

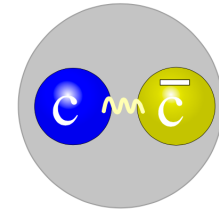
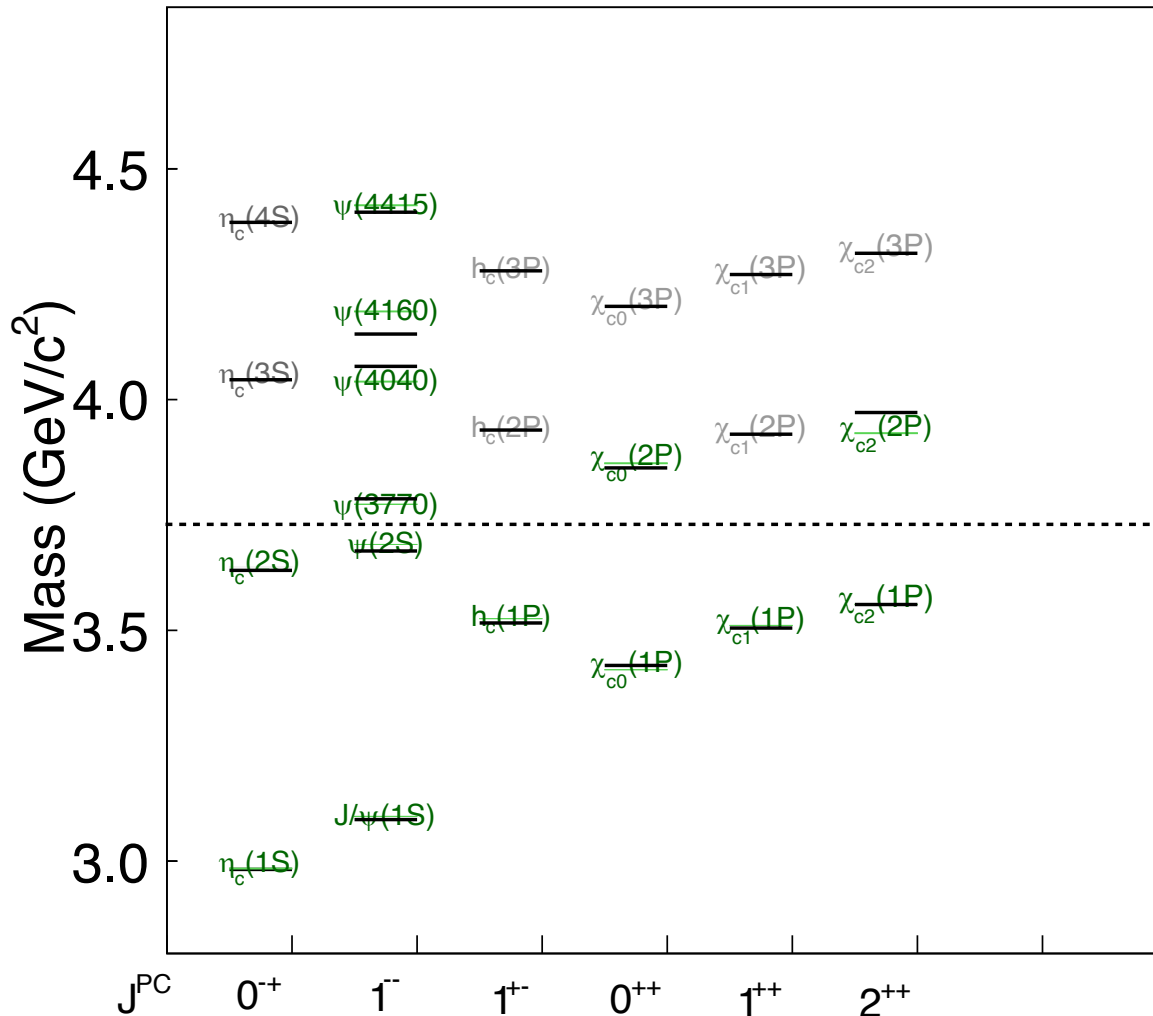
# Recent Results on the Y states at **BESIII**

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# Charmonium Spectroscopy



$$V_0^{(c\bar{c})}(r) = -\frac{4\alpha_s}{3r} + kr + \frac{32\pi\alpha_s}{9m_c^2} \vec{S}_c \cdot \vec{S}_{\bar{c}} \delta(r) + \frac{1}{m_c^2} \left[ \left( \frac{2\alpha_s}{r^3} - \frac{k}{2r} \right) \vec{L} \cdot \vec{S} + \frac{4\alpha_s}{r^3} T \right]$$

[PRD 72,054026 (2005)]

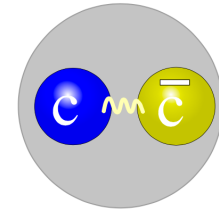
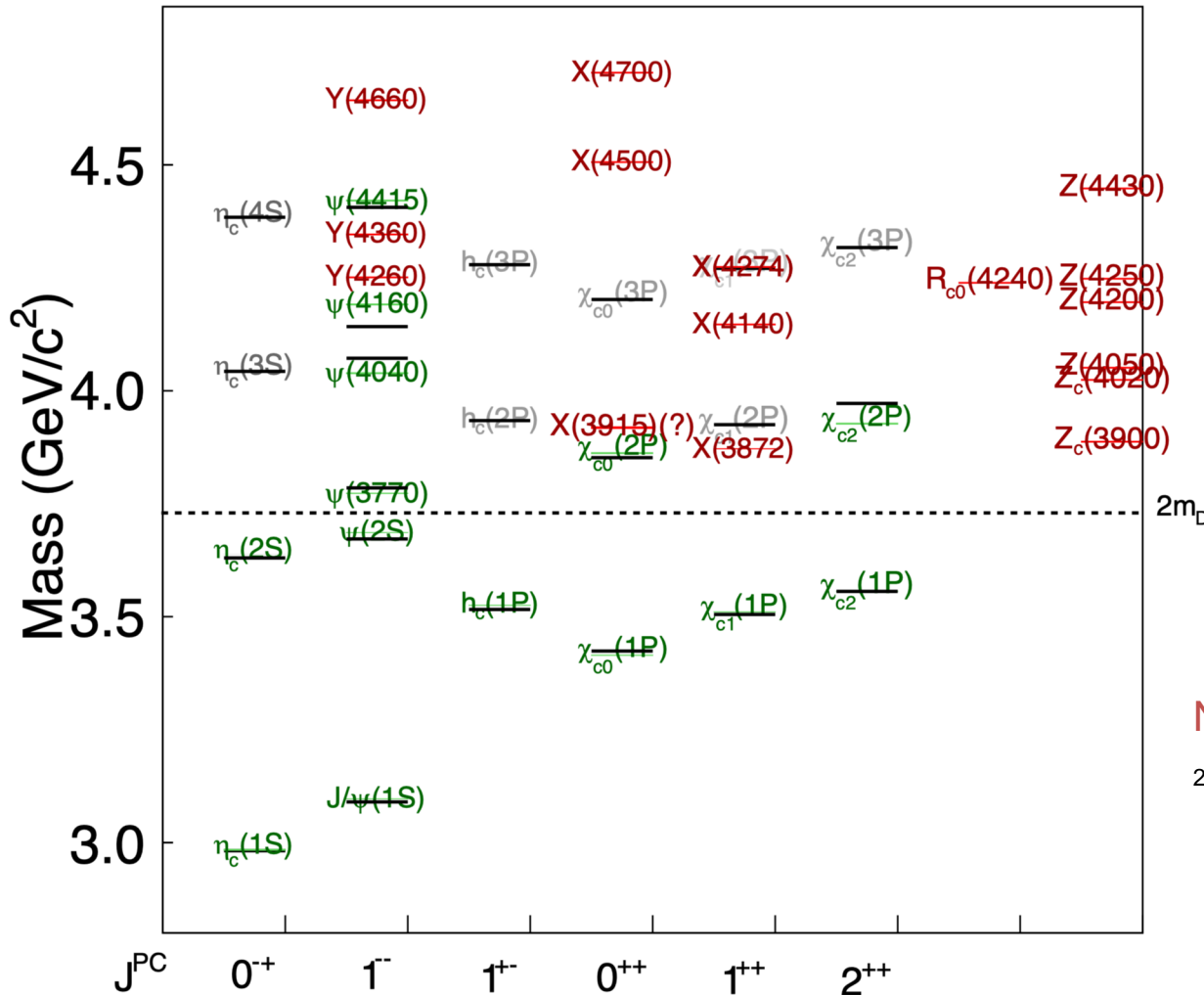
Notation:

$$2S+1L_J \quad P=(-1)^{L+1}$$

$$J^{PC} \quad C=(-1)^{L+S}$$

[Predictions: PRD 72,054026 (2005); Measurements: PDG]

# Charmonium Spectroscopy

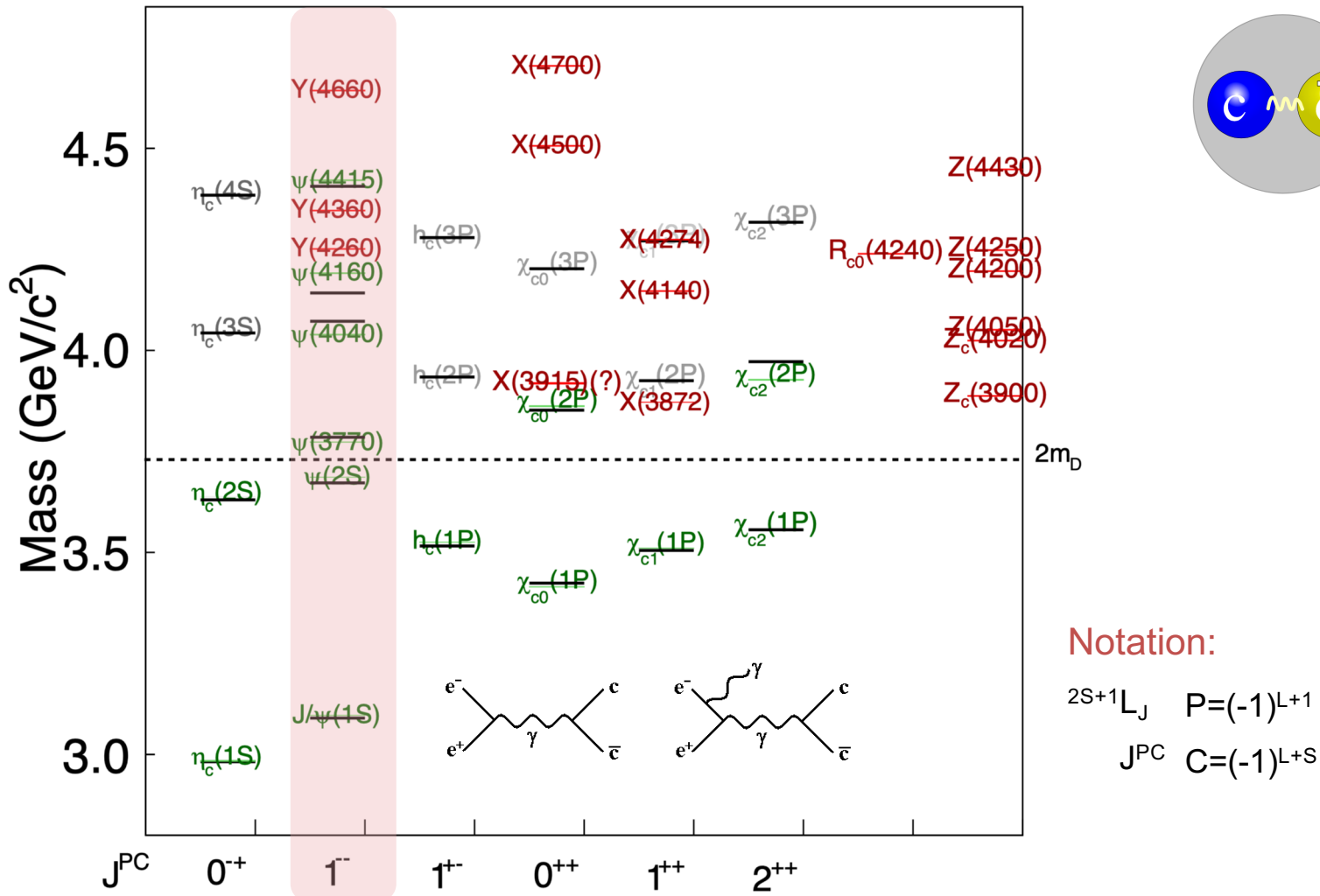


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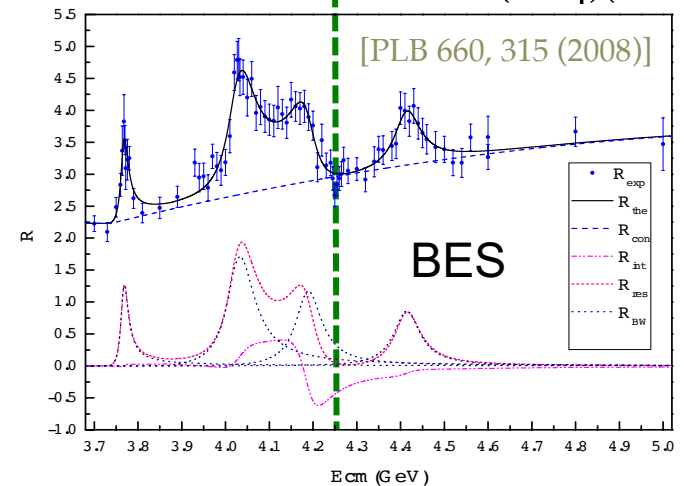
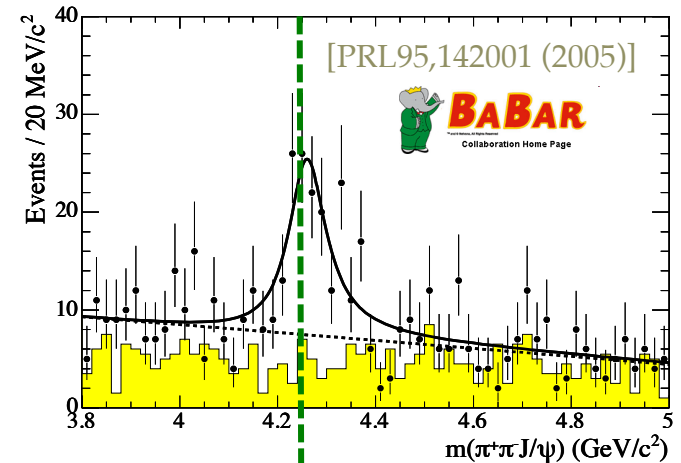
# Charmonium Spectroscopy



[Predictions: PRD 72,054026 (2005); Measurements: PDG]

