全国第十八届
重味物理和CP破坏研讨会

Recent XYZ results at BESIII

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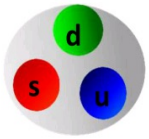
On behalf of the BESIII Collaboration

2021.11.12

Conventional and exotic Hadrons



Baryons are red-blue-green triplets

ordinary matter

Mesons are color-anticolor pairs

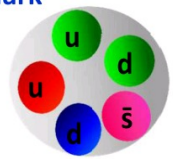
Λ=usd

π=ūd

Other possible combinations of quarks and gluons :

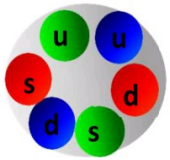
Pentaquark

S= +1 Baryon



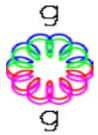
H di-Baryon

Tightly bound 6 quark state



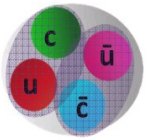
Glueball

Color-singlet multi-gluon bound state



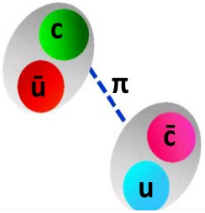
Tetraquark

Tightly bound diquark & anti-diquark

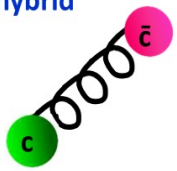


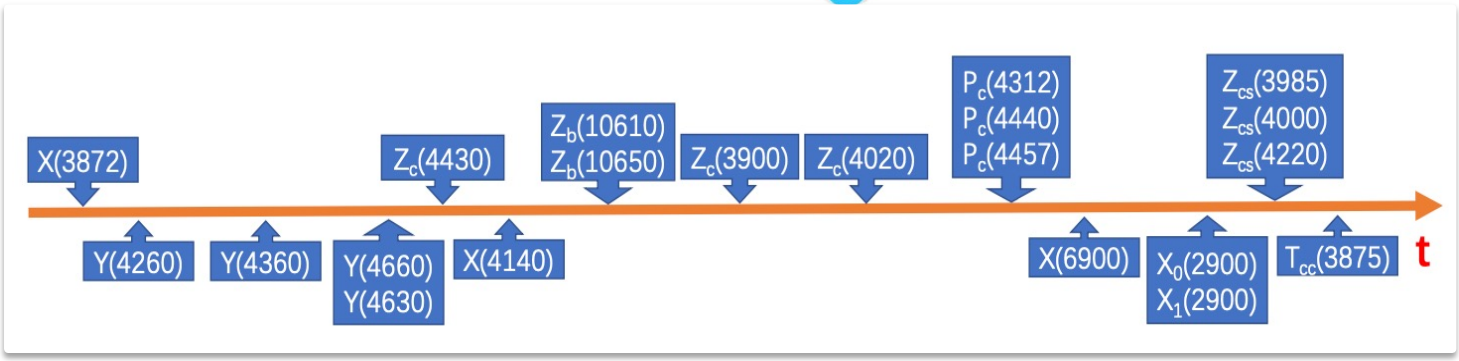
Molecule

loosely bound meson-antimeson "molecule"



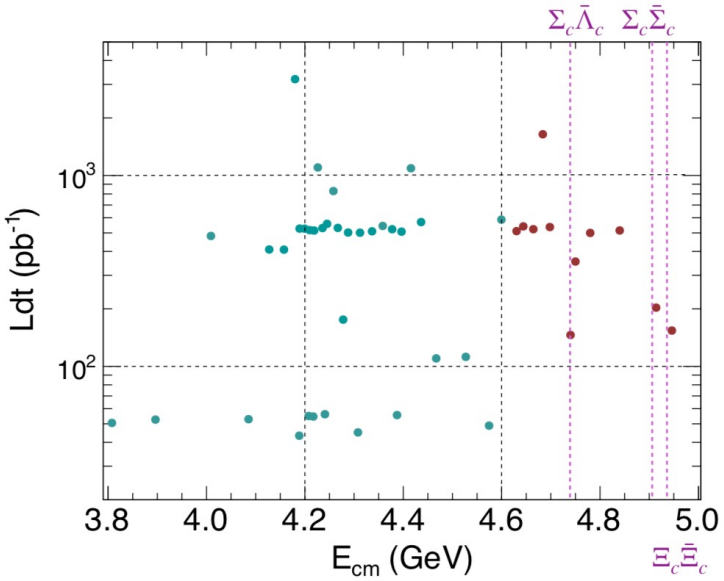
qq̄ -gluon hybrid mesons

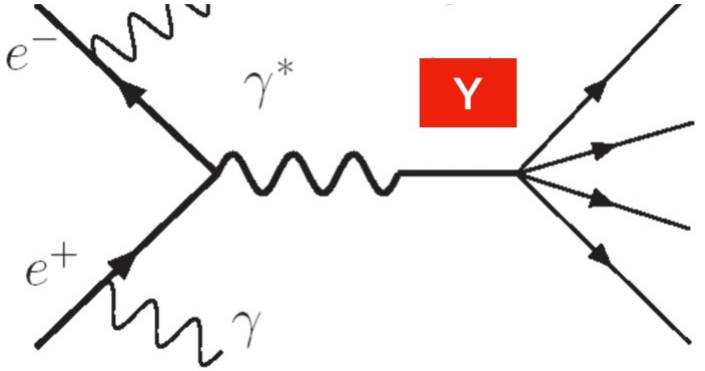




Lots of states with heavy quarks are observed since 2003 when X(3872) was discovered.

BESIII data Samples for XYZ study

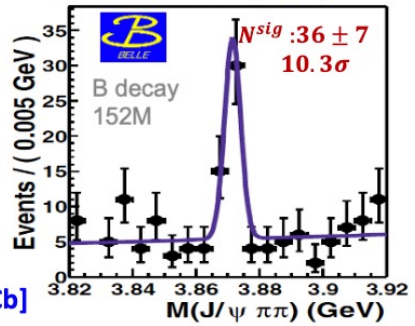




- BESIII can directly generate Y(1^{--}) states by e^+e^- annihilation.
- Study X and Z by radiative decay or hadronic transition from Y.
- BESIII accumulate ~23fb^{-1} e^+e^- collision data events from 3.8-4.92GeV.
- Data sample taken above 4.6GeV has been finished in 2020=>make Y(4660) study accessible.
- Search for more XYZ states, study their properties and new decays modes.
- Look for transitions between different states.

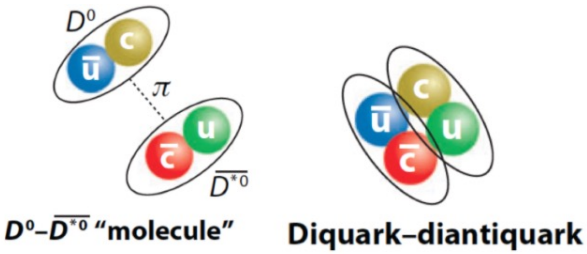
X(3872)

PRL 91, 262001 (2003)



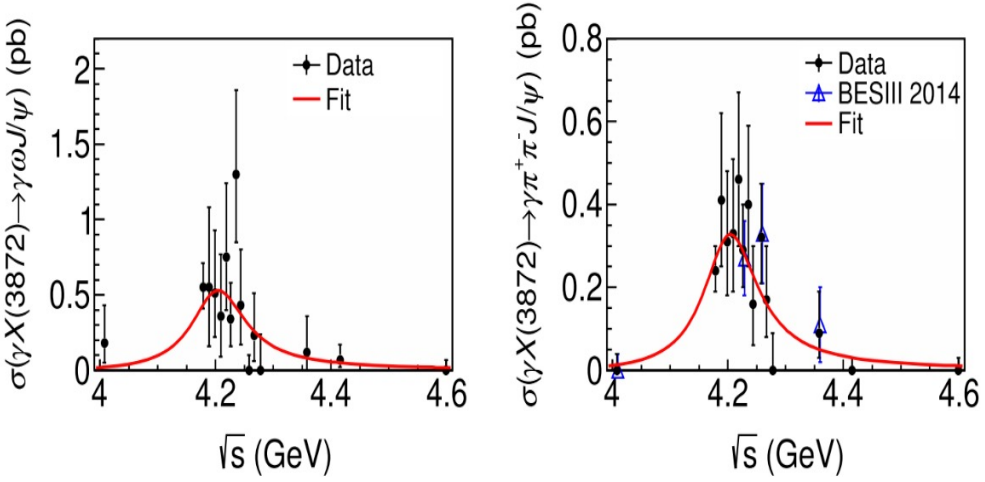
- $B^{\pm} \to K^{\pm}X(3872) \to K^{\pm}\pi^{+}\pi^{-}J/\psi$
  - first evidence from Belle: **PRL 91, 262001 (2003)**
  - confirmed by CDF and D0 **PRL 93, 072001 (2004) ; PRL 93, 162002 (2004)**
- $X(3872)$
  - mass:
    - $M = (3871.65 \pm 0.06)$ MeV **PDG2020, dominated by JHEP08, 123 (2020) [LHCb]**
    - very close to $D^0\overline{D}^{*0}$ mass threshold [(3871.69 ± 0.01) MeV]
  - width:
    - $\Gamma_{BW} = (1.19 \pm 0.21)$ MeV **PRD 102, 092005 (2020)**
  - J^{PC}: 1^{++} **PRL 110, 222001 (2013)**
  - produced in:
    - B decays, B_s decays, Λ_b decays, $p\overline{p}$ collision, pp collision, $PbPb$ collision, e^+e^- radiative transition, $\gamma\gamma^*$ processes
  - decay modes:
    - $D^0\overline{D}^{*0}$, $\pi^+\pi^-J/\psi$, $\pi^+\pi^-\pi^0J/\psi$, $\pi^0\chi_{cJ}$, $\gamma J/\psi$, $\gamma\psi(2S)$[?]

Explanations of the nature
- Bound molecule of D^0 and anti-D^{0*}
- Tetra-quark binding a di-quark and a di-antiquark
- Hybrid of charmonium and molecule
- ....



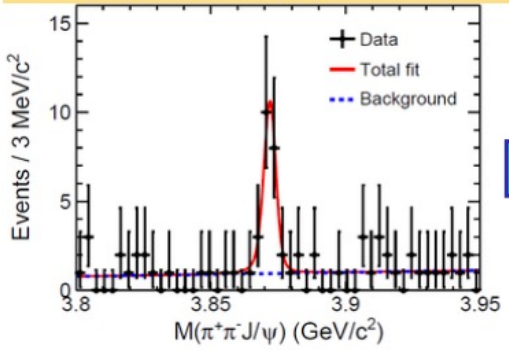
Production of X(3872) at BESIII

PRL 122, 232002 (2019)



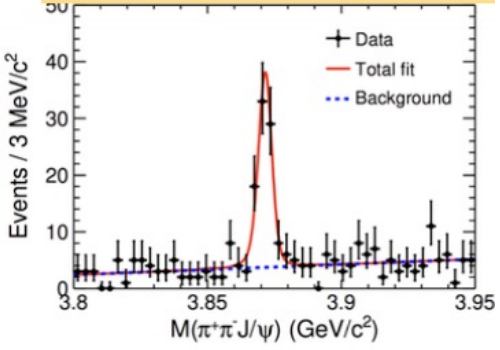
Production	experiments
B decays	BaBar, Belle, CMS, LHCb
B_s decays	CMS, LHCb
Λ_b decays	LHCb
$\bar{p}p$ collision	CDF, D0
pp collision	ATLAS, CMS, LHCb
PbPb collision	CMS
$e^+e^- \rightarrow \gamma X(3872)$	BESIII
$\gamma\gamma^* \rightarrow X(3872)$	Belle

BESIII, PRL 112, 092001 (2014)



4.0 fb^{-1}, 20±5 evts

PRL122, 232002 (2019)

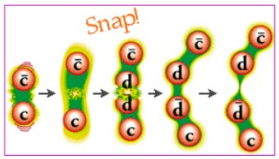


11.6 fb^{-1}, 79±9 evts

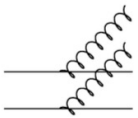
- $e^+e^- \rightarrow \gamma X(3872)$ is the only observed way to produce X(3872) at BESIII so far.
- Cross section Line shape is measured.
- X(3872) at BESIII: low background, low production.

