Recent results on Charm and Charmonium from BES Experiment

Chen Jiangchuan (for BES Collaboration)
Institute of High Energy Physics, CAS,Beijing China

The 2007 Europhysics Conference on High Energy Physics, 19-25 July, 2007, Manchester, England
(HEP2007)

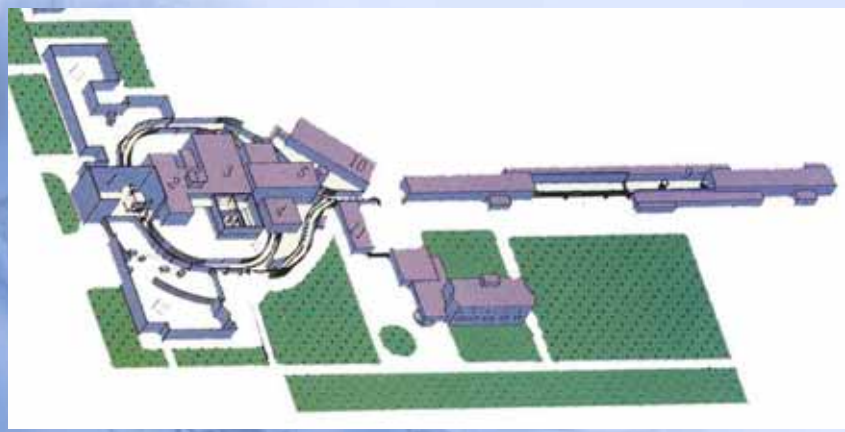
Outline

- **Search for Charmless Decays of $\psi(3770)$**
- **Inlcusive Semileptonic decays of D mesons**
- **A very broad 1^{--} resonance X(1580)**
- **$\psi(2S)$ radiative decay and χ_{cJ} decay**
- Summary

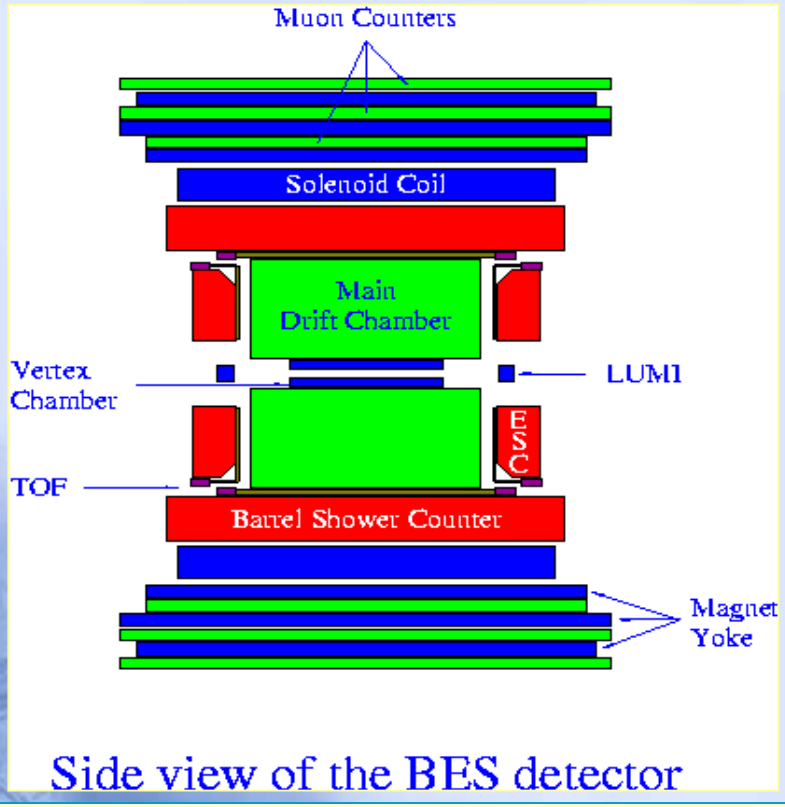
The Beijing Electron Positron Collider

L ~ ~5 $\times 10^{30}$ /cm^2·s at J/ψ peak

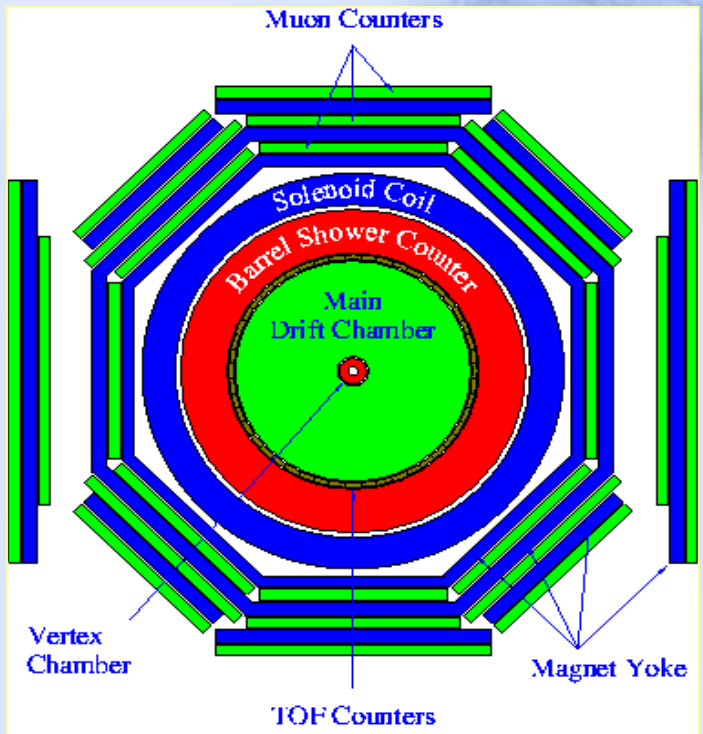
E_{cm}~2-5 GeV



BESII Detector



Side view of the BES detector



End view of the BES detector

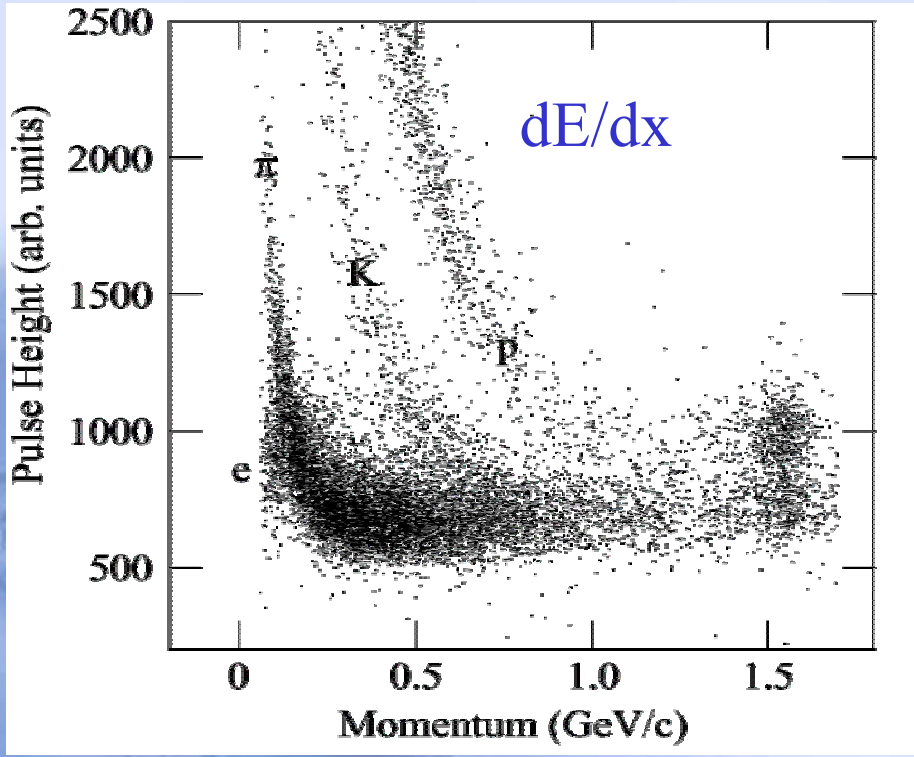
VC: σ_{xy} = 100 μm TOF: σ_T = 180 ps μ counter: $\sigma_{r\phi}$ = 3 cm

