Light flavor vector mesons between 2 and 3 GeV at BESIII

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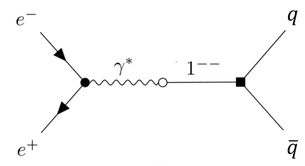
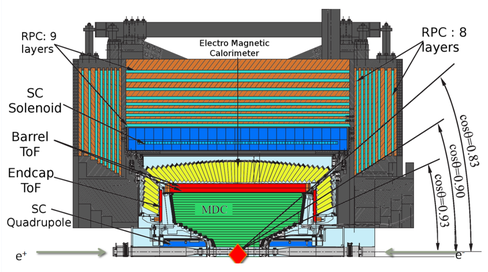
Introduction

- Observed light mesons above 2 GeV, e.g. ρ^*, ω^*, ϕ^*, poorly known
- $\sqrt{s} \in [2.0, 3.0]$ GeV: possible ρ^*, ω^*, ϕ^*
  - ρ^* states: $\rho(2000)$, $\rho(2150)$, $\rho(2270)$
  - ω^* states: $\omega(2205)$, $\omega(2290)$, $\omega(2330)$
  - ϕ^* states: $\phi(2170)$



- At BESIII, ρ, ω, 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

BeiJing Spectrometer III (BESIII) at BEPCII



MDC **M**ain **D**rift **C**hamber

TOF **T**ime **o**f **F**light

EMC **E**lectro**M**agnetic **C**alorimeter

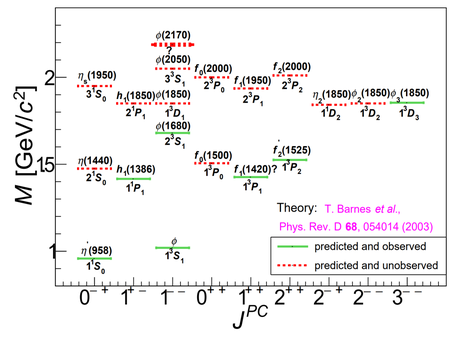
SC **S**uper**C**onducting Magnet

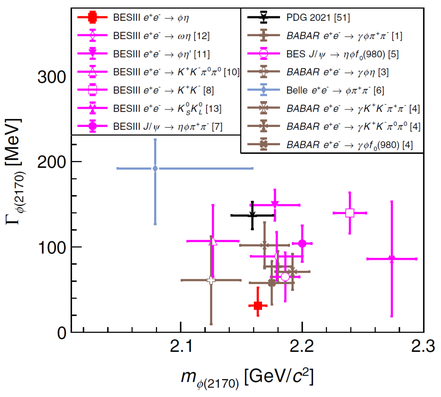
RPC Muon Counter: **R**esistive **P**late **C**hambers

650 pb^{-1} in 2.00 - 3.08 GeV collected in 2015

$\phi(2170)$

- $s\bar{s}$ analogue of $c\bar{c}$ and $b\bar{b}$, poorly known;
- $\phi(2170)$ as strange analogue of $Y(4260)$?
  1. $Y(2175) \to \pi^+\pi^-\phi(1020)$, strange
  2. $Y(4260) \to \pi^+\pi^- J/\Psi$, charm
  3. $\Upsilon(10860) \to \pi^+\pi^-\Upsilon(1S, 2S)$, bottom
- Published experimental results
  - inconsistency 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 $\Lambda\bar{\Lambda}$
  - $\phi f_0(980)$ resonance with FSI
  - three body system ϕKK

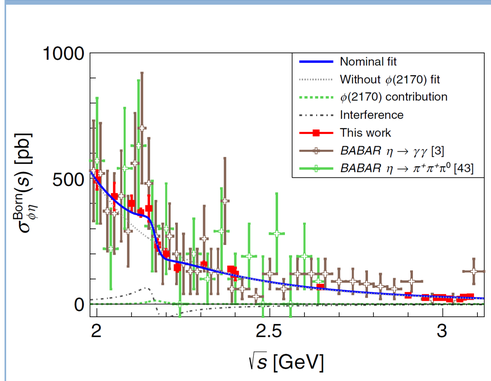




Study of $\phi(2170)$ at BESIII

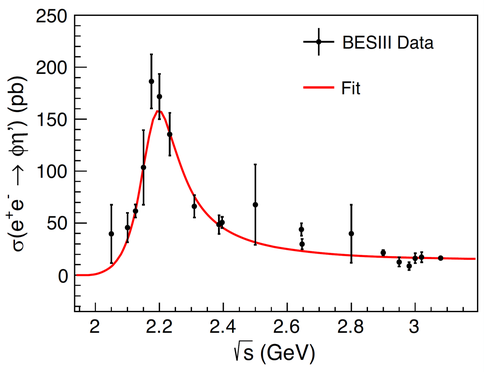
$e^+e^- \to \phi\eta$ and $\phi\eta'$

PRD 104, 032007 (2021); PRD 102, 012008 (2020)



