BESIII 研究进展综述

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第十一届xyz研讨会
贵州民族大学
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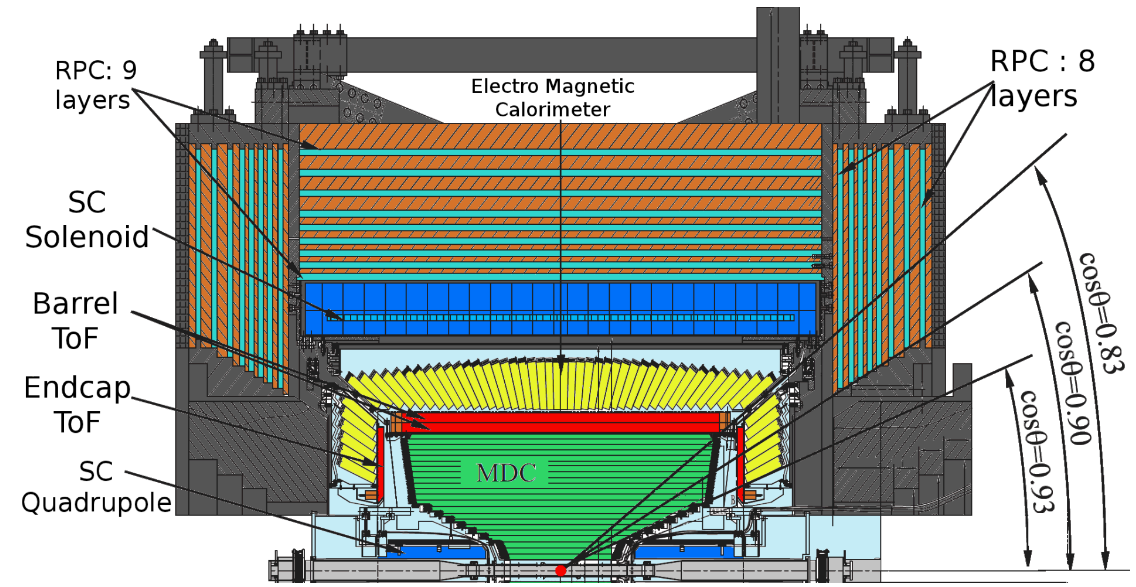
BEPCII and BESIII



- Start taking data in 2009.
- $\sqrt{s}$ = 1.84 – 4.946 GeV (tau-charm factory).
- Design Luminosity $L_{\mathrm{D}} = 1 \times 10^{33}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ @ 3.773 GeV

  (2016 achieved; 2022-2024 achieved $1.1 \times L_{\mathrm{D}}$).

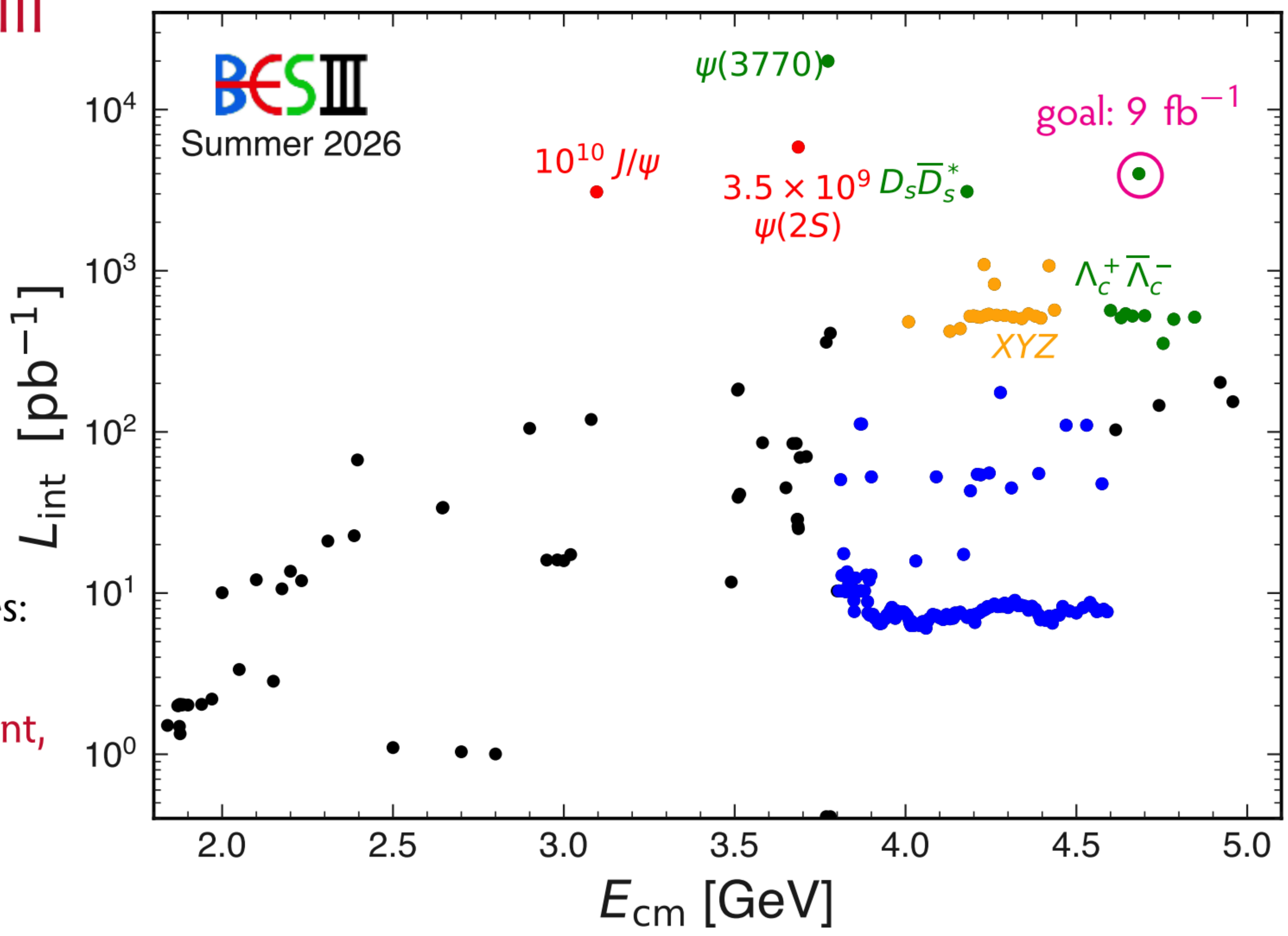
- Magnet: 1T Superconducting
- MDC: small cell & He gas
  - σ_{x_Y} = 130 μm
  - σ_p/p = 0.5% @1GeV
  - dE/dx = 6%
- TOF: plastic scintillator/MRPC
  - σ_T = 80 ps Barrel
  - σ_T = 110 (60) ps Endcap
- EMC: CsI crystals
  - ΔE/E = 2.5% @ 1GeV - Barrel
  - ΔE/E = 5% @ 1GeV - Endcap
- Muon ID: 9 layer RPC

BESIII Data

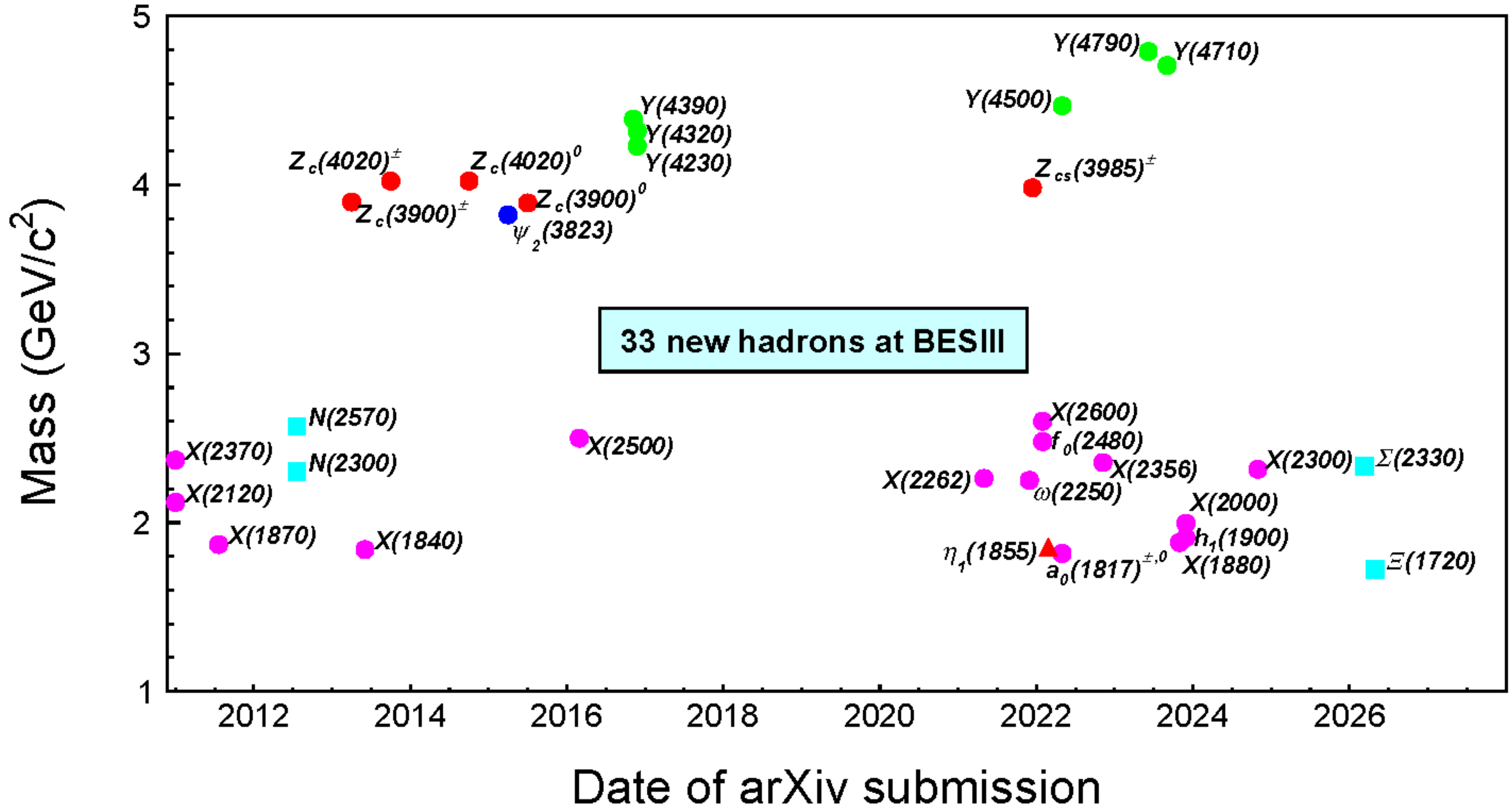
16 years data taking at BESIII

Data sets collected so far include

- 10×10^9 J/ψ events
- 3.5×10^9 ψ' events
- $20\ \text{fb}^{-1}$ on $\psi(3770)$
- scan data between
  1.8 and 3.08 GeV,
  and above 3.735 GeV
- large datasets for *XYZ* studies:
  scan with
  $> 500\ \text{pb}^{-1}$ per energy point,
  spaced 10 – 20 MeV apart



New hadrons discovered at BESIII

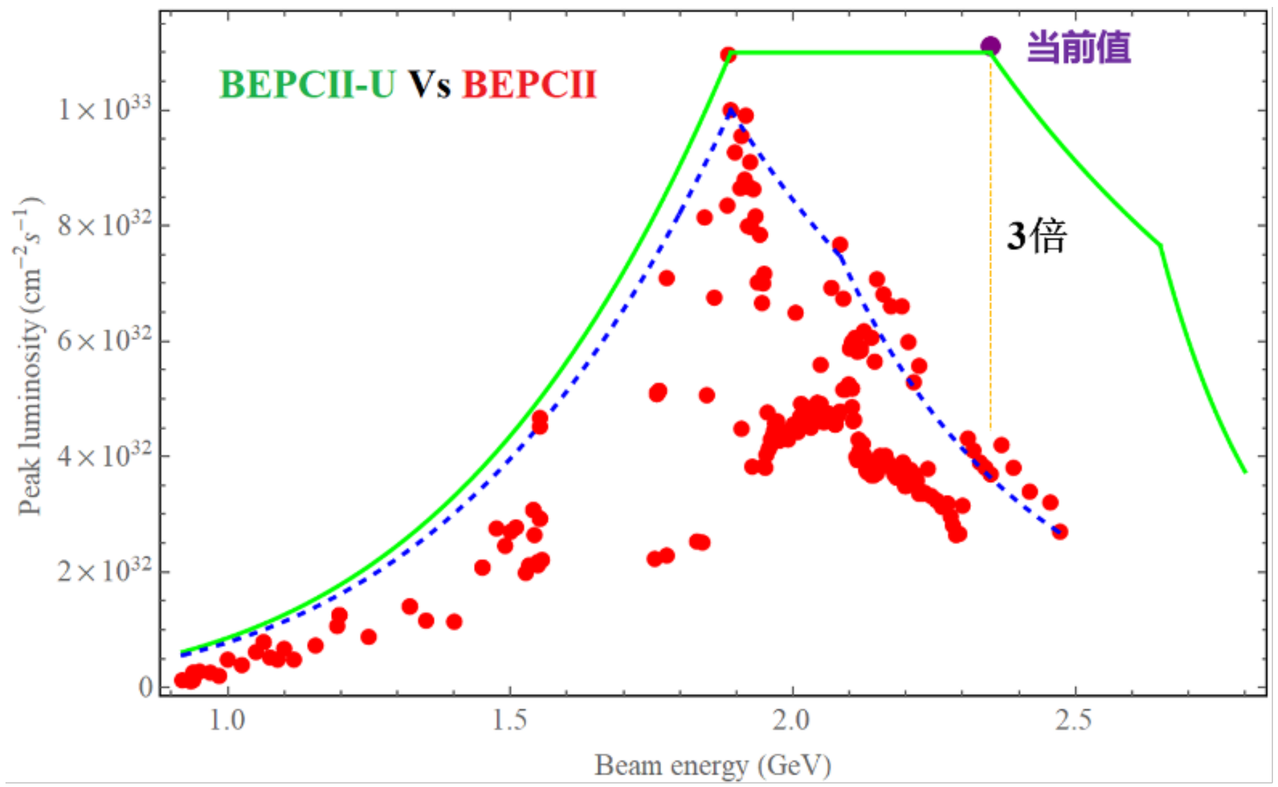


Zhiqing Liu & Ryan Mitchell, Science Bulletin 68 (2023) 2148–2150

BEPCII→ BEPCII-U

Aims

- 3 x luminosities at high energy region
- Operation above 5 GeV



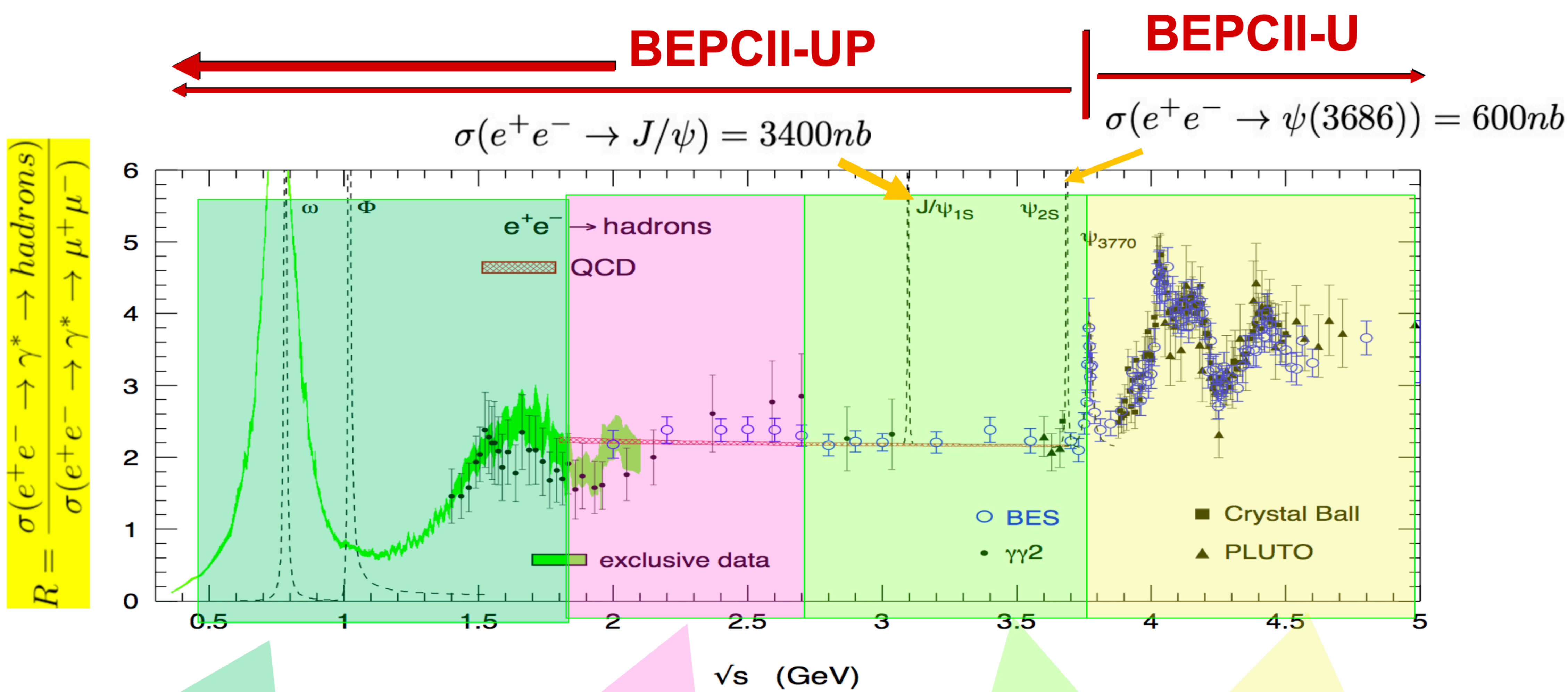
Achieved peak luminosities so far:

$\sqrt{s}$ [GeV]	$\mathcal{L}_{peak}$ [10^{33} cm^{-2} s^{-1}]	
3.686	1.05	exceeding design of BEPCII
4.68	1.06	reached 3× pre-upgrade value!

