

# Light flavor vector mesons between 2 and 3 GeV at BESIII

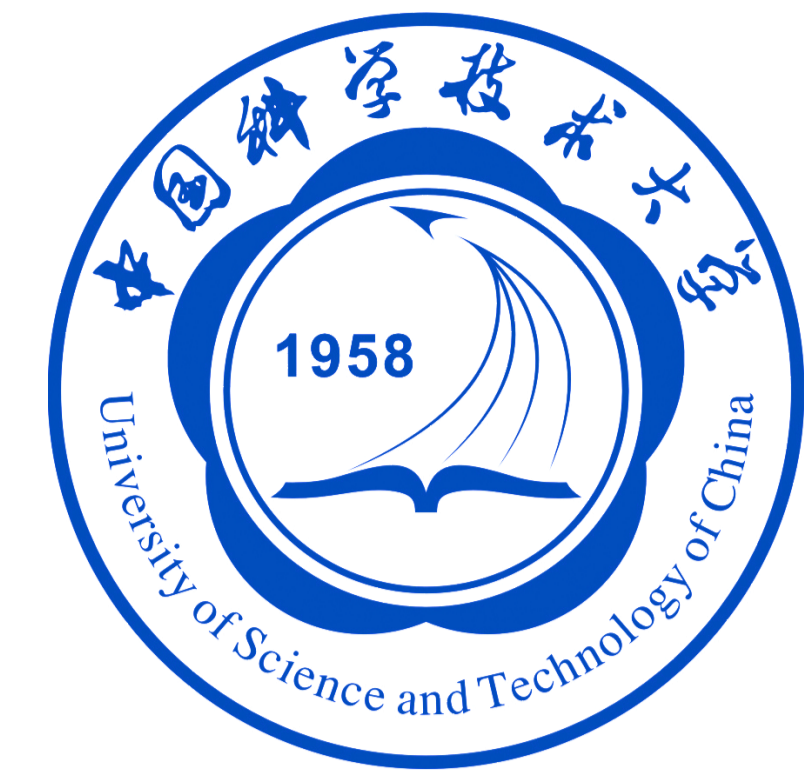
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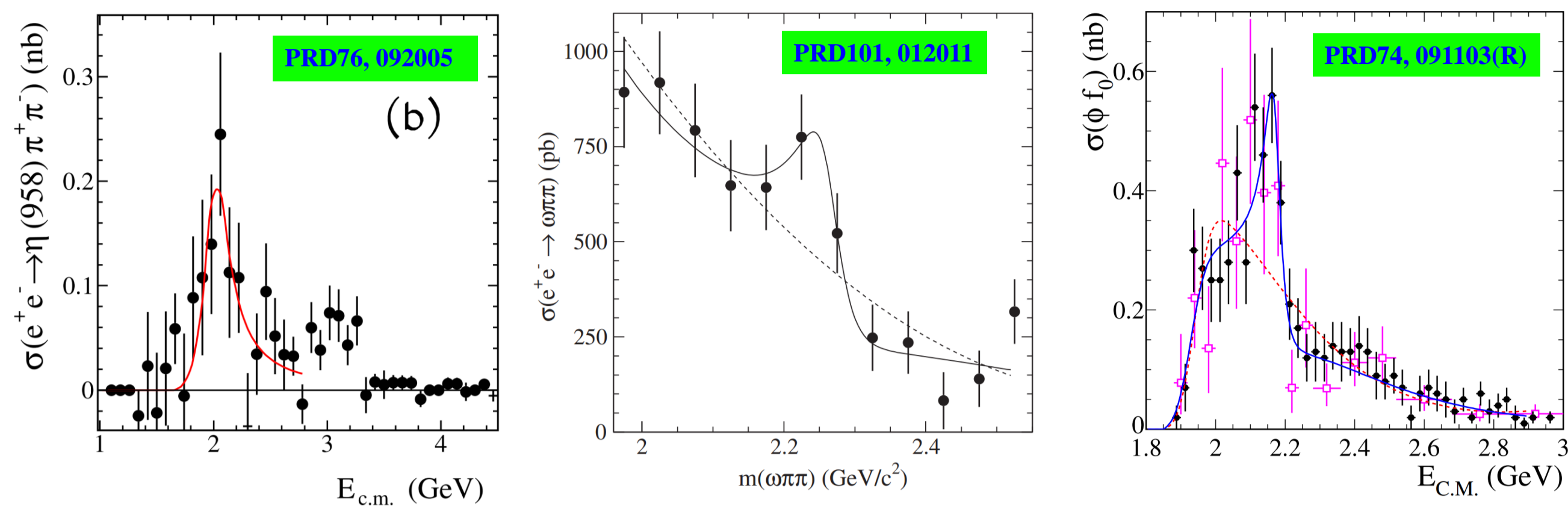
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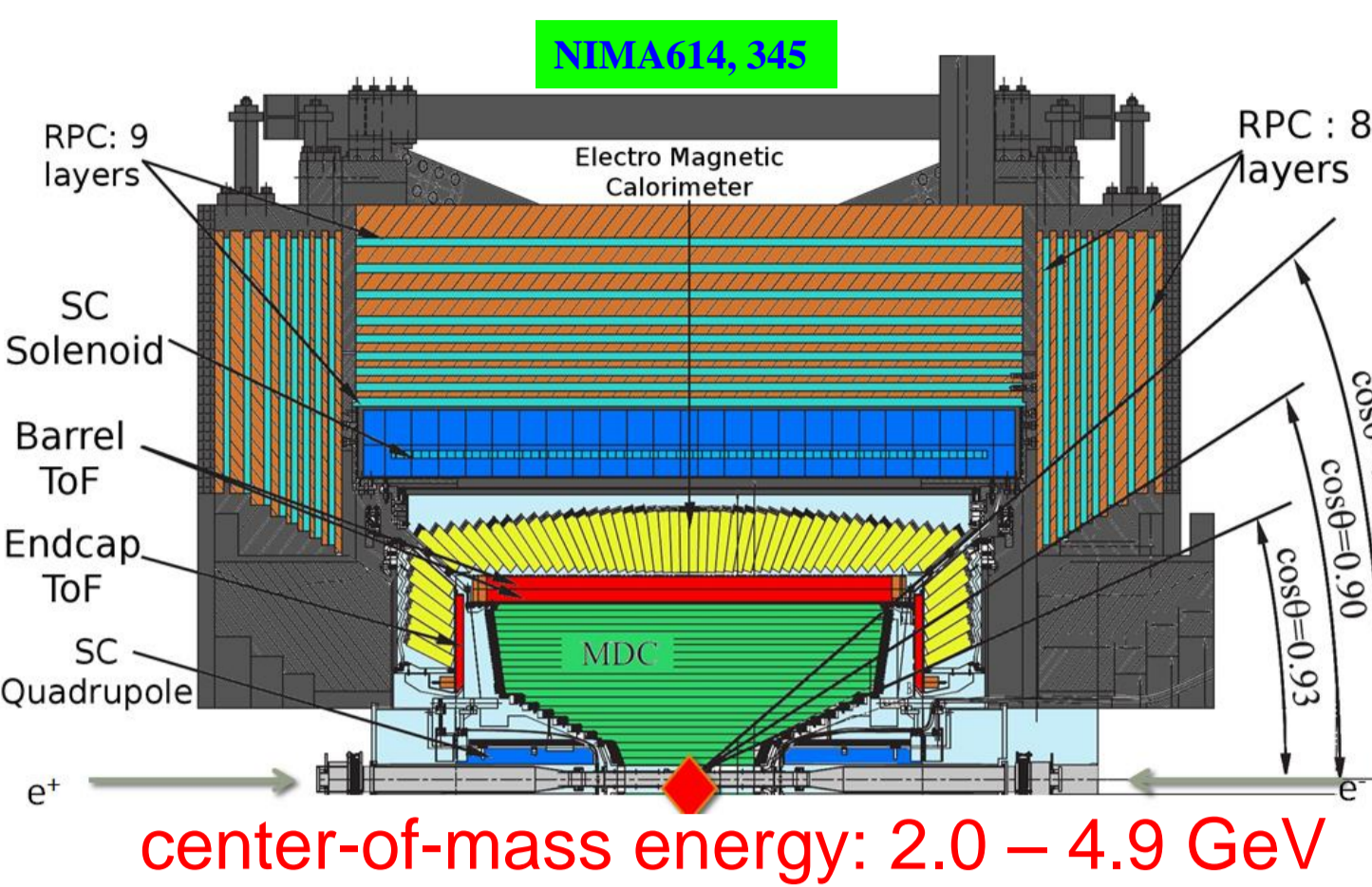
41<sup>st</sup> International Conference on High Energy Physics (ICHEP 2022)  
Bologna, Italy, 6–13 July 2022



