

BESIII



Vector Charmonium-like states at BESIII

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Hadron 2021, July 26 – 31, 2021

Introduction

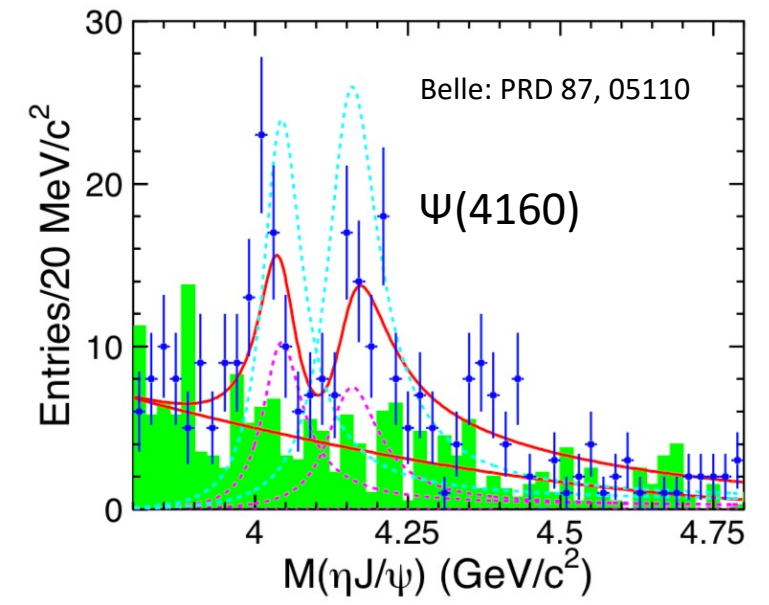
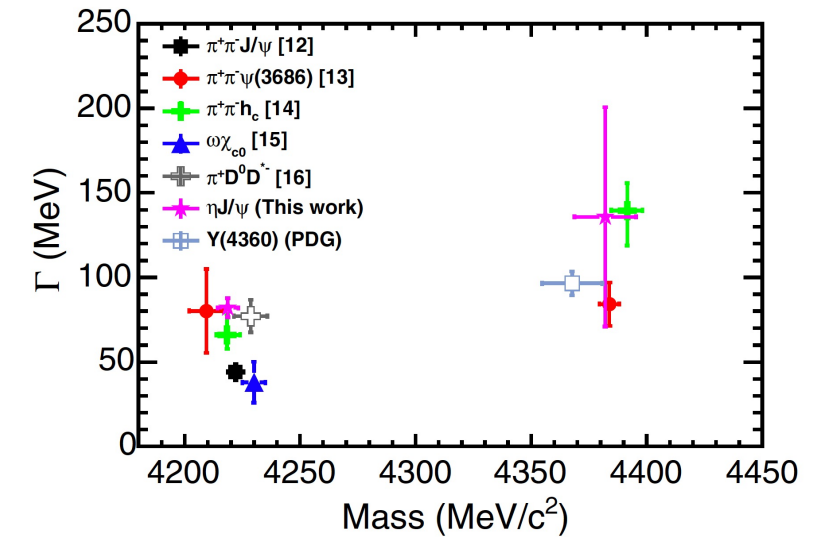
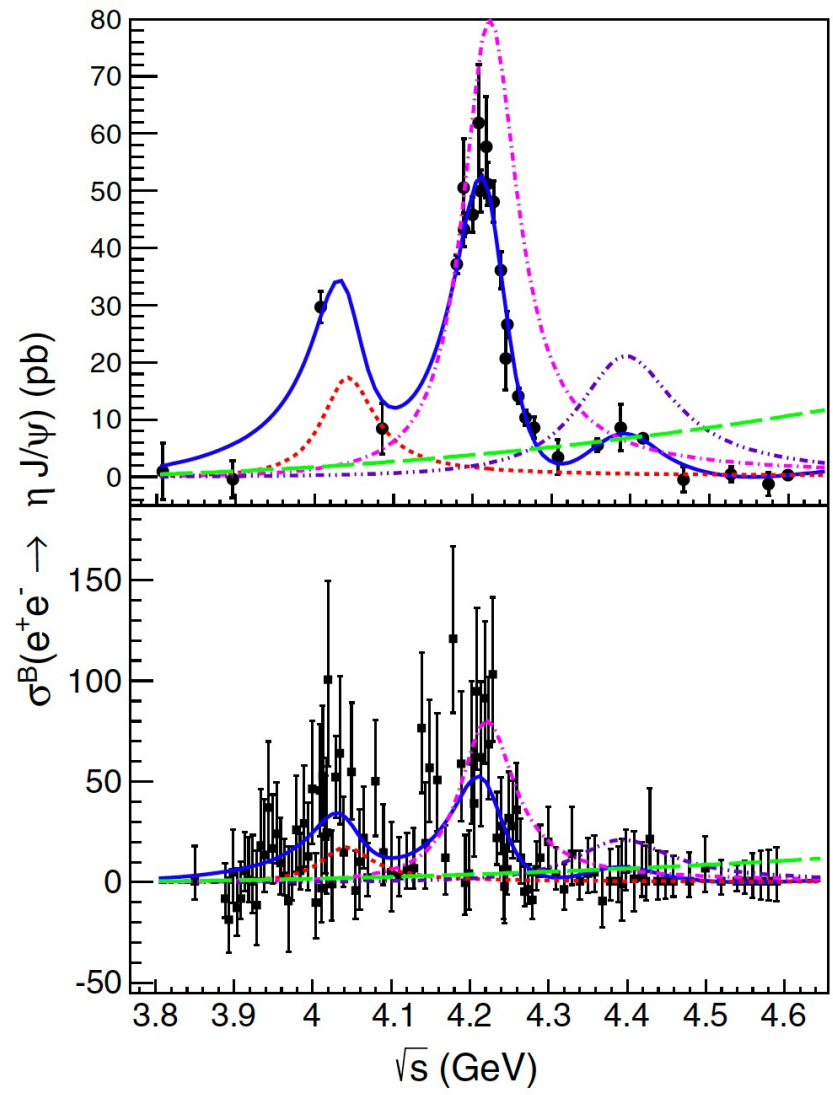
- Vector Charmonium-like States could be produced directly from electron-positron collision at BESIII
- They were observed in hidden-charm final states, and more decay modes are helpful for understanding their natures
- The recent results (within 2 years) from BESIII are covered in this talk in the order of : Charmonium + Light Hadron final state, Light Hadron final state, and leptonic final states
- The basic method is: measure the cross section as the function of center of mass energy, and look for peaks

