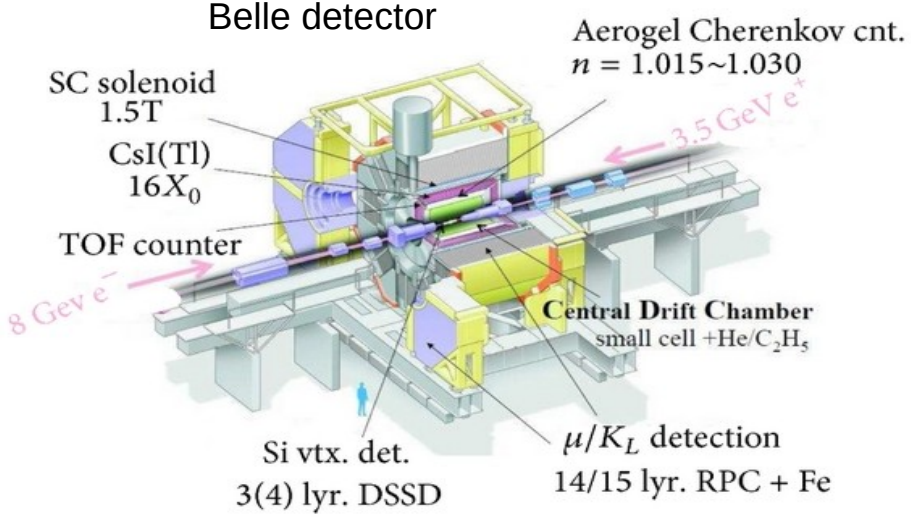
Search for B→Y(4260) K decays

Belle detector



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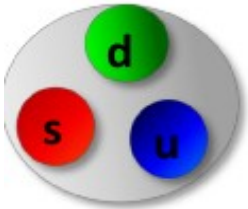
XXIII DAE-BRNS HIGH ENERGY PHYSICS SYMPOSIUM
10 December-14 December, 2018

Introduction

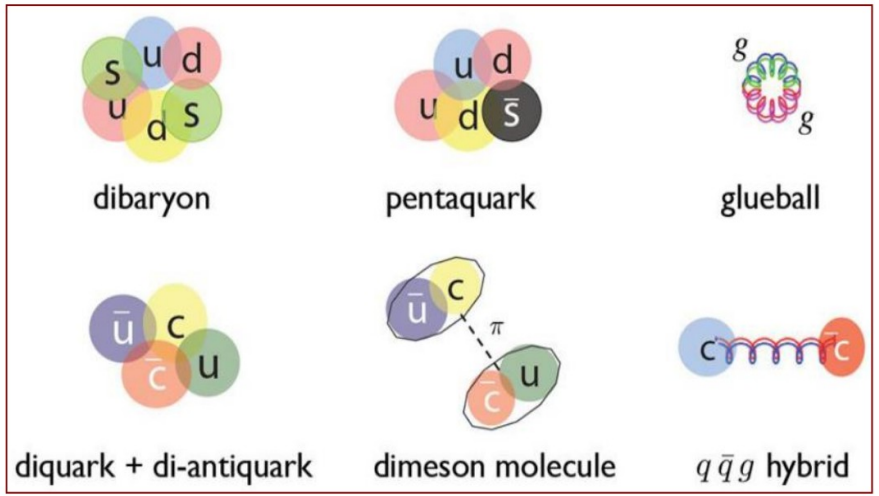
Quark model: M. Gell-Mann, Phys.Lett. 8, 214 (1964)

Classification scheme for hadrons in terms of valance quarks.
Hadrons are composed of mesons ($q\bar{q}$, $qqqq\bar{q}\bar{q}$, ...) and baryons (qqq, $qqqq\bar{q}$, ...).



Baryons (qqq)

Mesons ($q\bar{q}$)



- Glueball: N quarks = 0 (gg, ggg, ...)
- Hybrid: N quarks = 2 (or more) + excited gluon
- Multiquark state: N quarks > 3
- Molecule: bound state of more than 2 hadrons
- ...

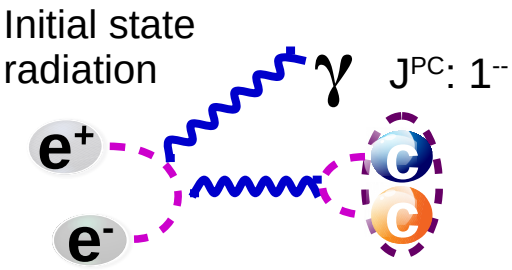
Not observed in conventional matter.
However, they should be allowed.

$X(3872)$, $Z_c(3900)$, $Z^+(4430)$,
$X(3915)$... were found in last decade.
Still their properties are not well understood.

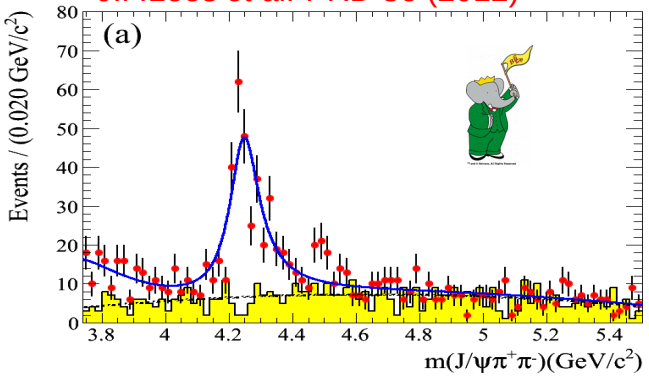
$Y(4260)$ is one of these state.

