Λ_c^+ decays at BESIII

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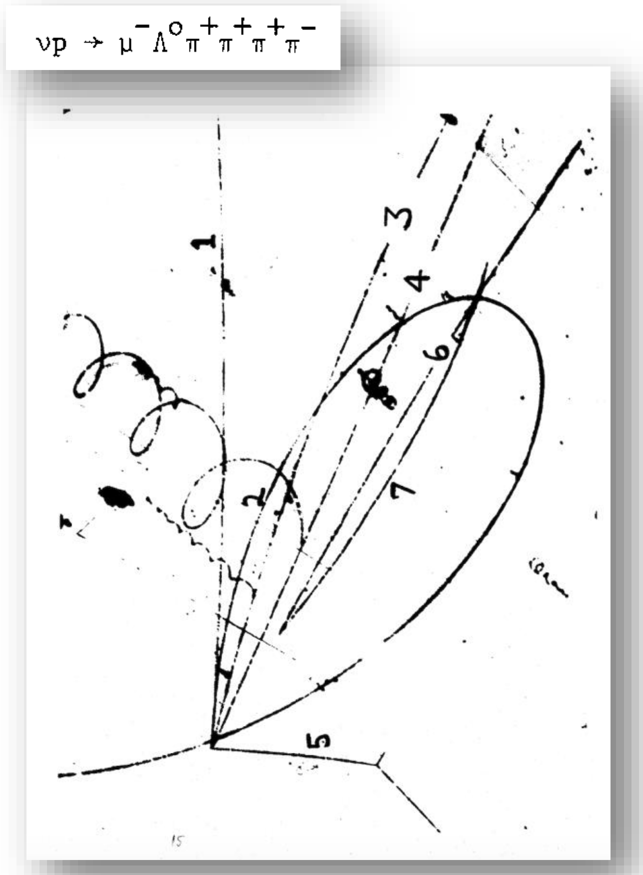
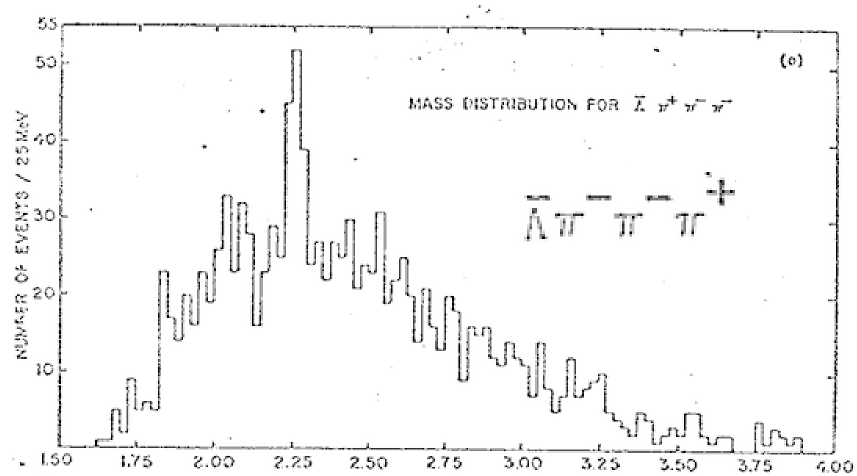
Outline

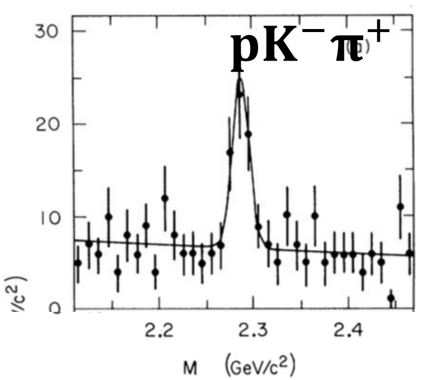
- Introduction
  - The lightest c-ed baryon Λ_c^+
- Λ_c^+ decays at BESIII
  - Λ_c^+ hadronic decays
  - Λ_c^+ semi-leptonic decay $\Lambda_c^+ \to \Lambda l^+ \nu_l$
- Summary

Discovery of the lightest heavy baryon

- First hint of charmed baryon Ξ_c^+ in BNL in 1975 **PRL34, 1125 (1975)**
- First evidence of Λ_c^+ at Fermi Lab in 1976 **PRL37, 882 (1976)**
- Λ_c^+ established in MarkII in 1980 **PRL44, 10 (1980)**



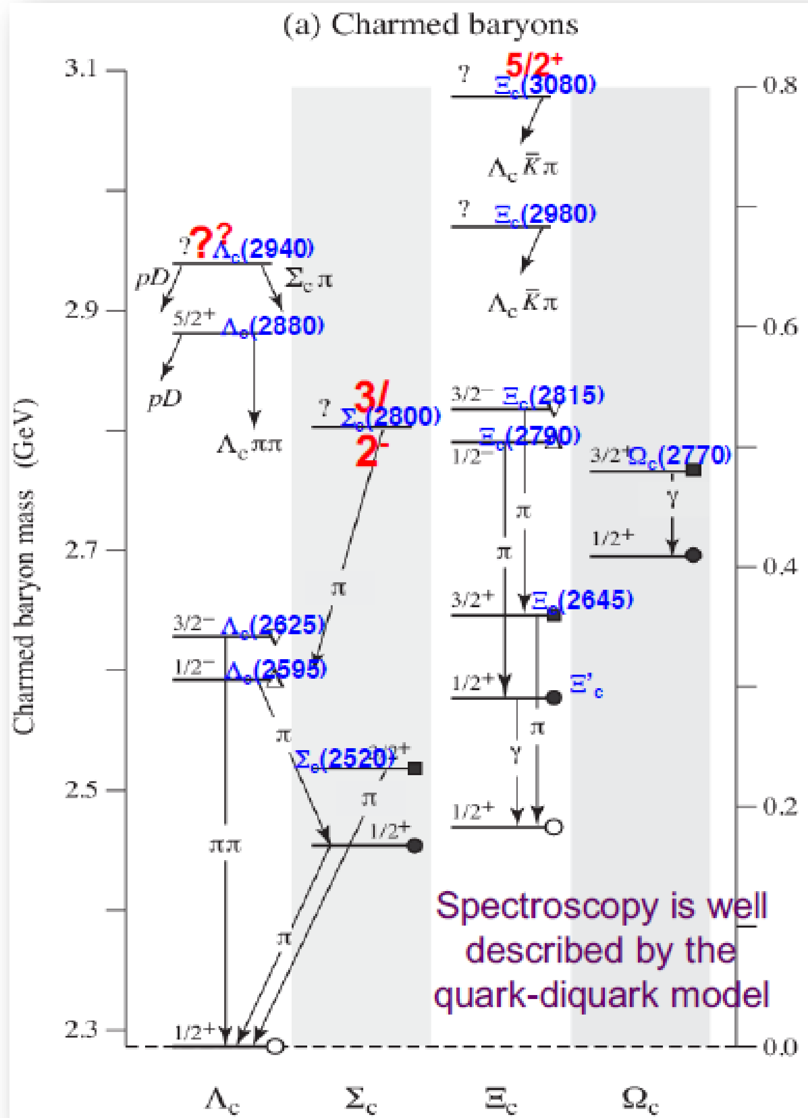




BESIII

The charmed baryon family

- **Singly charmed baryons**
  - ✓ Established ground states:
    $\Lambda_c^+,\ \Sigma_c\ ,\ \Xi_c^{(\prime)},\ \Omega_c$
  - ✓ Excited states are being explored
- **No observations of doubly or triply charmed baryons**



- ➢ Λ_c^+: decay only weakly, **many recent experimental progress since 2014**
- ➢ Σ_c : $B(\Sigma_c \to \Lambda_c^+\pi)$~100%; $B(\Sigma_c \to \Lambda_c^+\gamma)$?
- ➢ Ξ_c : decay only weakly; no absolute BF measured, most relative to $\Xi^-\pi^+(\pi^+)$
- ➢ Ω_c : decay only weakly; no absolute BF measured

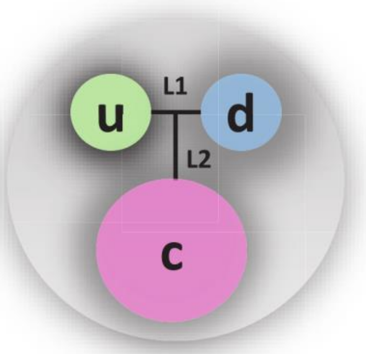
Λ_c^+:cornerstone of charmed baryon spectroscopy

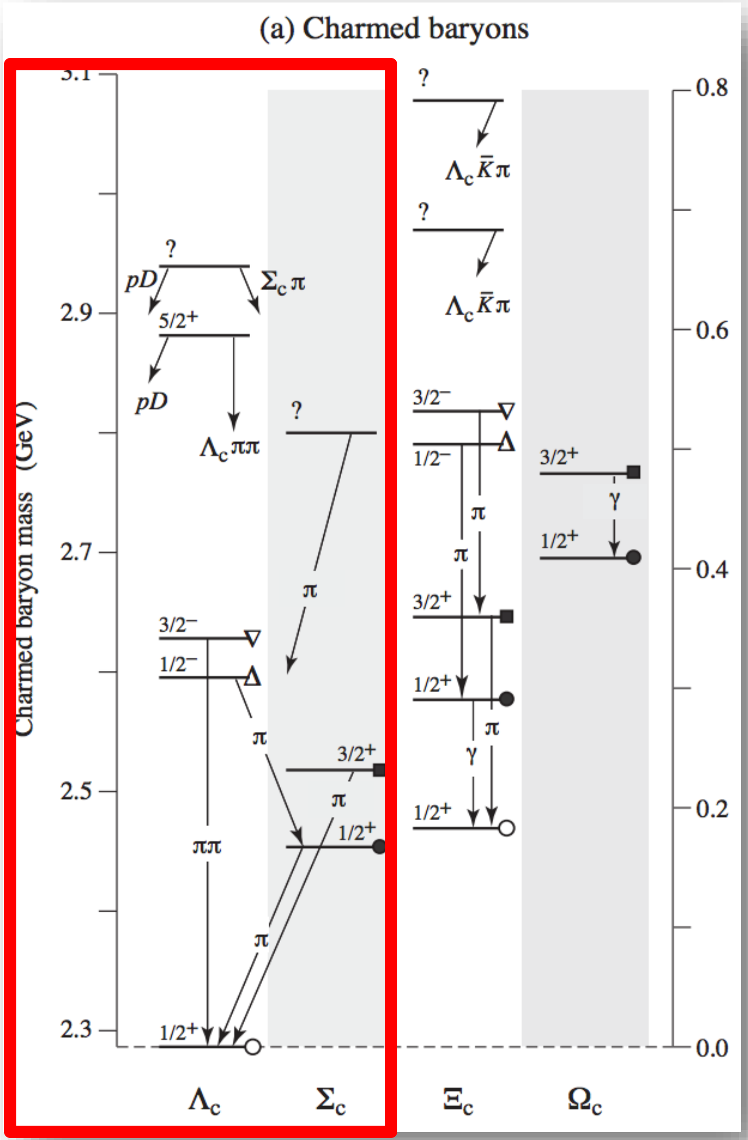
- **The lightest charmed baryon:2286.48MeV**

