Observation of the X(3823) at BESIII

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Represent the BESIII collaboration

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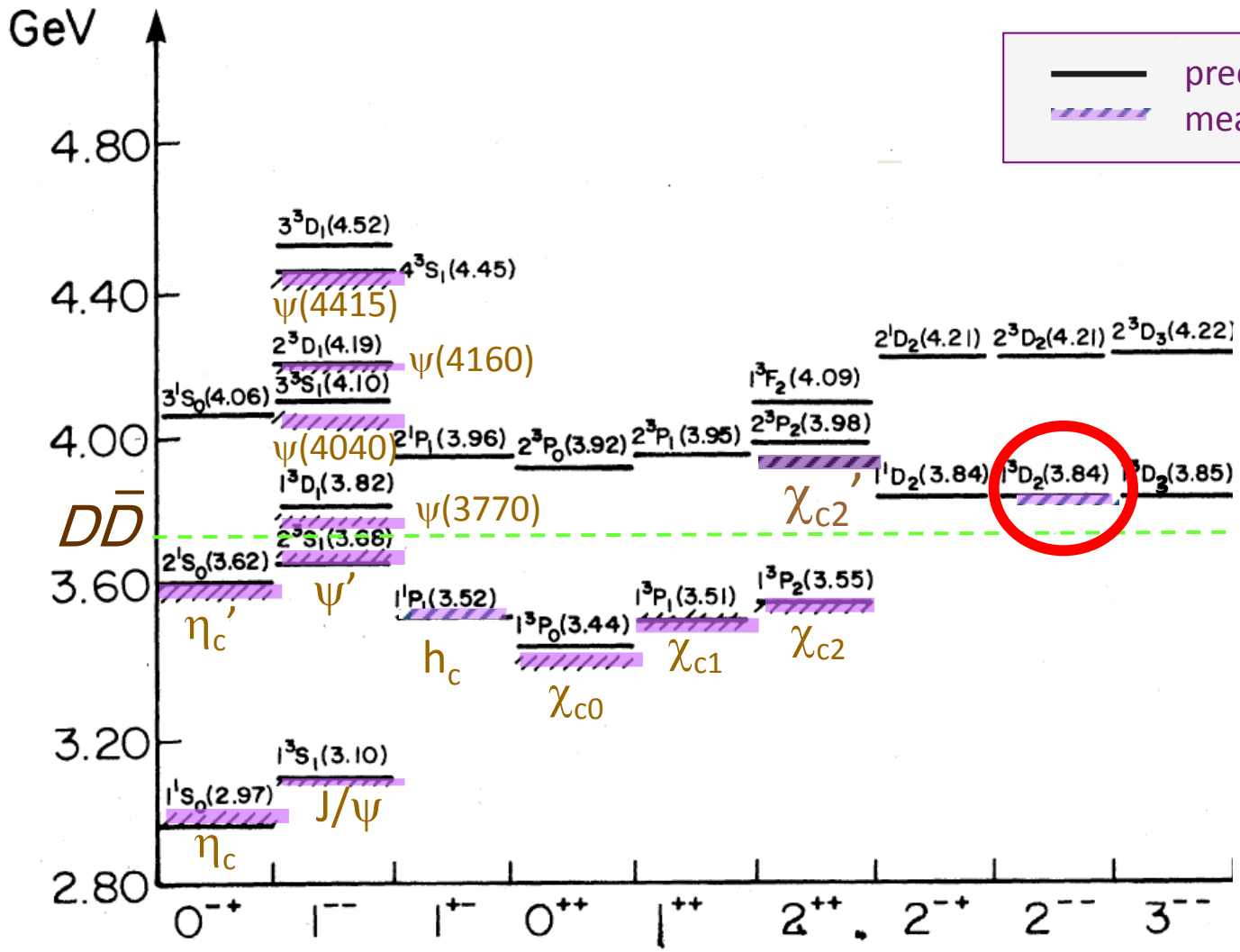
Charmonium Spectroscopy