$M = 2163.5 \pm 6.2 \pm 3.0$ MeV/c^2

$\Gamma = 31.1^{+21.1}_{-11.6} \pm 1.1$ MeV

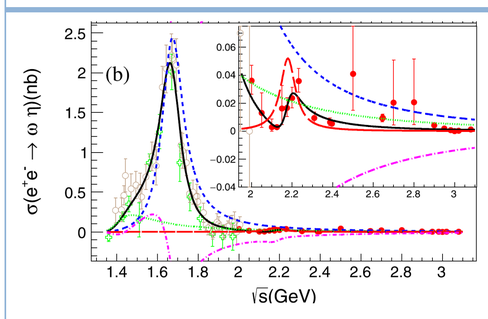


$M = 2177.5 \pm 4.8 \pm 19.5$ MeV/c^2

$\Gamma = 149.0 \pm 15.6 \pm 8.9$ MeV

$e^+e^- \to \omega\eta$

PLB 813, 136059 (2021)

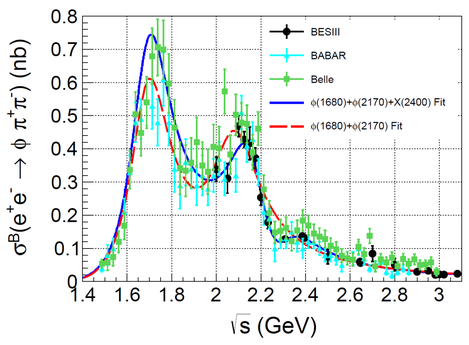


$M = 2176 \pm 24 \pm 3$ MeV/c^2

$\Gamma = 89 \pm 50 \pm 5$ MeV

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

arxiv:2112.13219

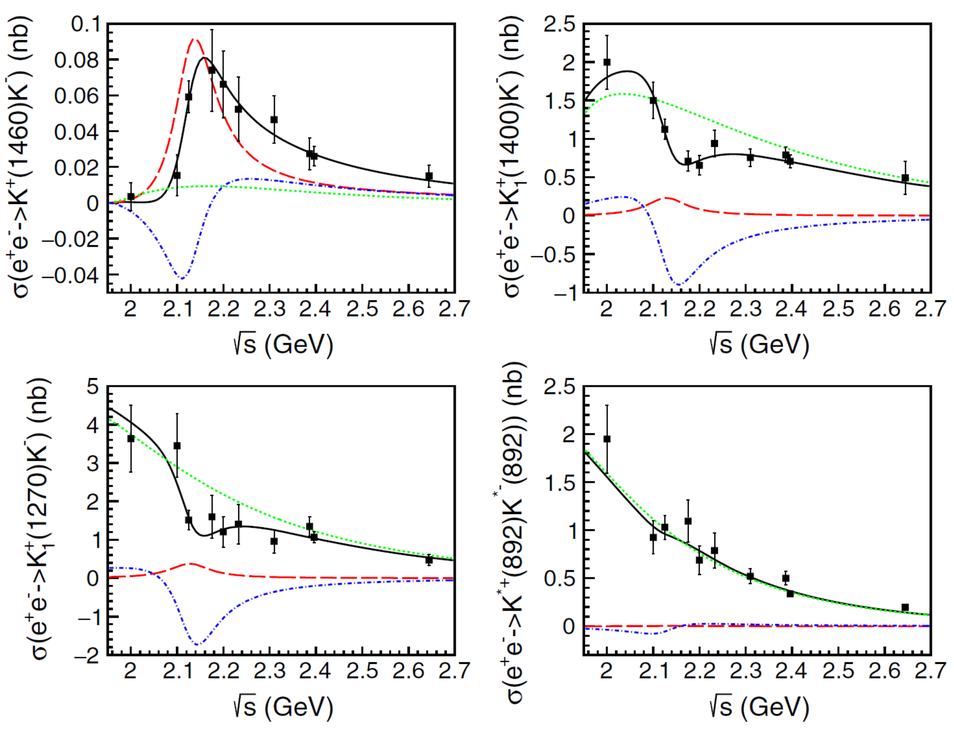


$M = 2158^{+30}_{-33} \pm 4$ MeV/c^2

$\Gamma = 218^{+81}_{-64} \pm 5$ MeV

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

PRL 124, 112001 (2020)



Partial Wave Analysis is performed to extract the intermediate subprocess

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

$\phi(2170) \to K^+(1460)K^-$: 4.8σ, unfavor $s\bar{s}g$, favor 2^3D_1

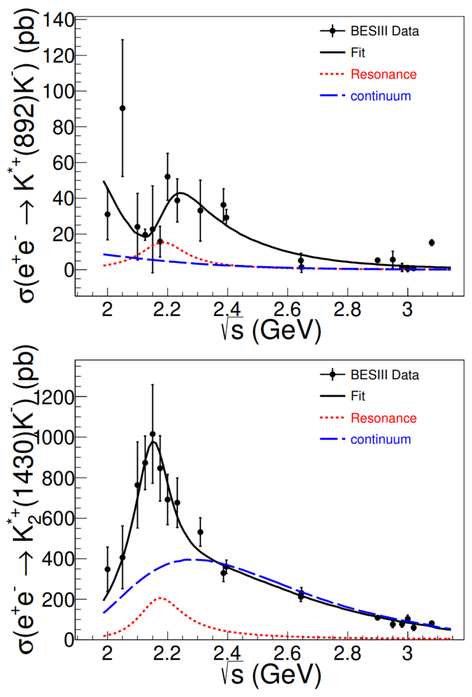
$\phi(2170) \to K_1^+(1400)K^-$: 4.5σ, favor $s\bar{s}g$

