How to extract the resonant parameters of the excited vector ψ states?

———Call for help from theorists.

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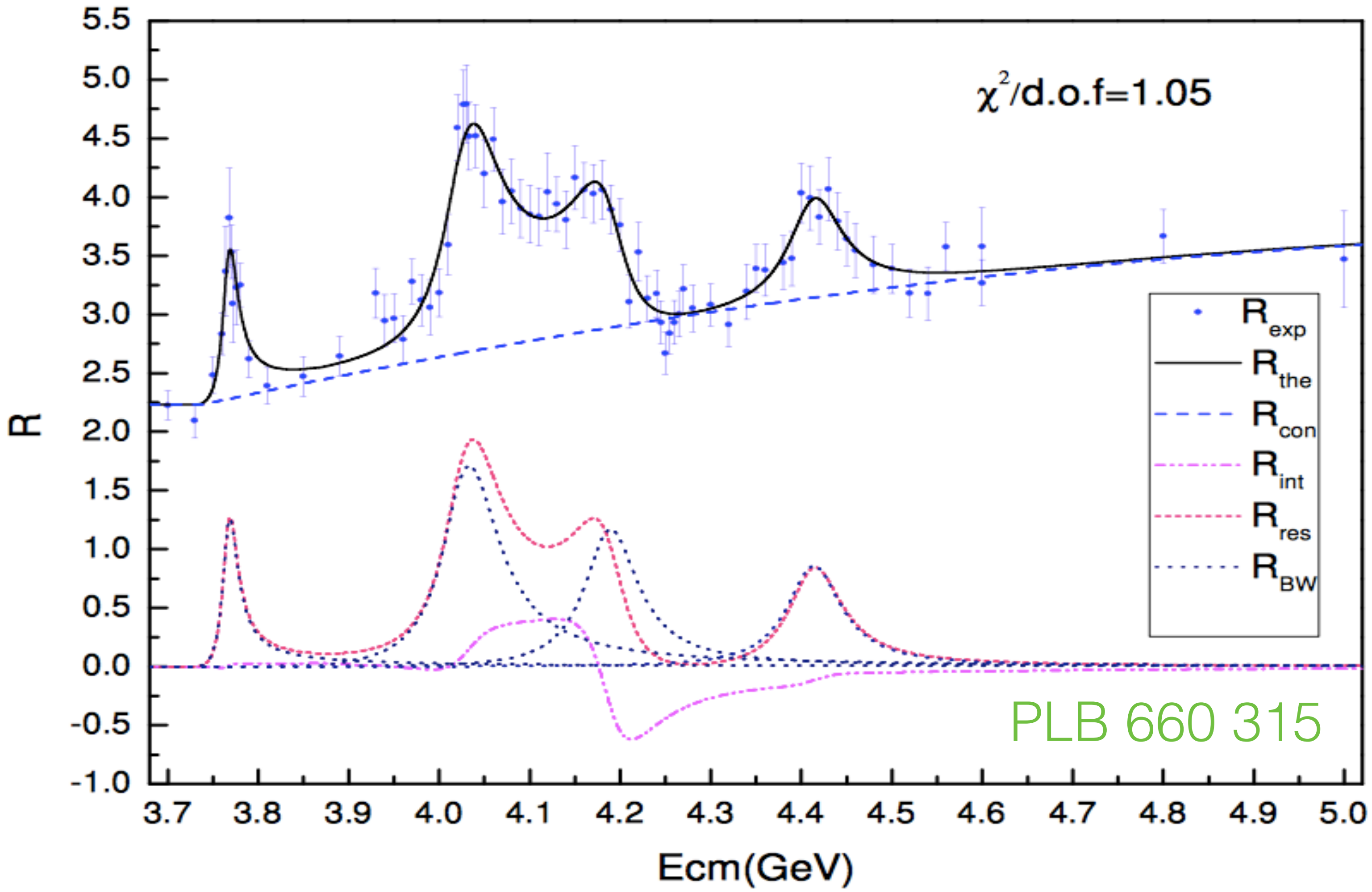
Outline

1. Motivation
2. Existing method
3. Problems for the existing method
4. Topics for discussion

Motivation

The S-wave or D-wave Charmonium states can be produced from the e^+e^- collision directly, and their resonant parameters can be extracted by fitting the R value.



