Charmed baryon decays at BESIII

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On behalf of BESIII Collaboration

HIGH ENERGY PHYSICS BRANCH OF CPS

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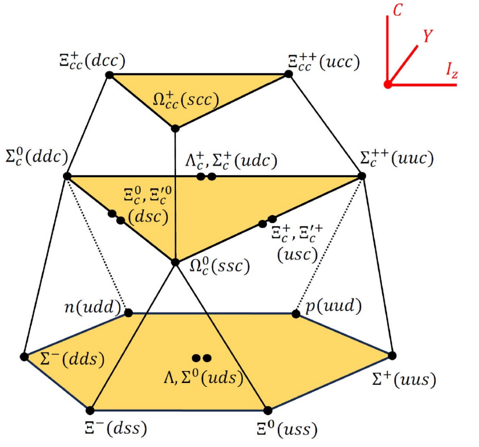
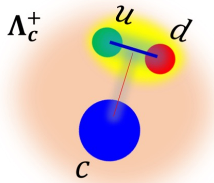
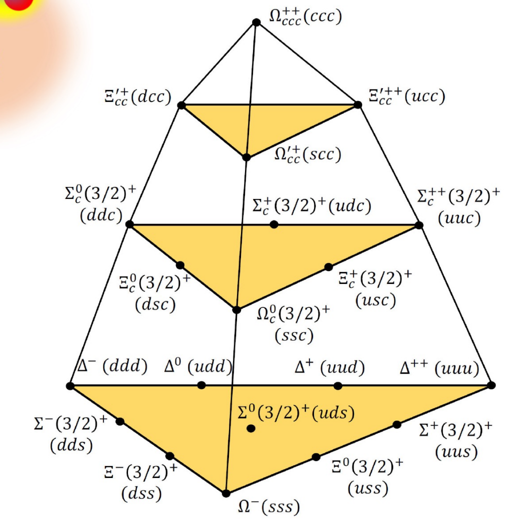
Introduction

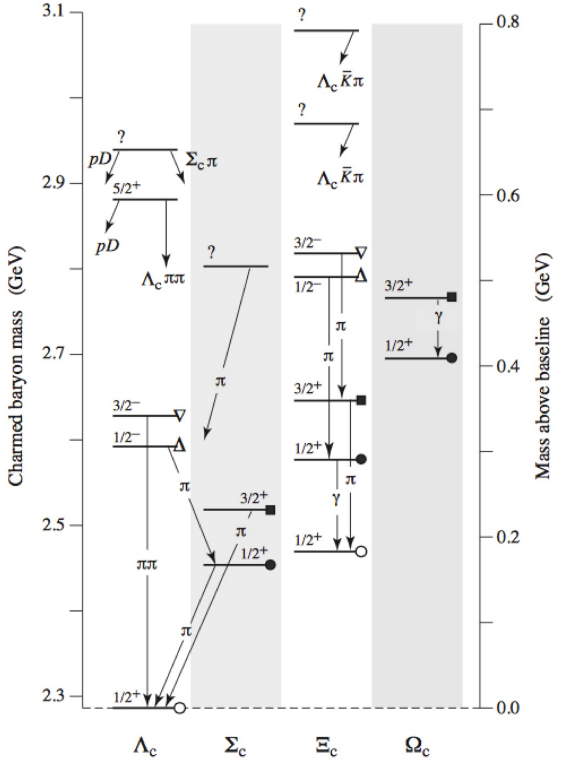
- **Charmed baryon spectroscopy**
  - Singly charmed baryons $\Lambda_c^+, \Sigma_c, \Xi_c, \Omega_c$ are well established, their excited spectra are being explored
  - Doubly charmed baryon $\Xi_{cc}^{++}, \Xi_{cc}^{+}$ & Ω_{cc}^{+} has been observed
  - No triply charmed baryon has been observed to date



- **The Λ_c^+ benchmark**
  - Lightest charm baryon, can only decay weakly
  - Essential inputs to charm & beauty physics





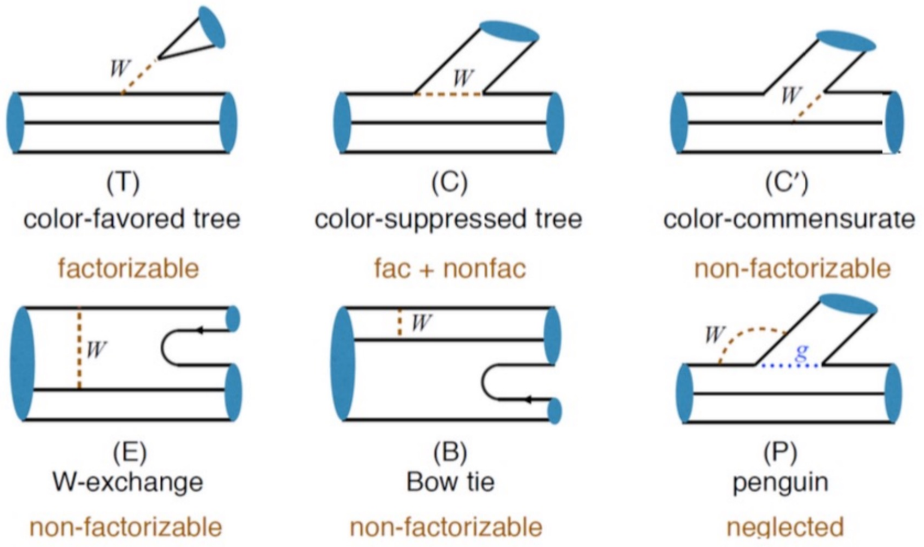


- **Naïve picture**
  - A heavy quark (c) & an unexcited zero-spin diquark (ud)
  - In heavy-quark limit, the heavy-quark spin decouples from the light degrees of freedom
  - Probe nonperturbative QCD and weak dynamics in a baryonic environment complementary to D meson decays.

Weak decays of Λ_c^+

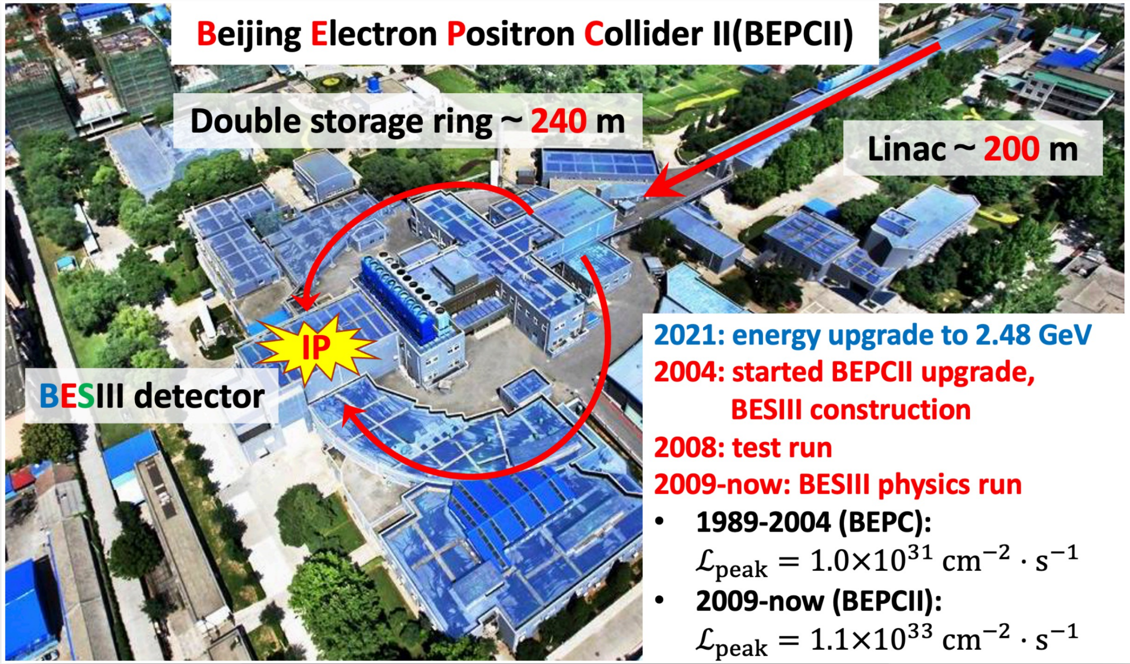
- **Theoretical challenge**
  - Charm quark lies in the transition region between perturbative & nonperturbative QCD.
  - Decay amplitudes contain both factorizable & nonfactorizable contributions.
  - W-exchange contribution can be sizable without color/helicity suppression

- **Frameworks developed to explain data and predict observables**
  - Heavy-quark effective theory and factorization
  - Various quark models, pole models, and current algebra
  - $SU(3)$ flavor symmetry, topological diagram, irreducible diagram
    - Parametrize & fit to data
  - Lattice QCD
    - From first principle



BESIII experiment

- **Beijing Electron-Positron Collider II (BEPCII)**

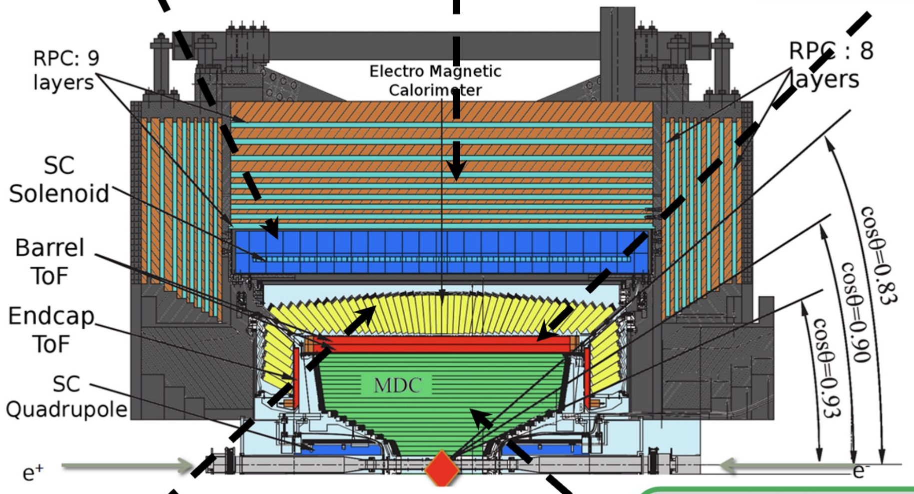


- **Beijing Spectrometer III (BESIII)**

Superconducting solenoid
- 1.0 T

Muon Counter (MUC)
- 9 layers (barrel) + 8 layers (end-cap)

