Hadronic b Decays

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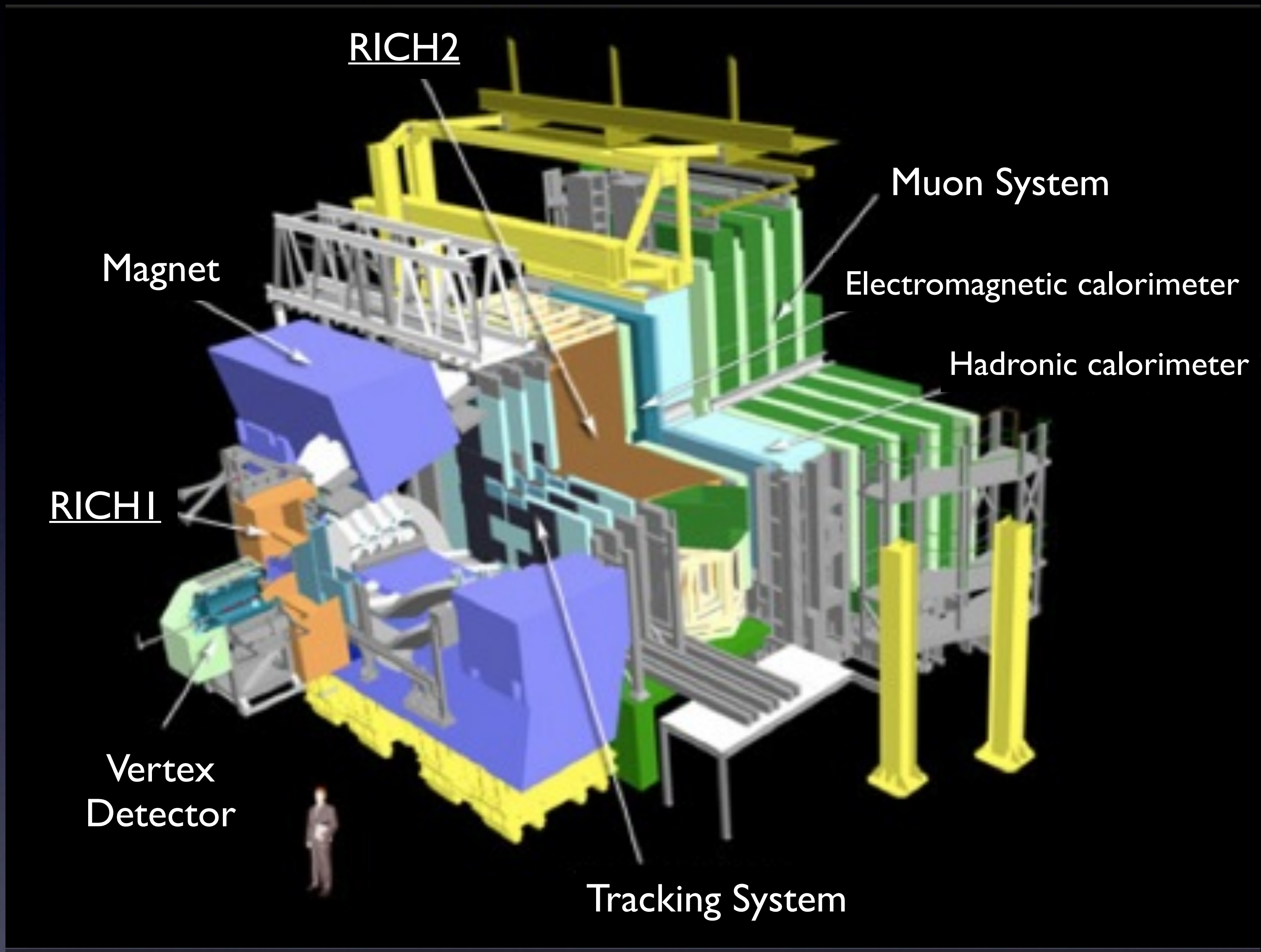
on behalf of the LHCb Collaboration

Les Recontres de Physique 2014

Hadronic b Decays @ LHCb

- Single Arm Spectrometer ($2<\eta<5$)
  - Excellent Vertex Resolution
  - Precise Tracking with Dipole Magnet
  - Hadronic PID over ~2-100 GeV/c using two RICH detectors
  - Calorimeters and Muon Detectors
  - Efficient Multi-Level Trigger



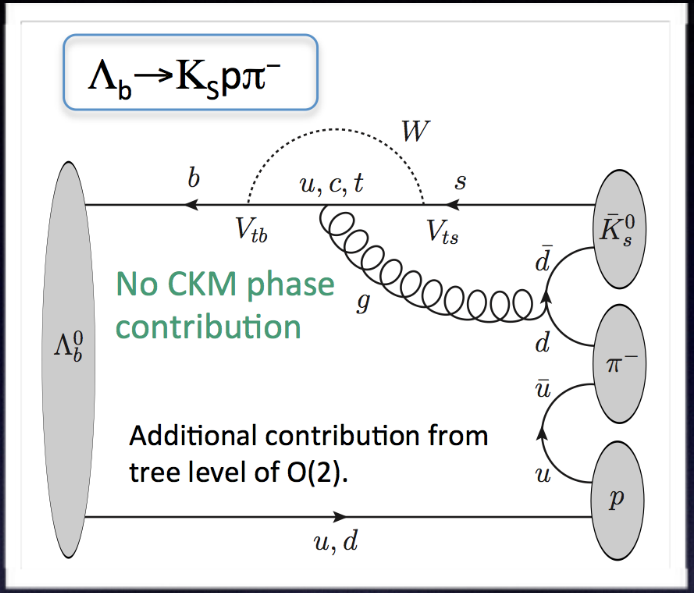
- ***Selected recent LHCb results that high-light hadronic capabilities :-***
  - Λ_b Ξ_b LHCb-PAPER-2013-061 $1\,fb^{-1}$
  - $b \to cc'$ LHCb-PAPER-2014-002 $3\,fb^{-1}$
  - B^+_c LHCb-PAPER-2013-044 $3\,fb^{-1}$
    LHCb-PAPER-2013-047 $3\,fb^{-1}$

Searches for Λ^0_b and Ξ^0_b Decays to $K_S p^{\pm} h^{\mp}$ ($h=K,\pi$)

LHCb-PAPER-2013-061

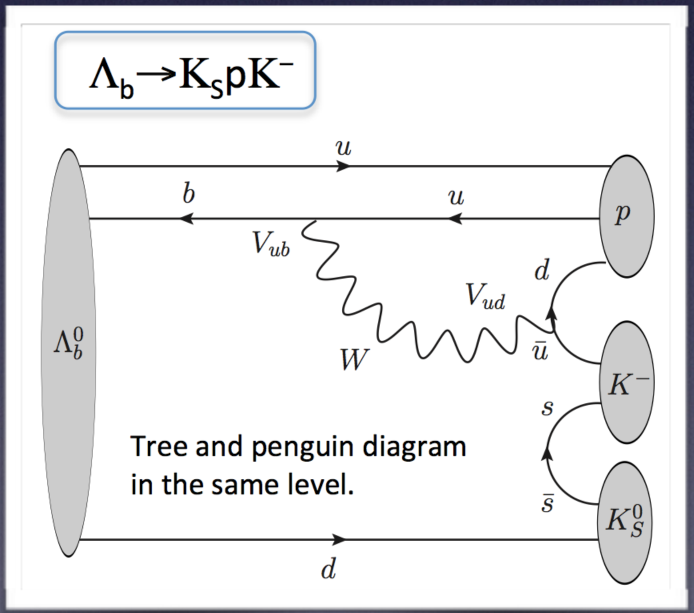
$\Lambda^0_b(\Xi^0_b)\to K_s ph$ (h=K,π)

- b baryons largely unexplored field.
  - Not all states observed (Σ^0_b) or single observation (e.g. $\Sigma^\pm_b$,Ξ^0_b)
  - Masses and lifetimes generally poorly known.
  - No observed charmless hadronic three body decay.
  - Complementary CP observables to b meson decays. e.g. Significant variation observed across phase-space in B meson decays. (See talk by M.Calvi)



No CKM phase contribution

Additional contribution from tree level of O(2).



Tree and penguin diagram in the same level.

- Present here :- LHCb-PAPER-2013-061
  - Search for ***previously unobserved*** $\Lambda^0_b(\Xi^0_b)\to K_s ph$ decays.
    - ***First measurement*** of $\mathcal{B}(\Lambda^0_b\to K_s p\pi)$
    - ***First measurement*** of $A_{CP}(\Lambda^0_b\to K_s p\pi)$

$\Lambda^0_b(\Xi^0_b)\rightarrow K_s ph$ Analysis

- Multi-variate selection of $b\rightarrow K_s(\pi^+\pi^-)ph$ (h=π,K).
  - Blind analysis optimised using a *F.o.M.* for expected sensitivity a=5σ.

$$FoM = \frac{\epsilon^{MVA}}{a/2 + \sqrt{B_{MVA}}}$$

- Hadronic PID used to reduce signal cross feed and suppress backgrounds.
- $\Lambda^0_b(\Xi^0_b)\rightarrow\Lambda_c^{\pm}(K_s p)h$, $D^{\pm}_s(K_s K)p$ identical final states. Isolated using $m(K_s p)$, $m(K_s K)$ cuts.
- Branching ratios measured relative to well known $\mathcal{B}(B^0\rightarrow K_s\pi^+\pi^-)$
  - Simultaneous fit across all decay modes (charm and charmless).
  - Selection efficiencies from data (PID) and MC (kinematic).

$$\frac{\mathcal{B}(\Lambda^0_b(\Xi^0_b)\rightarrow K^0_s ph)}{\mathcal{B}(B^0\rightarrow K^0_s\pi^{\pm}\pi^{\mp})} = \frac{\epsilon^{\text{Sel.}}_{B^0\rightarrow K^0_s\pi^{\pm}\pi^{\mp}}}{\epsilon^{\text{Sel.}}_{\Lambda^0_b(\Xi^0_b)\rightarrow K^0_s ph}} \times \frac{\epsilon^{\text{PID}}_{B^0\rightarrow K^0_s\pi^{\pm}\pi^{\mp}}}{\epsilon^{\text{PID}}_{\Lambda^0_b(\Xi^0_b)\rightarrow K^0_s ph}} \times \frac{N_{\Lambda^0_b(\Xi^0_b)\rightarrow K^0_s ph}}{N_{B^0\rightarrow K^0_s\pi^{\pm}\pi^{\mp}}} \times \frac{f_d}{f_{\Lambda_b(\Xi_b)}}$$

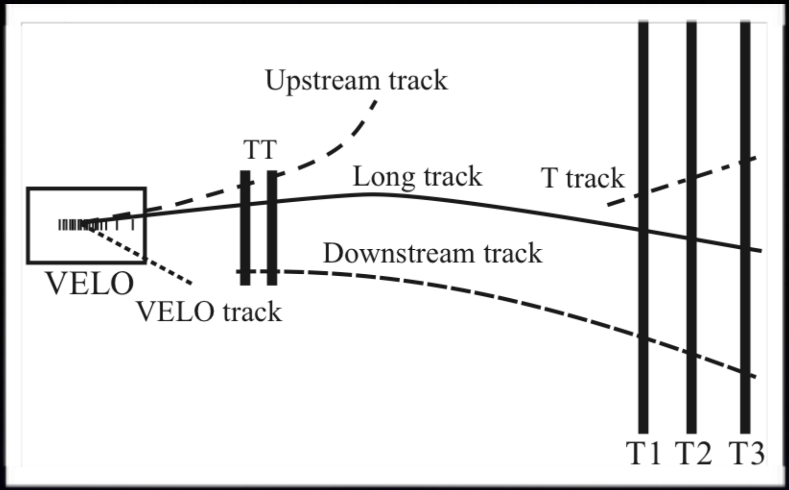
$$f_{\Lambda^0_b}/(f_u + f_d) = (0.404 \pm 0.110) \times [1 - (0.031 \pm 0.005) \times p_{\text{T}}(\text{GeV}/c)]$$

