Flavor Physics & CP Violation
25-30 May 2014, Marseille

Baryon b and heavy hadron decays

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On behalf of the LHCb Collaboration
Including results from BaBar, CMS, CDF and D0 Collaborations

Outline

Beauty mesons decays

- Z(4430) state in $B^0 \to \psi' K^+ \pi^-$ decay
- X(3872) state in $B^+ \to \psi^{(')} \gamma K^+$ decay
- X(4140) state in $B^+ \to J/\psi \varphi K^+$ decay
- Baryonic beauty meson decays

Beauty baryons decays

- Di-charm decays of Λ^0_b
- Decays of Ξ^0_b
- $\Lambda^0_b \to J/\psi p \pi^-$ decay
- $\Omega_b^- \to \Omega^0_c \pi^-$ decay

Beauty meson decays

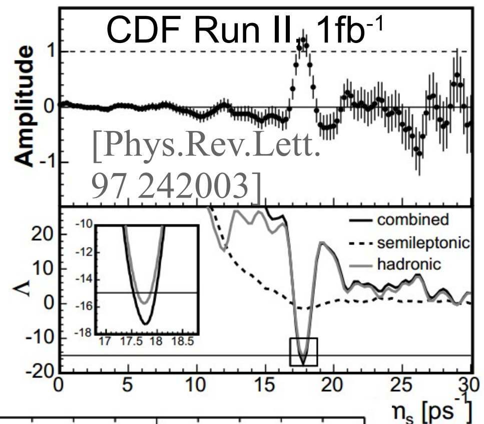
Beauty mesons

May be consiederd as «well-known» particles

With, probably, «less-well-known» B_c^+ meson

See previous talk by Lucio Anderlini

Masses and lifetimes are measured with accuracy (much) better than 1% and quantum numbers are well established

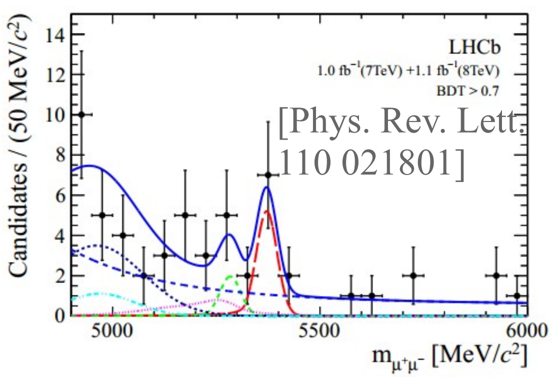


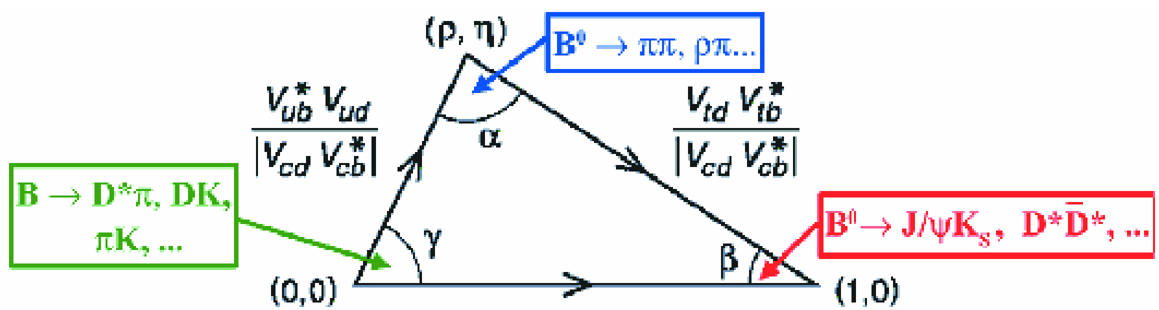
Play a major role in various studies

Fine effects in rare and very rare decays

Asymmetries: CP, forward-backward, isospin

And many others



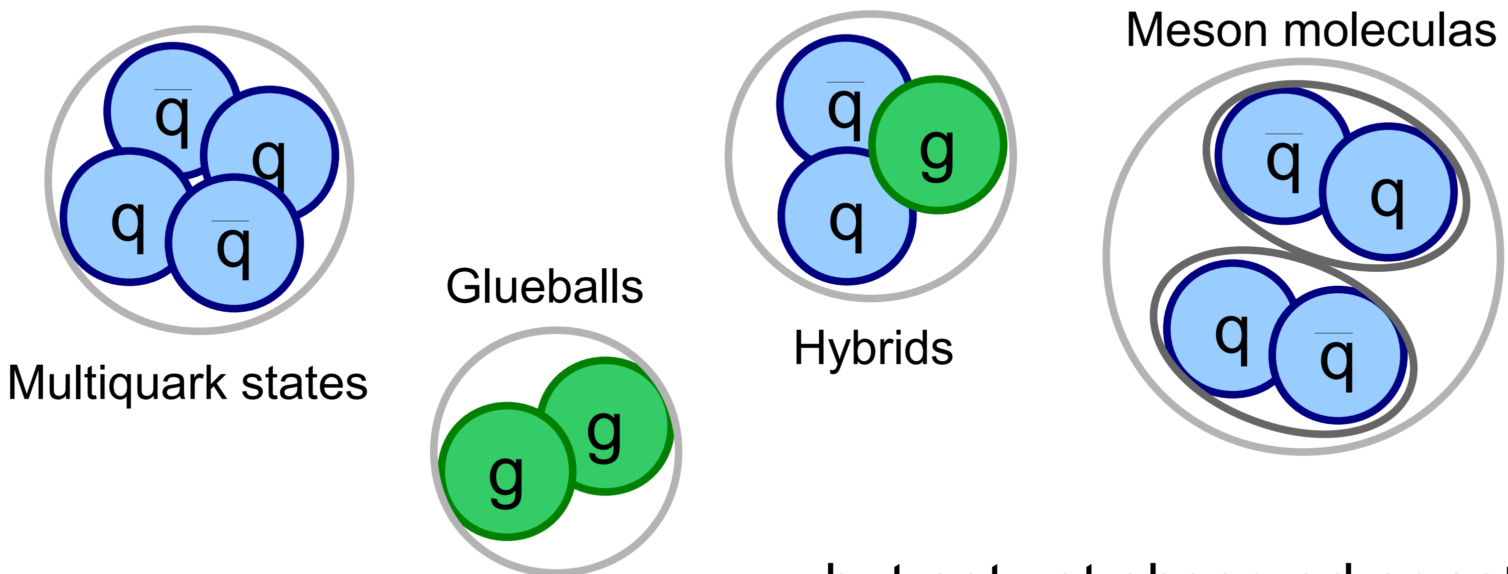


Still a wide field for research

Beauty mesons

Search for the exotic particles

Not, in principle, forbidden by the quark model...



…but not yet observed or established

Detailed talk by Ye Chen

Searches in the decays of beauty mesons allow amplitude analyses and helicity studies

Studies of the baryonic B-decays

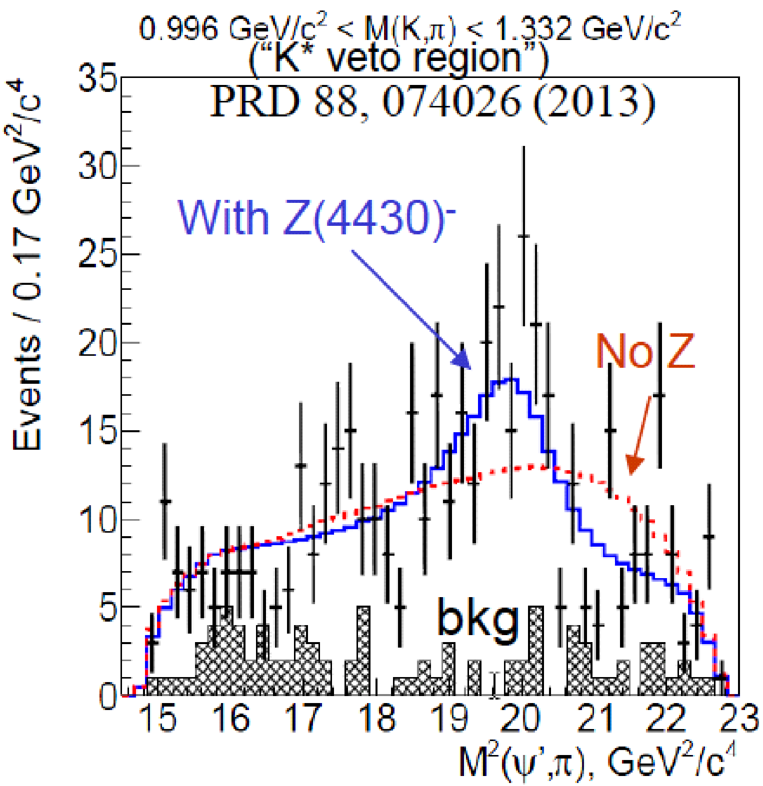
Detailed study of quark fragmentation into baryons

$Z(4430)^- \rightarrow \psi'\pi^-$ in $B^0 \rightarrow \psi' K^+\pi^-$ decay

First evidence found by the Belle collaboration in $B \rightarrow \psi' K\pi^-$ decay in 2008

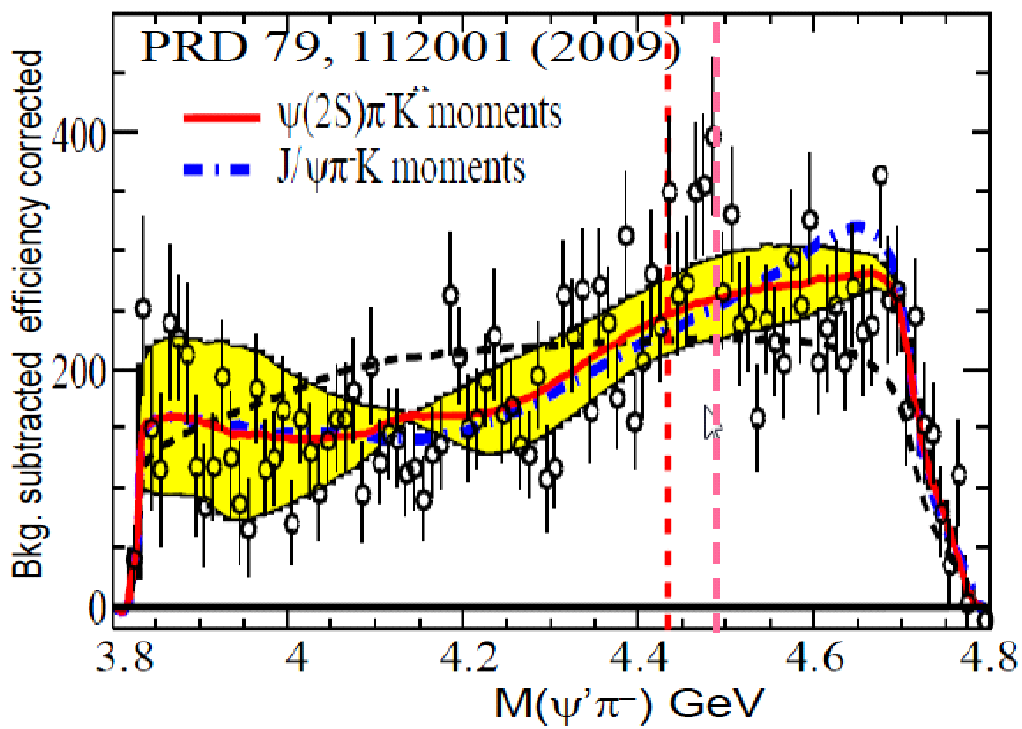
First unambigous evidence for the existence of mesons beyond the traditional $q\bar{q}$ model!

