



# Direct $CP$ violation in charmless three-body decays of $B^\pm$ mesons (ADDITIONAL INFORMATION)

LHCb collaboration<sup>†</sup>

## Abstract

Supplementary material for LHCb-PAPER-2021-049. This document contains supplementary material that will be posted on the public CDS record but will not appear in the paper. It contains figures of the projections of the two-body invariant mass distributions of  $B^\pm \rightarrow K^\pm \pi^- \pi^+$ ,  $B^\pm \rightarrow \pi^\pm \pi^- \pi^+$ ,  $B^\pm \rightarrow \pi^\pm K^- K^+$  and  $B^\pm \rightarrow K^\pm K^+ K^-$  decays. The figures show additional information related to the  $CP$  asymmetry in phase space.

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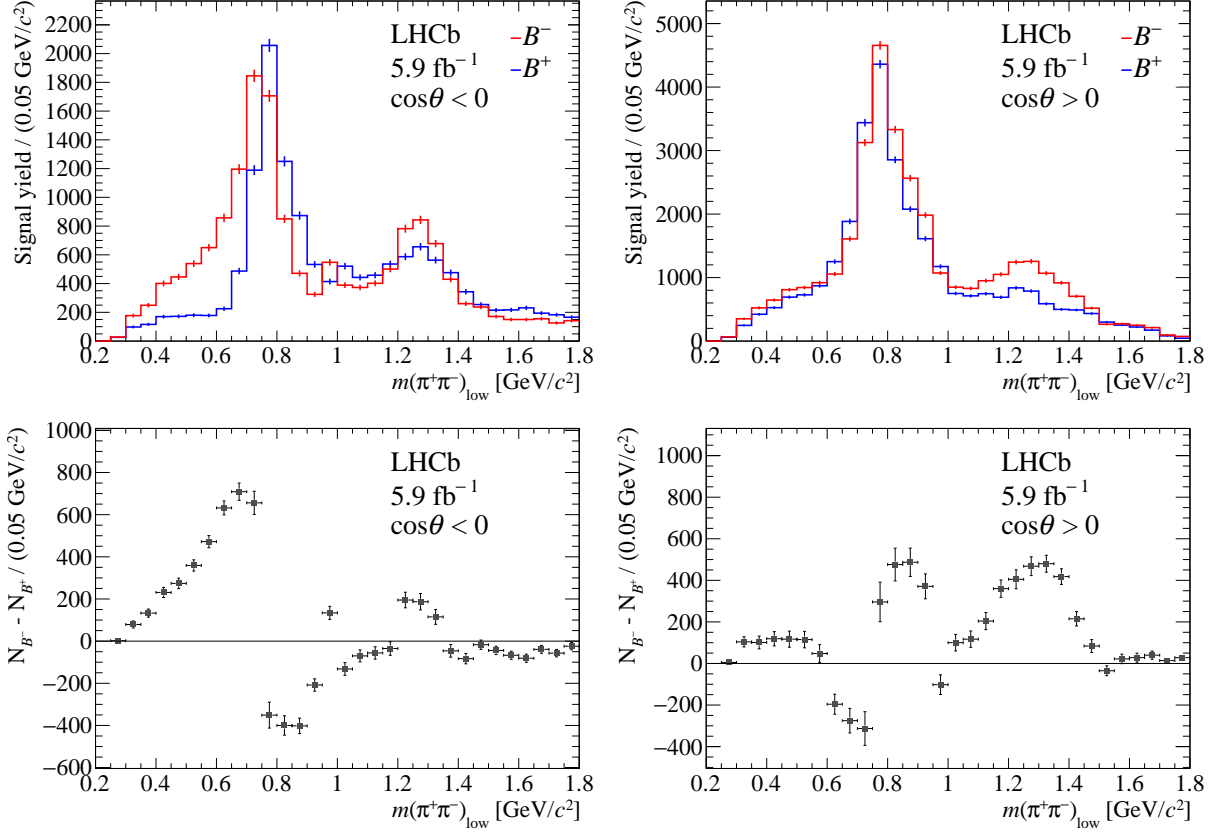


Figure 1: (Top): Yields of  $B^\pm \rightarrow \pi^\pm \pi^+ \pi^-$  decays projected onto bins of  $m(\pi^+ \pi^-)_{\text{low}}$ . (Bottom) The difference between the  $B^-$  and  $B^+$  yields. The plots on the left (right) show events with  $\cos\theta < 0$  ( $\cos\theta > 0$ ), where  $\cos\theta$  is defined in the text. The yields are acceptance-corrected and background-subtracted.

