Highlights on XYZ (charmonium-like) states and recent results on light hadron spectroscopy from BESIII

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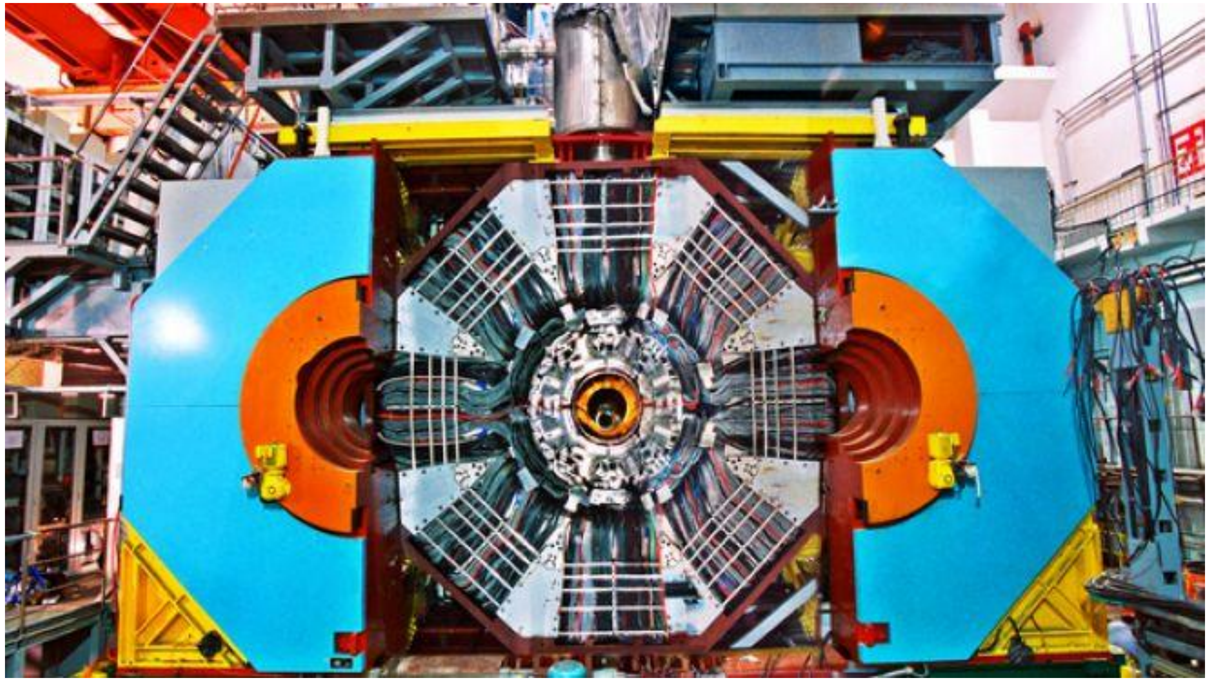
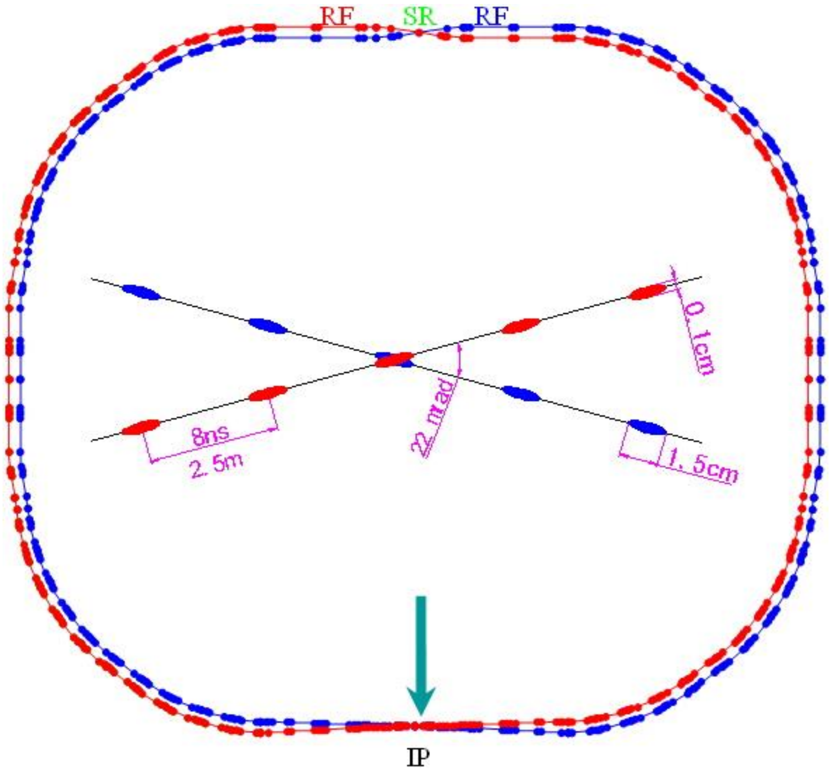
Outline

- Introduction
  - BEPCII
  - BESIII
  - Data set
- XYZ Physics
- Light hadron spectroscopy
- Summary



BEPCII



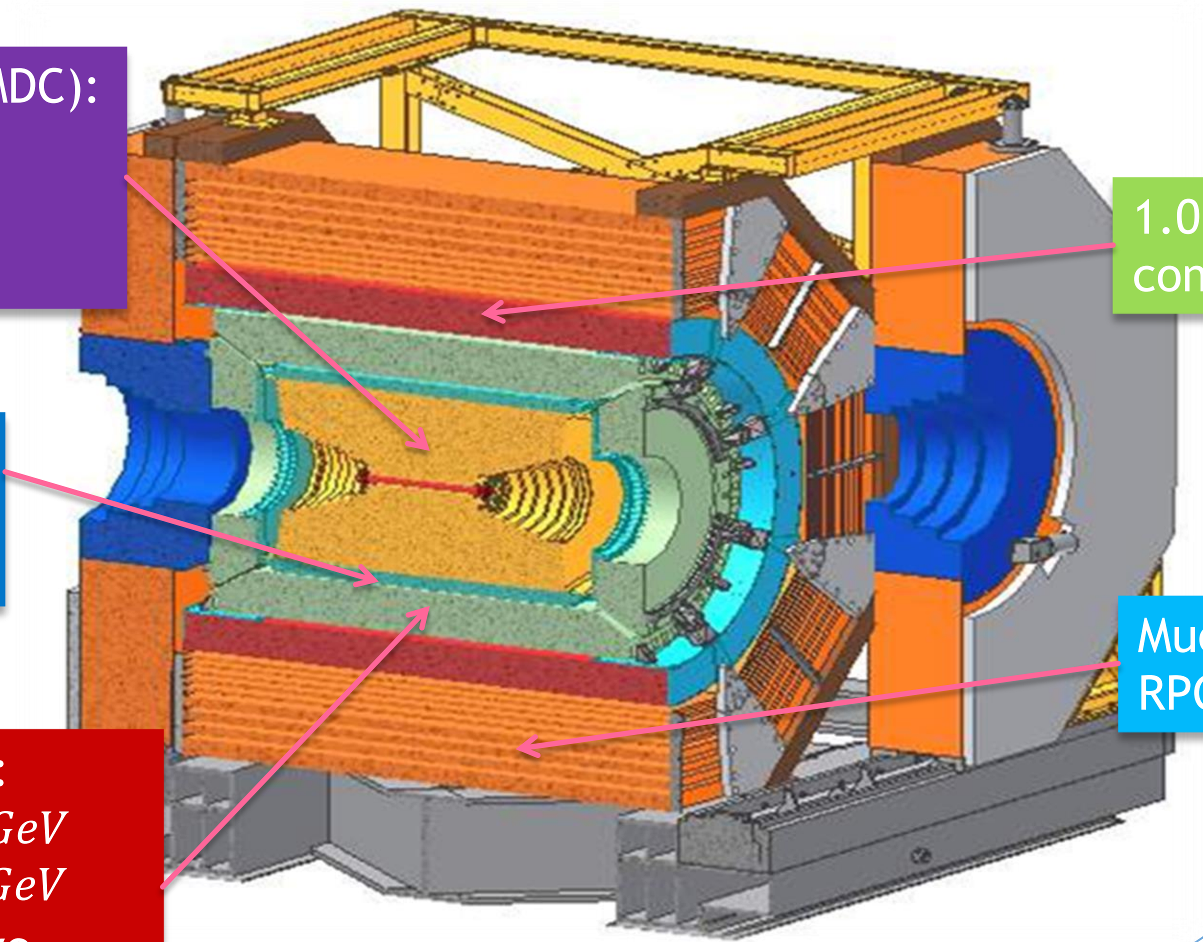
Beam energy range	1~2.3 GeV
Optimized beam energy region	1.89 GeV
Current of each beam in collision	0.93 A
Luminosity achieved	$0.7 \times 10^{33} \mathrm{cm}^{-2}\mathrm{s}^{-1}$
Beam lifetime	2.7 hrs
SR mode	0.25 A@2.5 GeV

BESIII

Main Drift Chamber (MDC):
$\sigma_{xy} = 135\ \mu m$
$\Delta P/P = 0.5\% \ @\ 1\ GeV$
$\sigma_{dE/dx} = 6\sim7\%$

TOF System:
$\sigma_T = 80$ ps @barrel
110 ps @endcap

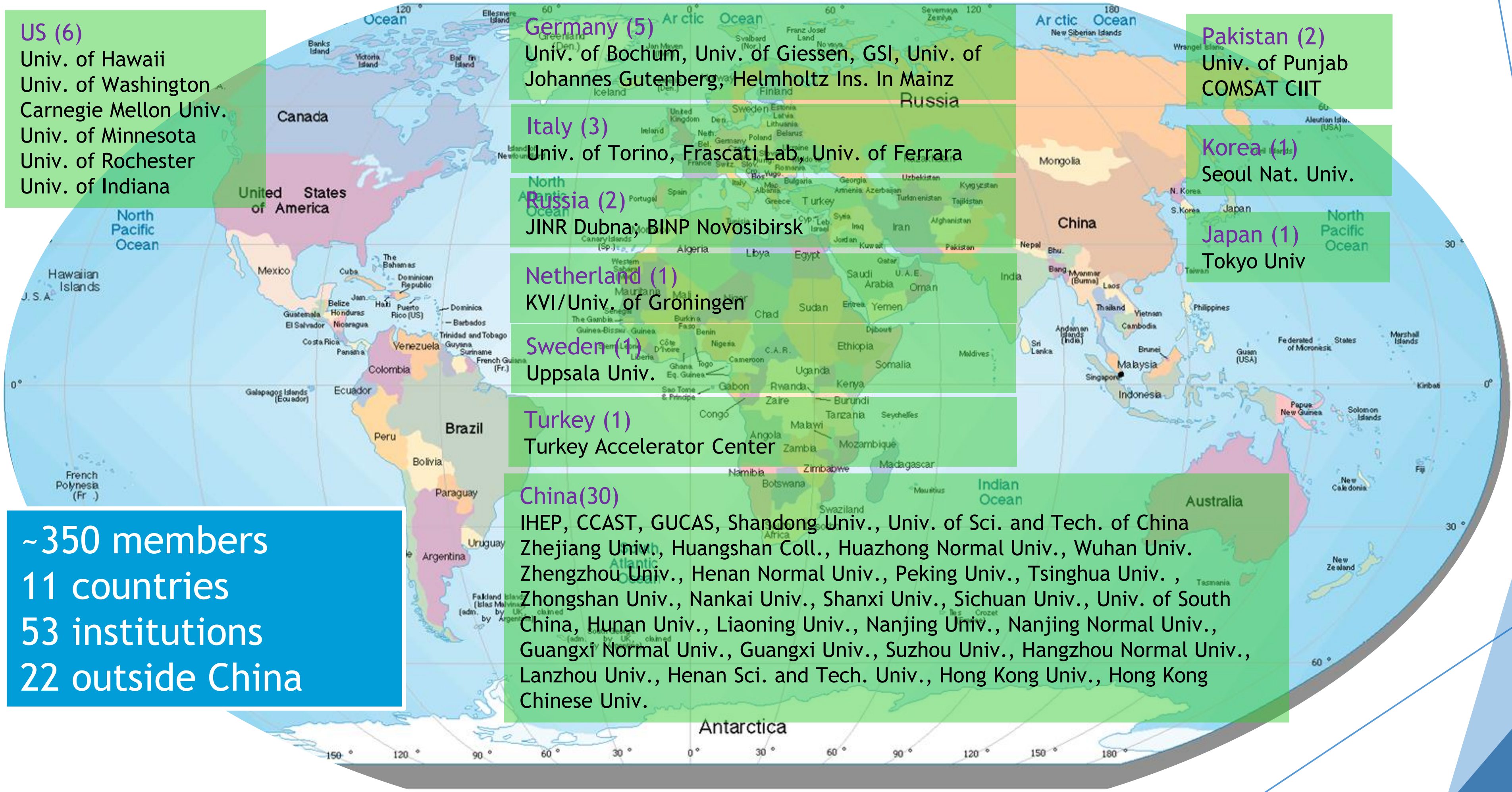
EM Calorimeter (EMC):
$\Delta E/E = 2.5\% \ @\ 1\ GeV$
$\sigma_{Z,\phi} = 0.6\ cm \ @\ 1\ GeV$
Barrel and endcap have different performance



1.0 Tesla Super-conducting Magnet

Muon Chamber (MUC):
RPC based

BESIII Collaboration



US (6)
Univ. of Hawaii
Univ. of Washington
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

Germany (5)
Univ. of Bochum, Univ. of Giessen, GSI, Univ. of Johannes Gutenberg, Helmholtz Ins. In Mainz

Italy (3)
Univ. of Torino, Frascati Lab, Univ. of Ferrara

Russia (2)
JINR Dubna; BINP Novosibirsk

Netherland (1)
KVI/Univ. of Groningen

Sweden (1)
Uppsala Univ.

Turkey (1)
Turkey Accelerator Center

Pakistan (2)
Univ. of Punjab
COMSAT CIIT

Korea (1)
Seoul Nat. Univ.

Japan (1)
Tokyo Univ

China(30)
IHEP, CCAST, GUCAS, Shandong Univ., Univ. of Sci. and Tech. of China Zhejiang Univ., Huangshan Coll., Huazhong Normal Univ., Wuhan Univ. Zhengzhou Univ., Henan Normal Univ., Peking Univ., Tsinghua Univ. , Zhongshan Univ., Nankai Univ., Shanxi Univ., Sichuan Univ., Univ. of South China, Hunan Univ., Liaoning Univ., Nanjing Univ., Nanjing Normal Univ., Guangxi Normal Univ., Guangxi Univ., Suzhou Univ., Hangzhou Normal Univ., Lanzhou Univ., Henan Sci. and Tech. Univ., Hong Kong Univ., Hong Kong Chinese Univ.