- Keep operation until ~2030

BEPCII→ BEPCII-U → BEPCII-UP (in planning)

曹俊，"BEPCII升级和高能所未来发展规划"， 2026 高能物理战略研讨会，广州



- 2.0GeV以下R值
- 奇异偶素物理
- 核子形状因子
- 强子真空极化

- 强子形状因子
- R值的精确测量
- 强子产生机制

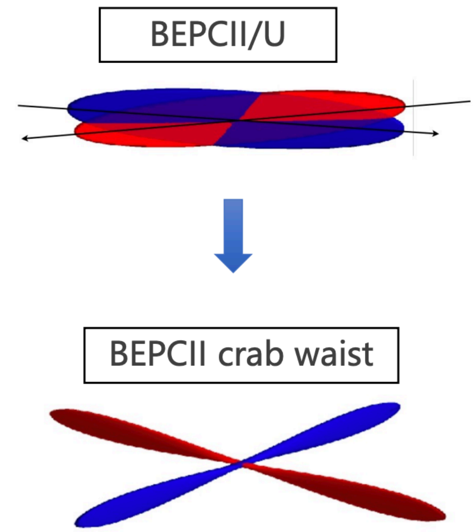
- 轻强子谱学
- 轻奇特强子态
- 陶轻子物理

- 粲偶素谱和XYZ粒子
- 粲介子和粲重子
- 粲夸克碎裂和重子极化

BEPCII→ BEPCII-U → BEPCII-UP (in planning)

曹俊，“BEPCII升级和高能所未来发展规划”， 2026 高能物理战略研讨会，广州

- BEPCII Crab Waist对撞方案和亮度升级 →
- **(基于CW技术的）BEPCII性能提升项目 (BEPCII Upgrade Plus，BEPCII-UP)**
  - ⇨ 1.89GeV束流能量以下，亮度**有望提高10倍**，运行能区有效下探至约**1.0 GeV**甚至0.6GeV
  - ⇨ 同时，考虑新的探测器技术，升级BESIII内径迹探测器，提高空间分辨率、探测效率
- **加速器升级内容**
  - ⇨ 1）直线增加阻尼环；2）内环注入区插入Wiggler；3）对撞区采用CW对撞
- **经费约3亿，其中加速器硬件成本2亿**
- **2030年左右实施升级，2028-2029生产部件，2027完成方案设计和研发**



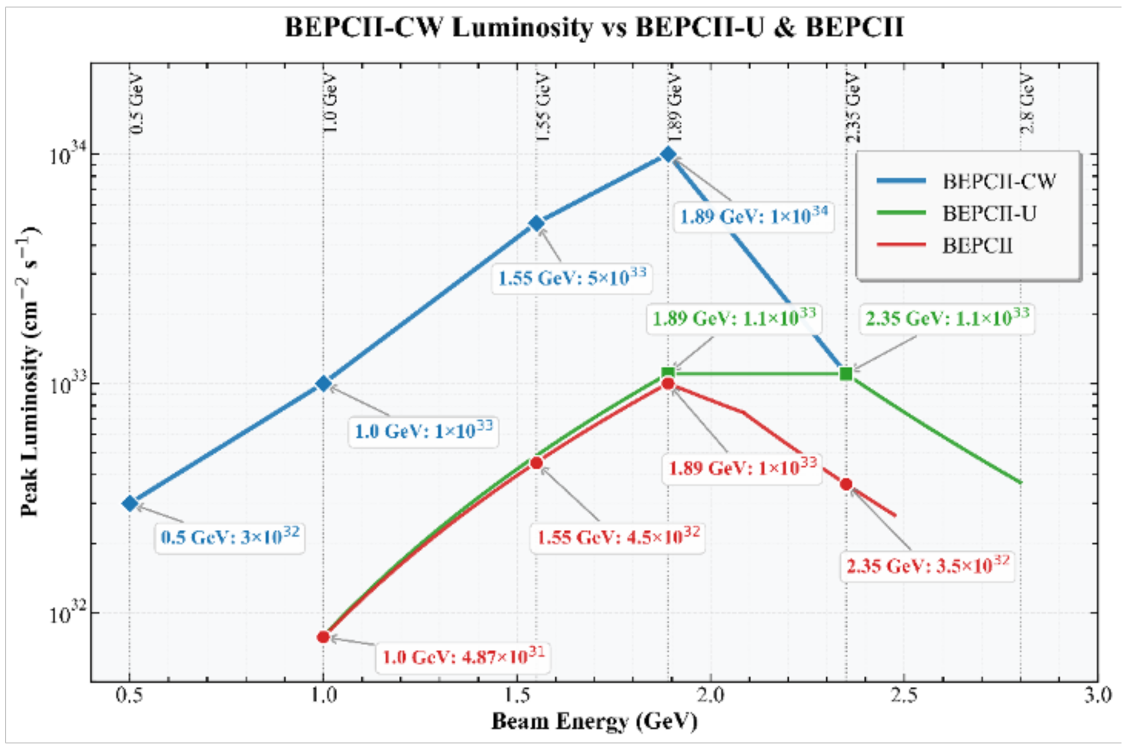
CW: small ε_x & DW: I_b=7.5mA ➔ 12.5mA, ξ_y=0.04 ➔ 0.09

$$L(\mathrm{cm^{-2}s^{-1}}) = 2.17\times10^{34}(1+R)\xi_y\frac{E(GeV)k_bI_b(A)}{\beta_y^*(cm)}$$

CW: β_y^* =13.5mm ➔ 5mm

(L_{CW}/ L_{BEPCII}) =(13.5/5) ×(0.09/0.04) × (12.5/7.5)=10.1

L_{BEPCII}=1.0×10 ^{33} cm^{-2}s^{-1} ➔ L_{CW} ~10×10 ^{33} cm^{-2}s^{-1}



BEPCII-UP 主要物理目标

曹俊，“BEPCII升级和高能所未来发展规划”， 2026 高能物理战略研讨会，广州

- 低能区（1.0-2.0GeV）最精确的R值/强子形状因子测量，误差<1%，攻克低能区强子真空极化(HVP)精度瓶颈，破解“缪子反常磁矩”之谜，为标准模型与新物理寻找关键线索
- 重子结构新认知：通过在【1.0-3.0GeV】能区精细能量扫描，精确测量核子/超子电磁形状因子和极化，深化对其内部动力学性质的理解
- 300亿$\psi(2S)$，助力胶球、混杂态等奇特强子态的寻找
- 精确粲物理：200 fb^{-1}积分亮度，为精确检验CKM幺正性和粲介子CP破坏提供坚实的实验基础，与LHCb和Belle II实验协同开启精确的重味物理新时代
- 加速器物理与技术：验证Crab Waist方案

Charmonium Spectroscopy

more results can be found in Kai Zhu’s talk

X(3872) charmless light hadron decay

PRD 113, L071102 (2026)

- No X(3872) charmless light hadron decays are observed in experiment so far.
- In a molecular nature of X(3872), Ref.[PRD 106, 074015 (2022)] predicted Br(X(3872)→VV, VP) via intermediate meson loops

Final states	$\theta = 0$	$\theta = \pi/6$	$\theta = \pi/4$
$\rho\rho$	$(0.15\text{–}7.86) \times 10^{-3}$	$(0.06\text{–}3.20) \times 10^{-2}$	$(0.83\text{–}4.29) \times 10^{-2}$
$K^{*+}K^{*-}$	$(0.08\text{–}4.11) \times 10^{-3}$	$(0.06\text{–}3.08) \times 10^{-3}$	$(0.04\text{–}2.05) \times 10^{-3}$
$K^{*0}\bar{K}^{*0}$	$\cdots$	$(0.11\text{–}5.36) \times 10^{-3}$	$(0.02\text{–}1.07) \times 10^{-2}$
$\omega\omega$	$(0.03\text{–}1.55) \times 10^{-3}$	$(0.12\text{–}6.28) \times 10^{-3}$	$(0.16\text{–}8.41) \times 10^{-3}$
$\rho^0\omega$	$(0.03\text{–}1.56) \times 10^{-3}$	$(0.02\text{–}1.25) \times 10^{-4}$	$(0.03\text{–}1.31) \times 10^{-3}$
$\rho^{\pm}\pi^{\mp}$	$(0.09\text{–}4.40) \times 10^{-2}$	$(0.004\text{–}1.87) \times 10^{-1}$	$(0.05\text{–}2.53) \times 10^{-1}$
$K^{*+}K^{-}$ + c.c.	$(0.08\text{–}3.99) \times 10^{-2}$	$(0.06\text{–}2.99) \times 10^{-2}$	$(0.04\text{–}1.99) \times 10^{-2}$
$K^{*0}\bar{K}^{0}$ + c.c.	$\cdots$	$(0.11\text{–}5.66) \times 10^{-2}$	$(0.02\text{–}1.13) \times 10^{-1}$

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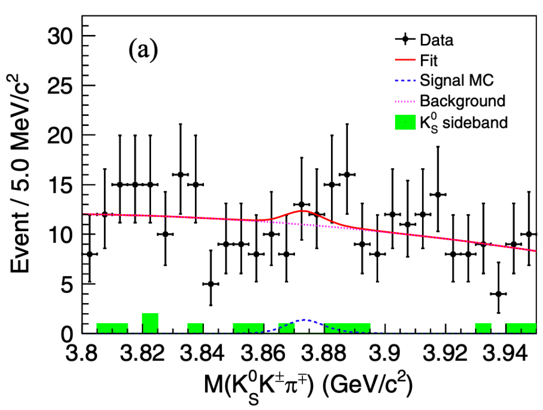
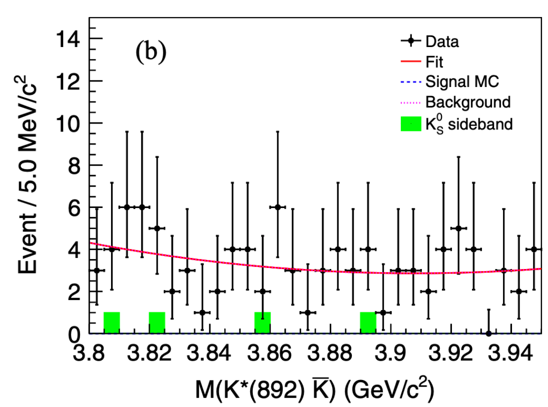
$K^{*+}K^- +$ c.c.	$(0.08\text{–}3.99) \times 10^{-2}$	$(0.06\text{–}2.99) \times 10^{-2}$	$(0.04\text{–}1.99) \times 10^{-2}$
$K^{*0}\bar{K}^0 +$ c.c.	...	$(0.11\text{–}5.66) \times 10^{-2}$	$(0.02\text{–}1.13) \times 10^{-1}$

- Search for X(3872)→KsK$^\pm\pi^\mp$ and K*(892)$^{\pm,0}$K$^{\mp,0}$ at $\sqrt{s}$ = 4.16-4.34 GeV



$$\frac{\mathcal{B}[X(3872)\to K^0_S K^\pm \pi^\mp]}{\mathcal{B}[X(3872)\to \pi^+\pi^- J/\psi]} < 0.07$$



$$\frac{\mathcal{B}[X(3872)\to K^*(892)\bar{K}]}{\mathcal{B}[X(3872)\to \pi^+\pi^- J/\psi]} < 0.10$$

With

$$\mathcal{B}(X(3872) \to \pi^+\pi^- J/\psi) = (4.3 \pm 1.4)\%$$

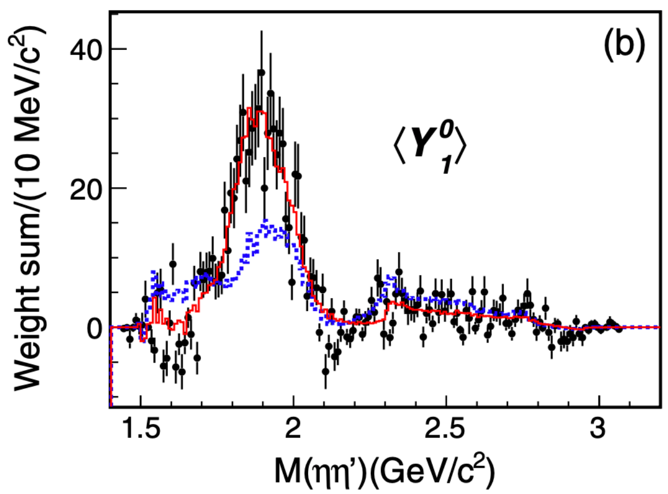
$$\mathcal{B}[X(3872) \to K^*(892)\bar{K}] < 0.60 \times 10^{-2}$$

$\chi_{c1}(1P)$

$K^*(892)^0\overline{K}^0$ + c.c.	$(1.04 \pm 0.15) \times 10^{-3}$
$K^*(892)^+K^-$ + c.c.	$(1.22 \pm 0.23) \times 10^{-3}$

Search for 1^{-+} exotic states

- Search for $J^{PC}=1^{-+}$ exotics
  - Conventional mesons within quark model can not produce states with J^{PC} = 0^{--}, 1^{-+}, 2^{+-}…
  - Experimental observation would reveal their unambiguous exotic signatures.
- BESIII observed $J^{PC}=1^{-+}$ isoscalar resonance $\eta_1(1855)$ in $J/\psi \to \gamma(\eta\eta')$



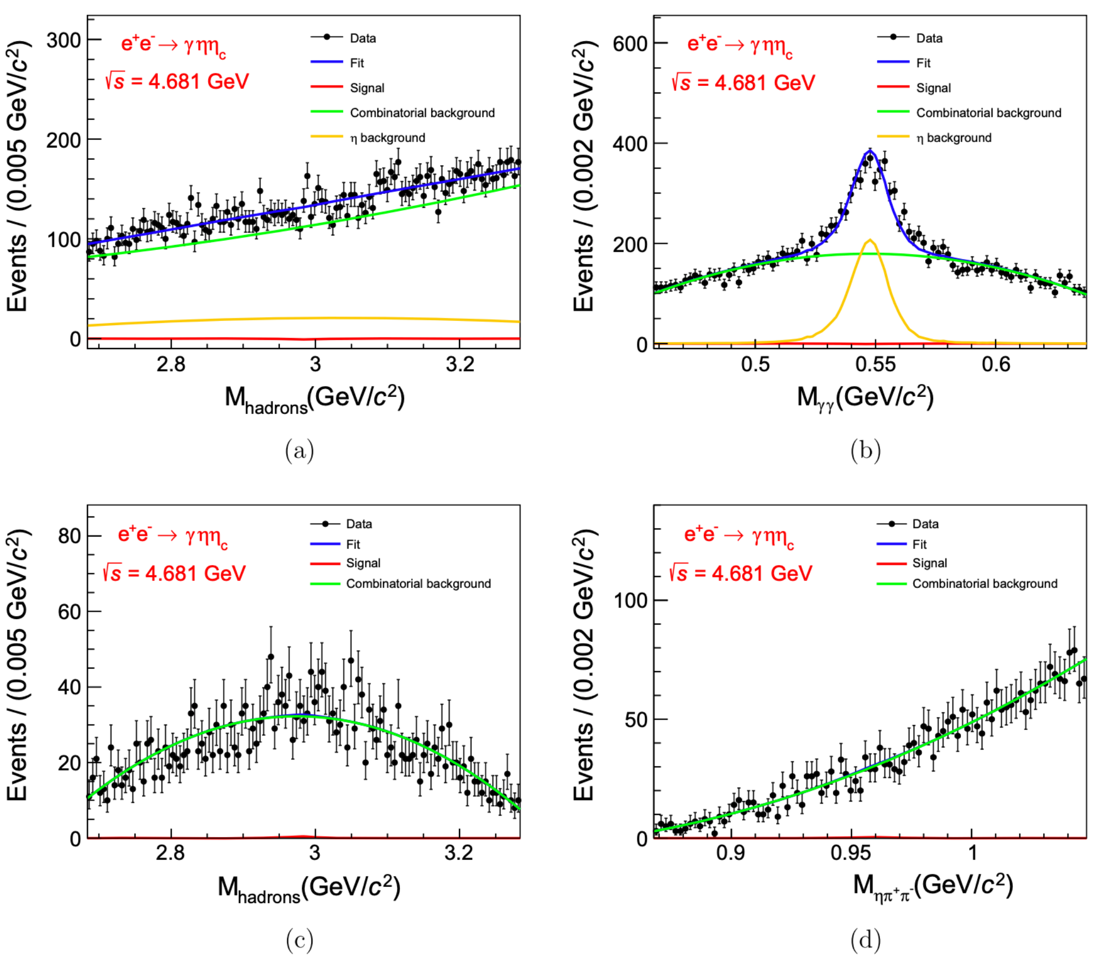
PRL 129, 192002 (2022)

