Recent results from Belle and status of Belle II

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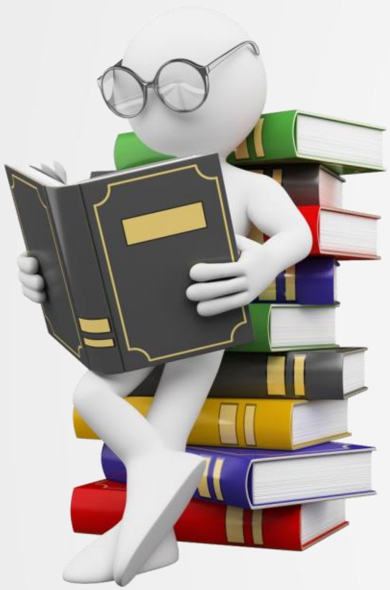
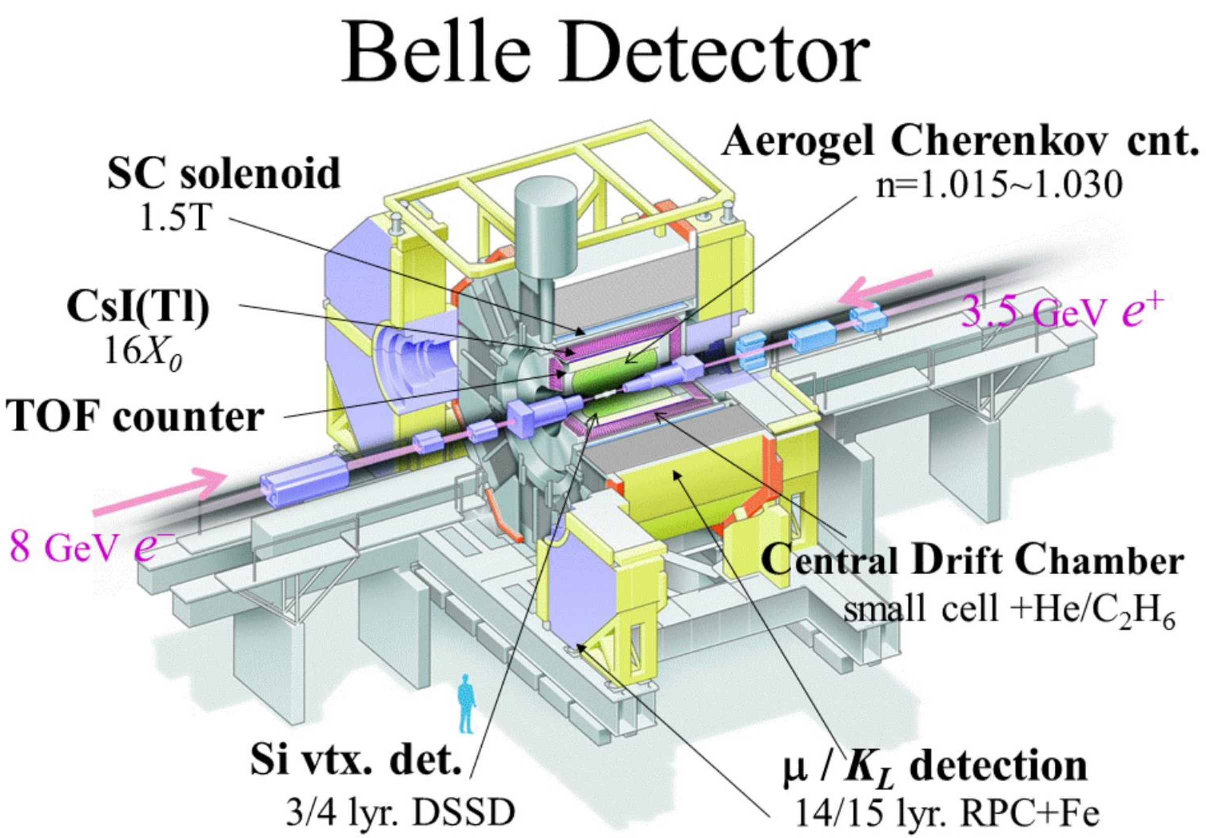
Outline



- **Observation of $\Xi_c(2930)^0$ and $\Xi_c(2930)^{\pm}$**
- **Measurement of Ξ_c absolute BRs**
- **Measurement of BRs for $B^- \to \bar{\Lambda}_c^- \Xi_c^{*0}$**
- **A charmoniumlike state in** $e^+e^- \to$ DsDs1(2536)
- Status of Belle II

Although Belle stopped data taking more than ten years ago and BelleII has already started data taking, Belle is still producing many excited results.

Belle experiment and data samples



Data taking: 1999—2010

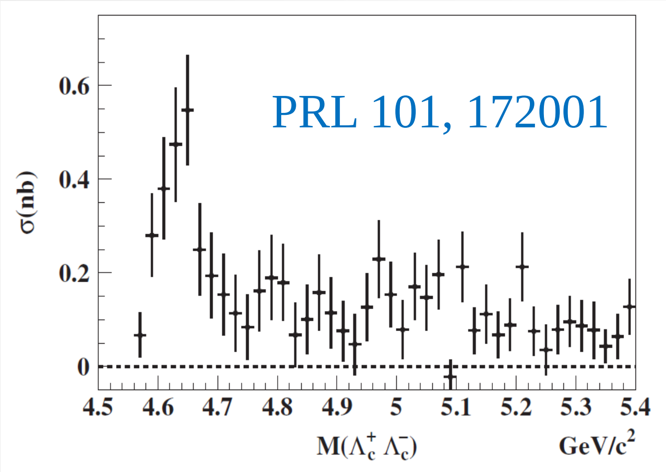
On/off/Scan Υ(nS) peaks

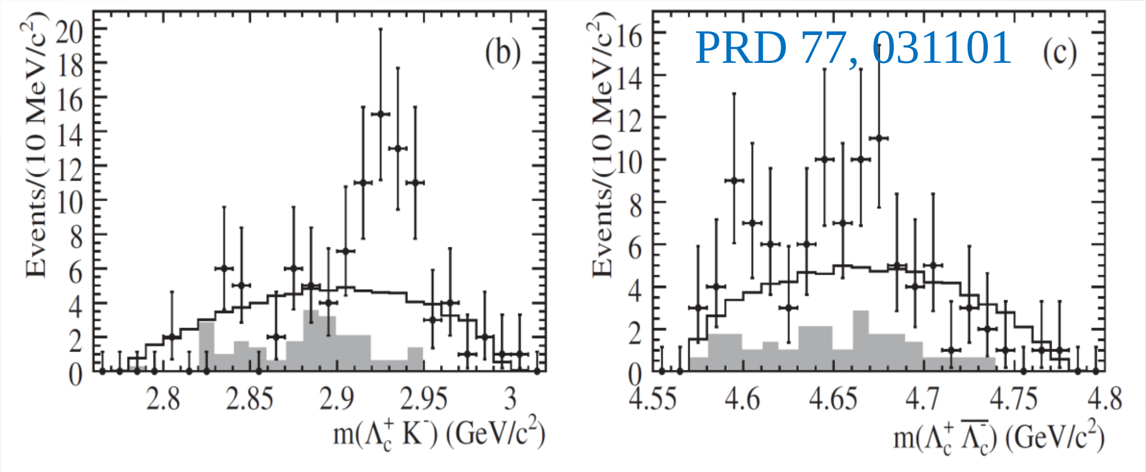
Total luminosity: 980 fb^{-1}

772M $B\bar{B}$ events @ Υ(4S)

$\Xi_c(2930)^0$ in $B^+ \to K^+\Lambda_c^+\bar{\Lambda}_c^-$

- Belle reported a structure, called Y(4630), in the $\Lambda_c^+\bar{\Lambda}_c^-$ invariant mass distribution in $e^+e^- \to \gamma_{ISR}\Lambda_c^+\bar{\Lambda}_c^-$ PRL 101, 172001
- BarBar once studied $B^+ \to K^+\Lambda_c^+\bar{\Lambda}_c^-$ and found two small peaks in $M_{\Lambda_c^+\bar{\Lambda}_c^-}$ spectrum and a vague structure named $\Xi_c(2930)$ is seen in the distribution of $M_{K\,\Lambda_c}$. Larger data is needed to verify them. PRD 77, 031101
- Also, some theory explained that Y(4660) has a large partial decay width to $\Lambda_c^+\bar{\Lambda}_c^-$ and it's spin partner Y(4616) is predicted. PRD 82, 094008; PRL102, 242004





About Y(4630/4660), please see below for our latest results in e^+e^- →DsDs1(2536)

$\Xi_c(2930)^0$ in $B^+ \to K^+\Lambda_c^+\overline{\Lambda}_c^-$

$\Xi_c(2930)$ *

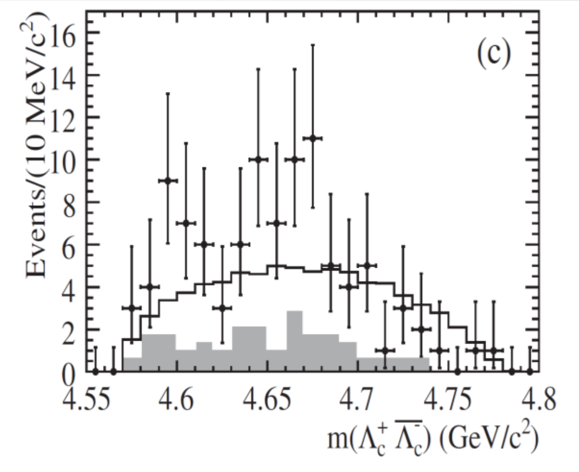
CHARMED BARYONS
($C = +1$)

$\Lambda_c^+ = udc$, $\Sigma_c^{++} = uuc$, $\Sigma_c^+ = udc$, $\Sigma_c^0 = ddc$, $\Xi_c^+ = usc$, $\Xi_c^0 = dsc$, $\Omega_c^0 = ssc$

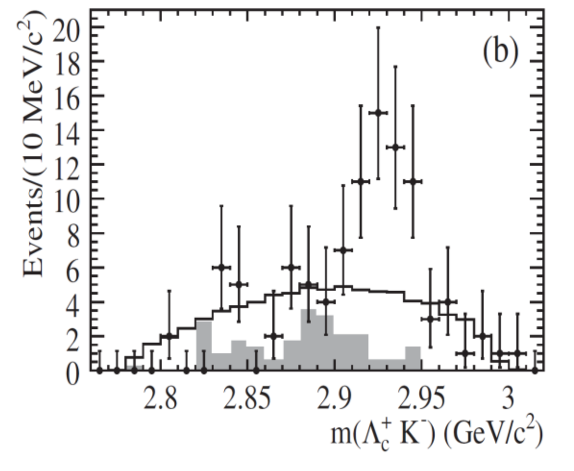
$\Xi_c(2930)$ $I(J^P) = ?(?^?)$

A peak seen in the $\Lambda_c^+ K^-$ mass projection of $B^- \to \Lambda_c^+ \overline{\Lambda}_c^- K^-$ events.

$\Xi_c(2930)$ MASS	2931 ± 6 MeV
$\Xi_c(2930)$ WIDTH	36 ± 13 MeV

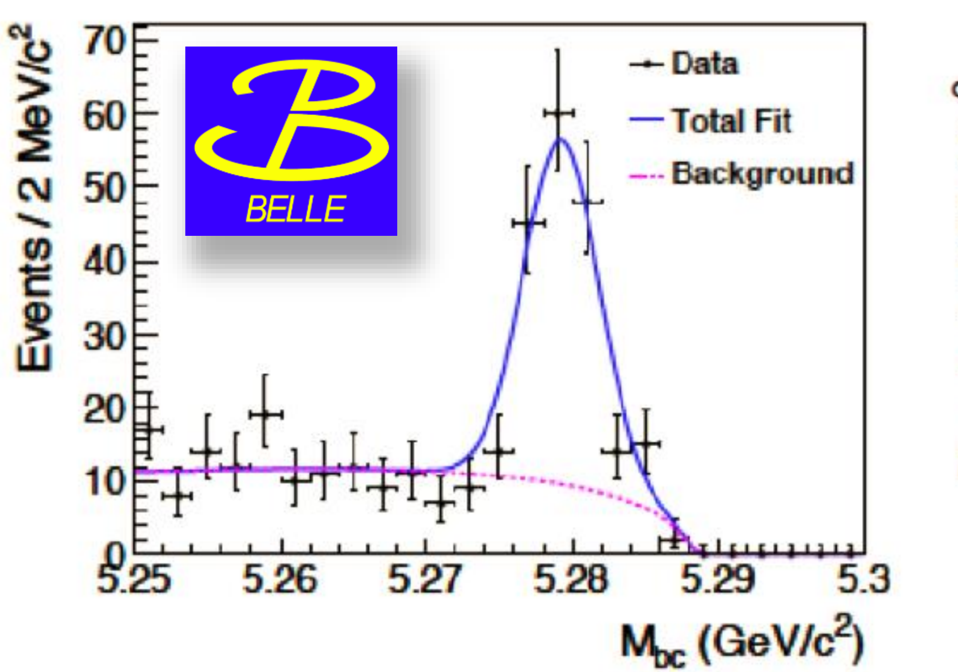


tion for experimental resolution, we obtain $m = 2931 \pm 3(\mathrm{stat}) \pm 5(\mathrm{syst})\ \mathrm{MeV}/c^2$ and $\Gamma = 36 \pm 7(\mathrm{stat}) \pm 11(\mathrm{syst})$ MeV. We do not see any such structure in the m_{ES} sideband region. This description is in good agreement with the data (χ^2 probability of 22%) and could be interpreted as a single Ξ_c^0 resonance with those parameters, though a more complicated explanation (e.g. two narrow resonances in close proximity) cannot be excluded.

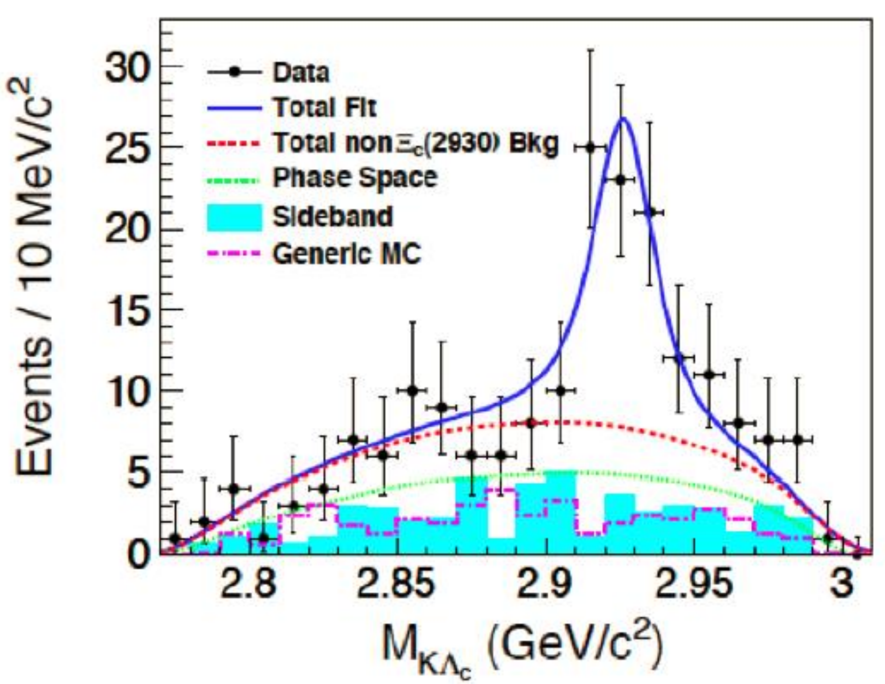


Observation of $\Xi_c(2930)^0$ in $B^+ \to K^+ \Lambda_c^+ \overline{\Lambda}_c^-$ at Belle

Y.B.Li, C.P.Shen et al (Belle)
Eur. Phys. J. C78, 252 (2018)



153±14 B decay signal events.
$Br(B^+ \to \Lambda_c^+ \Lambda_c^- K^+) = (4.80 \pm 0.43 \pm 0.68) \times 10^{-4}$



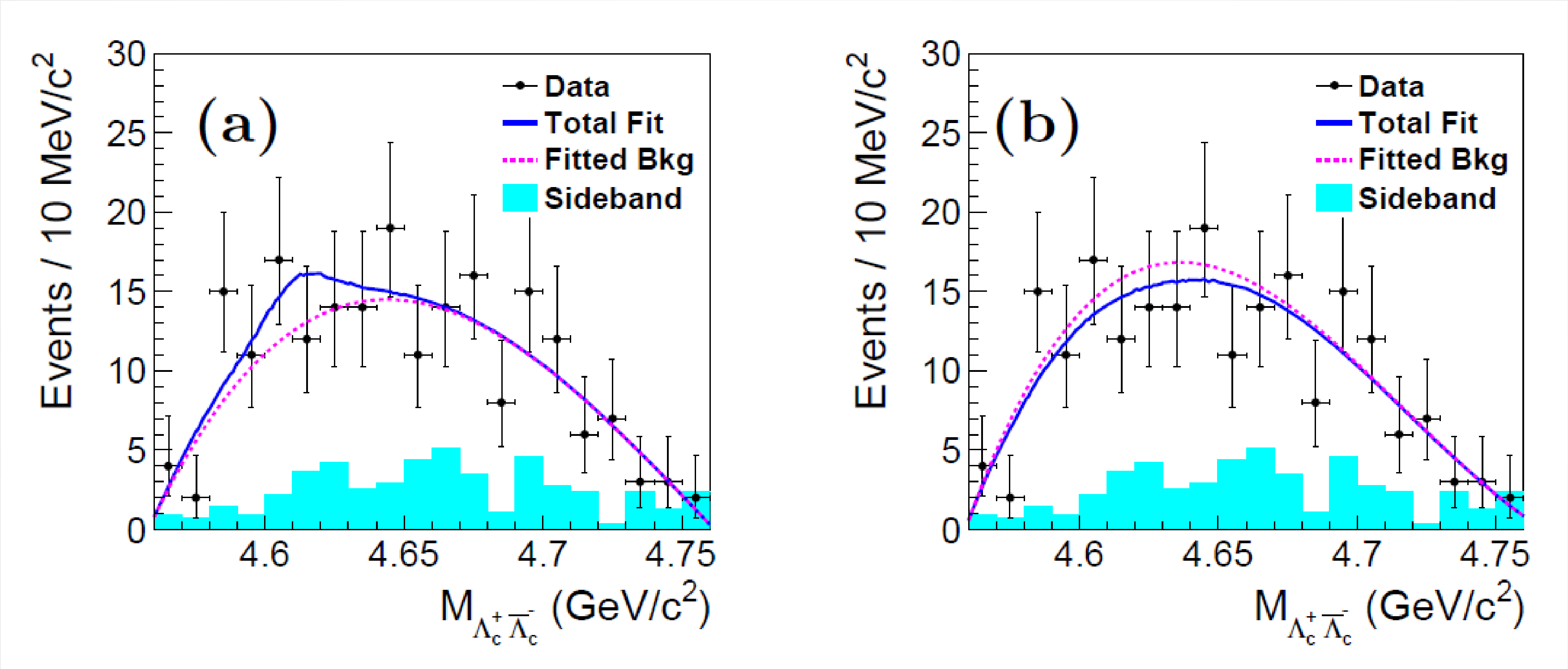
$\Xi_c(2930)^0 \to \Lambda_c^+ K^-$ 61±16 events
5.1σ significance

Clear confirmation for the BaBar claim, PRD77,031101(2008) and much more precise M=2928.9±3.0 +0.8/-12.0 MeV, Γ=19.5±8.4 +5.4/-7.9 MeV

- $\Xi_c(2930)^0 = csd$ is the first charmed-strange baryon established in B decay.