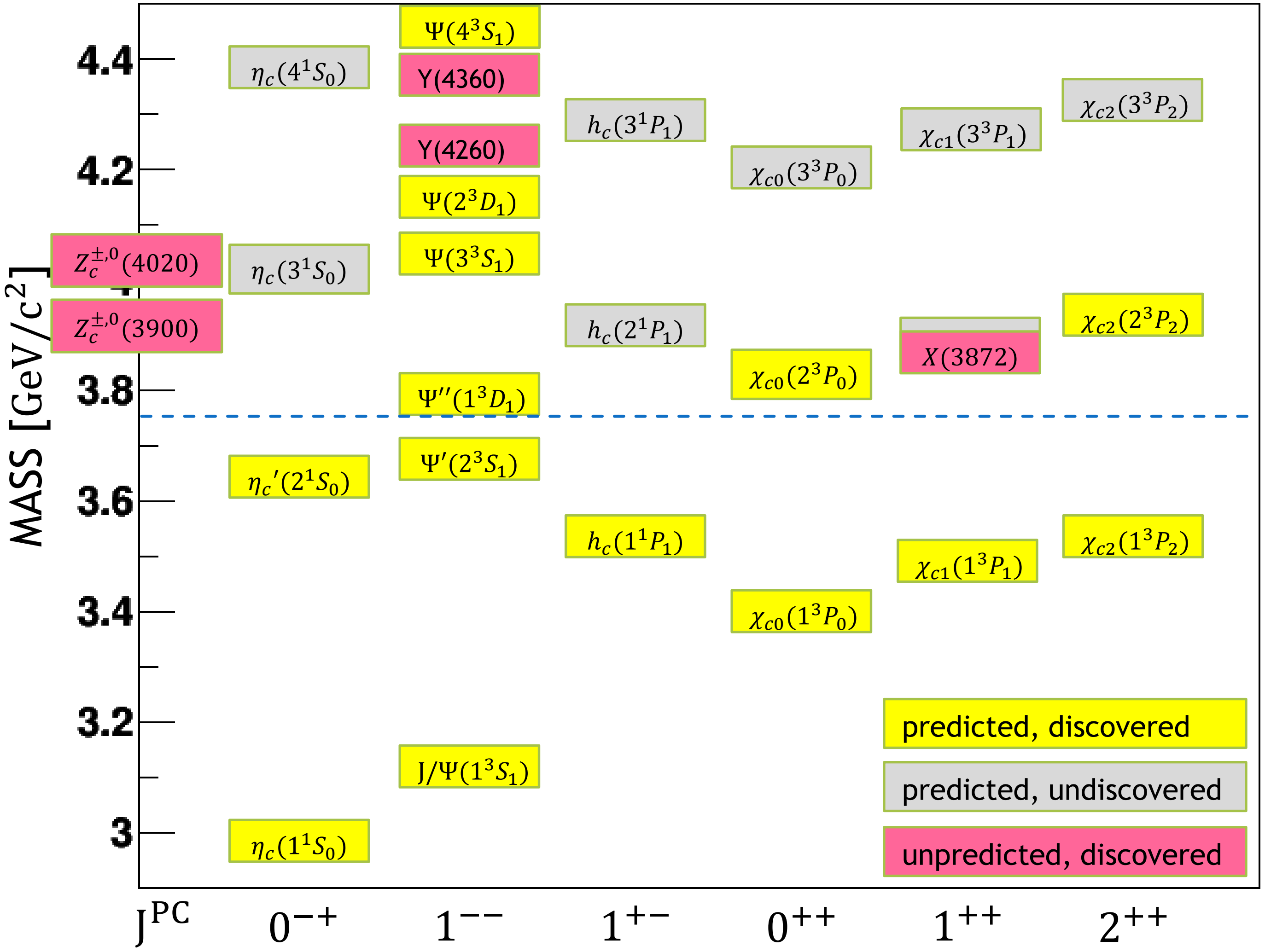
~350 members
11 countries
53 institutions
22 outside China

BESIII started data taking for physics since 2009

1.3×10^9	J/Ψ @ 3.097 GeV	2009 (0.225×10^9) + 2012
0.5×10^9	Ψ' @ 3.686 GeV	2009 (0.106×10^9) + 2012
$2.9\ \mathrm{fb}^{-1}$	$\Psi(3770)$ @ 3.773 GeV	2010 + 2011
$0.5\ \mathrm{fb}^{-1}$	$\Psi(4040)$ @ 4.009 GeV	2011
$0.024\ \mathrm{fb}^{-1}$	τ mass scan at around 3.554 GeV	2011
$1.9\ \mathrm{fb}^{-1}$	$\Upsilon(4260)$ @ 4.23 and 4.26 GeV	2013
$0.5\ \mathrm{fb}^{-1}$	$\Upsilon(4360)$ @ 4.36 GeV	2013
$0.5\ \mathrm{fb}^{-1}$	$\Upsilon(4260)$ and $\Upsilon(4360)$ scan	2013
$0.8\ \mathrm{fb}^{-1}$	R scan, 104 energy points between 3.85 and 4.59 GeV	2014
$1.0\ \mathrm{fb}^{-1}$	@ 4.42 GeV	2014
$0.1\ \mathrm{fb}^{-1}$	@ 4.47 GeV	2014
$0.1\ \mathrm{fb}^{-1}$	@ 4.53 GeV	2014
$0.04\ \mathrm{fb}^{-1}$	@ 4.575 GeV	2014
$0.5\ \mathrm{fb}^{-1}$	@ 4.60 GeV	2014

XYZ (charmonium-like) physics at BESIII

The Landscape



Prediction: Barnes, Swanson, and Godfrey, PRD 72, 054026 (2005)

- All states below $D\bar{D}$ threshold have been observed
- Many missing states above $D\bar{D}$ threshold
- Pattern of masses
- Transitions between states

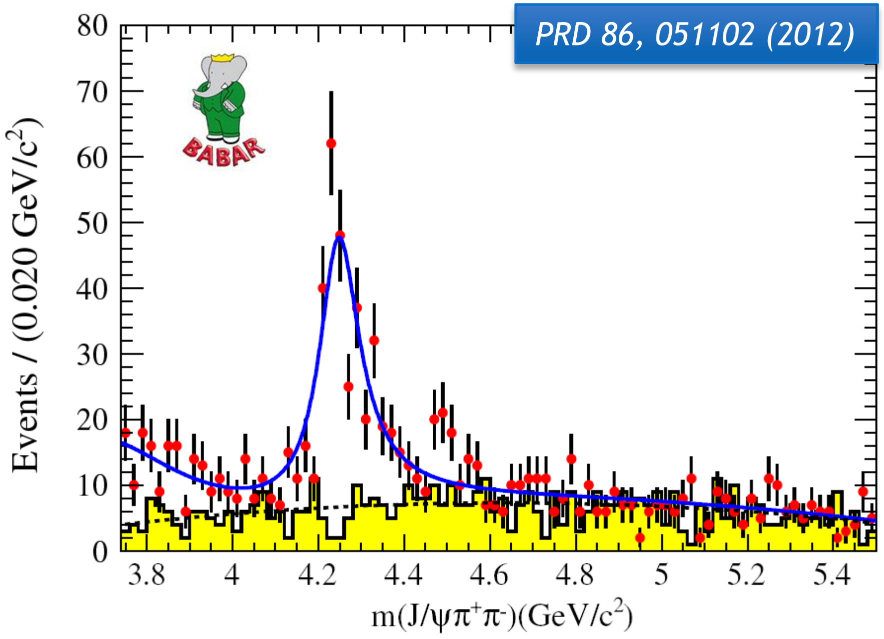
Y(4260)

- $J^{PC} = 1^{--}$ state produced in $e^+e^- \rightarrow \gamma_{ISR}\, \pi^+\, \pi^-\, J/\Psi$
- OZI favored decay is expected, but no obvious enhanced open-charm channel is observed

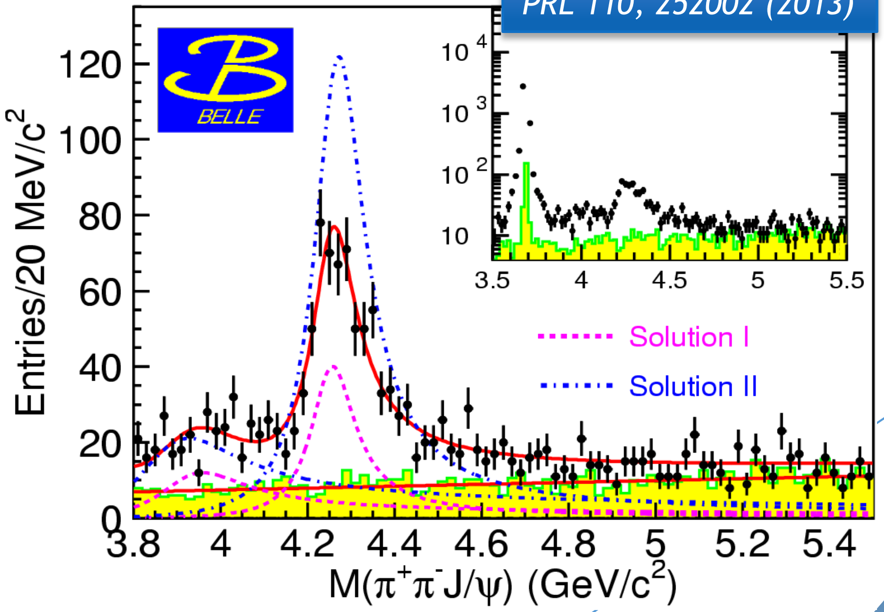
Final state (X)	$\frac{\sigma(Y(4260)\rightarrow X)}{\sigma(Y(4260)\rightarrow \pi^+\pi^- J/\psi)}$
$D\bar{D}$	<4.0
$D^*\bar{D}$	<45
$D^*\bar{D}^*$	<11
$D^*\bar{D}\pi$	<15
$D^*\bar{D}^*\pi$	<8.2
$D_s^+D_s^-$	<1.3
$D_s^{*+}D_s^-$	<0.8
$D_s^{*+}D_s^{*-}$	<9.5

CLEO-c

PRD 80, 072001 (2009)



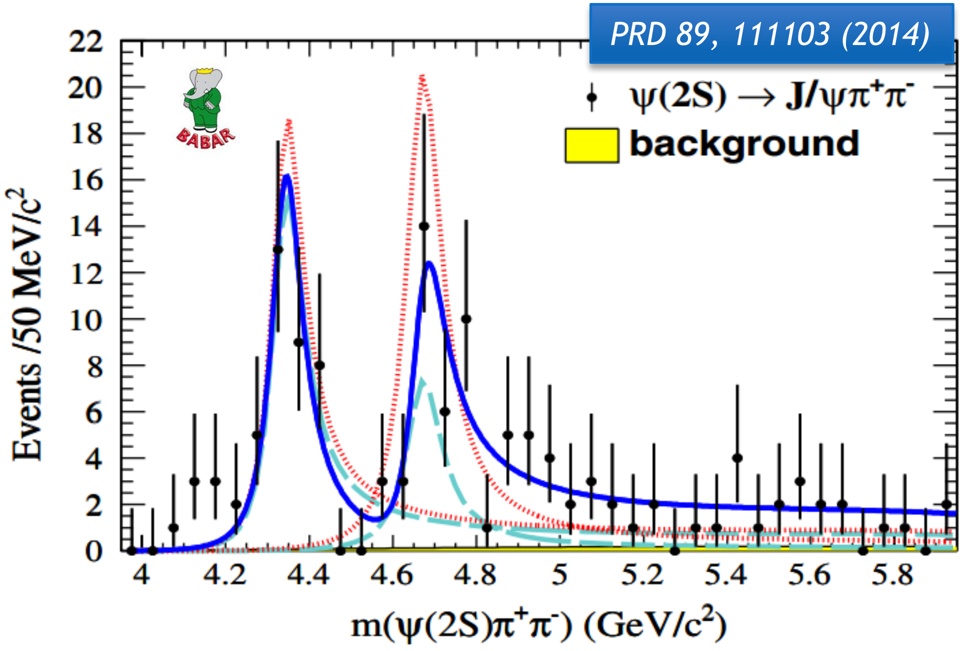
PRD 86, 051102 (2012)

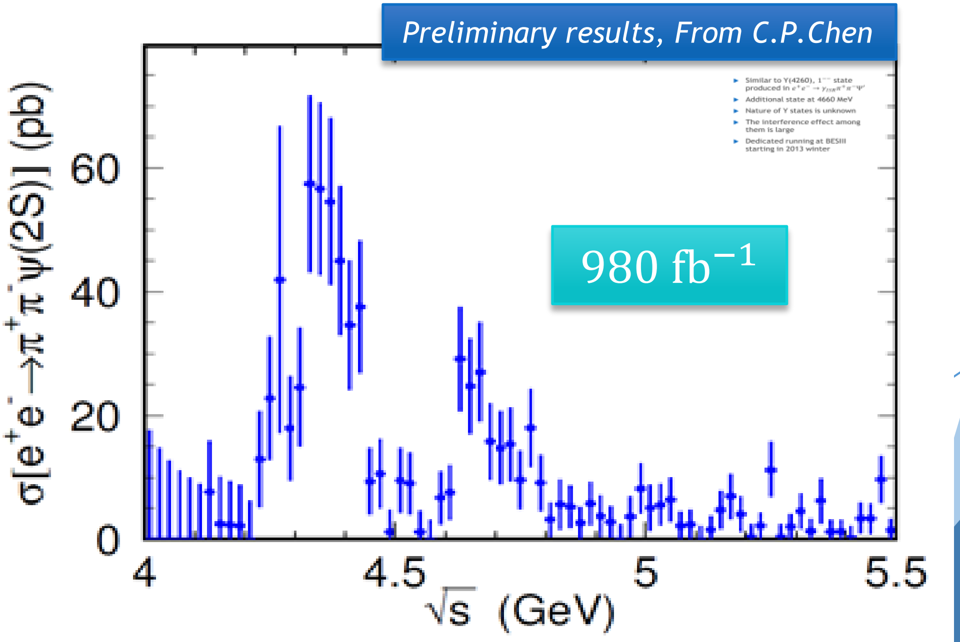


PRL 110, 252002 (2013)

Y(4360)

- Similar to Y(4260), 1^{--} state produced in $e^+e^- \to \gamma_{ISR}\pi^+\pi^-\Psi'$
- Additional state at 4660 MeV
- Nature of Y states is unknown
- The interference effect among them is large
- Dedicated running at BESIII starting in 2013 winter

