Overview on BESIII Results

Magnus Wolke Department of Physics and Astronomy

UPPSALA UNIVERSITET

Overview on BESIII Results

Focus: Charmonium-like states

Magnus Wolke Department of Physics and Astronomy

UPPSALA UNIVERSITET

Beijing **E**lectron-**P**ositron **C**ollider BEPCII

- symmetric e^+e^- collider
- $\sqrt{s}$ = 2.0 – 4.6 GeV
- design luminosity
  $1 \cdot 10^{33}$ $cm^{-2}s^{-1}$ (at $\psi(3770)$)
- energy spread ~$5 \cdot 10^{-4}$

BESIII

BEijing Spectrometer BESIII at BEPCII

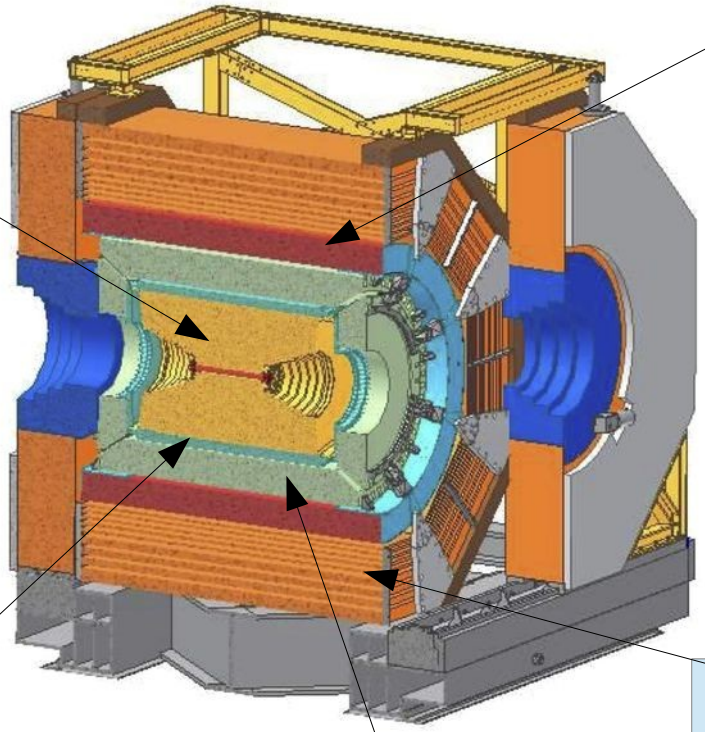
τ - charm factory

- charmonium spectroscopy, decays
- light hadron physics
- charm physics
- τ physics
- R scan

The BESIII Detector

Drift Chamber (MDC)
σP/P = 0.5% (1 GeV)
σ(dE/dx) = 6%

Superconducting magnet (1.0 Tesla)

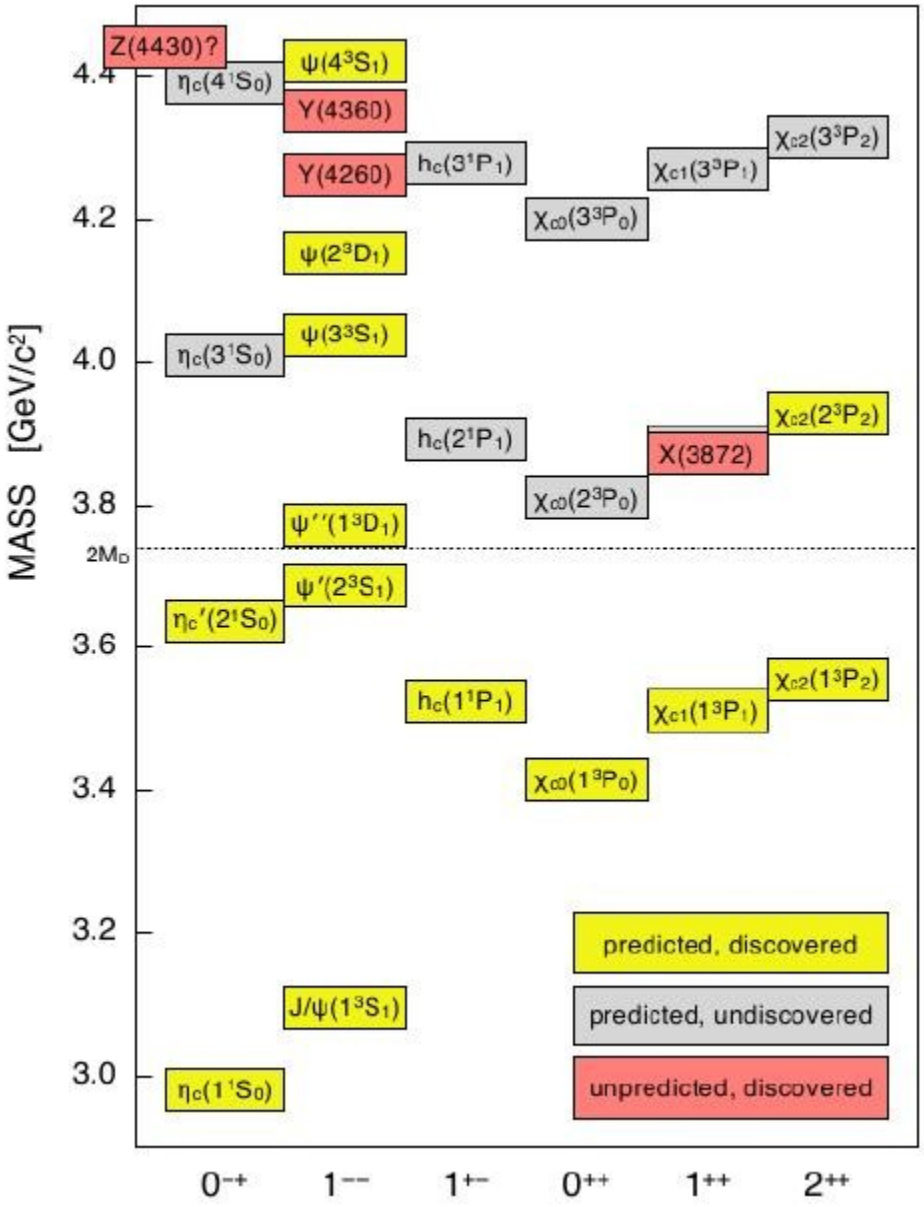


Time-of-Flight (TOF)
σ(t): 90 ps barrel
110 ps endcap

EMC (CsI)
σE/√E = 2.5% (1 GeV)
$\sigma_{x,\varphi}$ = 0.5 – 0.7 cm / √E

μ Counter
8-9 layers RPC
δR_{Φ} = 1.4 – 1.7 cm

Charmonium(-like) states before 2013



above open charm threshold:

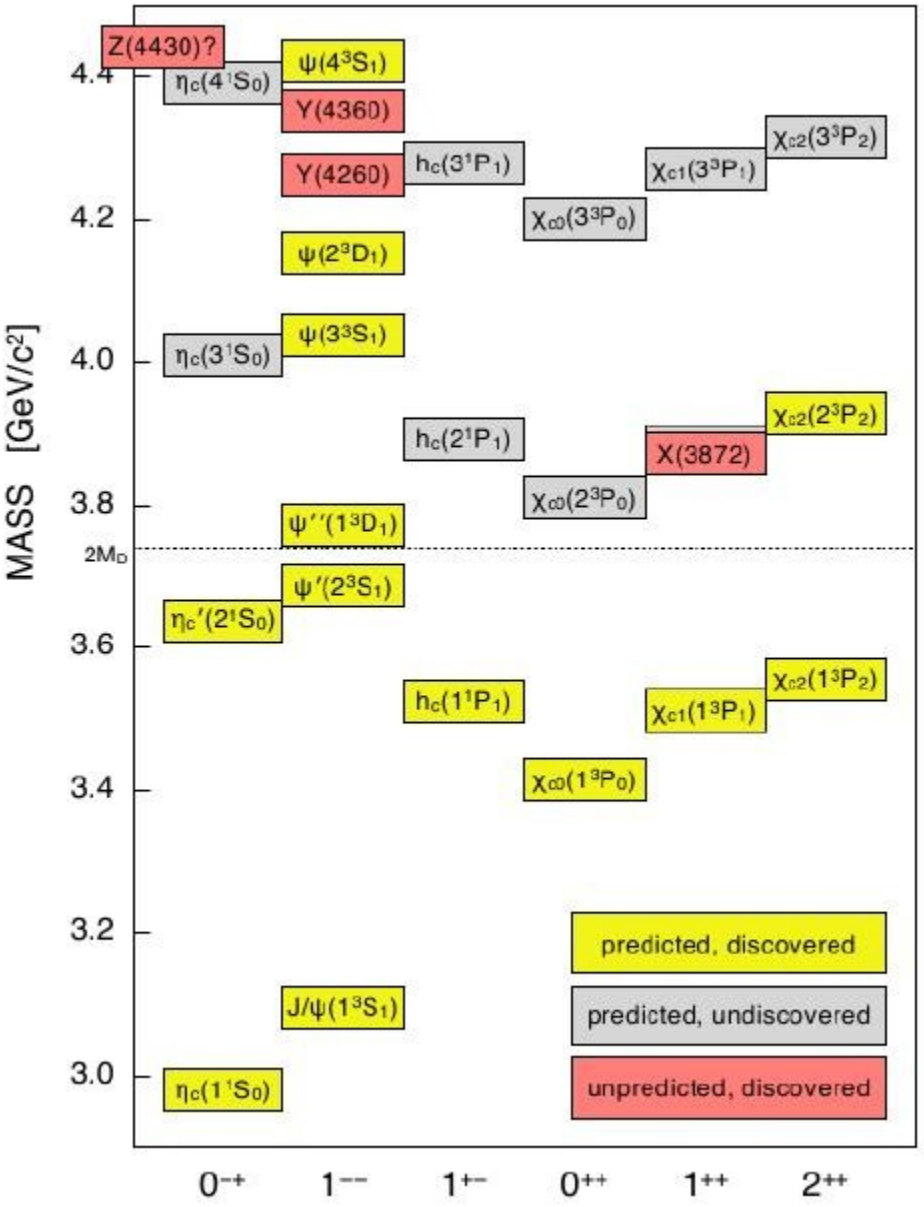
only few predicted states found

new states observed with properties different from expectations: **X,Y,Z states**

below open charm threshold:

good agreement between predicted and observed states

X, Y, Z states



Nomenclature:
(not valid for all states)

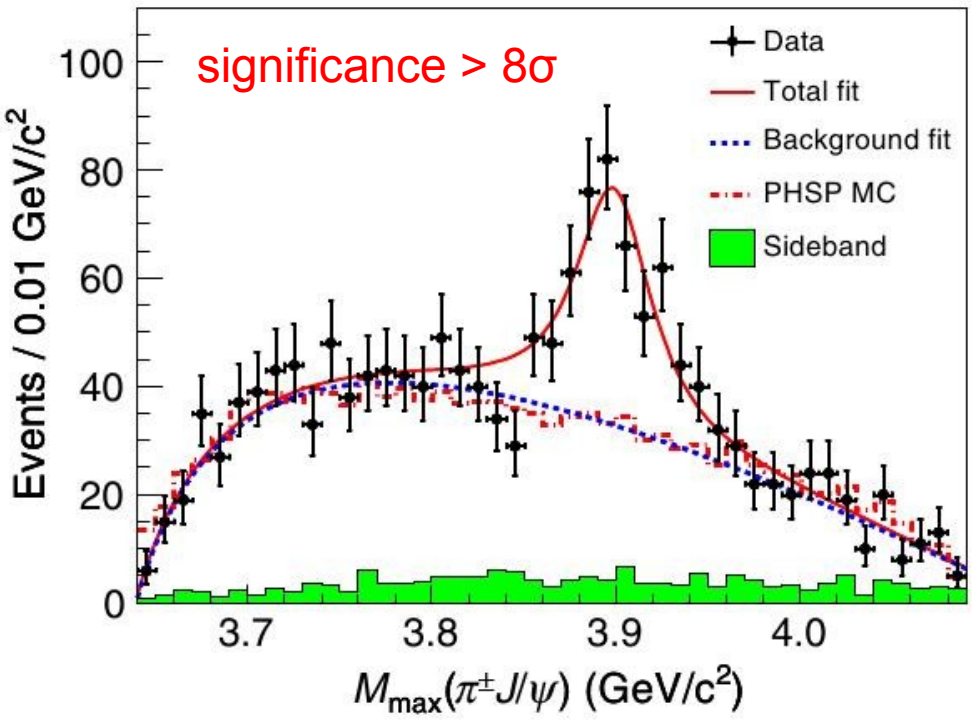
X: charmonium-like with J^{PC} different from 1^{--}
observed in B decays, pp, $p\bar{p}$

