Z_c and Z_b results

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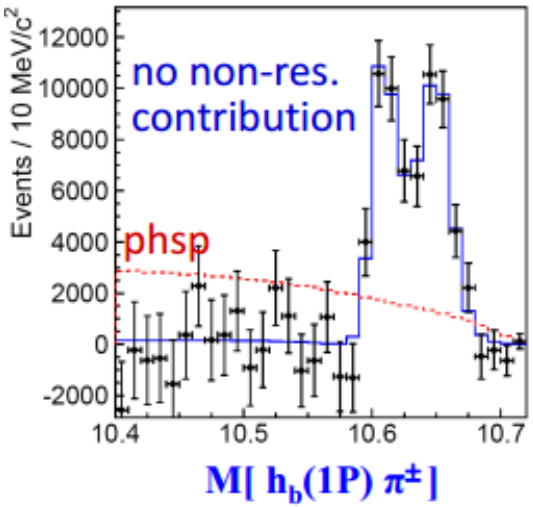
XYZ研讨会，北京

I. History of Z_b

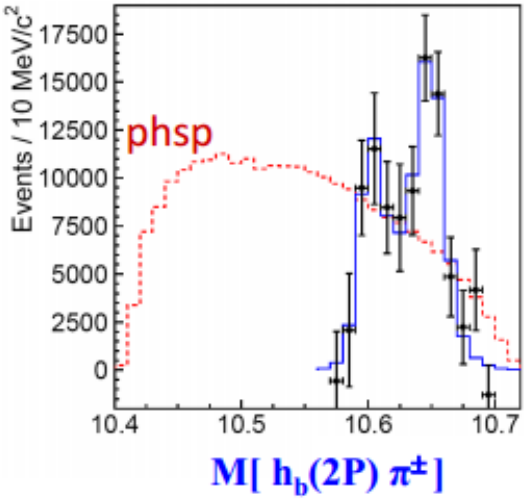
A brief history of Z_b

Belle PRL108,122001(2012)

$\Upsilon(5S) \to h_b(1P)\pi^+\pi^-$



$\Upsilon(5S) \to h_b(2P)\pi^+\pi^-$



Two peaks in all 5 modes

minimal quark content

$| b\bar{b}u\bar{d} \rangle$

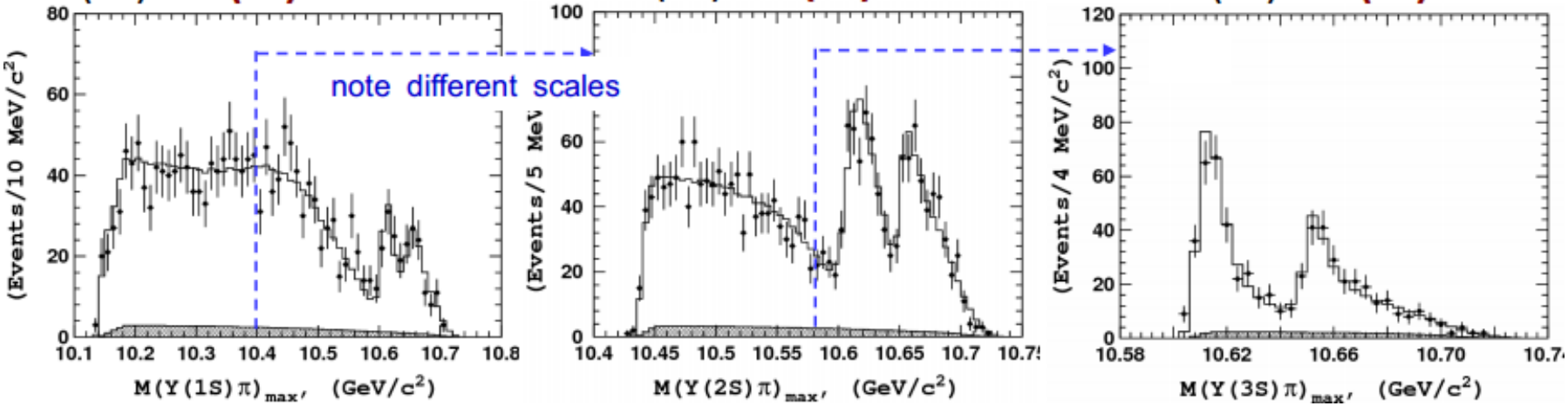
flavor-exotic states

Dalitz plot analysis

$\Upsilon(5S) \to \Upsilon(1S)\pi^+\pi^-$

$\Upsilon(5S) \to \Upsilon(2S)\pi^+\pi^-$

$\Upsilon(5S) \to \Upsilon(3S)\pi^+\pi^-$



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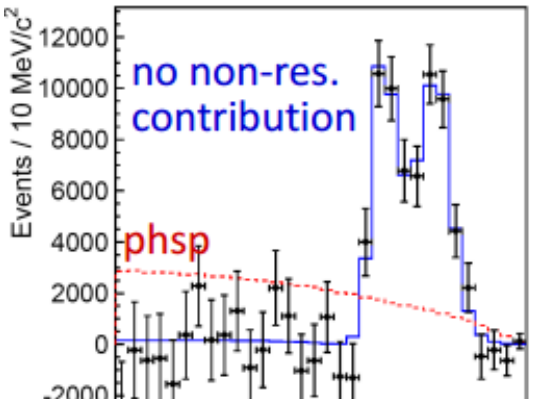

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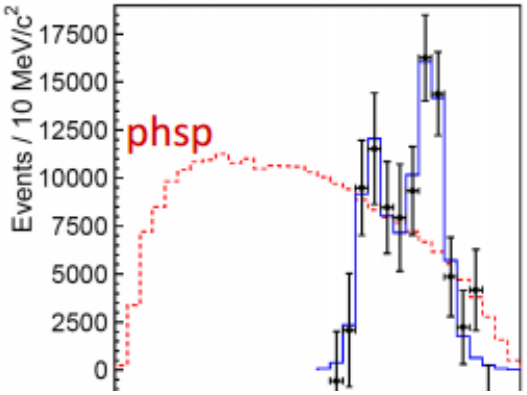

