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Erratum: Measurement of forward J/psi production cross-sections in pp collisions at root s = 13 TeV (vol 10, pg 172, 2015)

Dufour, L.; Onderwater, C. J. G.; Pellegrino, A.; LHCb Collaboration

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Erratum: Measurement of forward J/ψ production cross-sections in pp collisions at $\sqrt{s} = 13$ TeV



The LHCb collaboration

E-mail: yanxi.zhang@cern.ch

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An issue has been identified in the simulated samples used to calculate the track reconstruction efficiencies, which affects the published J/ψ production cross-section in pp collisions at $\sqrt{s} = 13$ TeV [1]. A brief description of the nature of the problem is provided and then the corrected results are given.

The charge collected in the LHCb VELO sensors is affected by radiation damage. One such effect, which is more pronounced in the outer regions of downstream sensors, arises from charge induction on second metal layer routing lines [2]. Prior to the start of Run 2, modifications were made to the digitization step in the LHCb simulation framework to model this effect. An error was made in the parametric implementation resulting in a reduction of the track reconstruction efficiency in simulation compared to data for tracks with low pseudorapidity. The tracking efficiency calibration procedure that was applied in this paper to the data and simulation [3] was unable to correct the mismodelling.

The results presented in the paper are affected, especially those at low rapidities, while the effect is marginal at high rapidities. Updated tracking calibrations have been implemented for this analysis, resulting in a change of the tracking efficiency and higher systematic uncertainties. Having resolved the issue, the corrected production cross-sections are $15.03 \pm 0.03 \pm 0.94 \mu\text{b}$ for prompt J/ψ and $2.25 \pm 0.01 \pm 0.14 \mu\text{b}$ for J/ψ from b -hadron decays, integrated over the kinematic coverage $p_T < 14 \text{ GeV}/c$ and $2.0 < y < 4.5$. The updated total $b\bar{b}$ production cross-section in 4π is found to be $\sigma(pp \rightarrow b\bar{b}X) = 495 \pm 2 \pm 52 \mu\text{b}$. The NRQCD [4] prediction agrees remarkably well with the experimental data for the prompt J/ψ production cross-section ratio, while the FONLL [5] prediction also provides a reasonably good agreement with our measurements for the J/ψ -from- b cross-section ratio.

All tables and figures with affected measurements are corrected and are given below, with the numbering and captions being identical to those in the original paper.

Source	Systematic uncertainty (%)
Luminosity	3.9
Hardware trigger	0.1 – 5.9
Software trigger	1.5
Muon ID	1.8
Tracking	1.9 – 8.2
Radiative tail	1.0
J/ψ vertex fit	0.4
Signal mass shape	1.0
$\mathcal{B}(J/\psi \rightarrow \mu^+\mu^-)$	0.6
p_T, y spectrum	0.1 – 6.5
Simulation statistics	0.5 – 10.0
t_z fit (J/ψ -from- b only)	0.1

Table 1. Relative systematic uncertainties (in %) on the J/ψ cross-section measurements. The uncertainty from the t_z fit only affects J/ψ -from- b mesons. Most of the uncertainties are fully correlated between bins, with the exception of the p_T, y spectrum dependence and the simulation statistics, which are considered uncorrelated.

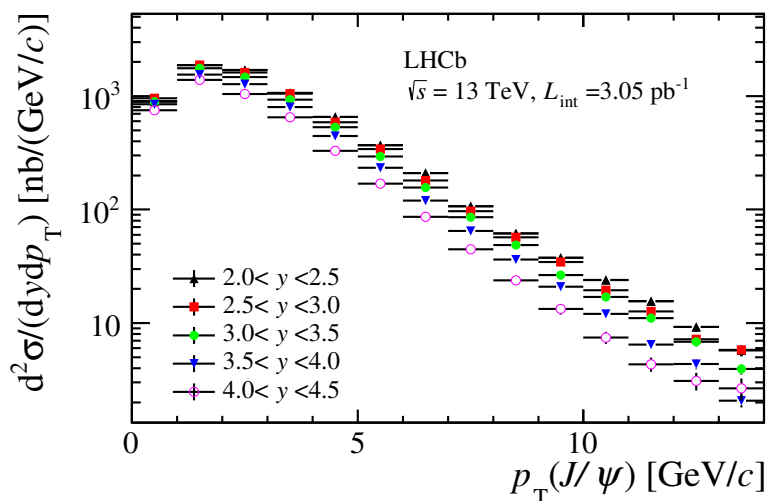


Figure 2. Double differential cross-section for prompt J/ψ mesons as a function of p_T in bins of y . Statistical and systematic uncertainties are added in quadrature.

p_T [GeV/ c]	$2.0 < y < 2.5$	$2.5 < y < 3.0$	$3.0 < y < 3.5$
0–1	906 ± 14 ± 44 ± 24	955 ± 9 ± 40 ± 12	892 ± 8 ± 41 ± 10
1–2	1880 ± 20 ± 88 ± 46	1876 ± 12 ± 77 ± 17	1764 ± 11 ± 81 ± 14
2–3	1697 ± 16 ± 75 ± 41	1612 ± 10 ± 66 ± 15	1470 ± 9 ± 66 ± 12
3–4	1069 ± 11 ± 46 ± 20	1055 ± 7 ± 43 ± 12	930 ± 6 ± 39 ± 9
4–5	656 ± 7 ± 28 ± 14	586 ± 5 ± 24 ± 7	531 ± 4 ± 22 ± 6
5–6	369 ± 5 ± 15 ± 9	342 ± 3 ± 14 ± 4	293 ± 3 ± 12 ± 4
6–7	210.3 ± 3.3 ± 8.6 ± 5.2	180.3 ± 2.1 ± 7.3 ± 2.8	156.1 ± 1.9 ± 6.3 ± 2.4
7–8	107.3 ± 2.1 ± 4.4 ± 3.3	96.7 ± 1.5 ± 3.9 ± 1.8	85.8 ± 1.4 ± 3.5 ± 1.7
8–9	61.7 ± 1.5 ± 2.5 ± 2.1	56.8 ± 1.1 ± 2.3 ± 1.4	48.8 ± 1.0 ± 2.0 ± 1.3
9–10	37.6 ± 1.1 ± 1.5 ± 1.5	34.6 ± 0.9 ± 1.4 ± 1.0	26.6 ± 0.7 ± 1.1 ± 0.8
10–11	23.9 ± 0.9 ± 1.0 ± 1.3	19.5 ± 0.6 ± 0.8 ± 0.7	17.0 ± 0.6 ± 0.7 ± 0.7
11–12	15.6 ± 0.7 ± 0.6 ± 1.0	12.7 ± 0.5 ± 0.5 ± 0.6	11.0 ± 0.5 ± 0.4 ± 0.5
12–13	9.2 ± 0.5 ± 0.4 ± 0.6	7.2 ± 0.4 ± 0.3 ± 0.4	6.8 ± 0.4 ± 0.3 ± 0.4
13–14	5.8 ± 0.4 ± 0.2 ± 0.5	5.8 ± 0.4 ± 0.2 ± 0.4	3.9 ± 0.3 ± 0.2 ± 0.3
	$3.5 < y < 4.0$	$4.0 < y < 4.5$	
0–1	850 ± 8 ± 48 ± 11	752 ± 9 ± 50 ± 16	
1–2	1545 ± 10 ± 90 ± 14	1387 ± 12 ± 99 ± 23	
2–3	1272 ± 8 ± 71 ± 13	1046 ± 10 ± 76 ± 24	
3–4	801 ± 6 ± 42 ± 9	649 ± 8 ± 44 ± 19	
4–5	444 ± 4 ± 21 ± 6	329 ± 5 ± 19 ± 8	
5–6	234 ± 3 ± 11 ± 4	169 ± 3 ± 9 ± 5	
6–7	119.6 ± 1.7 ± 5.2 ± 0.8	87.3 ± 2.1 ± 4.5 ± 1.0	
7–8	65.0 ± 1.3 ± 2.8 ± 1.5	44.6 ± 1.4 ± 2.2 ± 2.0	
8–9	36.4 ± 0.9 ± 1.5 ± 1.0	23.8 ± 1.0 ± 1.1 ± 1.2	
9–10	20.9 ± 0.7 ± 0.9 ± 0.8	13.3 ± 0.7 ± 0.6 ± 1.0	
10–11	12.1 ± 0.5 ± 0.5 ± 0.6	7.4 ± 0.5 ± 0.3 ± 0.6	
11–12	6.4 ± 0.3 ± 0.3 ± 0.3	4.3 ± 0.4 ± 0.2 ± 0.4	
12–13	4.4 ± 0.3 ± 0.2 ± 0.3	3.1 ± 0.3 ± 0.2 ± 0.4	
13–14	2.1 ± 0.2 ± 0.1 ± 0.2	2.7 ± 0.3 ± 0.1 ± 0.5	

Table 2. Double differential production cross-section in nb/(GeV/ c) for prompt J/ψ mesons in bins of (p_T, y) . The first uncertainties are statistical, the second are the correlated systematic uncertainties shared between bins and the last are the uncorrelated systematic uncertainties.