Time Of Flight (TOF)
- $\sigma_t = 90$ ps (barrel)
- $\sigma_t = 65$ ps (end cap)



Electromagnetic Calorimeter(EMC)
- $\Delta E/E = 2.5\%$ @ 1.0 GeV
- $\sigma_{\phi z} = 0.6$ cm @ 1.0 GeV

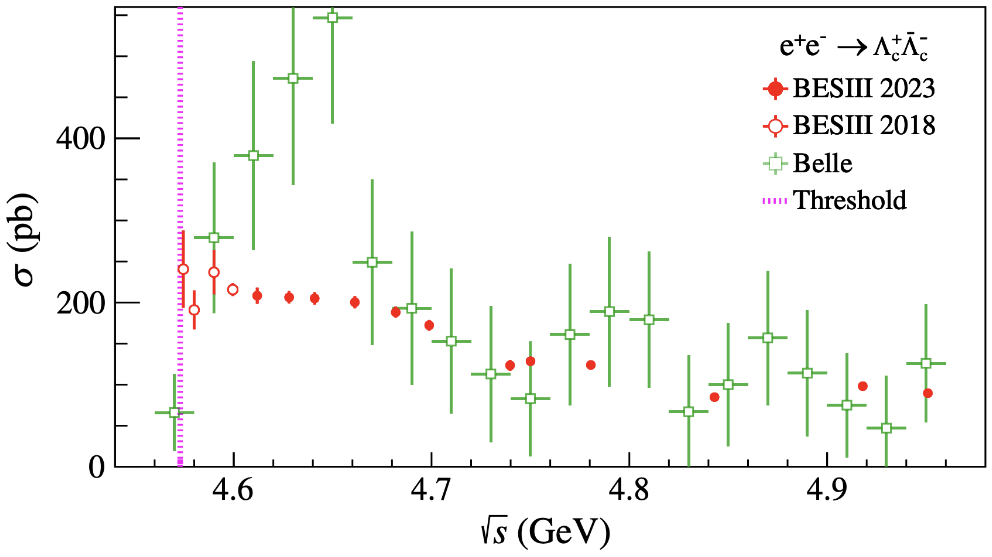
Main Drift Chamber (MDC)
- $\sigma_{xy} = 130\ \mu\text{m}$
- $\Delta P/P = 0.5\%$ @ 1.0 GeV
- $\sigma_{dE/dx} = 6 - 7\%$

Data samples

- **Total BESIII dataset:** about 50 fb^{-1} @ $\sqrt{s} = 1.8\sim4.95$ GeV after 17 years of data taking

- **Dedicated for charmed baryon studies**
  - 2014: 587 pb^{-1} @ $\sqrt{s} = 4.60$ GeV
  - 2020-2021: 3.9 fb^{-1} @ $\sqrt{s} = 4.61\sim4.70$ GeV
  - 2021-2022: 1.9 fb^{-1} @ $\sqrt{s} = 4.74\sim4.95$ GeV
  - Totally 6.5 fb^{-1} data from 13 energy points, about 1 million $\Lambda_c^+\bar{\Lambda}_c^-$ events

PRL **131**, 191901 (2023)

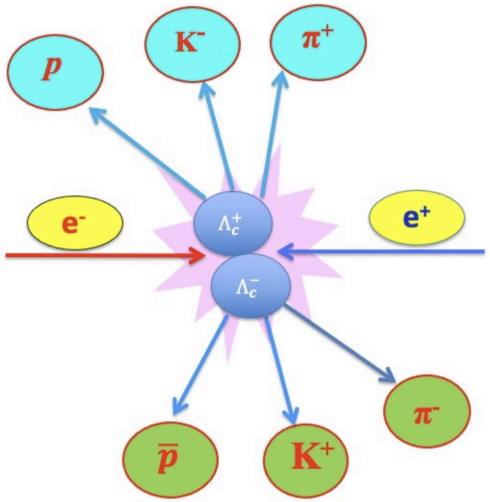


CPC **46**, 113003 (2022)

Sample	$E_{\rm cms}$/MeV	$\mathscr{L}_{\rm Bhabha}/\mathrm{pb}^{-1}$
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

Unique capabilities for charmed baryon studies (I)

- **Near-threshold pair production**
  - $e^+e^- \to \gamma^* \to \Lambda_c^+\bar{\Lambda}_c^-$ without accompanying hadrons
  - Low backgrounds and well constrained kinematics
    - $\Delta E = E_{\Lambda_c^+} - E_{beam}$
    - $M_{BC} = \sqrt{E_{beam}^2 - |p_{\Lambda_c^+}|^2}$



- **Double-tag method**
  - Reconstruct $\Lambda_c^+ \to$ signal, $\bar{\Lambda}_c^- \to$ hadronic tag modes simultaneously
  - Enables:
    - Absolute branching fraction measurement
    - Suppression of hadronic BKG
    - Inference of missing particles via recoiling
    - Cancellation systematics
  - Combined tag efficiency ~ 15%
    - Only 12 out of $\mathcal{O}(100)$ Λ_c^+ decays are used as tag modes
    - Deep learning methods are being explored to improve the efficiency

$$\mathcal{B}_{\rm sig} = \frac{\sum_{i,j} N_{\rm DT}^{i,j}}{\sum_{i,j}\left(\frac{N_{\rm ST}^{i,j}}{\epsilon_{\rm ST}^{i,j}} \cdot \epsilon_{\rm DT}^{i,j}\right)} = \frac{N_{\rm DT}}{\sum_{i,j}\left(\frac{N_{\rm ST}^{i,j}}{\epsilon_{\rm ST}^{i,j}} \cdot \epsilon_{\rm DT}^{i,j}\right)} = \frac{N_{\rm DT}}{N_{\rm ST} \cdot \epsilon^{\rm sig}},$$

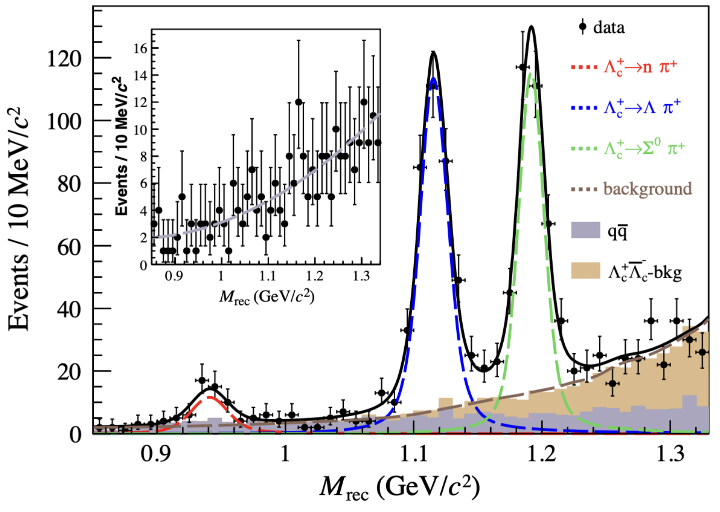
$$N_{\rm ST}^{i,j} = 2N^j_{\Lambda_c^+\bar{\Lambda}_c^-}\mathcal{B}^i_{\rm tag}\epsilon^{i,j}_{\rm ST}, \qquad \epsilon^{\rm sig} = \sum_{i,j}\left(\frac{N_{\rm ST}^{i,j}}{\epsilon_{\rm ST}^{i,j}} \cdot \epsilon_{\rm DT}^{i,j}\right) / \sum_{i,j} N_{\rm ST}^{i,j},$$

$$N_{\rm DT}^{i,j} = 2N^j_{\Lambda_c^+\bar{\Lambda}_c^-}\mathcal{B}^i_{\rm tag}\mathcal{B}_{\rm sig}\epsilon^{i,j}_{\rm DT}, \qquad N_{\rm ST} = \sum_{i,j} N_{\rm ST}^{i,j}$$

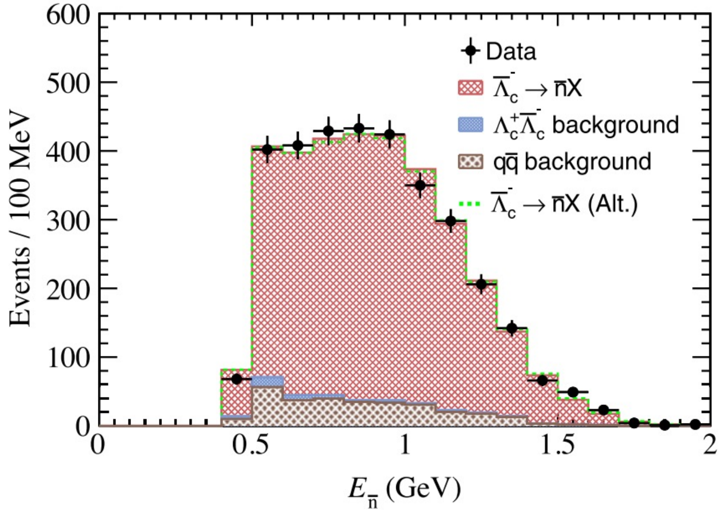
Unique capabilities for charmed baryon studies (II)

- **Neutral hadron $(n,\ K_L^0)$ detection**
  - BESIII has no dedicated hadronic calorimeter
  - Neutral hadrons can still deposit energy in EMC despite substantial leakage
  - Recoil mass method works when all other particles in event are explicitly reconstructed
  - Direct reconstruction of n & K_L^0 is challenging but feasible
  - Deep learning methods are being explored

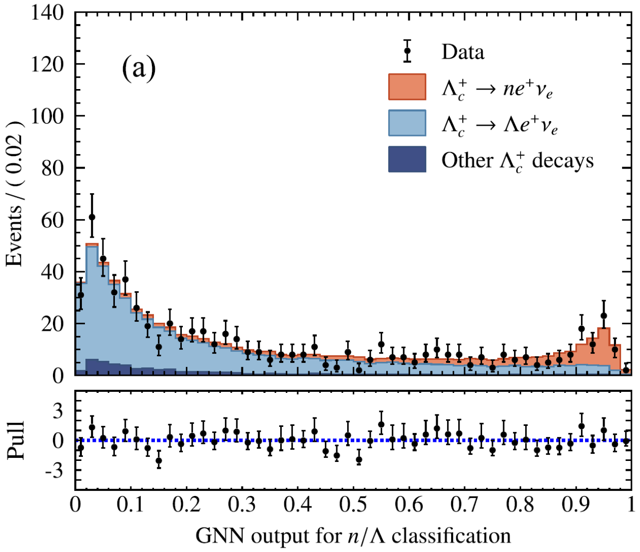
PRL **128**, 142001 (2022)