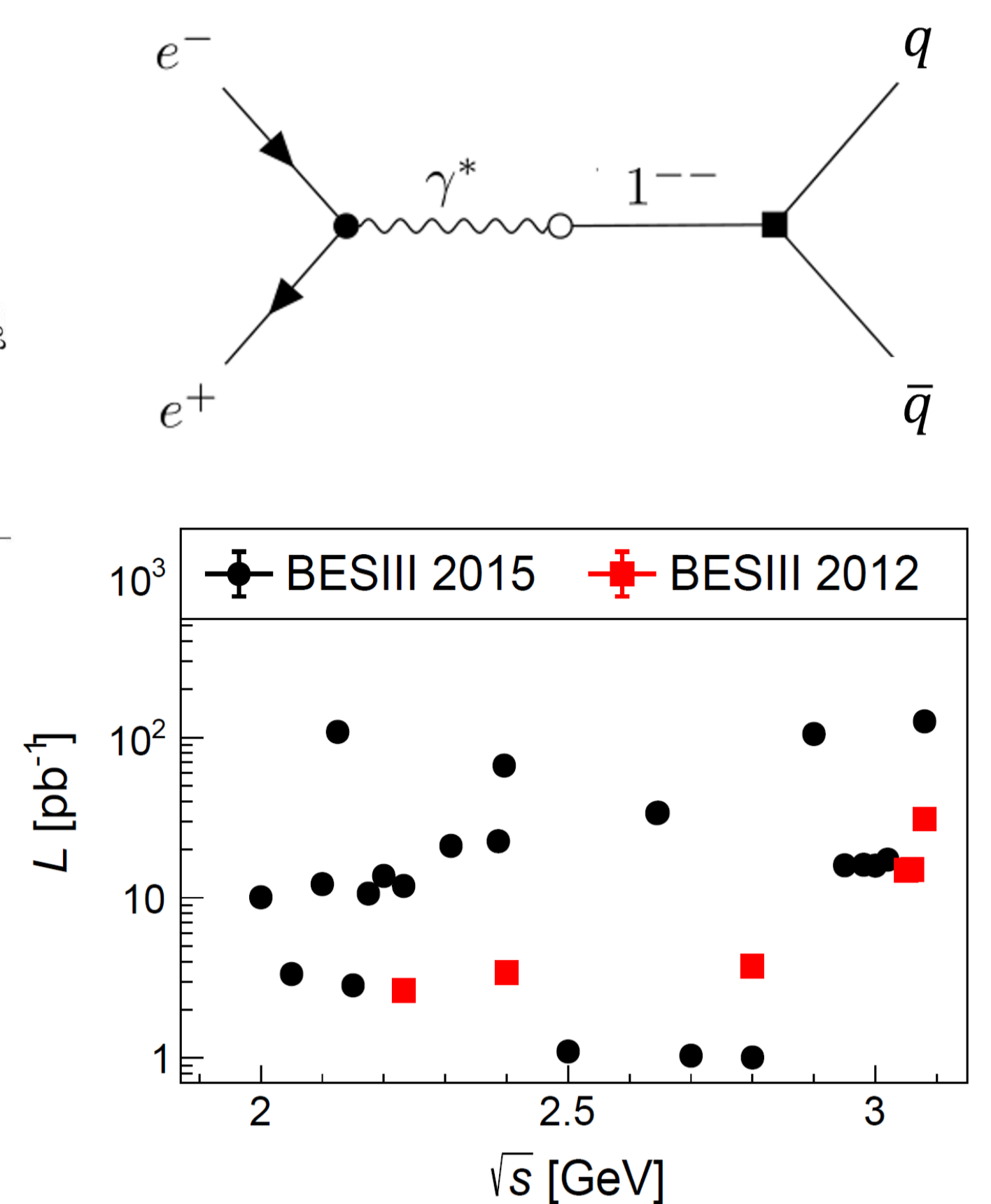
## Introduction:



- Observed light mesons above 2 GeV, e.g.  $\rho^*$ ,  $\omega^*$ ,  $\phi^*$ , poorly known!
- QCD predicts the existence of exotic states which have been widely studied in heavy flavor sector. What about in light flavor vector mesons?
- At BESIII,  $\rho$ ,  $\omega$  and  $\phi$  as well as their excited states are produced copiously