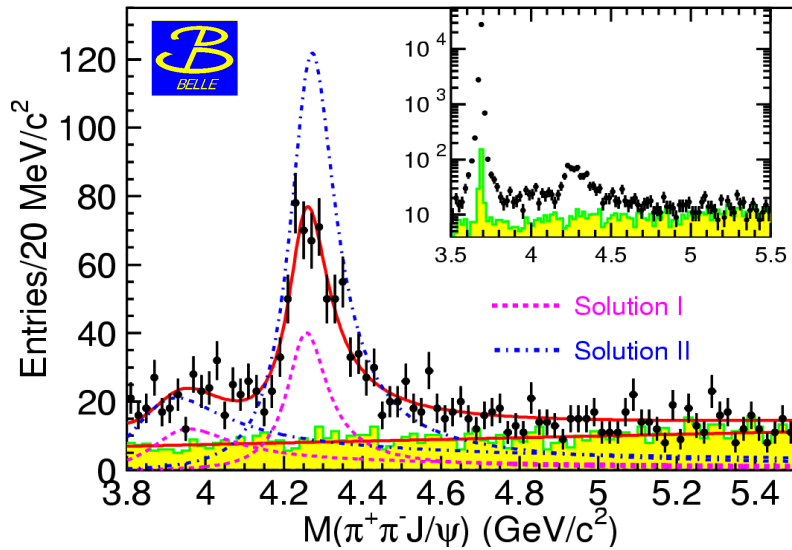
# Discovery

- First state -  $Y(4260)$ , discovered in ISR process at BaBar
  - $e^+e^- \rightarrow \gamma_{ISR} \pi^+ \pi^- J/\psi$
  - $M > 4$  GeV above  $D\bar{D}$  threshold
  - Not observed in inclusive hadron cross section
  - Not observed in open charm pair cross section
  - Confirmed by CLEO and Belle

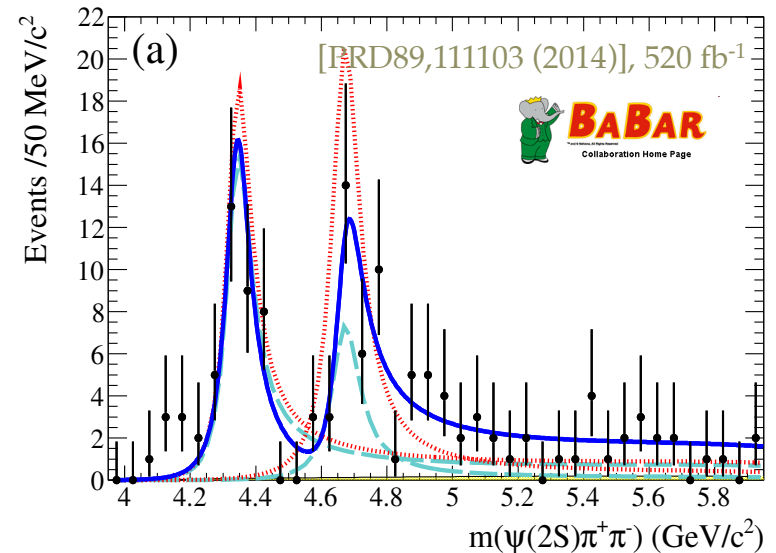
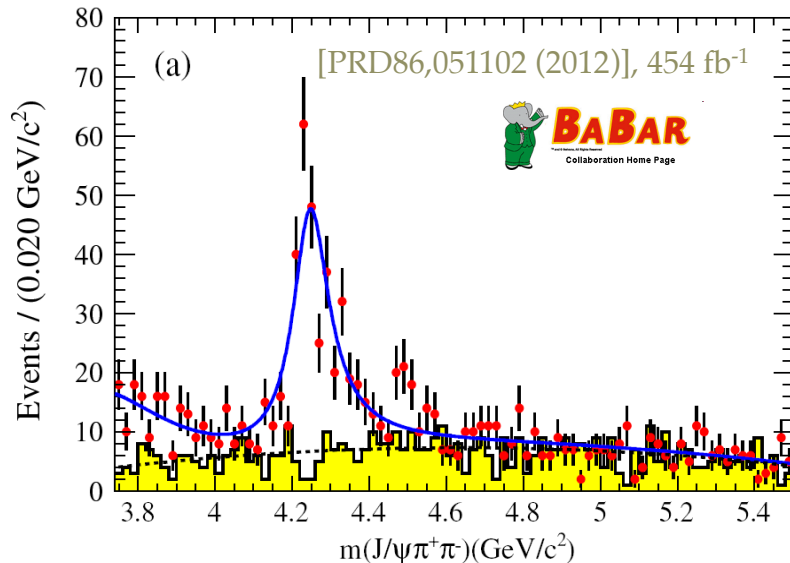
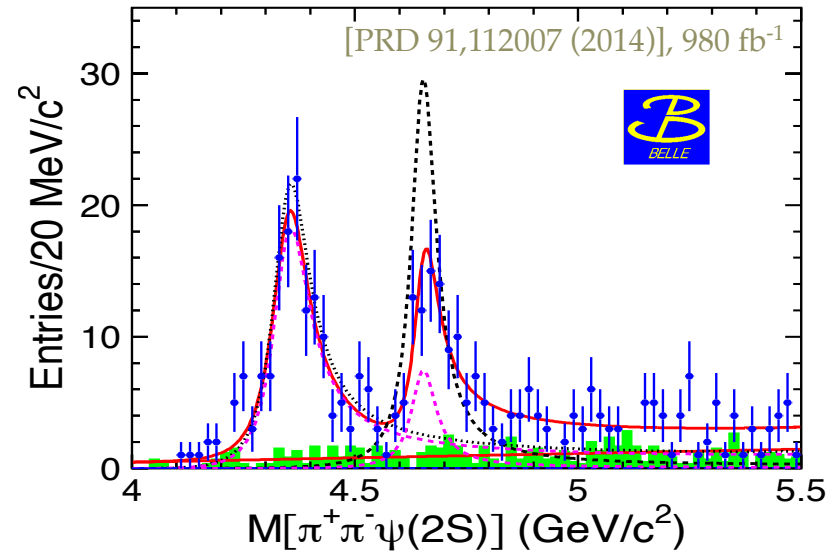


