Charmless two-dody B hadron decays at LHCb with 2010 data

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On behalf of the LHCb Collaboration

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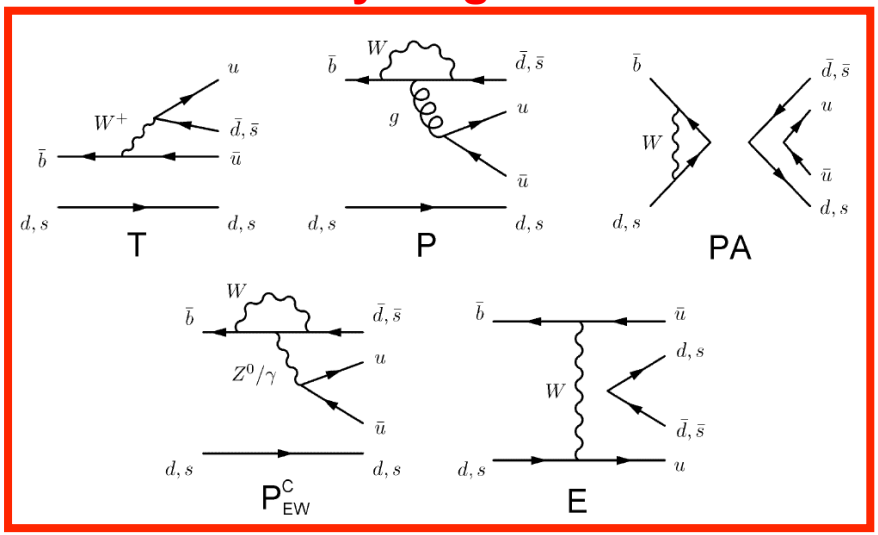
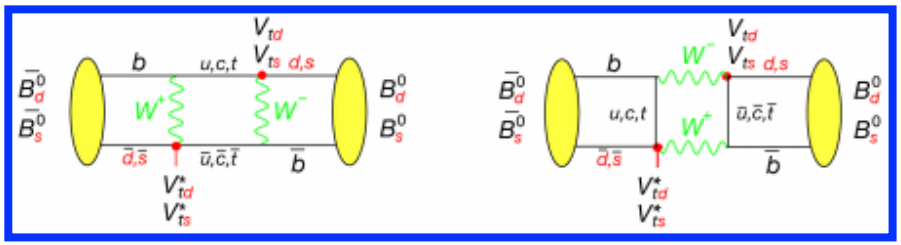
$B \to h^+ h'^-$ decay family

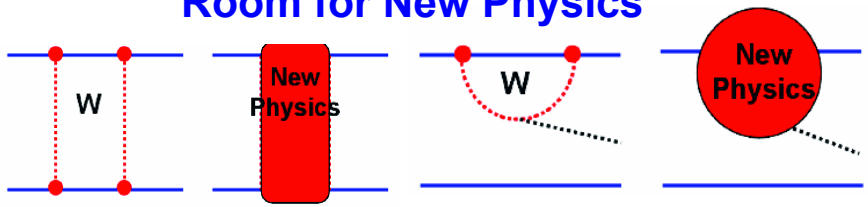
Decay diagrams



Mixing diagrams



Room for New Physics



- Many decay modes
  - $B^0 \to K\pi$, $B_s \to \pi K$, $B^0 \to \pi\pi$, $B_s \to KK$, $\Lambda_b \to pK$, $\Lambda_b \to p\pi$, $B^0 \to KK$, $B_s \to \pi\pi$
  - both **direct** and **time-dependent CP asymmetries** can be measured

- In this talk we present the preliminary measurement of **direct CP violation** in **$B^0 \to K\pi$** and **$B_s \to \pi K$ decays** using data collected by LHCb during 2010 $\int \mathcal{L}dt \approx 37\ \text{pb}^{-1}$

Calibration of PID

- Crucial aspect of this analysis
  - **PID** used to **disentangle the different final states**
  - **relative PID efficiencies** needed in order to determine the **yields of cross-feed backgrounds**

- Separation of **π**, **K** and **p** is obtained by means of the two LHCb **RICH** sub-detectors

