

# A Supplementary material for LHCb-PAPER-2016-044

Figure 1 shows the tree and penguin contributions to the  $D^0 \rightarrow \rho^0 \rho^0$  decay. Figures 2 and 3 show the distributions of  $p$ -values for the ten subsamples of the control channel  $D^0 \rightarrow K^- \pi^+ \pi^+ \pi^-$  for the  $P$ -even and  $P$ -odd  $CP$ -violation tests. The results are compatible with a uniform distribution of  $p$ -values with values between 3% and 87% (8% to 74%) for  $P$ -even ( $P$ -odd), which is consistent with the assumption that detection asymmetries are below the current level of sensitivity.

Local asymmetry significance plots for simulation of specific  $CP$ -violation scenarios and for data, for both the  $P$ -odd and  $P$ -even tests, are shown in the paper in Fig. ?? and Fig. ?? as one-dimensional projections onto two of the axes that are used in the tests. Figures 4 and 5 show the  $P$ -odd test projections onto the other three axes used in the tests in simulation and data, and the 2D projection.

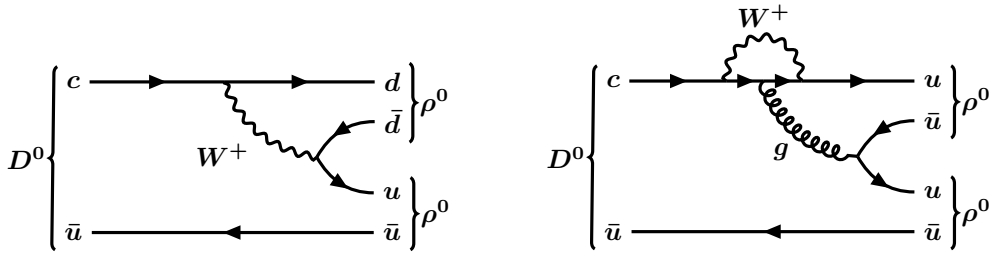


Figure 1: Feynman diagrams of tree and penguin contributions of  $D^0 \rightarrow \rho^0 \rho^0$  decay. Similar diagrams can be drawn for  $D^0 \rightarrow a_1^+ \pi^-$ .

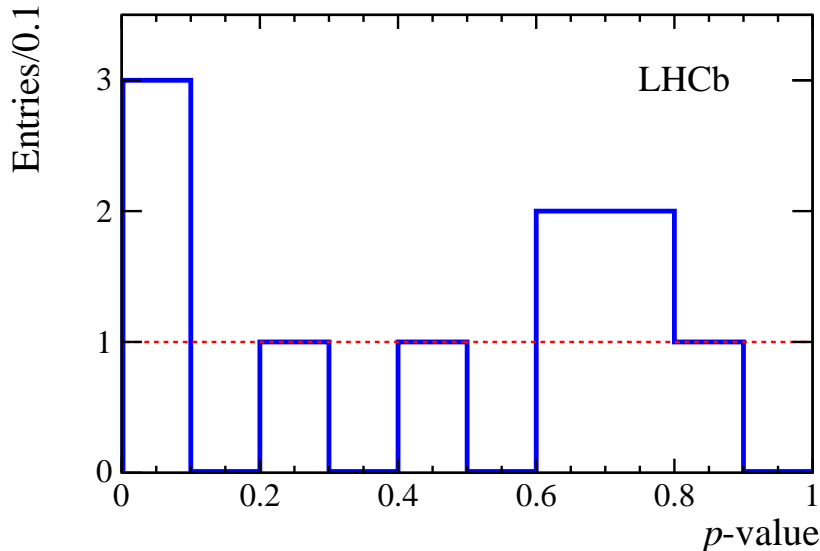


Figure 2: Distribution of  $p$ -values for ten subsamples of the control channel  $D^0 \rightarrow K^- \pi^+ \pi^+ \pi^-$  from the  $P$ -even  $CP$ -violation test. The red dashed line indicates the expected distribution.

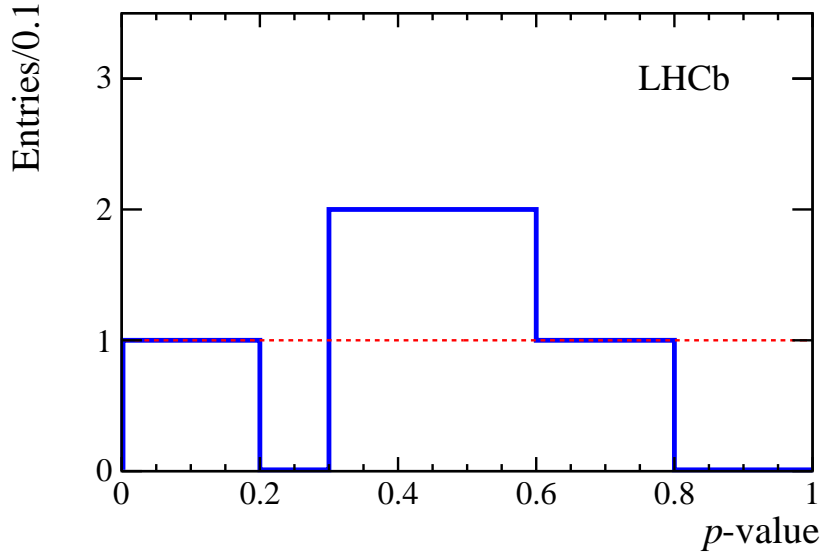


Figure 3: Distribution of  $p$ -values for ten subsamples of the control channel  $D^0 \rightarrow K^- \pi^+ \pi^+ \pi^-$  from the  $P$ -odd  $CP$ -violation test. The red dashed line indicates the expected distribution.

