Expanding Model Independent Approaches for Measuring the CKM angle γ at LHCb

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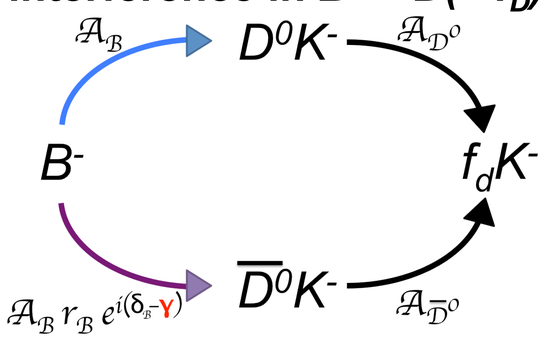
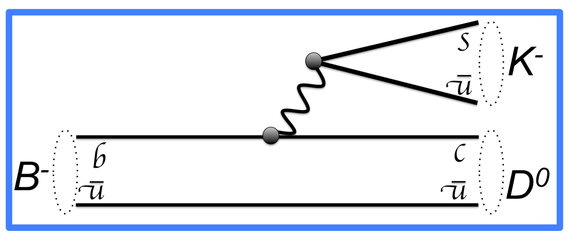
Measurement of CKM angle γ through interference in $B^{\pm}\to D(\to f_D)K^{\pm}$

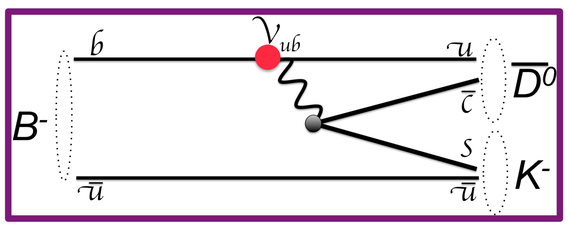


f_d: (**4-body**) final state accessible to both D^0 and $\overline{D}^0$

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



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



Partial decay width

$$d\Gamma_{B^-}(\mathbf{x}) \propto A^2_{D^0}(\mathbf{x}) + r_B^2 A^2_{\bar{D}^0}(\mathbf{x}) + 2A_{D^0}(\mathbf{x})A_{\bar{D}^0}(\mathbf{x})\left[x_- cos(\Delta\delta(\mathbf{x})) + y_- sin(\Delta\delta(\mathbf{x}))\right]$$

$$x_- = r_B\cos(\delta_B-\gamma) \qquad y_- = r_B\sin(\delta_B-\gamma)$$

γ becomes an observable through interference

Binned phase-space for the D decay

$$\mathcal{A}_{D^0}(\mathbf{x}) = A_{D^0}(\mathbf{x})e^{i\delta_{D^0}(\mathbf{x})} \qquad \Delta\delta(\mathbf{x}) = \delta_{D^0}(\mathbf{x}) - \delta_{\bar{D}^0}(\mathbf{x})$$

$$d\Gamma_{B^-}(\mathbf{x}) \propto A^2_{D^0}(\mathbf{x}) + r_B^2 A^2_{\bar{D}^0}(\mathbf{x}) + 2A_{D^0}(\mathbf{x})A_{\bar{D}^0}(\mathbf{x})\left[x_- cos(\Delta\delta(\mathbf{x})) + y_- sin(\Delta\delta(\mathbf{x}))\right]$$

easy — difficult — to determine

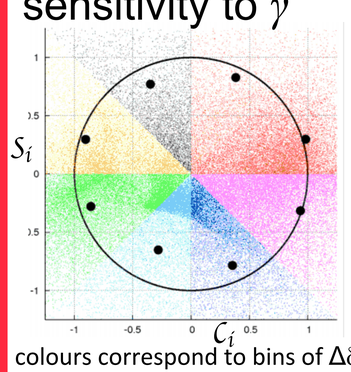
Binned five-dimensional phase-space:

$$N_i(B^-\to D^0K^-) \propto h\left(K_i + r_B^2K_{-i} + 2\sqrt{K_iK_{-i}}\left[x_-c_i + y_-s_i\right]\right)$$

$$c_i = \frac{\int_i A_{D^0}(\mathbf{x})A_{\bar{D}^0}(\mathbf{x})\cos(\Delta\delta(\mathbf{x}))d\mathbf{x}}{\sqrt{\int_i A^2_{D^0}(\mathbf{x})d\mathbf{x}\int_i A^2_{\bar{D}^0}(\mathbf{x})d\mathbf{x}}} \qquad K_i = \int_i A^2_{D^0}(\mathbf{x})d\mathbf{x}$$

