Time-dependent CP-violation measurements in $B^0 \to D^+D^-$ decays at LHCb

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Theory

One of the key goals of LHCb is overconstraining the **unitarity triangle** (UT), whose area is a measure for the amount of ***CP* violation** in the Standard Model.

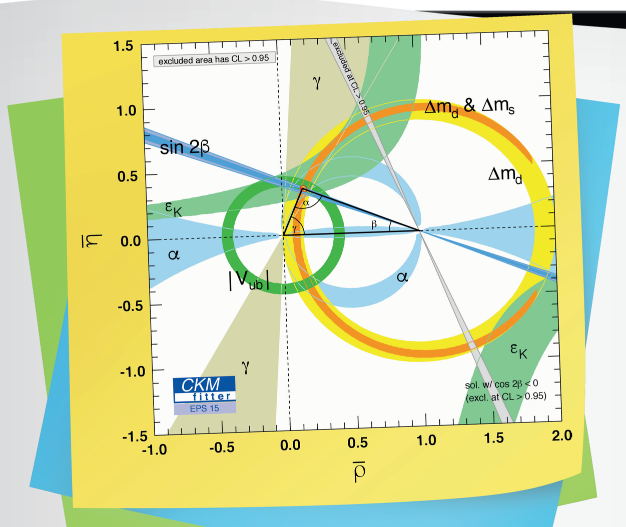
Interference in **mixing** and **decay** of B mesons causes **time-dependent** *CP* violation.

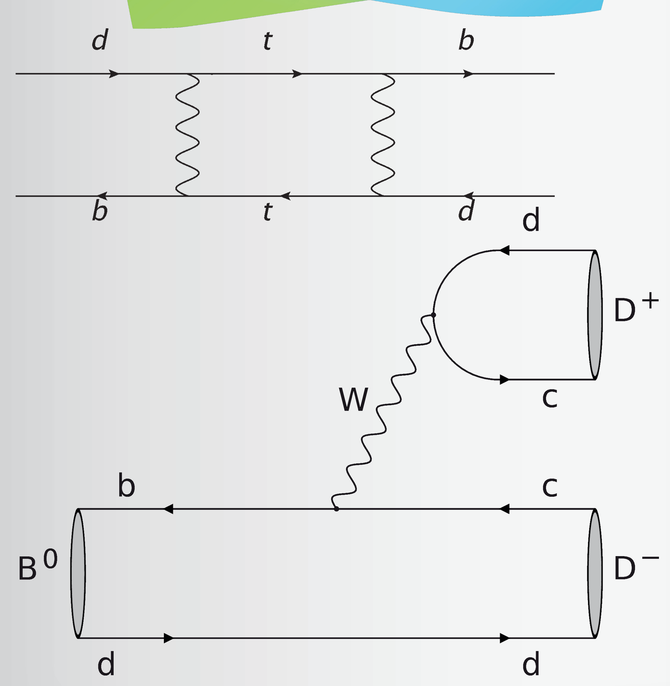
$$\frac{d\Gamma}{dt} \propto e^{-\Gamma t}\left[1 \pm C\cos(\Delta m t) \mp S\sin(\Delta m t)\right]$$

The ± refers to the two different flavors of the B meson: one with a b and anti-d quark, and one with a d and anti-b.

The ***CP*-violation observables** in this equation are C and S.

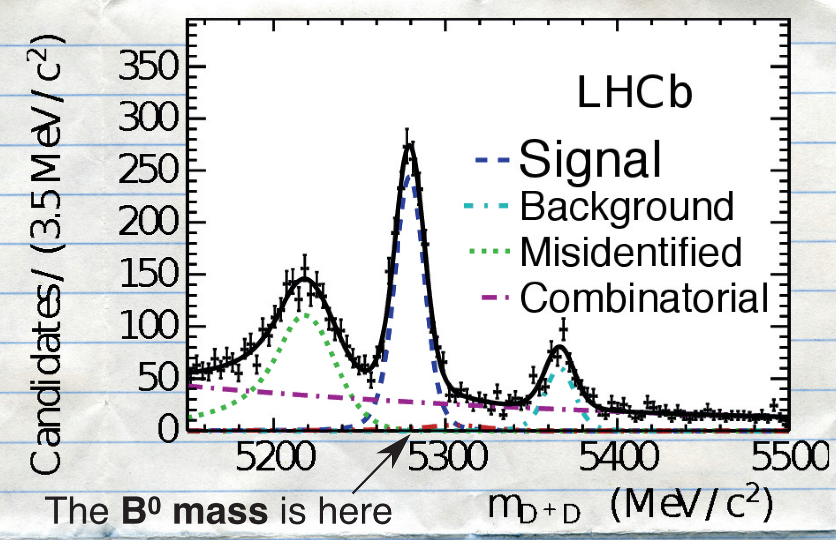
Here [1], we study the decay $B^0 \to D^+D^-$, and the measurement at hand is related to the **UT angle β**. The decay has many topologies, and deviations from the value of β as obtained from other analyses indicate contributions of higher-order diagrams, such as penguin topologies [2,3]. This allows us to constrain the contribution of these topologies.





