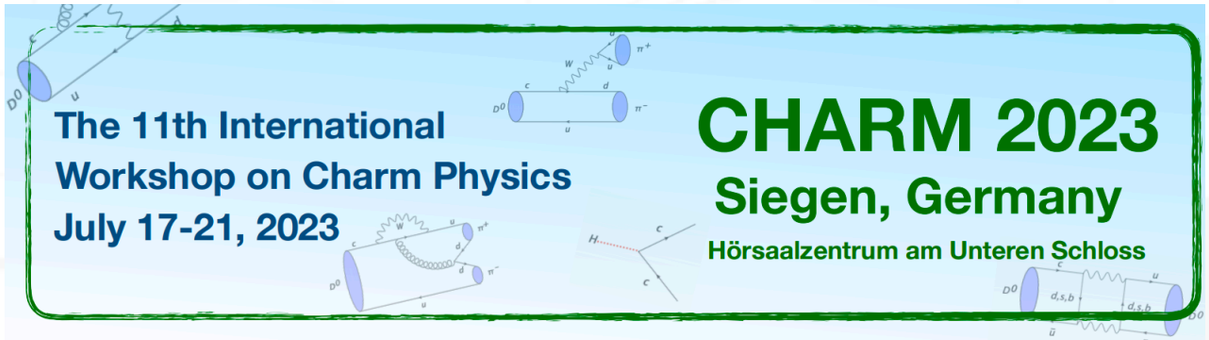
XYZ from BESIII

Chunhua Li
(on behalf of the BESIII Collaboration)
Liaoning Normal University
chunhua@lnnu.edu.cn



Outline

- Introduction
- BESIII Detector
- XYZ from BESIII
  - X(3872)
    - Productions: $e^+e^-\to\gamma X(3872)$, $\omega X(3872)$, $X(3872)$
    - Decays: $X(3872)\to\pi^0\chi_{c0}$, $\pi\pi\chi_{c0}$
    - A coupled channel analysis of the line shape
  - Y states with the exclusive process measurements
    - $e^+e^-\to\pi^+\pi^- J/\psi$, $\pi^+\pi^-\psi(2S)$, $\pi\pi\psi(3823)$, KKJ/ψ, $\phi\chi_{cJ}$
    - $e^+e^-\to D^{(*+)}D^{(*-)}$, $D_s^{*+}D_s^{*-}$, $D^0D^{*-}\pi+$, $D^{*0}D^{*-}\pi^+$, $D^+D^-\pi^+\pi^-$
  - $Z_{cs}(3985)$
- Summary

Hadrons

A SCHEMATIC MODEL OF BARYONS AND MESONS *

M. GELL-MANN
California Institute of Technology, Pasadena, California

Received 4 January 1964

- Meson:$q\bar{q}$, Baryon:qqq
- QCD allows hadrons beyond meson and baryon exist

...ero for all known baryons and ...teresting example of such a ...the triplet has spin $\frac{1}{2}$ and ...r particles d^-, s^-, u^0 and b^0 ...the leptons. ...e elegant scheme can be ...w non-integral values for the ...ense entirely with the basic ... to the triplet t the following ... $= -\frac{1}{3}$, and baryon number $\frac{1}{3}$. ...nembers $u^{\frac{2}{3}}$, $d^{-\frac{1}{3}}$, and $s^{-\frac{1}{3}}$ of ...'' 6) q and the members of the anti-triplet as anti-quarks $\bar{q}$. Baryons can now be constructed from quarks by using the combinations (qqq), $(qqqq\bar{q})$, etc., while mesons are made out of $(q\bar{q})$, $(qq\bar{q}\bar{q})$, etc. It is assuming that the lowest baryon configuration (qqq) gives just the representations **1**, **8**, and **10** that have been observed, while the lowest meson configuration $(q\bar{q})$ similarly gives just **1** and **8**.

...way the selection of specific components of the ...-spin by electromagnetism and the weak interactions determines the choice of isotopic spin and hypercharge directions.

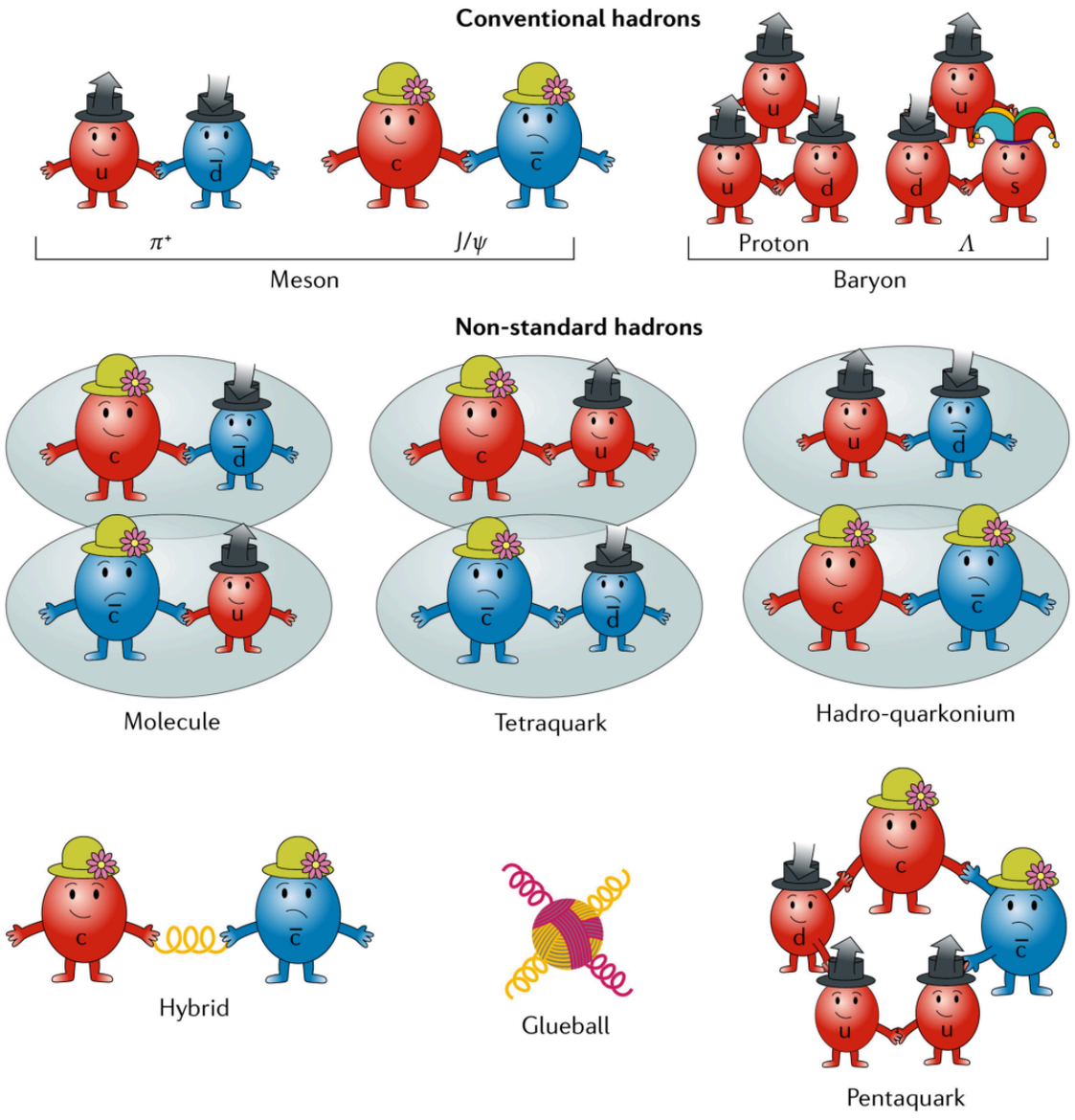
Even if we consider the scattering amplitudes of strongly interacting particles on the mass shell only and treat the matrix elements of the weak, electromagnetic, and gravitational interactions by means

AN SU_3 MODEL FOR STRONG INTERACTION SYMMETRY AND ITS BREAKING

G. Zweig *)
CERN - Geneva

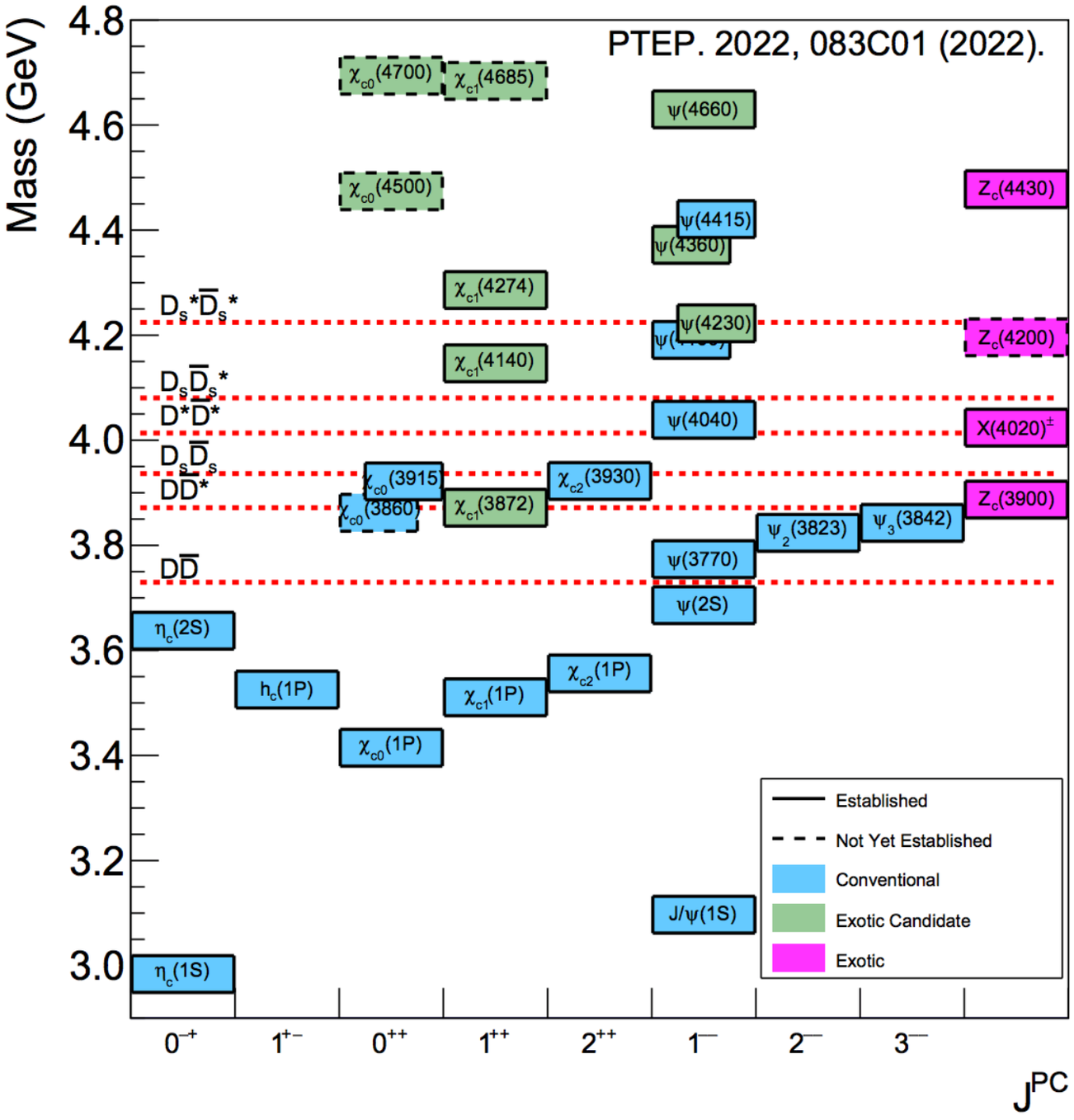
Both mesons and baryons are constructed from a set of three fundamental particles called aces. The aces

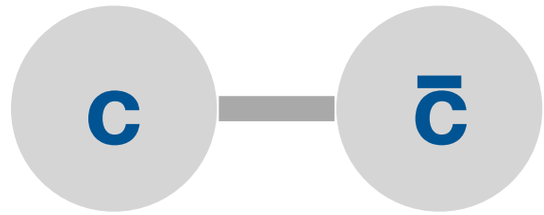
In general, we would expect that baryons are built not only from the product of three aces, AAA, but also from $\bar{A}AAAA$, $\bar{A}\bar{A}AAAAA$, etc., where $\bar{A}$ denotes an anti-ace. Similarly, mesons could be formed from $\bar{A}A$, $\bar{A}\bar{A}AA$ etc. For the low mass mesons and baryons we will assume the simplest possibilities, $\bar{A}A$ and AAA, that is, "deuces and treys".



CZY & S.L. Olsen, *Nature Reviews Physics* **1**, 480 (2019)

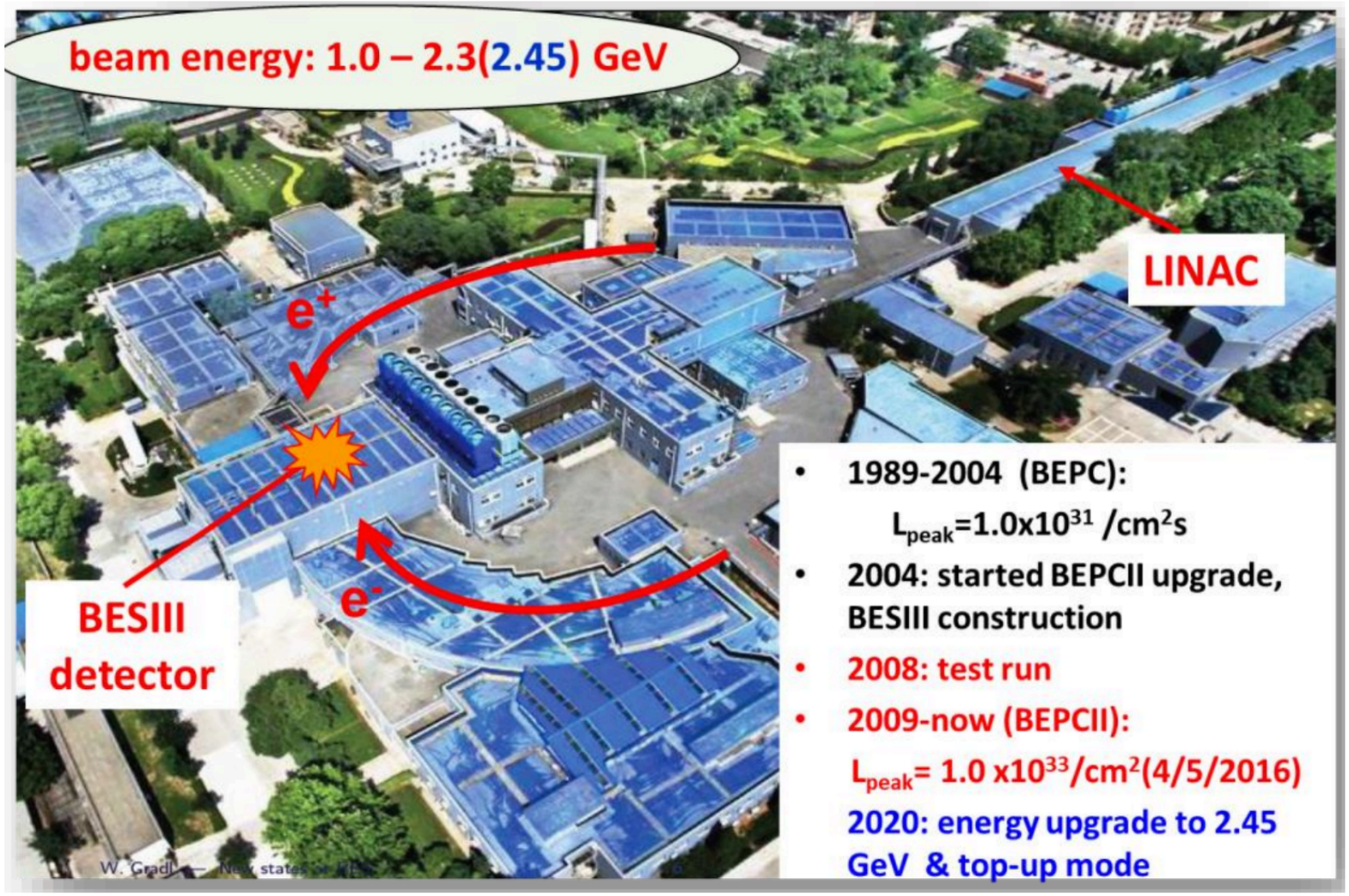
Charmonium(-like) Spectrum





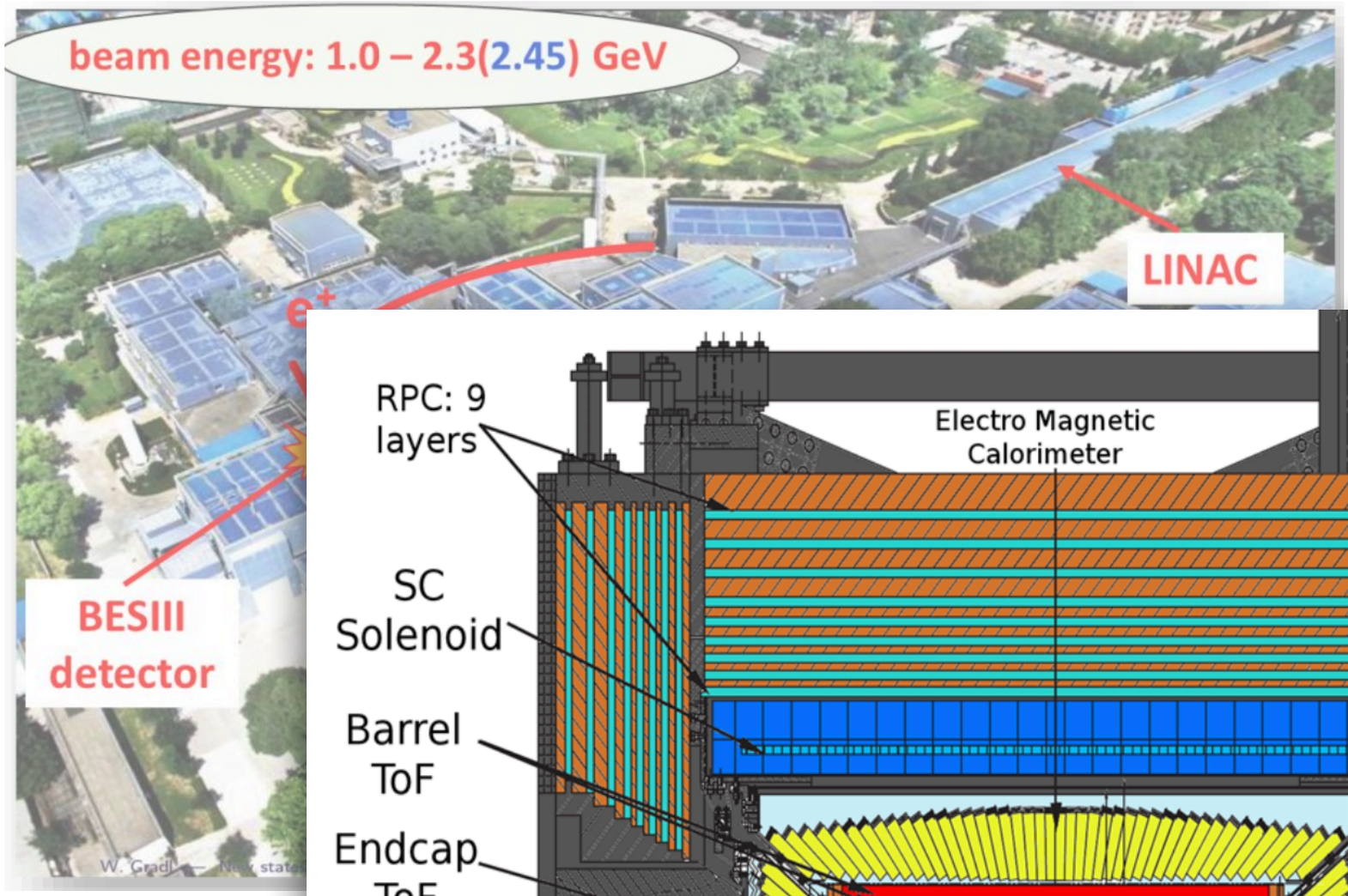
- The charmonium spectrum is calculated with the potential model.
- Good agreement between theory and experiment below the open-charm threshold.
- Exotic candidates are observed at experiments above the open-charm thresholds.

