



兰州大学
LANZHOU UNIVERSITY

BES III

Baryon Pair Production and Hyperon CPV

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第九届强子谱和强子结构研讨会，2026年7月17-21日，河南·新乡

Outline

□ Introduction

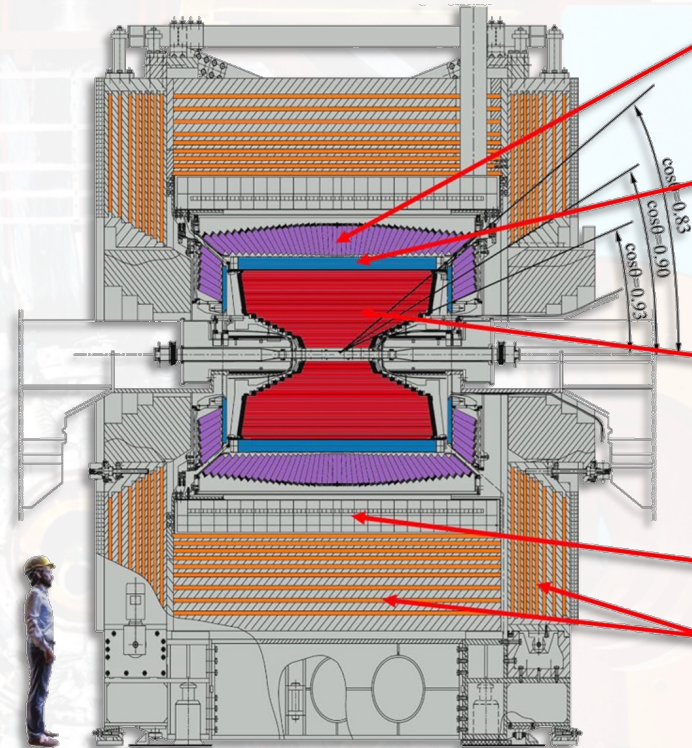
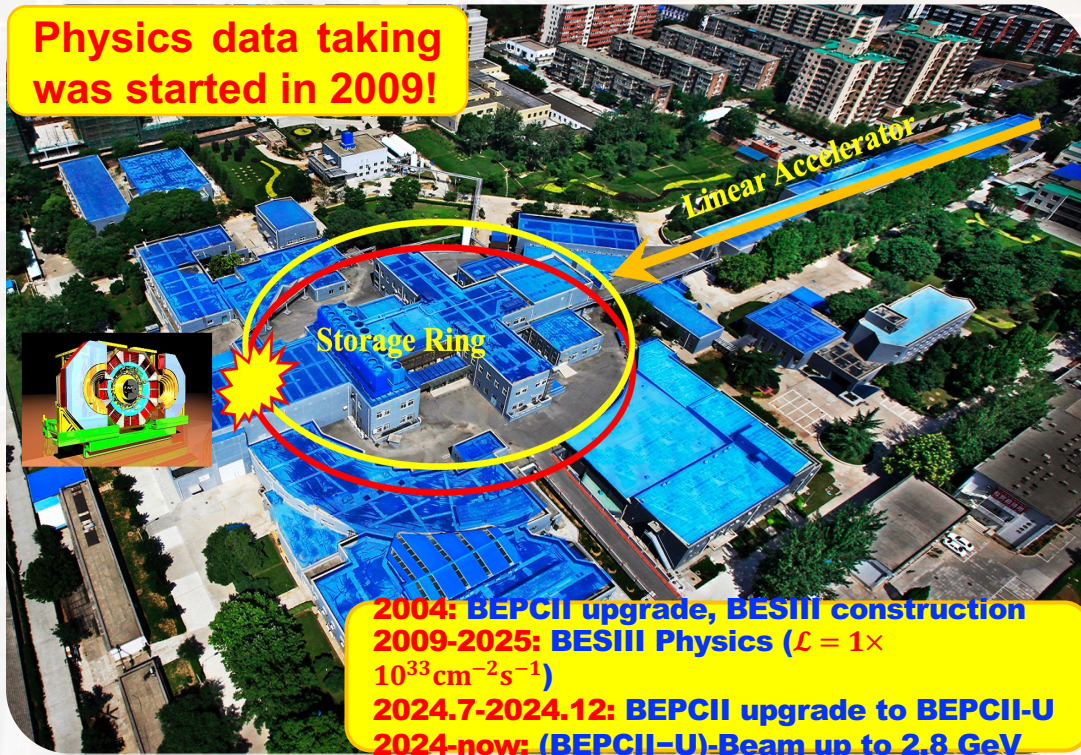
□ Hyperon/Baryon physics

- **Hyperon polarization/CPV/CEDM**
 - $J/\psi, \psi(3686) \rightarrow H\bar{H}$
- **Hyperon/Baryon pair production**
 - $e^+e^- \rightarrow B\bar{B}$ near threshold
 - $e^+e^- \rightarrow B\bar{B}$ above open-charm
- ~~Hyperon nucleon interaction~~
- ~~Hyperon rare decay~~
- ~~Baryon spectroscopy~~

□ Summary

BEPCII/BESIII

An excellent experiment & Great potential



EMC: CsI crystals

$\Delta E/E = 2.5\%$ @ 1 GeV (Barrel)

$\Delta E/E = 5.0\%$ @ 1 GeV (Endcap)

TOF:

$\sigma_T = 80 \text{ ps}$ (Barrel)

$\sigma_T = 110 (60) \text{ ps}$ (Endcap)

MDC: small cell & filled with helium (He)

$\sigma_{xy} = 130 \mu\text{m}$

$\sigma_p/p = 0.5\%$ @ 1 GeV

$dE/dx = 6\%$

Super Conducting Magnet: 1 T

Muon ID: 9 layers RPC

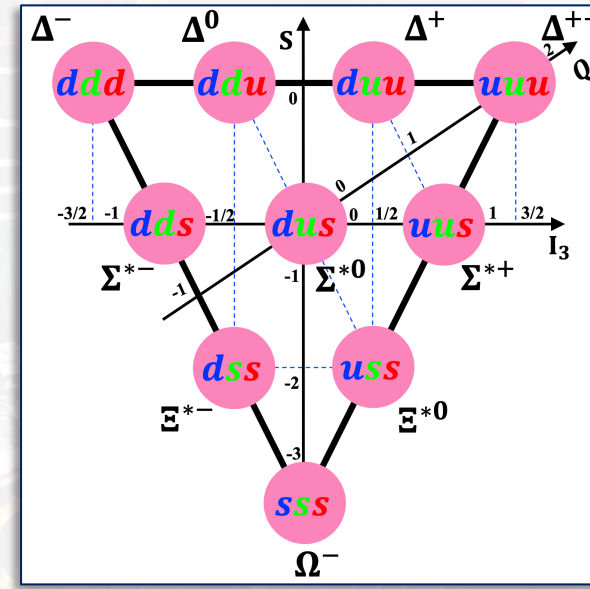
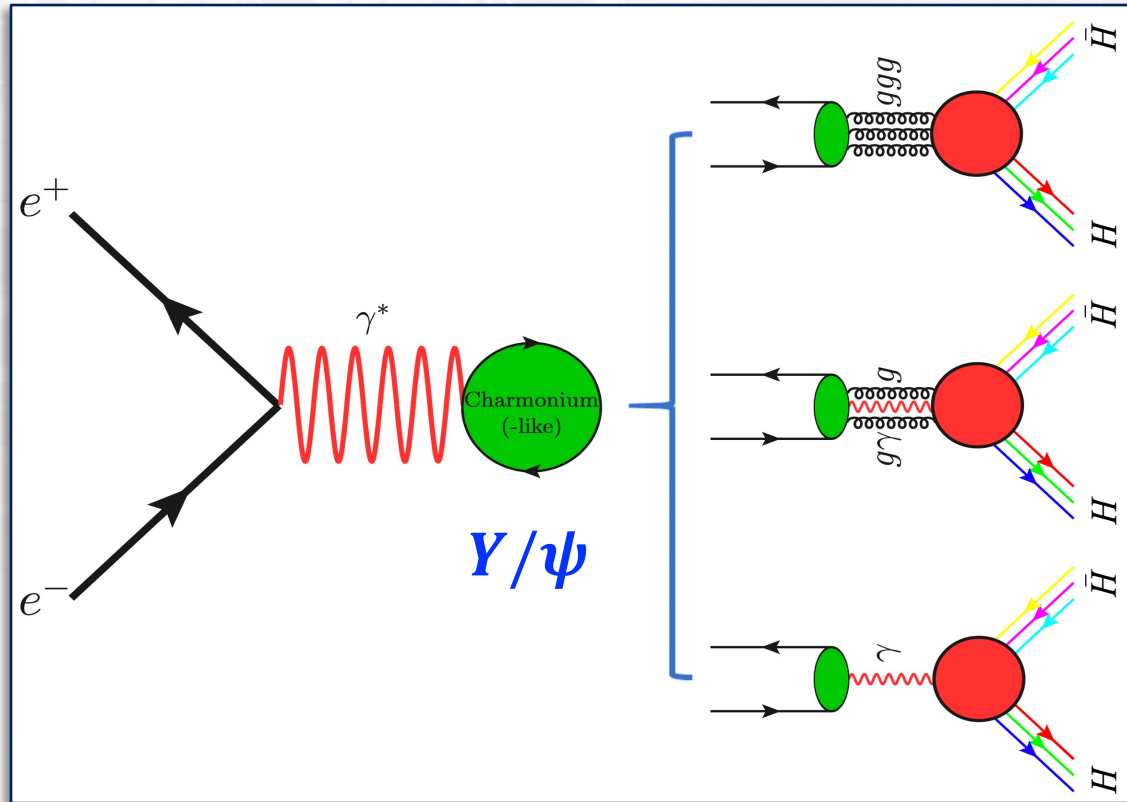
Muon ID: 9 layers RPC

Super Conducting Magnet: 1 T

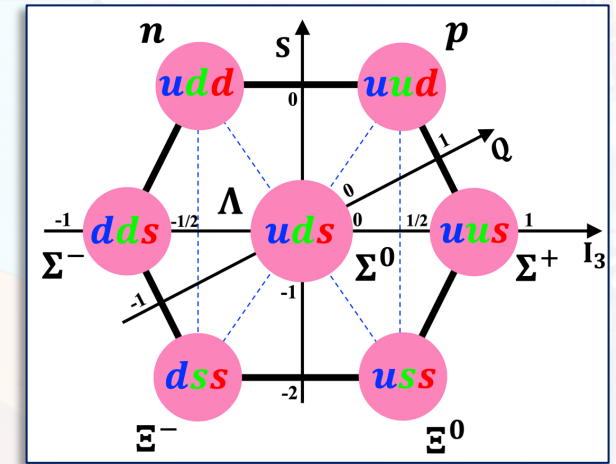
- ❑ Collected a world largest data sample in τ -charm physical region
 - **10B J/ψ , 2.7B $\psi(3686)$, 20/fb $\psi(3770)$ and ~30/fb R-scan & XYZ**
- ❑ Great potential for probing hadron physics

A Hyperon Factory

Hyperon/baryon pair production in Charmonium(-like) decay



Baryon Decuplet



Baryon Octuplet

- A hyperon/baryon factory, provide a rich laboratory for probing non-pQCD, hyperon/baryon property/CPV/EDM, pQCD, etc.

Outline

□ Introduction

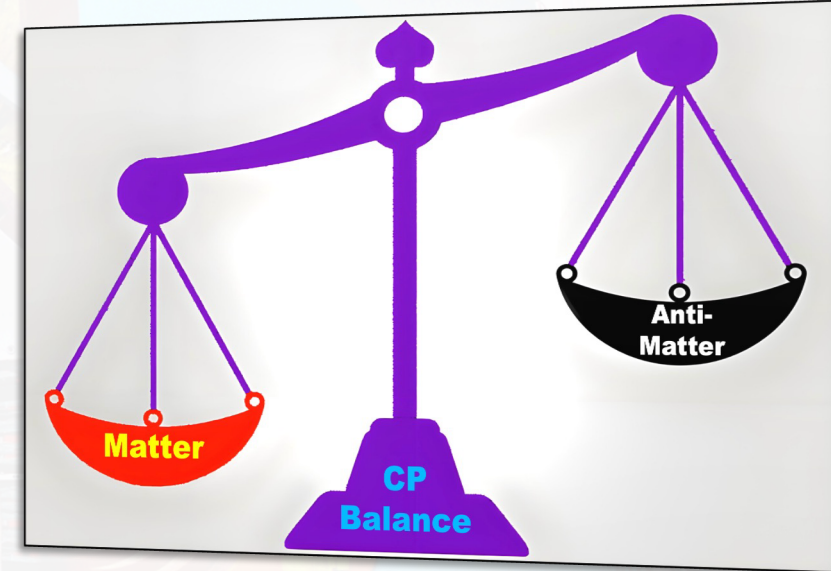
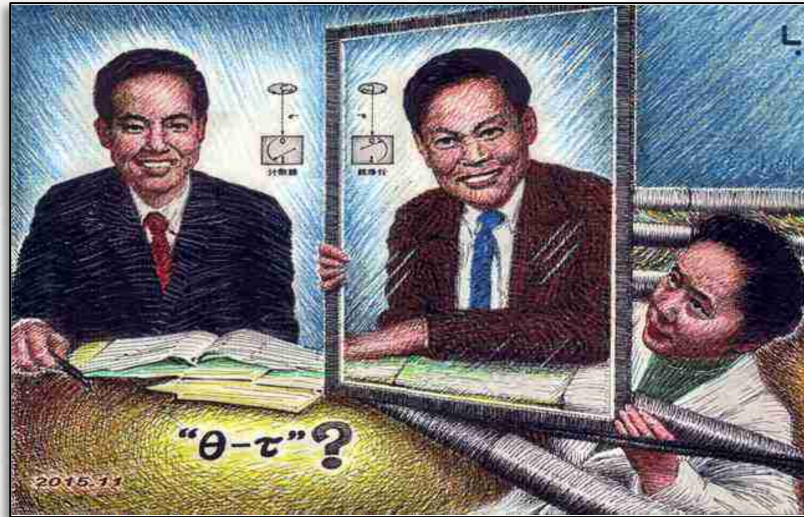
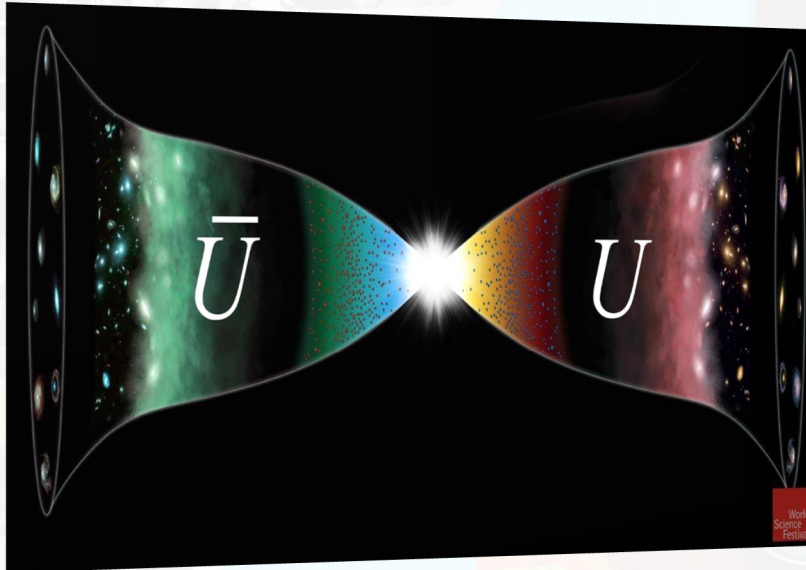
□ Hyperon/Baryon physics

