7 Supplementary material: visualization of the *CP* asymmetry

The time-dependent decay widths in Eq. (1) can be combined into a *CP* asymmetry explicitly dependent on m_{hh} and decay angles as

$$\frac{\overline{\Gamma}(t) - \Gamma(t)}{\overline{\Gamma}(t) + \Gamma(t)} = \mathcal{S}(m_{hh}, \Omega) \sin(\Delta m_d t) - \mathcal{C}(m_{hh}, \Omega) \cos(\Delta m_d t), \tag{15}$$

where

$$\mathcal{S}(m_{hh}, \Omega) = \frac{2\mathcal{I}m(\mathcal{A}^* \overline{\mathcal{A}})}{|\mathcal{A}|^2 + |\overline{\mathcal{A}}|^2}, \quad \text{and} \quad \mathcal{C}(m_{hh}, \Omega) = \frac{|\mathcal{A}|^2 - |\overline{\mathcal{A}}|^2}{|\mathcal{A}|^2 + |\overline{\mathcal{A}}|^2}. \tag{16}$$

Since the asymmetry depends on the location in the (m_{hh}, Ω) phase space, the overall asymmetry integrated over the phase space is diluted as both $\mathcal{S}$ and $\mathcal{C}$ change sign. It is also further diluted by other experimental effects, e.g. wrong flavour tagging. In order to view the time dependent asymmetry, we transform the event-by-event decay time by changing t to $t' = t + dt(m_{hh}, \Omega)$ by using

$$\begin{aligned} \cos[\Delta m_d dt(m_{hh}, \Omega)] &= \frac{\mathcal{S}(m_{hh}, \Omega)}{\sqrt{\mathcal{S}(m_{hh}, \Omega)^2 + \mathcal{C}(m_{hh}, \Omega)^2}} \\ \sin[\Delta m_d dt(m_{hh}, \Omega)] &= -\frac{\mathcal{C}(m_{hh}, \Omega)}{\sqrt{\mathcal{S}(m_{hh}, \Omega)^2 + \mathcal{C}(m_{hh}, \Omega)^2}}, \end{aligned} \tag{17}$$

where $\mathcal{S}(m_{hh}, \Omega)$ and $\mathcal{C}(m_{hh}, \Omega)$ are determined by the fit to the data. The asymmetry in Eq. (15) is transformed to a single sine function with positive coefficient:

$$\frac{\overline{\Gamma}(t') - \Gamma(t')}{\overline{\Gamma}(t') + \Gamma(t')} = \sqrt{\mathcal{S}(m_{hh}, \Omega)^2 + \mathcal{C}(m_{hh}, \Omega)^2} \sin(\Delta m_d t'). \tag{18}$$

The new asymmetry is not diluted by its location in phase space because only positive coefficients are summed. The quantity $\Delta m_d t'$ is taken to be modulo of 2π. The transformation only depends on the value of (m_{hh}, Ω), not the decay time t.

To obtain the data asymmetry distribution as function of t', we first calculate t' event-by-event for the data, the pseudo-experimental signal and background samples using the Fit 1 result. The pseudo-experimental samples are generated according to their PDFs used in the fit. The tagged B^0 and $\overset{(-)}{B}{}^0$ data t' distributions are subtracted by the corresponding background distributions, then asymmetries in bins of t' are calculated. The red curve is the expectation from Fit 1, obtained from the pseudo-experimental signal asymmetry distribution. The *CP* asymmetries for the sum of all resonant components are shown for the decay time in Fig. 7 and for the shifted decay time in Fig. 8. In the latter case the time modulation of the *CP* asymmetry is clearly seen.

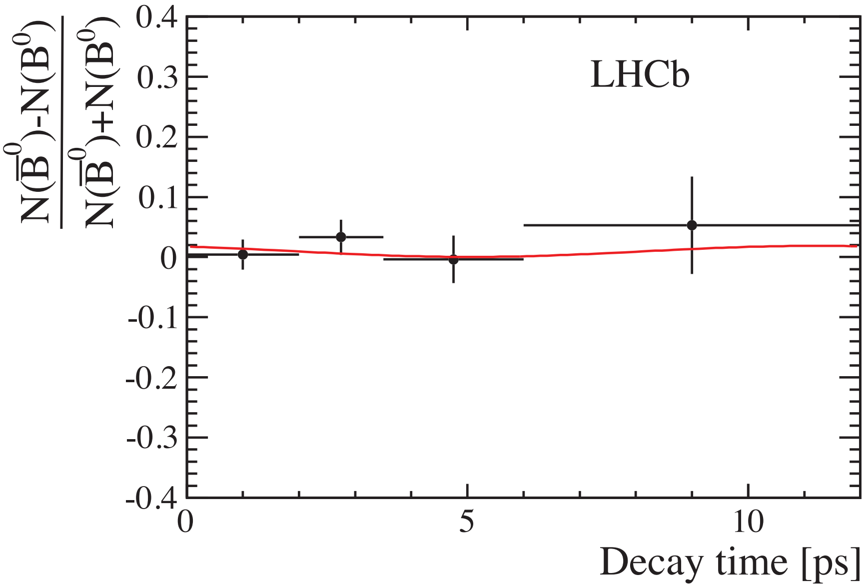

Figure 7: CP asymmetry as a function of decay time for all components in $\overset{(-)}{B}{}^0 \to J/\psi \pi^+\pi^-$.

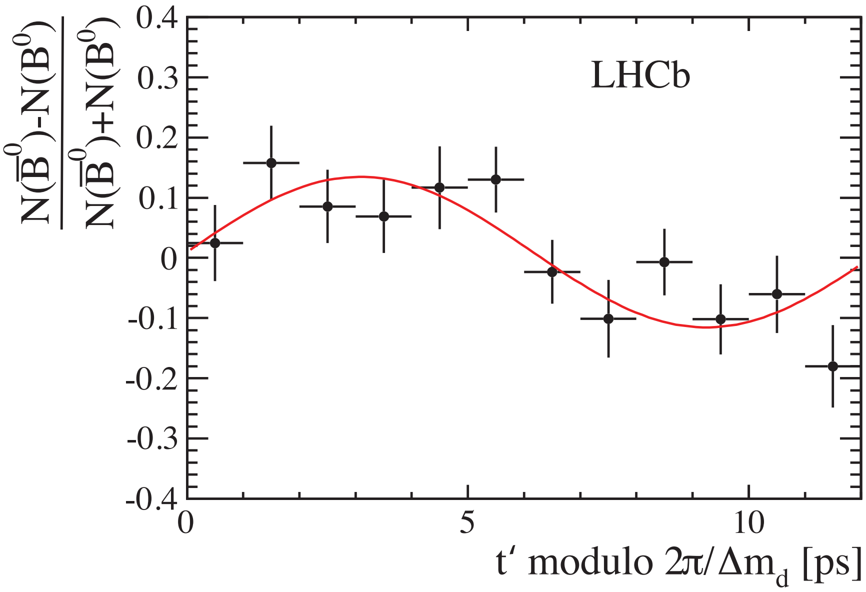

Figure 8: CP asymmetry as function of shifted decay time for all components in $\overset{(-)}{B}{}^0 \to J/\psi \pi^+\pi^-$.