Observation of the Y(4626) and other Y states at Belle

Xuyang GAO

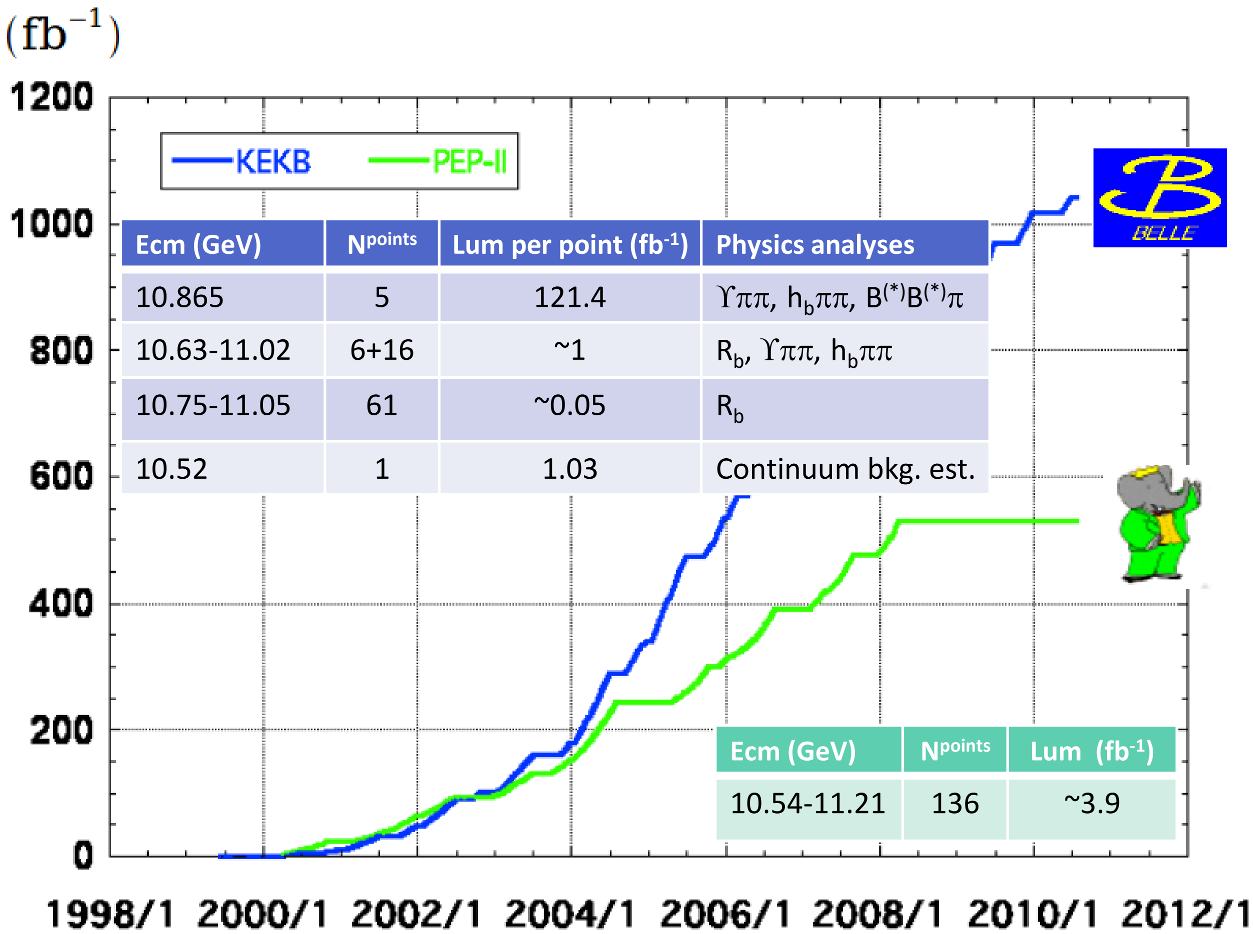
Outline

- Charmonium-like state Y(4660)/Y(4626)
  - Search for Y(4660) in $B^+(\overline{B}^0) \to K^+(\overline{K}^0)\Lambda_c^+\overline{\Lambda}_c^-$
  - Y(4626) in $e^+e^- \to \gamma_{ISR}D_s^+D_{s1}(2536)^-(\to \overline{D}^{*0}K^-/D^{*-}K_S^0)$+c.c.
  - Combined fit on $\pi^+\pi^-\psi'$, $D_s^+D_{s1}^-$, $\Lambda_c^+\Lambda_c^-$, for Y state at 4.6 GeV

- Bottomonium-like state Y(10750)
  - Y(10750) in $e^+e^- \to \pi^+\pi^-\Upsilon(nS)$
  - Fit Y(10750) on R_b (BaBar+Belle)

- $e^+e^- \to \gamma\chi_{cJ}$ / $\gamma\eta_c$
  - χ_{c1} in $e^+e^- \to \gamma\chi_{c1}$
  - Cross sections $e^+e^- \to \gamma\chi_{c1}$

Integrated luminosity of B factories



Ecm (GeV)	N^{points}	Lum per point (fb^{-1})	Physics analyses
10.865	5	121.4	$\Upsilon\pi\pi$, $h_b\pi\pi$, $B^{(*)}B^{(*)}\pi$
10.63-11.02	6+16	~1	R_b, $\Upsilon\pi\pi$, $h_b\pi\pi$
10.75-11.05	61	~0.05	R_b
10.52	1	1.03	Continuum bkg. est.

Ecm (GeV)	N^{points}	Lum (fb^{-1})
10.54-11.21	136	~3.9

> 1 ab^{-1}

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1}

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 25 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan:

~ 100 fb^{-1}

~ 550 fb^{-1}

On resonance:

$\Upsilon(4S)$: 433 fb^{-1}

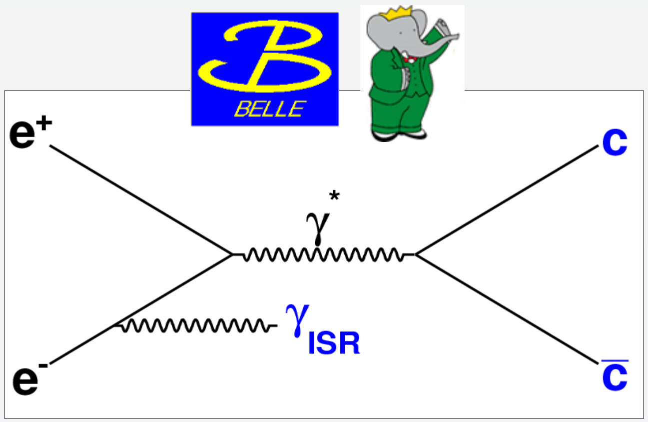
$\Upsilon(3S)$: 30 fb^{-1}

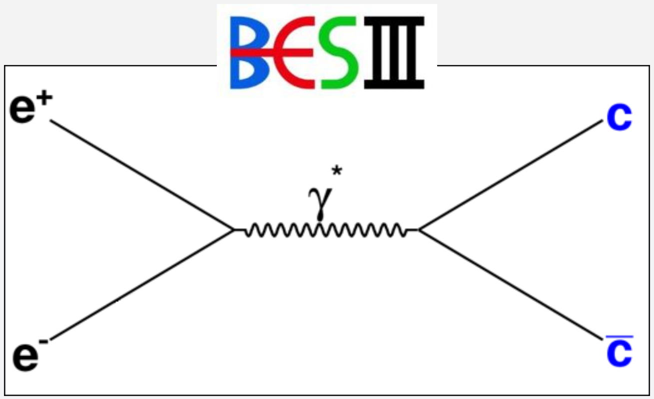
$\Upsilon(2S)$: 14 fb^{-1}

Off resonance:

~ 54 fb^{-1}

Y state at around 4.63 GeV



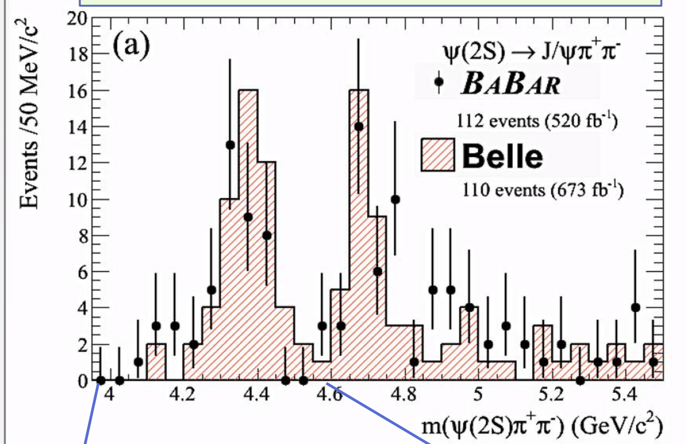


- Y states are good candidates for new types of exotic particles and stimulated many theoretical interpretations.

