Charged charmonium-like states as rescattering from conventional B decays

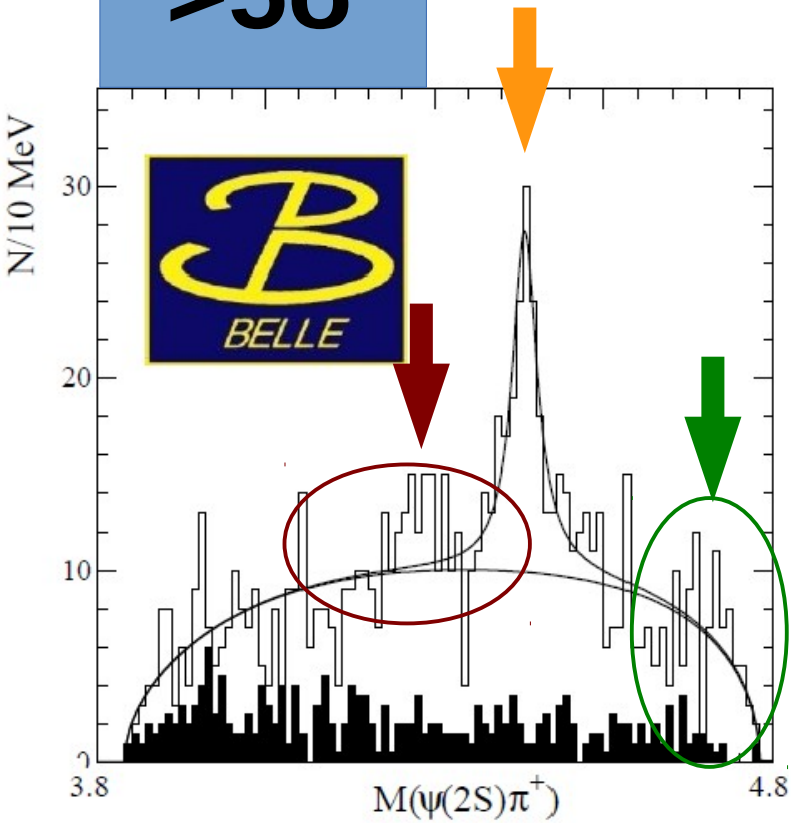
T.Uglov

MEPhI

Phys. Lett. B 748, 183 (2015)

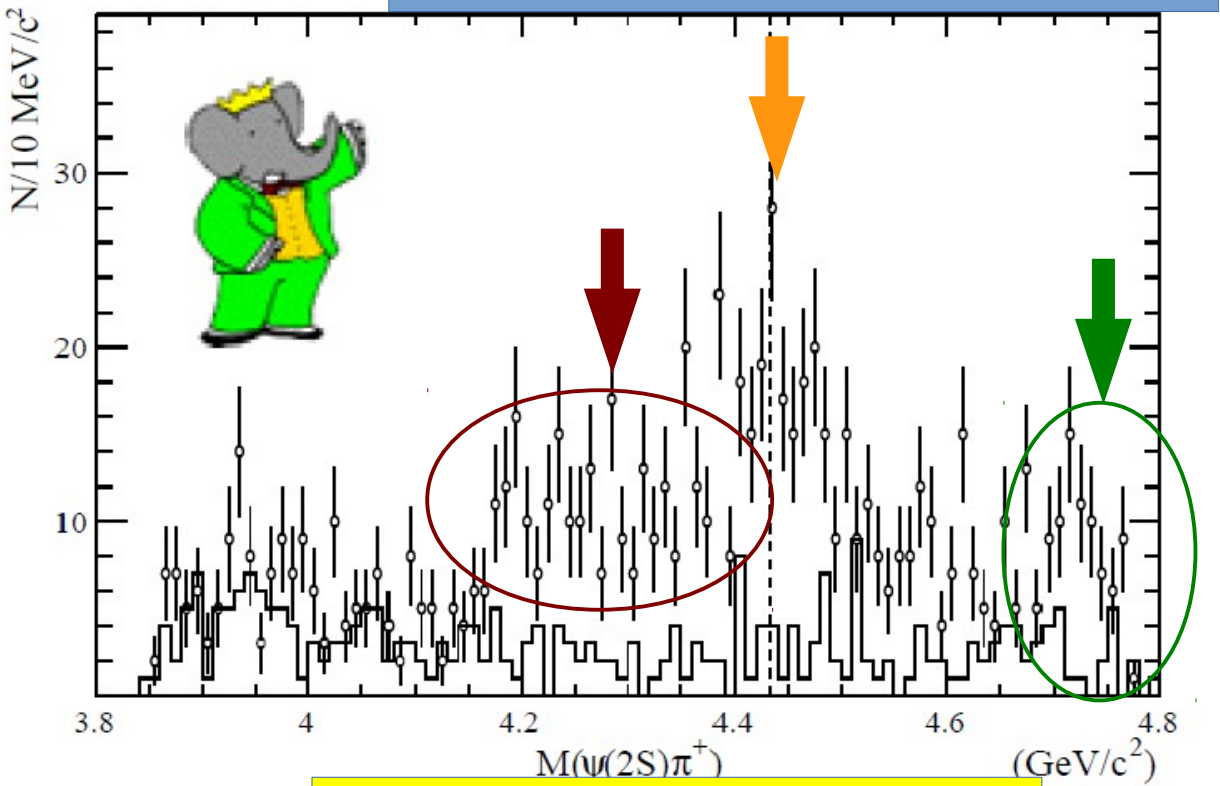
Z(4430) discovery: history

>5σ



PRL 100 142001 (2008)