Belle update: 4D fit



$Br(B^0 \rightarrow Z^- K^+) \times Br(Z^- \rightarrow \psi(2S)\pi^-) =$
$= (6.0\,^{+1.7}_{-2.0}\,^{+2.5}_{-1.4}) \times 10^{-5}$

BaBar approach: study of reflections of the $K\pi$ moments into the $\pi\psi'$ mass spectrum



Was not able to confirm/disprove the Belle result

$Br(B^0 \rightarrow Z^- K^+) \times Br(Z^- \rightarrow \psi(2S)\pi^-) < 3.1 \times 10^{-5}$

$Z(4430)^-$ state in $B^0 \to \psi' K^+ \pi^-$

[LHCb collaboration, arXiv:1404.1903, accepted to PRL]

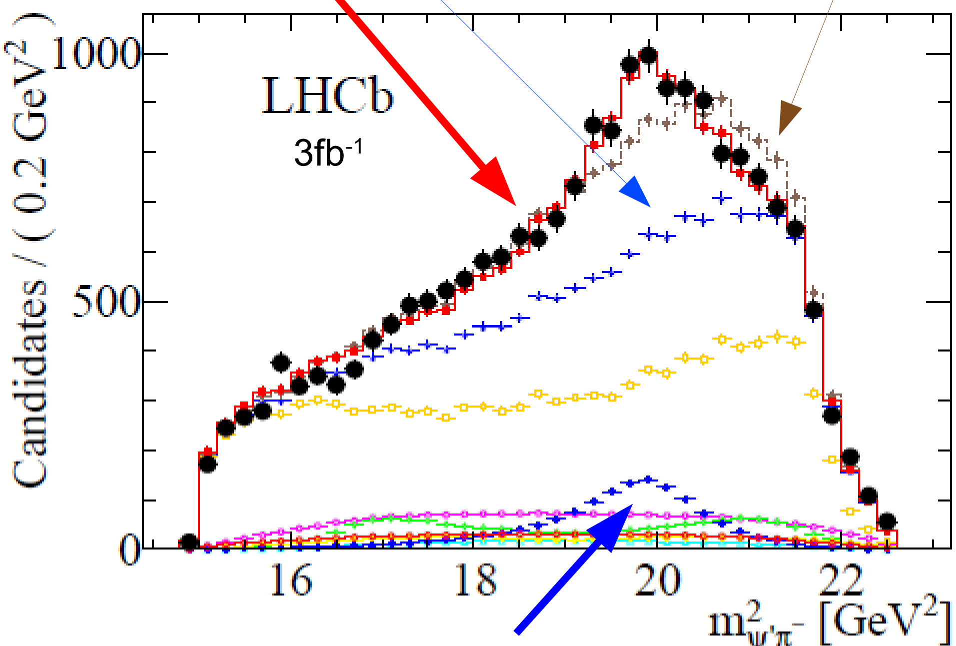
LHCb uses both approaches

4-dimensional fit method

Z(4430) excluded

Fit without Z(4430)

Total fit



Z(4430)

$M_z = 4475 \pm 7\ ^{+15}_{-25}$ MeV/c^2

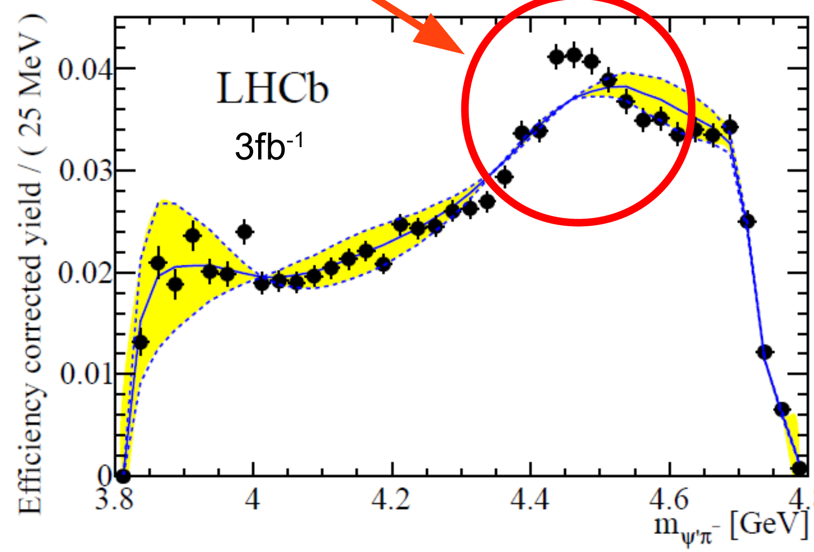
$\Gamma_z = 172 \pm 13\ ^{+37}_{-34}$ MeV/c^2

$J^P = 1^+$

Consistent with Belle result!

Moments reflections method

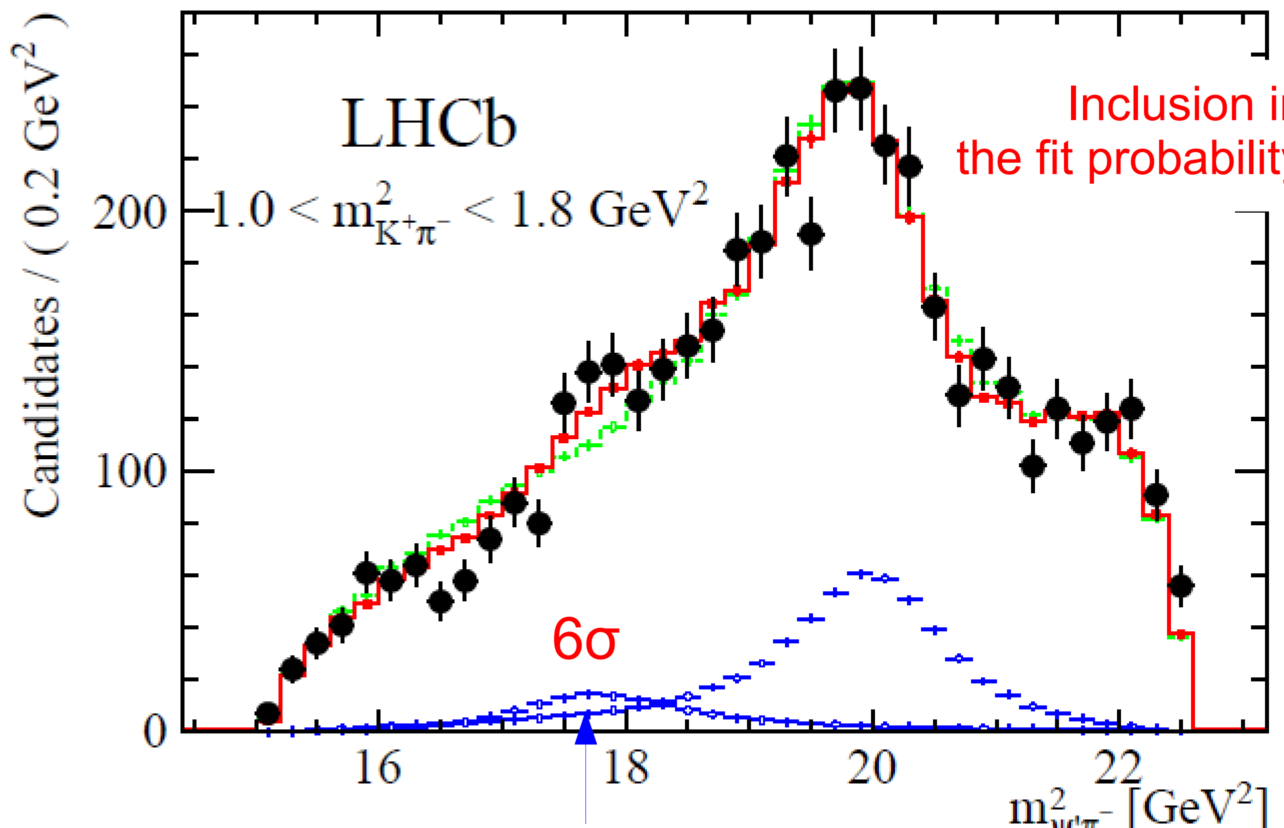
K* reflections do not describe the Z(4430) region



This approach does not allow to define the Z(4430) parameters

Additional state in $B^0 \to \psi' K^+ \pi^-$

[LHCb collaboration, arXiv:1404.1903, accepted to PRL]



Inclusion increases the fit probability 12% → 26%

0^- state is prefered over 1^-, 2^-, 2^+ by 8σ over 1^+ by 1σ

$M = 4239 \pm 18\,^{+45}_{-10}$ MeV/c^2

$\Gamma = 220 \pm 47\,^{+108}_{-74}$ MeV/c^2

One more Z resonance may be included

High statistical uncertainty with model-independent analysis

Argand diagram studies are inconclusive

Characterization as a resonance needs confirmation with larger samples

X(3872) state

Discovered by the Belle collaboration in 2003 in the $B^+ \to X(3872)K^+$ ($X(3872) \to J/\psi\pi\pi$) decay [arXiv:0809.1224]

Confirmed by Babar [PRD 77, 111101], CDF [PRL 103, 152001] and D0 [PRL 93, 162002]

Quantum numbers

CDF excluded all except:

1^{++} = $D\bar{D}$ molecule, tetraquark, $\chi_{c1}(2P)$

2^{-+} = $\eta_{c2}(1D)$

[PRL 98 (2007) 132002]

BaBar suggests:

1^{++} with 7% CL

2^{-+} with 68% CL

[PRD 82 (2010) 011101]

LHCb measurement

1^{++} with 34% probability

2^{-+} declined with 8.2σ significance

[PRL 110 (2013) 222001]

Mass world avarage: 3871.95 ± 0.50 MeV/c^2

[Belle, Phys.Rev. D84 052004]

Width: <1.2 MeV/c^2

[LHCb, Eur.Phys.J. C72 1972]

Measurement of the branching fractions ratio (R) of the decays $X(3872) \to \psi(2S)\gamma$ and $X(3872) \to J/\psi\gamma$ could help to distinguish between different interpretations.

