Supplementary material for LHCb-PAPER-2014-053

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

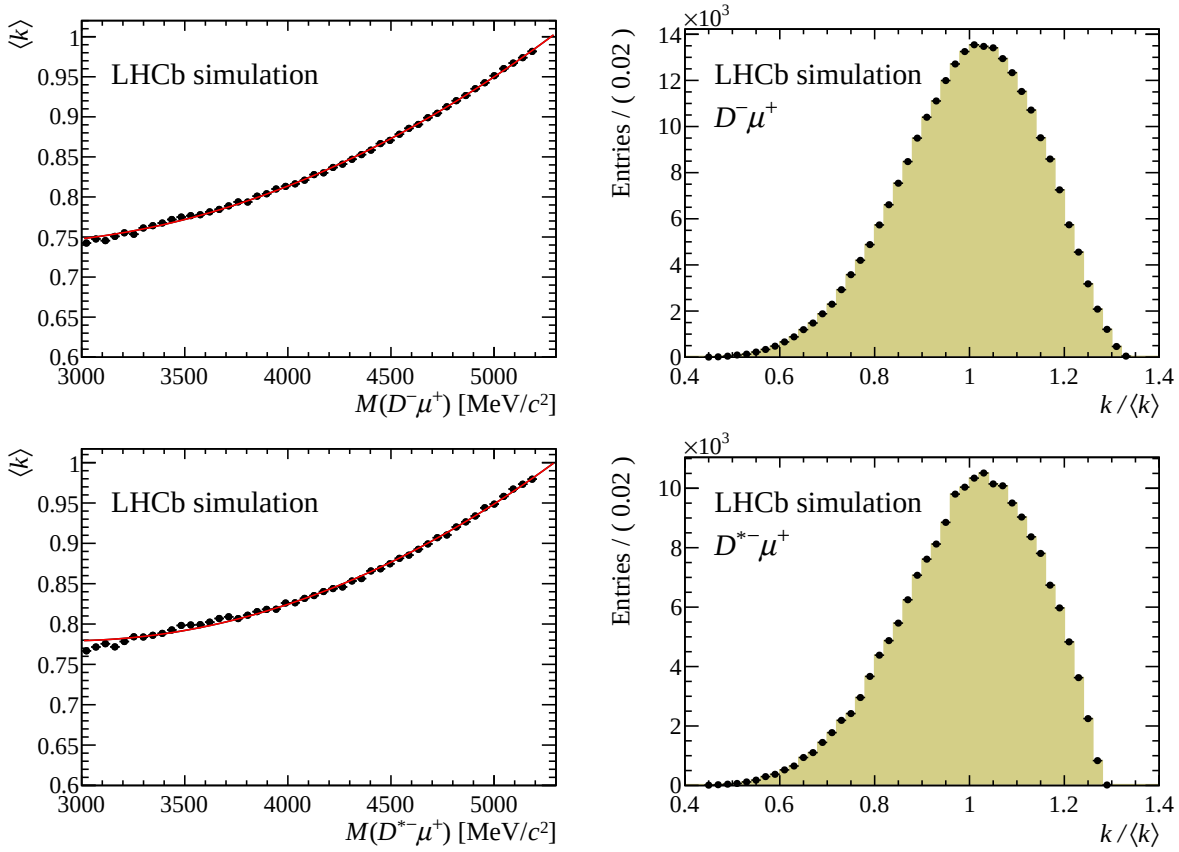

Figure 1: (left) The value of $\langle k \rangle$ as function of the invariant $D^{(*)-}\mu^+$ mass (top) for the $B^0 \to D^-\mu^+\nu_\mu X$ decay and (bottom) for the $B^0 \to D^{*-}\mu^+\nu_\mu X$ decay. The value of $\langle k \rangle$ is determined from simulation as the average ratio between the reconstructed and true momenta of the B^0 meson, $k \equiv p_{\rm rec}/p_{\rm true}$. The dependence on the $D^{(*)-}\mu^+$ mass is described by a polynomial function. (right) Distribution of $k/\langle k \rangle$, which is correcting for the $D^{(*)-}\mu^+$ mass dependence.