PRD **108**, L031101 (2023)



NatComm **16**, 681 (2025)

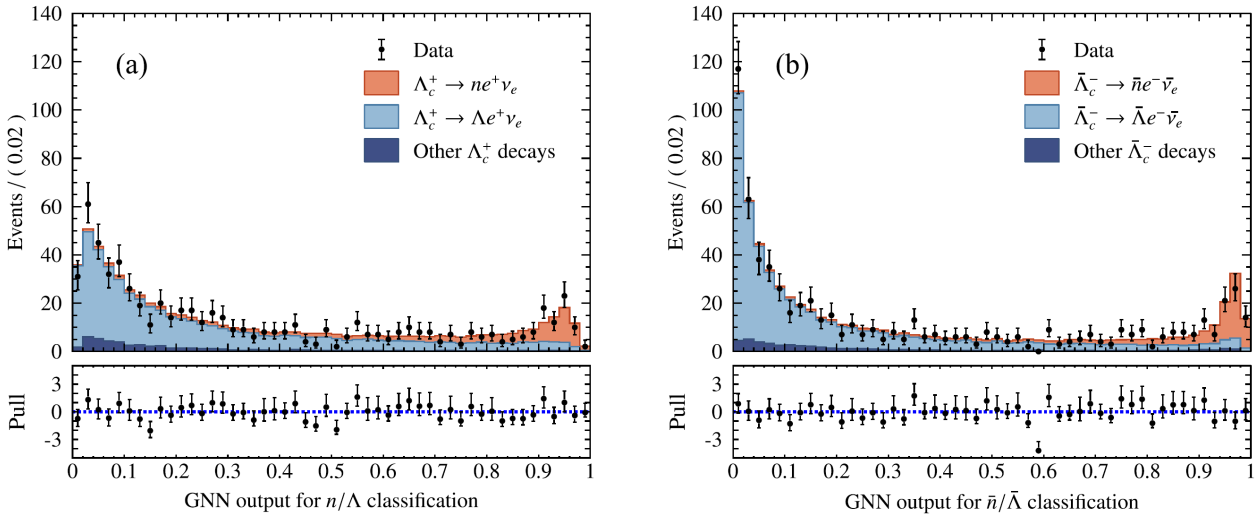


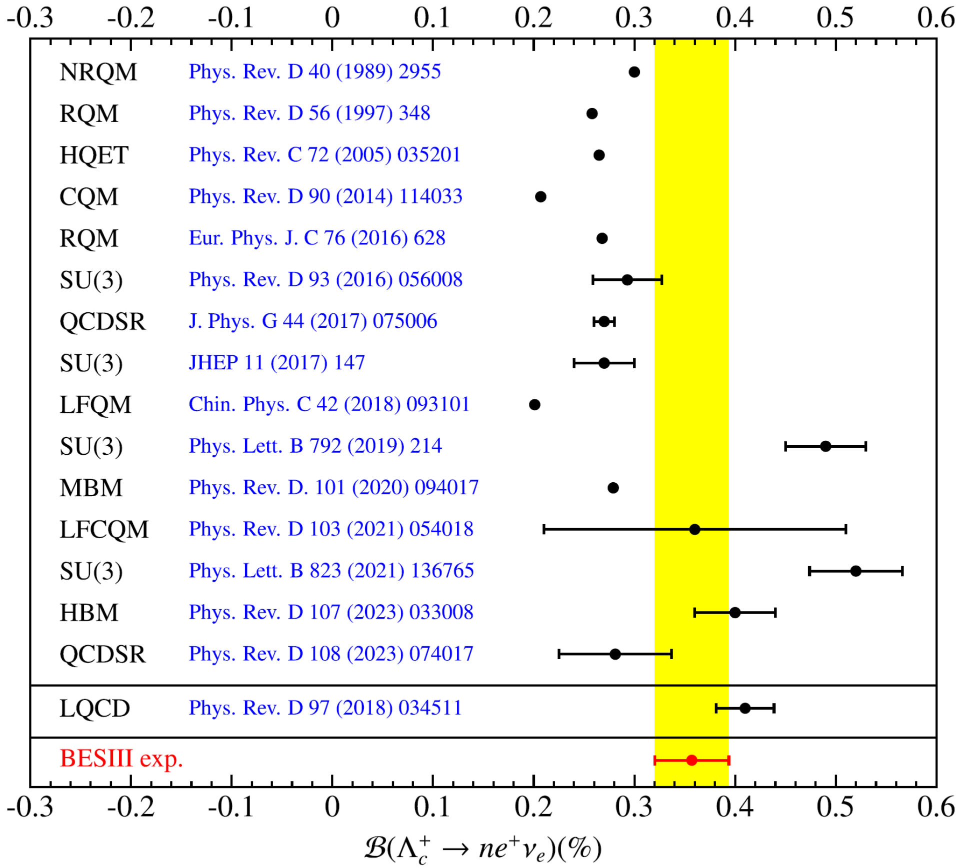
Recent physics results

- **Semi-leptonic decays**
  - $\Lambda_c^+ \to n e^+ \nu_e$ NatComm **16**, 681 (2025)
  - $\Lambda_c^+ \to \Sigma^\pm \pi^\mp e^+ \nu_e$ PRD **113**, 072014 (2026)
- **Two-body hadronic decays**
  - $\Lambda_c^+ \to p\pi^0$ PRD **111**, L051101 (2025)
  - $\Lambda_c^+ \to p\eta'$ arXiv: 2602.11974
  - $\Lambda_c^+ \to \Sigma^+\eta$ & $\Sigma^+\eta'$ JHEP **11**, 067 (2025)
  - Λ_c^+ transverse polarization arXiv: 2508.11400
- **Inclusive decays**
  - $\Lambda_c^+ \to \Lambda + X$ arXiv: 2602.24089
  - $\Lambda_c^+ \to K_S^0 + X$ JHEP **06**, 194 (2025)
- **Multi-body hadronic decays**
  - 12 exclusive channels JHEP **06**, 269 (2026)
  - $\Lambda_c^+ \to \Lambda\pi^+\eta$ PRL **134**, 021901 (2025)
  - $\Lambda_c^+ \to n\pi^+\eta$ arXiv: 2603.28232
  - $\Lambda_c^+ \to \Lambda K_S^0\pi^+$ & $\Lambda K_S^0 K^+$ PRD **111**, 012014 (2025)
  - $\Lambda_c^+ \to \Sigma^0 K_S^0\pi^+$ & $\Sigma^0 K_S^0 K^+$ JHEP **06**, 009 (2026)
  - $\Lambda_c^+ \to \Sigma^0 K^+\pi^0$ & $\Sigma^0 K^+\pi^+\pi^-$ CPC **49**, 073001 (2025)
  - $\Lambda_c^+ \to \Lambda K_S^0 K^+$ & $\Xi^0 K_S^0\pi^+$ PRD **112**, 032006 (2025)
  - $\Lambda_c^+ \to pK^+K^-$ arXiv: 2603.08469
- **Λ_c^+ excited states decays**
  - $\Lambda_c(2595/2625)^+ \to \Lambda_c^+\pi^+\pi^-$ PRD **109**, 112007 (2024)
  - $\Lambda_c(2595/2625)^+ \to \Lambda_c^+\pi^0\pi^0$ JHEP **08**, 065 (2025)

$\Lambda_c^+ \to n e^+ \nu_e$ (I)

NatComm **16**, 681 (2025)

