BESII J/ψ data status, quality check and future work

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Abstract

The status of about 22 million new collected BESII J/ψ data is briefly introduced and the quality check to these data is performed through the general check from bhabha, dimuon and hadron samples, the inclusive signal check and the check from $J/\psi \to \rho\pi$, K^*K, $\omega\pi\pi$ and $\phi\pi\pi$. All these checks show a good quality of the data. Basic work related to this data sample is mentioned and some very preliminary results are presented, including the results from inclusive γ spectrum. Some important physics topics based on new J/ψ data are listed for our future work.

1 Data sample

From November of 1999, BESII started her new run of J/ψ data taking. Till May 15 of 2000, about 22 million J/ψ events have been collected. In addition, 0.56 million online hadron events at $\psi(2S)$ energy and 10K online hadron events at 3.0 GeV are accumulated for determining the magnetic filed correction factor, J/ψ total number and background study. By the end of year 2001, we are going to accumulate 50 million J/ψ events.

The following is a list of the run numbers for each period of run. The data taking situation and J/ψ event samples in the world are shown in Fig. 1 and Fig. 2, respectively.

Run 13531 – Run 15442	(J/ψ)
Run 15443 – Run 15489	(3.0 GeV)
Run 15490 – Run 16835	(J/ψ)
Run 16853 – Run 17018	($\psi(2S)$)

