Recent J/ψ Physics Results from BES

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The partial wave analysis results for $J/\psi \to \gamma K^+K^-$ and $J/\psi \to \gamma K_s^0 K_s^0$ based on 5.8×10^7 BESII J/ψ events are reported, and 0^{++} is find to be dominant in 1.7GeV mass region of $K\bar{K}$ spectrum. The masses and widths of $f_2'(1525)$ and $f_0(1710)$ are given. The prliminary results of η_c mass measurement from six dacay channels are presented. we also introduce some J/ψ hadronic decays, one is the study of excited baryon states, the other is J/ψ three body decay.

1 Introduction

BES is a large general purpose solenoidal detector at the Beijing Electron positron collider(BEPC). The details of BESI are described in ref.[1]. The upgrades of BESI to BESII[2] include the replacement of the central drift chamber with a vertex chamber of 12 tracking layers, the installation of a new barrel time-of-flight counter(BTOF) with a time resolution of 180ps and the installation of a new main drift chamber(MDC), which has 10 tracking layers and provides a dE/dx resolution of $\sigma_{dE/dx} = 8.0\%$ for particle identification and $\sigma_p/p = 1.8\%\sqrt{1+p^2}$(p in GeV) momentum resolution for charged tracks. The barrel shower counter(BSC), which covers 80% of 4π solid angle, has a energy resolution of $\sigma_E/E = 22\%/\sqrt{E}$ and a spatial resolution of 7.9 mrad in ϕ and 2.3 cm in z, is located outside the TOF. Outermost is a μ identification system, which consists of three double layers of proportional tubes interspersed in the iron flux return of the magnet.

2 J/ψ data sample

At the end of April, 2001,BES had accumulated about 5.8×10^7 J/ψ events, which is the largest J/ψ data sample in the e^+e^- collision experiments of the world. Besides the high statistics, the data quality of the 5.8×10^7 J/ψ is quite good. Fig.1 shows the inclusive K_s^0 and ϕ signals. The signals are very clear and the fitted mass values are in good agreement with PDG's.

Base on the present data, plenty of physics topics are expected, such as the study of the light hadronic spectronscopy, glueball and hybrid search, study of excited baryon states, precise measurement, rare decays et al.

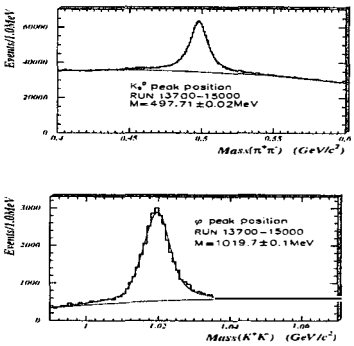

Figure 1: Inclusive K_s^0 and ϕ signal

3 Partial wave analysis(PWA) on $J/\psi \to \gamma K^+K^-$ and $K_s^0K_s^0$

One of the distinctive features of QCD as a non-Abelian gauge theory is the self-interaction of gluons. The indirect evidence for gluon-gluon interactions has been obtained at high energies. However, glueballs, the bound states of gluons, predicted by QCD, have not been confirmed yet. Therefore, the observation of glueballs is, to some extent, a direct test of QCD. Lattice QCD predicted that the ground scalar glueball should be in the mass range of 1.5–1.7GeV(Fig.2)[3]. The $f_0(1710)$, first observed by the Crystal Ball Collboration in $J/\psi \to \gamma\eta\eta$[4] has been considered as the lightest 0^{++} glueball candidate because of its large production rate in gluon rich processes, such as J/ψ radiative decays, pp central production etc. There are many results on $f_0(1710)$ from different process by several groups, but the spin-parity of $f_0(1710)$ is not very consistency[5].