Decay of X(3872)

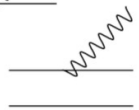
- Open charm
- Transitions
  - Hadronic transitions
  - Radiative transitions
- Hadronic decays
- Radiative decays



$\bar{D}^0D^{*0}$? Threshold?
$\bar{D}^0D^0\pi^0$ (non $\bar{D}^0D^{*0}$)
$\bar{D}^0D^0\gamma$ (non $\bar{D}^0D^{*0}$)
$D^+D^-\gamma$

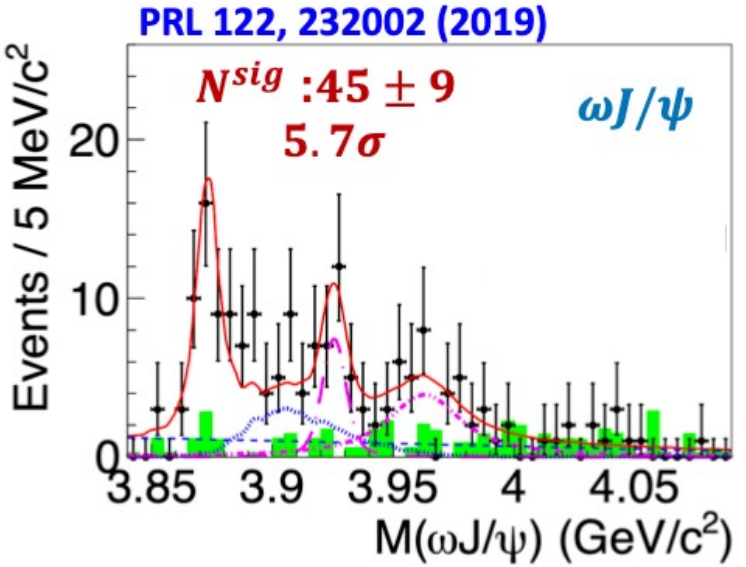


$\pi\pi J/\psi$, $\pi\pi\pi J/\psi$, $\pi\chi_{cJ}$, $\pi\pi\chi_{cJ}$, $\pi\pi\eta_c$, …



$\gamma J/\psi$, $\gamma\psi(2S)$

New measurements from BESIII & Belle.



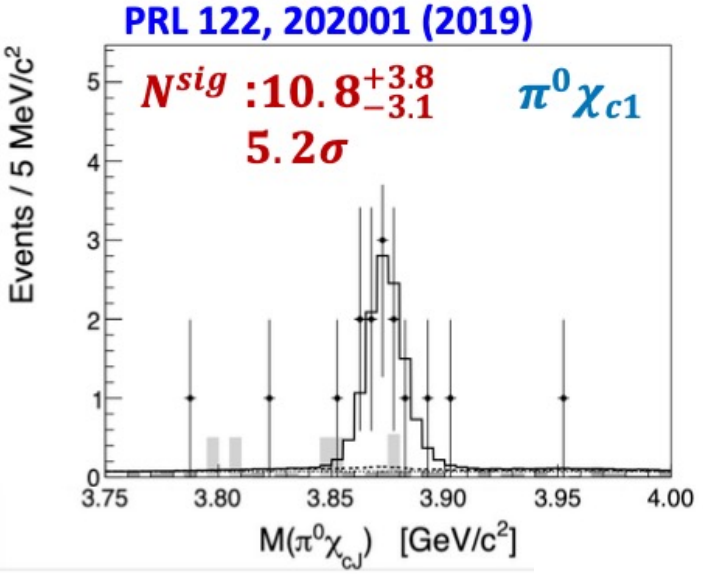
Index (i)	Parameters	Values	Experiments
	$X(3872) \to \pi^+\pi^- J/\psi$	$(\times 10^{-6})$	
1	$B^+ \to X(3872)K^+$	$8.61 \pm 0.82 \pm 0.52$	Belle [14]
2		$8.4 \pm 1.5 \pm 0.7$	BaBar [15]
3	$B^0 \to X(3872)K^0$	$4.3 \pm 1.2 \pm 0.4$	Belle [14]
4		$3.5 \pm 1.9 \pm 0.4$	BaBar [15]
	$X(3872) \to \gamma J/\psi$	$(\times 10^{-6})$	
5	$B^+ \to X(3872)K^+$	$1.78^{+0.48}_{-0.44} \pm 0.12$	Belle [22]
6		$2.8 \pm 0.8 \pm 0.1$	BaBar [23]
7	$B^0 \to X(3872)K^0$	$1.24^{+0.76}_{-0.61} \pm 0.11$	Belle [22]
8		$2.6 \pm 1.8 \pm 0.2$	BaBar [23]
	$X(3872) \to \gamma\psi(3686)$	$(\times 10^{-6})$	
9	$B^+ \to X(3872)K^+$	$0.83^{+1.98}_{-1.83} \pm 0.44$	Belle [22]
10		$9.5 \pm 2.7 \pm 0.6$	BaBar [23]
11	$B^0 \to X(3872)K^0$	$1.12^{+3.57}_{-2.90} \pm 0.57$	Belle [22]
12		$11.4 \pm 5.5 \pm 1.0$	BaBar [23]
	$X(3872) \to D^{*0}\bar{D}^0 + c.c.$	$(\times 10^{-4})$	
13	$B^+ \to X(3872)K^+$	$0.77 \pm 0.16 \pm 0.10$	Belle [16]
14		$1.67 \pm 0.36 \pm 0.47$	BaBar [17]
15	$B^0 \to X(3872)K^0$	$0.97 \pm 0.46 \pm 0.13$	Belle [16]
16		$2.22 \pm 1.05 \pm 0.42$	BaBar [17]
	$X(3872) \to \omega J/\psi$	$(\times 10^{-6})$	
17	$B^+ \to X(3872)K^+$	$6 \pm 2 \pm 1$	BaBar [18]
18	$B^0 \to X(3872)K^0$	$6 \pm 3 \pm 1$	BaBar [18]
	Ratios		
19	$\frac{B(X(3872)\to\gamma J/\psi)}{B(X(3872)\to\pi^+\pi^- J/\psi)}$	0.79 ± 0.28	BESIII [19]
20	$\frac{B(X(3872)\to D^{*0}\bar{D}^0+c.c.)}{B(X(3872)\to\pi^+\pi^- J/\psi)}$	14.81 ± 3.80	BESIII [19]
21	$\frac{B(X(3872)\to\omega J/\psi)}{B(X(3872)\to\pi^+\pi^- J/\psi)}$	$1.6^{+0.4}_{-0.3} \pm 0.2$	BESIII [20]
22	$\frac{B(X(3872)\to\pi^0\chi_{c1})}{B(X(3872)\to\pi^+\pi^- J/\psi)}$	$0.88^{+0.33}_{-0.27} \pm 0.10$	BESIII [21]
23	$\frac{B(X(3872)\to\gamma\psi(3686))}{B(X(3872)\to\gamma J/\psi)}$	$2.46 \pm 0.64 \pm 0.29$	LHCb [24]
	$B^+ \to X(3872)K^+$	$(\times 10^{-4})$	
24		$2.1 \pm 0.6 \pm 0.3$	BaBar [27]
25		$1.2 \pm 1.1 \pm 0.1$	Belle [26]

Global fit to X(3872) decays

- $B(X(3872) \to D^{*0}\bar{D}^0 + c.c.) = (52^{+25}_{-14})\%$
- $B(X(3872) \to \pi^+\pi^- J/\psi) = (4.1^{+1.9}_{-1.1})\%$
- $B(X(3872) \to \omega J/\psi) = (4.4^{+2.3}_{-1.3})\%$
- $B(X(3872) \to \gamma J/\psi) = (1.1^{+0.6}_{-0.3})\%$
- $B(X(3872) \to \pi^0\chi_{c1}) = (3.6^{+2.2}_{-1.6})\%$
- $B(X(3872) \to unknown) = (32^{+18}_{-32})\%$

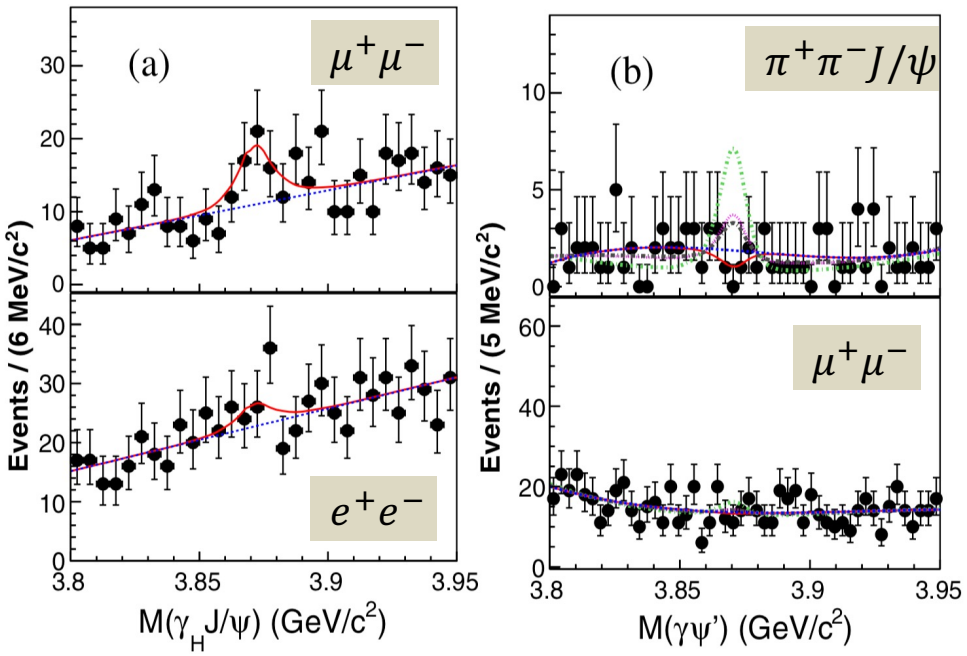
Parameter index	1	2	3	4	5	6	7	8
1	1	0.87	0.84	0.75	0.64	0.79	-0.95	-0.87
2		1	0.79	0.71	0.56	0.74	-0.90	-0.77
3			1	0.78	0.54	0.73	-0.88	-0.78
4				1	0.49	0.65	-0.79	-0.69
5					1	0.51	-0.61	-0.56
6						1	-0.82	-0.72
7							1	0.84

Chunhua Li and CZY, PRD 100, 094003 (2019)



Radiative transition of $X(3872) \to \gamma J/\psi, \gamma\psi(2S)$

PRL124.242001(2020)

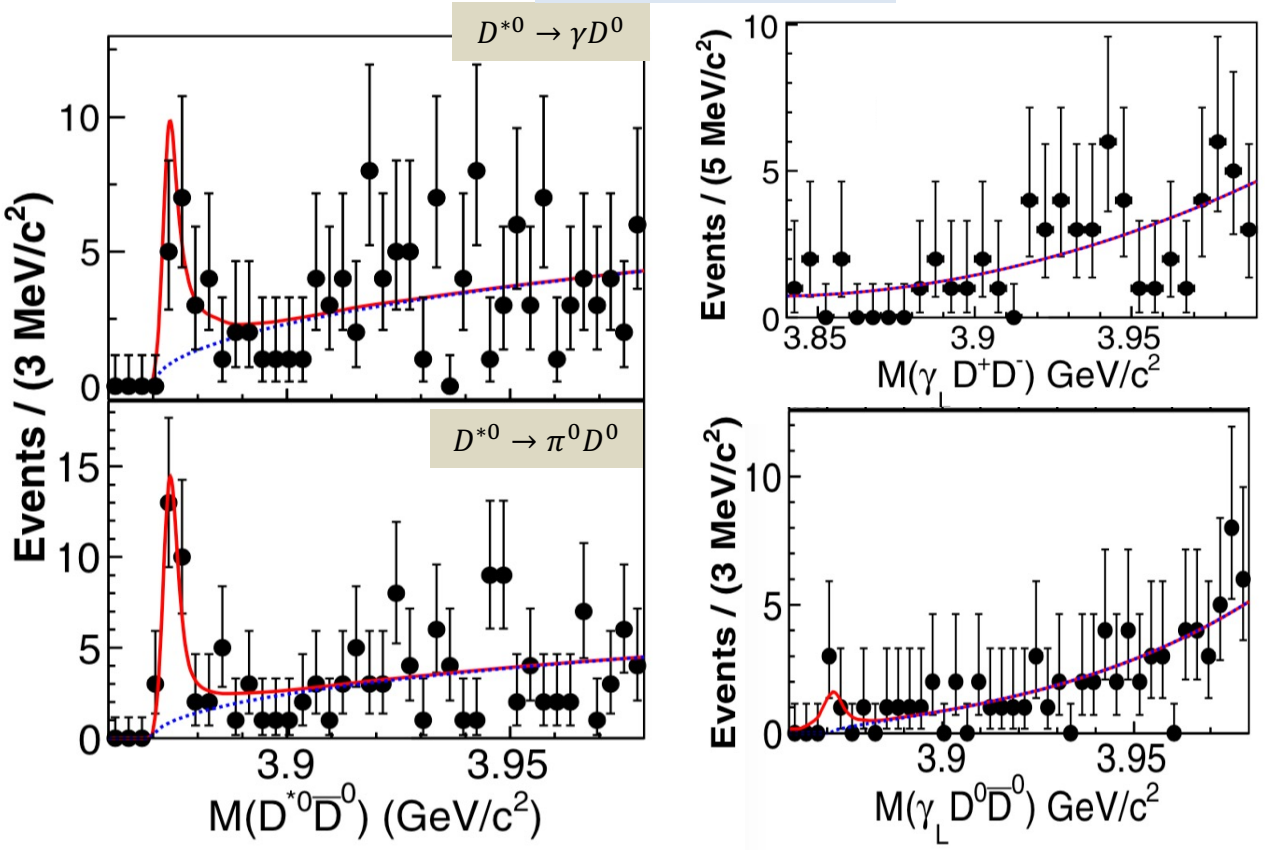


- Study the process of $X(3872) \to \gamma J/\psi$, $\gamma\psi(2S)$ with data sample between 4.178 and 4.278GeV.
- Find the evidence of $X(3872) \to \gamma J/\psi$ with 3.5σ.
- No evident signal for $X(3872) \to \gamma\psi(2S)$ decay at BESIII.