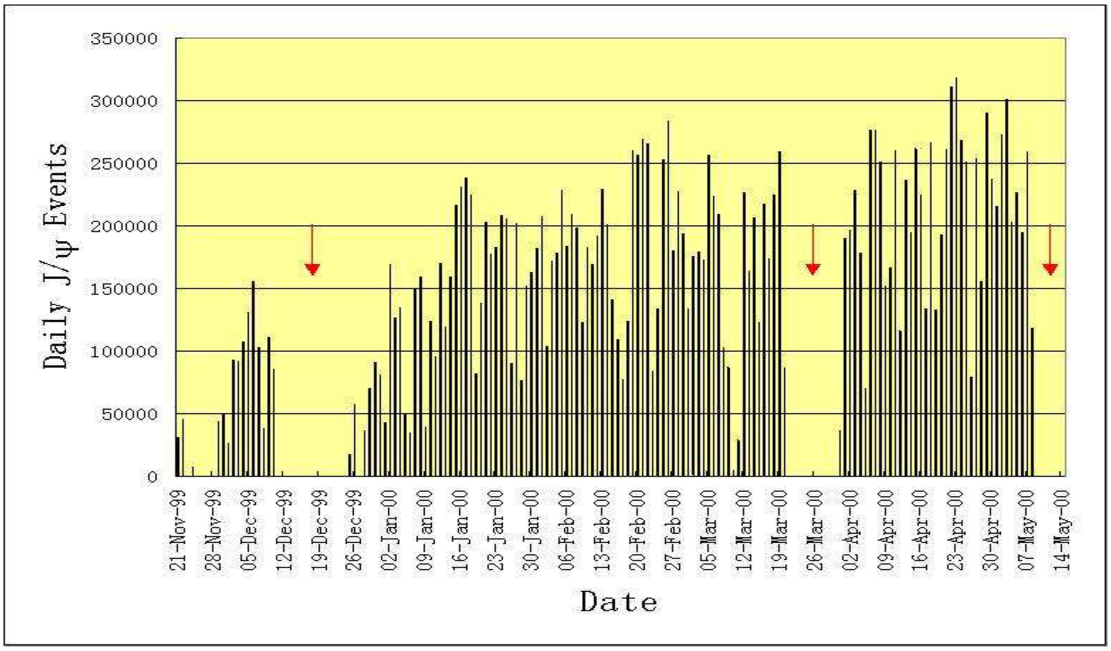

Figure 1: Daily J/ψ events

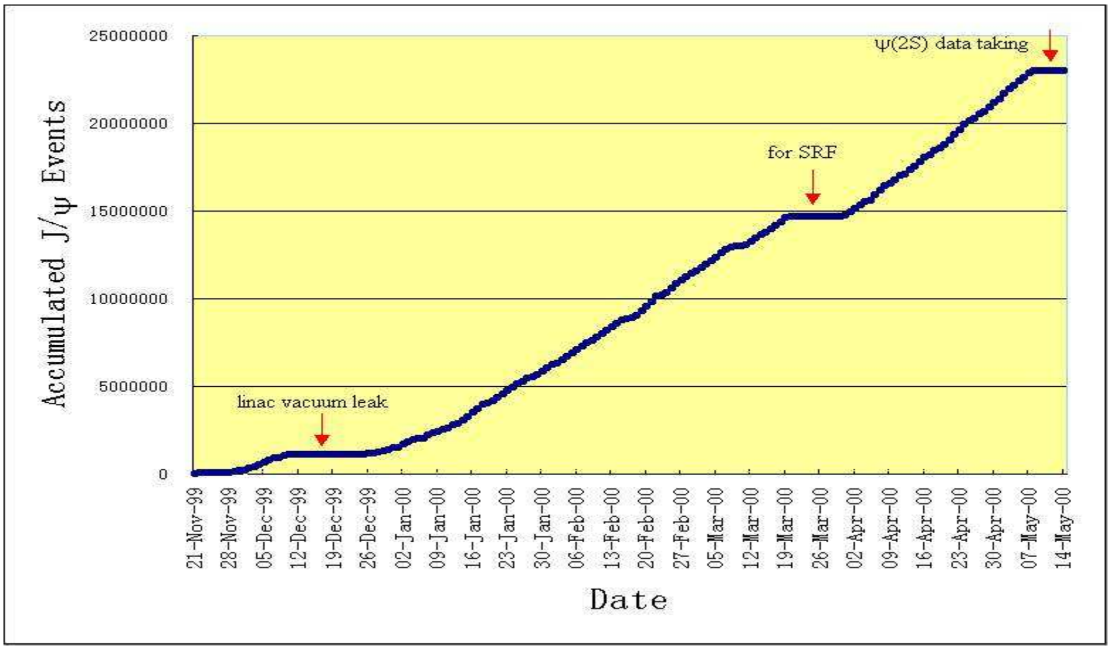

Figure 2: Integrated J/ψ events

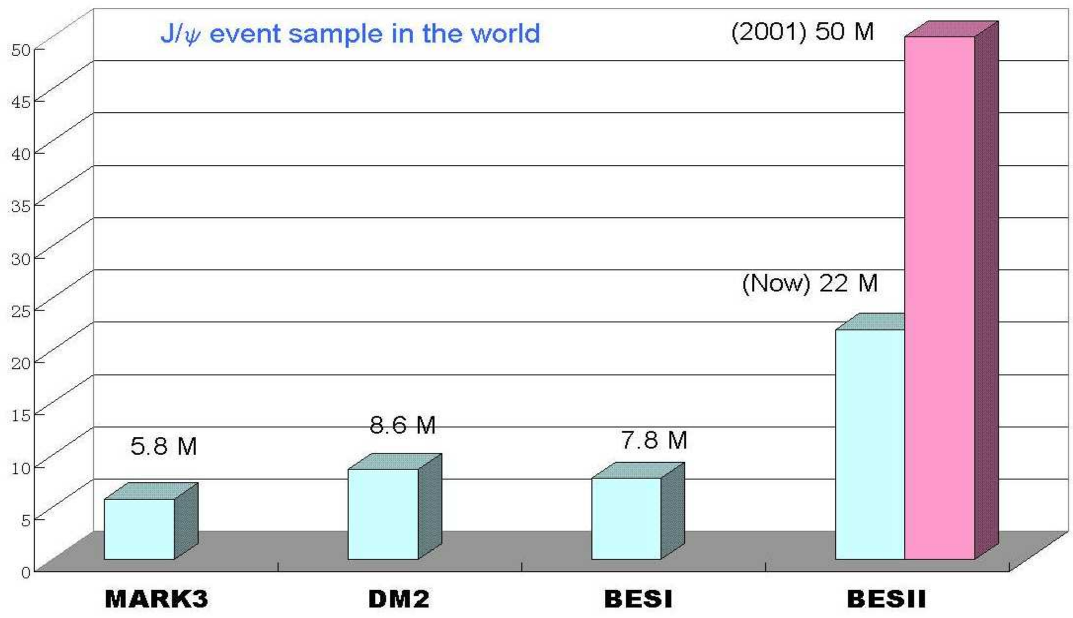

Figure 3: J/ψ event samples in the world

2 Data quality check

2.1 A general check from bb, $\mu\mu$ and hadron events

A general quality check from bb, $\mu\mu$ and hadron events is performed by choosing 3 groups of run: run13770 to run13800, run14601 to run14640 and run16601 to run16640. We also compared the data from run14601 – run14640 constructed with different reconstruction versions. Table 1 shows us the major parameters of subdetectors from BESI and BESII data. Compared with BESI, the time resolution of TOF for BESII (around 180 ps) is much better than that of BESI, and the momentum resolution of MDC ($\alpha \sim 1.6\% - 1.9\%$), as well as the energy resolution of BSC (around 23%) are slightly better for BESII. From this table and many other distributions which reveal the performance of each subdetector, we can see in general that BES was running smoothly and stably during the data taking period and the data quality is quite good. However, there are still some problems left to be understood and solved, such as the ϕ distribution for dimuon events and the abnormal fluctulation for the ratio of the number of 0-prong events to that of total events.

2.2 Inclusive signal check

Fig. 4 - Fig. 7 [2] show the inclusive Λ, K_s^0, K^* and ϕ signals of J/ψ decays for the data from run13700 to run15000, reconstructed with 2 reconstruction versions. The masses of the inclusive signals agree with the PDG values.

Table 1: Major parameters of sub-detectors [1]

Sub-detector ↓	BESI	13770-13800	14601-14640 (1st round rec.)	14601-14640 (2nd round rec.)	16601-16640
Vertex (cm)					
σ_{x_0}	0.09	0.13	0.13	0.12	0.12
σ_{y_0}	0.10	0.13	0.13	0.12	0.12
σ_{z_0}	3.8	2.8	2.8	2.9	3.0
MDC $\alpha(\%)$ $\sigma_p/p = \alpha\sqrt{1+p^2}$	2.0	2.5	1.7	2.0	1.9
dE/dx pulse height $\delta ph/ph(\%)$	7.9	8.3	8.3	8.3	8.1
TOF time resolution (ps)	369	177	177	183	191
BSC (cm)					
$\sigma_E/E = \alpha\%/\sqrt{E}$	25.0	24.3	23.1	23.1	23.1
σ_x	–	0.30	0.27	0.29	–
σ_y	–	0.27	0.28	0.28	–
σ_z	–	3.8	3.1	3.3	3.5
MUID (cm)					
σ_x	–	3.5	3.4	3.4	3.4
σ_y	–	3.5	3.3	3.5	3.5
σ_z	–	8.6	7.9	6.1	6.2

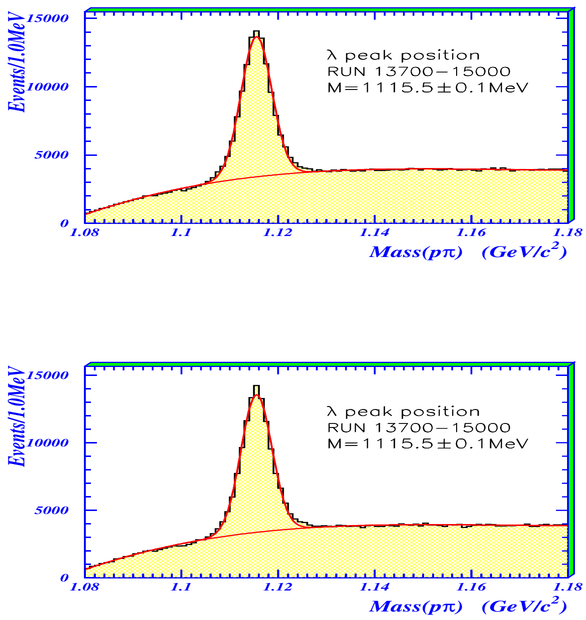

Figure 4: Inclusive Λ signal. up: 1st round rec., down: 2nd round rec.