LHCb-PAPER-2011-018

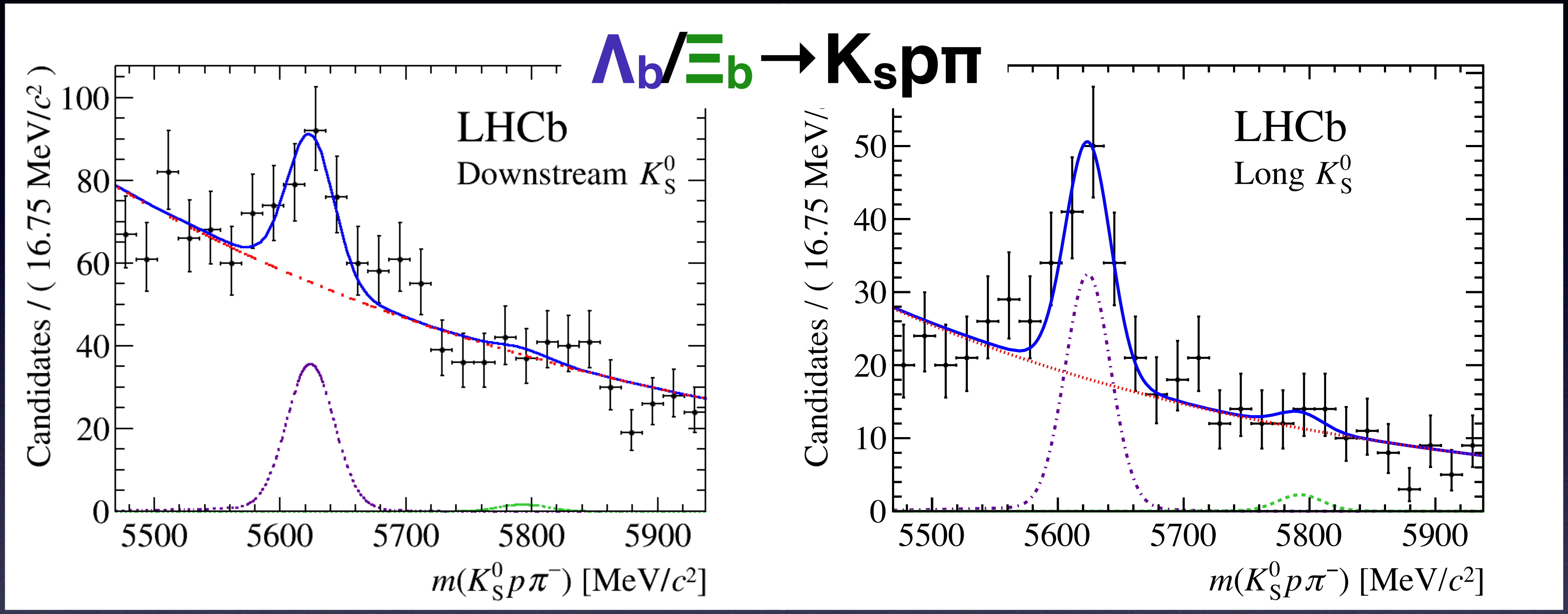
No measurement of f_d/f_{Ξ} → Results ∴ include this factor.

Unblinded : $\Lambda_b/\Xi_b \rightarrow K_s p h$

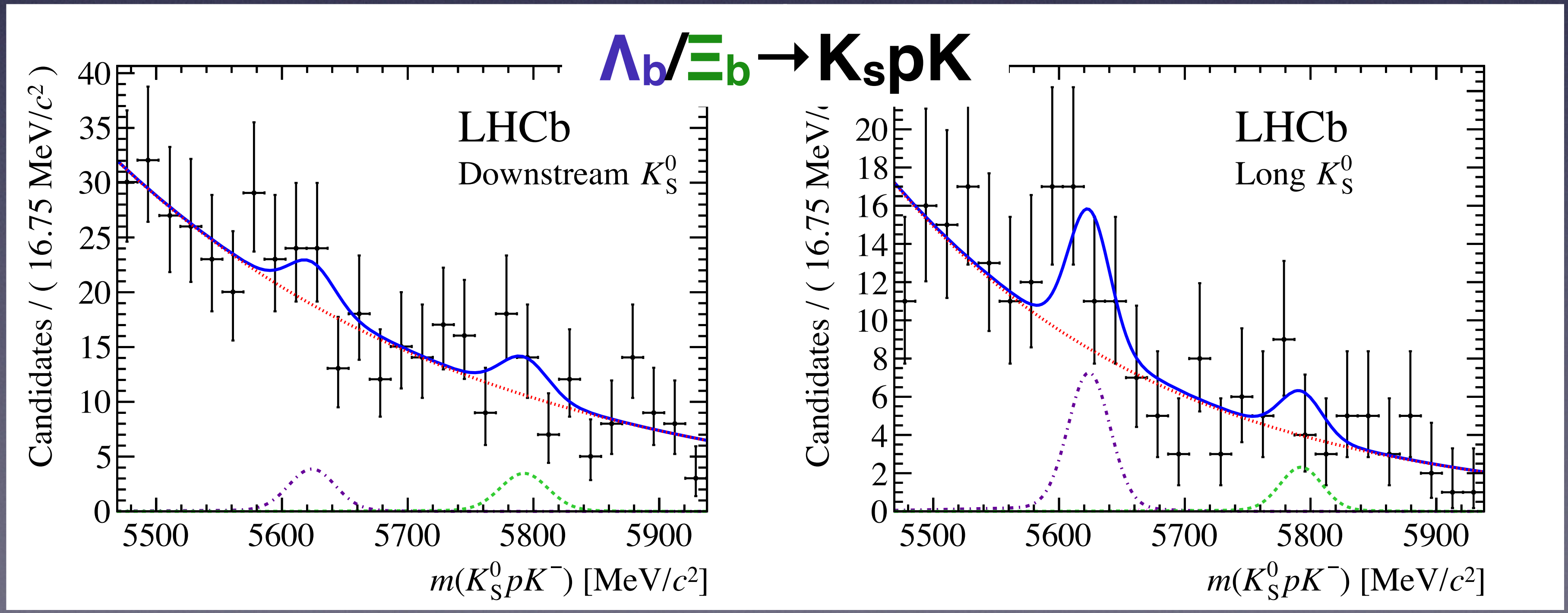
K^0_s candidates ‘Long’ or ‘Downstream’ depending on whether VELO was traversed (see talk by C. Marin Benito)



$\Lambda_b/\Xi_b \rightarrow K_s p\pi$

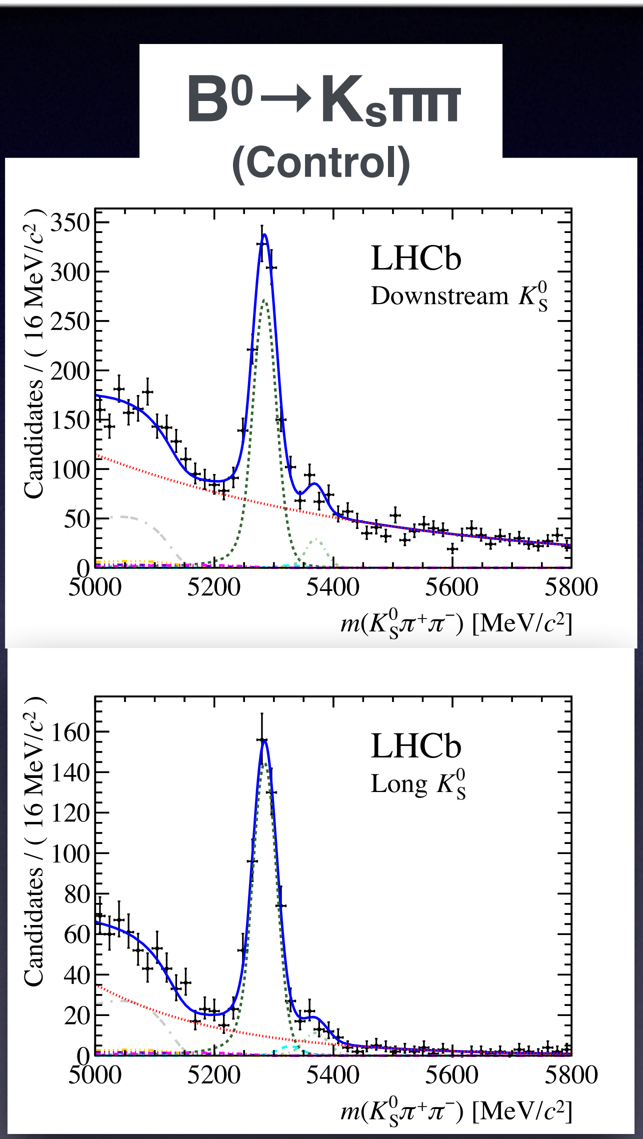


$\Lambda_b/\Xi_b \rightarrow K_s pK$



$B^0 \rightarrow K_s\pi\pi$

(Control)

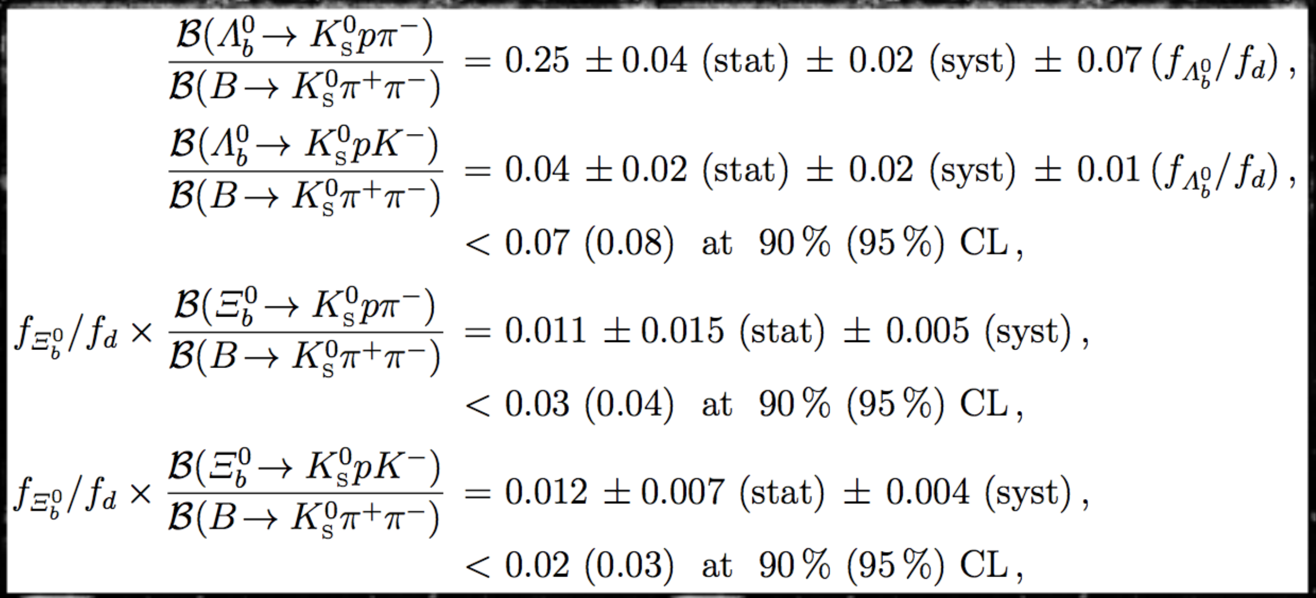


Combining Downstream and Long K_s modes, observe 8.6(2.1)σ significance for Λ_b π(K) modes

