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Line-shape analysis of charmonium resonances

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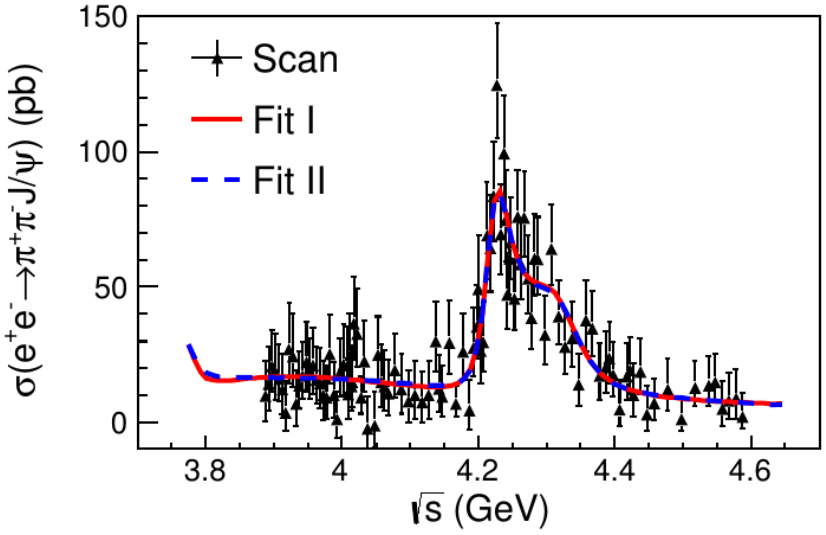
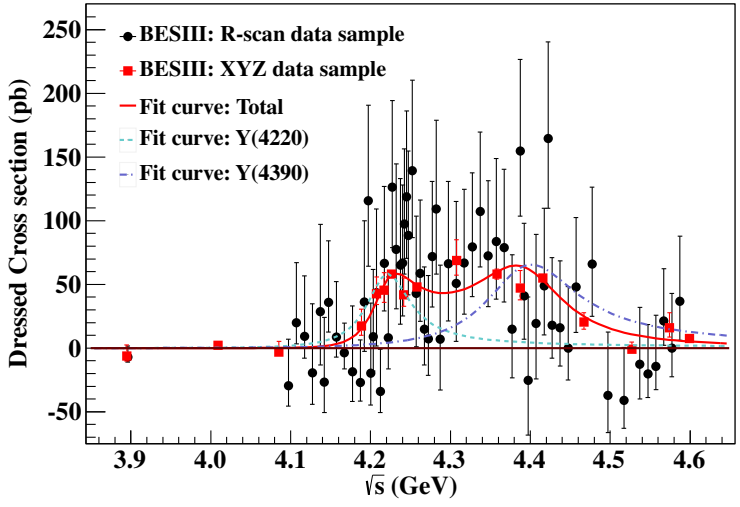
Introduction