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Fit results

Average over 5 channels

$M_1 = 10607.2 \pm 2.0$ MeV

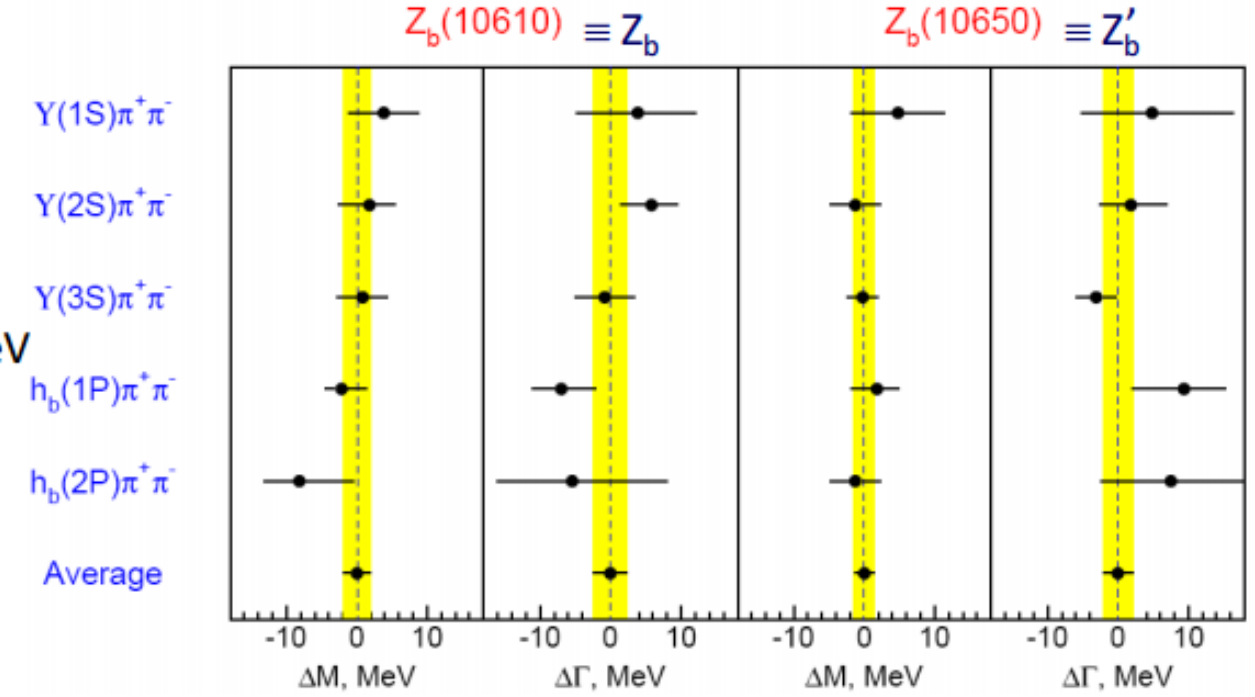
$\Gamma_1 = 18.4 \pm 2.4$ MeV

$M_{Zb} - (M_B + M_{B^*}) = +2.6 \pm 2.1$ MeV

$M_2 = 10652.2 \pm 1.5$ MeV

$\Gamma_2 = 11.5 \pm 2.2$ MeV

$M_{Zb'} - 2M_{B^*} = +1.8 \pm 1.7$ MeV



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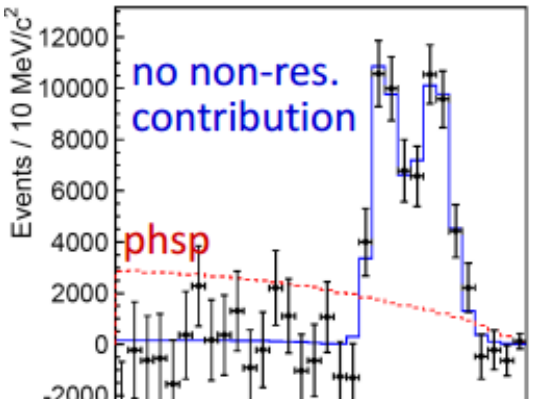

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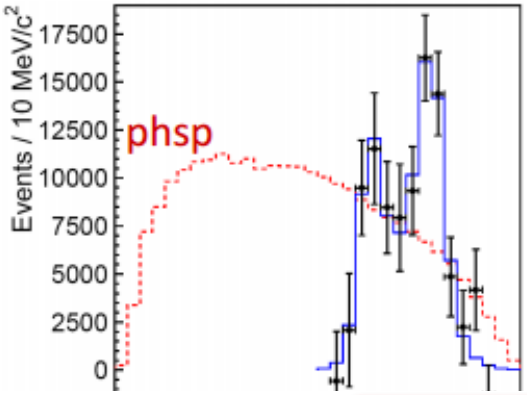

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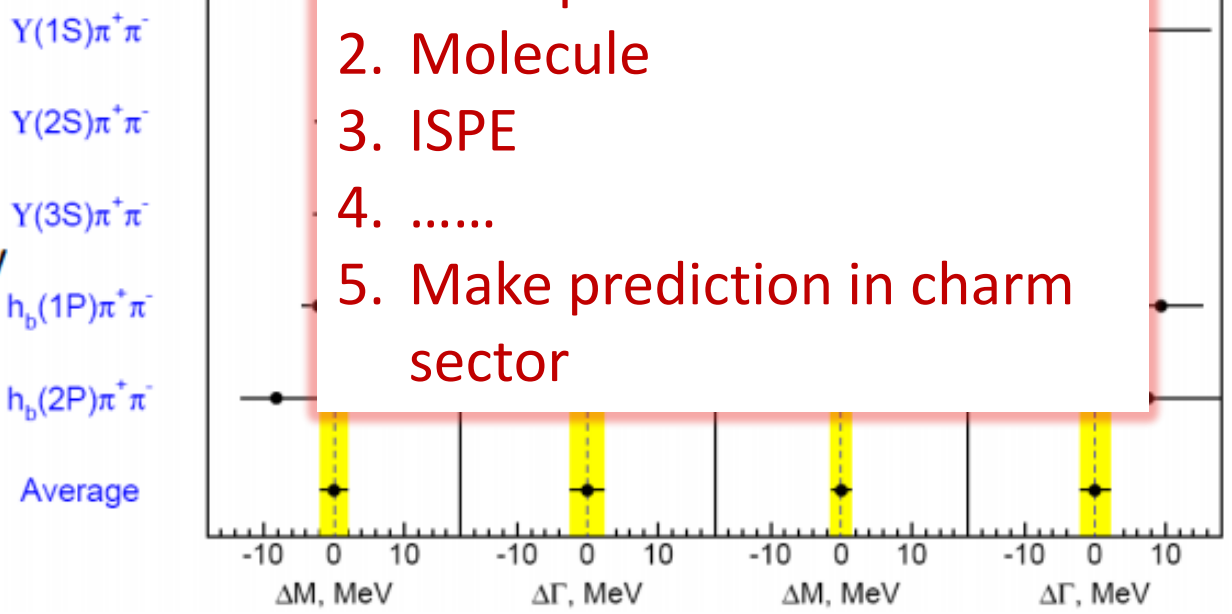
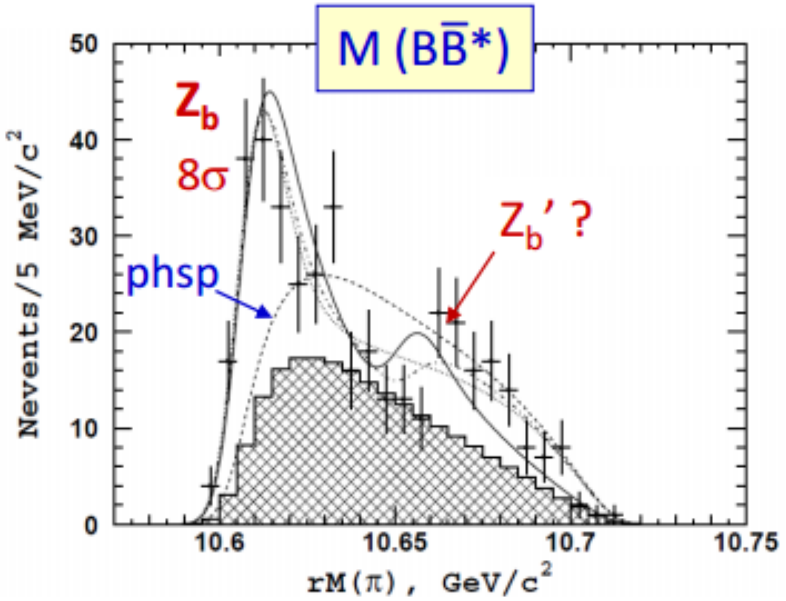
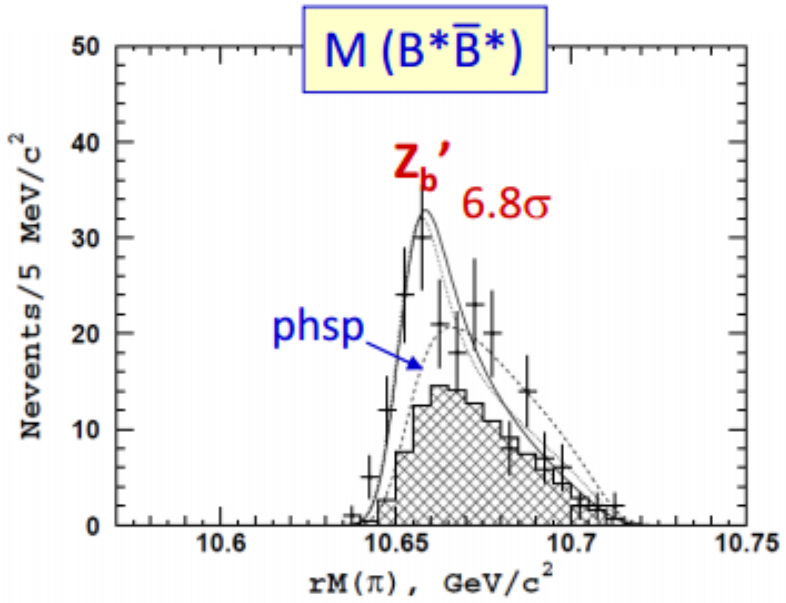


