B→ X(3872)K and Z(4430)K at Belle
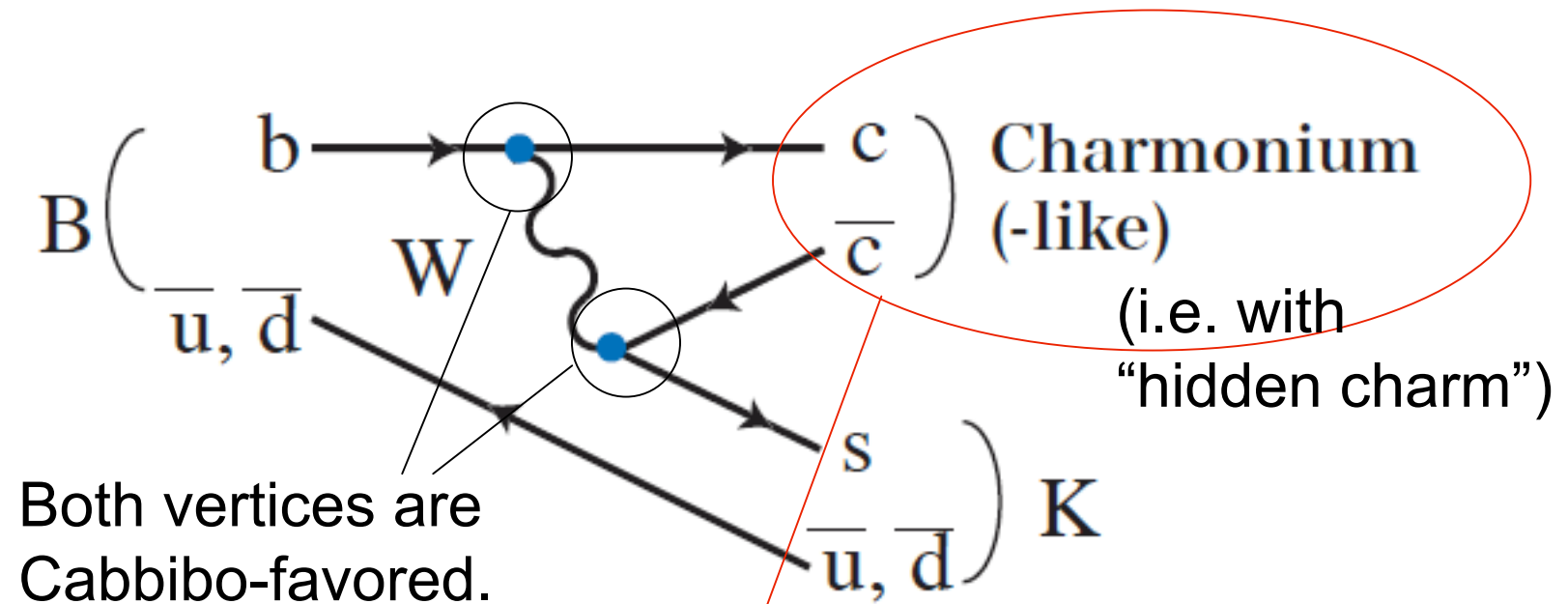
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QWG2007 at DESY 2007/Oct./19th

Introduction

A B-factory is functional as a Charmonium(-like) factory via B meson decay.

Both vertices are Cabbibo-favored.

Charmonium (-like)

(i.e. with "hidden charm")

Interesting place to carry out spectroscopy studies!

Outline

- Comparison between $B^{\pm} \rightarrow X(3872)K^{\pm}$ and $B^0 \rightarrow X(3872)K_S$

  – Is there suppression of $B^0 \rightarrow X(3872)K^0$?

  – Is there mass splitting between B^0 and $B^{\pm}$ decays into X(3872) K?

  Both important to select the model to describe X(3872).

- Observation of new resonance $Z(4430)^{\pm} \rightarrow \psi' \, \pi^{\pm}$ in $B \rightarrow \psi' \pi^{\pm} K$ decays

  – First observation of charged "hidden charm" object.