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

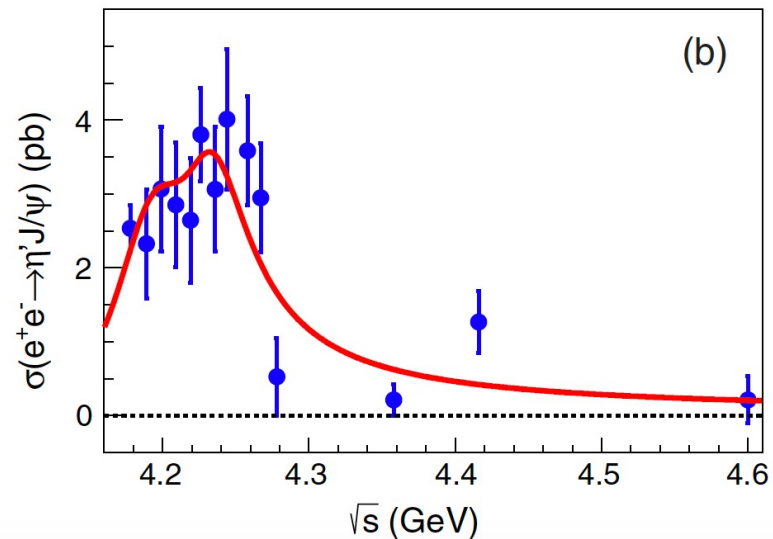
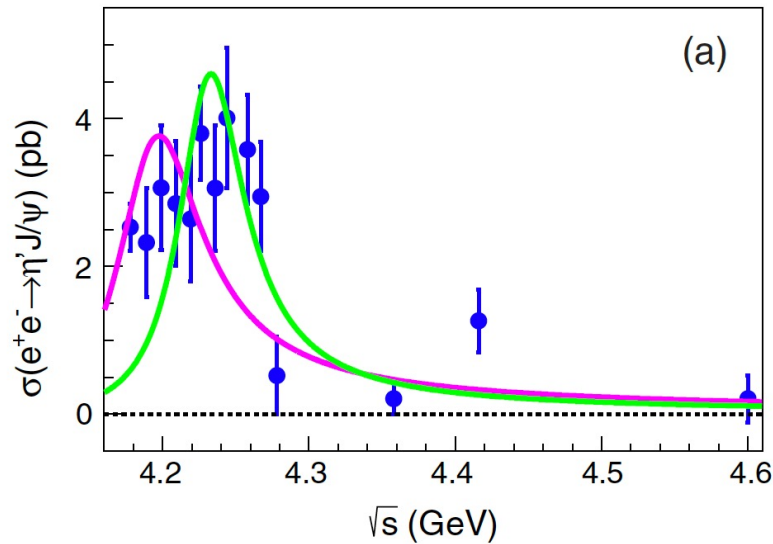
The cross section is at same order as $e^+e^- \rightarrow \pi\pi J/\psi$

3 structures are observed: $\Psi(4040) + \Upsilon(4220) + \Upsilon(4390)$

When assuming the second structure as $\Psi(4160)$, the significance is 8.1σ less than the assumption of $\Upsilon(4220)$



