Heavy flavour spectroscopy at LHCb

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On behalf of the LHCb collaboration

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in Quantum ChromoDynamics, Montpellier, France

Outline

- The LHCb detector
- Heavy Meson spectroscopy
  - D_{sJ} spectroscopy (LHCb-PAPER-2012-016)
  - B** spectroscopy (LHCb-CONF-2011-053)
- Heavy Baryon spectroscopy
  - Charged b-baryons (LHCb-CONF-2011-060)
  - Neutral b-baryons (LHCb-CONF-2011-036, arXiv:1205.3452)
  - Excited b-baryons (arXiv:1205.3452)

LHCb detector and dataset

- Optimized for the strongly forward peaked heavy quark production at LHC

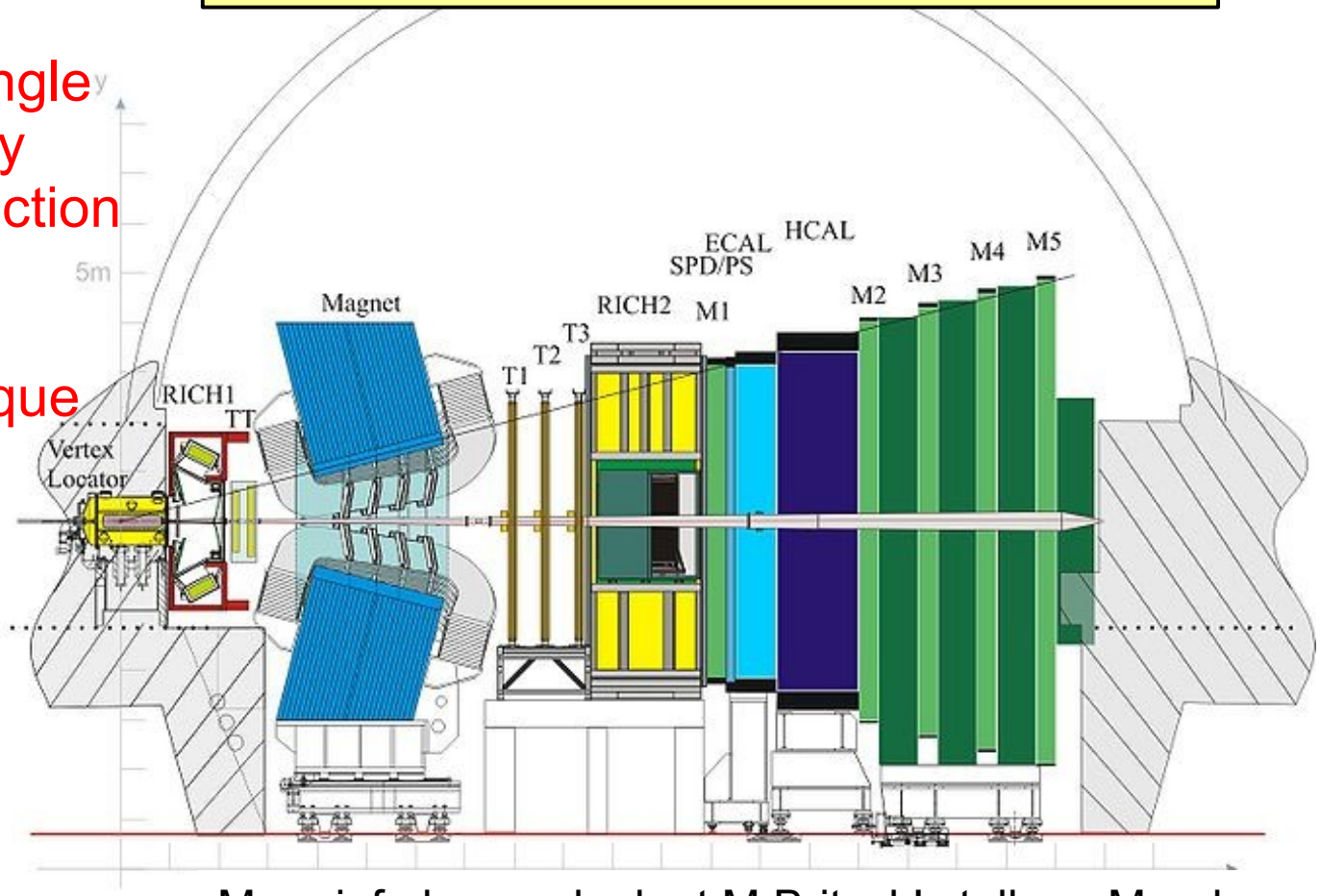
- Covers ~4% of the solid angle but captures ~40% of heavy flavour production cross-section

- Single-arm forward spectrometer, covers a unique rapidity range: $2<\eta<5$

- Great tracking, vertexing and PID performance

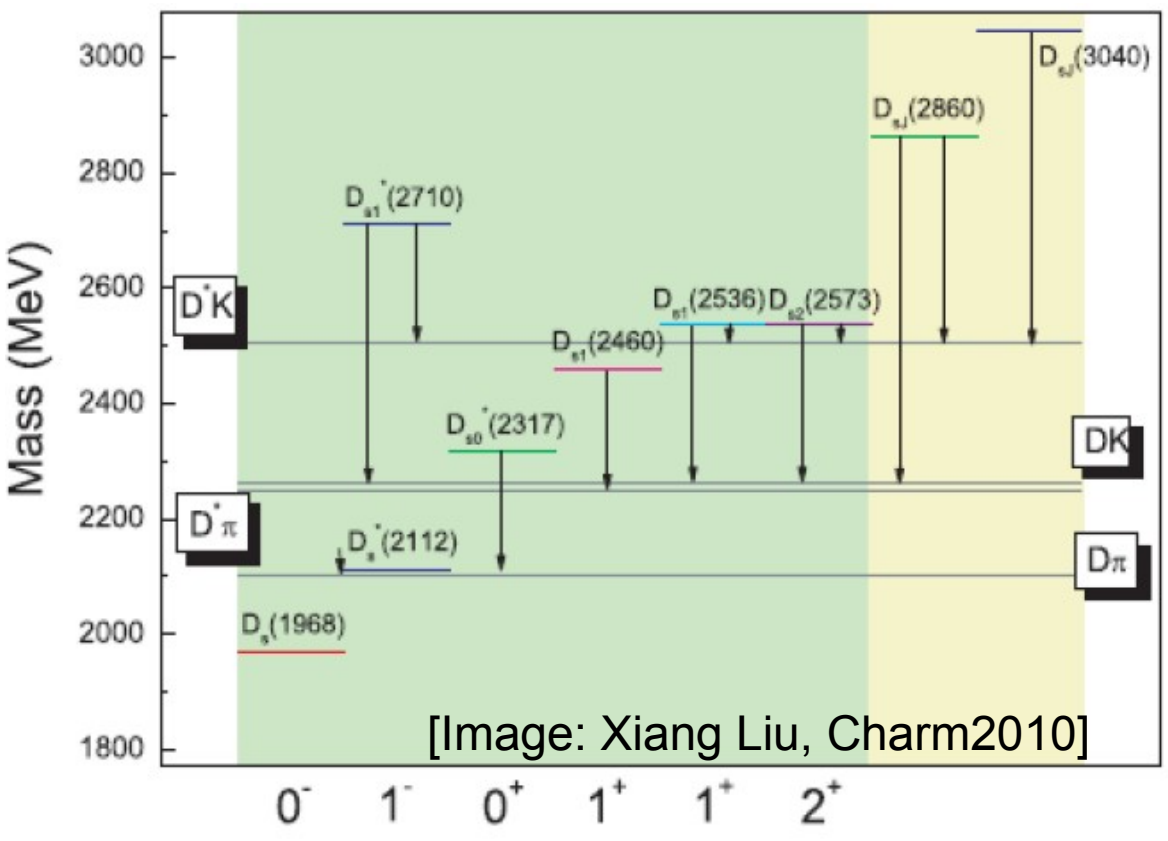
- Excellent machine for B and charm physics

2011 → L ~1.0/fb, $\sqrt{s}$ = 7TeV
2012 → L ~ 0.6/fb so far, $\sqrt{s}$ = 8TeV



More info have a look at M.Britsch's talk on Monday

D_{sJ} spectroscopy



NEW

LHCb studied the D^+K_S and D^0K^+ invariant mass spectra, and confirm the existence of the $D_{s1}^*(2700)^+$ and $D_{sJ}^*(2860)^+$ states.