… Branching Fractions →

LHCb-PAPER-2013-061

$\Lambda_b/\Xi_b \to K_s ph$ Branching Fractions



$$\frac{\mathcal{B}(\Lambda_b^0 \to K_S^0 p\pi^-)}{\mathcal{B}(B \to K_S^0\pi^+\pi^-)} = 0.25 \pm 0.04\,(\text{stat}) \pm 0.02\,(\text{syst}) \pm 0.07\,(f_{\Lambda_b^0}/f_d)\,,$$

$$\frac{\mathcal{B}(\Lambda_b^0 \to K_S^0 pK^-)}{\mathcal{B}(B \to K_S^0\pi^+\pi^-)} = 0.04 \pm 0.02\,(\text{stat}) \pm 0.02\,(\text{syst}) \pm 0.01\,(f_{\Lambda_b^0}/f_d)\,,$$

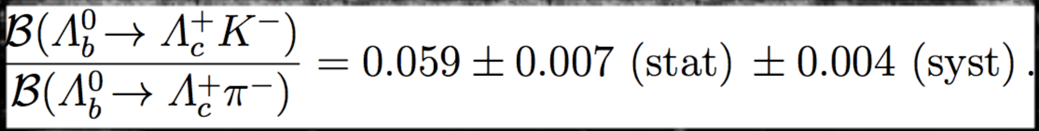
$$< 0.07\ (0.08)\ \text{at}\ 90\,\%\ (95\,\%)\ \text{CL}\,,$$

$$f_{\Xi_b^0}/f_d \times \frac{\mathcal{B}(\Xi_b^0 \to K_S^0 p\pi^-)}{\mathcal{B}(B \to K_S^0\pi^+\pi^-)} = 0.011 \pm 0.015\,(\text{stat}) \pm 0.005\,(\text{syst})\,,$$

$$< 0.03\ (0.04)\ \text{at}\ 90\,\%\ (95\,\%)\ \text{CL}\,,$$

$$f_{\Xi_b^0}/f_d \times \frac{\mathcal{B}(\Xi_b^0 \to K_S^0 pK^-)}{\mathcal{B}(B \to K_S^0\pi^+\pi^-)} = 0.012 \pm 0.007\,(\text{stat}) \pm 0.004\,(\text{syst})\,,$$

$$< 0.02\ (0.03)\ \text{at}\ 90\,\%\ (95\,\%)\ \text{CL}\,,$$



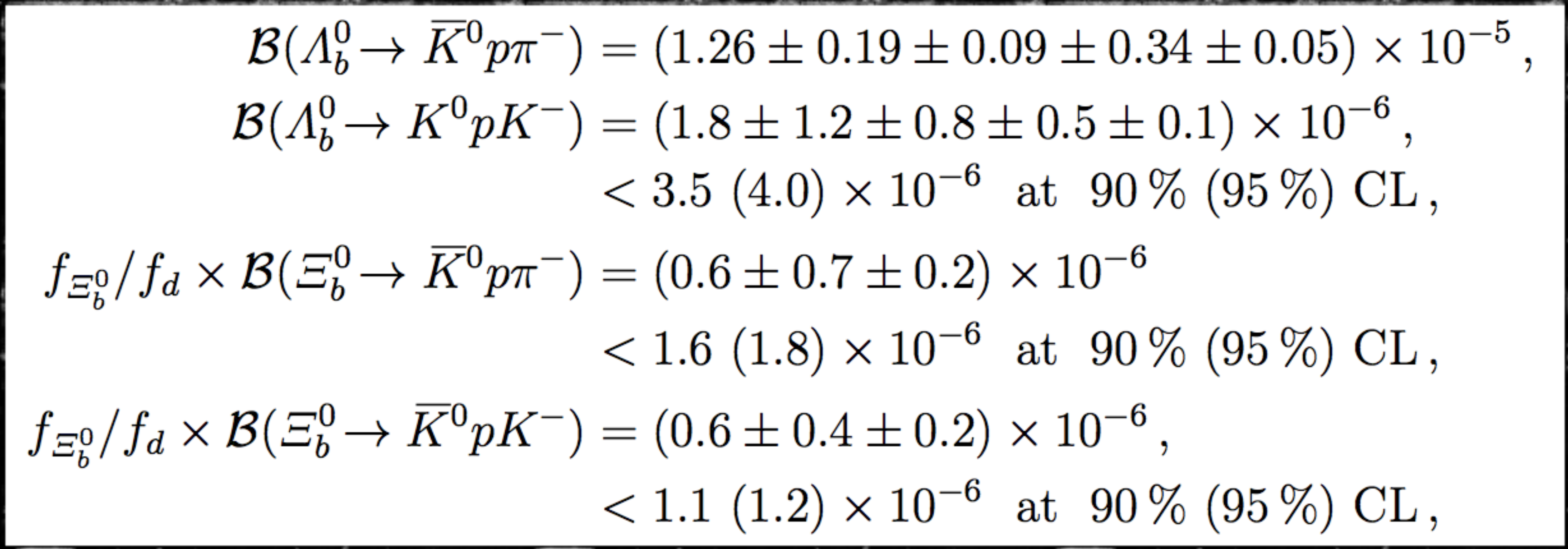
$$\frac{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ K^-)}{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ \pi^-)} = 0.059 \pm 0.007\,(\text{stat}) \pm 0.004\,(\text{syst})\,.$$

In agreement with LHCb-2013-056

- Limit systematics dominated by knowledge of efficiency variations across phase space
- Confidence Level limits determined for modes with less than 3σ significance

Using $\mathcal{B}(B^0 \to K^0\pi^+\pi^-) = (4.96 \pm 0.20) \times 10^{-5}$ (PDG) :-

First Observation



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

$$\mathcal{B}(\Lambda_b^0 \to K^0 pK^-) = (1.8 \pm 1.2 \pm 0.8 \pm 0.5 \pm 0.1) \times 10^{-6}\,,$$

$$< 3.5\ (4.0) \times 10^{-6}\ \text{at}\ 90\,\%\ (95\,\%)\ \text{CL}\,,$$

$$f_{\Xi_b^0}/f_d \times \mathcal{B}(\Xi_b^0 \to \overline{K}^0 p\pi^-) = (0.6 \pm 0.7 \pm 0.2) \times 10^{-6}$$

$$< 1.6\ (1.8) \times 10^{-6}\ \text{at}\ 90\,\%\ (95\,\%)\ \text{CL}\,,$$

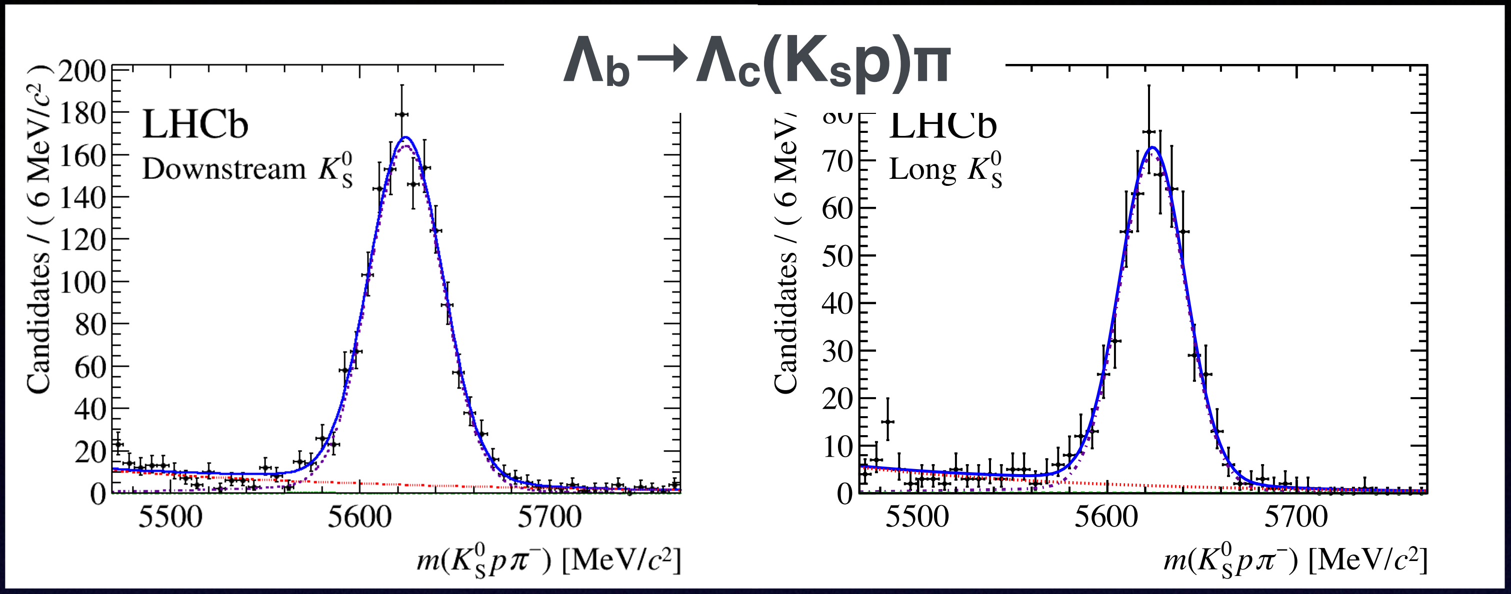
$$f_{\Xi_b^0}/f_d \times \mathcal{B}(\Xi_b^0 \to \overline{K}^0 pK^-) = (0.6 \pm 0.4 \pm 0.2) \times 10^{-6}\,,$$

$$< 1.1\ (1.2) \times 10^{-6}\ \text{at}\ 90\,\%\ (95\,\%)\ \text{CL}\,,$$

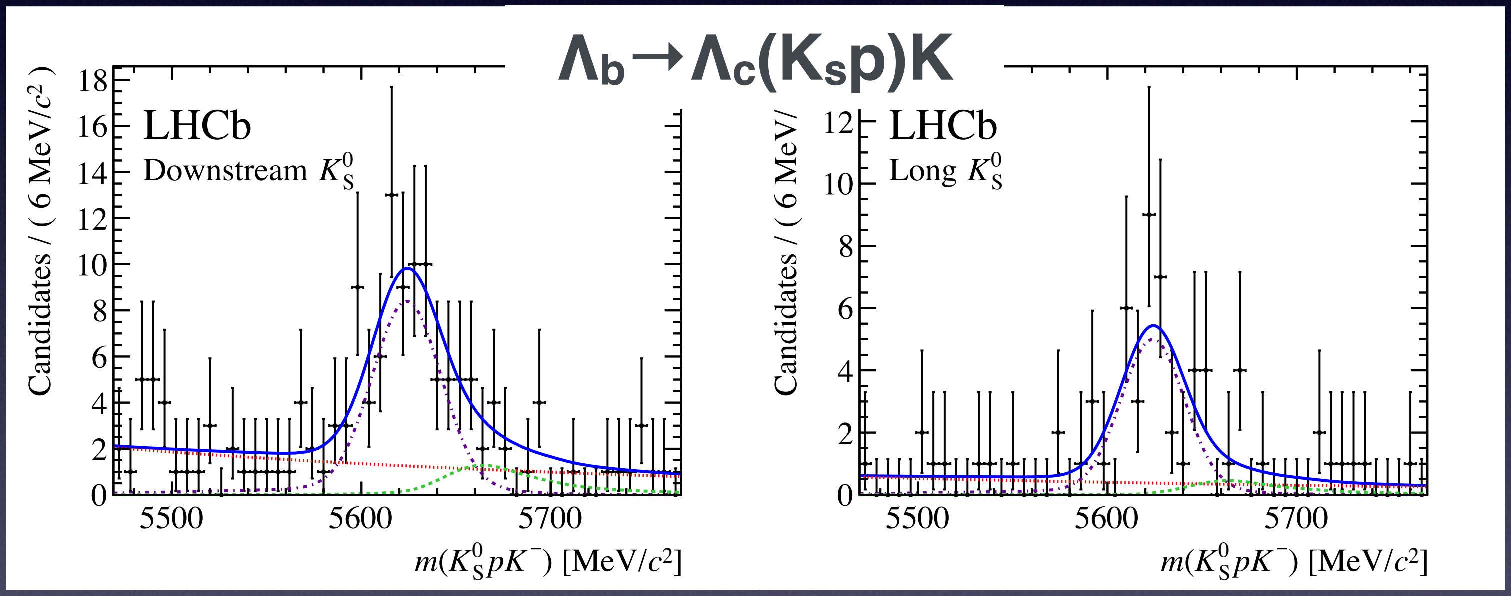
errors : ±stat.±syst.±f_Λ/f_d±$\mathcal{B}(B^0 \to K^0\pi^+\pi^-)$