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



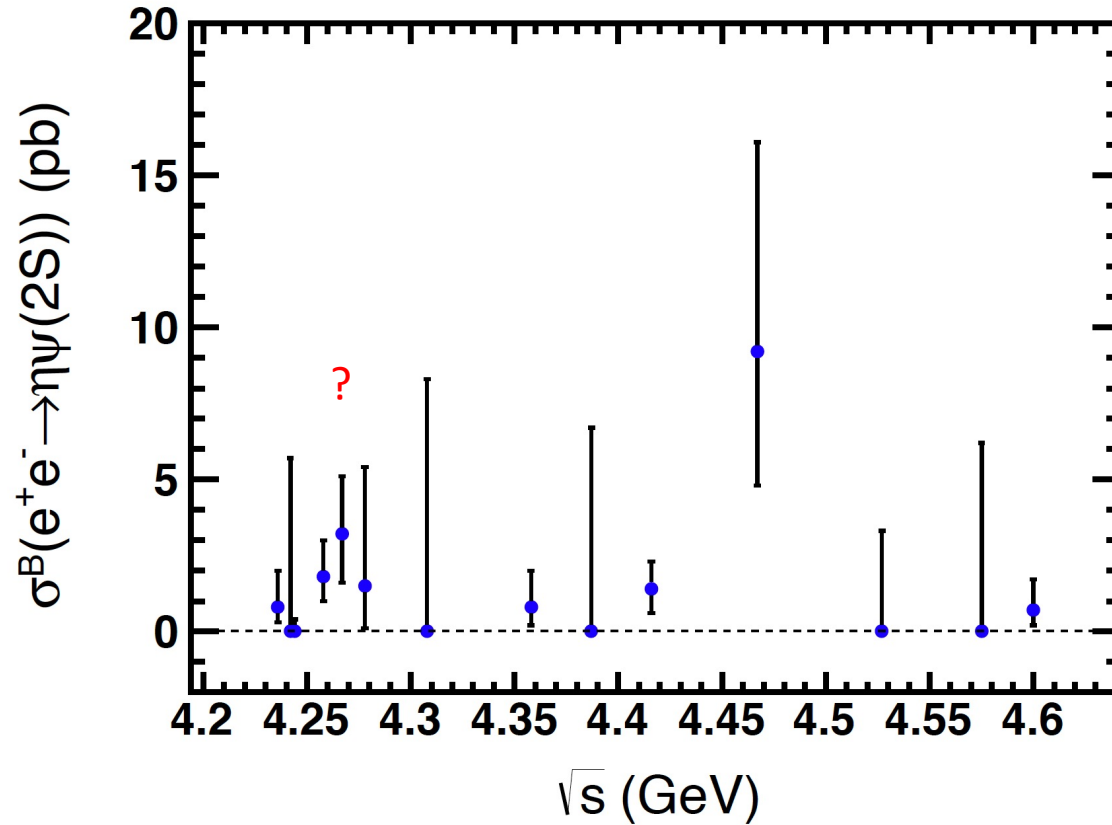
Enhancement around 4.2 GeV is clear

It could not be described by single $\psi(4160)$ or $Y(4260)$ well

$[\chi^2/\text{NDF}=38/13, 63/13]$

A coherent sum of the two offers better description $[\chi^2/\text{NDF}=19/11]$

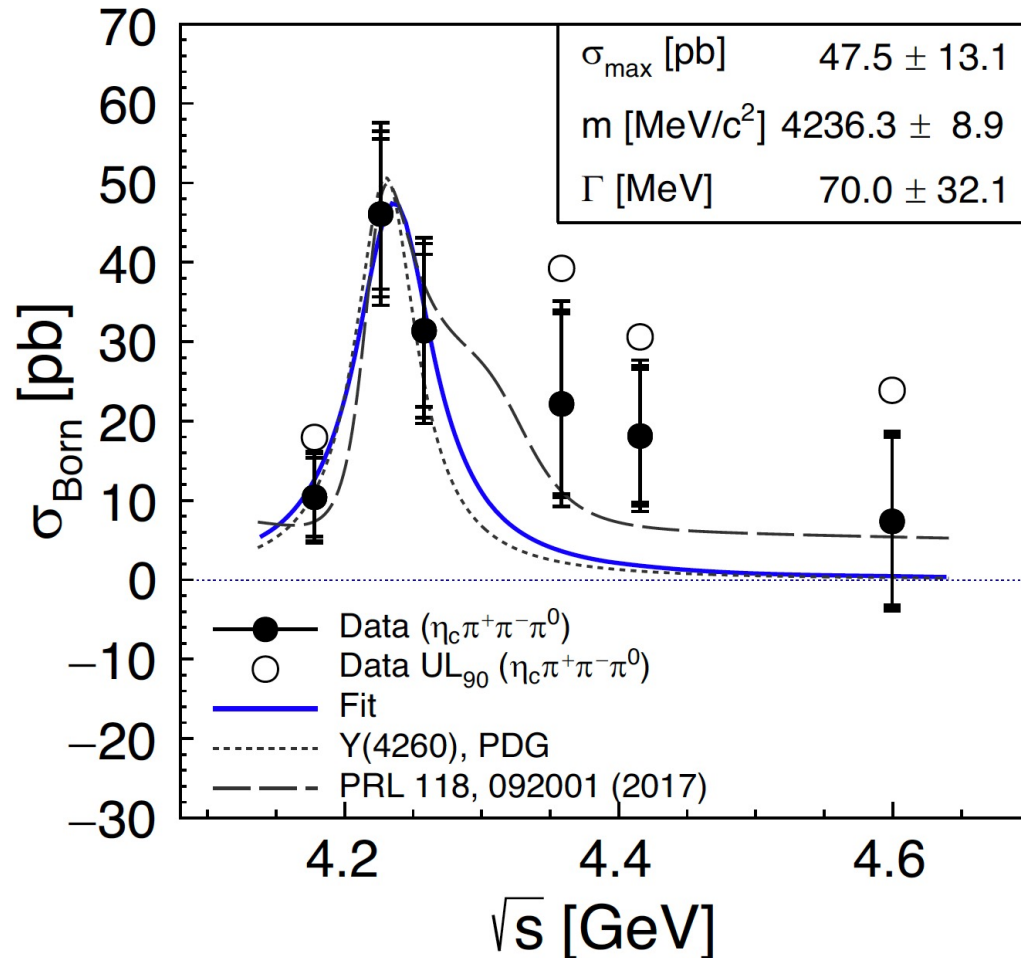