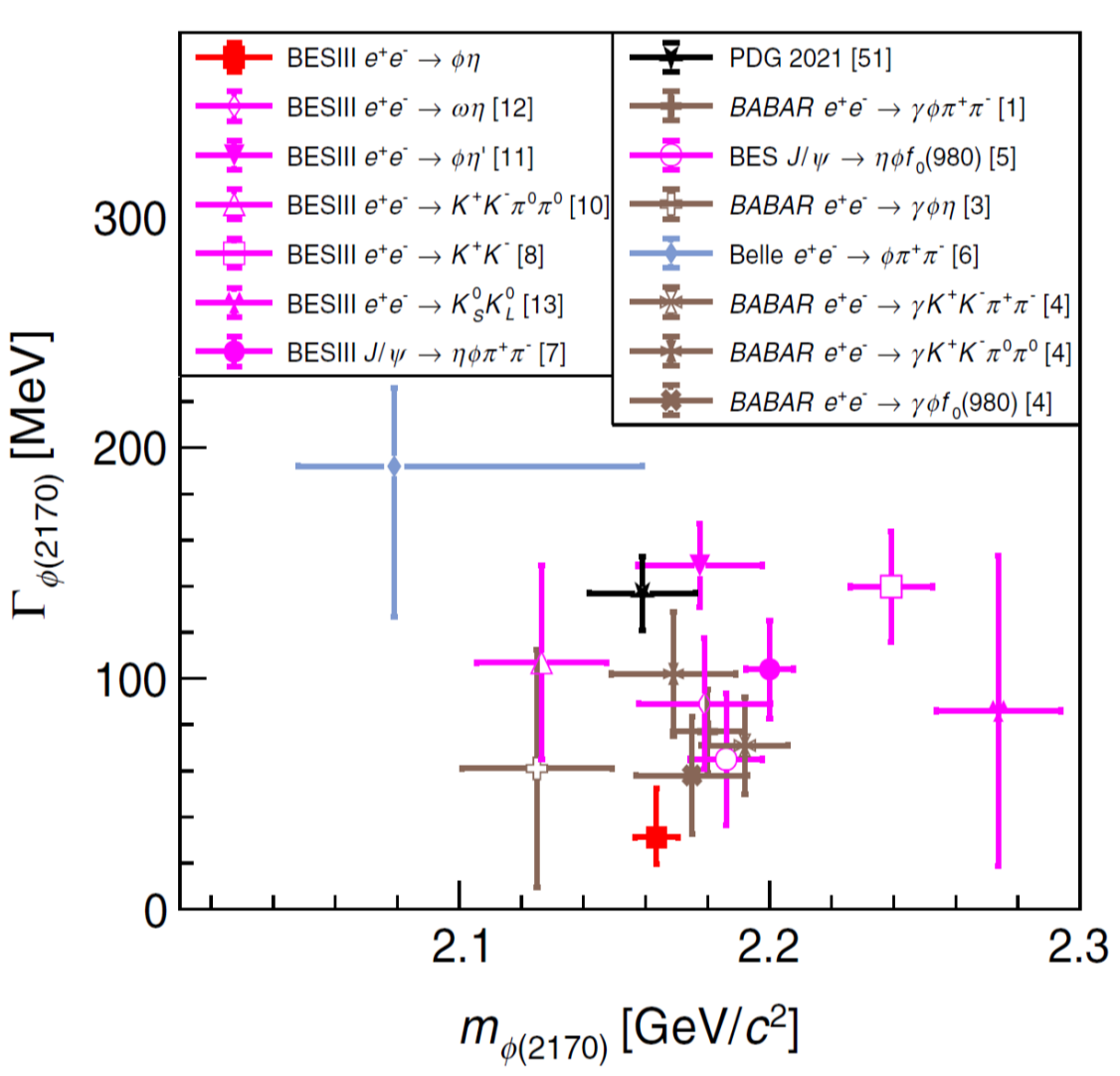


- 650 pb<sup>-1</sup> at  $\sqrt{s}$  between 2.00 and 3.08 GeV
- The excited vector mesons have been investigated extensively by measuring the line-shapes of light hadrons at BESIII



## $\phi(2170)$ :

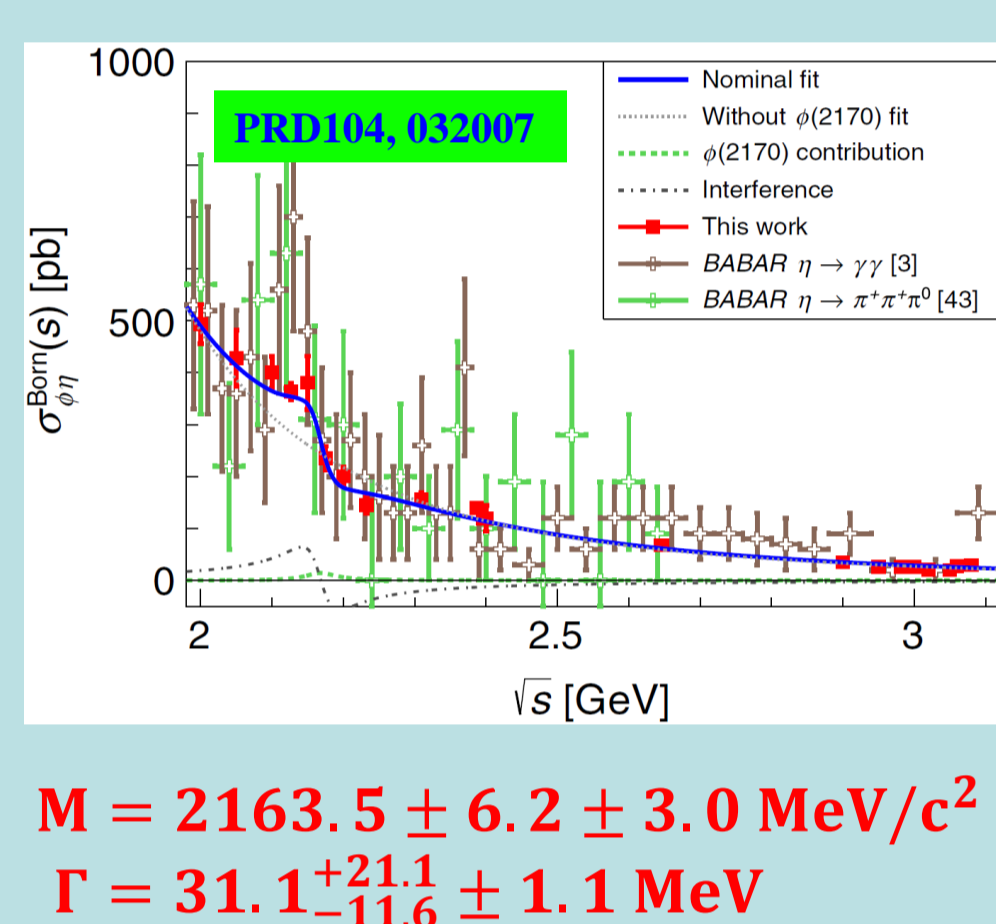
- $\phi(2170)$  as strange analogue of  $Y(4260)$
- $$e^-e^+ \rightarrow \begin{cases} Y(2175) \rightarrow \pi^+\pi^-\phi(1020) & \text{strange} \\ Y(4260) \rightarrow \pi^+\pi^-J/\psi & \text{charm} \\ Y(10860) \rightarrow \pi^+\pi^-Y(1S, 2S) & \text{bottom} \end{cases}$$
- Published experimental results:
  - inconsistence on mass and width
  - limited decay modes