p_T [GeV/ c]	$2.0 < y < 2.5$	$2.5 < y < 3.0$	$3.0 < y < 3.5$
0–1	$99.3 \pm 4.8 \pm 9.6 \pm 5.1$	$98.8 \pm 2.8 \pm 6.1 \pm 2.6$	$92.3 \pm 2.6 \pm 5.4 \pm 2.2$
1–2	$242.3 \pm 6.1 \pm 20.6 \pm 8.7$	$238.1 \pm 3.8 \pm 14.2 \pm 4.2$	$216.4 \pm 3.4 \pm 12.6 \pm 3.6$
2–3	$275.6 \pm 5.8 \pm 19.9 \pm 9.5$	$233.4 \pm 3.4 \pm 13.4 \pm 3.9$	$211.3 \pm 3.1 \pm 12.0 \pm 3.5$
3–4	$204.3 \pm 4.6 \pm 13.1 \pm 6.3$	$174.8 \pm 2.7 \pm 9.6 \pm 3.2$	$150.6 \pm 2.3 \pm 8.2 \pm 2.7$
4–5	$137.3 \pm 3.3 \pm 8.1 \pm 4.7$	$120.0 \pm 2.0 \pm 6.4 \pm 2.3$	$96.0 \pm 1.7 \pm 5.1 \pm 1.9$
5–6	$84.9 \pm 2.3 \pm 4.7 \pm 2.9$	$76.3 \pm 1.5 \pm 4.0 \pm 1.6$	$59.8 \pm 1.3 \pm 3.1 \pm 1.3$
6–7	$56.2 \pm 1.7 \pm 3.0 \pm 2.1$	$48.2 \pm 1.1 \pm 2.5 \pm 1.1$	$38.3 \pm 1.0 \pm 2.0 \pm 1.0$
7–8	$36.3 \pm 1.3 \pm 1.9 \pm 1.6$	$28.9 \pm 0.8 \pm 1.5 \pm 0.8$	$23.3 \pm 0.7 \pm 1.2 \pm 0.7$
8–9	$21.5 \pm 0.9 \pm 1.1 \pm 1.0$	$19.6 \pm 0.7 \pm 1.0 \pm 0.6$	$15.2 \pm 0.6 \pm 0.8 \pm 0.6$
9–10	$15.7 \pm 0.7 \pm 0.8 \pm 0.8$	$12.3 \pm 0.5 \pm 0.6 \pm 0.5$	$9.9 \pm 0.5 \pm 0.5 \pm 0.5$
10–11	$10.1 \pm 0.6 \pm 0.5 \pm 0.6$	$9.0 \pm 0.5 \pm 0.5 \pm 0.4$	$7.6 \pm 0.4 \pm 0.4 \pm 0.5$
11–12	$8.0 \pm 0.5 \pm 0.4 \pm 0.6$	$6.3 \pm 0.4 \pm 0.3 \pm 0.3$	$4.4 \pm 0.3 \pm 0.2 \pm 0.3$
12–13	$5.3 \pm 0.4 \pm 0.3 \pm 0.4$	$4.2 \pm 0.3 \pm 0.2 \pm 0.3$	$3.4 \pm 0.3 \pm 0.2 \pm 0.3$
13–14	$4.5 \pm 0.4 \pm 0.2 \pm 0.4$	$3.5 \pm 0.3 \pm 0.2 \pm 0.3$	$2.0 \pm 0.2 \pm 0.1 \pm 0.2$
	$3.5 < y < 4.0$	$4.0 < y < 4.5$	
0–1	$83.5 \pm 2.7 \pm 5.5 \pm 2.5$	$65.0 \pm 3.8 \pm 4.8 \pm 3.5$	
1–2	$182.1 \pm 3.4 \pm 12.2 \pm 3.8$	$139.5 \pm 4.6 \pm 11.0 \pm 5.3$	
2–3	$176.3 \pm 3.0 \pm 11.5 \pm 3.8$	$118.7 \pm 3.6 \pm 9.5 \pm 5.0$	
3–4	$118.9 \pm 2.3 \pm 7.3 \pm 2.7$	$86.6 \pm 3.0 \pm 6.6 \pm 4.4$	
4–5	$79.4 \pm 1.7 \pm 4.6 \pm 2.0$	$52.7 \pm 2.1 \pm 3.7 \pm 2.7$	
5–6	$43.5 \pm 1.2 \pm 2.5 \pm 1.2$	$28.2 \pm 1.4 \pm 1.9 \pm 1.6$	
6–7	$28.8 \pm 0.9 \pm 1.6 \pm 1.0$	$17.8 \pm 1.0 \pm 1.1 \pm 1.1$	
7–8	$17.4 \pm 0.7 \pm 1.0 \pm 0.7$	$9.5 \pm 0.7 \pm 0.6 \pm 0.7$	
8–9	$10.0 \pm 0.5 \pm 0.6 \pm 0.5$	$5.3 \pm 0.5 \pm 0.3 \pm 0.4$	
9–10	$8.1 \pm 0.5 \pm 0.5 \pm 0.5$	$4.9 \pm 0.5 \pm 0.3 \pm 0.6$	
10–11	$4.4 \pm 0.3 \pm 0.3 \pm 0.3$	$2.9 \pm 0.3 \pm 0.2 \pm 0.4$	
11–12	$3.0 \pm 0.3 \pm 0.2 \pm 0.3$	$2.5 \pm 0.3 \pm 0.2 \pm 0.4$	
12–13	$1.8 \pm 0.2 \pm 0.1 \pm 0.2$	$1.6 \pm 0.3 \pm 0.1 \pm 0.5$	
13–14	$1.5 \pm 0.2 \pm 0.1 \pm 0.2$	$0.5 \pm 0.1 \pm 0.0 \pm 0.1$	

Table 3. Double differential production cross-section in nb/(GeV/ c) for J/ψ -from- b mesons in bins of (p_T, y) . The first uncertainties are statistical, the second are the correlated systematic uncertainties shared between bins and the last are the uncorrelated systematic uncertainties.

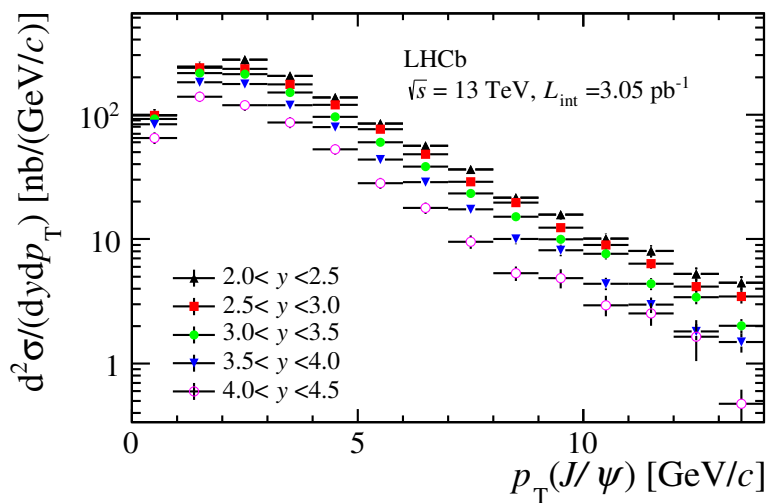


Figure 3. Double differential cross-section for J/ψ -from- b mesons as a function of p_T in bins of y . Statistical and systematic uncertainties are added in quadrature.

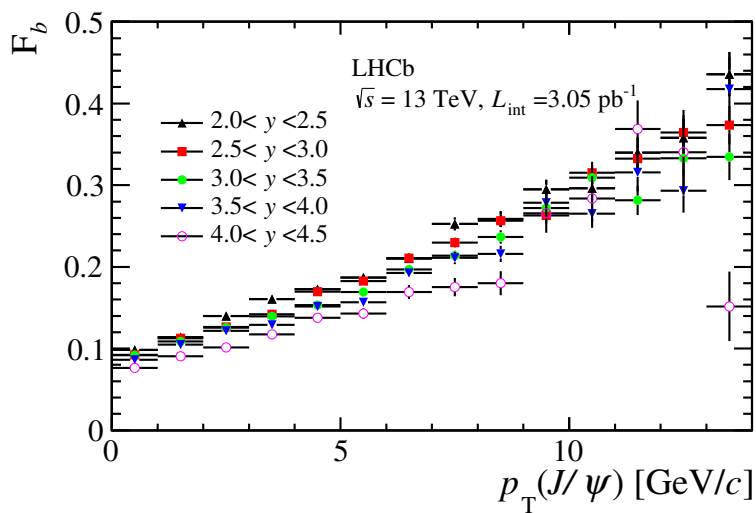


Figure 4. Fractions of J/ψ -from- b mesons in bins of J/ψ p_T and y . Statistical and systematic uncertainties are added in quadrature.