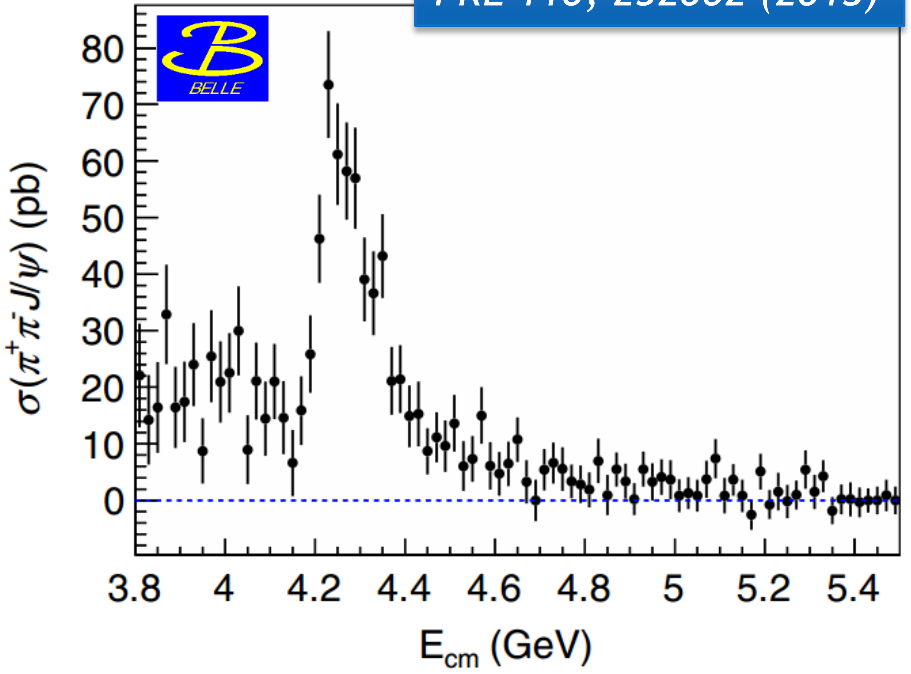




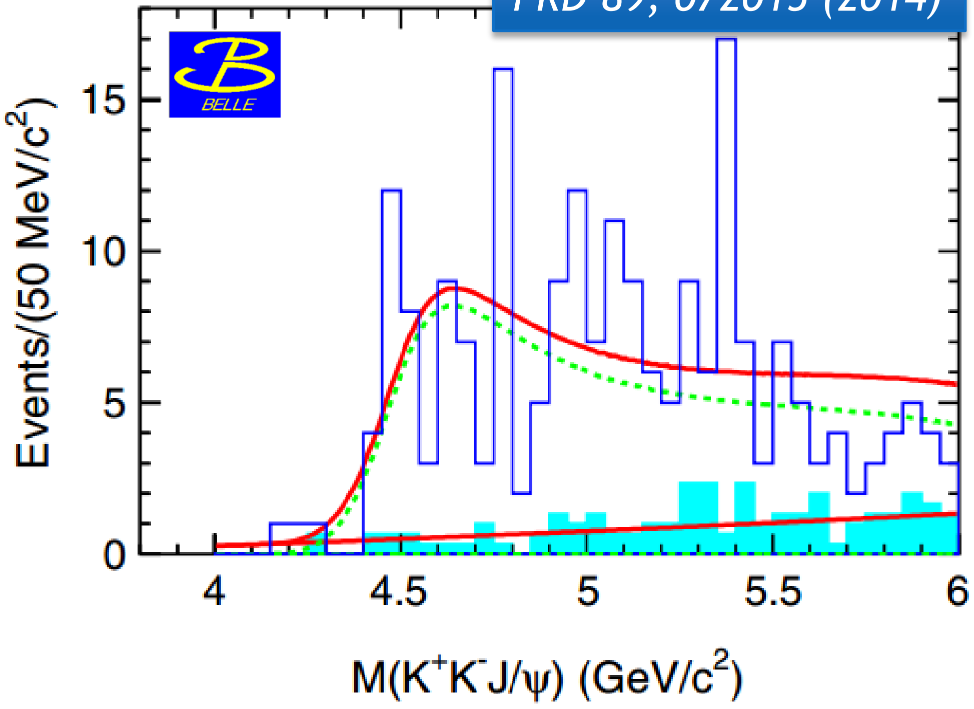
$e^+e^- \to \pi^+\pi^- J/\Psi$ at $E_{cm} = 4260\ \mathrm{MeV}$

- $\pi\pi\, J/\Psi$ is the only firmly established decay mode of Y(4260)

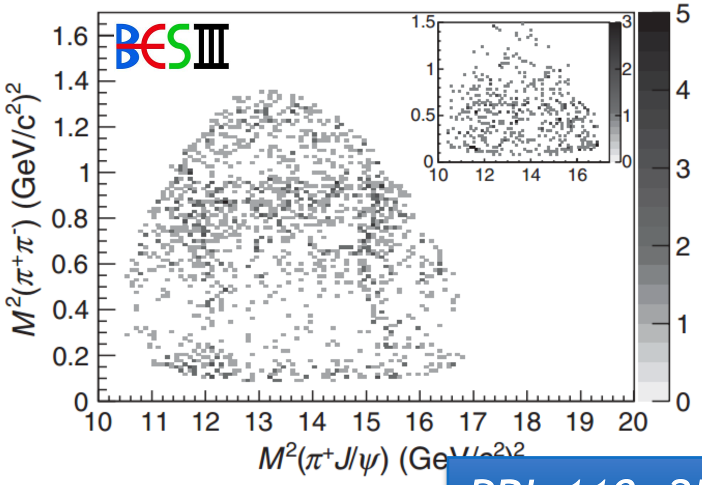
PRL 110, 252002 (2013)

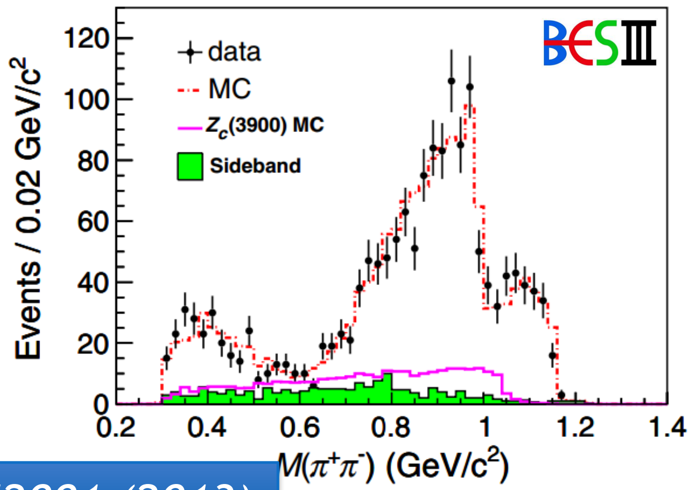


PRD 89, 072015 (2014)

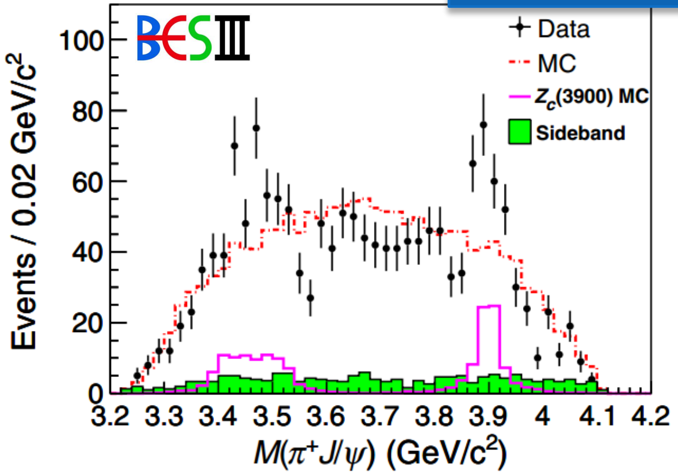


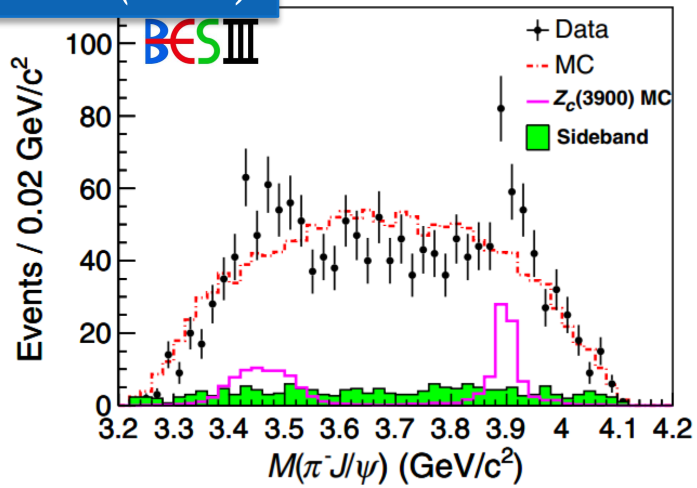
$e^+e^- \to \pi^+\pi^- J/\Psi$ at $E_{cm} = 4260$ MeV





PRL 110, 252001 (2013)

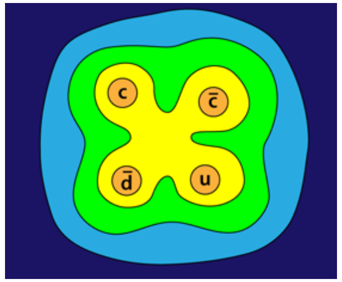




- Lum = 525 pb^{-1}
- Born cross section is $(62.9 \pm 1.9 \pm 3.7)$ pb
- Analysis is valid and unbiased

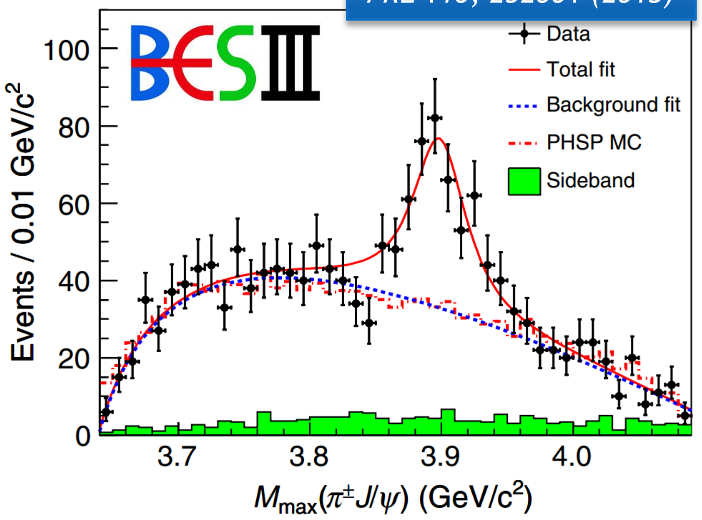
Discovery of $Z_c^{\pm}(3900)$

- $Z_c^{\pm}(3900) \rightarrow \pi^{\pm} J/\Psi$
- First confirmed particle made of four quarks
- More data is needed



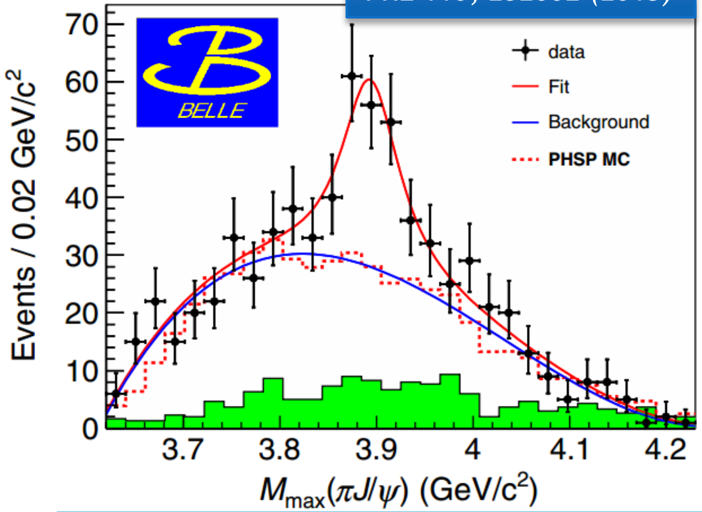
Viewpoint: New Particle Hints at Four-Quark Matter
http://physics.aps.org/articles/v6/69

PRL 110, 252001 (2013)



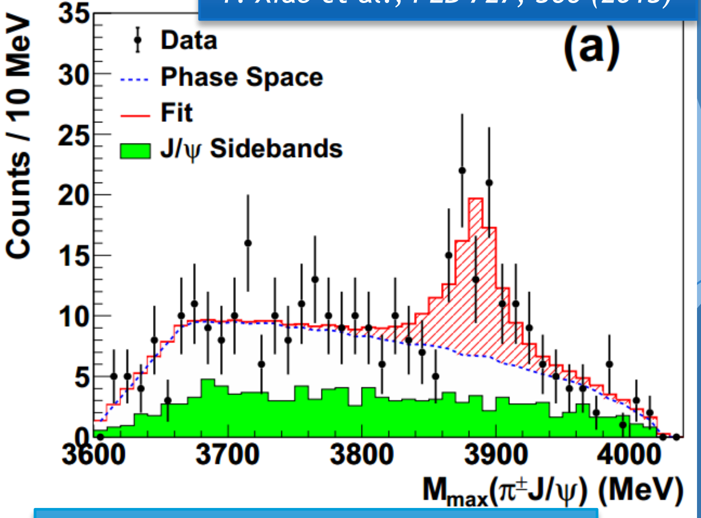
$\mathrm{M} = (3899.0 \pm 3.6 \pm 4.9)\mathrm{MeV}$
$\Gamma = (46 \pm 10 \pm 20)\mathrm{MeV}$

PRL 110, 252002 (2013)



$\mathrm{M} = (3894.5 \pm 6.6 \pm 4.5)\mathrm{MeV}$
$\Gamma = (63 \pm 24 \pm 26)\mathrm{MeV}$