Reconstruction of B decays

Example; $B^0 \rightarrow J/\psi\ K_S$

$\Delta E(GeV)$

$M_{bc}(GeV)$
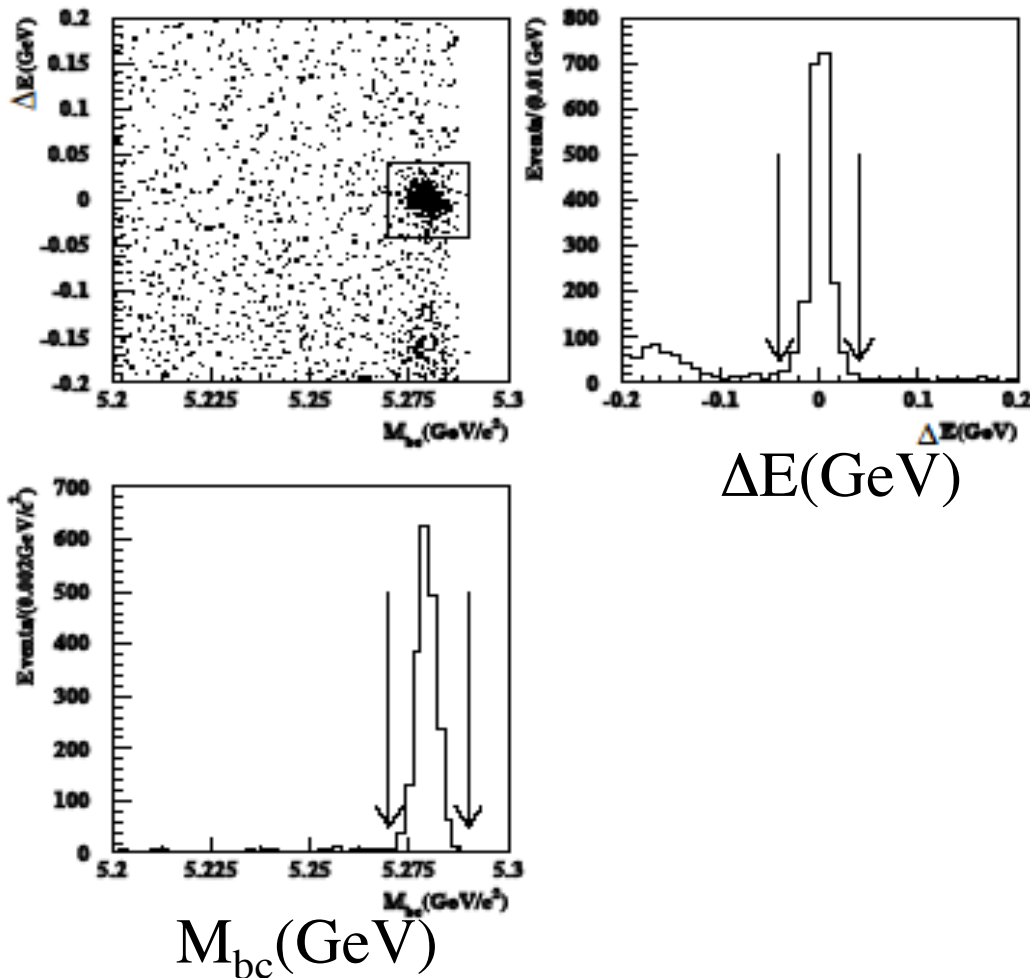
Using $\Upsilon(4S) \rightarrow B\bar{B}$ kinematics

$M_{bc} = \{ (E_{CM}/2)^2 - (\Sigma\ P_i)^2 \}^{1/2}$
(m_{ES} has the same meaning)
Signal peaks at B mass
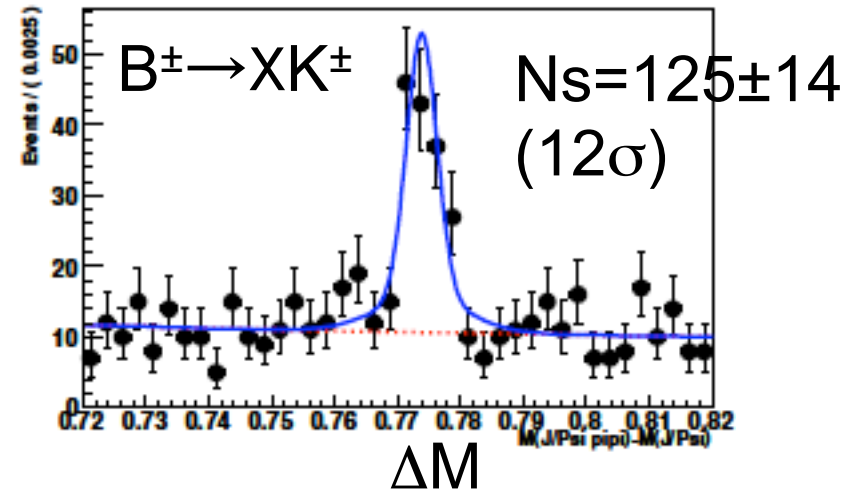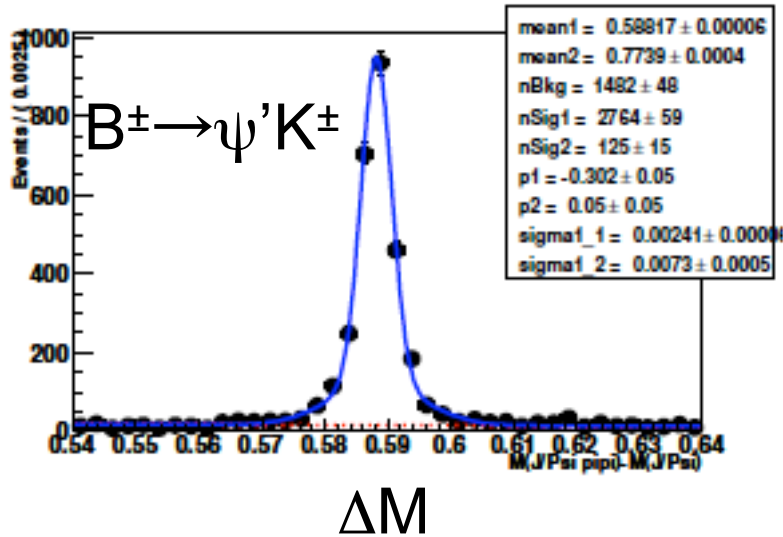(5.28GeV)