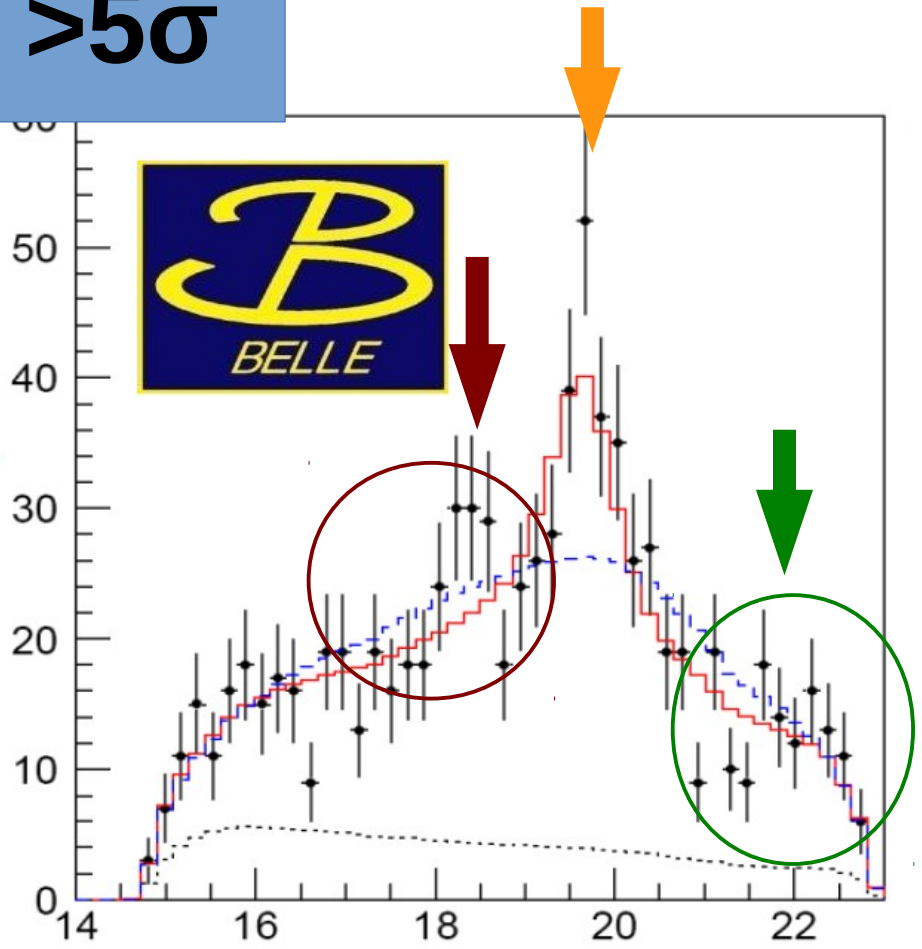
"no significant signal is observed"



PRD 79 112001 (2009)