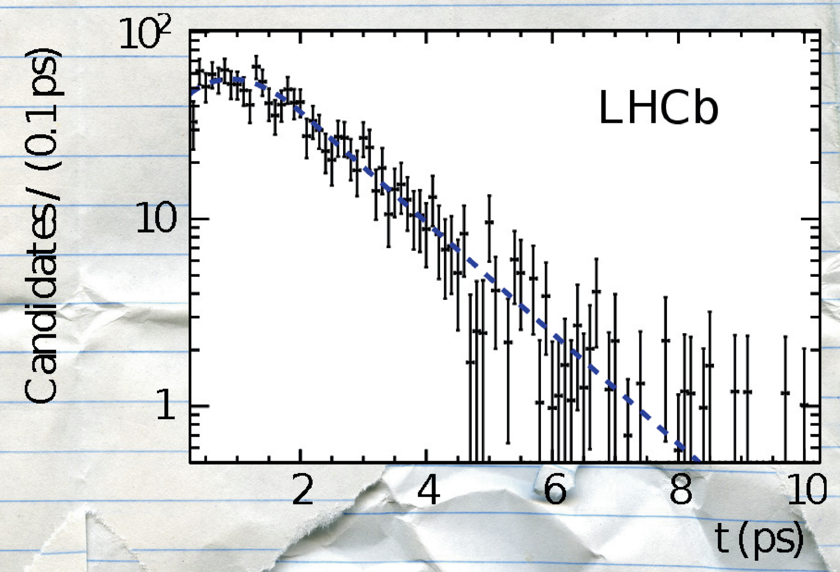
Mass Fit

Background is **statistically subtracted** using a **mass fit**, after selecting candidate events using a **multivariate analysis**. The other components visible in the plot are **misidentified** and **combinatorial** backgrounds.