Motivation

The resonant parameters are important IDs for the resonances, and a few vector exotic states are observed, such as Y(4008), Y(4260), Y(4360), Y(4630), Y(4660).

mass, total width, electronic width, phase angle

$$\mathcal{T}_r^f(W) = \frac{M_r\sqrt{\Gamma_r^{ee}\Gamma_r^f}}{W^2 - M_r^2 + iM_r\Gamma_r} e^{i\delta_r}$$

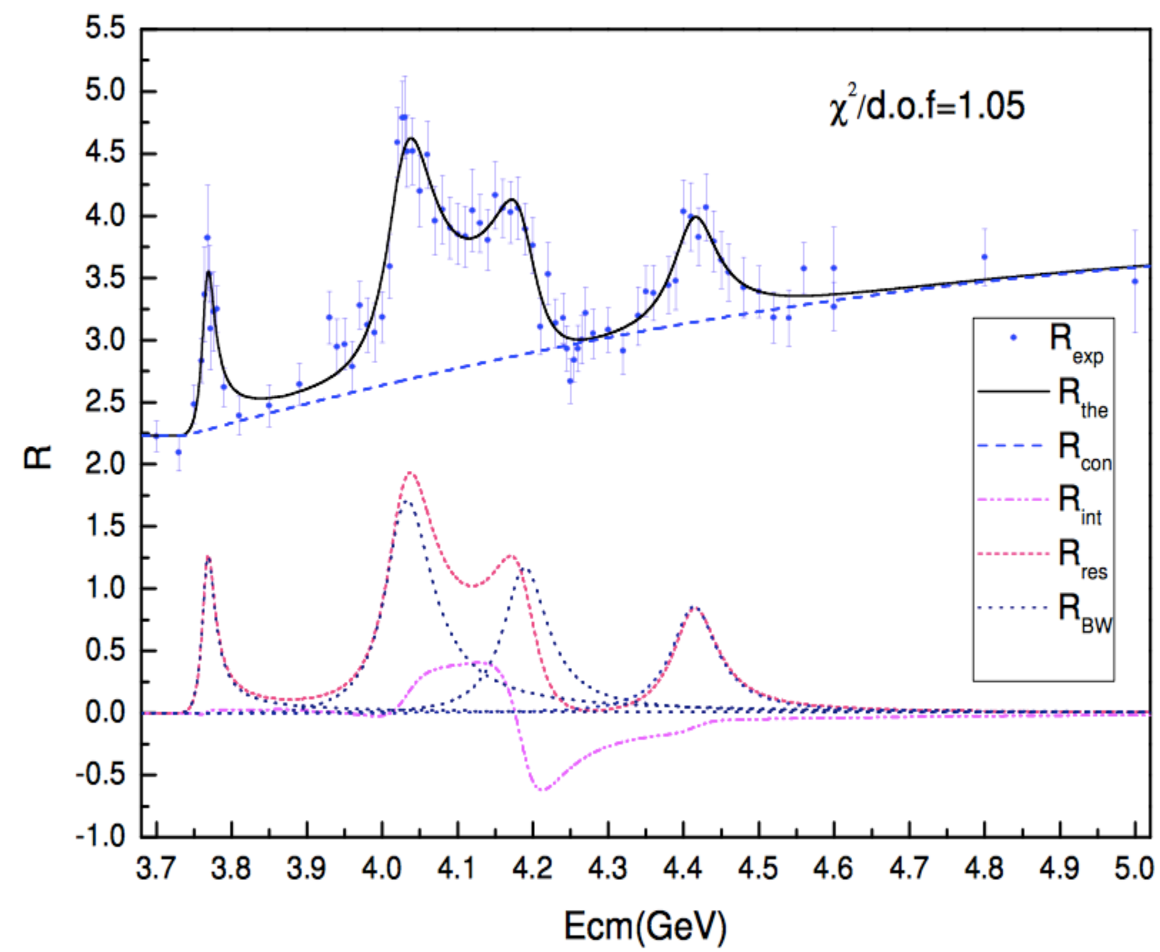
Motivation

A large data sample has been collected by BESIII, and a more sophisticate study of the resonant parameters can be achieved!

