New Belle results on X(3872)

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(for Belle Collaboration)

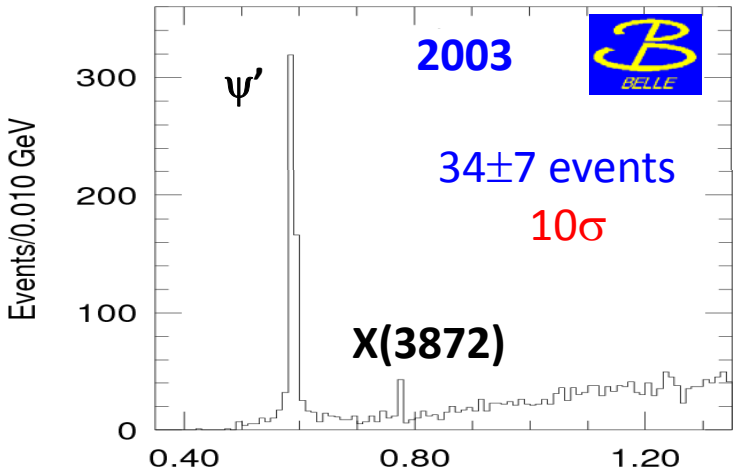
QWG Workshop
18-21 May' 10

Outline

- What so special about X(3872) ?
- Radiative decays of X(3872) (in B decays)
- Results & Discussion

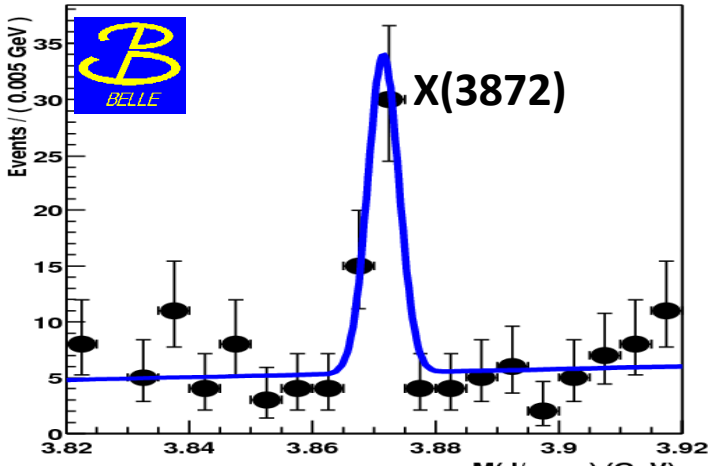
X(3872)

Discovered by Belle in $J/\psi\pi\pi$ decay mode PRL 91,262001(2003)

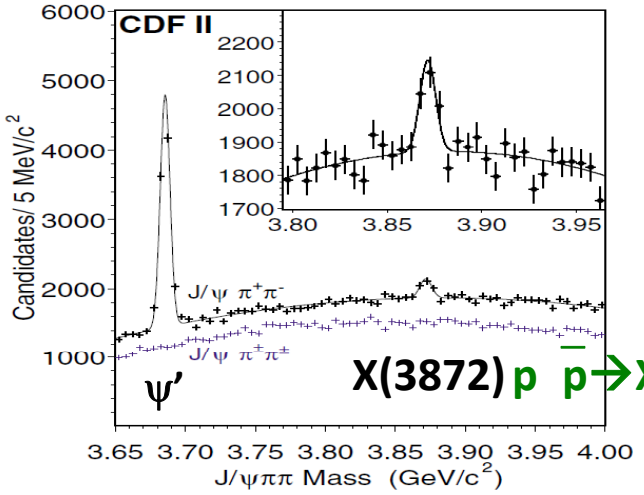


$B^+ \rightarrow X(3872)\, K^+$,
$X(3872) \rightarrow J/\psi\pi^+\pi^-$

$\Gamma < 2.3$ MeV
(90%CL)

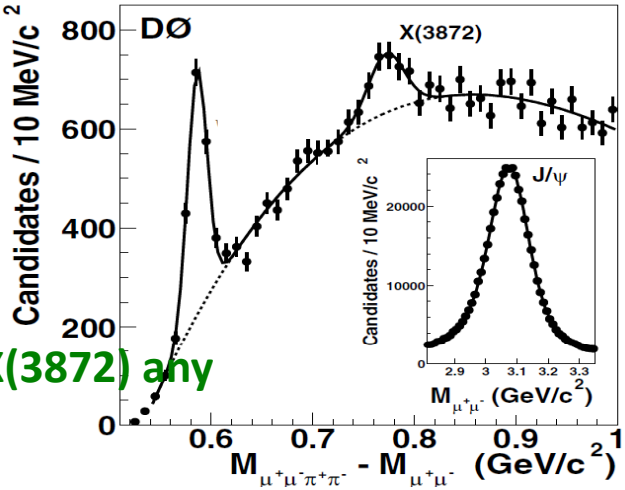


Soon confirmed by CDF, DO & BaBar

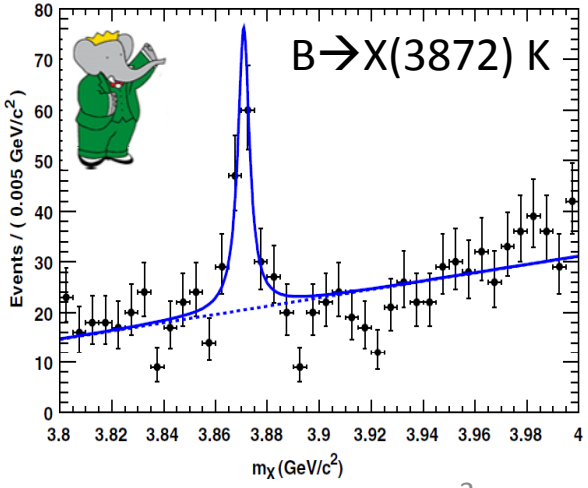


PRL 93,072001(2004)

X(3872) $p\bar{p} \rightarrow X(3872)$ any



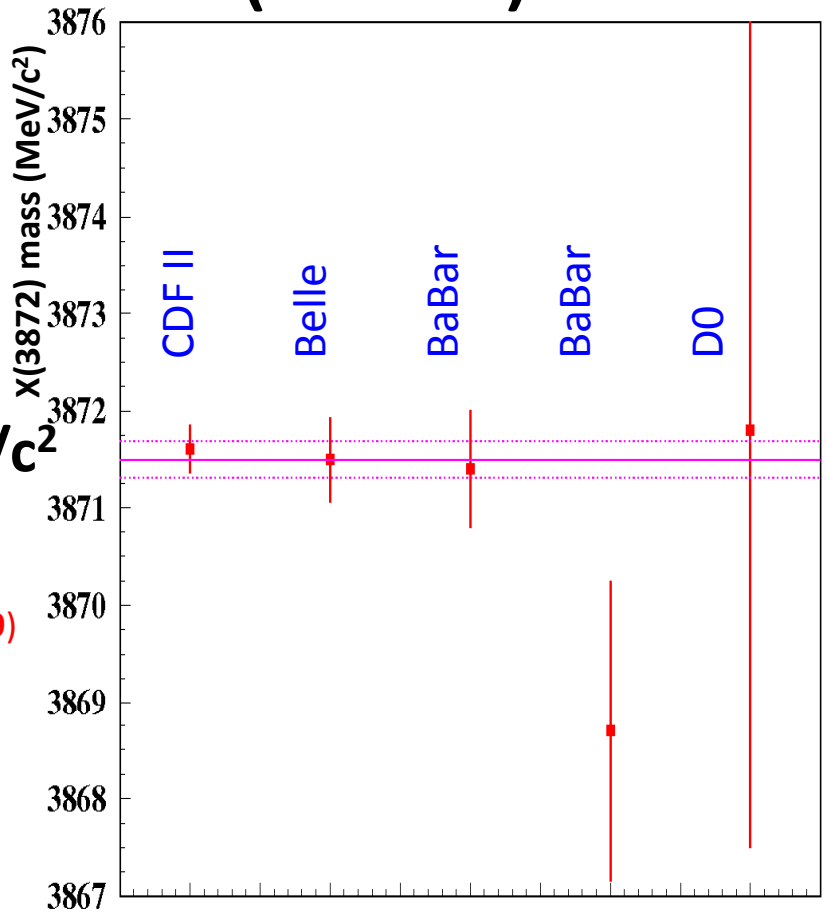
PRL 93,162002(2004)



PRD 71,071103(2005)

What so special about X(3872) ?

X(3872) found in $J/\psi\pi\pi$,
similar to ψ'
Another charmonium ?



"My own"
World average mass → 3871.5±0.2 MeV/c²

X(3872)→J/ψππ

CDF II 3871.61±0.16±0.19
PRL, 103, 152001 (2009)

Belle 3871.50±0.40±0.19
arXiv:0809.1224

Mass near D^0 and $\bar{D}^{*0}$ threshold → 3871.8± 0.4 MeV/c² **PDG**

How is it related to D^0 $\bar{D}^{*0}$? D^0 $\bar{D}^{*0}$ molecule or something else ?

X(3872) much narrower width ($\Gamma < 2.3$ MeV @ 90% CL) than other charmonium states above D $\bar{D}$ threshold.

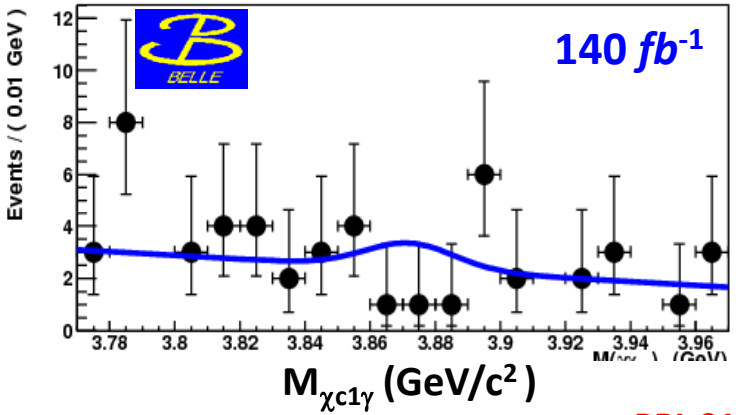
PRL, 91, 262001 (2003)

Observed in D^0 $\bar{D}^{*0}$ mode. **PRL 97,162002 (2006), PRD 77,011102 (2008) and PRD 81, 031103 (2010)**

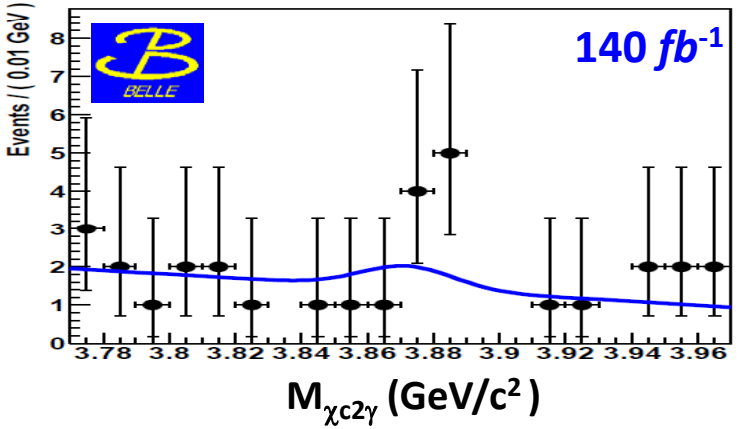
See backup for more details

Search for radiative decays to understand X(3872)