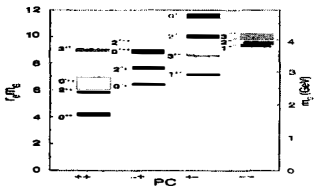

Figure 2: The mass spectrum of glueballs in the pure SU(3) gauge theory

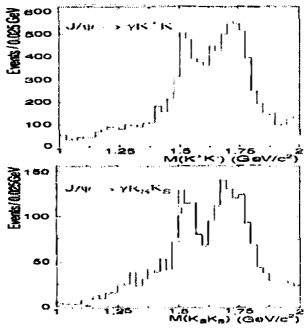

Figure 3: The invariant mass spectrum of $K\bar{K}$

Base on BESII 58 million J/ψ data, a partial wave ansalysis is performed to the $f_0(1710)$ mass region in $J/\psi \to \gamma K^+K^-$ and $J/\psi \to \gamma K_s^0K_s^0$ channels. Fig.3 shows the invariant mass spectrum of K^+K^- and $K_s^0K_s^0$. The amplitudes are fitted to relativistic covariant tensor expressions, the maximum likelihood method is employed in the fit and both global fit and bin-by-bin fit are done in the two channels. In the global fit, four partial waves $J/\psi \to \gamma f_2'(1525), f_0(1710), f_2(1270)$ and $f_0(1500)$ are fitted to data with a broad 0^{++} background.

Fig.4 is bin-by-bin results of combined $J/\psi \to \gamma K^+K^-$ and $\gamma K_s^0K_s^0$ analyses. Each bin is 40MeV, the 0^{++} and 2^{++} components are determined as point with error bars in each bin. The solid curve is the Breit-Wigner fit to each component. Fig.5 shows the comparison of bin-by-bin fit and global fit for $J/\psi \to \gamma K^+K^-$(upper) and $\gamma K_s^0K_s^0$(below). The solid curve is the fit to the points got from bin-by-bin fit, and the histograms are the projections of the results of the global fit.

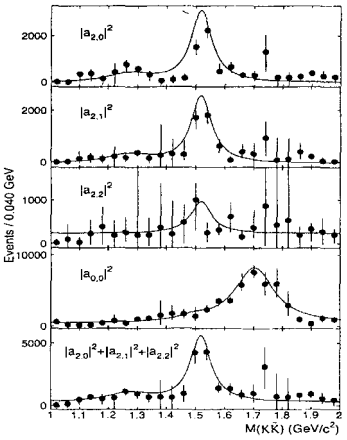

Figure 4: The bin-by-bin fit results

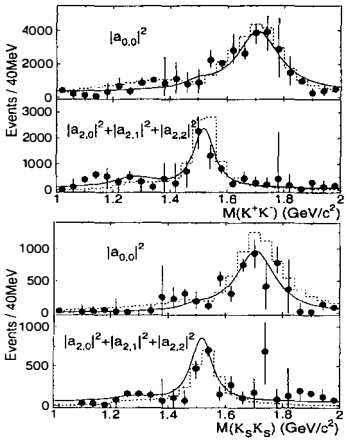

Figure 5: The global fit results

From the Fig.4,5, it is apparently that the 2^{++} distribution shows a clear signal corresponding to the $f_2'(1525)$ and also evidence of $f_2(1270)$, while 0^{++} is dominant in the $f_0(1710)$ region. The masses and widths of $f_2'(1525)$ and $f_0(1710)$ are given in Table 1.(The error is statistical error only)

Table 1: The mass and width of $f_2'(1525)$ and $f_0(1710)$

	Mass(MeV/c^2)	Width(MeV/c^2)
$f_2'(1525)$	1518 ± 6	84^{+28}_{-24}
$f_0(1710)$	1703^{+8}_{-10}	163^{+27}_{-22}