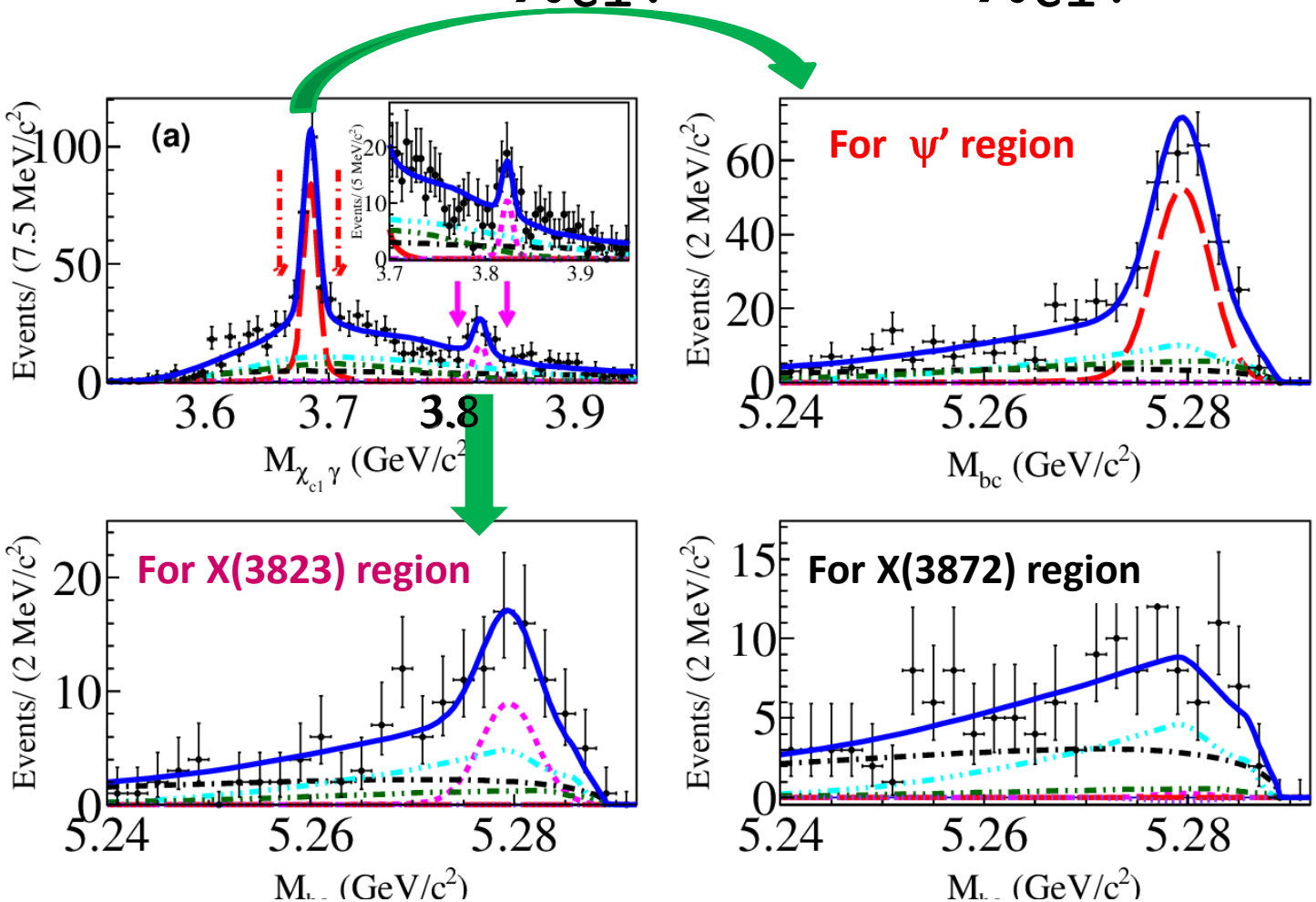
Godfrey & Isgur, PRD32, 189 (1985)



$\psi_2(1^3D_2)$ $J^{pc}=2^{--}$

1. In 1994, E705 experiment reported a candidate for the 1^3D_2 .
   PR,D50,4258
2. Belle reported evidence for X(3823)→ $\gamma\chi_{c1}$ in B decay, suggest a candidate for the 1^3D_2 state. *PRL 111,032001*
3. It is predicted to have large decay width to $\gamma\chi_{c1}$, $\gamma\chi_{c2}$. *PRL,89,162002*
4. The D-wave charmonium are expected 3.82—3.85 GeV
   PR,D17,3090; PR,D21,203
5. Narrow, $1^3D_2 \not\to D\bar{D}$ (C-parity violation).
   but below the DD* threshold
   PR,D32,189; PR,D69,094019

