中国组2026年在 Belle II上取得的成果

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Belle II实验冬季学校，东南大学， Nov 13 – 19, 2026

SuperKEKB 与 Belle II

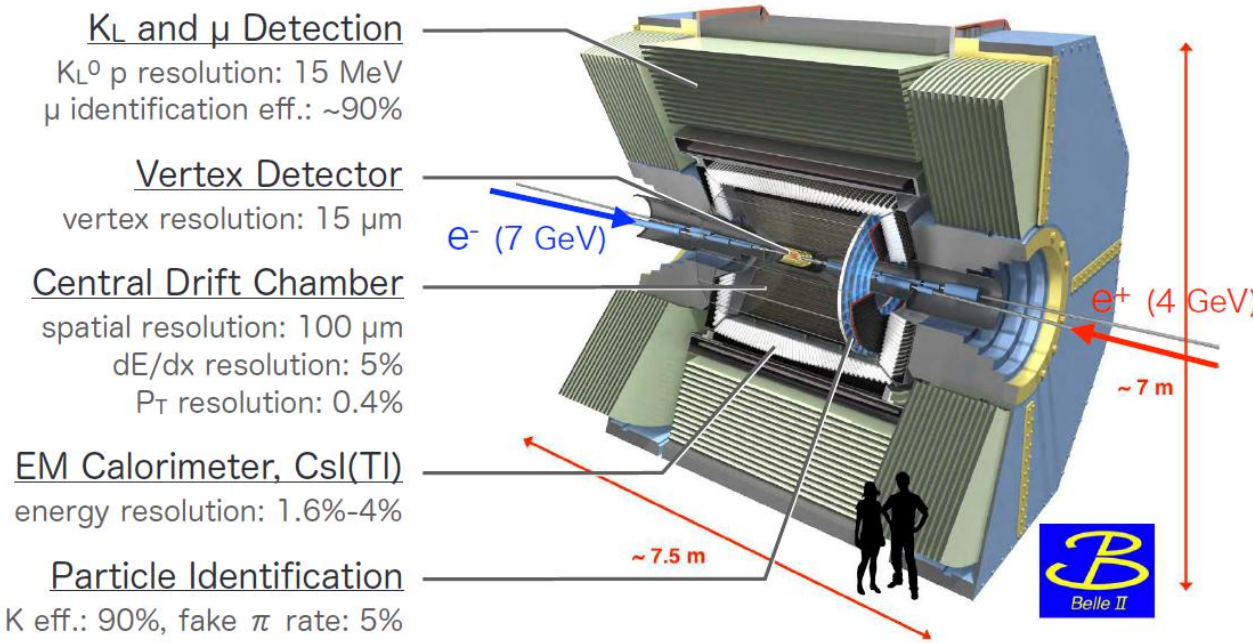


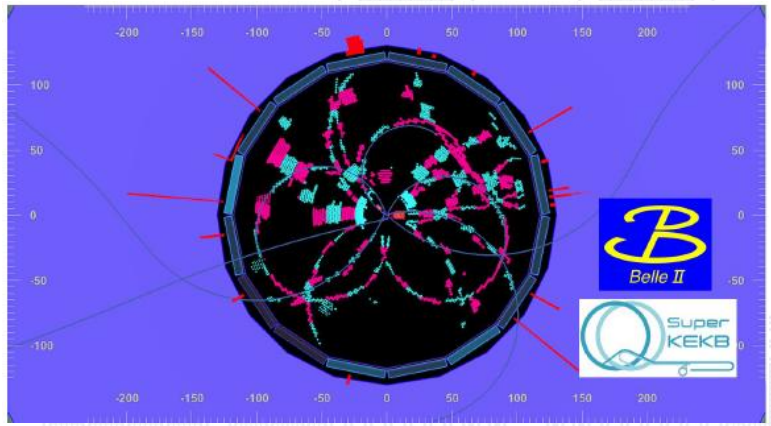
非对称束流：

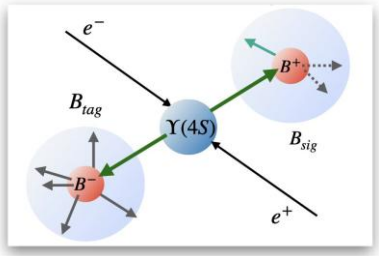
e^- 7 GeV、e^+ 4 GeV

已知初态，支持

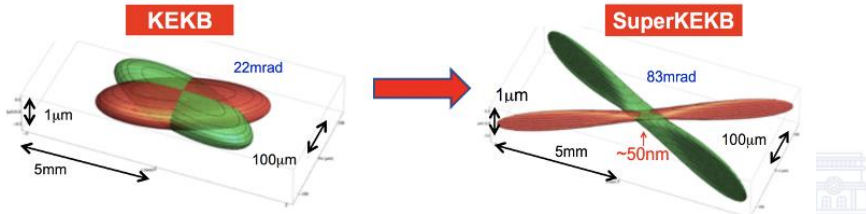
运动学约束与反冲测量







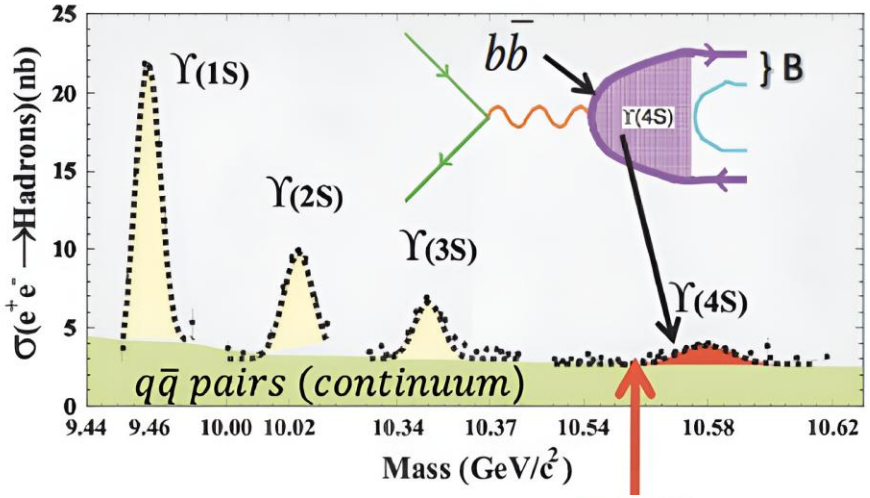
Nano-beam : 30X peak luminosity of Belle



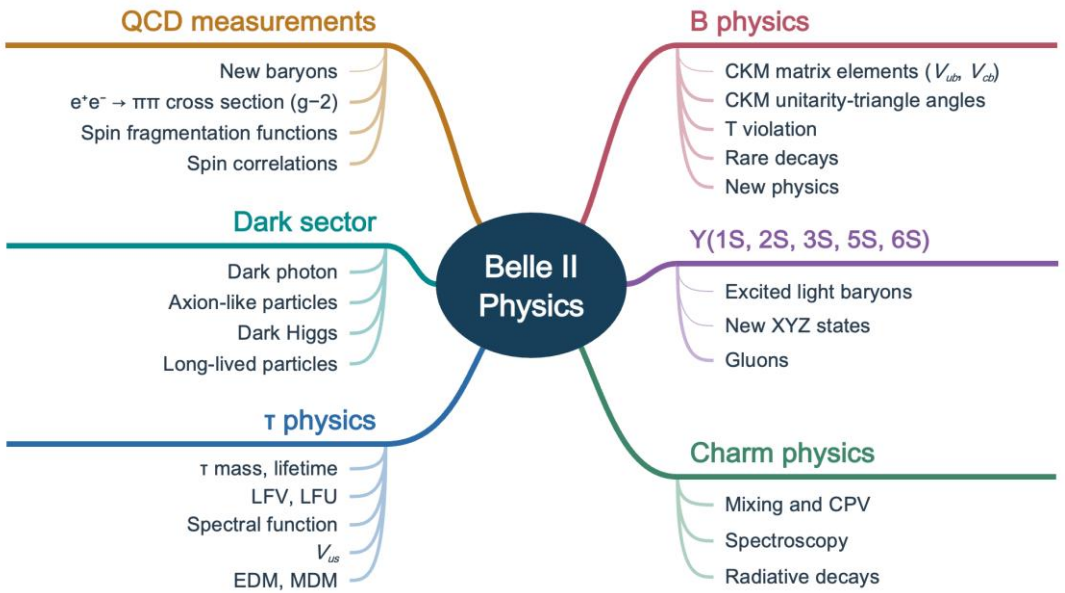
目前已经采集到 906 fb^{-1} 数据

- 目标亮度 L_{inst}: $6 \times 10^{35}\ cm^{-2}\ s^{-1}$
- 总计取书计划: $\sim 50 ab^{-1}$

Belle(II) 物理研究领域



$e^+e^- \to$	Cross section [nb]
$\Upsilon(4S)$	1.05 ± 0.10
$c\bar{c}$	1.30
$s\bar{s}$	0.38
$u\bar{u}$	1.61
$d\bar{d}$	0.40
$\tau^+\tau^-(\gamma)$	0.919
$\mu^+\mu^-(\gamma)$	1.148
$e^+e^-(\gamma)$	300 ± 3

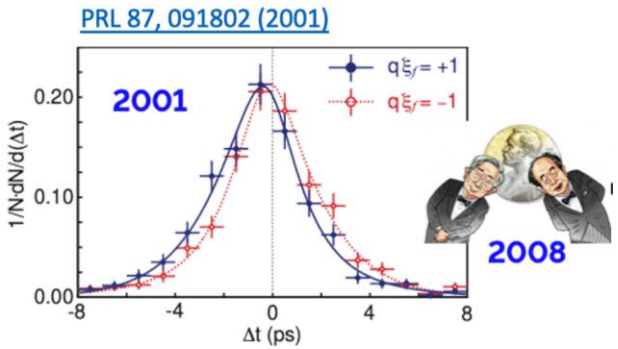


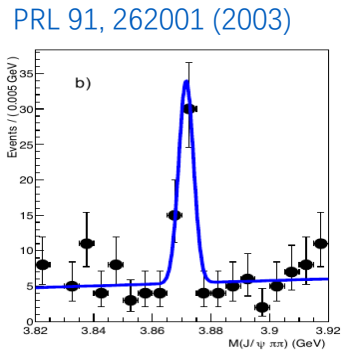
Belle II Physics Book, PTEP 2019, 123C01

Belle II 实验是 B 工厂；但是不只是B物理的摇篮！

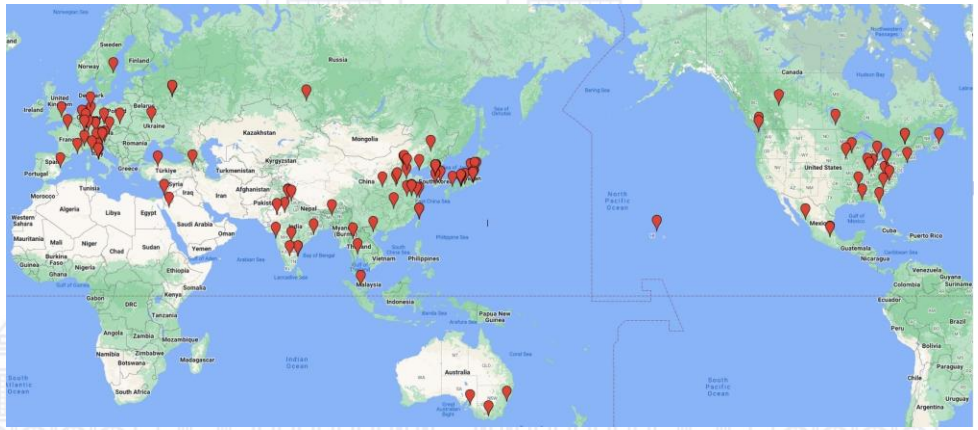
- 同时也是 τ, 粲 工厂
- 适合研究：
  - 谱学
  - 寻找dark sector; 有 missing energy 的过程（中子、中微子末态等）
  - 粒子寿命
  - 衰变时间依赖的分析

Belle：发现中性 B 介子 CP 破坏与 X(3872)





前者检验 CKM 机制，后者推动阈值附近强子结构研究。
Belle II 延续重味精密测量与强子谱学研究。



Belle II：1200余名成员
28个国家和地区，127个参与单位

中国参与单位17个
其中大陆15个、台湾地区2个

北京航空航天大学
复旦大学
河南师范大学
湖南师范大学
中科院高能所
吉林大学
辽宁师范大学
南京师范大学
南开大学
东南大学
山东大学
苏州大学
中国科学技术大学
西安交通大学
郑州大学

台湾地区：辅仁大学、台湾大学

第一届Belle合作中国组会议

2010年6月11-12日，怀柔



2010年（Belle）
高能所（7+8）
北京大学（1+2）
中国科技大学（2+3）
共23人

第八届Belle II合作中国组会议

2026年5月29日-6月1日，大连



中国组2026年在 Belle II上取得的成果

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Observation of the decays $B^+ \to \Sigma_c(2455)^{++}\bar{\Xi}_c'^{-}$ and $B^0 \to \Sigma_c(2455)^{0}\bar{\Xi}_c'^{0}$

Journal: PRD **114, 052016** (2026) arXiv:2606.12905 (1 citation; 2.4 cit/yr)

Contacts: Y. Li, C. P. Shen

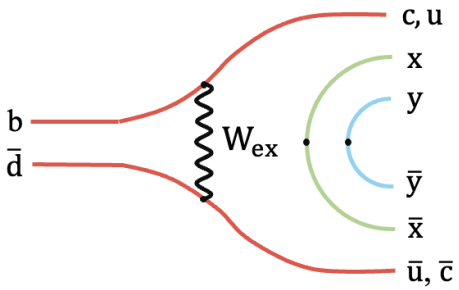
Referees: K. Schoenning, S. Raiz, K. Tanida
PC reader: J. Yelton
WG reviewer: P. Feichtinger
Inst Reviews: UNAM, Padova, KEK, McGill, Napoli

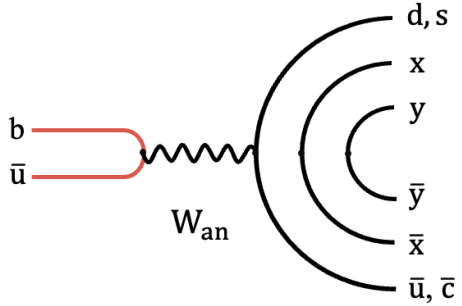
Registered: Sat Apr 18 2026
CWR1 ended: Sat May 2 midnight JST 2026
CWR2 ended: Wed Jun 3 midnight JST 2026 (expired) confirmed
Submitted: Fri Jun 12 2026 (+9 days)

Observation of the decay $B \to \Sigma_c(2455)\bar{\Xi}_c$

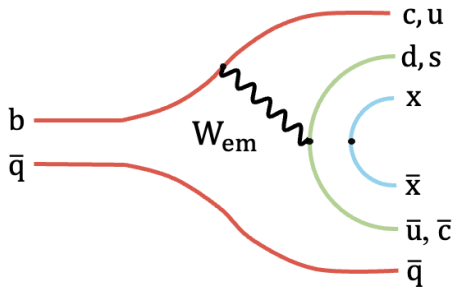
PRD 112, L051101 (2025)

- The tree-level two-body baryonic B decays can proceed through W-exchange ($W_{\rm ex}$), W-annihilation ($W_{\rm an}$), and internal W-emission ($W_{\rm em}$) diagrams.





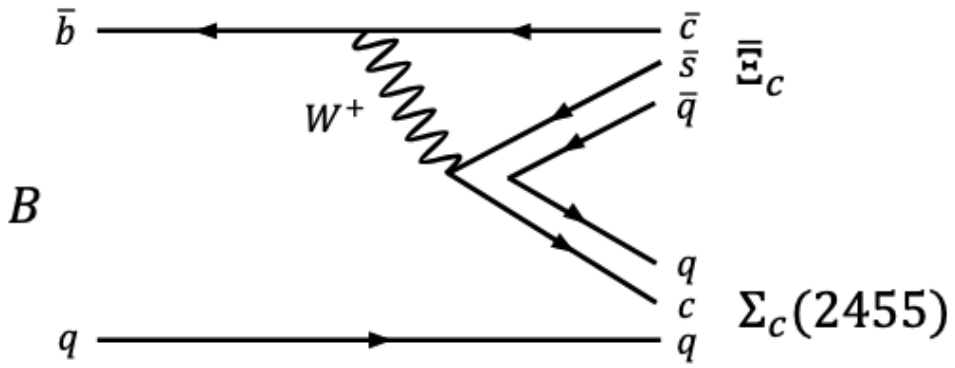
$W_{\rm ex}$ and $W_{\rm an}$: helicity suppressed



$W_{\rm em}$: nonfactorizable amplitude

- The decays $B \to \Sigma_c(2455)\bar{\Xi}_c$ proceed through a pure $W_{\rm em}$ diagram, providing a clean and ideal environment for studying nonfactorizable effects.

- The QCD sum rule predicts $\mathcal{B}(B \to \Sigma_c(2455)\bar{\Xi}_c) \sim 4\times10^{-3}$ [NPB 345 137 (1990)], while the diquark model estimates $\mathcal{B}(B \to \Sigma_c(2455)\bar{\Xi}_c)$ to be 30%–70% of $\mathcal{B}(B \to \Lambda_c\bar{\Xi}_c) \sim 10^{-3}$ [ZPC 51 445 (1991)].



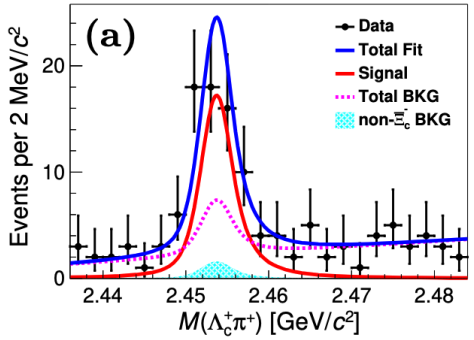
$\Sigma_c(2455)$: a sextet of flavor-symmetric states; $\bar{\Xi}_c$: an antitriplet of flavor-antisymmetric states

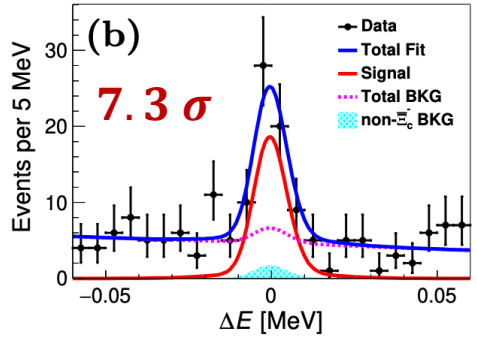
Observation of the decay $B \to \Sigma_c(2455)\bar{\Xi}_c$

PRD 112, L051101 (2025)

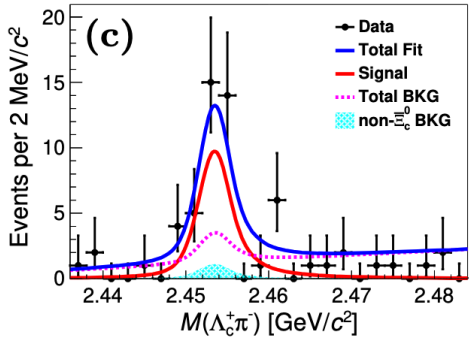
- We report the first observation of the decays $B^+ \to \Sigma_c(2455)^{++}\bar{\Xi}_c^-$ and $B^0 \to \Sigma_c(2455)^0\bar{\Xi}_c^0$, using the 772×10^6 and 387×10^6 $\Upsilon(4S)$ events collected by Belle and Belle II, respectively.
- We perform a 2D fit to the unbinned $M(\Lambda_c^+\pi^\pm)$ and ΔE distributions, simultaneously using four data sets: events from the signal and sideband regions of $M(\bar{\Xi}_c^{-,0})$.