$e^+e^- \rightarrow \eta \psi(2S)$



First observation of this production process (5σ)

Due to low statistics, it is hard to get the information about Y state from this cross section lineshape

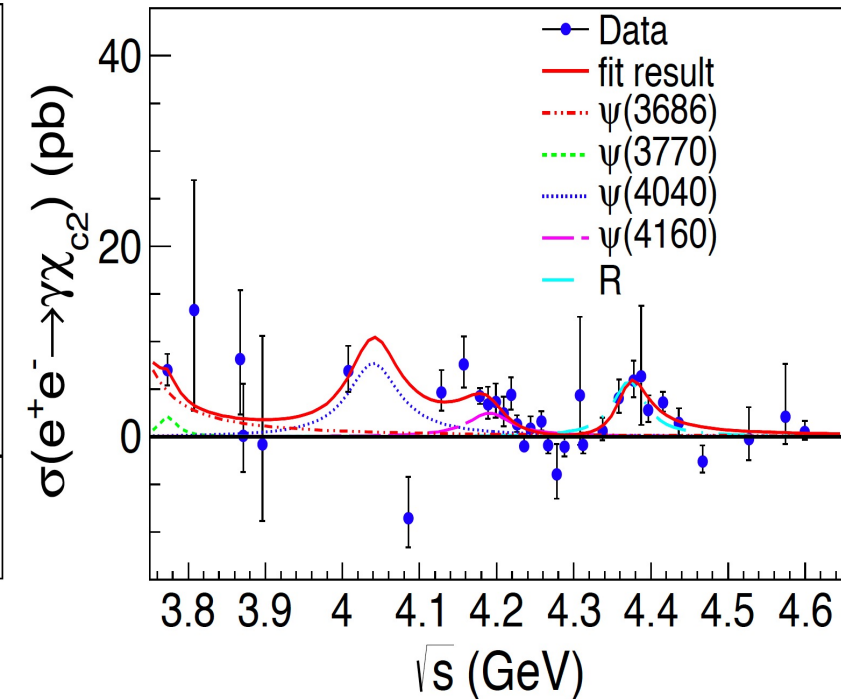
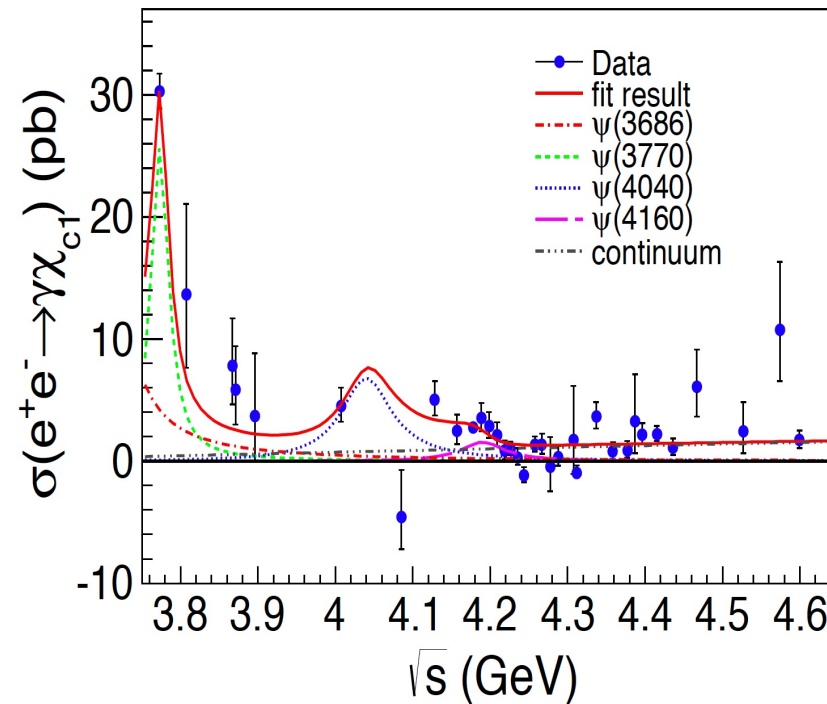
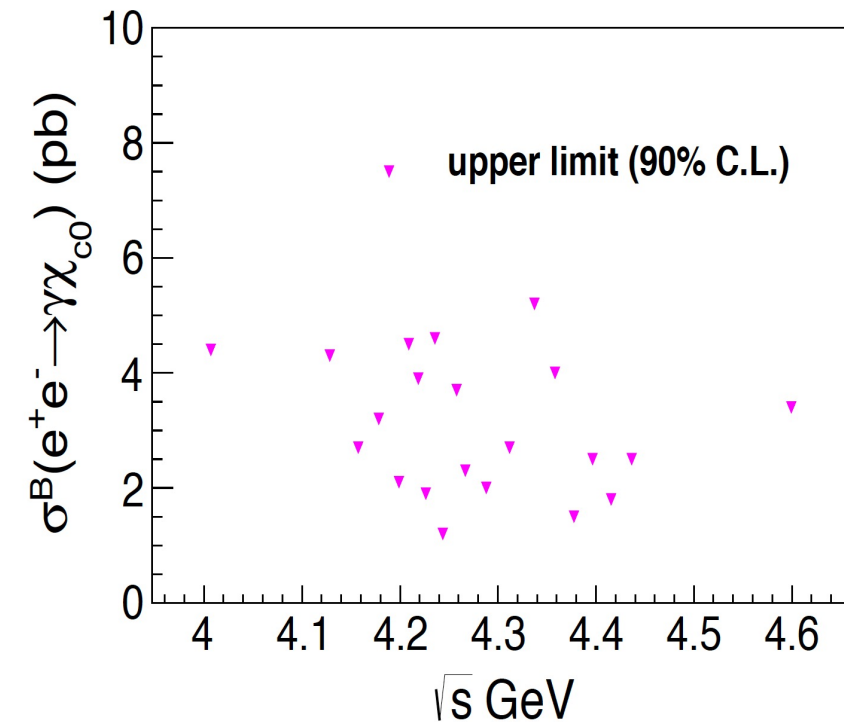
$e^+e^- \rightarrow \eta_c 3\pi$