X(3823)→$\chi_{c1}\gamma$ in B→$\chi_{c1}\gamma$K

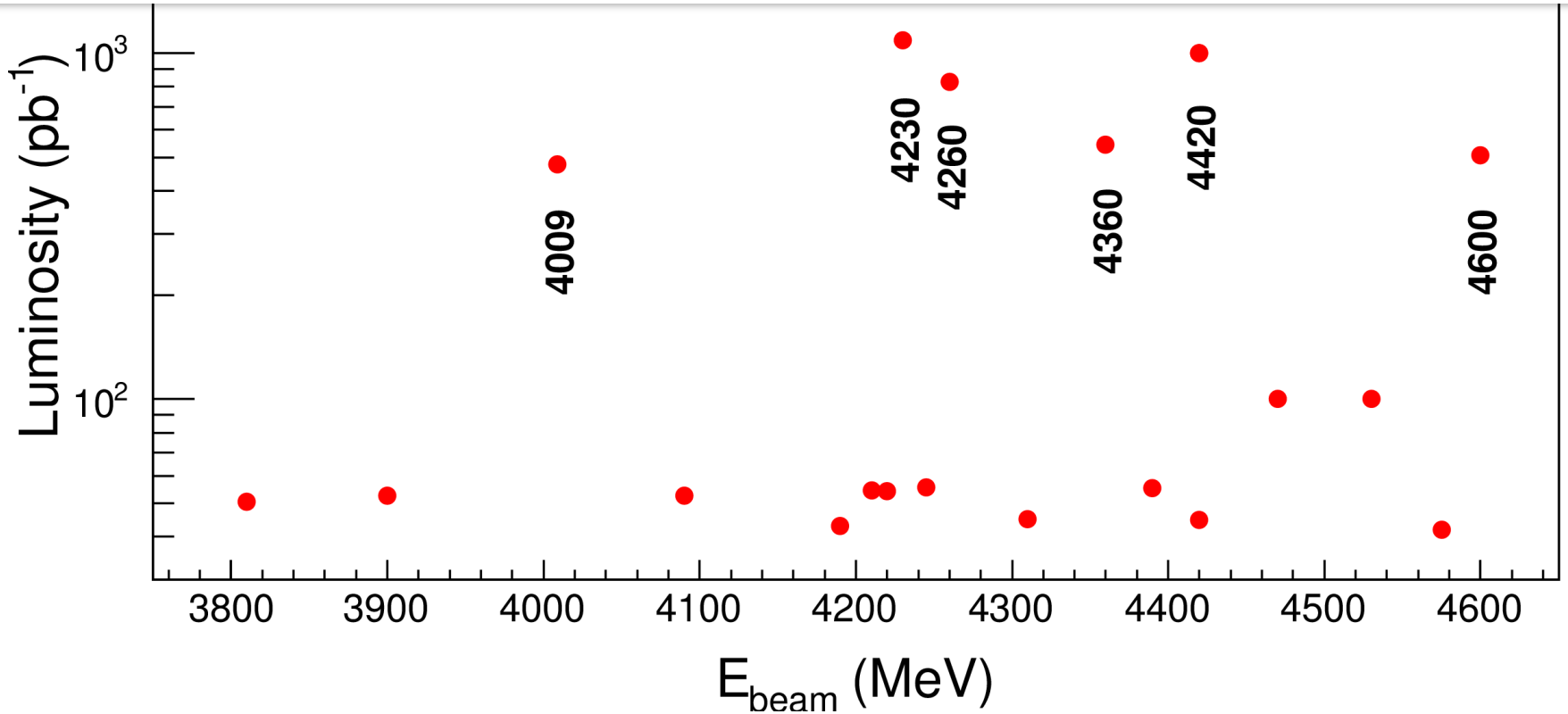


Sigificance: 3.8σ Mass=3823.1±1.8 ± 0.7 *MeV*

PRL 111,032001 (2013)

