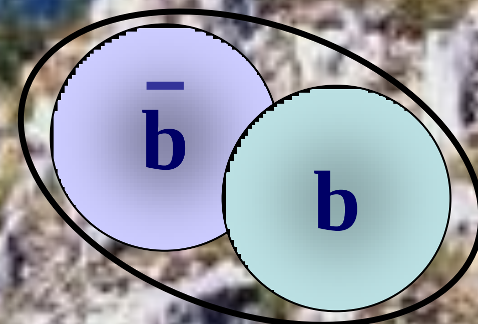
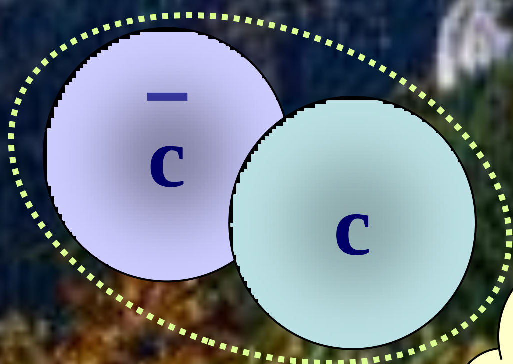
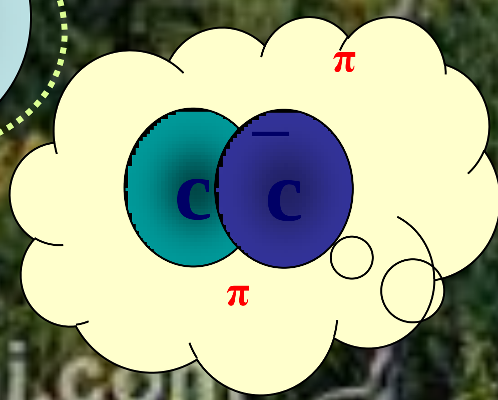
September 12-15, Physics in Collision 2012, Strbske Pleso, Slovakia

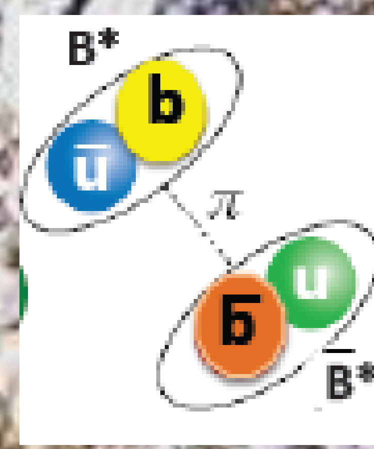
Quarkonium and Exotic Hadrons

Ruslan Chistov (ITEP, Moscow)
Representing
the Belle Collaboration

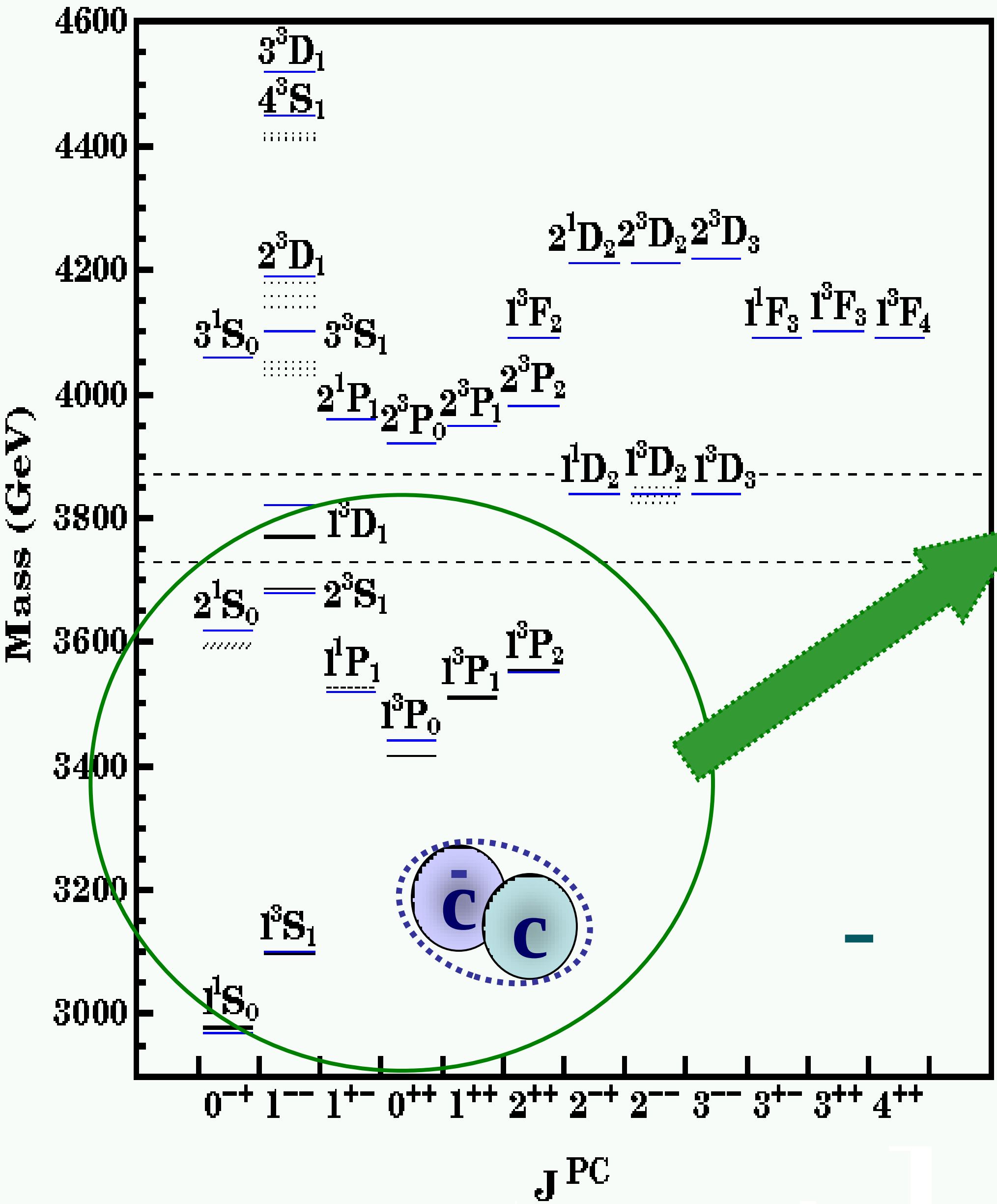








Predictions for conventional charmonia



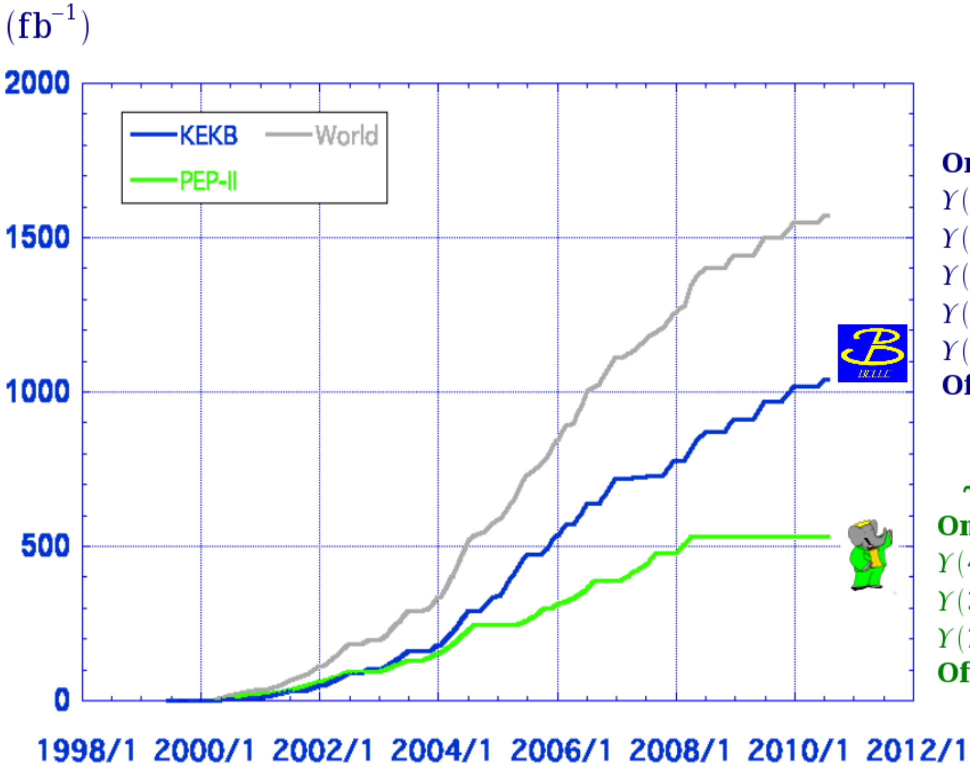
$\eta_c(1S) \equiv 1^1S_0$
$J/\psi \equiv 1^3S_1$
$\chi_{cJ}(1P) \equiv 1^3P_J$

Theory described well the observed spectrum of cc states →

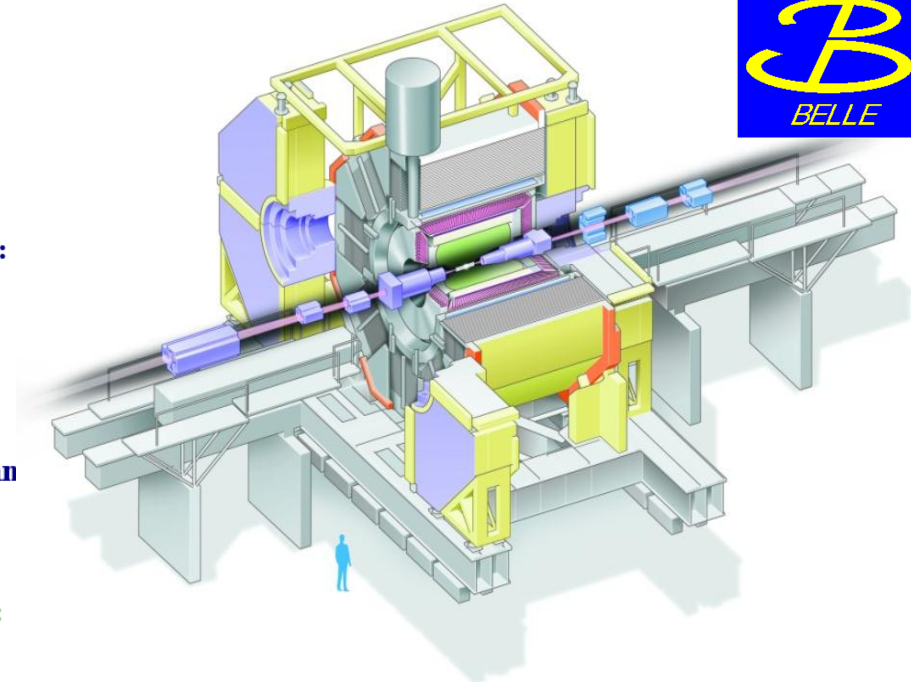
The charmonium system is ideal place to search for ***exotic states = deviations from conventional charmonium spectroscopy.***

Until the B-factories –
no evidence for such deviations

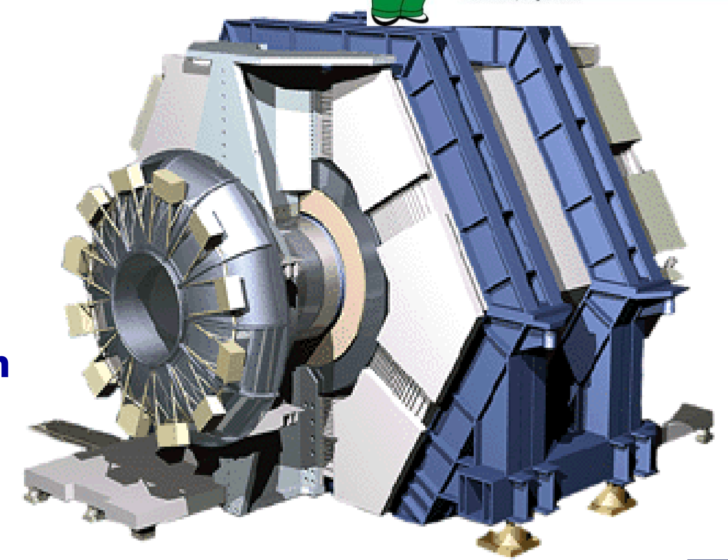
Luminosity at B factories



> 1 ab^{-1}
On resonance:
$\Upsilon(5S)$: 121 fb^{-1}
$\Upsilon(4S)$: 711 fb^{-1}
$\Upsilon(3S)$: 3 fb^{-1}
$\Upsilon(2S)$: 24 fb^{-1}
$\Upsilon(1S)$: 6 fb^{-1}
Off reson./scan
$\sim$100 fb^{-1}



~ 550 fb^{-1}
On resonance:
$\Upsilon(4S)$: 433 fb^{-1}
$\Upsilon(3S)$: 30 fb^{-1}
$\Upsilon(2S)$: 14 fb^{-1}
Off resonance:
$\sim$54 fb^{-1}



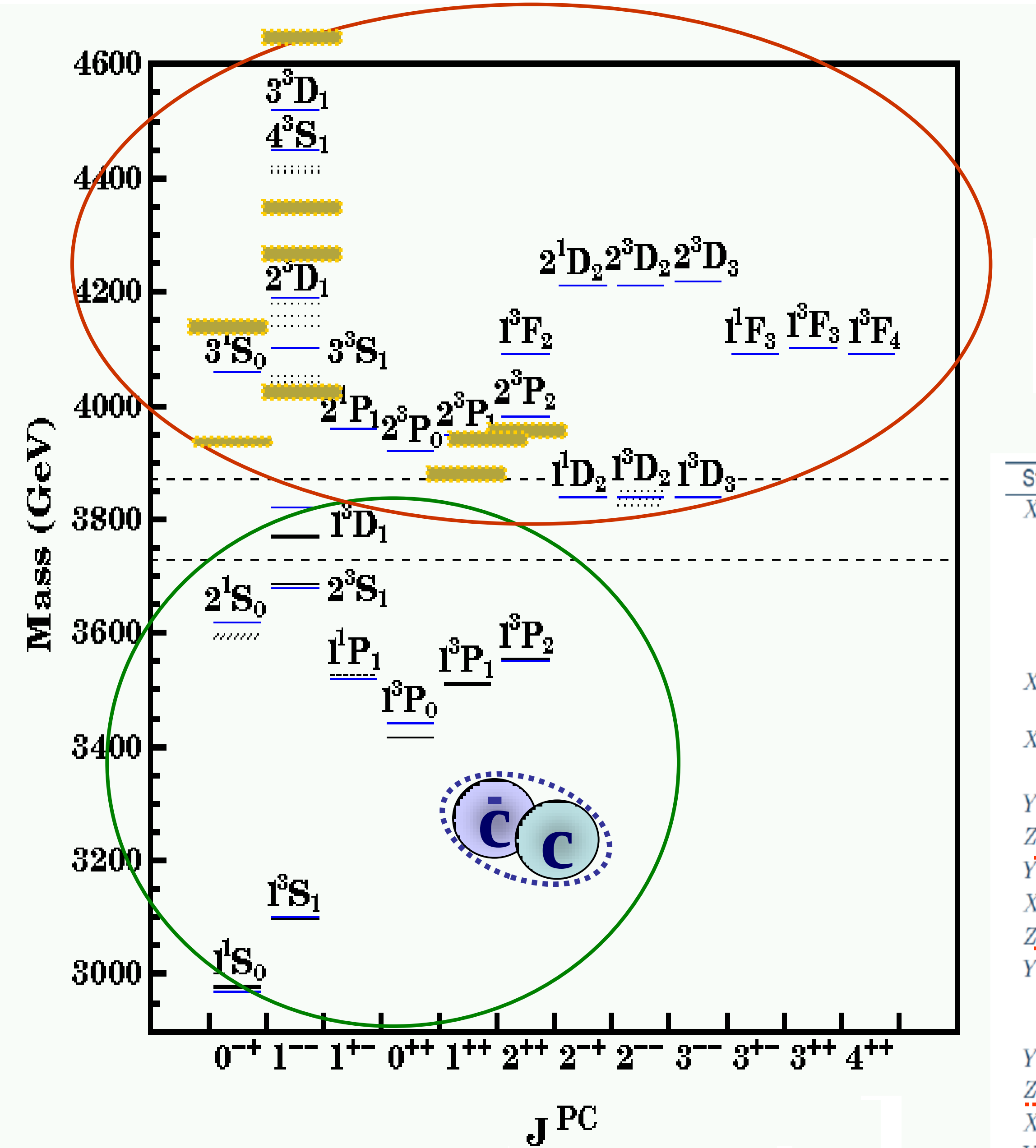
In sum $\mathcal{L}$ >1552 fb^{-1}

For 9 years the B-factories (and Tevatron) have observed a number of states that do not admit a conventional quarkonium interpretation.

These states could be made of more than 2 quarks.

So, unworried heavy quarkonium picture is broken!

New cc-like states

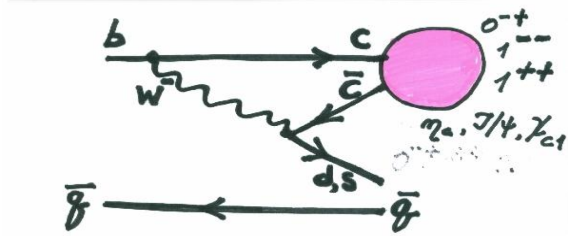


A number of unexpected exotic states above $D\bar{D}^{(*)}$ thresholds that do not fit into available $c\bar{c}$ slots

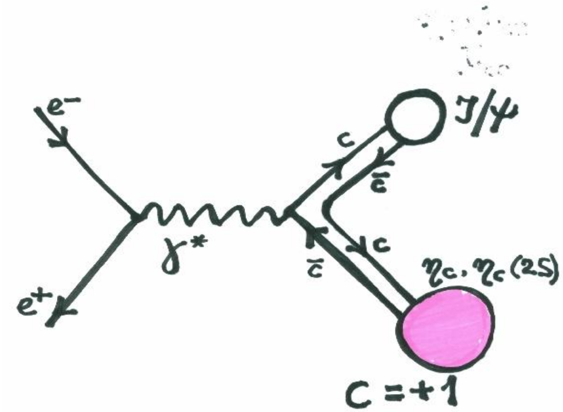
State	M, MeV	Γ, MeV	J^{PC}	Process
$X(3872)$	3871.52 ± 0.20	1.3 ± 0.6	$1^{++}/2^{-+}$	$B \to K(\pi^+\pi^- J/\psi)$
		(< 2.2)		$p\bar{p} \to (\pi^+\pi^- J/\psi) + ...$
				$B \to K(\omega J/\psi)$
				$B \to K(D^{*0}D^0)$
				$B \to K(\gamma J/\psi)$
				$B \to K(\gamma\psi(2S))$
$X(3915)$	3915.6 ± 3.1	28 ± 10	$0/2^{?+}$	$B \to K(\omega J/\psi)$
				$\gamma\gamma \to (\omega J/\psi)$
$X(3940)$	3942^{+9}_{-8}	37^{+27}_{-17}	$?^{?+}$	$e^+e^- \to J/\psi(D\bar{D}^*)$
				$e^+e^- \to J/\psi\,(...)$
$Y(4008)$	4008^{+121}_{-49}	226 ± 97	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$
$Z_1(4050)^+$	4051^{+24}_{-43}	82^{+51}_{-55}	?	$B \to K(\pi^+\chi_{c1}(1P))$
$Y(4140)$	4143.4 ± 3.0	15^{+11}_{-7}	$?^{?+}$	$B \to K(\phi J/\psi)$
$X(4160)$	4156^{+29}_{-25}	139^{+113}_{-65}	$?^{?+}$	$e^+e^- \to J/\psi(D\bar{D}^*)$
$Z_2(4250)^+$	4248^{+185}_{-45}	177^{+321}_{-72}	?	$B \to K(\pi^+\chi_{c1}(1P))$
$Y(4260)$	4263 ± 5	108 ± 14	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$
				$e^+e^- \to (\pi^+\pi^- J/\psi)$
				$e^+e^- \to (\pi^0\pi^0 J/\psi)$
$Y(4360)$	4353 ± 11	96 ± 42	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^-\psi')$
$Z(4430)^+$	4443^{+24}_{-18}	107^{+113}_{-71}	?	$B \to K(\pi^+\psi(2S))$
$X(4630)$	4634^{+9}_{-11}	92^{+41}_{-32}	1^{--}	$e^+e^- \to \gamma(\Lambda_c^+\Lambda_c^-)$
$Y(4660)$	4664 ± 12	48 ± 15	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^-\psi(2S))$

Charmonium (-like) production at B-factories

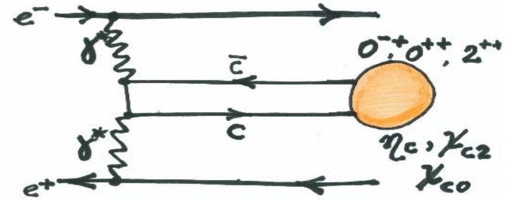
From B-decays, e.g. $B^+ \to X(3872)K^+$



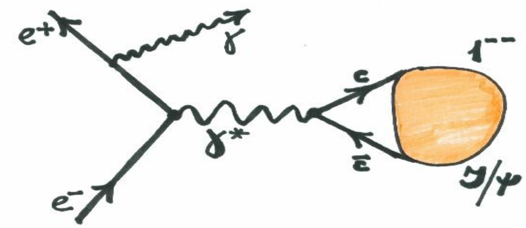
In double charmonium production,
e.g. $e^+e^- \to J/\psi\ X(3940)$



In $\gamma\gamma$ fusion,
e.g. $\gamma\gamma \to \eta_c(2S)$ or $\gamma\gamma \to Z(3930)$

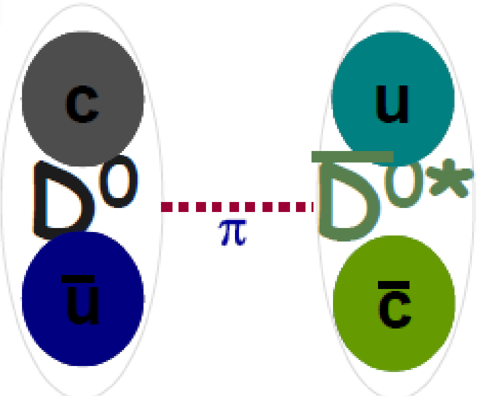


In radiative return, e.g.
$e^+e^- \to \gamma_{ISR} Y(4260) \to J/\psi\ \pi^+\pi^-$

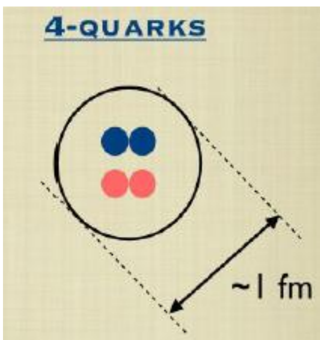


Exotic heavy quarkonium hadron:
WHAT COULD IT BE ?