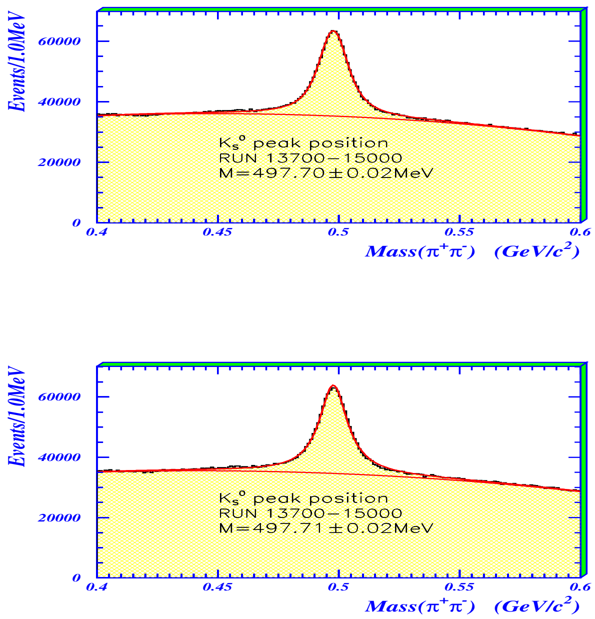

Figure 5: Inclusive K_s^0 signal. up: 1st round rec., down: 2nd round rec.

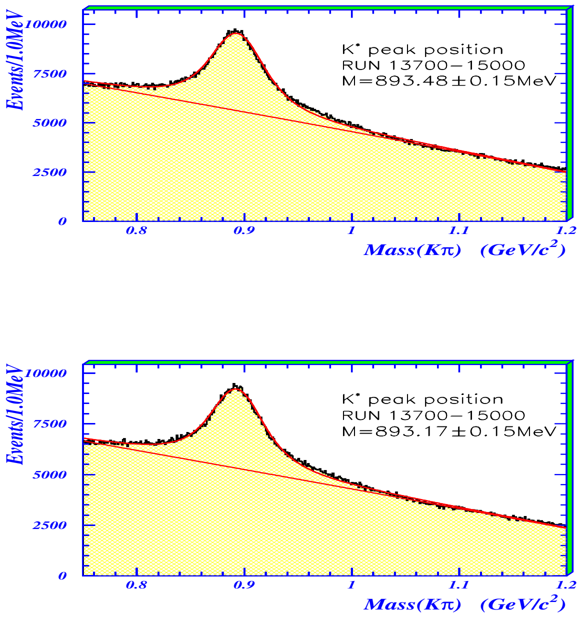

Figure 6: Inclusive K^* signal. up: 1st round rec., down: 2nd round rec.

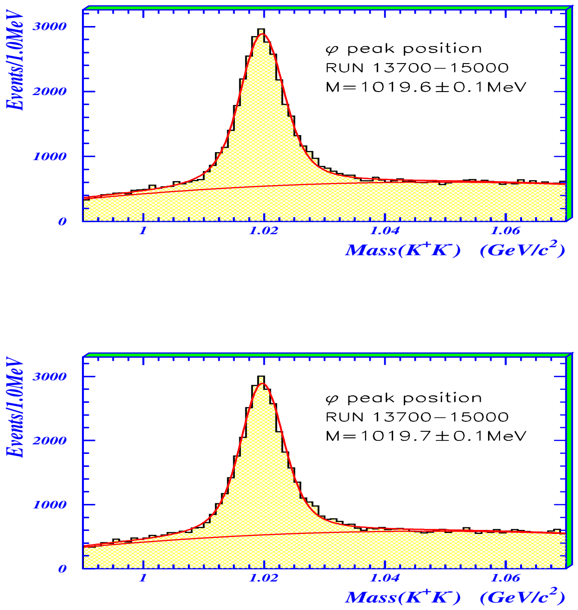

Figure 7: Inclusive ϕ signal. up: 1st round rec., down: 2nd round rec.

2.3 Quality check from some decay channels

We also looked at some decay channels which have relatively large branching ratios, such as, $J/\psi \to \rho\pi$, K^*K, $\phi\pi\pi$ and $\omega\pi\pi$. The invariant mass spectra for both BESI and BESII data are shown in Fig. 8 - Fig. 17. From these figures, it is obviously that the selection efficiency for BESII data is much higher than that for BESI data, and BESII data quality is quite good.

3 Basic work for BESII data

TELESIS, as an essential tool in data analysis, performs the kinematic fit by imposing energy and momentum constraints to energies and momenta of tracks and adjusts them within the measured errors to satisfy the energy and momentum conservation for a choosing process. Therefore, TELESIS can improve the momentum and energy resolution for both charged and neutral tracks and can suppress the background events. It is then very important that we have the correct track's momentum and error matrix before the kinematic fit.

In TELESIS package, dE/dx energy loss before the inner wall of MDC is calculated and the corrections, comming from the multiple Coulomb scattering (MCS) and dE/dx effects, to the geometric error matrix are made for charged tracks. In BESII, the formal central drift chamber was replaced by a vertex chamber and a new beam pipe was installed. According to the material parameters of BESII, the modification of TELESIS package concerning with the error matrix corrections for charged tracks has been finished [3]. The error matrix corrections for neutral tracks are in progress now.

The time resolution and time-offset corrections of TOF are studied based on BESII J/ψ data and a particle identification package for TOF is finished and will be released soon for public use [4].