Vector charmonium spectra and its isssues



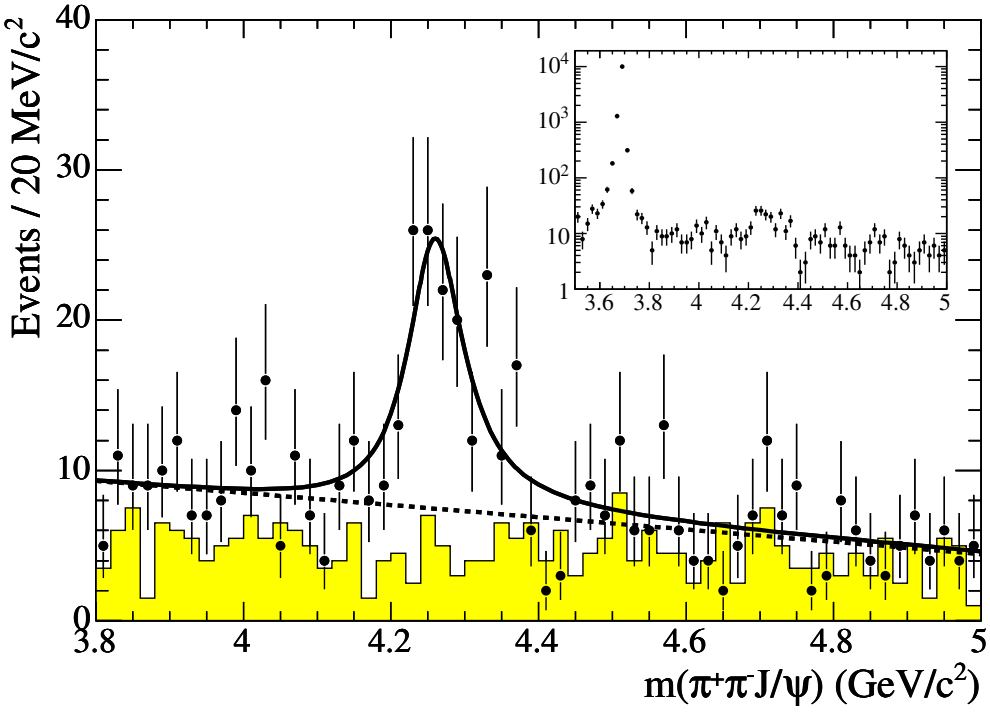


PRL118,092001(2017) BESIII,
$e^+e^- \to J/\psi\pi^+\pi^-$

$M \sim 4.22$ GeV, $\Gamma \sim 44$ MeV
$M \sim 4.32$ GeV, $\Gamma \sim 101$ MeV

PRL118,092002(2017) BESIII,
$e^+e^- \to h_c\pi^+\pi^-$

$M \sim 4.22$ GeV, $\Gamma \sim 66$ MeV
$M \sim 4.39$ GeV, $\Gamma \sim 140$ MeV



PRL95,142001 (2005) BABAR, $e^+e^- \to J/\psi\pi^+\pi^-$.