The experimental study of the D_{sJ} spectrum has prompted a quite large controversy:

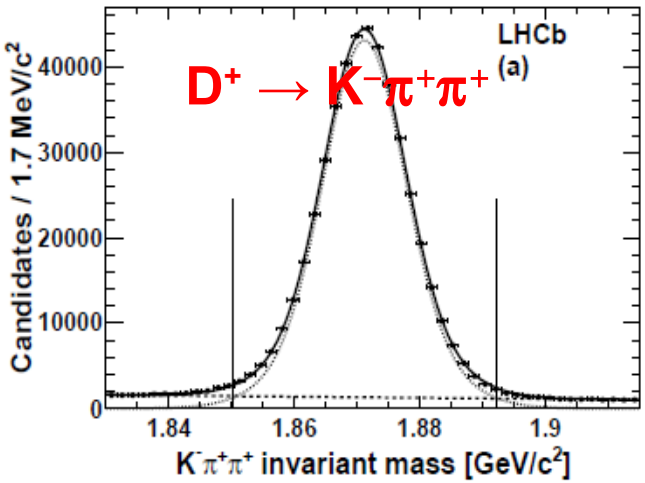
- $D_{s0}^*(2317)^+$ and $D_{s1}(2460)^+$ were discovered by the B-factories (2003) with masses smaller than expected from HQET
- A set of higher mass states observed by the B-factories (2006-2009), $D_{s1}^*(2700)$, $D_{sJ}^*(2860)$ and $D_{sJ}(3040)$, in DK and D*K final states
- Although $J^P=3^-$ spin assignment suggested for $D_{sJ}^*(2860)$, BR measurements are not compatible with BR predictions.

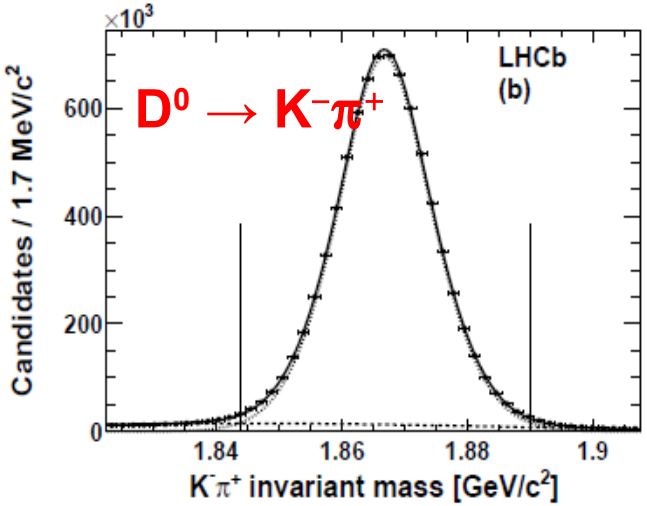
D^+K_s and D^0K^+ mass spectra

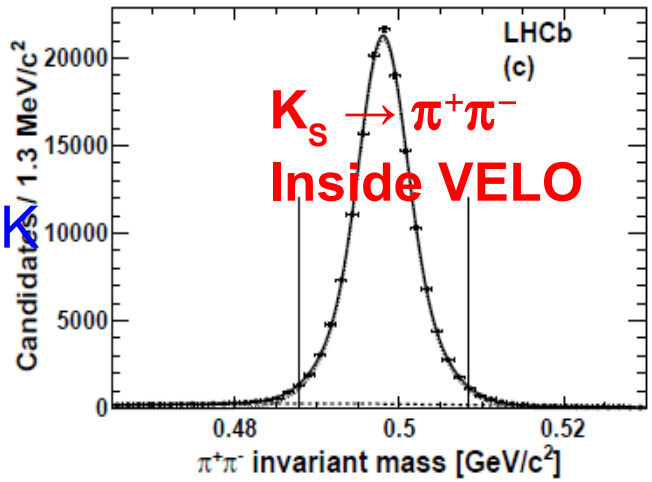
LHCb-PAPER-2012-016
PRELIMINARY

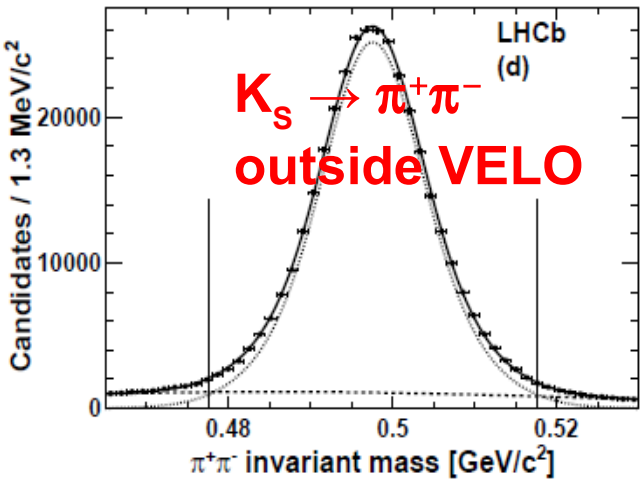
NEW

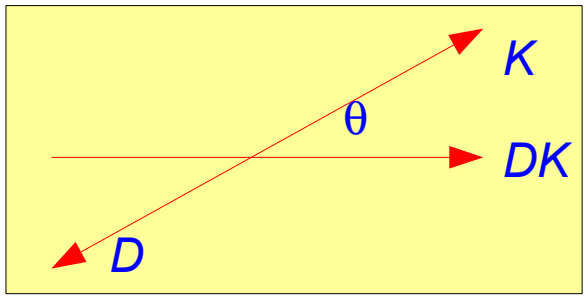
- L=1/fb of 2011 data
- Inclusive reconstruction of D^+K_s and D^0K^+ final states from pp collisions.
- Purity of prompt meson candidates >95%
- We select only candidates inside D and K_s signal regions