- $R=\frac{\mathcal{B}(X(3872)\to\gamma\psi(2S))}{\mathcal{B}(X(3872)\to\gamma J/\psi)}<0.59$ at 90% C.L. [A puzzle for $X(3872)$ decay]
  - Agree with Belle measurements <2.1. PRL107.09803
  - In tension with the LHCb measurement[2.46±0.64±0.29,NPB 886.665] and BaBar results [3.4±1.4, PRL102,132001].
- Not likely conventional charmonium(1.2~15), but rather a molecule(3~4)*10^{-3} or a molecule-charmonium mixture(0.5~5).

Study of $X(3872) \to D^0\bar{D}^{*0}$ and γD^+D^-

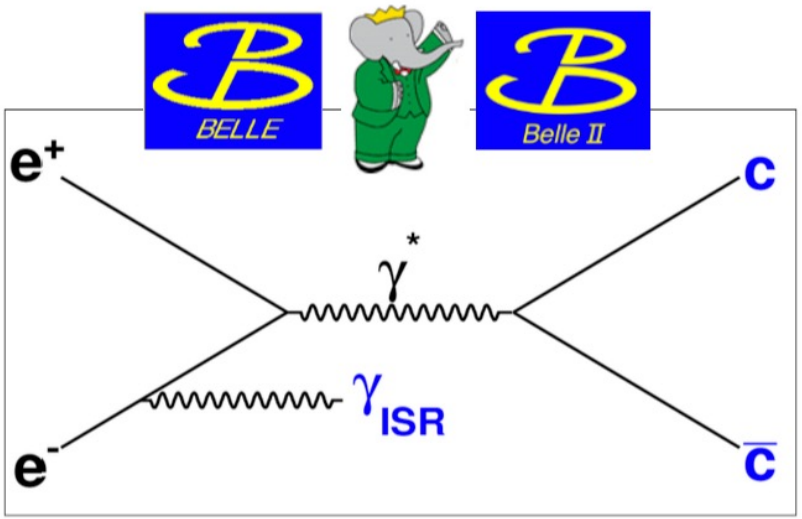
PRL124.242001(2020)

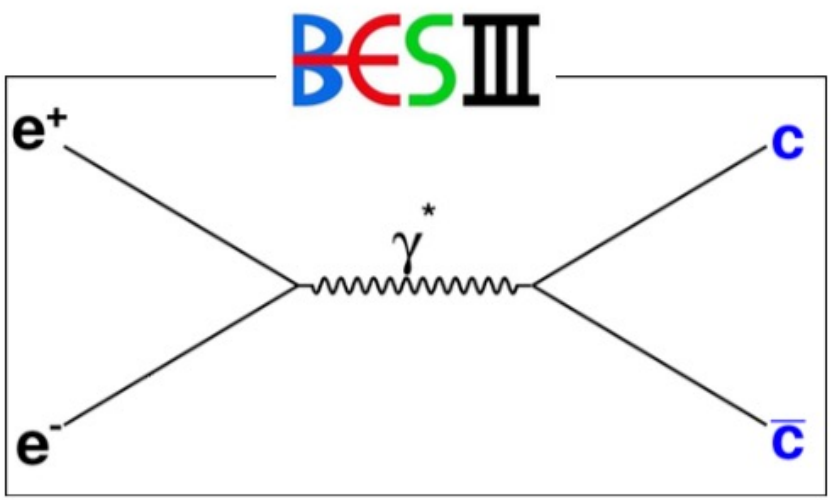


- BESIII observed $X(3872) \to D^{*0}\bar{D}^0$ with statistical significances of 7.4σ.
- No evident signal for γD^+D^- / $\gamma D^0\bar{D}^0$.
- BF ratio relative to $\pi^+\pi^- J/\psi$ is measured.

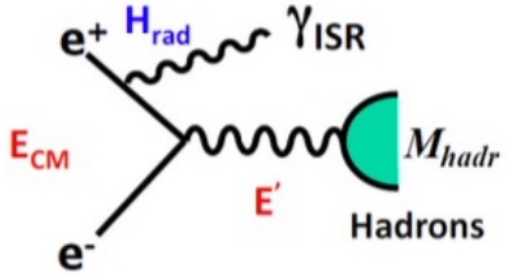
The Y states

Measurements of more final states for the Y and ψ states

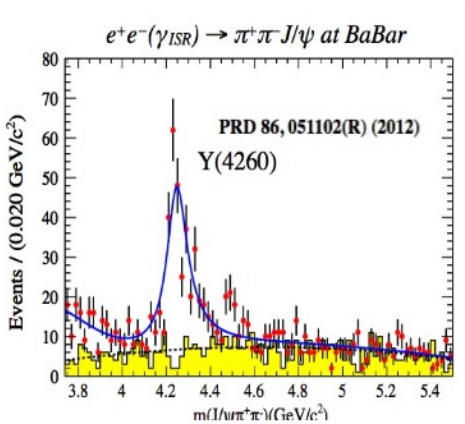


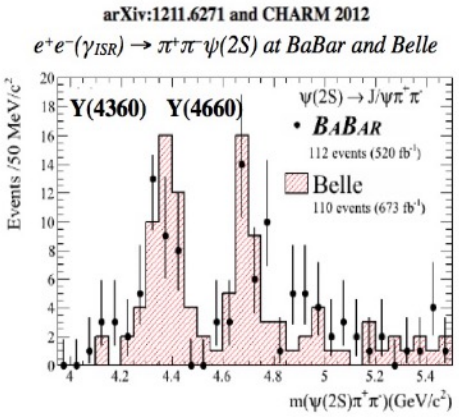


The Y states

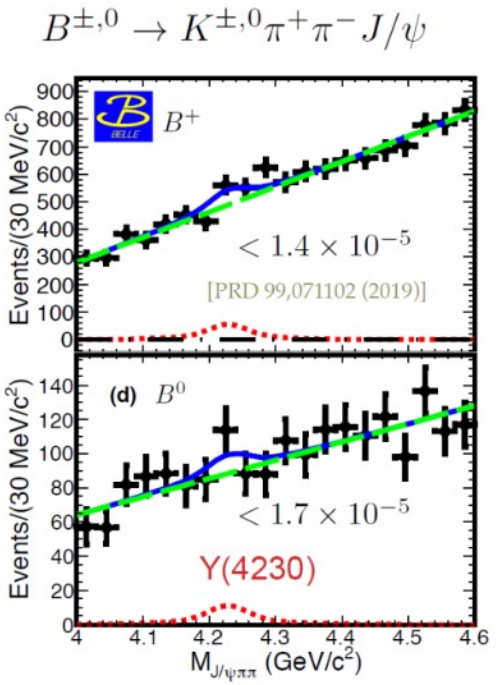


- The Y states discovered via initial states radiation(ISR) in e^+e^- annihilation have $J^{PC}=1^{--}$
- Direct e^+e^- annihilation experiment BESIII can measure cross section with higher precision at different energy points.

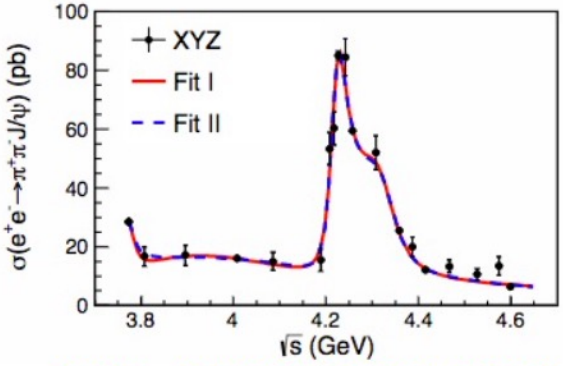




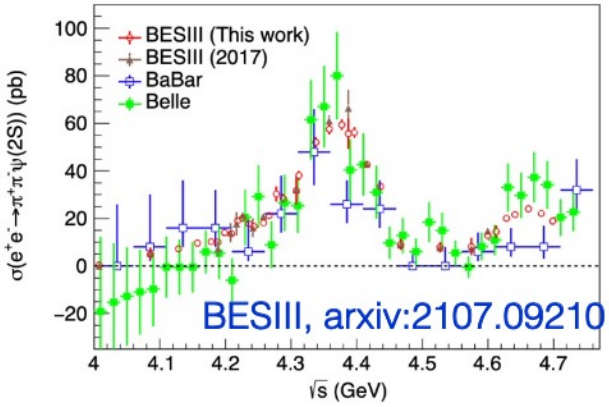
- **While not seen yet in B deca**



- **Improved knowledges from BESIII**



BESIII, PRL118, 092001 (2017)

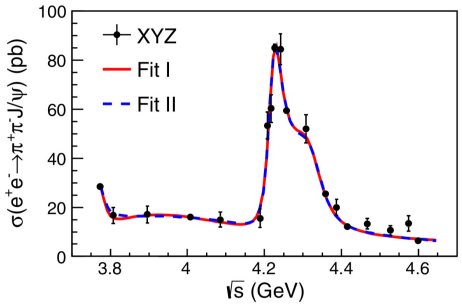


BESIII, arxiv:2107.09210

Y(4220)

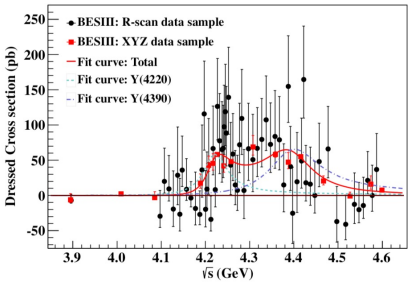
PRL.118.092001(2017)

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



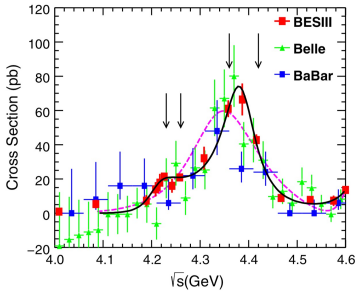
PRL.118.092002(2017)

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



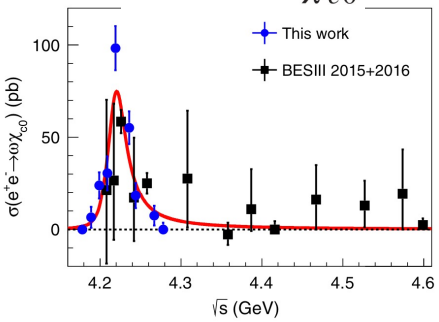
PRD.96.032004(2017)

$e^+e^- \to \pi^+\pi^-\psi(3686)$

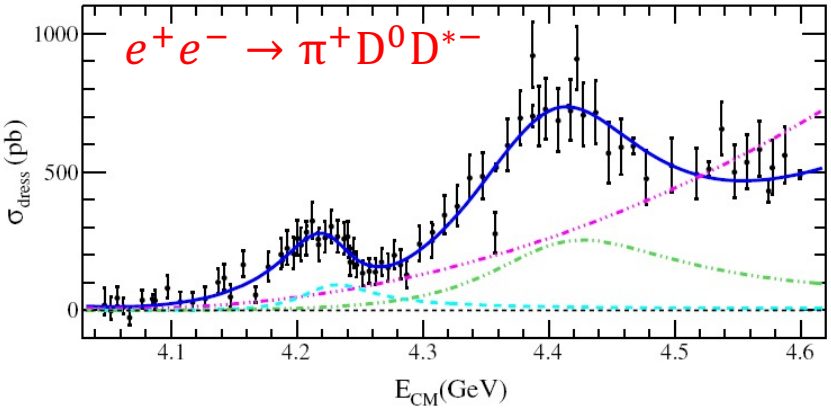


PRD.99. 091103(2019)

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



PRL. 122, 102002 (2019)

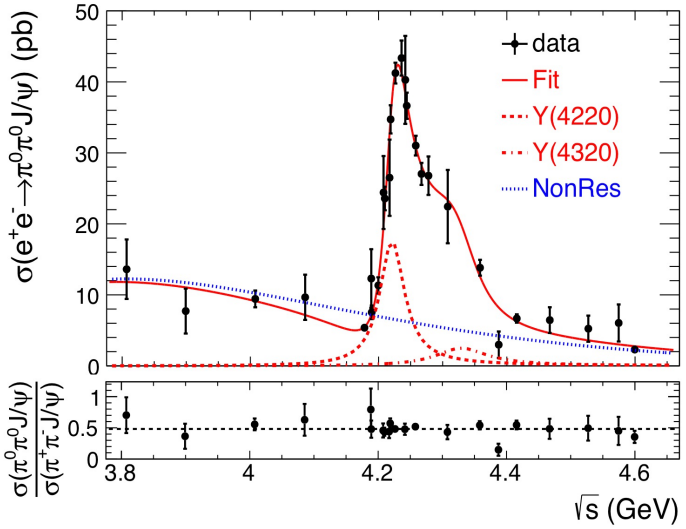


Y(4220) appeared in above processes.
Mass:4220MeV, Width~60 MeV!

