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Model-independent evidence for $J/\psi p$ contributions to $\Lambda_b^0 \to J/\psi p K^-$ decays

Supplemental material

The LHCb collaboration

Appendix: Supplemental material

Contents

1 Data sample

The definition of the signal and sideband regions is illustrated in Fig. 7. The background-subtracted and efficiency-corrected distribution of the data on the rectangular Dalitz plane $(m_{Kp}, \cos\theta_{\Lambda^*})$ is shown in Fig. 8.

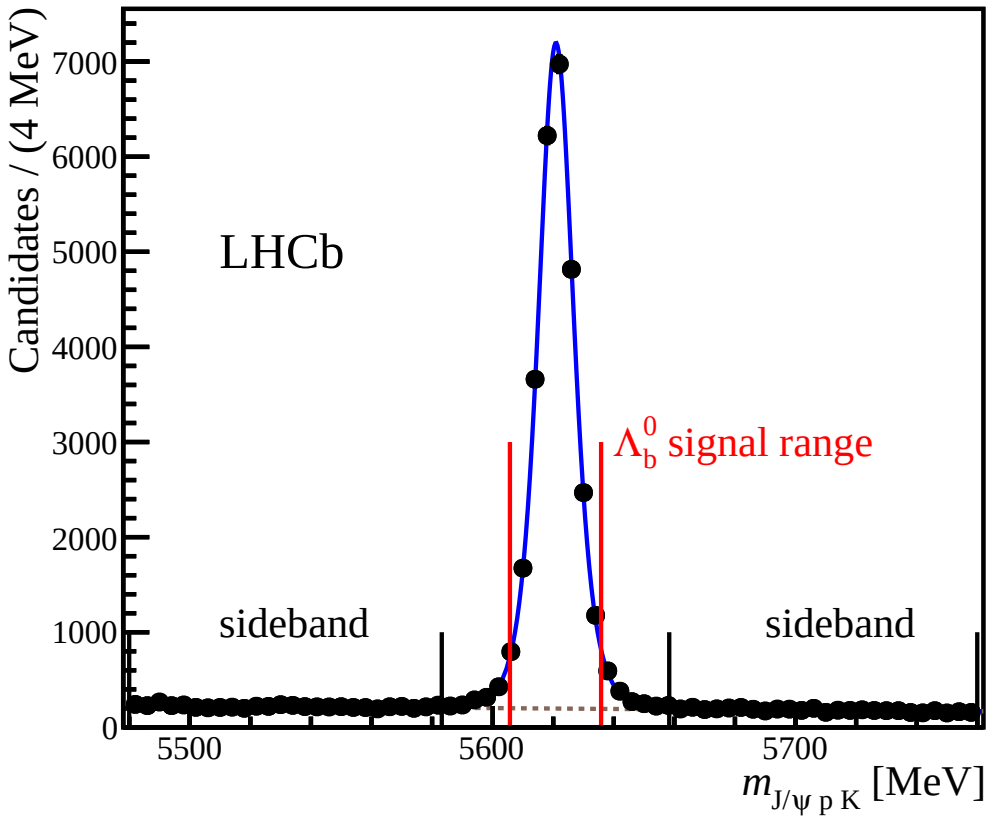

Figure 7: Distribution of $m_{J/\psi pK}$ in the data with the fit of signal and background components superimposed [1]. The fit is used to determine the background fraction β in the $\pm 2\sigma$ signal region around the Λ_b^0 peak (shown by the vertical red bars). The sidebands used in the background subtraction are also shown.

