Observation of CP violation in $B^{\pm}\to D^0K^{\pm}$ decays at LHCb

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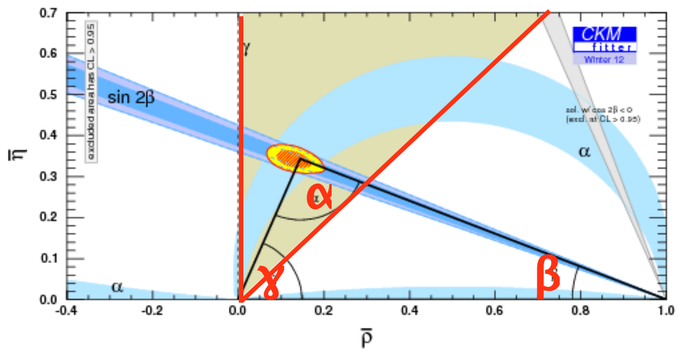
on behalf of the LHCb Collaboration

The CKM phase γ

CP violation enters the Standard Model through the complex phase in the CKM matrix.
Unitarity of the CKM matrix can be represented via 'unitarity triangles' where the sides represent the amplitudes of CKM elements and the angles represent relative phases.



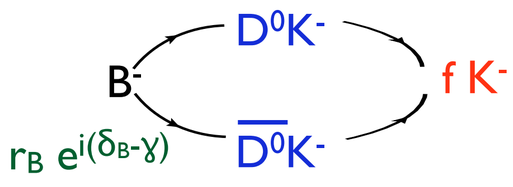
Of the phases, γ is the least well known:

$$\gamma = (66 \pm 12)^\circ$$ CKMfitter, direct measurements

Precise measurement of γ tests CKM unitarity:
α+β+γ=180°?

Measuring γ in B→DK

Sensitive to γ through interference between
$B^{\pm}\to D^0$ (→f) $K^{\pm}$ and $B^{\pm}\to \overline{D^0}$ (→f) $K^{\pm}$



Studied decays of the D⁰ to two daughters:

ADS: (flavour eigenstates)
D⁰→Kπ

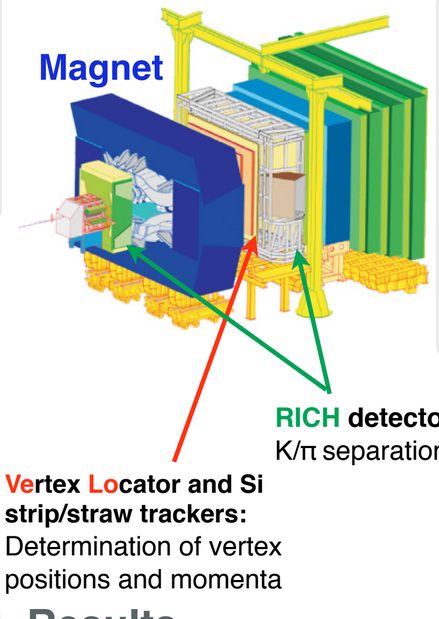
$$R_{ADS} = \frac{\Gamma(B^{\pm}\to [\pi K]_D K^{\pm})}{\Gamma(B^{\pm}\to [K\pi]_D K^{\pm})}$$

GLW: (CP eigenstates)
D⁰→KK,ππ

$$R_{CP+} = \frac{\Gamma(B^{\pm}\to [KK,\pi\pi]_D K^{\pm})}{\Gamma(B^{\pm}\to [K\pi]_D K^{\pm})}$$

$$A_{CP+} = \frac{\Gamma(B^{-}\to D_{CP}K^{-}) - \Gamma(B^{+}\to D_{CP}K^{-})}{\Gamma(B^{-}\to D_{CP}K^{-}) + \Gamma(B^{+}\to D_{CP}K^{+})}$$

Candidate selection

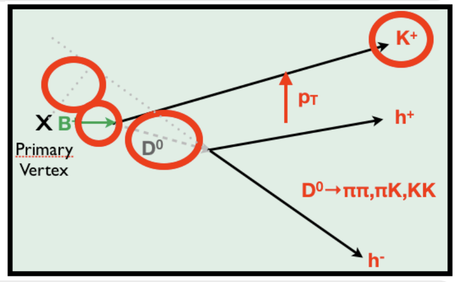


RICH detectors:
K/π separation

Vertex Locator and Si strip/straw trackers:
Determination of vertex positions and momenta

Employ full 2011 LHCb dataset ($1fb^{-1}$) and apply a 20-variable boosted decision tree, trained on signal MC and 2010 data sidebands.

The most effective variables are flight distances (of the B± and D⁰), impact parameters, requirements on p_t and on B± and D⁰ vertex qualities.



