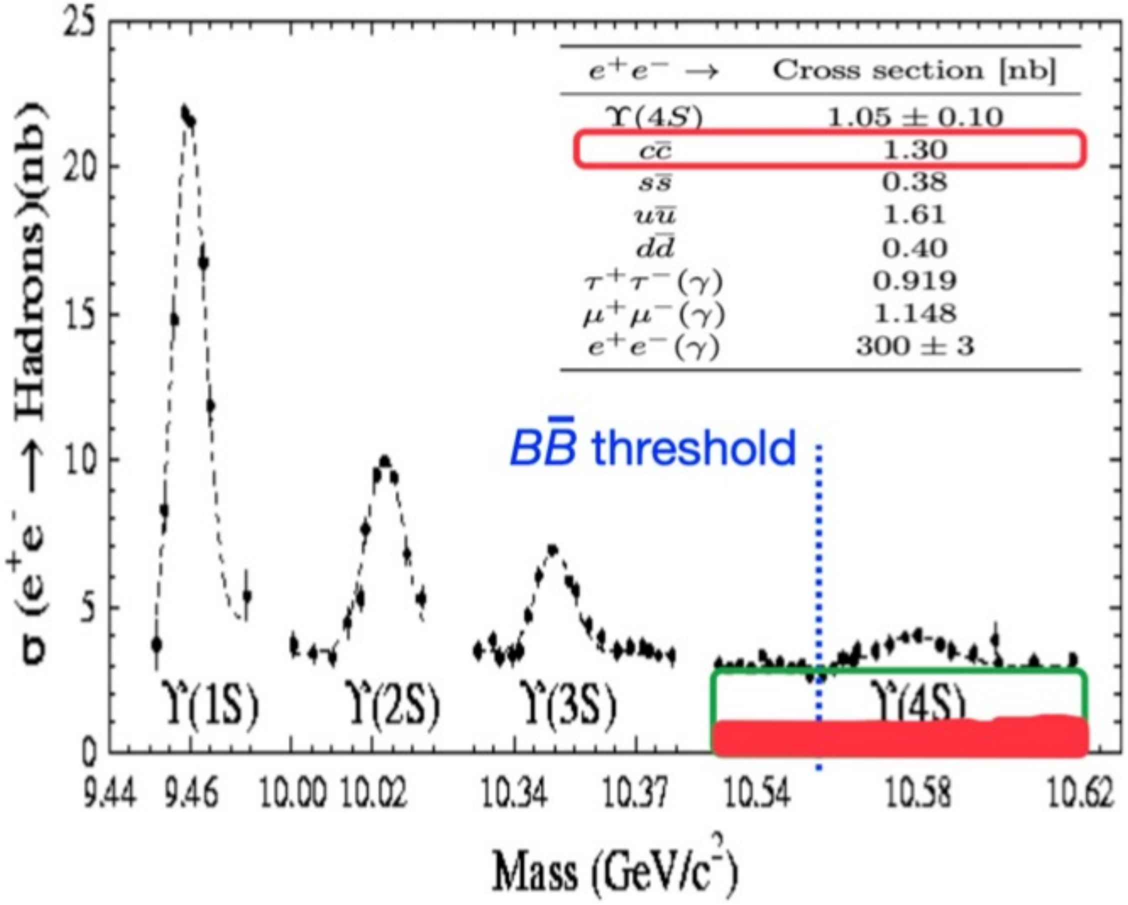
Belle(II)上粲重子实验进展

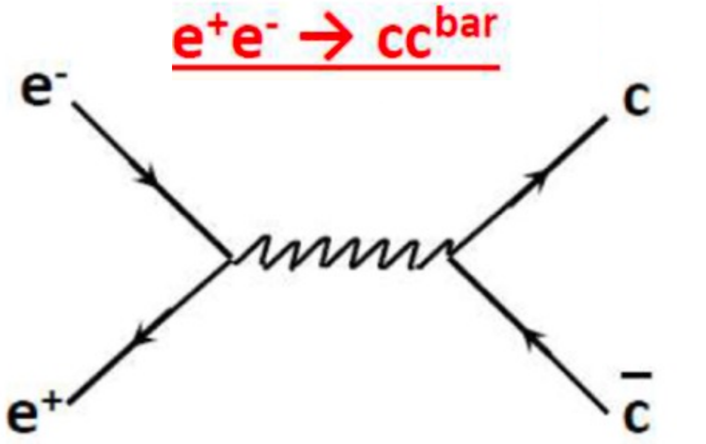
贾森 (东南大学)
on behalf of the Belle and Belle II Collaboration

第三届强子与重味物理理论与实验联合讨论会
2024年4月5 – 9日, 武汉

Dataset and charmed baryon production at Belle(II)

- In B-factories, e^+e^- collider at 10.58 GeV to make $\Upsilon(4S)$ resonance decaying into $B^0\overline{B}^0$ and B^+B^- in 96% of the time.
- Meanwhile, a large cross section for continuum processes $e^+e^- \to q\bar{q}$ ($q = u, d, s, c$).





Datasets	Luminosity
Belle	980 fb^{-1}
Belle II	426 fb^{-1}

Selected topics:

1. $\Xi_c^0 \to \Xi^0 h^0$ ($h^0 = \pi^0, \eta, \eta'$) [Preliminary results]
2. $\Xi_c^0 \to \Xi^0 \ell^+ \ell^-$ [PRD 109, 052003 (2024)]
3. $\Lambda_c^+ \to \Sigma^+ h^0$ ($h^0 = \pi^0, \eta, \eta'$) [PRD 107, 032003 (2023)]
4. $\Lambda_c^+ \to p K_S^0 K_S^0, p K_S^0 \eta$ [PRD 107, 032004 (2023)]
5. $\Lambda_c(2625)^+ \to \Sigma_c^{0,++} \pi$ [PRD 107, 032008 (2023)]
6. $\Lambda_c^+ \to \Lambda \pi^+ \pi^+ \pi^-$ [PRL 130, 151903 (2023)]
7. $\Omega_c^0 \to \Xi^- \pi^+ / \Xi^- K^+ / \Omega^- K^+$ [JHEP 01 (2023) 055]

Study of $\Xi_c^0 \to \Xi^0 h^0$ $(h^0 = \pi^0, \eta, \eta')$

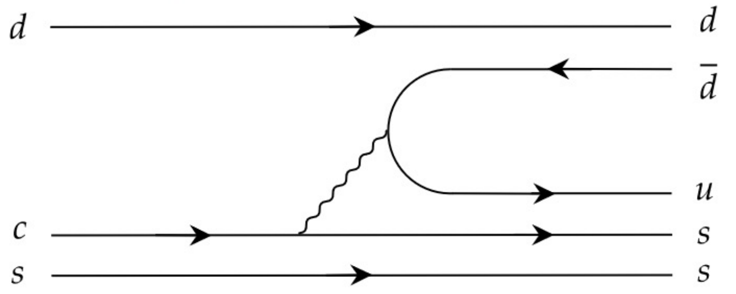
Motivation:

- Nonfactorizable amplitudes arising from internal W-emission and W-exchange lead to the difficulties for theoretical predictions in hadronic weak decay of charmed baryons.

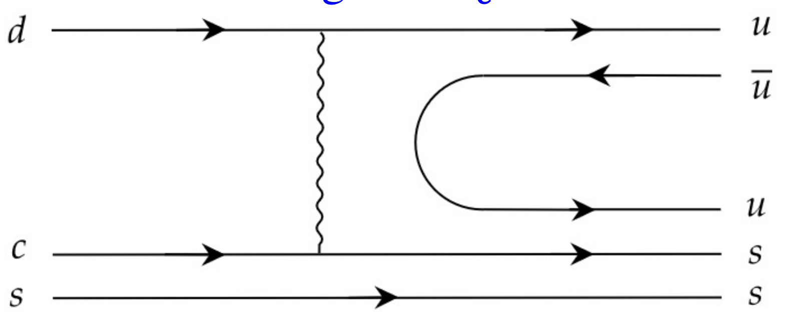
Theoretical predictions for branching fractions ($\times 10^{-3}$) and asymmetry parameters:

Reference	Model	$\mathcal{B}(\Xi_c^0 \to \Xi^0\pi^0)$	$\mathcal{B}(\Xi_c^0 \to \Xi^0\eta)$	$\mathcal{B}(\Xi_c^0 \to \Xi^0\eta')$	$\alpha(\Xi_c^0 \to \Xi^0\pi^0)$
Körner, Krämer [5]	quark	0.5	3.2	11.6	0.92
Xu, Kamal [7]	pole	7.7	-	-	0.92
Cheng, Tseng [8]	pole	3.8	-	-	-0.78
Cheng, Tseng [8]	CA	17.1	-	-	0.54
Żenczykowski [9]	pole	6.9	1.0	9.0	0.21
Ivanov *et al.* [6]	quark	0.5	3.7	4.1	0.94
Sharma, Verma [11]	CA	-	-	-	-0.8
Geng *et al.* [12]	SU(3)$_F$	4.3 ± 0.9	$1.7^{+1.0}_{-1.7}$	$8.6^{+11.0}_{-6.3}$	-
Geng *et al.* [13]	SU(3)$_F$	7.6 ± 1.0	10.3 ± 2.0	9.1 ± 4.1	$-1.00^{+0.07}_{-0.00}$
Zhao *et al.* [14]	SU(3)$_F$	4.7 ± 0.9	8.3 ± 2.3	7.2 ± 1.9	-
Zou *et al.* [10]	pole	18.2	26.7	-	-0.77
Huang *et al.* [15]	SU(3)$_F$	2.56 ± 0.93	-	-	-0.23 ± 0.60
Hsiao *et al.* [16]	SU(3)$_F$	6.0 ± 1.2	$4.2^{+1.6}_{-1.3}$	-	-
Hsiao *et al.* [16]	SU(3)$_F$-breaking	3.6 ± 1.2	7.3 ± 3.2	-	-
Zhong *et al.* [17]	SU(3)$_F$	$1.13^{+0.59}_{-0.49}$	1.56 ± 1.92	$0.683^{+3.272}_{-3.268}$	$0.50^{+0.37}_{-0.35}$
Zhong *et al.* [17]	SU(3)$_F$-breaking	$7.74^{+2.52}_{-2.32}$	$2.43^{+2.79}_{-2.90}$	$1.63^{+5.09}_{-5.14}$	$-0.29^{+0.20}_{-0.17}$
Xing *et al.* [18]	SU(3)$_F$	1.30 ± 0.51	-	-	-0.28 ± 0.18

