Observation of a DD* structure in $e^+e^- \to \pi^\pm (DD^*)^\mp$ at $\sqrt{s} = 4260 MeV$

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(BESIII Collaboration)

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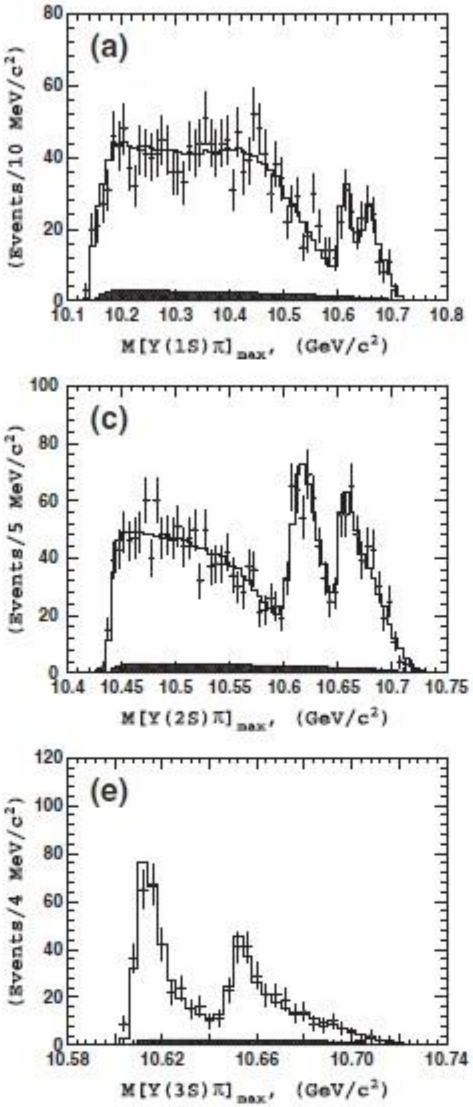
Outline

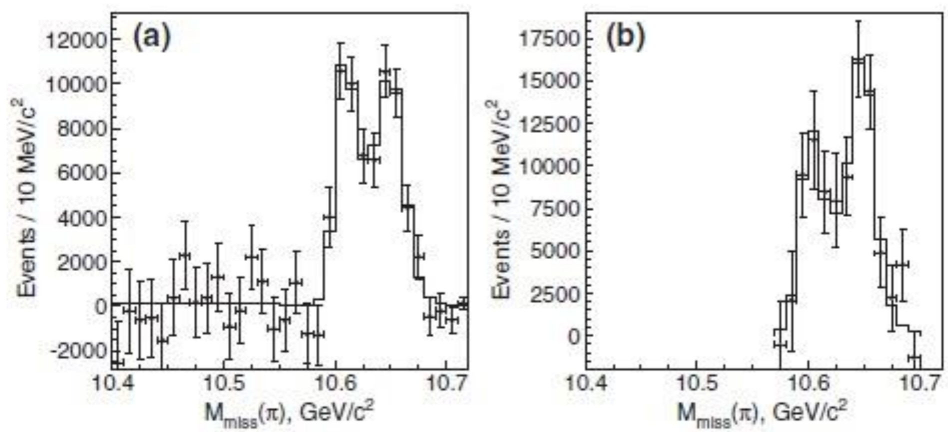
- Motivation
- Two independent analysis method:
  1)The $\pi^+ D^0$ tagging method:
    a)Tag D^0 by the decay $D^0 \to K^-\pi^+$
    b)Find an additional π^+, calculate the recoil mass of π^+D^0 and π^+
  2)The $\pi^+ D^-$ tagging method(II):
    a)Tag D^- by the decay $D^- \to K^+\pi^-\pi^-$
    b)Find an additional π^+, calculate the recoil mass of π^+D^- and π^+
- Angular distribution
- Cross sections
- Comparison between Zc(3885) and Zc(3900)

Motivation(I)