Model inspired binning:

bins with minimal variation of Δδ ➔ highest sensitivity to γ



colours correspond to bins of Δδ

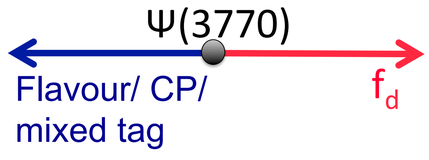
$\langle c_i\rangle = 0.04$

$\langle s_i\rangle = -0.01$

➔ use amplitude model to find the binning

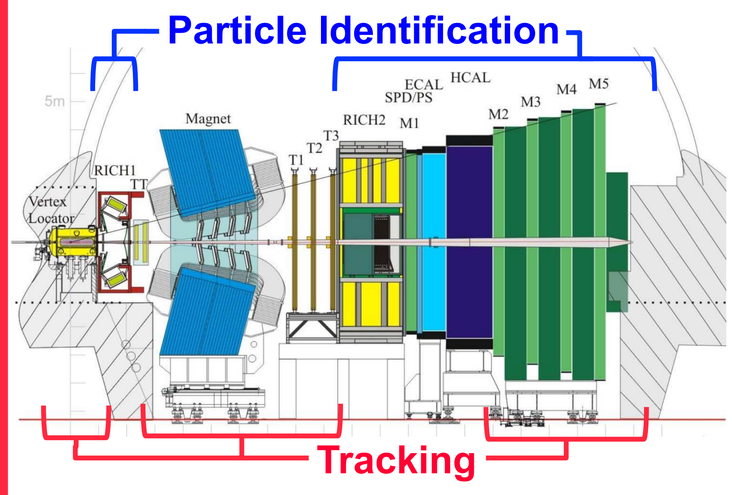
Model independent c_i and s_i:

- CLEO-c
- Correlated D^0-$\overline{D}^0$ decays



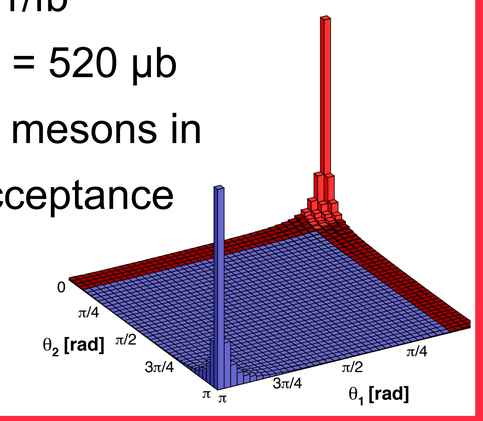
Binning influences **the sensitivity not the value of γ!**

The LHCb Experiment



Run II:

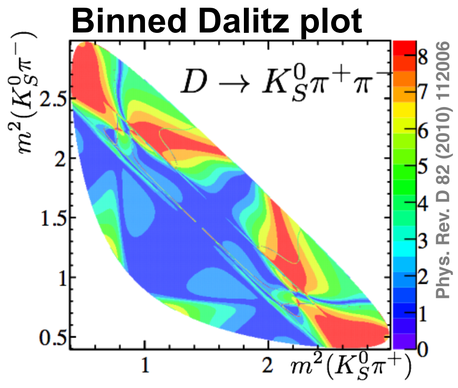
- $\mathcal{L}_{int}$ ~ 1.99 1/fb
- σ_{bb}(13TeV) = 520 μb
- $2.3\cdot10^{11}$ $B^{\pm}$ mesons in detector acceptance

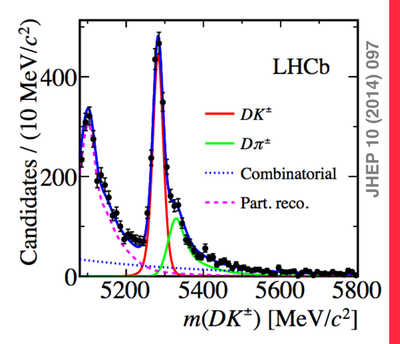


Current results

D→ $K_S\pi^+\pi^-$:

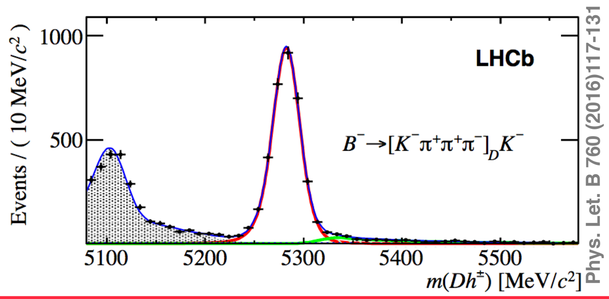
- Babar, Belle, LHCb Run I
- Binned
- Most precise measurement from single analysis
- LHCb: $\gamma = 62^{+15}_{-14}$ °

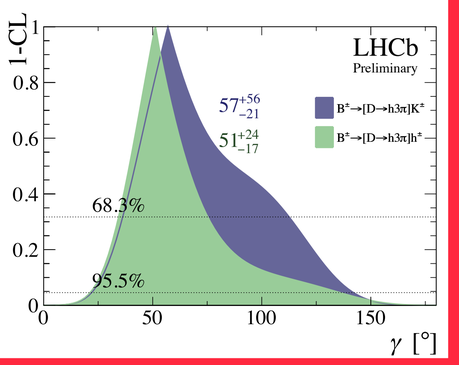




D→ $h\pi^+\pi^+\pi^-$:

- LHCb Run I
- Phase-space integrated
- $\gamma = 57^{+56}_{-21}$ °

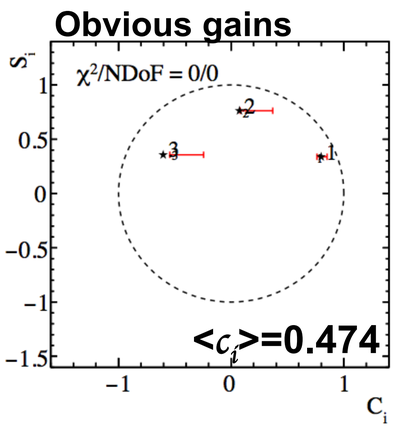


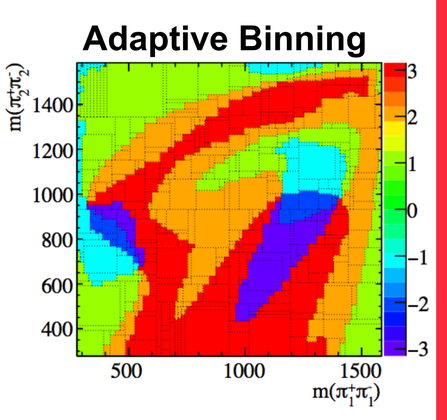


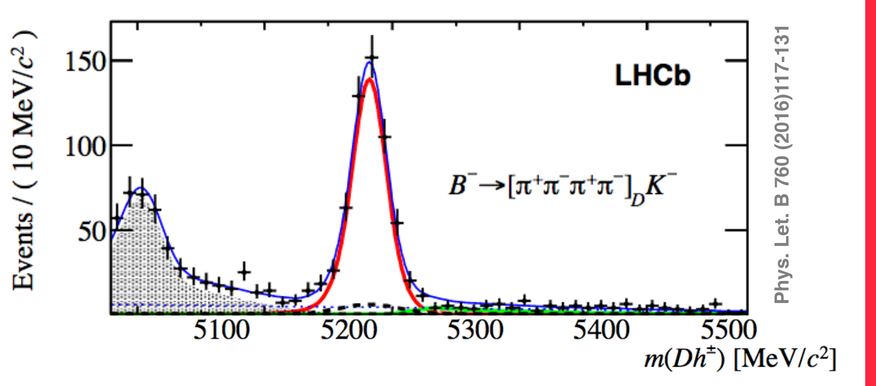
Future prospects

D→ $\pi^+\pi^-\pi^+\pi^-$:

- Self-conj. state → GGSZ
- Expect gain from binned analysis
- **5k $B^{\pm}\to D(\to4\pi)K^{\pm}$ events** after reconstruction and selection 2015 + 2016
- 5-dimensional phase-space **➔ adaptive binning**
- Similar sensitivity to γ as from D→$K_S\pi^+\pi^-$

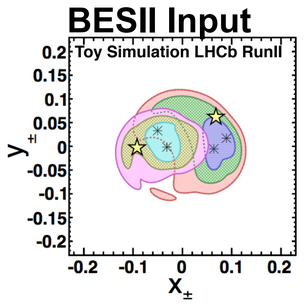


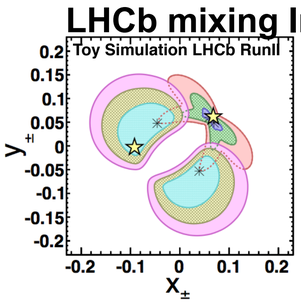


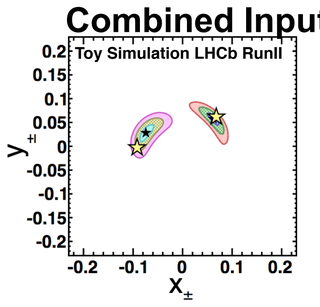


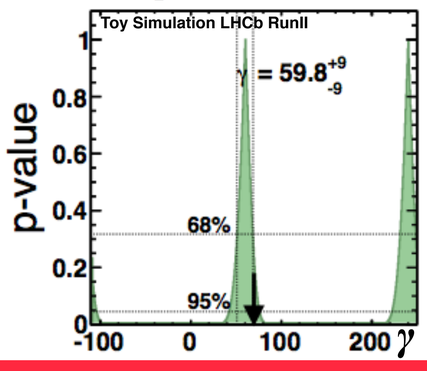
D→ $K^-\pi^+\pi^-\pi^+$:

- ADS mode
- 10× higher BR than D→$\pi^+\pi^-\pi^+\pi^-$
- Possible further input:
  - BESIII
  - LHCb D^0-D^0 mixing









Toy simulation with expected LHCb statistics at the end of Run II : $\sigma(\gamma) \sim 9°$