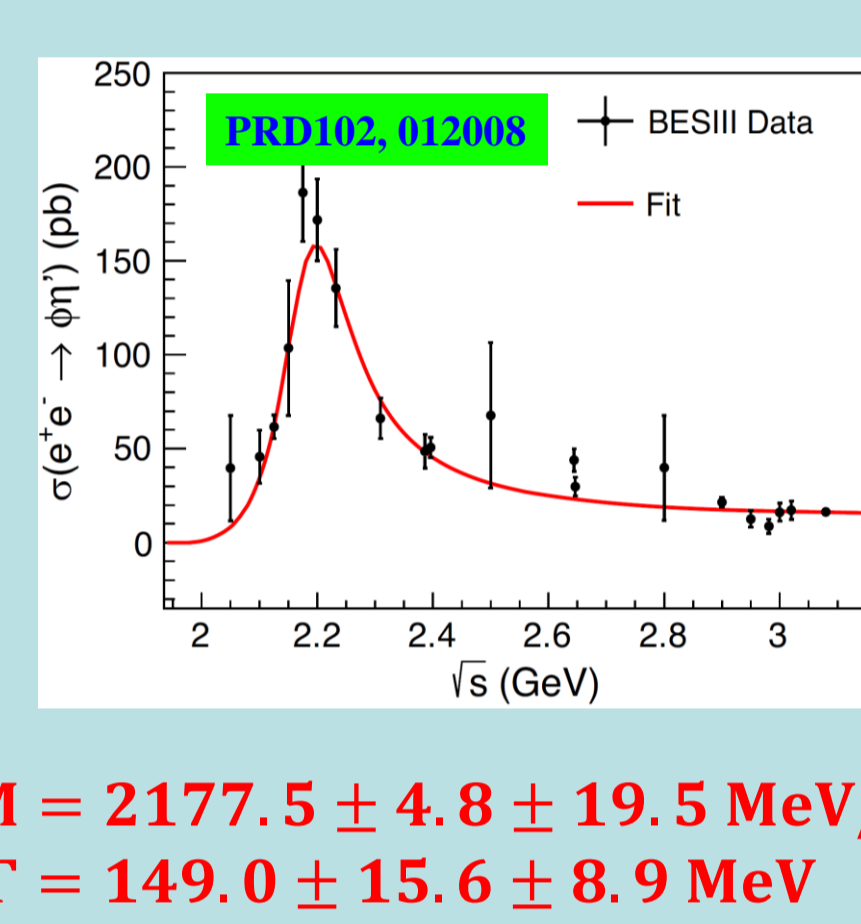
- Controversial theoretical explanations:
  - $s\bar{s}g$  hybrid
  - $2^3D_1$  or  $3^3S_1 s\bar{s}$
  - tetraquark
  - molecular state  $\Lambda\bar{\Lambda}$
  - three body system  $\phi KK$
  - $\phi f_0(980)$  resonance with FSI

**Not fully understood!**  
The study of more decay modes are necessary!

## Experimental studies at BESIII:



$M = 2163.5 \pm 6.2 \pm 3.0 \text{ MeV}/c^2$   
 $\Gamma = 31.1^{+21.1}_{-11.6} \pm 1.1 \text{ MeV}$



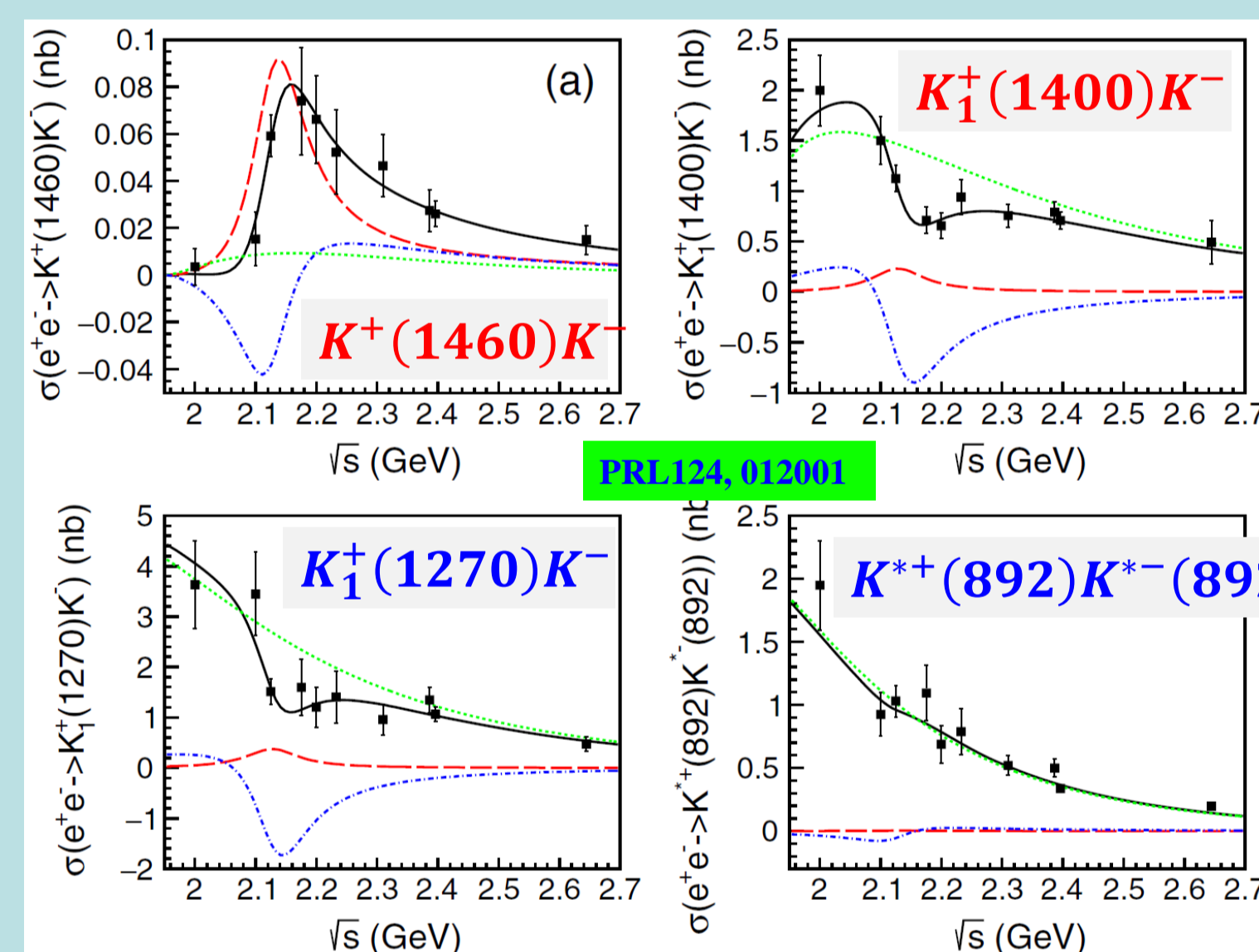
$M = 2177.5 \pm 4.8 \pm 19.5 \text{ MeV}/c^2$   
 $\Gamma = 149.0 \pm 15.6 \pm 8.9 \text{ MeV}$

