

STUDIES OF B-HADRON DECAYS TO CHARMLESS FINAL STATES AT LHCb

$B \rightarrow h^+ h^-$ ANALYSES

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On behalf of the LHCb collaboration

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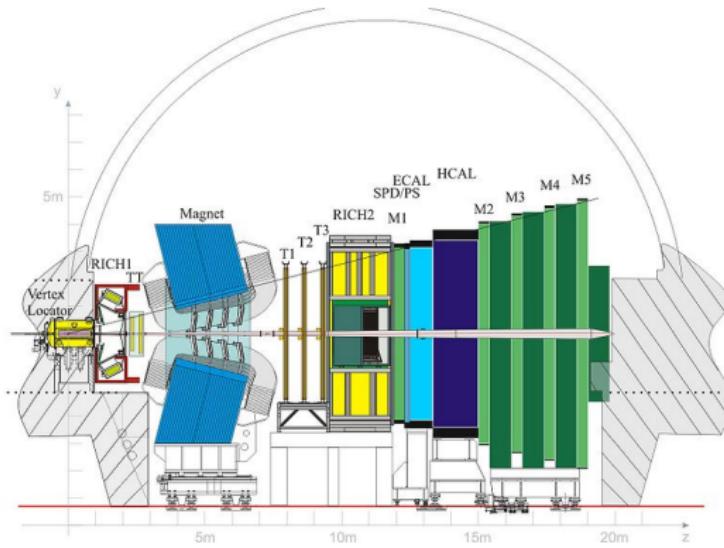
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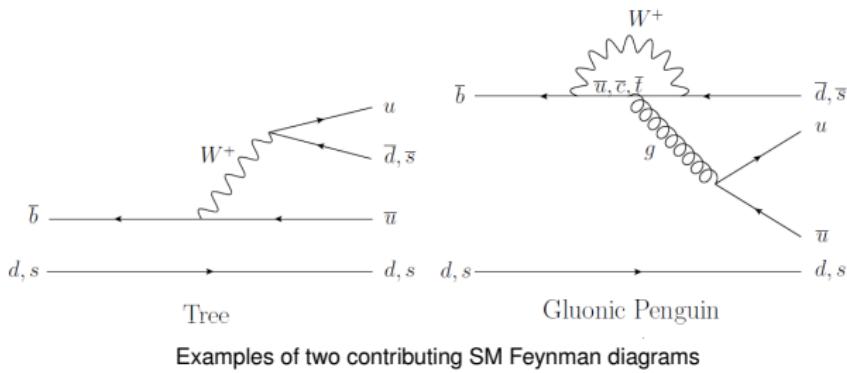
HADRONIC B-DECAYS AT LHCb

- Forward facing spectrometer which covers $\approx 2\%$ full solid angle
- Large background: **Trigger**
- Time dependent processes: **VELO**
- Hadronic final states: **RICH**



$B^0, B_s^0 \rightarrow h^+ h^-$ DECAYS ($h = \pi$ OR K)

Proceed through tree and penguin processes
Sensitive to BSM processes



EXPERIMENTAL POSSIBILITIES

- CP Asymmetries
- Lifetime measurements
- CKM angle γ

CURRENT AREAS OF ANALYSIS

ANALYSIS CONDUCTED

- Measurements of A_{CP} for $B^0 \rightarrow K^+ \pi^-$ and $B_s^0 \rightarrow \pi^+ K^-$
- Lifetime measurements of $B_s^0 \rightarrow K^+ K^-$
- Observations of rare decays in $B \rightarrow h^+ h'^-$ sector
- Analyses performed using:
 - 37 pb^{-1} from full integrated luminosity of 2010 data
 - 320 pb^{-1} from 2011 data analysed

$B^0 \rightarrow K^+ \pi^-$ AND $B_s^0 \rightarrow \pi^+ K^-$ \mathcal{CP} ASYMMETRIES

(LHCb-CONF-2011-011)

FIRST $B \rightarrow h^+ h'^-$ \mathcal{CP} ASYMMETRY MEASUREMENT AT LHCb

- Flavour specific final state
- Time Integrated and un-tagged analysis
- Many specific backgrounds: $B^0 \rightarrow \pi^+ \pi^-$, $B_s^0 \rightarrow K^+ K^-$, ...