T. Xiao et al., PLB 727, 366 (2013)

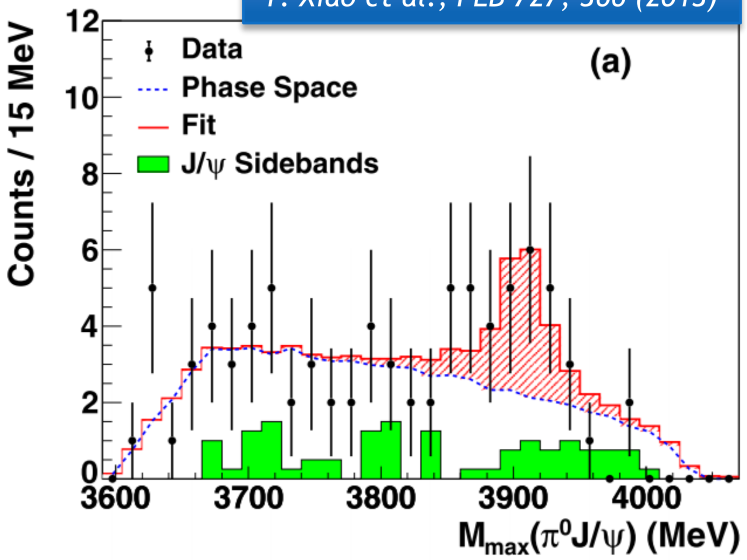


$\mathrm{M} = (3886 \pm 6 \pm 4)\mathrm{MeV}$
$\Gamma = (33 \pm 6 \pm 7)\mathrm{MeV}$

$Z_c^0(3900)$

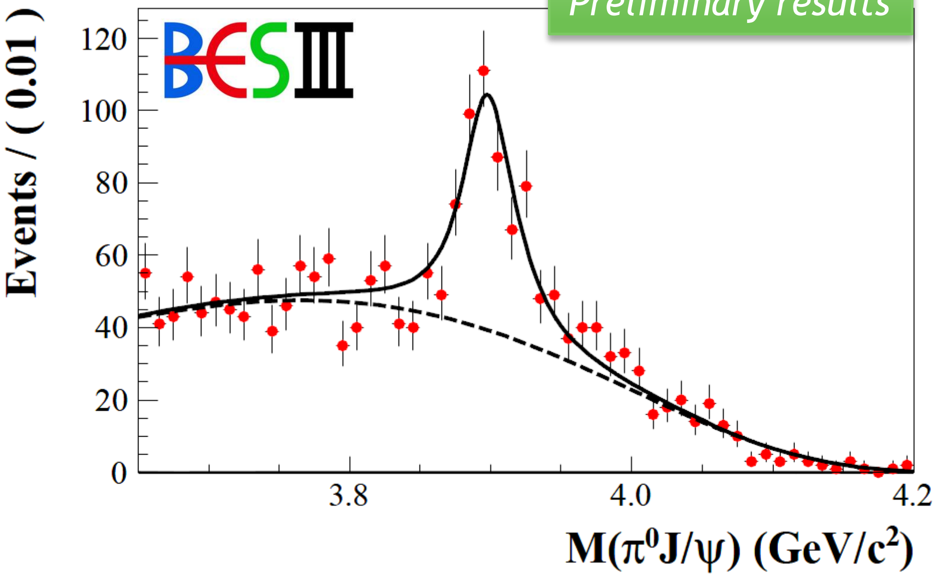
- Evidence of neutral iso-spin partner is observed in $e^+e^- \to \pi^0\pi^0 J/\psi$
- Production correlated with Y(4260) is suggestive

T. Xiao et al., PLB 727, 366 (2013)



$\mathrm{M} = (3886 \pm 6 \pm 4)\mathrm{MeV}$
$\Gamma = (33 \pm 6 \pm 7)\mathrm{MeV}$

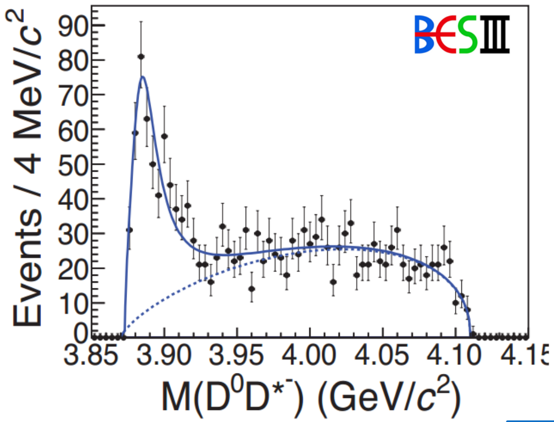
Preliminary results

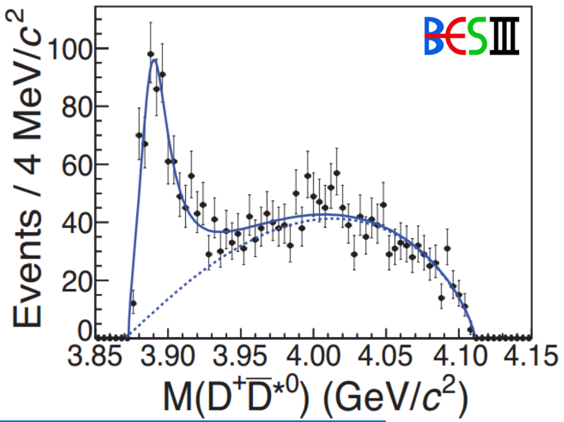


$\mathrm{M} = (3894.8 \pm 2.3 \pm 2.6)\mathrm{MeV}$
$\Gamma = (29.6 \pm 8.2 \pm 7.3)\mathrm{MeV}$

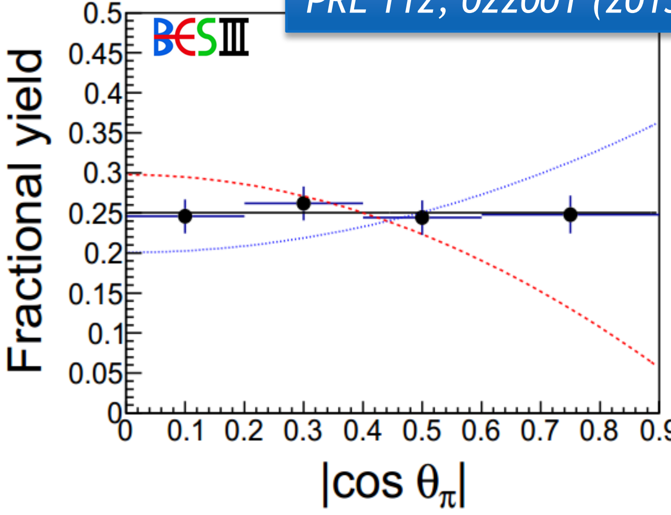
$e^+e^- \to \pi^\pm(D\bar{D}^*)^\mp$@ 4260 MeV

- $Z_c(3885)$ is observed in the $D\bar{D}^*$ invariant mass
- If $Z_c(3885)$ is $Z_c(3900)$
  $$\frac{\Gamma(Z_c(3900) \to D\bar{D}^*)}{\Gamma(Z_c(3900) \to \pi J/\Psi)} = 6.2 \pm 2.9$$
  much smaller than that of conventional charmonium states
- π angular distribution favors $J^P = 1^+$





PRL 112, 022001 (2013)

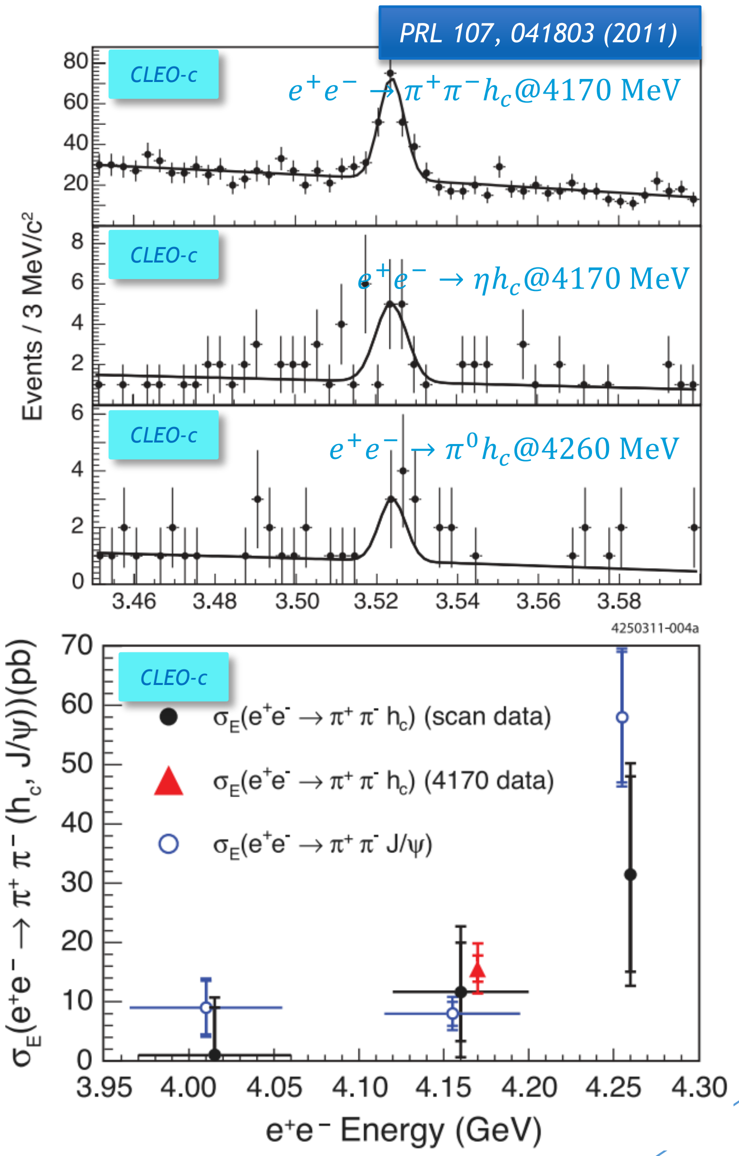


$\mathrm{M}[Z_c(3900)] = (3899.0 \pm 3.6 \pm 4.9)\mathrm{MeV}$
$\Gamma[Z_c(3900)] = (46 \pm 10 \pm 20)\mathrm{MeV}$

$\mathrm{M}[Z_c(3885)] = 3884 \pm 4$ MeV
$\Gamma[Z_c(3885)] = 25 \pm 11$ MeV

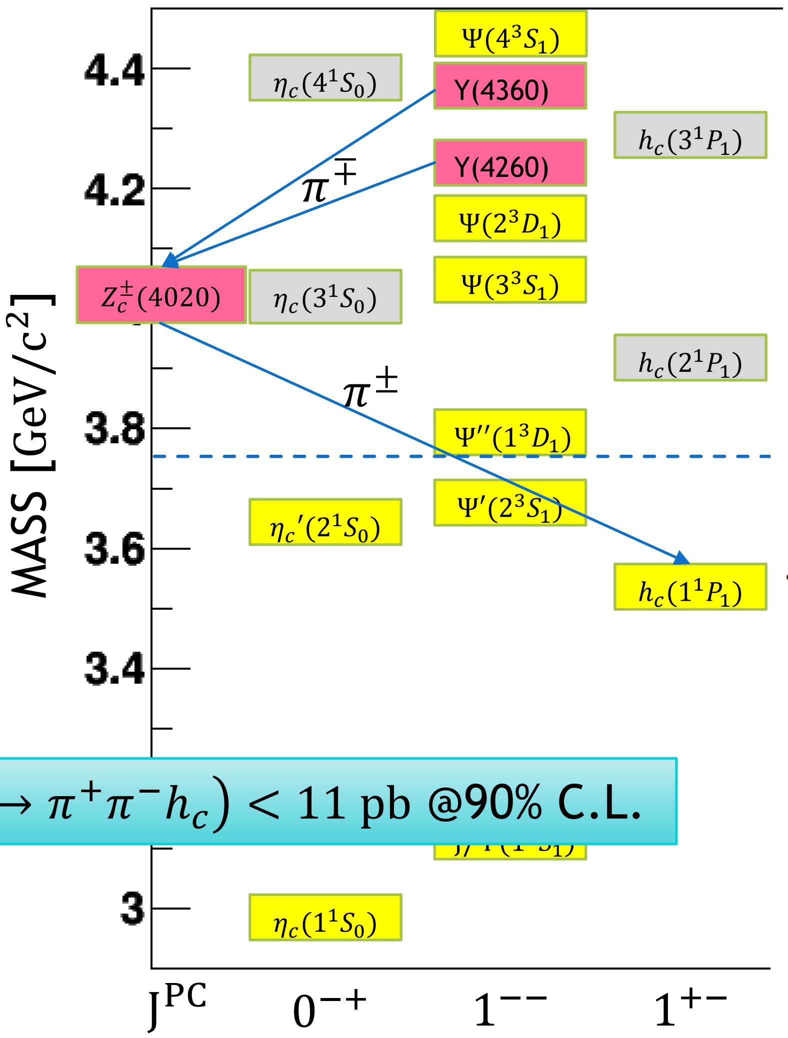
$e^+e^- \to \pi^+\pi^- h_c$

- Significant $\pi^+\pi^- h_c$ production at $E_{cm} = 4170\ \mathrm{MeV}$
- h_c is spin singlet (S=0) state different from J/ψ
- Correlated with Y(4260)?
- $\sigma(\pi^+\pi^- h_c)$ cross sections are comparable to $\sigma(\pi^+\pi^- J/\psi)$
- Search for $\pi^\pm h_c$ states
- $e^+e^- \to \pi^0\pi^0 h_c$ is also interesting



Discovery of $Z_c^{\pm}(4020)$

- No sharp structure in $\pi^+\pi^-h_c$ section, correlation with Y(4260) or Y(4360) unclear
- Narrow $\pi^{\pm}h_c$ structure observed
- No significance for $Z_c(3900) \to \pi^{\pm}h_c$

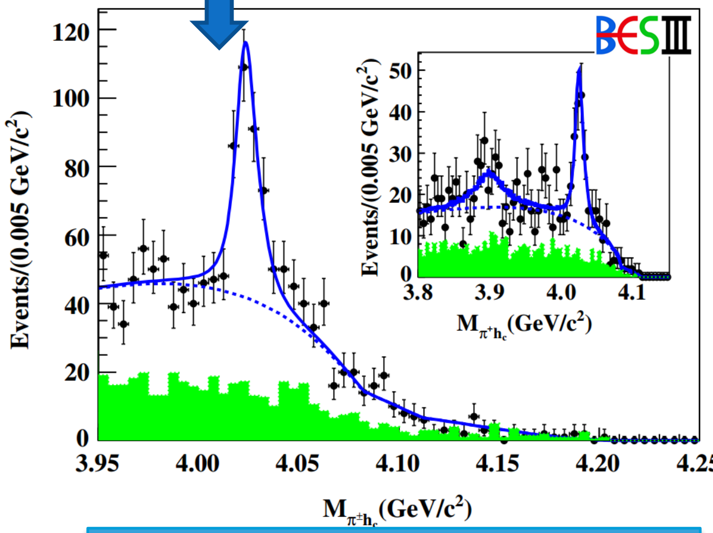


@ 4260 MeV

$\sigma(e^+e^- \to \pi^{\pm}Z_c^{\mp}(3900) \to \pi^+\pi^-h_c) < 11$ pb @90% C.L.