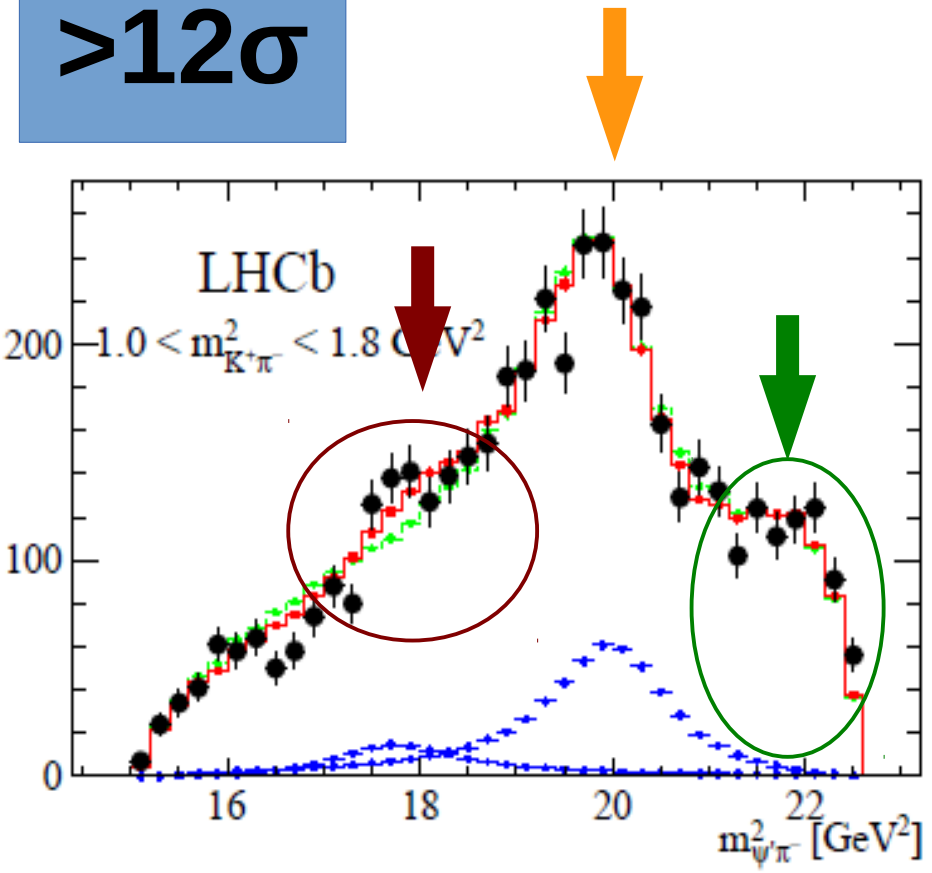
Z(4430) discovery: history

>5σ



PRD 80 031104 (2009)

>12σ



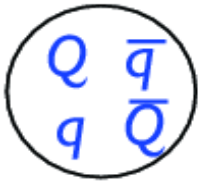
PRL 112, 222002 (2014)

Z(4430): possible interpretations

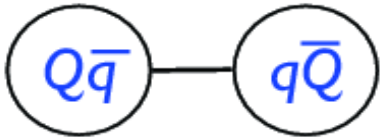
Models for XYZ Mesons

Quarkonium Tetraquarks

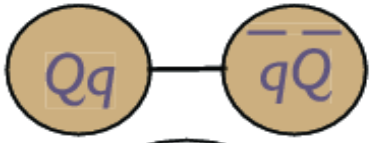
- compact tetraquark



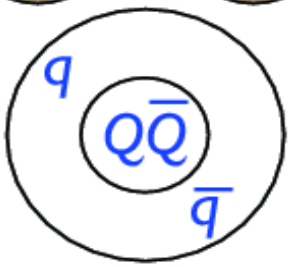
- meson molecule



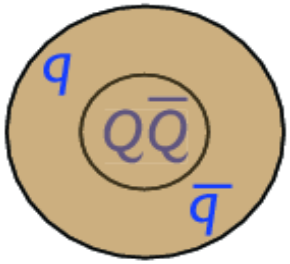
- diquark-onium



- hadro-quarkonium



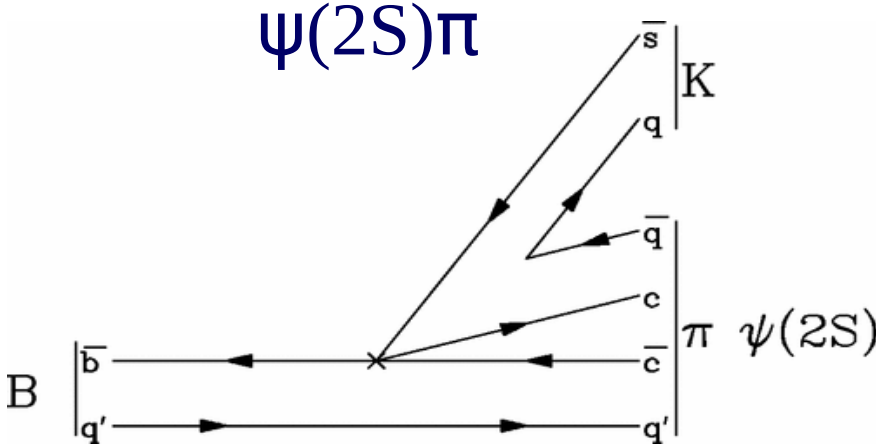
- quarkonium adjoint meson



Rescattering

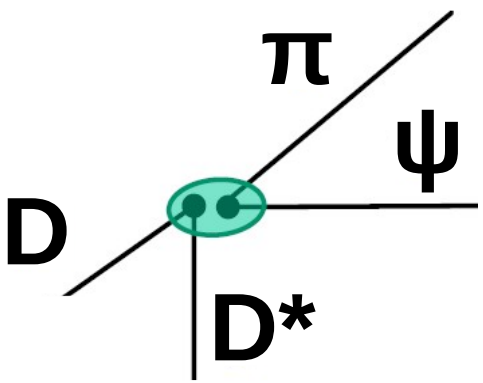
$B \to D^*\, D1(2420)\, K$

$\psi(2S)\pi$



PRD 76, 114002 (2007)

