

Supplemental Material for LHCb-PAPER-2015-036

The limits reported in the Letter assume a spin-zero hidden-sector boson. To convert these into limits for a spin-one boson, the ratio of efficiencies for the spin-one to spin-zero cases must be accounted for. Determining this ratio involves integrals of the form

$$\frac{\int f_j(\vec{\Omega})\epsilon(\vec{\Omega}, m^2(\mu^+\mu^-))d\vec{\Omega}}{\int f_{1c}(\vec{\Omega})\epsilon(\vec{\Omega}, m^2(\mu^+\mu^-))d\vec{\Omega}},$$

where $\vec{\Omega} = (\theta_K, \theta_\ell, \phi)$ (see Appendix A of Ref. [40] in the Letter for details on the angular basis), $\epsilon(\vec{\Omega}, m^2(\mu^+\mu^-))$ is the efficiency, $f_j(\vec{\Omega})$ are functions of the angles, and $f_{1c}(\vec{\Omega}) = \cos^2 \theta_K$. Figure 1 shows the values for

$$\begin{aligned} f_{1s}(\vec{\Omega}) &= \sin^2 \theta_K, \\ f_{2s}(\vec{\Omega}) &= \sin^2 \theta_K \cos 2\theta_\ell, \\ f_{2c}(\vec{\Omega}) &= \cos^2 \theta_K \cos 2\theta_\ell. \end{aligned}$$

All other integrals, each of which has a value of zero in the absence of inefficiency, have values $\mathcal{O}(0.01)$. Therefore, the following terms in the general angular distribution can be ignored when determining the limits:

$$\begin{aligned} f_3(\vec{\Omega}) &= \sin^2 \theta_K \sin^2 \theta_\ell \cos 2\phi, \\ f_4(\vec{\Omega}) &= \sin 2\theta_K \sin 2\theta_\ell \cos \phi, \\ f_5(\vec{\Omega}) &= \sin 2\theta_K \sin \theta_\ell \cos \phi, \\ f_{6s}(\vec{\Omega}) &= \sin^2 \theta_K \cos \theta_\ell, \\ f_{6c}(\vec{\Omega}) &= \cos^2 \theta_K \cos \theta_\ell, \\ f_7(\vec{\Omega}) &= \sin 2\theta_K \sin \theta_\ell \sin \phi, \\ f_8(\vec{\Omega}) &= \sin 2\theta_K \sin 2\theta_\ell \sin \phi, \\ f_9(\vec{\Omega}) &= \sin^2 \theta_K \sin^2 \theta_\ell \sin 2\phi. \end{aligned}$$

Figure 1 shows an example efficiency ratio for the case of a spin-one boson produced unpolarized in the decay. Since the $j = 3, 4, \dots, 9$ terms integrate to approximately zero, this same curve applies for any theory that predicts that the longitudinal polarization fraction of the K^{*0} is $F_L = 1/3$.

