



Erratum to: Updated measurement of time-dependent CP -violating observables in $B_s^0 \rightarrow J/\psi K^+ K^-$ decays

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Erratum to: Eur. Phys. J. C 79 (2019):706
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In the Introduction section of the original article [1], the parameter λ was defined erroneously. The correct definition is $\lambda \equiv (q/p) (\bar{A}/A)$.

In Table 4, the systematic uncertainties due to the mass-width parametrisation, the mass dependence on the decay time and angles and the multiple candidates were erroneously documented. The corrected table (Table 1) is shown below.

As a result, the total systematic uncertainty on the parameter δ_{\parallel} changes from 0.037 rad to 0.036 rad, and on the parameter $|A_0|^2$ from 0.0024 to 0.0023, both in Table 4 and in Eq. (15) of the original paper. The remaining systematic uncertainties are unchanged. The corrected Eq. (15) is

$$\begin{aligned}\phi_s &= -0.083 \pm 0.041 \pm 0.006 \text{ rad} \\ |\lambda| &= 1.012 \pm 0.016 \pm 0.006 \\ \Gamma_s - \Gamma_d &= -0.0041 \pm 0.0024 \pm 0.0015 \text{ ps}^{-1} \\ \Delta\Gamma_s &= 0.077 \pm 0.008 \pm 0.003 \text{ ps}^{-1} \\ \Delta m_s &= 17.703 \pm 0.059 \pm 0.018 \text{ ps}^{-1} \\ |A_{\perp}|^2 &= 0.2456 \pm 0.0040 \pm 0.0019 \\ |A_0|^2 &= 0.5186 \pm 0.0029 \pm 0.0023 \\ \delta_{\perp} - \delta_0 &= 2.64 \pm 0.13 \pm 0.10 \text{ rad} \\ \delta_{\parallel} - \delta_0 &= 3.06_{-0.07}^{+0.08} \pm 0.04 \text{ rad.}\end{aligned}\quad (15)$$

These changes have a small impact on the average of Run 1 and Run 2 $B_s^0 \rightarrow J/\psi K^+ K^-$ results presented in Eq. (16) in the original article, which changes to

$$\begin{aligned}\phi_s &= -0.081 \pm 0.032 \text{ rad} \\ |\lambda| &= 0.994 \pm 0.013 \\ \Gamma_s &= 0.6572 \pm 0.0023 \text{ ps}^{-1} \\ \Delta\Gamma_s &= 0.0777 \pm 0.0062 \text{ ps}^{-1} \\ \Delta m_s &= 17.694 \pm 0.042 \text{ ps}^{-1} \\ |A_{\perp}|^2 &= 0.2489 \pm 0.0035 \\ |A_0|^2 &= 0.5195 \pm 0.0034 \\ \delta_{\perp} - \delta_0 &= 2.87 \pm 0.11 \text{ rad} \\ \delta_{\parallel} - \delta_0 &= 3.153 \pm 0.079 \text{ rad.}\end{aligned}\quad (16)$$

The resulting correlation matrix is shown in Table 2, which replaces Table 6 of the original article.

The average of all LHCb measurements presented in Eq. (17) in the original article changes to

$$\begin{aligned}\phi_s &= -0.042 \pm 0.025 \text{ rad} \\ |\lambda| &= 0.993 \pm 0.010 \\ \Gamma_s &= 0.6563 \pm 0.0021 \text{ ps}^{-1} \\ \Delta\Gamma_s &= 0.0813 \pm 0.0048 \text{ ps}^{-1}.\end{aligned}\quad (17)$$

The resulting correlation matrix is shown in Table 3, which replaces Table 7 of the original article.

The changes in the combined results are small, the largest being $\Delta\Gamma_s$ in the $B_s^0 \rightarrow J/\psi K^+ K^-$ combination. It is at the level of 11% of the total uncertainty. These changes do not affect the conclusions of the paper.

Furthermore, Fig. 12 in the original article, presenting the combined LHCb results, is amended to reflect the changes and the correct version (Fig. 1) is shown below.

The original article can be found online at <https://doi.org/10.1140/epjc/s10052-019-7159-8>.

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Table 1 Summary of the systematic uncertainties

