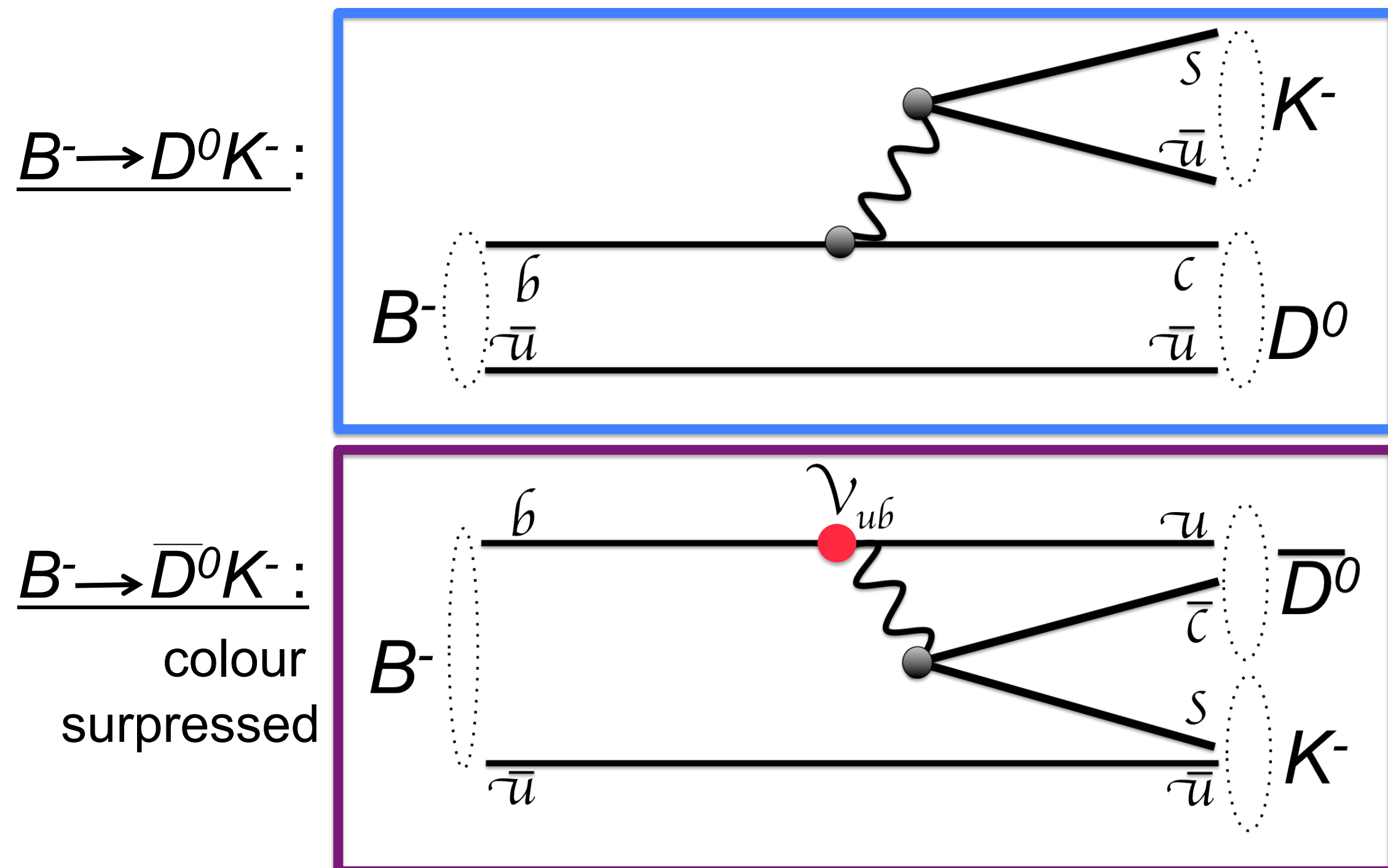
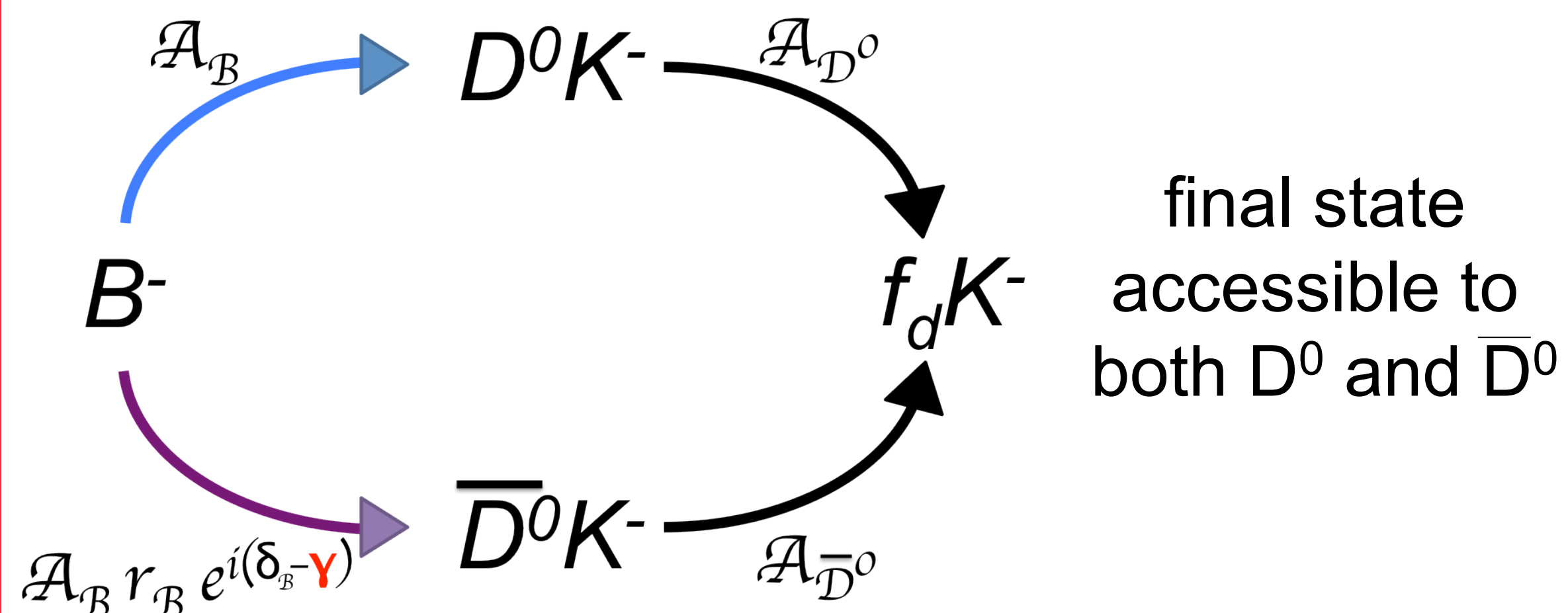