Data	R scan	XYZ	possible future
Energy (GeV)	3.85-4.59 at 100 points	3.81-4.60 at 20 points	4-4.6 at 60 points
Luminosity (pb^{-1})	800	5000	30000

Existing method

$R_{the} = R_{res} + R_{con}$
$R_{res} = \frac{12\pi}{s} \sum_f \vert \sum_r BW_r^f(\sqrt{s}) \vert$
$BW_r^f(\sqrt{s}) = \frac{M_r \sqrt{\Gamma_r^{ee} \Gamma_r^f}}{s - M_r^2 + iM_r \Gamma_r} e^{i\delta_r}$
$\Gamma_r(\sqrt{s}) = \Gamma_r^{QED}(\sqrt{s}) + \Gamma_r^{had}(\sqrt{s})$
$\Gamma_r^{had}(\sqrt{s}) = \frac{2M_r}{M_r + \sqrt{s}} \sum_f \Gamma_r^f(\sqrt{s})$
$\Gamma_r^f(\sqrt{s}) = \Gamma_r \sum_L \frac{Z_f^{2L+1}}{B_L}$
$R_{con} = C_0 + C_1(W + 2M_{D^\pm}) + C_2(W + 2M_{D^\pm})^2$



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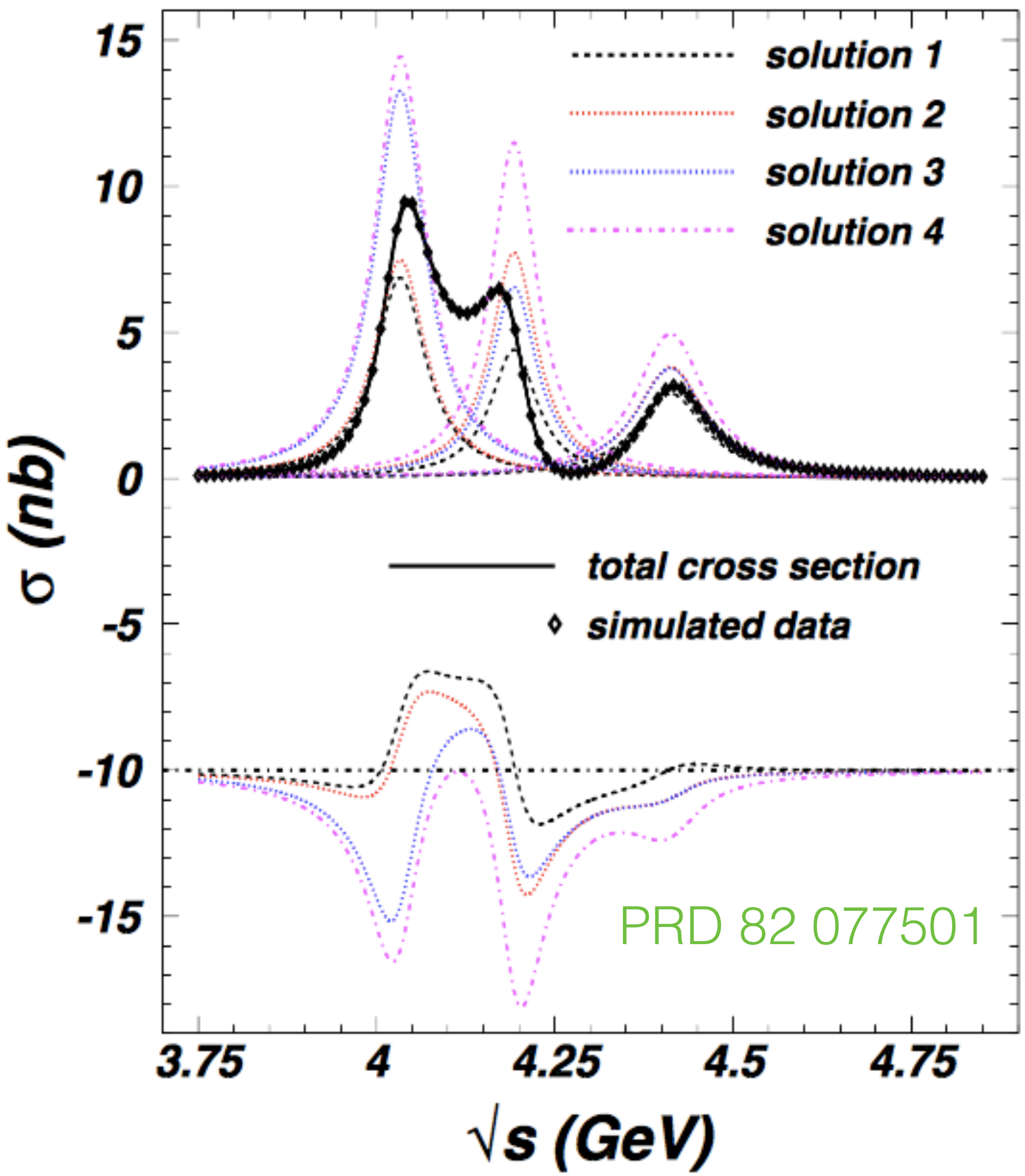
Existing method