Internal W-emission for $\Xi_c^0 \to \Xi^0 h^0$



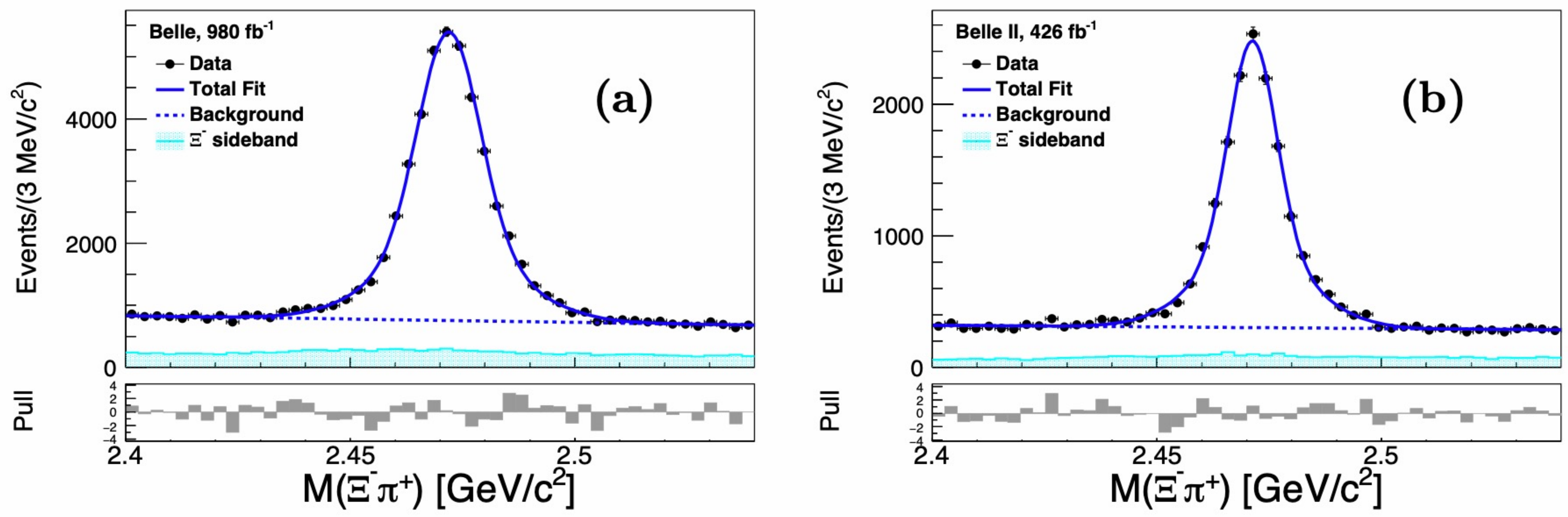
W-exchange for $\Xi_c^0 \to \Xi^0 h^0$



[5] Z. Phys. C 55 (1992) 659 [6] PRD 57 (1998) 6532 [7] PRD 46 (1992) 053004 [8] PRD 48 (1993) 4188 [9] PRD 50 (1994) 5787 [10] PRD 101 (2020) 014011 [11] EPJC 7 (1999) 217 [12] PRD 97 (2018) 073006 [13] PLB 794 (2019) 19 [14] JHEP 02 (2020) 165 [15] JHEP 03 (2022) 143 [16] JHEP 09 (2022) 35 [17] JHEP 02 (2023) 235 [18] PRD 108 (2023) 053004

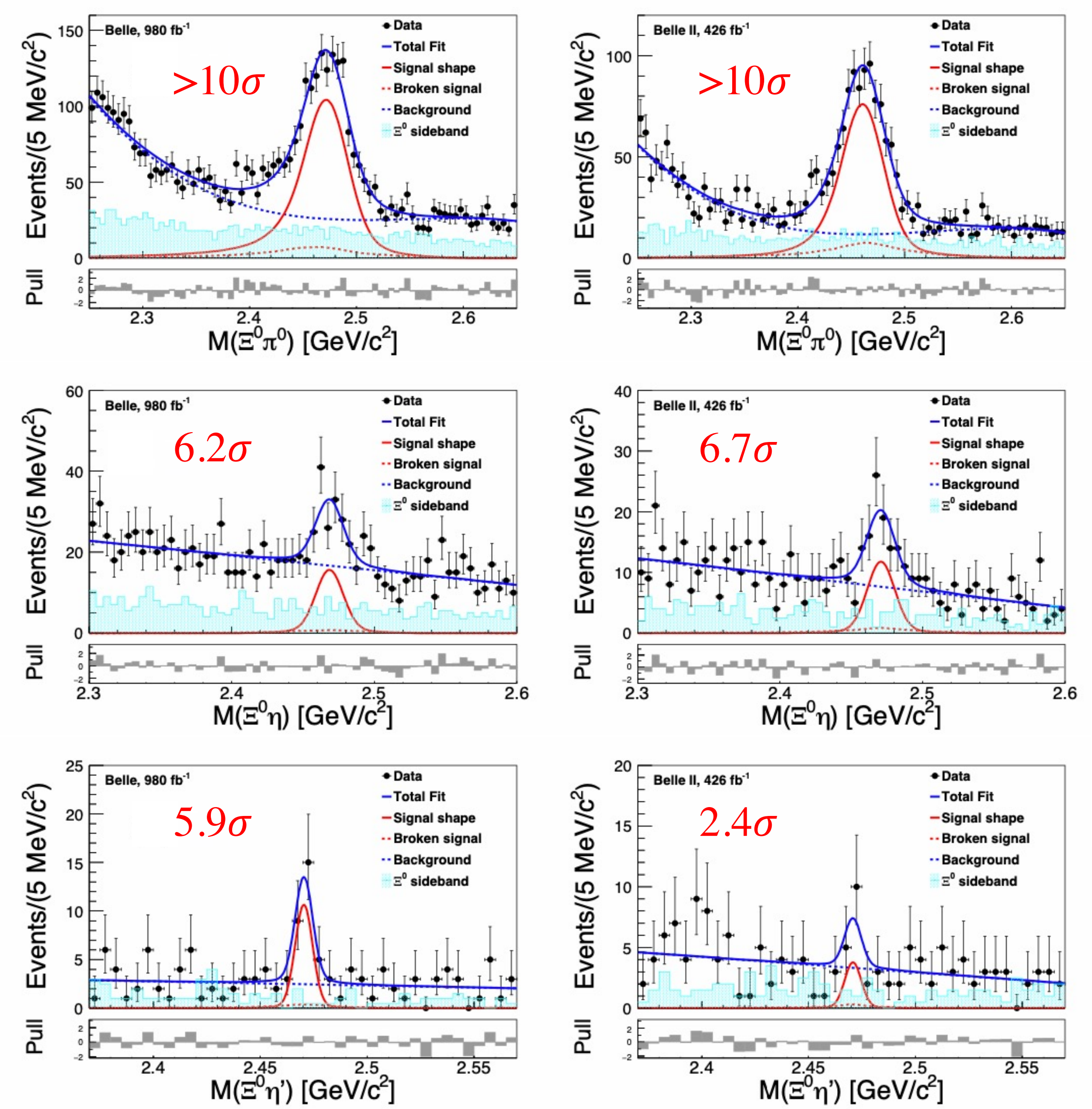
Reference mode of $\Xi_c^0 \to \Xi^- \pi^+$

First BELLE + Belle II combined charm measurement.



Datasets	Signal yield
Belle	36340±348
Belle II	13719±184

Branching fractions for $\Xi_c^0 \to \Xi^0 h^0$ ($h^0 = \pi^0, \eta, \eta'$)



Preliminary results, will be submitted to JHEP

Signal yield:

Channel	Belle	Belle II
$\Xi_c^0 \to \Xi^0\pi^0$	1315±66	869±46
$\Xi_c^0 \to \Xi^0\eta$	81±15	60±11
$\Xi_c^0 \to \Xi^0\eta'$	23±6	8±4

First measurement of the following BRs:

$$\mathcal{B}(\Xi_c^0 \to \Xi^0\pi^0) = (6.9 \pm 0.3(\text{stat.}) \pm 0.5(\text{syst.}) \pm 1.5(\text{norm.})) \times 10^{-3}$$

$$\mathcal{B}(\Xi_c^0 \to \Xi^0\eta) = (1.6 \pm 0.2(\text{stat.}) \pm 0.2(\text{syst.}) \pm 0.4(\text{norm.})) \times 10^{-3}$$

$$\mathcal{B}(\Xi_c^0 \to \Xi^0\eta') = (1.2 \pm 0.3(\text{stat.}) \pm 0.1(\text{syst.}) \pm 0.3(\text{norm.})) \times 10^{-3}$$

They are compatible with theoretical prediction based on SU(3)$_F$-breaking [JHEP 02, 235 (2023)].