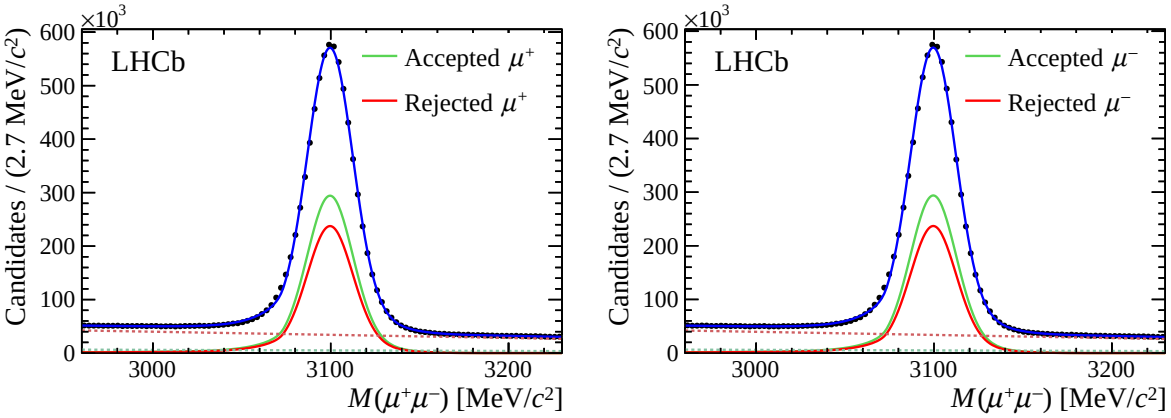

Figure 2: Invariant mass distributions of $J/\psi \to \mu^+\mu^-$ candidates, (left) where the positive muon is accepted or rejected, and (right) where the negative muon is accepted or rejected by the trigger and PID requirements. The results from the fits are overlaid, where the dashed lines show the combinatorial background shape. The yields obtained from these fits are used to determine the muon PID and trigger asymmetry.

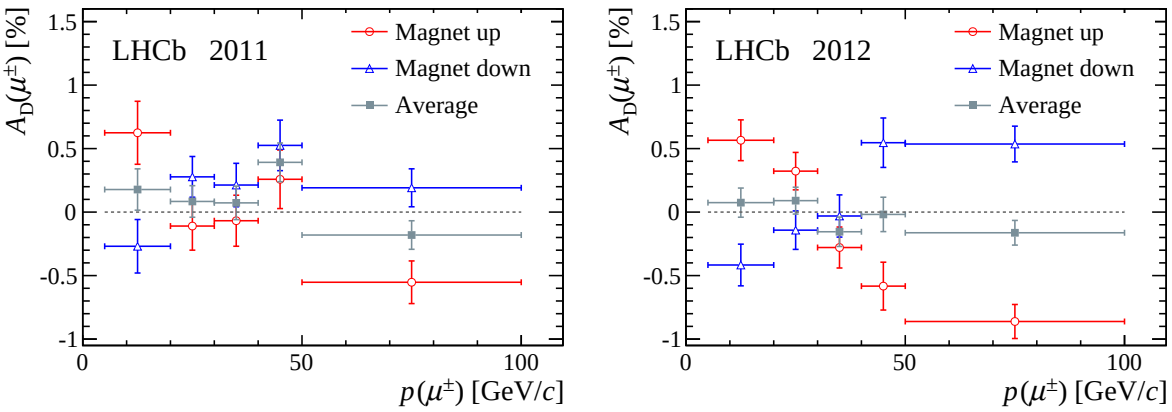

Figure 3: Detection asymmetry from the muon trigger and PID selection in bins of muon momentum for the two magnet polarities, for (left) 2011 data and (right) 2012 data.

Table 1: Overview of detection asymmetries in %, weighted for the $D^-\mu^+$ and for the $D^{*-}\mu^+$ samples. The first uncertainty is statistical, the second systematic. The systematic uncertainties are almost fully correlated between the different data samples.

