Determination of Total Number of J/ψ

Shuangshi Fang Yucan Zhu

fangss@hpws2.ihep.ac.cn

Contents

1. Introduction

- **The new J/ψ data has been collected in the period of November in 1999 to April in 2000.**

- **The run number for determining total J/ψ number is run13700 to run16835,runstatus to be used is 1 or 2.**

- **The total J/ψ number is important for J/ψ physics analyses.**

- **Using new ψ' data(run16853-17018) and the channel $\psi' \to \pi^+\pi^- J/\psi$ to detemine the total number of J/ψ.The mehtod is described as follows.**

2. Method

The principle is to use the formular:

$$N_{J/\psi} = \frac{N_{4prg} \cdot \epsilon_4^{scan}}{\epsilon_4^{tr} \cdot R_4}$$

where,
N_{4prg} **is the total reconstructed number of 4-prong;** ϵ_4^{scan} **and** ϵ_4^{tr} **is the manual scan efficiency and trigger efficiency of 4-prong,respectively;And** R_4 **is the ratio of 4-prong numbers to total** J/ψ **numbers, which was got through** $\psi' \rightarrow \pi^+ \pi^- J/\psi$**.**

3. Step

- **Counting the total 4-prong numbers: N_{4prg}=?**

- **Estimating the 4-prong manual scan efficiency: ϵ_4^{scan}=?**

- **Calculating the ratio of 4-prong numbers to total $J\psi$ numbers:R_4=?**

- **Determining the 4-prong trigger efficiency: ϵ_4^{tr}=?**

Step One

- **Four-prong-event should be meet:**
  - **Mfit=2 or Mfit=-19**
  - $|x|$ **<10cm;**$|y|$ **<10cm;**$|z|$ **<20cm**
  - ΣQ_i**=0**
  - **Runstatus 1 or 2**
- **Statistic results**
  $\mathbf{N}_{4prg}$**=5.9**$\times 10^6$

Step Two

- **Because not all four-prong-event come from J/ψ,we estiamte** ϵ_4^{scan} **by manual scan.**
- **Scan results:** ϵ_4^{scan} **=?**

Step Three

• Intoduction

In order to get R_4, $\psi' \rightarrow \pi^+\pi^- J/\psi$ was analysed. The line shape of J/ψ in M_{recoil}^{any} and M_{recoil}^{4prg} distibution is used to fit out the number of $N_{J/\psi}^{any}$ and $N_{J/\psi}^{4prg}$,respectively.And we can get $R_4 = \frac{N_{J/\psi}^{4prg}}{N_{J/\psi}^{any}}$.

• Event Selction

- **Nchrg $\geq$ 2**
- **Mfit=2 or Mfit=-19**
- **Pxyπ >0.06Gev**
- **$|x|$ <10cm;$|y|$ <10cm;$|z|$ <20cm**
- **$\sigma_{\pi^+_-}$ <3.0 (DEDX)**
- **$P_{\pi^+_-}$ $\leq$0.5Gev**
- **$|cos\theta_{\pi}|$ <0.8**
- **$|cos\theta_{\pi^+\pi^-}|$ <0.95**
- **At least two π was selected**

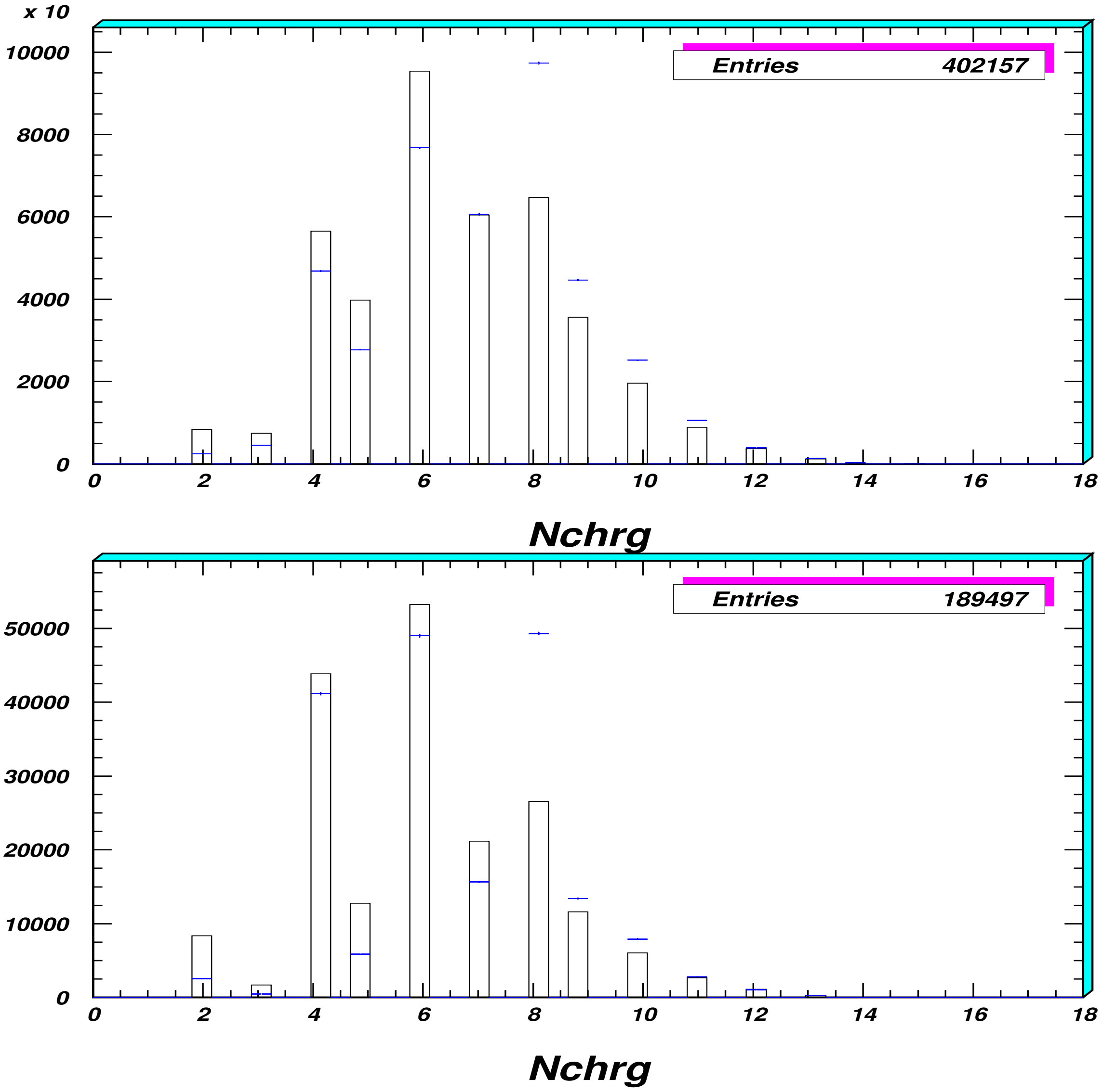


Figure 1: Nchrg distribution of anything events.The histogram is DATA and the cross is M.C.

Analyses of $\psi' \to \pi^+\pi^- J/\psi(J/\psi \to anything)$

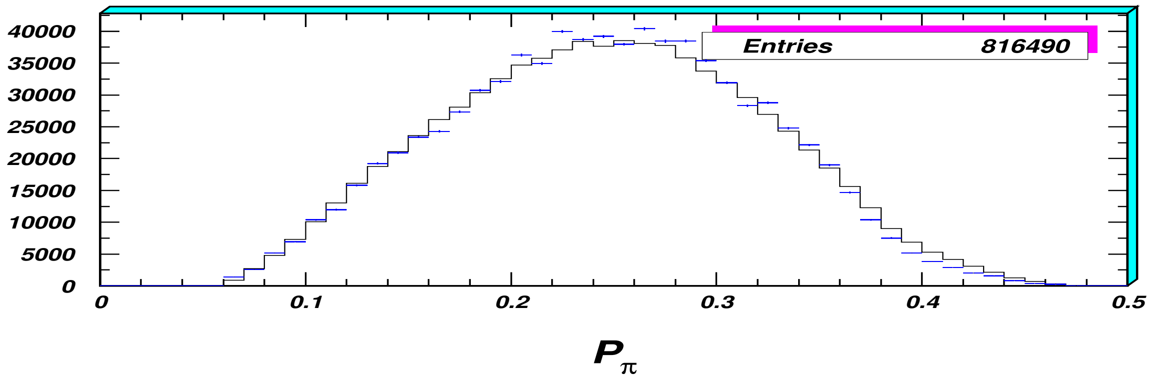


Figure 2: $P_{\pi^\pm}$ distribution of anything events.The histogram is DATA and the cross is M.C.