# Y from ISR Process

[PRL110,252002 (2013)], 967 fb<sup>-1</sup>

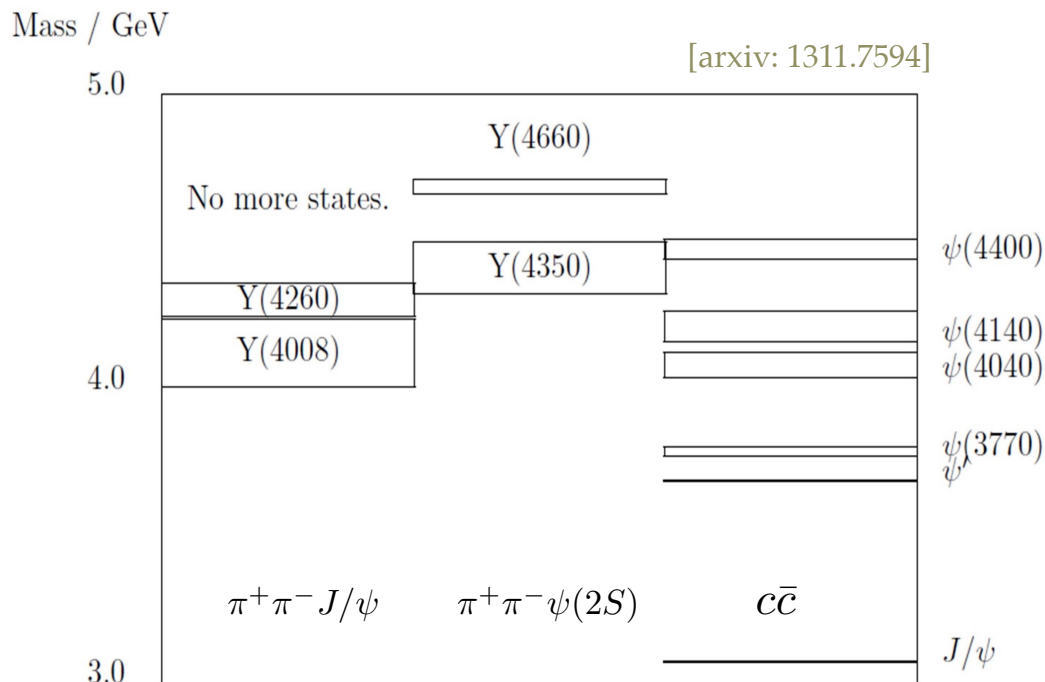


[PRD 91,112007 (2014)], 980 fb<sup>-1</sup>

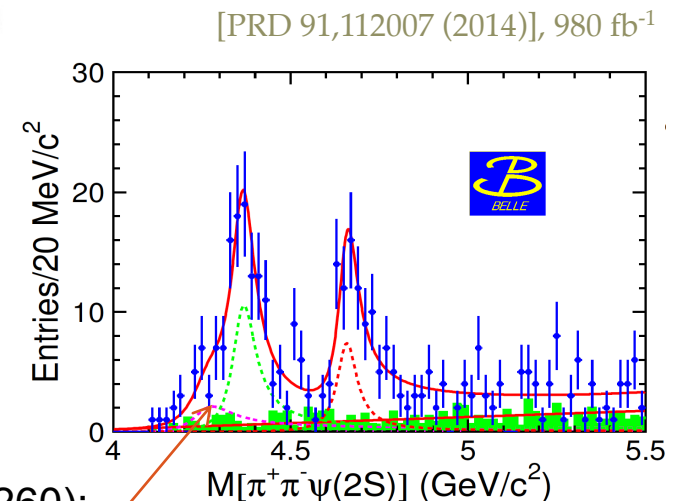


# Over Population 1<sup>-</sup> States

Above open charm threshold, 5 expected, 7 observed

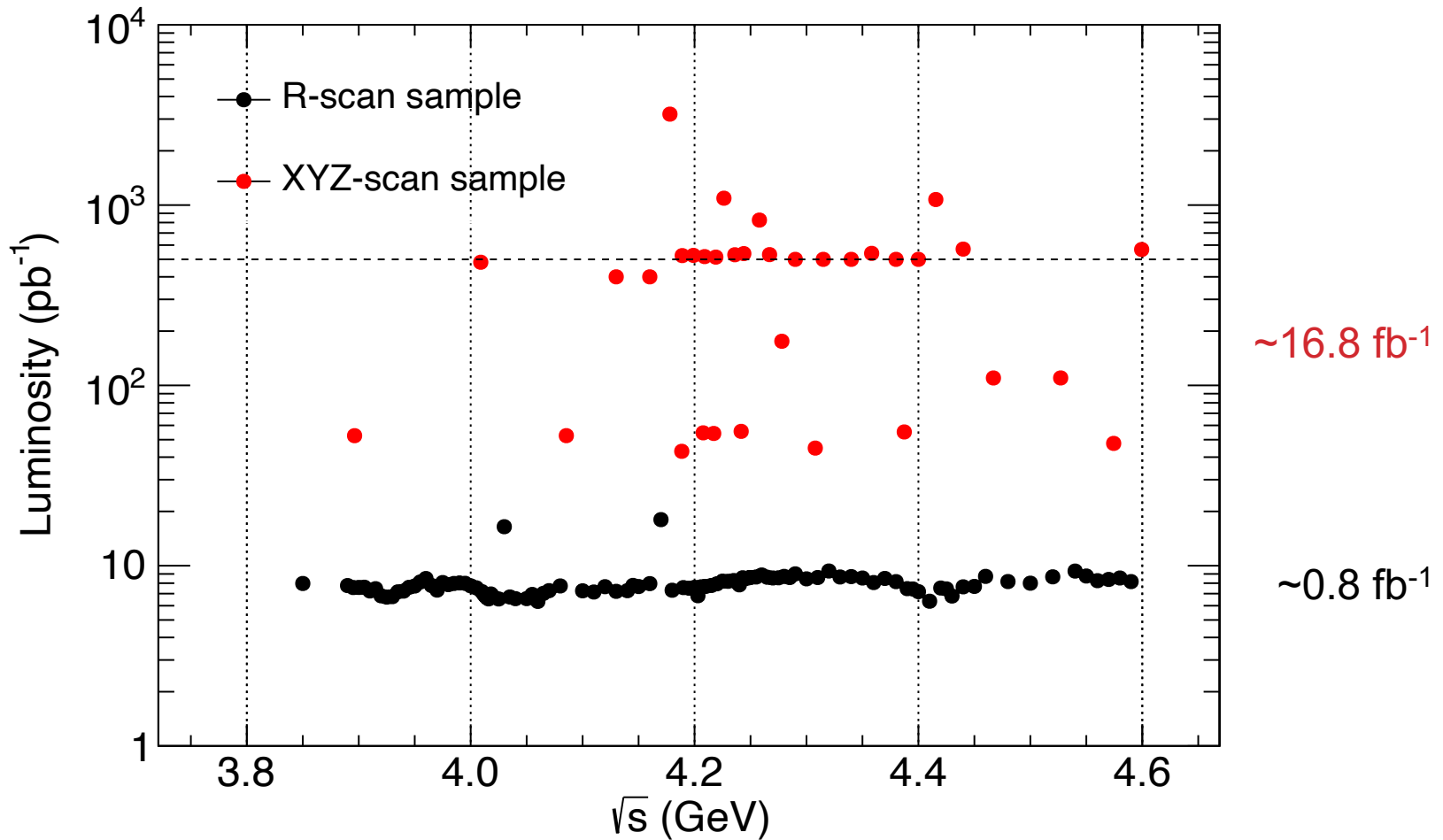


Before 2015



Y(4260):  
hint? (2.4 $\sigma$ )

