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Experimental study of the hyperon semileptonic decays and hyperon excited states at BESIII



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Outline

Why hyperon physics at BESIII?

10 billion J/ψ, 3 billion $\psi(2S)$

Large BFs in J/ψ, $\psi(2S)$ decays

Large datasets of hyperon pair

Hyperon pair production

Double tag method

Advantage of double tag method:

- ✓ Absolute BF
- ✓ Low background
- ✓ Cancel systematic uncertainties

Table 1: Hyperon pair production base on BESIII data

Decay mode	$\mathcal{B}(\times 10^{-3})$	$N_{B\bar{B}}(\times 10^6)$
$J/\psi \to \Lambda\bar{\Lambda}$	1.89 ± 0.09	19.06 ± 0.91
$J/\psi \to \Sigma^0\bar{\Sigma}^0$	1.17 ± 0.03	11.82 ± 0.32
$J/\psi \to \Sigma^+\bar{\Sigma}^-$	1.50 ± 0.24	15.13 ± 2.42
$J/\psi \to \Sigma(1385)^-\bar{\Sigma}^+$ (or c.c.)	0.31 ± 0.05	3.13 ± 0.50
$J/\psi \to \Sigma(1385)^-\bar{\Sigma}(1385)^+$ (or c.c.)	1.16 ± 0.05	11.70 ± 0.50
$J/\psi \to \Xi^0\bar{\Xi}^0$	1.17 ± 0.04	11.80 ± 0.40
$J/\psi \to \Xi^-\bar{\Xi}^+$	0.97 ± 0.08	9.78 ± 0.81
$J/\psi \to \Xi(1530)^0\bar{\Xi}^0$	0.32 ± 0.14	3.23 ± 1.41
$J/\psi \to \Xi(1530)^-\bar{\Xi}^+$	0.32 ± 0.01	3.21 ± 0.08
$\psi(2S) \to \Omega^-\bar{\Omega}^+$	0.06 ± 0.003	0.16 ± 0.01

Quantum correlated polarized-hyperon factories (BESIII&STCF)

4-momentum conservation

Known initial 4-momentum

Information of the neutrino

Full and even extra information!
Higher single-event sensitivity!

Hyperon semileptonic decays

- ✓ First Measurement of the Absolute Branching Fraction of $\Lambda \to p\mu^-\bar{\nu}_\mu$ — PRL **127**, 121802 (2021)
- ✓ First direct measurement of the absolute branching fraction of $\Sigma^+ \to \Lambda e^+\nu_e$ — PRD **107**, 072010 (2023)
- ■ Determination of CKM matrix element and axial vector form factors from weak decays of quantum-entangled strange baryons — arXiv:2509.09266
- □ Measurement of the absolute branching fraction of $\Omega^- \to \Xi^0 e^-\bar{\nu}_e$ — BAM-00874
- □ Search for the $|\Delta S| = 2$ hyperon semileptonic decay $\Xi^0 \to pe^-\bar{\nu}_e$ — BAM-00976

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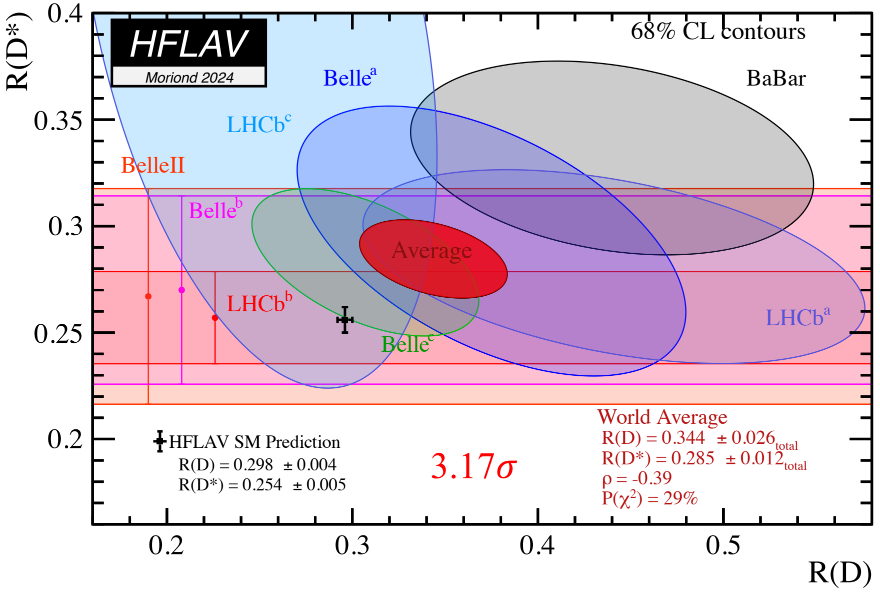
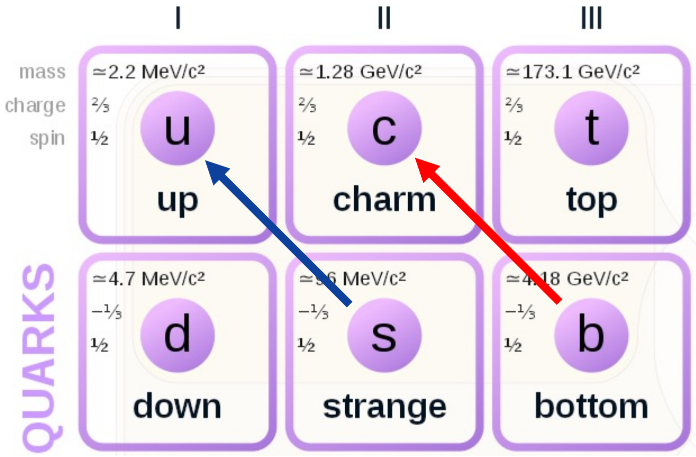
$$R(D^{(*)}) = \frac{\mathcal{B}(\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau)}{\mathcal{B}(\bar{B} \to D^{(*)}l^-\bar{\nu}_l)}$$

$$R^{\mu e} = \frac{\mathcal{B}(B \to b\mu^-\bar{\nu}_\mu)}{\mathcal{B}(B \to be^-\bar{\nu}_e)}$$

Average of R(D) and R(D*) from HFLAV (2024)





Experiment vs. SM NLO for $R^{\mu e}$ from hyperon semileptonic decays [PRL 114, 161802 (2015)].

$R^{\mu e}$	$\Lambda \to pl^-\bar{\nu}_l$	$\Sigma^- \to nl^-\bar{\nu}_l$	$\Xi^0 \to \Sigma^+l^-\bar{\nu}_l$	$\Xi^- \to \Lambda l^-\bar{\nu}_l$
Experiment	0.189±0.041	0.442±0.039	0.0092±0.0014	0.6±0.5
SM NLO	0.153±0.008	0.444±0.022	0.0084±0.0004	0.275±0.014

Research status

- Before our measurement, there are only **fixed-target experiments** performed about 50 years ago.
- All these previous branching fraction results are **relative with huge uncertainty**.
- The best previous result was obtained **based on only 14 events** selected from about 0.6M **bubble chamber pictures**.