First observation of this production process (5.2 σ)

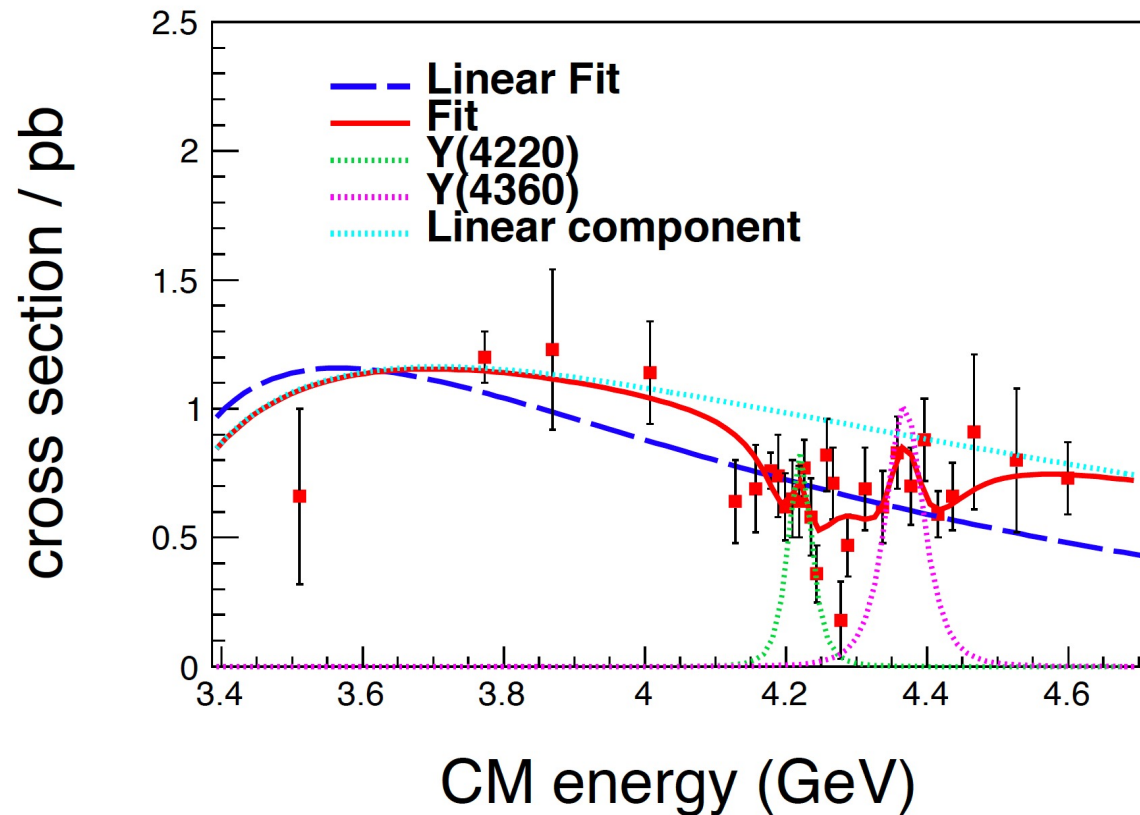
The cross section line shape is consistent with Y(4260)

