Hadronic Transitions Above 4 GeV at the BESIII Experiment

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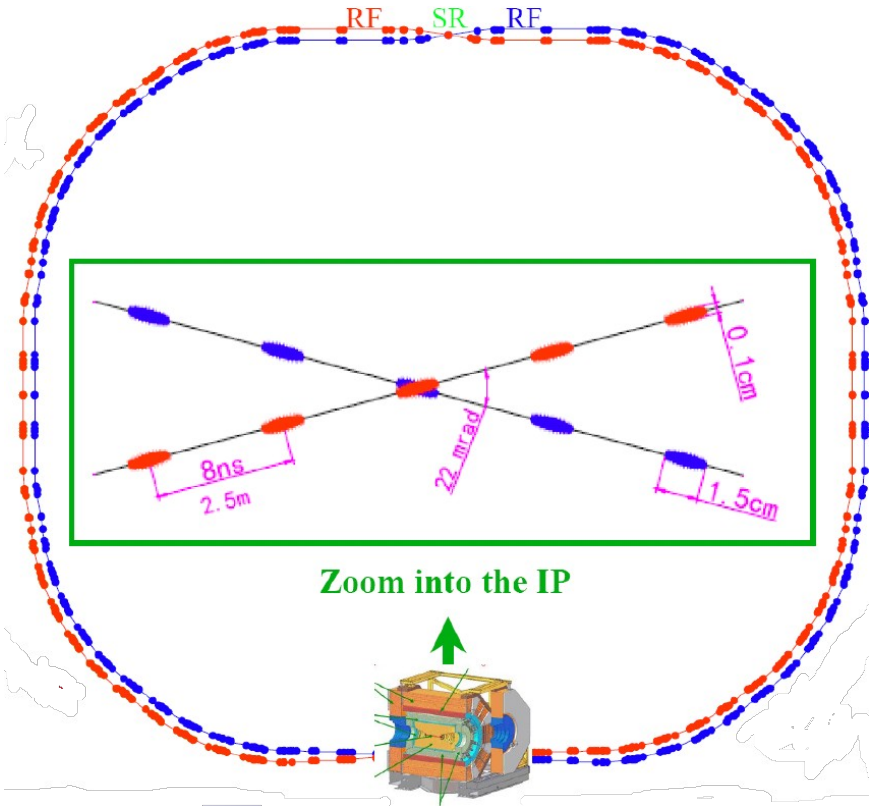
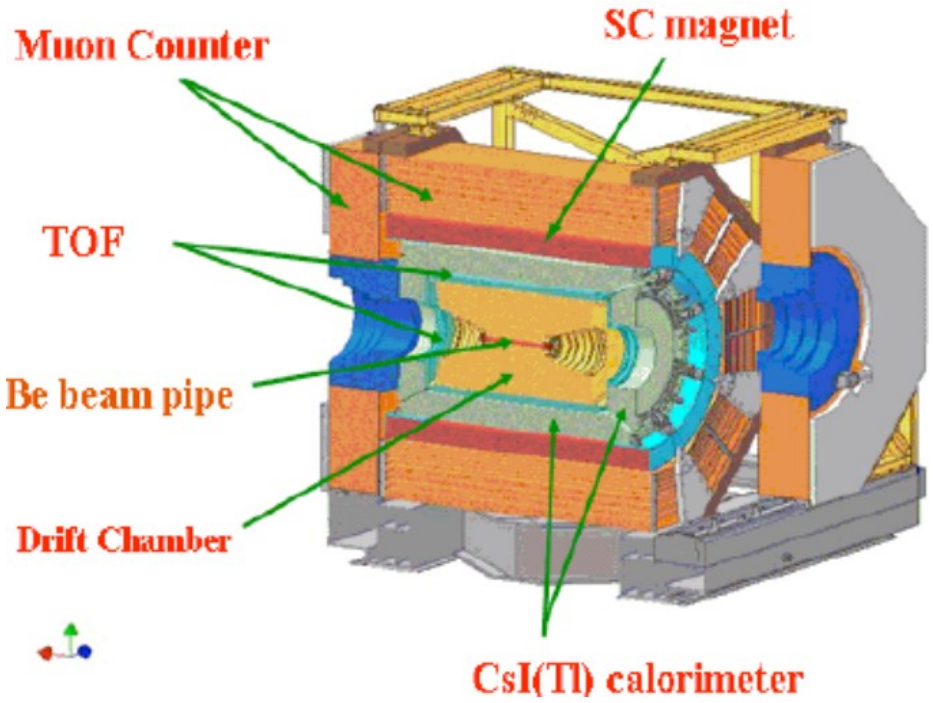
BESIII Experiment