The total J/ψ number is determined from $J/\psi \to \mu^+\mu^-$ [5]. A cross check of this determination will be performed through $J/\psi \to e^+e^-$ and $J/\psi \to 4$ prongs processes.

4 Some preliminary results

$\xi(2230)$, observed by some experiments including BES, is considered as a 2^{++} glueball candidate. Thus, the confirmation of this state is of great meanings. With new accumulated J/ψ events, we had a look at $J/\psi \to \gamma K^+K^-$ channel, the first place $\xi(2230)$ was found. Fig. 17 shows a peak around 2.23 GeV in K^+K^- invariant mass spectrum with only about 8 million J/ψ events. All 22 million J/ψ events will be used to reanalyze this channel.

J/ψ radiative decays $J/\psi \to \gamma X$ is a rich source of glueballs. Therefore, except for studying J/ψ radiative decays exclusively, the study of the inclusive γ spectrum is another way for us to hunt for glueballs. However, due to the poor energy resolution of BSC ($\sim 23\%/\sqrt{E}$), it's hard to have a convincing inclusive γ spectrum by detecting photons from BSC. Taking the advantage of the good momentum resolution of MDC ($\sim 1.8\%\sqrt{1+p^2}$), we use the γ conversion to e^+ and e^- and then measure the momenta and so energis of e^+ and e^- in MDC to avoid using BSC information [6]. The energy resolutions of e^+e^- at different energy of converted photons are plotted in Fig. 18, from which one can see that

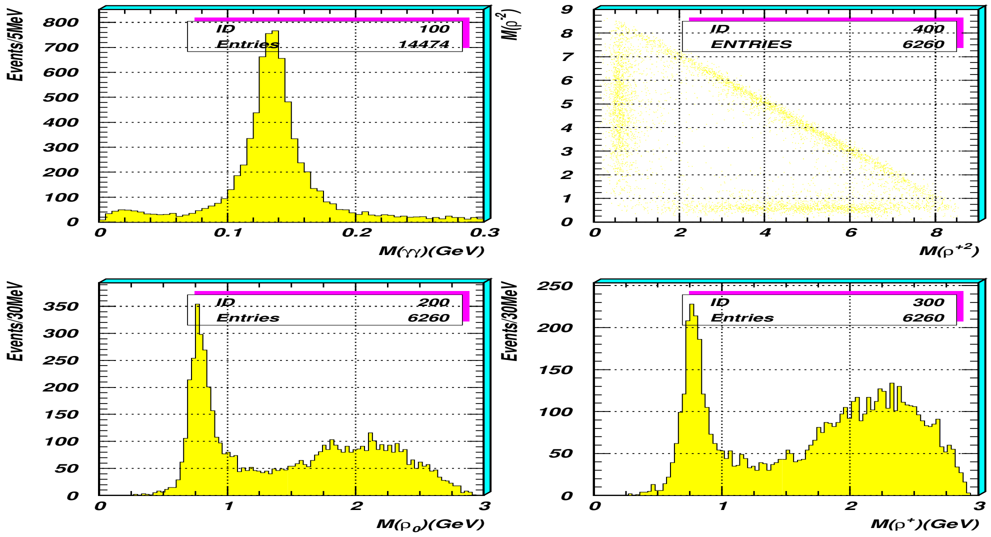

Figure 8: $J/\psi \to \rho\pi$, BESI data, Run462-961, $\sim$ 2.6M.

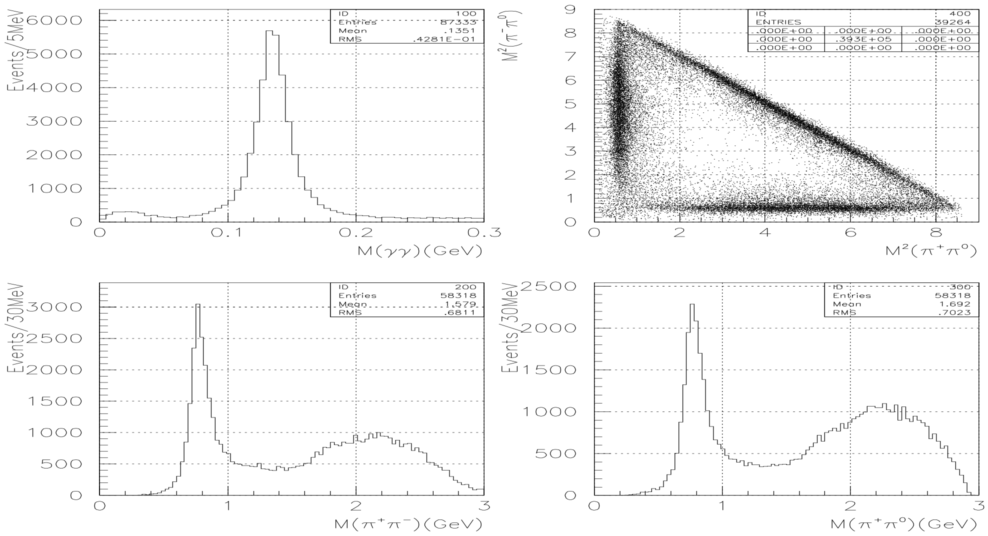

Figure 9: $J/\psi \to \rho\pi$, BESII data, Run13700-15032, $\sim$ 10M.

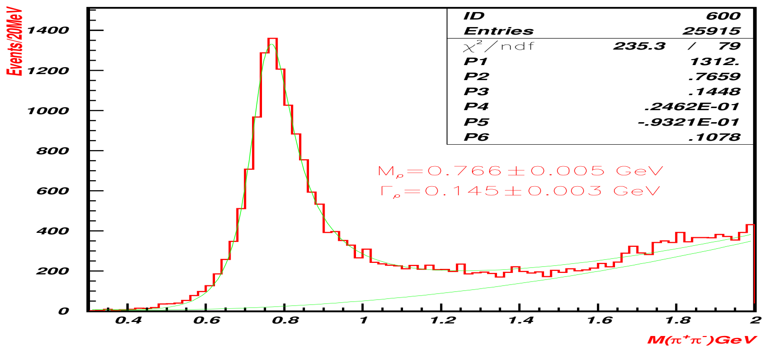

Figure 10: ρ mass fit, BESII data, Run13700-15032, $\sim$ 10M.