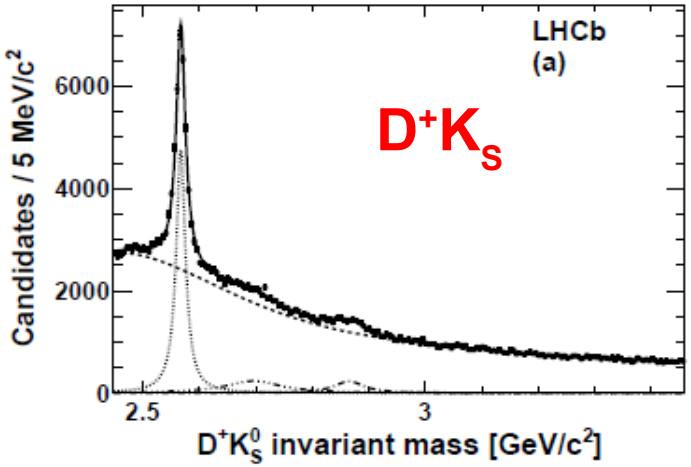


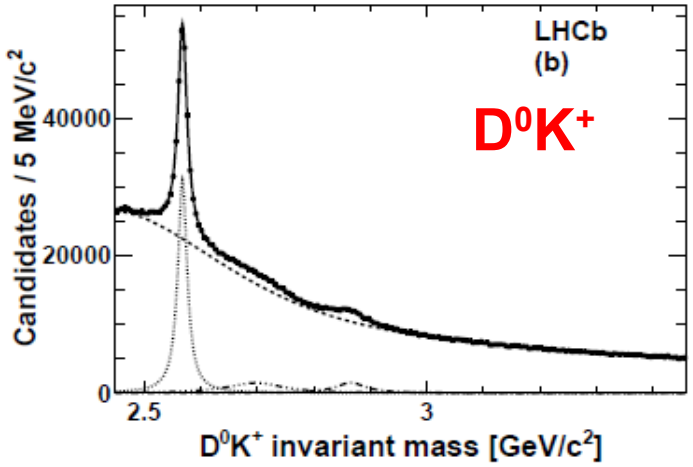


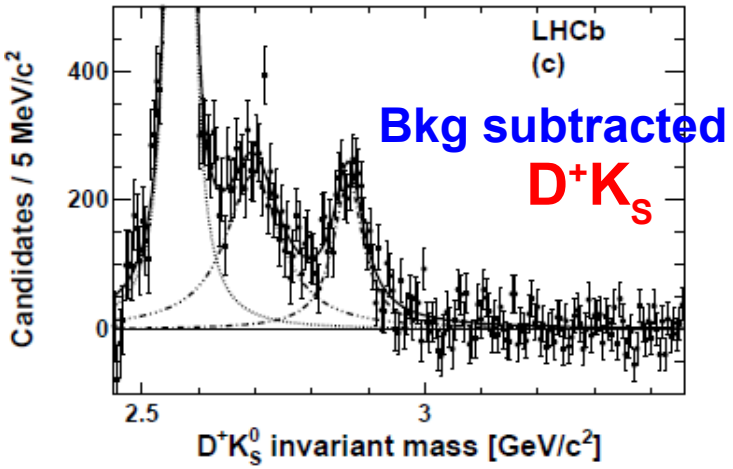


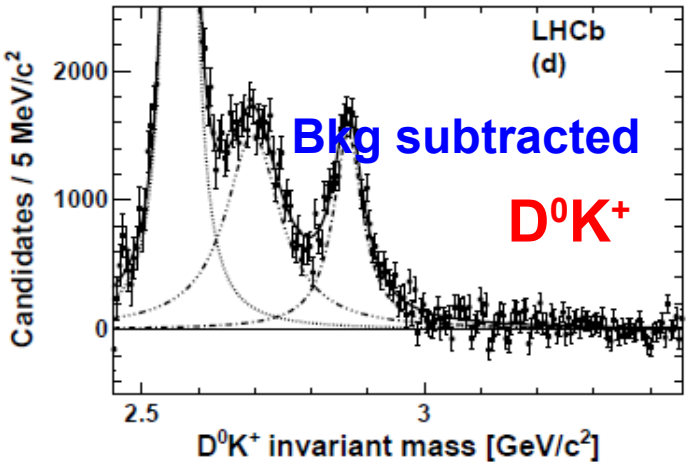


Very large combinatorial rejection by selecting cosθ>0









- $D_{s2}^*(2573)^+$ clear peak, $D_{s1}^*(2700)^+$ and $D_{sJ}^*(2860)^+$
- The states are described using relativistic BW lineshapes and the background as a linear combination of orthogonal polynomials
- Simultaneous fit

Yields

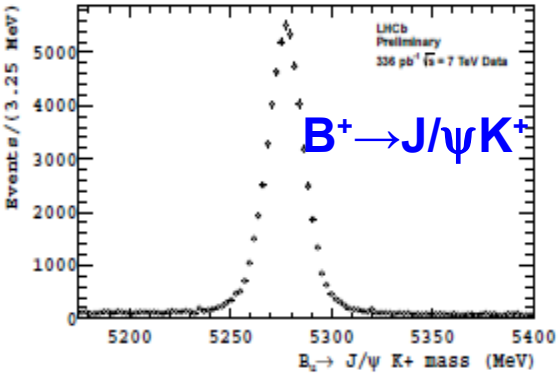
Decay mode	$D_{s1}^{*}(2700)^{+}$	$D_{sJ}^{*}(2860)^{+}$
$D^{+}K_{S}^{0}$	7897 ± 637	4456 ± 332
$D^{0}K^{+}$	49871 ± 2659	29172 ± 1306

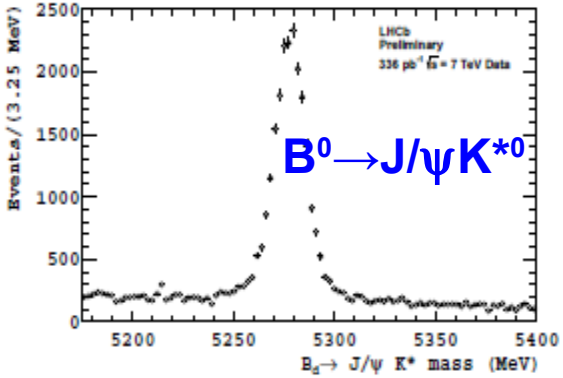
$$
\begin{aligned}
m(D_{s1}^{*}(2700)^{+}) &= 2709.4 \pm 1.9(\text{stat}) \pm 4.5\ (\text{syst})\ \text{MeV}/c^{2}, \\
\Gamma(D_{s1}^{*}(2700)^{+}) &= 121.7 \pm 7.3(\text{stat}) \pm 12.1(\text{syst})\ \text{MeV}, \\
m(D_{sJ}^{*}(2860)^{+}) &= 2866.7 \pm 1.0(\text{stat}) \pm 6.3\ (\text{syst})\ \text{MeV}/c^{2}, \\
\Gamma(D_{sJ}^{*}(2860)^{+}) &= 64.5 \pm 3.2(\text{stat}) \pm 6.6\ (\text{syst})\ \text{MeV}.
\end{aligned}
$$

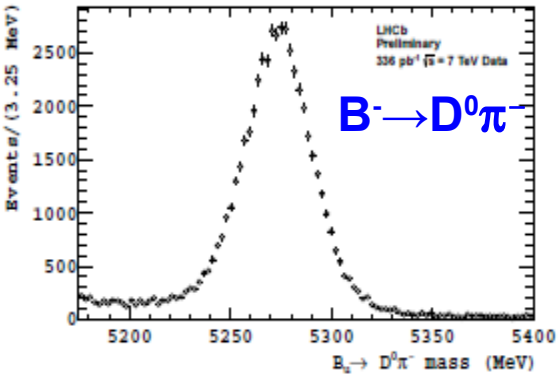
- Results are compatible with previous results from the B-factories
- First time $D_{s1}^{*}(2700)^{+}$ and $D_{sJ}^{*}(2860)^{+}$ are observed in hadronic collisions, and confirm the existence of these states
- Uncertainty dominated by systematic effects. Most contributing effect from background description
- Further analysis of the D*K final states is needed to complete the picture around the $D_{sJ}^{*}(2860)^{+}$ state

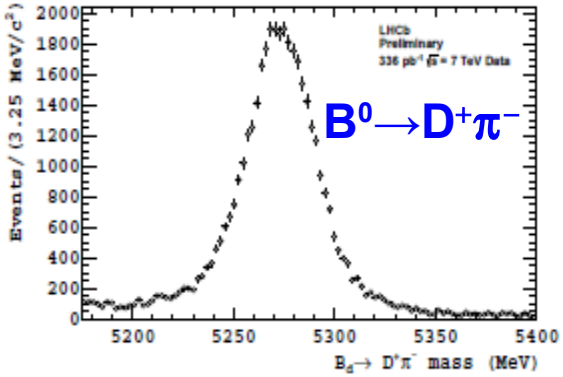
$B_{(s)}^{**}$ spectroscopy

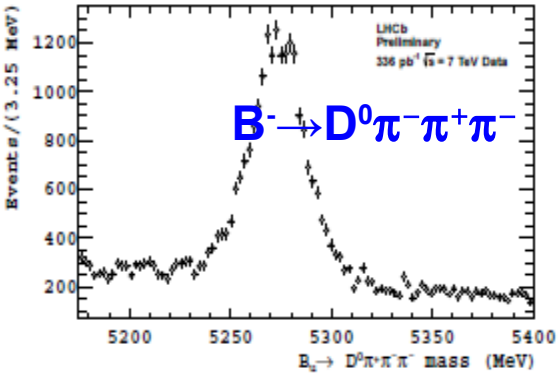
LHCb-CONF-2011-053
PRELIMINARY
336/pb, 2011 data