- **Hyperon polarization/CPV/CEDM**
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- Hyperon nucleon interaction
- Hyperon rare decay
- Baryon spectroscopy

□ Summary

Matter-antimatter Asymmetry

❑ One of the greatest mysteries of modern physics is to figure out why there is so much more matter than antimatter in the Universe

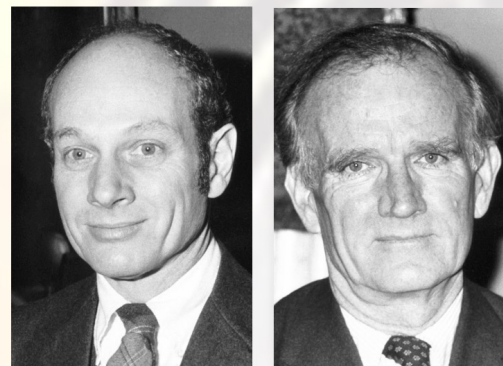
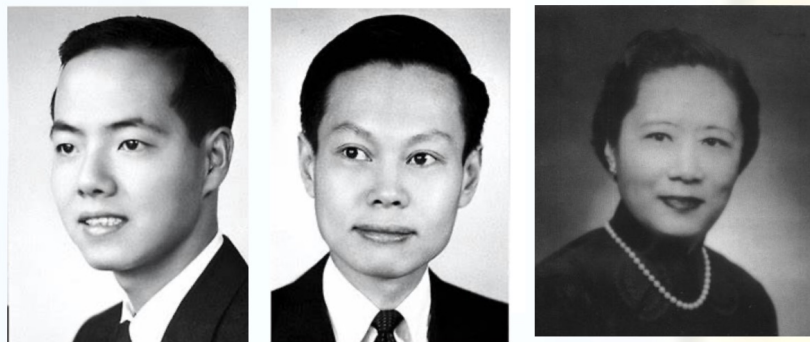


Sakharov three conditions

1. Baryon number **B** violation
2. **C and CP symmetry violation**
3. Interactions out of thermal equilibrium

CPV in collider experiment is the most fundamental one

History of CPV



**Parity Violation
in weak decay**

T.D. Lee and C.N. Yang
C.S. Wu *et al.*

**CP Violation
in K meson decay**

J.W. Cronin and
V.L. Fitch *et al.*

**CP Violation
in B^0 meson decay**

[BABAR] and [Belle]

**CP Violation
in D^0 meson decay**

[LHCb]

**CP Violation
in Λ_b^0 baryon decay**

[LHCb]

Cabibbo Mixing

N. Cabibbo

CKM Matrix

M. Kobayashi and
T. Maskawa

**CP Violation
in B_s^0 meson decay**

[LHCb]

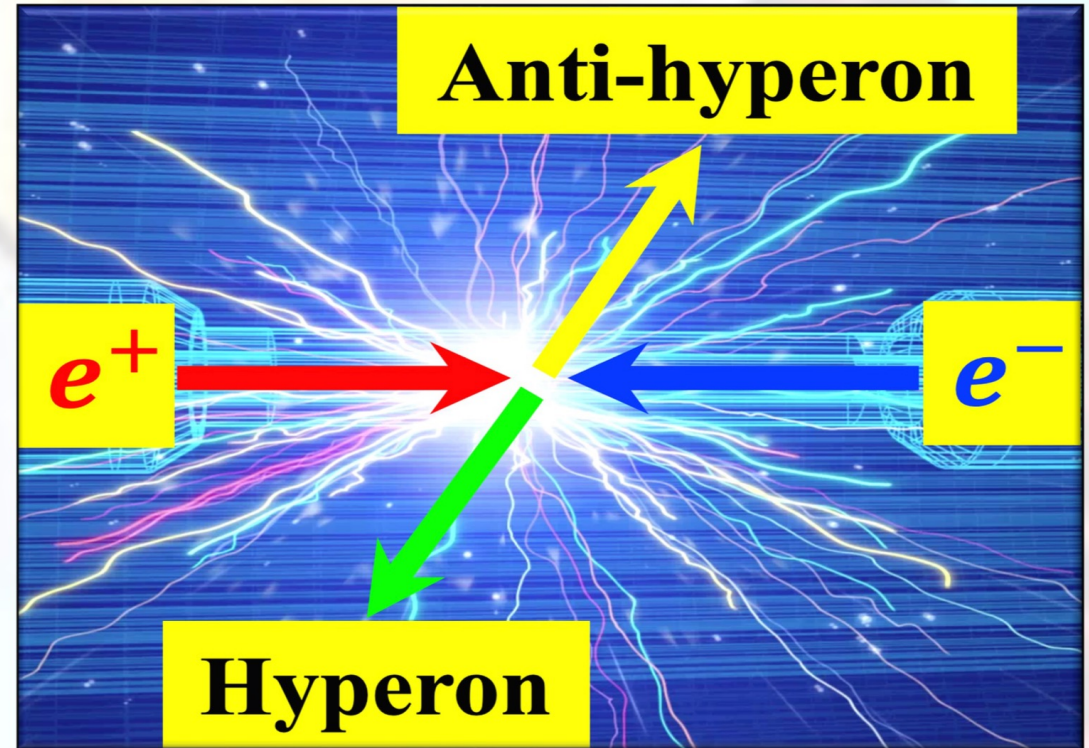
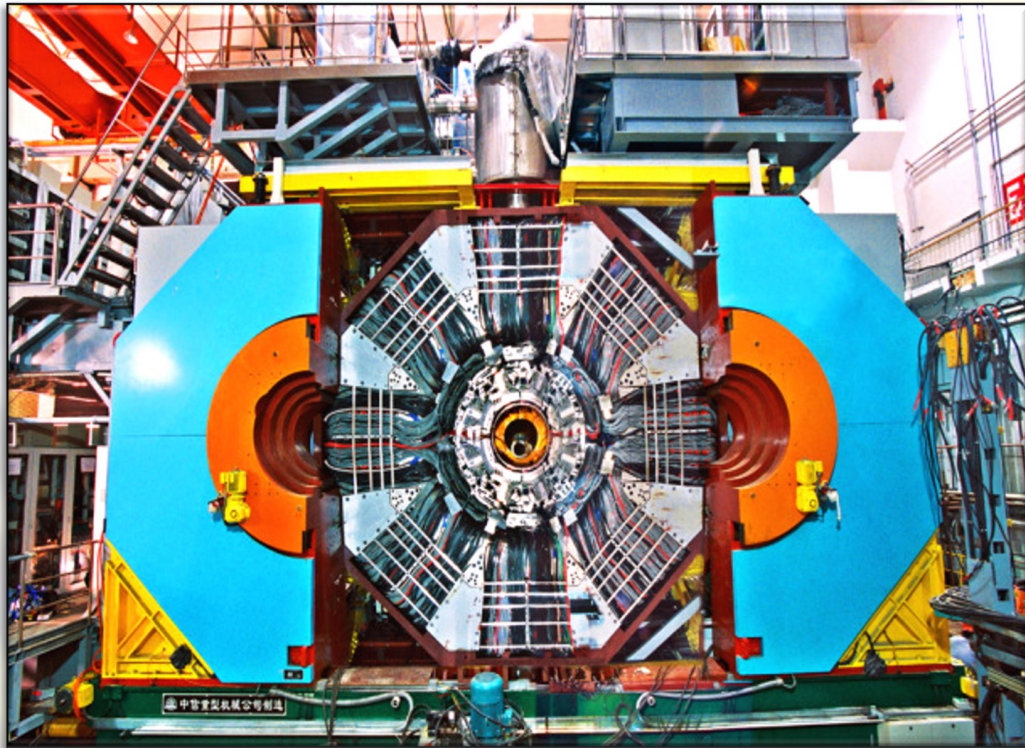
**CP Violation
in neutrino oscillation**

[T2K]



**Hyperon
CPV?**

Why hyperon CPV at BESIII



- ❑ World's largest data samples ★ 10B J/ψ and 3B $\psi(3686)$
- ❑ Large BR for hyperon pair production in J/ψ and $\psi(3686)$
- ❑ Quantum entangled pair production
- ❑ Clean background, etc.

100B J/ψ and 30B $\psi(3686)$?

Hyperon polarization and CPV

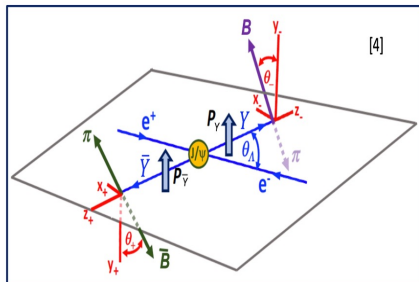
物理信息丰富，如何提取是关键

$$\mathcal{W}(\xi) = (1 + \alpha_\psi \cos^2 \theta) \sum_{\bar{\mu}\nu} C_{\bar{\mu}\nu}(\theta) \hat{n}_{\bar{\mu}} \hat{n}_\nu,$$

$$C_{\bar{\mu}\nu}(\theta) = 1/N \sum_i^{N(\cos \theta)} \hat{n}_{\bar{\mu}} \hat{n}_\nu,$$

$$\hat{n}_\mu = (1, \sin \theta_\Lambda \cos \phi_\Lambda, \sin \theta_\Lambda \sin \phi_\Lambda, \cos \theta_\Lambda),$$

$$\hat{n}_{\bar{\nu}} = (1, \sin \theta_{\bar{\Lambda}} \cos \phi_{\bar{\Lambda}}, \sin \theta_{\bar{\Lambda}} \sin \phi_{\bar{\Lambda}}, \cos \theta_{\bar{\Lambda}}).$$



$$\psi \rightarrow \Xi^- \bar{\Xi}^+$$

9个角度参数: $\theta_\Xi, \theta_\Lambda, \phi_\Lambda, \theta_{\bar{\Lambda}}, \phi_{\bar{\Lambda}}, \theta_p, \phi_p, \theta_{\bar{p}}, \phi_{\bar{p}}$

8个未知参数: $\alpha_\psi, \Delta\Phi, \alpha_\Xi, \Phi_\Xi, \alpha_\Lambda, \alpha_{\bar{\Xi}}, \Phi_{\bar{\Xi}}, \alpha_{\bar{\Lambda}}$

Transverse polarization

$$P_y(\cos \theta) = \frac{\sqrt{1 - \alpha_\psi^2 \sin^2(\Delta\Phi) \cos \theta \sin \theta}}{1 + \alpha_\psi \cos^2 \theta}$$

Relation of form factors G_M^ψ and G_E^ψ

$$\alpha_\psi = \frac{s |G_M^\psi|^2 - 4M_H^2 |G_E^\psi|^2}{s |G_M^\psi|^2 + 4M_H^2 |G_E^\psi|^2}$$

$$\frac{G_E^\psi}{G_M^\psi} = e^{i\Delta\Phi} \left| \frac{G_E^\psi}{G_M^\psi} \right|$$

Construct CPV observables

□ Amplitude: $H_{1/2} \rightarrow H_{1/2} + M_{pse}$:

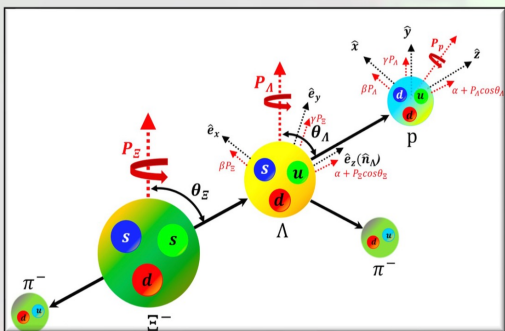
$$\mathcal{A} = \mathcal{S} + \mathcal{P} \sigma \cdot \hat{n}$$

$$\mathcal{S} = |\mathcal{S}| e^{i(\delta_S + \xi_S)}$$

$$\mathcal{P} = |\mathcal{P}| e^{i(\delta_P + \xi_P)}$$

■ Lee–Yang parameters^[3]

$$\begin{cases} \alpha_H = \frac{2\text{Re}(S^* P)}{|S|^2 + |P|^2} \\ \beta_H = \frac{2\text{Im}(S^* P)}{|S|^2 + |P|^2} \\ \gamma_H = \frac{|S|^2 - |P|^2}{|S|^2 + |P|^2} \end{cases} \begin{cases} \alpha_H^2 + \beta_H^2 + \gamma_H^2 = 1 \\ \beta_H = \sqrt{1 - \alpha_H^2} \sin \phi_H \\ \gamma_H = \sqrt{1 - \alpha_H^2} \cos \phi_H \\ \phi_H = \tan^{-1} \frac{\beta_H}{\gamma_H} \end{cases}$$



■ If CP conservation:

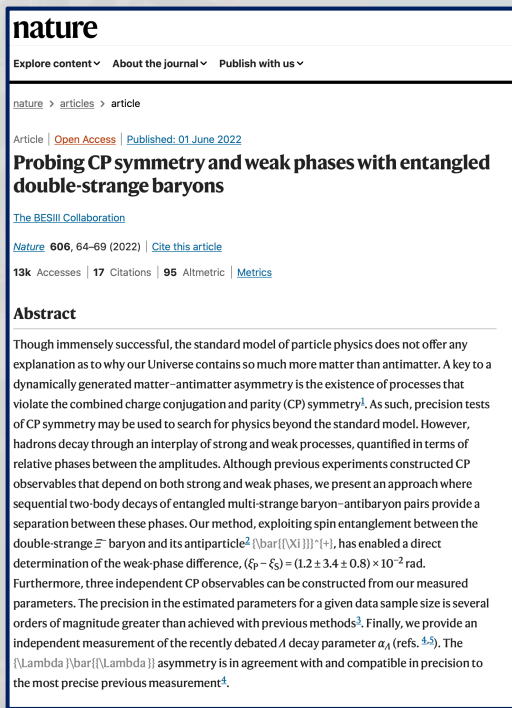
$$\alpha_H = -\alpha_{\bar{H}}, \dots$$

■ Then, one can construct CPV observables ($\Xi \rightarrow \pi\Lambda$)^[4]:

$$\begin{cases} A_{CP}^\Xi = \frac{a_\Xi + a_{\bar{\Xi}}}{a_\Xi - a_{\bar{\Xi}}} \\ B_{CP}^\Xi = \frac{\beta_\Xi + \beta_{\bar{\Xi}}}{\beta_\Xi - \beta_{\bar{\Xi}}} \\ C_{CP}^\Xi = \frac{\gamma_\Xi + \gamma_{\bar{\Xi}}}{\gamma_\Xi - \gamma_{\bar{\Xi}}} \end{cases} \begin{cases} \Delta\Phi_{CP}^\Xi = \frac{\Phi_\Xi + \Phi_{\bar{\Xi}}}{2} \\ \delta_P - \delta_S \approx \arctan\left(\frac{\beta_\Xi}{\alpha_\Xi}\right) \\ \approx \arctan\left(\frac{\sqrt{1 - \alpha_\Xi^2}}{\langle \alpha_\Xi \rangle}\right) < \Phi_\Xi > \\ \xi_P - \xi_S \approx \arctan\left(\frac{\beta_\Xi + \beta_{\bar{\Xi}}}{\alpha_\Xi - \alpha_{\bar{\Xi}}}\right) \\ \approx \frac{\sqrt{1 - \alpha_\Xi^2}}{\langle \alpha_\Xi \rangle} \Delta\Phi_{CP}^\Xi \end{cases}$$

$$e^+ e^- \rightarrow J/\psi \rightarrow \Xi^- \bar{\Xi}^+ \rightarrow \pi^+ \pi^- \Lambda \bar{\Lambda} \rightarrow p \bar{p} \pi^+ \pi^+ \pi^- \pi^-$$

- ❑ 首次利用处于量子纠缠的 $\Xi^- \bar{\Xi}^+$ 级联衰变，把导致正反物质不对称的弱作用从强作用里分离，开创了BESIII实验探索正反物质不对称的新方法



Nature 606, 64(2022)

参数	$J/\psi \rightarrow \Xi^- \bar{\Xi}^+$
α_ψ	$0.586 \pm 0.012 \pm 0.010$
$\Delta\Phi(\text{rad})$	$1.213 \pm 0.046 \pm 0.016$
α_Ξ	$-0.376 \pm 0.007 \pm 0.003$
$\phi_\Xi(\text{rad})$	$0.011 \pm 0.019 \pm 0.009$
$\alpha_{\bar{\Xi}}$	$0.371 \pm 0.007 \pm 0.002$
$\phi_{\bar{\Xi}}(\text{rad})$	$-0.021 \pm 0.019 \pm 0.007$
α_Λ	$0.757 \pm 0.011 \pm 0.008$
$\alpha_{\bar{\Lambda}}$	$-0.763 \pm 0.011 \pm 0.007$
$\xi_P - \xi_S(\text{rad})$	$0.012 \pm 0.034 \pm 0.008$
$\delta_P - \delta_S(\text{rad})$	$-0.040 \pm 0.033 \pm 0.017$
$A_{CP}^\Xi = \frac{\alpha_\Xi + \alpha_{\bar{\Xi}}}{\alpha_\Xi - \alpha_{\bar{\Xi}}}$	$0.006 \pm 0.013 \pm 0.006$
$A_{CP}^\Lambda = \frac{\alpha_\Lambda + \alpha_{\bar{\Lambda}}}{\alpha_\Lambda - \alpha_{\bar{\Lambda}}}$	$-0.004 \pm 0.012 \pm 0.009$
$\Delta\phi_{CP}^\Xi = \frac{\phi_\Xi + \phi_{\bar{\Xi}}}{2}(\text{rad})$	$-0.005 \pm 0.014 \pm 0.003$

~1B J/ψ

① 8个关键参数的精确测量

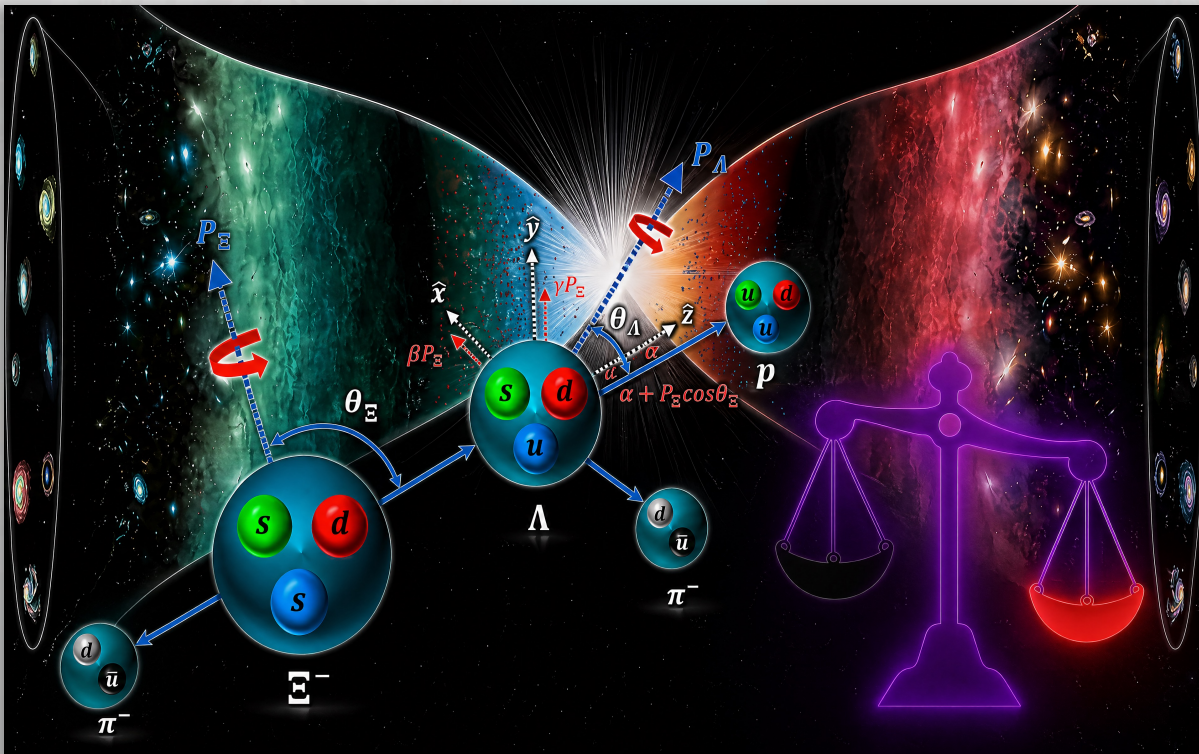
② 2个强弱相角差的首次和精确测量

③ 3个表征正反物质不对称性特征量的首次和精确测量 (10^{-2})

发展了九维角分布拟合方法，开创了BESIII实验探索正反物质不对称的新方法

Precise Measurement of Matter-Antimatter Asymmetry with Entangled Hyperon-Antihyperon Pair

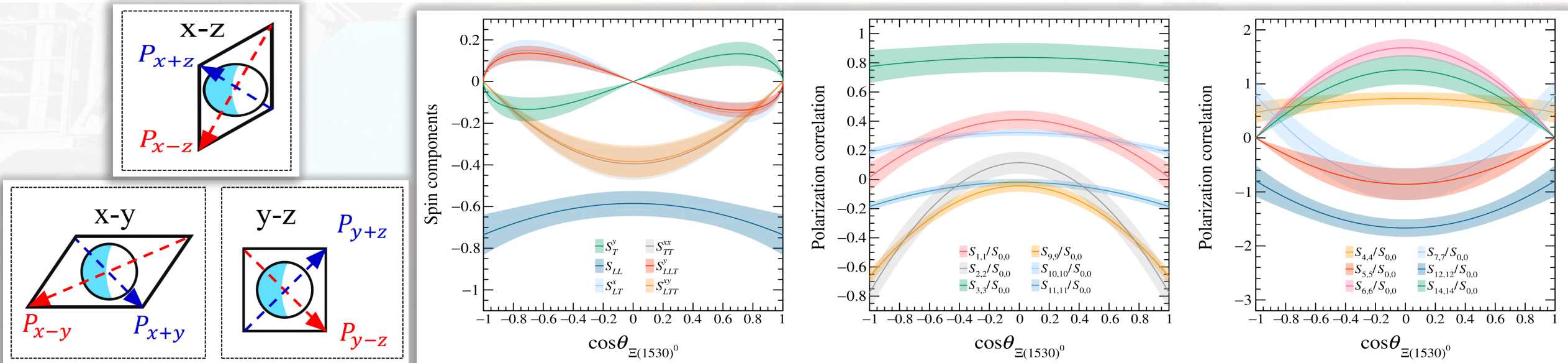
$\sim 10 \text{ B J}/\psi$



Parameter	This Letter	Previous best result
α_ψ	$0.5851 \pm 0.0044 \pm 0.0034$	$0.611 \pm 0.007^{+0.013}_{-0.007}$ [15]
$\Delta\Phi$ (rad)	$1.2205 \pm 0.0159 \pm 0.0056$	$1.30 \pm 0.03^{+0.02}_{-0.03}$ [15]
α_Ξ	$-0.3813 \pm 0.0026 \pm 0.0005$	$-0.367 \pm 0.004^{+0.003}_{-0.004}$ [15]
$\bar{\alpha}_\Xi$	$0.3873 \pm 0.0026 \pm 0.0006$	$0.374 \pm 0.004^{+0.003}_{-0.004}$ [15]
ϕ_Ξ (rad)	$-0.0008 \pm 0.0072 \pm 0.0010$	$-0.016 \pm 0.012^{+0.004}_{-0.008}$ [15]
$\bar{\phi}_\Xi$ (rad)	$0.0020 \pm 0.0072 \pm 0.0006$	$0.010 \pm 0.012^{+0.003}_{-0.013}$ [15]
α_Λ	$0.7434 \pm 0.0039 \pm 0.0015$	$0.7519 \pm 0.0036 \pm 0.0024$ [45]
$\bar{\alpha}_\Lambda$	$-0.7478 \pm 0.0038 \pm 0.0015$	$-0.7559 \pm 0.0036 \pm 0.0030$ [45]
$(\xi_P - \xi_S) \times 10^{-2}$ (rad)	$-0.2 \pm 1.2 \pm 0.1$	$0.7 \pm 2.0^{+1.8}_{-0.5}$ [15]
$(\delta_P - \delta_S) \times 10^{-2}$ (rad)	$0.3 \pm 1.2 \pm 0.2$	$3.3 \pm 2.0^{+0.8}_{-1.2}$ [15]
$A_{CP}^\Xi \times 10^{-3}$	$-7.8 \pm 4.8 \pm 0.8$	$-9 \pm 8^{+7}_{-2}$ [15]
$\Delta\phi_{CP}^\Xi \times 10^{-3}$ (rad)	$0.6 \pm 5.1 \pm 0.2$	$-3 \pm 8^{+3}_{-7}$ [15]
$A_{CP}^\Lambda \times 10^{-3}$	$-2.9 \pm 4.3 \pm 0.7$	$-2.5 \pm 4.6 \pm 1.2$ [45]
$\langle\alpha_\Xi\rangle$	$-0.3843 \pm 0.0018 \pm 0.0005$	$-0.373 \pm 0.005 \pm 0.002$ [16]
$\langle\phi_\Xi\rangle$ (rad)	$-0.0014 \pm 0.0050 \pm 0.0008$	$0.016 \pm 0.014 \pm 0.007$ [16]
$\langle\alpha_\Lambda\rangle$	$0.7456 \pm 0.0022 \pm 0.0014$	$0.7542 \pm 0.0010 \pm 0.0024$ [45]

超子衰变中迄今最精确的CP破坏参数的测量

Observation of $\Xi(1530)^0$ Polarization and Determination of Its Electric and Magnetic Moments in $\psi(3686) \rightarrow \Xi(1530)^0 \bar{\Xi}(1530)^0$

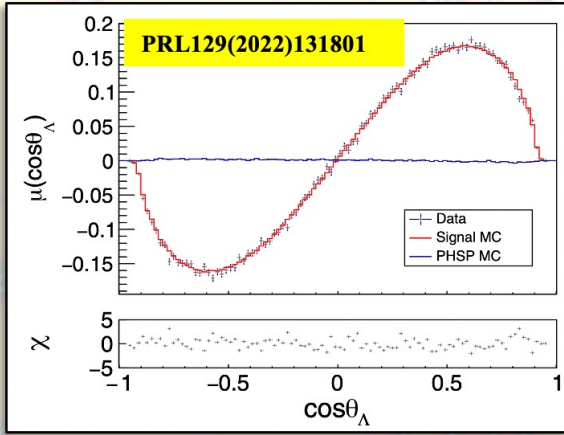


- **Spin-3/2 particles exhibit not only vector polarization but also tensor polarization**
- **Four independent form factors: electric charge (G_E), magnetic dipole (G_M), electric quadrupole (G_Q), and magnetic octupole (G_O) moments**
- **A more detailed picture of hyperon internal structure**

