BESIII实验粲重子极化研究进展

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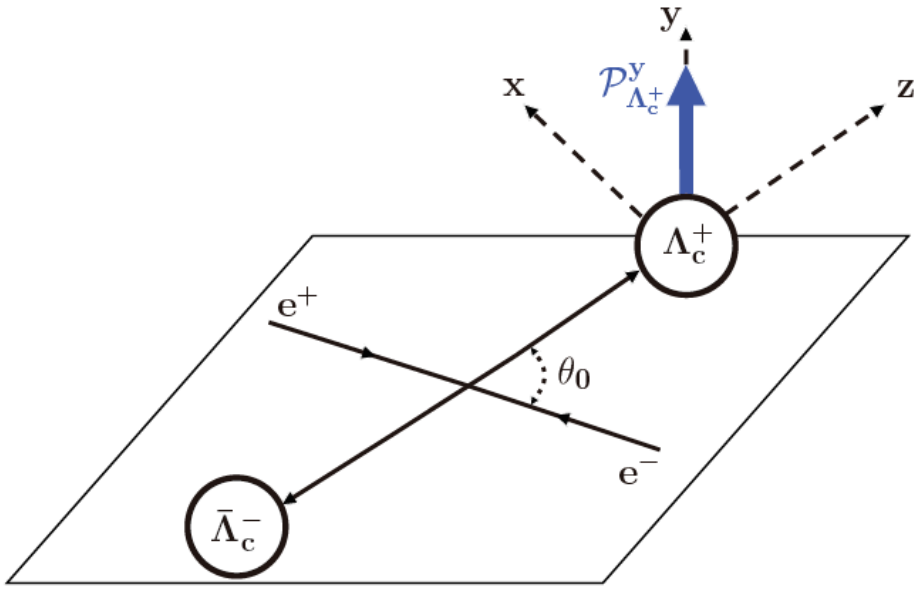
2026BESIII粲强子物理研讨会

2026年10月17日 成都

Outline

- Charmed baryon production and decay
- More information
  - Dynamic parameters? Phase shift? CPV observables?
- Experiment & Phenomenon
- Methods for measurement
  - Angular analysis? Partial wave analysis?
- Λ_c^+ polarization measurement overview
- Summary

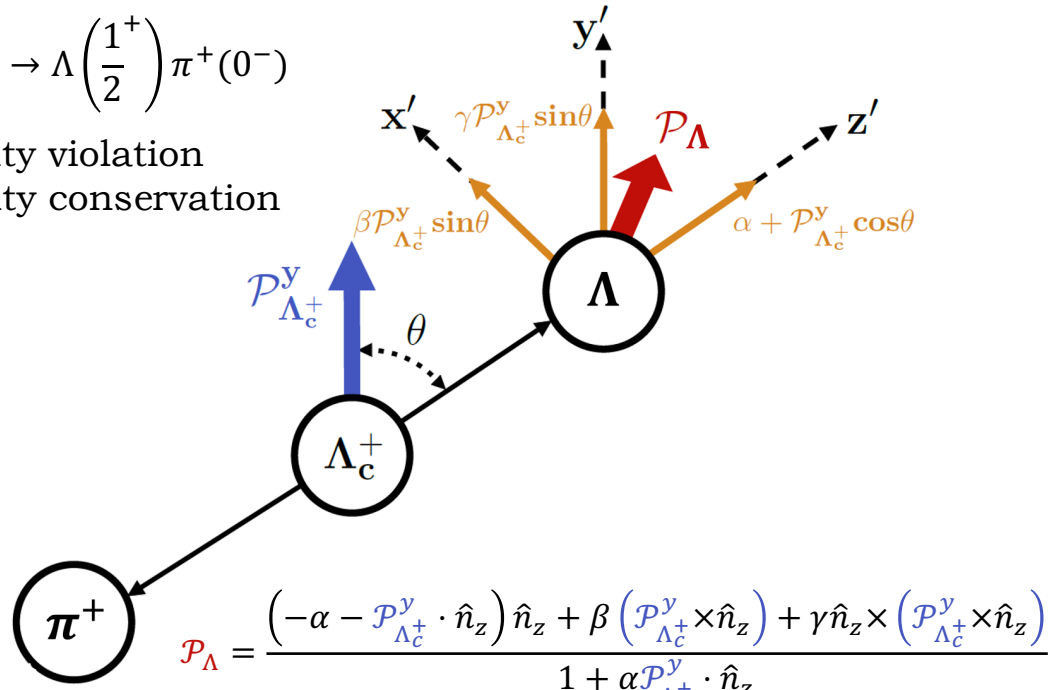
Charmed baryon production and decay



$$\mathcal{P}^{y}_{\Lambda_c^+}(\cos\theta_0) = \frac{3}{2(3+\alpha_0)}\sqrt{1-\alpha_0^2}\sin\theta_0\cos\theta_0\sin\Delta\Phi$$

$$\Lambda_c^+\left(\frac{1^+}{2}\right) \to \Lambda\left(\frac{1^+}{2}\right)\pi^+(0^-)$$

$s \to$ parity violation
$p \to$ parity conservation



$$\mathcal{P}_\Lambda = \frac{\left(-\alpha - \mathcal{P}^y_{\Lambda_c^+}\cdot\hat{n}_z\right)\hat{n}_z + \beta\left(\mathcal{P}^y_{\Lambda_c^+}\times\hat{n}_z\right) + \gamma\hat{n}_z\times\left(\mathcal{P}^y_{\Lambda_c^+}\times\hat{n}_z\right)}{1+\alpha\mathcal{P}^y_{\Lambda_c^+}\cdot\hat{n}_z}$$

$$\alpha = \frac{2\mathrm{Re}(s^*p)}{|s|^2+|p|^2} \quad \beta = \frac{2\mathrm{Im}(s^*p)}{|s|^2+|p|^2} \quad \gamma = \frac{|s|^2-|p|^2}{|s|^2+|p|^2}$$
$$\alpha^2+\beta^2+\gamma^2 = 1$$

If parity violation exists: $\alpha,\ \beta \neq 0,\ \gamma \neq -1$

- **Another definition:**

$$\alpha = \frac{\left|H_{\frac{1}{2}}\right|^2 - \left|H_{-\frac{1}{2}}\right|^2}{\left|H_{\frac{1}{2}}\right|^2 + \left|H_{-\frac{1}{2}}\right|^2} \qquad \begin{aligned}\beta &= \sqrt{1-\alpha^2}\sin\Delta \\ \gamma &= \sqrt{1-\alpha^2}\cos\Delta \\ \alpha^2+\beta^2+\gamma^2 &= 1\end{aligned} \qquad \Delta = \delta_{-\frac{1}{2}} - \delta_{\frac{1}{2}}$$

- **Transform using a simple linear relation**

$$H^{0\to1+2}_{\lambda_1,\lambda_2} = \sum_{ls} g_{ls}\sqrt{\frac{2l+1}{2J_0+1}}\langle ls,0\ \delta|J_0,\delta\rangle\langle J_1J_2,\lambda_1-\lambda_2|s,\delta\rangle$$

CP violation in charmed baryon

$\Lambda_c^+ \left(\frac{1}{2}^+\right) \to \Lambda \left(\frac{1}{2}^+\right) \pi^+(0^-)$ as an example:

$$s = |s|e^{i\xi_s}e^{i\phi_s} \qquad \bar{s} = -|s|e^{i\xi_s}e^{-i\phi_s}$$
$$p = |p|e^{i\xi_p}e^{i\phi_p} \qquad \bar{p} = |p|e^{i\xi_p}e^{-i\phi_p}$$

under CP transformation

ϕ weak phase
ξ strong phase

$$\left[\ \alpha = \frac{2\mathrm{Re}(s^*p)}{|s|^2+|p|^2} \quad \beta = \frac{2\mathrm{Im}(s^*p)}{|s|^2+|p|^2} \quad \gamma = \frac{|s|^2-|p|^2}{|s|^2+|p|^2}\ \right]$$

- If CP conserved:

$s \xrightarrow{\text{CP}} -s$

$p \xrightarrow{\text{CP}} p$

$$\alpha \xrightarrow{\text{CP}} \bar{\alpha} = -\alpha$$
$$\beta \xrightarrow{\text{CP}} \bar{\beta} = -\beta$$
$$\gamma \xrightarrow{\text{CP}} \bar{\gamma} = +\gamma$$

$$A_{CP}^{\alpha} = \frac{\alpha+\bar{\alpha}}{\alpha-\bar{\alpha}} = \tan\phi_{CP}\tan\Delta_S$$
$$\tan\phi_{CP} = \frac{\beta+\bar{\beta}}{\alpha-\bar{\alpha}} = \frac{\sqrt{1-\alpha^2}\sin\Delta + \sqrt{1-\bar{\alpha}^2}\sin\bar{\Delta}}{\alpha-\bar{\alpha}}$$
$$\tan\Delta_S = \frac{\beta-\bar{\beta}}{\alpha-\bar{\alpha}} = \frac{\sqrt{1-\alpha^2}\sin\Delta - \sqrt{1-\bar{\alpha}^2}\sin\bar{\Delta}}{\alpha-\bar{\alpha}}$$

All polarization induced CPV observables can be derived using $\alpha/\bar{\alpha}$ and $\Delta/\bar{\Delta}$.

More information

The amplitude for the two-body weak decay $B_i \to B_f + P$ can be parameterized as

$$M(B_i \to B_f + P) = i\bar{u}_f(A - B\gamma_5)u_i)$$

$$A \to s, B \to p/\kappa$$

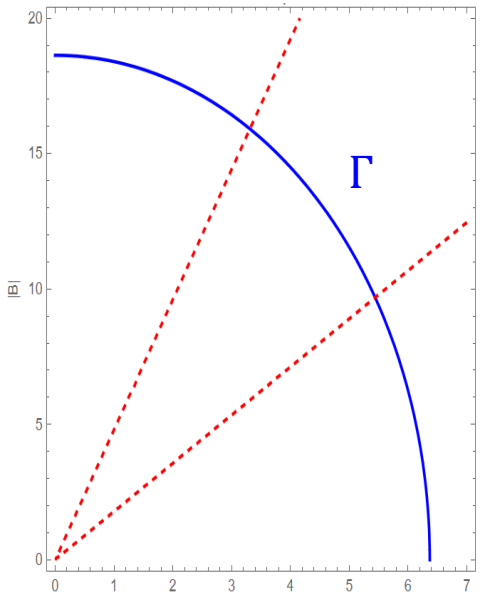
$$\kappa = |\vec{p}_c|/(E_\Lambda + m_\Lambda)$$

$$\Gamma = \frac{\mathcal{B}(\Lambda_c^+ \to \Lambda\pi^+)}{\tau_{\Lambda_c^+}} = \frac{|\vec{p}_c|}{8\pi}\left[\frac{(m_{\Lambda_c^+} + m_\Lambda)^2 - m_{\pi^+}^2}{m_{\Lambda_c^+}^2}|A|^2 + \frac{(m_{\Lambda_c^+} - m_\Lambda)^2 - m_{\pi^+}^2}{m_{\Lambda_c^+}^2}|B|^2\right]$$

$$\alpha = \frac{2\kappa|A||B|\cos(\delta_p - \delta_s)}{|A|^2 + \kappa^2|B|^2}$$

$$\Delta = \arctan\frac{2\kappa|A||B|\sin(\delta_p - \delta_s)}{|A|^2 - \kappa^2|B|^2}$$

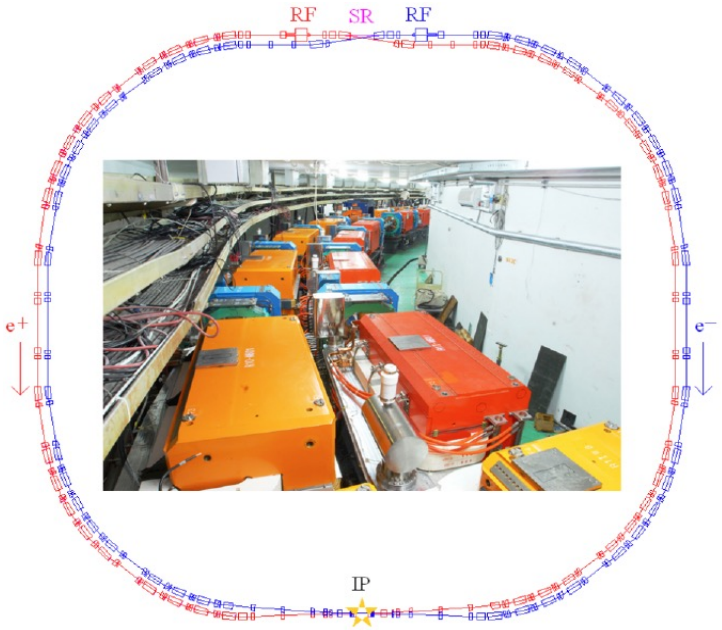
Three unknowns and
three independent equations



$$\gamma = \frac{|A|^2 - \kappa^2|B|^2}{|A|^2 + \kappa^2|B|^2}$$

✓ Once $\gamma > 0$ or $\gamma < 0$, one solution will be determined.