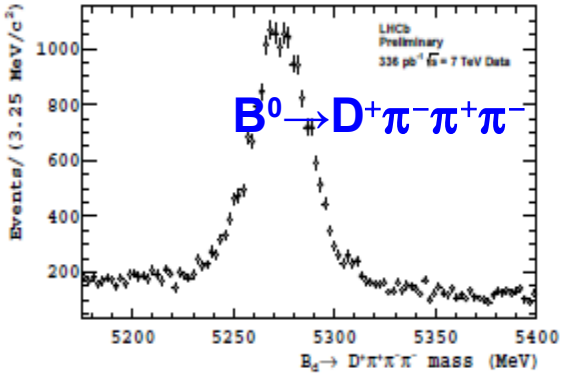






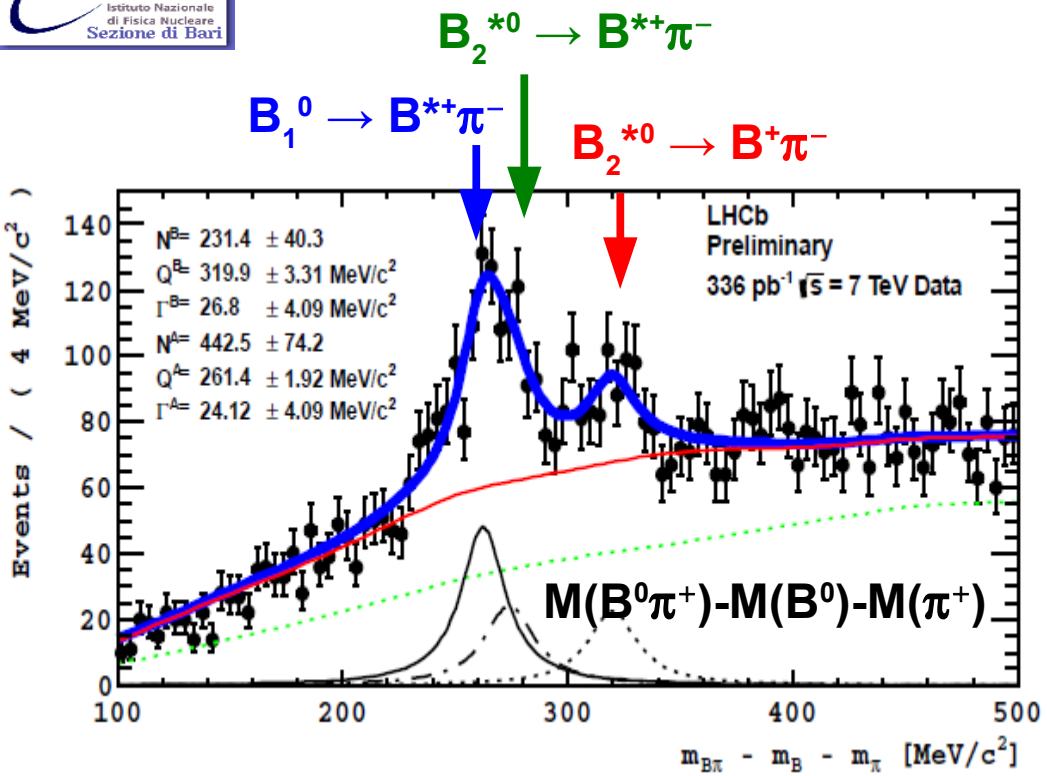


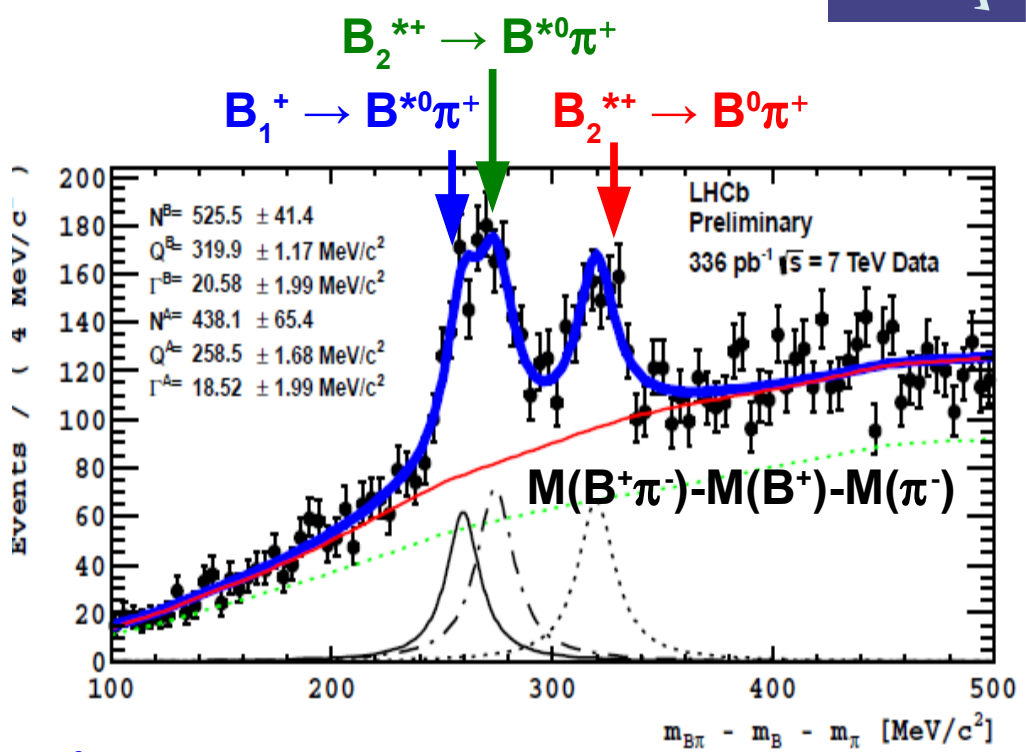




- B-mesons properties are predicted from HQET in the limit of infinite b-quark mass
- Reconstruction of Bh and B*(Bγ)h decay modes. Soft photon is not reconstructed
  - $J/\psi \to \mu^+\mu^-$
  - $D^0 \to K^-\pi^+$
  - $D^+ \to K^-\pi^+\pi^+$
  - $K^{*0}(892) \to K^+\pi^-$
  - Particle ID and track quality constraints applied to all tracks.
- Fits to Q=M(Bh)-M(B)-M(h) are performed