Towards a model-independent measurement of γ through $B^\pm \rightarrow D(\rightarrow 4\pi)K^\pm$ decays with LHCb and CLEO-c

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



Partial decay width

$$d\Gamma(B \rightarrow D^0(\rightarrow f_D)K^-) \propto A_B^2 \cdot \left(A_{D^0}^2 + r_B^2 A_{\bar{D}^0}^2 + 2r_B \Re(A_{D^0} A_{\bar{D}^0}^* e^{-i(\delta_B - \gamma)}) \right) dp$$

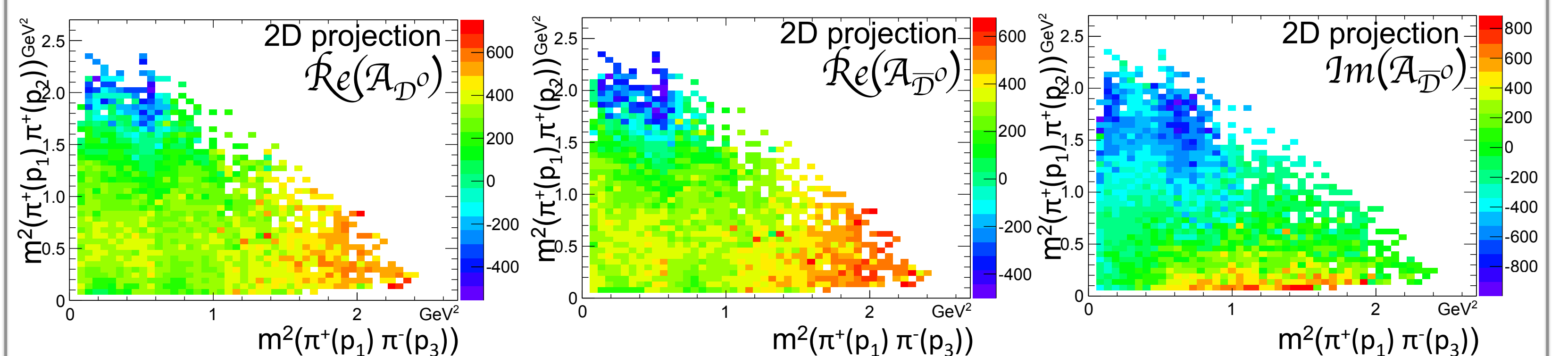
γ becomes an observable in the interference term