$M \sim 4.26$ GeV, $\Gamma = 50 - 90$ MeV

$\psi(3770)$, $\psi(4040)$, $\psi(4160)$, $\psi(4415)$

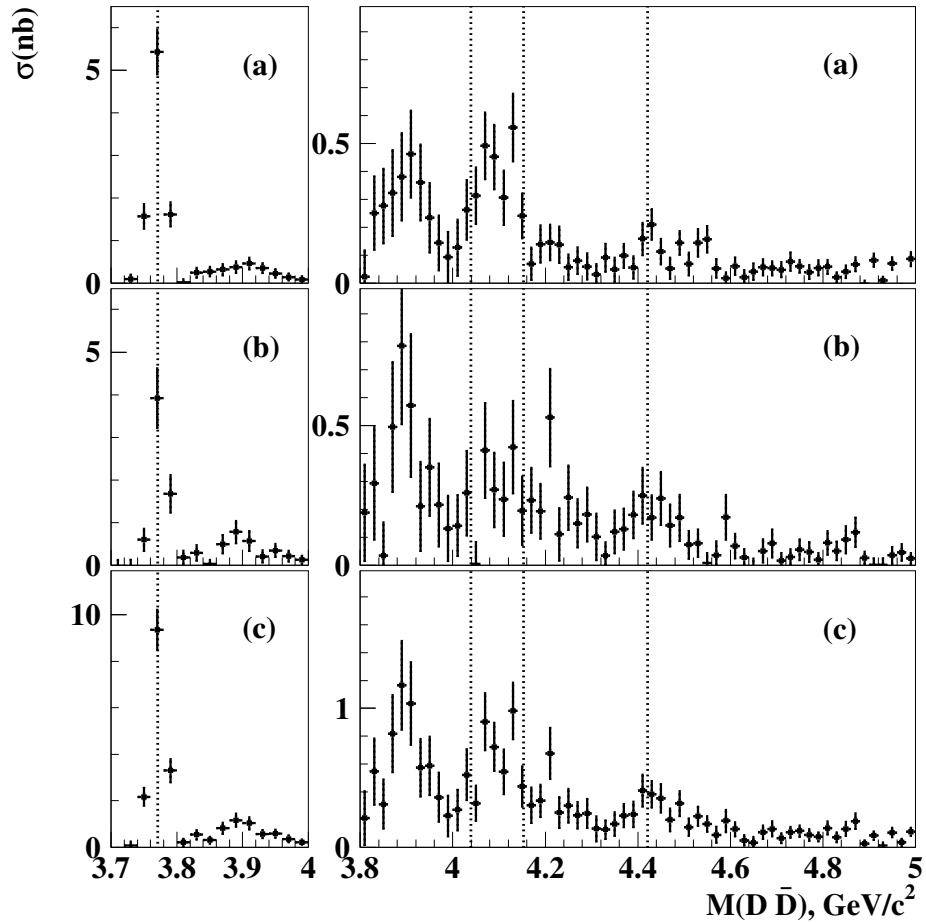
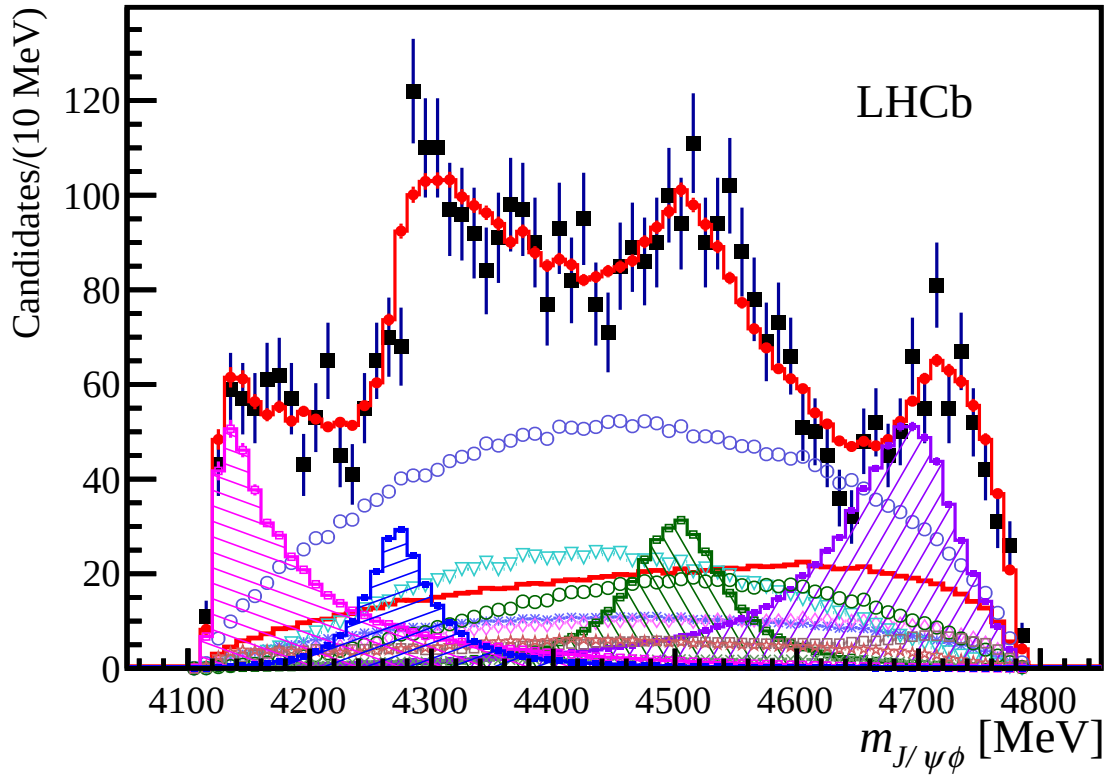


Figure: PRD77,011103(R)(2008) BELLE, $e^+e^- \to D\bar{D}$.