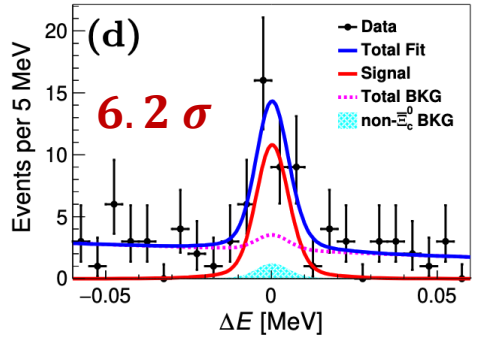
B^+





B^0





$$\mathcal{B}(B^+ \to \Sigma_c(2455)^{++}\bar{\Xi}_c^-) = \left(5.74 \pm 1.11 \pm 0.42^{+2.47}_{-1.53}\right)\times10^{-4}$$

$$\mathcal{B}(B^0 \to \Sigma_c(2455)^0\bar{\Xi}_c^0) = (4.83 \pm 1.12 \pm 0.37^{+0.72}_{-0.60})\times10^{-4}$$

- $\mathcal{B}(B \to \Sigma_c(2455)\bar{\Xi}_c)$ are larger than those of $B^+ \to \bar{\Sigma}_c(2455)^0 p$ and $B^0 \to \bar{\Sigma}_c(2455)^- p$:
  - Similar size of CKM matrix elements: $V_{bc} * V_{cs} \sim V_{bc} * V_{ud}$
  - Smaller phase-space

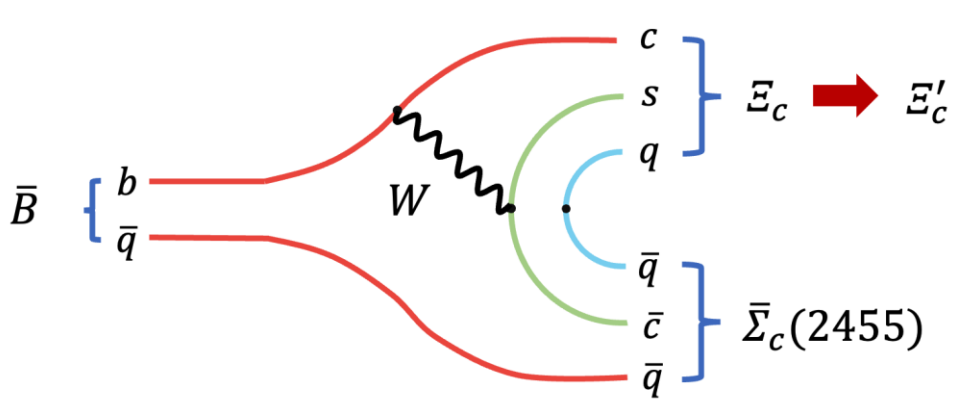
  [Int. J. Mod. Phys. A 21(2006) 4209]
- One possible mechanism is that hard gluons are not necessarily required for double-charm decays.

Observation of the decay $B \to \Sigma_c(2455)\bar{\Xi}'_c$

PRD 114, 052016 (2016)

- The decay $B \to \Sigma_c(2455)\bar{\Xi}'_c$ proceeds through the same type of diagram as $B \to \Sigma_c(2455)\bar{\Xi}_c$ and are therefore expected to have a branching fraction of similar magnitude.

- A comparison between $\mathcal{B}(B \to \Sigma_c(2455)\bar{\Xi}'_c)$ and $\mathcal{B}(B \to \Sigma_c(2455)\bar{\Xi}_c)$ could provide insight into the underlying dynamics of B decays to charmed baryon pairs belonging to different SU(3)-flavor multiplets.



internal W-boson emission nonfactorizable amplitude

- Using 772×10^6 and 521×10^6 $\Upsilon(4S)$ events collected by Belle and Belle II detector, we present the first search for the decays $B^+ \to \Sigma_c(2455)^{++}\bar{\Xi}'^{-}_c$ and $B^0 \to \Sigma_c(2455)^0\bar{\Xi}'^{0}_c$.

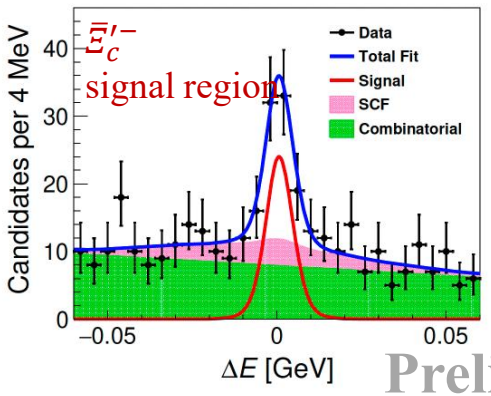
- This is the first search for B-meson decays into a pair of charmed baryon-antibaryon states, each belonging to the SU(3)-flavor sextet.

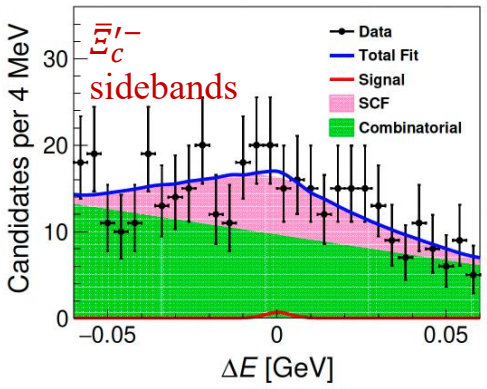
Observation of the decay $B \to \Sigma_c(2455)\bar{\Xi}'_c$

PRD 114, 052016 (2016)

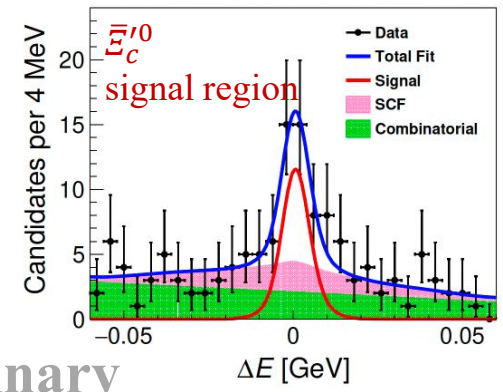
- To extract the signal yields, we perform a simultaneous unbinned maximum-likelihood fit to the ΔE distributions in the signal and sideband regions of $M(\gamma\bar{\Xi}_c)$ for the Belle and Belle II datasets.

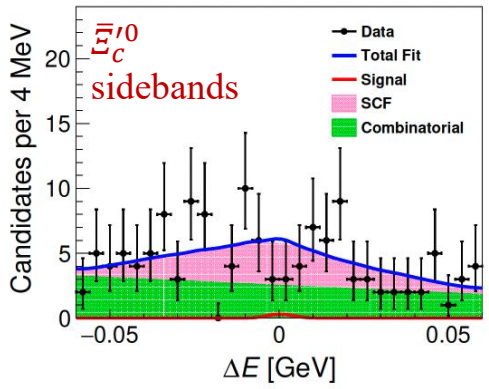
$B^+ \to \Sigma_c(2455)^{++}\bar{\Xi}'^-_c$





$B^0 \to \Sigma_c(2455)^0\bar{\Xi}'^0_c$





Preliminary

- ✓ The observed signal significances exceed 6.4σ for the charged mode and 5.3σ for the neutral mode including systematic uncertainties.
- ✓ The measured branching fractions are

$$\mathcal{B}(B^+ \to \Sigma_c(2455)^{++}\bar{\Xi}'^-_c) = \left(1.68 \pm 0.31 \pm 0.12^{+1.49}_{-0.54}\right)\times 10^{-3}$$

$$\mathcal{B}(B^0 \to \Sigma_c(2455)^0\bar{\Xi}'^0_c) = \left(1.28 \pm 0.32 \pm 0.10^{+0.30}_{-0.21}\right)\times 10^{-3}$$

Uncertainties are statistical, systematic, and from $\mathcal{B}(\bar{\Xi}_c \to X)$, respectively.

- ✓ The measured branching fractions are two to three times larger than those of $B^+ \to \Sigma_c(2455)^{++}\bar{\Xi}^-_c$ and $B^0 \to \Sigma_c(2455)^0\bar{\Xi}^0_c$, despite the smaller available phase space for these decays.

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Measurement of $R(D^{(*)})$ with the hadronic FEI tagging method using LS1 dataset

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Comments
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Code archive
Authors

Journal: Submitted to PhysRev arXiv:2609.21947 (2 [1] citations; 12.0 [6.0] cit/yr)

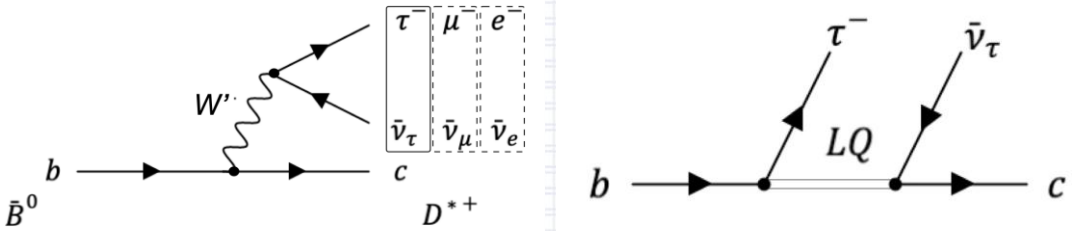
Contacts: T. Koga, L. Wang, Q. D. Zhou, T. Iijima, K. Hara, K. Matsuoka, K. R. Nakamura, K. Uno, A. Aggarwal, M. T. Prim
Referees: C. Schwanda, P. Goldenzweig, F. Meier
PC reader: M. Dorigo
WG reviewers: M. Hohmann, M. Mantovano
Inst Reviews: DESY, IJCLab, NNU, Fudan, UofA

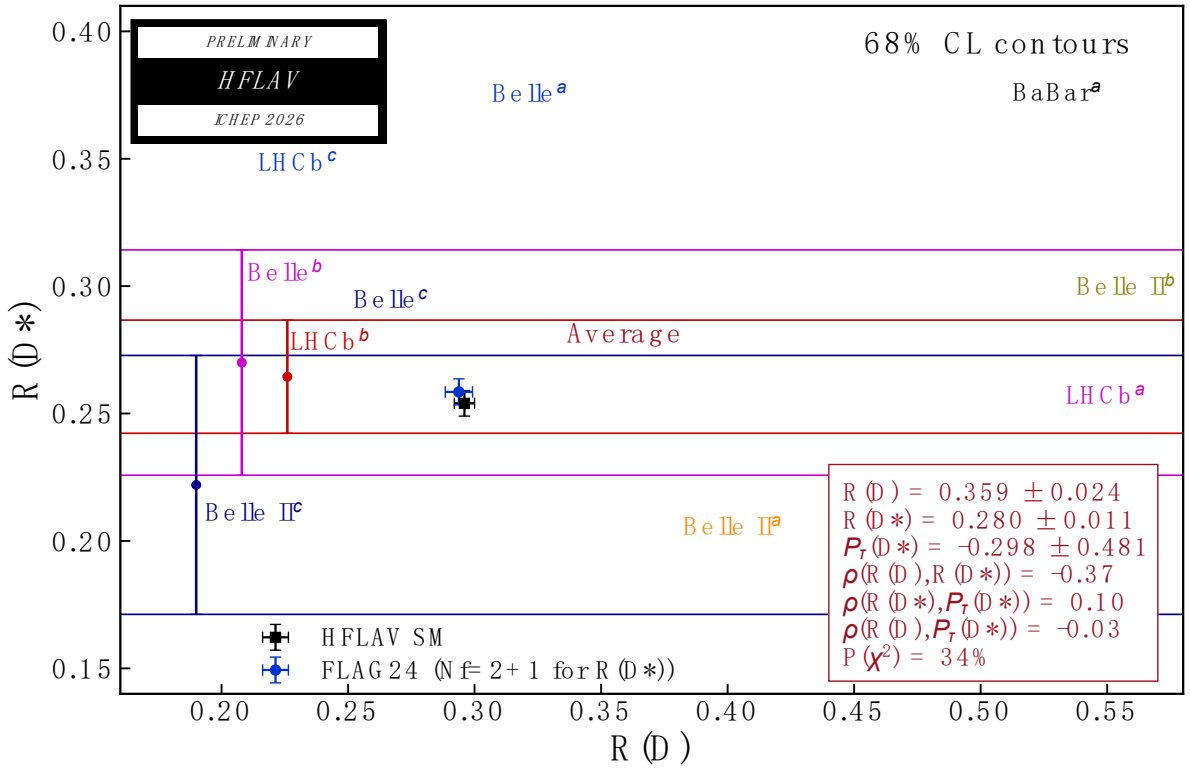
Registered: Sun Sep 7 2025
CWR1 ended: Sun Sep 21 midnight JST 2025
CWR2 ended: Wed Aug 5 midnight JST 2026 (expired) confirmed
Submitted: Tue Sep 22 2026 (+48 days)

Test of lepton flavor universality

- SM prediction vs. experimental average shows 3.7σ diviation
- Ratios of $b \to q\tau\nu/q\mu\nu/qe\nu$ branch fractions cancel out the uncertainties on $|V_{cb}|$, most uncertainties of **form factors** and the **experimental systematics**

$$R_{(D^*)} = \frac{Br(\bar{B}^0 \to D^{*+}\tau^-\bar{\nu}_\tau)}{Br(\bar{B}^0 \to D^{*+}\ell^-\bar{\nu}_\tau)}$$



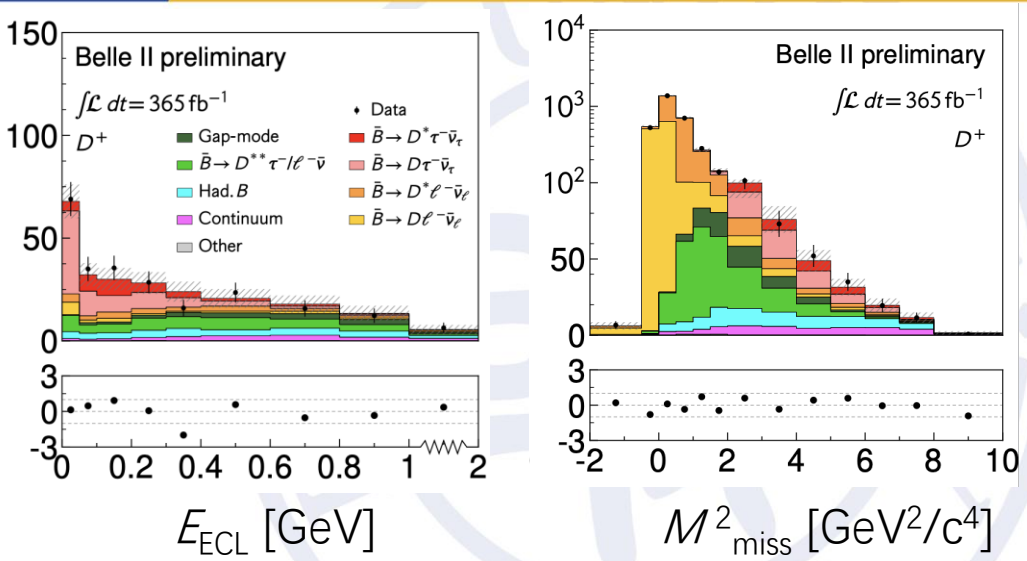


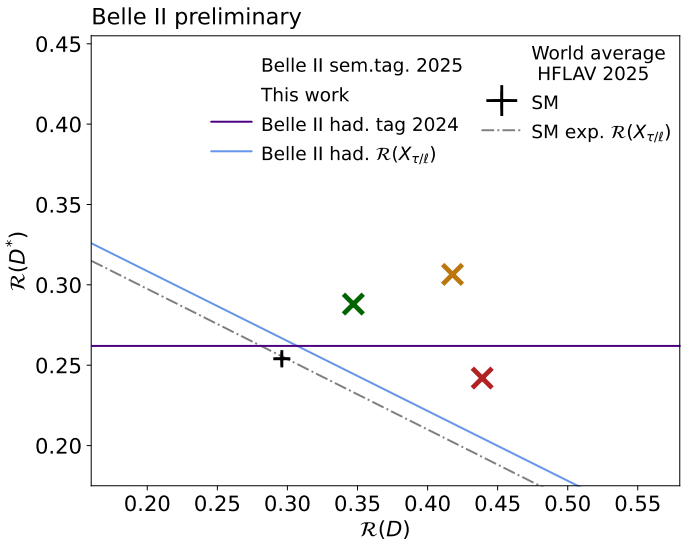
- Sensitive to New Physics (NP) because the massive 3rd generation b quark and τ lepton are involved, energy scale ~10 TeV

- Belle II UPDATED result for $R(D^{(*)})$ @ 365 fb^{-1}
  - Hadronic tag with FEI
  - Leptonic τ decays
  - $B \to D^{*+}$, $D^{*0}(\pi^0)$, $D^{*0}(\gamma)$, D^+,D^0,$\tau/l\nu$
- Main systematics
  - The finite size of the simulated samples
  - Branch fraction of $B \to D^{(*)}\eta l\nu$
- Belle II $R(D^{(*)})$ result with had. tag

$$R_{\tau/l}(D) = 0.439 \pm 0.055\ (\text{stat}) \pm 0.045\ (\text{syst})$$
$$R_{\tau/l}(D^*) = 0.242 \pm 0.019\ (\text{stat}) \pm 0.016\ (\text{syst})$$

- Similar sensitivity as Belle 15'result @ 711 fb^{-1} with only 365 fb^{-1}





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Measurement of inclusive $B \to X_u \ell \nu$ partial branching fractions and $|V_{ub}|$ at Belle II

Journal: PRD **113, 032004** (2026) arXiv:2512.08056 (12 [6] citations; 13.1 [6.5] cit/yr)

Contacts: T. Martinov, M. Hohmann, L. Cao, K. Tackmann, F. U. Bernlochner, M. Graf-Schreiber, M. Khan, M. Angelsmark, P. Urquijo

Referees: M. Dorigo, A. Gaz, R. Kowalewski

PC reader: M. Rozanska

WG reviewers: T. Koga, C.-L. Hsu

Inst Reviews: KEK, NTU-Taiwan, HEPHY Vienna, KISTI, BINP

Registered: Mon Jun 23 2025

CWR1 ended: Sun Jul 6 midnight JST 2025

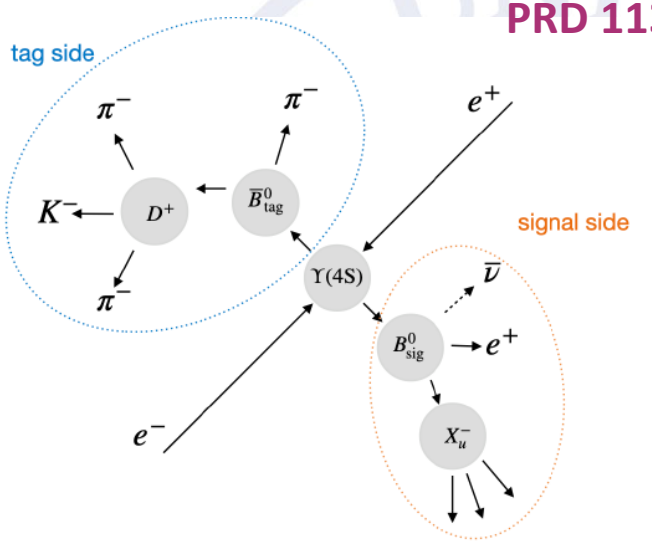
CWR2 ended: Mon Nov 17 midnight JST 2025 (expired)

Submitted: Wed Dec 10 2025 (+23 days)

