



兰州大学
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BESIII

Overview of Charmed baryon decays at BESIII

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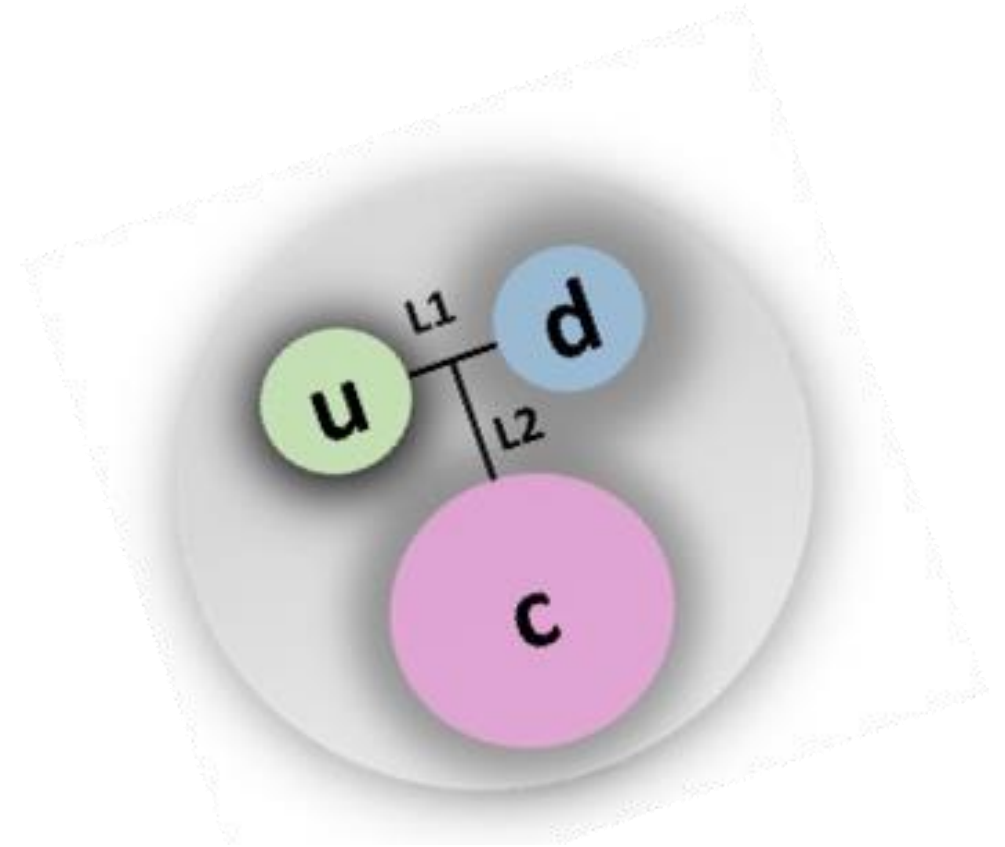
(on behalf of BESIII Collaboration)

XIV International Conference on New Frontiers in Physics, July.31, 2025

at the OAC, Kolymbari, Crete, Greece

Outline

- The lightest charm baryon Λ_c^+
- Charm baryon physics at BESIII
 - Λ_c^+ semi-leptonic decays
 - Λ_c^+ hadronic decays
- Summary



Λ_c^+ : The lightest charmed baryon spectroscopy

➤ Naive quark model picture:

- A heavy quark (c) with an unexcited spin-zero diquark ($u-d$)
- Diquark correlation is enhanced by weak Color Magnetic Interaction with a heavy quark (HQET)

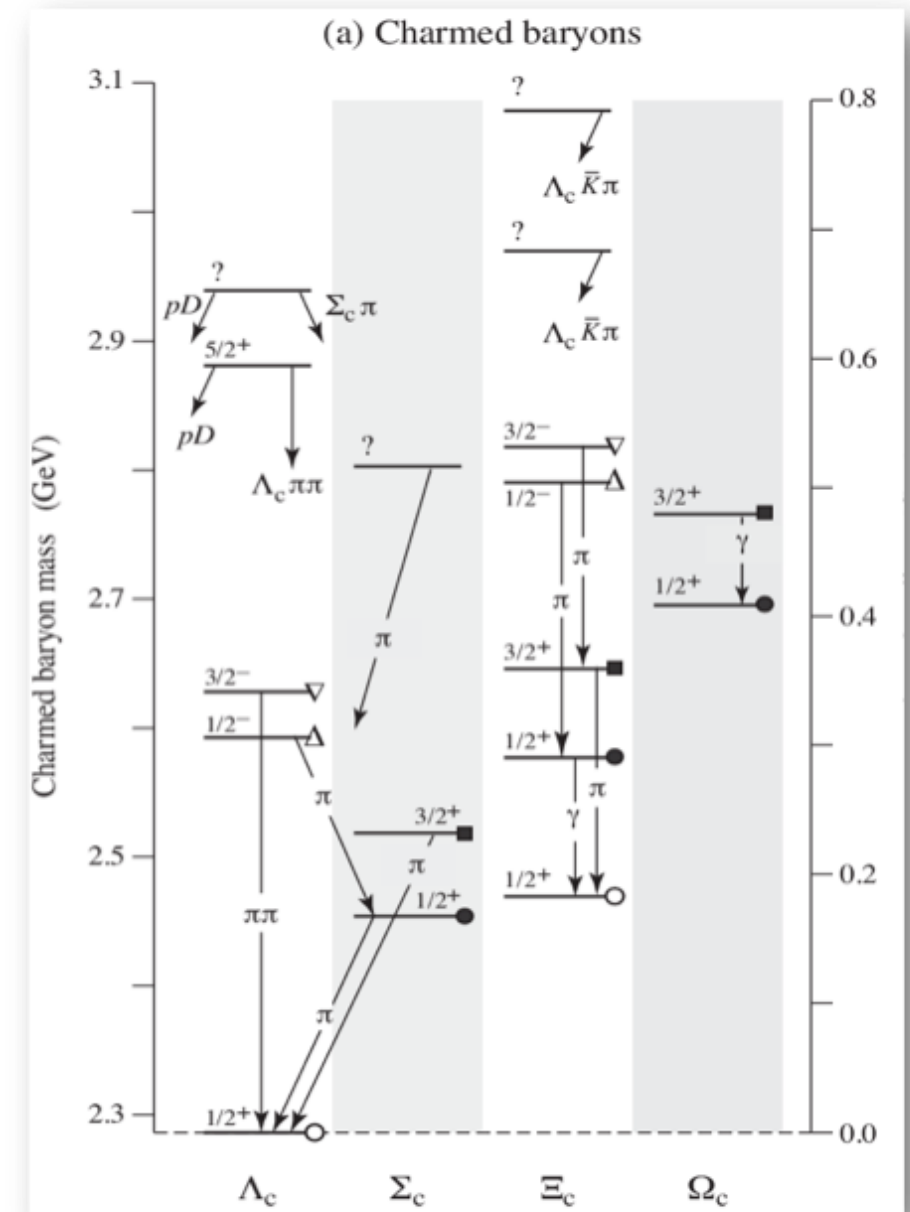
➤ Cornerstone of charmed baryons:

- Most of the charmed baryons will eventually decay to Λ_c^+

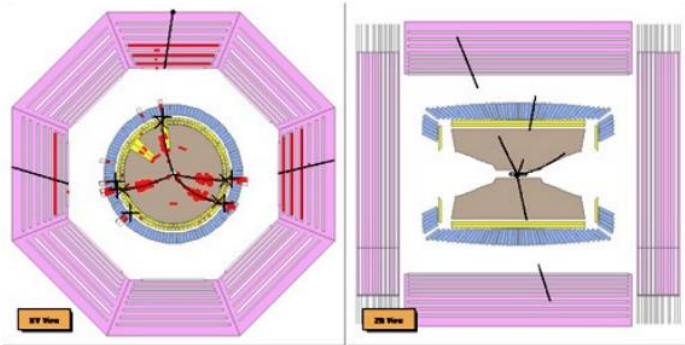
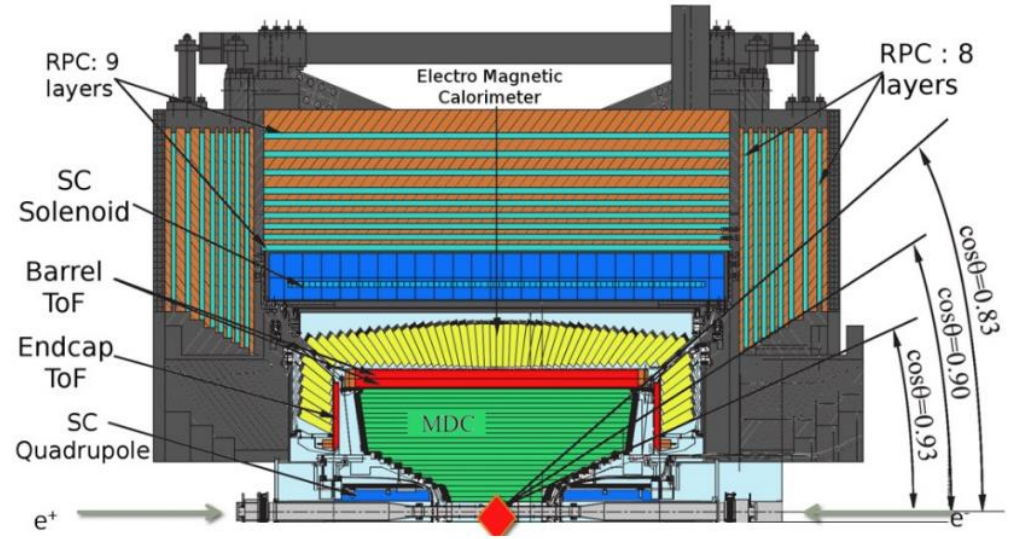
➤ Important input to study the decays of b flavor hadron involving Λ_c^+ final state and V_{ub} calculations

➤ The Λ_c^+ is one of important tagging hadrons in c -quark counting in the productions at high energy experiment

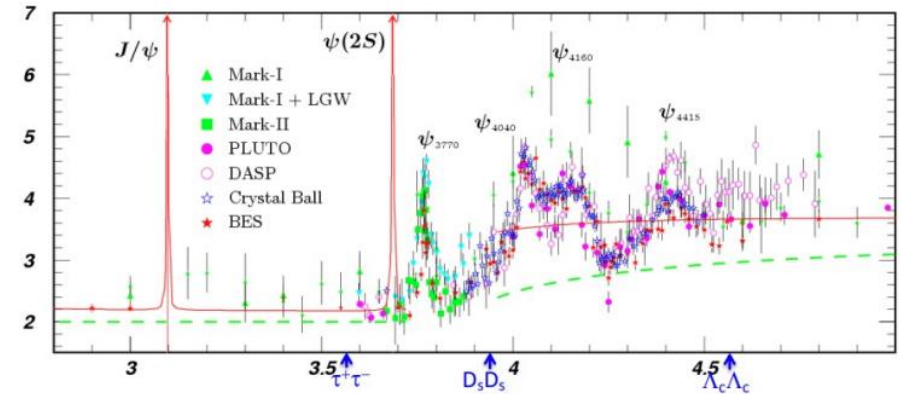
➤ Excellent platform for understanding non-perturbative QCD and weak decay mechanism