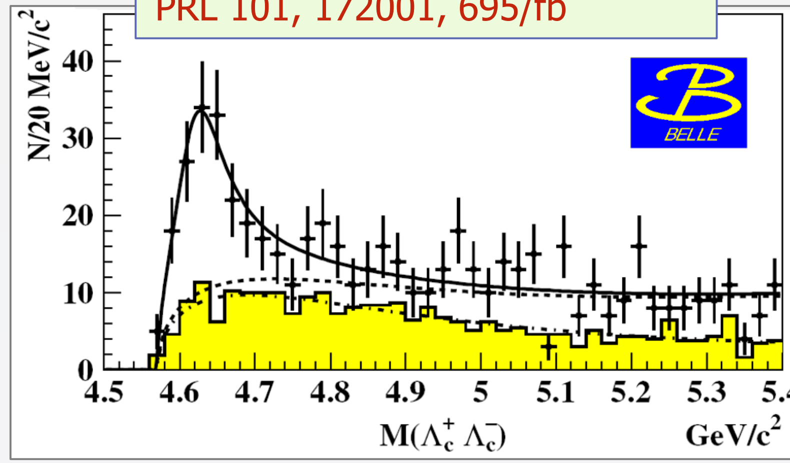
- Many Y states above DD threshold are observed/confirmed by B factories via ISR process, compatible with results in BESIII.

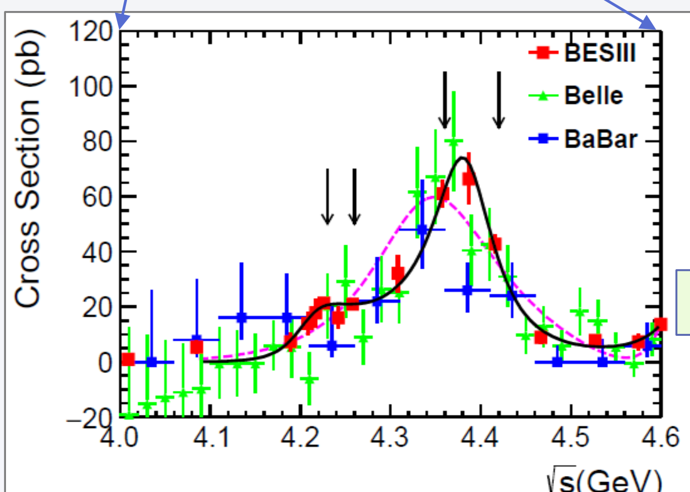
Review of the Y states at around 4.6 GeV

Belle: PRL 99, 142002 (673/fb)
BaBar: PRD 89, 111103 (520/fb)



PRL 101, 172001, 695/fb

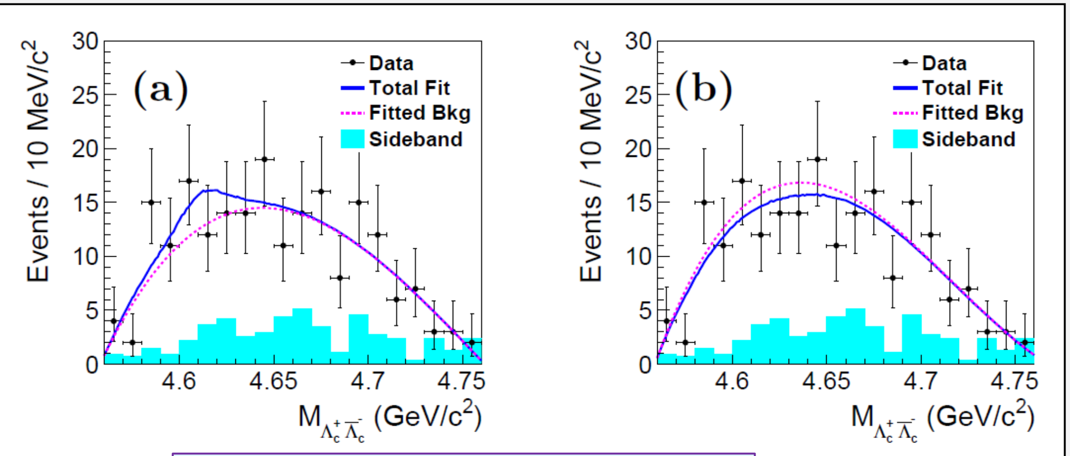




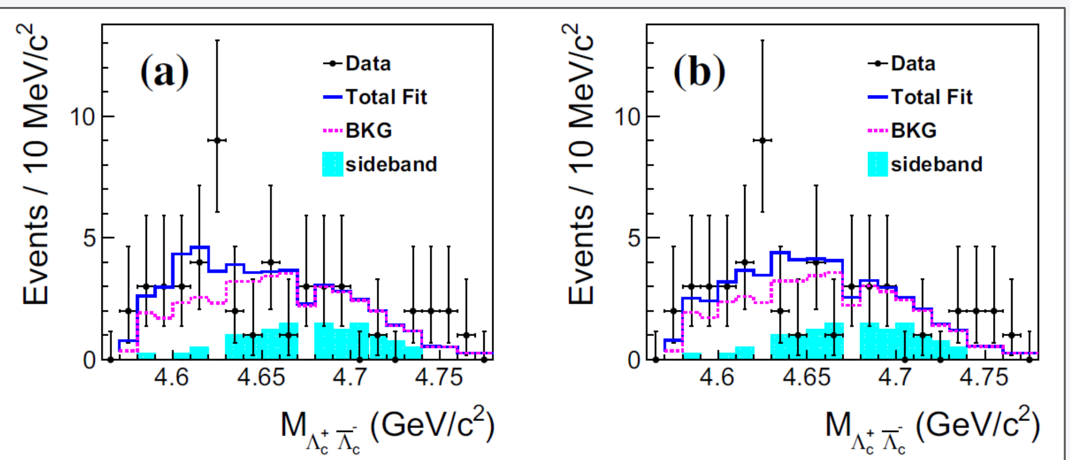
BESIII: PRD 96, 032004 (5.1/fb)

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

Search for Y(4660) and its spin partner in $B^+(\bar{B}^0) \to K^+(\bar{K}^0)\Lambda_c^+\bar{\Lambda}_c^-$ at Belle



Eur. Phys. J. C78, 252 (2018)



Eur. Phys. J. C78, 928 (2018)

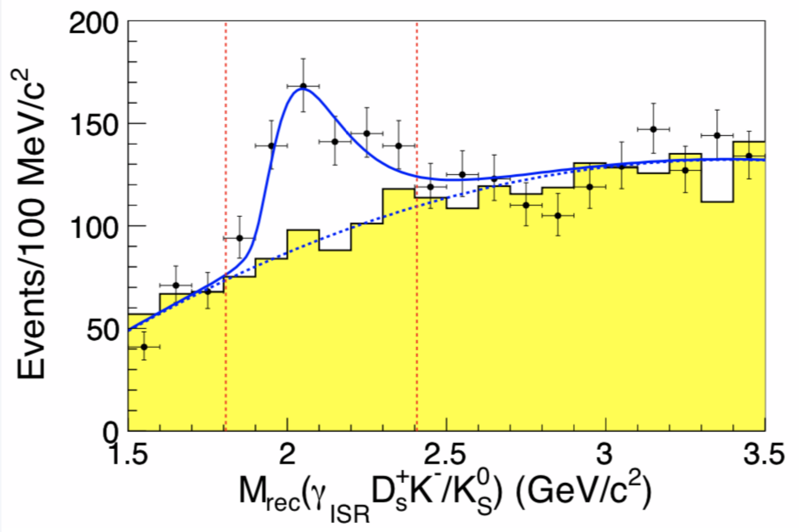
- No Y(4660) and its spin partner Y_η were observed in the $\Lambda_c^+\bar{\Lambda}_c^-$ invariant mass distribution.
- 90% C.L. upper limits of $B^+ \to K^+Y(4660) \to K^+\Lambda_c^+\bar{\Lambda}_c^-$ and $B^+ \to K^+Y_\eta \to K^+\Lambda_c^+\bar{\Lambda}_c^-$ are 1.2×10^{-4} and 2.0×10^{-4}.
- 90% C.L. upper limits of $\bar{B}^0 \to \bar{K}^0Y(4660) \to K^+\Lambda_c^+\bar{\Lambda}_c^-$ and $\bar{B}^0 \to K^0Y_\eta \to K^+\Lambda_c^+\bar{\Lambda}_c^-$ are 2.3×10^{-4} and 2.2×10^{-4}.