- Search for 1^{-+} charmonium-like exotic states via $e^+e^- \to \gamma(\eta\eta_c, \eta'\eta_c, D_sD_{s1}(2536))$
  - In a molecular picture, several 1^{-+} states were predicted, with masses close to hadron pair thresholds. PRD89,114013(2014),PRD101,076003(2020)
  - LQCD calculate 1^{-+} hybrid states with mass 4.13-4.33 GeV, decaying dominantly to $D_sD^*_s$, D_1D, D^*D, D^*D^* PRD89,114013(2014), JHEP07(2012)126, JHEP12(2016)089,PRD102,014023 (2020)

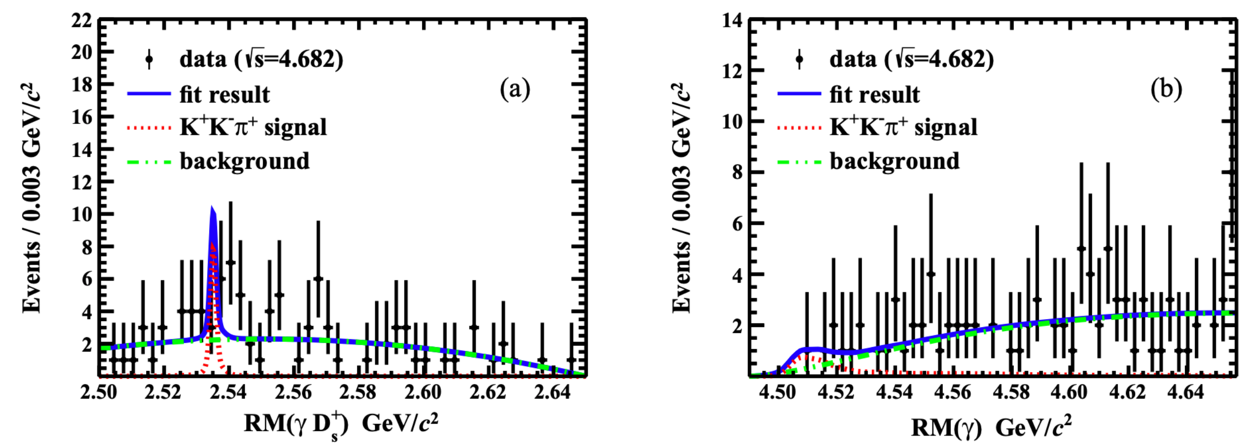
Search for 1^{-+} exotic states

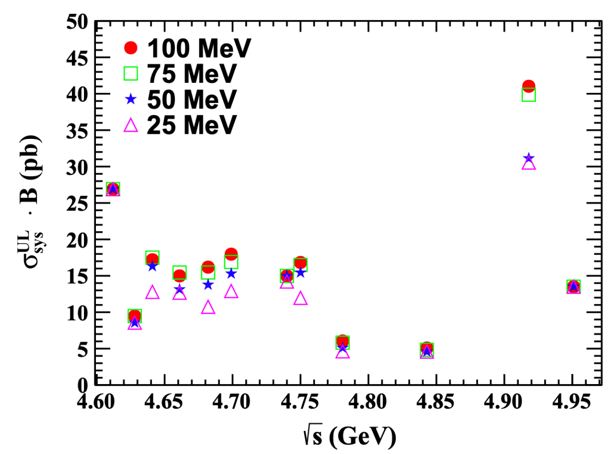
- Search for $J^{PC}=1^{-+}$ exotics in $e^+e^- \to \gamma(\eta\eta_c, \eta'\eta_c)$ at $\sqrt{s}$=4.258-4.681 GeV
- Provide the production upper limits

- Search for 1^{-+} exotic in $ee \to \gamma D_s D_{s1}(2536)$ at $\sqrt{s}$=4.612-4.951 GeV



PRD 111, 112007 (2025)





PRD 112, 032002 (2025)

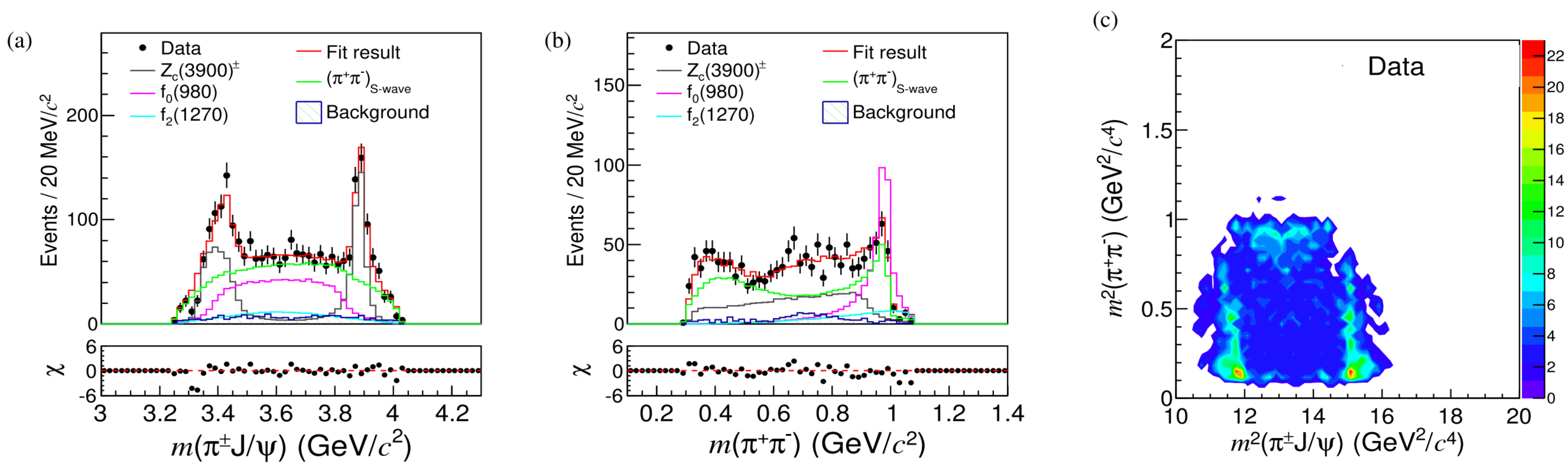
PWA of $e^+e^- \to \pi^+\pi^- J/\psi$

PRD 112, 092013 (2025)

- Dataset: $\sqrt{s} = 4.1271 - 4.3583$ GeV
- PWA includes the processes

$$e^+e^- \to \pi^\pm Z_c(3900)^\mp(\to \pi^\mp J/\psi)$$

$$e^+e^- \to f_j(\to \pi^+\pi^-)J/\psi \quad f_0(500), f_0(980), f_0(1370), \text{or } f_2(1270)$$



PWA of $e^+e^- \to \pi^+\pi^- J/\psi$

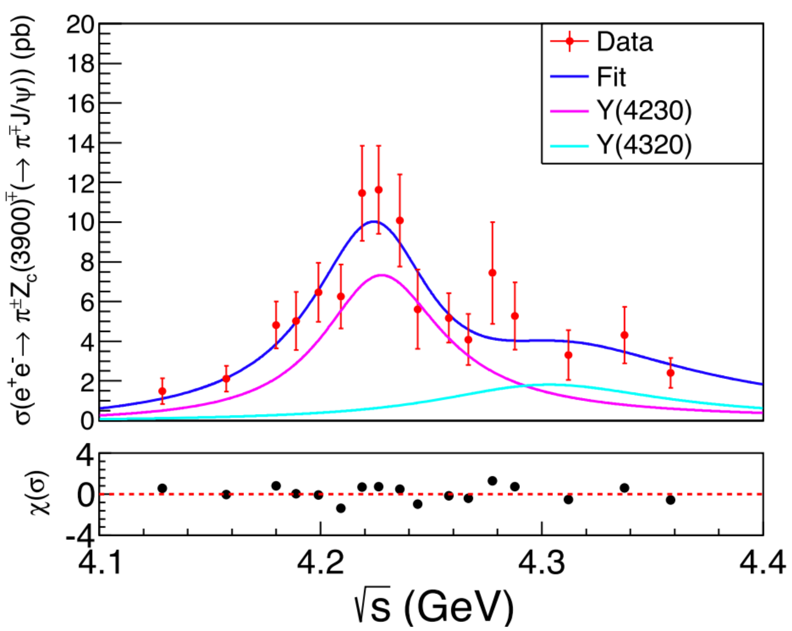
PRD 112, 092013 (2025)

- Determine $Z_c(3900)$ mass and width

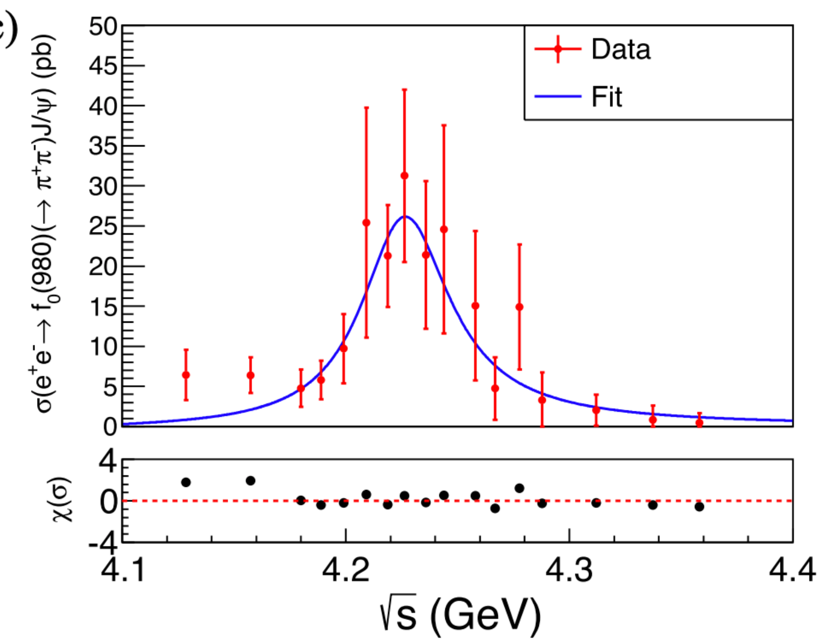
$$\mathrm{M} = 3884.6 \pm 0.7 \pm 3.3\ \mathrm{MeV}/\mathrm{c}^2$$
$$\Gamma = 37.2 \pm 1.3 \pm 6.6\ \mathrm{MeV}/c^2$$

- Fit to $\sqrt{s}$-dependent cross sections of $\pi Z_c(3900)$ and $f_0(980)J/\psi$

(a)



(c)

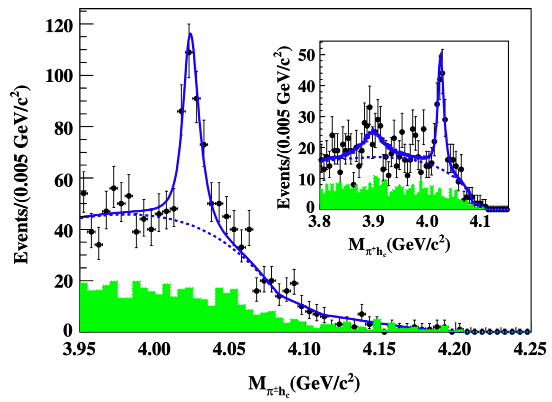


- Determine $\psi(4220)$ mass and width

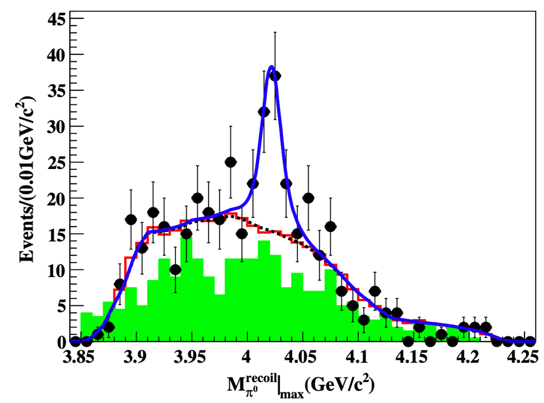
$$\mathrm{M} = 4225.7 \pm 4.1 \pm 3.4\ \mathrm{MeV}/c^2$$
$$\Gamma = 57.5 \pm 9.4 \pm 12.1\ \mathrm{MeV}$$

Multi-channel joint analysis of $T_{c\bar{c}}(4020)$

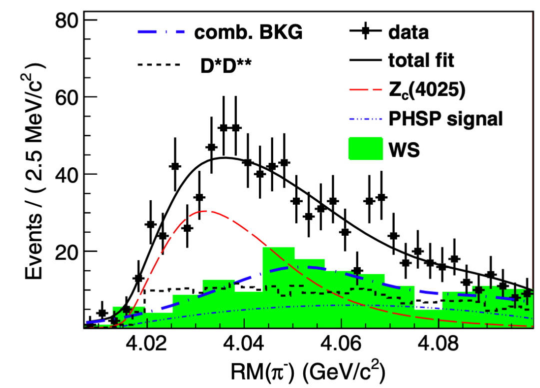
- Isotriplet states: Tcc(4020)/Tcc(4025) observed in πh_c, D*D*bar



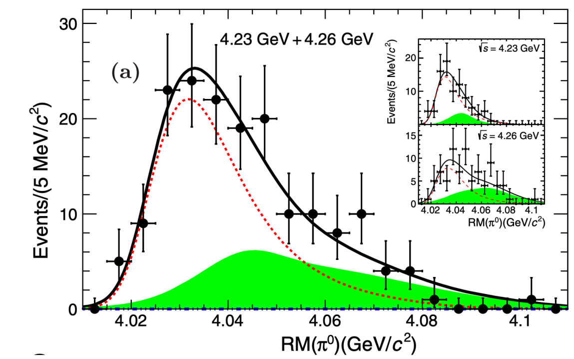
PRL 111, 242001 (2013)



PRL 113, 212002 (2014)

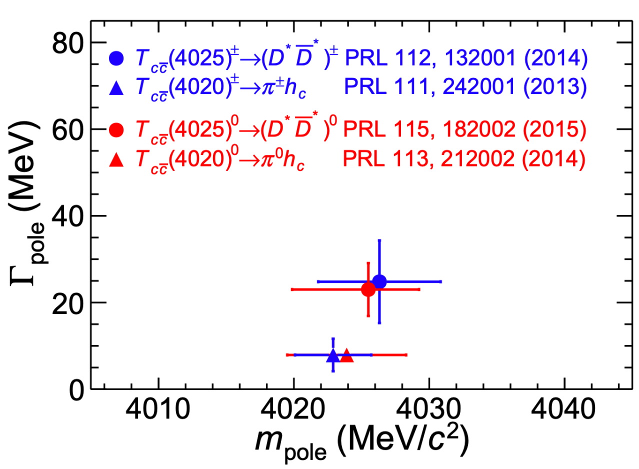


PRL 112, 132001 (2014)



PRL 115, 182002 (2015)

- Masses and widths



- Perform multi-channel joint PWA of the $T_{cc}(4020)$ at $\sqrt{s}$=4.395 and 4.416 GeV

$$T_{c\bar{c}}(4020)^- \to D^{*0}D^{*-},\ \pi^- J/\psi,\ \text{and}\ \pi^- h_c$$

Multi-channel joint analysis of $T_{c\bar{c}}(4020)$

arXiv:2603.05564

- Poles

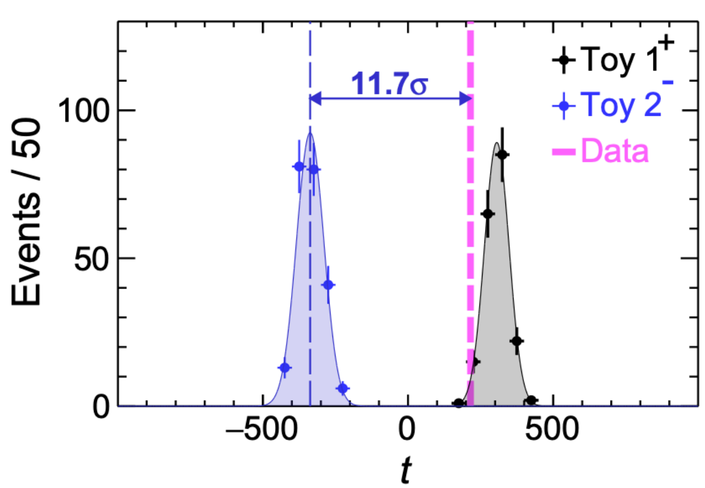
$$m_{\text{pole1}} = 4022.44 \pm 1.55\,\text{MeV}/c^2, \quad m_{\text{pole2}} = 4023.01 \pm 1.35\,\text{MeV}/c^2,$$
$$\Gamma_{\text{pole1}} = 38.54 \pm 2.94\,\text{MeV}, \quad \Gamma_{\text{pole2}} = 35.02 \pm 2.20\,\text{MeV}.$$

