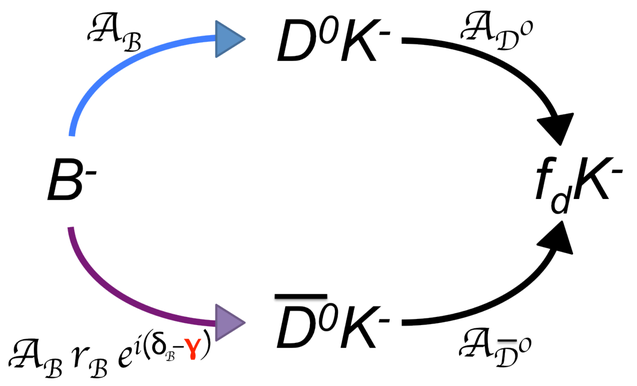
Towards a model-independent measurement of γ through $B^{\pm}\to D(\to 4\pi)K^{\pm}$ decays with LHCb and CLEO-c

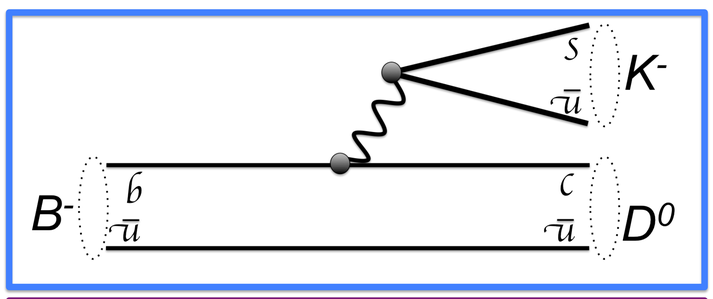
Claire Prouve, Jonas Rademaker – University of Bristol

Measurement of CKM angle γ through interference in $B^{\pm}\to D(\to f_D)K^{\pm}$

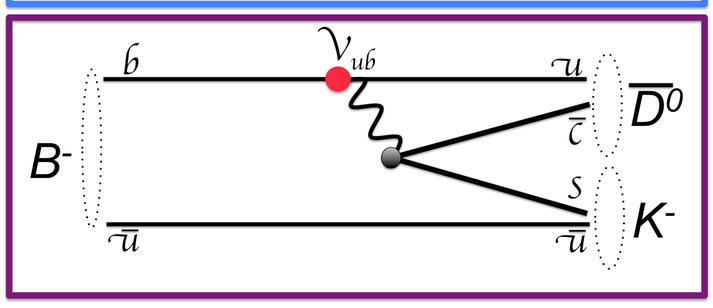


final state accessible to both D^0 and $\overline{D}^0$

$B^-\to D^0K^-$:



$B^-\to \overline{D}^0K^-$: colour surpressed



Partial decay width

$$d\Gamma(B\to D^0(\to f_D)K^-)\propto A_B^2\cdot\Big(A_{D^0}^2+r_B^2A_{\bar{D}^0}^2+2r_B\,\mathbb{R}(A_{D^0}A_{\bar{D}^0}^*\,e^{-i(\delta_B-\gamma)})\Big)dp$$

γ becomes an observable in the interference term

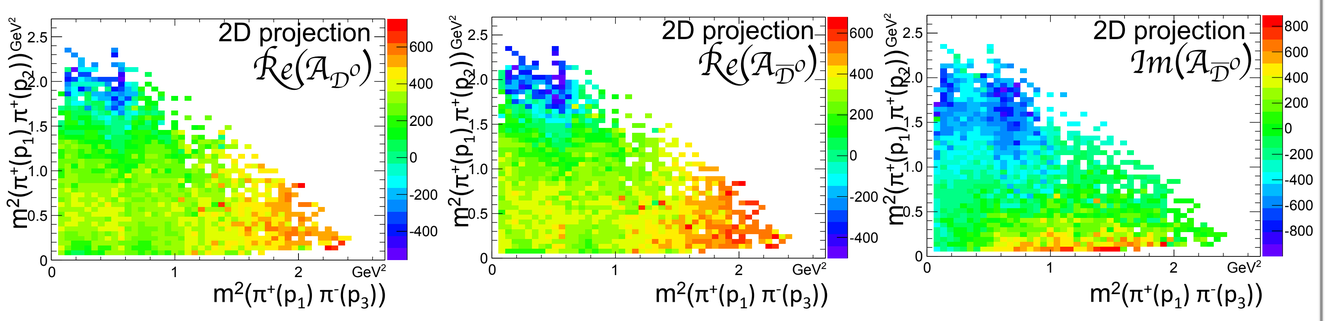
Reconstruction of the D mesons in self- conjugate final state $f_D = \pi^+(p_1)\,\pi^+(p_2)\,\pi^-(p_3)\,\pi^-(p_4)$

CP-conjugation*

$$A_{\bar{D}^0}(\pi^+(\vec{p_1})\pi^+(\vec{p_2})\pi^-(\vec{p_3})\pi^-(\vec{p_4})) = e^{i\Delta\delta(\vec{p_1},\vec{p_2},\vec{p_3},\vec{p_4})}A_{D^0}(\pi^+(-\vec{p_3})\pi^+(-\vec{p_4})\pi^-(-\vec{p_1})\pi^-(-\vec{p_2}))$$
$$\equiv e^{i\Delta\delta}\,\overline{A_{D^0}}$$

→ strong phase difference between A_{D^0} and $A_{\bar{D}^0}$

All amplitudes and phases depend on the point in phase space
→ **Dalitz plot analysis in 5 dimensions**



In order to extract **γ** the analysis has to be performed in bins of phase space.