BEPCII & BESIII



R



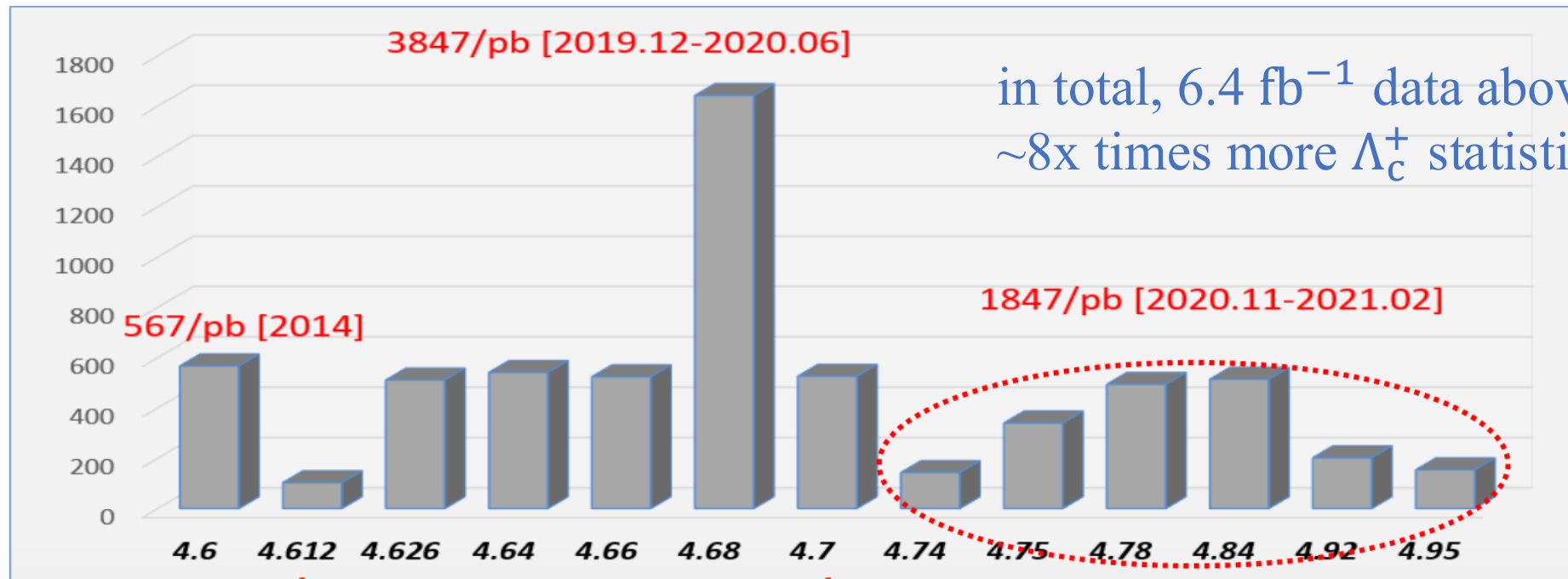
First HEP collider in China (1988)
c.m.s energy: 2 ~ 5 GeV
Max luminosity: $1 \times 10^{33} \text{cm}^{-2} \text{s}^{-1}$

Non-perturbative
 τ - *charm* region
 τ^\pm , D/D_S , Λ_c^+ ...

J/ψ : $2.97 \text{ fb}^{-1} (10\text{B})$
 $\psi(3686)$: $4.07 \text{ fb}^{-1} (2.7\text{B})$
 $\psi(3770)$: 20 fb^{-1}
 $4.6 \sim 4.95 \text{ GeV}$: 6.4 fb^{-1}

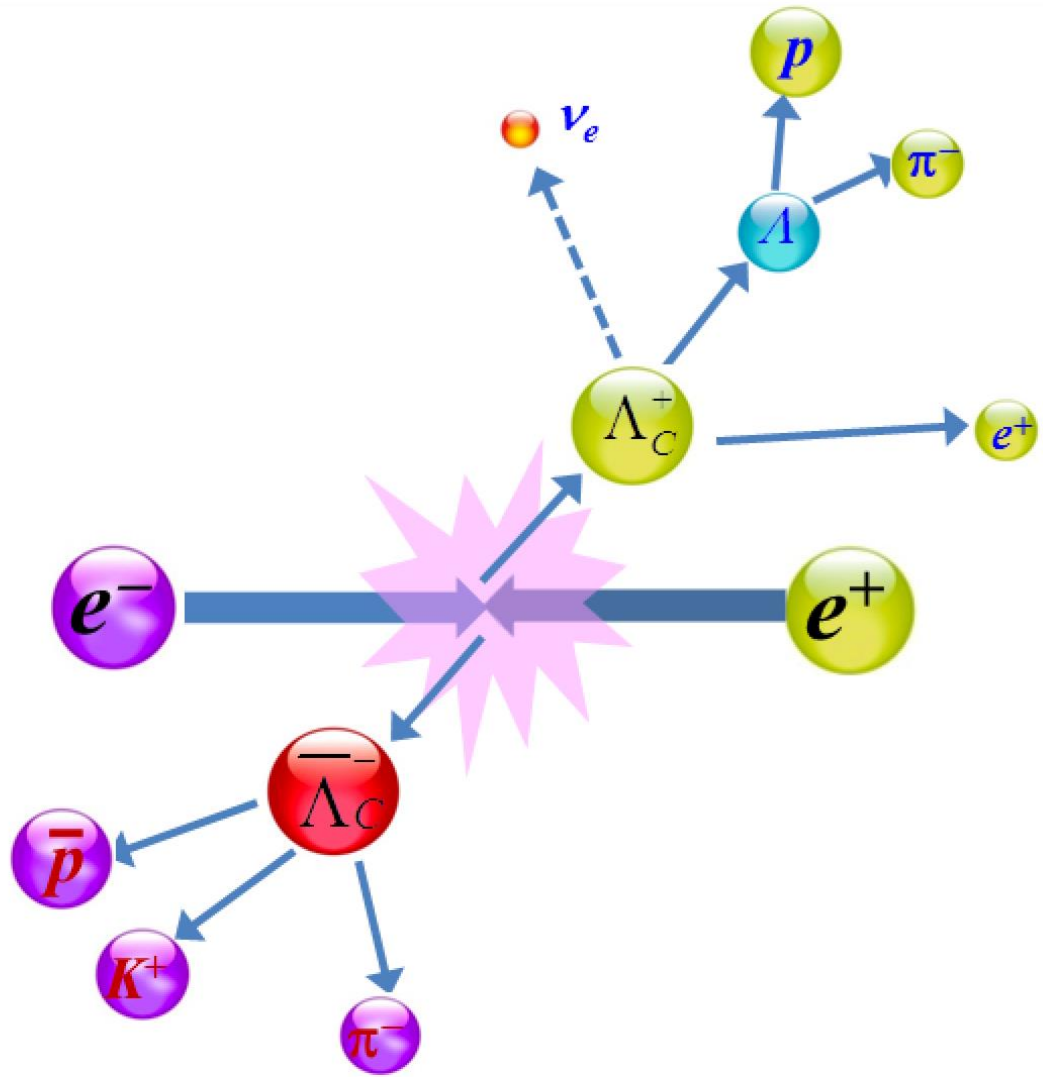
BESIII data taking at Λ_c^+ pair threshold

- Measurement using the **threshold pair-productions** via e^+e^- annihilations is unique: the most simple and straightforward
- **Double-tag (DT) method** can be used:
 - Lower backgrounds and kinematic relation to constrain missing particle
 - Most systematic uncertainties in tag side can be cancelled
 - Relatively **low efficiency**



in total, 6.4 fb^{-1} data above Λ_c^+ threshold
 $\sim 8x$ times more Λ_c^+ statistics

Production near threshold and tag technique



➤ Single Tag (ST)

$$\Delta E = E_{\Lambda_c^+} - E_{beam}$$

$$M_{BC} = \sqrt{E_{beam}^2 - |\vec{p}_{\Lambda_c^+}|^2}$$

➤ Double Tags (DT)

$$U_{miss} = E_{miss} - |\vec{p}_{miss}|$$

➤ Branching Fraction (\mathcal{B})

$$N^{ST} = 2N_{tot}B_{tag}\epsilon^{ST}$$

$$N^{semi} = 2N_{tot}B_{tag}B_{SL}\epsilon_{ij}^{DT}$$

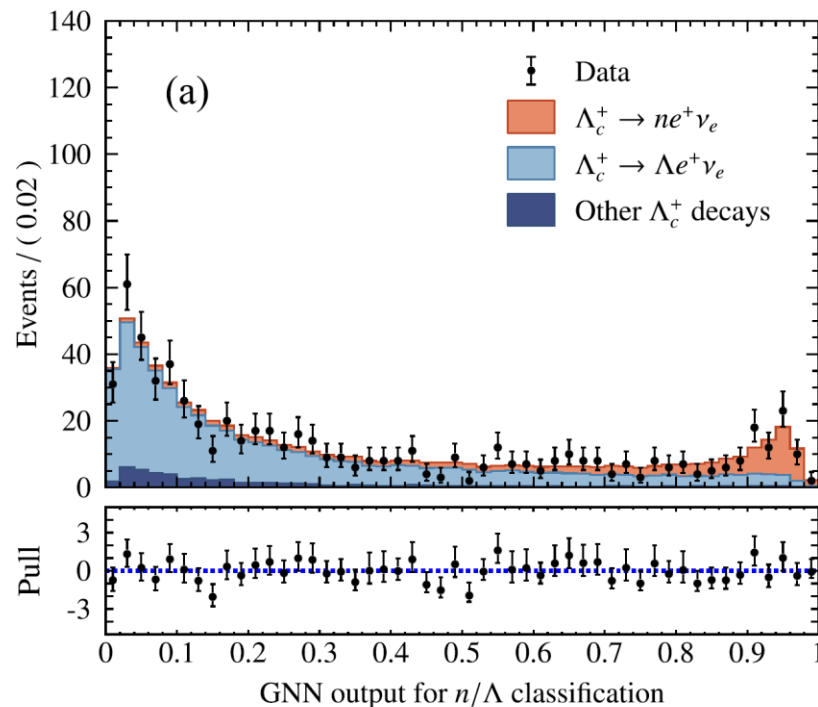
$$B_{SL} = \frac{N^{semi}}{N^{ST} \times \epsilon}$$

- Clean sample of ST charmed baryons can be fully reconstructed by hadronic decays with large BFs
- Based on this, one can access to absolute BFs and dynamics in the decays

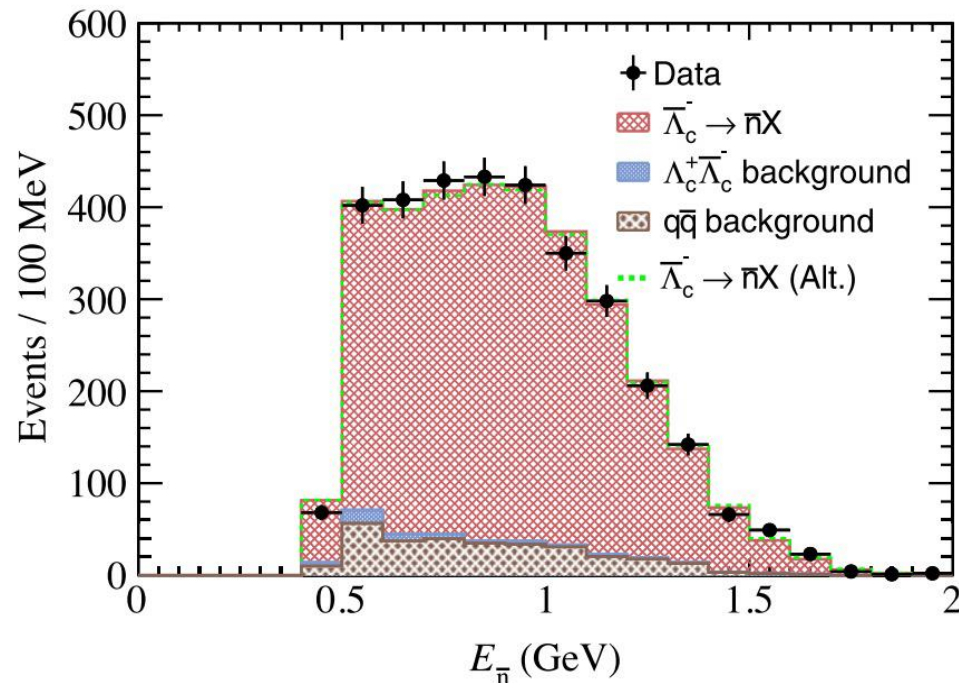
Deep learning method

- “Missing mass” method works when all other particles in event are **explicitly reconstructed**
- Direct reconstruction for n is challenging yet possible
- **Deep learning methods** are being explored to improve the efficiency
- Hadronic calorimeter is absent in BESIII detector, neutral hadrons can still deposit energy in EMC despite considerable leakage

