Observation of CP violation in B± → DK± decays at LHCb
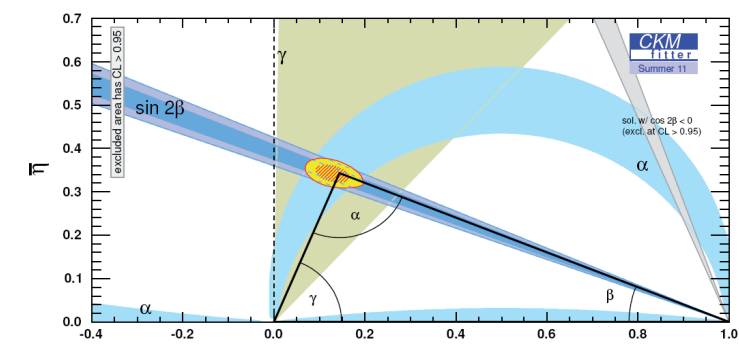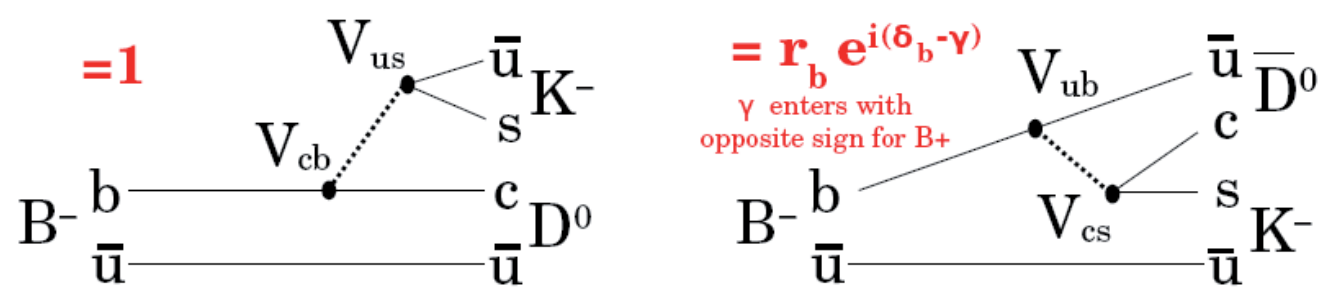
Paolo Gandini
on behalf of the LHCb collaboration

paolo.gandini@cern.ch

UNIVERSITY OF OXFORD

Motivation

$$\gamma = \arg\left(-\frac{V_{ub}^*}{V_{cb}^*}\right)$$

Tree level determination of γ using B → DK decays

=1

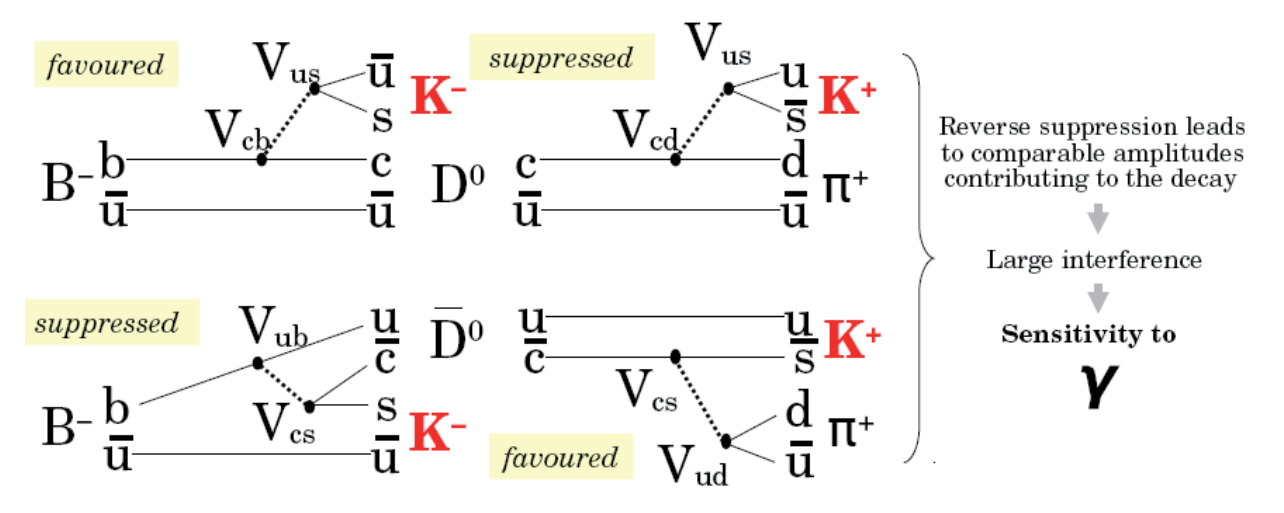$r_b\, e^{i(\delta_b - \gamma)}$
γ enters with opposite sign for B+