Rescattering $DD \to \psi\pi$



rescattering amplitude

$\bar{c}$-quark in D* meson

$$A \sim \int \Psi_D(c)\, \Psi_{D^*}(\bar{c})\, \Psi(c\bar{c})\, d^3p_c\, d^3p_{\bar{c}}$$

c-quark in D meson

$c\bar{c}$ wave function of ψ resonance

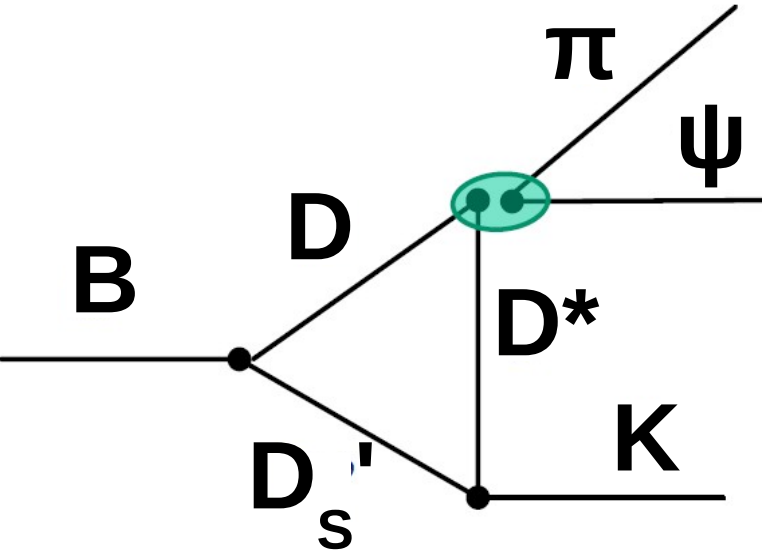
phase space element

<u>When we talk about rescatterng?</u>

- ✔ Large overlap of the wave-functions
- ✔ ($c\bar{c}$) pair with low momenta at small distance

→ Charmonium decays, B-meson decays, ISR, γγ-physics

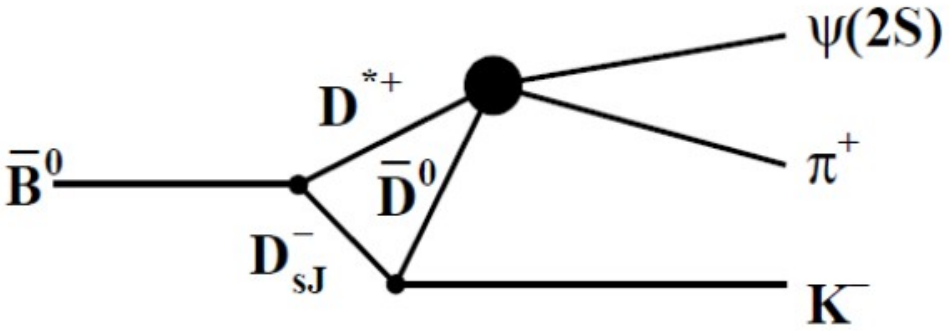
Rescattering in $B \to D_{sJ}D$ decay

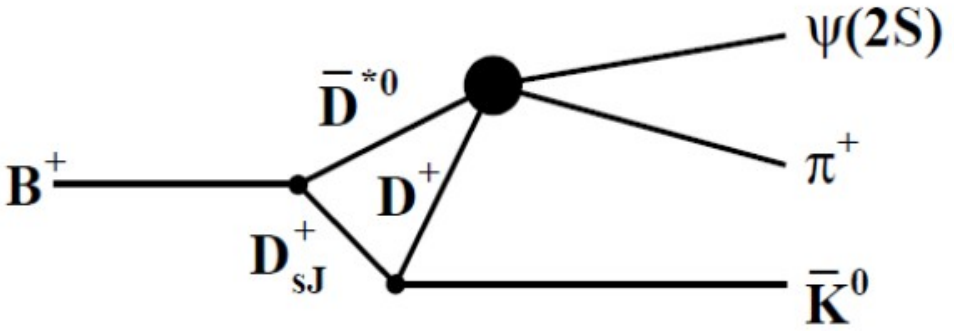


P.Pakhlov PLB **702**, 139 (2011)

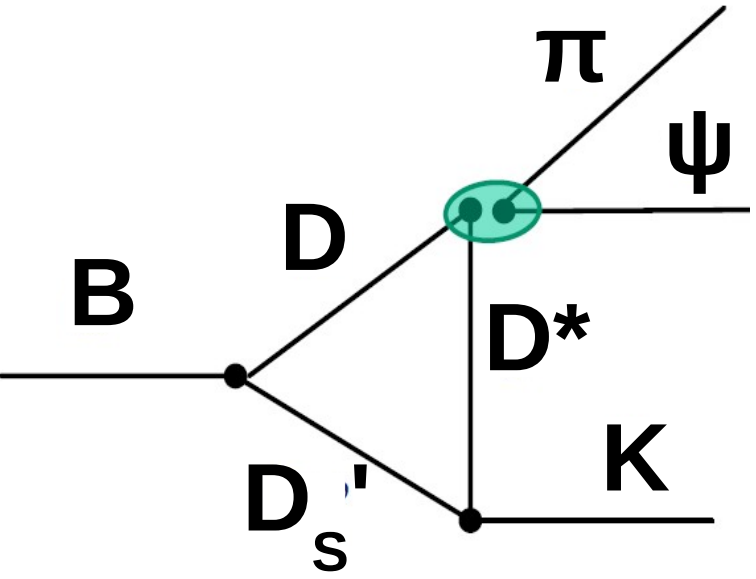
- $\tau(D_{sJ}) \ll \tau(D^*)$
- $\beta(c) \sim (0.2\text{-}0.5)$