PRL 111, 242001 (2013)

$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$n_{h_c}^{\mathrm{obs}}$	$\sigma(e^+e^- \to \pi^+\pi^-h_c)$ (pb)
3.900	52.8	<2.3	<8.3
4.009	482.0	<13	<5.0
4.090	51.0	<6.0	<13
4.190	43.0	8.8 ± 4.9	$17.7 \pm 9.8 \pm 1.6 \pm 2.8$
4.210	54.7	21.7 ± 5.9	$34.8 \pm 9.5 \pm 3.2 \pm 5.5$
4.220	54.6	26.6 ± 6.8	$41.9 \pm 10.7 \pm 3.8 \pm 6.6$
4.230	1090.0	646 ± 33	$50.2 \pm 2.7 \pm 4.6 \pm 7.9$
4.245	56.0	22.6 ± 7.1	$32.7 \pm 10.3 \pm 3.0 \pm 5.1$
4.260	826.8	416 ± 28	$41.0 \pm 2.8 \pm 3.7 \pm 6.4$
4.310	44.9	34.6 ± 7.2	$61.9 \pm 12.9 \pm 5.6 \pm 9.7$
4.360	544.5	357 ± 25	$52.3 \pm 3.7 \pm 4.8 \pm 8.2$
4.390	55.1	30.0 ± 7.8	$41.8 \pm 10.8 \pm 3.8 \pm 6.6$
4.420	44.7	29.1 ± 7.3	$49.4 \pm 12.4 \pm 4.5 \pm 7.6$

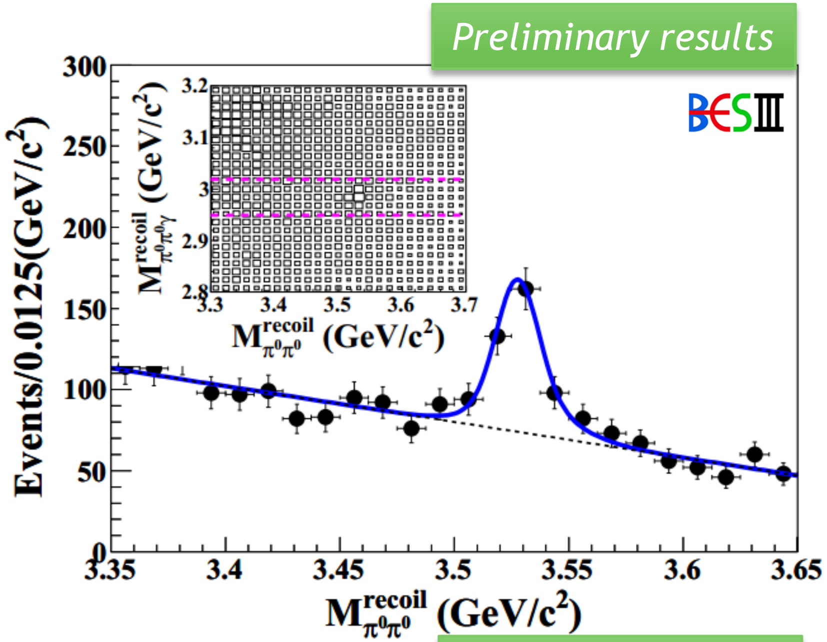


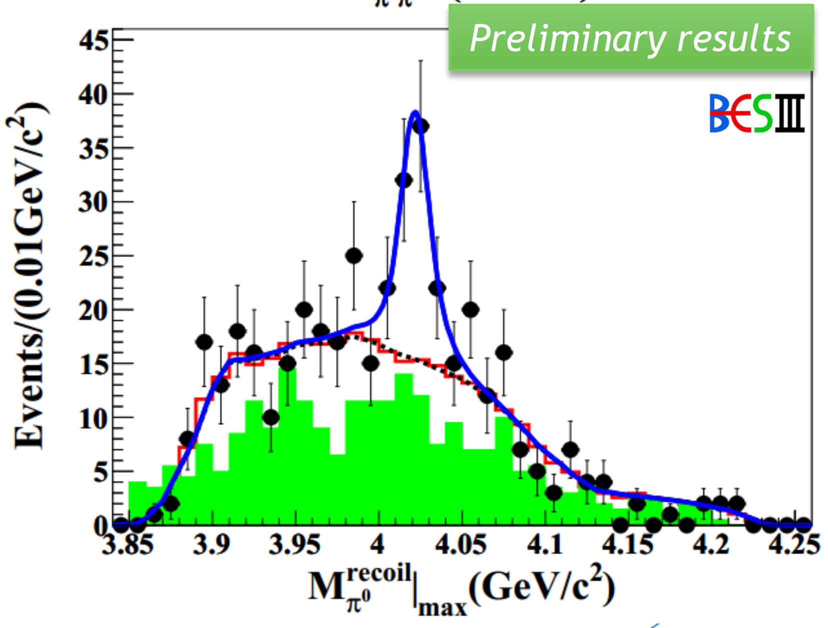
$M[Z_c(4020)] = 4023 \pm 3$ MeV
$\Gamma[Z_c(4020)] = 8 \pm 4$ MeV

$Z_c^0(4020)$

- Using data collected @4.23, 4.26 and 4.36 GeV to study $e^+e^- \to \pi^0\pi^0 h_c$
- The Born cross sections are found be about half of those of $e^+e^- \to \pi^+\pi^- h_c$
- Evidence of neutral iso-spin partner of $Z_c^{\pm}(4020)$

$M = (4023.6 \pm 2.2 \pm 3.9)\mathrm{MeV}$



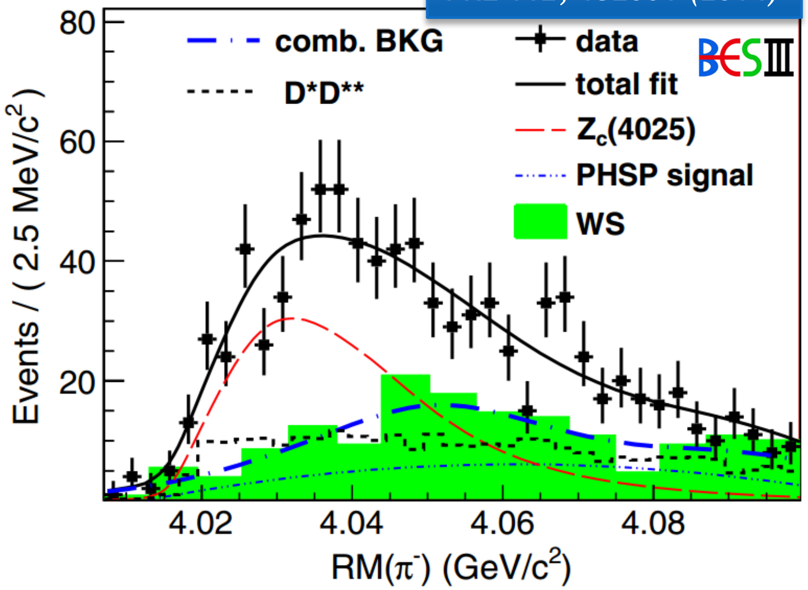


$e^+e^- \to \pi^\pm(D^*\overline{D^*})^\mp$ at $\mathrm{E_{cm}} = 4260$ MeV

- Deviation from phase space decay; Described by a charged state $Z_c^\pm(4025)$ decaying to $D^*\overline{D^*}$
- If $Z_c^\pm(4025)$ is the $Z_c^\pm(4020)$ observed in the $\pi^\pm h_c$ spectrum

$$\frac{\Gamma(Z_c(4020) \to D^*\overline{D^*})}{\Gamma(Z_c(4020) \to \pi h_c)} = 12 \pm 5$$

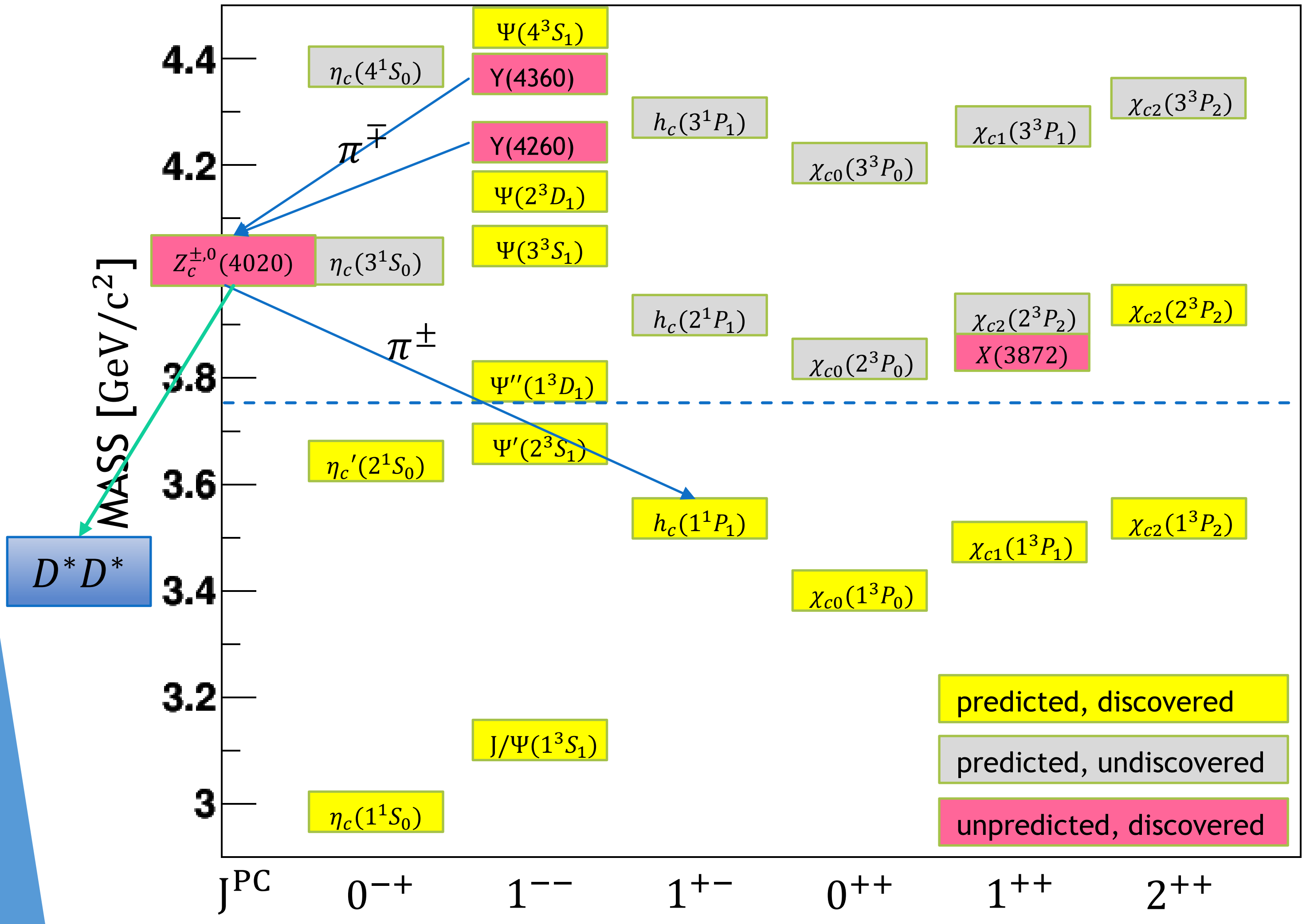
PRL 112, 132001 (2014)



$M[Z_c(4025)] = 4026 \pm 3$ MeV
$\Gamma[Z_c(4025)] = 25 \pm 6$ MeV

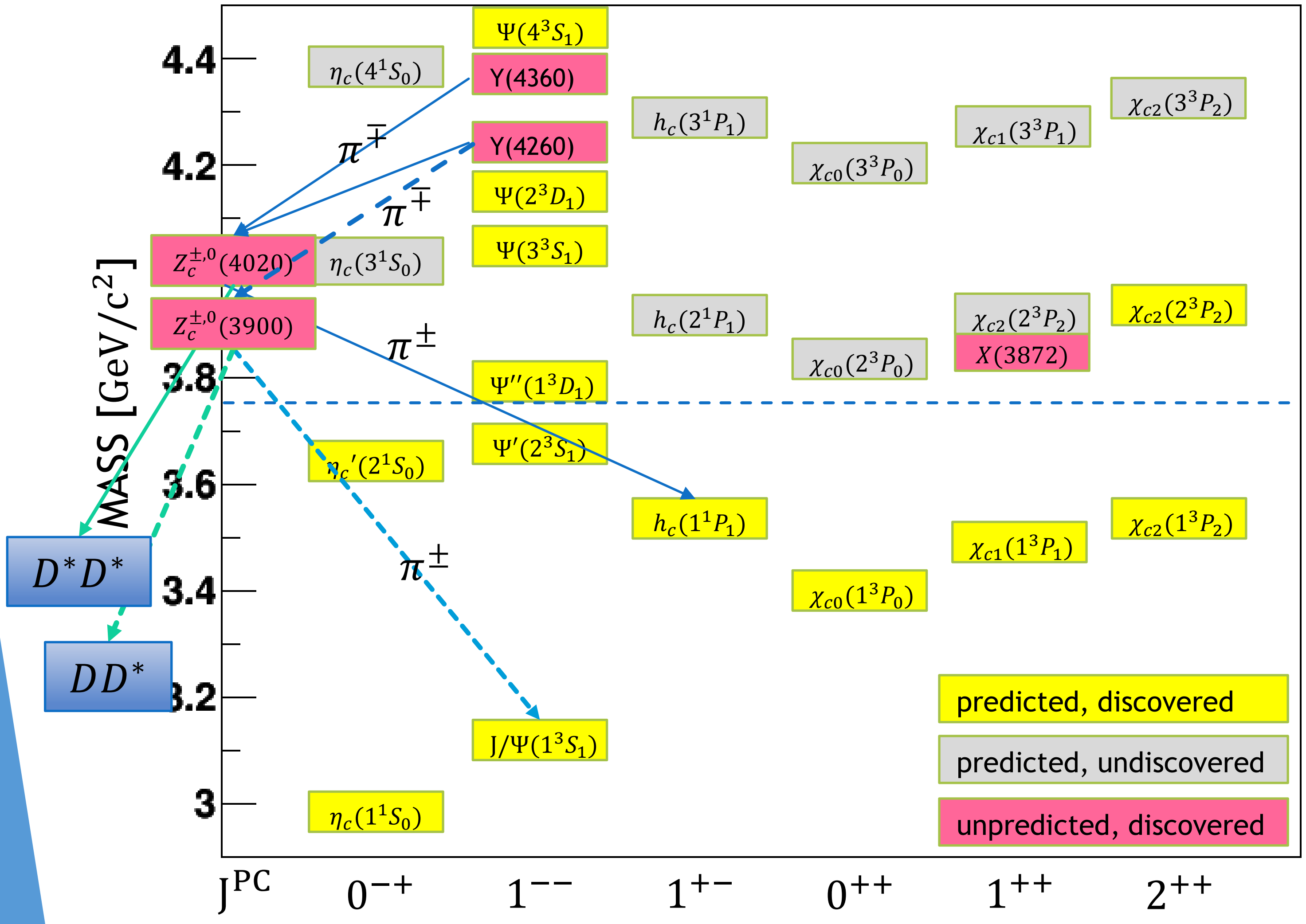
$M[Z_c(4020)] = 4023 \pm 3$ MeV
$\Gamma[Z_c(4020)] = 8 \pm 4$ MeV