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



$e^+e^- \rightarrow \gamma\chi_{c(1,2)}$ are observed for the first time (@4.178 GeV, 7.6 and 6.0 σ); One new resonance is needed to describe $e^+e^- \rightarrow \gamma\chi_{c2}$ cross section (6.0 σ), with mass and width consistent with Y(4360); Larger $B(\psi(4160) \rightarrow \gamma\chi_{c2})$ is observed than potential model prediction.

$$e^+e^- \rightarrow \phi\Lambda\bar{\Lambda}$$

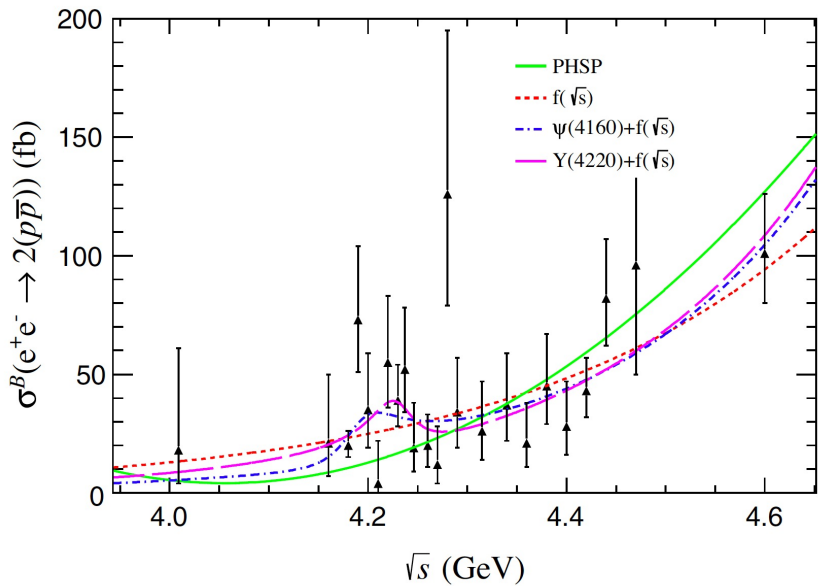


It is clear that the lineshape cannot be simply described with a continuum process parameterized as $1/s^n$ ($n = 2.2 \pm 0.4$). Peaking structures with statistical significances of 4.2σ and 3.1σ are seen around 4.23 and 4.36 GeV, respectively.

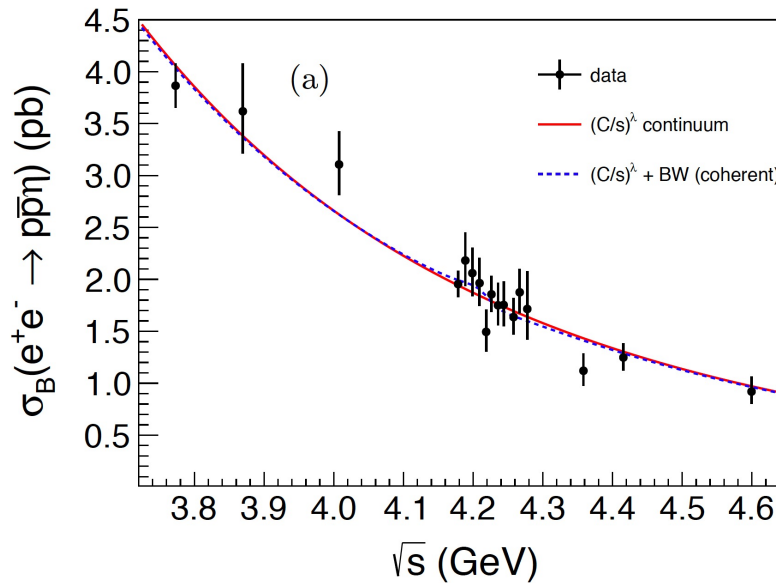
$e^+e^- \rightarrow$ light hadrons

PRD 103, 052003 (2021)