1. Tetraquark
2. Molecule
3. ISPE
4. ……
5. Make prediction in charm sector

Observation of $Z_b \to B\bar{B}^*$ and $Z_b' \to B^*\bar{B}^*$

arXiv:1209.6450





Channel	Fraction, %	
	$Z_b(10610)$	$Z_b(10650)$
$\Upsilon(1S)\pi^+$	0.32 ± 0.09	0.24 ± 0.07
$\Upsilon(2S)\pi^+$	4.38 ± 1.21	2.40 ± 0.63
$\Upsilon(3S)\pi^+$	2.15 ± 0.56	1.64 ± 0.40
$h_b(1P)\pi^+$	2.81 ± 1.10	7.43 ± 2.70
$h_b(2P)\pi^+$	4.34 ± 2.07	14.8 ± 6.22
$B^+\bar{B}^{*0} + \bar{B}^0 B^{*+}$	86.0 ± 3.6	$-$
$B^{*+}\bar{B}^{*0}$	$-$	73.4 ± 7.0

$BF[Z_b' \to B\bar{B}^*] = (25 \pm 10)\%$ insignificant

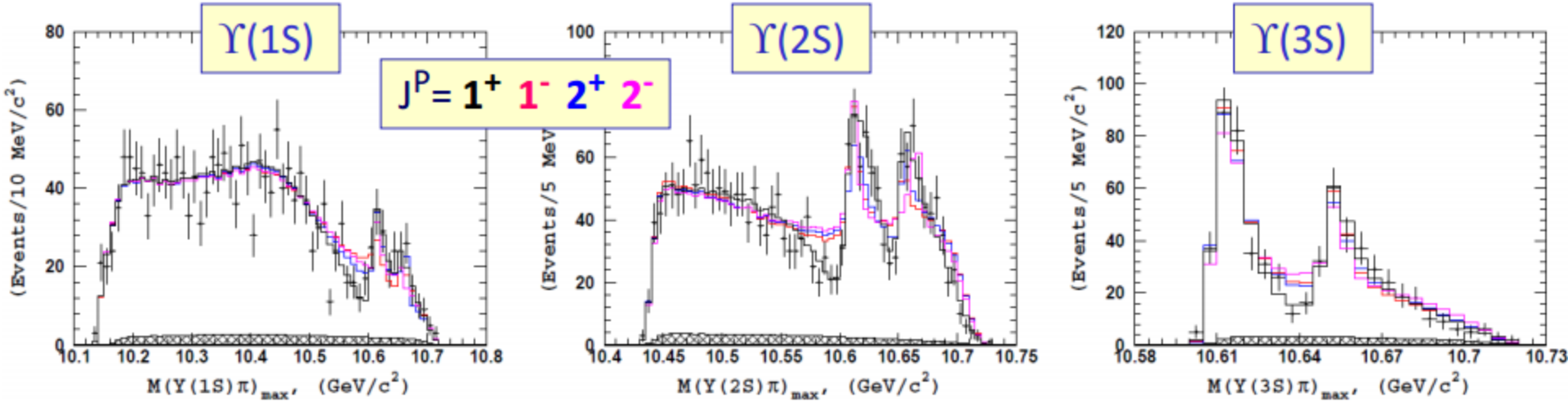
If included, other fractions of Z_b' are reduced by 1.33.

$Z_b' \to B\bar{B}^*$ is suppressed w.r.t. $B^*\bar{B}^*$ despite much larger PHSP.

Explanations:

Molecule ⇒ admixture of $B\bar{B}^*$ in Z_b' is small.
Challenging for tetraquark?

Comparison of spin-parity hypotheses



J^P hypothesis \ Decay Mode	$\Upsilon(1S)\pi^+\pi^-$	$\Upsilon(2S)\pi^+\pi^-$	$\Upsilon(3S)\pi^+\pi^-$	rejection power
1^+	0	0	0	
1^-	64	264	73	20σ
2^+	41	207	87	18σ
2^-	59	304	125	22σ

Δ2logL

Best discriminating power is in Υ(2S) channel where A_{Zb} and $A_{non\text{-}res}$ are of similar size.

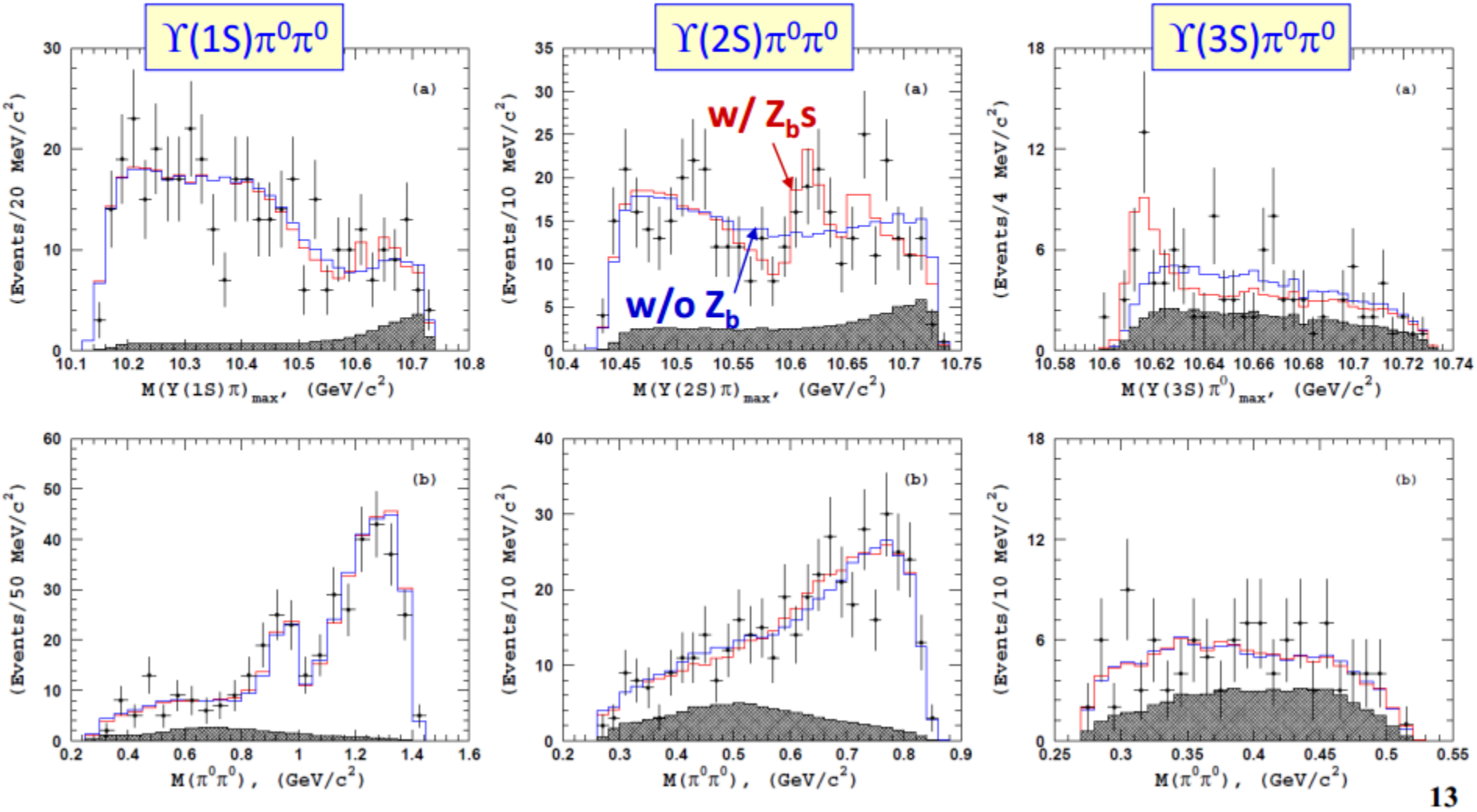
Spin-parity of $Z_b(10610)$ and $Z_b(10650)$ is $\mathbf{1^+}$. All other $J \leq 2$ are excluded.