BEPCII and BESIII

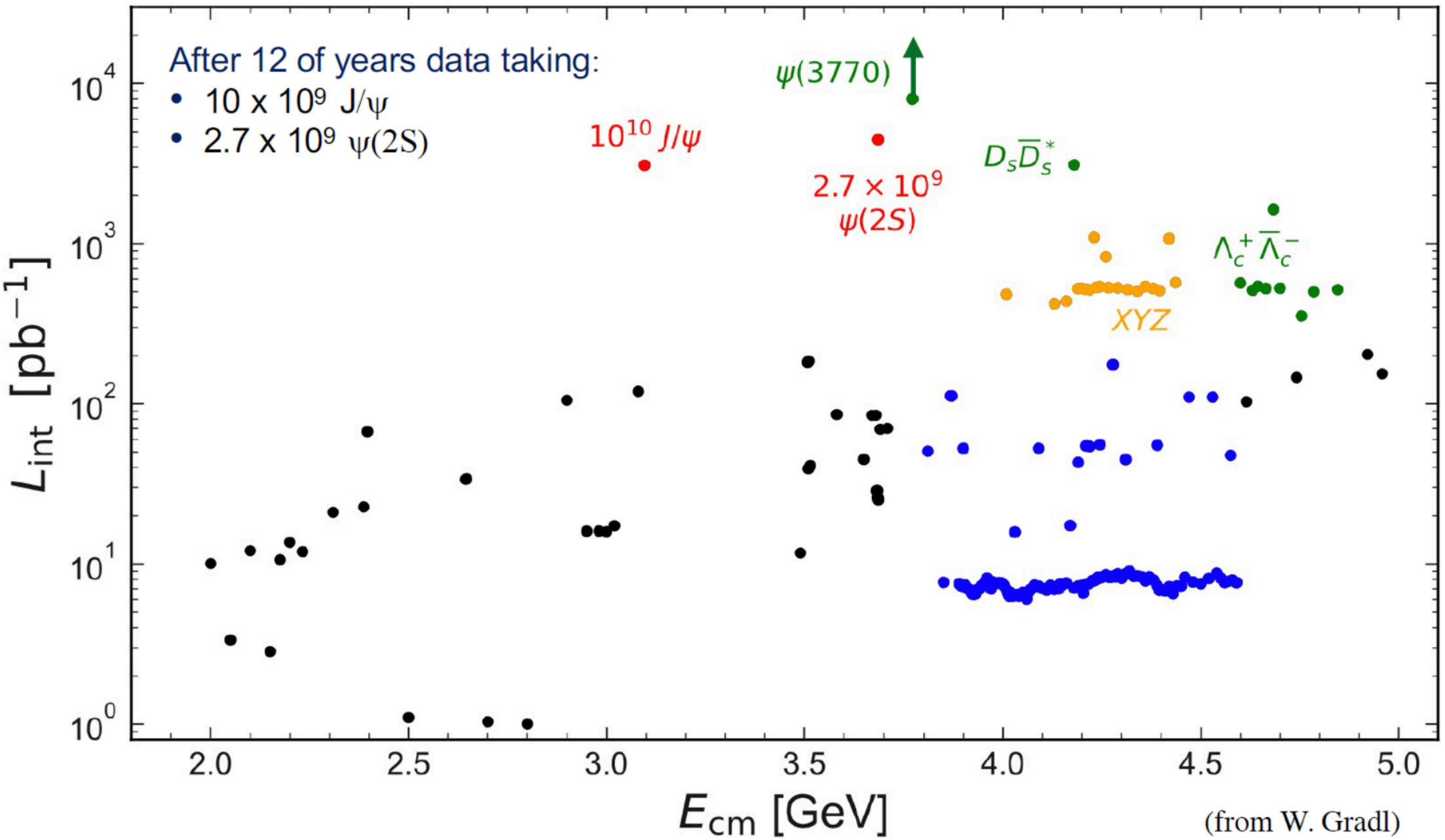


- 1989-2004 (BEPC):
  L_{peak}=1.0x10^{31} /cm^2s
- 2004: started BEPCII upgrade, BESIII construction
- 2008: test run
- 2009-now (BEPCII):
  L_{peak}= 1.0 x10^{33}/cm^2(4/5/2016)
  2020: energy upgrade to 2.45 GeV & top-up mode

BEPCII and BESIII

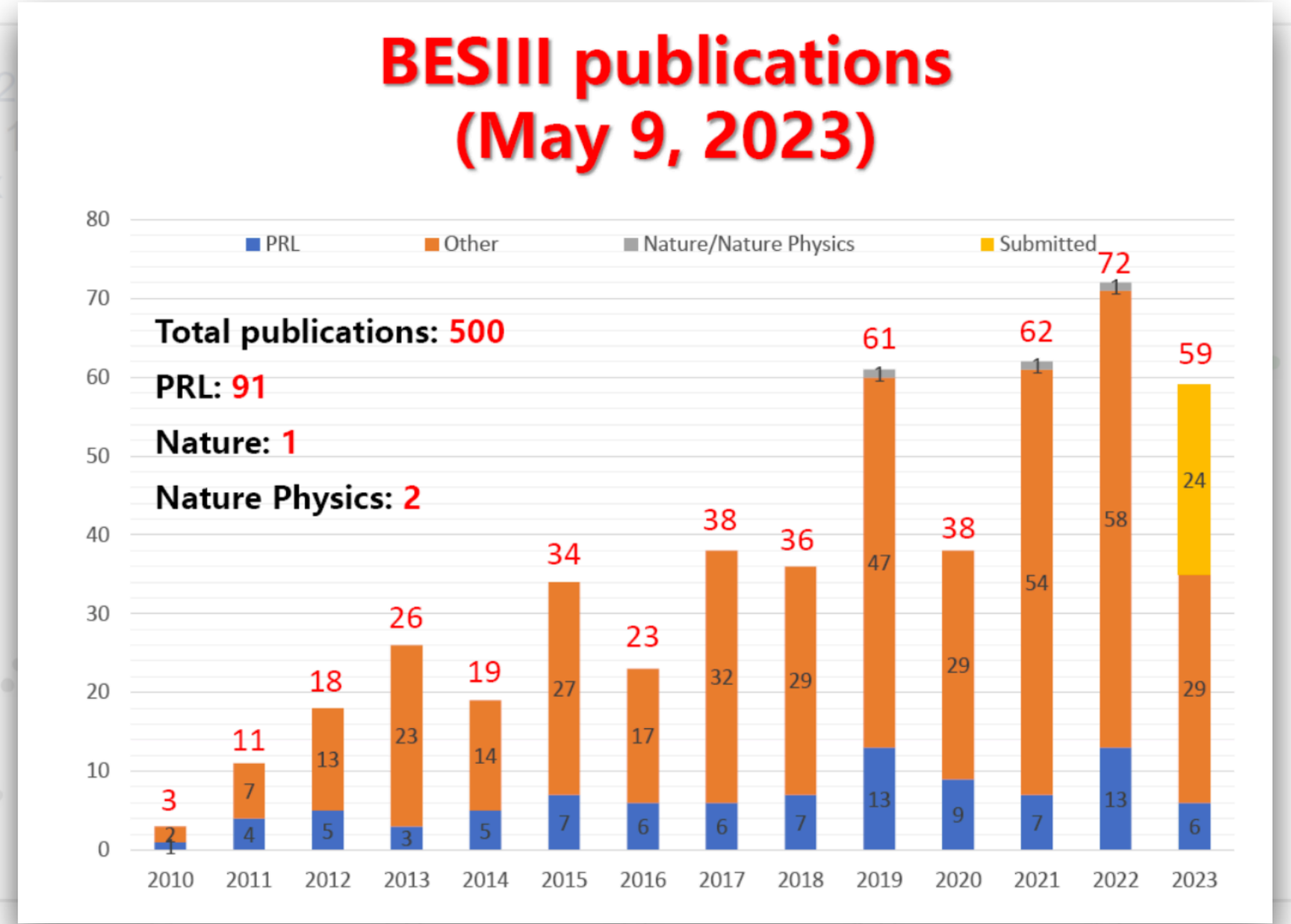


Data Samples at BESIII

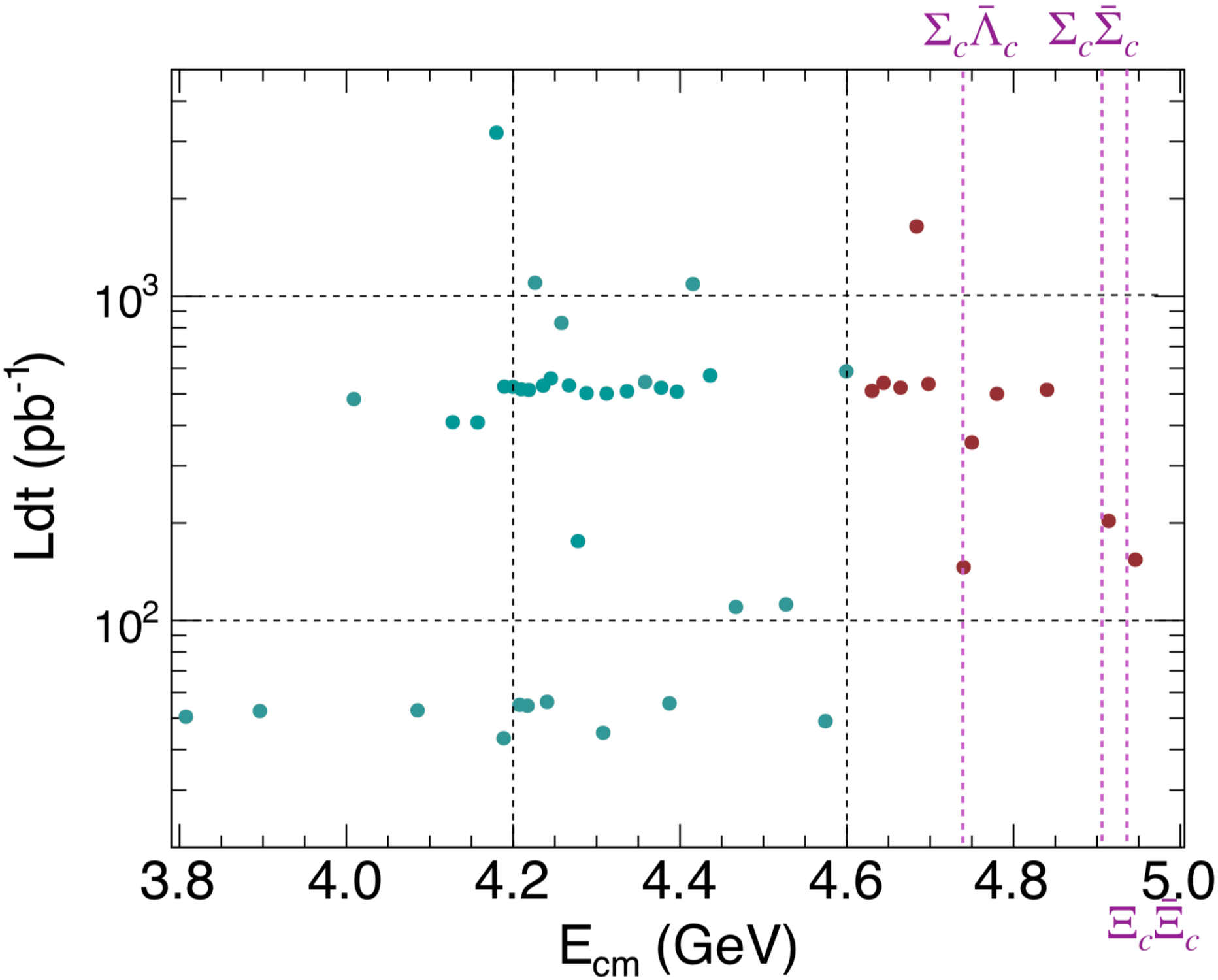


(from W. Gradl)

Data Samples BESIII



XYZ Data Samples at BESIII



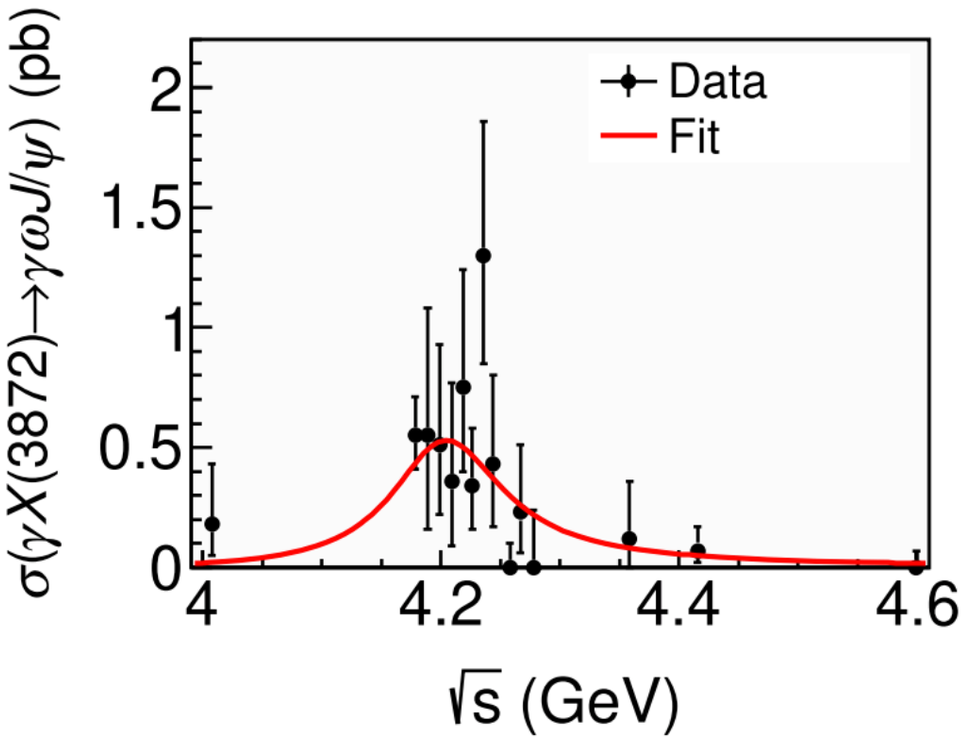
$e^+e^- \to \gamma X(3872)$

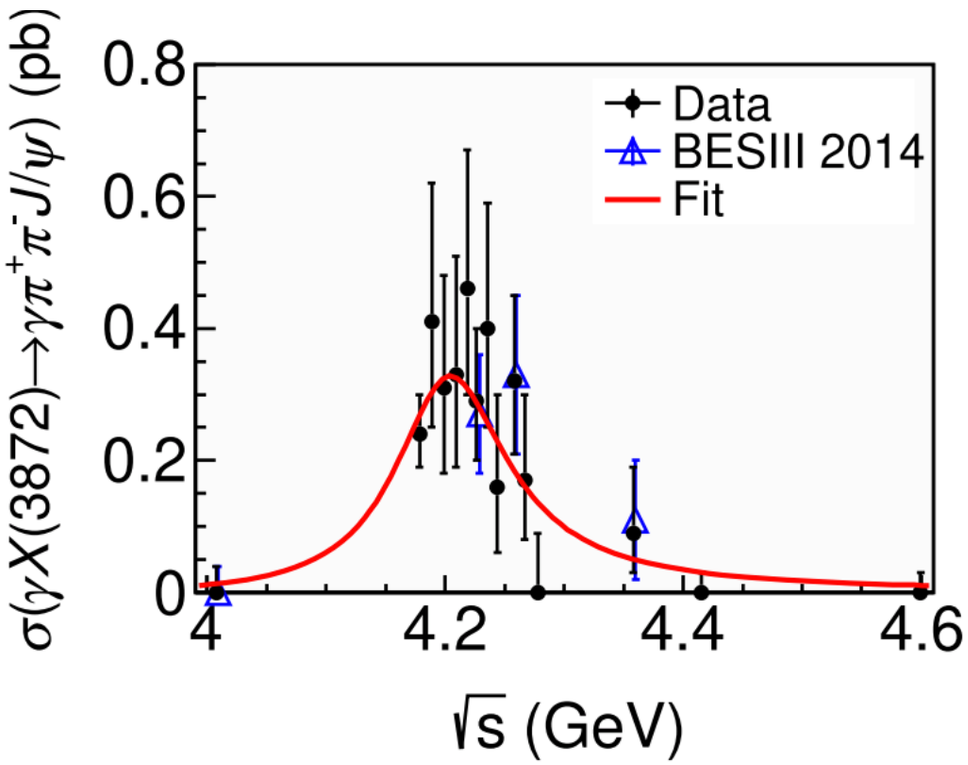
PRL 112, 092001 (2014)
PRL 122, 232002 (2019)

- Study the line shape of $e^+e^- \to \gamma X(3872)$ with the decays $X(3872) \to \pi^+\pi^- J/\psi$ and $\omega J/\psi$
- A single Breit-Wigner function to describe the line shape