Parameter	$\psi(4040)$	$\psi(4160)$	$\psi(4415)$
M (MeV)	4034 ± 6	4193 ± 7	4412 ± 15
Γ_t (MeV)	87 ± 11	79 ± 14	118 ± 32
$\Gamma_{ee}^{(1)}$ (keV)	0.66 ± 0.22	0.42 ± 0.16	0.45 ± 0.13
$\phi^{(1)}$ (radian)	0 (fixed)	2.7 ± 0.8	2.0 ± 0.9
$\Gamma_{ee}^{(2)}$ (keV)	0.72 ± 0.24	0.73 ± 0.18	0.60 ± 0.25
$\phi^{(2)}$ (radian)	0 (fixed)	3.1 ± 0.7	1.4 ± 1.2
$\Gamma_{ee}^{(3)}$ (keV)	1.28 ± 0.45	0.62 ± 0.30	0.59 ± 0.20
$\phi^{(3)}$ (radian)	0 (fixed)	3.7 ± 0.4	3.8 ± 0.8
$\Gamma_{ee}^{(4)}$ (keV)	1.41 ± 0.12	1.10 ± 0.15	0.78 ± 0.17
$\phi^{(4)}$ (radian)	0 (fixed)	4.1 ± 0.1	3.2 ± 0.3

The electronic width is closely related to the nature of the resonance!

Problem

1. The Breit-Wigner assumption is made.

The sum of more than 2 BW functions violates the unitarity (see Professor Christoph Hanhart's talk); multi-solutions.