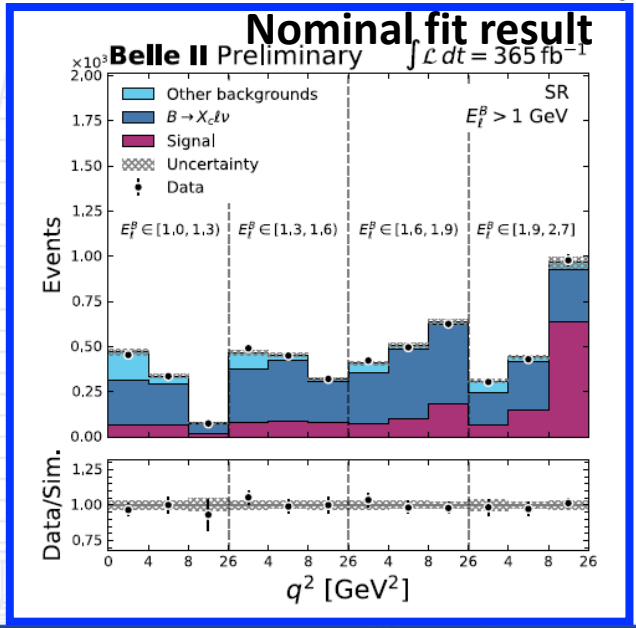
Inclusive $B \to X_u \ell \nu$

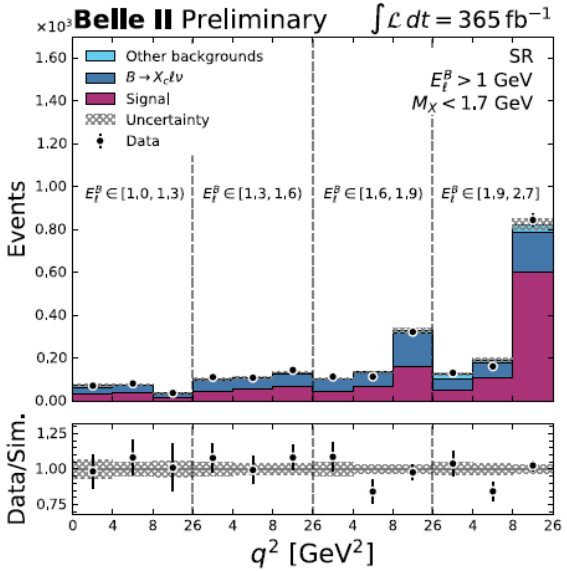
PRD 113 (2026) 032004

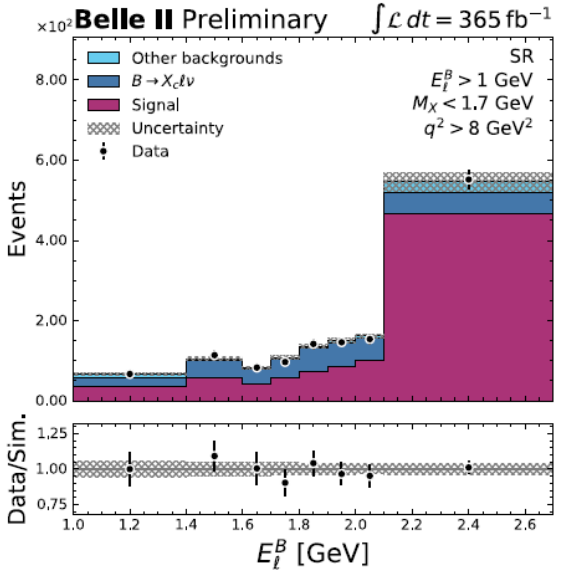
- **Reconstruct:** Combined signal lepton on the **signal side** with fully reconstructed hadronic B on **tag side**
- **Large backgrounds** from dominant $B \to X_c \ell \nu$ decays
  - Efficiently suppressed with MLP using different event shape variables
  - Normalization and shape mismodelling **corrected** using **control regions** in data
- **Extract signal** with 2D fit to lepton energy in B restframe E_ℓ^B & momentum transfer $q^2 = (p_\ell + p_\nu)^2$



Nominal fit result



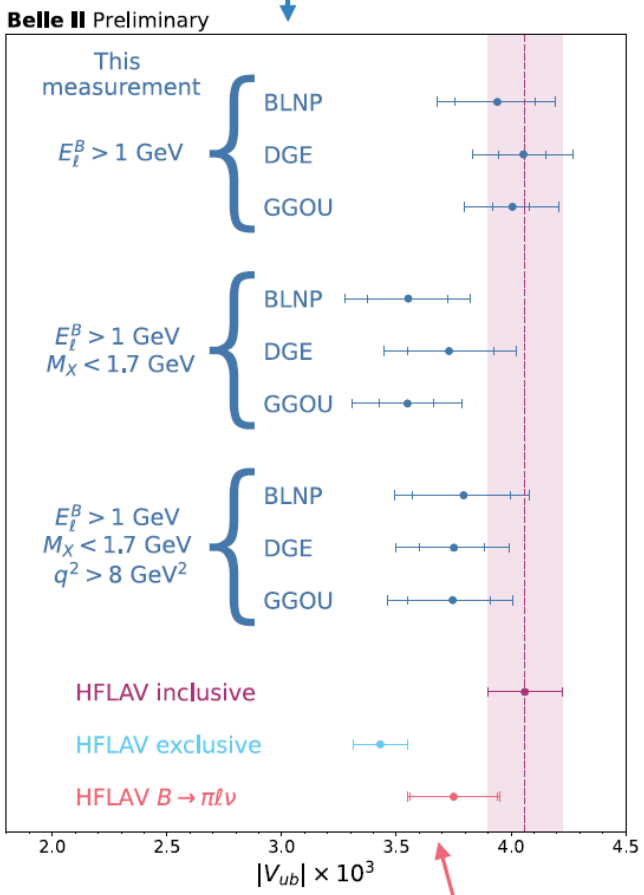




PRD 113 (2026) 032004

BLNP model:
PRD72,073006;
NPB 699,335
DGE model:
JHEP 01 (2006) 097
GGOU model:
JHEP 10 (2007) 058.

Predictions of the partial rate



Exclusive Average for $B \to \pi \ell \nu$:
$|V_{ub}| = (3.75 \pm 0.06_{\text{exp}} \pm 0.19_{\text{theo}}) \times 10^{-3}$

Determine $|V_{ub}|$ from the measured **partial branching fractions** in the 3 different phase space regions:

$$|V_{ub}| = \sqrt{\frac{\Delta\mathcal{B}(B \to X_u \ell^+ \nu_\ell)}{\tau_B \cdot \Delta\Gamma(B \to X_u \ell^+ \nu_\ell)}}$$

Nominal result: $E_\ell^B > 1$ GeV with GGOU

$$|V_{ub}| = (4.01 \pm 0.19^{+0.07}_{-0.08}) \times 10^{-3}$$

Covering 87% of phase space

Dominant systematics:

- $B \to X_u \ell \nu$ modelling: (m_b, a) where $a = f(m_b, \mu_\pi^2)$ in Kagan-Neubert scheme
- $B \to X_c \ell \nu$ composition differences between SR and CR
- X_u fragmentation modelling

Competitive with previous measurements!

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Authors

Observation of the radiative decay $D_{s0}^{\star}(2317)^{+} \to D_s^{\star+}\gamma$

Journal: PRL **136, 241901** (2026) arXiv:2510.27174 (14 [9] citations; 21.0 [13.5] cit/yr)
Contacts: Y. B. Li, C. P. Shen
Referees: G. B. Mohanty, K. Flood, R. Tiwary
PC reader: J. Yelton
Inst Reviews: DESY, KEK, TUM, Sydney, BINP

Registered: Sun Sep 7 2025
CWR1 ended: Sun Sep 21 midnight JST 2025
CWR2 ended: Mon Oct 27 midnight JST 2025 (expired) confirmed
Submitted: Thu Mar 19 2026 (+143 days)

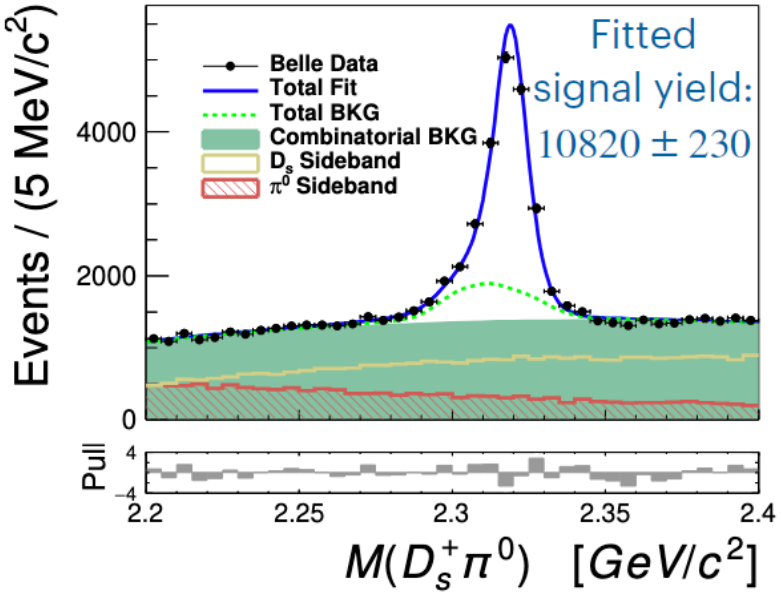
First observation of $D_{s0}^{*}(2317)^{+} \to D_{s}^{*+}\gamma$

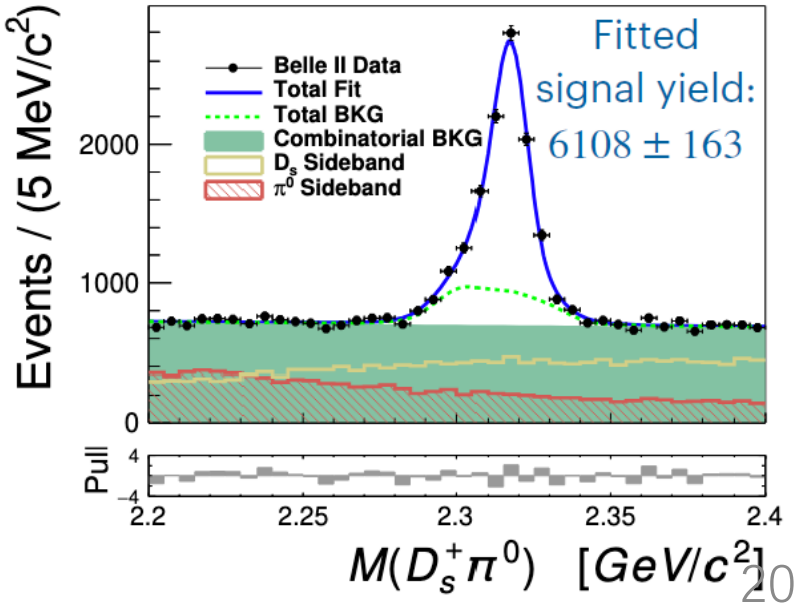
PRL 136, 241901 (2026)

Motivation and analysis strategy

- Nature of $D_{s0}^{*}(2317)^{+}$ and $D_{s1}(2460)^{+}$ unclear: $c\bar{s}$ states, hadronic molecules, mixed configs, tetraquarks → motivate further studies
- Reconstruct $D_s^+ \to \phi[\to K^+K^-]\pi^+$ and $D_s^+ \to \bar{K}^{*0}[\to K^-\pi^+]K^+$ decays $D_{s0}^{*}(2317)^{+}$ candidates from $D_s^{*+}\gamma$ or $D_s^+\pi^0$ combinations
- $D_{s0}^{*}(2317)^{+} \to D_s^+\pi^0$ as normalization channel: yield obtained from an unbinned maximum-likelihood fit to $M(D_s^+\pi^0)$ spectra
- Detailed study of background sources: use D_s and π^0 sidebands

  Peaking background from a missing γ in $D_{s1}(2460)^{+} \to D_s^{*+}\pi^0$ decays





First observation of $D_{s0}^{*}(2317)^{+} \to D_s^{*+}\gamma$

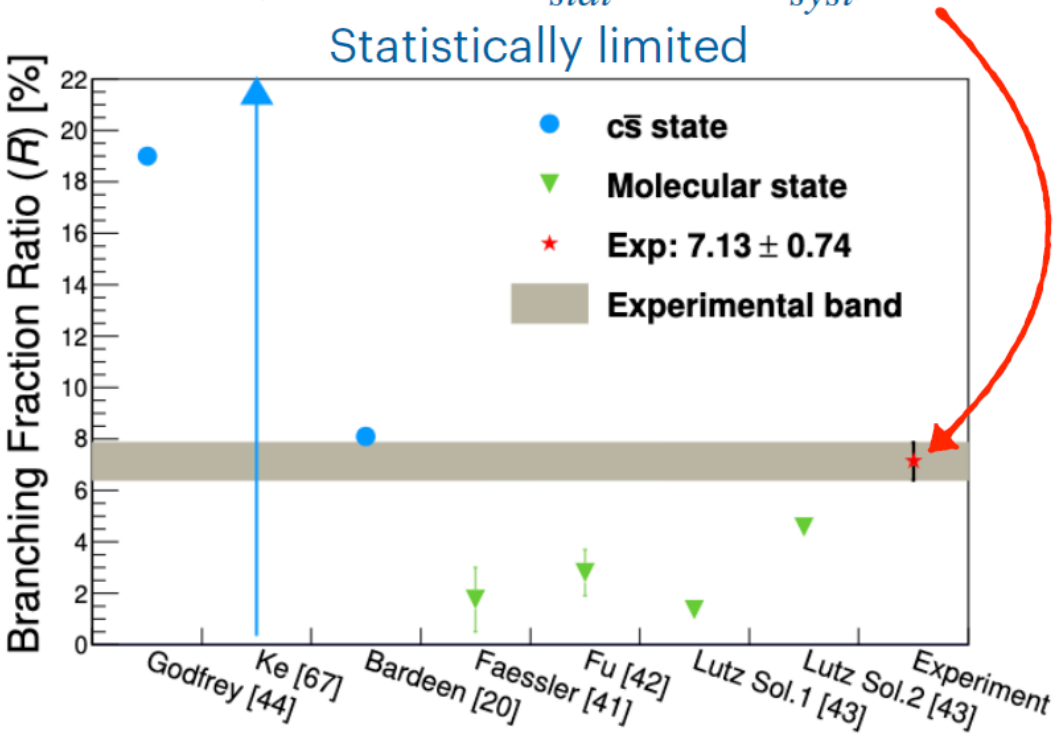
PRL 136, 241901 (2026)

Results

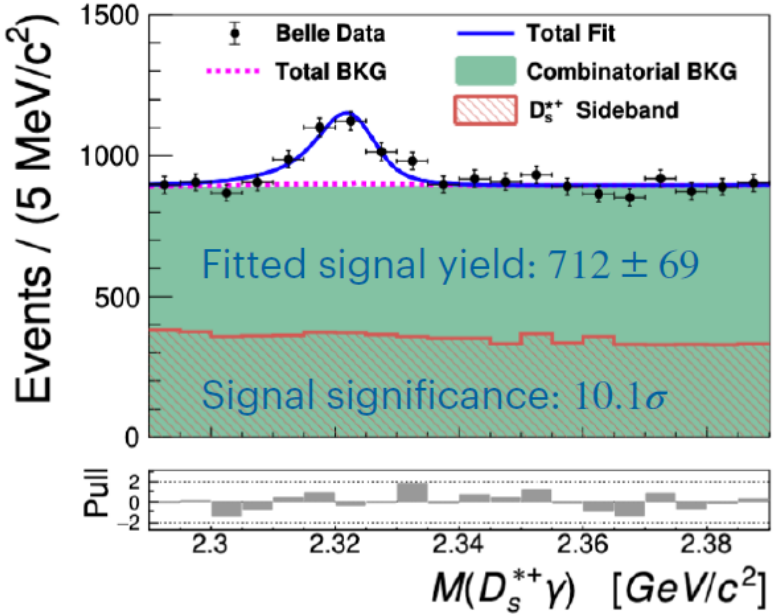
First measurement of $R = \mathcal{B}(D_{s0}^{*+} \to D_s^{*+}\gamma)/\mathcal{B}(D_{s0}^{*+} \to D_s^{+}\pi^0)$ using a simultaneous unbinned maximum-likelihood fit to $M(D_s^{*+}\gamma)$ spectra

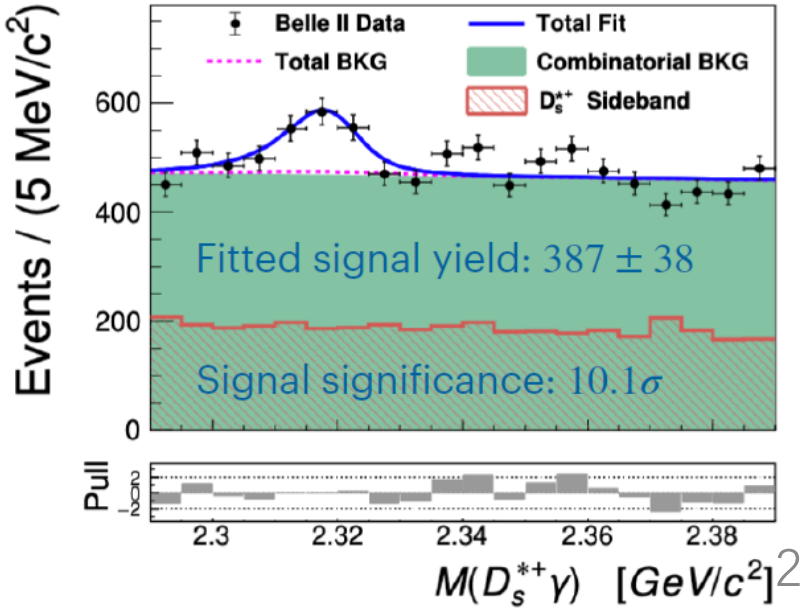
$$R = (7.14 \pm 0.70_{stat} \pm 0.23_{syst})\,\%$$

Statistically limited



Above molecular predictions, below quark-model expectations: could be a mixed configuration





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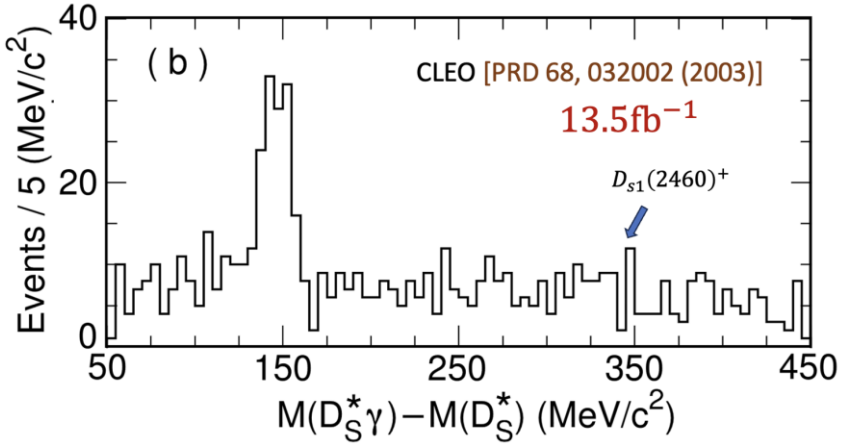
First observation of the $D_{s1}(2460)^+ \to D_s^{*+}\gamma$ decay and measurement of the branching-fraction ratio $\mathcal{B}[D_{s1}(2460)^+ \to D_s^{*+}\gamma]/\mathcal{B}[D_{s1}(2460)^+ \to D_s^{+}\gamma]$