$Z_c^{\pm,0}(4020)$ and $Z_c^{\pm,0}(3900)$



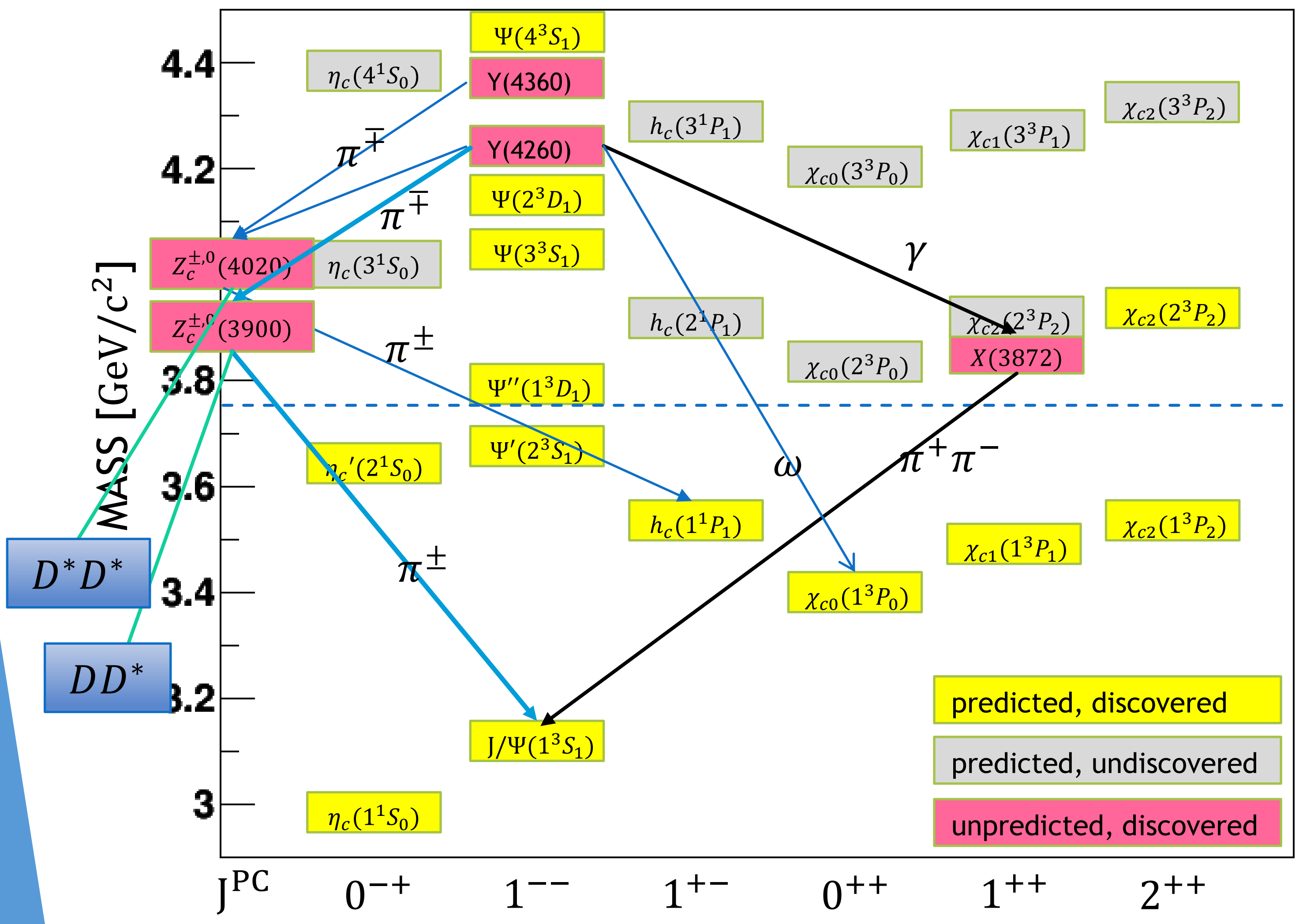
- Qualitatively similar to each other
- Correlation with Y(4360) or Y(4260) is clear or not?

$Z_c^{\pm,0}(4020)$ and $Z_c^{\pm,0}(3900)$



- Qualitatively similar to each other
- Correlation with Y(4360) or Y(4260) is clear or not?

$Z_c^{\pm,0}(4020)$ and $Z_c^{\pm,0}(3900)$

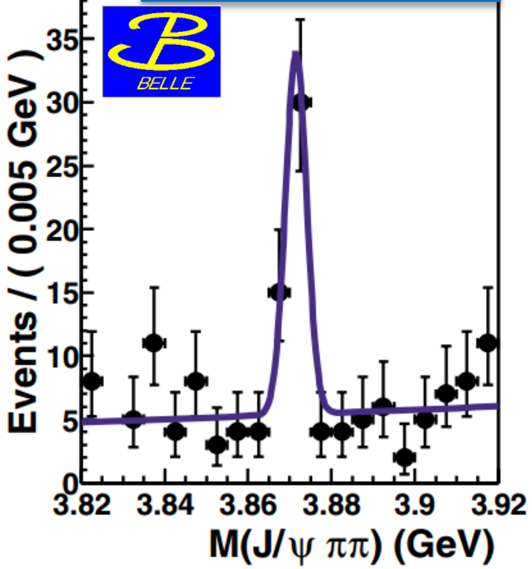


- Qualitatively similar to each other
- Correlation with Y(4360) or Y(4260) is clear or not?
- More interesting results

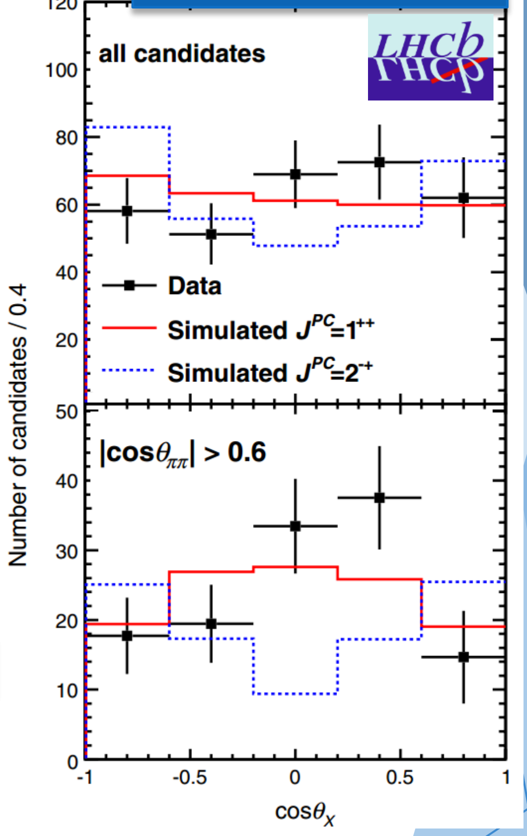
X(3872)

- Mass: Very close to $D^0 D^{*0}$ threshold
- Width: Very narrow (< 1.2 MeV)
- $J^{PC} = 1^{++}$
- Radiative transition to J/Ψ is observed
- Nature:
  - Bound $D^0 \overline{D^{*0}}$ “molecular” state?
  - Mixture of excited χ_{c1} and $D^0 \overline{D^{*0}}$ bound state?
  - If it is not χ'_{c1}, where is χ'_{c1}?

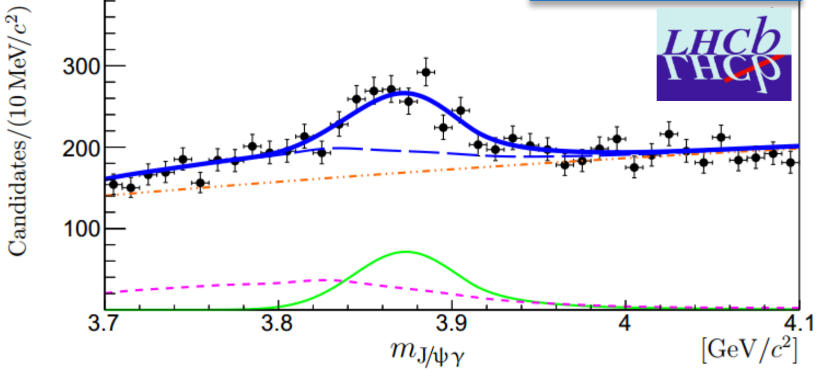
PRL 91, 262001 (2003)



PRL 110, 222001 (2013)



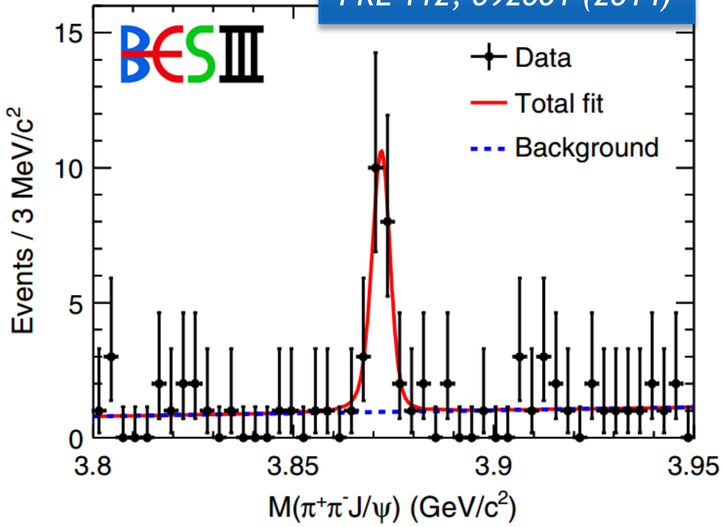
arXiv:1404.0275

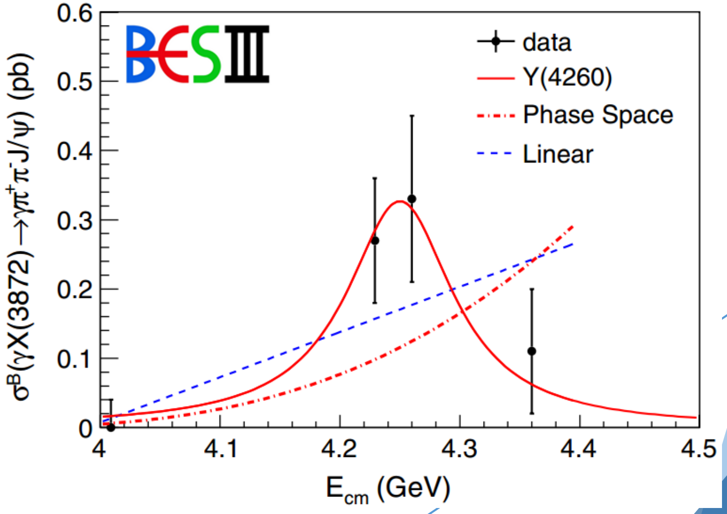


Observation of $e^+e^- \to \gamma X(3872)$

- Search for $\gamma X(3872)$ with $X(3872) \to \pi^+\pi^- J/\Psi$ at $\mathrm{E_{cm}} = 4.23, 4.26 \text{ and } 4.36\ \mathrm{GeV}$
- 6.3σ over all data
- Production in Y(4260) is suggestive, but not conclusive
$$\frac{B(Y(4260) \to \gamma X(3872))}{B(Y(4260) \to \pi^+\pi^- J/\Psi)} \approx 0.1$$
- Measuring transitions between states is essential

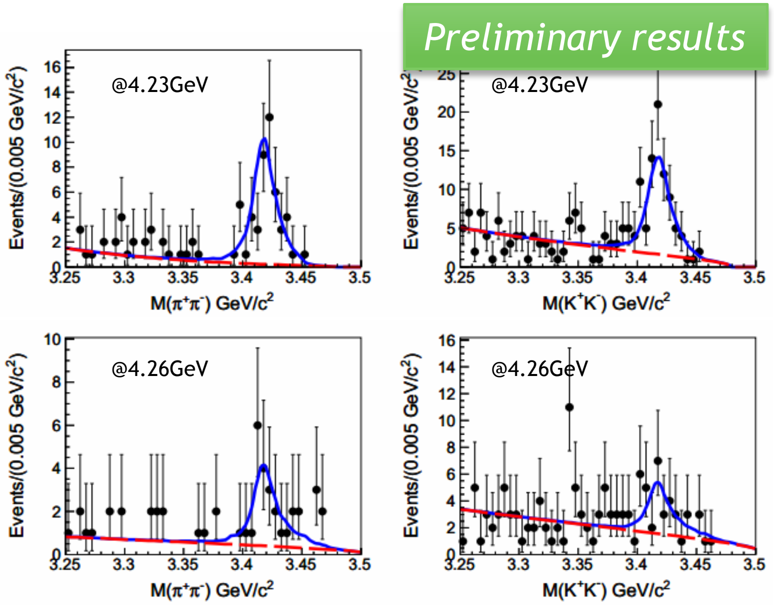
PRL 112, 092001 (2014)

