

Charmed baryon semileptonic decays

On the puzzle of $\Xi_c^0 \rightarrow \Xi^- \ell^+ \nu_\ell$

刘 佳 韦

June 28

2025

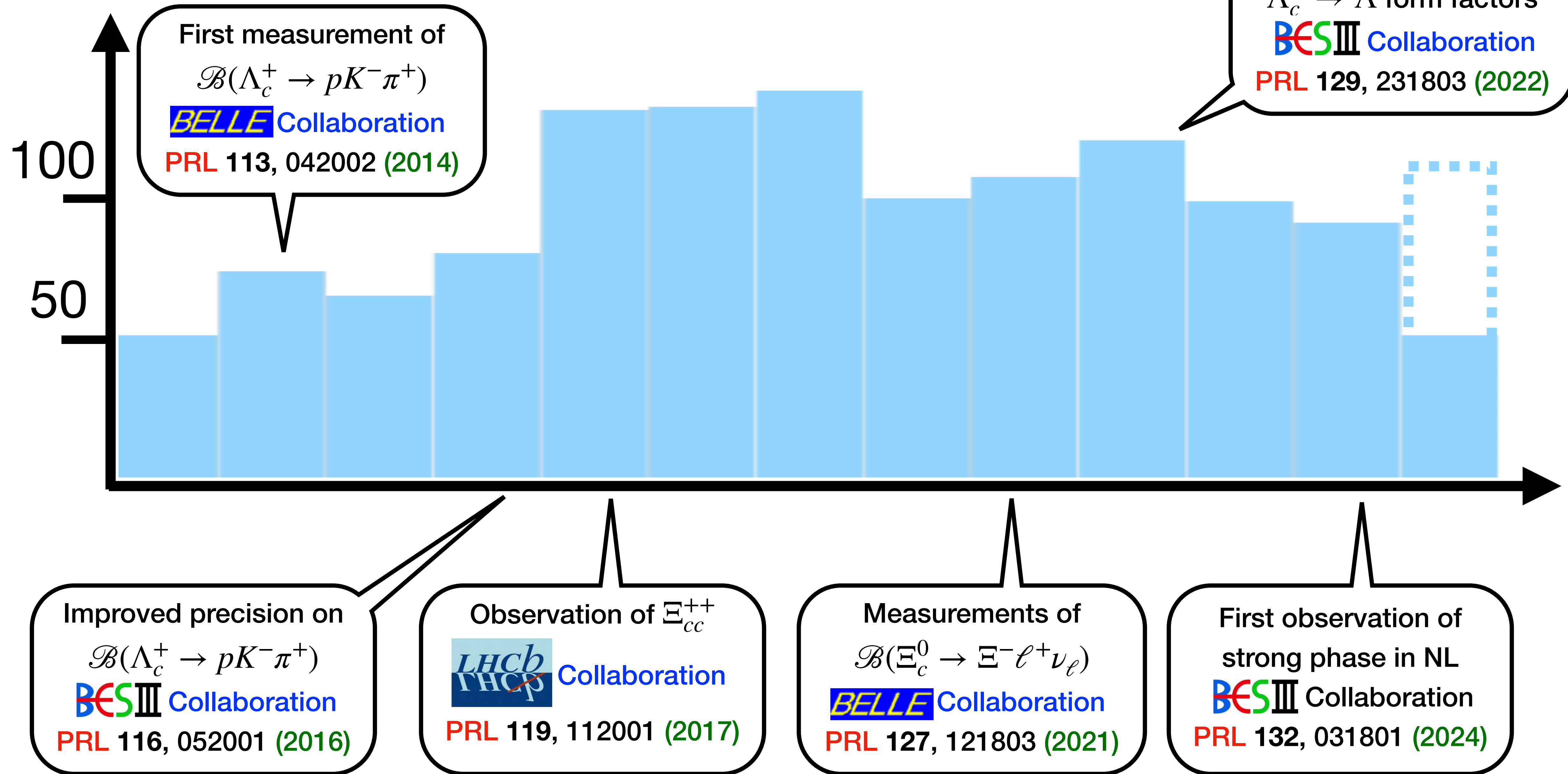
第三届



粲强子物理联合研讨会



- Numbers of articles related to charmed baryons from [Inspirehep](#)



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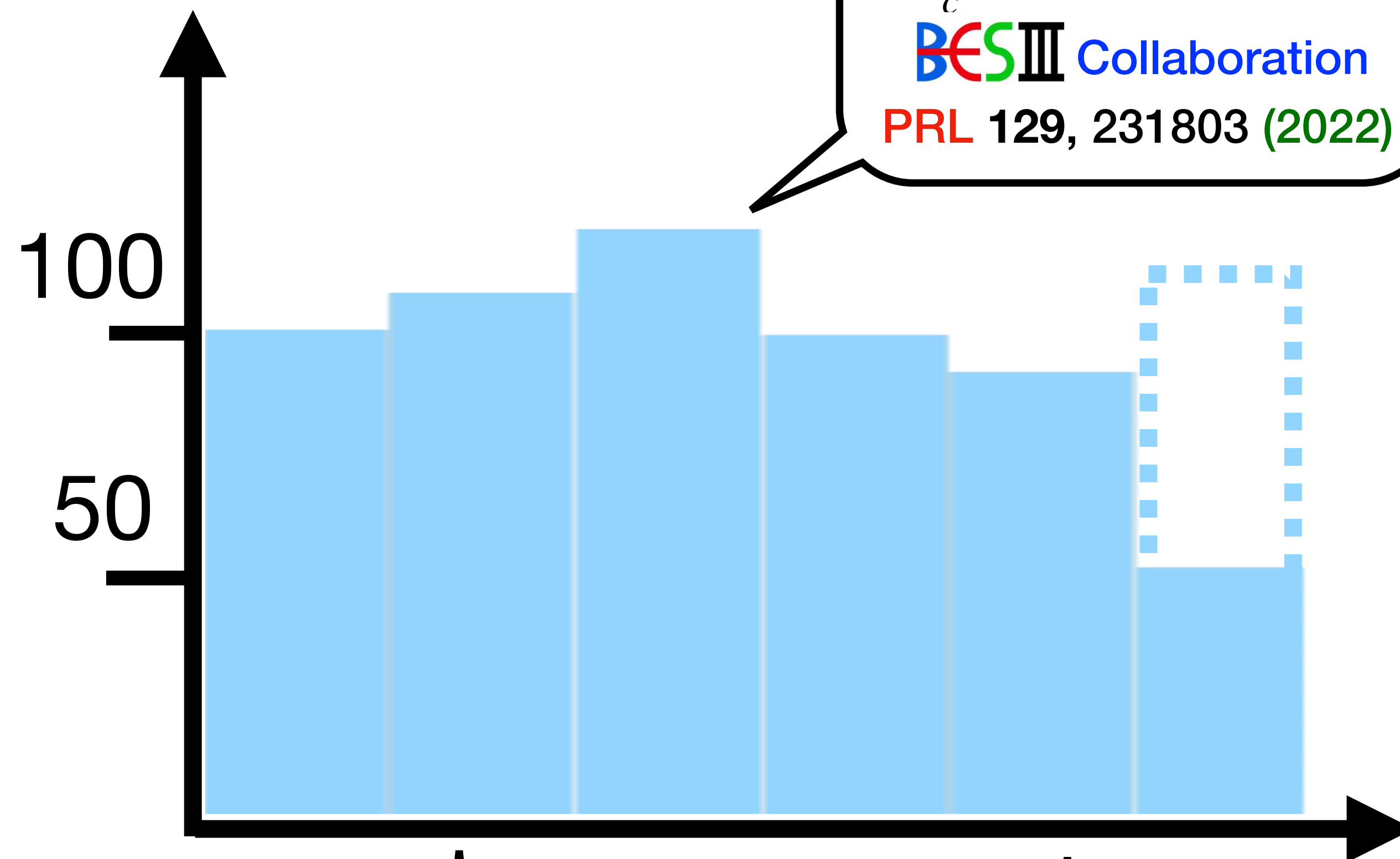
- Before 2020, studies focus on charmed baryons themselves.
- Since 2020, they have been used as tools to examine the standard model !

In semileptonic decays:

Form factors, Time-reversal asymmetries.

In nonleptonic decays:

CP violation



Measurements of $\Lambda_c^+ \rightarrow \Lambda$ form factors
BESIII Collaboration
 PRL 129, 231803 (2022)

Measurements of $\mathcal{B}(\Xi_c^0 \rightarrow \Xi^- \ell^+ \nu_\ell)$
BELLE Collaboration
 PRL 127, 121803 (2021)

First observation of strong phase in NL
BESIII Collaboration
 PRL 132, 031801 (2024)

First principle / reliable

- **Exclusive semileptonic decays**

Lattice QCD: $\Xi_c^0 \rightarrow \Xi^- \ell^+ \nu_\ell \dots$



- **Inclusive decays (clue 1)**



Heavy quark expansion: $\Lambda_c \rightarrow X \ell^+, \tau(\Lambda_c) \dots$

- **Interactions at hadron level**

Small released energy, χ PT: $\Xi_c^0 \rightarrow \Lambda_c^+ \pi^- \dots$

[2209.00257]

- **$SU(3)_F$ analysis (clue 2)**



2-body, 3-body, semileptonic...

Most general but requires (too) many parameters

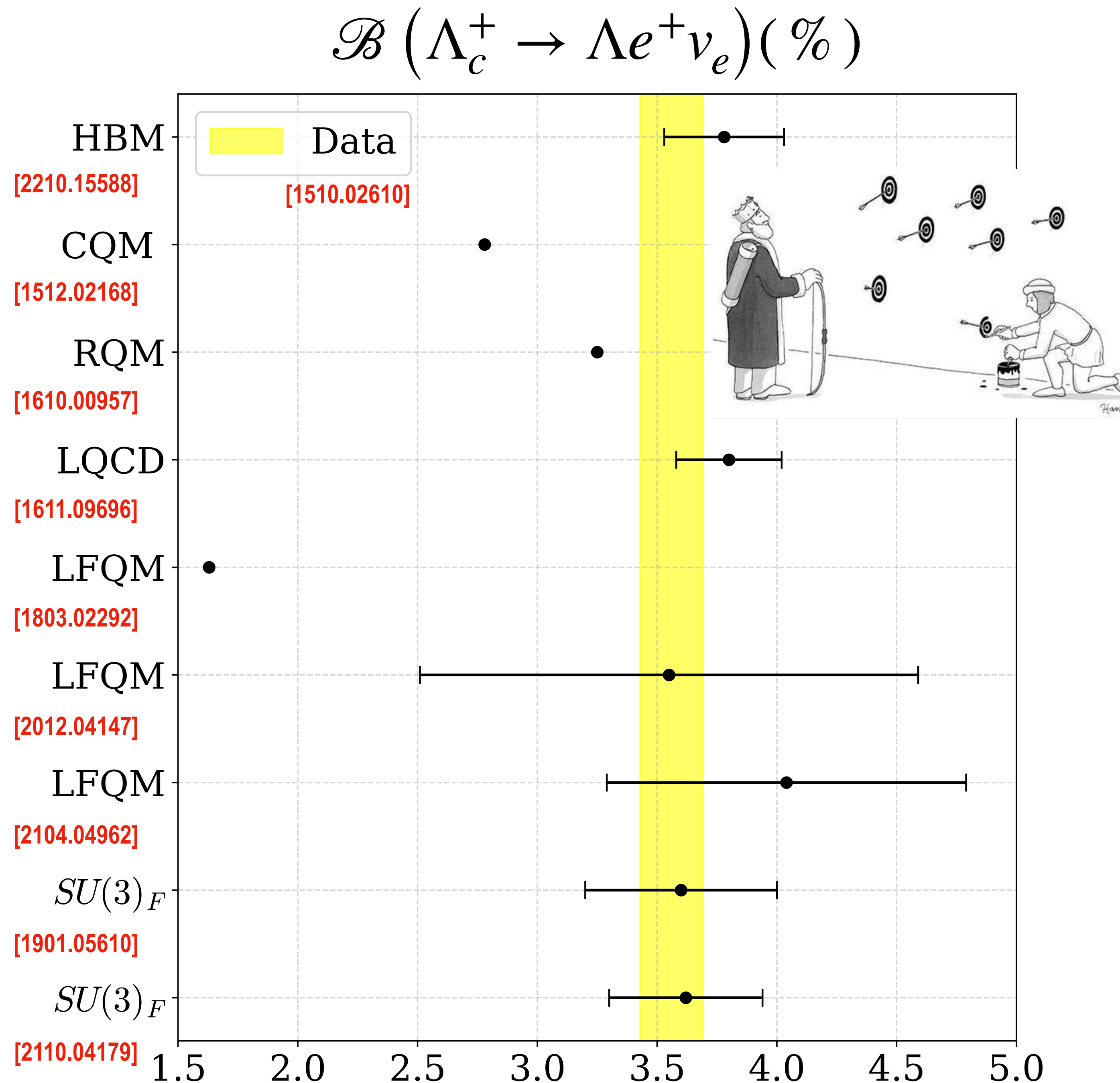
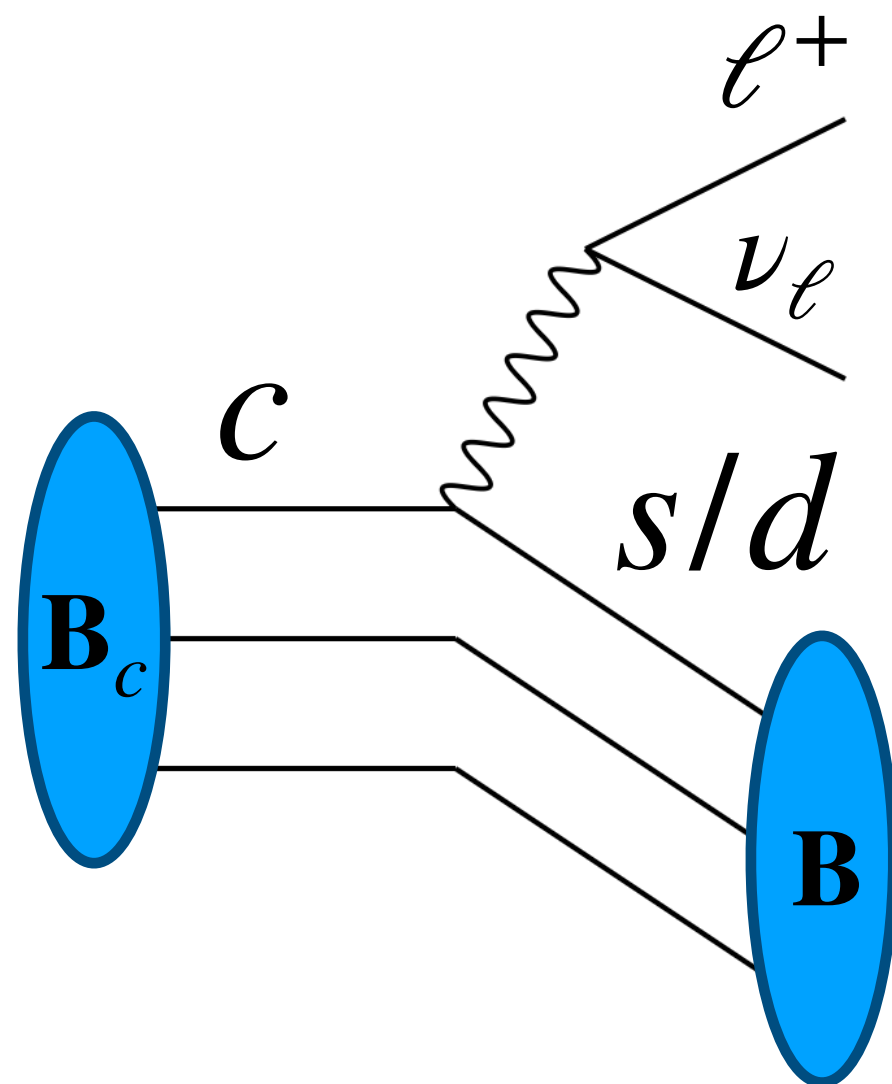
Number of parameters
and assumptions

