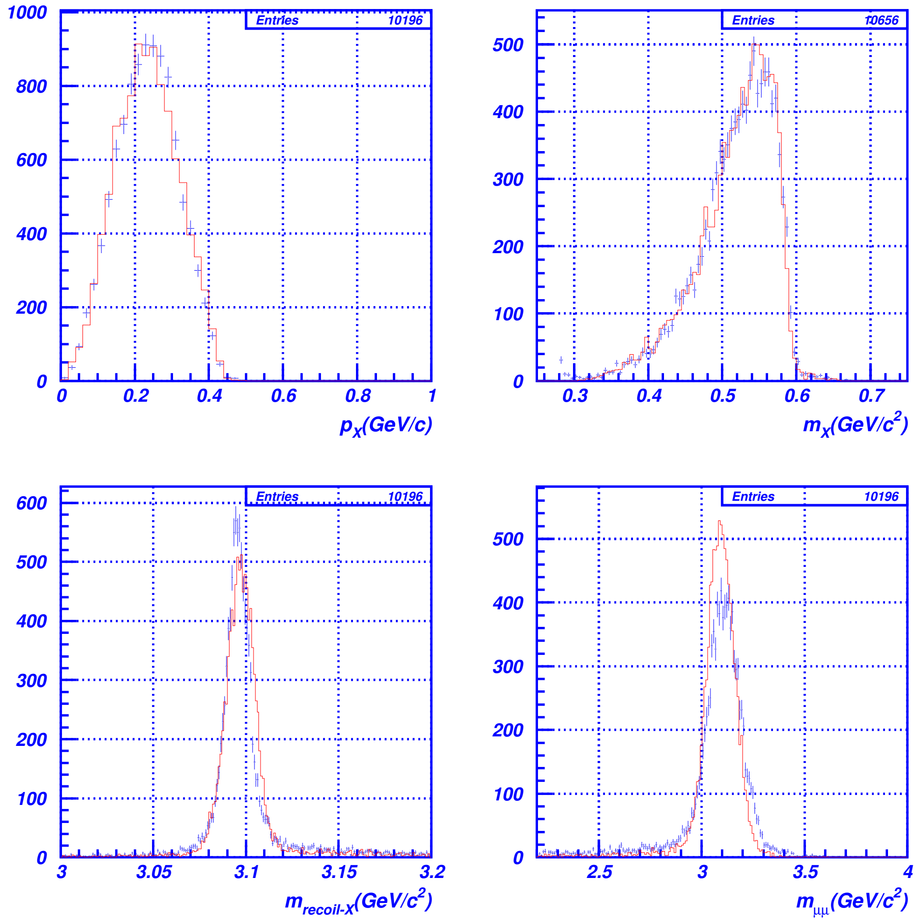


Figure 3: Distributions of X momentum, $\pi^+\pi^-$ invariant mass, mass recoiling against $\pi^+\pi^-$ and $\mu^+\mu^-$ invariant mass for $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$.

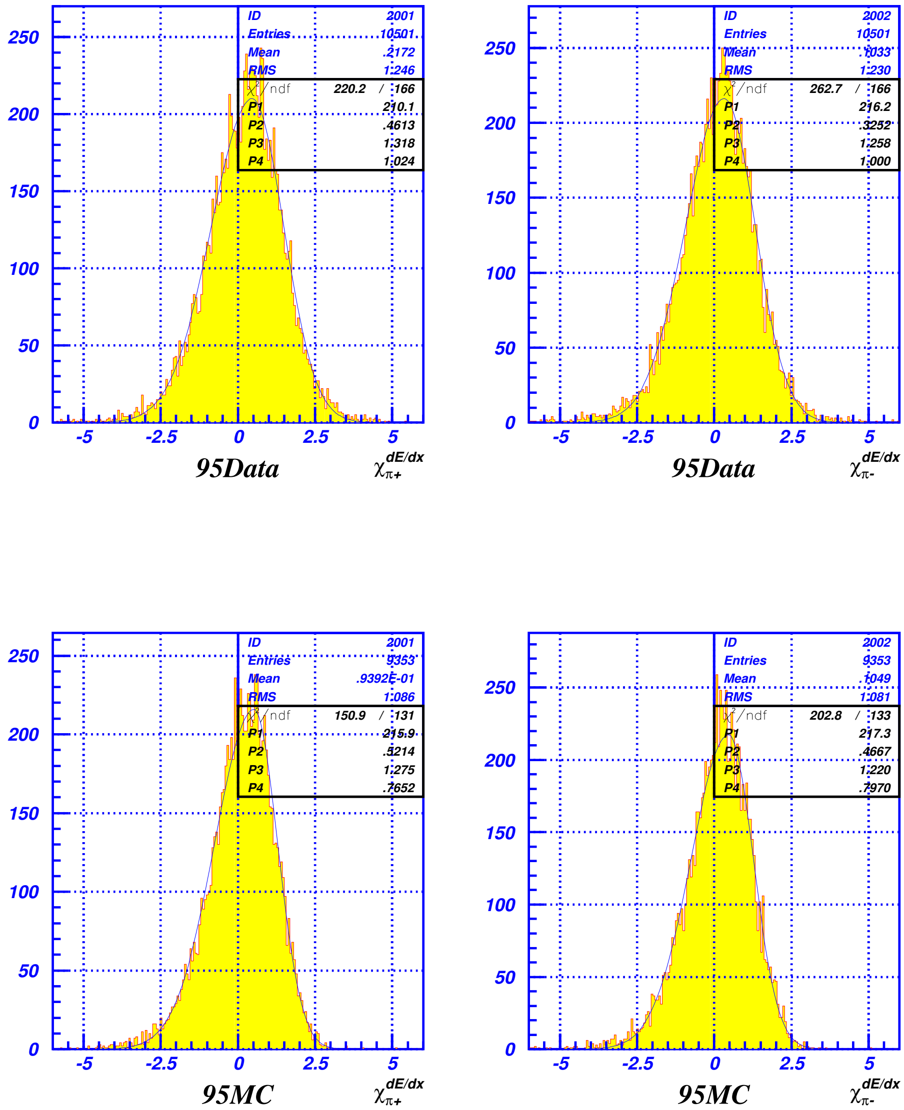


Figure 4: Distributions of $\chi_{\pi^\pm}^{dE/dx}$ and their fitting results.

Table 2: Correcting results of $\chi_{dE/dx}$ spectrums. $Mean$ is the value of peak point; σ^- is the left σ of spectrum and σ^+ is the right σ of spectrum. Subscripts π^+ and π^- present the different correction been done for them respectively.