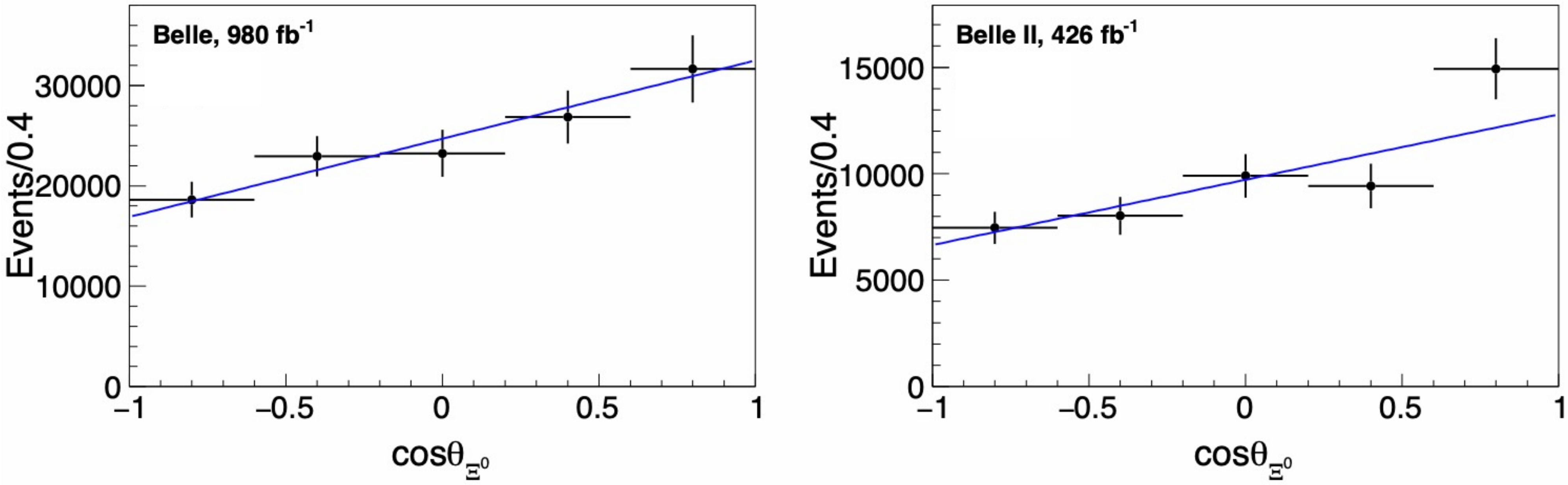
Asymmetry parameter for $\Xi_c^0 \to \Xi^0\pi^0$

The asymmetry parameter, related to P-violation, is measured through the differential decay rate:

Preliminary results

$$\frac{dN}{d\cos\theta_{\Xi^0}} \propto 1 + \alpha(\Xi_c^0 \to \Xi^0 h^0)\alpha(\Xi^0 \to \Lambda\pi^0)\cos\theta_{\Xi^0}$$

The $\cos\theta_{\Xi^0}$ is the angle between the Λ momentum vector and the opposite of the Ξ_c^0 momentum vector in the Ξ^0 rest frame.



The $\alpha(\Xi_c^0 \to \Xi^0\pi^0) = -0.90\pm0.15\pm0.23$, which is consistent with predictions based on the pole model [PRD 48 (1993) 4188, PRD 101 (2020) 014011], CA [EPJC 7 (1999) 217], and $SU(3)_F$ flavor symmetry [PLB 794 (2019) 19] approaches.

Search for the semileptonic decays of $\Xi_c^0 \to \Xi^0 \ell^+ \ell^-$

Motivation

- Few baryonic neutrino-less semileptonic decays were observed experimentally [1-4].
- Only upper limits were set for $\Lambda_c^+ \to p\ell^+\ell^-$ decay for the charmed baryons [5, 6].
- With the SU(3) flavor symmetry, $\mathcal{B}(\Xi_c^0 \to \Xi^0 e^+ e^-) \leq 2.35\times10^{-6}$ and $\mathcal{B}(\Xi_c^0 \to \Xi^0 \mu^+\mu^-) \leq 2.25\times10^{-6}$ [PRD 103, 013007 (2021)].
- It will help the understanding of the recent anomalies in $b \to s\ell^+\ell^-$ processes, i.e. $B \to K^{(*)}\ell^+\ell^-$.

decays	Experimental results on $\mathcal{B}_f$	Ref.
$\Xi^0 \to \Lambda e^+ e^-$	$(7.6 \pm 0.4 \pm 0.4 \pm 0.2) \times 10^{-6}$	[1] PLB 650, 1 (2007)
$\Sigma^+ \to p\mu^+\mu^-$	$(8.6^{+6.6}_{-5.4} \pm 5.5) \times 10^{-8}$	[2] PRL 94, 021801 (2005)
$\Lambda_b^0 \to \Lambda\mu^+\mu^-$	$(1.73 \pm 0.42 \pm 0.55) \times 10^{-6}$	[3] PRL 107, 201802 (2011)
$\Lambda_b^0 \to \Lambda\mu^+\mu^-$	$(0.96 \pm 0.16 \pm 0.13 \pm 0.21) \times 10^{-6}$	[4] JHEP 06, 115 (2015)
$\Lambda_c^+ \to p e^+ e^-$	$< 5.5\times10^{-6}$ @ 90% C. L.	[5] PRD 84, 072006 (2011)
$\Lambda_c^+ \to p\mu^+\mu^-$	$< 44\times10^{-6}$ @ 90% C. L.	[5] PRD 84, 072006 (2011)
$\Lambda_c^+ \to p\mu^+\mu^-$	$< 7.7\times10^{-8}$@ 90% C. L.	[6] PRD 97, 091101(2018)

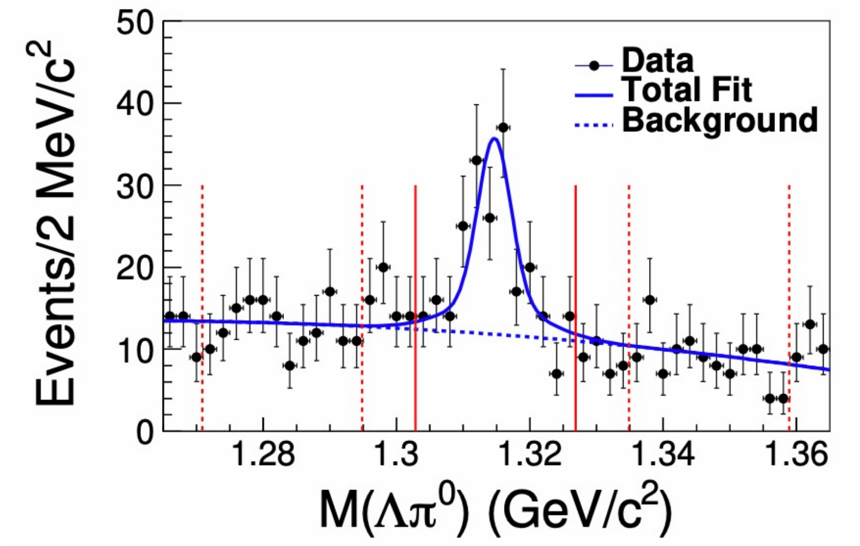
Search for the semileptonic decays of $\Xi_c^0 \to \Xi^0 \ell^+ \ell^-$

Results:

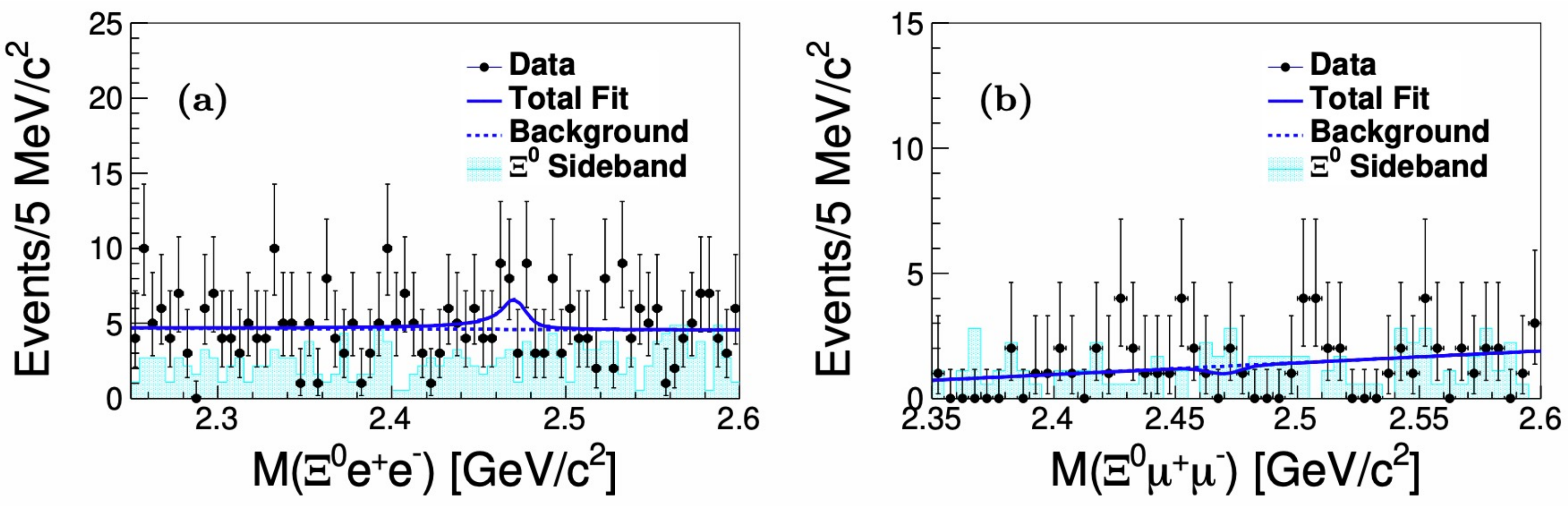
[PRD 109, 052003 (2024)]

Full Belle dataset

Ξ^0 reconstruction



$\Xi^0 \ell^+ \ell^-$ invariant-mass spectra

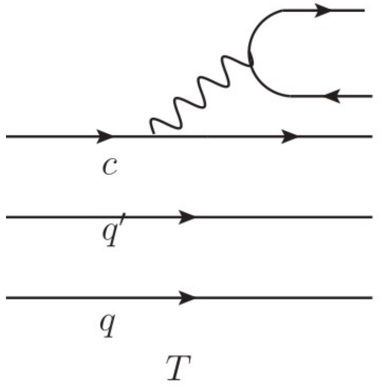


- No significant signals are observed in the $\Xi^0 \ell^+ \ell^-$ invariant-mass spectra.
- 90% credibility upper limits on branching fractions are set:
  - $\mathcal{B}(\Xi_c^0 \to \Xi^0 \ell^+ \ell^-)/\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+) < 6.7\ (4.3) \times 10^{-3}$ and
  - $\mathcal{B}(\Xi_c^0 \to \Xi^0 \ell^+ \ell^-) < 9.9\ (6.5) \times 10^{-5}$ for electron (muon) mode.