Theoretical predictions:

$c\bar{c}$: $R \sim 1.2 — 15$

$D\bar{D}^*$-molecule: $R \sim 3\times10^{-3}$

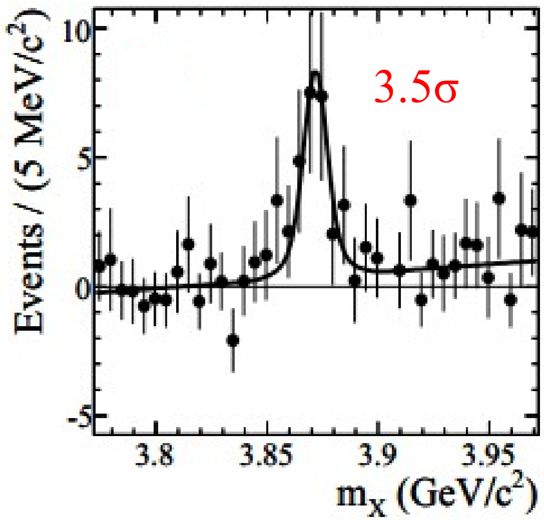
tetraquark or $c\bar{c}$ and $D\bar{D}^*$ admixture: $R = 0.5 — 5$

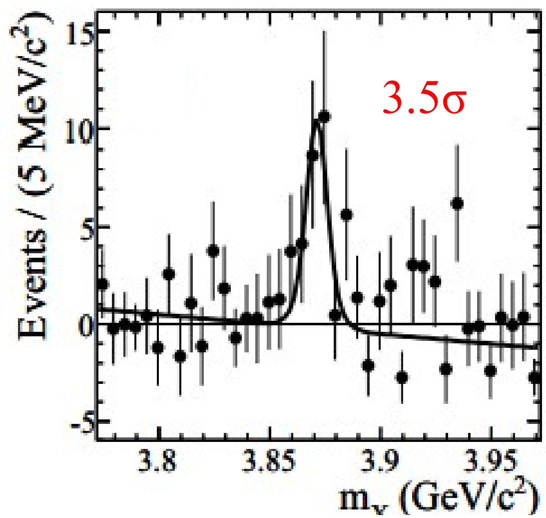
$X(3872) \to \psi^{(\prime)}\gamma$ in $B^+ \to \psi^{(\prime)}\gamma K^+$ decay

Previous measurements

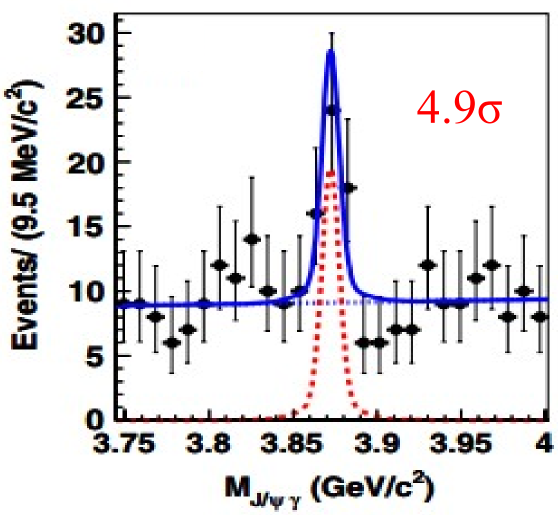
$X(3872) \to J/\psi\gamma$

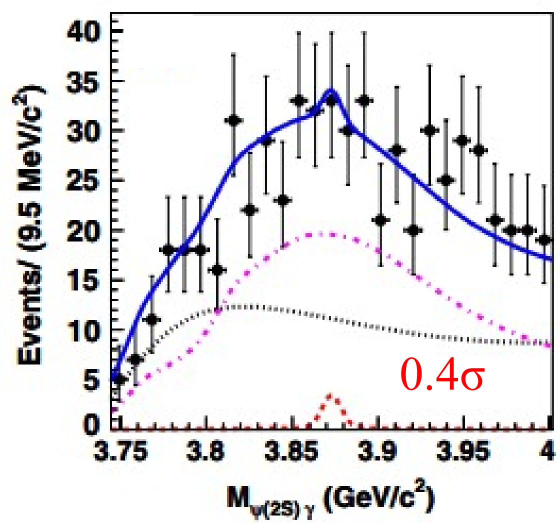
$X(3872) \to \psi(2S)\gamma$





BaBar: R = 3.4 ± 1.4
[PRL 102 (2009) 132001]



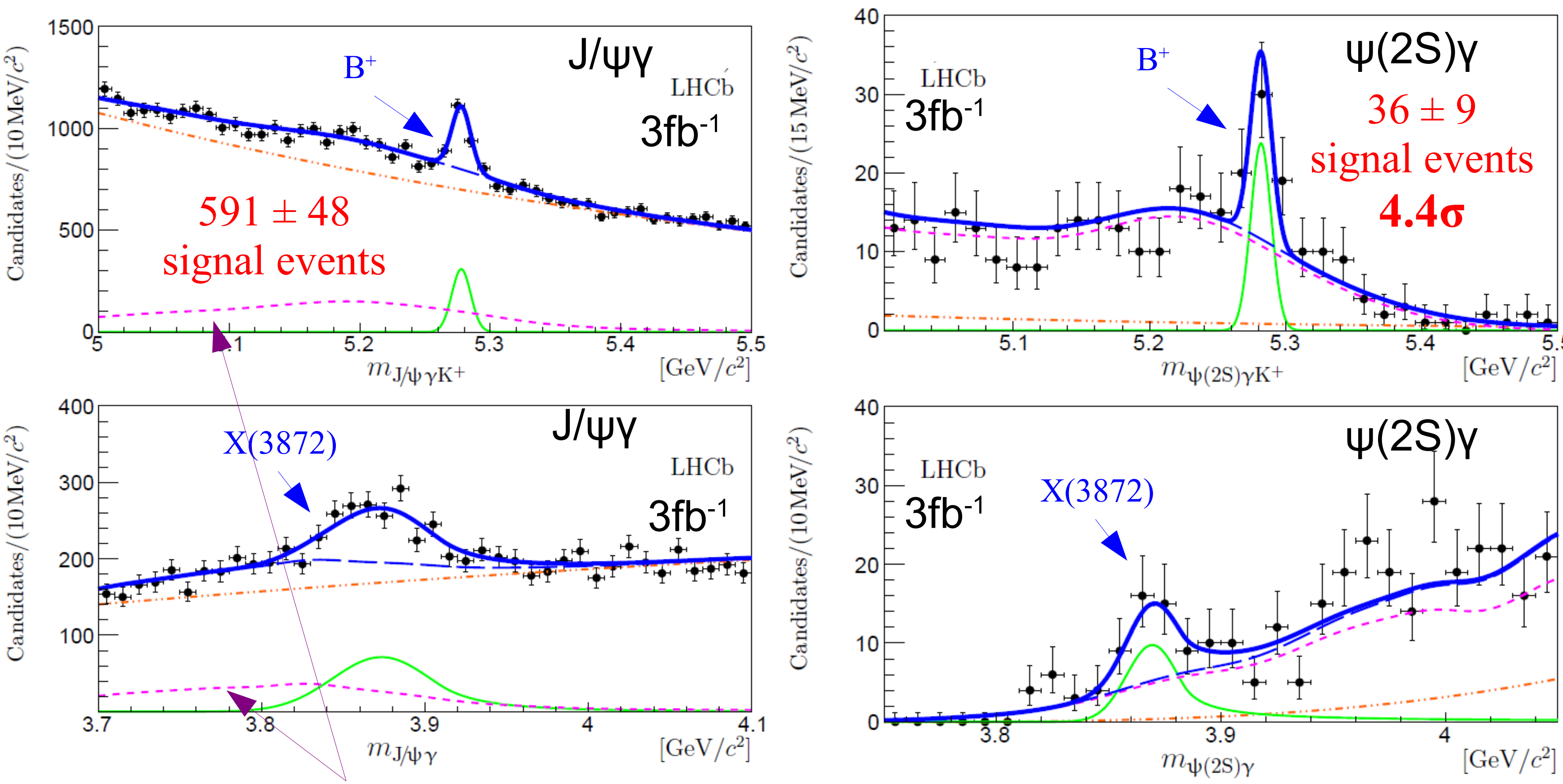


Belle:
R < 2.1 (@90% CL)
[PRL 107 (2011) 091803]

$X(3872)$ state in $B^+ \to \psi^{(\prime)}\gamma K^+$

[LHCb collaboration. arXiv:1404.0275]

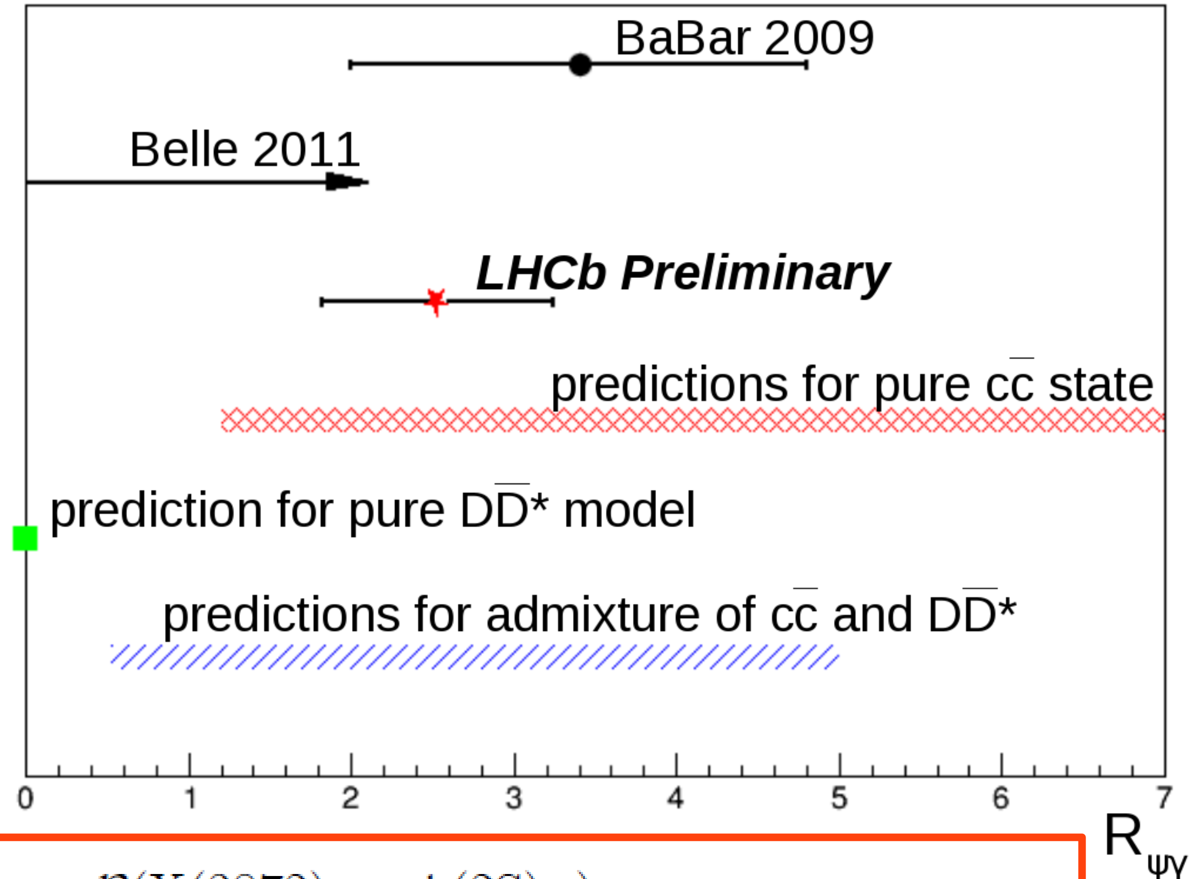
Decays reconstructed: $B^+ \to X(3872)K^+$
Two-dimensional fit in terms of $(M(B), M(\psi\gamma))$



Partially reconstructed $B^+ \to J/\psi K^{*+}(K^{*+} \to K\pi^0 (\to \gamma\gamma))$
and
$B \to \psi(2S)K^+X$ + random photon

$X(3872)$ state in $B^+ \to \psi^{(\prime)}\gamma K^+$

[LHCb collaboration. arXiv:1404.0275]



$$R_{\psi\gamma} = \frac{\mathcal{B}(X(3872) \to \psi(2S)\gamma)}{\mathcal{B}(X(3872) \to J/\psi\gamma)} = 2.46 \pm 0.64 \pm 0.29$$

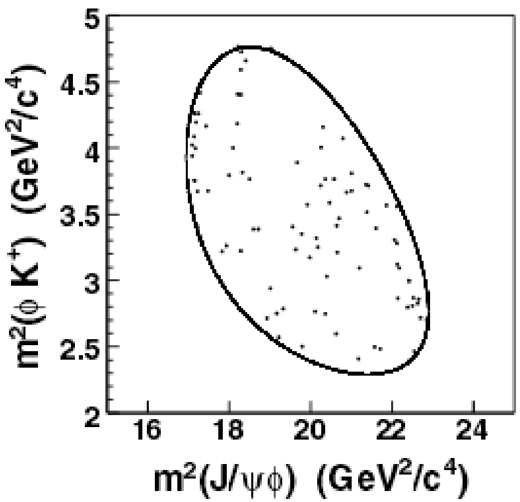
Most precise up to date!