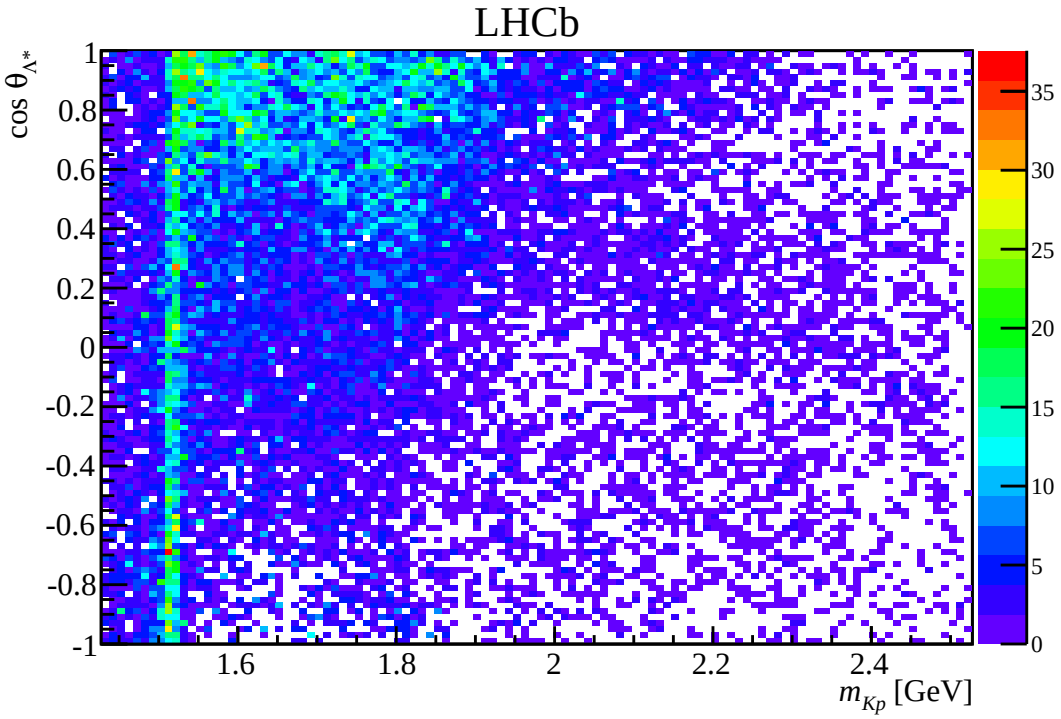

Figure 8: Background-subtracted and efficiency-corrected distribution of the cosine of the Λ^* helicity angle versus m_{Kp} for the data.

2 Simulations based on amplitude models

The rectangular Dalitz plane $(m_{Kp}, \cos\theta_{\Lambda^*})$ distributions for the large statistics pseudo-samples generated from the amplitude model with only the Λ^* resonances and from the amplitude model with only the $P_c(4380)^+$ and $P_c(4450)^+$ resonances are shown in Figs. 9 and 10, respectively. Parameters of the models, without and with the P_c^+ states, were determined by fitting the amplitude models to the data as described in Ref. [1].

The Legendre moments of $\cos\theta_{\Lambda^*}$ distributions ($\langle P_l^U \rangle^k$) in various bins of m_{Kp} are compared between these two simulated pseudo-samples in Fig. 11. The $l \leq l_{\rm max}(m_{Kp})$ filter, used in forming a numerical representation of the hypothesis that only K^-p contributions are present (H_0), is also illustrated in Fig. 11: moments in the shaded regions ($l > l_{\rm max}(m_{Kp})$) are neglected. The pentaquark resonances can induce significant values of the moments in these regions, as illustrated with the example amplitude model containing only P_c^+ states. The P_c^+ states also contribute significantly to the unshaded $l \leq l_{\rm max}(m_{Kp})$ regions, thus feeding into the numerical representation of the H_0 hypothesis, and decreasing the sensitivity of the model-independent approach to exotic hadron contributions. This is especially true for wide resonances, which contribute very little to high moments, as illustrated for the $P_c(4380)^+$ state in Fig. 12. The example amplitude model with only Λ^* resonances contributes to the unshaded regions only, as expected.