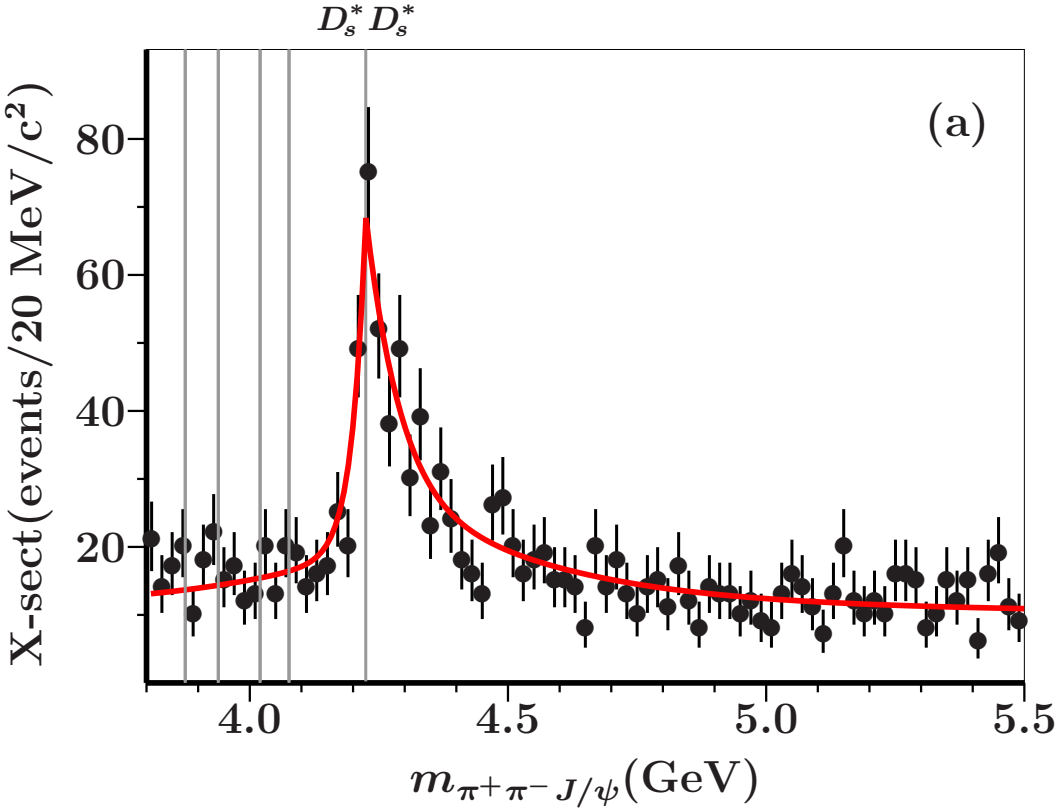
$\psi(3770)$, $\psi(4040)$, $\psi(4160)$, $\psi(4415)$



PRL118,0922003(2017) LHCb, $e^+e^- \to J/\psi\phi$.

$\therefore$ Different line-shapes in different channels does not correspond necessarily to different resonances (cf. plenary talk of I.Bendiaga - $f_0(980)$ in charm decays)

Phenomenological Analysis: Is the X(4260) a true resonance?



E. van Beveren and G. Rupp: PRD79,111501(R)(2009). Data from arXiv:0808.1543 [hep-ex] BABAR, $e^+e^- \to J/\psi\pi^+\pi^-$.