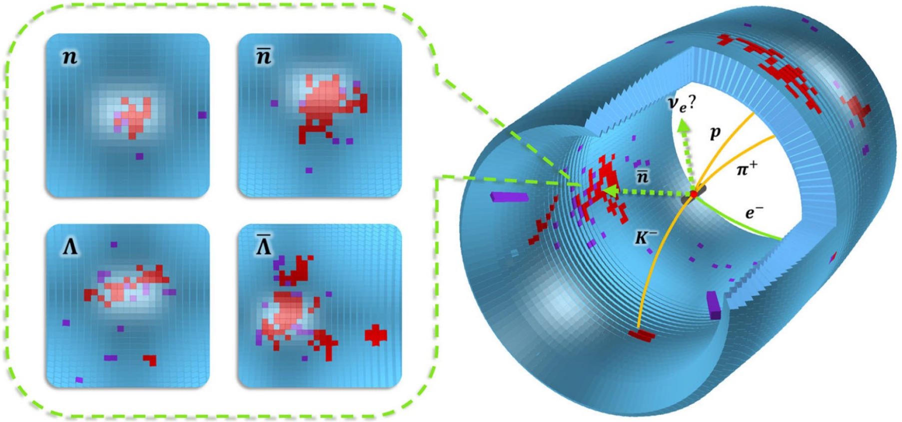


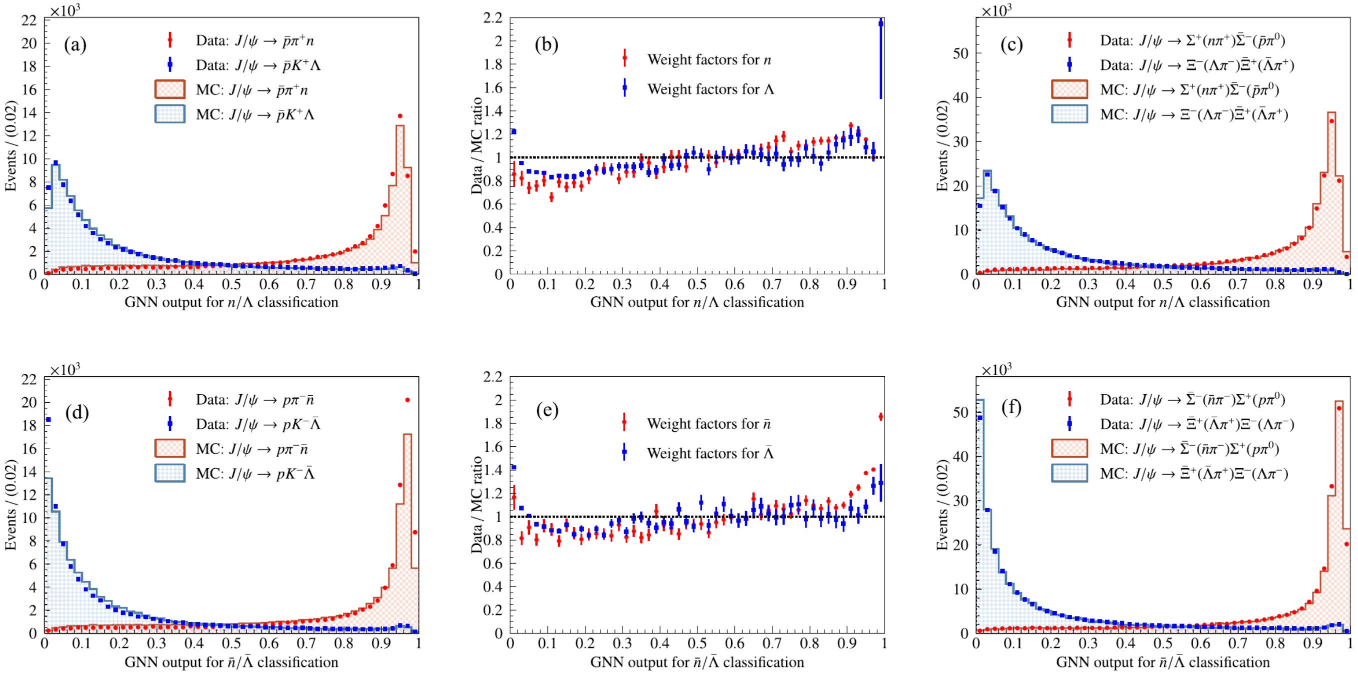


- **First observation of Cabibbo-suppressed $c \to d$ transition in Λ_c^+ semi-leptonic decays**
  - $\mathcal{B} = \left(0.357 \pm 0.334_{\text{stat.}} \pm 0.014_{\text{syst.}}\right)\%$ $(> 10\sigma)$
- **First extraction of $|V_{cd}|$ from charmed baryon decays**
  - Use LQCD form factors as input
  - $|V_{cd}| = 0.208 \pm 0.011_{\text{exp.}} \pm 0.007_{\text{LQCD}} \pm 0.011_{\tau_{\Lambda_c^+}}$
- **Provides a stringent test of theoretical predictions**

$\Lambda_c^+ \to n e^+ \nu_e$ (II)

- **A deep learning method separates signal from dominant $\Lambda_c^+ \to \Lambda(n\pi^0)e^+\nu_e$ background**
  - Use Graph Neural Network to distinguishes n/Λ energy deposition patterns in EMC
  - Establish a data-driven pipeline for training, calibration, validation, and systematic uncertainty quantification
    - Extensively utilize control samples from 10 billion J/ψ events collected at BESIII



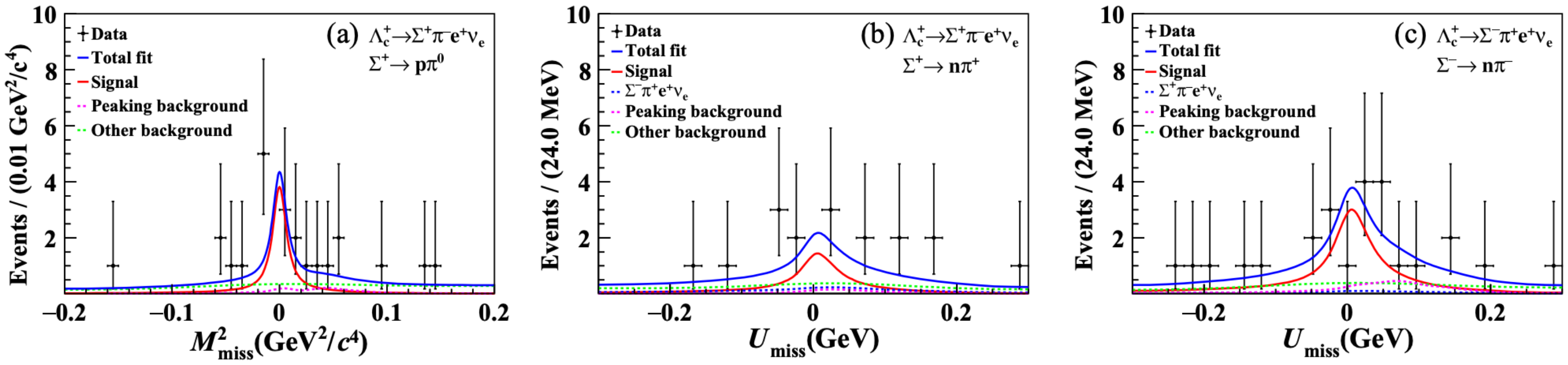


Applicable to more BESIII studies involving neutral hadrons, especially when recoil-mass constrains are unavailable.

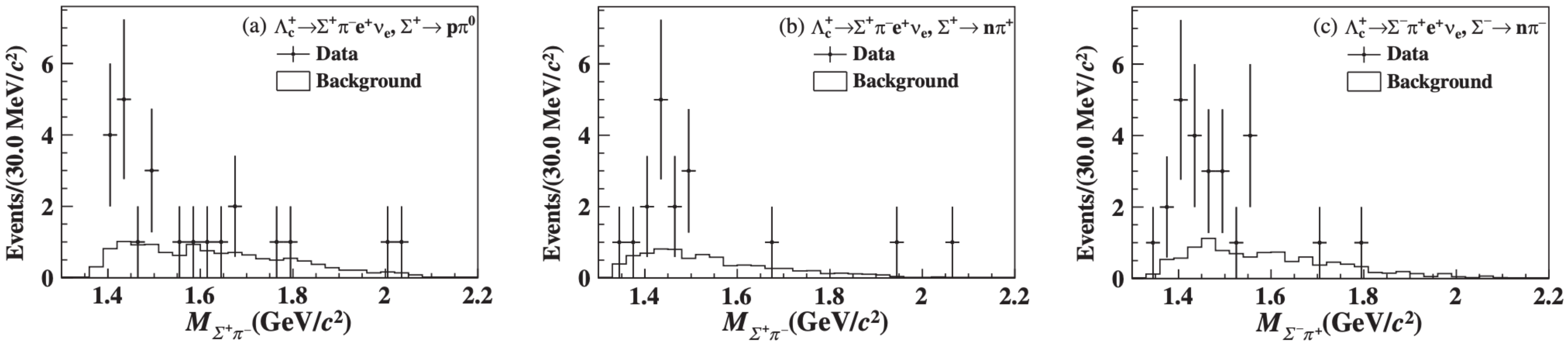
$\Lambda_c^+ \to \Sigma^\pm \pi^\mp e^+ \nu_e$

PRD **113**, 072014 (2026)

- **Evidence for the four-body semi-leptonic decay**
  - Assuming isospin symmetry, $\mathcal{B}\left(\Lambda_c^+ \to \Sigma^\pm \pi^\mp e^+ \nu_e\right) = \left(7.7^{+2.5}_{-2.3} \pm 1.3\right)\times 10^{-4}$ with 3.6σ

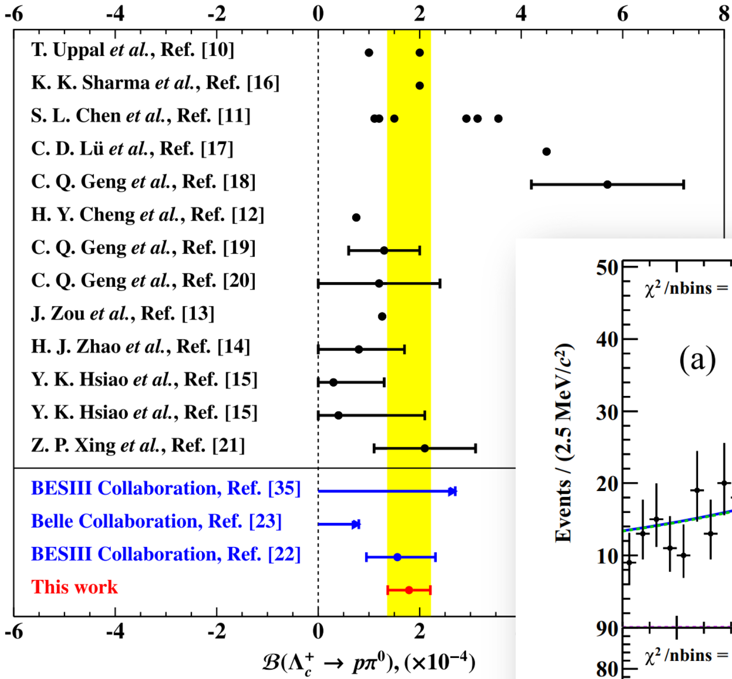


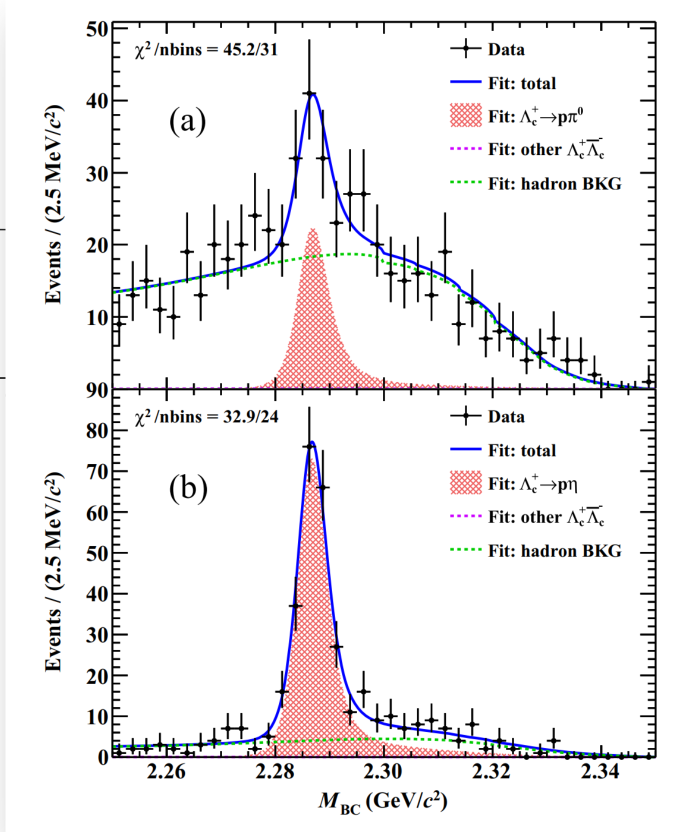
- **Signatures for $\Lambda(1405/1520)$ in $M(\Sigma\pi)$ spectrum**
  - Future combined analysis of pK^- & $\Sigma\pi$ channels will provide stronger constraints