As expected for S-wave molecule.

Dalitz plot analysis of $\Upsilon(5S)\to\Upsilon(nS)\pi^0\pi^0$

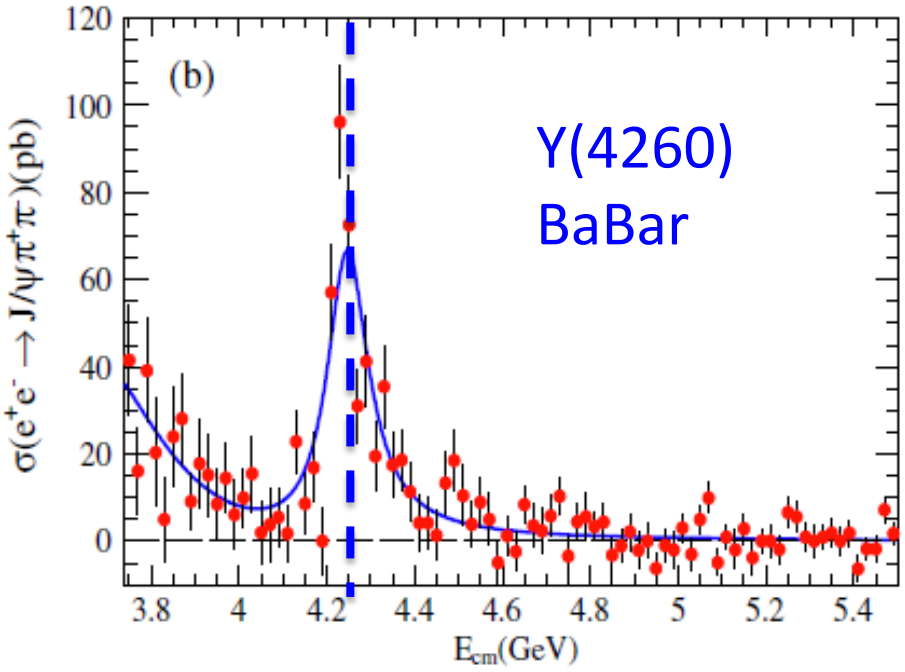
Analysis procedure is the same as for charged pions

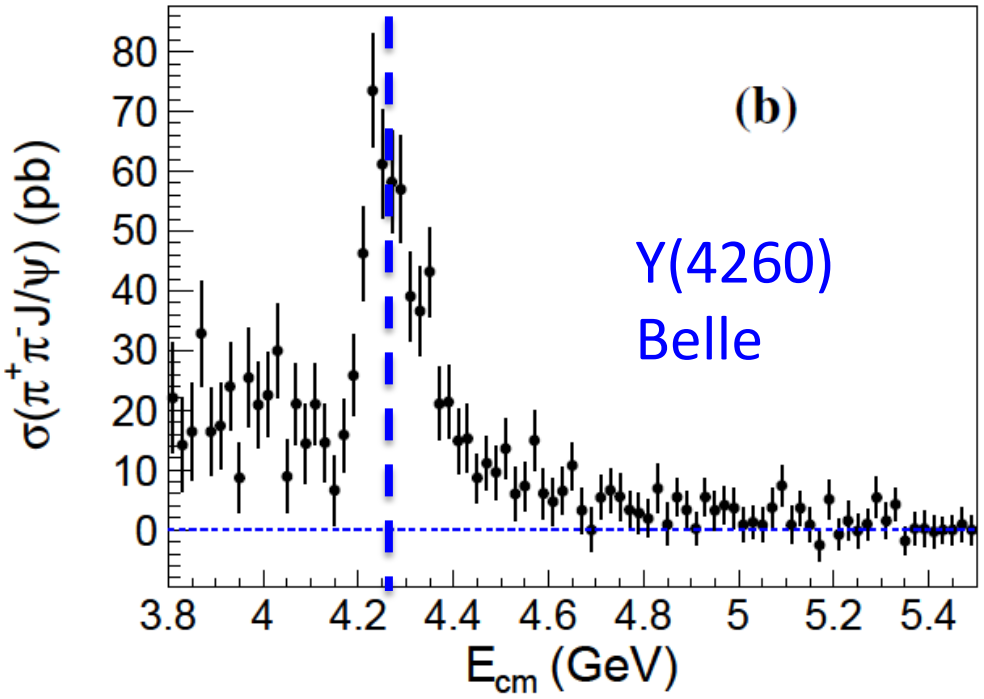
$$S(s1,s2) = A(Z_{b1}) + A(Z_{b2}) + A(f_0(980)) + A(f_2(1275)) + A_{NR}$$



II. Discovery of $Z_c(3900)$

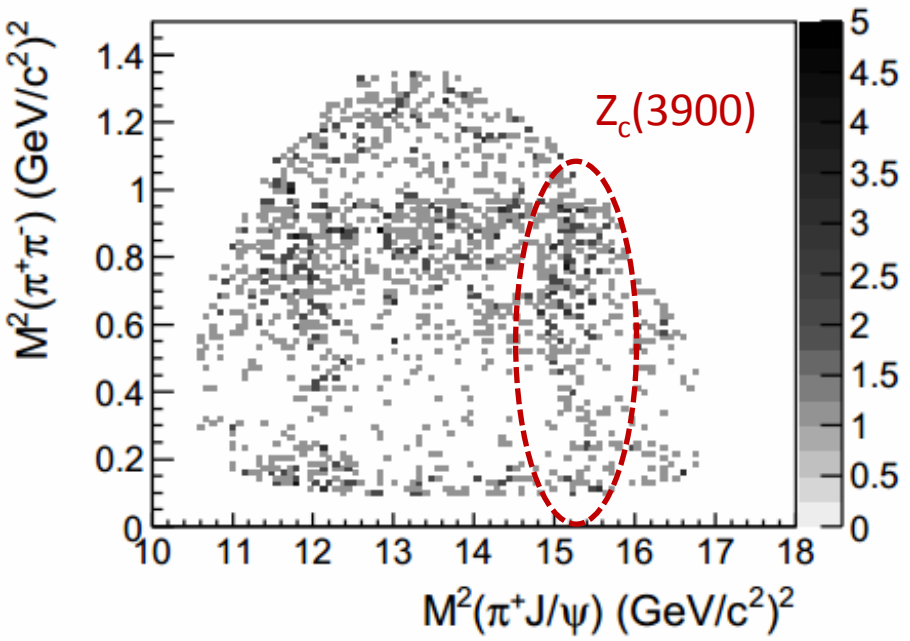
525/pb data at E_{cm}=4.26 GeV at BESIII

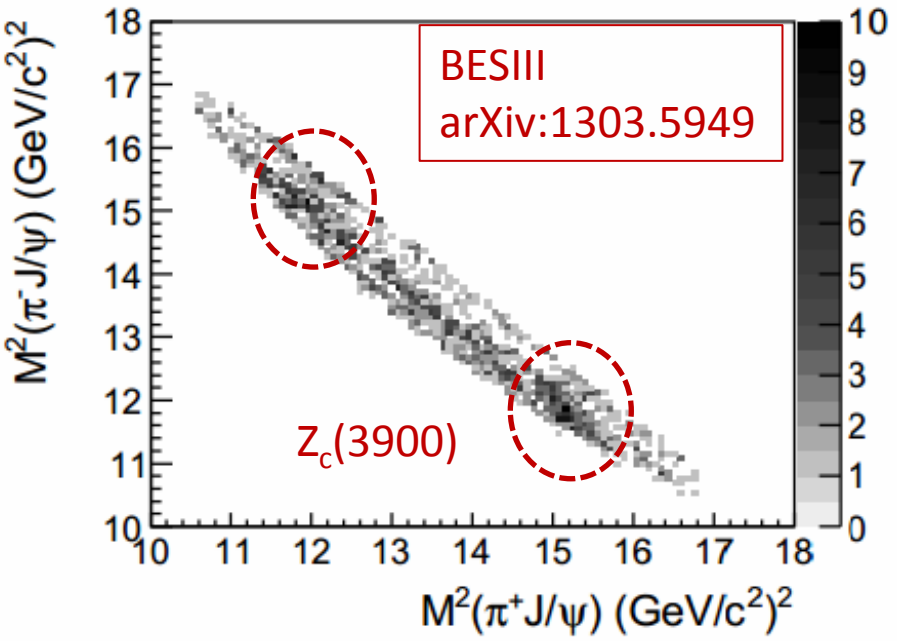




1. BESIII collect 525/pb data at E_{cm}=4.26 GeV (Dec, 2012 to Jan, 2013).
2. E_{cm} sits in the peak region of Y(4260) production cross section.
3. Study the e+e-→$\pi+\pi-J/\psi$ exclusive process from direct collision.
4. Measured production cross section: (62.9$\pm$1.9$\pm$3.7) pb.