e+e- Collider

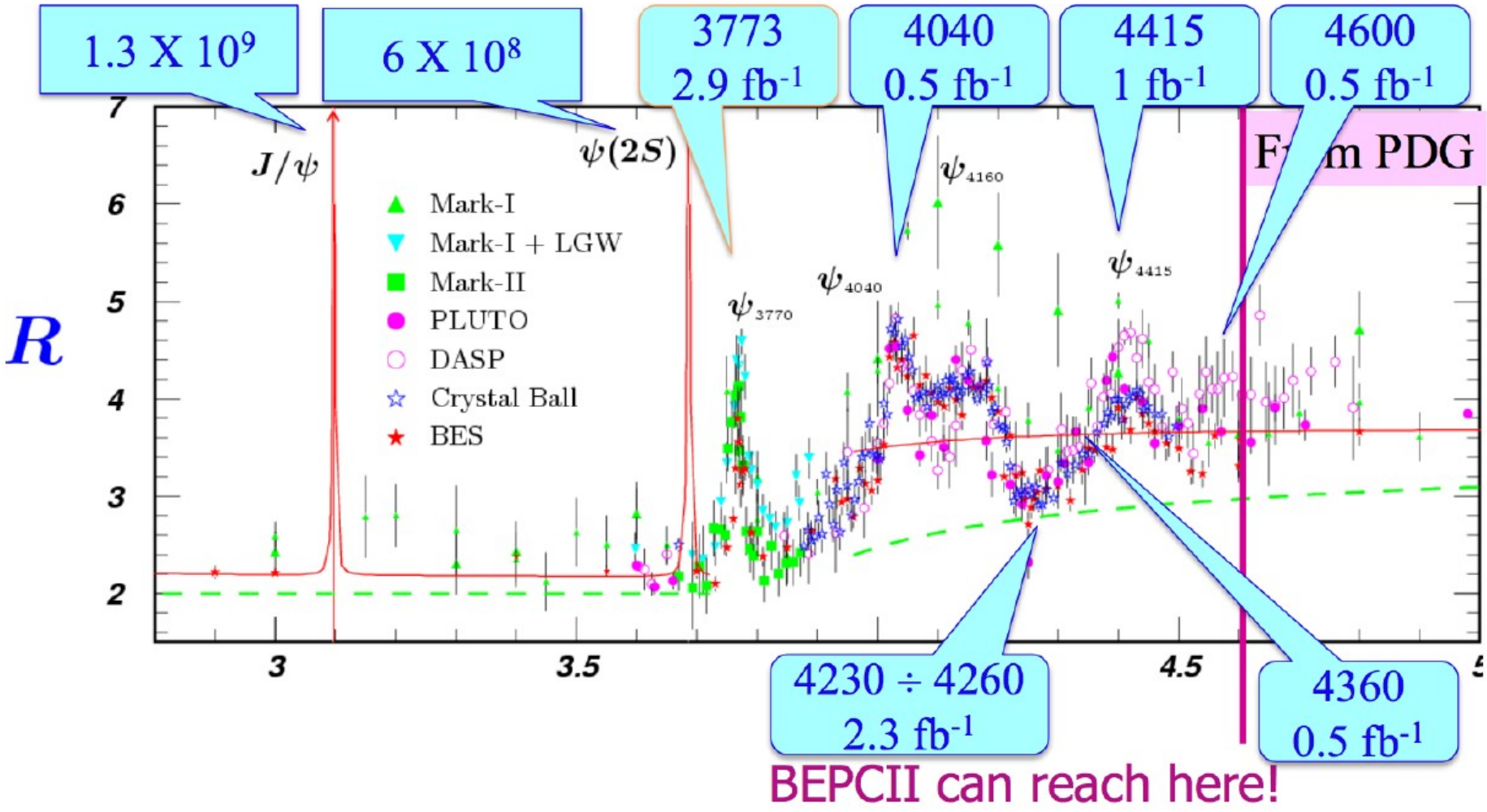
BEPC2



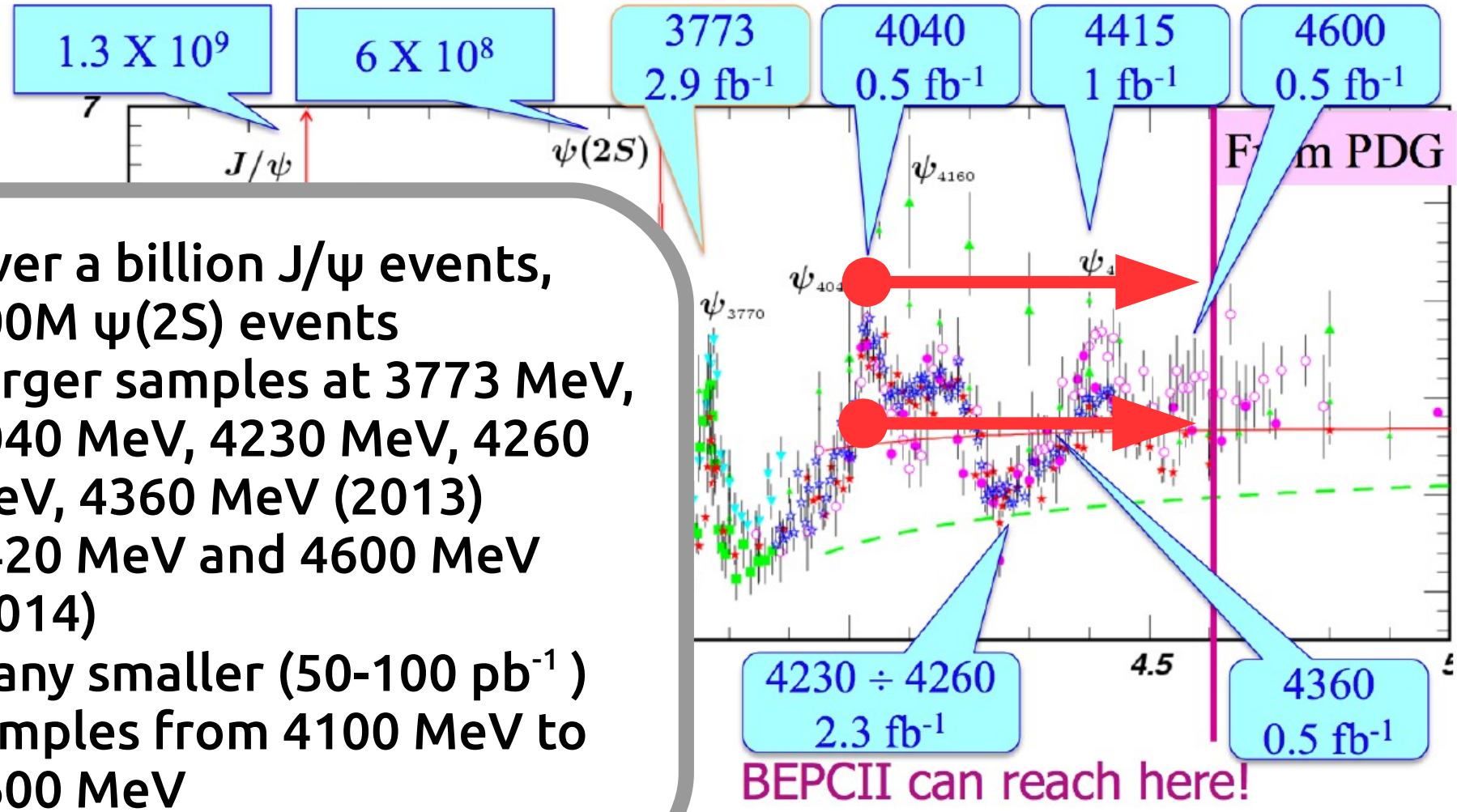
BESIII Detector



BESIII Data Samples



BESIII Data Samples

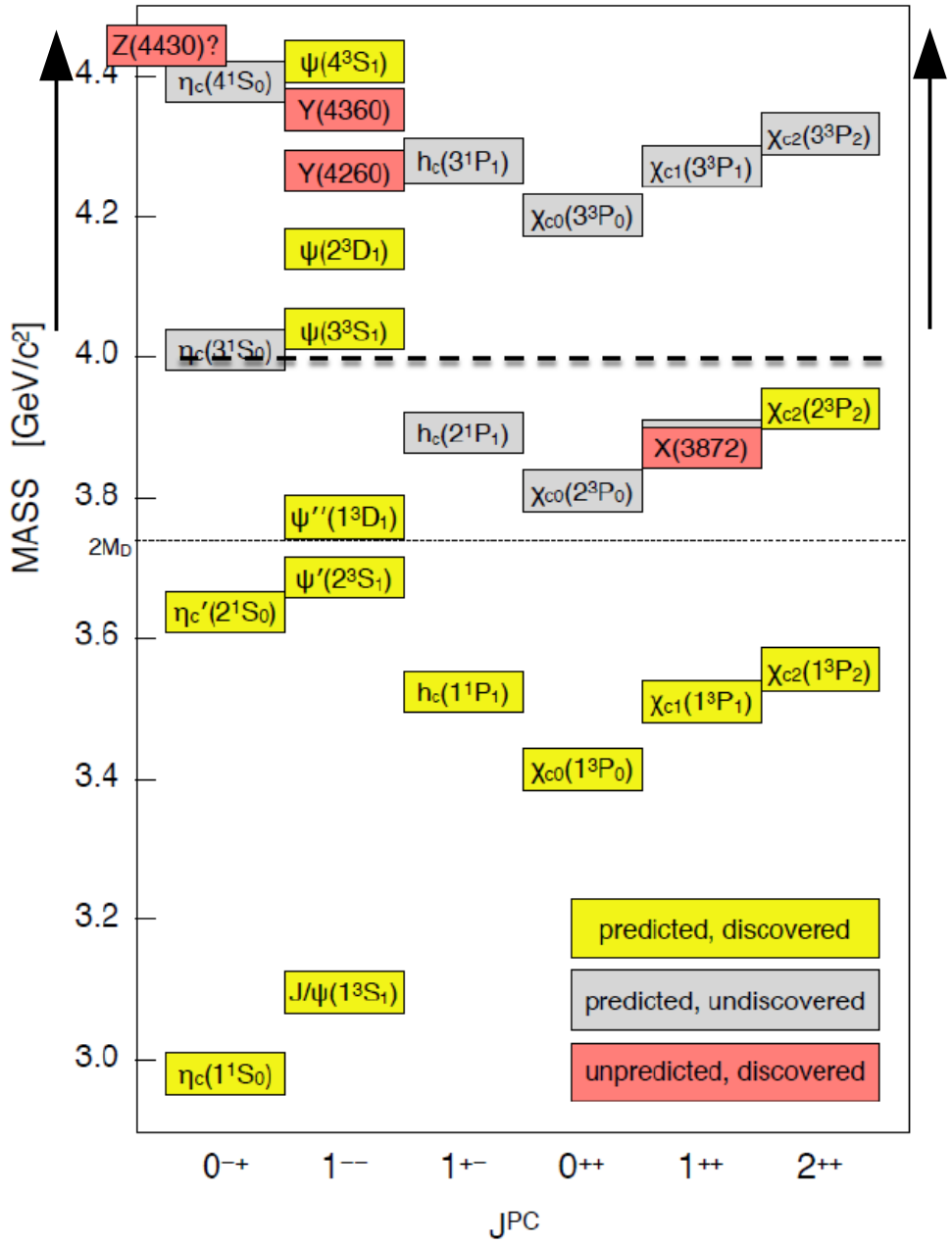


- Over a billion J/ψ events, 600M ψ(2S) events
- Larger samples at 3773 MeV, 4040 MeV, 4230 MeV, 4260 MeV, 4360 MeV (2013)
- 4420 MeV and 4600 MeV (2014)
- Many smaller (50-100 pb^{-1}) samples from 4100 MeV to 4600 MeV

Charmonium-like Spectrum

- Many predicted, yet undiscovered states
- A few discovered states that don't fit within the standard quark model
- DD Threshold
- Y(4260), Y(4360), Y(4660)
  - X(3872)
  - New Zc States