	Mean$_{\pi^+}$	$\sigma^-_{\pi^+}$	$\sigma^+_{\pi^+}$	Mean$_{\pi^-}$	$\sigma^-_{\pi^-}$	$\sigma^+_{\pi^-}$
Data93-94	.39299	1.2424	1.0440	.29235	1.2103	.95644
Data95	.46129	1.3181	1.0237	.32519	1.2579	1.0000
MC_V153	.46272	1.2254	.79377	.46720	1.2109	.77004
MC_V154	.52137	1.2748	.76518	.46666	1.2203	.79700

Table 3: Fitting results of mass spectrum recoiling against $\pi^+\pi^-$ for events $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$. M is fitted J/ψ mass; N_{reg} is the total events in the fitting region; $N^{obs}_{J/\psi}$ is J/ψ number in J/ψ peak; Γ and Σ are parameters of J/ψ line shape and they will be used in fitting for inclusive events.

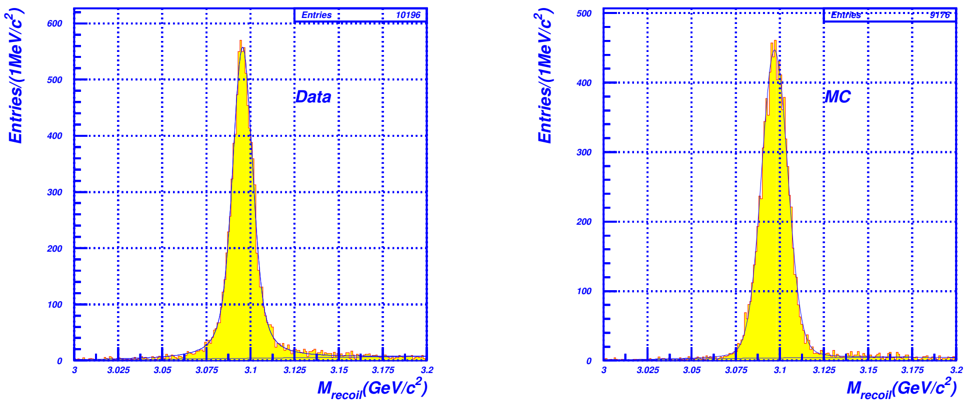
	$M(GeV/c^2)$	N_{reg}	$N^{obs}_{J/\psi} \pm \sigma_{N^{obs}_{J/\psi}}$	$\Gamma \pm \sigma_\Gamma(MeV)$	$\Sigma \pm \sigma_\Sigma(MeV)$
Data93-94	3.0956	5680	5175±68	5.7113±0.596	4.6649±0.283
Data95	3.0956	10196	9395±86	6.0904±0.391	4.2116±0.189
MC_V153	3.0971	4643	4302±52	1.7099±0.560	6.9757±0.212
MC_V154	3.0970	9176	8522±72	1.9284±0.414	6.9278±0.161

5 Fitting out $N^{obs}_{J/\psi}$

5.1 Selection of Events $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to anything$

The following are the event criteria:

- Skip Bad runs: $KJI > 1$ or 0
- More than two charged tracks: $N_{chrg} \geq 2$
- To select $\pi^\pm$:
  - $M_{fit} = 2, -19$
  - $p_{xy} > 0.10 GeV/c$
  - $p < 0.6 GeV/c$
  - $|cos\theta_{MDC}| < 0.75$
  - $|\chi^{cor}_{dE/dx}| < 3$
- More than two π: $N_\pi \geq 2$
- Cutting on invariant mass of $\pi^+\pi^-$: $M_{\pi^+\pi^-} > 0.36 GeV/c^2$



(a) (b)

Figure 5: $\pi^+\pi^-$ recoiling mass distributions of events $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$. (a) is the case of 1995's data, its details of fitting results can be seen in **Appendix B.1**; (b) is of Monte Carlo with version 154.

- Cutting on mass recoiling against $\pi^+\pi^-$: $3.0 < M_{recoil} < 3.2GeV/c^2$, where

$$M_{recoil} = \sqrt{(m_{\psi'} - E_{\pi^+} - E_{\pi^-})^2 - (\vec{p}_{\pi^+} + \vec{p}_{\pi^-})^2}$$

Figure 7 shows the distributions of $M_{\pi^+\pi^-}$ and M_{recoil}.

5.2 Estimating The Background

There are mainly three kind of backgrounds. They are considered separately as below:

1. The $\pi^+\pi^-$ combination coming from J/ψ's decay of channel $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \pi^+\pi^- + others$, to see Figure 6(a).

2. The $\pi^+\pi^-$ combination with one coming from ψ' and another coming from J/ψ in channel $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \pi^+\pi^- + others$, to see Figure 6(b).

3. The $\pi^+\pi^-$ combination coming from phase-space decays $\psi' \to n(\pi^+\pi^-) + others$, to see Figure 6(c).

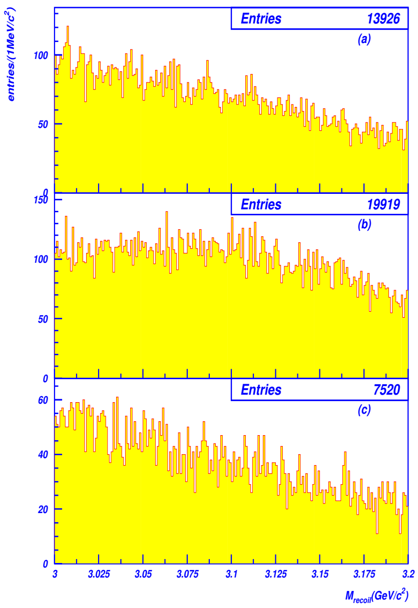


Figure 6: Distributions of M_{recoil}. (a) and (b) presents $\pi^+\pi^-$ coming from J/ψ and one from J/ψ and another from ψ' in decay $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to 3(\pi^+\pi^-)\pi^0$, (c) presents $\pi^+\pi^-$ coming from phase-space decay $\psi' \to 3(\pi^+\pi^-)\pi^0$.

After producing 10000 Monte Carlo events of channels $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to 3(\pi^+\pi^-)\pi^0$ and $\psi' \to 3(\pi^+\pi^-)\pi^0$ respectively and making the above three kind of $\pi^+\pi^-$ combination, the $\pi^+\pi^-$ recoiling mass spectrums can be plotted as in Figure 6. We can see that their shape are all flat. Therefore, polynomial is able to describe the background in the $\pi^+\pi^-$ recoiling mass spectrum of the inclusive events.