$\Delta E = \Sigma\ E_i - E_{CM}/2$
Signal peaks at 0.

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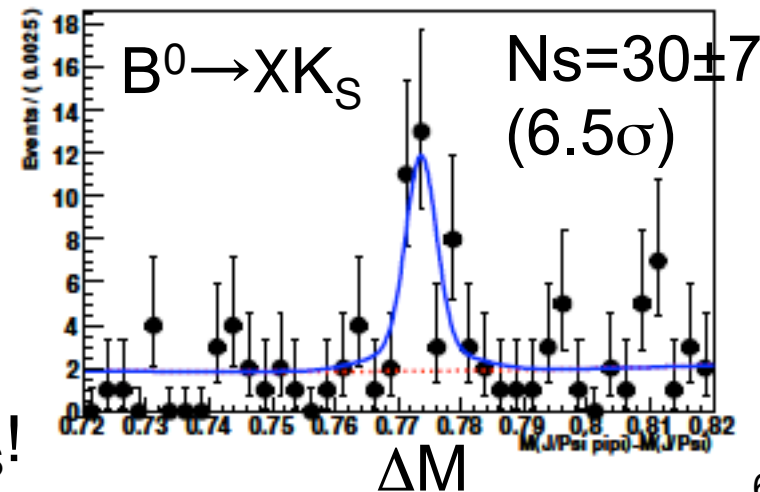# $B^{\pm} \rightarrow X(3872)K^{\pm}$ and $B^{0} \rightarrow X(3872)K_S$

Basic flow of the analysis;

• $B \rightarrow \psi'\ K$ and $B \rightarrow X(3872)\ K$ (ψ' or $X(3872) \rightarrow J/\psi\ \pi^+\pi^-$) are always reconstructed at same time. ($J/\psi \rightarrow e^+e^-$ or $\mu^+\mu^-$) (to utilize ψ' as a control sample as much as possible)

• Require $M_{\pi\pi} > (\ M_{J/\psi\pi\pi} - (M_{J/\psi} + 0.2 \text{GeV}/c^2)\ )$ to reduce combinatorial background.

• $R_2 < 0.4$ and $|\cos\theta_B| < 0.8$ for continuum(non-BB) suppression.

• See $\Delta M (= M_{J/\psi\pi\pi} - M_{ll})$ distribution for B candidate($|\Delta E| < 30 \text{MeV}$ and $M_{bc} > 5.27 \text{GeV}/c^2$).

$B^{\pm} \to X(3872)K^{\pm}$ and $B^0 \to X(3872)K_S$

$B^{\pm} \to \psi'K^{\pm}$

mean1 =	0.58817 ± 0.00006
mean2 =	0.7739 ± 0.0004
nBkg =	1482 ± 48
nSig1 =	2764 ± 59
nSig2 =	125 ± 15
p1 =	-0.302 ± 0.05
p2 =	0.05 ± 0.05
sigma1_1 =	0.00241 ± 0.0009
sigma1_2 =	0.0073 ± 0.0005

ΔM

$B^{\pm} \to XK^{\pm}$ Ns=125±14 (12σ)

ΔM

ΔM distributions for ψ' and X are fitted simultaneously; detector resolution effect is automatically calibrated by ψ'.

First observation of $B^0 \to X(3872)K_S$!

$B^0 \to XK_S$ Ns=30±7 (6.5σ)

ΔM

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$B^{\pm} \rightarrow X(3872)K^{\pm}$ and $B^0 \rightarrow X(3872)K_S$

- $\Delta M_X = M(X \text{ from } B^{\pm}) - M(X \text{ from } B^0)$
  $= (0.22 \pm 0.90 \pm 0.27) \text{MeV}/c^2$
  - No mass splitting signature.