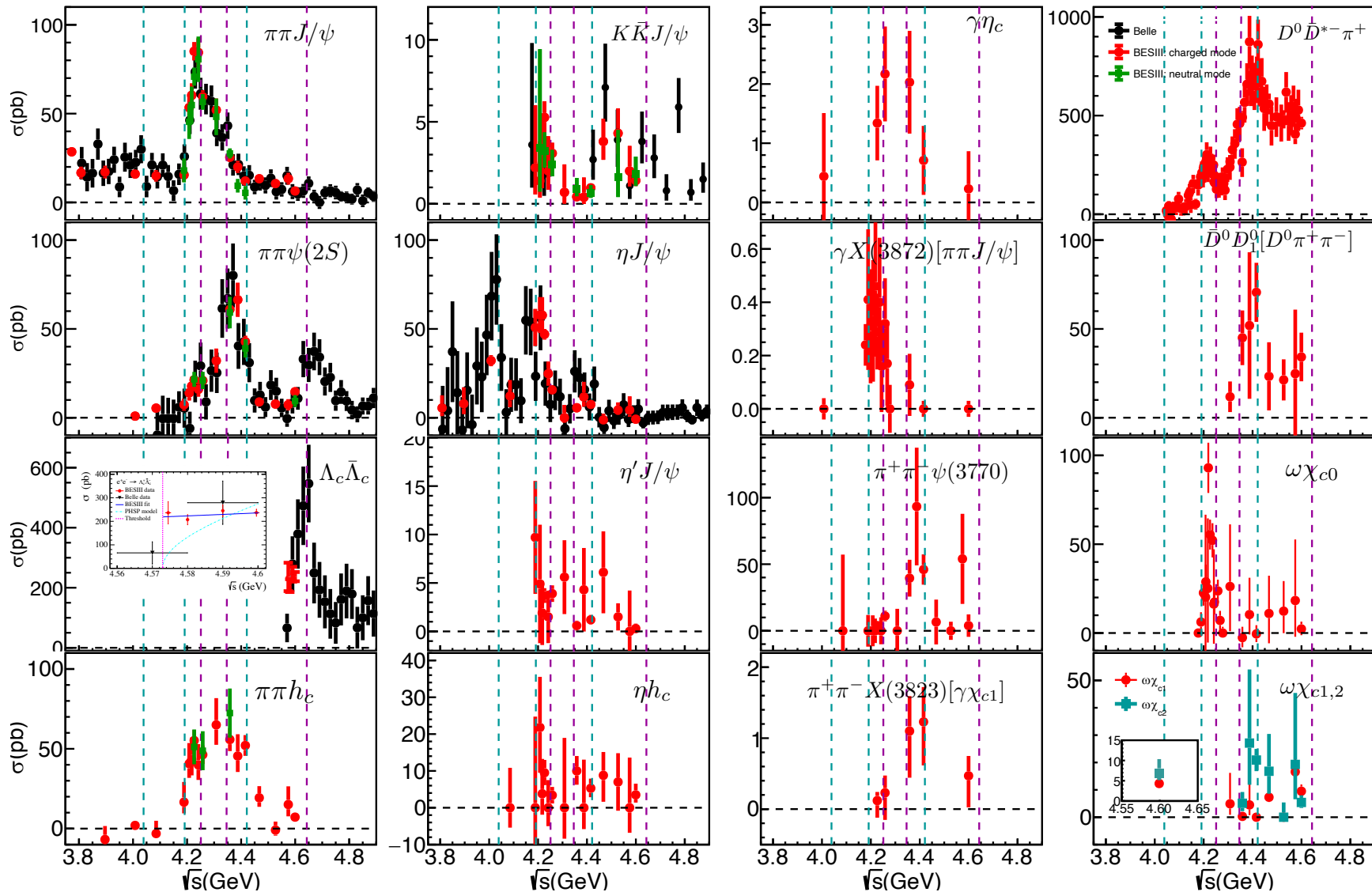
# High Lumi. Scan Sample



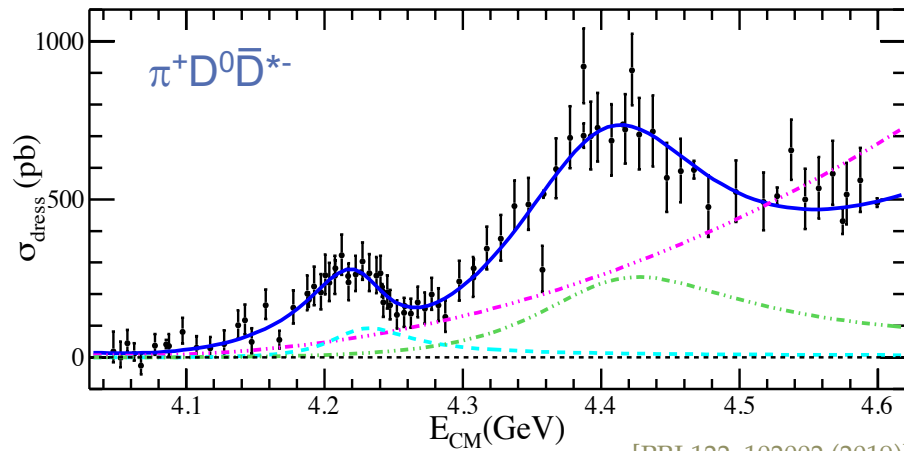
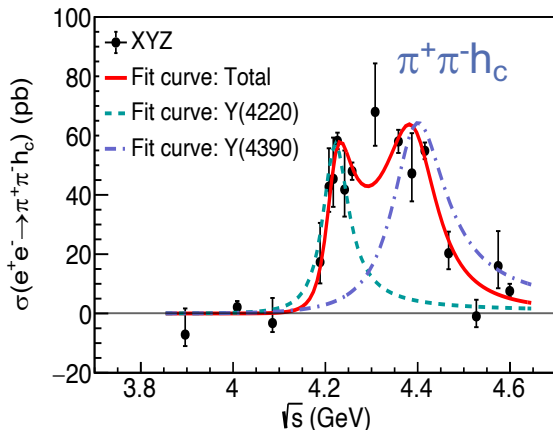
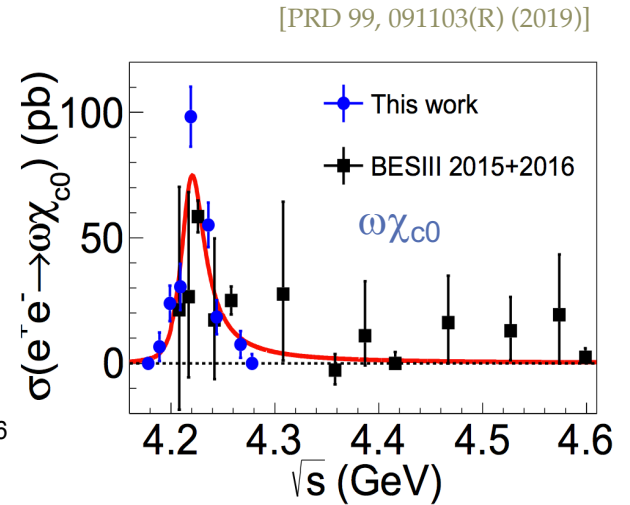
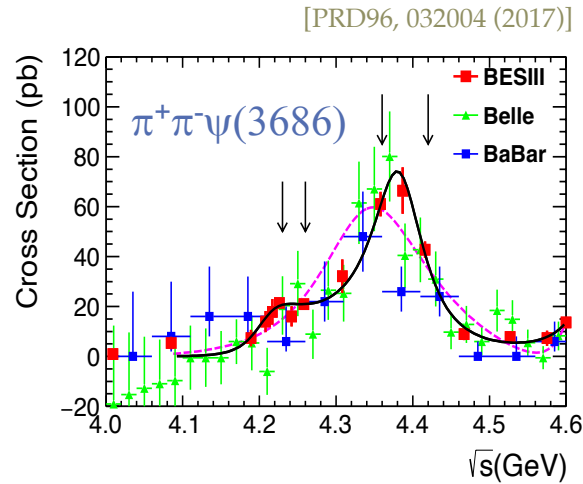
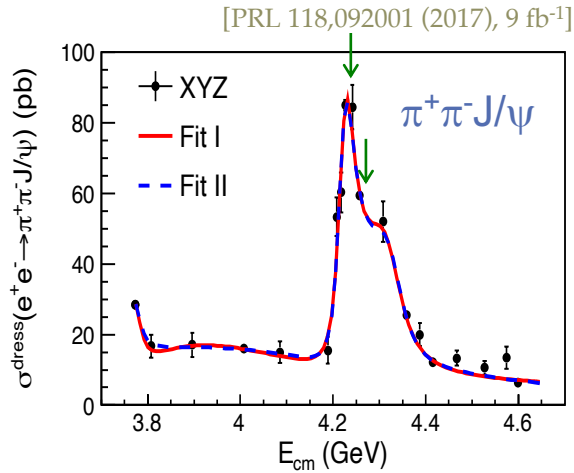
22 points with  $\mathcal{L} > 500 \text{ pb}^{-1}$ , 104 points with  $\mathcal{L} \sim 8 \text{ pb}^{-1}$