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

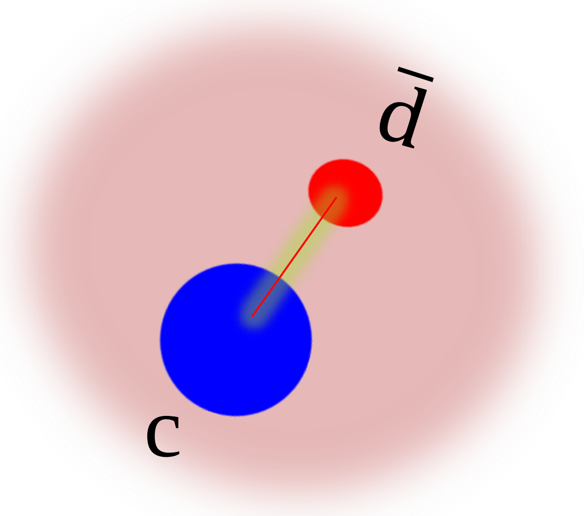
- **The Λ_c^+ is one of important tagging hadrons in c-quark counting in the productions at high energy energies**

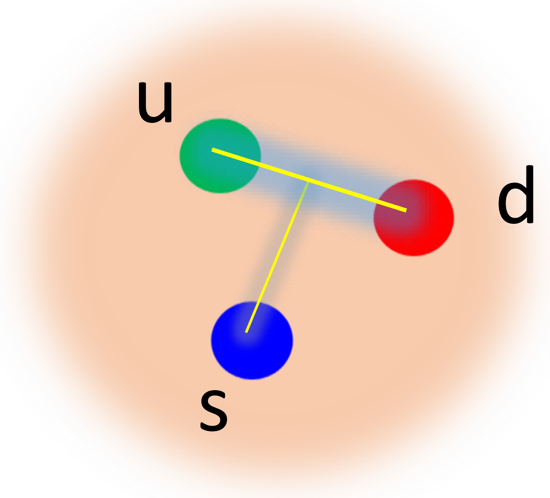
- **Quark model picture: a heavy quark (*c*) with an unexcited spin-zero diquark (*u*-*d*)**

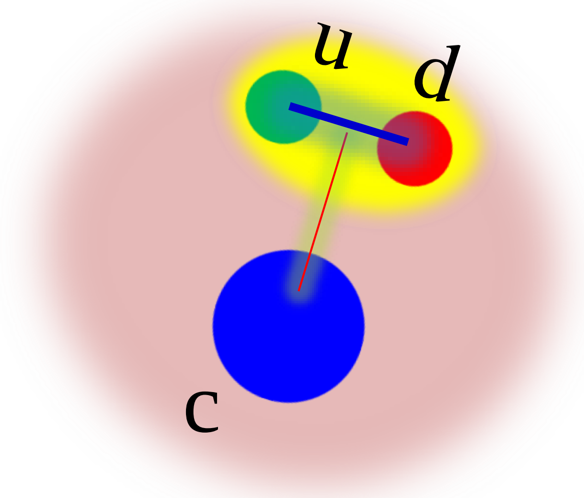




Quark model pictures







→ Charmed meson $(D^+[c\bar{d}])$

$m_d \ll m_c$ → **quark + heavy quark**
(q) (Q)

→ Strange baryons **(Λ[uds])**

$m_u, m_d \approx m_s$ → **(qqq)** uniform

→ Charmed baryon (Λ_c**[udc]**)

$m_u, m_d \ll m_c$ → **diquark + quark**
(qq) (Q)

- **Λ_c^+ may provide more powerful test on internal dynamics than D/Ds does !**
- **Diquark correlation is enhanced by weak Color Magnetic Interaction with a heavy quark.**

BESIII data taking @ $\Lambda_c^+\Lambda_c^-$ threshold

- **In 2014, BESIII took data above Λ_c pair threshold and run machine at 4.6GeV with excellent performance!**
- **This is a marvelous achievement of BEPCII !**
- **106×10^3 $\Lambda_c^+\Lambda_c^-$ pairs make sensitivity to 10^{-3}**
- **First direct measurement on Λ_c^+ BFs at threshold.**

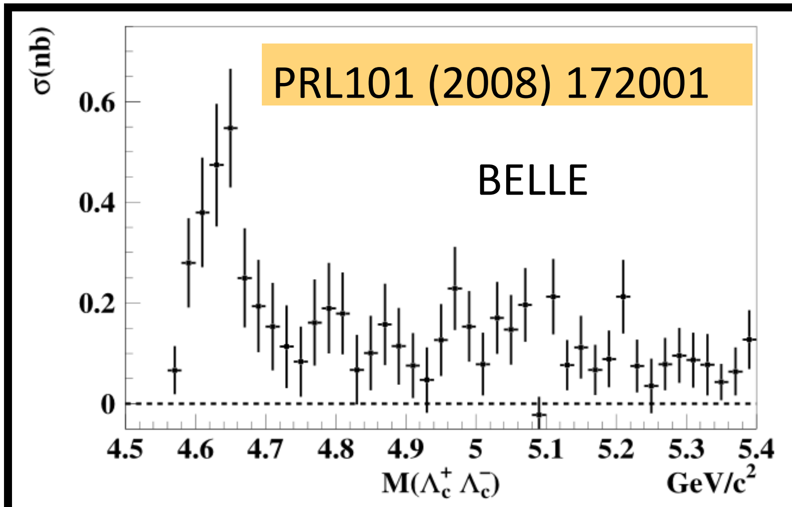
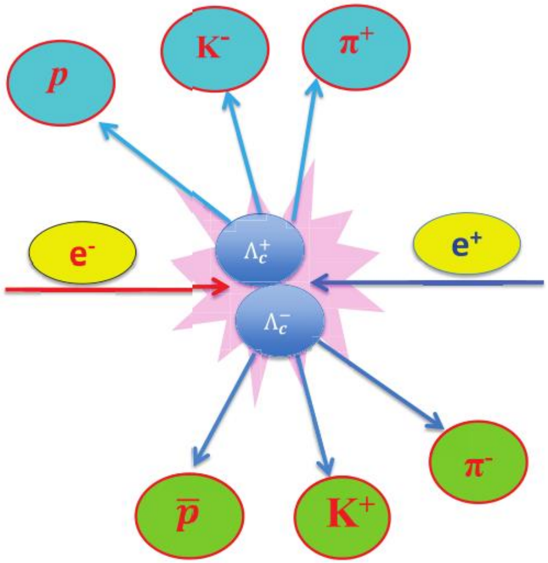
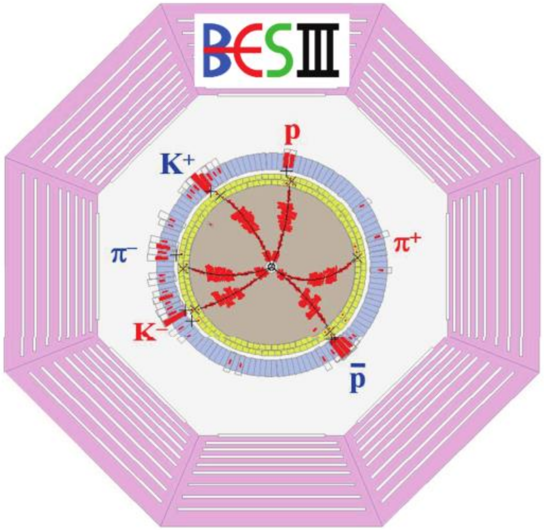


FIG. 4: The cross section for the exclusive process $e^+e^- \to \Lambda_c^+\Lambda_c^-$.

Energy(GeV)	lum.(pb^{-1})
4.575	~48
4.580	~8.5
4.590	~8.1
4.6	**~567**

Production near threshold and double tag technique





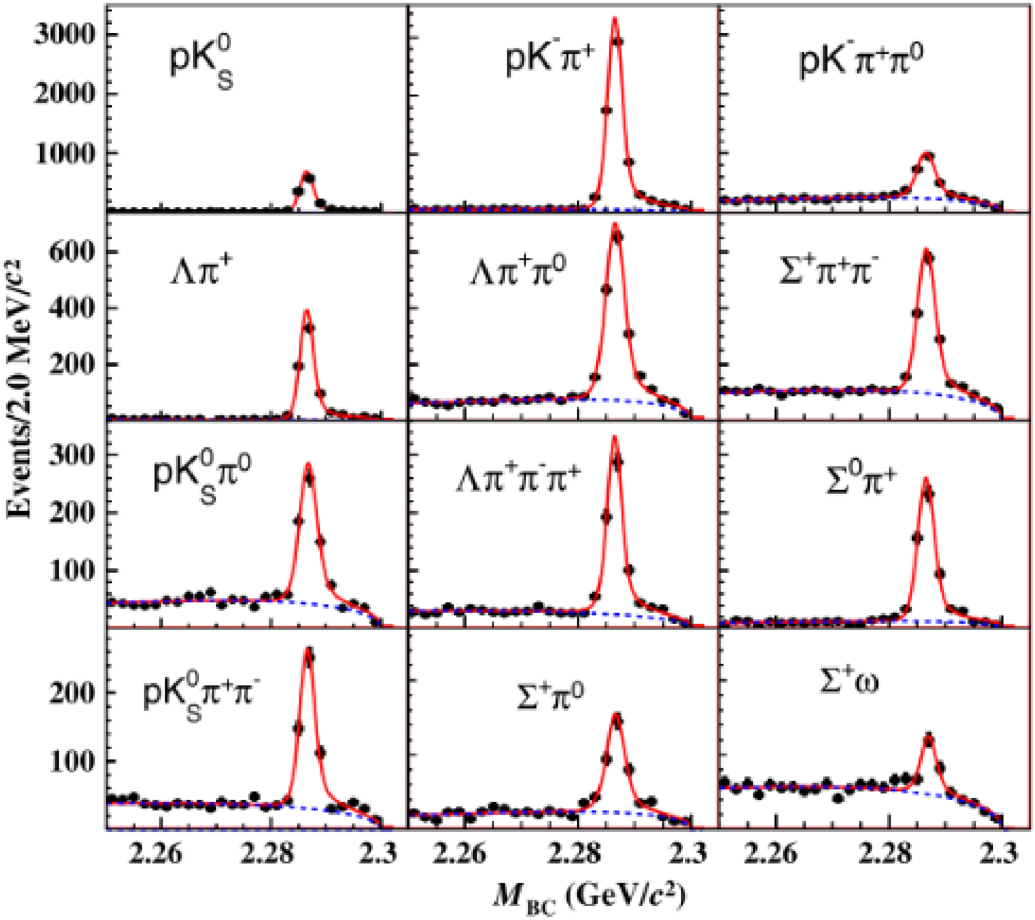
- $\Lambda_c^+\Lambda_c^-$ produced in pairs with no additional accompany hadrons.
- Clean backgrounds.
- Well constrained kinematics.
- Measure the probability of detecting signals in the singly tagged Λ_c^+ events.
- Systematic uncertainty in tag side are most cancelled.