$\Lambda \to p\mu^-\bar{\nu}_\mu$ PDG 2020

$\Gamma(\Lambda \to p\mu^-\bar{\nu}_\mu)/\Gamma(\Lambda \to N\pi)$

VALUE (10^{-4})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.57 ± 0.35	**OUR FIT**				
1.57 ± 0.35	**OUR AVERAGE**				
1.4 ±0.5	14	BAGGETT	1972B	HBC	K^-p at rest
2.4 ±0.8	9	CANTER	1971B	HBC	K^-p at rest
1.3 ±0.7	3	LIND	1964	RVUE	
1.5 ±1.2	2	RONNE	1964	FBC	

Hyperon semileptonic decays: $\Lambda \to p\mu^-\bar{\nu}_\mu$

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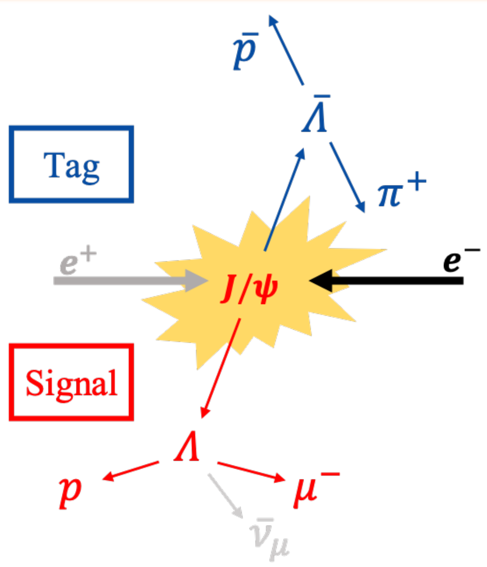
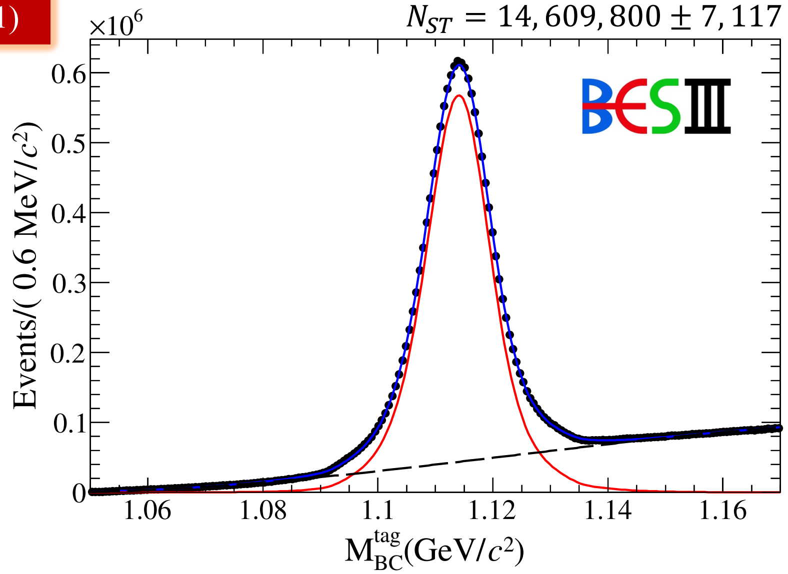
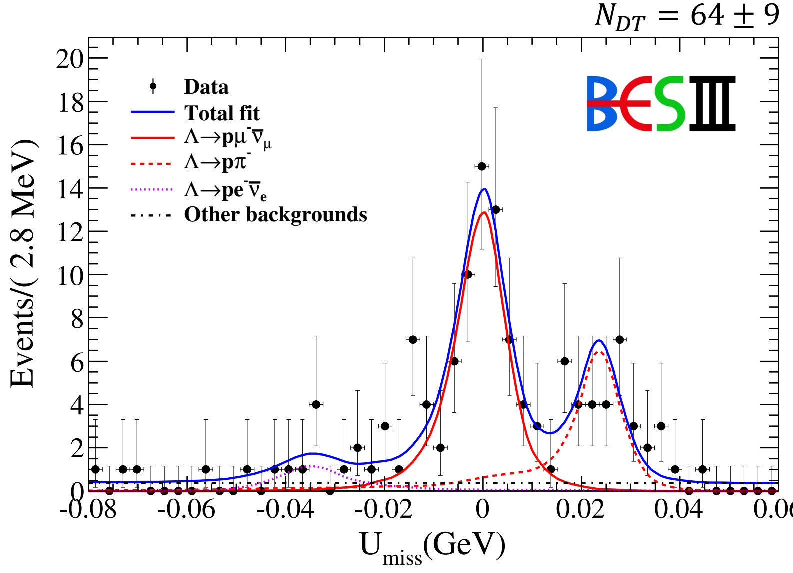
BESIII Collaboration, Phys. Rev. Lett. 127, 121802 (2021)







First absolute BF measurement

$$\mathcal{B}(\Lambda \to p\mu^-\bar{\nu}_\mu) = (1.48 \pm 0.21 \pm 0.08)\times 10^{-4}$$

- ✓ Update measurement after about 50 years break
- ✓ The first study at a collider experiment
- ✓ Precision improved with a factor of two

Test lepton flavor universality

$$R^{\mu e} = \frac{\mathcal{B}(\Lambda \to p\mu^-\bar{\nu}_\mu)}{\mathcal{B}(\Lambda \to pe^-\bar{\nu}_e)_{PDG}} = 0.178 \pm 0.028$$

Consistent with LFU

$R_{SM}^{\mu e} = 0.153 \pm 0.008$
PRL **114,** 161802 (2015)

Open a new area of studying hyperon semileptonic decays in electron-positron collisions!

Hyperon semileptonic decays

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Motivation

- About second-class currents, previous nuclear β decay experiments gave contradictory conclusions.
  - ✓ Refs. [1-4] are in favor of the existence of the second-class currents
  - ✓ Refs. [5-8] reported the absence of second-class currents.

- In hyperon β decay, flavor-SU(3)-symmetry-breaking effects [9-10] or second-class currents [11] can cause a nonzero axial-vector form factor g_2, and some of the experiments suggest a large g_2 [12].

[1] Phys. Rev. Lett. **35**, 1566 (1975).
[2] Phys. Rev. Lett. **34**, 1533 (1975).
[3] Phys. Rev. C **59**, 1113 (1999).
[4] Phys. Rev. C **95**, 035501 (2017).
[5] Phys. Rev. Lett. **26**, 1127 (1971).
[6] Phys. Rev. Lett. **32**, 314 (1974).
[7] Eur. Phys. J. A **7**, 307 (2000).
[8] Phys. Rev. C **84**, 055501 (2011).
[9] Phys. Rev. D **8**, 2963 (1973).
[10] Phys. Rev. D **79**, 074508 (2009).
[11] Annu. Rev. Nucl. Part. Sci. **53**, 39 (2003).
[12] Phys. Rev. D **3**, 2638 (1971).

Motivation

- In order to confirm the existence of second-class currents, a unique observable (R) was first proposed by S. Weinberg [1] in 1958.

$$R \equiv \frac{\Gamma(\Sigma^- \to \Lambda \mathrm{e}^- \bar{\nu}_\mathrm{e})}{\Gamma(\Sigma^+ \to \Lambda \mathrm{e}^+ \nu_\mathrm{e})}$$

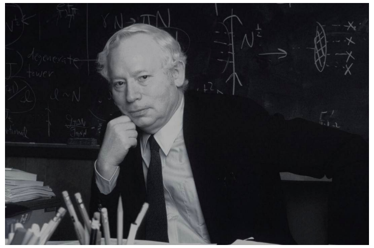
- If there is no second-class currents, R value should be just the phase-space ratio for these two decays , no matter flavor-SU(3)-symmetry-breaking effects exist or not, so any experimental deviation from this deduction would be decisive evidence for the existence of second-class currents.

PHYSICAL REVIEW VOLUME 112, NUMBER 4 NOVEMBER 15, 1958

Charge Symmetry of Weak Interactions*

STEVEN WEINBERG
Columbia University, New York, New York

(Received June 25, 1958)



[1] Phys. Rev. **112**, 1375 (1958).

Motivation

➢ T. D. Lee and C. N. Yang [1] calculate R on the basis of no second-class currents.

$$R = 1.57$$

PHYSICAL REVIEW VOLUME 119, NUMBER 4 AUGUST 15, 1960

Implications of the Intermediate Boson Basis of the Weak Interactions: Existence of a Quartet of Intermediate Bosons and Their Dual Isotopic Spin Transformation Properties

T. D. Lee
Columbia University, New York, New York

AND

C. N. Yang
Institute for Advanced Study, Princeton, New Jersey

(Received April 11, 1960)


Chen Ning Yang


Tsung-Dao Lee

[1] Phys. Rev. **119**, 1410 (1960).