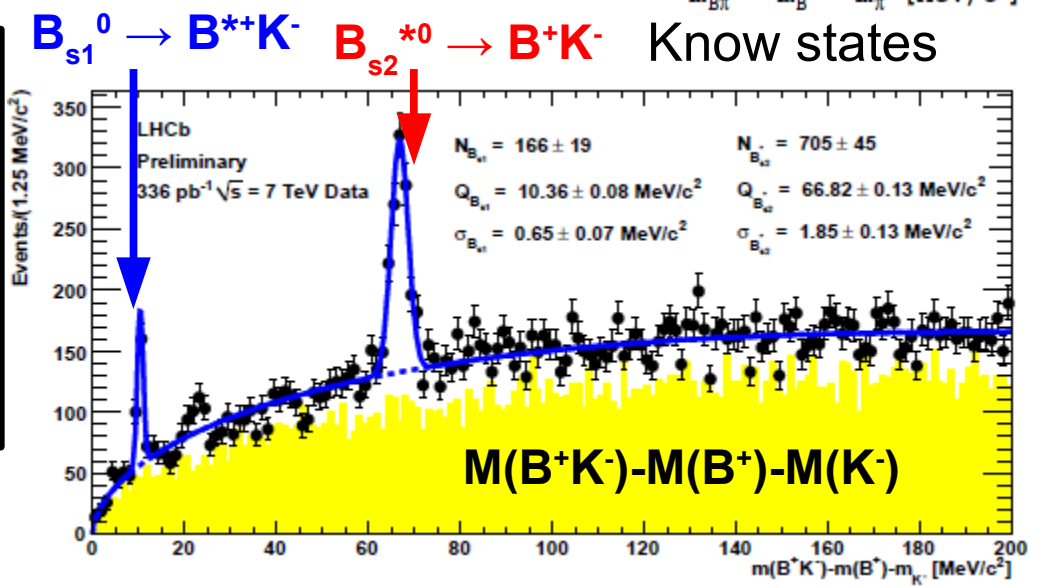
LHCb-CONF-2011-053
PRELIMINARY



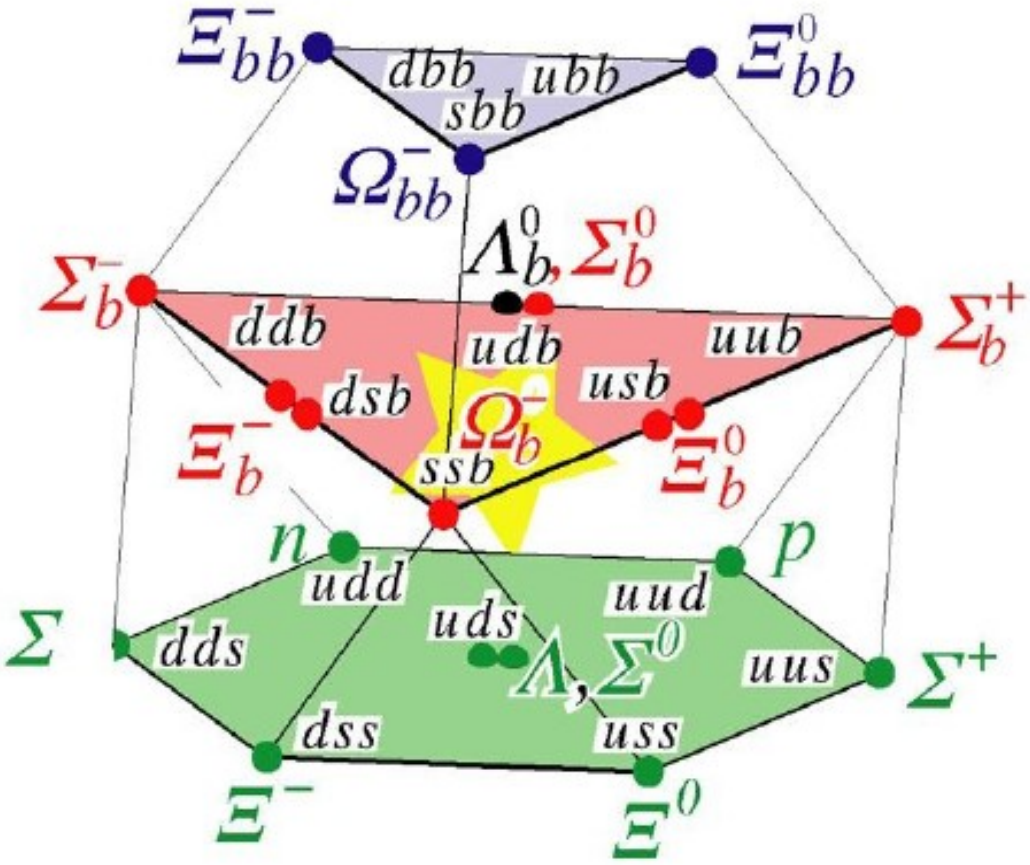


$$M_{B_{s1}^0} = (5828.99 \pm 0.08_{\rm stat} \pm 0.13_{\rm syst} \pm 0.45^{B\,\rm mass}_{\rm syst})\ {\rm MeV}/c^2,$$
$$M_{B_{s2}^{*0}} = (5839.67 \pm 0.13_{\rm stat} \pm 0.17_{\rm syst} \pm 0.29^{B\,\rm mass}_{\rm syst})\ {\rm MeV}/c^2,$$
$$M_{B_1^0} = (5724.1 \pm 1.7_{\rm stat} \pm 2.0_{\rm syst} \pm 0.5^{B\,\rm mass}_{\rm syst})\ {\rm MeV}/c^2,$$
$$M_{B_1^+} = (5726.3 \pm 1.9_{\rm stat} \pm 3.0_{\rm syst} \pm 0.5^{B\,\rm mass}_{\rm syst})\ {\rm MeV}/c^2,$$
$$M_{B_2^{*0}} = (5738.6 \pm 1.2_{\rm stat} \pm 1.2_{\rm syst} \pm 0.3^{B\,\rm mass}_{\rm syst})\ {\rm MeV}/c^2,$$
$$M_{B_2^{*+}} = (5739.0 \pm 3.3_{\rm stat} \pm 1.6_{\rm syst} \pm 0.3^{B\,\rm mass}_{\rm syst})\ {\rm MeV}/c^2,$$

B_1^+ and B_2^{*+} first observation.
Compatible with their isospin partners



Heavy baryon spectroscopy



- System of heavy quark and light diquark. Different QCD models predict different masses, lifetimes, branching ratios, spin-parity, etc... for many c- and b-hadrons

- Several charmed baryonic states studied at the B-factories

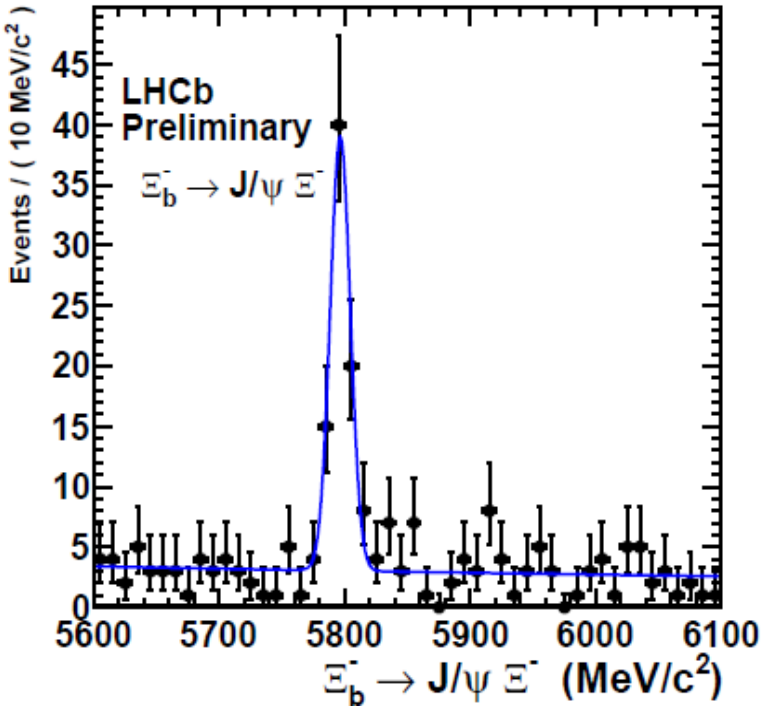
- b-baryon states are less well studied
  - 16 predicted ground states.