$\Lambda_c^+ \to p\pi^0$ (I)

PRD **111**, L051101 (2025)





- **Earlier measurements were in tension**
  - Belle 2021: $\mathcal{B} < 0.8\times10^{-4}$ @ 90% C. L.
  - BESIII 2023: $\mathcal{B} = (1.56^{+0.72}_{-0.58} \pm 0.20)\times10^{-4}$ with 3.7σ

- **A definitive observation is achieved recently**
  - Re-analysis data with new reconstruction method

$$\frac{\mathcal{B}(\Lambda_c^+\to p\pi^0)}{\mathcal{B}(\Lambda_c^+\to p\eta)} = 0.120 \pm 0.026_{\text{stat.}} \pm 0.007_{\text{syst.}} \text{ with } 5.4\sigma$$

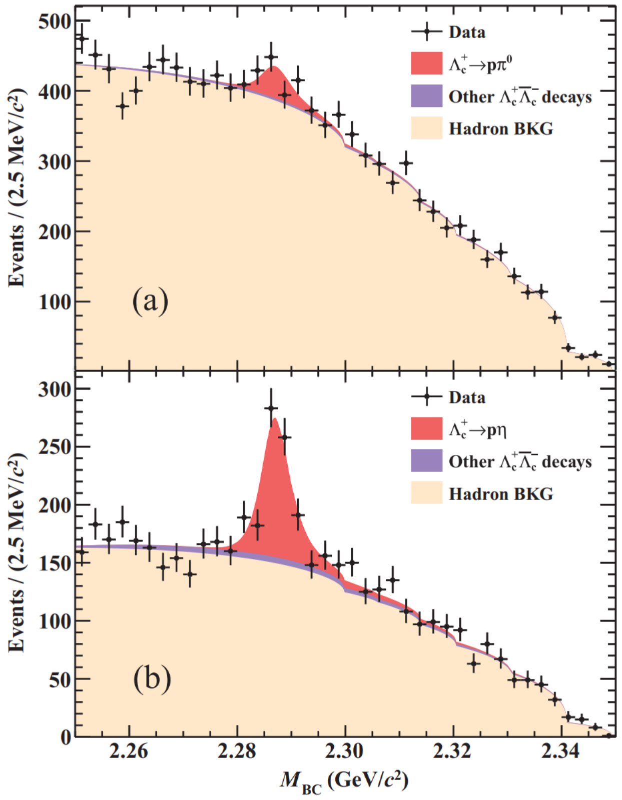
  - Take world average of $\Lambda_c^+ \to p\eta$ as input:

$$\mathcal{B}(\Lambda_c^+ \to p\pi^0) = (1.79 \pm 0.39_{\text{stat.}} \pm 0.11_{\text{syst.}} \pm 0.08_{\text{ref.}})\times10^{-4}$$

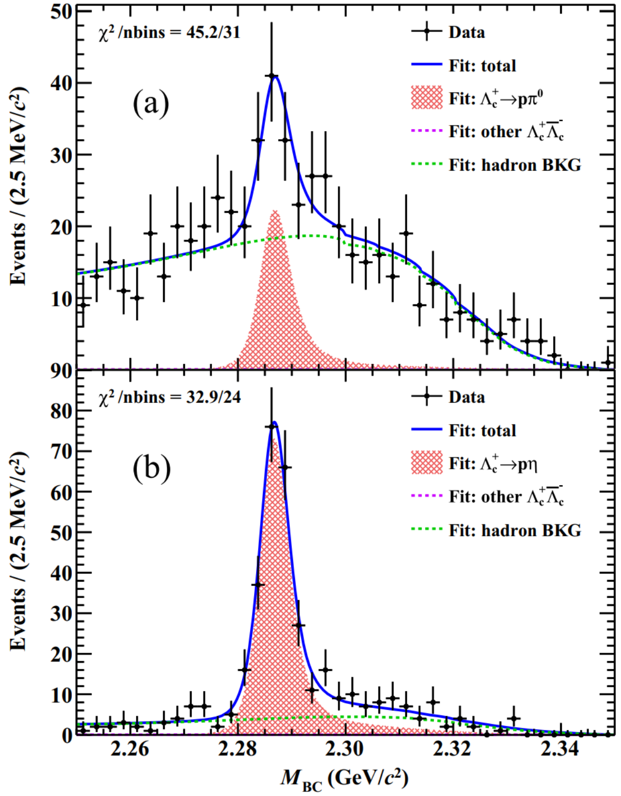
  - Consistent with earlier BESIII evidence, yet exceeds the upper limit set by Belle.

$\Lambda_c^+ \to p\pi^0$ (II)

- **A deep learning method efficiently suppresses non-Λ_c^+ hadronic backgrounds**
  - Exclusively constrain all possible $\overline{\Lambda}_c^-$ decays in $\Lambda_c^+\overline{\Lambda}_c^-$ pair production
  - Use Transformer-based DNN to classify signal & background decay topologies from all reconstructed particles in event
  - Study $\Lambda_c^+ \to p\eta(\gamma\gamma)$ as reference channel to calibrate DNN-related bias



DNN veto



The method can be extended to other background-limited Λ_c^+ measurements at BESIII.

Λ_c^+ transverse polarization (I)

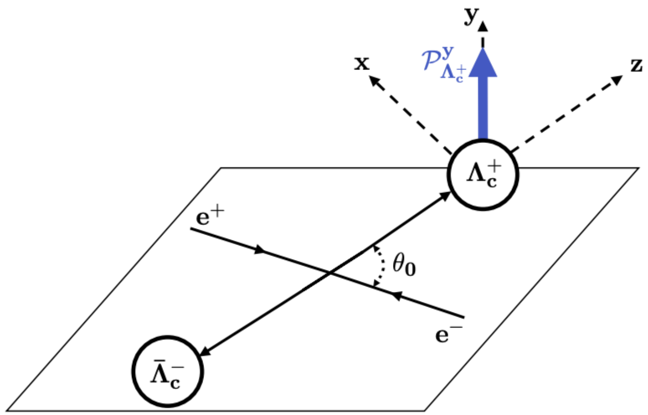
arXiv: 2508.11400
Accepted by PRX

- **Production & decay formalism for $e^+e^- \to \gamma^* \to \Lambda_c^+\bar{\Lambda}_c^-$**
  - Cross section parameterized by time-like electromagnetic form factors G_E & G_M
  - Their non-zero phase difference $\Delta\Phi$ generates a transverse polarization

$$\frac{d\sigma}{d\cos\theta_0} \propto 1 + \alpha_0 \cos^2\theta_0, \qquad \left|\frac{G_E}{G_M}\right| = \sqrt{\frac{1-\alpha_0}{(1-v^2)(1+\alpha_0)}}.$$

$$\Delta\Phi = \arg(G_M) - \arg(G_E)$$

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



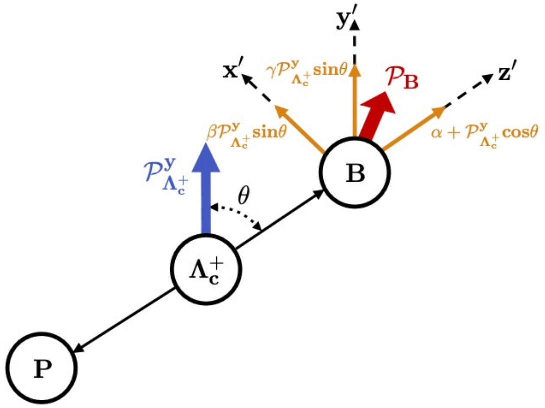
  - This polarization can be transferred to Λ_c^+ subsequent decays and analyzed through angular distributions of daughter baryons

$$\mathcal{M} = i\bar{u}_B(A - B\gamma_5)u_{\Lambda_c}, \qquad S \sim A, \quad P \sim \kappa B.$$

$$\alpha = \frac{2\,\mathrm{Re}(S^*P)}{|S|^2+|P|^2}, \quad \beta = \frac{2\,\mathrm{Im}(S^*P)}{|S|^2+|P|^2}, \quad \gamma = \frac{|S|^2-|P|^2}{|S|^2+|P|^2},$$

$$\alpha^2 + \beta^2 + \gamma^2 = 1.$$

$$\vec{P}_B = \frac{(\alpha + \vec{P}_{\Lambda_c}\cdot\hat{n})\hat{n} + \beta(\vec{P}_{\Lambda_c}\times\hat{n}) + \gamma\,\hat{n}\times(\vec{P}_{\Lambda_c}\times\hat{n})}{1+\alpha\,\vec{P}_{\Lambda_c}\cdot\hat{n}}.$$



