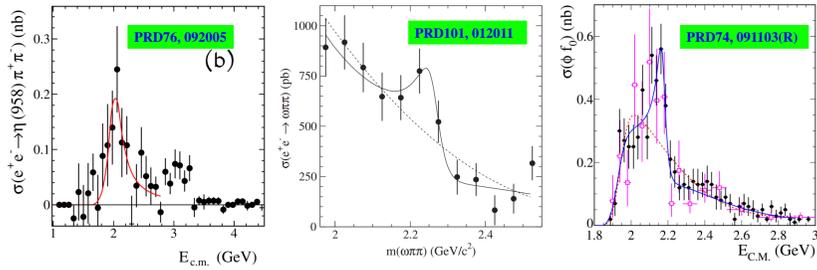
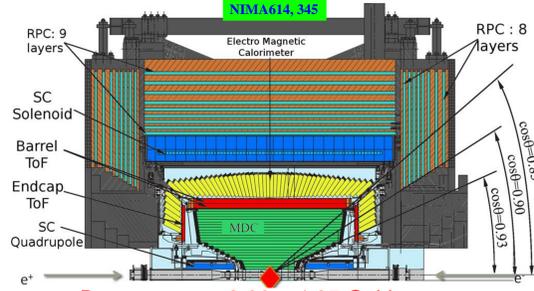
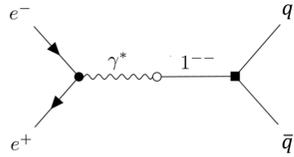


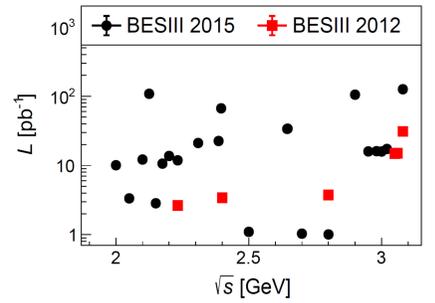
Introduction



- The properties of light mesons above 2 GeV, e.g. ρ^* , ω^* , ϕ^* , are ambiguous.
- $\sqrt{s} \in [2.0, 3.0]$ GeV:
 - ρ^* : $\rho(2000)$, $\rho(2150)$, $\rho(2270)$
 - ω^* : $\omega(2205)$, $\omega(2290)$, $\omega(2330)$
 - ϕ^* : $\phi(2170)$



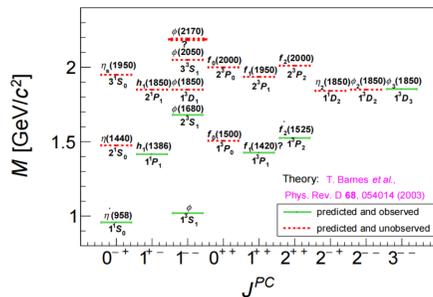
Beam energy: 2.00 – 4.95 GeV
Luminosity: $1 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$ at 3.773 GeV



- 650 pb^{-1} at \sqrt{s} between 2.00 and 3.08 GeV
- At BESIII ρ , ω and ϕ as well as their excited states are produced copiously
- The excited vector mesons have been investigated extensively by measuring the line-shapes of light hadrons at BESIII

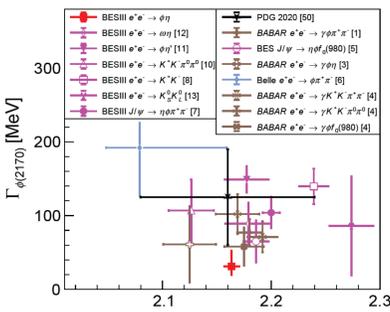
$\phi(2170)$

- Compared with $c\bar{c}$ and $b\bar{b}$, $s\bar{s}$ is poorly known.



- $\phi(2170)$ as strange analogue of $Y(4260)$
 - $e^-e^+ \rightarrow \begin{cases} Y(2175) \rightarrow \pi^+\pi^-\phi(1020) & \text{strange} \\ Y(4260) \rightarrow \pi^+\pi^-\psi & \text{charm} \\ Y(10860) \rightarrow \pi^+\pi^-\Upsilon(1S, 2S) & \text{bottom} \end{cases}$

- Published experimental results:

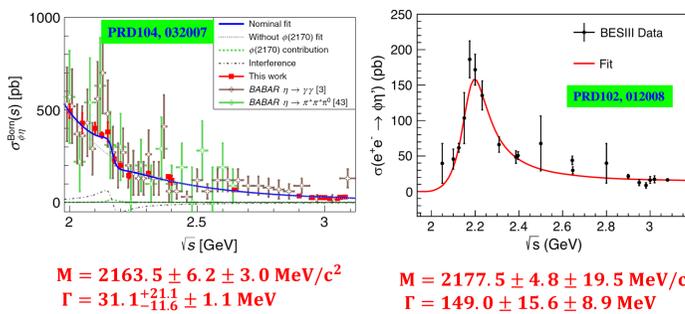


- Controversial theoretical explanations:
 - $s\bar{s}g$ hybrid
 - 2^3D_1 or $3^3S_1 s\bar{s}$
 - tetraquark
 - molecular state $\Lambda\bar{\Lambda}$
 - three body system ϕKK
 - $\phi f_0(980)$ resonance with FSI

Still not fully understood!

More studies needed, some ongoing at BESIII.

