

Spectroscopy of the new hidden-charm^{^ [and beauty?]} states at Belle

Bruce Yabsley

Belle / University of Sydney Particle Physics group / CoEPP

Quarkonium Working Group meeting, GSI Darmstadt,
5th October 2011



Outline

X(3872)

State of play in 2006

Belle updates in 2007–2010

New bounds on width, mass-difference, & other properties

The new state of play

Y(3940) and related states

$Y(4260) \rightarrow \pi^0\pi^0\psi$

Z states: charged hidden-charm (and beauty?) mesons

— following Roman Mizuk on h_b , Z_b , η_b this morning

- ▶ $\Upsilon(1S, 2S) \rightarrow \gamma X_{c\bar{c}}$ searches → X.L. Wang, Friday
- ▶ $\left\{ \begin{array}{l} \sigma(\Lambda_c^+ \Lambda_c^-) \text{ near-threshold enhancement} \\ \sigma(e^+ e^- \rightarrow D^{(*)+} D^{*-}) \end{array} \right.$ → Galina Pakhlova, Friday
- ▶ SuperKEKB / Belle II prospect → Steve Olsen, Friday



$X(3872)$: state of play in 2006

adapted from **Beauty 2006: Nucl. Phys. (Proc. Suppl.) 170, 248–253 (2007)**

- ▶ narrow; prominent $\pi^+\pi^-\psi$ decay [Belle discovery; CDF, D0, BaBar]
 - ▶ $\mathcal{B}(X \rightarrow \pi^+\pi^-\psi) > 4.2\%$ [BaBar inclusive, *PRD* **71**, 031501]
 - ▶ $\Gamma < 2.3 \text{ MeV}$ (90% C.L.) [Belle discovery]
- ▶ $M = (3871.2 \pm 0.5) \text{ MeV} \lesssim (m_{D^0} + m_{D^*})$ by 1σ [WA; CLEO]
- ▶ $p\bar{p}$ prodⁿ: $(16 \pm 5 \pm 2)\%$ b -decay, rest prompt; “ ψ' -like” [CDF]
- ▶ X^\pm not seen: not an isovector [BaBar *PRD* **71**, 031501]
- ▶ C -even, from $X \rightarrow \gamma\psi$ [Belle, BaBar] and $\pi^0\pi^+\pi^-\psi$ [Belle]
 - ▶ $X \rightarrow \rho\psi$ dominates, $L = 0, 1$ [CDF $M(\pi^+\pi^-)$ *PRL* **96**, 102002]
 - ▶ $J^{PC} = 1^{++}$ or 2^{-+} [CDF angular *PRL* **98**, 132002]
- ▶ $B^+ \text{ vs } B^0 \rightarrow K X$ “needs more data” TM [BaBar *PRD* **73**, 011101(R)]
- ▶ X peak in $B \rightarrow K D^0 \bar{D}^0 \pi^0$ needs confirmⁿ [Belle *PRL* **97**, 162002]
- ▶ loose ends: $\pi^0\pi^0\psi$, $\gamma\psi'$, $\pi^+\pi^-\eta_c$, $\gamma D\bar{D}$

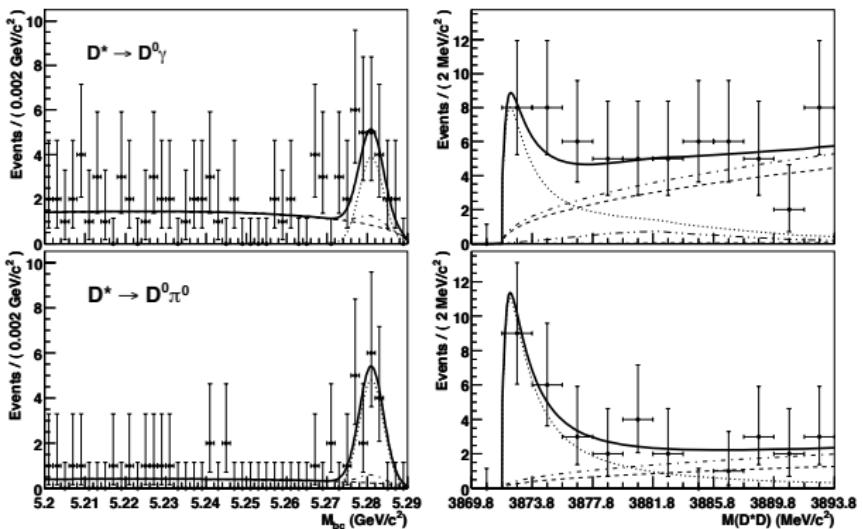


Update (1): $B \rightarrow KX [\rightarrow (\{\gamma, \pi^0\} D^0)_{D^{*0}} \bar{D}^0]$

T. Aushev, N. Zwahlen et al., PRD 81, 031103(R) (2010); cf. 77, 01102 (2008)

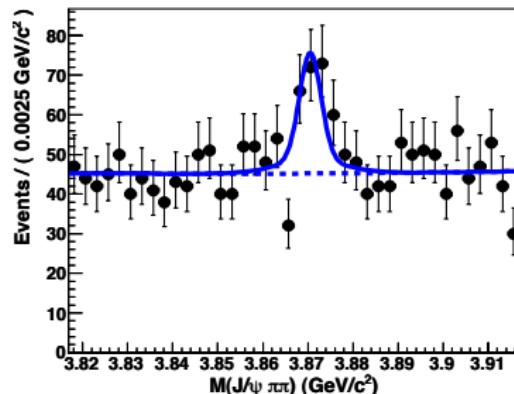
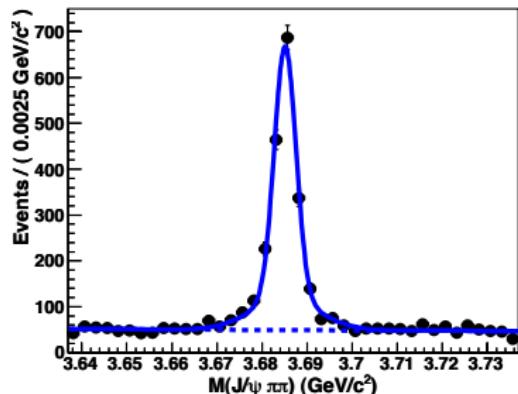
	$\mathcal{B}(B \rightarrow KX) \times \mathcal{B}(X \rightarrow D^{*0} \bar{D}^0)$	$M_{\text{peak}}(D^{*0} \bar{D}^0)$
Belle	$(0.80 \pm 0.20 \pm 0.10) \times 10^{-4}$	$(3872.9^{+0.6+0.4}_{-0.4-0.5}) \text{ MeV}$
cf. BaBar	$(1.67 \pm 0.36 \pm 0.47) \times 10^{-4}$	$(3875.1^{+0.7}_{-0.5} \pm 0.5) \text{ MeV}$

D^* constraint to separate sig/bkgd \implies no $\{\gamma, \pi^0\} D \bar{D}$ lineshape study



Update (2): $B^0 \rightarrow K^+ \pi^- X(3872)$ spectrum

I. Adachi et al., BELLE-CONF-0849, arXiv:0809.1224 [hep-ex]

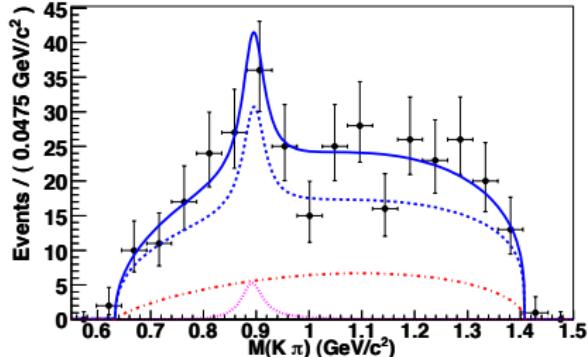
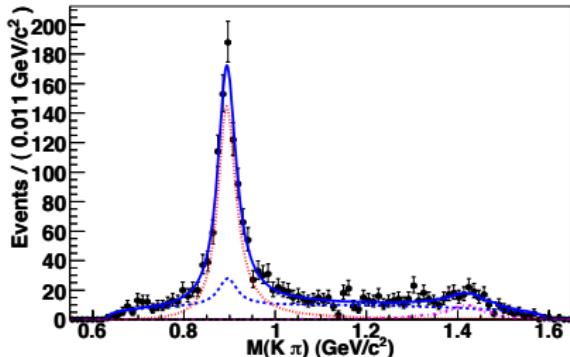