Discovery of $Z_c(3900)$





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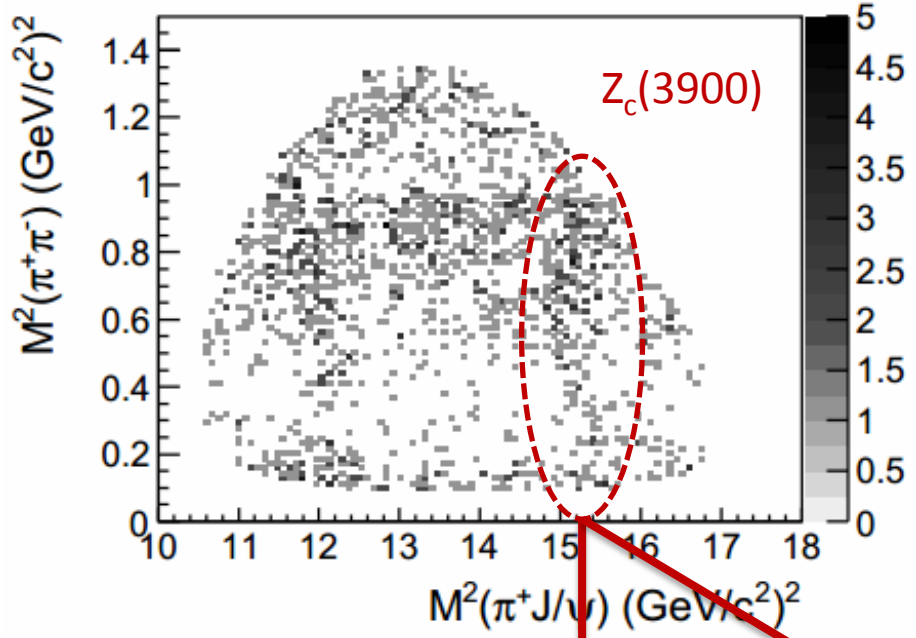
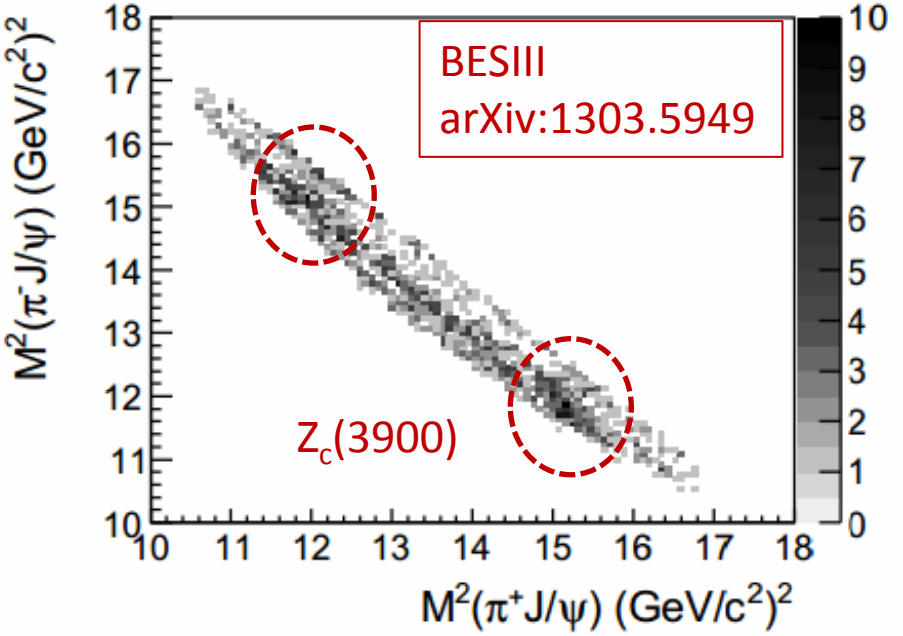
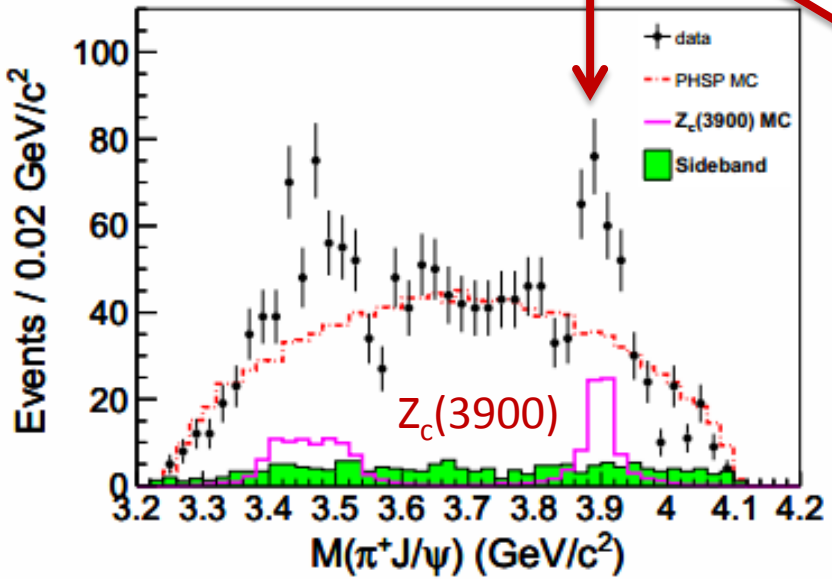
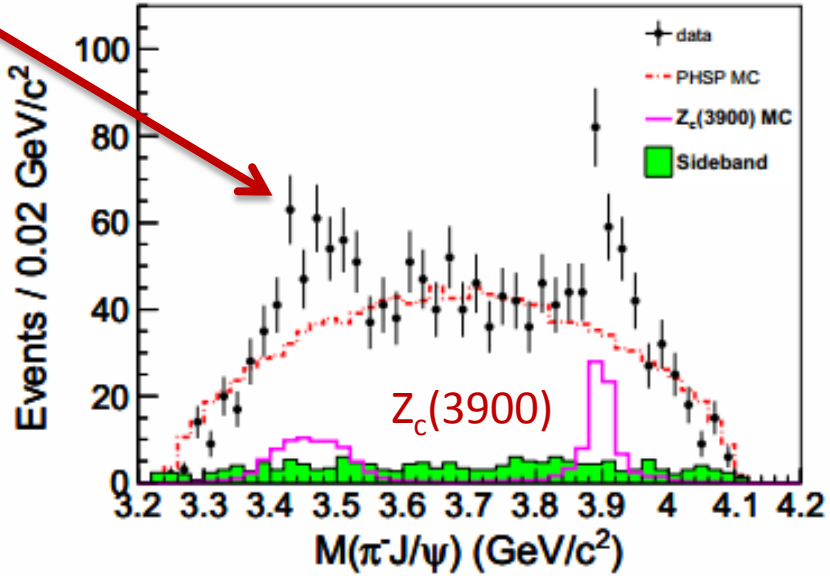
2. E_{cm} sits in the peak region of Y(4260) production cross section.
3. Study the e+e-→$\pi+\pi-J/\psi$ exclusive process from direct collision.
4. N(total)=1595 data events, N(background)~164.
5. Structure both in M($\pi\pi$) and M($\pi J/\psi$) mass distribution.