Y: charmonium-like with $J^{PC} = 1^{--}$
observed in e^+e^- annihilation, ISR

Z: charmonium-like, charged
must contain $c\bar{c}$ and light $q\bar{q}$ pair

Discovery of $Z_c^{\pm}(3900)$ in $e^+e^- \to \pi^+\pi^- J/\psi$

PRL 110 (2013) 252001 0.5 fb^{-1} 4.26 GeV



$Z_c^{\pm}(3900)$:

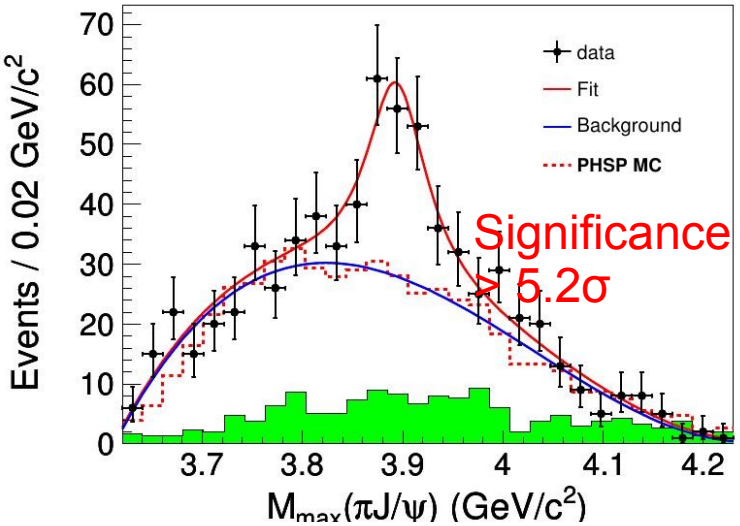
$m = (3899.0 \pm 3.6 \pm 4.9)$ MeV/c^2

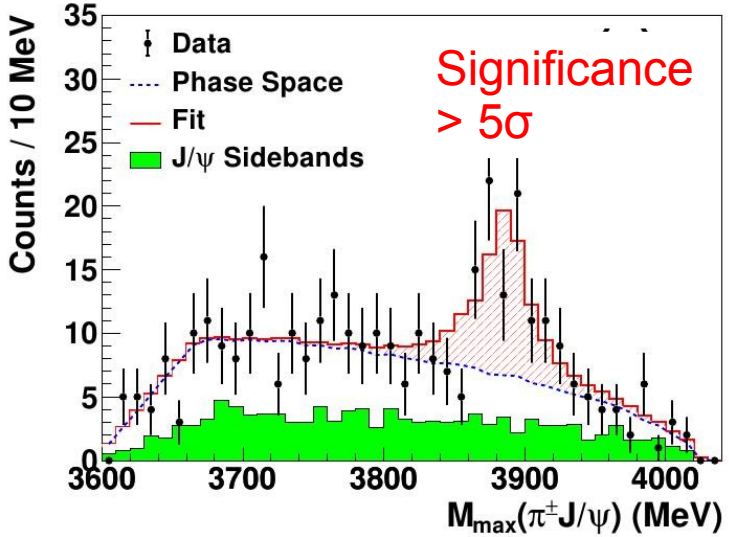
$\Gamma = (46 \pm 10 \pm 20)$ MeV

close to $D\bar{D}^*$ threshold
decays to J/Ψ → contains $c\bar{c}$
electric charge → contains $u\bar{d}$

→ contains at least 4 quarks

Confirmation of $Z_c^{\pm}(3900)$ in $e^+e^- \to \pi^+\pi^- J/\psi$





Belle: $e^+e^- \to \gamma_{ISR}\pi^+\pi^- J/\psi$

$m = (3894.5 \pm 6.6 \pm 4.5)$ MeV/c^2

$\Gamma = (63 \pm 24 \pm 26)$ MeV

PRL 110 (2013) 252002

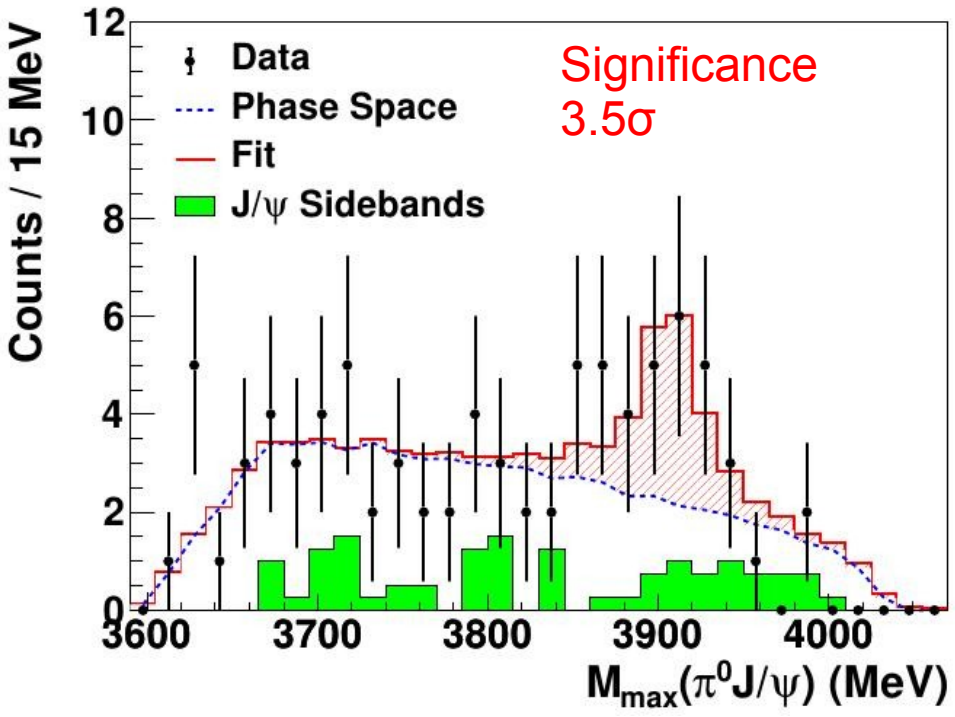
CLEO-c:

$m = (3886 \pm 4 \pm 2)$ MeV/c^2

$\Gamma = (37 \pm 4 \pm 8)$ MeV

PLB 727 (2013) 366 4.17 GeV

Evidence for $Z_c^0(3900)$ in $e^+e^- \to \pi^0\pi^0 J/\psi$



CLEO-c:

$m = (3904 \pm 9)$ MeV/c^2

Γ fixed to width of $Z_c^+(3900)$

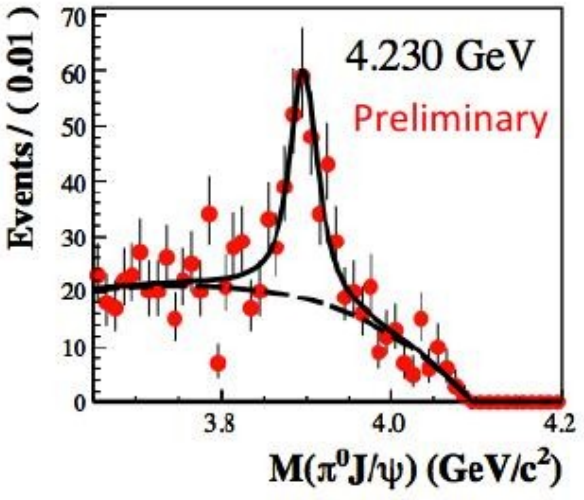
PLB 727 (2013) 366 4.17 GeV

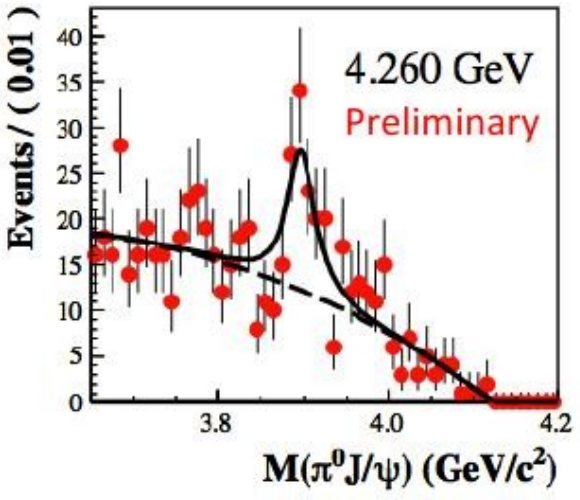
if confirmed, this would establish the **isospin triplet $Z_c^{\pm,0}(3900)$**

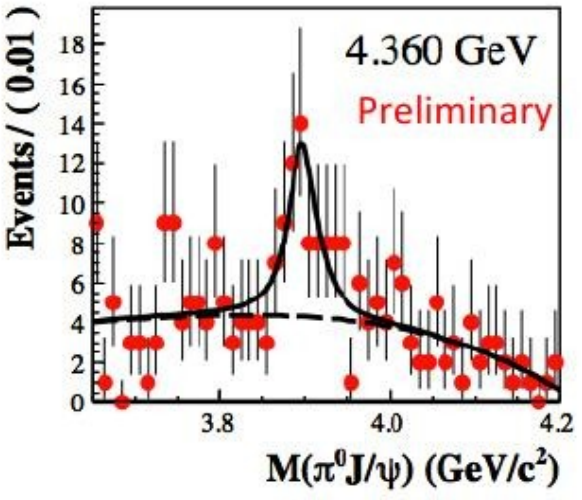
New BESIII analysis for $Z_c^0(3900)$ in $e^+e^- \to \pi^0\pi^0 J/\psi$

2.8 fb^{-1} data at 10 energies 4.19 – 4.42 GeV

observation of $Z_c^0(3900) \to \pi^0 J/\psi$ in $e^+e^- \to \pi^0\pi^0 J/\psi$ (> 10σ)







$Z_c^0(3900)$:

$m = (3894.8 \pm 2.3)$ MeV/c^2

$\Gamma = (29.6 \pm 8.2)$ MeV

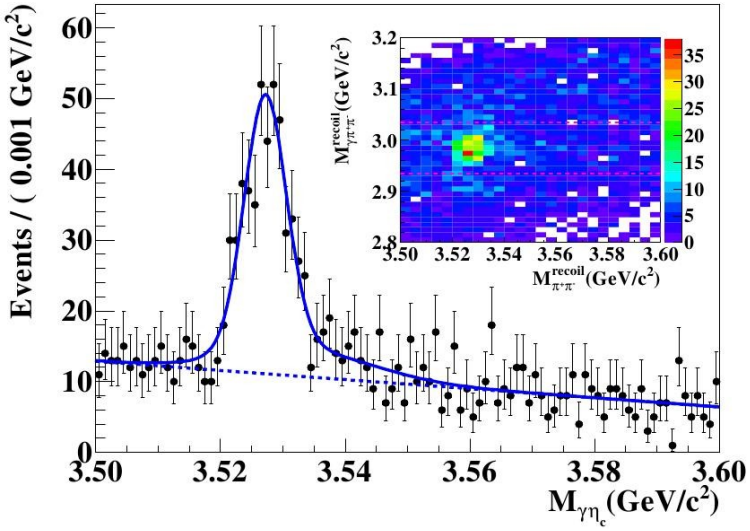
isospin triplet $Z_c^{\pm,0}(3900)$ confirmed