X(3872)→$\chi_{c1}\gamma$



X(3872) →$\chi_{c2}\gamma$

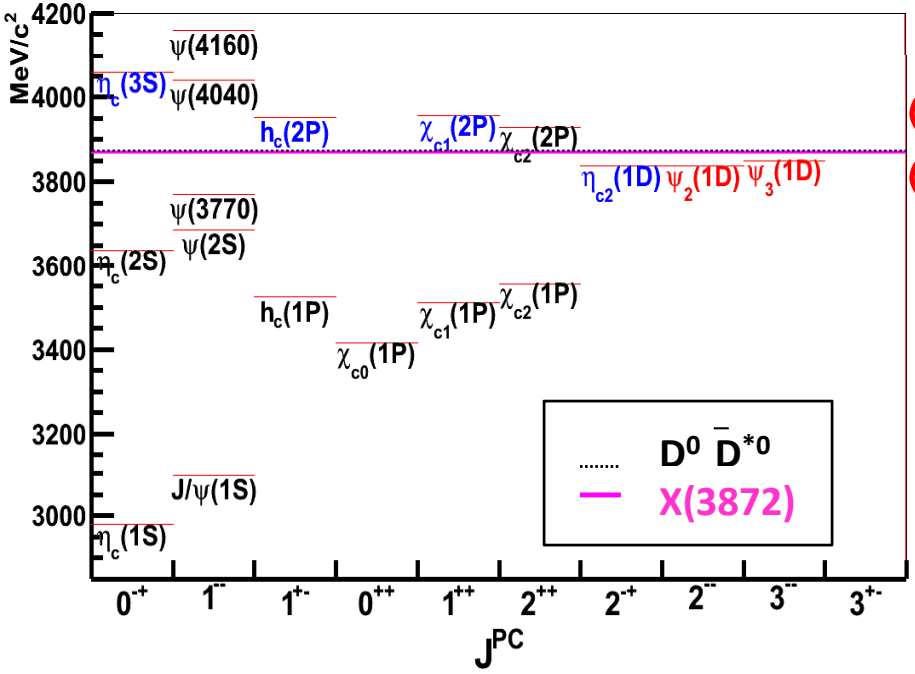


PRL 91, 262001 (2003)

$$\frac{\Gamma(X(3872)\to\chi_{c1}\gamma)}{\Gamma(X(3872)\to J/\psi\pi\pi)} < 0.9 \quad (90\%CL)$$

arXiv:0408116

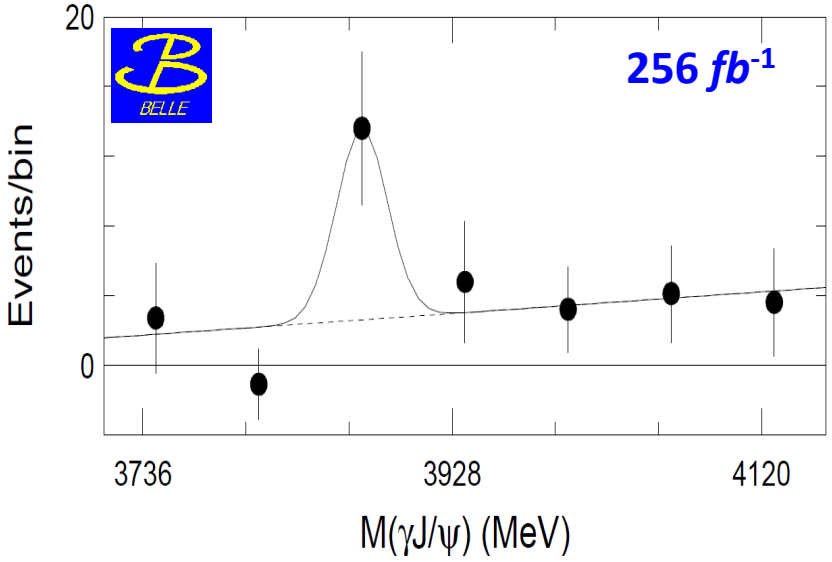
$$\frac{\Gamma(X(3872)\to\chi_{c2}\gamma)}{\Gamma(X(3872)\to J/\psi\pi\pi)} < 1.1 \quad (90\%CL)$$



- ψ_2 → $\Gamma(\gamma\chi_{c1})$ too small
- ψ_3 → $\Gamma(\gamma\chi_{c2})$ too small
- h_c' → Ruled out by angular distribution
- χ_{c1}' → $\Gamma(\gamma J/\psi)$ too small
- η_{c2} → BR(X→ J/ψππ) should be small
- η_c'' → should have high mass and large width

Not obvious charmonium candidate

Evidence of X(3872)→ J/ψγ



Belle found evidence for X(3872)→ J/ψγ in $B^+ \rightarrow X(3872)\, K^+$ decay mode

arXiv:0505037

13.6±4.4 events

$\mathcal{BR}(B^+ \rightarrow XK^+) \cdot \mathcal{BR}(X \rightarrow J/\psi\gamma) = (1.8 \pm 0.6 \pm 0.1) \times 10^{-6}$

+ve C parity

Confirmed by BaBar

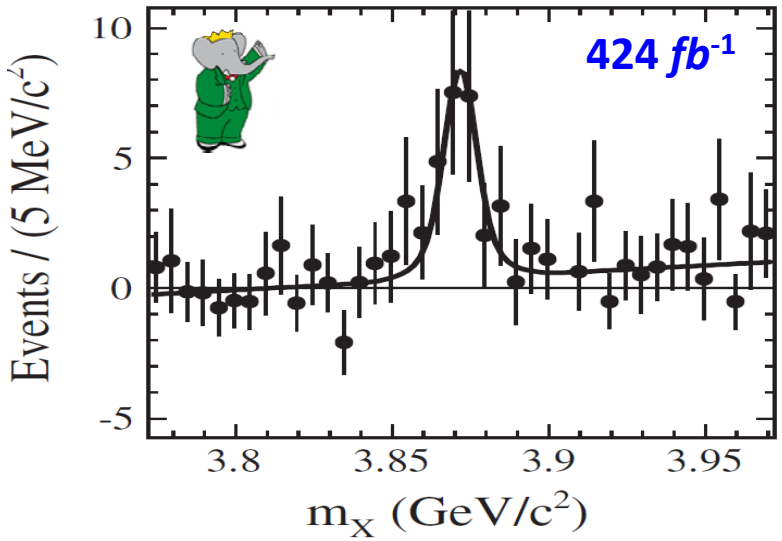
PRD 74, 071101 (2006)

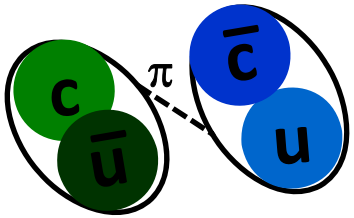
Recent update

23.0±6.4 events

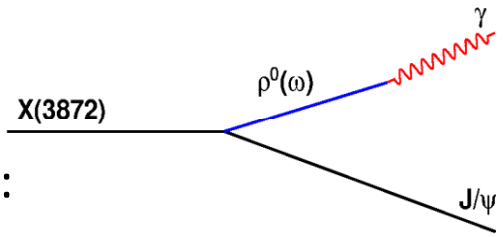
$\mathcal{BR}(B^+ \rightarrow XK^+) \cdot \mathcal{BR}(X \rightarrow J/\psi\gamma) = (2.8 \pm 0.8 \pm 0.1) \times 10^{-6}$

PRL 102, 132001 (2009)





$D^0\ \bar{D}^{*0}$ molecule

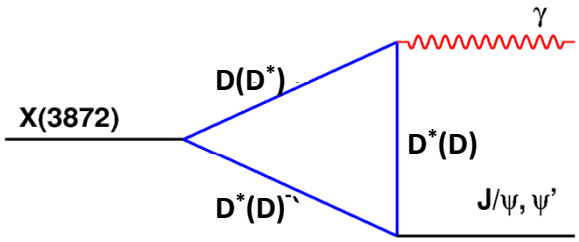


Radiative decays can proceed via two mechanisms:

- ✓ Vector meson dominance
- ✓ Light quark annihilation

If pure molecular :- Phys.Rept. 429,243(2006)

$\mathcal{BR}(X(3872) \rightarrow \psi'\gamma) < \mathcal{BR}(X(3872) \rightarrow J/\psi\gamma)$



Babar obtained an evidence of 25.4±7.4 events in 424 fb^{-1} for $B^- \rightarrow X(3872)(\psi'\gamma)K^-$.

$\mathcal{BR}(X(3872) \rightarrow \psi'\gamma) / \mathcal{BR}(X(3872) \rightarrow J/\psi\gamma) = 3.5 \pm 1.4$

PRL 102, 132001 (2009)

Indicates admixture of $D^0\ \bar{D}^{*0}$ bound state with a $c\ \bar{c}$ meson.

Belle should verify the finding and also provide an improved ratio.

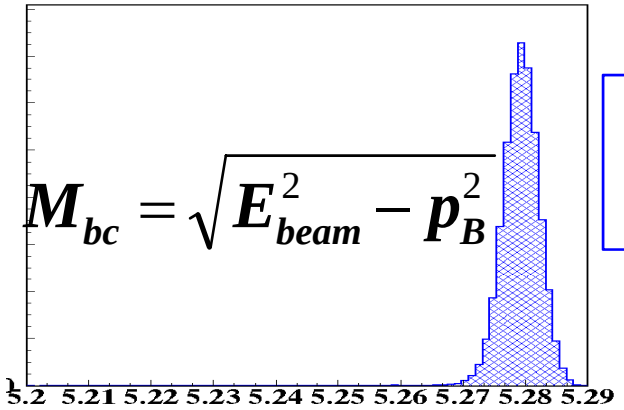
Radiative decays in *B* meson

X(3872) , $\chi_{c1,c2}$ → J/ψ γ

→ $e^+ e^-$ or $\mu^+\mu^-$

$\chi_{c1,c2}$ K (K_S^0)

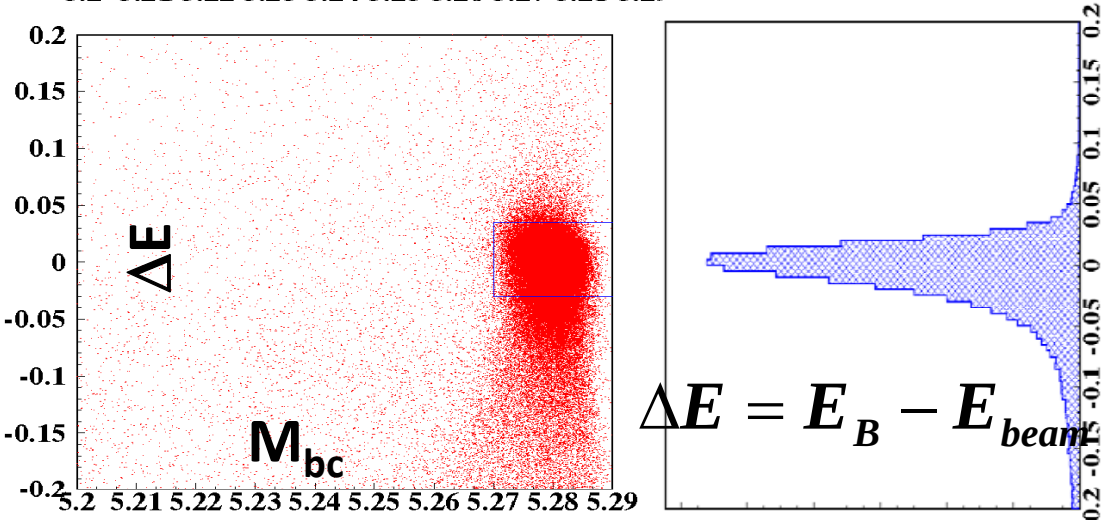
→ B



Reconstruction of B

X(3872) K (K_S^0)