$M(DD^*)=M(\psi'\pi)$





$Z^+(4430)$ in $B \to D_{sJ} D$ channel



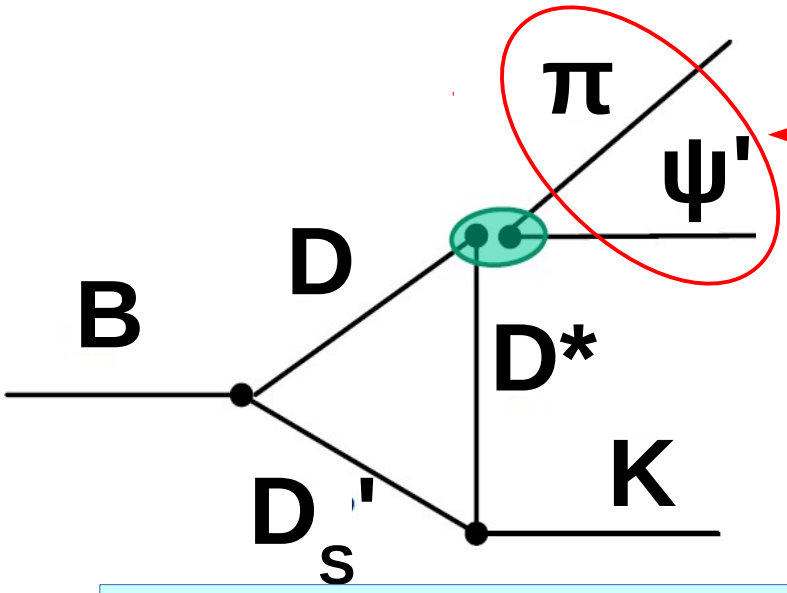
Assumptions:

- **$DD^* \to \psi'\pi$** decay goes is s-wave
- On-shell approximation works for this diagramm

- **$DD^* \to \psi'\pi$** amplitude does not change drastically in the region of 4-4.8 GeV

$M(\psi'\pi)$ spectrum lineshape for $J^P=1^+$ quantum numbers is similar to $Z^+(4430)$

Full rescattering amplitude



$Z^+(4430)$

$$A \sim \int \Psi_D(c)\, \Psi_{D^*}(\bar{c})\, \Psi(c\bar{c})\; d^3p_c\, d^3p_{\bar{c}}$$

A ~ BW(Ds'->D*K) x A(rescattering) x

A(Ds' decay) x A (D* spin rotation) x A (Z formation)

~1

$\sim d^1_{00}(\theta')$

θ' is angle btw. Ds' and Z in D* frame

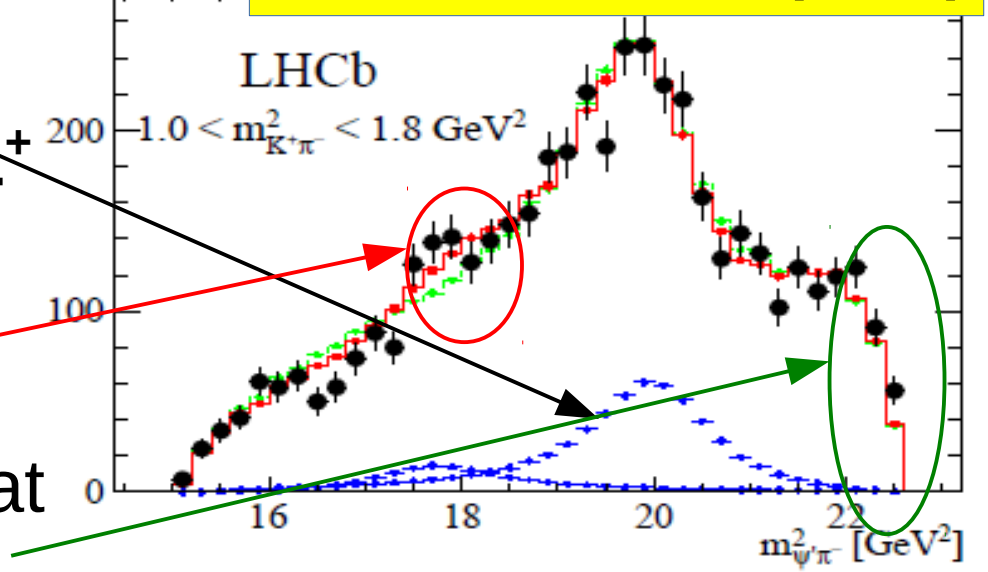
$d^1_{00}(\theta'')$

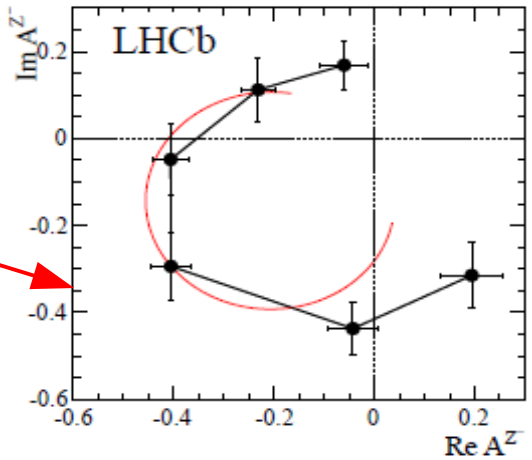
θ'' is D* helicity in Z frame

LHCb results

PRL 112, 222002 (2014)