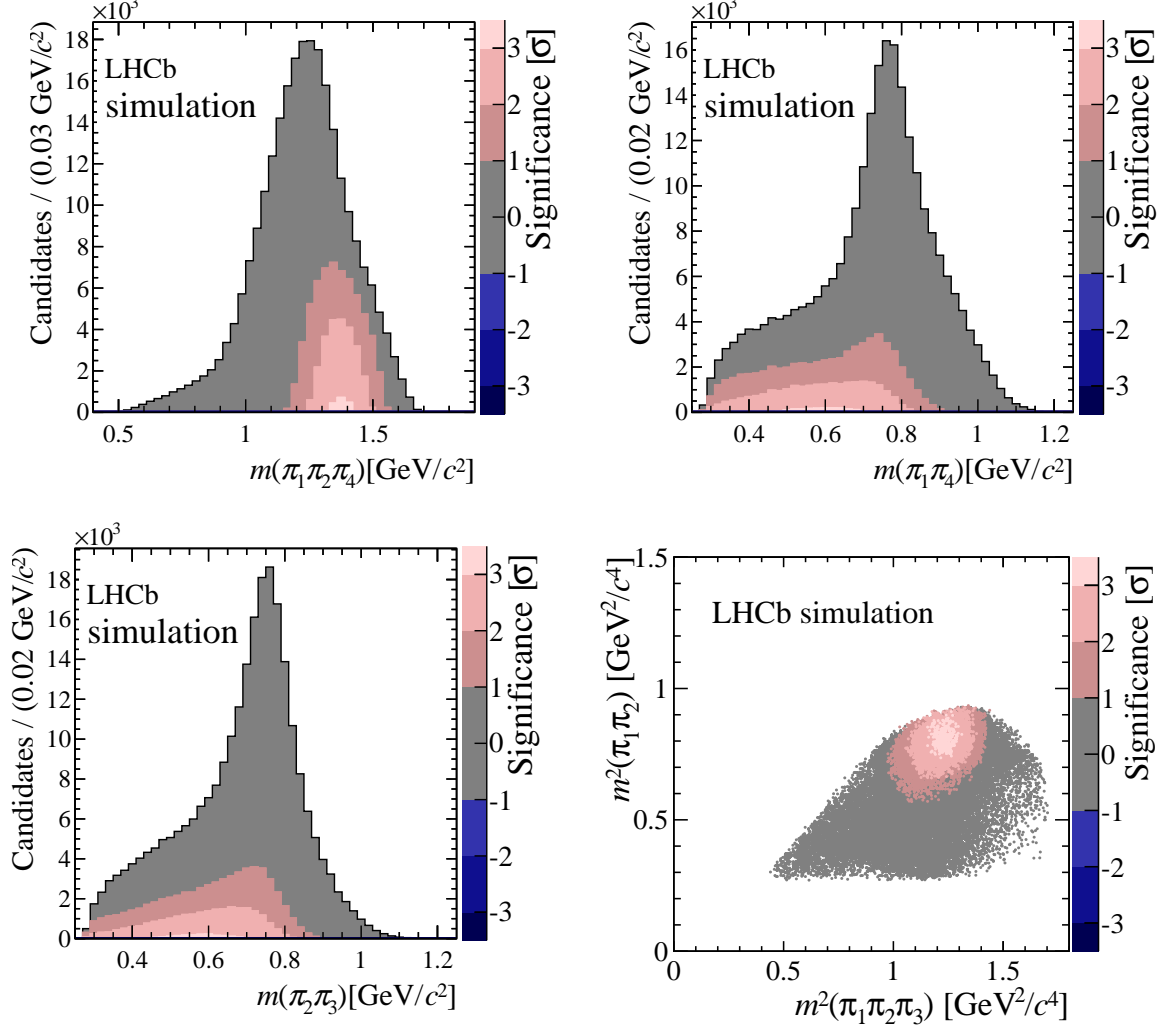


Figure 4: Local asymmetry significances in a simulation sample for a  $P$ -odd  $CP$ -violation test with  $3^\circ$  phase  $CP$  violation introduced in the P-wave  $\rho^0(770)\rho^0(770)$  resonance (see Sect. ??) projected onto the  $m(\pi_1\pi_2\pi_4)$ ,  $m(\pi_1\pi_4)$  and  $m(\pi_2\pi_3)$  axes, and onto 2D  $m(\pi_1\pi_2)$  versus  $m(\pi_1\pi_2\pi_3)$  plot. The grey area corresponds to candidates with a contribution to the  $T$ -value of less than one standard deviation. The pink (blue) area corresponds to candidates with a positive (negative) contribution to the  $T$ -value. Light, medium or dark shades of pink and blue correspond to between one and two, two and three, and more than three standard-deviation contributions, respectively.