MOLECULE



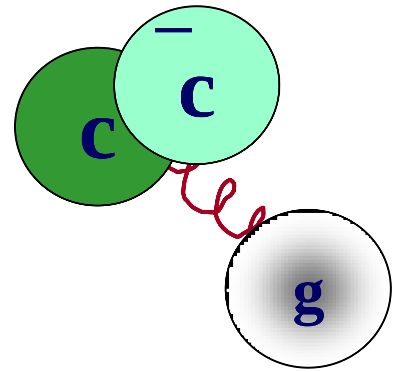
Bound state of two mesons



Bound quark pair neutralizing its color with bound antiquark pair

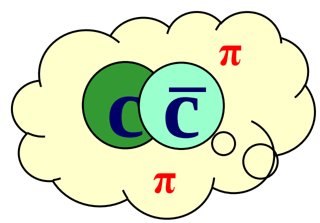
Lost regular heavy quarkonium or...

HYBRID



Bound state made of QQ and excited gluon field

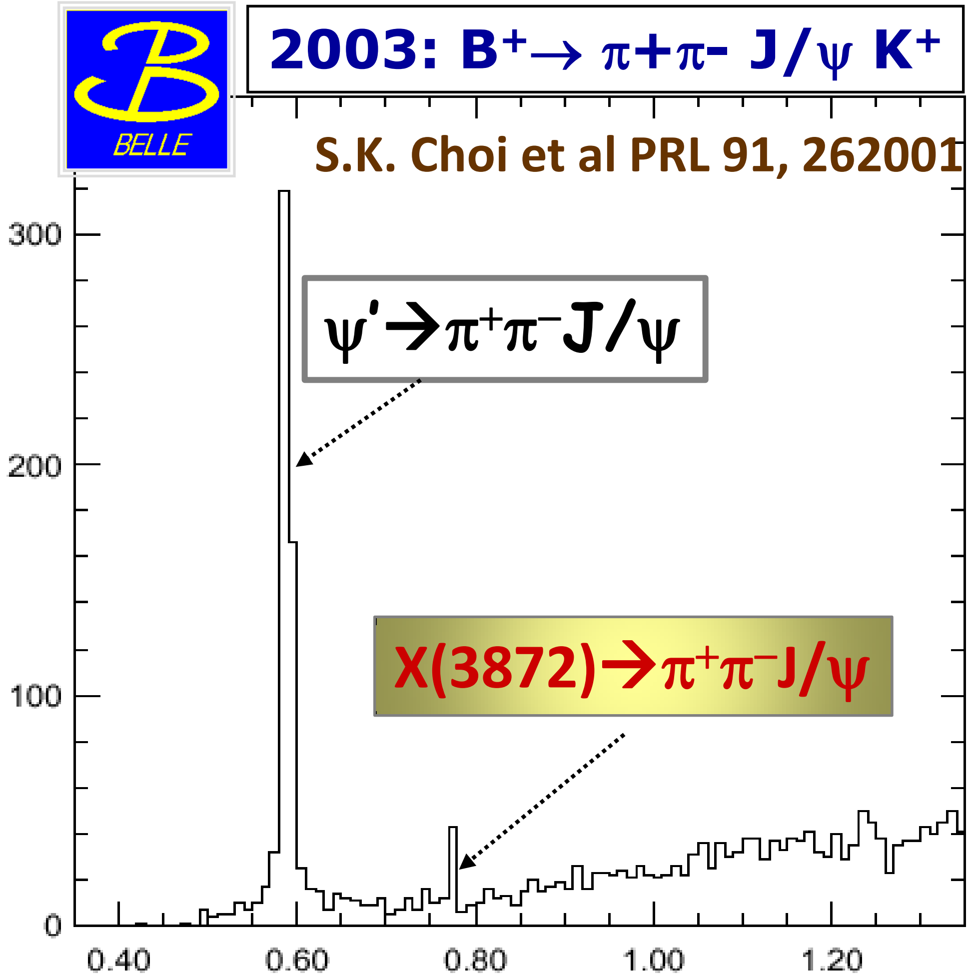
HADROCHARMONIUM



Heavy quarkonia embedded into light mesons without rearrengement of quarks

For the references and review see: N.Brambilla et al., Eur.Phys.J. C71 (2011) 1534

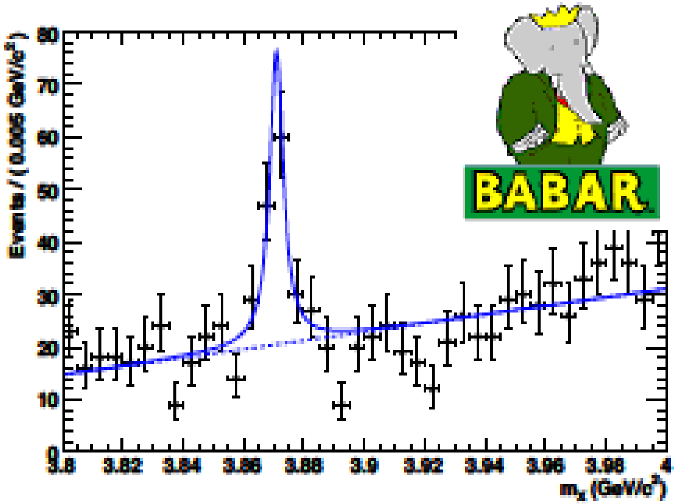
Unanticipated X(3872)

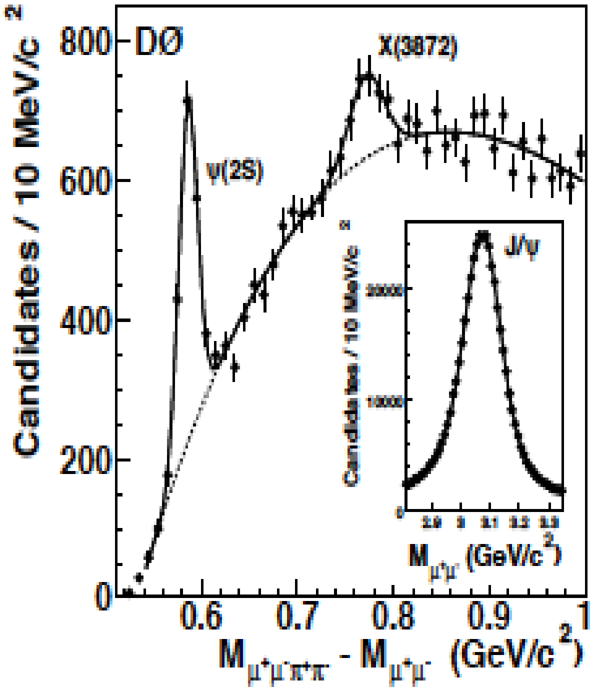


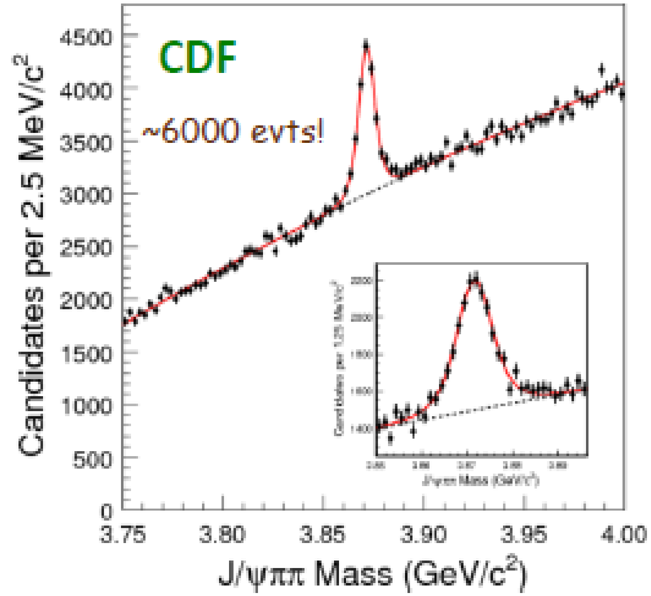
1st striking feature:

- **narrow width of X(3872) (above DD threshold!)**

X(3872)

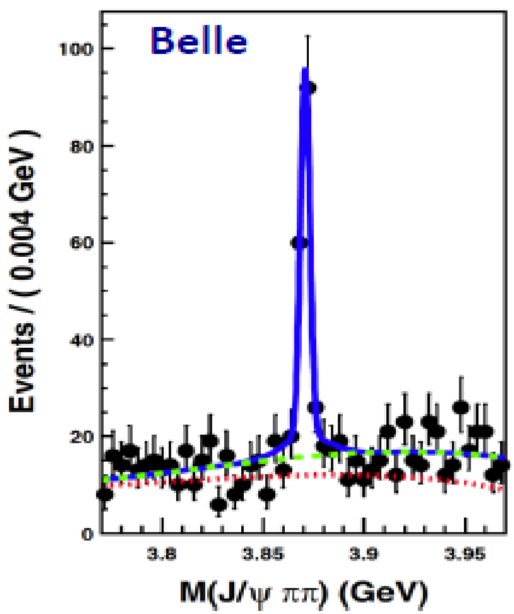






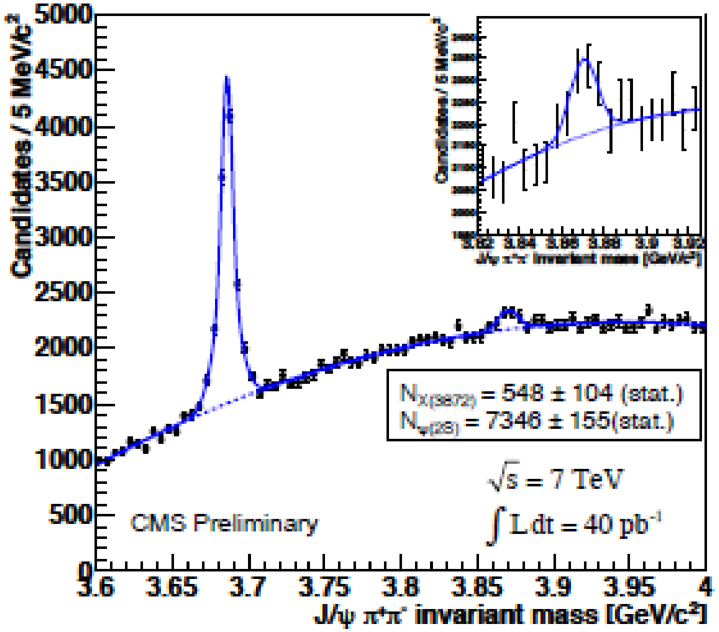
$M_X = 3871.61 \pm 0.16 \pm 0.19$ MeV

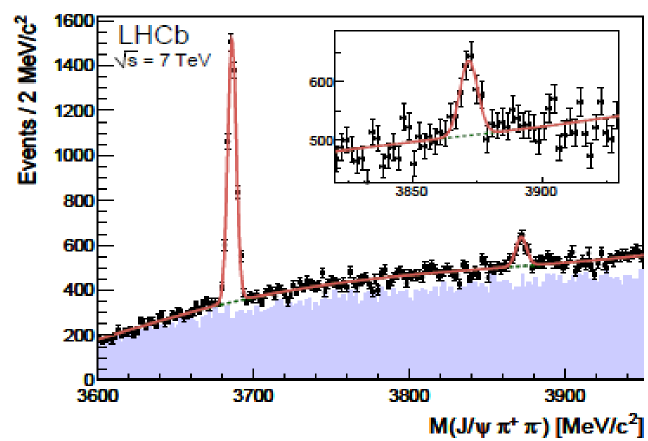
CDF: PRL 103 152001



$M_X = 3871.85 \pm 0.27 \pm 0.19$ MeV

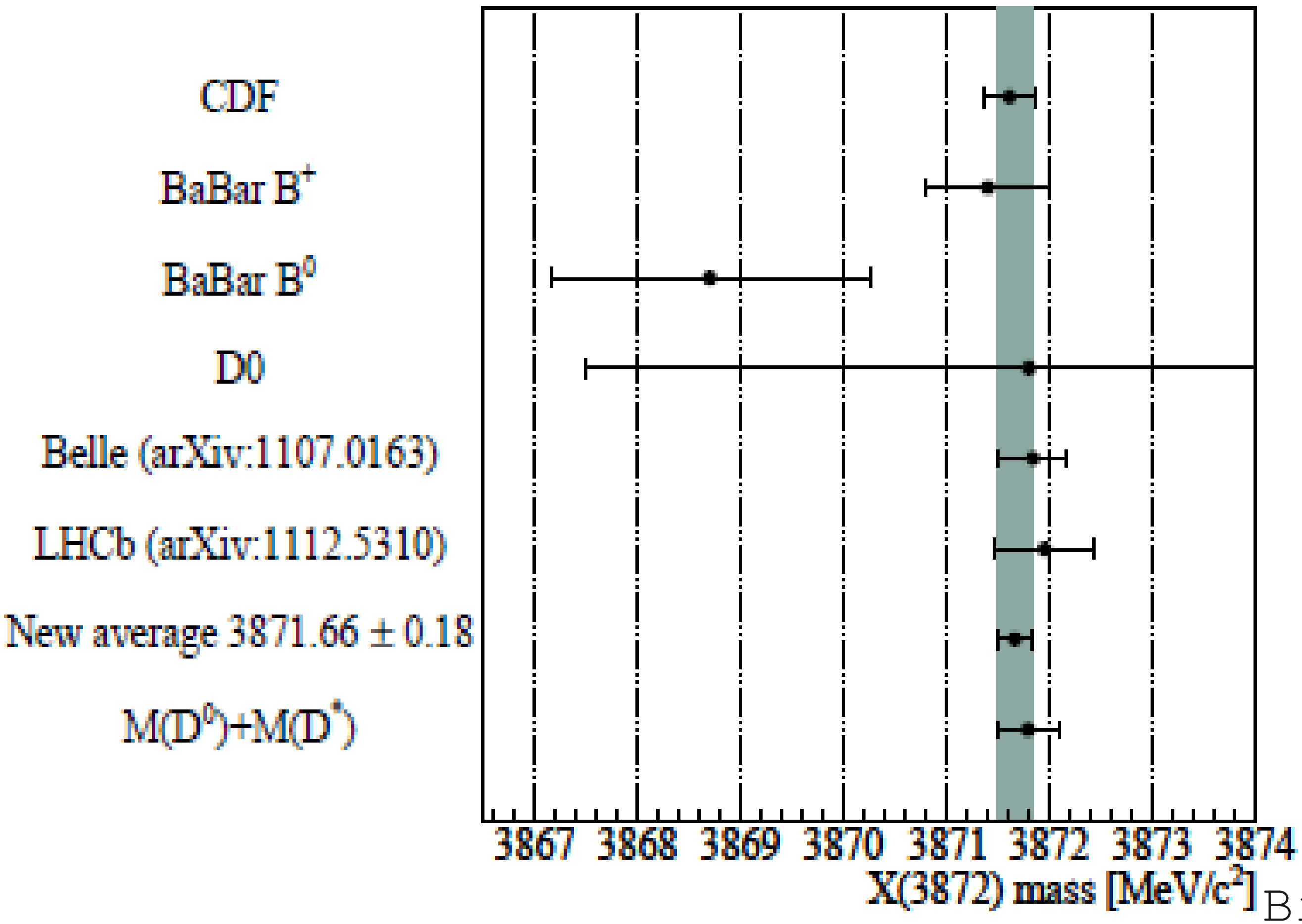
Belle: PRD 84 052004





[ref. arXiv:1112.5310]

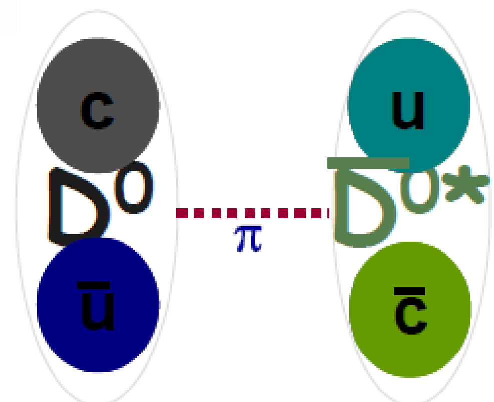
X(3872) precision mass measurement



2nd intriguing feature:

- **proximity of D^0D^{*0} threshold**

Molecule !



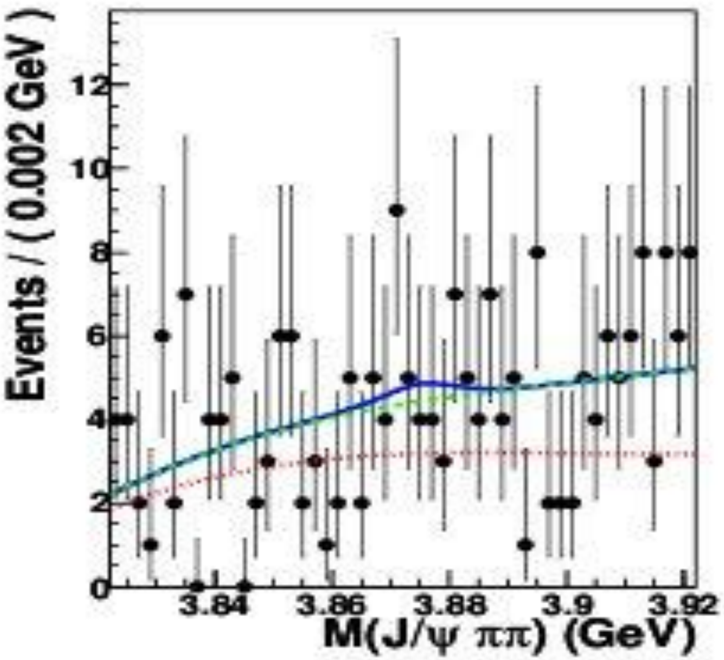
$M(X(3872)-(M(D^0)+M(D^{*0}))=$ -0.12 ± 0.35 MeV

Binding energy is small and D-mesons are very far apart in space- why decays to $J/\psi\pi^+\pi^-$?