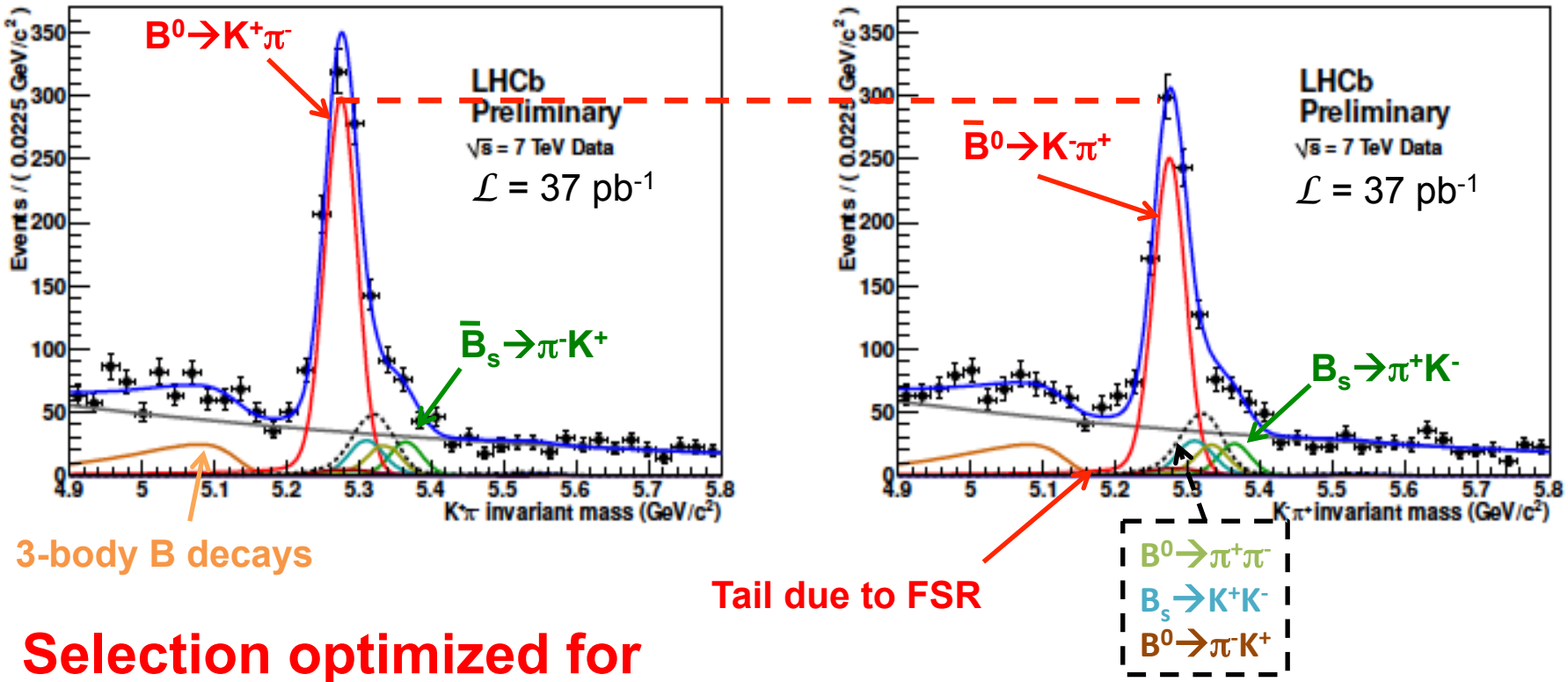
- PID calibration for π, K and p can be achieved by using **$D^* \rightarrow D^0(K\pi)\pi$** and **$\Lambda \rightarrow p\pi$** decays
  - **different phase space** with respect to **B→hh'**

- Performance of RICH PID depends on **phase space**
  - Need event reweighting to account for differences between kinematics of calibration and B→hh' samples

Raw CP asymmetries

$$A_{CP} = (N_{\bar{B}\to\bar{f}} - N_{B\to f})/(N_{\bar{B}\to\bar{f}} + N_{B\to f})$$