Search for Y(4660) and its spin part in $B^+ \to K^+ \Lambda_c^+ \bar{\Lambda}_c^-$ at Belle

Y.B.Li, C.P.Shen et al (Belle)
Eur. Phys. J. C78, 252 (2018)



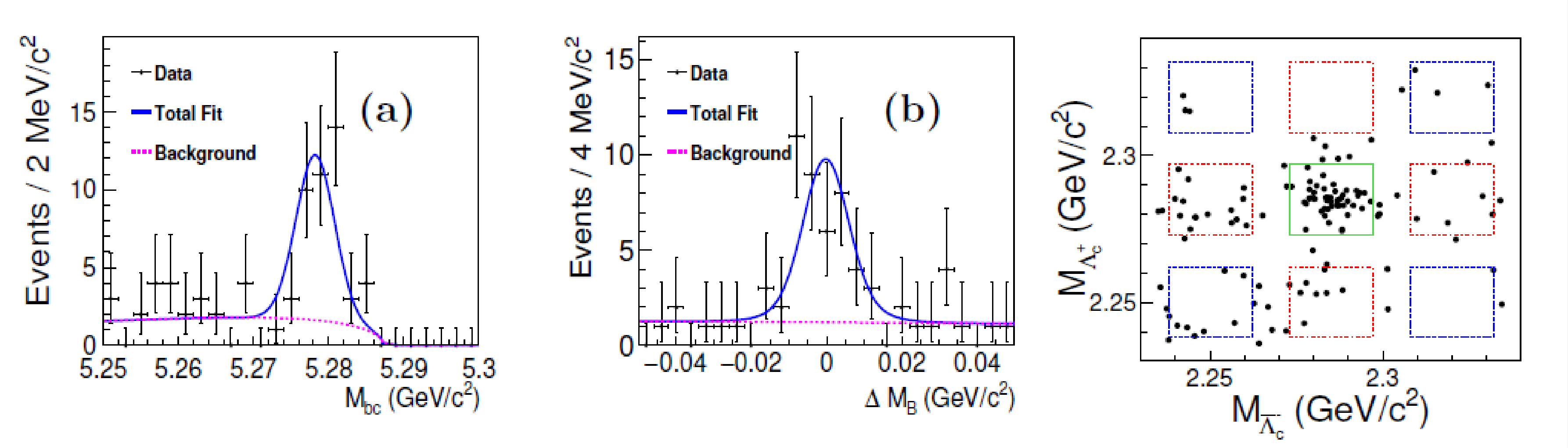
- No Y(4660) and its spin partner Y_η were observed in the $\Lambda_c^+ \bar{\Lambda}_c^-$ invariant mass distribution
- 90% C.L. upper limits of $B^+ \to K^+ Y(4660) \to K^+ \Lambda_c^+ \bar{\Lambda}_c^-$ and $B^+ \to K^+ Y_\eta \to K^+ \Lambda_c^+ \bar{\Lambda}_c^-$ are 1.2×10^{-4} and 2.0×10^{-4}.

Evidence of charged $\Xi_c(2930)$ in $B^0 \to K^0 \Lambda_c^+ \bar{\Lambda}_c^-$

BELLE

- Based on full $\Upsilon(4S)$ data set (772 M $B\bar{B}$ pairs) at Belle
- Three Λ_c decay channels:
  $\Lambda_c^+ \to pK^-\pi^+$, $\Lambda_c^+ \to pK_s(\pi^+\pi^-)$ and $\Lambda_c^+ \to \Lambda(p\pi^-)\pi^+$.
- B candidates extracted via 2D fit to M_{bc} and ΔM_B

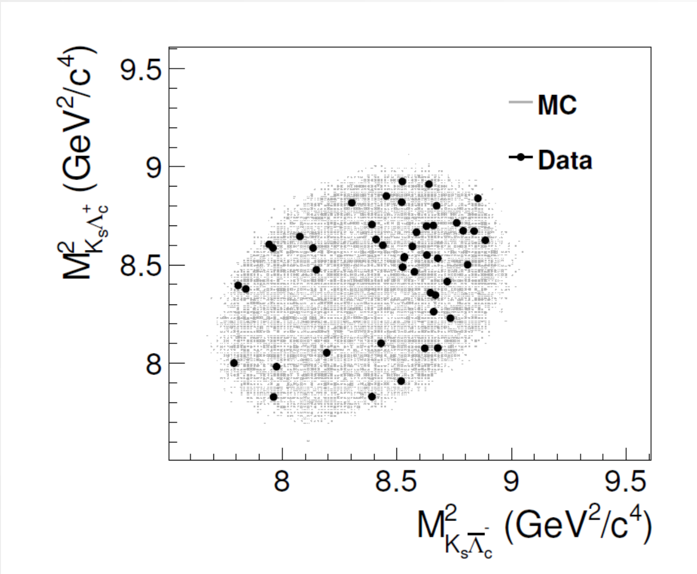
Y.B.Li, C.P.Shen et al (Belle) EPJC 78, 928 (2018)

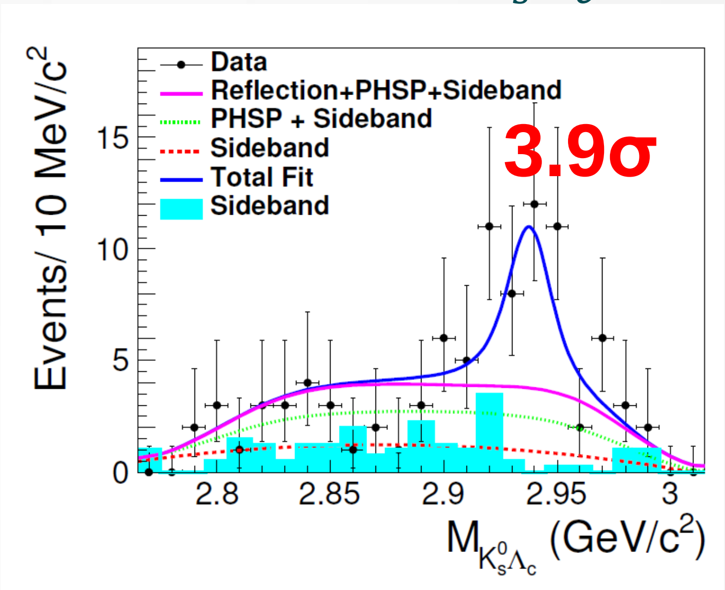


- Quite clear $\Lambda_c^+\bar{\Lambda}_c^-$ signals and B^0 signals.
  - $N^{\text{sig}} = 34.9 \pm 6.6$ with a statistical signal significance above 8.3σ
  - $\mathcal{B}(\bar{B}^0 \to \bar{K}^0 \Lambda_c^+ \bar{\Lambda}_c^-) = [3.99 \pm 0.76(\text{stat.}) \pm 0.51(\text{syst.})] \times 10^{-4}$

Evidence of charged $\Xi_c(2930)$ in $B^0 \to K^0 \Lambda_c^+ \bar{\Lambda}_c^-$

- Charged $\Xi_c(2930)$ extracted by fitting $M_{K_S^0 \Lambda_c}$





- $N(\Xi_c^{\pm}(2930))=21.2 \pm 4.6$, stat. significance 4.1σ
- $M(\Xi_c^{\pm}(2930))=2942.3 \pm 4.4 \pm 1.5$ MeV/c^2
- $\Gamma\ (\Xi_c^{\pm}(2930))=14.8 \pm 8.8 \pm 2.5$ MeV

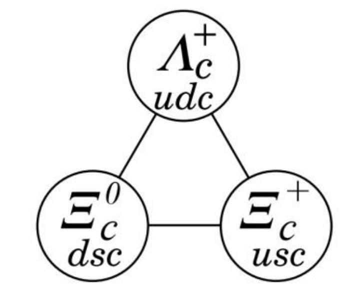
Y.B.Li, C.P.Shen et al (Belle)
EPJC 78, 928 (2018)

After this measurement, $* \to **$

$\Xi_c(2930)$ $\quad I(J^P) = ?(?^?)$ Status: $**$

Measurements of absolute Brs of Ξ_c^0

- Weak decays of charmed hadrons play an unique role in the study of strong interaction； the charmed-baryon sector also offers an unique and excellent laboratory for testing heavy-quark symmetry and light-quark chiral symmetry.
- For the charmed baryons of the SU(3) anti-triplet, only Λ_c absolute Brs were measured by Belle [PRL113,042002(2014), first time] and BESIII [PRL116,052001(2016)]
- Since Ξ_c^0 [PRL62,863(1989)] and Ξ_c^+[PLB122,455 (1983)] were discovered ~30 years ago, no absolute Brs could be measured.



- For Ξ_c^0, the Brs are all measured with ratios to the $\Xi^-\pi^+$, the so called reference mode.

Measurements of absolute Brs of Ξ_c^0

- Theory: $B(\Xi_c^0 \to \Xi^-\pi^+)$~1.12% or 0.74% [PRD48, 4188 (1993)], (2.24±0.34)% [JHEP03, 66(2018)], (1.91±0.17)% [1811.07265]
- The $B(\Xi_c^0 \to \Lambda K^-\pi^+)$/ $B(\Xi_c^0 \to \Xi^-\pi^+)$ = 1.07 ± 0.12± 0.07 and

$B(\Xi_c^0 \to pK^-K^-\pi^+)$/ $B(\Xi_c^0 \to \Xi^-\pi^+)$= 0.33 ± 0.03±0.03 [PLB 605,237]

- $\Xi_c^0 \to pK^-K^-\pi^+$ plays a fundamental role in lots of bottom baryons study at LHCb .
- How to measure Ξ_c^0 absolute Brs ? Model Independent !

$$\mathcal{B}(\Xi_c^0 \to \Xi^-\pi^+) \equiv \frac{\mathcal{B}(B^- \to \bar{\Lambda}_c^-\Xi_c^0)\mathcal{B}(\Xi_c^0 \to \Xi^-\pi^+)}{\mathcal{B}(B^- \to \bar{\Lambda}_c^-\Xi_c^0)},$$

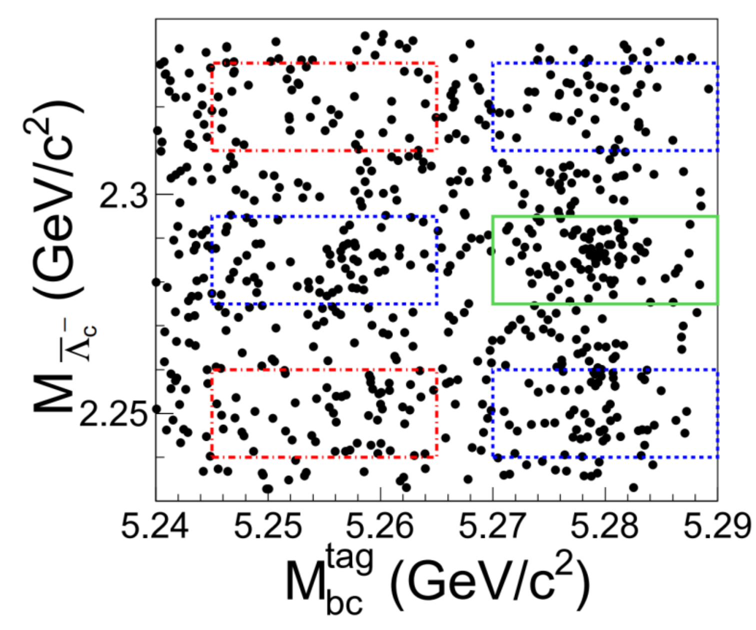
$$\mathcal{B}(\Xi_c^0 \to \Lambda K^-\pi^+) \equiv \frac{\mathcal{B}(B^- \to \bar{\Lambda}_c^-\Xi_c^0)\mathcal{B}(\Xi_c^0 \to \Lambda K^-\pi^+)}{\mathcal{B}(B^- \to \bar{\Lambda}_c^-\Xi_c^0)}.$$

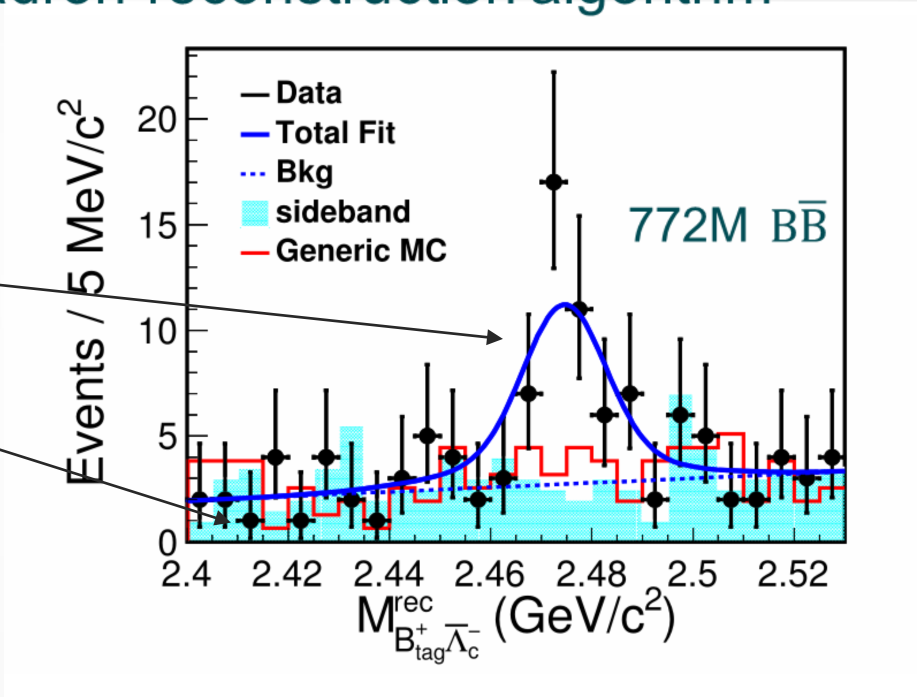
$$\mathcal{B}(\Xi_c^0 \to pK^-K^-\pi^+) \equiv \frac{\mathcal{B}(B^- \to \bar{\Lambda}_c^-\Xi_c^0)\mathcal{B}(\Xi_c^0 \to pK^-K^-\pi^+)}{\mathcal{B}(B^- \to \bar{\Lambda}_c^-\Xi_c^0)}.$$

- For inclusive $\boldsymbol{B^-} \to \bar{\boldsymbol{\Lambda}}_c^-\Xi_c^0$, Ξ_c^0 →anything, never measured before.
- For exclusive $B(\boldsymbol{B^-} \to \bar{\boldsymbol{\Lambda}}_c^-\Xi_c^0)$ $B(\Xi_c^0 \to \Xi^-\pi^+)$; $B(\boldsymbol{B^-} \to \bar{\boldsymbol{\Lambda}}_c^-\Xi_c^0)$ $B(\Xi_c^0 \to \Lambda K^-\pi^+)$, measured by Belle and BaBar with large errors.