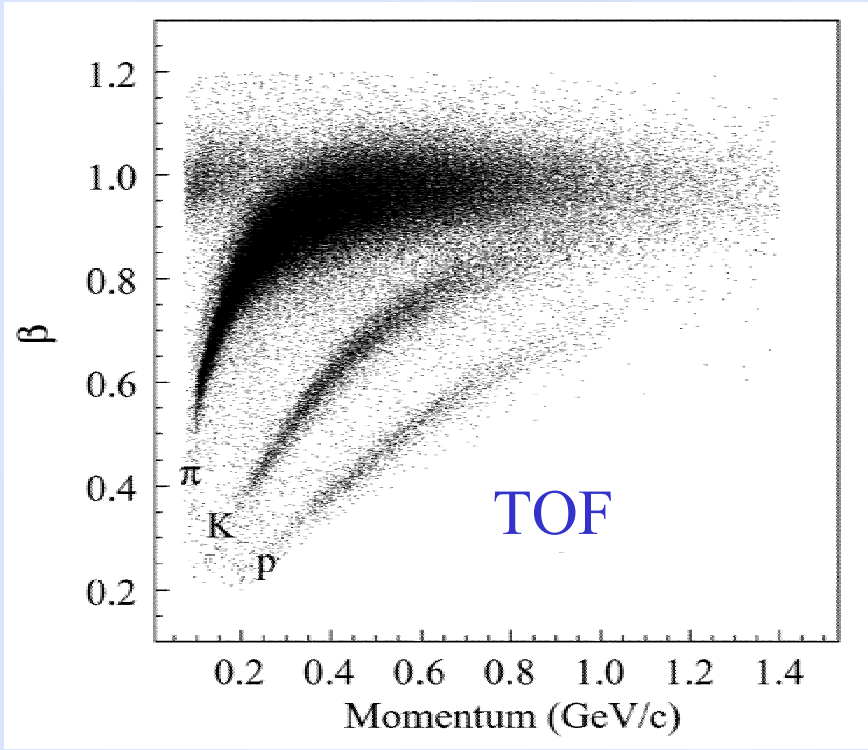
MDC: σ_{xy} = 220 μm BSC: $\Delta E/\sqrt{E}$ = 22 % σ_z = 5.5 cm

$\sigma_{dE/dx}$ = 8.5 % σ_ϕ = 7.9 mr B field: 0.4 T

$\Delta p/p = 1.78\%\sqrt{(1+p^2)}$ σ_z = 3.1 cm

Muon identification can be done by the Muon Counter for the charged track with momentum of great than 0.55 GeV/c

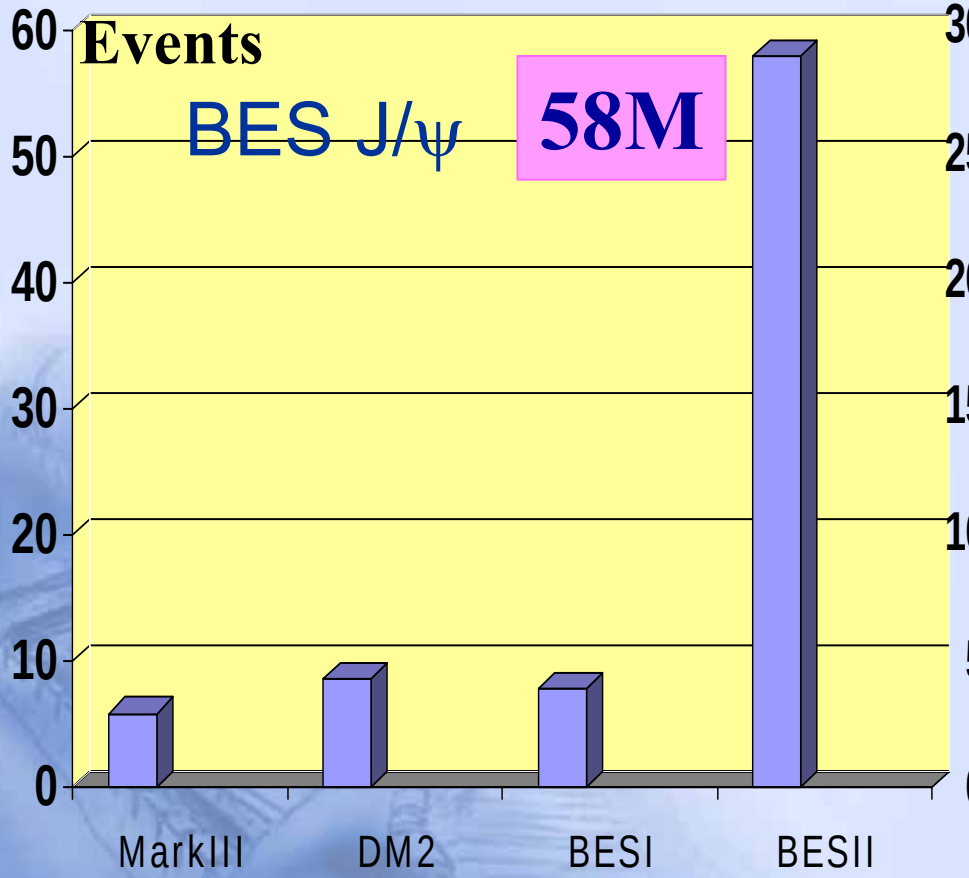


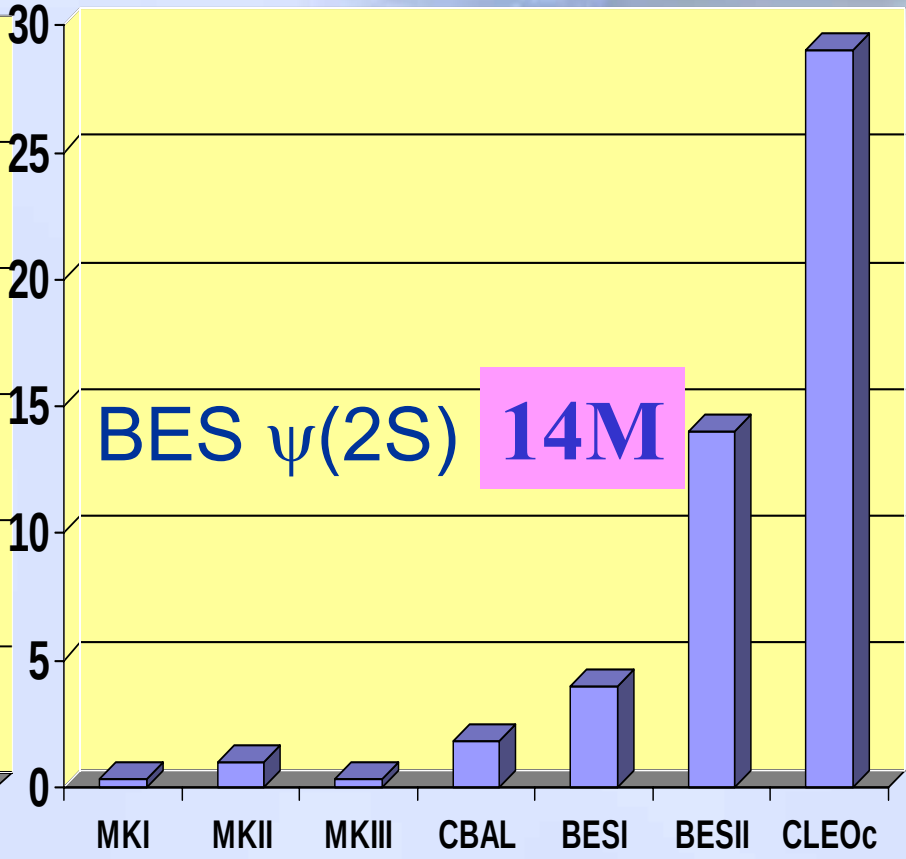


BESII ψ(3770) data sample of about 33 pb^{-1}

- about 17.3 pb^{-1} data taken at 3.773 GeV;
- about 7 pb^{-1} data taken from 3.768 GeV to 3.778 GeV;
- about 8 pb^{-1} data taken from 3.665 to 3.878 GeV;
- about 6.4pb^{-1} data taken at 3.650 GeV;
- about 1.0 pb^{-1} taken at 3.665 GeV.

World J/ψ and ψ(2S) Samples (10^6)





Recent results on Search for Chamless Decays of ψ(3770) from BES

ψ(3770) is thought to decay almost entirely to pure DDbar, but there is large discrepancy between $\sigma_{\psi(3770)}$ and $\sigma_{D\overline{D}}$

Cross section at peak (PDG04 parameters)

$$\sigma^{prd}_{\psi(3770)} = \frac{12\pi}{M^{2}_{\psi(3770)}} \times BF(\psi(3770) \to e^{+}e^{-}) = 11.6 \pm 1.8 \text{ nb}$$

before BES-II & CLEO-c

$$\sigma^{obs}(e^{+}e^{-} \to D\overline{D}) = 5.0 \pm 0.5 \text{ nb}$$ (Mark-III)

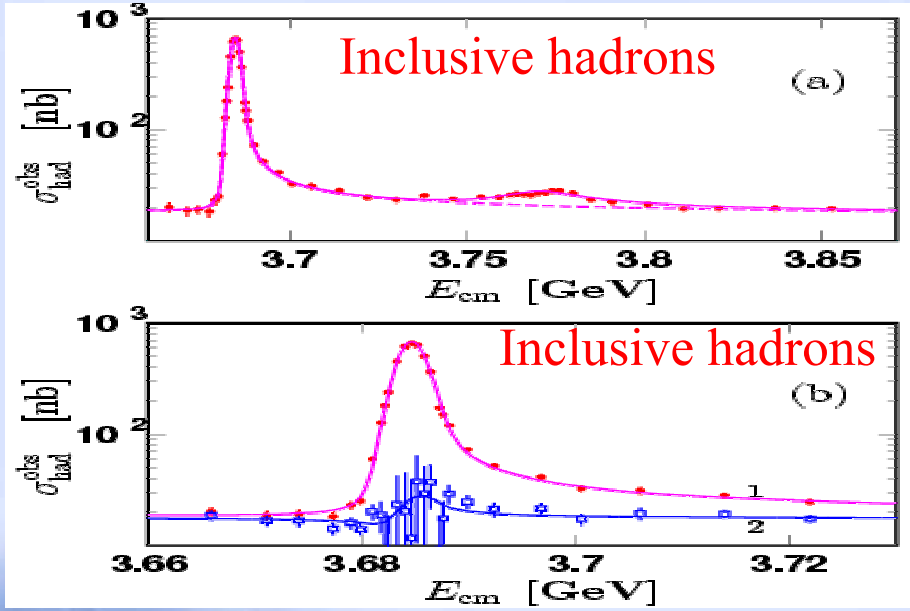
$$\sigma^{prd}(e^{+}e^{-} \to D\overline{D}) = 7.1 \pm 0.7 \text{ nb}$$