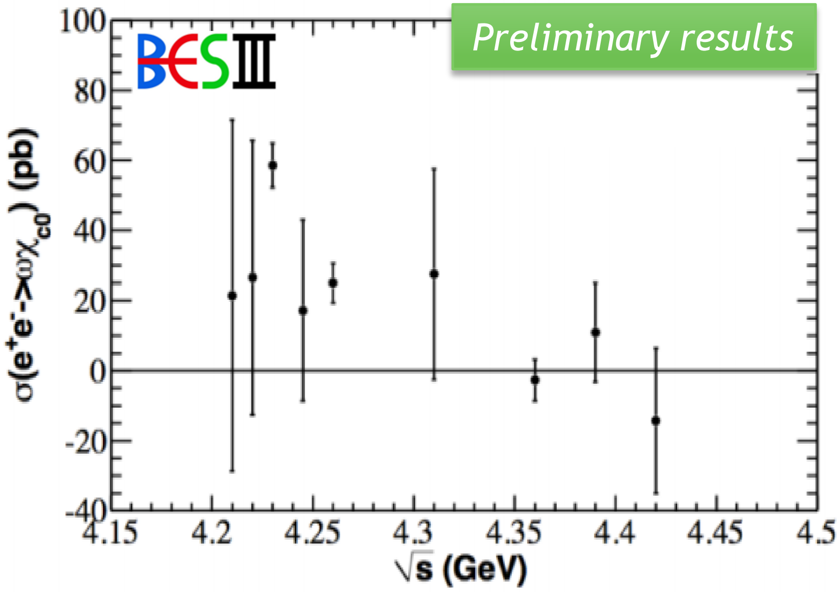




$e^+e^- \rightarrow \omega\chi_{c0}$

- Using data collected @4.23 and 4.26 GeV
- Fit with a single BW assumption, mass lower than 4.26 GeV
- No signal of $\omega\chi_{c1}$ or $\omega\chi_{c2}$ found between 4.19 and 4.42 GeV
- Disfavor Y(4260) is a $\omega\chi_{c1}$ molecule





Light hadron spectroscopy at BESIII

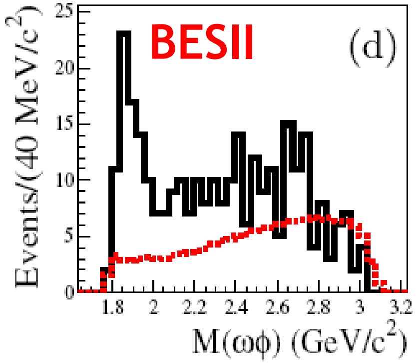
Overview of light hadron spectroscopy

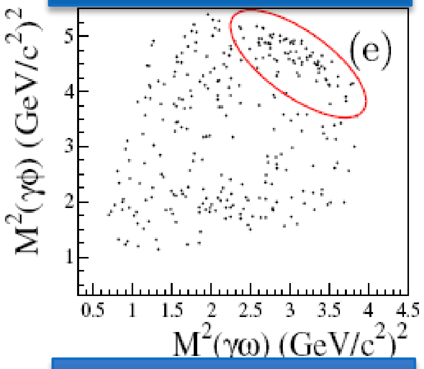
- Constituent Quark Model(CQM) has two types of hadrons
  - Mesons: $q\bar{q}$
  - Baryons: qqq
- QCD allows hadrons of other types
  - Multi-quark states: (more than 3 quarks)
  - Hybrids: $q\bar{q}g$
  - Glueballs: gg, ggg, …
- BESIII has collected the largest J/ψ and $\psi(2S)$ data sample in the world
  - 1.3 billion J/ψ events taken in 2009 and 2012
  - 0.5 billion $\psi(2S)$ events taken in 2009 and 2012
- Over the past few years, many new particles have been found or confirmed at BESIII
  - $X(p\bar{p})$, X(1835), X(1870), X(1810), X(1840), X(2120), X(2370), …

$\omega\varphi$ threshold enhancement in $J/\psi \to \gamma\omega\varphi$

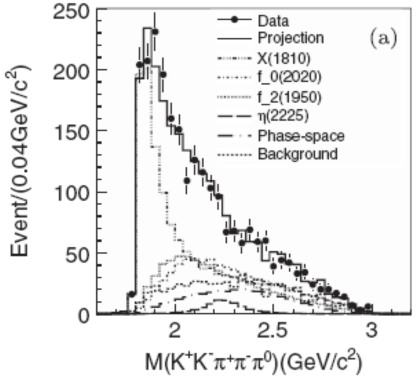
- J/ψ→γωφ is a DOZI process, but has a similar branch ratio compared to that of J/ψ→γϕϕ, an OZI process
  - Dynamical effect arising from intermediate meson re-scattering
  - A manifestation of $f_0(1710)$
  - Hadrons of new types: tetraquark, hybrid, glueball, …

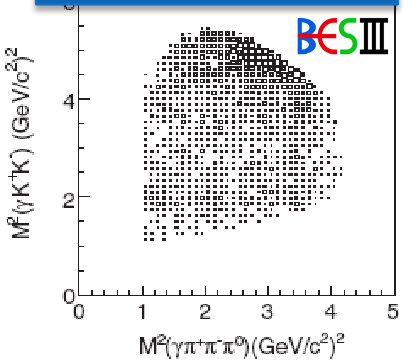
PRD 96, 162002 (2006)





PRD 96, 162002 (2006)

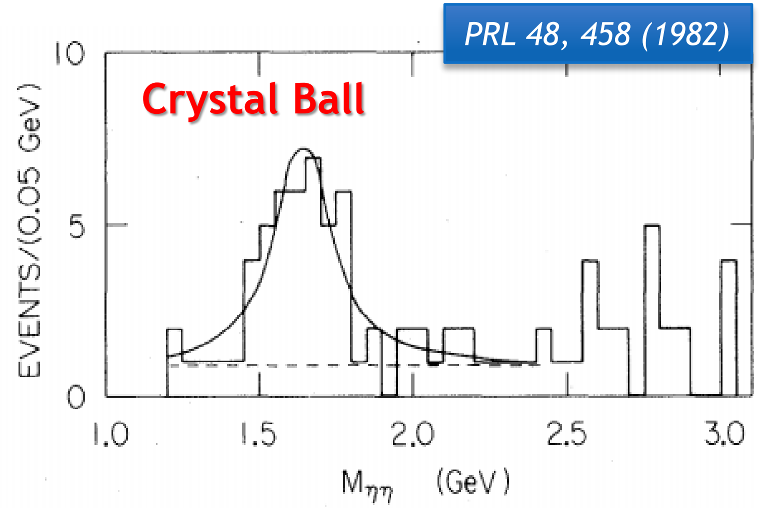


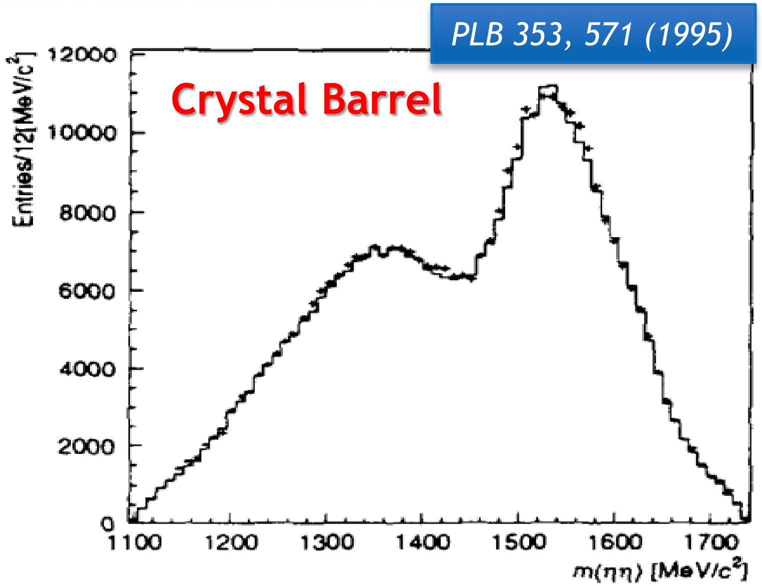


Resonance	J^{PC}	$M(\mathrm{MeV}/c^2)$	$\Gamma(\mathrm{MeV}/c^2)$	Events	ΔS	Δndf	Significance
$X(1810)$	0^{++}	1795 ± 7	95 ± 10	1319 ± 52	783	4	$>30\sigma$
$f_2(1950)$	2^{++}	1944	472	665 ± 40	211	2	20.4σ
$f_0(2020)$	0^{++}	1992	442	715 ± 45	100	2	13.9σ
$\eta(2225)$	0^{-+}	2226	185	70 ± 30	23	2	6.4σ
Coherent nonresonant component	0^{-+}	⋯	⋯	319 ± 24	45	2	9.1σ

Analysis of $J/\psi \to \gamma\eta\eta$

- Lattice QCD predicts the lowest lying 0^{++} glueball occurs in 1.5 to 1.7 GeV, and the lightest 2^{++} glueball has mass around 2.2GeV
- $\eta\eta$ system: Even^{++} states (mainly 0^{++} and 2^{++}), ideal place for search of scalar and tensor glueballs
  - Crystal Ball observed $\mathrm{f}_0(1710)$ in $J/\psi \to \gamma\eta\eta$
  - Crystal Barrel observed $\mathrm{f}_0(1500)$ in $p\bar{p} \to \pi^0\eta\eta$
  - Comparison to $\pi\pi$, $K\bar{K}$, $\eta\eta'$ system
- $J/\psi \to \gamma\eta\eta$ at BESIII
  - High statistics
  - EMC: CsI(T1) crystals, high performance
  - Low background

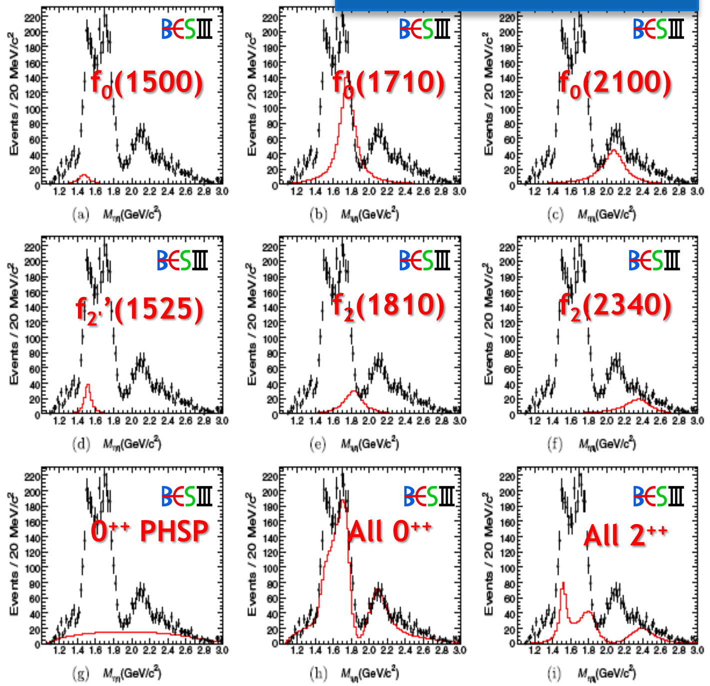




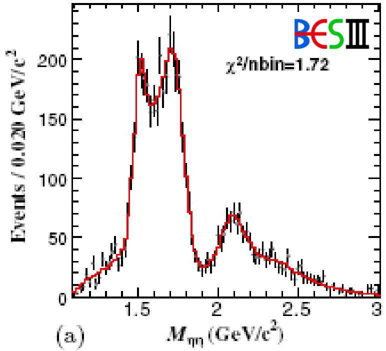
Partial Wave Analysis of $J/\psi \to \gamma\eta\eta$

PRD 87, 092009 (2013)

- $f_0(1710)$ and $f_0(2100)$ are dominant scalars, $f_0(1500)$ exists
- $f_2'(1525)$ is the dominant tensor, $f_2(1810)$ and $f_2(2340)$ exist
- Production rate of $f_0(1500)$ is approximately one order smaller than that of $f_0(1710)$ and $f_0(2100)$
- Production rate of $f_0(1710)$ in radiative J/ψ decays is compatible with LQCD's prediction on that of a pure gauge scalar glueball.
- Large overlap between $f_0(1710)$ and a glueball?



Resonance	B(J/ψ→γX→γηη)	Significance
$f_0(1500)$	$(1.65^{+0.36}_{-0.31}{}^{+0.51}_{-1.40})\times10^{-5}$	8.2σ
$f_0(1710)$	$(2.35^{+0.13}_{-0.11}{}^{+1.24}_{-0.74})\times10^{-4}$	25.0σ
$f_0(2100)$	$(1.13^{+0.09}_{-0.10}{}^{+0.64}_{-0.28})\times10^{-4}$	13.9σ
$f_2'(1525)$	$(3.42^{+0.43}_{-0.51}{}^{+1.37}_{-1.30})\times10^{-5}$	11.0σ
$f_2(1810)$	$(5.40^{+0.60}_{-0.67}{}^{+3.42}_{-2.35})\times10^{-5}$	6.4σ
$f_2(2340)$	$(5.60^{+0.62}_{-0.65}{}^{+2.37}_{-2.07})\times10^{-5}$	7.6σ
0^{++} PHSP	$(1.47^{+0.01}_{-0.02})\times10^{-4}$	12.4σ



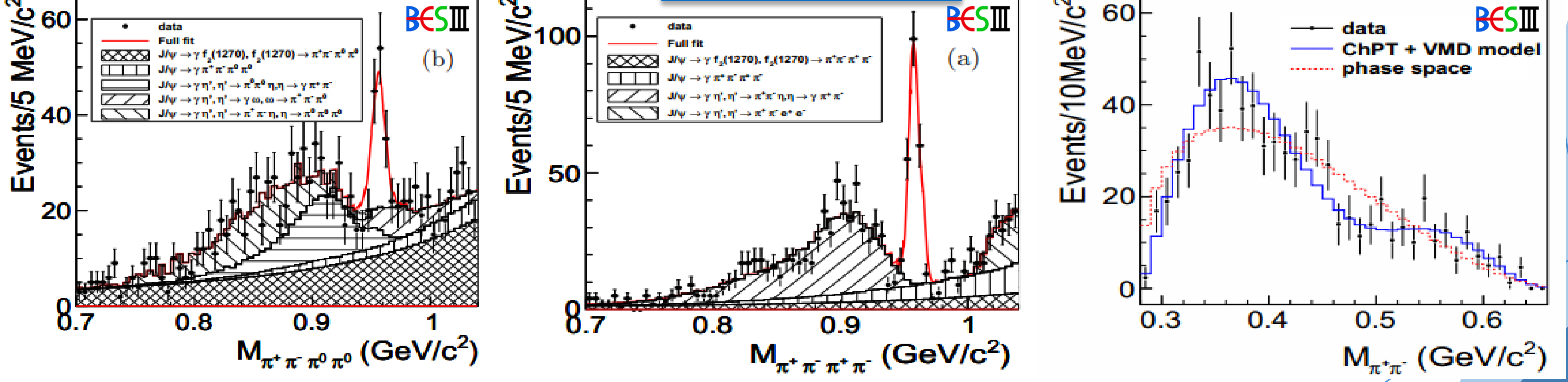
Observation of $\eta' \to \pi^+\pi^-\pi^+\pi^-(\pi^+\pi^-\pi^0\pi^0)$