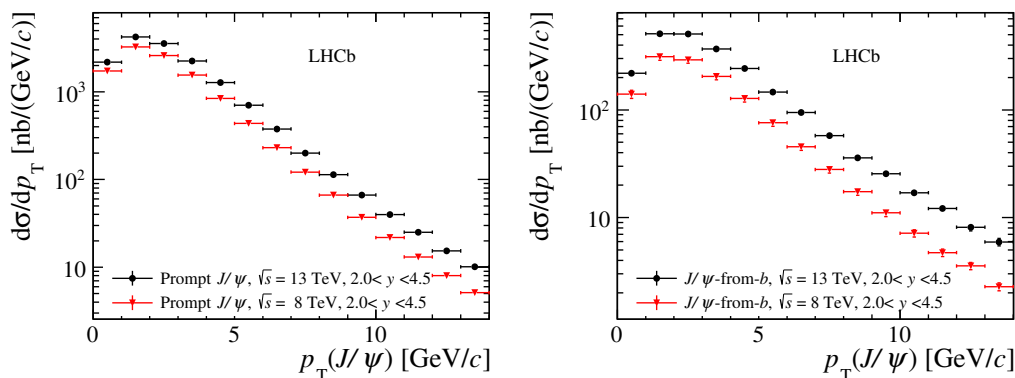


Figure 5. Differential cross-sections as a function of p_T integrated over y for (left) prompt J/ψ and (right) J/ψ -from- b mesons.

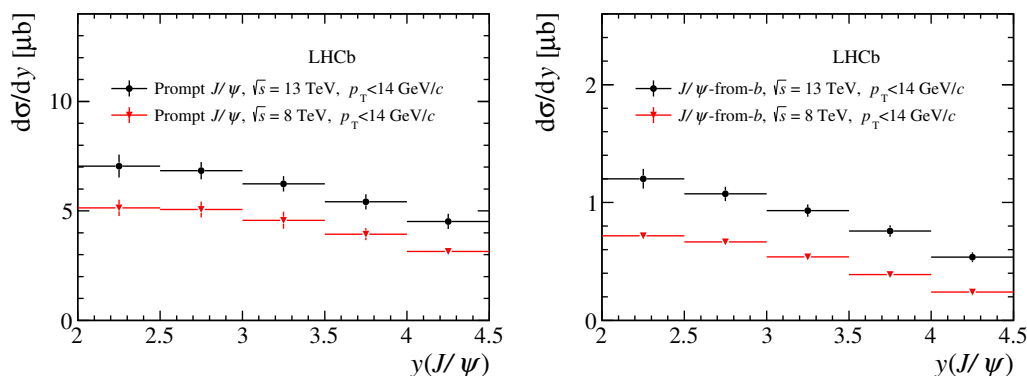


Figure 6. Differential cross-sections as a function of y integrated over p_T for (left) prompt J/ψ and (right) J/ψ -from- b mesons.

Source	Systematic uncertainty (%)
Luminosity	4.6
Trigger	1.5
Muon ID	2.2
Tracking	2.0
Signal mass shape	2.0
p_T, y spectrum, simulation statistics (t_z fits)	1.1 – 18.9

Table 4. Relative systematic uncertainty (in %) on the ratio of the cross-section in pp collisions at $\sqrt{s} = 13$ TeV relative to that at $\sqrt{s} = 8$ TeV. The systematic uncertainty from t_z fits only affects J/ψ -from- b .

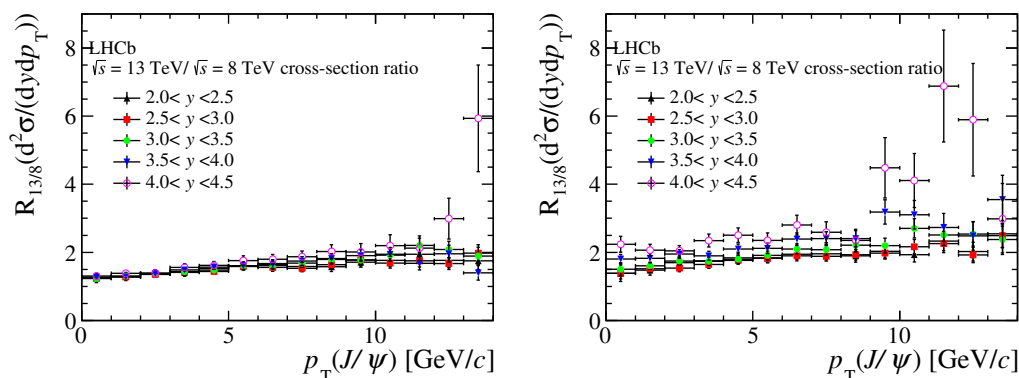


Figure 7. Ratios of differential cross-sections between measurements at $\sqrt{s} = 13$ TeV and $\sqrt{s} = 8$ TeV as a function of p_T in bins of y for (left) prompt J/ψ mesons and (right) J/ψ -from- b mesons.

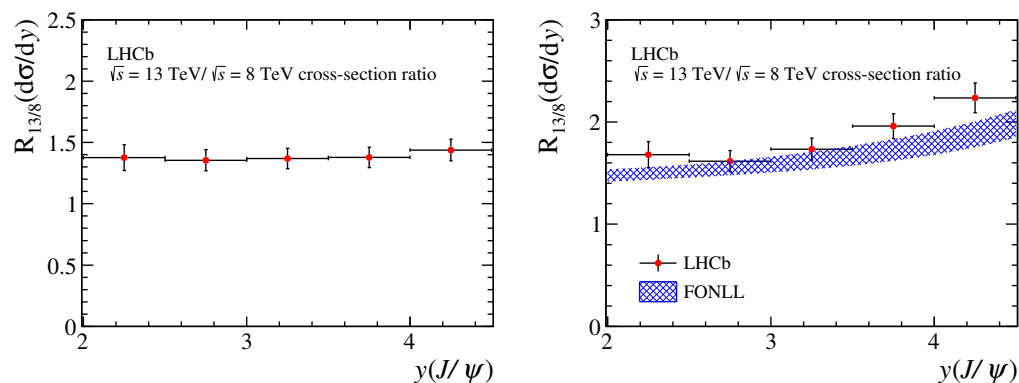


Figure 8. Ratios of differential cross-sections between measurements at $\sqrt{s} = 13$ TeV and $\sqrt{s} = 8$ TeV as a function of y integrated over p_T for (left) prompt J/ψ and (right) J/ψ -from- b mesons. The FONLL calculation is compared to the measured J/ψ -from- b production ratio.

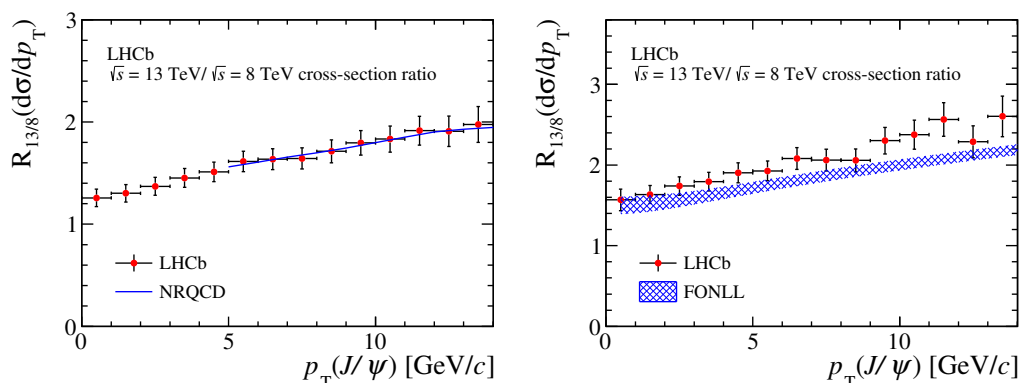


Figure 9. Ratios of differential cross-sections between measurements at $\sqrt{s} = 13$ TeV and $\sqrt{s} = 8$ TeV as a function of p_T integrated over y for (left) prompt J/ψ mesons and (right) J/ψ -from- b mesons. Calculations of NRQCD and FONLL are compared to prompt J/ψ mesons and J/ψ -from- b mesons, respectively.

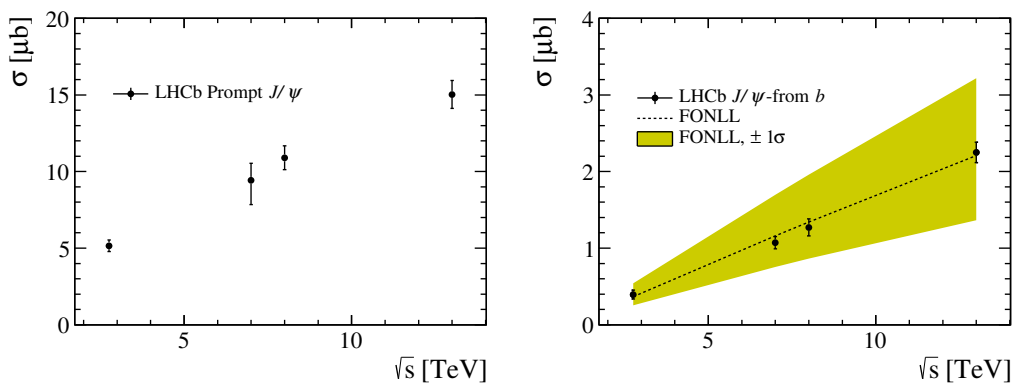


Figure 10. The J/ψ production cross-section for (left) prompt J/ψ and (right) J/ψ -from- b mesons as a function of pp collision energy in the LHCb fiducial region compared to the FONLL calculation. In general, the correlated and uncorrelated systematic uncertainties among different measurements are of comparable magnitude.