Raw $A_{CP}(B^0\to K\pi)$ = -0.086 ± 0.033



Selection optimized for $A_{CP}(B^0\to K\pi)$

$B^0\to K\pi$ yield

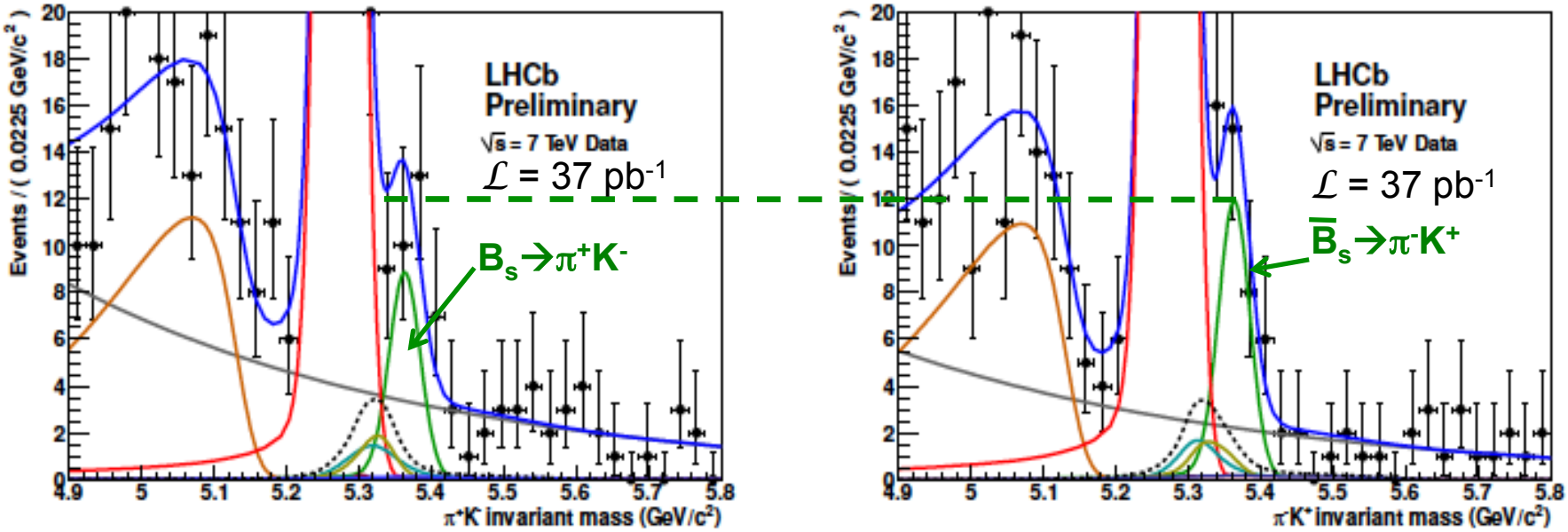
1447 ± 50 events

Cross-feed background mass shapes fixed from MC using a kernel estimation technique

Raw CP asymmetries

$$A_{CP} = (N_{\bar{B}\to\bar{f}} - N_{B\to f})/(N_{\bar{B}\to\bar{f}} + N_{B\to f})$$

Raw $A_{CP}(B_s \to \pi K) = 0.15 \pm 0.19$



Selection optimized for $A_{CP}(B_s \to \pi K)$

$B_s \to \pi K$ yield
52 ± 10 events

Corrections to the raw CP-asymmetry

Raw asymmetry measured in data

Instrumental charge asymmetry

$$A_{CP} = A_{CP}^{RAW} - A_D(K\pi) - \kappa A_P$$

Neutral B-meson production asymmetry

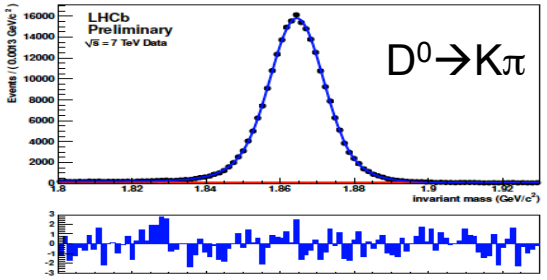
- **$A_D(K\pi)$ = -0.004 ± 0.004 (stat.)**
  - $K^+\pi^-$ and π^+K^- pairs have different strong interaction cross-sections with the detector material
  - Possible left-right detector asymmetries → comparison of data acquired with different magnet polarities
  - Instrumental asymmetry studied using $D^* \to D^0(K\pi)\pi$, $D^* \to D^0(KK)\pi$, $D^* \to D^0(\pi\pi)\pi$ and untagged $D^0 \to K\pi$ decays