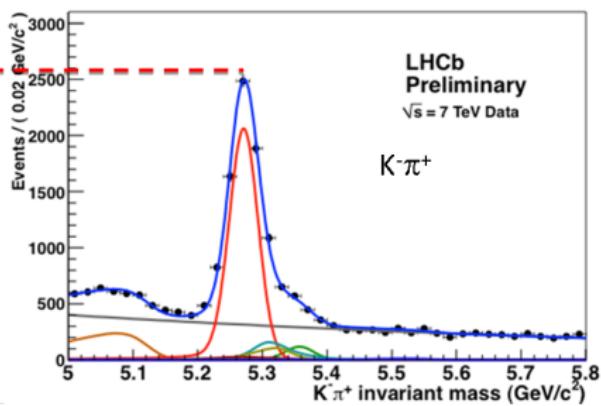
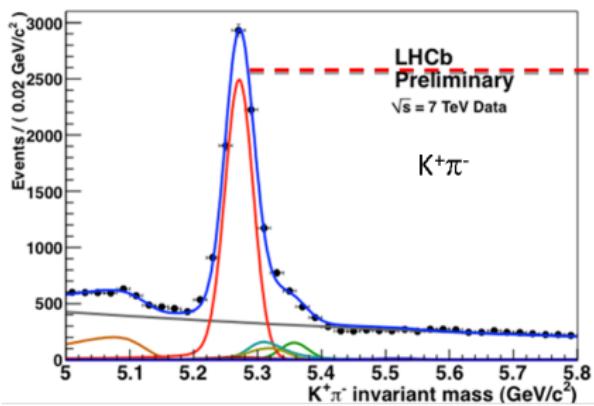
$$A_{CP} = \frac{\Gamma(\bar{B} \rightarrow \bar{f}) - \Gamma(B \rightarrow f)}{\Gamma(\bar{B} \rightarrow \bar{f}) + \Gamma(B \rightarrow f)}$$

TEST OF U-SPIN SYMMETRY ($d \leftrightarrow s$) (HEP-PH/9903456)

- $A_{CP}(B^0 \rightarrow K^+ \pi^-) \approx A_{dir}(B_s^0 \rightarrow K^+ K^-)$
- $A_{CP}(B_s^0 \rightarrow \pi^+ K^-) \approx A_{dir}(B^0 \rightarrow \pi^+ \pi^-)$

$B^0 \rightarrow K\pi$ RAW ASYMMETRIES

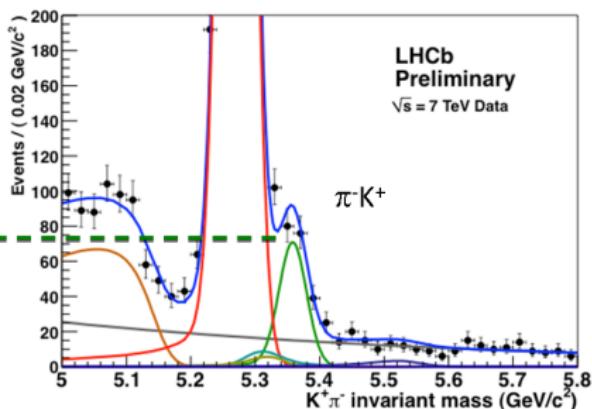
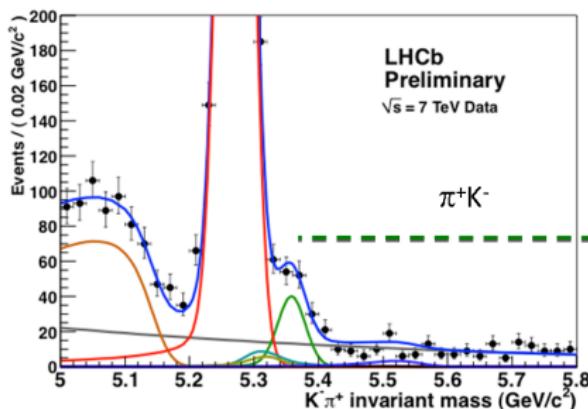
Mass fit to $B^0 \rightarrow K^+\pi^-$ (left) and $\bar{B}^0 \rightarrow K^-\pi^+$ (right)