- Branching fractions

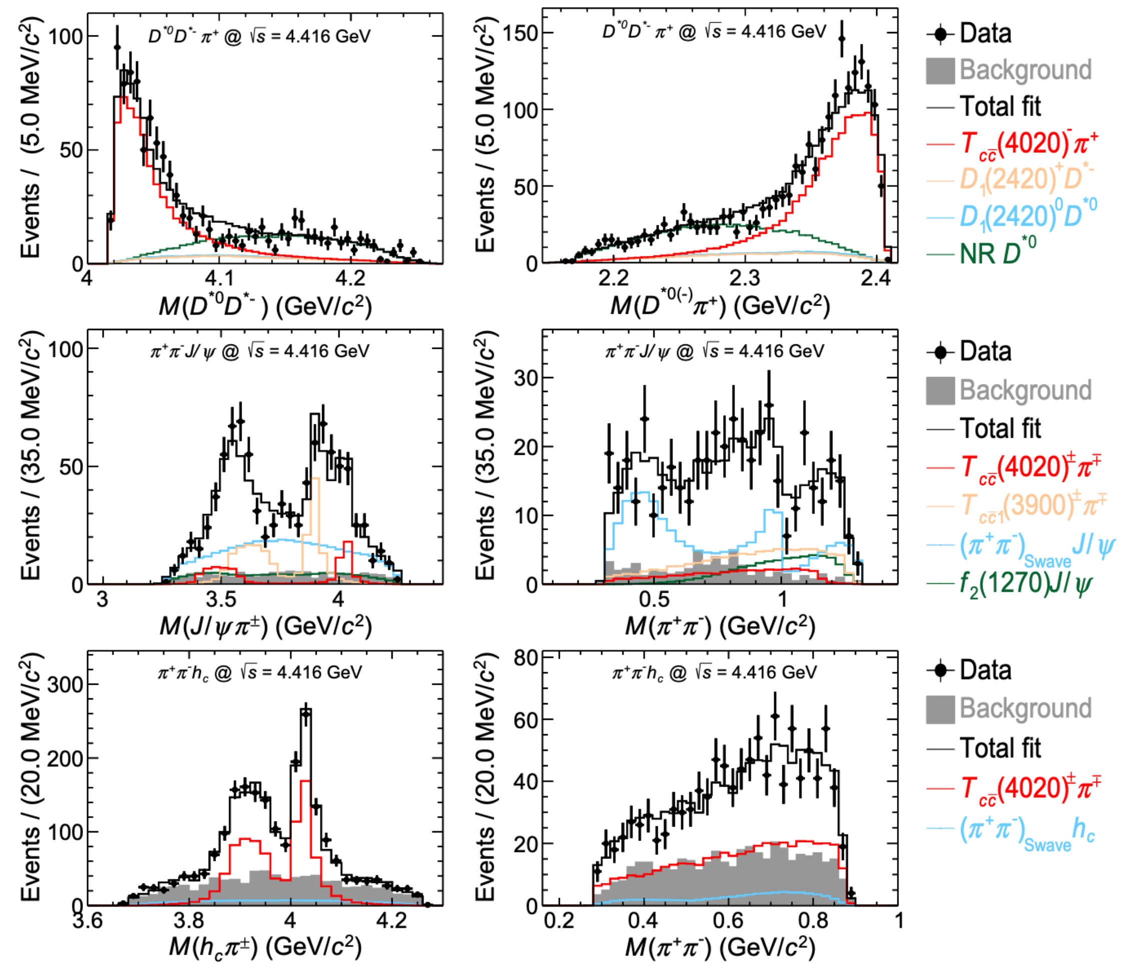
$$\frac{\mathcal{B}[T_{c\bar{c}}(4020)^- \to \pi^- J/\psi]}{\mathcal{B}[T_{c\bar{c}}(4020)^- \to D^{*0} D^{*-}]} = (3.6 \pm 0.6 \pm 1.6) \times 10^{-3}$$

$$\frac{\mathcal{B}[T_{c\bar{c}}(4020)^- \to \pi^- h_c]}{\mathcal{B}[T_{c\bar{c}}(4020)^- \to D^{*0} D^{*-}]} = (8.9 \pm 1.3 \pm 2.3) \times 10^{-2}$$

- $J^P=1^+$ with a significance 11.7σ



$$t \equiv -2[-\ln L^{1^+} - (-\ln L^{J^P})]$$



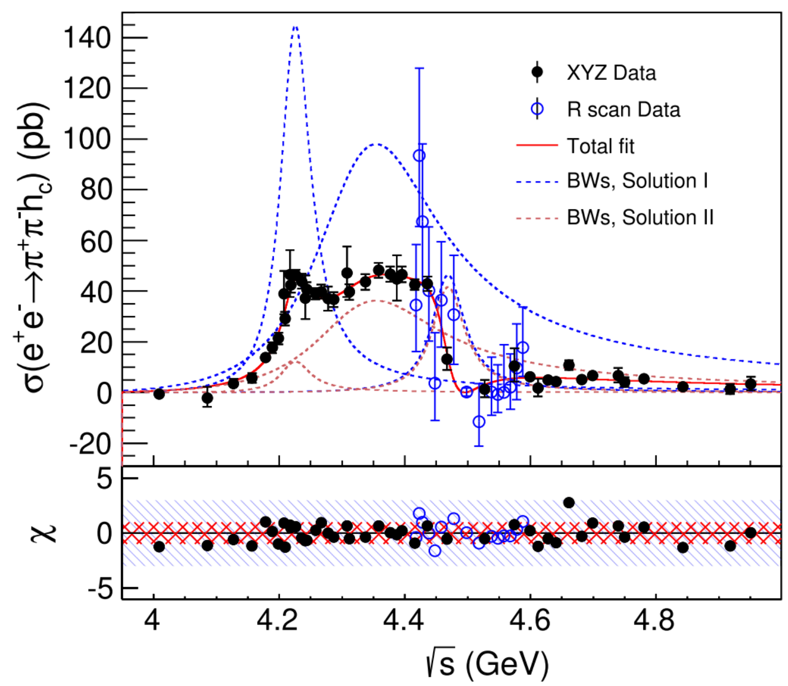
$$\sqrt{s} = 4.416\ \text{GeV}$$

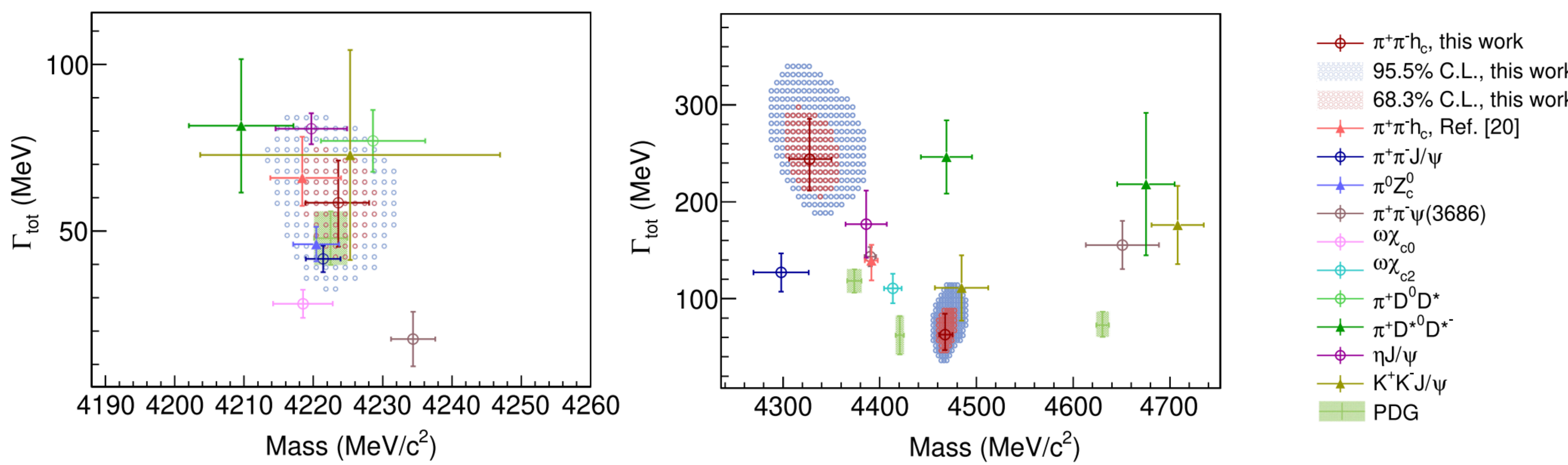
Study of √s-dependent line shape of σ($e^+e^-\to\pi^+\pi^-h_c$)

PRL 135, 071901 (2025)

- At least three resonant-structures to describe √s-dependent line shape of σ($e^+e^-\to\pi^+\pi^-h_c$)

$$M_1 = \left(4223.6^{+3.6+2.6}_{-3.7-2.9}\right)\ \mathrm{MeV}/c^2,\quad \Gamma_1 = \left(58.5^{+10.8+6.7}_{-11.4-6.5}\right)\ \mathrm{MeV}$$
$$M_2 = \left(4327.4^{+20.1+10.7}_{-18.8-9.3}\right)\ \mathrm{MeV}/c^2,\ \Gamma_2 = \left(244.1^{+34.0+24.2}_{-27.1-18.3}\right)\ \mathrm{MeV}$$
$$M_3 = \left(4467.4^{+7.2+3.2}_{-5.4-2.7}\right)\ \mathrm{MeV}/c^2,\quad \Gamma_3 = \left(62.8^{+19.2+9.9}_{-14.4-7.0}\right)\ \mathrm{MeV}$$

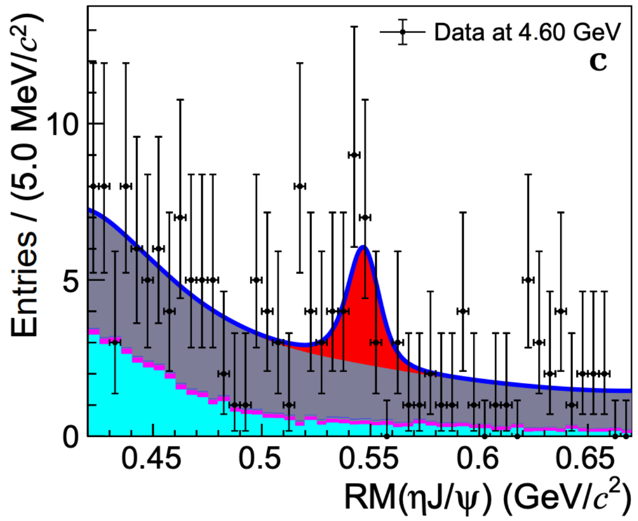


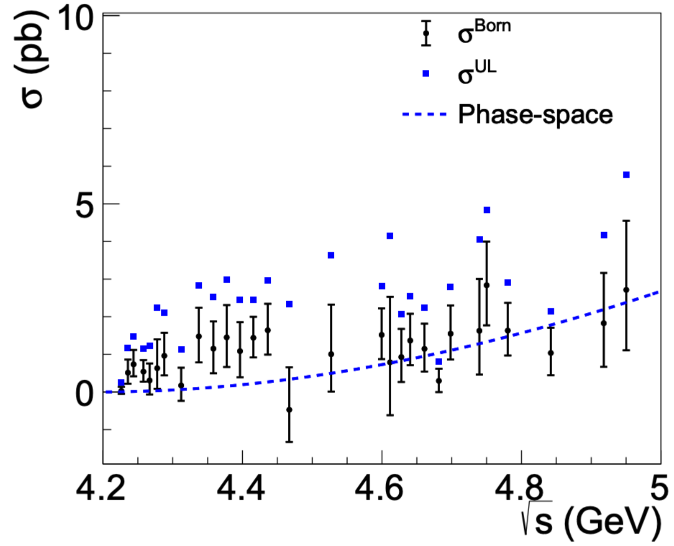


Search for $e^+e^- \to \eta\eta J/\psi$

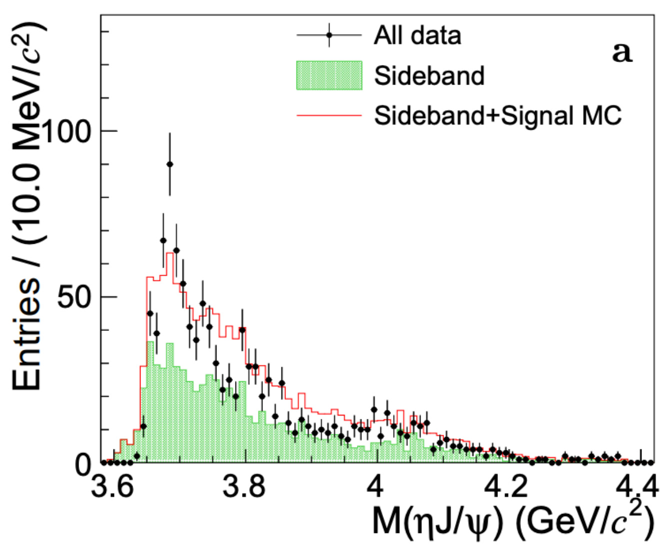
arXiv:2601.15882

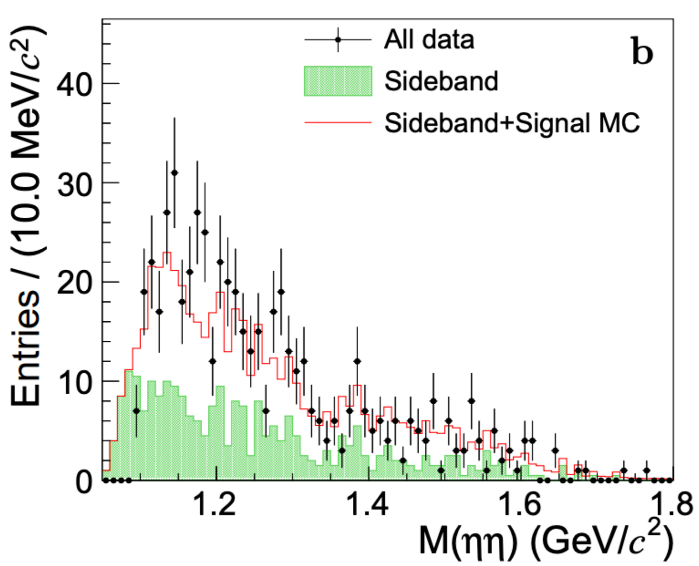
- Observation with significance larger than 5σ at 4.682 (5.7σ) and 4.750 GeV (8.9σ)





- Search for isospin partner to the isospin triplet Zc(3900) in the decay ηJ/ψ
  - See clear ee→ηψ(2S), ψ(2S)→ηJ/ψ
  - ee→f_2(1270)J/ψ may exist