Motivation

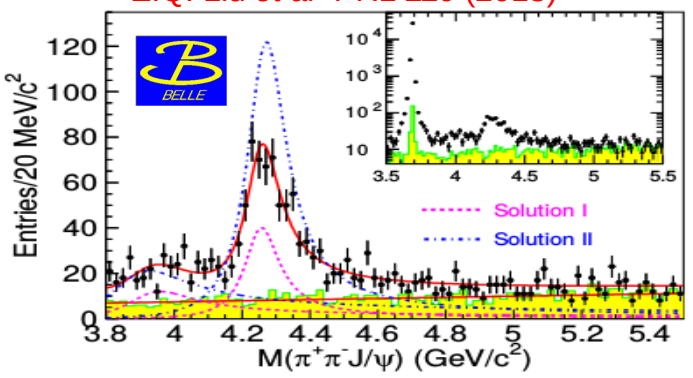
- *Y(4260)* was discovered in ISR by BaBar in 2005. B. Aubert et al. PRL 95 (2005)
- Mass: (4230 ± 8) MeV/c² , Width: (55 ± 19) MeV M. Tanabashiet al. (PDG), PRD 98 (2018)
- Confirmed by Belle and CLEO through ISR.



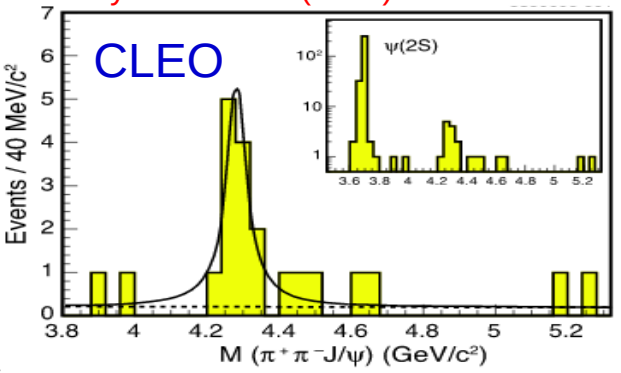
J.P.Lees *et al.* PRD **86** (2012)



Z.Q. Liu *et al* PRL **110** (2013)

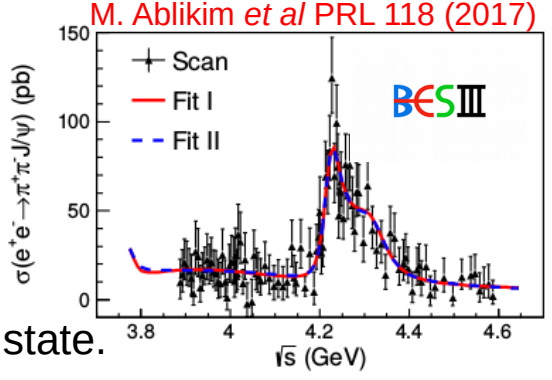


Phys.Rev. D 74 (2006) 091104



	BaBar	CLEO	Belle	BESIII
Mass (MeV/c²)	4244±5	4284^{+17}_{-16}	4295±10	4222.0±3.1
Width (MeV)	114^{+16}_{-15}	73^{+39}_{-25}	133±26	44.1±4.3

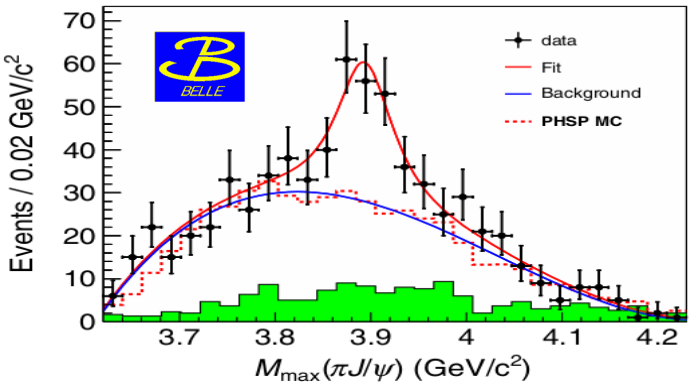
M. Ablikim *et al* PRL 118 (2017)



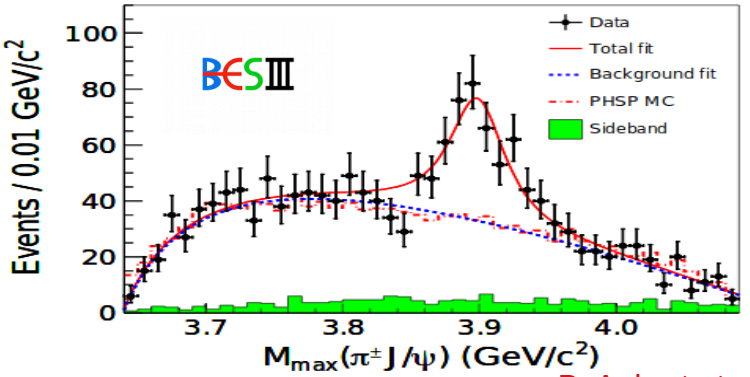
- BESIII suggest that there are two peaks at *Y(4260)* [*Y(4260) and Y(4360)*].
- Theory predicts *Y(4260)* to be charmonium-hybrid, tetraquark and admixture state. S. L. Zhu PLB 625 (2005)

- While studying decay of *Y(4260)*, a charged state $Z_c^+(3900)$ was found (observed by BESIII and Belle collaboration in mass spectrum of $Y(4260)\rightarrow J/\psi\pi^+\pi^-$ decay channel).
- 20 -30% of Br($Y\rightarrow J/\psi\pi\pi$) decay via Br $(Y \rightarrow Z_c^+\pi^-)$, where $Z_c^+ \rightarrow J/\psi\pi^+$.