5.3 Fitting Spectrum

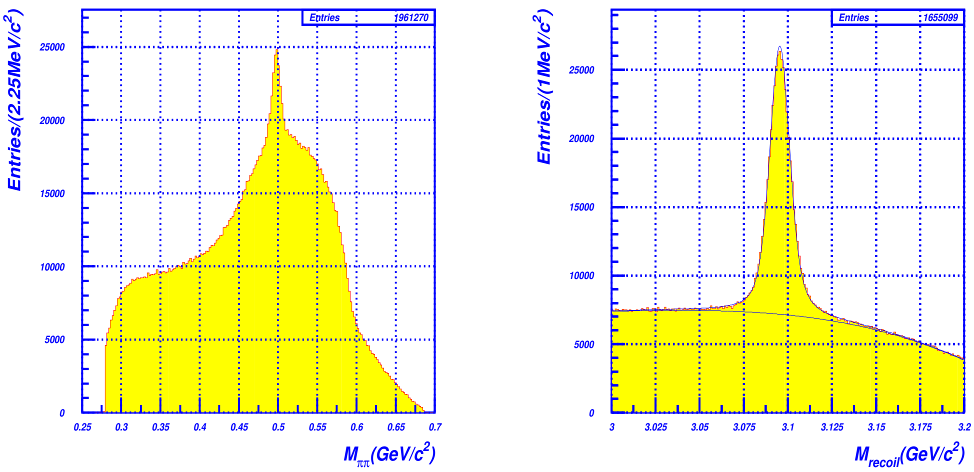
The M_{recoil} distribution is fitted using the sum of polynomial background and a Breit-Wigner(BW) curve convolved with a Gaussian resolution function, as shown in Figure 7(b). Fitting results are shown in Table 4.

6 Determining the Efficiency ε

The efficiency depends on the J/ψ charged-track multiplicity. To define *k-type* event that means the final state of J/ψ decay has k charged tracks, it is obvious that a detected *i-prong* events may come from every possible generated *k-type*

Table 4: Fitting results of $\pi^+\pi^-$ recoiling mass spectrum for events $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to anything$. M_{recoil} is the fitted reoiling mass; N^{reg} is the total events in fitting region; *Area* is the area factor of J/ψ peak and $N^{obs}_{J/\psi}$ is the number of J/ψ in its peak and it will be used to calculate the total number of ψ'

Data	KJI	M_{recoil}	N^{reg}	Area$\pm\sigma_A$	$N^{obs}_{J/\psi} \pm \sigma_{N^{obs}_{J/\psi}}$
93-94	>1	3.0954	883329	0.20762±0.00069	183396± 609
93-94	>0	3.0954	906632	0.20764±0.00068	188253± 617
95	>1	3.0955	1655098	0.20087±0.00050	332459± 832
95	>0	3.0954	1719809	0.20046±0.00049	344752± 846



(a) (b)

Figure 7: Distributions of $M_{\pi^+\pi^-}$ and M_{recoil} for events $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to anything$. The peak at $0.5GeV/c^2$ of (a) may be K^0. The smooth curve of (b) is its BW-fit shape and its details can be seen in **Appendix B.2**.

Table 5: Selection of Monte Carlo typical channels

k	*k_type channel*		$N^{prod}_{M.C.}$	$\varepsilon_k \pm \sigma_{\varepsilon_k}(\%)$	
				$Ver153$	$Ver154$
0	$J/\psi \to 3\gamma$		100000	47.45 ± 0.10	47.50 ± 0.10
2	$J/\psi \to \mu^+\mu^-$	(a)	100000	46.15 ± 0.09	46.36 ± 0.09
	$J/\psi \to \pi^+\pi^-\pi^0$	(b)	100000	45.68 ± 0.12	45.98 ± 0.12
	$0.8(a) + 0.2(b)$		100000	46.06 ± 0.08	46.28 ± 0.08
4	$J/\psi \to 2(\pi^+\pi^-)\pi^0$		100000	43.36 ± 0.19	43.49 ± 0.19
6	$J/\psi \to 3(\pi^+\pi^-)$		100000	41.87 ± 0.24	42.12 ± 0.24
8	$J/\psi \to 4(\pi^+\pi^-)$		100000	40.38 ± 0.32	40.82 ± 0.32

events($k \geq i$), namely,

$$N_i^{obs} = \sum_k \varepsilon_{ik} N_k^{prod} \tag{1}$$

with *k=0,2,4,. . .* , *i=0,1,2,3,. . .* , where the matrix element ε_{ik} gives the probability of an oberved *i-prong* event coming from a *k-type* event.

Taking sum over i and using $N^{obs}/N^{prod} = \varepsilon$, we have

$$N^{obs} = \sum_k \varepsilon_k N_k^{prod} \tag{2}$$

and

$$\varepsilon = \sum_k \varepsilon_k \omega_k, \tag{3}$$

where ε_k is the detection efficiency of *k-type* events and $\omega_k = N_k^{prod}/N^{prod}$ is the *k-type* events fraction, which represents the J/ψ charged-track-multiplicity distribution.

ε_k and ε_{ik} can be estimated by generating *k-type* events with decays of J/ψ into characteristic channels listed in Table 5. Figure 8 shows the M_{recoil} distributions of the five Monte Carlo channels and their fitting curves.

Solving the over determined equations (1) and (2), J/ψ charged-track-multiplicity distribution are estimated and detection efficiency ε can be gotten from equation (3). The results are shown in Table 6, in which σ_ε comes from errors of ε_k.

7 Analysis of Errors

On the one hand, because of a huge sum of ψ' data events, the statistical error is very small; on the other hand, besides some errors coming from analysis process, errors of the branching ratio will carry a considerable part into the the systematic error.

Table 6: *k-type* events fraction w_k and detection efficiency ε

Data	KJI	w_0	w_2	w_4	w_6	w_8	$\varepsilon \pm \sigma_\varepsilon (\%)$
93-94	>1	0.0115	0.3327	0.3950	0.1854	0.0754	43.80± 0.09
93-94	>0	0.0114	0.3331	0.3950	0.1857	0.0748	43.81± 0.09
95	>1	0.0101	0.3330	0.3981	0.1844	0.0744	44.01± 0.09
95	>0	0.0099	0.3333	0.3979	0.1847	0.0742	44.01± 0.09