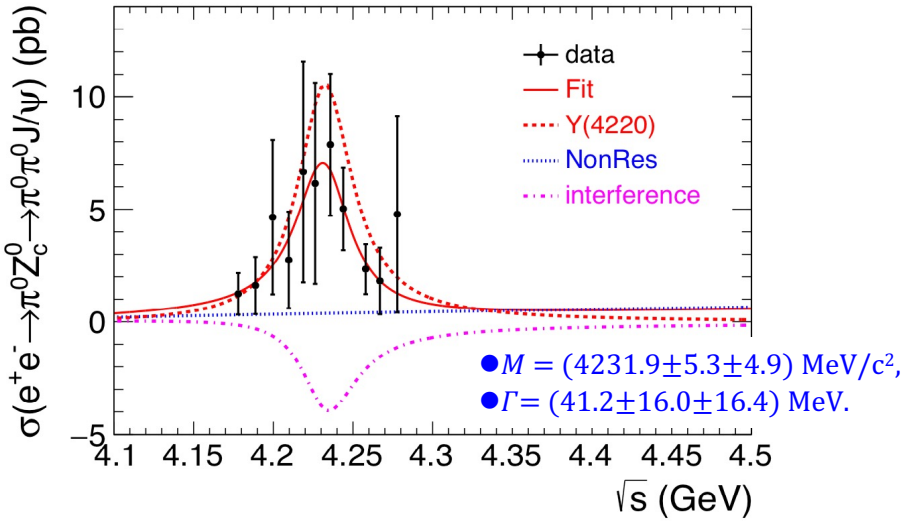
- Y(4260) has been discovered by BaBar experiment in the mass spectrum m($\pi^+\pi^- J/\psi$) and confirmed by Belle.
- BESIII measured the cross section of different processes.
- The mass and width of Y(4220) and Y(4360) from the different processes are measured.
- Two resonances describe the data with high significance than the fit with single peak.
- The intrinsic scenario for the difference on width is still unknown.
- Strategy: Search in many possible decay channels.

Cross section of $e^+e^-\to\pi^0\pi^0J/\psi$ and $e^+e^-\to\pi^0Z_c(3900)^0$, $Z_c(3900)^0\to\pi^0J/\psi$

PhysRevD.102.012009(2020)



0.48±0.02

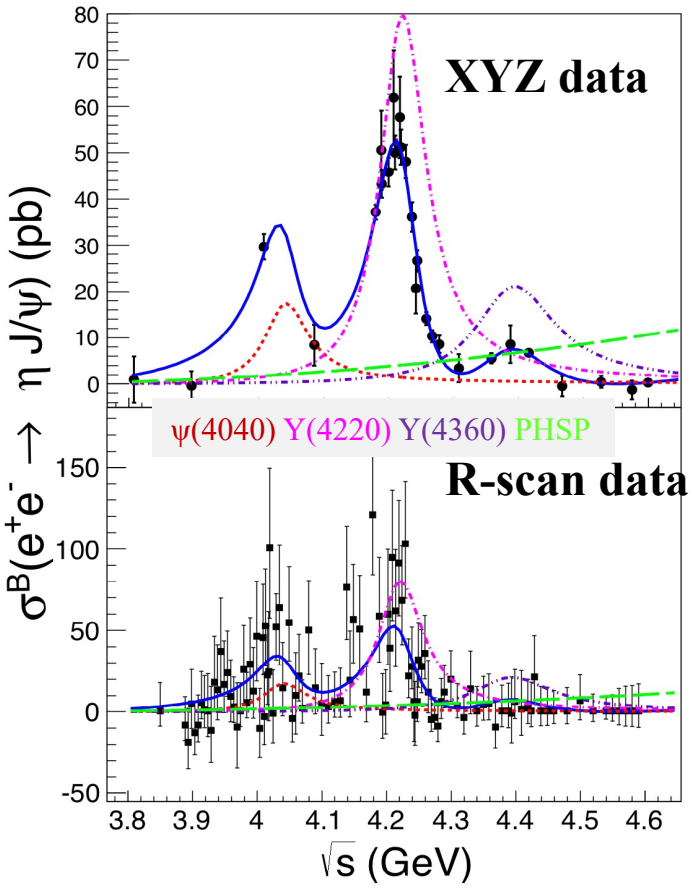


- Cross section of $e^+e^-\to\pi^0\pi^0J/\psi$ is measured with 12.4fb^{-1} dataset between 3.808 to 4.6 GeV.
- Confirms the existence of the charmonium-like state Y(4220).
- Mass and width of Y(4320) are fixed at the reported value in PRL118.092001(2017).
- Mass and width of Y(4220) is consistent with $e^+e^-\to\pi^+\pi^-J/\psi$.
  - $M(\mathrm{Y}(4220))$ = (4220.4±2.4±2.3) MeV/c²,
  - $\Gamma(\mathrm{Y}(4220))$ = (46.2±4.7±2.1) MeV.
- Strong correlation between the production of the Y(4220) and $Z_c(3900)$.

Cross section of $e^+e^- \to \eta J/\psi$

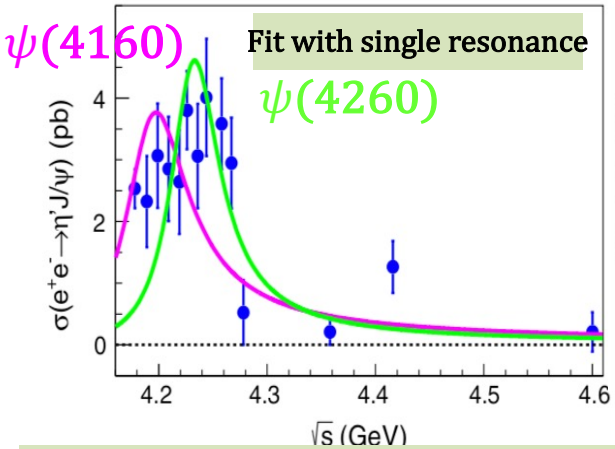
PhysRevD.102.031101(RC)(2021)

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

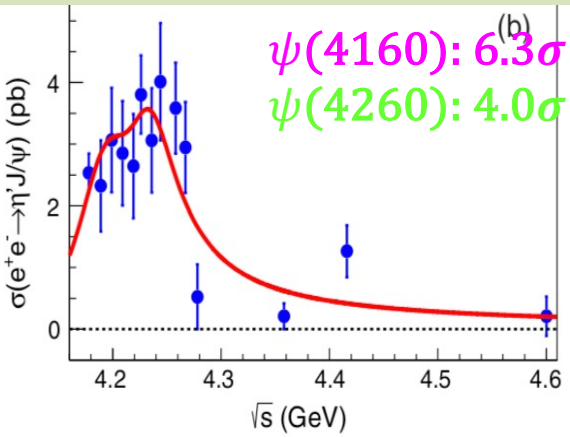


PRD101.012008(2020)

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

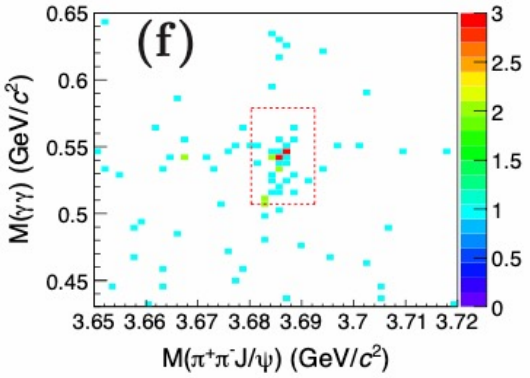


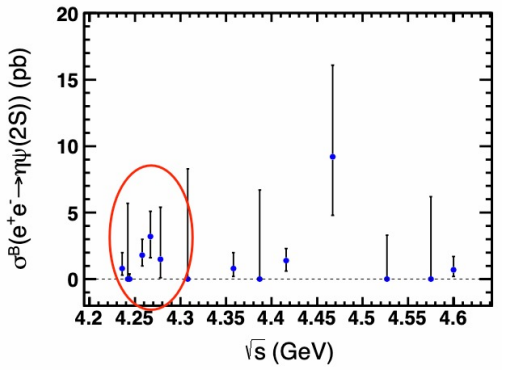
Coherent sum of ψ(4160) and ψ(4260) resonance



arXiv: 2103.01480

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

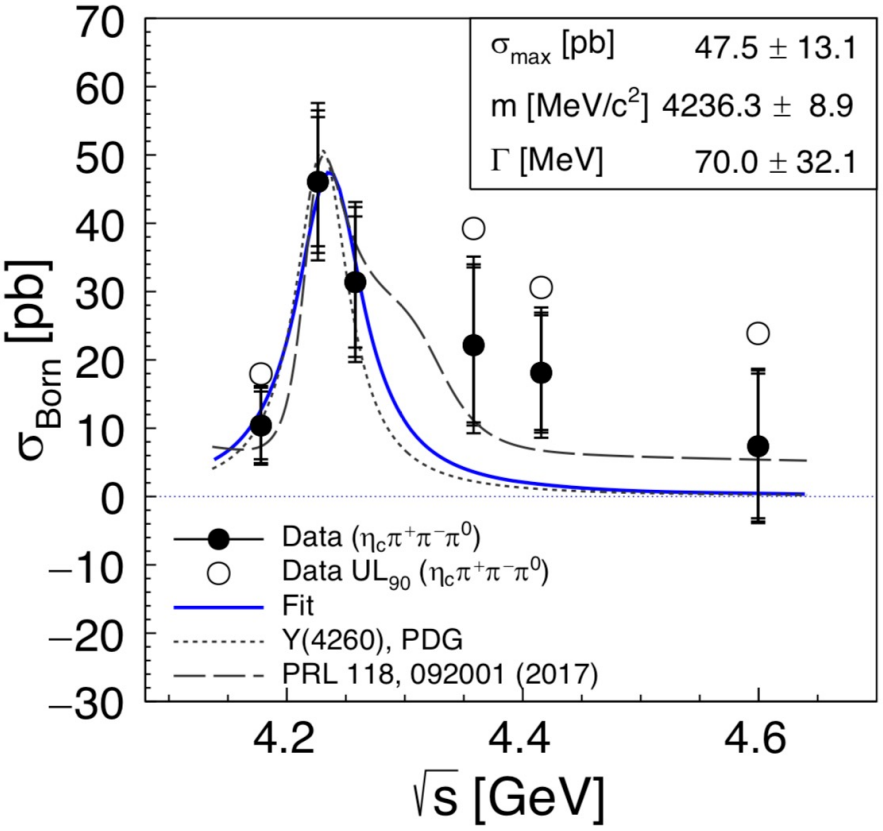




- The decays of the Y(4220) and Y(4360) into ηJ/ψ final states are observed first time.
- No significant structure in $\eta\psi(2S)$=>more data expected.