- Extracted from 320 pb⁻¹ of 2011 data

$B_s^0 \rightarrow \pi K$ RAW ASYMMETRIES

Mass fit to $B_s^0 \rightarrow \pi^+ K^-$ (left) and $\bar{B}_s^0 \rightarrow \pi^- K^+$ (right)



- Extracted from 320 pb^{-1} of 2011 data
- From these Raw results, we can extract the physical $A_{\mathcal{CP}}$ values

FROM RAW TO PHYSICAL ASYMMETRIES

CORRECTIONS

- detector-induced $K^+ \pi^- / K^- \pi^+$ charge asymmetries
- B production asymmetry

The physical CP asymmetries are then related to the "RAW" asymmetries by:

$$A_{CP}^{RAW}(B_{d/s}^0 \rightarrow K\pi) = A_{CP}(B_{d/s}^0 \rightarrow K\pi) + A_D(B_{d/s}^0 \rightarrow K\pi) + A_P(B_{d/s}^0 \rightarrow K\pi)$$

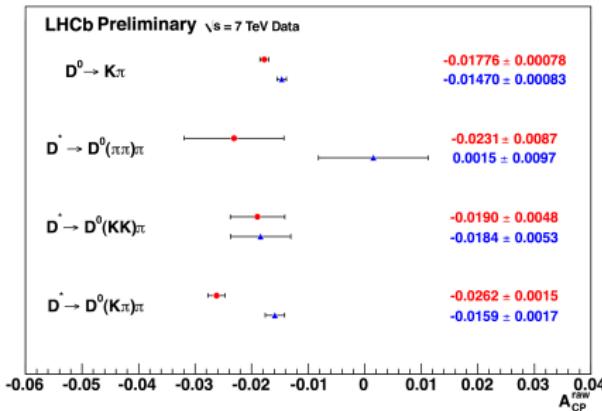
PRODUCTION ASYMMETRIES

- pp collider could produce a production asymmetry
- B^0 and B^+ share valence quark with the protons
- $A_P(B^0)$ measured from $B^\pm \rightarrow J/\psi(\mu^+\mu^-)K^\pm$
- $A_P(B^+) = A_P(B^0) = -0.024 \pm 0.013$

DETECTION ASYMMETRIES

DETERMINED FROM CHARM DECAYS

- Untagged D^0 and self-tagged $D^{*\pm} \rightarrow D^0\pi^\pm$
- Measure asymmetries of D^0 to KK, $\pi\pi$ and $K\pi$



$$\begin{aligned}
 A_{CP}^{RAW}(K\pi)^* &= A_{CP}(K\pi) + A_D(\pi_s) + A_D(K\pi) + A_P(D^*) \\
 A_{CP}^{RAW}(KK)^* &= A_{CP}(KK) + A_D(\pi_s) + A_P(D^*) \\
 A_{CP}^{RAW}(\pi\pi)^* &= A_{CP}(\pi\pi) + A_D(\pi_s) + A_P(D^*) \\
 A_{CP}^{RAW}(K\pi) &= A_{CP}(K\pi) + A_D(K\pi) + A_P(D^0)
 \end{aligned}$$