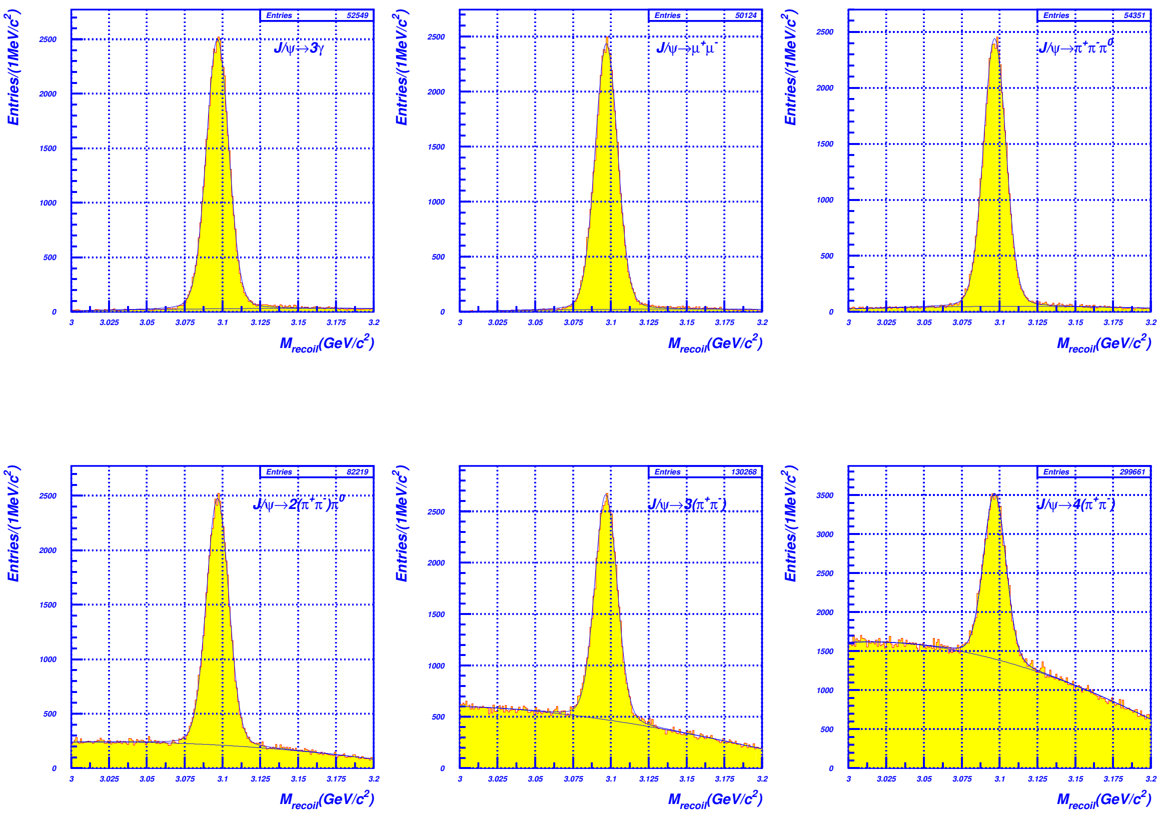


Figure 8: Distributions of M_{recoil} corresponding 6 typical Monte Carlo channels.

7.1 Statistical Error

It comes from statistical error of $N_{J/\psi}^{obs}$, namely,

$$\sigma_{sta}^{N} = N_{\psi'}^{prod} \cdot \frac{\sigma_{N_{J/\psi}^{obs}}}{N_{J/\psi}^{obs}} = \frac{\sigma_{N_{J/\psi}^{obs}}}{\varepsilon \cdot Br(\psi' \to \pi^+\pi^- J/\psi)}$$

7.2 Systematic Error

It arises from several sources:

- The error of fitting J/ψ line shape σ_{fit}^{N}, which means changing Γ and Σ with 1σ respectively to fit again to calculate the error.
- The error of ε, namely, $\sigma_{\varepsilon}^{N} = N_{\psi'}^{prod} \cdot \frac{\sigma_{\varepsilon}}{\varepsilon}$.
- The changes of $N_{\psi'}^{prod}$ caused by varying event selection criteria. That means, changing some criterion cut^i to point cut_j^i around the original cut point cut_0^i to get the ψ' events number $N_{cut_j^i} (j = 1, 2, \ldots, J)$, we can get:

  $$\sigma_{cut^i}^{N} = \sqrt{\sum_{j=1}^{J} (N_{cut_j^i} - N_{cut_0^i})^2 / J}$$

  where $N_{cut_0^i} = N_{\psi'}^{prod}$. Then, the error of all cuts will be:

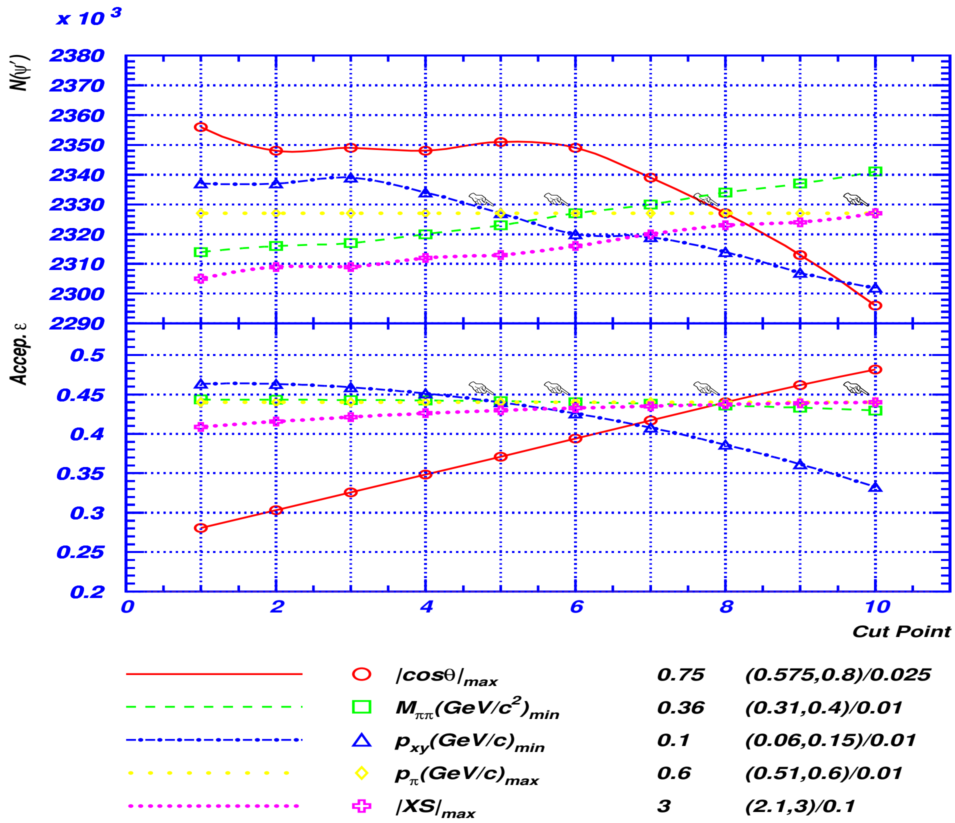
  $$\sigma_{cut}^{N} = \sqrt{\sum_i (\sigma_{cut^i}^{N})^2}$$

- The error of branching ratio $Br(\psi' \to \pi^+\pi^- J/\psi)$. it is the dominant source of systematic error.

  $$\sigma_{Br}^{N} = N_{\psi'}^{prod} \cdot \frac{\sigma_{Br}}{Br}$$

Therefore, the systematic error should be calculated as:

$$\sigma_{sys}^{N} = \sqrt{(\sigma_{fit}^{N})^2 + (\sigma_{\varepsilon}^{N})^2 + (\sigma_{cut}^{N})^2 + (\sigma_{Br}^{N})^2}$$