## I Two-body invariant-mass projections

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In Ref. [1] the raw asymmetry,  $A_{\text{raw}}$ , distributions in the Dalitz plots reveal rich structures in the low-mass regions which are more evident in the two-body invariant-mass projection plots. Figures 1, 2, 3 and 4 show the low-mass two-body invariant-mass projections for the  $B^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ ,  $B^\pm \rightarrow K^\pm \pi^+ \pi^-$ ,  $B^\pm \rightarrow K^\pm K^+ K^-$  and  $B^\pm \rightarrow \pi^\pm K^+ K^-$  decays, respectively. The projections are presented for positive and negative  $\cos\theta$ , where the helicity angle  $\theta$  is defined as the angle between the momenta of the unpaired hadron and the resonance decay product hadron with the opposite-sign charge. All four projections are compatible with the previous LHCb results [2]. Figures 1 and 2 clearly show that the yield asymmetries change sign at the  $\rho(770)$  mass due to the interference between the  $S$ - and  $P$ -wave as reported in the amplitude analyses of LHCb Run 1 data [3,4]. It is worth mentioning that the previous LHCb results for Fig. 2, shown in Fig. 5 of Ref. [2], has labels for  $\cos\theta > 0$  and  $\cos\theta < 0$  mistakenly switched.

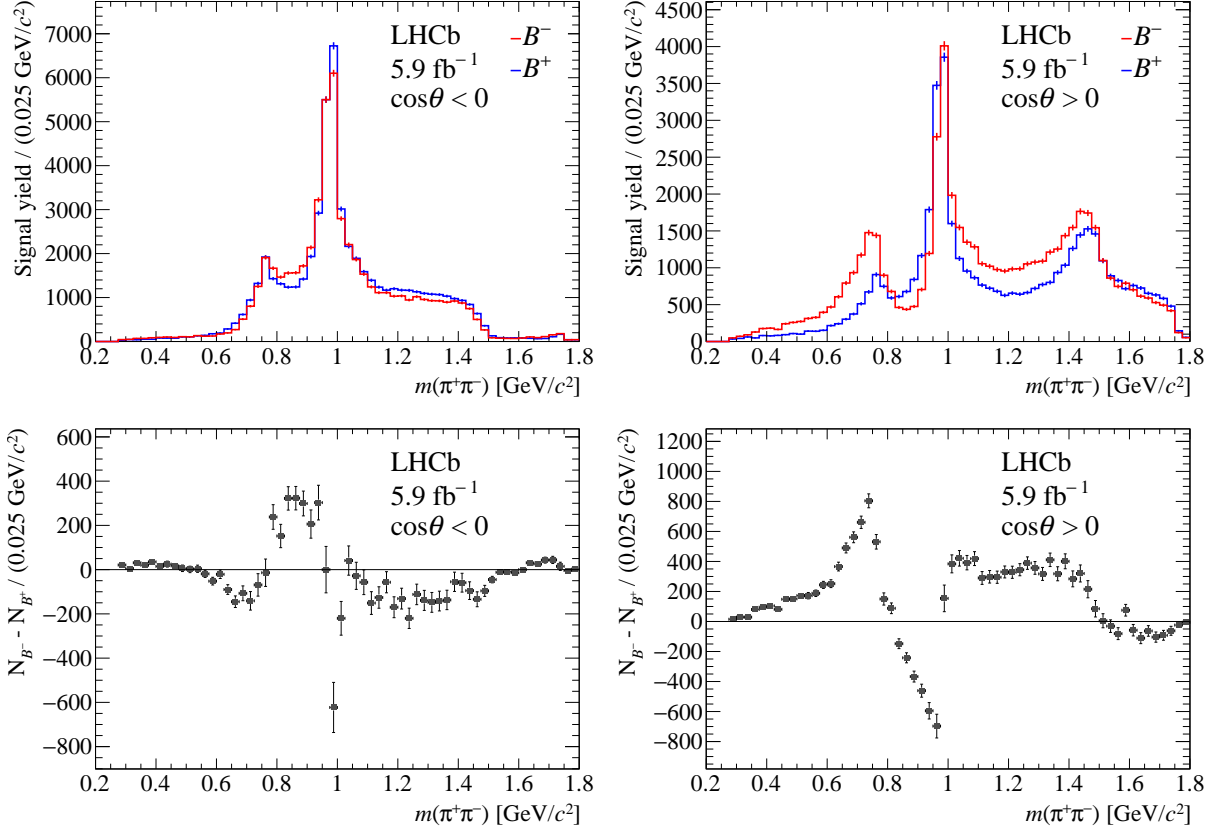


Figure 2: (Top): Yields of  $B^\pm \rightarrow K^\pm \pi^+ \pi^-$  decays projected onto bins of  $m(\pi^+ \pi^-)$ . (Bottom) The difference between the  $B^-$  and  $B^+$  yields. The plots on the left (right) show events with  $\cos \theta < 0$  ( $\cos \theta > 0$ ), where  $\cos \theta$  is defined in the text. The yields are acceptance-corrected and background-subtracted.

