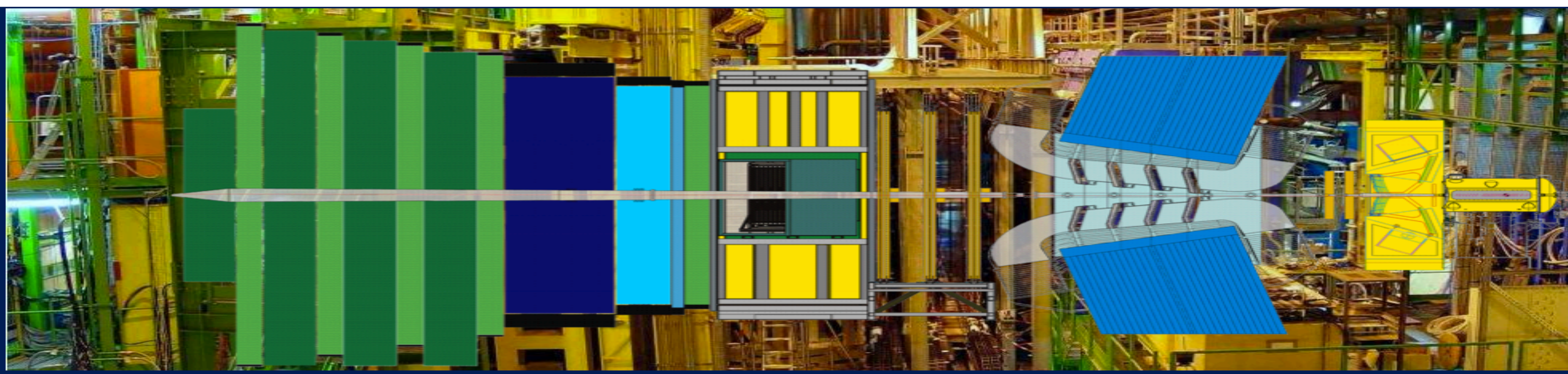

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Direct CP-asymmetries in $B^0 \rightarrow K\pi$ and $B_s \rightarrow \pi K$ decays at LHCb

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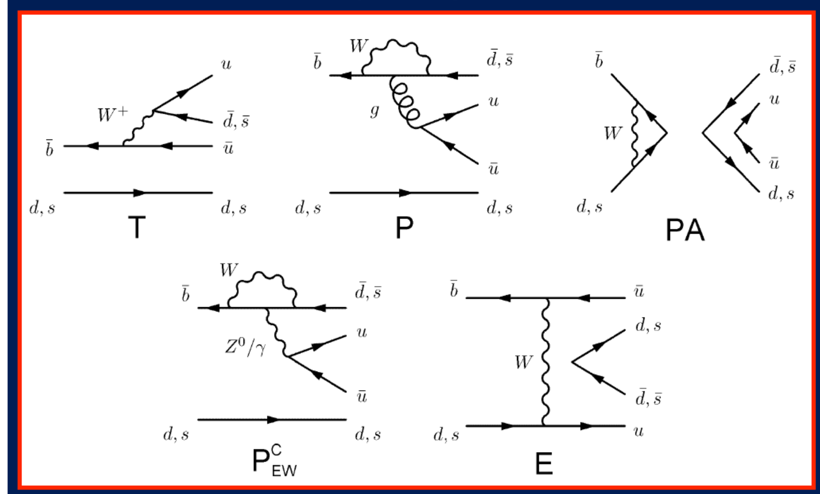
On behalf of the LHCb Collaboration

Abstract

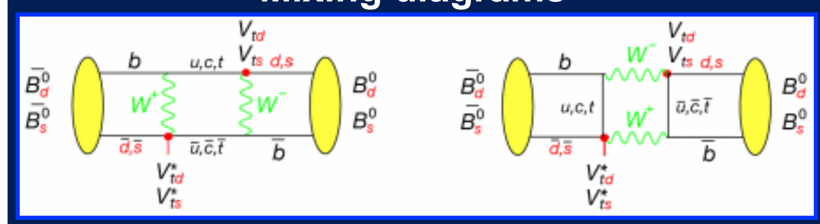
The LHCb experiment is designed to perform flavour physics measurements at the Large Hadron Collider. Using data collected during the 2010 run, we reconstructed a sample of $H_b \rightarrow h^+h'^-$ decays, where H_b can be either a B^0 meson, a B_s^0 meson or a Λ_b baryon, while h and h' stand for π, K or p. Such decays are sensitive probes of the Cabibbo-Kobayashi-Maskawa matrix and have the potential to reveal the presence of New Physics. We present preliminary measurements of the direct CP asymmetries in the $B^0 \rightarrow K^+\pi^-$ and $B_s^0 \rightarrow \pi^+K^-$ decays.