Z.Q. Liu et al. PRL 110 (2013)

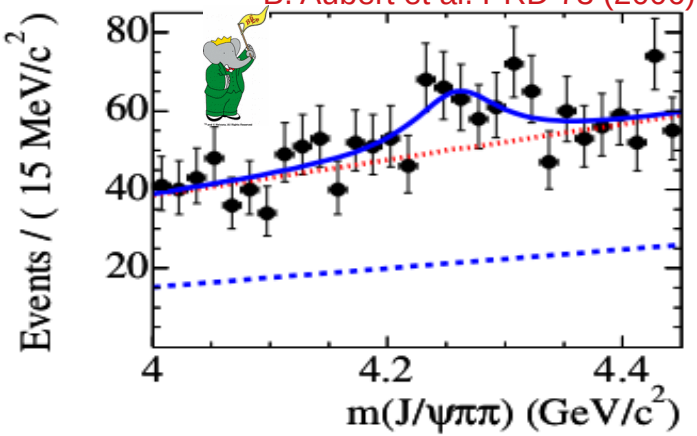


M. Ablikim et al. PRL 110 (2013)



- $Z_c^+(3900)$ is a strong contender for tetraquark.
- This support the exotic nature of $Y(4260)$.
- It will be interesting to see $B\rightarrow Y(4260)\,K$ decay mode.
- Theoretical prediction: R.M. Albuquerque et al PLB 747 83 (2015)
  - $3.0 \times 10^{-8} < Br(B^-\rightarrow K^- Y(4260), Y(4260)\rightarrow J/\psi\pi\pi) < 1.8 \times 10^{-6}$
  - Suggest Y(4260) is not pure charmonium state. It is admixture state.
- Initial search was carried out by BaBar using 232x 10^6 $B\bar{B}$ pairs.
  - $Br(B^-\rightarrow K^- Y(4260), Y(4260)\rightarrow J/\psi\pi\pi) < 2.9 \times 10^{-5}$ (3.1σ)

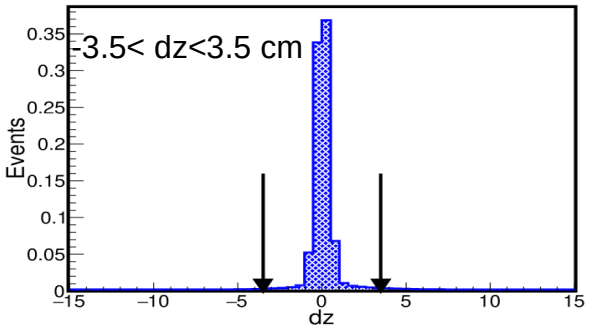
B. Aubert et al. PRD 73 (2006)

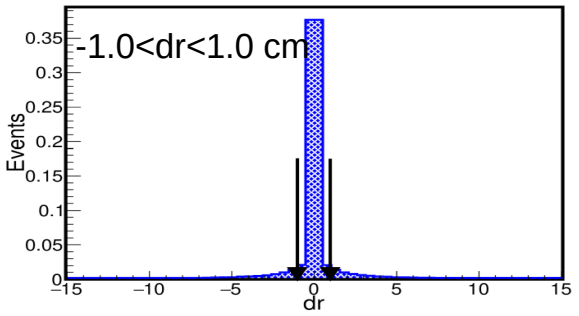


- Opportunity for Belle to search for this decay mode exploiting 3 times more data.

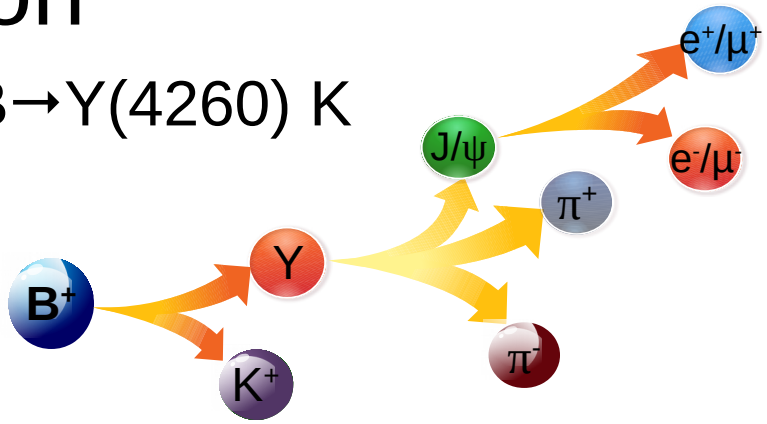
Reconstruction

dr: distance in tranverse plane
dz: distance in beam direction



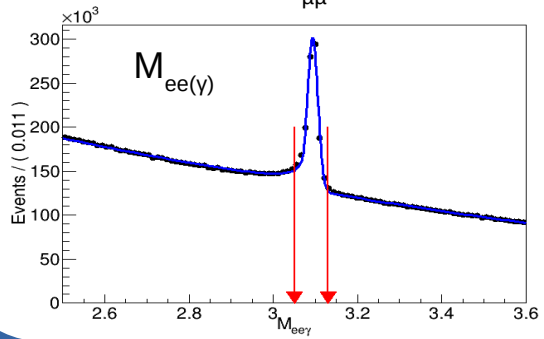


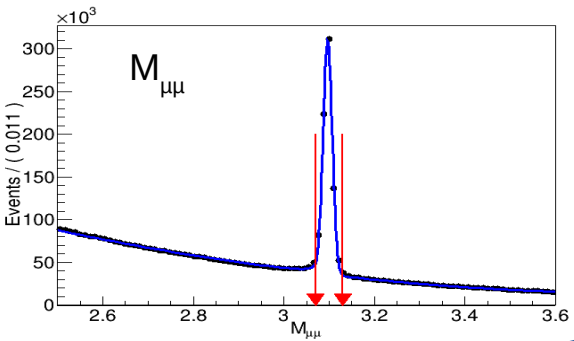
B→Y(4260) K



J/ψ reconstruction:

- J/ψ reconstructed from e^+e^- and $\mu^+\mu^-$
- $L_e > 0.01$, $L_\mu > 0.1$
- γ's within 0.05 radian of e^+ or e^-
- $3.05\ GeV/c^2 < M_{ee(\gamma)} < 3.13\ GeV/c^2$
- $3.07\ GeV/c^2 < M_{\mu\mu} < 3.13\ GeV/c^2$

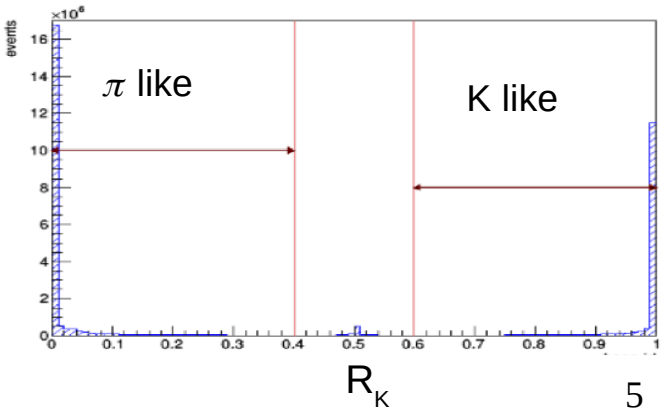




K/π selection:

$$R_{\pi(K)} = \frac{L_{\pi(K)}}{L_\pi + L_K}$$

$R_\pi > 0.6$
$R_K > 0.6$



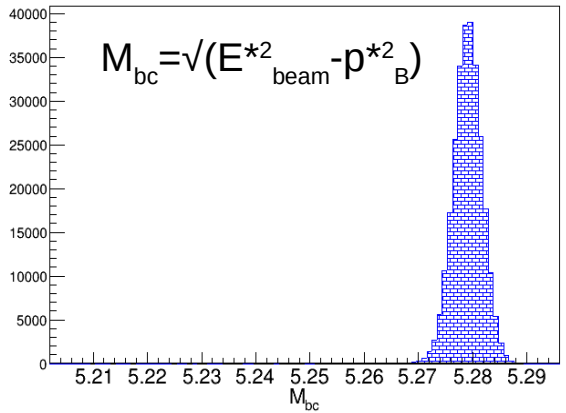
Analysis technique

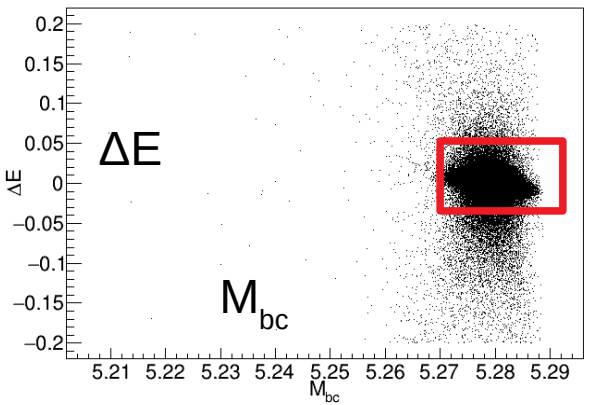
Common variables used:

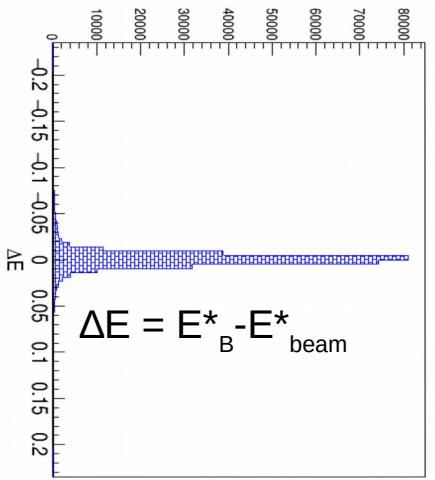
- $\Delta E = E^*_B - E^*_{beam}$
- $M_{bc} = \sqrt{(E^{*2}_{beam} - p^{*2}_B)}$
- $M_{J/\psi\pi\pi}$

$B \rightarrow Y(4260)\ K$
↳ $J/\psi\pi\pi$
↳ $e^+e^-/\mu^+\mu^-$

ΔE and M_{bc} are used to seperate the signal from the background.







Signal window cut in ΔE & M_{bc}:

- $|\Delta E| < 20$ MeV
- $M_{bc} > 5.27$ GeV

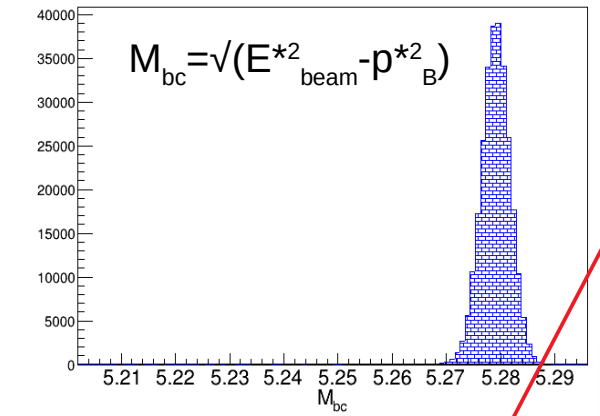
Analysis technique

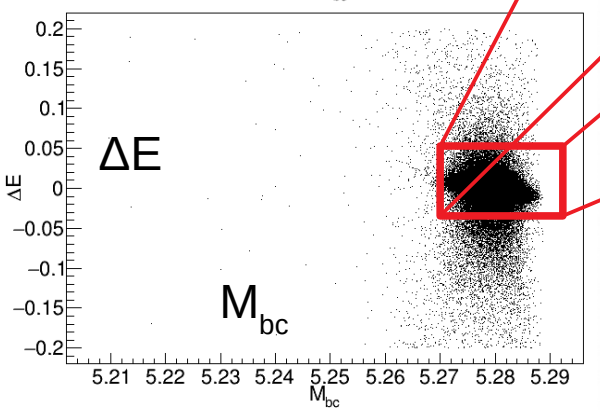
Common variables used:

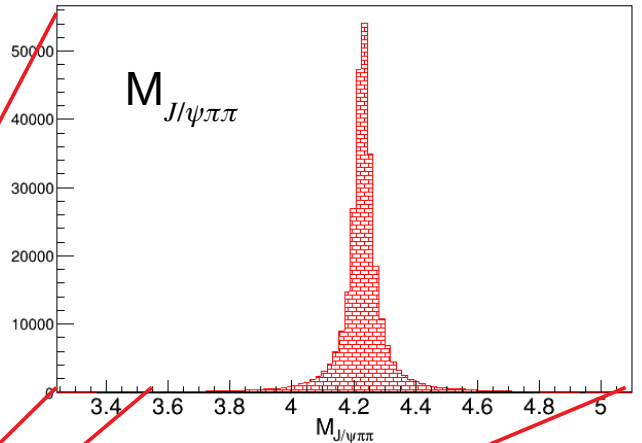
- $\Delta E = E^*_B - E^*_{beam}$
- $M_{bc} = \sqrt{(E^{*2}_{beam} - p^{*2}_B)}$
- $M_{J/\psi\pi\pi}$

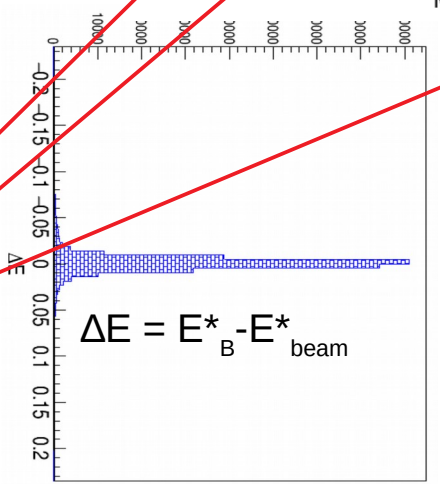
Peak will be at the mass of the resonance.

ΔE and M_{bc} are used to seperate the signal from the background.







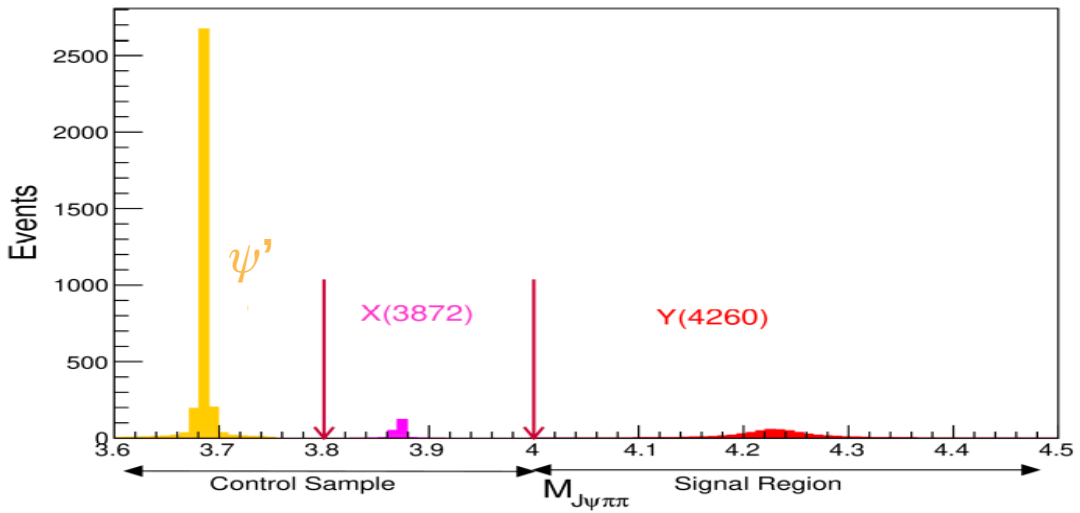


Signal window cut in ΔE & M_{bc}:

- $|\Delta E| < 20$ MeV
- $M_{bc} > 5.27$ GeV

Control sample

- Use of control sample:
  - Cross check reconstruction code and fitter.
  - To get the correction factor between data/MC.
- *B→ψ' K* and *B→X(3872) K*
  - High statistics
  - Similar event topology