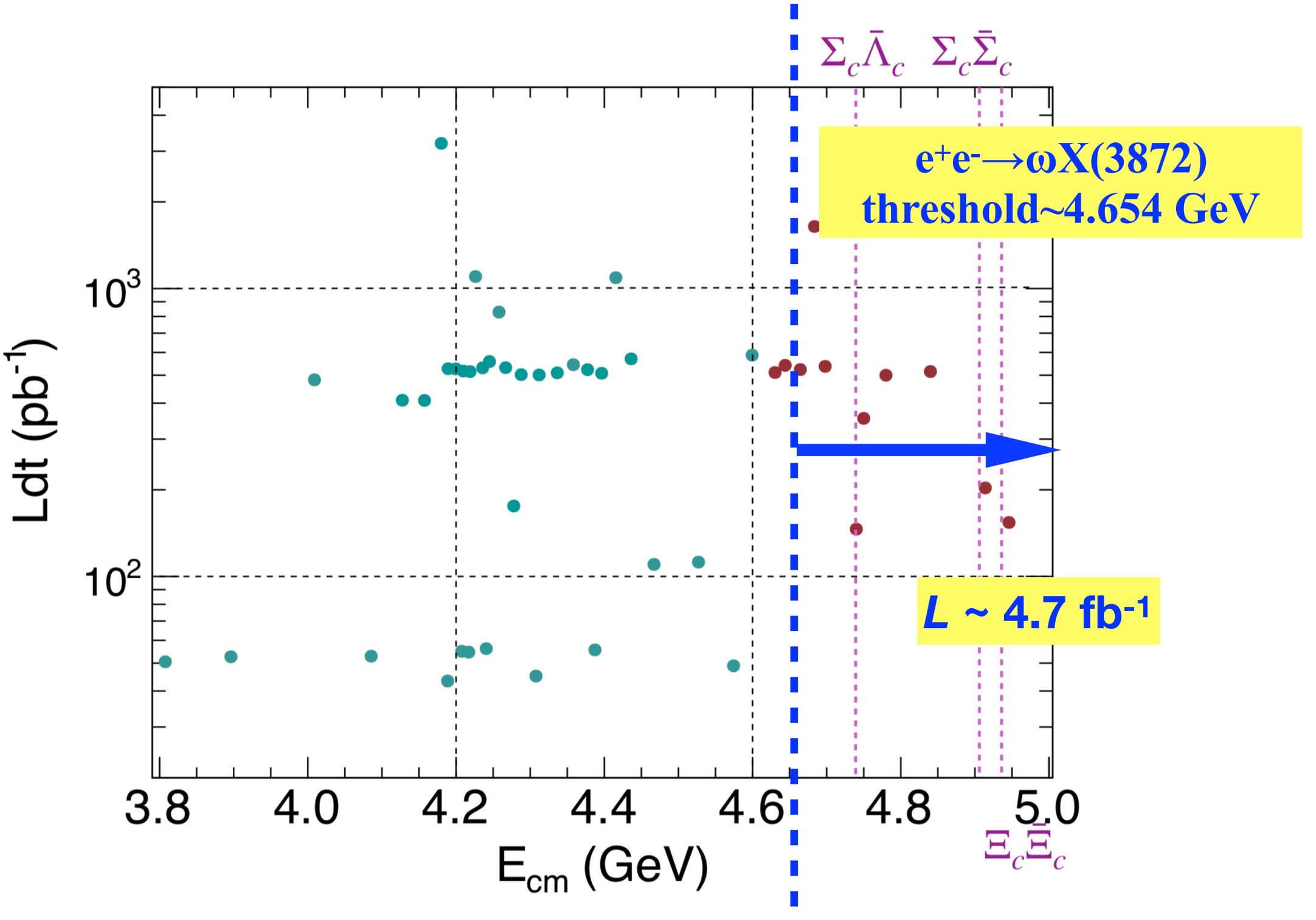
  M= $4200.6^{+7.9}_{-13.3} \pm 3.0\ \mathrm{MeV}/c^2$

  Γ= $115^{+38}_{-26} \pm 12\ \mathrm{MeV}$
- Agree with ψ(4230) parameters, and support the radiative transition ψ(4230)→γX(3872)



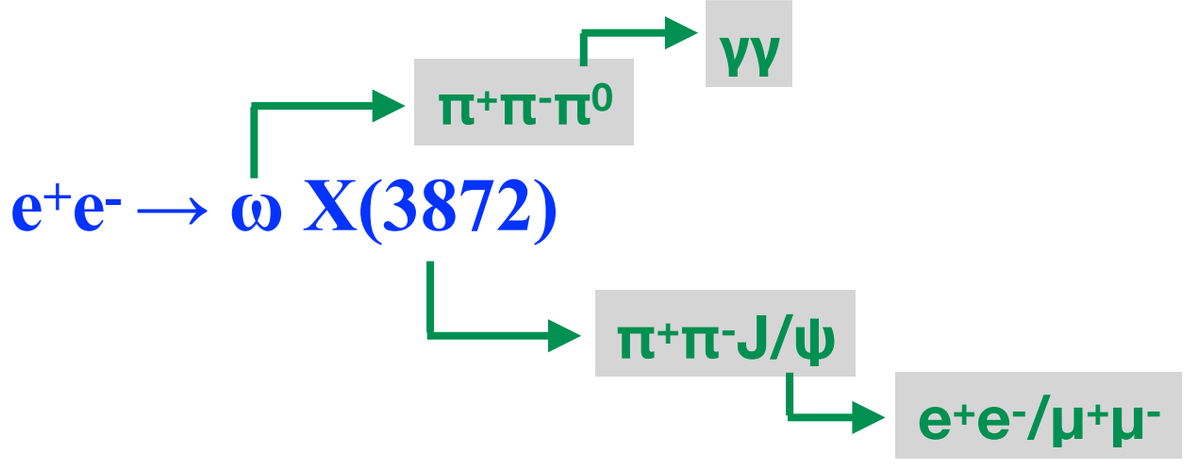


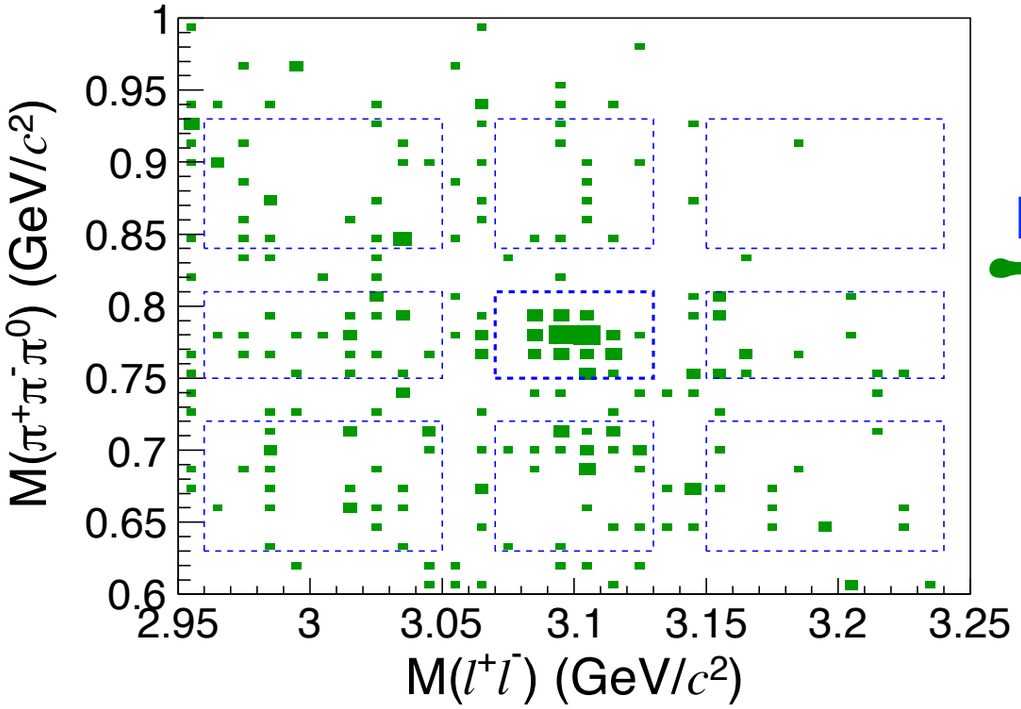
$e^+e^- \to \omega X(3872)$



$e^+e^- \to \omega X(3872)$

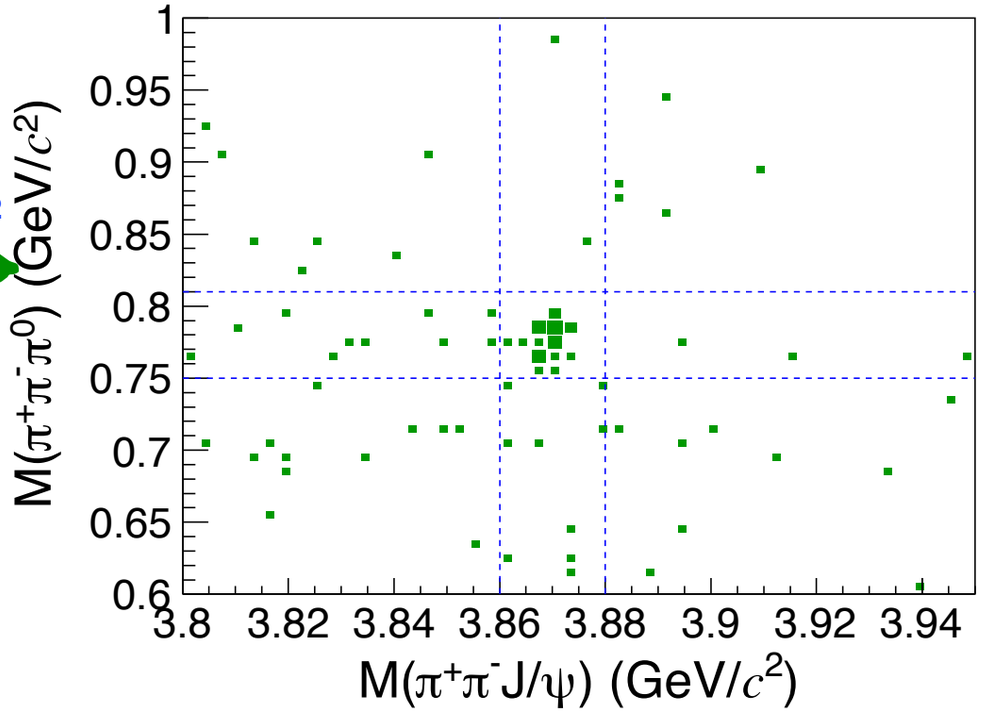
PRL 130, 151904 (2023)





M(π⁺π⁻π⁰) vs. M(l⁺l⁻)

M(l⁺l⁻): [3.07,3.13] GeV/c²

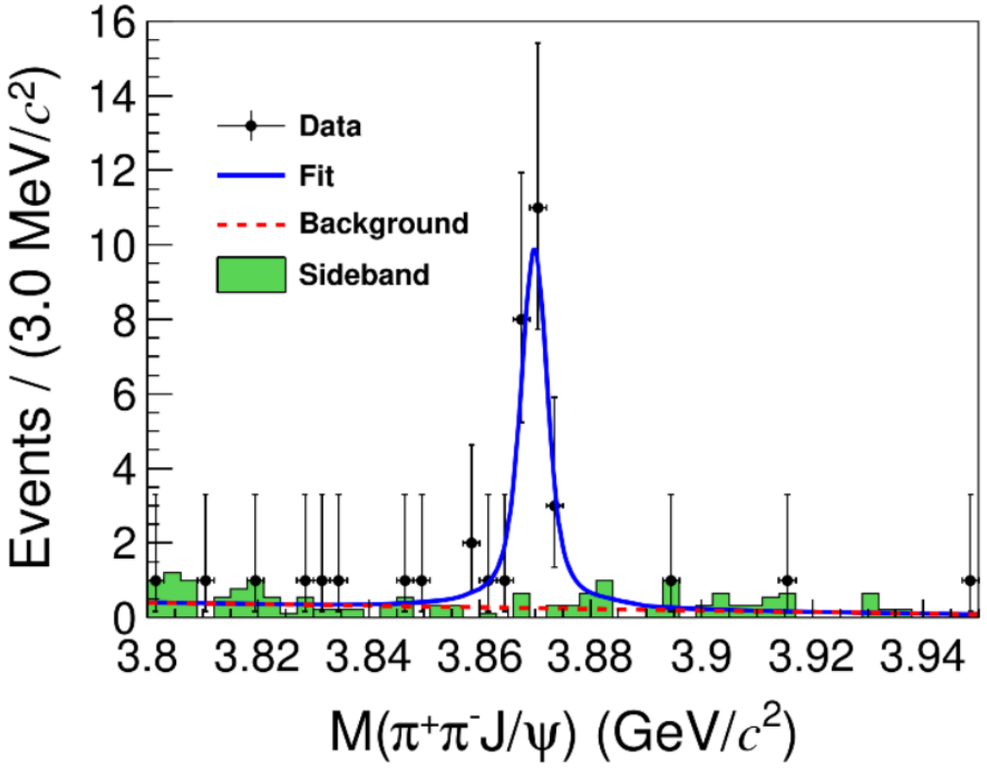


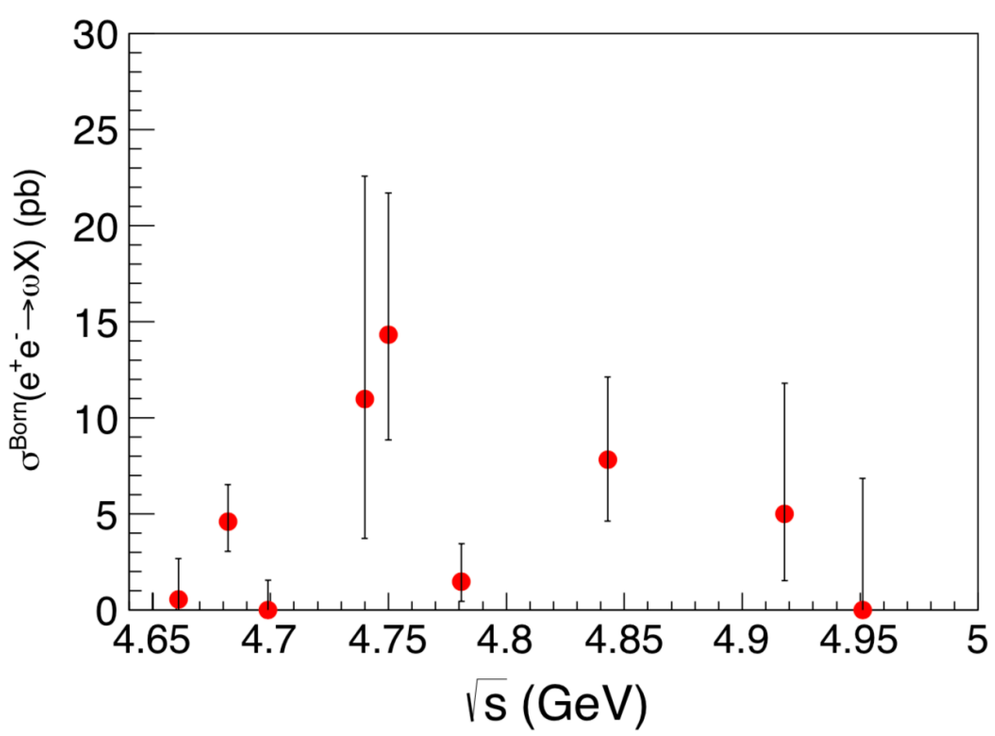
M(π⁺π⁻π⁰) vs. M(π⁺π⁻J/ψ)

$e^+e^-\to\omega X(3872)$

PRL 130, 151904 (2023)

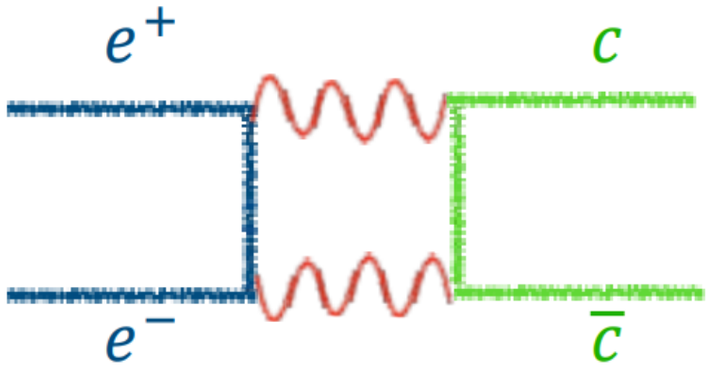
- Events accumulation in X(3872) signal regions
- Observed 24.6±5.4 signals with 7.8σ significance
- The cross section of $e^+e^-\to\omega X(3872)$ at each energy point is measured
  - Line shape indicates nontrivial structures





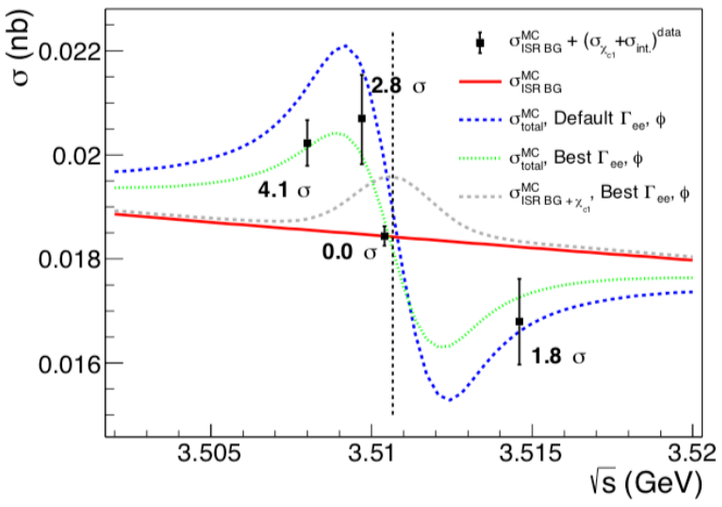
$e^+e^- \to X(3872)$

- Direct formation of C-even states with two-photon fusion process

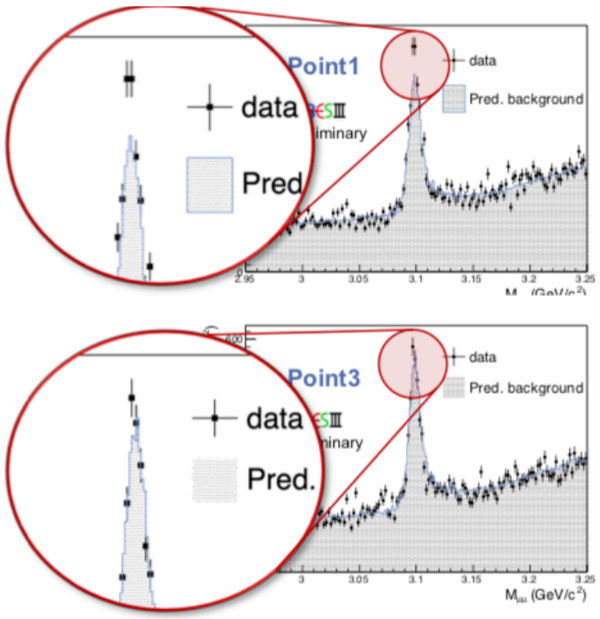


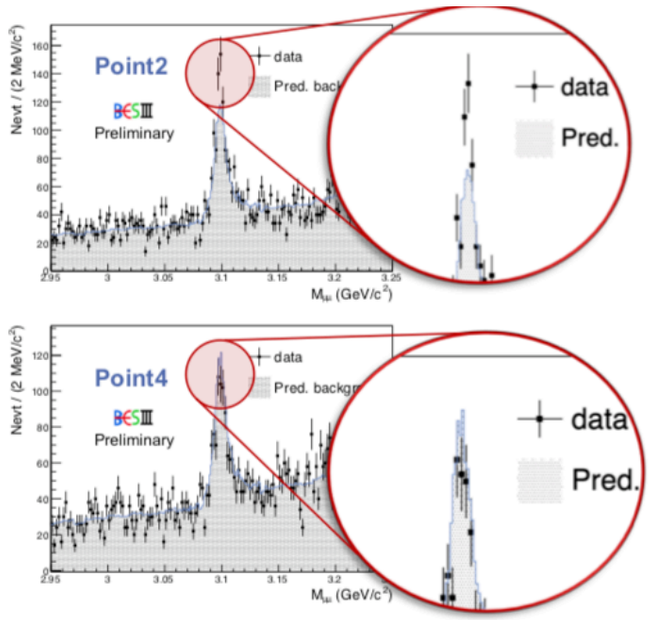
$J^{PC} = 1^{++}, 2^{++}$

- BESIII observed $e^+e^- \to \chi_{c1}(1P)$ with 5.1σ significance



PRL 129, 122001 (2022)