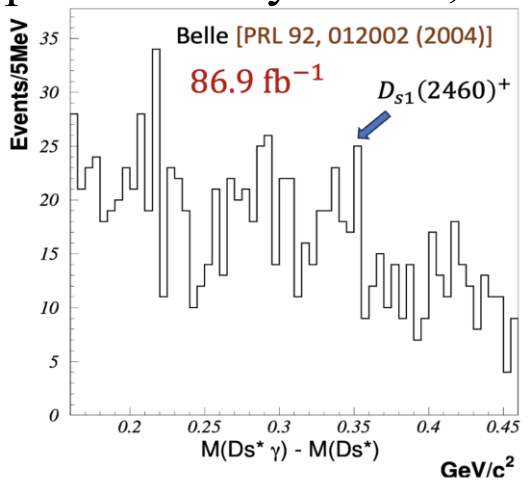
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Authors

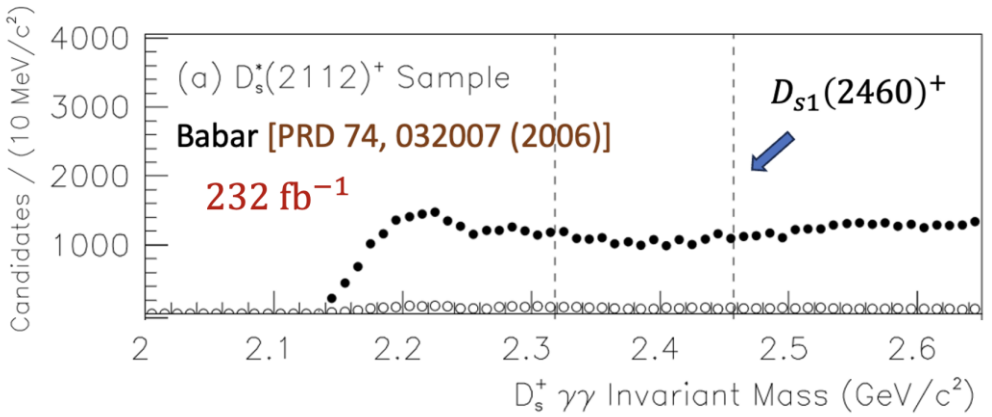
Journal:	To be submitted to PhysRev
Contacts:	Y. B. Li, Y. Li, C. P. Shen
Referees:	G. B. Mohanty, K. Flood, S. Das
PC reader:	J. Yelton
WG reviewer:	V. Bhardwaj
Inst Reviews:	KEK, Mainz, NPC, Soongsil, Ljubljana(Uni-LJ)
Registered:	Mon Sep 14 2026
CWR1 ended:	Mon Sep 28 midnight JST 2026
CWR2 ended:	Sun Oct 18 midnight JST 2026 (expired) confirmed
Submitted:	(not yet submitted)

First observation of the decay $D_{s1}(2460)^+ \to D_s^{*+}\gamma$

- The $D_{s1}(2460)^+$ with $J^P = 1^+$ can undergo radiative decays to both $D_s^+\gamma$ and $D_s^{*+}\gamma$ via E1 transition.
- The $D_{s1}(2460)^+ \to D_s^+\gamma$ was first observed by Belle [PRL 91, 262002 (2003)].
- Searches for $D_{s1}(2460)^+ \to D_s^{*+}\gamma$ were performed by CLEO, Belle, and BaBar, but no signal was observed.







- The branching-fraction ratio $\mathcal{R} = \mathcal{B}[D_{s1}(2460)^+ \to D_s^{*+}\gamma\,]/\mathcal{B}[D_{s1}(2460)^+ \to D_s^+\gamma\,]$ provides a cleaner probe of the internal structure of the $D_{s1}(2460)^+$, as common uncertainties are reduced in the ratio.
- Existing theoretical calculations predict a wide range of values for $\mathcal{R}$ [PLB 568, 254 (2003); PRD 68, 054024 (2003); NPA 958, 71 (2017); PRD 80, 034012 (2009); PRD 111, 114019 (2025); EPJA 58, 70 (2022); PRD 110, 094037 (2024)], motivating an experimental measurement to discriminate among different models.

First observation of the decay $D_{s1}(2460)^+ \to D_s^{*+}\gamma$

- In the $c\bar{s}$ picture, the $D_{s1}(2460)^+$ state is a mixture of the $S = 0$ ($^1P_1$ state) and $S = 1$ ($^3P_1$ state) P-wave states

$$\boldsymbol{D_{s1}(2460)^+ = \sin\theta|\,^1P_1\rangle + \cos\theta|\,^3P_1\rangle}$$

where θ is the $^1P_1 - {}^3P_1$ mixing angle.

[PRD 111, 114019 (2025); PRD 72, 094004 (2005); PRD 85, 034040 (2012)]

- Since the decays $D_{s1}(2460)^+ \to D_s^{*+}\gamma$ and $D_{s1}(2460)^+ \to D_s^{+}\gamma$ couple differently to the $^1P_1$ and $^3P_1$ components, $\mathcal{R}$ is sensitive to the mixing angle.

- For example, the radiative decay widths calculated in Ref. [PRD 72, 094004 (2005)] give

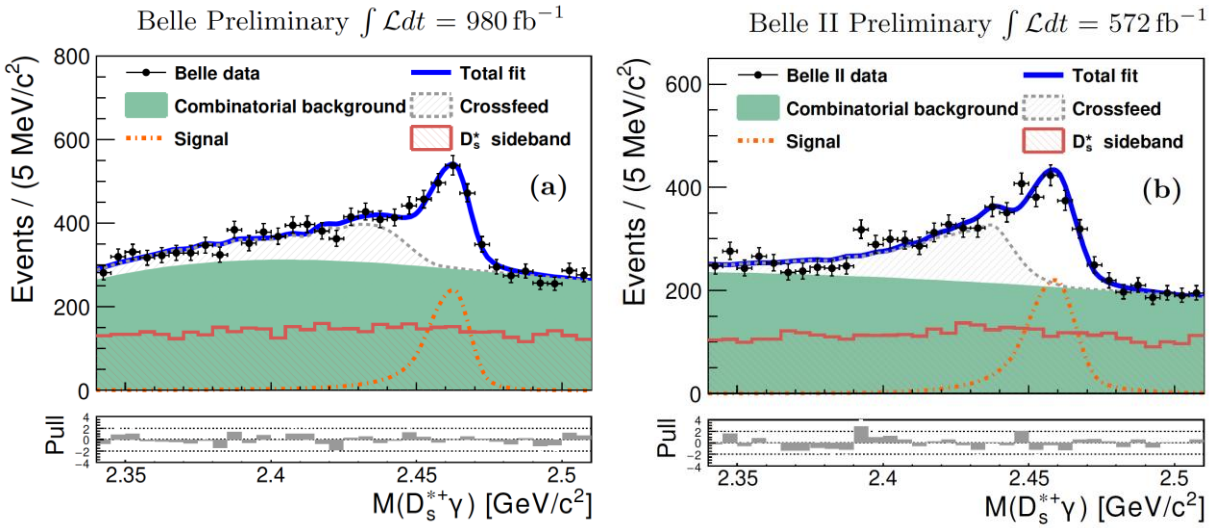
$$\Gamma(D_{s1}(2460)^+ \to D_s^{*+}\gamma) = 4.2\sin^2\theta \text{ keV}$$
$$\Gamma(D_{s1}(2460)^+ \to D_s^{+}\gamma) = 7.3\cos^2\theta \text{ keV}$$

$$\Rightarrow \quad \mathcal{R} = 0.58\tan^2\theta$$

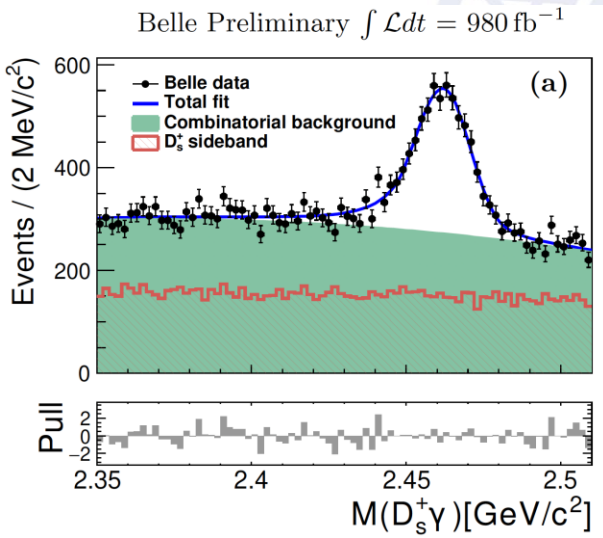
✓ In this work, we search for the radiative decay $D_{s1}(2460)^+ \to D_s^{*+}\gamma$ and measure the branching-fraction ratio $\mathcal{B}[D_{s1}(2460)^+ \to D_s^{*+}\gamma\,]/\mathcal{B}[D_{s1}(2460)^+ \to D_s^{+}\gamma\,]$ in $e^+e^- \to c\bar{c}$ production, using data samples of 980fb^{-1} and 572fb^{-1} collected by Belle and Belle II, respectively.

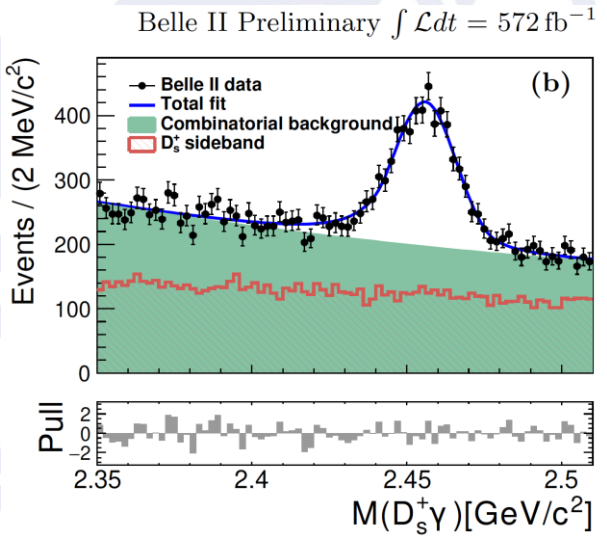
First observation of the decay $D_{s1}(2460)^+ \to D_s^{*+}\gamma$

$D_{s1}(2460)^+ \to D_s^{*+}\gamma$



$D_{s1}(2460)^+ \to D_s^{+}\gamma$





- The significance of the $D_{s1}(2460)^+ \to D_s^{*+}\gamma$ signal exceeds 10σ, including systematic uncertainties.
- Crossfeed: $D_{s1}(2460)^+ \to D_s^{*+}\pi^0(\to \gamma\gamma)$ with one photon missing.
- Crossfeed yield validated with fully reconstructed $D_{s1}(2460)^+ \to D_s^{*+}\pi^0$ in data: agreement within 1σ.
- Dedicated MC studies show that other known decay channels of the $D_{s0}(2317)^+$ or $D_{s1}(2460)^+$ do not produce peaking backgrounds in the targeted $M(D_s^{*+}\gamma)$ region.

First observation of the decay $D_{s1}(2460)^+ \to D_s^{*+}\gamma$

- $\mathcal{R}$ is extracted from a simultaneous fit to Belle and Belle II data.

$$\mathcal{R} = \frac{\mathcal{B}[D_{s1}(2460)^+ \to D_s^{*+}\gamma\,]}{\mathcal{B}[D_{s1}(2460)^+ \to D_s^{+}\gamma\,]}$$

$$= 0.74 \pm 0.05(\text{stat.}) \pm 0.06(\text{syst.}).$$

- Taking $\mathcal{B}[D_{s1}(2460)^+ \to D_s^{+}\gamma\,] = (18 \pm 4)\%$,

$$\mathcal{B}[D_{s1}(2460)^+ \to D_s^{*+}\gamma\,] = [13 \pm 1(\text{stat.}) \pm 1(\text{syst.}) \pm 3(\text{ext.})]\%.$$ [PDG 90% U.L.: < 8%]

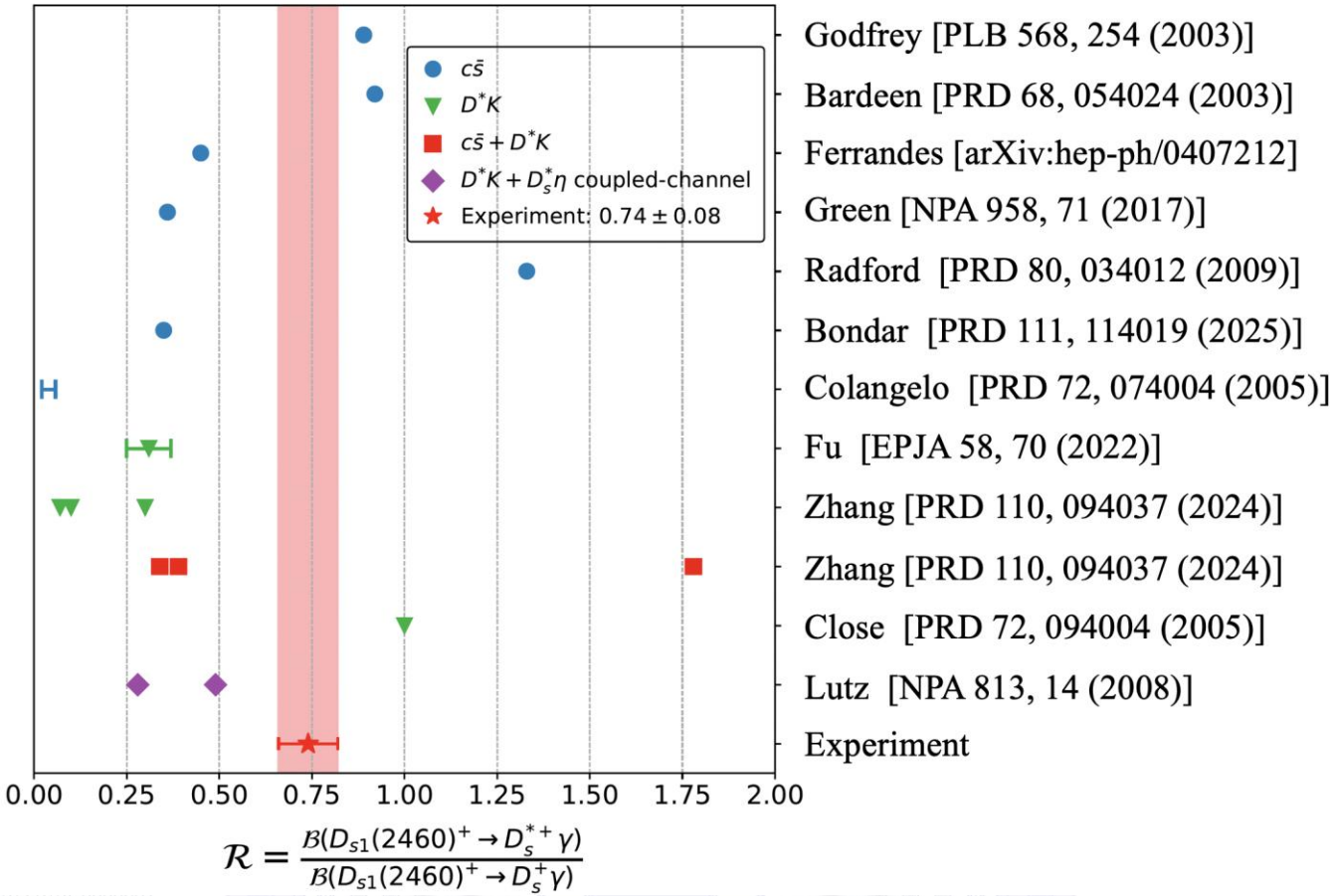
- $^1P_1 - ^3P_1$ mixing constraint ($c\bar{s}$ picture):

$$\mathcal{R} = 0.58\tan^2\theta$$

[PRD 72, 094004 (2005)]

$$\theta = [48.48^{+0.93}_{-1.00}(\text{stat.})^{+1.11}_{-1.20}(\text{syst.})]^\circ$$

Comparison of the measured $\mathcal{R}$ value with various theoretical predictions.



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Measurements of branching fractions of $\Xi_c^0 \to \Xi(1530)^-\pi^+$ and $\Xi_c^0 \to \Xi(1530)^0\pi^0$ decays at Belle and Belle II

Journal:	To be submitted to PhysRev
Contacts:	Y. W. Zhong, C. P. Shen
Referees:	R. Manfredi, D. E. Jaffe, D. Y. Kim
PC reader:	M. Dorigo
WG reviewer:	S. Choudhury
Inst Reviews:	IIT-Hyderabad, Chonnam, LNNU, BINP, S-Alabama
Registered:	Thu Oct 15 2026
CWR1 ended:	Thu Oct 29 midnight JST 2026
CWR2 ends:	Authorship-confirmation end date will be announced later confirmed

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Comments
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Code archive
Authors

First measurements of the branching fractions for the decay modes $\Xi_c^0 \to \Lambda\eta$ and $\Xi_c^0 \to \Lambda\eta'$ and search for the decay $\Xi_c^0 \to \Lambda\pi^0$ using Belle and Belle II data

Journal: PRD **113, 032015** (2026) arXiv:2510.20882 (5 [1] citations; 4.6 [0.9] cit/yr)

Contacts: J. S. Zhou, J. X. Cui, C. P. Shen
Referees: L. Santelj, G. Casarosa, R. Garg
PC reader: J. Yelton

Inst Reviews: Kyiv, Sydney, Hawaii, Tata, BNL

Registered: Wed Sep 10 2025
CWR1 ended: Wed Sep 24 midnight JST 2025
CWR2 ended: Thu Oct 16 midnight JST 2025 (expired) confirmed
Submitted: Mon Oct 27 2025 (+11 days)

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Comments
Mail archive
Code archive
Authors

Measurements of Branching fractions of $\Lambda_c^+ \to \Lambda K^+ \pi^0$ and $\Lambda_c^+ \to \Lambda K^+ \eta$ at Belle and Belle II

Journal:	Submitted to PhysRev arXiv:2610.31377 (0 citations; 0.0 cit/yr)
Contacts:	J. X. Cui, C. P. Shen
Referees:	C. Nunez, R. Garg, K. Tanida
PC reader:	A. Rostomyan
WG reviewer:	M. Reif
Inst Reviews:	NTU-Taiwan, BNL, ISU, Chula, IIT-Jodhpur
Registered:	Fri Jul 17 2026
CWR1 ended:	Fri Jul 31 midnight JST 2026
CWR2 ended:	Thu Oct 1 midnight JST 2026 (expired) confirmed
Submitted:	Mon Oct 26 2026 (+25 days)

$\Lambda_c^+ \to \Lambda K^+\pi^0/\eta$衰变分支比的测量

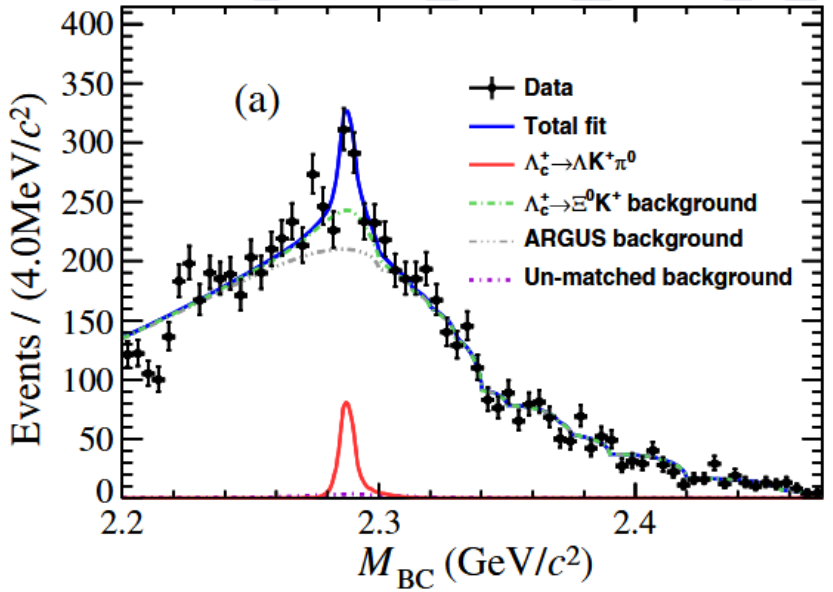
✓ 粲重子三体强子化弱衰变
- 检验$SU(3)_F$味对称性模型
- 理论预言困难：不可因子化振幅贡献
- 实验测量少