### $e^+e^- \rightarrow \phi\eta$ and $\phi\eta'$

$$\frac{B_{\phi\eta} \Gamma_{\phi(2170)} \Gamma_{\phi(2170)}^{e^+e^-}}{B_{\phi\eta'} \Gamma_{\phi(2170)} \Gamma_{\phi(2170)}^{e^+e^-}} = 0.03^{+0.02}_{-0.01}$$

Disfavors the  $s\bar{s}g$  interpretation.  
[PRD59, 034016; PLB650, 390]

### $e^+e^- \rightarrow K^+K^-\pi^0\pi^0$ and $K^+K^-\pi^0$



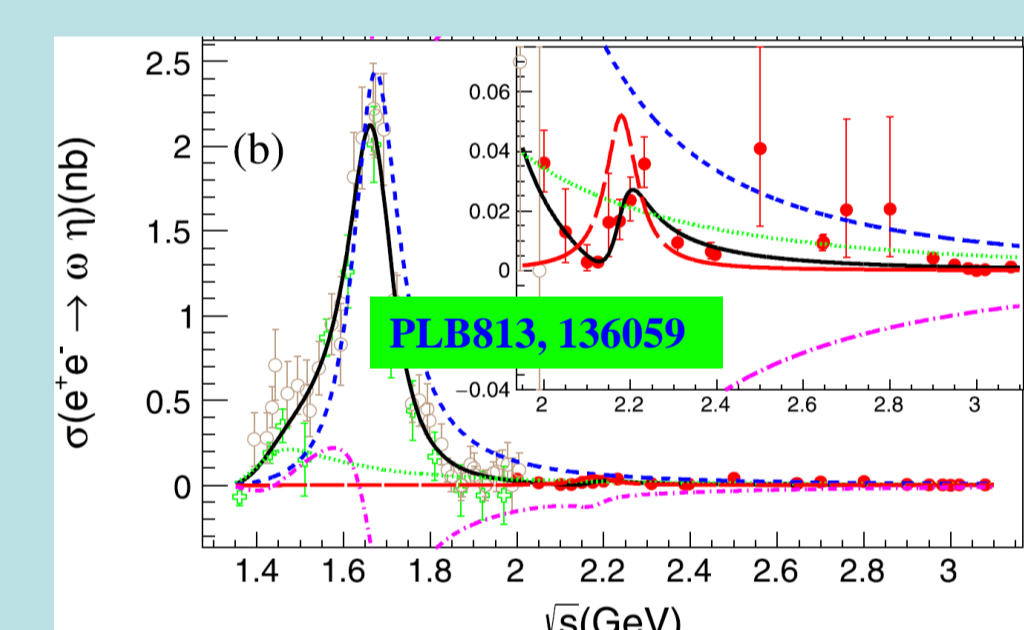
no significant  $e^+e^- \rightarrow KK^*(1410)$   
 $\phi(2170) \rightarrow K^+(1460)K^-$   
 $\phi(2170) \rightarrow K_1^+(1400)K^-$   
 $\phi(2170) \rightarrow K_1^+(1270)K^-$   
 $\phi(2170) \rightarrow K^{*+}(892)K^{*-}(892)$

$M = 2126.5 \pm 16.8 \pm 12.4 \text{ MeV}/c^2$   
 $\Gamma = 106.9 \pm 32.1 \pm 28.1 \text{ MeV}$

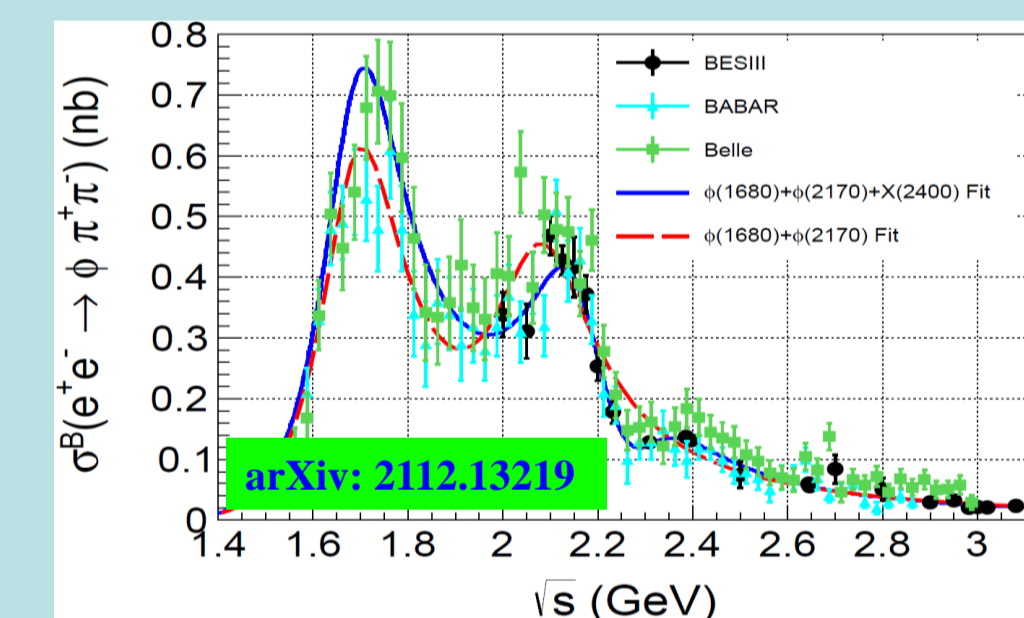
$\phi(2170) \rightarrow K^{*+}(892)K^-$   
 $\phi(2170) \rightarrow K_2^{*+}(1430)K^-$   
 $Br(\phi \rightarrow K^{*+}(1430)K^-) = 7.5 \pm 2.9$   
 $Br(\phi \rightarrow K^{*+}(892)K^-) = 21.9 \pm 4.2$

$M = 2208 \pm 19 \pm 24 \text{ MeV}/c^2$   
 $\Gamma = 168 \pm 24 \pm 39 \text{ MeV}$