NatComm **16**, 681 (2025)



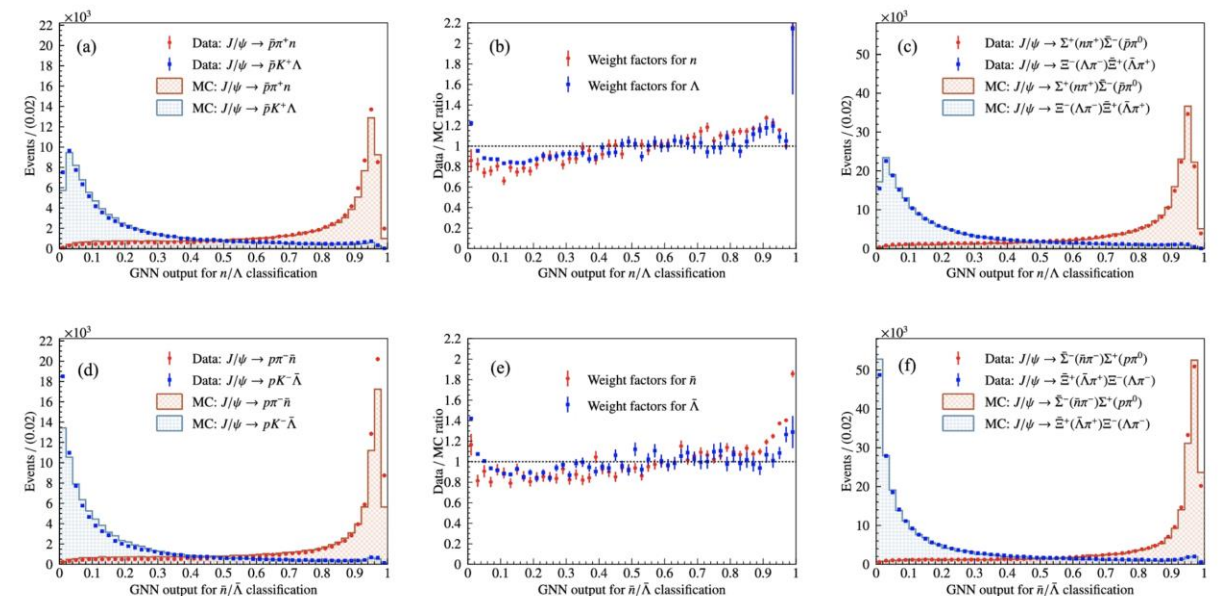
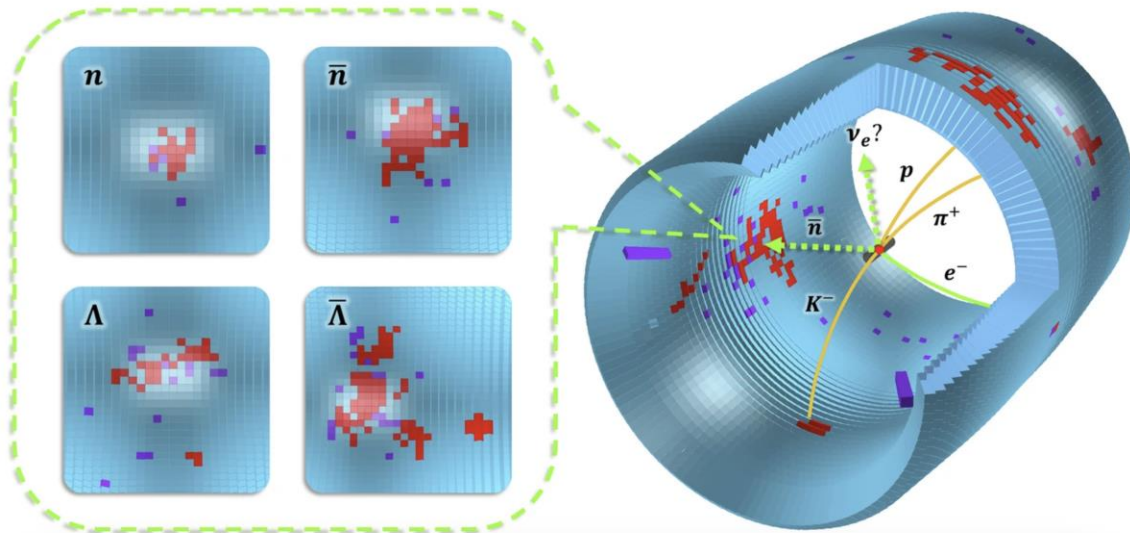
PRD **108**, L031101 (2023)

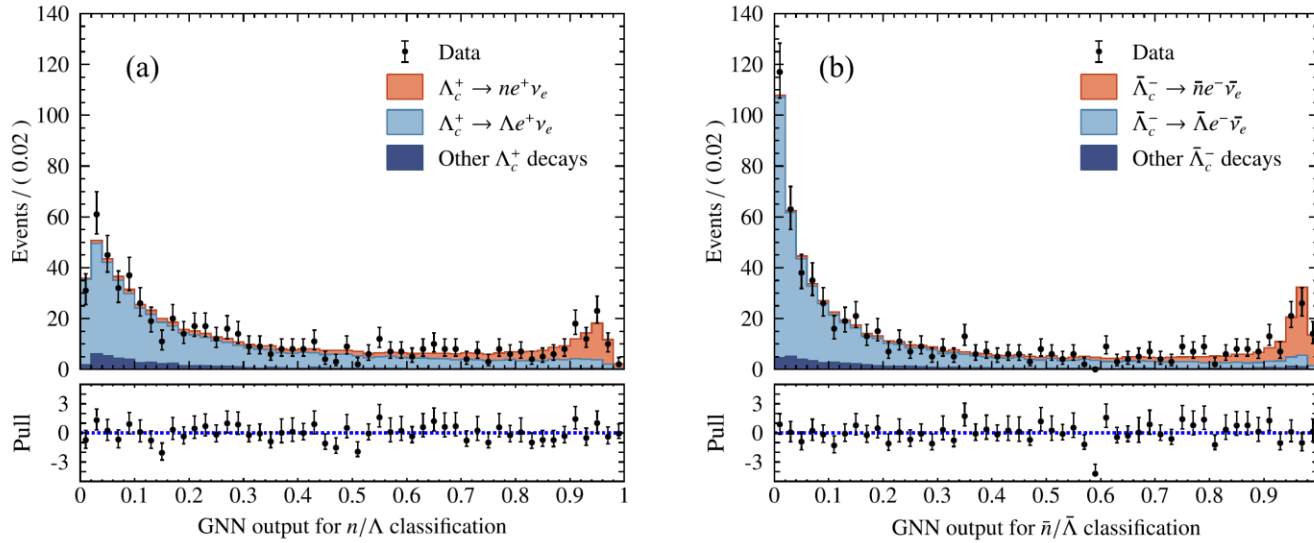


Study of $\Lambda_c^+ \rightarrow n e^+ \nu_e$ decay

NatComm 16, 681 (2025)

- Cabibbo-suppressed $c \rightarrow d$ transition in Λ_c^+ SL decay is never been observed
- The process is complicated by **two missing particles** (the neutron n and neutrino ν), as well as extensive background from $\Lambda_c^+ \rightarrow \Lambda(n\pi^0)e^+\nu_e$
- A novel **deep learning method** is developed to separate signal from dominant background
 - Use **Graph Neural Network** to classify n/Λ energy deposition patterns on EMC
 - Establish a data-driven pipeline for GNN training, calibration, validation and systematic uncertainty quantification.





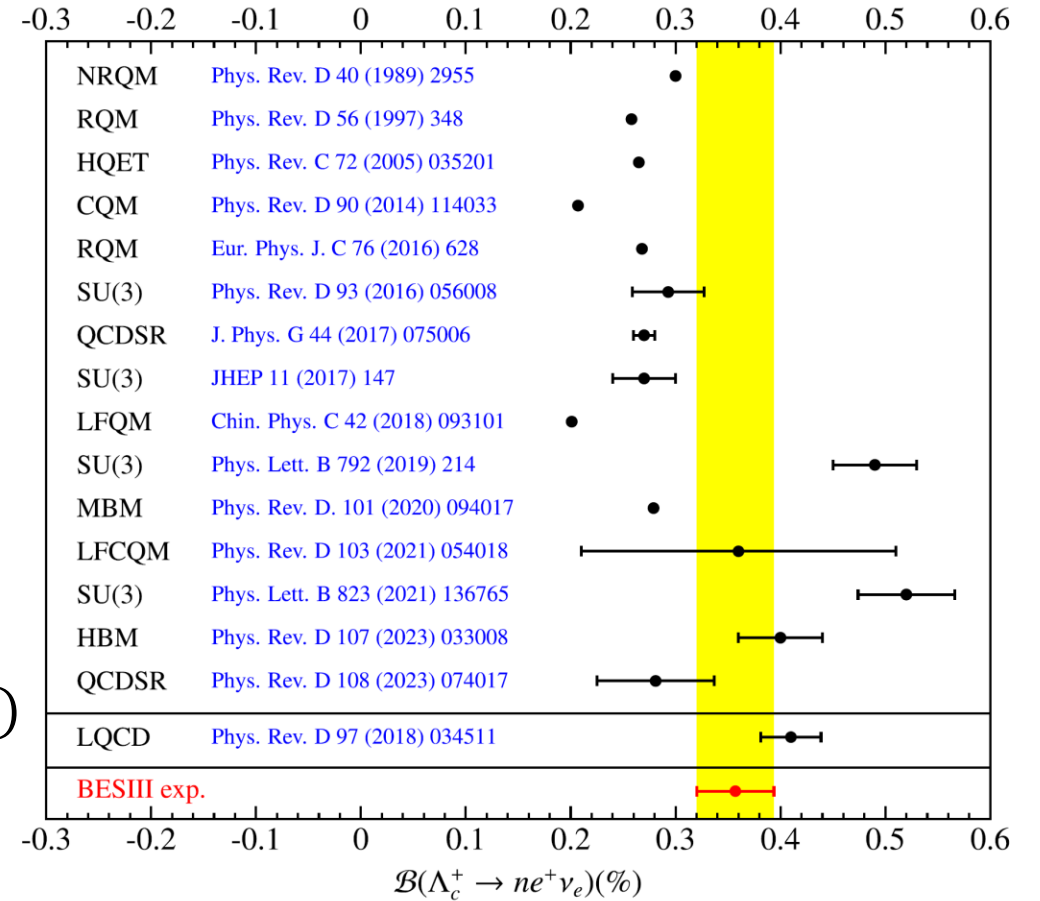
➤ $\mathcal{B}(\Lambda_c^+ \rightarrow ne^+\nu_e) = (0.357 \pm 0.334 \pm 0.014)\%$ ($> 10\sigma$)
consistent and precision comparable to LQCD