At BESIII,

In 2013-2014, 4.6 fb^{-1} at $\sqrt{S}$>3.8 GeV collected



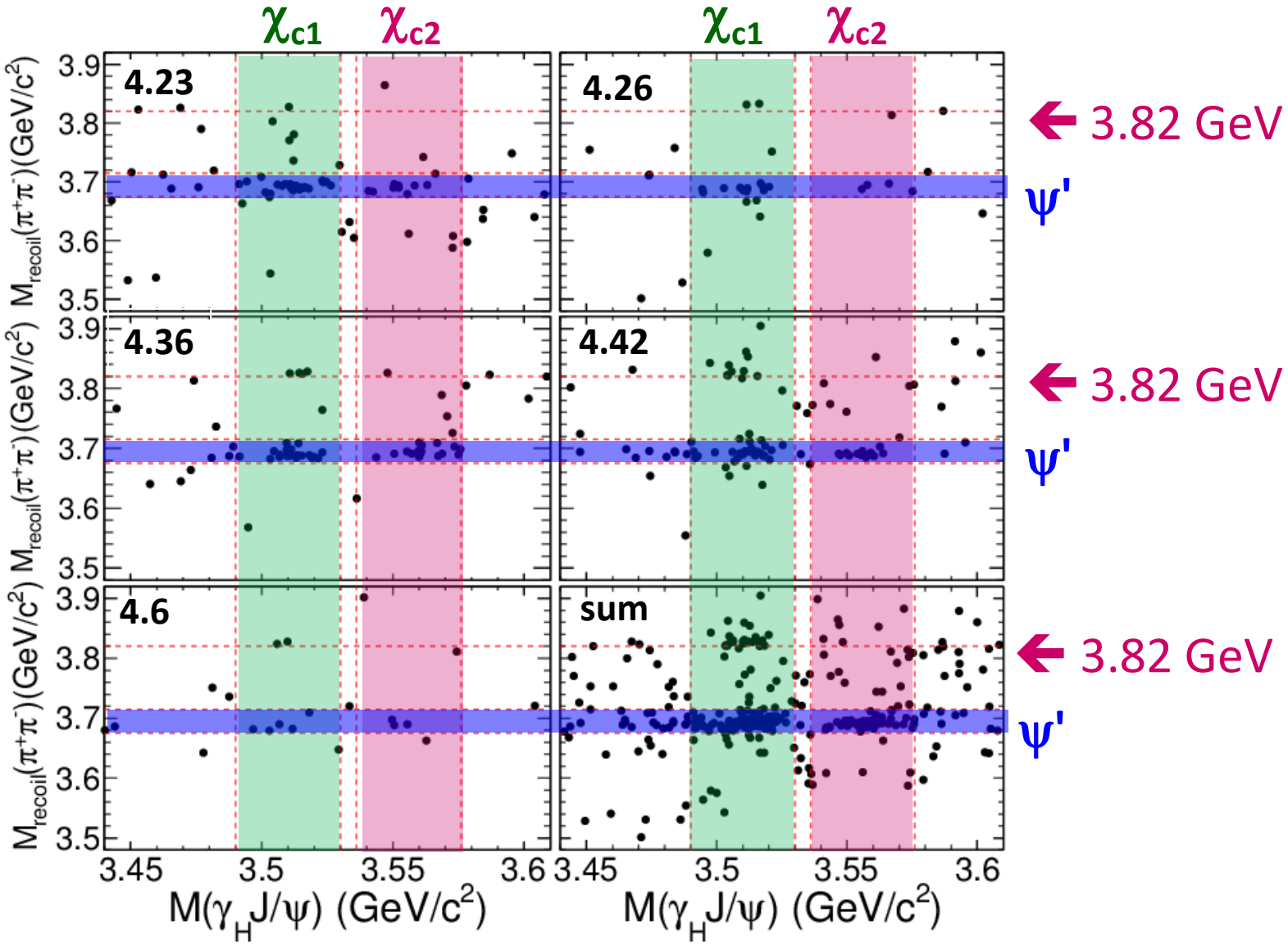
X(3823) Analysis at BESIII

- Data samples: 4.67 fb^{-1}
- Final state: $\pi\pi\ \gamma\chi_{cJ}$, $\chi_{cJ} \to \gamma J/\psi$, $J/\psi \to ll$
- Main bkg from ISR $\psi(2S)$, $\eta^{(\prime)}J/\psi$, vetoed by:
  $M(\gamma\ \gamma\ \pi^+\pi^-)>0.57$ GeV,
  $|M(\pi\pi J/\psi)-m(\psi')|>6$ MeV

