Recent BES results and future prospects

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Recent results on light hadron spectroscopy are reviewed, which include the observation of $X(1810)$ in $\omega\phi$ mass spectrum in $J/\psi \to \gamma\omega\phi$, the observation of a broad 1^{--} resonance of K^+K^- mass in $J/\psi \to K^+K^-\pi^0$ and the production of σ and κ. The first measurement of $\psi(2S)$ radiative decays, as well as the measurement of $\psi(3770)$ non-$D\bar{D}$ decays are presented too. The data samples used for these analyses consist of $5.8 \times 10^7 J/\psi$ events, $1.4 \times 10^7 \psi(2S)$ events and 33 pb^{-1} data at $\psi(3770)$. We also report the status of BESIII/BEPCII project.

1 Introduction

One of the distinctive features of QCD as a non-Abelian gauge theory is the self-interaction of gluons, which predicts the existence of the multi-quark states, *$q\bar{q}$-gluon* hybrids and glueballs. These states have been searched for many years by some experiments. However, none of them is identified after all the efforts. The 5.8×10^7 J/ψ events, accumulated with BES detector, provide a good laboratory for the search for non-$q\bar{q}$ states and study of light hadron spectroscopy. Here, we report the observation of $X(1810)$ in $\omega\phi$ mass spectrum in $J/\psi \to \gamma\omega\phi$, the observation of a broad 1^{--} resonance of K^+K^- mass in $J/\psi \to K^+K^-\pi^0$ and the production of σ and κ.

The radiative decays of $\psi(2S)$ have been limited due to low statistics in previous experiments. The measured branching ratios for radiative decays only sum up to about 0.05%, which is much lower than what expected. Based on $1.4 \times 10^7\psi(2S)$ events, the first measurements of some $\psi(2S)$ radiative decays are presented.

The $\psi(3770)$ was considered to decay almost entirely to pure $D\bar{D}$ because its mass is above the open charm-pair threshold and its width is two orders of magnitude larger than that of $\psi(2S)$. Since the first observation of $\psi(3770)$ non-$D\bar{D}$ decays to $\pi\pi J/\psi$ by BES, many searches for exclusive $\psi(3770)$ non-$D\bar{D}$ decays have been performed by CLEO and BES. We present the measurement of $\psi(3770)$ non-$D\bar{D}$ decay branching ratio from BESII 33 pb^{-1} $\psi(3770)$ data.

2 Light hadron spectroscopy

2.1 The $\omega\phi$ threshold enhancement $X(1810)$ in $J/\psi \to \gamma\omega\phi$

An enhancement near the $\omega\phi$ mass threshold is observed [1] in the OZI suppressed decays of $J/\psi \to \gamma\omega\phi$, based on a sample of 5.8×10^7 J/ψ events collected with the BESII detector. Figure 1 shows the $\omega\phi$ invariant mass distribution and a structure peaked near $\omega\phi$ threshold is observed. The dashed curve in the figure indicates how the acceptance varies with invariant mass.

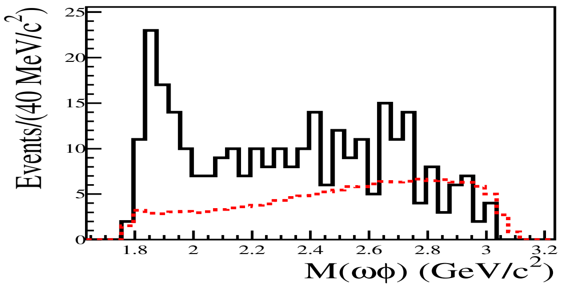

Figure 1: The $\omega\phi$ invariant mass distribution. The dashed curve shows the acceptance curve.

A partial wave analysis shows that the J^P of this enhancement favors 0^+ and its mass and width are $M = 1812^{+19}_{-26}(\mathrm{stat})\pm18(\mathrm{syst})\mathrm{MeV/c^2}$ and $\Gamma = 105 \pm 20$ (stat) $\pm$ 28 (syst) MeV/c^2. The product branching fraction is determined to be $B(J/\psi \to \gamma X) \cdot B(X \to \omega\phi) = (2.61 \pm 0.27(\mathrm{stat})\pm0.65(\mathrm{syst}))\times10^{-4}$. The mass and width of this state are not compatible with any known scalars listed in PDG. However, more statistics and further studies are needed to clarify this enhancement.