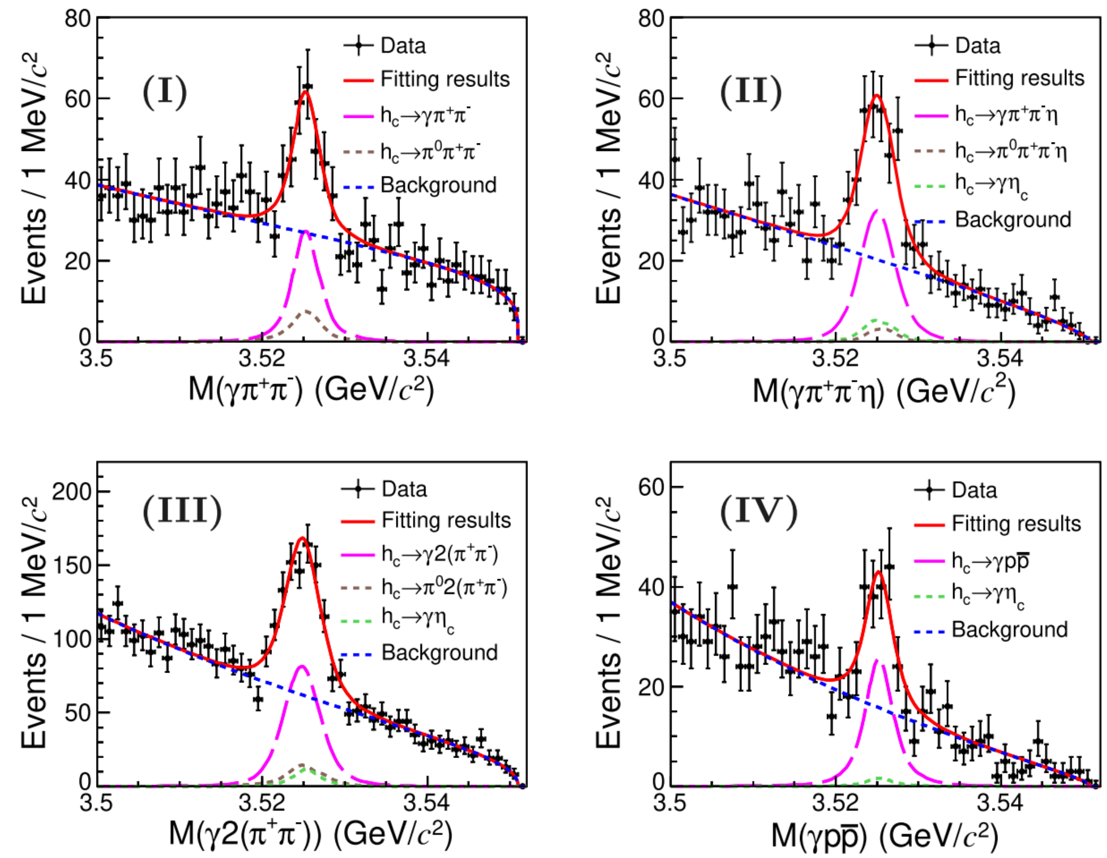


Measurements of h_c radiative decays

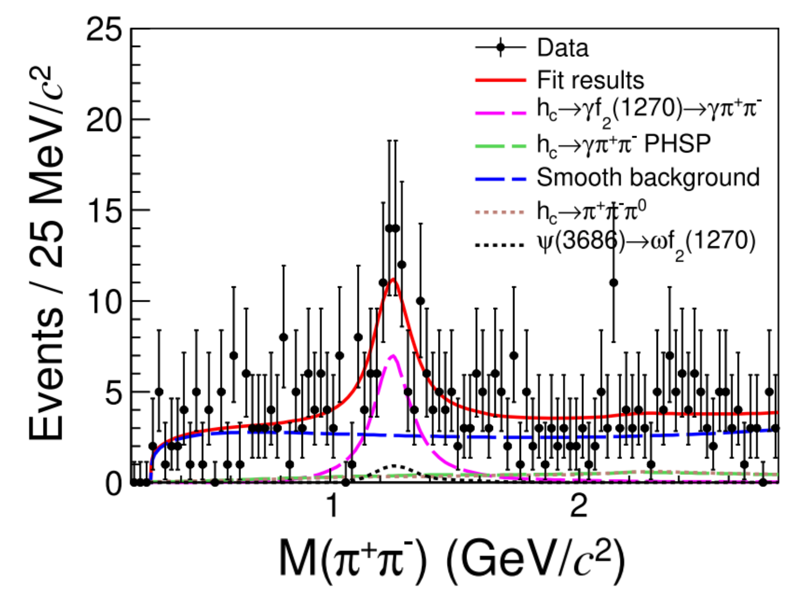
PRL 134, 241902 (2025)

- Observation of four h_c radiative decays to multiple light hadrons decay modes for the first time

Decay mode	Branching fraction	Significance
$h_c \to \gamma\pi^+\pi^-$	$(3.06 \pm 0.54 \pm 0.37 \pm 0.21) \times 10^{-4}$	5.4σ
$h_c \to \gamma\pi^+\pi^-\eta$	$(3.52 \pm 0.50 \pm 0.30 \pm 0.24) \times 10^{-3}$	7.5σ
$h_c \to \gamma 2(\pi^+\pi^-)$	$(2.19 \pm 0.20 \pm 0.16 \pm 0.15) \times 10^{-3}$	11.8σ
$h_c \to \gamma p\bar{p}$	$(3.34 \pm 0.53 \pm 0.33 \pm 0.23) \times 10^{-3}$	6.4σ
$h_c \to \gamma f_2(1270) \to \gamma\pi^+\pi^-$	$(1.81 \pm 0.35 \pm 0.19 \pm 0.12) \times 10^{-3}$	5.1σ



- The total measured branching fraction (~0.8%) is significantly lower than the predicted value 5.5% of Br(hc→γ+2g) [PRD 66, 014012 (2002)].
- First observation of h_c radiative to a tensor state $h_c \to \gamma f_2(1270)$



Observation of $\eta_c \to \gamma\gamma$ in $J/\psi \to \gamma\eta_c$

PRL 134, 181901 (2025)

- Data: $\psi(2S) \to \pi^+\pi^- J/\psi$, $J/\psi \to \gamma\eta_c$

- Neglect interference between η_c and non-resonance process

$$\mathcal{B}(J/\psi \to \gamma\eta_c) \times \mathcal{B}(\eta_c \to \gamma\gamma) = (5.23 \pm 0.26_{\text{stat}} \pm 0.30_{\text{syst}}) \times 10^{-6}$$

- Consistent with calculation of LQCD by NRQCD *[PRD 108, 014513 (2023)]*

$$(5.34 \pm 0.16) \times 10^{-6}$$

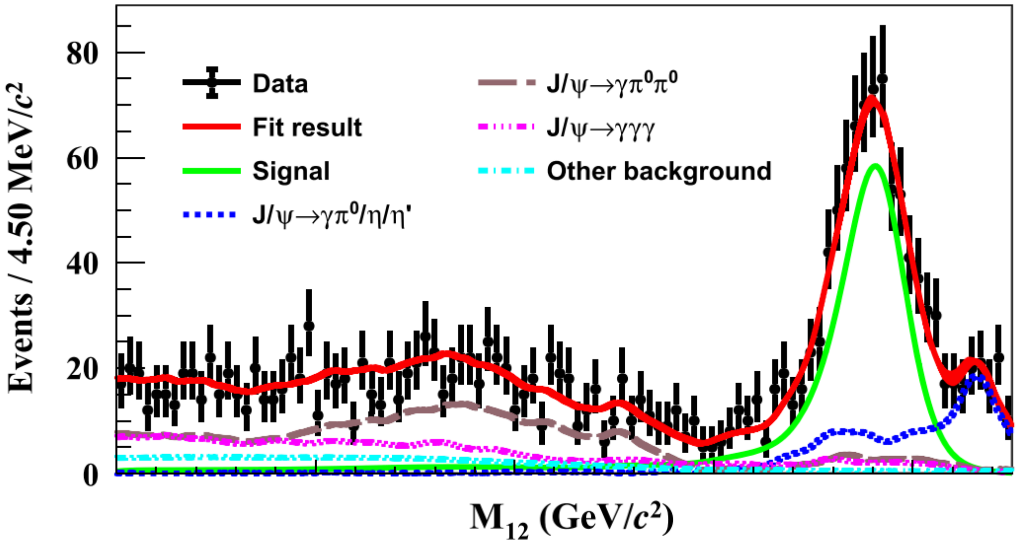
$$\Gamma(\eta_c \to \gamma\gamma) = \frac{\mathcal{B}(J/\psi \to \gamma\eta_c) \times \mathcal{B}(\eta_c \to \gamma\gamma)}{\mathcal{B}^{\text{PDG}}(J/\psi \to \gamma\eta_c)} \times \Gamma^{\text{PDG}}_{\eta_c}$$
$$= (11.30 \pm 0.56 \pm 0.66 \pm 1.14)\ \text{keV}$$

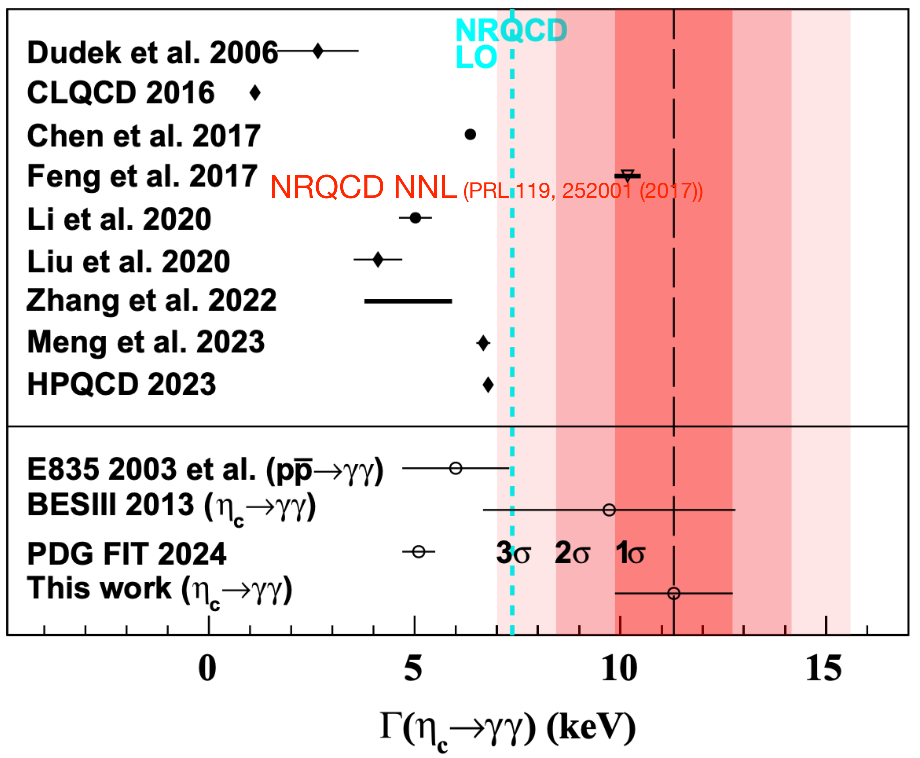
- With Interference (1.2σ compared to w/o inte.)
  - constructive interference

$$\mathcal{B}(J/\psi \to \gamma\eta_c) \times \mathcal{B}(\eta_c \to \gamma\gamma) = (4.13 \pm 0.20 \pm 0.23) \times 10^{-6}$$

  - destructive interference

$$\mathcal{B}(J/\psi \to \gamma\eta_c) \times \mathcal{B}(\eta_c \to \gamma\gamma) = (6.73 \pm 0.32 \pm 0.38) \times 10^{-6}$$

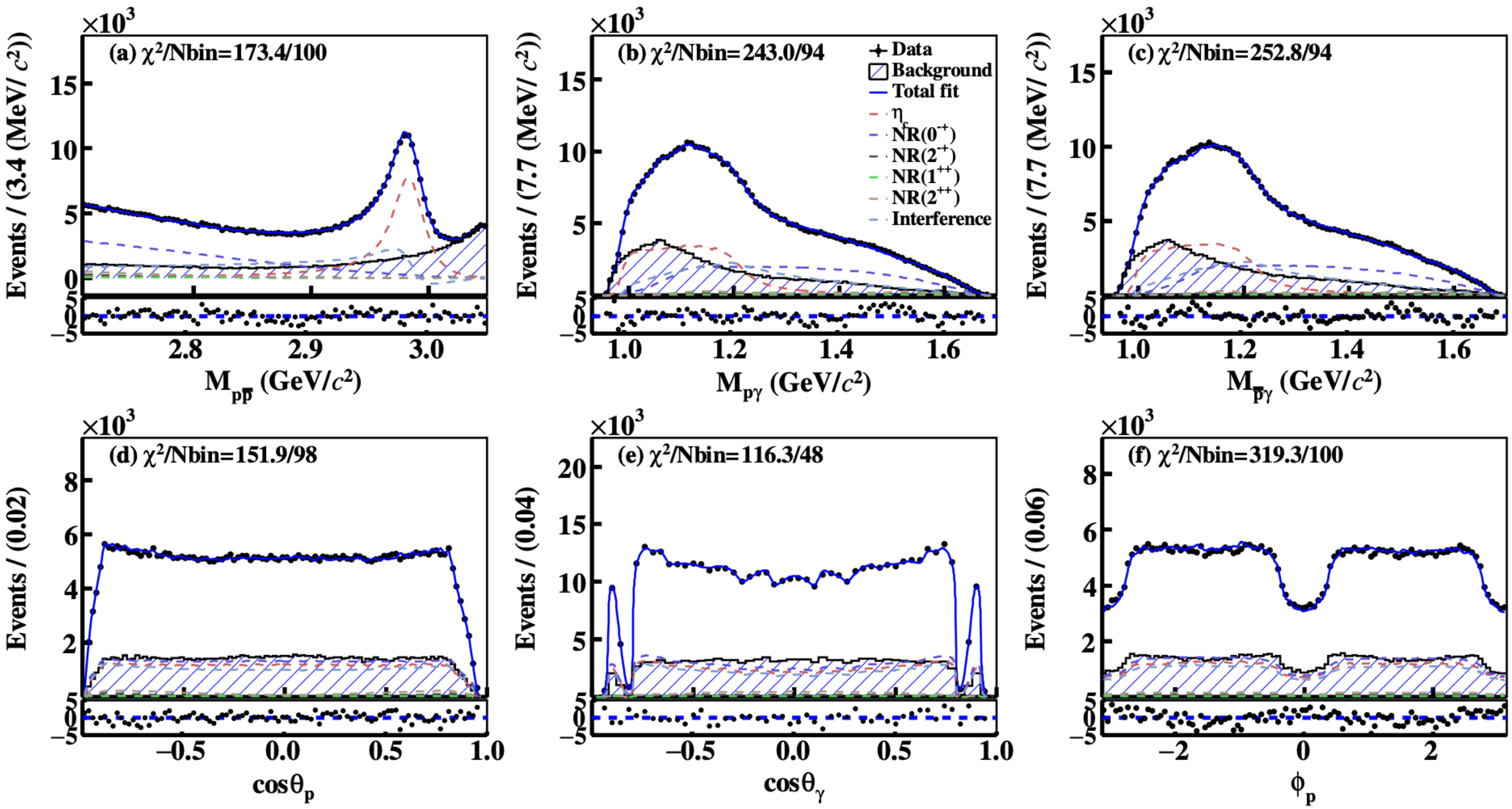




Amplitude analysis of $J/\psi \to \gamma\eta_c \to \gamma p\bar{p}$

PRL 136, 051901 (2026)

- 10 billion J/ψ events
- Amplitude analysis of $J/\psi \to \gamma\eta_c \to \gamma p\bar{p}$ in the η_c mass region [2.70,3.05] GeV/c^2



Amplitude analysis of $J/\psi \to \gamma\eta_c \to \gamma p\bar{p}$

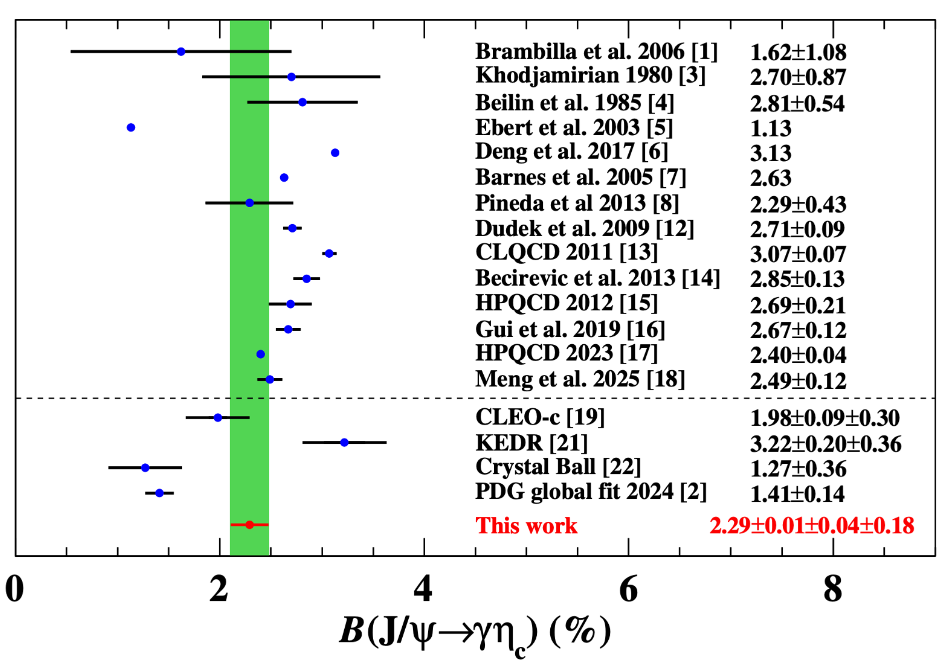
PRL 136,051901 (2026)