$Y(4626)$ in $e^+e^- \to \gamma_{ISR} D_s^+ D_{s1}(2536)^- (\to \bar{D}^{*0}K^- / D^{*-}K_S^0)$+c.c.

For $\bar{D}^{*0}K^-$ mode, full reconstruction of the γ_{ISR}, D_s^+ , and K^-.

D_s: $K^+K^-\pi^+$, K_sK^+, $K^+K^-\pi^+\pi^0$, $K_sK^+\pi^0$, $\eta\pi^+$, $\eta'\pi^+$,and require $D_s^+K^-\gamma_{ISR}$ recoil mass ~ $\bar{D}^{*0}$ mass.

For $D^{*-}K_S^0$ mode, full reconstruction of the γ_{ISR}, D_s^+ , and K_S^0, and do similar selection



- $M_{rec}(\gamma_{ISR}D_s^+K^-/K_S^0)$ distribution is making before applying the $\bar{D}^{*0}/D^{*-}$ mass constraint.
- Due to the poor mass resolution, the $\bar{D}^{*0}/D^{*-}$ signal is very wide.
- The yellow histogram shows the normalized $D_{s1}(2536)^-$ mass sidebands.

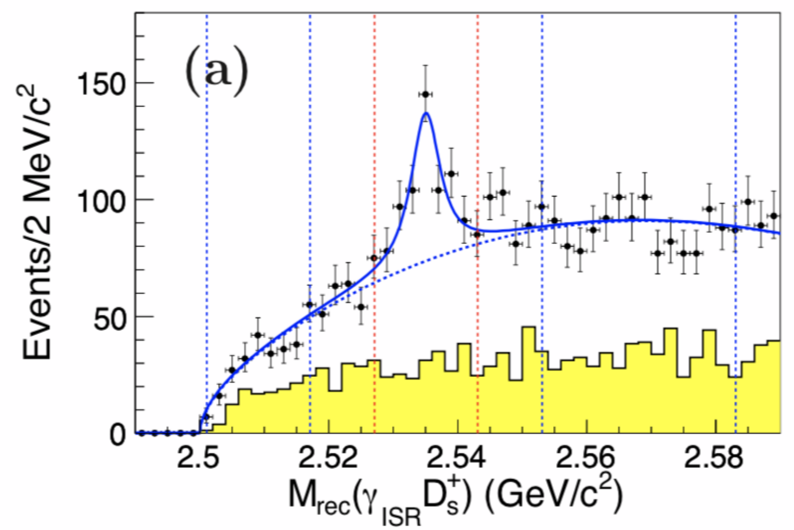
Phys. Rev. D 100, 111103(R) (2019)

Y(4626) in $e^+e^- \to \gamma_{ISR} D_s^+ D_{s1}(2536)^-(\to \bar{D}^{*0}K^-/D^{*-}K_S^0)$+c.c.

To improve mass resolution, $M_{rec}(\gamma_{ISR}D_s^+K^-)$ is constrained to nominal mass of $\bar{D}^{*0}$

The resolution of $M_{rec}(\gamma_{ISR})$ is drastically improved (~180 → ~ 5 MeV).

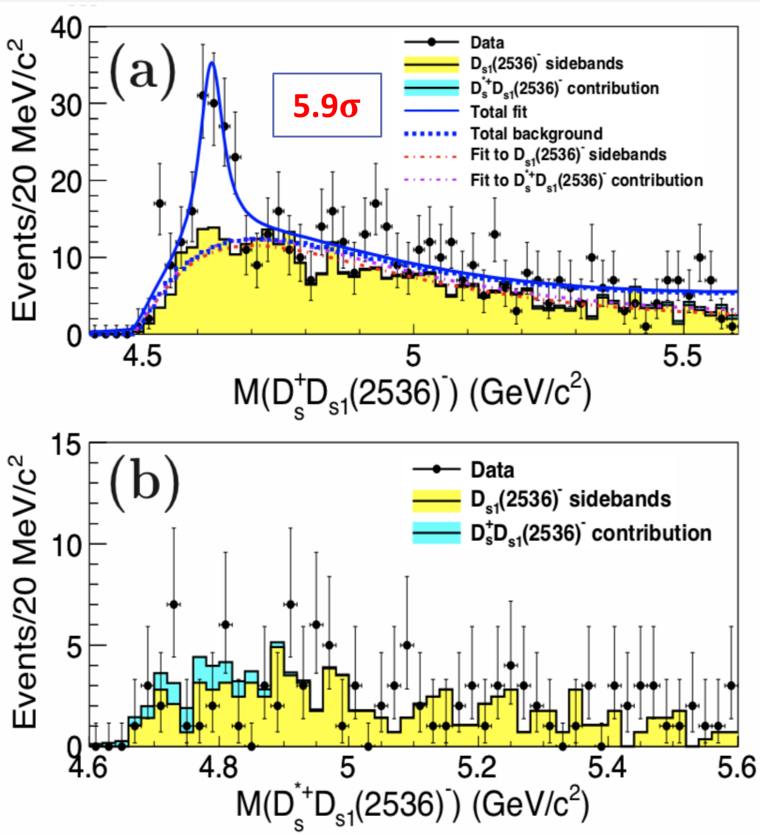
$$M_{rec}(\gamma_{ISR}D_s^+K^-) = \sqrt{(E^*_{c.m.} - E^*_{\gamma_{ISR}D_s^+K^-})^2 - \left(p^*_{\gamma_{ISR}D_s^+K^-}\right)^2}$$



- $M_{rec}(\gamma_{ISR}D_s^+)$ distribution is making after applying the $\bar{D}^{*0}/D^{*-}$ mass constraint.
- The yellow histogram shows the normalized D_s^+ mass sidebands.
- The fit yields 275±32 $D_{s1}(2536)^-$ signal events with the statistical significance of 8.0σ.

Phys. Rev. D 100, 111103(R) (2019)

$Y(4626)$ in $e^+e^- \to \gamma_{ISR} D_s^+ D_{s1}(2536)^- (\to \bar{D}^{*0}K^- / D^{*-}K_S^0)$+c.c.



Phys. Rev. D 100, 111103(R) (2019)

An unbinned simultaneous likelihood fit:

- Signal: BW convolved with a Gaussian function, then multiplied by an efficiency function
- $D_{s1}(2536)^-$ mass sidebands: threshold function
- $e^+e^- \to D_s^{*+}D_{s1}(2536)^-$ background: threshold function
- non-resonant: two-body phase space

$\mathbf{M=(4625.9^{+6.2}_{-6.0}(stat.) \pm 0.4(syst.)\ MeV/c^2}$
$\boldsymbol{\Gamma = (49.8^{+13.9}_{-11.5}(stat.) \pm 4.0(syst.)\ MeV}$
$\mathbf{\Gamma_{ee} \times \mathcal{B}(Y \to D_s^+ D_{s1}(2536)^-) \times \mathcal{B}(D_{s1}(2536)^- \to \bar{D}^{*0}K^-) = (14.3^{+2.8}_{-2.6}(stat.) \pm 1.5(syst.)\ eV}$

Possible background from $e^+e^- \to D_s^{*+}(\to D_s^+\gamma)D_{s1}(2536)^-$, where the photon from the D_s^{*+} remains undetected is studied in data, no obvious structure is observed in $e^+e^- \to D_s^{*+}(\to D_s^+\gamma)D_{s1}(2536)^-$.

