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Erratum

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

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In the Introduction section of the original article [1], the parameter λ was defined erroneously. The correct definition is $\lambda \equiv (q/p)\left(\overline{A}/A\right)$.

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 $\delta_\parallel$ 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

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

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

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

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

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

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 $B_s^0 \to J/\psi K^+K^-$ 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]	$\lvert\lambda\rvert$	$\Gamma_s - \Gamma_d$ [ps^{-1}]	$\Delta\Gamma_s$ [ps^{-1}]	Δm_s [ps^{-1}]	$\lvert A_\perp\rvert^2$	$\lvert A_0\rvert^2$	$\delta_\perp - \delta_0$ [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
$C_{\rm SP}$ 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	$\lvert\lambda\rvert$	Γ_s	$\Delta\Gamma_s$	Δm_s	$\lvert A_\perp\rvert^2$	$\lvert A_0\rvert^2$	$\delta_\perp - \delta_0$	$\delta_\parallel - \delta_0$
ϕ_s	1.00	0.10	−0.02	−0.03	0.02	0.01	−0.01	0.07	0.00
$\lvert\lambda\rvert$		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
$\lvert A_\perp\rvert^2$						1.00	−0.67	0.03	0.01
$\lvert A_0\rvert^2$							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	$\lvert\lambda\rvert$	Γ_s	$\Delta\Gamma_s$
ϕ_s	1.00	0.06	−0.01	−0.03
$\lvert\lambda\rvert$		1.00	0.03	−0.02
Γ_s			1.00	−0.17
$\Delta\Gamma_s$				1.00

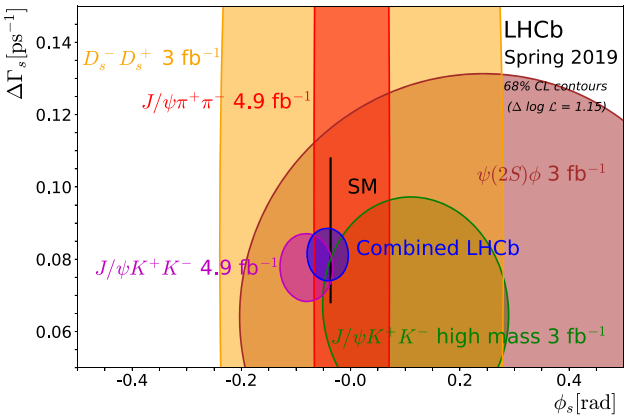

Fig. 1 Regions of 68% confidence level in the $\phi_s - \Delta\Gamma_s$ plane for the individual LHCb measurements and a combined contour (in blue). The $B_s^0 \to J/\psi K^+K^-$ (magenta) and $B_s^0 \to J/\psi\pi^+\pi^-$ [2] (red) contours show the Run 1 and Run 2 combined numbers. The ϕ_s [3] and $\Delta\Gamma_s$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

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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