Parameter	Value	Parameter	Value
α_ψ	$0.02 \pm 0.06 \pm 0.06$	h_1	$0.69 \pm 0.05 \pm 0.05$
α_1	$-0.42 \pm 0.08 \pm 0.05$	h_3	$0.43 \pm 0.04 \pm 0.04$
α_2	$0.75 \pm 0.06 \pm 0.06$	h_4	$0.43 \pm 0.03 \pm 0.03$
ϕ_1 (rad)	$-1.81 \pm 0.13 \pm 0.07$	ϕ'_1 (rad)	$0.56 \pm 0.11 \pm 0.06$
ϕ_3 (rad)	$2.37 \pm 0.08 \pm 0.05$	ϕ'_3 (rad)	$2.37 \pm 0.08 \pm 0.05$
ϕ_4 (rad)	$1.02 \pm 0.15 \pm 0.08$	ϕ'_4 (rad)	$-2.90 \pm 0.13 \pm 0.08$
$ G_E $	$0.0035 \pm 0.0006 \pm 0.0004$	$ G_M/G_E $	$1.61 \pm 0.33 \pm 0.22$
$ G_M $	$0.0056 \pm 0.0006 \pm 0.0003$	$ G_Q/G_E $	$3.71 \pm 0.63 \pm 0.38$
$ G_Q $	$0.0129 \pm 0.0007 \pm 0.0005$	$ G_O/G_E $	$1.13 \pm 0.20 \pm 0.13$
$ G_O $	$0.0039 \pm 0.0002 \pm 0.0001$		

More advances for hyperon polarization/CPV

$$J/\psi \rightarrow \Lambda \bar{\Lambda} \rightarrow p \pi^- \bar{p} \pi^+$$

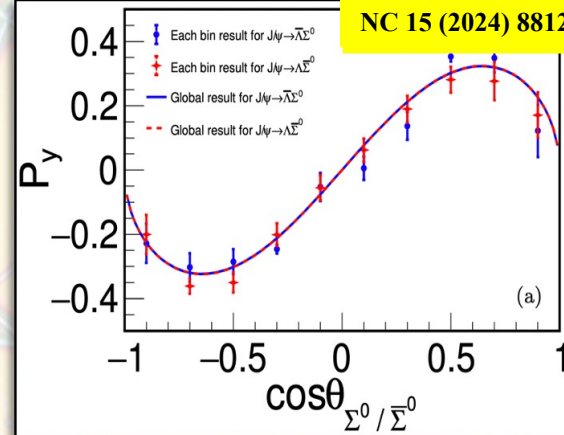


PRL129(2022)131801

$$\Delta\Phi = (43.1 \pm 0.2 \pm 0.4)^\circ$$

$$A_{CP} = (-2.5 \pm 4.6 \pm 1.2) \times 10^{-3}$$

$$J/\psi \rightarrow \Lambda \bar{\Sigma}^0 + \text{c.c.}$$



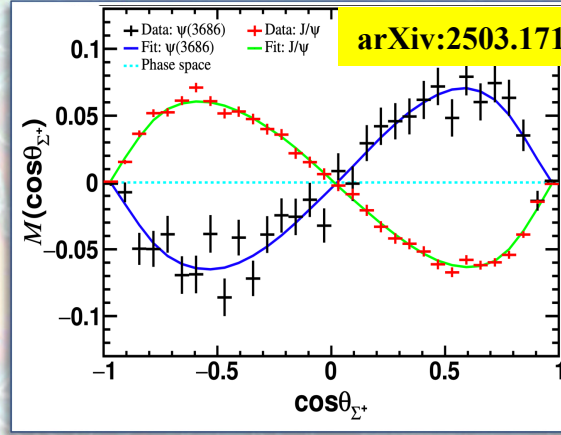
NC 15 (2024) 8812

$$\Delta\Phi_1 = (58.9 \pm 5.5 \pm 0.6)^\circ$$

$$\Delta\Phi_2 = (124.0 \pm 5.5 \pm 0.6)^\circ$$

$$\Delta\Phi_{CP} = |\pi - (\Delta\Phi_1 + \Delta\Phi_2)| \sim 0$$

$$\psi \rightarrow \Sigma^+ \bar{\Sigma}^- \rightarrow p \pi^0 \bar{p} \pi^0$$



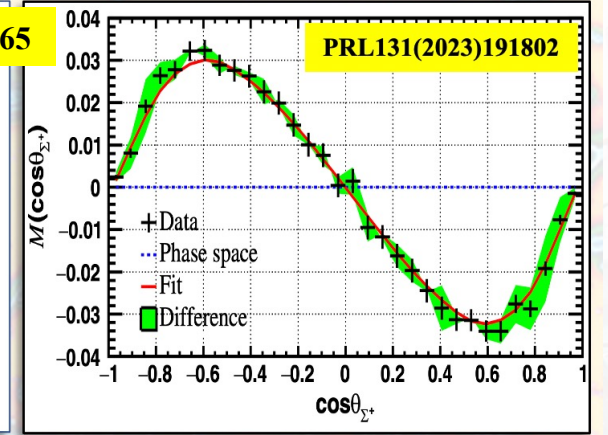
arXiv:2503.17165

$$\Delta\Phi_{J/\psi} = -(15.7 \pm 0.2 \pm 0.1)^\circ$$

$$\Delta\Phi_{\psi(3686)} = (24.5 \pm 1.2 \pm 0.2)^\circ$$

$$A_{CP} = -(1.2 \pm 0.8 \pm 0.3) \times 10^{-2}$$

$$J/\psi \rightarrow \Sigma^+ \bar{\Sigma}^- \rightarrow n \pi^+ \bar{p} \pi^0$$

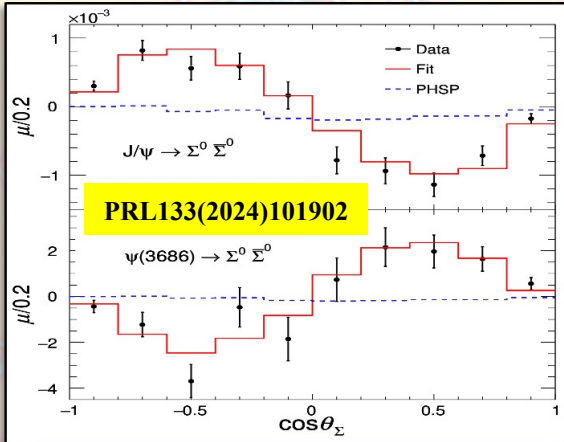


PRL131(2023)191802

$$\Delta\Phi = (-16.1 \pm 0.3 \pm 0.3)^\circ$$

$$A_{CP} = (-8.0 \pm 5.2 \pm 2.8) \times 10^{-2}$$

$$\psi \rightarrow \Sigma^0 \bar{\Sigma}^0 \rightarrow \gamma \gamma \Lambda \bar{\Lambda}$$



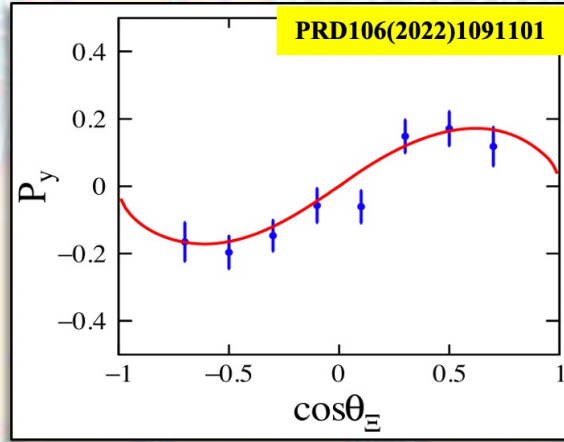
PRL133(2024)101902

$$\Delta\Phi_{J/\psi} = (4.8 \pm 0.4 \pm 0.2)^\circ$$

$$\Delta\Phi_{\psi(3686)} = (29.8 \pm 5.0 \pm 2.0)^\circ$$

$$A_{CP} = (0.4 \pm 2.9 \pm 1.3) \times 10^{-3}$$

$$\psi(3686) \rightarrow \Xi^- \bar{\Xi}^+ \rightarrow \pi^+ \pi^- \Lambda \bar{\Lambda}$$



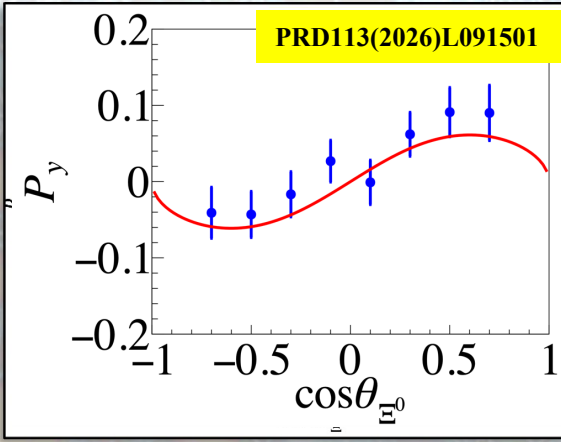
PRD106(2022)1091101

$$\Delta\Phi = (39 \pm 6 \pm 3)^\circ$$

$$A_{CP} = (-2 \pm 5 \pm 1) \times 10^{-2}$$

$$\Delta\Phi_{CP}^{\Xi} = (-5 \pm 5 \pm 1) \times 10^{-2}$$

$$\psi(3686) \rightarrow \Xi^0 \bar{\Xi}^0 \rightarrow \pi^0 \pi^0 \Lambda \bar{\Lambda}$$



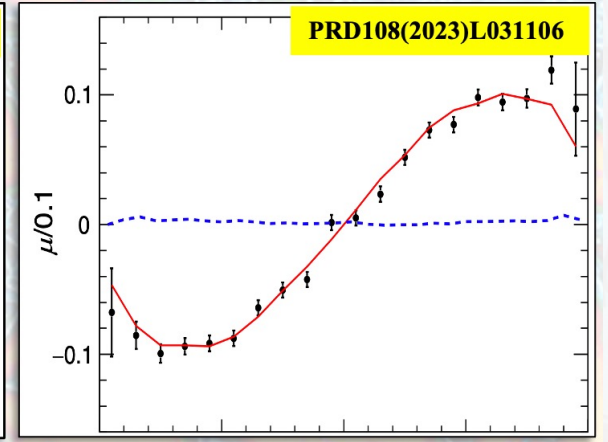
PRD113(2026)L091501

$$\Delta\Phi_\psi = (14.7 \pm 3.5 \pm 0.6)^\circ$$

$$A_{CP} = -(1.4 \pm 3.0 \pm 1.0) \times 10^{-2}$$

$$\Delta\Phi_{CP}^{\Xi} = (0.0 \pm 3.0 \pm 0.3) \times 10^{-2}$$

$$J/\psi \rightarrow \Xi^0 \bar{\Xi}^0 \rightarrow \pi^0 \pi^0 \Lambda \bar{\Lambda}$$



PRD108(2023)L031106

$$\Delta\Phi_{J/\psi} = (68 \pm 1 \pm 1)^\circ$$

$$A_{CP} = (-5.4 \pm 6.5 \pm 3.1) \times 10^{-3}$$

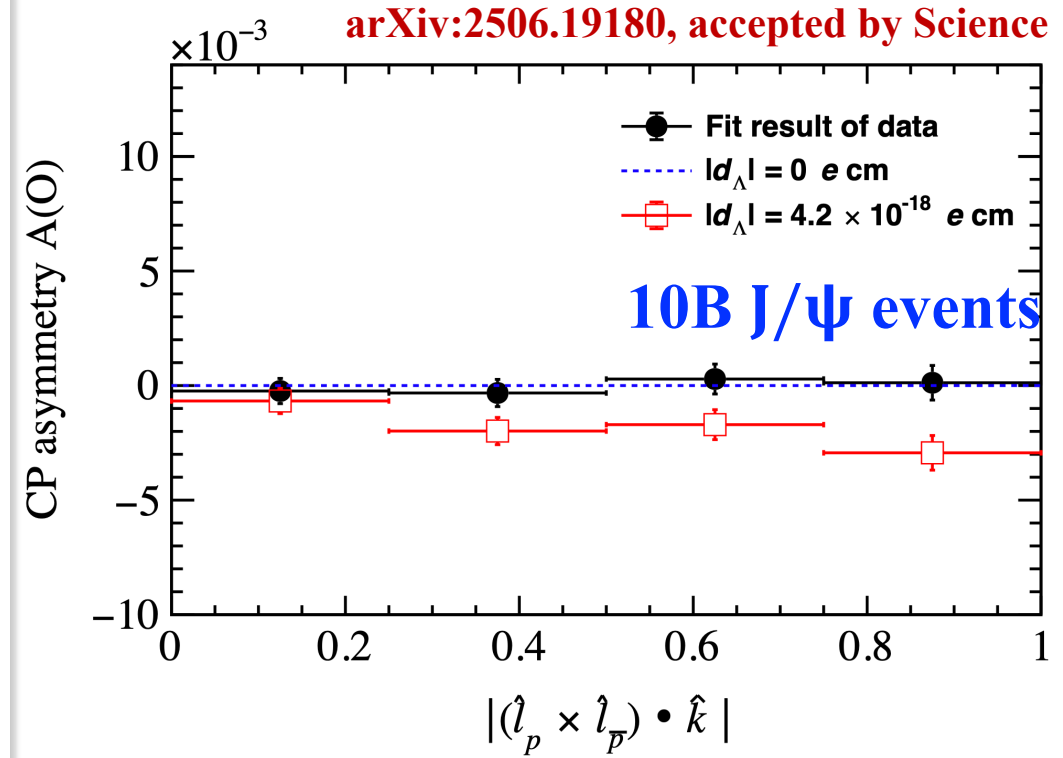
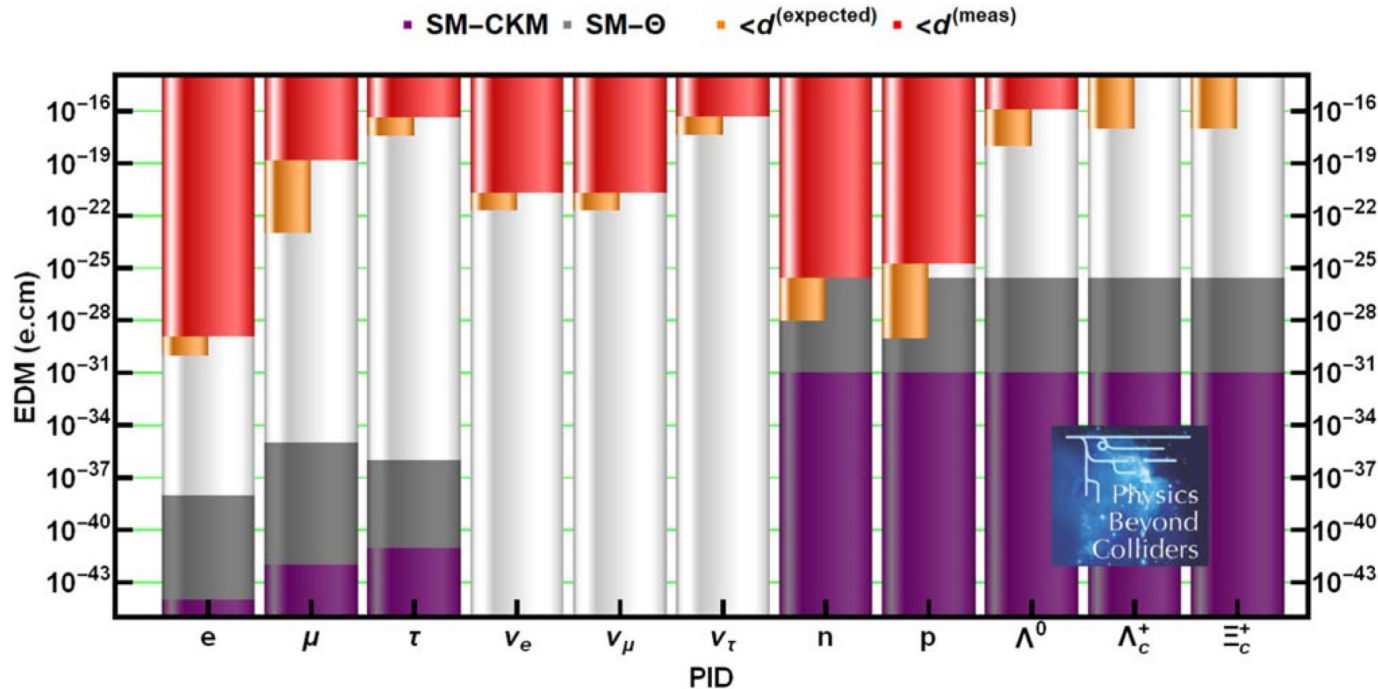
$$\Delta\Phi_{CP}^{\Xi} = (-0.1 \pm 6.9 \pm 0.9) \times 10^{-3}$$