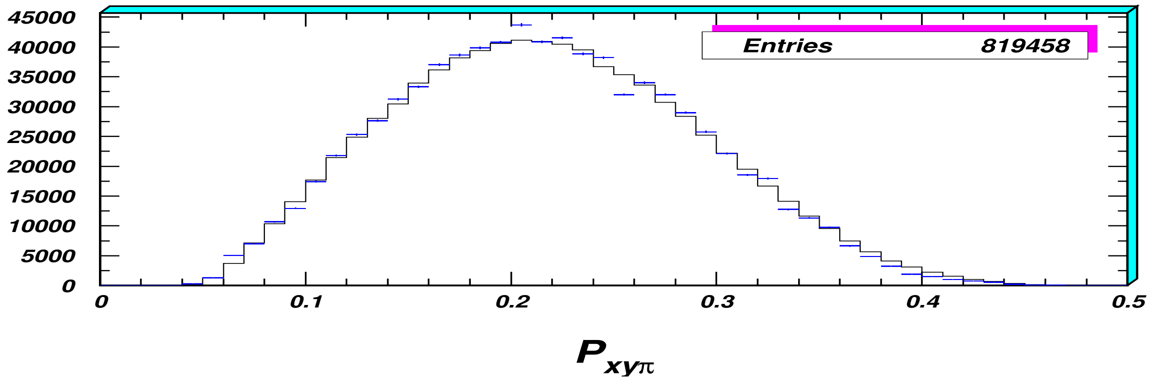


Figure 3: $P_{xy\pi^\pm}$ distribution of anything events.The histogram is DATA and the cross is M.C.

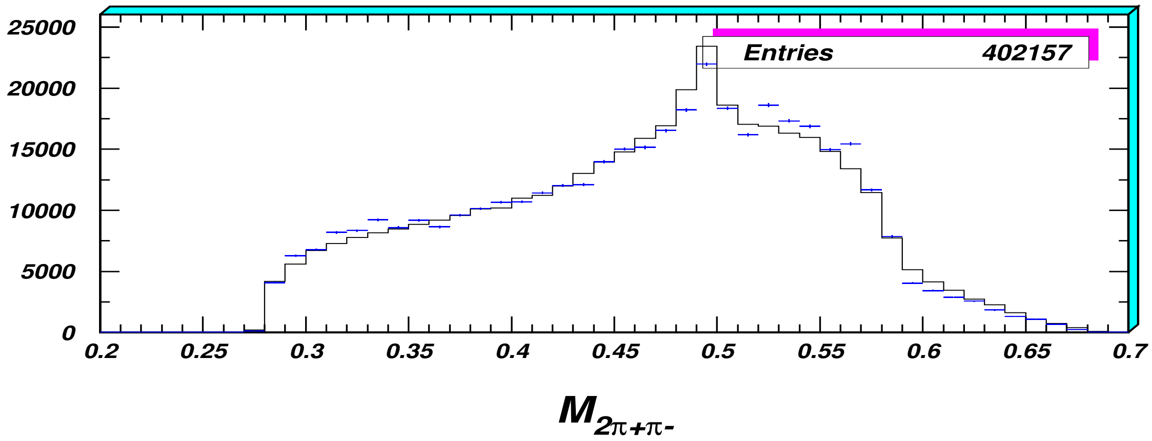


Figure 4: $M_{\pi^+\pi^-}$ distribution of anything events.The histogram is DATA and the cross is M.C.

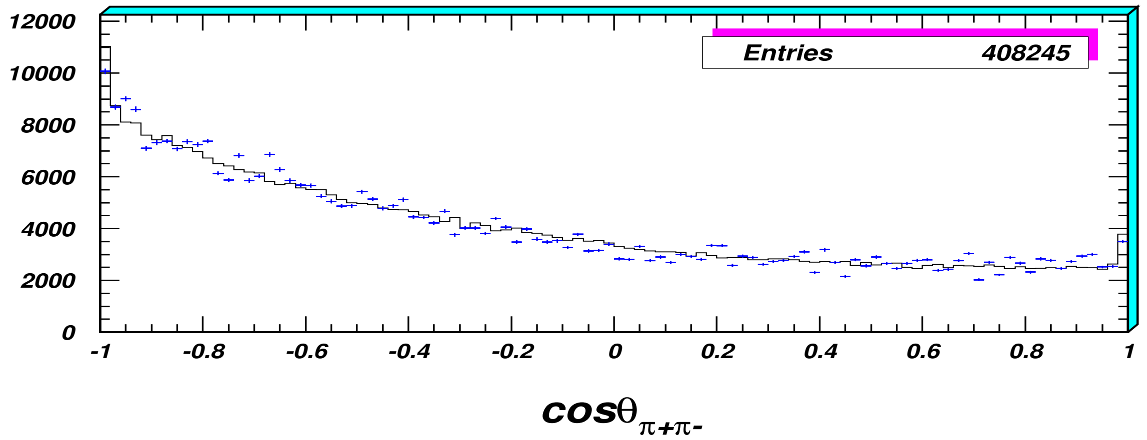


Figure 5: $|cos\theta_{\pi^+\pi^-}|$ distribution of anything events.The histogram is DATA and the cross is M.C.

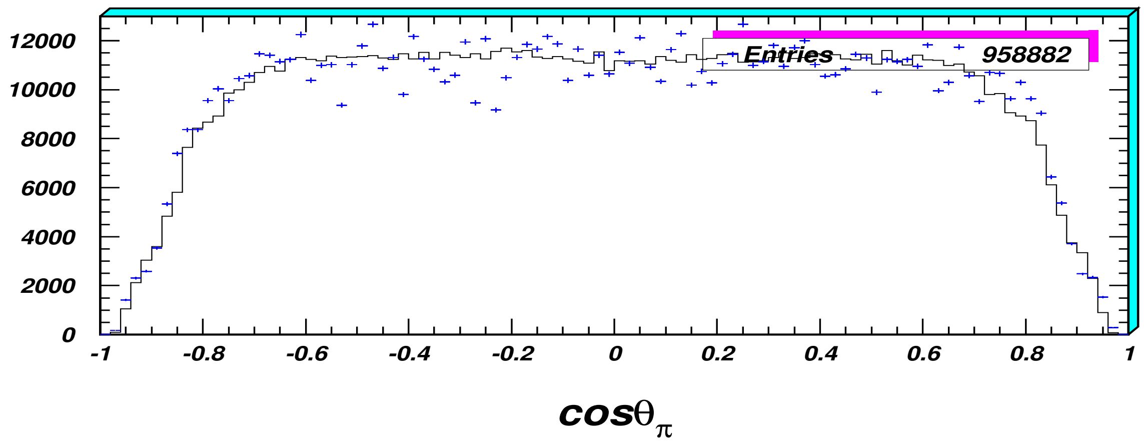


Figure 6: $cos\theta_{\pm}$ distribution of anything events.The histogram is DATA and the cross is M.C.