$\sqrt{s}$ (GeV)	Luminosity (pb^{-1})
4.190	43.1
4.210	54.6
4.220	54.1
4.230	1092
4.245	55.6
4.260	826
4.310	44.9
4.360	540
4.390	55.2
4.420	44.7+1029
4.470	110
4.530	110
4.575	47.7
4.600	567

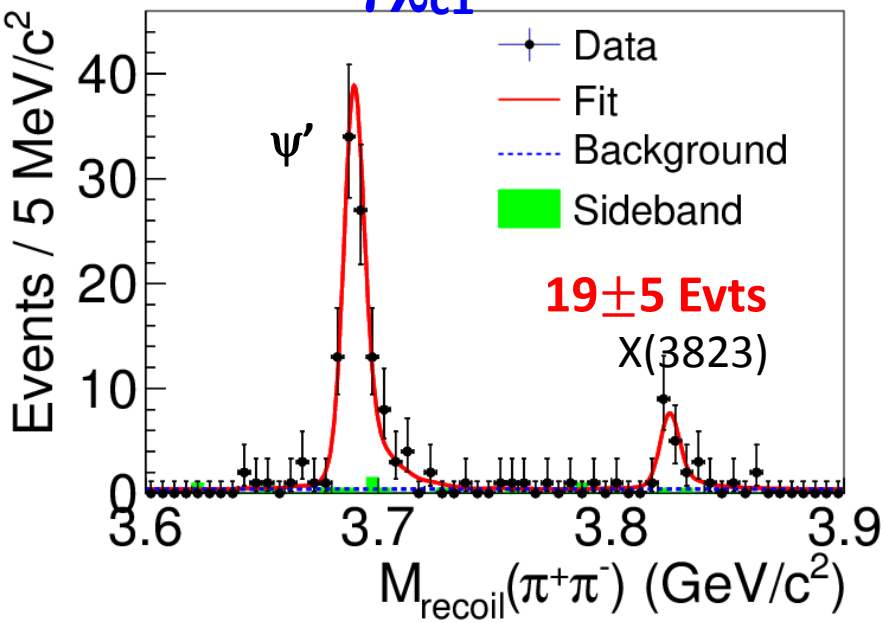
PRL 115, 011803(2014)

