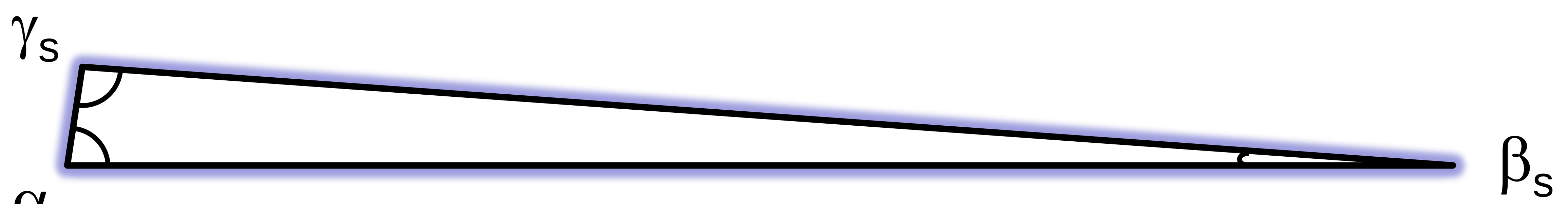

March 2012 LHCC : Student Poster Session

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Tagged time-dependent angular analysis of $B_s^0 \to J/\psi\phi$ decays at LHCb

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CKM angle ϕ_s and the golden channel $B_s^0 \to J/\psi\phi$

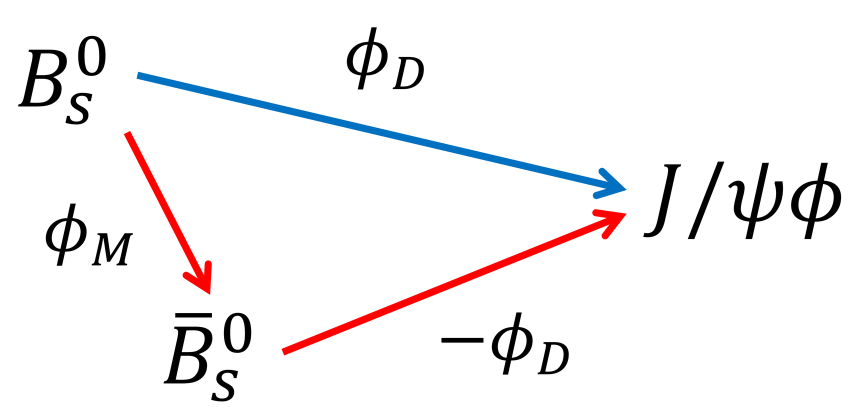
The CKM unitary triangle that can be characterised by B_s^0 meson decays is predicted to be much flatter than "the" unitary triangle (describing B^0 decays) due to the smallness of the angle, β_s.

The weak phase of the decay $B_s^0 \to J/\psi\phi$:

$$\phi_s^{J/\psi\phi} = \phi_M - 2\phi_D$$

is related, within the Standard Model (SM), to β_s and is predicted to be:

$$\phi_s^{J/\psi\phi,SM} \approx -2\beta_s = -(0.036 \pm 0.002)\ rad$$



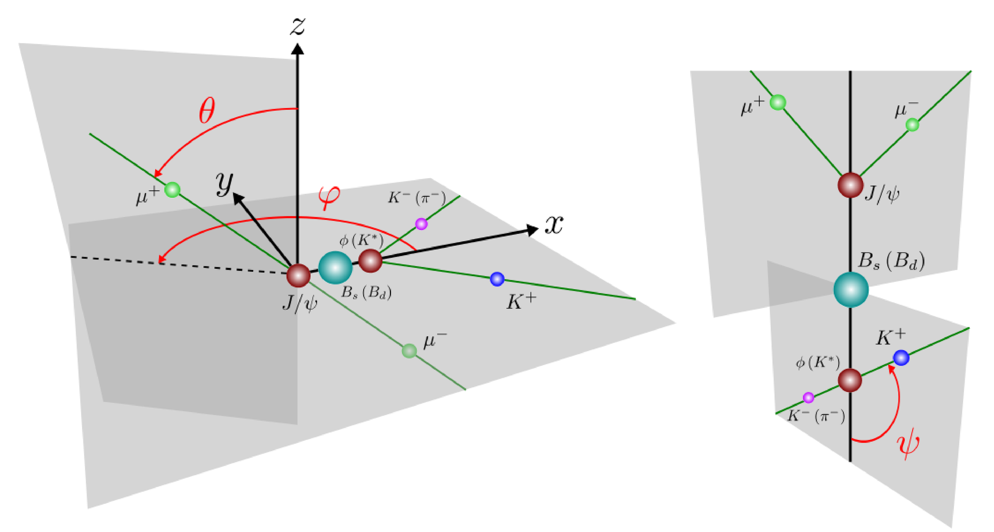
In the presence of new physics, new particles might enter in loop/box diagrams and modify the SM prediction of $\phi_s^{J/\psi\phi,SM}$ by:

$$\phi_s^{J/\psi\phi} = \phi_s^{J/\psi\phi,SM} + \phi_s^{J/\psi\phi,NP}$$

Therefore measuring ϕ_s in this channel makes $B_s^0 \to J/\psi\phi$ one of the prime decays for indirect searches of new physics.

Tagged time-dependent angular analysis

The $B_s^0 \to J/\psi\phi$ channel is made of a pseudo-scalar decaying into two vector mesons leading to an admixture of CP-even and CP-odd final states. The measurement of $\phi_s^{J/\psi\phi}$ require disentangling the CP admixture using an angular analysis of the decay products.



The differential decay rates are made of typical terms like:

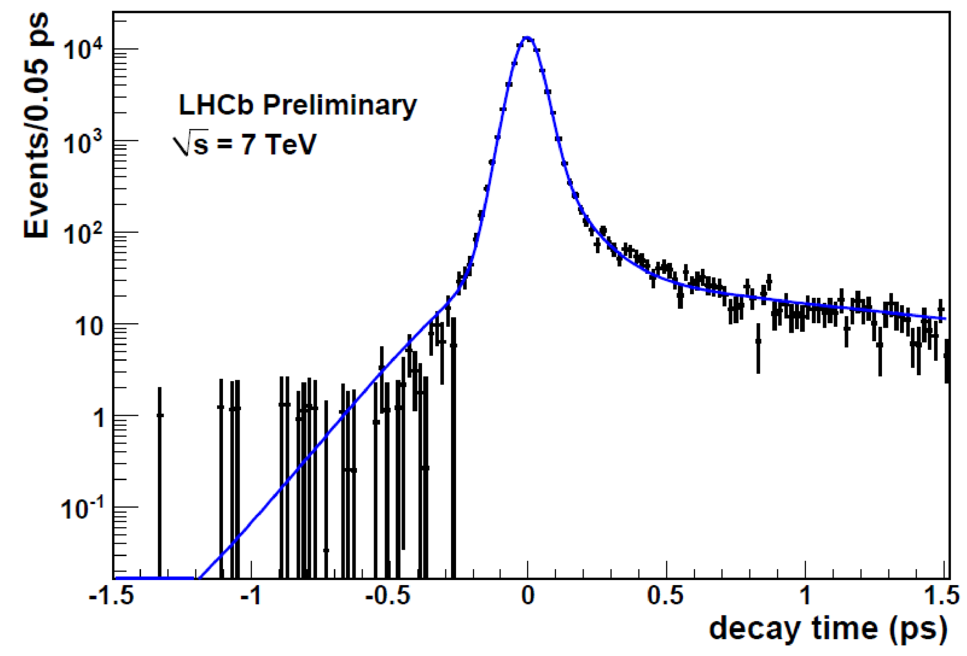
$$\sin(\phi) * D_{mistag} * D_t * \sin(\Delta m_s t)$$

where D_{mistag} is the dilution due to mistag and D_t is the dilution induced by finite decay time resolution.

In addition, angular and decay time acceptances must be taken into account.

Decay time resolution

The decay time resolution is described by a Gaussian of width $S_{\sigma_t} * \sigma_t$ where σ_t is the event-by-event decay time error and S_{σ_t} a scale factor. $< \sigma_t > \approx 45\ fs,\ S_{\sigma_t} = 1.45 \pm 0.06$ [1] has been measured using the $J/\psi \to \mu^+\mu^-$ component of the prompt background in data.



Flavour tagging

We use the «opposite-side» tagging [1]:

$$\epsilon_{tag} D^2 = (2.29 \pm 0.07 \pm 0.26)\%$$

→ LHCC poster: «Optimisation and calibration of the LHCb flavour tagging using 2011 data».