2.2 Observation of a broad 1^{--} resonance in $J/\psi \to K^+K^-\pi^0$

The Dalitz plot for the selected $J/\psi \to K^+K^-\pi^0$ events is shown in Figure 2(a) [2], where a broad K^+K^- band is evident in addition to the $K^*(892)$ and $K^*(1410)$ signals. This band corresponds to the broad peak observed around 1.5 GeV/c^2 in the K^+K^- invariant mass projection shown in Figure 2(b).

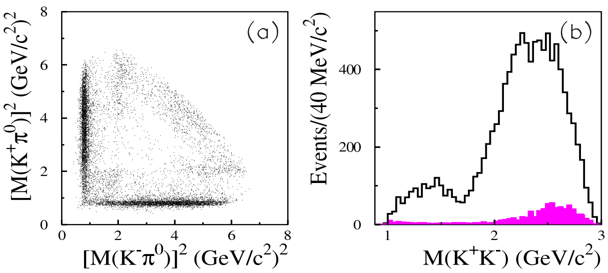

Figure 2: (a) The Dalitz plot for $KK\pi^0$ candidate events. (b) The KK invariant mass distribution for $KK\pi^0$ candidate events; the solid histogram is data and the shaded histogram is the background (normalized to data).

A partial wave analysis shows that the J^{pc} of this structure is 1^{--}. Its pole position is determined to be $(1576^{+49}_{-55}(\mathrm{stat})^{+98}_{-91}(\mathrm{syst}))$ MeV/c^2 - $i(409^{+11}_{-12}(\mathrm{stat})^{+32}_{-67}(\mathrm{syst}))$ MeV/c^2. These parameters are not compatible with any known meson resonances.

2.3 The σ and κ production

The existence of σ and κ has been controversal. BES studied $J/\psi \to \omega\pi^+\pi^-$ decays [3] based on 58M J/ψ events. Figure 3 shows the $\pi^+\pi^-$ invariant mass spectrum recoiling against ω. In addition to the well known $f_2(1270)$, a broad bump in the low mass region is clearly seen. Two independent partial wave analyses (PWA) are performed and different parametrizations of σ amplitude are used. All give the consistent results for σ pole position. The averaged pole is determined to be $(541 \pm 39$ - i $(252 \pm 42))$ MeV/c^2.

Based on 14M $\psi(2S)$ events collected at BESII, a partial wave analysis is performed to $\psi(2S) \to \pi^+\pi^- J/\psi$, with $J/\psi \to \mu^+\mu^-$ [4]. A severe suppression of the $\pi^+\pi^-$ invariant mass near the $\pi\pi$ threshold is distinctively different from the phase space shape, which suggests the σ production. Using different parametrizations of σ amplitude, the data can be fitted well through a strong cancellation between σ and a contact term. The obtained pole posision is $(554 \pm 14 \pm 53)$ - i $(242 \pm 5 \pm 24))$ MeV/c^2, which is consistent with that from $J/\psi \to \omega\pi^+\pi^-$.

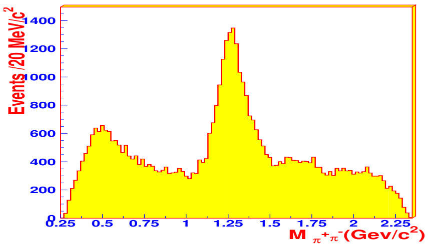

Figure 3: The $\pi^+\pi^-$ invariant mass in $J/\psi \to \omega\pi^+\pi^-$.