Data driven / fruitful

- **Semileptonic decays (exclusive)**

- Theoretical predictions range **widely**.

- Lattice predictions are **consistent** with data for Λ_c^+ decays.



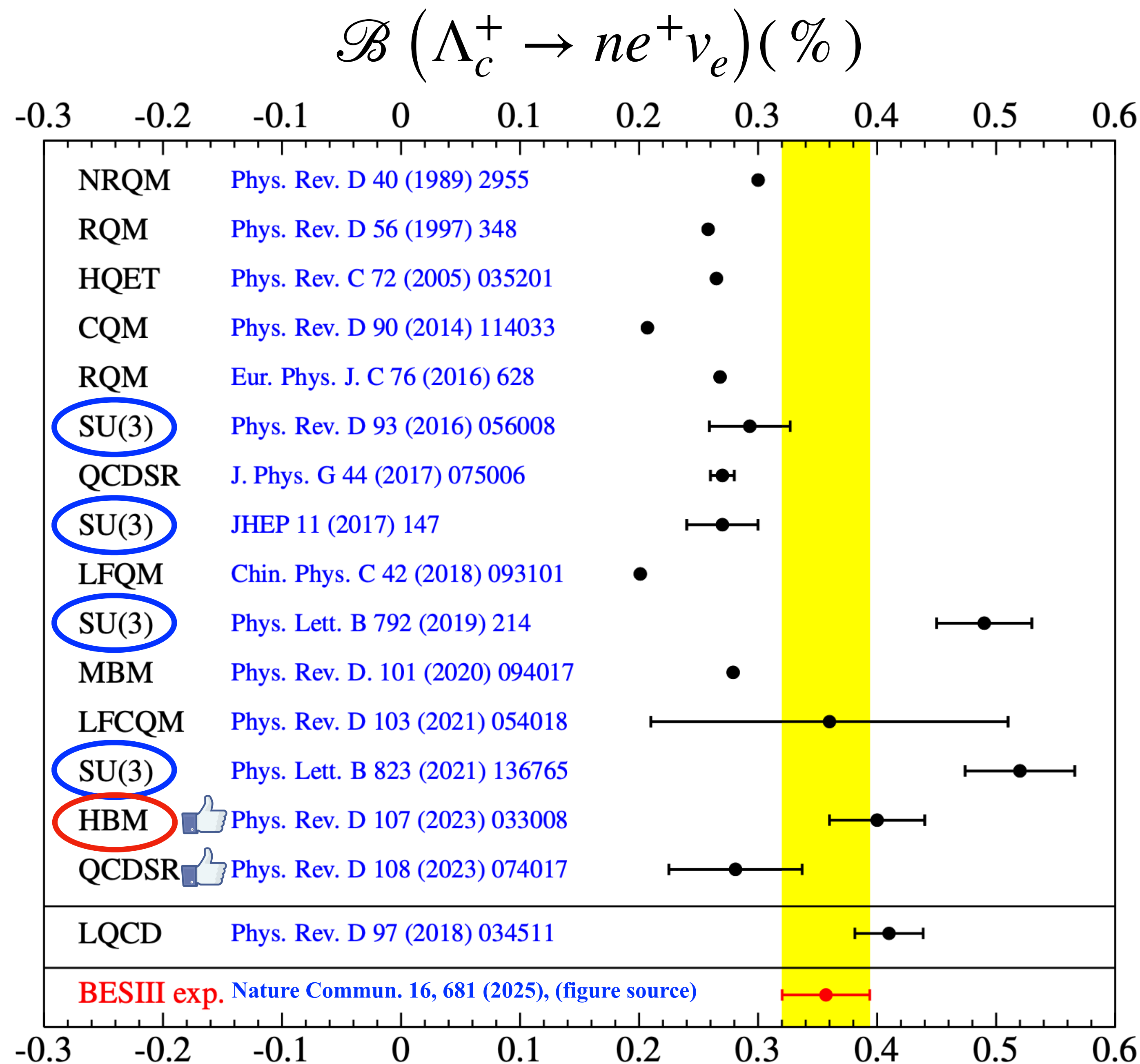
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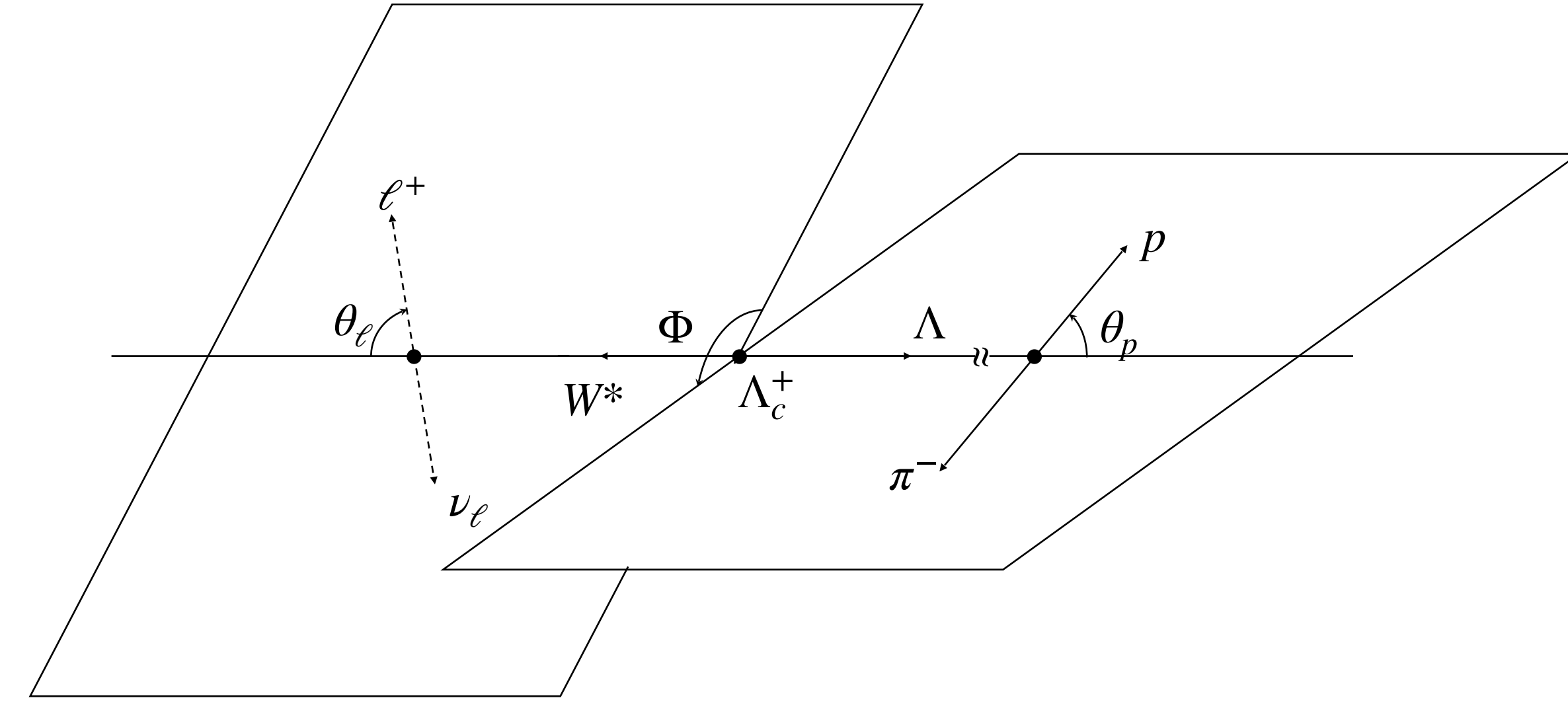
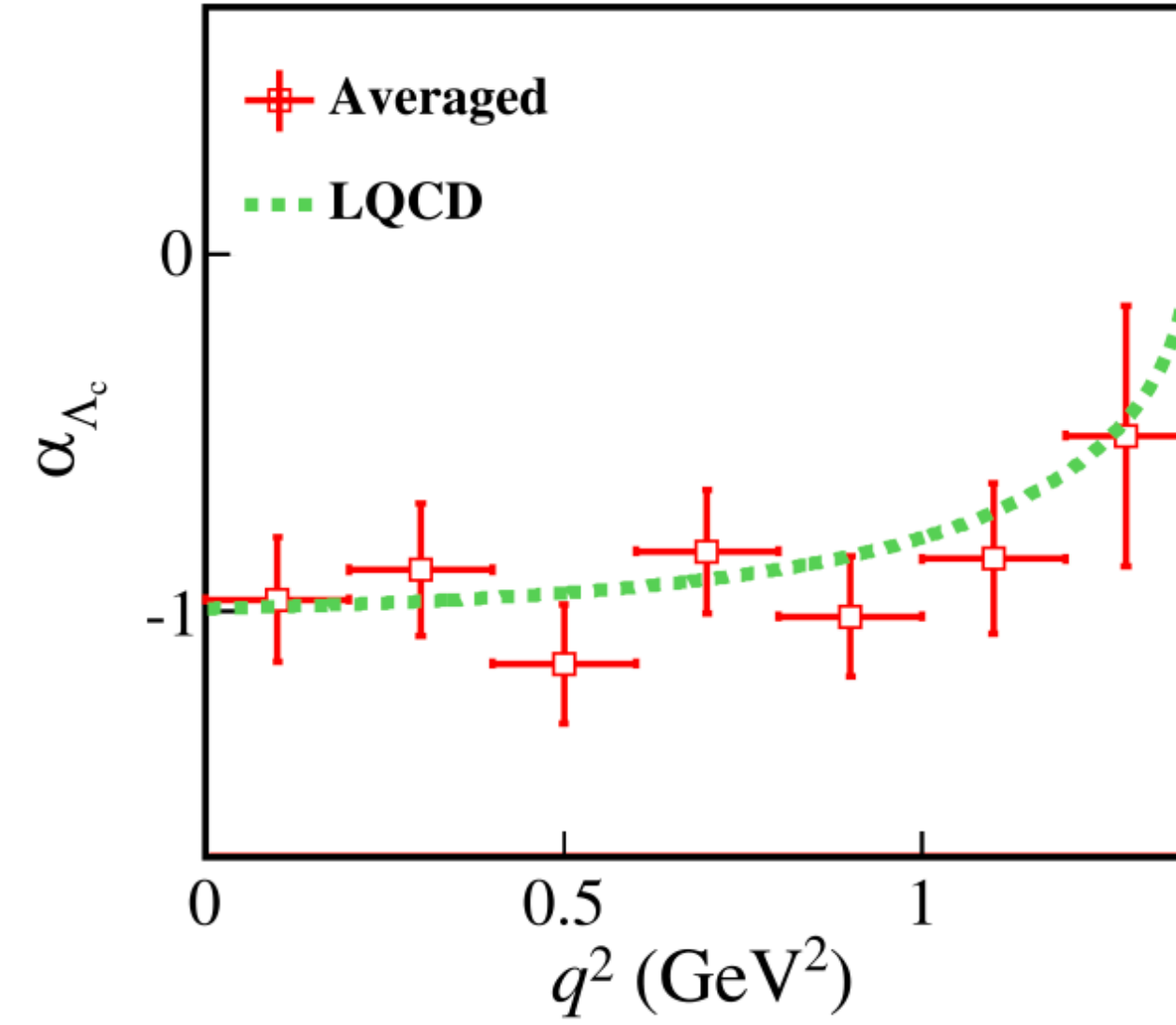
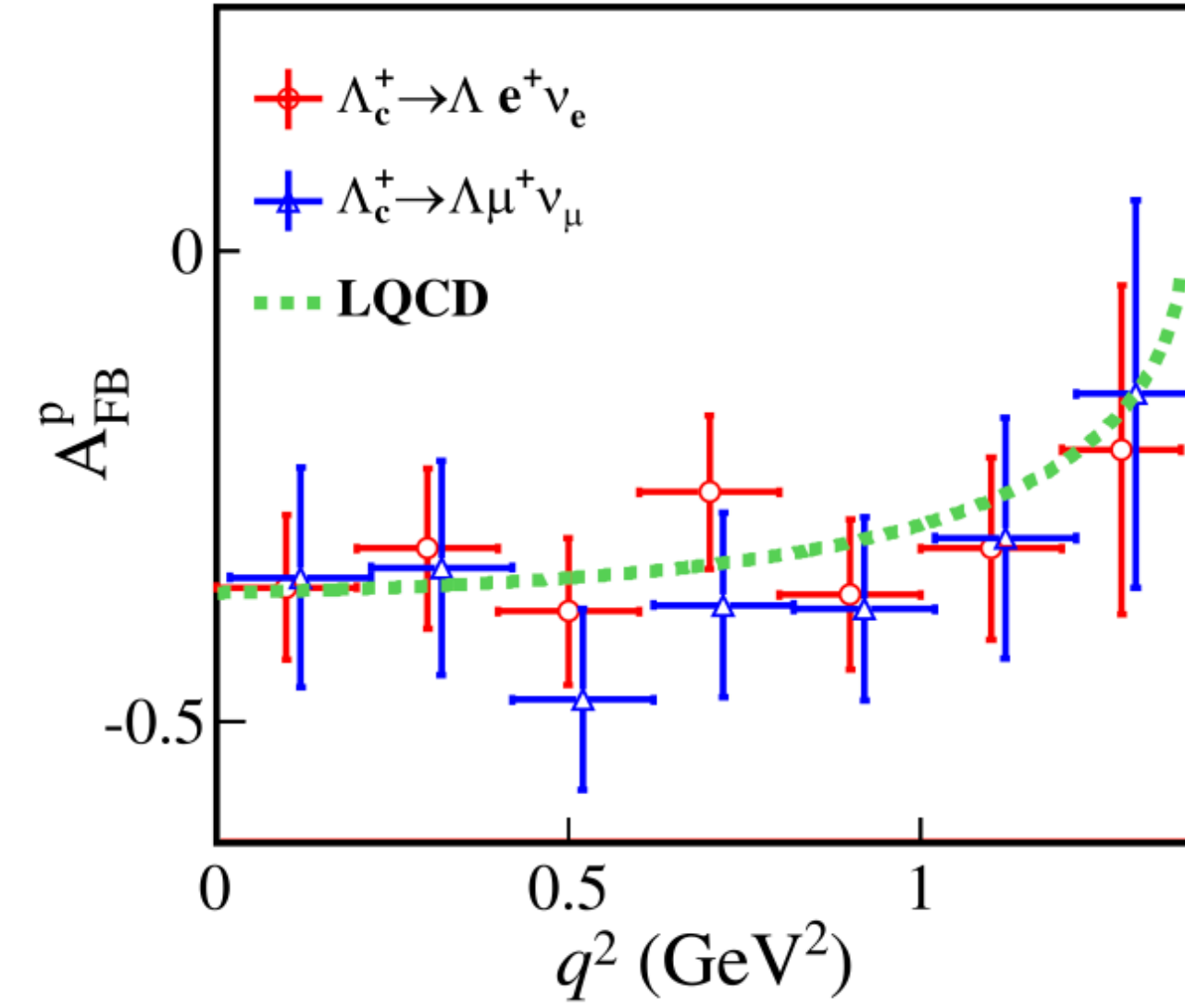
- Handling of **phase space** and the running of **form factors** generate main differences in $SU(3)_F$ analysis.