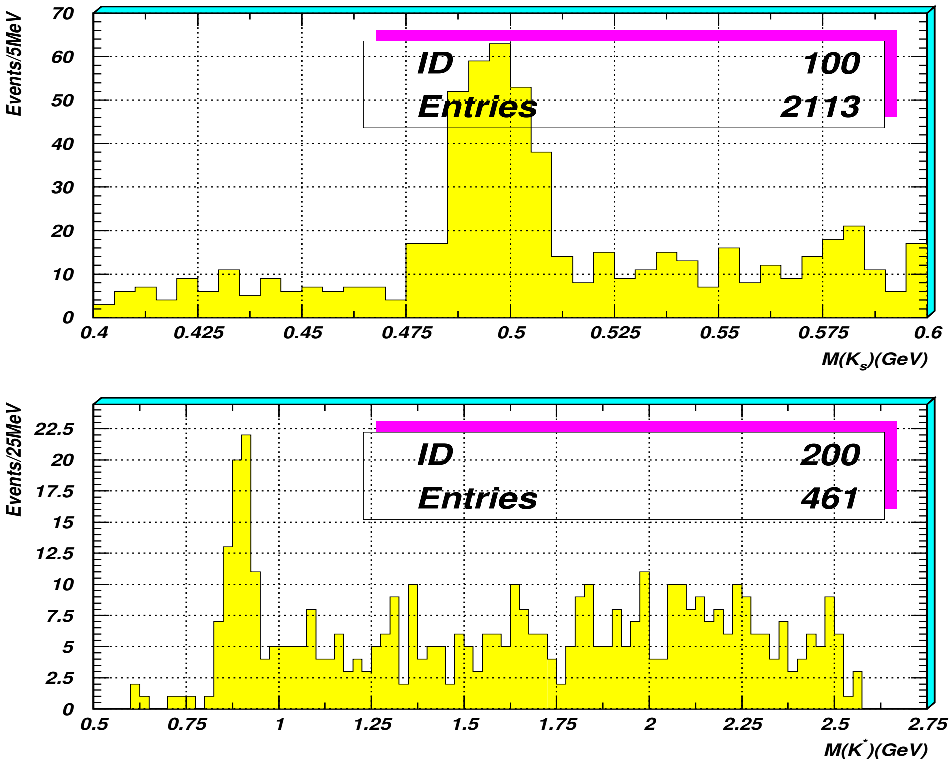

Figure 11: $J/\psi \to K^*K$, BESI data, Run462-961, $\sim$ 2.6M.

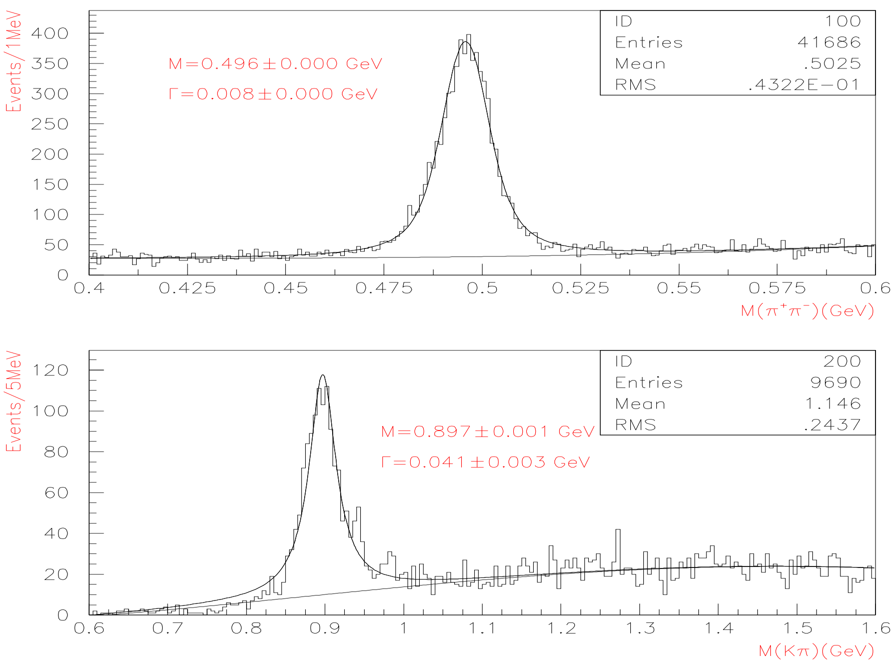

Figure 12: $J/\psi \to K^*K$, BESII data, Run13700-16835, $\sim$ 22M.