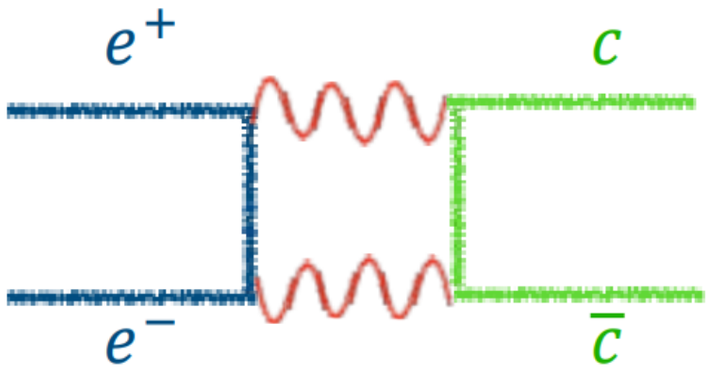




$e^+e^- \to X(3872)$

PRD 107, 032007 (2023)

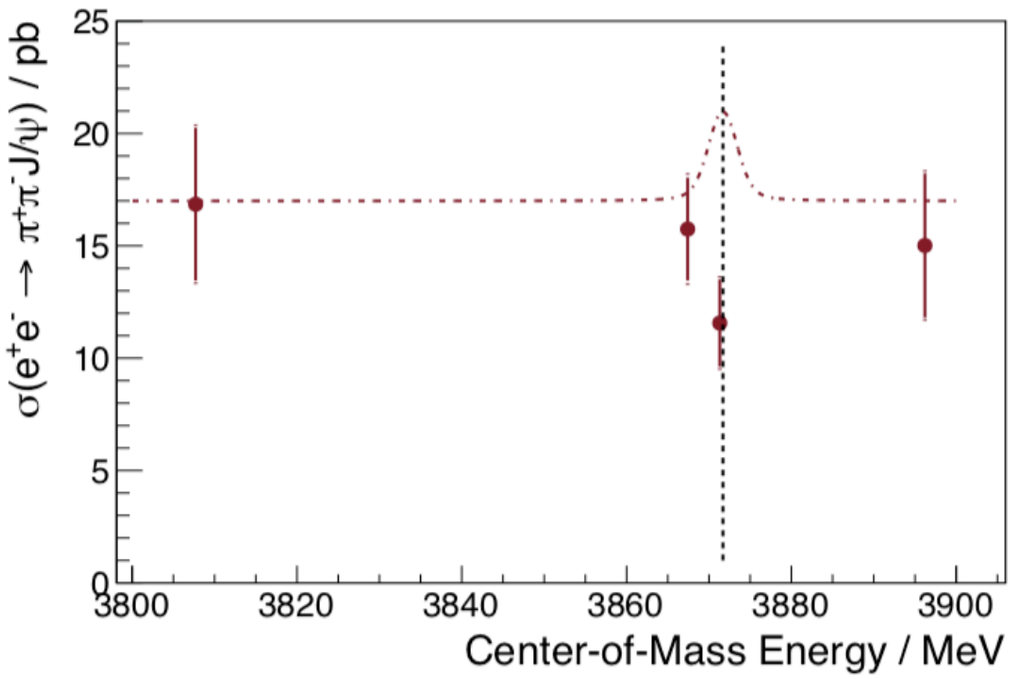
- Direct formation of C-even states with two-photon fusion process



$J^{PC} = 1^{++}, 2^{++}$

- Search for $e^+e^- \to X(3872)$

$$\Gamma_{ee} \times \mathcal{B}(X(3872) \to \pi^+\pi^- J/\psi) < 7.5 \times 10^{-3}\,\mathrm{eV}$$



X(3872) Decays

Chunhua Li & CZY, *PRD 100, 094003 (2019)*

Index (i)	Parameters	Values	Experiments
	$X(3872)\to\pi^+\pi^- J/\psi$	($\times10^{-6}$)	
1	$B^+\to X(3872)K^+$	$8.61\pm0.82\pm0.52$	Belle [14]
2		$8.4\pm1.5\pm0.7$	*BABAR* [15]
3	$B^0\to X(3872)K^0$	$4.3\pm1.2\pm0.4$	Belle [14]
4		$3.5\pm1.9\pm0.4$	*BABAR* [15]
	$X(3872)\to\gamma J/\psi$	($\times10^{-6}$)	
5	$B^+\to X(3872)K^+$	$1.78^{+0.48}_{-0.44}\pm0.12$	Belle [22]
6		$2.8\pm0.8\pm0.1$	*BABAR* [23]
7	$B^0\to X(3872)K^0$	$1.24^{+0.76}_{-0.61}\pm0.11$	Belle [22]
8		$2.6\pm1.8\pm0.2$	*BABAR* [23]
	$X(3872)\to\gamma\psi(3686)$	($\times10^{-6}$)	
9	$B^+\to X(3872)K^+$	$0.83^{+1.98}_{-1.83}\pm0.44$	Belle [22]
10		$9.5\pm2.7\pm0.6$	*BABAR* [23]
11	$B^0\to X(3872)K^0$	$1.12^{+3.57}_{-2.90}\pm0.57$	Belle [22]
12		$11.4\pm5.5\pm1.0$	*BABAR* [23]
	$X(3872)\to D^{*0}\bar{D}^0$ +c.c.	($\times10^{-4}$)	
13	$B^+\to X(3872)K^+$	$0.77\pm0.16\pm0.10$	Belle [16]
14		$1.67\pm0.36\pm0.47$	*BABAR* [17]
15	$B^0\to X(3872)K^0$	$0.97\pm0.46\pm0.13$	Belle [16]
16		$2.22\pm1.05\pm0.42$	*BABAR* [17]
	$X(3872)\to\omega J/\psi$	($\times10^{-6}$)	
17	$B^+\to X(3872)K^+$	$6\pm2\pm1$	*BABAR* [18]
18	$B^0\to X(3872)K^0$	$6\pm3\pm1$	*BABAR* [18]
	Ratios		
19	$\frac{\mathcal{B}(X(3872)\to\gamma J/\psi)}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)}$	0.79 ± 0.28	BESIII [19]
20	$\frac{\mathcal{B}(X(3872)\to D^{*0}\bar{D}^0+\text{c.c.})}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)}$	14.81 ± 3.80	BESIII [19]
21	$\frac{\mathcal{B}(X(3872)\to\omega J/\psi)}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)}$	$1.6^{+0.4}_{-0.3}\pm0.2$	BESIII [20]
22	$\frac{\mathcal{B}(X(3872)\to\pi^0\chi_{c1})}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)}$	$0.88^{+0.33}_{-0.27}\pm0.10$	BESIII [21]
23	$\frac{\mathcal{B}(X(3872)\to\gamma\psi(3686))}{\mathcal{B}(X(3872)\to\gamma J/\psi)}$	$2.46\pm0.64\pm0.29$	LHCb [24]
	$B^+\to X(3872)K^+$	($\times10^{-4}$)	
24		$2.1\pm0.6\pm0.3$	*BABAR* [27]
25		$1.2\pm1.1\pm0.1$	Belle [26]

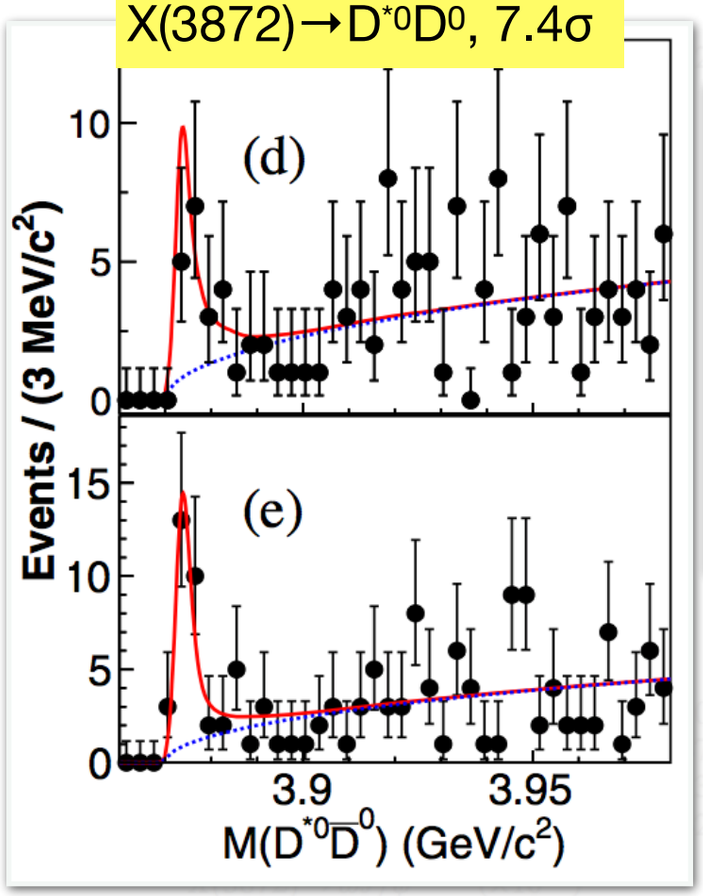
- Determination of X(3872) absolute branching fractions by globally analyzing all experimental measurements

Parameter index	Decay mode	Branching fraction
1	$X(3872)\to\pi^+\pi^- J/\psi$	$(4.1^{+1.9}_{-1.1})\%$
2	$X(3872)\to D^{*0}\bar{D}^0+c.c.$	$(52.4^{+25.3}_{-14.3})\%$
3	$X(3872)\to\gamma J/\psi$	$(1.1^{+0.6}_{-0.3})\%$
4	$X(3872)\to\gamma\psi(3686)$	$(2.4^{+1.3}_{-0.8})\%$
5	$X(3872)\to\pi^0\chi_{c1}$	$(3.6^{+2.2}_{-1.6})\%$
6	$X(3872)\to\omega J/\psi$	$(4.4^{+2.3}_{-1.3})\%$
7	$B^+\to X(3872)K^+$	$(1.9\pm0.6)\times10^{-4}$
8	$B^0\to X(3872)K^0$	$(1.1^{+0.5}_{-0.4})\times10^{-4}$
	$X(3872)\to$ unknown	$(31.9^{+18.1}_{-31.5})\%$

X(3872) Decays at BESIII

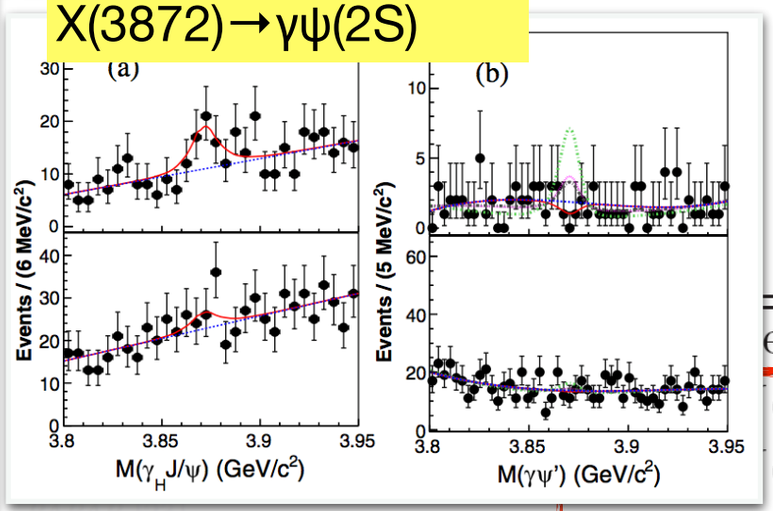
PRL 124, 242001 (2020)

X(3872)→$D^{*0}D^0$, 7.4σ



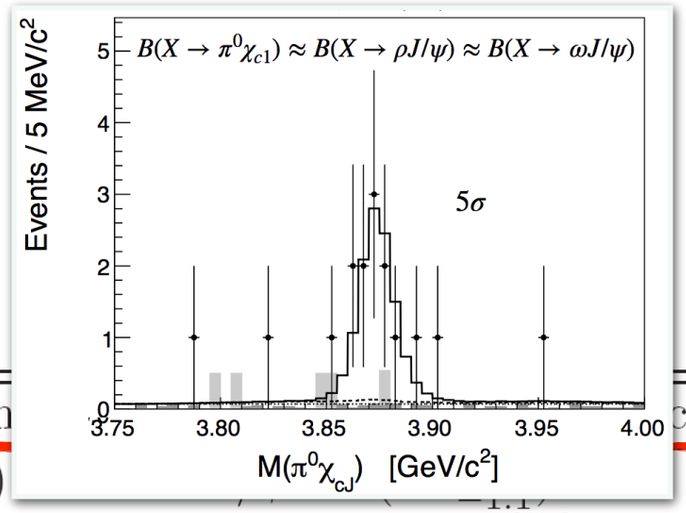
X(3872)→γJ/ψ, 3.5σ

X(3872)→γψ(2S)



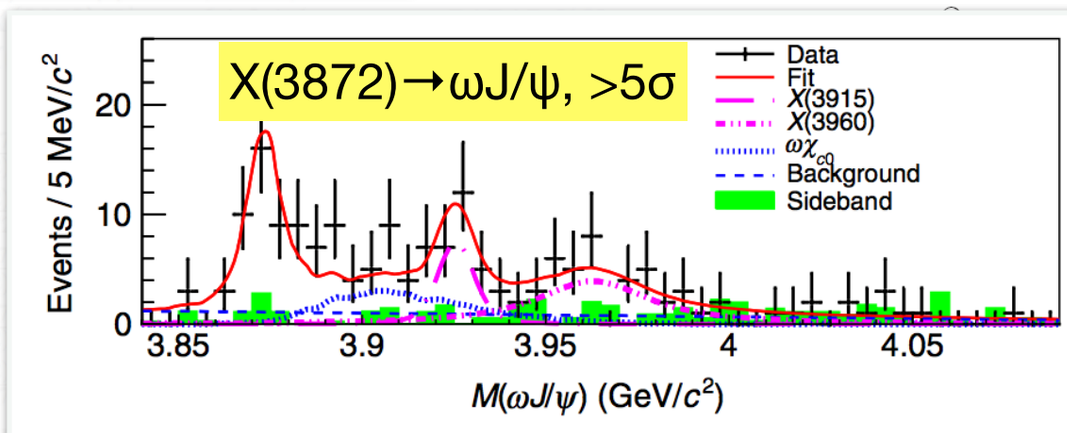
PRL 122, 202001 (2019)

X(3872)→$\pi^0\chi_{c1}$, 5σ



2	$X(3872) \to D^{*0}\bar{D}^0 + c.c.$	$(52.4^{+25.3}_{-14.3})\%$
3	$X(3872) \to \gamma J/\psi$	$(1.1^{+0.6}_{-0.3})\%$
4	$X(3872) \to \gamma\psi(3686)$	$(2.4^{+1.3}_{-0.8})\%$
5	$X(3872) \to \pi^0\chi_{c1}$	$(3.6^{+2.2}_{-1.6})\%$
6	$X(3872) \to \omega J/\psi$	$(4.4^{+2.3}_{-1.3})\%$
7	$B^+ \to X(3872)K^+$	$(1.9 \pm 0.6) \times 10^{-4}$
	$B^0 \to X(3872)K^0$	$(1.1^{+0.5}_{-0.4}) \times 10^{-4}$
	$X(3872) \to$ unknown	$(31.9^{+18.1}_{-31.5})\%$

X(3872)→ωJ/ψ, >5σ



PRL 122, 232002 (2019)

Search for X(3872)→$\pi^0\chi_{c0}$, $\pi\pi\chi_{c0}$

PRD 105, 072009 (2022)

Theoretical predictions [PRD 77, 014013 (2008)]

Interpretation	$\frac{\mathcal{B}(X(3872)\to\pi^0\chi_{c0})}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)}$	$\frac{\mathcal{B}(X(3872)\to\pi^0\chi_{c0})}{\mathcal{B}(X(3872)\to\pi^0\chi_{c1})}$
Four-quark/molecule	NA	2.97
$\chi_{c1}(2P)$	0.0	0.0

EFT predictions [PRD 79, 094013 (2009), PRD 78, 094019 (2008)]

$$\frac{\mathcal{B}(X(3872)\to\pi\pi\chi_{c0})}{\mathcal{B}(X(3872)\to\pi^0\chi_{c0})} \approx \mathcal{O}(10^{-3}) \text{ or } \mathcal{O}(10^{-5})$$

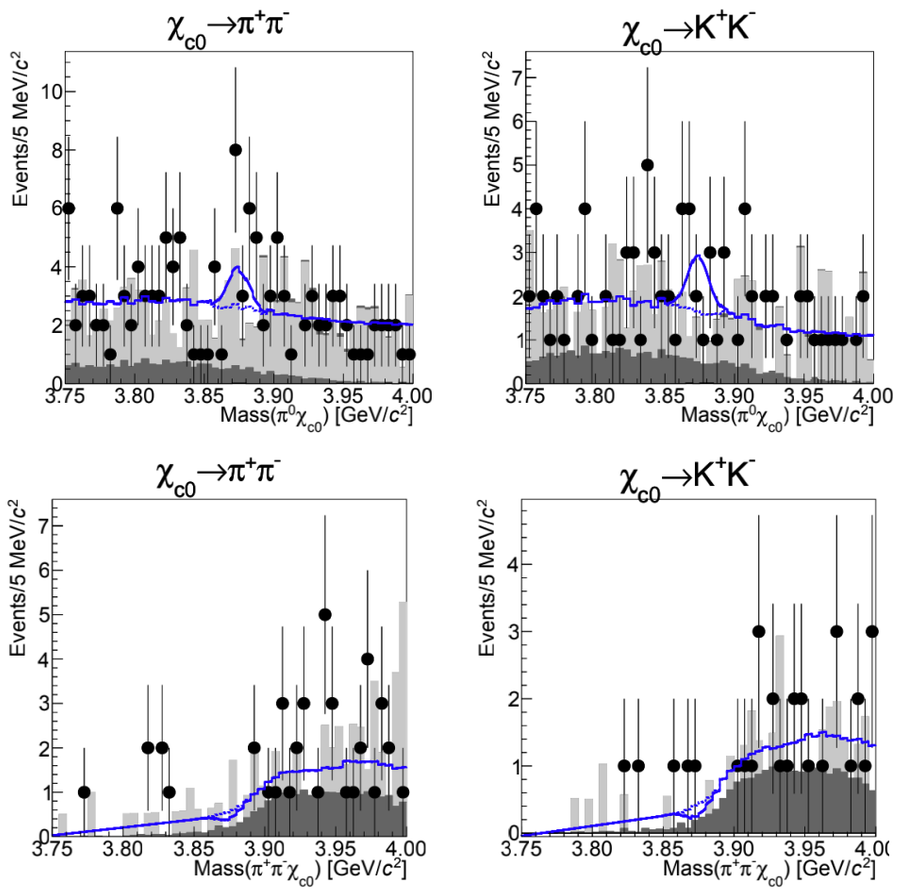
- Search for X(3872)→$\pi^0\chi_{c0}$ with 9.9fb^{-1} between 4.15-4.30 GeV

$$\frac{\mathcal{B}(X(3872)\to\pi^0\chi_{c0})}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)} < 3.6$$

$$\frac{\mathcal{B}(X(3872)\to\pi^0\chi_{c0})}{\mathcal{B}(X(3872)\to\pi^0\chi_{c1})} < 4.5$$

$$\frac{\mathcal{B}(X(3872)\to\pi^0\pi^0\chi_{c0})}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)} < 1.7$$

$$\frac{\mathcal{B}(X(3872)\to\pi^+\pi^-\chi_{c0})}{\mathcal{B}(X(3872)\to\pi^+\pi^- J/\psi)} < 0.56$$