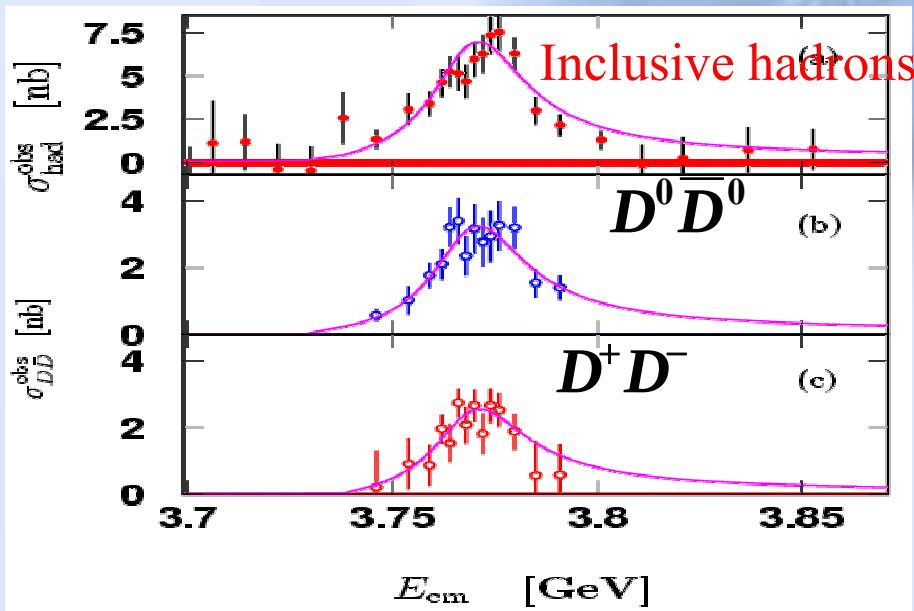
Long-standing puzzle of ψ(3770) production and decays

We should:

- directly measure $BF[\psi(3770) \to D^{0}\overline{D}^{0}, D^{+}D^{-}, D\overline{D}]$ and $BF[\psi(3770) \to non - D\overline{D}]$
- Search for exclusive non-DDbar decays

Line shape of the cross sections for hadron and DD-bar production





PRL97(2006)121801

Simultaneously fitting to the inclusive hadron and the DD-bar production cross sections

◆Branching fractions

$$BF(\psi(3770) \to D^0\bar{D}^0) = (46.7 \pm 4.7 \pm 2.3)\%$$

$$BF(\psi(3770) \to D^+D^-) = (36.9 \pm 3.7 \pm 2.8)\%$$

$$BF(\psi(3770) \to D\bar{D}) = (83.6 \pm 7.3 \pm 4.2)\%$$

$$BF(\psi(3770) \to non-D\bar{D}) = (16.4 \pm 7.3 \pm 4.2)\%$$

We shold search for exclusive non-$D\bar{D}$ decays.

Search for charmless decays of ψ(3770) (1)

Observed Cross Sections

Phys. Lett. B 650 (2007) 111

Events from J/ψ,ψ(3686) and $D\bar{D}$ have been subtracted

$e^+e^- \to$	$\sqrt{s} = 3.773$ GeV: σ (or σ^{up}) [pb]	$\sqrt{s} = 3.650$ GeV: σ (or σ^{up}) [pb]
$\phi\pi^0$	<3.5	<8.9
$\phi\eta$	<12.6	<18.0
$2(\pi^+\pi^-)$	$173.7 \pm 8.4 \pm 18.4$	$177.7 \pm 13.3 \pm 18.8$
$K^+K^-\pi^+\pi^-$	$131.7 \pm 10.1 \pm 14.1$	$161.7 \pm 17.9 \pm 17.1$
$\phi\pi^+\pi^-$	<11.1	<22.9
$2(K^+K^-)$	$19.9 \pm 3.6 \pm 2.1$	$24.1 \pm 6.5 \pm 2.6$
ϕK^+K^-	$15.8 \pm 5.1 \pm 1.8$	$17.4 \pm 9.2 \pm 2.0$
$p\bar{p}\pi^+\pi^-$	$33.2 \pm 3.4 \pm 3.8$	$42.1 \pm 6.1 \pm 4.8$
$p\bar{p}K^+K^-$	$7.1 \pm 2.0 \pm 0.8$	$6.1 \pm 3.1 \pm 0.7$
$\phi p\bar{p}$	<5.8	<9.1
$3(\pi^+\pi^-)$	$236.7 \pm 14.7 \pm 33.4$	$234.9 \pm 23.8 \pm 33.1$
$2(\pi^+\pi^-)\eta$	$153.7 \pm 40.1 \pm 18.4$	$86.6 \pm 40.3 \pm 10.4$
$2(\pi^+\pi^-)\pi^0$	$80.9 \pm 13.9 \pm 10.0$	$124.3 \pm 21.7 \pm 14.9$
$K^+K^-\pi^+\pi^-\pi^0$	$171.6 \pm 26.0 \pm 20.9$	$222.8 \pm 37.7 \pm 27.2$
$2(K^+K^-)\pi^0$	$18.1 \pm 7.7 \pm 2.1$	<23.0
$p\bar{p}\pi^0$	$10.1 \pm 2.2 \pm 1.0$	$9.2 \pm 3.4 \pm 1.0$
$p\bar{p}\pi^+\pi^-\pi^0$	$53.1 \pm 9.2 \pm 6.8$	$29.0 \pm 11.1 \pm 3.7$
$3(\pi^+\pi^-)\pi^0$	$105.8 \pm 34.4 \pm 16.9$	$126.6 \pm 47.1 \pm 19.2$

Upper Limits on the observed cross section for the ψ(3770) decay

$$\sigma_{\psi(3770)\to f} = \sigma^{3.773\ \mathrm{GeV}}_{e^+e^-\to f} - f_{\mathrm{co}} \times \sigma^{3.650\ \mathrm{GeV}}_{e^+e^-\to f}$$

where f_{co} is coefficient due to1/s dependence of the cross section.

Decay mode	$\sigma_{\psi(3770)\to f}$ [pb]	$\sigma^{\mathrm{up}}_{\psi(3770)\to f}$ [pb]	$\mathcal{B}^{\mathrm{up}}_{\psi(3770)\to f}$ [$\times 10^{-3}$]
$\phi\pi^0$	$<3.5^{tn}$	<3.5	<0.5
$\phi\eta$	$<12.6^{tn}$	<12.6	<1.9
$2(\pi^+\pi^-)$	$7.4 \pm 15.0 \pm 2.8 \pm 0.8$	<32.5	<4.8
$K^+K^-\pi^+\pi^-$	$-19.6 \pm 19.6 \pm 3.3 \pm 2.1^z$	<32.7	<4.8
$\phi\pi^+\pi^-$	$<11.1^{tn}$	<11.1	<1.6
$2(K^+K^-)$	$-2.7 \pm 7.1 \pm 0.5 \pm 0.3^z$	<11.6	<1.7
ϕK^+K^-	$-0.5 \pm 10.0 \pm 0.9 \pm 0.1^z$	<16.5	<2.4
$p\bar{p}\pi^+\pi^-$	$-6.2 \pm 6.6 \pm 0.6 \pm 0.7^z$	<11.0	<1.6
$p\bar{p}K^+K^-$	$1.4 \pm 3.5 \pm 0.1 \pm 0.2$	<7.2	<1.1
$\phi p\bar{p}$	$<5.8^{tn}$	<5.8	<0.9
$3(\pi^+\pi^-)$	$16.9 \pm 26.7 \pm 5.5 \pm 2.4$	<61.7	<9.1
$2(\pi^+\pi^-)\eta$	$72.7 \pm 55.0 \pm 7.3 \pm 8.2$	<164.7	<24.3
$2(\pi^+\pi^-)\pi^0$	$-35.4 \pm 24.6 \pm 6.6 \pm 4.0^z$	<42.3	<6.2
$K^+K^-\pi^+\pi^-\pi^0$	$-36.9 \pm 43.8 \pm 12.8 \pm 4.2^z$	<75.2	<11.1
$2(K^+K^-)\pi^0$	$18.1 \pm 7.7 \pm 0.7 \pm 2.0^n$	<31.2	<4.6
$p\bar{p}\pi^0$	$1.5 \pm 3.9 \pm 0.5 \pm 0.1$	<7.9	<1.2
$p\bar{p}\pi^+\pi^-\pi^0$	$26.0 \pm 13.9 \pm 2.6 \pm 3.2$	<49.7	<7.3
$3(\pi^+\pi^-)\pi^0$	$-12.7 \pm 55.9 \pm 8.7 \pm 1.8^z$	<92.8	<13.7