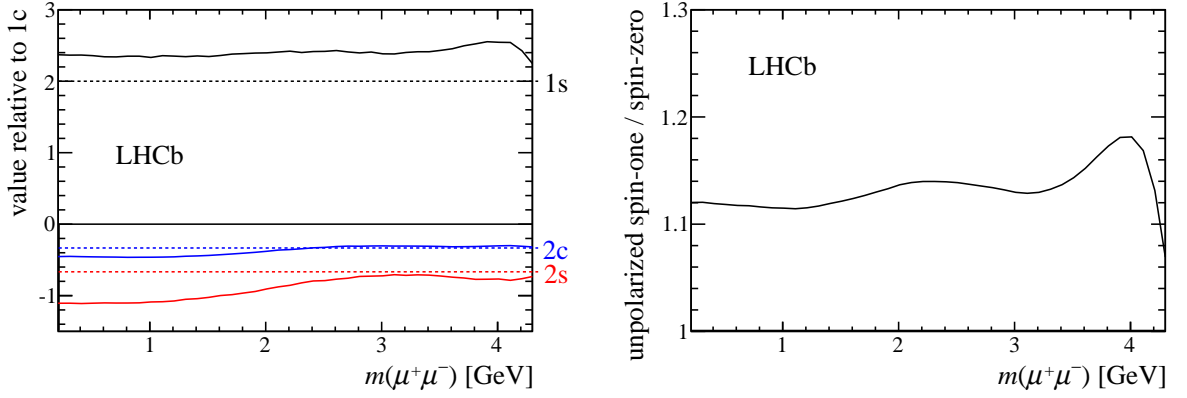


Figure 1: (left) Integral values for 1s, 2s and 2c relative to the value for 1c (see text for details). The dashed lines show the values in the absence of inefficiency. (right) Ratio of the efficiency for an unpolarized spin-one boson to that of a spin-zero boson.

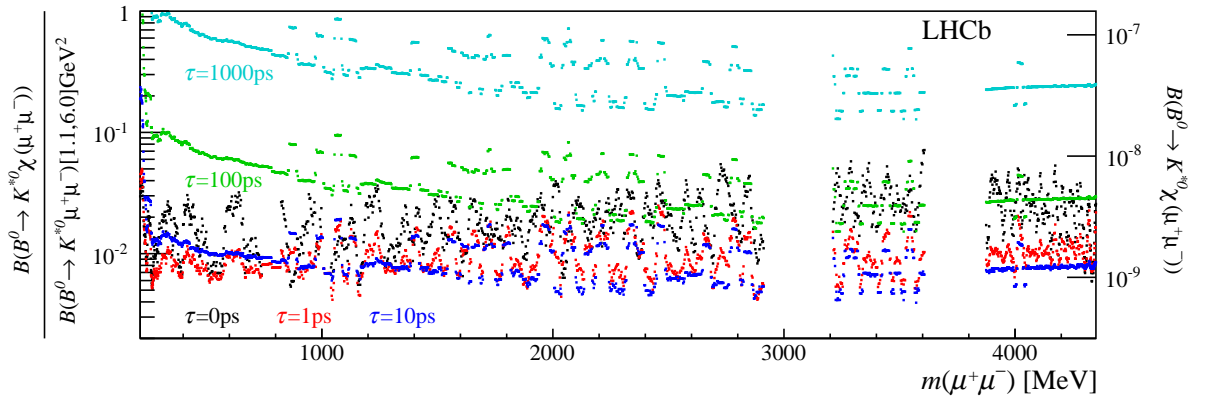


Figure 2: Upper limits at 95% CL for (left axis) $\mathcal{B}(B^0 \rightarrow K^{*0} \chi(\mu^+ \mu^-)) / \mathcal{B}(B^0 \rightarrow K^{*0} \mu^+ \mu^-)$, with $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ in $1.1 < m^2(\mu^+ \mu^-) < 6.0 \text{ GeV}^2$, and (right axis) $\mathcal{B}(B^0 \rightarrow K^{*0} \chi(\mu^+ \mu^-))$. Same as Fig. 4 in the Letter but including the $\tau = 0$ and 1 ps limits.