Precise Measurement of Λ Hyperon EDM

□ EDMs are important to probe new physics beyond SM at a level of TeV

J. Phys. G: Nucl. Part. Phys. **47** (2020) 010501

J Beacham *et al*

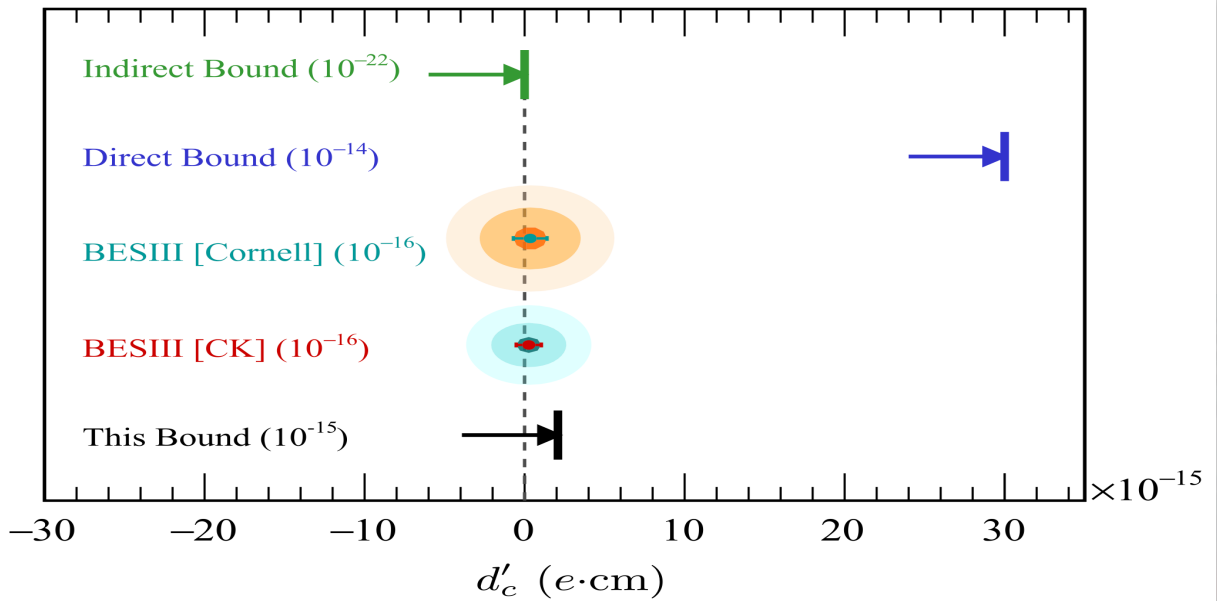
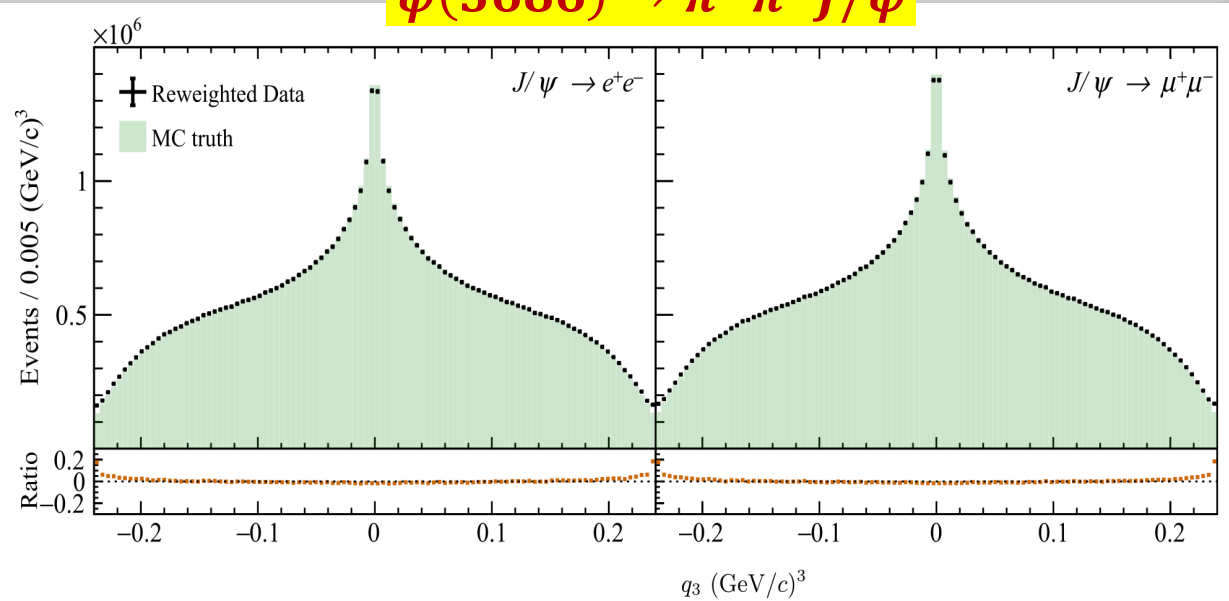


□ An upper bound for Λ EDM: $|d_\Lambda| < 6.5 \times 10^{-19} \text{ e cm}$ in $J/\psi \rightarrow \Lambda \bar{\Lambda}$

□ The result achieves a three-order-of-magnitude improvement over the previous upper limit in 1980s, providing stringent constraints on potential new physics

Precise Measurement of the Chromoelectric Dipole Moment of the Charm Quark

$\psi(3686) \rightarrow \pi^+ \pi^- J/\psi$



$$q_3 \equiv \vec{p}_{e^+} \cdot (\vec{p}_{\pi^+} - \vec{p}_{\pi^-}) \vec{p}_{e^+} \cdot \frac{\vec{p}_{\pi^+} \times \vec{p}_{\pi^-}}{|\vec{p}_{\pi^+} \times \vec{p}_{\pi^-}|}$$

$$A_{CP} = \frac{N_{\text{events}}(q_3 > 0) - N_{\text{events}}(q_3 < 0)}{N_{\text{events}}(q_3 > 0) + N_{\text{events}}(q_3 < 0)}$$

Parameter	$J/\psi \rightarrow e^+e^-$	$J/\psi \rightarrow \mu^+\mu^-$
$A_{CP} (\times 10^{-4})$	$3.3 \pm 2.9 \pm 0.4$	$-1.2 \pm 2.4 \pm 0.1$
$\langle A_{CP} \rangle (\times 10^{-4})$	$0.6 \pm 1.8 \pm 0.1$	
$d'_c [\text{CK}] (e \text{ cm})$	$(2.6 \pm 7.8 \pm 0.4 \pm 0.6) \times 10^{-16}$	
$d'_c [\text{Cornell}] (e \text{ cm})$	$(3.5 \pm 10.5 \pm 0.6 \pm 0.5) \times 10^{-16}$	
$ d'_c (e \text{ cm})$	$< 2.1 \times 10^{-15}$	

迄今最精确粲夸克色电偶极矩的测量，强相互作用电荷宇称破缺的首次探索

Outline

□ Introduction

□ Hyperon/Baryon physics

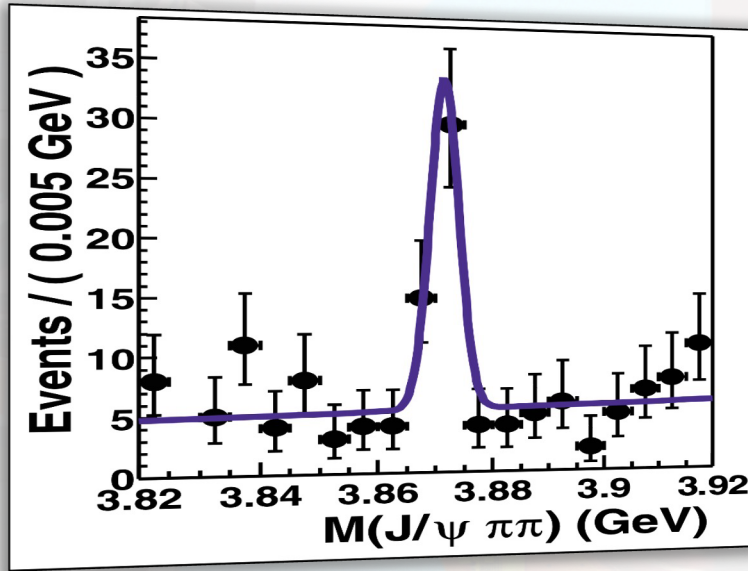
- Hyperon polarization/CPV/CEDM
- $J/\psi, \psi(3686)$
- **Hyperon/Baryon pair production**
 - $e^+e^- \rightarrow B\bar{B}$ near threshold
 - $e^+e^- \rightarrow B\bar{B}$ above open-charm
- Hyperon-nucleon interaction
- Hyperon rare decay
- Baryon spectroscopy

□ Summary

XYZ/Charmonium(-like)

□ A series of XYZ states observed in past decades

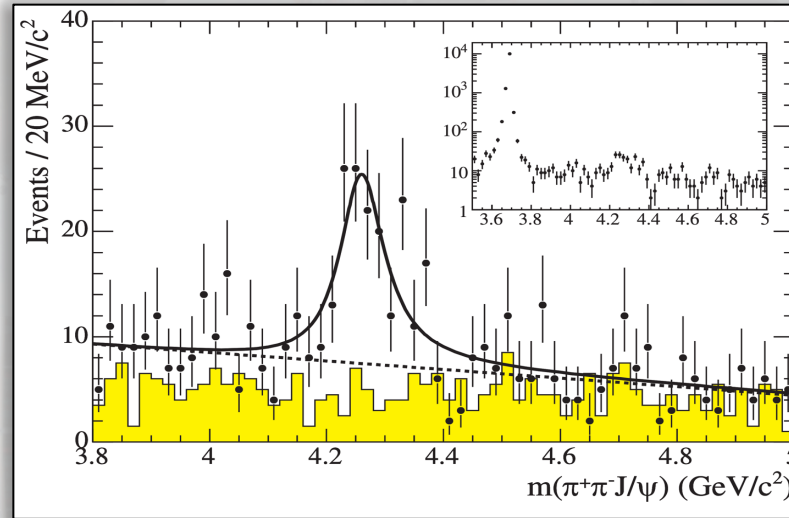
$X(3872)$



Phys. Rev. Lett. **91**, 262001(2003)



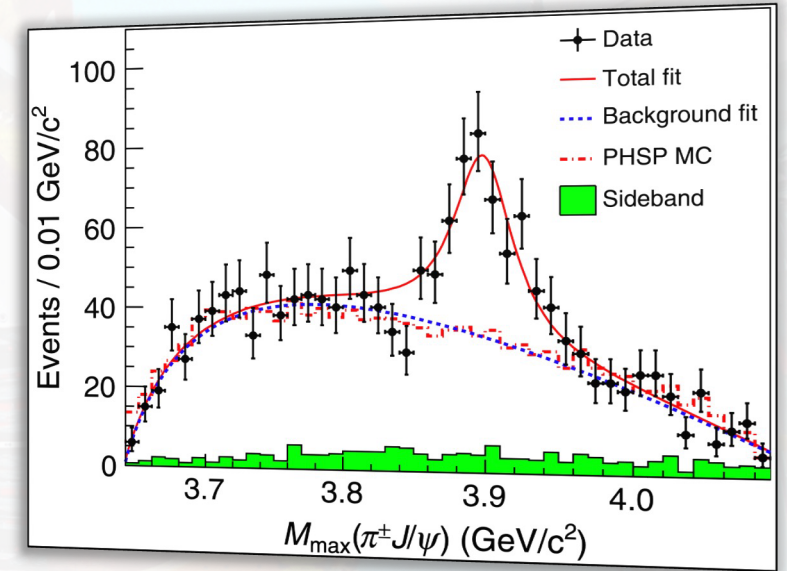
$Y(4260)$



Phys. Rev. Lett. **95**, 142001(2005)



$Z_c(3900)$



Phys. Rev. Lett. **110**, 252001(2013)



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Colloquium: Hadron production in open-charm meson pairs at e^+e^- colliders

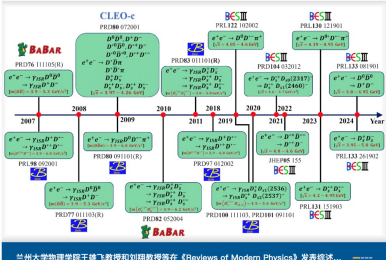
Xiongfei Wang^{ID*}, Xiang Liu^{ID†}, and Yuanning Gao^{ID}