- $c \rightarrow s$ and $c \rightarrow d$ can have sizable differences in **PS** and **FFs**.



see Dong's talk in this morning

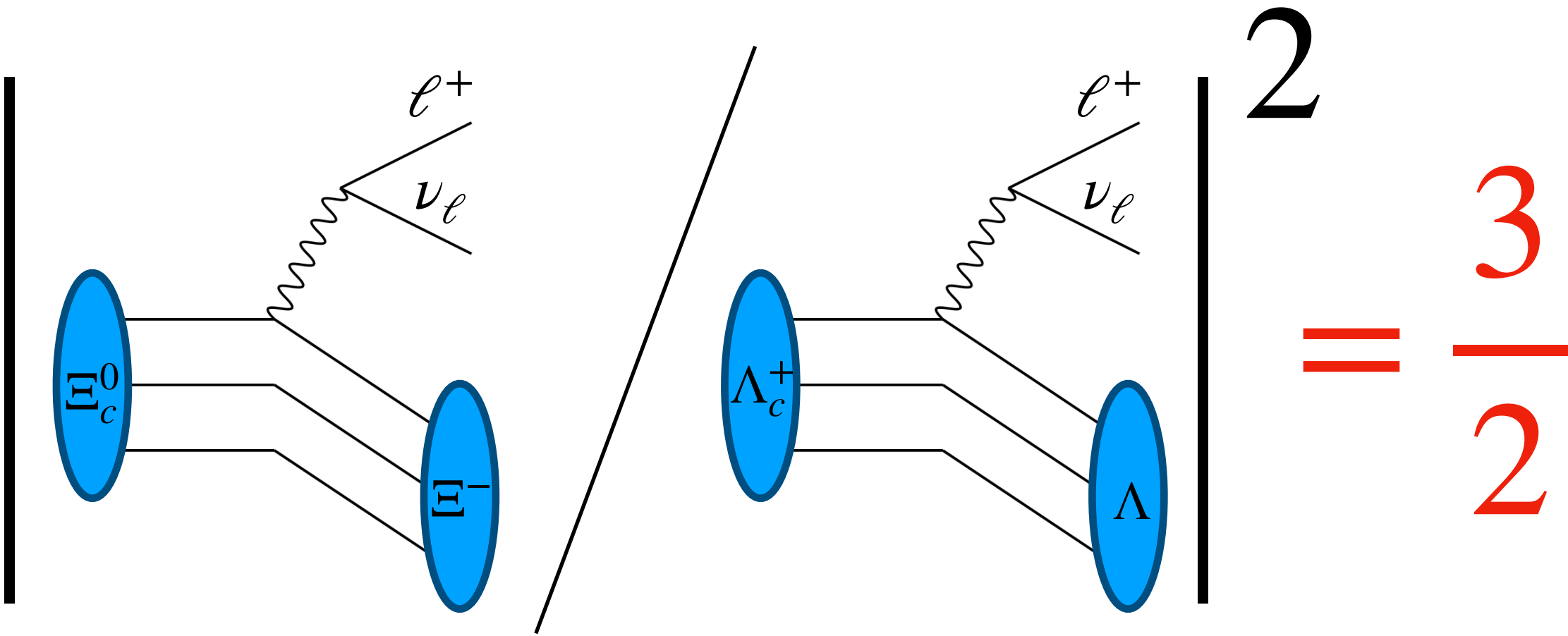
- Semileptonic decays (exclusive)



$$\begin{aligned}
 \frac{d^4\Gamma}{dq^2 d\cos\theta'_\ell d\cos\theta_p d\chi} &= \frac{G_F^2 |V_{cs}|^2}{2(2\pi)^4} \cdot \frac{Pq^2(1 - m_\ell^2/q^2)^2}{24M_{\Lambda_c}^2} \left\{ \frac{3}{8} (1 - \cos\theta'_\ell)^2 |H_{\frac{1}{2}1}|^2 (1 + \alpha_\Lambda \cos\theta_p) \right. \\
 &+ \frac{3}{8} (1 + \cos\theta'_\ell)^2 |H_{-\frac{1}{2}-1}|^2 (1 - \alpha_\Lambda \cos\theta_p) \\
 &+ \frac{3}{4} \sin^2\theta'_\ell [|H_{\frac{1}{2}0}|^2 (1 + \alpha_\Lambda \cos\theta_p) + |H_{-\frac{1}{2}0}|^2 (1 - \alpha_\Lambda \cos\theta_p)] + \frac{3}{2\sqrt{2}} \alpha_\Lambda \cos\chi \sin\theta'_\ell \sin\theta_p \\
 &\left. \times [(1 - \cos\theta'_\ell) H_{-\frac{1}{2}0} H_{\frac{1}{2}1} + (1 + \cos\theta'_\ell) H_{\frac{1}{2}0} H_{-\frac{1}{2}-1}] + \mathcal{H}_{m_\ell^2} \right\},
 \end{aligned}$$

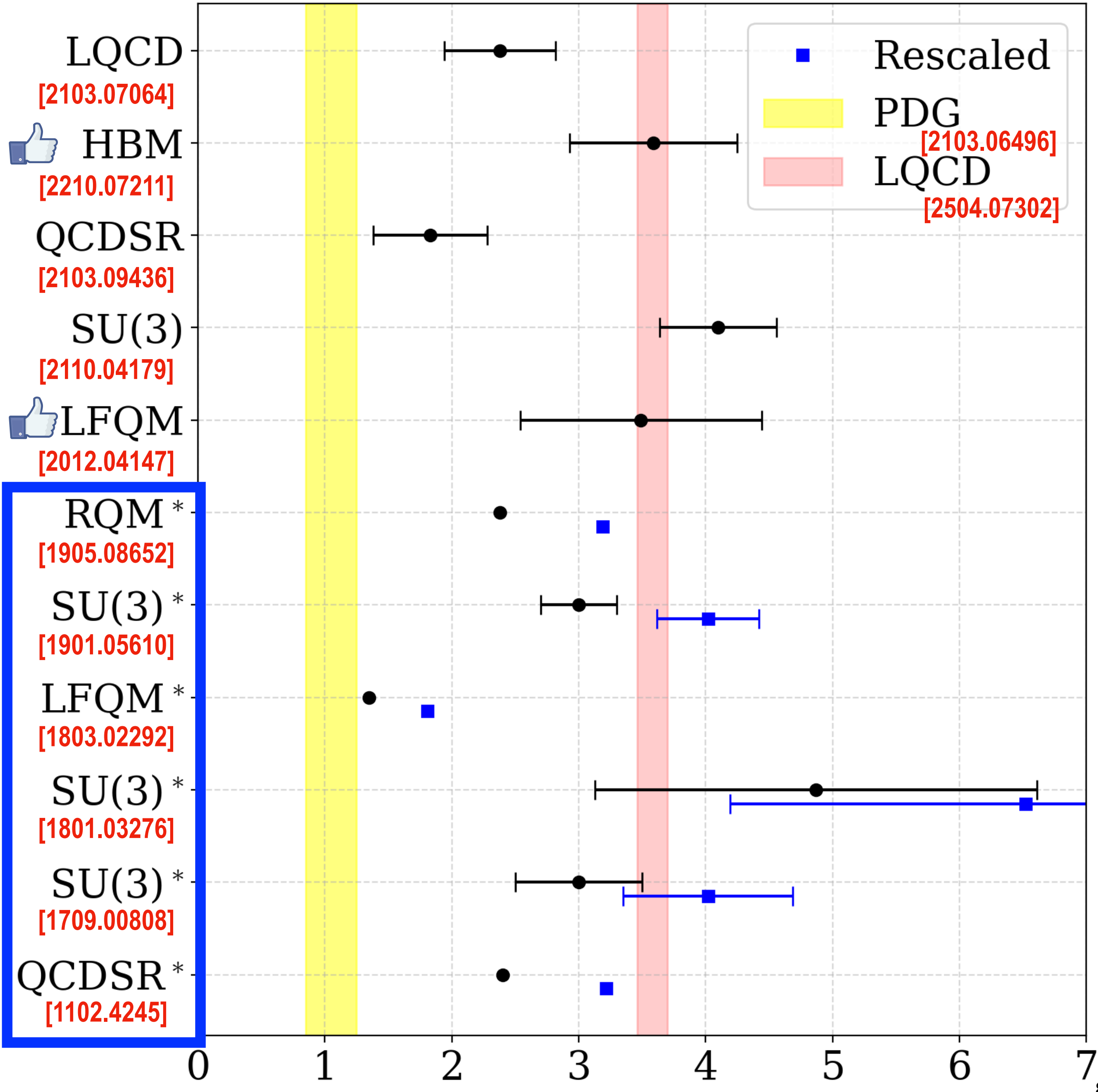
- **Semileptonic decays (exclusive)**

- Use $\tau_{\Xi_c^0}^* = 0.15$ ps instead of 0.118 ps.
- So far, there is **no** literature that can explain satisfactorily the smallness of it.
- What's worse, the $SU(3)_F$ symmetry for $C \rightarrow S$ indicates:



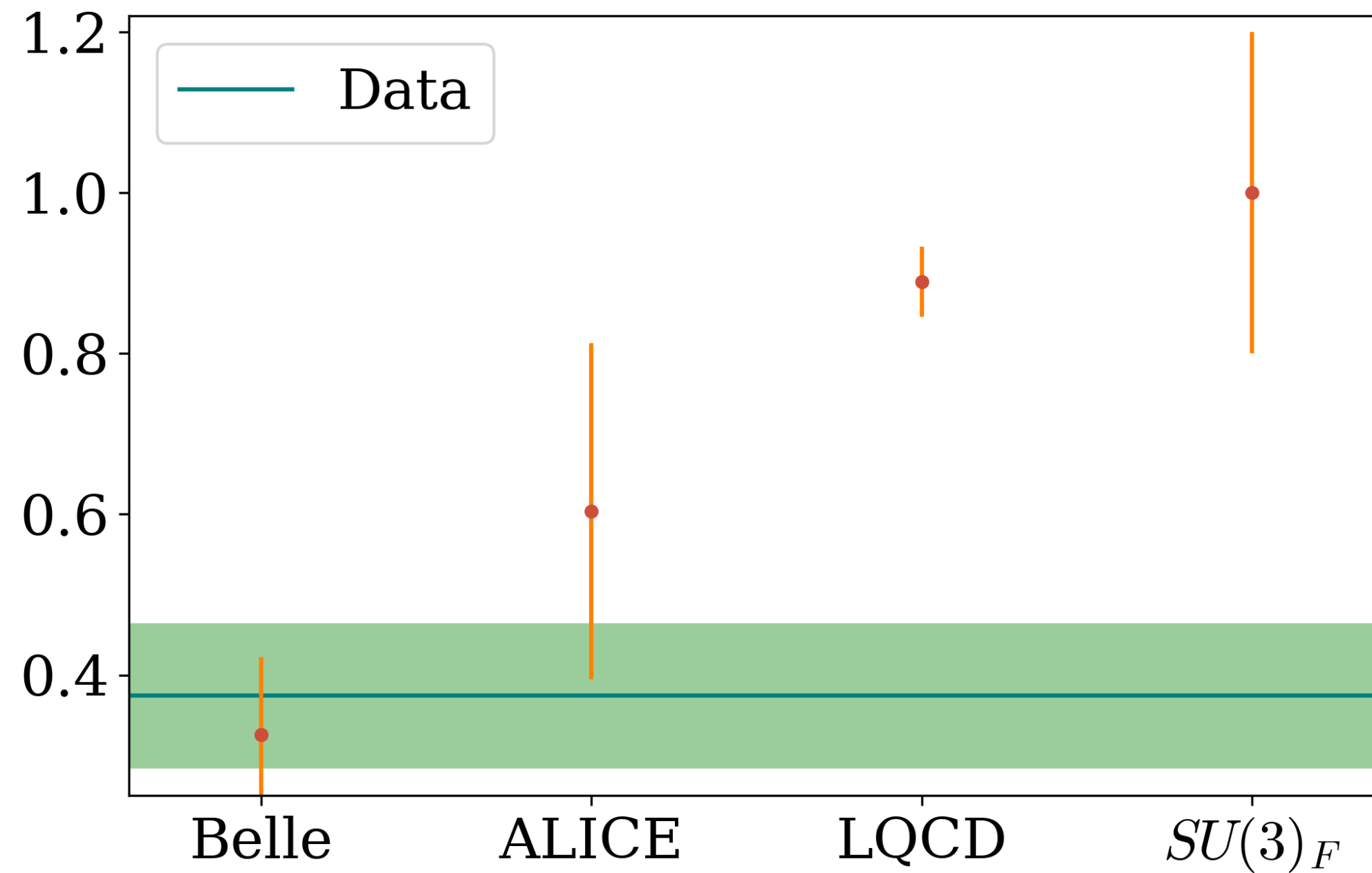
- It is around **0.3** instead! Both are $C \rightarrow S$ transitions, and large $SU(3)_F$ breaking is unexpected.

$$\mathcal{B} \left(\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e \right) (\%)$$



Semileptonic decays (exclusive)

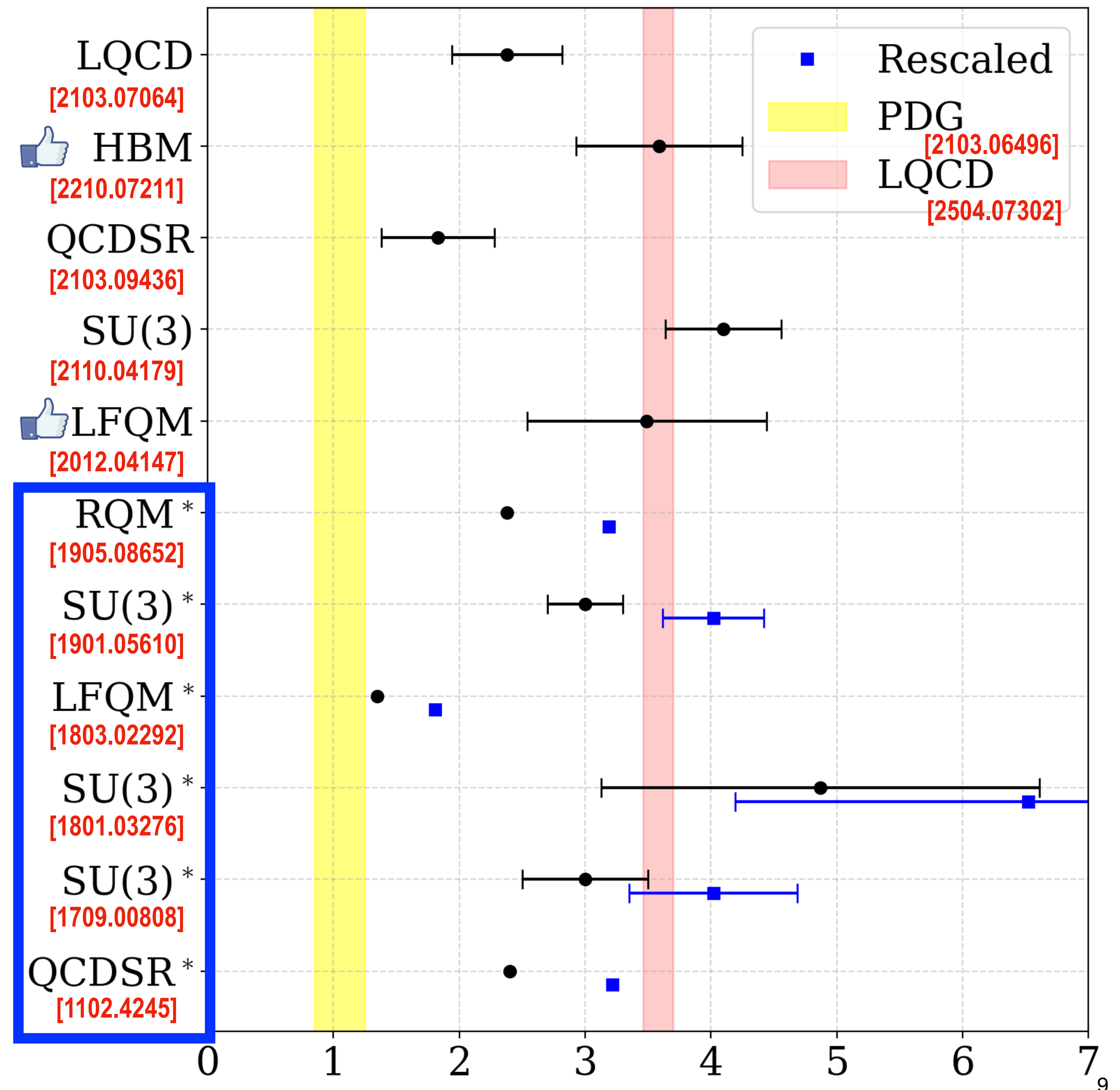
- Use $\tau_{\Xi_c^0} = 0.15$ ps instead of 0.118 ps.
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$$\frac{\Gamma(D_s^+ \rightarrow \phi e^+ \nu_e)}{\Gamma(D^+ \rightarrow \bar{K}^{*0} e^+ \nu_e)} = 0.91 \pm 0.06$$

PDG

$$\mathcal{B}(\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e) (\%)$$



- **Semileptonic decays (exclusive)**

- Difficult to explain the data with NP with the meson sector unaffected.

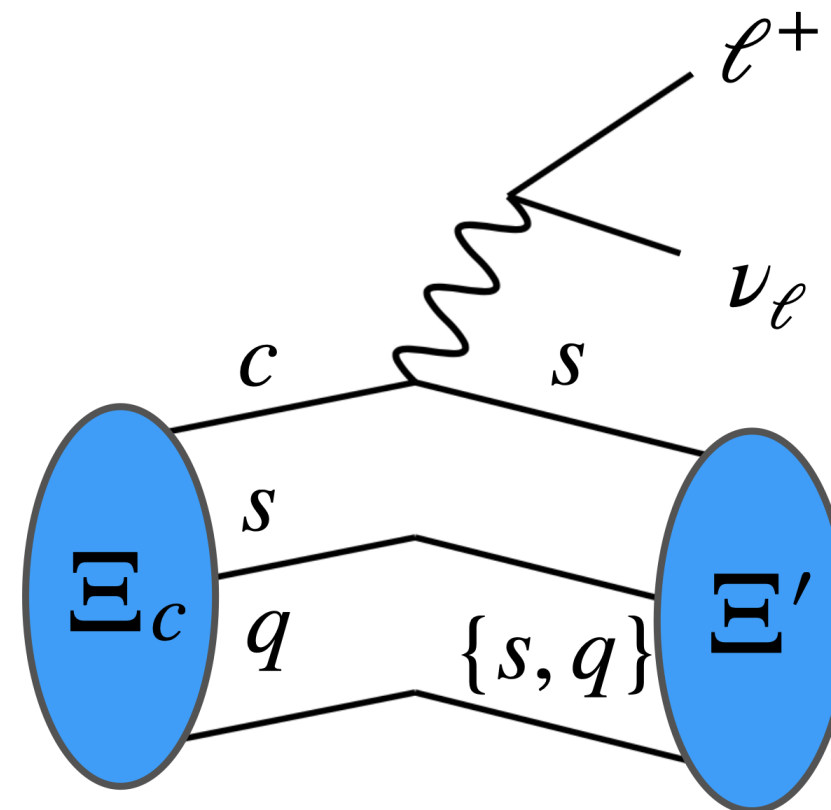
- A **possible** explanation: [2110.04179]

$$\Xi_c = \cos \theta \Xi_c^{\bar{3}} + \sin \theta \Xi_c^6$$

- The form factors of $\Xi_c^{\bar{3}}$ and Ξ_c^6 **destructively** interfere. With $\theta \approx 25^\circ$, the data can be explained: [2210.07211]

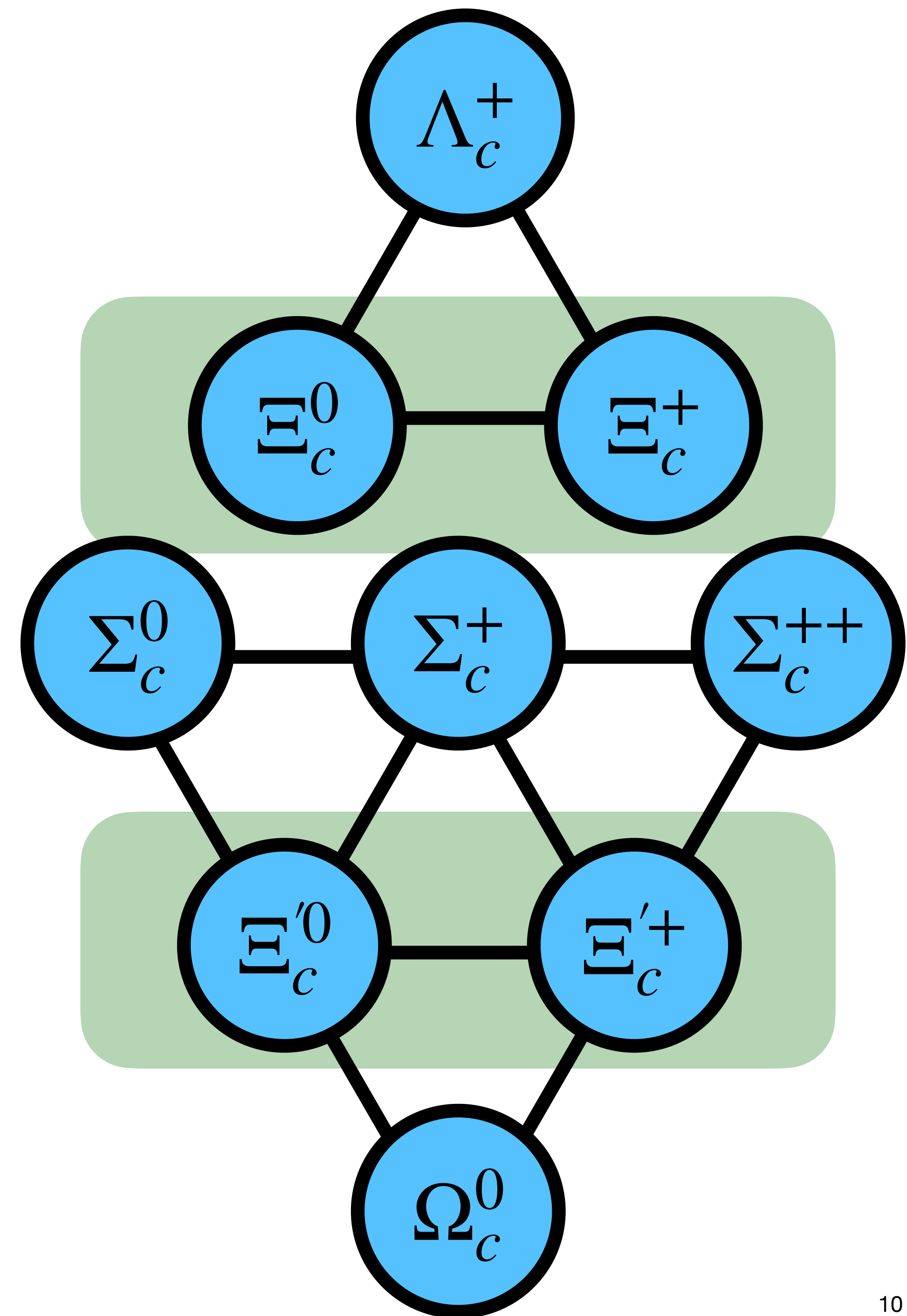
$$\mathcal{B}(\Xi_c^0 \rightarrow \Xi'(1520)\ell^+\nu_\ell) \approx 5 \times 10^{-3}$$

$$\mathcal{B}(\Xi_c^+ \rightarrow \Xi'(1520)\ell^+\nu_\ell) \approx 1.3 \%$$



- Unfortunately, it was soon realized from **lattice QCD**, **sum rules** and **LFQM** that the mixing angle is tiny.