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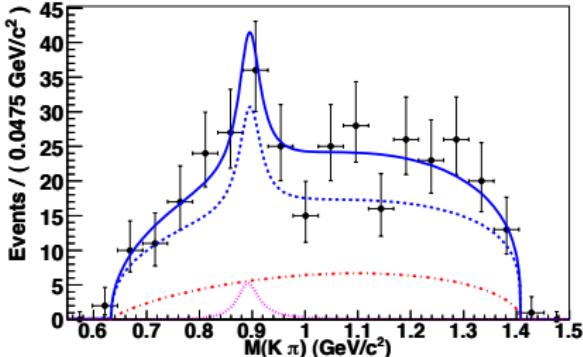
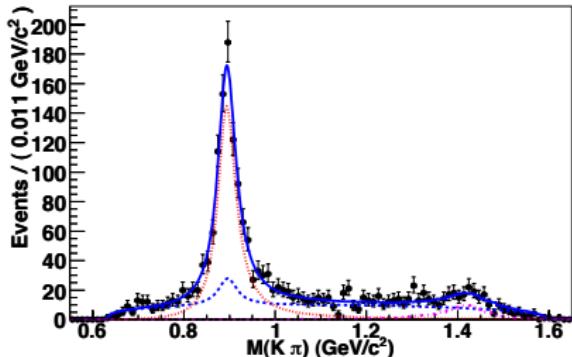


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- ▶ bkgd: phase space + $K^*(892)^0$ B-W from $\pi\pi\psi$ sidebands
- ▶ signal: $\begin{cases} \psi' : & K^*(892)^0 \text{ B-W} \& K_2^*(1430)^0 \text{ MC shape} \\ X(3872) : & K^*(892)^0 \text{ B-W} \& \text{phase space from MC} \end{cases}$



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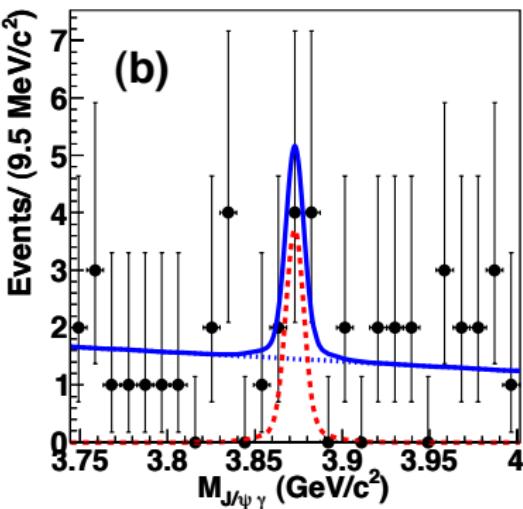
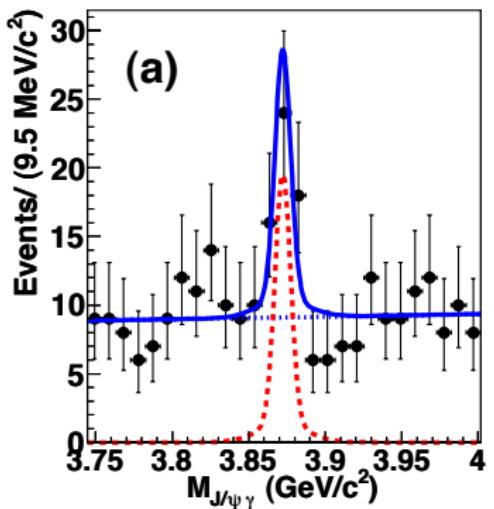


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- ▶ strong $(K\pi)_{non-res}$, no significant $K^* \dots$ cf. ψ' & other $(c\bar{c})_{res}$



Update (3): $B \rightarrow KX[\rightarrow \gamma \{\psi, \psi'\}]$ searches

V. Bhardwaj, Trabelsi, Singh, Choi, Olsen et al., PRL 107, 091803 (2011)



$$K^+ X : \mathcal{B}_{\text{Belle}}(10^{-6}) \quad \mathcal{B}_{\text{BaBar}}(10^{-6})$$

$$\gamma\psi \quad 1.78^{+0.48}_{-0.44} \pm 0.12 \quad 2.8 \pm 0.8 \pm 0.1$$

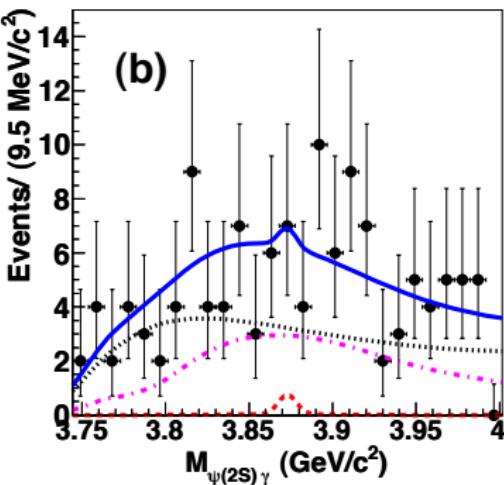
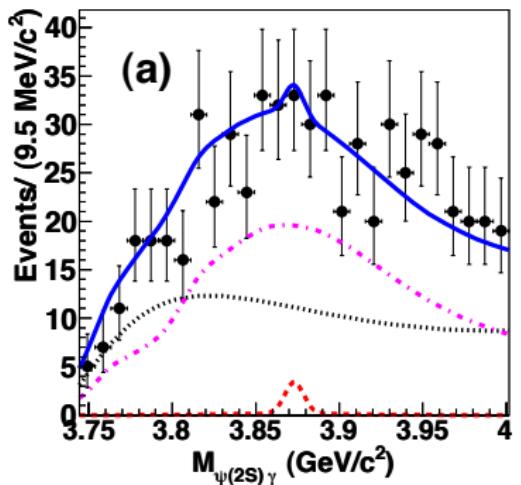
$$\gamma\psi' \quad 0.83^{+1.98}_{-1.83} \pm 0.44 \quad 9.5 \pm 2.7 \pm 0.6$$

no Belle evidence for $\gamma\psi'$;
marginal consistency
(at best) with BaBar



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New bounds on X width, ΔM , & other properties

S.-K. Choi, S.L. Olsen, K. Trabelsi et al., Phys. Rev. D 84, 052004 (2011)

- ▶ full 711 fb^{-1} $\Upsilon(4S)$ data: 772×10^6 $B\bar{B}$ pairs
- ▶ development of technique from discovery paper:
 - ▶ $M' = M(\pi^+\pi^-\ell^+\ell^-) - M(\ell^+\ell^-) + m_\psi$
 - ▶ $M(\pi^+\pi^-) > M' - (m_\psi + 150 \text{ MeV})$:
yields smooth bkgd under X , & similar behaviour to ψ' case
 - ▶ 3D fit to $(M_{bc}, \Delta E, M')$
- ▶ many results tested against an independent analysis
- ▶ calibrated against
 - MC for a range of ψ' , X masses
 - large ψ' peak
- ▶ updated mass measurement (see ΔM later)