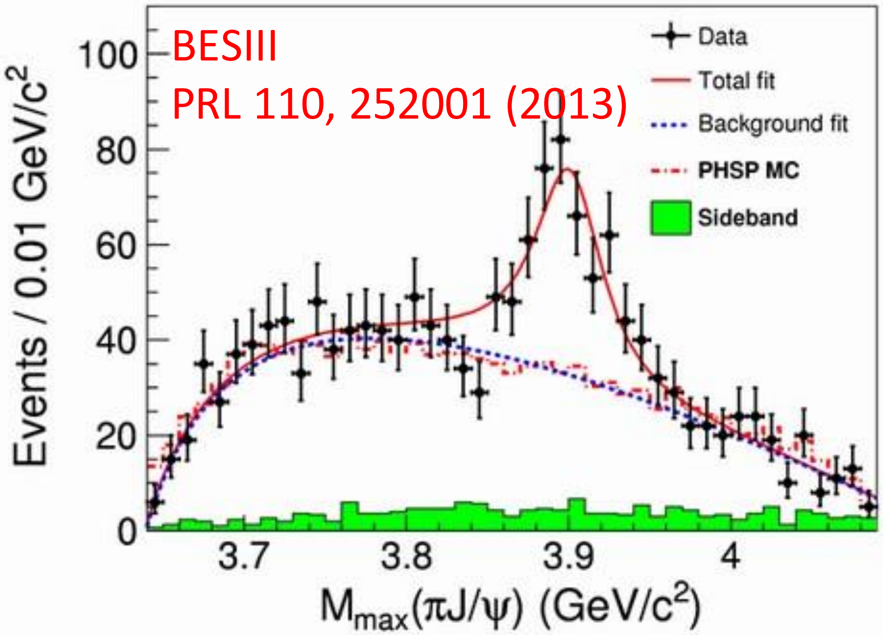


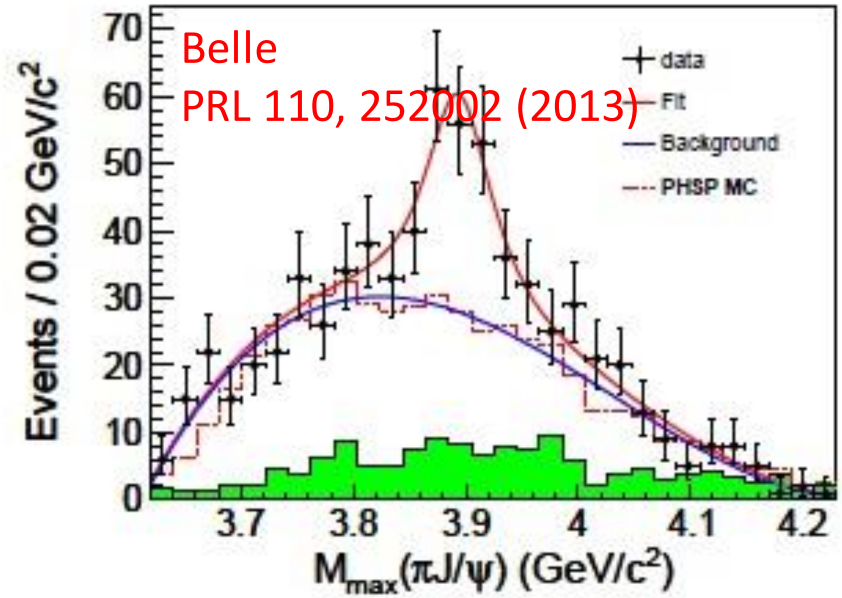
- The Belle Collaboration observed two charged structures in
  $\Upsilon(5S)\rightarrow\pi^+\pi^-\ \Upsilon(nS)$, n=1,2,3
  $\Upsilon(5S)\rightarrow\pi^+\pi^-\ h_b(mP)$, m=1,2
- $Z_b(10610)$ and $Z_b(10650)$ near mass of BB* and B*B*

Phys. Rev. Lett. 108, 122001 (2012)



Motivation(II)



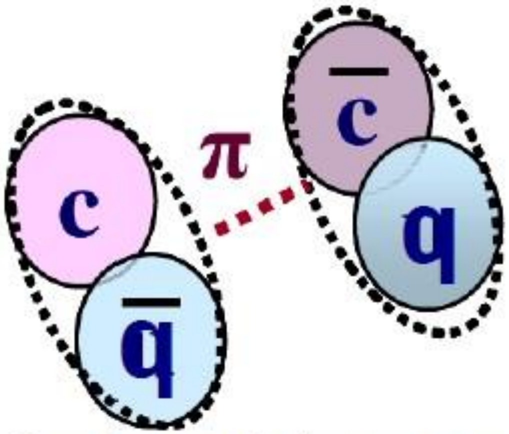


- BESIII, Belle and Cleo Collaboration discover the new charged structure Zc(3900) in $Y(4260)\to\pi^+\pi^- J/\psi$.
- The mass of Zc(3900) is near DD* mass, it is very interesting to see whether Zc decays into DD*

What is Zc(3900)$^{\pm}$ and Y(4260)?

Molecule ?
Tetraquark?
Hybrid?
Hadro-charmonium ?
ISPS model?

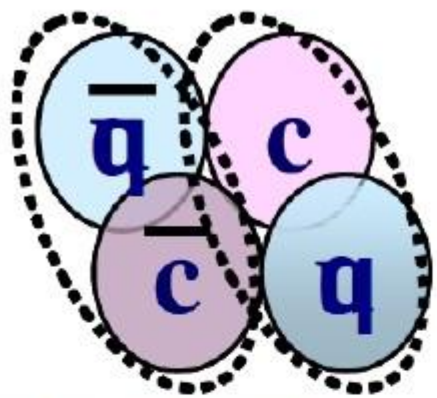
Hadronic molecule



2 color-neutral mesons
with soft pion exchange

arXiv:1303.6608,
arXiv:1304.2882, 1304.1850

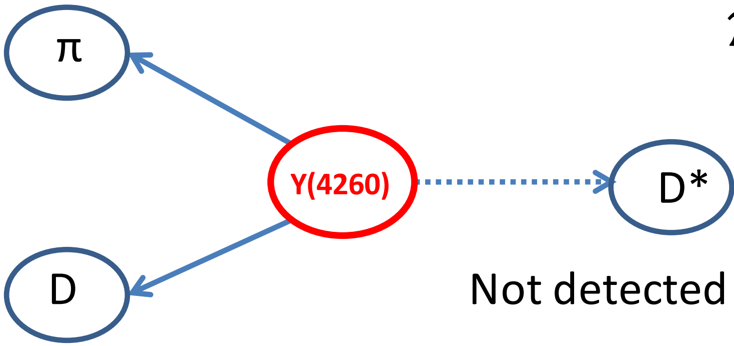
Tetraquark



Diquark-antidiquark
with gluon exchange

arXiv:1303.6857
arXiv:1304.0345, 1304.1301

Partial reconstruction technique



$\pi^{\pm}(DD^{*})^{\mp}$ includes 4 decay modes:

1) $\pi^{+}D^{0}D^{*-}$+c.c., $D^{*-} \to \pi^{0} D^{-}$

2) $\pi^{+}D^{-}D^{*0}$+c.c., $D^{*0} \to \gamma/\pi^{0} D^{0}$

We only reconstruct the bachelor pion and a single D.