- $R = \dfrac{Br(B^0 \rightarrow X(3872)K^0)}{Br(B^{\pm} \rightarrow X(3872)K^{\pm})} = 0.94 \pm 0.24 \pm 0.10$

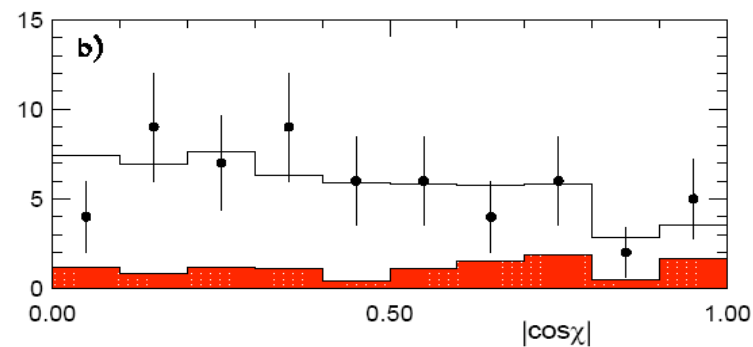 - Charged and neutral B mesons decay into X(3872) with comparable branching fraction.

Other known facts (rev.)

- Decay into $D^0\bar{D}^0\pi^0$ seen.

  PRL 97, 162002 (2006)

- Likely $J^{PC}=1^{++}$.

  – Decay into $J/\psi\,\gamma$ seen.(C=+1)

  – Angular distribution favors $J^P=1^+$.