4 η_c mass measurement

A precise knowledge of the mass difference between the $J/\psi(1^{--})$ and $\eta_c(0^{-+})$ charmonium states is usefull for the determination of the strength of spin-spin interaction term in non-relativistic potential model. While the J/ψ mass has been determined with high accuracy to be 3.096 ± 0.04, but the η_c mass measurements listed in PDG 2000 are much different, and the fit to the measurements has a confidence level of only 0.001. Resently, there are some news results from L3(1999)[6],BESI[7],and CLE●[8], but the results have poor internal consistency still. So additional precise measurements are needed for both η_c mass and width. Six different radiative decays channels $J/\psi \to \gamma\eta_c$ have been performed to study η_c mass at BESII. The fit values of the number of events and mass of η_c for the individual channel are show in Table 2 (The errors are statistical only). In our fit, Γ is fixed at 16.5MeV, which is the weighted average of PGD(2000),BESI and CLEO values. Combine the weighted average with the results for the six channels, the mass of η_c is given as $m_{\eta_c} = 2977.6 \pm 0.8$(The error is statistical)

Table 2: The number of events and mass of η_c

Channel	No. of events	Mass(MeV/c^2)
$K^+K^-\pi^+\pi^-$	350.0 ± 39.3	2981.0 ± 2.1
$\pi^+\pi^-\pi^+\pi^-$	452.5 ± 61.3	2977.2 ± 3.3
$K^\pm K_s^0\pi^\mp$	552.9 ± 39.0	2974.5 ± 1.3
$\phi\phi$	92.9 ± 14.4	2978.8 ± 2.6
$K^+K^-\pi^0$	221.8 ± 45.7	2976.1 ± 4.9
$p\bar{p}$	214.0 ± 24.5	2980.6 ± 1.8

5 J/ψ hadronic decay

5.1 *Excited baryon states*

Baryon spectroscopy is important for understanding the internal structure of nucleon, but our understanding on baryon spectroscopy is still poor. J/ψ decay has its own advantage to study baryon spectroscopy and will play a important role in baryon spectroscopy. The PWA analyses of two decay channels $J/\psi \to p\bar{p}\pi^0$ and $J/\psi \to p\pi^-\bar{n}$ have been performed to sudy the excited baryons. Fig.6 and Fig.7 show the invariant masses of $p\pi^0$(Fig.6) and $N\pi^-$(Fig.7). The two peaks around 1.5GeV and 1.65GeV are very clear in both channels, PWA is in progress now.

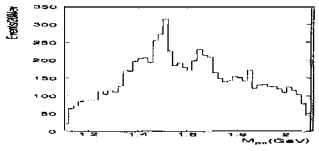

Figure 6: The invariant mass of $p\pi^0$ in $J/\psi \to p\bar{p}\pi^0$

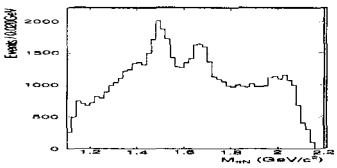

Figure 7: The invariant mass of $\pi^-\bar{n}$ in $J/\psi \to p\pi^-\bar{n}$

5.2 *Three body decay*

Three body decay channels are importance to study hadron spectroscopy. Both MARKIII and DM2 had analyzed these channels for the study of $f_0(980)$, $f_2'(1525)$ and the structure around 1.7GeV[9],[10],[11],[12]. Here are the preliminary results of BESII.

Fig.8 shows the ω singnal and $\pi^+\pi^-$ invariant mass of $J/\psi \to \omega\pi^+\pi^-$. The shadow indicateds the background. The well knowm $f_2(1270)$ is very clear, and a broad bump exists in the low mass region, which many people are interested in.

Fig.9 shows the ω singnal and K^+K^- invariant mass of $J/\psi \to \omega K^+K^-$. The main feature of this channel is the peak around 1.75, the threshold effect and $f_2(1270)$. The background is from $J/\psi \to \omega\pi^+\pi^-$

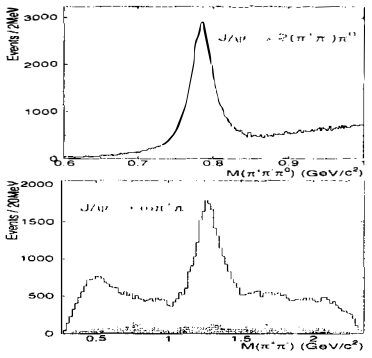

Figure 8: The ω singnal and $\pi^+\pi^-$ invariant mass of $J/\psi \to \omega\pi^+\pi^-$ channel