σ_{tot} (μb)	$\sqrt{s} = 2.76 \text{ TeV}$	$\sqrt{s} = 7 \text{ TeV}$	$\sqrt{s} = 8 \text{ TeV}$	$\sqrt{s} = 13 \text{ TeV}$
Prompt J/ψ	$5.2 \pm 0.3 \pm 0.3$	$9.4 \pm 0.5^{+0.7}_{-1.0}$	$10.9 \pm 0.5 \pm 0.6$	$15.0 \pm 0.6 \pm 0.7$
J/ψ -from- b	$0.39 \pm 0.04 \pm 0.04$	$1.07 \pm 0.05 \pm 0.06$	$1.27 \pm 0.06 \pm 0.09$	$2.25 \pm 0.09 \pm 0.10$

Table 5. Production cross-sections of prompt J/ψ and J/ψ -from- b mesons, integrated over the LHCb fiducial region, in pp collisions at various centre-of-mass energies. The first uncertainty is the uncorrelated component, and the second the correlated one.

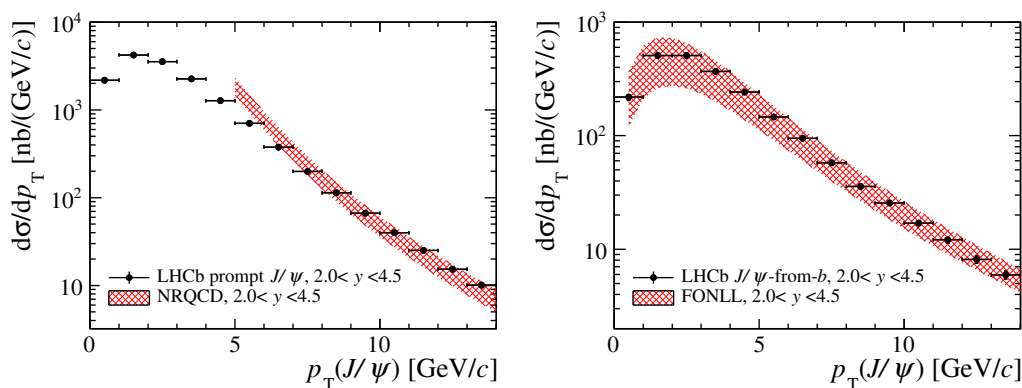


Figure 11. Differential cross-sections as a function of p_T integrated over y in the range $2.0 < y < 4.5$, (left) compared with the NRQCD calculation for prompt J/ψ and (right) compared with the FONLL calculation for J/ψ -from- b mesons.

$p_T[\text{GeV}/c]$	$2 < y < 2.5$	$2.5 < y < 3$	$3 < y < 3.5$	$3.5 < y < 4$	$4 < y < 4.5$
0 – 1	9.8 ± 0.5	9.2 ± 0.3	9.2 ± 0.3	8.6 ± 0.3	7.6 ± 0.4
1 – 2	11.4 ± 0.3	11.2 ± 0.2	10.9 ± 0.2	10.5 ± 0.2	9.1 ± 0.3
2 – 3	14.0 ± 0.3	12.6 ± 0.2	12.5 ± 0.2	12.2 ± 0.2	10.1 ± 0.3
3 – 4	16.0 ± 0.3	14.2 ± 0.2	13.9 ± 0.2	12.9 ± 0.2	11.8 ± 0.4
4 – 5	17.3 ± 0.4	17.0 ± 0.3	15.3 ± 0.3	15.2 ± 0.3	13.8 ± 0.5
5 – 6	18.7 ± 0.5	18.2 ± 0.3	16.9 ± 0.3	15.7 ± 0.4	14.3 ± 0.6
6 – 7	21.0 ± 0.6	21.1 ± 0.4	19.7 ± 0.5	19.3 ± 0.6	16.9 ± 0.9
7 – 8	25.3 ± 0.8	23.0 ± 0.6	21.3 ± 0.6	21.1 ± 0.7	17.5 ± 1.1
8 – 9	25.9 ± 1.0	25.6 ± 0.8	23.7 ± 0.8	21.6 ± 1.0	18.0 ± 1.5
9 – 10	29.5 ± 1.2	26.3 ± 1.0	27.2 ± 1.1	27.9 ± 1.3	26.6 ± 2.4
10 – 11	29.6 ± 1.5	31.5 ± 1.3	30.9 ± 1.4	26.5 ± 1.7	28.4 ± 2.8
11 – 12	34.0 ± 1.9	33.3 ± 1.6	28.1 ± 1.8	31.5 ± 2.3	36.9 ± 3.5
12 – 13	35.8 ± 2.3	36.5 ± 2.1	33.3 ± 2.2	29.3 ± 2.7	34.0 ± 5.2
13 – 14	43.6 ± 2.7	37.3 ± 2.3	33.4 ± 2.8	41.7 ± 3.9	15.2 ± 4.3

Table 6. The fraction of J/ψ -from- b mesons (in %) in bins of the J/ψ transverse momentum and rapidity. The uncertainties are statistical only. The systematic uncertainties are negligible.

p_T [GeV/c]	Prompt J/ψ	J/ψ -from- b
0–1	$2177 \pm 10 \pm 17 \pm 146$	$219.4 \pm 3.9 \pm 1.8 \pm 14.8$
1–2	$4226 \pm 14 \pm 29 \pm 278$	$509.2 \pm 4.9 \pm 3.6 \pm 33.5$
2–3	$3548 \pm 12 \pm 26 \pm 223$	$507.6 \pm 4.4 \pm 4.0 \pm 31.9$
3–4	$2251 \pm 9 \pm 16 \pm 134$	$367.6 \pm 3.5 \pm 2.7 \pm 21.9$
4–5	$1273 \pm 5 \pm 9 \pm 72$	$242.7 \pm 2.5 \pm 1.9 \pm 13.8$
5–6	$703.7 \pm 3.8 \pm 6.0 \pm 38.9$	$146.3 \pm 1.8 \pm 1.3 \pm 8.1$
6–7	$376.8 \pm 2.6 \pm 3.7 \pm 20.5$	$94.6 \pm 1.3 \pm 0.9 \pm 5.1$
7–8	$199.7 \pm 1.7 \pm 2.4 \pm 10.8$	$57.7 \pm 1.0 \pm 0.7 \pm 3.1$
8–9	$113.8 \pm 1.2 \pm 1.6 \pm 6.1$	$35.8 \pm 0.7 \pm 0.5 \pm 1.9$
9–10	$66.5 \pm 0.9 \pm 1.2 \pm 3.6$	$25.5 \pm 0.6 \pm 0.5 \pm 1.4$
10–11	$39.9 \pm 0.7 \pm 0.9 \pm 2.1$	$17.0 \pm 0.5 \pm 0.4 \pm 0.9$
11–12	$25.1 \pm 0.6 \pm 0.7 \pm 1.3$	$12.1 \pm 0.4 \pm 0.3 \pm 0.6$
12–13	$15.4 \pm 0.4 \pm 0.5 \pm 0.8$	$8.1 \pm 0.3 \pm 0.3 \pm 0.4$
13–14	$10.1 \pm 0.3 \pm 0.4 \pm 0.5$	$5.9 \pm 0.3 \pm 0.2 \pm 0.3$

Table 7. Differential cross-sections $d\sigma/dp_T$ (in nb/(GeV/c)) for prompt J/ψ and J/ψ -from- b mesons, integrated over y . The first uncertainties are statistical and the second (third) are uncorrelated (correlated) systematic uncertainties amongst bins.

y	Prompt J/ψ	J/ψ -from- b
2.0 – 2.5	$7.049 \pm 0.033 \pm 0.072 \pm 0.516$	$1.201 \pm 0.012 \pm 0.011 \pm 0.083$
2.5 – 3.0	$6.840 \pm 0.021 \pm 0.029 \pm 0.390$	$1.073 \pm 0.007 \pm 0.004 \pm 0.060$
3.0 – 3.5	$6.236 \pm 0.018 \pm 0.024 \pm 0.350$	$0.930 \pm 0.006 \pm 0.003 \pm 0.052$
3.5 – 4.0	$5.413 \pm 0.017 \pm 0.025 \pm 0.344$	$0.759 \pm 0.006 \pm 0.003 \pm 0.048$
4.0 – 4.5	$4.519 \pm 0.020 \pm 0.043 \pm 0.343$	$0.536 \pm 0.008 \pm 0.005 \pm 0.040$

Table 8. Differential cross-sections $d\sigma/dy$ (in μb) for prompt J/ψ and J/ψ -from- b mesons, integrated over p_T . The first uncertainties are statistical and the second (third) are the uncorrelated (correlated) systematic uncertainties.