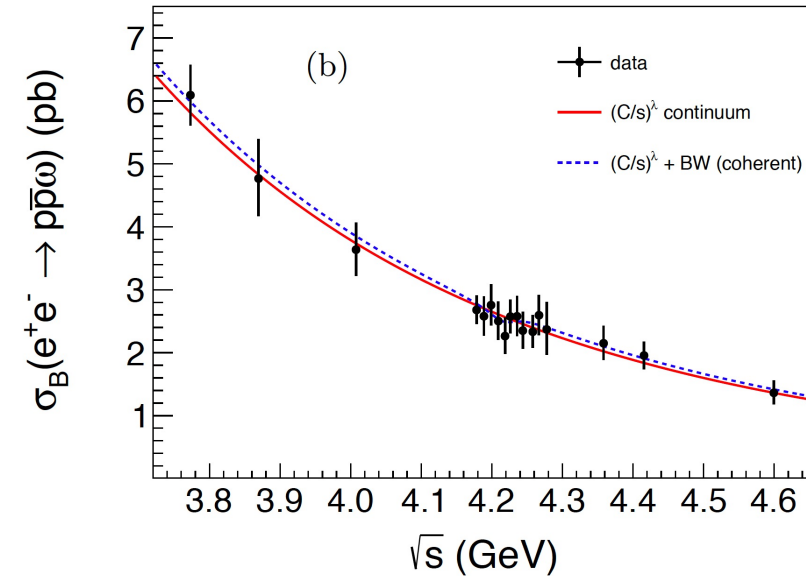
arXiv: 2102.04268



$e^+e^- \rightarrow 2(p\bar{p})$



$e^+e^- \rightarrow \eta(p\bar{p})$

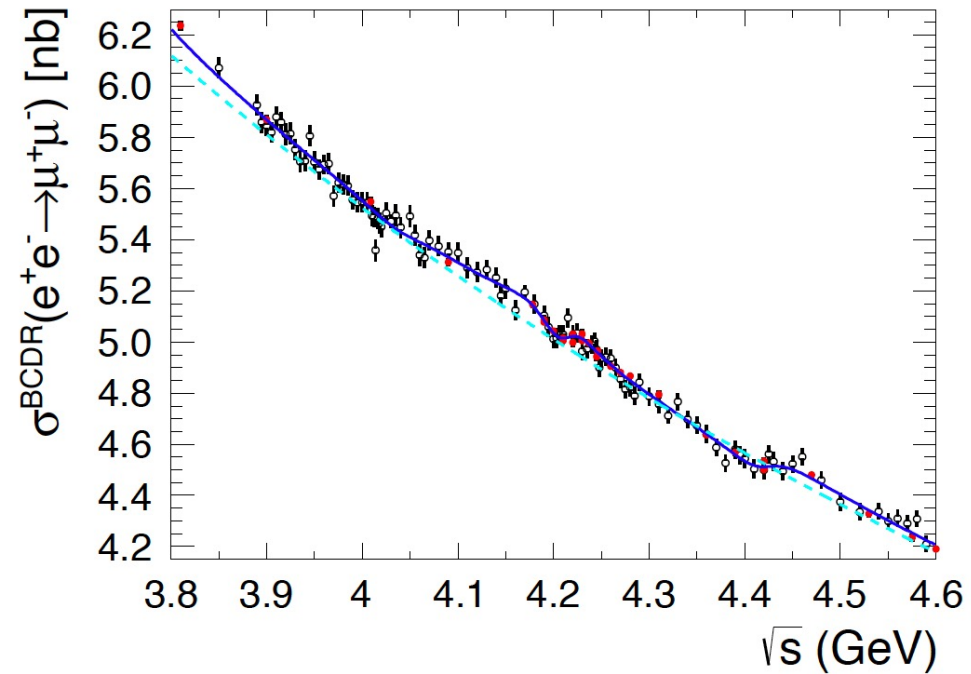
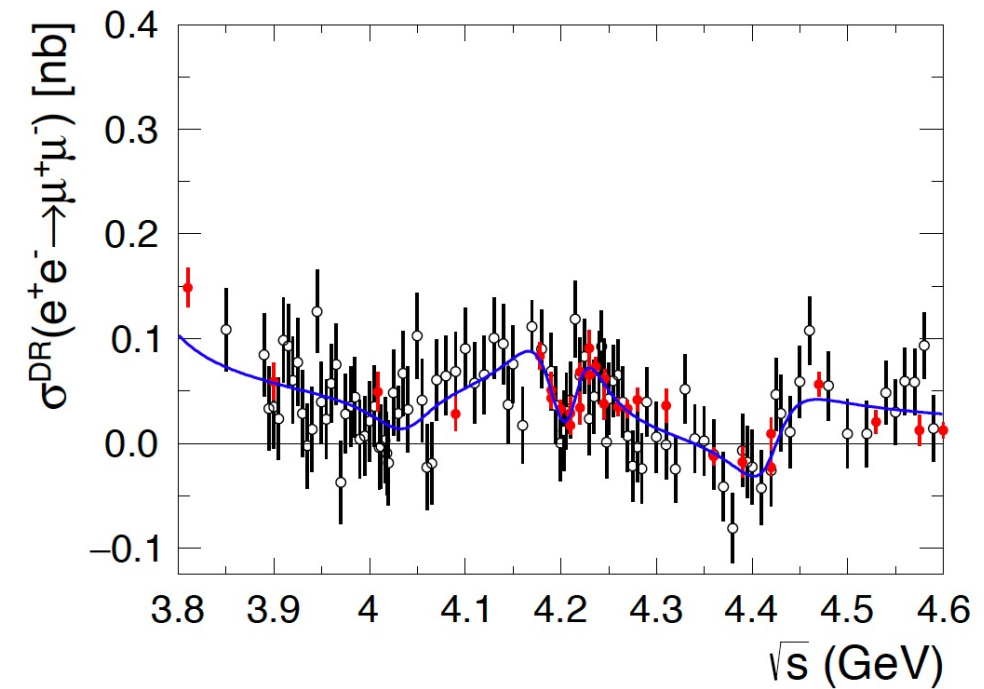


$e^+e^- \rightarrow \omega(p\bar{p})$

No significant Y state is observed

$$e^+e^- \rightarrow \mu^+\mu^-$$

Dressed Cross Section

Subtracting continuum and $\psi(3686)$ 

Structure around 4.22 GeV

Summary

Vector Charmonium-like states are studied/searched at BESIII

- ❖ Light hadron+Charmonium final state
- ❖ Light hadron final state
- ❖ Leptonic final state
- ❖ Open charm final state will come soon

BESIII will run another 10 years!