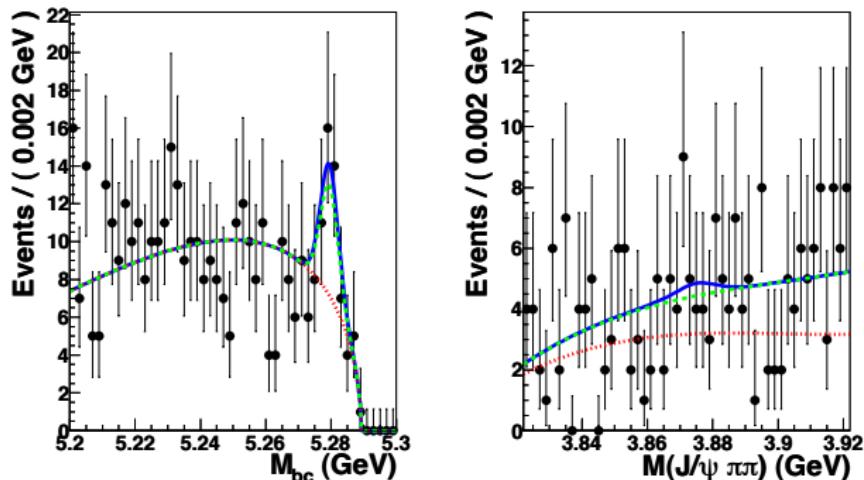
$$M = (3871.85 \pm 0.27 \text{ (stat.)} \pm 0.19 \text{ (syst.)}) \text{ MeV}$$

cf. $(3872.0 \pm 0.6 \text{ (stat.)} \pm 0.5 \text{ (syst.)}) \text{ MeV}$ (2003 paper)



New bounds (1): on charged partner states X^\pm

S.-K. Choi, S.L. Olsen, K. Trabelsi et al., Phys. Rev. D 84, 052004 (2011)



$$\mathcal{B}(\bar{B}^0 \rightarrow K^- X^+) \times \mathcal{B}(X^+ \rightarrow \rho^+ \psi) < 4.2 \times 10^{-6} \quad (< 5.4 \text{ BaBar})$$

$$\mathcal{B}(B^+ \rightarrow K^0 X^+) \times \mathcal{B}(X^+ \rightarrow \rho^+ \psi) < 6.1 \times 10^{-6} \quad (< 22 \text{ BaBar})$$

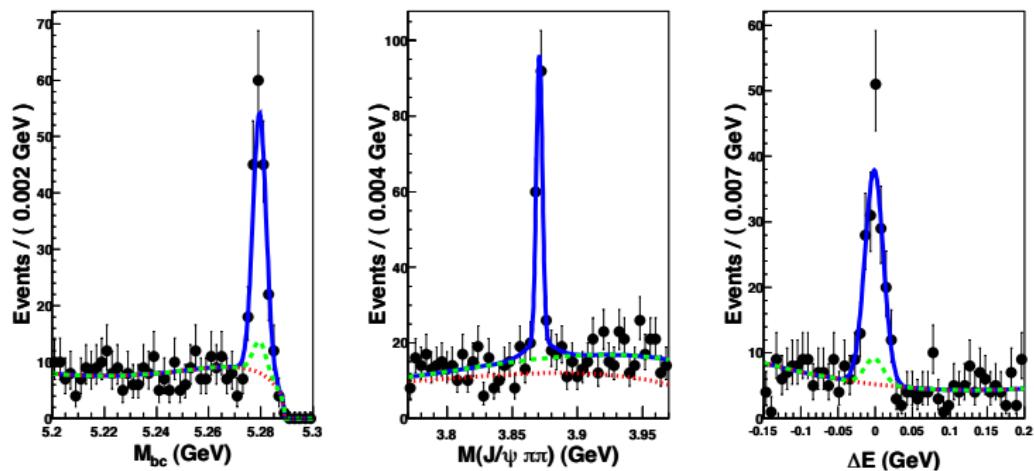
cf. $X(3872)$ discovery mode

$$(8.63 \pm 0.82 \pm 0.52) \times 10^{-6}$$



New bounds (2): on ΔM (versus $X_{u,d}$ framework)

S.-K. Choi, S.L. Olsen, K. Trabelsi et al., Phys. Rev. D 84, 052004 (2011)



this analysis

cf. BaBar PRD 71, 031501

$$R = \mathcal{B}_{K^0 X} / \mathcal{B}_{K^+ X} \quad 0.50 \pm 0.14 \pm 0.04 \quad 0.41 \pm 0.24 \pm 0.05$$

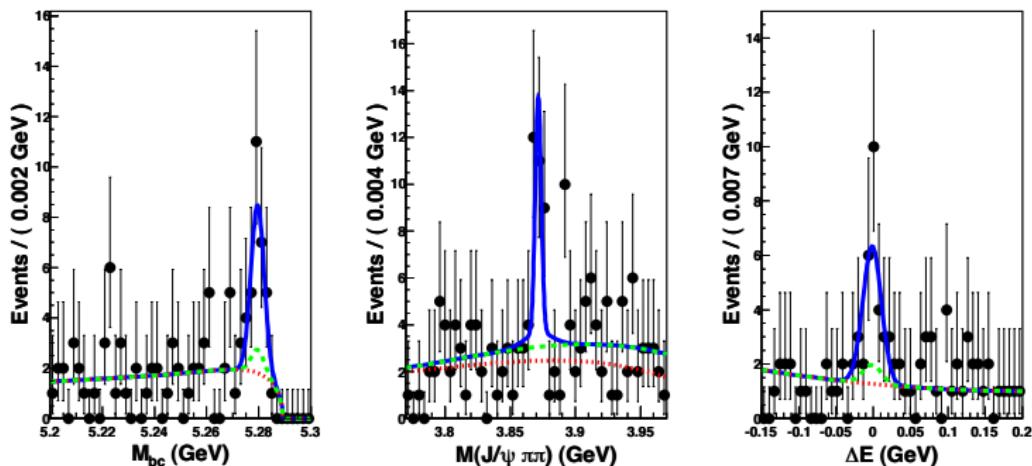
$$\delta m = M_{K^+ X} - M_{K_S^0 X} \quad (-0.71 \pm 0.96 \pm 0.19) \text{ MeV} \quad (+2.7 \pm 1.6 \pm 0.4) \text{ MeV}$$

[note withdrawal of molecule \rightarrow low- R claim: Braaten & Lu, PRD 77, 014029 (2008)]



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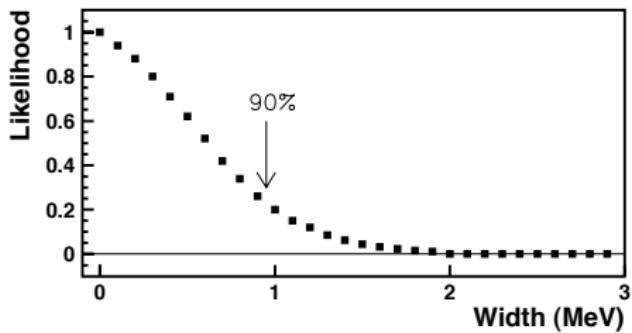
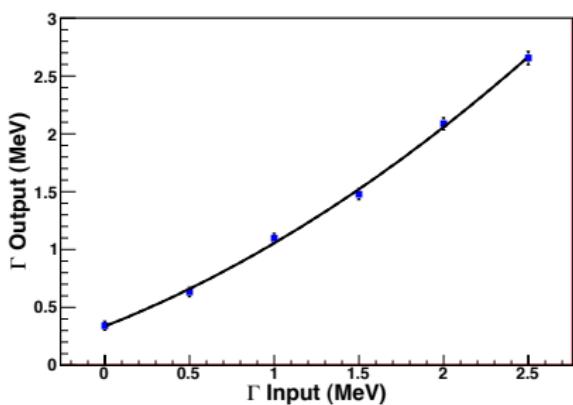
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New bounds (3): on the intrinsic width

S.-K. Choi, S.L. Olsen, K. Trabelsi et al., Phys. Rev. D 84, 052004 (2011)

- ▶ width results limited by experimental resolution
- ▶ not improved since original discovery paper
- ▶ 3D fit quite sensitive to width (M_{bc} vs $M(\pi^+\pi^-\psi)$ yields)
- ▶ mean yields tested with MC; method also tested on ψ'