Discovery of $Z_c(3900)$









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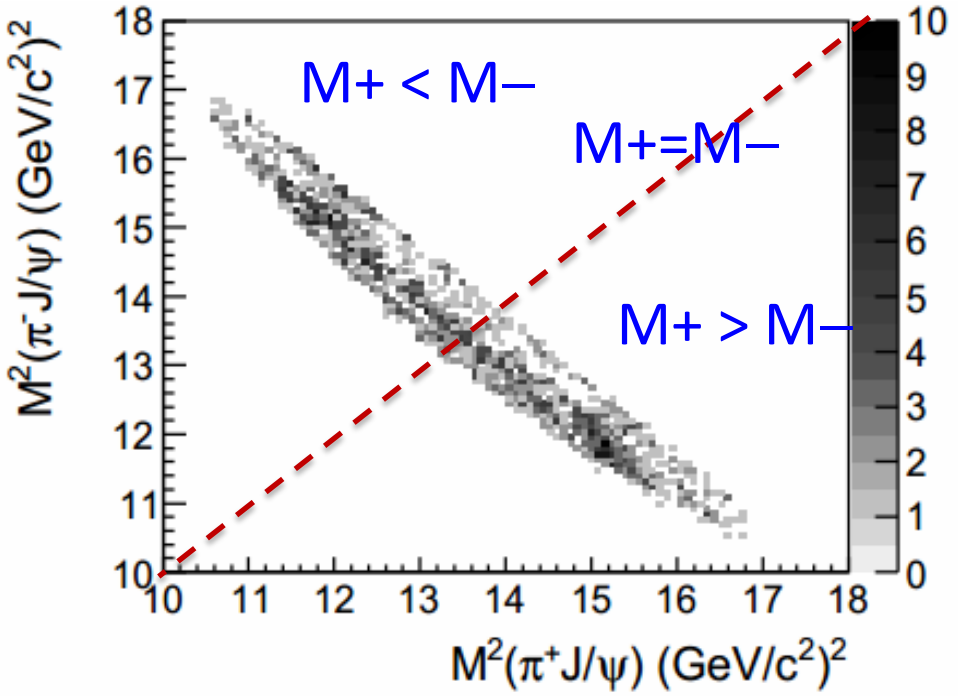
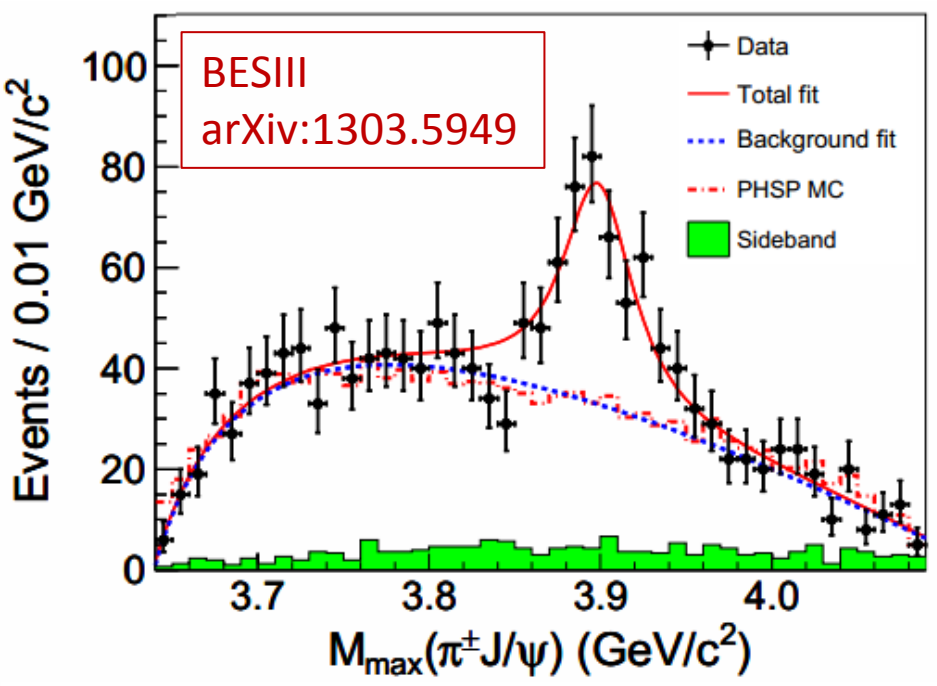
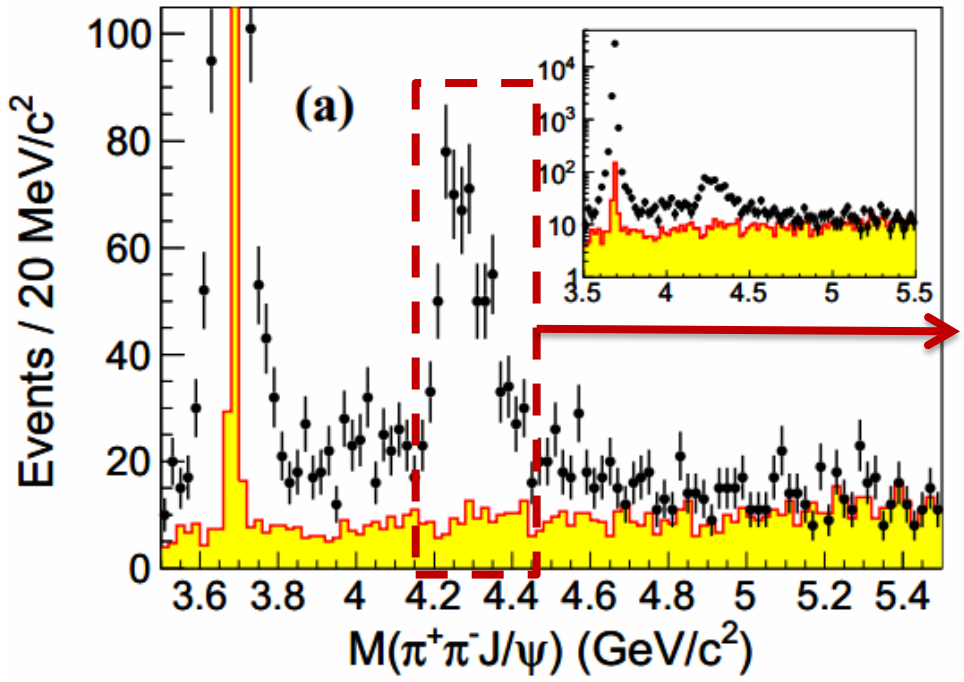
Fit the $M_{max}(\pi J/\psi)$ mass distribution

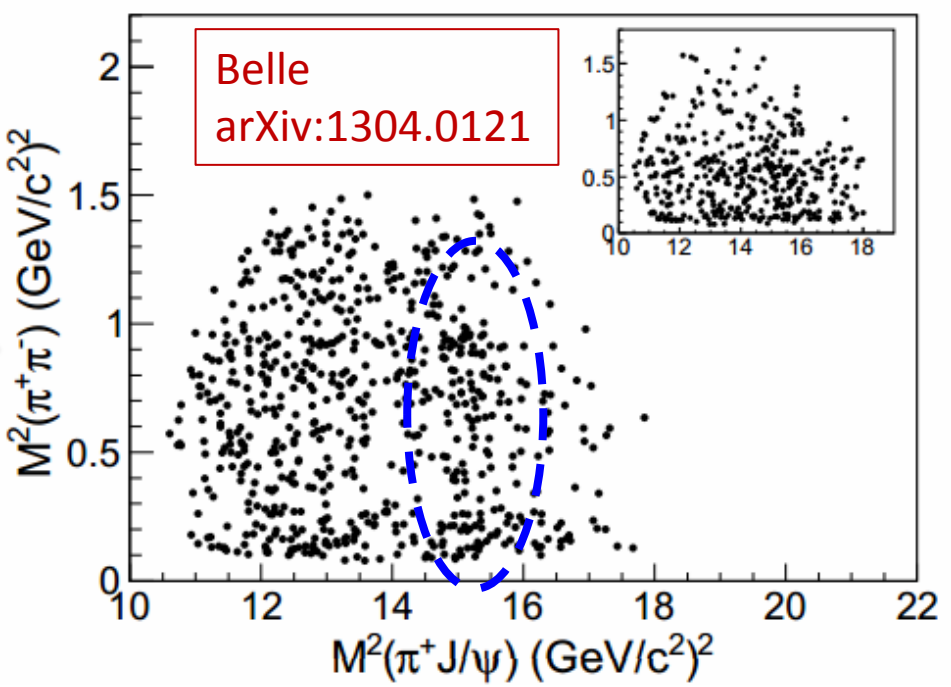




1. Divided by diagonal line into two half Dalitz plot and project.
2. Equivalent to fit $M_{max}(\pi^{\pm} J/\psi)$ mass distribution.
3. Best Way to avoid double counting.
4. S-Wave Breit Wigner; p*q phase space factor; efficiency applied.
5. $M=(3899.0 \pm 3.6 \pm 4.9)$MeV; $\Gamma=(46 \pm 10 \pm 20)$MeV.
6. Statistical significance: >8σ, discovery!