p_T [GeV/c]	$2 < y < 2.5$	$2.5 < y < 3$	$3 < y < 3.5$	$3.5 < y < 4$	$4 < y < 4.5$	$2 < y < 4.5$
0 – 1	1.25 ± 0.14	1.24 ± 0.09	1.23 ± 0.08	1.27 ± 0.08	1.30 ± 0.09	1.26 ± 0.09
1 – 2	1.29 ± 0.12	1.28 ± 0.09	1.30 ± 0.08	1.28 ± 0.08	1.39 ± 0.09	1.30 ± 0.09
2 – 3	1.38 ± 0.11	1.35 ± 0.09	1.36 ± 0.08	1.38 ± 0.08	1.39 ± 0.09	1.37 ± 0.09
3 – 4	1.41 ± 0.11	1.43 ± 0.09	1.43 ± 0.09	1.48 ± 0.09	1.56 ± 0.11	1.45 ± 0.09
4 – 5	1.52 ± 0.13	1.44 ± 0.09	1.48 ± 0.09	1.56 ± 0.10	1.62 ± 0.11	1.51 ± 0.10
5 – 6	1.60 ± 0.11	1.58 ± 0.10	1.61 ± 0.10	1.60 ± 0.10	1.76 ± 0.14	1.61 ± 0.10
6 – 7	1.67 ± 0.12	1.56 ± 0.11	1.61 ± 0.11	1.64 ± 0.11	1.80 ± 0.14	1.64 ± 0.10
7 – 8	1.58 ± 0.12	1.53 ± 0.10	1.68 ± 0.12	1.75 ± 0.13	1.87 ± 0.17	1.64 ± 0.10
8 – 9	1.58 ± 0.14	1.64 ± 0.12	1.79 ± 0.14	1.82 ± 0.15	2.02 ± 0.20	1.71 ± 0.11
9 – 10	1.71 ± 0.15	1.78 ± 0.14	1.77 ± 0.15	1.90 ± 0.17	2.01 ± 0.25	1.80 ± 0.12
10 – 11	1.76 ± 0.17	1.69 ± 0.14	1.92 ± 0.17	1.94 ± 0.20	2.20 ± 0.32	1.83 ± 0.13
11 – 12	1.94 ± 0.21	1.75 ± 0.18	2.20 ± 0.21	1.68 ± 0.19	2.12 ± 0.36	1.92 ± 0.14
12 – 13	1.76 ± 0.21	1.67 ± 0.17	2.08 ± 0.24	1.96 ± 0.25	2.99 ± 0.60	1.91 ± 0.15
13 – 14	1.75 ± 0.25	1.98 ± 0.25	1.89 ± 0.26	1.40 ± 0.21	5.94 ± 1.57	1.98 ± 0.17
0 – 14	1.38 ± 0.11	1.36 ± 0.09	1.37 ± 0.08	1.38 ± 0.08	1.44 ± 0.09	—

Table 9. The ratio of cross-sections between measurements at 13 TeV and 8 TeV in different bins of p_T and y for prompt J/ψ mesons. The systematic errors are negligible.

p_T [GeV/c]	$2 < y < 2.5$	$2.5 < y < 3$	$3 < y < 3.5$	$3.5 < y < 4$	$4 < y < 4.5$	$2 < y < 4.5$
0 – 1	1.39 ± 0.24	1.38 ± 0.16	1.50 ± 0.19	1.80 ± 0.14	2.24 ± 0.24	1.57 ± 0.13
1 – 2	1.48 ± 0.14	1.52 ± 0.11	1.61 ± 0.11	1.83 ± 0.14	2.07 ± 0.17	1.63 ± 0.11
2 – 3	1.70 ± 0.15	1.54 ± 0.11	1.74 ± 0.11	1.95 ± 0.13	2.04 ± 0.15	1.74 ± 0.11
3 – 4	1.75 ± 0.14	1.64 ± 0.11	1.73 ± 0.11	1.90 ± 0.13	2.35 ± 0.19	1.80 ± 0.12
4 – 5	1.84 ± 0.16	1.77 ± 0.12	1.80 ± 0.12	2.10 ± 0.14	2.50 ± 0.21	1.90 ± 0.12
5 – 6	1.84 ± 0.14	1.82 ± 0.13	1.91 ± 0.13	2.12 ± 0.15	2.35 ± 0.22	1.93 ± 0.12
6 – 7	1.95 ± 0.15	1.90 ± 0.15	2.10 ± 0.15	2.39 ± 0.18	2.80 ± 0.29	2.08 ± 0.13
7 – 8	1.96 ± 0.17	1.89 ± 0.14	2.08 ± 0.16	2.40 ± 0.20	2.59 ± 0.31	2.06 ± 0.14
8 – 9	1.90 ± 0.19	1.93 ± 0.16	2.21 ± 0.20	2.40 ± 0.24	2.35 ± 0.33	2.06 ± 0.14
9 – 10	2.03 ± 0.20	1.98 ± 0.18	2.20 ± 0.22	3.19 ± 0.35	4.48 ± 0.89	2.30 ± 0.16
10 – 11	1.93 ± 0.22	2.16 ± 0.21	2.70 ± 0.28	3.10 ± 0.42	4.11 ± 0.79	2.38 ± 0.18
11 – 12	2.33 ± 0.28	2.25 ± 0.26	2.51 ± 0.31	2.73 ± 0.41	6.88 ± 1.64	2.57 ± 0.21
12 – 13	2.02 ± 0.28	1.92 ± 0.23	2.54 ± 0.36	2.48 ± 0.42	5.89 ± 1.65	2.29 ± 0.20
13 – 14	2.54 ± 0.40	2.49 ± 0.35	2.38 ± 0.39	3.55 ± 0.71	2.98 ± 1.04	2.60 ± 0.25
0 – 14	1.68 ± 0.13	1.62 ± 0.10	1.73 ± 0.11	1.96 ± 0.12	2.24 ± 0.15	—

Table 10. The ratio of cross-sections between measurements at 13 TeV and 8 TeV in different bins of p_T and y for J/ψ -from- b mesons. The systematic uncertainties are negligible.

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References

- [1] LHCb collaboration, *Measurement of forward J/ψ production cross-sections in pp collisions at $\sqrt{s} = 13$ TeV*, *JHEP* **10** (2015) 172 [[arXiv:1509.00771](https://arxiv.org/abs/1509.00771)] [[INSPIRE](#)].
- [2] A. Affolder et al., *Radiation damage in the LHCb vertex locator*, 2013 *JINST* **8** P08002 [[arXiv:1302.5259](https://arxiv.org/abs/1302.5259)] [[INSPIRE](#)].
- [3] LHCb collaboration, *Measurement of the track reconstruction efficiency at LHCb*, 2015 *JINST* **10** P02007 [[arXiv:1408.1251](https://arxiv.org/abs/1408.1251)] [[INSPIRE](#)].
- [4] H.S. Shao, H. Han, Y.Q. Ma, C. Meng, Y.J. Zhang and K.T. Chao, *Yields and polarizations of prompt J/ψ and $\psi(2S)$ production in hadronic collisions*, *JHEP* **05** (2015) 103 [[arXiv:1411.3300](https://arxiv.org/abs/1411.3300)] [[INSPIRE](#)].
- [5] M. Cacciari, M. Greco and P. Nason, *The p_T spectrum in heavy flavor hadroproduction*, *JHEP* **05** (1998) 007 [[hep-ph/9803400](https://arxiv.org/abs/hep-ph/9803400)] [[INSPIRE](#)].