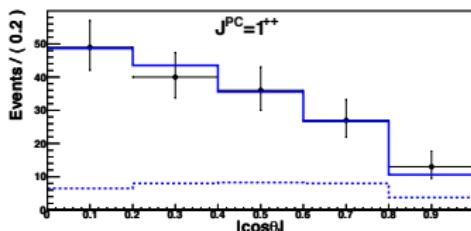
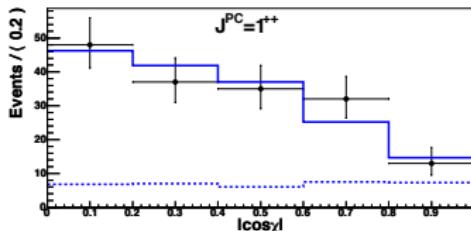
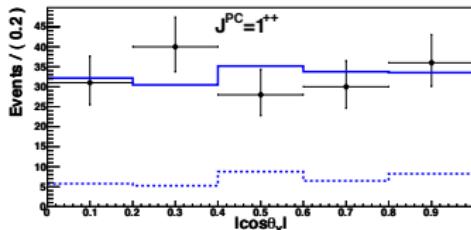
$\Gamma_X < 1.2 \text{ MeV} (90\%)$
after $\Gamma_{\psi'}$ bias correction



New bounds (4): on J^{PC} from angular analysis

S.-K. Choi, S.L. Olsen, K. Trabelsi et al., Phys. Rev. D 84, 052004 (2011)

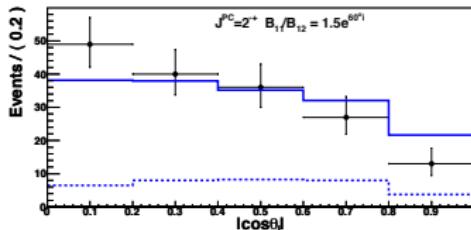
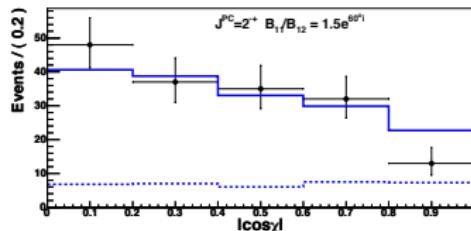
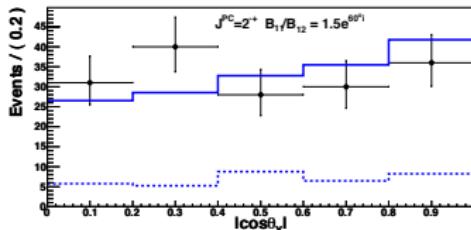
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PRL 98, 132002 (2007)
 - ▶ better S/B
- ▶ Belle: $\begin{cases} \frac{1}{10} \times \text{yield} : \text{stat-limited} \\ \text{B-decay} : 2 \text{ extra angles} \end{cases}$
- ▶ 1D fits in θ_X and Rosner angles
[from PRD 70, 094023 (2004)]:
 θ_ℓ : ℓ^+ zenith angle w.r.to $K\pi$ plane
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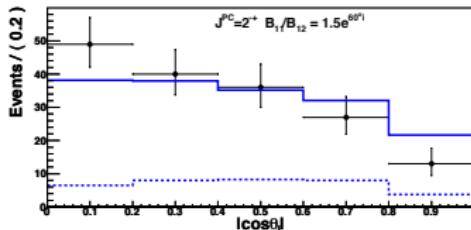
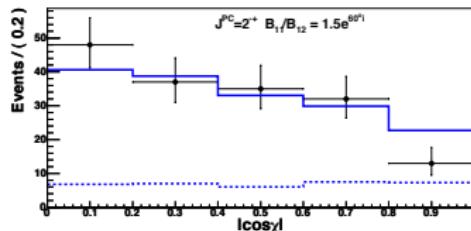
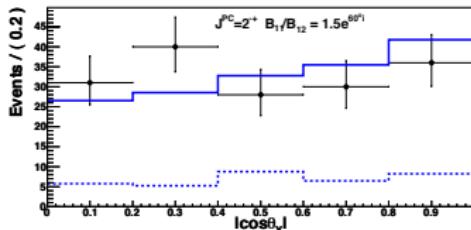
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- ▶ per CDF: 2^{-+} is still in play



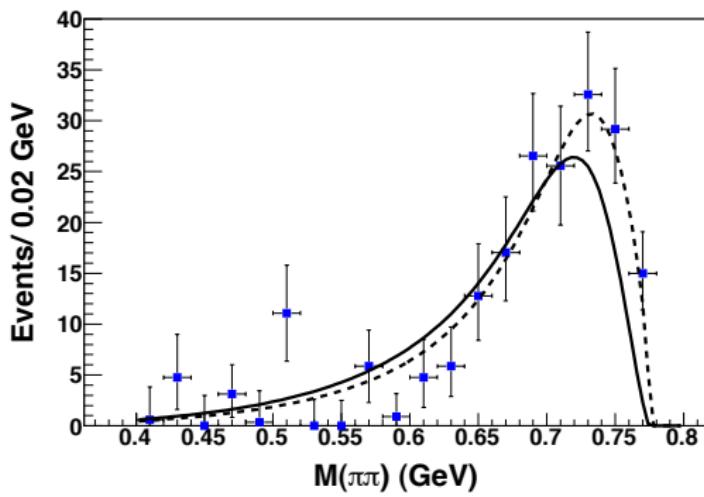
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- ▶ CDF [PRL 96, 102002 (2006)] included Blatt-Weisskopf factors and ρ - ω interference → rendered P-wave fit equally good

- ▶ $\rho\psi$ fit to final data
- ▶ without ρ - ω int:

L	χ^2/n_{dof}
0 (dashed)	17.5/18
1 (solid)	32.1/18



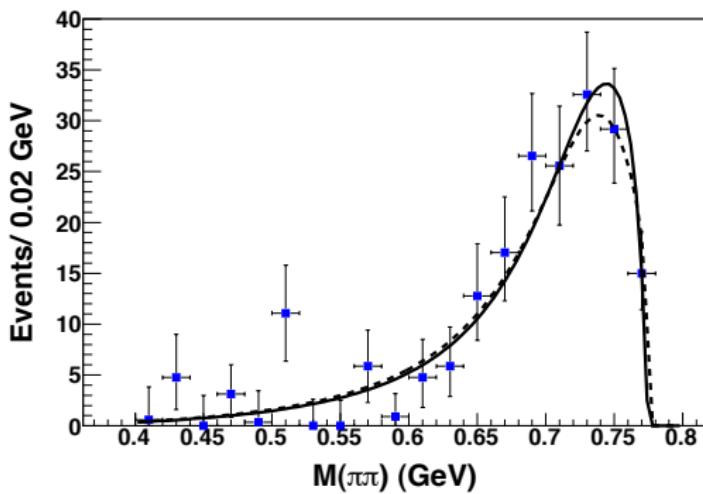
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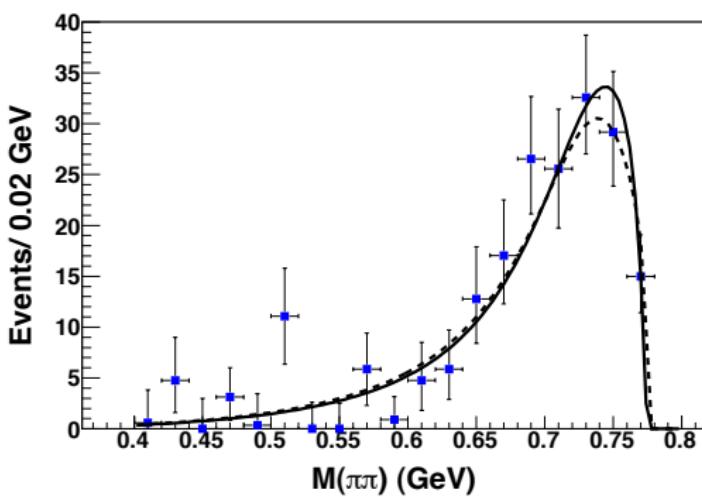
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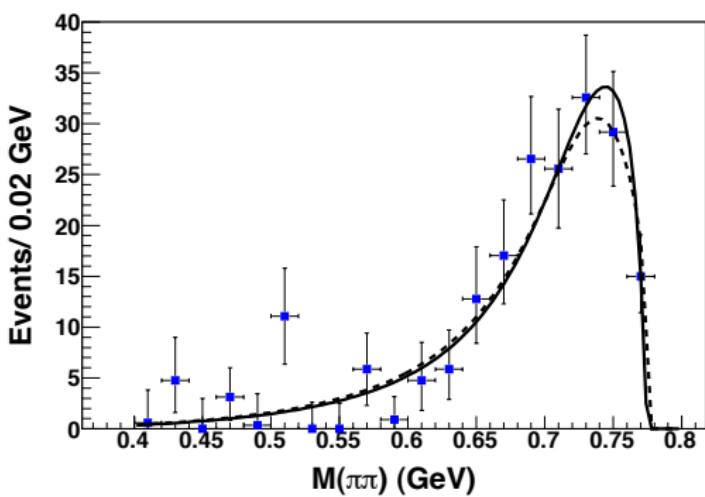
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- ▶ 2^{-+} lives to fight on ...