$A_{CP} \rightarrow$ Physical Asymmetries

$A_D \rightarrow$ Instrumental Asymmetries

$A_P \rightarrow$ Production Asymmetries

Raw asymmetries for magnetic field
Up and Down

$$A_D(K\pi) = -0.004 \pm 0.004$$

$B^0 \rightarrow K^+ \pi^-$ AND $B_s^0 \rightarrow \pi^+ K^-$ RESULTS

LHCb MEASUREMENTS (320 PB^{-1})

- $A_{CP}(B^0 \rightarrow K^+ \pi^-) = -0.088 \pm 0.011 \text{ (stat)} \pm 0.008 \text{ (syst)}$
- $A_{CP}(B_s^0 \rightarrow \pi^+ K^-) = 0.27 \pm 0.08 \text{ (stat)} \pm 0.02 \text{ (syst)}$

CURRENT WORLD-BEST MEASUREMENTS

- $A_{CP}(B^0 \rightarrow K^+ \pi^-) = -0.098 \pm 0.013 \quad (\text{PDG})$
- $A_{CP}(B_s^0 \rightarrow \pi^+ K^-) = 0.39 \pm 0.15 \pm 0.08 \quad (\text{CDF})$ (PRL 106, 181802 (2011))

$B_s^0 \rightarrow K^+ K^-$ LIFETIME MEASUREMENT (LHCb-CONF-2011-018)

Decay into a CP even final state: $K^+ K^-$

- Mass Eigenstates $|B_L\rangle$ (light) and $|B_H\rangle$ (heavy)
- CP conserved: only accessible from B_L
- CP violation: mix of B_L and B_H
- SM predicts very small CP violation

Lifetime distribution, without initial flavour (B_s^0 or \bar{B}_s^0) discrimination:

$$\Gamma(t) \propto \left[(1 - A_{\Delta\Gamma}) e^{-\Gamma_L t} + (1 + A_{\Delta\Gamma}) e^{-\Gamma_H t} \right]$$

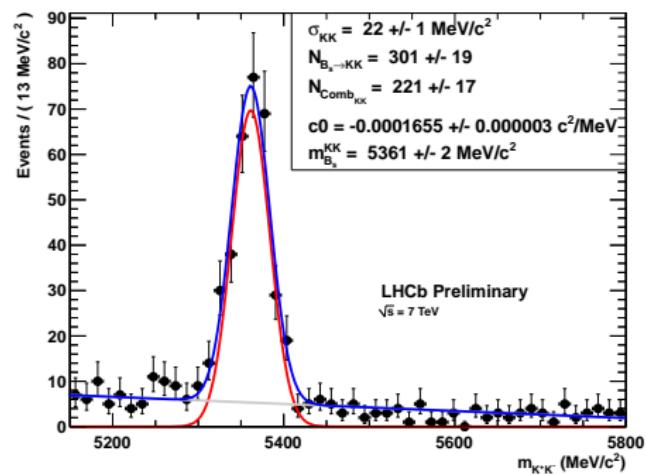
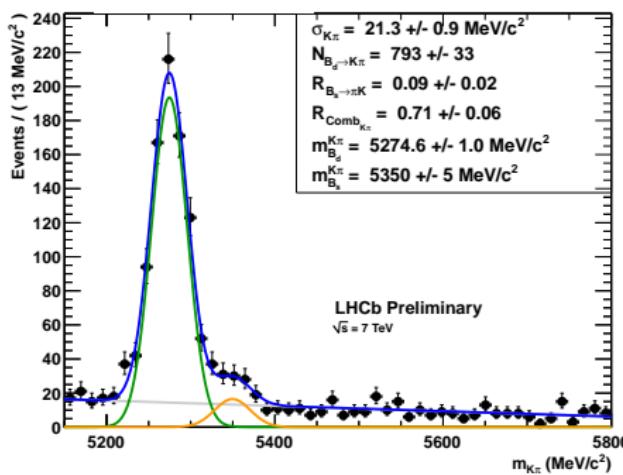
Where $A_{\Delta\Gamma}$ is defined as

$$A_{\Delta\Gamma} = \frac{R_H - R_L}{R_H + R_L} \quad \text{where SM} \quad A_{\Delta\Gamma}(B_s^0 \rightarrow K^+ K^-) = -0.97^{+0.014}_{-0.009}$$