BESIII Experiment



BEPCII

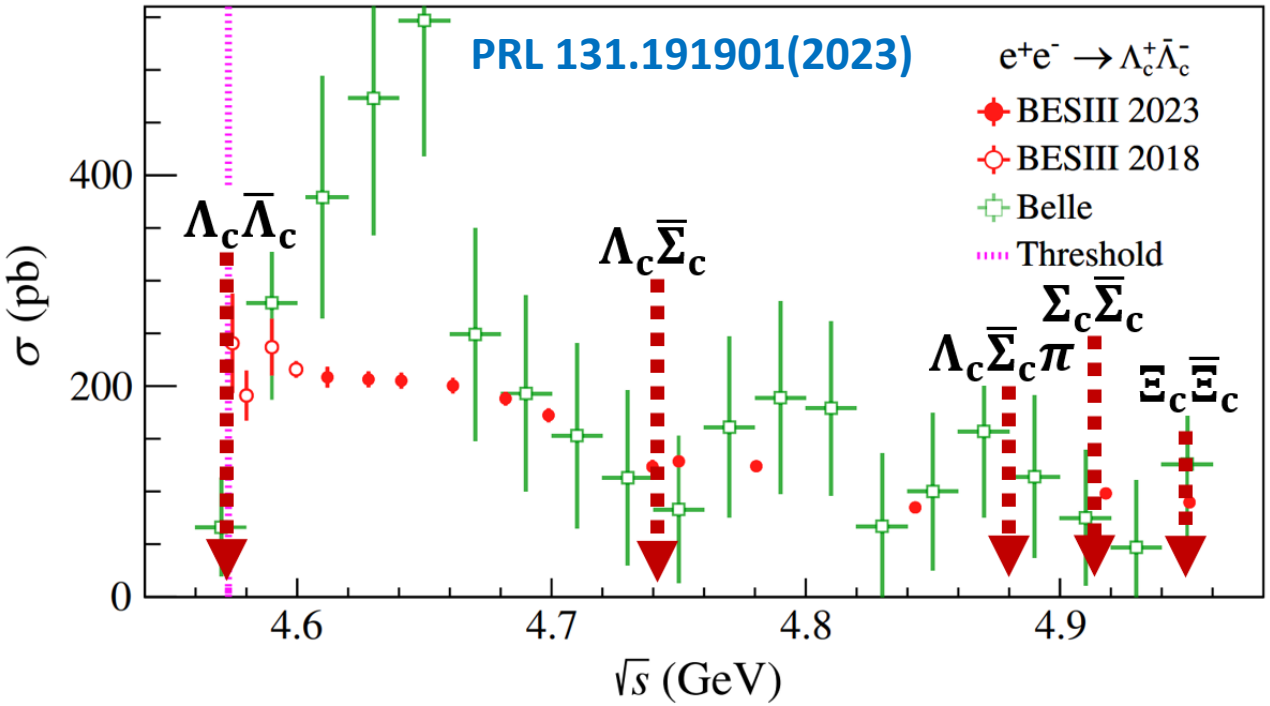
- First collision in 2008 & physics run in 2009.
- $\sqrt{s} = 2.0 - 4.951$ GeV (tau-charm factory).
- Design luminosity $L = 1\times10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$@ 3.773GeV
  (2016 achieved; 2022-2023 achieved 1.1L).
- Max beam energy is designed to be 2.8 GeV in BEPCII-U.

BESIII

Exps.	MDC Spatial resolution	MDC dE/dx resolution	EMC Energy resolution
CLEO-c	110 μm	5%	2.2-2.4 %
BaBar	125 μm	7%	2.67 %
Belle	130 μm	5.6%	2.2 %
BESIII	130 μm	6%	2.5%

Datasets on BESIII experiment

➢ *Close to the production threshold, a relatively clean background environment.*



Sample	E_{cms}/MeV	$\mathscr{L}_{Bhabha}$/pb^{-1}
4610	4611.86±0.12±0.30	103.65±0.05±0.55
4620	4628.00±0.06±0.32	521.53±0.11±2.76
4640	4640.91±0.06±0.38	551.65±0.12±2.92
4660	4661.24±0.06±0.29	529.43±0.12±2.81
4680	4681.92±0.08±0.29	1667.39±0.21±8.84
4700	4698.82±0.10±0.36	535.54±0.12±2.84
4740	4739.70±0.20±0.30	163.87±0.07±0.87
4750	4750.05±0.12±0.29	366.55±0.10±1.94
4780	4780.54±0.12±0.30	511.47±0.12±2.71
4840	4843.07±0.20±0.31	525.16±0.12±2.78
4920	4918.02±0.34±0.34	207.82±0.08±1.10
4950	4950.93±0.36±0.38	159.28±0.07±0.84

CPC 46.113003(2022)

Available data for charmed baryons

✓ 0.587 fb^{-1} at 4.6 GeV (35 days in 2014)

✓ 3.9 fb^{-1} scan at 4.61, 4.63, 4.64, 4.66, 4.68, 4.70 GeV (186 days in 2020)

✓ 1.93 fb^{-1} scan at 4.74, 4.75, 4.78, 4.84, 4.92, 4.95 GeV (99 days in 2021)

Total:
6.4 fb^{-1}

Experiment & Phenomenon

Predictions and measurements	$\alpha_{\Lambda_c^+}^{pK_s^0}$	$\alpha_{\Lambda_c^+}^{\Lambda\pi^+}$	$\alpha_{\Lambda_c^+}^{\Sigma^0\pi^+}$	$\alpha_{\Lambda_c^+}^{\Sigma^+\pi^0}$	$\alpha_{\Lambda_c^+}^{\Xi^0K^+}$
CLEO(1990) [3]	-	$-1.0^{+0.4}_{-0.1}$	-	-	-
ARGUS(1992) [4]	-	-0.96 ± 0.42	-	-	-
Körner(1992), CCQM [5]	-0.10	-0.70	0.70	0.71	0
Xu(1992), Pole [6]	0.51	-0.67	0.92	0.92	0
Cheng, Tseng(1992), Pole [7]	-0.49	-0.96	0.83	0.83	-
Cheng, Tseng(1993), Pole [8]	-0.49	-0.95	0.78	0.78	-
Źencaykowski(1994), Pole [9]	-0.90	-0.86	-0.76	-0.76	0
Źencaykowski(1994), Pole [10]	-0.66	-0.99	0.39	0.39	0
CLEO(1995) [11]	-	$-0.94^{+0.21+0.12}_{-0.06-0.06}$	-	$-0.45 \pm 0.31 \pm 0.06$	-
Alakabha Datta(1995), CA [12]	-0.91	-0.94	-0.47	-0.47	-
Ivanov(1998), CCQM [13]	-0.97	-0.95	0.43	0.43	0
Sharma(1999), CA [14]	-0.99	-0.99	-0.31	-0.31	0
FOCUS(2006) [15]	-	$-0.78 \pm 0.16 \pm 0.19$	-	-	-
BESIII(2018) [16]	$0.18 \pm 0.43 \pm 0.14$	$-0.80 \pm 0.11 \pm 0.02$	$-0.73 \pm 0.17 \pm 0.07$	$-0.57 \pm 0.10 \pm 0.07$	-
Geng(2019), SU(3) [17]	$-0.89^{+0.26}_{-0.11}$			7	$0.94^{+0.06}_{-0.11}$
Zou(2020), CA [18]	-0.75				0.90
BELLE(2022) [19, 20]	-			0.02	-
Zhong(2022), SU(3)^a [21] (a)	-0.57 ± 0.21			3	$0.91^{+0.03}_{-0.04}$
Zhong(2022), SU(3)^b [21] (b)	-0.29 ± 0.24			03	0.99 ± 0.01
Liu(2023), Pole [22]	-0.81 ± 0.05			4	0.95 ± 0.02
Liu(2023), LP [22]	-0.68 ± 0.01			94	-0.02
BESIII(2023) [23]	-				0.01 ± 0.16
Geng(2023), SU(3) [24]	-0.40 ± 0.49			2	-0.15 ± 0.14
Zhong(2024), TDA [25]	0.01 ± 0.24				-0.16 ± 0.13
Zhong(2024), IRA [25]	0.03 ± 0.24	-0.76 ± 0.01	-0.48 ± 0.02	-0.48 ± 0.02	-0.19 ± 0.12
LHCb(2024) [34]	$-0.754 \pm 0.008 \pm 0.006$	$-0.785 \pm 0.006 \pm 0.003$	-	-	-
Zhong(2024), TDA [33]	-0.74 ± 0.03	-0.76 ± 0.01	-0.47 ± 0.01	-0.47 ± 0.01	-0.04 ± 0.12
Zhong(2024), IRA [33]	-0.74 ± 0.03	-0.76 ± 0.01	-0.47 ± 0.01	-0.47 ± 0.01	-0.06 ± 0.12
PDG Fit(2025) [35]	-0.754 ± 0.010	-0.768 ± 0.015	-0.466 ± 0.018	-0.484 ± 0.027	···

- ✓ So wide prediction range (-0.99 to 0.51), need experimental verification.
- ✓ SU(3) respected (a) and SU(3) broken (b) is so different for this channel.

Experiment & Phenomenon

Predictions and measurements	$\alpha^{pK_s^0}_{\Lambda_c^+}$	$\alpha^{\Lambda\pi^+}_{\Lambda_c^+}$	$\alpha^{\Sigma^0\pi^+}_{\Lambda_c^+}$	$\alpha^{\Sigma^+\pi^0}_{\Lambda_c^+}$	$\alpha^{\Xi^0K^+}_{\Lambda_c^+}$
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Sharma(1999), CA [14]	-0.99	-0.99	-0.31	-0.31	0
FOCUS(2006) [15]			-	-	-
BESIII(2018) [16]	0.18		$-0.73 \pm 0.17 \pm 0.07$	$-0.57 \pm 0.10 \pm 0.07$	-
Geng(2019), SU(3) [17]			-0.35 ± 0.27	-0.35 ± 0.27	$0.94^{+0.06}_{-0.11}$
Zou(2020), CA [18]			-0.76	-0.76	0.90
BELLE(2022) [19, 20]			3 $-0.463 \pm 0.016 \pm 0.008$	$-0.48 \pm 0.02 \pm 0.02$	-
Zhong(2022), SU(3)^a [21]			-0.47 ± 0.03	-0.47 ± 0.03	$0.91^{+0.03}_{-0.04}$
Zhong(2022), SU(3)^b [21]			-0.47 ± 0.03	-0.47 ± 0.03	0.99 ± 0.01
Liu(2023), Pole [22]			-0.47 ± 0.01	-0.45 ± 0.04	0.95 ± 0.02
Liu(2023), LP [22]			-0.47 ± 0.01	-0.45 ± 0.04	-0.02
BESIII(2023) [23]			-	-	0.01 ± 0.16
Geng(2023), SU(3) [24]	-0.40 ± 0.49	-0.75 ± 0.01	-0.47 ± 0.02	-0.47 ± 0.02	-0.15 ± 0.14
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✓ Almost all prediction gives a same value in this two channel since the SU(3) symmetry.