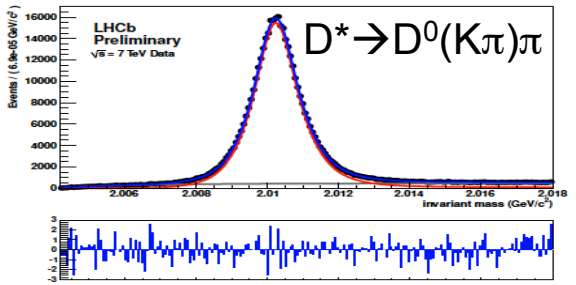
$$A_{CP}^{RAW}(K\pi)^* = A_{CP}(K\pi) + A_D(\pi_s) + A_D(K\pi) + A_P(D^*)$$

$$A_{CP}^{RAW}(KK)^* = A_{CP}(KK) + A_D(\pi_s) + A_P(D^*)$$

$$A_{CP}^{RAW}(\pi\pi)^* = A_{CP}(\pi\pi) + A_D(\pi_s) + A_P(D^*)$$

$$A_{CP}^{RAW}(K\pi) = A_{CP}(K\pi) + A_D(K\pi) + A_P(D^0)$$





Corrections to the raw CP-asymmetry

Raw asymmetry measured in data

Instrumental charge asymmetry

$$A_{CP} = A_{CP}^{RAW} - A_D(K\pi) - \kappa A_P$$

Neutral B-meson production asymmetry

- **A_P = -0.024 ± 0.013 (stat.) ± 0.010 (syst.)**
  - Constrained using $B^{\pm} \rightarrow J/\psi K^{\pm}$ decays
  - κ factor depends on the selection and on the time-evolution of the B-meson
  - From fragmentation models $A_P(B^+)$ and $A_P(B^0)$ differ by 1% at most → syst. error

$$\kappa = \frac{\int \left(e^{-\Gamma t'} \cos \Delta m t'\right) \varepsilon(t) dt}{\int \left(e^{-\Gamma t'} \cosh \frac{\Delta\Gamma}{2} t'\right) \varepsilon(t) dt}$$

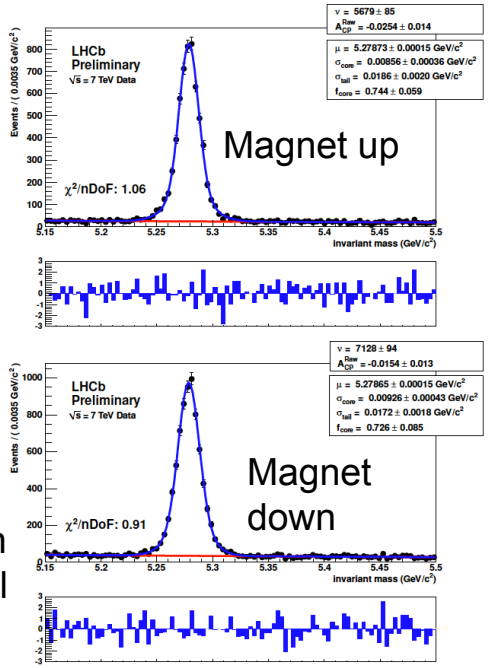
Acceptance as proper-time function introduced by selection cuts

Using:

- $\varepsilon(t)$ from MC
- Γ_d, Γ_s, Δm_d, Δm_s, $\Delta\Gamma_s$ from PDG
- $\Delta\Gamma_d$=0

Channel	κ
$B^0 \rightarrow K^+\pi^-$	0.33
$B_s^0 \rightarrow \pi^+K^-$	0.015

Fast oscillation of B_s dilutes production asymmetries effect to a negligible level



Summary of systematics

- Identified three main categories of systematic errors affecting $A_{CP}(B^0 \to K^+\pi^-)$ and for $A_{CP}(B_s \to \pi^+K^-)$
  - **PID calibration**
  - **modelling of signal and background**
  - **instrumental and production asymmetries**

Systematic uncertainty	$A_{CP}(B^0 \to K^+\pi^-)$	$A_{CP}(B_s^0 \to \pi^+K^-)$
PID calibration	0.0021	0.001
Final state radiation	0.0034	0.011
Signal model	0.0019	0.009
Combinatorial background model	negligible	0.013
Cross-feed background model (shift)	0.0009	0.005
Cross-feed background model (smearing)	0.0006	0.006
Instrumental asymmetry	0.0042	0.004
Production asymmetry	0.0054	negligible
Total	0.0082	0.021