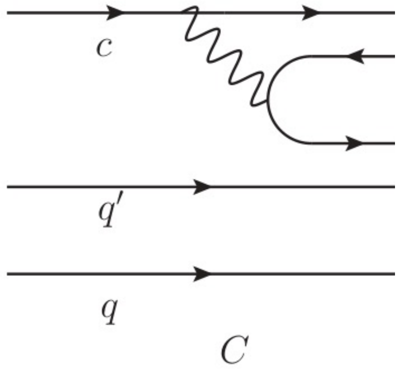
Measurements of $\Lambda_c^+ \to \Sigma^+\pi^0, \Sigma^+\eta$, and $\Sigma^+\eta'$

Motivation

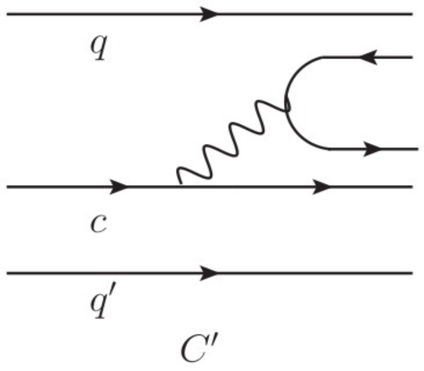
- For the charmed baryon weak decays: $\mathbf{B_c} \to \mathbf{B} + \mathbf{M}$, there are six topological diagrams. Among them, T and C are factorizable, while C′ and E_{1-3} are nonfactorizable.
- All the nonfactorizable diagrams contribute to $\Lambda_c^+ \to \Sigma^+\eta(\eta')$.



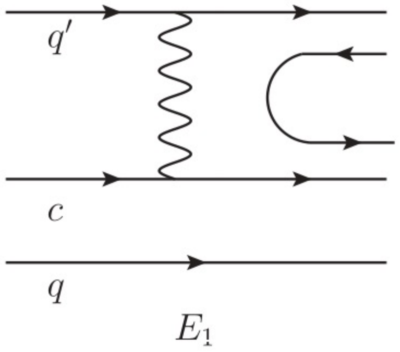
external W-emission T

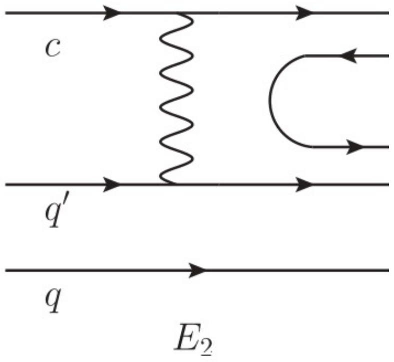


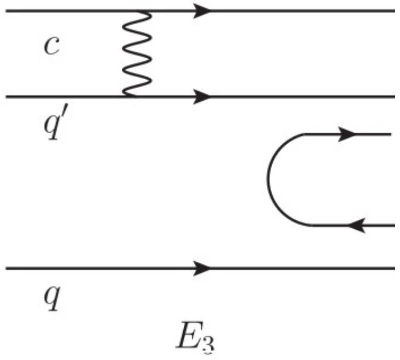
internal W-emission C



inner W-emission C′







W-exchange diagrams E_1, E_2, E_3

Measurements of $\Lambda_c^+ \to \Sigma^+\pi^0, \Sigma^+\eta$, and $\Sigma^+\eta'$

Motivation

- Theoretical predictions on the branching fractions and asymmetry parameters of $\Lambda_c^+ \to \Sigma^+\eta(\eta')$ vary across.
- Branching fractions of $\Lambda_c^+ \to \Sigma^+\eta(\eta')$ are measured with large uncertainty ($\delta B/B>40\%$). Decay asymmetry parameters for these two modes have never been measured.

Decay	Körner [1]	Ivanov [2]	Żenczykowski [7]	Sharma [8]	Zou [10]	Geng [11]	Experiment [18]
$\Lambda_c^+\to\Sigma^+\eta$	0.16	0.11	0.90	0.57	0.74	0.32±0.13	0.44±0.20
$\Lambda_c^+\to\Sigma^+\eta'$	1.28	0.12	0.11	0.10	–	1.44±0.56	1.5±0.6
$\Lambda_c^+\to\Sigma^+\pi^0$	0.70	0.43	0.39	−0.31	−0.76	−0.35±0.27	−0.55±0.11
$\Lambda_c^+\to\Sigma^+\eta$	0.33	0.55	0.00	−0.91	−0.95	−0.40±0.47	–
$\Lambda_c^+\to\Sigma^+\eta'$	−0.45	−0.05	−0.91	0.78	0.68	$1.00^{+0.00}_{-0.17}$	–

$\times 10^{-2}$

Branching fractions

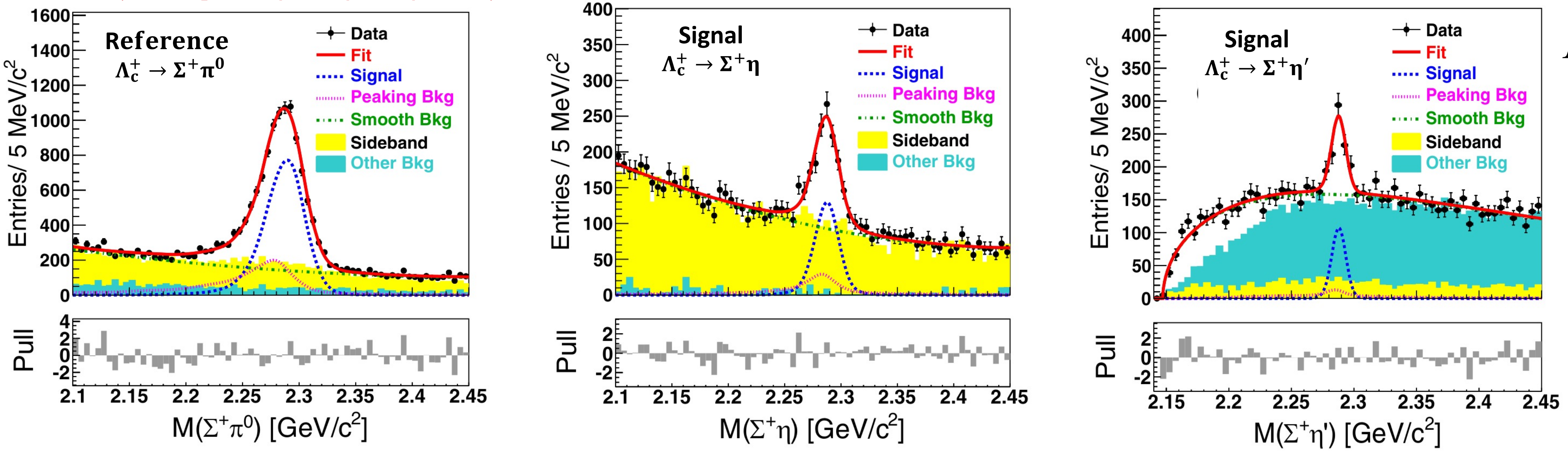
Asymmetry parameters

[1] Z. Phys. C 55, 659 (1992) [2] PRD 57, 5632 (1998) [7] PRD 50, 5787 (1994) [8] EPJC 7, 217 (1999) [10] PRD 49, 3417 (1994) [11] PLB 794, 19 (2019) [18] PTEP 2022, 083C01 (2022)

Measurements of $\Lambda_c^+ \to \Sigma^+\pi^0, \Sigma^+\eta$, and $\Sigma^+\eta'$

- **Measurements of branching fractions of $\Lambda_c^+ \to \Sigma^+\eta$ and $\Lambda_c^+ \to \Sigma^+\eta'$** [PRD 107, 032003 (2023)]

$(\Sigma^+ \to p\pi^0;\ \eta' \to \eta\pi\pi;\ \eta \to \gamma\gamma)$



Full Belle dataset

$$\frac{B(\Lambda_c^+\to\Sigma^+\eta)}{B(\Lambda_c^+\to\Sigma^+\pi^0)} = 0.25 \pm 0.03 \pm 0.01; \qquad B(\Lambda_c^+ \to \Sigma^+\eta) = (3.14 \pm 0.35 \pm 0.11 \pm 0.25)\times 10^{-3}$$

$$\frac{B(\Lambda_c^+\to\Sigma^+\eta')}{B(\Lambda_c^+\to\Sigma^+\pi^0)} = 0.33 \pm 0.06 \pm 0.02; \qquad B(\Lambda_c^+ \to \Sigma^+\eta') = (4.16 \pm 0.75 \pm 0.21 \pm 0.33)\times 10^{-3}$$

statistical systematical from $B(\Lambda_c^+ \to \Sigma^+\pi^0)$

PDG: $B(\Lambda_c^+ \to \Sigma^+\eta) = (4.4 \pm 2.0)\times 10^{-3}$

PDG: $B(\Lambda_c^+ \to \Sigma^+\eta') = (15 \pm 6)\times 10^{-3}$

Consistent with PDG. Most precise result to date.