✓ 研究目标：$\Lambda_c^+ \to \Lambda K^+\pi^0/\eta$
- 单卡比玻压低过程
- 理论预言差异较大

$\mathcal{B}(\Lambda_c^+ \to \Lambda K^+\pi^0)$ (10^{-3})	$\mathcal{B}(\Lambda_c^+ \to \Lambda K^+\eta)$ (10^{-4})	Reference
4.5 ± 0.8	1.9 ± 0.6	[1]PRD 99, 073003(2019)
3.5 ± 0.6	0.45 ± 0.10	[2]EPJC 79, 946(2019)
1.36 ± 0.25	0.59 ± 0.24	[3]PRD 109, 093002(2024)

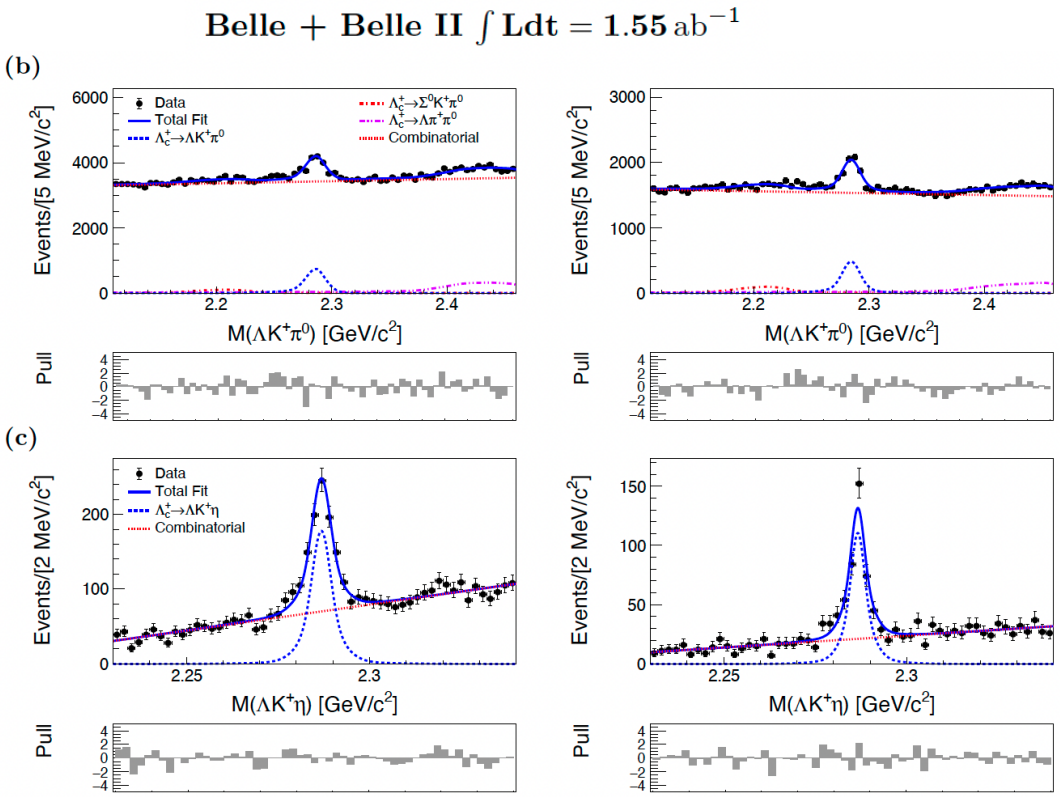
✓ 理论文章[3]：考虑了更完整的有效哈密顿量⇒与实验测量相符

✓ BESIII实验首次观测到$\Lambda_c^+ \to \Lambda K^+\pi^0$
[Phys. Rev. D 109, 032003 (2024)]
- 衰变分支比
$(1.49 \pm 0.27 \pm 0.05 \pm 0.08)\times10^{-3}$
- 统计误差主导
- 与理论预言[1, 2]不符

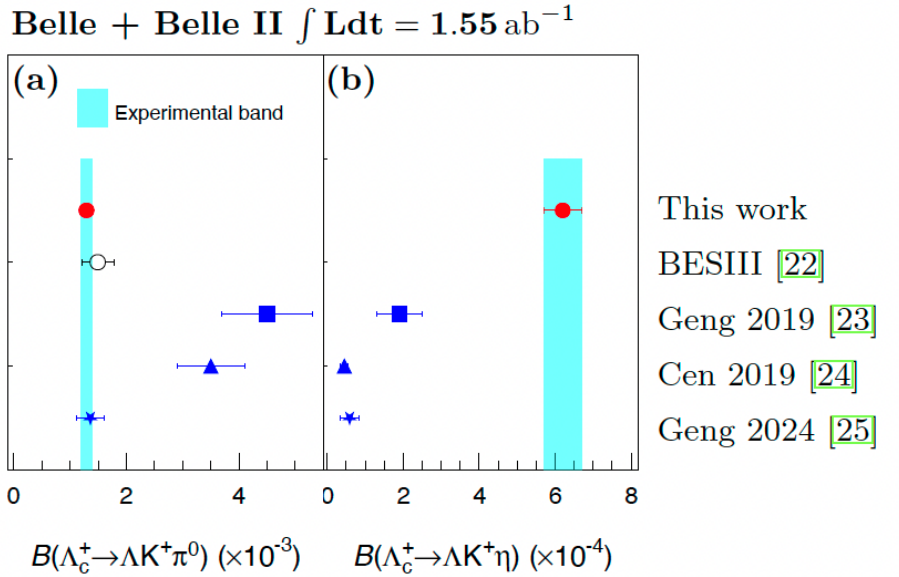


$\Lambda_c^+ \to \Lambda K^+\pi^0/\eta$衰变分支比的测量

✓ 观测到明显的信号



✓ 测量结果



- $\mathcal{B}(\Lambda_c^+ \to \Lambda K^+\pi^0) = (1.29 \pm 0.05 \pm 0.05 \pm 0.06)\times 10^{-3}$

与BESIII测量、最新的理论预言一致，精度提高

- $\mathcal{B}(\Lambda_c^+ \to \Lambda K^+\eta) = (6.20 \pm 0.25 \pm 0.31 \pm 0.30)\times 10^{-4}$

首次测量，显著高于所有的理论预言

✓ 文章已投稿至Phys. Rev. D [arXiv:2610.31377]

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First evidence of $X(3872) \to \pi^0 \chi_{c0}(1P)$ and search for $X(3915) \to \pi^0 \chi_{c1}(1P)$

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Comments
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Code archive
Authors

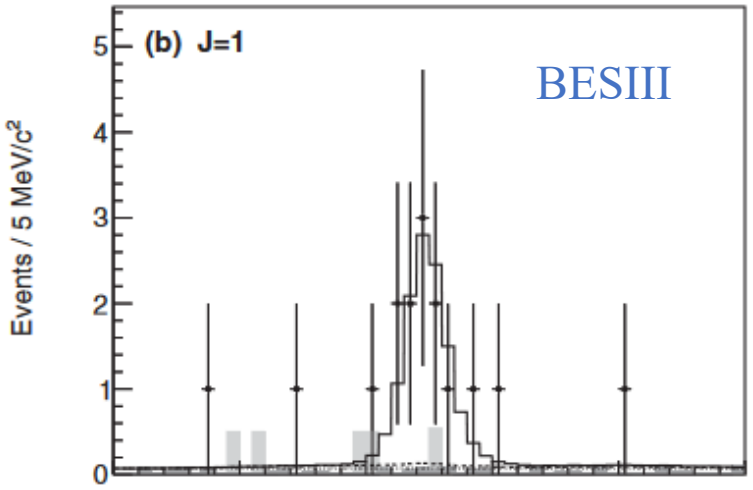
Journal: Submitted to PhysRev arXiv:2606.24578 (1 citation; 2.4 cit/yr)
Contacts: J. X. Cui, S. Jia, C. P. Shen
Referees: V. Bhardwaj, M. Starič, S. B. Yang
PC reader: C. Chen
Inst Reviews: KEK, Bonn, NPC, CMU, Napoli

Registered: Thu Mar 26 2026
CWR1 ended: Thu Apr 9 midnight JST 2026
CWR2 ended: Fri Jun 5 midnight JST 2026 (expired) confirmed
Submitted: Wed Jun 24 2026 (+19 days)

First evidence of $X(3872) \to \pi^0\chi_{c0}(1P)$ and search for $X(3915) \to \pi^0\chi_{c1}(1P)$

- The pionic transitions $X(3872) \to \pi^0\chi_{cJ}(1P)$: Sensitive to its internal structure [PRD 77, 014013 (2008)]
  - As a charmonium 2^3P_1 state: expected to be weak; for example, $\Gamma(2^3P_1 \to \chi_{c1}\pi^0)\sim 0.06$ keV
  - J=0 mode is further suppressed, $\Gamma(2^3P_1 \to \chi_{c0}\pi^0)\sim 0$; $\Gamma_0:\Gamma_1:\Gamma_2\sim 0:2.7:1$
  - As a four-quark/molecular state: greatly enhanced and exhibit comparable rates; $\Gamma_0:\Gamma_1:\Gamma_2\sim 2.88:0.97:1$
- The $X(3915) \to \pi^0\chi_{c1}(1P)$ may be enhanced and searched for on the same mass spectrum
  - J=0 and J=2 modes are forbidden by P-conservation
- $X(3872) \to \pi^0\chi_{c1}$ was first observed by BESIII via $e^+e^- \to \gamma X(3872)$[PRL 122, 202001 (2019)]

- $\Gamma_1/\Gamma_{\pi\pi J/\psi} \equiv \mathcal{B}(X(3872) \to \pi^0\chi_{c1})/\mathcal{B}(X(3872) \to \pi^+\pi^- J/\psi = 0.88^{+0.33}_{-0.27} \pm 0.10$; $\Gamma_0/\Gamma_{\pi\pi J/\psi} < 19$; $\Gamma_2/\Gamma_{\pi\pi J/\psi} < 1.1$

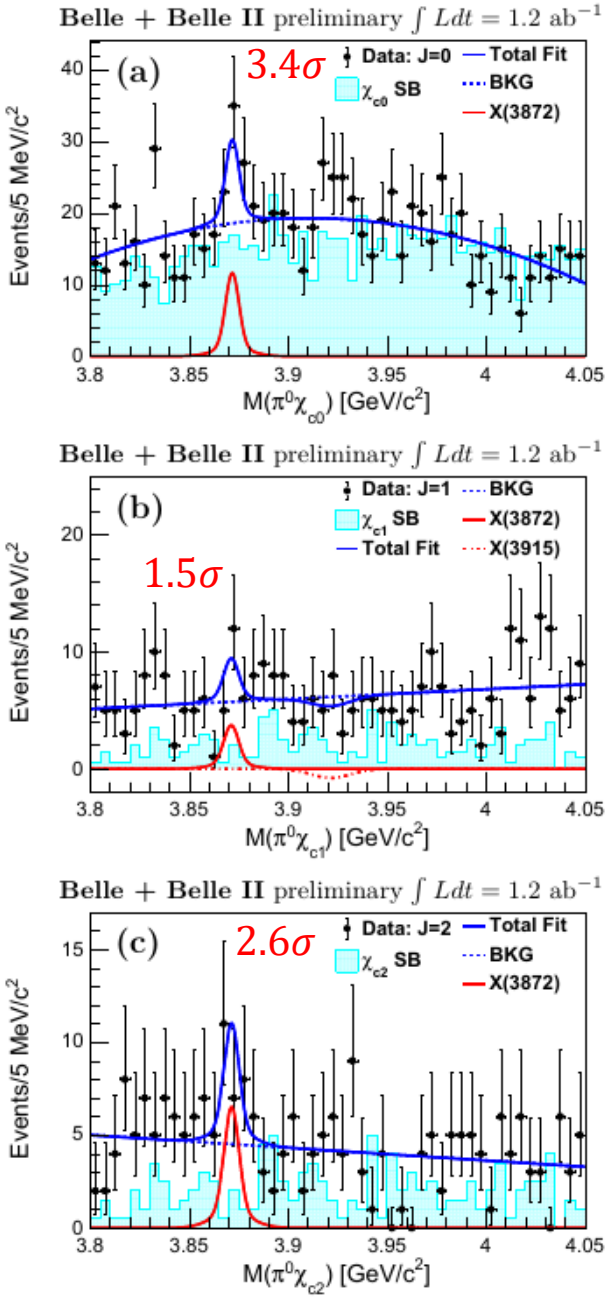


BESIII [PRL 122, 202001 (2019)]

- Belle reported the upper limit $\Gamma_1/\Gamma_{\pi\pi J/\psi} < 0.97$ [PRD 99, 111101 (2019)]
- BESIII updated the upper limit $\Gamma_0/\Gamma_{\pi\pi J/\psi} < 3.6$ [PRD 105, 072009 (2022)]
- No J=0 and J=2 modes are found yet

- Search for the $X(3872) \to \pi^0\chi_{cJ}$ and $X(3915) \to \pi^0\chi_{c1}$ decays via $B^+ \to \pi^0\chi_{cJ}K^+$ processes in Belle and Belle II

First evidence of $X(3872) \to \pi^0\chi_{c0}(1P)$ and search for $X(3915) \to \pi^0\chi_{c1}(1P)$

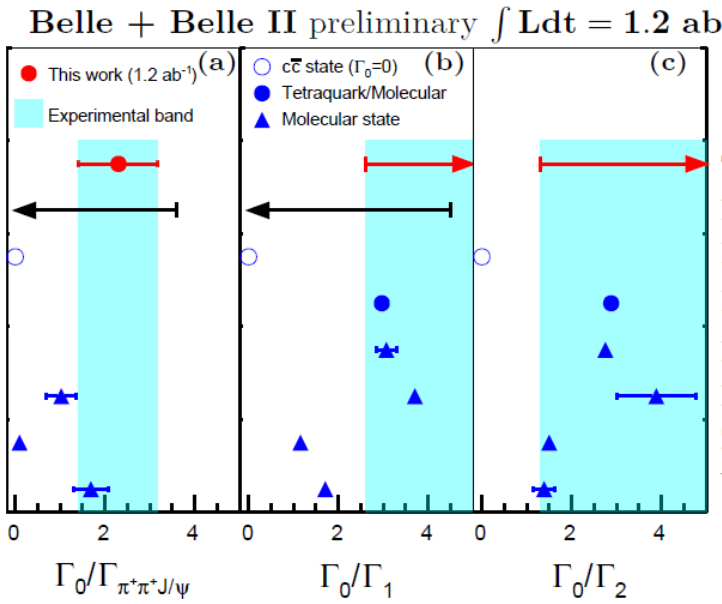


- First evidence of $X(3872) \to \pi^0\chi_{c0}$: 23.7 ± 8.1 events; $\Gamma_0/\Gamma_{\pi\pi J/\psi} = 2.3 \pm 0.8 \pm 0.4$
- No significant signals for other modes are observed:

$$\Gamma_1/\Gamma_{\pi\pi J/\psi} < 0.9,\ \Gamma_2/\Gamma_{\pi\pi J/\psi} < 1.8;\ \Gamma_0/\Gamma_1 > 2.6,\ \Gamma_0/\Gamma_2 > 1.3$$

arXiv:2606.24578

- A comparison on (a) $\Gamma_0/\Gamma_{\pi^+\pi^- J/\psi}$,(b) Γ_0/Γ_1, (c) Γ_0/Γ_2



This work
BESIII [12]
Dubynskiy [8]
Dubynskiy [8]
Fleming [9]
Dong [13]
Zhou [14]
Wu [15]

[12] PRD 105, 072009 (2022)
[8] PRD 77, 014013 (2008)
[9] PRD 78, 094019 (2008)
[13] PRD 79, 094013 (2009)
[14] PRD 100, 094025 (2019)
[15] EPJC 81, 193 (2021)

- Disfavor a pure charmonium interpretation: $\Gamma(\chi_{c1}(2P) \to \pi^0\chi_{c0})$ should be zero
- Consistent with most of predictions in molecular scenario
- Absolute $\mathcal{B}(X(3872) \to \pi^0\chi_{c0}) = (9.9 \pm 4.8)\%$, might be the largest hidden charm decay mode up to now

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Code archive
Authors

Study of $e^+e^- \to h^+h^- J/\psi\, h = (\pi, K, p)$ via initial-state radiation at Belle II

Journal: PRD **113, 112010** (2026) arXiv:2602.13569 (2 citations; 2.7 cit/yr)
Contacts: Y. P. Liao, S. Jia, C. P. Shen, C. Z. Yuan
Referees: J. H. Yin, N. Rout, G. Pakhlova
PC reader: C. Chen
Inst Reviews: Bonn, Trieste, KEK, MPP, Tokyo Metropolitan

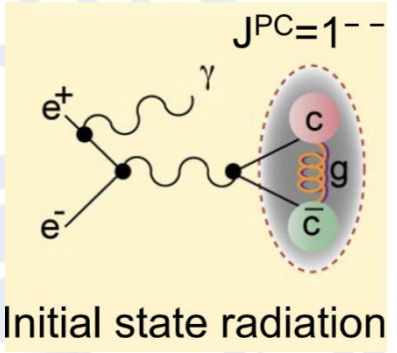
Registered: Thu Jul 17 2025
CWR1 ended: Fri Aug 1 midnight JST 2025
CWR2 ended: Fri Jan 16 midnight JST 2026 (expired) confirmed
Submitted: Tue Feb 17 2026 (+32 days)

Adavantages of ISR:

- Allows to study energies below $E_{c.m.}$
- Wide energy range available
- Measure more precisely the line-shapes

Disadvantages of ISR:

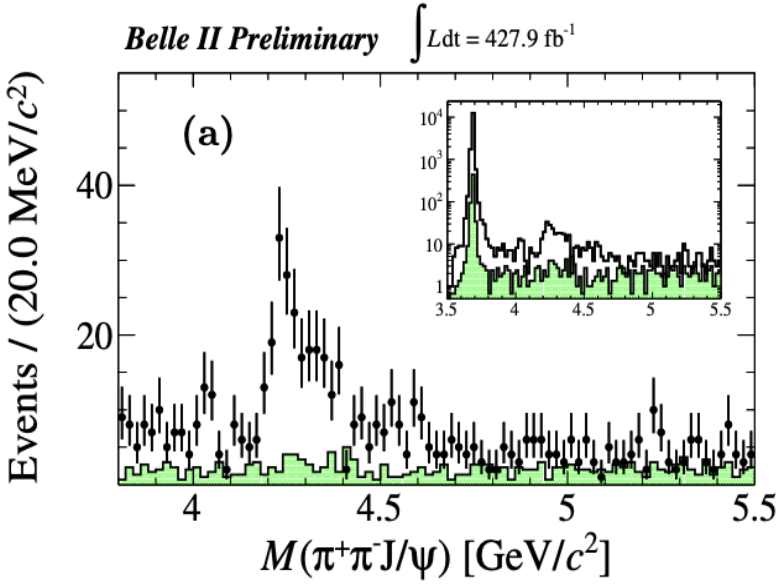
- The effective integrated luminosity decreases as the c.m. energy decreases
- The detection efficiency is also smaller

