1 Supplementary material for LHCb-PAPER-2015-005

This appendix contains supplementary material that will posted on the public cds record but will not appear in the paper.

1.1 Confidence intervals obtained with the Feldman–Cousins method

To study the stability of the maximum likelihood implementation, pseudoexperiments are performed with alternative assumptions for the values of the $B_s^0 \to J/\psi\, K_S^0$ *CP* asymmetries. In cases where values of the direct and mixing-induced *CP* asymmetries $C_{\rm dir}$ and $S_{\rm mix}$ are close to the physical boundaries, overcoverage of up to 20% is observed.

The Feldman–Cousins method [1, 2] is utilised to determine confidence intervals not affected by overcoverage. Systematic uncertainties are added directly to the likelihood by means of Gaussian functions, following the method in Ref. [2].

The results for the intervals at 68.3% confidence level for the $B_s^0 \to J/\psi\, K_S^0$ *CP* asymmetries are

$$\begin{aligned} \mathcal{A}_{\Delta\Gamma}\left(B_s^0 \to J/\psi\, K_S^0\right) &\in [-0.15, 1.21]\,, \\ C_{\rm dir}\left(B_s^0 \to J/\psi\, K_S^0\right) &\in [-0.68, 0.14]\,, \\ S_{\rm mix}\left(B_s^0 \to J/\psi\, K_S^0\right) &\in [-0.48, 0.31]\,. \end{aligned}$$

These values are in very good agreement with the point estimates reported in Sec. **??**. Confidence level (CL) plots for the three $B_s^0 \to J/\psi\, K_S^0$ *CP* asymmetries are given in Fig. 1. For the $C_{\rm dir}$ and $S_{\rm mix}$ asymmetries, deviations from the likelihood profile expectation become apparent at larger confidence levels.

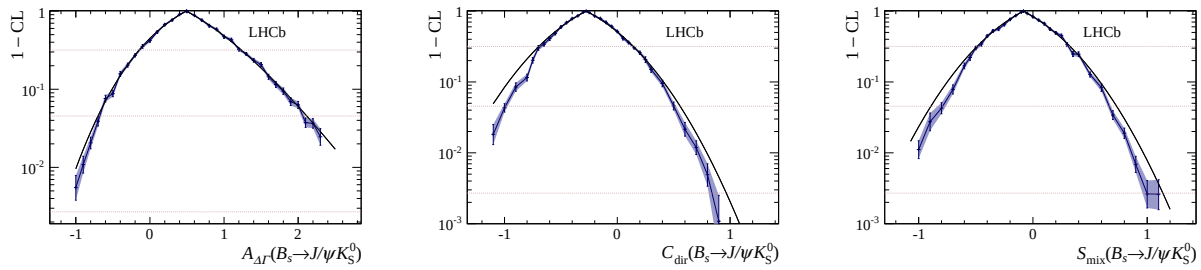

Figure 1: Confidence level contours obtained with the Feldman–Cousins method (blue) [1, 2] for the three $B_s^0 \to J/\psi\, K_S^0$ *CP* asymmetries: (left) $\mathcal{A}_{\Delta\Gamma}$, (middle) $C_{\rm dir}$, (right) $S_{\rm mix}$. The expectation from the likelihood profile (black) is shown as well.

1.2 Full correlation matrix

The statistical correlation matrix associated with the main fit results presented in Sec. **??** is given in Table 1.

Table 1: Statistical correlation matrix for the $B_s^0 \to J/\psi K_S^0$ CP asymmetries and relevant nuisance parameters. Here $\Gamma_s = 1/\tau_{B_s^0}$ is the inverse of the B_s^0 lifetime.

	$\mathcal{A}_{\Delta\Gamma}$	$C_{\rm dir}$	$S_{\rm mix}$	Δm_s	Γ_s	$\Delta\Gamma_s$	Long $A_{\rm prod}(B_s^0)$	Down. $A_{\rm prod}(B_s^0)$	τ_{B^0}
$\mathcal{A}_{\Delta\Gamma}$	1.00	−0.07	−0.01	0.00	0.09	−0.10	0.00	0.00	0.06
$C_{\rm dir}$		1.00	−0.06	−0.01	−0.01	0.00	−0.02	0.02	−0.01
$S_{\rm mix}$			1.00	−0.01	0.00	0.00	−0.02	0.13	0.00
Δm_s				1.00	0.00	0.00	0.00	−0.01	0.00
Γ_s					1.00	−0.27	0.00	0.00	0.00
$\Delta\Gamma_s$						1.00	0.00	0.00	0.00
$A_{\rm prod}({\rm Long}, B_s^0)$							1.00	0.00	0.00
$A_{\rm prod}({\rm Down.}, B_s^0)$								1.00	0.00
τ_{B^0}									1.00

References

[1] G. J. Feldman and R. D. Cousins, *A unified approach to the classical statistical analysis of small signals*, Phys. Rev. **D57** (1998) 3873, arXiv:physics/9711021.

[2] T. M. Karbach, *Feldman-Cousins confidence levels – toy MC method*, arXiv:1109.0714.