Experimental results at BESIII:

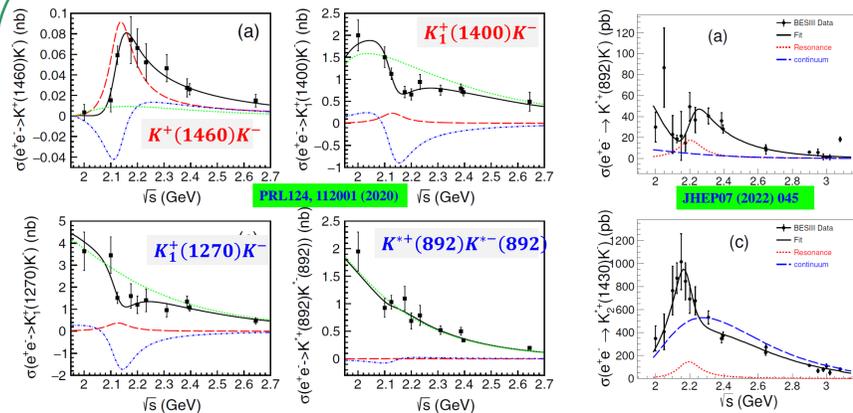


$e^+e^- \rightarrow \phi\eta$ and $\phi\eta'$

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

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

$e^+e^- \rightarrow K^+K^-\pi^0\pi^0$ and $K^+K^-\pi^0$ (Partial Wave Analysis)



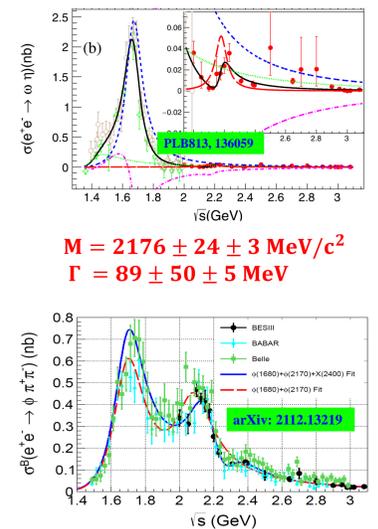
No significant $e^+e^- \rightarrow KK^*(1410)$
 $\phi(2170) \rightarrow K^+(1460)K^-$
 $\phi(2170) \rightarrow K_1^+(1400)K^-$
 $\phi(2170) \rightarrow K_1^+(1270)K^-$
 $\phi(2170) \rightarrow K^{*+}(892)K^{*-}(892)$

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

$\phi(2170) \rightarrow K^{*+}(892)K^-$
 $\phi(2170) \rightarrow K_2^{*+}(1430)K^-$
 $\mathcal{B}r(\phi \rightarrow K_2^{*+}(1430)K^-) = 12.6 \pm 4.5$
 $\mathcal{B}r(\phi \rightarrow K^{*+}(892)K^-) = (22.7 \pm 4.1)$

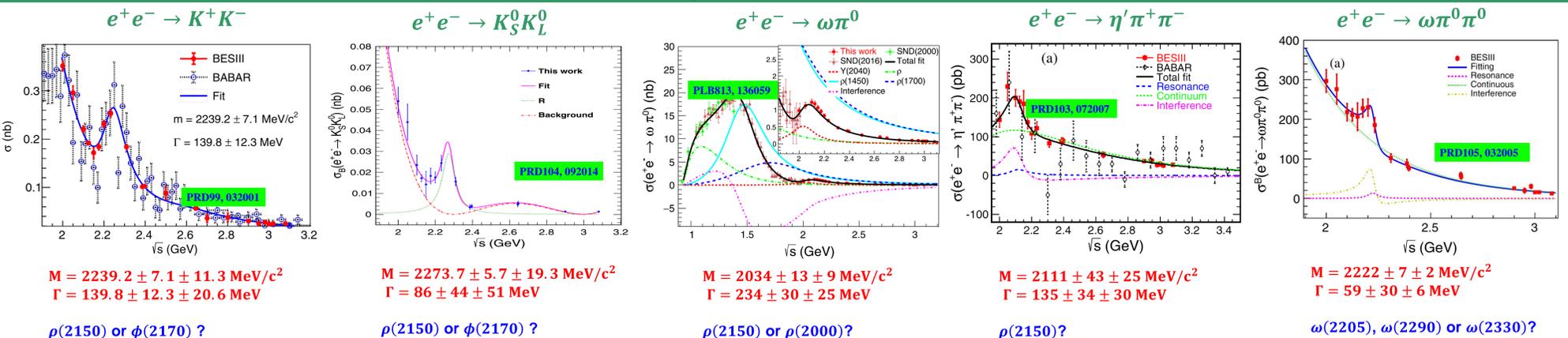
$M = 2190 \pm 19 \pm 37 \text{ MeV}/c^2$
 $\Gamma = 191 \pm 28 \pm 60 \text{ MeV}$

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



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

ρ^* and ω^*



$M = 2239.2 \pm 7.1 \pm 11.3 \text{ MeV}/c^2$
 $\Gamma = 139.8 \pm 12.3 \pm 20.6 \text{ MeV}$
 $\rho(2150)$ 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 $\omega(2330)$?

Insufficient experimental information, more studies are ongoing at BESIII.

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 ρ^* , ω^* , ϕ^* call for further studies, like couple-channel analysis or partial wave analysis.