| Source | ϕ_s [rad] | $ \lambda $ | $\Gamma_s - \Gamma_d$ [ps ⁻¹] | $\Delta\Gamma_s$ [ps ⁻¹] | Δm_s [ps ⁻¹] | $ A_{\perp} ^2$ | $ A_0 ^2$ | $\delta_{\perp} - \delta_0$ [rad] | $\delta_{\parallel} - \delta_0$ [rad] |
|--|----------------|-------------|---|--------------------------------------|----------------------------------|-----------------|-----------|-----------------------------------|---------------------------------------|
| Mass: width parametrisation | - | - | - | 0.0002 | 0.001 | 0.0004 | 0.0006 | - | 0.003 |
| Mass: decay-time & angles dependence | 0.004 | 0.0037 | 0.0007 | 0.0022 | 0.016 | 0.0005 | 0.0002 | 0.05 | 0.009 |
| Multiple candidates | 0.0011 | 0.0011 | 0.0003 | 0.0001 | 0.001 | 0.0001 | 0.0001 | 0.01 | 0.002 |
| Fit bias | 0.0010 | - | - | 0.0003 | 0.001 | 0.0006 | 0.0001 | 0.02 | 0.033 |
| C _{SP} factors | 0.0010 | 0.0010 | - | 0.0001 | 0.002 | 0.0001 | - | 0.01 | 0.005 |
| Time resolution: model applicability | - | - | - | - | 0.001 | - | - | - | 0.001 |
| Time resolution: t bias | 0.0032 | 0.0010 | 0.0002 | 0.0003 | 0.005 | - | - | 0.08 | 0.001 |
| Time resolution: wrong PV | - | - | - | - | 0.001 | - | - | - | 0.001 |
| Angular efficiency: simulated sample size | 0.0011 | 0.0018 | - | - | 0.001 | 0.0004 | 0.0003 | - | 0.004 |
| Angular efficiency: weighting | 0.0022 | 0.0043 | 0.0001 | 0.0002 | 0.001 | 0.0011 | 0.0020 | 0.01 | 0.008 |
| Angular efficiency: clone candidates | 0.0005 | 0.0014 | 0.0002 | 0.0001 | - | 0.0001 | 0.0002 | - | 0.002 |
| Angular efficiency: t & σ_t dependence | 0.0012 | 0.0007 | 0.0002 | 0.0010 | 0.003 | 0.0012 | 0.0008 | 0.03 | 0.006 |
| Decay-time efficiency: statistical | - | - | 0.0012 | 0.0008 | - | 0.0003 | 0.0002 | - | - |
| Decay-time efficiency: kinematic weighting | - | - | 0.0002 | - | - | - | - | - | - |
| Decay-time efficiency: PDF weighting | - | - | 0.0001 | 0.0001 | - | - | - | - | - |
| Decay-time efficiency: $\Delta\Gamma_s = 0$ simulation | - | - | 0.0003 | 0.0005 | - | 0.0002 | 0.0001 | - | - |
| Length scale | - | - | - | - | 0.004 | - | - | - | - |
| Quadratic sum of syst. | 0.0061 | 0.0064 | 0.0015 | 0.0026 | 0.018 | 0.0019 | 0.0023 | 0.10 | 0.036 |

Table 2 Correlation matrix for the results in Eq. (16) taking into account correlated systematics between Run 1 and the 2015 and 2016 results

| | ϕ_s | $ \lambda $ | Γ_s | $\Delta\Gamma_s$ | Δm_s | $ A_{\perp} ^2$ | $ A_0 ^2$ | $\delta_{\perp} - \delta_0$ | $\delta_{\parallel} - \delta_0$ |
|---------------------------------|----------|-------------|------------|------------------|--------------|-----------------|-----------|-----------------------------|---------------------------------|
| ϕ_s | 1.00 | 0.10 | -0.02 | -0.03 | 0.02 | 0.01 | -0.01 | 0.07 | 0.00 |
| $ \lambda $ | | 1.00 | 0.04 | -0.04 | -0.05 | 0.03 | -0.02 | -0.04 | 0.03 |
| Γ_s | | | 1.00 | -0.35 | 0.04 | 0.28 | -0.17 | 0.01 | 0.01 |
| $\Delta\Gamma_s$ | | | | 1.00 | -0.01 | -0.62 | 0.40 | -0.05 | -0.01 |
| Δm_s | | | | | 1.00 | 0.01 | -0.01 | 0.62 | 0.02 |
| $ A_{\perp} ^2$ | | | | | | 1.00 | -0.67 | 0.03 | 0.01 |
| $ A_0 ^2$ | | | | | | | 1.00 | -0.06 | -0.06 |
| $\delta_{\perp} - \delta_0$ | | | | | | | | 1.00 | 0.28 |
| $\delta_{\parallel} - \delta_0$ | | | | | | | | | 1.00 |

Table 3 Correlation matrix for the results in Eq. (17) obtained taking into account correlated systematics between the considered analyses

| | ϕ_s | $ \lambda $ | Γ_s | $\Delta\Gamma_s$ |
|------------------|----------|-------------|------------|------------------|
| ϕ_s | 1.00 | 0.06 | -0.01 | -0.03 |
| $ \lambda $ | | 1.00 | 0.03 | -0.02 |
| Γ_s | | | 1.00 | -0.17 |
| $\Delta\Gamma_s$ | | | | 1.00 |

Data Availability Statement This manuscript has no associated data or the data will not be deposited. [Authors’ comment: All LHCb scientific output is published in journals, with preliminary results made available in Conference Reports. All are Open Access, without restriction on use beyond the standard conditions agreed by CERN. Data associated to the plots in this publication as well as in supplementary materials are made available on the CERN document server at <http://cdsweb.cern.ch/record/2679467>. This information is taken from the LHCb External Data Access Policy which can be downloaded at <http://opendata.cern.ch/record/410>.]

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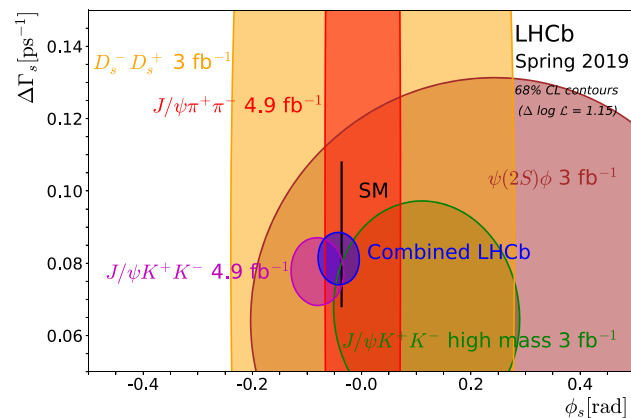


Fig. 1 Regions of 68% confidence level in the $\phi_s - \Delta\Gamma_s$ plane for the individual LHCb measurements and a combined contour (in blue). The $B_s^0 \rightarrow J/\psi K^+ K^-$ (magenta) and $B_s^0 \rightarrow J/\psi \pi^+ \pi^-$ [2] (red) contours show the Run 1 and Run 2 combined numbers. The ϕ_s [3] and $\Delta\Gamma_s$ [4] predictions are indicated by the thin black rectangle

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