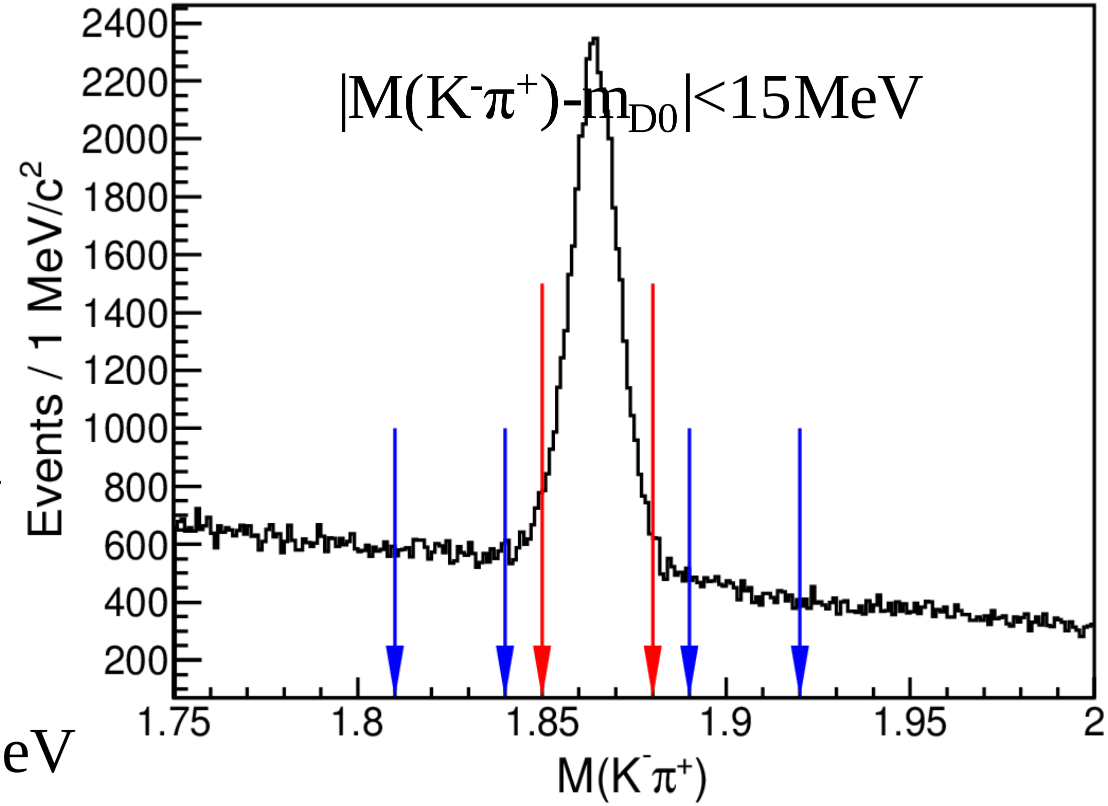
- If we tag a π^{+} and D^{0}, we select the events: $\pi^{+}D^{0}D^{*-}$ and $\pi^{+}D^{-}D^{*0}$ ($D^{*0} \to \gamma/\pi^{0} D^{0}$)
- If we tag a π^{+} and D^{-}, we select the events: $\pi^{+}D^{0}D^{*-}$ ($D^{*-} \to \pi^{0} D^{-}$) and $\pi^{+}D^{-}D^{*0}$ ($D^{*0} \to \gamma/\pi^{0} D^{0}$)
- The events from the isospin decays are cross feeding events.