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

$$A_{D^0}(\pi^+(p_1)\pi^+(p_2)\pi^-(p_3)\pi^-(p_4)) \stackrel{\text{CP-conjugation}^*}{=} e^{i\Delta\delta(p_1, p_2, p_3, p_4)} A_{D^0}(\pi^+(-p_3)\pi^+(-p_4)\pi^-(-p_1)\pi^-(-p_2)) \equiv e^{i\Delta\delta} \overline{A_{D^0}}$$

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

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:

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

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

amplitude-weighted average of $\cos(\Delta\delta)$

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

amplitude-weighted average of $\sin(\Delta\delta)$

(*) 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 $\Psi(3770) \rightarrow DD$

c_i : Reconstruct $D \rightarrow 4\pi$ as flavour or CP eigenstate by using **opposite side tagging** and combine information of **CP (M_i^\pm)** and **flavour (K_i)** Dalitz plots

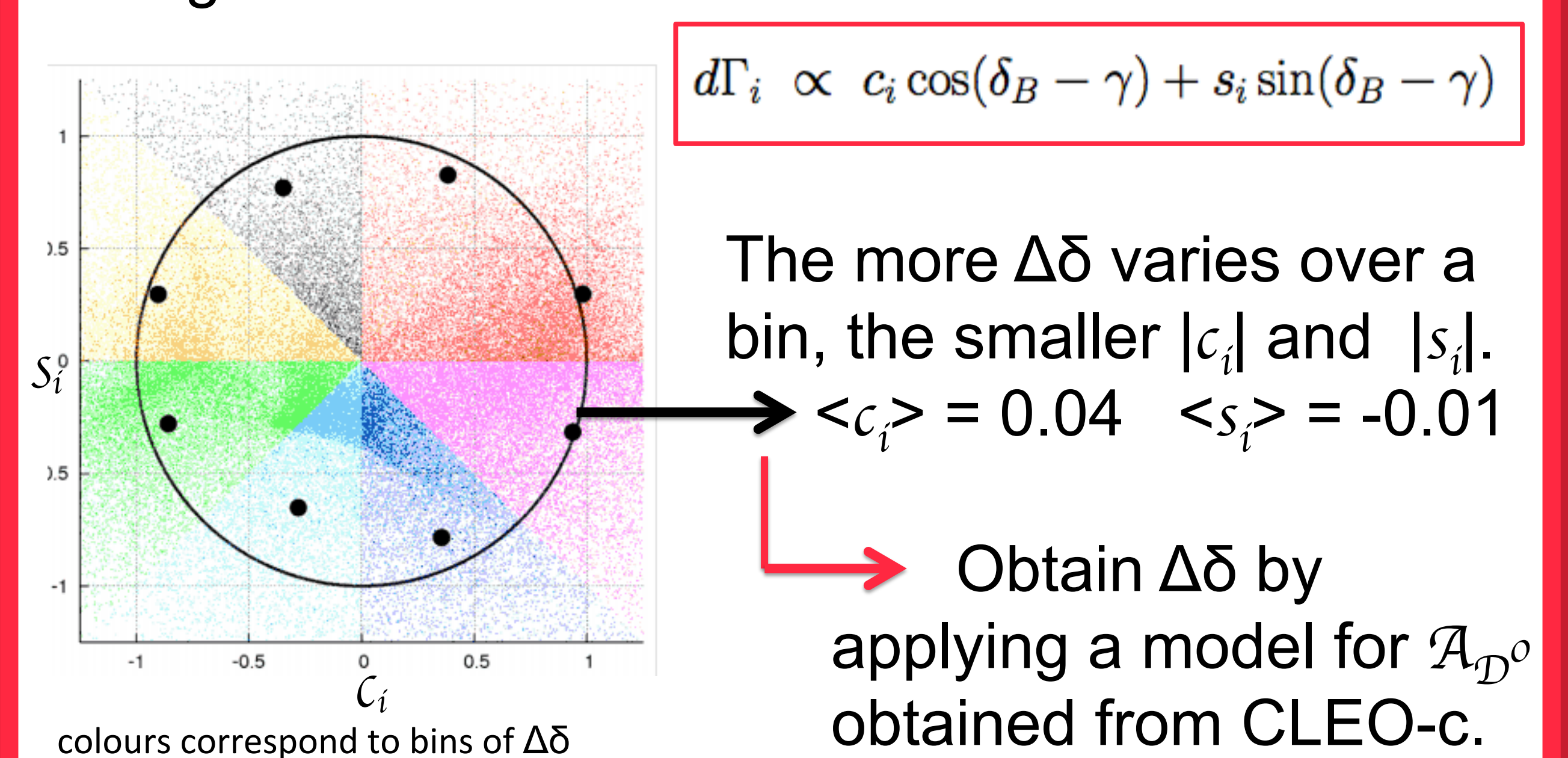
$$M_i^\pm = h_{CP^\pm} \left(K_i \pm 2c_i \sqrt{K_i K_i} + K_i \right)$$