Motivation

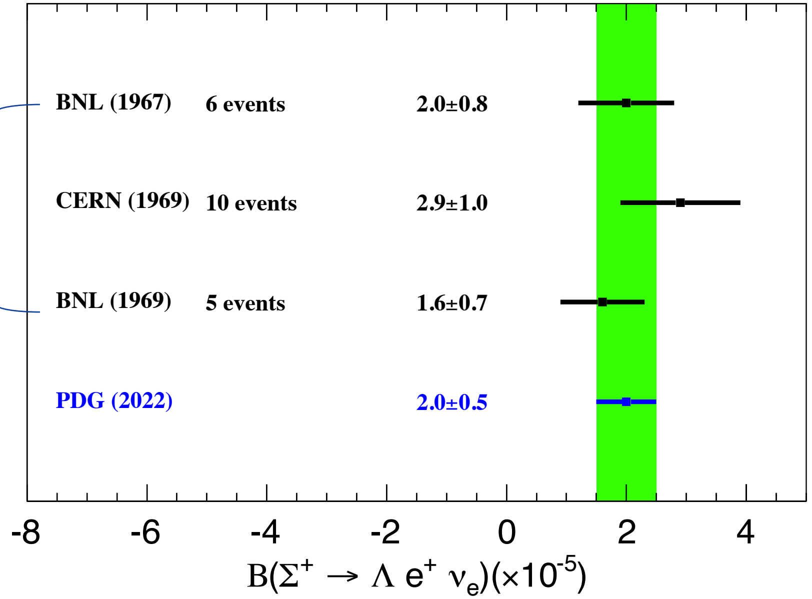
$$R \equiv \frac{\Gamma(\Sigma^- \to \Lambda e^- \bar{\nu}_e)}{\Gamma(\Sigma^+ \to \Lambda e^+ \nu_e)} = \frac{\mathcal{B}(\Sigma^- \to \Lambda e^- \bar{\nu}_e) \cdot \tau_{\Sigma^+}}{\mathcal{B}(\Sigma^+ \to \Lambda e^+ \nu_e) \cdot \tau_{\Sigma^-}}$$

From PDG2022 [1]:

$\sigma(\tau_{\Sigma^+}) \sim 0.3\%$ $\sigma[\mathcal{B}(\Sigma^- \to \Lambda e^- \bar{\nu}_e)] \sim 4.7\%$

$\sigma(\tau_{\Sigma^-}) \sim 0.7\%$ $\sigma[\mathcal{B}(\Sigma^+ \to \Lambda e^+ \nu_e)] \sim 25\%$

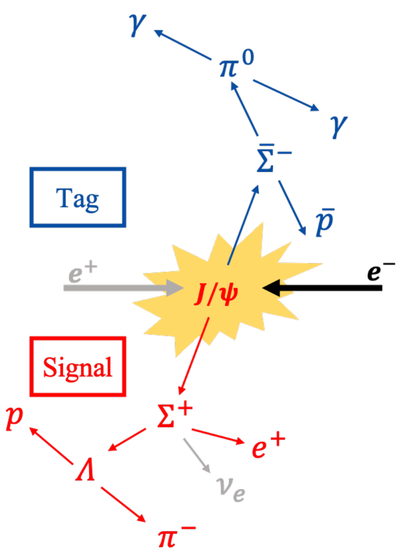
1. Fixed-target experiments
2. Bubble chamber pictures
3. Indirect measurement

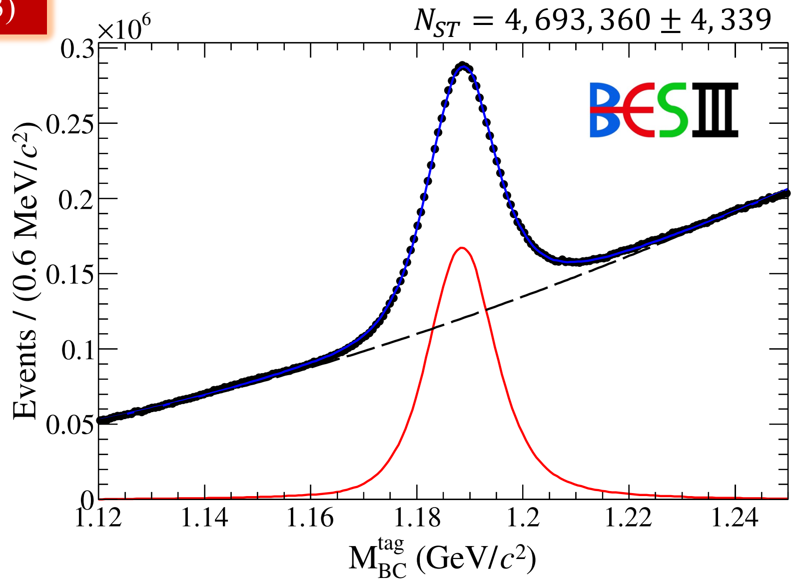


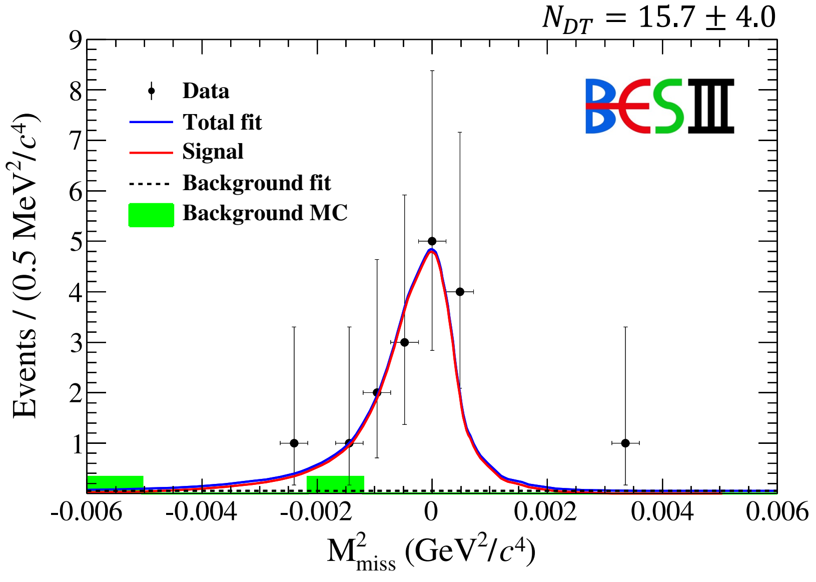
[1] Prog. Theor. Exp. Phys. **2022**, 083C01 (2022).

Hyperon semileptonic decays: $\Sigma^+ \to \Lambda e^+ \nu_e$

BESIII Collaboration, Phys. Rev. D 107, 072010 (2023)







First derect measurement of absolute BF

$$\mathcal{B}(\Sigma^+ \to \Lambda e^+ \nu_e) = (2.93 \pm 0.74 \pm 0.13)\times 10^{-5}$$

- ✓ Update measurement after about 50 years break
- ✓ The first study at a collider experiment
- ✓ The most precise result in a single experiment

Search for second-class currents

$$R \equiv \frac{\Gamma(\Sigma^- \to \Lambda e^- \bar{\nu}_e)}{\Gamma(\Sigma^+ \to \Lambda e^+ \nu_e)} = \frac{\mathcal{B}(\Sigma^- \to \Lambda e^- \bar{\nu}_e)_{PDG} \cdot \tau_{\Sigma^+ PDG}}{\mathcal{B}(\Sigma^+ \to \Lambda e^+ \nu_e) \cdot \tau_{\Sigma^- PDG}} = 1.06 \pm 0.28$$

NO evidence for the second-class currents is founded.

Hyperon semileptonic decays

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In the SM: First-row unitarity relation

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1$$

2.3σ tension

A hint of new physics?