[2103.09436, 2303.17865, 2305.08050, 2309.05432, 2309.16386]



First principle / reliable

Number of parameters
and assumptions



Data driven / fruitful

- **Inclusive decays (clue 1)**



Heavy quark expansion: $\Lambda_c \rightarrow X\ell^+, \tau(\Lambda_c)\dots$



● Inclusive decays - theory

Hai-Yang Cheng, March 19, 2018, see the first talk in this morning

	Γ^{dec}	Γ^{ann}	Γ_-^{int}	Γ_+^{int}	Γ_{SL}	Γ^{tot}	$\tau(10^{-13} s)$	$\tau_{\text{expt}}(10^{-13} s)$
Λ_c^+	1.012	1.883	-0.209	0.021	0.308	3.015	2.18	2.00 ± 0.06
Ξ_c^+	1.012	0.115	-0.189	0.353	0.524	1.854	3.55	4.42 ± 0.26
Ξ_c^0	1.012	2.160		0.351	0.524	4.083	1.61	$1.12^{+0.13}_{-0.10}$
Ω_c^0	1.155	0.126		0.346	0.520	2.855	2.31	0.69 ± 0.12

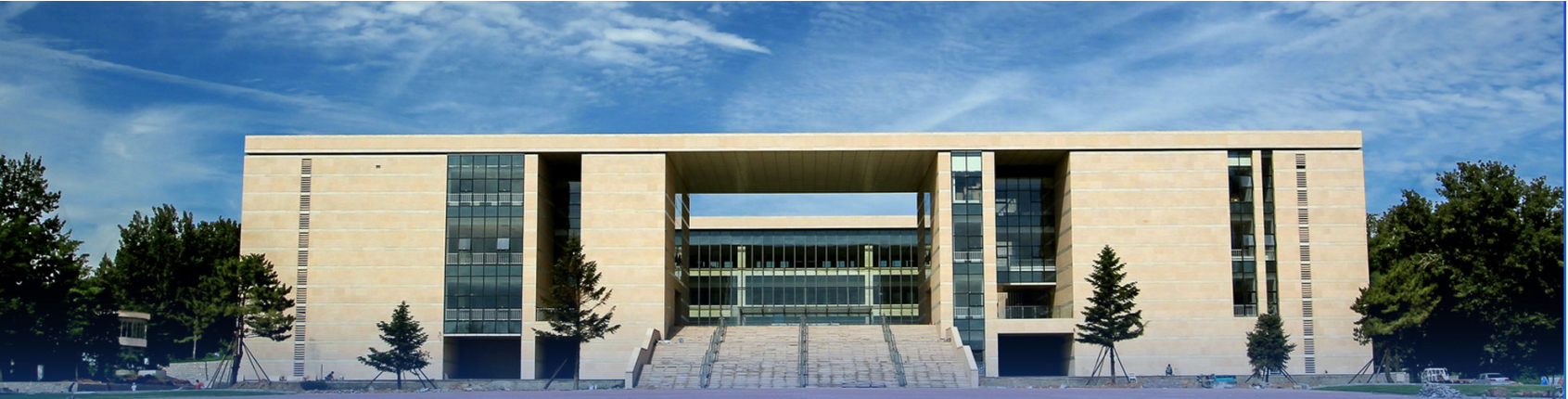
By the end of the work, I was very disappointed because although the lifetime of Ξ_c^+ as well as its ratio to Λ_c^+ lifetime were largely improved by including dim-7 effects, the predicted Ω_c lifetime becomes the longest one, opposite to the experiment.

LHCb, June 8, 2018

	$\tau(\Xi_c^+)$	$\tau(\Lambda_c^+)$	$\tau(\Xi_c^0)$	$\tau(\Omega_c^0)$
PDG (2004-2018) [10]	442 ± 26	200 ± 6	112^{+13}_{-10}	69 ± 12
LHCb (2018) [12]				268 ± 26
LHCb (2019) [14]	457 ± 6	203.5 ± 2.2	154.5 ± 2.6	
PDG (2020) [11]	456 ± 5	202.4 ± 3.1	153 ± 6	268 ± 26
LHCb (2021) [15]			148.0 ± 3.2	276.5 ± 14.1
World average (2021)	456 ± 5	202.4 ± 3.1	152.0 ± 2.0	274.5 ± 12.4

(The Belle II Collaboration)

We report on a measurement of the Ω_c^0 lifetime using $\Omega_c^0 \rightarrow \Omega^- \pi^+$ decays reconstructed in $e^+e^- \rightarrow c\bar{c}$ data collected by the Belle II experiment and corresponding to 207 fb^{-1} of integrated luminosity. The result, $\tau(\Omega_c^0) = 243 \pm 48 \text{ (stat)} \pm 11 \text{ (syst) fs}$, agrees with recent measurements indicating that the Ω_c^0 is not the shortest-lived weakly decaying charmed baryon.



The 2nd International Workshop
on High Intensity Electron-Positron Accelerator
@2-7GeV in China

HIEPA

March 19-21, 2018

University of Chinese Academy of Sciences,
Yanqihu Campus, Huairou, Beijing, China,

High Intensity Electron Positron Accelerator (HIEPA) is one of the possible future collider project post BEPCII/BESIII in China. The 2nd international workshop for HIEPA will invite both high energy physicists and accelerator experts to review the physics potentials and the conceptual designs of both detector and accelerators at the HIEPA facility. In addition, we will take this opportunity to discuss the possibilities of worldwide cooperation and formation of an international collaboration.



Supported by
the Collaborative Innovation Center for Elementary Particles and Interactions
USTC and UCAS.
<http://cicpi.ustc.edu.cn/hiepa2018/>

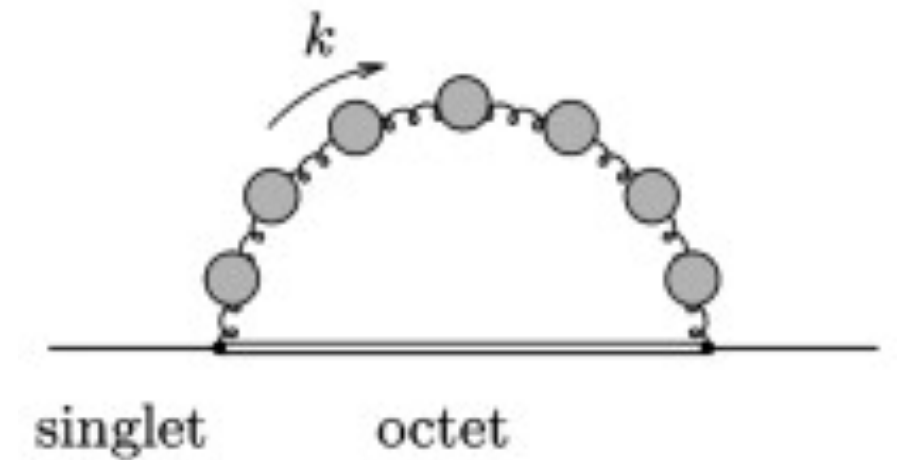
- Inclusive decays - theory

Pole mass, non-perturbative input

[2502.05901]

$$\frac{1}{m_a} \text{Im}(A_{a \rightarrow a}) = \frac{i}{2m_a} \int \left\langle T \left(\mathcal{H}_{\text{eff}}(x) \mathcal{H}_{\text{eff}}(0) \right) \right\rangle d^4x = \frac{1}{m_a} \sum_{n \in \mathcal{N}} \frac{m_Q^k}{m_Q^n} \langle C_n O_n \rangle$$

Separating energy scales $\underbrace{M_W}_{\mathcal{H}_{\text{eff}}} \gg \underbrace{m_Q}_{C_n} \gg \underbrace{\Lambda_{\text{QCD}}}_{\langle O_n \rangle}$



$$\frac{1}{m_a} \text{Im} \left(\underbrace{\text{Diagram 1}}_{\propto m_Q^5} + \underbrace{\text{Diagram 2} + \text{Diagram 3} + \text{Diagram 4}}_{\propto (4\pi)^2 m_Q^2} \right) = \Gamma_{\text{total}}$$

The diagrams are:

- Diagram 1: A bubble diagram with a horizontal line labeled Q and a vertical line labeled Q . The bubble contains a horizontal line labeled q_2 and a vertical line labeled q_3 . The top of the bubble is labeled \bar{q}_1 .
- Diagram 2: A box diagram with a horizontal line labeled Q and a vertical line labeled Q . The box contains a horizontal line labeled q_3 and a vertical line labeled q_1 . The top of the box is labeled q_2 .
- Diagram 3: A box diagram with a horizontal line labeled Q and a vertical line labeled Q . The box contains a horizontal line labeled q_3 and a vertical line labeled q_2 . The top of the box is labeled q_1 .
- Diagram 4: A box diagram with a horizontal line labeled Q and a vertical line labeled Q . The box contains a horizontal line labeled q_2 and a vertical line labeled q_3 . The top of the box is labeled \bar{q}_1 .

- Inclusive decays - theory

$$(m_b, m_c, \Lambda_{QCD}) = (4.8, 1.5, 0.3) \text{ GeV}$$

$$\left(\left(\frac{\Lambda_{QCD}}{m_b} \right)^3, \left(\frac{\Lambda_{QCD}}{m_c} \right)^3, 16\pi^2 \right) \approx \left(\frac{1}{4000}, \frac{1}{125}, 160 \right)$$

- The dim-6 operators are of order $\mathcal{O}(10^{-2})$ and $\mathcal{O}(1)$ relative to the dim-3 ones.

$$\frac{1}{m_a} \text{Im} \left(\underbrace{\text{Diagram 1}}_{\propto m_Q^5} + \underbrace{\text{Diagram 2} + \text{Diagram 3} + \text{Diagram 4}}_{\propto (4\pi)^2 m_Q^2} \right) = \Gamma_{\text{total}}$$

The diagrams are:

- Diagram 1:** A bubble diagram with two vertices (crosses) connected by a horizontal line. The top arc is labeled \bar{q}_1 , the bottom arc is labeled q_3 , and the horizontal line is labeled q_2 . External lines are labeled Q on the left and Q on the right.
- Diagram 2:** A box diagram with two horizontal lines. The top line has arrows pointing right, labeled Q at both ends and q_3 in the middle. The bottom line has arrows pointing right, labeled q_1 at both ends and q_2 in the middle. Vertical wavy lines connect the top and bottom lines at the left and right vertices.
- Diagram 3:** A box diagram similar to Diagram 2, but with the wavy lines crossing each other.
- Diagram 4:** A diagram with two horizontal lines. The top line has arrows pointing right, labeled Q at both ends and q_2 in the middle. The bottom line has arrows pointing right, labeled q_3 at both ends. A loop is formed by two wavy lines connecting the top and bottom lines, with a vertex labeled \bar{q}_1 on the top wavy line.

• Inclusive decays - theory

- Symbolically, the transition operators read:

$$\frac{G_F^2 m_Q^5}{192 \pi^3} \xi \left(c_{3,Q} \bar{Q} Q + \frac{c_{5,Q}}{m_Q^2} \bar{Q} \sigma \cdot G Q + \frac{c_{6,Q}}{m_Q^3} T_6 + \frac{c_{7,Q}}{m_Q^4} T_7 + \dots \right)$$

- In Cabibbo-favored decays, Ξ_c receive **dim-6** operators contributions but Λ_c^+ does not!
- Since **dim-3** and **dim-6** SL operators are in the same sign:

$$\Gamma_{\Xi_c}^{\text{SL}} = \Gamma_{\Xi_c}^{\text{SL}}(\text{dim-3}) + \Gamma_{\Xi_c}^{\text{SL}}(\text{dim-6}) = \Gamma_{\Lambda_c^+}^{\text{SL}} + \Gamma_{\Xi_c}^{\text{SL}}(\text{dim-6}) \geq \Gamma_{\Lambda_c^+}^{\text{SL}}$$