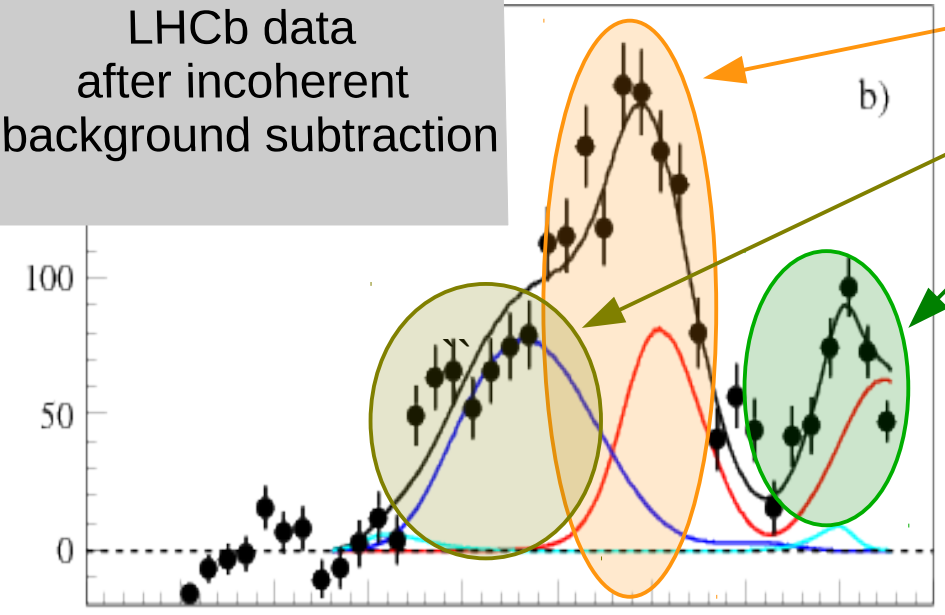
- Z(4430) quantum numbers: 1^+
- ~5σ structure at ~4200 МэВ
- Underestimation of the signal at higher mass region
- Breit-Wigner-like phase change Z(4430)

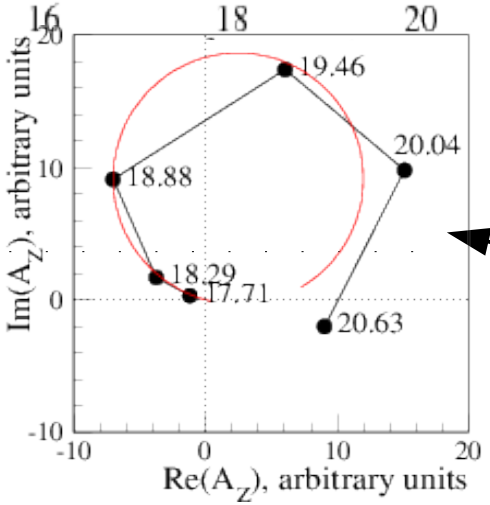




LHCb mass spectrum with rescattering

LHCb data
after incoherent
background subtraction





- ✔ Z(4430) qunatum numbers: **1**$^+$
- ✔ Broad structure at ~ 4200 MeV
- ✔ Bump at the end of the