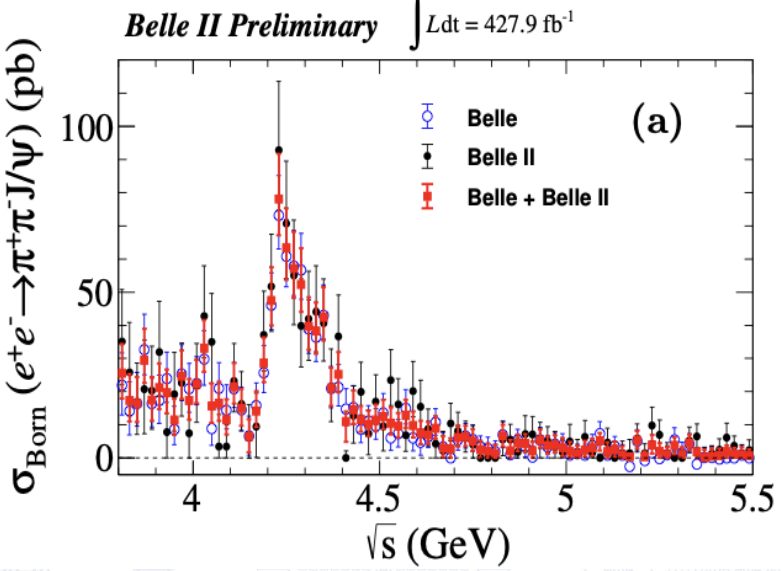


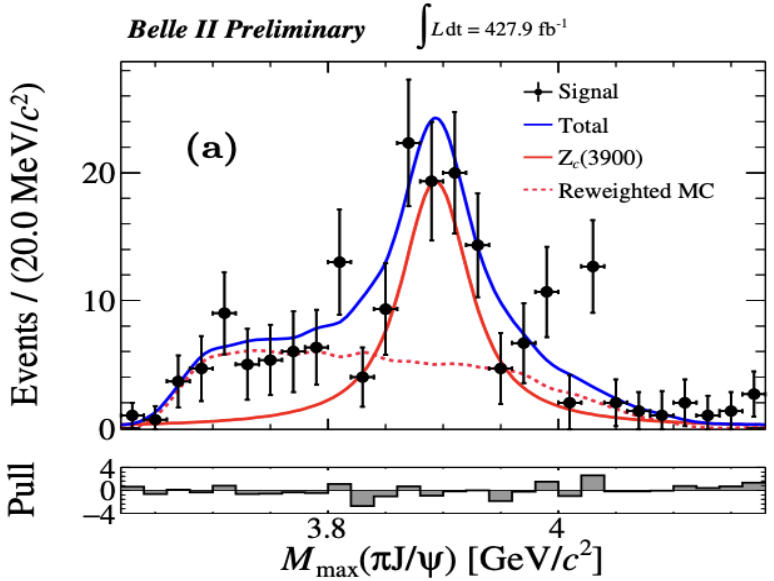
Initial state radiation

$e^+e^- \to \pi^+\pi^- J/\psi$ via ISR:

PRD 113, 112010 (2026)



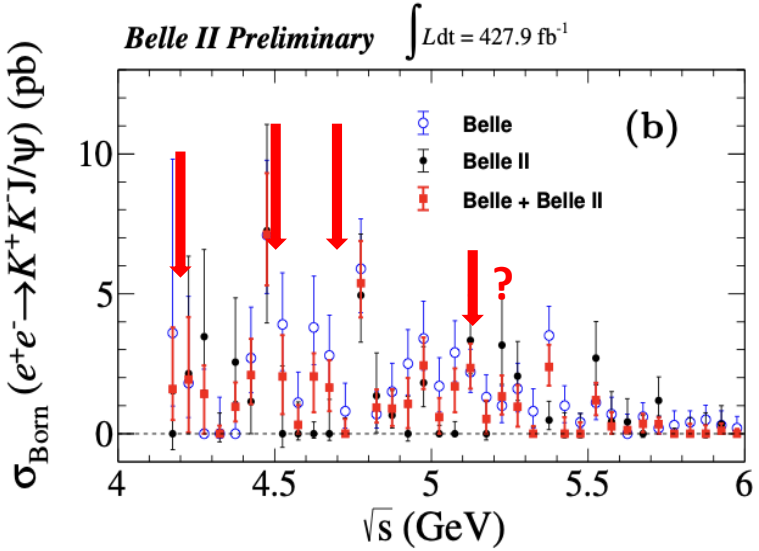


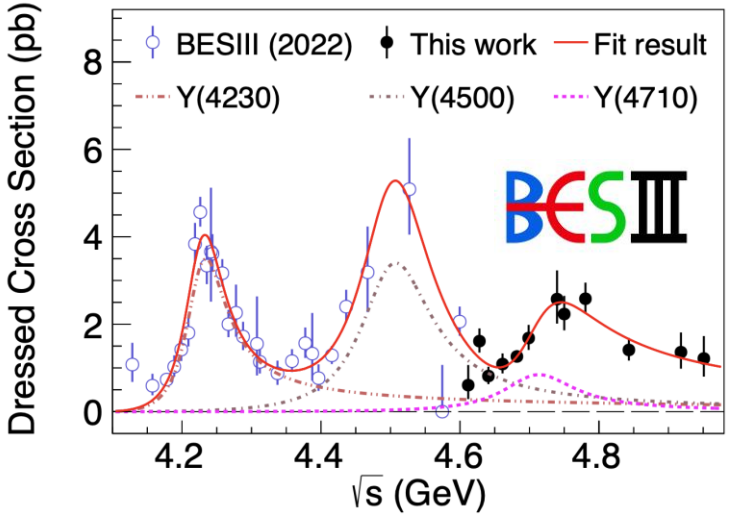


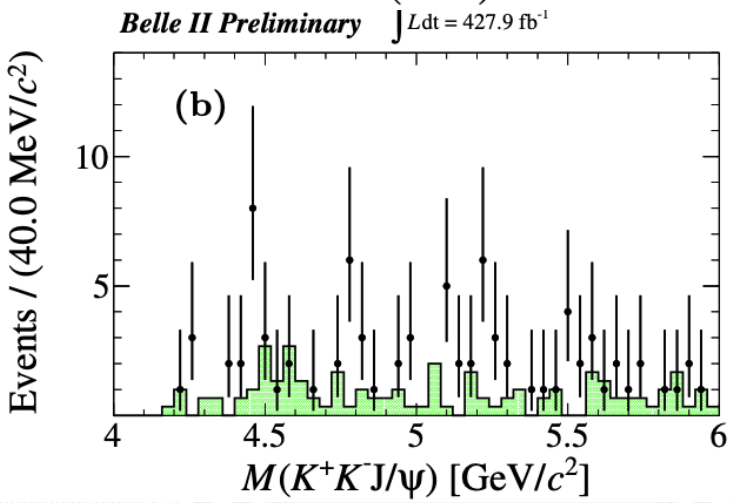
- **We can see the Y(4008) evidence and Y(4230/4320) signal.**
- **The significance of $Z_c(3900)$ is 5.3σ.**

$e^+e^- \to K^+K^-J/\psi$ via ISR:

PRL 131, 211902 (2023)



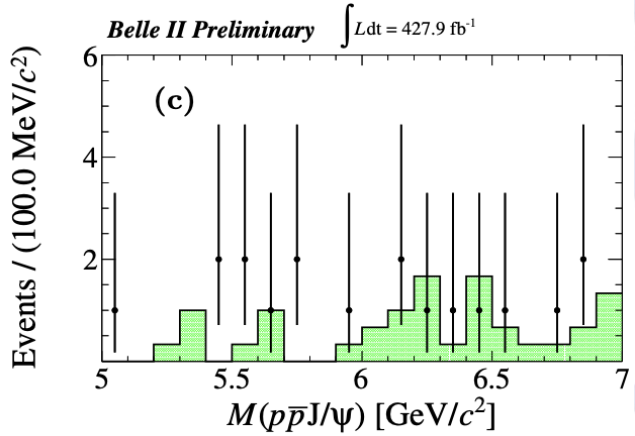


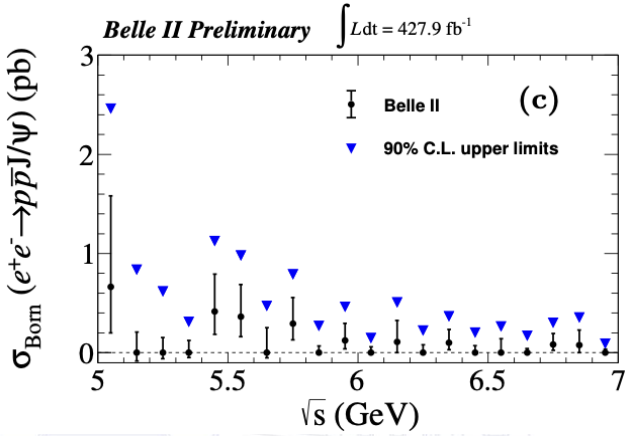


- **No clear signals were observed at Belle II.**
- **More data are needed.**

$e^+e^- \to p\bar{p}J/\psi$ via ISR:

The cross section for $e^+e^- \to P_c\bar{p}$ is estimated to be $\lesssim \mathcal{O}(0.1$ pb) [arXiv: 2508.08694].





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First measurement of the masses of the $\Upsilon_1(1D)$ and $\Upsilon_3(1D)$ states and the energy dependence of the cross sections for $e^+e^- \to \Upsilon_J(1D)\eta$ and $e^+e^- \to \Upsilon_J(1D)\pi^+\pi^-$

Journal: PRL **137, 191901** (2026) arXiv:2607.04369 (1 [0] citation; 3.0 [0.0] cit/yr)

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CWR2 ended: Sat Jun 27 midnight JST 2026 (expired) confirmed
Submitted: Tue Jul 7 2026 (+10 days)

First measurement of the masses of the $\Upsilon_1(1D)$ and $\Upsilon_3(1D)$ states and energy dependences of cross sections for $e^+e^- \to \Upsilon_J(1D)\eta$ and $e^+e^- \to \Upsilon_J(1D)\pi^+\pi^-$

- Up to now, only one D-wave bottomonium state, $\Upsilon_2(1D)$, was observed by CLEO and BaBar [PRD 70, 032001 (2004), PRD 82, 111102 (2010)]. The mass of $\Upsilon_2(1D)$ is (10163.7±1.4) MeV/c^2.
- Belle studied $e^+e^- \to \Upsilon_J(1D)\eta$ and $e^+e^- \to \Upsilon_J(1D)\pi^+\pi^-$ at $\sqrt{s}$ = 10.866 GeV in the recoil mass spectra of η and $\pi^+\pi^-$ [EPJC 78, 633 (2018), PRL 108, 032001 (2012)].
- The $\Upsilon_J(1D)$ masses have been predicted by theory. However, there are no reported experimental results in the mass differences among $\Upsilon_1(1D)$, $\Upsilon_2(1D)$, and $\Upsilon_3(1D)$.

References	$\Upsilon_1(1D)$ mass (MeV/c^2)	$\Upsilon_2(1D)$ mass (MeV/c^2)	$\Upsilon_3(1D)$ mass (MeV/c^2)
PRD 93, 074027 (2016)	10117	10122	10127
PRD 92, 054034 (2015)	10138	10147	10155
PRD 95, 074002 (2017)	10146	10153	10157
EPJC 78, 915 (2018)	10153	10162	10170

- Within the hadronic loop mechanism, the branching fractions for $\Upsilon(10860,11020) \to \Upsilon_J(1D)\eta$ and $\Upsilon(10860) \to \Upsilon_J(1D)\pi^+\pi^-$ range in magnitude from 10^{-4} to 10^{-3} [PRD 94, 094039 (2016), PRD 97, 094018 (2018), PRD 102, 114037 (2020)].

The table on the right shows the data used in this analysis.

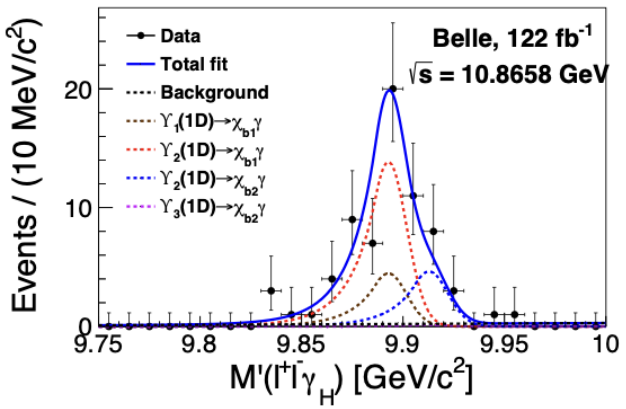
$\sqrt{s}$ (MeV)	$\mathcal{L}$ (fb^{-1})
10731.3	0.946
10771.2	0.955
10829.5	1.697
10848.9	0.989
10857.4	0.988
10865.8	122.0
10877.8	0.978
10882.8	1.848
10888.9	0.990
10898.3	2.408
10907.3	0.980
10928.7	1.149
10957.5	0.969
10975.3	0.999
10990.4	0.985
11003.9	0.976
11014.8	0.771
11018.5	0.859
11020.8	0.982

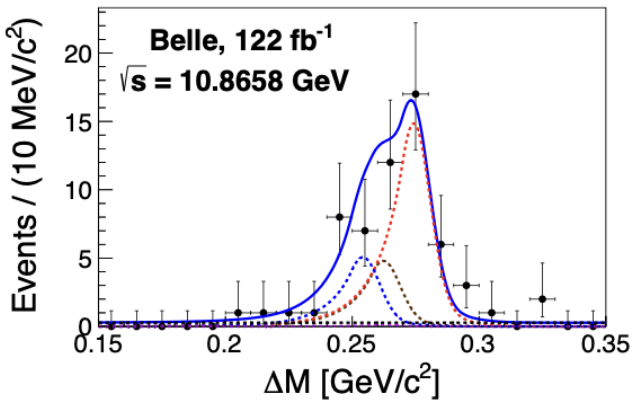
Yields and Masses at $\sqrt{s}$ = 10.866 GeV

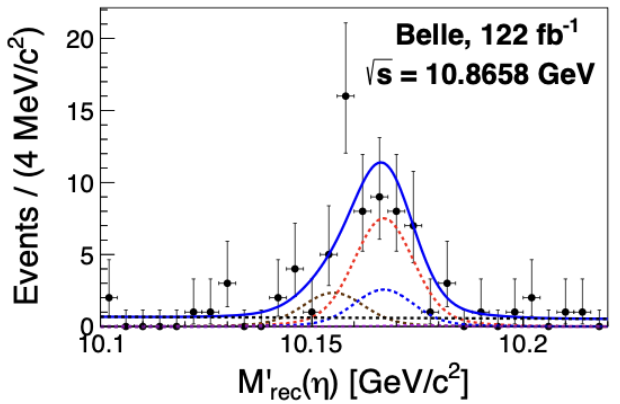
PRL 137, 191901 (2026)

$\Upsilon_J(1D) \to \chi_{b1,b2}\gamma_L$, $\chi_{b1,b2} \to \Upsilon(1S)\gamma_H$, $\Upsilon(1S) \to \ell^+\ell^-$

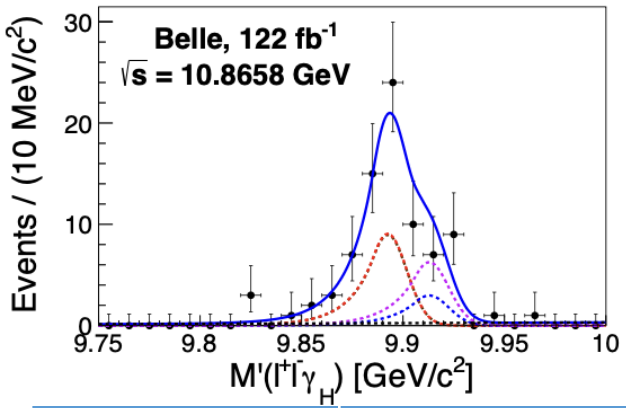
$e^+e^- \to \Upsilon_J(1D)\eta$ Three-dimensional fit results

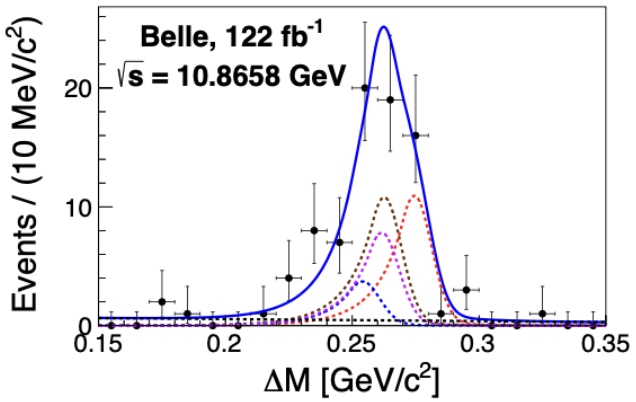


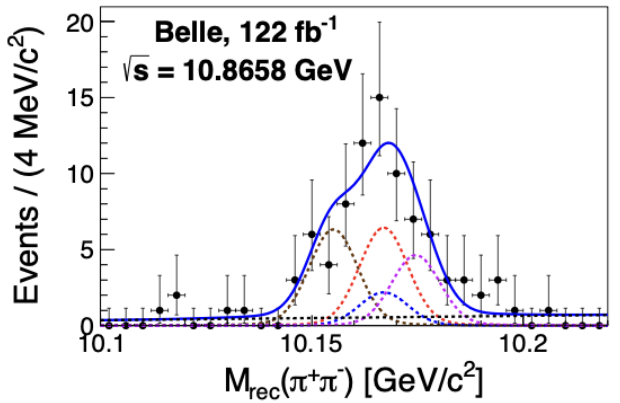




$e^+e^- \to \Upsilon_J(1D)\pi^+\pi^-$ $\Delta M = M(\ell^+\ell^-\gamma_H\gamma_L) - M(\ell^+\ell^-\gamma_H)$







The systematic uncertainty is calculated by changing the fit models, including the fit range, peak position, mass resolution, polynomial order, the yield ratio between $\eta \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\pi^0$.