# Measurements at BESIII



# Y(4220)

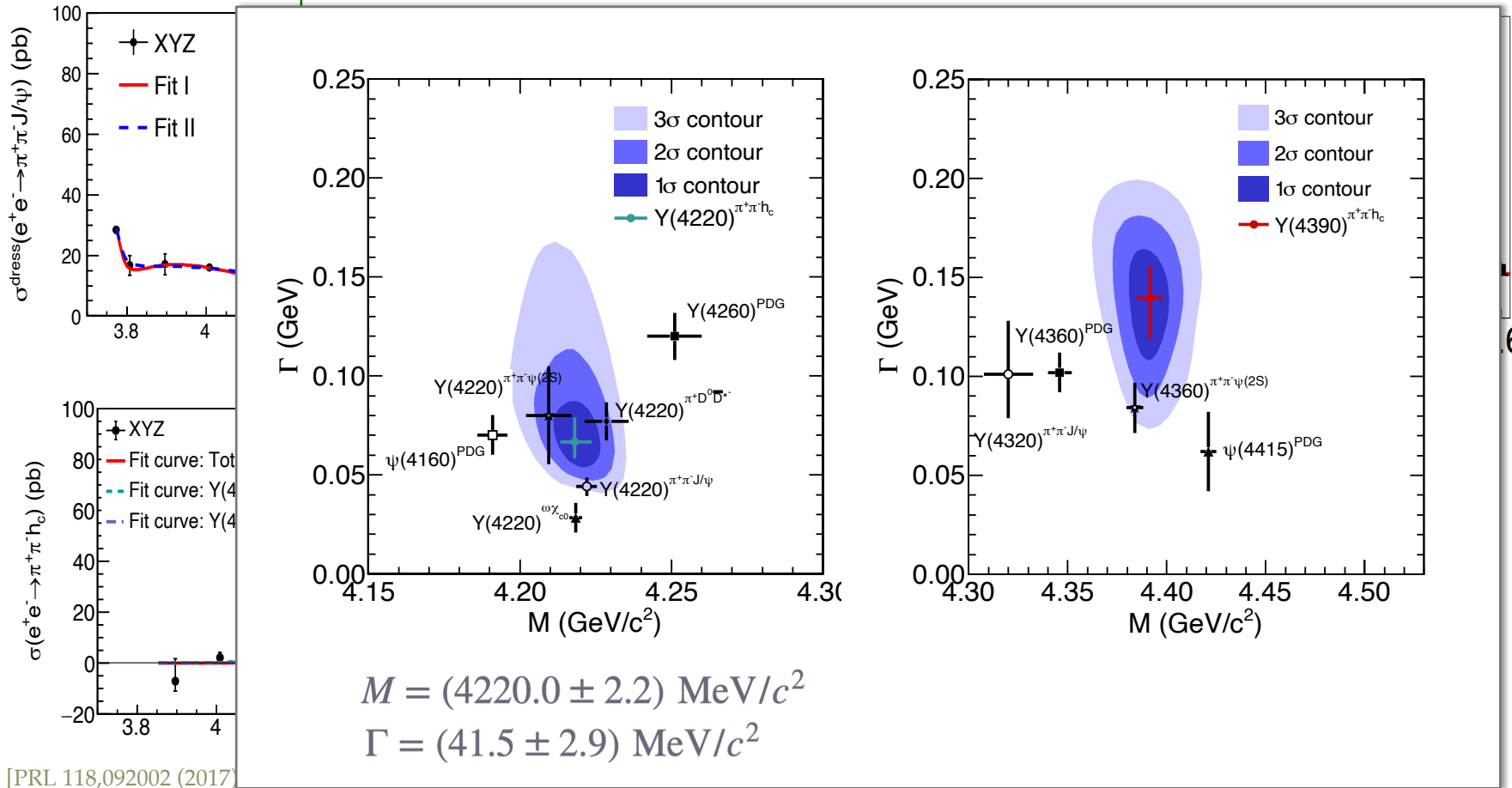


# Y(4220)

[PRL 118,092001 (2017), 9 fb<sup>-1</sup>]

[PRD96, 032004 (2017)]

[PRD 99, 091103(R) (2019)]



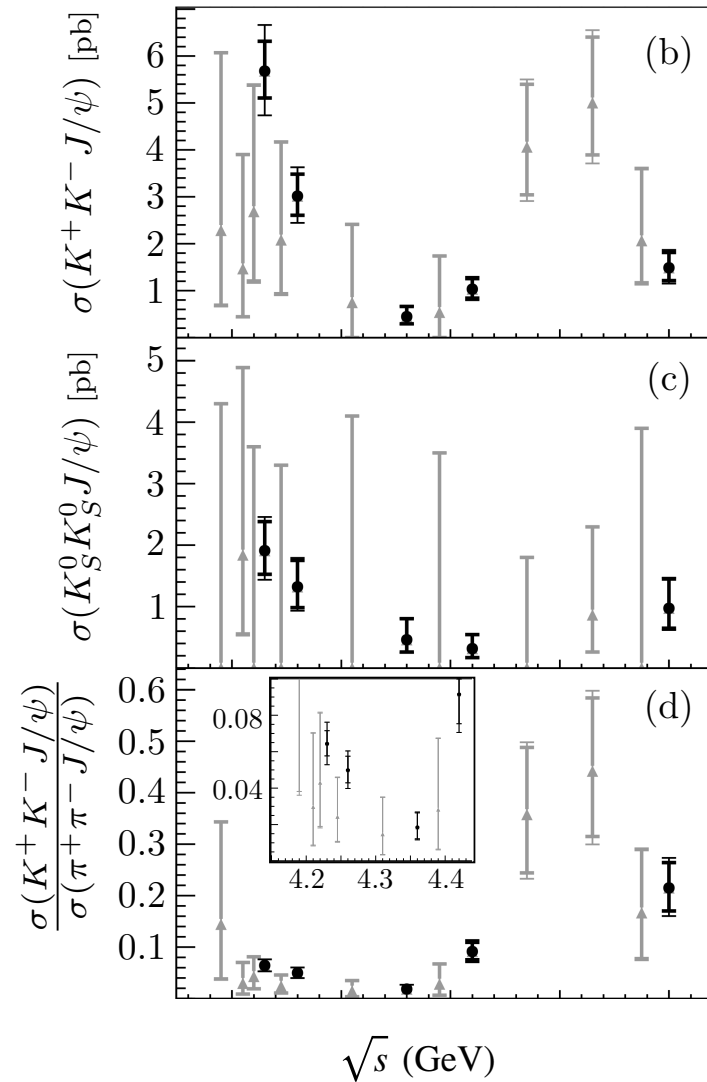
[PRL 118,092002 (2017)]

[PRL122, 102002 (2019)]