The LHCb collaboration

R. Aaij³⁸, B. Adeva³⁷, M. Adinolfi⁴⁶, A. Affolder⁵², Z. Ajaltouni⁵, S. Akar⁶, J. Albrecht⁹, F. Alessio³⁸, M. Alexander⁵¹, S. Ali⁴¹, G. Alkhazov³⁰, P. Alvarez Cartelle⁵³, A.A. Alves Jr⁵⁷, S. Amato², S. Amerio²², Y. Amhis⁷, L. An³, L. Anderlini¹⁷, J. Anderson⁴⁰, G. Andreassi³⁹, M. Andreotti^{16,f}, J.E. Andrews⁵⁸, R.B. Appleby⁵⁴, O. Aquines Gutierrez¹⁰, F. Archilli³⁸, P. d'Argent¹¹, A. Artamonov³⁵, M. Artuso⁵⁹, E. Aslanides⁶, G. Auriemma^{25,m}, M. Baalouch⁵, S. Bachmann¹¹, J.J. Back⁴⁸, A. Badalov³⁶, C. Baesso⁶⁰, W. Baldini^{16,38}, R.J. Barlow⁵⁴, C. Barschel³⁸, S. Barsuk⁷, W. Barter³⁸, V. Batzskaya²⁸, V. Battista³⁹, A. Bay³⁹, L. Beaucourt⁴, J. Beddow⁵¹, F. Bedeschi²³, I. Bediaga¹, L.J. Bel⁴¹, V. Bellee³⁹, N. Belloli^{20,j}, I. Belyaev³¹, E. Ben-Haim⁸, G. Bencivenni¹⁸, S. Benson³⁸, J. Benton⁴⁶, A. Berezhnoy³², R. Bernet⁴⁰, A. Bertolin²², M.-O. Bettler³⁸, M. van Beuzekom⁴¹, A. Bien¹¹, S. Bifani⁴⁵, P. Billoir⁸, T. Bird⁵⁴, A. Birnkraut⁹, A. Bizzeti^{17,h}, T. Blake⁴⁸, F. Blanc³⁹, J. Blouw¹⁰, S. Blusk⁵⁹, V. Bocci²⁵, A. Bondar³⁴, N. Bondar^{30,38}, W. Bonivento¹⁵, S. Borghi⁵⁴, M. Borsato⁷, T.J.V. Bowcock⁵², E. Bowen⁴⁰, C. Bozzi¹⁶, S. Braun¹¹, M. Britsch¹⁰, T. Britton⁵⁹, J. Brodzicka⁵⁴, N.H. Brook⁴⁶, E. Buchanan⁴⁶, A. Bursche⁴⁰, J. Buytaert³⁸, S. Cadeddu¹⁵, R. Calabrese^{16,f}, M. Calvi^{20,j}, M. Calvo Gomez^{36,o}, P. Campana¹⁸, D. Campora Perez³⁸, L. Capriotti⁵⁴, A. Carbone^{14,d}, G. Carboni^{24,k}, R. Cardinale^{19,i}, A. Cardini¹⁵, P. Carniti^{20,j}, L. Carson⁵⁰, K. Carvalho Akiba^{2,38}, G. Casse⁵², L. Cassina^{20,j}, L. Castillo Garcia³⁸, M. Cattaneo³⁸, Ch. Cauet⁹, G. Cavallero¹⁹, R. Cenci^{23,s}, M. Charles⁸, Ph. Charpentier³⁸, M. Chefdeville⁴, S. Chen⁵⁴, S.-F. Cheung⁵⁵, N. Chiapolini⁴⁰, M. Chrzaszcz⁴⁰, X. Cid Vidal³⁸, G. Ciezarek⁴¹, P.E.L. Clarke⁵⁰, M. Clemencic³⁸, H.V. Cliff⁴⁷, J. Closier³⁸, V. Coco³⁸, J. Cogan⁶, E. Cogneras⁵, V. Cogoni^{15,e}, L. Cojocariu²⁹, G. Collazuol²², P. Collins³⁸, A. Comerma-Montells¹¹, A. Contu¹⁵, A. Cook⁴⁶, M. Coombes⁴⁶, S. Coquereau⁸, G. Corti³⁸, M. Corvo^{16,f}, B. Couturier³⁸, G.A. Cowan⁵⁰, D.C. Craik⁴⁸, A. Crocombe⁴⁸, M. Cruz Torres⁶⁰, S. Cunliffe⁵³, R. Currie⁵³, C. D'Ambrosio³⁸, E. Dall'Occo⁴¹, J. Dalseno⁴⁶, P.N.Y. David⁴¹, A. Davis⁵⁷, K. De Bruyn⁶, S. De Capua⁵⁴, M. De Cian¹¹, J.M. De Miranda¹, L. De Paula², P. De Simone¹⁸, C.-T. Dean⁵¹, D. Decamp⁴, M. Deckenhoff⁹, L. Del Buono⁸, N. Déleage⁴, M. Demmer⁹, D. Derkach⁶⁵, O. Deschamps⁵, F. Dettori³⁸, B. Dey²¹, A. Di Canto³⁸, F. Di Ruscio²⁴, H. Dijkstra³⁸, S. Donleavy⁵², F. Dordei¹¹, M. Dorigo³⁹, A. Dosil Suárez³⁷, D. Dossett⁴⁸, A. Dovbnya⁴³, K. Dreimanis⁵², L. Dufour⁴¹, G. Dujany⁵⁴, F. Dupertuis³⁹, P. Durante³⁸, R. Dzhelyadin³⁵, A. Dziurda²⁶, A. Dzyuba³⁰, S. Easo^{49,38}, U. Egede⁵³, V. Egorychev³¹, S. Eidelman³⁴, S. Eisenhardt⁵⁰, U. Eitschberger⁹, R. Ekelhof⁹, L. Eklund⁵¹, I. El Rifai⁵, Ch. Elsasser⁴⁰, S. Ely⁵⁹, S. Esen¹¹, H.M. Evans⁴⁷, T. Evans⁵⁵, A. Falabella¹⁴, C. Färber³⁸, N. Farley⁴⁵, S. Farry⁵², R. Fay⁵², D. Ferguson⁵⁰, V. Fernandez Albor³⁷, F. Ferrari¹⁴, F. Ferreira Rodrigues¹, M. Ferro-Luzzi³⁸, S. Filippov³³, M. Fiore^{16,38,f}, M. Fiorini^{16,f}, M. Firlej²⁷, C. Fitzpatrick³⁹, T. Fiutowski²⁷, K. Fohl³⁸, P. Fol⁵³, M. Fontana¹⁵, F. Fontanelli^{19,i}, R. Forty³⁸, O. Francisco², M. Frank³⁸, C. Frei³⁸, M. Frosini¹⁷, J. Fu²¹, E. Furfaro^{24,k}, A. Gallas Torreira³⁷, D. Galli^{14,d}, S. Gallorini²², S. Gambetta⁵⁰, M. Gandelman², P. Gandini⁵⁵, Y. Gao³, J. García Pardiñas³⁷, J. Garra Tico⁴⁷, L. Garrido³⁶, D. Gascon³⁶, C. Gaspar³⁸, R. Gauld⁵⁵, L. Gavardi⁹, G. Gazzoni⁵, D. Gerick¹¹, E. Gersabeck¹¹, M. Gersabeck⁵⁴, T. Gershon⁴⁸, Ph. Ghez⁴, S. Gianì³⁹, V. Gibson⁴⁷, O.G. Girard³⁹, L. Giubega²⁹, V.V. Gligorov³⁸, C. Göbel⁶⁰, D. Golubkov³¹, A. Golutvin^{53,38}, A. Gomes^{1,a}, C. Gotti^{20,j}, M. Grabalosa Gándara⁵, R. Graciani Diaz³⁶, L.A. Granado Cardoso³⁸, E. Graugés³⁶, E. Graverini⁴⁰, G. Graziani¹⁷, A. Grecu²⁹, E. Greening⁵⁵, S. Gregson⁴⁷, P. Griffith⁴⁵, L. Grillo¹¹, O. Grünberg⁶³, B. Gui⁵⁹, E. Gushchin³³, Yu. Guz^{35,38}, T. Gys³⁸, T. Hadavizadeh⁵⁵, C. Hadjivasiliou⁵⁹, G. Haefeli³⁹, C. Haen³⁸, S.C. Haines⁴⁷, S. Hall⁵³, B. Hamilton⁵⁸, X. Han¹¹, S. Hansmann-Menzemer¹¹, N. Harnew⁵⁵, S.T. Harnew⁴⁶, J. Harrison⁵⁴, J. He³⁸, T. Head³⁹, V. Heijne⁴¹, K. Hennessy⁵², P. Henrard⁵, L. Henry⁸, E. van Herwijnen³⁸, M. Heß⁶³, A. Hicheur²,