Results and outlook

- Using data collected during 2010 we provide preliminary values of the direct CP asymmetries $A_{CP}(B^0 \to K\pi)$ and $A_{CP}(B_s \to \pi K)$

LHCb preliminary

$$A_{CP}(B^0 \to K^+\pi^-) = -0.074 \pm 0.033 \pm 0.008$$
$$A_{CP}(B_s^0 \to \pi^+ K^-) = 0.15 \pm 0.19 \pm 0.02$$

HFAG averages

$$A_{CP}(B^0 \to K^+\pi^-) = -0.098^{+0.012}_{-0.011}$$
$$A_{CP}(B_s^0 \to \pi^+ K^-) = 0.39 \pm 0.17$$

Measurements already competitive with only 37 pb^{-1} of integrated luminosity

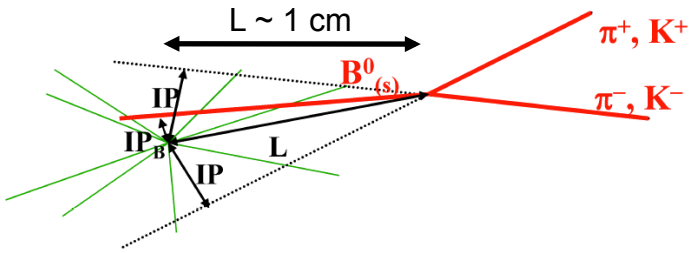
LHCb is expected to significantly contribute to the world average by 2011

- Other measurements to come in 2011
  - **relative branching fractions of all decay modes**
  - **direct CP asymmetries in $\Lambda_b \to pK$ and $\Lambda_b \to p\pi$ decays**
  - **time-dependent CP asymmetries** of $B^0 \to \pi^+\pi^-$ and $B_s \to K^+K^-$

Backup

Event selection

- Two sets of optimal selection cuts have been identified in order to obtain the best sensitivity either on the direct CP asymmetry $A_{CP}(B^0 \to K\pi)$ or on $A_{CP}(B_s \to \pi K)$



Optimized selection for $A_{CP}(B^0 \to K\pi)$

Cut type	Accepted regions
Track p_T [GeV/c]	> 1.1
Track IP [μm]	> 150
Track χ^2/d.o.f.	< 3
$\max(p_T^{h^+}, p_T^{h'^-})$ [GeV/c]	> 2.8
$\max(IP^h, IP^{h'^-})$ [μm]	> 300
p_T^B [GeV/c]	> 2.2
$\tau_{\pi\pi}^B$ [ps]	> 0.9

Optimized selection for $A_{CP}(B_s \to \pi K)$

Cut type	Accepted regions
Track p_T [GeV/c]	> 1.2
Track IP [μm]	> 200
Track χ^2/d.o.f.	< 3
$\max(p_T^{h^+}, p_T^{h'^-})$ [GeV/c]	> 3
$\max(IP^h, IP^{h'^-})$ [μm]	> 400
p_T^B [GeV/c]	> 2.4
$\tau_{\pi\pi}^B$ [ps]	> 1.2

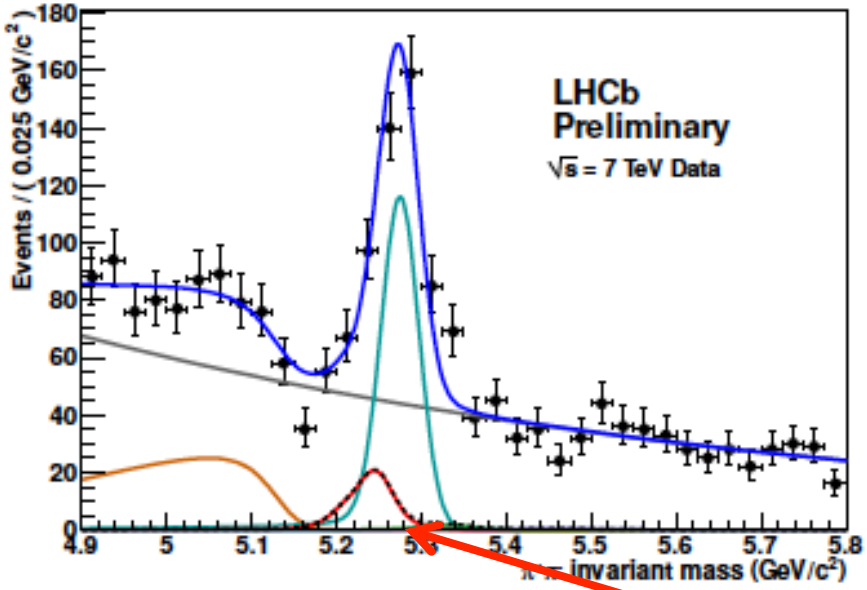
- The excellent PID capabilities of the two LHCb RICH sub-detectors have been exploited to separate the sample into different final states
- PID observables: $\Delta\log\mathcal{L}_{hh'}$ is the difference between logarithms of the likelihoods of the h and h' hypotheses (where h.h' = π,K,p)