$B_s^0 \rightarrow K^+ K^-$ LIFETIME MEASUREMENT

Experimental Challenge

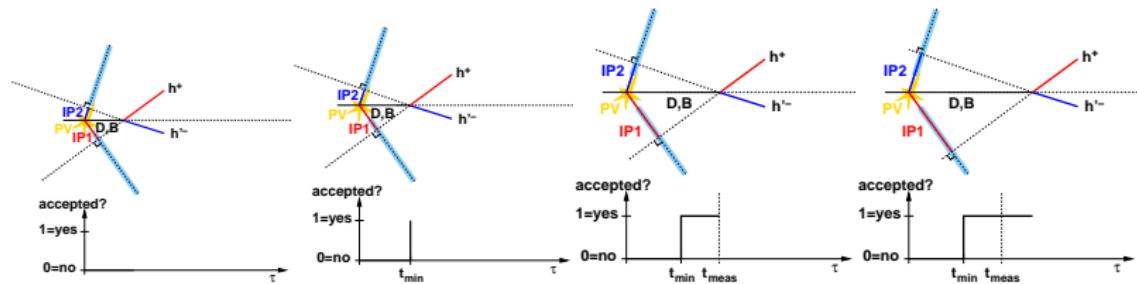
- The event selection introduce a lifetime bias
- Two different analysis methods used



LIFETIME MEASUREMENT METHODS

ABSOLUTE LIFETIME MEASUREMENT

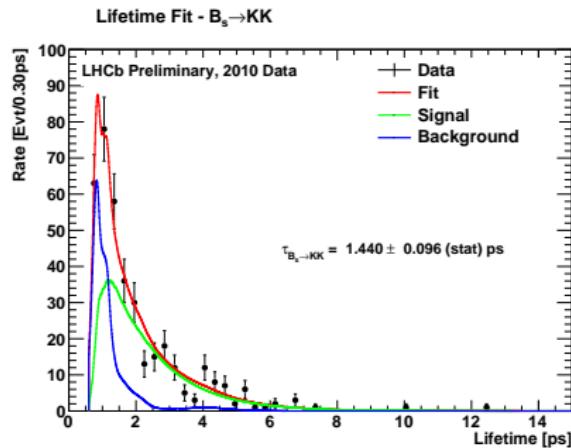
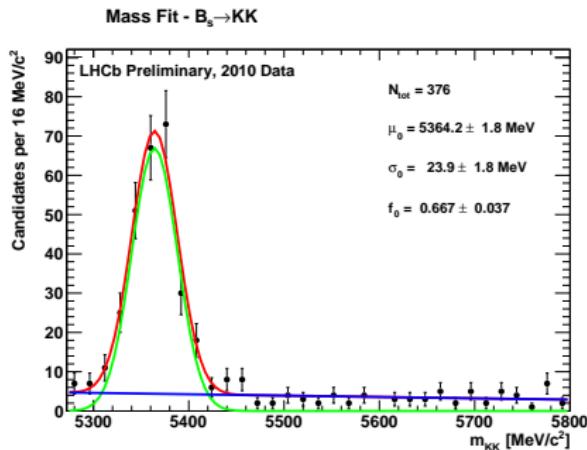
- The acceptance function is determined per event
 - Trigger and Selection re-run for all hypothetical lifetimes
 - The step function is parametrised by the parameter t_{min}



RELATIVE LIFETIME MEASUREMENT

- Compare to kinematically similar $B^0 \rightarrow K^+ \pi^-$
- Acceptance cancel in the ratio