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adapted from **Beauty 2006: Nucl. Phys. (Proc. Suppl.) 170, 248–253 (2007)**

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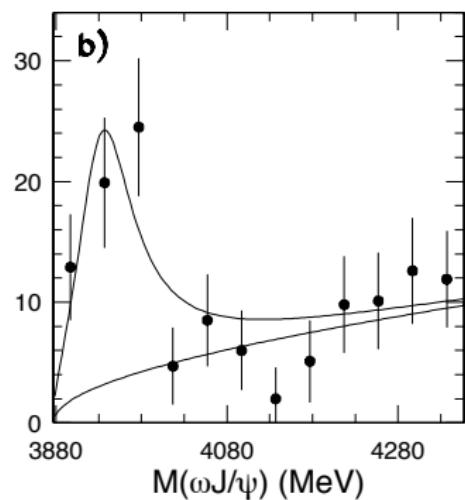
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 - ▶ $\Gamma < 1.2 \text{ MeV}$ (90% C.L.) [Belle *PRD* 84, 052004]
- ▶ $M = (3871.71 \pm 0.19) \text{ MeV} \stackrel{\Delta \ll \sigma}{\equiv} (m_{D^0} + m_{D^*})$ [private WA; $S < 1$]
- ▶ $p\bar{p}$ prodⁿ: $(16 \pm 5 \pm 2)\%$ b -decay, rest prompt; “ ψ' -like” [CDF]
- ▶ X^\pm still not seen: not an isovector [BaBar; Belle *PRD* 84, 052004]
- ▶ C -even, from $X \rightarrow \gamma\psi$ [Belle, BaBar] and $\pi^0\pi^+\pi^-\psi$ [Belle]
 - ▶ $X \rightarrow \rho\psi$ dominates, $L = 0, 1$ [CDF & Belle $M(\pi^+\pi^-)$]
 - ▶ $J^{PC} = 1^{++}$ or 2^{-+} [CDF & Belle angular; note BaBar $\pi^0\pi^+\pi^-\psi$]
- ▶ $B^+ \text{ vs } B^0 \rightarrow KX$: ΔM disfavoured [BaBar & Belle]
- ▶ large $\mathcal{B}(X \rightarrow (\{\gamma, \pi^0\}D^0)_{D^{*0}}\bar{D}^0)$ [Belle & BaBar]
- ▶ loose ends: $\pi^0\pi^0\psi$, $\underline{\gamma\psi'}$, $\pi^+\pi^-\eta_c$, $\{\gamma, \pi^0\}D\bar{D}$ lineshape
- **radiative (disputed) & lineshape crucial for structure**



$Y(3940)$ and related states: in B decays

Belle PRL 94, 182002 (2005); BaBar PRL 101, 082001 (2008)

- ▶ cf. $\begin{cases} X(3940) [??\eta_c(3S)] & e^+e^- \rightarrow \psi X \\ Y(3940) [?????????] & B \rightarrow KY [\rightarrow \omega\psi] \\ Z(3930) [?\chi_{c2}(2P)] & \gamma\gamma \rightarrow Z [\rightarrow D\bar{D}] \end{cases}$
- ▶ difficult to understand as $(c\bar{c})_{res}$, or even as hybrid or other exotic
⇒ least-believed of the early “XYZ”
- ▶ Belle discovery paper:
threshold $q^*(M) + S\text{-wave B-W}$



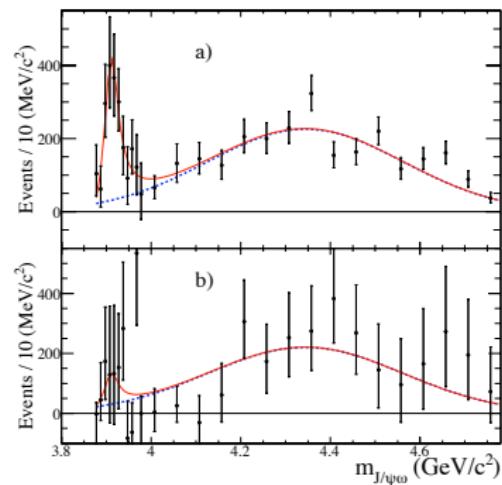
	M (MeV)	Γ (MeV)	$R_Y = \mathcal{B}_{B^0}/\mathcal{B}_{B^+}$ [$R_{\text{non-res}}$]
Belle*	$3943 \pm 11 \pm 13$	$87 \pm 22 \pm 26$	$[0.97^{+0.23+0.03}_{-0.22-0.02}]$
BaBar*	$3914.6^{+3.8}_{-3.4} \pm 1.9$	$34^{+12}_{-8} \pm 5$	$0.27^{+0.28+0.04}_{-0.23-0.01}$



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- ▶ difficult to understand as $(c\bar{c})_{res}$, or even as hybrid or other exotic
➡ least-believed of the early “XYZ”
- ▶ BaBar confirmation:
Gaussian bkgd + S-wave B-W signal



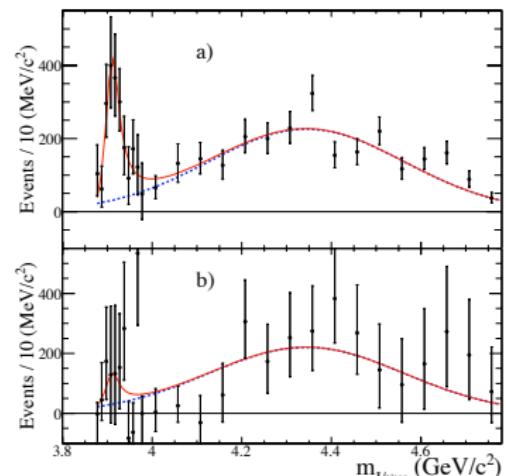
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➡ least-believed of the early “XYZ”
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Gaussian bkgd + S-wave B-W signal
* fits too different to compare params:



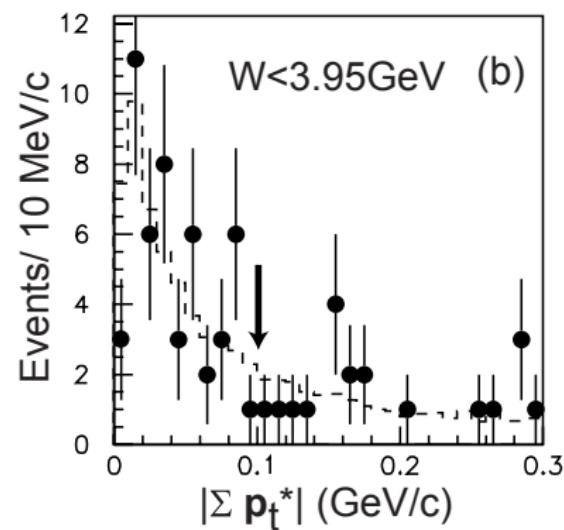
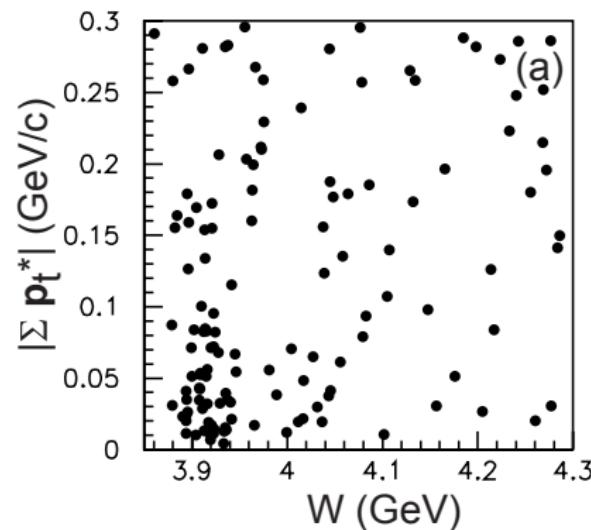
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$Y(3940)$ and related states: in $\gamma\gamma$ events