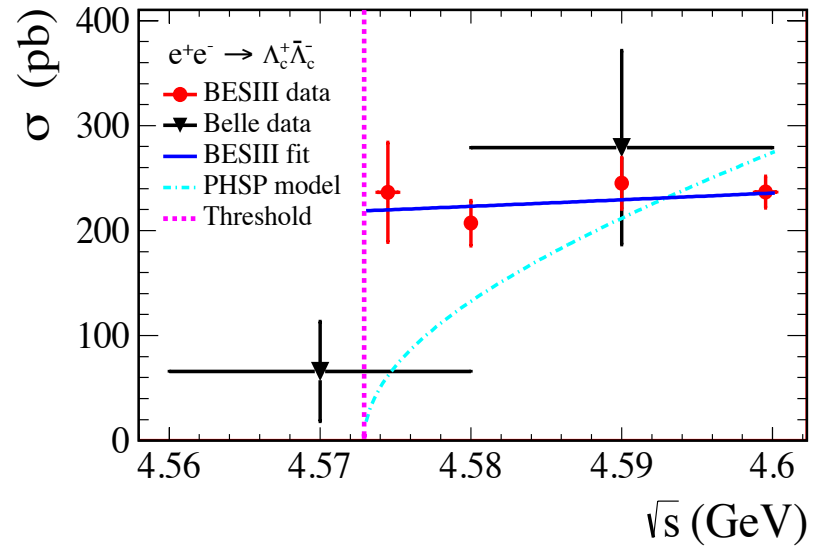
Proper parameterization, couple channel effects!

# $e^+e^- \rightarrow KKJ/\psi$

[PRD 97,071101 (2018)]

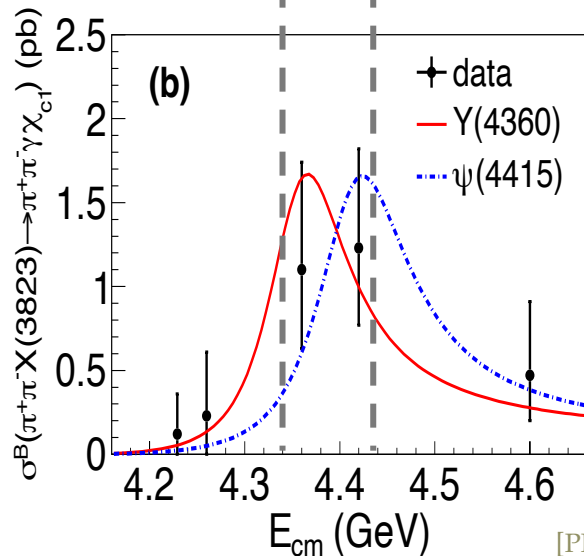
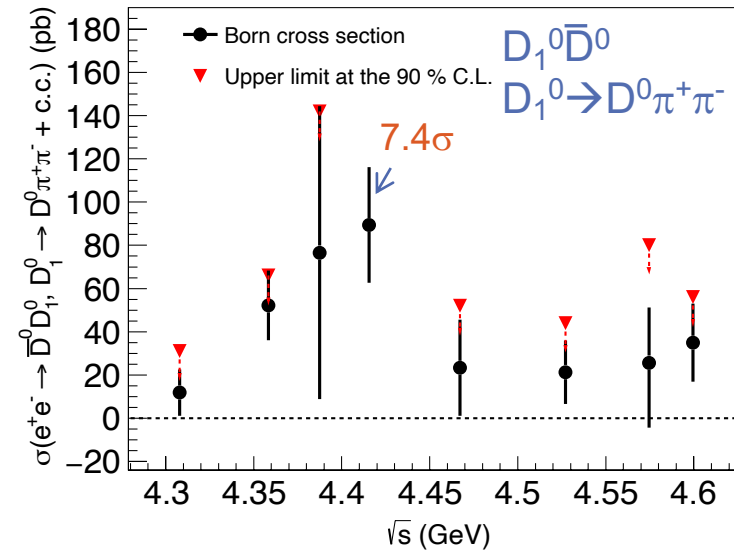
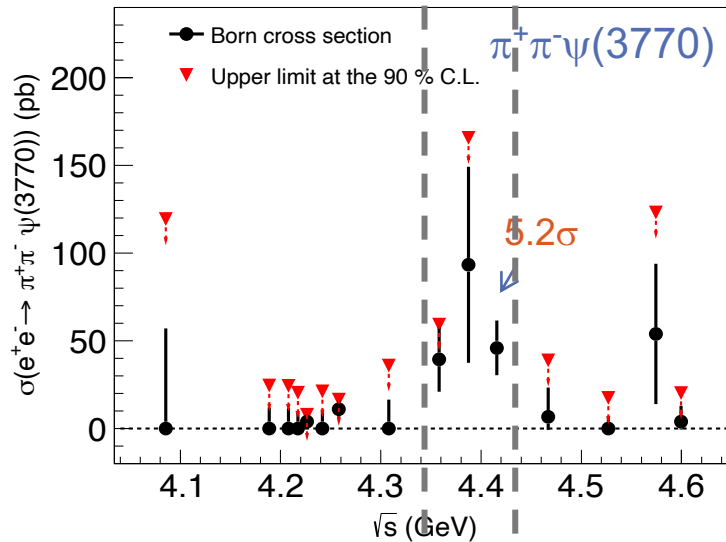


# $e^+e^- \rightarrow \Lambda_c^+\bar{\Lambda}_c^-$



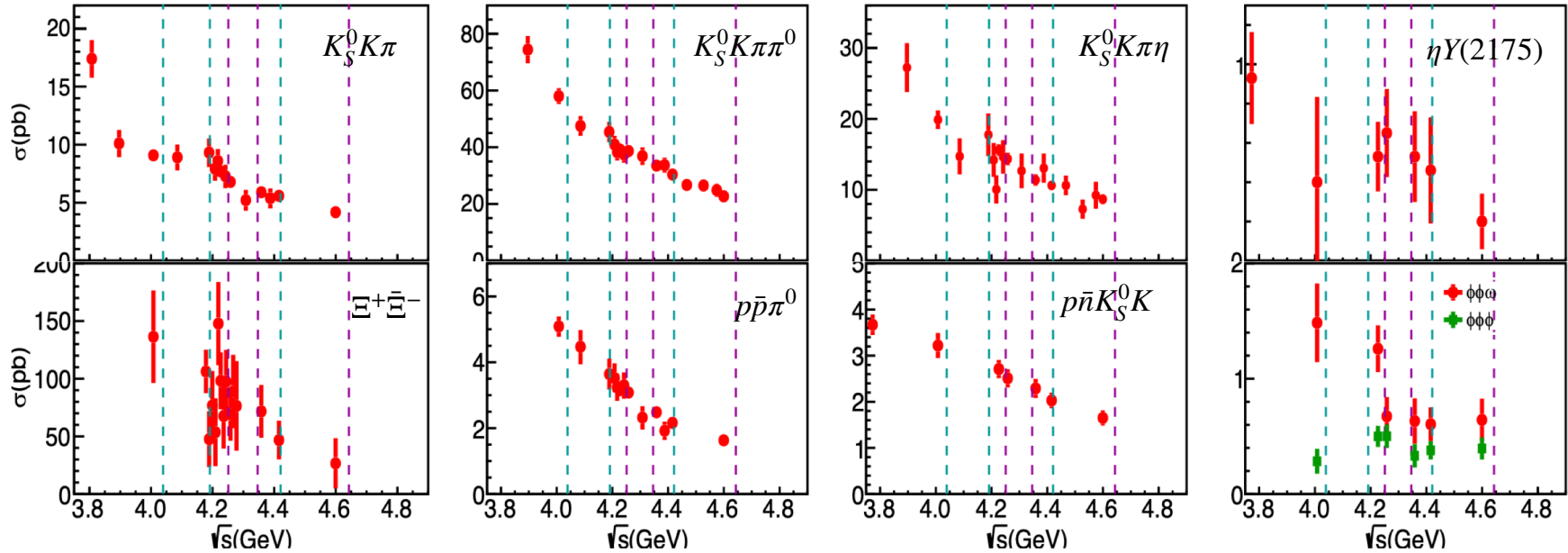
# $e^+e^- \rightarrow \pi^+\pi^-D\bar{D}$