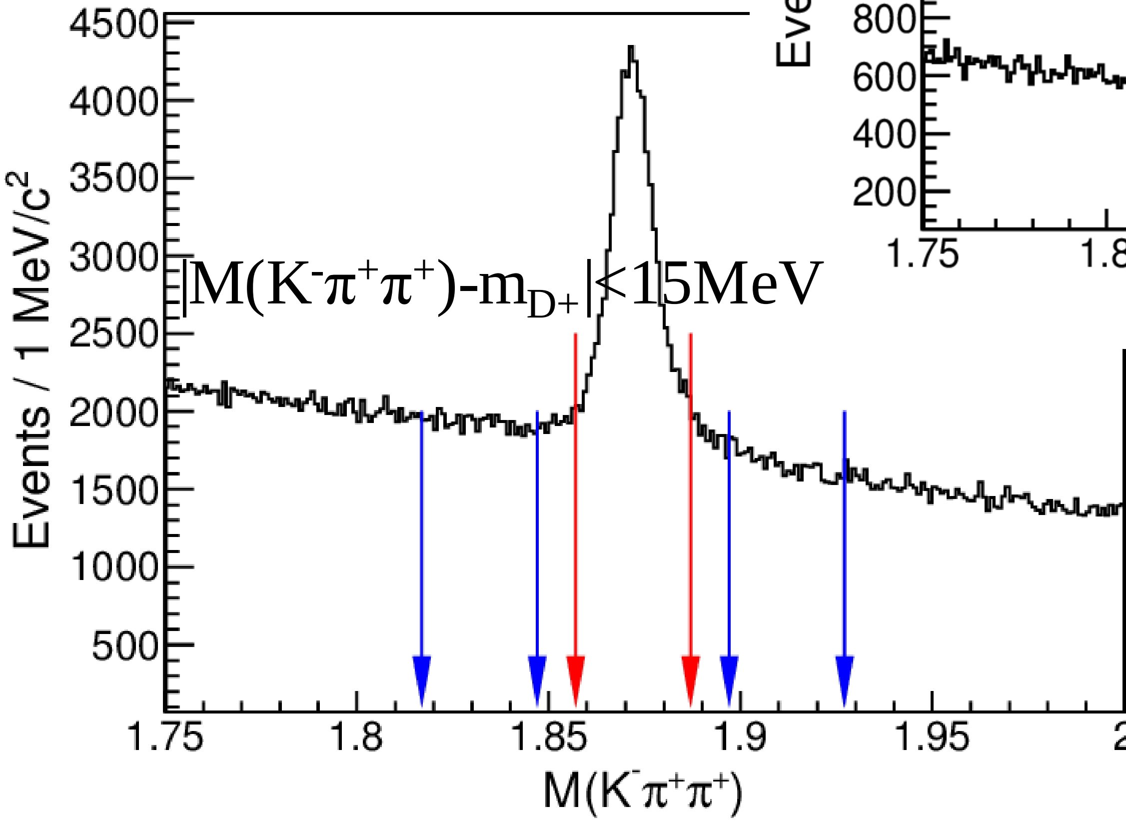
Events Selections

- Idea: Tag the single D and bachelor **π** in **π**DD^*
- Method:
  - Tag D using the decay $D^0 \to K^- \pi^+$, $D^- \to K^+ \pi^- \pi^-$
  - Finding one or more additional **π**
  - Finding D* by calculating the recoil mass of D**π**
- Kinematic Fit:
  - Constraint the mass: $M(K^- \pi^+) = m_{D0}$, $M(K^+ \pi^- \pi^-) = m_{D-}$
  - Constraint the missing mass of **π**D:

    $M^{recoil}(\pi^+ D^0) = m_{D*-}$, $M(\pi^+ D^-) = m_{D*0}$
  - $\chi^2 < 30$

Signal of D


|M(K⁻π⁺)-m_D0|<15MeV
Events / 1 MeV/c²
M(K⁻π⁺)


|M(K⁻π⁺π⁺)-m_D+|<15MeV
Events / 1 MeV/c²
M(K⁻π⁺π⁺)