Phys. Lett. B 650 (2007) 111

Search for charmless decays of ψ(3770) (2)

Observed Cross Sections (preliminary)

Events from J/ψ,ψ(3686) and $D\bar{D}$ have been subtracted

$e^+e^- \to$	$\sqrt{s} = 3.773$ GeV: σ (or σ^{UP}) [pb]	$\sqrt{s} = 3.650$ GeV: σ (or σ^{UP}) [pb]
$K^+K^-2(\pi^+\pi^-)$	$168.0 \pm 18.2 \pm 23.7$	$164.9 \pm 30.3 \pm 23.2$
$2(K^+K^-)\pi^+\pi^-$	$11.9 \pm 5.8 \pm 1.7$	< 49.1
$p\bar{p}2(\pi^+\pi^-)$	$23.5 \pm 5.0 \pm 3.5$	$22.8 \pm 8.4 \pm 3.4$
$4(\pi^+\pi^-)$	$131.8 \pm 19.5 \pm 23.6$	$76.2 \pm 24.4 \pm 13.9$
$K^+K^-2(\pi^+\pi^-)\pi^0$	$231.5 \pm 63.6 \pm 37.5$	< 375.2
$4(\pi^+\pi^-)\pi^0$	< 206.9	< 119.4
$\rho^0\pi^+\pi^-$	$111.9 \pm 13.1 \pm 13.1$	$113.6 \pm 21.3 \pm 13.1$
$\rho^0K^+K^-$	$34.2 \pm 11.5 \pm 4.4$	$57.6 \pm 17.9 \pm 6.3$
$\rho^0p\bar{p}$	$13.1 \pm 3.2 \pm 1.8$	$17.7 \pm 6.2 \pm 2.8$
$K^{*0}K^-\pi^+ + c.c.$	$94.7 \pm 15.5 \pm 10.4$	$85.5 \pm 26.3 \pm 14.4$
$\Lambda\bar{\Lambda}$	< 2.5	< 6.1
$\Lambda\bar{\Lambda}\pi^+\pi^-$	< 26.7	< 42.9

Upper Limits on the observed cross section for the ψ(3770) decay

$$\sigma_{\psi(3770)\to f} = \sigma^{3.773\ \mathrm{GeV}}_{e^+e^-\to f} - f_{\mathrm{co}} \times \sigma^{3.650\ \mathrm{GeV}}_{e^+e^-\to f}$$

where f_{co} is coefficient due to1/s dependence of the cross section.

Preliminary

Decay Mode	$\sigma_{\psi(3770)\to f}$ [pb]	$\sigma^{\mathrm{up}}_{\psi(3770)\to f}$ [pb]	$\mathcal{B}^{\mathrm{up}}_{\psi(3770)\to f}$ [$\times 10^{-3}$]
$K^+K^-2(\pi^+\pi^-)$	$13.7 \pm 33.7 \pm 4.3 \pm 1.9$	< 69.5	< 10.3
$2(K^+K^-)\pi^+\pi^-$	$11.9 \pm 5.8 \pm 0.4 \pm 1.7^n$	< 21.8	< 3.2
$p\bar{p}2(\pi^+\pi^-)$	$2.2 \pm 9.3 \pm 0.5 \pm 0.3$	< 17.5	< 2.6
$4(\pi^+\pi^-)$	$60.5 \pm 30.0 \pm 3.0 \pm 10.7$	< 113.1	< 16.7
$K^+K^-2(\pi^+\pi^-)\pi^0$	$231.5 \pm 63.6 \pm 13.4 \pm 33.6^n$	< 351.5	< 52.0
$4(\pi^+\pi^-)\pi^0$	$< 206.9^{tn}$	< 206.9	< 30.6
$\rho^0\pi^+\pi^-$	$5.6 \pm 23.9 \pm 6.0 \pm 0.6$	< 46.6	< 6.9
$\rho^0K^+K^-$	$-19.7 \pm 20.3 \pm 3.4 \pm 2.1^z$	< 33.9	< 5.0
$\rho^0p\bar{p}$	$-3.5 \pm 6.6 \pm 1.1 \pm 0.4^z$	< 11.4	< 1.7
$K^{*0}K^-\pi^+ + c.c.$	$14.7 \pm 29.1 \pm 3.3 \pm 1.5$	< 65.8	< 9.7
$\Lambda\bar{\Lambda}$	$< 2.5^{tn}$	< 2.5	< 0.4
$\Lambda\bar{\Lambda}\pi^+\pi^-$	$< 26.9^{tn}$	< 26.9	< 4.4

Recent results on D meson inclusive decays from BES

- $BF(D^0 \rightarrow \mu^+ X)$ and $BF(D^+ \rightarrow \mu^+ X)$
- $BF(D^0 \rightarrow e^+ X)$ and $BF(D^+ \rightarrow e^+ X)$
- $BF(D^0 \rightarrow K^+ X)$ and $BF(D^+ \rightarrow K^+ X)$
- $BF(D^0 \rightarrow K^- X)$ and $BF(D^+ \rightarrow K^- X)$

D Mesons Inclusive Decays

$$\frac{\tau(D^+)}{\tau(D^0)} = 2.54 \pm 0.02$$

→ D^+ has a significantly longer lifetime.

$$\Gamma_{SL}(D \to X l^+ \nu_l) = \frac{G_F^2}{192\pi^3} m_c^5 f(\frac{m_s}{m_c})$$

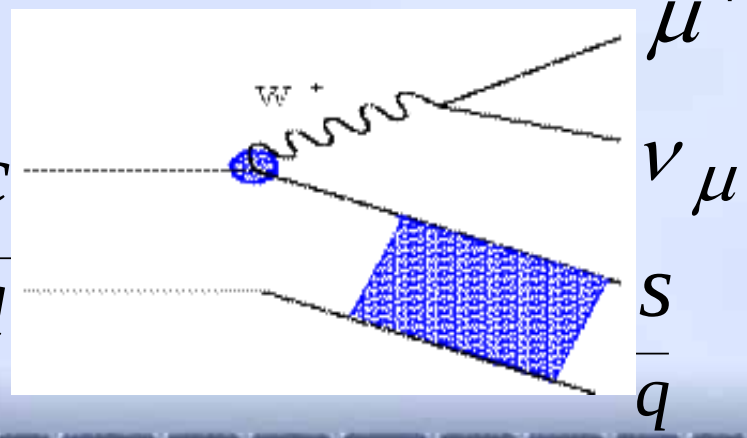
$$\frac{\Gamma_{SL}(D^+ \to l^+ X)}{\Gamma_{SL}(D^0 \to l^+ X)} \approx 1$$

GIM scheme of the weak interaction expects that the inclusive partial widths for D^+ and D^0 semileptonic decays to be about equal.

$$\frac{BF(D^+ \to l^+ X)}{BF(D^0 \to l^+ X)} \approx \frac{\tau(D^+)}{\tau(D^0)}$$

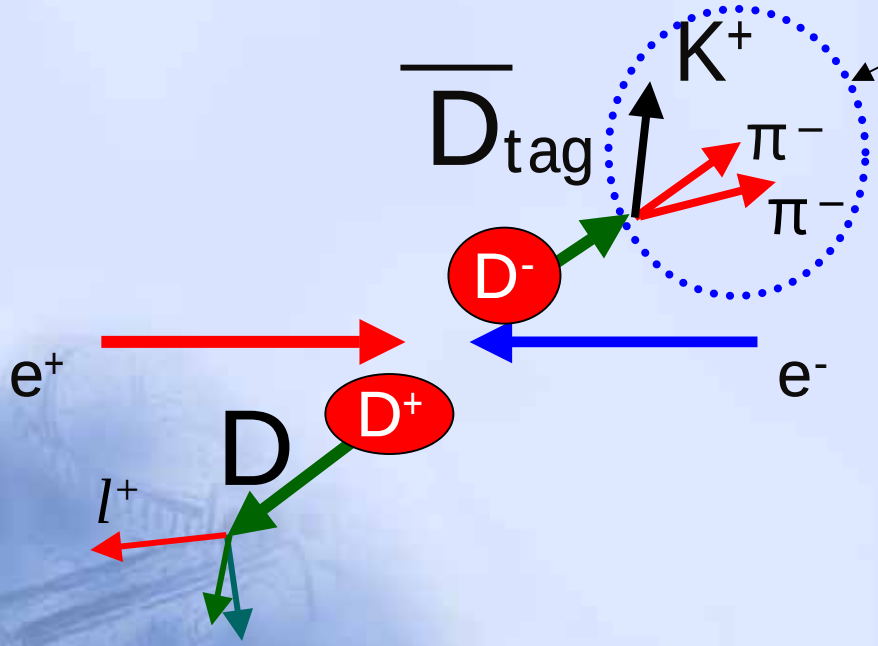
As a probe of the relative lifetimes of D^+ and D^0.