→ B



Signal window cut in ΔE & M_{bc}

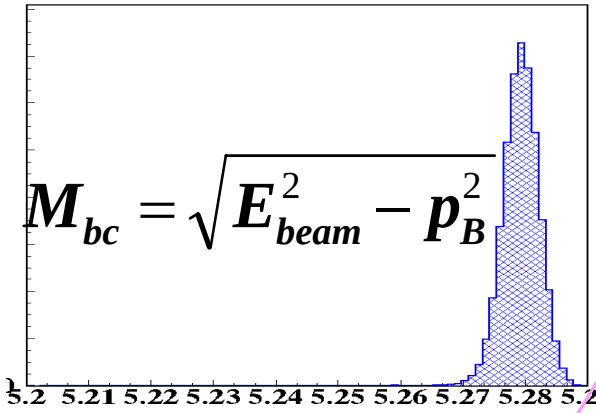
MC for illustration purpose

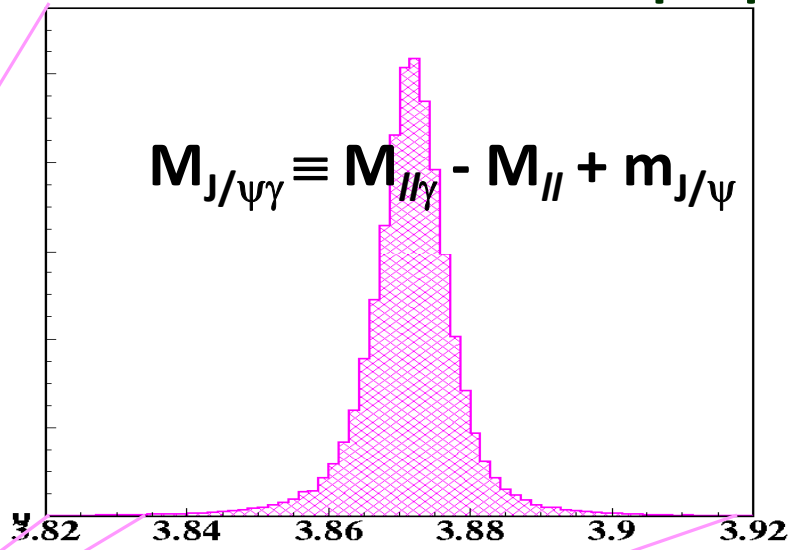
Radiative decays in *B* meson

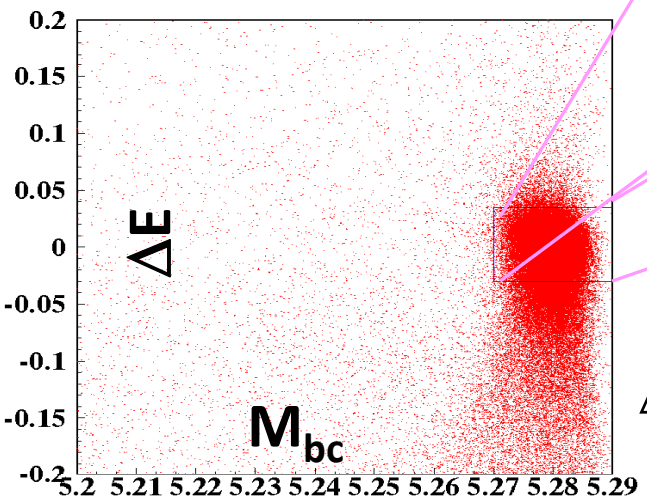
MC for illustration purpose

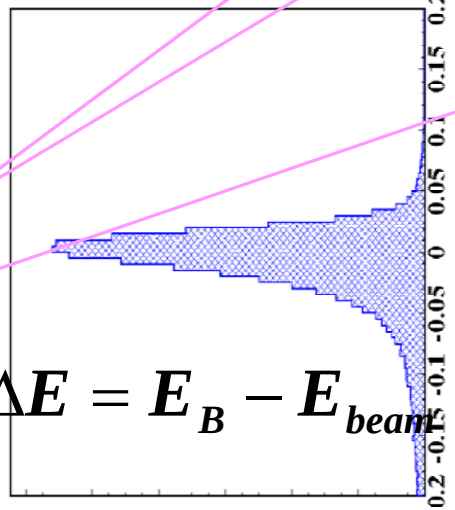
X(3872) , $\chi_{c1,c2}$ → J/ψ γ

↳ $e^+ e^-$ or $\mu^+\mu^-$









Signal window cut in ΔE & M_{bc}

E_γ scaled (ΔE=0) to improve the resolution of $M_{J/\psi\gamma}$

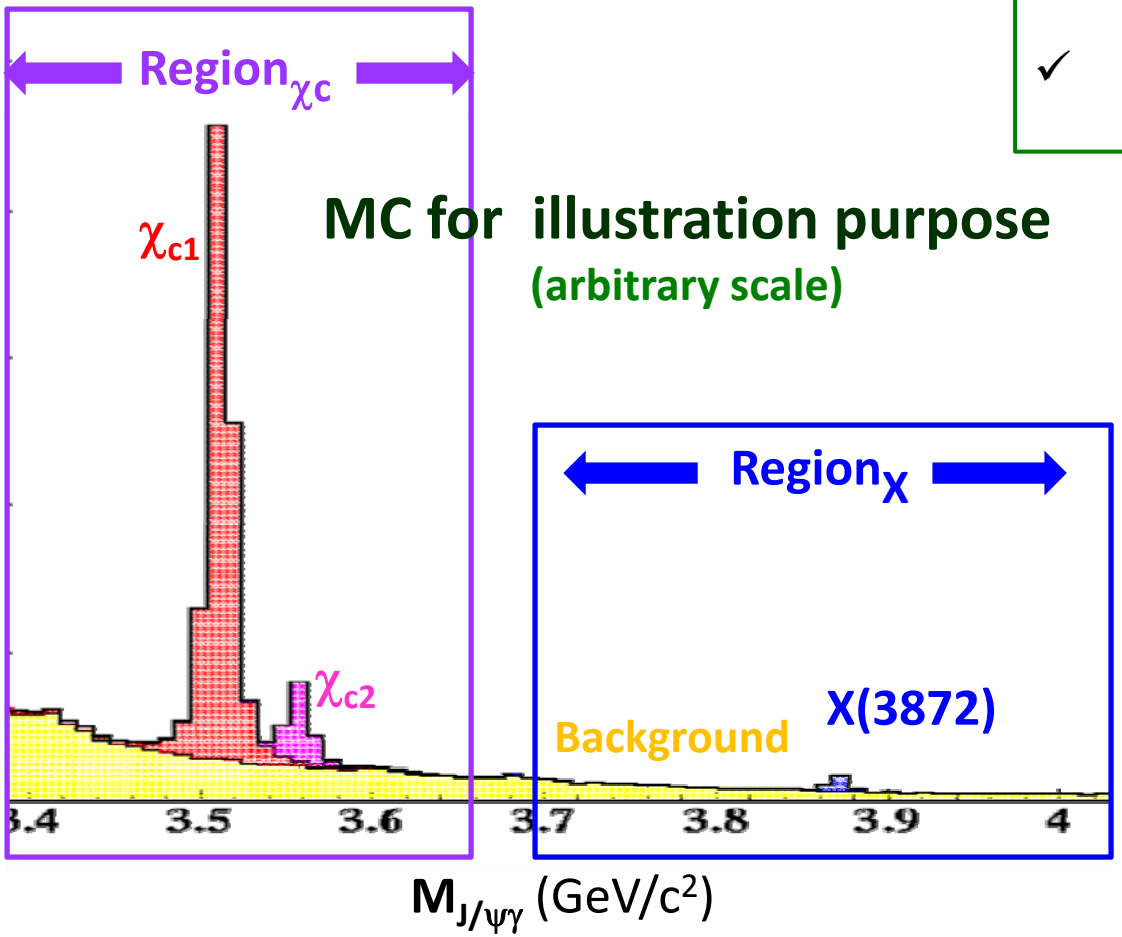
Fit to $M_{J/\psi\gamma} \equiv M_{ll\gamma} - M_{ll} + m_{J/\psi}$; $m_{J/\psi}$ is PDG mass

Study of B→(J/ψγ) K

- χ_{c1} K^+ good control sample
- Same final state : J/ψ γ

Photon selection

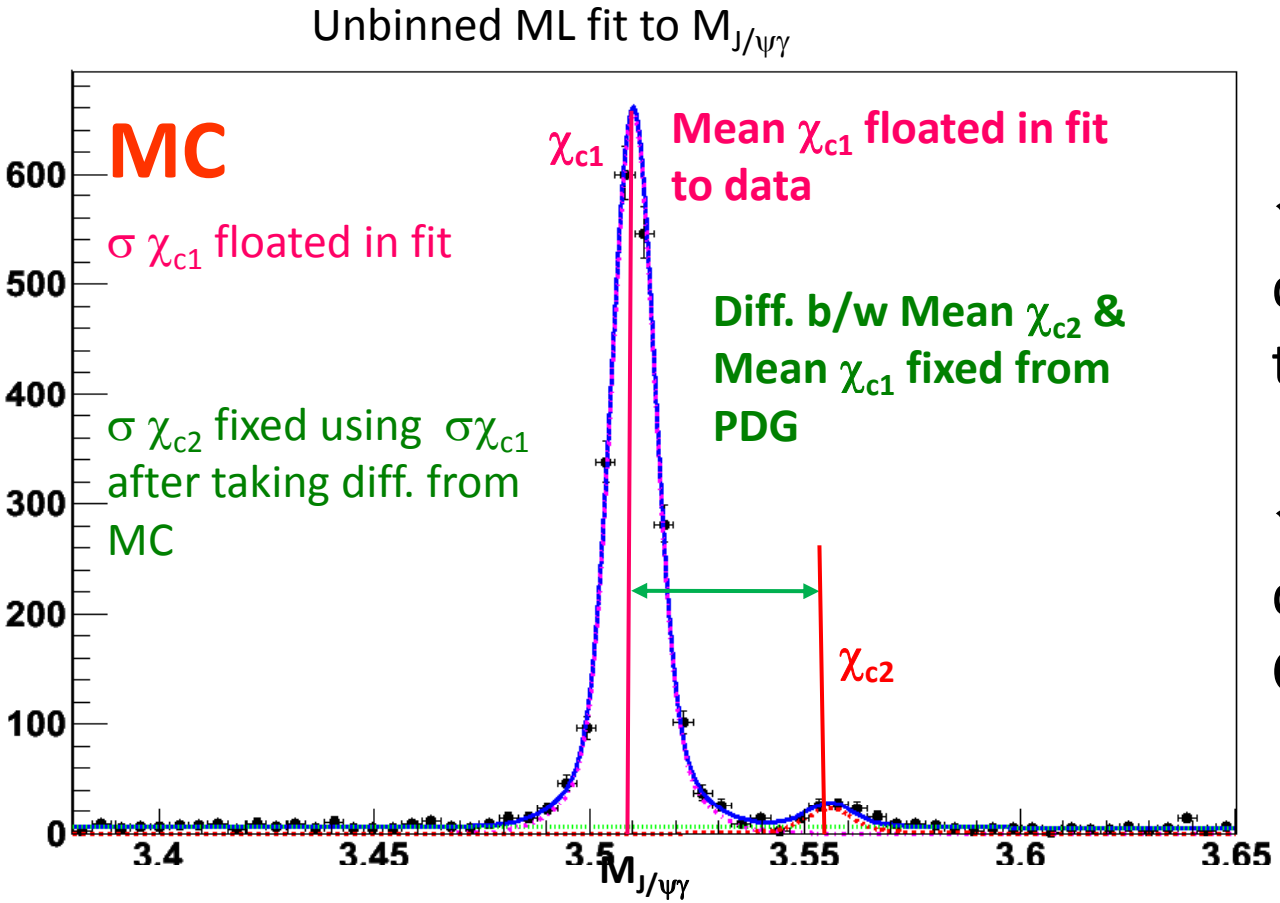
- ✓ E_γ > 290 MeV for $\chi_{c1,c2}$
  E_γ > 470 MeV for X(3872)
- ✓ π^0 veto
- ✓ $\cos\theta_{hel}$ cut to reduce the background



- ✓ **Region$_{\chi c}$ studied first**
- ✓ **Then Region$_X$**

Fit strategy for $\chi_{c1,c2}$ fit

❖ 0.5 Million events generated to determine signal PDF.



✓ Signal PDF is described by sum of two Gaussians

✓ Background is described by 2nd order Chebyshev polynomial

✓ **Fit demonstrated on 10,000 toy MC sample**

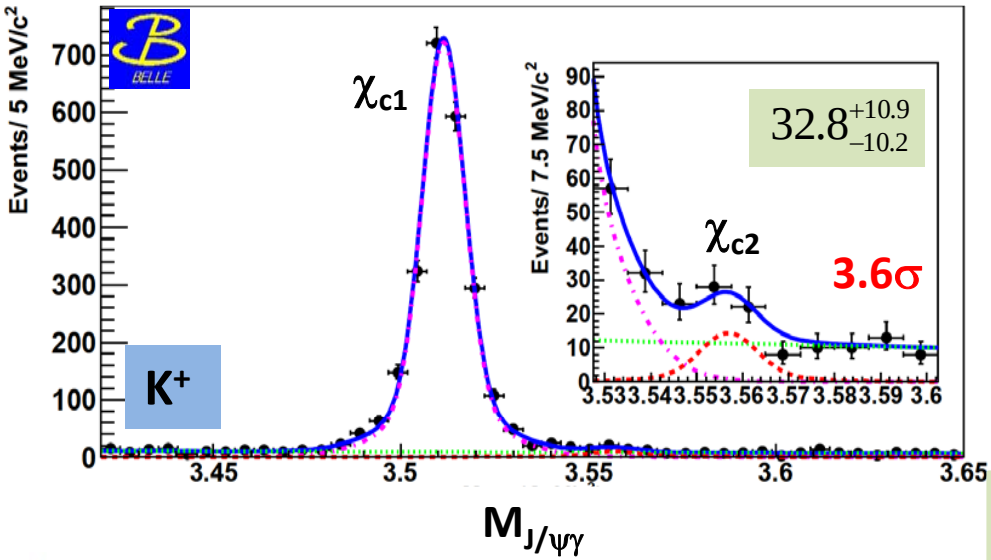
✓ **No significant bias observed in the fitter**

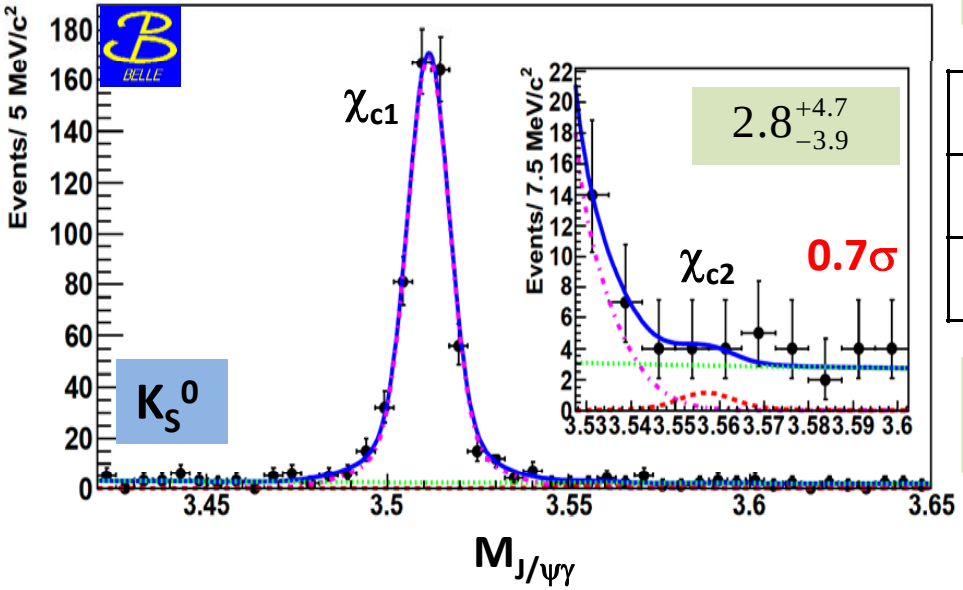
772 M $B\bar{B}$

Preliminary result

$B \rightarrow \chi_{c1,c2}\ K$

$B \rightarrow (J/\psi\gamma)\ K$





First Evidence for $B^+ \rightarrow \chi_{c2}\ K^+$

Mode	Events	Significance Σ (σ)
$B^+ \rightarrow \chi_{c1}\ K^+$	$2308\ ^{+53}_{-52}$	
$B^+ \rightarrow \chi_{c2}\ K^+$	$32.8^{+10.9}_{-10.2}$	**3.6**

