Supplementary material for LHCb-PAPER-2021-003

Cabibbo-suppression in b-hadron decays

The measurement of $\mathcal{B}(\Lambda_b^0 \to \chi_{c1} p\pi^-)/\mathcal{B}(\Lambda_b^0 \to \chi_{c1} pK^-)$ is compared with previous measurements of branching fraction ratios between Cabibbo-suppressed and Cabibbo-favoured decays of b-hadrons. The ratios are defined as

$$R \equiv \frac{\mathcal{B}(\text{suppressed})}{\mathcal{B}(\text{favoured})}. \tag{S1a}$$

The corresponding phase space-corrected ratios R^Φ are defined as

$$R^\Phi \equiv \frac{\mathcal{B}(\text{suppressed})}{\mathcal{B}(\text{favoured})} \times \frac{\Phi(\text{favoured})}{\Phi(\text{suppressed})}, \tag{S1b}$$

where Φ denotes the two- or three-body phase space. For three-body decays, the resonant structure is neglected. These ratios R and R^Φ are shown in Fig. S1 and listed in Table S1.

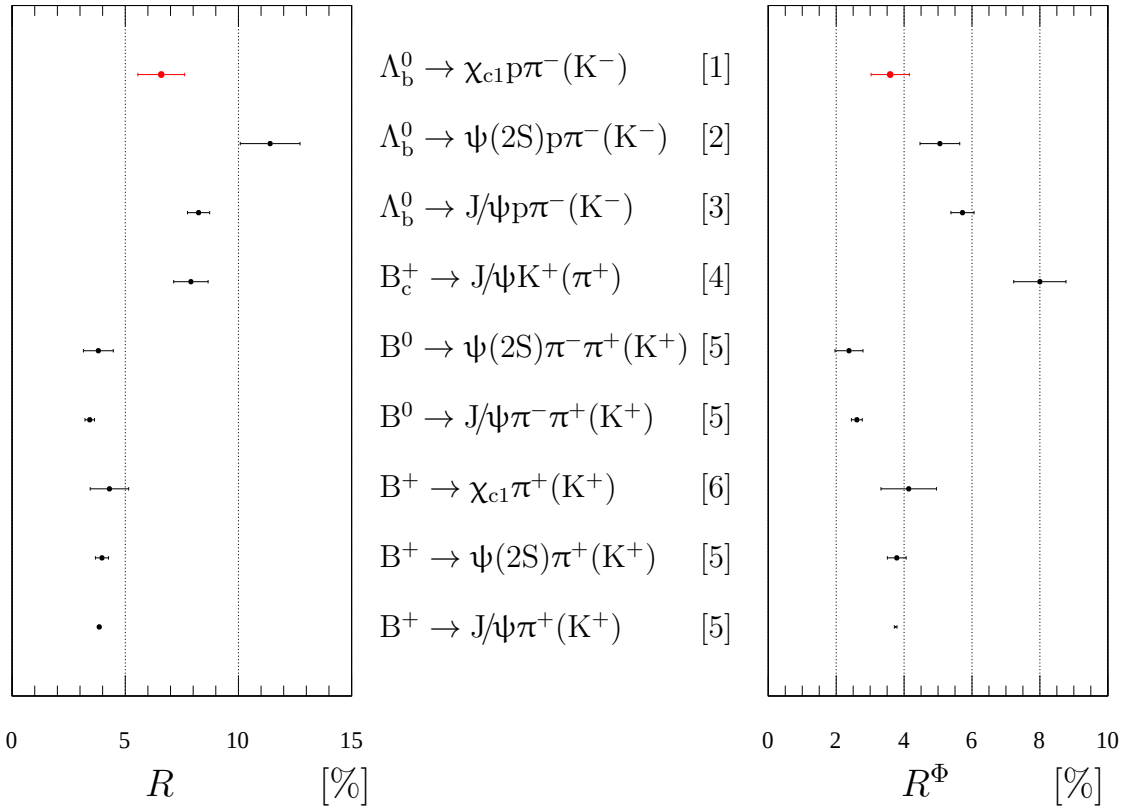

Figure S1: The ratios R and R^Φ for selected two- and three-body decays of beauty hadrons.

Table S1: The ratios R and R^{Φ} for selected two- and three-body decays of beauty hadrons.