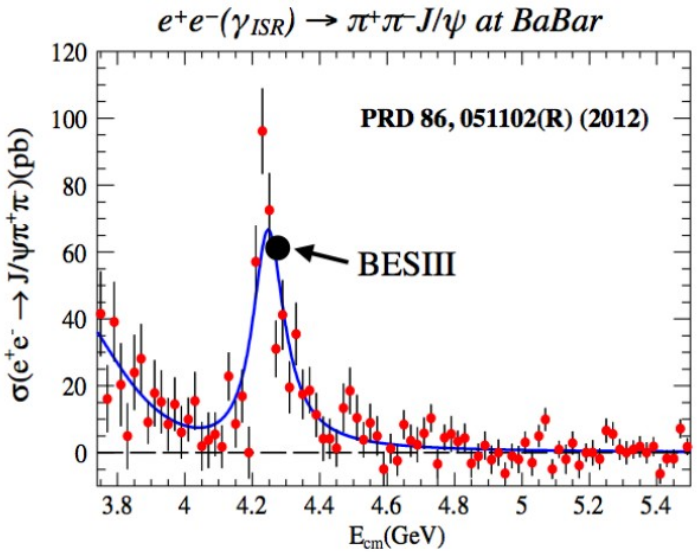
  (See “Exotic Zc at BESIII”,Wei Shan)

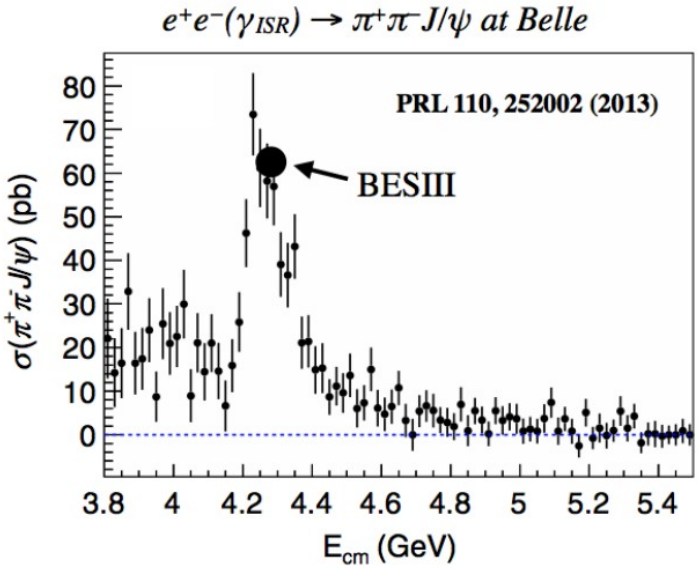


Hadronic Transitions Above 4 GeV

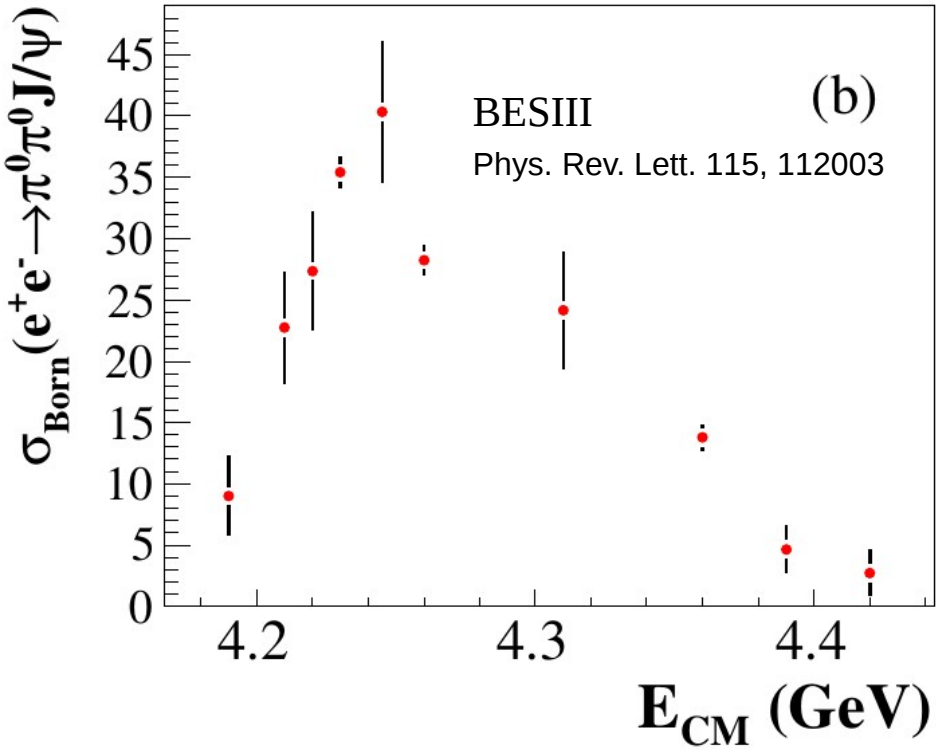
- $\pi^+\pi^-$ J/ψ, $\pi^0\pi^0$ J/ψ
- $\pi^+\pi^-$ h_c, $\pi^0\pi^0$ h_c
- $\omega\chi_{c0}$, $\omega\chi_{c1}$, $\omega\chi_{c2}$
- ηJ/ψ, η' J/ψ, $\eta'\pi^0$J/ψ

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





$\pi^0\pi^0\ J/\psi$



- Y(4260)
- Cross-section Lineshapes consistent with Isospin
- Exploration of Exotic Zc states

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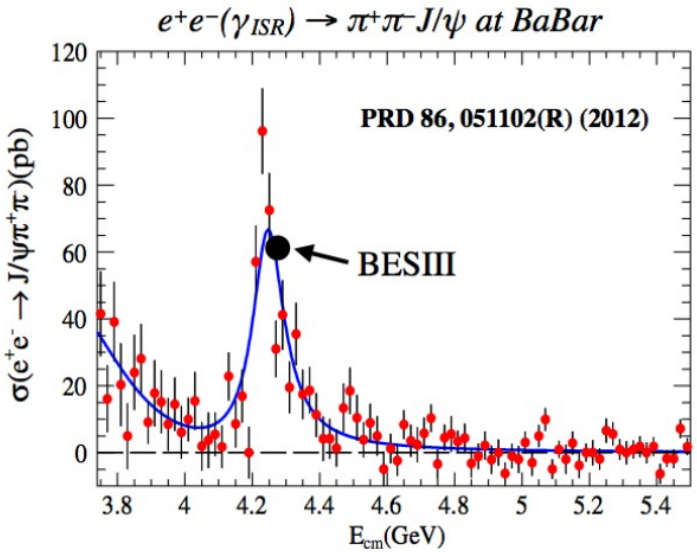
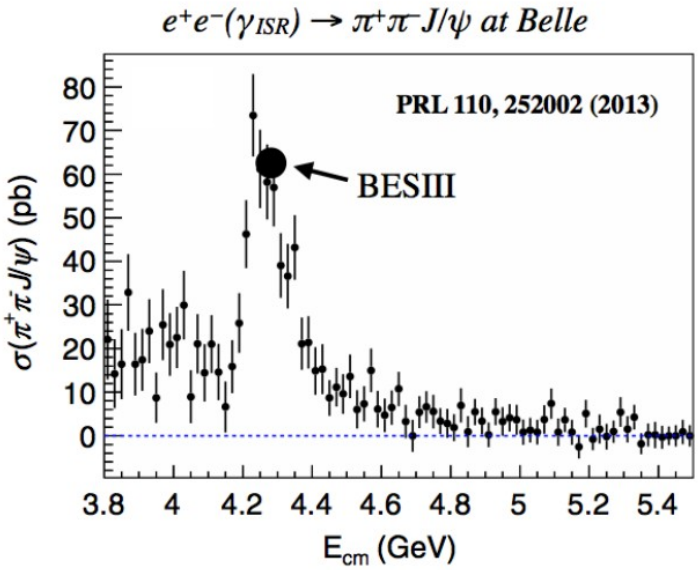
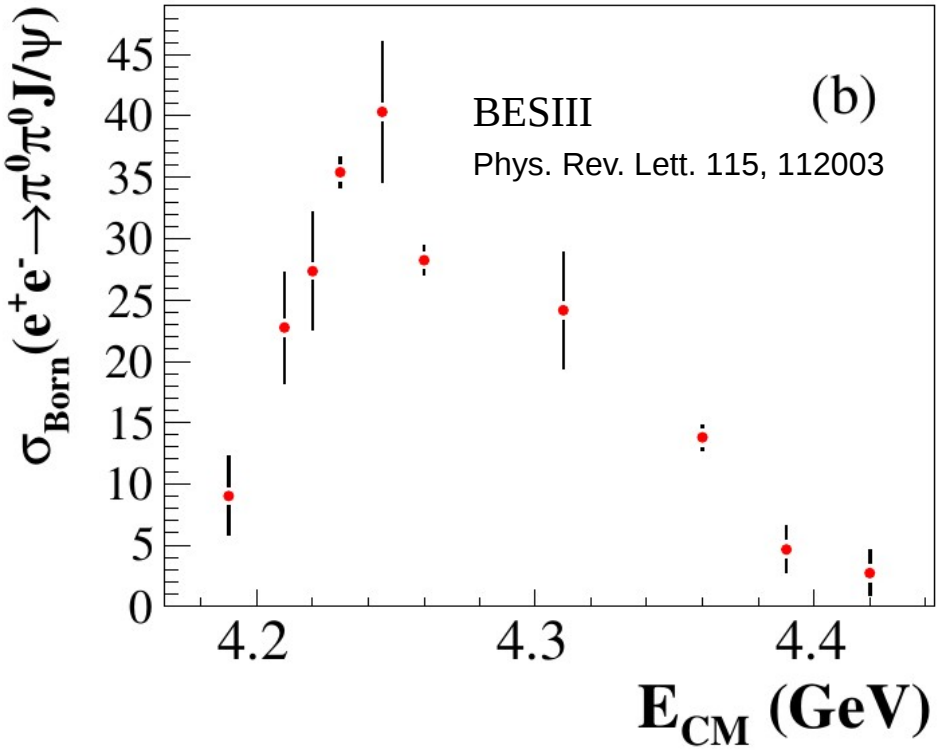
$e^+e^- \rightarrow \pi\pi\ J/\psi$