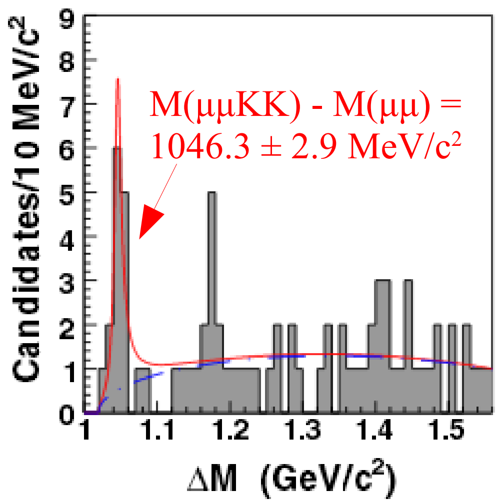
Compatible with, but more precise than previous measurements

Supports the c$\bar{c}$ interpretation as well as molecular-charmonium mixture

$X(4140) \rightarrow J/\psi\varphi$ in $B^+ \rightarrow J/\psi\varphi K^+$ decay

First evidence by the CDF collaboration (2009)
[Phys. Rev.Lett. 102, 242002]





Not predicted by the quark model with $q\bar{q}$ mesons and qqq baryons

Nature is not quite established:

- $c\bar{c}$ bound state?
- $D\bar{D}$-molecule?
- hybrid particle $q\bar{q}g$?
- four-quark combination?

Not yet confirmed

Belle collaboration (2010):

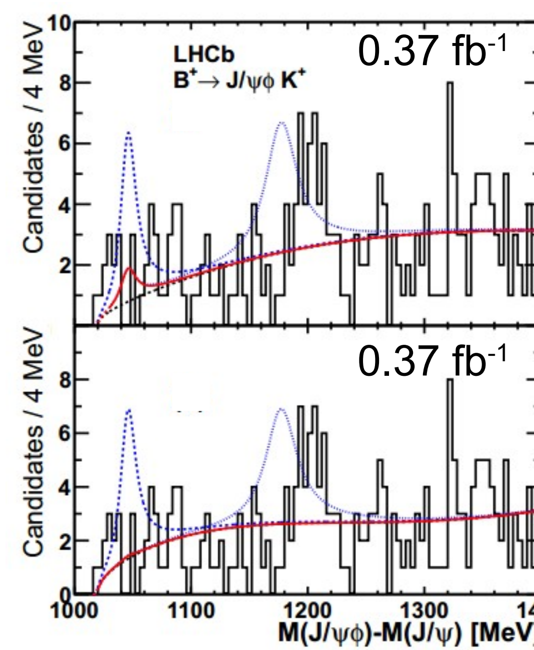
- $\gamma\gamma \rightarrow J/\psi\varphi$ process
- no significant signal
- upper limit on $\Gamma_{\gamma\gamma} \times BR(X(4140) \rightarrow J/\psi\varphi)$
  - for $J^P = 0^+$ and 2^+

[Phys. Rev. Lett.104, 112004]

LHCb collaboration (2012):

- No narrow state is seen
- Excess at 4.3 GeV/c^2 is seen

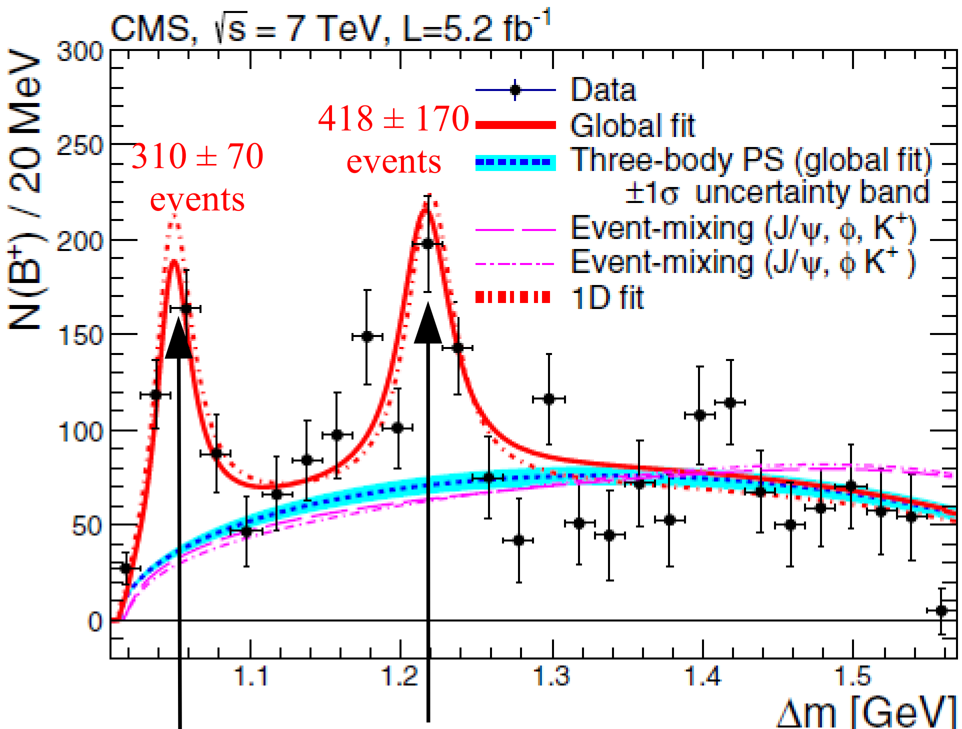
[Phys. Rev. D 85, 091103]



$X(4140)$ in $B^+ \to J/\psi\varphi K^+$

Fit B-meson mass in bins of
$\Delta m = m(\mu^+\mu^-K^+K^-) - m(\mu^+\mu^-)$

[CMS collaboration, arXiv:1309.6920]



Cut-based analysis

Check K^+K^- mass by sideband subtraction

Contributions from $J/\psi f_0(980)K^+$ and non-resonant $J/\psi K^+K^-K^+$ are negligible

Possible contributions from other B-hadron decays are examined with simulation

$B^0_s \to \psi(2S)\varphi$, $\psi(2S) \to J/\psi\pi^+\pi^-$ cut-off

$\Delta m = 1217.1 \pm 5.3\ \mathrm{MeV}/c^2$
$\Gamma = 38^{+30}_{-15}\ \mathrm{MeV}/c^2$

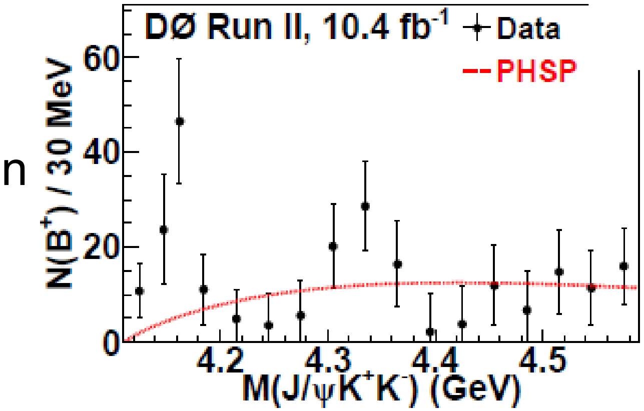
Still a possibility of reflections contribution

$\Delta m = 1051.3 \pm 2.4\ \mathrm{MeV}/c^2$
$\Gamma = 28^{+15}_{-11}\ \mathrm{MeV}/c^2$
$-2\Delta\ln\mathcal{L} = 58$

Could be consistent with the CDF result!

$X(4140)$ in $B^+ \rightarrow J/\psi\varphi K^+$

[D0 collaboration, Phys. Rev. D 89, 012004 (2014)]



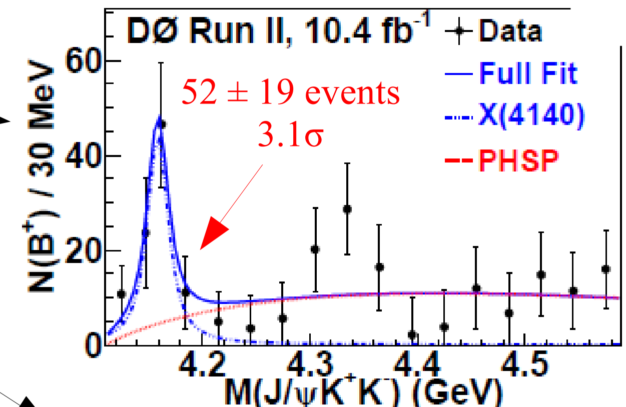
Cut-based analysis

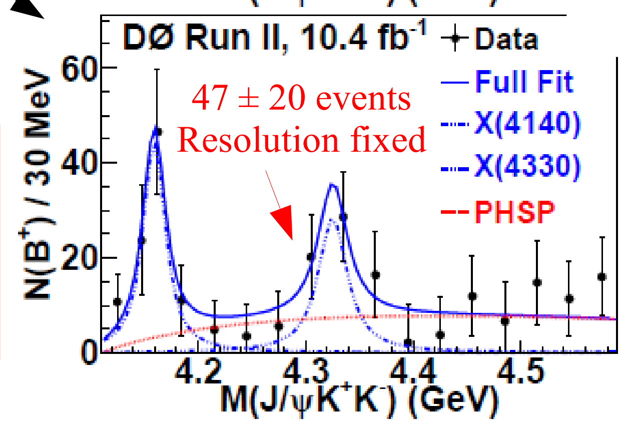
- $\psi(2S)$ region is vetoed in $J/\psi\pi^+\pi^-$ invariant mass
- No other possible resonances contributions are seen

Fit B-meson mass in bins of $J/\psi K^+K^-$ mass

Two structures are seen in the spectrum:

- X(4140) with
  - $M = 4159.0 \pm 4.3$ MeV/c^2
  - $\Gamma = 19.9 \pm 12.0$ MeV/c^2
- One more
  - $M = 4328.0 \pm 12.0$ MeV/c^2
  - $\Gamma = 30$ MeV/c^2 — fixed from the CDF fit





Systematical uncertainties:

- Precision of B^+-meson mass measurement
- $J/\psi\varphi$ mass resolution
- Variation of $J/\psi\varphi$ reconstruction efficiency

An evidence of resonance is seen with 3.1σ significance

$M = 4159.0 \pm 4.3 \pm 6.6$ MeV/c^2

$\Gamma = 19.9 \pm 12.0^{+1}_{-8}$ MeV/c^2

Fraction in the $B^+ \rightarrow J/\psi\varphi K^+$ decay — $(21 \pm 8 \pm 4)\%$

Consistent with CDF and CMS results

$X(4140)$ in $B^+ \to J/\psi\phi K^+$

[Preliminary results, Gianluigi Cibinetto "Studies of quarkonium production at BABAR" at DIS2014]