LHCb-PAPER-2013-061

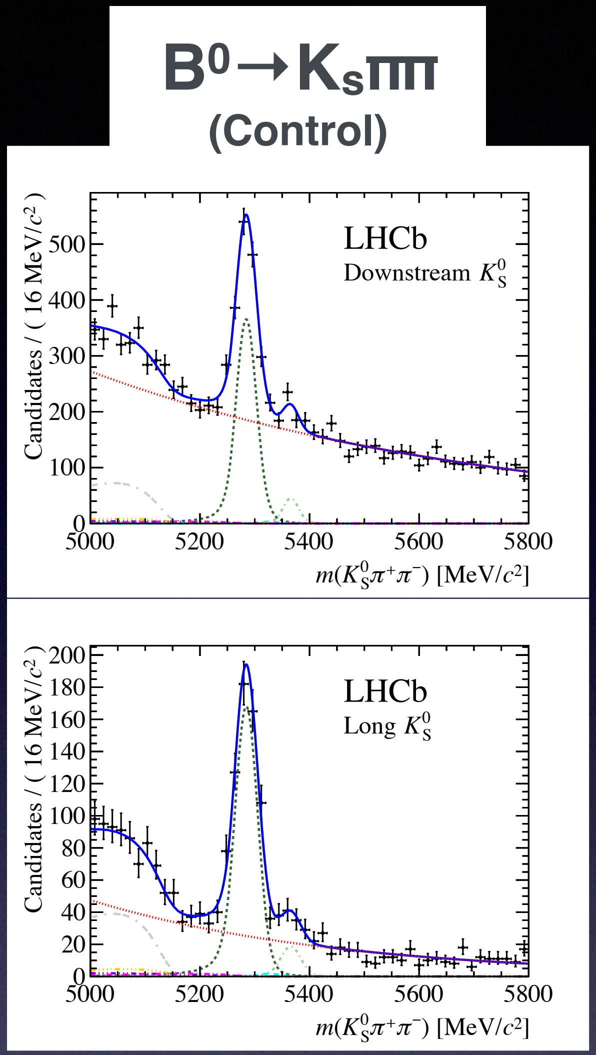
$\Lambda_b \to \Lambda_c(K_s p)h$ Results



$\Lambda_b \to \Lambda_c(K_s p)\pi$



$\Lambda_b \to \Lambda_c(K_s p)K$



$B^0 \to K_s\pi\pi$

(Control)

$$\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+(\to p\overline{K}^0)\pi^-) = (1.40 \pm 0.07 \pm 0.08 \pm 0.38 \pm 0.06) \times 10^{-4},$$

$$\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+(\to p\overline{K}^0)K^-) = (0.83 \pm 0.10 \pm 0.06 \pm 0.23 \pm 0.03) \times 10^{-5},$$

Using PDG for Λ_c $\mathcal{B}$'s can extract absolute branching fractions :-

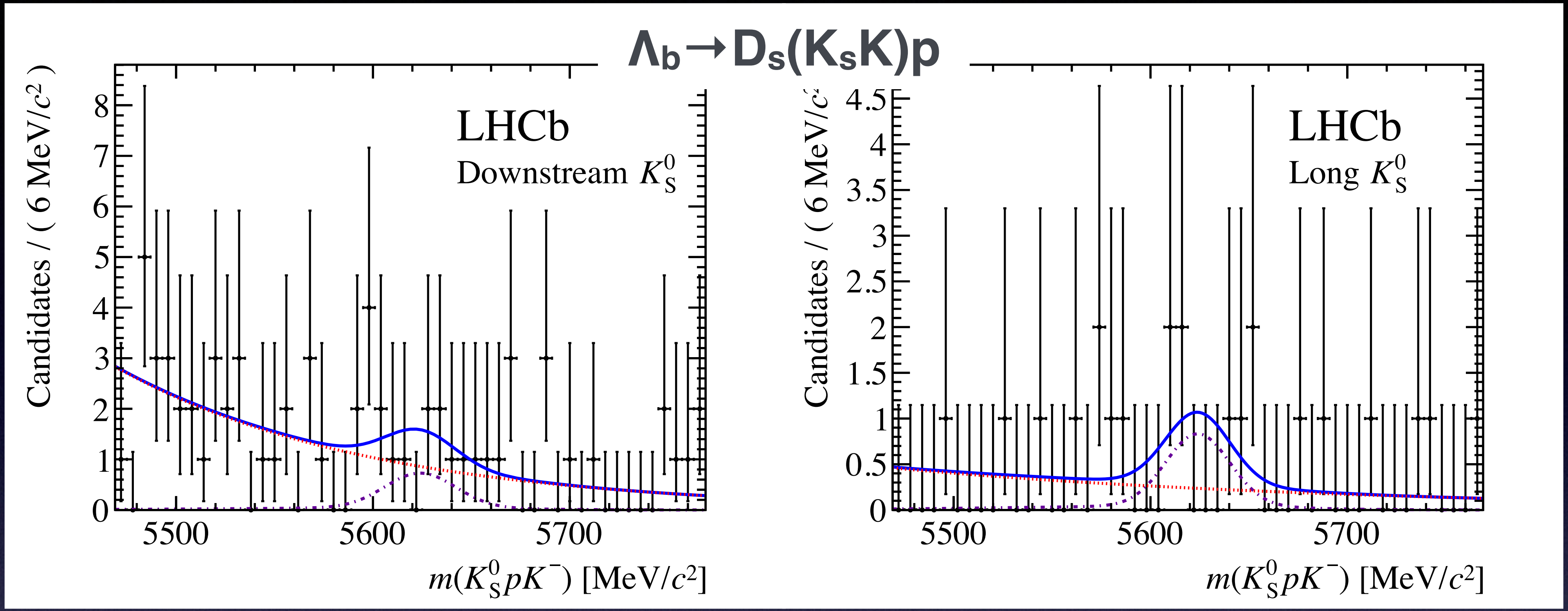
$$\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+\pi^-) = (5.97 \pm 0.28 \pm 0.34 \pm 0.70 \pm 0.24) \times 10^{-3},$$

$$\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+K^-) = (3.55 \pm 0.44 \pm 0.24 \pm 0.41 \pm 0.14) \times 10^{-4}.$$

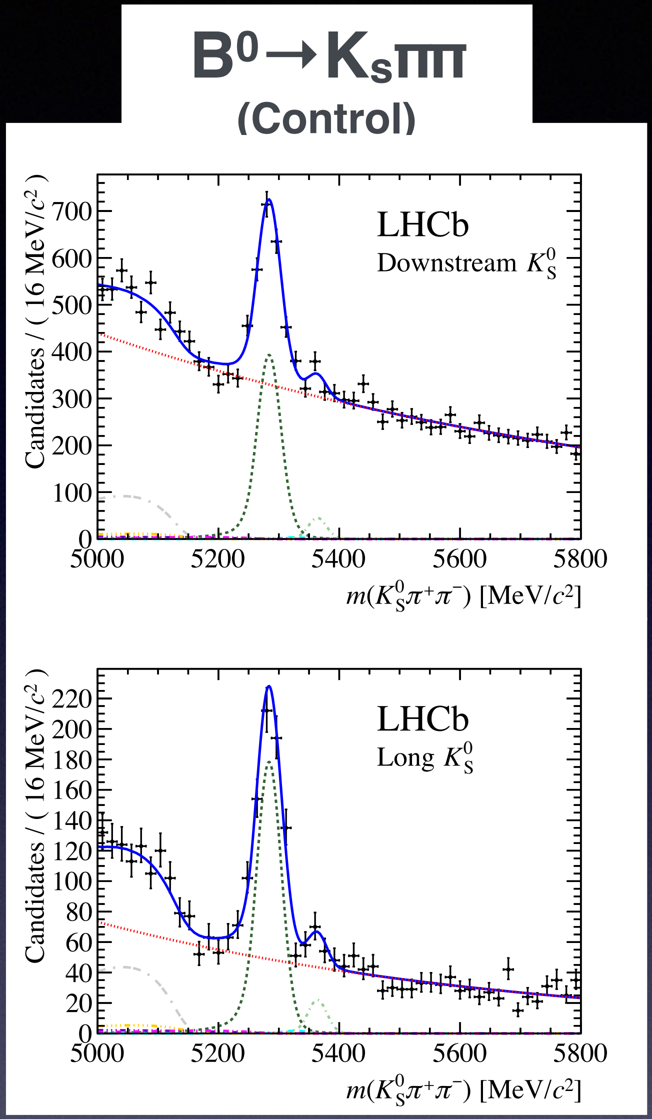
LHCb-PAPER-2013-061

errors : ±stat.±syst.±f_Λ/f_d±$\mathcal{B}(B^0 \to K^0\pi^+\pi^-)$

$\Lambda_b \to D_s(K_sK)p$ Results



Signal below 2σ significance



$$\mathcal{B}(\Lambda_b^0 \to D_s^-(\to K^0K^-)p) = (2.0 \pm 1.1 \pm 0.2 \pm 0.5 \pm 0.1) \times 10^{-6}\,, \\ < 3.5\ (3.9) \times 10^{-6} \ \text{at} \ \ 90\,\%\ (95\,\%)\ \text{CL}\,,$$

Using PDG for $\mathcal{B}(D^-_s \to K^0K^-)$:-

$$\mathcal{B}(\Lambda_b^0 \to D_s^- p) = (2.7 \pm 1.4 \pm 0.2 \pm 0.7 \pm 0.1 \pm 0.1) \times 10^{-4} \\ < 4.8\ (5.3) \times 10^{-4} \ \text{at} \ \ 90\,\%\ (95\,\%)\ \text{CL}\,,$$

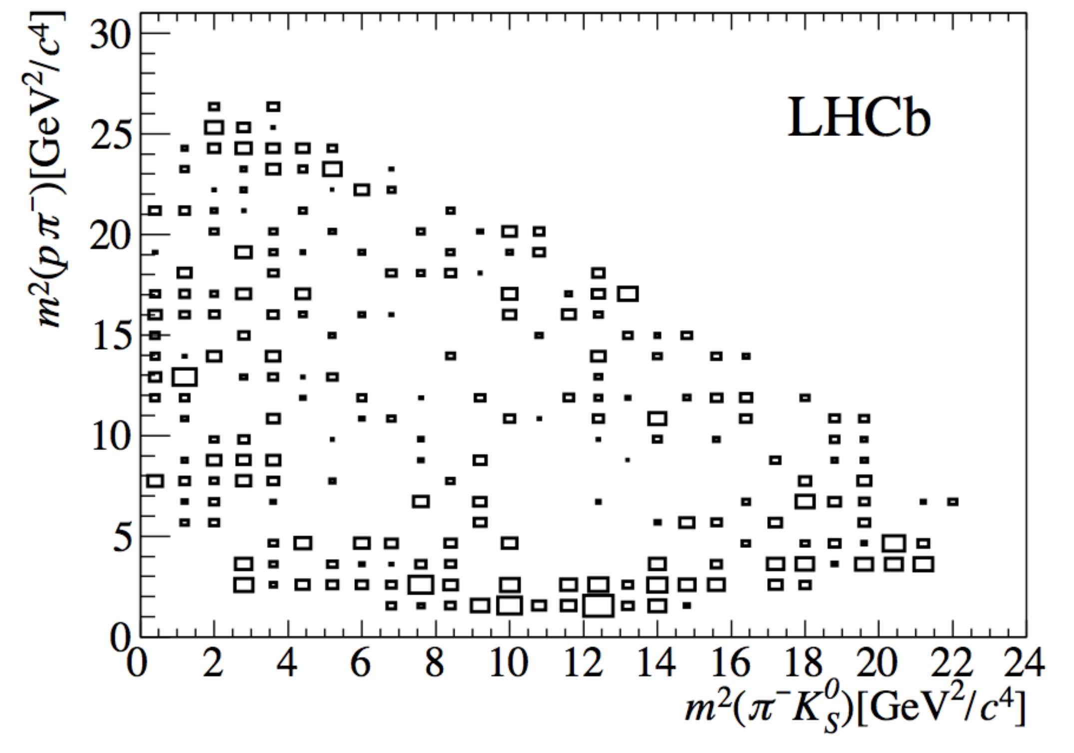
First Measurements

errors : ±stat.±syst.±f_Λ/f_d±$\mathcal{B}(B^0 \to K^0\pi^+\pi^-)$±$\mathcal{B}(D^-_s \to K^0K^-)$