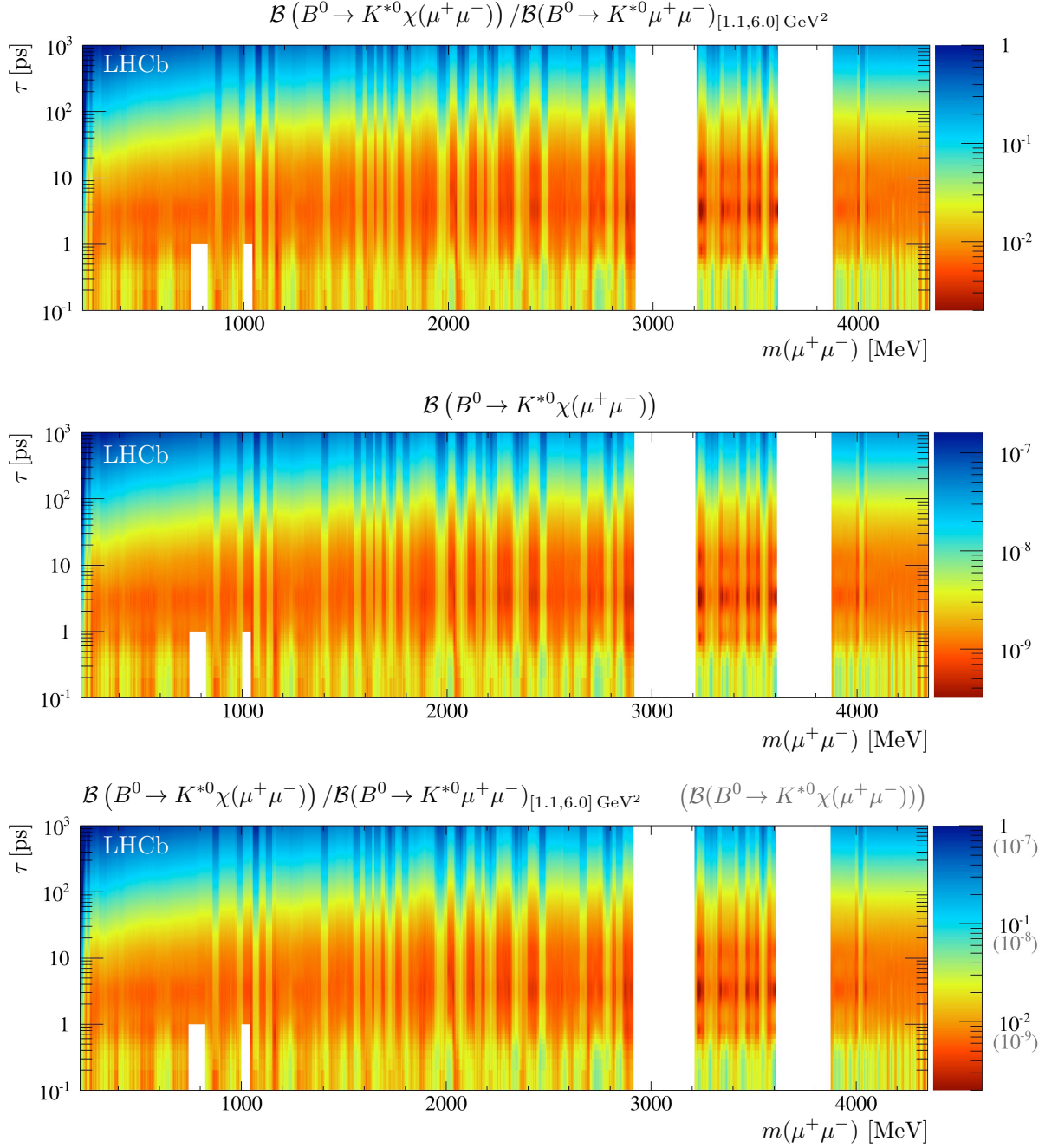


Figure 3: Upper limits at 95% CL for (top) $\mathcal{B}(B^0 \rightarrow K^{*0} \chi(\mu^+ \mu^-)) / \mathcal{B}(B^0 \rightarrow K^{*0} \mu^+ \mu^-)$, with $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ in $1.1 < m^2(\mu^+ \mu^-) < 6.0 \text{ GeV}^2$, (middle) $\mathcal{B}(B^0 \rightarrow K^{*0} \chi(\mu^+ \mu^-))$, and (bottom) both relative and absolute limits. The ω and ϕ resonance regions are only excluded in the prompt region. A utility is provided to obtain these limits for any $(m(\chi), \tau(\chi))$ in the zip file (see the README).