GLW (Gronau, London, Wyler)

$B^\pm \to D^0_{CP}\, K^\pm$ $D^0 \to CP$-eigenstate

Decay proceeds through two amplitudes

Colour FAVOURED
Colour SUPPRESSED   *Interference limited*

Phys. Lett. B 265 17 (1991) $(\pi\pi, KK)$

ADS (Atwood, Dunietz, Soni)

$B^\pm \to D^0\, K^\pm$ $D^0 \to NOT\ CP$-eigenstate

favoured / suppressed

Reverse suppression leads to comparable amplitudes contributing to the decay

Large interference

Sensitivity to γ

Phys. Rev. Lett. 78 (1997) 3257-3260 $(K^+\pi^-, \pi^+K^-)$

Outline

- Analysis is based on full 2011 dataset : 1.0 fb^{-1}
- We reconstruct every mass combination
- B → [hh]$_D$ h where h = pion or kaon
- Extract Ratios & Asymmetries with simultaneous fit
- Most systematic uncertainties cancel

CP modes

$$R_{CP+} = \frac{<\Gamma(B^\pm \to [\pi\pi]_D K^\pm), \Gamma(B^\pm \to [KK]_D K^\pm)>}{\Gamma(B^\pm \to [K\pi]_D K^\pm)} = 1 + r_B^2 + 2r_B\cos\delta_B\cos\gamma$$

favoured mode

average of KK and ππ modes

$$A_{CP+} = \frac{\Gamma(B^- \to D_{CP}K^-) - \Gamma(B^+ \to D_{CP}K^+)}{\Gamma(B^- \to D_{CP}K^-) + \Gamma(B^+ \to D_{CP}K^+)} = \frac{2r_B\sin\delta_B\sin\gamma}{1 + r_B^2 + 2r_B\cos\delta_B\cos\gamma}$$

ADS mode / favoured mode

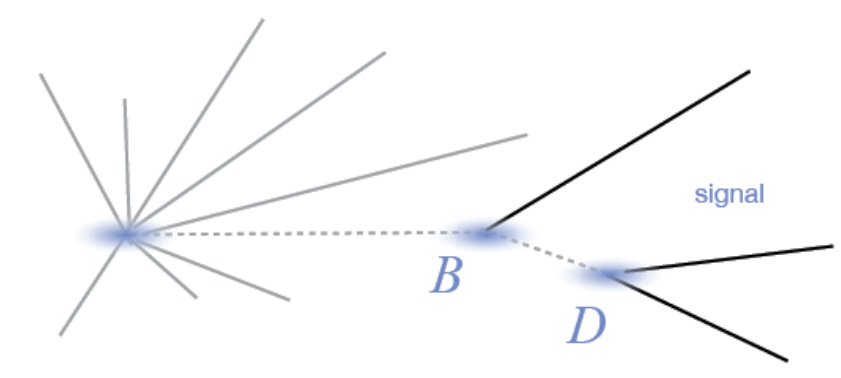$$R^{ADS} = \frac{\Gamma(B^\pm \to [\pi K]_D K^\pm)}{\Gamma(B^\pm \to [K\pi]_D K^\pm)} = \frac{r_B^2 + r_D^2 + 2r_Br_D\cos(\delta_B + \delta_D)\cos\gamma}{1 + (r_Br_D)^2 + 2r_Br_D\cos(\delta_B - \delta_D)\cos\gamma}$$