$\phi(2170) \to K_1^+(1270)K^-$ or $K^{*+}(892)K^{*-}(892) < 2\sigma$

No significant $e^+e^- \to KK^*(1410)$ observed

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

JHEP 07, 045 (2022)



Partial Wave Analysis performed

$\phi(2170) \to K_2^{*+}(1430)K^-$: 7.1σ

$\phi(2170) \to K^{*+}(892)K^-$: 7.1σ

$M = 2190 \pm 19 \pm 37$ MeV/c^2

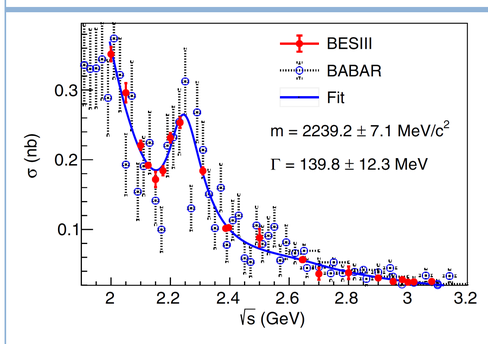
$\Gamma = 191 \pm 28 \pm 60$ MeV

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

Study of ρ^* and ω^* at BESIII

$e^+e^- \to K^+K^-$

PRD 99, 032001 (2019)



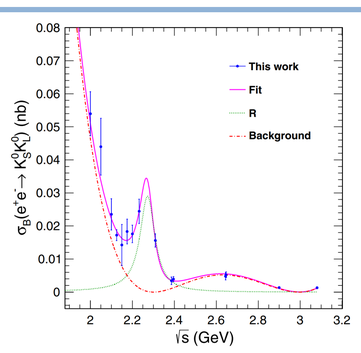
$M = 2239.2 \pm 7.1 \pm 11.3$ MeV/c^2

$\Gamma = 139.8 \pm 12.3 \pm 20.6$ MeV

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

$e^+e^- \to K_SK_L$

PRD 104, 092014 (2021)



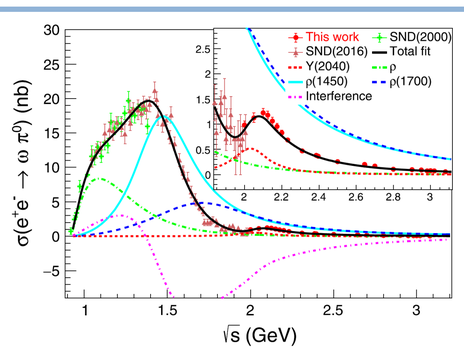
$M = 2273.7 \pm 5.7 \pm 19.3$ MeV/c^2

$\Gamma = 86 \pm 44 \pm 51$ MeV

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

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

PLB 813, 136059 (2021)



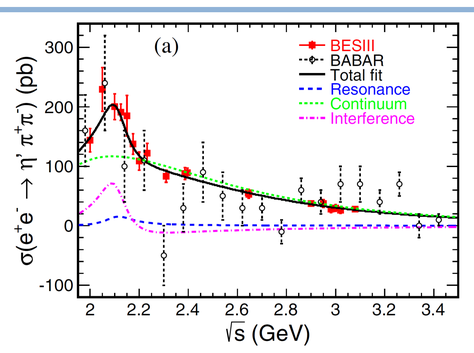
$M = 2034 \pm 13 \pm 9$ MeV/c^2

$\Gamma = 234 \pm 30 \pm 25$ MeV

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

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

PRD 103, 072007 (2021)



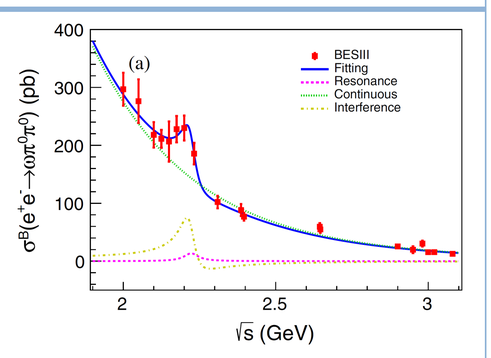
$M = 2111 \pm 43 \pm 25$ MeV/c^2

$\Gamma = 135 \pm 34 \pm 30$ MeV

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

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

PRD 105, 032005 (2022)



$M = 2222 \pm 7 \pm 2$ MeV/c^2

$\Gamma = 59 \pm 30 \pm 6$ MeV

ω^*?

Summary

- 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^* need further studies, like couple-channel analysis or partial wave analysis

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