The κ is studied in $J/\psi \to K^* K\pi$ with partial wave analysis at BES [5]. Fig. 4 is the $K\pi$ invariant mass spectrum which recoils against $K^*(892)$. The crosses are data and histograms represent the PWA fit projection. The shaded area shows the κ contribution. The pole of κ from $J/\psi \to K^* K\pi$ is determined to be $(841 \pm 30^{+81}_{-73}) - i(309 \pm 45^{+48}_{-72})$ MeV/c^2.

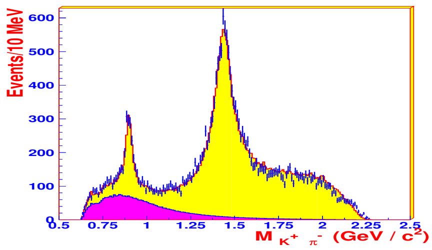

Figure 4: The $K\pi$ invariant mass recoiling against K^*. The crosses are data and histograms represent the PWA fit projection. The shaded area shows the κ contribution.

3 First measurement of $\psi(2S)$ radiative decays

The first measurements of branching fractions or upper limits for $\psi(2S)$ decays into $\gamma p\bar{p}$, $\gamma 2(\pi^+\pi^-)$, $\gamma K_s K\pi$, $\gamma K^+K^-\pi^+\pi^-$, $\gamma K^{*0}K^-\pi^+$+$c.c.$, $\gamma K^{*0}\bar{K}^{*0}$, $\gamma\pi^+\pi^- p\bar{p}$, $\gamma 2(K^+K^-)$, $\gamma 3(\pi^+\pi^-)$, and $\gamma 2(\pi^+\pi^-)K^+K^-$ with the invariant mass of hadrons below 2.9 GeV/c^2 are performed [6]. The branching fractions of $\psi(2S)$ decays into $2(\pi^+\pi^-)\pi^0$, $\omega\pi^+\pi^-$, $\omega f_2(1270)$, $b_1^\pm\pi^\mp$, and $\pi^0 2(\pi^+\pi^-)K^+K^-$ are also measured. Table 1 summarizes the branching fractions or upper limits for the $\psi(2S)$ radiative decays analyzed.

Table 1: Results for $\psi(2S) \to \gamma + hadrons$. For each final state, the following quantities are given: the number of events for m_{hs} <2.9GeV/c^2 in $\psi(2S)$ data, N^{Tot}; the number of background events from $\psi(2S)$ decays and QED processes, N^{Bg}; the number of signal events, N^{Sig}; and the weighted averaged efficiency, ϵ; the branching fraction with statistical and systematic errors or the upper limit on the branching fraction at the 90% C.L. Possible interference effects for the modes with intermediate states are ignored.

Mode	N^{Tot}	N^{Bg}	N^{Sig}	$\epsilon(\%)$	$\mathcal{B}(\times 10^{-5})$
$\gamma p\bar{p}$	329	187	142 ± 18	35.3	2.9±0.4±0.4
$\gamma 2(\pi^+\pi^-)$	1697	1114	583 ± 41	10.4	39.6±2.8±5.0
$\gamma K^0_S K^+\pi^- + c.c.$	–	–	115 ± 16	4.83	25.6±3.6±3.6
$\gamma K^+K^-\pi^+\pi^-$	361	229	132 ± 19	4.94	19.1±2.7±4.3
$\gamma K^{*0} K^+\pi^- + c.c.$	–	–	237 ± 39	6.86	37.0±6.1±7.2
$\gamma K^{*0}\bar{K}^{*0}$	58	17	41 ± 8	2.75	24.0±4.5±5.0
$\gamma\pi^+\pi^- p\bar{p}$	55	38	17 ± 7	4.47	2.8±1.2±0.5
$\gamma K^+K^-K^+K^-$	15	8	< 14	2.93	< 4.0
$\gamma 3(\pi^+\pi^-)$	118	95	< 45	1.97	< 17
$\gamma 2(\pi^+\pi^-)K^+K^-$	17	13	< 15.5	0.69	< 22