$\pi^0\pi^0\ J/\psi$



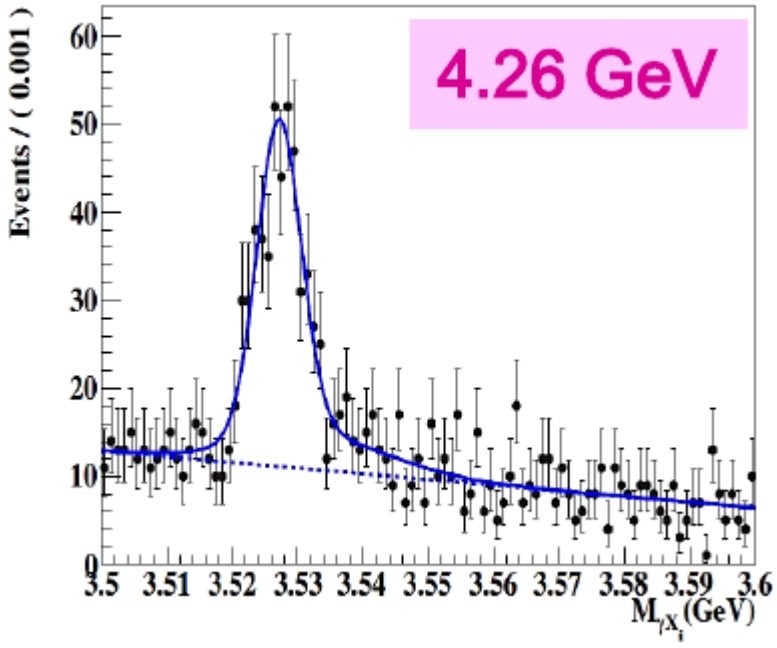
- **e+e- → KKJ/ψ** results pending

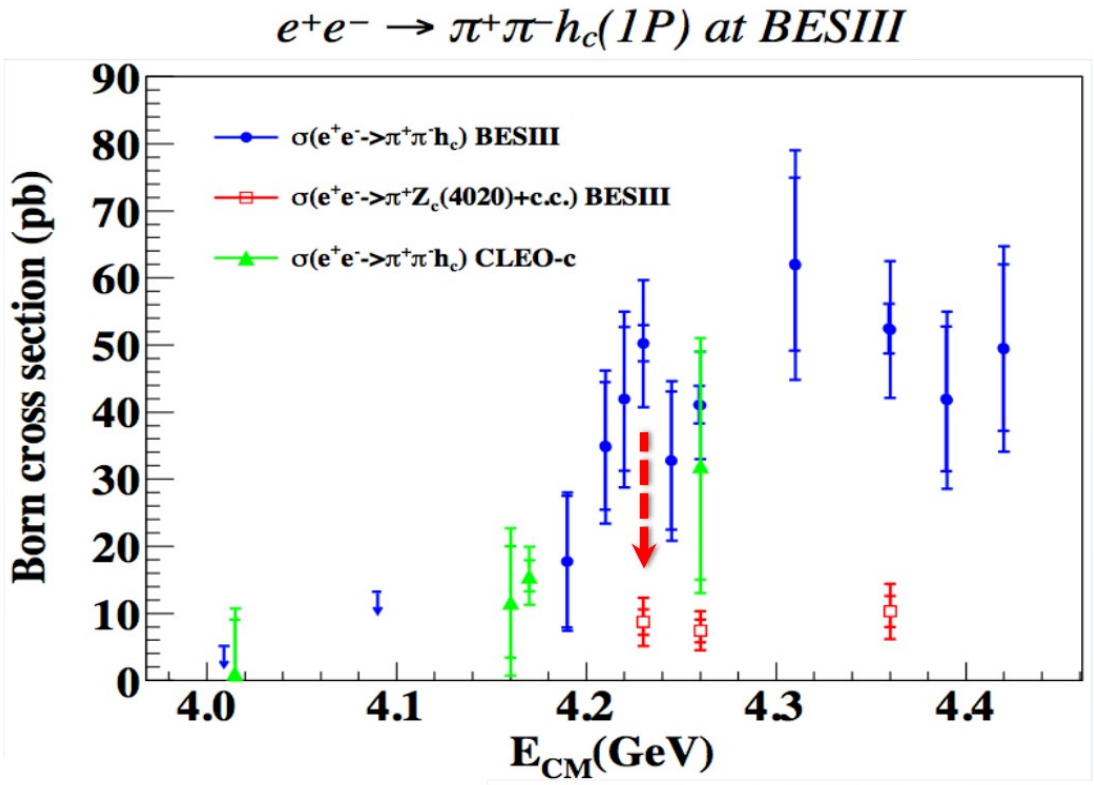
$e^+e^- \rightarrow \pi\pi\, h_c$

$e^+e^- \rightarrow \pi^+\pi^-\, h_c$

→ $\pi^+\pi^-\, [\gamma\eta_c]$

→ $\pi^+\pi^-\gamma$ [16 Had. Modes]





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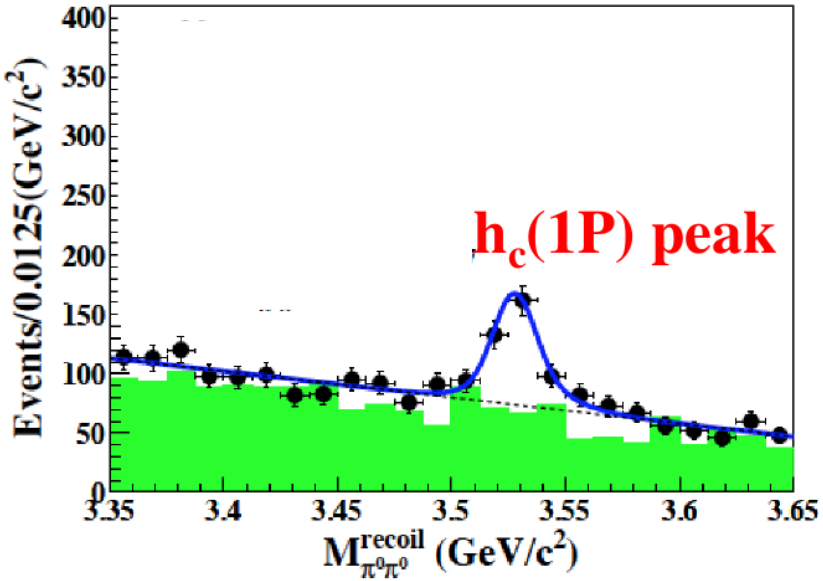
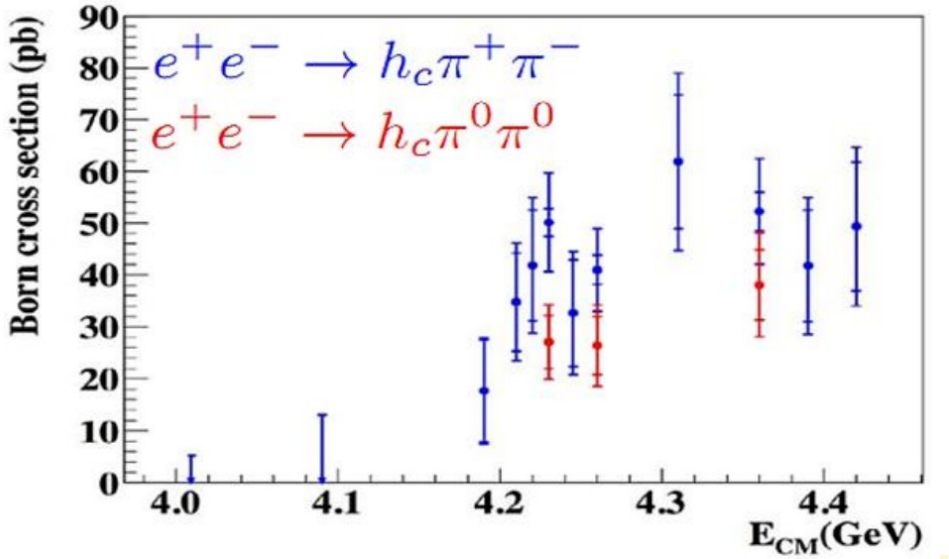
Phys.Rev.Lett. 111 (2013) 24, 242001