$e^+e^- \to \eta_c\pi^+\pi^-\pi^0$

PRD103.032006(2021)



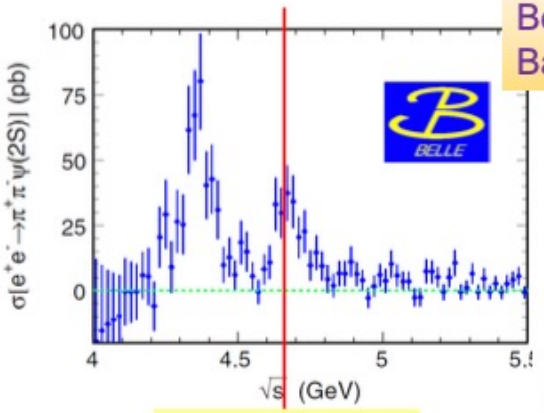
- The Born cross section is fitted with a Breit-Wigner function, shown as blue line in the plot.

- Using data taken at center-of-mass energies $\sqrt{s}$ from 4.18 to 4.6GeV.
- Significant $e^+e^- \to \eta_c\pi^+\pi^-\pi^0$ production at $\sqrt{s}$=4.23GeV and 4.26GeV($>3.0\sigma$), and larger than 5.0σ summing up different $\sqrt{s}$ points.
- Observe a significant energy-dependent Born cross section measured to be consistent with the production via the intermediate Y(4260) resonance.

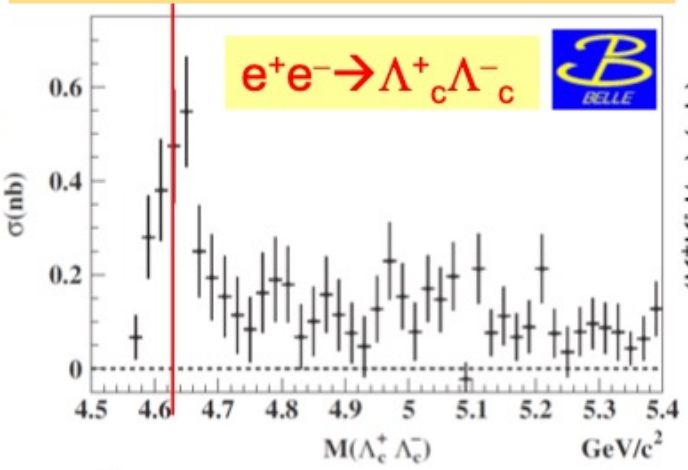
Y(4630) ? Y(4660)

Belle: PRD91, 112007 (2015), 980/fb
BaBar: PRD89, 111103 (2014), 520/fb

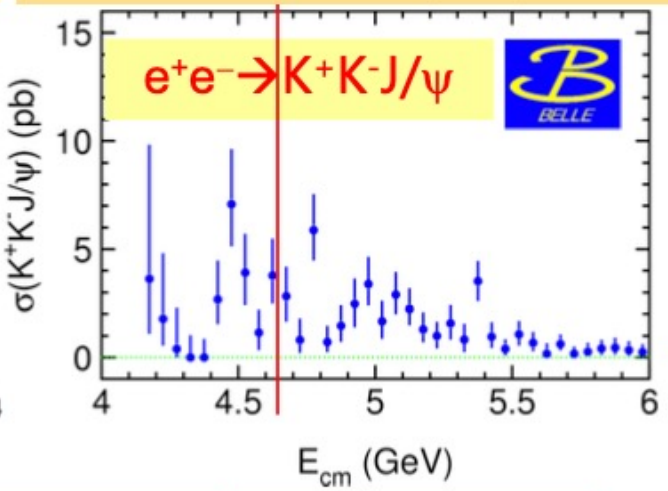
Y(4660) discovered by Belle in 2007
Y(4630) discovered by Belle in 2008

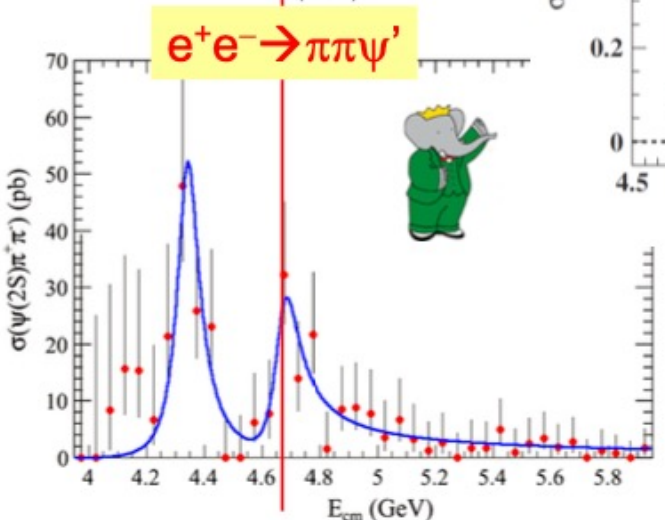


Belle: PRL101, 172001 (2008), 695/fb



Belle: PRD89, 072015 (2014), 980/fb



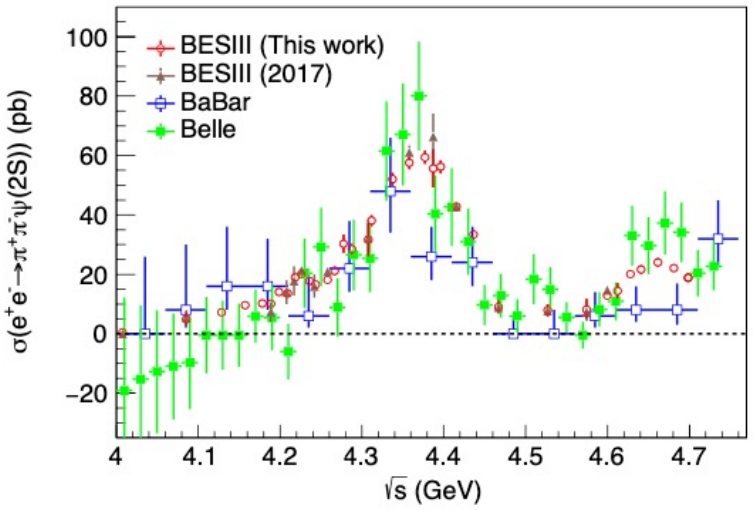


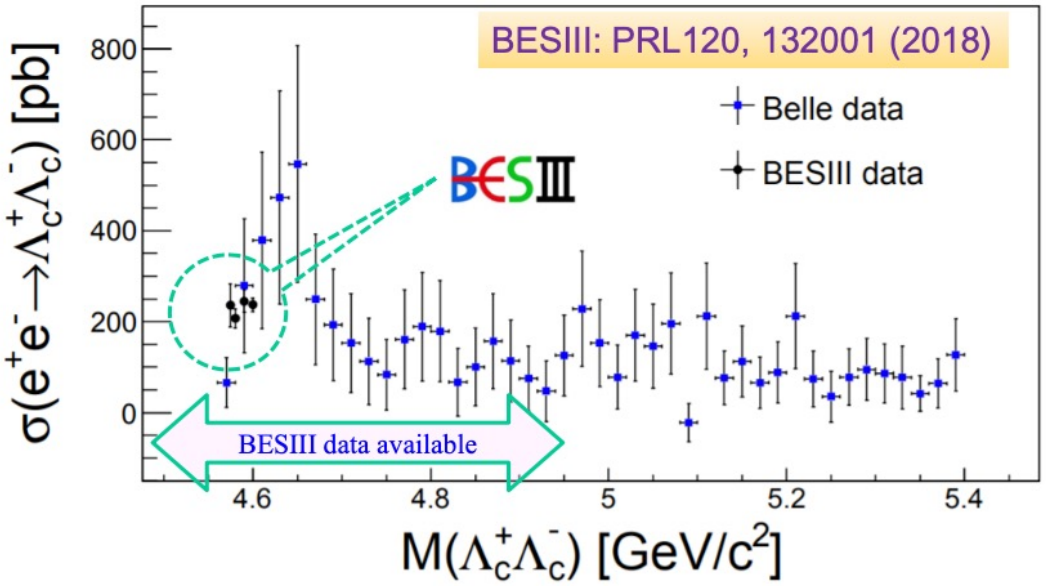
Experiment	Mass (MeV)	Width (MeV)
Belle, $\Lambda_c^+\Lambda_c^-$	$4634^{+8}_{-7}{}^{+5}_{-8}$	$92^{+40}_{-24}{}^{+10}_{-21}$
Belle, $\pi\pi\psi'$	4652±10±8	68±11±1
BaBar, $\pi\pi\psi'$	4669±21±3	104±48±10

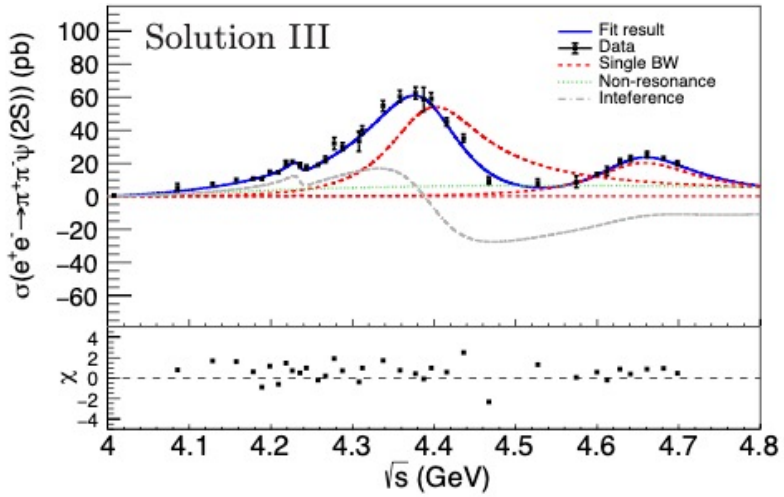
Taken from Prof. Yuan's Slides

Recent BESIII measurement

arXiv:2107.09210



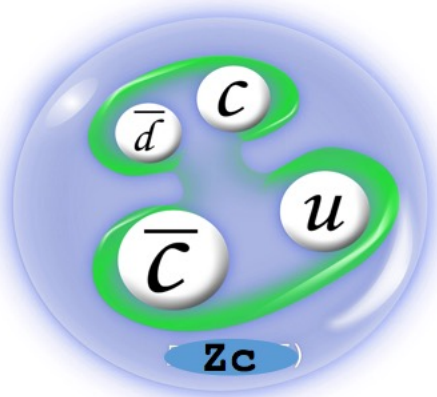


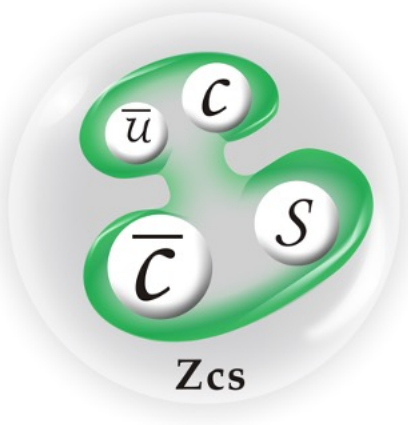


- BESIII data confirmed Belle&BaBar's results with much higher precision.
- BESIII will provide more precise $e^+e^- \to \Lambda_c^+\Lambda_c^-$ cross section results using the data from threshold to 4.95 GeV.
- Considering the cross section results of $e^+e^- \to D_sD_{s1}$、D_sD_{s2}, tension between open charm and charmonium modes are noticed.