$\Upsilon_2(1D)$ mass
(10167.0±1.0±0.2) MeV/c^2
$\Delta m_{21} = m(\Upsilon_2(1D)) - m(\Upsilon_1(1D))$
(11.8±1.5±0.4) MeV/c^2
$\Delta m_{32} = m(\Upsilon_3(1D)) - m(\Upsilon_2(1D))$
(7.6±2.4±0.6) MeV/c^2

Channel	N^{sig} ($e^+e^- \to \Upsilon_J(1D)\eta$)	N^{sig} ($e^+e^- \to \Upsilon_J(1D)\pi^+\pi^-$)	$\Sigma_{stat.}$ ($\Sigma_{syst.}$)
$\Upsilon_1(1D) \to \chi_{b1}\gamma$	12.2±6.3	24.7±6.5	5.1σ (4.8σ)
$\Upsilon_2(1D) \to \chi_{b1}\gamma$	37.8±8.0	25.0±6.7	>10σ (>10σ)
$\Upsilon_2(1D) \to \chi_{b2}\gamma$	12.9±6.0	8.5±4.2	
$\Upsilon_3(1D) \to \chi_{b2}\gamma$	0.3±2.8	17.9±6.7	3.1σ (3.0σ)

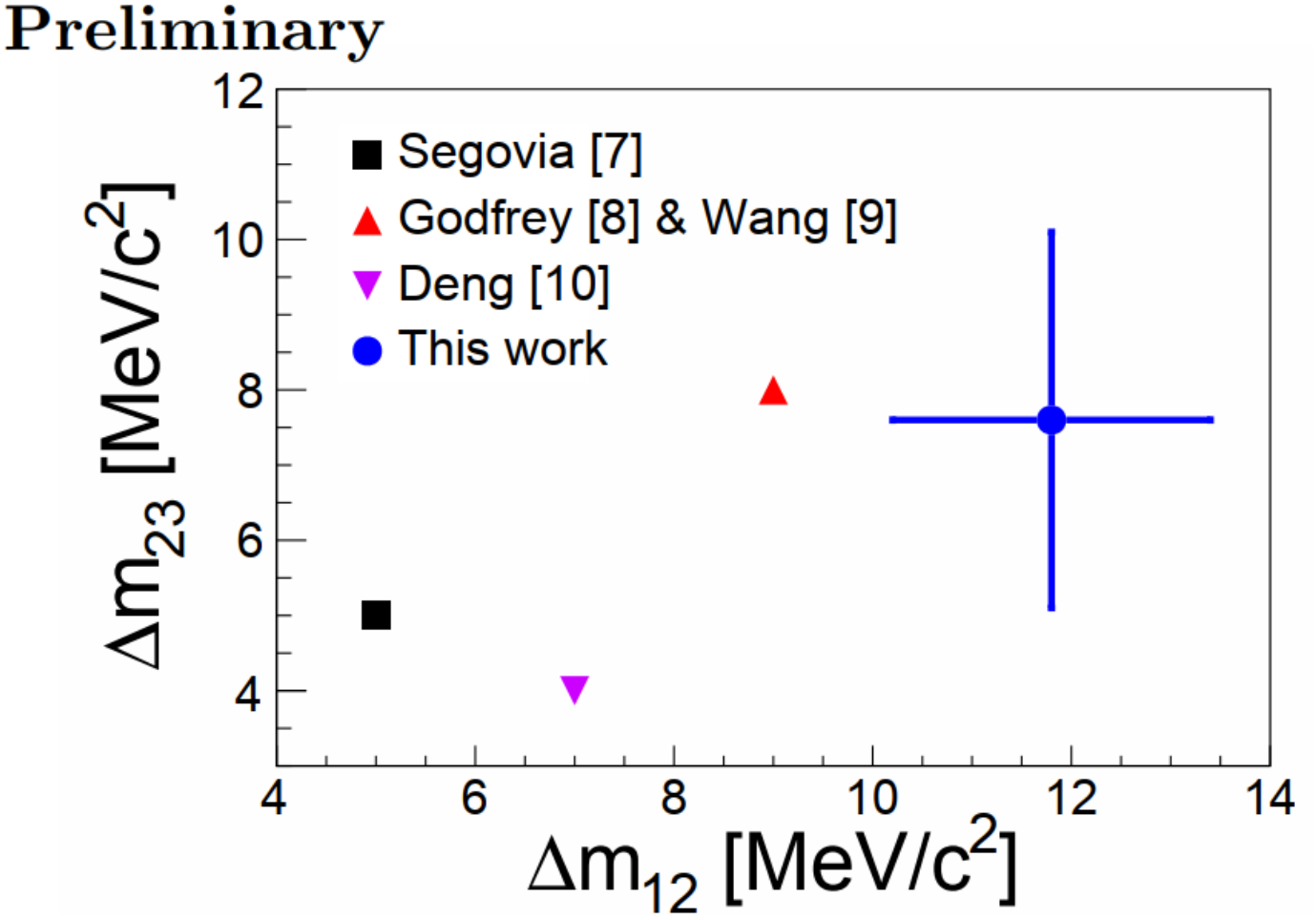
From the fit:

$$\frac{\mathcal{B}(\Upsilon_2(1D)\to\chi_{b2}\gamma)}{\mathcal{B}(\Upsilon_2(1D)\to\chi_{b1}\gamma)} = 0.66\pm0.27\pm0.15$$

Consistent with the prediction of ≈0.3 in PRD 92, 054034 (2015) within ±1.2σ.

The comparison of mass splittings Δm_{12} and Δm_{23} with different theoretical predictions.

PRL 137, 191901 (2026)



Segovia [7]: nonrelativistic constituent quark model [PRD 93, 074027 (2016)]

Godfrey [8]: relativistic quark model [PRD 92, 054034 (2015)]

Wang [9]: modified relativistic quark model with a screening effect [EPJC 78, 915 (2018)]

Deng [10]: screened potential model [PRD 95, 074002 (2017)]

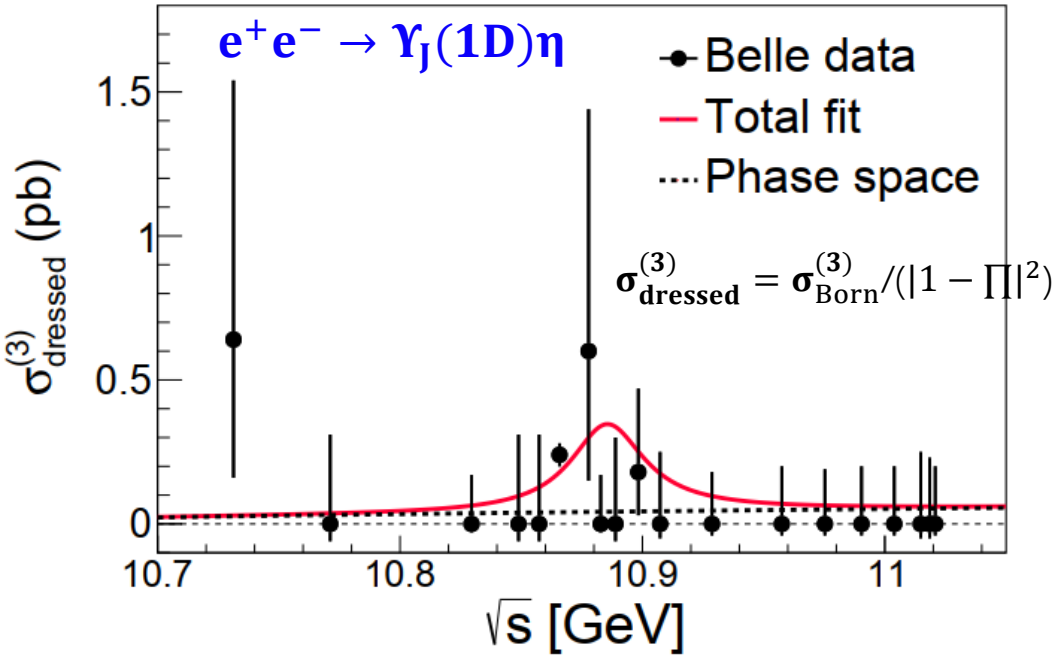
The dressed cross sections as a function of C.M. energy:

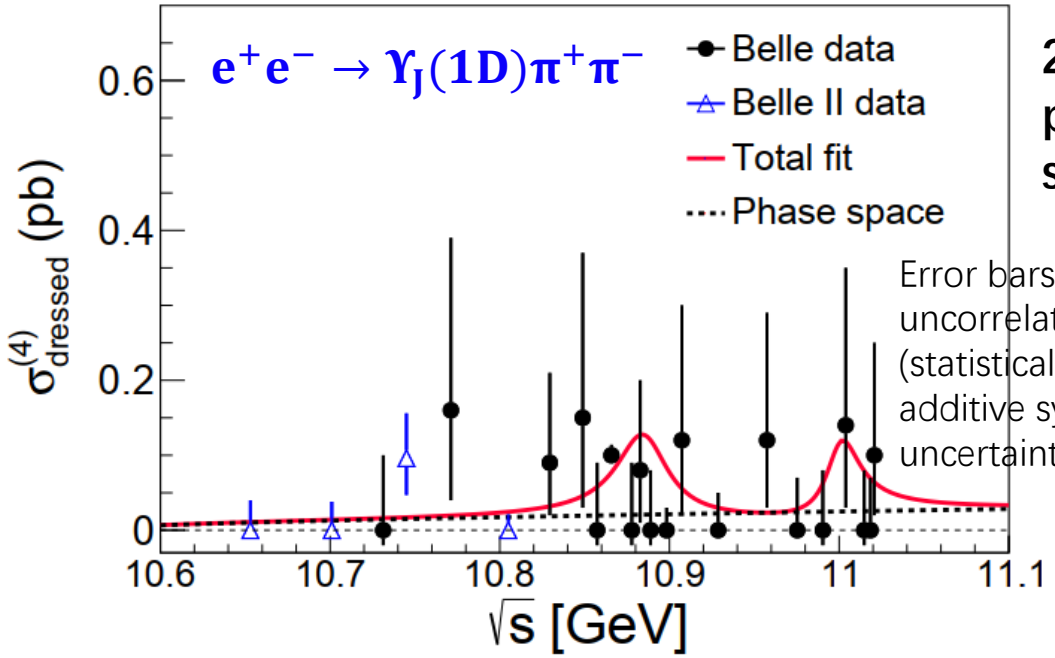
$$\sigma^{(3)}_{\rm Born} = \sigma_{\rm Born}(e^+e^- \to \Upsilon_J(1D)\eta)\,\mathcal{B}(\Upsilon_J(1D) \to \chi_{b1,b2}\gamma)\,\mathcal{B}(\chi_{b1,b2} \to \Upsilon(1S)\gamma)$$

$$\sigma^{(4)}_{\rm Born} = \sigma_{\rm Born}(e^+e^- \to \Upsilon_J(1D)\pi^+\pi^-)\,\mathcal{B}(\Upsilon_J(1D) \to \chi_{b1,b2}\gamma)\,\mathcal{B}(\chi_{b1,b2} \to \Upsilon(1S)\gamma)$$

The fit function as below

$$\Big|\sum_{i=1}^{2}\frac{\sqrt{12\pi\Gamma_{ee,i}\mathcal{B}_i\Gamma_i}}{s-M_i^2-iM_i\Gamma_i}\sqrt{\frac{\Phi(\sqrt{s})}{\Phi(M_i)}}e^{i\phi}\Big|^2 + c_{\rm NR}\Phi(\sqrt{s})$$





2 BWs + phase-space

Error bars represent the tota uncorrelated uncertainties (statistical uncertainty + additive systematic uncertainty).

- The dots show the dressed cross sections measured in this work.
- The triangles show the dressed cross sections for $e^+e^- \to \Upsilon_J(1D)\pi^+\pi^-$ at Belle II [JHEP 06, 278 (2026)].

The signal significances of fit outputs are less than 3σ, the upper limits at 90% C.L. are also given in square brackets. arXiv:2607.04369

$\Gamma_{ee}\mathcal{B}(\Upsilon(10860) \to \Upsilon_J(1D)\eta)\mathcal{B}_f$	$(0.091 \pm 0.039 \pm 0.016)$ $[<0.14]$
$\Gamma_{ee}\mathcal{B}(\Upsilon(11020) \to \Upsilon_J(1D)\eta)\mathcal{B}_f$	$(0.000 \pm 0.018 \pm 0.005)$ $[<0.04]$
$\Gamma_{ee}\mathcal{B}(\Upsilon(10860) \to \Upsilon_J(1D)\pi^+\pi^-)\mathcal{B}_f$	$(0.034 \pm 0.013 \pm 0.006)$ $[<0.06]$
$\Gamma_{ee}\mathcal{B}(\Upsilon(11020) \to \Upsilon_J(1D)\pi^+\pi^-)\mathcal{B}_f$	$(0.020 \pm 0.016 \pm 0.005)$ $[<0.05]$

$$\mathcal{B}_{\rm f} = \mathcal{B}(\Upsilon_{\rm J}(1{\rm D}) \to \chi_{\rm b1,b2}\gamma)\mathcal{B}(\chi_{\rm b1,b2} \to \Upsilon(1{\rm S})\gamma)$$

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Improved measurement of Born cross sections for $e^+e^- \to \chi_{bJ}\omega$ and $\chi_{bJ}\,(\pi^+\pi^-\pi^0)_{\mathrm{non}-\omega}\;(J=0,\,1,\,2)$ at Belle and Belle II

Journal: JHEP 04 **2026**, 101 (2026) arXiv:2510.25461 (5 [2] citations; 4.6 [1.8] cit/yr)

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CWR1 ended: Sat Sep 7 midnight JST 2024
CWR2 ended: Mon Feb 24 midnight JST 2025 (expired) confirmed
Submitted: Thu Oct 30 2025 (+248 days)

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Observation of $e^+e^- \to \eta\Upsilon(2S)$ and search for $e^+e^- \to \eta\Upsilon(1S)$, γX_b at $\sqrt{s}$ near 10.75 GeV

Journal: PRD **113, L051102** (2026) arXiv:2509.01917 (7 [1] citations; 6.0 [0.9] cit/yr)
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Registered: Tue Apr 1 2025
CWR1 ended: Wed Apr 16 midnight JST 2025
CWR2 ended: Tue Jul 22 midnight JST 2025 (expired) confirmed
Submitted: Wed Sep 3 2025 (+43 days)

89

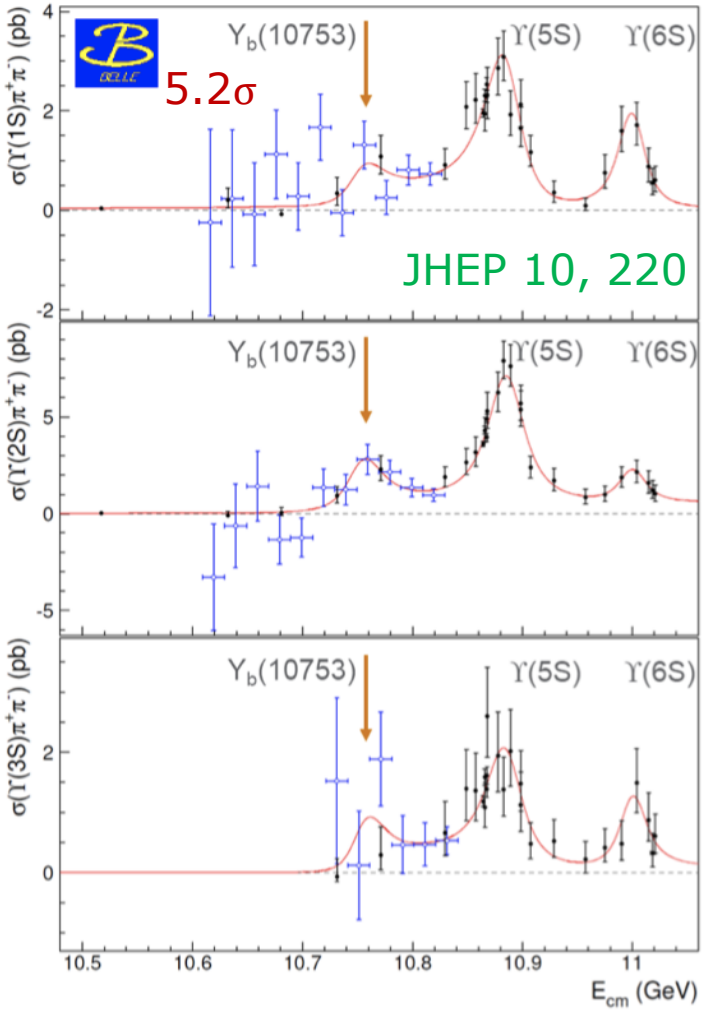
Search for $e^+e^- \to \gamma\chi_{bJ}$ $(J = 0, 1, 2)$ at $\sqrt{s}$ near 10.746 GeV at Belle II

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Comments
Mail archive
Code archive
Authors

Journal: PRD **113, 052009** (2026) arXiv:2508.16036 (1 [0] citation; 0.8 [0.0] cit/yr)
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Referees: J. H. Yin, K. Flood, A. Kuzmin
PC reader: C. Chen
Inst Reviews: TUM, Indiana, Pisa, BNL, USTC

Registered: Mon May 12 2025
CWR1 ended: Tue May 27 midnight JST 2025
CWR2 ended: Sun Jul 20 midnight JST 2025 (expired) confirmed
Submitted: Mon Aug 25 2025 (+36 days)

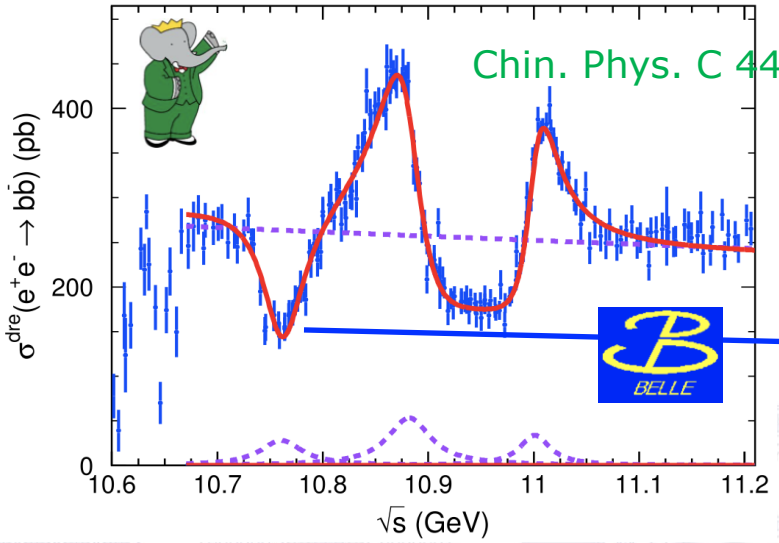
Discovery of $\Upsilon(10753)$



JHEP 10, 220 (2019)

- Belle: several ~1fb^{-1} scan points below $\Upsilon(5S)$
- New structure observed in $\pi^+\pi^-\Upsilon(nS)$ transitions

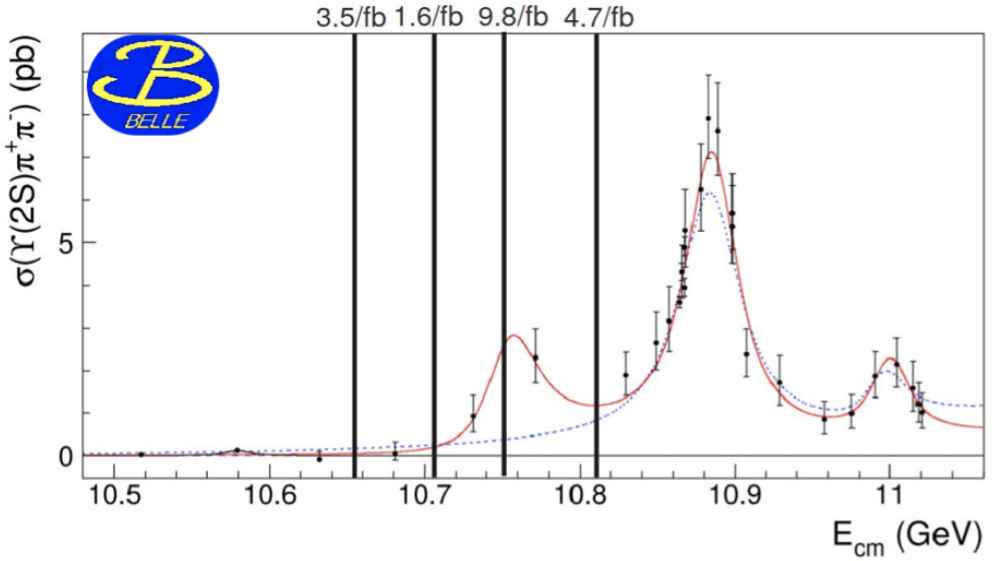
	$\Upsilon(10860)$	$\Upsilon(11020)$	New structure
M (MeV/c^2)	$10885.3 \pm 1.5\,^{+2.2}_{-0.9}$	$11000.0^{+4.0\,+1.0}_{-4.5\,-1.3}$	$10752.7 \pm 5.9\,^{+0.7}_{-1.1}$
Γ (MeV)	$36.6^{+4.5\,+0.5}_{-3.9\,-1.1}$	$23.8^{+8.0\,+0.7}_{-6.8\,-1.8}$	$35.5^{+17.6\,+3.9}_{-11.3\,-3.3}$

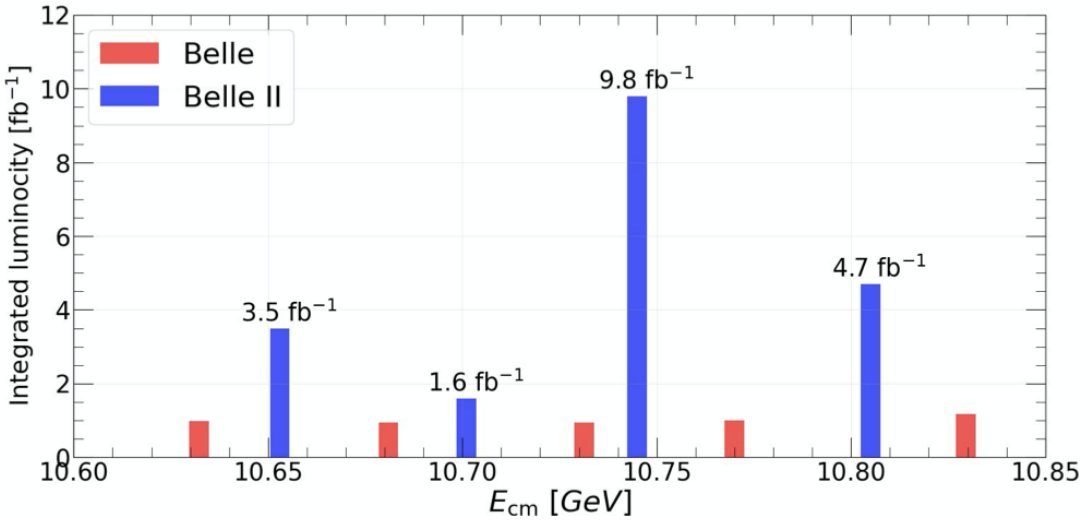


Chin. Phys. C 44 (2020) 8, 083001

A dip at 10.75 GeV may correspond to $\Upsilon(10753)$.