Λ_c^+ reconstruction at BESIII

- Λ_c -tagging package
- ΔE and M_{BC}
- Well controlled background
- ~15400 ST yields

$$M_{BC} \equiv \sqrt{E_{\rm beam}^2/c^4 - p_{\Lambda_c^+}^2/c^2}$$

$$\Delta E \equiv E_{\Lambda_c^+} - E_{\rm beam},$$



衰变方式
$K_S^0 \to \pi^+\pi^-$
$\pi^0 \to \gamma\gamma$
$\Lambda \to p\pi^-$
$\Sigma^0 \to \Lambda\gamma$
$\Sigma^+ \to p\pi^0$
$\omega \to \pi^+\pi^-\pi^0$

衰变道
pK_S^0
$pK^-\pi^+$
$pK_S^0\pi^0$
$pK_S^0\pi^+\pi^-$
$pK^-\pi^+\pi^0$
$\Lambda\pi^+$
$\Lambda\pi^+\pi^0$
$\Lambda\pi^+\pi^-\pi^+$
$\Sigma^0\pi^+$
$\Sigma^+\pi^0$
$\Sigma^+\pi^+\pi^-$
$\Sigma^+\omega$

Results of 12 Λ_c^+ hadronic decay BFs

PRL 116, 052001 (2016)

567pb^{-1} @ 4.6 GeV

Mode	This work (%)	PDG (%)	BELLE $\mathcal{B}$
pK_S^0	$1.52 \pm 0.08 \pm 0.03$	1.15 ± 0.30	
$pK^-\pi^+$	$5.84 \pm 0.27 \pm 0.23$	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S^0\pi^0$	$1.87 \pm 0.13 \pm 0.05$	1.65 ± 0.50	
$pK_S^0\pi^+\pi^-$	$1.53 \pm 0.11 \pm 0.09$	1.30 ± 0.35	
$pK^-\pi^+\pi^0$	$4.53 \pm 0.23 \pm 0.30$	3.4 ± 1.0	
$\Lambda\pi^+$	$1.24 \pm 0.07 \pm 0.03$	1.07 ± 0.28	
$\Lambda\pi^+\pi^0$	$7.01 \pm 0.37 \pm 0.19$	3.6 ± 1.3	
$\Lambda\pi^+\pi^-\pi^+$	$3.81 \pm 0.24 \pm 0.18$	2.6 ± 0.7	
$\Sigma^0\pi^+$	$1.27 \pm 0.08 \pm 0.03$	1.05 ± 0.28	
$\Sigma^+\pi^0$	$1.18 \pm 0.10 \pm 0.03$	1.00 ± 0.34	
$\Sigma^+\pi^+\pi^-$	$4.25 \pm 0.24 \pm 0.20$	3.6 ± 1.0	
$\Sigma^+\omega$	$1.56 \pm 0.20 \pm 0.07$	2.7 ± 1.0	

粲强子	强子衰变道	精度（$\delta\mathcal{B}/\mathcal{B}$）
D^0	$\mathcal{B}(K^-\pi^+) = (3.88 \pm 0.05)\%$	1.3%
D^+	$\mathcal{B}(K^-\pi^+\pi^+) = (9.13 \pm 0.19)\%$	2.1%
D_s^+	$\mathcal{B}(K^+K^-\pi^+) = (5.39 \pm 0.21)\%$	3.9%
	$\mathcal{B}(pK^-\pi^+) = (5.0 \pm 1.3)\%$ [PDG2014]	26%
Λ_c^+	$\mathcal{B}(pK^-\pi^+) = (6.84 \pm 0.36)\%$ [BELLE]	5.3%
	$\mathcal{B}(pK^-\pi^+) = (5.84 \pm 0.35)\%$ [BESIII]	6.0%

- **First direct measurement on Λ_c^+ BFs at threshold**
- **A least square global fit are performed to improve the precision.**
- **Model independently**
- **The precision of B(pKπ) are comparable with Belle's**
- **Improved precisions of the other 11 modes significantly**
- **The precisions of Λc decay rates is reaching to the level of charmed mesons!**

"BESIII make first direct measurement of the Λ_c^+ at threshold"

PRL 116, 052001 (2016)

567pb^{-1} @ 4.6 GeV

Mode
pK_S^0
$pK^-\pi^+$
$pK_S^0\pi^0$
$pK_S^0\pi^+$
$pK^-\pi^+$
$\Lambda\pi^+$
$\Lambda\pi^+\pi^0$
$\Lambda\pi^+\pi^-$
$\Sigma^0\pi^+$
$\Sigma^+\pi^0$
$\Sigma^+\pi^+\pi$
$\Sigma^+\omega$

粲强子

D^0

D^+

D_s^+

Λ_c^+

- First direct measurement on

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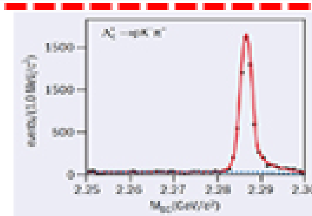
Mar 18, 2016

BESIII makes first direct measurement of the Λ_c at threshold

The charmed baryon, Λ_c, was first observed at Fermilab in 1976. Now, 40 years later, the Beijing Spectrometer (BESIII) experiment at the Beijing Electron-Positron Collider II (BEPCII) has measured the absolute branching fraction of $\Lambda^+_c \to pK^-\pi^+$ at threshold for the first time.



Beam-constrained mass distribution

Because the decays of the Λ^+_c to hadrons proceed only through the weak interaction, their branching fractions are key probes for understanding weak interactions inside of a baryon. In particular, precise measurements of the decays of the Λ^+_c will provide important information on the final-state strong interaction in the charm sector, thereby improving the understanding of quantum chromodynamics in the non-perturbative energy region. In addition, because most of the

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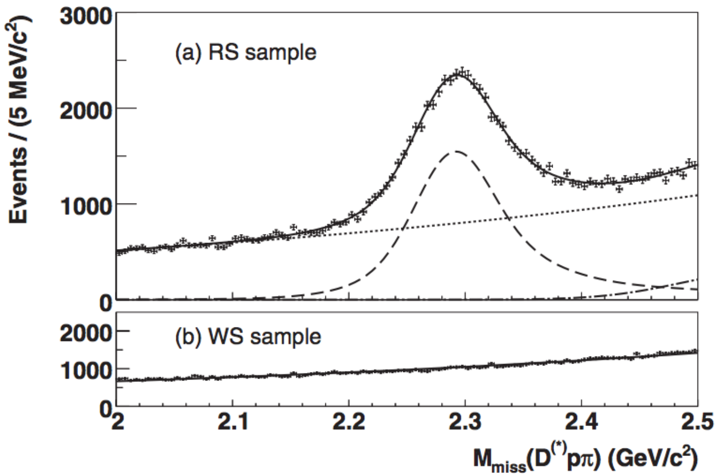
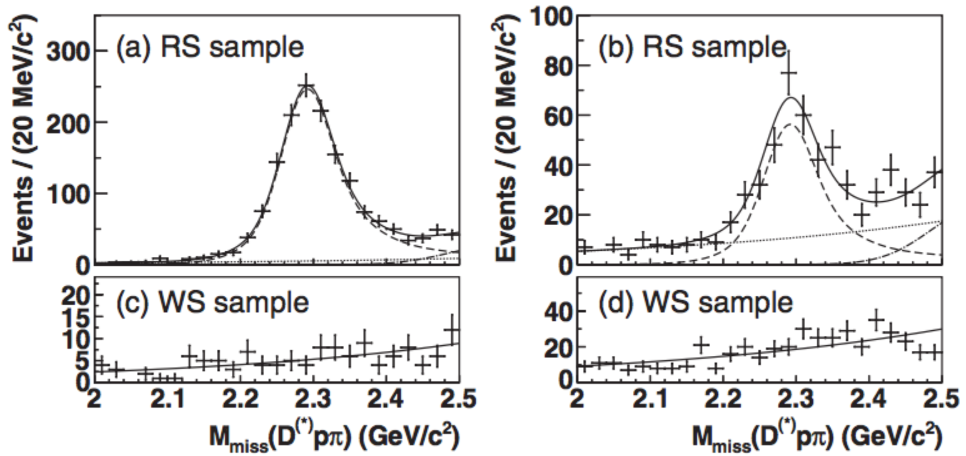
First precise measurement of $B(\Lambda_c^+ \to pK^-\pi^+)$

- **The number of Λc baryons is determined by reconstructing the recoiling $D^{(*)-}\bar{p}\pi^+$**
- **system in events of the type $e^+e^- \to D^{(*)-}\bar{p}\pi^+\Lambda_c^+$**