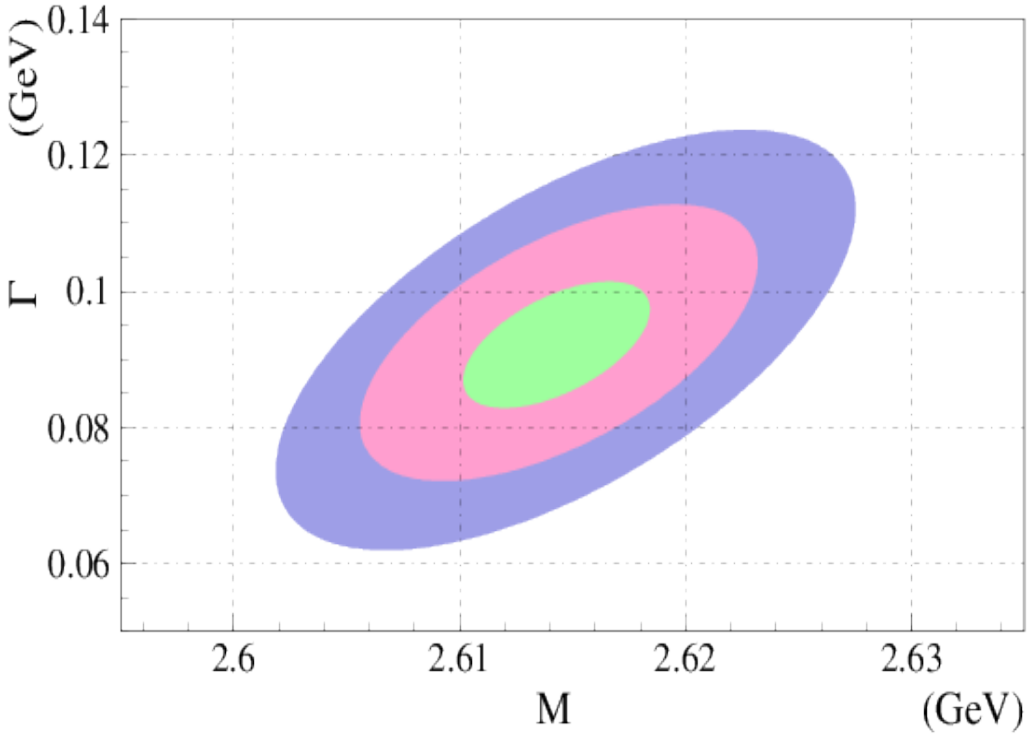
Predicted well before
the first measurement
of Z(4430) quantum
numbers by Belle and LHCb

PLB **702**, 139 (2011)

BW-like phase movement

(in opposite direction, though)

Ds' parameters estimation



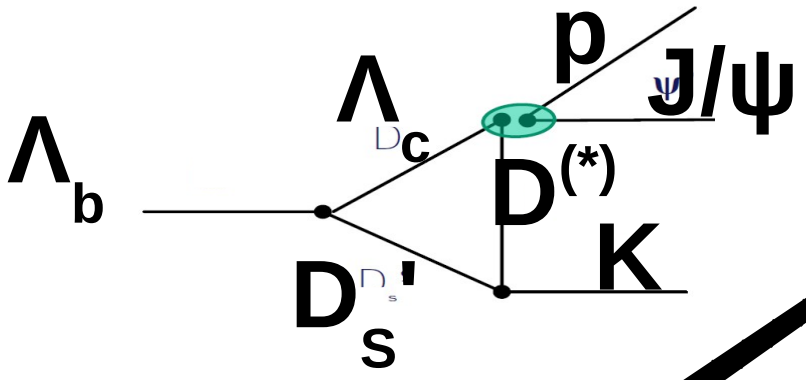
- Perform a fit with various values of Ds' mass and width
- Find best fit quality

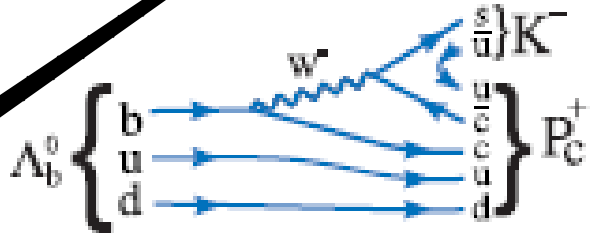
$$M = (2614 \pm 4^{+20}_{-13})\,\mathrm{MeV},\ \Gamma = (92 \pm 10 \pm 10)\,\mathrm{MeV}$$

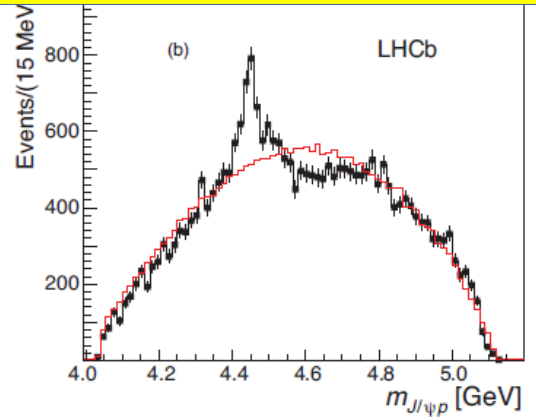
Conclusions

- ✔ Ψ'π spectrum from B->Kψ'π could be described without exotic states introduction
- ✔ Model reproduces all main features :
  - ✔ $Z(4430)^+$ quantum numbers
  - ✔ Bump at the end of the spectrum
  - ✔ Broad structure at 4200 MeV
  - ✔ Resonance-like phase change

LHCb: PRL 115 072001 (2015)