LHCb-PAPER-2013-061

$\mathcal{A}_{\mathrm{CP}}(\Lambda^0_b \to K_s p\pi)$

Background subtracted, efficiency corrected $\Lambda^0_b \to K_s p\pi$ Dalitz Plot



- Significant signal observed for $\Lambda_b \to K_s p\pi$
  - Phase space integrated CP asymmetry measurement (assuming no structure). Likelihood fit extended to include raw $\mathcal{A}_{\mathrm{CP}}$.
- Detection ($\mathcal{A}_{\mathrm{D}}$) and Production ($\mathcal{A}_{\mathrm{P}}$) asymmetries from topologically identical $\Lambda_b \to \Lambda_c(K_s p)h$ decays (negligible CP asymmetry expected).
  - Systematics dominated by $\mathcal{A}_{\mathrm{P}}+\mathcal{A}_{\mathrm{D}}$ uncertainty from $\Lambda_b \to \Lambda_c(K_s p)h$ fit.

$$\mathcal{A}_{CP}^{\mathrm{RAW}} = \frac{N_{\bar{f}} - N_f}{N_{\bar{f}} + N_f},$$

$$\mathcal{A}_{CP} = \mathcal{A}_{CP}^{\mathrm{RAW}} - \mathcal{A}_{\mathrm{P}} - \mathcal{A}_{\mathrm{D}}$$

$$\mathcal{A}_{CP}^{\mathrm{RAW}}(\Lambda_b^0 \to \Lambda_c^+(K^0_S p)\pi^-) = -0.047 \pm 0.027$$

$$\mathcal{A}_{CP}^{\mathrm{RAW}}(\Lambda_b^0 \to K^0_S p\pi^-) = 0.17 \pm 0.13$$

$$\mathcal{A}^{CP}(\Lambda_b^0 \to K^0_{\mathrm{S}} p\pi^-) = 0.22 \pm 0.13\ (\mathrm{stat}) \pm 0.03\ (\mathrm{syst})$$

consistent with zero

expect improvement with full 3fb^{-1} analysis

LHCb-PAPER-2013-061

$b \rightarrow c\bar{c}'$

LHCb-PAPER-2014-002

$b \to cc'$ Decays

- Interesting avenue for studies of new physics beyond the Standard Model
  - sin(2β) from $B^0 \to D^+ D^-$ Complementary to e.g. $B^0 \to (c\bar{c})K^0_s$
  - ϕ_s from $B^0_s \to D^+_s D^-_s$
  - Weak phase γ (assuming U-spin symmetry)

- b decays to charm baryon pairs expected but currently unobserved.
  - Potential backgrounds in many analyses probing CKM parameters.

- Precise measurements of b baryon masses provide tests of QCD mass spectrum models.

- Present here :- LHCb-PAPER-2014-002 (Update to LHCb-CONF-2012-009)
  - *First Observation* of $\Lambda^0_b \to \Lambda^+_c D^-_{(s)}$
  - Most precise measurement of $\mathcal{B}(B^0_{(s)} \to D^+ D^-_s)$
  - Search for the decays $B^0_s \to \Lambda^+_c \Lambda^-_c$

$B\rightarrow cc'$ Analysis

- Multi-variate selection of $D/\Lambda_c \rightarrow (hh,hhh)$ (h=p,K,π) trained on b→cπ events *from data.*
- K/π cross feed suppressed, with PID, kinematic isolation and $|m_{KK}-m_{\phi}|$ cuts.
- Efficiencies determined from *independent* b→cπ data sample.

- Systematics :
  - Largely cancel for same final states. (f_s/f_d and b lifetime differences)
  - For different final states, selection efficiencies, fit model, f_s/f_d, D branching ratios considered.

$$\begin{aligned}
\frac{\mathcal{B}(B_s\to D_sD)}{\mathcal{B}(B_d\to D_sD)} &= \frac{f_d}{f_s}\cdot\frac{N(B_s\to D_sD)}{N(B_d\to D_sD)}, && (2)\\
\frac{\mathcal{B}(\Lambda_b\to D\Lambda_c)}{\mathcal{B}(\Lambda_b\to D_s\Lambda_c)} &= \frac{\mathcal{B}(D_s\to KK\pi)}{\mathcal{B}(D\to K\pi\pi)}\cdot\frac{N(\Lambda_b\to D\Lambda_c)}{N(\Lambda_b\to D_s\Lambda_c)}\cdot\frac{\epsilon(\Lambda_b\to\Lambda_cD_s)}{\epsilon(\Lambda_b\to\Lambda_cD)}, && (3)\\
\frac{\mathcal{B}(B_d\to\Lambda_c\bar{\Lambda}_c)}{\mathcal{B}(B_d\to D_sD)} &= \frac{\mathcal{B}(D\to K\pi\pi)\mathcal{B}(D_s\to KK\pi)}{(\mathcal{B}(\Lambda_c\to pK\pi))^2}\cdot\frac{N(B_d\to\Lambda_c\bar{\Lambda}_c)}{N(B_d\to D_sD)}\cdot\frac{\epsilon(B_d\to D_sD)}{\epsilon(B_d\to\Lambda_c\bar{\Lambda}_c)}, && (4)\\
\frac{\mathcal{B}(B_s\to\Lambda_c\bar{\Lambda}_c)}{\mathcal{B}(B_s\to D_sD)} &= \kappa\cdot\frac{\mathcal{B}(D\to K\pi\pi)\mathcal{B}(D_s\to KK\pi)}{(\mathcal{B}(\Lambda_c\to pK\pi))^2}\cdot\frac{N(B_s\to\Lambda_c\bar{\Lambda}_c)}{N(B_s\to D_sD)}\cdot\frac{\epsilon(B_s\to D_sD)}{\epsilon(B_s\to\Lambda_c\bar{\Lambda}_c)} && (5)
\end{aligned}$$

$$\begin{aligned}
\left[\frac{\mathcal{B}(\Lambda_b\to D_s\Lambda_c)}{\mathcal{B}(B_d\to D_sD)}\right]\Big/\left[\frac{\mathcal{B}(\Lambda_b\to\Lambda_c\pi)}{\mathcal{B}(B_d\to D\pi)}\right] = {}&\left[\frac{N(\Lambda_b\to\Lambda_cD)}{N(B_d\to D_sD)}\cdot\frac{\epsilon(B_d\to D_sD)}{\epsilon(\Lambda_b\to\Lambda_cD)}\right]\\
&\Big/\left[\frac{N(\Lambda_b\to\Lambda_c\pi)}{N(B_d\to D\pi)}\cdot\frac{\epsilon(B_d\to D\pi)}{\epsilon(\Lambda_b\to\Lambda_c\pi)}\right].
\end{aligned}$$