Significance include systematics

$\mathcal{BR}(B^+ \rightarrow \chi_{c2}\ K^+) = (1.11 \pm 0.35 \pm 0.09) \times 10^{-5}$

Mode	Events	Σ (σ)
$B^0 \rightarrow \chi_{c1} K_S^0$	542 ± 24	
$B^0 \rightarrow \chi_{c2} K_S^0$	$2.8^{+4.7}_{-3.9}$	**0.7**

$\mathcal{BR}(B^0 \rightarrow \chi_{c2}\ K^0) < 1.5 \times 10^{-5}$ (@ 90% CL)

772 M $B\bar{B}$

Preliminary result

Fit results

B→(J/ψγ) K

Mode	Events	Σ (σ)	$\mathcal{BR}$		
			Belle	PDG	BaBar
$B\to\chi_{c1}K$				(10^{-4})	
$K^{\pm}$	2308^{+53}_{-52}		$4.94\pm0.11\pm0.33$	5.1 ± 0.5	$4.5\pm0.1\pm0.3$
K^0	542 ± 24		$3.78^{+0.17}_{-0.16}\pm0.33$	3.9 ± 0.4	$4.2\pm0.3\pm0.3$
$B\to\chi_{c2}K$				(10^{-5})	
$K^{\pm}$	$32.8^{+10.9}_{-10.2}$	3.6	$1.11^{+0.36}_{-0.34}\pm0.09$	<2.9	<1.8
K^0	$2.8^{+4.7}_{-3.9}$	0.7	$0.32^{+0.53}_{-0.44}\pm0.03$ <1.5 (@ 90% CL)	<2.6	<2.8

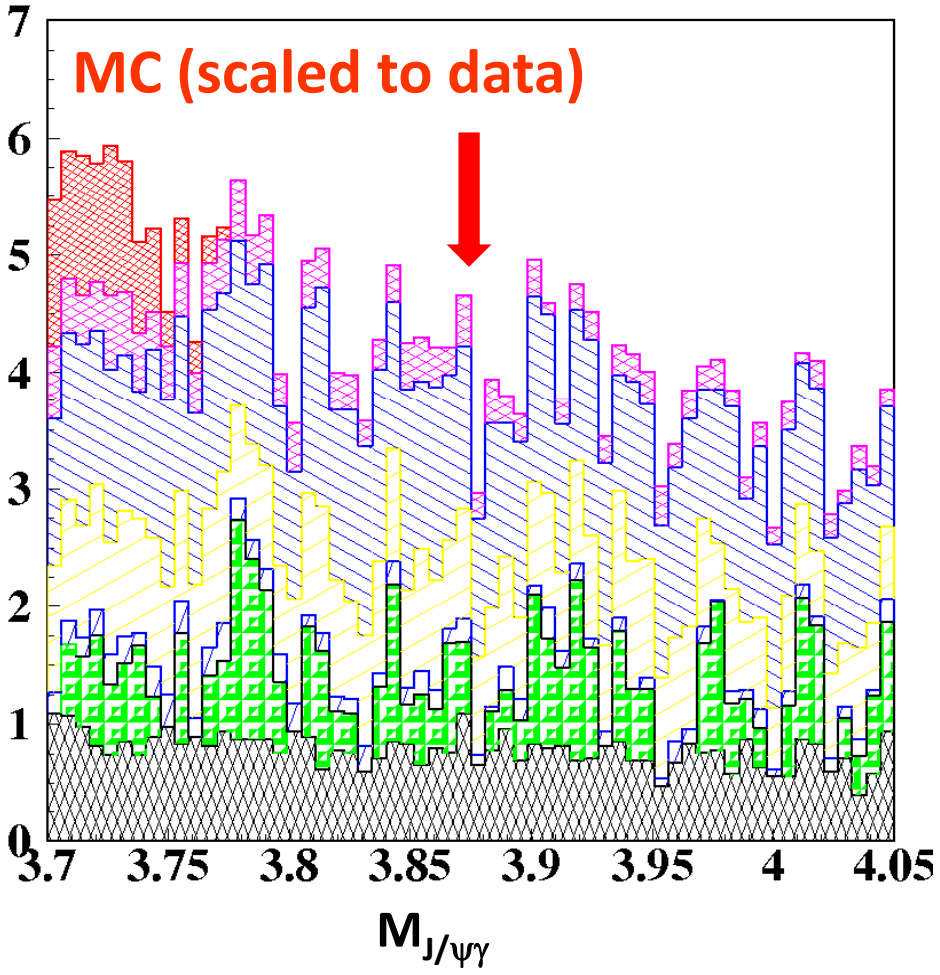
First evidence for $B^+\to\chi_{c2}(J/\psi\gamma)K^+$

Results consistent with PDG and BaBar's measurement

B→(J/ψγ) K

Background study

✓ After successful validation of analysis strategy in $\chi_{c1,c2}$ K



- Went for X(3872)→ J/ψγ
- Almost same background

$B^+ \rightarrow \psi' K^+$

$B^0 \rightarrow J/\psi\, K^{*0}$

$B^+ \rightarrow J/\psi\, K^{*+}$

$J/\psi K(1270)$, $J/\psi\, K_2^*(1430)$

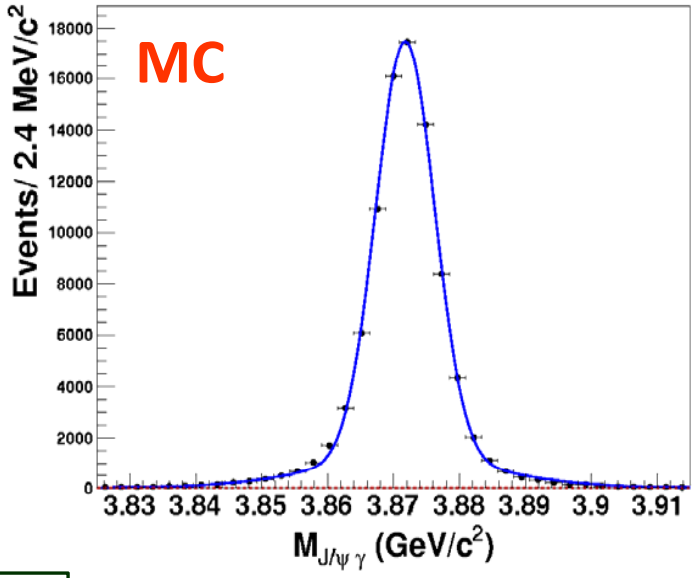
non-J/ψ (data sideband)

Combinatorial

No peaking structure in X(3872) signal region

Fit strategy for X(3872)

X(3872)→J/ψγ



- 0.5 Million events generated to determine signal PDF
- Signal PDF described by sum of two Gaussians

Background described by :

1st order Chebyshev polynomial

Unbinned ML fit to $M_{J/\psi\gamma}$

- Mean X(3872) fix using Mean χ_{c1} after applying diff.* from Mass X(3872) & Mass χ_{c1}
- σ X(3872) fixed using $\sigma\chi_{c1}$ after taking diff. from MC

* X(3872)→ J/ψππ world average used and for χ_{c1} PDG is used

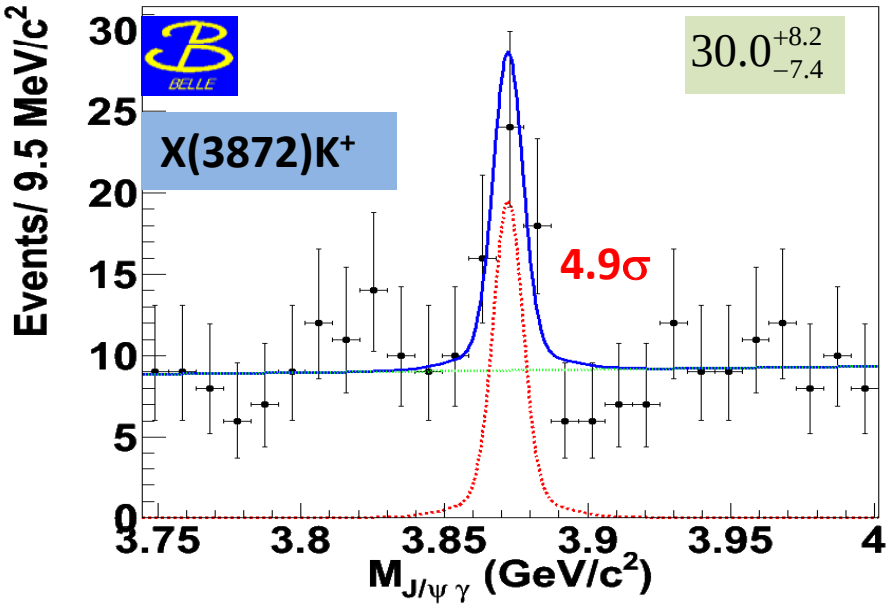
- ✓ **Fit demonstrated on 10,000 toy MC sample**
- ✓ **No significant bias observed in the fitter**

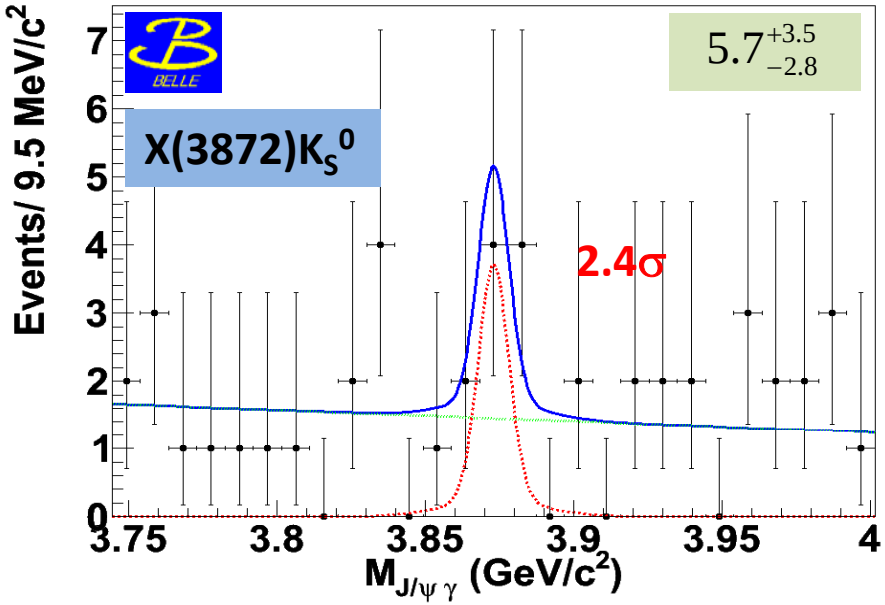
772 M $B\bar{B}$

Preliminary result

B→X(3872)K

B→(J/ψγ) K





Mode	Events	Significance
$B^+ \to X(3872)\,K^+$	$30.0^{+8.2}_{-7.4}$	4.9 σ
$B^0 \to X(3872)\,K^0_S$	$5.7^{+3.5}_{-2.8}$	2.4 σ

Clear observation of X(3872) → J/ψγ in $B^+ \to X(3872)K^+$

- $\mathcal{BR}$ **($B^+ \to X(3872)\,K^+$) x $\mathcal{BR}$(X(3872) → J/ψγ) is (1.78±0.46±0.12) x 10^{-6}**

Consistent with Belle previous Evidence

arXiv:0505037

$$\frac{\mathcal{BR}(X(3872) \to J/\psi\gamma)}{\mathcal{BR}(X(3872) \to J/\psi\pi\pi)} = 0.22 \pm 0.05$$

Using Belle X(3872)→J/ψππ result from

arXiv:0809.1224

- $\mathcal{BR}$ **($B^0 \to X(3872)\,K^0$) x $\mathcal{BR}$(X(3872) → J/ψγ) is < 2.4 x 10^{-6} (@ 90% CL)**

Preliminary result

Fit results

Mode	Events	Σ (σ)	$\mathcal{BR}^{\star}$ (10^{-6})	
			Belle	BaBar
$K^{\pm}$	$30.0^{+8.2}_{-7.4}$	4.9	$1.78^{+0.48}_{-0.44} \pm 0.12$	2.8±0.8±0.1
K^0	$5.7^{+3.5}_{-2.8}$	2.4	$1.24^{+0.76}_{-0.61} \pm 0.11$ <2.4 (@ 90% CL)	<4.9

$^{\star}\mathcal{BR}$(B→X(3872)K) . $\mathcal{BR}$(X(3872)→J/ψγ)