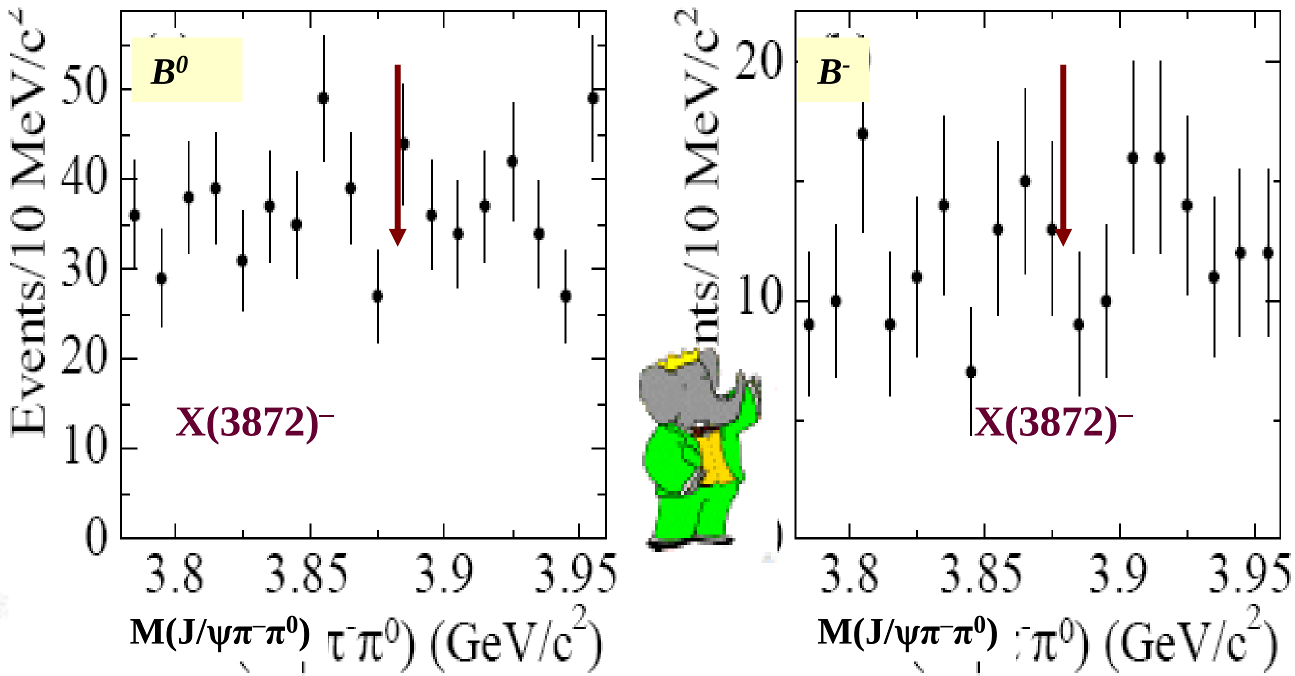
X(3872): isosinglet or a member of the triplet?

Search for a charged partner of X in $X^+ \rightarrow \rho^+ J/\psi$

Belle: PRD 84 052004

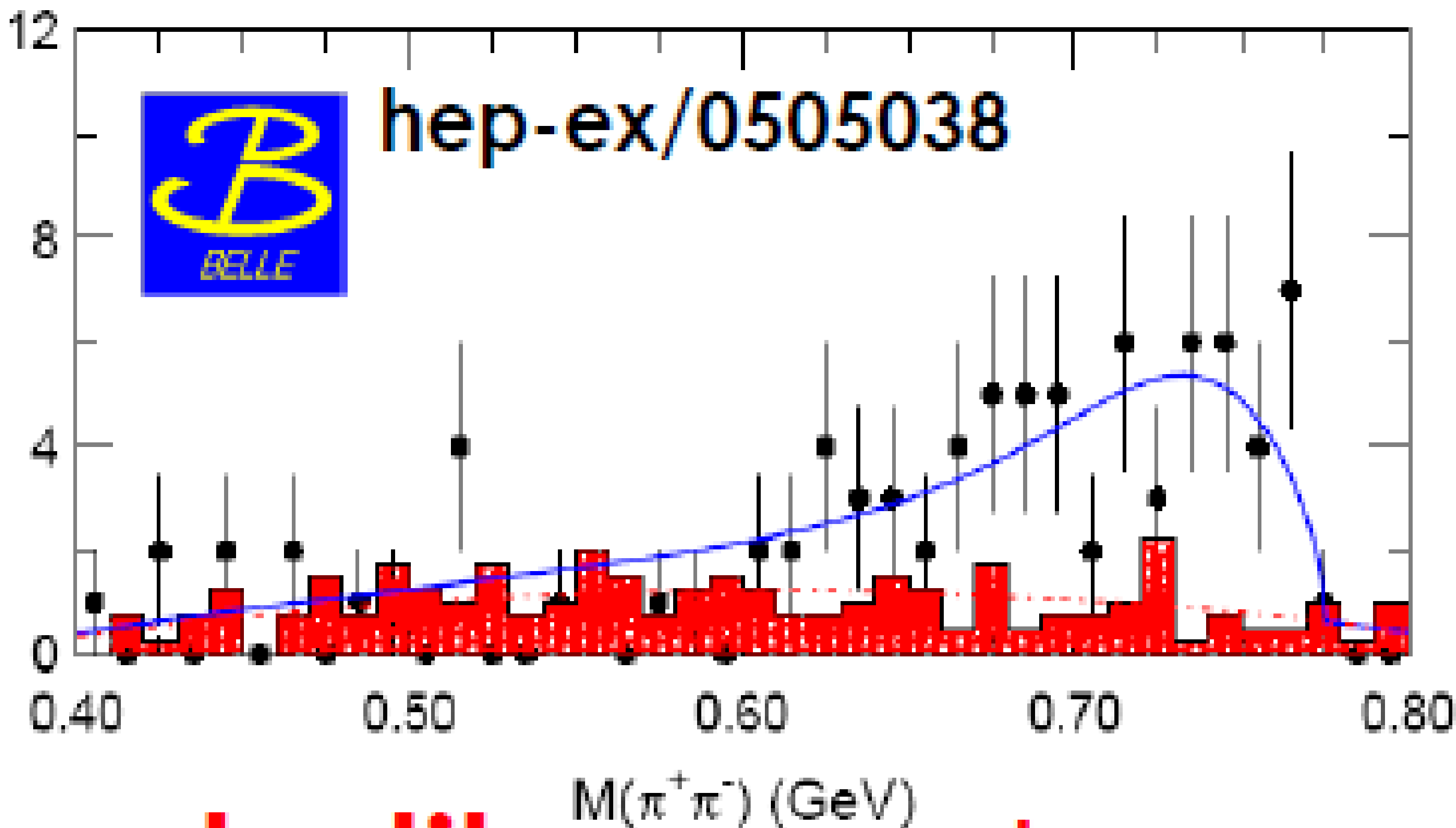


Phys.Rev.D71, 031501 (2005)



Null result! ⇒ X has no charged partners

$M(\pi^+\pi^-)$ in $X(3872) \to J/\psi\, \pi^+\pi^-$

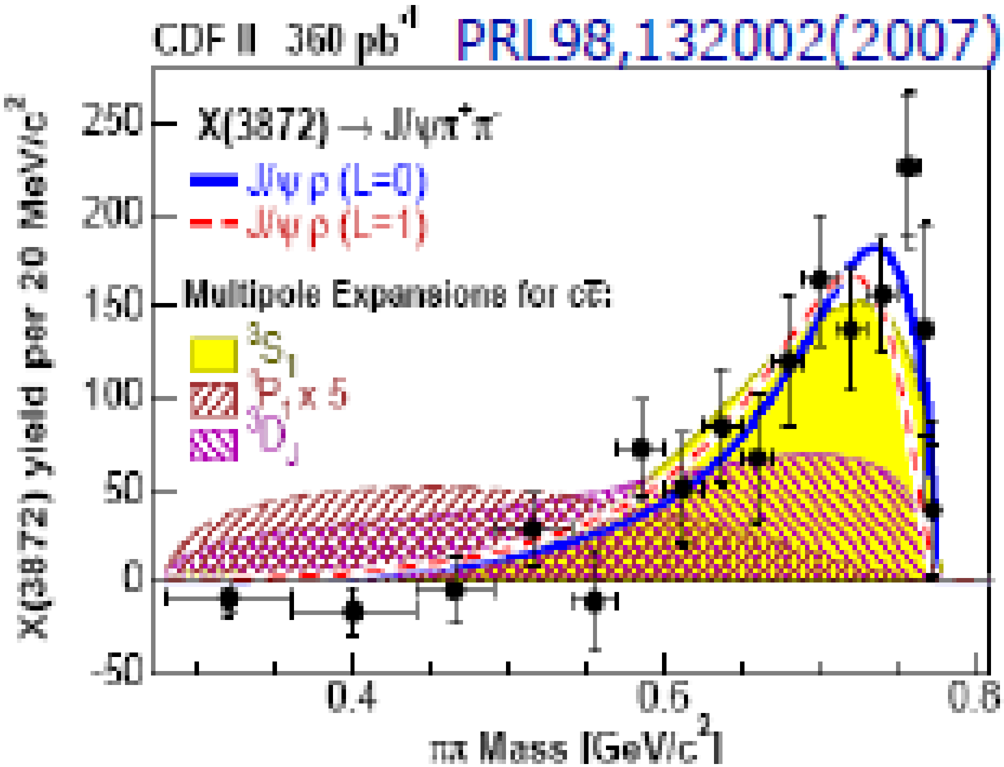


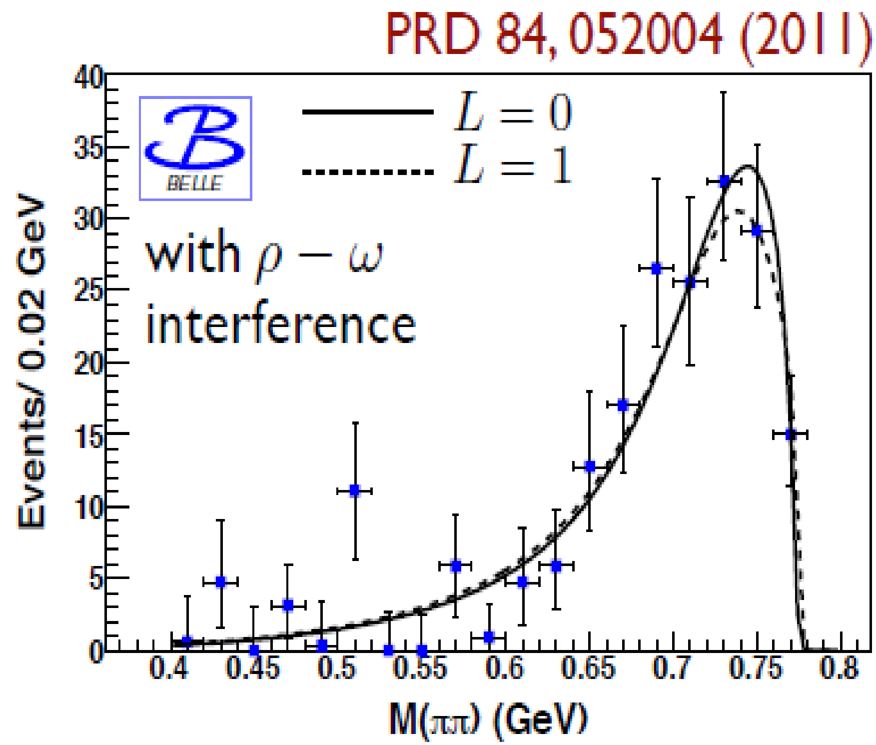
Looks like $\rho \to \pi^+\pi^-$

C-parity of X(3872) is +1

$J/\psi\ \rho$ in S or P wave would indicate P-parity +1 or -1

$M(\pi^+\pi^-)$ in $X(3872)\to J/\psi\,\pi^+\pi^-$ decay



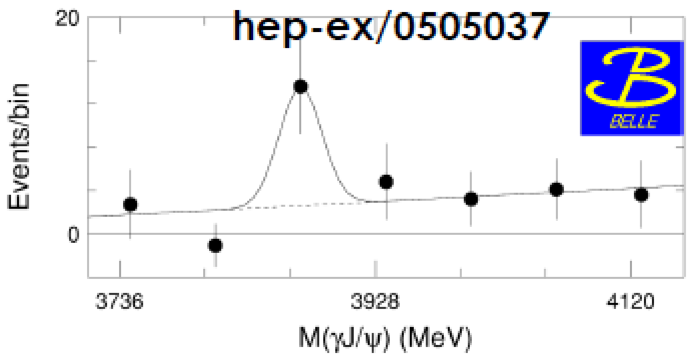


Dipion mass is really consistent with ρ^0

⇒ **C=+1 but cannot now distinguish $J/\psi\ \rho$ in S or P wave (P=+1 or -1)**

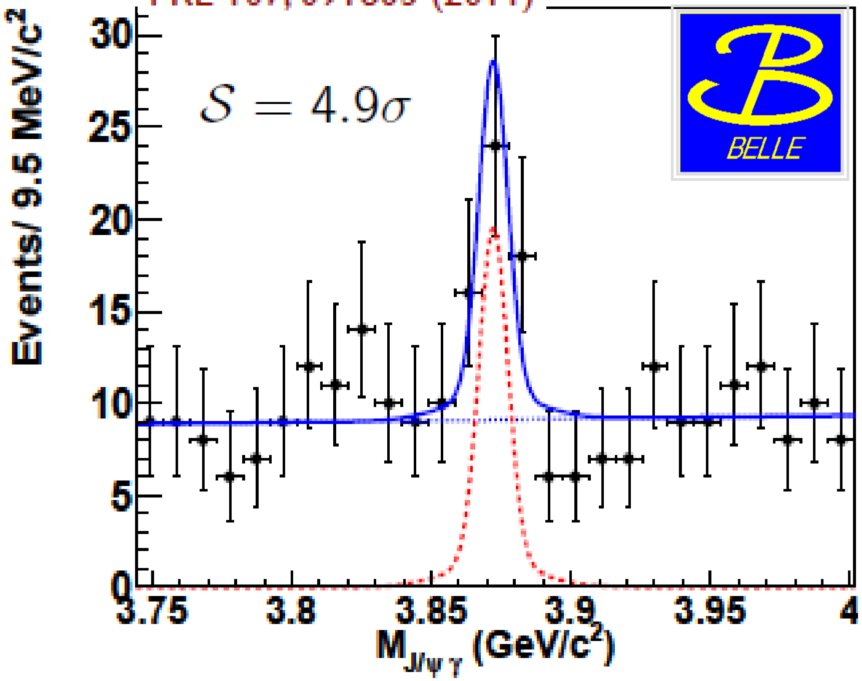
⇒ **Isospin violation if X is ordinary cc**

$X(3872) \rightarrow J/\psi\,\gamma$

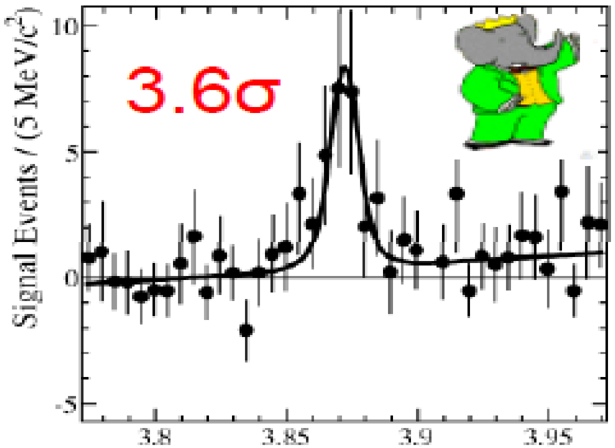


Observation of radiative decay ultimately established C=+1

PRL 107, 091803 (2011)



PRL 102, 132001 (2009)



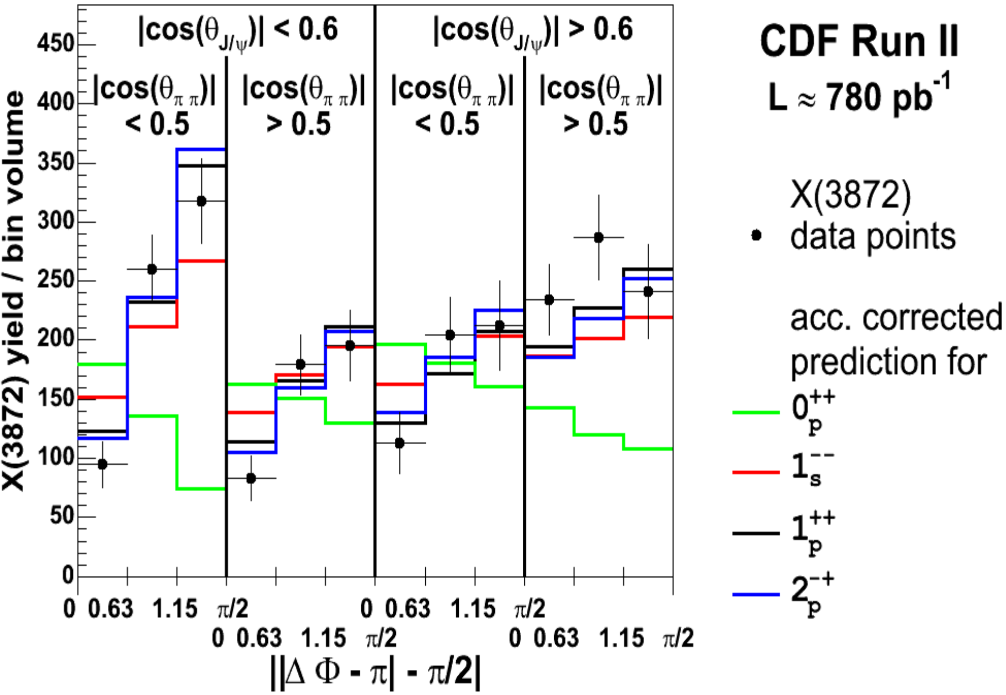
Radiative decay mode also indicates on the presence of cc component in X wave function !!