$e^+e^- \rightarrow \pi\pi\, h_c$

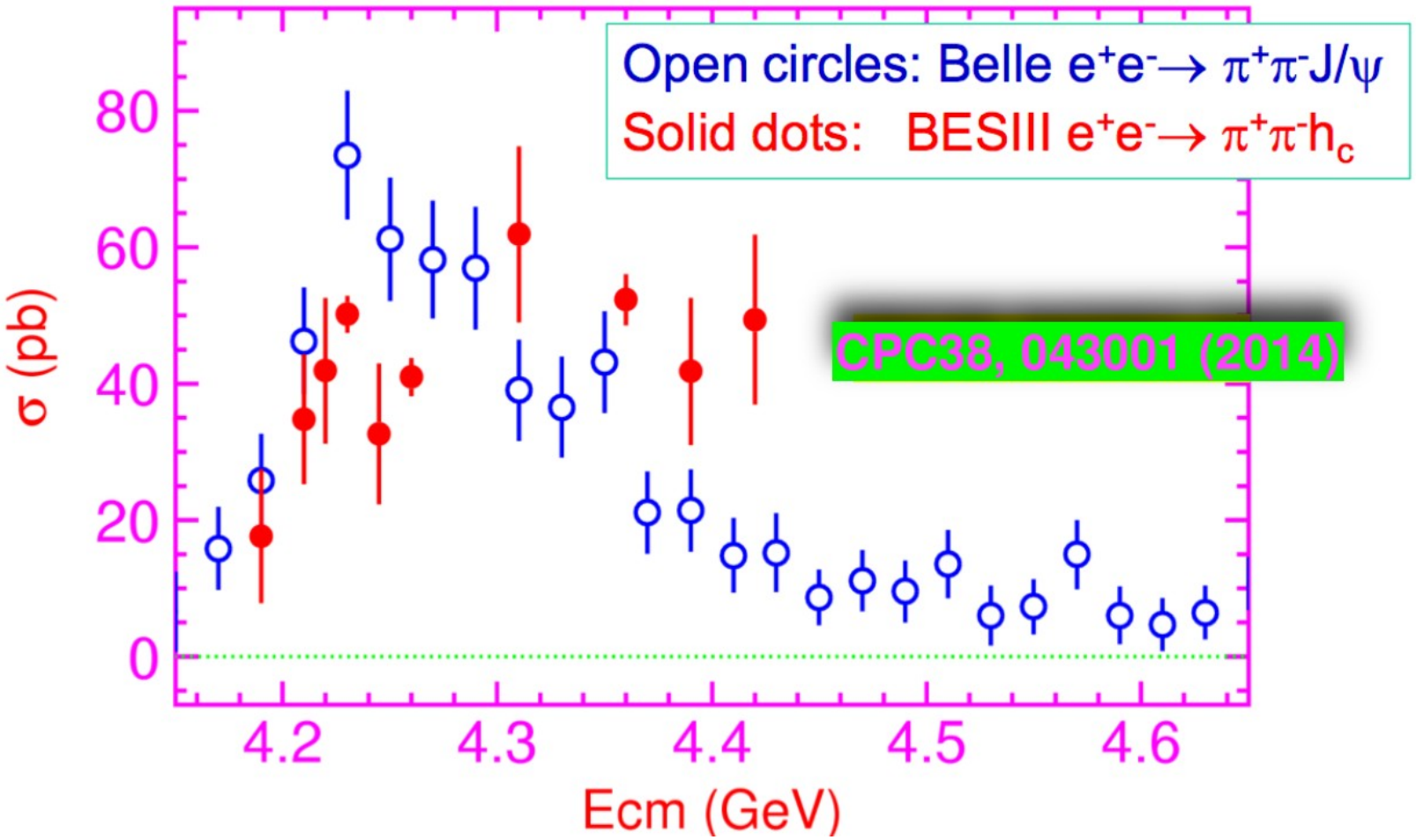
$e^+e^- \rightarrow \pi^0\pi^0\, h_c$





Phys.Rev.Lett. 113 (2014) 21, 212002

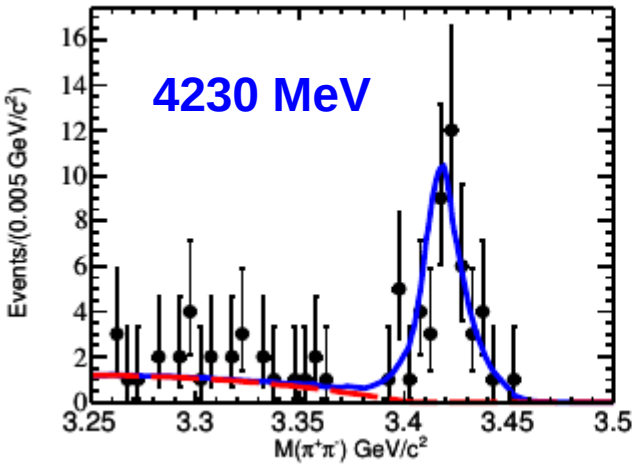
$e^+e^- \rightarrow \pi\pi\, J/\psi$ and $\pi\pi\, h_c$

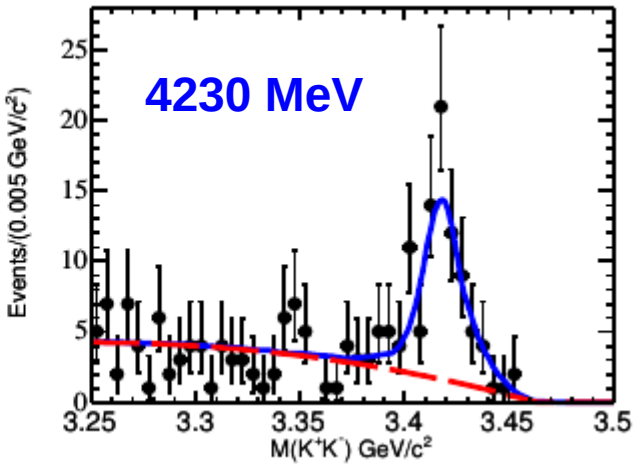


- Similar magnitude of cross-sections, Spin 0, Spin 1
- Lineshapes appear to be different, more data and beam energies needed

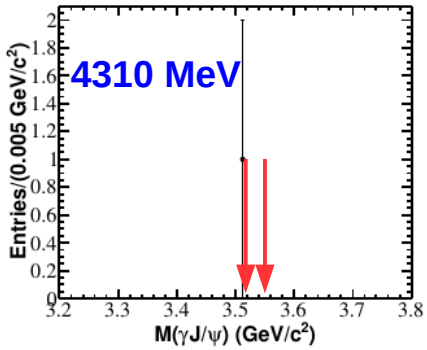
$e^+e^- \rightarrow \omega\chi_{cJ}$

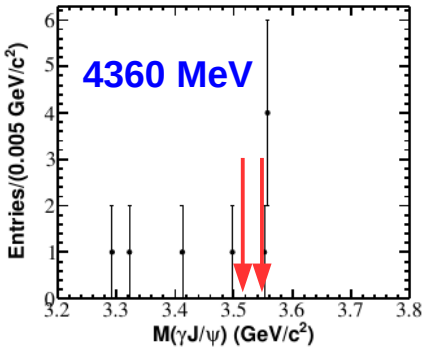
$\chi_{c0} \rightarrow$
$\pi^+\pi^-$ / K^+K^-