S. Uehara et al., Phys. Rev. Lett. 104, 092001 (2010)

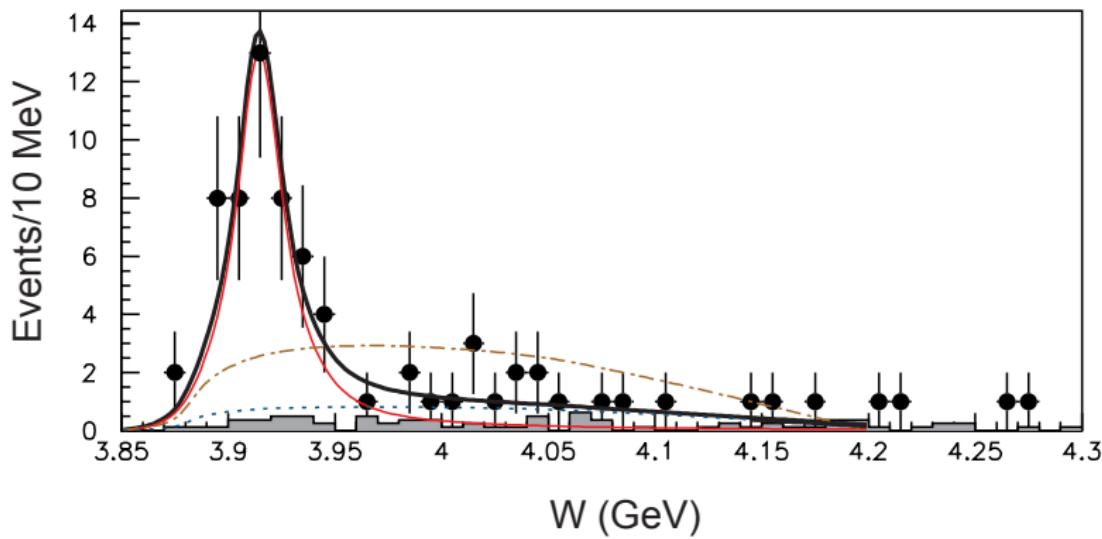
shown at QWG 2010 / Fermilab: clean $e^+e^- \rightarrow e^+e^-(\gamma\gamma) [\rightarrow \omega\psi]$



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S. Uehara et al., Phys. Rev. Lett. 104, 092001 (2010)

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S-wave B-W signal (variable Γ) + background quadratic in p^*
cf. background-only fit [non- $\omega\psi$ backgrounds shaded]



$Y(3940)$ and related states: a partial summary

PRL's 94, 182002; 96, 082003; 100, 202001; 101, 082001; 104, 092001

	M (MeV)	Γ (MeV)	notes
[94] $B \rightarrow KY [\rightarrow \omega\psi]^*$	$3943 \pm 11 \pm 13$	$87 \pm 22 \pm 26$	mysterious {final state, M }
[101] $B \rightarrow KY [\rightarrow \omega\psi]^*$	$3914.6_{-3.4}^{+3.8} \pm 1.9$	$34_{-8}^{+12} \pm 5$	pref. for B^+ over B^0 prod ⁿ
[104] $\gamma\gamma \rightarrow \omega\psi$	$3915 \pm 3 \pm 2$	$17 \pm 10 \pm 3$	implied $\Gamma_{\omega\psi} \sim \mathcal{O}(1 \text{ MeV})$
[96] $\gamma\gamma \rightarrow (D\bar{D})_Z$	$3929 \pm 5 \pm 2$	$29 \pm 10 \pm 2$	$Z(3930) \stackrel{?}{\equiv} \chi_{c2}(2P)$
[100] $e^+e^- \rightarrow \psi(D^*\bar{D})_X$	$3942_{-6}^{+7} \pm 6$	$37_{-15}^{+26} \pm 8$	$X(3940) \stackrel{??}{\equiv} \eta_c 3S;$

So we come back to the naïve three-state interpretation:

- ▶ $X(3940) \rightarrow D^*\bar{D}$, among other states seen in $e^+e^- \rightarrow \psi X$
- ▶ $Z(3930)$ as an unmysterious $\chi_{c2}(2P)$ [“Z” label re-purposed]
- ▶ “ $Y(3940)$ ” $\rightarrow \omega\psi$ of mysterious structure, in B-decay & $\gamma\gamma$

with some caveats:[100]

- ▶ limits on $X - Y$ identity in an earlier Belle paper withdrawn
- ▶ X prodⁿ $c\bar{c}$ -like, but $e^+e^- \rightarrow \psi(c\bar{c})_{res}$ prodⁿ not understood



$Y(4260)$: decays other than $\pi^+\pi^-\psi$

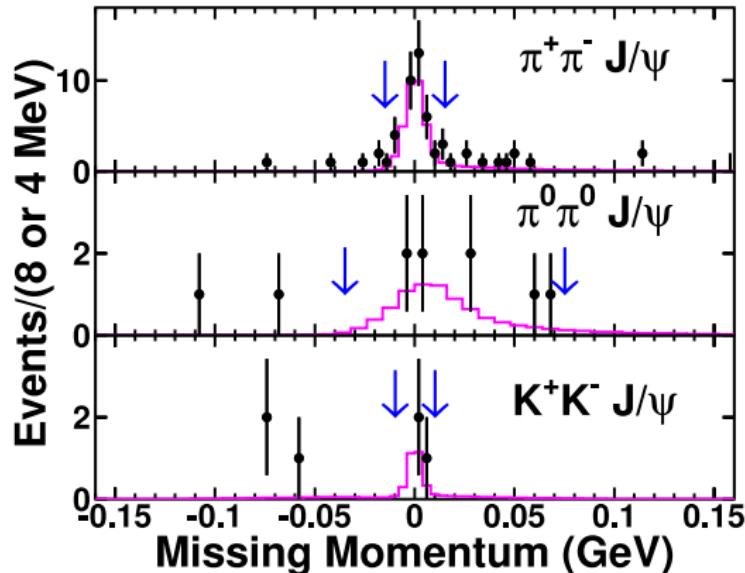
CLEO T.E. Coan et al., PRL 96, 162003 (2006);

Belle C.Z. Yuan, C.P. Shen, P. Wang, X.L. Wang et al., PRD 77, 011105(R) (2008)

original supernumerary vector

- ▶ best-attested & studied
- ▶ discovered in $\pi^+\pi^-\psi$
- ▶ CLEO $e^+e^- \rightarrow h(h')Y$:

mode	σ (pb)
$\pi^+\pi^-\psi$	$58^{+12}_{-10} \pm 4$
$\pi^0\pi^0\psi$	$23^{+12}_{-8} \pm 1$
$K^+K^-\psi$	$9^{+9}_{-5} \pm 1$
...	...



