Evidence of a Resonant Structure in the $e^+e^- \to \pi^+ D^0 D^{*-}$ Cross Section between 4.05 and 4.60 GeV

Phys. Rev. L 122, 102002 (2019)

Gu Shan

2019.4.12

JC 103 report

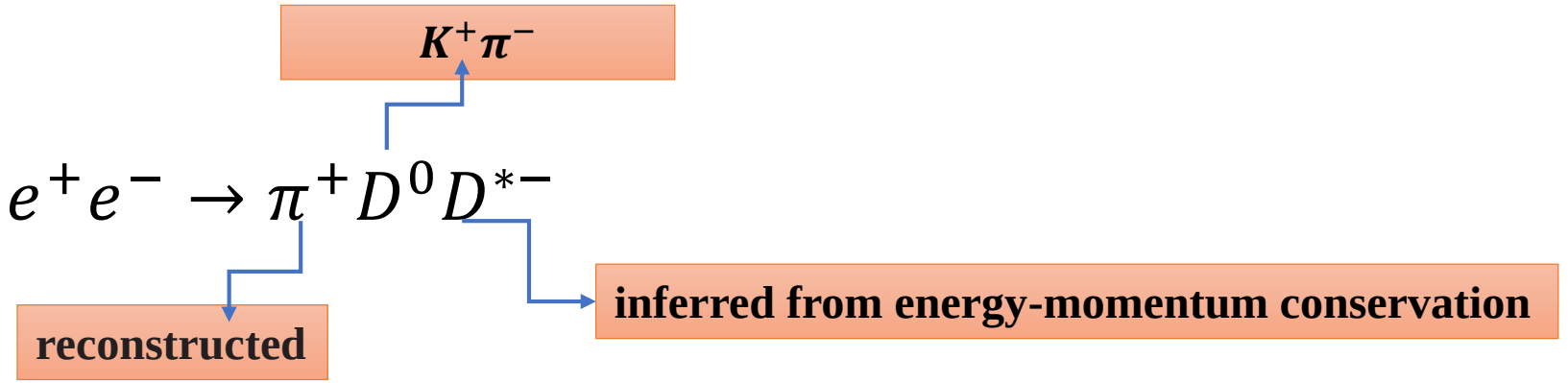
Introduction

- Y(4260) was observed only in hidden-charm processes, while its mass is close to open-charm thresholds, studies of the open-charm production cross section in e^+e^- annihilation will provide important information on its properties.

- The production of $e^+e^- \to \pi D\bar{D}^*$ is expected to be strongly enhanced above the nominal $D\bar{D}_1(2420)$threshold and could be a key for understanding existing puzzles with these Y states.

- In this Letter, we report improved measurements of the production cross section of $e^+e^- \to \pi^+ D^0 D^{*-}$ at center-of-mass energies from 4.05 to 4.60 GeV using data samples taken at 84 energy points with the BESIII detector.

Event topology



- Charge-conjugate modes are implied, unless otherwise noted.

Fit to the D^{*-} mass

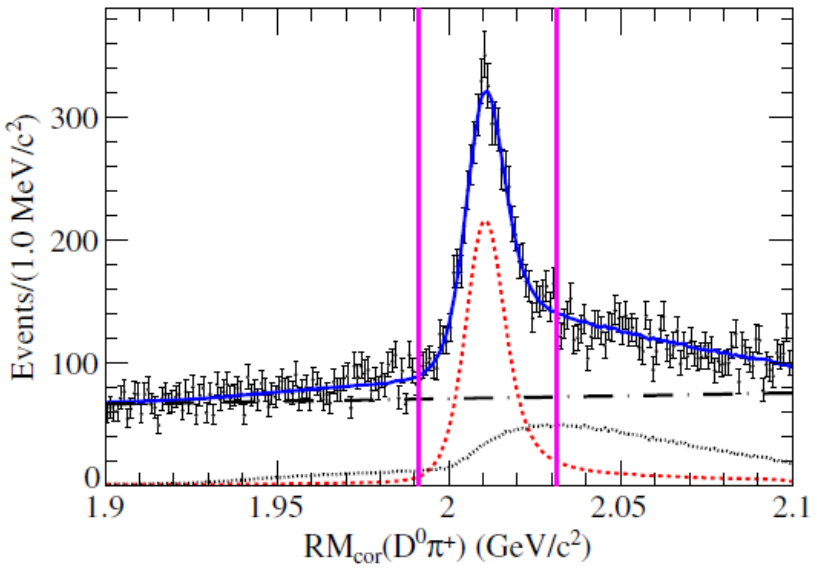


FIG. 1. Fit to the distribution of $RM_{\rm cor}(D^0\pi^+)$ for the data sample at $\sqrt{s} = 4.5995$ GeV. The black dots with error bars are data, the solid line (blue) describes the total fit, the dashed line (red) describes the signal shape, and the dotted and dash-dotted lines (black) describe BKG1 and BKG2, respectively. The pink vertical lines mark the signal region.

inferred by the invariant mass recoiling against the $D^0\pi^+$ system, RM($D^0\pi^+$)

The signal region is defined as

$$|RM_{\rm cor}(D^0\pi^+) - \Delta M - m(D^{*-})| < 20\,{\rm MeV}/c^2$$

Calculation of born cross sections

$$\sigma_{\text{Born}} = \sigma_{\text{dress}}|1-\Pi|^2$$

$$= \frac{N^{\text{obs}}}{\mathcal{L}(1+\delta)\frac{1}{|1-\Pi|^2}\mathcal{B}(D^0 \to K^-\pi^+)\epsilon},$$

the ISR correction factor

the correction factor for vacuum polarization

Question from Xin: For the paper in equation 2, could you explain what does the "dress cross-section" mean?