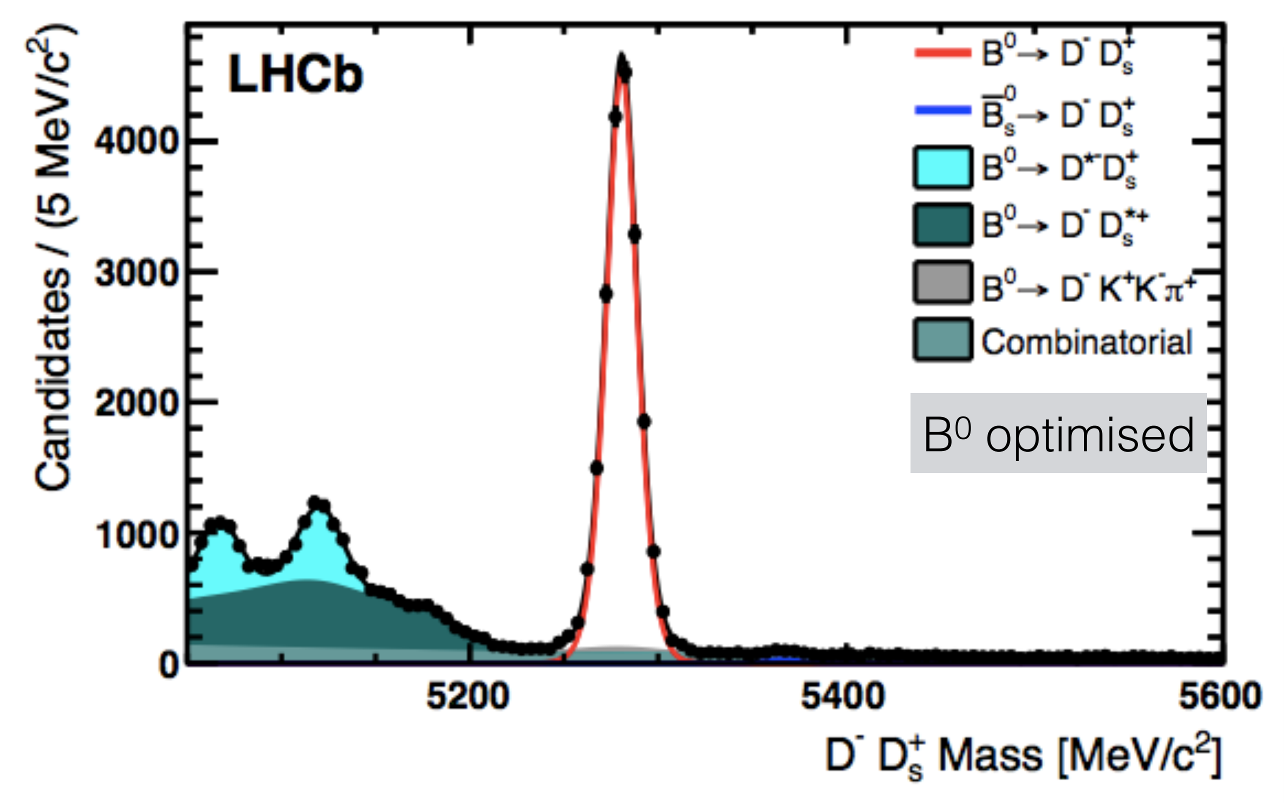
$$f_s/f_d = 0.259 \pm 0.015$$

LHCb-CONF-2013-011

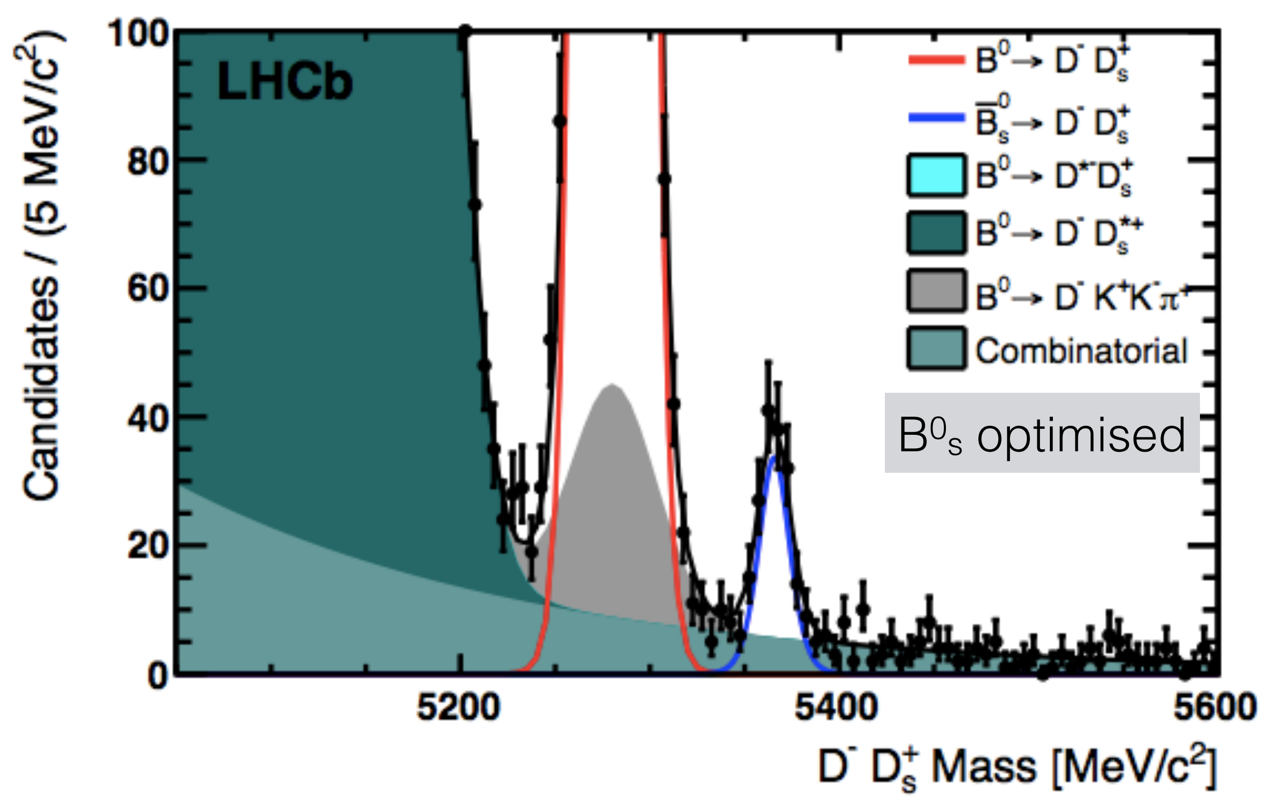
κ=1.058 - Correction factor for observed shorter B_s lifetime to CP even eigenstates

Relative efficiencies $R_{B^0/B^0_s}, R_{B^-/B^0_s}$ extracted from MC

$B^0_{(s)} \to D^+ D^-_s$



B^0 optimised



B^0_s optimised

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

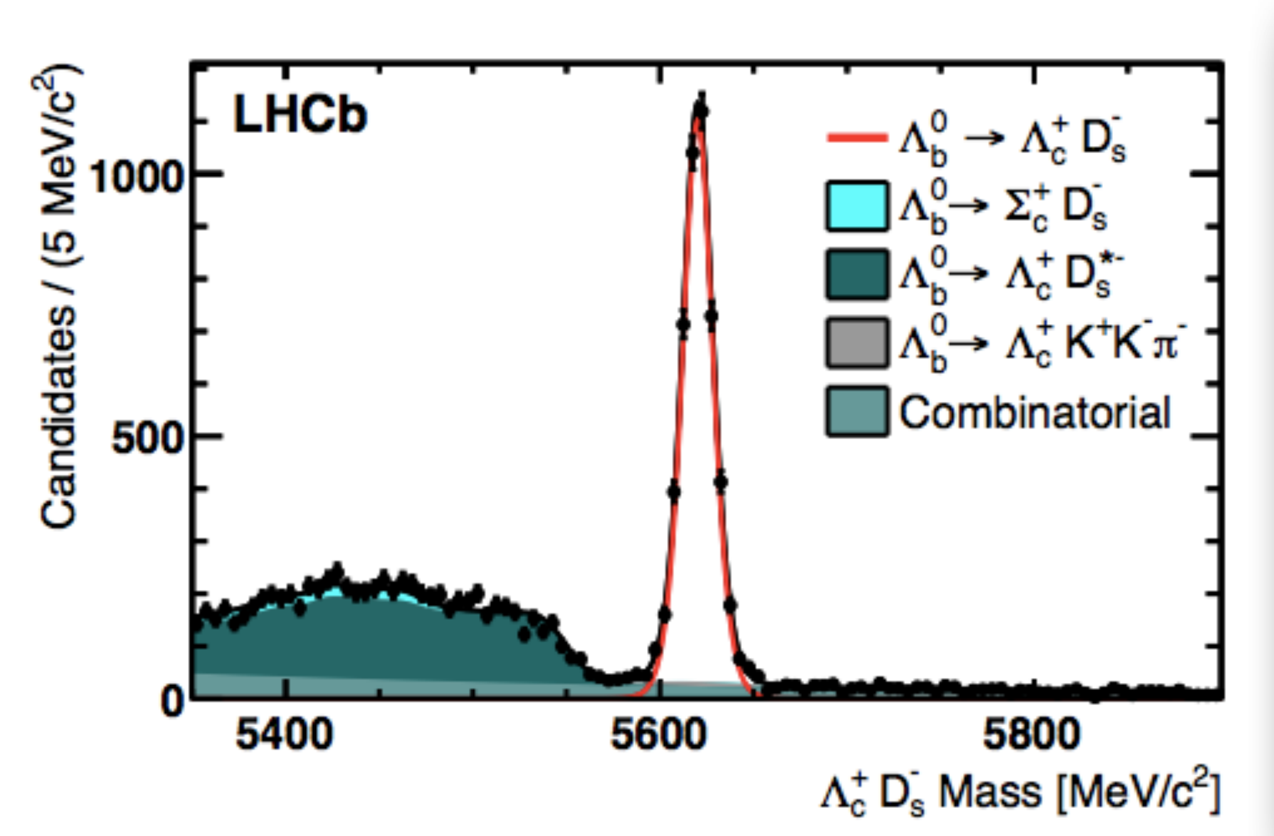
- Systematic error dominated by knowledge of b production fractions
- Using :- PDG $\mathcal{B}(B^0 \to D^+ D^-_s) = (7.2 \pm 0.8) \times 10^{-3}$

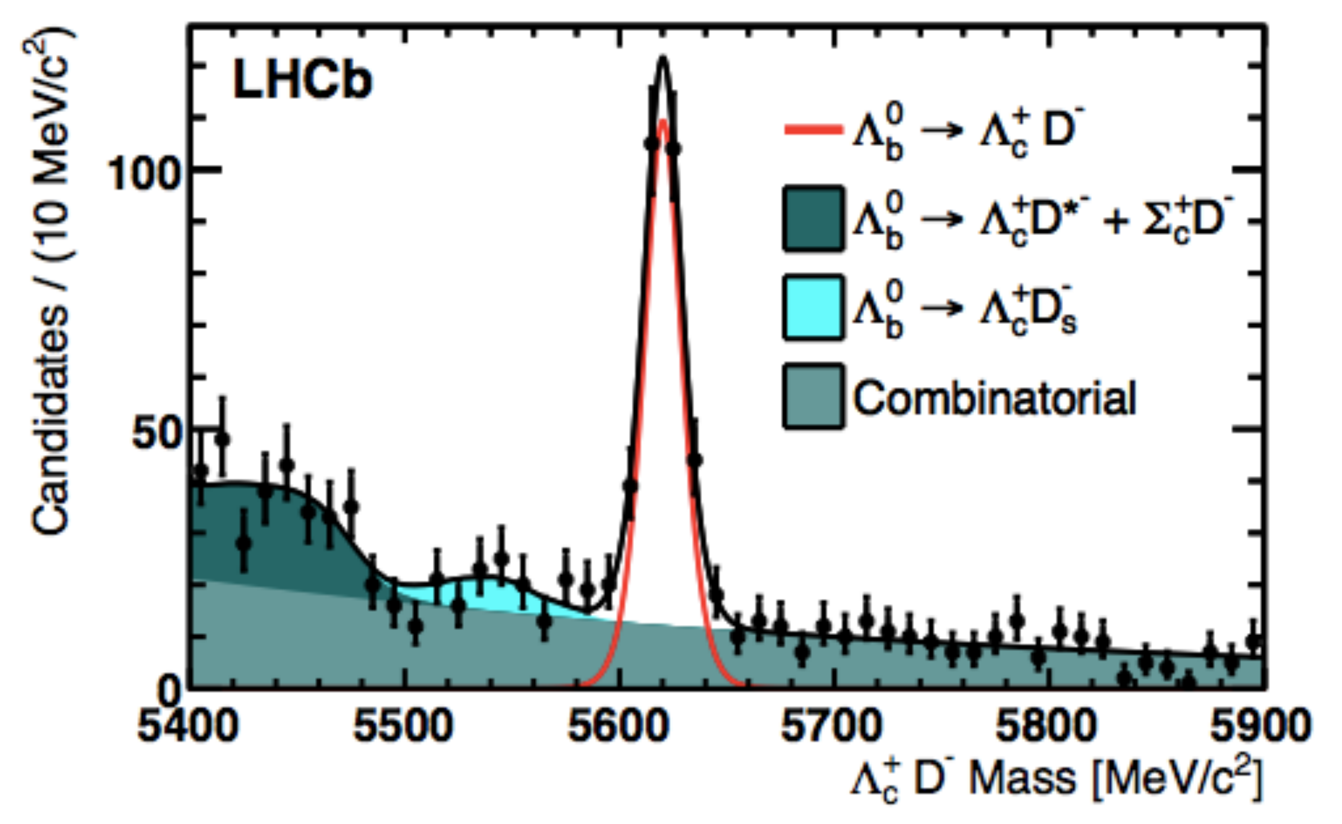
$$\mathcal{B}(B^0_s \to D^+ D^-_s) = (2.7 \pm 0.5) \times 10^{-4},$$

Most precise measurement to date of $\mathcal{B}(B^0_s \to D^+ D^-_s)$

LHCb-PAPER-2014-002

$\Lambda^0_b \to \Lambda^+_c D^-_{(s)}$ - First Observations





$$\frac{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ D^-)}{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ D_s^-)} = 0.042 \underset{\text{(stat.)}}{\pm 0.003} \underset{\text{(syst.)}}{\pm 0.003},$$

Consistent with $|V_{cd}/V_{cs}|^2$ expectation.