Interpretation of the Y(4626)

Tetraquark state

- Yue Tan and Jialun Ping, *"Y(4626) in a chiral constituent quark model"*, arXiv:1911.02461
- Chengrong Denga, Hong Chen, and Jialun Ping, *"Can the state Y(4626) be a P-wave tetraquark state $[cs][\bar{c}\bar{s}]$?"*, arXiv:1912.07174

Molecular state

- Jun He, Yi Liu, Jun-Tao Zhu, Dian-Yong Chen, *"Y(4626) as a molecular state from interaction $D_s^* \bar{D}_{s1}(2536) - D_s \bar{D}_{s1}(2536)$"*, arXiv:1912.08420

High charmonia

- Jun-Zhang Wang, Ri-Qing Qian, Xiang Liu, and Takayuki Matsuki, *"Are the Y states around 4.6 GeV from e^+e^- annihilation higher charmonia?"*, arXiv:2001.00175

Next, may these rates be estimated according to $D_sD_{s1}(2536)$?

Experimental measurements:

Y(4660) →

- $D_s{}^*D_{s0}(2317)$
- $D_sD_{s1}(2460)$
- $D_s{}^*D_{s1}(2460)$
- $D_sD_{s2}(2573)$

at Belle with ISR; and at BESIII with data to be taken in 2019-2020 running year

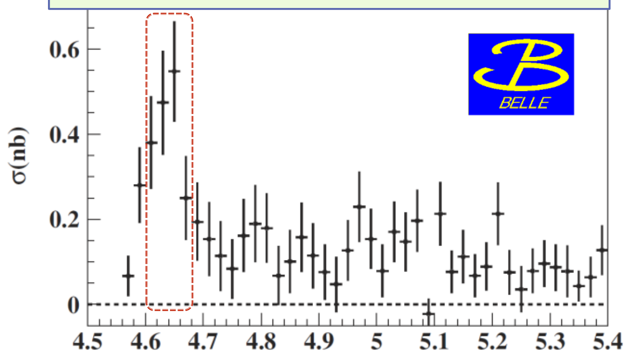
(E_{cm} = 4.62, 4.64, 4.66, 4.68, 4.70 GeV, 500 pb^{-1} at each energy points)

Y(4626) = Y(4660)?

Similar mass and width of Y state at around 4.6 GeV in following channels, are they from same resonance?

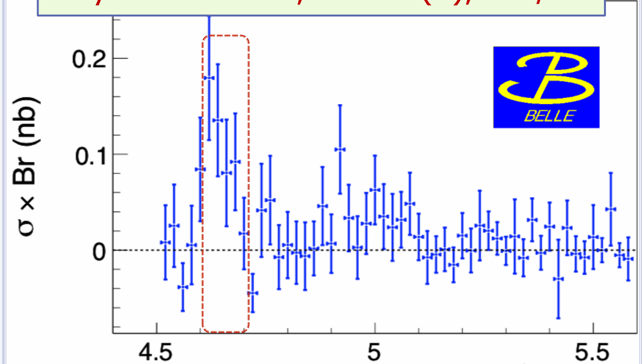
Experiment	Mass (MeV)	Width (MeV)
Belle, $\Lambda^+_c\Lambda^-_c$	$4634\,^{+8}_{-7}\,^{+5}_{-8}$	$92\,^{+40}_{-24}\,^{+10}_{-21}$
Belle, $\pi\pi\psi'$	$4652\pm10\pm8$	$68\pm11\pm1$
BaBar, $\pi\pi\psi'$	$4669\pm21\pm3$	$104\pm48\pm10$
Belle, D_sD_{s1}	$4625.9\,^{+6.2}_{-6.0}\pm0.4$	$49.8\,^{+13.9}_{-11.5}\pm4.0$

PRL 101, 172001, 695/fb



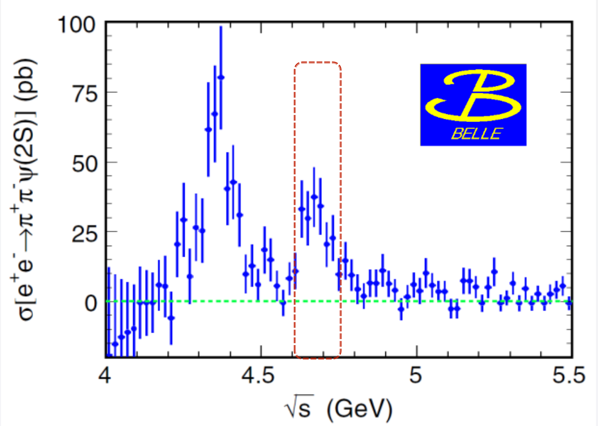
$e^+e^- \to \Lambda_c^+\Lambda_c^-$

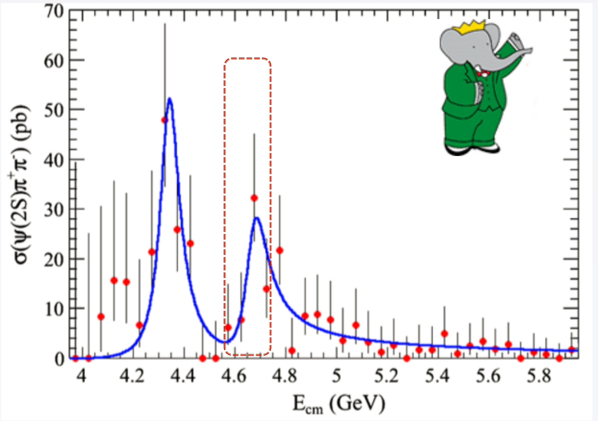
Phys. Rev. D 100, 111103(R), 922/fb



$e^+e^- \to D_s^+D_{s1}^-$

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





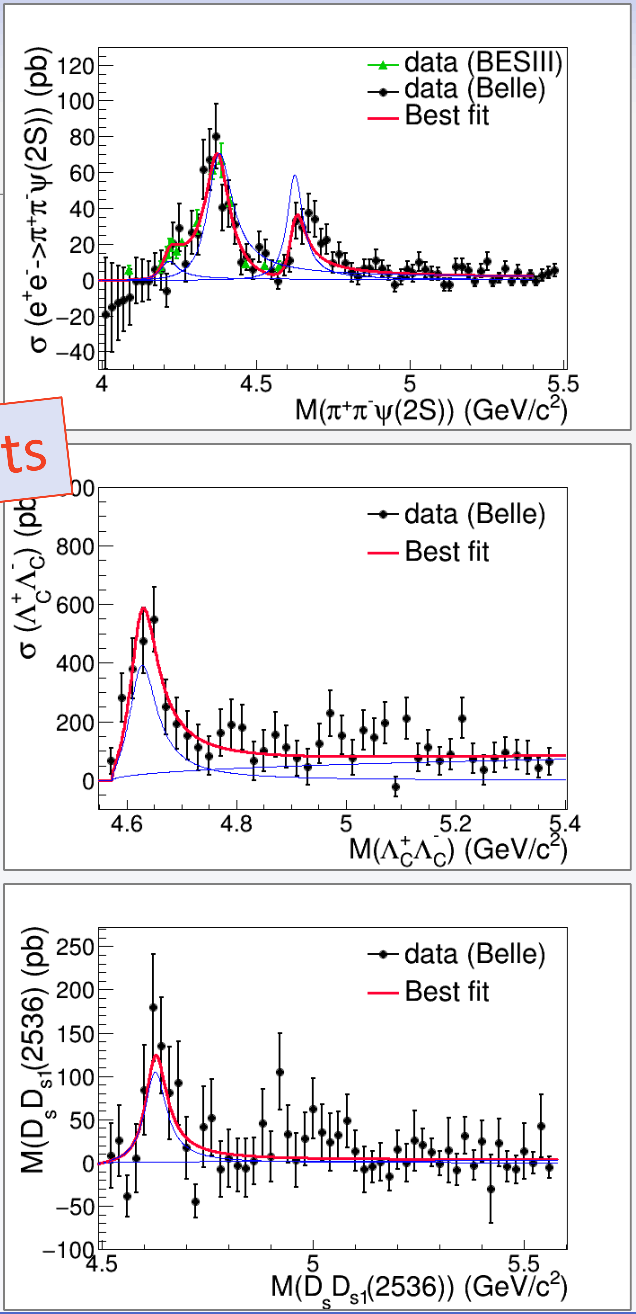
$e^+e^- \to \pi^+\pi^-\psi'$

$Y(4626) = Y(4660)?$

- Consider all possible signals at 4.63 GeV from same resonance, fit on the cross sections simultaneously:

M = 4623.7 ± 4.4 MeV/c^2
Γ = 62.0 $\pm$ 6.8 MeV

Preliminary results

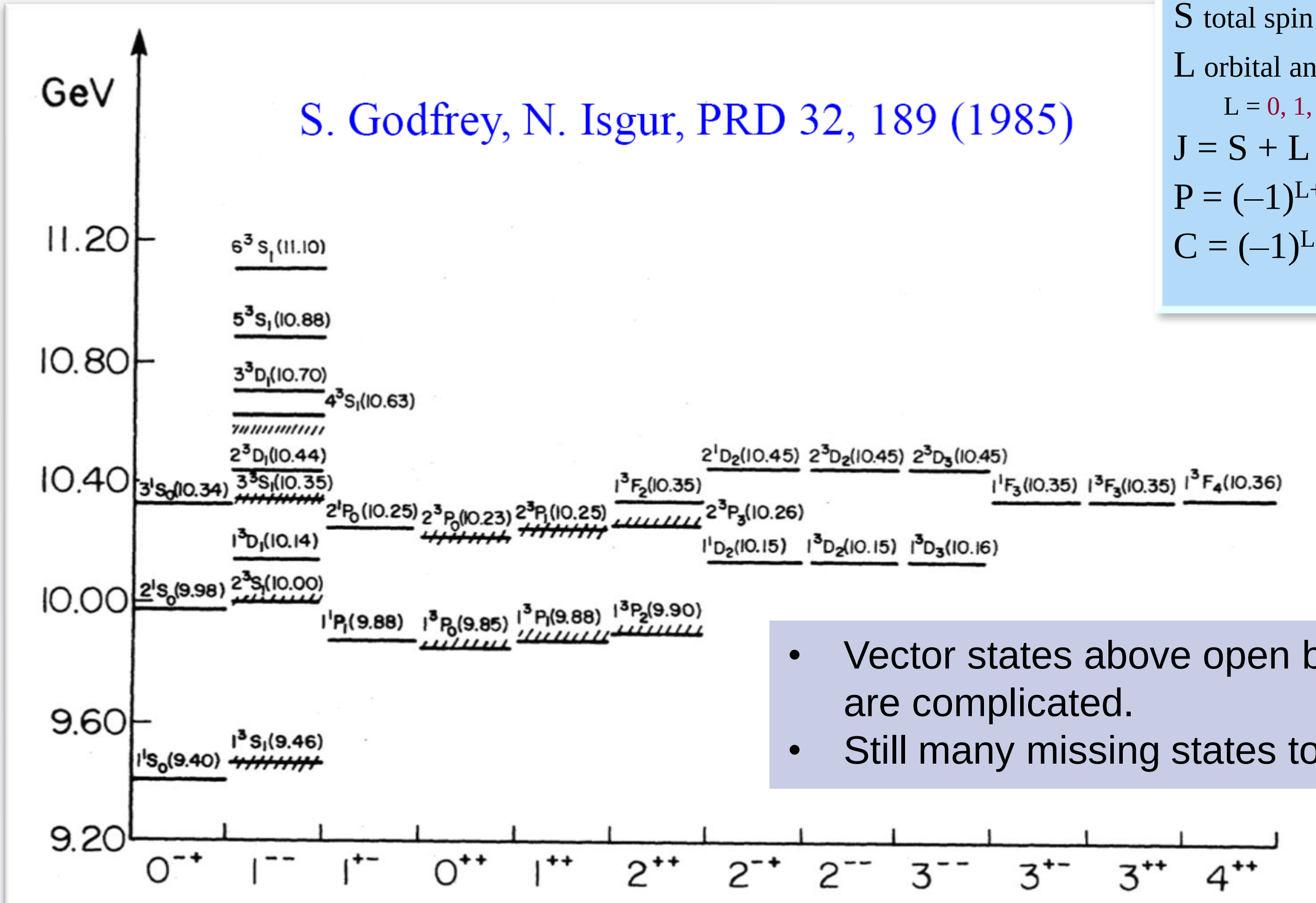


- Why does Y(4660) couple to $\bar{s}s$ strongly?
- Why does Y(4660) couple to charmed baryon strongly?

Interpretations:

- ☐ Charmonium?
- ☐ Molecule [f0(980)ψ', $\bar{\Lambda}$cΛc]?
- ☐ Hadron-charmonium?
- ☐ Tetraquark state?
- ☐ Hybrid?

The bottomonium spectrum



S. Godfrey, N. Isgur, PRD 32, 189 (1985)

$n^{(2S+1)}L_J$

n radial quantum number

S total spin of b & b-bar

L orbital angular momentum

L = 0, 1, 2 ... correspond to S, P, D, …

$J = S + L$

$P = (-1)^{L+1}$ parity

$C = (-1)^{L+S}$ charge-parity

- Vector states above open bottom threshold are complicated.
- Still many missing states to be discovered.

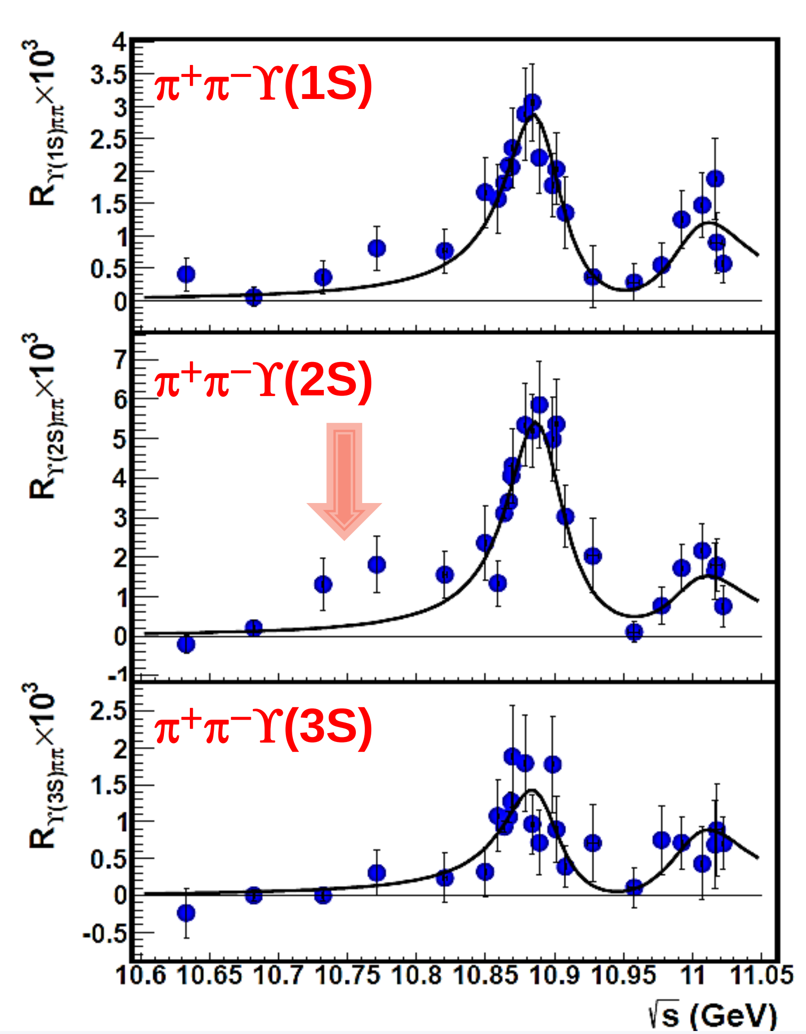
Visible cross sections of $e^+e^- \rightarrow \pi^+\pi^-\Upsilon(nS)$

- Tag $\Upsilon(nS) \rightarrow \mu^+\mu^-$ and select $\pi^+\pi^-$
- Fit on the mass spectrum with $|A_{5S}+e^{i\phi}A_{6S}|^2$

$\Upsilon(5S)$	Mass	$(10891.9 \pm 3.2 \pm^{0.6}_{1.5})$ MeV
	Width	$(53.7 \pm^{7.1}_{5.6} \pm^{0.9}_{5.4})$ MeV
$\Upsilon(6S)$	Mass	$(10987.5 \pm^{6.4}_{2.5} \pm^{2.2}_{2.1})$ MeV
	Width	$(61 \pm^{9}_{19} \pm^{2}_{20})$ MeV

- Results agree with previous measurements
- There seems a resonance at 10.75 GeV?