$J/\psi \to \mu^+\mu^-$ and $J/\psi \to e^+e^-$ modes are used for the search

Dalitz plot fit

- phase space distribution + two incoherent Breit-Wigner distributions
- Breit-Wigner parameters are fixed at values measured by the CDF

Fit fractions with the assumption of two resonances:

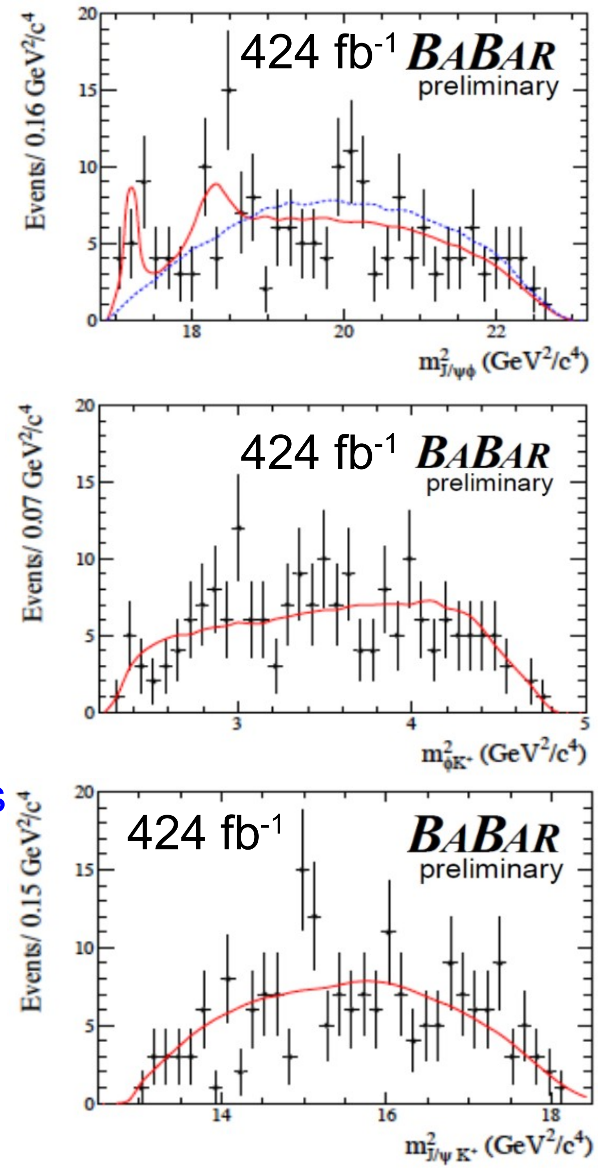
f(4140) = (7.3 ± 2.5 ± 3.8)%; upper limit = 12.1% (90%CL)
f(4270) = (7.7 ± 3.7 ± 5.2)%; upper limit = 16.4% (90%CL)

No clear conclusion from BaBar due to the lack of statistics

No strong tension between the various results

Waiting for more results from experiments

A detailed amplitude analysis is required to finally confirm the state



Baryonic decays of B-mesons

Motivation

- Approximately 7% of B-meson decay modes have baryons in the final states [PDG, Phys. Rev. D 86, 010001]
  - makes it convenient to study of quark fragmentation into baryons
  - studies of influence of resonant subchannels may help

- Perturbative QCD can not be applied due to the low energy scale

- Meson pole model predicts an enhancement over phase space at low baryon-antibaryon mass [Phys. Lett. 174, 18771881]
  - explains the enhancement observed in the decays $B^- \to \Lambda_c \bar{p} \pi^-$, $B^- \to p\bar{p}K^-$, $\bar{B}^0 \to D^0 p\bar{p}$.

- For baryon pole models no enhancement is predicted

$\overline{B}^0 \to D^0\Lambda\overline{\Lambda}$ decay

[BaBar collaboration, arXiv:1401.5990]

$\overline{B}^0 \to D^0\Lambda\overline{\Lambda}$, with $\Lambda \to p\pi^-$ and $D^0 \to K^-\pi^+,\ K^-\pi^+\pi^+\pi^-,\ K^-\pi^+\pi^0$

471×10^6 $B\overline{B}$ pairs

Cut-based selection

Fit simultaneously for three different D^0 decay modes

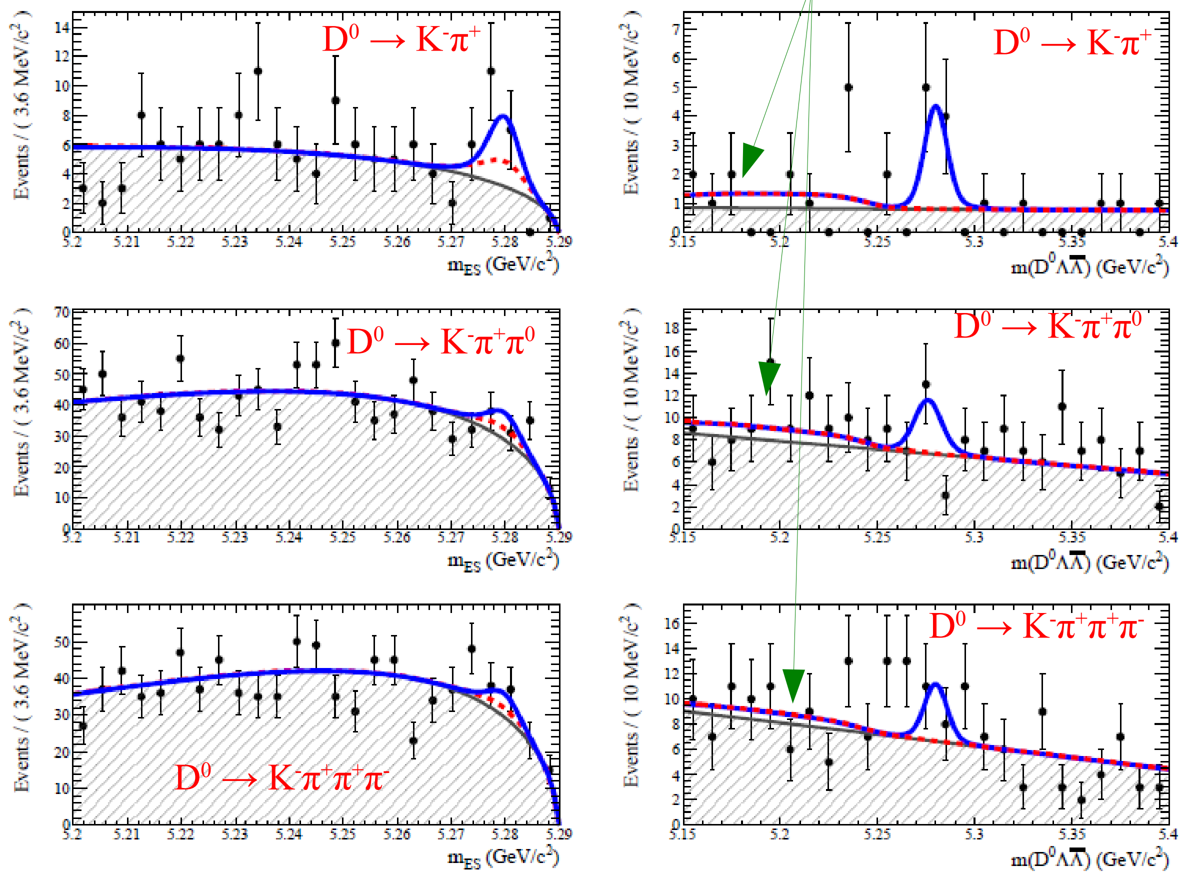
Statistical significances:

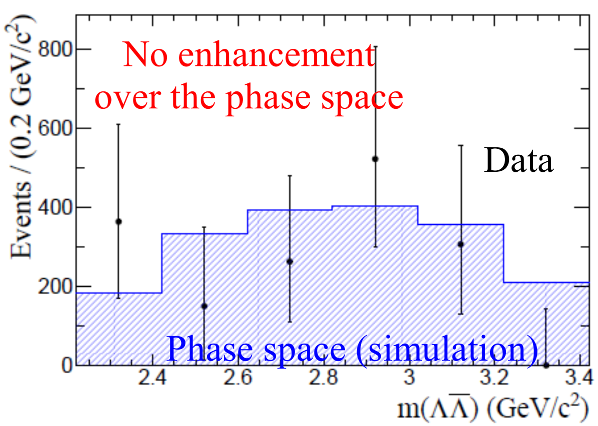
$\overline{B}^0 \to D^0\Lambda\overline{\Lambda}$ 3.4σ

$\overline{B}^0 \to D^0\Sigma^0\overline{\Lambda}$ 1.2σ

Peaking background, included in the fit

$\overline{B}^0 \to D^0\Sigma^0\overline{\Lambda}(\Sigma^0 \to \Lambda\gamma)$





$$\mathcal{B}(\overline{B}^0 \to D^0\Lambda\overline{\Lambda}) = (9.8^{+2.9}_{-2.6} \pm 1.9)\times10^{-6},$$

$$\mathcal{B}(\overline{B}^0 \to D^0\Sigma^0\overline{\Lambda} + \overline{B}^0 \to D^0\Lambda\overline{\Sigma}^0) < 3.1\times10^{-5}.$$

Consistent with Belle measurement and simple models of hadronization

$\overline{B}^0 \to \Lambda_c^+ \bar{p} p \bar{p}$ decay

[BaBar collaboration, arXiv:1312.6800]

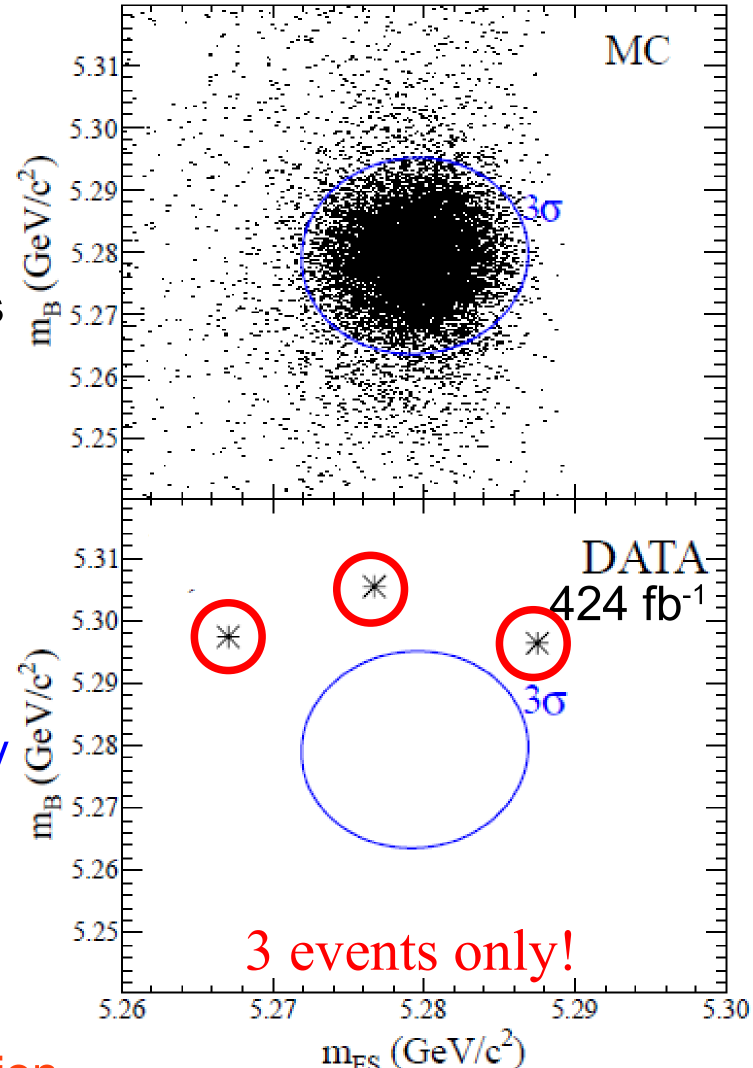
Cut-based analysis

$\Lambda_c^+ \to pK^-\pi^+$ mode is used

Selection efficiency is determined from simulation

Simulation is validated with the help of

$B \to \overline{D}^{(*)}D^{(*)}K$ and $\overline{B}^0 \to \Lambda_c^+\bar{p}\pi^+\pi^-$ decay channels