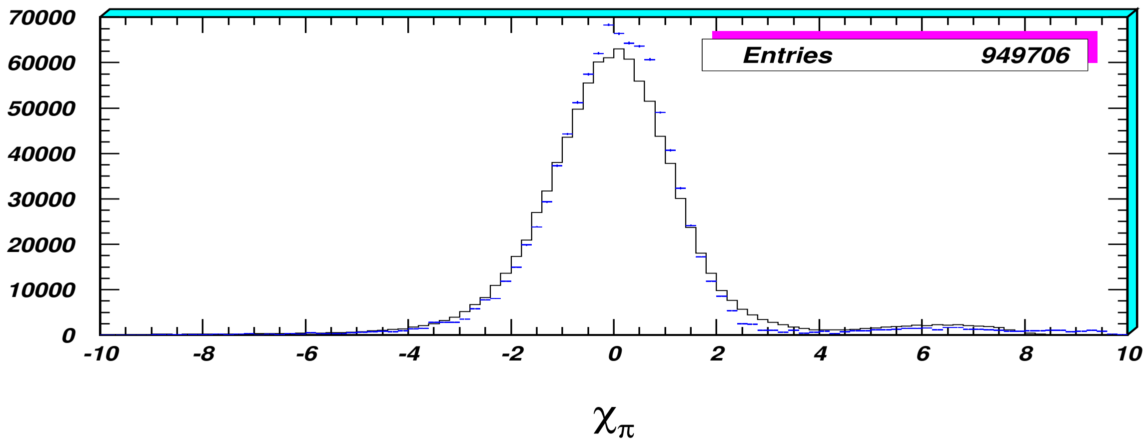


Figure 7: $\chi^{DEDX}_{\pi^{\pm}}$ distribution of anything events.The histogram is DATA and the cross is M.C.

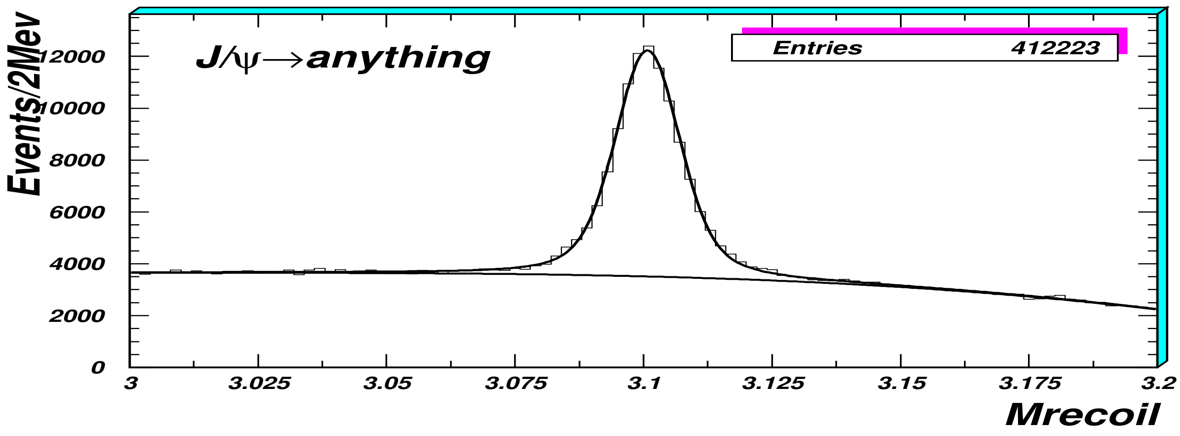


Figure 8: BW-fit of M_{recoil} of anthing events.(DATA)

```
================================================================================
I                      Summary Of BWFIT Results                                I
================================================================================
Histogram ID=   100  AdapQuad Breit-Wigner Fit using  100 Points
Fit Parameters:Npoly=   4 Nbw=   1 Namp=   0 Range=      3.000 To      3.200
Hist. Chisq =     133.70 for   6 params &  93 DF.
Chisquare Probability =   0.37%. Mean and S.D. for pulls:   -0.0040    1.1563
Likelihood ratio and probability             :     95.328        41.37%
Final Value of Log Likelihood                :   -701840.39
Error Correspond to a Function Chage         :     0.50
Phase Space limits for tails corrections     :      0.280GEV     2.817GEV
Breit-Wigner efficiency correction factors   :     0.982
Include Breit-Wigner tails outside fit region :       0.003
Efficiency-corrected events in fit region     :   412222.[average eff. :1.000]
---THE FITTED VALUES AND ERRORS OF THE PARAMETERS:---
    LEG1Value :-0.18689    Error(Cov,-/+):   0.297E-02  0.00      0.00
    LEG2Value :-0.11427    Error(Cov,-/+):   0.495E-02  0.00      0.00
    LEG3Value :-0.28635E-01Error(Cov,-/+):   0.459E-02  0.00      0.00
    AREAValue : 0.19365    Error(Cov,-/+):   0.155E-02  0.00      0.00
    RESLValue : 0.50000E-02Error(Cov,-/+):    0.00      0.00      0.00
    GAMAValue : 0.56340E-02Error(Cov,-/+):   0.145E-03  0.00      0.00
    MASSValue :  3.1008    Error(Cov,-/+):   0.412E-04  0.00      0.00
```

Figure 9: BW-fit results of M_{recoil} of anthing events.(DATA)

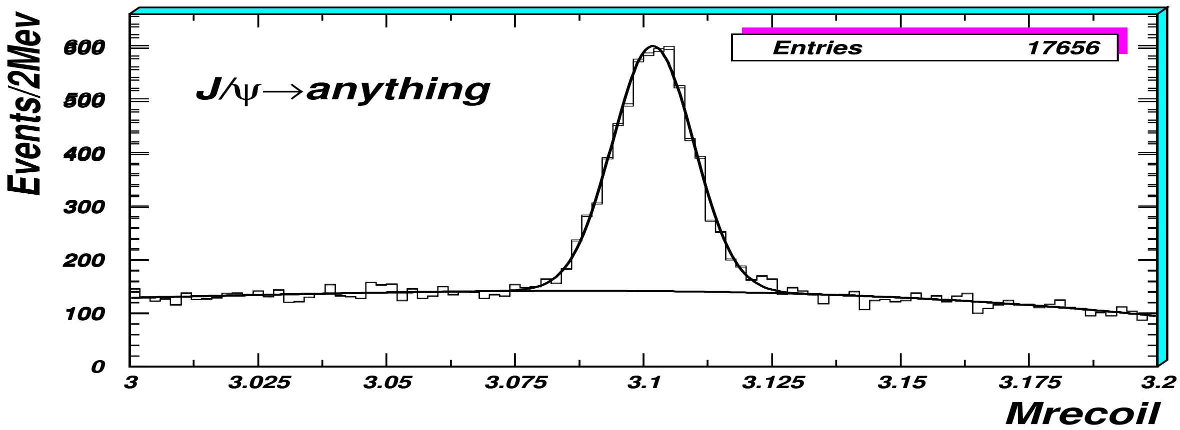


Figure 10: BW-fit of M_{recoil} of anthing events.(MC)

```
===============================================================================
I                     Summary Of BWFIT Results                                I
===============================================================================
Histogram ID=   100  Simpsons Breit-Wigner Fit using  100 Points
Fit Parameters:Npoly=   4 Nbw=   1 Namp=   0 Range=      3.000 To      3.200
Hist. Chisq =      73.08 for   6 params &  93 DF.
Chisquare Probability =  93.70%. Mean and S.D. for pulls:   -0.0009    0.8549
Likelihood ratio and probability             :     71.703        95.05%
Final Value of Log Likelihood                :    -31196.53
Error Correspond to a Function Chage         :     0.50
Phase Space limits for tails corrections     :      0.280GEV     2.817GEV
Breit-Wigner efficiency correction factors   :     1.000
Include Breit-Wigner tails outside fit region :      0.000
Efficiency-corrected events in fit region    :    17656.[average eff. :1.000]
---THE FITTED VALUES AND ERRORS OF THE PARAMETERS:---
    LEG1Value :-0.98768E-01Error(Cov,-/+):   0.147E-01  0.00      0.00
    LEG2Value :-0.15070    Error(Cov,-/+):   0.226E-01  0.00      0.00
    LEG3Value :-0.30905E-01Error(Cov,-/+):   0.229E-01  0.00      0.00
    AREAValue : 0.25673    Error(Cov,-/+):   0.546E-02  0.00      0.00
    RESLValue : 0.79006E-02Error(Cov,-/+):   0.178E-03  0.00      0.00
    GAMAValue :  0.0000    Error(Cov,-/+):    0.00      0.00      0.00
    MASSValue :  3.1018    Error(Cov,-/+):   0.177E-03  0.00      0.00
```

Figure 11: BW-fit results of M_{recoil} of anthing events.(MC)