The $H_b \rightarrow hh'$ decay family

Decay diagrams



Mixing diagrams



Charmless charged two-body B hadron decays

$B^0 \rightarrow \pi^+\pi^-$	$B^0 \rightarrow K^+\pi^-$	$\Lambda_b \rightarrow pK^-$	$B^0 \rightarrow K^+K^-$
$B_s \rightarrow K^+K^-$	$B_s \rightarrow \pi^+K^-$	$\Lambda_b \rightarrow p\pi^-$	$B_s \rightarrow \pi^+\pi^-$

The Feynmann diagrams contributing to such decays are tree (T), strong penguins (P), electroweak penguins (P^C_{EW}), penguin annihilation (PA) and exchange (E). In addition one have to take into account the oscillation of B^0 and B_s mesons between their CP-conjugate states, process governed by mixing diagrams.

The analysis of such channels allows to measure both charge CP-asymmetries in flavour-specific modes and time-dependent CP-asymmetries in decays to CP eigenstates.

The presence of loop diagrams both in the decay graphs and in the mixing graphs makes this analysis a suitable place where to look for New Physics effects. New virtual particles may show up inside the loops, altering in a sizeable the Standard Model expectations.

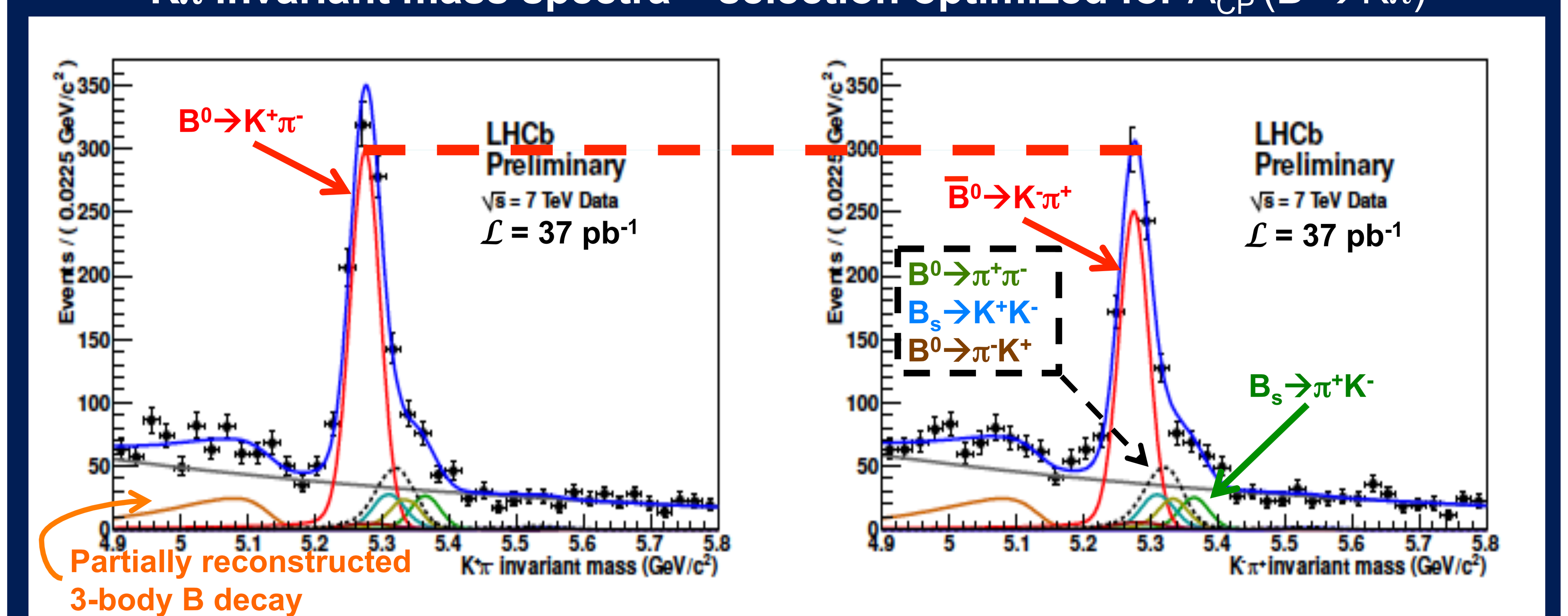
Within the validity of the U-spin symmetry (invariance of strong interaction dynamics under the d <-> s quark exchange), it will be possible to measure the angle γ of the CKM-matrix [R. Fleischer, Phys. Lett. B459, 1999]. The measurement of the angle γ from these decays might reveal New Physics effects, as the value can differ from that extracted using tree-level decays.