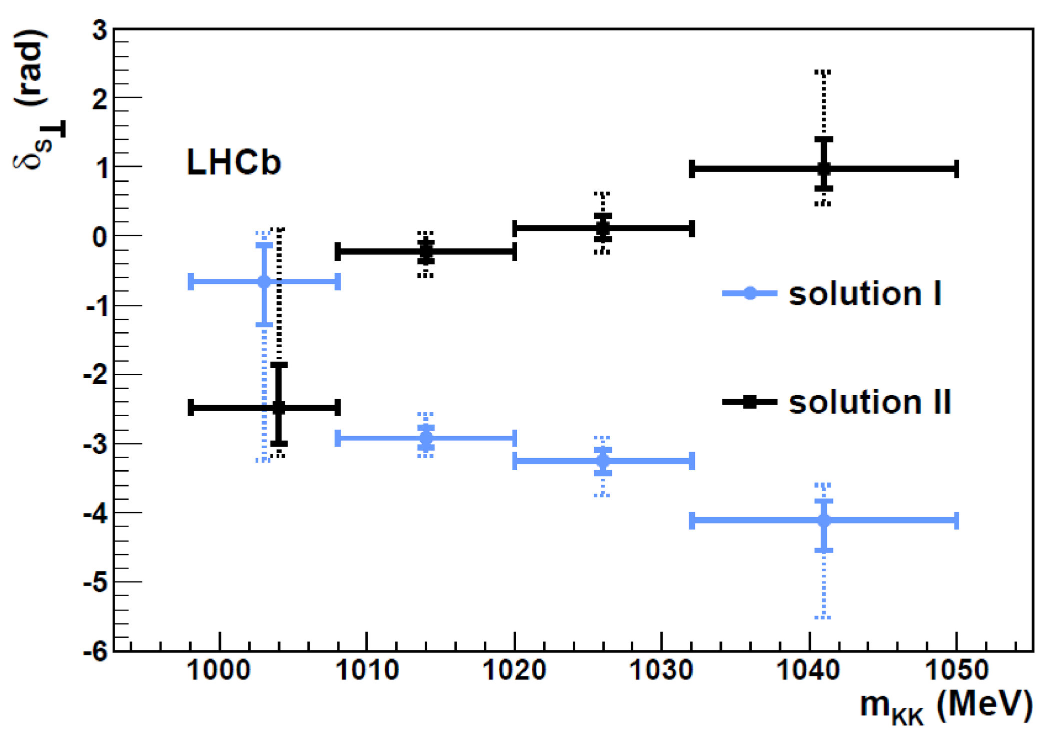
Solving the ambiguity: Sign of $\Delta\Gamma_s$ with 0.37 fb^{-1}

The $B_s^0 \to J/\psi\phi$ decay rates are invariant under the transformation $(\phi_s, \Delta\Gamma_s) \leftrightarrow (\pi - \phi_s, -\Delta\Gamma_s)$.

The LHCb analysis of $B_s^0 \to J/\psi\phi$ decays with 0.37 fb^{-1} showed that the almost CP-even mass eigenstate decays faster than the CP-odd state [2]. The ambiguity can be solved by measuring the strong phase difference between the P-wave and the S-wave of the K^+K^- final state around the $\phi(1020)$ meson [3].

The physical solution has decreasing phase difference as function of K^+K^- mass.

- Solution I : $\Delta\Gamma_s > 0$ and ϕ_s close to 0
- Solution II : $\Delta\Gamma_s < 0$ and ϕ_s close to π



The solution with $\Delta\Gamma_s > 0$ and ϕ_s close to 0 is favoured [3].