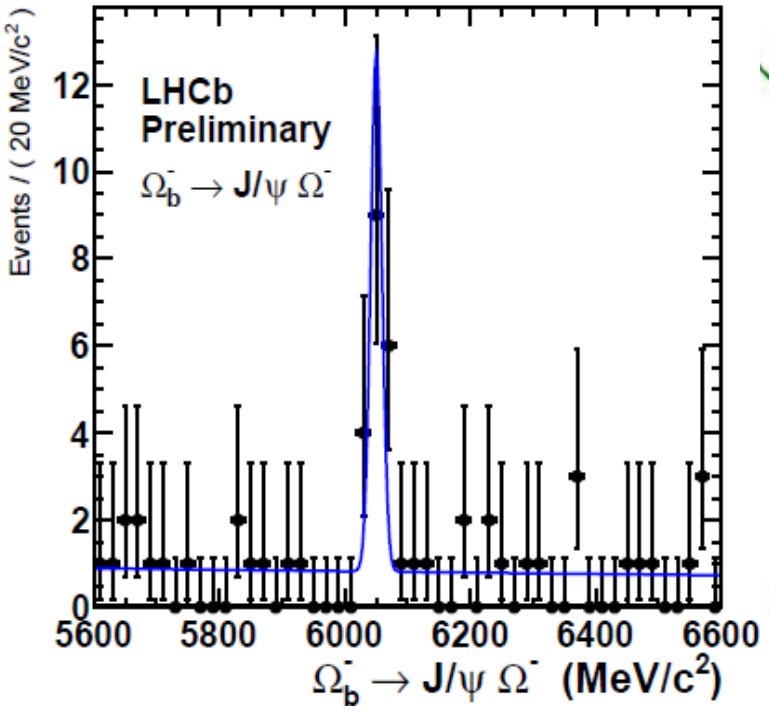
Charged b-baryons

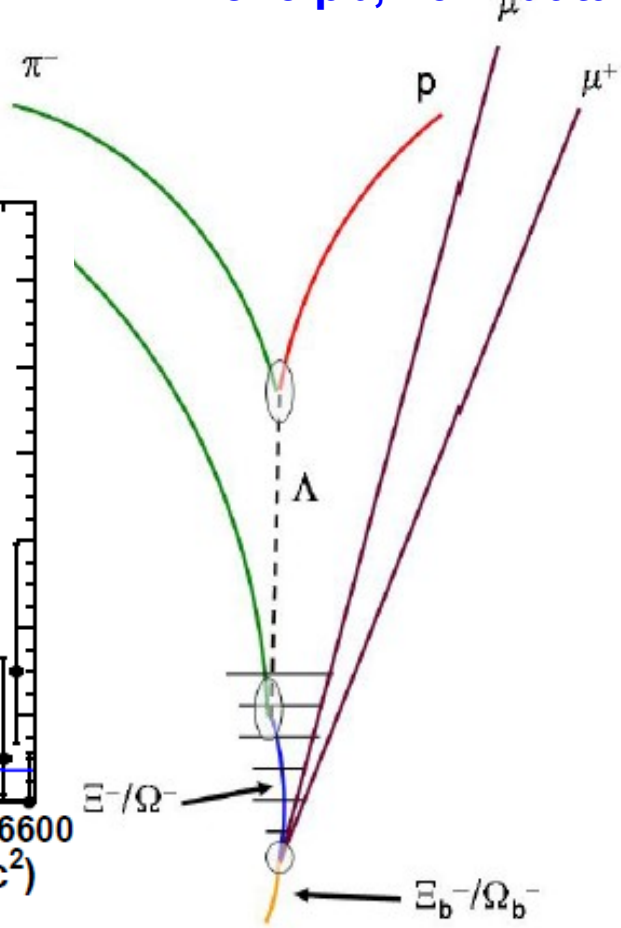
- Reconstructed modes
  - $\Xi_b^- \to J/\psi(\mu^+\mu^-)\Xi^-(\Lambda(p\pi^-)\pi^-)$
  - $\Omega_b^- \to J/\psi(\mu^+\mu^-)\Omega^-(\Lambda(p\pi^-)K^-)$
- Momentum scale calibration using B^+, B^0 and Λ_b decays largest systematic effect

LHCb-CONF-2011-060
PRELIMINARY

576/pb, 2011 data





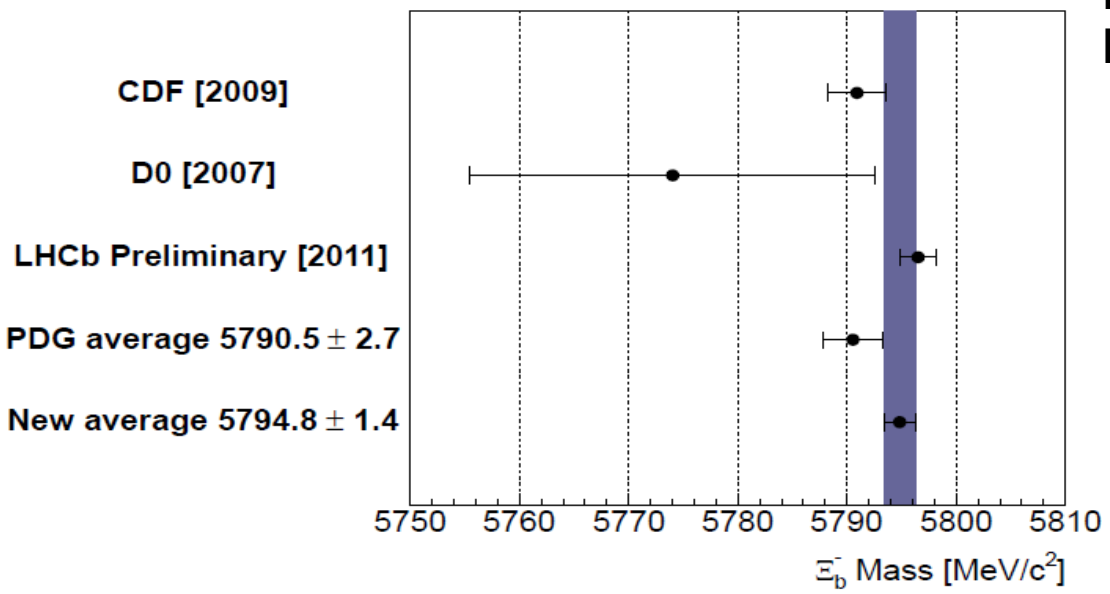


Decay mode	Yield
$\Xi_b^- \to J/\psi\,\Xi^-$	72.2 ± 9.4
$\Omega_b^- \to J/\psi\,\Omega^-$	$13.9^{+4.5}_{-3.8}$

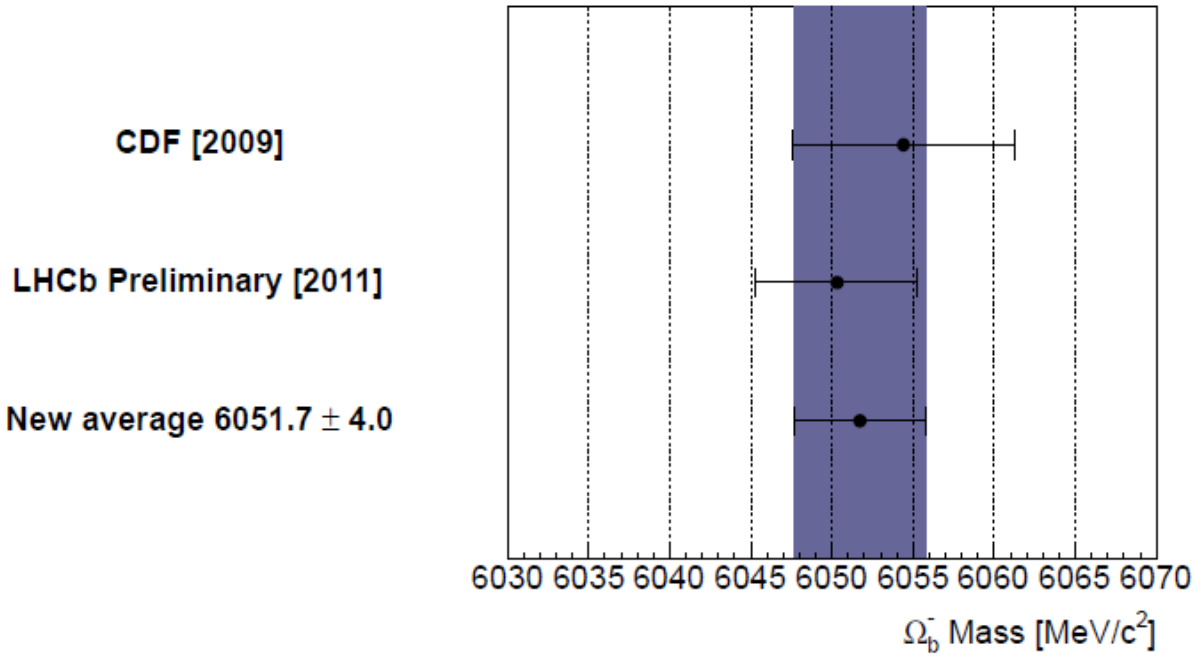
$$\text{Mass } \Xi_b^- : 5796.5 \pm 1.2 \pm 1.2 \text{ MeV}/c^2$$