Detection asymmetry	$D^-\mu^+$ sample	$D^{*-}\mu^+$ sample
2011 magnet up:		
$K\pi$ final state	$1.58 \pm 0.23 \pm 0.07$	$1.95 \pm 0.22 \pm 0.10$
$\pi\mu$ final state	$0.31 \pm 0.08 \pm 0.05$	$0.04 \pm 0.08 \pm 0.05$
Total	$1.88 \pm 0.25 \pm 0.08$	$1.99 \pm 0.23 \pm 0.11$
2011 magnet down:		
$K\pi$ final state	$1.07 \pm 0.20 \pm 0.07$	$-0.01 \pm 0.19 \pm 0.10$
$\pi\mu$ final state	$-0.19 \pm 0.08 \pm 0.05$	$-0.12 \pm 0.07 \pm 0.05$
Total	$0.88 \pm 0.21 \pm 0.08$	$-0.13 \pm 0.20 \pm 0.11$
2012 magnet up:		
$K\pi$ final state	$1.27 \pm 0.13 \pm 0.07$	$1.42 \pm 0.15 \pm 0.10$
$\pi\mu$ final state	$-0.07 \pm 0.05 \pm 0.05$	$-0.10 \pm 0.05 \pm 0.05$
Total	$1.20 \pm 0.14 \pm 0.08$	$1.32 \pm 0.16 \pm 0.11$
2012 magnet down:		
$K\pi$ final state	$0.97 \pm 0.13 \pm 0.07$	$0.25 \pm 0.14 \pm 0.10$
$\pi\mu$ final state	$-0.02 \pm 0.05 \pm 0.05$	$-0.06 \pm 0.05 \pm 0.05$
Total	$0.95 \pm 0.14 \pm 0.08$	$0.19 \pm 0.15 \pm 0.11$

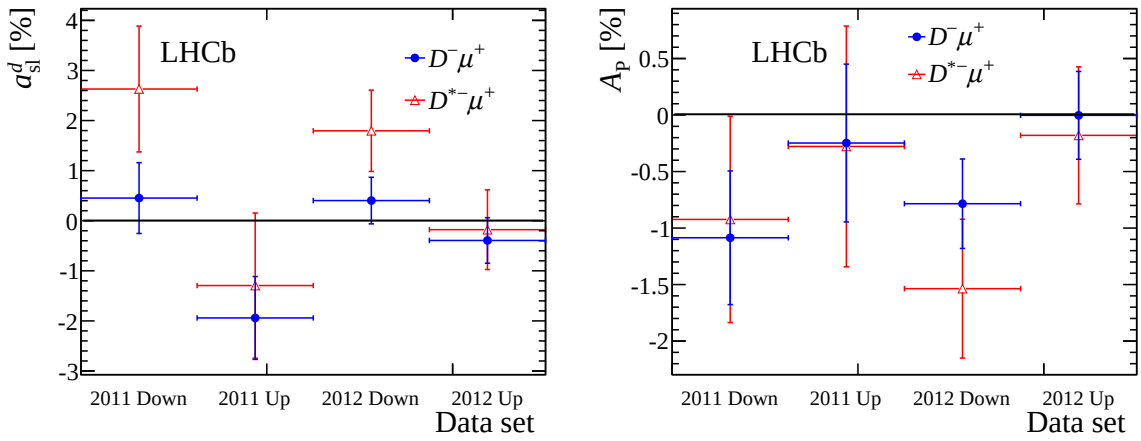

Figure 4: Fit results for (left) $a^d_{\rm sl}$ and (right) $A_{\rm P}$ for the different run periods and magnet polarities for the $D^-\mu^+$ and $D^{*-}\mu^+$ samples.

Table 2: Fit results for (left) $a^d_{\rm sl}$ and (right) $A_{\rm P}$ for the different run periods and magnet polarities for the $D^-\mu^+$ and $D^{*-}\mu^+$ samples. These results are shown in Fig. 4.

Data sample		$a^d_{\rm sl}$	$A_{\rm P}$
$D^-\mu^+$	2011 magnet up	-0.019 ± 0.008	-0.003 ± 0.005
$D^-\mu^+$	2011 magnet down	0.005 ± 0.007	-0.011 ± 0.004
$D^-\mu^+$	2012 magnet up	-0.004 ± 0.005	-0.000 ± 0.003
$D^-\mu^+$	2012 magnet down	0.004 ± 0.005	-0.008 ± 0.003
$D^{*-}\mu^+$	2011 magnet up	-0.013 ± 0.015	-0.003 ± 0.010
$D^{*-}\mu^+$	2011 magnet down	0.026 ± 0.013	-0.009 ± 0.008
$D^{*-}\mu^+$	2012 magnet up	-0.002 ± 0.008	-0.002 ± 0.005
$D^{*-}\mu^+$	2012 magnet down	0.018 ± 0.008	-0.015 ± 0.005

Table 3: Overview of previous measurements of $a^d_{\rm sl}$ and $a^s_{\rm sl}$ (first uncertainty is statistical, second systematic) and averages from the Heavy Flavor Averaging Group. Earlier measurements from LEP, which do not distinguish between the B^0 and B^0_s contribution, are not included.