Analyses of $\psi' \to \pi^+\pi^- J/\psi (J/\psi \to 4 - prongs)$

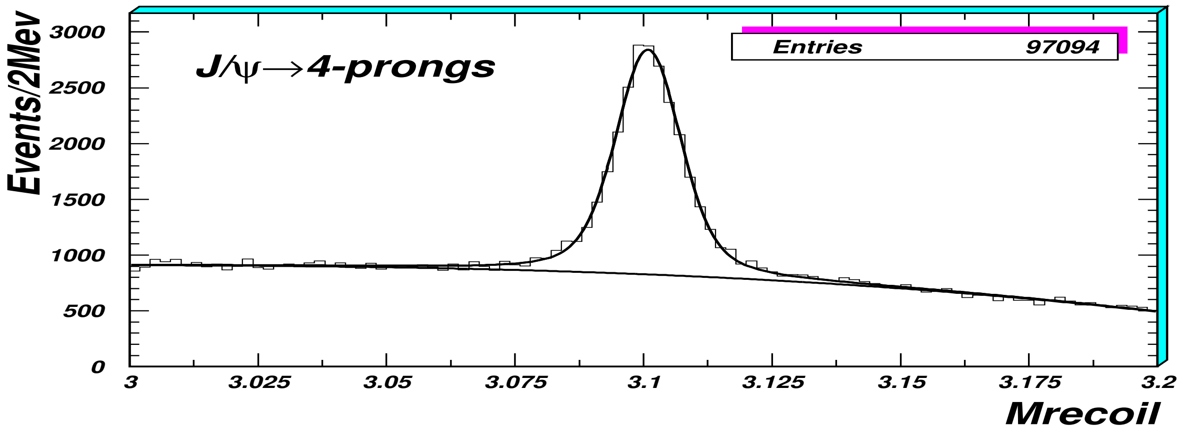


Figure 12: BW-fit of M_{recoil} of 4-prongs events.(DATA)

```
==============================================================================
I                      Summary Of BWFIT Results                              I
==============================================================================
Histogram ID=   100  AdapQuad Breit-Wigner Fit using  100 Points
Fit Parameters:Npoly=   4 Nbw=   1 Namp=   0 Range=      3.000 To      3.200
Hist. Chisq =       92.71 for   6 params &  93 DF.
Chisquare Probability =  48.89%. Mean and S.D. for pulls:   -0.0021    0.9629
Likelihood ratio and probability            :     83.673        74.50%
Final Value of Log Likelihood               :   -165430.81
Error Correspond to a Function Chage        :      0.50
Phase Space limits for tails corrections    :       0.280GEV     2.817GEV
Breit-Wigner efficiency correction factors  :      0.982
Include Breit-Wigner tails outside fit region :      0.003
Efficiency-corrected events in fit region   :    97094.[average eff. :1.000]
---THE FITTED VALUES AND ERRORS OF THE PARAMETERS:---
    LEG1Value :-0.25286    Error(Cov,-/+):   0.612E-02  0.00      0.00
    LEG2Value :-0.10927    Error(Cov,-/+):   0.102E-01  0.00      0.00
    LEG3Value :-0.12871E-01Error(Cov,-/+):   0.942E-02  0.00      0.00
    AREAValue : 0.19135    Error(Cov,-/+):   0.323E-02  0.00      0.00
    RESLValue : 0.50000E-02Error(Cov,-/+):    0.00      0.00      0.00
    GAMAValue : 0.57448E-02Error(Cov,-/+):   0.309E-03  0.00      0.00
    MASSValue :  3.1009    Error(Cov,-/+):   0.867E-04  0.00      0.00
```

Figure 13: BW-fit results of M_{recoil} of 4-prongs events.(DATA)

Step Four

- **The data we used have no trigger information,how to restore the trigger information of $J/\psi \to$ 4-prong sample to determine the trigger efficiency?**

Analyses of $\psi' \to \pi^+\pi^- J/\psi (J/\psi \to l^+ + l^-)$

Events Selection

1. $\pi^+\pi^-$ selection cuts

- **P**$_{\pi^\pm}$ <**0.6Gev**
- $|cos\theta_\pm|$ <**0.75**
- **Pxy>0.1Gev**
- $cos\theta_{\pi^+\pi^-}$ <**0.9**
- $\sqrt{\chi^2_{\pi^-} + \chi^2_{\pi^+}}$ <**3.0**
- $|M_{recoil} - 3.1|$ <**0.1Gev**

2. $\mathbf{l^+l^-}$ selection cuts

- **P**$l^\pm$ >**0.6Gev**
- **P**l^+ >**1.3Gev or P**l^- >**1.3Gev or P**l^-**+ P**l^+ >**2.4Gev**
- **cos**$\theta_{l^+l^-}$ >**-0.9**
- **e**$^+$ **e**$^-$
  - $|cos\theta^+_-|$ <**0.75**
  - μ**ID**$_-$**+** μ**ID**$_+$ <**2**
- $\mu^+\mu^-$
  - $|cos\theta^\pm|$ <**0.6**
  - μ**ID**$_-$ $\geq$**2,** μ**ID**$_+$ $\geq$**2**

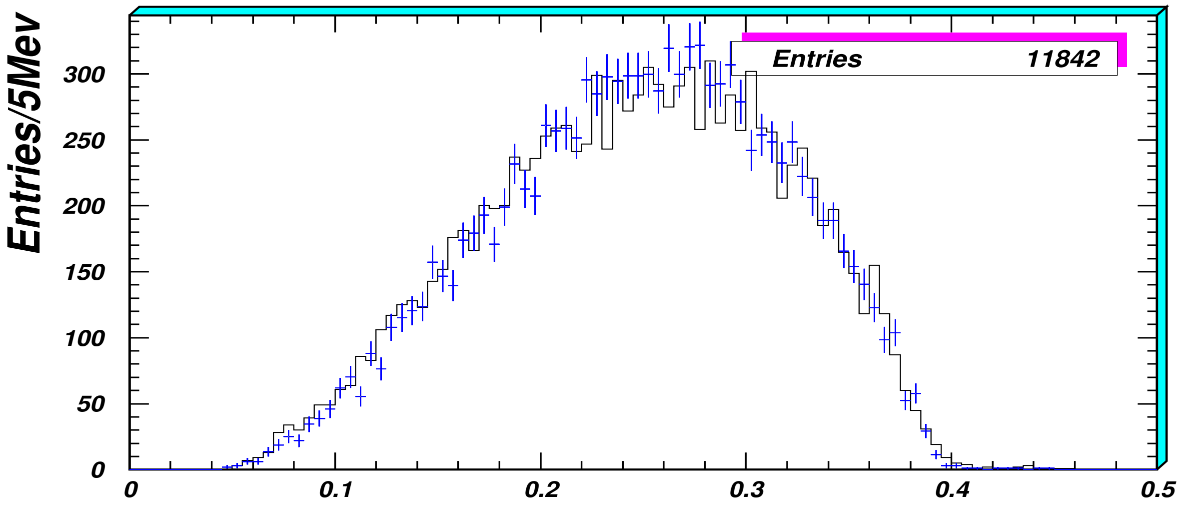


Figure 14: p_π distribution without p_π cut and pxy $_\pi$ cut, the histogram represent the data and the cross for Monto Carlo.