Measurements of Br of $B^- \to \bar{\Lambda}_c^- \Xi_c^0$, $\Xi_c^0 \to$anything

- The $\bar{\Lambda}_c^-$ reconstructed via its $\bar{p}K^+\pi^-$ and $\bar{p}K_s^0$ decays
- A tagged B meson candidate, B_{tag}^+, is reconstructed using a neural network based on the full hadron-reconstruction algorithm





- An unbinned maximum likelihood fit: N(Ξ_c^0)=40.9 $\pm$9.0, 5.5σ(stat.)
- B($B^- \to \bar{\Lambda}_c^- \Xi_c^0$, Ξ_c^0 →anything)= $(9.51 \pm 2.10 \pm 0.88) \times 10^{-4}$ for the first time

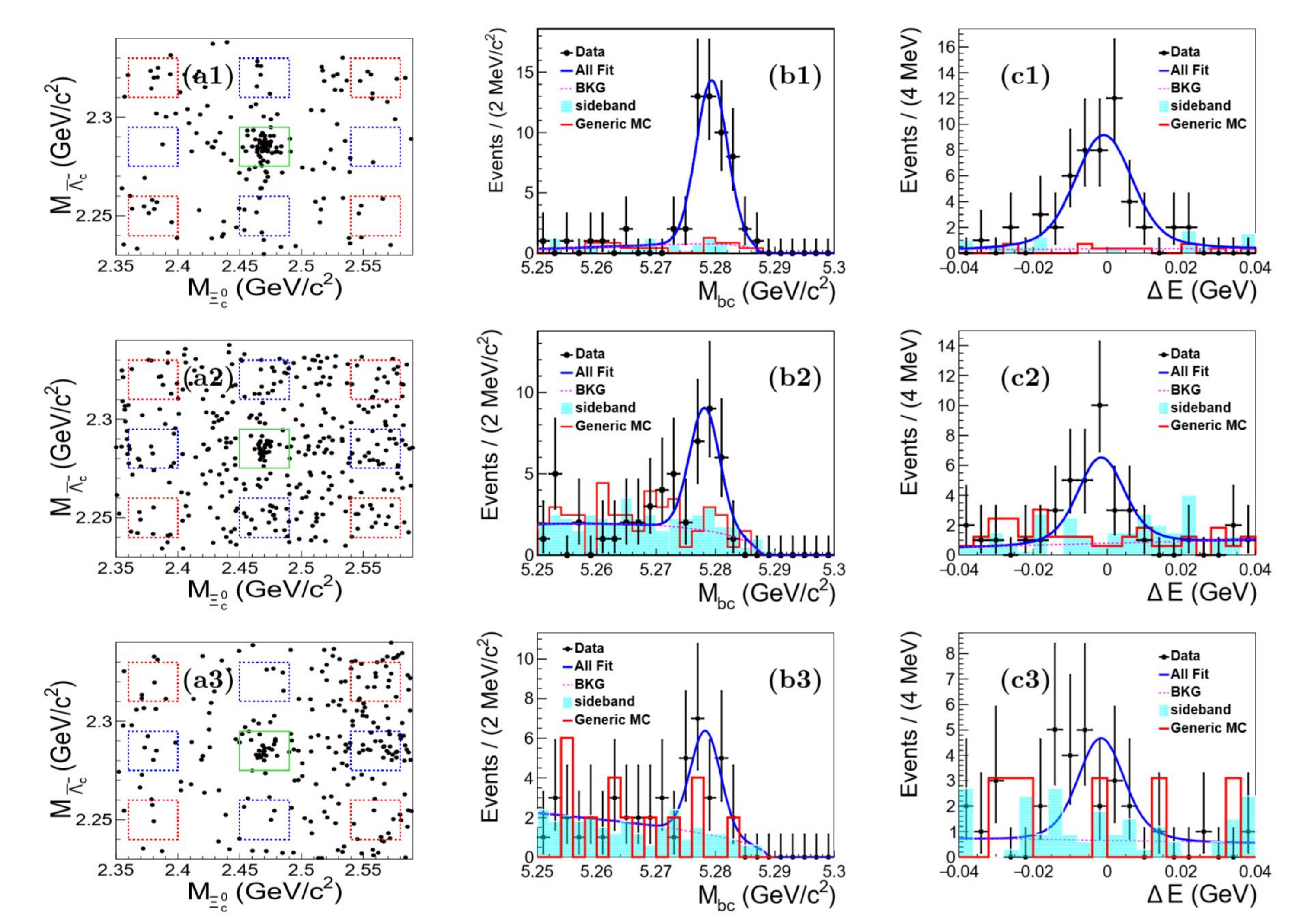
Y.B.Li, C.P.Shen et al. (Belle) PRL122, 082001 (2019)

Measurements of Brs of $B^- \to \bar{\Lambda}_c^- \Xi_c^0$, with $\Xi_c^0 \to \Xi^- \pi^+$; $\Xi_c^0 \to \Lambda K^- \pi^+$; $\Xi_c^0 \to p K^- K^- \pi^+$

$\Xi^- \pi^+$
44.8 ± 7.3
9.5σ

$\Lambda K^- \pi^+$
24.1 ±5.5
6.8σ

$p K^- K^- \pi^+$
16.6 ± 5.4
4.6σ



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Measurements of absolute Brs of Ξ_c^0

Summary of the measured branching fractions and the ratios of Ξ_c^0 decays

Y.B.Li, C.P.Shen et al (Belle) PRL122, 082001 (2019)

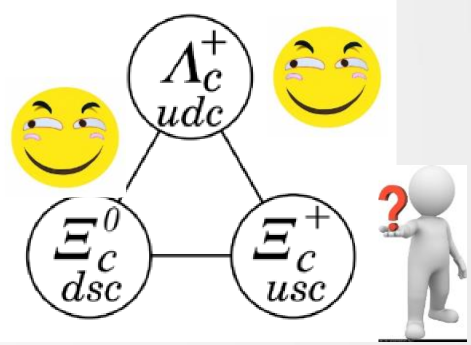
BF	Result	Theory	PDG
$\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c^0)$	$(9.51 \pm 2.10 \pm 0.88) \times 10^{-4}$	$\sim 10^{-3}$	
$\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c^0)\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+)$	$(1.71 \pm 0.28 \pm 0.15) \times 10^{-5}$		$(2.4 \pm 0.9) \times 10^{-5}$
$\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c^0)\mathcal{B}(\Xi_c^0 \to \Lambda K^- \pi^+)$	$(1.11 \pm 0.26 \pm 0.10) \times 10^{-5}$		$(2.1 \pm 0.9) \times 10^{-5}$
$\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c^0)\mathcal{B}(\Xi_c^0 \to p K^- K^- \pi^+)$	$(5.47 \pm 1.78 \pm 0.57) \times 10^{-6}$		
$\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+)$	$(1.80 \pm 0.50 \pm 0.14)\%$	1.12% or 0.74%	
$\mathcal{B}(\Xi_c^0 \to \Lambda K^- \pi^+)$	$(1.17 \pm 0.37 \pm 0.09)\%$		
$\mathcal{B}(\Xi_c^0 \to p K^- K^- \pi^+)$	$(0.58 \pm 0.23 \pm 0.05)\%$		
$\mathcal{B}(\Xi_c^0 \to \Lambda K^- \pi^+)/\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+)$	$0.65 \pm 0.18 \pm 0.04$		1.07 ± 0.14
$\mathcal{B}(\Xi_c^0 \to p K^- K^- \pi^+)/\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+)$	$0.32 \pm 0.12 \pm 0.07$		0.34 ± 0.04

- We have performed an analysis of $B^- \to \bar{\Lambda}_c^- \Xi_c^0$ inclusively and exclusively
- First model-independent measurement of absolute Brs of Ξ_c^0 decays
- The branching fraction $B(B^- \to \bar{\Lambda}_c^- \Xi_c^0)$ is measured for the first time
- The $B(\Xi_c^0 \to \Xi^- \pi^+)$ can be used to determine the BR of other Ξ_c^0 decays.

Measurements of absolute Brs of Ξ_c^+

- The decays of charmed baryons in experiment are needed to extract the non-perturbative contribution thus important to constrain phenomenological models of strong interaction.

- For the SU(3) anti-triplet charmed baryons the branching fractions of $\boldsymbol{\Lambda_c^+}$ [PRL 113,042003(2014); PRL 116,052001(2016)] and Ξ_c^0 [PRL 122,082001(2019)] has been measured.



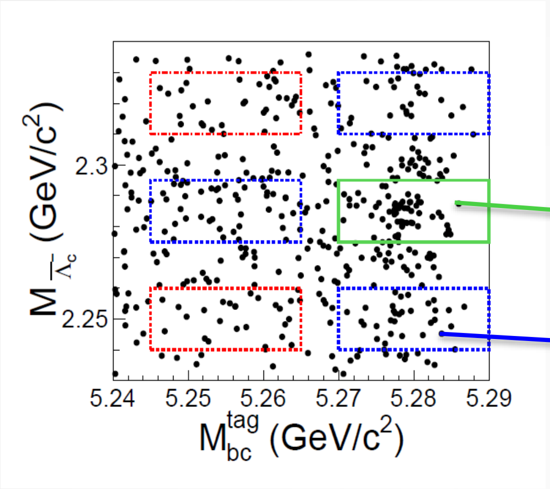
- The Brs of remaining Ξ_c^+ are all measured with ratio to the $\Xi_c^+ \rightarrow \boldsymbol{\Xi^- \pi^+ \pi^+}$

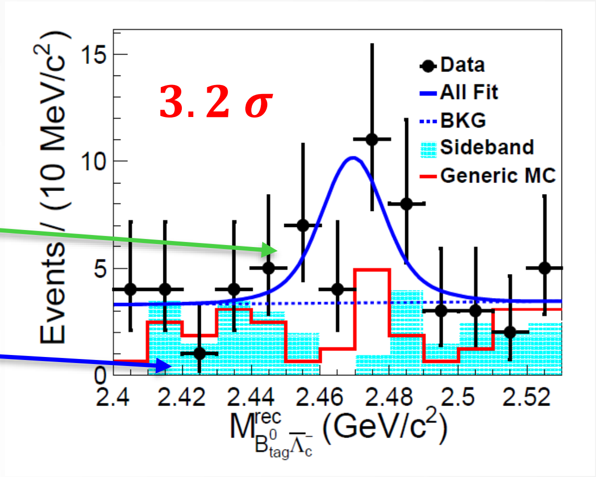
- The comparison of Ξ_c^+ decays with those of Λ_c^+ and and Ξ_c^0 can also provide an important test of SU(3) flavor symmetry.

$\Xi_c^+ \rightarrow p\, K^- \pi^+$ is a particularly important decay mode as it is the one most often used to reconstruct Ξ_c^+ candidates at hadron collider experiments, such as LHCb. Theory predicts the $B(\Xi_c^+ \rightarrow p\, K^- \pi^+)=(2.2\pm0.8)\%$ [EPJC 78, 224 (2018); Chin. Phys. C 42, 051001 (2018)].

Measurement of Ξ_c^+ absolute BRs

Measurement $\mathcal{B}(\bar{B}^0 \to \overline{\Lambda}_c^- \Xi_c^+)$ with $\Xi_c^+ \to anythings$





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PRD 100, 031101 (2019)

- reconstruct $\overline{\Lambda}_c^-$ via $\bar{p}K^+\pi^-$ decay mode
- tag a B^0 with neural network based Full-Reconstruction algorithm.
- An unbinned maximum likelihood fit: $N(\Xi_c^+) = 18.8 \pm 6.8$
- $\mathcal{B}(\bar{B}^0 \to \overline{\Lambda}_c^- \Xi_c^+) = [1.16 \pm 0.42(stat.) \pm 0.15(syst.)] \times 10^{-3}$

Measurement of Ξ_c^+ absolute BRs

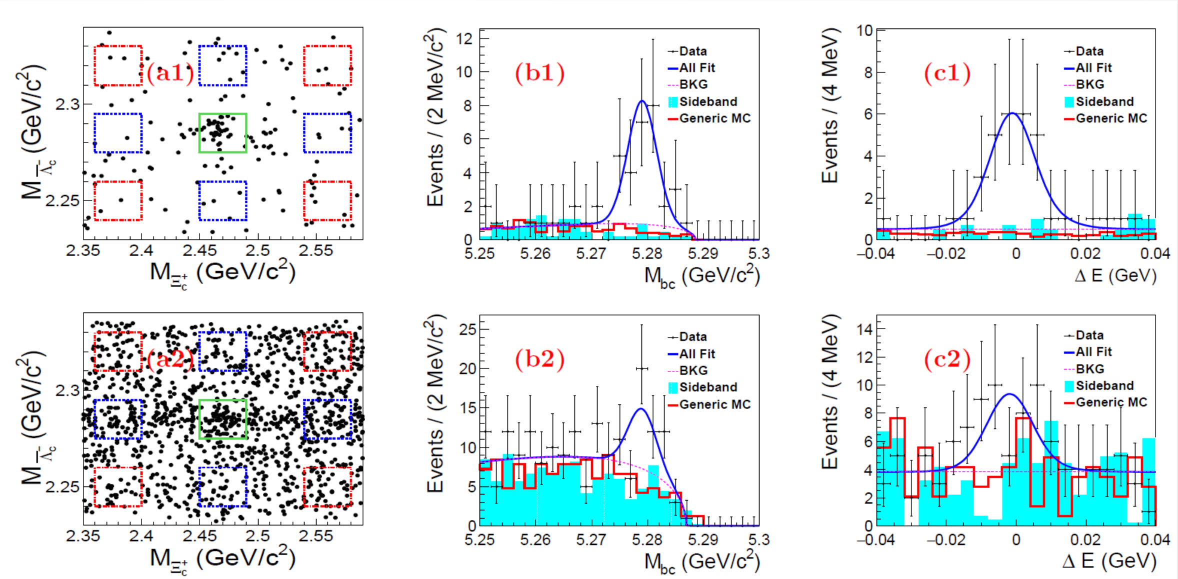
Measurement $\mathcal{B}(\bar{B}^0 \to \bar{\Lambda}_c^- \Xi_c^+)$
with $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ or $pK^-\pi^+$

$\Xi_c^+ \to \Xi^-\pi^+\pi^+$
$N = 24.2 \pm 5.4$

6.9σ

$\Xi_c^+ \to pK^-\pi^+$
$N = 24.0 \pm 6.9$

4.5σ



Y. B. Li. C. P. Shen et al (Belle) PRD 100, 031101 (2019)

Measurement of Ξ_c^+ absolute BRs

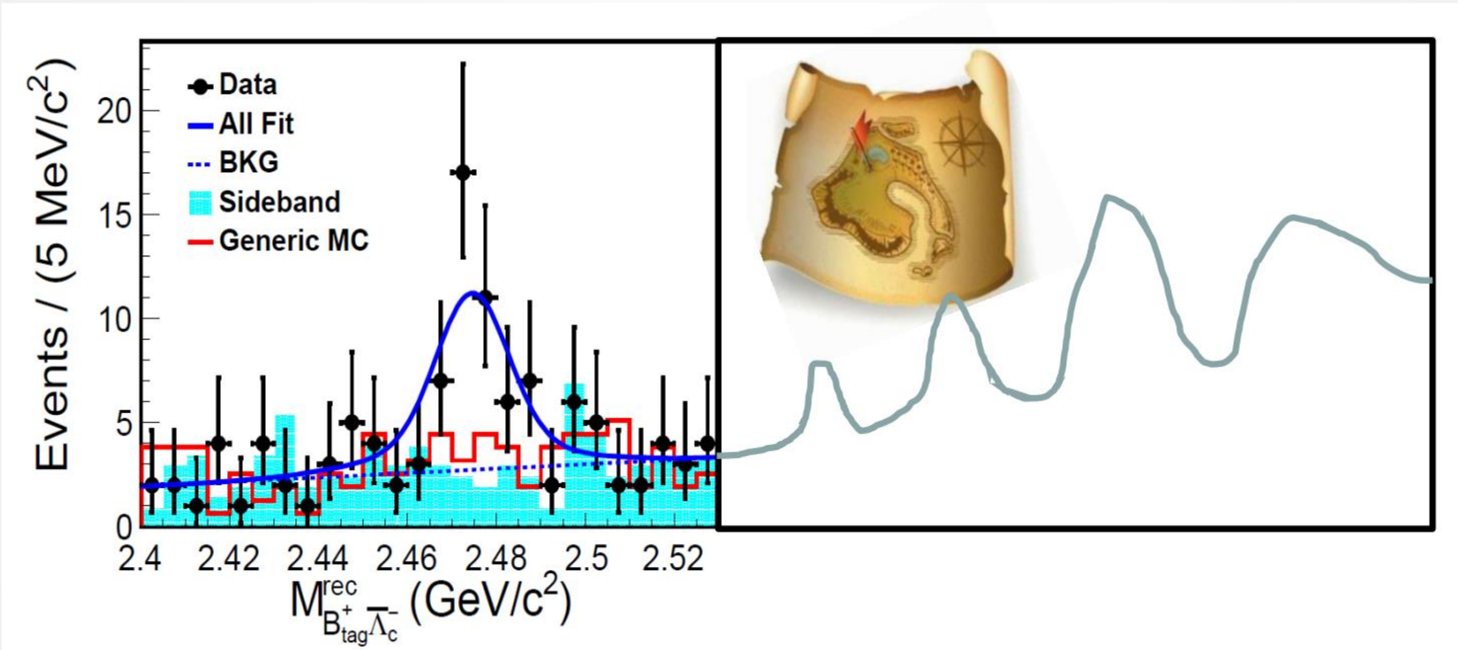
Y. B. Li. C. P. Shen et al (Belle) PRD 100, 031101 (2019)

BF	Result	Theory	PDG
$\mathcal{B}(\bar{B}^0 \to \bar{\Lambda}_c^- \Xi_c^+)$	$(1.16 \pm 0.42 \pm 0.15) \times 10^{-3}$	$\sim 10^{-3}$	
$\mathcal{B}(\bar{B}^0 \to \bar{\Lambda}_c^- \Xi_c^+))\mathcal{B}(\Xi_c^+ \to \Xi^- \pi^+ \pi^+)$	$(3.32 \pm 0.74 \pm 0.33) \times 10^{-5}$		$(1.8 \pm 1.8) \times 10^{-5}$
$\mathcal{B}(\bar{B}^0 \to \bar{\Lambda}_c^- \Xi_c^+)\mathcal{B}(\Xi_c^+ \to p K^- \pi^+)$	$(5.27 \pm 1.51 \pm 0.69) \times 10^{-5}$		
$\mathcal{B}(\Xi_c^+ \to \Xi^- \pi^+ \pi^+)$	$(2.86 \pm 1.21 \pm 0.38)\%$	$(1.47 \pm 0.84)\%$	
$\mathcal{B}(\Xi_c^+ \to p K^- \pi^+)$	$(0.45 \pm 0.21 \pm 0.07)\%$	$(2.2 \pm 0.8)\%$	
$\mathcal{B}(\Xi_c^+ \to p K^- \pi^+)/\mathcal{B}(\Xi_c^+ \to \Xi^- \pi^+ \pi^+)$	$0.16 \pm 0.06 \pm 0.02$		0.21 ± 0.04

- First model –independent $\mathcal{B}\left(\bar{B}^0 \to \bar{\Lambda}_c^- \Xi_c^+\right)$ measurement
- $\mathcal{B}(\Xi_c^+ \to \Xi^- \pi^+ \pi^+)$ can be used to determine the BR of other Ξ_c^+ decay

Measurements of the Branching Fractions $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c^{\prime 0})$, $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2645)^0)$ and $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2790)^0)$ at Belle

NEW



Measurements of the Branching Fractions $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c'^0)$, $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2645)^0)$ and $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2790)^0)$ at Belle

NEW

1. Recently, the absolute branching fractions of the two Ξ_c ground states, Ξ_c^0 and Ξ_c^+, have been measured by Belle.
2. They first measured the branching fraction for $B^- \to \bar{\Lambda}_c^- \Xi_c^0$ using a missing-mass technique (inclusive process); then they measured the product branching fraction for $(B^- \to \bar{\Lambda}_c^- \Xi_c^0)(\Xi_c^0 \to \Xi^- \pi^+)$ (exclusive process). The Ξ_c^0 absolute branching fractions can be obtained by dividing the result of exclusive process by the result of inclusive process .
3. Now a nature question is : in the inclusive process, *i.e.* Λ_c recoil side, they only focused on the Ξ_c^0 signal region, may we observe excited Ξ_c^0 states in the higher recoil mass region.
4. In this analysis, we checked the higher recoil mass region, *i.e.* the excited Ξ_c^0 states. We measured the branching fractions of the inclusive process, but we didn't observe the signal in the exclusive process.