Exp. & Ref.	Method	Measurement
CLEO [1]	Dileptons + partial hadronic	$a^d_{\rm sl} = (1.4 \pm 4.1 \pm 0.6)\%$
Belle [2]	Dileptons	$a^d_{\rm sl} = (-0.11 \pm 0.79 \pm 0.85)\%$
BaBar [3]	Full hadronic rec.	$a^d_{\rm sl} = (-5.8 \pm 2.6 \pm 2.2)\%$
BaBar [4]	Dileptons	$a^d_{\rm sl} = (0.16 \pm 0.54 \pm 0.38)\%$
BaBar [5]	Partial semilept.	$a^d_{\rm sl} = (0.06 \pm 0.17^{+0.38}_{-0.32})\%$
Average of B factories above [6]		$a^d_{\rm sl} = (0.02 \pm 0.32)\%$
D0 [7]	Partial semilept.	$a^d_{\rm sl} = (0.68 \pm 0.45 \pm 0.14)\%$
D0 [8]	Dimuon	$a^d_{\rm sl} = (-0.62 \pm 0.42)\%$
		$a^s_{\rm sl} = (-0.86 \pm 0.74)\%$
		$\rho = -0.79$
D0 [9]	Partial semilept.	$a^s_{\rm sl} = (-1.12 \pm 0.74 \pm 0.17)\%$
LHCb [10]	Partial semilept.	$a^s_{\rm sl} = (-0.06 \pm 0.50 \pm 0.36)\%$
Average of all measurements above [6]		$a^d_{\rm sl} = (-0.09 \pm 0.21)\%$
		$a^s_{\rm sl} = (-0.77 \pm 0.42)\%$

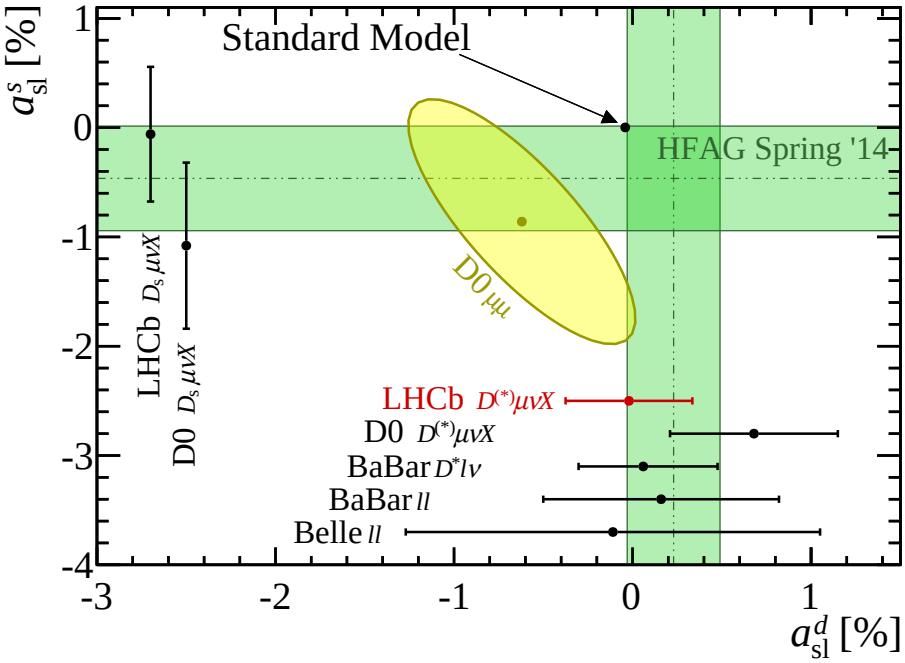

Figure 5: Overview of measurements in the $a^d_{\rm sl}$-$a^s_{\rm sl}$ plane. The 68% confidence level contours are displayed. The HFAG averages do not include the $a^d_{\rm sl}$ result in this paper and the D0 dimuon result. The numerical values of the previous measurements are given in Table 3.

Supplementary references

References

[1] CLEO collaboration, D. Jaffe *et al.*, *Bounds on the CP asymmetry in like-sign dileptons from $B^0\overline{B}^0$ meson decays*, Phys. Rev. Lett. **86** (2001) 5000, arXiv:hep-ex/0101006

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[5] BaBar collaboration, J. P. Lees *et al.*, *Search for CP violation in B^0-$\overline{B}^0$ mixing using partial reconstruction of $B^0 \to D^{*-}X\ell^+\nu_\ell$ and a kaon tag*, Phys. Rev. Lett. **111** (2013) 101802, arXiv:1305.1575

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