s_i : Reconstruct $\Psi(3770) \rightarrow (DD) \rightarrow (4\pi)(4\pi')$ and use **interference between both possible decay paths**

$$M_{ij} = h_{corr} \left(K_i K_j + K_i K_j - 2\sqrt{K_i K_j K_i K_j} (c_i c_j + s_i s_j) \right)$$

Model inspired binning

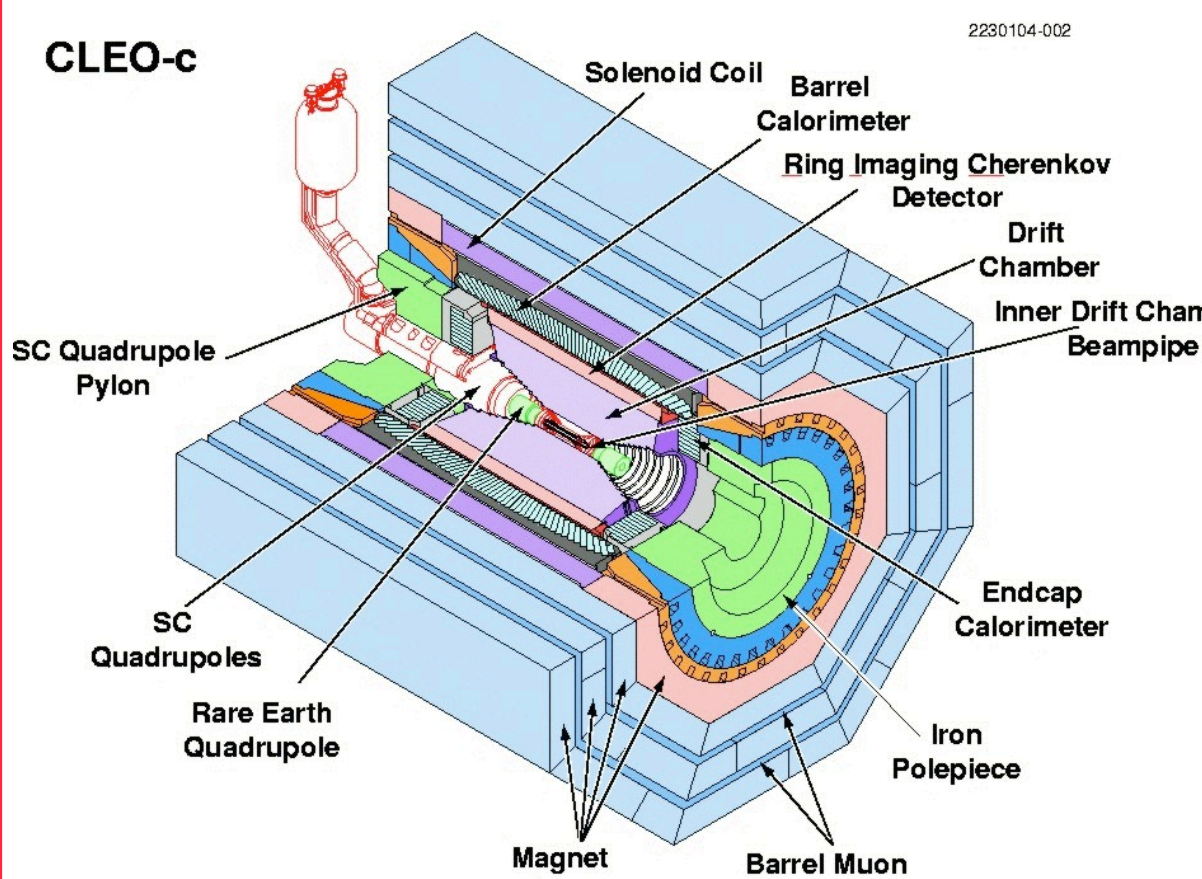
The highest sensitivity to γ can be obtained by using **bins with minimal variation of $\Delta\delta$** .