Answer : σ_{Born} is the observed cross section, when considering the correction factor for vacuum polarization, $\sigma_{Born} \times \frac{1}{|1-\Pi|^2}$, it is the so called dress cross-section, σ_{dress} .

Dressed cross section

Two resonance were observed

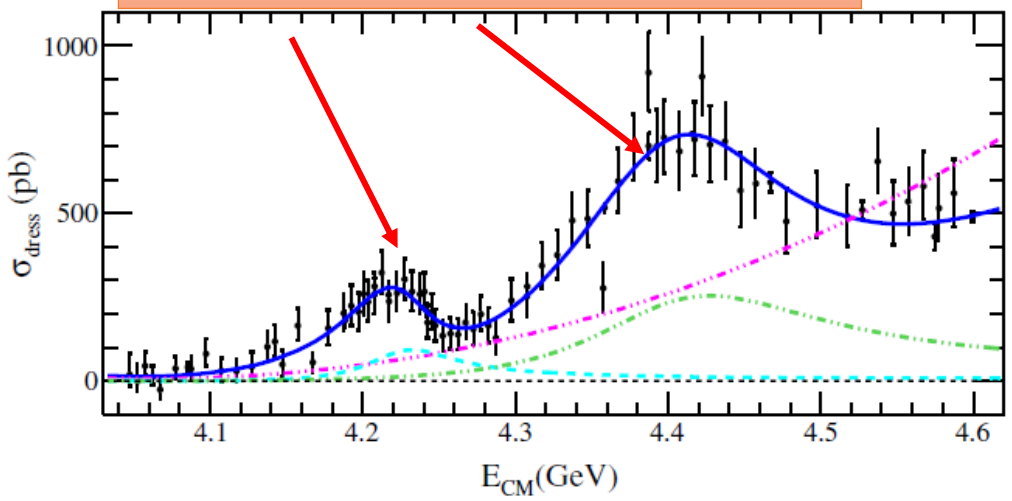


FIG. 2. Fit to the dressed cross section of $e^+e^- \to \pi^+ D^0 D^{*-}$, where the black dots with error bars are the measured cross sections and the blue line shows the fit result. The error bars are statistical only. The pink dashed triple-dot line describes the phase-space contribution, the green dashed double-dot line describes the R_2 contribution, and the light blue dashed line describes the R_1 contribution.

TABLE II. The fitted parameters of the cross sections of $e^+e^- \to \pi^+ D^0 D^{*-}$. The uncertainties are statistical only.

Parameter	Solution I	Solution II	Solution III	Solution IV
c (MeV$^{-3/2}$)		$(6.2 \pm 0.5) \times 10^{-4}$		
M_1 (MeV/c^2)		4228.6 ± 4.1		
Γ_1 (MeV)		77.0 ± 6.8		
M_2 (MeV/c^2)		4404.7 ± 7.4		
Γ_2 (MeV)		191.9 ± 13.0		
Γ_1^{el} (eV)	77.4 ± 10.1	8.6 ± 1.6	99.5 ± 14.6	11.1 ± 2.3
Γ_2^{el} (eV)	100.4 ± 13.3	64.2 ± 8.0	664.2 ± 80.0	423.0 ± 47.0
ϕ_1 (rad)	-2.0 ± 0.1	3.0 ± 0.2	-0.9 ± 0.1	-2.2 ± 0.1
ϕ_2 (rad)	2.1 ± 0.2	2.5 ± 0.2	-2.3 ± 0.1	-1.9 ± 0.1

Question from Amit: what is R1 and R2 in Fig-2?Can you please explain Fig-2 a little bit?

Answer: Two enhancements obtained from the fit result of the cross section.

Question from Yuhang: In FIG2,what's meaning of the phase-space contribution?

- Answer: For each energy point, we generate MC samples of the signal process according to phase space (PHSP MC).

In dynamical system theory, a **phase space** is a space in which all possible states of a system are represented, with each possible state corresponding to one unique point in the phase space. For mechanical systems, the phase space usually consists of all possible values of position and momentum variables. The concept of phase space was developed in the late 19th century by Ludwig Boltzmann, Henri Poincaré, and Willard Gibbs.

- Question from Ryuta: could you explain about the relationship of those ?

1) Y(4260) without open charm channel decay (==dip) and DD1bar(2420) molecule interpretation

2) observation of open charm channel ($\pi^+ D^0 D^{*-}$) with Y(4220)

- Answer: We didn't observe Y(4260), it is just observed in the hidden-charm processes. DD1bar(2420) molecule model is proposed as an interpretation of the Y(4260). We observed the Y(4220) in this paper.

- Phys. Rev. D 90, 074039 (2014).
- Phys. Rev. Lett. 111, 132003 (2013);
- Phys. Rev.D 94, 054035 (2016).