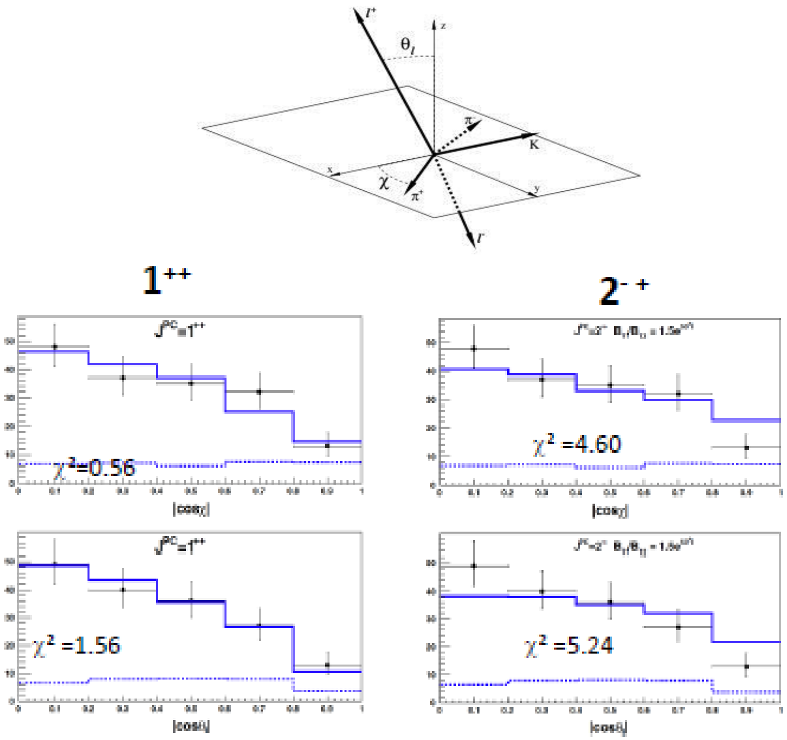
Belle: $\mathcal{B}(B^+ \rightarrow K^+X) \times \mathcal{B}(X \rightarrow J/\psi\,\gamma) = (1.8 \pm 0.5) \times 10^{-6}$

BaBar: $(2.8 \pm 0.8) \times 10^{-6}$

Angular analysis in X(3872)→J/ψ π⁺π⁻ decay

CDF PRL 98, 132002 (2007)





Belle: PRD 84 052004

2⁻⁺ has higher χ² and fewer dof than 1⁺⁺

CDF and Belle: conclusion is the same:

Angular analysis chooses $J^{PC}=1^{++}$
but 2^{-+} not ruled out at current statistics

But remember aboutf rad.decay, JPC=2-+ state would have to undergo a high-order multipole transition → strongly suppressed + B→K cc (J=2) suppressed ⇒ 1++ favourable

List of remaining information on X(3872):

- **Belle & BaBar:** $Br(X \to J/\psi\ \omega)/Br(X \to J/\psi \pi^+\pi^-) = 0.85 \pm 0.26$ - **Isospin violation**

- Belle & BaBar: $Br(X \to J/\psi \pi^+\pi^-)/Br(X \to D^{*0}D^0) \sim 0.1$ - X is related to $D^{*0}D^0$ system

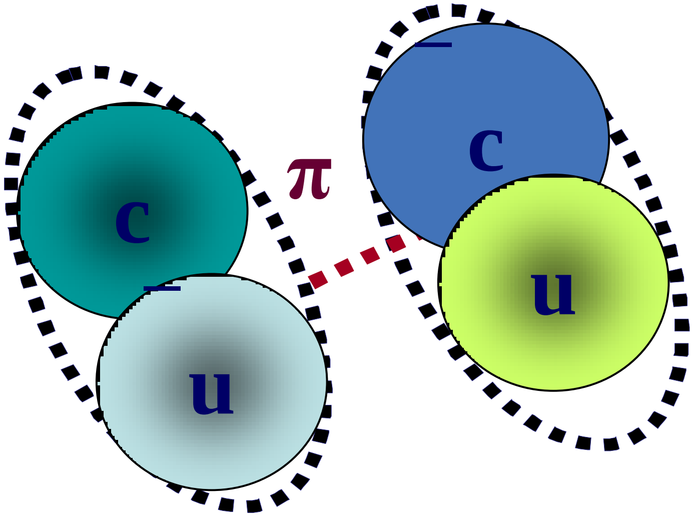
- CDF: Production properties of prompt X are very similar to those of the $\psi(2S)$; only 16% from B-mesons → How could it be for such a fragile object as molecular-type X(3872)?

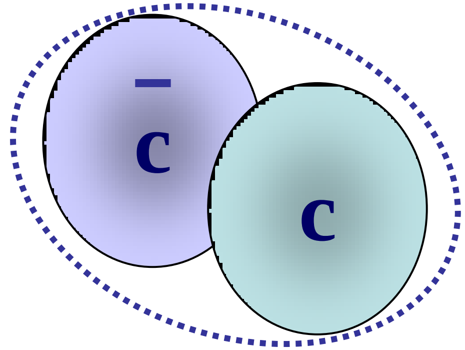
- **Belle: the X from B^0 and B^+ is the same particle,**
$\Delta M(X) = -0.69 \pm 0.97 \pm 0.19$ MeV – disfavors tetraquark model

- Belle new result:
No evidence for C=-1 partner of X in $X \to \chi_{c1,2}\ \gamma$ or $X \to J/\psi\ \eta$ - disfavors tetraquark model

- Belle:
$Br(B \to X\ K^{*0})/Br(B \to X\ (K\pi)_{NR}) < 0.5$ at 90% CL –
in contrast with ratios closer to 3 for known conventional cc

Plausible option for X(3872): a mixture of





'peripheral' part
dominant at large distance

'core' part
localized at short distance,
e.g. 2^3P_1+'others'..

Isospin mixed
pionic transitions

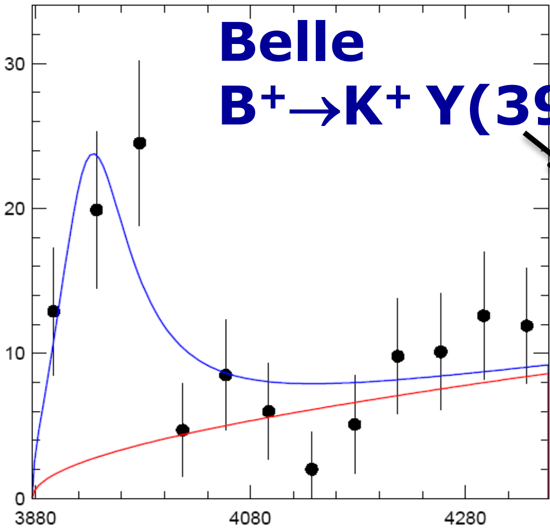
Production of X

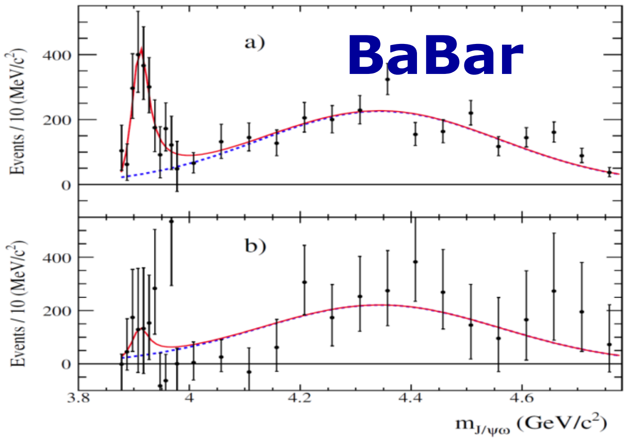
One or other part may be important in specific processes

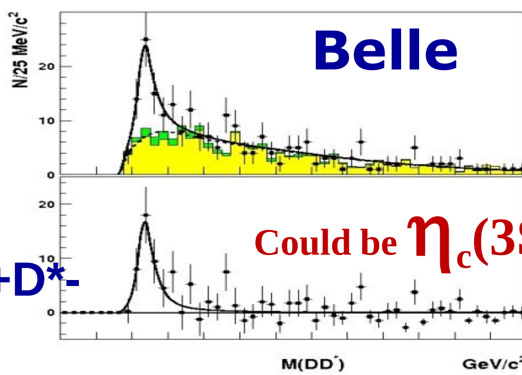
M.B.Voloshin,
0711.4556

X, Y, Z at ~ 3940 MeV/c²

Different decay modes
and/or production processes



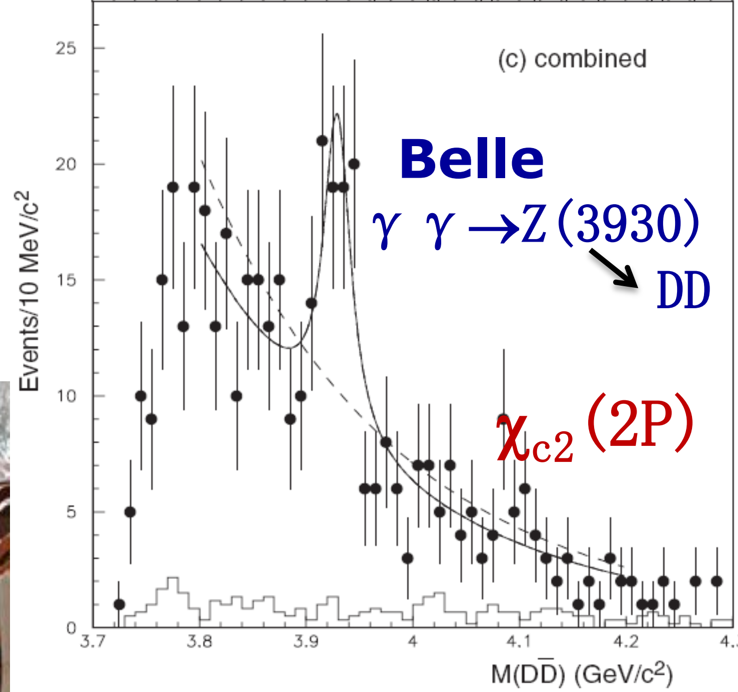


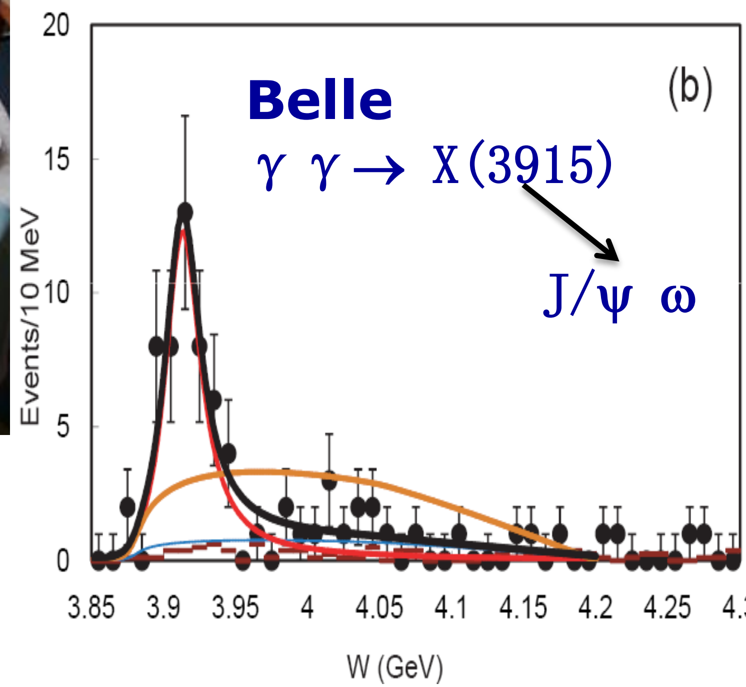


$e^+e^- \to J/\psi\, X(3940)$

$\searrow D^+D^{*-}$

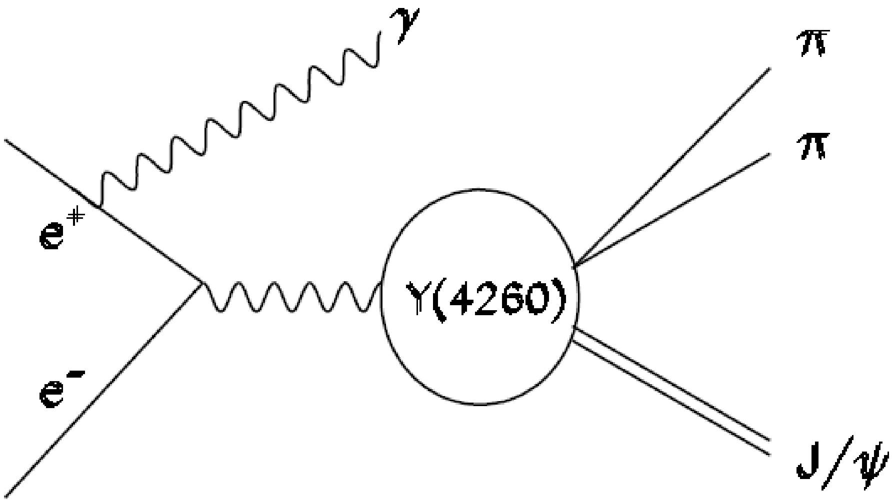
Could be $\eta_c(3S)$

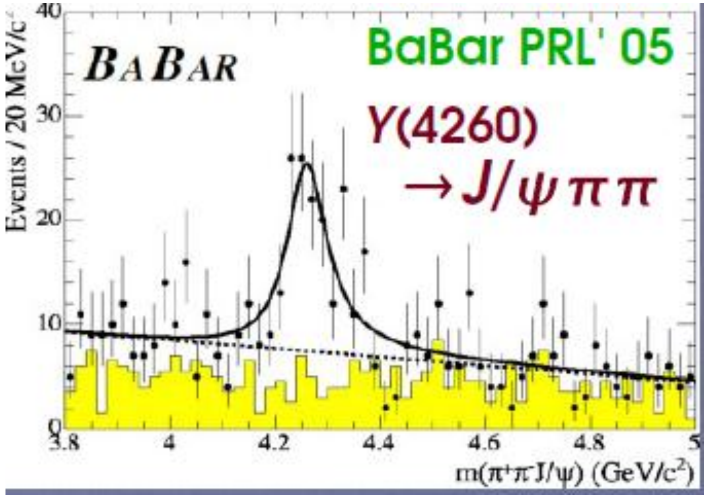


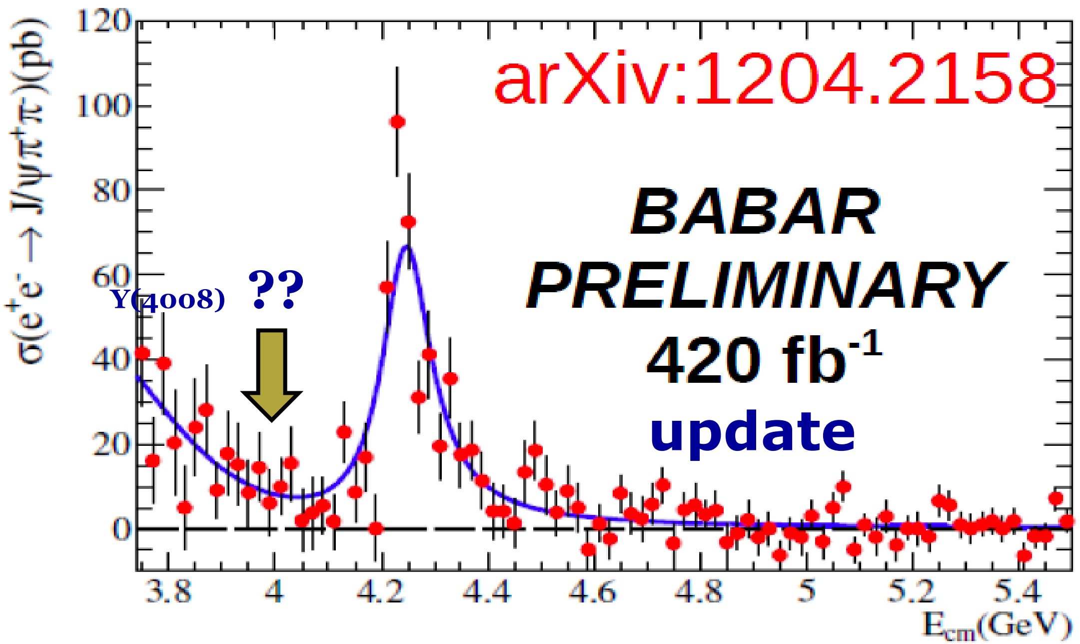


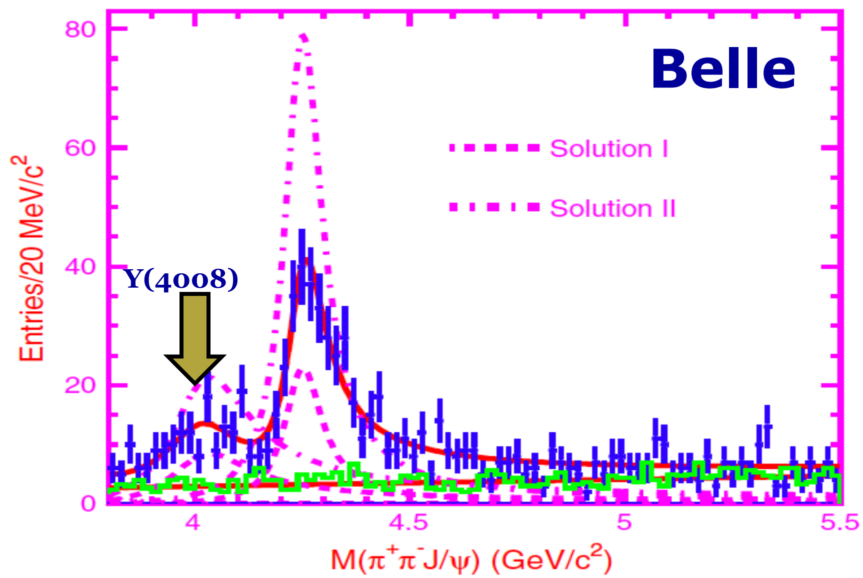
$J/\psi\ \pi^+\pi^-$

Y States in ISR, $J^{PC}=1^{--}$



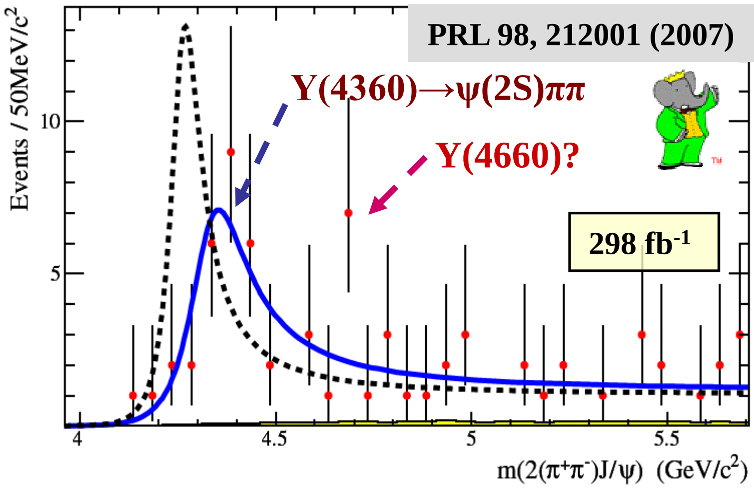


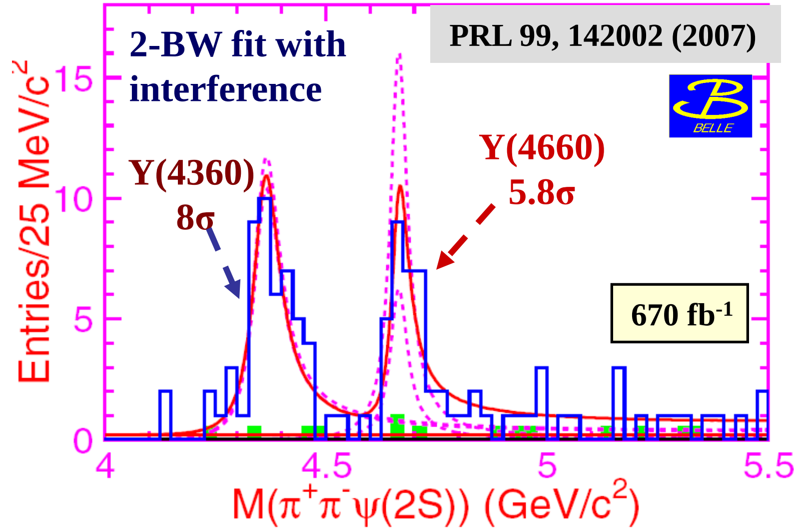




$\psi(2S)\,\pi^+\pi^-$

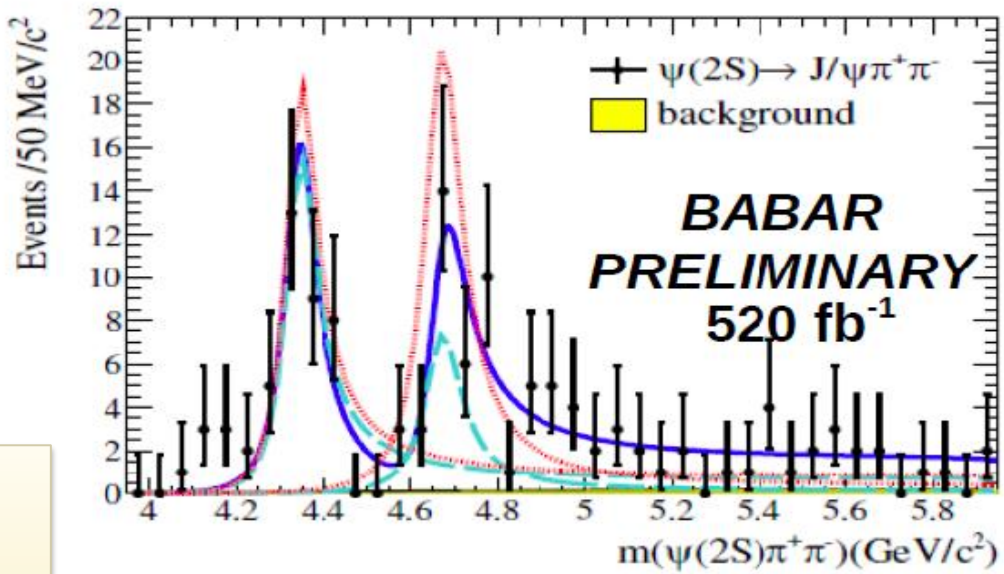
Y States in ISR, $J^{PC}=1^{--}$





No signal in D(*)D(*), too large partial widths to cc and light mesons – inconsistent with conventional charmonium