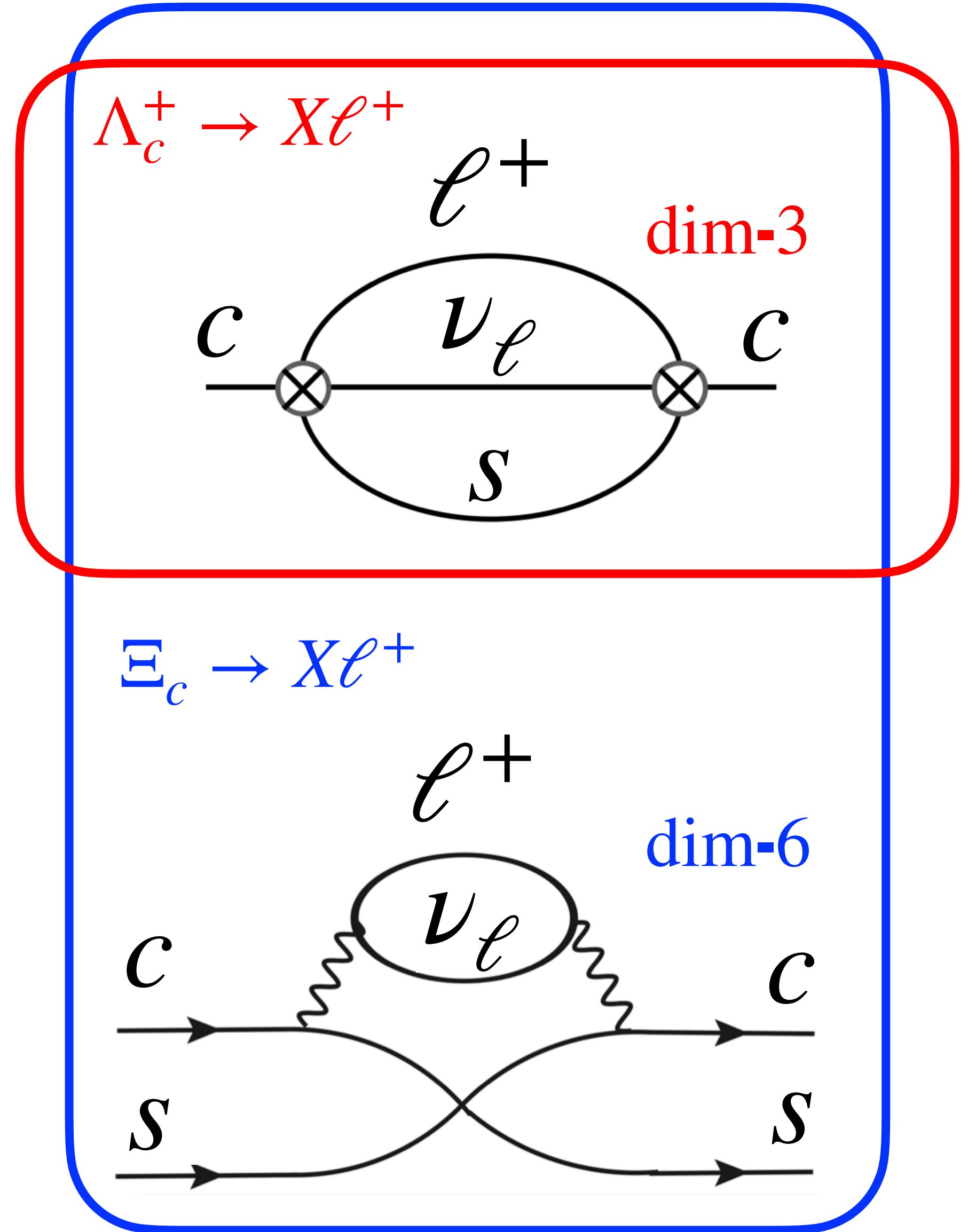
- BESIII** reveals the 90% saturation of: [2212.03753]

$$\mathcal{B}(\Lambda_c^+ \rightarrow X e^+) = (4.06 \pm 13) \% \approx \textcolor{red}{1.1} \mathcal{B}(\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e)$$

$$\mathcal{B}(\Xi_c^0 \rightarrow X \ell^+ \nu_\ell) \geq 2.6 \%$$

- From $\mathcal{B}(\Xi_c^0 \rightarrow \Xi^- \ell^+ \nu_\ell) = (1.05 \pm 0.20) \%$ we have

$$\frac{\mathcal{B}(\Xi_c^0 \rightarrow X e^+)}{\mathcal{B}(\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e)} \geq \textcolor{red}{2}$$



- Inclusive decays - numerical results

$$\begin{aligned}
 L_{\mathcal{B}_Q}^q &\equiv \left\langle (Q_\alpha^\dagger L^\mu q_\alpha) \left(q_\beta^\dagger L_\mu Q_\beta \right) \right\rangle_{\mathcal{B}_Q}, & \tilde{L}_{\mathcal{B}_Q}^q &\equiv \left\langle (Q_\alpha^\dagger L^\mu q_\beta) \left(q_\beta^\dagger L_\mu Q_\alpha \right) \right\rangle_{\mathcal{B}_Q} \\
 S_{\mathcal{B}_Q}^q &\equiv \left\langle (\overline{Q}_\alpha q_\alpha) (\overline{q}_\beta Q_\beta) \right\rangle_{\mathcal{B}_Q}, & \tilde{S}_{\mathcal{B}_Q}^q &\equiv \left\langle (\overline{Q}_\alpha q_\beta) (\overline{q}_\beta Q_\alpha) \right\rangle_{\mathcal{B}_Q}, \\
 P_{\mathcal{B}_Q}^q &\equiv \left\langle (\overline{Q}_\alpha \gamma_5 q_\alpha) (\overline{q}_\beta \gamma_5 Q_\beta) \right\rangle_{\mathcal{B}_Q}, & \tilde{P}_{\mathcal{B}_Q}^q &\equiv \left\langle (\overline{Q}_\alpha \gamma_5 q_\beta) (\overline{q}_\beta \gamma_5 Q_\alpha) \right\rangle_{\mathcal{B}_Q},
 \end{aligned}$$

$L_{\Lambda_b}^{q_I} = -3.2 \pm 1.6$

[2305.00665]

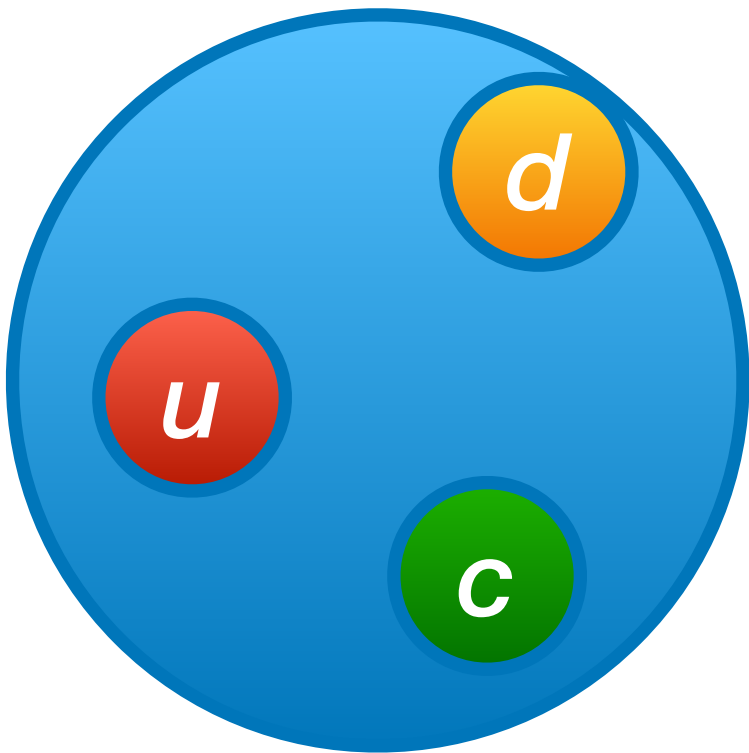
$-2.38 \pm 0.11 \pm 0.34 \pm 0.22$

[PLB 387, 371(1996)]

From QCD and HQET sum rules

Model	(\mathcal{B}_Q, q)	(Λ_b, q_I)	(Ξ_b, q_I)	(Ξ_b, s)	(Ω_b, s)	(Λ_c, q_I)	(Ξ_c, q_I)	(Ξ_c, s)	(Ω_c, s)
BM ^a	$L_{\mathcal{B}_Q}^q$	−5.44	−5.15	−5.88	−34.12	−4.83	−4.87	−5.34	−31.63
	$S_{\mathcal{B}_Q}^q$	2.44	2.32	2.74	−5.41	1.96	1.98	2.32	−4.65
	$P_{\mathcal{B}_Q}^q$	−0.27	−0.25	−0.20	−0.62	−0.44	−0.44	−0.34	−1.12
NRQM	$L_{\mathcal{B}_Q}^q$	−13(5)	−14(5)	−18(6)	−126(60)	−5.1(15)	−5.4(16)	−7.4(22)	−46(14)
	$S_{\mathcal{B}_Q}^q$	7(2)	7(2)	9(3)	−21(10)	2.5(8)	2.7(8)	3.7(11)	−7.7(23)
	$P_{\mathcal{B}_Q}^q$	0	0	0	0	0	0	0	0

[2305.00665]



Bag is localized and it cannot be 3-momentum eigenstate. Underestimate the 4-quark operator by 2.

● Inclusive decays - numerical results

- The prediction of $\Lambda_c^+ \rightarrow X e^+$ is well **consistent** with the data of $(4.06 \pm 0.13) \%$.
- For Λ_c^+, Ξ_c the **HQE** of $\Gamma_3 > \Gamma_6 > \Gamma_7$ holds but not true for Ω_c .
- The prediction of $\mathcal{B}(\Xi_c^0 \rightarrow X e^+)$ is consistent with the lattice result of $\mathcal{B}(\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e) \approx (3.58 \pm 0.12) \%$ together with the ansatz of **lowest bound-state saturation**.
- We are working on both dim-7 NLO and doubly charmed baryons predictions.

B_c		Γ_3^{SL}	Γ_6^{SL}	Γ_7^{SL}	$\mathcal{B}_e^{\text{SL}}(\%)$
Λ_c^+	LO	0.40(13) _m	0.01	0	8.25(78) _m (44) _μ (37) ₄ (37) _s
	NLO	0.35(11) _m	0.01	-	4.57(42) _m (24) _μ (21) ₄ (13) _s
Ξ_c^0	LO	0.40(14) _m	0.36	-0.15	8.99(58) _m (29) _μ (25) ₄ (43) _s
	NLO	0.35(12) _m	0.18	-	4.40(45) _m (22) _μ (19) ₄ (30) _s
Ξ_c^+	LO	0.40(14) _m	0.35	-0.15	18.59(26) _m (22) _μ (19) ₄ (39) _s
	NLO	0.35(12) _m	0.18	-	8.57(20) _m (5) _μ (5) ₄ (44) _s
Ω_c^0	LO	0.42(14) _m	1.22	-0.83	13.51(42) _m (10) _μ (8) ₄ (23) _s
	NLO	0.37(12) _m	0.61	-	1.88(1.33) _m (47) _μ (40) ₄ (85) _s

[2305.00665]

First principle / reliable

Number of parameters
and assumptions



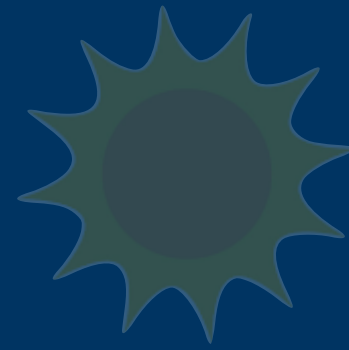
Data driven / fruitful

- $SU(3)_F$ analysis (clue 2)



2-body, 3-body, semileptonic...

Most general but requires (too) many parameters



- **SU(3) flavor perspective of charmed baryon decays**

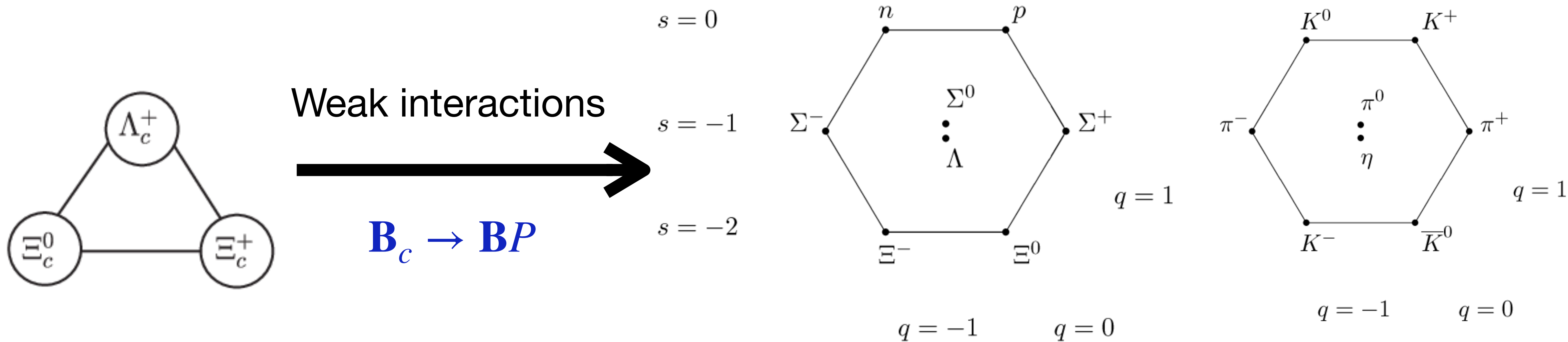


Murray Gell-Mann 1929-2019

By far, the only **reliable (?)** way is the **$SU(3)_F$ symmetry**.

PRD 54, 2132 (1996), **PRD** 93, 056008 (2016), **NPB** 956, 115048 (2020)

JHEP 09, 035 (2022), **JHEP** 03, 143 (2022), **PRD** 109, 114027 (2024) ...