Experiment & Phenomenon

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Sharma(1999), CA [14]	-0.99	-0.99	-0.31	-0.31	0
FOCUS(2006) [15]	-	$-0.78 \pm 0.16 \pm 0.19$	-	-	-
BESIII(2018) [16]	$0.18 \pm 0.43 \pm 0.14$	$-0.80 \pm 0.11 \pm 0.02$	$-0.73 \pm 0.17 \pm 0.07$	$-0.57 \pm 0.10 \pm 0.07$	-
Geng(2019), SU(3) [17]	$-0.89^{+0.26}_{-0.11}$	-0.87 ± 0.10	-0.35 ± 0.27	-0.35 ± 0.27	$0.94^{+0.06}_{-0.11}$
Zou(2020), CA [18]	-0.75	-0.93	-0.76	-0.76	0.90
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Zhong(2022), SU(3)^b [21]	-0.29 ± 0.24	-0.75 ± 0.01	-0.47 ± 0.03	-0.47 ± 0.03	0.99 ± 0.01
Liu(2023), Pole [22]	-0.81 ± 0.05	-0.75 ± 0.01	-0.47 ± 0.01	-0.45 ± 0.04	0.95 ± 0.02
Liu(2023), LP [22]	-0.68 ± 0.01	-0.75 ± 0.01	-0.47 ± 0.0	✓ Not very large.	-0.02
BESIII(2023) [23]	-	-	-		0.01 ± 0.16
Geng(2023), SU(3) [24]	-0.40 ± 0.49	-0.75 ± 0.01	-0.47 ± 0.0		-0.15 ± 0.14
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Current results on BESIII

I. Angular analysis

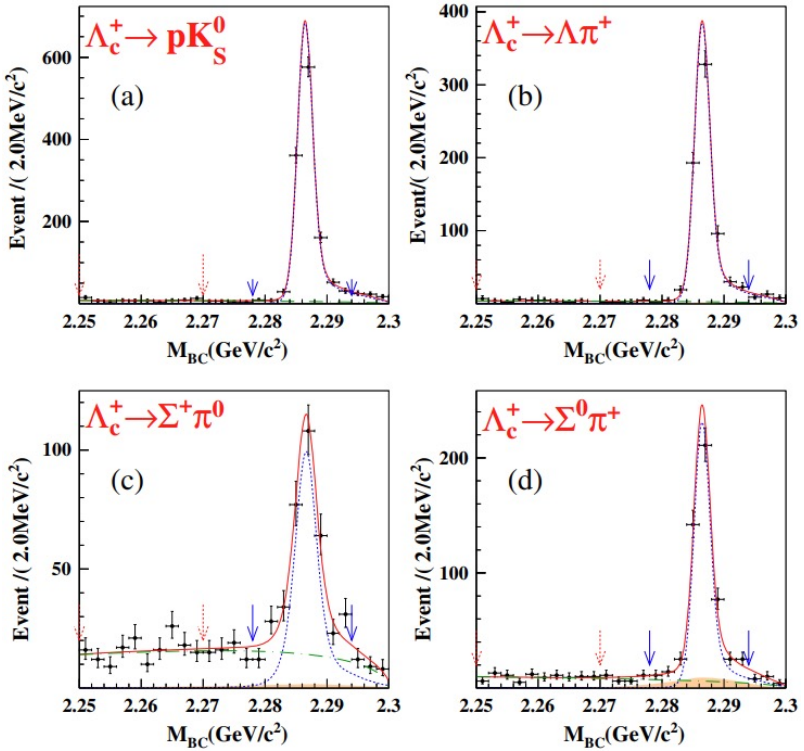
$\Lambda_c^+ \to pK_S^0, \Lambda\pi^+, \Sigma^0\pi^+, \Sigma^+\pi^0$	587 pb^{-1}	PRD 100.072004 (2019)
$\Lambda_c^+ \to \Xi^0 K^+$		PRL 132.031801 (2024)
$\Lambda_c^+ \to pK_S^0, \Lambda\pi^+, \Sigma^0\pi^+, \Sigma^+\pi^0$	6417 pb^{-1}	PRX 16.031058 (2026)
$\Lambda_c^+ \to \Lambda X$		PRL 137.131902 (2026)

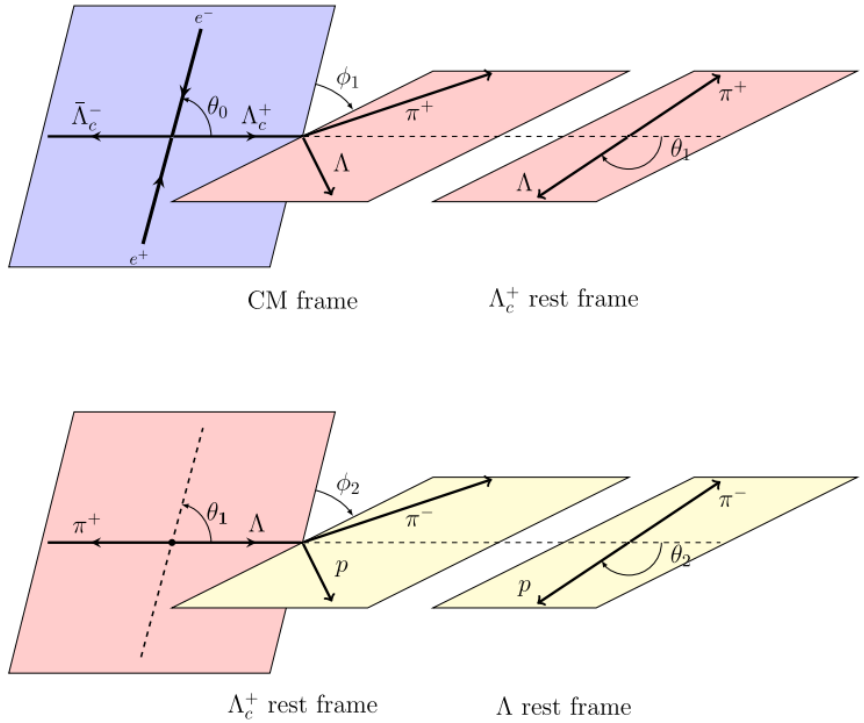
II. Partial wave analysis

$\Lambda_c^+ \to \Lambda\pi^+\pi^0$	JHEP 12.033 (2022)
$\Lambda_c^+ \to \Lambda\pi^+\eta$	PRL 134.021901 (2025)

First Λ_c^+ polarization measurement in the BESIII experiment

PRD 100.072004 (2019)





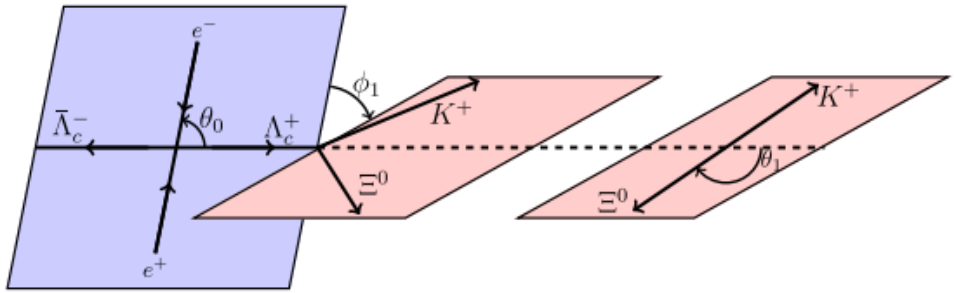
$$
\begin{aligned}
&\frac{d\Gamma}{d\cos\theta_0 d\cos\theta_1 d\cos\theta_2 d\phi_1 d\phi_2} \\
&\propto 2 + 2\alpha_0 \cos^2\theta_0 \\
&+ \sqrt{1-\alpha_0^2}\alpha_\Lambda \sin\Delta_0 \sin(2\theta_0)\sin\theta_1\cos\theta_2\sin\phi_1 \\
&+ \sqrt{1-\alpha_0^2}\alpha_\Lambda \sin\Delta_0 \sin(2\theta_0)\cos\theta_1\sin\theta_2\sin\phi_1 \\
&\times \sqrt{1-(\alpha^+_{\Lambda\pi^+})^2}\cos(\Delta_1^{\Lambda\pi^+}+\phi_2) \\
&+ \sqrt{1-\alpha_0^2}\alpha_\Lambda \sin\Delta_0 \sin(2\theta_0)\sin\theta_2\cos\phi_1 \\
&\times \sqrt{1-(\alpha^+_{\Lambda\pi^+})^2}\sin(\Delta_1^{\Lambda\pi^+}+\phi_2) \\
&+ \sqrt{1-\alpha_0^2}\sin\Delta_0\sin(2\theta_0)\sin\theta_1\sin\phi_1\alpha^+_{\Lambda\pi^+} \\
&+ 2\alpha_0\alpha_\Lambda\cos^2\theta_0\cos\theta_2\alpha^+_{\Lambda\pi^+} + 2\alpha_\Lambda\cos\theta_2\alpha^+_{\Lambda\pi^+}
\end{aligned}
$$

Parameters	$\Lambda_c^+ \to pK_S^0$	$\Lambda\pi^+$	$\Sigma^+\pi^0$	$\Sigma^0\pi^+$
α_{BP}^+	$0.18 \pm 0.43 \pm 0.14$	$-0.80 \pm 0.11 \pm 0.02$	$-0.57 \pm 0.10 \pm 0.07$	$-0.73 \pm 0.17 \pm 0.07$
α_{BP}^+ (PDG)	...	-0.91 ± 0.15	-0.45 ± 0.32	...
β_{BP}	...	$0.06^{+0.58+0.05}_{-0.47-0.06}$	$-0.66^{+0.46+0.22}_{-0.25-0.02}$	$0.48^{+0.35+0.07}_{-0.57-0.13}$
γ_{BP}	...	$-0.60^{+0.96+0.17}_{-0.05-0.03}$	$-0.48^{+0.45+0.21}_{-0.42-0.04}$	$0.49^{+0.35+0.07}_{-0.56-0.12}$
Δ_1^{BP}(rad)	...	$3.0 \pm 2.4 \pm 1.0$	$4.1 \pm 1.1 \pm 0.6$	$0.8 \pm 1.2 \pm 0.2$

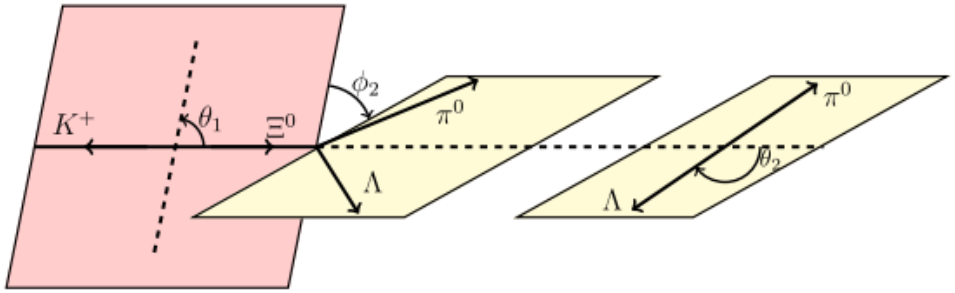
Angular analysis: $\Lambda_c^+ \to \Xi^0 K^+$

PRL 132.031801 (2024)

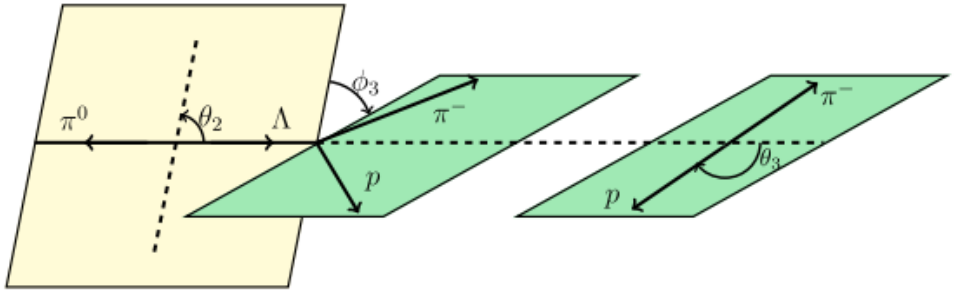
- Focus on the polarization in the pure W-exchange diagram $\Lambda_c^+ \to \Xi^0 K^+$.