The $Z_{c(s)}$ states

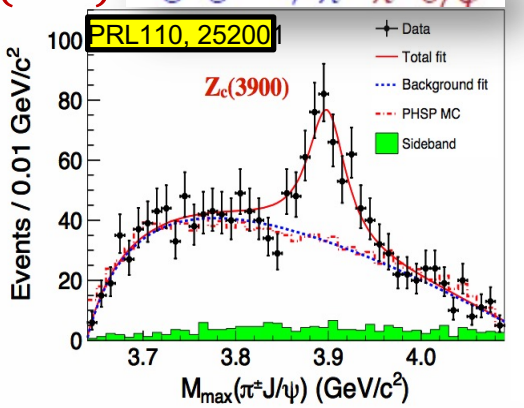
Charmonium-like states **carrying** electric charge;
must contain at least $c\bar{c}$ and a light $q\bar{q}$ pair



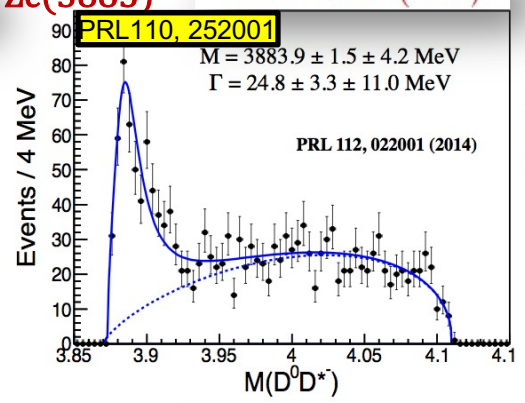


Z_c states from e^+e^- annihilation

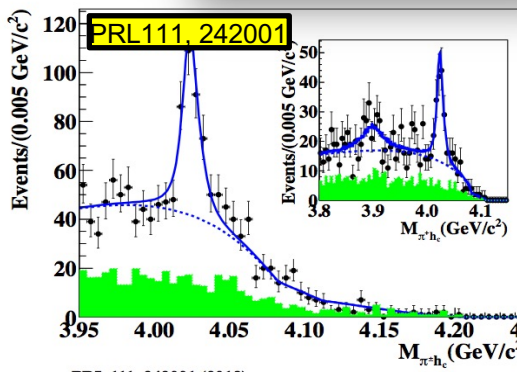
Zc(3900)$^+$ $e^+e^- \to \pi^-\pi^+ J/\psi$



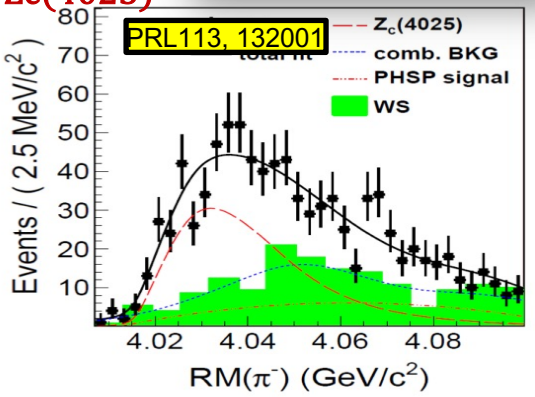
Zc(3885)$^+$ $e^+e^- \to \pi^-(D\bar{D}^*)^+$



Zc(4020)$^+$ $e^+e^- \to \pi^-\pi^+ h_c$



Zc(4025)$^+$ $e^+e^- \to \pi^-(D^*\bar{D}^*)^+$



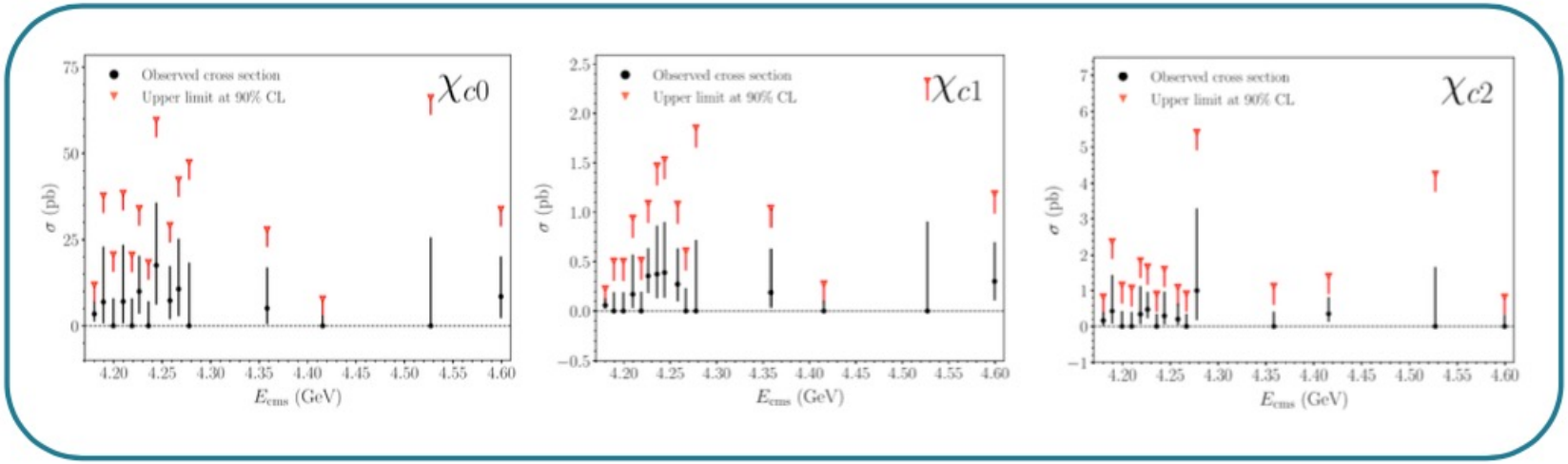
State	Mass (MeV/c^2)	Width (MeV)
$Z_c(3900)^\pm$	$3899.0 \pm 3.6 \pm 4.9$	$46 \pm 10 \pm 20$
$Z_c(3900)^0$	$3894.8 \pm 2.3 \pm 2.7$	$29.6 \pm 8.2 \pm 8.2$
$Z_c(3885)^\pm$	$3883.9 \pm 1.5 \pm 4.2$ Single D tag	$24.8 \pm 3.3 \pm 11.0$ Single D tag
	$3881.7 \pm 1.6 \pm 2.1$ Double D tag	$26.6 \pm 2.0 \pm 2.3$ Double D tag
$Z_c(3885)^0$	$3885.7^{+4.3}_{-5.7} \pm 8.4$	$35^{+11}_{-12} \pm 15$
$Z_c(4020)^\pm$	$4022.9 \pm 0.8 \pm 2.7$	$7.9 \pm 2.7 \pm 2.6$
$Z_c(4020)^0$	$4023.9 \pm 2.2 \pm 3.8$	fixed
$Z_c(4025)^\pm$	$4026.3 \pm 2.6 \pm 3.7$	$24.8 \pm 5.6 \pm 7.7$
$Z_c(4025)^0$	$4025.5^{+2.0}_{-4.7} \pm 3.1$	$23.0 \pm 6.0 \pm 1.0$

- Zc states observed at BESIII.
- Both in charged and neutral modes .
- Searching for more Zc/Zcs structures are important to identify their nature.

Search for Z_c in $e^+e^- \to \chi_{cJ}\pi^+\pi^-$

- ✓ Belle reported the results of $Z_c(4050)^+$ and $Z_c(4025)^+$ in $\bar{B}^0 \to K^- Z_c^+, Z_c^+ \to \pi^+ \chi_{cJ}$ [PRD 78, 072004(2008)], while BaBar did not confirm them.
- ✓ BESIII studies $e^+e^- \to \pi^+\pi^-\chi_{cJ}, \chi_{cJ} \to \gamma J/\psi(l^+l^-)$ from 4.178 GeV to 4.600 GeV
- ✓ None of the process are observed and upper limits of the production cross sections are determined.
- ✓ Hence, they can be the upper limits of the product cross sections of

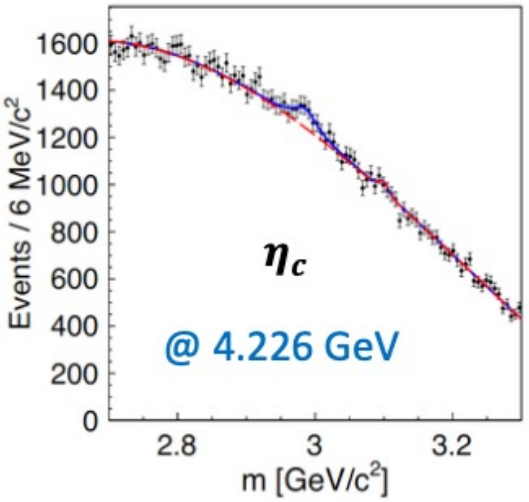
$$e^+e^- \to \pi^- Z_c(4050)^+ + c.c., Z_c(4050)^+ \to \pi^+ \chi_{cJ}$$

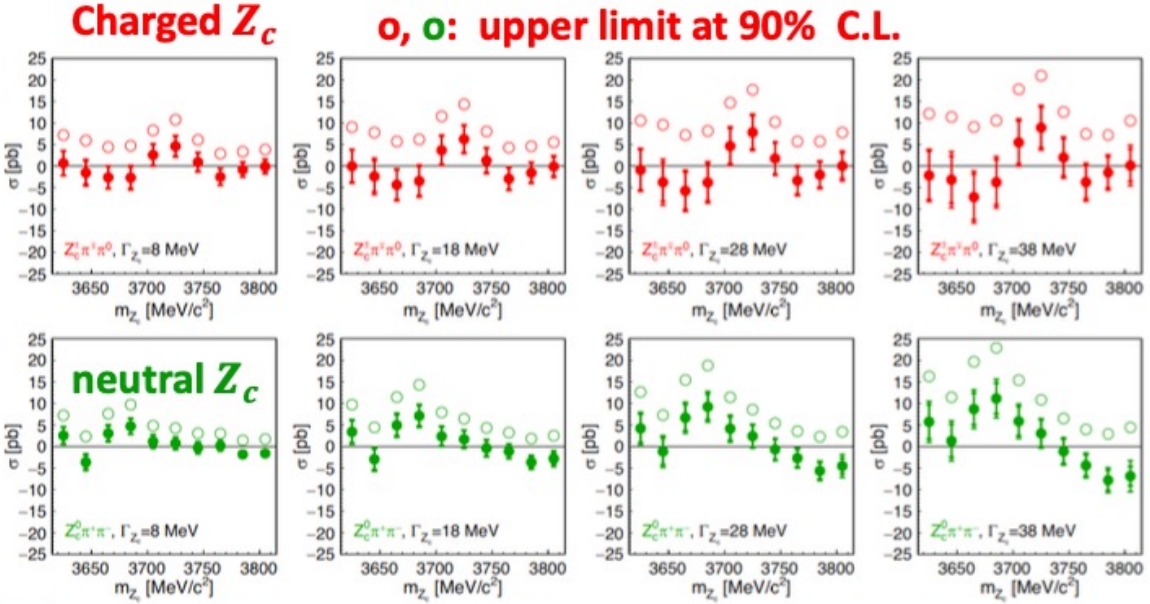


PRD 103, 052010 (2021)

Search for Z_c state in $e^+e^- \to \eta_c\pi^+\pi^-\pi^0$

- ✓ LHCb reported an evidence of $Z_c(4100)^+ \to \pi^+\eta_c$ in $\bar{B}^0 \to K^- Z_c(4100)^+$ with 3σ. with $M = 4096 \pm 20^{+18}_{-22}$ MeV/c^2, $\Gamma = 152 \pm 58^{+60}_{-35}$ MeV and $J^P = 0^+/1^-$. [EPJC 78, 1019 (2018)]
- ✓ Studies of $e^+e^- \to \pi^+\pi^-\pi^0\eta_c, \pi^+\pi^-\eta_c, \gamma\pi^0\eta_c$ at 6 energy points from 4.178 GeV to 4.600 GeV. η_c is reconstructed in 16 decay modes.
- ✓ Only evidence of $e^+e^- \to \pi^+\pi^-\pi^0\eta_c$ @ 4.226 GeV (**4.1σ**).
- ✓ Different mass and width assumptions in the vicinity of $D\bar{D}$ mass are tested for $Z_c^+ \to \pi^+\eta_c$ and $Z_c^0 \to \pi^0\eta_c$ in $e^+e^- \to \pi^+\pi^-\pi^0\eta_c$ @ 4.226 GeV and found to be not significant.