Missing Λ_c^+: N_{incl}=36447±432



Tagging $\Lambda_c^+ \to pK^-\pi^+$ N(pKpi)=1359±45

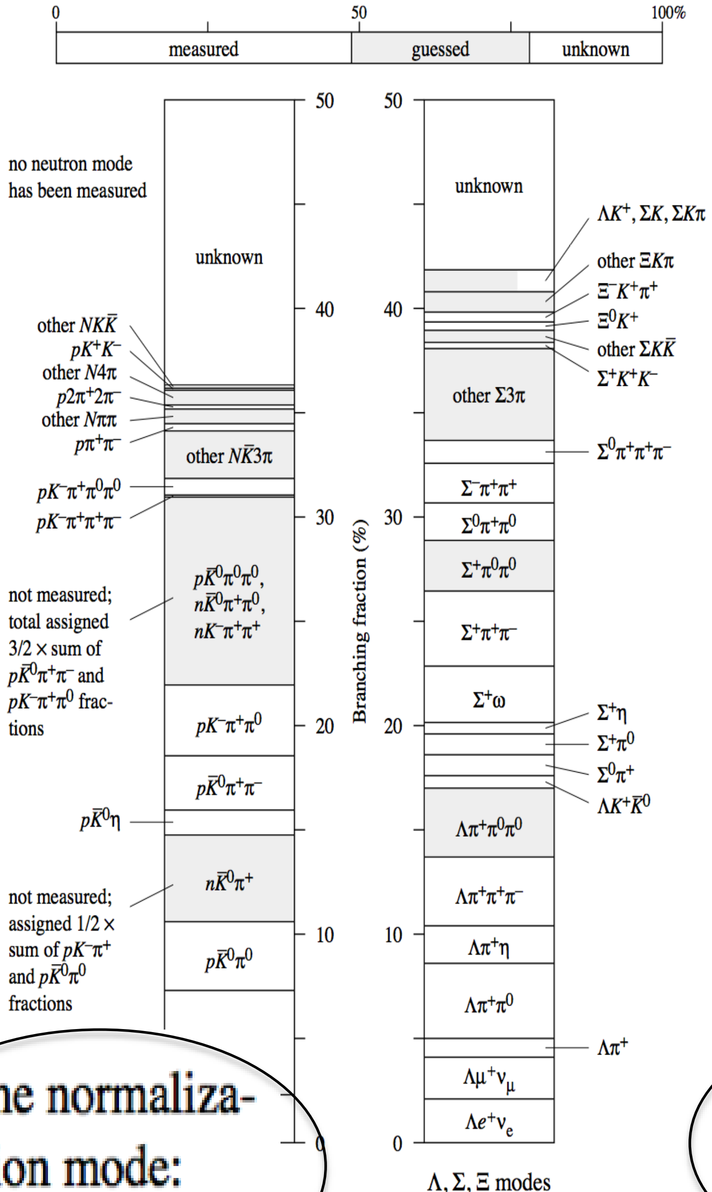


PRL 113, 042002 (2014)

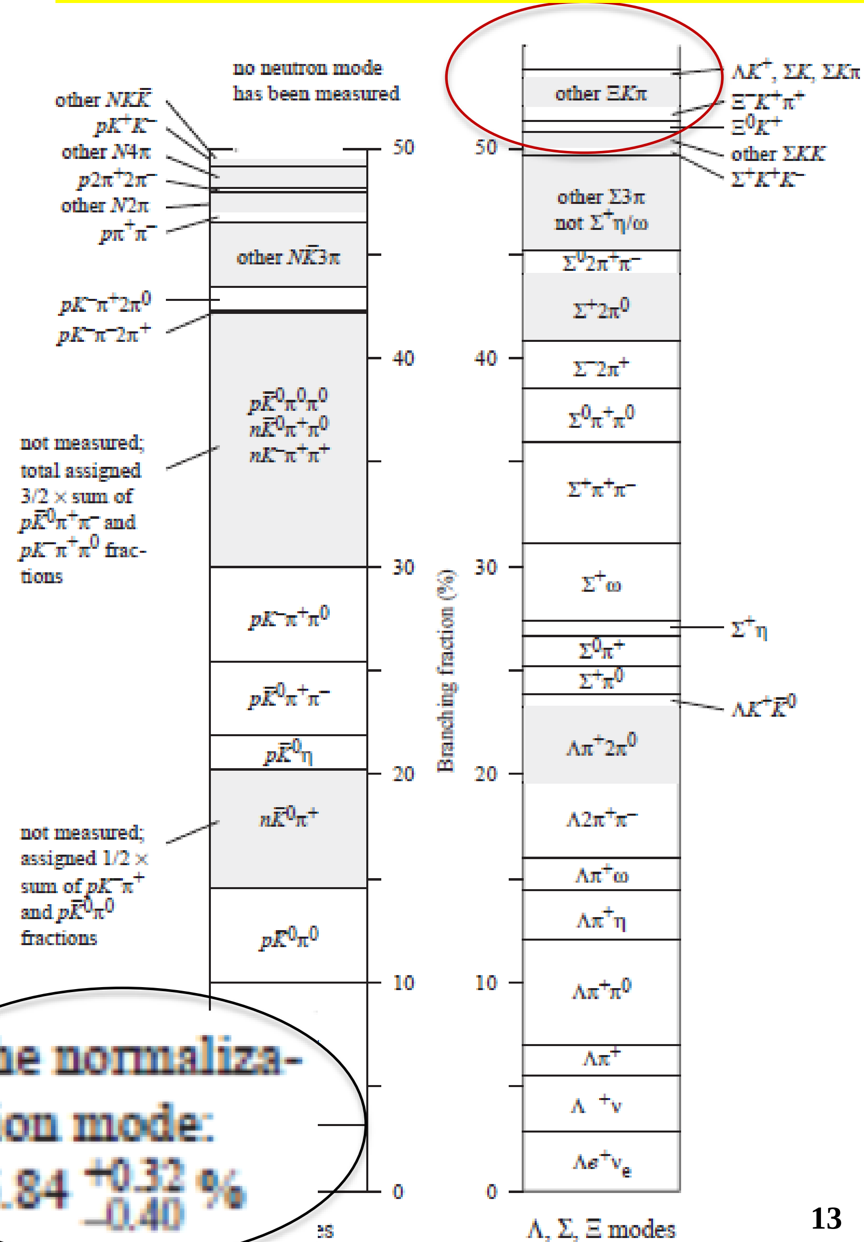
$$\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+) = \frac{N(\Lambda_c^+ \to pK^-\pi^+)}{N_{\rm inc}^{\Lambda_c} f_{\rm bias}\,\varepsilon(\Lambda_c^+ \to pK^-\pi^+)} = (6.84 \pm 0.24^{+0.21}_{-0.27})\%$$

PDG2014

Total BF overflows after taking into account BEELE's $B(\Lambda_c^+ \to pK^-\pi^+)$?



the normalization mode: 5.0 ± 1.3 %

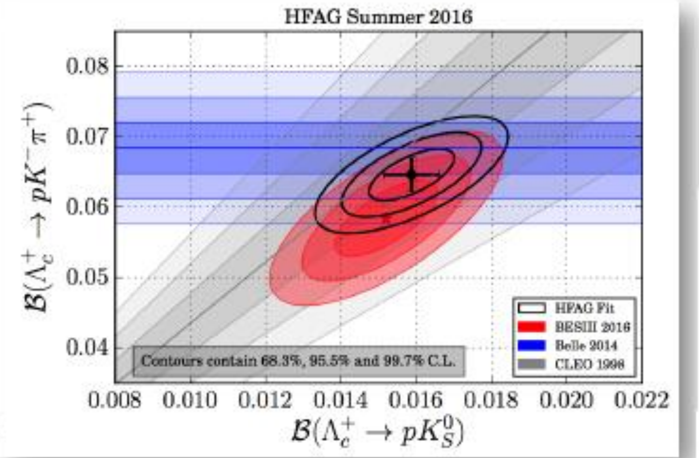


the normalization mode: $6.84^{+0.32}_{-0.40}$ %

HFAG Fit to world BF data

- A fitter to constrain the 12 hadronic BFs and 1 SL BF, based on all the existing experimental data
- Correlated systematics are fully taken into account

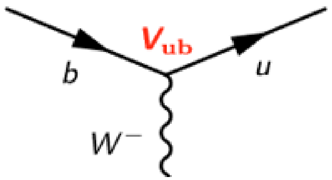
Mode	HFAG 2016 (%)	BESIII (%)	PDG 2014 (%)	BELLE (%)
pK_S^0	1.59 ± 0.07	$1.52 \pm 0.08 \pm 0.03$	1.15 ± 0.30	
$pK^-\pi^+$	6.46 ± 0.24	$5.84 \pm 0.27 \pm 0.23$	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S^0\pi^0$	2.03 ± 0.12	$1.87 \pm 0.13 \pm 0.05$	1.65 ± 0.50	
$pK_S^0\pi^+\pi^-$	1.69 ± 0.11	$1.53 \pm 0.11 \pm 0.09$	1.30 ± 0.35	
$pK^-\pi^+\pi^0$	5.05 ± 0.29	$4.53 \pm 0.23 \pm 0.30$	3.4 ± 1.0	
$\Lambda\pi^+$	1.28 ± 0.06	$1.24 \pm 0.07 \pm 0.03$	1.07 ± 0.28	
$\Lambda\pi^+\pi^0$	7.09 ± 0.36	$7.01 \pm 0.37 \pm 0.19$	3.6 ± 1.3	
$\Lambda\pi^+\pi^-\pi^+$	3.73 ± 0.21	$3.81 \pm 0.24 \pm 0.18$	2.6 ± 0.7	
$\Sigma^0\pi^+$	1.31 ± 0.07	$1.27 \pm 0.08 \pm 0.03$	1.05 ± 0.28	
$\Sigma^+\pi^0$	1.25 ± 0.09	$1.18 \pm 0.10 \pm 0.03$	1.00 ± 0.34	
$\Sigma^+\pi^+\pi^-$	4.64 ± 0.24	$4.25 \pm 0.24 \pm 0.20$	3.6 ± 1.0	
$\Sigma^+\omega$	1.77 ± 0.21	$1.56 \pm 0.20 \pm 0.07$	2.7 ± 1.0	
$\Lambda e^+\nu_e$	3.18 ± 0.32	$3.63 \pm 0.38 \pm 0.20$	2.1 ± 0.6	



The least overall χ^2/ndf=30.0/23=1.3

Precise $B(pK^-\pi^+)$ is useful for constrain V_{ub} determined via baryonic mode

