

Methods for measuring γ at tree-level

CP Violation Seminar

Krzysztof Janas



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Short introduction

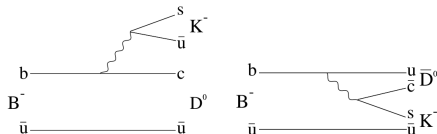
There is two main ways to measure γ on LHCb:

- direct CPV - CPV in decay (time-independent measurements),
- indirect CPV - CPV in mixing (time-dependent measurements),

with analysis different B mesons decays.

Both method use process at tree-level, what means that there is any loop in Feynman diagrams.

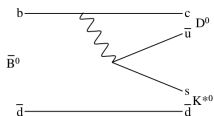
Time-integrated measurements of $B^- \rightarrow DK^-$



- $B^- \rightarrow D^0 K^-$
- It depends on V_{cb}
- $B^- \rightarrow \bar{D}^0 K^-$
- It depends on V_{ub}
- Colour suppression
- The weak-phase difference between V_{ub} and V_{cb} is $-\gamma$.¹
- Interference between these two amplitudes when the D^0 or \bar{D}^0 decay to the same final state gives sensitivity to $-\gamma$.

¹This is assuming that there is a negligible weak-phase difference between V_{us} and V_{cs} , which is a good approximation in the three-generation quark model.

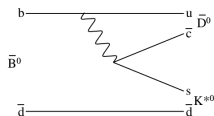
Time-integrated measurements of $\bar{B}^0 \rightarrow DK^{*0}$



- $\bar{B}^0 \rightarrow D^0 K^{*0}$

- It depends on V_{cb}

- Colour suppression



- $\bar{B}^0 \rightarrow \bar{D}^0 K^{*0}$

- It depends on V_{ub}

- Colour suppression

Both diagrams are colour colour suppressed, which

- reduces the branching fraction, but
- increases the size of the interference.

Different D -decay modes

The measurement of γ with $B^- \rightarrow DK^-$ depends on D -decay modes.

- GLW - Gronau, London and Wyler - final states: $\pi^+\pi^-$ or K^+K^- ;
- ADS - Atwood, Dunietz and Soni - final states: π^+K^- or π^-K^+ ;
- Dalitz plot analyses with $D \rightarrow K_S^0\pi^+\pi^-$ (more complicated).

Parameters in time-integrated measurements

as an example: GVL method

Additional parameters in time-integrated measurements:

- r_B - ratio between the magnitude of the suppressed amplitude and the favoured amplitude; the size of r_B governs the amount of interference and hence the sensitivity of measurement to γ .
- δ_B - the strong-phase difference between two amplitudes.

Parameters in time-integrated measurements

as an example: GVL method

The results of measurements of the $B \rightarrow DK^-$ GLW modes are presented in terms of the asymmetries A_{\pm} and ratios R_{\pm} :²

$$\begin{aligned} A_{\pm} &= \frac{\Gamma(B^- \rightarrow D_{\pm}K^-) - \Gamma(B^+ \rightarrow D_{\pm}K^+)}{\Gamma(B^- \rightarrow D_{\pm}K^-) + \Gamma(B^+ \rightarrow D_{\pm}K^+)} \\ &= \frac{\pm 2r_B \sin \delta_B \sin \gamma}{1 + r_B^2 \pm 2r_B \cos \delta_B \cos \gamma} \\ R_{\pm} &= 2 \frac{\Gamma(B^- \rightarrow D_{\pm}K^-) + \Gamma(B^+ \rightarrow D_{\pm}K^+)}{\Gamma(B^- \rightarrow D^0K^-) + \Gamma(B^+ \rightarrow D^0K^+)} \\ &= 1 + r_B^2 \pm 2r_B \cos \delta_B \cos \gamma \end{aligned}$$

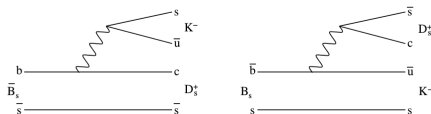
Only three of these parameters are independent: $A_+R_+ = -A_-R_-$.

²Where D_{\pm} denotes a decay of a D^0 or \bar{D}^0 to a CP_{\pm} eigenstate

- convention: $D_{\pm} = \frac{1}{2}(D^0 \pm \bar{D}^0)$

Time-dependent measurements of $\bar{B}_s^0 \rightarrow D_s^\pm K^\mp$

Measurements of the time-dependent CP asymmetries in $\bar{B}_s^0 \rightarrow D_s^\pm K^\mp$ allows $\gamma - \varphi_M$ to be determined. The φ_M is the B_s^0 mixing phase, it can be measurement in $\bar{B}_s^0 \rightarrow J/\psi\phi$ decay.



The tree-level sensitivity to γ arises from the interference between the direct decay of B_s^0 and \bar{B}_s^0 to $D_s^+ K^-$ and decay after mixing.

Other time-dependent CP asymmetries in $B^0 \rightarrow D^\pm \pi^\mp$ allow $\gamma + 2\beta$ to be measured (similar formalism, a bit different practice).

Results

Results received by two collaborations:

Parameter	UTfit	CKMfitter
γ	$(78 \pm 12)^\circ$	$(70_{-29}^{+27})^\circ$
r_B	0.102 ± 0.017	$0.087_{-0.018}^{+0.022}$
δ_B	–	$(110_{-27}^{+22})^\circ$