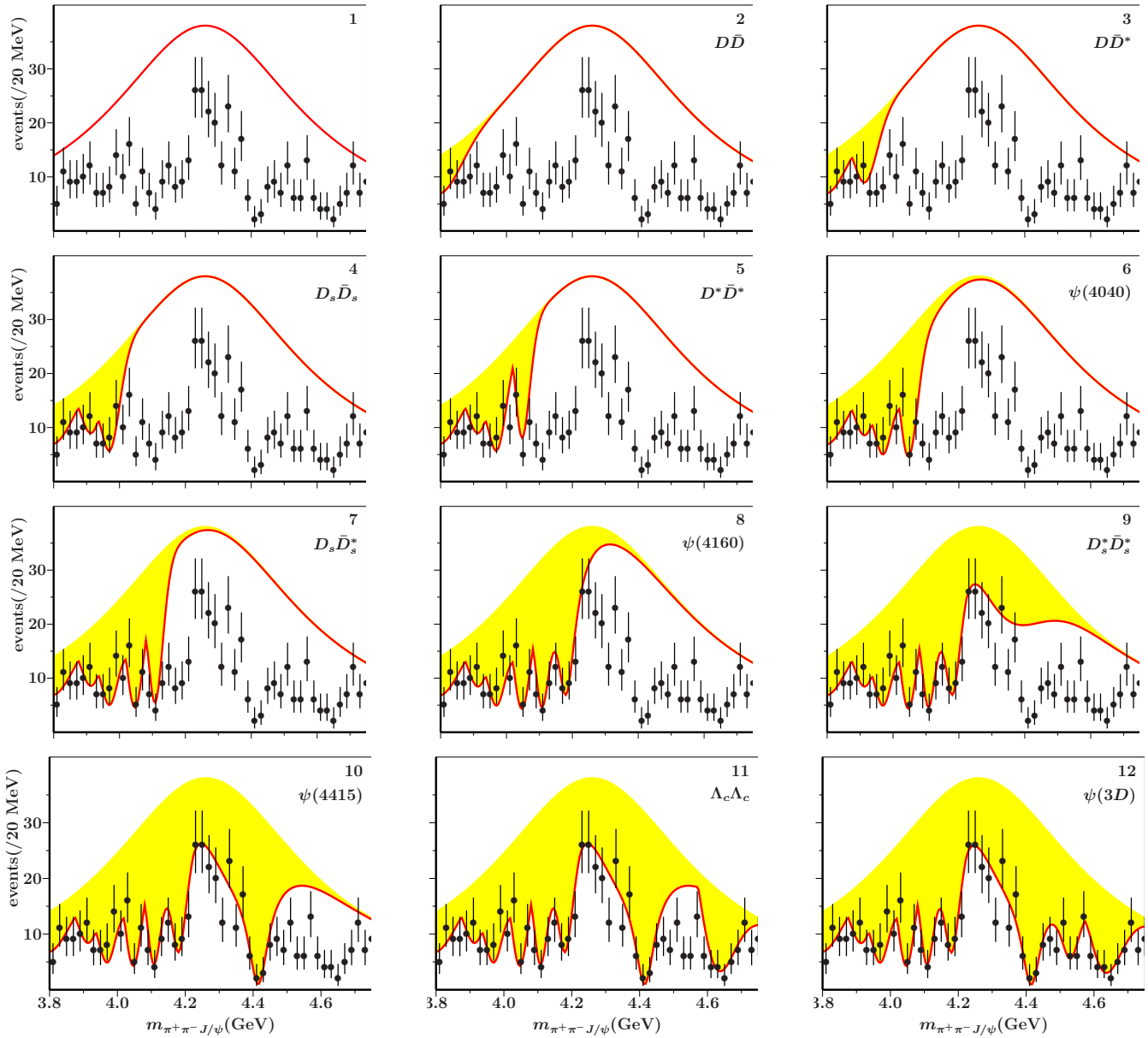