A coupled channel analysis of the X(3872) line shape at BESIII

BESIII Preliminary

Line shape parameterization

$$\frac{d\mathrm{Br}(D^0\bar{D}^0\pi^0)}{dE} = \boldsymbol{B}\frac{1}{2\pi}\times\frac{g * k_{\mathrm{eff}}(E)}{|D(E)|^2}\times \mathrm{Br}(D^{*0}\to D^0\pi^0)$$

$$\frac{d\mathrm{Br}(\pi^+\pi^- J/\psi)}{dE} = \boldsymbol{B}\frac{1}{2\pi}\times\frac{\Gamma_{\pi^+\pi^- J/\psi}}{|D(E)|^2}$$

$$D(E) = E - E_X + \frac{1}{2}g * \left(\kappa_{\mathrm{eff}}(E) + ik_{\mathrm{eff}}(E) + \kappa^c_{\mathrm{eff}}(E) + ik^c_{\mathrm{eff}}(E)\right) + \frac{i}{2}\Gamma_0$$

$$k_{\mathrm{eff}}(E) = \sqrt{\mu_p}\sqrt{\sqrt{(E-E_R)^2+\Gamma^2/4}+E-E_R}$$

$$\kappa_{\mathrm{eff}}(E) = -\sqrt{\mu_p}\sqrt{\sqrt{(E-E_R)^2+\Gamma^2/4}-E+E_R}$$

$$+\sqrt{\mu_p}\sqrt{\sqrt{(E_X-E_R)^2+\Gamma_X^2/4}-E_X+E_R}$$

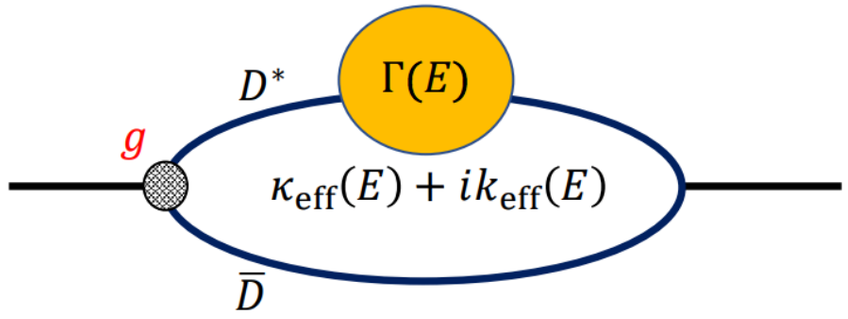
$$\Gamma_0 = \Gamma_{\pi^+\pi^- J/\psi} + \Gamma_{known} + \Gamma_{unknown}$$

$$E_X = M_X - (m_{D^0} + m_{\bar{D}^0} + m_{\pi^0})$$

$\boldsymbol{B}$: the global normalization

* superscript c: charged $D^{*+}D^-$
* Due to the limited statistics, $\boldsymbol{\Gamma_{unknown}/\Gamma_{\pi^+\pi^- J/\psi}}$ is fixed [Chunhua Li, Chang-Zheng Yuan, PRD 100, 094003 (2019)]

[C. Hanhart, PRD 81, 094028 (2010)]



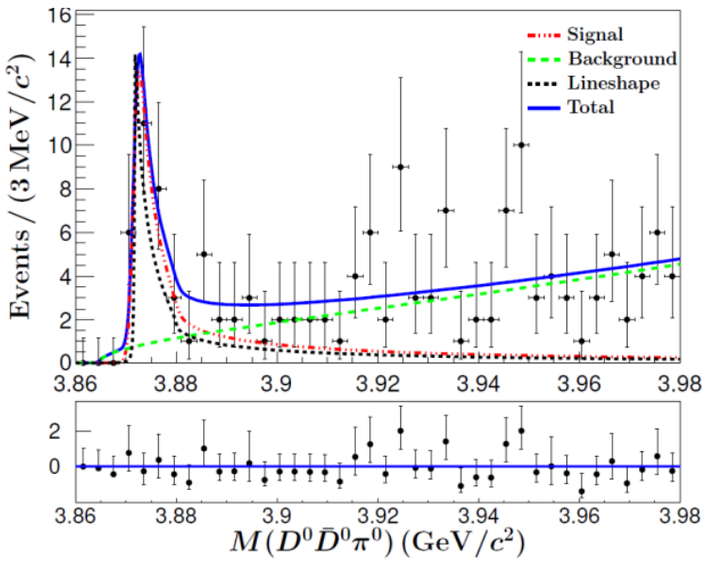
Key features:

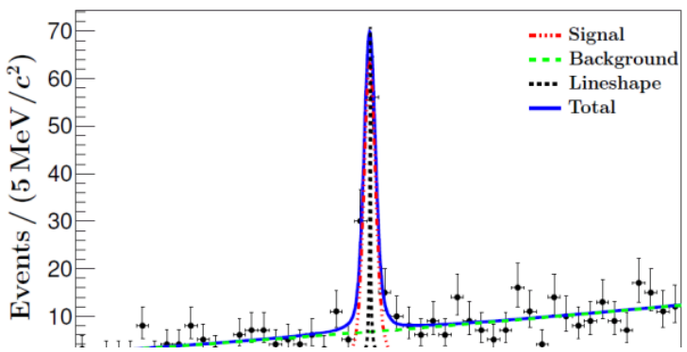
- Model independent
- Including the $D^*\bar{D}$ self energy terms
- Including the width of D^*
- Including the coupled channel effect
- Fit parameters: g, $\Gamma_{\pi^+\pi^- J/\psi}$, M_X

A coupled channel analysis of the X(3872) line shape at BESIII

BESIII Preliminary

Fit results

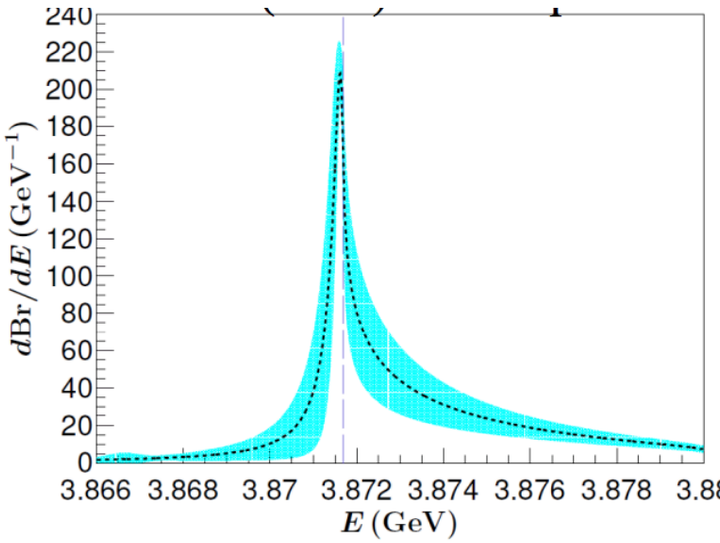




$\mu^{prod}_{X(3872)} = (9.8 \pm 3.9) \times 10^4$

Large systematic uncertainty from

$\Gamma_{unknow}/\Gamma_{\pi^+\pi^- J/\psi}$



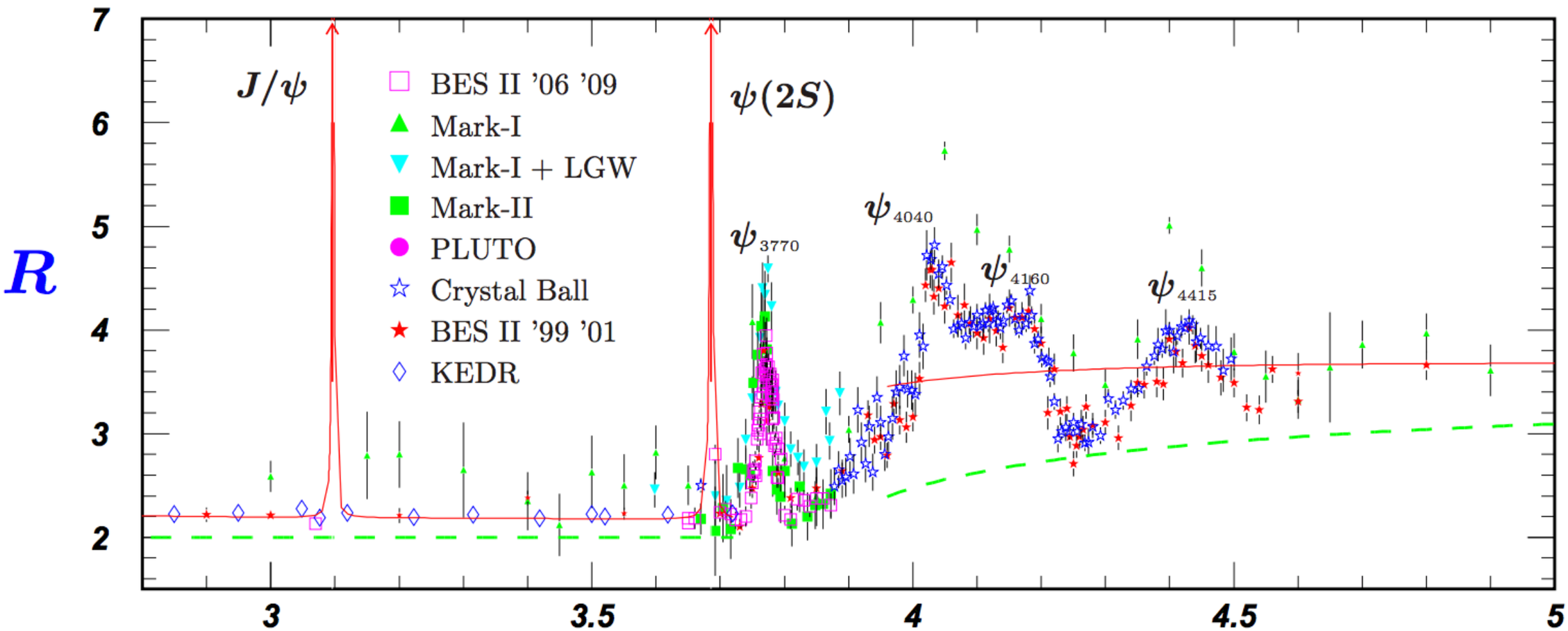
Parameters	g	Γ_0 (MeV)	M_X (MeV)
Fit results	0.16 ± 0.10	2.67 ± 1.77	3871.63 ± 0.13
g	1.00	0.89	−0.60
Γ_0		1.00	−0.29
M_X			1.00

$\mu^{prod}_{X(3872)} = (9.8 \pm 3.9) \times 10^4$

Large systematic uncertainty from

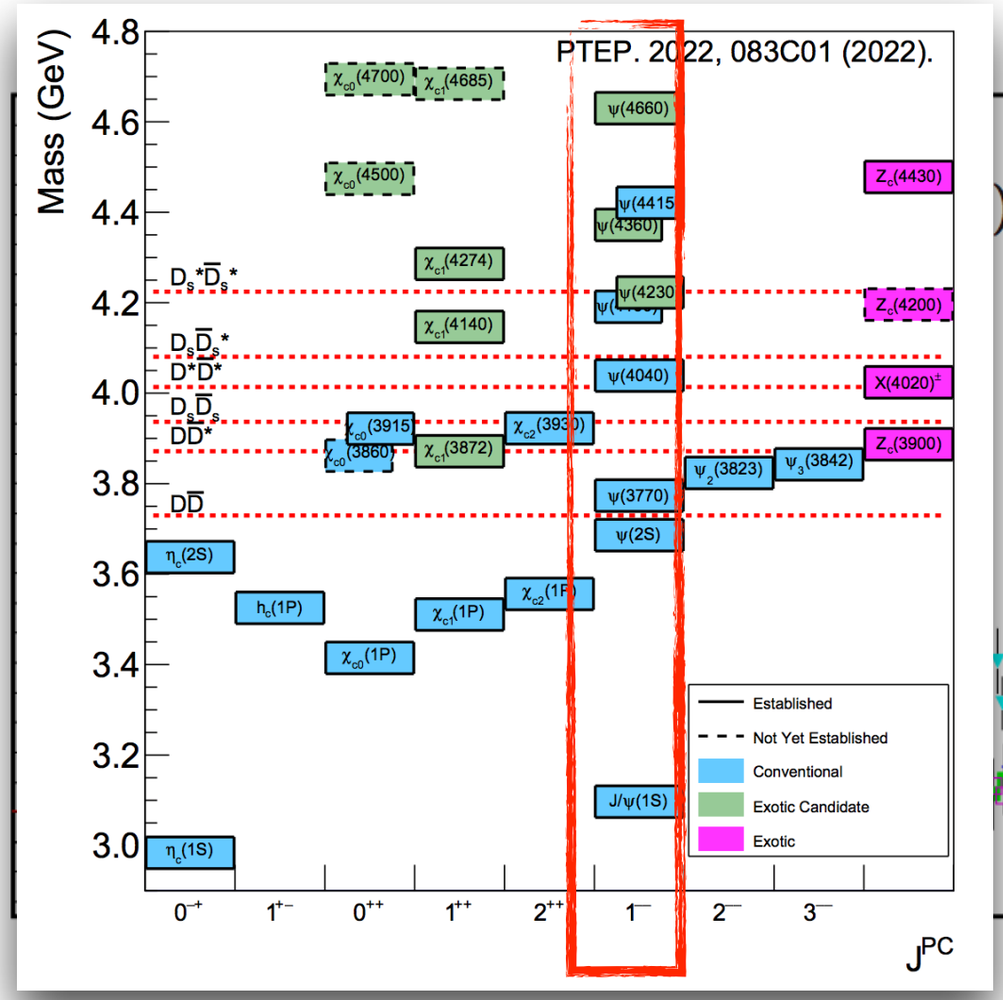
$\Gamma_{unknow}/\Gamma_{\pi^+\pi^- J/\psi}$

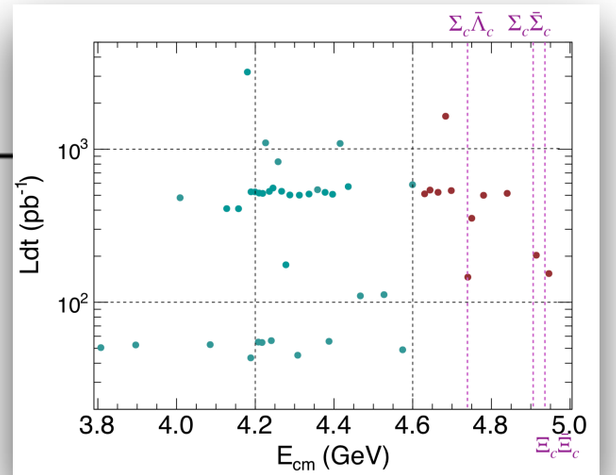
Y States



PTEP 2022, 083C01 (2022)

Y States





Measure exclusive processes precisely

PTEP 2022, 083C01 (2022)

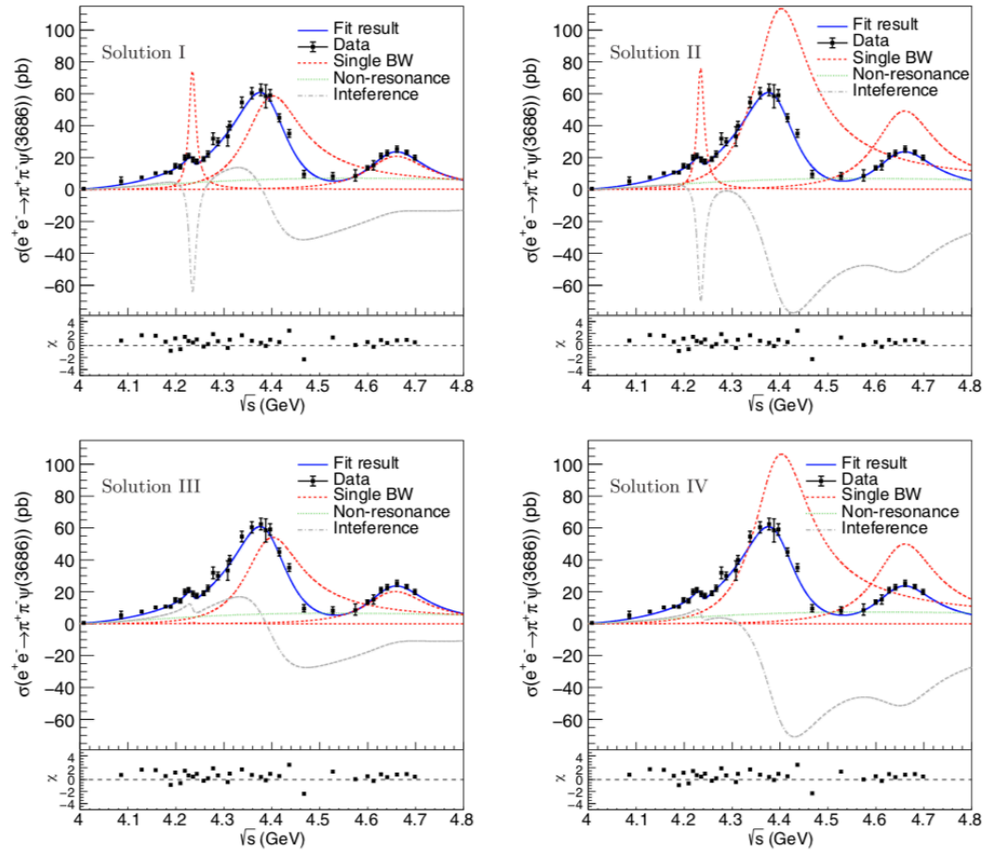
Y States

- Measure the √s-dependent cross section of exclusive processes with high precision.
- Model the line shape of cross section with a coherent sum of multiple Breit-Wigner functions together with the continuum and near threshold components.

$$\sigma^{\text{dressed}}(\sqrt{s}) = \left| \sum\nolimits_k e^{i\phi_k} \cdot BW_k(s) + e^{i\phi_{\text{cont}}} \cdot \psi_{\text{cont}} \right|^2,$$

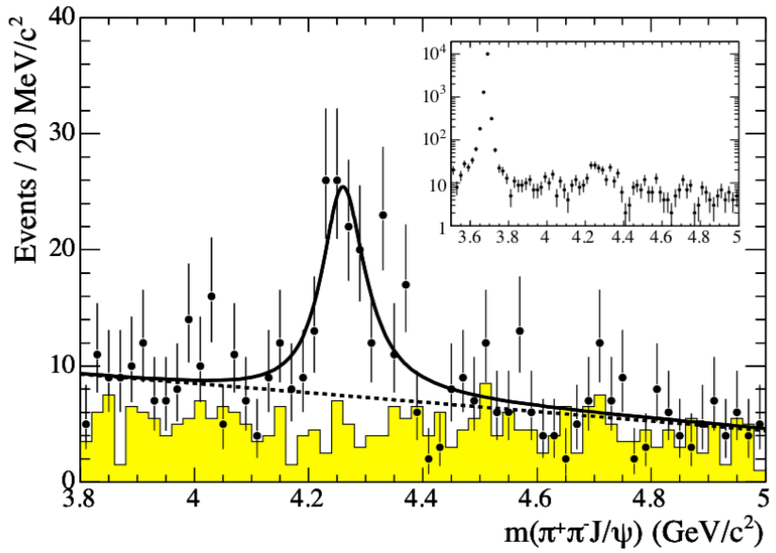
$$BW_k(s) = \frac{M_k}{\sqrt{s}} \frac{\sqrt{12\pi\Gamma_k^{\text{tot}}\Gamma_k^{ee}B_k}}{s - M_k^2 + iM_k\Gamma_k^{\text{tot}}} \sqrt{\frac{\Phi(\sqrt{s})}{\Phi(M_k)}},$$

- Fit gives multiple solutions with different magnitudes but the same mass and width for a resonance.