LHCb-CONF-2011-060
PRELIMINARY

Best Ξ_b^- mass measurement up to date



$$\text{Mass } \Omega_b^- : 6050.3 \pm 4.5 \pm 2.2 \text{ MeV}/c^2$$



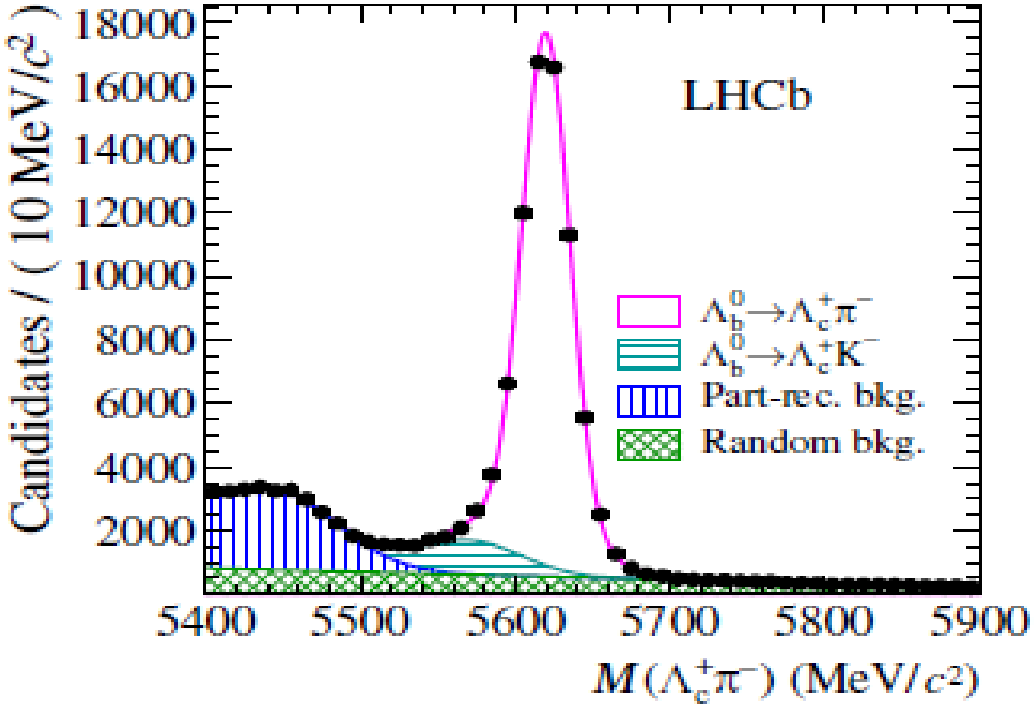
6.7σ discrepancy from CDF+LHCb with DØ result, 6165±16

[D0, PRL101,232002(2008)]
[CDF, PRD80,072003(2009)]

Neutral b-baryons

arXiv:1205.3452

1/fb, 2011 data



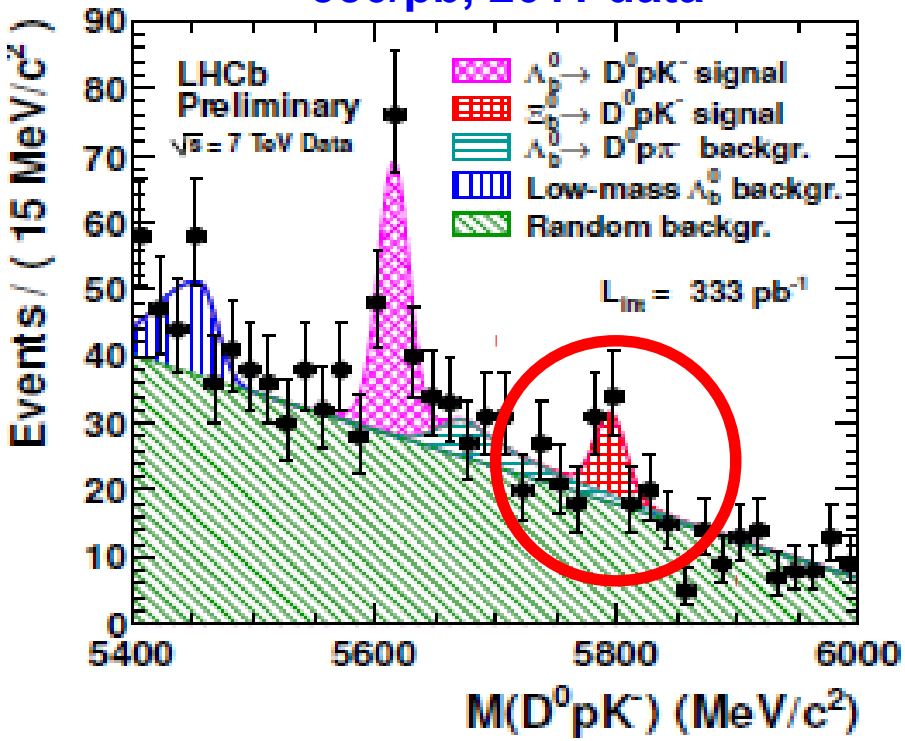
- $\Lambda_b^0 \to \Lambda_c^+(pK^-\pi^+)\pi^-$
- 70540±330 signal events
- A large and clean peak of the Λ_b^0, b-baryon ground state.

Perfect for spectroscopy studies (following slides)

LHCb-CONF-2011-036

PRELIMINARY

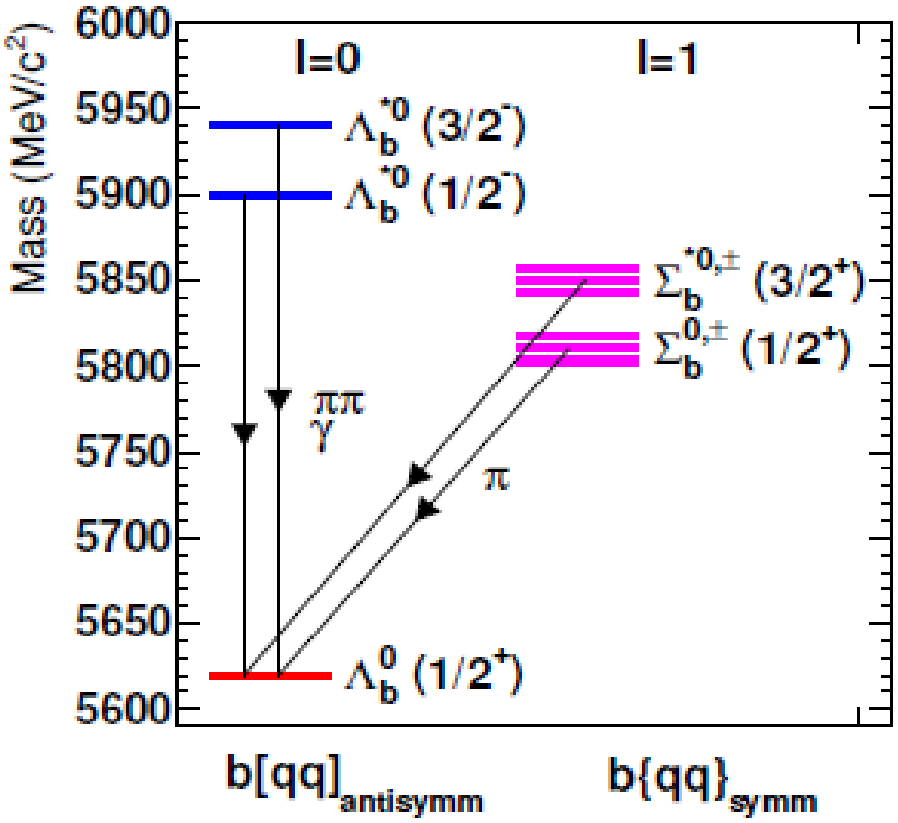
330/pb, 2011 data



- $\Xi_b^0 \to D^0pK^-$
- 27±10 signal events, 2.6σ
- $M(\Xi_b^0)$=5802.0 ± 5.5 ± 1.7MeV
- Consistent with recent CDF measurement