(D^0/D^+)



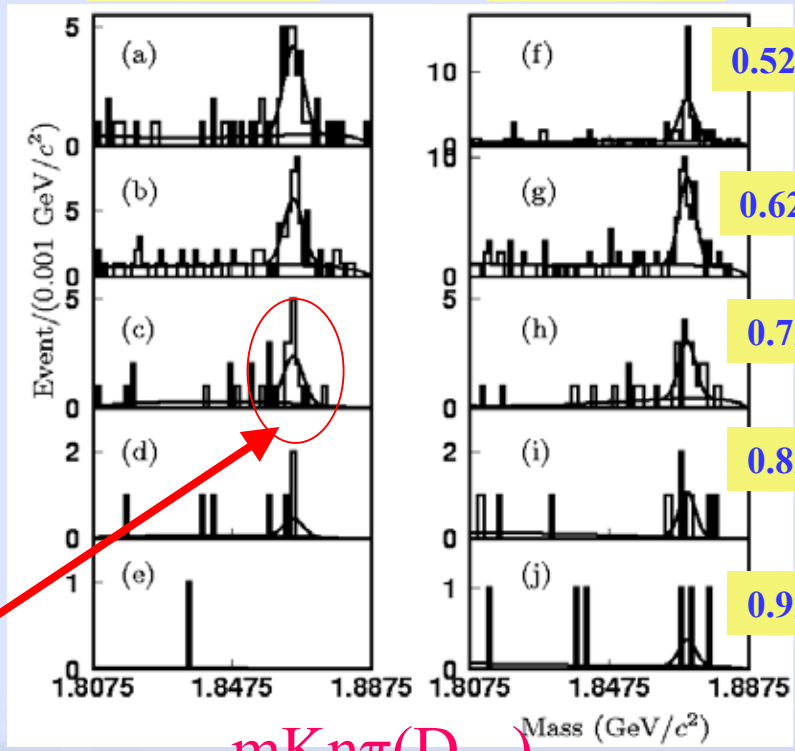
◆ Absolute Measurements

The ψ(3770) lies near the DD-bar production threshold, DD-bar paired produced. With the singly tagged D sample, we can do some absolute measurements on its recoil side.



Singly tagged D sample

$D^0 \to \mu X$ $D^+ \to \mu X$ P_T



0.52-0.62 GeV

0.62-0.72 GeV

0.72-0.82 GeV

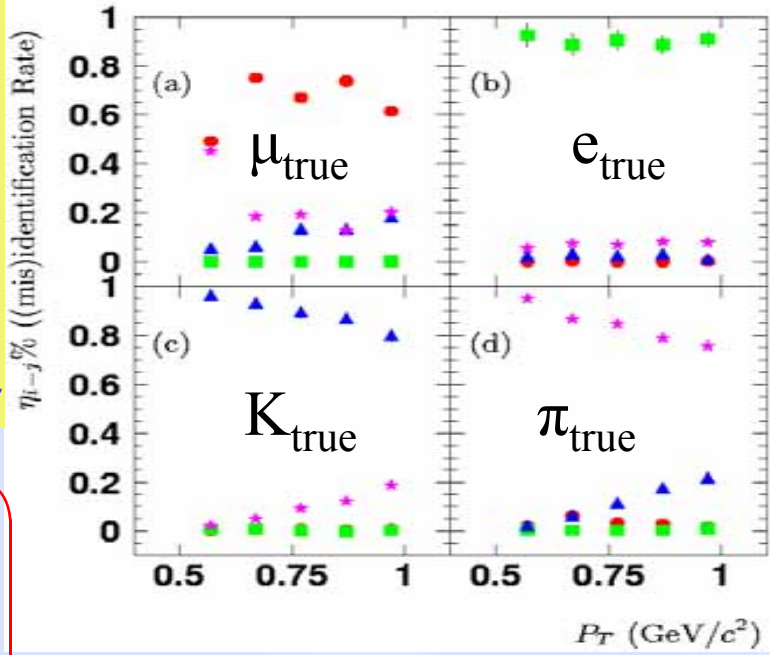
0.82-0.92 GeV

0.92-1.02 GeV

N^{μ}_{obs}

$mKn\pi(D_{tag})$

$$N^{\mu}_{obs} = N^{\mu}_{true}\varepsilon_{\mu\mu} + N^{e}_{true}\varepsilon_{e\mu} + N^{k}_{true}\varepsilon_{k\mu} + N^{\pi}_{true}\varepsilon_{\pi\mu}$$
$$N^{e}_{obs} = N^{\mu}_{true}\varepsilon_{\mu e} + N^{e}_{true}\varepsilon_{ee} + N^{k}_{true}\varepsilon_{ke} + N^{\pi}_{true}\varepsilon_{\pi e}$$
$$N^{k}_{obs} = N^{\mu}_{true}\varepsilon_{\mu k} + N^{e}_{true}\varepsilon_{ek} + N^{k}_{true}\varepsilon_{kk} + N^{\pi}_{true}\varepsilon_{\pi k}$$
$$N^{\pi}_{obs} = N^{\mu}_{true}\varepsilon_{\mu\pi} + N^{e}_{true}\varepsilon_{e\pi} + N^{k}_{true}\varepsilon_{k\pi} + N^{\pi}_{true}\varepsilon_{\pi\pi}$$



$$\begin{pmatrix} N^{\mu}_{true} \\ N^{e}_{true} \\ N^{k}_{true} \\ N^{\pi}_{true} \end{pmatrix} = \begin{pmatrix} \varepsilon_{\mu\mu} & \varepsilon_{e\mu} & \varepsilon_{k\mu} & \varepsilon_{\pi\mu} \\ \varepsilon_{\mu e} & \varepsilon_{ee} & \varepsilon_{ke} & \varepsilon_{\pi e} \\ \varepsilon_{\mu k} & \varepsilon_{ek} & \varepsilon_{kk} & \varepsilon_{\pi k} \\ \varepsilon_{\mu\pi} & \varepsilon_{e\pi} & \varepsilon_{k\pi} & \varepsilon_{\pi\pi} \end{pmatrix}^{-1} \times \begin{pmatrix} N^{\mu}_{obs} \\ N^{e}_{obs} \\ N^{k}_{obs} \\ N^{\pi}_{obs} \end{pmatrix}$$

ε_{im}= ratio of a particle "i" to be identified as "m"

N_{obs}^{i} =observed particle i

N_{true}^{i} = true particle i

Results of BF($D^0 \to \mu X$) and BF($D^+ \to \mu X$)

TABLE I: Comparison of the measured branching fractions for the inclusive semimuonic decays of D mesons with those measured by ARGUS [9], CHORUS [10] and those given by PDG [1], where BF_{D^0} and BF_{D^+} represent the $BF(D^0 \to \mu X)(\%)$ and $BF(D^+ \to \mu X)(\%)$, respectively

Preliminary

PDG07 6.6±0.6

	BESII	ARGUS	CHORUS	PDG(06)
BF_{D^0}	6.8±1.5±0.6	6.0±0.7±1.2	6.5±1.2±0.3	6.5±0.7
BF_{D^+}	17.6±2.7±1.3	-	-	-
$\frac{BF_{D^+}}{BF_{D^0}}$	2.59±0.70±0.15	-	-	-
$\frac{\tau(D^+)}{\tau(D^0)}$	-	-	-	2.54±0.02

Measured first time

Results of BF(D→e$^+$X) and BF(D→KX)

Preliminary

$$BF(D^+ \to e^+X) = (15.2 \pm 1.0 \pm 0.7)\%,$$

$$BF(D^0 \to e^+X) = (6.3 \pm 0.7 \pm 0.4)\%,$$

$$\frac{\Gamma(D^+ \to e^+X)}{\Gamma(D^0 \to e^+X)} = 0.95 \pm 0.12 \pm 0.06$$

$$BF(D^+ \to K^-X) = (24.7 \pm 1.3 \pm 1.2)\%,$$

Pdg2007: (27.5±2.4)%

$$BF(D^+ \to K^+X) = (6.1 \pm 0.9 \pm 0.4)\%,$$

Pdg2007: (5.5±1.6)%

$$BF(D^0 \to K^-X) = (57.8 \pm 1.6 \pm 3.4)\%$$

Pdg2007: (53±4)%

$$BF(D^0 \to K^+X) = (3.5 \pm 0.7 \pm 0.3)\%,$$

Pdg2007: $(3.4^{+0.6}_{-0.4})\%$

	$Br(D^0 \to e^+X)(\%)$	$Br(D^+ \to e^+X)(\%)$
CLEO-c	6.46±0.17±0.13	16.13±0.20±0.33
MarkIII	7.5±1.1±0.4	17.0±1.9±0.7
Bes-II	6.3±0.7±0.4	15.2±1.0±0.7
PDG2007	6.55±0.17	16.1±0.4