Invariant mass fit and raw CP-asymmetries

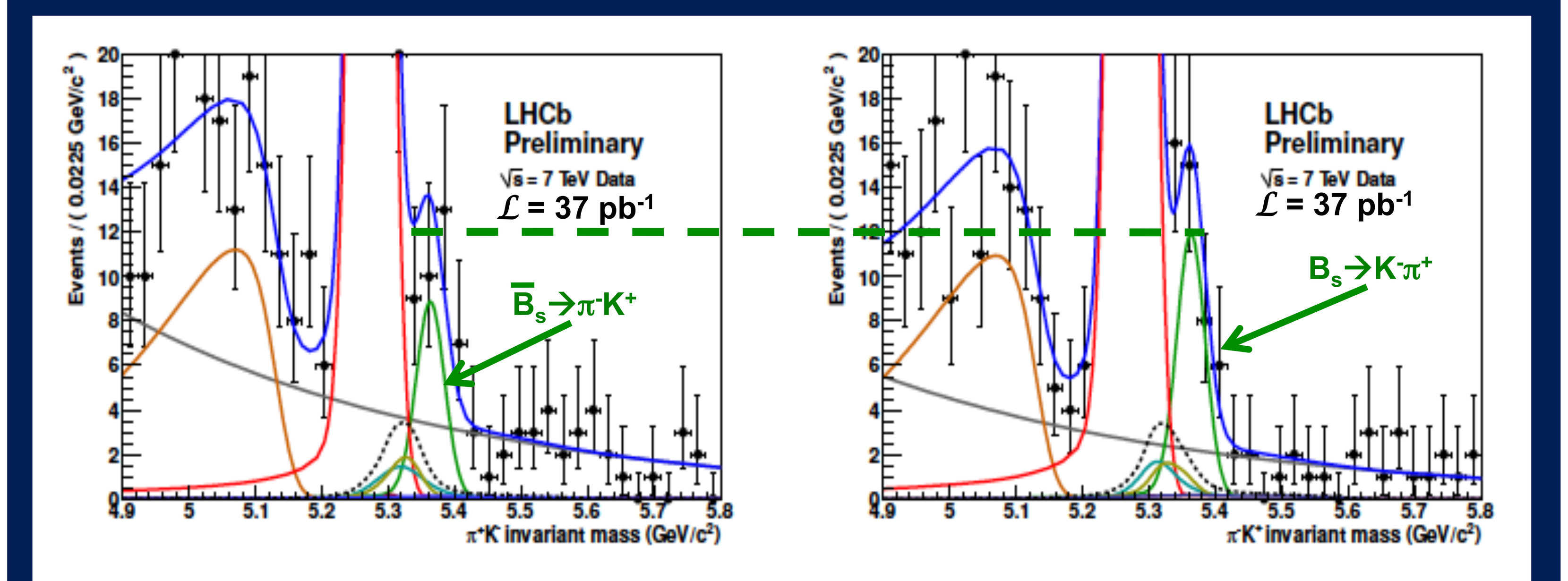
Once the sample is separated into different final states we can perform a fit to the invariant mass distributions in order to extract the raw CP-asymmetries. The fit function takes into account the two signal ($B^0 \rightarrow K\pi$ in red and $B_s \rightarrow \pi K$ in green), the combinatorial background (in gray) the partially reconstructed 3-body B decays (in orange) and the cross-feed backgrounds (dashed black line) which are dominated by $B^0 \rightarrow \pi^+\pi^-$ and $B_s \rightarrow K^+K^-$ decays.

We determined two sets of event selection criteria in order to obtain the best sensitivity either on $A_{CP}(B^0 \rightarrow K\pi)$ or on $A_{CP}(B_s \rightarrow \pi K)$.

$K\pi$ invariant mass spectra – selection optimized for $A_{CP}(B^0 \rightarrow K\pi)$



$K\pi$ invariant mass spectra – selection optimized for $A_{CP}(B_s \rightarrow \pi K)$



The raw CP-asymmetries are visible from the plots (see red and green dashed lines).