➤ First determination of $|V_{cd}|$ from charmed baryon decays

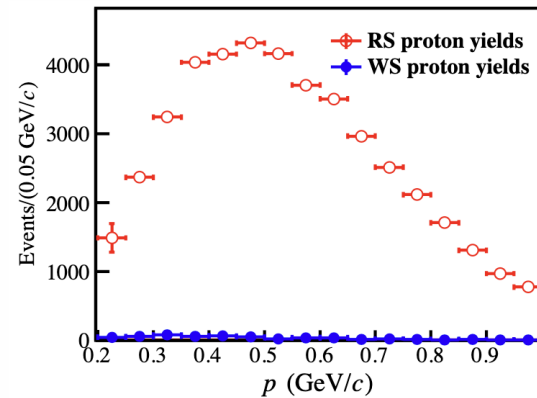
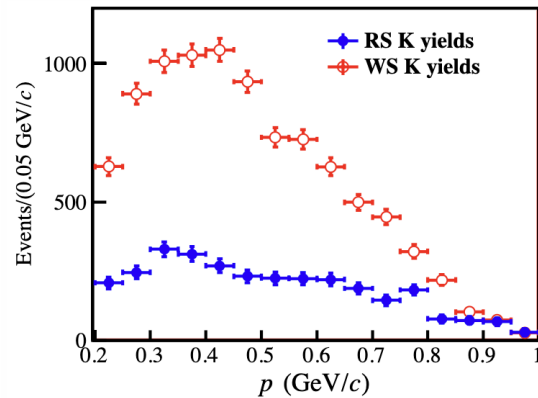
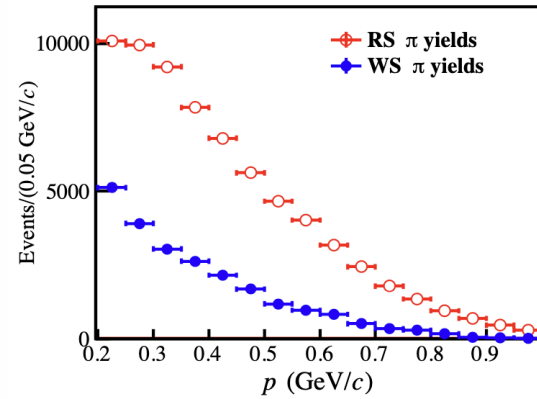
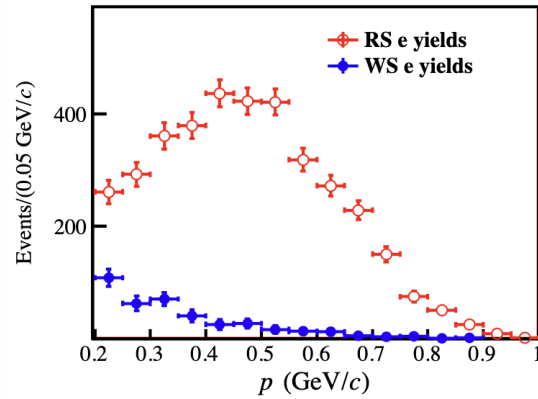
Take form factors from LQCD as input

$$|V_{cd}| = 0.208 \pm 0.011_{exp} \pm 0.007_{LQCD} + 0.011\tau_{\Lambda_c^+}$$

➤ Extendable to more BESIII studies involving neutral hadrons, especially those who can't be reconstructed by recoil mass



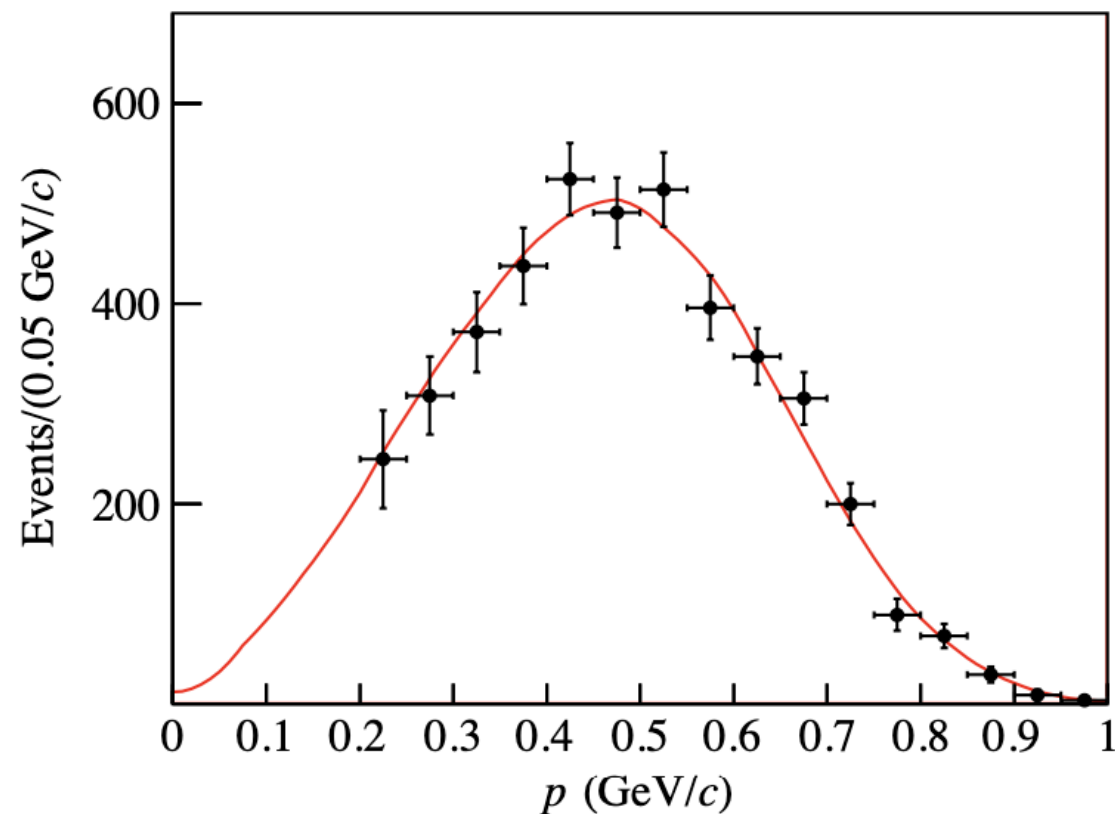
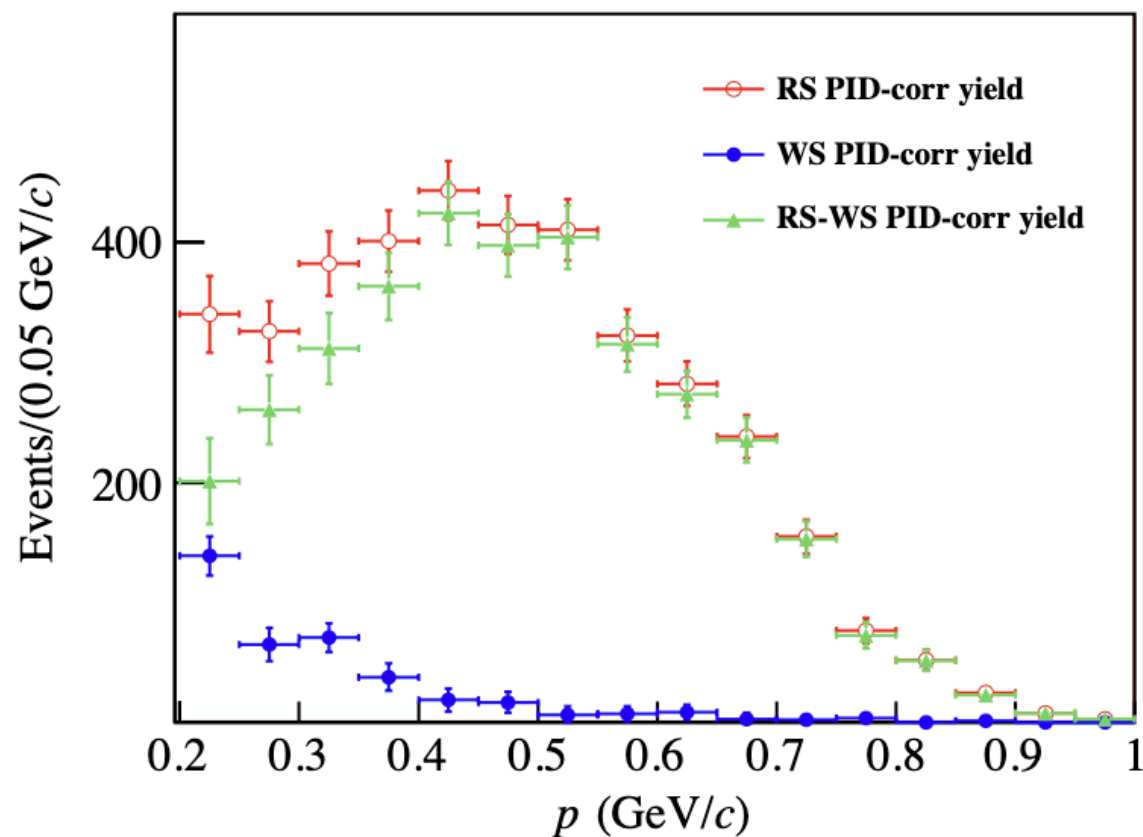
- Further Λ_c^+ SL decays may exist
- Comparing with the charge-averaged non-strange SL decay width is helpful for testing current theoretical predictions
- Unfolding method to obtain true signal yields. The matrix can be obtained using selected control samples



RS (WS): the charge of the track is required to be opposite (equal) to the ST Λ_c^- candidate.

$$\begin{bmatrix} N_e^{\text{obs}} \\ N_\pi^{\text{obs}} \\ N_K^{\text{obs}} \\ N_p^{\text{obs}} \end{bmatrix} = \begin{bmatrix} P_{e \rightarrow e} & P_{\pi \rightarrow e} & P_{K \rightarrow e} & P_{p \rightarrow e} \\ P_{e \rightarrow \pi} & P_{\pi \rightarrow \pi} & P_{K \rightarrow \pi} & P_{p \rightarrow \pi} \\ P_{e \rightarrow K} & P_{\pi \rightarrow K} & P_{K \rightarrow K} & P_{p \rightarrow K} \\ P_{e \rightarrow p} & P_{\pi \rightarrow p} & P_{K \rightarrow p} & P_{p \rightarrow p} \end{bmatrix} \begin{bmatrix} N_e^{\text{true}} \\ N_\pi^{\text{true}} \\ N_K^{\text{true}} \\ N_p^{\text{true}} \end{bmatrix}$$

Correction (see text)	RS yields	WS yields
Observed yields	3706 ± 71	394 ± 31
PID unfolding yields	3865 ± 80	376 ± 33
WS subtraction	3489 ± 87	
Tracking unfolding yields	4333 ± 107	
Extrapolation	4692 ± 117	



➤ The precision is improved by threefold [Phys. Rev. Lett. 121, 251801 (2018)]

$$\mathcal{B}(\Lambda_c^+ \rightarrow X e^+ \nu_e) = (4.06 \pm 0.10 \pm 0.09)\%$$

$$\mathcal{B}(\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e) = (3.56 \pm 0.11 \pm 0.07)\%$$

$$\mathcal{B}(\Lambda_c^+ \rightarrow n e^+ \nu_e) = (0.357 \pm 0.334 \pm 0.014)\%$$

$$\mathcal{B}(\Lambda_c^+ \rightarrow p K^- e^+ \nu_e) = (0.88 \pm 0.15 \pm 0.07) \times 10^{-3}$$

Unknow decay: 0.06%

Decay Asymmetry of $\Lambda_c^+ \rightarrow \Xi^0 K^+$

PhysRevLett.132.031801 (2024)