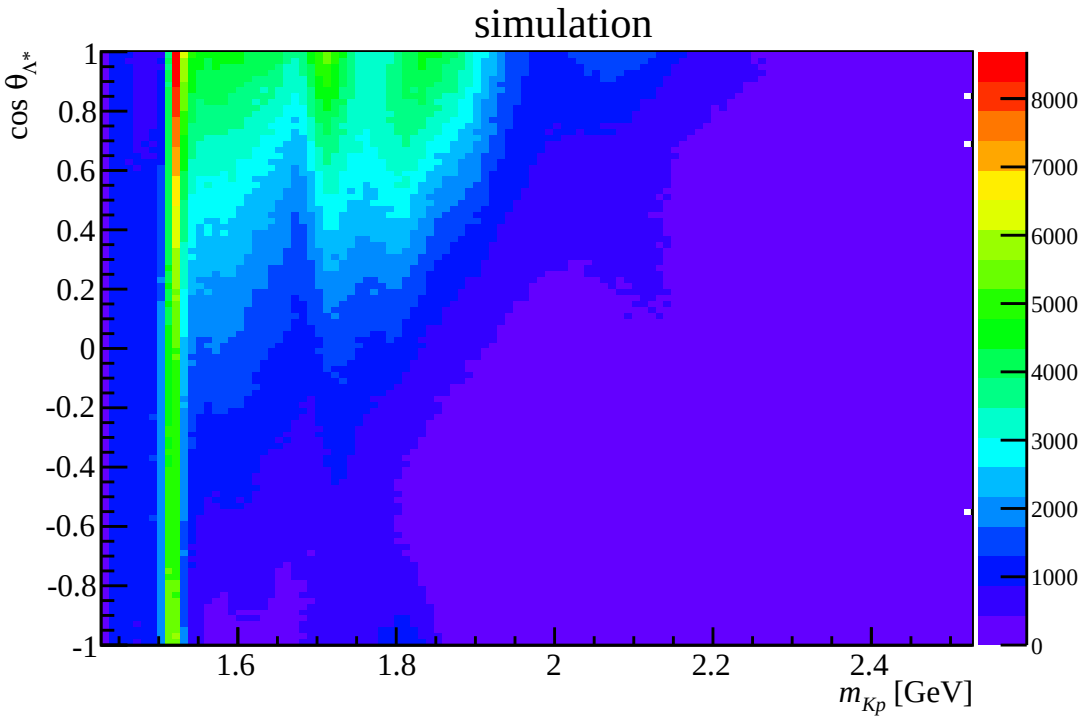

Figure 9: Distribution in a pseudoexperiment of the cosine of the Λ^* helicity angle versus m_{Kp} for the amplitude model with Λ^* resonances only.

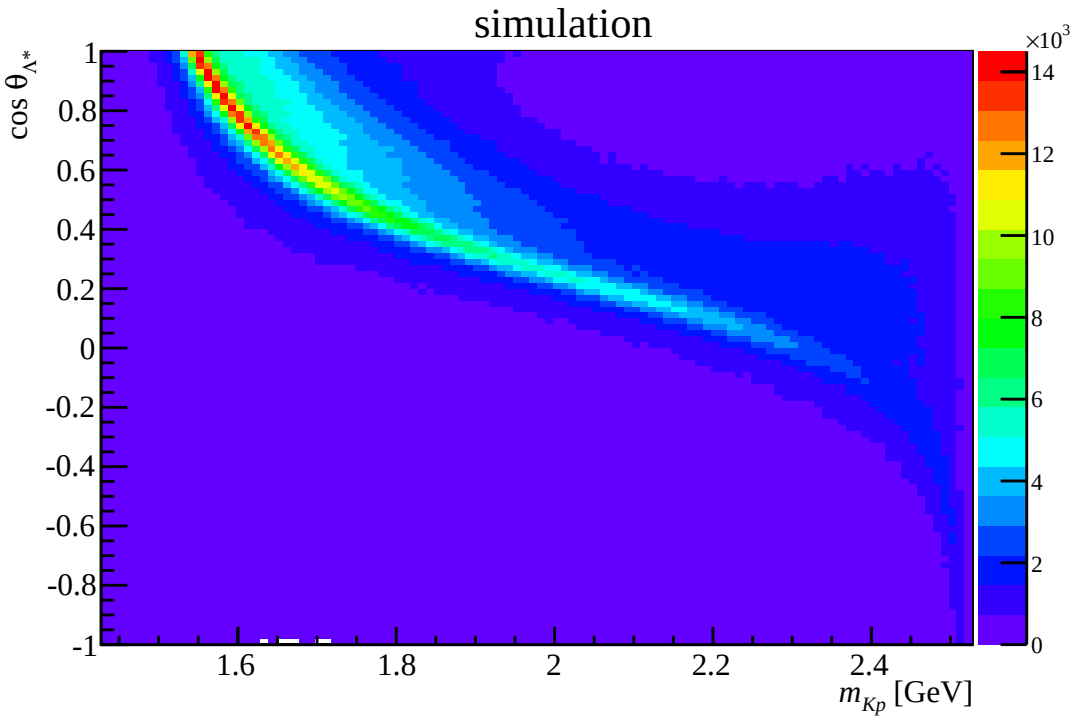

Figure 10: Distribution in a pseudoexperiment of the cosine of the Λ^* helicity angle versus m_{Kp} for the amplitude model with the $P_c(4380)^+$ and $P_c(4450)^+$ resonances only.