PRD 93, 011101(R) (2016)



Update cross sections of $e^+e^- \rightarrow \pi^+\pi^-\Upsilon(nS)$

Same data samples, but with improved analysis

Previous analysis

- tag $\Upsilon(nS)\rightarrow\mu^+\mu^-$ and select $\pi^+\pi^-$
- Count numbers of events in signal and sideband regions
- Reported visible cross section

New analysis

- tag $\Upsilon(nS)\rightarrow\mu^+\mu^-/e^+e^-$ and select $\pi^+\pi^-$
- Fit with well constrained signal and background shapes
- Initial state radiation correction is considered, and ISR of $\Upsilon(5S)$ peak data supply useful information on the cross section line shapes

Precision improves by 30% + observation of Y(10750)!

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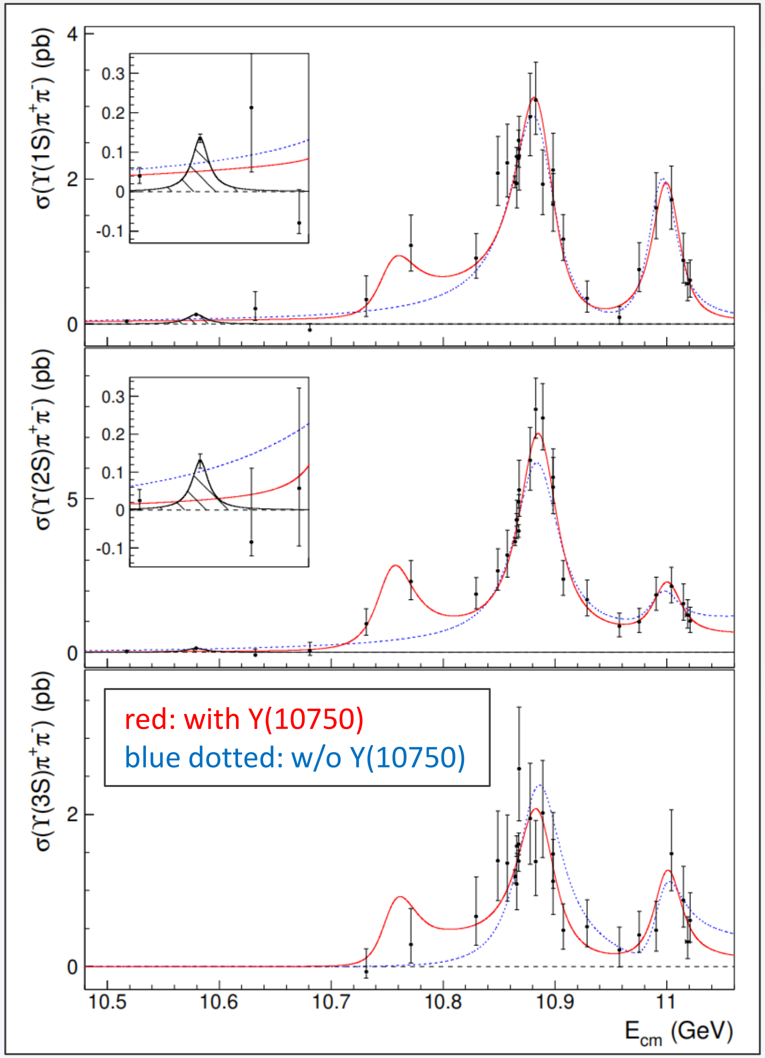
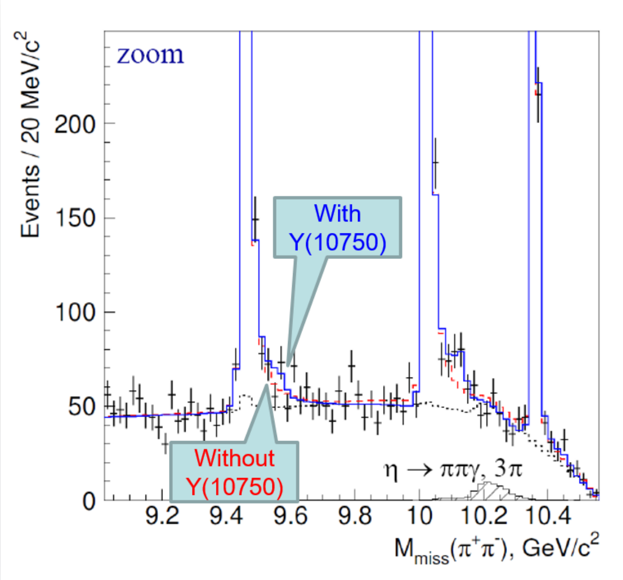
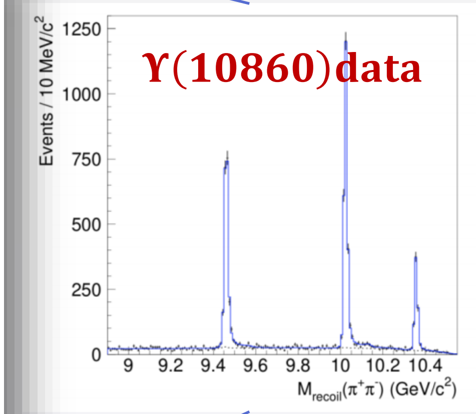
Observation of Υ(10750)

- Scan data: 22 points, each point 1 fb^{-1}
- **Υ(10860)** on-resonance data: 121 fb^{-1} (10.864 ~ 10.868 GeV)
- Continuum data at 10.52 GeV, 60 fb^{-1}







ISR tails are described well with Y(10750)

	Υ(10860)	Υ(11020)	New structure
M (MeV/c^2)	$10885.3 \pm 1.5^{+2.2}_{-0.9}$	$11000.0^{+4.0}_{-4.5}{}^{+1.0}_{-1.3}$	$10752.7 \pm 5.9^{+0.7}_{-1.1}$
Γ (MeV)	$36.6^{+4.5}_{-3.9}{}^{+0.5}_{-1.1}$	$23.8^{+8.0}_{-6.8}{}^{+0.7}_{-1.8}$	$35.5^{+17.6}_{-11.3}{}^{+3.9}_{-3.3}$

Global significance: 6.8σ

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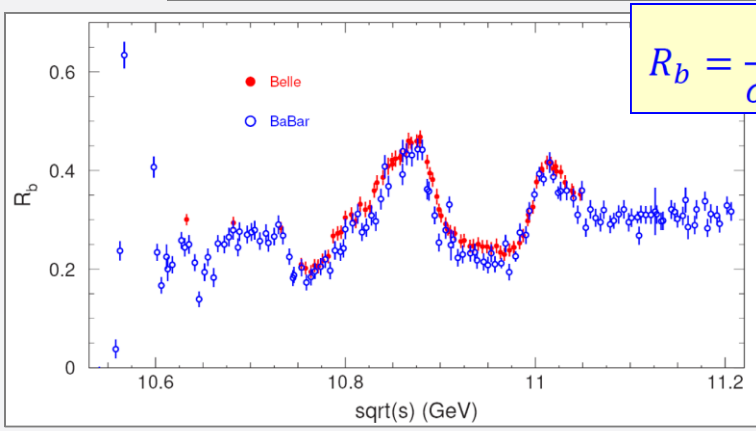
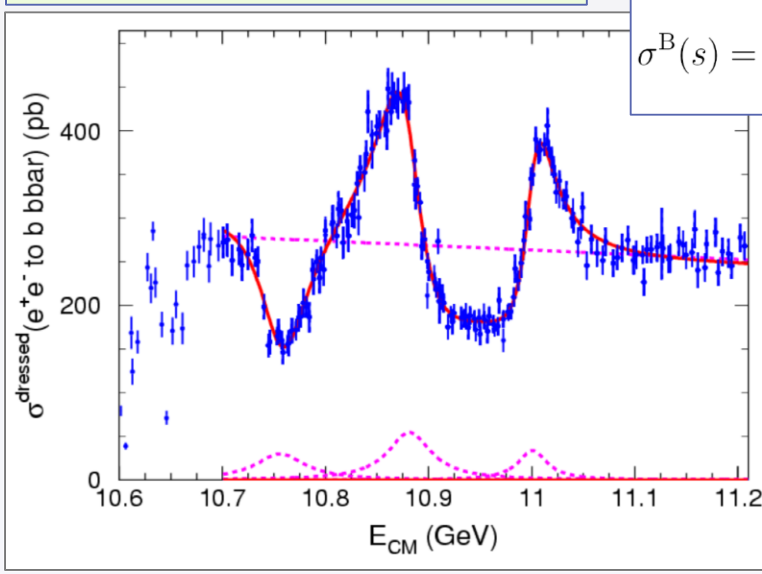
BaBar & Belle measured visible and dressed cross sections



$$R_b = \frac{\sigma(e^+e^- \to b\bar{b})}{\sigma^0(e^+e^- \to \mu^+\mu^-)}$$

- Try to get Y(10750) information from R_b data (BaBar+Belle)
- Y(10750) interferences with other amplitudes destructively and produces a dip.