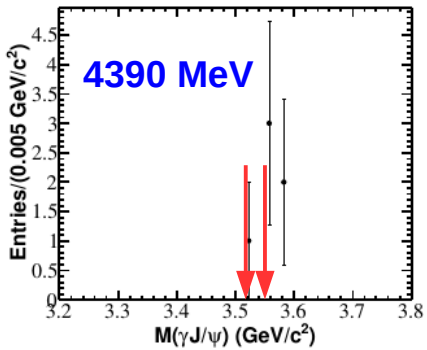


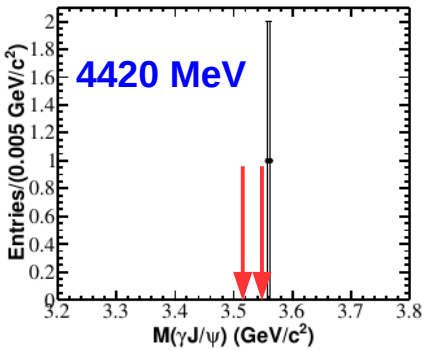


$\chi_{c1}/\chi_{c2} \rightarrow \gamma$ J/ψ



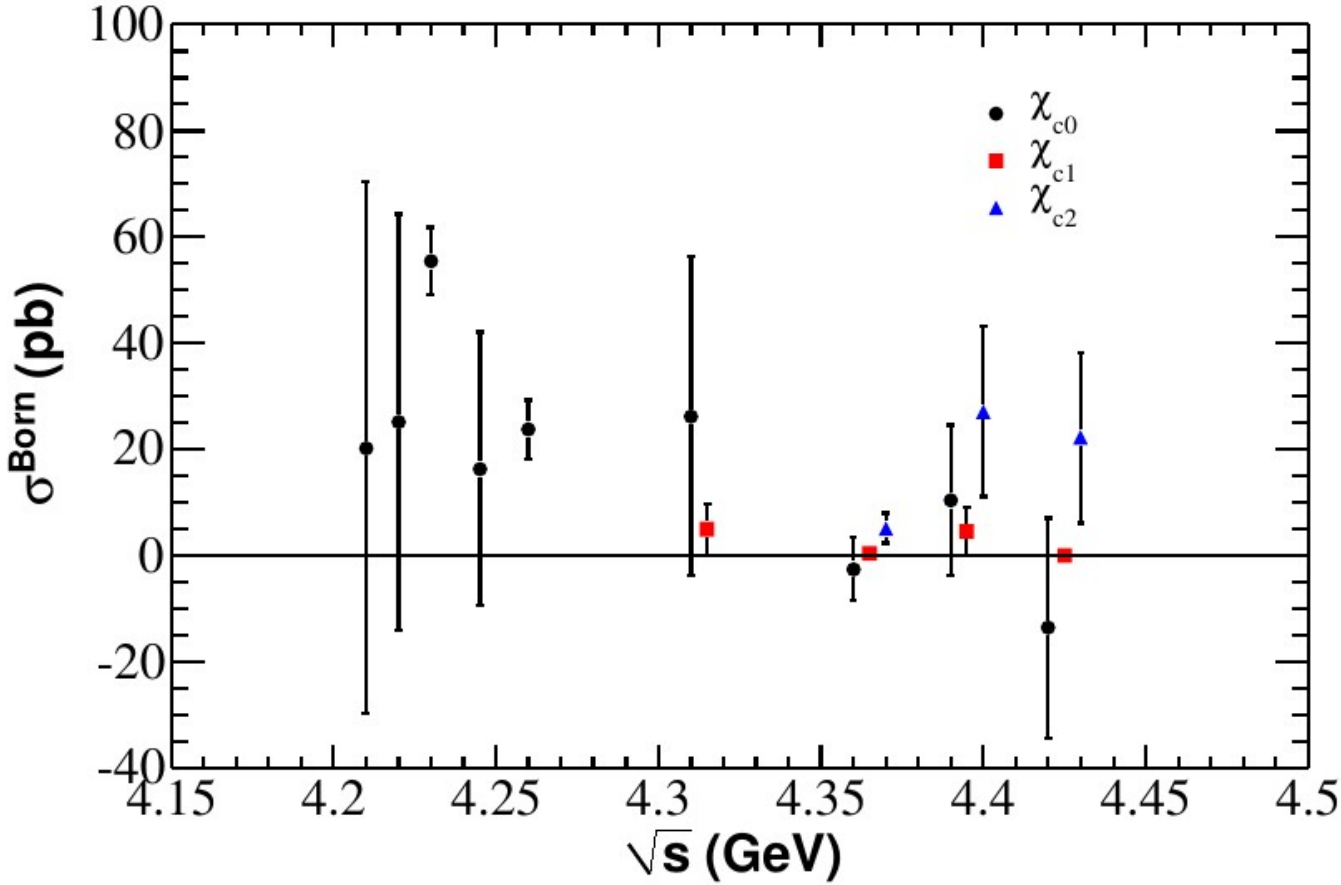






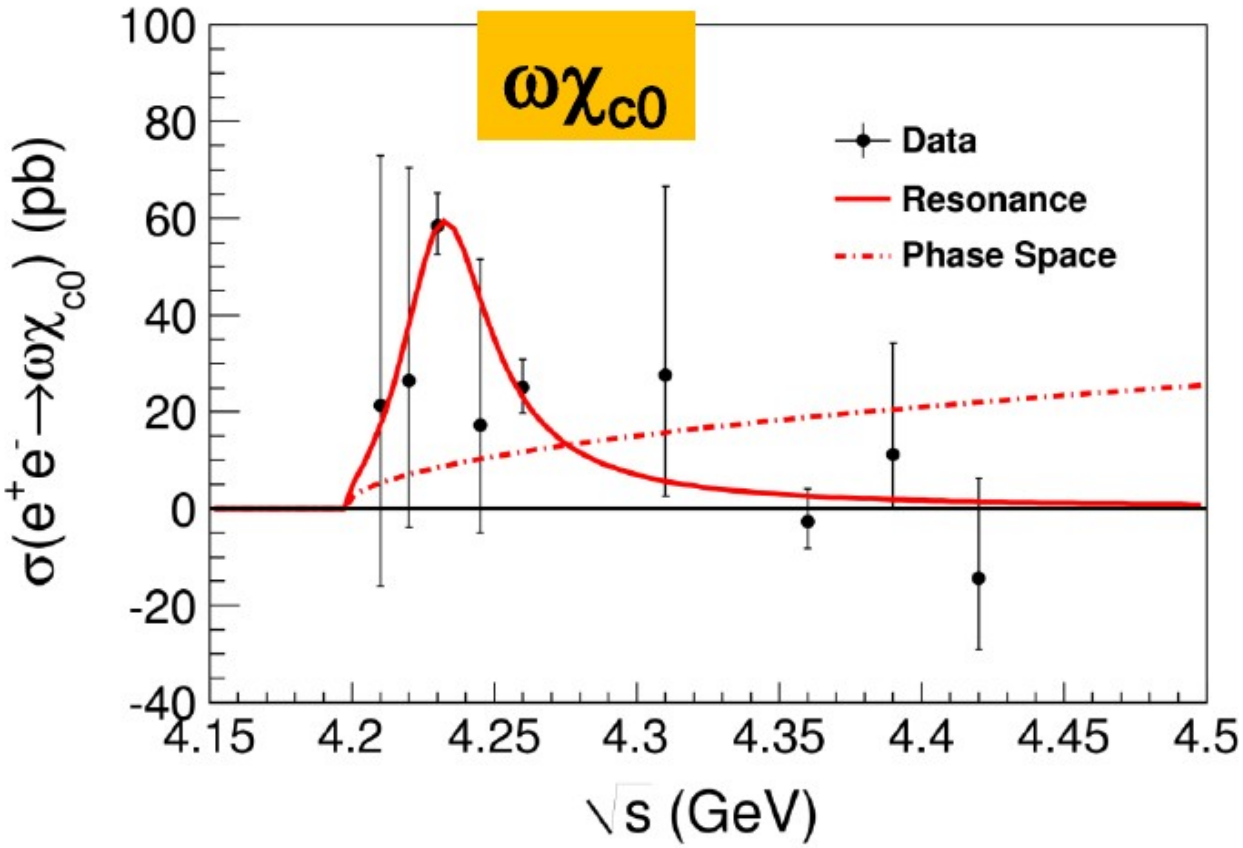
Phys.Rev.Lett. 114 (2015) 9, 092003

$e^+e^- \rightarrow \omega\chi_{cJ}$



Phys.Rev.Lett. 114 (2015) 9, 092003

$e^+e^- \rightarrow \omega\chi_{cJ}$