B^+ →X(3872) (J/ψγ) K^+ mode is now clearly established

B→(ψ'γ) K

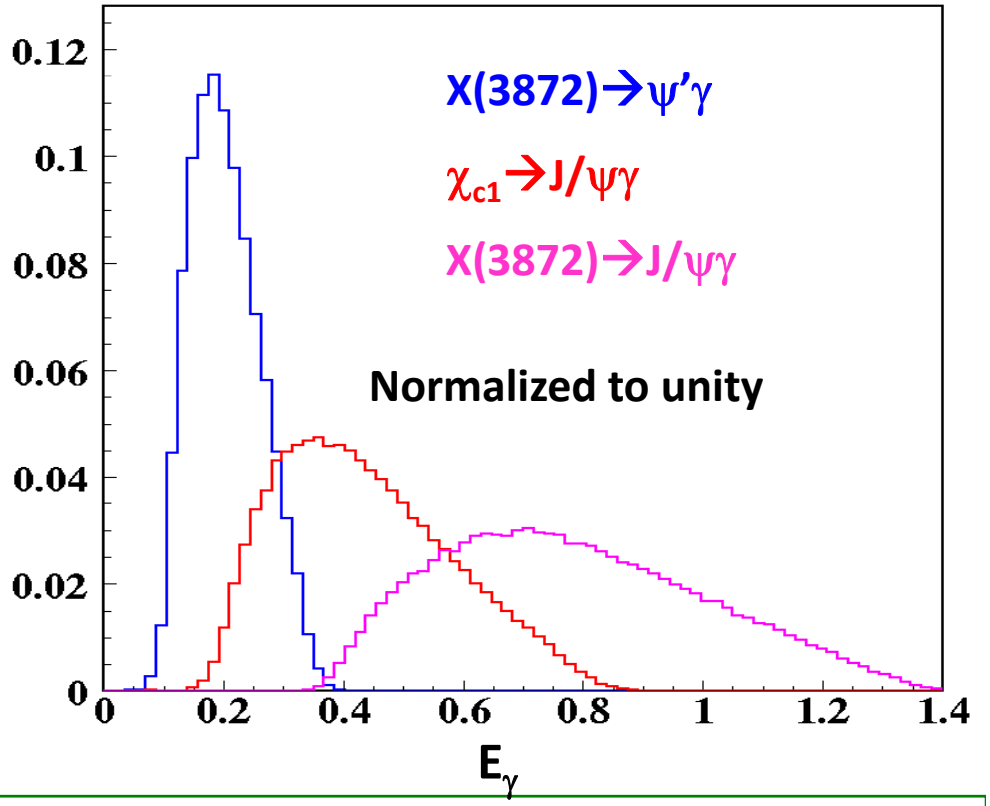
MC

X(3872) → ψ' γ

→ J/ψπ⁺π⁻

or

→ e⁺ e⁻ or μ⁺μ⁻



- **Low energy γ**
- **Cuts used to reduce background in B→ (J/ψγ) K study, reduce more signal than background in B→(ψ'γ) K**

Photon selection

✓ E_γ > 100 MeV

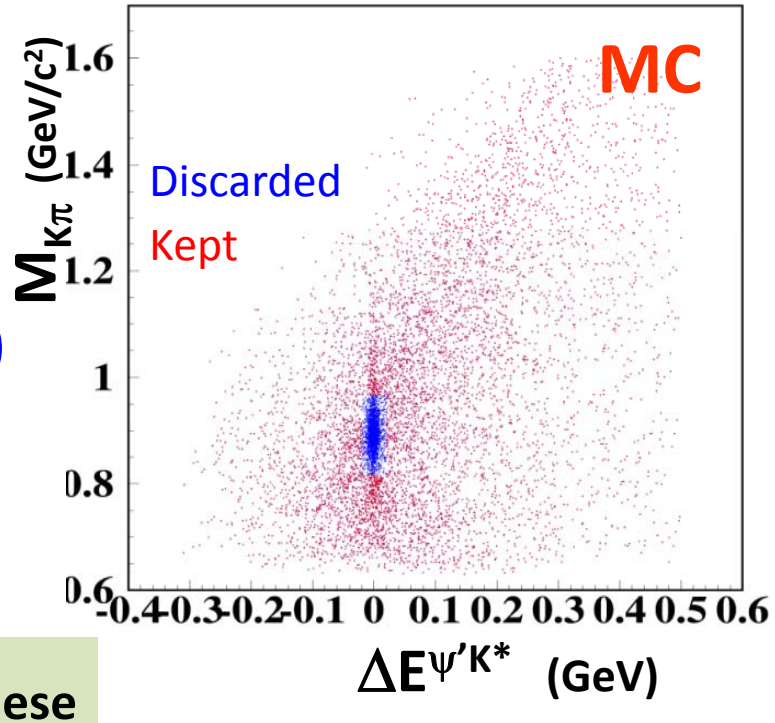
- ψ' K* veto used to reduce background coming from B→ψ' K*

ψ' K* veto

Veto to reduce background coming from ψ' K*

- **Look for additional $\pi^{+/0}$ in the event**
- **Associate this $\pi^{+/0}$ with ψ' and K (from X(3872) K candidates) to form ψ' K***

- ✓ $\Delta E^{\psi' K^*}$ ($\equiv E_{\psi'} + E_K + E_\pi - E^{cm}_{beam}$),
- ✓ $M_{K\pi}$, invariant mass of K π.
- ✓ $M_{bc}^{\psi' K^*} = \sqrt{(E^{cm}_{beam}{}^2 - (p_{\psi'} + p_K + p_\pi)^2)}$



if

$|\Delta E^{\psi' K^*}| < 20$ MeV

$M_{K\pi} \in (892 \pm 75)$ MeV/c²

$M_{bc}^{\psi' K^*} > 5.27$ GeV/c²

⇒ **Rejected these events**

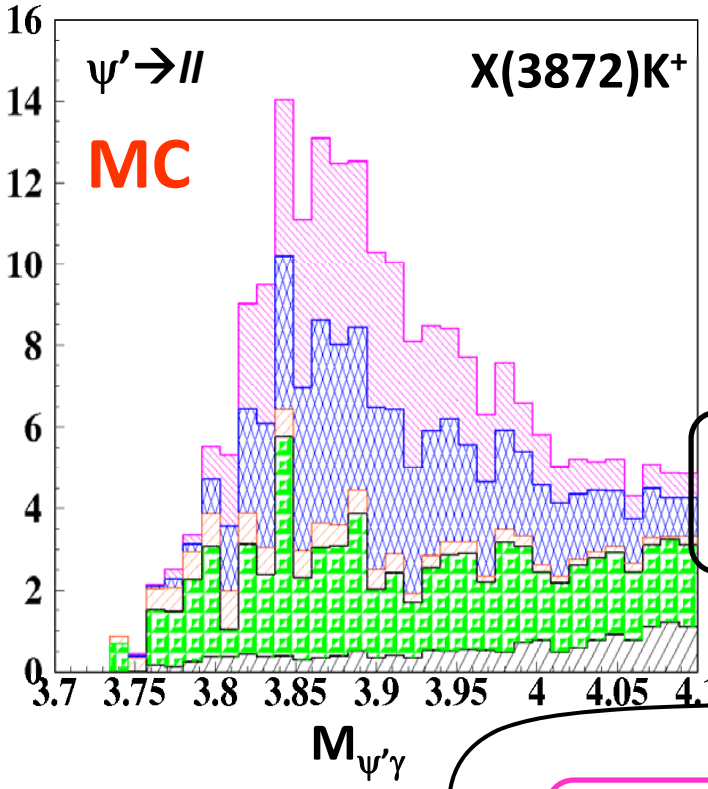
❖ **ψ' K* background is reduced by ~40%**

whereas signal loss is ~15%

B→(ψ'γ) K

Background study

Scaled to data



Consist of 5 parts :

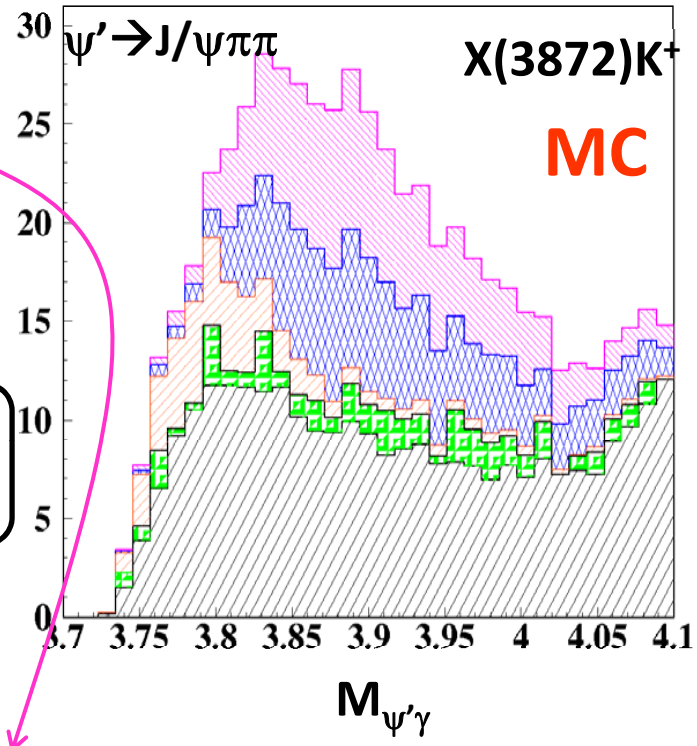
$B^0 \to \psi' K^{*0}$

$B^+ \to \psi' K^{*+}$

$B^+ \to \psi' K^+$

$B^0 \to \psi' K_S^0$

Combinatorial including non ψ component



Parameterize and fix using generated ψ' K* and ψ' K large samples (few 100 x data size)

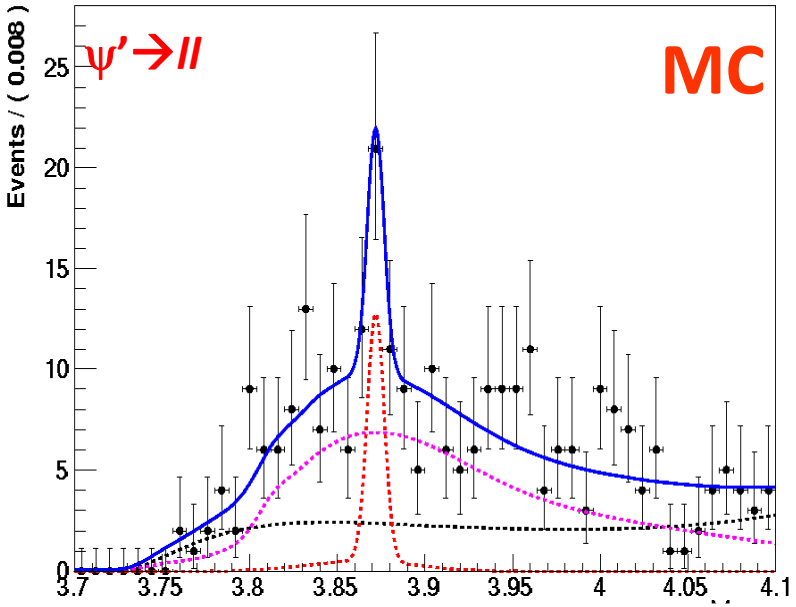
Parameterize and fix using large B→ ψ X MC and non-ψ data sideband

ψ refers to J/ψ or ψ'

M_{bc} data sideband is used to verify our understanding of the background

MC to illustrate simultaneous fit to ψ' sub decay modes(*ll* and J/ψππ)

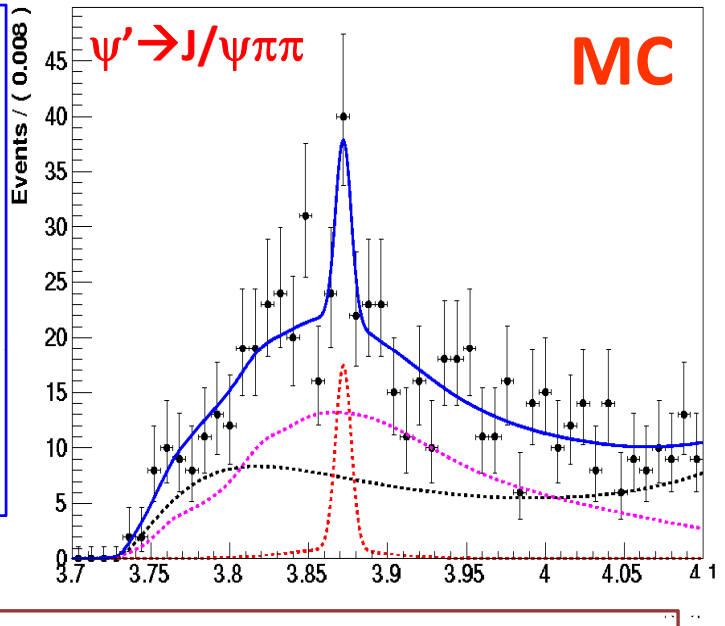
Unbinned ML fit



Signal PDF

(ψ'K* +ψ' K) background PDF

Combinatorial



- ✓ Background shape → explained in previous slide.
- ✓ Mean X(3872) fix using Mean χ_{c1} after applying difference from Mass X(3872) & Mass $\chi_{c1,}$ while σ X(3872) fixed using $\sigma\chi_{c1}$ after taking diff. from MC.
- ✓Two free parameters in the fit for background in each sub-decay mode and branching fraction common to both.
- ✓ 5 free parameters.