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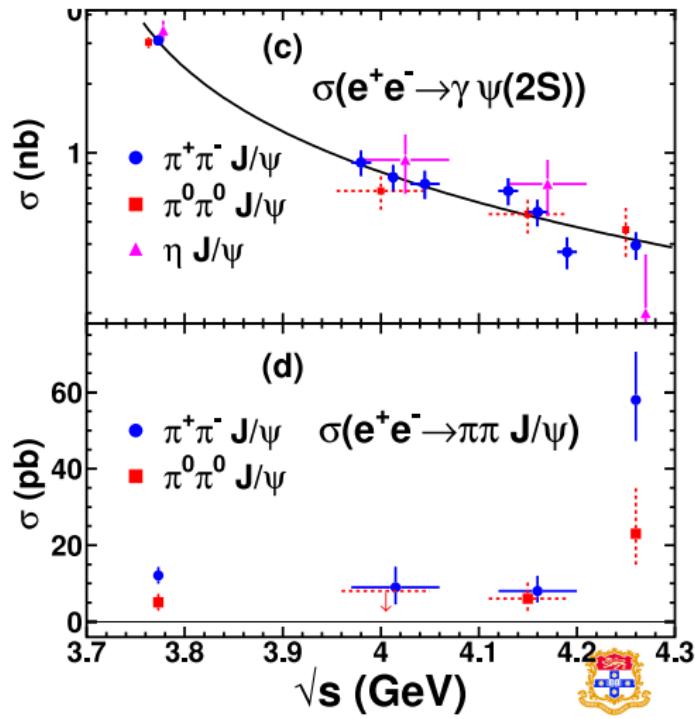
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- ▶ lineshape untested ...



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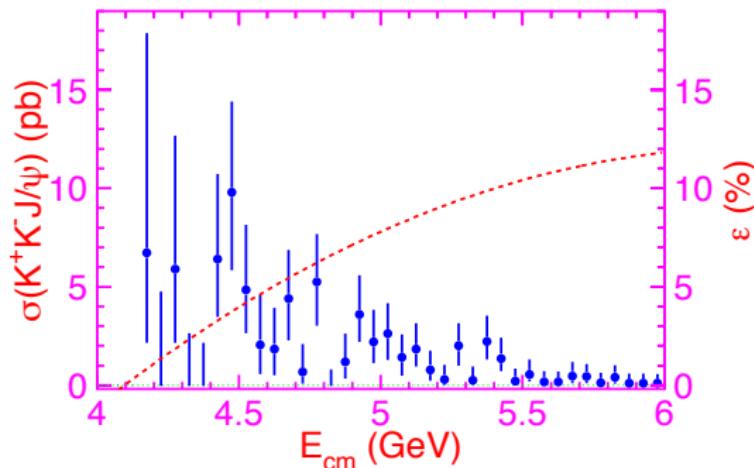
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- ▶ lineshape untested ... Belle's ISR $K^+K^-\psi$ study inconclusive:

$$\mathcal{B}_{K^+K^-\psi} \Gamma_{e^+e^-} < 1.2 \text{ eV} \text{ (90%)} \text{ cf. } 5.9^{+1.2}_{-0.9} \pi^+\pi^-\psi \text{ WA} \approx \text{CLEO}$$

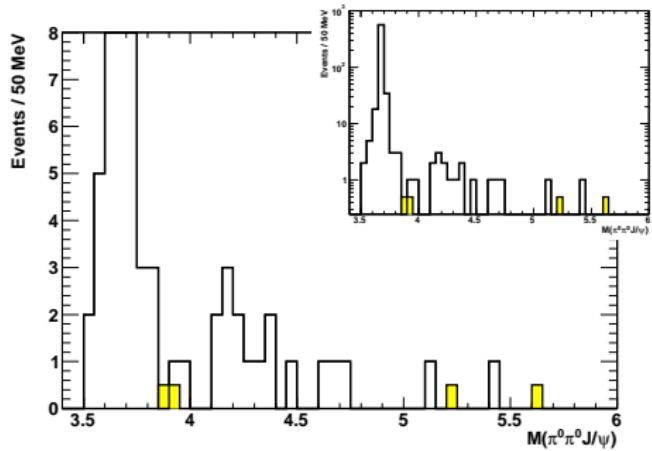


$\Upsilon(4260) \rightarrow \pi^0\pi^0\psi$ in ISR

Belle preliminary, ICHEP 2011

fully reconstructed $e^+e^- \rightarrow \gamma_{ISR}\pi^0\pi^0\psi \rightarrow \mu^+\mu^-$ events (clean):

- ▶ 2 tracks passing qual. cuts
 - ▶ $|M(\mu\mu) - m_\psi| < 25 \text{ MeV}$
 - ▶ $E(\gamma) > 35 \text{ MeV};$
 $|M(\gamma\gamma) - m_{\pi^0}| < 15 \text{ MeV};$
 $\cos \theta_\gamma$ for cand. selⁿ
 - ▶ $p_\perp(\pi^0\pi^0\psi) < 50 \text{ MeV}$
w.r.to ISR photon
 - ▶ $|M_{\text{recoil}}^2| < 1.2 \text{ GeV}$
 - ▶ clean sample; ψ' calibration

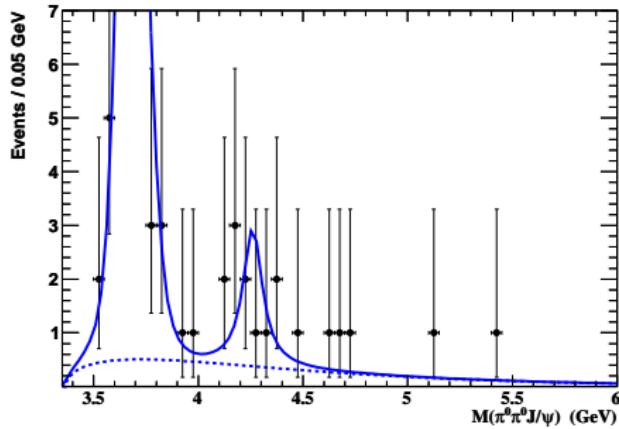


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 - ▶ clean sample; ψ' calibration signal; cf. ψ sidebands
 - ▶ fit: threshold fⁿ, ψ' shape from MC, B-W for $Y(4260)$ [params fixed]
 $\Gamma_{e^+e^-} - \mathcal{B}_{\pi^0\pi^0\psi} = (3.18^{+1.82+0.63}_{-1.52-0.35}) \text{ eV} \sim \frac{1}{2} \times 5.9^{+1.2}_{-0.9} \text{ eV}$ ($\pi^+\pi^-\psi$ PDG)



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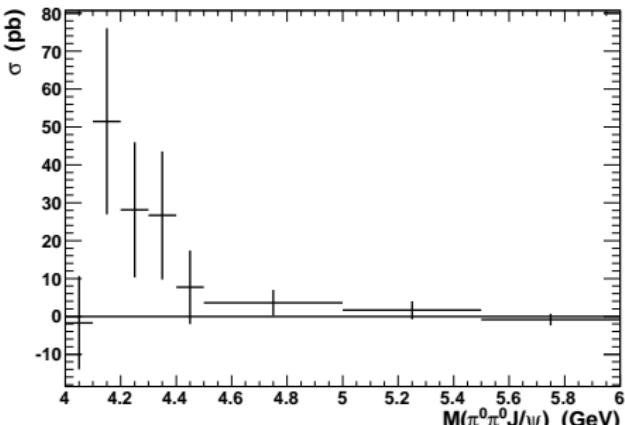


$Y(4260) \rightarrow \pi^0\pi^0\psi$ in ISR

Belle preliminary, ICHEP 2011

fully reconstructed $e^+e^- \rightarrow \gamma_{ISR}\pi^0\pi^0\psi [\rightarrow \mu^+\mu^-]$ events (clean):

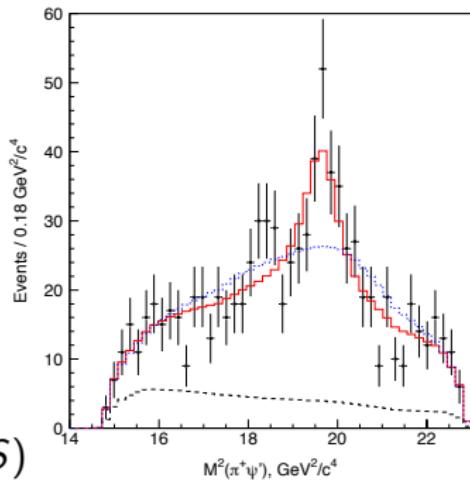
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- ▶ cross-section consistent with CLEO ... and with 4260 origin