BaBar: PRL102, 012001 (2009)
Belle: PRD 93, 011101(R) (2016)



$$\sigma^B(s) = \frac{\sigma^{obs}(s)}{(1+\delta(s))\cdot\frac{1}{|1-\Pi(s)|^2}}$$

Coherent sum of a continuum amplitude ($\propto 1/\sqrt{s}$) and 3 BW functions (constant width).

Free parameters:

- Mass M
- width Γ
- leptonic partial width Γ_{ee}
- relative phase ϕ

The analysis is done by Changzheng Yuan, Xiangkun Dong, Xiaohu Mo, and Ping Wang.

Fit results (mass & width)

Preliminary results

	$\Upsilon(10860)$	$\Upsilon(11020)$	Y(10750)
M (MeV/ c^2)	10881±1	11000±1	10756±3
Γ(MeV)	51±2	34±2	58±5

Fit to BaBar & Belle R_b data, Statistical error only

	$\Upsilon(10860)$	$\Upsilon(11020)$	New structure
M (MeV/c^2)	$10885.3 \pm 1.5\,^{+2.2}_{-0.9}$	$11000.0^{+4.0\,+1.0}_{-4.5\,-1.3}$	$10752.7 \pm 5.9\,^{+0.7}_{-1.1}$
Γ (MeV)	$36.6^{+4.5\,+0.5}_{-3.9\,-1.1}$	$23.8^{+8.0\,+0.7}_{-6.8\,-1.8}$	$35.5^{+17.6\,+3.9}_{-11.3\,-3.3}$

Fit to Belle $e^+e^- \to \pi^+\pi^-\Upsilon(nS)$

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PDG(2019)	$\Upsilon(10860)$	$\Upsilon(11020)$
M (MeV/ c^2)	$10889.9\,^{+3.2}_{-2.6}$	$10992.9\,^{+10.0}_{-3.1}$
Γ(MeV)	$51\,^{+6}_{-7}$	$49\,^{+9}_{-15}$

PDG 2019

The analysis is done by Changzheng Yuan, Xiangkun Dong, Xiaohu Mo, and Ping Wang.

Fit results (electronic partial width)

Fit to BaBar & Belle R_b data, Statistical error only

Preliminary results

	Y(10750)	Υ(5S)	Υ(6S)
Γ_{ee} (eV) [sol.1]	13.7±1.8	22.4±1.3	9.5±0.6
Γ_{ee} (eV) [sol.2]	14.3±1.9	26.0±1.7	309±13
Γ_{ee} (eV) [sol.3]	16.5±2.3	510±19	11.1±0.8
Γ_{ee} (eV) [sol.4]	17.2±2.4	594±27	364±18
Γ_{ee} (eV) [sol.5]	415±40	25.4±1.8	9.7±0.6
Γ_{ee} (eV) [sol.6]	432±43	29.6±2.2	316±13
Γ_{ee} (eV) [sol.7]	498±55	580±28	11.4±0.8
Γ_{ee} (eV) [sol.8]	519±58	674±37	373±19

The analysis is done by Changzheng Yuan, Xiangkun Dong, Xiaohu Mo, and Ping Wang.

Fit to Belle $e^+e^- \rightarrow \pi^+\pi^-\Upsilon(nS)$

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$\Gamma_{ee}B(\pi\pi\Upsilon)$ [eV]	$\Upsilon(10860)$	$\Upsilon(11020)$	Y(10750)
$\Upsilon(1S)\pi^+\pi^-$	$0.75-1.43$	$0.38-0.54$	$0.12-0.47$
$\Upsilon(2S)\pi^+\pi^-$	$1.35-3.80$	$0.13-1.16$	$0.53-1.22$
$\Upsilon(3S)\pi^+\pi^-$	$0.43-1.03$	$0.17-0.49$	$0.21-0.26$

If we take the small partial width solutions, BFs of Y/Υ(nS)→Υ(mS)$\pi\pi$ are ~ 1-10% level;

If we take the large partial width solutions, BFs of Y/Υ(nS)→Υ(mS)$\pi\pi$ are ~ 0.1-0.5% level.

Interpretation of the Y(10750)

D-wave bottomonium

- Bing Chen, Ailin Zhang, Jin He, *"Bottomonium spectrum in the relativistic flux tube model (3D)"* , arXiv:1910.06065
- Qi Li, Ming-Sheng Liu, Qi-Fang Lü, Long-Cheng Gui, Xian-Hui Zhong, *"Canonical interpretation of Y(10750) and Y(10860) in the Y family (4D)"*, arXiv:1905.10344

$\bar{B}^{(*)}B^{(*)}$ dynamically generated pole

- Pedro Bicudo, Marco Cardoso, Nuno Cardoso, Marc Wagner, *"Bottomonium resonances with I=0 from lattice QCD correlation functions with static and light quarks"*, arXiv:1910.04827

Hybrid

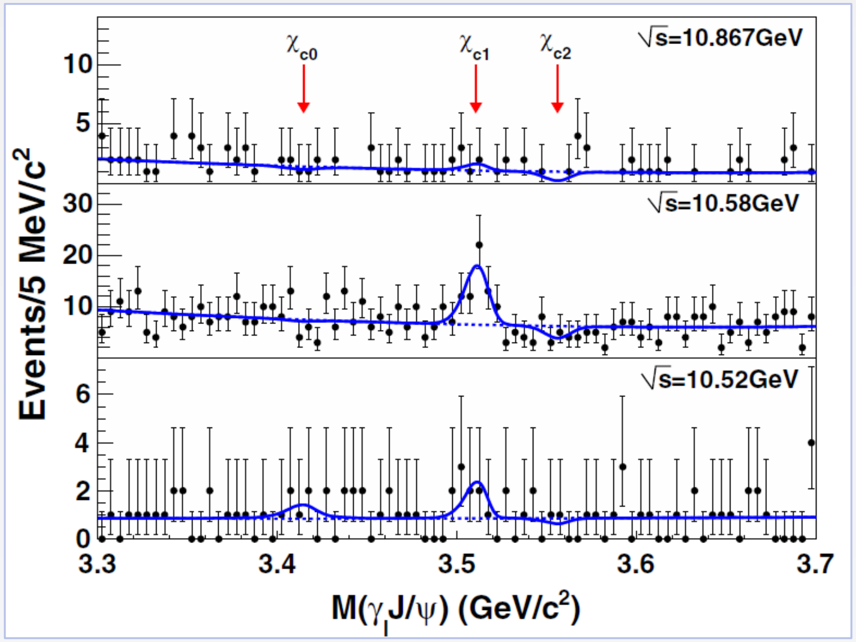
- Jaume Tarrús Castellà, *"Spin Structure of heavy-quark hybrids"*, arXiv:1908.05179