Cabibbo-suppressed	Cabibbo-favoured	R [%]	R^{Φ} [%]	Ref.
$\Lambda_b^0 \to \chi_{c1} p\pi^-$	$\Lambda_b^0 \to \chi_{c1} pK^-$	6.59 ± 1.03	3.59 ± 0.56	[1]
$\Lambda_b^0 \to \psi(2S) p\pi^-$	$\Lambda_b^0 \to \psi(2S) pK^-$	11.40 ± 1.32	5.05 ± 0.59	[2]
$\Lambda_b^0 \to J/\psi p\pi^-$	$\Lambda_b^0 \to J/\psi pK^-$	8.24 ± 0.49	5.72 ± 0.34	[3]
$B_c^+ \to J/\psi K^-$	$B_c^+ \to J/\psi \pi^-$	7.90 ± 0.76	8.00 ± 0.77	[4]
$B^0 \to \psi(2S)\pi^+\pi^-$	$B^0 \to \psi(2S)K^+\pi^-$	3.81 ± 0.66	2.38 ± 0.41	[5]
$B^0 \to J/\psi\pi^+\pi^-$	$B^0 \to J/\psi K^+\pi^-$	3.43 ± 0.21	2.61 ± 0.16	[5]
$B^+ \to \chi_{c1}\pi^+$	$B^+ \to \chi_{c1}K^+$	4.30 ± 0.85	4.14 ± 0.82	[6]
$B^+ \to \psi(2S)\pi^+$	$B^+ \to \psi(2S)K^+$	3.97 ± 0.29	3.78 ± 0.28	[5]
$B^+ \to J/\psi\pi^+$	$B^+ \to J/\psi K^+$	3.85 ± 0.04	3.75 ± 0.04	[5]

$J/\psi\gamma$ mass spectra from $\Lambda_b^0 \to \chi_{cJ} p\pi^-$ and $\Lambda_b^0 \to \chi_{cJ} pK^-$ decays

Background-subtracted $J/\psi\gamma$ mass spectra from $\Lambda_b^0 \to \chi_{cJ} p\pi^-$ and $\Lambda_b^0 \to \chi_{cJ} pK^-$ decays are shown in Fig. S2, where *sPlot* technique [7] is used for background-subtraction with $\chi_{c1} p\pi^-$ and $\chi_{c1} pK^-$ masses as discriminating variables.

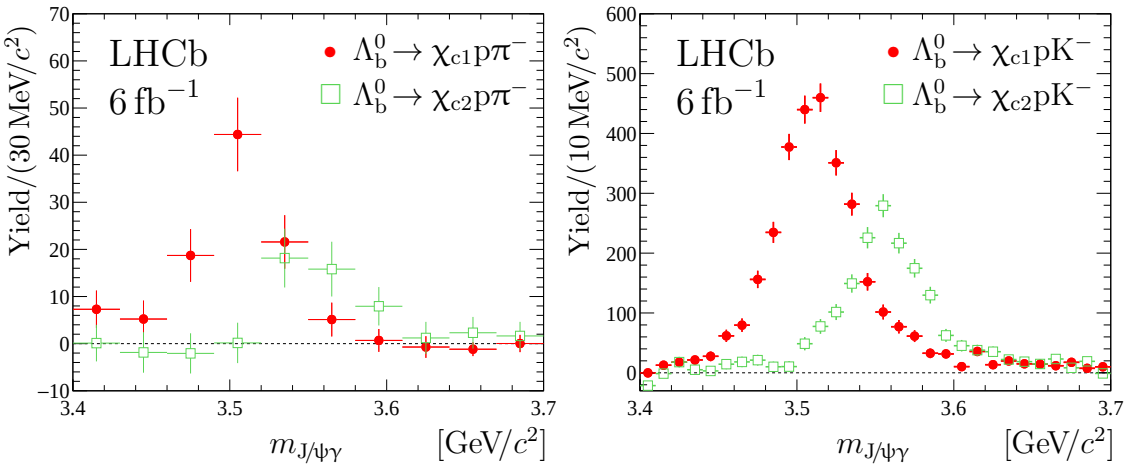

Figure S2: Background-subtracted $J/\psi\gamma$ mass spectra from (left) $\Lambda_b^0 \to \chi_{cJ} p\pi^-$ and (right) $\Lambda_b^0 \to \chi_{cJ} pK^-$ decays.

References

[1] LHCb collaboration, R. Aaij *et al.*, *Observation of the decay* $\Lambda_b^0 \to \chi_{c1} p \pi^-$, arXiv:2103.04949, submitted to JHEP.

[2] LHCb collaboration, R. Aaij *et al.*, *Observation of the decay* $\Lambda_b^0 \to \psi(2S) p \pi^-$, JHEP **08** (2018) 131, arXiv:1806.08084.

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[4] LHCb collaboration, R. Aaij *et al.*, *Measurement of the ratio of branching fractions* $\mathcal{B}(B_c^+ \to J/\psi K^+)/\mathcal{B}(B_c^+ \to J/\psi \pi^+)$, JHEP **09** (2016) 153, arXiv:1607.06823.

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[7] M. Pivk and F. R. Le Diberder, *sPlot: A statistical tool to unfold data distributions*, Nucl. Instrum. Meth. **A555** (2005) 356, arXiv:physics/0402083.