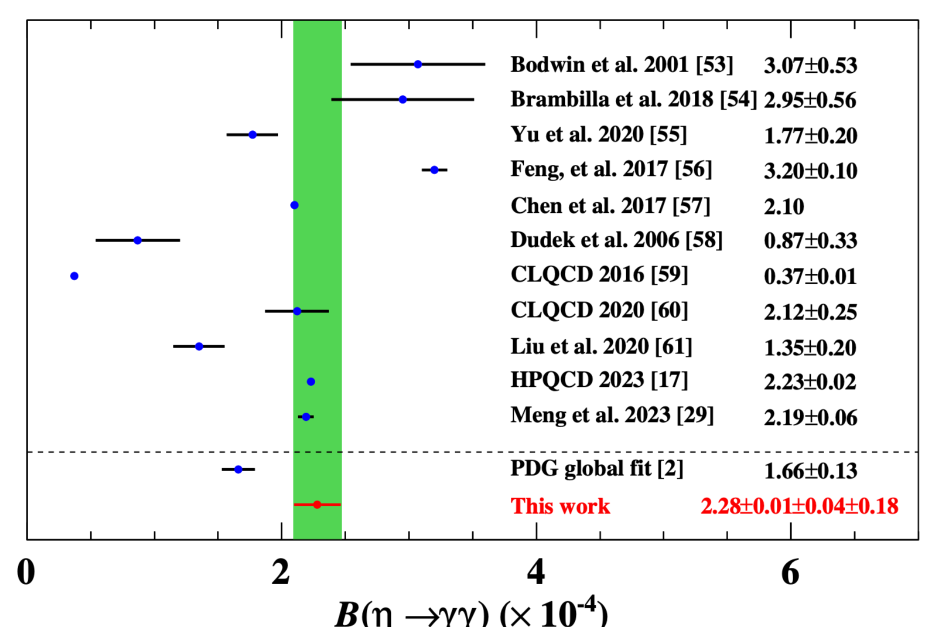
$$B(J/\psi \to \gamma\eta_c) \times B(\eta_c \to \gamma\gamma) = (5.23 \pm 0.26 \pm 0.30) \times 10^{-6}$$
$$B(\eta_c \to \gamma\gamma) \times B(\eta_c \to p\bar{p}) = (2.1 \pm 0.3) \times 10^{-7}$$
$$B(J/\psi \to \gamma\eta_c) \times B(\eta_c \to p\bar{p}) = (2.11 \pm 0.02 \pm 0.07) \times 10^{-5}$$

$\Rightarrow$

$$B(J/\psi \to \gamma\eta_c) = (2.29 \pm 0.19)\%$$
$$B(\eta_c \to \gamma\gamma) = (2.28 \pm 0.19) \times 10^{-4}$$
$$B(\eta_c \to p\bar{p}) = (0.92 \pm 0.08) \times 10^{-3}$$

- Consistent with some LQCD calculations *[PRD 108, 014513 (2023), PRD 111, 014508 (2025), Sci. Bull. 68, 1880 (2023)]*
- 3σ deviation from the PDG global fit



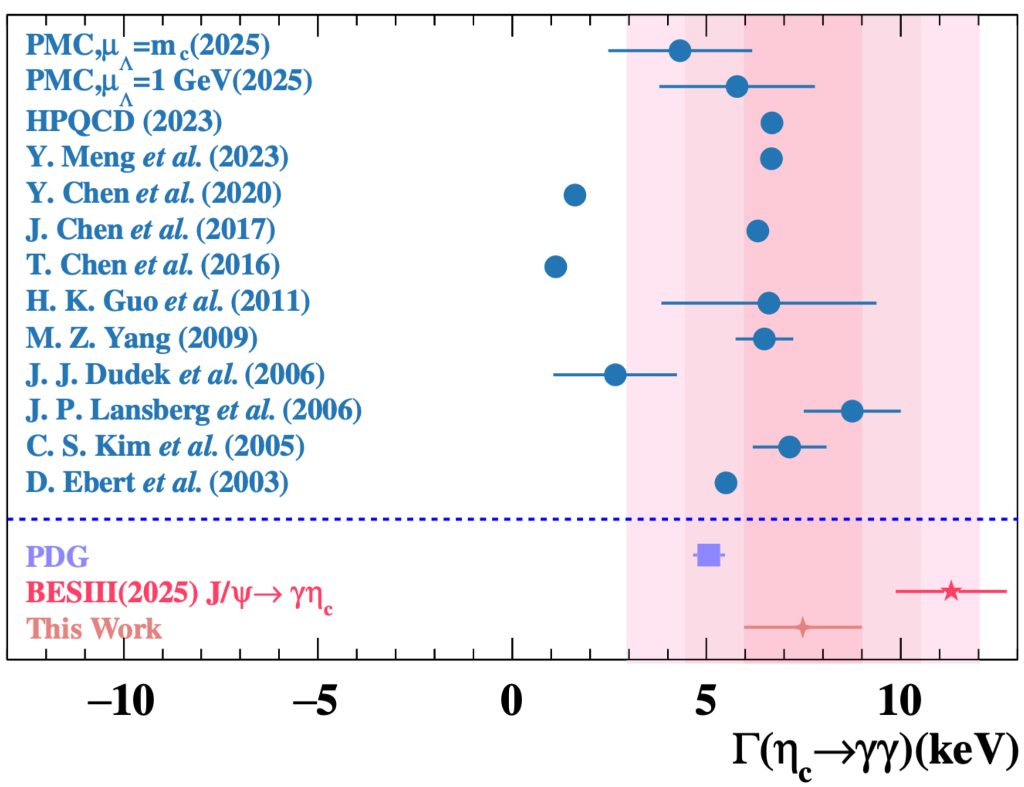


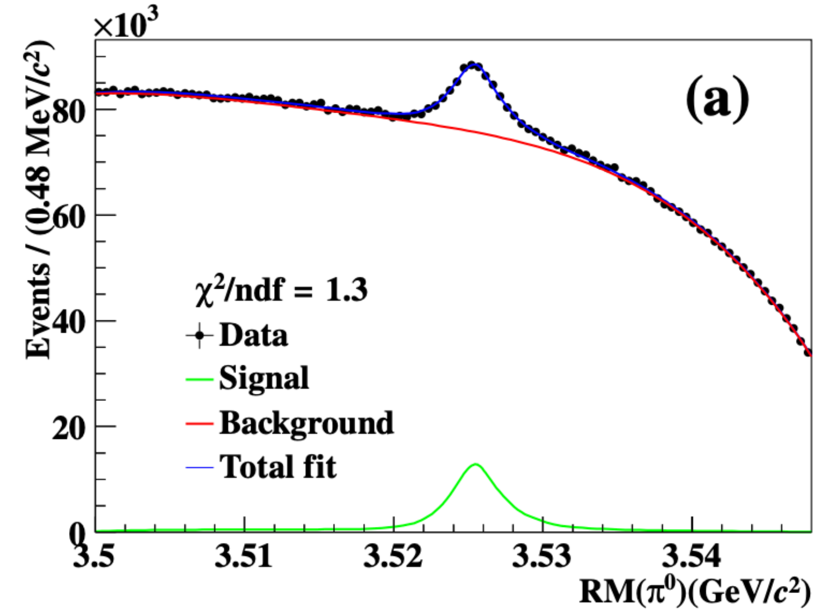
First measurement of Br($\eta_c \to \gamma\gamma$)

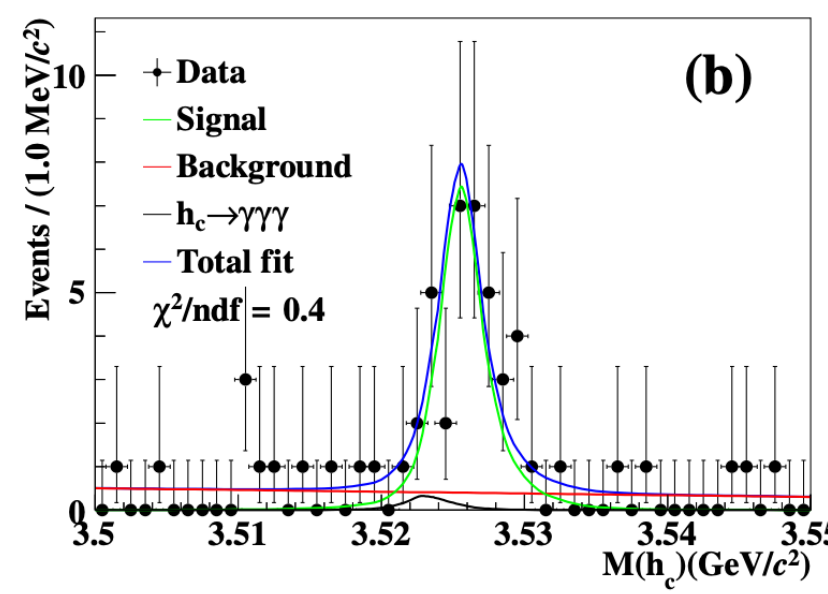
arXiv: 2601.11236, accepted by PRL

- 2.7x10^9 $\psi(2S)$ events
- η_c production: $\psi(2S) \to \pi^0 h_c$, $h_c \to \gamma\eta_c$, $\eta_c \to \gamma\gamma$
- Low background level
- Consistent with LQCD and combined BFs in J/ψ radiative decays

$$\Gamma(\eta_c \to \gamma\gamma) = (7.48 \pm 1.48_{\text{stat.}} \pm 0.30_{\text{syst.}})\ \text{keV}$$







Light hadron spectroscopy

more results can be found in Beijing Liu's talk

Glueball-like particle X(2370)

- X(2370) was first observed in $J/\psi \to \gamma X$, $X \to \pi^+\pi^-\eta'$ with 6.4σ with 225M J/ψ events
- PWA of $J/\psi \to \gamma K_S^0 K_S^0 \eta'$ to determine
  - $J^{PC} = 0^{-+}$
  - $\Gamma = 188^{+18}_{-17}\,(\text{stat})^{+124}_{-33}\,(\text{syst})$ MeV

    $M = 2395 \pm 11\,(\text{stat})^{+26}_{-94}\,(\text{syst})$ MeV/c^2

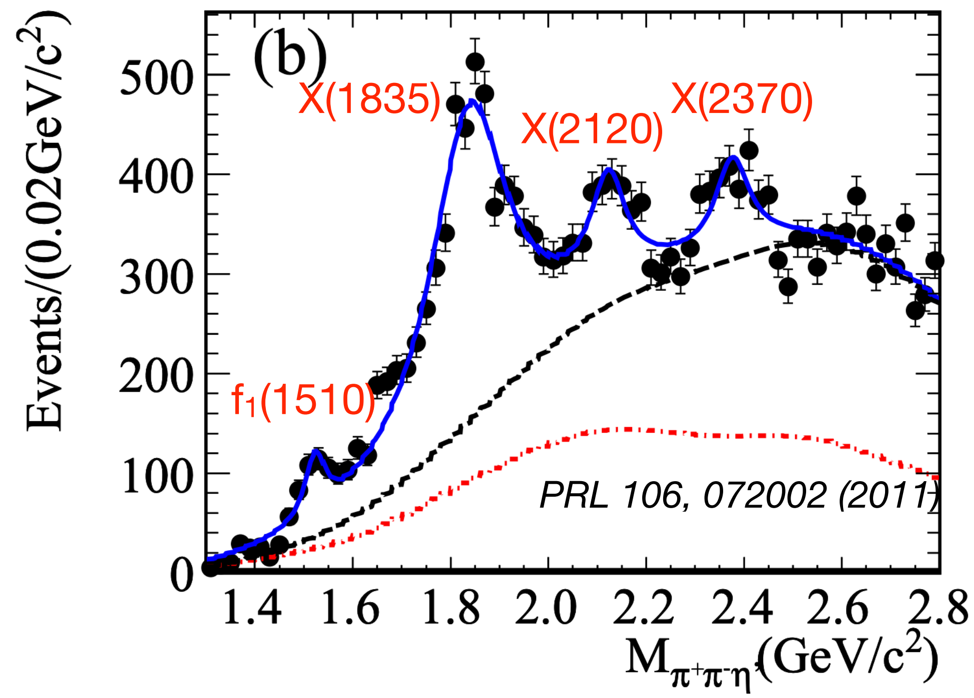
    $\mathscr{B}[J/\psi \to \gamma X(2370), X(2370) \to f_0(980)\eta', f_0(980) \to K_S^0 K_S^0]$

    $= (1.31 \pm 0.22\,(\text{stat})^{+2.85}_{-0.84}\,(\text{syst})) \times 10^{-5}$
- LQCD *[PRD 100, 054511 (2019)]* predicted the pseudoscalar 0^{-+} glueball

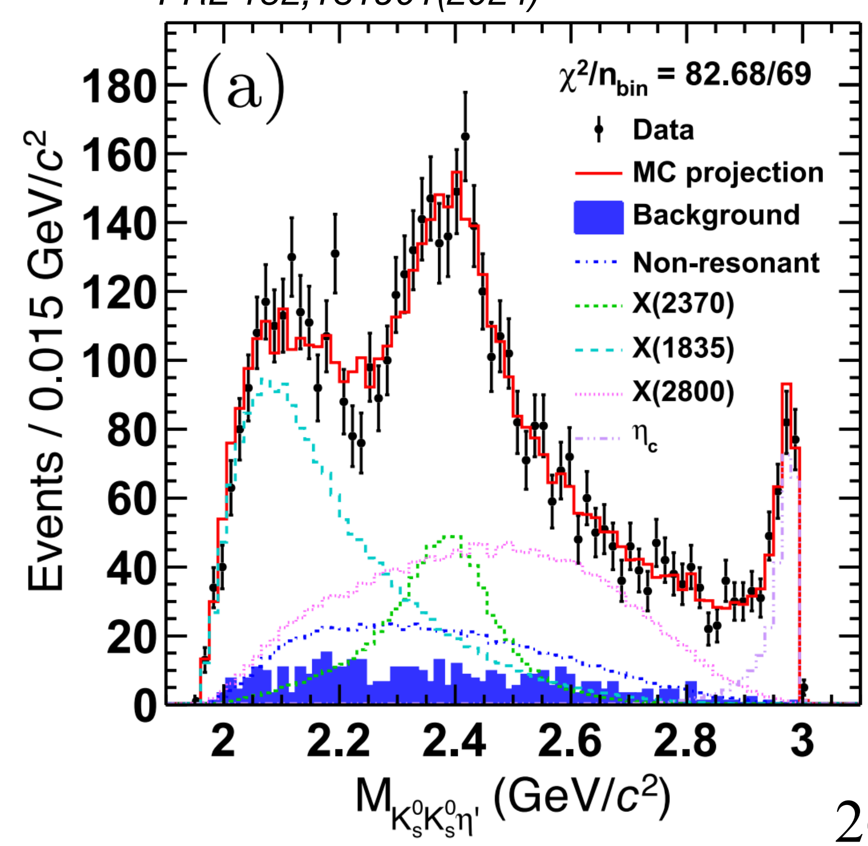
  $M = (2395 \pm 14)$ MeV

  $\Gamma(J/\psi \to \gamma G_{0^{-+}}) = 0.0215(74)$ keV

  $\mathrm{Br}(J/\psi \to \gamma G_{0^{-+}}) = 2.31(80) \times 10^{-4}$



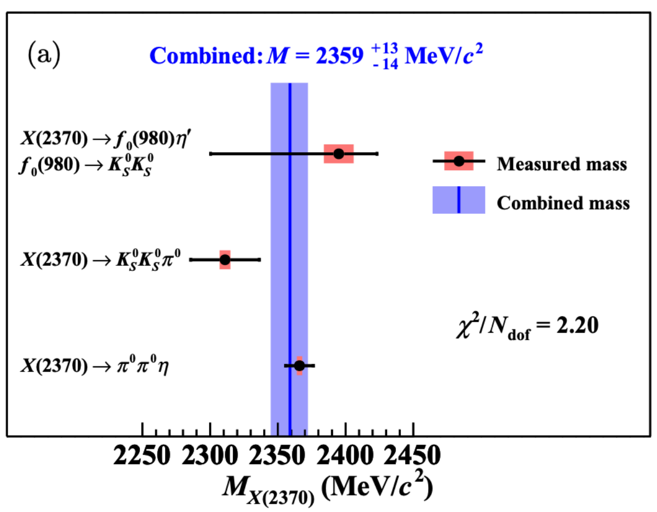
PRL 132,181901(2024)

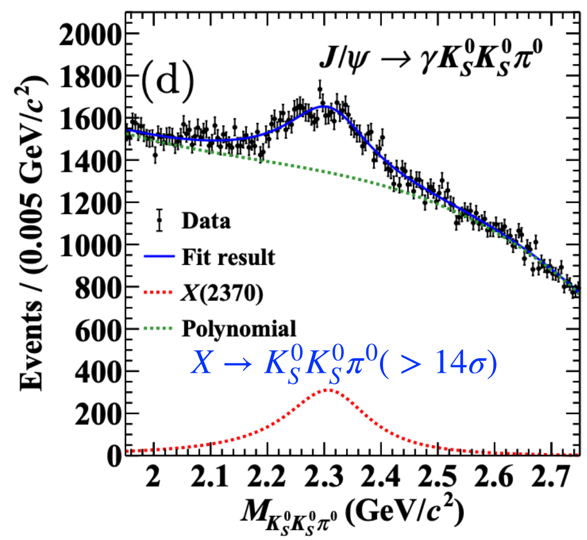


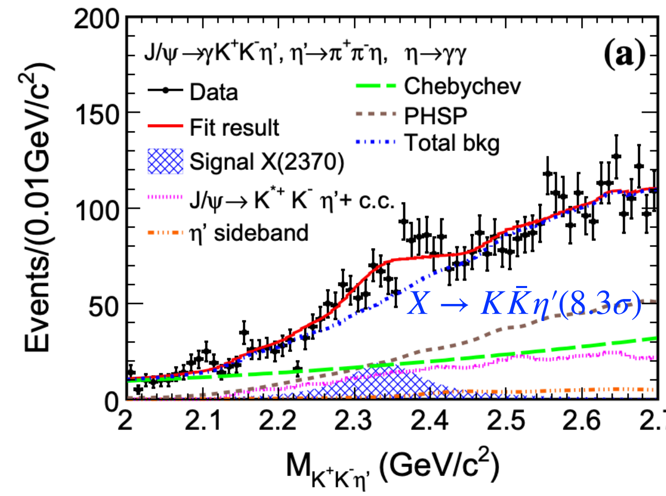
Glueball-like particle X(2370)