CM frame $\quad$ Λ_c^+ rest frame



Λ_c^+ rest frame $\quad$ Ξ^0 rest frame



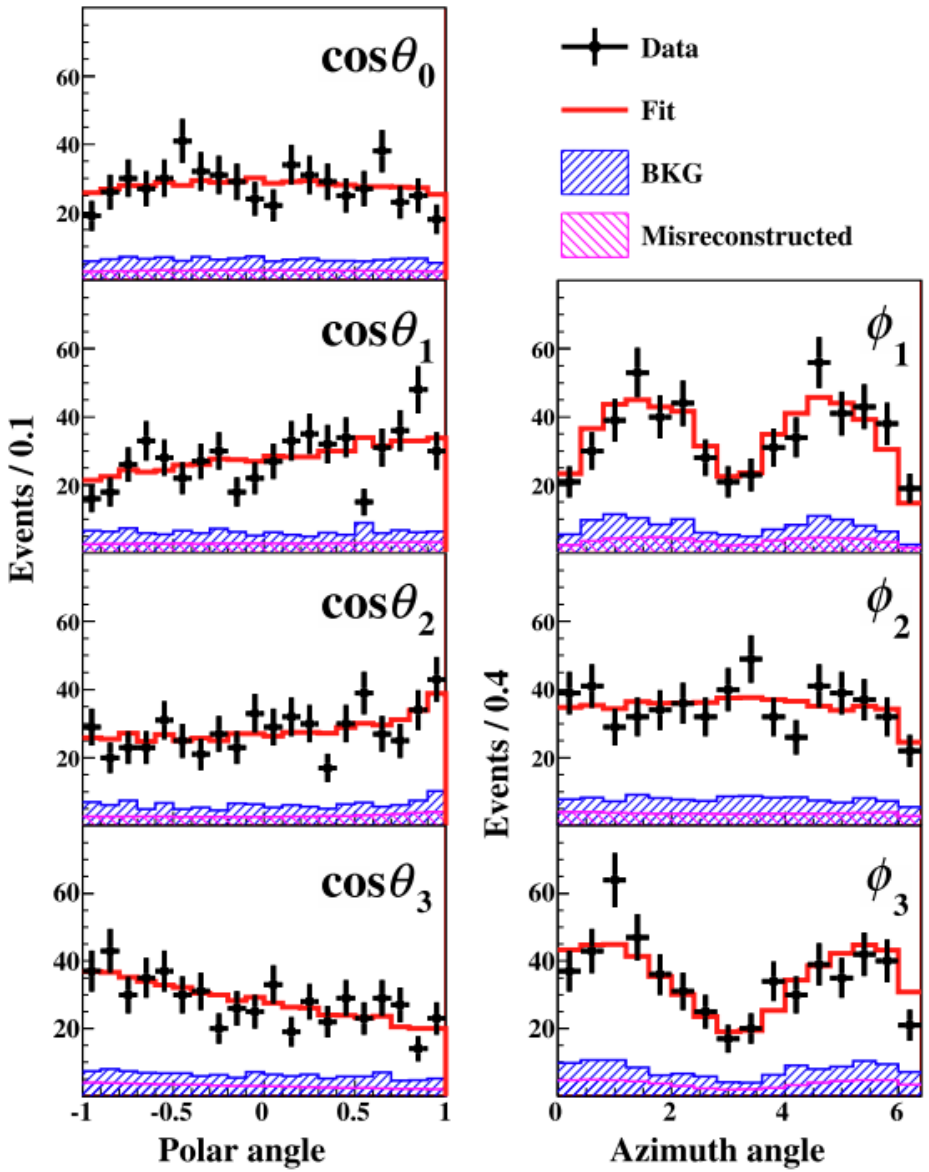
Ξ^0 rest frame $\quad$ Λ rest frame

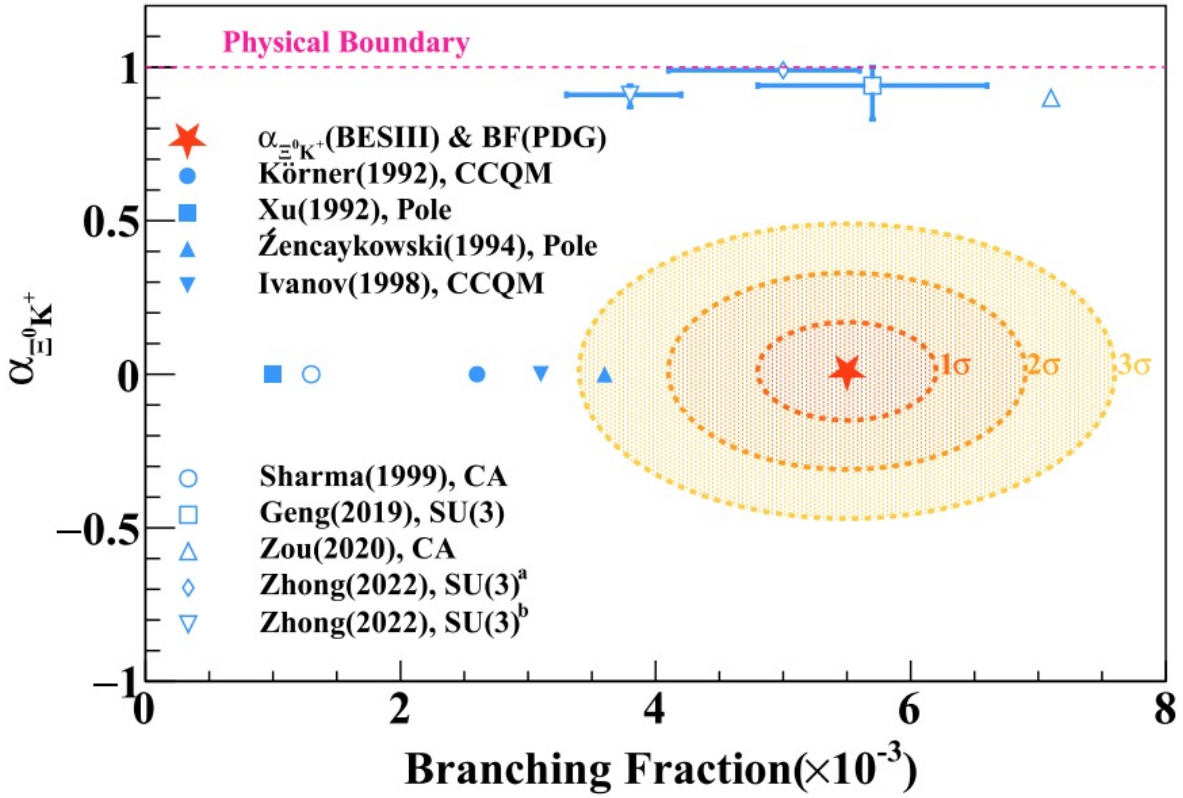
$$
\begin{aligned}
&\frac{d\Gamma}{d\cos\theta_0\, d\cos\theta_1\, d\cos\theta_2\, d\cos\theta_3\, d\phi_1\, d\phi_2\, d\phi_3} \\
&\propto 1 + \alpha_0 \cos^2\theta_0 \\
&+ (1 + \alpha_0\cos^2\theta_0)\ \alpha_{\Xi^0 K^+}\alpha_{\Lambda\pi^0}\cos\theta_2 \\
&+ (1 + \alpha_0\cos^2\theta_0)\ \alpha_{\Xi^0 K^+}\alpha_{p\pi^-}\cos\theta_2\cos\theta_3 \\
&+ (1 + \alpha_0\cos^2\theta_0)\ \alpha_{\Lambda\pi^0}\alpha_{p\pi^-}\cos\theta_3 \\
&- (1 + \alpha_0\cos^2\theta_0)\ \alpha_{\Xi^0 K^+}\sqrt{1-\alpha_{\Lambda\pi^0}^2}\ \alpha_{p\pi^-}\sin\theta_2\sin\theta_3\cos(\Delta_{\Lambda\pi^0} + \phi_3) \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\alpha_{\Xi^0 K^+}\sin\theta_1\sin\phi_1 \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\alpha_{\Lambda\pi^0}\sin\theta_1\sin\phi_1\cos\theta_2 \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\alpha_{\Xi^0 K^+}\alpha_{\Lambda\pi^0}\alpha_{p\pi^-}\sin\theta_1\sin\phi_1\cos\theta_3 \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\alpha_{p\pi^-}\sin\theta_1\sin\phi_1\cos\theta_2\cos\theta_3 \\
&- \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Lambda\pi^0}^2}\ \alpha_{p\pi^-}\sin\theta_1\sin\phi_1\sin\theta_2\sin\theta_3\cos(\Delta_{\Lambda\pi^0} + \phi_3) \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\ \alpha_{\Lambda\pi^0}\cos\phi_1\sin\theta_2\sin(\Delta_{\Xi^0 K^+} + \phi_2) \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\ \alpha_{\Lambda\pi^0}\cos\theta_1\sin\phi_1\sin\theta_2\cos(\Delta_{\Xi^0 K^+} + \phi_2) \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\ \alpha_{p\pi^-}\cos\theta_1\sin\phi_1\sin\theta_2\cos(\Delta_{\Xi^0 K^+} + \phi_2)\cos\theta_3 \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\ \alpha_{p\pi^-}\cos\phi_1\sin\theta_2\sin(\Delta_{\Xi^0 K^+} + \phi_2)\cos\theta_3 \\
&- \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\sqrt{1-\alpha_{\Lambda\pi^0}^2}\ \alpha_{p\pi^-}\cos\theta_1\sin\phi_1\sin(\Delta_{\Xi^0 K^+} + \phi_2)\sin\theta_3\sin(\Delta_{\Lambda\pi^0} + \phi_3) \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\sqrt{1-\alpha_{\Lambda\pi^0}^2}\ \alpha_{p\pi^-}\cos\theta_1\sin\phi_1\cos\theta_2\cos(\Delta_{\Xi^0 K^+} + \phi_2)\sin\theta_3\cos(\Delta_{\Lambda\pi^0} + \phi_3) \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\sqrt{1-\alpha_{\Lambda\pi^0}^2}\ \alpha_{p\pi^-}\cos\phi_1\cos(\Delta_{\Xi^0 K^+} + \phi_2)\sin\theta_3\sin(\Delta_{\Lambda\pi^0} + \phi_3) \\
&+ \sqrt{1-\alpha_0^2}\ \sin\Delta_0\sin\theta_0\cos\theta_0\sqrt{1-\alpha_{\Xi^0 K^+}^2}\sqrt{1-\alpha_{\Lambda\pi^0}^2}\ \alpha_{p\pi^-}\cos\phi_1\cos\theta_2\sin(\Delta_{\Xi^0 K^+} + \phi_2)\sin\theta_3\cos(\Delta_{\Lambda\pi^0} + \phi_3)
\end{aligned}
$$

A seven-dimensional angular analysis.

Angular analysis: $\Lambda_c^+ \to \Xi^0 K^+$

PRL 132.031801 (2024)





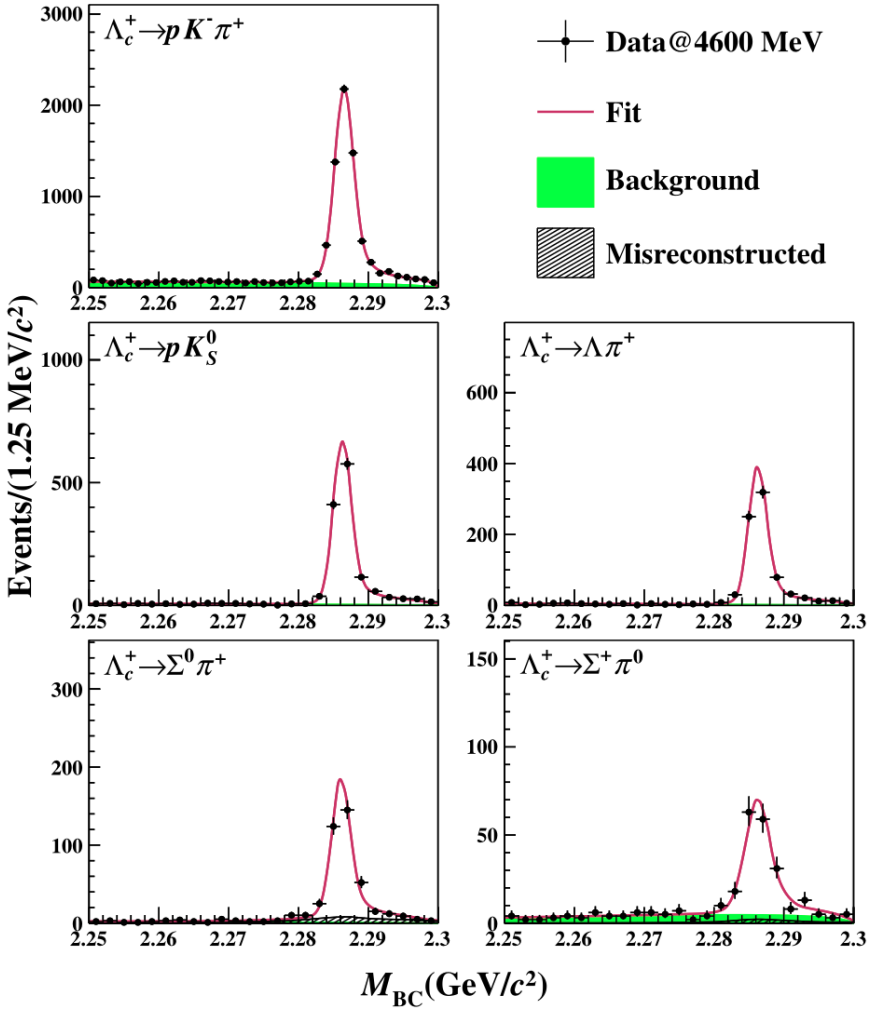
$\alpha_{\Xi^0K^+} = 0.01 \pm 0.16 \pm 0.03$