Using LHCb-PAPER-2014-004
for $\mathcal{B}(\Lambda_b \to \Lambda_c \pi)/\mathcal{B}(B^0 \to D\pi)$:-

$$\begin{aligned} \mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ D_s^-) &= (1.0 \pm 0.1) \times 10^{-2}, \\ \mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ D^-) &= (4.3 \pm 0.5) \times 10^{-4}, \end{aligned}$$

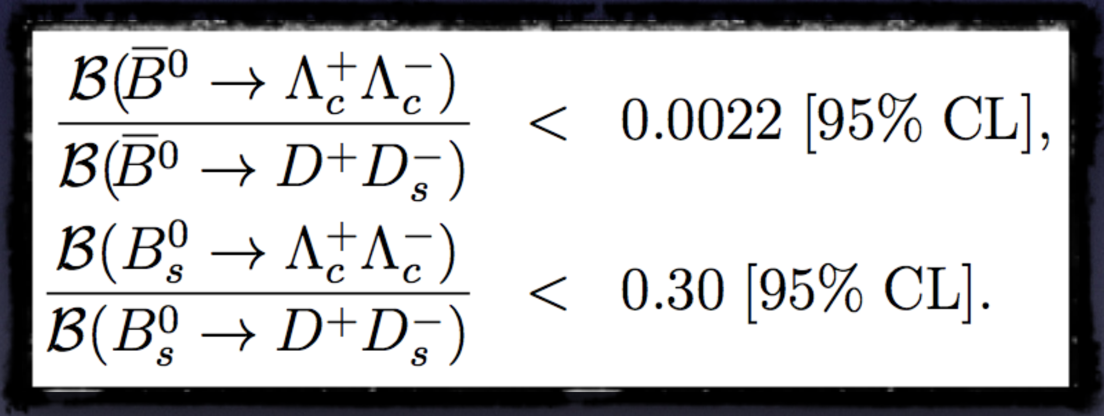
LHCb Preliminary

LHCb-PAPER-2014-002

Search for $B_{(s)} \rightarrow \Lambda_c^+ \Lambda_c^-$

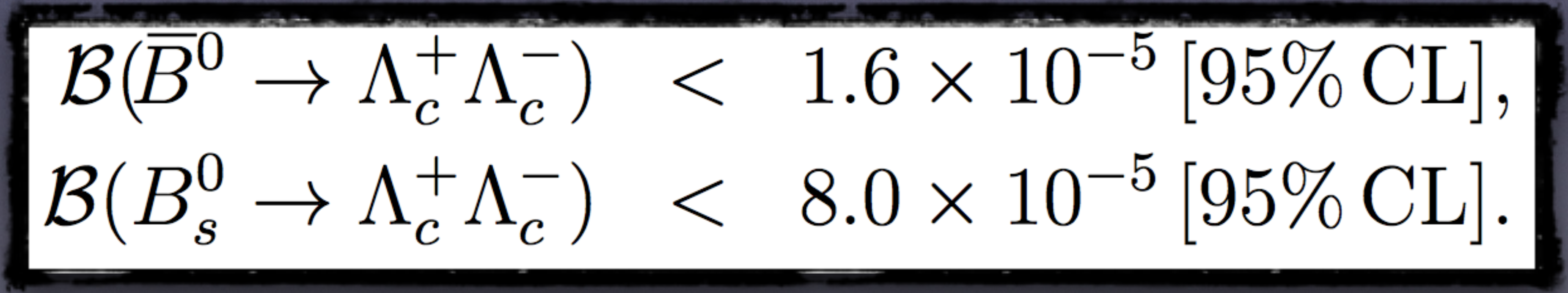
- 2σ search windows centred around nominal $B_{(s)}$ masses.
- Background expectations from D sidebands.
- No significant excesses observed.
- ***World best limits*** set using known D_s^- [1], D^- [2] and Λ_c^+ [3] branching fractions.

1. PDG(2012)
2. arXiv:1312.1312
3. arXiv:1321.7826



$$\frac{\mathcal{B}(\overline{B}^0 \rightarrow \Lambda_c^+ \Lambda_c^-)}{\mathcal{B}(\overline{B}^0 \rightarrow D^+ D_s^-)} < 0.0022 \text{ [95\% CL]},$$

$$\frac{\mathcal{B}(B_s^0 \rightarrow \Lambda_c^+ \Lambda_c^-)}{\mathcal{B}(B_s^0 \rightarrow D^+ D_s^-)} < 0.30 \text{ [95\% CL]}.$$



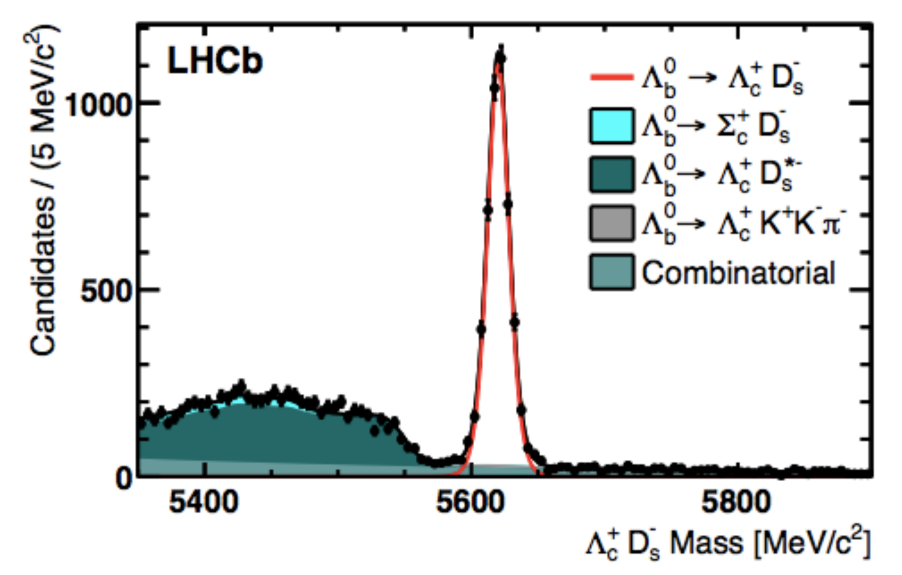
$$\mathcal{B}(\overline{B}^0 \rightarrow \Lambda_c^+ \Lambda_c^-) < 1.6 \times 10^{-5} \text{ [95\% CL]},$$

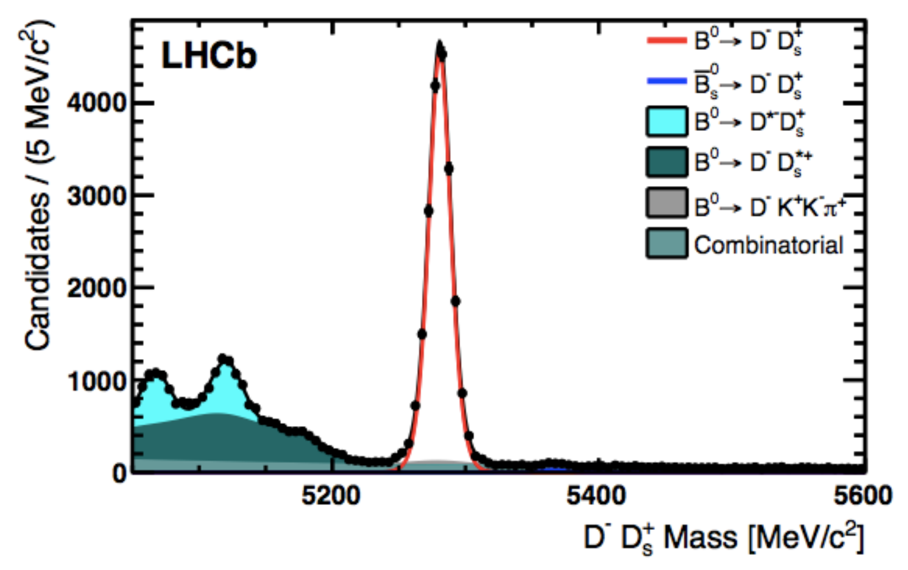
$$\mathcal{B}(B_s^0 \rightarrow \Lambda_c^+ \Lambda_c^-) < 8.0 \times 10^{-5} \text{ [95\% CL]}.$$

Λ^0_b Mass

- $\Lambda^0_b \to \Lambda^+_c D^-_s$ and $B^0 \to D^+ D^-_s$ kinematically very similar; Allows precise mass difference measurement.
    - Minimises uncertainty from LHCb mass scale precision.
- Track momentum scale error 0.03%
- Dominant systematic error from charm hadron masses,

$M(\Lambda^+_c)$	PDG
$M(D^-_{(s)})$	PDG + LHCb-PAPER-2013-011





$$M(\Lambda_b^0) - M(\bar{B}^0) = 339.72 \pm 0.24\,(\text{stat}) \pm 0.18\,(\text{syst})\ \text{MeV}/c^2$$

Use PDG for $M(B^0)$ gives most precise result to date :-

$$M(\Lambda_b^0) = 5619.3 \pm 0.3\ \text{MeV}/c^2$$

LHCb-PAPER-2014-002

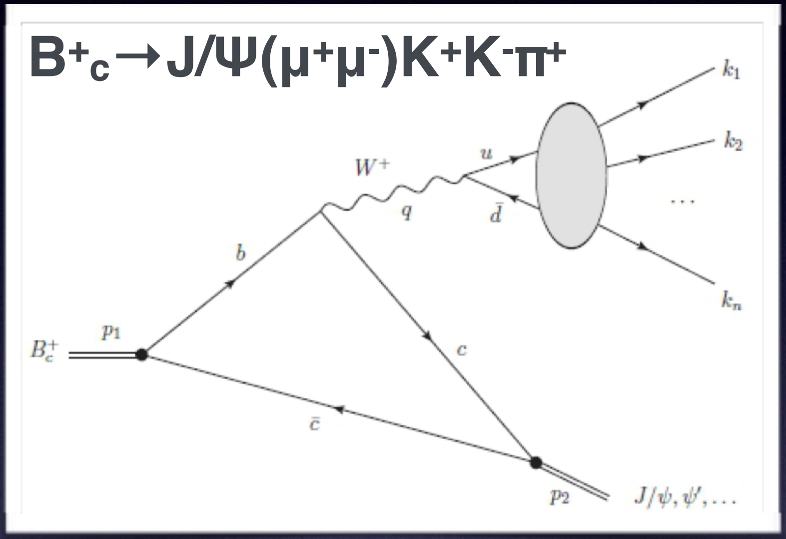
B^+_c Decays

LHCb-PAPER-2013-044
LHCb-PAPER-2013-047

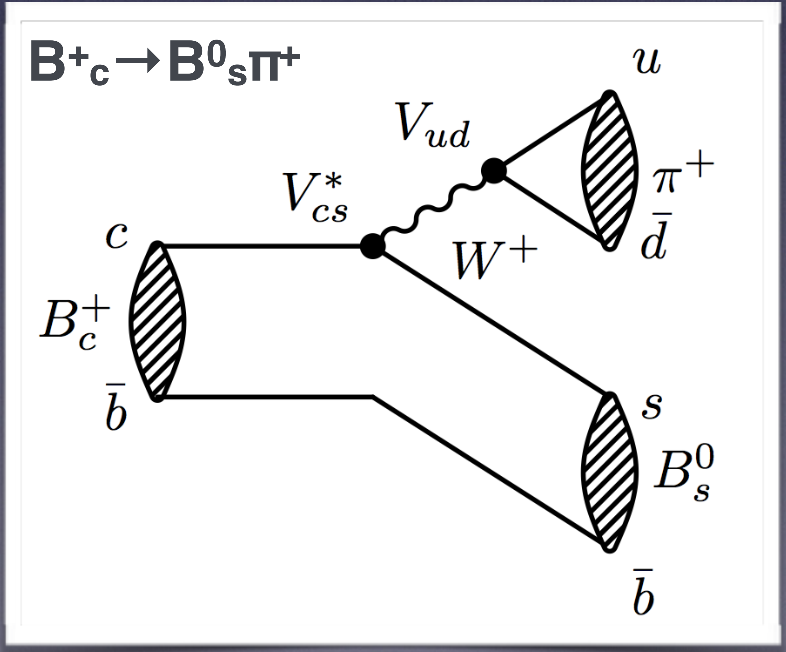
B^+_c Decays

- B^+_c composed of two heavy quarks, unique in Standard Model.
- Although discovered in 1998 (CDF), few decay channels have been observed.

- Measurements presented here :-
- **$B^+_c \rightarrow J/\Psi(\mu^+\mu^-)K^+K^-\pi^+$**
  - Branching fractions give insights into $B^+_c \rightarrow J/\Psi W^+$ form factors and virtual W^+ hadronisation.