..and problem with the absence of vacant $J^{PC}=1^{--}$ cc states



- ✓ **<u>Charmonium hybrids</u> (LQCD expect ~ 4.2 GeV)**
- ✓ **<u>Hadro-charmonium</u>**
- ✓ **<u>Multiquark states (</u>[cq][cq] tetraquark)**

Charged Charmonium-like States at Belle or so charming exotics

2007:

$Z(4430)^+$

2008:

$Z_2(4250)^+$

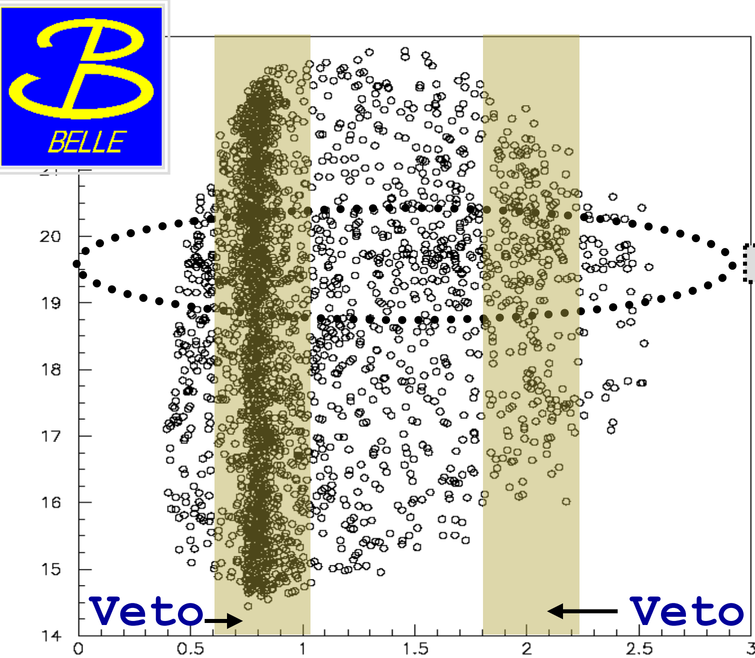
$Z_1(4050)^+$

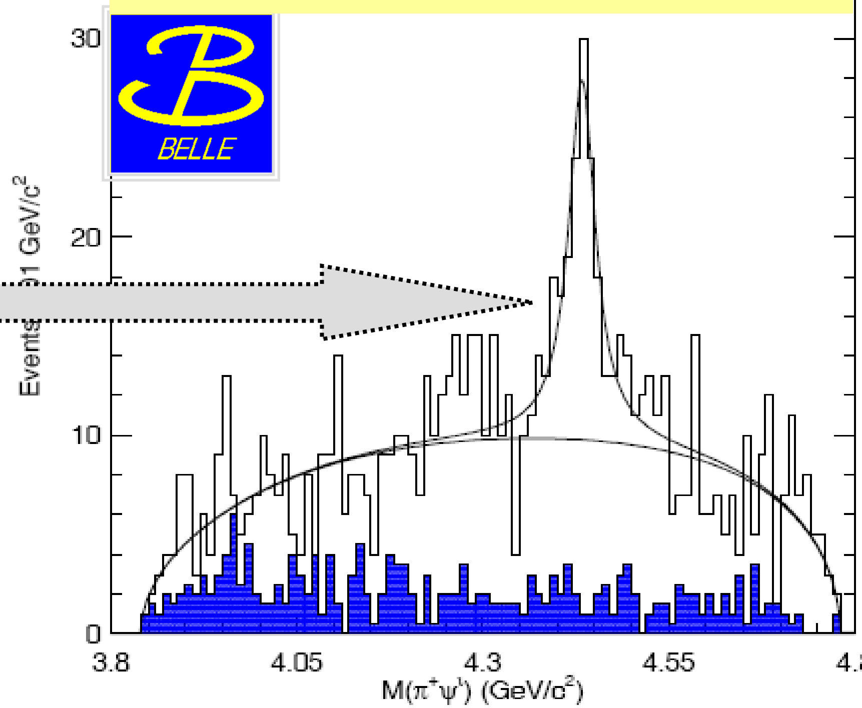
Charged Charmonium-like States $Z(4430)^+$ at Belle

$\psi(2S)\pi^+$

$B^0 \to \pi^+\psi(2S) K^-$

PRL 100, 142001 (2008)





Fit: S-wave Breit-Wigner +
Background with kinematic thresholds

Cross-checks:
$Z(4430)^+$ is present in both ψ' subsamples

This Z+ has no chance to be a pure cc (unlike neutral XYZ)

Total significance: 6.5 σ

M = (4433±4±1) MeV

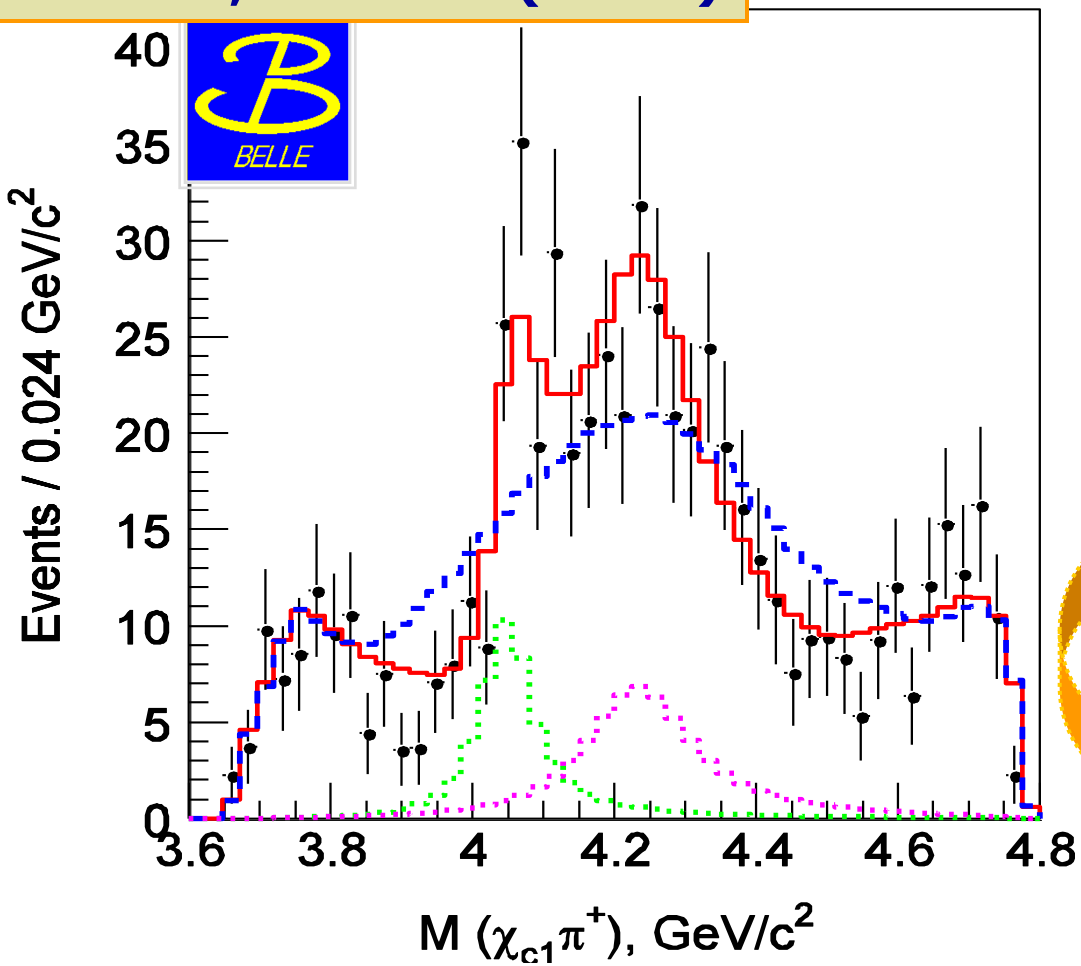
$\Gamma = (44^{+17}_{-13}{}^{+30}_{-11})$ MeV

$Br(B\to KZ) \times Br(Z\to\psi(2S)\pi^+) = (4.1\pm1.0\pm1.3)\cdot10^{-5}$

New charged Z's decaying into $\pi^+\chi_{c1}$

$B^0 \to \pi+\chi_{c1}$ K-

PRD 78, 072004 (2008)



No discrimination between J=0 or 1

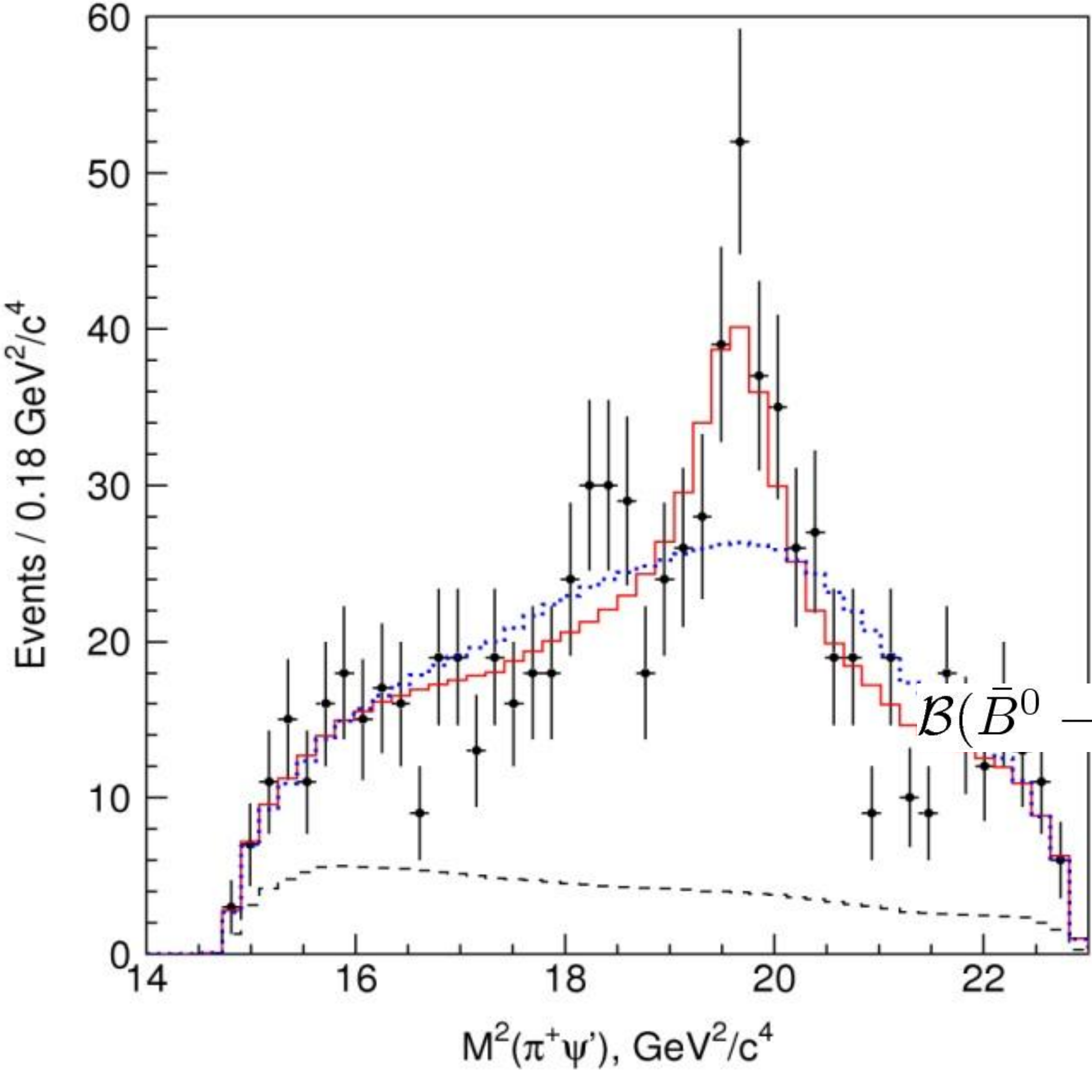
$$M_1 = (4051 \pm 14^{+20}_{-41})\ \text{MeV}/c^2,$$
$$\Gamma_1 = (82^{+21+47}_{-17-22})\ \text{MeV},$$
$$M_2 = (4248^{+44+180}_{-29-35})\ \text{MeV}/c^2,$$
$$\Gamma_2 = (177^{+54+316}_{-39-61})\ \text{MeV},$$

with the product branching fractions of

$$\mathcal{B}(\bar{B}^0 \to K^- Z_1^+) \times \mathcal{B}(Z_1^+ \to \pi^+ \chi_{c1}) = (3.0^{+1.5+3.7}_{-0.8-1.6}) \times 10^{-5},$$
$$\mathcal{B}(\bar{B}^0 \to K^- Z_2^+) \times \mathcal{B}(Z_2^+ \to \pi^+ \chi_{c1}) = (4.0^{+2.3+19.7}_{-0.9-0.5}) \times 10^{-5}.$$

are the same order as obtained for other, possibly exotic X,Y,Z states.

Updated parameters of Z(4430)$^+$ from the Dalitz plot fit



Belle confirms the original result on Z(4430)$^+$

$$M = (4443^{+15+17}_{-12-13})\ \mathrm{MeV}/c^2$$

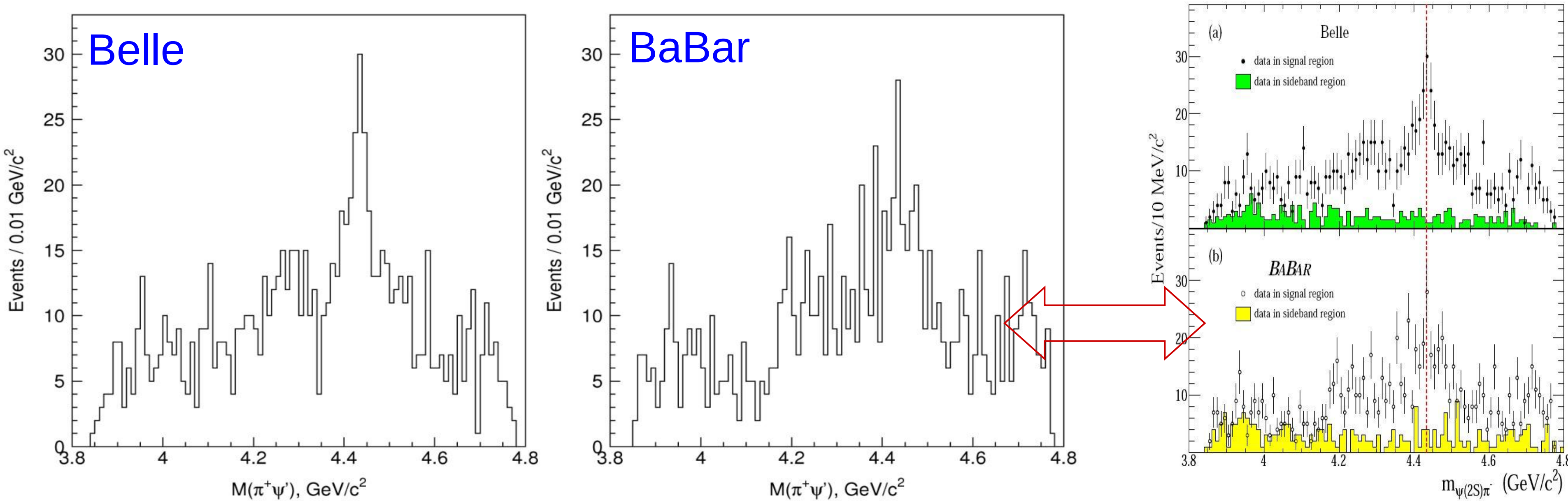
$$\Gamma = (109^{+86+57}_{-43-52})\ \mathrm{MeV}$$

$$\mathcal{B}(\bar{B}^0 \to K^- Z(4430)^+) \times \mathcal{B}(Z(4430)^+ \to \pi^+\psi') = (3.2^{+1.8+5.3}_{-0.9-1.6}) \times 10^{-5}$$

Comparison with BaBar *(arXiv:0811.0564)*

BaBar paper: Belle and BaBar data **are statistically consistent**.

⇔ peak in $M(\pi^+\psi')$ is present also in BaBar data with similar to Belle shape:



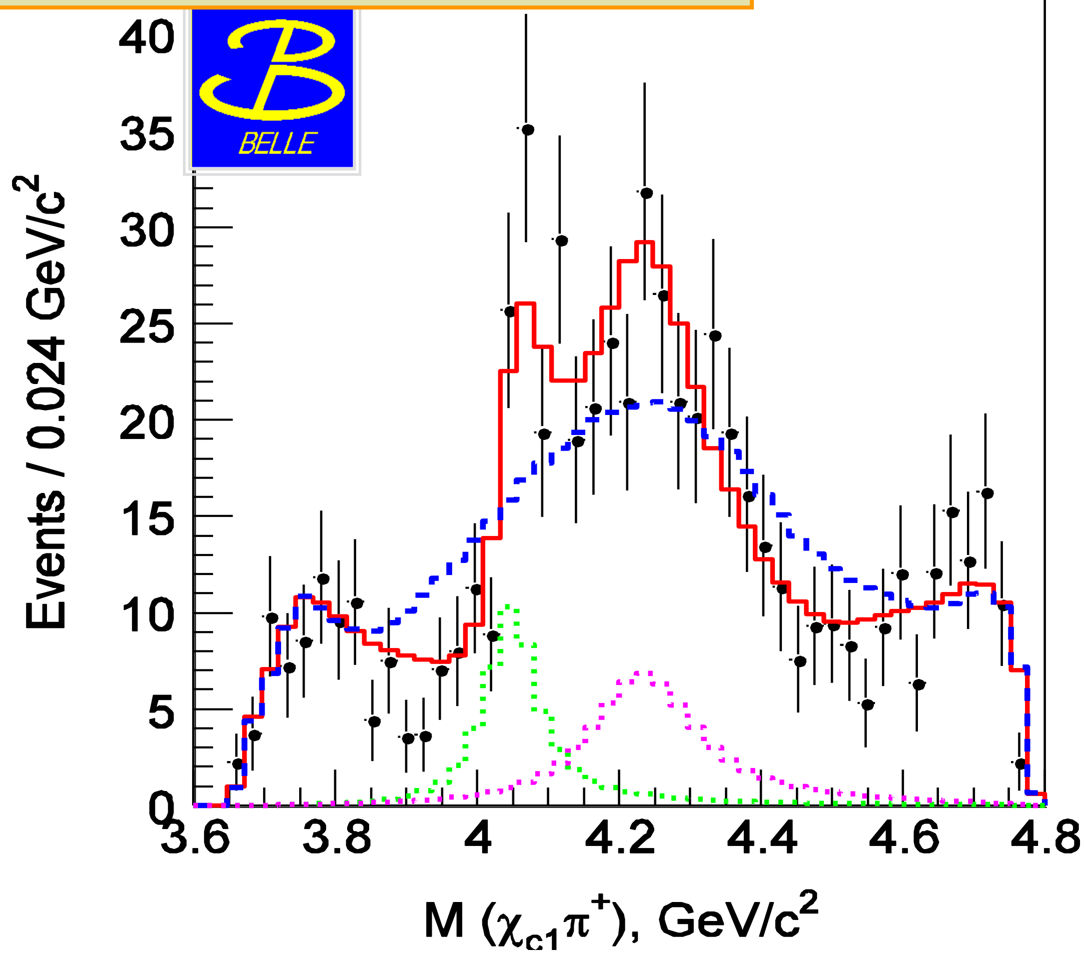
Why different significances are reported? (6.4σ Belle vs. 1.9–3.1σ BaBar)

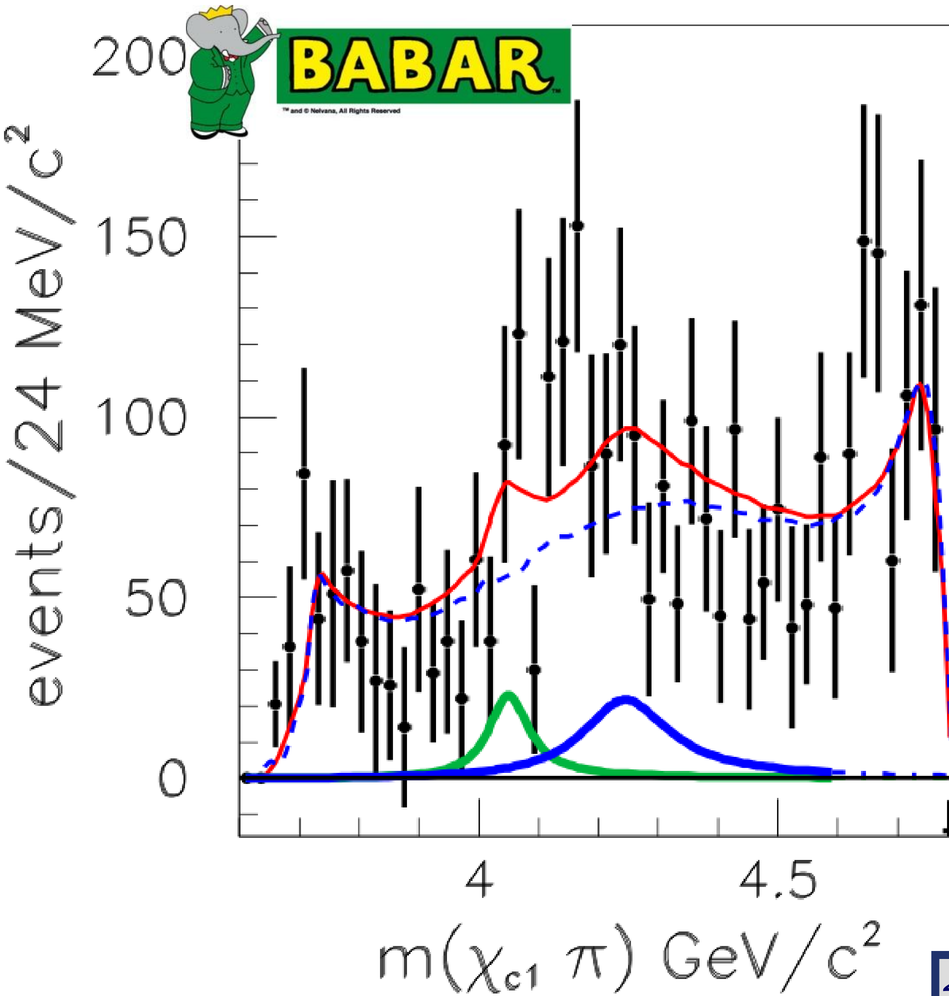
⇔ assumption about background is crucial.