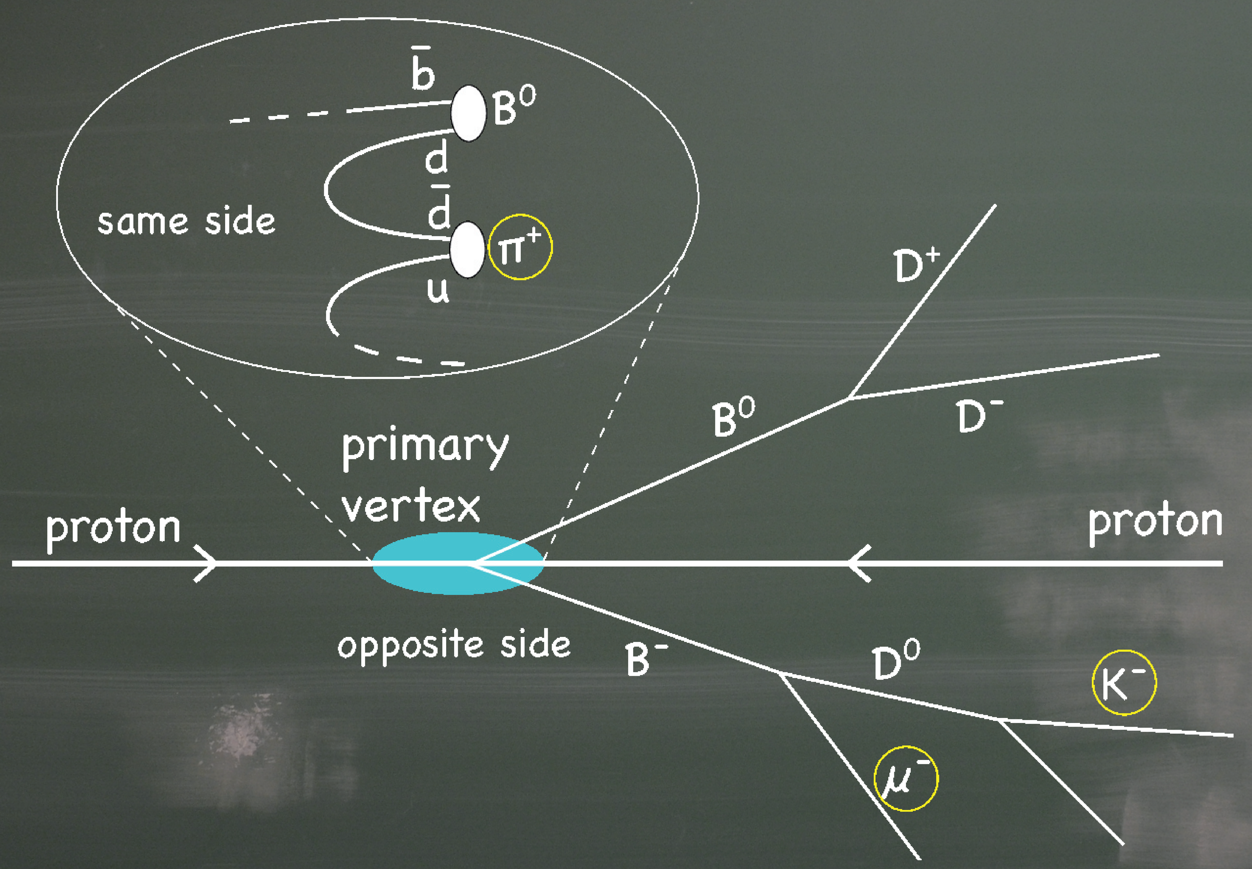


Decay-time Fit

The resulting **decay-time distribution** after the weighting is shown below.



Tagging: we need to know in which flavor the B^0's were **produced**. This is done by analysing particles accompanying the candidate event [4,5]. The **tagging power** is **(8.1 ± 0.6)%**, and the tagging is calibrated using the decay channel $B^0 \to D_s^+D^-$.