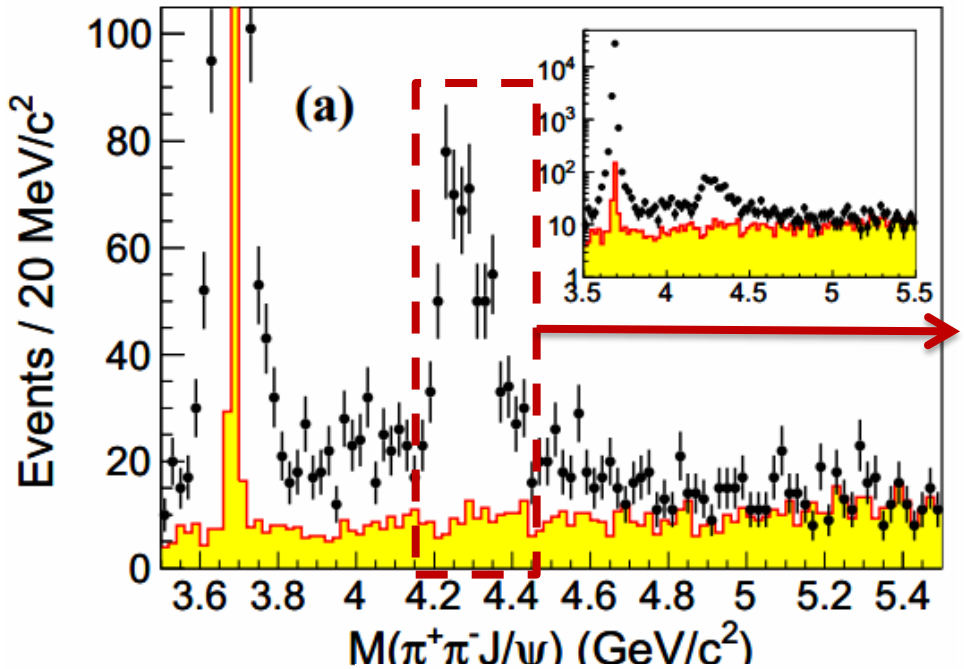
Discovery of $Z(3895)^{\pm}$ at Belle

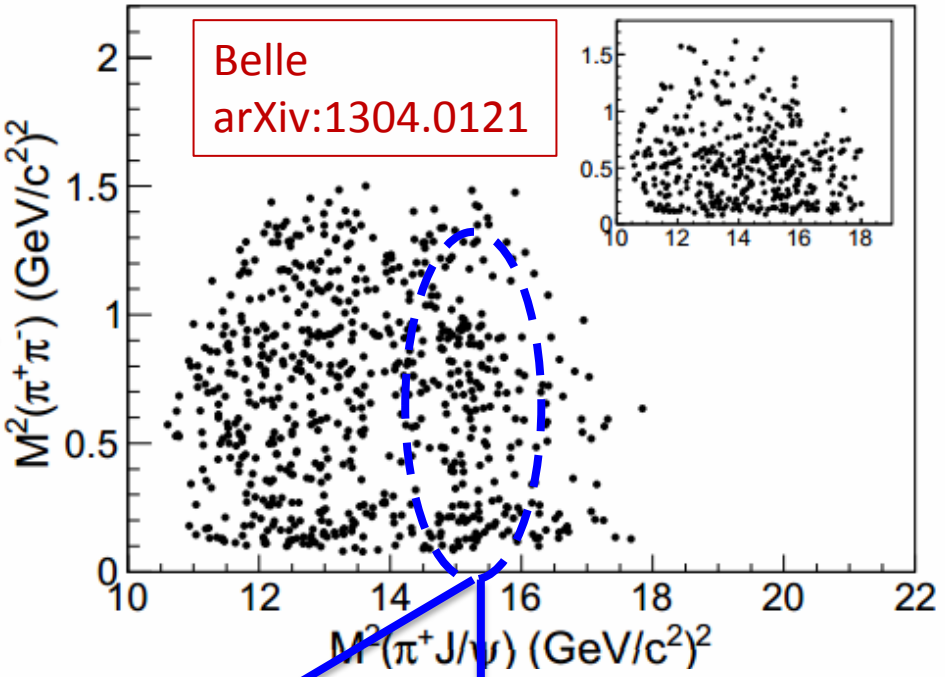




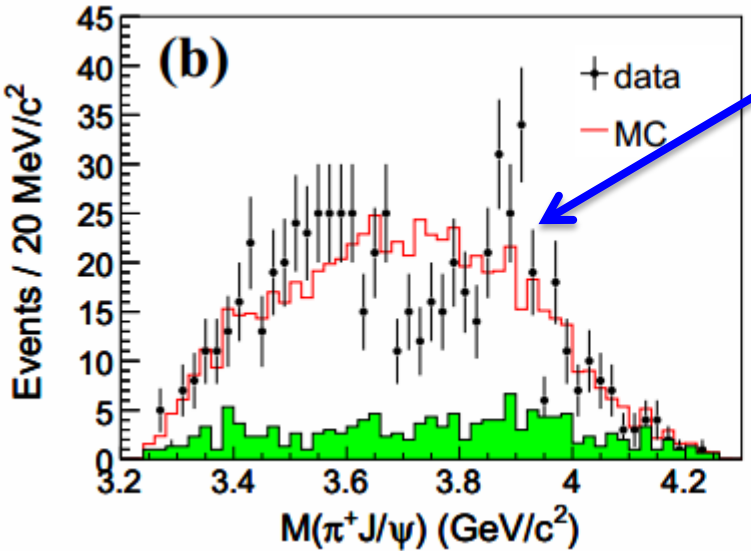
1. Belle collected data at Y(nS) (n=1,…,5) resonance and nearby energy.
2. Full Belle data sample used: Lum=967/fb data.
3. Using Initial-State-Radiation (ISR) method, e+e- c.m energy radiative return to 4 - 5 GeV region.
4. $4.15<M(\pi^+\pi^-J/\psi)<4.45$ GeV to select Y(4260) resonance.
5. Dalitz plot also shows structures.