New charged Z's decaying into $\pi^+\chi_{c1}$

*comparison with the result from BaBar

PRD 78, 072004 (2008)





Belle remains confident that their analysis is sound and the peaks in $\pi^+\psi'$ and $\pi^+\chi_{c1}$ masses are not due to the reflections from the dynamics in $K\pi$ system

Interpretation of Z^+

Charged, I=1

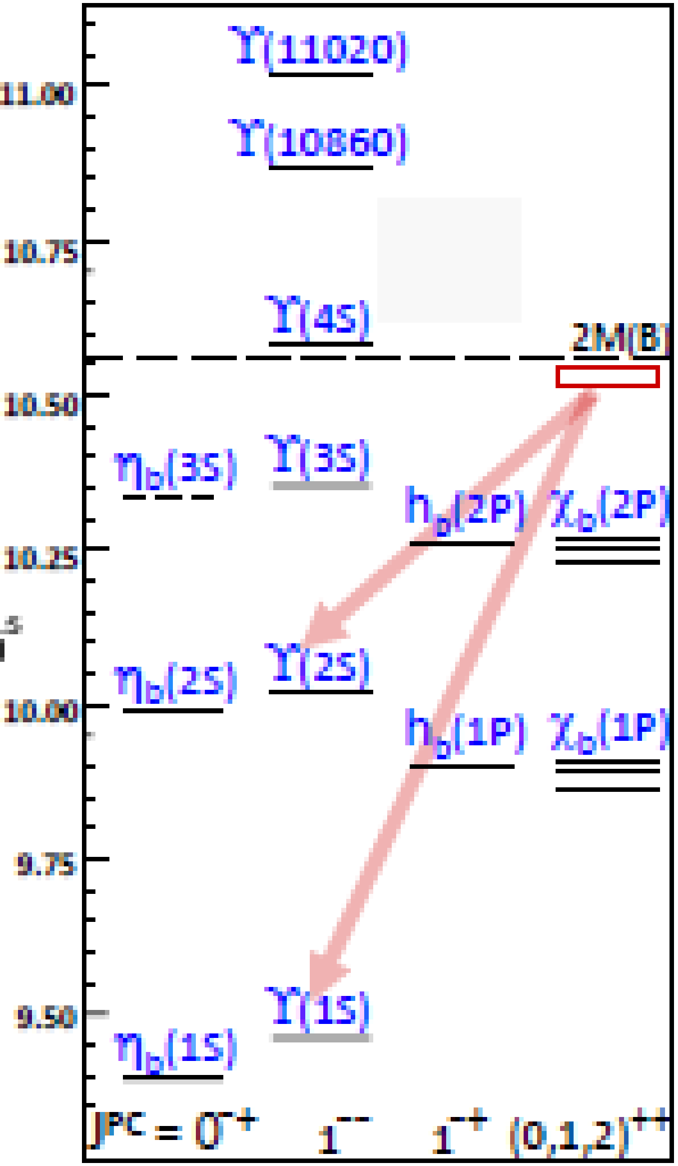
Cannot be a conventional charmonium or hybrid state

Should contain light quarks in addition to cc

A variety of interpretations (not a complete list…):

- **D^*D_1 molecular state** (X. Liu *and* Y.R. Liu, 0711.0494);
- **radially excited tetraquark** (L.Maiani, A.D.Polosa, V.Riquer, 0708.3997);
- **hadro-charmonium** (S.Dubinskiy,M.B.Voloshin,0803.2224)

Recently observed conventional bottomonium $\chi_b(3P)$

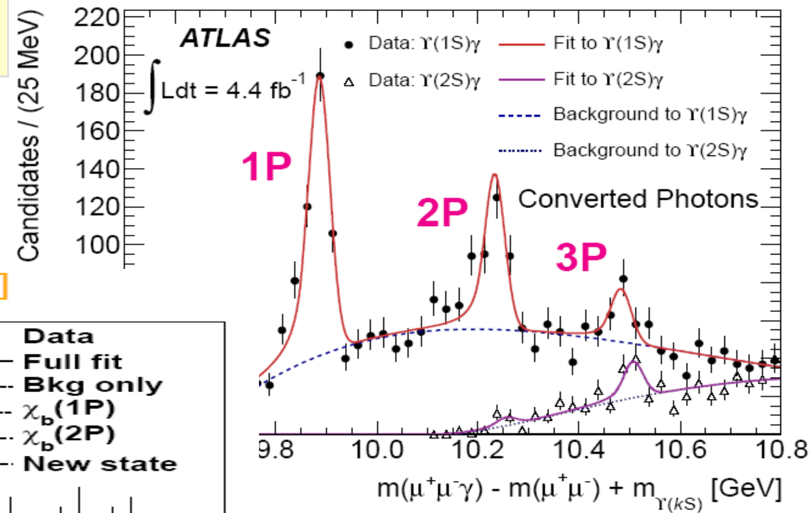


Spin-averaged M[χb(3P)]

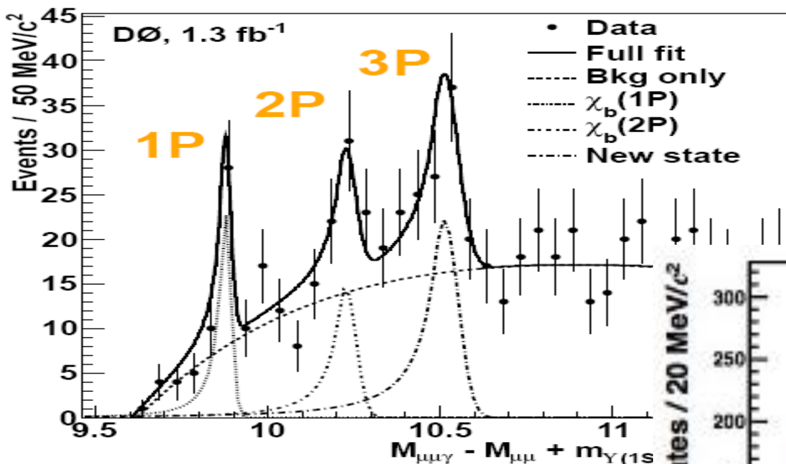
$\chi_b(3P) \to \Upsilon(1,2S)\,\gamma \to \mu^+\mu^-\,\gamma$

[ATLAS PRL108,152001(2012)]

10530 ± 9 ± 5 MeV

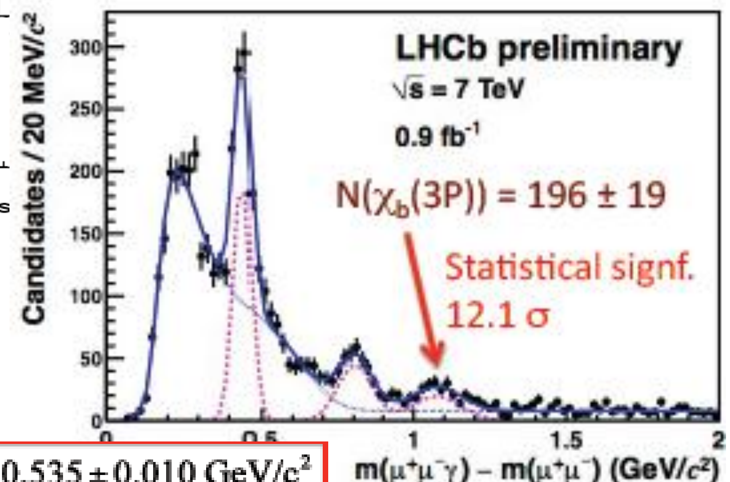


[D0 arXiv:1203.6034]



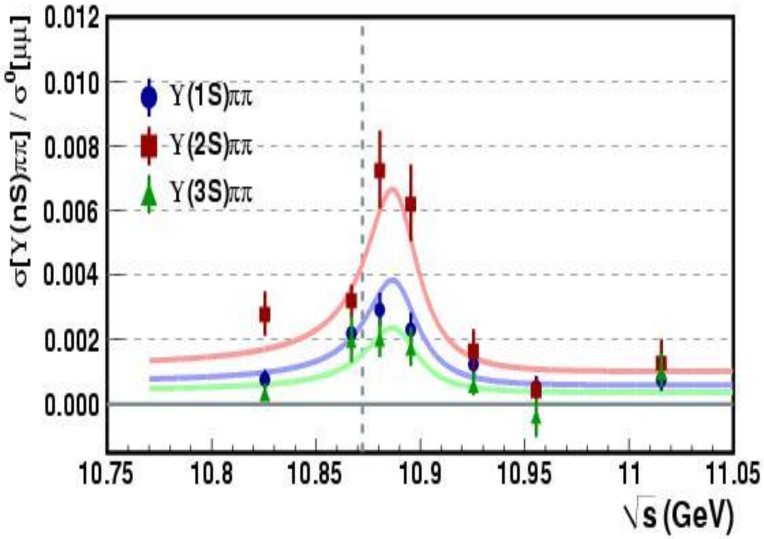
10551 ± 14 ±17 MeV

theory 10525

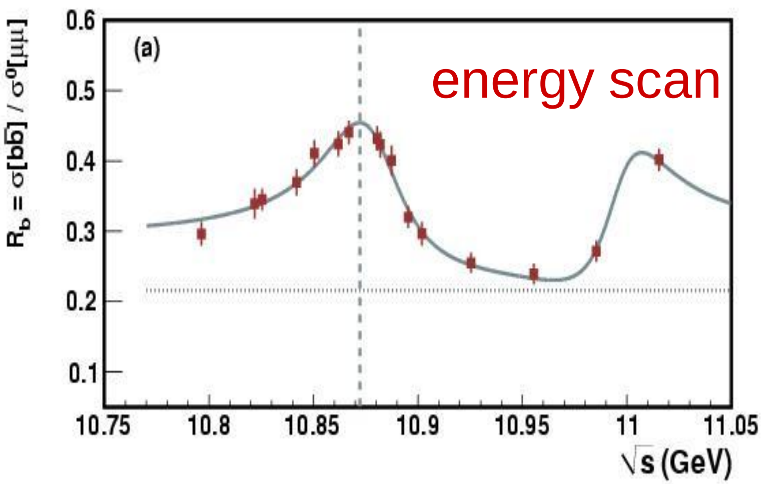


$m(\chi_b[3P]) = 10.535 \pm 0.010\ \mathrm{GeV}/c^2$

Anomalous production of $\Upsilon(nS)\pi^+\pi^-$ from $\Upsilon(5S)$ at Belle



$\Upsilon(5S) \to \Upsilon(1S)\pi^+\pi^-$	$0.59 \pm 0.04 \pm 0.09$
$\Upsilon(5S) \to \Upsilon(2S)\pi^+\pi^-$	$0.85 \pm 0.07 \pm 0.16$
$\Upsilon(5S) \to \Upsilon(3S)\pi^+\pi^-$	$0.52^{+0.20}_{-0.17} \pm 0.10$
$\Upsilon(2S) \to \Upsilon(1S)\pi^+\pi^-$	0.0060
$\Upsilon(3S) \to \Upsilon(1S)\pi^+\pi^-$	0.0009
$\Upsilon(4S) \to \Upsilon(1S)\pi^+\pi^-$	0.0019



$\Gamma[\Upsilon(\mathbf{5S}) \to \Upsilon(1,2,3S)\, \pi^+\pi^-] >> \Gamma[\Upsilon(\mathbf{4,3,2S}) \to \Upsilon(1S)\, \pi^+\pi^-]$

Remember Y(4260) with anomalous $\Gamma(J/\psi\, \pi^+\pi^-)$ - analogue Y_b close to $\Upsilon(5S)$?

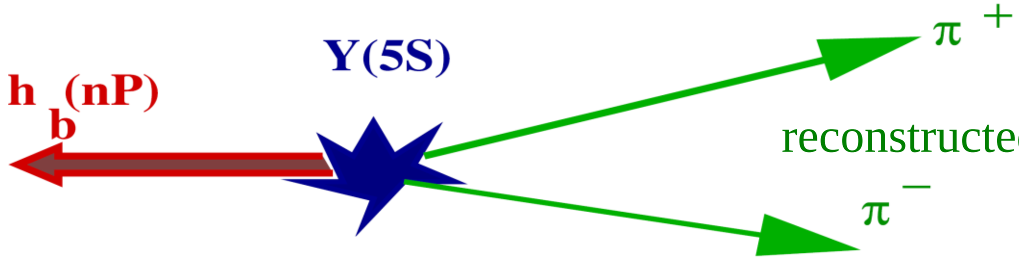
shapes of R_b and $\sigma(\Upsilon\pi\pi)$ are different at 2σ

CLEO observed $e^+e^- \to h_c\, \pi^+\pi^-$ @ E_{CM}=4170MeV

$\Rightarrow$ Motivation to search for h_b at $\Upsilon(5S)$

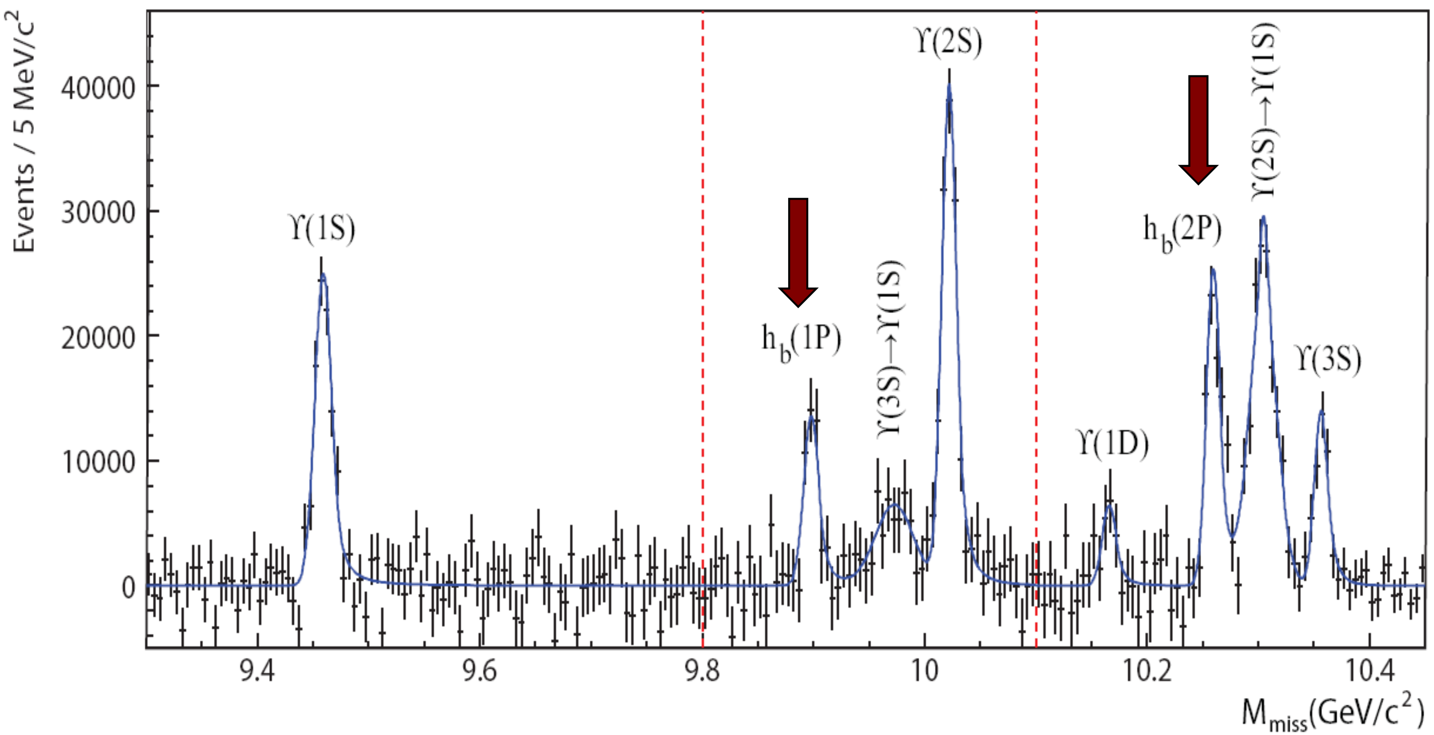
Search for and **observation** of h_b and h_b' at Belle

$e^+e^- \to \Upsilon(5S) \to h_b(nP)\ \pi^+\pi^-$



"Missing mass" = $\sqrt{(P_{e+e-} - P_{\pi+\pi-})^2}$

Known Upsilons are our guide and reference!



Deviations from Center of Gravity of χ_{bJ} masses:

ΔM_{HF}(**1P**) = +0.8 ± 1.1 MeV
ΔM_{HF}(**2P**) = +0.5 ± 1.2 MeV,
Consistent with 0,
as expected.
... BUT production rates....