- First observation the branching ratios
- Clearly support the model:
  Chiral perturbation and Vector-meson dominance

$$B(\eta' \to \pi^+\pi^-\pi^+\pi^-) = (8.53 \pm 0.69 \pm 0.64) \times 10^{-5}$$

$$B(\eta' \to \pi^+\pi^-\pi^0\pi^0) = (1.82 \pm 0.35 \pm 0.18) \times 10^{-4}$$

PRL 112, 251801 (2014)

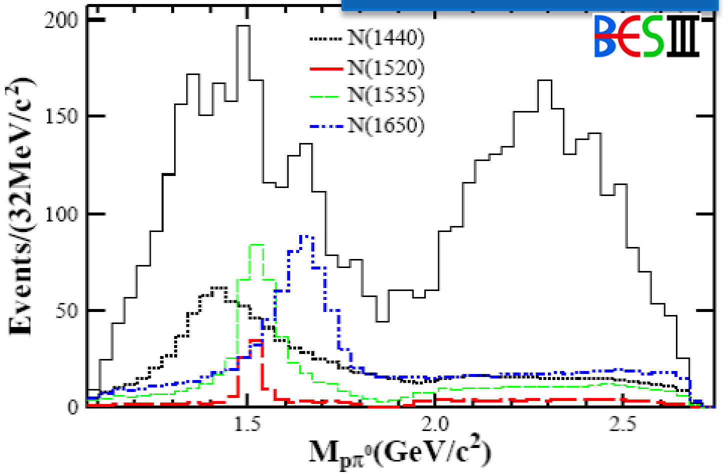


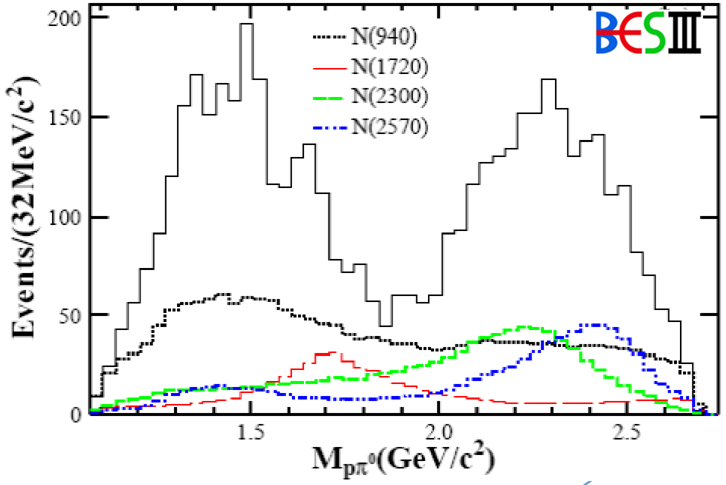
PWA of $\psi(2S) \to p\bar{p}\pi^0$

- Two new baryonic excited states are observed in PWA:
  $N(2300)$ $[\mathrm{J^P} = 1/2^+]$,
  $N(2570)$ $[\mathrm{J^P} = 5/2^-]$
- $N(1885)$ or $N(2065)$ has not been found

Resonance	$M(\mathrm{MeV}/c^2)$	$\Gamma(\mathrm{MeV}/c^2)$	ΔS	ΔN_{dof}	Sig.
$N(1440)$	1390^{+11+21}_{-21-30}	$340^{+46+70}_{-40-156}$	72.5	4	11.5σ
$N(1520)$	1510^{+3+11}_{-7-9}	115^{+20+0}_{-15-40}	19.8	6	5.0σ
$N(1535)$	1535^{+9+15}_{-8-22}	120^{+20+0}_{-20-42}	49.4	4	9.3σ
$N(1650)$	1650^{+5+11}_{-5-30}	150^{+21+14}_{-22-50}	82.1	4	12.2σ
$N(1720)$	1700^{+30+32}_{-28-35}	$450^{+109+149}_{-94-44}$	55.6	6	9.6σ
N(2300)	$\mathbf{2300^{+40+109}_{-30-0}}$	$\mathbf{340^{+30+110}_{-30-58}}$	**120.7**	**4**	$\mathbf{15.0\sigma}$
N(2570)	$\mathbf{2570^{+19+34}_{-10-10}}$	$\mathbf{250^{+14+69}_{-24-21}}$	**78.9**	**6**	$\mathbf{11.7\sigma}$

PRL 110, 022001 (2013)



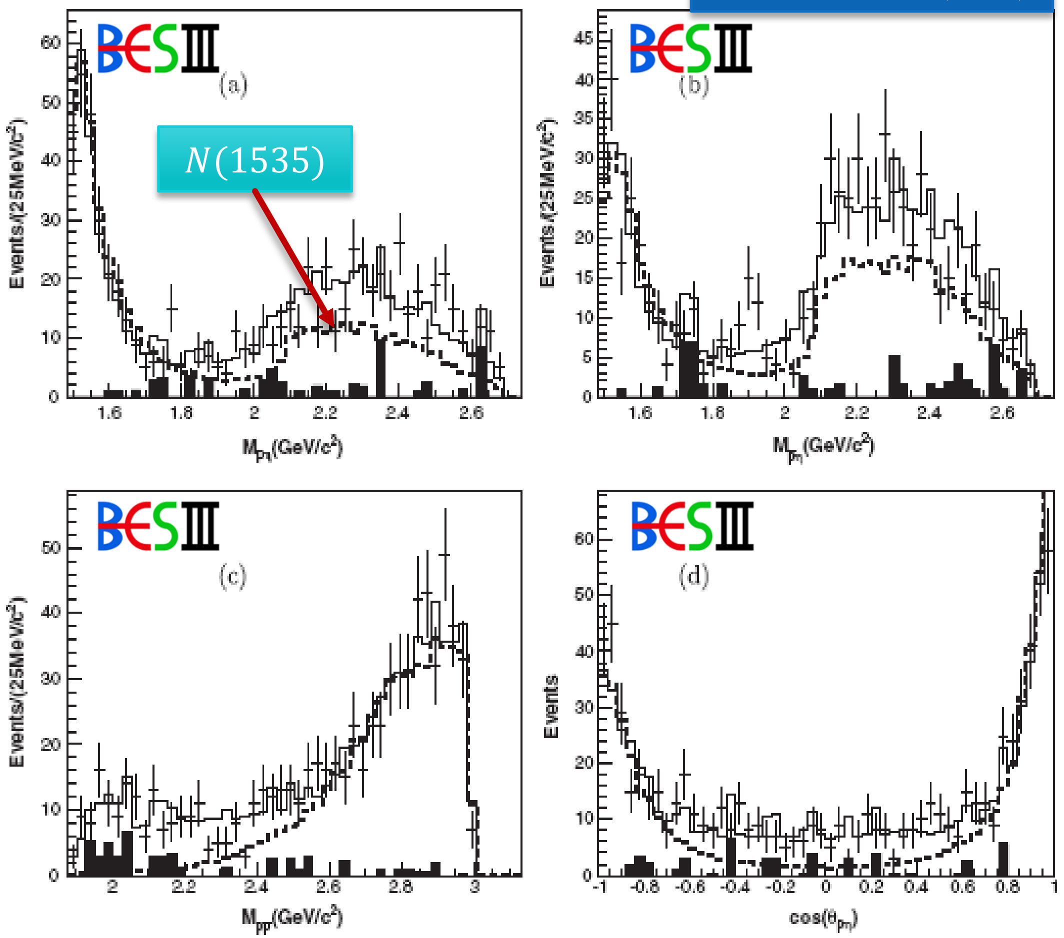


PWA of $\psi(2S) \to p\bar{p}\eta$

- $\psi(2S) \to N(1535)\bar{p}$ is dominant
- $\mathrm{J}^{\mathrm{P}} = 1/2^{-}$
- No evidence for a $p\bar{p}$ resonance that was observed by BESII and CLEO-c without PWA

$$\mathrm{M} = 1524 \pm 5^{+10}_{-4}\ \mathrm{MeV}$$
$$\Gamma = 130^{+27}_{-24}{}^{+57}_{-10}\ \mathrm{MeV}$$

PRD 88, 032010 (2013)

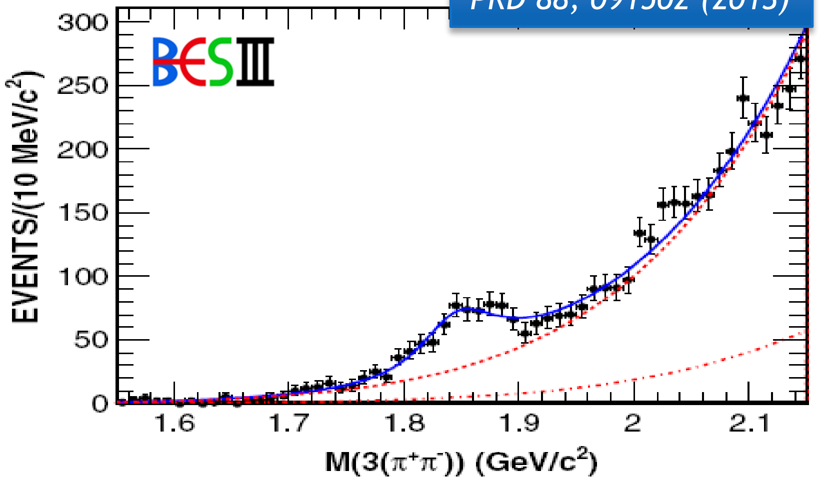


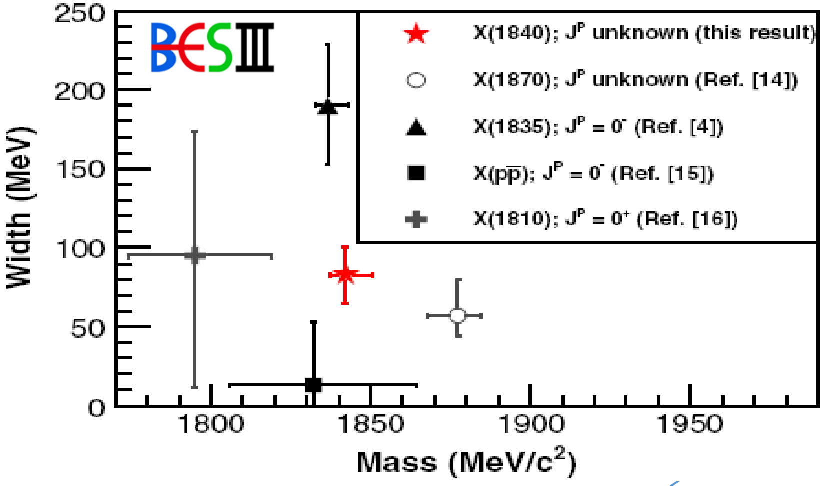
X(1840) in $J/\psi \to \gamma 3(\pi^+\pi^-)$

- A distinct enhancement can be clearly seen on mass spectrum of $3(\pi^+\pi^-)$ around 1.84 GeV
- Mass is consistent with that of X(1835), but the width is much smaller
- A new decay modes of X(1835)?
  - X(1835) is likely to have similar properties as η_c. $3(\pi^+\pi^-)$ is a relatively large decay mode of η_c, also for X(1835)?

$$M = 1842.2 \pm 4.2^{+7.1}_{-2.6}\ \mathrm{MeV}$$
$$\Gamma = 82 \pm 14 \pm 11\ \mathrm{MeV}$$

PRD 88, 091502 (2013)





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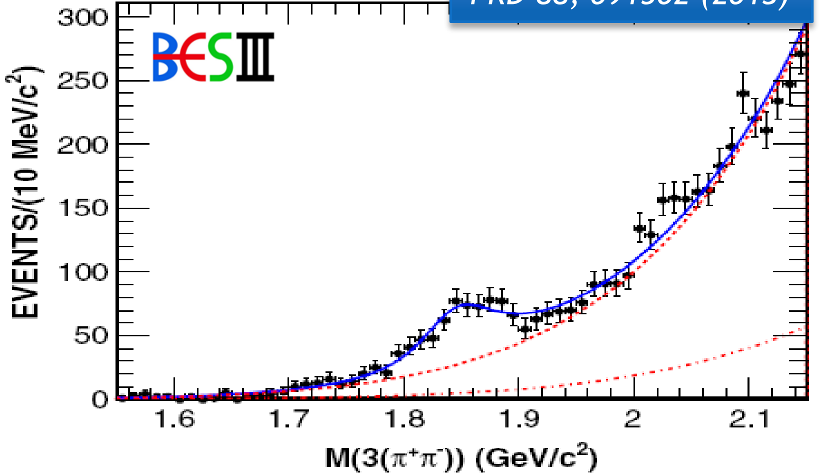
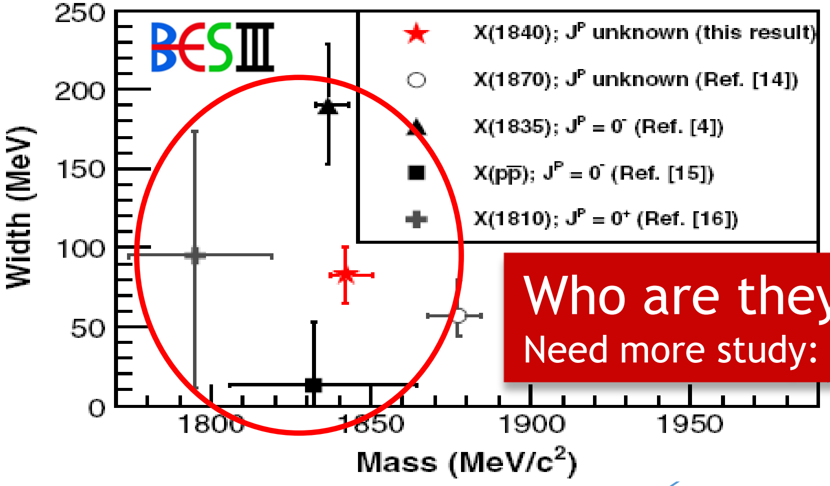
PRD 88, 091502 (2013)





Who are they?
Need more study: more data, PWA…

Summary of Observations

- Lots of XYZ results at BESIII
  - Charged Z particles are observed, very close to the DD* and D*D* threshold, at least four quark exotics
  - New production mode of $X(3872)$
  - Y resonances are very likely related to these particles' production
  - Observation of $e^+e^- \to \omega\chi_{c0}$, no $\omega\chi_{c1}$ or $\omega\chi_{c2}$ @ [4.19, 4.42 GeV]

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  - First observation of $X(1840) \to 3(\pi^+\pi^-)$
  - Study of $\eta\eta$ system
  - Observation of $\eta' \to \pi^+\pi^-\pi^+\pi^-(\pi^+\pi^-\pi^0\pi^0)$
  - Study of N^* baryons in $\psi(2S) \to p\bar{p}\pi^0, p\bar{p}\eta$

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- With more data sample accumulated at BESIII, exciting future is ahead!

Thanks a lot!