CKM matrix element V_{ub}



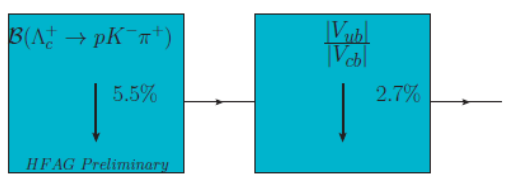
$$V_{\rm CKM} = \begin{pmatrix} V_{\rm ud} & V_{\rm us} & V_{\rm ub} \\ V_{\rm cd} & V_{\rm cs} & V_{\rm cb} \\ V_{\rm td} & V_{\rm ts} & V_{\rm tb} \end{pmatrix}, \quad \frac{\sigma(V_{\rm CKM})}{V_{\rm CKM}}^{\text{PDG 2014}} \sim \begin{pmatrix} 0.02\% & 0.3\% & 12\% \\ 4\% & 2\% & 2\% \\ 7\% & 7\% & 3\% \end{pmatrix}$$

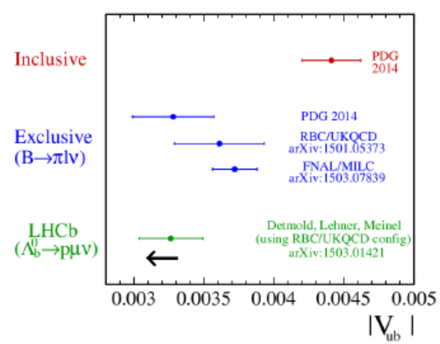
$$\underbrace{\frac{\mathcal{B}(\Lambda_b \to p\mu^-\nu_\mu)}{\mathcal{B}(\Lambda_b \to \Lambda_c^+\mu^-\nu_\mu)}}_{\text{Measure this experimentally}} = \frac{|V_{\rm ub}|^2}{|V_{\rm cb}|^2} \times \underbrace{\frac{G(\Lambda_b \to p\mu^-\nu_\mu)}{G(\Lambda_b \to \Lambda_c^+\mu^-\nu_\mu)}}_{\text{Get this from theory}}$$

Measure this experimentally **Get this from theory**

New HFAG world average for $\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)$

- In measurement of $\Lambda_b^0 \to p\mu^-\overline{\nu}$, $\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)$ used published by Belle, with $6.84 \pm 0.24^{+0.21}_{-0.27}\%$
- Another measurement was published later using BESIII data
- HFAG performed global fit to all branching fractions of the Cabibbo-favoured Λ_c^+ decays yielding $6.46 \pm 0.24\%$



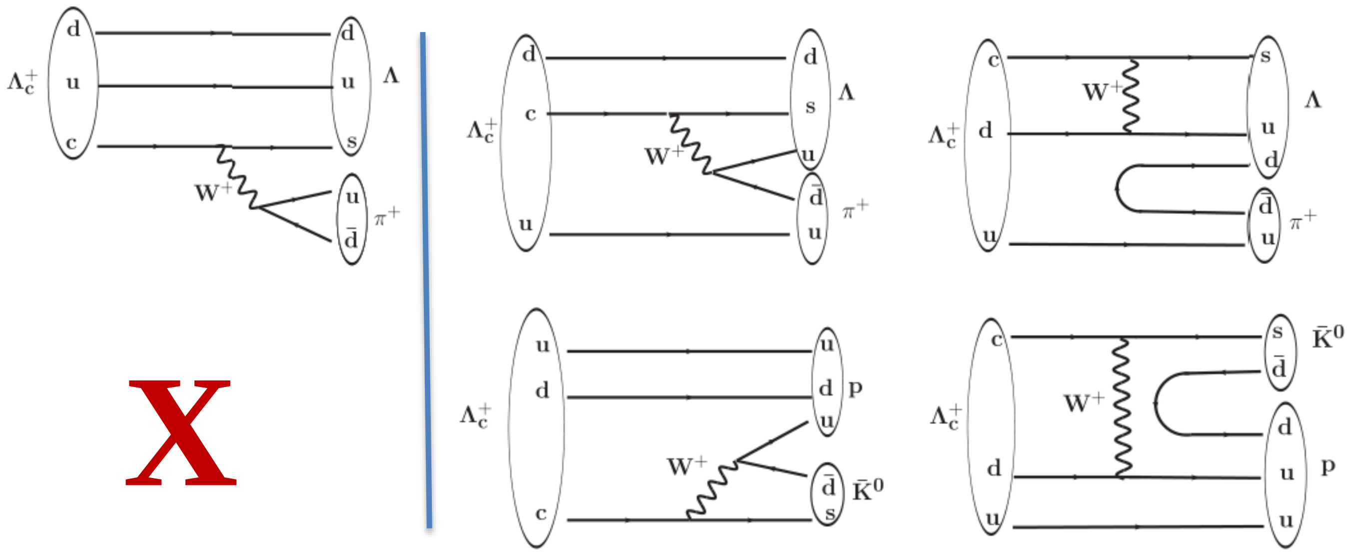


A conflict: $B(\Lambda_c^+ \to p\overline{K^0})$ v.s. $B(\Lambda_c^+ \to \Lambda\pi^+)$

T: external W-emission | C: internal W-emission | W: W-exchange

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

$\Lambda_c^+ \to p\overline{K^0}$



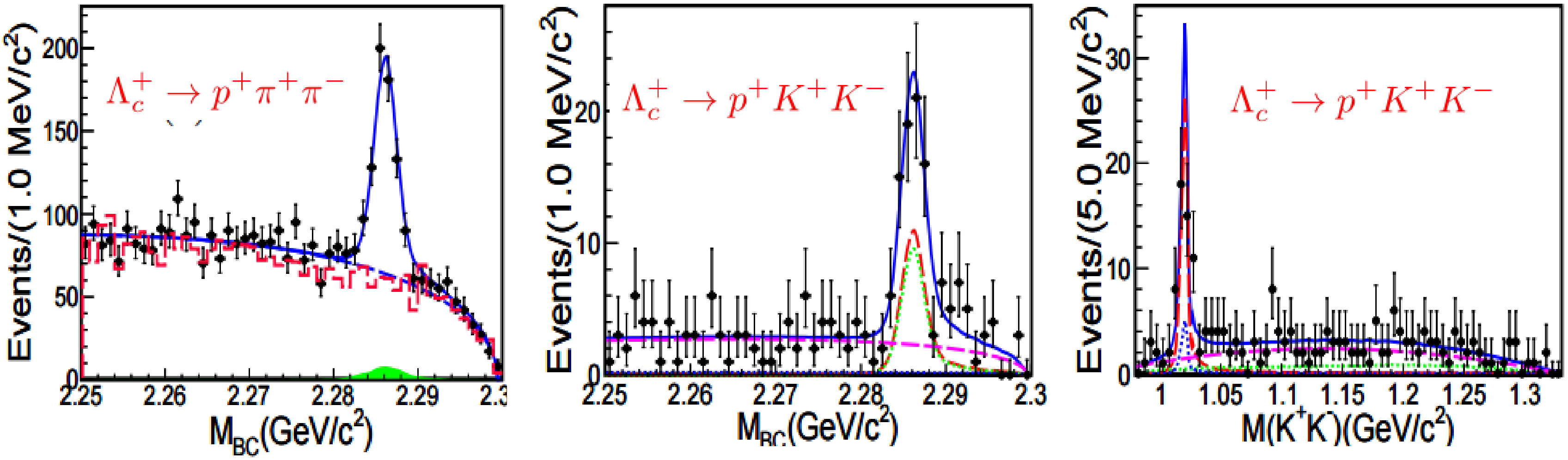
factorizable | non-factorizable

- In naïve quark-diquark model, C- and W-diagram are suppressed, hence $B(\Lambda_c^+ \to p\overline{K^0}) << B(\Lambda_c^+ \to \Lambda\pi^+)$
- But BESIII measures: $B(\Lambda_c^+ \to p\overline{K^0}) = (3.04 \pm 0.18)\%$; $B(\Lambda_c^+ \to \Lambda\pi^+) = (1.24 \pm 0.08)\%$
- The non-factorizable C- and W-diagram are not trivial
- Experimental studies on the non-factorizable C- and W-diagrams is critical in understanding the Λ_c^+ internal dynamics

Singly Cabibbo-Suppressed Decays of $\Lambda_c^+ \to p\pi^+\pi^-$ and $\Lambda_c^+ \to pK^+K^-$

- **Sensitive to nonfactorizable contributions from W-exchange diagrams**
- **ST method: $\Lambda_c^+ \to pK^-\pi^+$ as ref. mode**

arXiv:1608.00407 submitted to PRL



Decay modes	$\mathcal{B}_{mode}/\mathcal{B}_{ref.}$ (this work)	$\mathcal{B}_{mode}/\mathcal{B}_{ref.}$ ([28])
$\Lambda_c^+ \to p\pi^+\pi^-$	$(6.70 \pm 0.48 \pm 0.25) \times 10^{-2}$	–
$\Lambda_c^+ \to p\phi$	$(1.81 \pm 0.33 \pm 0.13) \times 10^{-2}$	$0.015 \pm 0.002 \pm 0.002$
$\Lambda_c^+ \to pK^+K^-$ (non-ϕ)	$(9.36 \pm 2.22 \pm 0.71) \times 10^{-3}$	$0.007 \pm 0.002 \pm 0.002$
–	$\mathcal{B}_{mode}$	$\mathcal{B}$(PDG)
$\Lambda_c^+ \to p\pi^+\pi^-$	$(3.91 \pm 0.28 \pm 0.15 \pm 0.24) \times 10^{-3}$	$(3.5 \pm 2.0) \times 10^{-3}$
$\Lambda_c^+ \to p\phi$	$(1.06 \pm 0.19 \pm 0.08 \pm 0.06) \times 10^{-3}$	$(8.2 \pm 2.7) \times 10^{-4}$
$\Lambda_c^+ \to pK^+K^-$ (non-ϕ)	$(5.47 \pm 1.30 \pm 0.41 \pm 0.33) \times 10^{-4}$	$(3.5 \pm 1.7) \times 10^{-4}$

first observation ($\Lambda_c^+ \to p\pi^+\pi^-$)

improved precision ($\Lambda_c^+ \to p\phi$, $\Lambda_c^+ \to pK^+K^-$ (non-ϕ))