CP	$\|cos\theta\|_{max}$	$N(\psi')$	$M_{\pi\pi}(GeV/c^2)_{min}$	$N(\psi')$	$p_{xy}(GeV/c)_{min}$	$N(\psi')$	$p_{\pi}(GeV/c)_{max}$	$N(\psi')$	$\|XS\|_{max}$	$N(\psi')$
1	0.575	2.356E+06	0.310	2.314E+06	0.060	2.337E+06	0.510	2.327E+06	2.100	2.305E+06
2	0.600	2.348E+06	0.320	2.316E+06	0.070	2.337E+06	0.520	2.327E+06	2.200	2.309E+06
3	0.625	2.349E+06	0.330	2.317E+06	0.080	2.339E+06	0.530	2.327E+06	2.300	2.309E+06
4	0.650	2.348E+06	0.340	2.320E+06	0.090	2.334E+06	0.540	2.327E+06	2.400	2.312E+06
5	0.675	2.351E+06	0.350	2.323E+06	✂ 0.100	2.327E+06	0.550	2.327E+06	2.500	2.313E+06
6	0.700	2.349E+06	✂ 0.360	2.327E+06	0.110	2.320E+06	0.560	2.327E+06	2.600	2.316E+06
7	0.725	2.339E+06	0.370	2.330E+06	0.120	2.319E+06	0.570	2.327E+06	2.700	2.320E+06
8	✂ 0.750	2.327E+06	0.380	2.334E+06	0.130	2.314E+06	0.580	2.327E+06	2.800	2.323E+06
9	0.775	2.313E+06	0.390	2.337E+06	0.140	2.307E+06	0.590	2.327E+06	2.900	2.324E+06
10	0.800	2.296E+06	0.400	2.341E+06	0.150	2.302E+06	✂ 0.600	2.327E+06	✂ 3.000	2.327E+06

CP	$\|cos\theta\|_{max}$	Accep. ε	$M_{\pi\pi}(GeV/c^2)_{min}$	Accep. ε	$p_{xy}(GeV/c)_{min}$	Accep. ε	$p_{\pi}(GeV/c)_{max}$	Accep. ε	$\|XS\|_{max}$	Accep. ε
1	0.575	0.2806	0.310	0.4436	0.060	0.4635	0.510	0.4401	2.100	0.4088
2	0.600	0.3030	0.320	0.4433	0.070	0.4634	0.520	0.4401	2.200	0.4156
3	0.625	0.3256	0.330	0.4430	0.080	0.4592	0.530	0.4401	2.300	0.4214
4	0.650	0.3482	0.340	0.4424	0.090	0.4513	0.540	0.4401	2.400	0.4261
5	0.675	0.3710	0.350	0.4415	✂ 0.100	0.4401	0.550	0.4401	2.500	0.4299
6	0.700	0.3940	✂ 0.360	0.4401	0.110	0.4260	0.560	0.4401	2.600	0.4328
7	0.725	0.4172	0.370	0.4384	0.120	0.4079	0.570	0.4401	2.700	0.4352
8	✂ 0.750	0.4401	0.380	0.4359	0.130	0.3863	0.580	0.4401	2.800	0.4373
9	0.775	0.4618	0.390	0.4332	0.140	0.3614	0.590	0.4401	2.900	0.4389
10	0.800	0.4816	0.400	0.4297	0.150	0.3326	✂ 0.600	0.4401	✂ 3.000	0.4401

Figure 9: Waving of $N_{\psi'}^{prod}$ and ε while criteria vary in the vicinity of original cut points. The criteria are $|cos\theta_{\pi}^{MDC}| < 0.75$, $M_{\pi^+\pi^-} > 0.36GeV/c^2$, $p_{xy} > 0.1GeV/c$, $p_{\pi} < 0.6GeV/c$ and $|\chi_{\pi}^{dE/dx}| < 3$

Table 7: Criteria producing systematic errors and their changing scope for errors calculating. *Cut Point* means the cut using in event selection.

Criterion	Cut Point	Changing Scope	Changing Step
$\|cos\theta_\pi^{MDC}\|_{max}$	0.75	0.575-0.800	0.025
$M_{\pi^+\pi^-}(GeV/c^2)_{min}$	0.36	0.31-0.40	0.01
$p_{xy}(GeV/c)_{min}$	0.10	0.06-0.15	0.01
$p_\pi(GeV/c)_{max}$	0.60	0.51-0.60	0.01
$\|\chi_\pi^{dE/dx}\|_{max}$	3.0	2.1-3.0	0.1

8 Results

8.1 Correction for Monte Carlo real_Ver153

It is special of the reconstruction program for the 93/94 data, which is a little different with BES-V85 being used and now reserved as file

DISK$BES8:[USERPP.COMMON]REC_PSIP.EXE_85

in VAX. But in HP-BES environment, it is impossible to reproduce the corresponding program now, and I used BES-V86 for the Monte Carlo production and reconstruction. So it is necessary to compare the difference between them.

The channel $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$ is used to do this, namely, producing and reconstructing Monte Carlo events in old and new environment respectively and analyzing them to get the efficiencies ε. So the ratio of the old ε to the new one can be used to corrected the results of 93/94 data. Table 8

Table 8: Correction of Monte Carlo real_Ver153

SOBER	Rec.	DRUNK	ε
VAX PPGEN87	DISK$BES8:[USERPP.COMMON] REC_PSIP.EXE_85	HP bes86 + drunk.f	4672/10000
HP ppgen86	RecV86	HP bes86	4674/10000

shows the case of SOBER, Reconstruction, DRUNK and ε. From this table, the ratio α can be obtained:

$$\alpha = \frac{\varepsilon_{VAX}}{\varepsilon_{HP}} = \frac{0.4672}{0.4674} = 0.9996$$

In case of $N_{\psi'} = N_{J/\psi}/\varepsilon$, the corrected ψ' total number will be:

$$N_{\psi'}^{cor} = \frac{N_{\psi'}}{\alpha}.$$

For the correcting range are all less than 0.1%, which is even less than the statistical error of the results. So this correction will be ignored.

8.2 Comparison with Yuan Changzheng's Results

Originally, Yuan Changzheng has obtained the results of 93/94 data. In his analysis, the cut of $cos\theta_\pi^{MDC}$ is:

$$cos\theta_\pi^{MDC} > 0.8$$

Changing my this cut from 0.75 to 0.8, the comparison of our results can be gotten as Table 9. The difference between the results of Yuan and me is about

Table 9: Comparison with Yuan Changzheng's results of 93/94 data

	My Results	Yuan's Results	Δ
$\varepsilon(\%)$	48.00	48.52	1%
$N_{J/\psi}^{obs}(\times 10^6)$	0.204	0.200	2%
$N_{\psi'}^{prod}(\times 10^6)$	1.310	1.271	3%

3%, which is in the range of systematic error. However, where does this 3% come from? That means, where do the 1% of ε and 2% of $N_{J/\psi}^{obs}$ come from? There are still some differences between our analyses:

- I used the newest reconstruction version data instead of Yuan's using the older;
- Instead of Yuan's using the combination of channels of $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$ and $\psi' \to \pi^+\pi^- J/\psi, J/\psi \to e^+e^-$, I used the channel $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$ only to get the J/ψ line shape, in this way, the systematic error of J/ψ line shape is decreased;
- In the determination of efficiency ε, I used 10 times Monte Carlo events (namely, 10^6) of Yuan's;
- Basing on much more Monte Carlo statistic, my event multiplicity weights $\omega_k(k = 0, 2, ..., 8)$ come from resolving equations (1) and (2) only. This makes my results be more independent. comparatively, Yuan also uesd some other sources of ω_k.