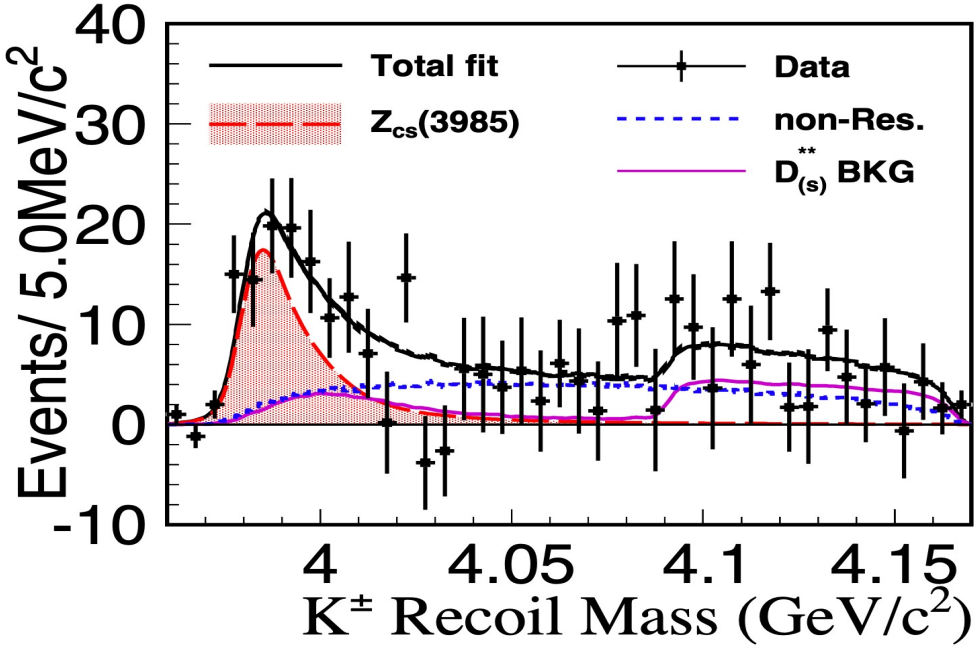


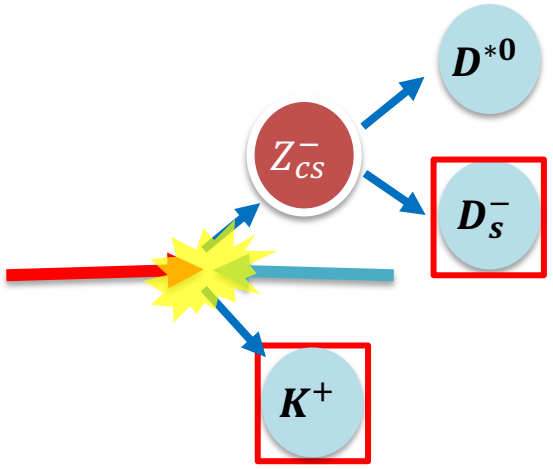
PRD 103, 032006 (2021)

Observation of $Z_{cs}(3985)^-$

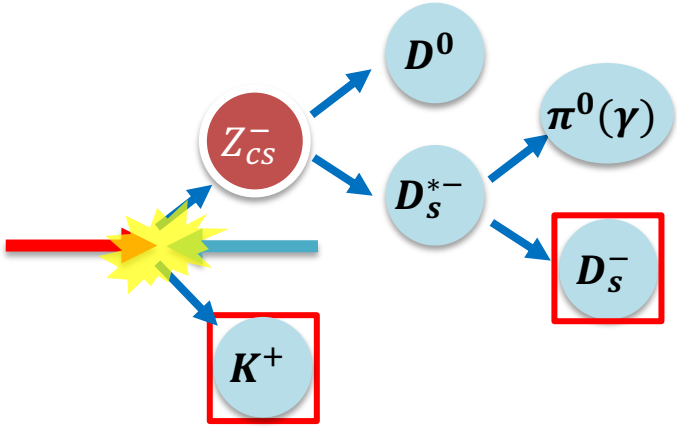
- $e^+e^- \to K^+(D_s^-D^{*0} + D_s^{*-}D^0)$.
- 3.7fb^{-1} data between 4.62 and 4.7GeV.
- Partial reconstruction of the process, tag K^+ and D_s^-.
- Study the mass spectrum of **recoil mass of K^+**.

PRL126.102001(2021)





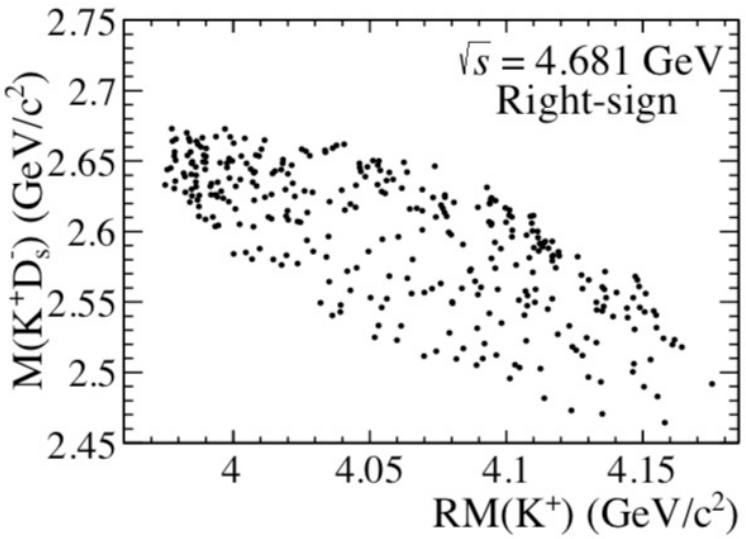
$e^+e^- \to K^+D_s^-D^{*0}$

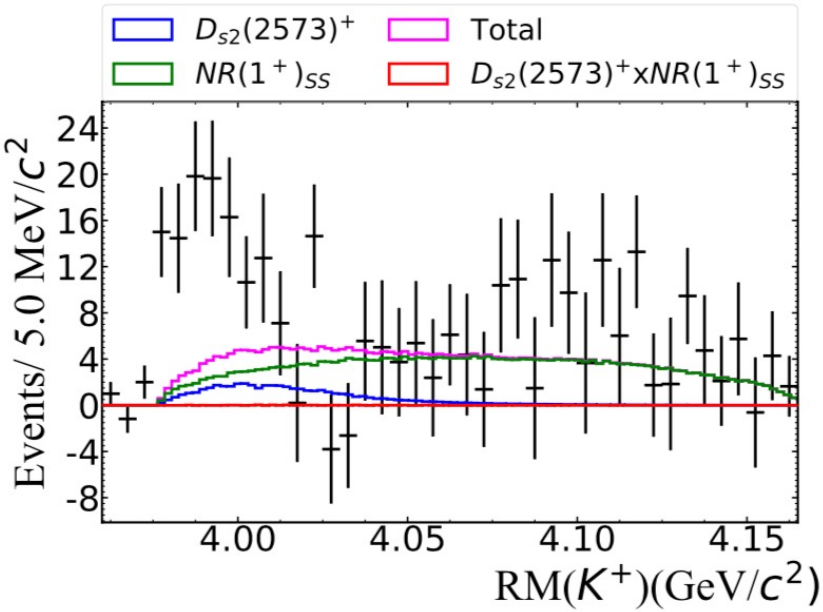


$e^+e^- \to K^+D_s^{*-}D^0$

Observation of $Z_{cs}(3985)^-$

PRL126.102001(2021)

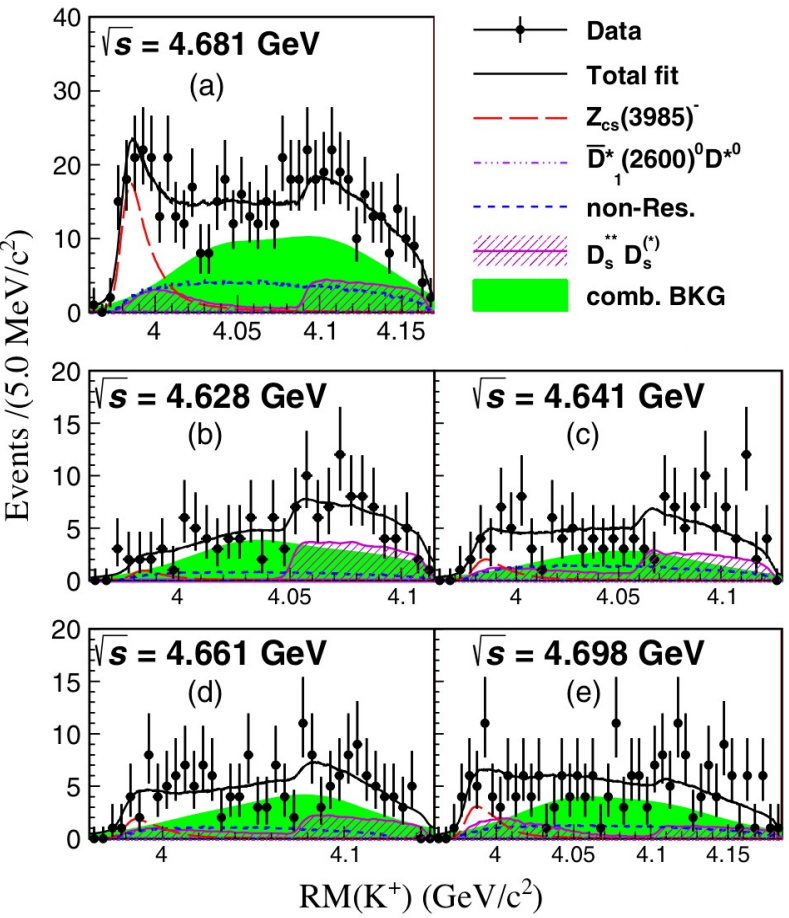




- A structure next to threshold raging from 3.96 to 4.02GeV/c^2.
- The enhancement cannot be attributed to the non-resonant (NR) signal process $e^+e^- \to K^+(D_s^- D^{*0} + D_s^{*-} D^0)$.
- Cannot be described by any processes involved excited D*(s) and even the interference between any two open-charm processes.

Observation of $Z_{cs}(3985)^-$

PRL126.102001(2021)



- The J^P of $Z_{cs}(3985)^-$ is assumed as 1^+; =>(S,S) is the most promising configuration.
- Simultaneous unbinned maximum likelihood fit to five data samples.
- $Z_{cs}(3985)^-$ signal shape: S-wave Breit-Wigner with mass dependent width with phase-space factor.

$$\mathcal{F}_j(M) \propto \left| \frac{\sqrt{q \cdot p_j}}{M^2 - m_0^2 + im_0(f\Gamma_1(M) + (1-f)\Gamma_2(M))} \right|^2$$

$$\Gamma_j(M) = \Gamma_0 \cdot \frac{p_j}{p_j^*} \cdot \frac{m_0}{M}$$

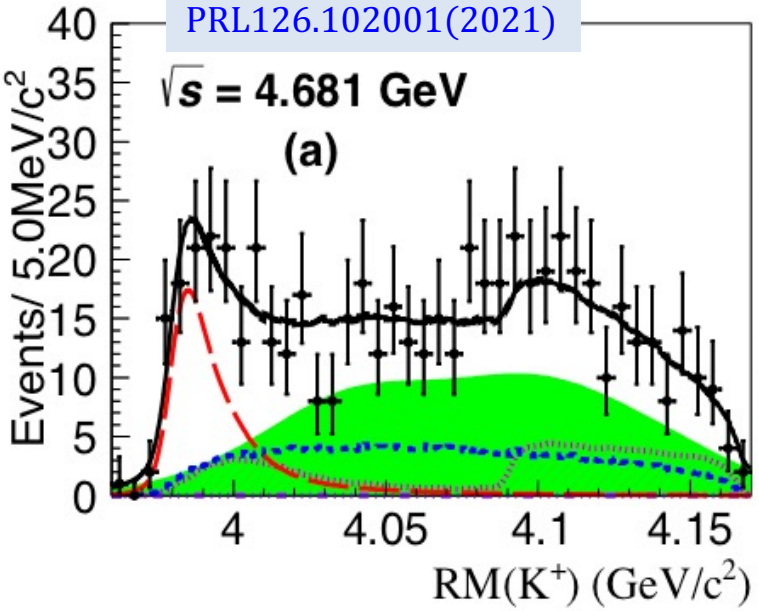
$$m_0(Z_{cs}(3985)^-) = 3985.2^{+2.1}_{-2.0}(stat.) \pm 1.7(sys.)\ \mathrm{MeV}/c^2$$

$$\Gamma_0(Z_{cs}(3985)^-) = 13.8^{+8.1}_{-5.2}(stat.) \pm 4.9(\mathrm{sys.})\mathrm{MeV}.$$

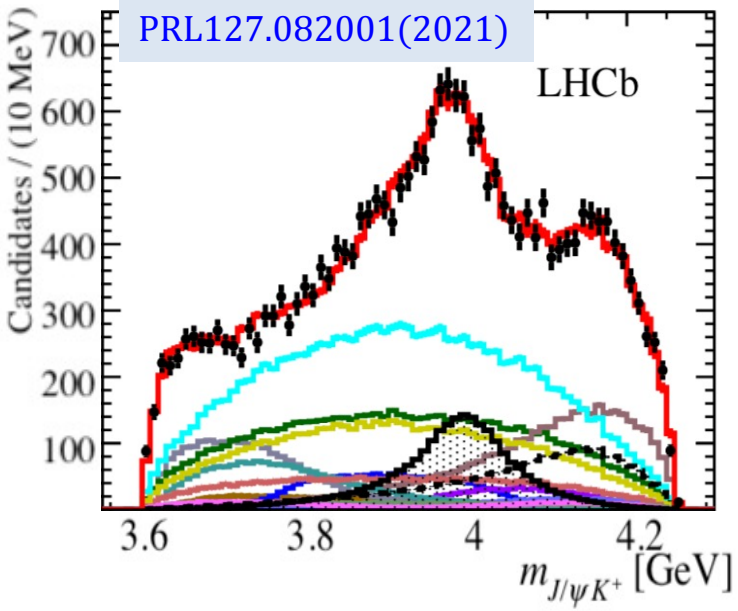
- The significance with systematic uncertainties and look-elsewhere effect considered is evaluated to **5.3σ.**
- At least four quark state (***$c\bar{c}s\bar{u}$***).
- Only a few MeV higher than the threshold of $D_S^- D^{*0}/D_S^{*-} D^0$ (3975.2/3977.0)MeV.