preliminary

Study of $e^+e^- \to h_c \pi\pi$

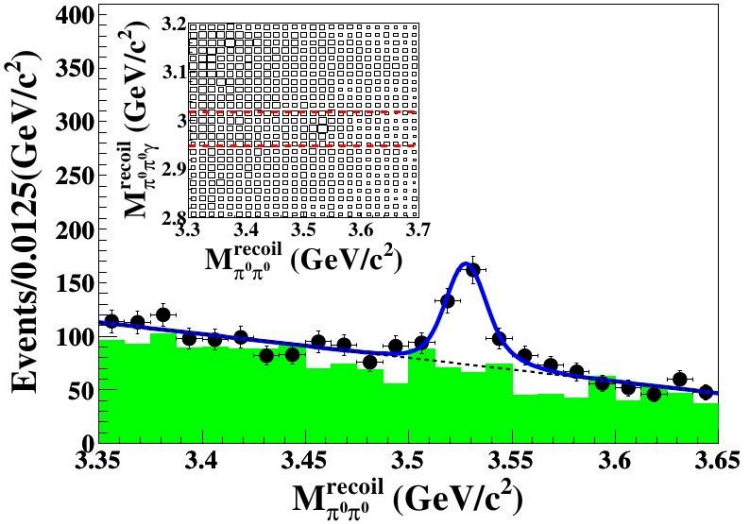
$e^+e^- \to \pi^+\pi^- h_c$

PRL 111 (2013) 242001 4.26 GeV



first observation of $e^+e^- \to \pi^0\pi^0 h_c$

1409.6577 [hep-ex] 4.23, 4.26, 4.36 GeV



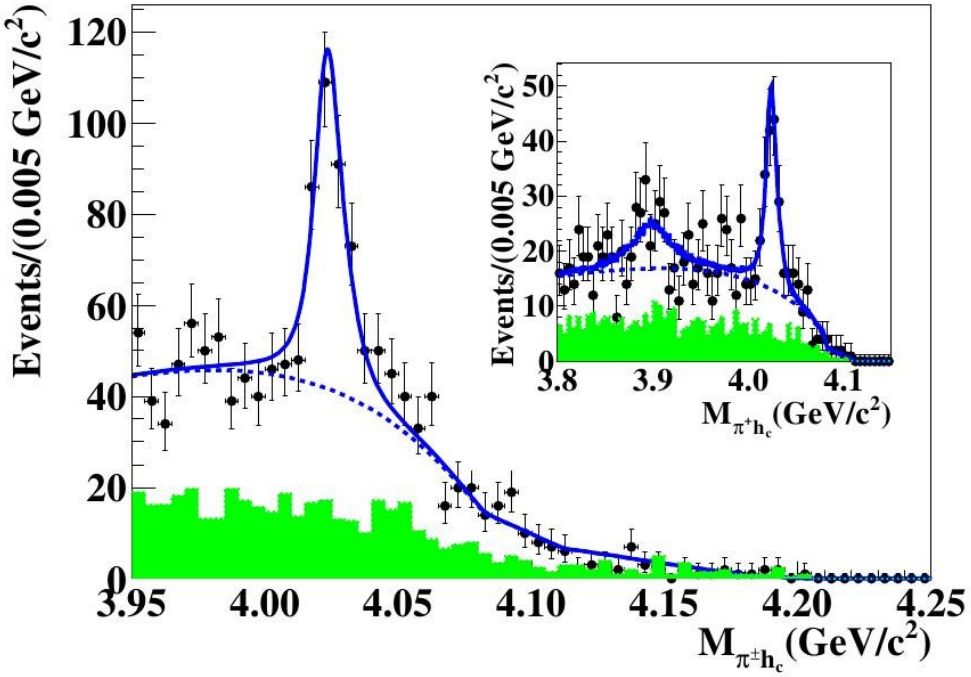
reconstruction of $h_c \to \eta_c\gamma$ including 16 hadronic η_c decay modes

➡ search for resonances decaying into $h_c\pi^\pm$ and $h_c\pi^0$

Observation of $Z_c^{\pm}(4020)$

first observation of $Z_c^{\pm}(4020) \to \pi^{\pm} h_c$ in $e^+e^- \to \pi^+\pi^- h_c$

PRL 111 (2013) 242001 4.23, 4.26, 4.36 GeV



$Z_c^{\pm}(4020)$:

$m = (4022.9 \pm 0.8 \pm 2.7)$ MeV/c^2

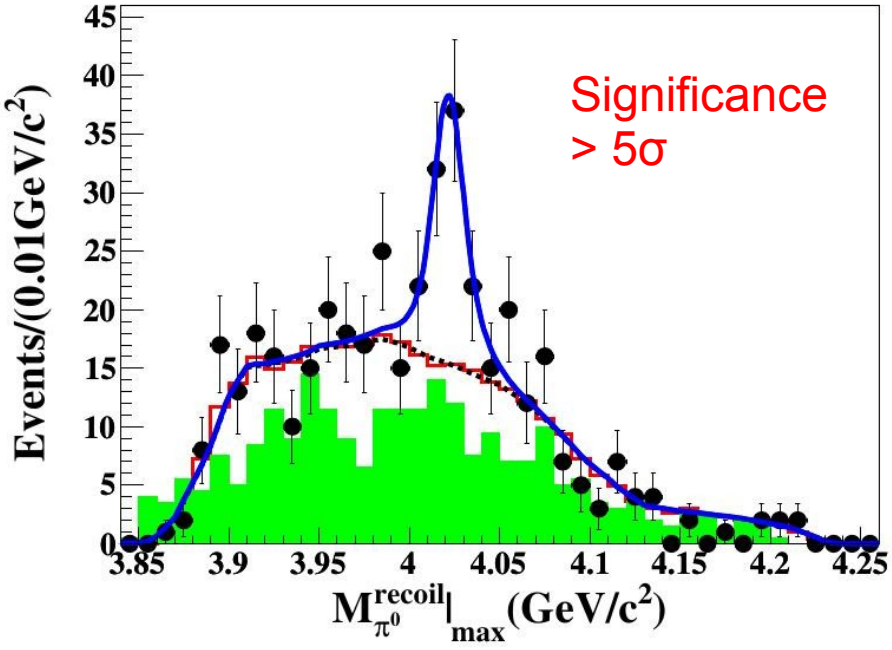
$\Gamma = (7.9 \pm 2.7 \pm 2.6)$ MeV

close to $(D^*\bar{D}^*)^{\pm}$ threshold

...and evidence for $Z_c^0(4020)$

$Z_c^0(4020) \to \pi^0 h_c$ in $e^+e^- \to \pi^0\pi^0 h_c$

1409.6577 [hep-ex] 4.23, 4.26, 4.36 GeV



$Z_c^0(4020)$:

$m = (4023.6 \pm 2.2 \pm 3.9)$ MeV/c^2

Γ fixed to width of $Z_c^+(4020)$

isospin triplet $Z_c^{\pm,0}(4020)$ most likely

$(D\bar{D}^{*})$ system

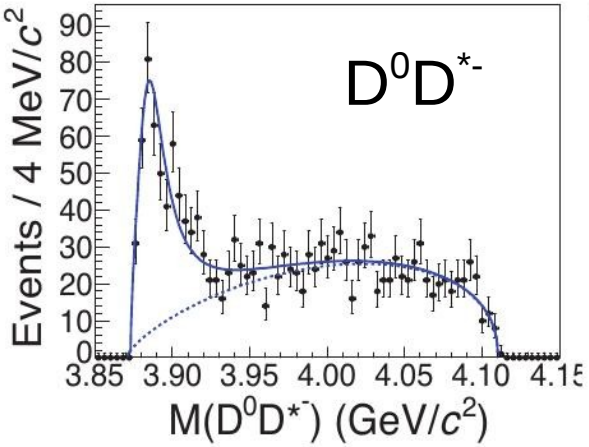
$e^+e^- \to \pi^\pm (D\bar{D}^{*})^\pm$

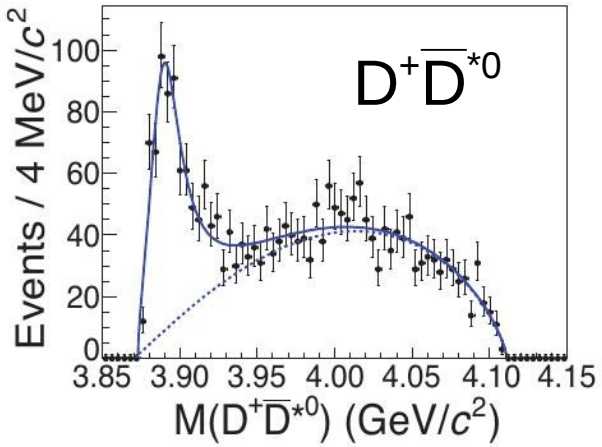
PRL 112 (2014) 022001 4.26 GeV

both channels:
enhancement at $(D\bar{D}^{*})$-threshold

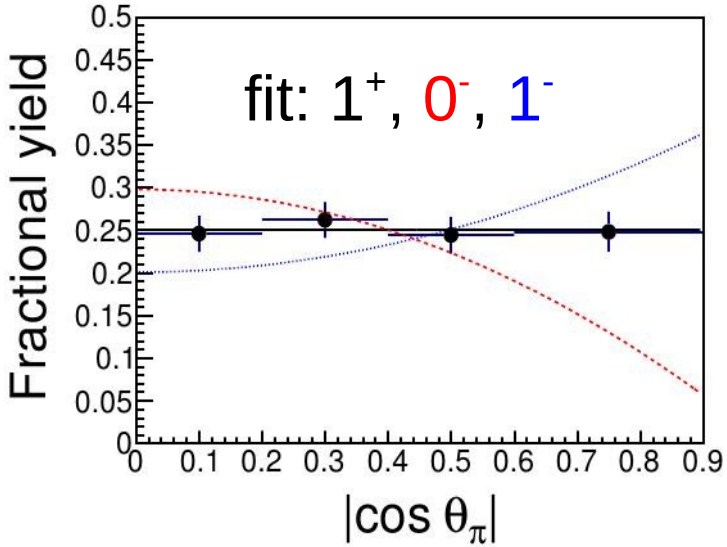
BW-fit of $Z_c(3885)$:

$m = (3883.9 \pm 1.5 \pm 4.2)$ MeV/c^2
$\Gamma = (24.8 \pm 3.3 \pm 11.0)$ MeV





very similar to $Z_c^+(3900)$ → same state? → coupled channel analysis mandatory



fit to angular distribution
favors $J^P = 1^+$

$(D^{*}\bar{D}^{*})$ system

$e^{+}e^{-} \rightarrow \pi^{\pm}(D^{*}\bar{D}^{*})^{\pm}$

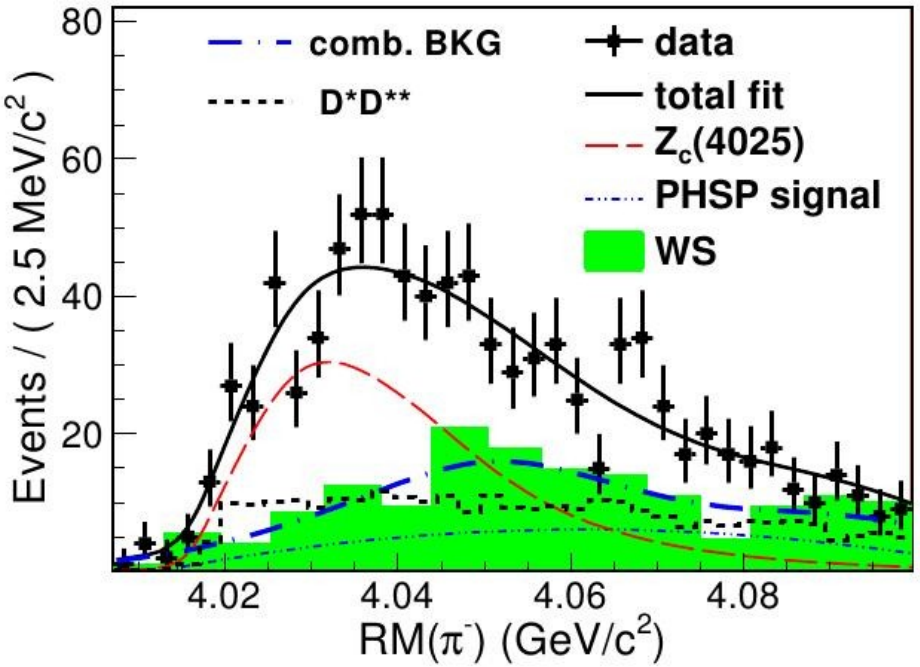
enhancement at $(D\bar{D}^{*})$-threshold