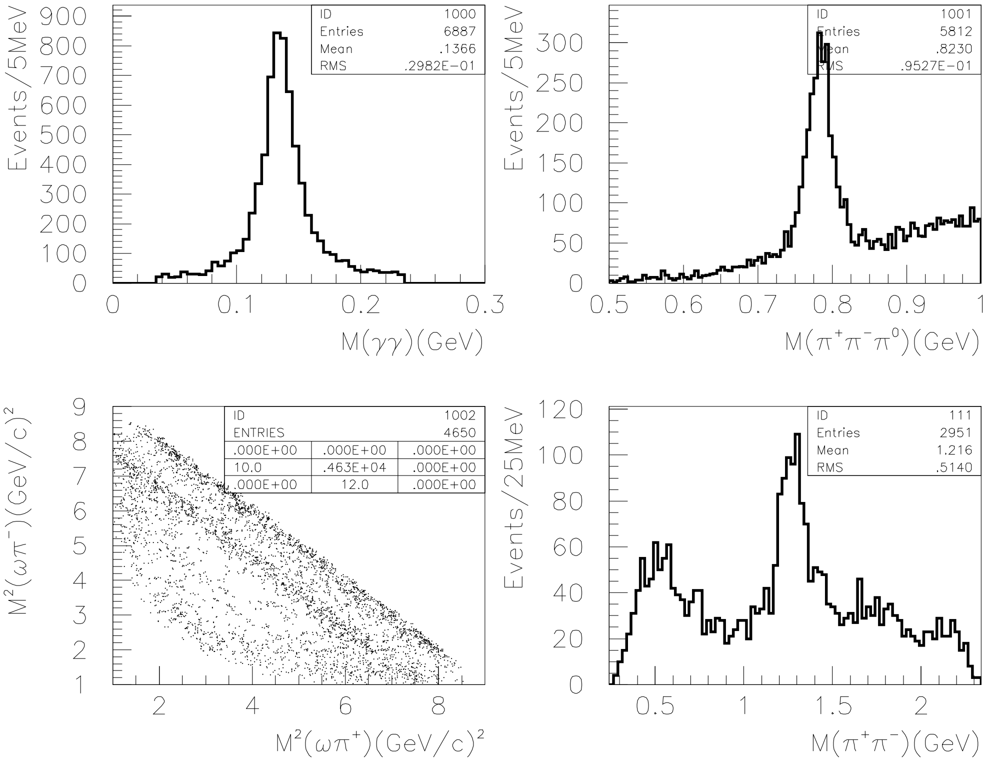

Figure 13: $J/\psi \to \omega\pi\pi$, BESI data, Run462-3738, $\sim$ 7.8M.

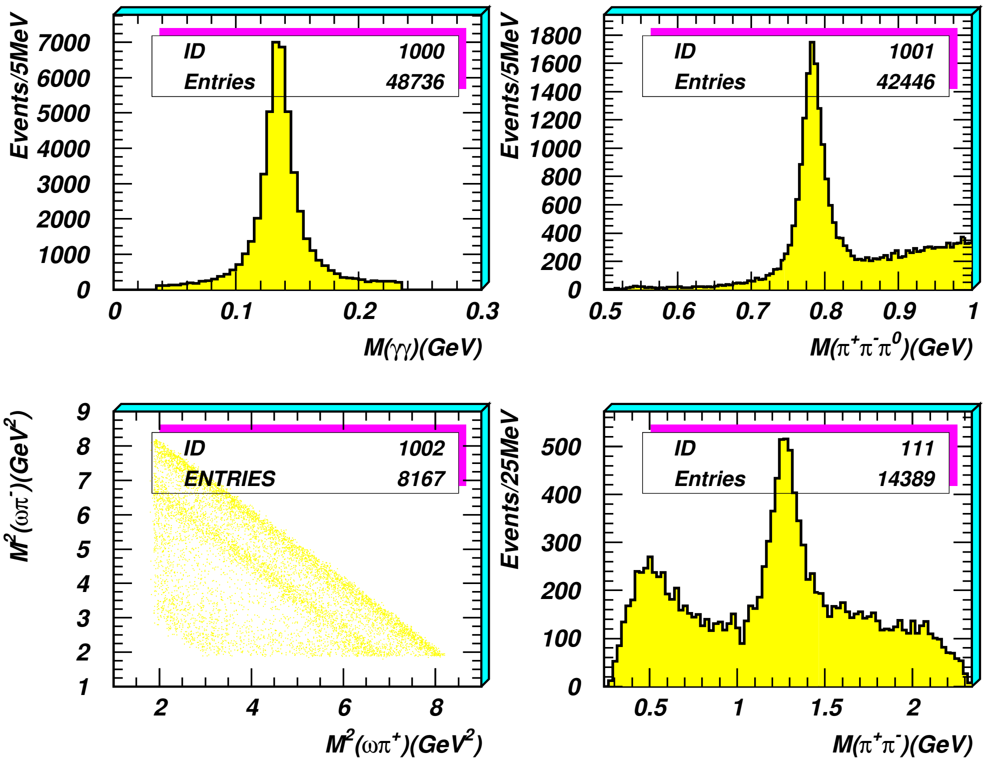

Figure 14: $J/\psi \to \omega\pi\pi$, BESII data, Run13700-16835, $\sim$ 22M.

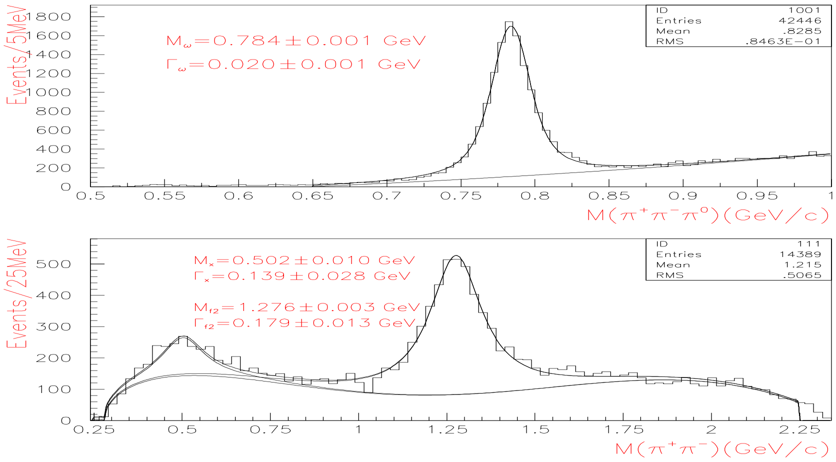

Figure 15: $J/\psi \to \omega\pi\pi$, BESII data, Run13700-16835, $\sim$ 22M.