D. Hill⁵⁵, M. Hoballah⁵, C. Hombach⁵⁴, W. Hulsbergen⁴¹, T. Humair⁵³, N. Hussain⁵⁵,
 D. Hutchcroft⁵², D. Hynds⁵¹, M. Idzik²⁷, P. Ilten⁵⁶, R. Jacobsson³⁸, A. Jaeger¹¹, J. Jalocha⁵⁵,
 E. Jans⁴¹, A. Jawahery⁵⁸, F. Jing³, M. John⁵⁵, D. Johnson³⁸, C.R. Jones⁴⁷, C. Joram³⁸,
 B. Jost³⁸, N. Jurik⁵⁹, S. Kandybei⁴³, W. Kanso⁶, M. Karacson³⁸, T.M. Karbach^{38,†}, S. Karodia⁵¹,
 M. Kecke¹¹, M. Kelsey⁵⁹, I.R. Kenyon⁴⁵, M. Kenzie³⁸, T. Ketel⁴², E. Khairullin⁶⁵,
 B. Khanji^{20,38,j}, C. Khurewathanakul³⁹, S. Klaver⁵⁴, K. Klimaszewski²⁸, O. Kochebina⁷,
 M. Kolpin¹¹, I. Komarov³⁹, R.F. Koopman⁴², P. Koppenburg^{41,38}, M. Kozeiha⁵, L. Kravchuk³³,
 K. Kreplin¹¹, M. Kreps⁴⁸, G. Krocker¹¹, P. Krokovny³⁴, F. Kruse⁹, W. Krzemien²⁸,
 W. Kucewicz^{26,n}, M. Kucharczyk²⁶, V. Kudryavtsev³⁴, A. K. Kuonen³⁹, K. Kurek²⁸,
 T. Kvaratskheliya³¹, D. Lacarrere³⁸, G. Lafferty⁵⁴, A. Lai¹⁵, D. Lambert⁵⁰, G. Lanfranchi¹⁸,
 C. Langenbruch⁴⁸, B. Langhans³⁸, T. Latham⁴⁸, C. Lazzeroni⁴⁵, R. Le Gac⁶, J. van Leerdam⁴¹,
 J.-P. Lees⁴, R. Lefèvre⁵, A. Leflat^{32,38}, J. Lefrançois⁷, E. Lemos Cid³⁷, O. Leroy⁶, T. Lesiak²⁶,
 B. Leverington¹¹, Y. Li⁷, T. Likhomanenko^{65,64}, M. Liles⁵², R. Lindner³⁸, C. Linn³⁸,
 F. Lionetto⁴⁰, B. Liu¹⁵, X. Liu³, D. Loh⁴⁸, I. Longstaff⁵¹, J.H. Lopes², D. Lucchesi^{22,q},
 M. Lucio Martinez³⁷, H. Luo⁵⁰, A. Lupato²², E. Luppi^{16,f}, O. Lupton⁵⁵, A. Lusiani²³,
 F. Machefert⁷, F. Maciuc²⁹, O. Maev³⁰, K. Maguire⁵⁴, S. Malde⁵⁵, A. Malinin⁶⁴, G. Manca⁷,
 G. Mancinelli⁶, P. Manning⁵⁹, A. Mapelli³⁸, J. Maratas⁵, J.F. Marchand⁴, U. Marconi¹⁴,
 C. Marin Benito³⁶, P. Marino^{23,38,s}, J. Marks¹¹, G. Martellotti²⁵, M. Martin⁶, M. Martinelli³⁹,
 D. Martinez Santos³⁷, F. Martinez Vidal⁶⁶, D. Martins Tostes², A. Massafferri¹, R. Matev³⁸,
 A. Mathad⁴⁸, Z. Mathe³⁸, C. Matteuzzi²⁰, A. Mauri⁴⁰, B. Maurin³⁹, A. Mazurov⁴⁵,
 M. McCann⁵³, J. McCarthy⁴⁵, A. McNab⁵⁴, R. McNulty¹², B. Meadows⁵⁷, F. Meier⁹,
 M. Meissner¹¹, D. Melnychuk²⁸, M. Merk⁴¹, E. Michielin²², D.A. Milanes⁶², M.-N. Minard⁴,
 D.S. Mitzel¹¹, J. Molina Rodriguez⁶⁰, I.A. Monroy⁶², S. Monteil⁵, M. Morandin²², P. Morawski²⁷,
 A. Mordà⁶, M.J. Morello^{23,s}, J. Moron²⁷, A.B. Morris⁵⁰, R. Mountain⁵⁹, F. Muheim⁵⁰,
 D. Müller⁵⁴, J. Müller⁹, K. Müller⁴⁰, V. Müller⁹, M. Mussini¹⁴, B. Muster³⁹, P. Naik⁴⁶,
 T. Nakada³⁹, R. Nandakumar⁴⁹, A. Nandi⁵⁵, I. Nasteva², M. Needham⁵⁰, N. Neri²¹, S. Neubert¹¹,
 N. Neufeld³⁸, M. Neuner¹¹, A.D. Nguyen³⁹, T.D. Nguyen³⁹, C. Nguyen-Mau^{39,p}, V. Niess⁵,
 R. Niet⁹, N. Nikitin³², T. Nikodem¹¹, A. Novoselov³⁵, D.P. O'Hanlon⁴⁸, A. Oblakowska-Mucha²⁷,
 V. Obraztsov³⁵, S. Ogilvy⁵¹, O. Okhrimenko⁴⁴, R. Oldeman^{15,e}, C.J.G. Onderwater⁶⁷,
 B. Osorio Rodrigues¹, J.M. Otalora Goicochea², A. Otto³⁸, P. Owen⁵³, A. Oyanguren⁶⁶,
 A. Palano^{13,c}, F. Palombo^{21,t}, M. Palutan¹⁸, J. Panman³⁸, A. Papanestis⁴⁹, M. Pappagallo⁵¹,
 L.L. Pappalardo^{16,f}, C. Pappenheimer⁵⁷, W. Parker⁵⁸, C. Parkes⁵⁴, G. Passaleva¹⁷, G.D. Patel⁵²,
 M. Patel⁵³, C. Patrignani^{19,i}, A. Pearce^{54,49}, A. Pellegrino⁴¹, G. Penso^{25,l}, M. Pepe Altarelli³⁸,
 S. Perazzini^{14,d}, P. Perret⁵, L. Pescatore⁴⁵, K. Petridis⁴⁶, A. Petrolini^{19,i}, M. Petruzzio²¹,
 E. Picatoste Olloqui³⁶, B. Pietrzyk⁴, T. Pilar⁴⁸, D. Pinci²⁵, A. Pistone¹⁹, A. Piucci¹¹,
 S. Playfer⁵⁰, M. Plo Casasus³⁷, T. Poikela³⁸, F. Polci⁸, A. Poluektov^{48,34}, I. Polyakov³¹,
 E. Polycarpo², A. Popov³⁵, D. Popov^{10,38}, B. Popovici²⁹, C. Potterat², E. Price⁴⁶, J.D. Price⁵²,
 J. Prisciandaro³⁷, A. Pritchard⁵², C. Prouve⁴⁶, V. Pugatch⁴⁴, A. Puig Navarro³⁹, G. Punzi^{23,r},
 W. Qian⁴, R. Quagliani^{7,46}, B. Rachwal²⁶, J.H. Rademacker⁴⁶, M. Rama²³, M.S. Rangel²,
 I. Raniuk⁴³, N. Rauschmayr³⁸, G. Raven⁴², F. Redi⁵³, S. Reichert⁵⁴, M.M. Reid⁴⁸, A.C. dos Reis¹,
 S. Ricciardi⁴⁹, S. Richards⁴⁶, M. Rihl³⁸, K. Rinnert⁵², V. Rives Molina³⁶, P. Robbe^{7,38},
 A.B. Rodrigues¹, E. Rodrigues⁵⁴, J.A. Rodriguez Lopez⁶², P. Rodriguez Perez⁵⁴, S. Roiser³⁸,
 V. Romanovsky³⁵, A. Romero Vidal³⁷, J. W. Ronayne¹², M. Rotondo²², J. Rouvinet³⁹, T. Ruf³⁸,
 P. Ruiz Valls⁶⁶, J.J. Saborido Silva³⁷, N. Sagidova³⁰, P. Sail⁵¹, B. Saitta^{15,e},
 V. Salustino Guimaraes², C. Sanchez Mayordomo⁶⁶, B. Sanmartin Sedes³⁷, R. Santacesaria²⁵,
 C. Santamarina Rios³⁷, M. Santimaria¹⁸, E. Santovetti^{24,k}, A. Sarti^{18,l}, C. Satriano^{25,m},
 A. Satta²⁴, D.M. Saunders⁴⁶, D. Savrina^{31,32}, M. Schiller³⁸, H. Schindler³⁸, M. Schlupp⁹,
 M. Schmelling¹⁰, T. Schmelzer⁹, B. Schmidt³⁸, O. Schneider³⁹, A. Schopper³⁸, M. Schubiger³⁹,

M.-H. Schune⁷, R. Schwemmer³⁸, B. Sciascia¹⁸, A. Sciubba^{25,l}, A. Semennikov³¹, N. Serra⁴⁰, J. Serrano⁶, L. Sestini²², P. Seyfert²⁰, M. Shapkin³⁵, I. Shapoval^{16,43,f}, Y. Sheheglov³⁰, T. Shears⁵², L. Shekhtman³⁴, V. Shevchenko⁶⁴, A. Shires⁹, B.G. Siddi¹⁶, R. Silva Coutinho^{48,40}, L. Silva de Oliveira², G. Simi²², M. Sirendi⁴⁷, N. Skidmore⁴⁶, T. Skwarnicki⁵⁹, E. Smith^{55,49}, E. Smith⁵³, I.T. Smith⁵⁰, J. Smith⁴⁷, M. Smith⁵⁴, H. Snoek⁴¹, M.D. Sokoloff^{57,38}, F.J.P. Soler⁵¹, F. Soomro³⁹, D. Souza⁴⁶, B. Souza De Paula², B. Spaan⁹, P. Spradlin⁵¹, S. Sridharan³⁸, F. Stagni³⁸, M. Stahl¹¹, S. Stahl³⁸, S. Stefkova⁵³, O. Steinkamp⁴⁰, O. Stenyakin³⁵, S. Stevenson⁵⁵, S. Stoica²⁹, S. Stone⁵⁹, B. Storaci⁴⁰, S. Stracka^{23,s}, M. Straticiuc²⁹, U. Straumann⁴⁰, L. Sun⁵⁷, W. Sutcliffe⁵³, K. Swientek²⁷, S. Swientek⁹, V. Syropoulos⁴², M. Szczekowski²⁸, T. Szumlak²⁷, S. T'Jampens⁴, A. Tayduganov⁶, T. Tekampe⁹, M. Teklishyn⁷, G. Tellarini^{16,f}, F. Teubert³⁸, C. Thomas⁵⁵, E. Thomas³⁸, J. van Tilburg⁴¹, V. Tisserand⁴, M. Tobin³⁹, J. Todd⁵⁷, S. Tol⁴², L. Tomassetti^{16,f}, D. Tonelli³⁸, S. Topp-Joergensen⁵⁵, N. Torr⁵⁵, E. Tournefier⁴, S. Tourneur³⁹, K. Trabelsi³⁹, M.T. Tran³⁹, M. Tresch⁴⁰, A. Trisovic³⁸, A. Tsaregorodtsev⁶, P. Tsopelas⁴¹, N. Tuning^{41,38}, A. Ukleja²⁸, A. Ustyuzhanin^{65,64}, U. Uwer¹¹, C. Vacca^{15,e}, V. Vagnoni¹⁴, G. Valenti¹⁴, A. Vallier⁷, R. Vazquez Gomez¹⁸, P. Vazquez Regueiro³⁷, C. Vázquez Sierra³⁷, S. Vecchi¹⁶, J.J. Velthuis⁴⁶, M. Veltri^{17,g}, G. Veneziano³⁹, M. Vesterinen¹¹, B. Viaud⁷, D. Vieira², M. Vieites Diaz³⁷, X. Vilasis-Cardona^{36,o}, V. Volkov³², A. Vollhardt⁴⁰, D. Volynsky¹⁰, D. Voong⁴⁶, A. Vorobyev³⁰, V. Vorobyev³⁴, C. Voß⁶³, J.A. de Vries⁴¹, R. Waldi⁶³, C. Wallace⁴⁸, R. Wallace¹², J. Walsh²³, S. Wandernoth¹¹, J. Wang⁵⁹, D.R. Ward⁴⁷, N.K. Watson⁴⁵, D. Websdale⁵³, A. Weiden⁴⁰, M. Whitehead⁴⁸, G. Wilkinson^{55,38}, M. Wilkinson⁵⁹, M. Williams³⁸, M.P. Williams⁴⁵, M. Williams⁵⁶, T. Williams⁴⁵, F.F. Wilson⁴⁹, J. Wimberley⁵⁸, J. Wishahi⁹, W. Wislicki²⁸, M. Witek²⁶, G. Wormser⁷, S.A. Wotton⁴⁷, S. Wright⁴⁷, K. Wyllie³⁸, Y. Xie⁶¹, Z. Xu³⁹, Z. Yang³, J. Yu⁶¹, X. Yuan³⁴, O. Yushchenko³⁵, M. Zangoli¹⁴, M. Zavertyaev^{10,b}, L. Zhang³, Y. Zhang³, A. Zhelezov¹¹, A. Zhokhov³¹, L. Zhong³, S. Zucchelli¹⁴