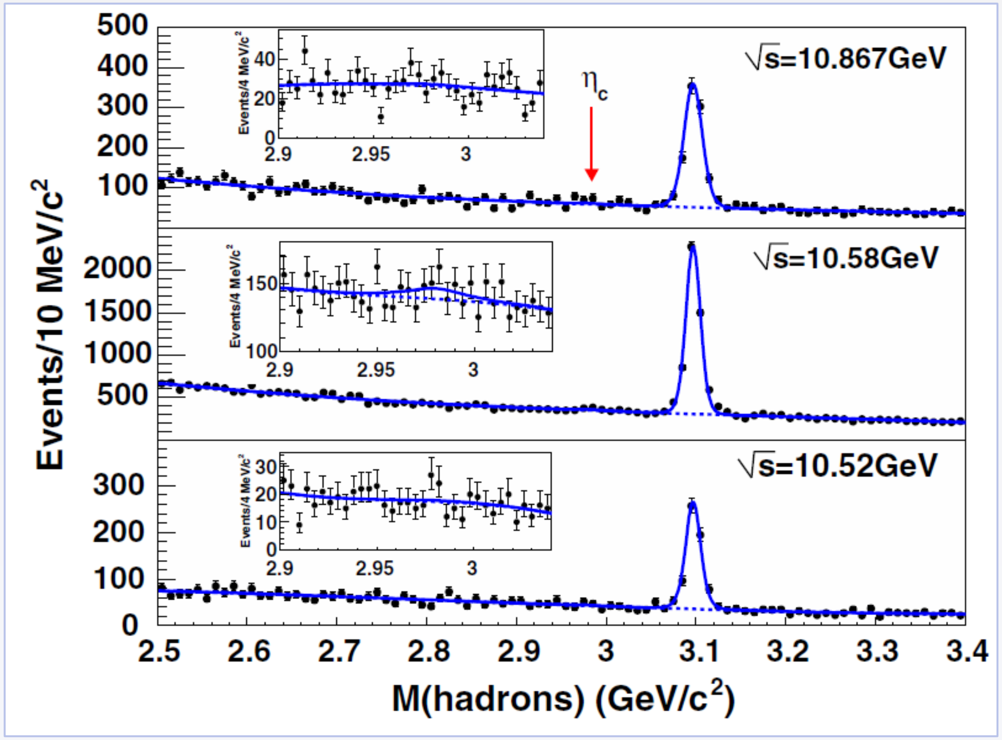
Tetraquark state

- Ahmed Ali, Luciano Maiani, Alexander Ya. Parkhomenko, Wei Wang, *"Interpretation of Yb (10753) as a tetraquark and its production mechanism"*, arXiv:1910.07671
- Zhi-Gang Wang, *"Vector hidden-bottom tetraquark candidate: Y(10750)"*, Chin. Phys. C43 (2019) 123102

$e^+e^- \rightarrow \gamma\chi_{cJ} / \gamma\eta_c$

- χ_{c1} signal is observed in $\Upsilon(4S)$ sample with significance of 5.2σ
- No evidence of χ_{c0}, χ_{c2}, η_c





Born cross section	$17.3\ ^{+4.2}_{-3.9} \pm 1.7$ fb

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η_c is reconstructed in five final states

Cross section of $e^+e^- \to \gamma\chi_{c1}$

- Combining the measurement of $\sigma_B(e^+e^- \to \gamma\chi_{c1})$ in BESIII and this analysis,
- Cross section as a function of $1/s^n$ is shown:

Cross section *s*-dependence	$1/s^{2.1\,^{+0.3}_{-0.4}\pm0.3}$

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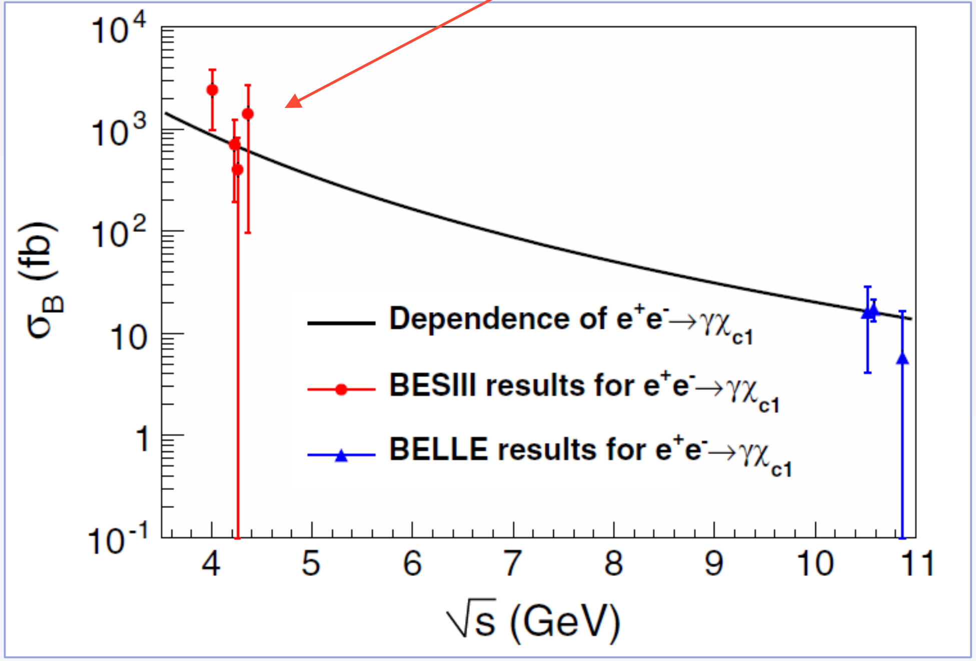

- Adding an additional possible resonance, such as $\psi(4040)$, $\psi(4160)$, $\psi(4260)$, or $\Upsilon(4S)$, the largest change in the fitted value of n is 0.3

- The result is consistent with the prediction by NRQCD with all leading relativistic corrections included

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Summary

- Belle try to search for Y(4660) and its spin partner in $B^+(\overline{B}^0) \to K^+(\overline{K}^0)\Lambda_c^+\overline{\Lambda}_c^-$, 90% C.L. upper limits of $B^+(\overline{B}^0) \to K^+(\overline{K}^0)Y(4660)(\to \Lambda_c^+\overline{\Lambda}_c^-)$ are set.

$B^+ \to K^+Y(4660)\ \vert K^+Y_\eta \to K^+\Lambda_c^+\overline{\Lambda}_c^-$	$1.2\times 10^{-4}\ \vert\ 2.0 \times 10^{-4}$
$\overline{B}^0 \to \overline{K}^0Y(4660)\vert K^0Y_\eta \to K^+\Lambda_c^+\overline{\Lambda}_c^-$	$2.3 \times 10^{-4}\ \vert\ 2.2 \times 10^{-4}$

- Y(4626) is observed in $e^+e^- \to \gamma_{ISR}D_s^+D_{s1}(2536)^-$+c.c.

$M = 4625.9\ ^{+6.2}_{-6.0} \pm 0.4$ MeV
$\Gamma = 49.8\ ^{+13.9}_{-11.5} \pm 4.0$ MeV

Maybe: Tetraquark state
Molecular state
High charmonia

- If combine $\pi^+\pi^-\psi'$, $D_s^+D_{s1}^-$, $\Lambda_c^+\Lambda_c^-$, with assumption that the states at around 4.63 GeV are one, and fit simultaneously:

$M = 4623.7 \pm 4.4$ MeV
$\Gamma = 62.0 \pm 6.8$ MeV

Summary

- Y(10750) is **observed** in $e^+e^- \to \pi^+\pi^- \Upsilon(nS)$

$M = 10752.7 \pm 5.9\ ^{+0.7}_{-1.1}$ MeV
$\Gamma = 35.5\ ^{+17.6}_{-11.3}\ ^{+3.9}_{-3.3}$ MeV

  Maybe: D-wave bottomonium
  $\bar{B}^{(*)}B^{(*)}$ dynamically generated pole
  Hybrid
  Tetraquark state

- Measured cross sections agree with previous measurements.
- Y(10750) interferences with other amplitudes **destructively** and produces a dip in $e^+e^- \to \bar{b}b$ cross sections.
- Leptonic partial widths of Y(10750), $\Upsilon(10860)$, $\Upsilon(11020)$ can be determined by fitting on the combined BaBar & Belle R_b data.

Summary

- χ_{c1} signal is observed in $\Upsilon(4S)$ sample in the process $e^+e^- \to \gamma\chi_{c1}$
- Combining the measurement of $\sigma_B(e^+e^- \to \gamma\chi_{c1})$ in BESIII, cross sections are fitted as a function of $1/s^n$, and result is consistent with the prediction by NRQCD with all leading relativistic corrections included

$\sigma_B(e^+e^- \to \gamma\chi_{c1})$ at $\Upsilon(4S)$	$17.3\ ^{+4.2}_{-3.9} \pm 1.7$ fb
Cross section s-dependence	$1/s^{2.1\ ^{+0.3}_{-0.4} \pm 0.3}$

Thanks!

- Further data in Belle2 & BESIII data expected for deeper understanding on these Y states.