772 M $B\bar{B}$

Fit validation MC

B→(ψ'γ) K

B→ X(3872) K X(3872)→ψ' γ		Efficiency(%) (typical error ~ 0.1%)	Expected yield*
ψ'→*ll*	K^+	21.6	24.1 ± 6.8
	K_S^0	16.3	7.6 ± 3.6
ψ'→J/ψ ππ	K^+	12.1	34.8± 9.9
	K_S^0	8.7	10.4 ± 5.0

*assuming BaBar's branching fraction for X(3872) →ψ' γ $K^+(K^0)$
→ 9.5±2.7 (11.4±5.5) x 10^{-6}

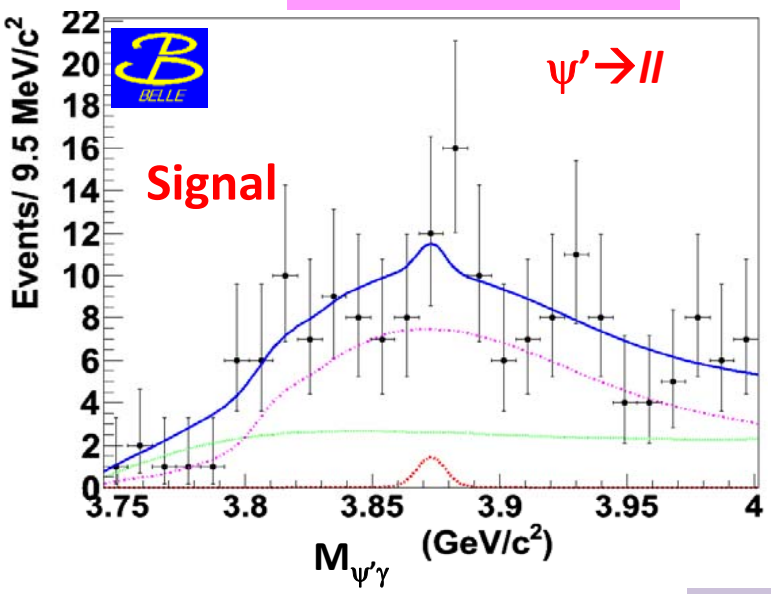
- ✓ Fit successful demonstrated on 10,000 toy MC sample
- ✓ No significant bias observed in the fitter
- ✓ 50 (fully simulated) pseudo-experiment successfully tested

772 M $B\bar{B}$

Preliminary result

B→X(3872)K

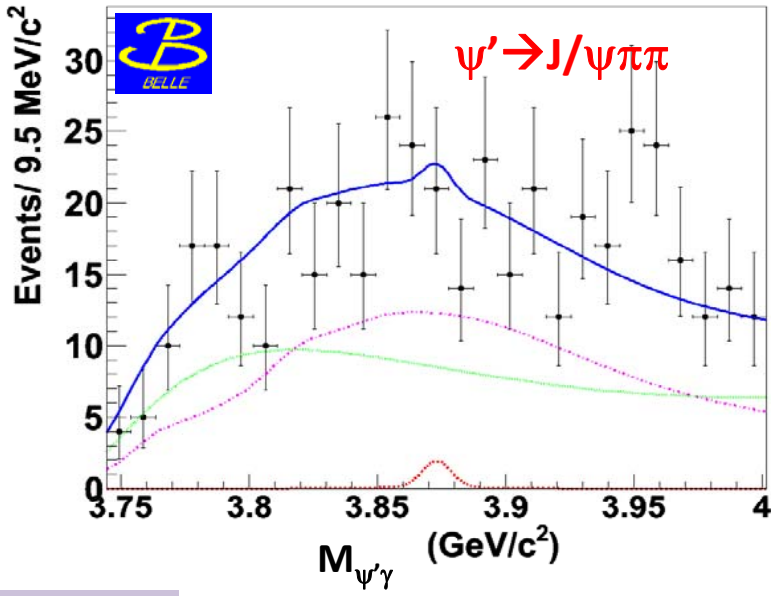
B→(ψ'γ) K



$B^{\pm}$→ $XK^{\pm}$

$5.0^{+11.9}_{-11.0}$

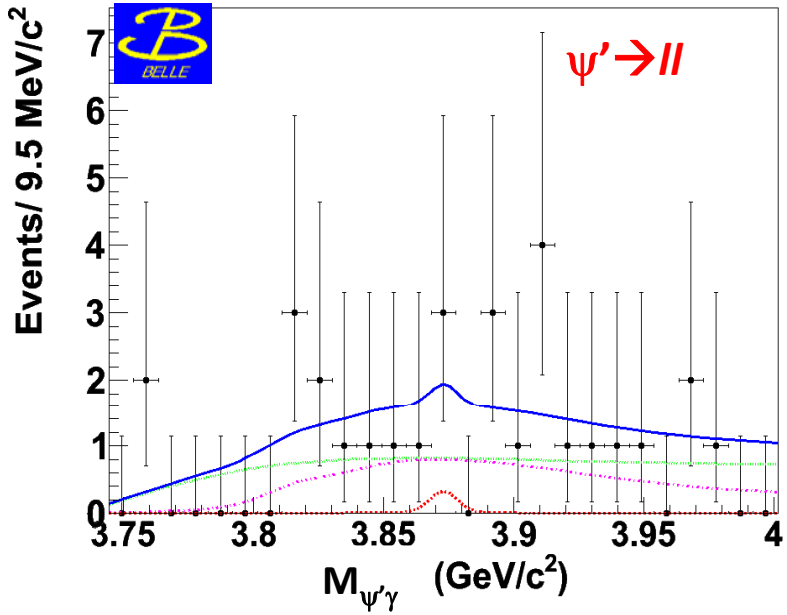
0.4σ



ψ'K*, ψ'K background component

No signal observed

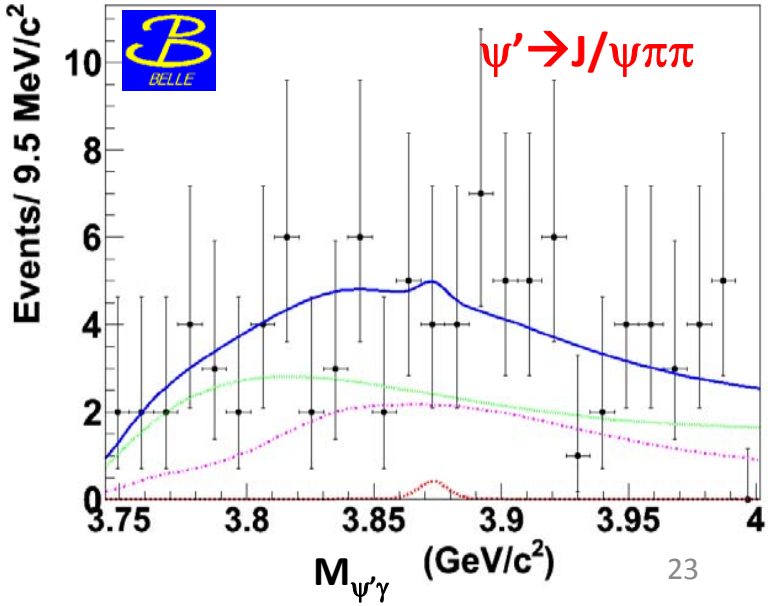
Combinatorial background



B^0→ XK_S^0

$1.5^{+4.8}_{-3.9}$

0.2σ



772 M $B\bar{B}$

Preliminary result

Fit results

B→(ψ'γ) K

No signal is observed in X(3872)→ψ'γ

Mode X(3872)→ψ'γ	Events	Σ (σ)	$\mathcal{BR}$ (10^{-6})	
			Belle	BaBar
$B^{\pm}$→X(3872)$K^{\pm}$	$5.0^{+11.9}_{-11.0}$	0.4	< 3.4 (@90%)	9.5±2.7±0.6 (3.5σ)
B^0→X(3872)K^0	$1.5^{+4.8}_{-3.9}$	0.2	< 6.6 (@90%)	< 19.0

$\mathcal{BR}$ ($B^{\pm}$→X(3872) $K^{\pm}$) x (X(3872)→ψ'γ) < 3.4 x 10^{-6} (@ 90% CL)

$$\frac{\mathcal{BR}(X(3872) \to \psi'\gamma)}{\mathcal{BR}(X(3872) \to J/\psi\gamma)} < 2.1 \quad (@\ 90\%\ CL)$$

- A complete independent analysis (different selection and fitter, 3D) was performed on the same data sample and is consistent with this result.

Conclusion

- B→ (J/ψγ) K
  - ✓ $B^+ \rightarrow X(3872)(J/\psi\,\gamma)\,K^+$ is clearly observed
  - ✓ Evidence for $B^+ \rightarrow \chi_{c2}\,K^+$
  - ✓ Most precise measurements
  - ✓ In agreement with world average, Belle previous result and BaBar's result

- B→(ψ'γ) K
  - ✓ **No signal observed in X(3872)→ψ'γ**
  - ✓ **$\mathcal{BR}$ ($B^\pm \rightarrow X(3872)\,K^\pm$) x ($X(3872) \rightarrow \psi'\gamma$) < 3.4 x 10^{-6} (@ 90% CL)**
  - ✓ **$\mathcal{BR}(X(3872) \rightarrow \psi'\,\gamma) / \mathcal{BR}(X(3872) \rightarrow J/\psi\,\gamma) < 2.1$**

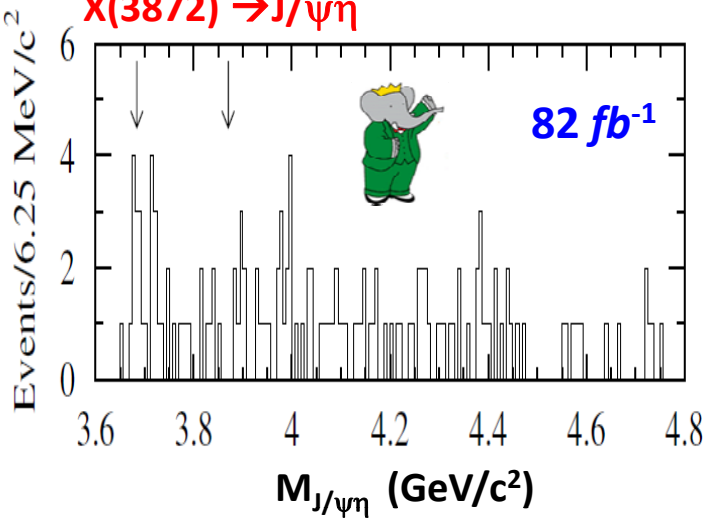
- What we can say:
  - ✓ $c\bar{c}$ admixture may not be as large as was recently discussed.
  - ✓ Can molecular or any other model explain X(3872) ?

Thank you


Backup Wizard
Welcome to the Backup Wizard
This wizard helps you back up your hard disk data.
To continue, click Next
< Back
Next >
Cancel

Exotic X(3872) search in other modes

X(3872) →J/ψη



May be charmonium or a hybrid state

✓ If charmonium than

$\mathcal{BR}$(X(3872) (J/ψη) K ~ 3 x 10 $^{-6}$

✓ If hybrid charmonium than $\mathcal{BR}$might be enhanced

PRL 93, 041801 (2004)

$\mathcal{BR}$(X(3872) (J/ψη) K < 7.7 x 10 $^{-6}$ (90% CL)

X(3872)→D^{*0} $\bar{D}^0$

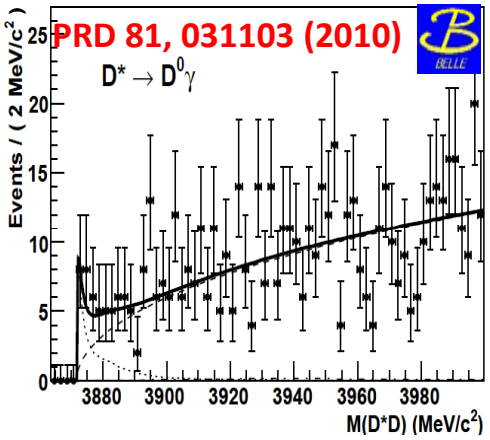
X(3872) loosely bound molecule → enhancement in D^{*0} $\bar{D}^0$ invariant mass near Threshold

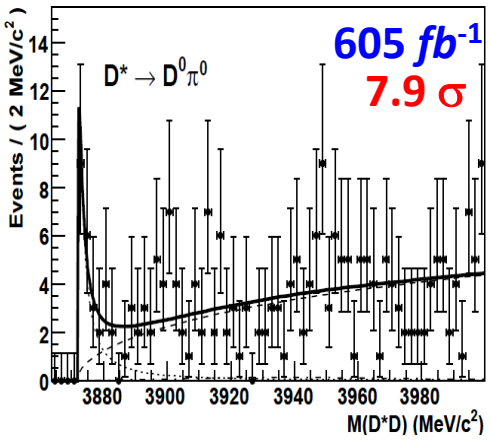
Belle & BaBar both observe X(3872)→D^{*0} $\bar{D}^0$ but they got slight shift in mass

Mass→ $3875.2 \pm 0.7^{+0.3}_{-1.6} \pm 0.8$ MeV/c² PRL 97,162002 (2006)

Mass→ $3875.1^{+0.7}_{-0.5} \pm 0.5$ MeV/c² PRD 77,011102 (2008)

Different X(3875) ??