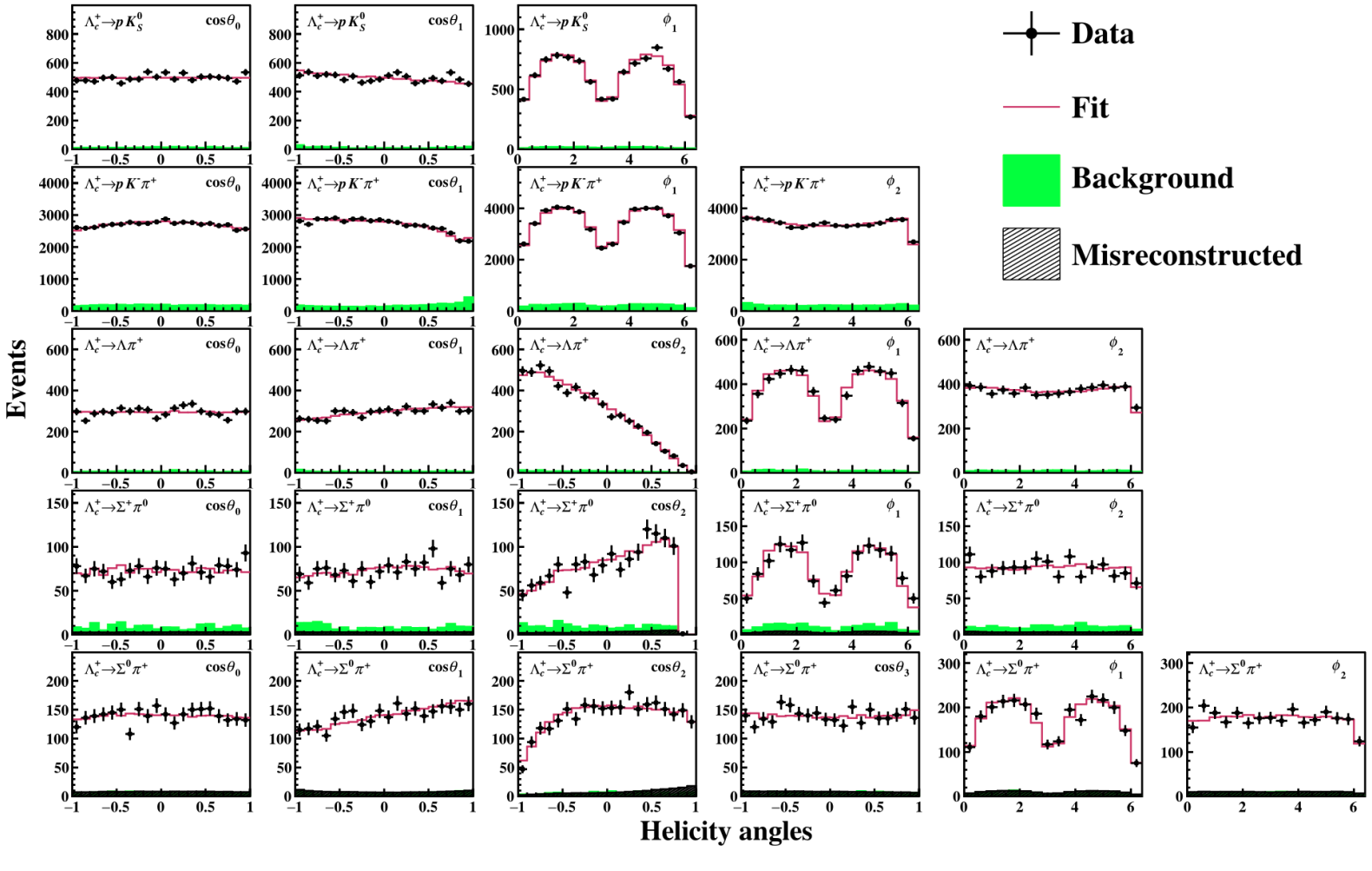
$\Delta_{\Xi^0K^+} = 3.84 \pm 0.90 \pm 0.17$ rad

Strong phase shift: $-1.55(1.59) \pm 0.25 \pm 0.05$ rad

Λ_c^+ production and decay dynamic

PRX 16.031058 (2026)





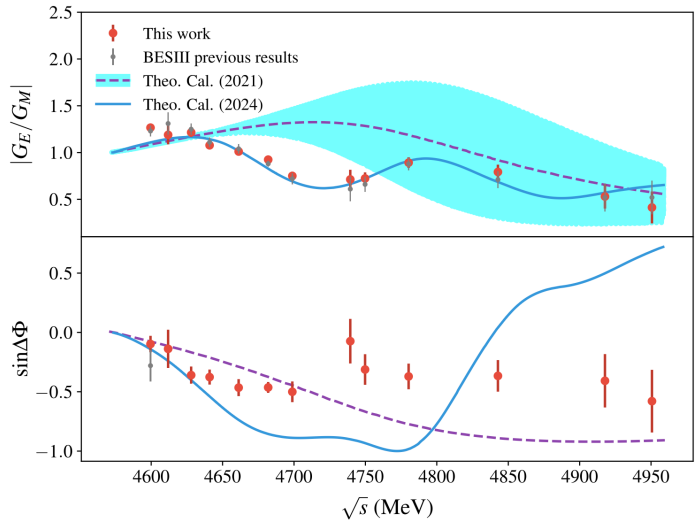
Much more data than previous measurement!

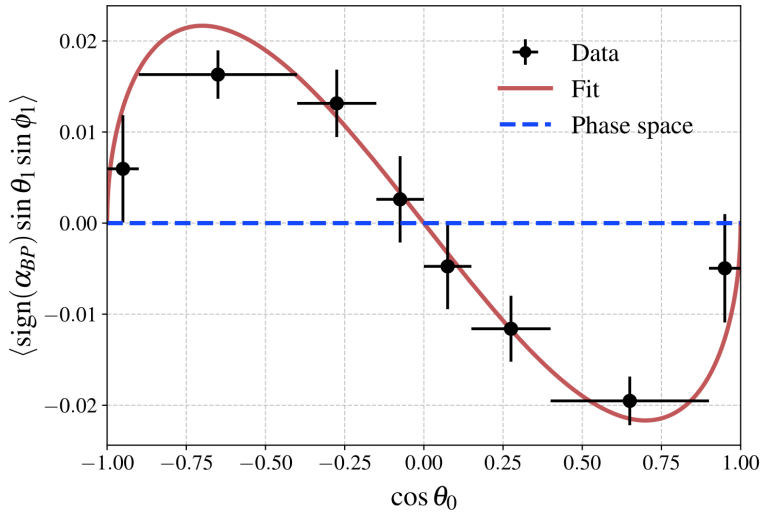
Observation of Λ_c^+ transverse polarization

PRX 16.031058 (2026)

$\sqrt{s}$ (MeV)	α_0 in previous work [21,93]	α_0 in this work	$\sin\Delta\Phi$	SL	$\sqrt{\langle\lvert\mathcal{P}^y_{\Lambda_c^+}\rvert^2\rangle}(\%)$
4600	$-0.20 \pm 0.04 \pm 0.02$	$-0.226 \pm 0.030 \pm 0.004$	$-0.098 \pm 0.069 \pm 0.009$	2.2σ	$3.81^{+2.66}_{-2.41} \pm 0.23$
4612	$-0.26 \pm 0.09 \pm 0.01$	$-0.163 \pm 0.082 \pm 0.012$	$-0.139 \pm 0.160 \pm 0.033$	1.1σ	$5.34^{+5.84}_{-3.68} \pm 0.92$
4628	$-0.21 \pm 0.04 \pm 0.01$	$-0.181 \pm 0.038 \pm 0.001$	$-0.368 \pm 0.077 \pm 0.011$	6.8σ	$14.19 \pm 2.96 \pm 0.42$
4641	$-0.09 \pm 0.05 \pm 0.01$	$-0.060 \pm 0.039 \pm 0.004$	$-0.386 \pm 0.067 \pm 0.014$	7.5σ	$14.41 \pm 2.49 \pm 0.34$
4661	$-0.02 \pm 0.05 \pm 0.01$	$0.008 \pm 0.044 \pm 0.003$	$-0.484 \pm 0.079 \pm 0.018$	8.6σ	$17.63 \pm 2.85 \pm 0.22$
4682	$0.15 \pm 0.03 \pm 0.01$	$0.102 \pm 0.029 \pm 0.003$	$-0.482 \pm 0.048 \pm 0.019$	14.1σ	$16.86 \pm 1.63 \pm 0.28$
4699	$0.34 \pm 0.07 \pm 0.01$	$0.305 \pm 0.055 \pm 0.010$	$-0.524 \pm 0.098 \pm 0.025$	7.2σ	$16.35 \pm 2.98 \pm 0.37$
4740	$0.49 \pm 0.16 \pm 0.03$	$0.358 \pm 0.126 \pm 0.009$	$-0.074 \pm 0.189 \pm 0.015$	0.3σ	$2.22^{+5.10}_{-1.52} \pm 0.45$
4750	$0.42 \pm 0.10 \pm 0.01$	$0.347 \pm 0.079 \pm 0.005$	$-0.318 \pm 0.135 \pm 0.018$	3.2σ	$9.64^{+4.02}_{-4.04} \pm 0.51$
4781	$0.17 \pm 0.07 \pm 0.01$	$0.157 \pm 0.062 \pm 0.008$	$-0.380 \pm 0.114 \pm 0.025$	5.1σ	$12.94^{+3.79}_{-3.86} \pm 0.44$
4843	$0.38 \pm 0.10 \pm 0.01$	$0.282 \pm 0.089 \pm 0.020$	$-0.375 \pm 0.140 \pm 0.032$	3.6σ	$11.87^{+4.35}_{-4.39} \pm 0.91$
4918	$0.62 \pm 0.17 \pm 0.01$	$0.609 \pm 0.152 \pm 0.019$	$-0.420 \pm 0.248 \pm 0.022$	1.9σ	$9.95^{+5.33}_{-5.55} \pm 0.34$
4951	$0.63 \pm 0.21 \pm 0.01$	$0.746 \pm 0.183 \pm 0.009$	$-0.618 \pm 0.326 \pm 0.050$	1.7σ	$11.81^{+6.10}_{-6.72} \pm 0.97$

Significant polarization



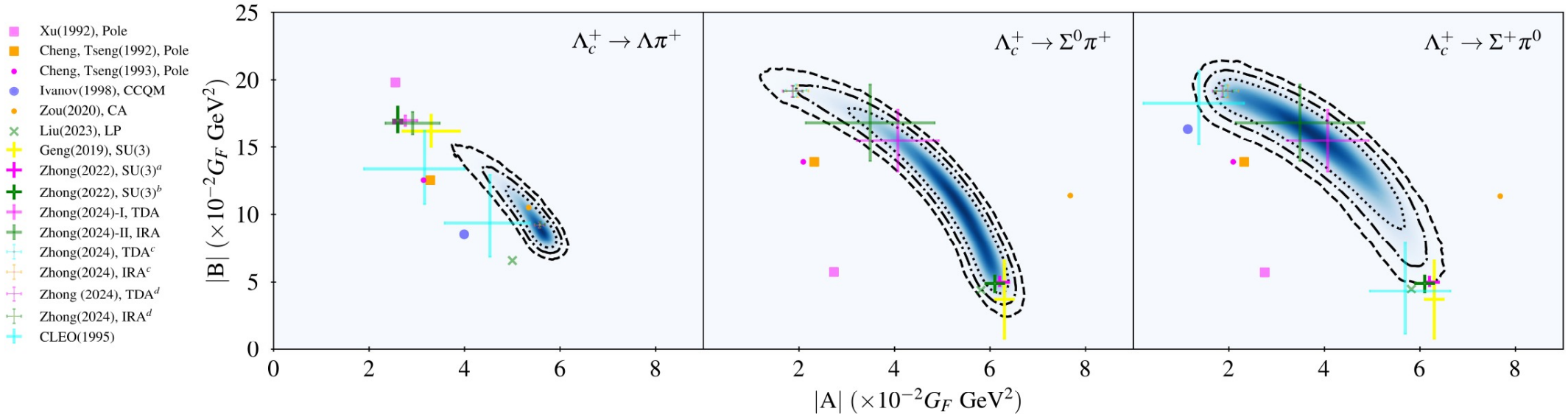


Λ_c^+ decay dynamic

PRX 16.031058 (2026)