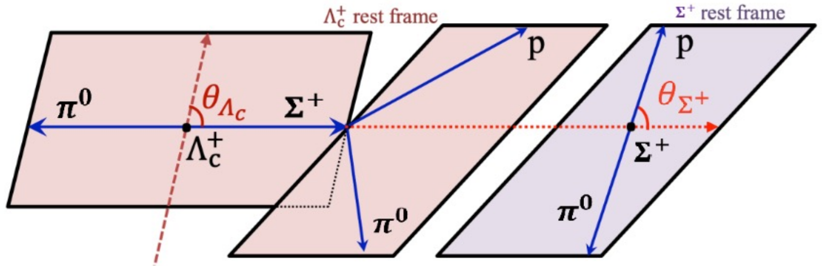
Measurements of $\Lambda_c^+ \to \Sigma^+\pi^0, \Sigma^+\eta$, and $\Sigma^+\eta'$

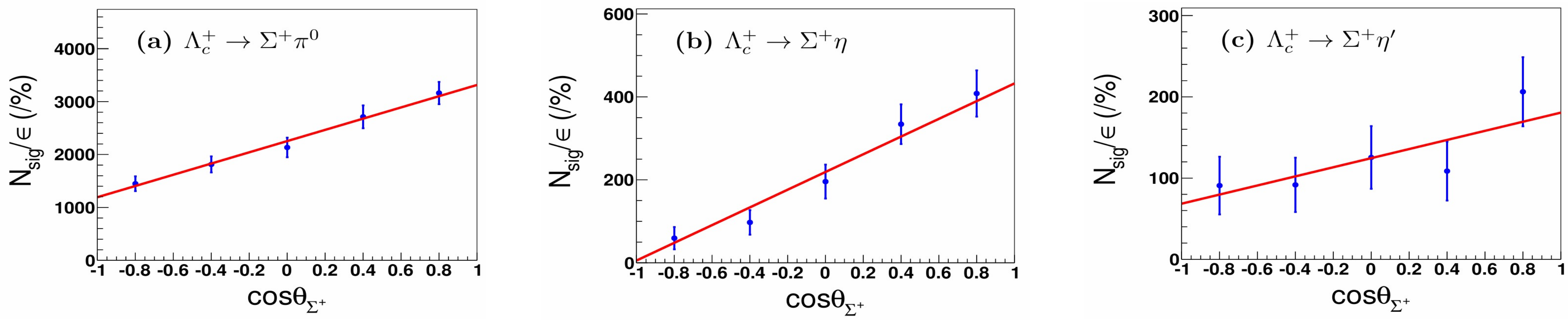
■ Measurements of asymmetry parameters of $\Lambda_c^+ \to \Sigma^+\pi^0$, $\Sigma^+\eta$, and $\Sigma^+\eta'$ [PRD 107, 032003 (2023)]

The differential decay rate depends on the asymmetry parameter α_{Σ^+X} as:

$$\frac{dN}{d\cos\theta_{\Sigma^+}} \propto 1 + \alpha_{\Sigma^+X}\alpha_{p\pi^0}\cos\theta_{\Sigma^+}$$

$\alpha_{p\pi^0} = -0.982 \pm 0.014$ from world average value.





- $\alpha_{\Sigma^+\pi^0} = -0.48 \pm 0.02 \pm 0.02$
  - ➢ agrees with the world average value: -0.55 ± 0.11.
  - ➢ with much improved precision
  - ➢ The consistency with $\alpha_{\Sigma^0\pi^+} = -0.463 \pm 0.016 \pm 0.008$ [Sci.Bull. 68 (2023) 583] indicates no isospin symmetry broken.
- $\alpha_{\Sigma^+\eta} = -0.99 \pm 0.03 \pm 0.05$ and $\alpha_{\Sigma^+\eta'} = -0.46 \pm 0.06 \pm 0.03$
  - ➢ measured for the first time

Branching fractions of $\Lambda_c^+ \to pK_S^0K_S^0, pK_S^0\eta$

■Motivation

- No result of branching fraction for $\Lambda_c^+ \to pK_S^0K_S^0$ (singly Cabibbo-suppressed) is reported. According to theoretically results based on $SU(3)_F$ symmetry [EPJC 79 (2019) 946], $\mathcal{B}(\Lambda_c^+ \to pK_S^0K_S^0) = (1.9 \pm 0.4)\times10^{-3}$.

- Measured branching fraction $B(\Lambda_c^+ \to pK_S^0\eta) = (4.15 \pm 0.90)\times10^{-3}$ has large uncertainty (δB/B~20%) [PDG].

- Check Dalitz-plot for the intermediate resonances existence, e.g. $N^*(1535)\to p\eta$.

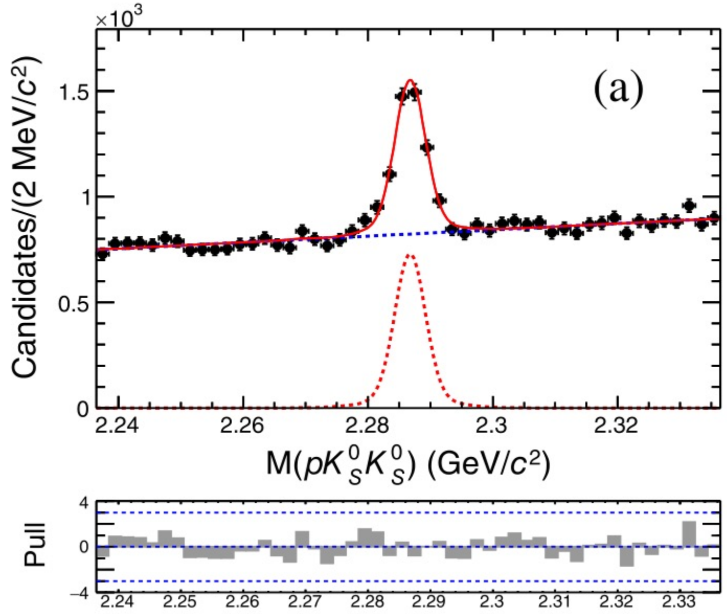
Branching fractions of $\Lambda_c^+ \to pK_S^0K_S^0, pK_S^0\eta$

■Signal Yield Extraction

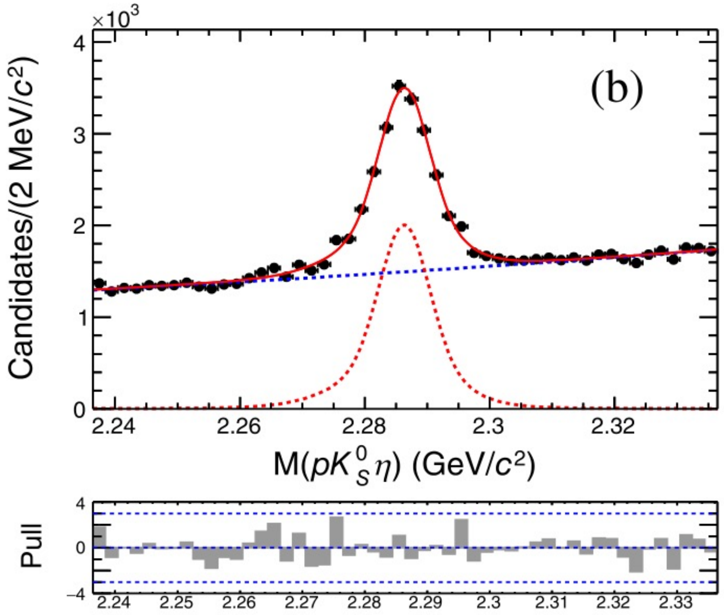
[PRD 107, 032004 (2023)]