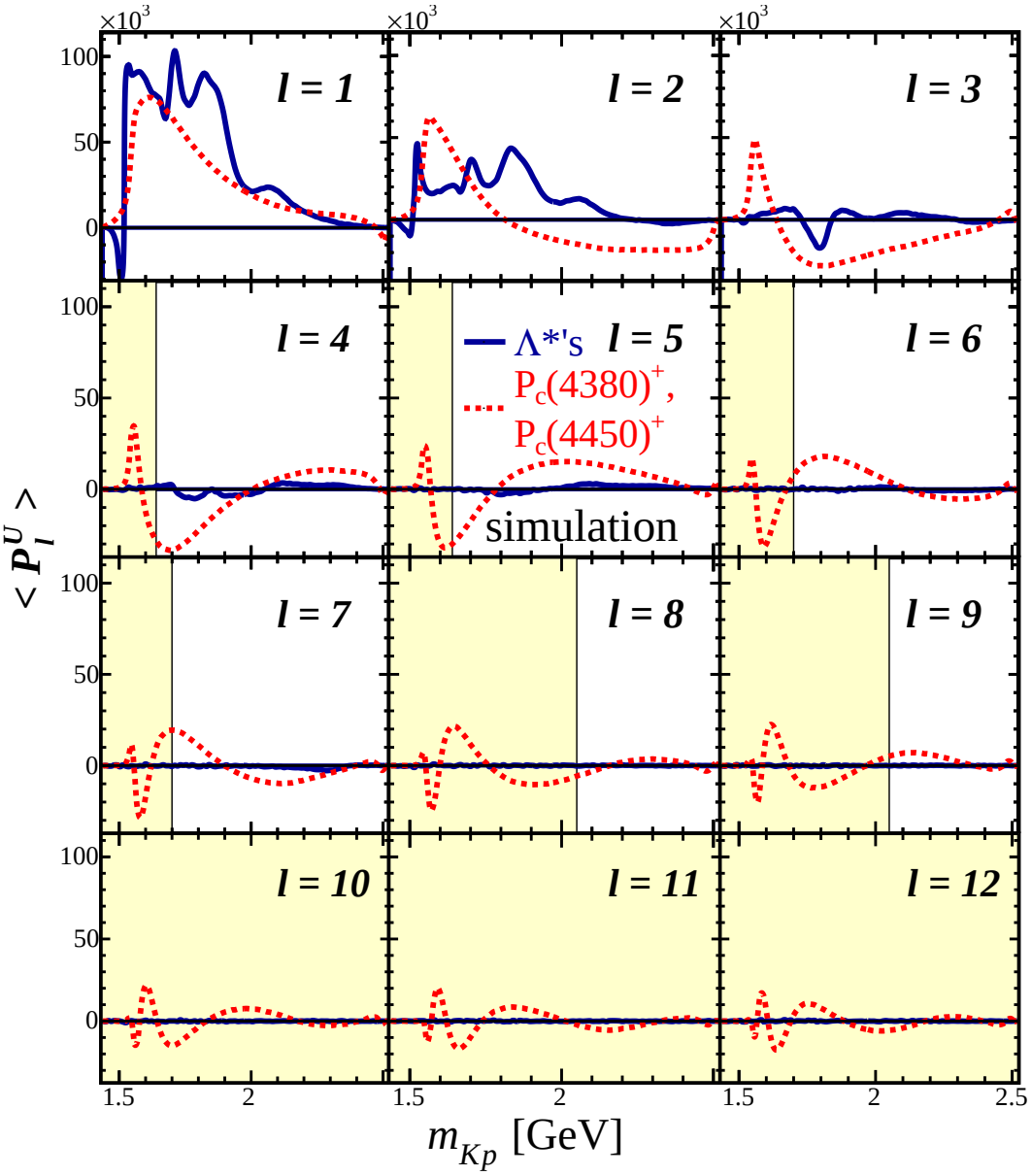

Figure 11: Legendre moments of $\cos\theta_{\Lambda^*}$ as a function of m_{Kp} for the simulated data from the amplitude models with only Λ^* (solid blue lines) and with only $P_c(4380)^+$, $P_c(4450)^+$ contributions (dashed red lines), scaled by 0.5. The regions excluded by the $l \leq l_{\max}(m_{Kp})$ filter are shaded.