Preliminary results with 1.0 fb^{-1}

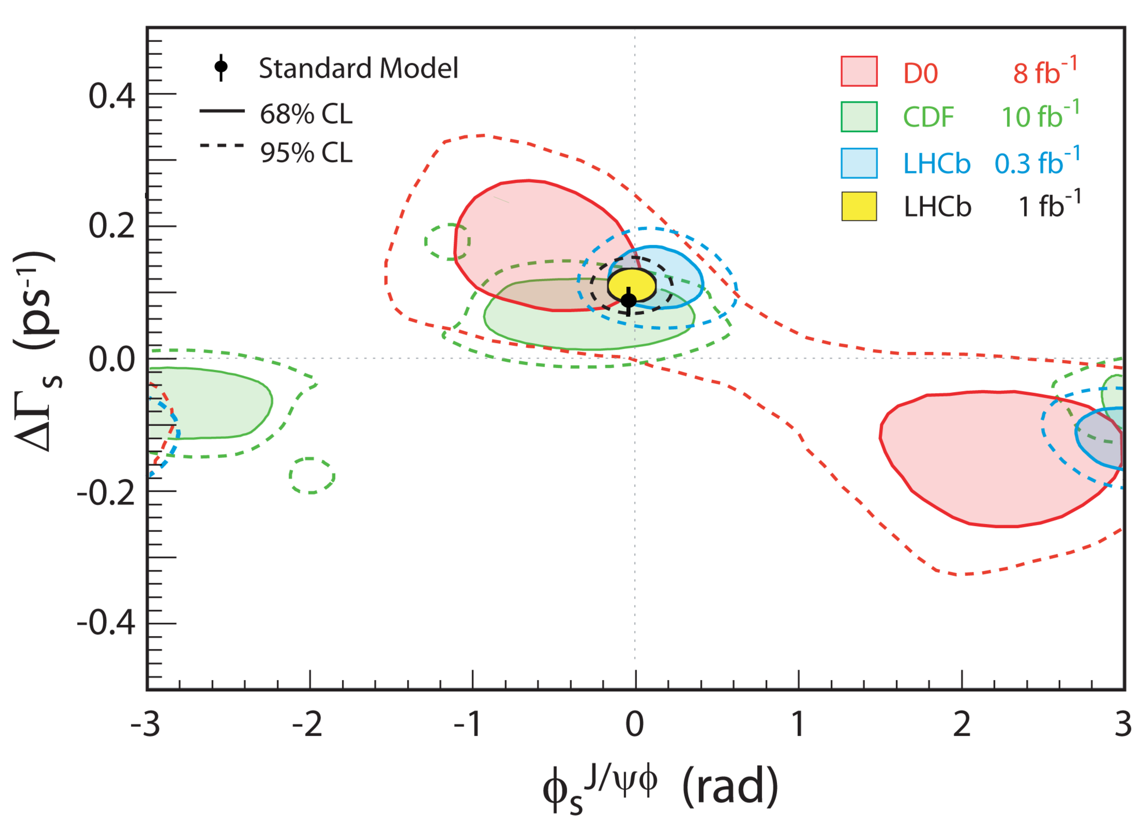
LHCb-CONF-2012-002

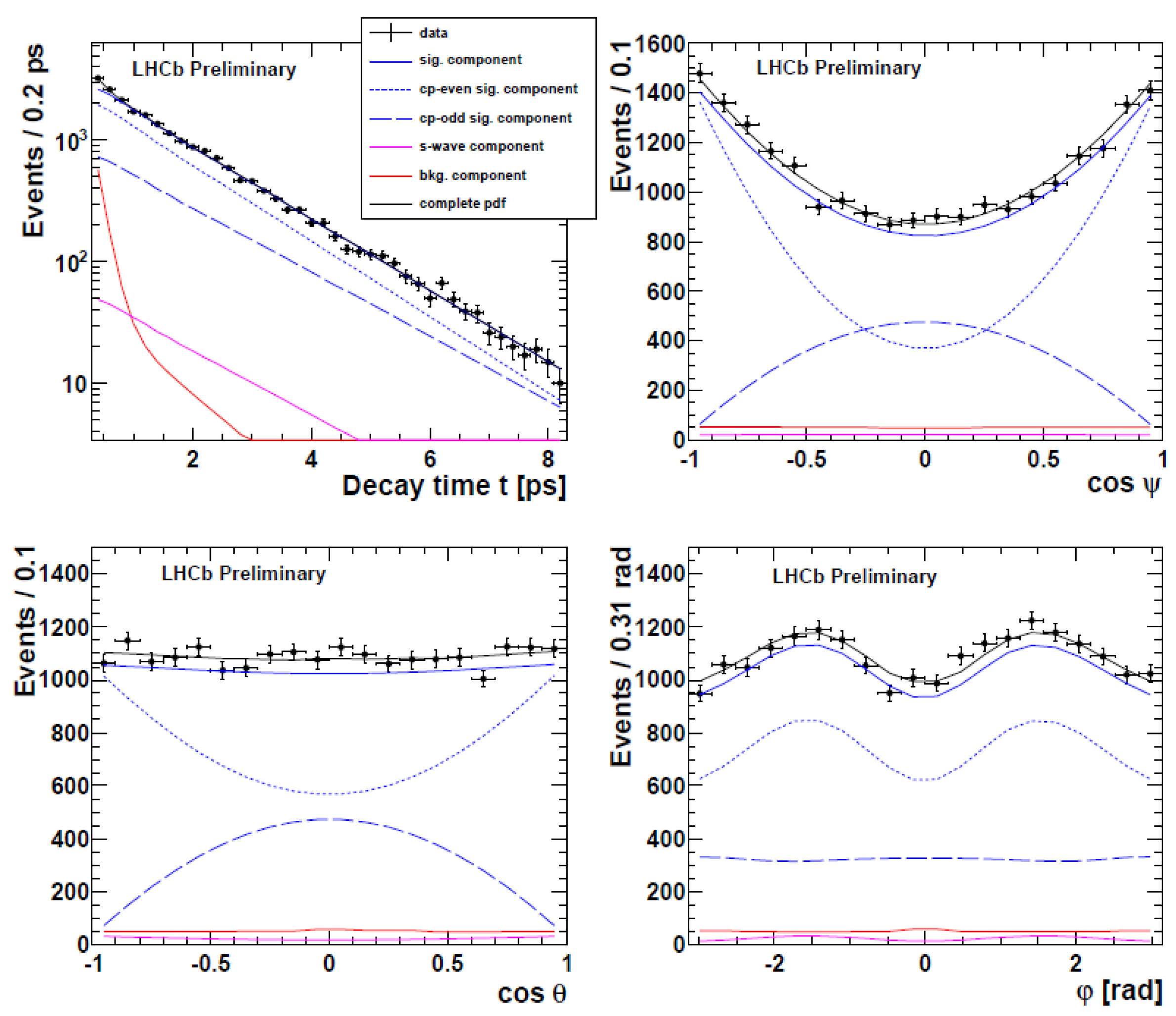
Using $\Delta m_s = 17.63 \pm 0.11\ ps^{-1}$ from the analysis of $B_s^0 \to D_s^-(3)\pi$ decays [5] as input, the world's most precise measurement of $\phi_s^{J/\psi\phi}$ and the first direct observation of non-zero $\Delta\Gamma_s$ has been measured [1]:

$$\phi_s^{J/\psi\phi} = -0.001 \pm 0.101\ (stat) \pm 0.027\ (syst)\ rad,$$

$$\Gamma_s = 0.6580 \pm 0.0054\ (stat) \pm 0.0066\ (syst)\ ps^{-1},$$

$$\Delta\Gamma_s = 0.116 \pm 0.018\ (stat) \pm 0.006\ (syst)\ ps^{-1}$$





A tagged time-dependent analysis of $B_s^0 \to J/\psi\pi^+\pi^-$ [4] has been performed and the preliminary combined result gives for ϕ_s [1]:

$$\phi_s = -0.002 \pm 0.083\ (stat) \pm 0.027\ (syst)\ rad$$

that is in good agreement with SM predictions and gives no sign of new physics yet.

References

[1] LHCb Collaboration, "Tagged time-dependent angular analysis of $B_s^0 \to J/\psi\phi$ decays at LHCb", LHCb-CONF-2012-002.

[2] LHCb Collaboration, "Measurement of the *CP*-violating phase ϕ_s in the decay $B_s^0 \to J/\psi\phi$", LHCB-PAPER-2011-021, arXiv:1112.3183, *Phys. Rev. Lett.* 108, 101803 (2012).

[3] LHCb Collaboration, "Determination of the sign of the decay width difference in the B_s^0 system", LHCB-PAPER-2011-028, arXiv:1202.4717, for submission to PRL.

[4] LHCb Collaboration, "Measurement of ϕ_s in $B_s^0 \to J/\psi\pi^+\pi^-$ decays", LHCB-PAPER-2012-006, for submission to PLB.

[5] LHCb Collaboration, "Measurement of the $B_s^0 - \bar{B}_s^0$ oscillation frequency Δm_s in $B_s^0 \to D_s^-(3)\pi$ decays", LHCB-PAPER-2011-010, arXiv:1112.4311, *Phys. Lett. B* 709 (2012) 177-184.