Recoil mass of πD

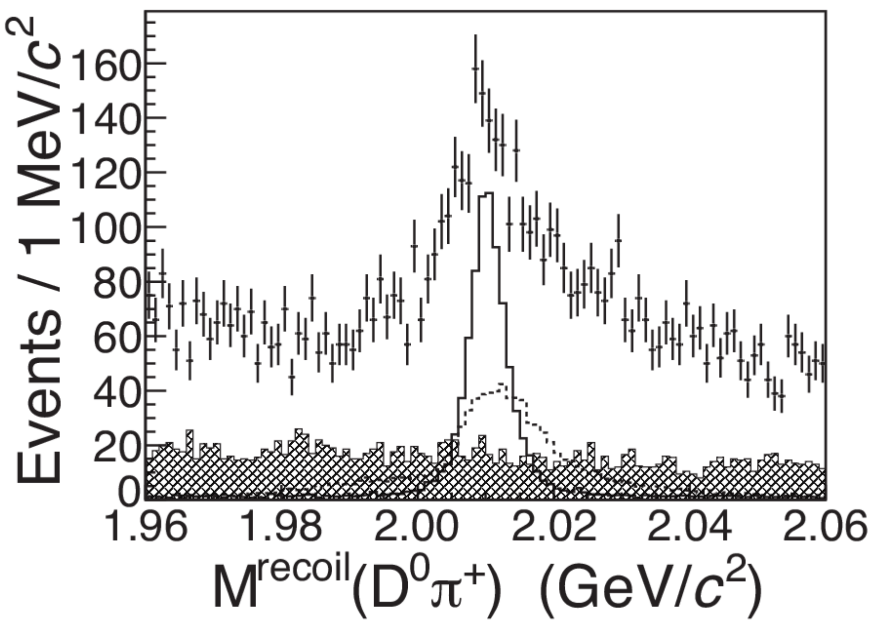
$\pi^+ D^0$ tagging method

Dots with error bars: Data

Solid: $e^+e^- \to \pi^+ D^0 D^{*-}$

Dash: $e^+e^- \to \pi^+ D^- D^{*0}$, where DD*form a resonance

Hatch: Events from D^0 sideband



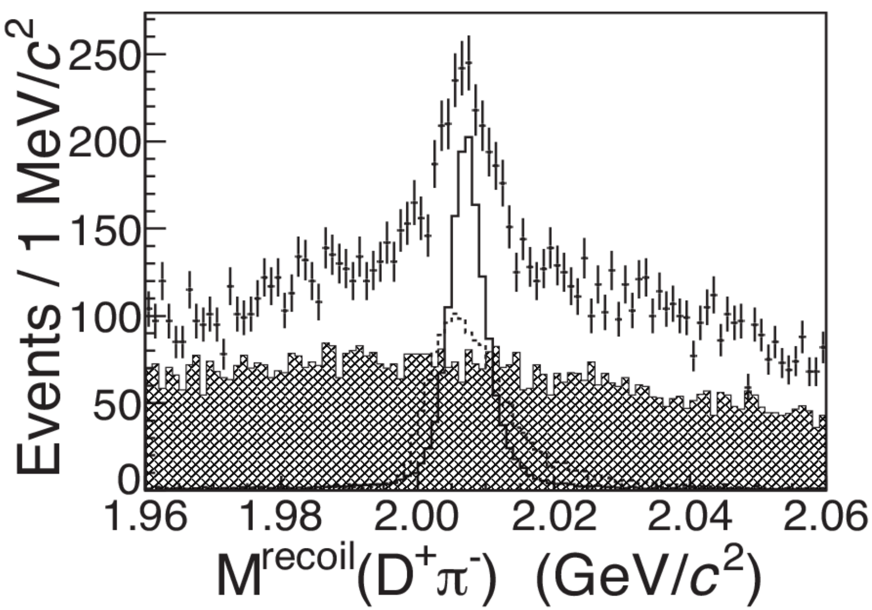
$\pi^+ D^-$ tagging method

Dots with error bars: Data

Solid: $e^+e^- \to \pi^+ D^- D^{*0}$

Dash: $e^+e^- \to \pi^+ D^0 D^{*-}$, where DD*form a reson

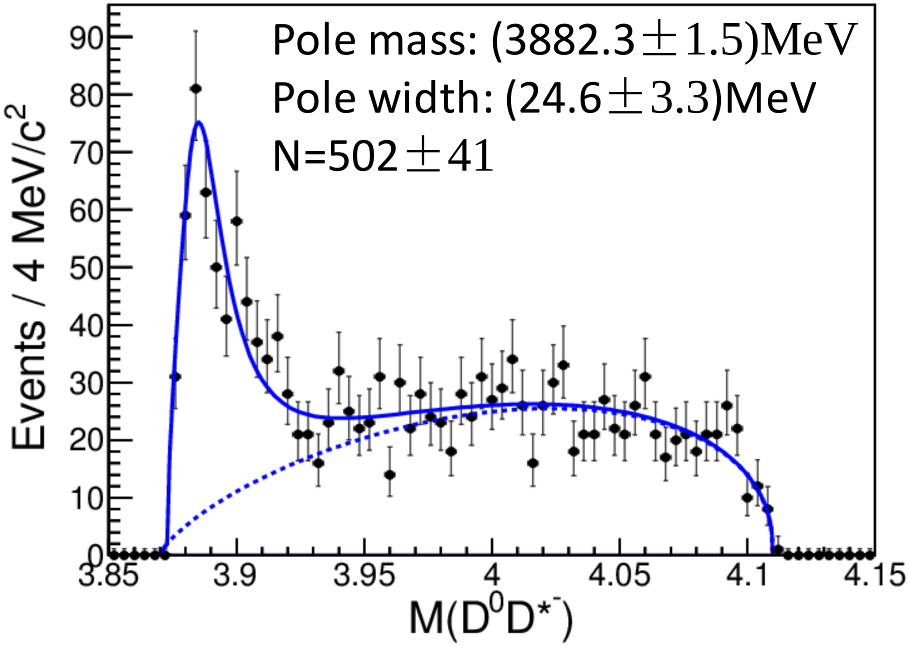
Hatch: Events from D^- sideband



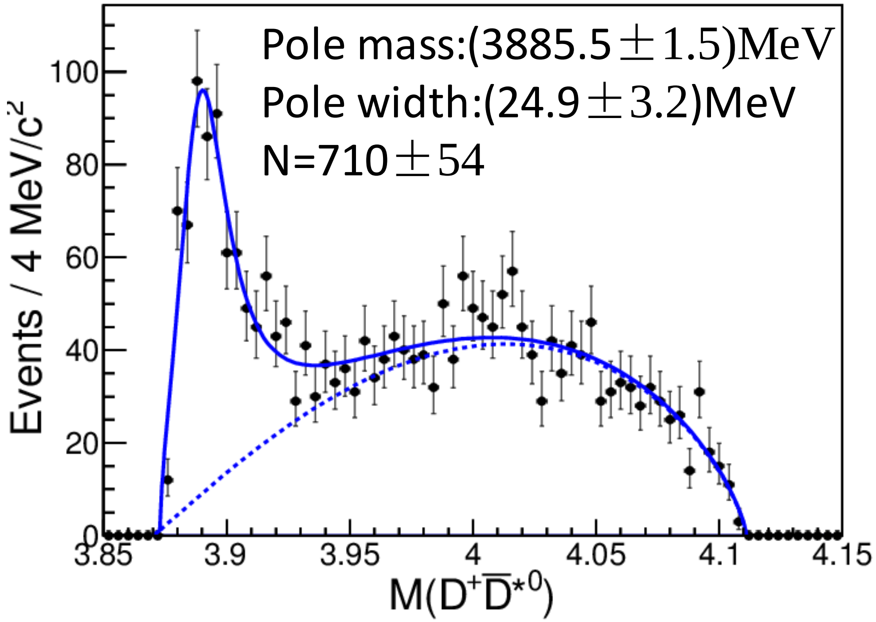
We can see clear signal of D*

Mass of DD*