Parameter	$\Lambda_c^+ \to pK_S^0$	$\Lambda_c^+ \to \Lambda\pi^+$	$\Lambda_c^+ \to \Sigma^0\pi^+$	$\Lambda_c^+ \to \Sigma^+\pi^0$
$\langle\alpha_{BP}\rangle$	$-0.914^{+0.132}_{-0.086} \pm 0.030$	$-0.789 \pm 0.032 \pm 0.011$	$-0.499 \pm 0.079 \pm 0.010$	$-0.590 \pm 0.049 \pm 0.023$
$\langle\Delta_{BP}\rangle$	···	$0.638 \pm 0.444 \pm 0.015$	$1.083 \pm 0.634 \pm 0.027$	$1.898 \pm 0.602 \pm 0.044$
$\langle\beta_{BP}\rangle$	···	$0.366^{+0.173}_{-0.246} \pm 0.011$	$0.766^{+0.084}_{-0.352} \pm 0.012$	$0.764^{+0.051}_{-0.236} \pm 0.019$
$\langle\gamma_{BP}\rangle$	···	$0.493^{+0.103}_{-0.202} \pm 0.013$	$0.406^{+0.358}_{-0.528} \pm 0.021$	$-0.260^{+0.477}_{-0.384} \pm 0.030$
$\langle\Delta_S\rangle$	···	$2.71^{+0.28}_{-0.17} \pm 0.02$	$2.15^{+0.30}_{-0.09} \pm 0.02$	$2.23^{+0.19}_{-0.06} \pm 0.03$
$\tan\langle\Delta_S\rangle$	···	$-0.46^{+0.29}_{-0.21} \pm 0.02$	$-1.53^{+0.68}_{-0.42} \pm 0.05$	$-1.29^{+0.40}_{-0.18} \pm 0.08$

Large phase shift!

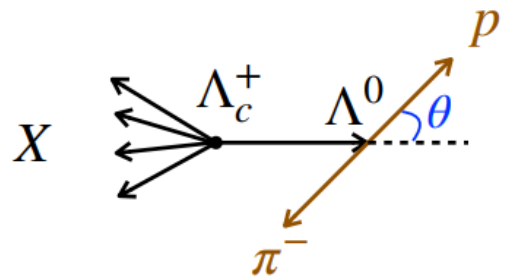


CP measurement in inclusive decay $\Lambda_c^+ \to \Lambda X$

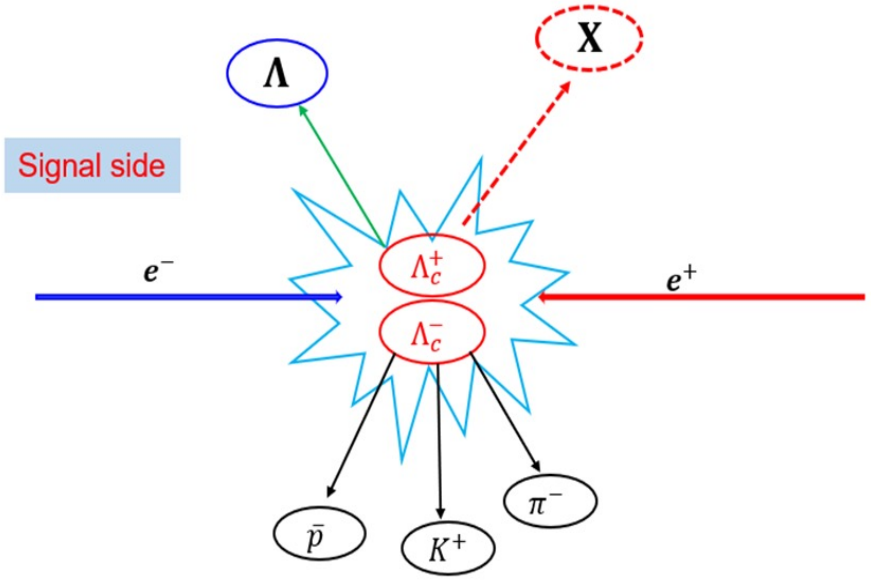
PRL 137.131902 (2026)

Two-body decays like $\Lambda_c^+ \to \Lambda\pi^+$ $\quad \frac{d\Gamma}{dcos\theta} \propto 1 + \alpha_{\Lambda_c}\alpha_\Lambda cos\theta$

Inclusive decays like $\Lambda_c^+ \to \Lambda X$ $\quad \frac{d\Gamma}{dcos\theta} \propto 1 + \alpha\alpha_\Lambda cos\theta$



Longitudinal polarization of Λ from Λ_c^+ decays.



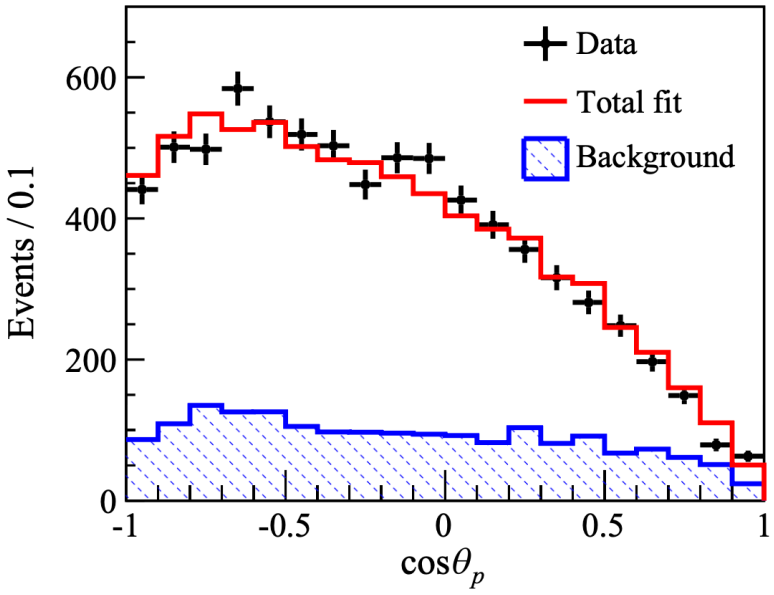
$$\frac{d\Gamma}{dcos\theta} \propto 1 + \mathcal{P}(q^2)\alpha_\Lambda cos\theta$$

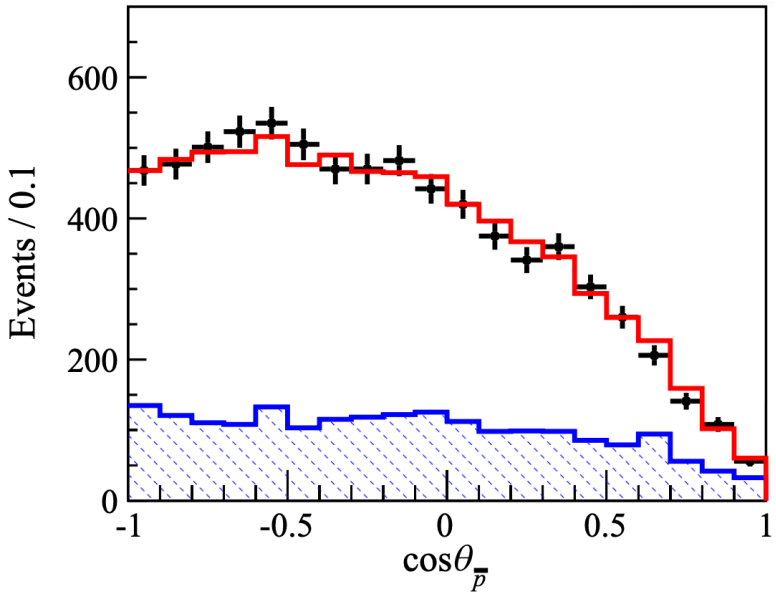
$$A_{CP}^{\alpha} = \frac{\mathcal{P}\boldsymbol{\alpha_\Lambda} + \bar{\mathcal{P}}\boldsymbol{\alpha_{\bar{\Lambda}}}}{\mathcal{P}\boldsymbol{\alpha_\Lambda} - \bar{\mathcal{P}}\boldsymbol{\alpha_{\bar{\Lambda}}}}$$

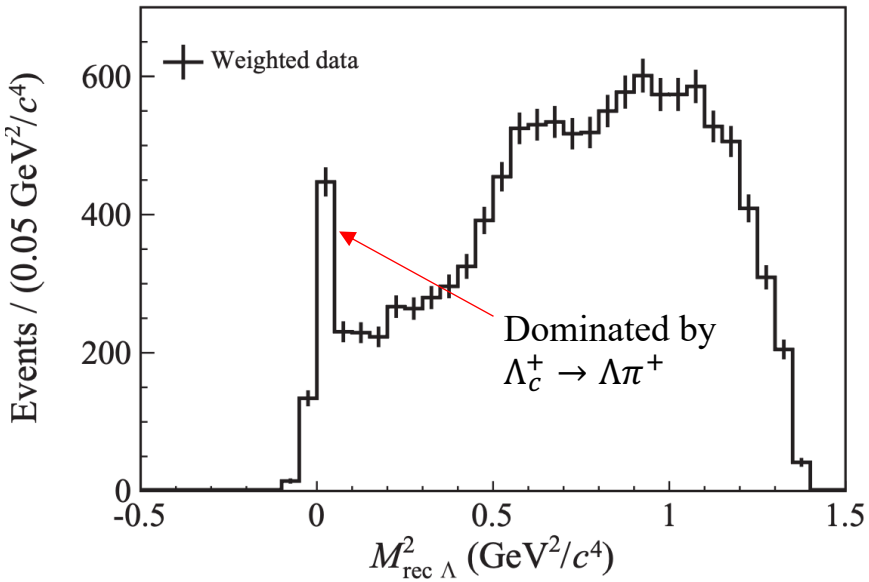
J. P. Wang and F. S. Yu
PLB 849.138460 (2024)

CP measurement in inclusive decay $\Lambda_c^+ \to \Lambda X$

PRL 137.131902 (2026)







Parameters	Results
A_{CP}^{dir}	$0.015 \pm 0.010 \pm 0.010$
$\mathcal{P}_\Lambda \alpha_-$	$-0.293 \pm 0.041 \pm 0.015$
$\bar{\mathcal{P}}_{\bar{\Lambda}} \alpha_+$	$-0.218 \pm 0.042 \pm 0.013$
$\mathcal{P}_\Lambda$	$-0.393 \pm 0.055 \pm 0.020$
$\bar{\mathcal{P}}_{\bar{\Lambda}}$	$0.288 \pm 0.056 \pm 0.017$
A_{CP}^{pol}	$0.15 \pm 0.12 \pm 0.03$

No CPV evidence found in A_{CP}^{dir} and A_{CP}^{pol}

Multi-body decays

- The definition of polarization parameters:

$$\left[\alpha = \frac{2\mathrm{Re}(s^* p)}{|s|^2 + |p|^2} \quad \beta = \frac{2\mathrm{Im}(s^* p)}{|s|^2 + |p|^2} \quad \gamma = \frac{|s|^2 - |p|^2}{|s|^2 + |p|^2}\right]$$

If s and p can be measured directly, all information will be derived.

Partial wave analysis is a good choice for multi-body decays.