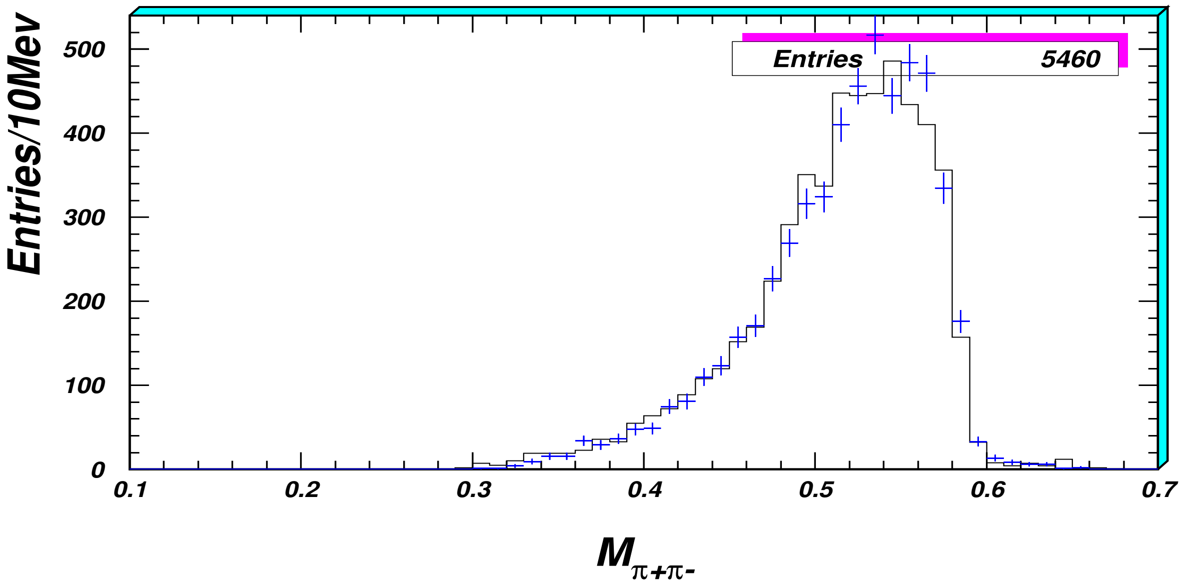


Figure 15: $M_{\pi^+\pi^-}$ distribution. The histogram represent the data and the cross for Monto Carlo.

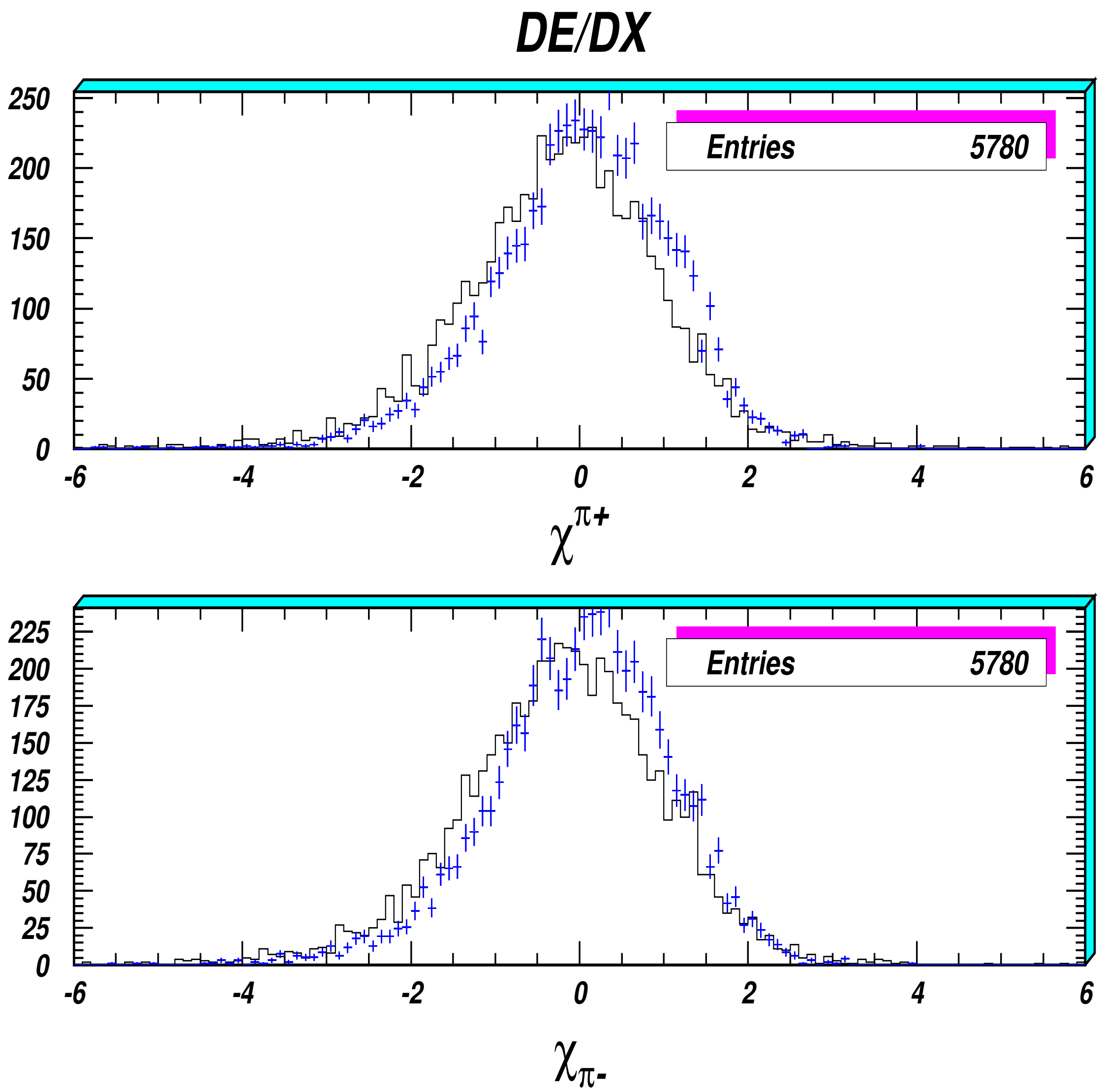


Figure 16: χ_π distribution and fittin results.The histogram represent the data and the cross for Monto Carlo

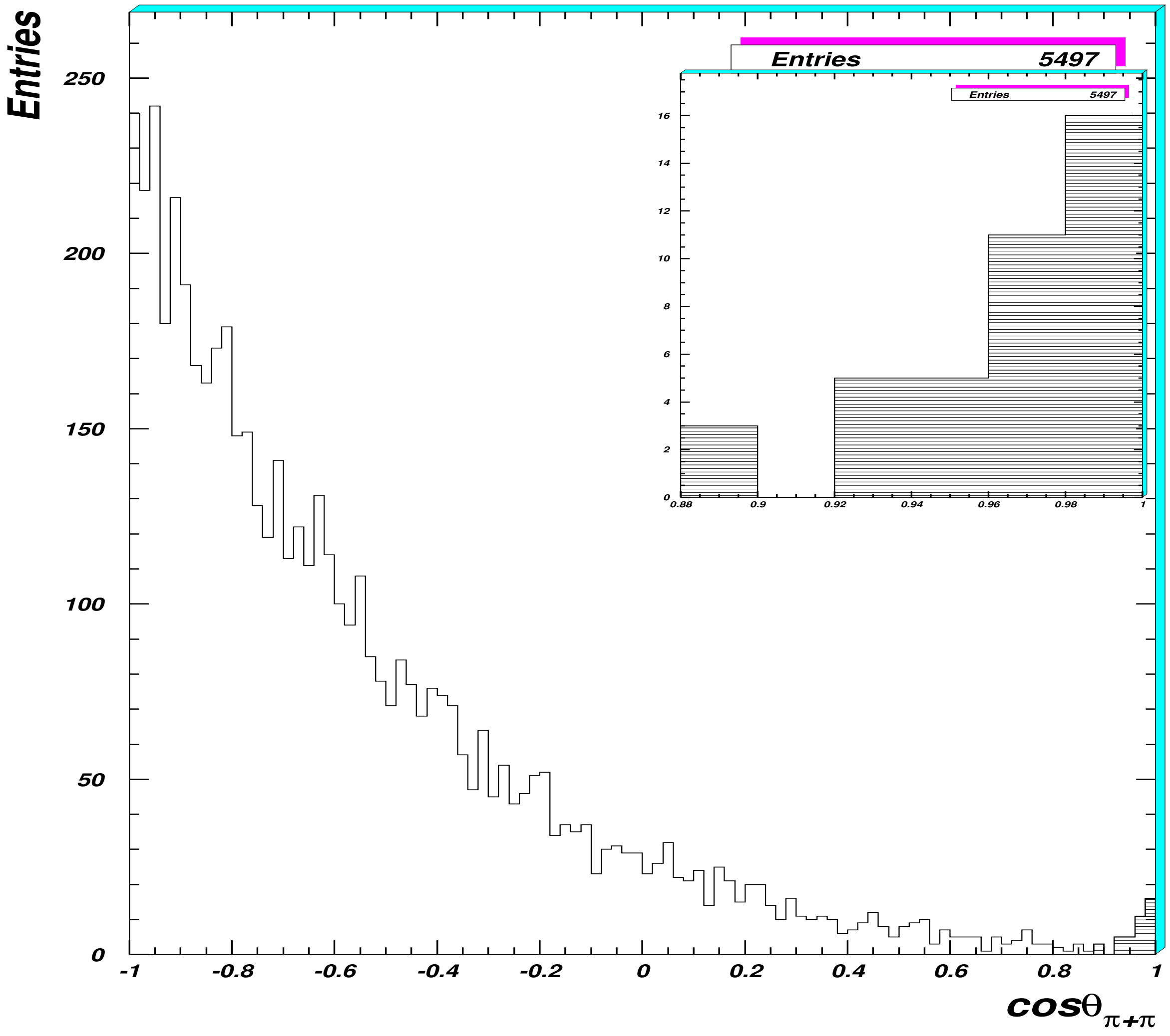


Figure 17: $\cos\theta_{\pi^+\pi^-}$ distribution.The high contribution near to 1 comes from the γ-conversion e^+e^-. represent the data and the cross for Monto Carlo.