Y. B. Li *et al.* (Belle Collaboration), Phys. Rev. Lett **122**, 082001 (2019).

Y. B. Li *et al.* (Belle Collaboration), Phys. Rev. D **100**, 031101(R) (2019).

Measurements of the Branching Fractions $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c'^0)$, $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2645)^0)$ and $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2790)^0)$ at Belle

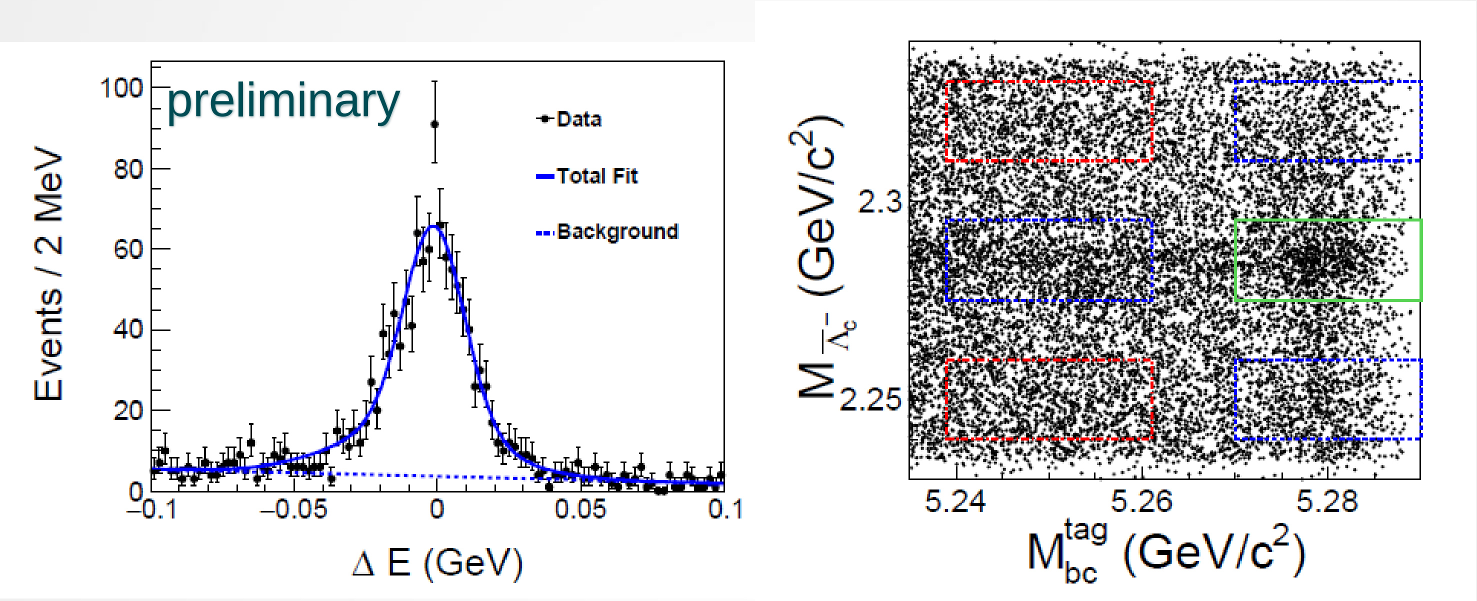
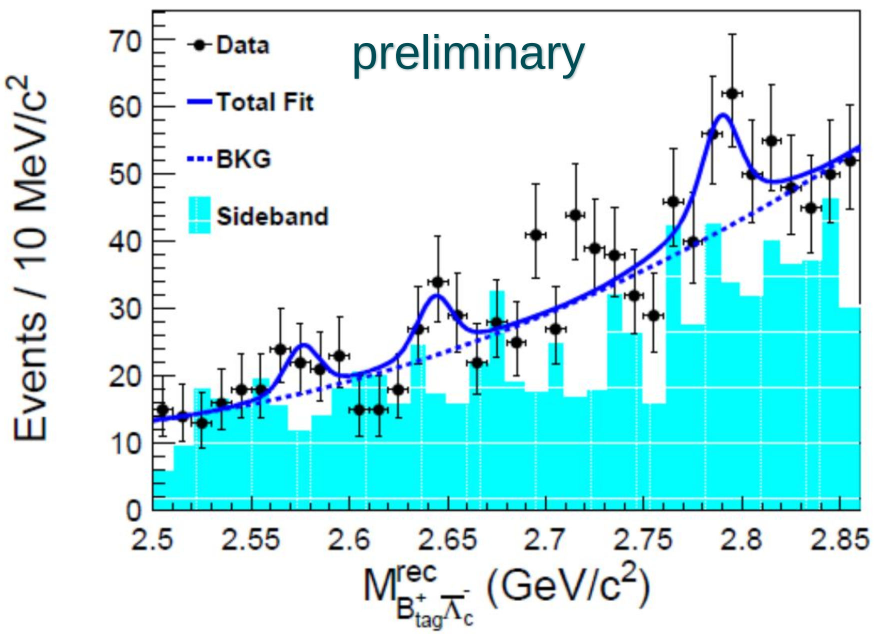


Figure: ΔE distribution and the scatter plot of $M_{\rm bc}$ of $B^+_{\rm tag}$ versus $M_{\bar{\Lambda}_c^-}$ of signal side in Ξ_c^{*0} signal region, *i.e.*, 2.5 GeV/c^2 $< M^{\rm rec}_{B^+_{\rm tag}\bar{\Lambda}_c^-} <$ 2.86 GeV/c^2 from real data.

1. We take $|\Delta E| < 0.04$ GeV ($\sim 3\sigma$) as ΔE signal region.
2. The normalized contribution from $M_{\rm bc}$ and $M_{\bar{\Lambda}_c^-}$ sidebands is estimated using the half the number of events in blue dashed boxes, minus one-fourth the number of events in red dashed boxes.

Measurements of the Branching Fractions $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c'^0)$, $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2645)^0)$ and $\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c(2790)^0)$ at Belle

NEW



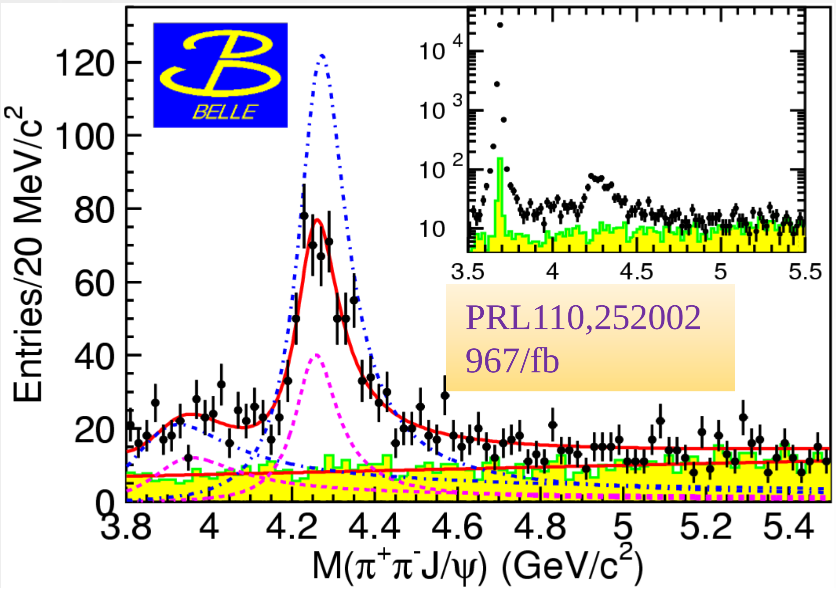
The empty space between the fitted background level and the normalized sidebands histogram is the contribution from other multi-body $B^- \to \bar{\Lambda}_c^- + anything$ decays.

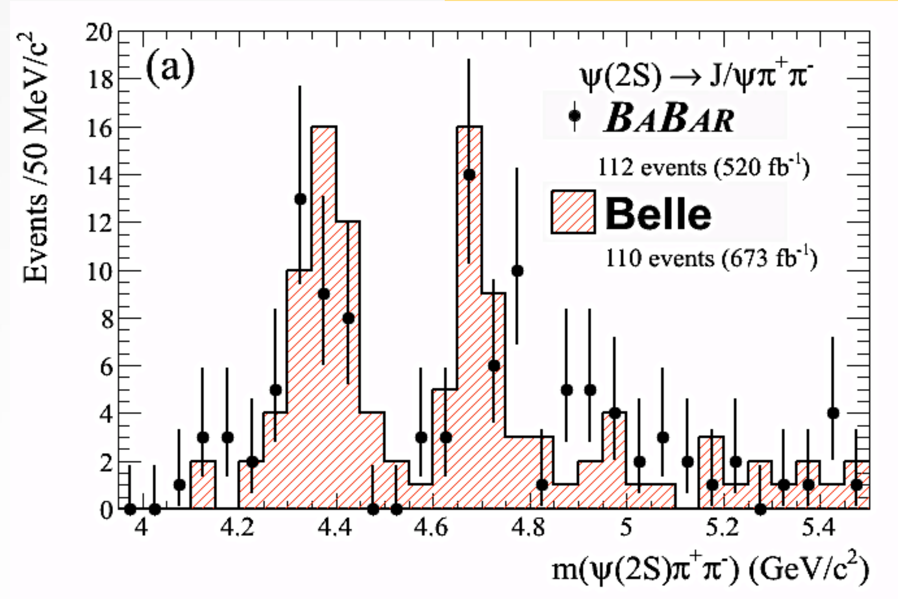
Since in the fit to the data the statistical significances of $\Xi_c'^0$ and $\Xi_c(2645)^0$ are less than 3σ, upper limits at 90% credibility level (C.L.) on the numbers of $\Xi_c'^0$ and $\Xi_c(2645)^0$ are determined.

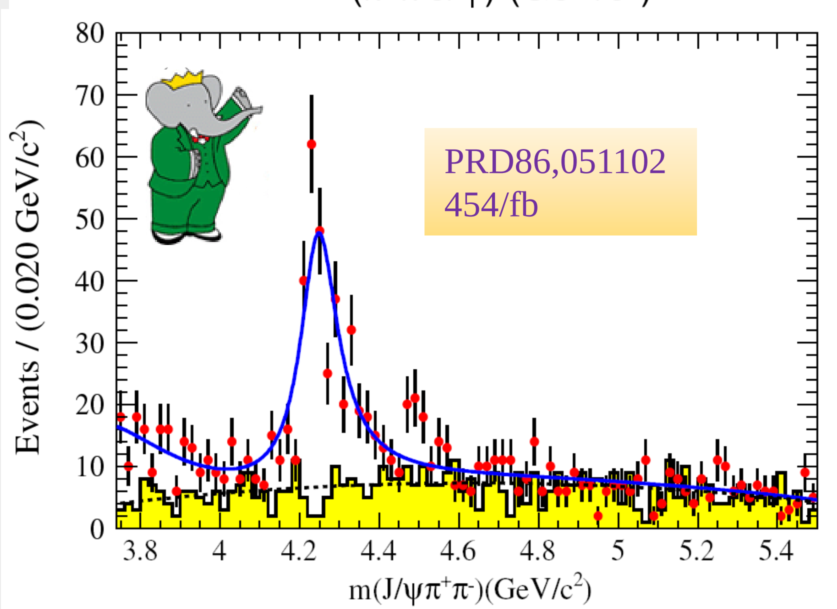
	$N_{\rm sig}$	$\mathcal{B}(B^- \to \bar{\Lambda}_c^- \Xi_c^{*0})$ [Upper Limit]	Significance (σ)
$\Xi_c'^0$	18 ± 10	$(3.4 \pm 2.0 \pm 0.4) \times 10^{-4}$ $[6.5 \times 10^{-4}]$	1.7
$\Xi_c(2645)^0$	24 ± 13	$(4.4 \pm 2.4 \pm 0.5) \times 10^{-4}$ $[7.9 \times 10^{-4}]$	1.9
$\Xi_c(2790)^0$	60 ± 22	$(1.1 \pm 0.4 \pm 0.2) \times 10^{-3}$	3.1

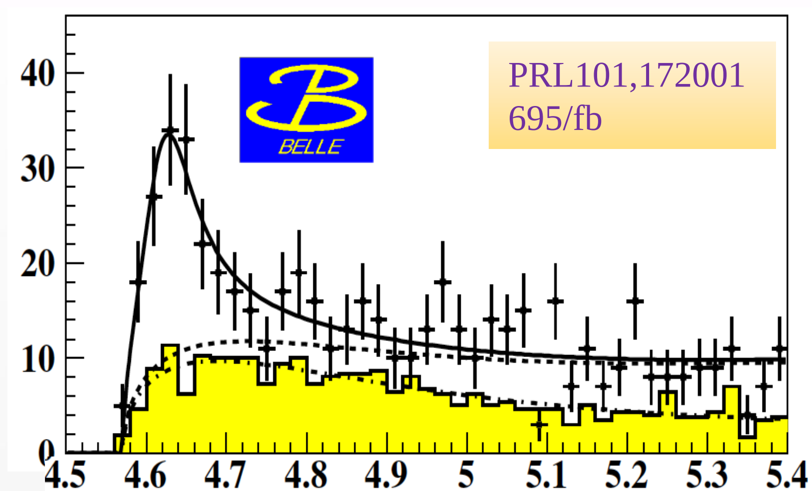
The Y states

Belle: PRL99,142002, 670/fb
BaBar: PRD89, 111103, 520/fb





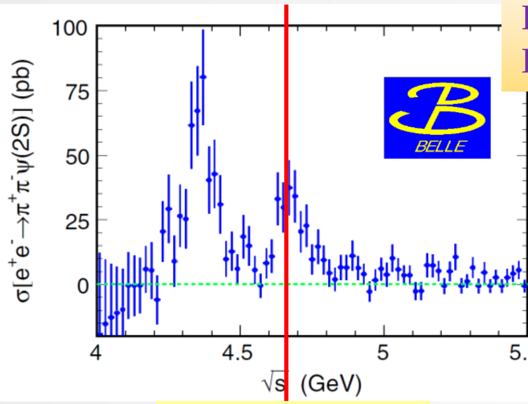


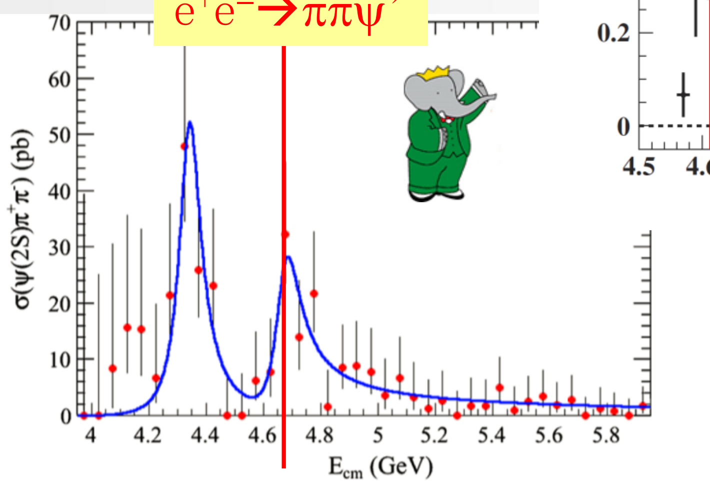


$M(\Lambda_c^+\Lambda_c^-)$

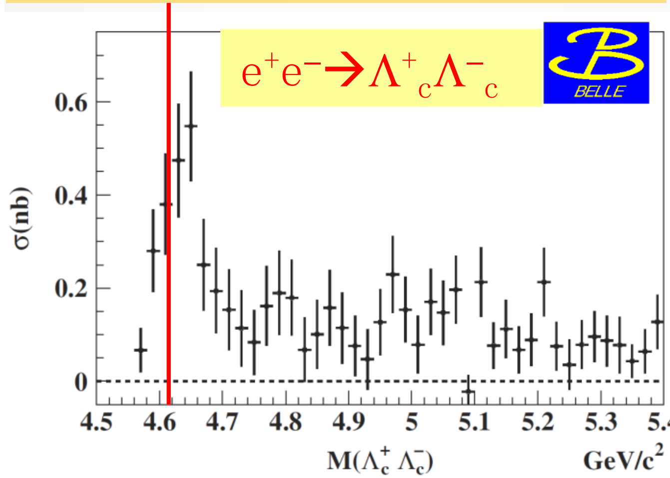
Y(4630)=Y(4660)? Are there other decay modes?