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

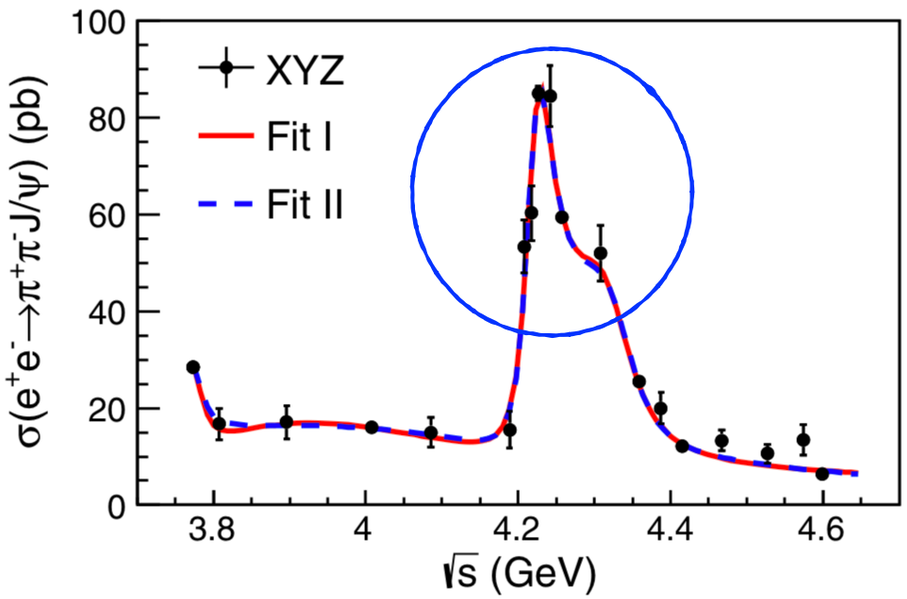
- First vector charmonium-like state Y(4260) was observed by BaBar in 2005.
- Fine structure around 4.26 GeV appear precise measurement in 2017, Y(4260)→ Y(4230)+Y(4320)
- Update measurement with more datasets in 2022 confirm the fine structure.



Named as ψ(4230) in PDG, also known as Y(4220), Y(4260)

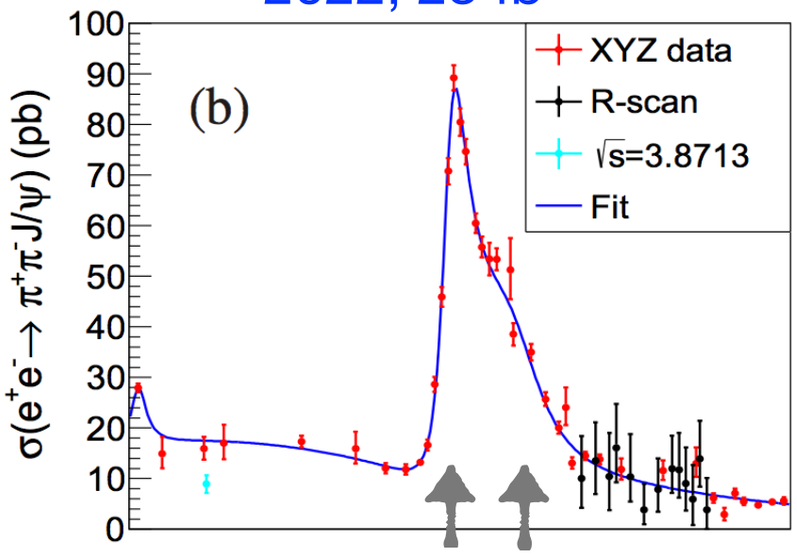
BaBar, PRL 95, 142001 (2005)

2017, 9 fb^{-1}



PRL 118, 092001 (2017)

2022, 23 fb^{-1}

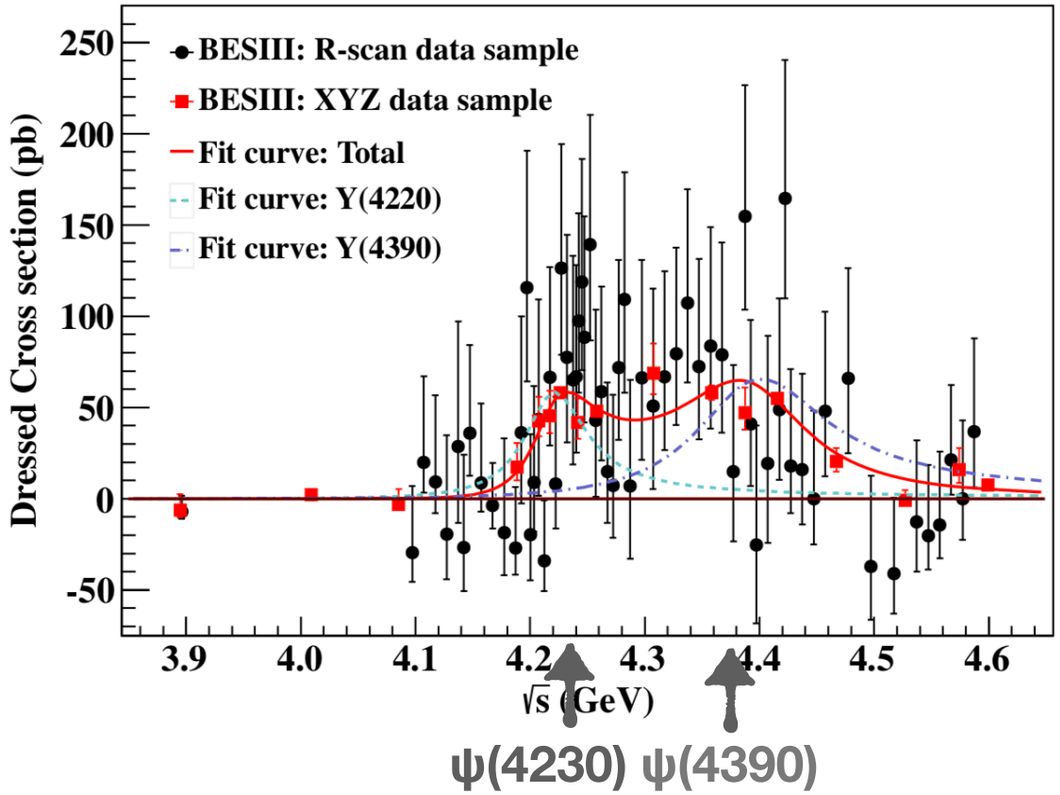


PRD 106, 072001 (2022)

$e^+e^-\to\pi^+\pi^- h_c(1P)$, $\pi^+\pi^-\psi(2S)$

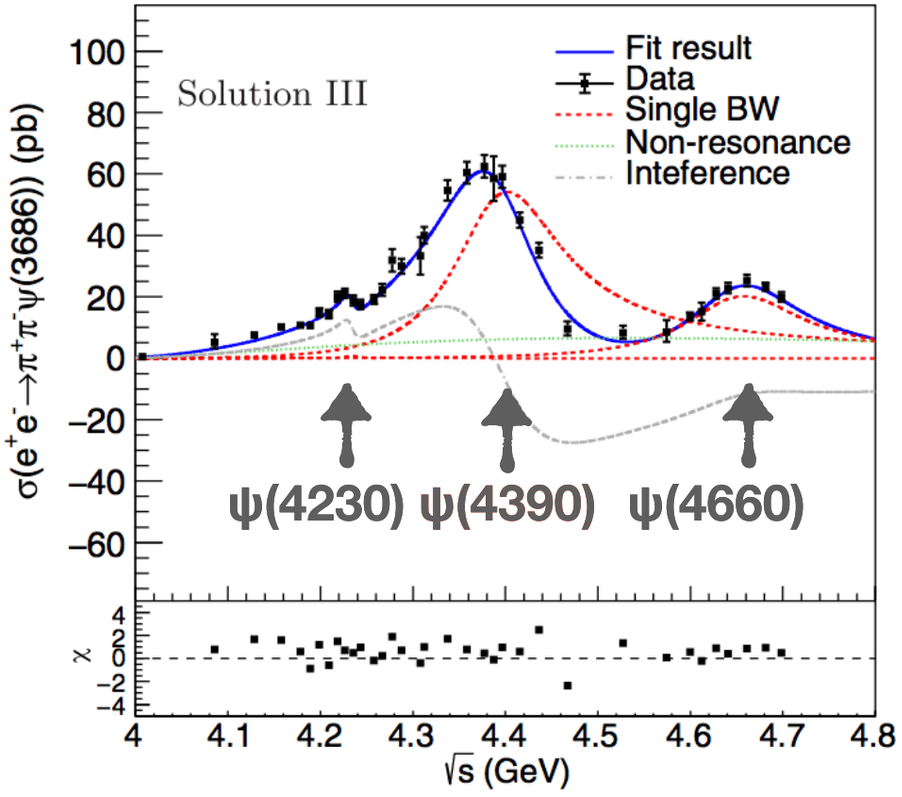
- Precisely determine the line shape of $e^+e^-\to\pi^+\pi^- h_c$ cross section, benefit from both the unique datasets and excellent reconstruction of h_c at BESIII.
- $\pi^+\pi^-\psi(2S)$ line shape confirms the $\psi(4390)$ announced in $\pi^+\pi^- h_c$. Also clear $\psi(4660)\to\ \pi^+\pi^-\psi(2S)$
- $\psi(4230)\to\pi^+\pi^- h_c$ and $\pi^+\pi^-\psi(2S)$

$e^+e^-\to\pi^+\pi^- h_c$



PRL 118, 092002 (2017)

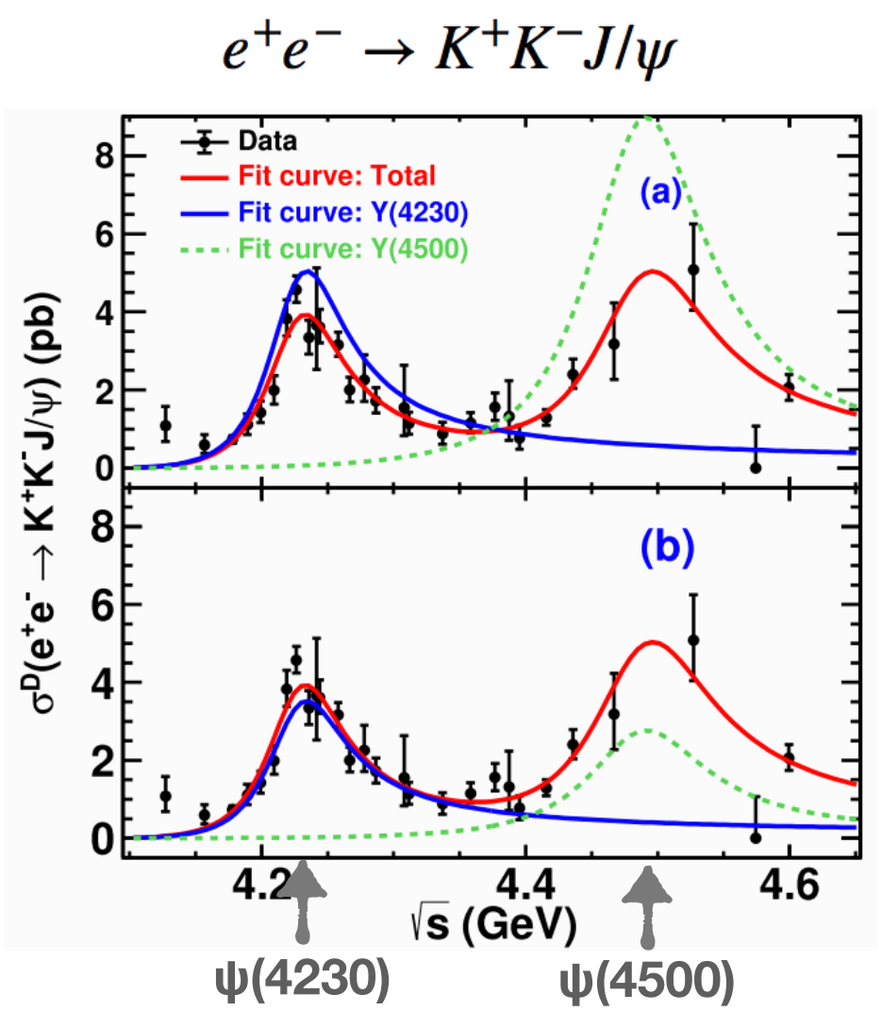
$e^+e^-\to\pi^+\pi^-\psi(2S)$



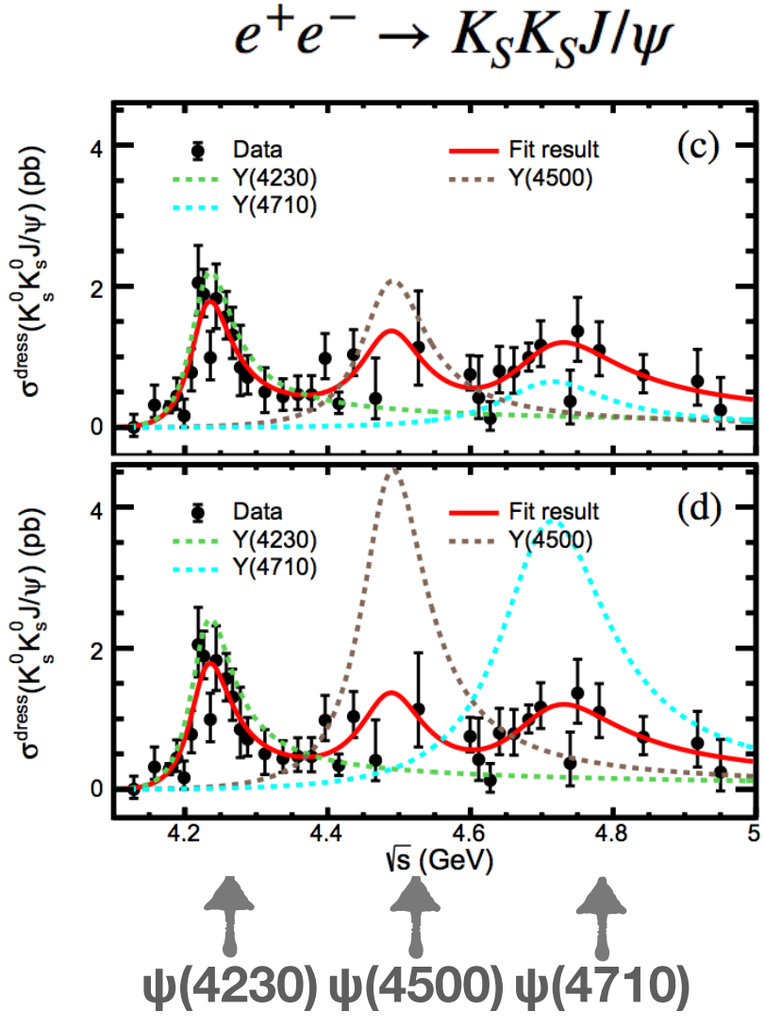
PRD 104, 052012 (2021)

$e^+e^-\to K^+K^-J/\psi$, KsKs J/ψ

- Observations of $\psi(4230)\to K^+K^-J/\Psi$, KsKs J/ψ
- Two new structures $\psi(4500)$ and $\psi(4710)$ are needed to describe the line shape.



CPC 46,111002 (2022)



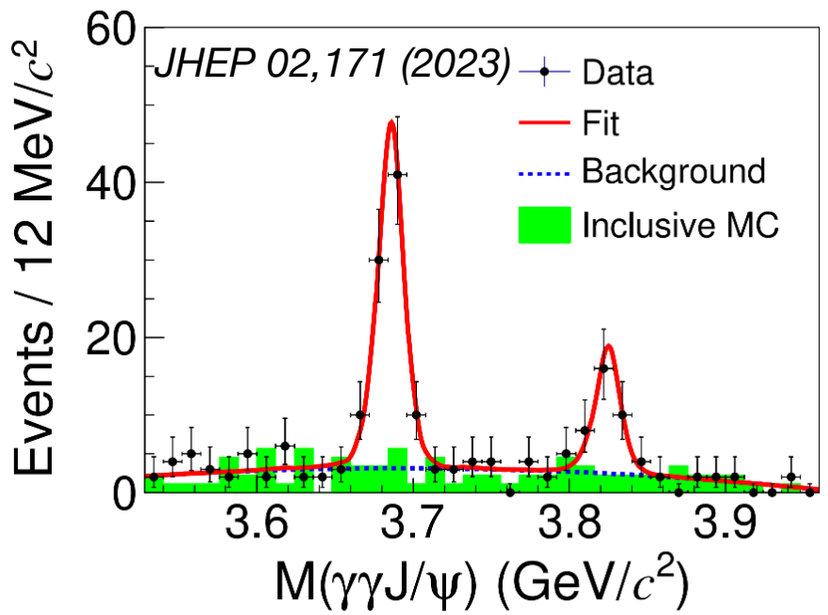
PRD 107,092005 (2023)

$e^+e^- \to \pi^+\pi^-\psi_2(3823)$, $\pi^0\pi^0\psi_2(3823)$

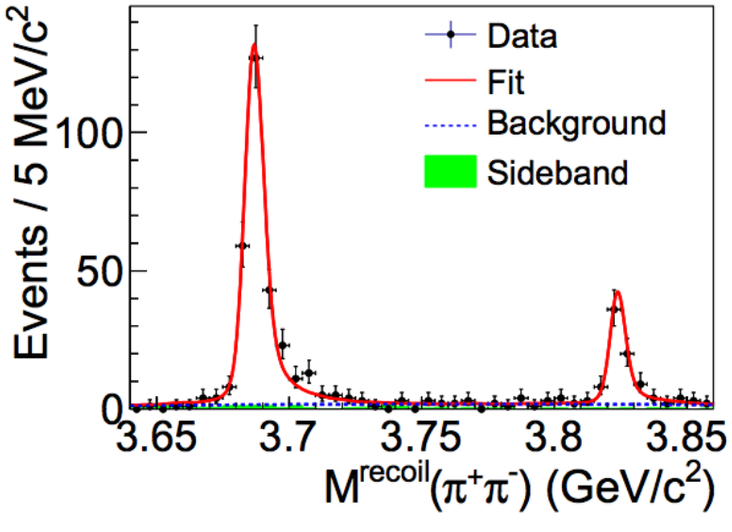
- Observation of $e^+e^- \to \pi^0\pi^0\psi_2(3823)$

$$\frac{\sigma[e^+e^- \to \pi^0\pi^0\psi_2(3823)]}{\sigma[e^+e^- \to \pi^+\pi^-\psi_2(3823)]} = 0.57 \pm 0.14 \pm 0.05$$

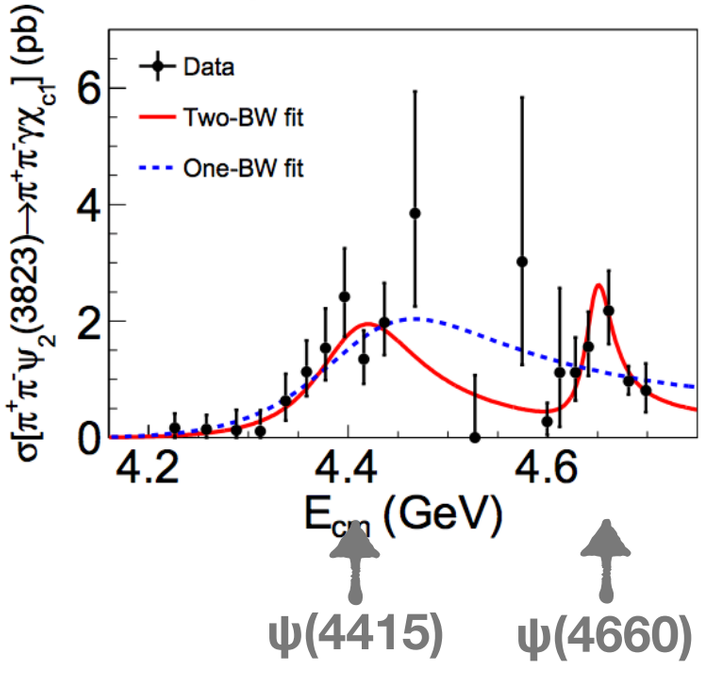
Consistent with the isospin symmetry



- Update the measurement of $e^+e^- \to \pi^+\pi^-\psi_2(3823)$
  - More datasets
  - Partial reconstruction to improve the reconstruction efficiency
- First observation of vector Y-states coupling to D-wave charmonium state