BW Fit:
M = 4230 ± 8 ± 6 MeV
W = 38 ± 12 ± 2 MeV
> 9σ signal

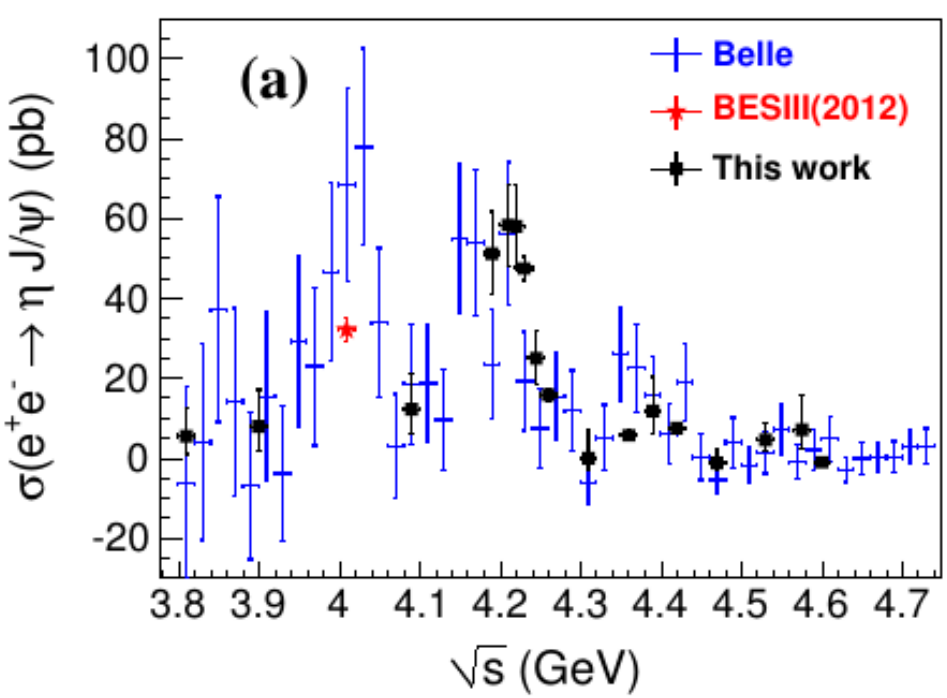
Tetraquark? [arXiv: 1412.7196] ψ(4S)? [EPJC74, 3208(2014)]
Threshold?
Interesting $\chi_{c1,2}$ results in review.

Phys.Rev.Lett. 114 (2015) 9, 092003

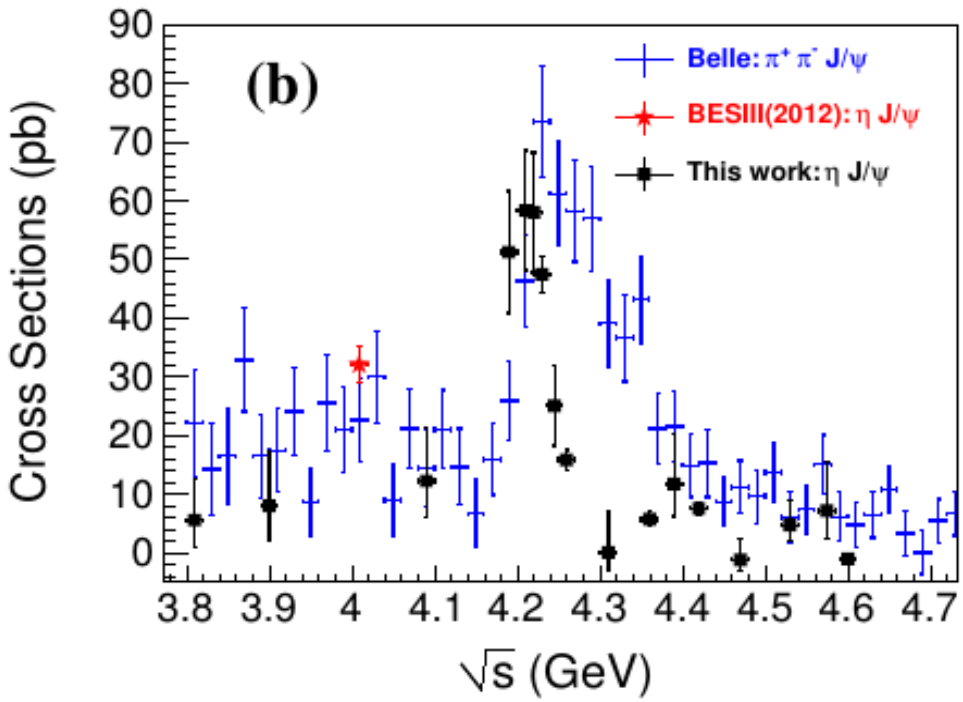
$e^+e^- \rightarrow \eta J/\psi$

e+e- → η J/ψ
→ (γγ) (l^+l^-)