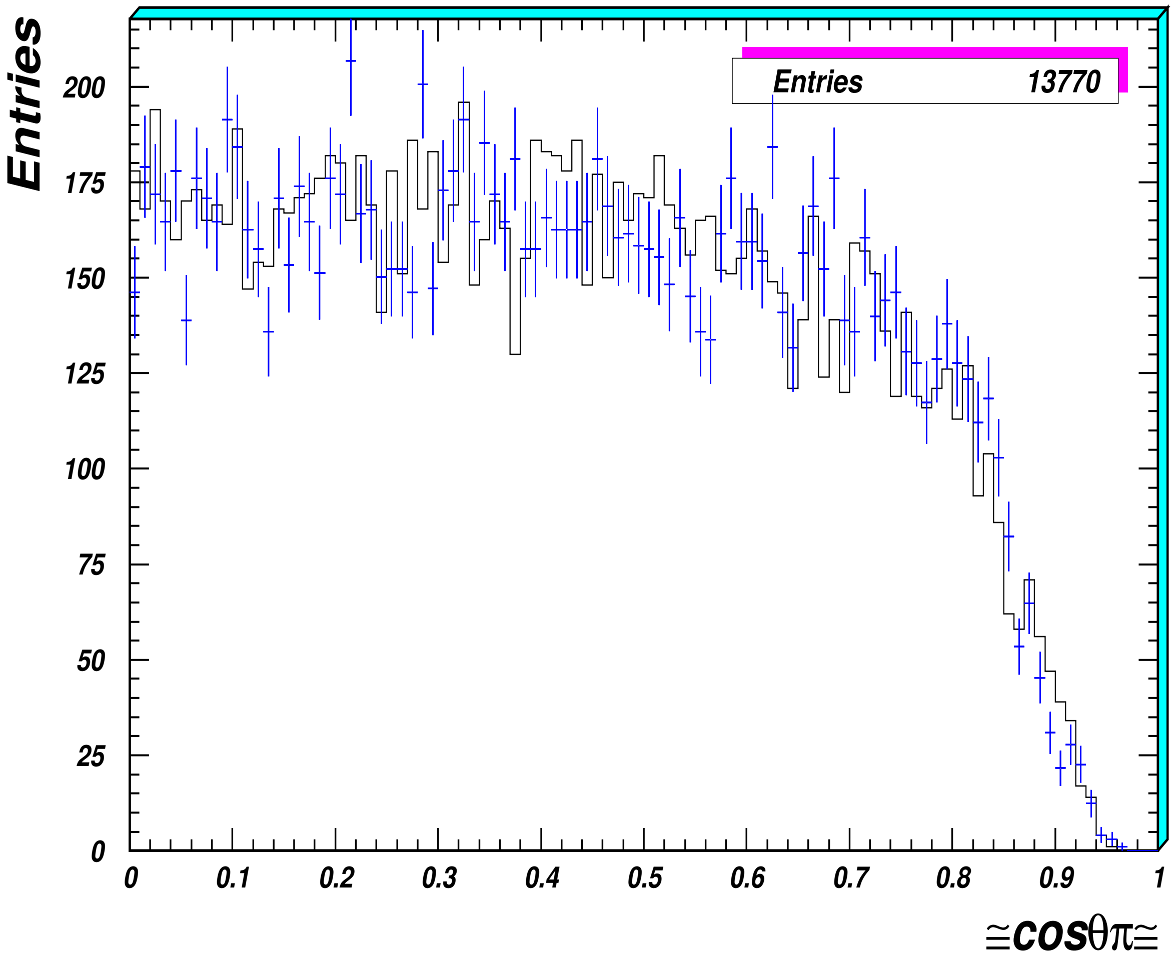


Figure 18: $|cos\theta_{\pi\pm}|$ distribution. the histogram represent the data and the cross for Monto Carlo.

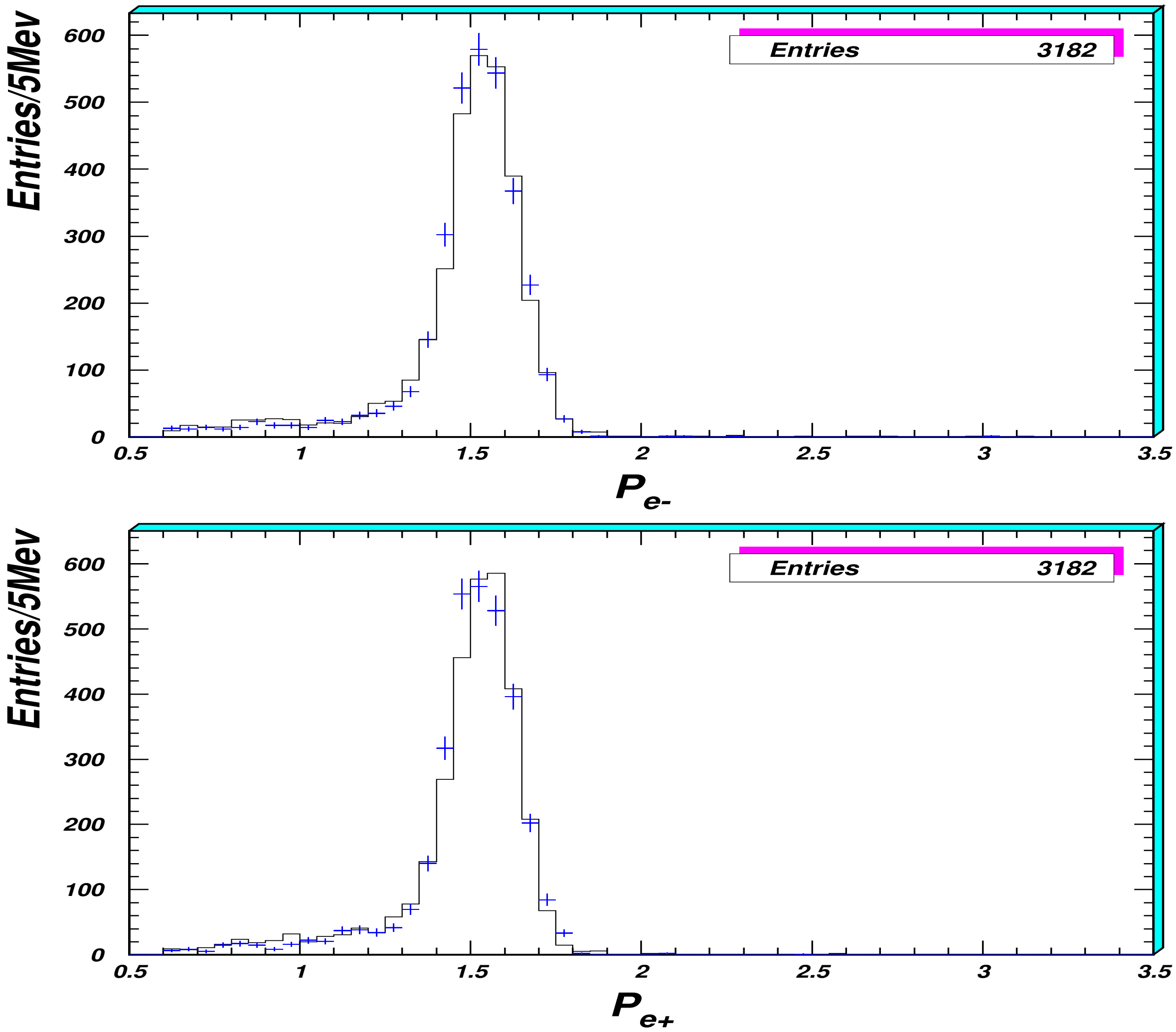


Figure 19: Pe distribution.the histogram represent the data and the cross for Monto Carlo.