Bayesian approach for the upper limit derivation

$$\mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \bar{p} p \bar{p}) \times \frac{\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)}{0.050} < 2.8 \times 10^{-6} \text{ at } 90\,\% \text{ C.L.},$$

Normalization by the world average

In comparison with non-resonant $\overline{B}^0 \to \Lambda_c^+\bar{p}\pi^+\pi^-$ decay

$$\frac{\mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \bar{p} p \bar{p})}{\mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \bar{p}\pi^+\pi^-)_{\mathrm{non-res}}} \lesssim \frac{1}{220}$$

No significant increase of the branching fraction related to the threshold enhancement

Di-charm decays

[LHCb collaboration, Phys. Rev. Lett. 112, 202001]

Several di-charm final states are reconstructed

$B^0_s \to D^+ D_s^-$
$\overline{B}^0 \to D^+ D_s^-$
$B^0_s \to \Lambda^+_c \Lambda^-_c$
$\overline{B}^0 \to \Lambda^+_c \Lambda^-_c$

with
$\Lambda^+_c \to p K^- \pi^+$
$D^+ \to K^- \pi^+ \pi^+$
$D_s^+ \to K^+ K^- \pi^+$

Boosted decision tree for event selection

Most precise up to date!

$$\frac{\mathcal{B}(B^0_s \to D^+ D^-_s)}{\mathcal{B}(\overline{B}^0 \to D^+ D^-_s)} = 0.038 \pm 0.004\,(\text{stat}) \pm 0.003\,(\text{syst}).$$

For the $B^0_{(s)} \to \Lambda^+_c \Lambda^-_c$ search:

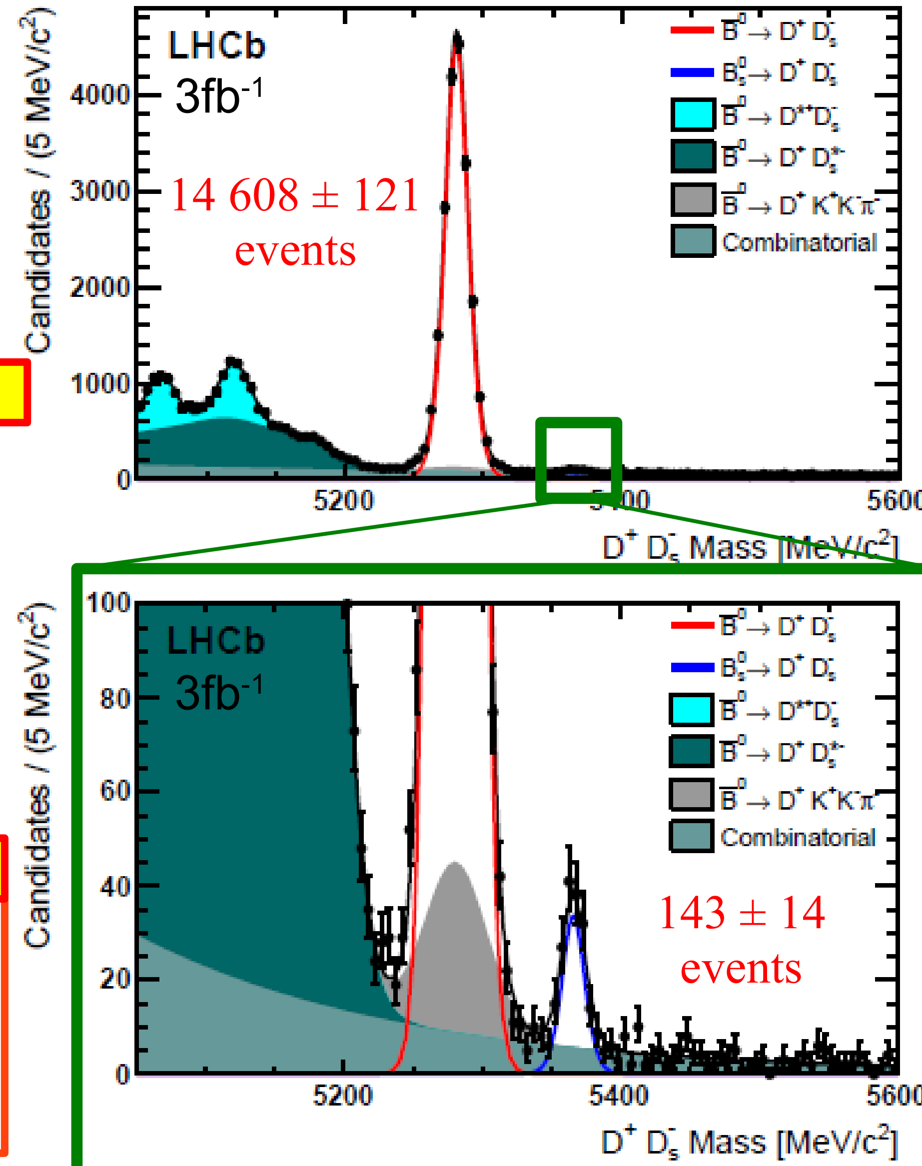
Signal region selected to retain 95% of signal candidates

Background level obtained from charm-hadrons sidebands

Most stringent!

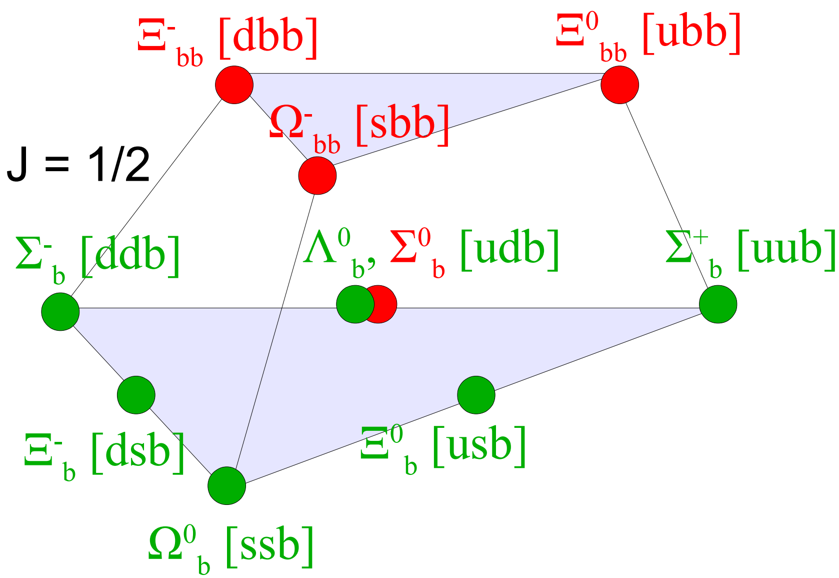
$$\frac{\mathcal{B}(\overline{B}^0 \to \Lambda^+_c \Lambda^-_c)}{\mathcal{B}(\overline{B}^0 \to D^+ D^-_s)} < 0.0022 \text{ [95\% C.L.]},$$

$$\frac{\mathcal{B}(B^0_s \to \Lambda^+_c \Lambda^-_c)}{\mathcal{B}(B^0_s \to D^+ D^-_s)} < 0.30 \text{ [95\% C.L.]}.$$



Beauty baryon decays

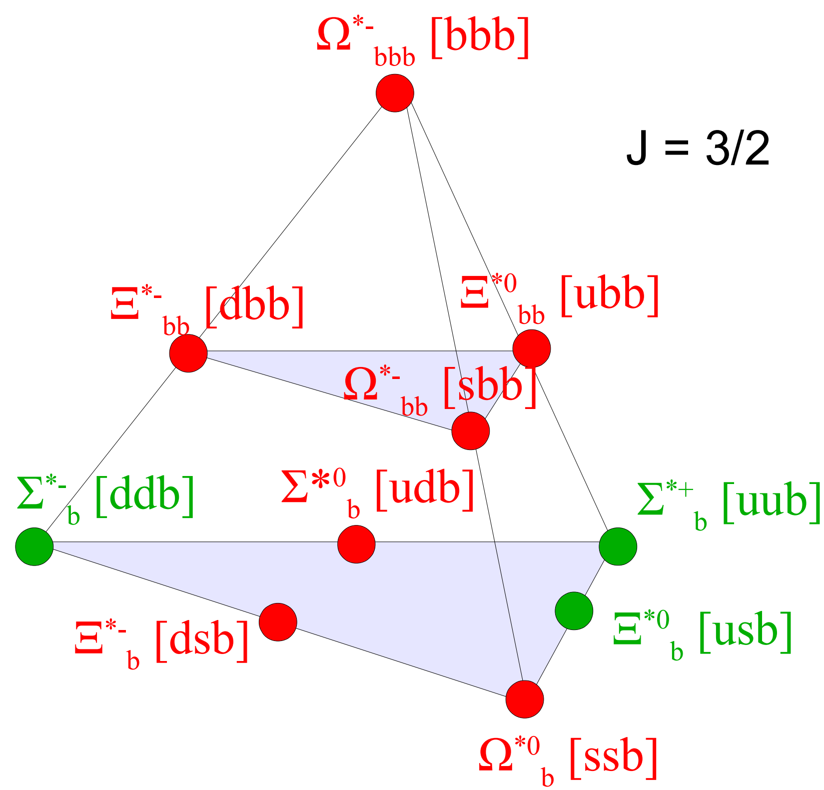
Beauty baryons



Most of the J = 1/2 states with single b-quark have been observed except for Σ^0_b

Quantum numbers have not yet been measured

Masses and lifetimes are poorly known



PDG lists

~ 20 decays for Λ^0_b-baryon

not more than 2 decays for each of the others

Motivation

- Search for new predicted beauty baryons
- Precise measurement of masses and lifetimes and quantum numbers
  - check a number of QCD models
- Measurement of the CP-violation and γ angle of the Unitarity Triangle
  See talk by Vincent Tisserand
- Non-zero Λ_b spin allows to exploit it as a powerful probe of the helicity structure of the heavy quark effective Hamiltonian

Di-charm decays of Λ^0_b

[LHCb collaboration, Phys. Rev. Lett. 112, 202001]

Branching fractions are expected to be at the same level as for the beauty mesons (~1%)

Comparison of baryon and meson branching fractions could be a probe of factorization in these decays.