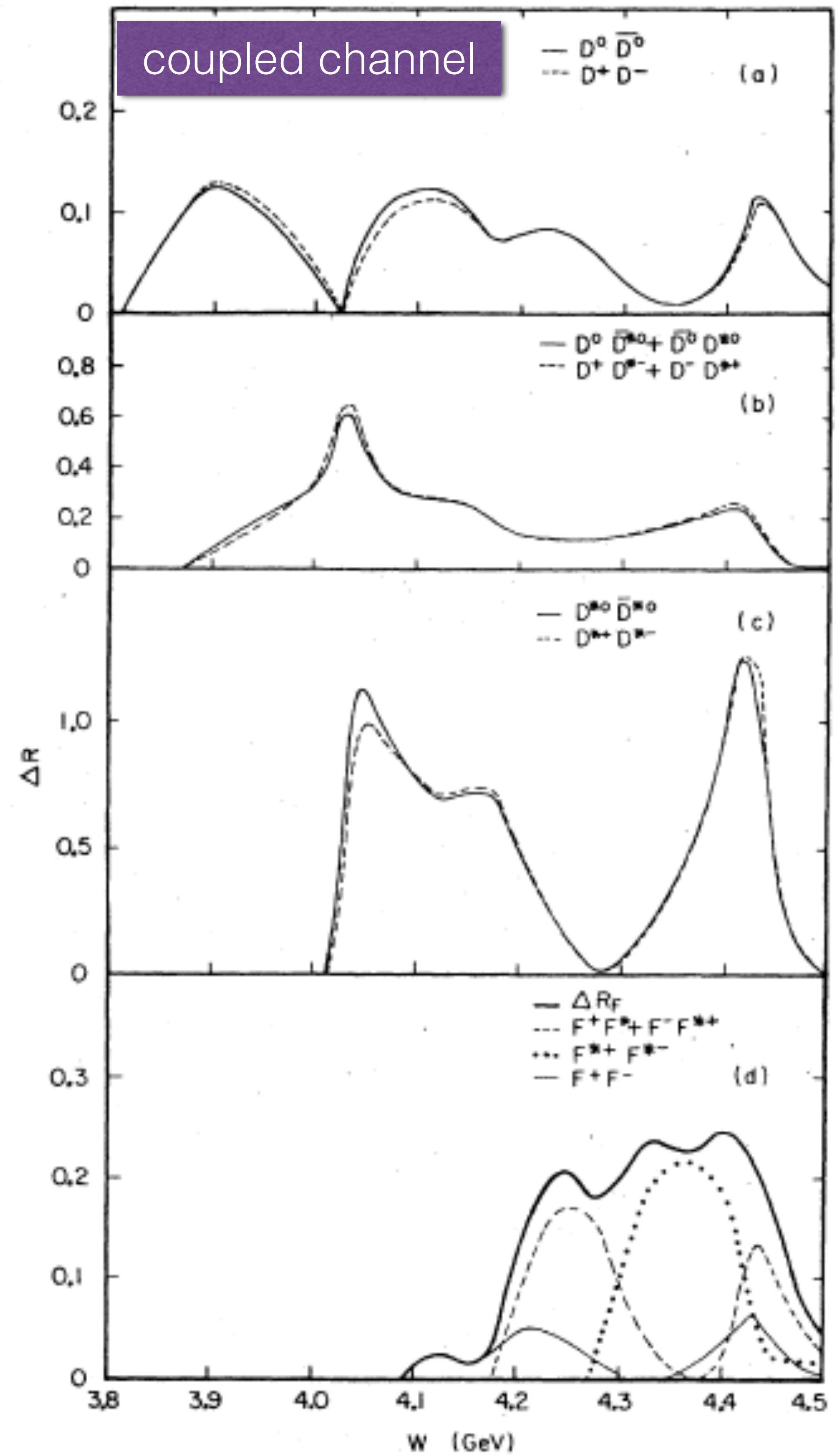
2. The energy dependent partial width is not based on experimental data.

$$\Gamma_r^f(\sqrt{s}) = \Gamma_r \sum_L \frac{Z_f^{2L+1}}{B_L}$$

$$Z_f = \rho P_f$$

p is the decay momentum, ρ is the range of interaction (a few fermi)

$$B_0 = 1 \qquad B_1 = 1 + Z^2 \qquad B_2 = 9 + 3Z^2 + Z^4$$



Topics for discussion

1.Is there any other model which is better than the naive BW? Such as the K-matrix?

2. Is the exclusive cross section measurement very important for extracting the resonant parameters? Such as the cross section measurement of DD, DD*, D*D*, DD*π……(the answer is yes from Estia Eichten's talk, how about the precision required?)

3. The Rc can be measured also by selecting the charmed meson, is it more useful to extract the resonant parameters?

4. What can the R value and the parameters of the traditional Charmonium states tell us about the nature of the XYZ states?

Your suggestions are very welcome!

back up

$$\sigma_D = \sigma_{D^0 X} + \sigma_{D^+ Y} + \sigma_{D_s^+ Z}$$