M_{reoil} ($\pi\pi$) vs. M($\gamma J/\psi$) for Selected Events

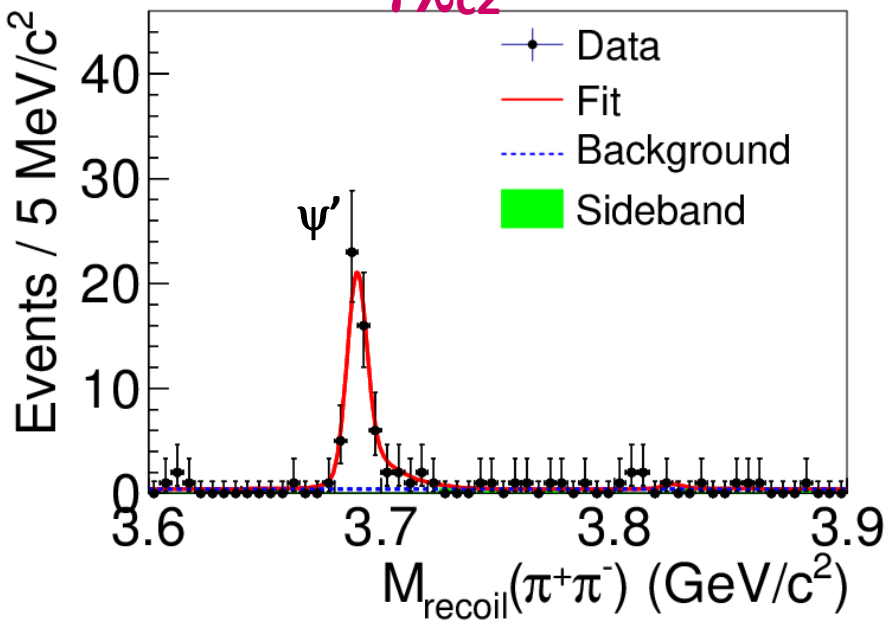


Simultaneous Fit to the $M_{recoil}(\pi^+\pi^-)$

For $\gamma\chi_{c1}$ events



For $\gamma\chi_{c2}$ events



- ψ' is used to calibrate the absolute mass scale.
- Simultaneous fit with common X(3823) mass for diff. energies and for $\gamma\chi_{c1}$, $\gamma\chi_{c2}$ mode.
- Signal: MC shape ⊗ Gauss; bkg: linear function.

M=3821.7±1.3MeV

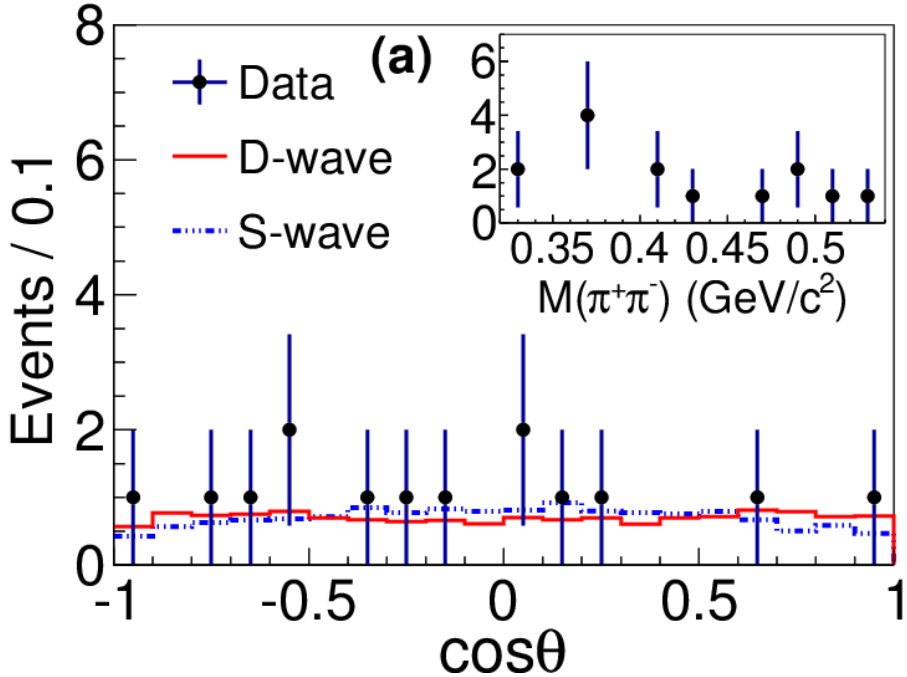
Γ(x)<16 MeV at 90% C.L.