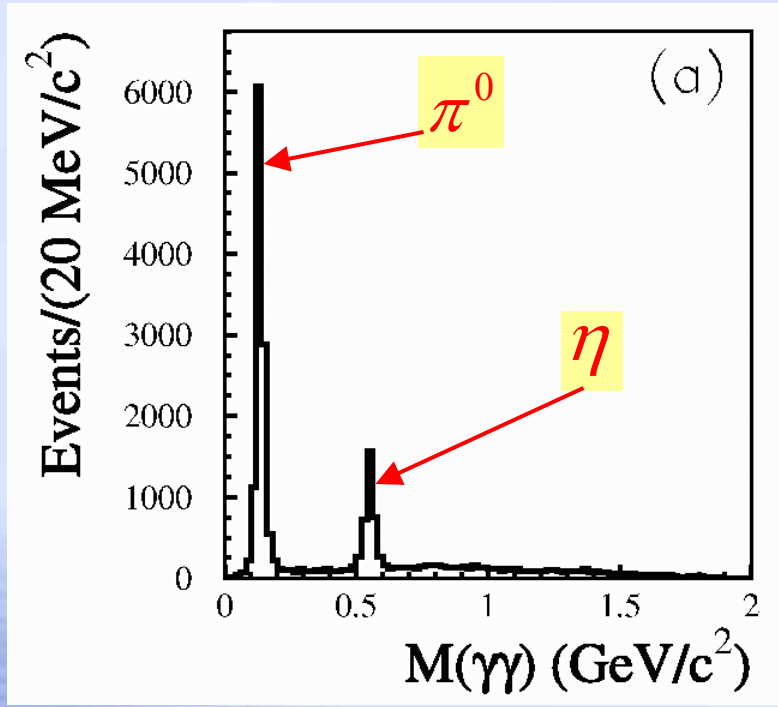
Results Comparison

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

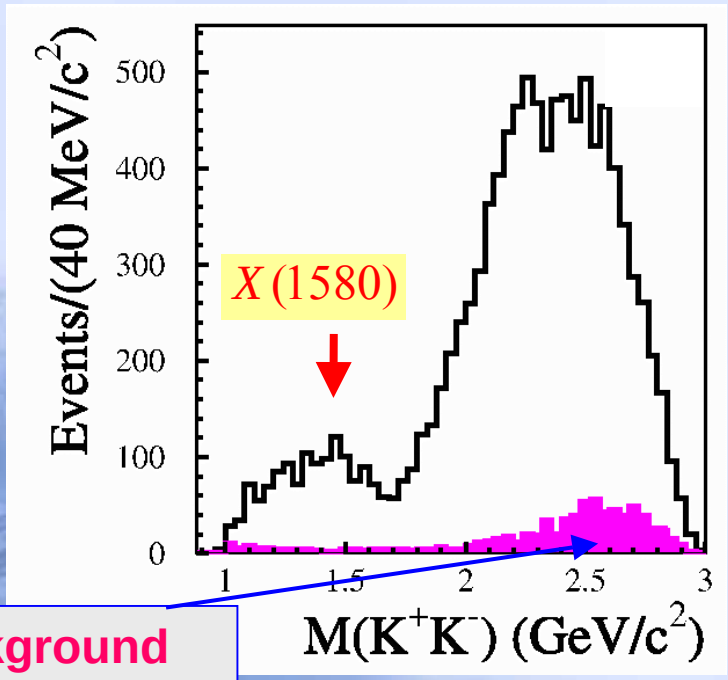
Phys. Rev. Lett. 97, 142002 (2006)

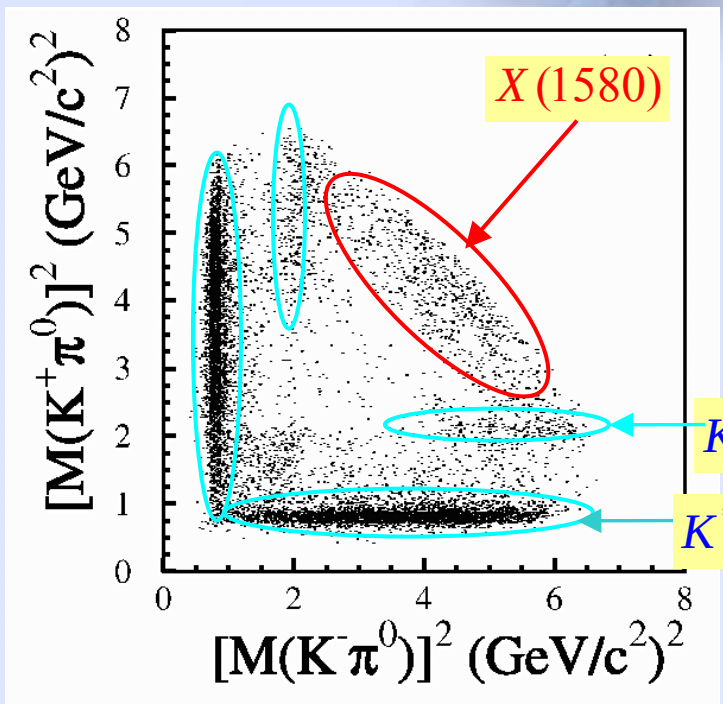
$J/\psi \rightarrow K^+K^- \pi^0$

very clean π^0 signal



$J/\psi \rightarrow K^+K^-\pi^0$





PID and kinematic fit can significantly reduce the dominant background from $J/\psi \rightarrow \pi^+\pi^-\pi^0$.

Partial Wave Analysis of $J/\psi \to K^+K^-\pi^0$ events

- Parity conservations in $J/\psi \to K^+K^-\pi^0$ requires that spin-parity of K^+K^- should be 1^{--},3^{--},…

- PWA fit with $X, \rho(1700), K^*(890), K^*(1410)$ and phase space (PS) gives :

  - $J^{PC} = 1^{--}$

    (3^{--} can be ruled out by much worse likelihood)

  - X pole position $(1576^{+49+98}_{-55-91}) - i(409^{+11+32}_{-12-67})\ MeV/c^2$

  - $Br(J/\psi \to X\pi^0) \cdot Br(X \to K^+K^-) = (8.5 \pm 0.6^{+2.7}_{-3.6}) \times 10^{-4}$

  - big destructive interference among $X, \rho(1700)$ and PS

Broad X cannot be fit with known mesons or their interference

- **It is unlikely to be ρ(1450), because:**
  - **The parameters of the X is incompatible with ρ(1450).**
  - **ρ(1450) has very small fraction to KK. From PDG:**

$$Br(\rho(1450) \to K^+K^-) < 1.6 \times 10^{-3} \quad (95\% C.L.)$$

- **It cannot be fit with the interference of ρ(770) , ρ(1900) and ρ(2150):**
  - **The log-likelihood value worsens by 85 ($\Delta\chi^2$=170).**

How to understand broad X(1580)?

- **Search of a similar structure in $J/\psi \to K_S K \pi$ will help to determine its isospin.**

- **X(1580) could have different nature from conventional mesons:**
  - **There are already many 1- - mesons nearby.**
  - **Width is much broader than other mesons.**
  - **Broad width is expected for a multiquark state.**

$\psi(2S)$ radiative decay and χ_{cJ} decay

ψ(2S) radiative decay

$\psi(2S) \to \gamma\eta\pi^+\pi^-, \gamma K\bar{K}\pi$

Summary of branching fractions for $\psi(2S)$ decays into $\gamma\eta\pi\pi$ and $\gamma K\bar{K}\pi$ final states.