$\Lambda_c^+ \to p\phi$: test large-N_c expansion

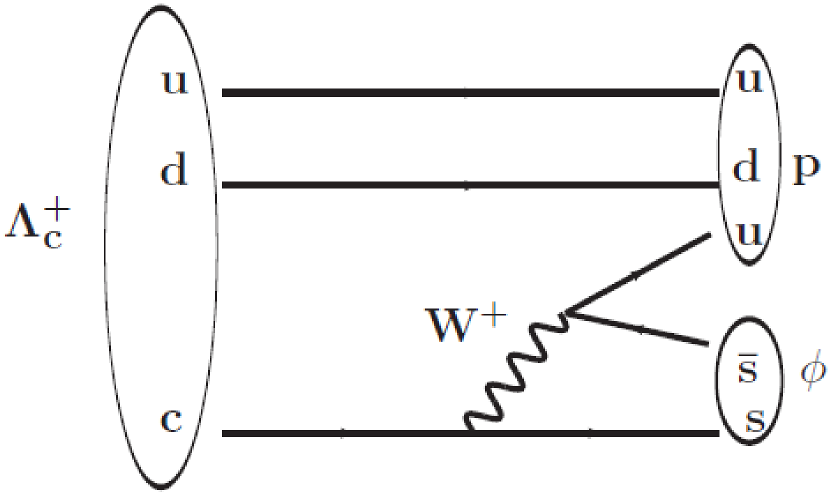
- **Charmed meson decays**

  $a_1 = c_1(\mu) + c_2(\mu)\,(1/N_c + \chi_1(\mu))$,

  $a_2 = c_2(\mu) + c_1(\mu)\,(1/N_c + \chi_2(\mu))$,

  If $\chi_1 = \chi_2 = 0$,   naïve factorization

  If $\chi_1 = \chi_2 = -1/N_c$, large-N_c factorization

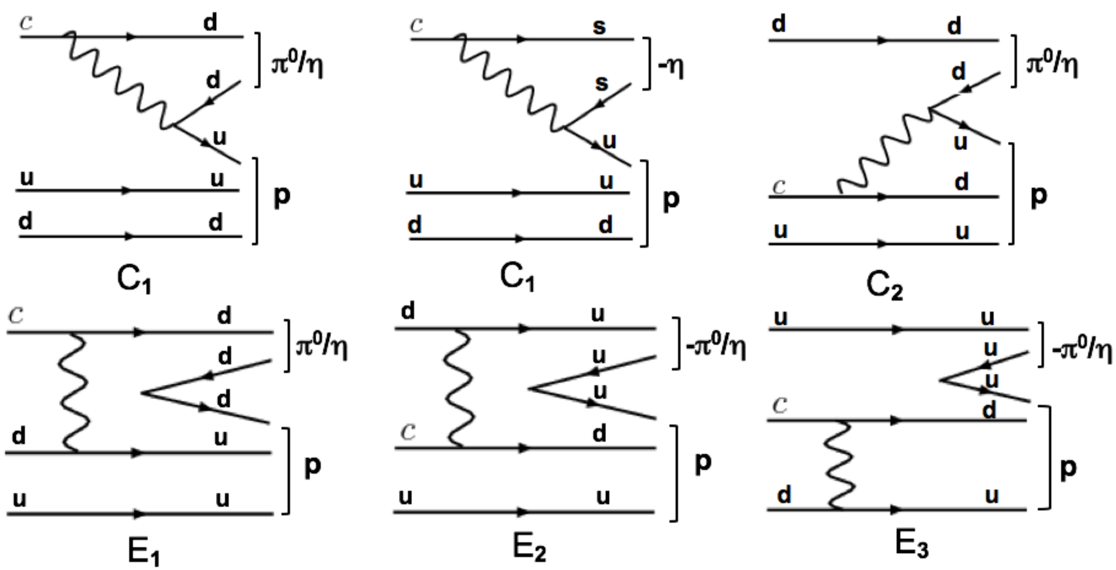


- $\Lambda_c^+ \to p\phi$ proceeds only through internal W-emission diagram with BF = $(1.12\pm0.23)\times10^{-3}$
- $\Rightarrow$ **$|a_2|=0.70\pm0.07$, close to** $c_2(m_c)$**≈ -0.59**
- **$1/N_c$ is also applicable to charmed baryon sector.**
- **BESIII measurement are consistent with previous measurement.**

Singly Cabibbo-Suppressed Decay

$\Gamma(\Lambda_c^+ \to p\eta) > \Gamma(\Lambda_c^+ \to p\pi^0)$

Singly Cabibbo-suppressed modes: $\Lambda_c^+ \to p\pi^0, p\eta$



$\pi^0 = (d\bar{d} - u\bar{u})/\sqrt{2}, \quad \eta = (d\bar{d} + u\bar{u} - s\bar{s})/\sqrt{3}$ for $\eta - \eta'$ mixing angle $= 19.5^0$

$A(\Lambda_c^+ \to p\pi^0) = (C_1 + C_2 + E_1 - E_2 - E_3)/\sqrt{2}$

$A(\Lambda_c^+ \to p\eta) = (2C_1 + C_2 + E_1 + E_2 + E_3)/\sqrt{3}$

It is most likely that

$\Gamma(\Lambda_c^+ \to p\eta) >> \Gamma(\Lambda_c^+ \to p\pi^0)$

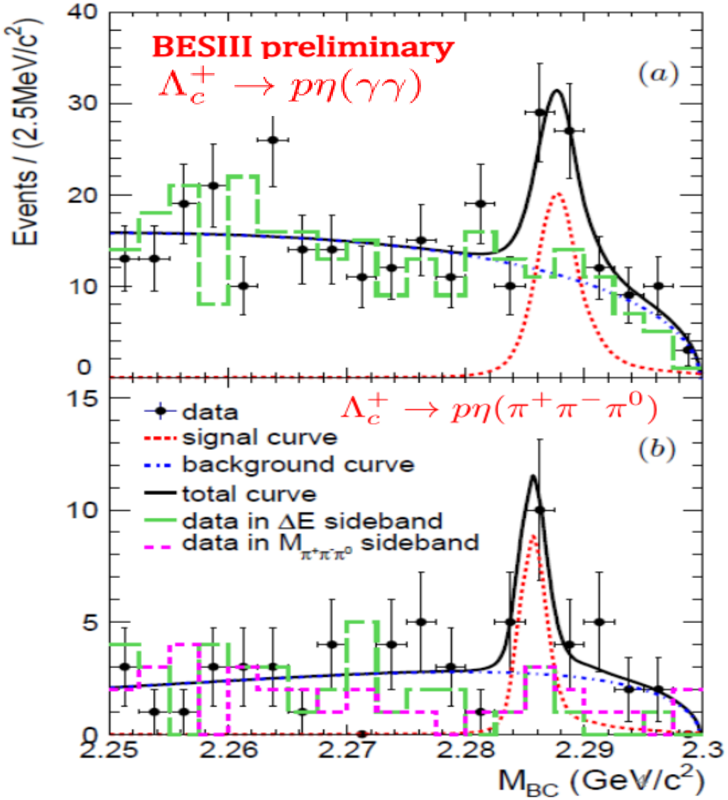
30

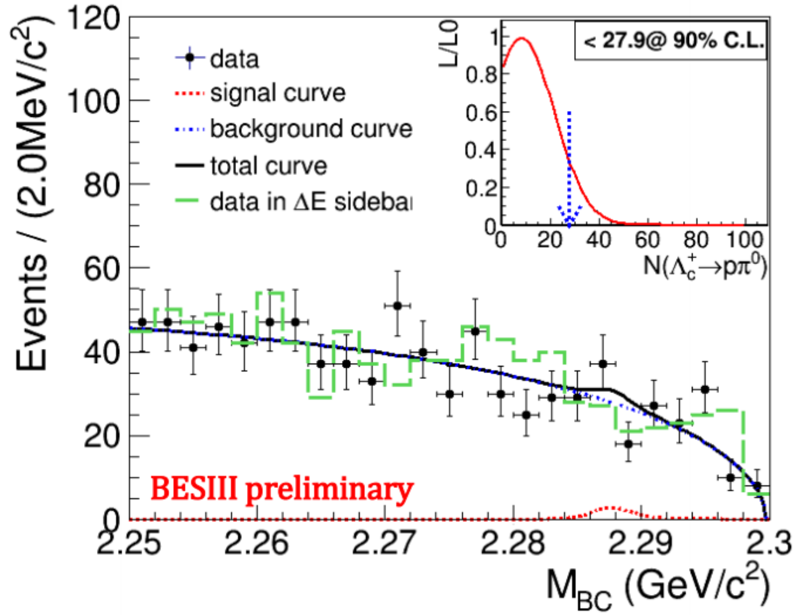
From Prof. Hai-Yang Cheng's report.

- **More precise comparison of the two BFs are desired to explore the interference of different non-factorizable diagrams**
- **BESIII Preliminary result support the theoretic prediction.**

Singly Cabibbo-Suppressed Decay of $\Lambda_c^+ \to p\pi^0, p\eta$

- Their relative size essential to understand the interference of different non-factorizable diagrams





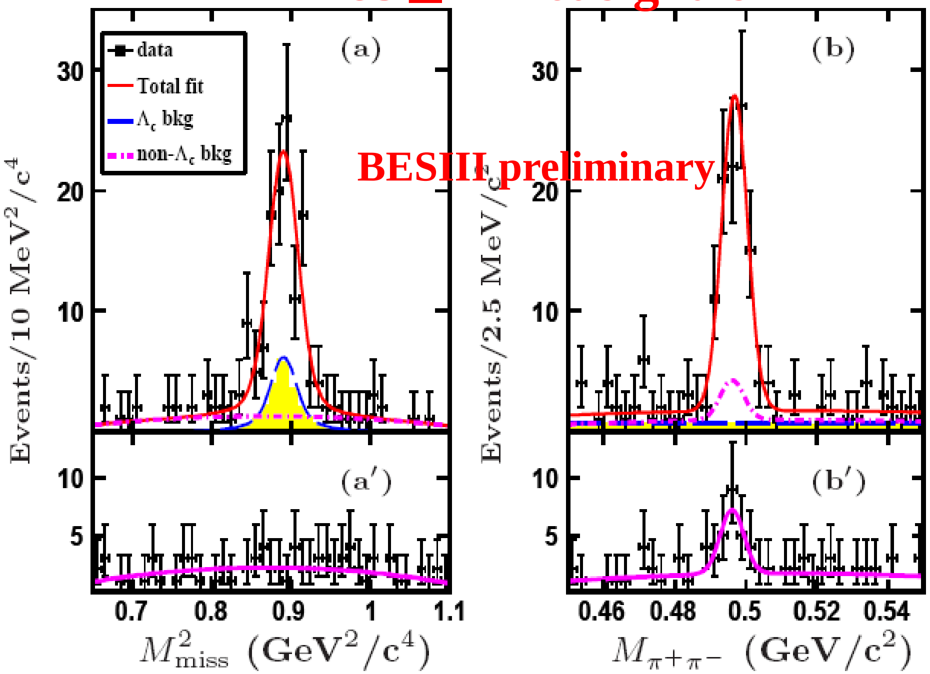
$$B = \frac{N^{obs}}{2 \cdot N_{\Lambda_c^+ \overline{\Lambda}_c^-} \cdot \varepsilon \cdot B_{int}}$$