PDG 2024: Independent measurements

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 0.9984 \pm 0.0007$$

- $|V_{ub}|$: Small（$|V_{ub}|^2 \cong 1.5\times10^{-5}$） ➡ The effect could be ignored in current precision
- $|V_{ud}|$: Most precise; results from different decays are consistent at $\mathcal{O}(10^{-4})$ ➡ Precise and reliable
- $|V_{us}|$: $\sigma\,(|V_{us}|) = 2.6\times\sigma\,(|V_{ud}|)$; inconsistence between results from different decays

PRL **92**, 251803 (2004)

Most precise	Second most precise	Largest uncertainty
Kaon: 2.3σ tension from CKM unitarity	**Tau**: 3.6σ deviation from CKM unitarity	**Hyperon**: consistent with CKM unitarity
$\lvert V_{us}\rvert = 0.2243 \pm 0.0008$	$\lvert V_{us}\rvert = 0.2207 \pm 0.0014$	$\lvert V_{us}\rvert = 0.2250 \pm 0.0027$
PDG 2024	HFLAV 2022	**Dominated by the $\Lambda \to pe^-\bar{\nu}_e$**

2.2σ tension

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Decay width of $\Lambda \to pe^-\bar{\nu}_e$ in the SM

PRD **70**, 114036 (2004)

$$\Gamma_{\rm SM} = \frac{\mathcal{B}_{\Lambda\to pe^-\bar{\nu}_e}}{\tau_\Lambda} = \frac{G_F^2|V_{us}|^2 f_1(0)^2\Delta^5}{60\pi^3}\left[\left(1-\frac{3}{2}\delta+\frac{6}{7}\delta^2\right)+\frac{4}{7}\delta^2 g_w^2\right.$$
$$\left.+\left(3-\frac{9}{2}\delta+\frac{12}{7}\delta^2\right)g_{av}^2+\frac{12}{7}\delta^2 g_{av2}^2+\frac{6}{7}\delta^2 g_w+(-4\delta+6\delta^2)g_{av}g_{av2}\right]$$

$$\Delta \equiv M_\Lambda - M_p$$

$$\delta \equiv \frac{M_\Lambda - M_p}{M_\Lambda}$$

- Extracting $|V_{us}|$, requires $\mathcal{B}_{\Lambda\to pe^-\bar{\nu}_e}$, $f_1(0)$, $g_{av} \equiv \frac{g_1(0)}{f_1(0)}$, $g_w \equiv \frac{f_2(0)}{f_1(0)}$, and $g_{av2} \equiv \frac{g_2(0)}{f_1(0)}$,
  - $f_1(0)$: From LQCD
  - $\mathcal{B}_{\Lambda\to pe^-\bar{\nu}_e}$, g_{av}, g_w, and g_{av2}: From experimental measurement

Hyperon semileptonic decays: $\Lambda \to p e^- \bar{\nu}_e$

Research status of $\mathcal{B}_{\Lambda \to p e^- \bar{\nu}_e}$

- Only relative BF
- Old results (>40 years)
- Only fixed target experiment

$\Gamma(\Lambda \to p e^- \bar{\nu}_e)/\Gamma(\Lambda \to p \pi^-)$ — PDG 2024 — Γ_5/Γ_1

VALUE (10^{-3})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.301 ± 0.019	OUR AVERAGE				
1.335 ± 0.056	7111	BOURQUIN	1983	SPEC	SPS hyperon beam
1.313 ± 0.024	10k	WISE	1980	SPEC	
1.23 ± 0.11	544	LINDQUIST	1977	SPEC	$\pi^- p \to K^0 \Lambda$
1.27 ± 0.07	1089	KATZ	1973	HBC	
1.31 ± 0.06	1078	ALTHOFF	1971	OSPK	
1.17 ± 0.13	86	[1] CANTER	1971	HBC	$K^- p$ at rest
1.20 ± 0.12	143	[2] MALONEY	1969	HBC	
1.17 ± 0.18	120	[2] BAGLIN	1964	FBC	K^- freon 1.45 GeV/c
1.23 ± 0.20	150	[2] ELY	1963	FBC	
• • We do not use the following data for averages, fits, limits, etc. • •					
1.32 ± 0.15	218	[1] LINDQUIST	1971	OSPK	See LINDQUIST 1977

Research status of g_{av}

All assume $g_2 = 0$

Old results (>30 years)

Only fixed target experiment

g_A / g_V FOR $\Lambda \to pe^-\bar{\nu}_e$

PDGID:S018AV

INSPI

PDG 2024

Measurements with fewer than 500 events have been omitted. Where necessary, signs have been changed to agree with our conventions, which are given in the "Note on Baryon Decay Parameters" in the neutron Listings. The measurements all assume that the form factor $g_2 = 0$. See also the footnote on DWORKIN 1990 .

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
-0.718 ± 0.015 OUR AVERAGE					
$-0.719 \pm 0.016 \pm 0.012$	37k	[1] DWORKIN	1990	SPEC	$e\nu$ angular corr.
-0.70 ± 0.03	7111	BOURQUIN	1983	SPEC	$\Xi \to \Lambda\pi^-$
-0.734 ± 0.031	10k	[2] WISE	1981	SPEC	$e\nu$ angular correl.
• • We do not use the following data for averages, fits, limits, etc. • •					
-0.63 ± 0.06	817	ALTHOFF	1973	OSPK	Polarized Λ

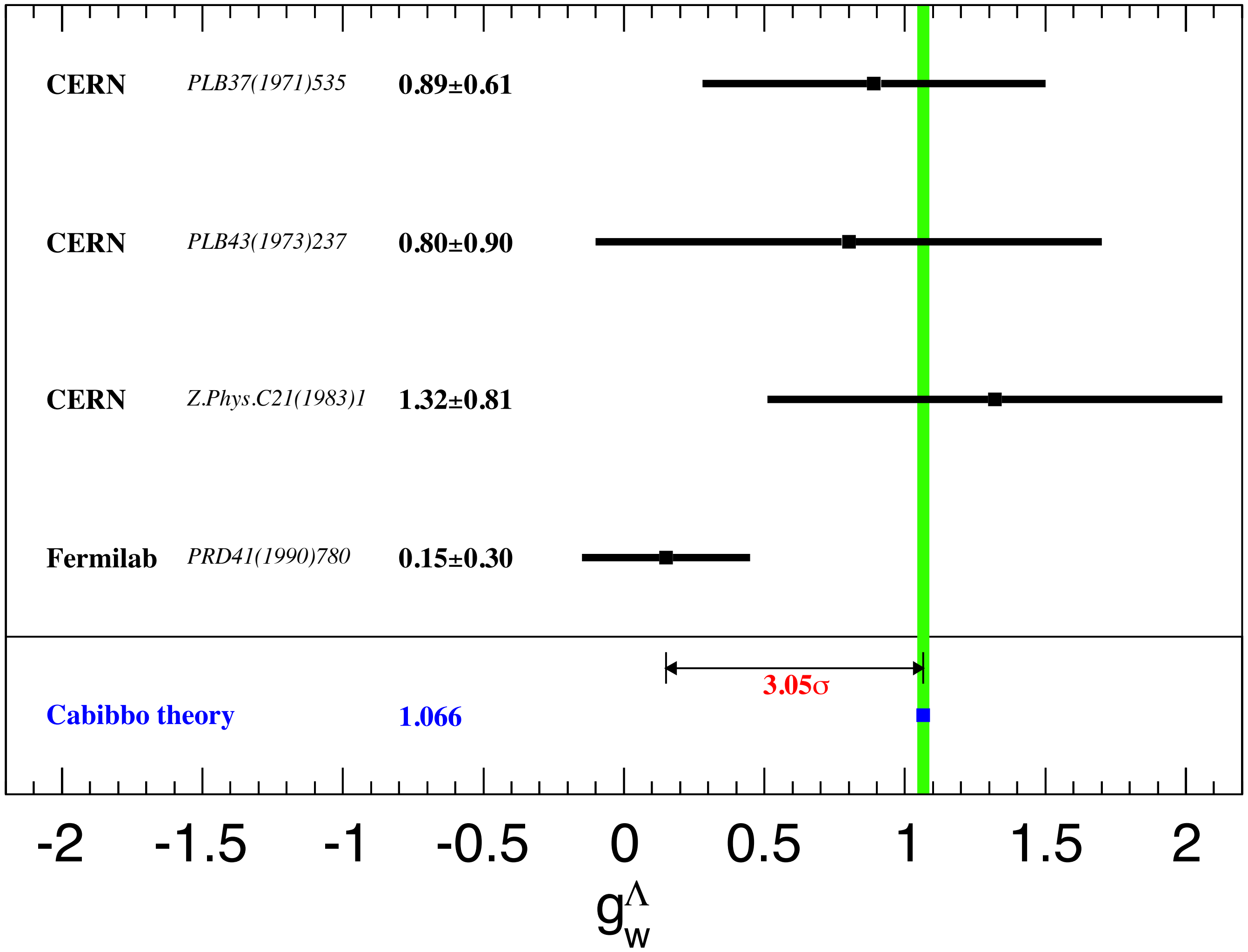
Research status of g_w, and g_{av2}

g_w:

- Results are old and scarce
- 3.05σ deviation
- Only fixed target experiment

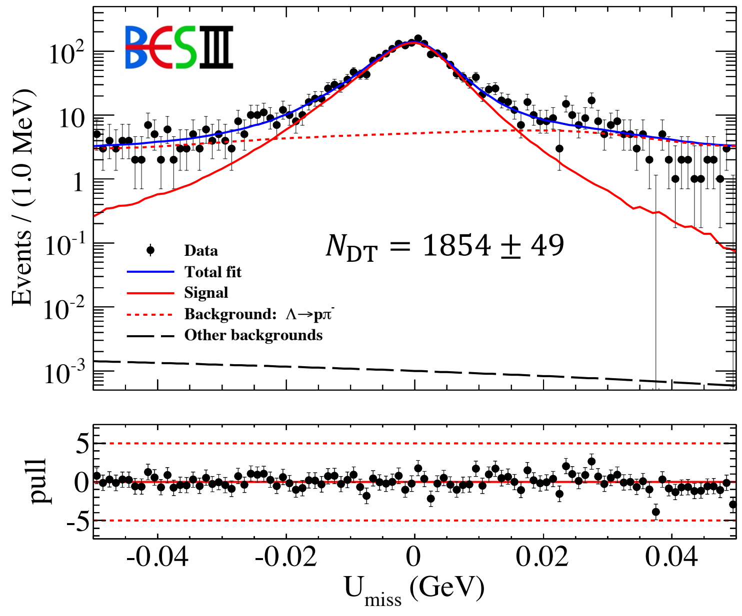
g_{av2}:

- No experimental measurement



Hyperon semileptonic decays: $\Lambda \to p e^- \bar{\nu}_e$

BESIII Collaboration, arXiv:2509.09266



Observable	This work	Previous result
g_{av}^-	$0.742^{+0.075}_{-0.057} \pm 0.009$	0.718 ± 0.015 [PDG2024]
g_{av}^+	$-0.706^{+0.069}_{-0.073} \pm 0.014$	-
$\langle g_{av} \rangle$	$0.729^{+0.048}_{-0.047} \pm 0.007$	-
g_w^-	$0.93 \pm 0.51 \pm 0.17$	0.15 ± 0.30 [PRD41(1990)780]
g_w^+	$0.89 \pm 0.49 \pm 0.20$	-
$\langle g_w \rangle$	$0.89 \pm 0.35 \pm 0.14$	-
$\langle g_{av} \rangle$	$0.706^{+0.089}_{-0.086}$	-
$\langle g_w \rangle$	$0.77^{+0.53}_{-0.49}$	-
$\langle g_{av2} \rangle$	$-0.19^{+0.65}_{-0.63}$	-

Assuming $g_{av2} = 0$

First absolute BF measurement

$$\mathcal{B}(\Lambda \to p e^- \bar{\nu}_e) = (8.16 \pm 0.22 \pm 0.15)\times 10^{-4}$$

Used approach allows FF extraction with reasonable uncertainties using limited data

- This work: $1.8 \cdot 10^3$ events $\to$ $\sigma_{\langle g_{av} \rangle} = 0.049$, $\sigma_{\langle g_w \rangle} = 0.38$
- Fermilab [PRD41(1990)780]: $37 \cdot 10^3$ events $\to$ $\sigma_{g_{av}} = 0.020$, $\sigma_{g_w} = 0.30$

Hyperon semileptonic decays: $\Lambda \to pe^-\bar{\nu}_e$

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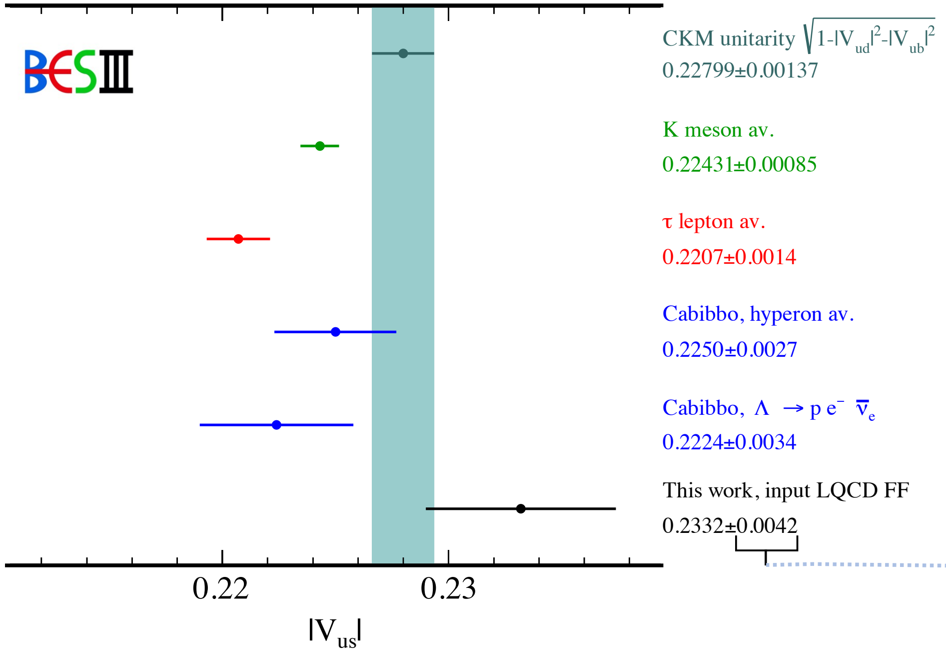
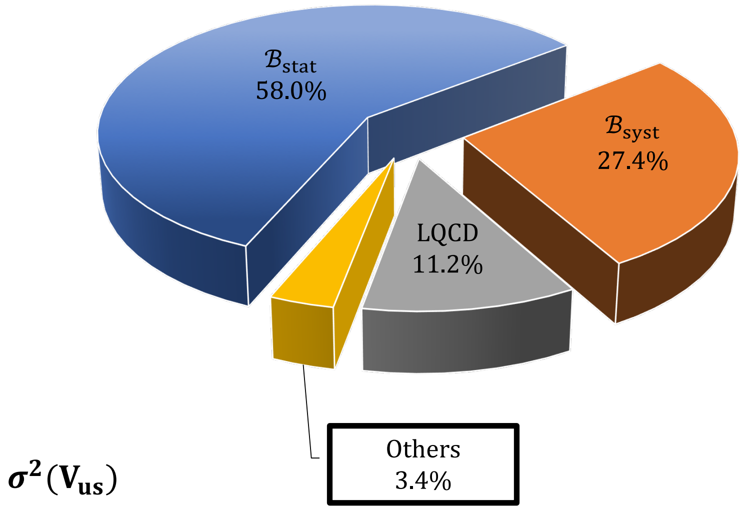
BESIII Collaboration, arXiv:2509.09266

- Assume SU(3) is conserved, $f_1 = \sqrt{3/2}$ [PRL92(2004)251803]
  $|V_{us}|_{\mathrm{SU(3)}} = 0.2199 \pm 0.0036_{\mathrm{BESIII\ BF}} \pm 0.0087_{\mathrm{BESIII\ FF}} \pm 0.0004_{\tau_\Lambda} \pm 0.0005_{\mathrm{RC}}$

- Using LQCD FF prediction [arXiv:2507.09970]
  $|V_{us}|_{\mathrm{LQCD}} = 0.2332 \pm 0.0039_{\mathrm{BESIII\ BF}} \pm 0.0004_{\tau_\Lambda} \pm 0.0006_{\mathrm{RC}} \pm 0.0014_{\mathrm{LQCD}}$