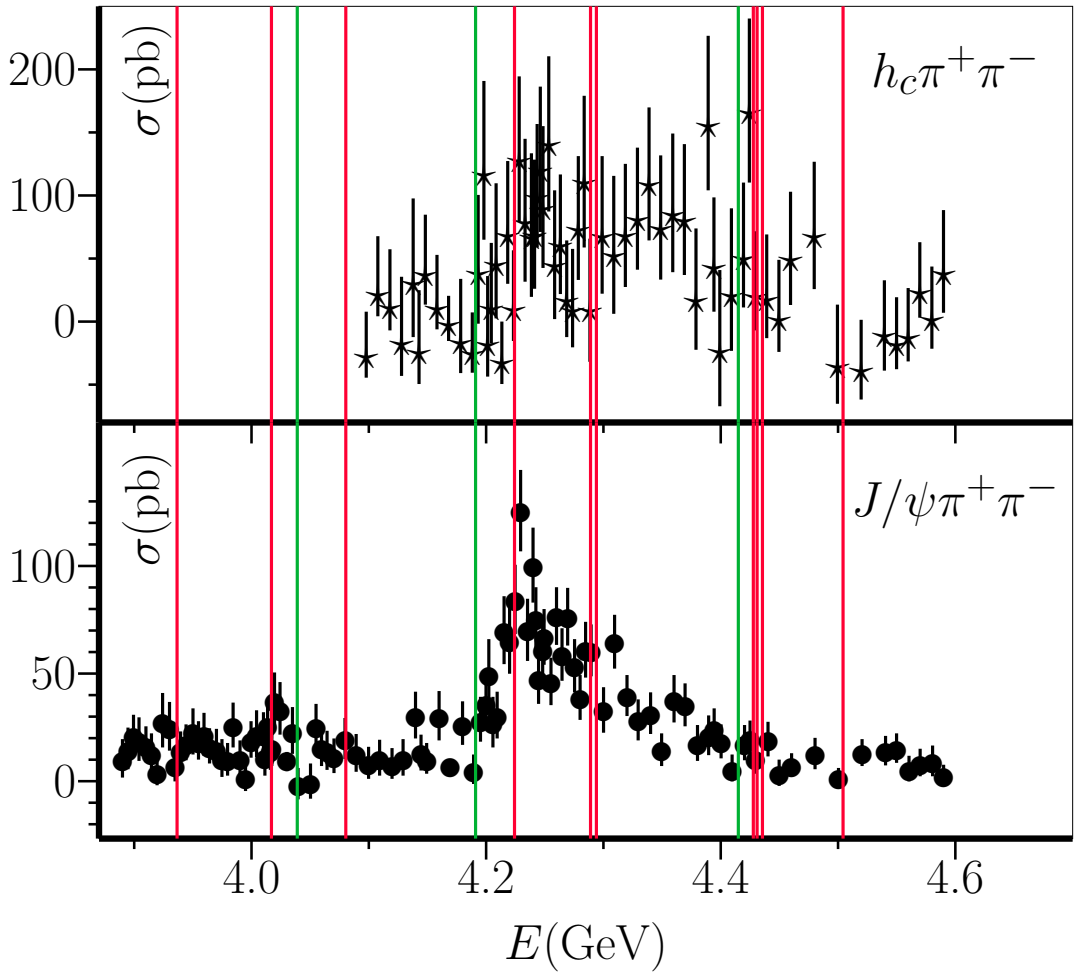