$B \rightarrow \psi'\, K$

↳ $J/\psi\pi\pi$

↳ $e^+e^-/\mu^+\mu^-$

B→X(3872) K

↳ $J/\psi\pi\pi$

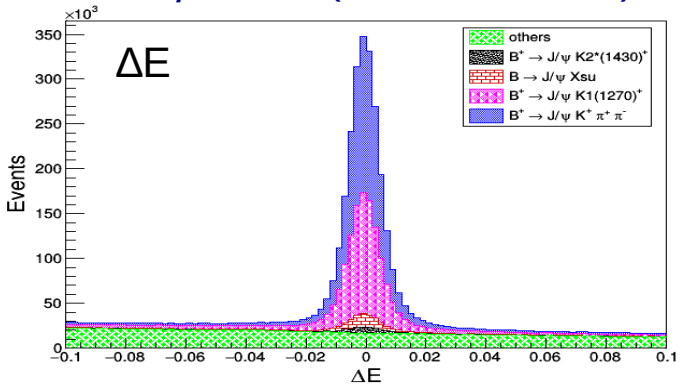
↳ $e^+e^-/\mu^+\mu^-$

Same selection criteria is used as used for B→Y(4260) K

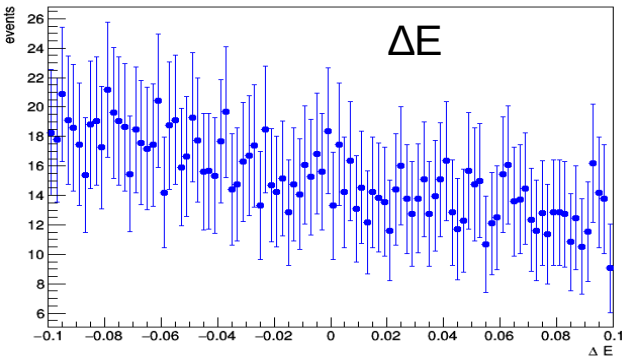
Background study

- -20 MeV < ΔE < 20 MeV
- M_{bc}>5.27 GeV

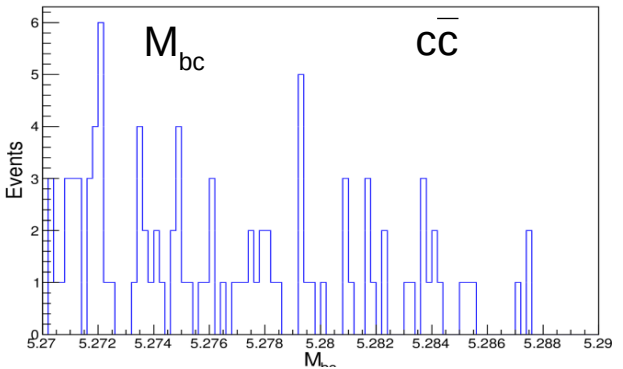
B→J/ψ X MC (100 times data)