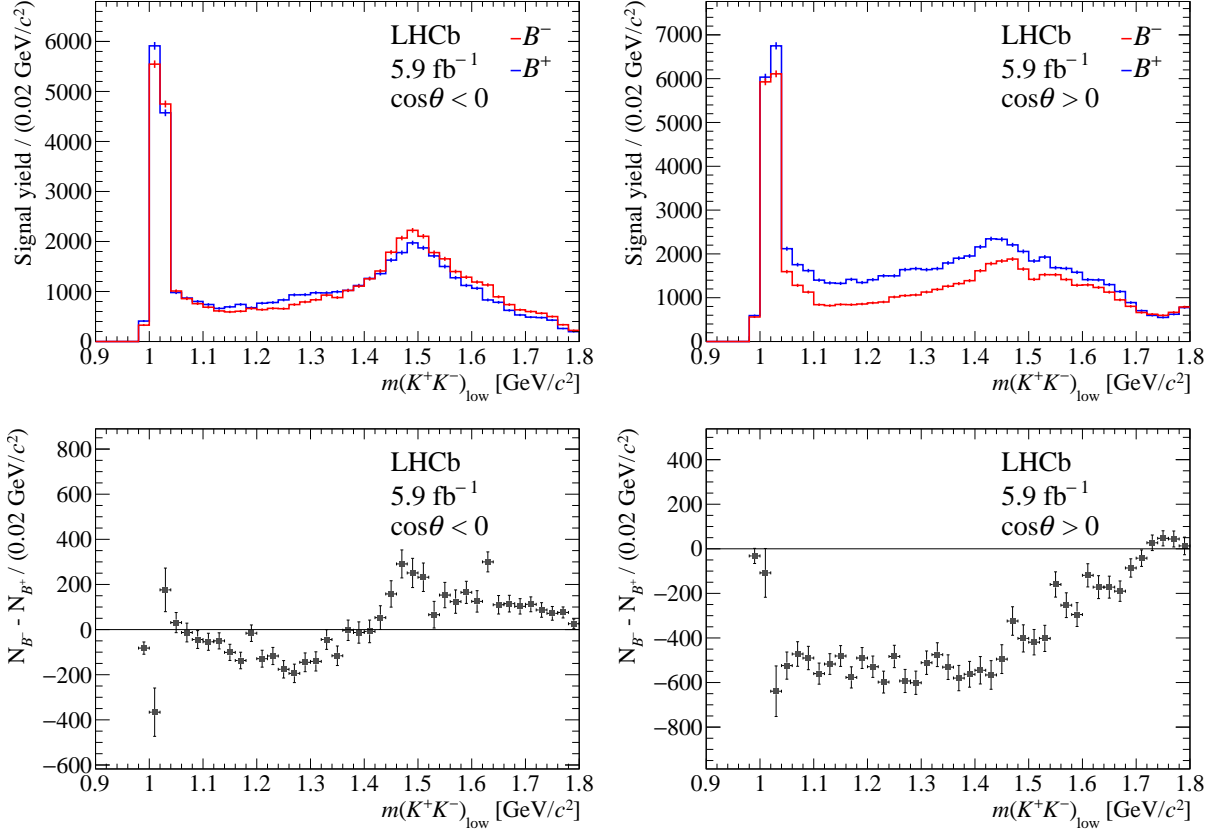


Figure 3: (Top): Yields of  $B^\pm \rightarrow K^\pm K^+ K^-$  decays projected onto bins of  $m(K^+ K^-)_{\text{low}}$ . (Bottom) The difference between the  $B^-$  and  $B^+$  yields. The plots on the left (right) show events with  $\cos\theta < 0$  ( $\cos\theta > 0$ ), where  $\cos\theta$  is defined in the text. The yields are acceptance-corrected and background-subtracted.