Results

ADS analysis: $B^{\pm}\to D^0$ (→Kπ) $K^{\pm}$

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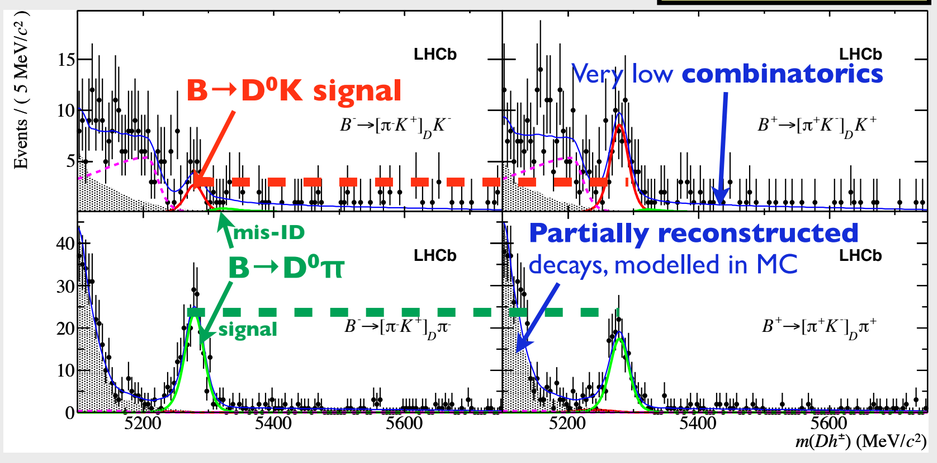

First observation of the suppressed ADS mode
Direct CP violation observed in $B^-\to D^0K^-$ with **5.8σ significance**

Summary

1) CKM phase γ is the least well known CKM phase: 12°
2) Observe direct CPV in B→D(Kπ)K at 5.8σ and non-zero B→D(hh)K CPV at 4.5σ
3) Prepare to reduce γ ambiguities using Dalitz analysis of **B→D(K_S π π)K**

GLW analysis:
$B^{\pm}\to D^0$ (→hh) $K^{\pm}$
h=π,K

Combined non-zero $B^{\pm}\to DK^{\pm}$ CPV significance is **4.5σ**

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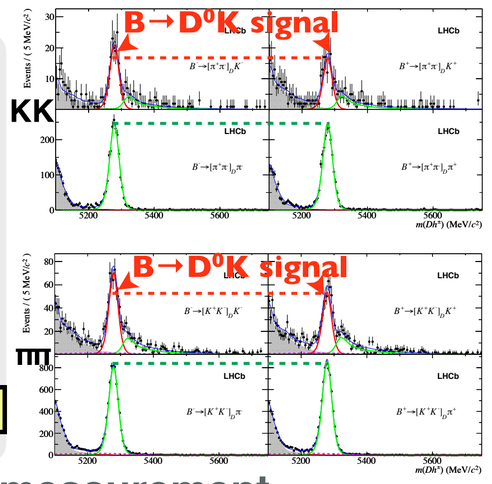
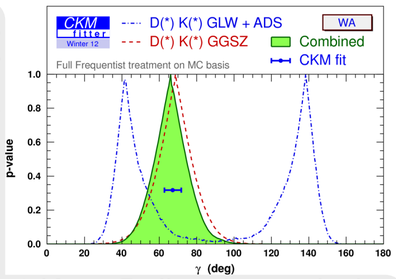


Outlook for γ measurement

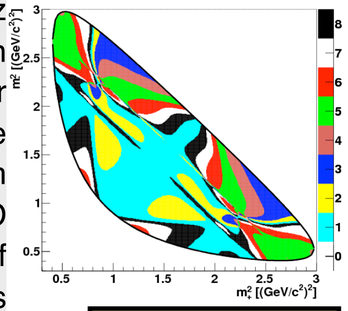
A four-fold γ ambiguity is intrinsic to the ADS/GLW approach. This can be reduced using other final states of the D⁰ meson, e.g. $K_S\pi^+\pi^-$



Study of $B^{\pm}\to D^0$ (→$K_S\pi^+\pi^-$) $K^{\pm}$ ⇒ Dalitz plot analysis.

Dalitz Plots display multi-body phase space. They are constructed by taking two pairs of the three final particles, adding their four-momenta, and then determining the invariant mass squared of the sum.

As well as the 'weak phase' γ, a 'strong phase' enters from the strong decay of the D⁰. This phase depends upon position in the Dalitz plot. The strong phase can be taken from a model or averaged in regions (see right) of the Dalitz plot from charm studies at the CLEO experiment, independent of a model. A Dalitz analysis can then be performed at LHCb to obtain γ.



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