  hep-ex/0505037, hep-ex/0505038.
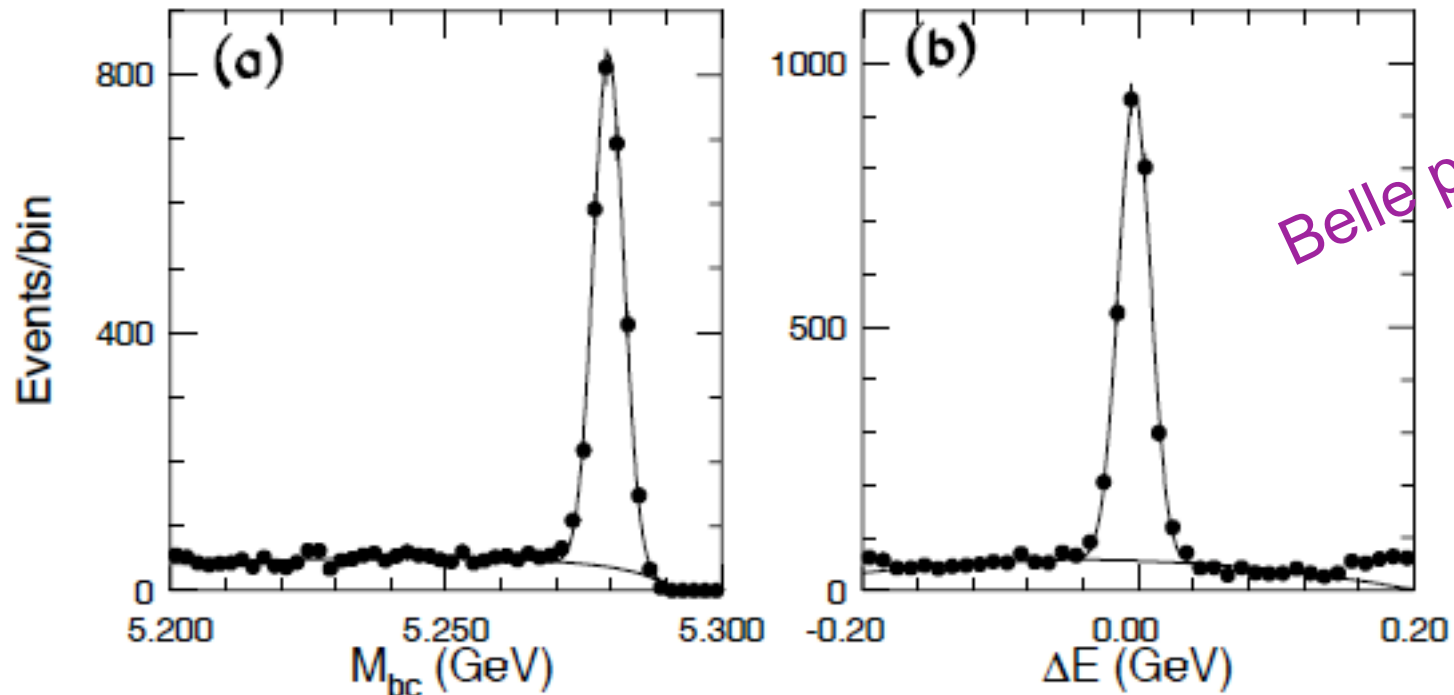

$|cos\theta_l|$

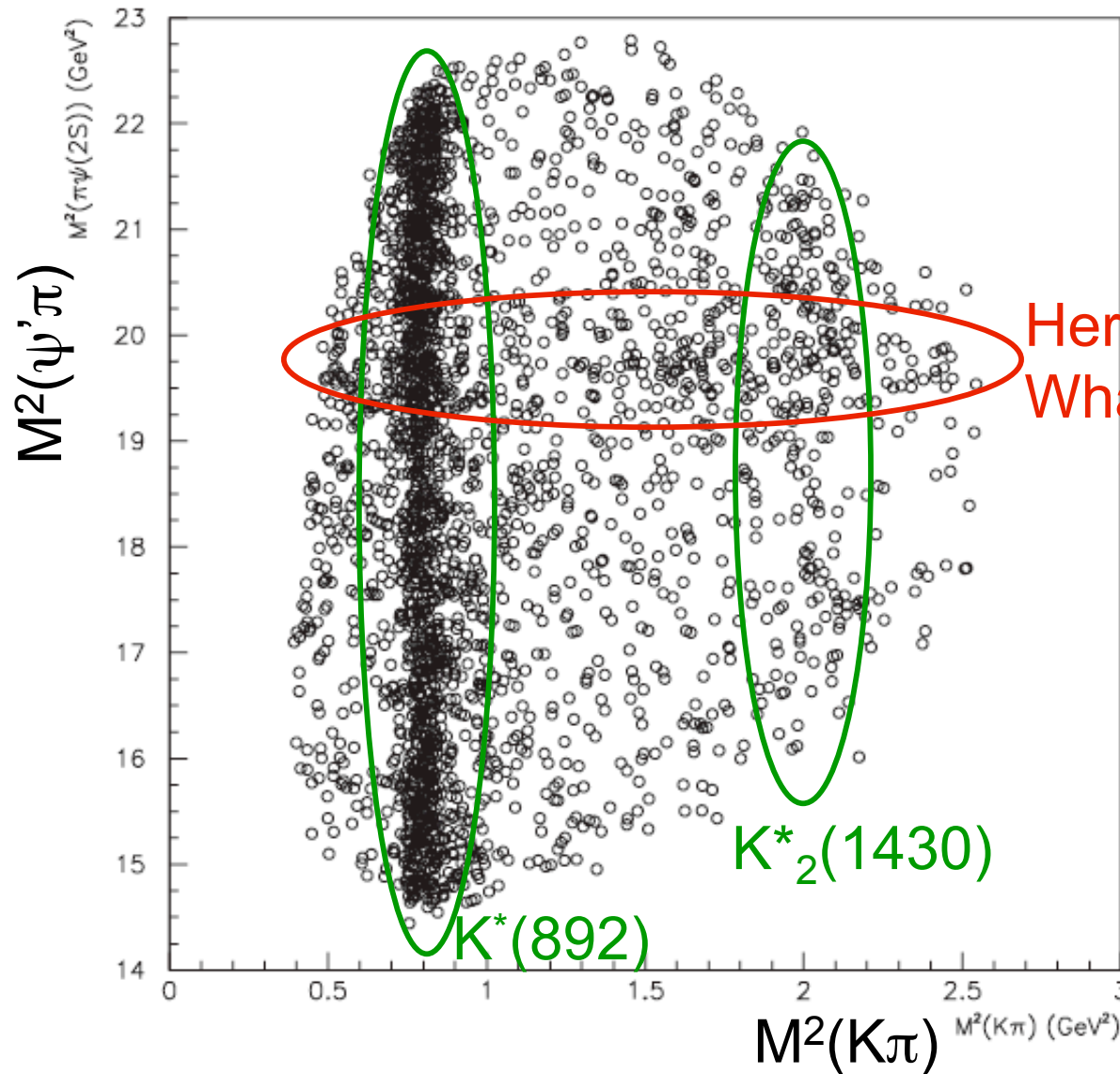$|cos\chi|$
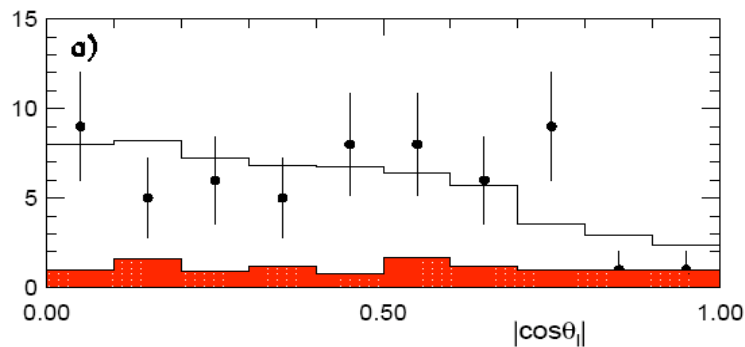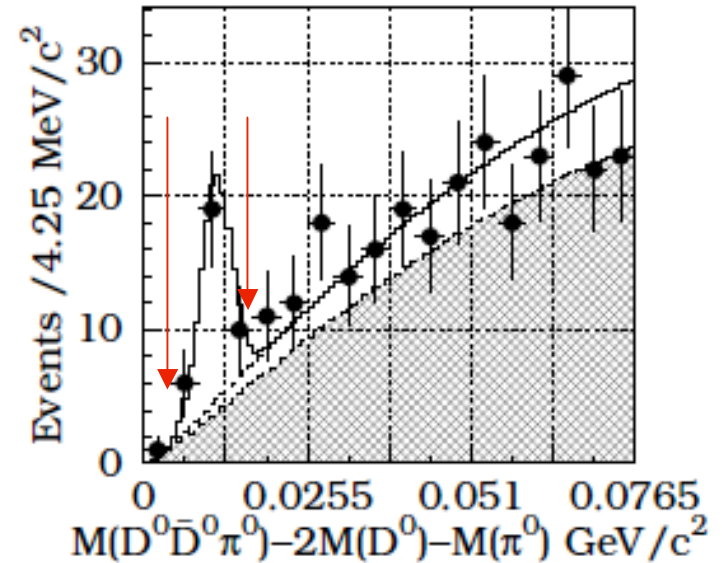
Observation of B→Z(4430)±K