Orbitally excited b-baryons

- Excited Λ_b^0 states: $J^P=1/2^-$ and $3/2^-$
- Foreseen decays to $\Lambda_b^0\pi^+\pi^-$ and $\Lambda_b^0\gamma$
- No experimental evidence before LHCb
- Many theoretical predictions

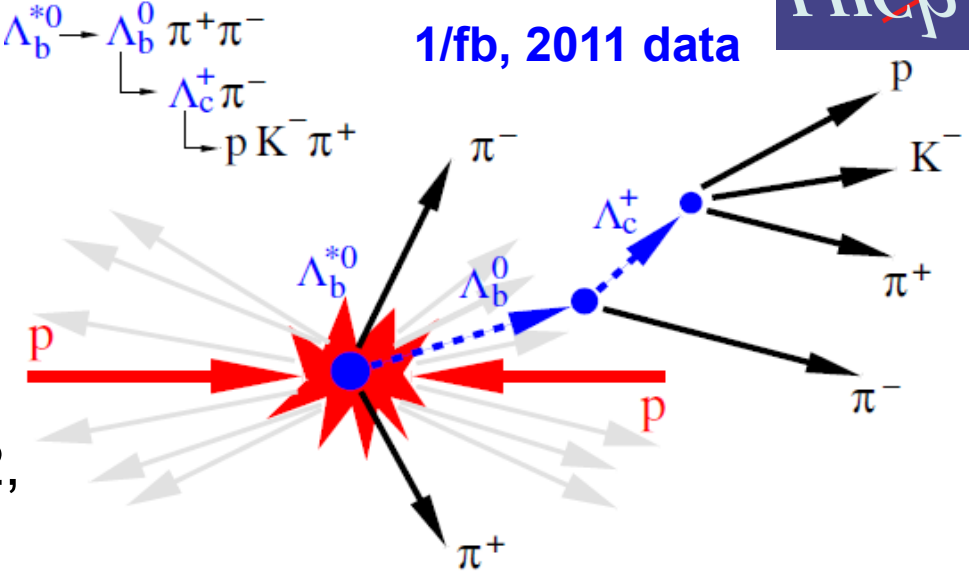


Reference	$M[\Lambda_b^{*0}(1/2^-)]$	$M[\Lambda_b^{*0}(3/2^-)]$
Capstick, Isgur [PRD 34 2809 (1986)]	5912	5920
Baccouche, et al. [hep-ph/0105148]	5920 (spin-averaged)	
Garcilazo, et al. [hep-ph/0703257]	5890	5890
Ebert, et al. [arXiv:0705.2957]	5930	5947
Karliner, et al. [arXiv:0804.1575]	5929 ± 2	5940 ± 2
Roberts, Pervin [arXiv:0711.2492]	5939	5941

arXiv:1205.3452

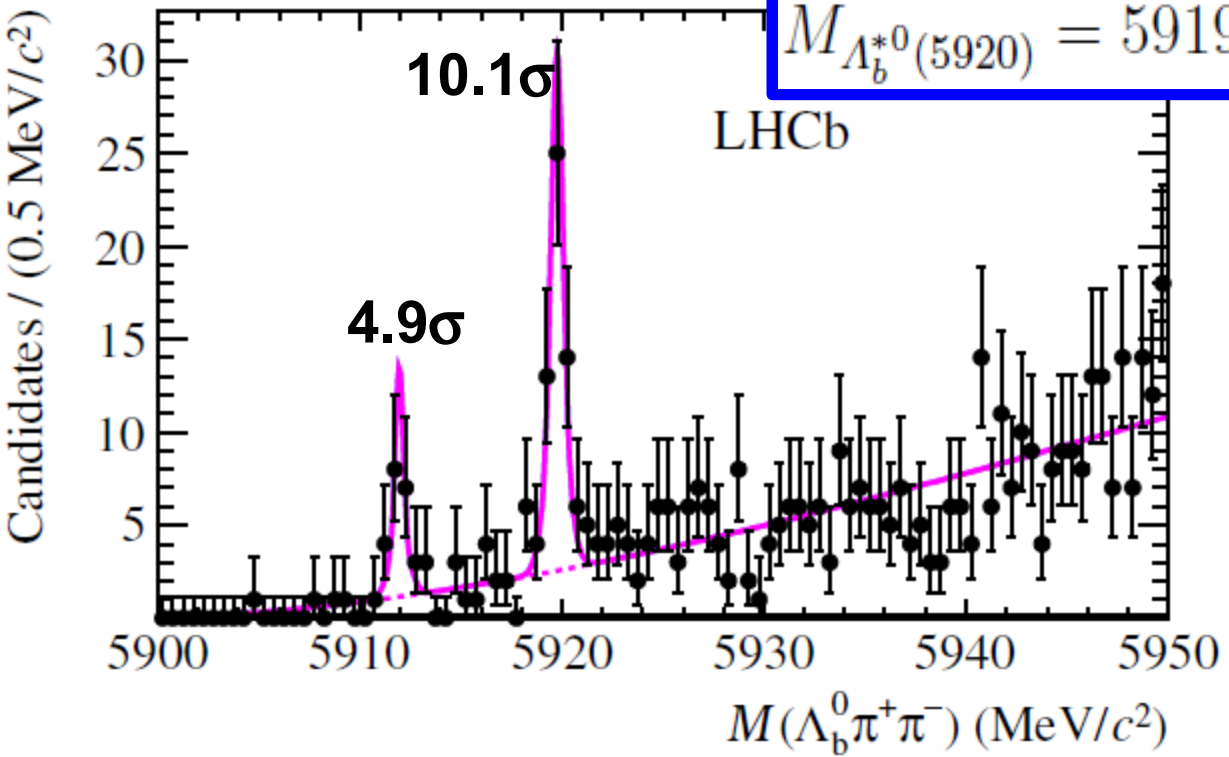
1/fb, 2011 data

- Prompt $\Lambda_b^{*0} \to \Lambda_b^0 \pi^+\pi^-$ reconstruction
- Vertex and mass constraint to Λ_b^0 and Λ_c
- States observed slightly above the Λ_b^0 threshold. Q~12, 20MeV
  - Remarkably good mass resolution ~0.2, 0.3 MeV



$$M_{\Lambda_b^{*0}(5912)} = 5911.95 \pm 0.12 \pm 0.03 \pm 0.66\ \text{MeV}/c^2$$
$$M_{\Lambda_b^{*0}(5920)} = 5919.76 \pm 0.07 \pm 0.02 \pm 0.66\ \text{MeV}/c^2$$

Λ_b^0 mass



$\Gamma(\Lambda_b^{*0}(5912)) < 0.82$ MeV

$\Gamma(\Lambda_b^{*0}(5920)) < 0.71$ MeV

First observation of orbitally excited b baryons

Conclusions

- We present some of the LHCb results on heavy flavors spectroscopy

- The collaboration is actively working in order to perform new measurements and update previous with the full data sample

- LHCb is in a great position to perform precise and competitive measurements, and ready to explore the nature of the production and the spectra of states, in the heavy flavors sector