$$A^{ADS} = \frac{\Gamma(B^- \to D_{ADS}K^-) - \Gamma(B^+ \to D_{ADS}K^+)}{\Gamma(B^- \to D_{ADS}K^-) + \Gamma(B^+ \to D_{ADS}K^+)} = \frac{2r_Br_D\sin(\delta_B + \delta_D)\sin\gamma}{r_B^2 + r_D^2 + 2r_Br_D\cos(\delta_B + \delta_D)\cos\gamma}$$
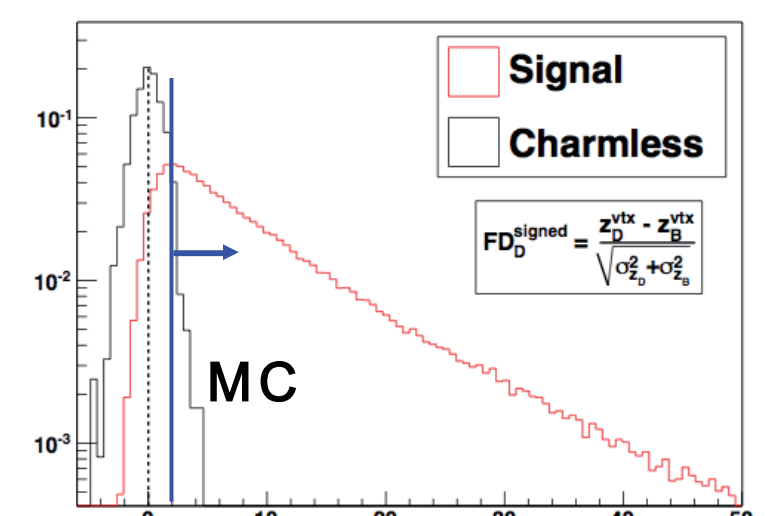
Selection

- Most background from combinatoric
- Use MVA method: **BDT with 20 variables**
- Train on **Signal MC** vs **2010 Sidebands** (35 pb^{-1} independent sample)

Peaking Background
Charmless B decays
Internal cross feed btw modes
Exploit forward boost in LHCb

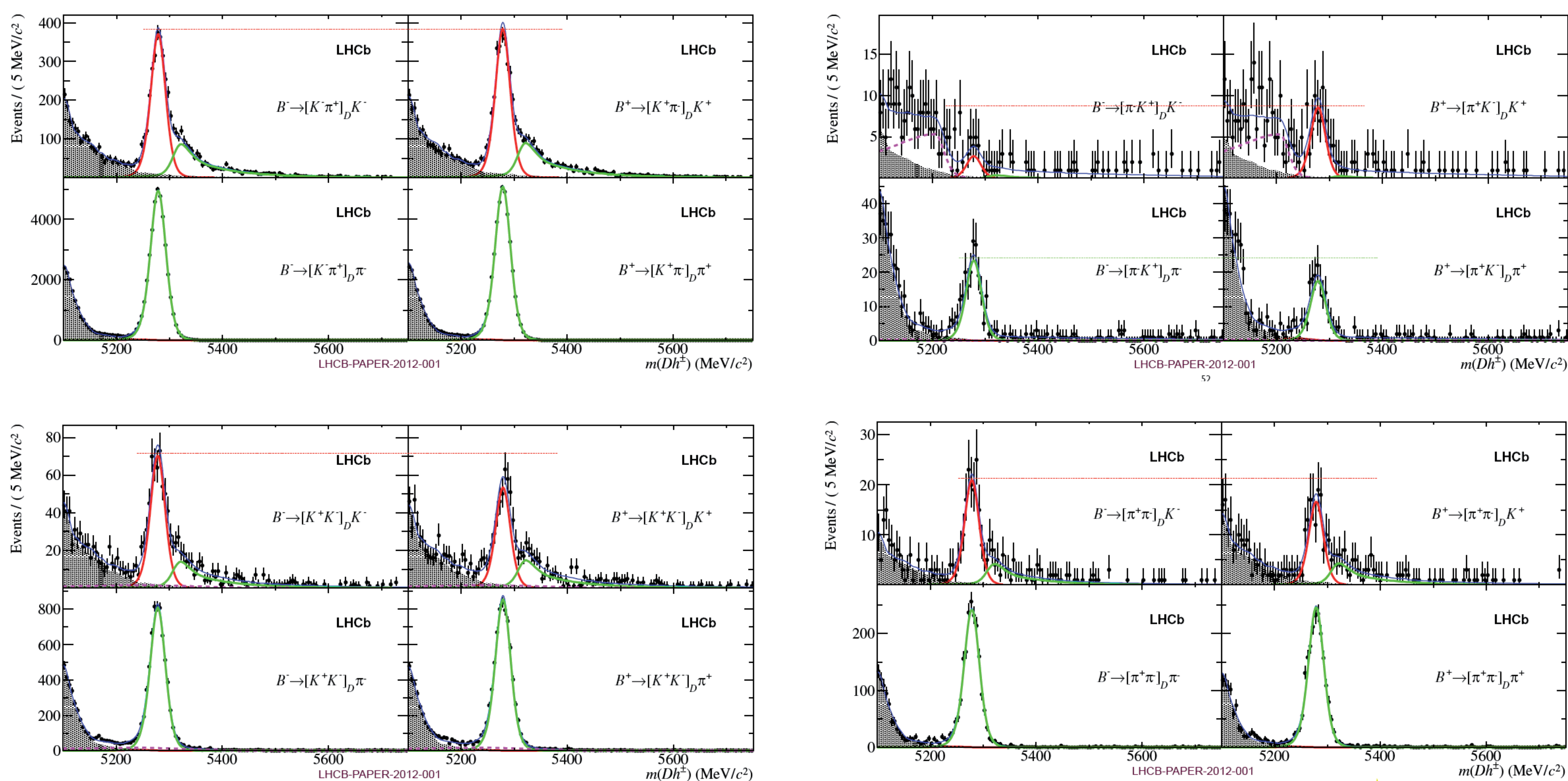e.g. $B^\pm \to [\pi\pi]_D K^\pm$ suffers from:

$B^\pm \to K\pi\pi^\pm$ Charmless
$B^\pm \to [K\pi]_D\pi^\pm$ Cross feed
$B^\pm \to [\pi\pi\pi^0]_D\pi^\pm$ Part. reco. cross feed

Signal / Charmless

MC

Results

arXiv:1203.3662

$B^- \to [K^-\pi^+]_D K^-$ LHCb
$B^+ \to [K^+\pi^-]_D K^+$ LHCb
$B^- \to [K^-\pi^+]_D \pi^-$ LHCb
$B^+ \to [K^+\pi^-]_D \pi^+$ LHCb

$B^- \to [\pi^-K^+]_D K^-$ LHCb
$B^+ \to [\pi^+K^-]_D K^+$ LHCb
$B^- \to [\pi^-K^+]_D \pi^-$ LHCb
$B^+ \to [\pi^+K^-]_D \pi^+$ LHCb

$B^- \to [K^+K^-]_D K^-$ LHCb
$B^+ \to [K^+K^-]_D K^+$ LHCb
$B^- \to [K^+K^-]_D \pi^-$ LHCb
$B^+ \to [K^+K^-]_D \pi^+$ LHCb

$B^- \to [\pi^+\pi^-]_D K^-$ LHCb
$B^+ \to [\pi^+\pi^-]_D K^+$ LHCb
$B^- \to [\pi^+\pi^-]_D \pi^-$ LHCb
$B^+ \to [\pi^+\pi^-]_D \pi^+$ LHCb

$m(Dh^\pm)$ (MeV/c^2)

LHCB-PAPER-2012-001

- Asymmetries of most abundant B → Dh ~ 0
- Asymmetries of B → [KKππ]$_D$ π consistent with 0
- Evidence of A$_{CP+}$ with 4.5 sigma significance!

$$R_{CP+} = 1.007 \pm 0.038 \pm 0.012$$
$$A_{CP+} = 0.145 \pm 0.032 \pm 0.010 \quad (4.5\sigma)$$

$$R_{ADS(K)} = 0.0152 \pm 0.0020 \pm 0.0004 \quad (10\sigma)$$
$$A_{ADS(K)} = -0.520 \pm 0.150 \pm 0.021 \quad (4.0\sigma)$$
$$R_{ADS(\pi)} = 0.00410 \pm 0.00025 \pm 0.00005$$
$$A_{ADS(\pi)} = 0.1426 \pm 0.0621 \pm 0.0110 \quad (2.4\sigma)$$

Combining all together...

CP violation is observed in B→DK with a significance of 5.8σ