The former two reasons cause the $N_{J/\psi}^{obs}$'s 2% and the later two reasons cause the ε's 1% and they combined yield the final 3%.

From the above comparison, my results in Table 10 are recommended, of which the $cos\theta_\pi^{MDC}$ cut is 0.75.

8.3 Results

Finally, the ψ' events number of the new and old data with different good run selection can be gotten, as seen in Table 10. All calculating details about the above analysis can be seen in **Appendix C**.

Table 10: Number of ψ' events at BES

Data	KJI	$N_{\psi'} \pm \sigma_{sta} \pm \sigma_{sys} (\times 10^6)$
93-94	>1	1.292± 0.004± 0.112
93-94	>0	1.326± 0.004± 0.115
95	>1	2.327± 0.006± 0.195
95	>0	2.418± 0.006± 0.203
All	>1	3.619± 0.007± 0.225
All	>0	3.744± 0.007± 0.233

References

[1] Yuan Changzheng, Master dissertation.

[2] Yuan Changzheng, μ identification subroutine:
hpws4:/u/u01b/wangm/psp/npsp/ycz_muid.f.

[3] F. A. Harris, Monte Carlo-Date Comparison of $\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \mu^+\mu^-$ and the Number of ψ' Events.

[4] Chen Yu, Monte Carlo generator for ψ' events: PPGEN.

Thank You

My thanks to all who helped me with this work. My especial thanks to Yifan Gu, Changzheng Yuan and Jin Li. My thanks also go to Fred A. Harris for his advice to my sober-cards. My mistakes are my own.