TF-PWA

A general and user-friendly partial wave analysis framework

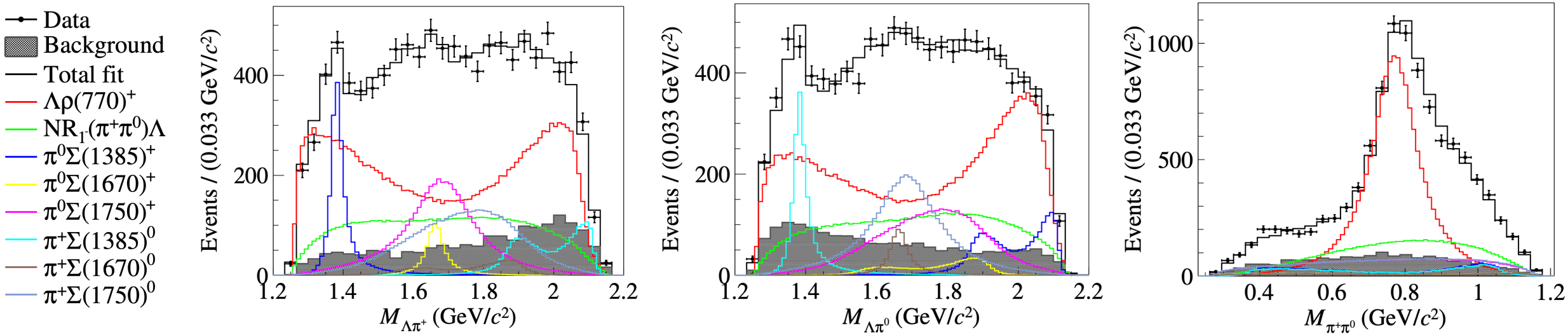
- Developed and updated by Yi Jiang @ UCAS
- Home page: **https://github.com/jiangyi15/tf-pwa**

s and p of all intermediate resonance states

- ✓ Polarization parameters
- ✓ Branching fraction

Partial wave analysis: $\Lambda_c^+ \to \Lambda\pi^+\pi^0$

JHEP 12.033 (2022)



$$H^{\rho}_{-\frac{1}{2},-1} = -\frac{g^{\rho}_{0,\frac{1}{2}}}{\sqrt{3}} + \frac{g^{\rho}_{1,\frac{1}{2}}}{\sqrt{3}} - \frac{g^{\rho}_{1,\frac{3}{2}}}{\sqrt{6}} + \frac{g^{\rho}_{2,\frac{3}{2}}}{\sqrt{6}}, \quad H^{\rho}_{\frac{1}{2},0} = \frac{g^{\rho}_{0,\frac{1}{2}}}{\sqrt{6}} - \frac{g^{\rho}_{1,\frac{1}{2}}}{\sqrt{6}} - \frac{g^{\rho}_{1,\frac{3}{2}}}{\sqrt{3}} + \frac{g^{\rho}_{2,\frac{3}{2}}}{\sqrt{3}},$$

$$H^{\rho}_{-\frac{1}{2},0} = -\frac{g^{\rho}_{0,\frac{1}{2}}}{\sqrt{6}} - \frac{g^{\rho}_{1,\frac{1}{2}}}{\sqrt{6}} - \frac{g^{\rho}_{1,\frac{3}{2}}}{\sqrt{3}} - \frac{g^{\rho}_{2,\frac{3}{2}}}{\sqrt{3}}, \quad H^{\rho}_{\frac{1}{2},1} = \frac{g^{\rho}_{0,\frac{1}{2}}}{\sqrt{3}} + \frac{g^{\rho}_{1,\frac{1}{2}}}{\sqrt{3}} - \frac{g^{\rho}_{1,\frac{3}{2}}}{\sqrt{6}} - \frac{g^{\rho}_{2,\frac{3}{2}}}{\sqrt{6}}.$$

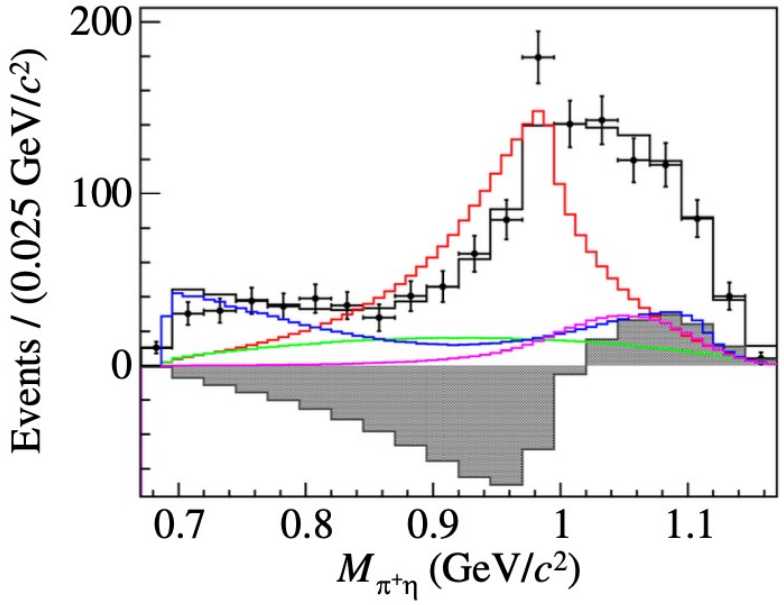
$$\alpha_{\Lambda\rho(770)^+} = \frac{|H^{\rho}_{\frac{1}{2},1}|^2 - |H^{\rho}_{-\frac{1}{2},-1}|^2 + |H^{\rho}_{\frac{1}{2},0}|^2 - |H^{\rho}_{-\frac{1}{2},0}|^2}{|H^{\rho}_{\frac{1}{2},1}|^2 + |H^{\rho}_{-\frac{1}{2},-1}|^2 + |H^{\rho}_{\frac{1}{2},0}|^2 + |H^{\rho}_{-\frac{1}{2},0}|^2}$$

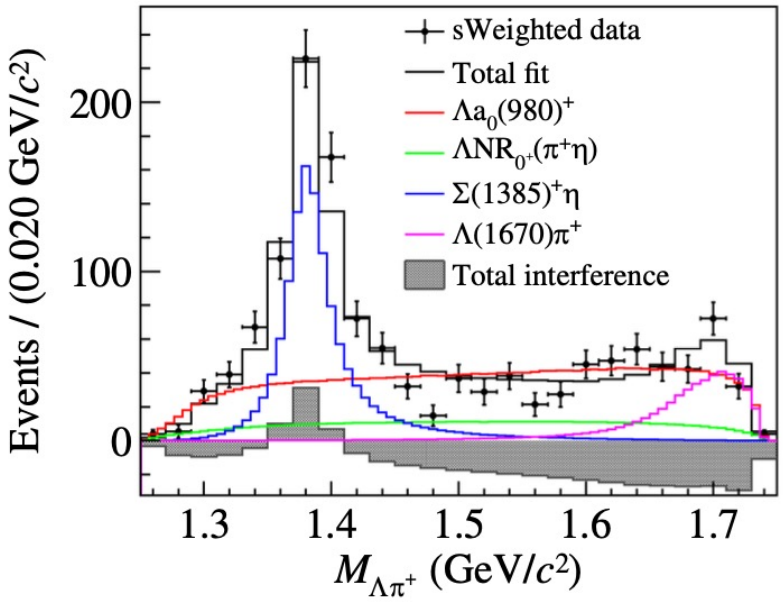
$$= \frac{\sqrt{\frac{1}{9}} \cdot 2 \cdot \Re\left(g^{\rho}_{0,\frac{1}{2}} \cdot \bar{g}^{\rho}_{1,\frac{1}{2}} - g^{\rho}_{1,\frac{3}{2}} \cdot \bar{g}^{\rho}_{2,\frac{3}{2}}\right) - \sqrt{\frac{8}{9}} \cdot 2 \cdot \Re\left(g^{\rho}_{0,\frac{1}{2}} \cdot \bar{g}^{\rho}_{1,\frac{3}{2}} + g^{\rho}_{1,\frac{1}{2}} \cdot \bar{g}^{\rho}_{2,\frac{3}{2}}\right)}{|g^{\rho}_{0,\frac{1}{2}}|^2 + |g^{\rho}_{1,\frac{1}{2}}|^2 + |g^{\rho}_{1,\frac{3}{2}}|^2 + |g^{\rho}_{2,\frac{3}{2}}|^2}$$

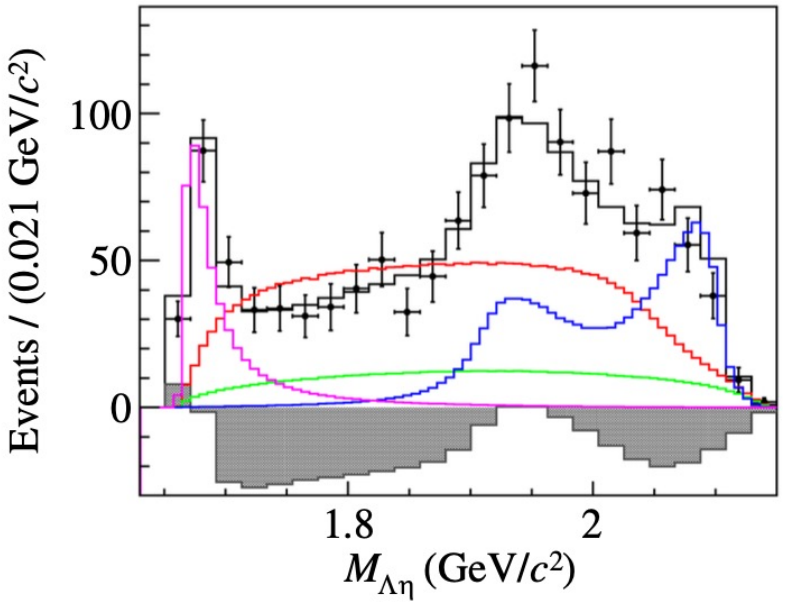
	Theoretical calculation		This work	PDG
$10^2 \times \mathcal{B}(\Lambda_c^+ \to \Lambda\rho(770)^+)$	4.81 ± 0.58 [13]	4.0 [14, 15]	4.06 ± 0.52	< 6
$10^3 \times \mathcal{B}(\Lambda_c^+ \to \Sigma(1385)^+\pi^0)$	2.8 ± 0.4 [16]	2.2 ± 0.4 [17]	5.86 ± 0.80	—
$10^3 \times \mathcal{B}(\Lambda_c^+ \to \Sigma(1385)^0\pi^+)$	2.8 ± 0.4 [16]	2.2 ± 0.4 [17]	6.47 ± 0.96	—
$\alpha_{\Lambda\rho(770)^+}$	-0.27 ± 0.04 [13]	-0.32 [14, 15]	-0.763 ± 0.070	—
$\alpha_{\Sigma(1385)^+\pi^0}$	$-0.91^{+0.45}_{-0.10}$ [17]		-0.917 ± 0.089	—
$\alpha_{\Sigma(1385)^0\pi^+}$	$-0.91^{+0.45}_{-0.10}$ [17]		-0.79 ± 0.11	—

Partial wave analysis: $\Lambda_c^+ \to \Lambda\pi^+\eta$

PRL 134.021901 (2025)







$$\alpha_{\Lambda a_0(980)^+} = \frac{\left|H^{\Lambda_c^+\to\Lambda a_0(980)^+}_{\frac{1}{2},0}\right|^2 - \left|H^{\Lambda_c^+\to\Lambda a_0(980)^+}_{-\frac{1}{2},0}\right|^2}{\left|H^{\Lambda_c^+\to\Lambda a_0(980)^+}_{\frac{1}{2},0}\right|^2 + \left|H^{\Lambda_c^+\to\Lambda a_0(980)^+}_{-\frac{1}{2},0}\right|^2} = -\frac{2\,\mathrm{Re}\left(g^{\Lambda_c^+\to\Lambda a_0(980)^+}_{0,\frac{1}{2}} \cdot g^{\Lambda_c^+\to\Lambda a_0(980)^+ *}_{1,\frac{1}{2}}\right)}{\left|g^{\Lambda_c^+\to\Lambda a_0(980)^+}_{0,\frac{1}{2}}\right|^2 + \left|g^{\Lambda_c^+\to\Lambda a_0(980)^+}_{1,\frac{1}{2}}\right|^2}$$

$$\alpha_{\Sigma(1385)^+\eta} = \frac{\left|H^{\Lambda_c^+\to\eta\Sigma(1385)^+}_{0,\frac{1}{2}}\right|^2 - \left|H^{\Lambda_c^+\to\eta\Sigma(1385)^+}_{0,-\frac{1}{2}}\right|^2}{\left|H^{\Lambda_c^+\to\eta\Sigma(1385)^+}_{0,\frac{1}{2}}\right|^2 + \left|H^{\Lambda_c^+\to\eta\Sigma(1385)^+}_{0,-\frac{1}{2}}\right|^2} = \frac{2\,\mathrm{Re}\left(g^{\Lambda_c^+\to\eta\Sigma(1385)^+}_{1,\frac{3}{2}} \cdot g^{\Lambda_c^+\to\eta\Sigma(1385)^+ *}_{2,\frac{3}{2}}\right)}{\left|g^{\Lambda_c^+\to\eta\Sigma(1385)^+}_{1,\frac{3}{2}}\right|^2 + \left|g^{\Lambda_c^+\to\eta\Sigma(1385)^+}_{2,\frac{3}{2}}\right|^2}$$

$$\alpha_{\Lambda(1670)^0\pi^+} = \frac{\left|H^{\Lambda_c^+\to\pi^+\Lambda(1670)^0}_{0,\frac{1}{2}}\right|^2 - \left|H^{\Lambda_c^+\to\pi^+\Lambda(1670)^0}_{0,-\frac{1}{2}}\right|^2}{\left|H^{\Lambda_c^+\to\pi^+\Lambda(1670)^0}_{0,\frac{1}{2}}\right|^2 + \left|H^{\Lambda_c^+\to\pi^+\Lambda(1670)^0}_{0,-\frac{1}{2}}\right|^2} = \frac{2\,\mathrm{Re}\left(g^{\Lambda_c^+\to\pi^+\Lambda(1670)^0}_{0,\frac{1}{2}} \cdot g^{\Lambda_c^+\to\pi^+\Lambda(1670)^0 *}_{1,\frac{1}{2}}\right)}{\left|g^{\Lambda_c^+\to\pi^+\Lambda(1670)^0}_{0,\frac{1}{2}}\right|^2 + \left|g^{\Lambda_c^+\to\pi^+\Lambda(1670)^0}_{1,\frac{1}{2}}\right|^2}$$