[PRD 100, 032005 (2019)]



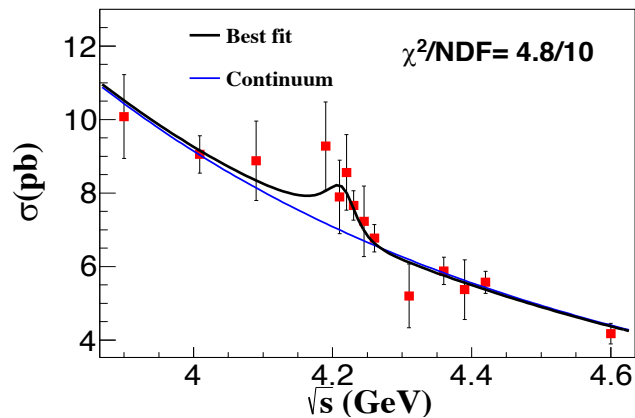
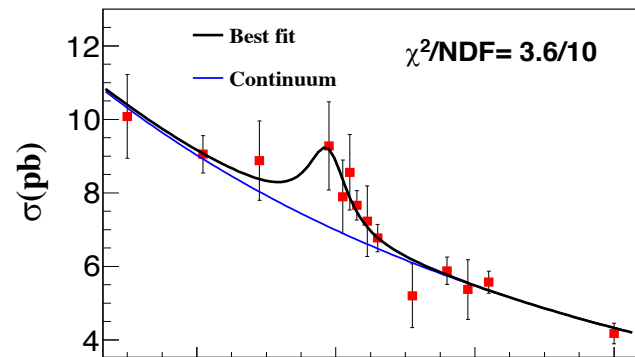
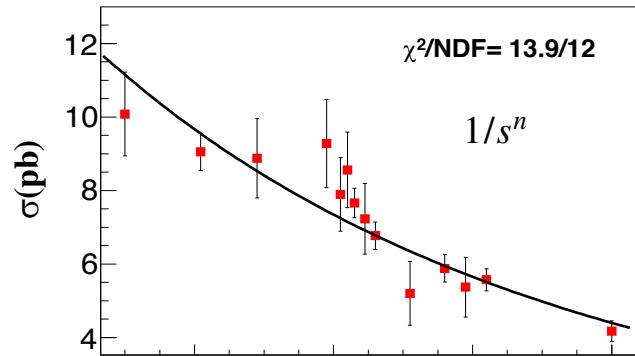
[PRL 115, 011803 (2015)]

# Measurements at BESIII



# $e^+e^- \rightarrow K_S^0 K \pi$

[PRD 99, 072005 (2019)]



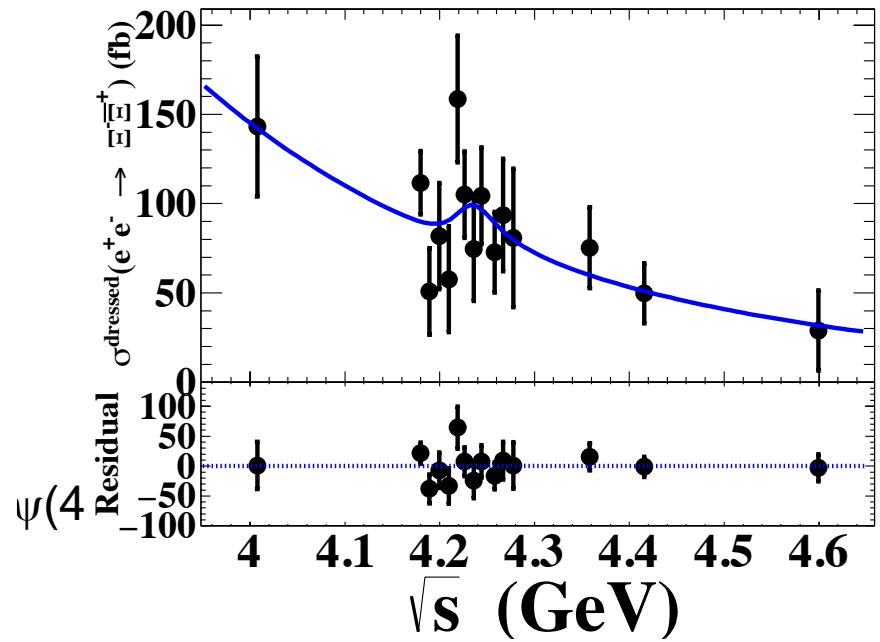
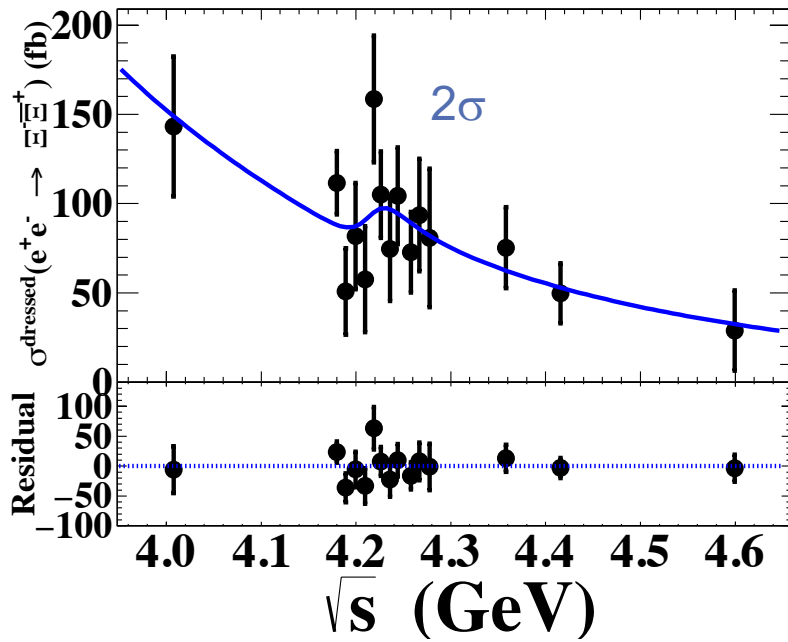
$$|a \cdot \sqrt{1/s^n} + e^{i\phi} BW|^2$$

$\psi(4160), 2.5\sigma$

$Y(4220), 2.2\sigma$

# $e^+e^- \rightarrow \Xi^+ \bar{\Xi}^-$

[arXiv:1910.04921]



$$|a \cdot \sqrt{1/s^n} + e^{i\phi} BW|^2$$



# Summary

- **Overpopulation of  $1^-$  states above 4 GeV**
  - Cross section measurement with much improved precision,  $Y(4260) \rightarrow Y(4230)$ ; multi decay modes
  - Light hadron final states
- **Data above 4.6 GeV at BESIII in near future**
  - To 4.7 GeV this year
  - To 4.9 GeV
- **Global and simultaneous study of different final states needed**

THANK YOU!