4 $\psi(3770)$ non-$D\bar{D}$ decays

With the data taken at BESII, the R values for inclusive hadronic event production at the center-of-mass energies of 3.650, 3.665 and 3.773 GeV are measured [7]. The lowest order cross section for $\psi(3770)$ production is determined to be $\sigma^{\rm B}_{\psi(3770)} = (9.575 \pm 0.256 \pm 0.813)$ nb at 3.773 GeV, the branching fractions for $\psi(3770)$ decays are $BF(\psi(3770) \to D^0\bar{D}^0) = (48.9 \pm 1.2 \pm 3.8)\%$, $BF(\psi(3770) \to D^+D^-) = (35.0 \pm 1.1 \pm 3.3)\%$ and $BF(\psi(3770) \to D\bar{D}) = (83.9 \pm 1.6 \pm 5.7)\%$, which result in the total non-$D\bar{D}$ branching fraction of $\psi(3770)$ decay to be $BF(\psi(3770) \to {\rm non}-D\bar{D}) = (16.1 \pm 1.6 \pm 5.7)\%$.

By analyzing the line-shapes of the cross sections for inclusive hadron, $D^0\bar{D}^0$ and D^+D^- event production in the range from 3.660 GeV to 3.872 GeV covering both $\psi(2S)$ and $\psi(3770)$ resonances, we extract the branching fractions for $\psi(3770)$ decay into $D^0\bar{D}^0$ and D^+D^- respectively to be $B(\psi(3770) \to D^0\bar{D}^0) = (46.7 \pm 4.7 \pm 2.3)\%$ and $B(\psi(3770) \to D^+D^-) = (36.9 \pm 3.7 \pm 2.8)\%$, which give $B(\psi(3770) \to D\bar{D}) = (83.6 \pm 7.3 \pm 4.2)\%$ and non-$D\bar{D}$ branching fraction of $\psi(3770)$ to be $B(\psi(3770) \to non - D\bar{D}) = (16.4 \pm 7.3 \pm 4.2)\%$ [8].

5 Search for η/η' invisible decays from $J/\psi \to \phi\eta/\eta'$

Using a data sample of 5.8×10^7 J/ψ decays collected with the BES II detector at the BEPC, searches for invisible decays of η and η' in J/ψ to $\phi\eta$ and $\phi\eta'$ are performed [9]. No signals are found for the invisible decays of either η or η', and upper limits at the 90% confidence level are determined to be 1.65×10^{-3} for the ratio $B(\eta \to invisible)/B(\eta \to \gamma\gamma)$ and 6.69×10^{-2} for $B(\eta' \to invisible)/B(\eta' \to \gamma\gamma)$. These are the first searches for η and η' decays into invisible final states.

6 BESIII/BEPCII project

Beijing Electron Positron Collider (BEPC) and the detector BEijing Spectrometer (BES) were constructed and started to take data in 1989. At the end of 2003, the proposal of upgrading BEPC/BESII was approved by Chinese government and the construction was started. The accelerator has two storage rings with a circumstance of 224m, one for electron and one for positron, each with 93 bunches spaced by 8 ns. The peak luminosity is expected to be $10^{33}{\rm cm}^{-2}{\rm s}^{-1}$ at the beam energy of 1.89 GeV. At the moment, the LINAC has been installed and tested successfully. The storage rings have been installed and is commisioning for synchrotron radiation run.

BESIII detector consists of a drift chamber (MDC) which has a small cell structure filled with a helium-based gas, an electromagnetic calorimeter (EMC) made of CsI(Tl) crystals, time-of-flight counters (TOF) for particle identification made of plastic scintillators, a muon system made of Resistive Plate Chambers (RPC) and a super conducting magnet. The designed single wire spatial resolution, dE/dx resolution and momentum resolution for the MDC are 130μm, 6% and 0.5 % $\sqrt{1+p^2}$ (p in GeV/c), respectively. The time resolution for TOF is $\sigma_{TOF} = 100$ ps for Bhabha events and the energy resolution for photons is $\sigma_E/E \simeq 2.5$ % $/\sqrt{E}$ (E in GeV) in EMC. The mass production of detector components is underway. Some have already been installed and are being tested. We expect to complete the detector installation at the end of this year and to start the data taking in 2008.

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