Show more

Rev. Mod. Phys. **98**, 021001 – Published 3 April, 2026

DOI: <https://doi.org/10.1103/2mrp-chly>

兰大·头条



兰大新闻

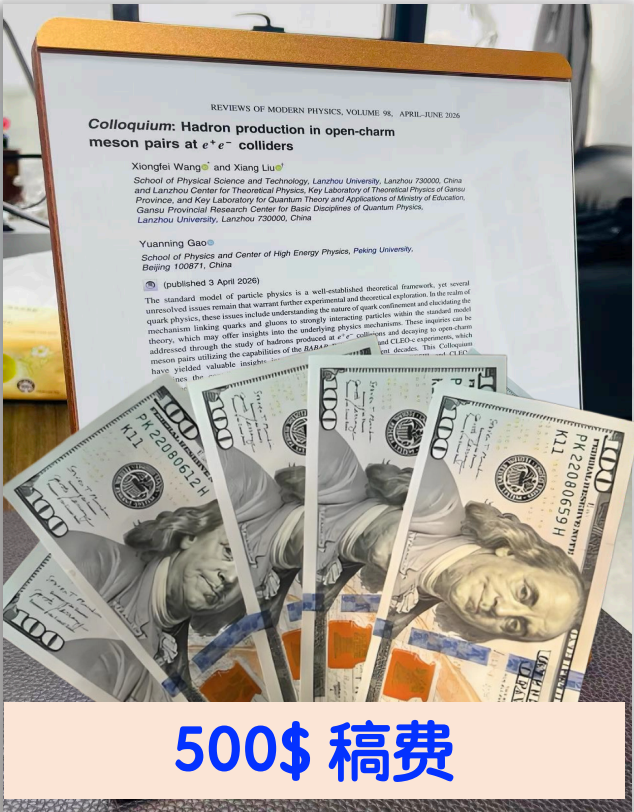
兰大新闻2026第5期

兰州大学：坚持学改一体推进 推动学习教育走深走实

兰州大学与中国气象局深化局校合作 签署战略合作协议

兰园史学奠基人 薪火相传启新章——兰州大学兰园史学分会正式成立

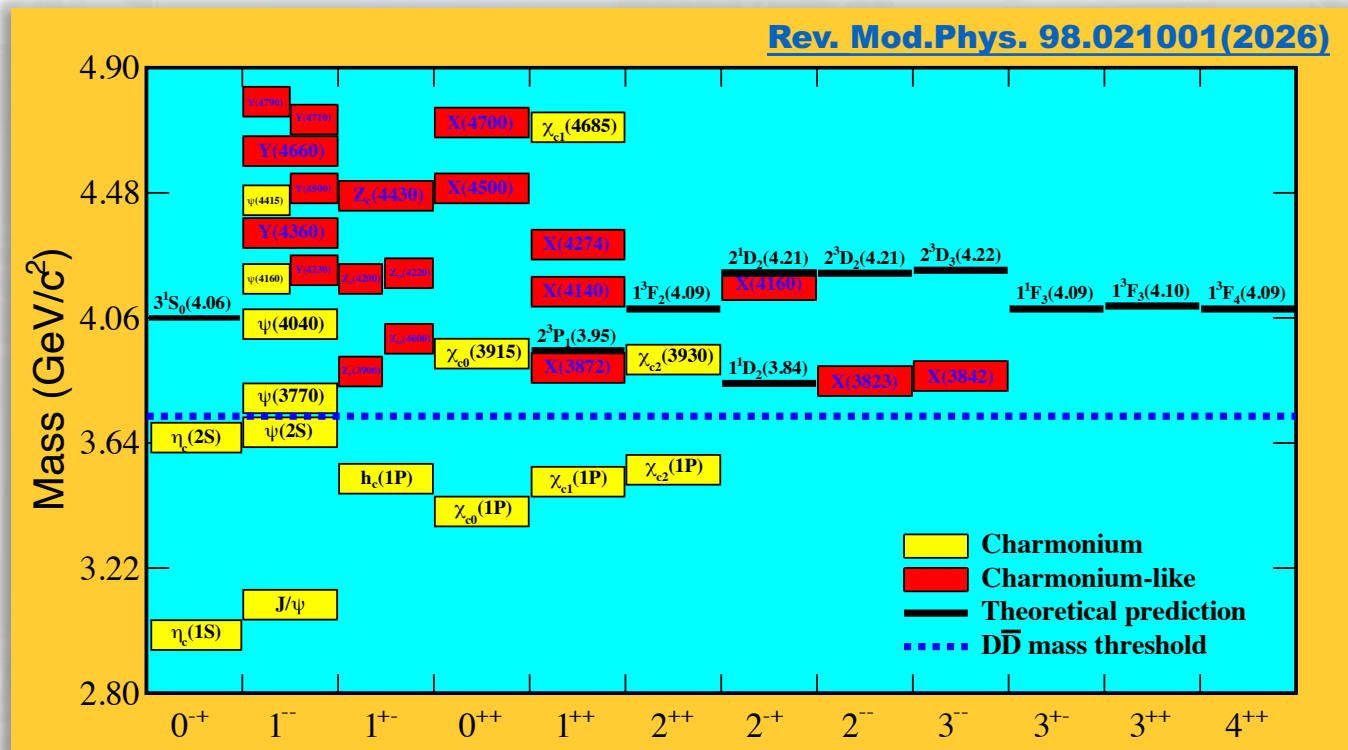
兰州大学新闻传播学院教授荣获第六届中国出版政府奖优秀出版人奖



系统阐述了正负电子对撞机上粲介子对末态强子产生的研究进展
全面梳理了粲偶素物理领域过去 50 年的实验成果，是该领域的首个全面专题综述
对理解XYZ粒子性质提供了重要的实验信息

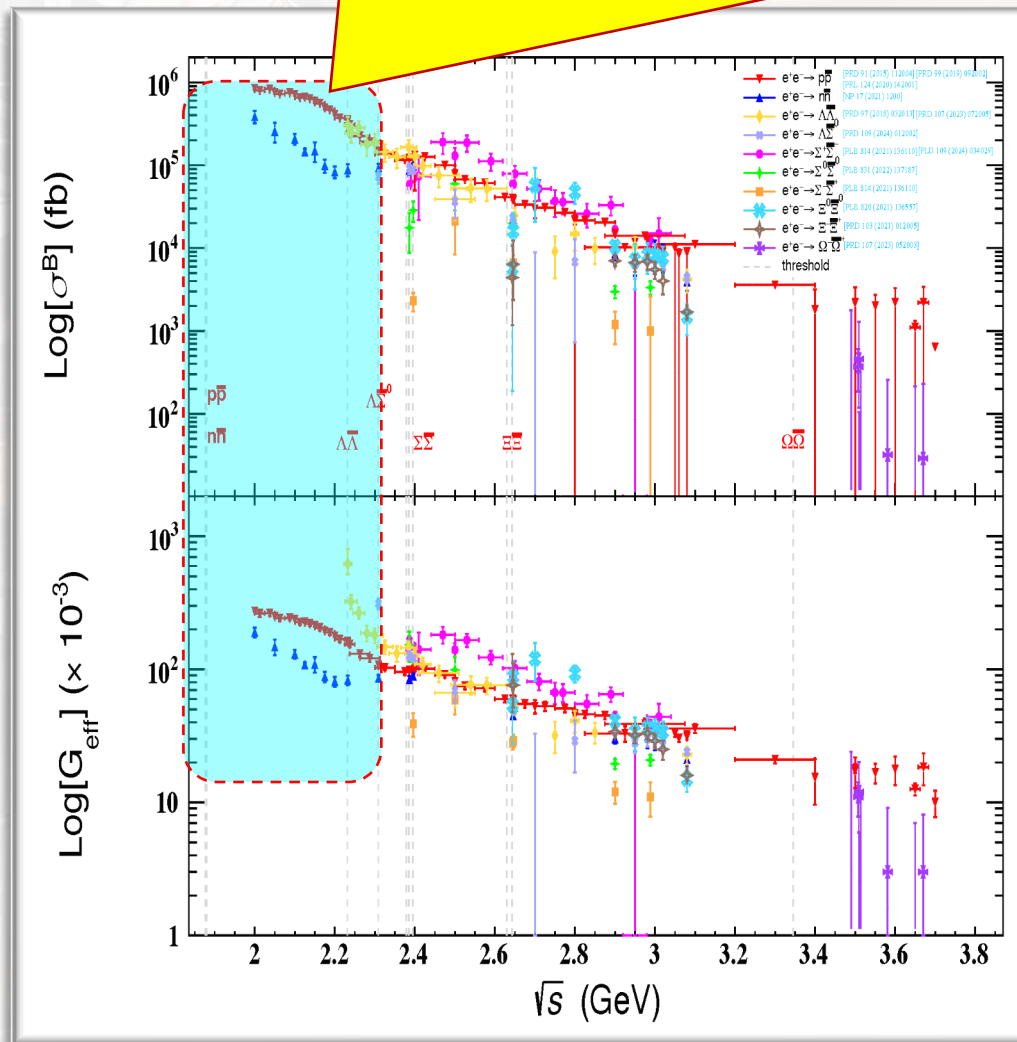
XYZ/Charmonium-like

- **Conventional Charmonium states**: Nonrelativistic $c\bar{c}$ bound state
- **XYZ/Charmonium-like states**: Various scenarios, such as molecule state, hybrid states, tetraquark states, etc., have been proposed



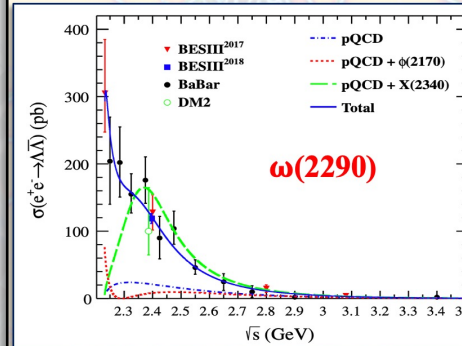
$e^+e^- \rightarrow H\bar{H}$ near threshold

Threshold enhancement ($p\bar{p}/n\bar{n}/\Lambda\bar{\Lambda}/\Lambda\bar{\Sigma}^0$)

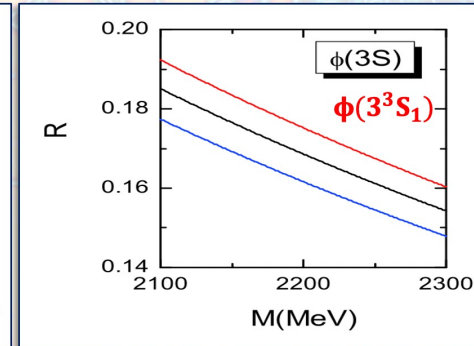


Various scenarios

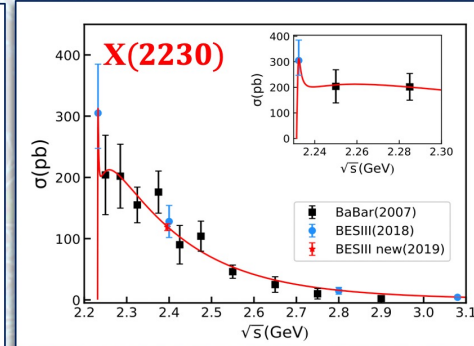
Xu Cao *et al.*, PRD98 (2018)094006



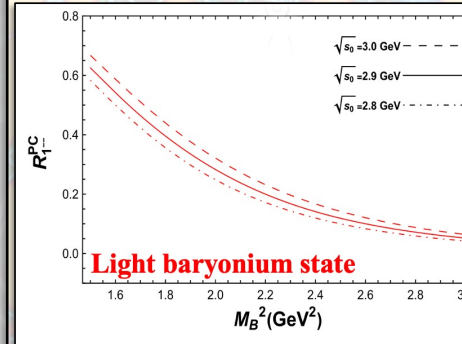
Li-Ye Xiao *et al.*, CPC43(2019)113105



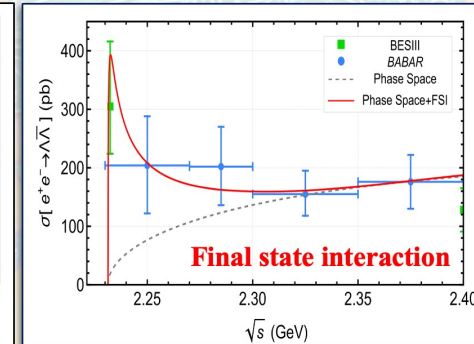
Jujun Xie *et al.*, CPL39(2022)011201



Bing-Dong Wa *et al.*, PRD105(2022)014016



Ri-Qing Qian *et al.*, PRD107(2023)L091502



(More ...)



Still not been understood well!