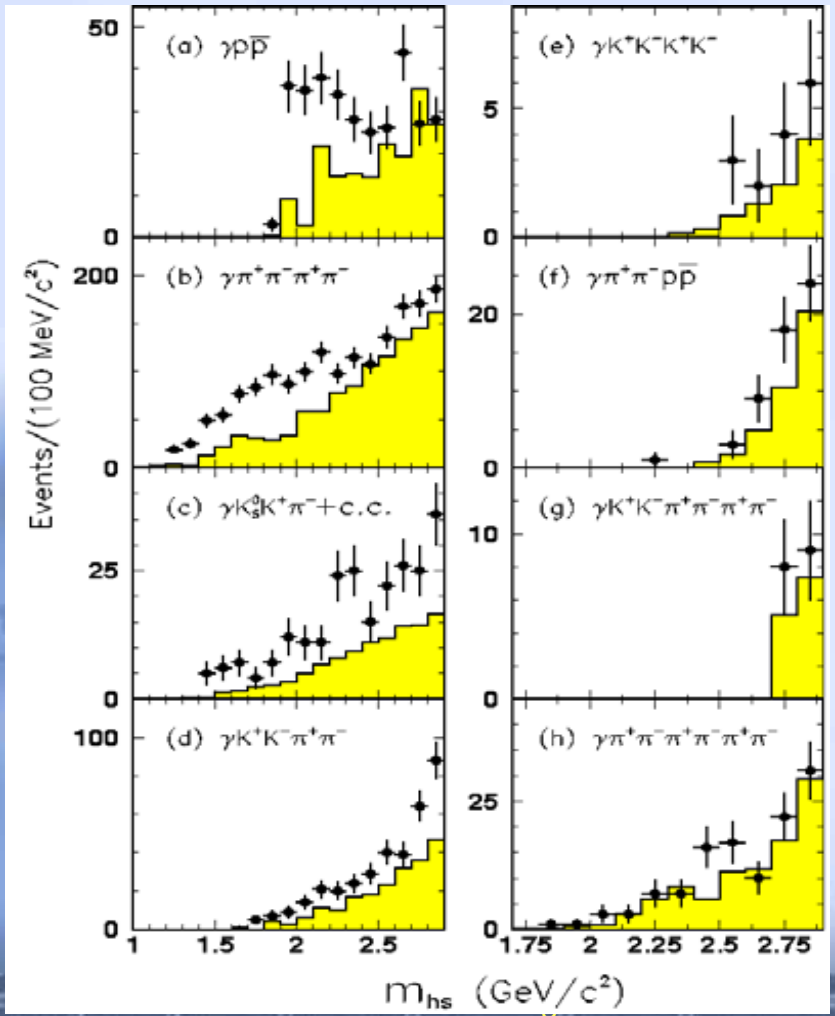
Channel ($\psi(2S) \to$)	$n^{sig.}$	ε (%)	$\mathcal{B}_{\psi(2S)\to}(\times 10^{-4})$	$\mathcal{B}_{J/\psi\to}(\times 10^{-4})$	$\frac{\mathcal{B}(\psi(2S))}{\mathcal{B}(J/\psi)}$(%)
$\gamma\eta\pi^+\pi^-$ [a]	418±60	8.69	8.71±1.25±1.64	–	–
$\gamma\eta\pi^+\pi^-$ [b]	–	–	3.60±1.42±1.83	39±7.3	9.2±6.2
$\gamma\eta'(958)$	23±5	7.58	1.24±0.27±0.15	43.1±3	2.9±0.7
$\gamma\eta(1405) \to \gamma\eta\pi^+\pi^-$	10±7	5.06	0.36±0.25±0.05	3.0±0.5	12±10
	< 24	5.06	< 1.0	3.0±0.5	< 33
$\gamma\eta(1475) \to \gamma\eta\pi^+\pi^-$	< 20	4.80	< 0.83	3.0±0.5	< 28
$\gamma\eta(1405) \to \gamma K\bar{K}\pi$ [c]	< 11	4.54	< 0.8	28 ± 6	< 2.9
$\gamma\eta(1475) \to \gamma K\bar{K}\pi$ [c]	< 16	4.58	< 1.5	28 ± 6	< 5.4
$\gamma\eta(1405) \to \gamma K\bar{K}\pi$ [d]	< 9	3.63	< 1.3	28 ± 6	< 4.6
$\gamma\eta(1475) \to \gamma K\bar{K}\pi$ [d]	< 9	3.54	< 1.4	28 ± 6	< 5.0

[a] all processes in the $\psi(2S) \to \gamma\eta\pi^+\pi^-$;
[b] all processes excluding $\psi(2S) \to \gamma\chi_{c1} \to \gamma\eta\pi^+\pi^-$;
[c] the decay mode is $\gamma K^0_S K^+\pi^- + c.c.$;
[d] the decay mode is $\gamma K^+K^-\pi^0$.

PRD74, 072001(2006)

ψ(2S) radiative decay

Many channels for ψ(2S)→γ+hadrons with the invariant mass of hadrons below 2.9GeV have been studied.



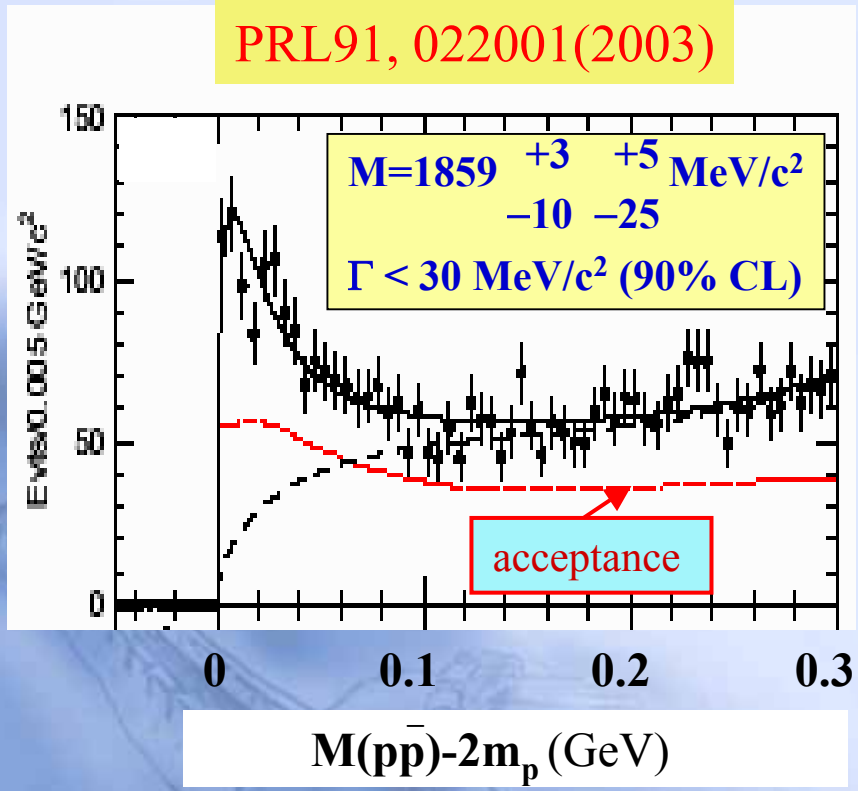
Mode	N^{Tot}	N^{Bg}	N^{Sig}	$\epsilon(\%)$	$\mathcal{B}(\times 10^{-5})$
$\gamma p\bar{p}$	329	187	142 ± 18	35.3	$2.9 \pm 0.4 \pm 0.4$
$\gamma 2(\pi^+\pi^-)$	1697	1114	583 ± 41	10.4	$39.6 \pm 2.8 \pm 5.0$
$\gamma K^0_S K^+\pi^- + c.c.$	–	–	115 ± 16	4.83	$25.6 \pm 3.6 \pm 3.6$
$\gamma K^+K^-\pi^+\pi^-$	361	229	132 ± 19	4.94	$19.1 \pm 2.7 \pm 4.3$
$\gamma K^{*0}K^+\pi^- + c.c.$	–	–	237 ± 39	6.86	$37.0 \pm 6.1 \pm 7.2$
$\gamma K^{*0}\bar{K}^{*0}$	58	17	41 ± 8	2.75	$24.0 \pm 4.5 \pm 5.0$
$\gamma\pi^+\pi^- p\bar{p}$	55	38	17 ± 7	4.47	$2.8 \pm 1.2 \pm 0.7$
$\gamma K^+K^-K^+K^-$	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

PRL99, 011802 (2007)

Search for the strong $p\bar{p}$ mass threshold enhancement X(1860) in $\psi(2S) \to \gamma p\bar{p}$

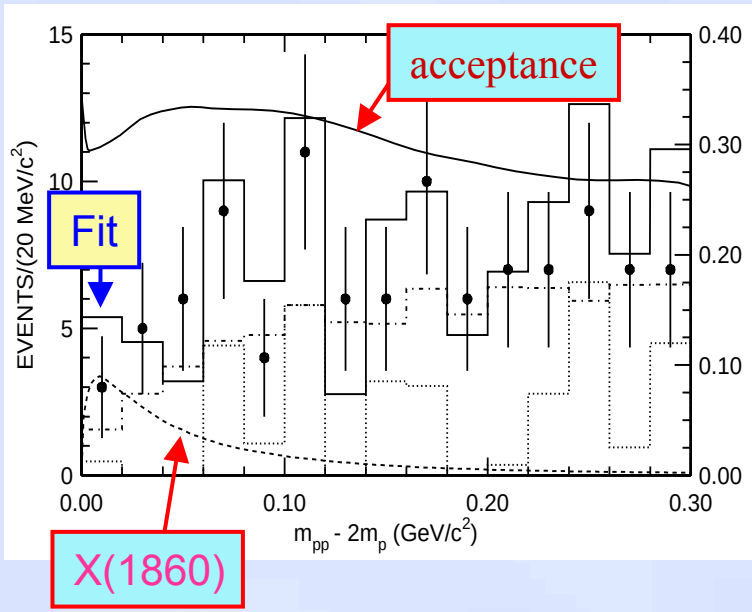
- A strong $p\bar{p}$ mass threshold enhancement was observed in $J/\psi \to \gamma p\bar{p}$

PRL91, 022001(2003)



$B(J/\psi \to \gamma X(1860) \to \gamma p\bar{p}) \sim 7 \times 10^{-5}$

- No obvious strong $p\bar{p}$ mass threshold enhancement was observed in $\psi(2S) \to \gamma p\bar{p}$



$B(\psi(2S) \to \gamma X(1860) \to \gamma p\bar{p}) < 5.4 \times 10^{-6}$ @ 90% CL

χ_{cJ} decay

$$\chi_{cJ} \to \phi\phi, \phi K^+K^-, K^+K^-K^+K^-$$
$$\chi_{cJ} \to K_S^0 K^+\pi^- + c.c.$$
$$\chi_{cJ} \to \eta\pi^+\pi^-, a_0(890)\pi, \eta f_2(1270)$$

PLB642,197(2006)

PRD74,072001(2006)

PRD74,072001(2006)