- pure W-exchange process
 - Only receives non-factorizable contribution
 - Long-standing puzzle on how large the S-wave amplitude
- Fit to joint angular distribution

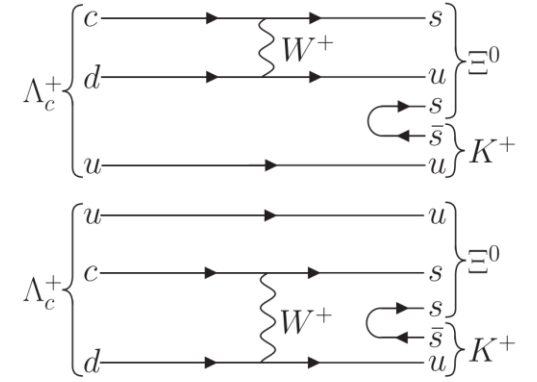
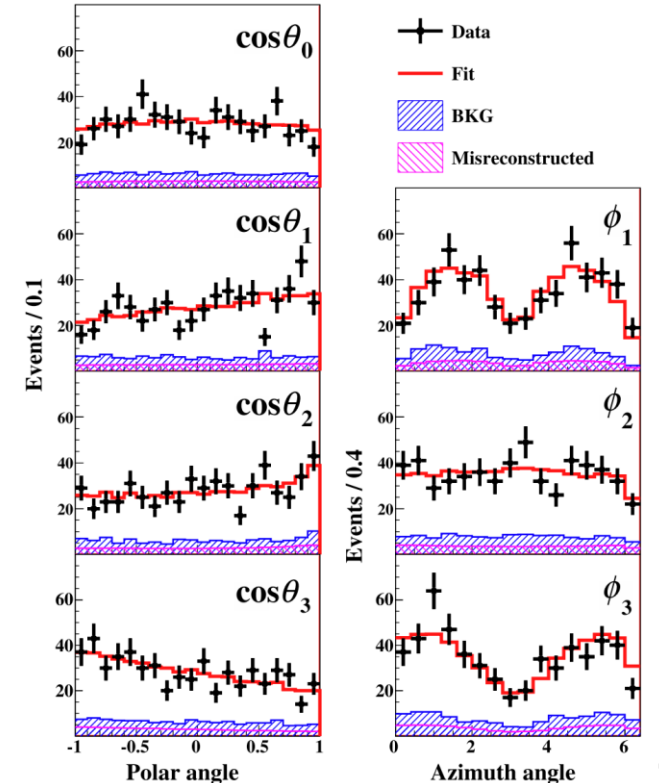
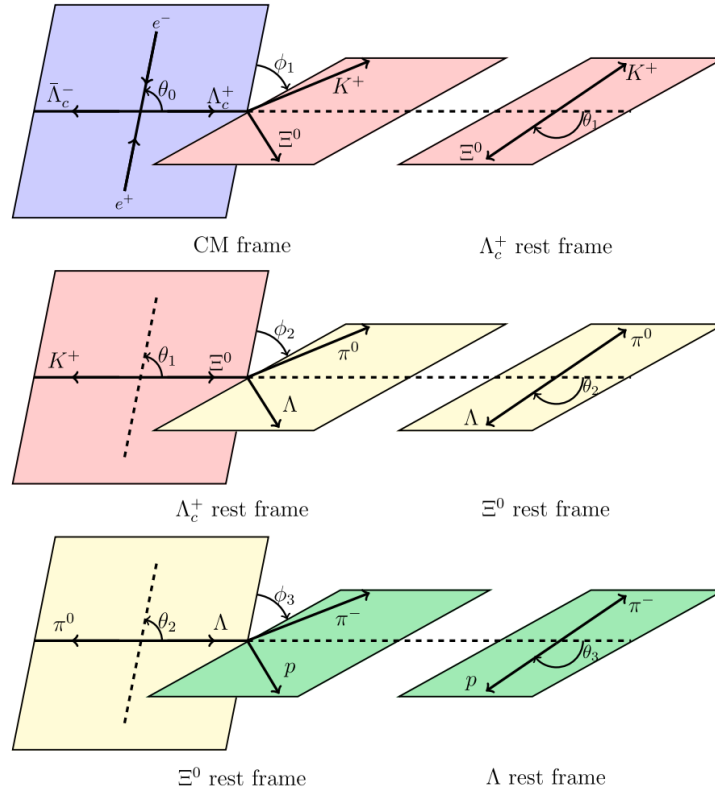


FIG. 1. Feynman diagrams for $\Lambda_c^+ \rightarrow \Xi^0 K^+$.

$$\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)$$



➤ Decay asymmetry results

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

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

$$\beta_{\Xi^0 K^+} = -0.64 \pm 0.69 \pm 0.13$$

$$\gamma_{\Xi^0 K^+} = -0.77 \pm 0.58 \pm 0.11$$

➤ Phase difference between **S** and **P**-waves

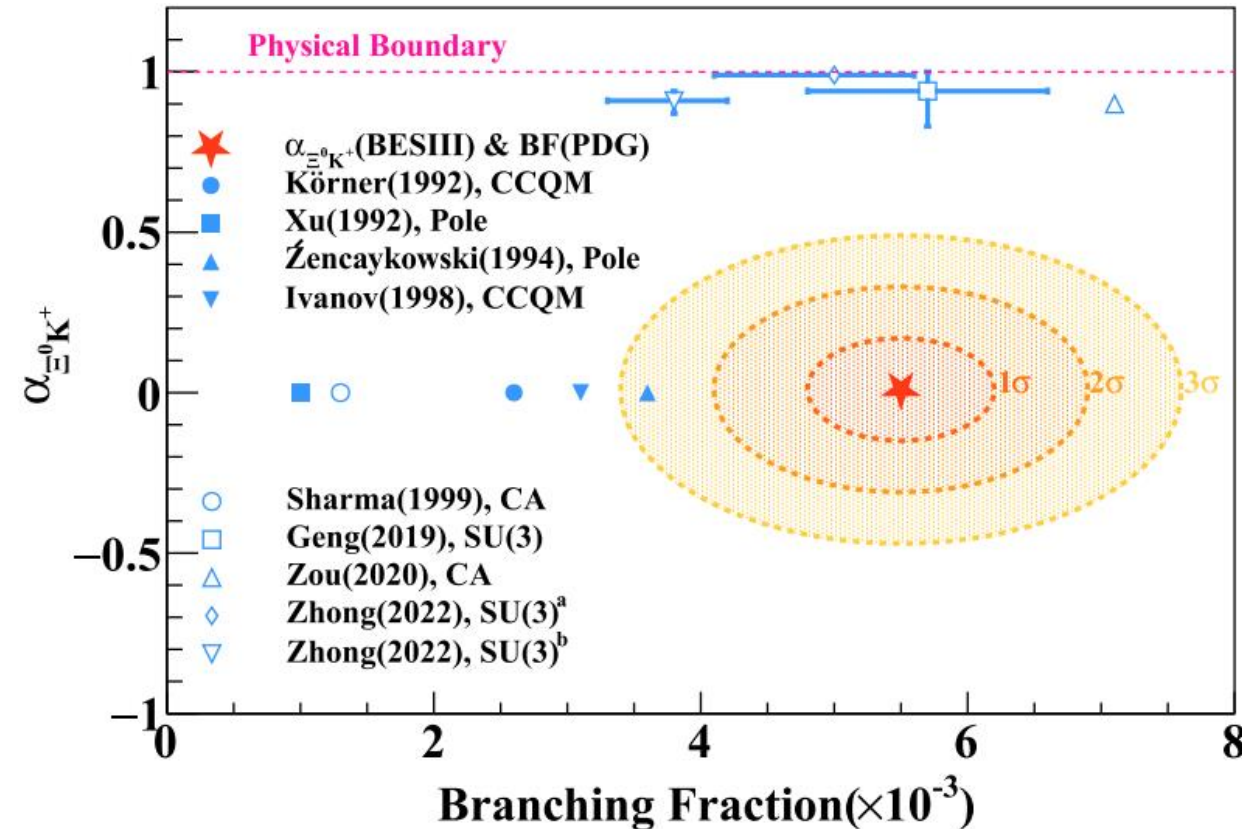
$$\text{Solution1: } \delta_p - \delta_s = -1.55 \pm 0.25 \pm 0.05$$

$$\text{Solution2: } \delta_p - \delta_s = 1.59 \pm 0.25 \pm 0.05$$

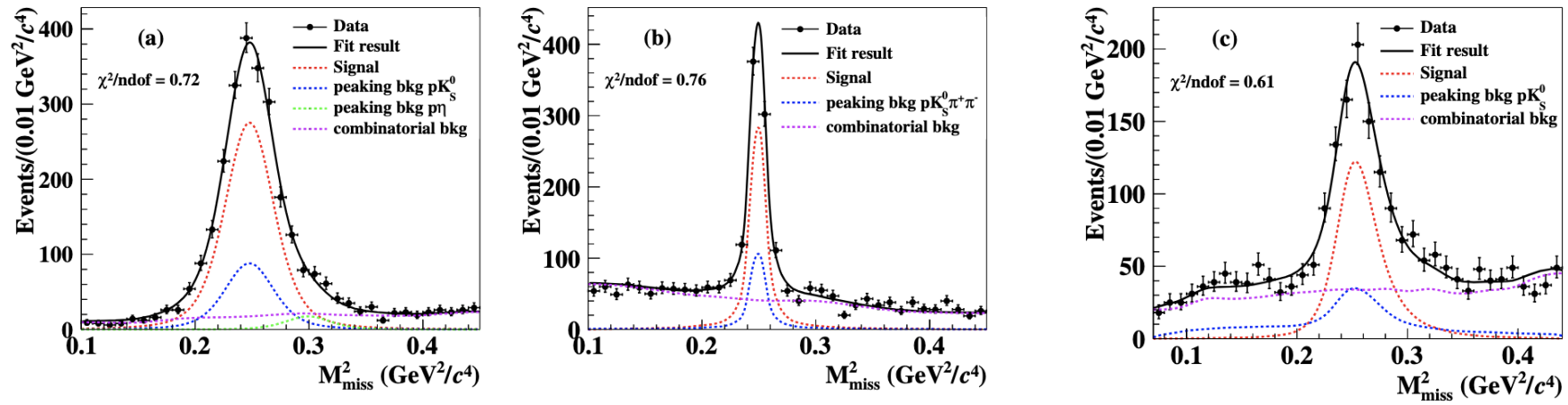
➤ $\alpha_{\Xi^0 K^+}$ is in good agreement with zero, providing strong identification for theoretical predictions

➤ $\cos(\delta_p - \delta_s)$ is measured to close to zero, which is not considered in previous literature

➤ Fills the long-standing puzzle on how to model $\alpha_{\Xi^0 K^+}$ and $\mathcal{B}(\Lambda_c^+ \rightarrow \Xi^0 K^+)$ simultaneously



- $K_S^0 - K_L^0$ asymmetry arises from interference of CF and DCS, provide new way to indirect search for DCS, non-zero asymmetry value indicates existence of DCS decays
- The ratio of amplitudes for CF and DCS is expected to be proportional to $|V_{ud}^*V_{cs}/V_{us}^*V_{cd}|$