$\psi'\pi^\pm K$(K is either $K^\mp$ or K_S) is combined to form B candidate.
ψ' is reconstructed by e^+e^-, $\mu^+\mu^-$ or $J/\psi\,\pi^+\pi^-$ modes.
B→ $\psi'\pi^\pm K$ candidates exhibit relatively clean signature.

Belle preliminary

Let's see Dalitz distribution to distinguish B→ $\psi'K^*$ decays from other contributions.

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Dalitz distribution

Here, clustering of events. What is this?
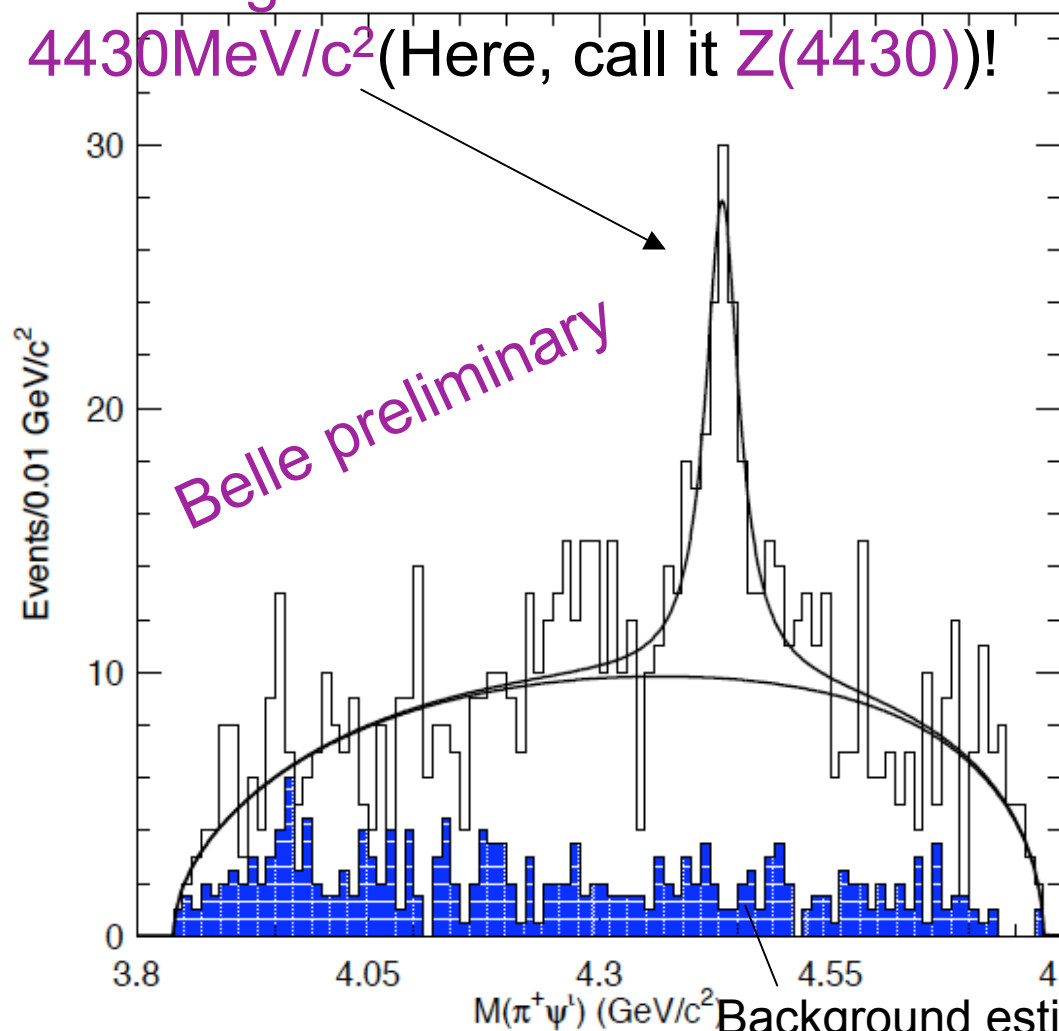
$K^*_2(1430)$

$K^*(892)$

Belle preliminary

After K* veto

Require $|M_{K\pi} - M_{K^*(892)}| > 0.1$ GeV and $|M_{K\pi} - M_{K^*_2(1430)}| > 0.1$ GeV.
Still clear B decay signature is there → What is this?