Binned decay width:

$$\frac{d\Gamma}{dp_i+\Delta p}\propto 2r_B\Big[c_i\cos(\delta_B-\gamma)+s_i\sin(\delta_B-\gamma)\Big]$$

$$c_i=\frac{1}{N}\int_{p_i}^{p_i+\Delta p}dp\,\frac{d\Phi}{dp}\,A_{D^0}\,\overline{A_{D^0}}\,\cos(\Delta\delta)$$

amplitude-weighted average of cos(Δδ)

$$s_i=\frac{1}{N}\int_{p_i}^{p_i+\Delta p}dp\,\frac{d\Phi}{dp}\,A_{D^0}\,\overline{A_{D^0}}\,\sin(\Delta\delta)$$

amplitude-weighted average of sin(Δδ)

(*) Assuming no CP-V in the D decays and neglecting 2nd order effects from charm mixing.

Model independent determination of c_i and s_i with CLEO-c using correlated D meson pairs from Ψ(3770)→DD

c_i : Reconstruct D→4π as flavour or CP eigenstate by using **opposite side tagging** → combine information of **CP ($M^{\pm}_i$)** and **flavour (K_i)** Dalizt plots

Ψ(3770)

Flavour/ CP eigenstate ($\pi^+(p_1)\,\pi^+(p_2)\,\pi^-(p_3)\,\pi^-(p_4)$)

$$M_i^{\pm}=h_{CP\pm}\left(K_i\pm 2c_i\sqrt{K_iK_{\bar{i}}}+K_{\bar{i}}\right)$$

s_i : Reconstruct Ψ(3770)→(DD)→(4π)(4π′) and use **interference effects between both possible decay paths**

Ψ(3770)

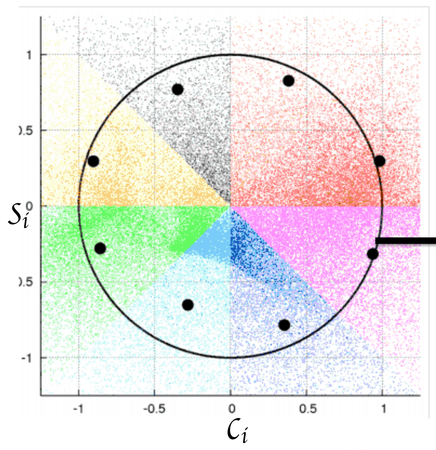
($\pi^+(p'_1)\,\pi^+(p'_2)\,\pi^-(p'_3)\,\pi^-(p'_4)$) ($\pi^+(p_1)\,\pi^+(p_2)\,\pi^-(p_3)\,\pi^-(p_4)$)

Event rate in i^{th} bin of first and j^{th} bin of second Dalitz plot:

$$M_{ij}=h_{corr}\Big(K_iK_{\bar{j}}+K_{\bar{i}}K_j-2\sqrt{K_iK_{\bar{j}}K_{\bar{i}}K_j}\,(c_ic_j+s_is_j)\Big)$$

Model inspired binning

The highest sensitivity to γ can be obtained by using **bins with minimal variation of Δδ**.



colours correspond to bins of Δδ

$$d\Gamma_i\ \propto\ c_i\cos(\delta_B-\gamma)+s_i\sin(\delta_B-\gamma)$$

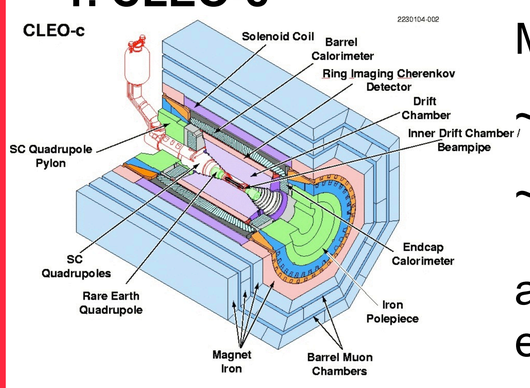
The more Δδ varies over a bin, the smaller $|c_i|$ and $|s_i|$.
$\langle c_i\rangle$ = 0.04 $\langle s_i\rangle$ = -0.01

Obtain Δδ by applying a model for $\mathcal{A}_{\mathcal{D}^0}$ obtained from CLEO-c.

Note: The binning only influences **the sensitivity** of the γ measurement but **not the γ value itself**.

Analysis procedure for the future:

1. CLEO-c



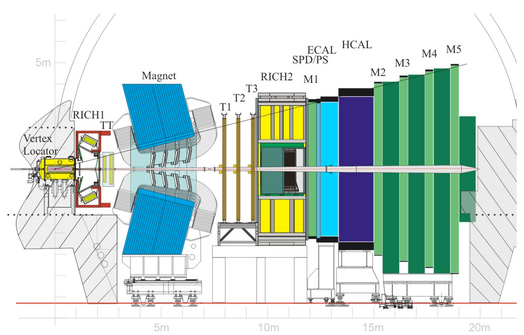
Measurement of c_i and s_i using

~ 9500 flavour tagged

~ 1000 CP tagged $D(\to 4\pi)$ events

and performing a 5 dimensional fit for each bin in phase space.

2. LHCb



Simultaneous fit of r_B, δ_B and γ in all bins of phase space using

a few 10^3 $B^{\pm}\to D(\to 4\pi)K^{\pm}$ events

and the c_i and s_i extracted from CLEO-c.