Compared to Belle η J/ψ



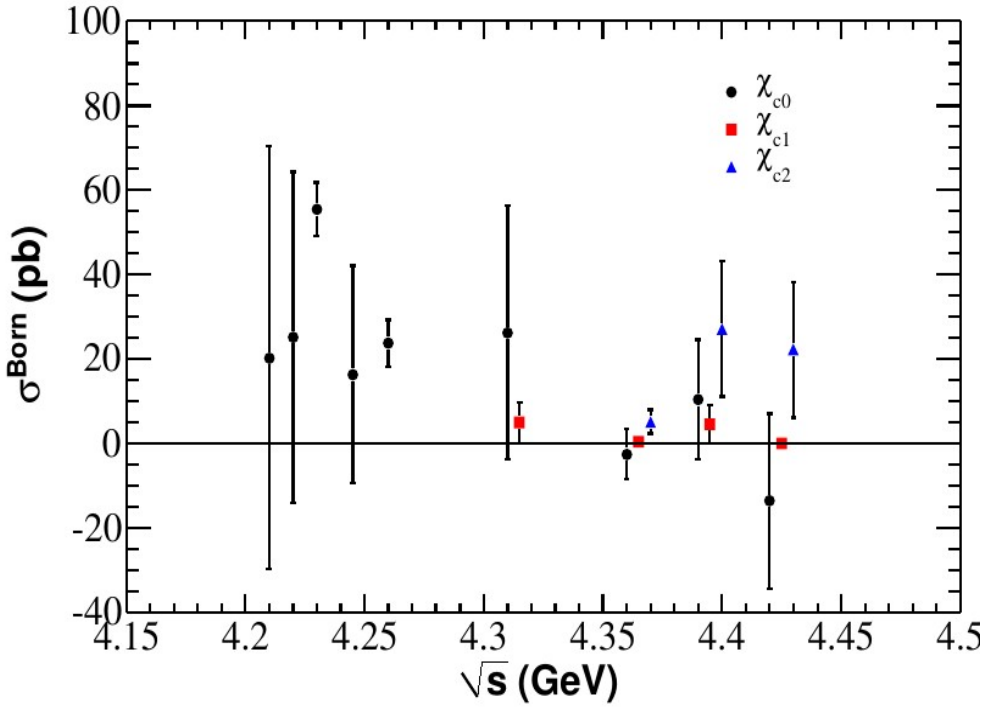
Compared to Belle ππ J/ψ



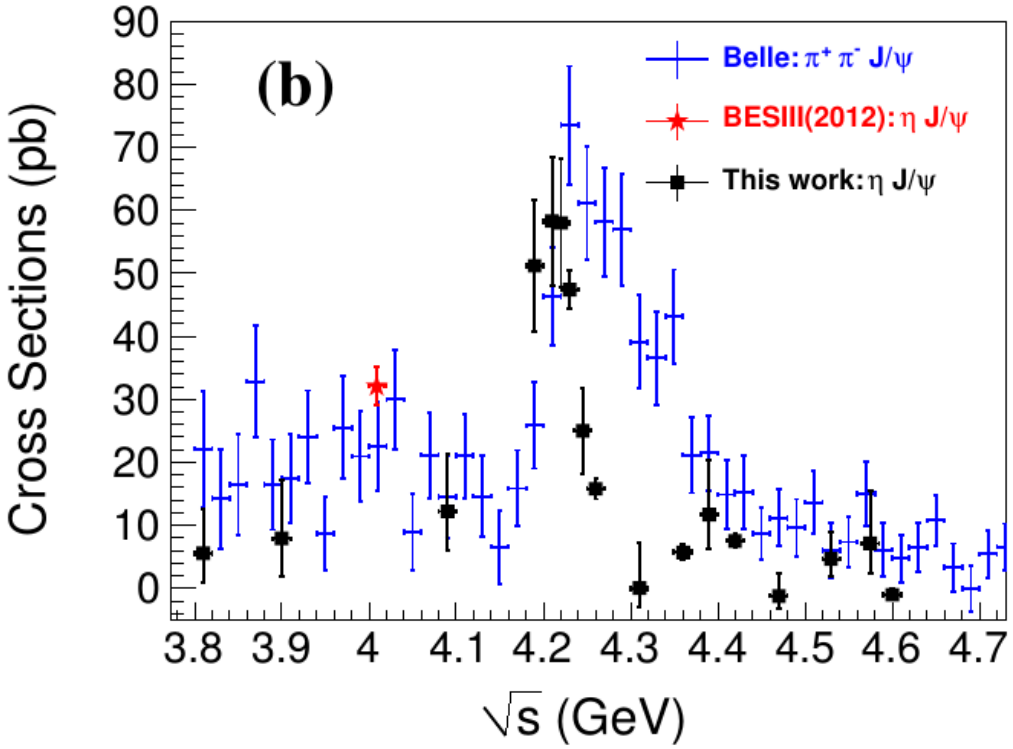
Phys.Rev. D91 (2015) 11, 112005

$e^+e^- \rightarrow \eta J/\psi$

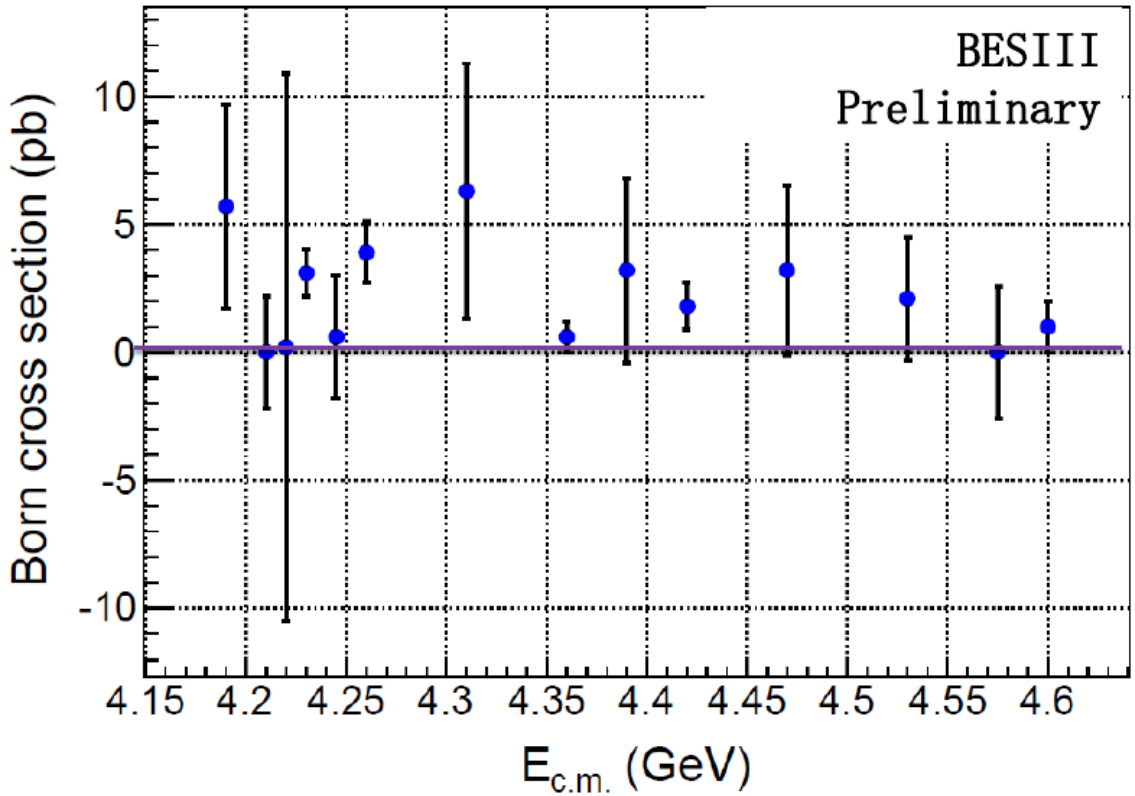
$\omega\chi_{c0}$



$\eta J/\psi$

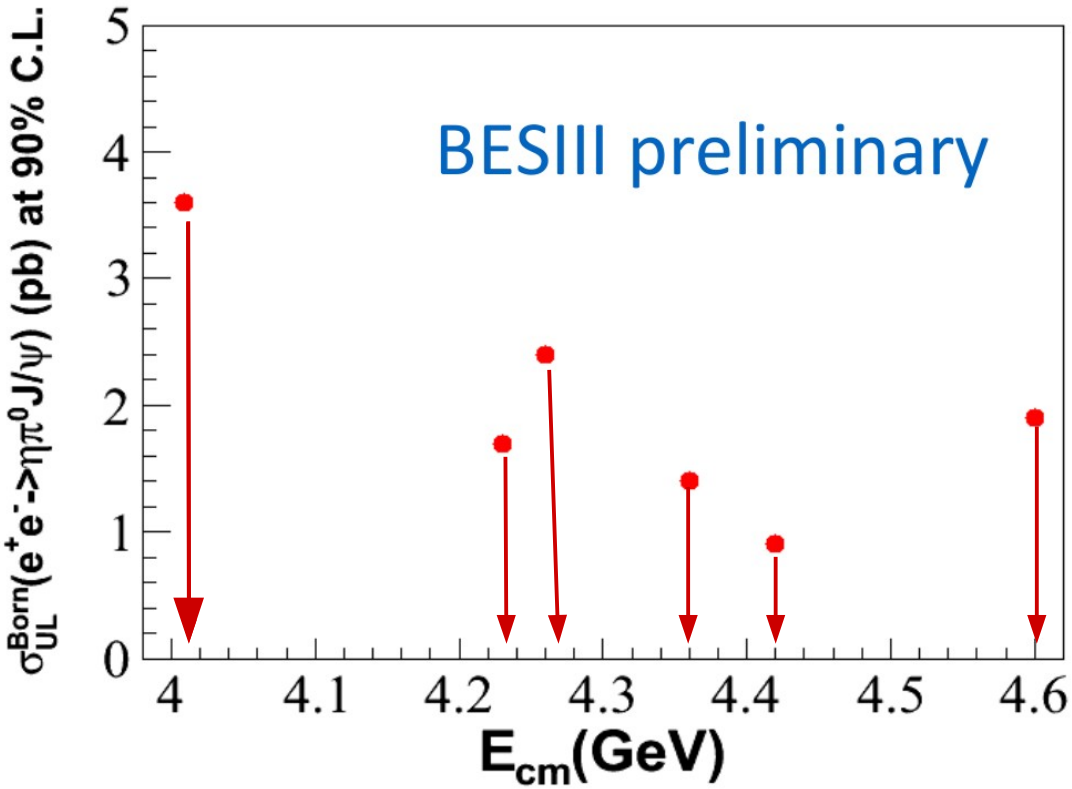


$e^+e^- \rightarrow \eta' J/\psi$



- Other hadronic transitions used for theoretical tests
- $\eta' J/\psi$: NRQCD, similar magnitude to $\eta J\psi$ [PRD 89, 074006 (2014)]
- Not the case, <5 pb to $\eta J\psi$ 55 pb
- Observations at 4230 MeV, 4260 MeV

$e^+e^- \rightarrow \eta\pi^0 J/\psi$



- $\eta\pi^0 J/\psi$: Y(4260) as $D_1 D$ Molecule [X.G. Wu et al., PRD 89, 054038.]
- Predicts 0.05 pb @ 4260 MeV.
- 100x factor of luminosity needed.

Conclusion

- Many new exciting Hadronic state analyses above 4 GeV at BESIII
- Wide variety of lineshapes depending on mode
  - $\pi\pi$ J/ψ
  - $\pi\pi$ h_c
  - $\omega\chi_{c0}$ / ηJ/ψ
- Hadronic transition lineshapes in this region are good sources to study the new exotic Zc family
- Expect more data, more center-of-mass energy points, and improved precision in results over the months and years to come.