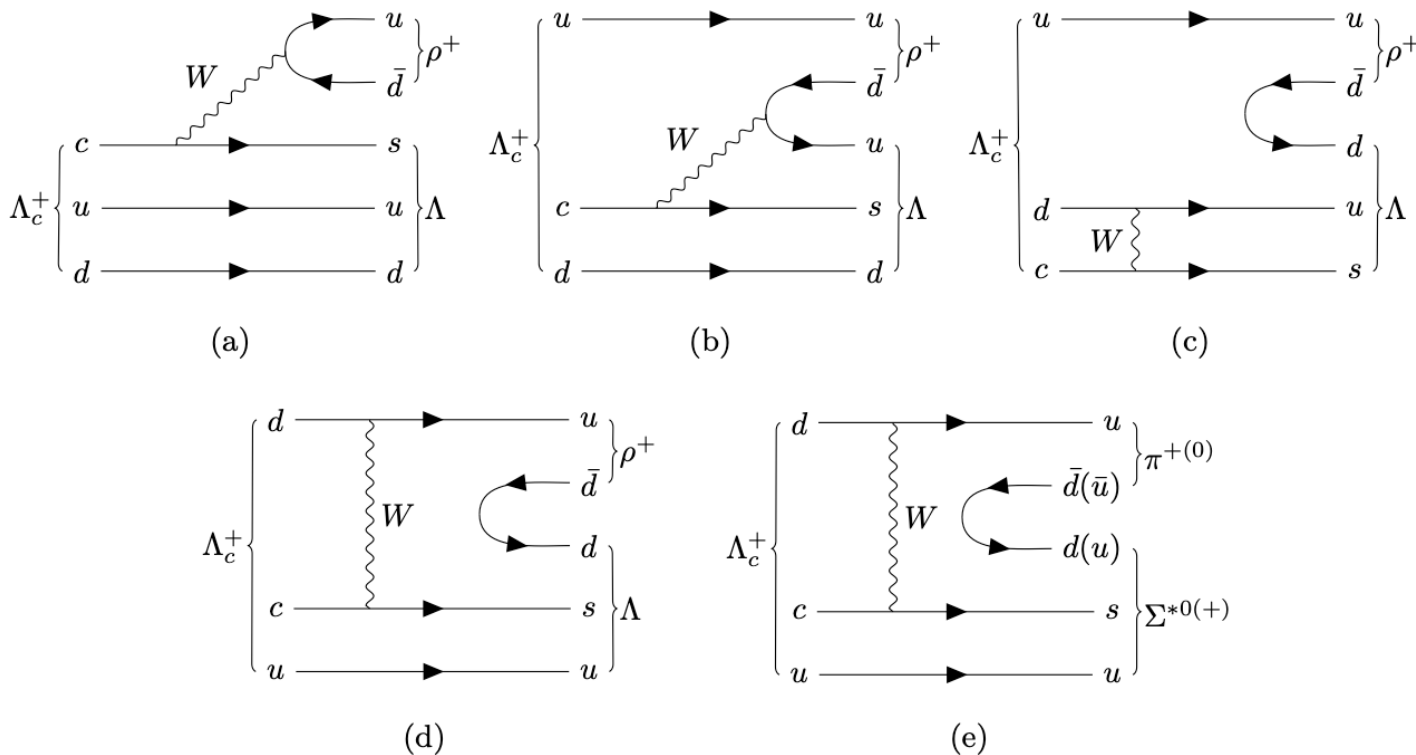


Mode	$\mathcal{B}(\Lambda_c^+ \rightarrow K_L^0 X)$ (%)	$\mathcal{B}(\Lambda_c^+ \rightarrow K_S^0 X)$ (%) [22]	$R(\Lambda_c^+, K_{L,S}^0 X)$
$\Lambda_c^+ \rightarrow pK_{L,S}^0$	$1.67 \pm 0.06 \pm 0.04$	1.59 ± 0.07	-0.025 ± 0.031
$\Lambda_c^+ \rightarrow pK_{L,S}^0\pi^+\pi^-$	$1.69 \pm 0.10 \pm 0.05$	1.60 ± 0.11	-0.027 ± 0.048
$\Lambda_c^+ \rightarrow pK_{L,S}^0\pi^0$	$2.02 \pm 0.13 \pm 0.05$	1.96 ± 0.12	-0.015 ± 0.046

$$R(\Lambda_c^+, K_{S,L}^0 X) = \frac{\mathcal{B}(\Lambda_c^+ \rightarrow K_S^0 X) - \mathcal{B}(\Lambda_c^+ \rightarrow K_L^0 X)}{\mathcal{B}(\Lambda_c^+ \rightarrow K_S^0 X) + \mathcal{B}(\Lambda_c^+ \rightarrow K_L^0 X)}$$

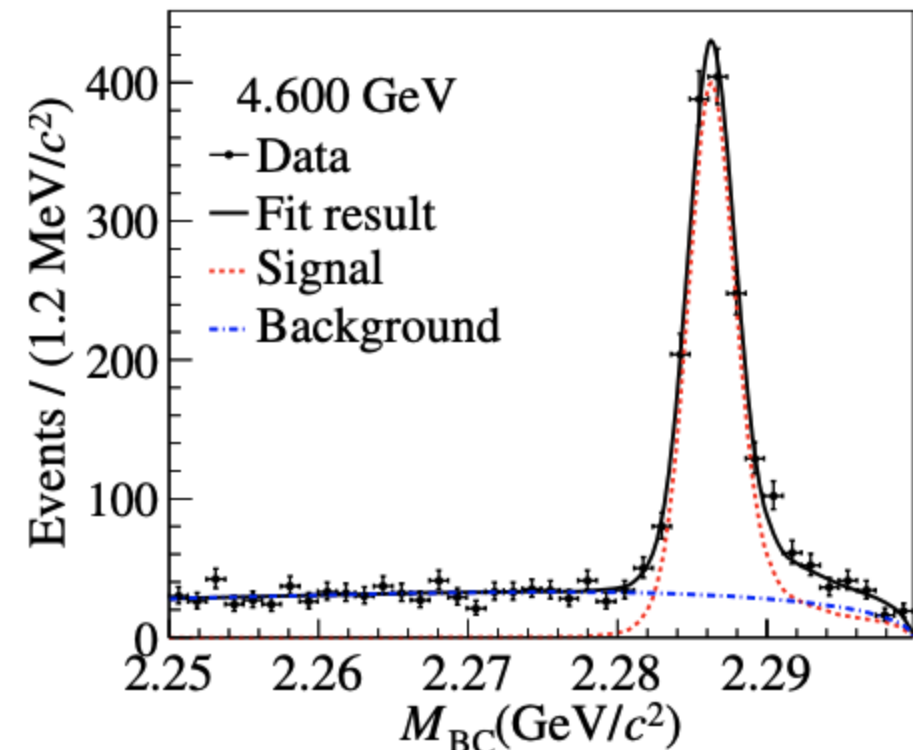
- No obvious asymmetry is observed in any of the three decays
- $R(\Lambda_c^+, K_{S,L}^0 X)$ in $\Lambda_c^+ \rightarrow pK_{L,S}^0$ is compatible with SU(3) prediction of (-0.010,0.087)

- First amplitude analysis of charmed baryon multi-hadronic decays
- Crucial test on $\Lambda_c^+ \rightarrow \Lambda \rho(770), \Sigma(1385) \pi^+$ which suffer non-factorizable contributions
- The single tag method is applied to select $\Lambda_c^+ \rightarrow \Lambda \pi^+ \pi^0$ events
- BF and decay asymmetry parameters are determined



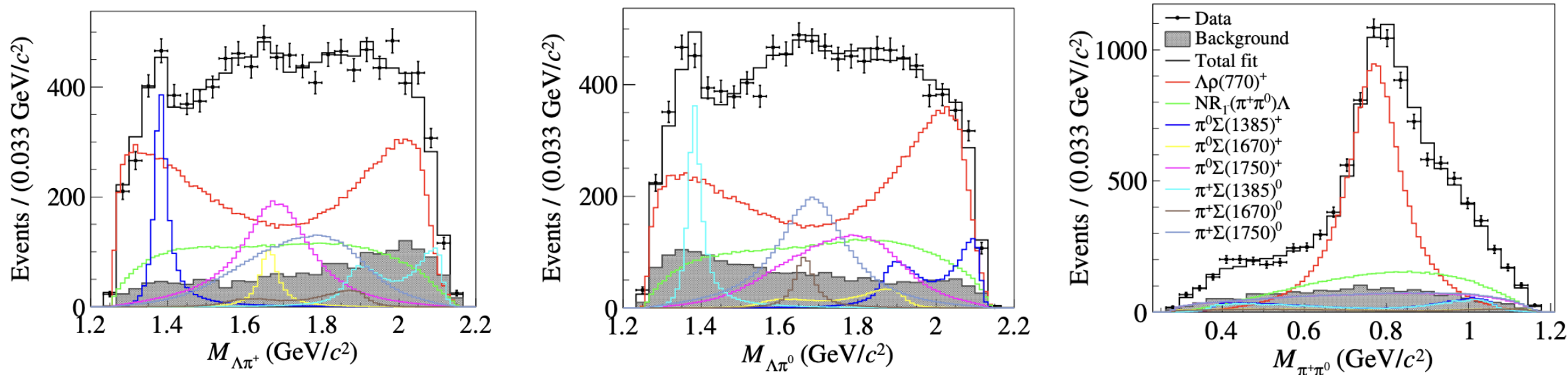
(a) Factorizable (b-e) non-factorizable

~10k signal events
Signal purity > 80%



➤ Helicity amplitude fit implemented by TF-PWA (<https://github.com/jiangyi15/tf-pwa>)

TF-PWA



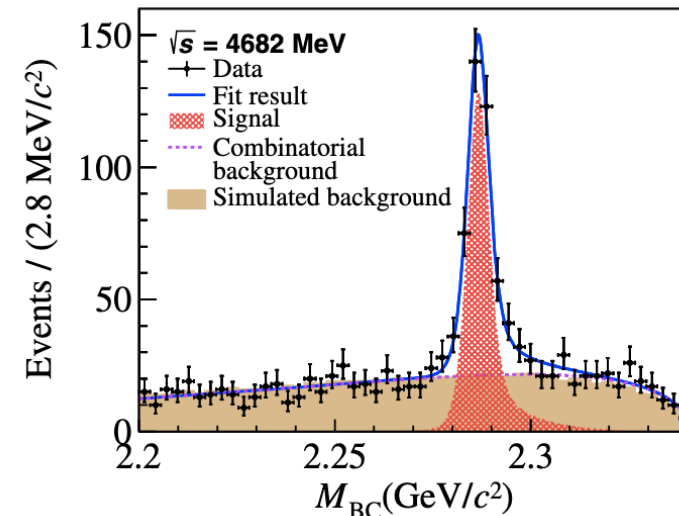
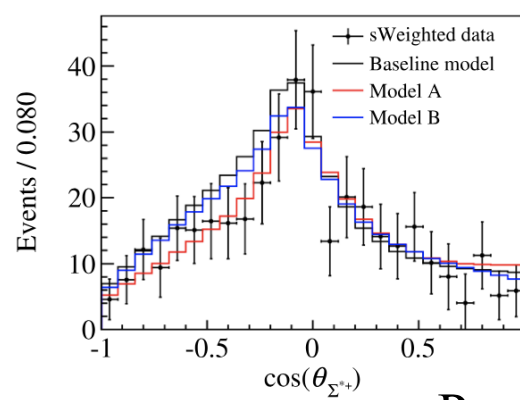
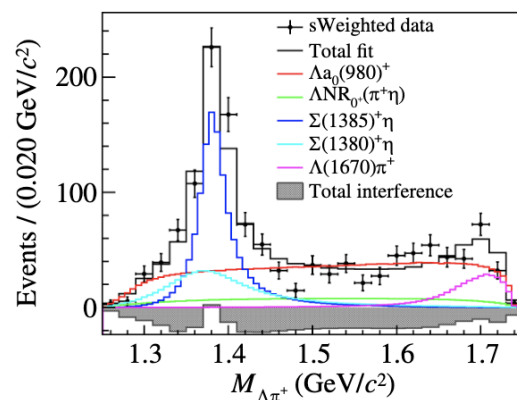
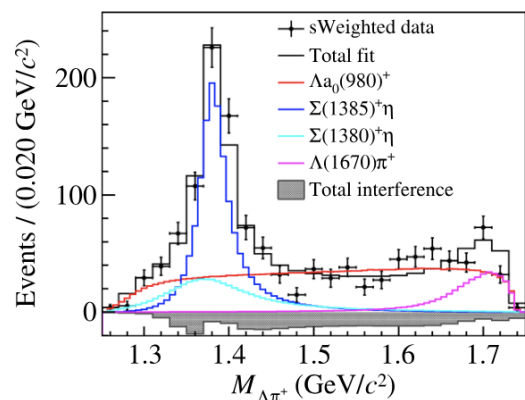
	Theoretical calculation		This work	PDG
$10^2 \times \mathcal{B}(\Lambda_c^+ \rightarrow \Lambda \rho(770)^+)$	4.81 ± 0.58 [13]	4.0 [14, 15]	4.06 ± 0.52	< 6
$10^3 \times \mathcal{B}(\Lambda_c^+ \rightarrow \Sigma(1385)^+ \pi^0)$	2.8 ± 0.4 [16]	2.2 ± 0.4 [17]	5.86 ± 0.80	—
$10^3 \times \mathcal{B}(\Lambda_c^+ \rightarrow \Sigma(1385)^0 \pi^+)$	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 of $\Lambda_c^+ \rightarrow \Lambda\pi^+\eta$