Process	FF (%)	$\mathcal{S}$	α
$\Lambda a_0(980)^+$	$54.0 \pm 8.4 \pm 2.6$	13.1σ	$-0.91^{+0.18}_{-0.09} \pm 0.08$
$\Sigma(1385)^+\eta$	$30.4 \pm 2.6 \pm 0.7$	22.5σ	$-0.61 \pm 0.15 \pm 0.04$
$\Lambda(1670)\pi^+$	$14.1 \pm 2.8 \pm 1.2$	11.7σ	$0.21 \pm 0.27 \pm 0.33$
ΛNR_{0^+}	15.4 ± 5.3	6.7σ	$\cdots$

Λ_c^+ polarization measurement overview

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Mode	α	Experiment
Nucleon-involved		
$\Lambda_c^+ \to pK_S^0$	-0.75 ± 0.10	LHCb(2024)[161]
	$-0.92^{+0.14}_{-0.09}$	BESIII(2025)[160]
$\Lambda_c^+ \to p\bar{K}_0^*(700)^0$	-0.1 ± 0.7	LHCb(2023)[91]
$\Lambda_c^+ \to p\bar{K}_0^*(892)^0$	0.87 ± 0.03	LHCb(2023)[91]
$\Lambda_c^+ \to p\bar{K}_0^*(1430)^0$	0.34 ± 0.14	LHCb(2023)[91]
$\Lambda_c^+ \to \Delta(1232)^{++}K^-$	0.55 ± 0.04	LHCb(2023)[91]
$\Lambda_c^+ \to \Delta(1600)^{++}K^-$	-0.50 ± 0.18	LHCb(2023)[91]
$\Lambda_c^+ \to \Delta(1700)^{++}K^-$	0.22 ± 0.08	LHCb(2023)[91]
Λ-involved		
$\Lambda_c^+ \to \Lambda\pi^+$	-0.785 ± 0.007	LHCb(2024)[161]
	-0.755 ± 0.006	Belle(2023)[138]
	-0.790 ± 0.033	BESIII(2025)[160]
$\Lambda_c^+ \to \Lambda K^+$	-0.59 ± 0.05	Belle(2023)[138]
	-0.52 ± 0.05	LHCb(2024)[161]
$\Lambda_c^+ \to \Lambda\rho(770)^+$	-0.763 ± 0.070	BESIII(2022)[98]
$\Lambda_c^+ \to \Lambda a(980)^+$	$-0.91^{+0.20}_{-0.12}$	BESIII(2025)[154]
$\Lambda_c^+ \to \Lambda(1405)\pi^+$	0.58 ± 0.28	LHCb(2023)[91]
$\Lambda_c^+ \to \Lambda(1520)\pi^+$	0.93 ± 0.09	LHCb(2023)[91]

Mode	β	Experiment
$\Lambda_c^+ \to \Lambda\pi^+$	0.378 ± 0.015	LHCb(2024)[161]
	$0.37^{+0.17}_{-0.25}$	BESIII(2025)[160]
$\Lambda_c^+ \to \Sigma^0\pi^+$	$0.70^{+0.14}_{-0.48}$	BESIII(2025)[160]
$\Lambda_c^+ \to \Sigma^+\pi^0$	$0.76^{+0.05}_{-0.24}$	BESIII(2025)[160]
$\Lambda_c^+ \to \Xi^0K^+$	-0.64 ± 0.70	BESIII(2024)[162]
$\Lambda_c^+ \to \Lambda K^+$	0.33 ± 0.08	LHCb(2024)[161]

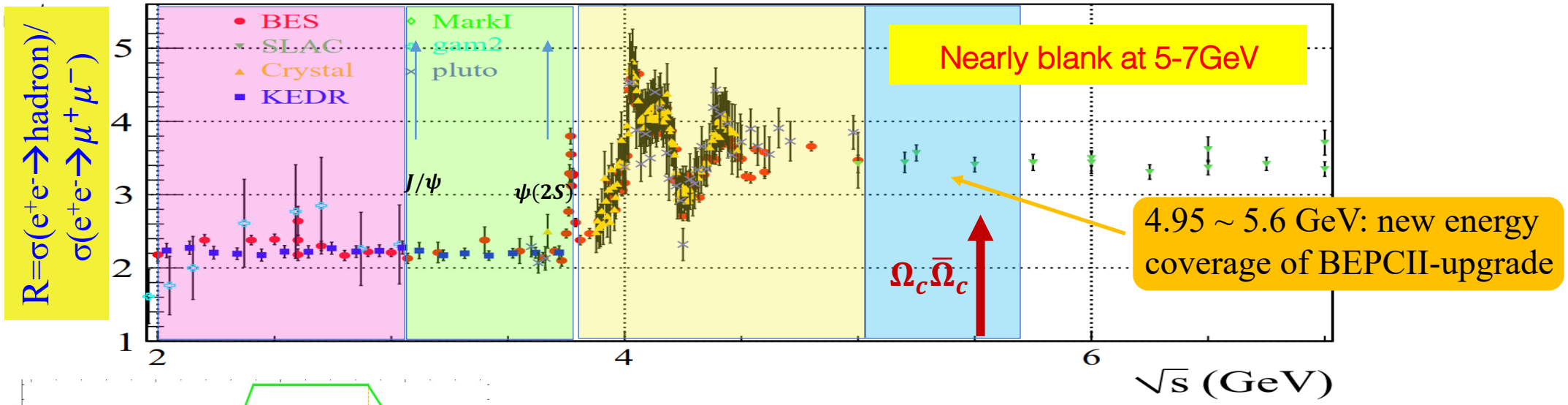
Mode	α	Experiment
$\Lambda_c^+ \to \Lambda(1600)\pi^+$	0.2 ± 0.5	LHCb(2023)[91]
$\Lambda_c^+ \to \Lambda(1670)\pi^+$	0.82 ± 0.08	LHCb(2023)[91]
	0.21 ± 0.43	BESIII(2025)[154]
$\Lambda_c^+ \to \Lambda(1690)\pi^+$	0.958 ± 0.034	LHCb(2023)[91]
$\Lambda_c^+ \to \Lambda(2000)\pi^+$	-0.57 ± 0.19	LHCb(2023)[91]
Σ-involved		
$\Lambda_c^+ \to \Sigma^+\pi^0$	-0.48 ± 0.03	Belle(2023)[103]
	-0.59 ± 0.05	BESIII(2025)[160]
$\Lambda_c^+ \to \Sigma^+\eta$	-0.99 ± 0.06	Belle(2023)[103]
$\Lambda_c^+ \to \Sigma^+\eta'$	-0.46 ± 0.07	Belle(2023)[103]
$\Lambda_c^+ \to \Sigma^0\pi^+$	-0.46 ± 0.02	Belle(2023)[138]
	-0.50 ± 0.08	BESIII(2025)[160]
$\Lambda_c^+ \to \Sigma(1385)^+\pi^0$	-0.917 ± 0.089	BESIII(2022)[98]
$\Lambda_c^+ \to \Sigma(1385)^+\eta$	-0.61 ± 0.16	BESIII(2025)[154]
$\Lambda_c^+ \to \Sigma(1385)^0\pi^+$	-0.79 ± 0.11	BESIII(2022)[98]
$\Lambda_c^+ \to \Sigma^0K^+$	-0.54 ± 0.20	Belle(2023)[138]
Ξ-involved		
$\Lambda_c^+ \to \Xi^0K^+$	0.01 ± 0.16	BESIII(2024)[162]

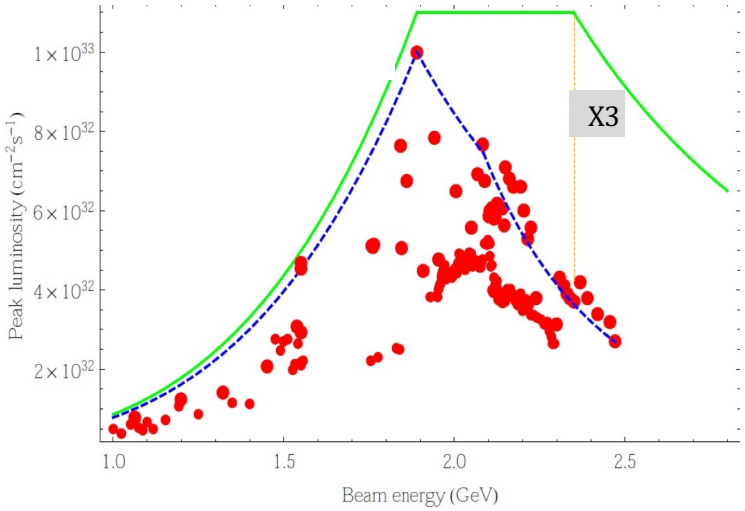
Mode	γ	Experiment
$\Lambda_c^+ \to \Lambda\pi^+$	0.491 ± 0.012	LHCb(2024)[161]
	$0.64^{+0.10}_{-0.20}$	BESIII(2025)[160]
$\Lambda_c^+ \to \Sigma^0\pi^+$	$-0.50^{+0.59}_{-0.30}$	BESIII(2025)[160]
$\Lambda_c^+ \to \Sigma^+\pi^0$	$-0.26^{+0.48}_{-0.38}$	BESIII(2025)[160]
$\Lambda_c^+ \to \Xi^0K^+$	-0.77 ± 0.59	BESIII(2024)[162]
$\Lambda_c^+ \to \Lambda K^+$	-0.799 ± 0.041	LHCb(2024)[161]

- ✓ Partial wave analysis is an effective tool for analyzing multibody decay, and the polarization of many two-body processes in multibody decay is measuring.
  - ✓ $\Lambda_c^+ \to pK^-\pi^+$
  - ✓ $\Lambda_c^+ \to pK_s^0\pi^0$
  - ✓ $\Lambda_c^+ \to pK^-\pi^+\pi^0$
  - ✓ $\Lambda_c^+ \to nK_s^0\pi^+$
- ✓ Could be released in 2027
  - $\Lambda_c^+ \to \Sigma^-\pi^+\pi^+$
  - $\Lambda_c^+ \to \Sigma^+\pi^+\pi^-$

Proposal of the BEPCII upgrade

- optimized energy at 2.35 GeV with luminosity 3 times higher than the current BEPCII.





Energy thresholds

✓	$\Lambda_c^+\bar{\Sigma}_c^-$	4.74 GeV
✓	$\Lambda_c^+\bar{\Sigma}_c\ \pi$	4.88 GeV
✓	$\Sigma_c\ \bar{\Sigma}_c$	4.91 GeV
✓	$\Xi_c\ \bar{\Xi}_c$	4.95 GeV
✓	$\Omega_c^0\bar{\Omega}_c^0$	5.4 GeV

- BEPCII-U reached the designed luminosity at E_{beam}= 2.35 GeV

- Began a new round of Λ_c^+ data taking @4.68 GeV on Feb.27 2026
- Very smooth data taking （~4fb^{-1}）

Summary

- ✓ BESIII collected a large amount of Λ_c^+ data near the threshold, which enable polarization parameters to be measured.
- ✓ Significant Λ_c^+ transverse polarization observed in the BESIII experiment can be used to study polarization in more decay channels.
- ✓ Polarization can help us obtain more decay information, such as amplitude magnitude, strong phase shift, and CPV observables.
- ✓ Especially with strong phase shift, the performance of Λ_c^+ and hyperons is completely different, which has been confirmed by LHCb/BESIII in $\Lambda_c^+ \to \Lambda\pi^+/\Sigma^0\pi^+/\Sigma^+\pi^0$ channels.
- ✓ Plan to take data to study $\Xi_c^{0,+}$ baryons.

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