$\pi^+ D^0$ tagging method

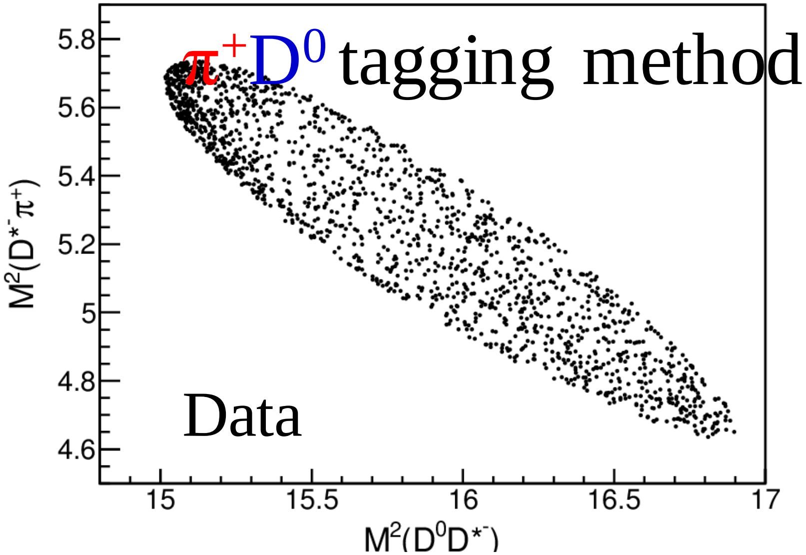


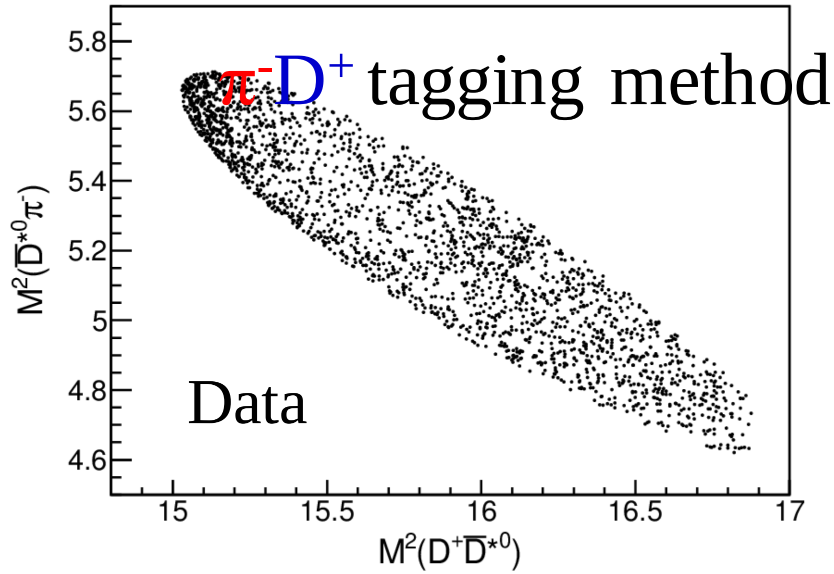
$\pi^- D^+$ tagging method

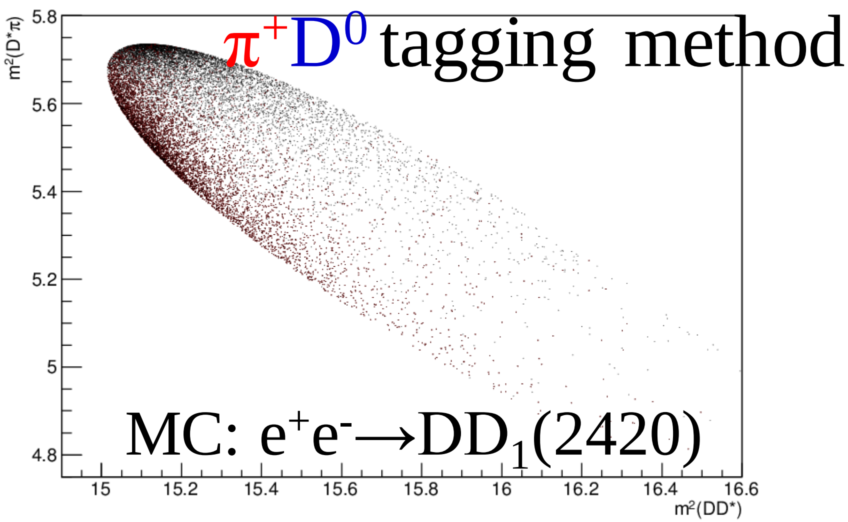


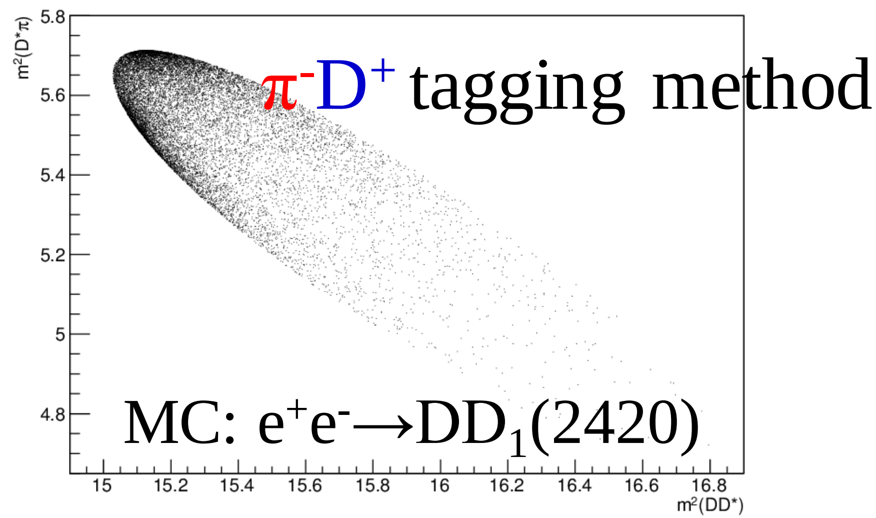
Using the function $(x-3.87)^c(4.11-x)^d$ as the background shape
We named the new structure as "Zc(3885)"

Dalitz Plot


π^+D^0 tagging method
Data
$M^2(D^{*-}\pi^+)$
$M^2(D^0D^{*-})$


π^-D^+ tagging method
Data
$M^2(\bar{D}^{*0}\pi^-)$
$M^2(D^+\bar{D}^{*0})$

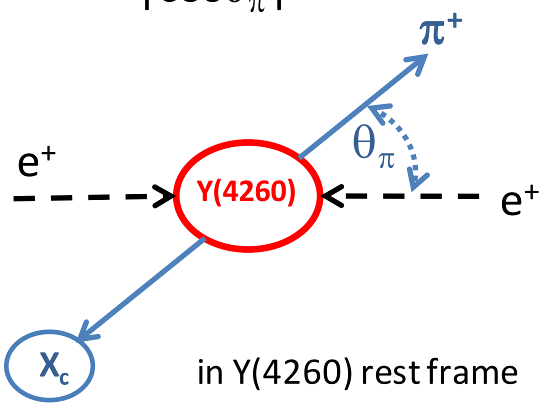

π^+D^0 tagging method
MC: $e^+e^-\rightarrow DD_1(2420)$
$m^2(D^*\pi)$