Hyperon semileptonic decays

- ✓ First Measurement of the Absolute Branching Fraction of $\Lambda \to p\mu^- \bar{\nu}_\mu$ — PRL **127**, 121802 (2021)
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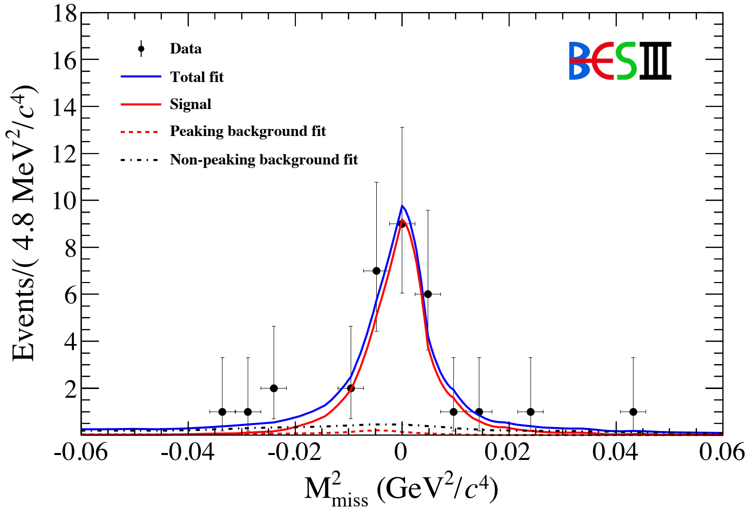
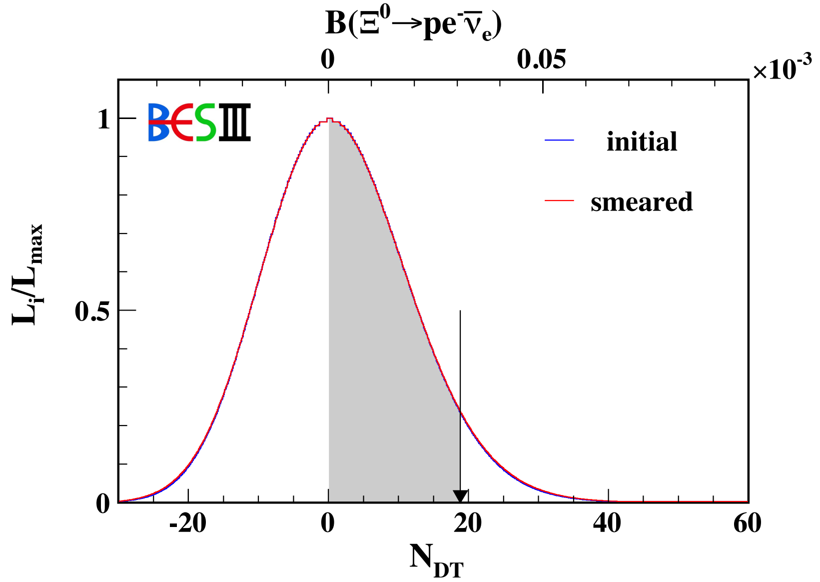
Measurement of the absolute branching fraction of $\Omega^- \to \Xi^0 e^- \bar{\nu}_e$ (BAM-00874)



$$\mathcal{B}_{\Omega^- \to \Xi^0 e^- \bar{\nu}_e} = [5.17 \pm 1.22(stat) \pm 0.33(syst)]\times 10^{-3}$$

The precision is improved by a factor of larger than two compared to the previous world average value.

Search for the $|\Delta S| = 2$ hyperon semileptonic decay $\Xi^0 \to p e^- \bar{\nu}_e$ (BAM-00976)



$$\mathcal{B}_{\Xi^0 \to p e^- \bar{\nu}_e} < 3.1\times 10^{-5}\ @90\%\ C.L.$$

This result represents an improvement of two orders of magnitude over the previous upper limit.

Hyperon excited states

- ✓ Evidence for Two Excited Ω^- Hyperons — PRL **134**, 131903 (2025)
- ☐ Study of $\psi(2S) \rightarrow K^-\Lambda\,\bar{\Xi}(1530)^+ + c.c.$ — BESIII DocDB-doc-1535

Hyperon excited states

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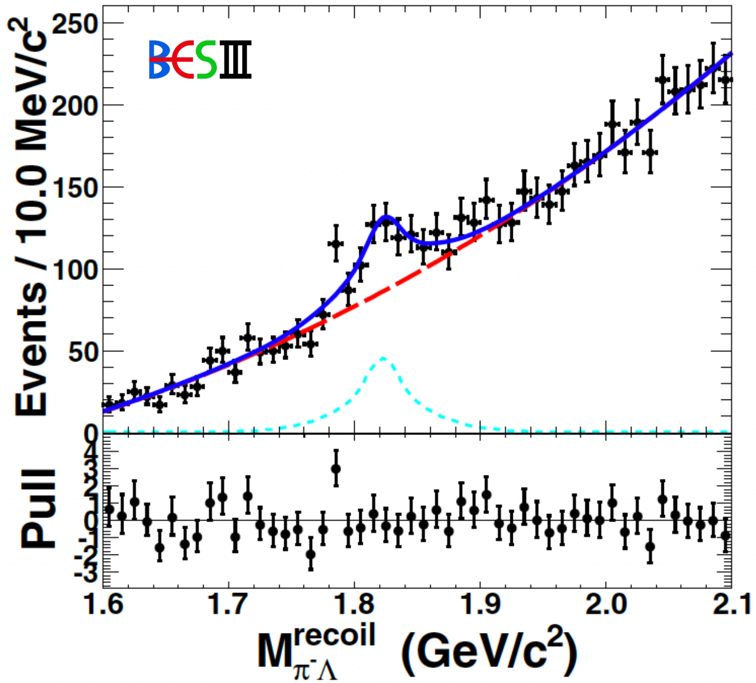
Hyperon excited states: Ω^*

Ω^- From PDG	$3/2^+$	****
$\Omega(2012)^-$	$?^-$	***
$\Omega(2250)^-$		***
$\Omega(2380)^-$		**
$\Omega(2470)^-$		**

**** Existence is certain, and properties are at least fairly explored.

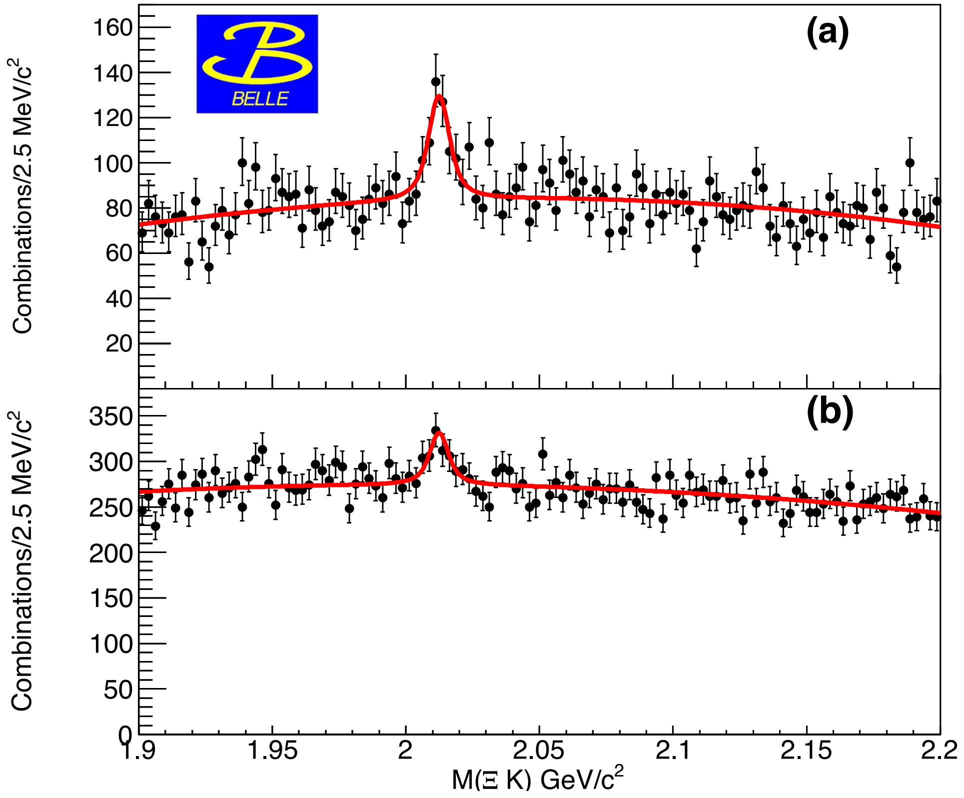
*** Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, etc. are not well determined.

** Evidence of existence is only fair.



- There are only 4 excited Ω^- hyperons in the PDG, and for 2 of them "the evidences of existence are only fair".
- According to quark model, many excited Ω^- hyperons are "missed" on the experiment. [PRD **101**, 016002(2020), etc]
- BESIII so far has collected large data sample at center-of-mass energy above open charm threshold, and $\Xi(1820)^-$ was confirmed using this data sample. [PRL **124**, 032002 (2020)]

We can search for excited Ω^- hyperons using the XYZ data.