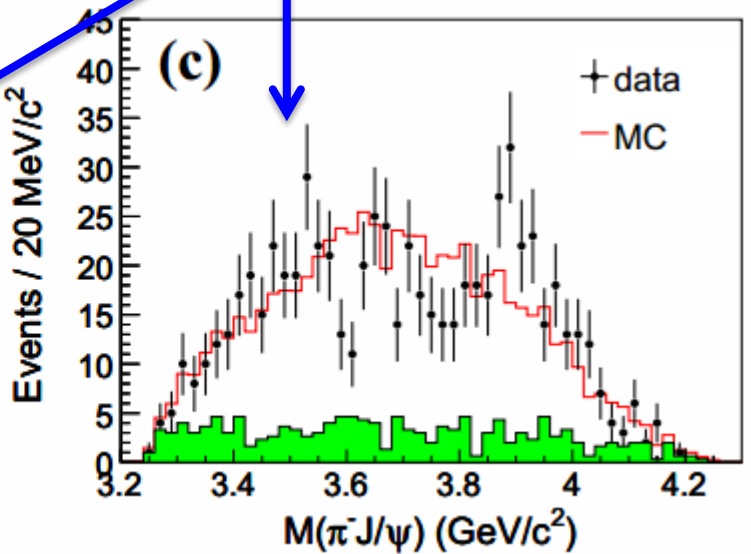
Discovery of $Z(3895)^{\pm}$ at Belle





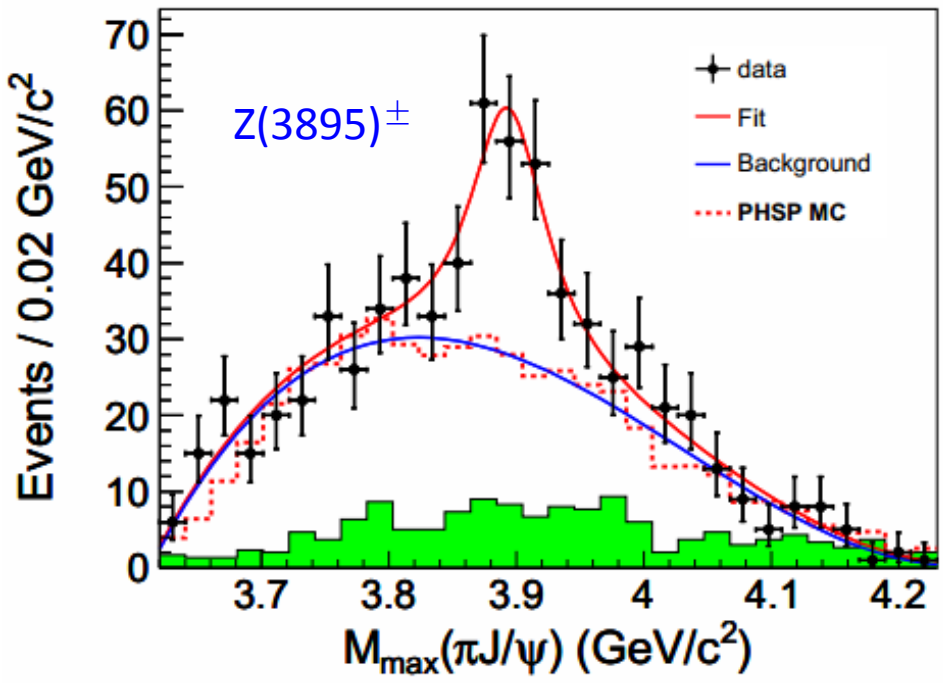
1. Belle colle
2. Full Belle
3. Using Init
   return to
4. 4.15<M(π
5. Dalitz plo



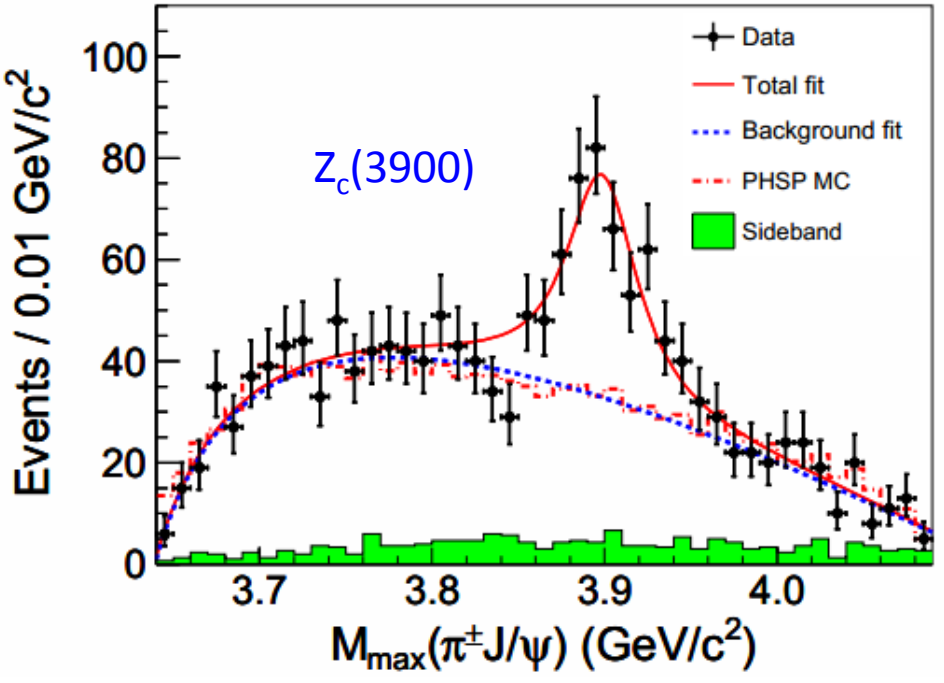


Fit $M_{max}(\pi^{\pm}J/\psi)$ mass distribution

Belle arXiv:1304.0121



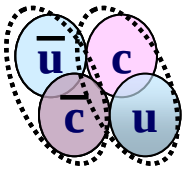
BESIII arXiv:1303.5949



1. Belle use the same fit strategy to $M_{max}(\pi J/\psi)$ distribution.
2. S-Wave BW, p*q phase space factor, efficiency applied.
3. Belle observed 689 events, with 139 background.
4. M=(3894.5$\pm$6.6$\pm$4.5) MeV; Γ=(63$\pm$24$\pm$26) MeV.
5. Significance:5.2σ, Zc(3900)=$Z(3895)^{\pm}$, K. Seth confirms.

The nature of $Z_c(3900)$?

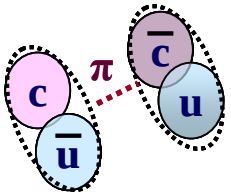
tetraquark



L. Maiani
…

+

molecule



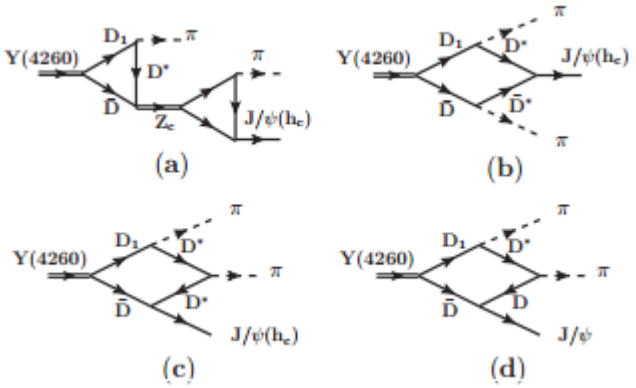
F. K. Guo
U. G. Meissner
…

=

Four quarks, exotic !

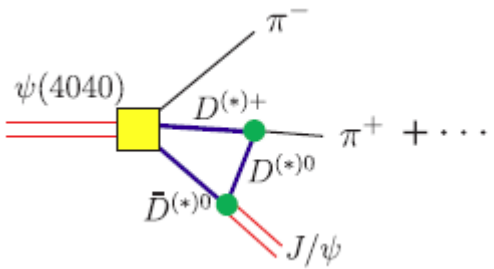
M. B. Voloshin
…

Meson loop



Q. Zhao
…

ISPE model



D. Y. Chen &
X. Liu
…

Questions to be answer?

1. What's the spin-parity of it? 1^+ ? BESIII
2. Search for Zc' in $\pi^{\pm}J/\psi$?
3. Dominant decay mode? DD*? Branching ratios or cross sections? BESIII
4. Is there a neutral partner Z^0? BESIII
5. Is there a partner Z_c' existed? What's its mass? Favor tetraquark or molecule?
6. Can we hunt it in $\pi^+\pi^- h_c$ & D*D*? BESIII
7. Can we expected it in B meson decays? Belle or BaBar

Summary

1. Belle observed Z_b in the beauty sector (from Y(5S) decay).
2. BESIII observed Z_c in the charm sector (from Y(4260) decay).
3. BESIII becomes a new star in the "XYZ" field.

Thank you!