Belle preliminary
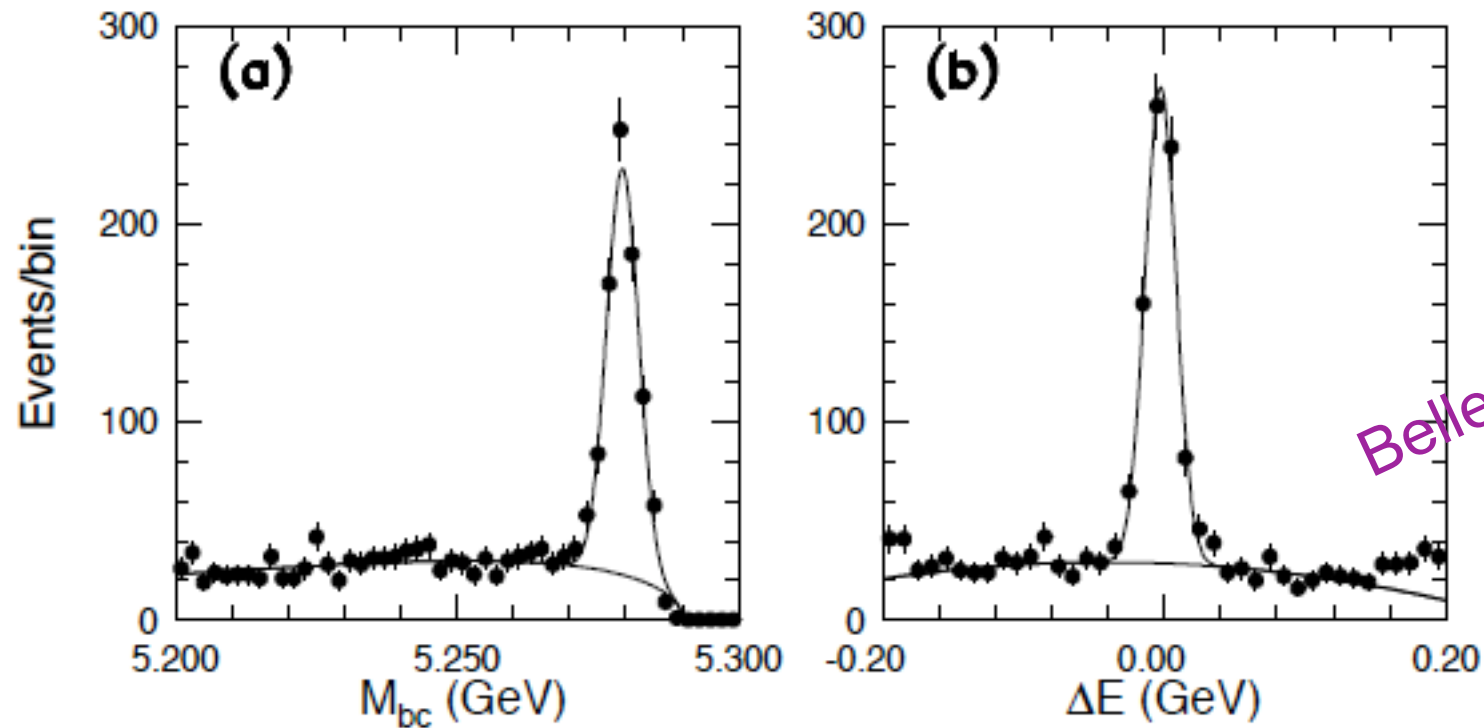
M$_{\psi'\pi}$ projection

Clear signature of a resonance at 4430MeV/c^2(Here, call it Z(4430))!

Belle preliminary

Events/0.01 GeV/c^2

M($\pi^+\psi'$) (GeV/c^2)

Fit : Breit-Wigner (peak) + empirical phase space function.

N_{peak}=124±30events(7.3σ)
M=4433±4±1 MeV/c^2
Γ=44 +17/-13 +30/-11 MeV.

This is the candidate for a CHARGED charmonium-like state!

If it is a meson state, must be exotic.

Support tetraquark or mesonic molecule picture. More data needed to determine J^{PC}.

Background estimated from the ΔE sideband.

hep-ex/0708.1790

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More information

The peak at 4430MeV/c^2 is apparent in all the sub-decay modes.