Ratio of production rates:

spin-flip

$$\frac{\Gamma[\Upsilon(5S) \to h_b(nP)\,\pi^+\pi^-]}{\Gamma[\Upsilon(5S) \to \Upsilon(2S)\,\pi^+\pi^-]} = \begin{array}{ll} 0.45 \pm 0.08^{+0.07}_{-0.12} & \text{for } h_b(1P) \\ 0.77 \pm 0.08^{+0.22}_{-0.17} & \text{for } h_b(2P) \end{array}$$

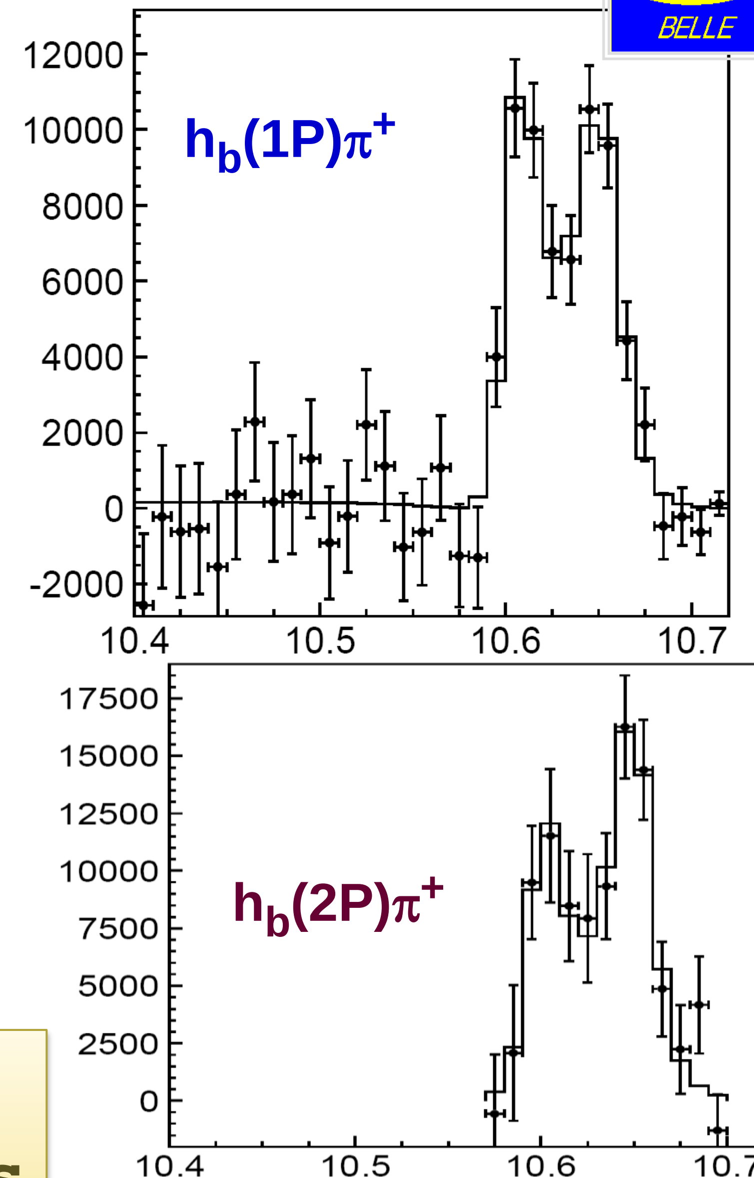
no spin-flip

This process - with spin-flip of heavy quark - is not suppressed !

$\Rightarrow$ Mechanism of $\Upsilon(5S) \to h_b(nP)\,\pi^+\pi^-$ decay violates Heavy Quark Spin Symmetry

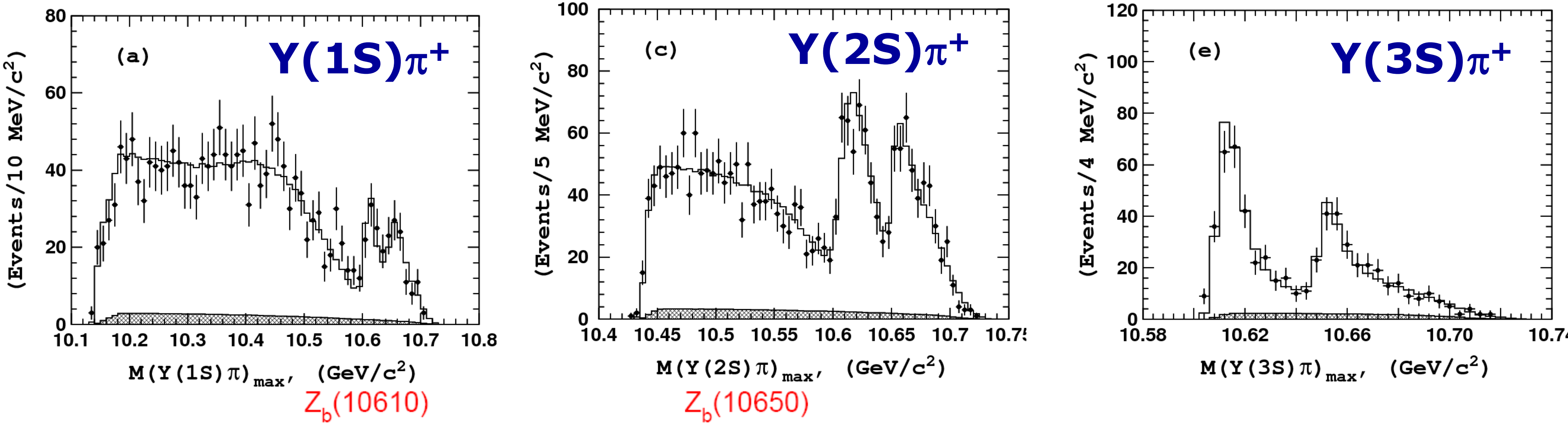
Study res. structure

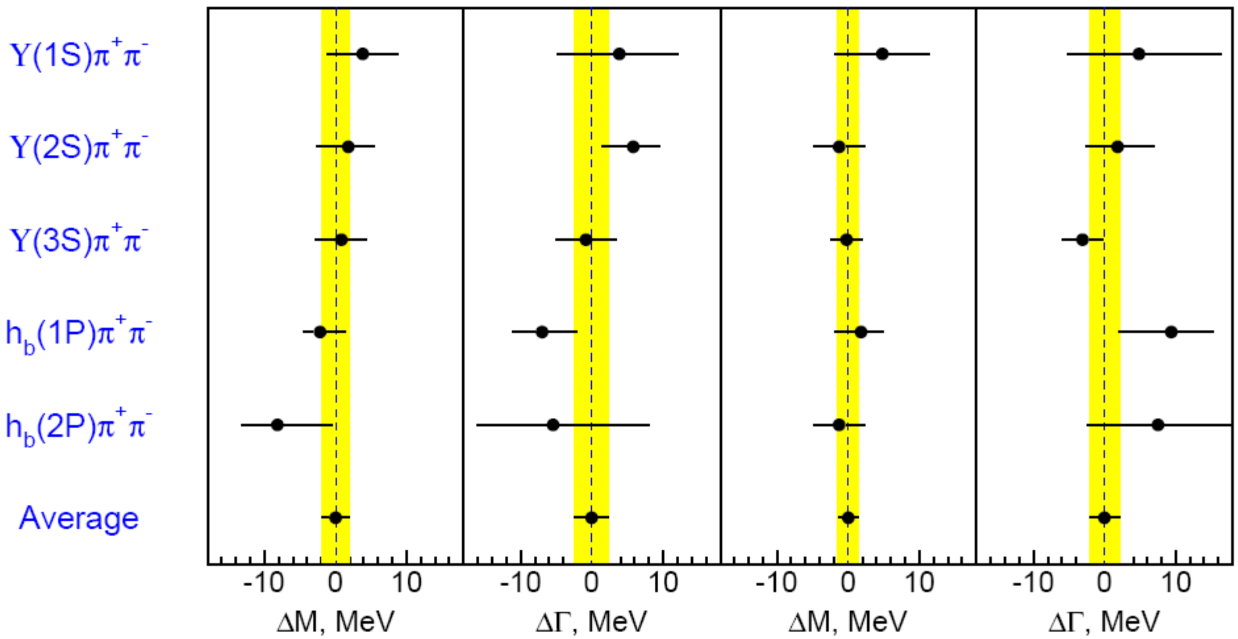
Resonant structure in $\Upsilon(5S) \to h_b(1,2\ P)\ \pi^+\pi^-$



First observation of charged bottomonium-like states

Resonant structure in $\Upsilon(5S) \to Y(1,2,3S)\pi^+\pi^-$





Average over 5 channels:

$\langle M_1 \rangle = 10607.2 \pm 2.0$ MeV

$\langle \Gamma_1 \rangle = 18.4 \pm 2.4$ MeV

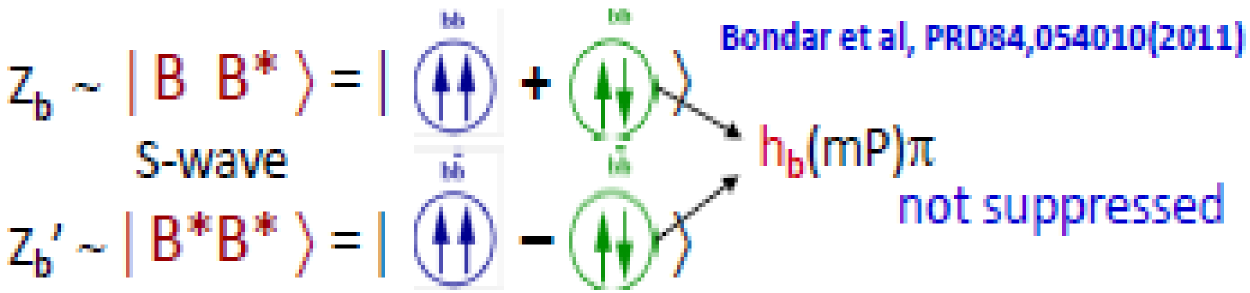
$\langle M_2 \rangle = 10652.2 \pm 1.5$ MeV

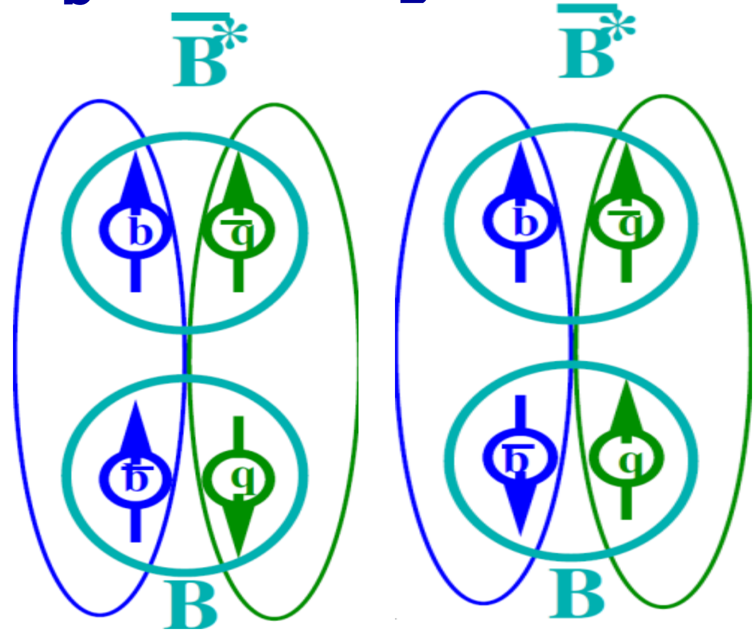
$\langle \Gamma_2 \rangle = 11.5 \pm 2.2$ MeV

Belle PRL108,122001(2012)

Heavy quark structure in Z_b^+ and $Z_b'^+$

Wave func. at large distance – B(*)B*





Explains

- Why $h_b\pi\pi$ is unsuppressed relative to $\Upsilon\pi\pi$
- Relative phase ~0 for Υ and ~180^0 for h_b
- Production rates of $Z_b(10610)$ and $Z_b(10650)$ are similar
- Widths

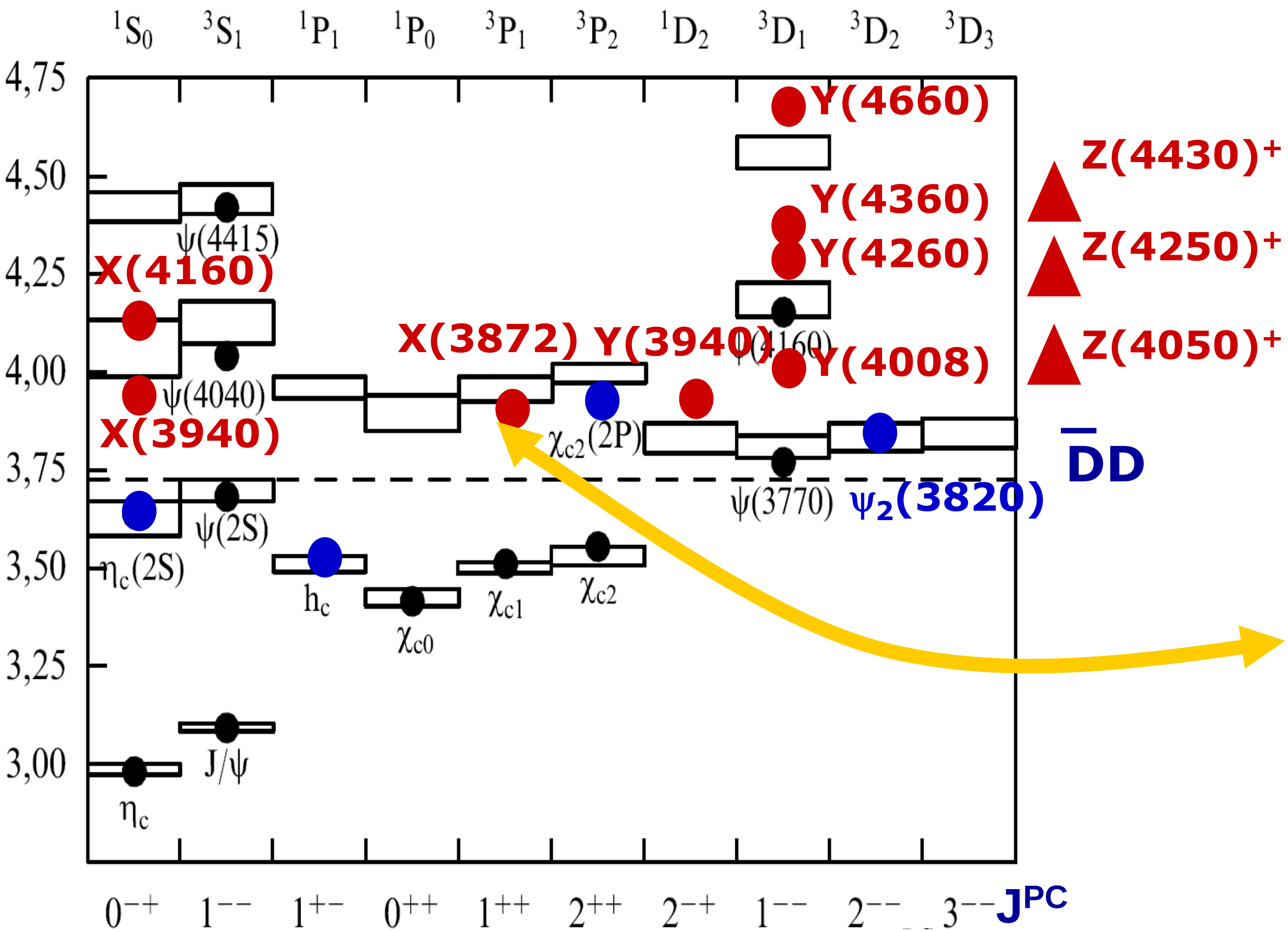
Other possible interpretations of peaks in Mass((bb)π^+)

✓ Coupled channel resonances (I.V.Danilkin et al, arXiv:1106.1552)

✓ Cusp (D.Bugg Europhys.Lett.96 (2011),arXiv:1105.5492)

✓ Tetraquark (M.Karliner, H.Lipkin, arXiv:0802.0649)

Summary (charmonium-like)

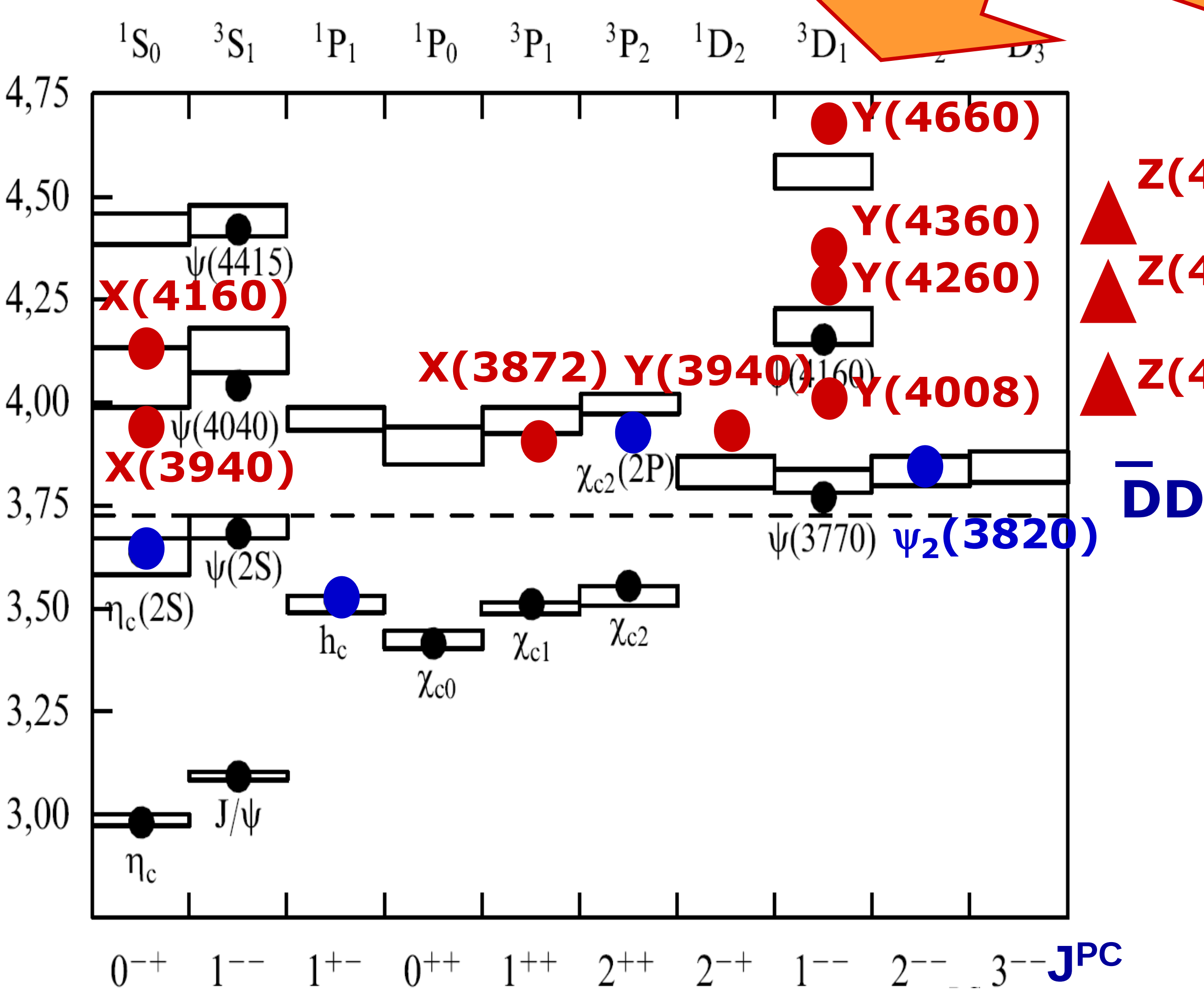


Heavy quarkonium have got new intense life due to discovery of unanticipated charmonium-like states XYZ at Belle and BaBar

These new states are studying now both experimentally and theoretically:

--- X(3872) was confirmed by CDF, D0, BaBar and recently LHCb!