Belle: PRD91, 112007 (2015), 980/fb
BaBar: PRD89, 111103 (2014), 520/fb

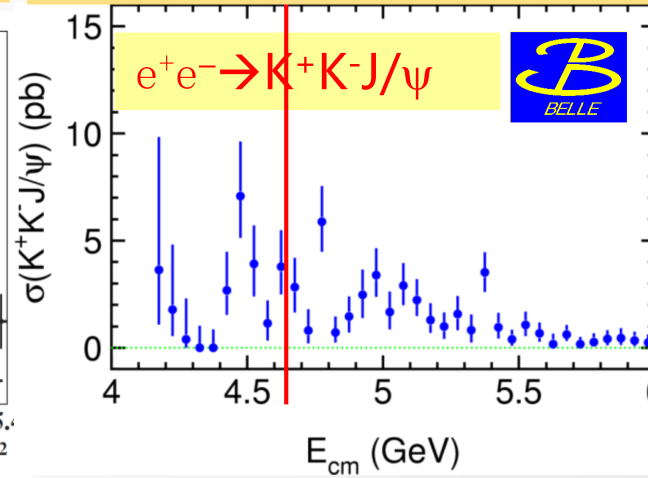




Belle: PRL101, 172001 (2008), 695/fb



Belle: PRD89, 072015 (2014), 980/fb



Experiment	Mass (MeV)	Width (MeV)
Belle, $\Lambda^+_c\Lambda^-_c$	$4634^{+8}_{-7}{}^{+5}_{-8}$	$92^{+40}_{-24}{}^{+10}_{-21}$
Belle, $\pi\pi\psi'$	4652±10±8	68±11±1
BaBar, $\pi\pi\psi'$	4669±21±3	104±48±10

$e^+e^- \to \gamma_{ISR} D_s^+ D_{s1}(2536)^- (\to \bar{D}^{*0} K^- / D^{*-} K_S^0)$+c.c.

$\sqrt{s}$ (GeV)	Luminosity (fb^{-1})
10.52	89.5±1.3
10.58	711±10
10.867	121.4±1.7
Total	921.9±12.9

For $\bar{D}^{*0}K^-$ mode, full reconstruction of the γ_{ISR}, D_s^+ , and K^-

- D_s: $K^+K^-\pi^+$, K_sK^+, $K^+K^-\pi^+\pi^0$, $K_sK^+\pi^0$, $\eta\pi^+$, $\eta'\pi^+$
- and require $D_s^+K^-\gamma_{ISR}$ recoil mass ~ $\bar{D}^{*0}$ mass

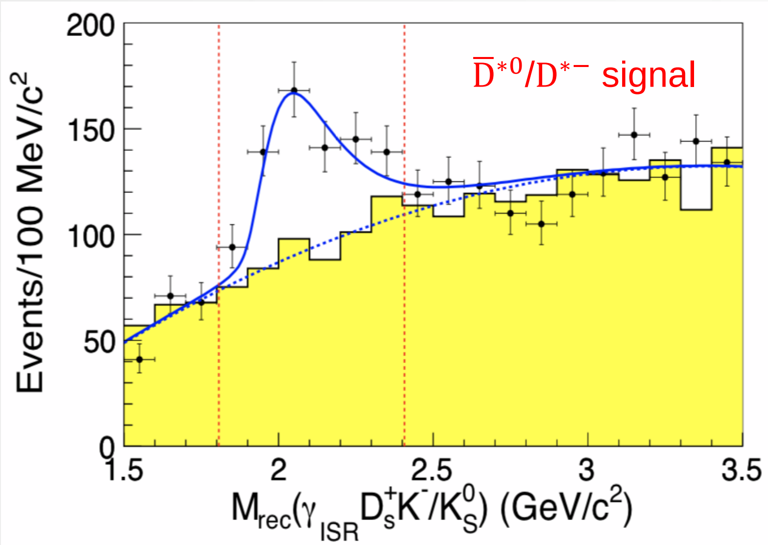
$$M_{rec}(\gamma_{ISR}D_s^+K^-) = \sqrt{(E^*_{c.m.} - E^*_{\gamma_{ISR}D_s^+K^-})^2 - \left(p^*_{\gamma_{ISR}D_s^+K^-}\right)^2}$$

- To improve mass resolution, $M_{rec}(\gamma_{ISR}D_s^+K^-)$ is constrained to nominal mass of $\bar{D}^{*0}$: the resolution of $M_{rec}(\gamma_{ISR})$ is drastically improved (~180 → ~ 5 MeV).

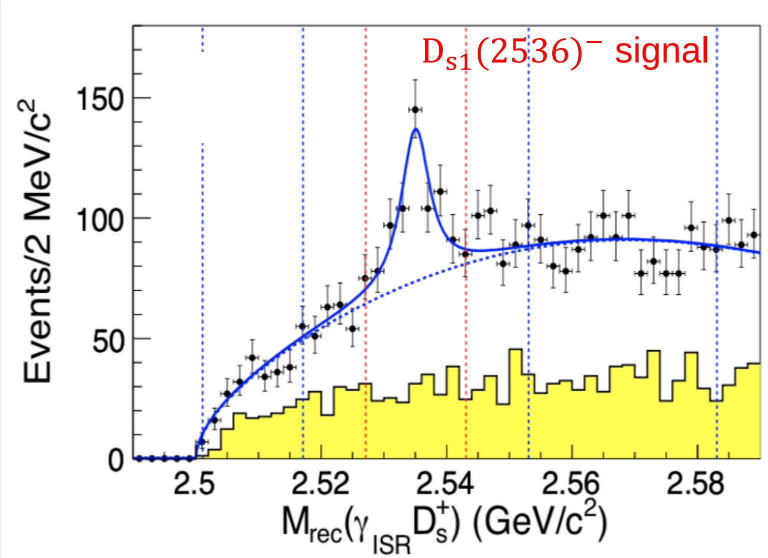
For $D^{*-}K_S^0$ mode, full reconstruction of the γ_{ISR}, D_s^+ , and K_S^0, and do similar selection

S.Jia, C.P.Shen, C.Z.Yuan, X.L.Wang et al.(Belle): arXiv:1911.00671

$M_{rec}(\gamma_{ISR} D_s^+ K^- / K_S^0)$ and $M_{rec}(\gamma_{ISR} D_s^+)$

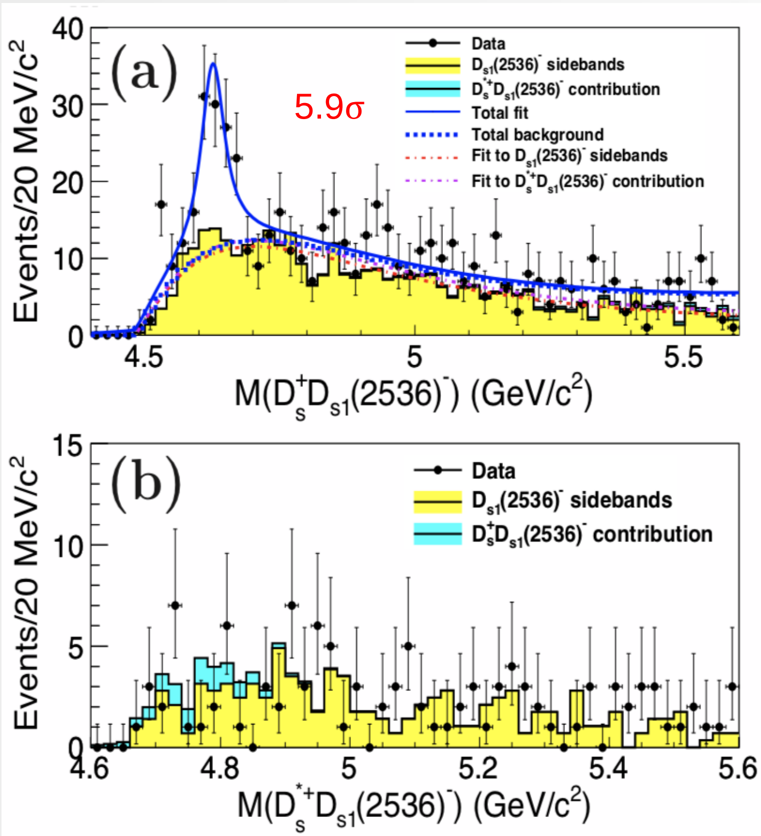


- $M_{rec}(\gamma_{ISR} D_s^+ K^- / K_S^0)$ distribution is making before applying the $\bar{D}^{*0}/D^{*-}$ mass constraint.
- Due to the poor mass resolution, the $\bar{D}^{*0}/D^{*-}$ signal is very wide.
- The yellow histogram shows the normalized $D_{s1}(2536)^-$ mass sidebands (see below).



- $M_{rec}(\gamma_{ISR} D_s^+)$ distribution is making after applying the $\bar{D}^{*0}/D^{*-}$ mass constraint.
- The yellow histogram shows the normalized D_s^+ mass sidebands.
- The fit yields 275$\pm$32 $D_{s1}(2536)^-$ signal events with the statistical significance of 8.0σ.

final mass spectrum $M(D_s^+ D_{s1}(2536)^-)$



An unbinned simultaneous likelihood fit:

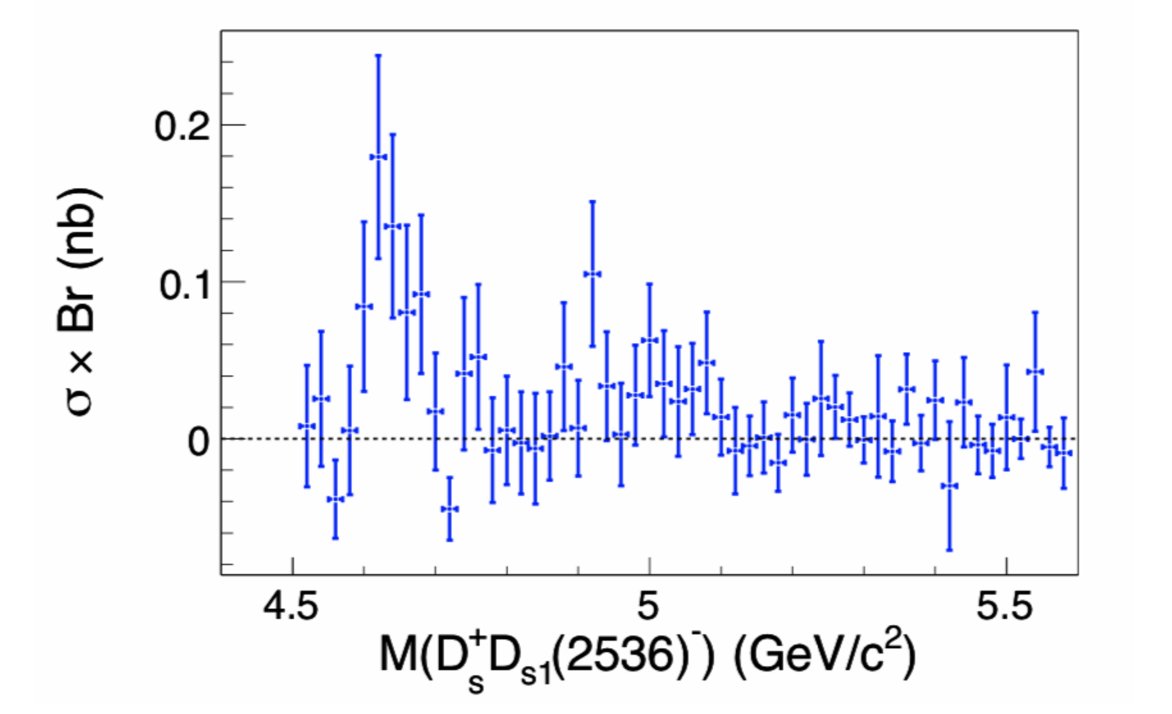
- signal: BW convolved with a Gaussian function, then multiplied by an efficiency function
- $D_{s1}(2536)^-$ mass sidebands: threshold function
- $e^+e^- \to D_s^{*+} D_{s1}(2536)^-$ background: threshold function
- non-resonant: two-body phase space

$M = (4625.9^{+6.2}_{-6.0}(\text{stat.}) \pm 0.4(\text{syst.})\ \text{MeV}/c^2$
$\Gamma = (49.8^{+13.9}_{-11.5}(\text{stat.}) \pm 4.0(\text{syst.})\ \text{MeV}$
$\Gamma_{ee} \times \mathcal{B}(Y \to D_s^+ D_{s1}(2536)^-) \times \mathcal{B}(D_{s1}(2536)^- \to \bar{D}^{*0} K^-) = (14.3^{+2.8}_{-2.6}(\text{stat.}) \pm 1.5(\text{syst.})\ \text{eV}$

Possible background from $e^+e^- \to D_s^{*+}(\to D_s^+\gamma) D_{s1}(2536)^-$, where the photon from the D_s^{*+} remains undetected is studied in data, no obvious structure is observed in $e^+e^- \to D_s^{*+}(\to D_s^+\gamma) D_{s1}(2536)^-$.

Cross section

The product of $e^+e^- \to D_s^+ D_{s1}(2536)^- + c.c.$ cross section and $B(D_{s1}(2536)^- \to \bar{D}^{*0}K^-)$.



The peak value of the $\sigma \times$B at $M(D_s^+ D_{s1}(2536)^-)$ ~ 4.63 GeV is (0.18±0.06) nb.

If $B(D_{s1}(2536)^- \to \bar{D}^{*0}K^-)$=50%

➔ Peak cross section ~ 0.4 nb

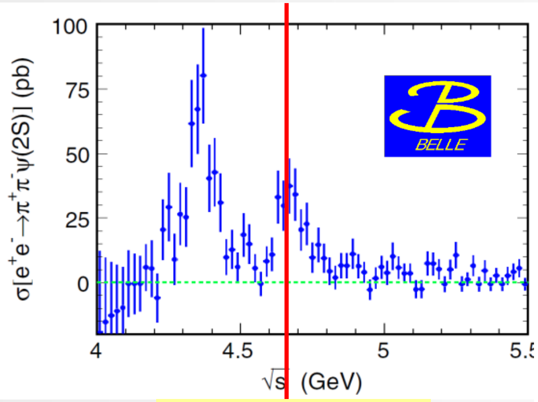
S.Jia, **C.P.Shen**, **C.Z.Yuan**, **X.L.Wang et al.(Belle): arXiv:1911.00671**

Y(4630)=Y(4660)?

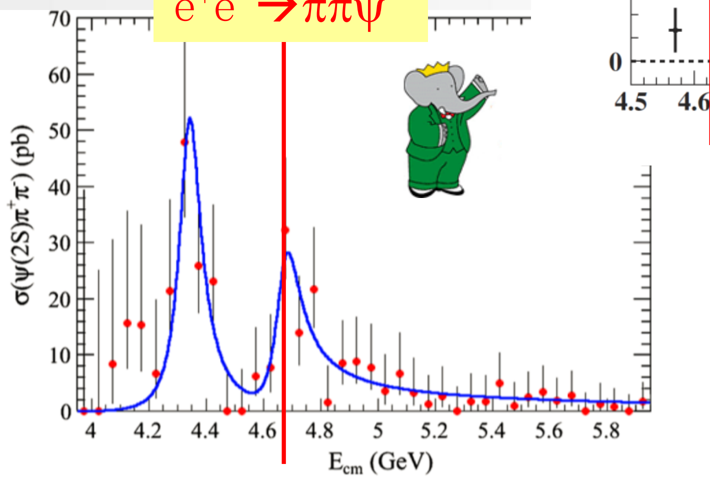
Belle: PRD91, 112007 (2015), 980/fb
BaBar: PRD89, 111103 (2014), 520/fb

Belle: PRL101, 172001 (2008), 695/fb

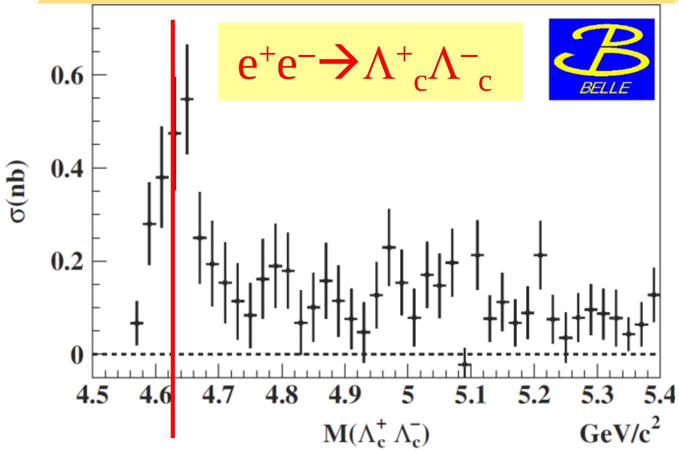
Belle preliminary, 922/fb

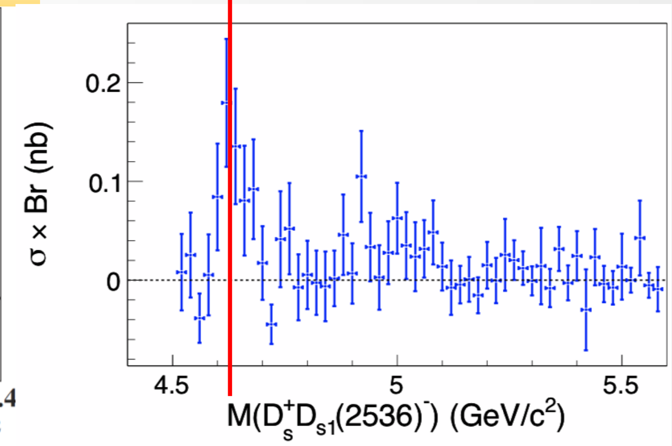


$e^+e^-\to\pi\pi\psi'$



$e^+e^-\to\Lambda^+_c\Lambda^-_c$





Experiment	Mass (MeV)	Width (MeV)
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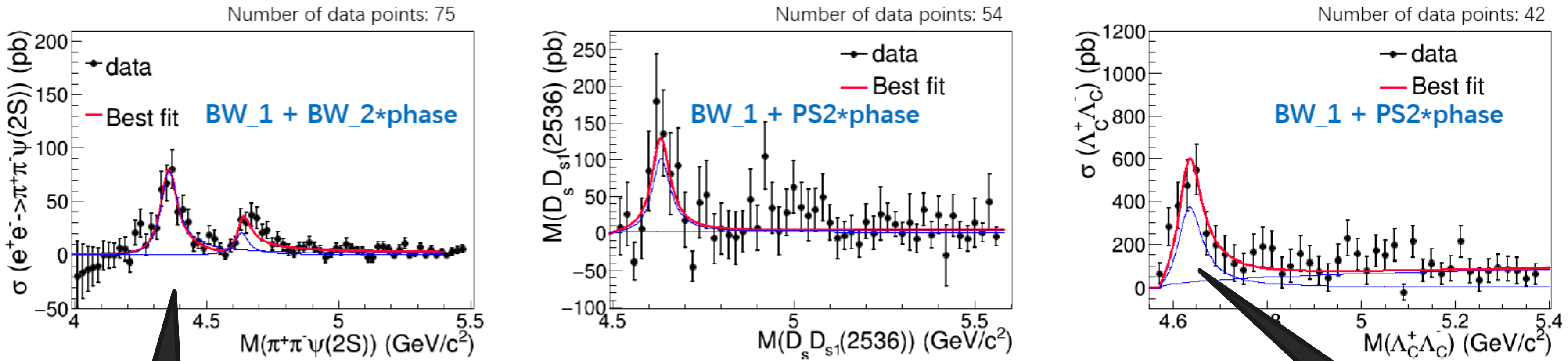
Belle, $\pi\pi\psi'$	4652±10±8	68±11±1
BaBar, $\pi\pi\psi'$	4669±21±3	104±48±10
Belle, D_sD_{s1}	$4635.9^{+6.2}_{-6.0}\pm0.4$	$49.8^{+13.9}_{-11.5}\pm4.0$