- BESIII preliminary results:
  $B(\Lambda_c^+ \to p\eta) = (1.24 \pm 0.28 \pm 0.10) \times 10^{-3}$;
  $B(\Lambda_c^+ \to p\pi^0) < 2.7 \times 10^{-4}$;
  $B(\Lambda_c^+ \to p\pi^0)/B(\Lambda_c^+ \to p\eta) < 0.24$
- First evidence for $\Lambda_c^+ \to p\eta$ with 4.2σ

Measurements of channels involving a neutron

Observation of $\Lambda_c^+ \rightarrow nK_S^0\pi^+$

83 ± 11 net signals

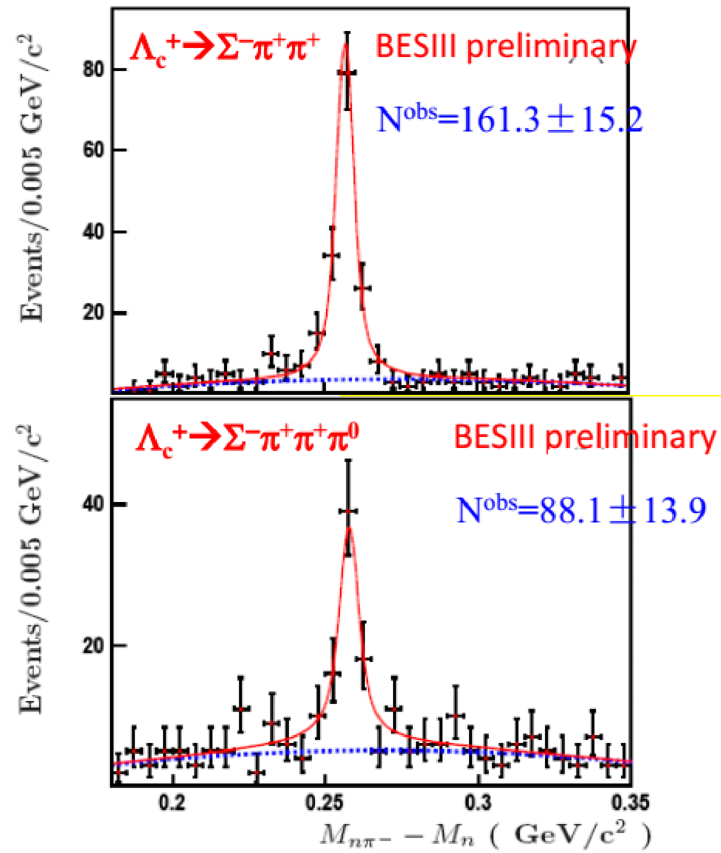


$B[\Lambda_c^+ \rightarrow nK_S^0\pi^+] = (1.82\pm0.23\pm0.11)\%$
$B[\Lambda_c^+ \rightarrow nK^0\pi^+]/B[\Lambda_c^+ \rightarrow pK^-\pi^+] = 0.62\pm0.09$
$B[\Lambda_c^+ \rightarrow nK^0\pi^+]/B[\Lambda_c^+ \rightarrow pK^0\pi^0] = 0.97\pm0.16$

to test final state interactions and isospin asymmetry in the charmed baryon sector

[PRD93, 056008 (2016)]

Observation of a large-rate channel $\Lambda_c^+ \rightarrow \Sigma^- \pi^+\pi^+\pi^0$



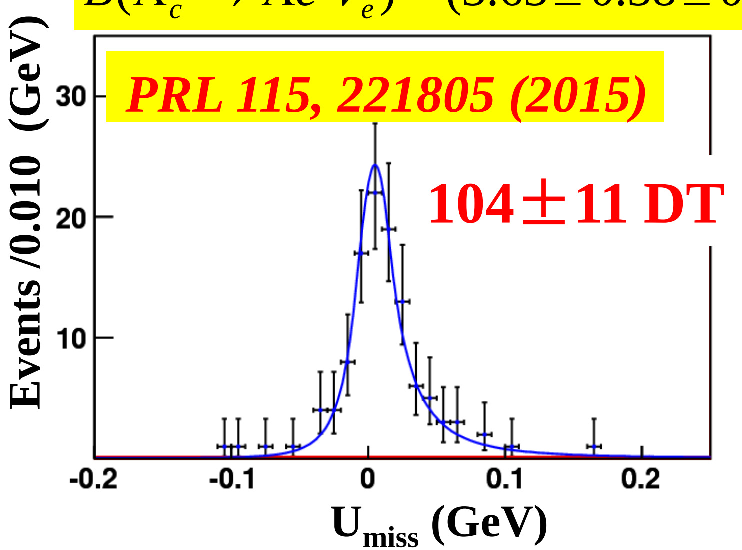
- $B(\Lambda_c \rightarrow \Sigma^-\pi^+\pi^+) = (1.81\pm0.17)\%$,
  [more precise than old result (2.3±0.4)%]
- $B(\Lambda_c \rightarrow \Sigma^- \pi^+\pi^+\pi^0) = (2.11\pm0.33)\%$

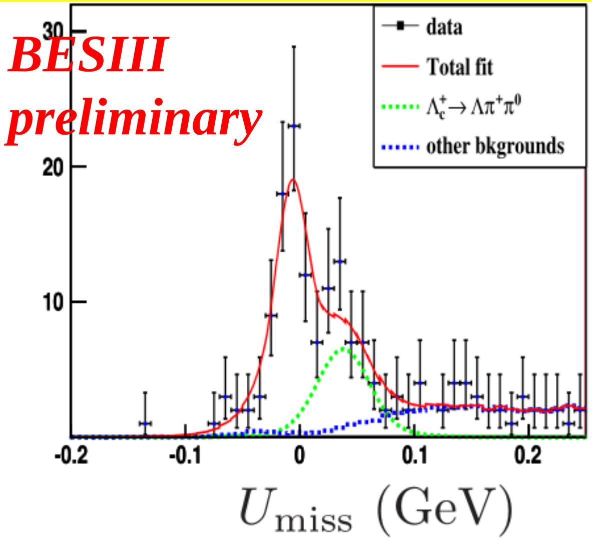
Absolute BFs for semi-leptonic (SL) $\Lambda_c^+ \to \Lambda l^+ \nu$

- No absolute measurements yet
  - ✓ $B(\Lambda_c^+ \to \Lambda e^+ \nu)$: poor precision in PDG2014 $(2.1 \pm 0.6)\%$
  - ✓ $B(\Lambda_c^+ \to \Lambda \mu^+ \nu)$: no measurement
- BESIII uses the DT method and missing-mass technique at threshold: 11 ST modes are used, except $\Sigma^+\omega$
- **An optimized missing mass:** $U_{\text{miss}} = E_{\text{miss}} - c|\vec{p}_{\text{miss}}|$ which takes into account beam energy constrain.

$B(\Lambda_c^+ \to \Lambda e^+ \nu_e) = (3.63 \pm 0.38 \pm 0.20)\%$

$B[\Lambda_c^+ \to \Lambda \mu^+ \nu_\mu] = (3.49 \pm 0.46 \pm 0.26)\%$



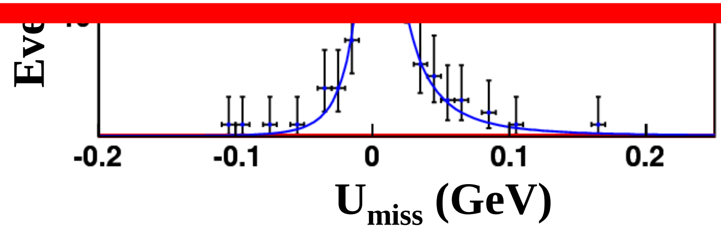


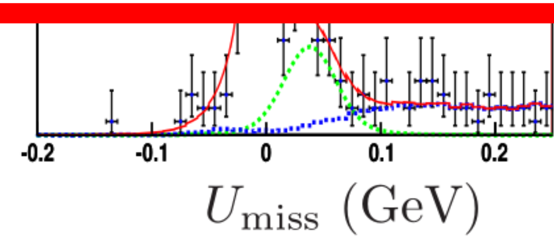
$\Gamma[\Lambda_c^+ \to \Lambda \mu^+ \nu_\mu]/\Gamma[\Lambda_c^+ \to \Lambda e^+ \nu_e] = 0.96 \pm 0.16 \pm 0.04$ (preliminary)

Absolute BFs for semi-leptonic (SL) $\Lambda_c^+ \rightarrow \Lambda l^+ \nu$

- No absolute measurements yet
  - ✓ $B(\Lambda_c^+ \rightarrow \Lambda e^+ \nu)$: poor precision in PDG2014 $(2.1 \pm 0.6)\%$

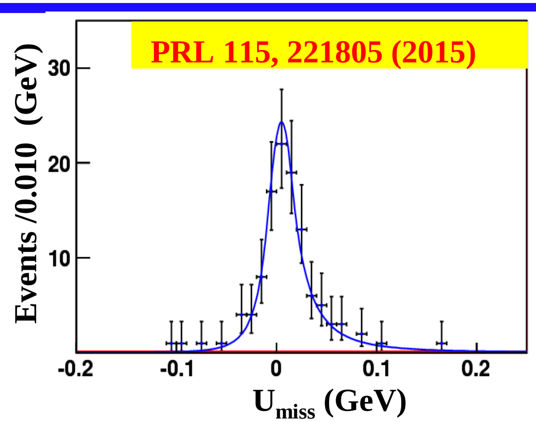
粲强子	半轻衰变道	精度（$\delta\mathcal{B}/\mathcal{B}$）
D^0	$\mathcal{B}(K^- e^+ \nu_e) = (3.55 \pm 0.05)\%$	1.4%
D^+	$\mathcal{B}(\bar{K}^0 e^+ \nu_e) = (8.83 \pm 0.22)\%$	2.5%
D_s^+	$\mathcal{B}(\phi e^+ \nu_e) = (2.49 \pm 0.14)\%$	5.6%
Λ_c^+	$\mathcal{B}(\Lambda e^+ \nu_e) = (2.1 \pm 0.6)\%$ [PDG2014]	29%
	$\mathcal{B}(\Lambda e^+ \nu_e) = (3.63 \pm 0.43)\%$ [BESIII]	12%