$m^2(DD^*)$


π^-D^+ tagging method
MC: $e^+e^-\rightarrow DD_1(2420)$
$m^2(D^*\pi)$
$m^2(DD^*)$

Angular distributions

-consider only lowest partial waves-

$|\cos\theta_\pi|$



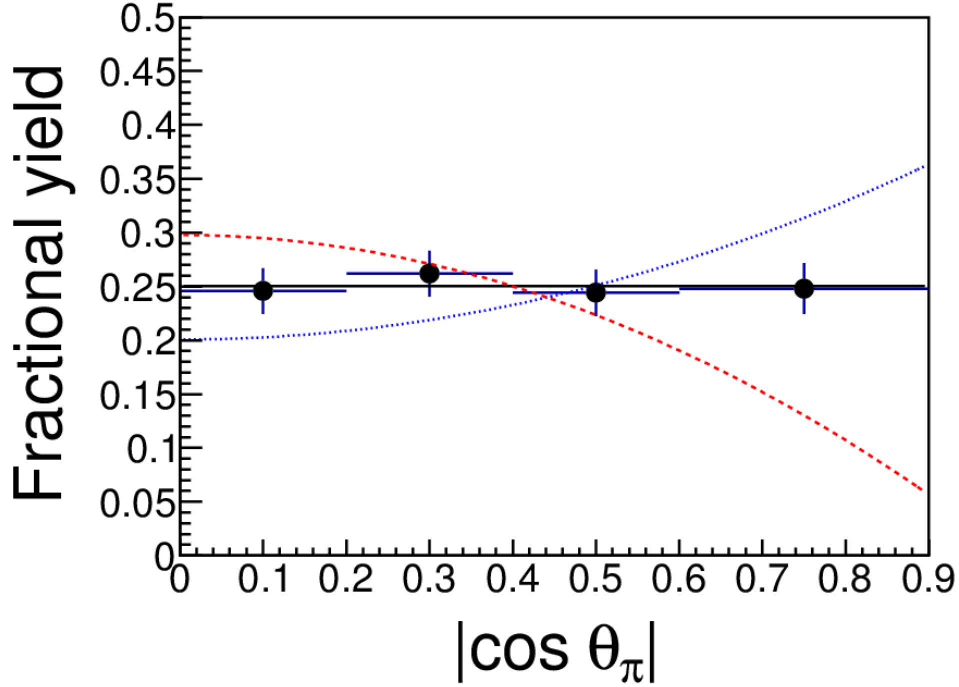
in Y(4260) rest frame

J^P	L	$dN/d\|\cos\theta_\pi\|$
1^+	S-wave	flat
0^-	P-wave	$\sin^2\theta_\pi$
1^-	P-wave	$1+\cos^2\theta_\pi$

$|\cos\theta_\pi|$ distributions in four bins

$\pi^+ D^0$ tagging method and $\pi^+ D^-$ tagging method

Averaged together



We can see the $|\cos\theta_\pi|$ distributions for both tagging methods are flat, suggesting the Zc(3885) is a 1^+ state