### $e^+e^- \rightarrow \omega\eta$ and $\phi\pi^+\pi^-$

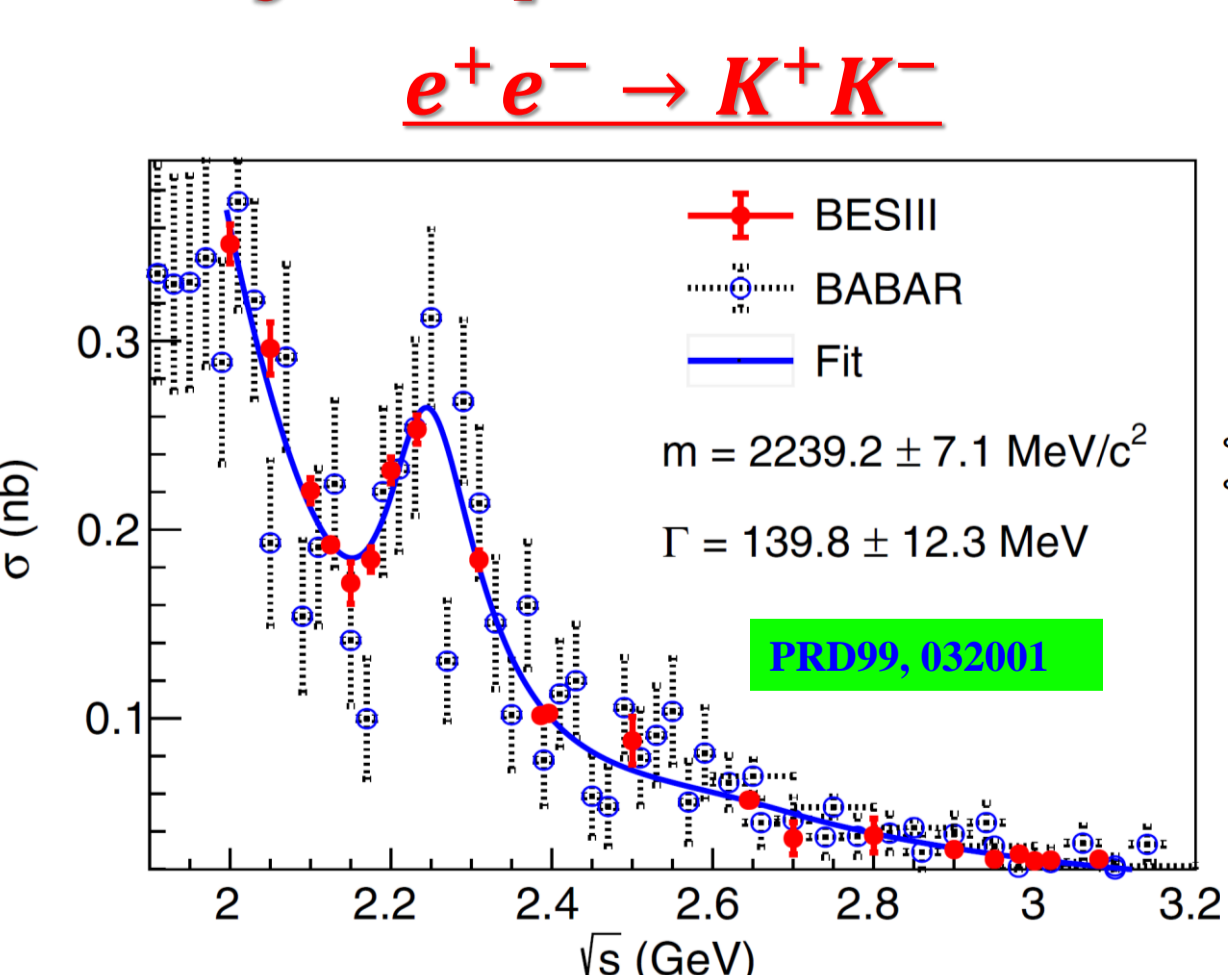


$M = 2176 \pm 24 \pm 3 \text{ MeV}/c^2$   
 $\Gamma = 89 \pm 50 \pm 5 \text{ MeV}$



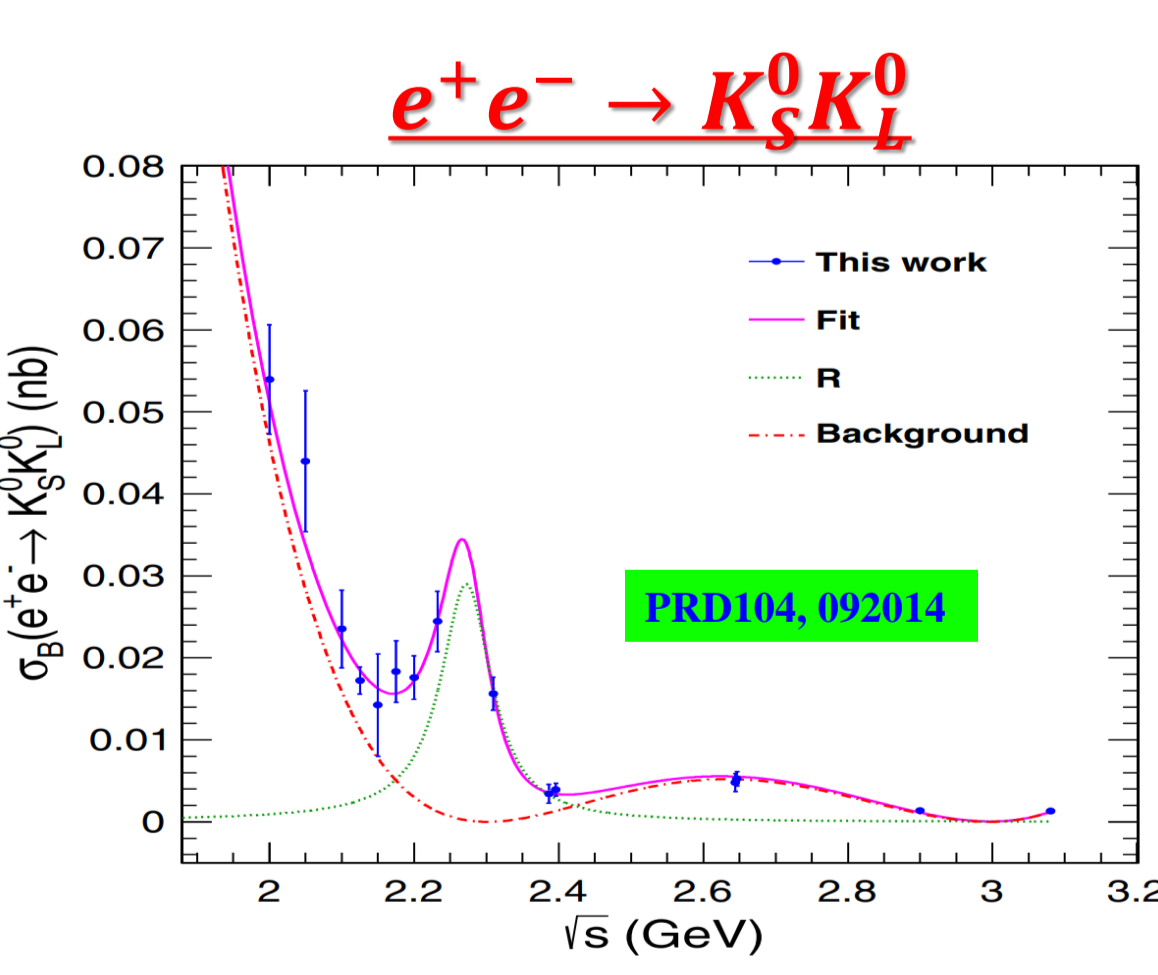
$M = 2158^{+30}_{-33} \pm 4 \text{ MeV}/c^2$   
 $\Gamma = 218^{+81}_{-64} \pm 5 \text{ MeV}$