Figure: E. van Beveren, G. Rupp and G. Segovia PRL105,102001(2010) Data from PRL95,142001(2005) BABAR, $e^+e^- \to J/\psi\pi^+\pi^-$.

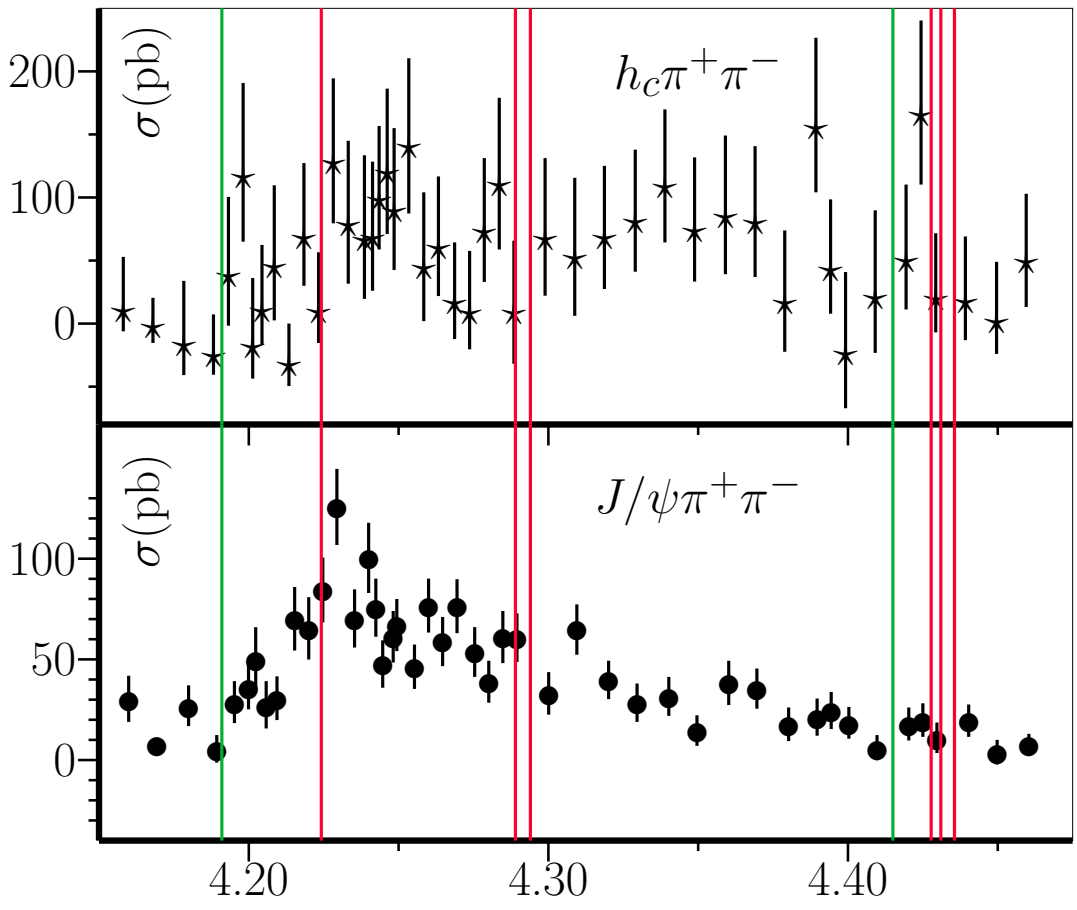
Our Analysis: Beginning

$D_s D_s$, $D^* D^*$, $D_s D_s^*$, $D_s^* D_s^*$, DD_1, $D^* D_1$, $D_s D_{1s}$



$\psi(4040)$, $\psi(4160)$, $\psi(4415)$

$D_s^* D_s^*$, DD_1, $D^* D_1$, $D_s D_{1s}$



$\psi(4160)$, $\psi(4415)$

Within an Effective Lagrangian Model

Our hypothesis:

The 4.26 GeV and 4.36 GeV structures may be threshold enhancements generated by the $\psi(4160)$ resonance.

Similar idea in D. Gamermann and E. Oset EPJA36,189(2008), where the tail of an hypothetical scalar charmonium at 3.7 GeV appears in channel DD^*.

Defining an effective Lagrangian with interaction terms:

$$\mathcal{L}_I = ig_{\psi VV}\ \Psi_{\mu\nu}\left(D_s^{*\mu}\bar{D}_s^{*\nu} - D_s^{*\nu}\bar{D}_s^{*\mu}\right), \quad \Psi_{\mu\nu} = \partial_\mu\psi_\nu - \partial_\nu\psi_\mu$$

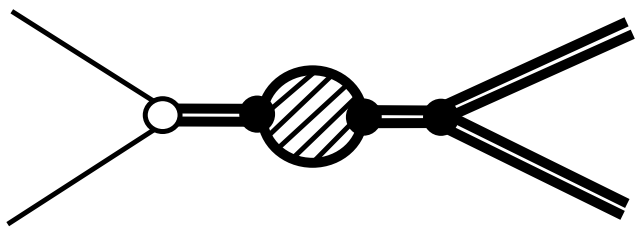
$$\mathcal{L}_{II} = ig_{\psi PA}\ \psi_\mu\left(D\bar{D}_1^\mu - D_1^\mu\bar{D}\right)$$