References

[1] LHCb collaboration, R. Aaij *et al.*, *Observation of $J/\psi p$ resonances consistent with pentaquark states in $\Lambda_b^0 \to J/\psi p K^-$ decays*, Phys. Rev. Lett. **115** (2015) 072001, arXiv:1507.03414.

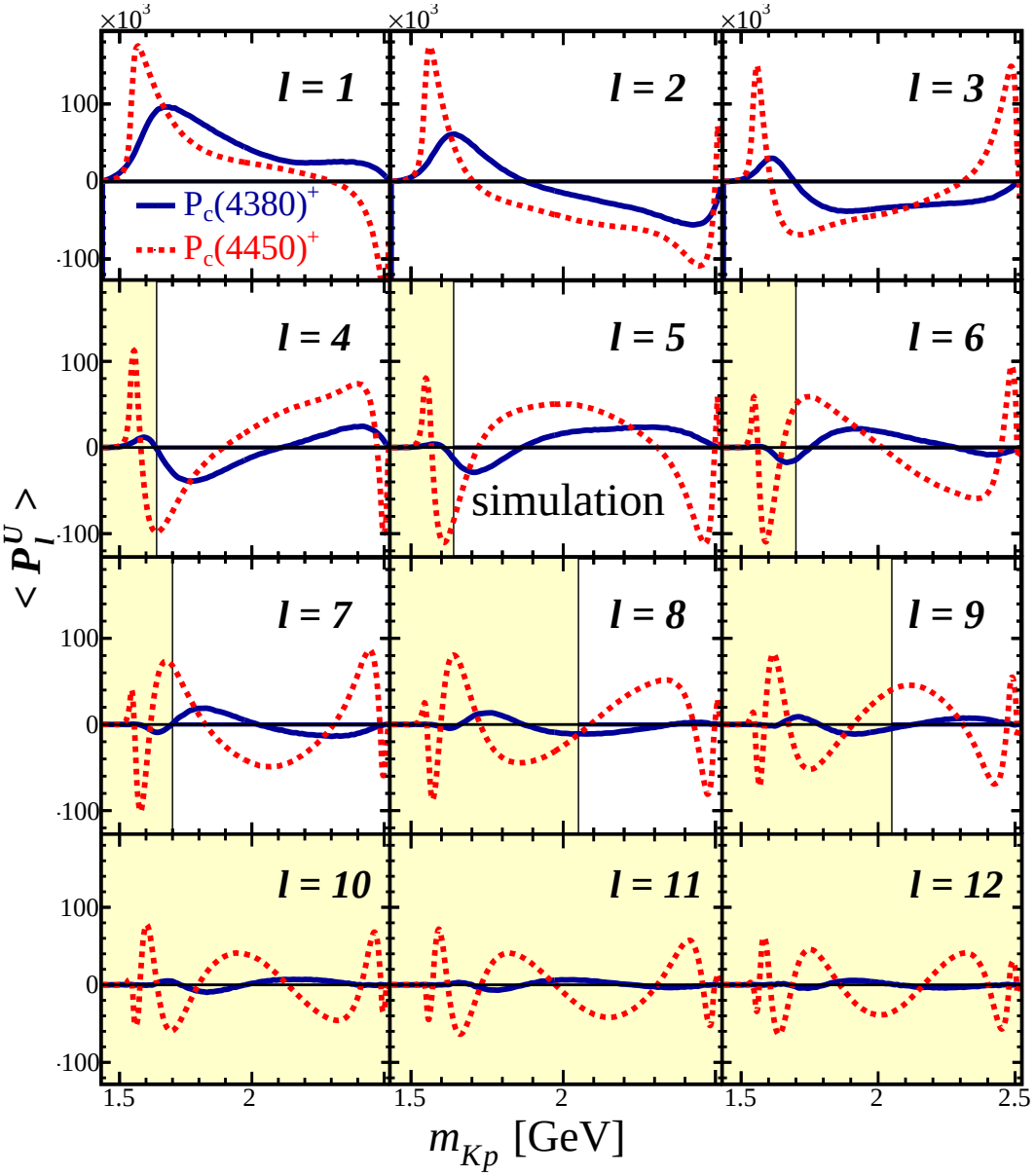

Figure 12: Legendre moments of $\cos\theta_{\Lambda^*}$ as a function of m_{Kp} for the simulated data from amplitude models with only $P_c(4380)^+$ (solid blue lines) and only $P_c(4450)^+$ contributions (dashed red line).