$Z_{cs}(3985)^-$ and $Z_{cs}(4000)^-$

PRL126.102001(2021)



PRL127.082001(2021)



$m_0(Z_{cs}(3985)^-) = 3985.2^{+2.1}_{-2.0}(stat.) \pm 1.7(sys.)\ MeV/c^2$

$\Gamma_0(Z_{cs}(3985)^-) = 13.8^{+8.1}_{-5.2}(stat.) \pm 4.9(sys.)MeV.$

$m_0(Z_{cs}(4000)^-) = 4003 \pm 6(stat.)^{+4}_{-14}\ (sys.)$ MeV/c^2

$\Gamma_0(Z_{cs}(4000)^-) = 131 \pm 15(stat.) \pm 26(sys.)$MeV.

- Could $Z_{cs}(3985)^-$ and $Z_{cs}(4000)^-$ are the same state? =>Mass consistent within 1σ while width differs significantly.
- A tetraquark state or a molecule-like? Or threshold kinematic effects ? Or other scenario?
- Study $D_s^- D^{*0}/D_s^{*-} D^0/\ K^+ J/\psi$ system from B decay in e^+e^- annihilation are needed. =>No clear structure from Belle study in $e^+e^- \rightarrow\ K^+K^-J/\psi$ PRD89, 072015 (2014).
- BESIII will release K^+K^-J/ψ result with same data sample.

Summary

- Lots of progress in the study charmonium like states at BESIII.
- Unique data samples from 4.0 to 4.9GeV at BESIII provide good opportunity to study XYZ.
- New decay modes observed for X(3872).
- More final states for the Y and ψ study are measured.
- $Z_{cs}(3985)^-$ was observed in $e^+e^- \to K^+(D_s^- D^{*0} + D_s^{*-} D^0)$.
  - Strangeness-partner of $Z_c(3900)$?
- More analysis results on XYZ are in progress.

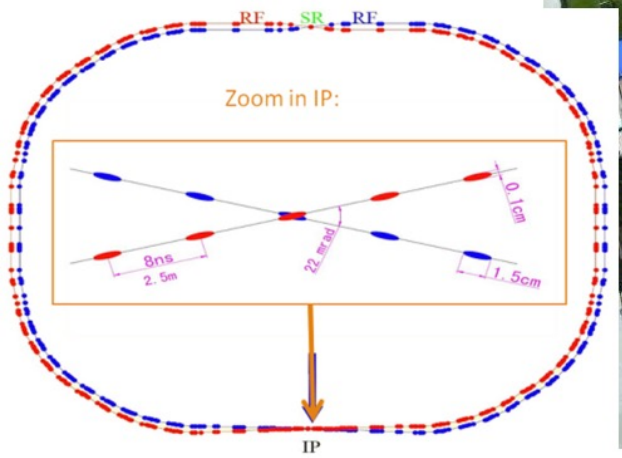
Thanks for your attention!

Beijing Electron and Positron Collider(BEPCII)

Beam Energy: 1~2.3 GeV(upgrade 2.45 GeV)

Crossing angle: ±11 mrad

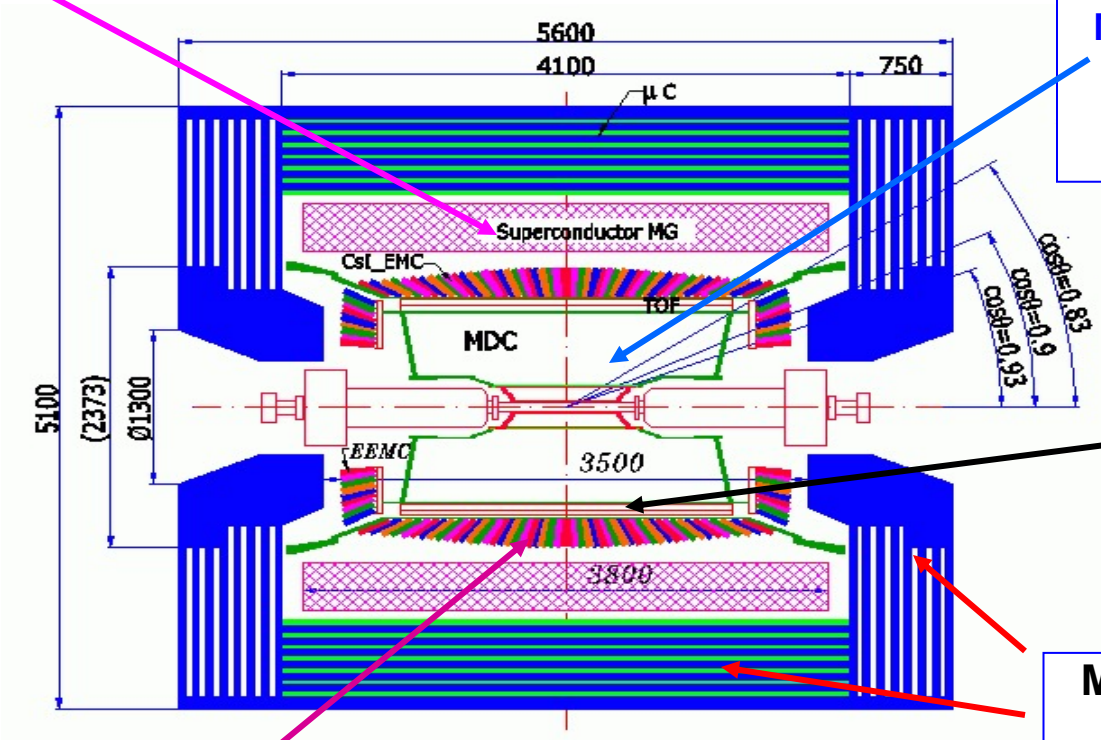
Design luminosity: $10^{33}cm^{-2}s^{-1}$ at $\sqrt{s} = 3.78$ GeV(achieved in 2016)



The BESIII Detector

NIM A614, 345 (2010)

Magnet: 1T Super conducting



MDC: small cell & He gas
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

TOF:
σ_T = 60 ps Barrel
70 ps Endcap

Muon ID: 8~9 layer RPC
$\sigma_{R\Phi}$=1.4 cm~1.7 cm

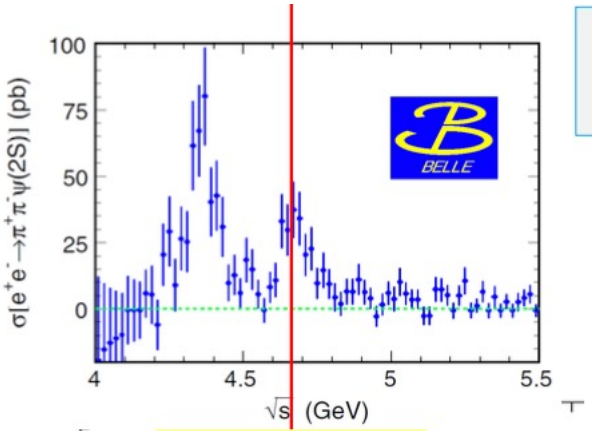
EMCAL: CsI crystal
ΔE/E = 2.5% @1 GeV
$\sigma_{\varphi,z}$ = 0.5~0.7 cm/√E

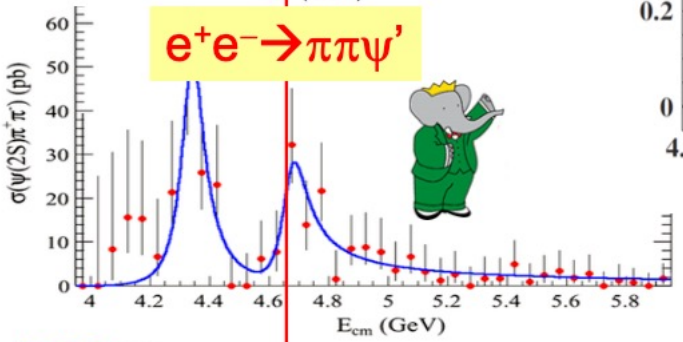
Data Acquisition:
Event rate = 3 kHz
Throughput ~ 50 MB/s

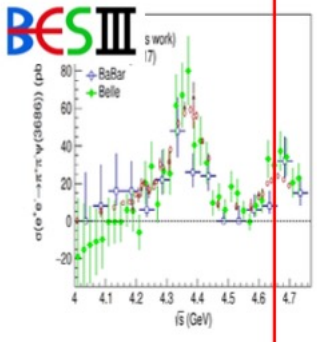
Trigger: Tracks & Showers
Pipelined; Latency = 6.4 μs

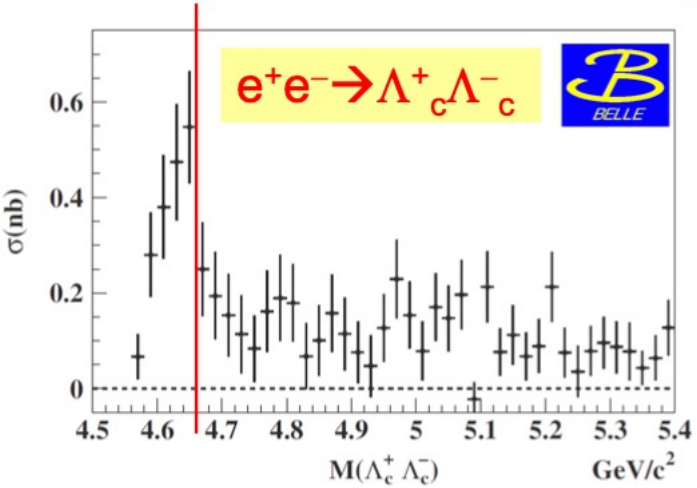
The new BESIII detector is hermetic for neutral and charged particle with excellent resolution, PID, and large coverage.

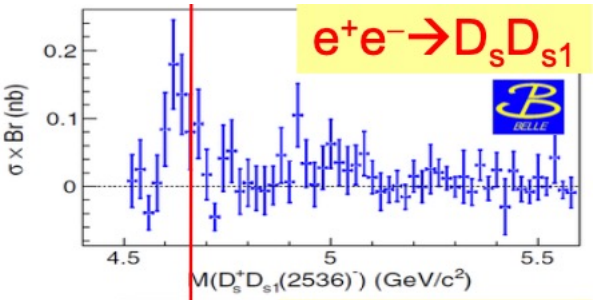
Y(4630)? Y(4660)?

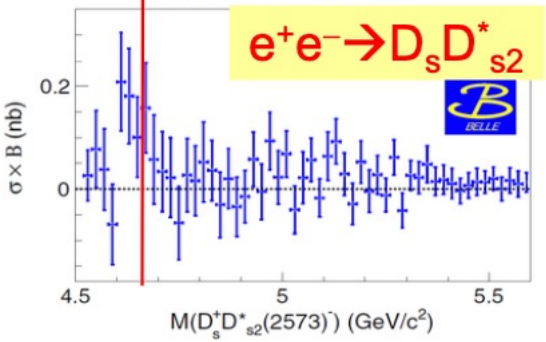












Tension between open charm & charmonium modes.

Parametrization affects the resonance parameters.

Experiment	Mass (MeV)	Width (MeV)
Belle, $\pi\pi\psi'$	$4652\pm10\pm8$	$68\pm11\pm1$
BaBar, $\pi\pi\psi'$	$4669\pm21\pm3$	$104\pm48\pm10$
BESIII, $\pi\pi\psi'$	$4651\pm38\pm2$	$155\pm25\pm1$
Belle, $\Lambda^+_c\Lambda^-_c$	$4634^{+8}_{-7}{}^{+5}_{-8}$	$92^{+40}_{-24}{}^{+10}_{-21}$
Belle, D_sD_{s1}	$4625.9^{+6.2}_{-6.0}\pm0.4$	$49.8^{+13.9}_{-11.5}\pm4.0$
Belle, $D_sD^*_{s2}$	$4619.8^{+8.9}_{-8.0}\pm2.3$	$47.0^{+31.3}_{-14.8}\pm4.6$

Taken from Prof. Yuan's Slides