A combined fit to Belle data by X.Y.Gao, S.Jia, C.P.Shen [preliminary]



parameter	mean value		statistic error	Unit	comments
M(Y(4660))	4631.45	+/-	7.28	(MeV/c^2)	Mass of Y(4660)
Width(Y(4660))	60.90	+/-	8.97	(MeV/c^2)	Width of Y(4660)
gaB_pipipsi2S(Y(4660))	1.81	+/-	0.52	(eV/c^2)	in pi pi psi(2S) final state
M(Y(4360))	4353.58	+/-	6.46	(MeV/c^2)	Mass of Y(4360)
width(Y(4360))	77.29	+/-	10.03	(MeV/c^2)	Width of Y(4360)
gaB_pipipsi2S(Y(4360))	7.71	+/-	0.81	(eV/c^2)	in pi pi psi(2S) final state
Phase_pipipsi2S(Y(4360))	-0.30	+/-	0.34	rad	in pi pi psi(2S) final state
gaB_DsDs1(Y(4660))	9.00	+/-	3.10	(eV/c^2)	in Ds Ds1(2536) final state
Const_PS2_DsDs1	-7.19	+/-	4.64	none	in Ds Ds1(2537) final state
Phase_PS2_DsDs1	-1.35	+/-	1.21	rad	in Ds Ds1(2538) final state
gaB_lambdac(Y(4660))	32.93	+/-	5.94	(eV/c^2)	in Lambda_c Lambda_c final state
Const_PS2_lambdac(Y(4660))	32.33	+/-	4.34	none	in Lambda_c Lambda_c final state
Phase_PS2_lambdac(Y(4660))	1.43	+/-	0.52	rad	in Lambda_c Lambda_c final state

High precision BESIII data should be added

Should be renormalized with new Λc BR

Number of data points : 171
Chi^2 = 140.38

What is Y(4660)?

- Charmonium?
- Molecule [$f_0(980)\psi'$, $\bar{\Lambda}_c\Lambda_c$]?
- Hadron-charmonium?
- Tetraquark state?
- Hybrid?
- ……

Experimental measurements:

Y(4660) →

- $D_s^* D_{s0}(2317)$
- $D_s D_{s1}(2460)$
- $D_s^* D_{s1}(2460)$
- $D_s D_{s2}(2573)$

May these rates be estimated according to $D_s D_{s1}(2536)$?

at Belle with ISR; and

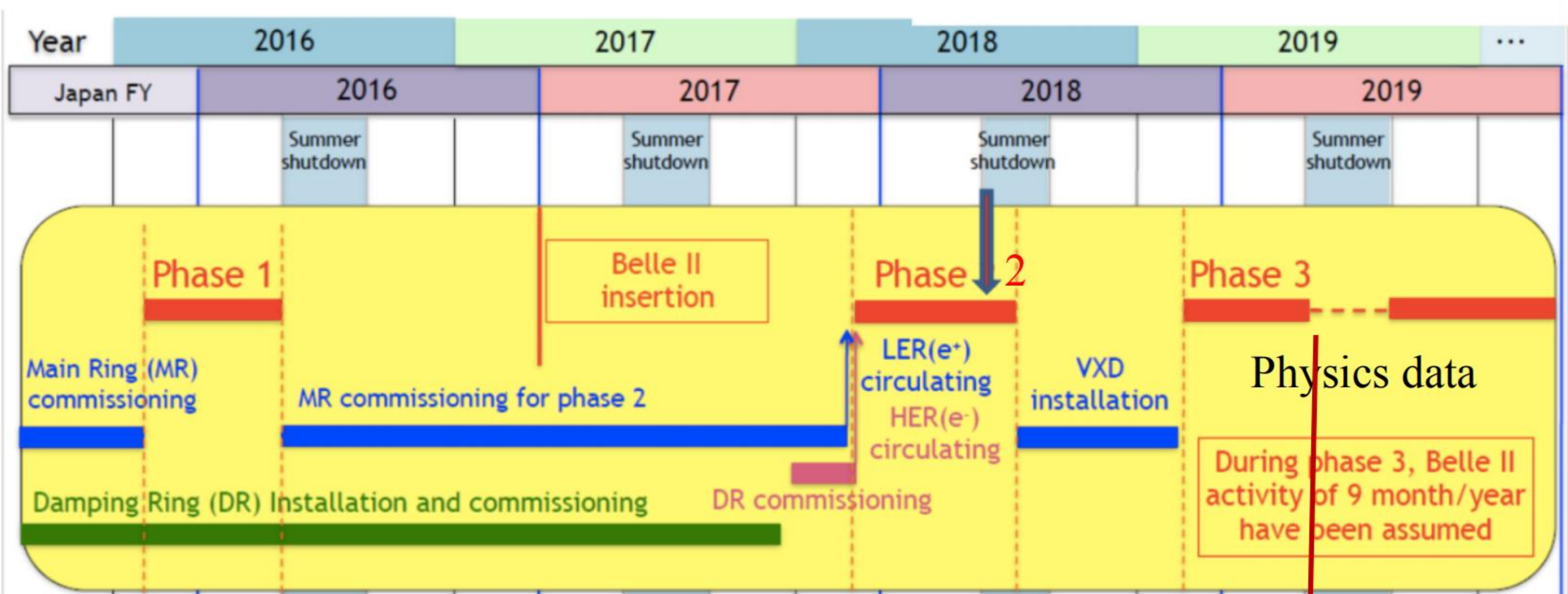
at BESIII with data to be taken in 2019-2020 running year (E_{cm}=4.62, 4.64, 4.66, 4.68, 4.70 GeV, 500 pb^{-1} at each energy)

Why does Y(4660) couple to $s\bar{s}$ strongly?
Why does Y(4660) couple to charmed baryon strongly?

Belle II and LHCb: competition and complementarity

Property	LHCb	Belle II
$\sigma_{b\bar{b}}$ (nb)	~150,000	~1
$\int L\,dt$ (fb^{-1}) by ~2027	~25	~50,000
Background level	High	Low
Typical efficiency	Low	High
π^0, K_S efficiency	Low	High
Initial state	Not well known	Well known
Decay-time resolution	Excellent	Good
Collision spot size	Large	Tiny
Heavy bottom hadrons	B_s, B_c, b-baryons	Partly B_s
τ physics capability	Limited	Excellent
B-flavor tagging efficiency	3.5 - 6%	36%

Start-up schedule



First collisions, 26 April, 2018

- Collected ~ 5 fb^{-1}
  - 0.5% of Belle
- Mostly at $L \sim 0.5\times10^{34}\ \mathrm{cm}^2\mathrm{s}^{-1}$
  - 25% of KEKB
- Reached $L \sim 1.2\times10^{34}\ \mathrm{cm}^2\mathrm{s}^{-1}$
  - With high background
  - Ongoing work on background

The first Belle II collaboration paper has been submitted to arXiv and "Chinese Physics C"

(https://arxiv.org/abs/1910.05365)

Cornell University

arXiv.org > hep-ex > arXiv:1910.05365

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High Energy Physics - Experiment

Measurement of the integrated luminosity of the Phase 2 data of the Belle II experiment

Belle II Collaboration: F. Abudinén, I. Adachi, P. Ahlburg, H. Aihara, N. Akopov, A. Aloisio, L. Andricek, N. Anh Ky, D. M. Asner, H. Atmacan, T. Aushev, V. Aushev, K. Azmi, V. Babu, S. Baehr, S. Bahinipati, A. M. Bakich, P. Bambade, Sw. Banerjee, S. Bansal, V. Bansal, M. Barrett, J. Baudot, A. Beaulieu, J. Becker, P. K. Behera, J. V. Bennett, E. Bernieri, F. U. Bernlochner, M. Bertemes, M. Bessner, S. Bettarini, V. Bhardwaj, F. Bianchi, T. Bilka, S. Bilokin, D. Biswas, G. Bonvicini, A. Bozek, M. Bračko, P. Branchini, N. Braun, T. E. Browder, A. Budano, S. Bussino, M. Campajola, L. Cao, G. Casarosa, C. Cecchi, D. Červenkov, M.-C. Chang, P. Chang, R. Cheaib, V. Chekelian, Y. Q. Chen, Y.-T. Chen, B. G. Cheon, K. Chilikin, H.-E. Cho, K. Cho, S. Choudhury, D. Cinabro, L. Corona, L. M. Cremaldi, S. Cunliffe, T. Czank, F. Dattola, E. De La Cruz-Burelo, G. De Nardo, M. De Nuccio, G. De Pietro, R. de Sangro, M. Destefanis, S. Dey, A. De Yta-Hernandez, F. Di Capua, S. Di Carlo, J. Dingfelder, Z. Doležal, I. Domínguez Jiménez, T. V. Dong, K. Dort, S. Dubey, S. Duell, S. Eidelman, M. Eliachevitch, T. Ferber, D. Ferlewicz, G. Finocchiaro, S. Fiore, A. Fodor, F. Forti, A. Frey, B. G. Fulsom, M. Gabriel, E. Ganiev, M. Garcia-Hernandez, A. Garmash, V. Gaur et al. (299 additional authors not shown)

(Submitted on 11 Oct 2019)

From April to July 2018, a data sample at the peak energy of the $\Upsilon(4S)$ resonance was collected with the Belle~II detector at the SuperKEKB electron-positron collider. This is the first data sample of the Belle~II experiment. Using Bhabha scattering events, we measure the integrated luminosity of the data sample to be $(496.7 \pm 0.3 \pm 3.5)$~pb^{-1}, where the first uncertainty is statistical and the second is systematic. A measurement with digamma events is performed as a cross-check, and the obtained result is in agreement with the nominal result. This work provides a basis for future luminosity measurements at Belle~II.

Comments: 12 pages, 2 figures, the first Belle II Collaboration paper
Subjects: **High Energy Physics - Experiment (hep-ex)**

Quick review of Phase-3 2019 Spring

- Phase-3 2019 Spring run started from 11th, March, and ended 1st, July, 2019.
- Aims of Phase-3 2019 Spring:
  - Starting full-scale physics run with complete VXD in Belle II.
  - Accelerator and collision tunings with lower β^* for higher luminosity.

Phase 2 dataset:

→ ~0.5 fb^{-1} recorded

(only ~half of this has fully working triggers)

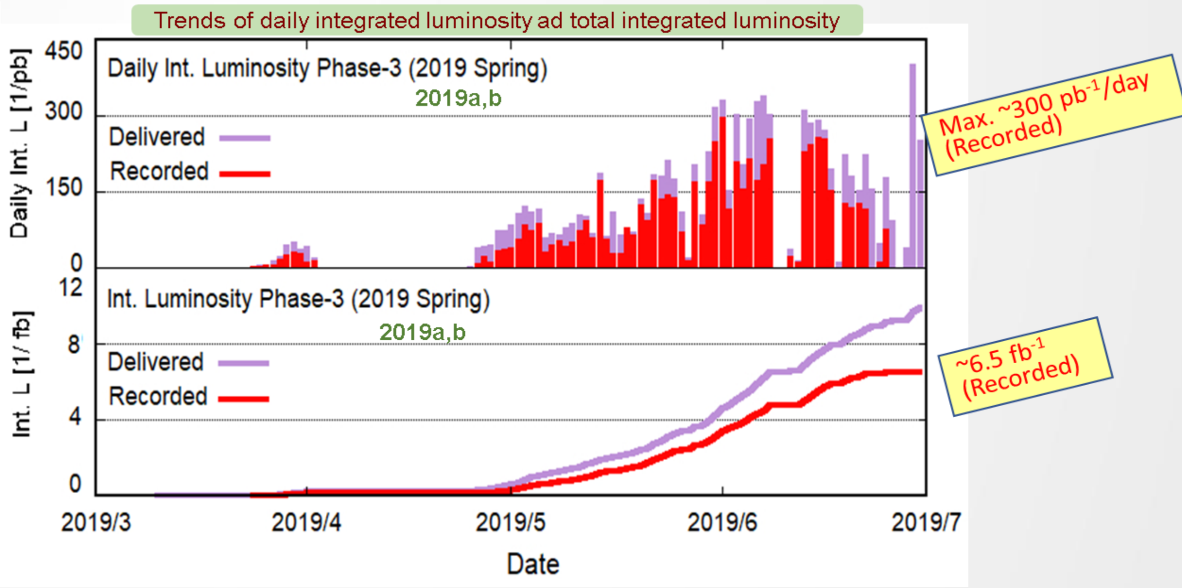
Phase 3 dataset:

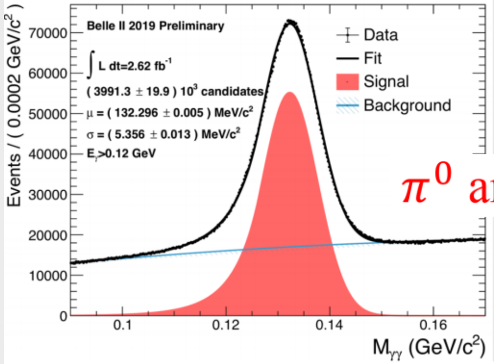
→ 6.49 fb^{-1} of which:

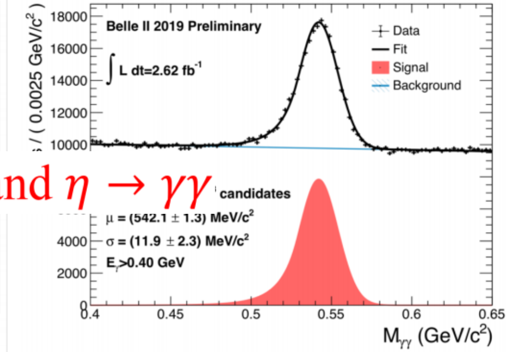
→ 5.60 (5.15) fb^{-1} Υ(4S)

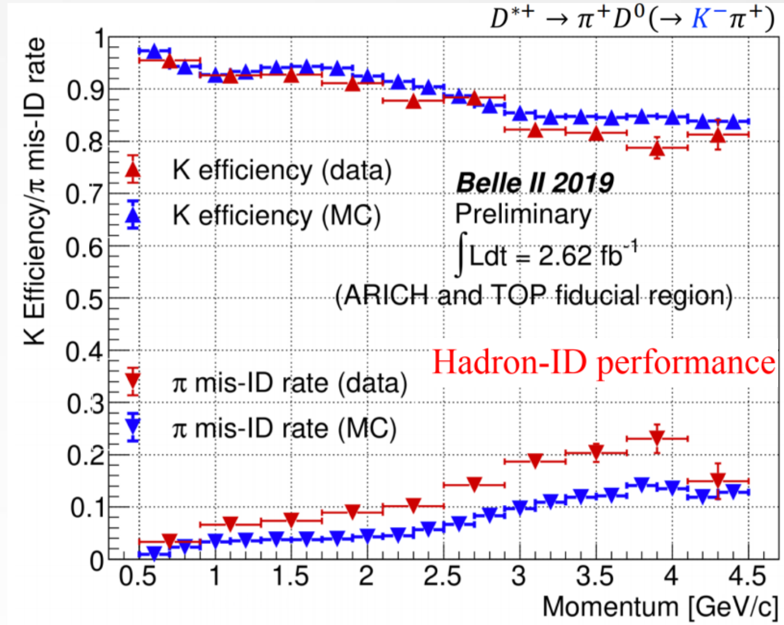
→ 0.83 (0.83) fb^{-1} off-resonance

recorded (good for analysis)