J. Yelton *et al.* (Belle Collaboration), PRL **121**, 052003 (2018)

In 2018, Belle experiment discovered the excited baryon $\Omega(2012)^-$ in the ΞK mass spectrum.

$$M_{\Omega(2012)^-} = 2012.4 \pm 0.7 \pm 0.6\ \ \mathrm{MeV}/c^2$$

$$\Gamma_{\Omega(2012)^-} = 6.4^{+2.5}_{-2.0} \pm 1.6\ \mathrm{MeV}$$

Before our study, it had only been observed by the Belle experiment and had not been confirmed by any other experiments.

Hyperon excited states: Ω^*

Fudan University

$$\mathcal{R}_{\Xi\bar{K}}^{\Xi\pi\bar{K}} \equiv \frac{\mathcal{B}[\Omega(2012) \to \Xi(1530)\bar{K} \to \Xi\pi\bar{K}]}{\mathcal{B}[\Omega(2012) \to \Xi\bar{K}]}$$

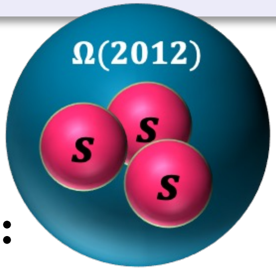
Belle 2019 measurement:
S. Jia *et al.* (Belle Collaboration), PRD **100**, 032006 (2019)

$$\mathcal{R}_{\Xi\bar{K}}^{\Xi\pi\bar{K}} < 11.9\% \ (90\% \text{ C.L.})$$

Belle 2022 measurement:
S. Jia *et al.* (Belle Collaboration), PLB **860**, 139224 (2025)

$$\mathcal{R}_{\Xi\bar{K}}^{\Xi\pi\bar{K}} = 0.99 \pm 0.26 \pm 0.06$$

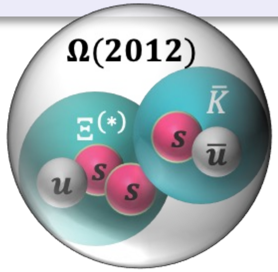
Very different



Conventional quark model:
Consistent with Belle 2019 measurement

M. S. Liu, K. L. Wang, Q. F. Lü, and X. H. Zhong PRD **101**, 016002 (2020);
R. N. Faustov and V. O. Galkin, PRD **92**, 054005 (2015);
Y. Chen and B. Q. Ma, Nucl. Phys. A **831**, 1 (2009);
M. Pervin and W. Roberts, PRC **77**, 025202 (2008);
Y. Oh, PRD **75**, 074002 (2007).
……

VS



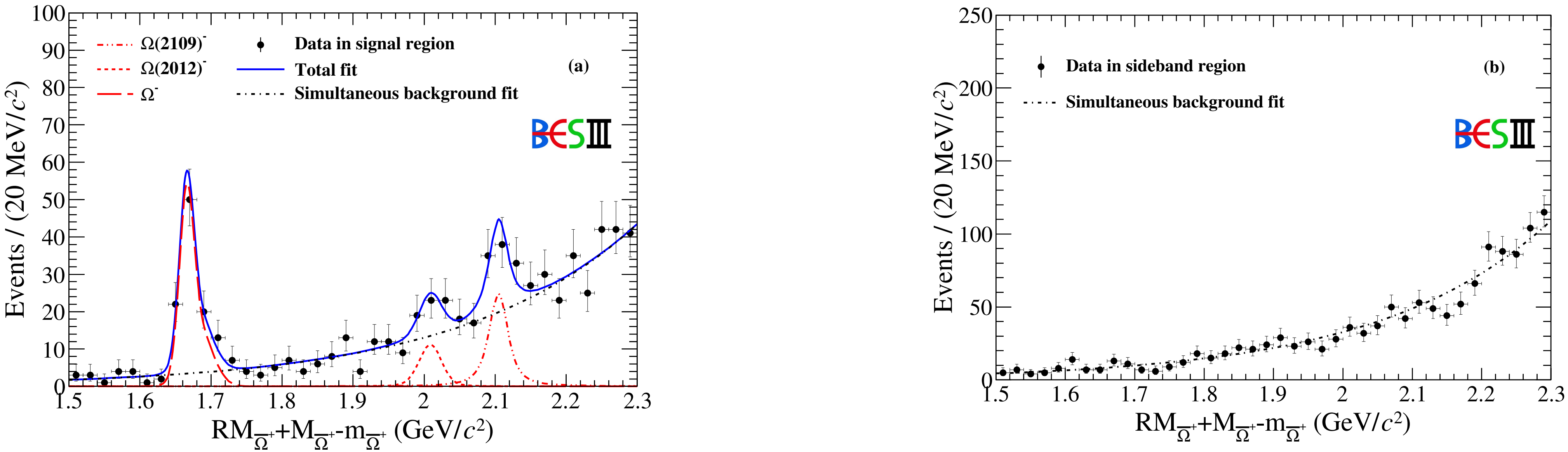
Molecules:
Consistent with Belle 2022 measurement

Y. H. LinN. Ikeno, G. Toledo, and E. Oset, PRD **101**, 094016 (2020);
Y. H. Lin, F. Wang, and B. S. Zou, PRD **102**, 074025 (2020);
C. H. Zeng, J. X. Lu, E. Wang, J. J. Xie, and L. S. Geng, PRD **102**, 076009 (2020);
J. X. Lu, C. H. Zeng, E. Wang, J. J. Xie, and L. S. Geng, EPJC **80**, 361 (2020);
Y. H. Lin and B. S. Zou, PRD **98**, 056013 (2018).
……

Hyperon excited states: Ω^*

BESIII Collaboration, Phys. Rev. Lett. 134, 131903 (2025)

From $\sqrt{s} = 4.130$ to 4.700 GeV. ($\sim 19\ fb^{-1}$ data in total)



$\boldsymbol{\Omega(2109)^-}$

$N_{\Omega(2109)^-} = 53 \pm 19$

$M_{\Omega(2109)^-} = [2108.5 \pm 5.2_{stat} \pm 0.9_{syst}]\ \mathrm{MeV}/c^2$

$\Gamma_{\Omega(2109)^-} = [18.3 \pm 16.4_{stat} \pm 5.7_{syst}]\ \mathrm{MeV}$

Significance = 4.1σ [A new excited Ω state]

$\boldsymbol{\Omega(2012)^-}$

$N_{\Omega(2012)^-} = 24 \pm 8$

Significance = 3.5σ

$\boldsymbol{\Omega(1672)^-}$

$N_{\Omega(1672)^-} = 92 \pm 11$

BESIII Collaboration, Phys. Rev. Lett. 134, 131903 (2025)

$\Omega(2109)^-$, significance = 4.1σ **[A new excited Ω state]**

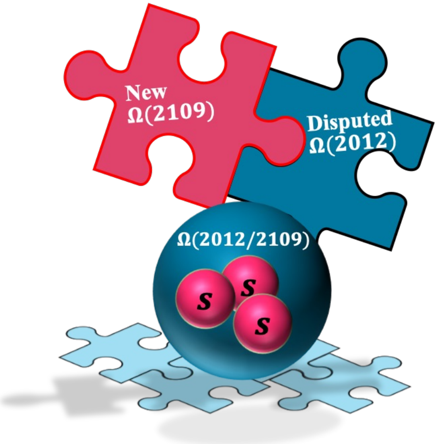
$$M_{\Omega(2109)^-} = [2108.5 \pm 5.2(\text{stat.}) \pm 0.9(\text{syst.})]\ \text{MeV}/c^2$$

$$\Gamma_{\Omega(2109)^-} = [18.3 \pm 16.4(\text{stat.}) \pm 5.7(\text{syst.})]\ \text{MeV}$$