Significance: 6.2 σ in $\gamma\chi_{c1}$

No X(3823) events in $\gamma\chi_{c2}$

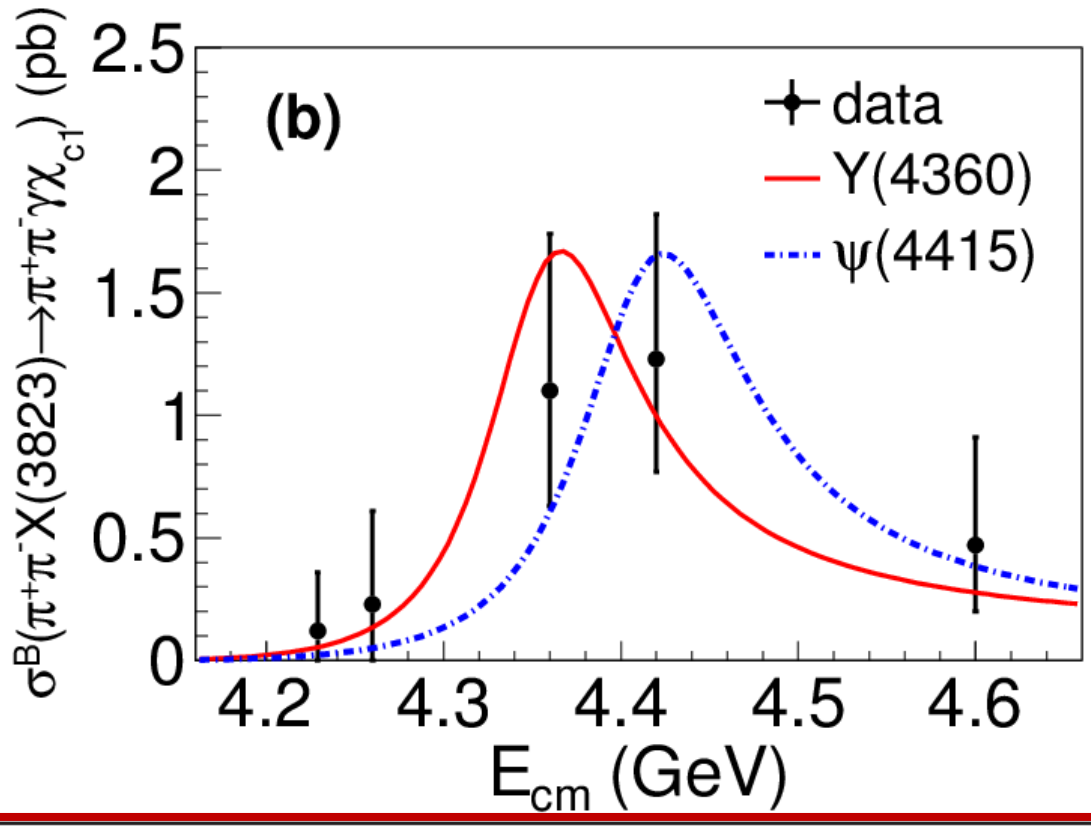
$\mathcal{B}(X\rightarrow\gamma\chi_{c2})/\mathcal{B}(X\rightarrow\gamma\chi_{c1})<0.42$

Angular Distribution of $e^+e^- \rightarrow \pi^+\pi^- X(3823)$



Assume the ππ dominated by **S-wave**, **D-wave** between the ππ system and X(3823);
Due to limited statistics, both S-wave and D-wave hypotheses can be accepted.

The Cross-section



$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$N^{\rm obs}$	ϵ	$1+\delta$	$1/\lvert 1-\Pi\rvert^2$	$\sigma_X^B \cdot \mathcal{B}_1$ (pb)	$\sigma_X^B \cdot \mathcal{B}_2$ (pb)
4.230	1092	$0.7^{+1.4}_{-0.7}$ (<3.8)	0.168	0.755	1.056	$0.12^{+0.24}_{-0.12} \pm 0.02$ (<0.64)	...
4.260	826	$1.1^{+1.8}_{-1.2}$ (<4.6)	0.178	0.751	1.054	$0.23^{+0.38}_{-0.24} \pm 0.04$ (<0.98)	...
4.360	540	$3.9^{+2.3}_{-1.7}$ (<8.2)	0.196	0.795	1.051	$1.10^{+0.64}_{-0.47} \pm 0.15$ (<2.27)	(<1.92)
4.420	1074	$7.5^{+3.6}_{-2.8}$ (<13.4)	0.145	0.967	1.053	$1.23^{+0.59}_{-0.46} \pm 0.17$ (<2.19)	(<0.54)
4.600	567	$1.9^{+1.8}_{-1.1}$ (<5.4)	0.157	1.075	1.055	$0.47^{+0.44}_{-0.27} \pm 0.07$ (<1.32)	...