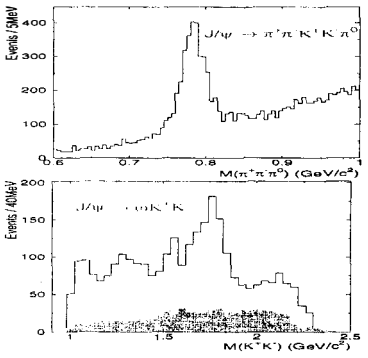

Figure 9: The ω singnal and $\pi^+\pi^-$ invariant mass of $J/\psi \to \omega\pi^+\pi^-$ channel

Fig.10 shows the ϕ signal and $\pi^+\pi^-$ invariant mass of $J/\psi \to \phi\pi^+\pi^-$ channel. There are a strong $f_0(980)$, and two bumps around 1335 and 1770MeV. Fig.11 shows the ϕ signal and K^+K^- invariant mass of $J/\psi \to \phi K^+K^-$ channel. The tail of $f_0(980)$ in the low K^+K^- mass spectum and strong $f_2'(1525)$ are clearly seen.

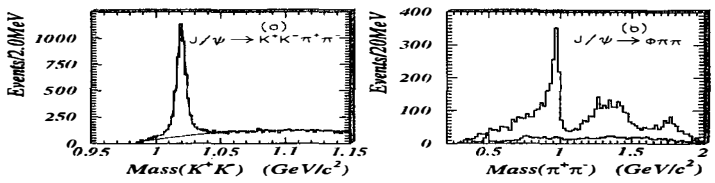

Figure 10: The ϕ singnal and $\pi^+\pi^-$ invariant mass of $J/\psi \to \phi\pi^+\pi^-$ channel

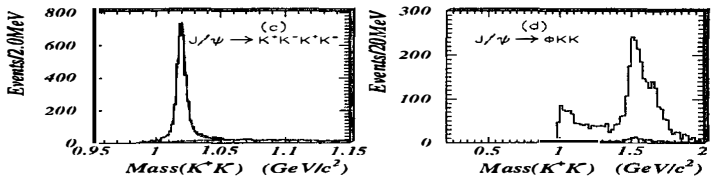

Figure 11: The ϕ singnal and K^+K^- invariant mass of $J/\psi \to \phi K^+K^-$ channel

6 summary

By the end of 2001, BESII has accumulated 5.8×10^7 J/ψ data. Base on 5.8×10^7 BESII J/ψ data, a partial wave is applied to $J/\psi \to \gamma K\bar{K}$ decay, and 0^{++} is found to be dominant in the $f_0(1710)$ mass region. Six radiative decay channels have been studied for the measurement of η_c mass, the measured η_c mass is in good agreement with PDG(2000). Some hadronic decays are in the study .

References

1. BES Collaboration, J.Z.Bai et al., Nucl. Instrum. Methods in Phys Res. Sect. A**344** 319(1994)
2. BES Collaboration, J.Z.Bai et al., Nucl. Instrum. Methods in Phys Res. Sect. A**458** 627(2001)
3. C.Morningstar and M.Peardon, Phy.Rev D **60** 034509(1999)
4. C.Edwards et al. Phys. Rev.Lett **56** 107(1986)
5. PDG(2000) 471
6. P.Abreu et al.,Phys.Lett B**231** 479(1998)
7. BES Collaboration, J.Z.Bai et al.,Phys. Rev.D**62** 072001(2000)
8. G.Bagelin et al., Phys.Rev.Lett, D**85** 2095(2000)
9. J.E. Augustin et al., Nucl. Phys B**320** 1(1989)
10. A.Falvard et al., Phys.Rev.Lett, D**38** 2706(1988)
11. L.Kopke in:Proc.XXIIIrd Int.Conf.on High Energy physics(Berkeley,1986),ed. S.Loken(World Scientific,Singapore,1987) and Santa Cruz preprint SCIPP86/74
12. A.Falvard et at., Phys.Rev.D**38** 2706(1988)