The measured values are:

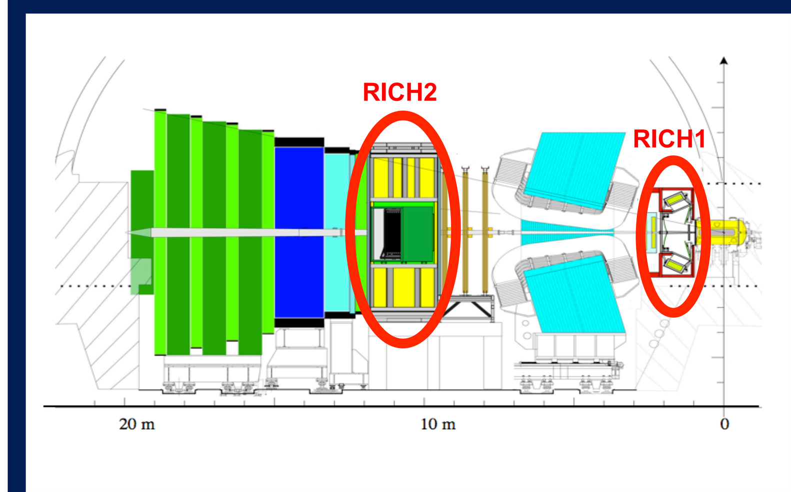
Raw $A_{CP}(B^0 \rightarrow K\pi)$ = -0.086 ± 0.033

Raw $A_{CP}(B_s \rightarrow \pi K)$ = -0.15 ± 0.19

Calibration of particle ID

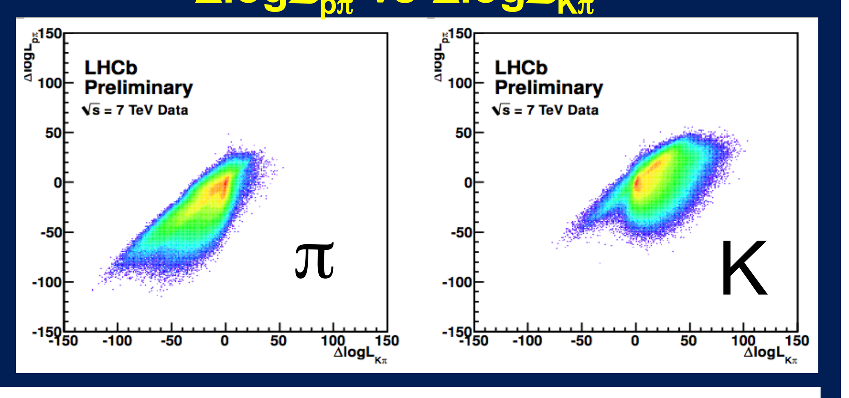
The calibration of particle identification is a crucial aspect of the analysis as different final states with overlapped invariant mass peaks must be disentangled. PID efficiencies are needed in order to evaluate the yields of cross-feed backgrounds.

At LHCb the PID is provided by two RICH (Ring Imaging Cherenkov) sub-detectors. Using information from these sub-detectors we obtain the PID observable $\Delta\log\mathcal{L}_{hh'}$ which is the difference between the logarithms of the likelihoods of the h and h' hypotheses (where h,h' = π,K,p).

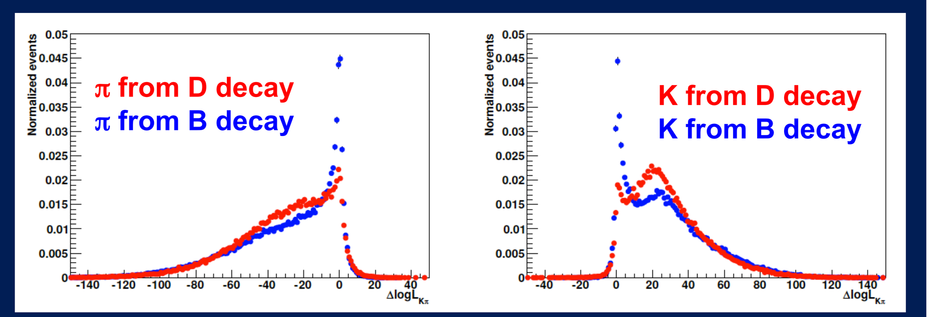


In order to calibrate such observable we used a sample of true π, K and p coming from $D^* \rightarrow D^0(K\pi)\pi$ and $\Lambda \rightarrow p\pi$ decays.