Λ_c^+ transverse polarization (II)

arXiv: 2508.11400
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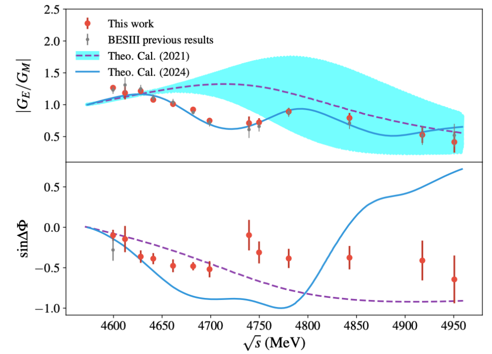
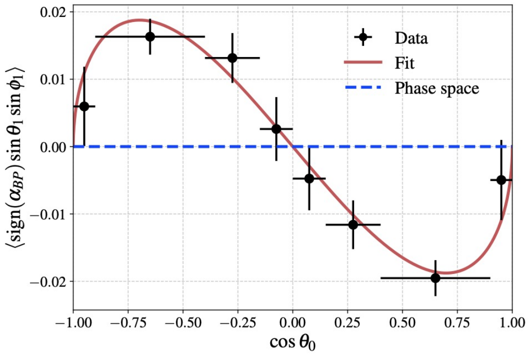
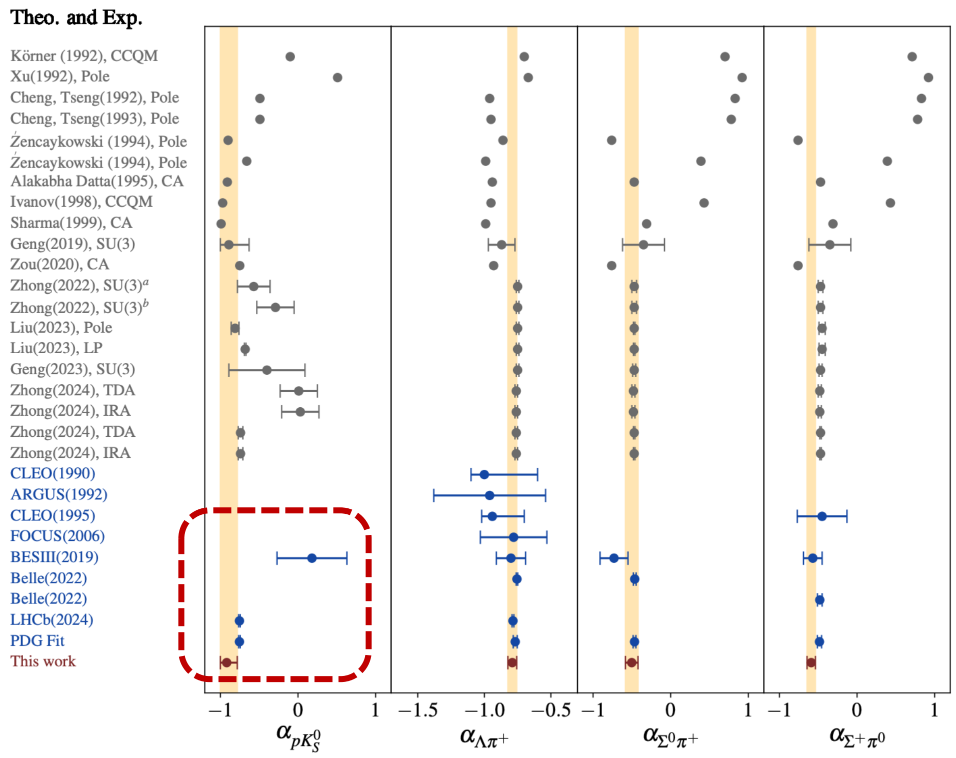






- **Simultaneous angular analysis on five decay channels**
  - $pK^-\pi^+, pK_S^0, \Lambda\pi^+, \Sigma^0\pi^+, \Sigma^+\pi^0$
- **First observation of Λ_c^+ transverse polarization**
  - Negative non-zero $\Delta\Phi$ up to 14.1σ
- **Updated measurements of decay asymmetries**
  - $\alpha_{pK_S^0}$ become consistent with other theories & experiments
- **Large $S-P$ strong-phase differences**
  - Indicate sizable final-state interactions and hadronic rescattering in charmed-baryon decays
- **New observables for CPV test**

Parameter	$\Lambda_c^+ \to pK_S^0$	$\Lambda_c^+ \to \Lambda\pi^+$	$\Lambda_c^+ \to \Sigma^0\pi^+$	$\Lambda_c^+ \to \Sigma^+\pi^0$
$\langle\alpha_{BP}\rangle$	$-0.918^{+0.133}_{-0.082} \pm 0.031$	$-0.790 \pm 0.032 \pm 0.009$	$-0.502 \pm 0.080 \pm 0.009$	$-0.590 \pm 0.049 \pm 0.022$
$\langle\Delta_{BP}\rangle$	$\cdots$	$0.637 \pm 0.444 \pm 0.014$	$2.190 \pm 0.730 \pm 0.029$	$1.901 \pm 0.603 \pm 0.040$
$\langle\beta_{BP}\rangle$	$\cdots$	$0.365^{+0.173}_{-0.246} \pm 0.010$	$0.704^{+0.143}_{-0.480} \pm 0.015$	$0.764^{+0.051}_{-0.237} \pm 0.018$
$\langle\gamma_{BP}\rangle$	$\cdots$	$0.637^{+0.103}_{-0.202} \pm 0.011$	$-0.502^{+0.591}_{-0.303} \pm 0.021$	$-0.262^{+0.478}_{-0.383} \pm 0.031$
$\delta_p - \delta_s$	$\cdots$	$2.71^{+0.28}_{-0.17} \pm 0.02$	$2.19^{+0.49}_{-0.13} \pm 0.02$	$2.23^{+0.19}_{-0.06} \pm 0.03$
$A_{CP}^{\alpha_{BP}}$	$0.079^{+0.115}_{-0.101} \pm 0.019$	$0.002 \pm 0.047 \pm 0.017$	$0.206^{+0.188}_{-0.156} \pm 0.028$	$-0.086 \pm 0.081 \pm 0.029$
$\tan\phi_{CP}$	$\cdots$	$0.232 \pm 0.242 \pm 0.025$	$0.393 \pm 0.651 \pm 0.042$	$-0.007 \pm 0.474 \pm 0.034$
$\tan\Delta_S$	$\cdots$	$-0.475 \pm 0.242 \pm 0.029$	$-1.411 \pm 0.672 \pm 0.062$	$-1.297 \pm 0.478 \pm 0.068$

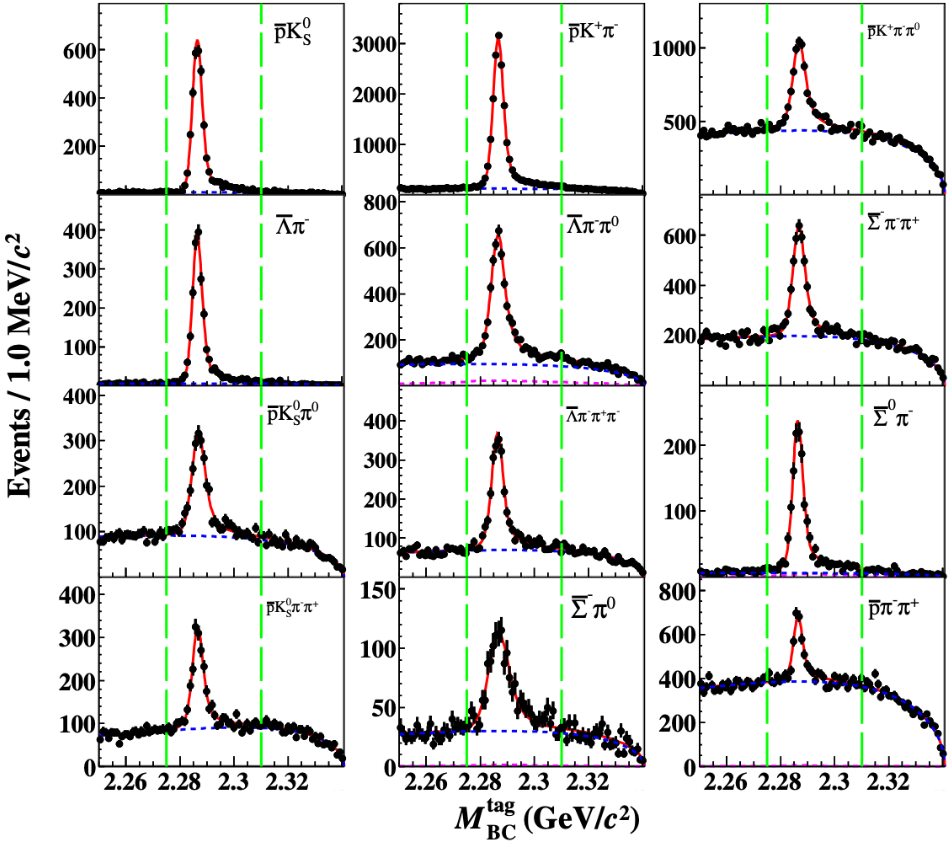
Λ_c^+ dominant hadronic decay BFs

JHEP **06**, 269 (2026)

- **Most precise measurements to date**
  - Cover 12 dominant hadronic decay channels
  - A global fit to constrain different decay modes simultaneously
  - 2~3x of precision improvement
  - Also update $e^+e^- \to \Lambda_c^+\overline{\Lambda}_c^-$ Born cross sections and form factors

Signal mode	Global fit	PDG
pK_S^0	$1.696 \pm 0.033 \pm 0.048$	1.61 ± 0.07
$pK^-\pi^+$	$6.61 \pm 0.11 \pm 0.12$	6.35 ± 0.25
$pK_S^0\pi^0$	$2.186 \pm 0.057 \pm 0.048$	1.99 ± 0.12
$pK_S^0\pi^+\pi^-$	$1.883 \pm 0.040 \pm 0.070$	1.62 ± 0.11
$pK^-\pi^+\pi^0$	$4.89 \pm 0.10 \pm 0.11$	4.52 ± 0.28
$\Lambda\pi^+$	$1.322 \pm 0.027 \pm 0.026$	1.31 ± 0.05
$\Lambda\pi^+\pi^0$	$6.67 \pm 0.13 \pm 0.10$	7.10 ± 0.34
$\Lambda\pi^+\pi^-\pi^+$	$4.092 \pm 0.091 \pm 0.096$	3.67 ± 0.26
$\Sigma^0\pi^+$	$1.449 \pm 0.034 \pm 0.025$	1.29 ± 0.05
$\Sigma^+\pi^0$	$1.374 \pm 0.044 \pm 0.032$	1.26 ± 0.10
$\Sigma^+\pi^+\pi^-$	$4.58 \pm 0.10 \pm 0.10$	4.54 ± 0.20
$p\pi^+\pi^-$	$0.499 \pm 0.016 \pm 0.010$	0.47 ± 0.02