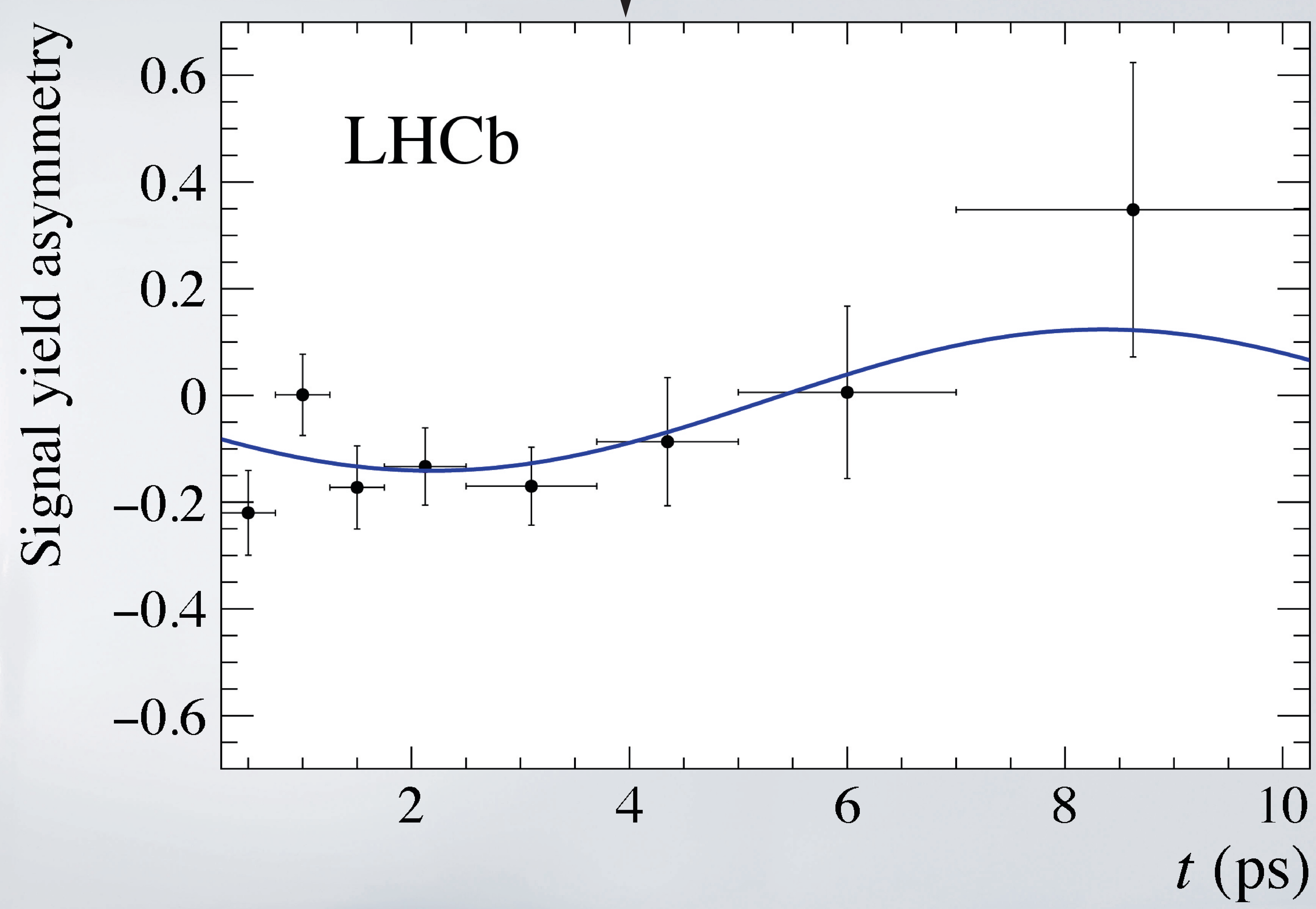
Systematics

The largest source of systematic uncertainties is the influence of singly-charmed backgrounds, such as $B^0 \to DKK\pi$.

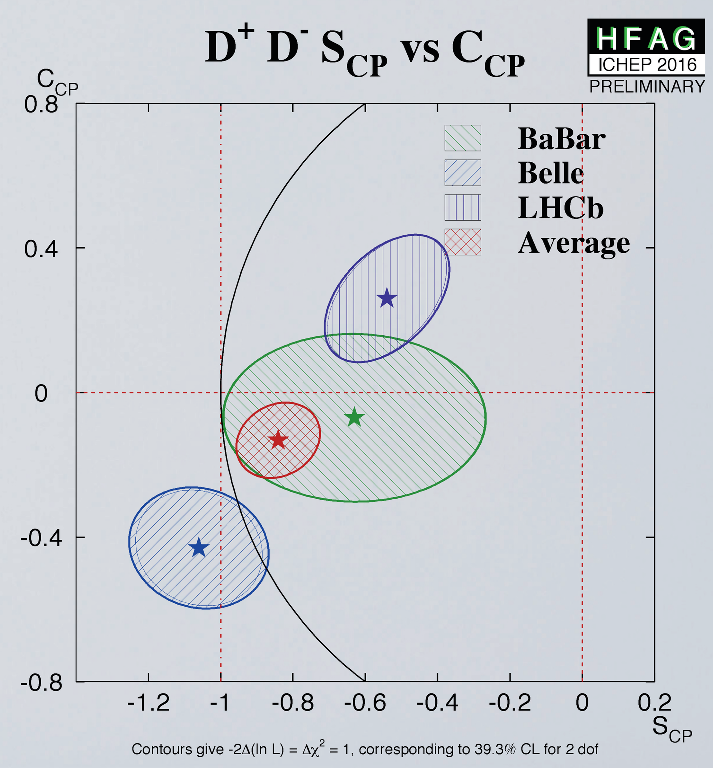
Results

$$S = -0.54\,^{+0.17}_{-0.16}\,(\text{stat.}) \pm 0.05\,(\text{syst.})$$

$$C = 0.26\,^{+0.18}_{-0.17}\,(\text{stat.}) \pm 0.02\,(\text{syst.})$$



To the left is the **time-dependent asymmetry**, the normalized difference between the number of B^0's and its anti-particle. By performing a likelihood fit to the decay-time distribution, shown above, and including tagging information in this fit, we can extract the CP observables S and C.



References
[1] LHCb Collaboration, R. Aaij *et al.*, *Measurement of CP violation in $B^0 \to D^+D^-$ decays*, in preparation
[2] M. Jung and S. Schacht, *Standard model predictions and new physics sensitivity in B → DD decays*, Phys. Rev. D91 (2015) 034027, arXiv:1410.8396
[3] L.J. Bel et al., *Anatomy of $B \to D\overline{D}$ decays*, JHEP 07 (2015) 108, arXiv:1505.01361
[4] LHCb collaboration, R. Aaij *et al.*, *Opposite-side flavour tagging of B mesons at the LHCb experiment*, Eur. Phys. J. C72 (2012) 2022, arXiv:1202.4979
[5] LHCb collaboration, R. Aaij *et al.*, *B flavour tagging using charm decays at the LHCb experiment*, JINST 10 (2015) P10005, arXiv:1507.07892

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