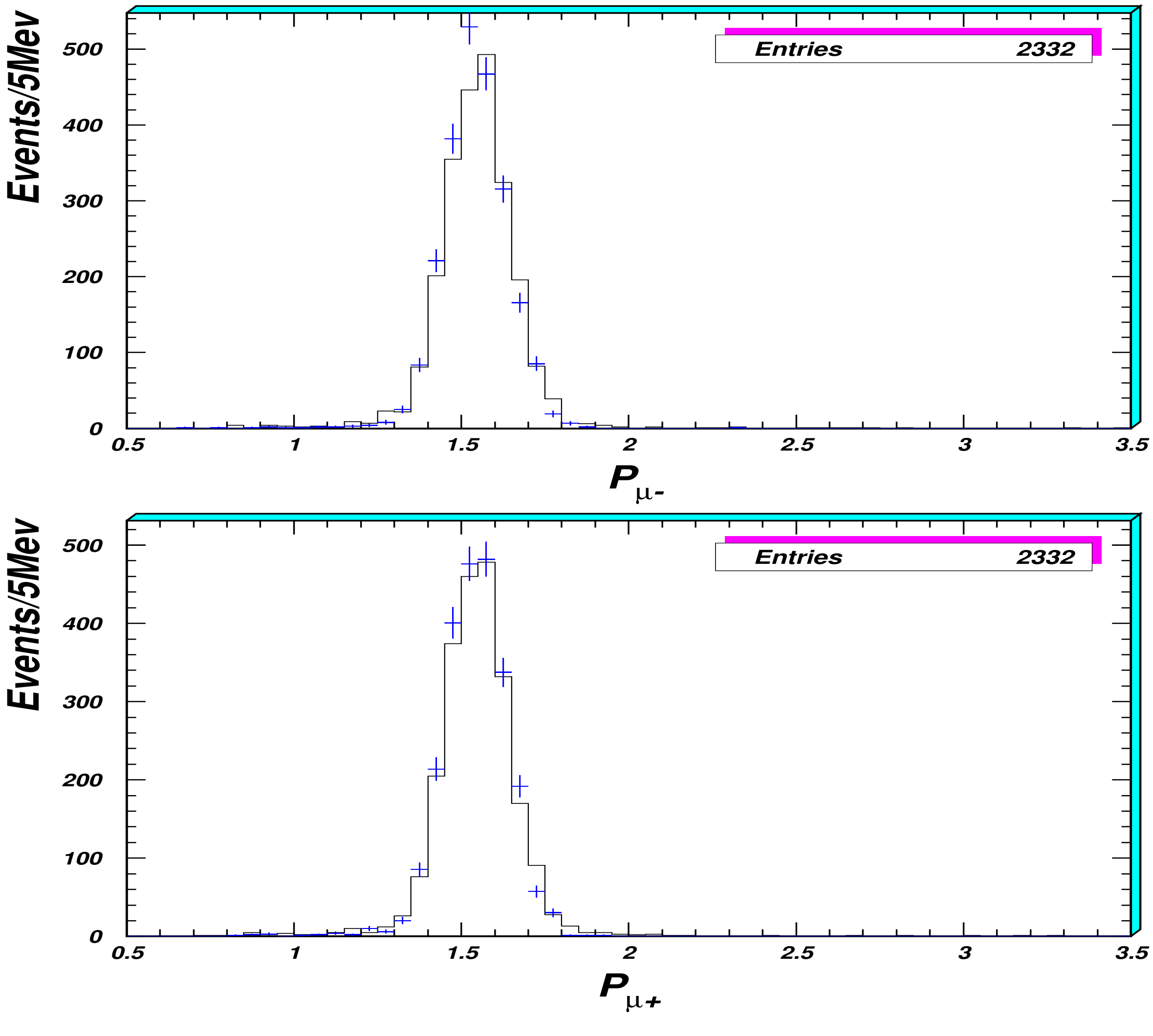
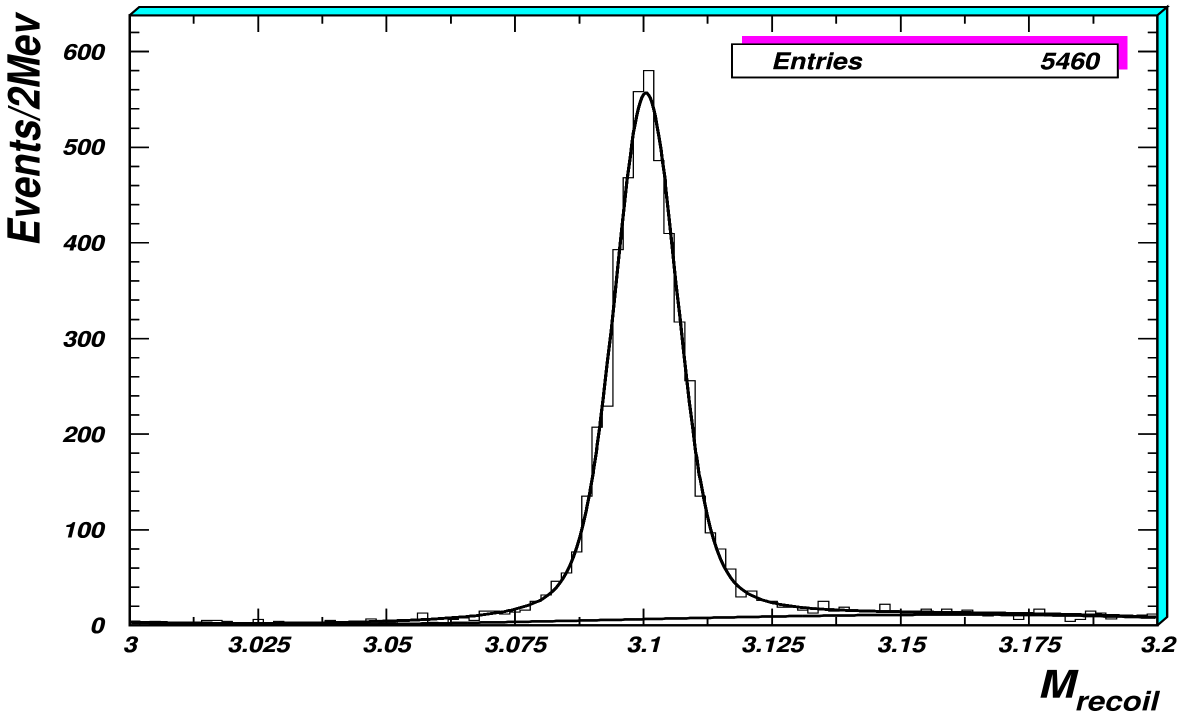
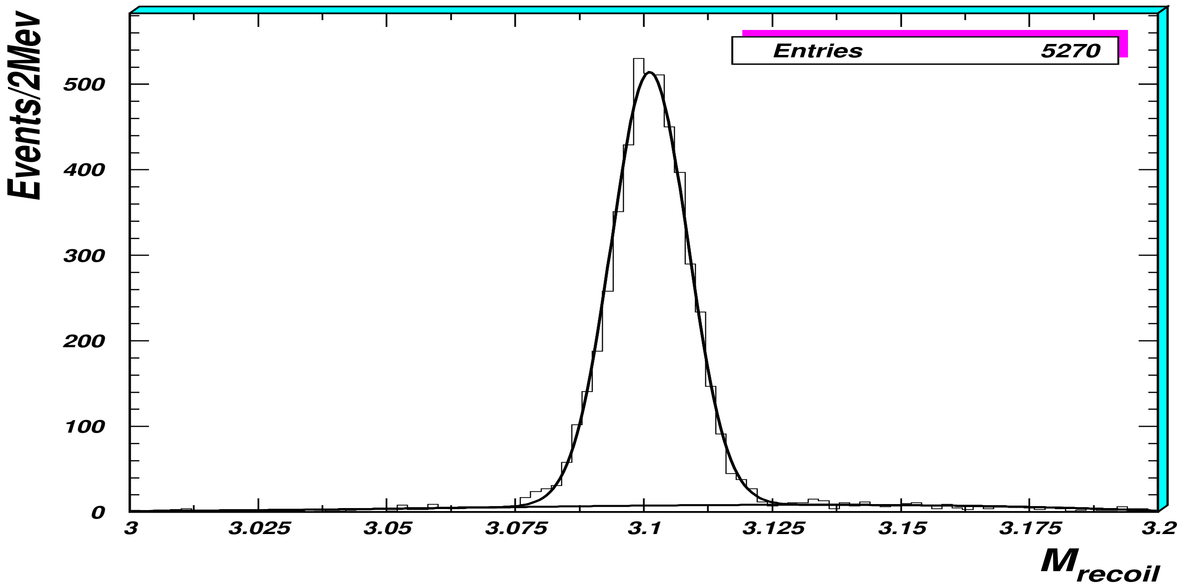