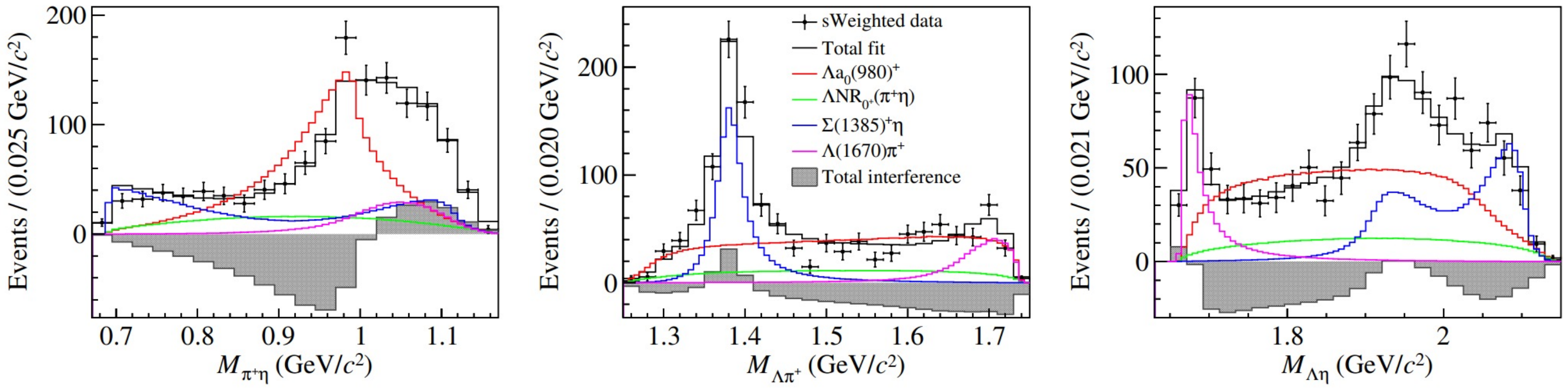
$\sqrt{s}$(MeV)	σ(pb)	$\lvert G_{\rm eff}\rvert(\times 10^{-2})$
4599.53	$213.1 \pm 3.9 \pm 1.9$	$53.8 \pm 0.5 \pm 0.2$
4611.86	$211.5 \pm 6.0 \pm 2.0$	$49.5 \pm 0.7 \pm 0.2$
4628.00	$207.6 \pm 3.7 \pm 1.8$	$45.6 \pm 0.4 \pm 0.2$
4640.91	$206.5 \pm 4.1 \pm 1.9$	$43.5 \pm 0.4 \pm 0.2$
4661.24	$206.2 \pm 3.9 \pm 2.0$	$41.2 \pm 0.4 \pm 0.2$
4681.92	$192.0 \pm 3.3 \pm 1.8$	$38.1 \pm 0.4 \pm 0.2$
4698.82	$172.0 \pm 3.5 \pm 2.2$	$35.0 \pm 0.4 \pm 0.2$



Essential inputs to other flavor facilities.

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

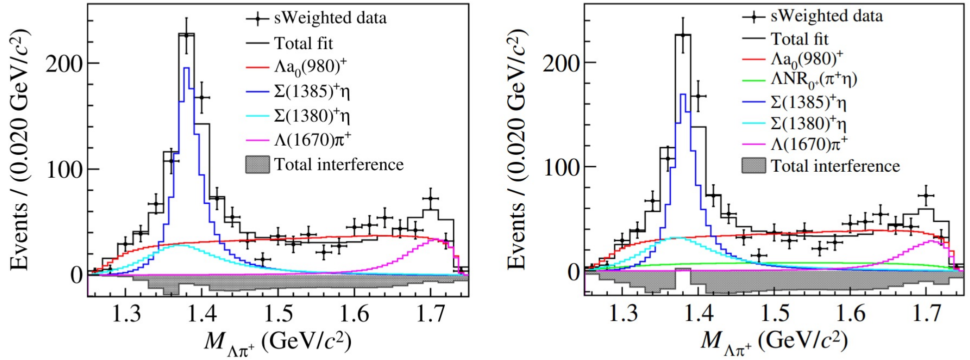
PRL **134**, 021901 (2025)



Much interest goes to intermediate light resonances; Partial wave analysis is implemented to extract them reliably.

- **Precise measurement for absolute BF**
  - $\mathcal{B}(\Lambda_c^+ \to \Lambda\pi^+\eta) = (1.94 \pm 0.07 \pm 0.11)\%$
- **First observation of $\Lambda_c^+ \to \Lambda a_0(980)^+$**
  - $\mathcal{B}(\Lambda_c^+ \to \Lambda a_0(980)^+) \times \mathcal{B}(a_0(980)^+ \to \pi^+\eta) = \left(1.05 \pm 0.16_{\text{stat.}} \pm 0.05_{\text{syst.}} \pm 0.07_{\text{ext.}}\right)\%$ with 13.1σ
  - Larger than theoretical calculations by 1-2 orders of magnitude
- **Evidence of potential pentaquark state $\Sigma(1380)^+$**
  - Statistical significance 6.1σ (3.3σ) without (with) $\pi^+\eta$ non-resonant contribution

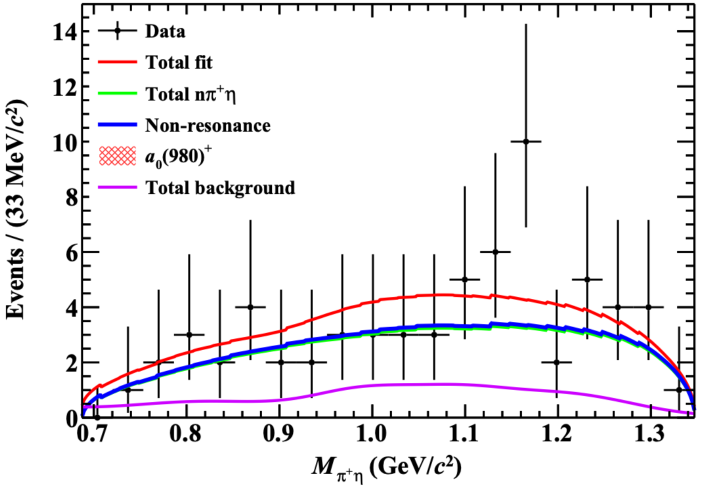
Process	FF (%)	$\mathcal{S}$	α
$\Lambda a_0(980)^+$	$54.0 \pm 8.4 \pm 2.6$	13.1σ	$-0.91^{+0.18}_{-0.09} \pm 0.08$
$\Sigma(1385)^+\eta$	$30.4 \pm 2.6 \pm 0.7$	22.5σ	$-0.61 \pm 0.15 \pm 0.04$
$\Lambda(1670)\pi^+$	$14.1 \pm 2.8 \pm 1.2$	11.7σ	$0.21 \pm 0.27 \pm 0.33$
ΛNR_{0^+}	15.4 ± 5.3	6.7σ	$\cdots$

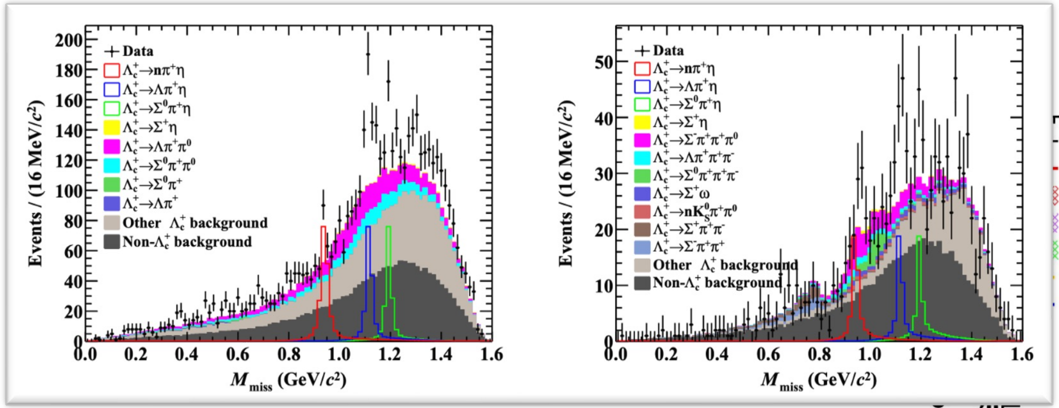


$\Lambda_c^+ \to n\pi^+\eta$

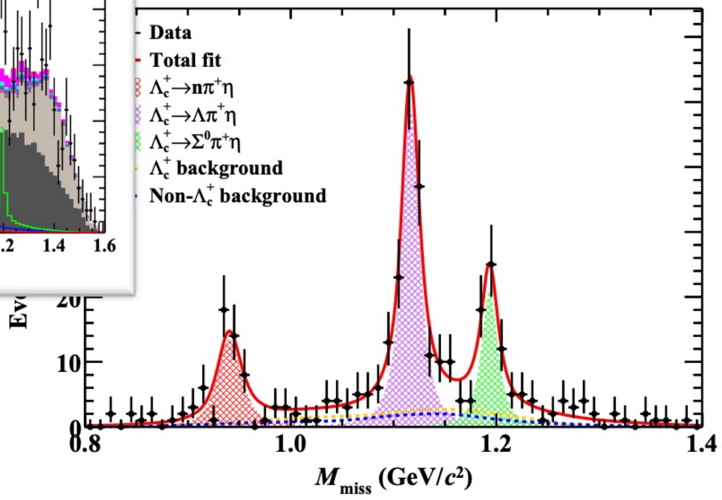
arXiv: 2603.28232
Accepted by JHEP

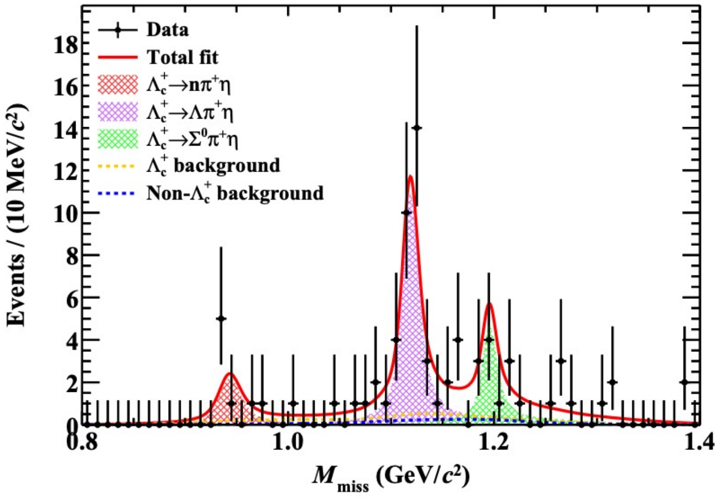
- **First observation of the three-body decay**
  - $\mathcal{B}(\Lambda_c^+ \to n\pi^+\eta) = (2.94 \pm 0.59_{stat.} \pm 0.23_{syst.} \pm 0.13_{ref.})\times 10^{-3}$ with 9.5σ
- **Upper limit on $\Lambda_c^+ \to na_0(980)^+$**
  - $\mathcal{B}(\Lambda_c^+ \to na_0(980)^+)\times\mathcal{B}(a_0(980)^+ \to \pi^+\eta) < 8.4\times 10^{-4}$ @ 90% C.L.
- **A deep learning method suppresses hadronic backgrounds efficiently**