Most channels are measured for the first time

$\chi_{cJ} \to K^+ K^- K^+ K^-$

Channel	$2(K^+K^-)(\times 10^{-3})$		$\phi K^+K^-(\times 10^{-3})$	$\phi\phi(\times 10^{-3})$	
	BES-II	PDG	BES-II	BES-II	PDG
χ_{c0}	$3.47 \pm 0.22 \pm 0.48$	2.3 ± 0.5	$1.02 \pm 0.22 \pm 0.15$	$0.94 \pm 0.21 \pm 0.14$	1.0 ± 0.6
χ_{c1}	$0.68 \pm 0.13 \pm 0.10$	0.42 ± 0.19	$0.44 \pm 0.14 \pm 0.07$	–	–
χ_{c2}	$1.88 \pm 0.18 \pm 0.28$	1.8 ± 0.5	$1.46 \pm 0.21 \pm 0.22$	$1.48 \pm 0.26 \pm 0.23$	2.4 ± 0.9

$\chi_{cJ} \to \pi^+\pi^-\pi^\pm K^\pm, \gamma\gamma\pi^+\pi^-$

Mode	$\mathrm{Br}(\times 10^{-3})$	$\mathrm{Br}(\times 10^{-3})$(CLEO-c)
$\chi_{c1} \to K_S K^+\pi^- + c.c.$	$4.1 \pm 0.3 \pm 0.7$	$\bar{K}^0 K^+\pi^-$: $8.4 \pm 0.5 \pm 0.6 \pm 0.5$
$\chi_{c2} \to K_S K^+\pi^- + c.c.$	$0.8 \pm 0.3 \pm 0.2$	$\bar{K}^0 K^+\pi^-$: $1.5 \pm 0.2 \pm 0.1 \pm 0.1$
$\chi_{c1} \to \eta\pi\pi$	$6.1 \pm 0.8 \pm 1.0$	$5.2 \pm 0.3 \pm 0.3 \pm 0.3$
$\chi_{c1} \to a_0^+\pi^- \to \eta\pi^+\pi^-$	$2.0 \pm 0.5 \pm 0.5$	
$\chi_{c1} \to f_2(1270)\eta$	$2.1 \pm 0.5 \pm 0.4$	

Summary

- **Search for charmless decays of ψ(3770) in BES-II (30 modes)**

Decay mode	$\sigma_{\psi(3770)\to f}$ [pb]	$\sigma^{\rm up}_{\psi(3770)\to f}$ [pb]	$\mathcal{B}^{\rm up}_{\psi(3770)\to f}$ [$\times10^{-3}$]
$\phi\pi^0$	$<3.5^{tn}$	<3.5	<0.5
$\phi\eta$	$<12.6^{tn}$	<12.6	<1.9
$2(\pi^+\pi^-)$	$7.4\pm15.0\pm2.8\pm0.8$	<32.5	<4.8
$K^+K^-\pi^+\pi^-$	$-19.6\pm19.6\pm3.3\pm2.1^z$	<32.7	<4.8
$\phi\pi^+\pi^-$	$<11.1^{tn}$	<11.1	<1.6
$2(K^+K^-)$	$-2.7\pm7.1\pm0.5\pm0.3^z$	<11.6	<1.7
ϕK^+K^-	$-0.5\pm10.0\pm0.9\pm0.1^z$	<16.5	<2.4
$p\bar{p}\pi^+\pi^-$	$-6.2\pm6.6\pm0.6\pm0.7^z$	<11.0	<1.6
$p\bar{p}K^+K^-$	$1.4\pm3.5\pm0.1\pm0.2$	<7.2	<1.1
$\phi p\bar{p}$	$<5.8^{tn}$	<5.8	<0.9
$3(\pi^+\pi^-)$	$16.9\pm26.7\pm5.5\pm2.4$	<61.7	<9.1
$2(\pi^+\pi^-)\eta$	$72.7\pm55.0\pm7.3\pm8.2$	<164.7	<24.3
$2(\pi^+\pi^-)\pi^0$	$-35.4\pm24.6\pm6.6\pm4.0^z$	<42.3	<6.2
$K^+K^-\pi^+\pi^-\pi^0$	$-36.9\pm43.8\pm12.8\pm4.2^z$	<75.2	<11.1
$2(K^+K^-)\pi^0$	$18.1\pm7.7\pm0.7\pm2.0^n$	<31.2	<4.6
$p\bar{p}\pi^0$	$1.5\pm3.9\pm0.5\pm0.1$	<7.9	<1.2
$p\bar{p}\pi^+\pi^-\pi^0$	$26.0\pm13.9\pm2.6\pm3.2$	<49.7	<7.3
$3(\pi^+\pi^-)\pi^0$	$-12.7\pm55.9\pm8.7\pm1.8^z$	<92.8	<13.7

Phys. Lett. B 650 (2007) 111

Decay Mode	$\sigma_{\psi(3770)\to f}$ [pb]	$\sigma^{\rm up}_{\psi(3770)\to f}$ [pb]	$\mathcal{B}^{\rm up}_{\psi(3770)\to f}$ [$\times10^{-3}$]
$K^+K^-2(\pi^+\pi^-)$	$13.7\pm33.7\pm4.3\pm1.9$	< 69.5	< 10.3
$2(K^+K^-)\pi^+\pi^-$	$11.9\pm5.8\pm0.4\pm1.7^n$	< 21.8	< 3.2
$p\bar{p}2(\pi^+\pi^-)$	$2.2\pm9.3\pm0.5\pm0.3$	< 17.5	< 2.6
$4(\pi^+\pi^-)$	$60.5\pm30.0\pm3.0\pm10.7$	< 113.1	< 16.7
$K^+K^-2(\pi^+\pi^-)\pi^0$	$231.5\pm63.6\pm13.4\pm33.6^n$	< 351.5	< 52.0
$4(\pi^+\pi^-)\pi^0$	$<206.9^{tn}$	< 206.9	< 30.6
$\rho^0\pi^+\pi^-$	$5.6\pm23.9\pm6.0\pm0.6$	< 46.6	< 6.9
$\rho^0K^+K^-$	$-19.7\pm20.3\pm3.4\pm2.1^z$	< 33.9	< 5.0
$\rho^0p\bar{p}$	$-3.5\pm6.6\pm1.1\pm0.1$	< 11.4	< 1.7
$K^{*0}K^-\pi^+ + c.c.$	$34.7\pm29.1\pm3.3\pm1.5$	< 65.8	< 9.7
$\Lambda\bar{\Lambda}$	$<2.5^{tn}$	< 2.5	< 0.4
$\Lambda\bar{\Lambda}\pi^+\pi^-$	$<26.9^{tn}$	< 26.9	< 4.4

BES II Preliminary

Results of BF($D^0 \to \mu X$) and BF($D^+ \to \mu X$)

TABLE I: Comparison of the measured branching fractions for the inclusive semimuonic decays of D mesons with those measured by ARGUS [9], CHORUS [10] and those given by PDG [1], where BF_{D^0} and BF_{D^+} represent the $BF(D^0 \to \mu X)(\%)$ and $BF(D^+ \to \mu X)(\%)$, respectively

PDG07 6.6±0.6

Preliminary

	BESII	ARGUS	CHORUS	PDG(06)
BF_{D^0}	6.8±1.5±0.6	6.0±0.7±1.2	6.5±1.2±0.3	6.5±0.7
BF_{D^+}	17.6±2.7±1.3	-	-	-
$\frac{BF_{D^+}}{BF_{D^0}}$	2.59±0.70±0.15	-	-	-
$\frac{\tau(D^+)}{\tau(D^0)}$	-	-	-	2.54±0.02

Measured for the first time

BES II Preliminary

Results of BF($D \to e^+X$) and BF($D \to KX$)

$$BF(D^+ \to e^+X) = (15.2 \pm 1.0 \pm 0.7)\%,$$

$$BF(D^0 \to e^+X) = (6.3 \pm 0.7 \pm 0.4)\%,$$

$$\frac{\Gamma(D^+ \to e^+X)}{\Gamma(D^0 \to e^+X)} = 0.95 \pm 0.12 \pm 0.06$$

$$BF(D^+ \to K^-X) = (24.7 \pm 1.3 \pm 1.2)\%,$$ Pdg2007: (27.5±2.4)%

$$BF(D^+ \to K^+X) = (6.1 \pm 0.9 \pm 0.4)\%,$$ Pdg2007: (5.5±1.6)%

$$BF(D^0 \to K^-X) = (57.8 \pm 1.6 \pm 3.4)\%$$ Pdg2007: (53±4)%

$$BF(D^0 \to K^+X) = (3.5 \pm 0.7 \pm 0.3)\%,$$ Pdg2007: $(3.4^{+0.6}_{-0.4})$%

	$Br(D^0 \to e^+X)(\%)$	$Br(D^+ \to e^+X)(\%)$
CLEO-c	6.46±0.17±0.13	16.13±0.20±0.33
MarkIII	7.5±1.1±0.4	17.0±1.9±0.7
Bes-II	6.3±0.7±0.4	15.2±1.0±0.7
PDG2007	6.55±0.17	16.1±0.4

Results Comparison

Summary

Summary

- A very broad 1^{--} resonance X(1580) is observed in $J/\psi \to K^+K^-\pi^0$.
- A lot of $\psi(2S)$ radiative decays are measured.
- Many χ_{cJ} decay modes are observed and most are measured for the first time

谢 谢！

Thank You！