Cross Section Calculations
Assuming Isospin symmetry

- For the π^+D^0 tagging method, we use

$$\sigma(e^+e^- \to \pi^+ X_c^-) \times \mathcal{B}(X_c^- \to (D\bar{D}^*)^-) = \frac{N(X_c^- \to (DD^*)^-)}{\mathcal{L}(1+\delta)\mathcal{B}(D^0 \to K^-\pi^+)(\epsilon_1+\epsilon_2)/2} \quad (1)$$

$=(84.6 \pm 6.9)$pb

- For the π^-D^+ tagging method, we use

$$\sigma(e^+e^- \to \pi^- X_c^+) \times \mathcal{B}(X_c^+ \to (D\bar{D}^*)^+) = \frac{N(X_c^+ \to (DD^*)^+)}{\mathcal{L}(1+\delta)\mathcal{B}(D^+ \to K^-\pi^+\pi^+)[\epsilon_1+\mathcal{B}(D^{*+} \to \pi^0 D^+)\epsilon_2]/2} \quad (2)$$

$=(82.3 \pm 6.3)$pb

The cross sections for the two tagging methods are consistent.

Systematical Errors

Source	Mass(MeV)	Width(MeV)	Cross Section(%)
Tracking &PID	/	/	±4/6
D mass	/	/	±1
D^0 & D^+ BFs	/	/	±1
Kinematic Fit	/	/	±4
Signal shape	±1/2	±3	±5
Bg Shape	±4.0/3.8	±10.4/10.7	±24
Line shape	/	/	±0.6
MC efficiency			±6/3
Luminosity	/	/	±1
Rad. Corr.	/	/	±5
Total	±4.1/4.3	±10.8/11.1	±26.4/26.3

Are Zc (3885)$^{\pm}$ and $Z_c(3900)^{\pm}$ the same?

Zc(3885) and Z_c(3900) Comparison

	Zc(3885)(MeV)	Zc(3900)(MeV)
Mass	~3883.9 ± 1.5 ± 4.2	3899 ± 3.6 ± 4.9
Width	~24.8 ± 3.3 ± 11.0	46 ± 10 ± 26
Number of events	502/710	307 ± 48
Production cross section	83.5 ± 6.6 ± 22pb	13.5 ± 2.1 ± 4.8pb

If Zc(3885)=Zc(3900), $\frac{Br(Zc\to DD^{*})}{Br(Zc\to \pi J/\psi)} \approx 6.2 \pm 1.1 \pm 2.7$

Paper submitted (Arxiv:1310.1163)

arXiv.org > hep-ex > arXiv:1310.1163

Search or

High Energy Physics - Experiment

Observation of a charged (DD*bar)- mass peak in e+e- --> pi+ (DD*bar)- at Ecm=4.26 GeV

M. Ablikim, M. N. Achasov, O. Albayrak, D. J. Ambrose, for the BESIII Collaboration

(Submitted on 4 Oct 2013 (v1), last revised 8 Oct 2013 (this version, v2))

We report on a study of the process e+e- --> pi+(D D*bar)- at Ecm=4.26 GeV using a 525 /pb data sample collected with the BESIII detector at the BEPCII storage ring. A distinct charged structure is observed in the (DD*bar)- invariant mass distribution. When fitted to a mass-dependent-width Breit-Wigner lineshape, the pole mass and width are determined to be M_pole=(3883.9 +- 1.5 +- 4.2) MeV and Gamma_pole=(24.8 +- 3.3 +- 11.0) MeV. The mass and width of the structure, which we refer to as Z_c(3885), are 2sigma and 1sigma, respectively, below those of the Z_c(3900) --> pi+J/psi peak observed by BESIII and Belle in pi+pi-J/psi final states produced at the same center-of-mass energy. The angular distribution of the pi Z_c(3885) system favors a JP=1+ quantum number assignment for the structure and disfavors 1- or 0-. The Born cross section times the DD*bar branching fraction of the Z_(3885) is measured to be sigma(e+e- --> pi+ Z_c(3885)-) x Bf(Z_c(3885)-->DD*bar)=(83.5 +-6.6 +- 22.0) pb. Assuming the Z_c(3885) --> DD*bar signal reported here and the Z_c(3900) --> pi J/psi signal are from the same source, the partial width ratio Gamma(Z_c(3885) --> DD*bar)/Gamma(Z_c(3900) -->pi J/psi)=6.2 +- 1.1 +- 2.7 is determined.

Comments:	7 pages, 3 figures and 3 tables, submitted for publication in Physical Review Letters, references added
Subjects:	**High Energy Physics - Experiment (hep-ex)**
Cite as:	**arXiv:1310.1163 [hep-ex]**
	(or **arXiv:1310.1163v2 [hep-ex]** for this version)

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From: Stephen L. Olsen [view email]
[v1] Fri, 4 Oct 2013 04:36:05 GMT (516kb)
[v2] Tue, 8 Oct 2013 02:26:58 GMT (516kb)

Comments from PRL referees

All three referees recommend for publication in PRL

LK13824/Ablikim

The paper is well written and the analysis is sound and well-done. The results shown in the paper are very important. I suggest to publish (Phys. Rev. Lett.) this paper draft as soon as possible.

The observation is a key measurement towards the understanding of exotic bound states, and the publication will likely generate a lot of interest, as well as trigger future experimental and theoretical work. Therefore I recommend publication in PRL.

This paper reports a significant new result and definitely merits publication in PRL. Some comments and suggestions for improvement follow.

Current status of the paper

- We prepared the revised manuscript and reply to comments.
- The paper will be resubmitted soon.

Thanks