Unique scan data near $\sqrt{s}$ = 10.75 GeV



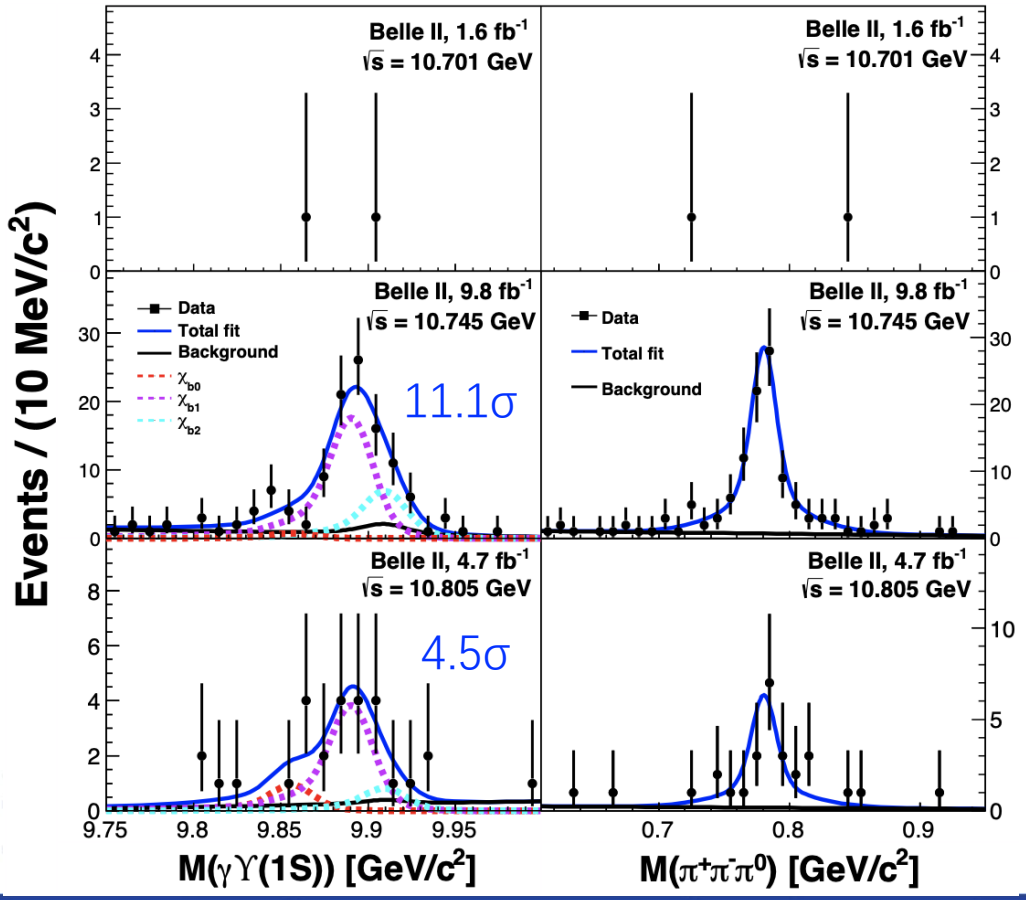


- In November 2021, Belle II collected 19 fb^{-1} of unique data at energies above the ϒ(4S): four energy scan points around 10.75 GeV.
- Belle II collected the data in the gaps between Belle energy scan points.
- Physics goal: understand the nature of the ϒ(10753) energy region.

Observation of $\Upsilon(10753) \to \omega\chi_{bJ}$

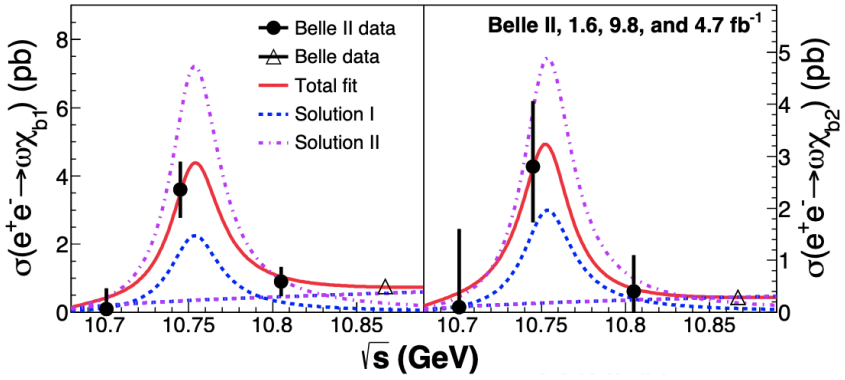
PRL 130, 091902 (2023)

Two dimensional unbinned maximum likelihood fits to the $M(\gamma\Upsilon(1S))$ and $M(\pi^+\pi^-\pi^0)$ distributions.



Channel	$\sqrt{s}$ (GeV)	N^{sig}	$\sigma^{(UL)}_{Born}$ (pb)
$\omega\chi_{b1}$	10.745	$68.9^{+13.7}_{-13.5}$	$3.6^{+0.7}_{-0.7} \pm 0.4$
$\omega\chi_{b2}$		$27.6^{+11.6}_{-10.0}$	$2.8^{+1.2}_{-1.0} \pm 0.5$
$\omega\chi_{b1}$	10.805	$15.0^{+6.8}_{-6.2}$	1.6 @90% C.L.
$\omega\chi_{b2}$		$3.3^{+5.3}_{-3.8}$	1.5 @90% C.L.

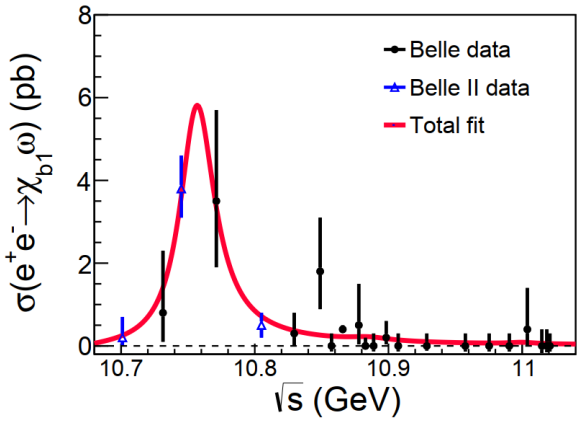
The $e^+e^- \to \omega\chi_{bJ}$ (J = 1, 2) cross sections peak at $\Upsilon(10753)$.

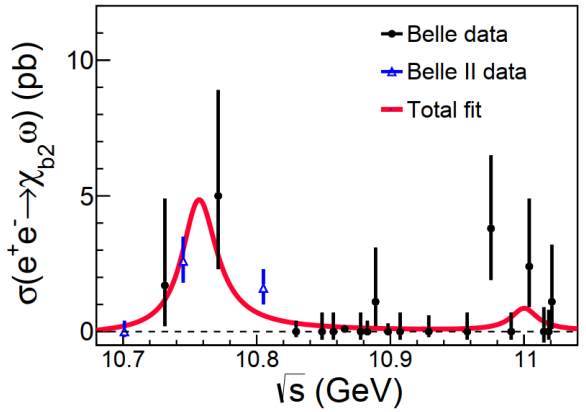


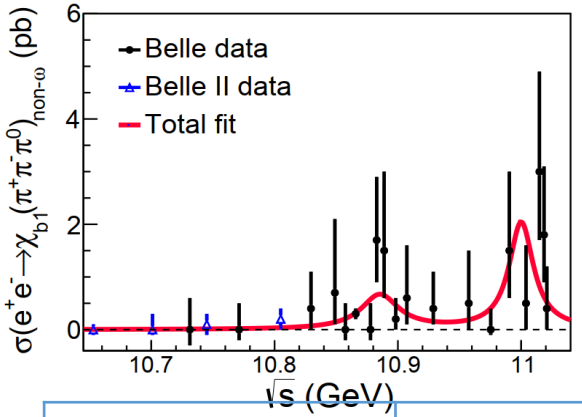
The points at $\sqrt{s}$ = 10.867 GeV are from Belle measurements [PRL 113, 142001 (2014)].

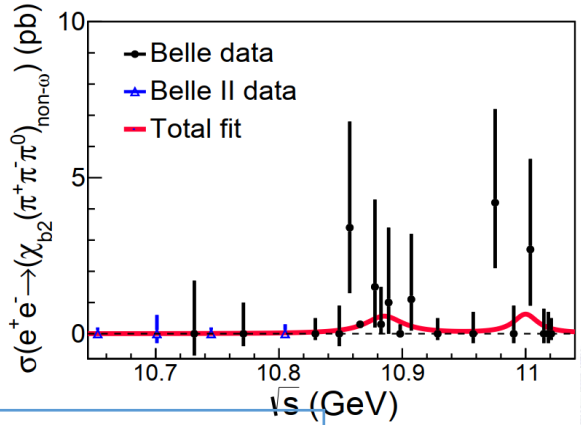
JHEP 04 (2026) 101

$e^+e^- \to \omega\chi_{bJ}$ and $e^+e^- \to (\pi^+\pi^-\pi^0)_{non-\omega}\chi_{bJ}$ at Belle and Belle II









$\Upsilon(10753)$ mass	(10756.1±4.3) MeV/c^2
$\Upsilon(10753)$ width	(32.2±18.7) MeV

$$\frac{\sigma(e^+e^-\to\chi_{bJ}(1P)\omega)}{\sigma(e^+e^-\to\Upsilon(nS)\pi^+\pi^-)}$$

1.5 at $\sqrt{s}$ ~ 10.75 GeV

0.15 at $\sqrt{s}$ ~ 10.867 GeV

This may indicate the difference in the internal structures of $\Upsilon(10753)$ and $\Upsilon(10860)$.

$$\mathcal{B}(\Upsilon(10753)\to\chi_{b1}\omega)/\mathcal{B}(\Upsilon(10753)\to\chi_{b2}\omega)$$

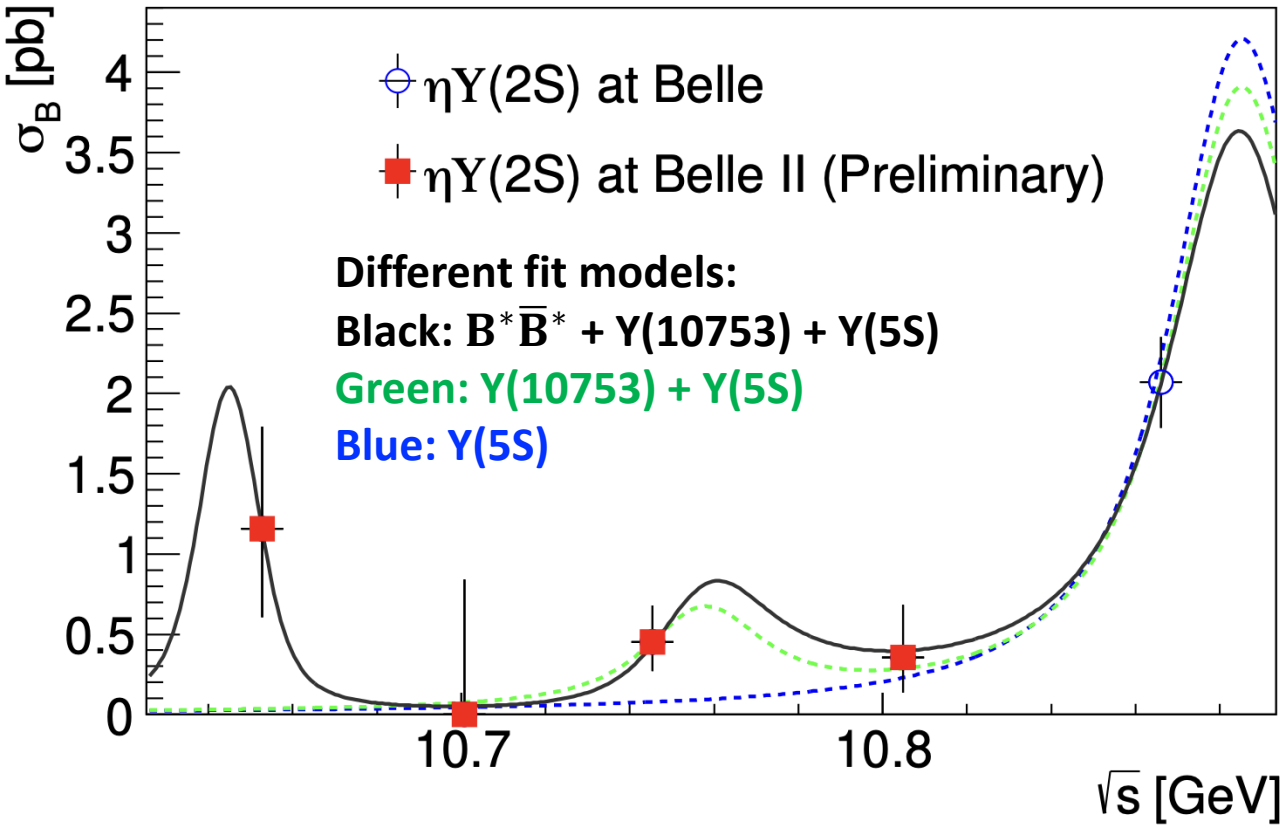
$$\downarrow$$

1.13±0.38±0.34

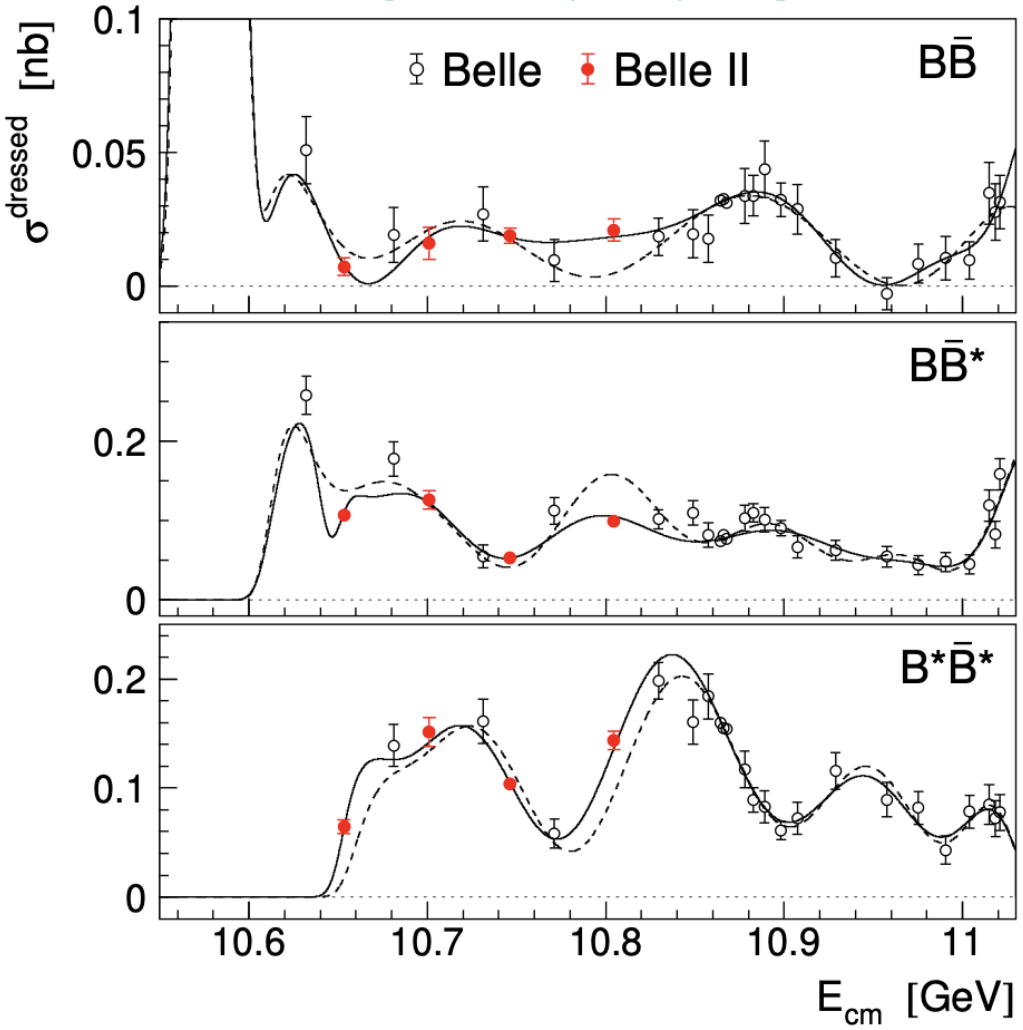
- The $(\pi^+\pi^-\pi^0)_{non-\omega}\chi_{bJ}$ excess maybe due the cascade decay of $\Upsilon(10860, 11020) \to Z_b\pi \to \chi_{bJ}\rho\pi$ [PRD 90, 014036 (2014)].

$e^+e^- \to \eta\Upsilon(2S)$ and $e^+e^- \to B^{(*)}\bar{B}^{(*)}$

[PRD 113, L051102 (2026)]



[JHEP 10 (2024) 114]



- The Born cross section of $e^+e^- \to \eta\Upsilon(2S)$ around $B^*\bar{B}^*$ mass is relatively large.

The significance of $B^*\bar{B}^*$ bound state is larger than 3.2σ

Rapid increase of $\sigma_{B^*\bar{B}^*}$ just above the threshold.

A new bottomonium-like state around $B^*\bar{B}^*$ threshold?

The $Y_b(10650)$ is predicted in Refs. [arXiv:2505.02742, arXiv:2508.11127, arXiv:2505.03647].

2026 Belle II发表论文情况（中国大陆组主要贡献）

- **B物理：　2 PRD, 1 PRL(submitted)**
- **底偶素：　3 PRD, 1 PRL, 1 JHEP**
- **奇特态：　1PRD; 1 PRL(submitted)**
- **粲重子：　1 PRD; 1 PRD(submitted); 1 PRD(to be submitted)**
- **粲介子：　1PRL; 1PRL (to be submitted)**

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