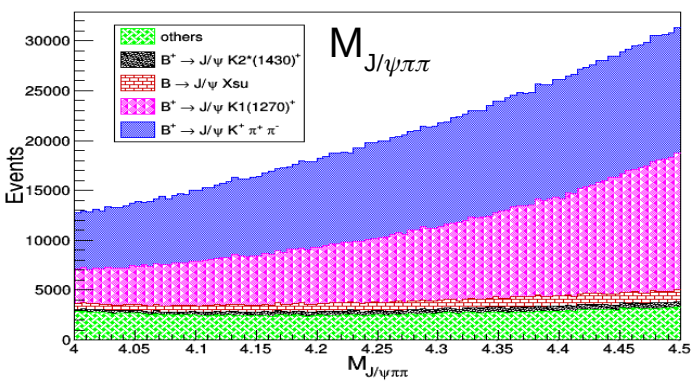


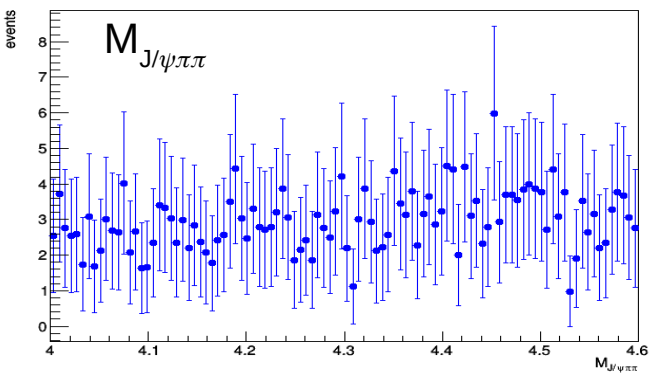
J/ψ side band Data

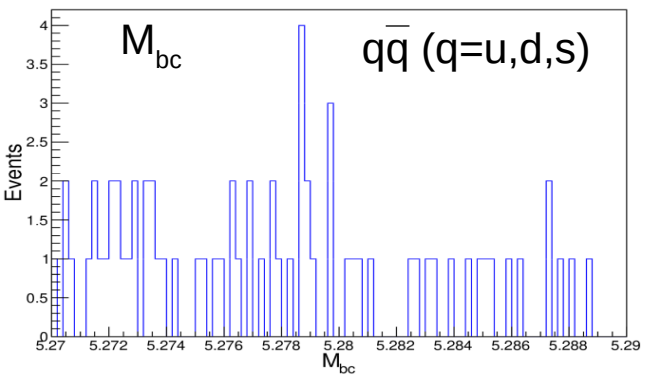


On resonance MC







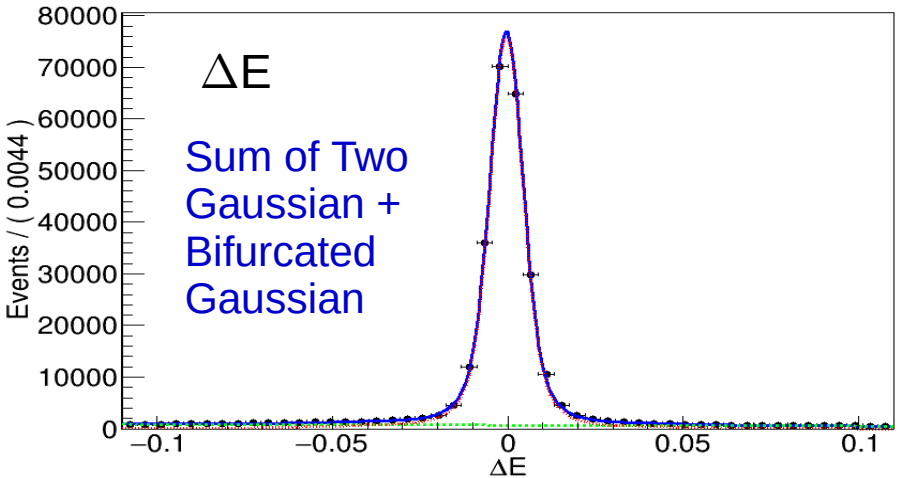


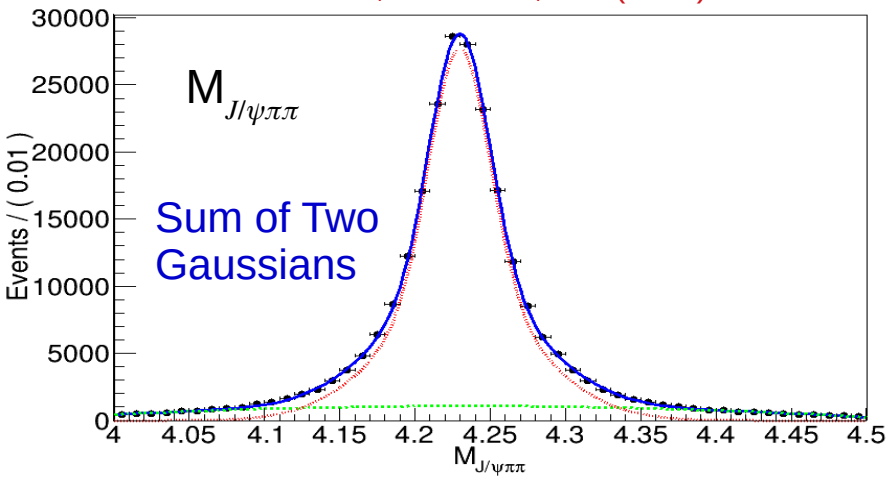
No peaking background is observed in $M_{J/\psi\pi\pi}$ signal region.

Signal Extraction

- PDF is determined on MC sample.
- Fit ΔE and get background subtract $M_{J/\psi\pi\pi}$ distribution.
- Signal is extracted from fit to the ${}_s\mathcal{P}$lot distribution of $M_{J/\psi\pi\pi}$.

M. Pivk and F. R. Le Diberder, NIMA 555, 356 (2005).



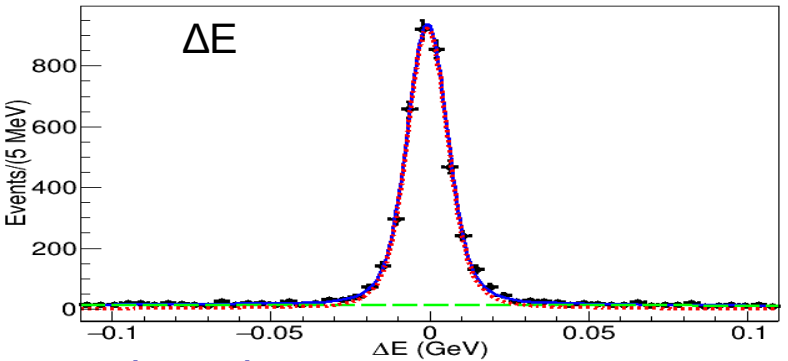


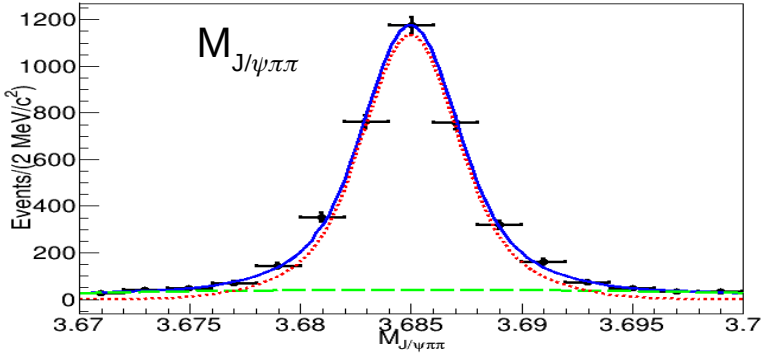
Decay mode	Efficiency(%)
$B\to\psi'(\to J/\psi\pi\pi)K$	18.0
$B\to X(3872)(\to J/\psi\pi\pi)K$	23.7
$B\to Y(4260)(\to J/\psi\pi\pi)K$	20.0

Branching fraction for control sample

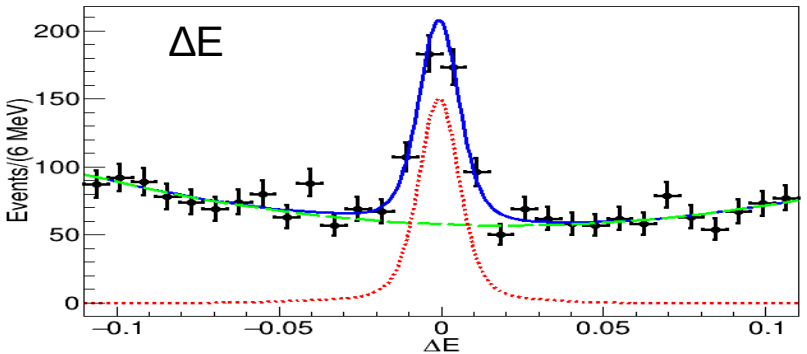
B→ψ'K

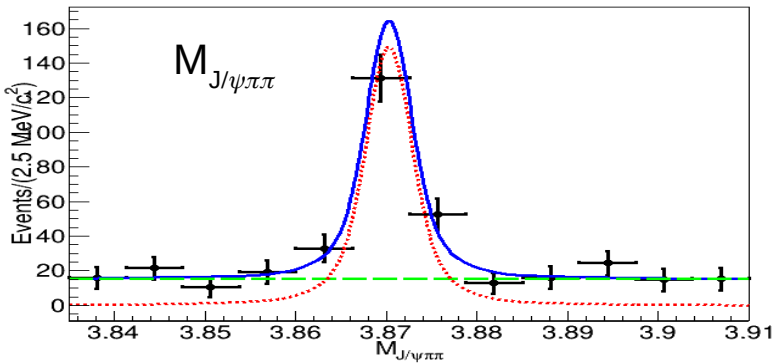
Fit to data





B→X(3872)K





S. -K. Choi et al. PRD 84 (2011).

Decay Mode	Previous	Measured
B→ψ' K (×10^{-4})	6.5±0.1	6.5±0.2
B→X(3872)K (×10^{-6})	8.6±0.8	9.1±0.6