RESULTS: $B_s^0 \rightarrow K^+ K^-$ LIFETIME



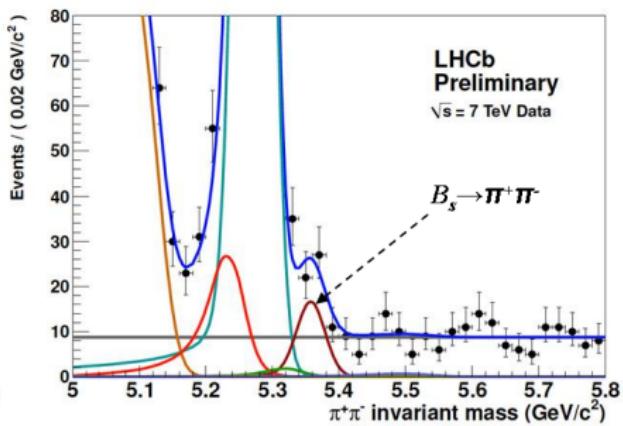
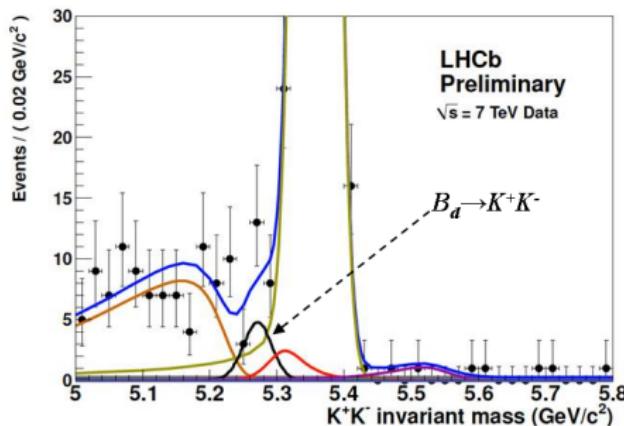
LHCb PRELIMINARY $\hat{\tau}_{B_s^0 \rightarrow K^+ K^-} = 1.440 \pm 0.096 \text{ (stat)} \pm 0.010 \text{ (syst)} \text{ ps}$

CDF PRELIMINARY: $\hat{\tau}_{B_s^0 \rightarrow K^+ K^-} = 1.58 \pm 0.18 \text{ (stat)} \pm 0.02 \text{ (syst)} \text{ ps}$ (CDF Note 06-01-26)

SM PREDICTION: $\hat{\tau}_{B_s^0 \rightarrow K^+ K^-} = 1.390 \pm 0.032 \text{ ps}$ (hep-ph/0612167)

Publication in preparation

RARE DECAY OBSERVATIONS (LHCb-TALK-2011-139)



PRELIMINARY BRANCHING RATIOS

- $BR(B^0 \rightarrow K^+ K^-) = (0.13^{+0.06}_{-0.05} \text{ (stat)} \pm 0.07 \text{ (syst)}) \times 10^{-6}$
- $BR(B_s^0 \rightarrow \pi^+ \pi^-) = (0.98^{+0.23}_{-0.19} \text{ (stat)} \pm 0.11 \text{ (syst)}) \times 10^{-6}$

First observation of $B_s^0 \rightarrow \pi^+ \pi^-$ with a significance of $> 5\sigma$

SUMMARY

- LHCb has a rich program of studying hadronic B decays
- Promising results in the $B \rightarrow h^+ h^-$ sector already from 2010 and 2011 Data, e.g.
 - Worlds best measurements of A_{CP} from $B^0 \rightarrow K^+ \pi^-$
 - First evidence of CP violation in $B_s^0 \rightarrow \pi^+ K^-$ to 3σ
 - World best measurement of $B_s^0 \rightarrow K^+ K^-$ lifetime to be improved with 2011 data
 - First observations of $B_s^0 \rightarrow \pi^+ \pi^-$ and measurement of the *B.R.*
- Further analysis involving Λ_b 's and $B \rightarrow hh$ decays being conducted
- Future work has the potential to measure the unitarity angle γ through $B^0 \rightarrow \pi^+ \pi^-$ and $B_s^0 \rightarrow K^+ K^-$ modes