$\Delta\log\mathcal{L}_{p\pi}$ vs $\Delta\log\mathcal{L}_{K\pi}$



The decay products of the calibration samples have a different phase space with respect to those of $H_b \rightarrow hh'$ decays, hence we perform a reweighting of the $\Delta\log\mathcal{L}$ distributions. As we have to separate π, K and p we need to use a pair of PID observables (e.g. $\Delta\log\mathcal{L}_{K\pi}$ and $\Delta\log\mathcal{L}_{p\pi}$) and take into account their correlations.



$$f\left(\Delta\log\mathcal{L}^+_{K\pi},\ \Delta\log\mathcal{L}^+_{p\pi},\ \Delta\log\mathcal{L}^-_{K\pi},\ \Delta\log\mathcal{L}^-_{p\pi},\ p^+,\ p^-,\ p^+_T,\ p^-_T\right) = $$
$$= \boxed{g^+\left(\Delta\log\mathcal{L}^+_{K\pi},\ \Delta\log\mathcal{L}^+_{p\pi}\ |\ p^+,\ p^+_T\right)\cdot g^-\left(\Delta\log\mathcal{L}^-_{K\pi},\ \Delta\log\mathcal{L}^-_{p\pi}\ |\ p^-,\ p^-_T\right)}\cdot \boxed{h\left(p^+,\ p^-,\ p^+_T,\ p^-_T\right)}$$

Joint p and p_T distributions of B meson decay products

Conditional $\Delta\log\mathcal{L}$ distributions obtained from calibration samples

Corrections to the raw CP-asymmetries

The raw CP-asymmetries obtained from the invariant mass fits must be corrected in order to obtain the physical values of A_{CP}.

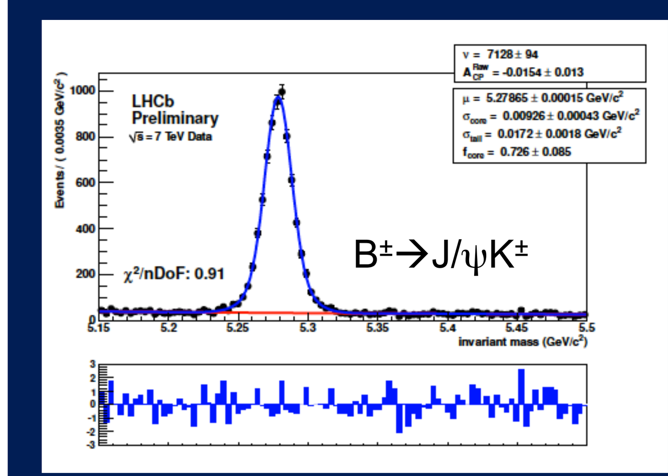
$$\boxed{A_{CP}} = A^{RAW}_{CP} - \boxed{A_D(K\pi)} - \kappa\boxed{A_P}$$

A_{CP} → Physical asymmetry
A_D → Detector induced asymmetry
A_P → Production asymmetry

The instrumental $K^+\pi^-/K^-\pi^+$ charge asymmetry has been studied using high statistics samples of $D^* \rightarrow D^0(K\pi)\pi_s$, $D^* \rightarrow D^0(KK)\pi_s$, $D^* \rightarrow D^0(\pi\pi)\pi_s$ and untagged $D^0 \rightarrow K\pi$ decays. Measuring raw asymmetries of these decays and using world averages of involved physical A_{CP} asymmetries it is possible to determine $A_D(K\pi)$.

$$A^{RAW}_{CP}(K\pi)^* = A_{CP}(K\pi) + A_D(\pi_s) + A_D(K\pi) + A_P(D^*)$$
$$A^{RAW}_{CP}(KK)^* = A_{CP}(KK) + A_D(\pi_s) + A_P(D^*)$$
$$A^{RAW}_{CP}(\pi\pi)^* = A_{CP}(\pi\pi) + A_D(\pi_s) + A_P(D^*)$$
$$A^{RAW}_{CP}(K\pi) = A_{CP}(K\pi) + A_D(K\pi) + A_P(D^0)$$

$A_D(K\pi)$ = -0.004 ± 0.004



As LHC is a p-p collider we have an initial matter/anti-matter imbalance which may give rise to a B-meson production asymmetry. Such a possible initial asymmetry has been studied by means of $B^\pm \rightarrow J/\psi K^\pm$ decays. A systematic error of 0.010 has been added in order to take into account possible different production asymmetries of charged and neutral B mesons.

A_P = -0.025 ± 0.014 ± 0.010

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

κ factor depends on selection and time evolution of neutral B-meson

Results

LHCb preliminary

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

HFAG averages

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

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

LHCb is expected to significantly improve the current knowledge with 2011 data