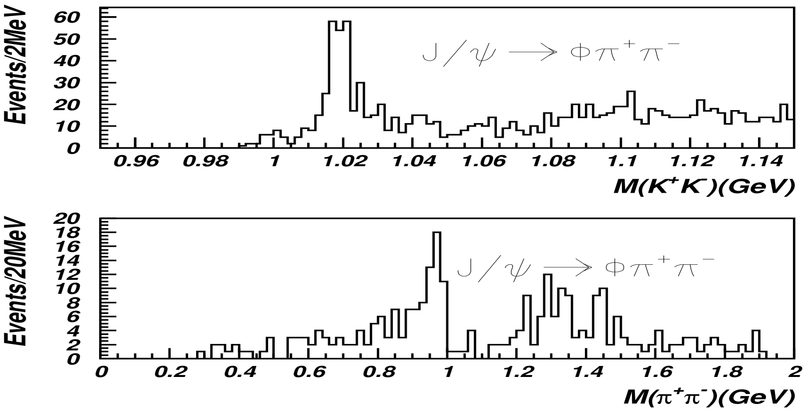

Figure 16: $J/\psi \to \phi\pi\pi$, BESI data, Run462-3738, $\sim$ 7.8M.

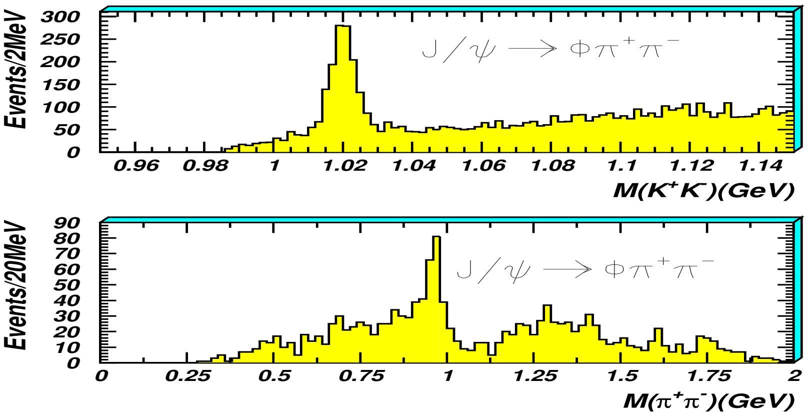

Figure 17: $J/\psi \to \phi\pi\pi$, BESII data, Run13700-16835, $\sim$ 22M.

the energy resolution is about 12 MeV when $E_{e^+} + E_{e^-} = 0.75$ GeV (*i.e.* $E_\gamma = 0.75$ GeV), corresponding to $\xi(2230)$ mass. Fig. 19 is the inclusive $E_{e^+} + E_{e^-}$ spectrum. At the energy of $E_{e^+} + E_{e^-} = 0.75$ GeV, there is a clear peak, which, to some extent, implies the existence of $\xi(2230)$.

The results given above are still very preliminary. More careful analysis will be performed further and more statistics is needed to have a convincing conclusion.

5 Physics topics

Based on the new collected J/ψ events with large statistics and good quality, many new physics results will be produced in the future.

5.1 Hunt for non-$q\bar{q}$ states

According to QCD, which is considered as an elementary theory describing the strong interaction, there exist 8 kinds of colored gauge boson – gluons and these gluons can interact with each other. Thus QCD predicts the existence of other types of hadrons with explicit gluonic degrees of freedom – glueball, hybrid. Therefore, the observation of non-$q\bar{q}$ states experimentaly will be a direct test of QCD.

J/ψ decays is a good lab. to hunt for non-$q\bar{q}$ states.

There are some candidates for glueballs, such as $\xi(2230)$, $f_0(1710)$, $f_0(1500)$ and $\iota/\eta(1440)$. Listed below are some physics topics for the search of glueballs.

- $\xi(2230)$
  - $J/\psi \to \gamma K^+K^-$, $\gamma K_s^0 K_s^0$, $\gamma\pi\pi$ and $\gamma p\bar{p}$
  - $J/\psi \to \gamma\eta\eta$, $\gamma\eta\eta'$, $\gamma\eta'\eta'$
  - $J/\psi \to \gamma K^+K^-K^+K^-$, $\gamma\pi^+\pi^-\pi^+\pi^-$, $\gamma K^+K^-\pi^+\pi^-$, ...
  - explore more decay modes of $\xi(2230)$
  - inclusive γ spectrum
- $f_J(1710)$, $f_0(1500)$
  - $J/\psi \to \gamma K\overline{K}$, $\gamma\pi\pi$, $\gamma\pi\pi\pi\pi$
  - $J/\psi \to \gamma\eta\eta$, $\gamma\eta\eta'$, ...
- $\iota/\eta(1440)$
  - $J/\psi \to \gamma K\overline{K}\pi$, $\gamma\eta\pi^+\pi^-$
  - $J/\psi \to \gamma\gamma\rho$, $\gamma\gamma\phi$, $\gamma\gamma\omega$, ...

According to the theoretical prediction, glueballs with exotic quantum numbers will not appear below 3.0 GeV, while the exotic hybrid states don't have this limitation. Therefore, hunting for the exotic hybrid states from J/ψ hadronic decays becomes very important.

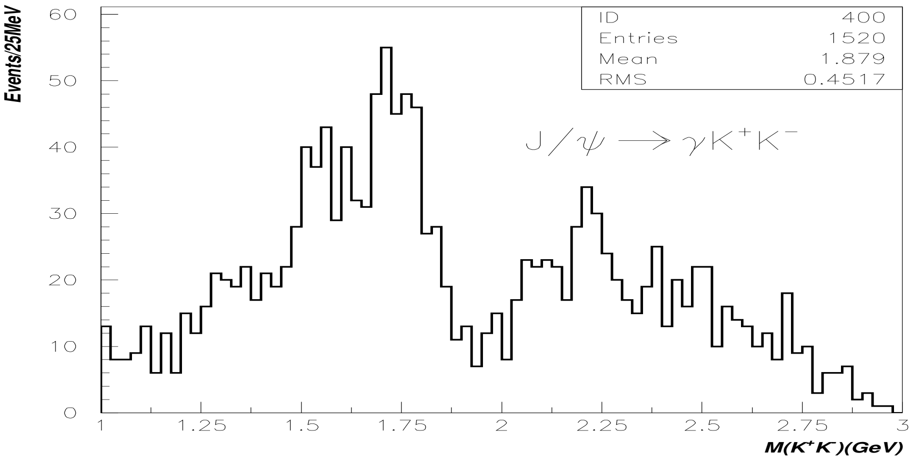

Figure 18: $J/\psi \to \gamma K^+K^-$, BESII data, Run13700-14884, $\sim$ 8M.