- Established decays

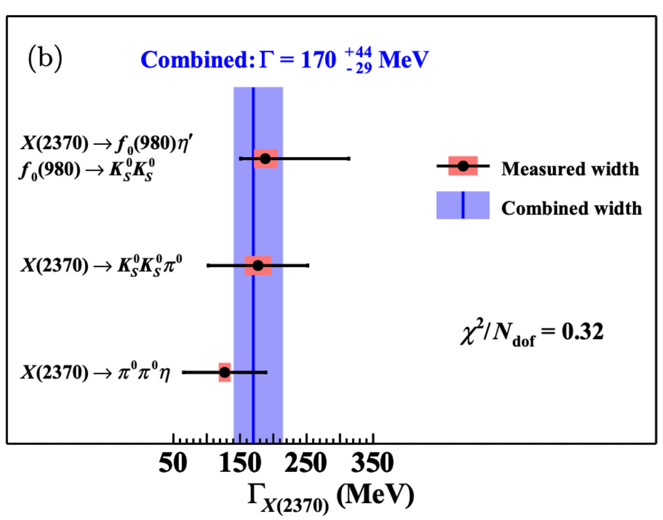
  $X(2370) \to \pi\pi\eta', K\bar{K}\eta', K\bar{K}\pi, \pi\pi\eta, K\bar{K}\eta, a(980)\pi^0$
- Decays in analogy to η_c

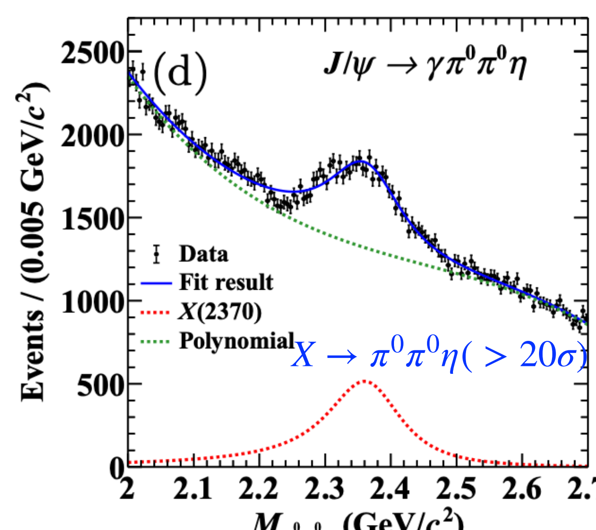


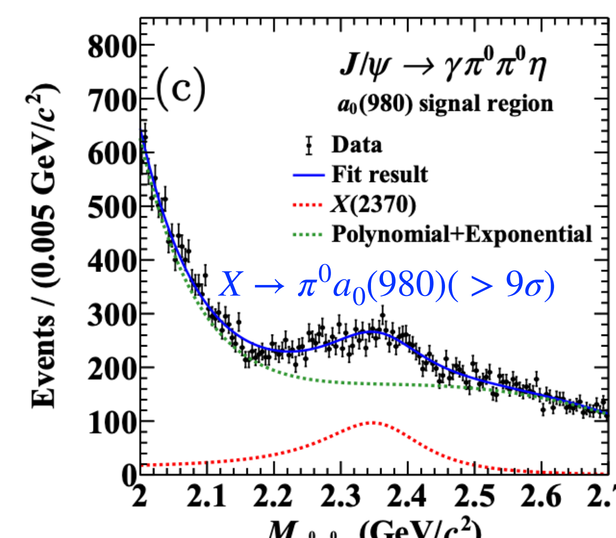




EPJC (2020) 80:746







arXiv: :2605.26495

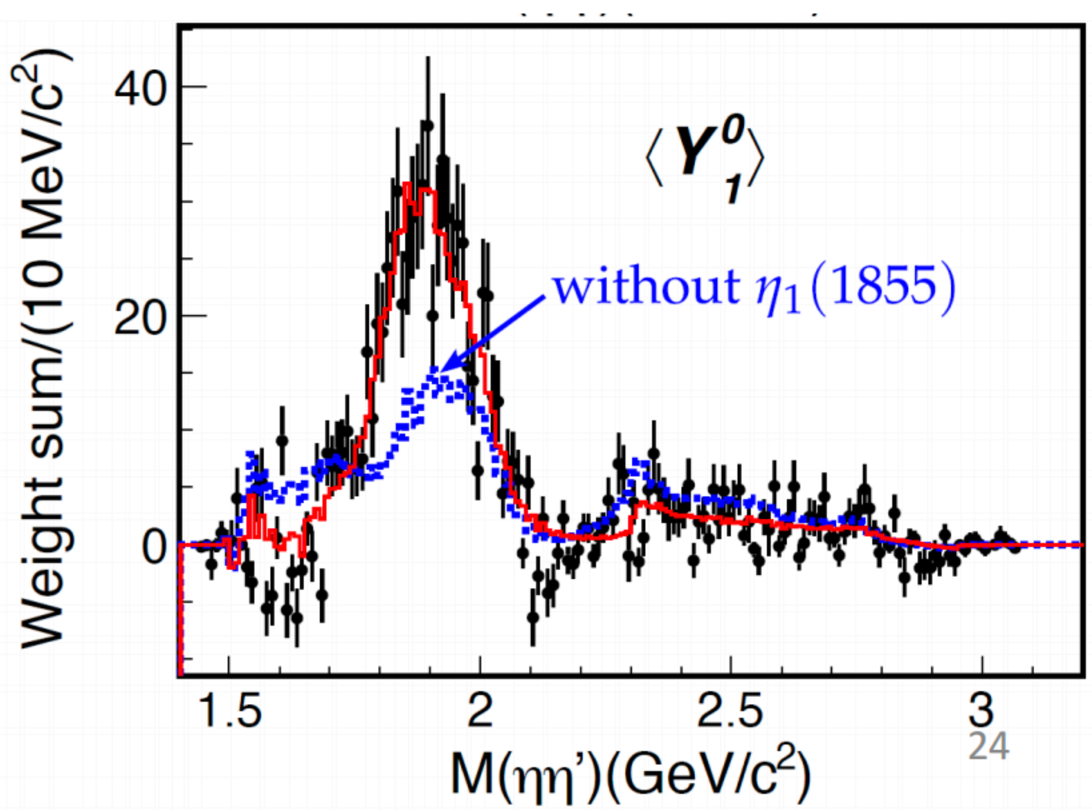
arXiv: :2605.26495

1^{-+} exotic state $\eta_1(1855)$

- $\eta_1(1855)$ was first observed in $J/\psi \to \gamma\eta\eta'$ (>19 σ)
  - exotic quantum-number $J^{PC}=1^{-+}$

$$M = (1855 \pm 9^{+6}_{-1})\ \mathrm{MeV}/c^2,\ \Gamma = (188 \pm 18^{+3}_{-8})\ \mathrm{MeV}/c^2$$
$$B(J/\psi \to \gamma\eta_1(1855) \to \gamma\eta\eta') = \left(2.70 \pm 0.41^{+0.16}_{-0.35}\right) \times 10^{-6}$$

  - Mass and width consistent with LQCD calculations for the 1^{-+} hybrid *[PRD 88, 094505 (2013)]*

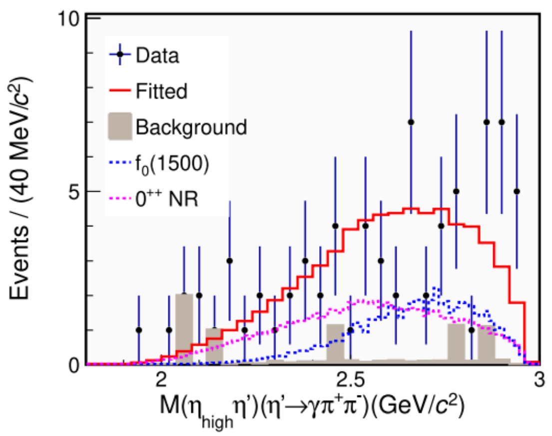


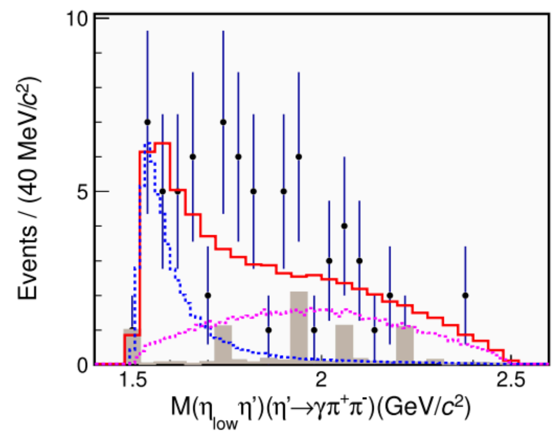
PRL 129 192002(2022)

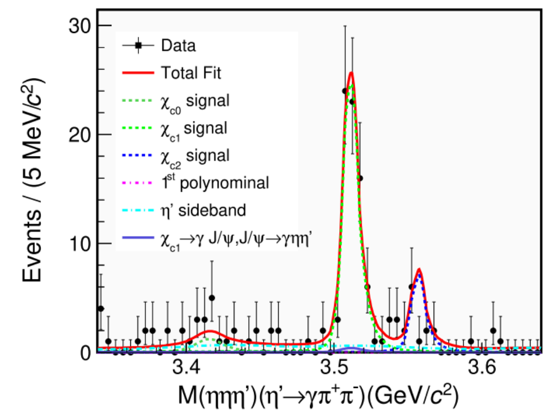
Search for $\eta_1(1855)$ in $\chi_{c1} \to \eta\eta\eta'$ and $J/\psi \to \omega\eta\eta'$

- Search for $\eta_1(1855)$ in $\chi_{c1} \to \eta\eta\eta'$ *[CPC 49, 123001 (2025)]*

$$\mathcal{B}(\chi_{c1} \to \eta_1(1855)\eta) \cdot \mathcal{B}(\eta_1(1855) \to \eta\eta') < 9.79 \times 10^{-5}$$



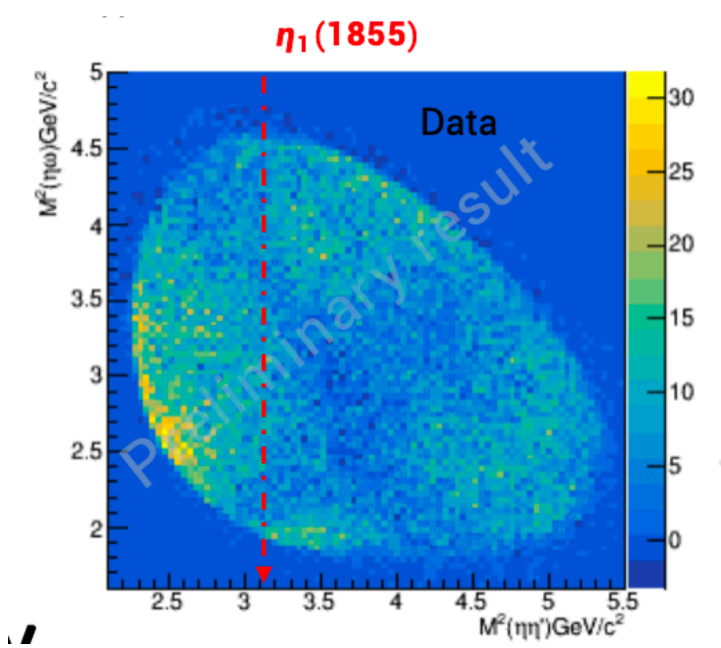


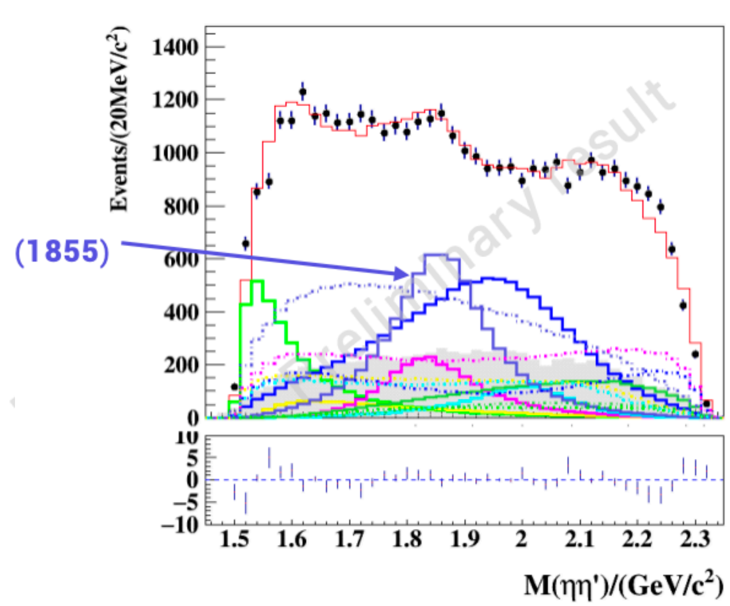


- Observation of in $J/\psi \to \omega\eta_1(1855)$ in $J/\psi \to \omega\eta\eta'$ *[Preliminary]*

$$Br(J/\psi \to \omega\eta_1(1855)) \cdot Br(\eta_1(1855) \to \eta\eta') = (1.15 \pm 0.01^{+0.10}_{-0.45}) \times 10^{-4}$$

$$(Br(J/\psi \to \gamma\eta_1(1855)) \cdot Br(\eta_1(1855) \to \eta\eta') = (2.70 \pm 0.41^{+0.16}_{-0.35}) \times 10^{-6}).$$





Study of $J/\psi \to \gamma R \to \gamma\gamma V$ ($V=\rho/\phi/\omega$)

- $J/\psi \to \gamma R$, $R \to \gamma V$ ($V=\rho/\omega/\phi$) is the flavor-filtering process, helping to study the quark-gluon component of the intermediate resonance *[AIP Conf. Proc., 1182(1):471–474, 2009]*
- Theoretical prediction: glueball/hybrids $\to \gamma V$ is suppressed, an important test for glueballs and hybrids *[PRD, 107(11):114020, 2023; Nucl. Phys. A, 1037:122683, 2023]*
  - X(1835): different theoretical interpretations exist, e.g., $N\bar{N}$ bound state, second excited state of η', η_c glueball mixture, or pseudoscalar glueball. Further study of its quark-gluon composition is needed *[PRC, 72:011001, 2005; PRD, 83:114007, 2011; PRD, 73:014023, 2006; PRD, 72:097502, 2005]*
  - X(2370): its mass is consistent with the LQCD prediction for the pseudoscalar glueball (2.3-2.4 GeV) *[PRD, 100(5):054511, 2019; . PRD, 82:074026, 2010; PRD, 87(5):054036, 2013; PLB, 827:136960, 2022]*