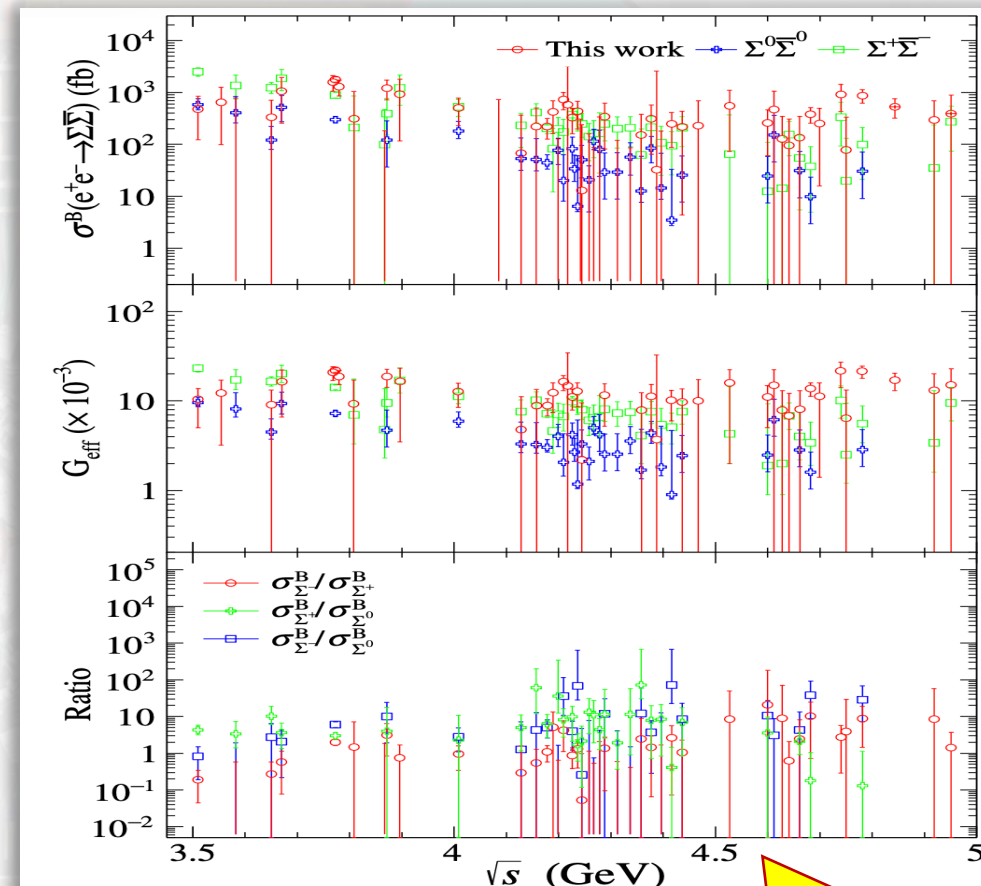
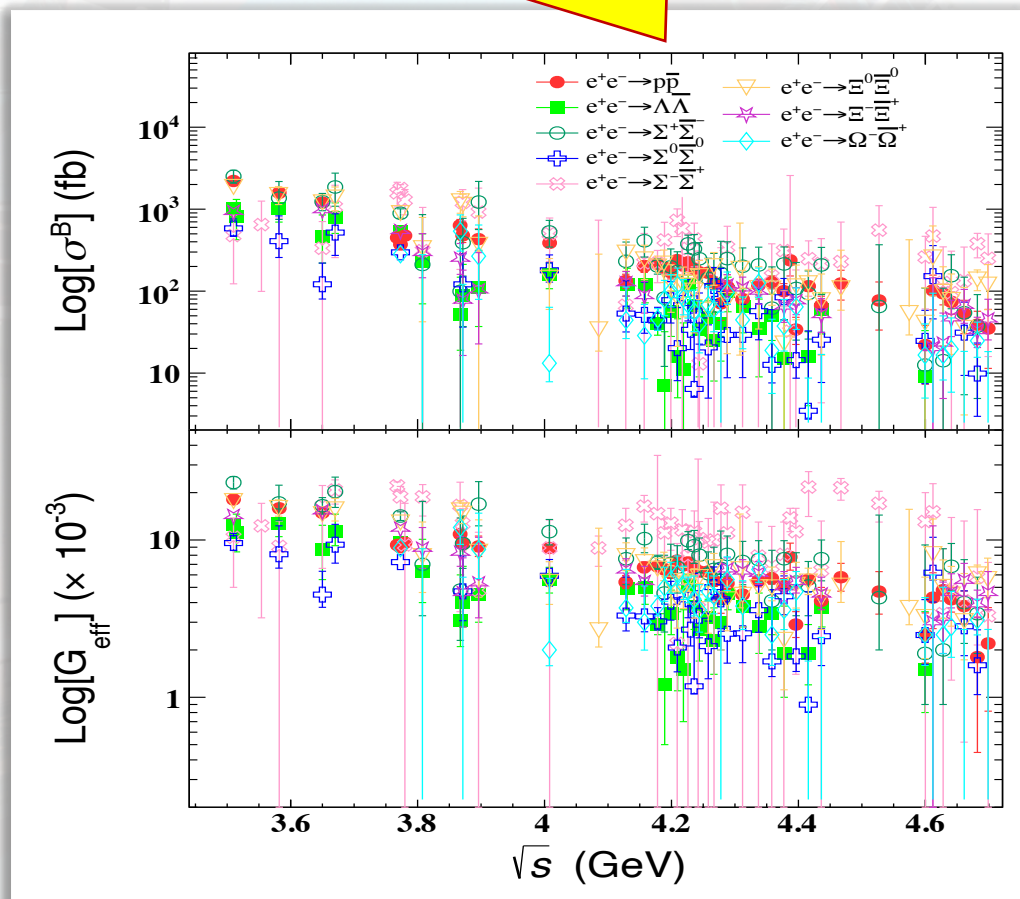
Need more effort!

$$e^+e^- \rightarrow H\bar{H} @ \sqrt{s} = 3.5 - 4.9 \text{ GeV}$$

[PRL124\(2020\) 032002](#)
[PRD\(L\)104\(2021\)L091104](#)
[JHEP11\(2023\)228](#)
[JHEP11\(2024\)062](#)
[JHEP05\(2024\)022](#)
[PRD\(L\)111\(2025\)L051502](#)
[arXiv: 2602.23835](#)

□ Study for hyperon pair production, **test for VMD** **dominated theoretical models**

Systematic scan/study for baryon pair production cross-section

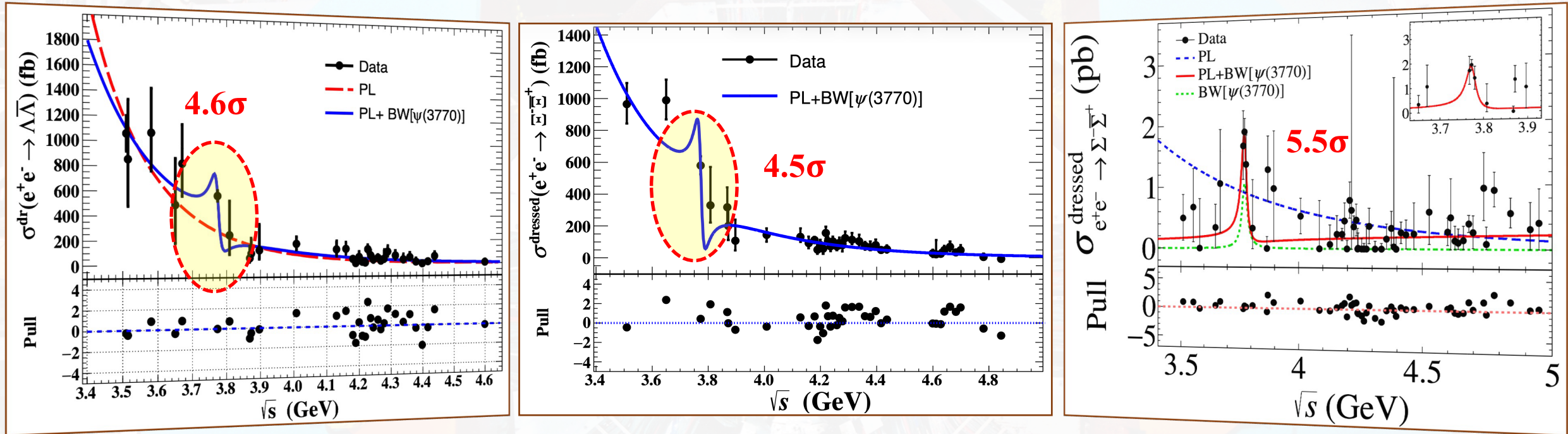


Validate the VMD dominated theoretical models

$$e^+e^- \rightarrow H\bar{H} @ \sqrt{s} = 3.5 - 4.9 \text{ GeV}$$

[PRL124\(2020\) 032002](#)
[PRD\(L\)104\(2021\)L091104](#)
[JHEP11\(2023\)228](#)
[JHEP11\(2024\)062](#)
[JHEP05\(2024\)022](#)
[PRD\(L\)111\(2025\)L051502](#)
[arXiv: 2602.23835](#)

□ Study for hyperon pair production, **search for charmonium(-like) resonance**

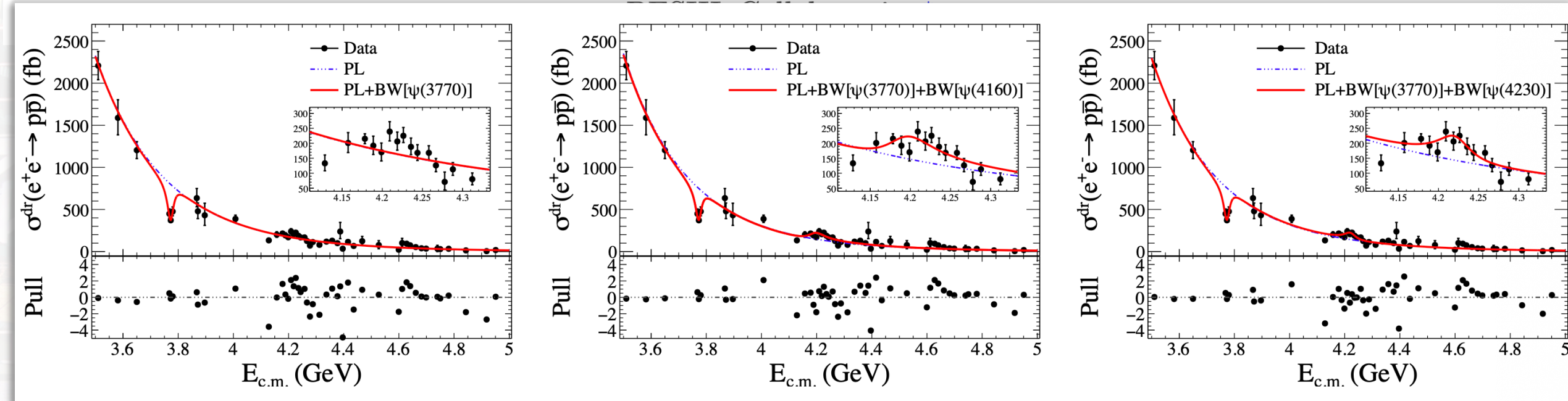


- **Observation of $\psi(3770) \rightarrow \Sigma^-\bar{\Sigma}^+$ and Evidence of $\psi(4160) \rightarrow \Lambda\bar{\Lambda}, \Xi^-\bar{\Xi}^+$**
- **No significance for other Charmonium(-like) observed**
- **More experiment information for constraint for pQCD**

Observation of $\psi(3770) \rightarrow p\bar{p}$ and Measurement of Electromagnetic Form Factors of Proton at $\sqrt{s} = 3.510 - 4.946$ GeV

[arXiv: 2606.22759](#)

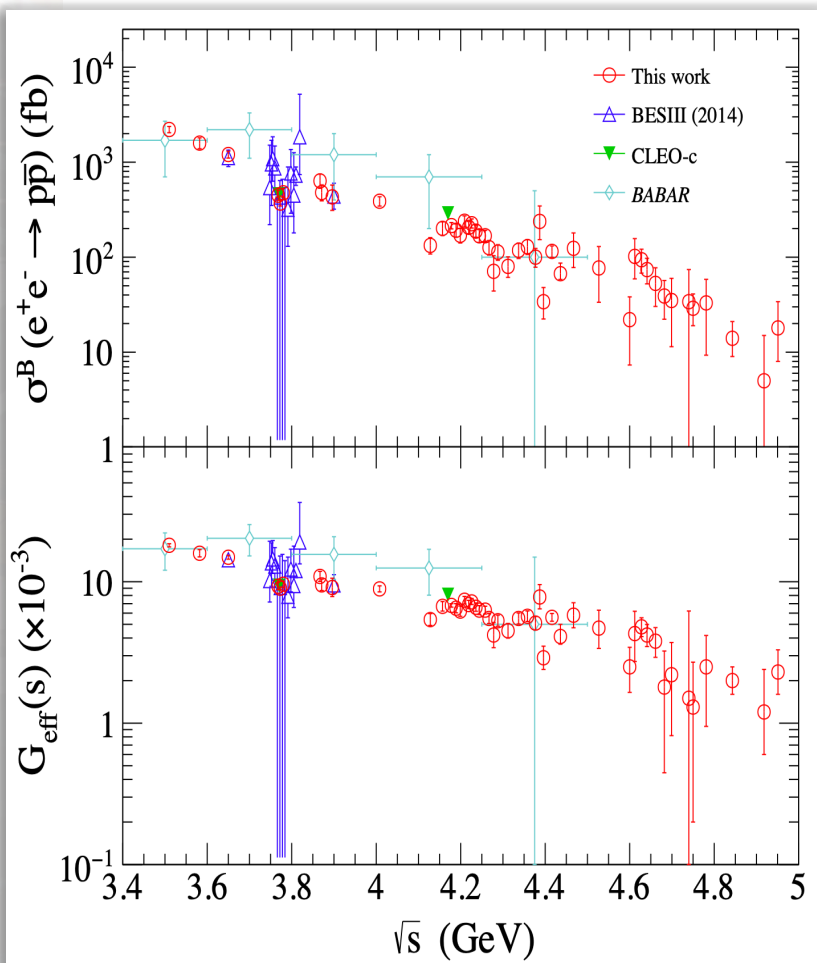
[arXiv: 2606.22762](#)



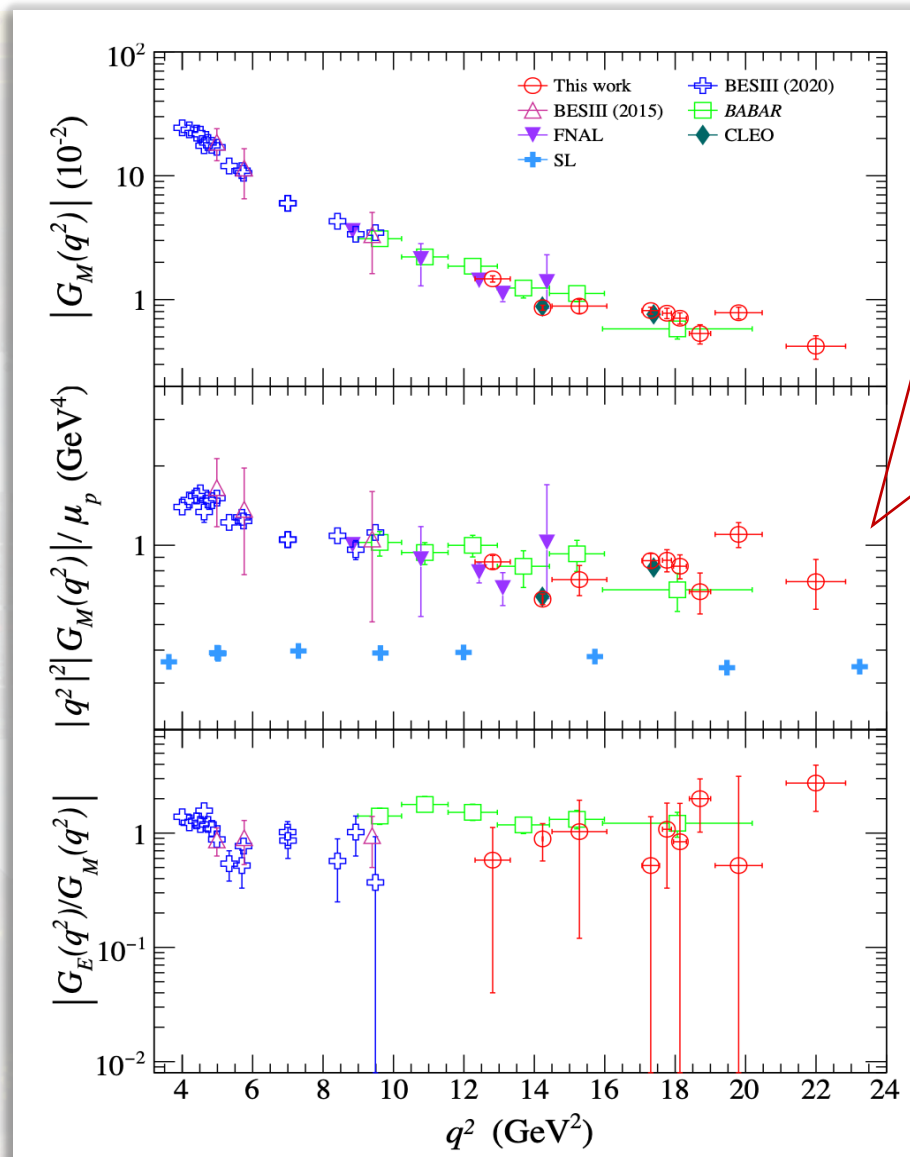
➤ **Observation of $\psi(3770) \rightarrow p\bar{p}$ (6.6σ)**