Summary (charmonium-like)



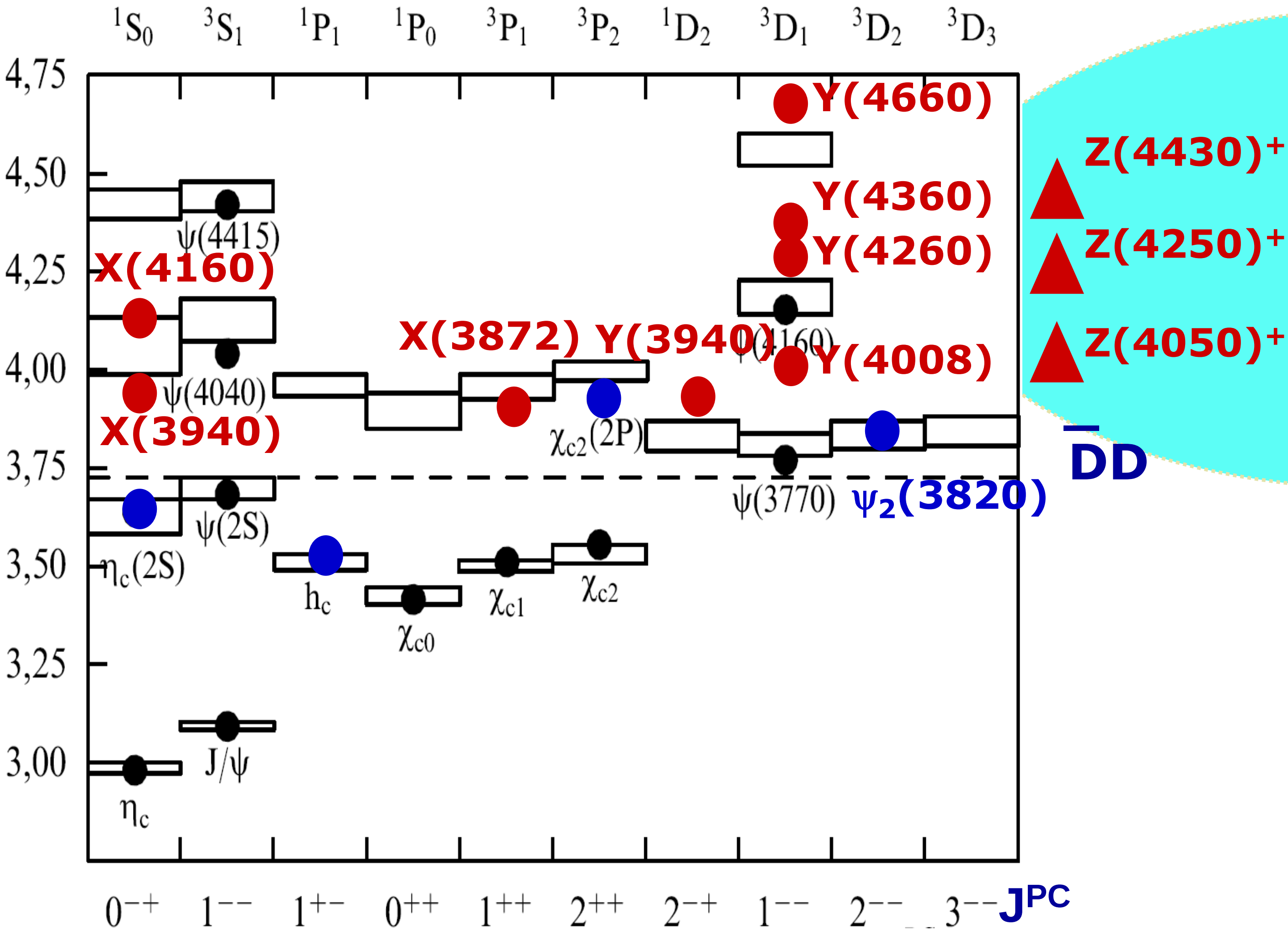
--- Y's states found in ISR processes: 1⁻⁻

But none of them Are found so far in Inclusive R or exclusive (DD, DD*, DsDs, Λc+Λc- , DD*π) hadronic cross sections spectra

Very unusual , non-charmonium cc-like states!

Hadrocharmonium or Thetraquarks or ccg hybrid

Summary (charmonium-like)



And finally yet-unconfirmed "smoking gun" for manifestly exotic charged charmonium-like states: Z's+

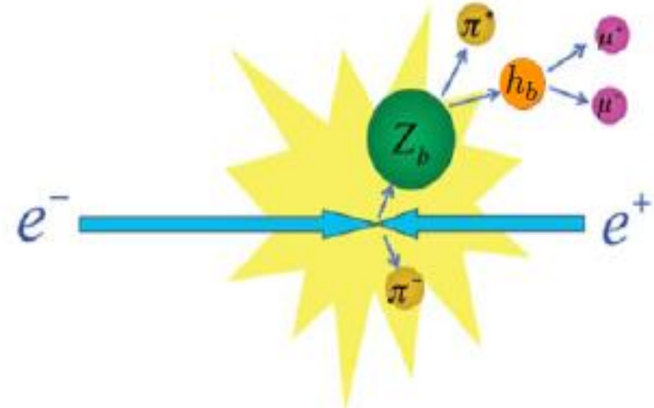
Summary (bottomonia and Z_b^+)

• h_b and h_b', $\eta_b(1S)$ and $\eta_b(2S)$ (not covered in this talk) at Belle; highly excited $\chi_b(3P)$ at D0, LHCb and ATLAS

Breakthrough in bottomonium physics above BB threshold:

- Exotics: two charged Z_b^+ bottomonium-like states in 5 decay modes at Belle:

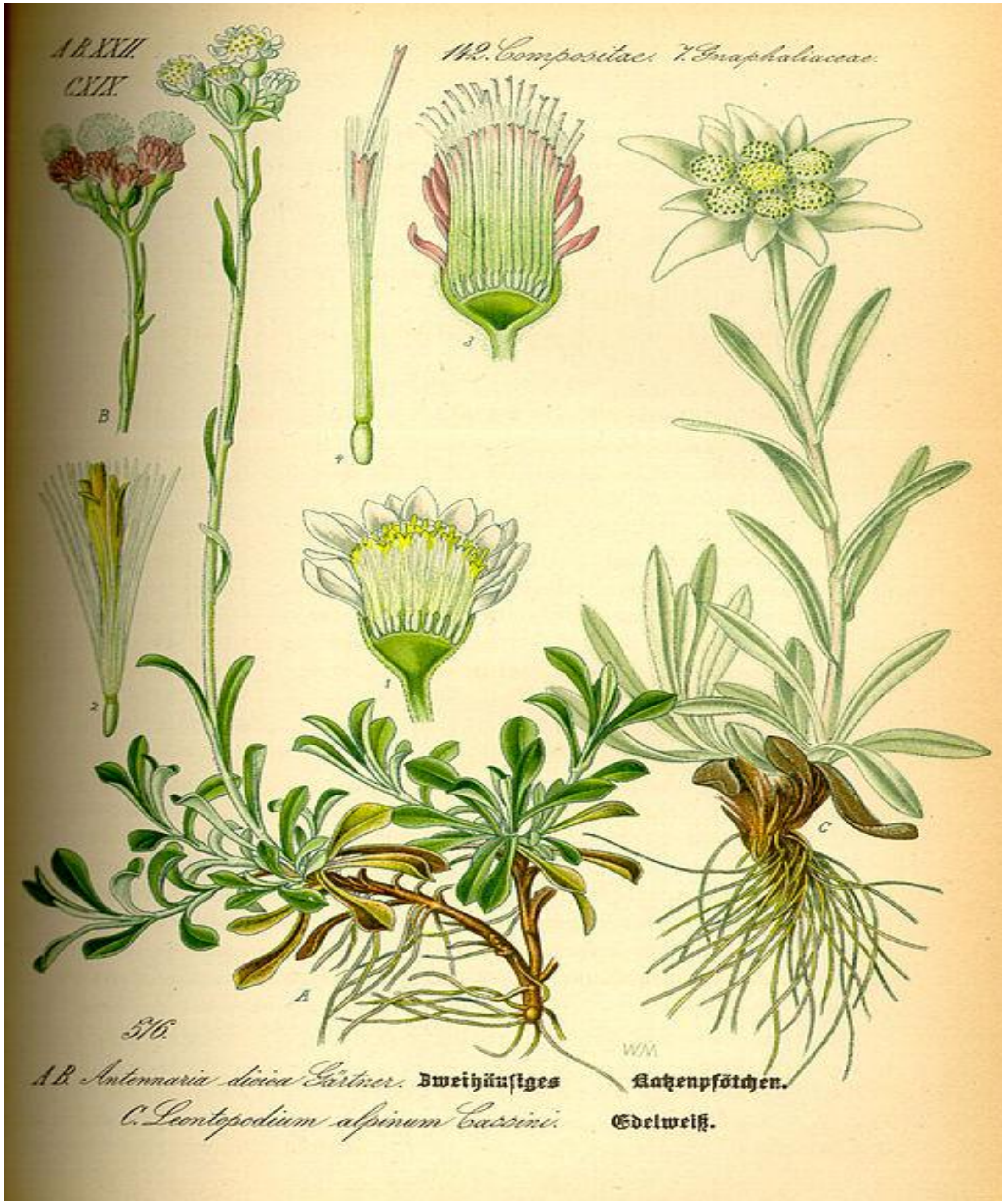
$\Upsilon(1S)\pi^+$, $\Upsilon(2S)\pi^+$, $\Upsilon(3S)\pi^+$, $h_b(1P)\pi^+$, $h_b(2P)\pi^+$



- Properties of Z_b^+ states – stimulated theoretical investigations – are consistent with molecular structure.

(+predicts many new yet-unobserved states)

Final conclusions or enjoyable creatures above open flavor thresholds



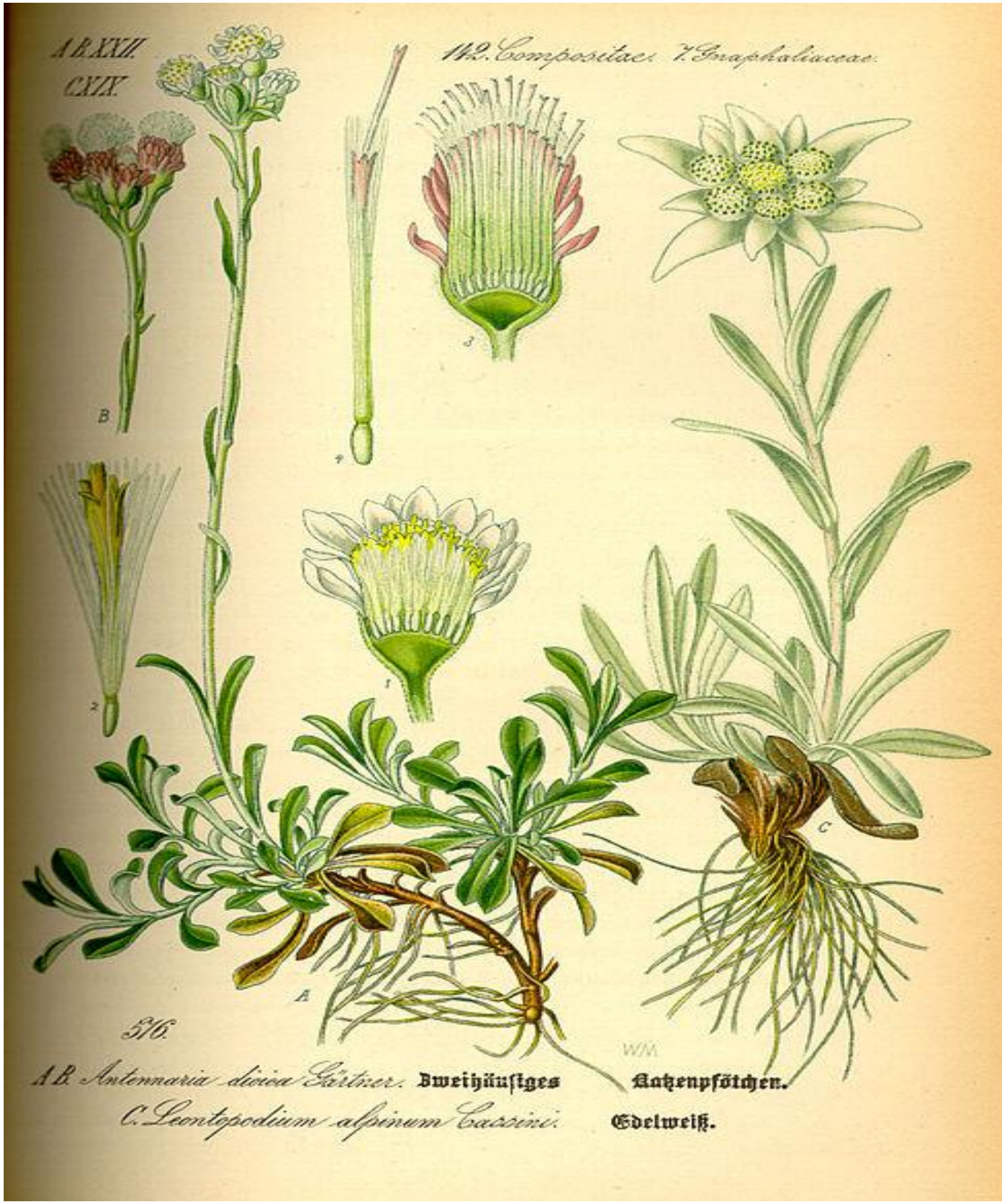
Current picture of quarkonium-like (≡exotic) states is rather scattered.

There is no theoretical model which is coherently described all experimental data.

X,Y,Z states remain a mystery; new efforts are needed

Contribution from
high-statistics measurements
is important:
LHC, Super B-factories.

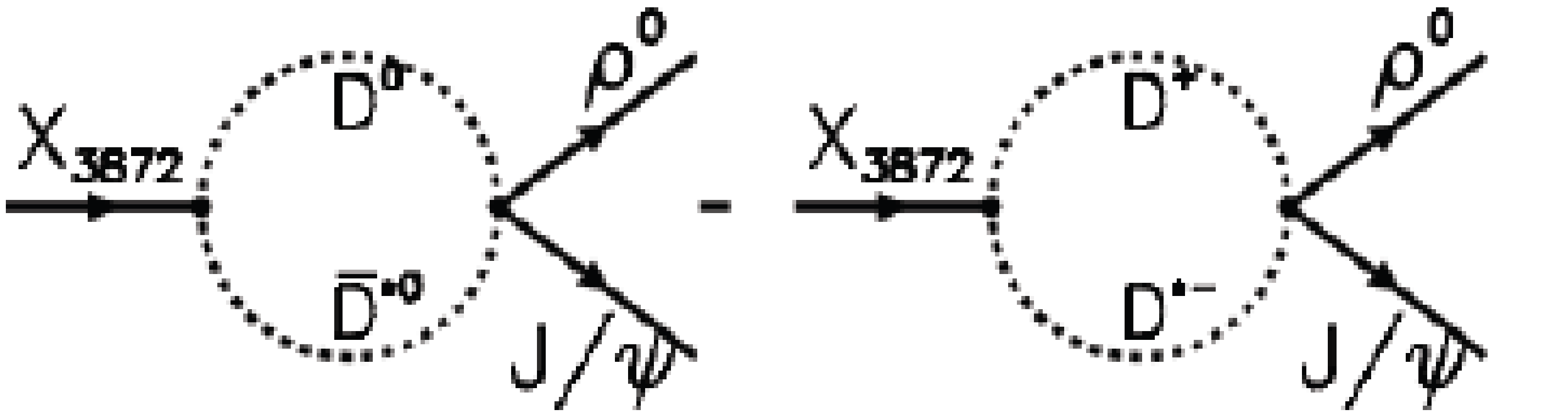
Final conclusions



D'akujem
Thank you

Back-up slides

Isospin Violation in X(3872) decay:



≈on mass shell ≈8 MeV off mass shell

Summary of Belle results on charged Z's

• 2007: Belle observed first charged charmoniumlike state, $Z(4430)^+$ decaying into $\psi'\pi^+$

• 2008: Belle continued the study of $B \to K\pi(c\bar{c})$ decays and observed two new charged charmoniumlike states $Z(4050)^+$ and $Z(4250)^+$, decaying into $\pi^+\chi_{c1}$

• Update on $Z(4430)^+$:
Dalitz Plot analysis confirms original observation.
The $Z(4430)^+$ has a significance of 6.4σ. The parameters of $Z(4430)^+$ from the DP analysis agree and supersede previous Belle measurement. BaBar has not confirmed $Z(4430)^+$ production but not exclude it.

These states have similar character: have non-zero electric charge and decay into ordinary charmonia and π^+.
The current options for their nature include tetraquark, molecular type states and hadro-charmonium.

Conventional charmonia

$J = S + L$

$P = (-1)^{L+1}$

$C = (-1)^{L+S}$

$n^{(2S+1)}L_J$

n radial quantum number

S total spin of q-antiq

L relative orbital ang. mom.

Comments on new 1^{--} Y's and Z^+

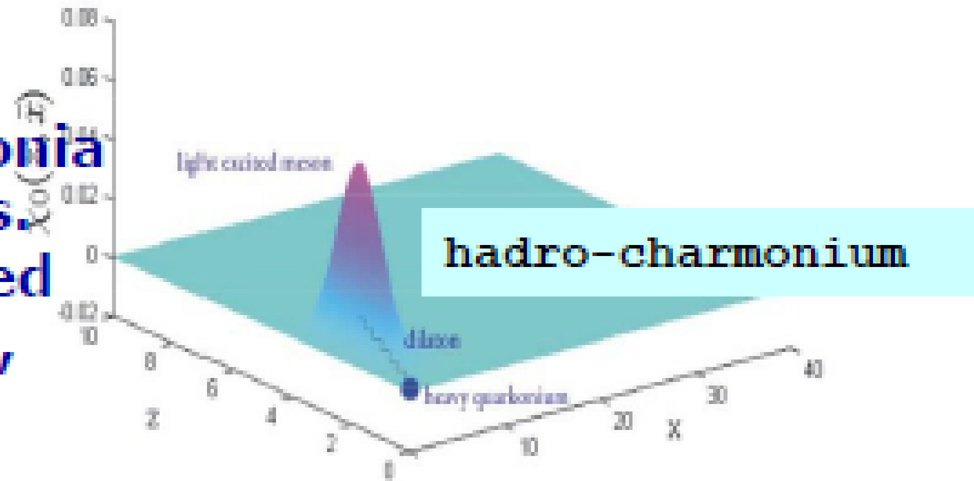
What is the interpretation of these most recent new states?

Different, but maybe not too orthogonal pictures:

These states are new states of matter:
ccg, molecule or 4-quark -
obviously not simple qq systems

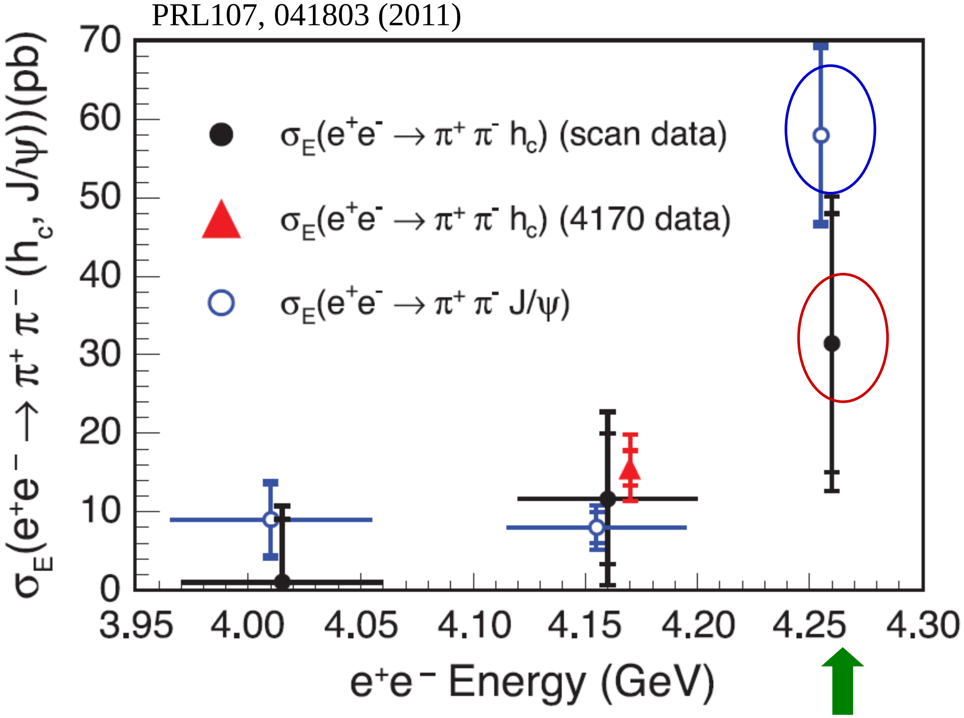
OR

Just the manifestation of new features of QCD: heavy quarkonia can be embedded into light mesons. The properties of both are preserved as they are separated by scale size, w/o rearrangement of quark's ?



S.Dubinskiy,M.B.Voloshin,0803.2224

PRL107, 041803 (2011)



Y(4260)

rise in $\sigma(h_c\pi^+\pi^-)$
@ Y(4260) ?

4260