Figure 20: Pμ distribution.the histogram represent the data and the cross for Monto Carlo.




```
===============================================================================
I                      Summary Of BWFIT Results                              I
===============================================================================
Histogram ID=   100  AdapQuad Breit-Wigner Fit using  100 Points
Fit Parameters:Npoly=   4 Nbw=   1 Namp=   0 Range=      3.000 To      3.200
Hist. Chisq =     108.99 for   7 params &  92 DF.
Chisquare Probability =  10.91%. Mean and S.D. for pulls:   -0.0081    1.0439
Likelihood ratio and probability              :    112.254         7.43%
Final Value of Log Likelihood                 :    -15797.16
Error Correspond to a Function Chage          :     0.50
Phase Space limits for tails corrections      :      0.280GEV     2.817GEV
Breit-Wigner efficiency correction factors    :     0.985
Include Breit-Wigner tails outside fit region :       0.002
Efficiency-corrected events in fit region     :     5460.[average eff. :1.000]
---THE FITTED VALUES AND ERRORS OF THE PARAMETERS:---
    LEG1Value :  1.0170    Error(Cov,-/+):   0.110      0.00      0.00
    LEG2Value :-0.11347    Error(Cov,-/+):   0.166      0.00      0.00
    LEG3Value :-0.61019    Error(Cov,-/+):   0.122      0.00      0.00
    AREAValue : 0.88738    Error(Cov,-/+):   0.122E-01  0.00      0.00
    RESLValue : 0.50652E-02Error(Cov,-/+):   0.264E-03  0.00      0.00
    GAMAValue : 0.48300E-02Error(Cov,-/+):   0.599E-03  0.00      0.00
    MASSValue :  3.1005    Error(Cov,-/+):   0.113E-03  0.00      0.00
```

Figure 21: BW-fit of invariant mass recoiling $m_{\pi^+\pi^-}$(DATA)




```
=============================================================================
I                     Summary Of BWFIT Results                              I
=============================================================================
Histogram ID=   100  Simpsons Breit-Wigner Fit using  100 Points
Fit Parameters:Npoly=   4 Nbw=   1 Namp=   0 Range=      3.000 To      3.200
Hist. Chisq =     107.94 for   6 params &  93 DF.
Chisquare Probability =  13.79%. Mean and S.D. for pulls:   -0.0011    1.0389
Likelihood ratio and probability            :    107.139        14.99%
Final Value of Log Likelihood               :    -16310.78
Error Correspond to a Function Chage        :     0.50
Phase Space limits for tails corrections    :      0.280GEV     2.817GEV
Breit-Wigner efficiency correction factors  :     1.000
Include Breit-Wigner tails outside fit region :      0.000
Efficiency-corrected events in fit region   :     5270.[average eff. :1.000]
---THE FITTED VALUES AND ERRORS OF THE PARAMETERS:---
    LEG1Value : 0.42412    Error(Cov,-/+):   0.623E-01  0.00      0.00
    LEG2Value :-0.76439    Error(Cov,-/+):   0.672E-01  0.00      0.00
    LEG3Value :-0.40542    Error(Cov,-/+):   0.887E-01  0.00      0.00
    AREAValue : 0.89740    Error(Cov,-/+):   0.541E-02  0.00      0.00
    RESLValue : 0.74486E-02Error(Cov,-/+):   0.939E-04  0.00      0.00
    GAMAValue :  0.0000    Error(Cov,-/+):    0.00      0.00      0.00
    MASSValue :  3.1011    Error(Cov,-/+):   0.116E-03  0.00      0.00
```

Figure 22: BW-fit results of invariant mass recoiling $M_{\pi^+\pi^-}$(MC)

Preliminary Results

nia	$J/\psi \rightarrow$	N_{ll}^{sel}	Area	N_{ll}^{obs}	Mrecoil(Mev)
DATA	$e^+ + e^-$	3130	0.8791± 0.0165	2752± 52	3100.3±0.15
	$\mu^+ + \mu^-$	2330	0.8963± 0.0183	2088±42	3100.6±0.17
	$l^+ + l^-$	5460	0.8874± 0.0122	4845±66	3100.5±0.11
	any(ΣQ=0)	190900	0.23093± 0.00228	44084±435	3100.9±0.042
	any($\Sigma Q \neq$)	412223	0.193653± 0.00155	79826±638	3100.8±0.040
	4-pn(ΣQ=0)	53683	0.20356±0.00442	10927±237	3100.7±0.085
	4-pn($\Sigma Q \neq$0)	97094	0.19135±0.00323	18578±313	3100.8±0.082
M.C.	$e^+ + e^-$	2864	0.90114± 0.0072	2751± 21	3101.2±0.155
	$\mu^+ + \mu^-$	2327	0.89866± 0.0082	2088±44	3100.8±0.17
	$l^+ + l^-$	5270	0.8974± 0.0054	5203±28	3101.1±0.12
	any(ΣQ=0)	7921	0.32365±0.00819	2564±64	3101.6±0.161
	any(ΣQ≠0)	17656	0.25673±0.00546	4533±96	3101.7±0.165
	4-prong	− − − − −	− − − − −	− − − − −	− − − − −

Table 1: Mrecoil fitting results .

Summary

1. **In absence of trigger,and manual scan fficiency,we get the R_4=0.2341±0.0082 and the number of J/ψ is about 2.57×10^7.**
2. **We also don't allow for the deference of dedective fficiency between the J/ψ →anything and J/ψ →4-prongs.**

	$J/\psi \to$	$\Gamma \pm \sigma_\Gamma$ (Mev)	R $\pm\sigma_R$(Mev)
DATA	$e^+ + e^-$	4.456± 0.823	5.330±0.351
	$\mu^+ + \mu^-$	5.161±0.876	4.774±0.399
	$l^+ + l^-$	5.065± 0.264	4.830±0.599
	any(ΣQ=0)	5.528±0.180	5.000±0.000
	any(ΣQ≠0)	5.634±0.145	5.000±0.000
	4-pn(ΣQ=0)	6.319±0.407	5.000±0.000
	4-pn(ΣQ≠0)	5.745±0.309	5.000±0.000
M.C.	$e^+ + e^-$	− − − − − −	7.416±0.123
	$\mu^+ + \mu^-$	− − − − − −	7.343±0.136
	$l^+ + l^-$	− − − − − −	7.445± 0.094
	any(ΣQ=0)	− − − − − −	7.832± 0.215
	any(ΣQ≠0)	− − − − − −	7.901± 0.178
	4-prongs	− − − − − −	− − − − − −

Table 2: Mrecoil fitting results of parameters

$J/\psi \to$	e$^+ + e^-$	$\mu^+ + \mu^-$	l$^+ + l^-$	anything
N$_{J/\psi}$	177109±3631	166157±3812	154797±2309	176108±4001(ΣQ≠0)

Table 3: Number of J/ψ determined ,respectively,by $J/\psi \to e^+ + e^-$,$\mu^+ + \mu^-$, $l^+ + l^-$ and anything.