## Study of $\rho^*$ and $\omega^*$ at BESIII:



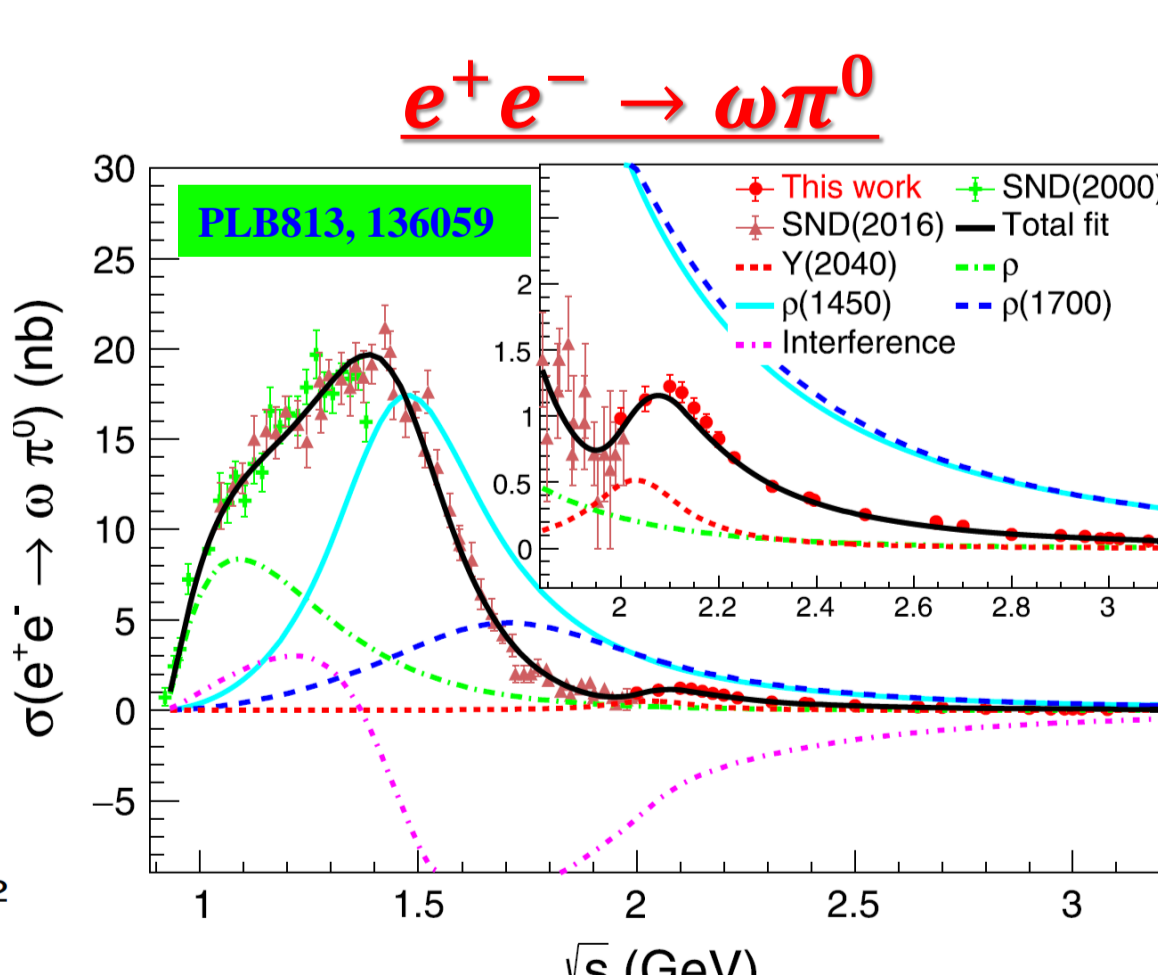
$M = 2239.2 \pm 7.1 \pm 11.3 \text{ MeV}/c^2$   
 $\Gamma = 139.8 \pm 12.3 \pm 20.6 \text{ MeV}$

$\rho(2150)$  or  $\phi(2170)$ ?



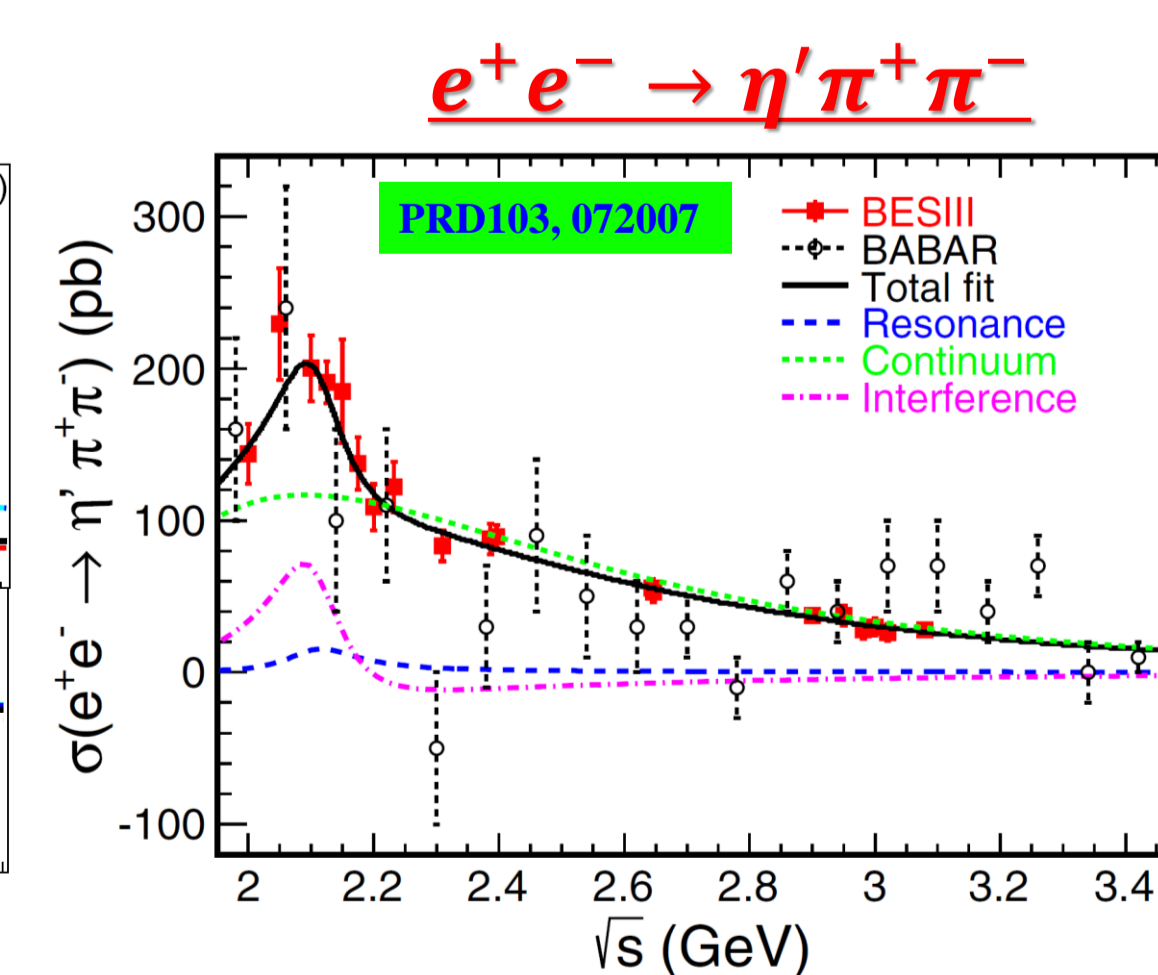
$M = 2273.7 \pm 5.7 \pm 19.3 \text{ MeV}/c^2$   
 $\Gamma = 86 \pm 44 \pm 51 \text{ MeV}$