PRL 129,102003 (2022)

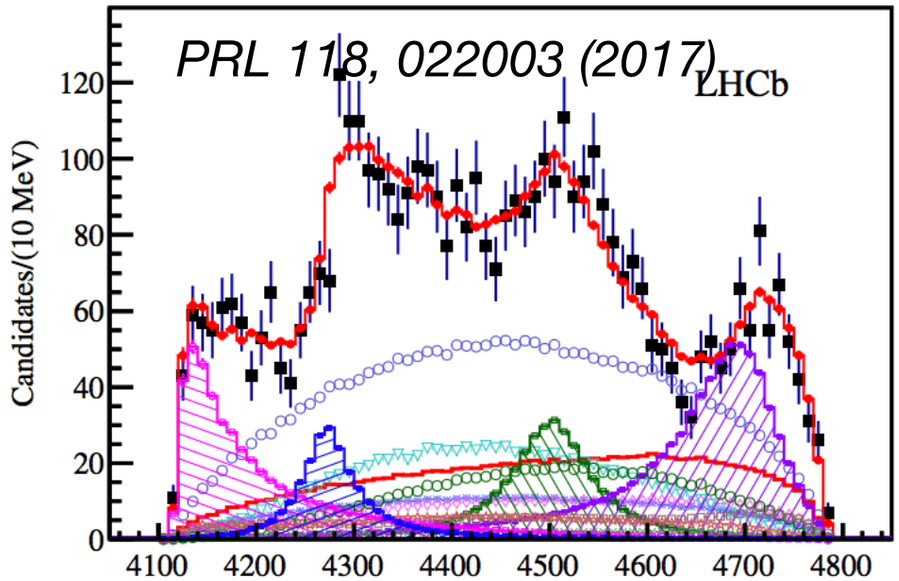


$J^{PC}[\psi_2(3823)]=2^{--}$

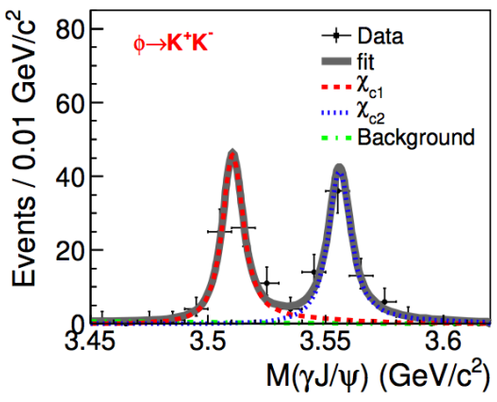
$e^+e^- \to \gamma\phi J/\psi$

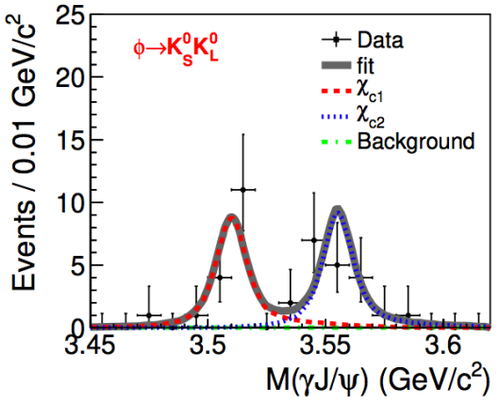
JHEP 01, 132 (2023)

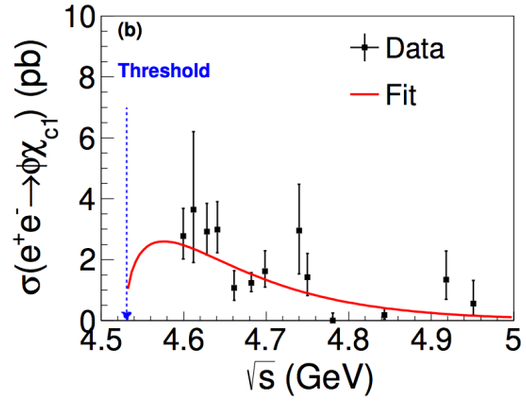
- Why is $e^+e^- \to \gamma\phi J/\psi$
  - Search for hadronic decay $e+e- \to \phi\chi_{c1,2} \to \phi[\gamma J/\psi]$
  - LHCb reports X(4140)/X(4274)/X(4500)/ X(4700)$\to\phi J/\psi$ in the full amplitude analysis of $B+ \to \phi J/\psi K+$

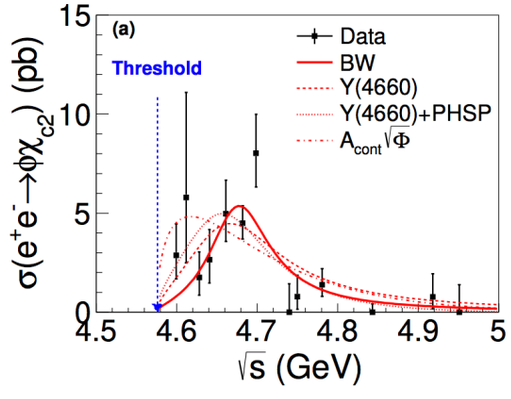


- Measurements of $e+e- \to \phi\chi_{c1,2}$





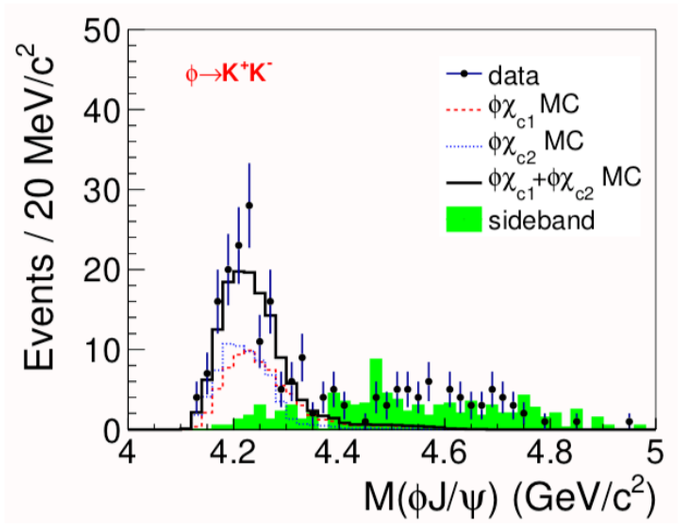


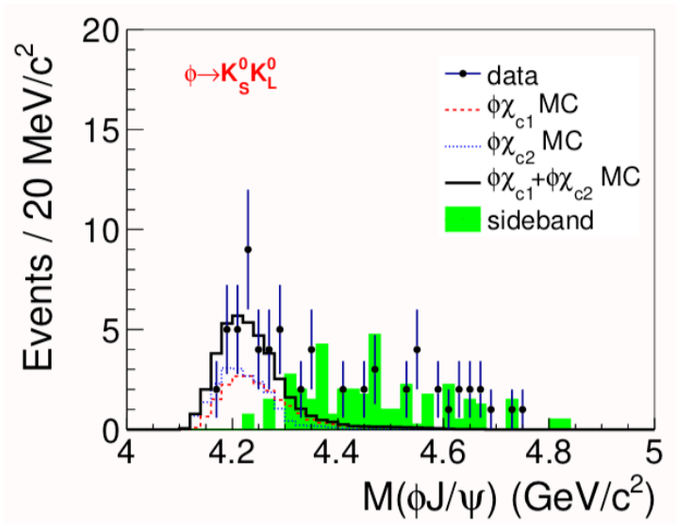


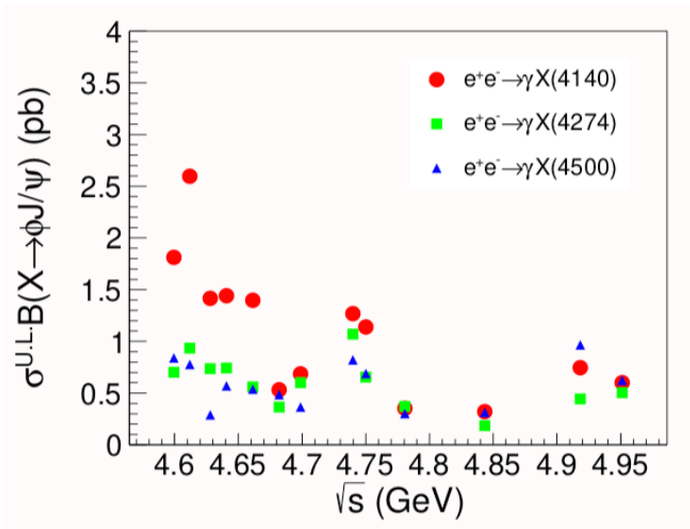
$e^+e^- \to \gamma\phi J/\psi$

JHEP 01, 132 (2023)

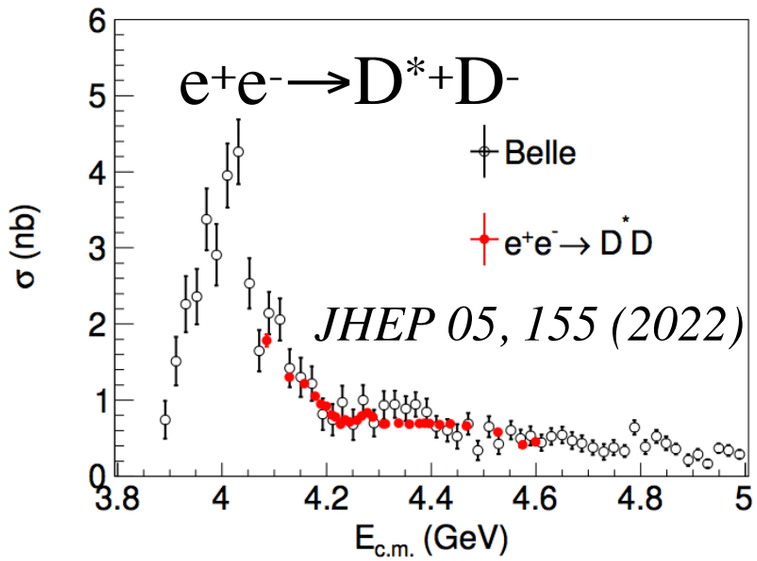
- Search for e+e-→γ X(4140)/X(4274)/X(4500) →γϕJ/ψ
  - $e^+e^- \to \gamma\phi J/\psi$ signals are from $e^+e^- \to \phi\chi_{c1,2}$
  - No significant e+e-→γ X→γϕJ/ψ signals

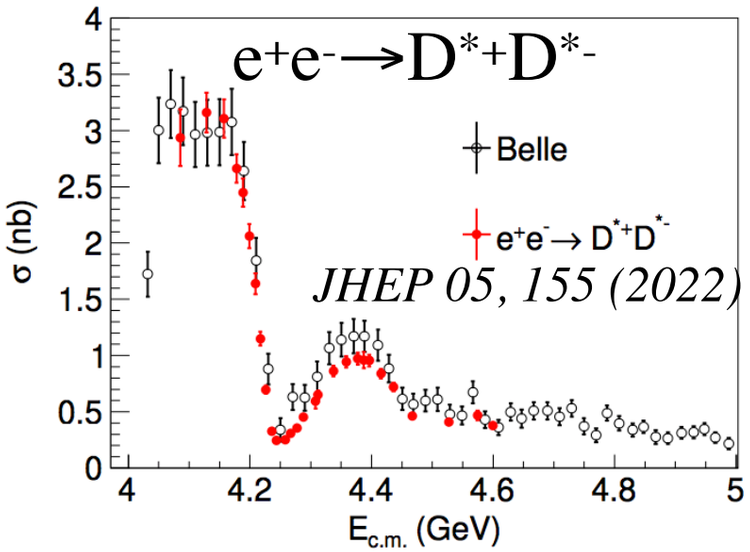


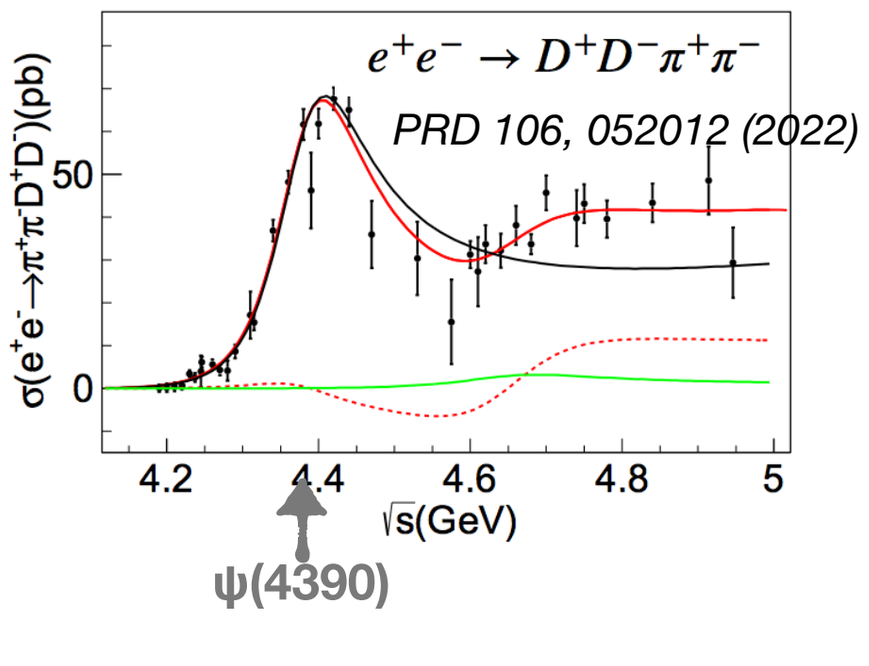




$e^+e^-\to$open charm at BESIII

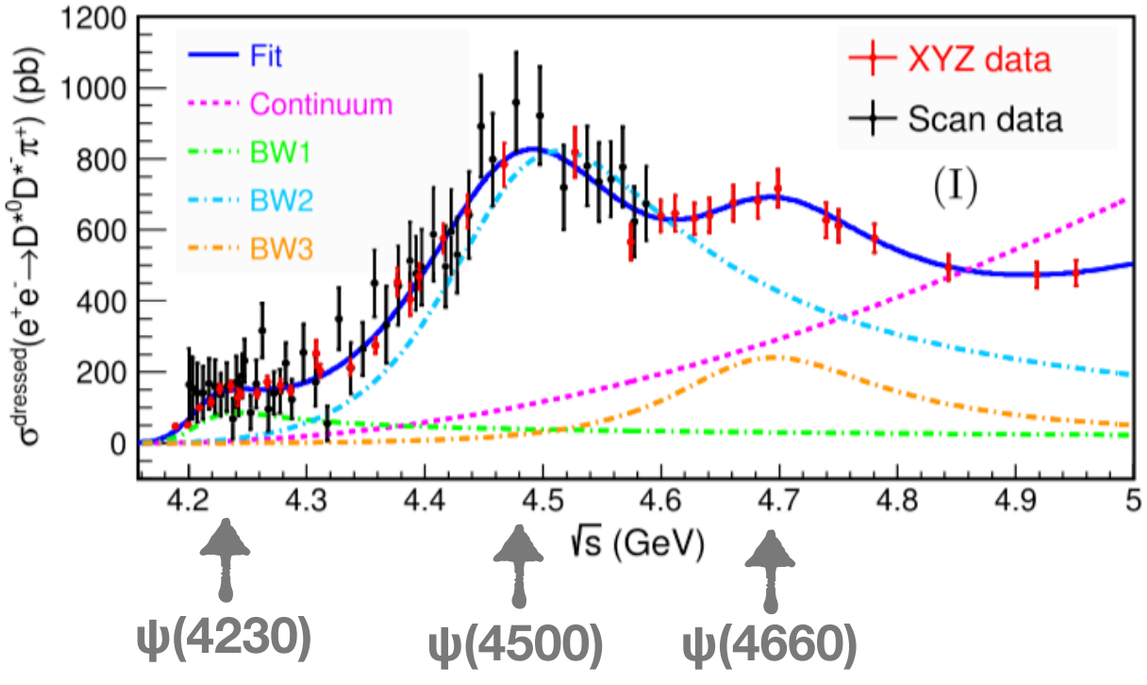






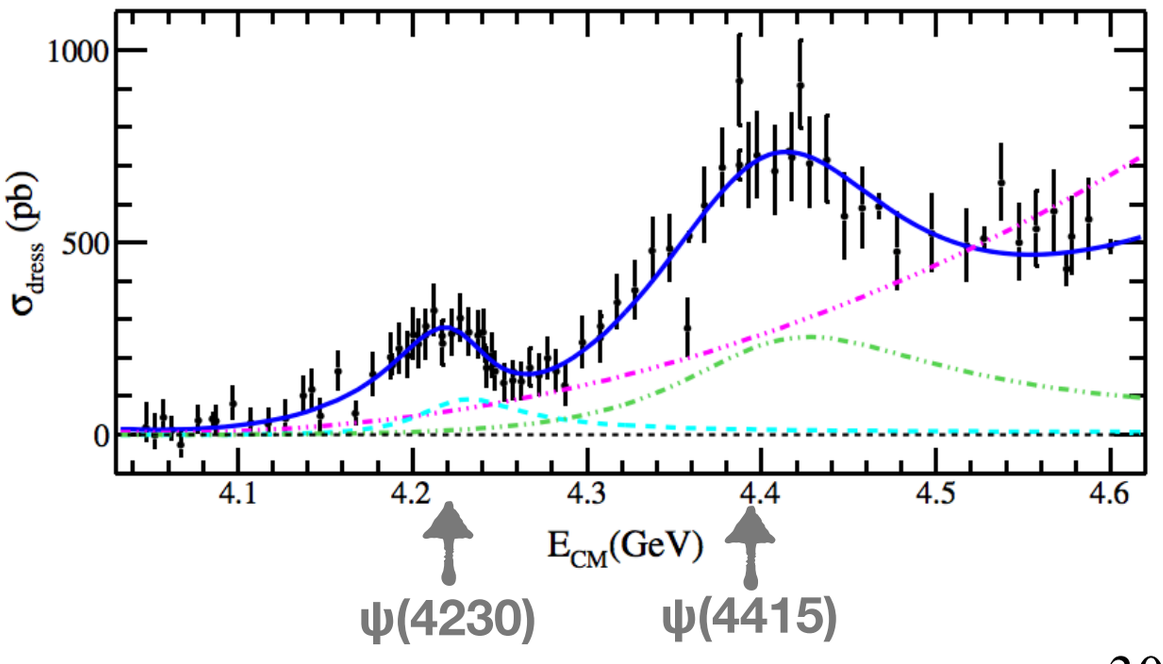
$e^+e^- \to D^{*0}D^{*-}\pi^+$

PRL 130, 121901 (2023)