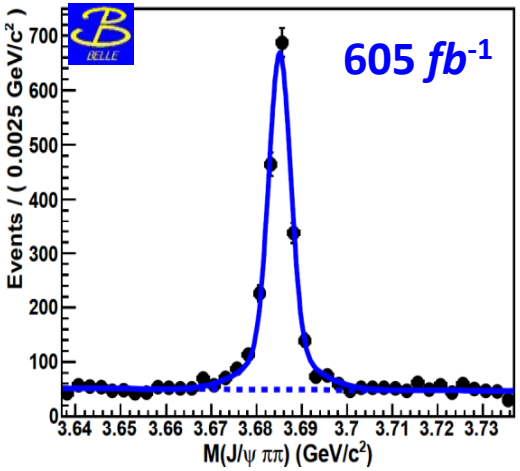
More sophisticated analysis at Belle gave :

Mass → $3872.9^{+0.6\ +0.4}_{-0.4\ -0.5}$ MeV/c²

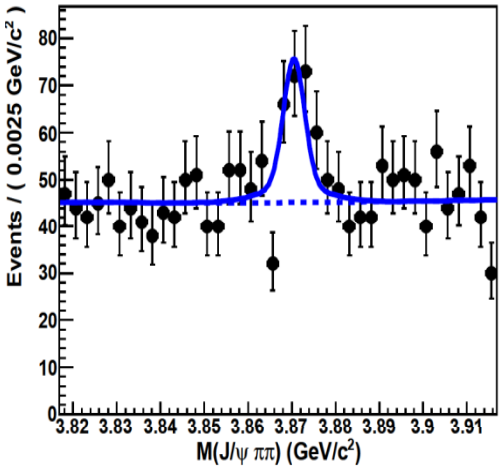
PRD 81, 031103 (2010)

Also in B→ X(3872) Kπ

$B^0 \to \psi' K^+\pi^-$



$B^0 \to X(3872) K^+\pi^-$



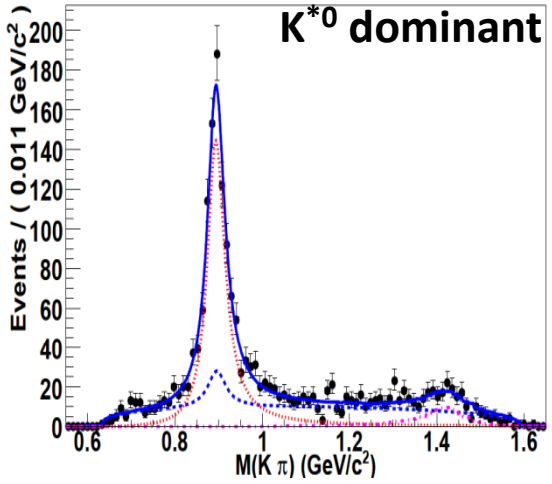
arXiv:0809.1224

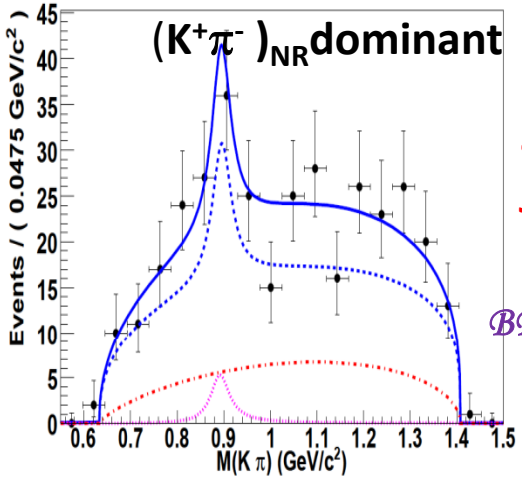
$$\frac{\mathcal{BR}(B^0 \to X(3872)K^0)}{\mathcal{BR}(B^+ \to X(3872)K^+)} = 0.82 \pm 0.22 \pm 0.05$$

$$\delta M_X = M^{from\ B^\pm}_{X(3872)} - M^{from\ B^0}_{X(3872)}$$

$$= (0.18 \pm 0.89 \pm 0.26)\ \text{MeV}/c^2$$

Rules out X(3872) from being a tetraquark PRD 71, 014028





$\mathcal{BR}(B^0 \to X(3872)\,(K^+\pi^-)_{NR}) \times \mathcal{BR}(X(3872) \to J/\psi\pi\pi)$

$= (8.1 \pm 2.0 \pm 1.2) \times 10^{-6}$

$\mathcal{BR}(B^0 \to X(3872)\,K^{*0}) \times \mathcal{BR}(X(3872) \to J/\psi\pi\pi)$

$< 3.4 \times 10^{-6}$ (90% CL)

B→X ($K^+\pi^-$) non resonant contribution dominates unlike charmonium

- ✓ Neutral and charged equal production is difficult to explain by molecular model

Systematic Uncertainties

Main sources of systematic errors in this analysis:-

- Kaon-identification
- K_S^0 reconstruction
- Lepton- identification
- γ-identification
- Secondary Branching fraction
- $N_{B\bar{B}}$
- PDF
- Tracking
- Difference between data and MC in behavior to (E_γ, $\cos\theta_{hel}$, π^0 veto and ΔE) cuts
- $\cos\theta_{hel}$ distribution
- Fit bias

Systematic Uncertainties

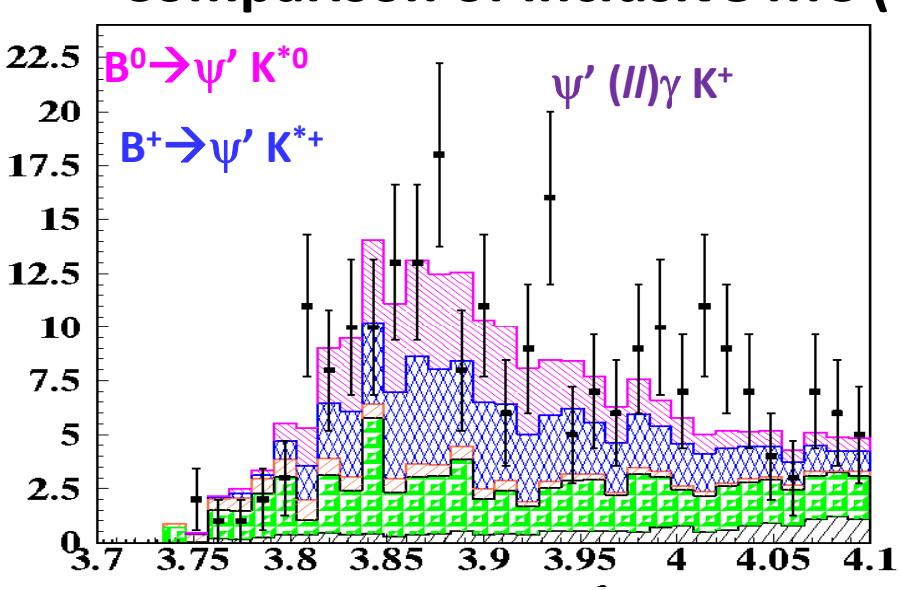
$B \to (J/\psi\gamma)\, K$

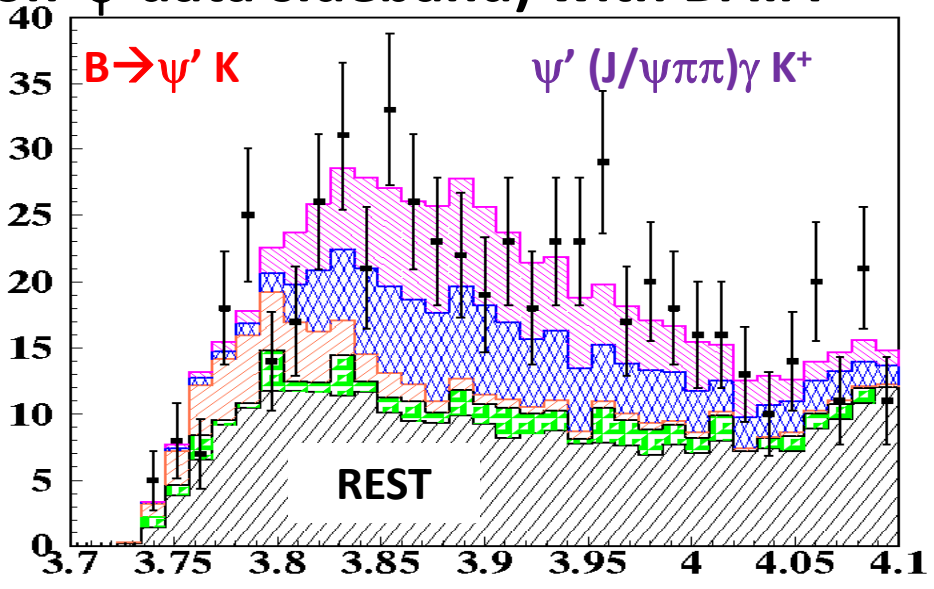
Sources	Systematic error (%)					
	$B \to \chi_{c1} K$		$B \to \chi_{c2} K$		$B \to X(3872) K$	
	K^+	K_S^0	K^+	K_S^0	K^+	K_S^0
K-identification	0.6	_	0.6	_	0.5	_
K_S^0 reconstruction	_	4.5	_	4.5	_	4.5
Lepton identification	1.1	1.1	1.1	1.1	1.1	1.1
γ identification	2	2	2	2	2	2
MC	0.3	0.4	0.4	0.4	0.3	0.3
Secondary $\mathcal{BR}$	4.5	4.5	4.1	4.2	0.7	0.7
$N_{B\bar{B}}$	1.4	1.4	1.4	1.4	1.4	1.4
Tracking	3.0	4.0	3.0	4.0	3.0	4.0
PDF	0.7	1.1	3.8	3.8	1.8	1.8
Fit bias	_	_	0.5	2.1	0.5	0.2
MC, data diff	3.0	3.0	3.0	3.0	3.0	3.0
$\text{Cos}\theta_{hel}$	_	_	3.8	3.8	4.2	4.2
Total	6.8	8.6	8.4	9.9	6.8	8.6

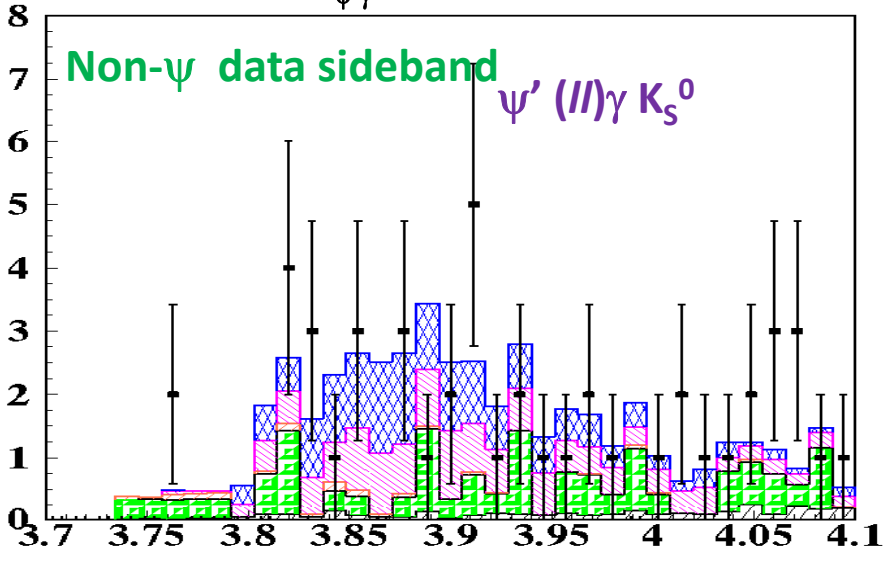
Systematic Uncertainties

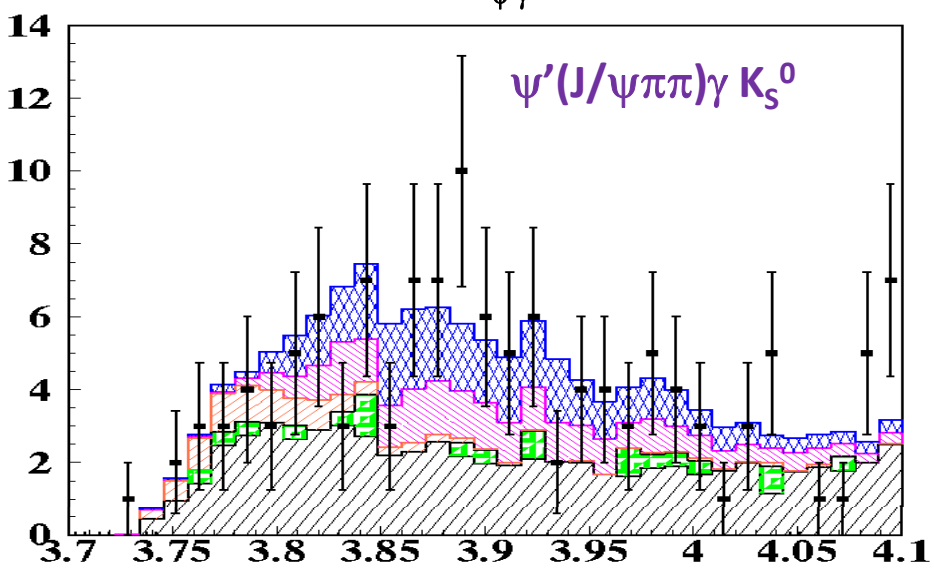
Sources	Systematic error (%)	
	$B^+ \to (\psi'\gamma)K^+$	$B^0 \to (\psi'\gamma)K_S^0$
K-identification	0.9	_
K_S^0 reconstruction	_	4.5
Lepton identification	1.1	1.1
γ identification	3	3
MC	0.4	0.4
Secondary $\mathcal{BR}$	2.4	2.4
$N_{B\bar{B}}$	1.4	1.4
Tracking	4.2	5.2
PDF	50	50
Fit bias	16	6
Total	53	51

Comparison of inclusive MC (+ non-ψ data sideband) with DATA





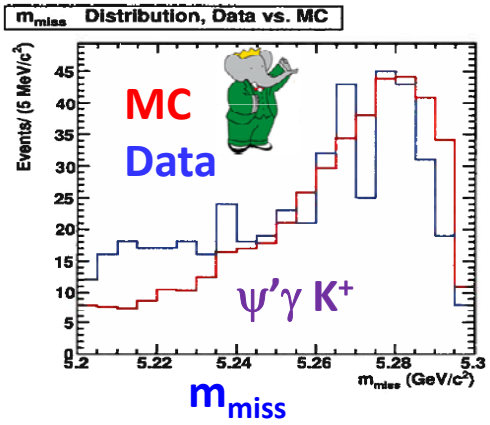


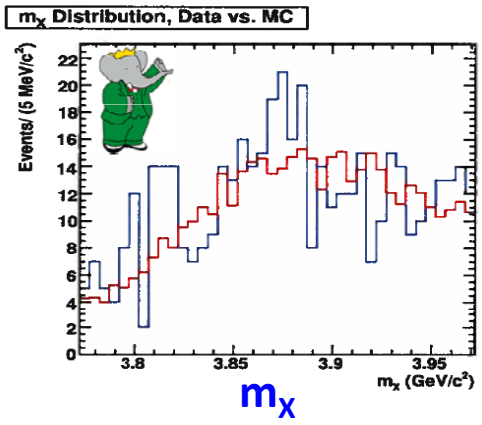


MC agrees quite well with Data.. No sign of signal…….