Full Belle dataset

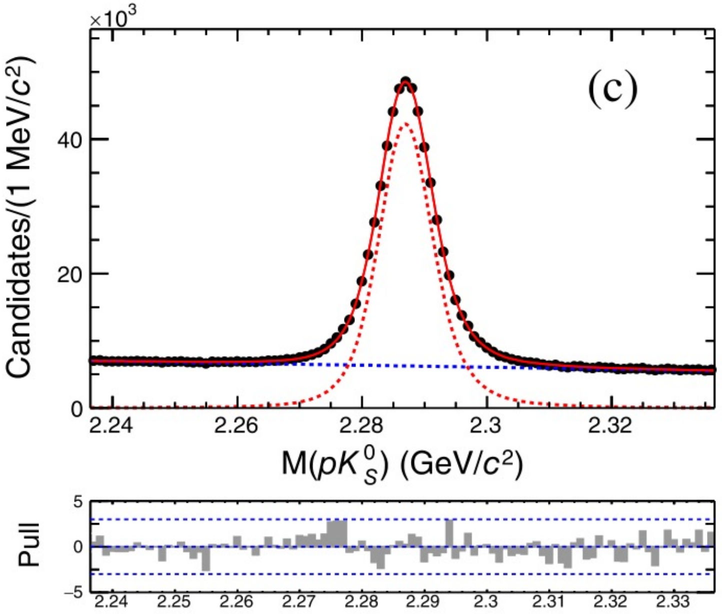
Signal: $\Lambda_c^+ \to pK_S^0K_S^0$



Signal: $\Lambda_c^+ \to pK_S^0\eta$



Reference: $\Lambda_c^+ \to pK_S^0$

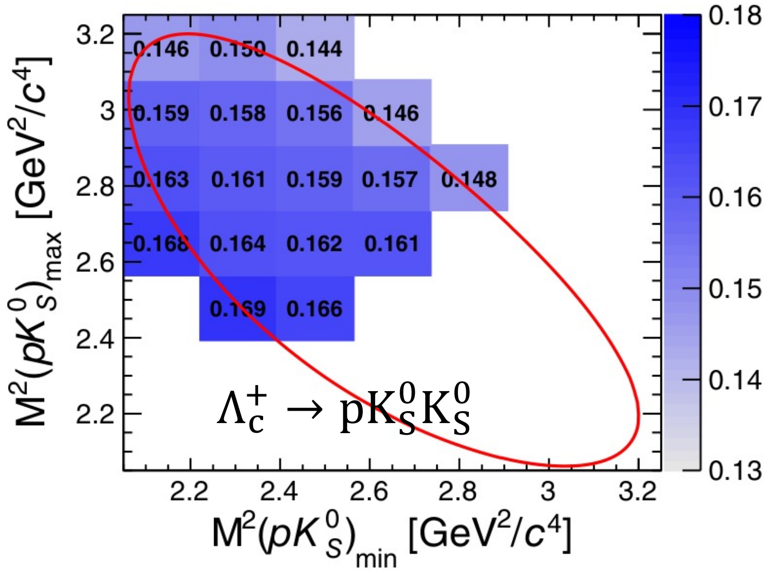


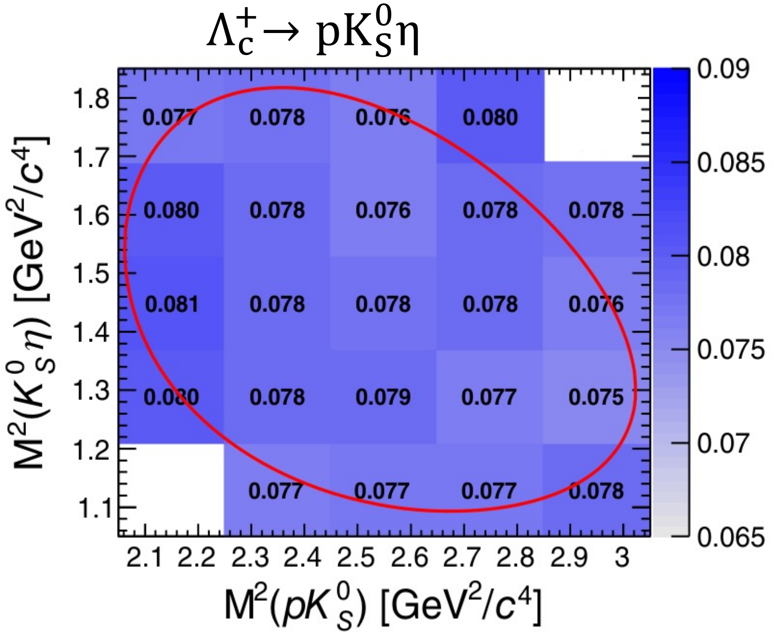
Yields	$\Lambda_c^+ \to pK_S^0K_S^0$	$\Lambda_c^+ \to pK_S^0\eta$	$\Lambda_c^+ \to pK_S^0$
$N_{\text{sig}}^{\text{FR}}$	2442 ± 103	12877 ± 317	515296 ± 1129

Branching fractions of $\Lambda_c^+ \to pK_S^0K_S^0, pK_S^0\eta$

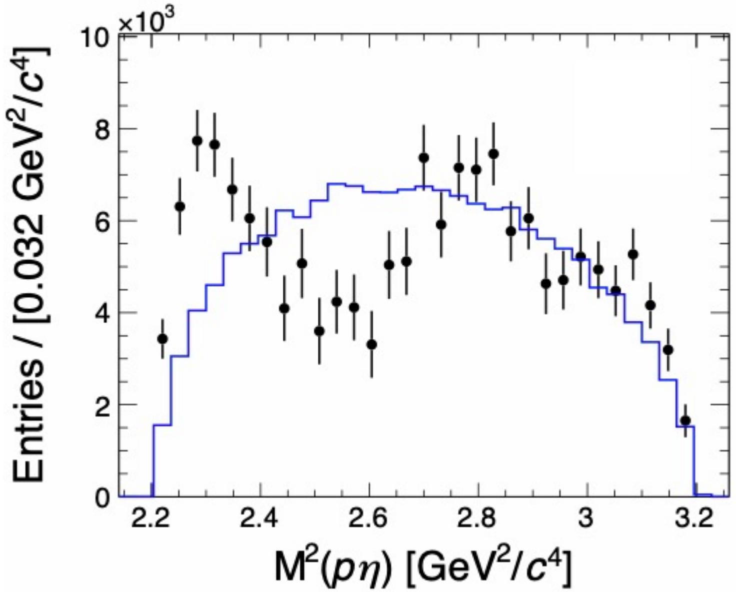
[PRD 107, 032004 (2023)]

■ Efficiency Plane





N*(1535) is observed in M(pη).



■ Branching fraction

- $\frac{B(\Lambda_c^+\to pK_S^0K_S^0)}{B(\Lambda_c^+\to pK_S^0)} = (1.48 \pm 0.08 \pm 0.04)\times10^{-2}$ ➡ $B(\Lambda_c^+ \to pK_S^0K_S^0) = (2.35 \pm 0.12 \pm 0.07 \pm 0.12)\times10^{-4}$
  - ➢ First observation
- $\frac{B(\Lambda_c^+\to pK_S^0\eta)}{B(\Lambda_c^+\to pK_S^0)} = (2.73 \pm 0.06 \pm 0.13)\times10^{-1}$ ➡ $B(\Lambda_c^+ \to pK_S^0\eta) = (4.35 \pm 0.10 \pm 0.20 \pm 0.22)\times10^{-3}$
  - ➢ Consistent with world average value $(4.15 \pm 0.90)\times10^{-3}$ and threefold improvement in precision.

Mass and width of $\Lambda_c(2625)^+$ and BR of $\Lambda_c(2625)^+ \to \Sigma_c^{0,++}\pi$

■ Motivation

- $\Lambda_c(2625)^+ (J^P = 3/2^-)$ is the excited state of Λ_c^+. It dominantly decays to $\Lambda_c^+\pi^+\pi^-$ via P-wave decay. The D-wave decay $\Lambda_c(2625)^+ \to \Sigma_c^{0,++}\pi$ is also allowed, but its contribution is known to be small.

- The mass of the $\Lambda_c(2625)^+$, relative to the Λ_c^+ mass, is already relatively well known [PRD 84,012003 (2011)], but the large Belle data sample allows for a more precise measurement.

- No intrinsic width of the $\Lambda_c(2625)^+$ has yet been measured, and the current upper limit $\Gamma < 0.97\ \mathrm{MeV}/c^2$ at 90% confidence level is based on the CDF measurement in 2011 [PRD 84,012003 (2011)].

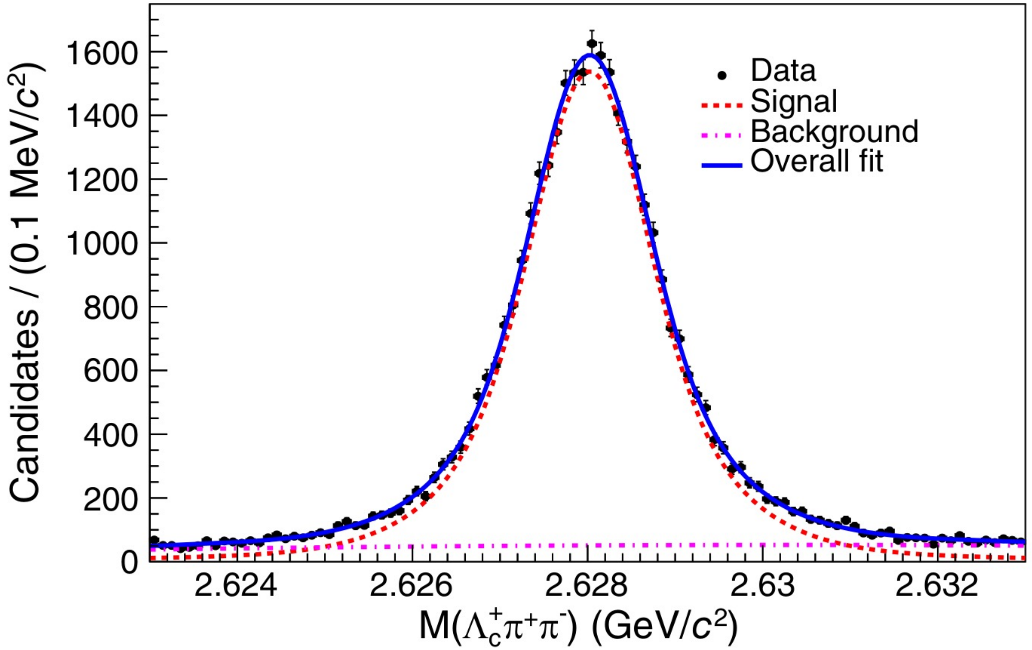
Mass and width of $\Lambda_c(2625)^+$ and BR of $\Lambda_c(2625)^+ \to \Sigma_c^{0,++}\pi$

■ Measurements of mass and width

[PRD 107, 032008 (2023)]

Reconstruction mode: $\Lambda_c(2625)^+ \to \Lambda_c^+\pi^+\pi^-, \Lambda_c^+ \to pK^-\pi^+$

Full Belle dataset



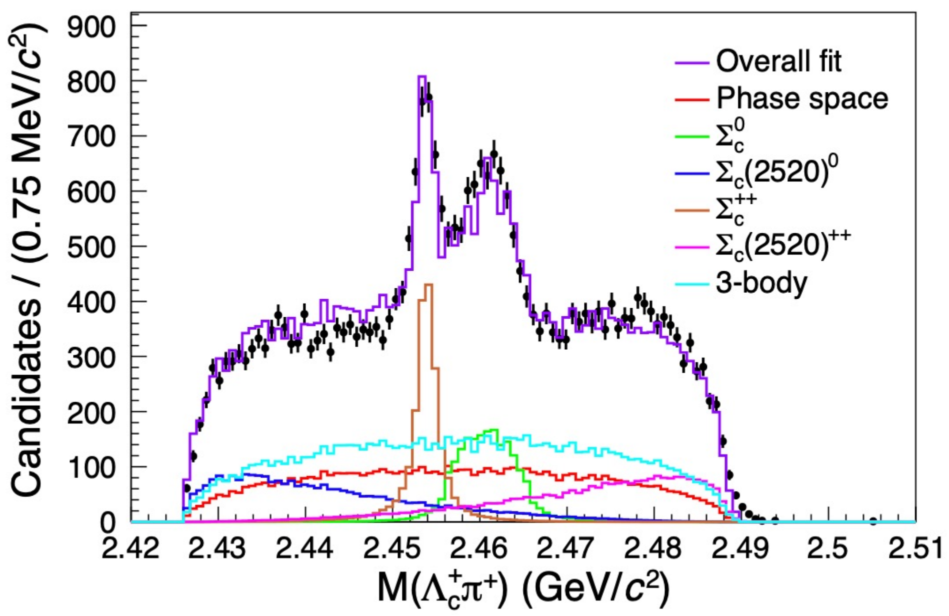
- $M[\Lambda_c(2625)^+] - M(\Lambda_c^+) = 341.518 \pm 0.006 \pm 0.049\ \mathrm{MeV}/c^2$
  - consistent with the world average value $341.65 \pm 0.13\ \mathrm{MeV}/\ c^2$
  - has approximately half the uncertainty
- $\Gamma[\Lambda_c(2625)^+] < 0.52\ \mathrm{MeV}$
  - a factor of 2 more stringent than the previous limit $\Gamma < 0.97\ \mathrm{MeV}$
  - An improved limit on the width of the $\Lambda_c(2625)^+$ will help to constrain various theoretical predictions.