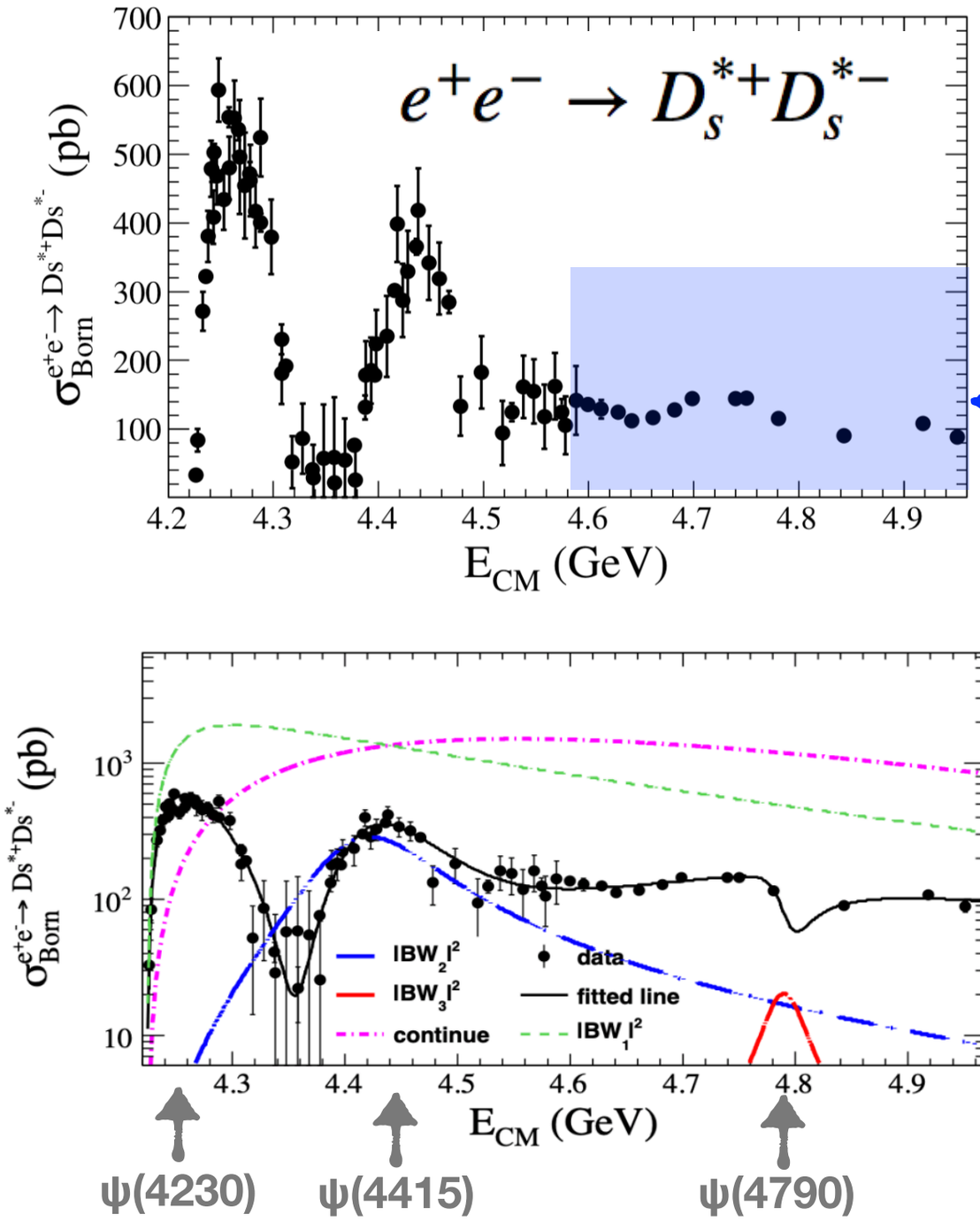
$e^+e^- \to D^0D^{*-}\pi^+$

PRL 122, 102002 (2019)



$e^+e^-\rightarrow$open charm at BESIII

arXiv:2305.10789
Submitted to PRL



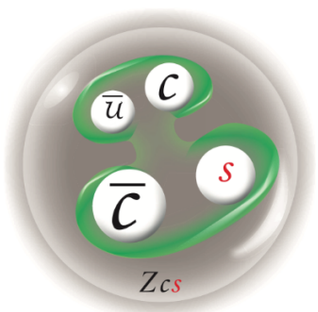
high precision

6.1σ

$Z_{cs}(3985)$

PRL 126,102001 (2021)

$$e^+e^- \to K^+(D_s^- D^{*0} + D_s^{*-} D^0)$$

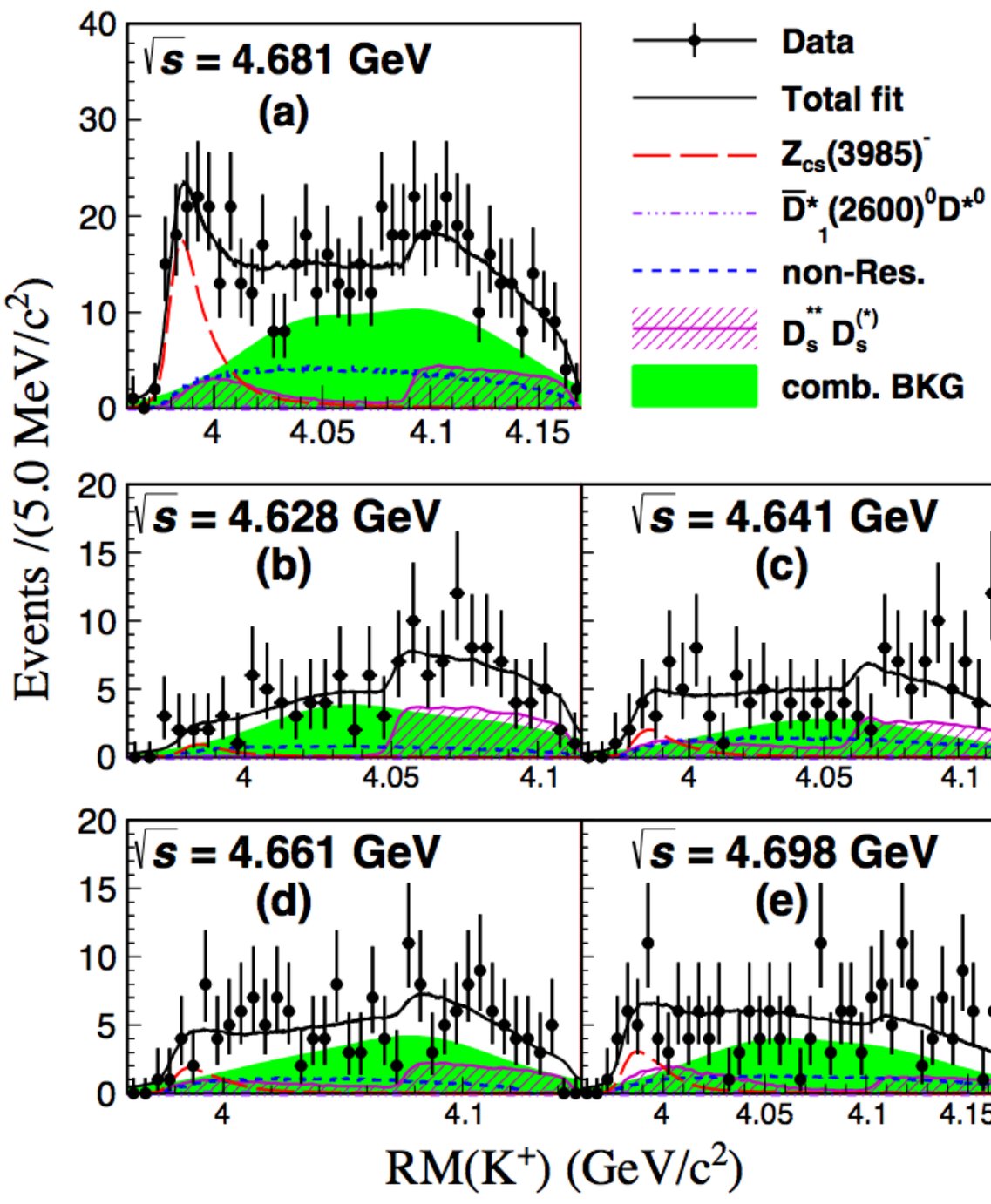


$Z_{cs}(3985)$

- 5.3σ significance

M= $(3982.5^{+1.8}_{-2.6} \pm 2.1)$ MeV/c^2

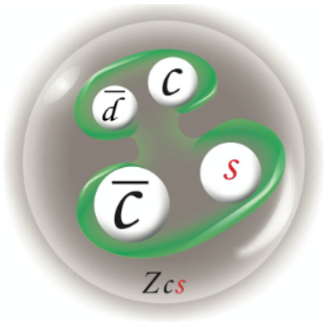
Γ= $(12.8^{+5.3}_{-4.4} \pm 3.0)$ MeV



$Z_{cs}(3985)^0$

PRL 129, 112003 (2022)

$$e^+e^- \to K_S(D_s^- D^{*+} + D_s^{*-} D^+)$$

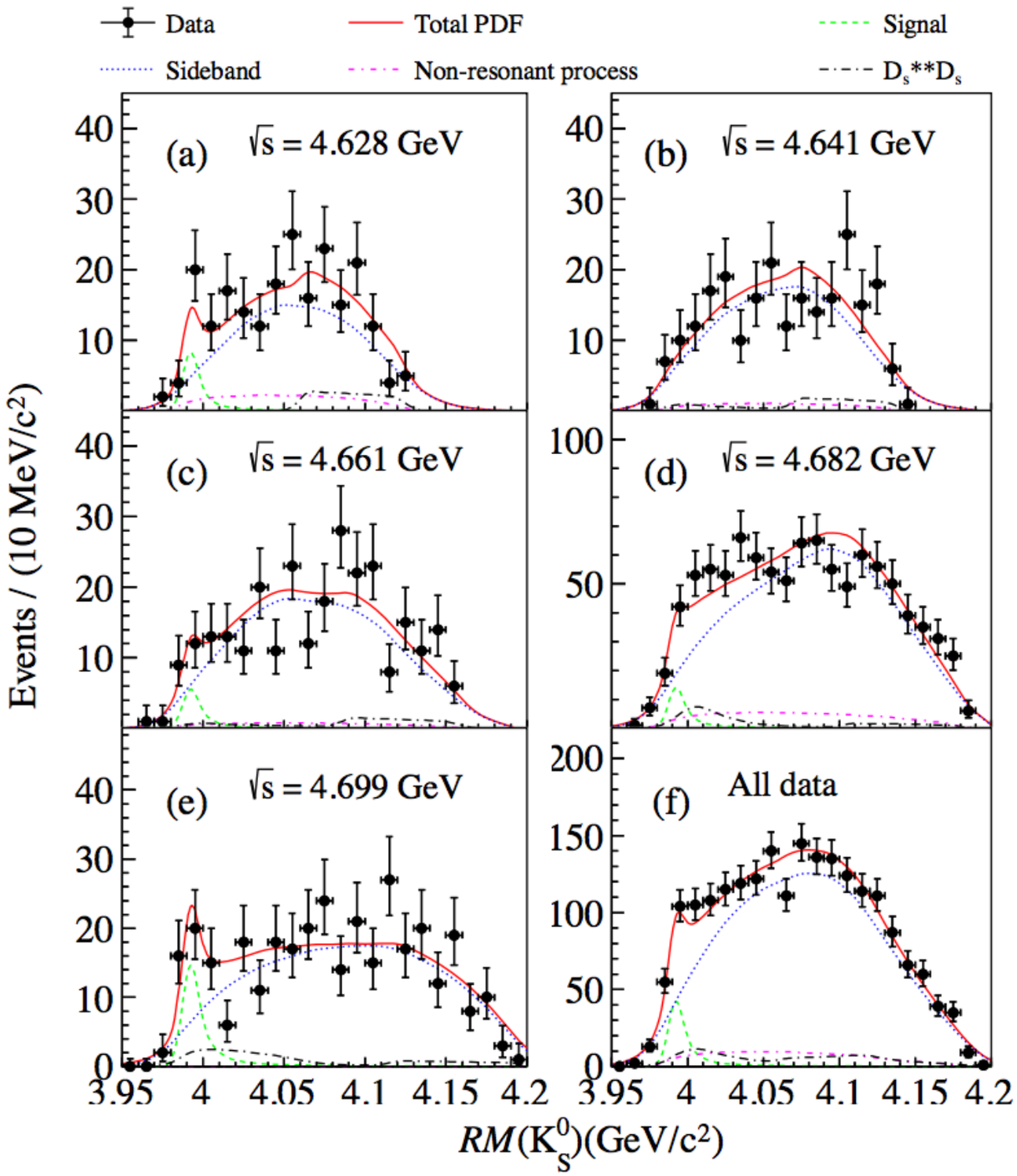


$Z_{cs}(3985)^0$

- 4.6σ significance
- Isospin partner of $Z_{cs}(3985)$

M= $(3992.2 \pm 1.7 \pm 1.6)\ \mathrm{MeV}/c^2$

Γ= $(7.7^{+4.1}_{-3.8} \pm 4.3)\ \mathrm{MeV}$



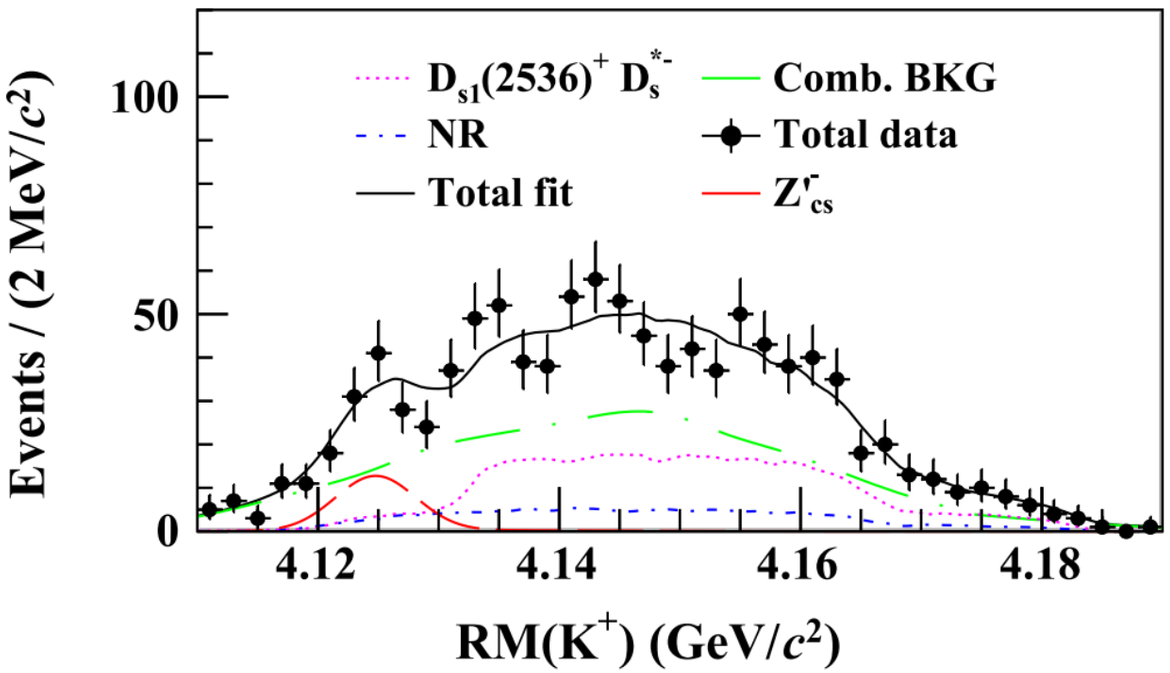
Search for Z'_{cs}

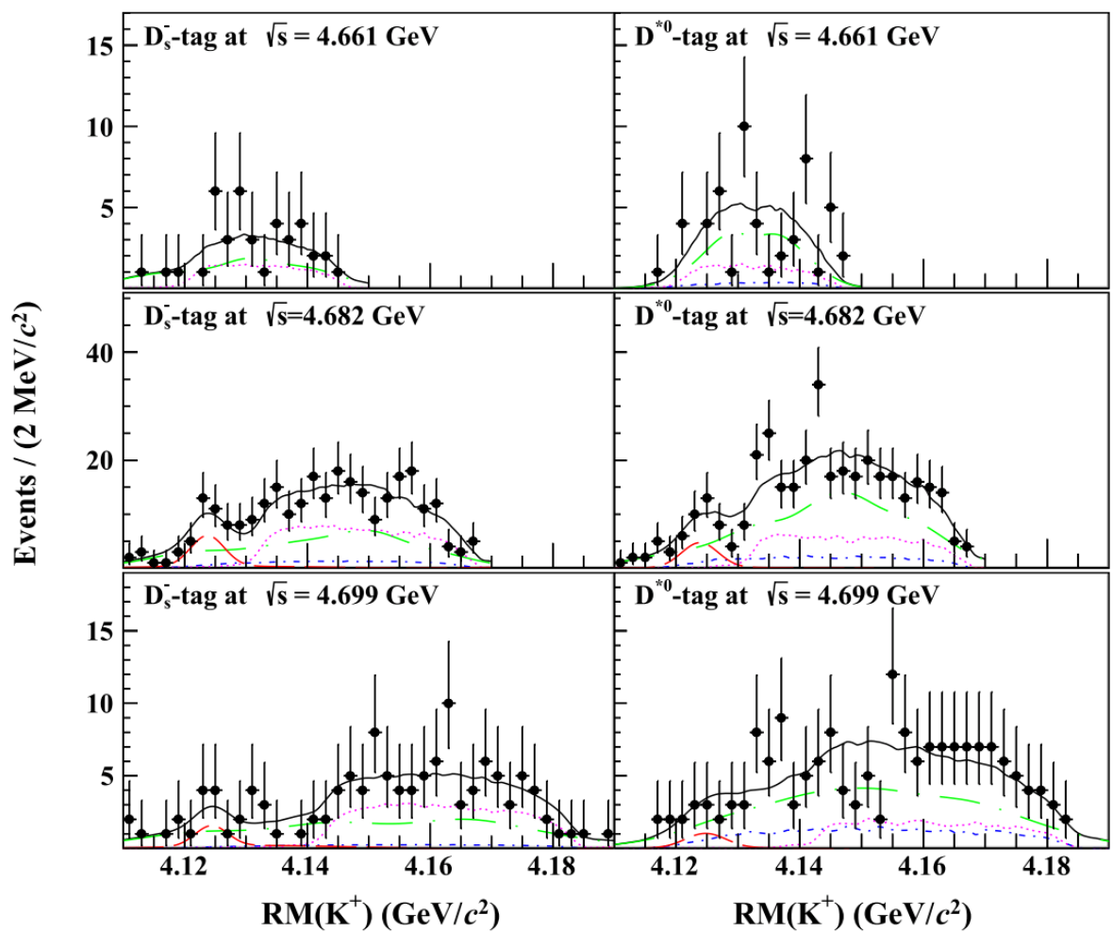
CPC 47, 033001 (2023)

$$Z'_{cs} \text{ in } e^+e^- \to K^+(D_s^{*-}D^{*0})$$

2.1σ significance

$M=(4123.5 \pm 0.7_{\text{stat.}} \pm 4.7_{\text{syst.}})\text{MeV}/c^2$





Summary

- BESIII keeps making contributions to the XYZ physics
  - Investigate the X(3872) in productions, decays and line shape.
  - Vector Y states
    - A series of √s-dependent cross sections of exclusive processes are measured with high precision using the BESIII unique XYZ data.
    - A series of vector resonances are reported.
      - Global analysis of these measurements is essential to explore the correlation between these structures.
  - Observations of the tetraquark states with strangeness.

- BEPCII Upgrade (BEPCII-U) in 2024
  - Beam energy up to 2.8 GeV
  - 3x BEPCII luminosity above 4 GeV