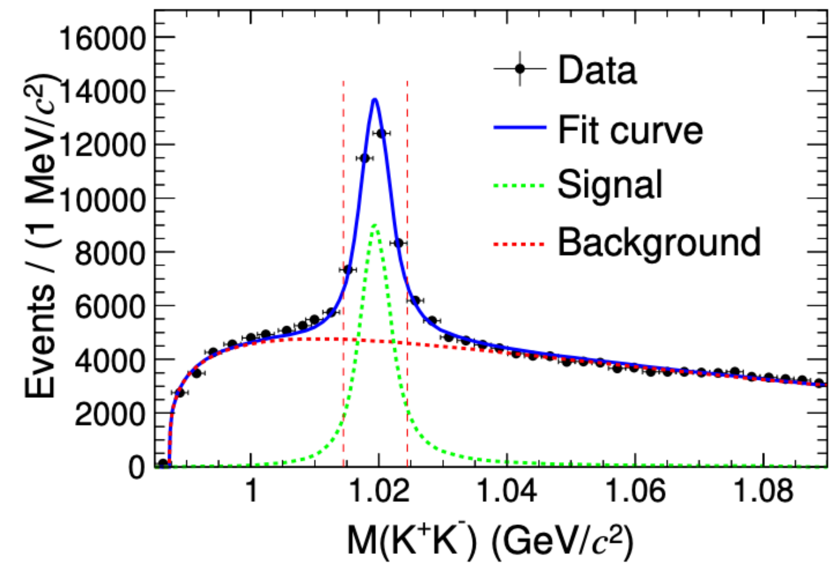
Search for J/ψ→γ*R*→γγϕ

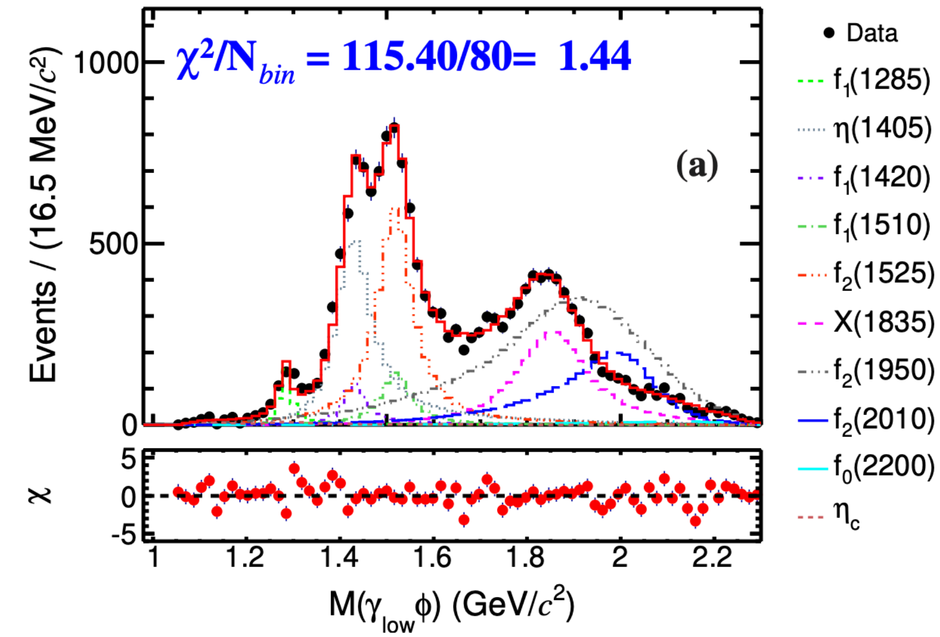
PRD111.052011(2025)

- Observation of *X(1835)*→γϕ indicates that X(1835) is a radial excited state of η’ containing $s\bar{s}$ quarks

PRD 83, 114007 (2011); 73, 014023 (2006)

Resonance	M (MeV/c^2)	Γ (MeV)	$\mathcal{B}$ ($\times 10^{-6}$)	Significance
$f_1(1285)$	1281.9	22.7	$0.29\pm0.03^{+0.11}_{-0.09}$	17.3σ
$f_1(1420)$	1426.3	54.5	$0.55\pm0.07^{+0.18}_{-0.17}$	9.0σ
$\eta(1405)$	$1422.0 \pm 2.1^{+5.9}_{-7.8}$	$86.3 \pm 2.7^{+6.6}_{-17.4}$	$3.57\pm0.18^{+0.59}_{-0.61}$	18.9σ
$f_1(1510)$	1518.0	73.0	$0.78\pm0.09^{+0.34}_{-0.30}$	5.3σ
$f_2(1525)$	1517.4	86.0	$2.76\pm0.18^{+0.90}_{-0.61}$	16.4σ
$X(1835)$	$1849.3 \pm 3.0^{+7.6}_{-10.0}$	$179.6 \pm 8.7^{+22.5}_{-27.9}$	$3.37\pm0.19^{+0.78}_{-1.10}$	15.3σ
$f_2(1950)$	1936.0	464.0	$9.96\pm0.60^{+3.44}_{-2.13}$	13.1σ
$f_2(2010)$	2011.0	202.0	$4.63\pm0.43^{+1.42}_{-1.46}$	11.3σ
$f_0(2200)$	2187.0	207.0	$0.20\pm0.04^{+0.05}_{-0.07}$	6.3σ
η_c	2983.9	32.0	$0.21\pm0.03^{+0.05}_{-0.07}$	12.9σ



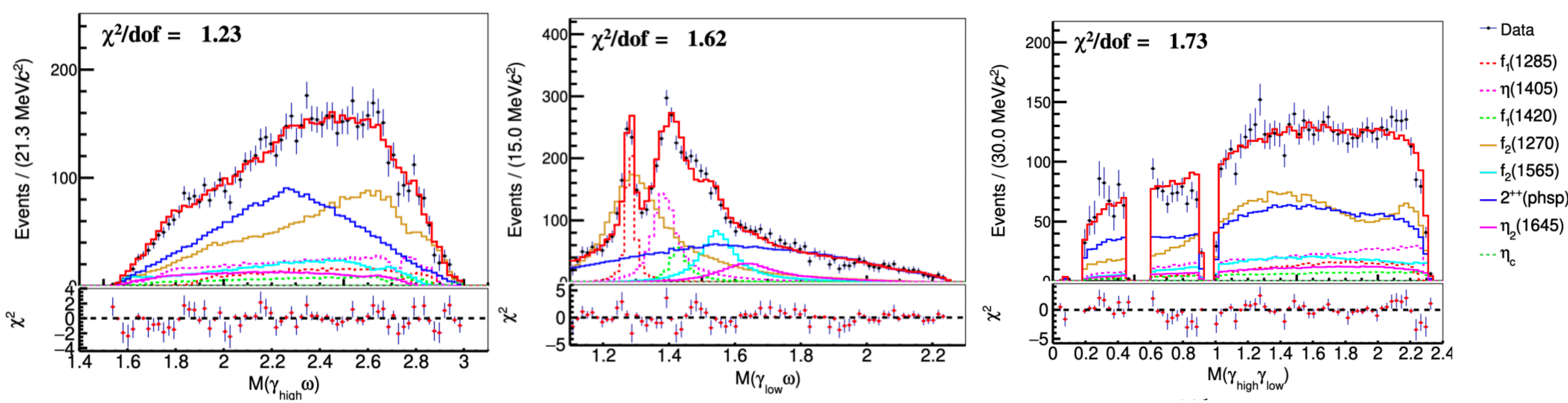


- No significant η_1(1855) or X(2370) contributions

$$\mathcal{B}(J/\psi \to \gamma\eta_1(1855) \to \gamma\gamma\phi) < 4.74 \times 10^{-6}$$
$$\mathcal{B}(J/\psi \to \gamma X(2370) \to \gamma\gamma\phi) < 1.08 \times 10^{-7}$$

- Don’t does not contradict the theoretical expectations for the proposed natures of glueball for X(2370) ($<10^{-8}$) and $s\bar{s}g$ hybrid state for η_1(1855) ($<10^{-9}$)

Search for J/ψ→γR→γγω



- No significant X(1835)→γω： X(1835) is more likely to be an excited $s\bar{s}$ state of η′

- No significant η₁(1855) or X(2370) contributions
- Consistent with theoretical predictions of glueball and hybrid

Resonance	$J/\psi \to \gamma R \to \gamma\gamma\omega(\times 10^{-6})$	$J/\psi \to \gamma R \to \gamma\gamma\phi(\times 10^{-6})$	$\frac{\Gamma(R\to\gamma\omega)}{\Gamma(R\to\gamma\phi)}$
$f_1(1285)$	$1.73 \pm 0.12^{+0.13}_{-0.18}$	$0.29 \pm 0.03^{+0.11}_{-0.09}$	3.5 ± 1.5
$f_1(1420)$	$0.88 \pm 0.10^{+0.20}_{-0.49}$	$0.55 \pm 0.07^{+0.18}_{-0.17}$	1.1 ± 0.7
$\eta(1405)$	$3.54 \pm 0.20^{+0.65}_{-0.24}$	$3.57 \pm 0.18^{+0.59}_{-0.61}$	0.3 ± 0.1
η_c	$0.20 \pm 0.06^{+0.03}_{-0.09}$	$0.21 \pm 0.03^{+0.05}_{-0.07}$	0.8 ± 0.5
$\eta(1295)$	< 0.35	< 0.84	
$\eta(1475)$	< 0.14	< 0.38	
$X(1835)$	< 0.11	$3.37 \pm 0.19^{+0.78}_{-1.10}$	
$X(2370)$	< 0.04	< 0.11	
$\eta_1(1855)$	< 0.33	< 4.74	

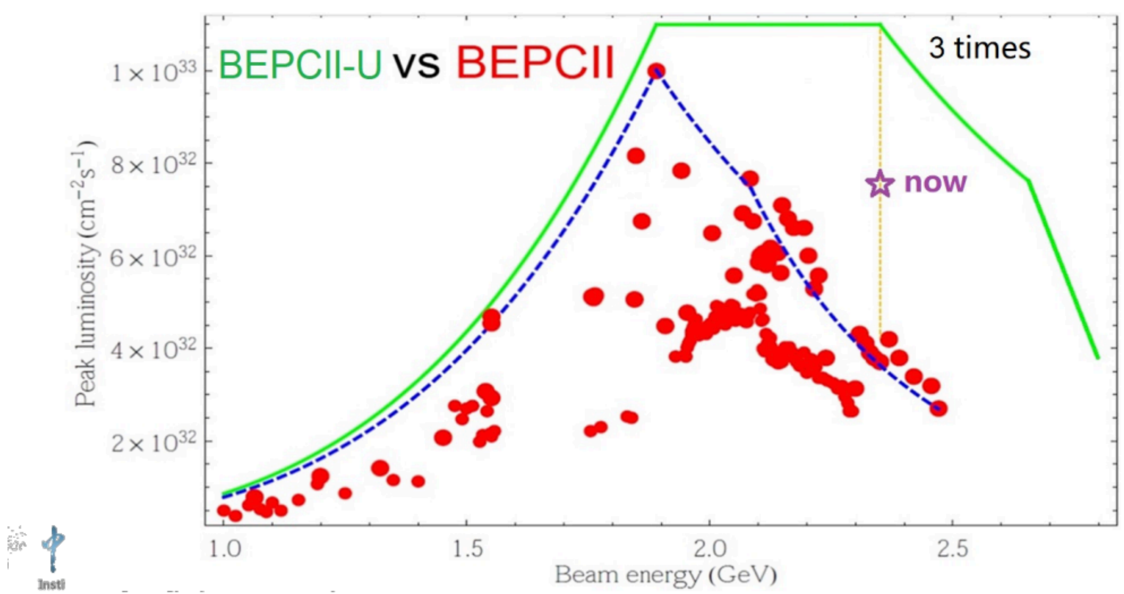
Summary

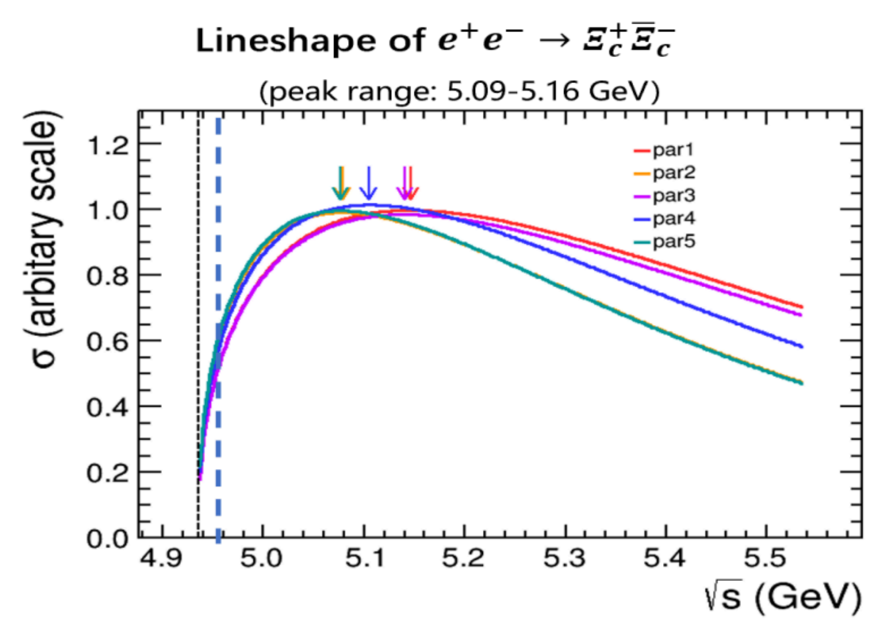
- BESIII has collected 10B J/ψ, 2.7B $\psi(2S)$, 20 fb^{-1} $\psi(3770)$, and extensive XYZ scan data.
- Based on these data, many important research results have been published.
- BEPCII plans to implement a Crab Waist upgrade, which will boost low-energy luminosity by up to a factor of 10 in the 1.0–2.0 GeV energy range, scheduled for around 2030, along with an inner tracker upgrade.
- More results are expected to be published in the future

BEPCII→ BEPCII-U

Two-year data-taking plan

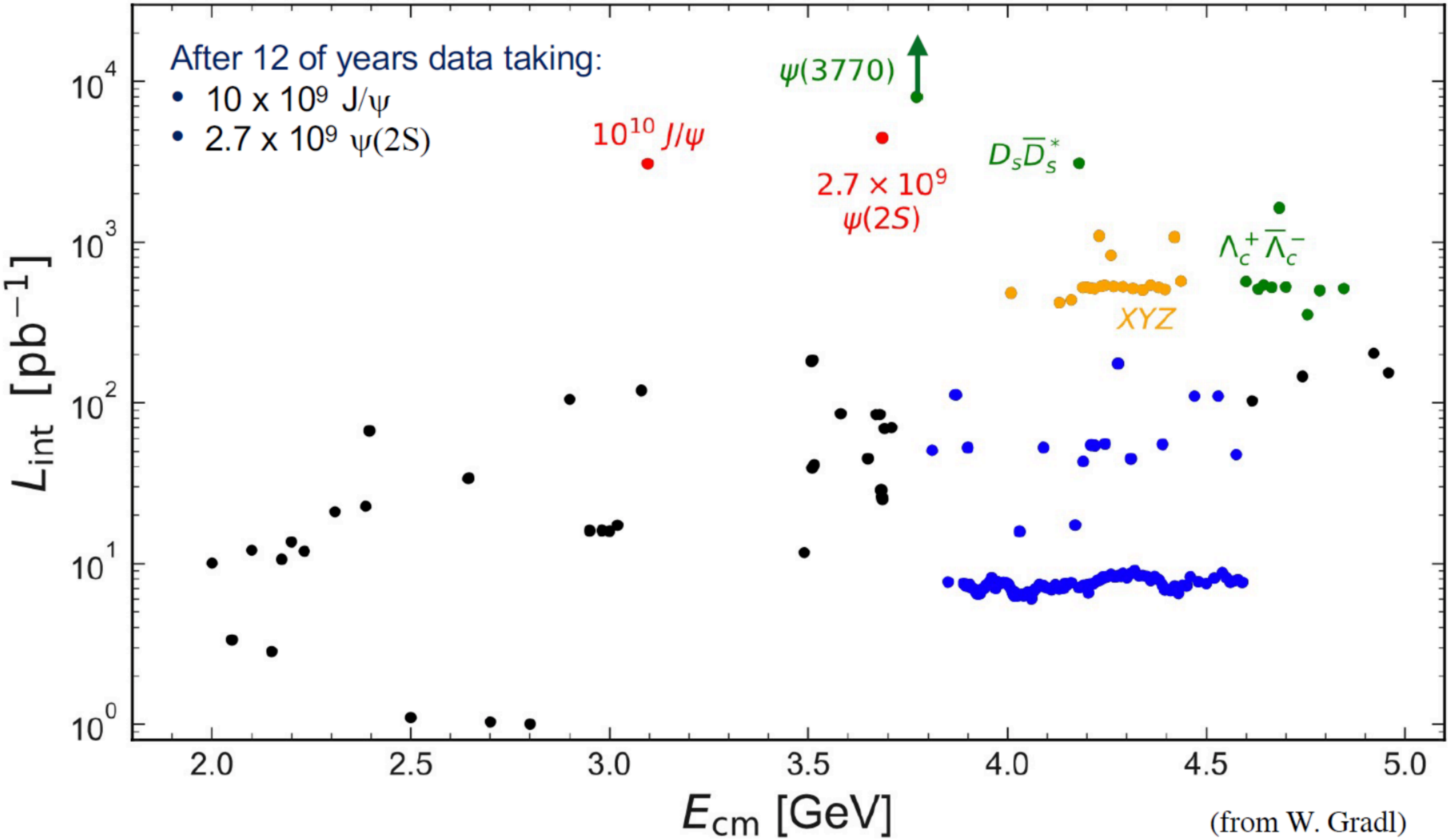
- ✓ Additional 5.0 fb^{-1} @4.68 GeV [4.14 + 5.0 = 9.0 fb^{-1} as planed] : ~5 months
- ✓ 3.870[400 pb^{-1}], 3.8716[400 pb^{-1}], 3.874[400 pb^{-1}] for $X(3872)$: ~1 month
- ✓ 3.554[600 pb^{-1}], 3.5580[200 pb^{-1}], 3.560[300 pb^{-1}] for χ_{c2}: ~1 month
- ✓ Scan above $\Xi_c\bar{\Xi}_c$ threshold (4.95GeV - 5.10 GeV):
  scan data: 2 fb^{-1} @ 20 energy points [optimization of the scan scheme is needed]
  data@ maximal cross-section: 10 fb^{-1}
  Total sample 12 fb^{-1}: 1.5 years





阈值能量：4.9354 GeV
4.951 GeV对应峰值截面的46%-55%

Data Samples at BESIII



(from W. Gradl)