$K^+\pi^-$ PID cuts for $A_{CP}(B^0 \to K^+\pi^-)$	π^+K^- PID cuts for $A_{CP}(B_s^0 \to \pi^+K^-)$
$\Delta\log\mathcal{L}_{K\pi}(h^+) > 0$ $\Delta\log\mathcal{L}_{K\pi}(h^-) < 0$ $\Delta\log\mathcal{L}_{pK}(h^+) < 5$ $\Delta\log\mathcal{L}_{p\pi}(h^-) < 5$	$\Delta\log\mathcal{L}_{K\pi}(h^+) < -7$ $\Delta\log\mathcal{L}_{K\pi}(h^-) > 7$ $\Delta\log\mathcal{L}_{pK}(h^+) < 5$ $\Delta\log\mathcal{L}_{p\pi}(h^-) < 5$

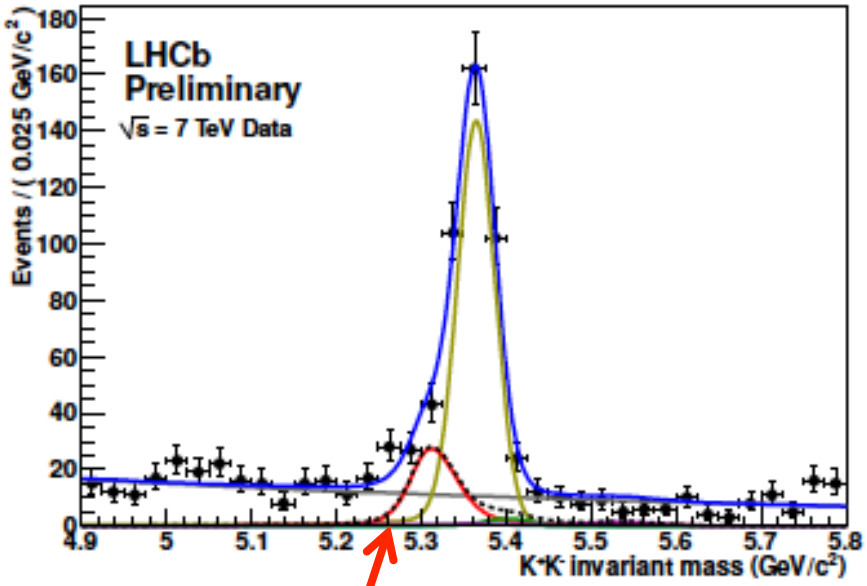
$B^0 \to \pi^+\pi^-$ and $B_s \to K^+K^-$

Selection optimized for $A_{CP}(B^0 \to K\pi)$

$B^0 \to \pi^+\pi^-$ yield: 275 ± 24



$B_s \to K^+K^-$ yield: 333 ± 21



$\pi^+\pi^-$	K^+K^-
$\Delta \log \mathcal{L}_{K\pi}(h^+) < -3$	$\Delta \log \mathcal{L}_{K\pi}(h^+) > 3$
$\Delta \log \mathcal{L}_{K\pi}(h^-) < -3$	$\Delta \log \mathcal{L}_{K\pi}(h^-) > 3$
$\Delta \log \mathcal{L}_{p\pi}(h^+) < 5$	$\Delta \log \mathcal{L}_{pK}(h^+) < 5$
$\Delta \log \mathcal{L}_{p\pi}(h^-) < 5$	$\Delta \log \mathcal{L}_{pK}(h^-) < 5$