Thanks very much for your attention!

Upgraded Beijing Electron Positron Collider (BEPCII)



Beam energy:
1-2.5 GeV

Design luminosity:
 $1 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$

Optimum energy:
1.89 GeV

Energy spread:
 5.16×10^{-4}

Bunch length: 1.5 cm

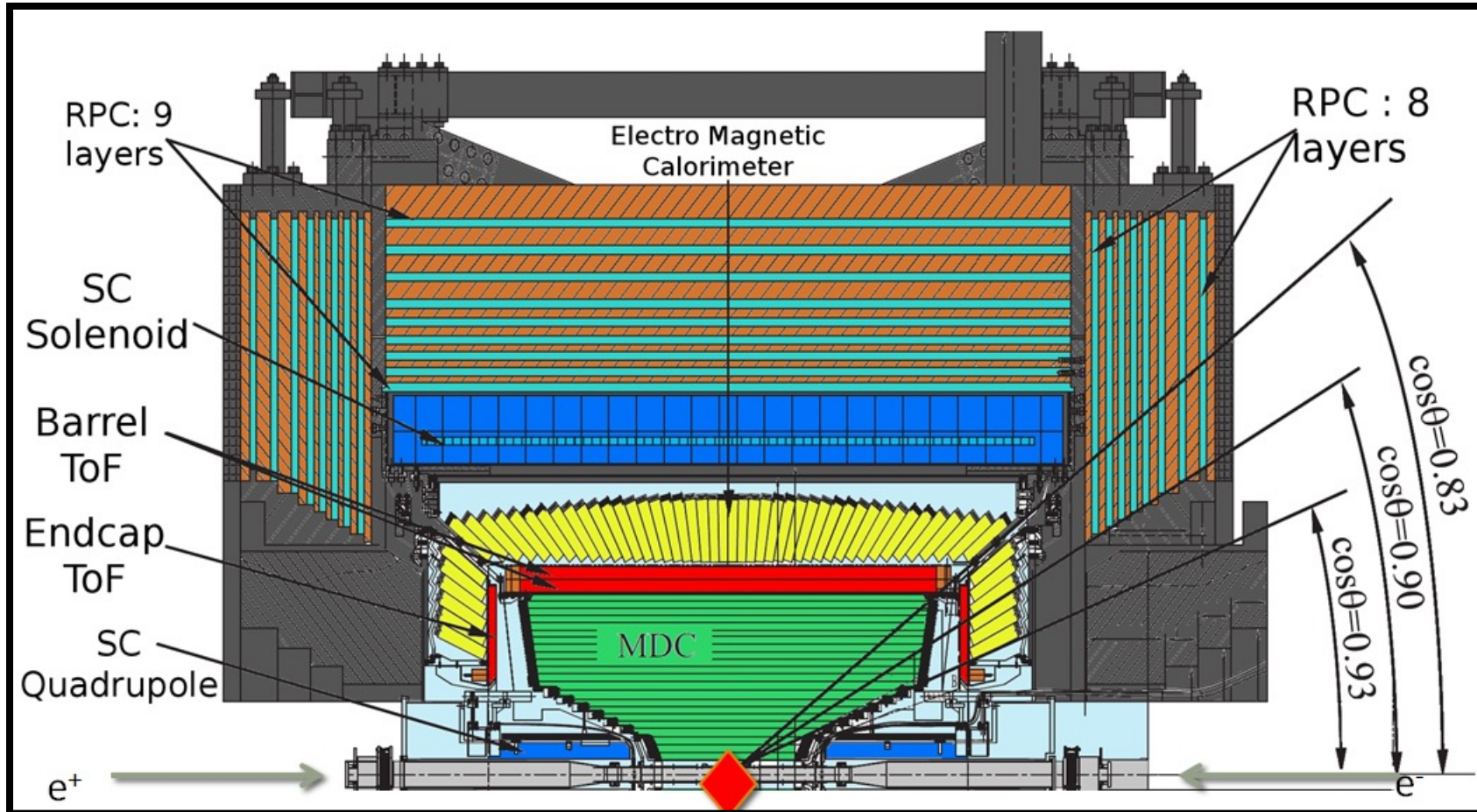
Total current: 0.91 A

Linac: ~200 m

Circular: ~240 m

Double rings with
tiny crossing angle

BESIII detector



Charged-particle momentum resolution@1GeV: 0.5%

Photon energy resolution@1 GeV: 2.5% (5%) for barrel (endcap); position resolution 6mm

dE/dx resolution: 6% for electrons from Bhabha process

Time resolution of TOF: 68 ps (60 ps) for barrel (endcap)

SC magnetic: 1 T

Trigger and DAQ: 4 kHz, with event size 12 Kbytes

>500 Members from 72 institutions in 15 countries!