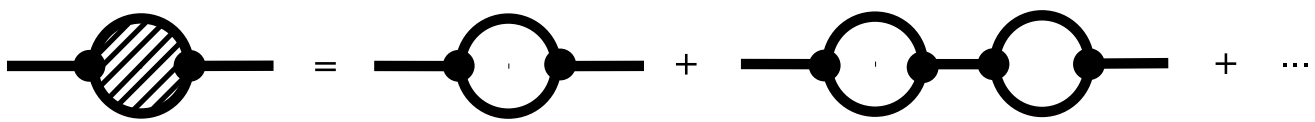
Building a propagator

$$\Sigma(s) = \Omega(s) + i\sqrt{s}\Gamma(s), \quad \Omega,\ \Gamma \in \Re.$$

$$\Gamma(s) = \frac{1}{8\pi}\frac{p(s)}{s}|\mathcal{M}|^2, \quad \Omega(s) = \frac{1}{\pi}\int_{s_{th}}^{\infty}\frac{\sqrt{s'}\Gamma(s')}{s'-s}\,\mathrm{d}s'$$

$$\Delta(s) = \frac{1}{s - m_\psi^2 + \Sigma(s)}.$$

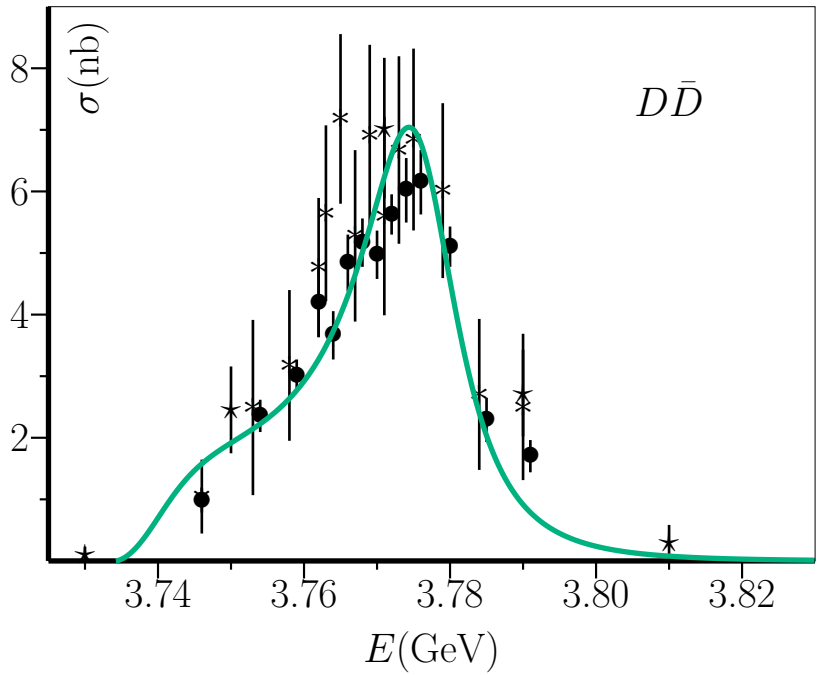




Recent Results on Vector Charmonium: the $\psi(3770)$

preliminary version in arXiv:1708.02041[hep-ph]
(extended version to be published soon)

$$\mathcal{L}_I = ig_{\psi DD}\psi_\mu\left(\partial^\mu D\bar{D} - \partial^\mu \bar{D}D\right)$$



Data from BES, $e^+e^- \to D\bar{D}$.

Summary and Conclusions

- Careful is needed when analyzing the bumps in the data.
- A systematic study of a resonance needs comparative observations in different channels.
- Interference studies between kinematical threshold effects and dynamical effects generated by resonances is fundamental to interpret correctly the experimental data.
- We propose an effective Lagrangian approach to study the interference among the $\psi(4160)$ and channels $D_s^* D_s^*$ and DD_1.

$\therefore$