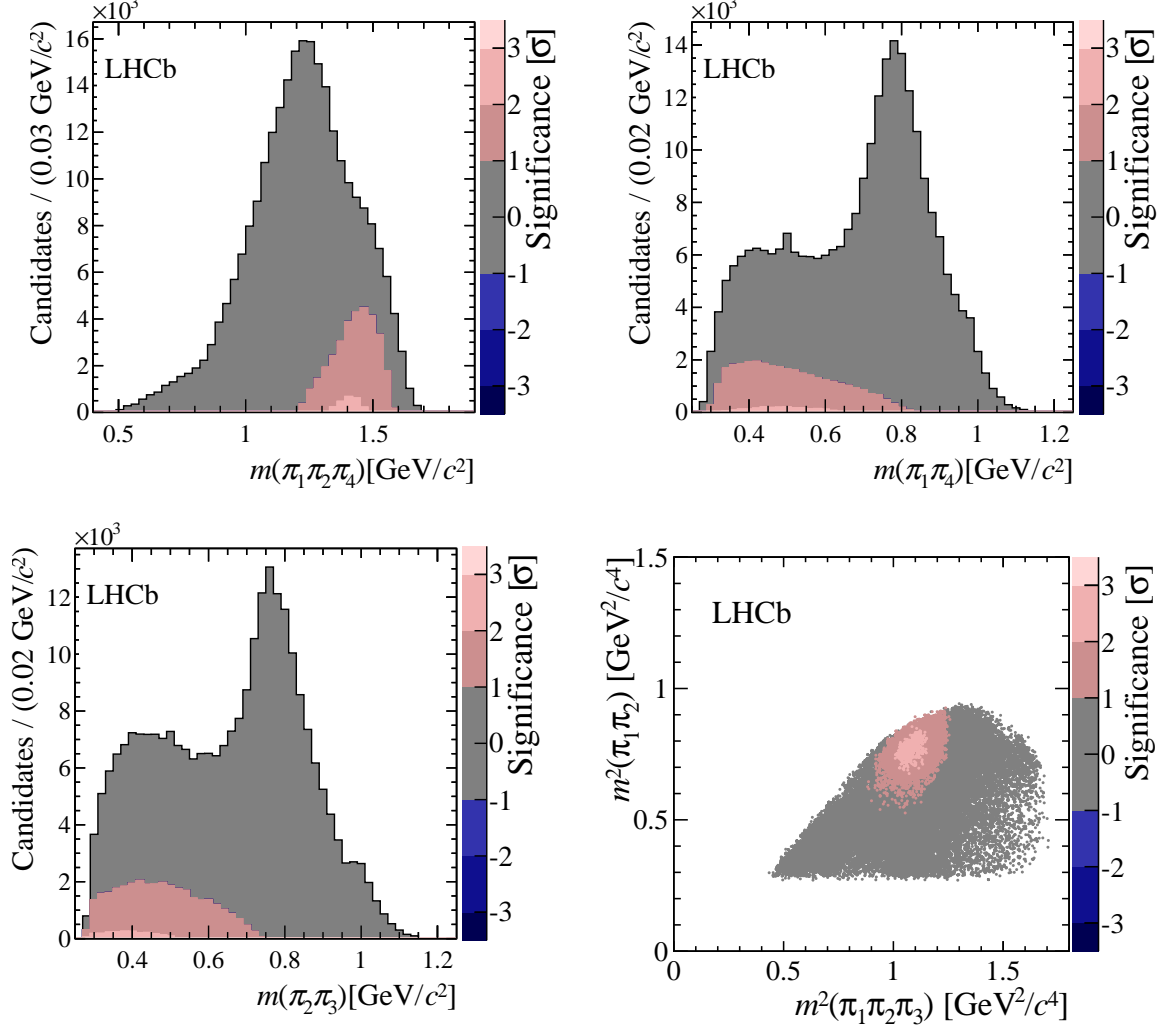


Figure 5: Local asymmetry significances in data for the  $P$ -odd  $CP$ -violation test projected onto the  $m(\pi_1\pi_2\pi_4)$ ,  $m(\pi_1\pi_4)$  and  $m(\pi_2\pi_3)$  axes, and onto 2D  $m(\pi_1\pi_2)$  versus  $m(\pi_1\pi_2\pi_3)$  plot. The positive (negative) asymmetry significance is set for sample I + IV having positive (negative) contribution to the measured  $T$  value (see Sect. ??). The grey area corresponds to candidates with a contribution to the  $T$ -value of less than one standard deviation. The pink (blue) area corresponds to candidates with a positive (negative) contribution to the  $T$ -value. Light, medium or dark shades of pink and blue correspond to between one and two, two and three, and more than three standard-deviation contributions, respectively.