DNN veto



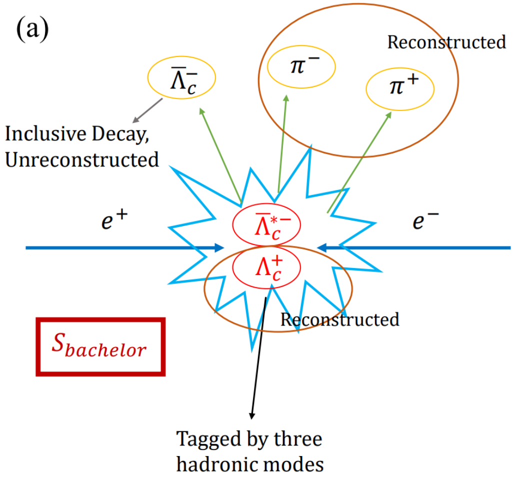


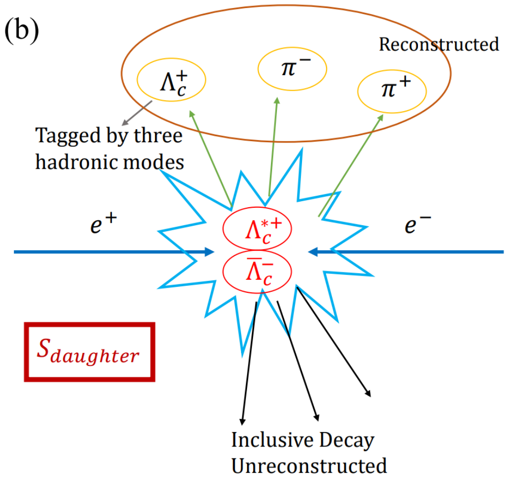
$\Lambda_c^{*+} \to \Lambda_c^+\pi^+\pi^-$ & $\Lambda_c^+\pi^0\pi^0$

PRD **109**, 112007 (2024)
JHEP **08**, 065 (2025)

Partial reconstruction of $e^+e^- \to \Lambda_c^{*+}\bar{\Lambda}_c^-$

- Treat one $\Lambda_c^+(\bar{\Lambda}_c^-)$ as missing particle
- Recoil it using energy-momentum conservation
- Improved efficiency, ensure model independency

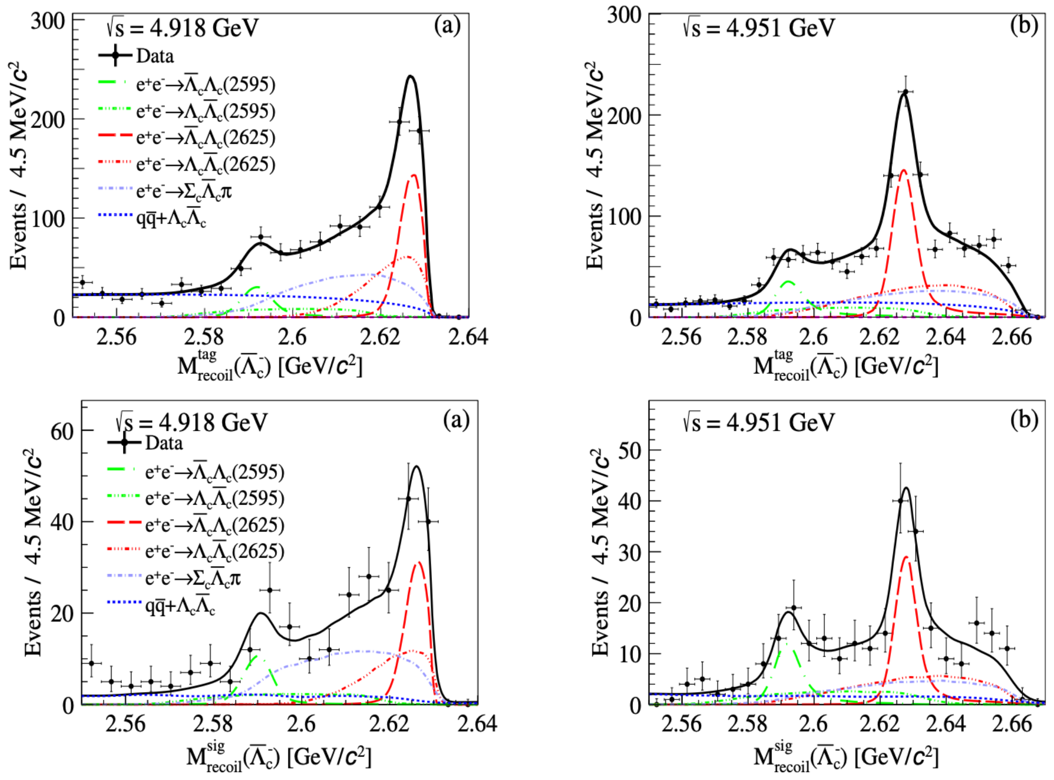




Essential inputs to calibrate Λ_c^{*+} measurements.

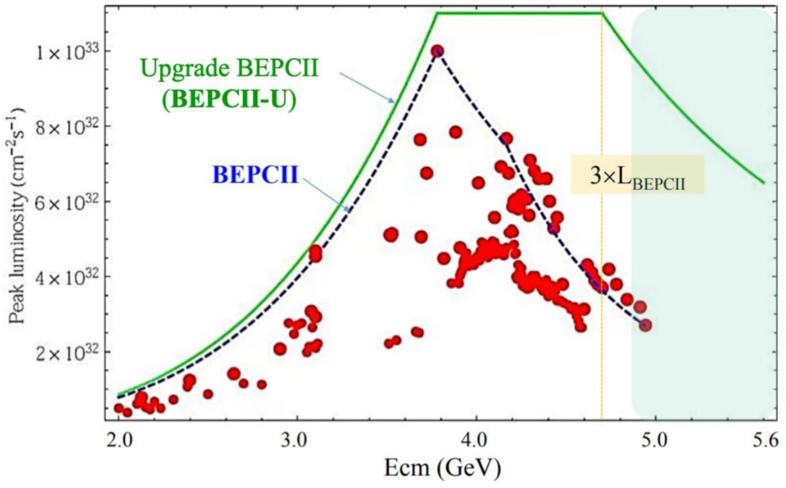
First BF measurements

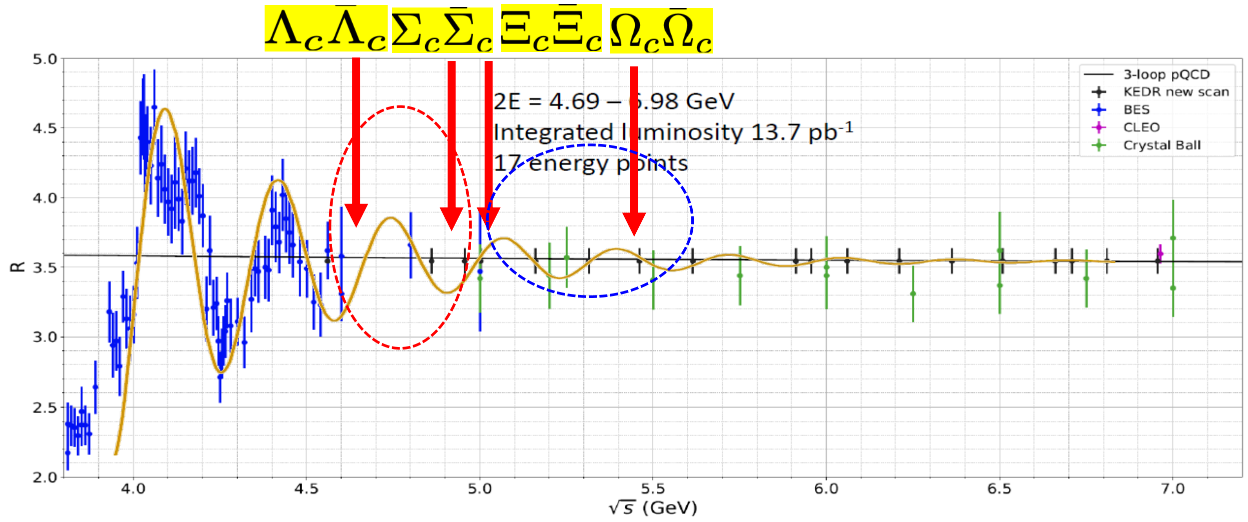
- $\mathcal{B}(\Lambda_c(2625)^+ \to \Lambda_c^+\pi^+\pi^-) = (51.1 \pm 5.8 \pm 3.5)\%$
- $\mathcal{B}(\Lambda_c(2625)^+ \to \Lambda_c^+\pi^0\pi^0) = (41.0 \pm 5.2 \pm 3.3)\%$
- $\mathcal{B}(\Lambda_c(2595)^+ \to \Lambda_c^+\pi^+\pi^-) < 58.0\%$ @ 90% C. L.
- $\mathcal{B}(\Lambda_c(2595)^+ \to \Lambda_c^+\pi^0\pi^0) = (59.5 \pm 11.1 \pm 7.9)\%$



Prospect

- **BEPCII(-U) & BESIII have finished a major machine upgrade**
  - Triple the luminosity @ 4.7 GeV → more Λ_c^+ data
  - Extend the center-of-mass energy up to 5.6 GeV → near-threshold pair-production for $\Sigma_c, \Xi_c, \Omega_c$
  - Replace inner MDC with CGEM detector





- **New charmed baryon datasets are being taken**
  - Additional 9 fb^{-1} data @ 4.68 GeV → triple current data statistics
  - Energy scan around $\Xi_c\bar{\Xi}_c$ threshold

Summary

- **BESIII has collected dedicated data samples for charmed baryons** around the pair production threshold.

- **Recent Λ_c^+ studies in 2024-2026 include:**
  - New and rare semi-leptonic decays
  - Cabibbo-suppressed two-body decays and first observation of Λ_c^+ transverse polarization
  - Multi-body hadronic decays and studies of intermediate light-hadron structures

- **Deep learning methods** bring impressive and reliable physics results in these investigations.

- **The upgraded BEPCII(-U) & BESIII** will provide more opportunities for charm baryon physics.

Thanks for your attention!