$\rho(2150)$  or  $\phi(2170)$ ?



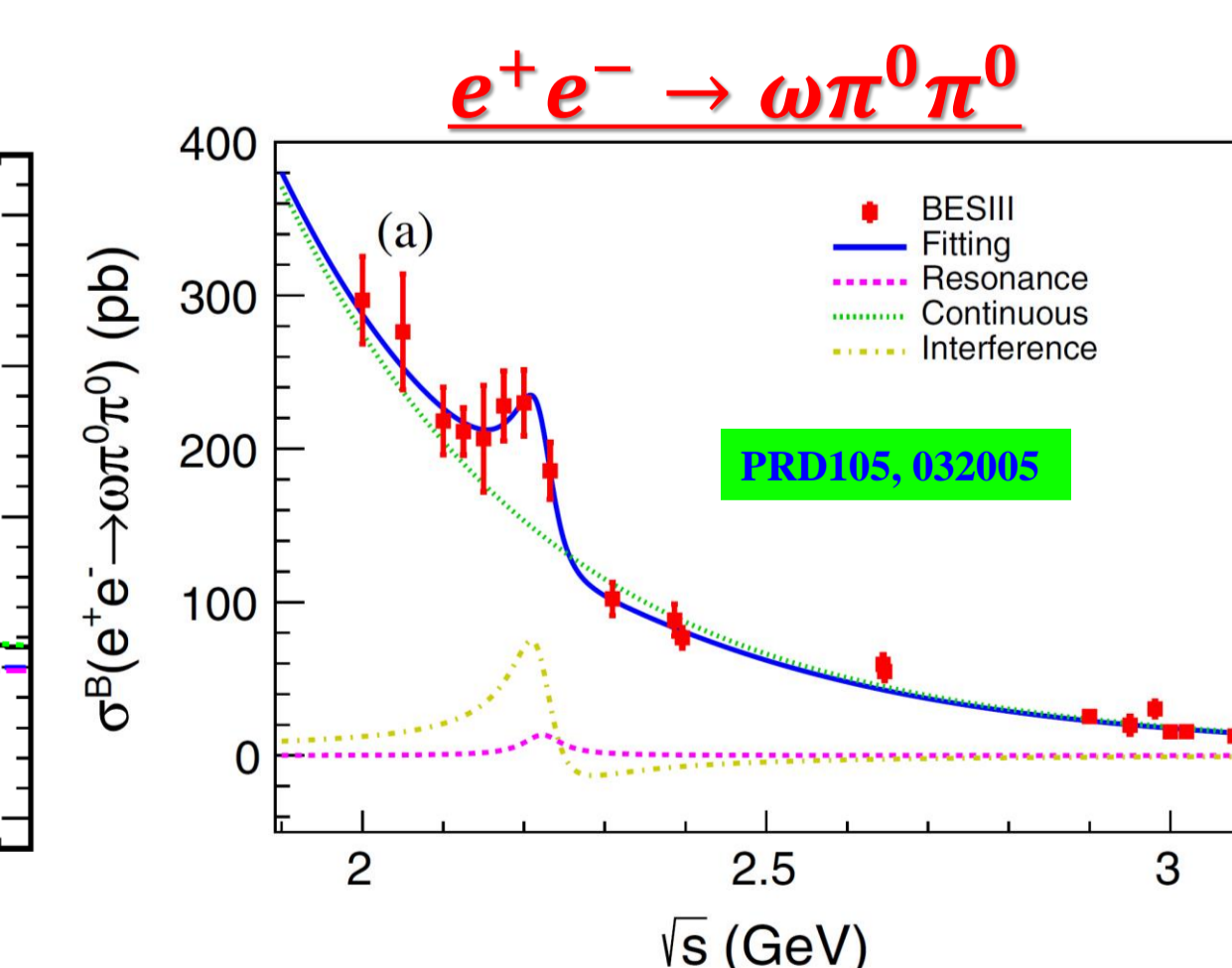
$M = 2034 \pm 13 \pm 9 \text{ MeV}/c^2$   
 $\Gamma = 234 \pm 30 \pm 25 \text{ MeV}$

$\rho(2150)$  or  $\rho(2000)$ ?



$M = 2111 \pm 43 \pm 25 \text{ MeV}/c^2$   
 $\Gamma = 135 \pm 34 \pm 30 \text{ MeV}$

$\rho(2150)$ ?

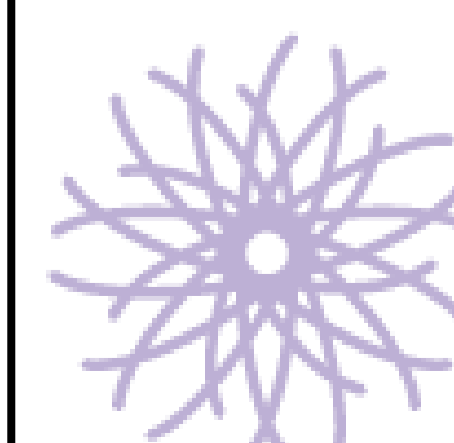


$M = 2222 \pm 7 \pm 2 \text{ MeV}/c^2$   
 $\Gamma = 59 \pm 30 \pm 6 \text{ MeV}$

$\omega(2205)$ ,  $\omega(2290)$  or  $\omega(2330)$ ?

## summary and outlook:

- Experimental studies at BESIII provide important inputs for understanding the properties of light flavor vector states between 2 to 3 GeV
- The nature of  $\rho^*$ ,  $\omega^*$ ,  $\phi^*$  call for further studies, like couple-channel analysis or partial wave analysis
- In the future, larger data samples taken by BESIII and Belle II will provide good opportunity to study these states as well as search for the unobserved  $\rho^*$ ,  $\omega^*$ ,  $\phi^*$  states



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