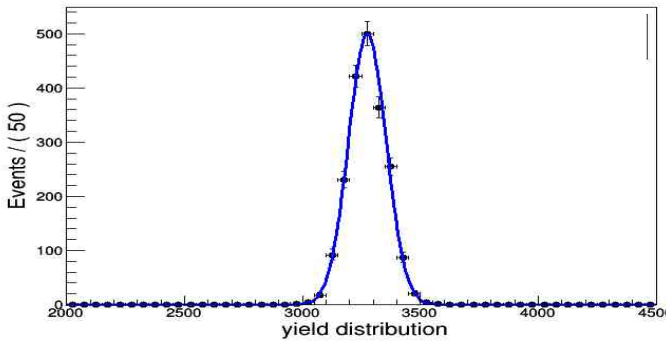
Result found to be consistent with previous results within 1σ.

Fit validation

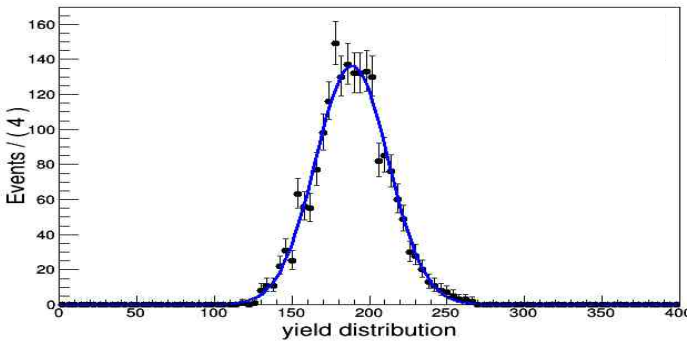
- 2000 samples of expected signal and background events are generated.
- Fit is performed on each generated sample.

Yield distribution

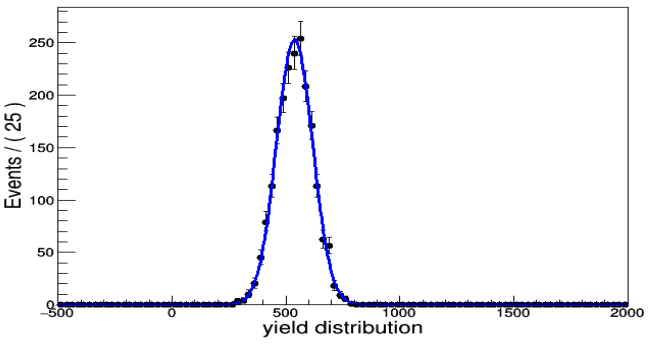
B→ψ'K



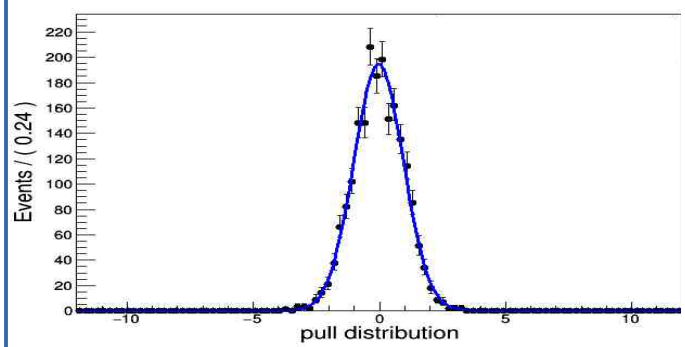
B→X(3872)K

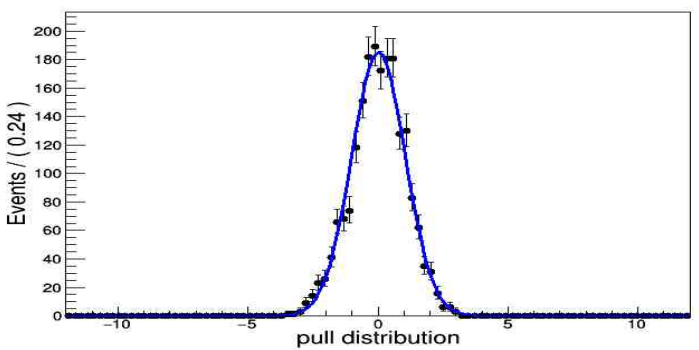


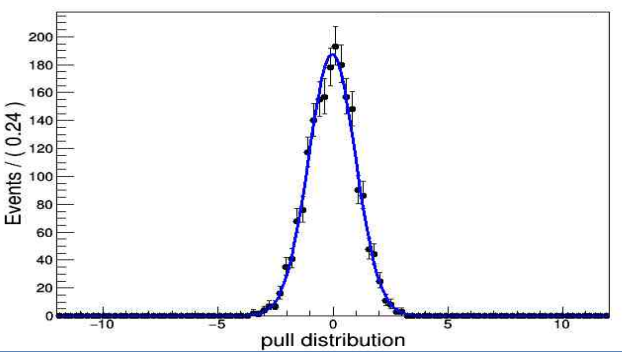
B→Y(4260)K



Pull distribution







No significant bias is observed. Fitter is working perfectly.

Summary

- Search for B→Y(4260)K is crucial to understand the structure for Y(4260).
- No peaking background is expected in $M_{J/\psi\pi\pi}$ signal region.
- Branching fraction measurement for control samples are consistent with world average values.
- Fits are validated and no significant bias is observed.

Future Plan:

- Results are in internal review and will be out soon...