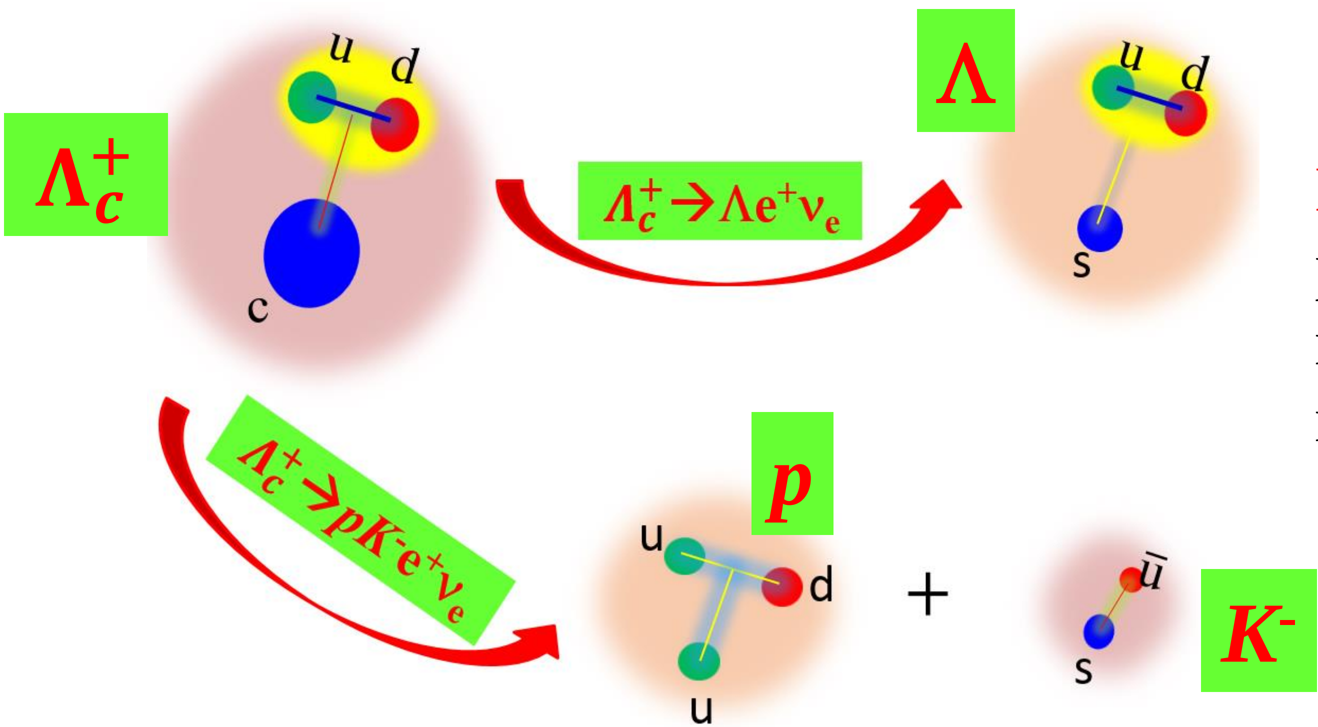
$\Gamma[\Lambda_c^+ \rightarrow \Lambda \mu^+ \nu_\mu]/\Gamma[\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e] = 0.96 \pm 0.16 \pm 0.04$ (preliminary)

$\Lambda_c^+ \to \Lambda e^+ \nu_e$ dominate the semi-leptonic decays



PDG result:
$B[\Lambda_c^+ \to e^+ + X] = (4.5 \pm 1.7)\%$

$B[\Lambda_c^+ \to \Lambda e^+ \nu] = (3.63 \pm 0.38 \pm 0.20)\%$



Diquark correlation play an important role in the dynamic revolution.

Summary

- **Threshold data at BESIII opens a new door to direct measurements of the decays ➔precise study of Λc decays**

- **A larger data set could help to improve our knowledge on Λ_c^+ decays.**

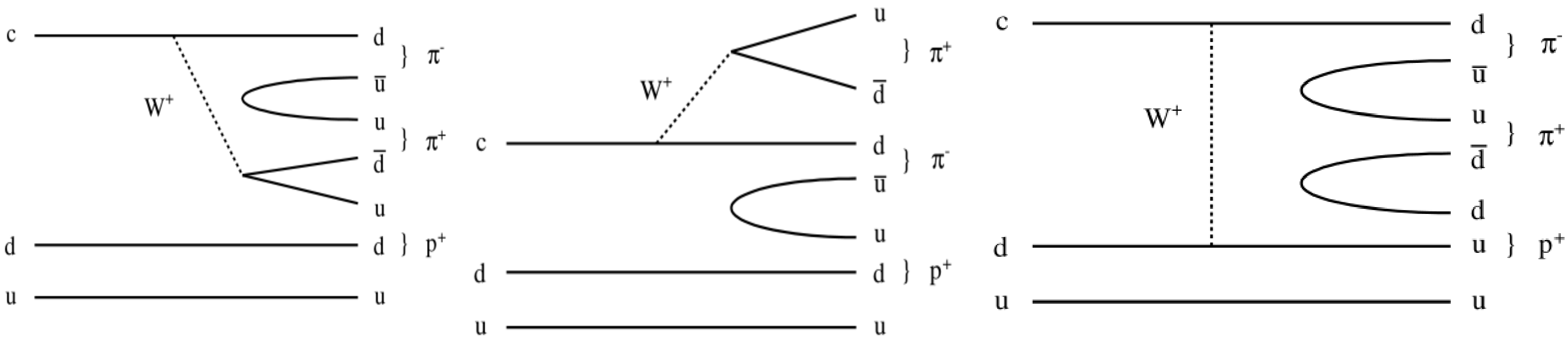
- **Many Λ_c^+ related topics in BESIII are in progress.**
  - ◆ Measurement of Λ_c^+ -->Λ + anything （See Xiao Dong's talk)

- **BESIII and B factories will be complementary in Λc decays and provide the precise measurements in the future several years.**

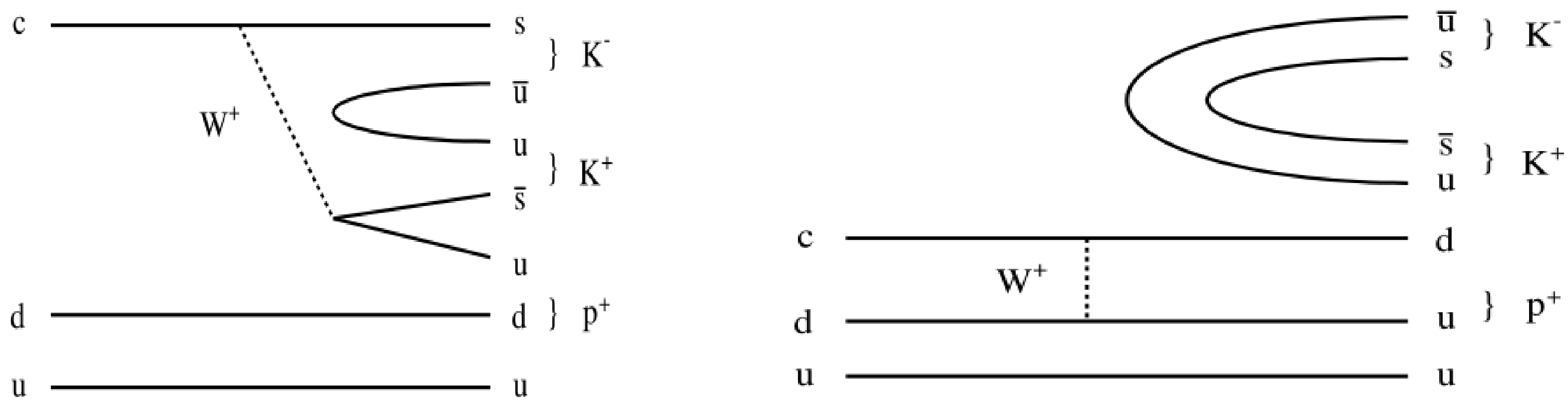
谢谢！

Backup Slides

Measurements of Cabibbo-suppressed decay $\Lambda_c^+ \rightarrow pK^+K^-$ and $p\pi^+\pi^-$

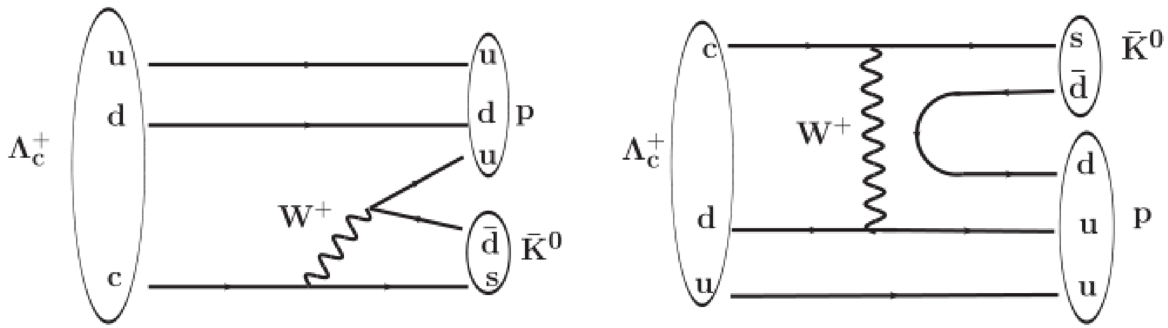


$\Lambda_c^+ \rightarrow p\pi^+\pi^-$



$\Lambda_c^+ \rightarrow pK^+K^-$

Λ_c^+ weak decays: W-exchange



- Experimental measurement of $B(\Lambda_c^+ \rightarrow p\overline{K^0})$ are not consistent with theoretically factorization approach at tree level.
- Contrary to charmed meson, W-exchange contribution is important（NO CS and HS）
- W-exchange are non-factorizable. There contribution can be only determined by experiment measurement.
- Search for process happened only through W-exchange process to extract their contribution are key to factorization approach

$$\Lambda_c^+ \rightarrow \Xi^0 K^+, \Xi^{*0} K^+, \Delta^{++} K^-, \Sigma^+ K^+ K^-$$