A Subroutine *skip_bad_run.f*

This subroutine was written by Chen Yu(*cheny@bepc5.ihep.ac.cn*), and it is now in the directory '/data/d09/wangm/common' of the **HP_UX** environment in the Computer Center of **IHEP**.

```
        SUBROUTINE SKIP_BAD_RUN(IJK,KJI)

C*******************************************************************
C       Input IJK as RUN# this program returns KJI to
C              show the run status
C
C       KJI = 0 : bad run, should not be used,
C       KIJ = 1 : bad run, recommended not be used,
C       KIJ = 2 : good run, with some problems, but
C                 recommended be used,
C       KIJ = 3 : good run.
C
C       DON'T modify this program unless after announcing in
C       our group meeting.
C                               YUANCZ,  9-DEC-1992
C       Some more bad runs are put in this list because of bad
C       luminocity, It's really a pity, but we have no other
C       choice.
C                               YUANCZ, 23-DEC-1992
C
C       Some more bad runs are put in this list for new psi' data
C       taking from 12,DEC,1993 to 6,JAN,1994.
C
C                               ChenY and YuanCZ, 30-Jan-1994
C
C Since some offline problems, e.g. REC, TOF, read error, have been solved,
C       those runs are good runs for new psi' data.
C In your subroutine, if KJI returns for RUN5738 -- 6059 :
C       KJI > 2 : excelent 266 runs, total number is (1074+-7+-94)x1000;
C       KJI > 1 : good 307 runs, Lum Monitor is maybe available;
C       KJI > 0 : satisfactroy 316 runs, recommended be used,
C                 luminosity depend upon large angle Bhabha.
C
C                                       Chen Yu,  24-MAR-1994
C
C Append to 95' psi' data list: Run7761--8100 taken from Feb 17 to Apr 1.
C                                       Chen Yu,  30-MAY-1995
C
C Append to 95' psi' data list: Run7430--7760 taken from Jan 1 to Jan 29.
C                                       Chen Yu,  5-JULY-1995
```

```
C
C----------------------------------------------------------------
C
      INTEGER IJK,KJI
                                    KJI = 3
                                                      ! problem(s)
      IF    (IJK.EQ.2447)           KJI = 0           !luminocity
      IF    (IJK.EQ.2470)           KJI = 0           !prg ratio, only
      IF    (IJK.EQ.2471)           KJI = 0           ! 2-mu open
      IF    (IJK.EQ.2479)           KJI = 0           !lower sigma, lum
      IF    (IJK.EQ.2480)           KJI = 0           !luminocity
      IF    (IJK.EQ.2485)           KJI = 0           !luminocity
      IF    (IJK.EQ.2492)           KJI = 0           !luminocity
      IF    (IJK.EQ.2497)           KJI = 0           !luminocity
      IF    (IJK.EQ.3460)           KJI = 0           !prg ratio, sigma
      IF    (IJK.EQ.3469)           KJI = 0           !lower sigma

      IF    (IJK.EQ.3470)           KJI = 1           !total, bhabha sigma
      IF    (IJK.EQ.3475)           KJI = 1           !prg ratio, lum
      IF    (IJK.EQ.3480)           KJI = 1           !prg ratio
      IF    (IJK.EQ.3482)           KJI = 1           !hadron cross section

      IF    (IJK.GE.3492.AND.
     >        IJK.LE.3494                             !less 0 prong events
     >    .OR.IJK.GE.3495.AND.
     >        IJK.LE.3512)          KJI = 2

C For new psi prime data , added by CHenY and YuanCZ.      30-JAN-1994
C For new psi prime data , modified by CHenY and YuanCZ.   24-MAR-1994

C Offline problems
      IF    (IJK.EQ.5739)           KJI = 0           !energy
      IF    (IJK.EQ.5748)           KJI = 0           !energy, dEdx etc.
      IF    (IJK.EQ.5763)           KJI = 0           !trigger CH2 open
      IF    (IJK.EQ.5867)           KJI = 0           !Bhabha
      IF    (IJK.EQ.6018)           KJI = 0           !Dimu, TOF
      IF    (IJK.EQ.6054)           KJI = 0           !skipped run number

C Offline problems
      IF    (IJK.EQ.5773)           KJI = 1           !Lum
      IF    (IJK.EQ.5821)           KJI = 1           !Lum
      IF    (IJK.EQ.5891)           KJI = 1           !Lum, REC
      IF    (IJK.EQ.5983)           KJI = 1           !Lum
      IF    (IJK.EQ.5984)           KJI = 1           !Lum
      IF    (IJK.EQ.6022)           KJI = 1           !Lum
```

```
C Online problems
        IF    (IJK.EQ.5815)             KJI = 1         !Lum
        IF    (IJK.EQ.5851)             KJI = 1         !Lum
        IF    (IJK.EQ.5897)             KJI = 1         !Lum

C Offline problems  (Some problems have been solved.)
        IF    (IJK.EQ.5741)             KJI = 2         !energy
        IF    (IJK.EQ.5759)             KJI = 2         !TOF
        IF    (IJK.EQ.5779)             KJI = 2         !TOF
        IF    (IJK.EQ.5841)             KJI = 2         !TOF
        IF    (IJK.EQ.5902)             KJI = 2         !no sorting
        IF    (IJK.EQ.5907)             KJI = 2         !Bhabha
        IF    (IJK.EQ.5911)             KJI = 2         !no sorting
        IF    (IJK.EQ.5933)             KJI = 2         !offline read error
        IF    (IJK.EQ.5947)             KJI = 2         !Dimu,REC
        IF    (IJK.EQ.5978)             KJI = 2         !Dimu
        IF    (IJK.EQ.5986)             KJI = 2         !MDC hit
        IF    (IJK.EQ.5987)             KJI = 2         !Prong, REC
        IF    (IJK.EQ.6016)             KJI = 2         !TOF
        IF    (IJK.EQ.6017)             KJI = 2         !REC
C Online problems
        IF    (IJK.EQ.5774)             KJI = 2         !TOF
        IF    (IJK.EQ.5775)             KJI = 2         !TOF
C Online calibration problems
        IF    (IJK.GE.5950 .AND.
     >         IJK.LE.5965)             KJI = 2         !10/8 dead muon channels
        IF    (IJK.GE.6050 .AND.
     >         IJK.LE.6059)             KJI = 2         !1 TOF dead channel

C For 95' psi prime data (Run7761--8100), added by CHENY.    24-MAY-1995
C Run7889, 7890, 7891, 8005 (4 Runs) have not processed by DP Group
C   for read error ?                                    Chen Yu

C Online and offline problems
        IF    (IJK.GE.7922 .AND.
     >         IJK.LE.7924)             KJI = 0         !BSC dead block
        IF    (IJK.EQ.7964)             KJI = 0         !seperate beam
        IF    (IJK.EQ.8020)             KJI = 0         !skipped run number
        IF    (IJK.EQ.8064)             KJI = 0         !single beam
```

```
C Online and offline problems
        IF    (IJK.GE.7761 .AND.
     >          IJK.LE.7770)            KJI = 1          !L2,3 in muon counter
        IF    (IJK.EQ.7980)            KJI = 1          !TRG, Large Bhabha
        IF    (IJK.EQ.7981)            KJI = 1          !TRG, Large Bhabha

C Online and offline problems
        IF    (IJK.GE.7771 .AND.
     >          IJK.LE.7774)            KJI = 2          !scan
        IF    (IJK.GE.7787 .AND.
     >          IJK.LE.7789)            KJI = 2          !magnet
        IF    (IJK.EQ.7790)            KJI = 2          !magnet, lum
        IF    (IJK.EQ.7804)            KJI = 2          !ESC
        IF    (IJK.GE.7810 .AND.
     >          IJK.LE.7814)            KJI = 2          !lum
        IF    (IJK.EQ.7822)            KJI = 2          !beam
        IF    (IJK.EQ.7827)            KJI = 2          !lum
        IF    (IJK.EQ.7833)            KJI = 2          !lum
        IF    (IJK.EQ.7835)            KJI = 2          !BSC
        IF    (IJK.GE.7839 .AND.
     >          IJK.LE.7841)            KJI = 2          !lack of lum
        IF    (IJK.EQ.7844)            KJI = 2          !ESC
        IF    (IJK.EQ.7859)            KJI = 2          !beam
        IF    (IJK.EQ.7860)            KJI = 2          !CDC
        IF    (IJK.EQ.7892)            KJI = 2          !power stop, large lum
        IF    (IJK.EQ.7907)            KJI = 2          !little lum
        IF    (IJK.EQ.7921)            KJI = 2          !magnet, lack of lum
        IF    (IJK.EQ.7925)            KJI = 2          !BSC, lack of lum
        IF    (IJK.EQ.7926)            KJI = 2          !magnet
        IF    (IJK.EQ.7927)            KJI = 2          !magnet
        IF    (IJK.EQ.7958)            KJI = 2          !TRG
        IF    (IJK.EQ.7965)            KJI = 2          !little lum
        IF    (IJK.EQ.7970)            KJI = 2          !TRG
        IF    (IJK.EQ.7978)            KJI = 2          !TRG
        IF    (IJK.EQ.8008)            KJI = 2          !lum
        IF    (IJK.EQ.8009)            KJI = 2          !lum
        IF    (IJK.EQ.8013)            KJI = 2          !magnet
        IF    (IJK.EQ.8029)            KJI = 2          !magnet
        IF    (IJK.EQ.8030)            KJI = 2          !magnet
        IF    (IJK.EQ.8041)            KJI = 2          !lack of lum
        IF    (IJK.EQ.8042)            KJI = 2          !lack of lum
        IF    (IJK.GE.8090 .AND.
     >          IJK.LE.8092)            KJI = 2          !background test
```

```
C For 95' psi prime data (Run7430--7760), added by CHENY.  5-JULY-1995
C Because there are the Runs of KJI=0 in the Run range of KJI=1,
C   the new order (first KJI=2, 1, 0) should be used.
C Run7437, 7475, 7697, 7711, 7729 (5 Runs) have not processed by DP Group
C   for read error ?                                     Chen Yu

C Online problems
        IF     (IJK.EQ.7500)             KJI = 2          !BSC
        IF     (IJK.EQ.7518)             KJI = 2          !Muon Counter
        IF     (IJK.EQ.7522)             KJI = 2          !Muon Counter
        IF     (IJK.EQ.7558)             KJI = 2          !little lum
        IF     (IJK.GE.7603 .AND.
     >          IJK.LE.7607)             KJI = 2          !scan
        IF     (IJK.GE.7620 .AND.
     >          IJK.LE.7622)             KJI = 2          !BSC
        IF     (IJK.EQ.7648)             KJI = 2          !MDC hit(offline)
        IF     (IJK.EQ.7742)             KJI = 2          !MDC hit(offline)

C Online and offline problems
        IF     (IJK.GE.7430 .AND.
     >          IJK.LE.7486)             KJI = 1          !scan, trigger

C Online and offline problems
        IF     (IJK.GE.7430 .AND.
     >          IJK.LE.7438)             KJI = 0          !scan, energy
        IF     (IJK.GE.7452 .AND.
     >          IJK.LE.7459)             KJI = 0          !scan, energy
        IF     (IJK.EQ.7462)             KJI = 0          !empty
        IF     (IJK.EQ.7465)             KJI = 0          !energy
        IF     (IJK.EQ.7470)             KJI = 0          !energy
        IF     (IJK.EQ.7474)             KJI = 0          !more hadron
        IF     (IJK.EQ.7509)             KJI = 0          !cosmic test
        IF     (IJK.GE.7570 .AND.
     >          IJK.LE.7576)             KJI = 0          !high trg rate
        IF     (IJK.EQ.7580)             KJI = 0          !empty
        IF     (IJK.EQ.7578)             KJI = 0          !too little for 2-prong
        IF     (IJK.GE.7582 .AND.
     >          IJK.LE.7586)             KJI = 0          !lack of neu. channel
        IF     (IJK.EQ.7594)             KJI = 0          !no events (REC?)
        IF     (IJK.GE.7595 .AND.
     >          IJK.LE.7602)             KJI = 0          !J/psi scan

        RETURN
        END
```