$\Lambda^0_b \to \Lambda^+_c D^-_s$

$\Lambda^0_b \to \Lambda^+_c D^-$

with

$\Lambda^+_c \to p K^- \pi^+$

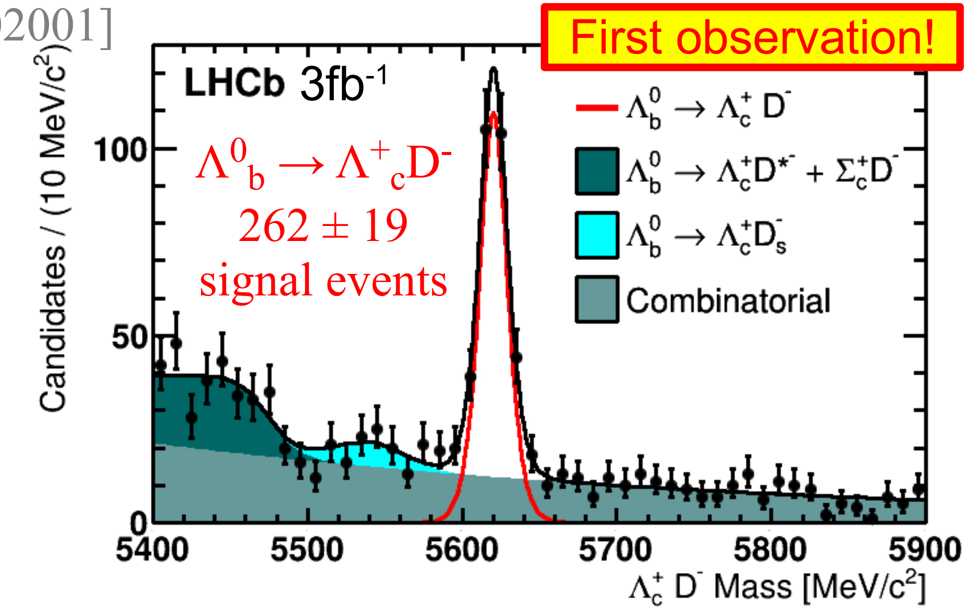
$D^+ \to K^- \pi^+ \pi^+$

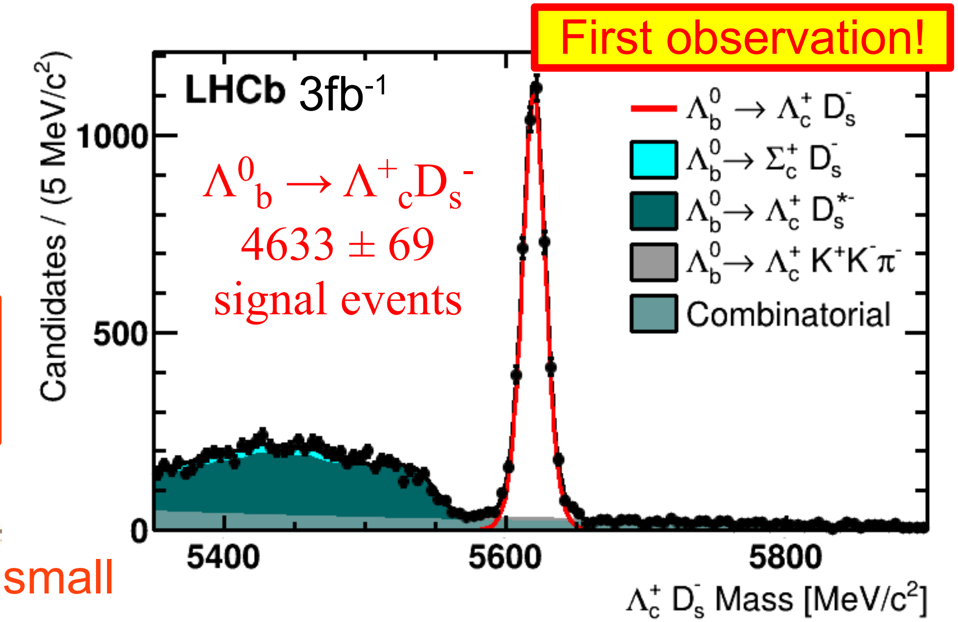
$D_s^+ \to K^+ K^- \pi^+$

BDT for event selection

$$\frac{\mathcal{B}(\Lambda^0_b \to \Lambda^+_c D^-)}{\mathcal{B}(\Lambda^0_b \to \Lambda^+_c D^-_s)} = 0.042 \pm 0.003\,(\mathrm{stat}) \pm 0.003\,(\mathrm{syst}).$$

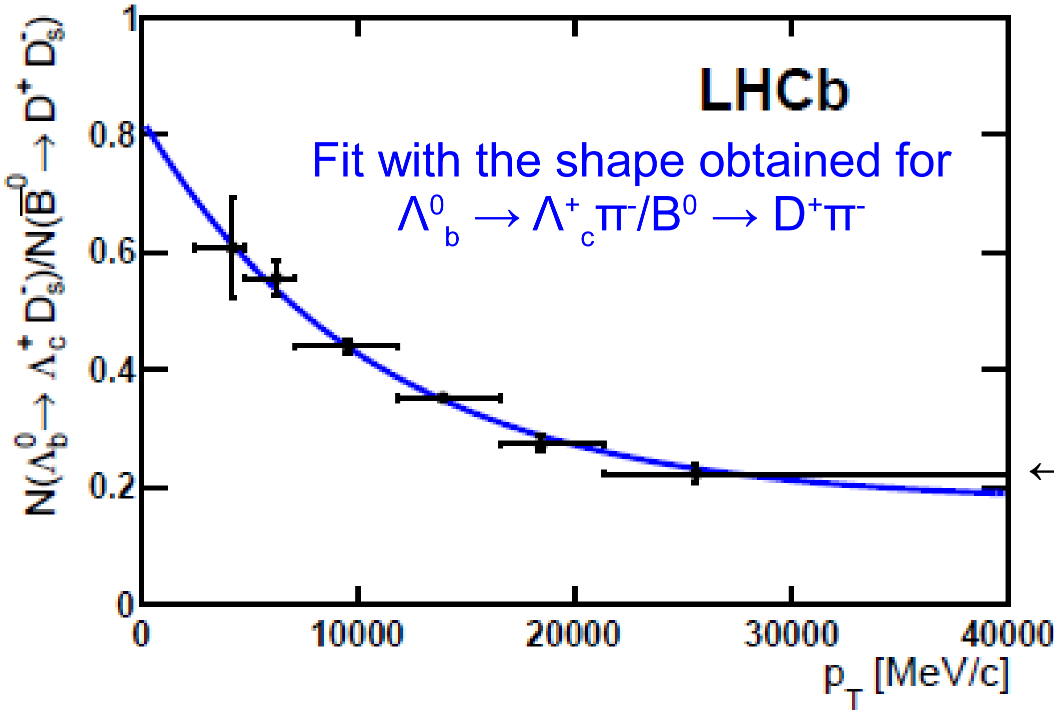
Consistent with $|V_{cd}/V_{cs}|^2 \times (f_D/f_{D_s})^2 \approx 0.034$,
assuming nonfactorisable contributions are small





Di-charm decays of Λ^0_b

[LHCb collaboration, Phys. Rev. Lett. 112, 202001]



In normalisation to $\bar{B}^0 \to D^+D_s^-$ decay

Production rate depends on the transverse momentum
[LHCb collaboration LHCb-PAPER-2014-004]

← efficiency-corrected event yields ratio

$$\left[\frac{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ D_s^-)}{\mathcal{B}(\bar{B}^0 \to D^+ D_s^-)}\right] \Big/ \left[\frac{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ \pi^-)}{\mathcal{B}(\bar{B}^0 \to D^+ \pi^-)}\right] = 0.96 \pm 0.02\,(\mathrm{stat}) \pm 0.06\,(\mathrm{syst}).$$

Using the known branching fractions for $\bar{B}^0 \to D^+D^-_s$, $\Lambda^0_b \to \Lambda^+_c\pi^-$ and $\bar{B}^0 \to D^+\pi^-$

$$\boxed{\begin{aligned} \mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ D_s^-) &= (1.1 \pm 0.1) \times 10^{-2}, \\ \mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ D^-) &= (4.7 \pm 0.6) \times 10^{-4}, \end{aligned}}$$

Consistent with theoretical prediction

$\Lambda^0_b \to J/\psi p \pi^-$ decay

[LHCb-PAPER-2014-020, submitted to JHEP]

First observation!

Measured through normalisation to $\Lambda^0_b \to J/\psi p K^-$ decay

Loose cut-based preselection

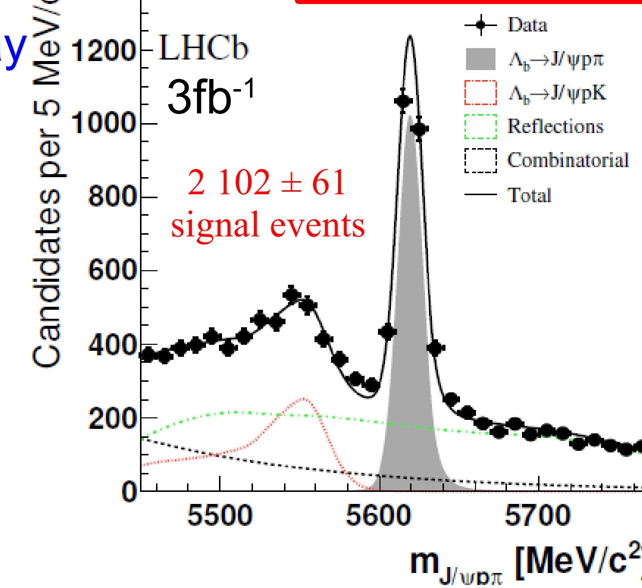
- $J/\psi \to \mu\mu$ used for reconstruction
- $\Lambda^0_b \to J/\psi \Lambda$ contribution and possible reflection from $B^0_s \to J/\psi \varphi$ decays are vetoed

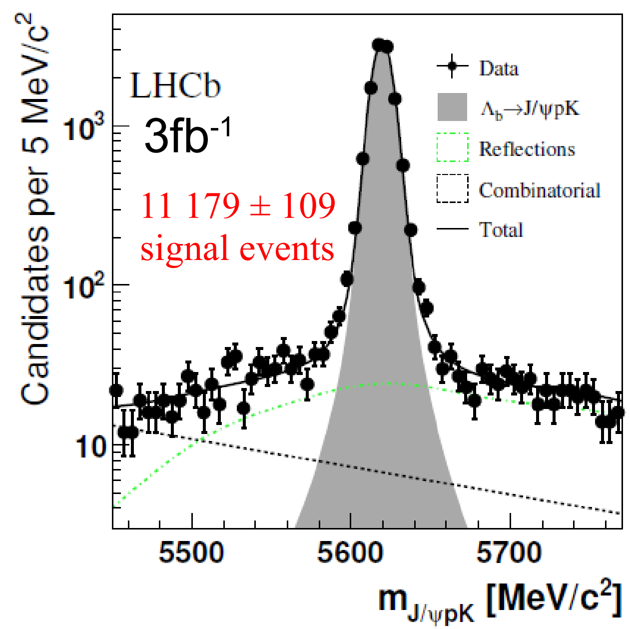
Neural network

- trained on the half of pre-selected $\Lambda^0_b \to J/\psi p K^-$ events
- all possible reflections from B^0, B^0_s and Λ^0_b decays are excluded for the training