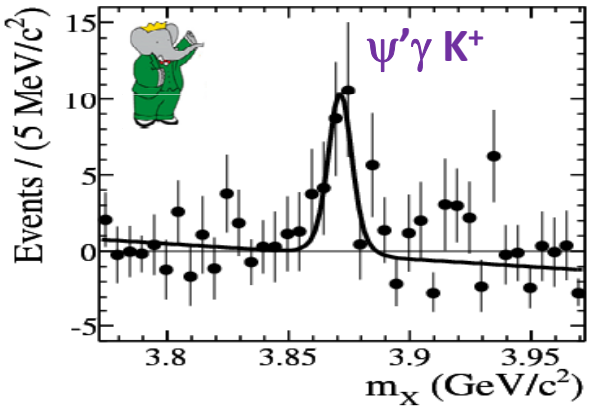
Belle Babar comparison

- BaBar used 1d UML fit to m_{miss} and use $_s$Plot to project signal in m_X
- We use 1d UML fit to $M_{\psi'\gamma}$ to extract yield

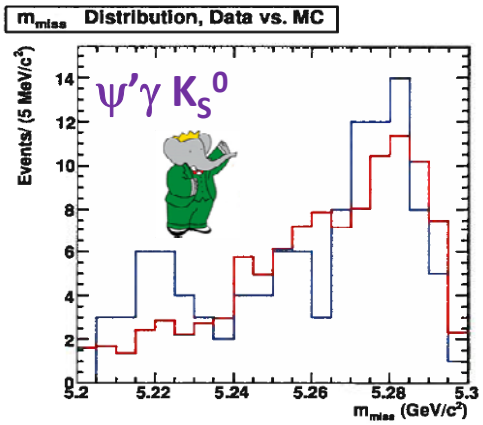


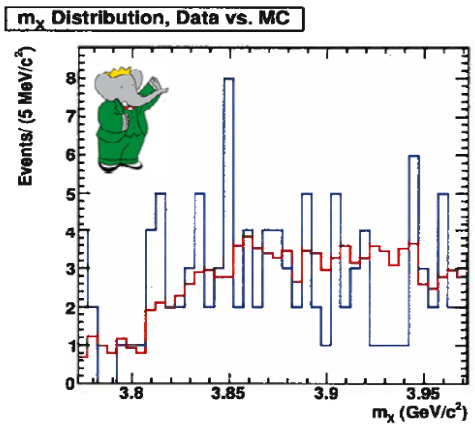


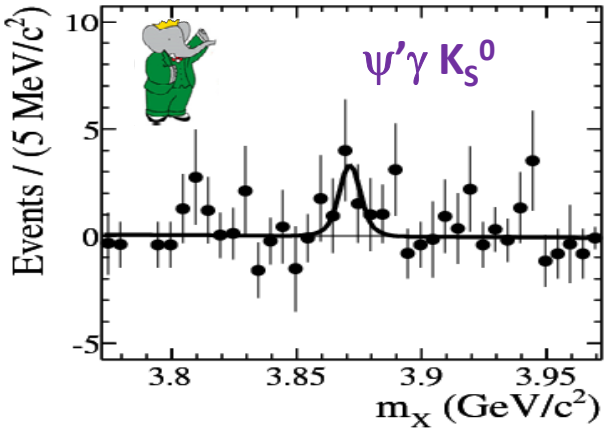
Raw distribution from Fulsom's thesis



$_s$Plot projection in m_X bins







Belle / BaBar

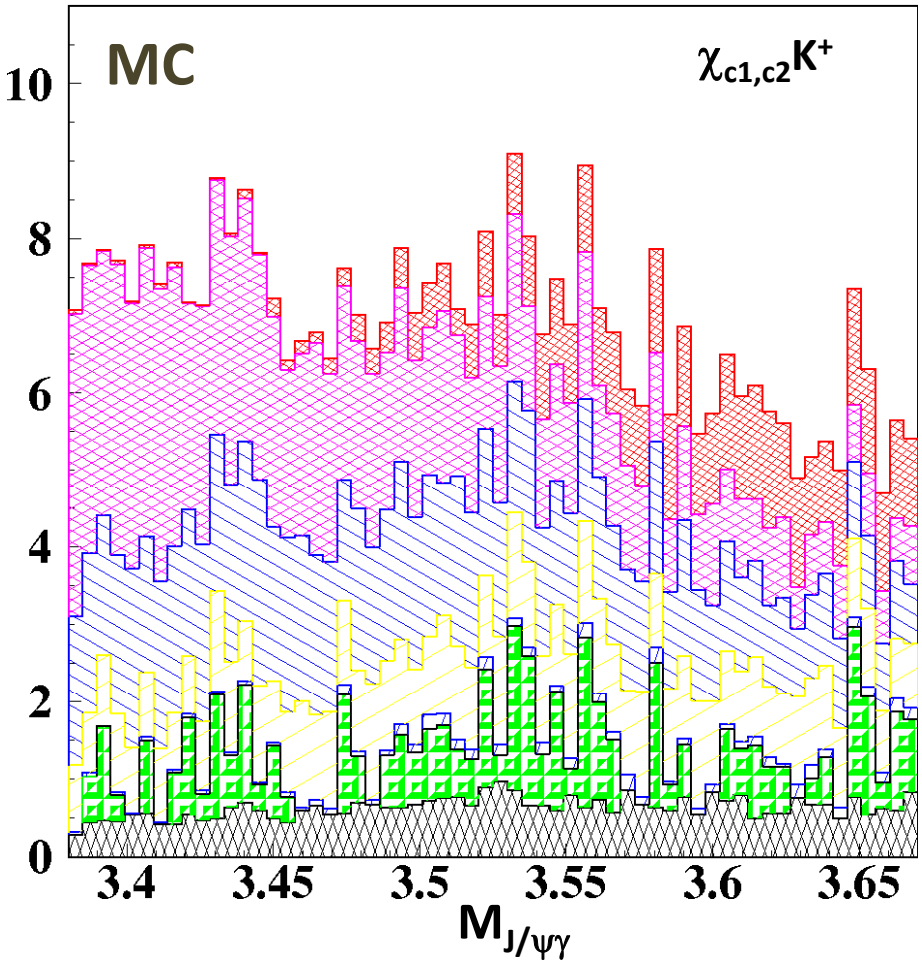
Mode	Belle			BaBar		
	ε (%)	Yield	$\mathcal{BR}$	ε (%)	Yield	$\mathcal{BR}$
$B \to \chi_{c1} K$			**, x 10^{-4}**			**, x 10^{-4}**
K^+	14.8	2308±52	4.9±0.1±0.3	11.0	1018±34	4.5±0.1±0.3
K^0	13.2	542±24	$3.78^{+0.17}_{-0.16} \pm 0.33$	8.7	242±16	4.2±0.3±0.3
$B \to \chi_{c2} K$			**, x 10^{-5}**			**, x 10^{-5}**
K^+	16.6	$32.8^{+10.9}_{-10.2}$	$1.11^{+0.36}_{-0.34} \pm 0.09$	12.3	14.0±7.9	<1.8
K^0	13.2	$2.8^{+4.7}_{-3.9}$	<1.5	11.1	6.1±3.9	<2.8
$B \to X(3872)\ (J/\psi\gamma)\ K$			**, x 10^{-6}**			**, x 10^{-6}**
K^+	18.3	$30^{+8.2}_{-7.4}$	$1.78^{+0.48}_{-0.44} \pm 0.12$	14.5	23.0±6.4	2.8±0.8±0.1
K^0	14.5	$5.7^{+3.5}_{-2.8}$	<2.4	11.1	5.3±3.6	<4.9
$B \to X(3872)\ (\psi'\gamma)\ K$			**, x 10^{-6}**			**, x 10^{-6}**
K^+	14.7	$5.0^{+11.9}_{-11.0}$	< 3.4	10.4	25.4±7.3	9.5±2.7±0.6
K^0	10.8	$1.5^{+4.8}_{-3.9}$	< 6.6	8.4	8.0±3.9	<19

B→(J/ψγ) K

$\chi_{c1,c2}K$

Background study

Scale to data sample size



- Large B→ J/ψ X sample (50 x data) used
- Non-J/ψ data sideband (3 x data) used

$B^+ \rightarrow \psi' K^+$

$B^0 \rightarrow J/\psi\, K^{*0}$

$B^+ \rightarrow J/\psi\, K^{*+}$

$J/\psi K(1270)$, $J/\psi\, K_2^*(1430)$

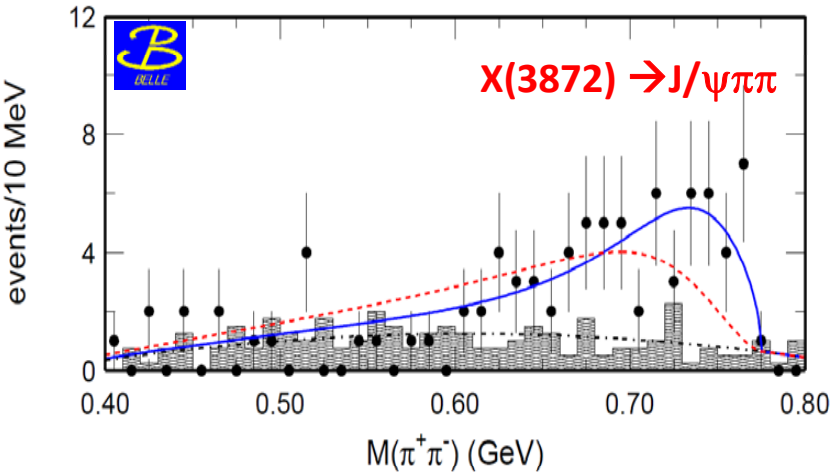
non-J/ψ (data sideband)

Combinatorial

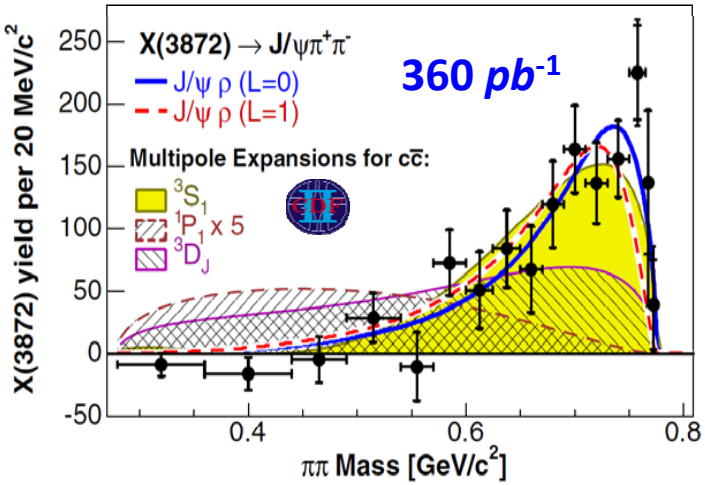
✓ **Background is flat in the fitting region.**

✓ **J/ψ inclusive + non-J/ψ (J/ψ sideband using data) agrees quite well with data.**

Exotic X(3872) search in other modes



PRL 96, 102002 (2006)



$M_{\pi\pi}$ favours X(3872)→J/ψρ
⇒ +ve C-parity

Angular analysis at Belle[1] and CDF[2]
⇒ **J^{PC}** as **1^{++}** or **2^{-+}**

[1] arXiv:0505038
[2] PRL98,132002(2007)

X(3872) J^{PC}

PRL98, 132002 (2007)