• SU(3) flavor perspective of charmed baryon decays

- Predicted **direct** relations:

PLB 794, 19(2019)

$$\Gamma(\Lambda_c^+ \rightarrow \Sigma^+ K_S^0) = \Gamma(\Lambda_c^+ \rightarrow \Sigma^0 K^+) = s_c^2 \Gamma(\Xi_c^0 \rightarrow \Xi^0 \pi^0)$$

$\mathcal{B}(\Lambda_c^+ \rightarrow \Sigma^+ K_S^0, \Sigma^0 K^+)$ **BESIII**

$$(4.7 \pm 1.0) \times 10^{-4}$$

$$\approx (4.8 \pm 1.4) \times 10^{-4}$$

PRD 106, 052003 (2022)

$\mathcal{B}(\Xi_c^0 \rightarrow \Xi^0 \pi^0)$ **BELLE**











$$(7.1 \pm 0.4)_{th} \times 10^{-3}$$

$$(6.9 \pm 1.4)_{exp} \times 10^{-3}$$

JHEP 10, 045 (2024)

- Tests on **predictions** of **global fits** since last year:

PRD 109, 093001; PRD 109, L071302

	PDG (2023)	Theory (2023)	Data (2025)	
 $\alpha(\Lambda_c^+ \rightarrow p K_S^0)$	0.18 ± 0.45	-0.40 ± 0.49	-0.744 ± 0.015	
 $10^4 \mathcal{B}(\Lambda_c^+ \rightarrow p \pi^0)$	< 0.8	1.6 ± 0.2	1.79 ± 0.41	
 $10^3 \mathcal{B}(\Lambda_c^+ \rightarrow \Lambda K_S^0 \pi^+)$	None	1.97 ± 0.38	1.73 ± 0.28	
 $10^3 \mathcal{B}(\Xi_c^0 \rightarrow \Xi^0 \eta)$	None	2.94 ± 0.97	1.6 ± 0.5	
 $10^3 \mathcal{B}(\Xi_c^0 \rightarrow \Xi^0 \eta')$	None	5.66 ± 0.93	1.2 ± 0.4	

There are some **shortcomings** in $SU(3)_F$ symmetry approach.

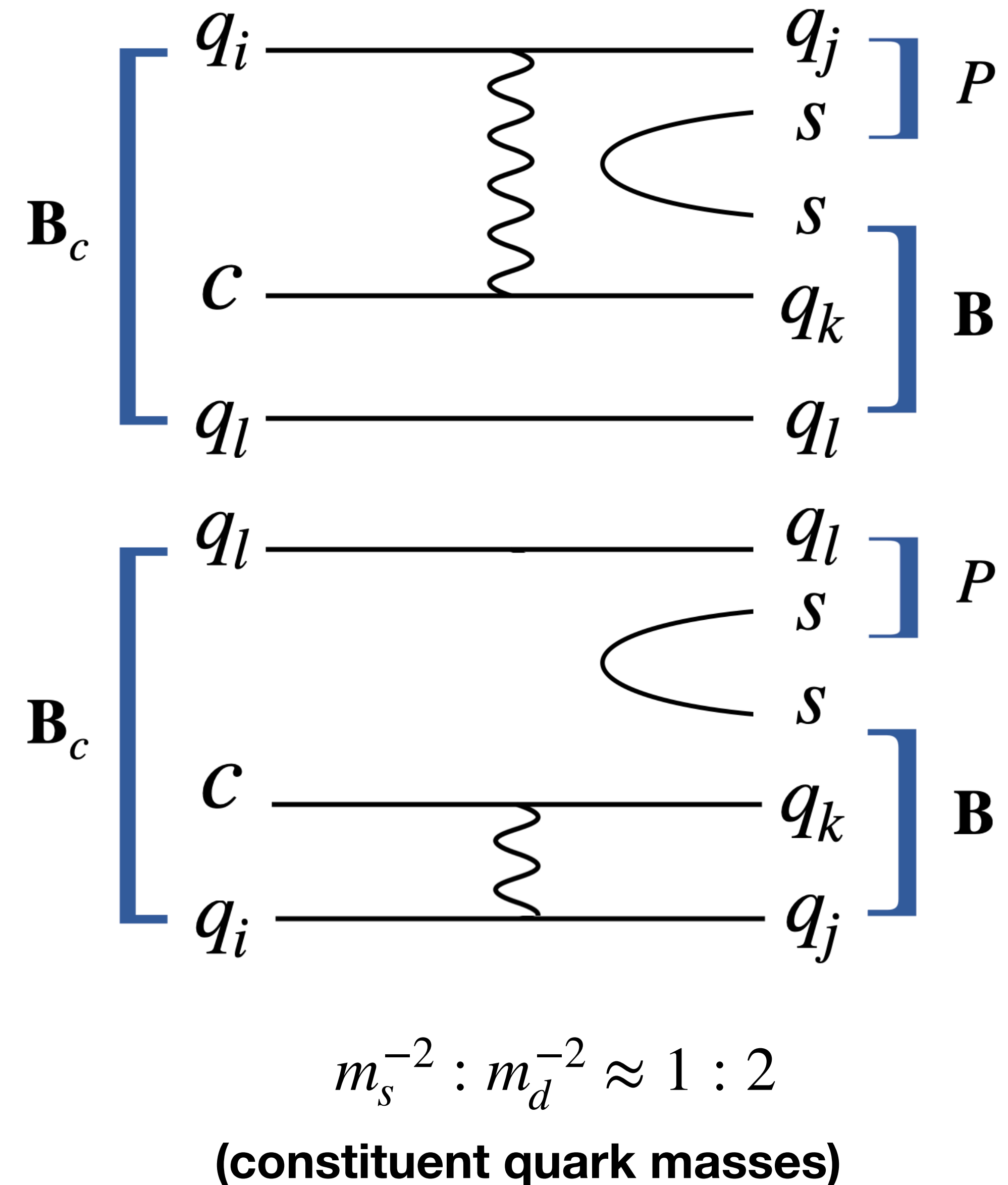
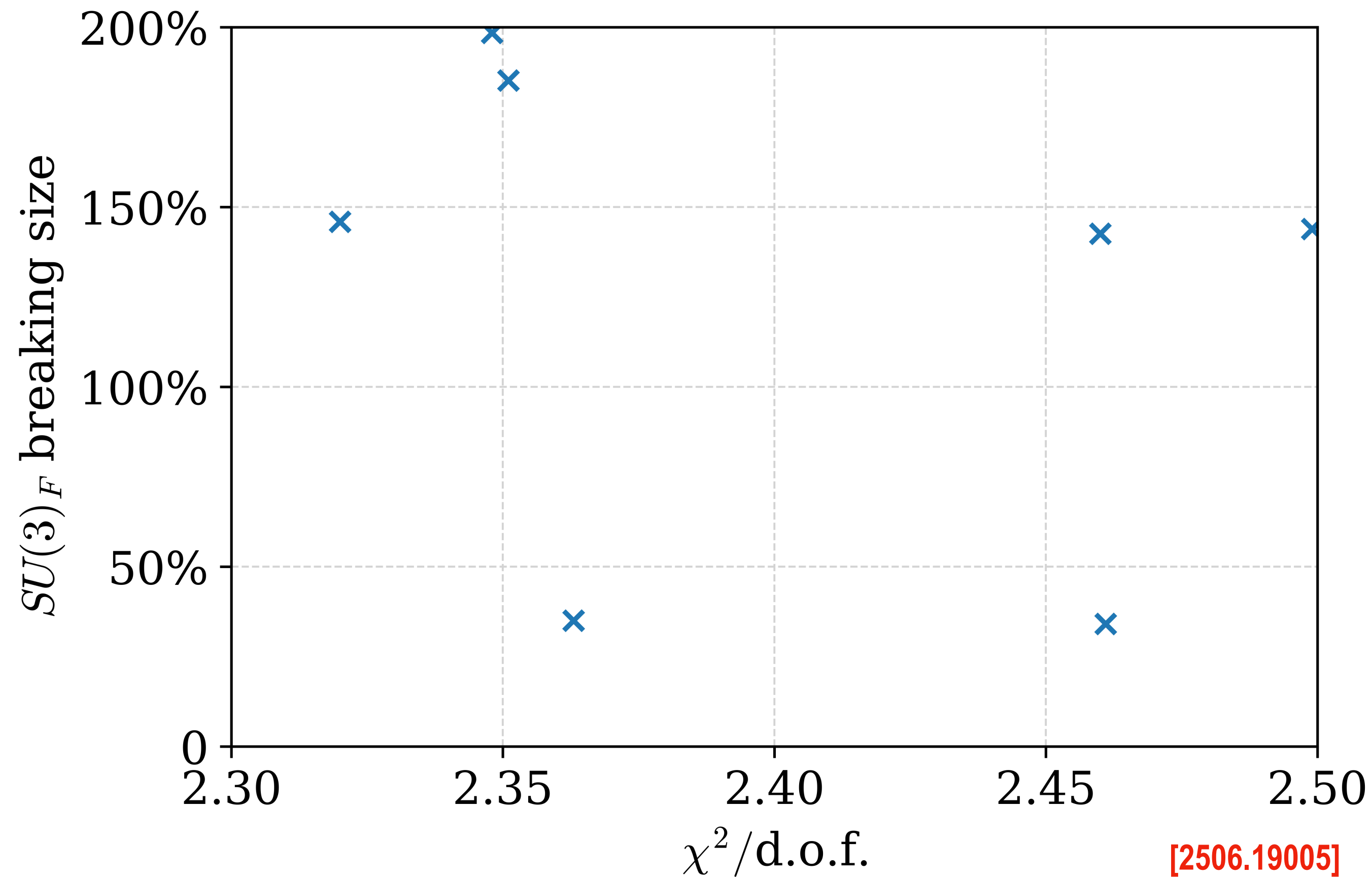
see Li's talk in this morning

• SU(3) flavor perspective of charmed baryon decays



The $SU(3)_F$ is an approximate symmetry with **errors** in 10^{-1} .

We propose a new scenario that incorporates the $SU(3)_F$ **breaking** of strange quark pair production from the vacuum.

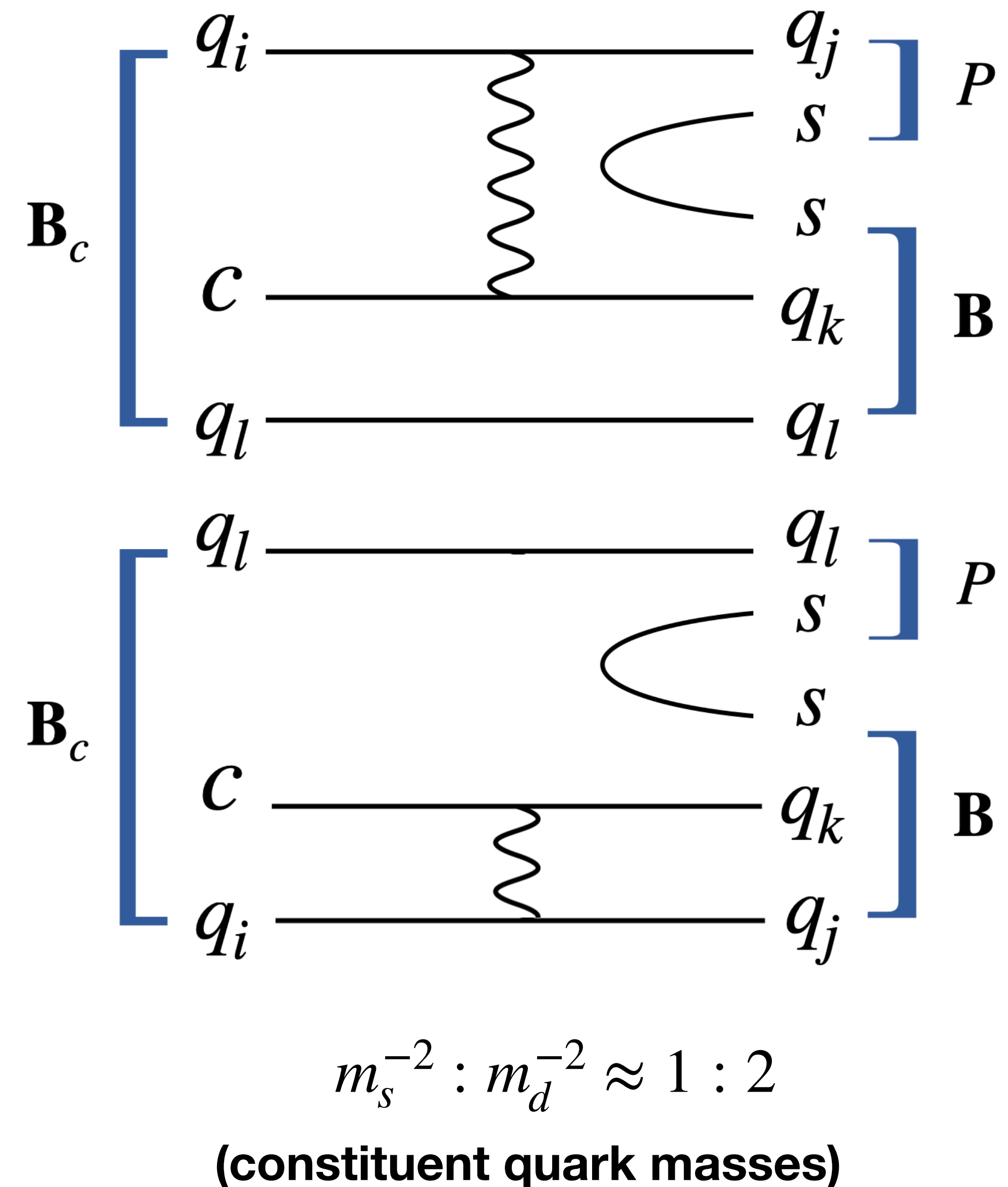
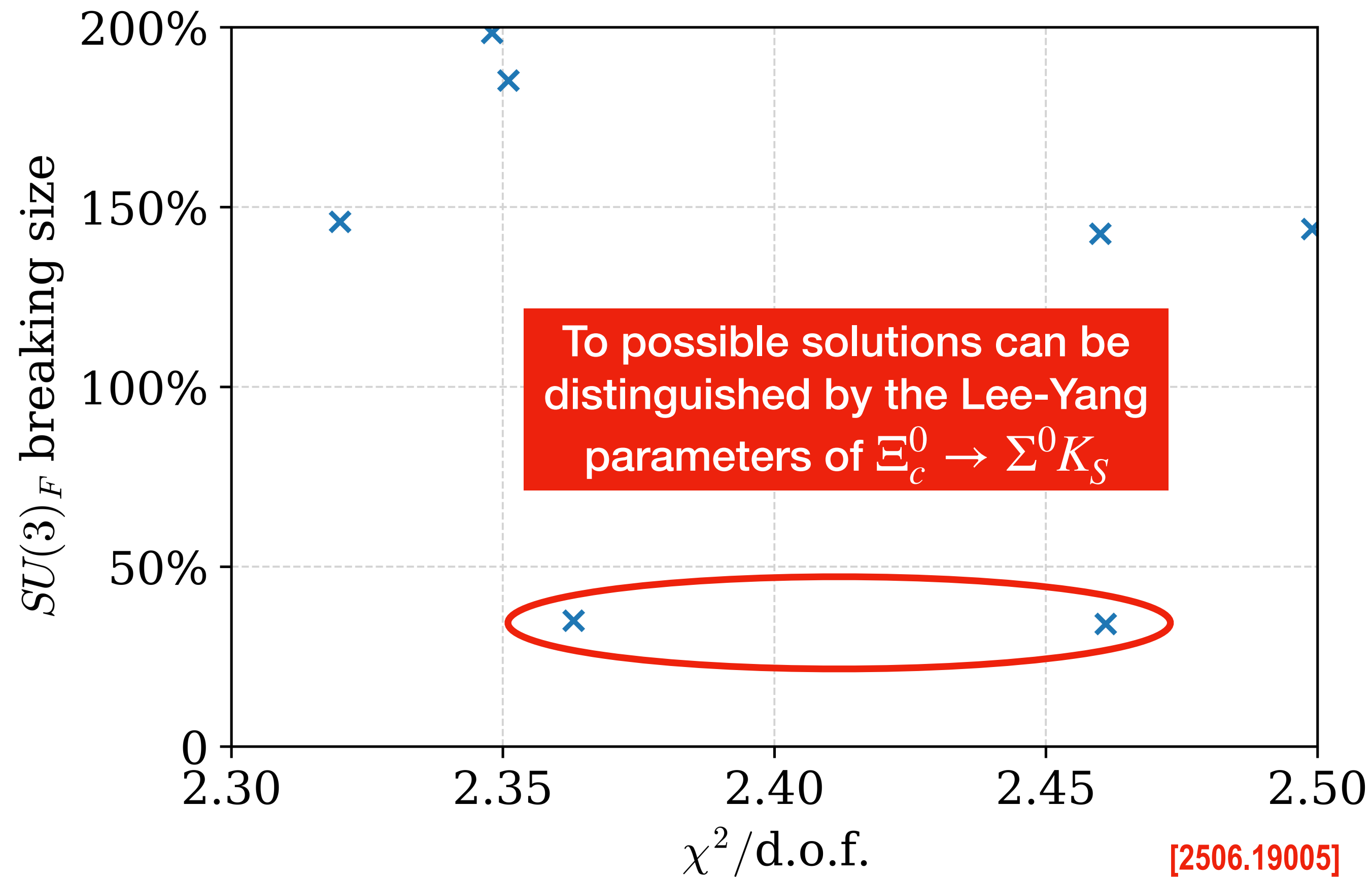