BW-fit of $Z_c(4025)$:

$m = (4026.3 \pm 2.6 \pm 3.7)$ MeV/c^2

$\Gamma = (24.8 \pm 5.6 \pm 7.7)$ MeV

PRL 112 (2014) 132001 4.26 GeV



π^{-} recoil mass from $e^{+}e^{-} \rightarrow \pi^{-}D^{*+}\bar{D}^{*0}$

very similar to $Z_c^{+}(4020)$ → same state? → coupled channel analysis mandatory

Z_c states at BESIII

channel	mass [MeV]	width [MeV]	
$J/\Psi\pi^{\pm}$	$3899.0 \pm 3.6 \pm 4.9$	$46 \pm 10 \pm 20$	$Z_c(3900)$ (I=1)
$J/\Psi\pi^{0}$	3894.8 ± 2.3	29.6 ± 8.2 (prel.)	
$(D\bar{D}^*)$	$3883.9 \pm 1.5 \pm 4.2$	$24.8 \pm 3.3 \pm 11.0$	$Z_c(3885)$? $D\bar{D}^*$ thresh 3875 MeV
$h_c\pi^{\pm}$	$4022.9 \pm 0.8 \pm 2.7$	$7.9 \pm 2.7 \pm 2.6$	$Z_c(4020)$ (I=1)
$h_c\pi^{0}$	$4023.6 \pm 2.2 \pm 3.9$	fixed	
$(D^*\bar{D}^*)$	$4026.3 \pm 2.6 \pm 3.7$	$24.0 \pm 5.6 \pm 7.7$	$Z_c(4025)$? $D^*\bar{D}^*$ thresh 4017 MeV

states must contain at least four quarks – what is their nature?

tetraquarks (Maiani, Ali et al.)

hadronic molecules (Meissner, Guo et al.)

hadro-charmonia (Voloshin)

meson loop (Zhao et al.)

ISPE model (Liu et al.)

Z_c states at BESIII

channel	mass [MeV]	width [MeV]	
$J/\Psi\pi^{\pm}$	$3899.0 \pm 3.6 \pm 4.9$	$46 \pm 10 \pm 20$	$Z_c(3900)$ (I=1)
$J/\Psi\pi^{0}$	3894.8 ± 2.3	29.6 ± 8.2 (prel.)	
$(D\bar{D}^*)$	$3883.9 \pm 1.5 \pm 4.2$	$24.8 \pm 3.3 \pm 11.0$	$Z_c(3885)$? $D\bar{D}^*$ thresh 3875 MeV
$h_c\pi^{\pm}$	$4022.9 \pm 0.8 \pm 2.7$	$7.9 \pm 2.7 \pm 2.6$	$Z_c(4020)$ (I=1)
$h_c\pi^{0}$	$4023.6 \pm 2.2 \pm 3.9$	fixed	
$(D^*\bar{D}^*)$	$4026.3 \pm 2.6 \pm 3.7$	$24.0 \pm 5.6 \pm 7.7$	$Z_c(4025)$? $D^*\bar{D}^*$ thresh 4017 MeV

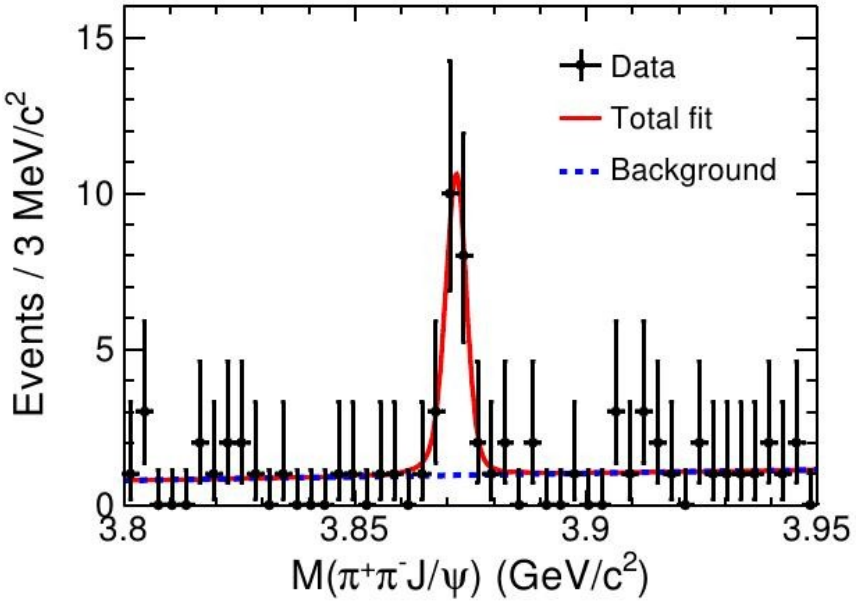
to be done:

determine J^{PC}

perform coupled-channel analysis of open/hidden charm channels

First observation of $e^+e^- \to \gamma X(3872)$

PRL 112 (2014) 092001 4.009, 4.229, 4.26, 4.36 GeV



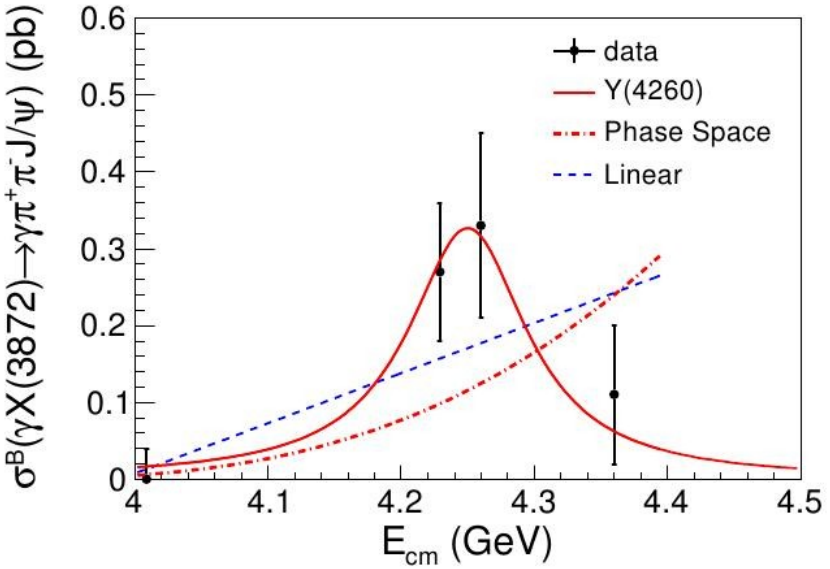
$e^+e^- \to \gamma X(3872) \to \gamma\pi^+\pi^- J/\Psi$

X(3872):

$m = (3871.9 \pm 0.7 \pm 0.2)\ \mathrm{MeV}/c^2$

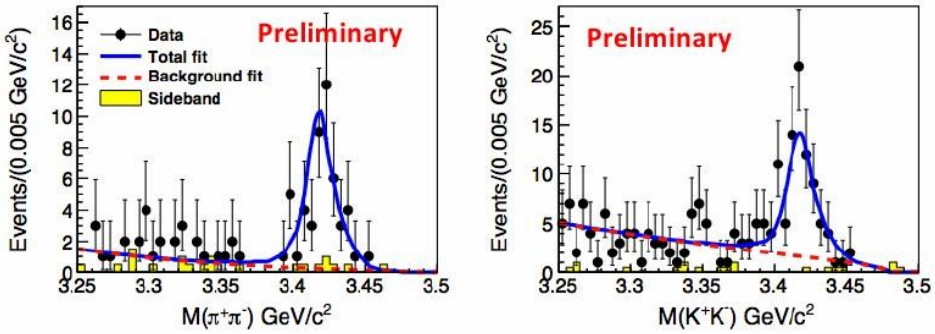
$\Gamma < 2.4$ MeV (90% cl)

cross section suggests production in Y(4260) decays

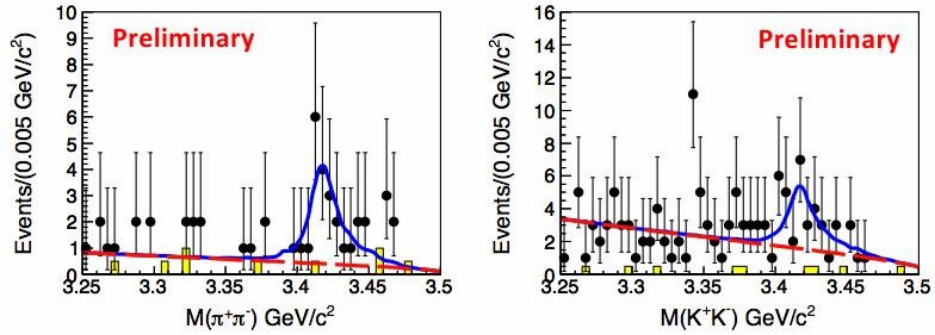


First observation of $e^+e^- \to \omega x_{c0}$

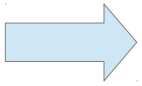
4.23 GeV



4.26 GeV



single BW fit:
mass lower
than Y(4260)

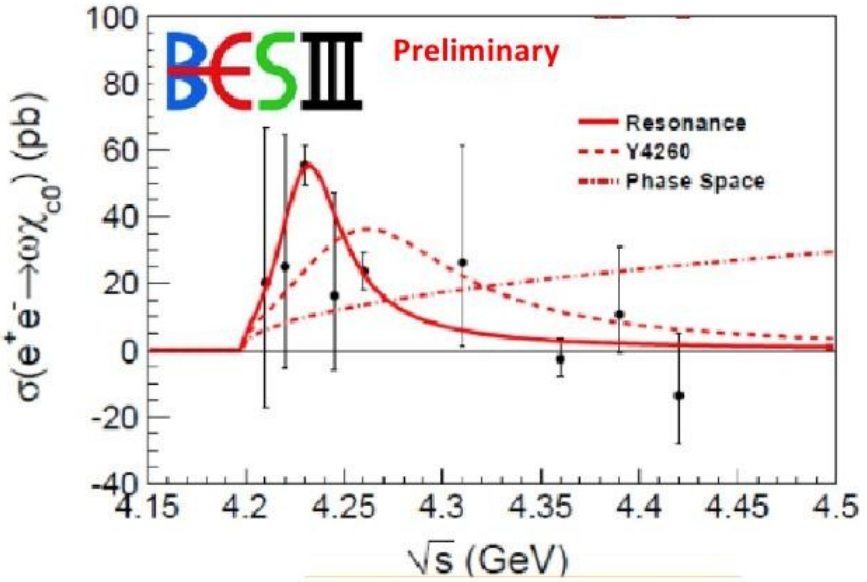


√S: 4.21 – 4.42 GeV

exclusive analysis $e^+e^- \to \omega\chi_{cJ}$

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

$\chi_{c0} \to \pi^+\pi^-, K^+K^-$ $\chi_{c1,2} \to \gamma J/\Psi$



Overview on BESIII Results

X, Y, Z charmonium-like states established, nature unclear

$Z_c(3900)$, $Z_c(4020)$ isospin triplets observed/confirmed

New BESIII data 4.26 – 4.42 GeV ⟶ more results soon

Magnus Wolke Department of Physics and Astronomy

UPPSALA UNIVERSITET

The BESIII Collaboration