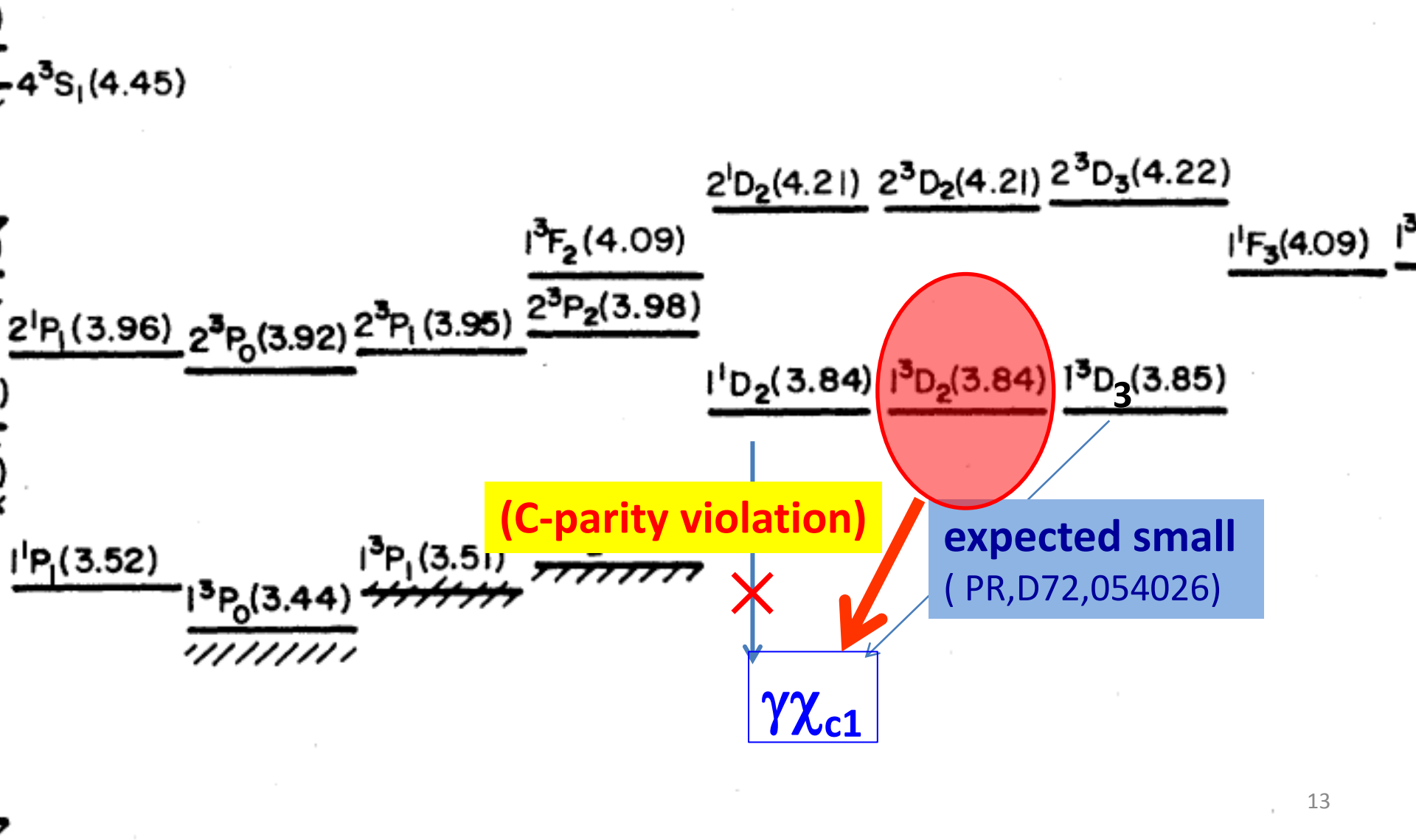
Uncertainties for the Mass Measurement

Source	Mass (MeV/c^2)
Absolute mass scale	0.9
Background shape	0.3
Fit model	0.1
Resolution	0.3
Total	1.0

Uncertainties for the σ Measurement

Source	error (%)
Luminosity	1.0
Tracking	4.0
Photon	2.0
Background shape	2.9
Line-shape	6.0
Kinematic fit	1.5
J/ψ mass window	1.6
Branching ratios	4.5
Fit model	5.2
Decay model	5.0
Others	1.0
Total	12.0

Good Candidate of $\psi(1^3D_2)$



Summary

- BESIII observed **X(3823)** with data samples $\sqrt{s}$>4 GeV, the mass agrees with Belle and prediction.

- $\mathcal{B}(X(3823)\rightarrow\gamma\chi_{c2})/\mathcal{B}(X(3823)\rightarrow\gamma\chi_{c1})<0.42$

- A good candidate for $\mathbf{1^3D_2}$; to clarify that it is connected with $\psi(4415)$ or $Y(4360)$ needs more data at more energies.