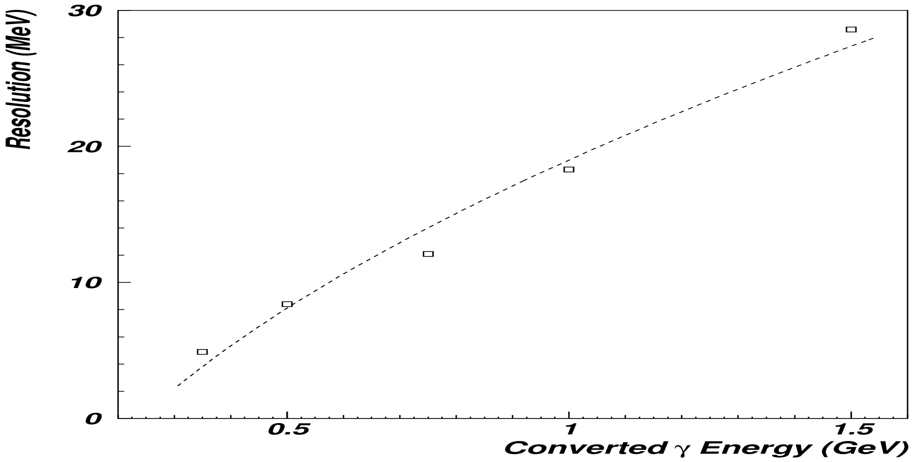

Figure 19: Energy resolutions of e^+e^- at different energy of converted photons, BESII data, $\sim$ 22M.

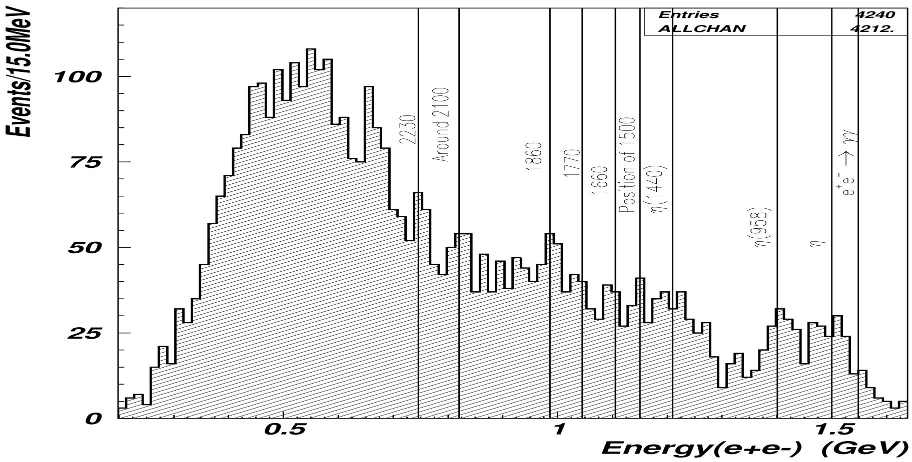

Figure 20: Spectrum of $E_{e^+} + E_{e^-}$, BESII data, $\sim$ 22M.

5.2 N^* physics

N^* states are the excitation states of nucleon with strangeness 0 and isospin 1/2. N^* physics is one of the important source of information to understand nucleon internal structure. In J/ψ decays, the branching ratios of $J/\psi \to p\bar{p}\pi^0$, $p\bar{p}\eta$, $p\bar{p}\omega$ and ... are not small. So, J/ψ decays is a good place to study N^* physics. Some of the decay channels listed below are under studied now, and some of them will be analyzed in the near future.

- $J/\psi \to p\bar{p}\pi^0$
- $J/\psi \to p\bar{p}\eta$
- $J/\psi \to \bar{p}\pi^+ n$
- $J/\psi \to p\bar{p}\omega$
- $J/\psi \to p\bar{p}\eta'$
- $J/\psi \to p\bar{p}\phi$

5.3 Rare decays

Search for the rare decay mode $J/\psi \to e\mu$ to test lepton flavor conservation law is another important physics topic.

5.4 Other interesting topics

- the nature of $f_0(980)$ and $a_0(980)$
- study of isospin violation processes $J/\psi \to \omega\pi$, ...
- J/ψ baryonic decays.
- ...

6 Summary

BES has already collected about 22 million J/ψ events. The data has been calibrated and reconstructed. The quality check to these data through a general check from bhabha, dimuon and hadron samples, a inclusive signal check and a check from $J/\psi \to \rho\pi$, K^*K, $\omega\pi\pi$ and $\phi\pi\pi$ shows that the data quality is good in general and the detection efficiency is much higher, though there are still some problems. The modification of TELESIS package concerning with the error matrix corrections, coming from the multiple Coulomb scattering (MCS) and dE/dx effects, for charged tracks is done. We also obtain a preliminary J/ψ total number from $J/\psi \to \mu\mu$ process. Some very preliminary results are obtained based on 22 million J/ψ events. By the end of year 2001, BES is going to accumulate 50 million J/ψ events.

References

[1] Guo Zijin, BES monthly meeting talk.

[2] Dong Liaoyuan, BES monthly meeting talk.

[3] Lu Feng, BES 2000 annual meeting talk.

[4] Peng Haiping, BES 2000 annual meeting talk.

[5] Heng Yuekun, BES 2000 annual meeting talk.

[6] Li Haibo, BES 2000 annual meeting talk.