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The large χ^2 is mainly contributed by two channels:

	PDG	$SU(3)_F$ conserved	$SU(3)_F$ broken ^[2506.19005]
$10^2 \mathcal{B}(\Xi_c^0 \rightarrow \Xi^- \pi^+)$	1.43 ± 0.32	2.72 ± 0.09	2.9 ± 0.1
$10^2 \mathcal{B}(\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+)$	2.9 ± 1.3	6.82 ± 0.36	6.0 ± 0.4

Both of them are the normalized channels in $\Xi_c^{0,+}$, indicating an possible **underestimation of factor two** in the experimental side.

Same **underestimations** occurs in $\Xi_c^0 \rightarrow \Xi^- \ell^+ \nu_\ell$.

	PDG	$SU(3)_F$	Lattice	Lattice
$10^2 \mathcal{B}(\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e)$	$1.05 \pm 0.20^*$	4.10 ± 0.46	2.38 ± 0.44	3.58 ± 0.12
$10^2 \mathcal{B}(\Xi_c^0 \rightarrow \Xi^- \mu^+ \nu_\mu)$	$1.02 \pm 0.21^*$	3.98 ± 0.57	2.29 ± 0.42	3.47 ± 0.12

*Using $\mathcal{B}(\Xi_c^0 \rightarrow \Xi^- \pi^+) = (1.42 \pm 0.32) \%$

^[2110.04179]

^[2103.07064]

^[2504.07302]

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Same **underestimations** occurs in $\Xi_c^0 \rightarrow \Xi^- \ell^+ \nu_\ell$.

	PDG	$SU(3)_F$	Lattice	Lattice
$10^2 \mathcal{B}(\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e)$	$2.12 \pm 0.13^*$	4.10 ± 0.46	2.38 ± 0.44	3.58 ± 0.12
$10^2 \mathcal{B}(\Xi_c^0 \rightarrow \Xi^- \mu^+ \nu_\mu)$	$2.05 \pm 0.19^*$	3.98 ± 0.57	2.29 ± 0.42	3.47 ± 0.12

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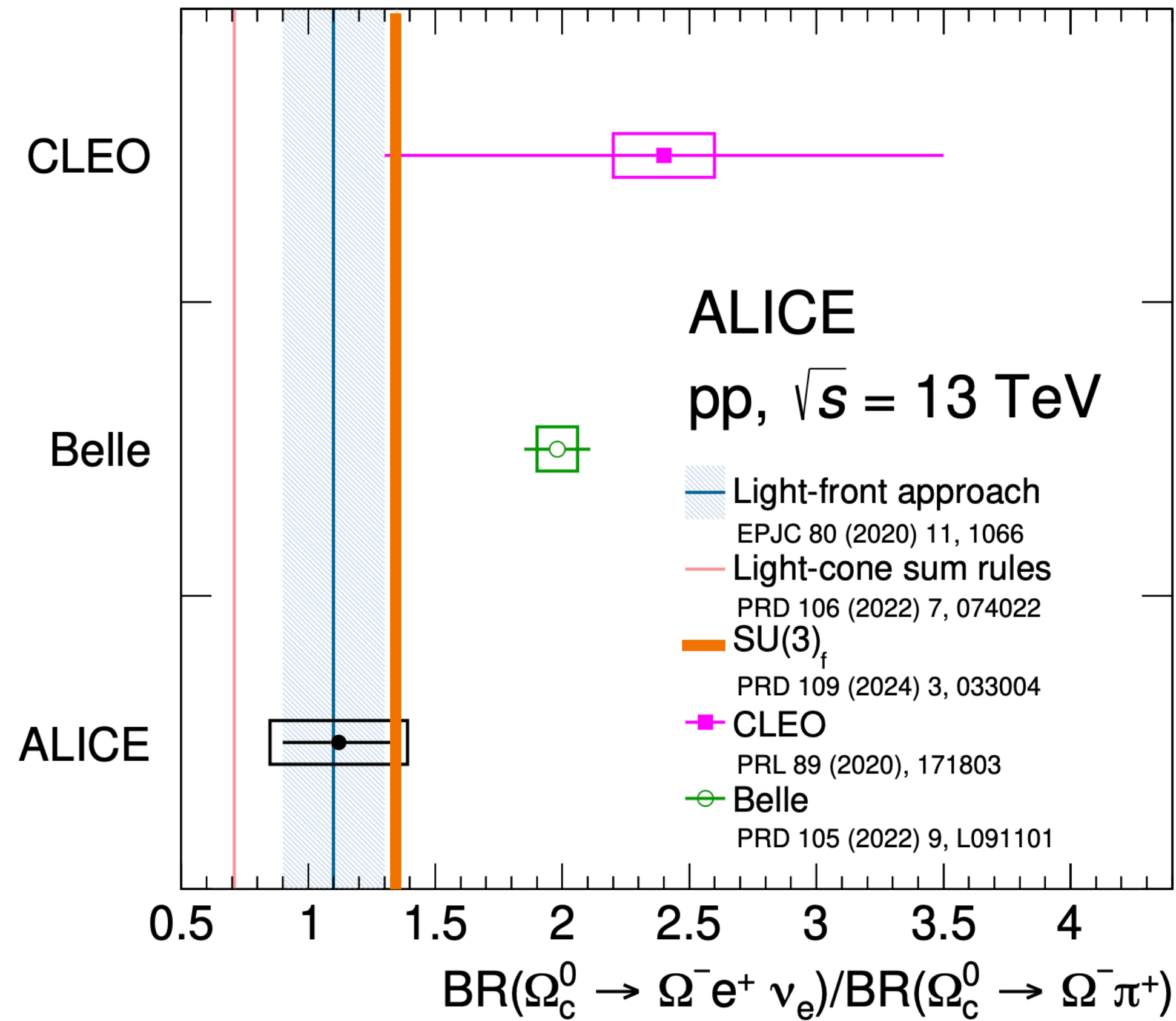
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^[2504.07302]

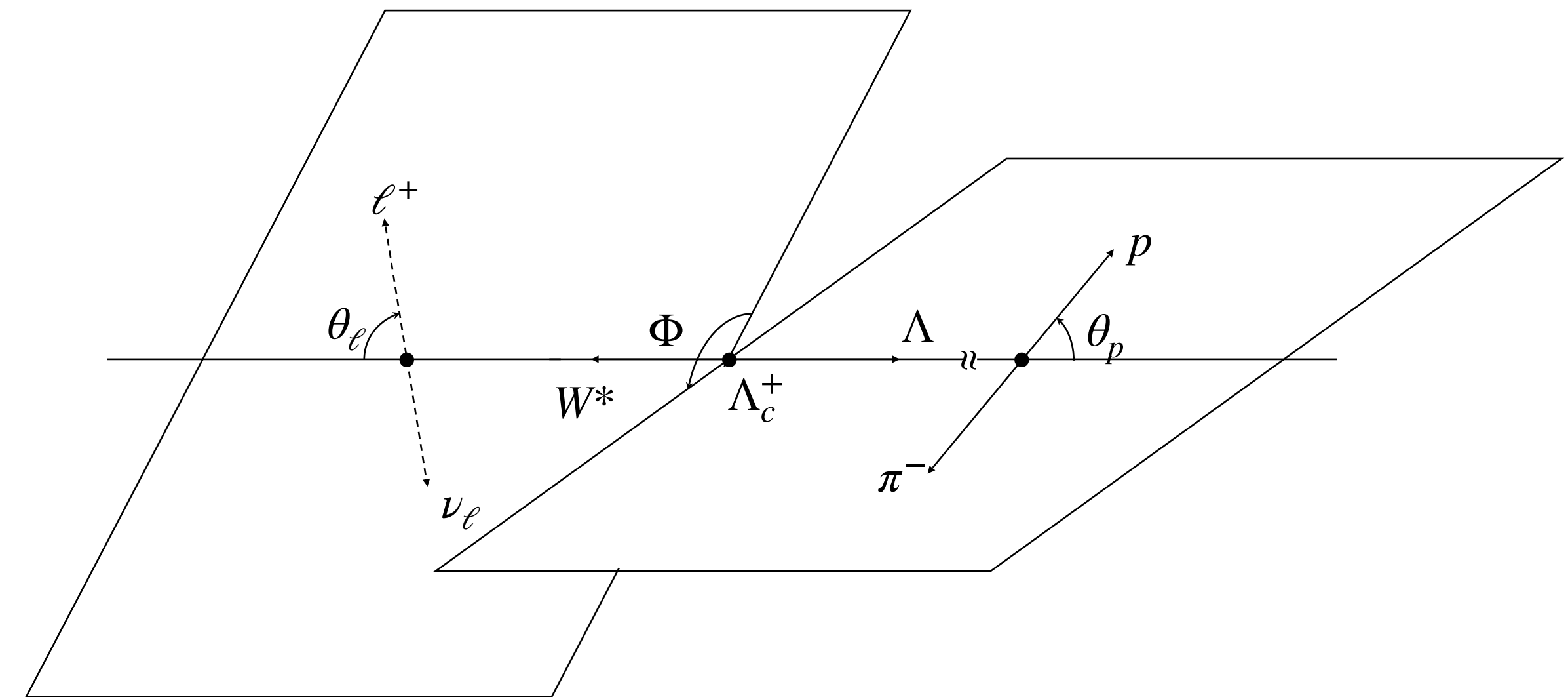
- Semileptonic decays (exclusive): Future aspect

Probing other charmed baryons



[2404.17272]

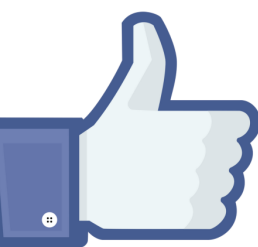
Triple product asymmetries



Vanish in the SM.



NP unlikely shares the same complex phase with the SM.



$$\begin{aligned} \mathcal{T}_p(\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e) &= -0.021 \pm 0.041_{\text{stat}} \pm 0.001_{\text{syst}} \\ \mathcal{T}_p(\Lambda_c^+ \rightarrow \Lambda \mu^+ \nu_\mu) &= 0.068 \pm 0.055_{\text{stat}} \pm 0.002_{\text{syst}} \end{aligned}$$

PRD 108, L031105 (2023)

$\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e$ remains one of the most urgent problems to solve in charm decays.

The study of charmed baryon decays — as fascinating as it is flavorful!



$$\mathcal{B}(\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e) (\%)$$