PhysRevLett.134.021901

- Opportunity to probe lighter exotic states
- Nature of scalar meson $a_0(980)^+$ remains elusive
- Golden channel to study low-lying excited baryons like $\Sigma_{1/2}^*$

ST with 6.1 fb^{-1} data from 4.6-4.843 GeV



Precise measurement for absolute BF
 $B(\Lambda_c^+ \rightarrow \Lambda\pi^+\eta) = (1.94 \pm 0.07 \pm 0.01)\%$

- Evidence for potential pentaquark state $\Sigma(1380)^+$
 - Statistical significance 6.1σ (3.3σ) without (with) $\pi^+\eta$ non-resonant contribution
- $\alpha(\Lambda_c^+ \rightarrow \Sigma(1385)\eta)$ consistent with $-0.97_{-0.03}^{+0.43}$ in SU(3)
- $\alpha(\Lambda_c^+ \rightarrow \Lambda a_0(980))$ contradicts with the small value (~ 0) in Triangle re-scattering

Process	FF (%)	\mathcal{S}	α
$\Lambda a_0(980)^+$	$54.0 \pm 8.4 \pm 2.6$	13.1σ	$-0.91_{-0.09}^{+0.18} \pm 0.08$
$\Sigma(1385)^+\eta$	$30.4 \pm 2.6 \pm 0.7$	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	...

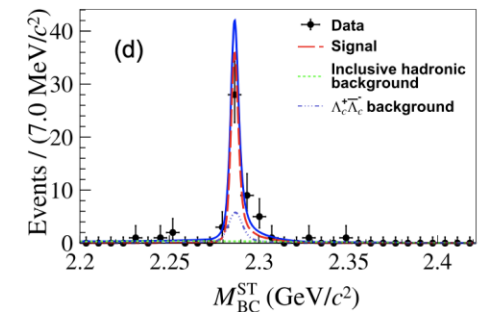
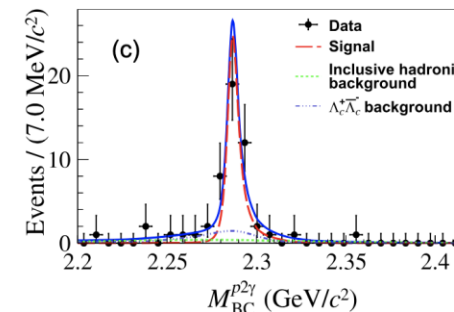
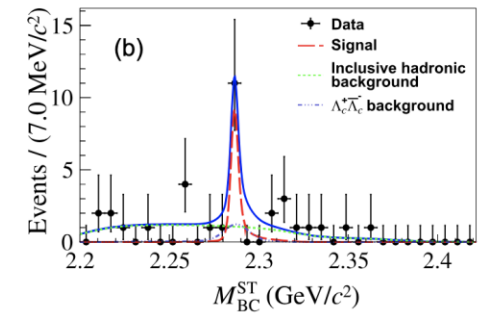
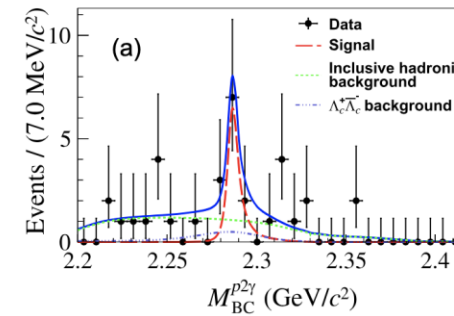
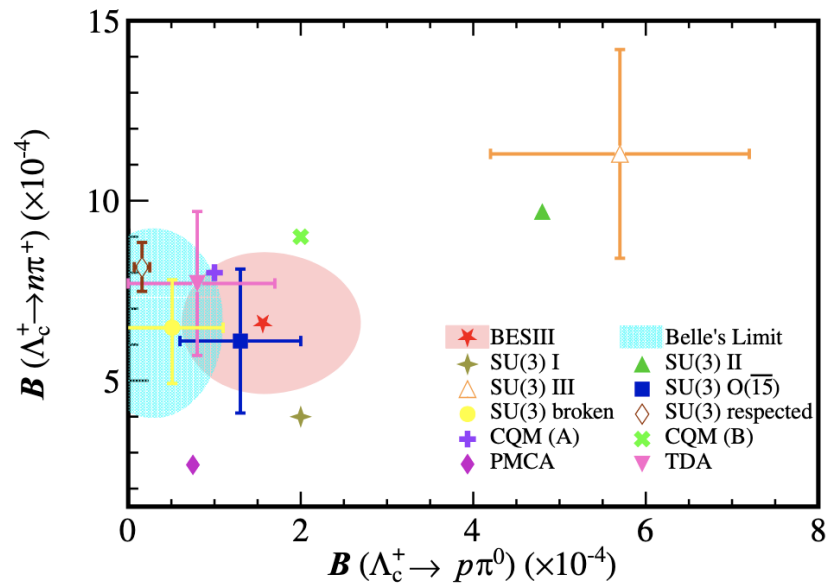
➤ A long-standing contradiction between experimental results and SU(3) predictions.

➤ Previous experimental results show inconsistency:

- BESIII 2017 with ST: $\mathcal{B}(\Lambda_c^+ \rightarrow p\pi^0) < 2.7 \times 10^{-4}$ @90% C.L.
- Belle 2021: $\mathcal{B}(\Lambda_c^+ \rightarrow p\pi^0) < 0.8 \times 10^{-4}$ @90% C.L.

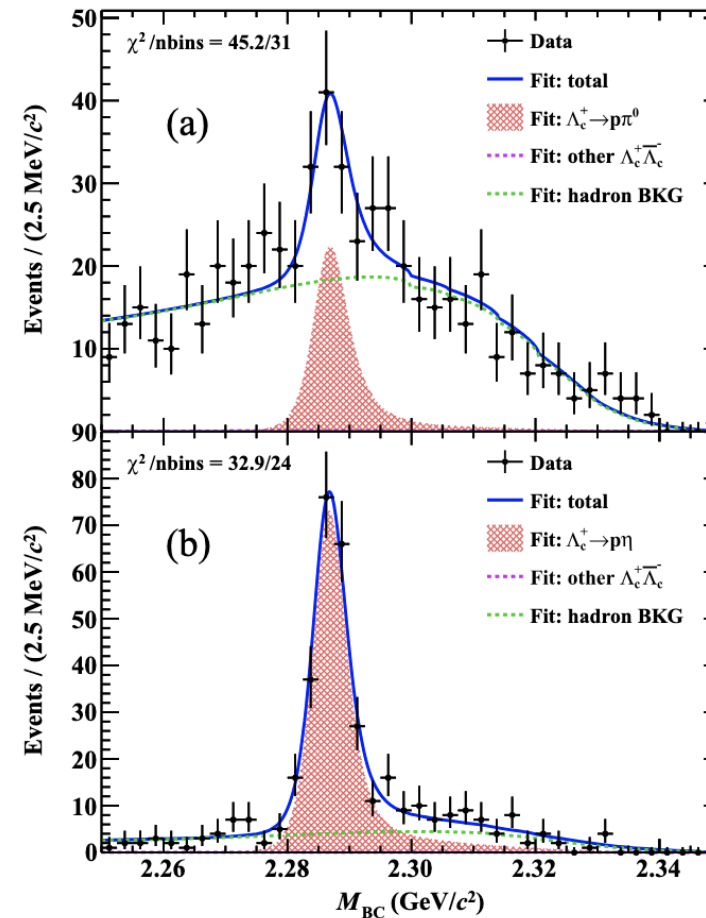
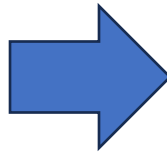
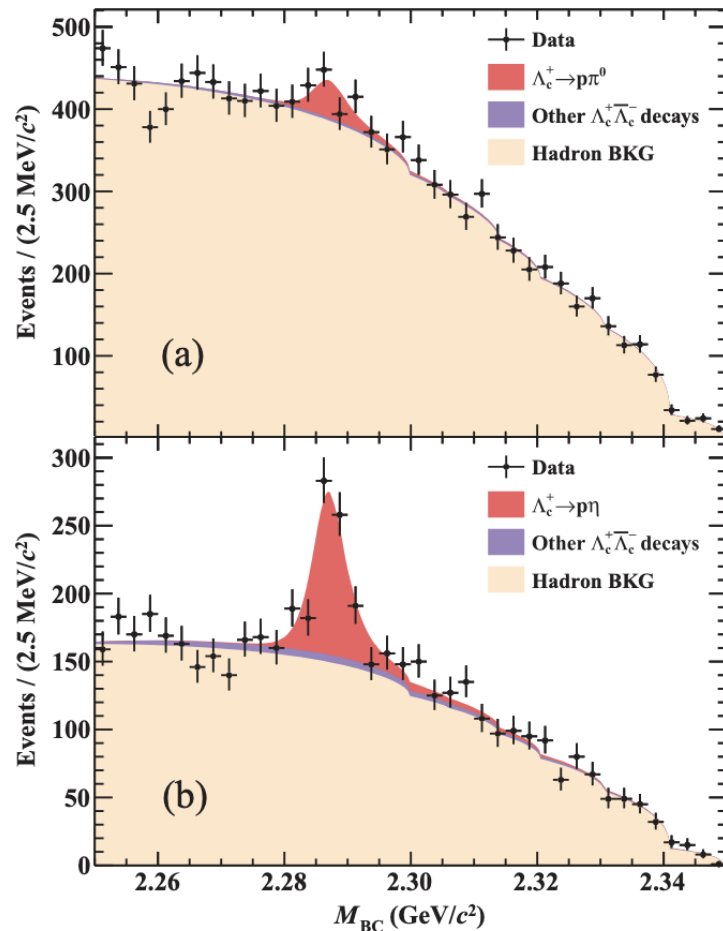
BESIII 2024 with DT:

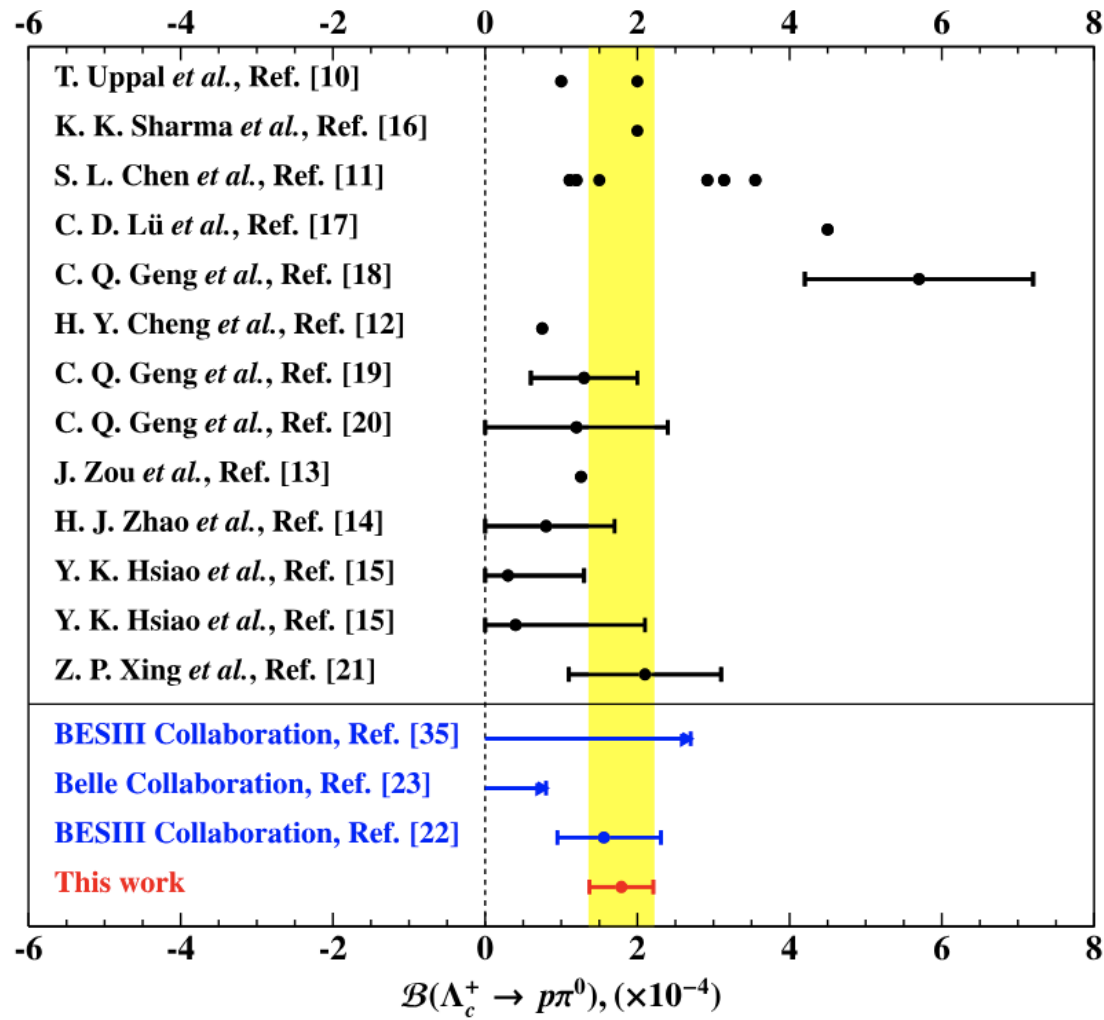
$$\mathcal{B}(\Lambda_c^+ \rightarrow p\pi^0) = (1.56_{-0.58}^{+0.72} \pm 0.20) \times 10^{-4} \text{ with } 3.7 \sigma$$



➤ A novel deep learning method is developed

- Use Transformer-based DNN to classify signal & background decay topologies
- Study $\Lambda_c^+ \rightarrow p\eta(\gamma\gamma)$ as reference channel to calibrate DNN-related bias





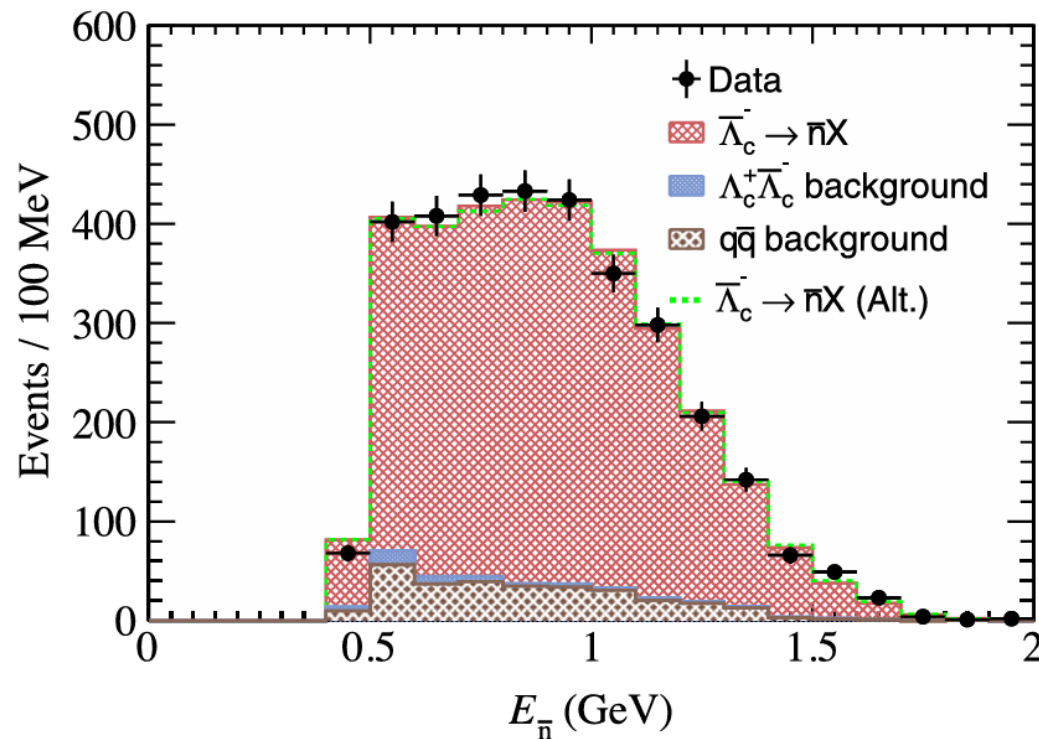
$$\Rightarrow \frac{\mathcal{B}(\Lambda_c^+ \rightarrow p\pi^0)}{\mathcal{B}(\Lambda_c^+ \rightarrow p\eta)} = 0.120 \pm 0.026 \pm 0.007 \text{ with } 5.4\sigma$$

Take world average of $\Lambda_c^+ \rightarrow p\eta$ as input:

$$\mathcal{B}(\Lambda_c^+ \rightarrow p\pi^0) = (1.79 \pm 0.39 \pm 0.11 \pm 0.08) \times 10^{-4}$$

- Consistent with previous BESIII evidence, yet exceeds the upper limit set by Belle
- The deep learning approach could be directly applicable to many other studies...

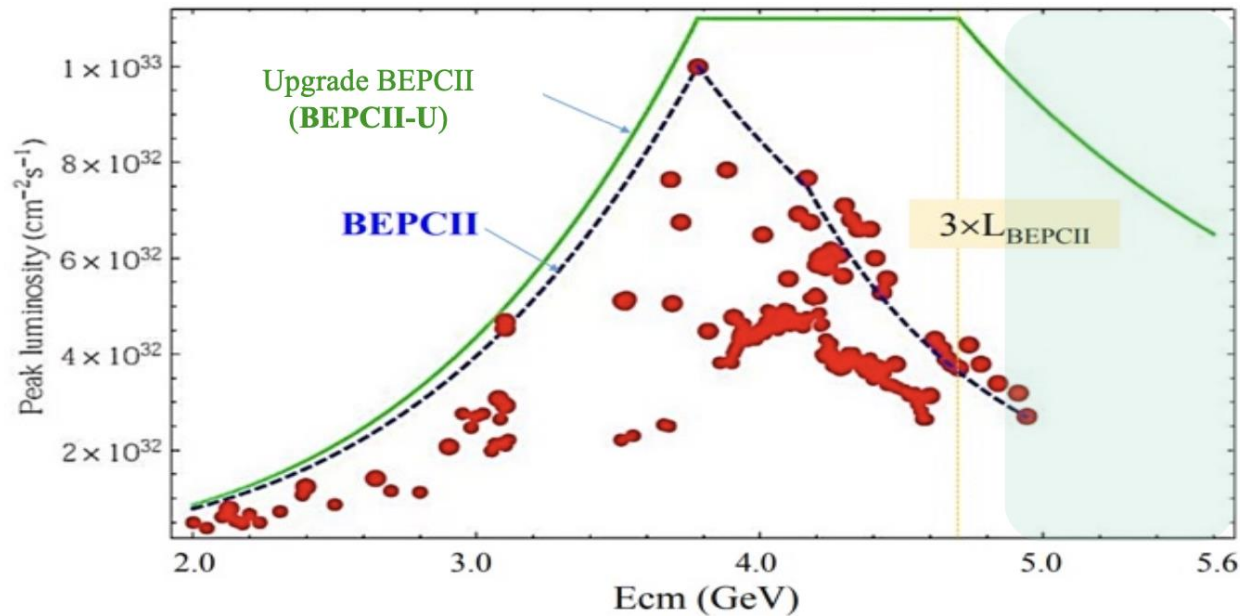
- Search for unknown channels
- Test isospin symmetry between inclusive proton & neutron decays
- The deposited energy in EMC is used to identify \bar{n}
- Data-driven technique to model \bar{n} behavior in the detector



- Absolute BFs are measured to be $\mathcal{B}(\bar{\Lambda}_c^- \rightarrow \bar{n}X) = (33.5 \pm 0.7 \pm 1.2)\%$
- Asymmetry between $\mathcal{B}(\Lambda_c^+ \rightarrow nX)$ and $\mathcal{B}(\Lambda_c^+ \rightarrow pX)$ is observed

Summary

- BESIII has made pretty good progresses on the exploration of the charmed baryon Λ_c^+
- Near threshold production is unique to directly measure the Λ_c^+ decay properties
- Opportunities to study other charmed baryons ($\Sigma_c, \Xi_c, \Omega_c$) in the BEPCII-U phase



Energy thresholds

$$\begin{aligned}
 e^+e^- &\rightarrow \Lambda_c^+\bar{\Sigma}_c^- & 4.74 \text{ GeV} \\
 e^+e^- &\rightarrow \Lambda_c^+\bar{\Sigma}_c^0\pi & 4.88 \text{ GeV} \\
 e^+e^- &\rightarrow \Sigma_c^+\bar{\Sigma}_c^- & 4.91 \text{ GeV} \\
 e^+e^- &\rightarrow \Xi_c^+\bar{\Xi}_c^- & 4.94 \text{ GeV} \\
 e^+e^- &\rightarrow \Omega_c^+\bar{\Omega}_c^- & 5.40 \text{ GeV}
 \end{aligned}$$

	cross-sections	at different \sqrt{s}	at different \sqrt{s}	
4.6 - 4.9 GeV	Charmed baryon/ XYZ cross-sections	0.56 fb^{-1} at 4.6 GeV	15 fb^{-1} at different \sqrt{s}	1490/600 days
4.74 GeV	$\Sigma_c^+\Lambda_c^-$ cross-section	N/A	1.0 fb^{-1}	100/40 days
4.91 GeV	$\Sigma_c^+\Sigma_c^-$ cross-section	N/A	1.0 fb^{-1}	120/50 days
4.95 GeV	Ξ_c decays	N/A	1.0 fb^{-1}	130/50 days