Reflections compositions:

$\Lambda^0_b \to J/\psi p K^-$	$\Lambda^0_b \to J/\psi p \pi^-$
$B^0 \to J/\psi \pi^+ K^-$ ($\pi^+ \to p$)	$\Lambda^0_b \to J/\psi p K^-$ ($K^- \to \pi^-$)
$B^0_s \to J/\psi K^+ K^-$ ($K^+ \to p$)	$B^0 \to J/\psi \pi^- K^+$ ($K^+ \to p$)
$\Lambda^0_b \to J/\psi p K^-$ ($K^+ \leftrightarrow p$)	$B^0_s \to J/\psi K^+ K^-$ ($K^+ \to p$, $K^- \to \pi^-$)



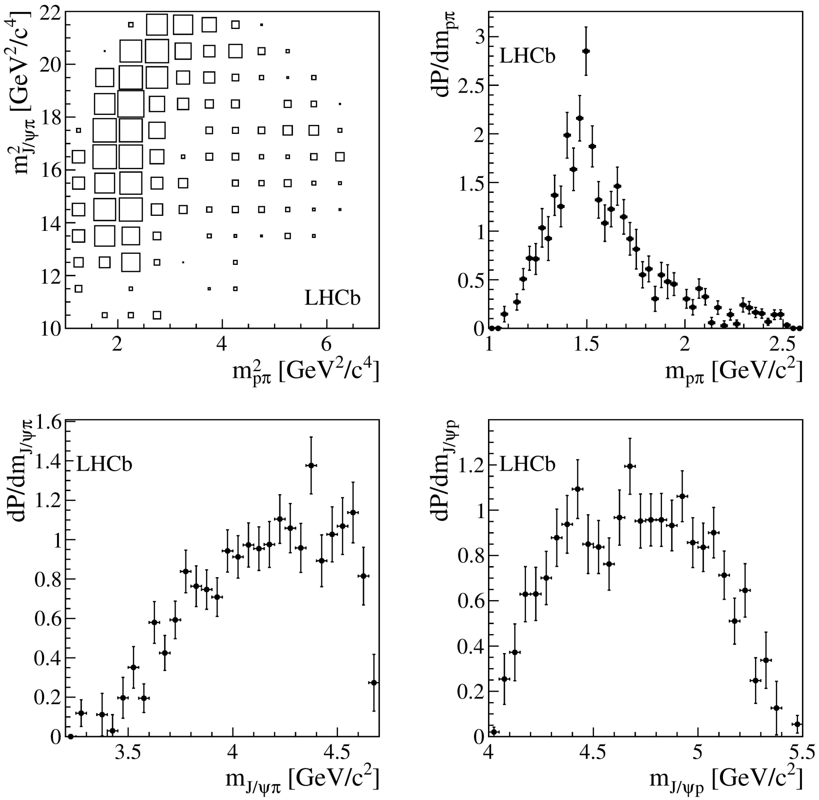


$\Lambda^0_b \to J/\psi p \pi^-$ decay

[LHCb-PAPER-2014-020, submitted to JHEP]

$$\boxed{\frac{\mathcal{B}(\Lambda_b^0 \to J/\psi\, p\pi^-)}{\mathcal{B}(\Lambda_b^0 \to J/\psi\, pK^-)} = \frac{N(\Lambda_b^0 \to J/\psi\, p\pi^-)}{N(\Lambda_b^0 \to J/\psi\, pK^-)} \times \frac{\eta(\Lambda_b^0 \to J/\psi\, pK^-)}{\eta(\Lambda_b^0 \to J/\psi\, p\pi^-)} = 0.0824 \pm 0.0025\,(\text{stat.}) \pm 0.0042\,(\text{syst.})}$$

First look at the intermediate resonances (no Dalitz-plot fit yet)



Efficiency-corrected, background-subtracted Dalitz plot for $\Lambda^0_b \to J/\psi p\pi^-$ decay with its projections

Λ^0_b mass is used as the discriminating variable

Invariant mass of $p\pi$ combinations is highly populated with resonances (as expected)

Subject of a further study

Ξ^0_b decays

[LHCb collaboration, JHEP04 (2014) 087]

Search for the $\Xi^0_b \to K^0_S p h^-$ (h = K, π)

BDT is used for event selection

$B^0 \to K^0\pi^+\pi^-$ and simulation as the signal sample

$K^0\pi^+\pi^-$ as a background sample

Normalization channel

$B^0 \to K^0\pi^+\pi^-$

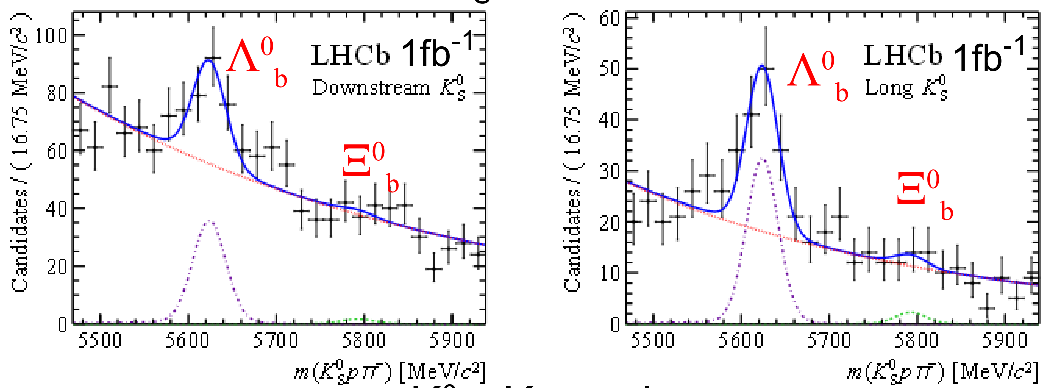
Statistical significances:

$\Lambda^0_b \to K^0_S p\pi^-$: 8.6σ

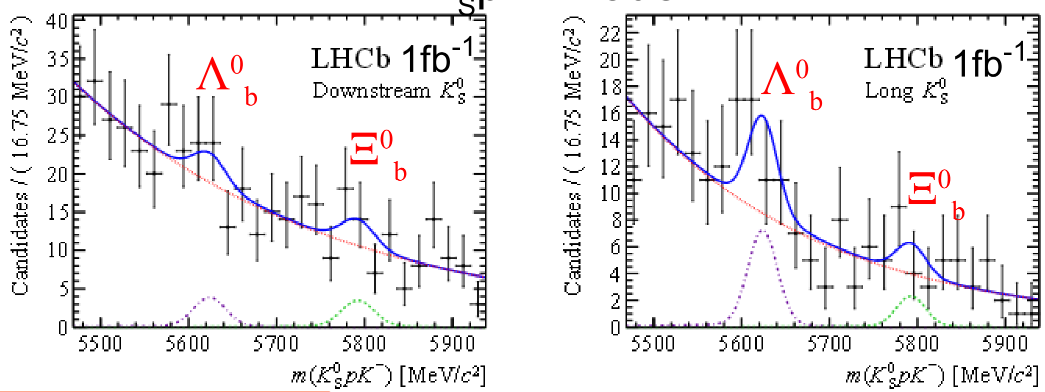
$\Lambda^0_b \to K^0_S pK^-$: 2.1σ

Ξ^0_b signals below 2.0σ

$K^0_S p\pi^-$ mode



$K^0_S pK^-$ mode



$$\mathcal{B}(\Lambda^0_b \to \overline{K}^0 p\pi^-) = (1.26 \pm 0.19 \pm 0.09 \pm 0.34 \pm 0.05) \times 10^{-5}$$

$$\mathcal{B}(\Lambda^0_b \to K^0 pK^-) < 3.5\ (4.0) \times 10^{-6} \ \text{at} \ 90\,\%\ (95\,\%)\ \text{CL}$$

$$f_{\Xi^0_b}/f_d \times \mathcal{B}(\Xi^0_b \to \overline{K}^0 p\pi^-) < 1.6\ (1.8) \times 10^{-6} \ \text{at} \ 90\,\%\ (95\,\%)\ \text{CL}$$

$$f_{\Xi^0_b}/f_d \times \mathcal{B}(\Xi^0_b \to \overline{K}^0 pK^-) < 1.1\ (1.2) \times 10^{-6} \ \text{at} \ 90\,\%\ (95\,\%)\ \text{CL}$$

More new Ξ^0_b decays are discussed in talk by Vincent Tisserand

$\Omega_b^- \rightarrow \Omega_c^0 \pi^-$ decay

[CDF collaboration, arXiv:1403.8126]

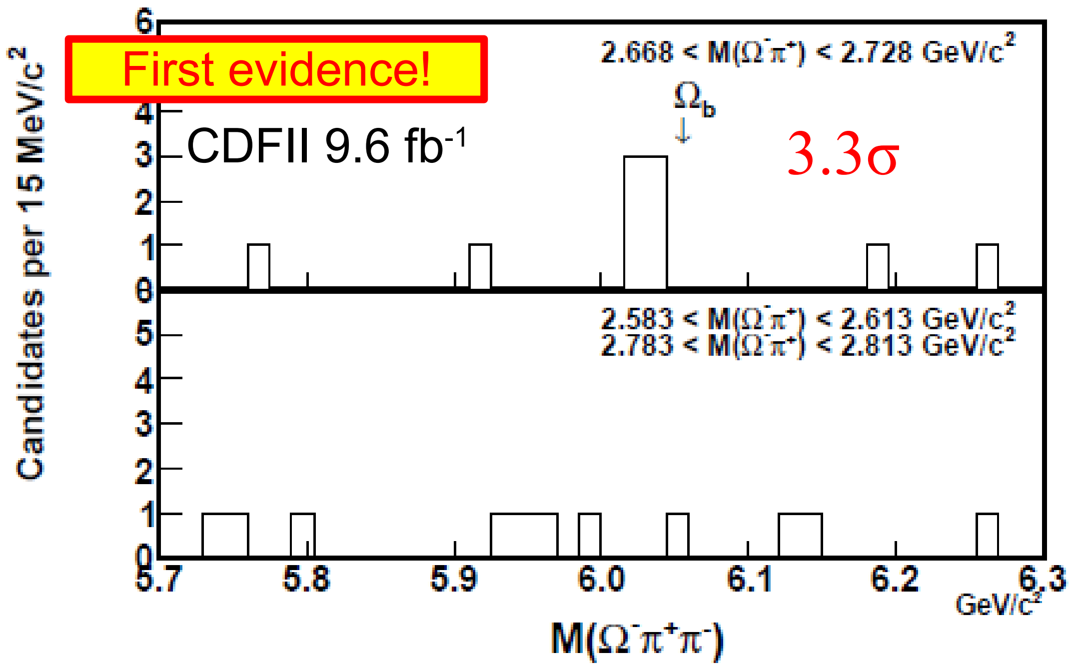
Cut-based analysis

$\Omega_b^- \rightarrow \Omega_c^0 \pi^-$

$\Omega_c^0 \rightarrow \Omega^- \pi^+$

$\Omega^- \rightarrow \Lambda K^-$

$\Lambda \rightarrow p \pi^-$



Statistical significance:

Obtained as twice logarithm of probability difference between signal and null hypotheses

Probablity of background fluctuation:

Tested with simulation (10^7 «experiments»)

Found to be 5.5×10^{-4}

Summary

A great job has been made by the experiments

Beauty particles decays bring plenty of new information in various areas

Still a great area for further studies

Looking forward for new exciting results!

Thank you for your attention!