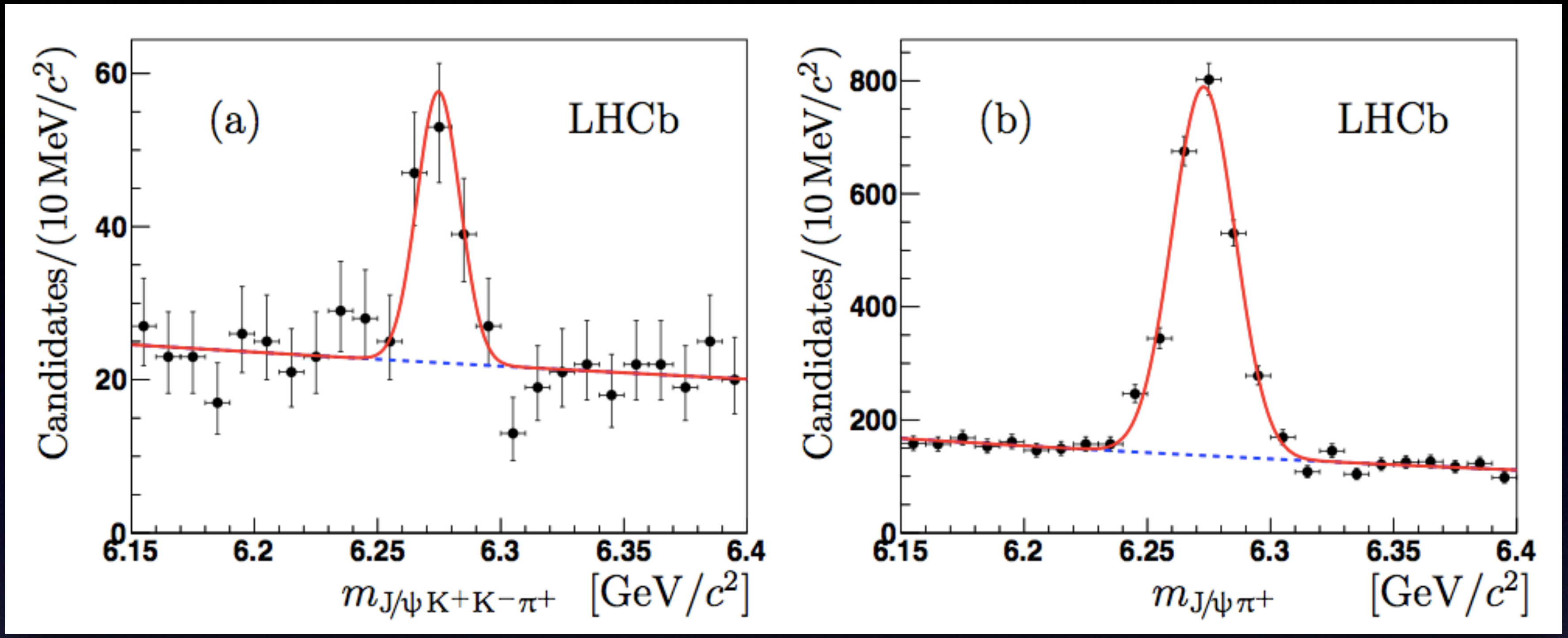


- **$B^+_c \rightarrow B^0_s\pi^+$** { with $B^0_s \rightarrow D^-_s(K^+K^-\pi^-)\pi^+$, $J/\Psi(\mu^+\mu^-)\phi(K^+K^-)$ }
  - First observation of B^+_c decay to a b hadron.
  - Wide range of predictions for $\mathcal{B}(B^+_c \rightarrow B^0_s\pi^+)$ 2.5%-16.4%
    - Higher order HQET corrections large (m_c/m_b c.f. Λ_{QCD}/m_b)



$B^+_c \rightarrow J/\Psi(\mu^+\mu^-)K^+K^-\pi^+$

- Common kinematic and π PID selection for signal and normalisation channel $B^+_c \rightarrow J/\Psi\pi^+$.
- Additional signal K PID criteria.
- Many systematics cancel in $\mathcal{B}$ ratio
- Selection efficiencies from Monte Carlo simulations.



$$\frac{\mathcal{B}\left(B_c^+ \rightarrow J/\psi K^+K^-\pi^+\right)}{\mathcal{B}\left(B_c^+ \rightarrow J/\psi\pi^+\right)} = \frac{N\left(B_c^+ \rightarrow J/\psi K^+K^-\pi^+\right)}{N\left(B_c^+ \rightarrow J/\psi\pi^+\right)} \times \frac{\varepsilon(B_c^+ \rightarrow J/\psi\pi^+)}{\varepsilon(B_c^+ \rightarrow J/\psi K^+K^-\pi^+)}$$

$$\boxed{\frac{\mathcal{B}\left(B_c^+ \rightarrow J/\psi K^+K^-\pi^+\right)}{\mathcal{B}\left(B_c^+ \rightarrow J/\psi\pi^+\right)} = 0.53 \pm 0.10 \pm 0.05,}$$

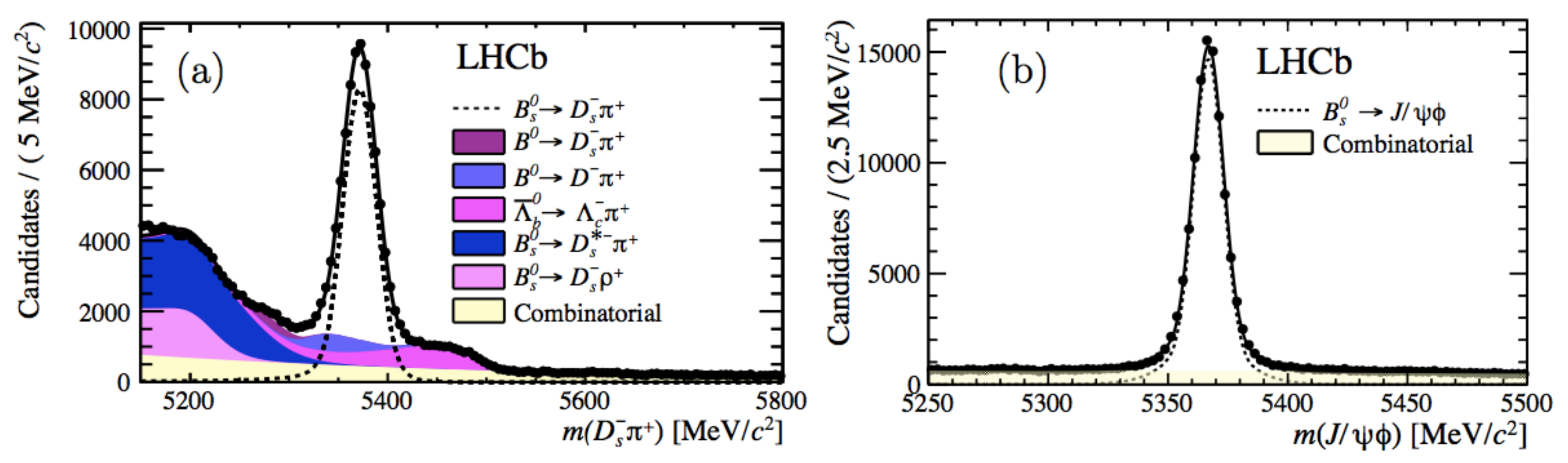
- ***First Observation***
- **Largest contribution from $B^+_c \rightarrow J/\Psi K^+K^{*0}$**
- **In agreement with form factor predictions**
  arXiv:1307.0953

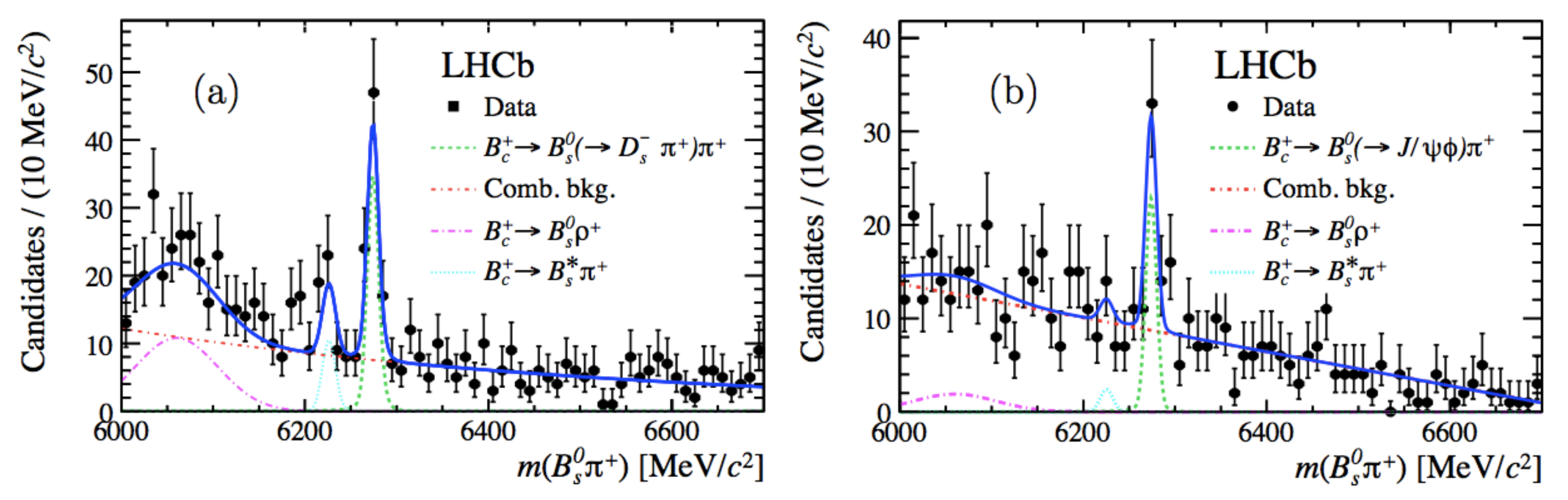
LHCb-PAPER-2013-047

LHCb-PAPER-2013-044

$B^+_c \rightarrow B^0_s \pi^+$

- MVA Selections for both B_s and B_c candidates.
    - Signal (MC)
    - Background (Sidebands)
- RICH PID for K/π
- Selection efficiencies from Monte Carlo simulations.
- Largest systematic from B^+_c lifetime.





$$\frac{\sigma(B^+_c)}{\sigma(B^0_s)} \times \mathcal{B}(B^+_c \to B^0_s \pi^+) = \left(2.37 \pm 0.31\,(\text{stat}) \pm 0.11\,(\text{syst})\,^{+0.17}_{-0.13}\,(\tau_{B^+_c})\right) \times 10^{-3}$$

- ***First observed weak B→B decay***
- O(1 in 500) observed B^0_s decays originate from B^+_c
- Precise extraction of $\mathcal{B}(B^+_c \to B^0_s \pi^+)$ requires additional input, but largest exclusive weak $\mathcal{B}$(B) observed.

Summary

- **LHCb performed flawlessly in LHC Run1, collecting 3fb^{-1}.**

- **Selected Decays high-lightling some recent recents**
  - ***b→cc'*** LHCb-PAPER-2014-002
    - ***First Observation*** of $\Lambda^0_b \to \Lambda^+_c D^-_{(s)}$
    - ***Current World best*** measurement of $\mathcal{B}(B^0_{(s)} \to D^+ D^-_s)$
    - Search for the decays $B^0_s \to \Lambda^+_c \Lambda^-_c$
  - **Λ_b Ξ_b** LHCb-PAPER-2013-61
    - ***First measurement*** of $\mathcal{B}(\Lambda^0_b \to K_s p\pi)$
    - ***First measurement*** of $A_{CP}(\Lambda^0_b \to K_s p\pi)$
  - **B^+_c** LHCb-PAPER-2013-044, LHCb-PAPER-2013-047
    - ***First observation*** of B^+_c decay to a b hadron.

… and plenty more to come in Run2