B BW-Fit results

B.1 $\psi' \to \pi^+\pi^- J/\psi,\ J/\psi \to \mu^+\mu^-$

This is the case for 95's data with skip-bad-run> 1, corresponding to Figure 5(a). The other cases are similar.

```
==============================================='=================================
I                       Summary Of BWFIT Results'                              I
==============================================='=================================
Histogram ID=  2000  AdapQuad Breit-Wigner Fit using  200 Points
Fit Parameters:Npoly=   3 Nbw=   1 Namp=   0 Range=      3.000 To      3.200
Hist. Chisq =     246.68 for   6 params & 193 DF.
Chisquare Probability =    .54%. Mean and S.D. for pulls:    -.0115    1.1105
Likelihood ratio and probability            :    257.725          .13%
Final Value of Log Likelihood               :    -29997.23
Error Correspond to a Function Chage        :      .50
Phase Space limits for tails corrections    :       .280GEV     2.817GEV
Breit-Wigner efficiency correction factors  :      .981
Include Breit-Wigner tails outside fit region :       .003
Efficiency-corrected events in fit region   :    10196.[average eff. :1.000]
---THE FITTED VALUES AND ERRORS OF THE PARAMETERS:---
    leg1Value :  .85803    Error(Cov,-/+):    .129      .000E+00  .000E+00
    leg2Value : -.47259E-01Error(Cov,-/+):    .161      .000E+00  .000E+00
    areaValue :  .92140    Error(Cov,-/+):    .840E-02  .000E+00  .000E+00
    RESLValue :  .42116E-02Error(Cov,-/+):    .189E-03  .000E+00  .000E+00
    GAMAValue :  .60904E-02Error(Cov,-/+):    .391E-03  .000E+00  .000E+00
    MASSValue :  3.0956    Error(Cov,-/+):    .777E-04  .000E+00  .000E+00
```

B.2 $\psi' \to \pi^+\pi^- J/\psi,\ J/\psi \to anything$

This is the case for 95's data with skip-bad-run> 1, corresponding to Figure 7(b). The other cases are similar.

```
==============================================='=================================
I                       Summary Of BWFIT Results'                              I
==============================================='=================================
Histogram ID=  1008  Simpsons Breit-Wigner Fit using  200 Points
Fit Parameters:Npoly=   4 Nbw=   1 Namp=   0 Range=      3.000 To      3.200
Hist. Chisq =     375.83 for   5 params & 194 DF.
Chisquare Probability =    .00%. Mean and S.D. for pulls:     .0157    1.3707
Likelihood ratio and probability            :    615.689          .00%
Final Value of Log Likelihood               :  -2843680.91
Error Correspond to a Function Chage        :      .50
Phase Space limits for tails corrections    :       .280GEV     2.817GEV
Breit-Wigner efficiency correction factors  :      .981
Include Breit-Wigner tails outside fit region :       .003
Efficiency-corrected events in fit region   :  1655098.[average eff. :1.000]
---THE FITTED VALUES AND ERRORS OF THE PARAMETERS:---
    LEG1Value : -.24056    Error(Cov,-/+):    .146E-02  .000E+00  .000E+00
    LEG2Value : -.15294    Error(Cov,-/+):    .213E-02  .000E+00  .000E+00
    LEG3Value : -.30441E-01Error(Cov,-/+):    .229E-02  .000E+00  .000E+00
    AREAValue :  .20050    Error(Cov,-/+):    .502E-03  .000E+00  .000E+00
    RESLValue :  .42116E-02Error(Cov,-/+):    .000E+00  .000E+00  .000E+00
    GAMAValue :  .60904E-02Error(Cov,-/+):    .000E+00  .000E+00  .000E+00
    MASSValue :  3.0955    Error(Cov,-/+):    .187E-04  .000E+00  .000E+00
```

C Details for calculating $N_{\psi'}^{prod}$

This is the case of 95's data with skip-bad-run> 1. The other cases are similar.

```
>>>>>>>>>>>>>>>>>>>>>>>> Total Number of PSIP <<<<<<<<<<<<<<<<<<<<<<<<
............................ RUN7430-8100 ............................
...........................SKIP-BAD-RUN 1.............................

>>>>>>>>>>Fitting parameters:
                    Gamma          Resolution
            DATA:   .60904E-02     .42116E-02
            MC  :   .19284E-02     .69278E-02

>>>>>>>>>>Correction of Chi_pi in dE/dx:
        Mean pi+  Sig- pi+  Sig+ pi+  Mean pi-  Sig- pi-  Sig+ pi-
MC      0.5214    1.2748    0.7652    0.4667    1.2203    0.7970
DATA    0.4613    1.3181    1.0237    0.3252    1.2579    1.0000

**************************** Typical Channal ****************************
   Channel  Njsi.obs  Fit Area  Sig Area      Eff.  Sig Eff.
    ppj3ga     52549    0.9040    0.0019    0.4750    0.0010
    ppj3pi     54351    0.8459    0.0021    0.4598    0.0012
    ppj5pi     82219    0.5289    0.0023    0.4349    0.0019
    ppj6pi    130268    0.3234    0.0018    0.4212    0.0024
    ppj8pi    299661    0.1362    0.0011    0.4082    0.0032
    ppj2mu     50124    0.9250    0.0018    0.4636    0.0009

**************************** WT. calc. Array ****************************
   Nprong   Njsi.obs   Eff 3ga   Eff 3pi   Eff 5pi   Eff 6pi   Eff 8pi
     ALL    331847.    0.4750    0.4629    0.4349    0.4212    0.4082
       2     10700.    0.4153    0.0412    0.0001    0.0000    0.0000
       3     20512.    0.0115    0.0375    0.0025    0.0001    0.0000
       4     98193.    0.0448    0.3740    0.0259    0.0012    0.0001
       5     52193.    0.0017    0.0054    0.1257    0.0121    0.0009
       6     75483.    0.0016    0.0044    0.2520    0.0591    0.0063
       7     34425.    0.0001    0.0002    0.0174    0.1589    0.0314
       8     26211.    0.0001    0.0000    0.0105    0.1846    0.0965
       9      8996.    0.0000    0.0000    0.0006    0.0052    0.1549
      10      3584.    0.0000    0.0000    0.0001    0.0002    0.1129
      11      1247.    0.0000    0.0000    0.0001    0.0000    0.0051
      12       425.    0.0000    0.0000    0.0000    0.0000    0.0001

****************************** Weights  ******************************
        0.0101      0.3330      0.3981      0.1844      0.0744
**********************************************************************
Efficiency(+/-)Sigeff=  0.4401(+/-)0.0009
**************************** System Error ***************************
     SNfit        SNeff        SNcut        SNbes        SNbr
  0.4711E+05  0.4956E+04  0.3135E+05  0.5680E+05  0.1868E+06

****************************** Results  ******************************
* NPSP(+/-)SNSTA(+/-)SNSYS:   0.2327E+07  0.5827E+04  0.1952E+06     *
**********************************************************************

                                                 Thu Sep  5 18:03:07 1996
```