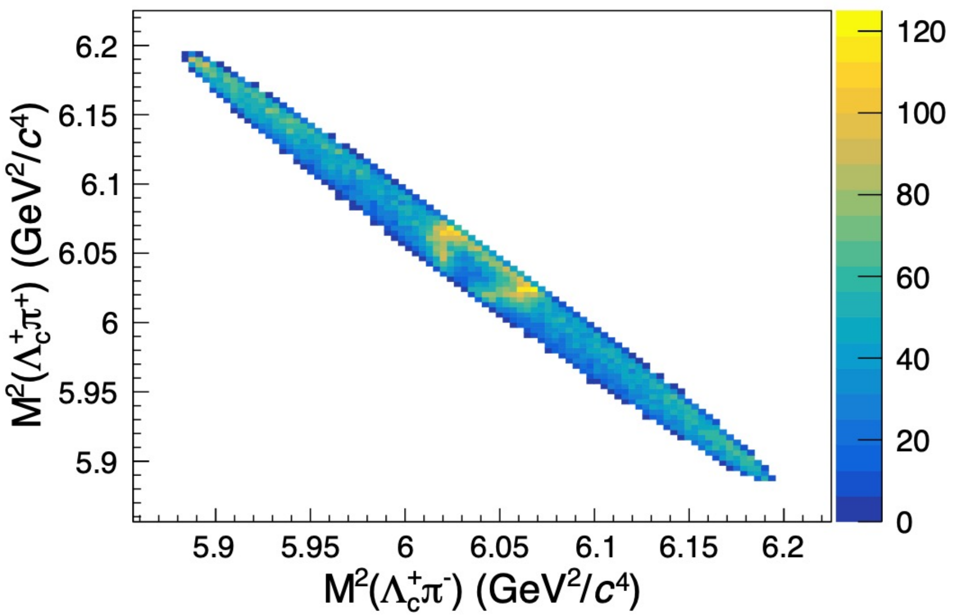
Mass and width of $\Lambda_c(2625)^+$ and BR of $\Lambda_c(2625)^+ \to \Sigma_c^{0,++}\pi$

■ Measurements of branching fractions

[PRD 107, 032008 (2023)]

Full Dalitz plot fitted with AmpTools is performed [PRD 98, 114007 (2018)].





$$\frac{B(\Lambda_c(2625)^+ \to \Sigma_c^0\pi)}{B(\Lambda_c(2625)^+ \to \Lambda_c^+\pi^+\pi^-)} = (5.19 \pm 0.23 \pm 0.40)\%$$

$$\frac{B(\Lambda_c(2625)^+ \to \Sigma_c^{++}\pi)}{B(\Lambda_c(2625)^+ \to \Lambda_c^+\pi^+\pi^-)} = (5.13 \pm 0.26 \pm 0.32)\%$$

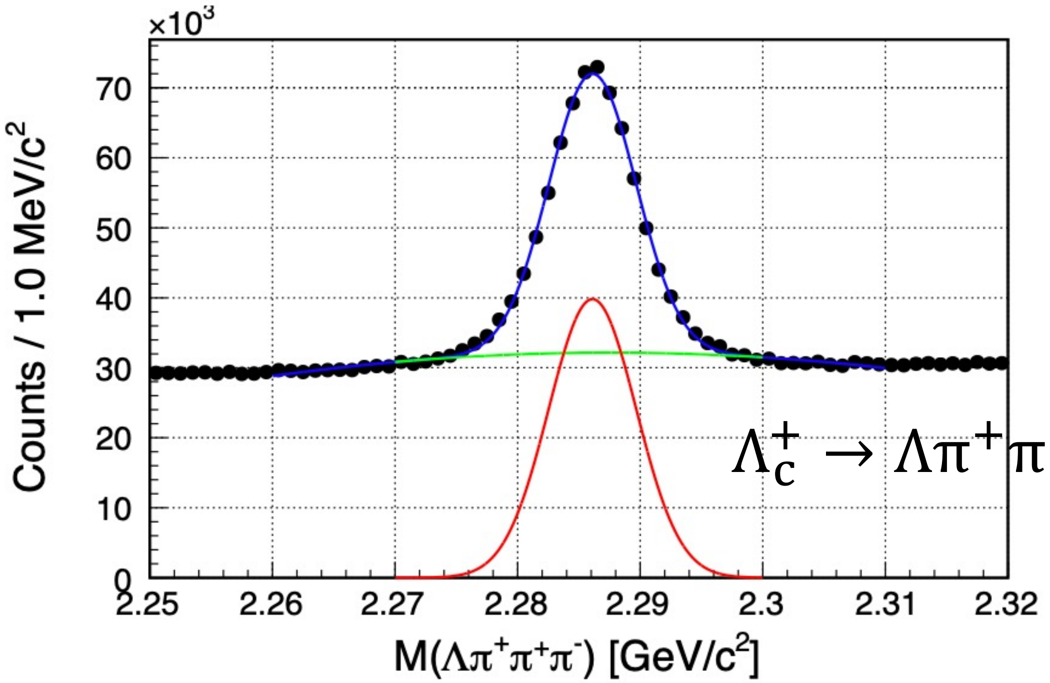
- ☐ The measured branching fraction ratios agree with PDG values and are the most precise to date.
- ☐ Our measurements align with the prediction that assuming $\Lambda_c(2625)^+$ is a λ mode excitation [PRD 98, 114007 (2018)].

Peak at $\bar{K}N$ threshold in $\Lambda_c^+ \to \Lambda\pi^+\pi^+\pi^-$

[PRL 130, 151903 (2023)]

■Motivation

- The $\Lambda(1405)$ (I = 0) state, which has been interpreted as an orbitally excited quark-diquark [PRC 49, 2831 (1994)], or as a $\bar{K}N$ bound state [PRL 114, 132002 (2015)].
- The $\bar{K}N$ (I = 1) interaction is a virtual state could exist [PLB 500, 263 (2001)] and could be observed as a threshold cusp.



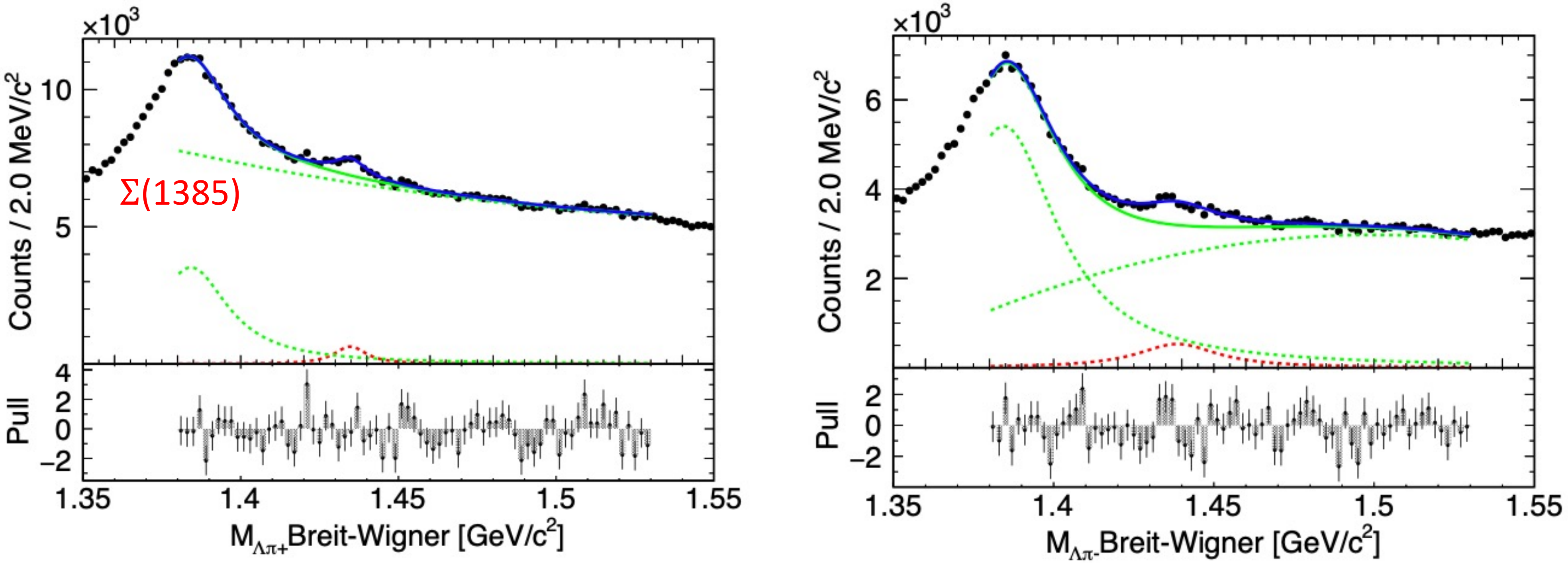
$\Lambda_c^+ \to \Lambda\pi^+\pi^+\pi^-$

Full Belle dataset

Peak at $\bar{K}N$ threshold in $\Lambda_c^+ \to \Lambda\pi^+\pi^+\pi^-$

[PRL 130, 151903 (2023)]