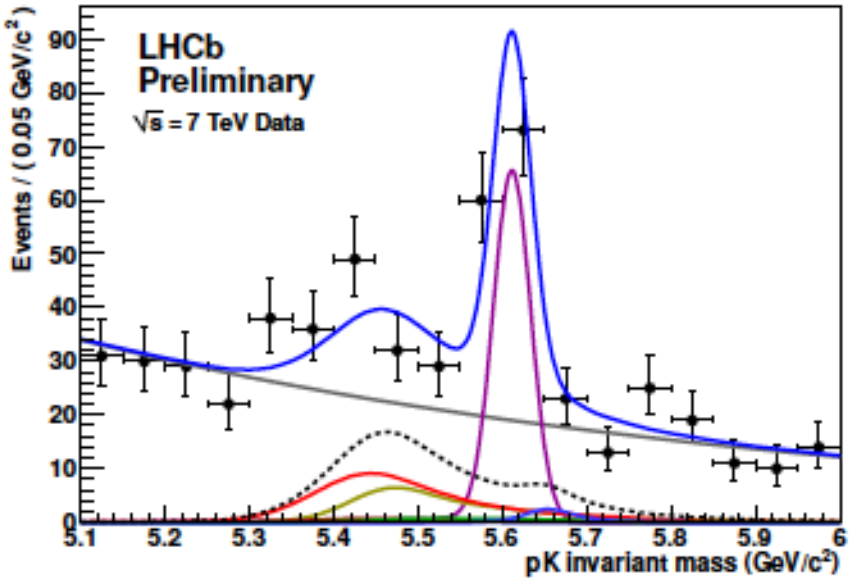
Cross feed backgrounds dominated by $B^0 \to K\pi$ decays

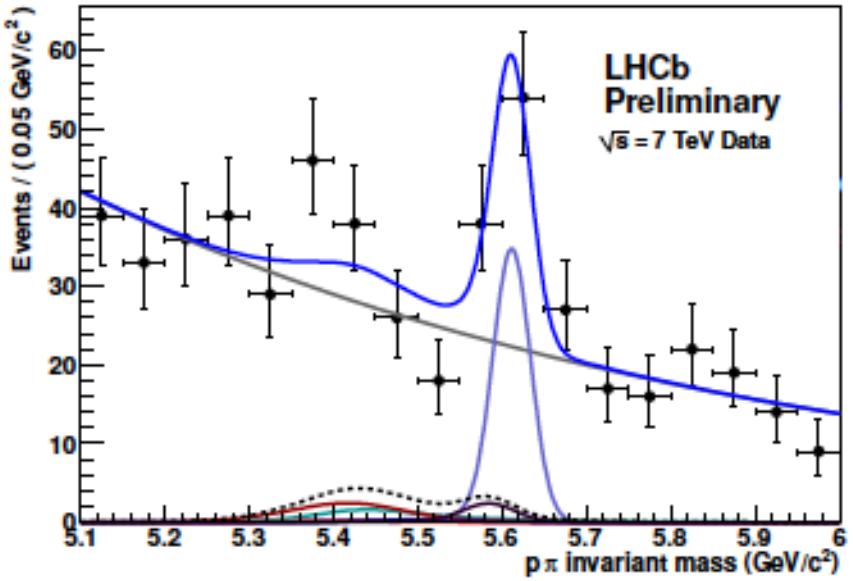
$\Lambda_b \rightarrow pK$ and $\Lambda_b \rightarrow p\pi$

Selection optimized for $A_{CP}(B^0 \rightarrow K\pi)$

$\Lambda_b \rightarrow pK$ yield: 76 ± 12

$\Lambda_b \rightarrow p\pi$ yield: 41 ± 10





pK^-	$p\pi^-$
$\Delta \log \mathcal{L}_{pK}(h^+) > 5$	$\Delta \log \mathcal{L}_{pK}(h^+) > 10$
$\Delta \log \mathcal{L}_{K\pi}(h^-) > 3$	$\Delta \log \mathcal{L}_{K\pi}(h^-) < -3$
$\Delta \log \mathcal{L}_{p\pi}(h^+) > 5$	$\Delta \log \mathcal{L}_{p\pi}(h^+) > 10$
$\Delta \log \mathcal{L}_{pK}(h^-) < 5$	$\Delta \log \mathcal{L}_{p\pi}(h^-) < 5$