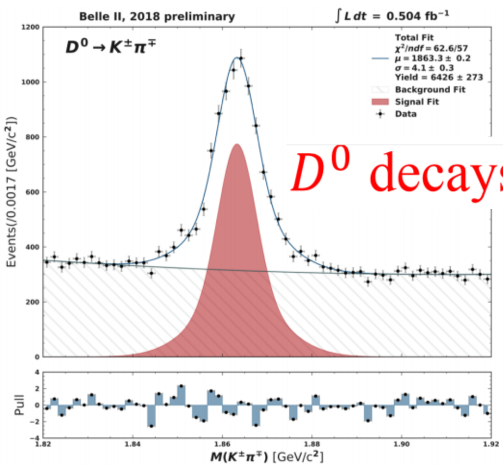




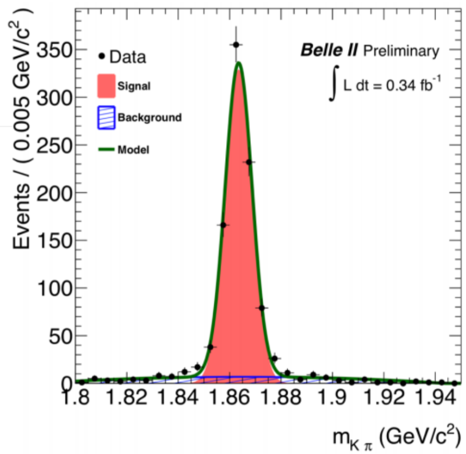


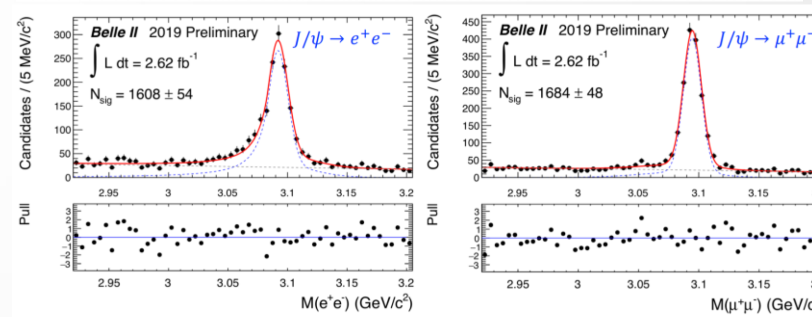


BELLE2-NOTE-PL-2019-024



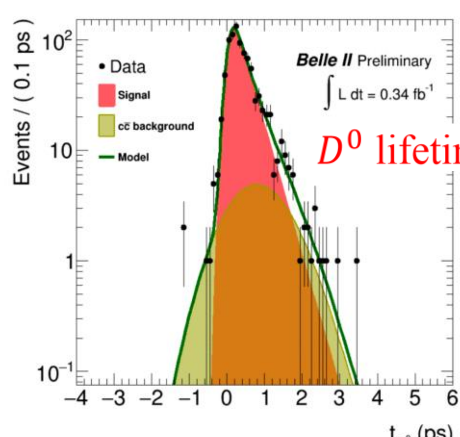
BELLE2-NOTE-PL-2019-003





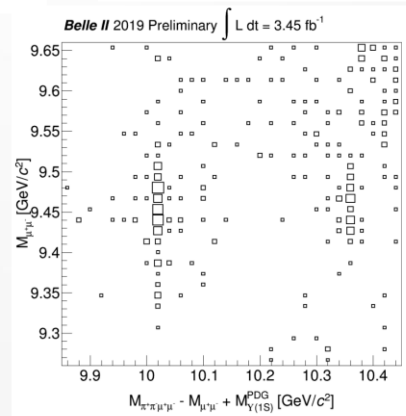
Inclusive reconstruction of $D^0 \to K^-\pi^+$

With D^0 produced in $D^{*+} \to D^0\pi^+$

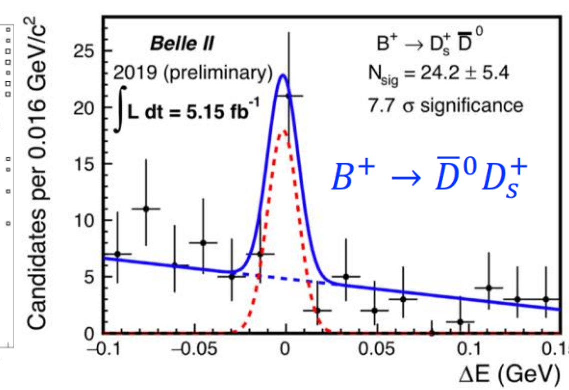


parameter	extracted value
N^1_{sig}	$(81 \pm 6) \cdot 10$
μ_1 (fs)	31 ± 16
σ_1 (fs)	127 ± 15
N^2_{sig}	$(10 \pm 5) \cdot 10$
μ_2 (ps)	(0.48 ± 0.17)
σ_2 (ps)	(0.73 ± 0.13)
τ (fs)	(370 ± 40)

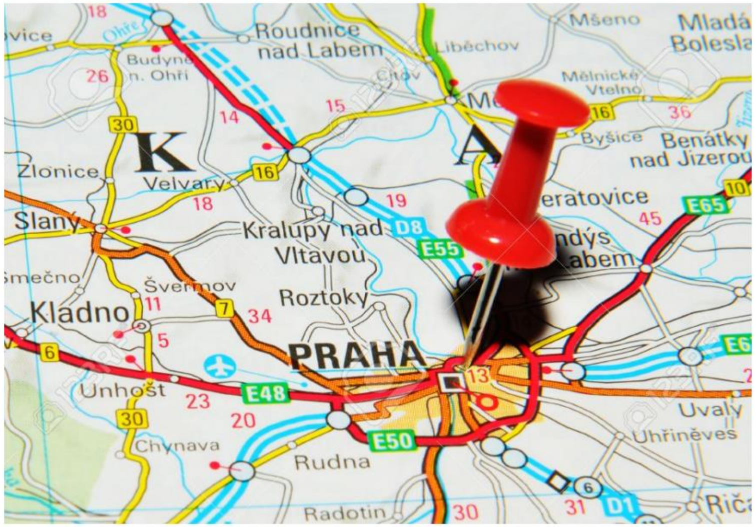
PDG: 410.1 ± 1.5 fs



$\Upsilon(3S, 2S) \to \Upsilon(1S)\pi^+\pi^-$



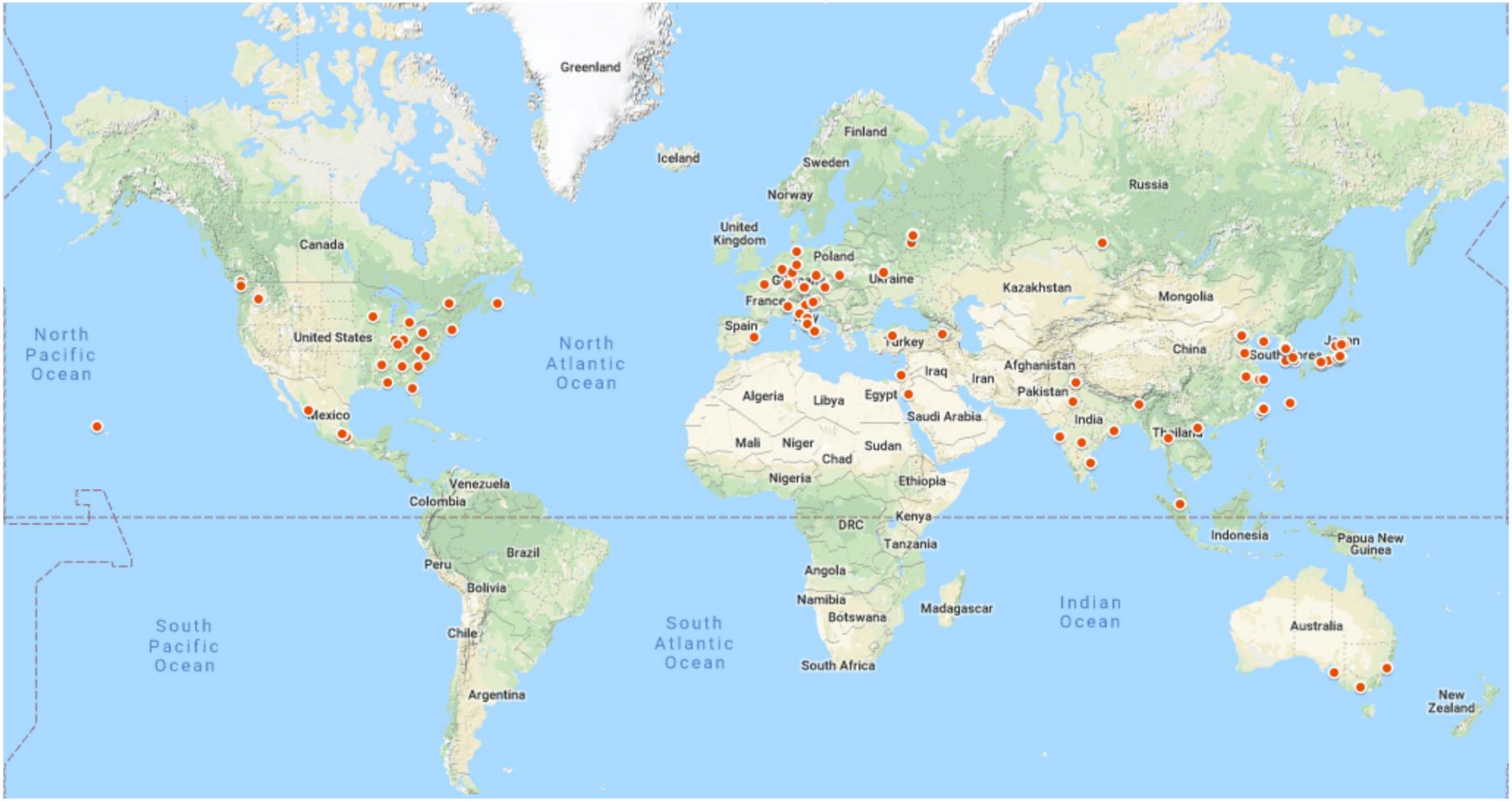
Goals for Summer 2020 (200 fb^{-1})



- Exclusive V_{ub} from $B \to \pi l \nu$, V_{cb} from $B \to D^* l \nu$, rediscovery of $B \to D^* \tau \nu$;
- Rediscovery of $b \to s l^+ l^-$ and of inclusive $b \to s \gamma$;
- Publication quality measurement of TD CP asymmetry in $B^\circ \to J/\psi K^\circ$;
- Rediscovery of $B^\circ \to \pi^\circ \pi^\circ$;
- Resolution and systematics on $D^\circ \to K_s \pi^+ \pi^-$ Dalitz Plot;
- First look at ϕ_3 with GLW and (Belle + Belle II) GGSZ;
- Z charged states, search for Y states in ISR;
- Analysis of $\tau \to h \omega \nu$ and $\tau \to l \alpha (\to \text{invis.})$;
- More Z' searches, Dark Photon and Long Lived Particles (LLP's);
- Perform measurements for which BaBar and Belle did not use full luminosity.

Luminosity goal for ICHEP 2020 is 200/fb

The Belle II Collaboration



- 26 countries, 113 institutions, close to 1000 collaborators

Summary

- Although Belle has stopped data taking for ~10 years ago, we are still producing exciting results [China group has made great contributions].
- Belle II started data taking on 25 March with its full detector.
- Belle II will reach 50 ab^{-1} by 2027, which will provide greater sensitivity and precise measurements in hadron physics

Belle II physics book (arXiv:1808.10567):
https://arxiv.org/abs/1808.10567

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Thanks for your attention

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Observation of $\Xi^0(1620)$ and evidence for $\Xi^0(1690)$

List of Ξ(S=-2) particles from PDG

PRL 122, 072501 (2019)

Particle	J^P	Overall status	Status as seen in — $\Xi\pi$	ΛK	ΣK	$\Xi(1530)\pi$	Other channels
$\Xi(1318)$	1/2+	****					Decays weakly
$\Xi(1530)$	3/2+	****	****				
$\Xi(1620)$	½-?	*	*				
$\Xi(1690)$		***		***	**		
$\Xi(1820)$	3/2−	***	**	***	**	**	
$\Xi(1950)$		***	**	**		*	
$\Xi(2030)$		***		**	***		
$\Xi(2120)$		*		*			
$\Xi(2250)$		**					3-body decays
$\Xi(2370)$		**					3-body decays
$\Xi(2500)$		*		*	*		3-body decays

**** Existence is certain, and properties are at least fairly well explored.
*** Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, *etc.* are not well determined.
** Evidence of existence is only fair.
* Evidence of existence is poor.

- NOT much is known about Ξ^*
- Not found ½-? With L =1
- **Ξ(1620)** and **Ξ(1690)** are candidates
- $\Xi\pi$ is possible mode

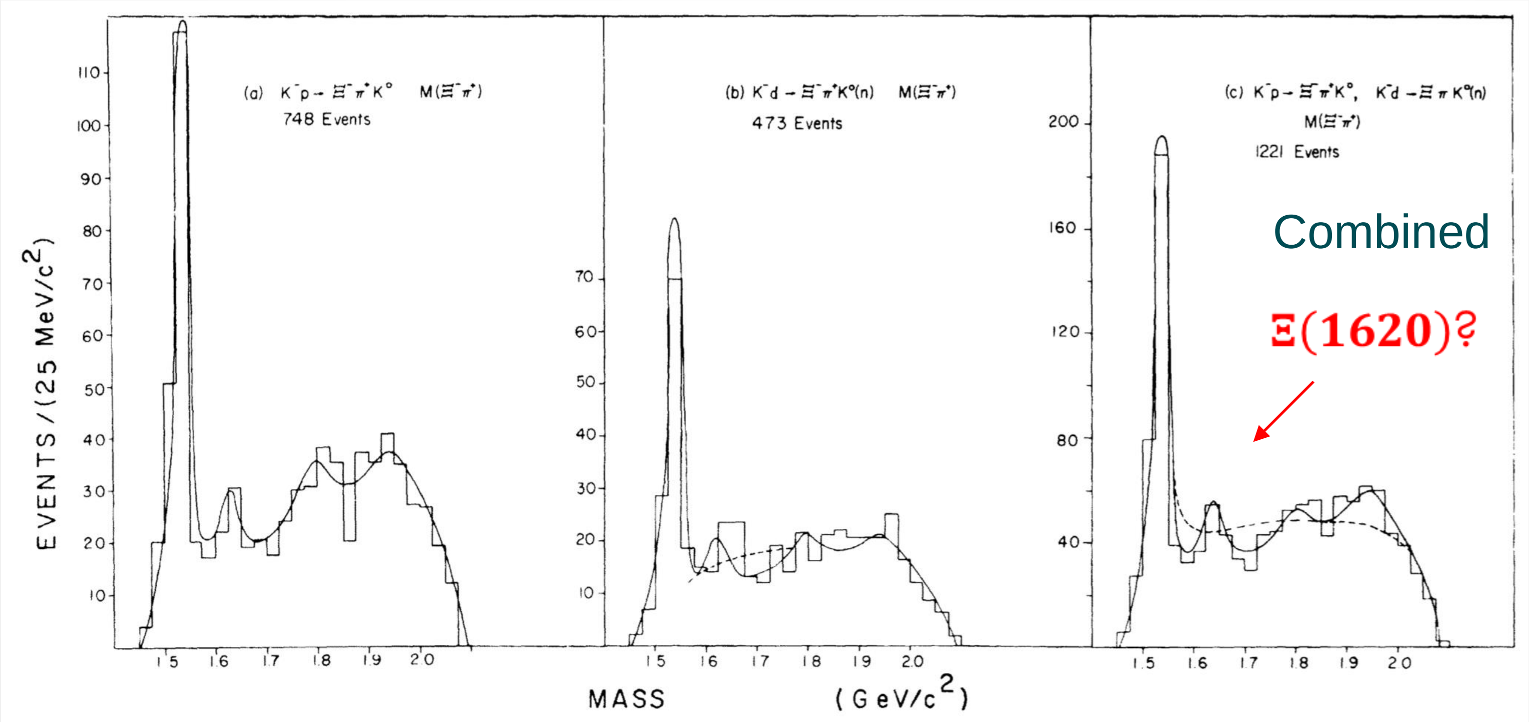
Status of the $\Xi(1620)$

One star:
Evidence of existence is poor
E. Briefel, PRD 16, 2706 (1977)

The data for this analysis came from two separate exposures, consisting of ~10^6 pictures each, of the BNL 31-in. bubble chamber to a separated beam of 2.87-GeV/c K^- mesons. During the first

But !!
J.K.Hassall says “no evidence”
In NPB189 (1981) 397

the Argonne 12 foot bubble chamber



The $\Xi^-\pi^+$ effective-mass distributions for the reaction $K^-p \to \Xi^-\pi^+K^0$

Search for $\Xi^0(1620)$ and $\Xi^0(1690)$ at Belle

PRL 122, 072501 (2019)

Search for $\Xi^0(1620)$ and $\Xi^0(1690)$ at Belle in below channel: $\Xi_c^+ \to \Xi^{*0}\pi^+$, $\Xi^{*0} \to \Xi^-\pi^+$

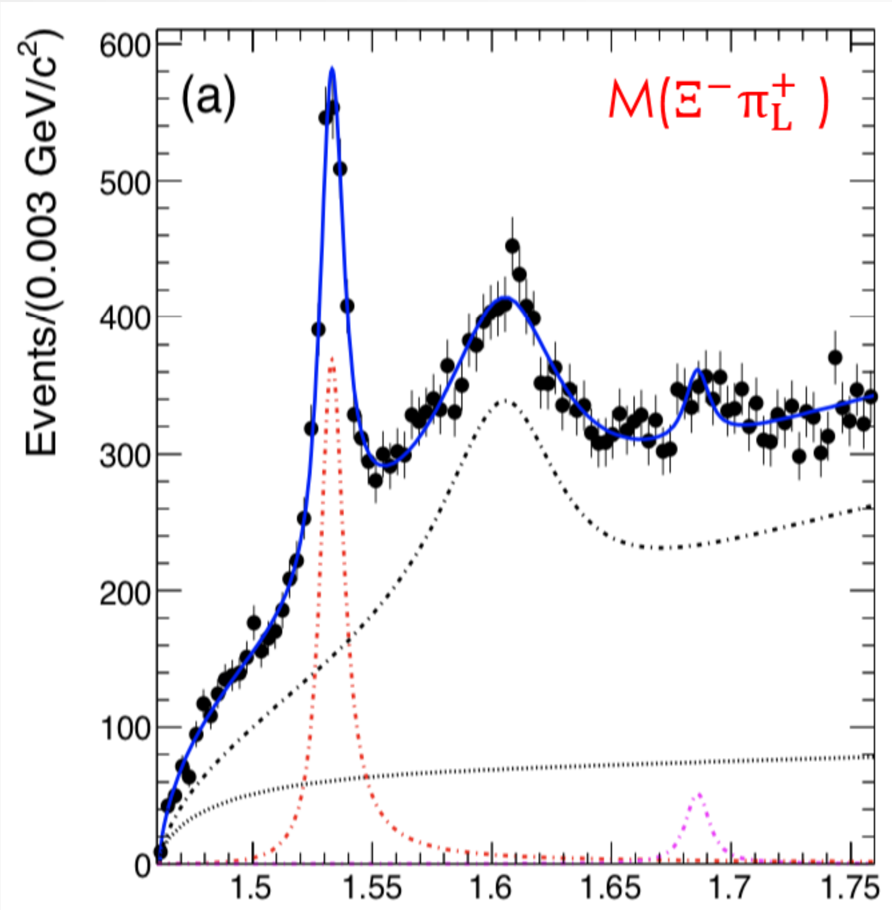
Data set: Total 980fb^{-1}

Data sample	Luminosity(fb^{-1})	Data sample	Luminosity(fb^{-1})
$\Upsilon(1S)$	5.74	$\Upsilon(2S)$	24.91
$\Upsilon(3S)$	2.9	e^+e^- at $\sqrt{s}$=10.52GeV	89.5
e^+e^- at $\sqrt{s}$=10.58GeV	711.0	e^+e^- at $\sqrt{s}$=10.867GeV	121.4

Crucial Selection criteria:

- To purify the Ξ_c^+ samples, the scaled momentum $x_p = \frac{p_{CM}}{\sqrt{\frac{1}{4}s - m(\Xi_c^+)^2}} < 0.5$
- The retained Ξ^- candidates are combined with the lower and higher momentum pions, as labeled π_L^+ and π_H^+.
- A vertex fit is applied to the $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ decay, and the $\chi^2 < 50$

Observation of $\Xi^0(1620)$ and evidence for $\Xi^0(1690)$



PRL 122, 072501 (2019)

In the simultaneous fit

- The $\Xi^0(1530)$ and $\Xi^0(1690)$ signals are modeled with P- and S-wave relativistic BW functions.
- The $\Xi^0(1620)$ signal is modeled with the S-wave relativistic BW function.
- The interference between $\Xi^0(1620)$ and the S-wave non-resonant process is taken into account.
- The combinatorial backgrounds are described by a threshold.