¹ Centro Brasileiro de Pesquisas Físicas (CBPF), Rio de Janeiro, Brazil

² Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

³ Center for High Energy Physics, Tsinghua University, Beijing, China

⁴ LAPP, Université Savoie Mont-Blanc, CNRS/IN2P3, Annecy-Le-Vieux, France

⁵ Clermont Université, Université Blaise Pascal, CNRS/IN2P3, LPC, Clermont-Ferrand, France

⁶ CPPM, Aix-Marseille Université, CNRS/IN2P3, Marseille, France

⁷ LAL, Université Paris-Sud, CNRS/IN2P3, Orsay, France

⁸ LPNHE, Université Pierre et Marie Curie, Université Paris Diderot, CNRS/IN2P3, Paris, France

⁹ Fakultät Physik, Technische Universität Dortmund, Dortmund, Germany

¹⁰ Max-Planck-Institut für Kernphysik (MPIK), Heidelberg, Germany

¹¹ Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany

¹² School of Physics, University College Dublin, Dublin, Ireland

¹³ Sezione INFN di Bari, Bari, Italy

¹⁴ Sezione INFN di Bologna, Bologna, Italy

¹⁵ Sezione INFN di Cagliari, Cagliari, Italy

¹⁶ Sezione INFN di Ferrara, Ferrara, Italy

¹⁷ Sezione INFN di Firenze, Firenze, Italy

¹⁸ Laboratori Nazionali dell'INFN di Frascati, Frascati, Italy

¹⁹ Sezione INFN di Genova, Genova, Italy

²⁰ Sezione INFN di Milano Bicocca, Milano, Italy

²¹ Sezione INFN di Milano, Milano, Italy

²² Sezione INFN di Padova, Padova, Italy

²³ Sezione INFN di Pisa, Pisa, Italy

²⁴ Sezione INFN di Roma Tor Vergata, Roma, Italy

²⁵ Sezione INFN di Roma La Sapienza, Roma, Italy

- ²⁶ *Henryk Niewodniczanski Institute of Nuclear Physics Polish Academy of Sciences, Kraków, Poland*
- ²⁷ *AGH - University of Science and Technology, Faculty of Physics and Applied Computer Science, Kraków, Poland*
- ²⁸ *National Center for Nuclear Research (NCBJ), Warsaw, Poland*
- ²⁹ *Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest-Magurele, Romania*
- ³⁰ *Petersburg Nuclear Physics Institute (PNPI), Gatchina, Russia*
- ³¹ *Institute of Theoretical and Experimental Physics (ITEP), Moscow, Russia*
- ³² *Institute of Nuclear Physics, Moscow State University (SINP MSU), Moscow, Russia*
- ³³ *Institute for Nuclear Research of the Russian Academy of Sciences (INR RAN), Moscow, Russia*
- ³⁴ *Budker Institute of Nuclear Physics (SB RAS) and Novosibirsk State University, Novosibirsk, Russia*
- ³⁵ *Institute for High Energy Physics (IHEP), Protvino, Russia*
- ³⁶ *Universitat de Barcelona, Barcelona, Spain*
- ³⁷ *Universidad de Santiago de Compostela, Santiago de Compostela, Spain*
- ³⁸ *European Organization for Nuclear Research (CERN), Geneva, Switzerland*
- ³⁹ *Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland*
- ⁴⁰ *Physik-Institut, Universität Zürich, Zürich, Switzerland*
- ⁴¹ *Nikhef National Institute for Subatomic Physics, Amsterdam, The Netherlands*
- ⁴² *Nikhef National Institute for Subatomic Physics and VU University Amsterdam, Amsterdam, The Netherlands*
- ⁴³ *NSC Kharkiv Institute of Physics and Technology (NSC KIPT), Kharkiv, Ukraine*
- ⁴⁴ *Institute for Nuclear Research of the National Academy of Sciences (KINR), Kyiv, Ukraine*
- ⁴⁵ *University of Birmingham, Birmingham, United Kingdom*
- ⁴⁶ *H.H. Wills Physics Laboratory, University of Bristol, Bristol, United Kingdom*
- ⁴⁷ *Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
- ⁴⁸ *Department of Physics, University of Warwick, Coventry, United Kingdom*
- ⁴⁹ *STFC Rutherford Appleton Laboratory, Didcot, United Kingdom*
- ⁵⁰ *School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
- ⁵¹ *School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
- ⁵² *Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
- ⁵³ *Imperial College London, London, United Kingdom*
- ⁵⁴ *School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
- ⁵⁵ *Department of Physics, University of Oxford, Oxford, United Kingdom*
- ⁵⁶ *Massachusetts Institute of Technology, Cambridge, MA, United States*
- ⁵⁷ *University of Cincinnati, Cincinnati, OH, United States*
- ⁵⁸ *University of Maryland, College Park, MD, United States*
- ⁵⁹ *Syracuse University, Syracuse, NY, United States*
- ⁶⁰ *Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil, associated to²*
- ⁶¹ *Institute of Particle Physics, Central China Normal University, Wuhan, Hubei, China, associated to³*
- ⁶² *Departamento de Física , Universidad Nacional de Colombia, Bogota, Colombia, associated to⁸*
- ⁶³ *Institut für Physik, Universität Rostock, Rostock, Germany, associated to¹¹*
- ⁶⁴ *National Research Centre Kurchatov Institute, Moscow, Russia, associated to³¹*
- ⁶⁵ *Yandex School of Data Analysis, Moscow, Russia, associated to³¹*
- ⁶⁶ *Instituto de Física Corpuscular (IFIC), Universitat de Valencia-CSIC, Valencia, Spain, associated to³⁶*
- ⁶⁷ *Van Swinderen Institute, University of Groningen, Groningen, The Netherlands, associated to⁴¹*
- ^a *Universidade Federal do Triângulo Mineiro (UFTM), Uberaba-MG, Brazil*
- ^b *P.N. Lebedev Physical Institute, Russian Academy of Science (LPI RAS), Moscow, Russia*

- ^c *Università di Bari, Bari, Italy*
- ^d *Università di Bologna, Bologna, Italy*
- ^e *Università di Cagliari, Cagliari, Italy*
- ^f *Università di Ferrara, Ferrara, Italy*
- ^g *Università di Urbino, Urbino, Italy*
- ^h *Università di Modena e Reggio Emilia, Modena, Italy*
- ⁱ *Università di Genova, Genova, Italy*
- ^j *Università di Milano Bicocca, Milano, Italy*
- ^k *Università di Roma Tor Vergata, Roma, Italy*
- ^l *Università di Roma La Sapienza, Roma, Italy*
- ^m *Università della Basilicata, Potenza, Italy*
- ⁿ *AGH - University of Science and Technology, Faculty of Computer Science, Electronics and Telecommunications, Kraków, Poland*
- ^o *LIFAELS, La Salle, Universitat Ramon Llull, Barcelona, Spain*
- ^p *Hanoi University of Science, Hanoi, Viet Nam*
- ^q *Università di Padova, Padova, Italy*
- ^r *Università di Pisa, Pisa, Italy*
- ^s *Scuola Normale Superiore, Pisa, Italy*
- ^t *Università degli Studi di Milano, Milano, Italy*
- [†] *Deceased*