Subset	Signal events	Mass (GeV)	Width (GeV)	signif. (σ)	constr. yield ($\Gamma = 0.044$GeV)
$\psi' \rightarrow \pi^+\pi^- J/\psi$	52.9 ± 15.1	4.435 ± 0.004	$0.026^{+0.013}_{-0.008}$	5.5	67.3 ± 14.9
$\psi' \rightarrow \ell^+\ell^-$	104.8 ± 34.5	4.435 ± 0.010	$0.097^{+0.041}_{-0.031}$	5.6	60.1 ± 13.8
$J/\psi(\psi') \rightarrow e^+e^-$	45.4 ± 16.6	4.430 ± 0.010	$0.052^{+0.026}_{-0.020}$	4.1	40.9 ± 11.9
$J/\psi(\psi') \rightarrow \mu^+\mu^-$	79.4 ± 24.6	4.434 ± 0.004	$0.039^{+0.022}_{-0.013}$	6.1	84.8 ± 17.0
$K^\pm\pi^\mp\psi'$	106.5 ± 26.6	4.434 ± 0.005	$0.046^{+0.017}_{-0.013}$	6.6	104.7 ± 18.6
$K^0_S\pi^\mp\psi'$	21.0 ± 8.3	4.430 ± 0.009	0.046-fixed	3.0	20.6 ± 8.2
vary K^* veto	238.1 ± 64.2	4.436 ± 0.005	$0.068^{+0.031}_{-0.019}$	7.9	178.4 ± 26.4

More information(2)

The peak is quite unlikely to be formed by
feed across from other B decay modes into ψ' K π.

K* veto regions

Belle preliminary
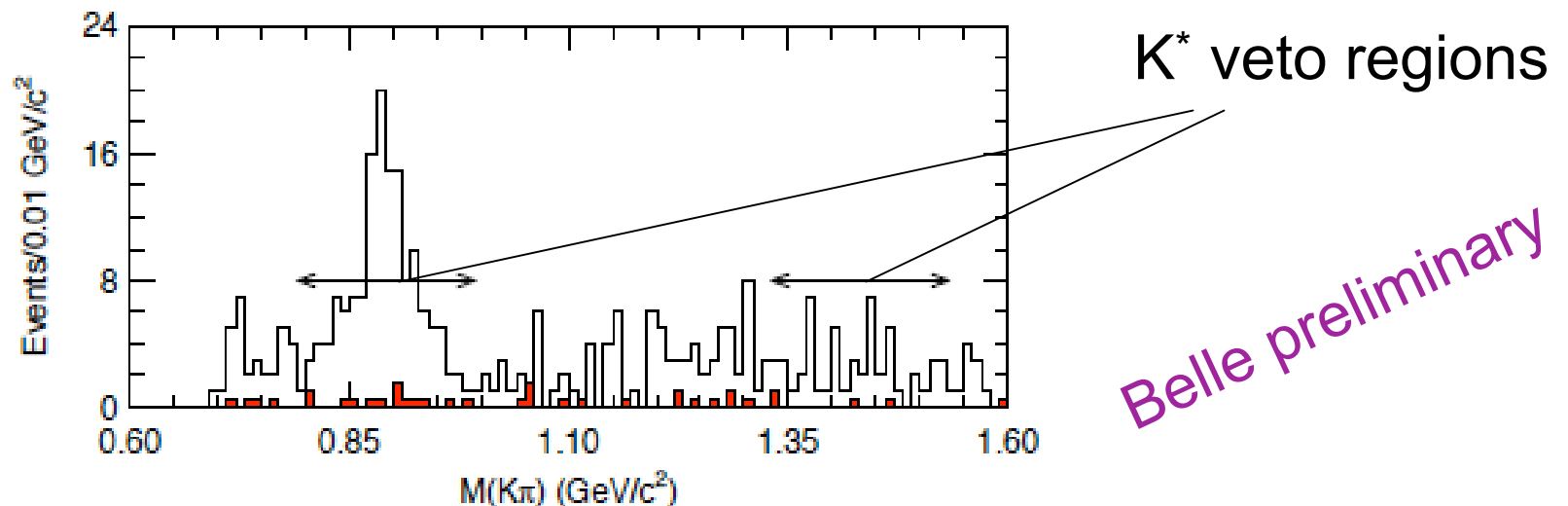
Selecting | $M_{\psi'\pi}$ - 4430MeV/c^2 |<30MeV/c^2,
look $M_{K\pi}$ without K* veto.
→No peak structure other than already vetoed K* states.

Summary

- B$^\pm$→X(3872)K$^\pm$ and B^0→X(3872)K$_S$

  – Branching fractions are comparable, No mass splitting signature, for charged and neutral B decays into X(3872).

  – Disfavored the models predicting significantly different properties between charged and neutral B into X(3872).

- Observed Z(4430)→ψ'$\pi^\pm$ in B→ψ' $\pi^\pm$ K decays

  – First charged object of "hidden charm" exotics.

  – Support existence of tetraqualrk or mesonic molecule.

  – To determine J^{PC}, more data needed.