$\Xi^0(1620)$ **state**	
Mass (MeV/c^2)	$1610.4 \pm 6.0^{+5.9}_{-3.5}$
Width (MeV)	$59.9 \pm 4.8^{+2.8}_{-3.0}$

When the S-wave (P-wave) relativistic BW with fixed mass and width is used as the fitting function, the significance for $\Xi^0(1690)$ is 4.6σ (4.0σ).

Observation of an excited Ω^- baryon

PRL 121, 052003 (2018)

Ω^- = s s s (S=-3, I=0)

1. Ω^- excited states have proved difficult to find

- Only one excited Ω^- state, $\Omega(2250)$, has been confirmed until now.
- In addition, evidence for two other states of Ω^- was reported.
- The masses of these excited Ω^- are much higher than the ground state (>600MeV).

2. $\Omega^{*-} \rightarrow \Omega^- + \pi^0$ is highly suppressed since Ω^- has isospin zero

3. Preferred modes

- $\boldsymbol{\Omega^{*-} \rightarrow \Xi^- + K_S^0}$ ✓
- $\boldsymbol{\Omega^{*-} \rightarrow \Xi^0 + K^-}$ ✓
- Low-lying states
- Analogous to $\Omega_c^0 \rightarrow \Xi_c^+ K^-$

[R. Aaij et al. PRL 118, 182001 (2017)]
[J. Yelton et al. PRD 97, 051102 (2018)]

Data sample	Luminosity(fb^{-1})	Events ($\times 10^8$)
$\Upsilon(1S)$	5.7	1.02
$\Upsilon(2S)$	24.9	1.58
$\Upsilon(3S)$	2.9	-

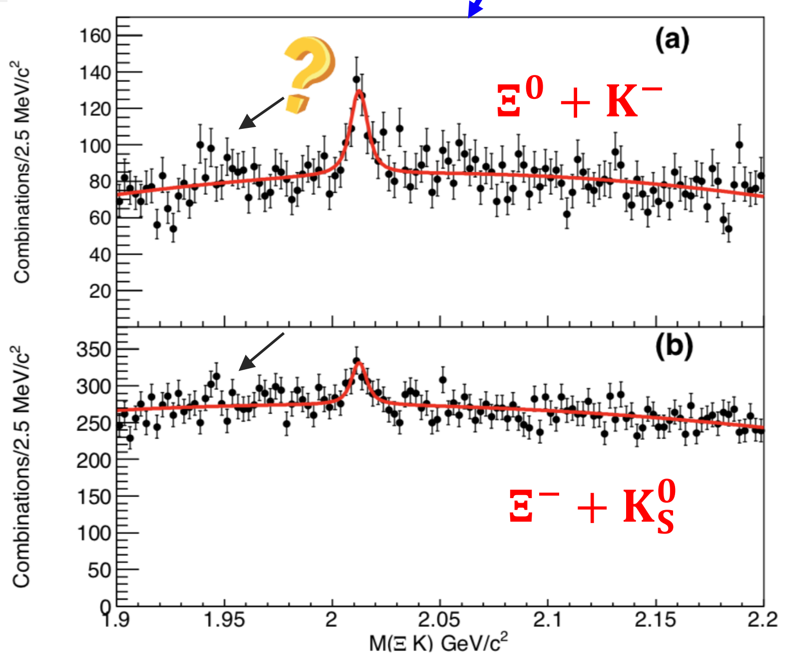
- Decays of these narrow resonances proceed via gluons.
- Production of baryon is enhanced.

Observation of an excited Ω^- baryon

Results & Summary

$$\mathcal{R} = \frac{\mathcal{B}(\Omega^{*-}\to\Xi^0 K^-)}{\mathcal{B}(\Omega^{*-}\to\Xi^-\bar{K}^0)} = 1.2 \pm 0.3$$

Data	Mode	Mass (MeV/c^2)	Yield	Γ(MeV)	χ^2/d.o.f.	n_σ
$\Upsilon(1S,2S,3S)$	$\Xi^0 K^-$, $\Xi^- K_S^0$ (simultaneous)	2012.4 ± 0.7	242 ± 48, 279 ± 71	$6.4^{+2.5}_{-2.0}$	227/230	8.3
$\Upsilon(1S,2S,3S)$	$\Xi^0 K^-$	2012.6 ± 0.8	239 ± 53	6.1 ± 2.6	115/114	6.9
$\Upsilon(1S,2S,3S)$	$\Xi^- K_S^0$	2012.0 ± 1.1	286 ± 87	6.8 ± 3.3	101/114	4.4
Other	$\Xi^0 K^-$	2012.4 (Fixed)	209 ± 63	6.4 (Fixed)	102/116	3.4
Other	$\Xi^- K_S^0$	2012.4 (Fixed)	153 ± 89	6.4 (Fixed)	133/116	1.7



PRL 121, 052003 (2018)

- The gap in the spectrum between the ground state and this excited state (~340 MeV) is smaller than in other Ω^- excited states, which is closer to the negative-parity orbital excitations of many other baryons.
- The narrow width observed implies that the quantum number $J^P = \frac{3}{2}^-$ is preferable.

Theoretical interpretation for the $\Omega^*(2012)$

It is generally accepted that $\Omega^*(2012)$ is 1P orbital excitation of the ground state Ω baryon with the three strange quarks, whose quantum numbers are $J^P = \frac{3}{2}^-$.

Notably, the newly observed $\Omega^*(2012)$ is revealed as a KΞ(1530) hadronic molecule.
[PRD 98, 054009 (2018),
PRD 98, 056013 (2018),
arXiv:1807.02145,
arXiv:1807.06485,
arXiv:1807.06485,
......]
The $K\Xi\pi$ three-body component is largely dominant.

From PRD 98, 056013 (2018

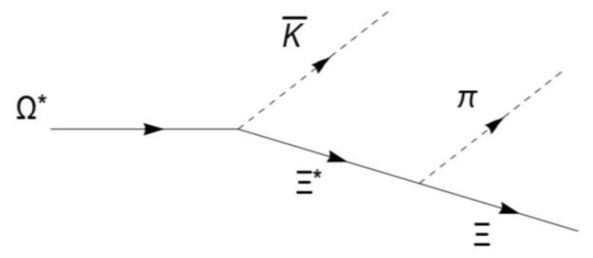


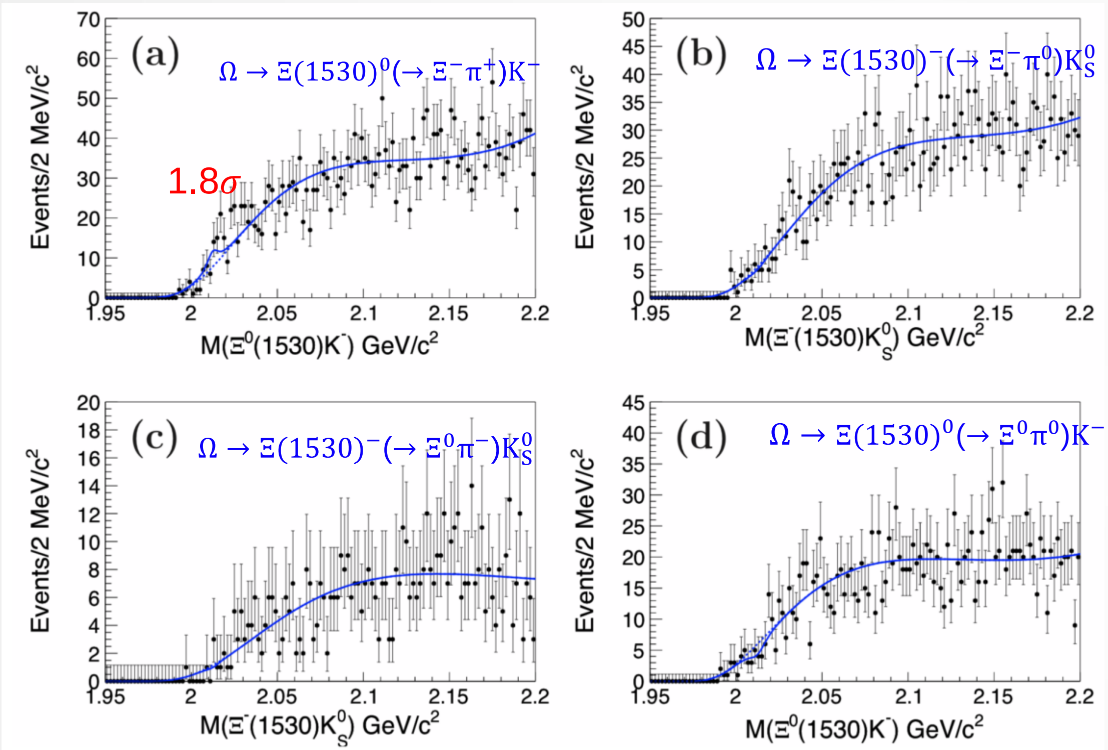
FIG. 1: The three-body decays of Ω(2012) in the $K\Xi(1530)$ molecular picture.

Mode	$J^P = \frac{3}{2}^-$ Ω(2012) ($K\Xi(1530)$) Widths (MeV)	Branch Ratio(%)
$K\Xi$	0.4	14.3
$K\pi\Xi$	2.4	85.7
Total	2.8	100.0

Search for $\Omega(2012) \to K\Xi(1530) \to K\pi\Xi$

We use the same data samples to search for $\Omega(2012) \to K\Xi(1530) \to K\pi\Xi$ in the decay of the narrow resonances $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$.

arxiv: 1906.00194



No clear $\Omega(2012)$ signals are observed.
We give the upper limits on the ratios of the branching fractions at 90% C.L. as below.

$$R^{\Xi^-\pi^+K^-}_{\Xi^-\bar{K}^0} = \frac{\mathcal{B}(\Omega \to \Xi(1530)^0(\to \Xi^-\pi^+)K^-)}{\mathcal{B}(\Omega \to \Xi^-\bar{K}^0)} < 9.3\%$$

$$R^{\Xi^-\pi^0\bar{K}^0}_{\Xi^-\bar{K}^0} = \frac{\mathcal{B}(\Omega \to \Xi(1530)^-(\to \Xi^-\pi^0)\bar{K}^0)}{\mathcal{B}(\Omega \to \Xi^-\bar{K}^0)} < 81.1\%$$

$$R^{\Xi^0\pi^-\bar{K}^0}_{\Xi^0K^-} = \frac{\mathcal{B}(\Omega \to \Xi(1530)^-(\to \Xi^0\pi^-)\bar{K}^0)}{\mathcal{B}(\Omega \to \Xi^0K^-)} < 21.3\%$$

$$R^{\Xi^0\pi^0K^-}_{\Xi^0K^-} = \frac{\mathcal{B}(\Omega \to \Xi(1530)^0(\to \Xi^0\pi^0)K^-)}{\mathcal{B}(\Omega \to \Xi^0K^-)} < 30.4\%$$

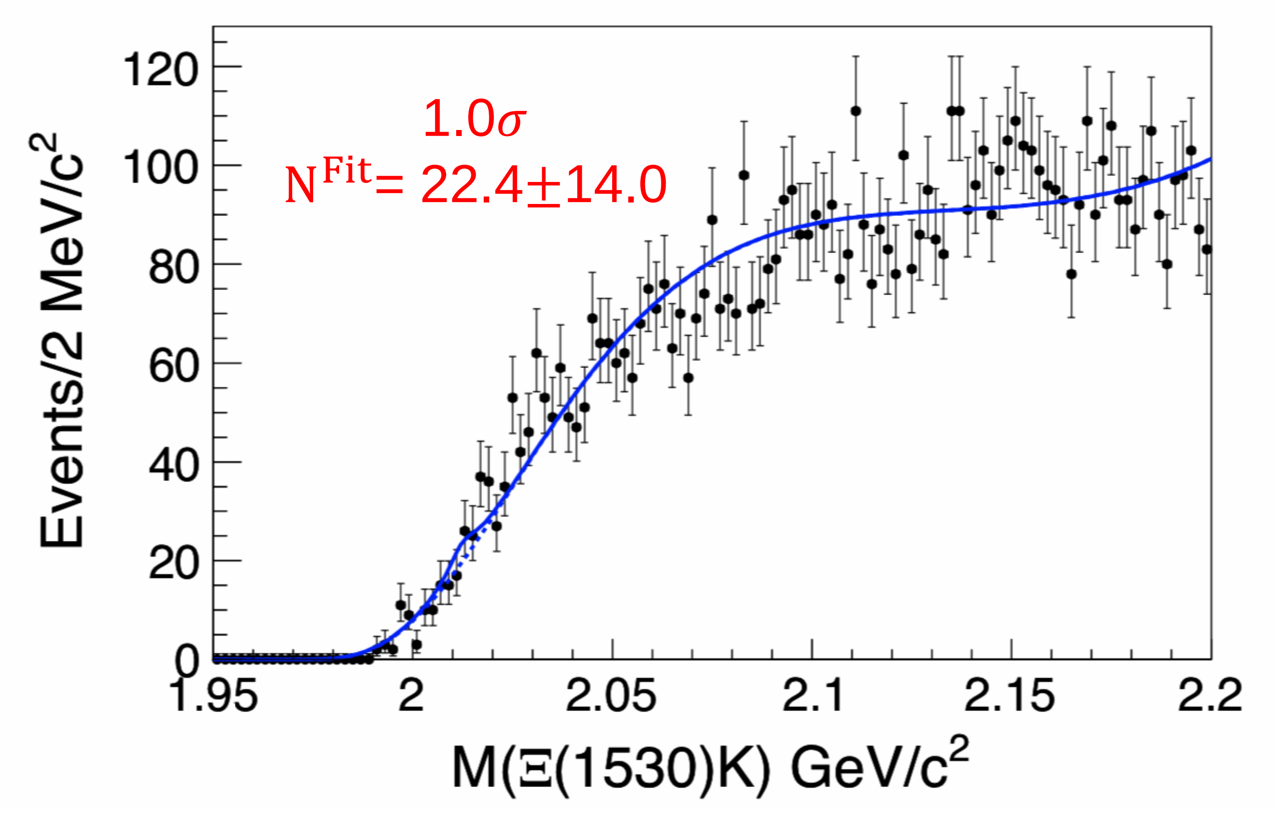
$$R^{\Xi^-\pi^+K^-}_{\Xi^0K^-} = \frac{\mathcal{B}(\Omega \to \Xi(1530)^0(\to \Xi^-\pi^+)K^-)}{\mathcal{B}(\Omega \to \Xi^0K^-)} < 7.8\%$$

$$R^{\Xi^0\pi^-\bar{K}^0}_{\Xi^-\bar{K}^0} = \frac{\mathcal{B}(\Omega \to \Xi(1530)^-(\to \Xi^-\pi^0)\bar{K}^0)}{\mathcal{B}(\Omega \to \Xi^-\bar{K}^0)} < 25.6\%$$

Mode	N^{Fit}	N^{UL}
$\Omega \to \Xi(1530)^0(\to \Xi^-\pi^+)K^-$	22.5±12.9	41.0
$\Omega \to \Xi(1530)^-(\to \Xi^-\pi^0)K^0_S$	-3.5±11.6	16.6
$\Omega \to \Xi(1530)^-(\to \Xi^0\pi^-)K^0_S$	-1.0±3.6	7.2
$\Omega \to \Xi(1530)^0(\to \Xi^0\pi^0)K^-$	-12.0±9.8	13.2

Search for Ω(2012) → KΞ(1530) → KπΞ

A simultaneous fit to all three-body decay modes is performed.



$$R_{\Xi K}^{\Xi\pi K} = \frac{\mathcal{B}(\Omega\to\Xi(1530)(\to\Xi\pi)K)}{\mathcal{B}(\Omega\to\Xi K)} = (6.0\pm3.7(\text{stat.})\pm1.3(\text{syst.}))\%$$

$$R_{\Xi K}^{\Xi\pi K} = \frac{\mathcal{B}(\Omega\to\Xi(1530)(\to\Xi\pi)K)}{\mathcal{B}(\Omega\to\Xi K)} < 11.9\% \text{ at } 90\% \text{ C.L.}$$