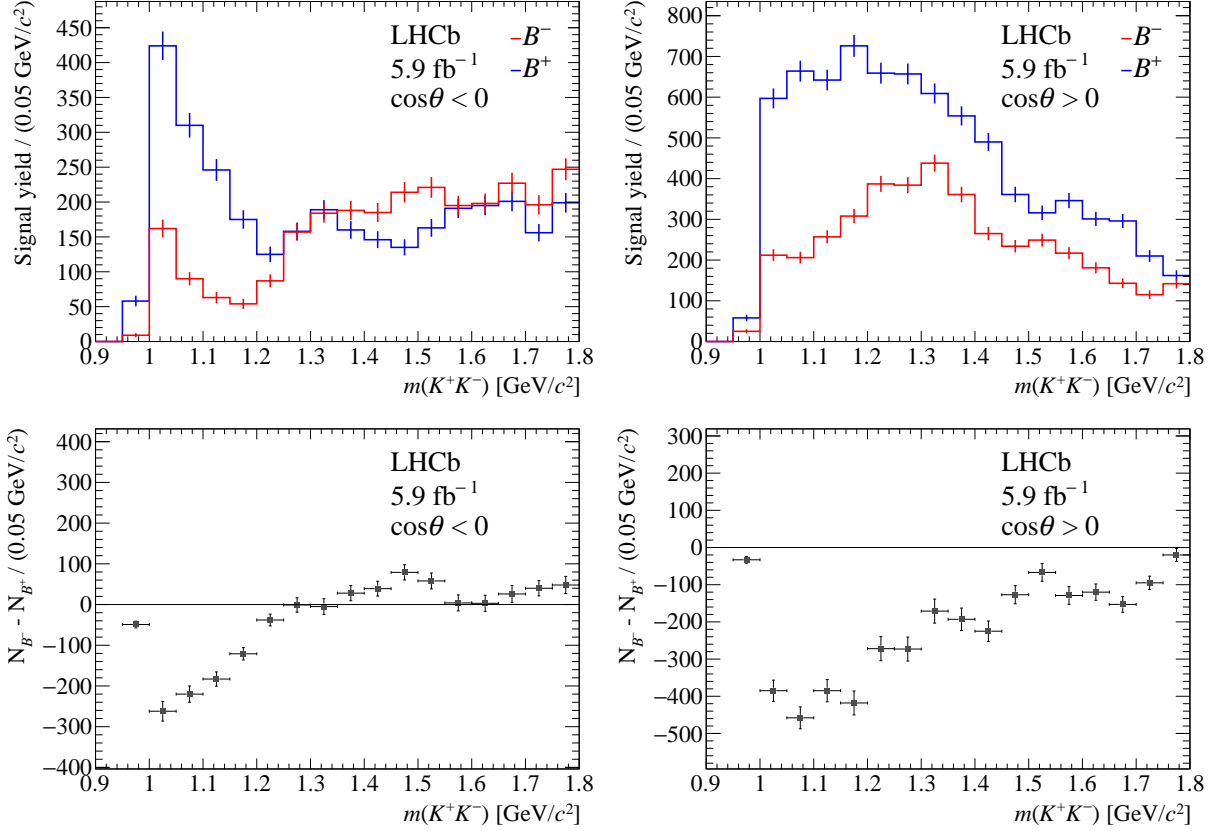


Figure 4: (Top): Yields of  $B^\pm \rightarrow \pi^\pm K^+ K^-$  decays projected onto bins of  $m(K^+ K^-)$ . (Bottom) The difference between the  $B^-$  and  $B^+$  yields. The plots on the left (right) show events with  $\cos\theta < 0$  ( $\cos\theta > 0$ ), where  $\cos\theta$  is defined in the text. The yields are acceptance-corrected and background-subtracted.

## References

- [1] LHCb Collaboration, R. Aaij *et al.*, *Direct CP violation in charmless three-body decays of  $B^\pm$  mesons*, Phys. Rev. **D108** (2023) 012008, [arXiv:2206.07622](#).
- [2] LHCb collaboration, R. Aaij *et al.*, *Measurement of CP violation in the three-body phase space of charmless  $B^\pm$  decays*, Phys. Rev. **D90** (2014) 112004, [arXiv:1408.5373](#).
- [3] LHCb Collaboration, R. Aaij *et al.*, *Amplitude analysis of the  $B^+ \rightarrow \pi^+\pi^+\pi^-$  decay*, Phys. Rev. **D101** (2020) 012006, [arXiv:1909.05212](#).
- [4] LHCb Collaboration, R. Aaij *et al.*, *Observation of several sources of CP violation in  $B^+ \rightarrow \pi^+\pi^+\pi^-$  decays*, Phys. Rev. Lett. **124** (2020) 031801, [arXiv:1909.05211](#).