➤ **A structure near 4.2 GeV is observed with significances of 4.6σ or 4.8σ for the $\psi(4160)$ or $Y(4230)$ hypotheses including systematic uncertainties**

Observation of $\psi(3770) \rightarrow p\bar{p}$ and Measurement of Electromagnetic Form Factors of Proton at $\sqrt{s} = 3.510 - 4.946$ GeV



[arXiv: 2606.22759](https://arxiv.org/abs/2606.22759)
[arXiv: 2606.22762](https://arxiv.org/abs/2606.22762)



- 在大动量转移能区 ($\sim 20 \text{ GeV}^2$)，实验测得的Time-like电磁形状因子比Space-like值高出约两倍，这与QCD预言的二者近似一致存在明显偏离。
- 需进一步理解背后的物理！

$$e^+e^- \rightarrow pK^-\bar{\Lambda}/K\bar{\Xi}\Lambda(\Sigma)/\phi(\omega)\Lambda\bar{\Lambda} @ \sqrt{s} = 3.5 - 4.9 \text{ GeV}$$

□ More study for **three-body** baryonic final states production, search for **Charmonium(-like) states**

[JHEP12\(2023\)027](#)

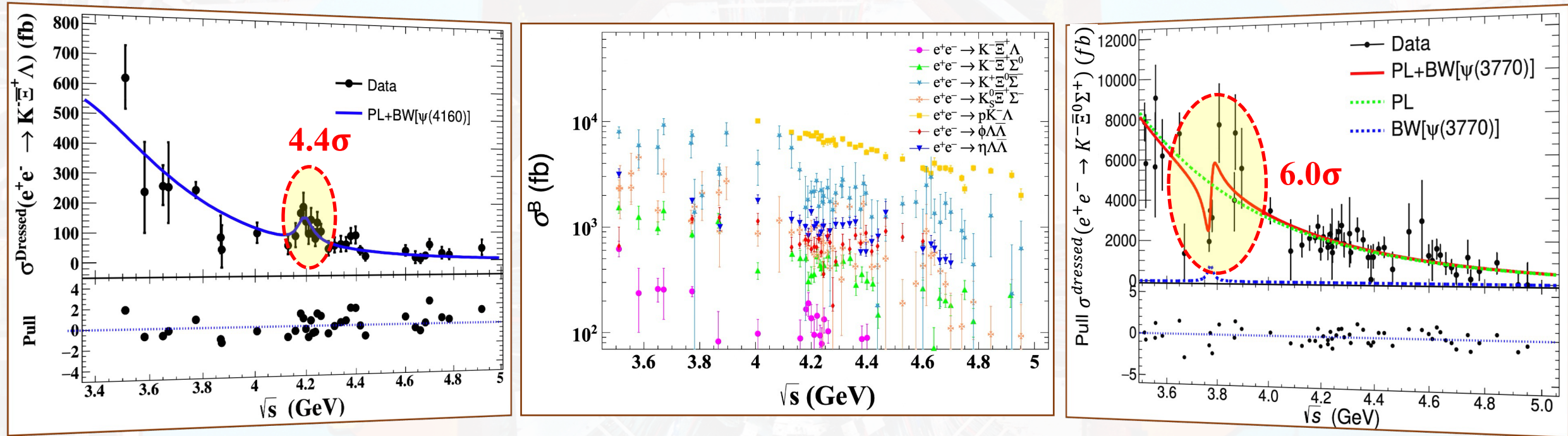
[JHEP07\(2024\)258](#)

[PRD104\(2021\)052006](#)

[PRD107\(2023\)112001](#)

[PRL131\(2023\)151901](#)

[arXiv:2605.19780](#)

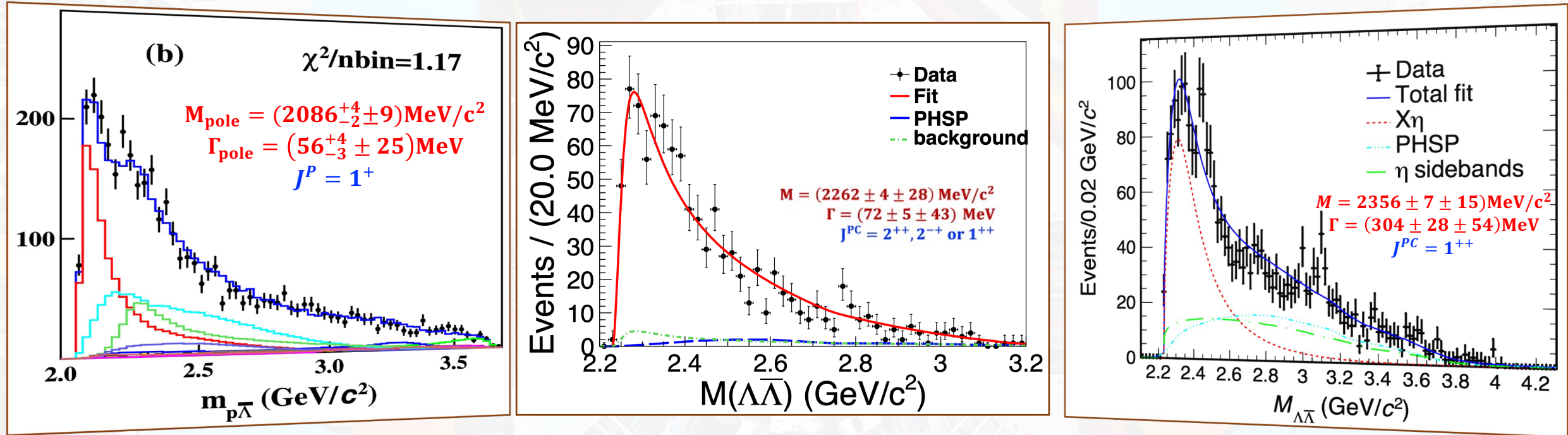


- Evidence of $\psi(4160) \rightarrow K^-\bar{\Xi}^+\Lambda$ and **observation of $\psi(3770) \rightarrow K^-\bar{\Xi}^0\Lambda$**
- No significance for other Charmonium(-like) observed
- More information for charmless decay of Charmonium(-like)

$$e^+e^- \rightarrow pK^-\bar{\Lambda}/\phi(\eta)\Lambda\bar{\Lambda} @ \sqrt{s} = 3.5 - 4.9 \text{ GeV}$$

PRD104(2021)052006
PRD107(2023)112001
PRL131(2023)151901

- Study for **three-body** baryonic final states production, search for excited baryon/meson states

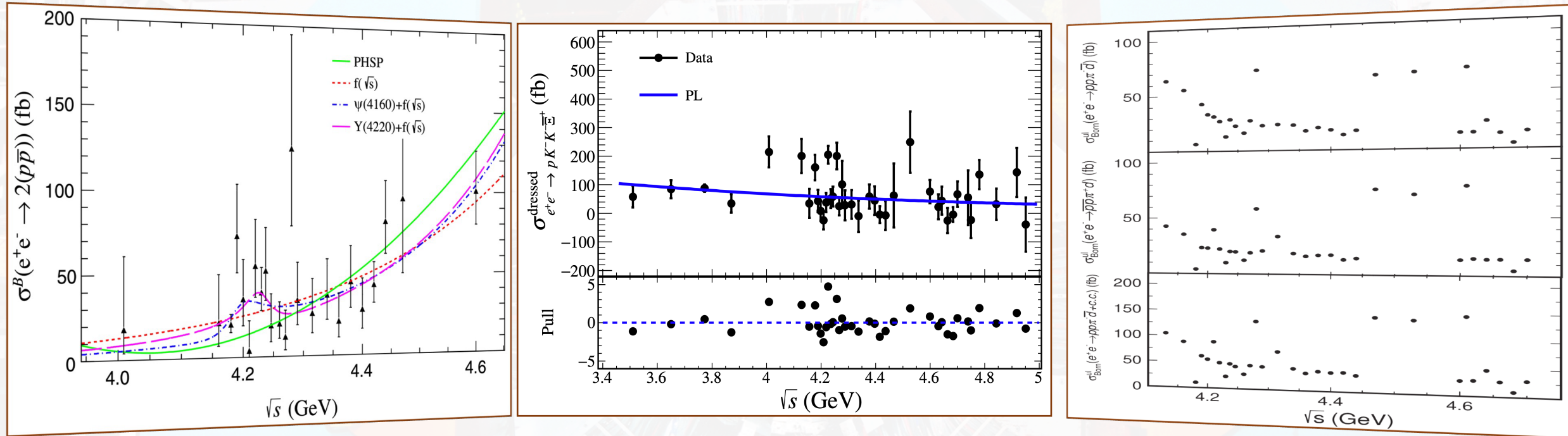


- Observations of near $\Lambda\bar{\Lambda}$ and $p\bar{\Lambda}$ enhancements
- More excited states and more constraint for pQCD

$e^+e^- \rightarrow$ multi-body final states @ $\sqrt{s} = 3.5 - 4.9$ GeV

□ More study for **multi-body** baryonic final states production, search for **Charmonium(-like) states**

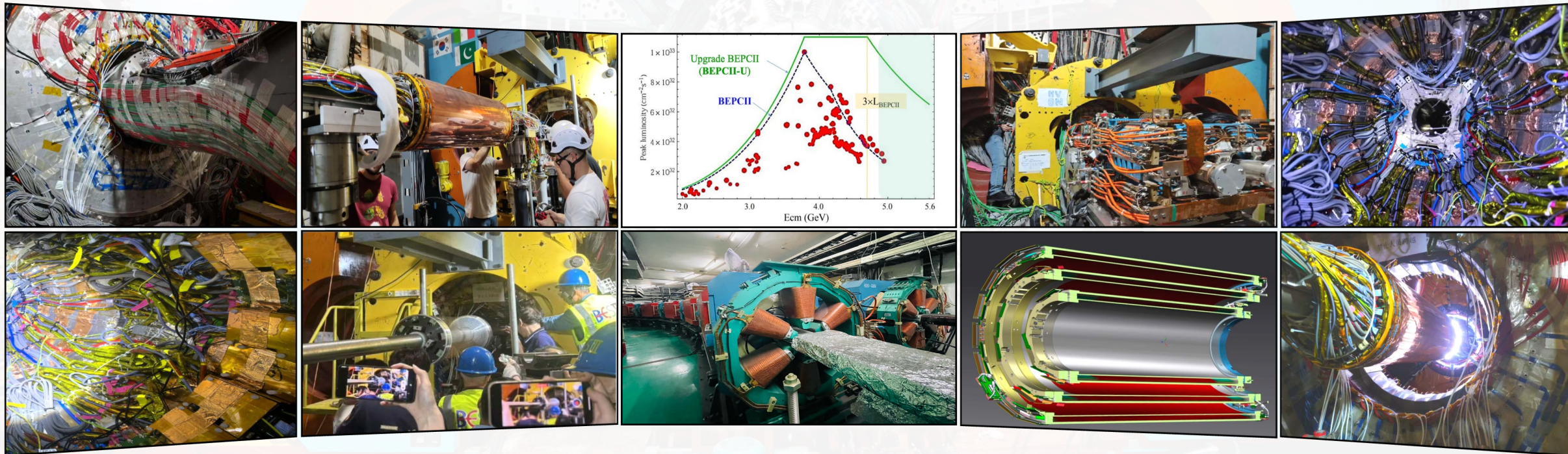
[PRD103\(2021\)052003](#)
[PRD109\(2024\)092013](#)
[JHEP11\(2025\)111](#)



- **No any Charmonium(-like) states observed, No deuteron signal observed**
- **More excited states and more constraint for pQCD**

Summary

- ❑ **BESIII has been running successfully (>16 years)**
- ❑ **2024-2025, BESIII detector and BEPCII upgrade**
 - Upgrade in beam energy up to 2.8 GeV and luminosity (BEPCII-UP, 3X)
 - A new inner tracker (CGEM) for BESIII detector was installed
 - Opportunities to study the baryons physics in the BEPCII-UP



Summary

□ Many studies for hyperon/baryon physics achieved

- Hyperon polarization observed
- CPV in hyperon: $O(\sim 10^{-3})$ [SM $\sim 10^{-4}$]
- A more strict upper bound for Λ –EDM and CEDM
- Observation: $\psi(3770) \rightarrow p\bar{p}, \Sigma^- \bar{\Sigma}^+$ and $K^+ \Xi^0 \bar{\Sigma}^-$
- Evidence: $Y(4230) \rightarrow p\bar{p}$
- Evidence: $\psi(3770) \rightarrow \Lambda \bar{\Lambda}, \Xi^- \bar{\Xi}^+$ and $\psi(4160) \rightarrow K^- \bar{E}^+ \Lambda$
- Production for two/three/four-body hyperon final states
- ...

□ More new results are on the way