Z_c (manifestly exotic) in the light of new Z_b results

R. Mizuk et al., PRD 80, 031104(R) (2009); & Chistov et al., 78, 072004 (2008)

- ▶ Belle sees resonance-like peak
 $Z(4430)^+ \rightarrow \pi^+ \psi'$ in $B \rightarrow K\pi^+\psi'$
- ▶ not seen by BaBar; consistency?
- ▶ Belle (Dalitz) reanalysis: \rightarrow
 $(M, \Gamma) = (4443^{+15+19}_{-12-13}, 107^{+86+74}_{-43-56}) \text{ MeV}$
- ▶ +2 states in $\bar{B}^0 \rightarrow K^- Z [\rightarrow \pi^+ \chi_{c1}]$
- ▶ $B \rightarrow K\pi^+\psi$ being studied
- ▶ in hidden beauty, v.large $\Gamma_{\pi\pi\gamma(nS)}$ for $\Upsilon(5S)$
 - something going on above $B\bar{B}$ threshold
 $cf.$ CLEO $\sigma_{4170}(\pi^+\pi^- h_c) \sim \sigma_{4170}(\pi^+\pi^- \psi)$



Roman Mizuk presentation: consistent peaks in fits to

$\Upsilon(5S) \rightarrow \pi^- Z_b^+ [\rightarrow \pi^- h_b(nP)]$ and Dalitz $\pi^- Z_b^+ [\rightarrow \pi^- \Upsilon(mS)]$



BACKUP SLIDES:



$Y(4260) \rightarrow \pi^0\pi^0\psi$ in ISR: systematics

Belle preliminary, ICHEP 2011

Table 1: Summary of systematic uncertainties.

Source	Error on yield (%)	
Luminosity	± 1.4	
Branching Fractions	± 1.0	
MuID	± 2.7	
Tracking	± 2.0	
Trigger	± 2.8	
Cut selection	+3.2	-2.8
$Y(4260)$ mass and width	+5.5	-5.7
Choice of fit function	+18.3	-7.8
Sum in quadrature	+20	-11



$Y(4260) \rightarrow \pi^0\pi^0\psi$ in ISR: summary of fit results

Belle preliminary, ICHEP 2011

Table 2: Results of fit to $M(\pi^0\pi^0J/\psi)$ spectrum. The non-resonant contribution is fit using a falling exponential with threshold function.

Parameter	Value	Positive error	Negative error	Units
$\Gamma_{e^+e^-} \cdot \mathcal{B}(Y(4260) \rightarrow \pi^0\pi^0J/\psi)$	3.19	+1.82	-1.53	eV
$N(\psi(2S))$	629	+26	-25	
$\psi(2S)$ mean	3.6842	+0.0005	-0.0005	GeV
$N(1\gamma_{bkg})/N(\psi(2S))$	23	+4	-4	%
$N(> 1\gamma_{bkg})/N(\psi(2S))$	3.6	+3.5	-3.4	%
$N(\text{non-resonant})$	14	+8	-7	
Non-resonant shape parameter	-1.4	+0.7	-0.6	



$e^+ e^- \rightarrow \psi D^{(*)} \bar{D}^{(*)}$: states above threshold

P. Pakhlov et al, Phys. Rev. Lett. 100, 202001 (2008)

refinement of $M_{\text{recoil}}(\psi)$ method:

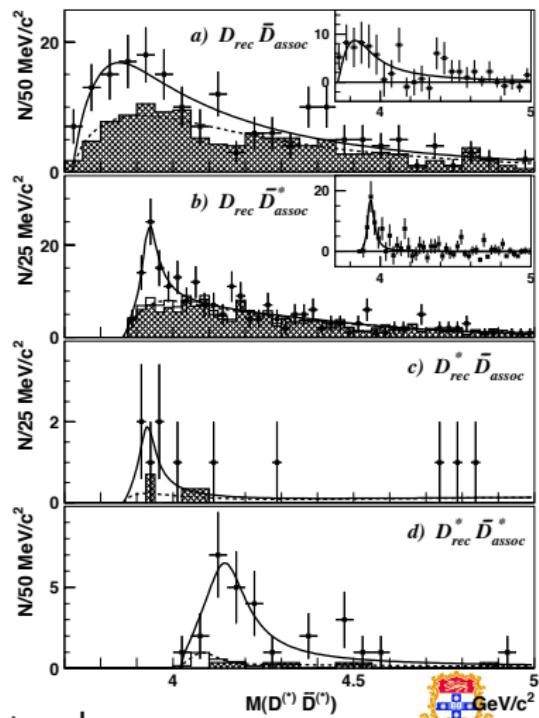
- ▶ D reconstruction; refit $\rightarrow m_D$
- ▶ tag: $|M_{\text{recoil}}(\psi D^{(*)} - m_{\text{tag}})| < 70 \text{ MeV}$
and constrain $\rightarrow m_{\text{tag}} = m_{D^{(*)}}$
- ▶ fit $M(D^{(*)} \bar{D}^{(*)})$: bkgd (sideband) +
x-feed + threshold f^n + rel. S-wave B-W

$$\sigma(e^+ e^- \rightarrow \psi X) \times \mathcal{B}(X \rightarrow D^{(*)} \bar{D}^{(*)})$$

$X(3940)$	$D\bar{D}^*$	$(13.9^{+6.4}_{-4.1}) \text{ fb}$	$[6.0\sigma]$
$X(4160)$	$D^* \bar{D}^*$	$(24.7^{+12.8}_{-8.3}) \text{ fb}$	$[5.5\sigma]$

cf. $\psi(nS) \eta_c(mS)$: $\sim 20 \text{ fb}$ for $m, n \in \{1, 2\}$:

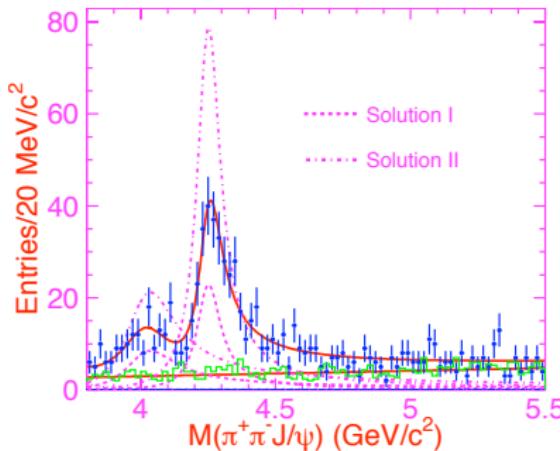
- ▶ consistent with X as $c\bar{c}$ states?
- ▶ production mechanism still not understood



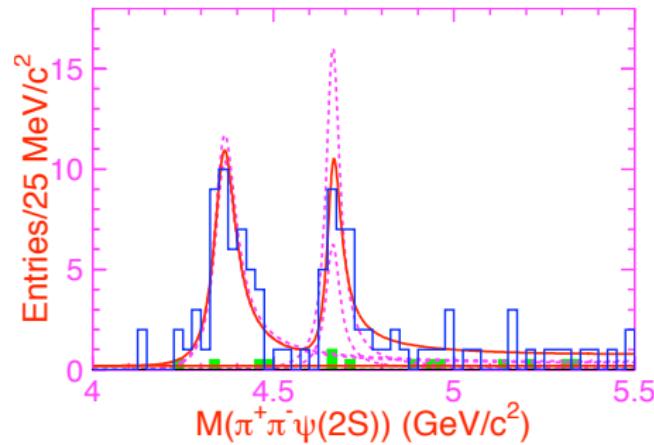
GeV/c²

1^{--} states seen in ISR (following BaBar)

C.Z. Yuan et al, PRL 99, 182004; X.L. Wang et al, PRL 99, 142002 (2007);



- ▶ confirms $Y(4260)$ [also CLEO]
- ▶ amplitude nontrivial near 4050 MeV



- ▶ confirms $\pi^+\pi^-\psi'$ signal
- ▶ splits “ $Y(4360)$ ” peak → two

none seen in ISR $D^{(*)}\bar{D}^{(*)}$: e.g. explicit BaBar $Y(4260)$ limit

$$\mathcal{B}_{D\bar{D}}/\mathcal{B}_{\pi^+\pi^-\psi} < 1.0 \text{ at 90% C.L. } [\text{arXiv:0710.1371} \rightarrow \text{PRD}]$$