Consistent

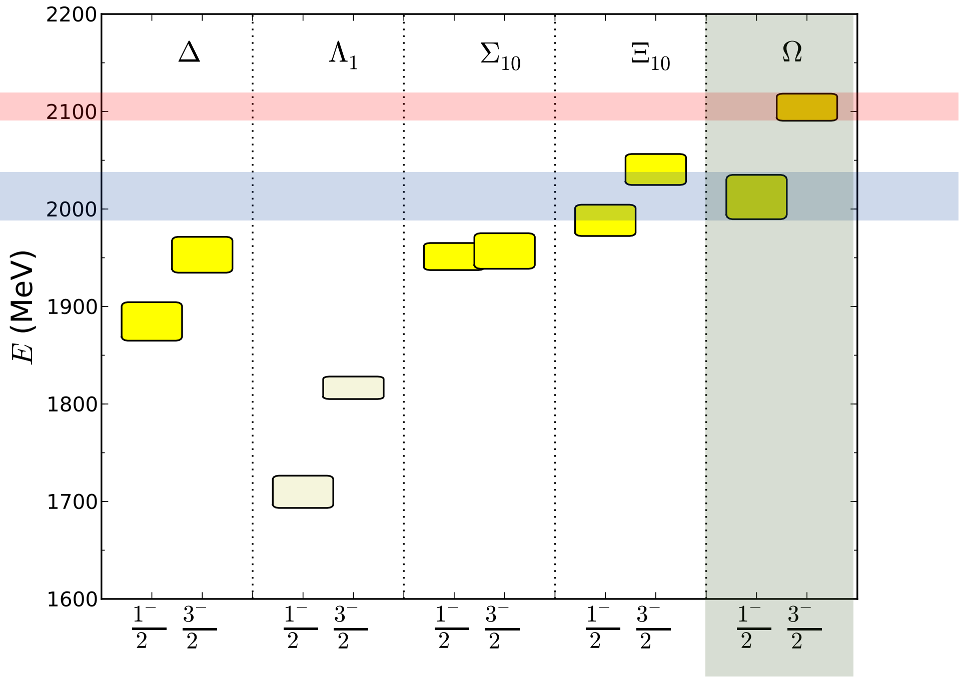
$\Omega(2012)^-$, significance = 3.5σ

$$M_{\Omega(2012)^-} = [2012.4 \pm 0.9]\ \text{MeV}/c^2\ \text{(PDG)}$$



Implying that $\Omega(2109)^-$ and $\Omega(2012)^-$ are probably conventional three-quark baryons, rather than molecules.

LQCD, Hadron Spectrum Collaboration
PRD **87**, 054506 (2013)



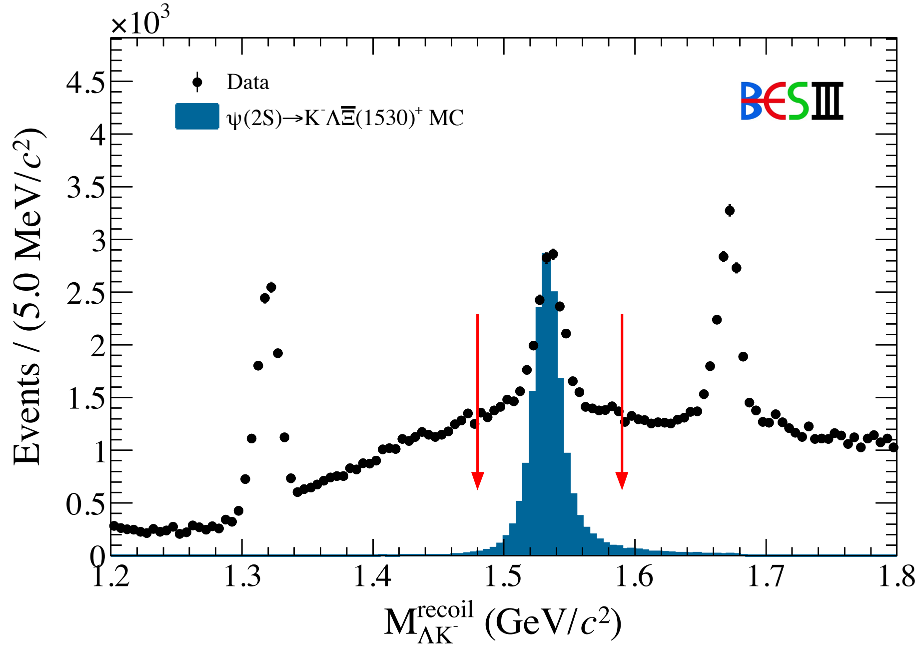
Hyperon excited states

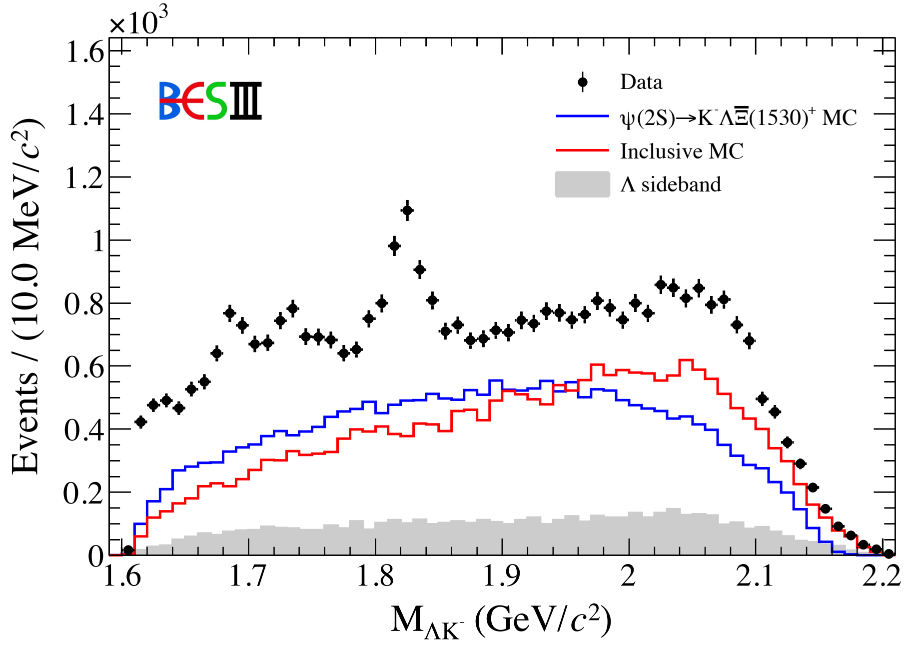
✓ Evidence for Two Excited Ω^- Hyperons — PRL **134**, 131903 (2025)

- Study of $\psi(2S) \to K^- \Lambda \bar{\Xi}(1530)^+ + c.c.$ — BESIII DocDB-doc-1535

Study of $\psi(2S) \to K^- \Lambda \bar{\Xi}(1530)^+ + c.c.$

BESIII DocDB-doc-1535





- Obvious signal events of $\psi(2S) \to K^- \Lambda \bar{\Xi}(1530)^+ + c.c.$ are observed.
- Some contributions of Ξ^* to the ΛK^- mass spectrum have been observed; further investigations are underway.

Summary

Fudan University

- During my Ph.D study, I focused on hyperon physics and contributed to these analyses:
  - **Hyperon semileptonic decays**
    1. **First Measurement of the Absolute Branching Fraction of $\Lambda \to p\mu^-\bar{\nu}$** — **PRL 127, 121802 (2021)**
    2. First direct measurement of the absolute branching fraction of $\Sigma^+ \to \Lambda e^+ \nu_e$ — PRD 107, 072010 (2023)
    3. Determination of CKM matrix element and axial vector form factors from weak decays of quantum-entangled strange baryons — arXiv:2509.09266
    4. Measurement of the absolute branching fraction of $\Omega^- \to \Xi^0 e^- \bar{\nu}_e$ — BAM-00874
    5. Search for the $|\Delta S| = 2$ hyperon semileptonic decay $\Xi^0 \to p e^- \bar{\nu}_e$ — BAM-00976
  - **Hyperon excited states**
    6. **Evidence for Two Excited Ω^- Hyperons** — **PRL 134, 131903 (2025)**
    7. Study of $\psi(2S) \to K^- \Lambda \bar{\Xi}(1530)^+ + c.c.$ — BESIII DocDB-doc-1535
- I will continue the journey with the hyperons.

Thank you to all my colleagues in the BESIII collaboration.
It has been a great honor to work with you during my doctoral studies.
Looking forward to continuing our collaboration in the future.