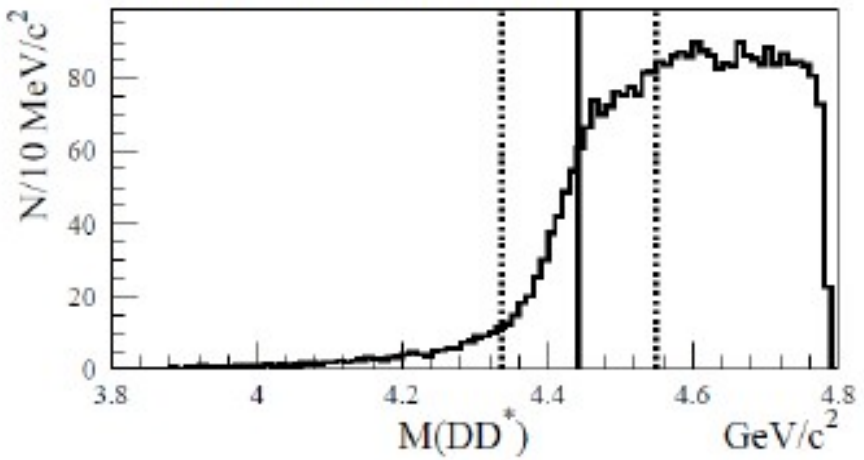


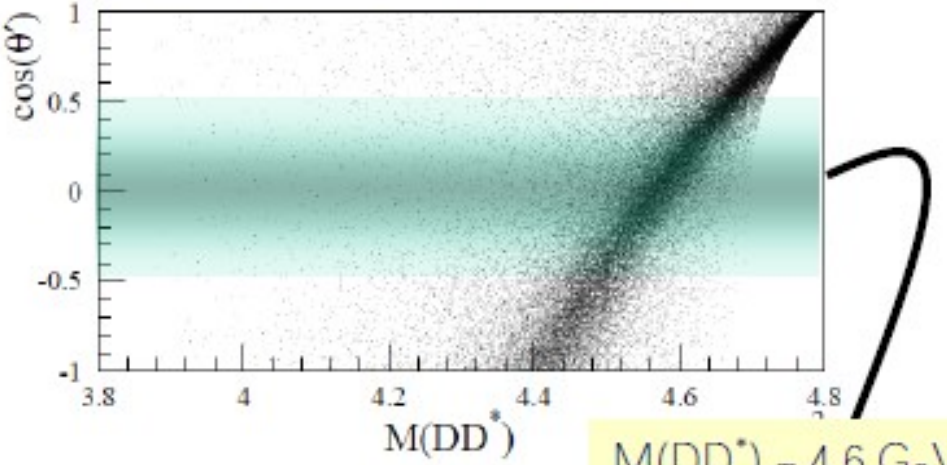
BACKUP

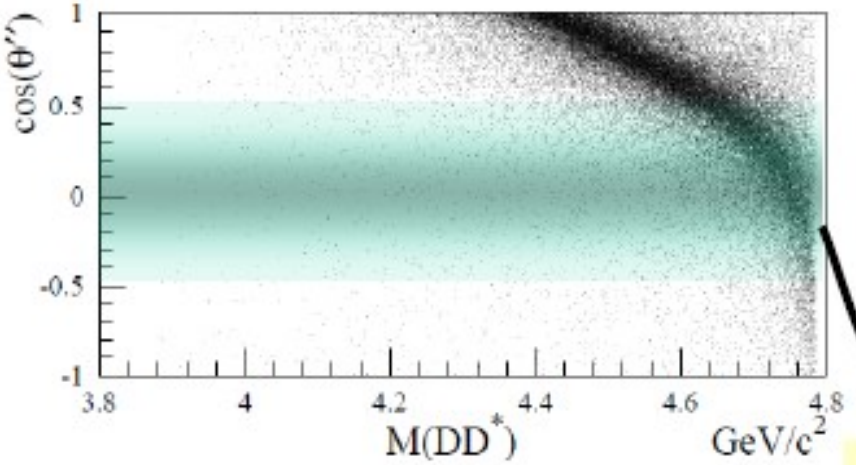
Why rescattering results in a peak?

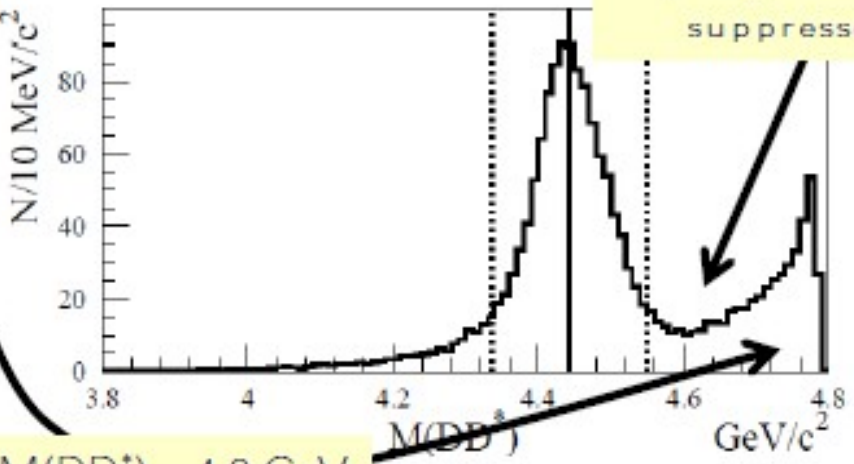
$M(DD^*)$ distribution from $B \to$ Scalar Scalar is flat

cos(angle rotation D^* spin) correlates with $M(DD^*)$









$M(DD^*)$ – 4.6 GeV suppressed

$M(DD^*)$ – 4.8 GeV suppressed