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

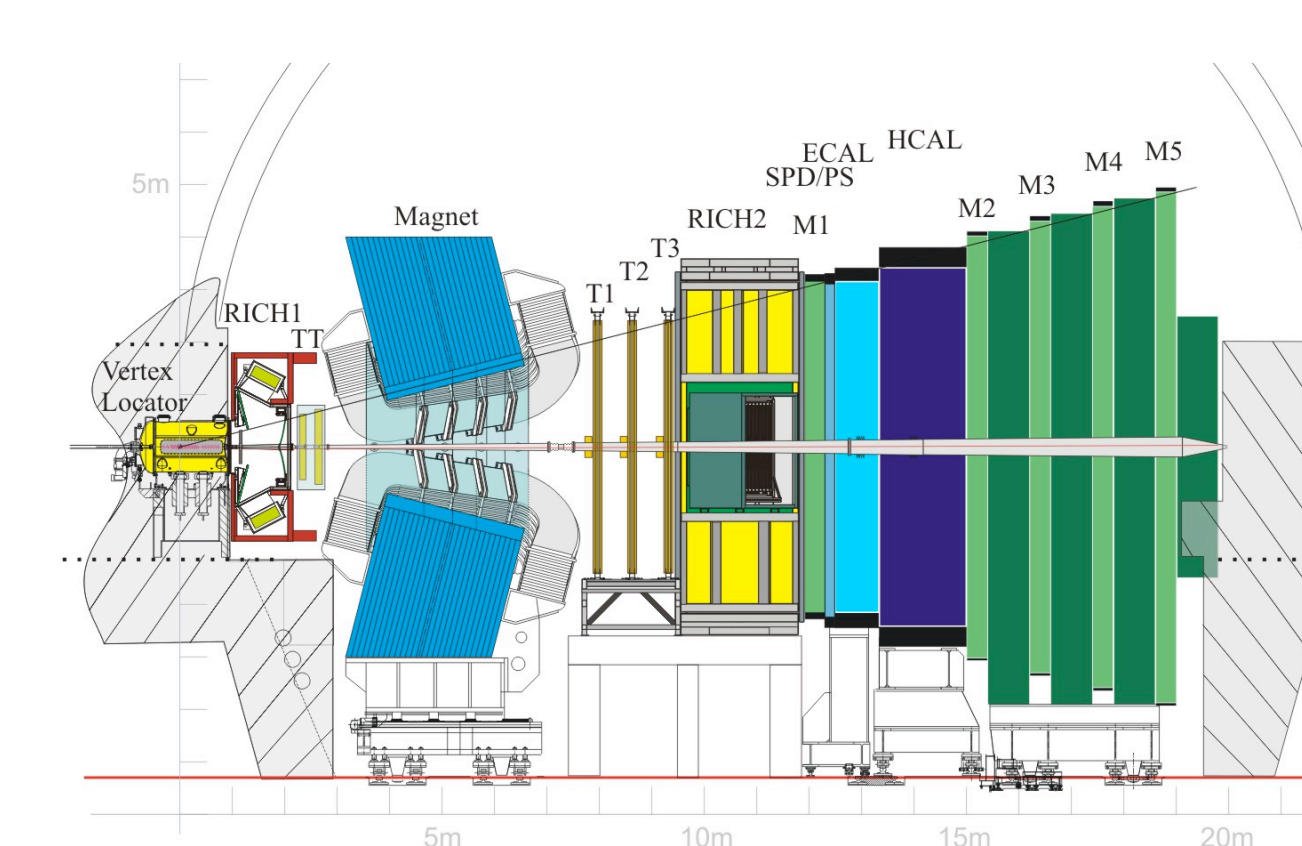
~ 9500 flavour tagged

~ 1000 CP tagged

$D(\rightarrow 4\pi)$ 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 $B^\pm \rightarrow D(\rightarrow 4\pi)K^\pm$ events

and the c_i and s_i extracted from CLEO-c.