Full Belle dataset



Standard Breit-Wigner

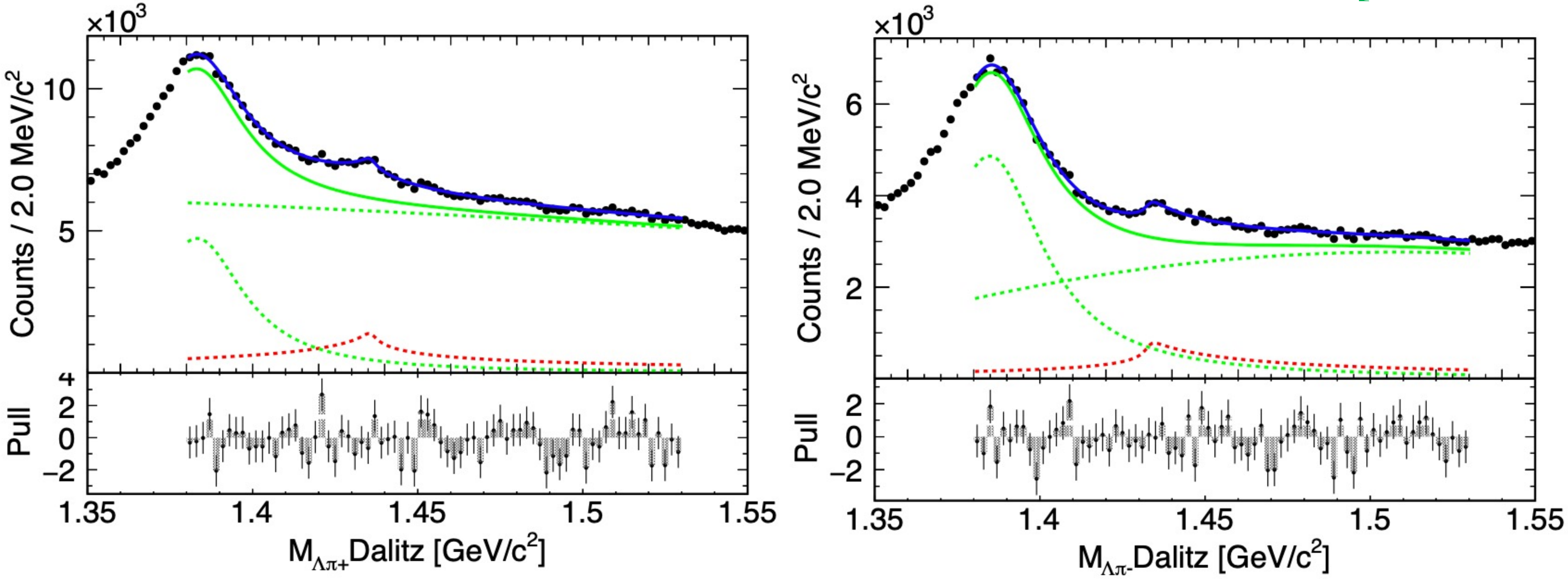
$$f_{\rm BW} = \frac{\Gamma/2}{(E - E_{\rm BW})^2 + \Gamma^2/4}$$

Mode	Mass (MeV/c²)	Width (MeV)	χ^2/NDF
$\Lambda\pi^+$	1434.3±0.6±0.9	11.5±2.8±5.3	74/68
$\Lambda\pi^-$	1438.5±0.9±2.5	33.0±7.5±23.6	92/68

Peak at $\bar{K}N$ threshold in $\Lambda_c^+ \to \Lambda\pi^+\pi^+\pi^-$

[PRL 130, 151903 (2023)]

Full Belle dataset



Dalitz model gives slightly better χ^2/NDF, but the difference is not significant.

Dalitz model (cusp) [Czech. J. Phys. B 32, 1021 (1982)]
For scattering length A=a+ib and decay momentum k/κ.

$$f_D = \frac{4\pi b}{(1+kb)^2 + (ka)^2}, E > m_{\bar{K}N}$$
$$= \frac{4\pi b}{(1+\kappa a)^2 + (\kappa b)^2}, E < m_{\bar{K}N}$$

Mode	a [fm]	b [fm]	χ^2/NDF
$\Lambda\pi^+$	0.48±0.32±0.38	1.22±0.83±2.54	69/68
$\Lambda\pi^-$	1.24±0.57±1.56	0.18±0.13±0.20	78/68

Obtained center values for a are larger than most theories (e.g., $a(K^-n)$=0.3~0.6 fm for [Nucl. Phys. A 881, 98 (2012)]), but with large uncertainties.

Evidence for $\Omega_c^0 \to \Xi^-\pi^+$ and search for $\Omega_c^0 \to \Xi^-K^+$ and Ω^-K^+ decays

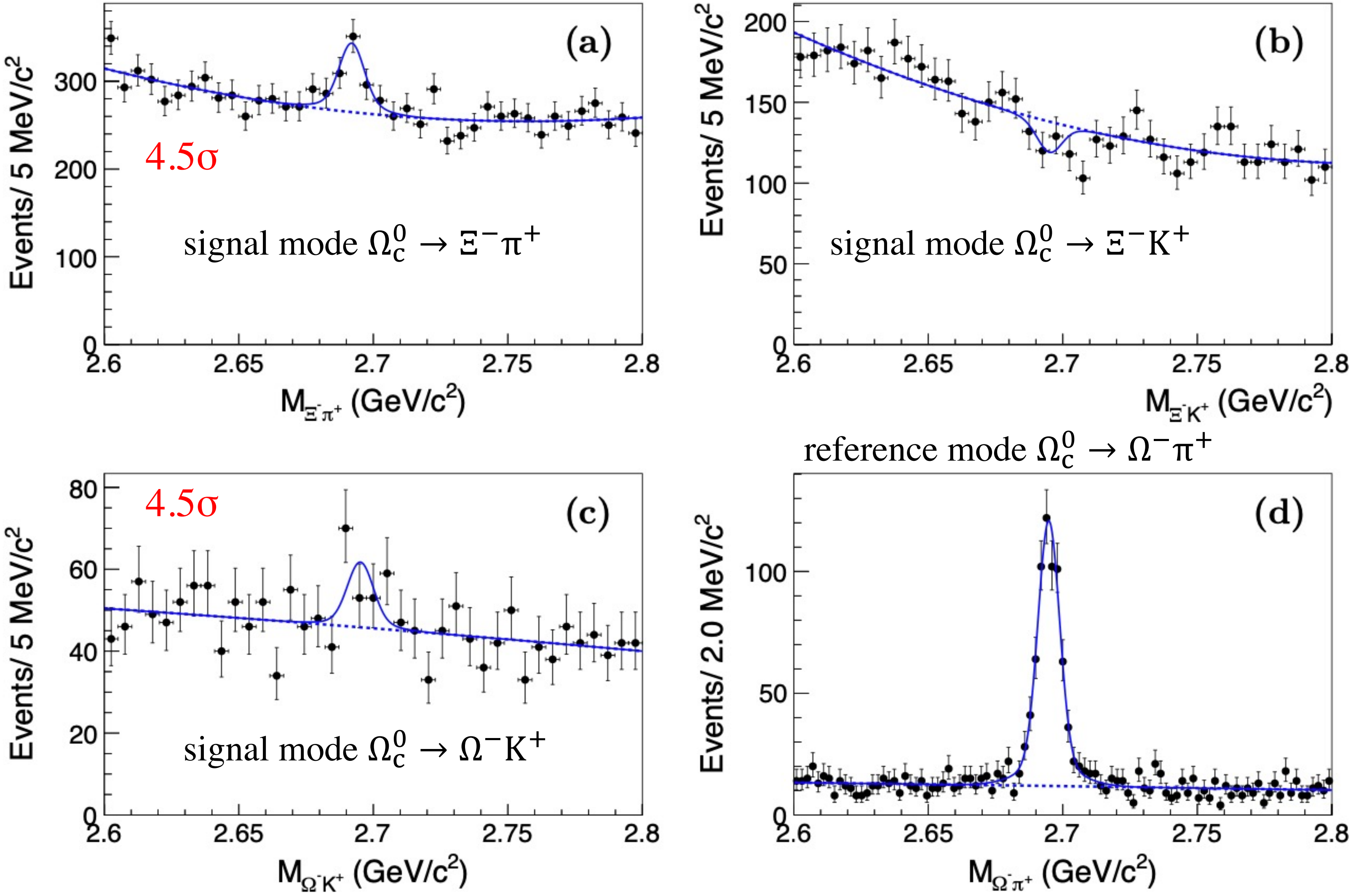
- The theoretical study of hadronic weak decays of the Ω_c^0 has a long history. But due to the low production rate of Ω_c^0 and low detection efficiency for long-lived final states, our knowledge of the Ω_c^0 state is very limited.
- The singly Cabibbo-suppressed decay $\Omega_c^0 \to \Xi^-\pi^+$ and doubly Cabibbo-suppressed decay $\Omega_c^0 \to \Xi^-K^+$ decays have been studied systematically in various theoretical models.

Predicted ratios of branching fractions for using light-front quark model (LFQM), pole model, and current algebra (CA).

Branching fraction ratios	LFQM CPC 42, 093101 (2018)	Pole model and CA PRD 101, 094033 (2020)
$\mathcal{B}(\Omega_c^0 \to \Xi^-\pi^+)/\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+)$	1.96×10^{-3}	1.04×10^{-1}
$\mathcal{B}(\Omega_c^0 \to \Xi^-K^+)/\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+)$	1.74×10^{-4}	1.06×10^{-2}

[JHEP 01 (2023) 055]

Full Belle dataset



The first evidence of $\Omega_c^0 \to \Xi^- \pi^+$ with a signal significance of 4.5σ including systematic uncertainties.

No significant signals are found in $\Omega_c^0 \to \Omega^- K^+$ and $\Omega_c^0 \to \Omega^- \pi^+$.

$\mathcal{B}(\Omega_c^0 \to \Xi^- \pi^+)/\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+) = 0.253 \pm 0.053(\text{stat.}) \pm 0.030(\text{syst.})$
$\mathcal{B}(\Omega_c^0 \to \Xi^- K^+)/\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+) < 0.070$
$\mathcal{B}(\Omega_c^0 \to \Omega^- K^+)/\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+) < 0.29$

Summary

- At Belle, we are still producing excited results for Λ_c, Ξ_c, and Ω_c charmed baryons.
- We are combining Belle and Belle II data to study charmed baryon decays.
- These experimental results will be useful to future constrain the parameter space of the theoretical models [quark model, chiral symmetry…] and can be applied to other heavy quark systems.
- In the future, Belle II will provide greater sensitivity and precise measurements in charmed baryon physics with 50 ab^{-1}.

Thanks for your attentions!