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Uncovering light scalars with exotic Higgs decays to $b\bar{b}\mu\mu$

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The search for exotic Higgs decays are an essential probe of new physics. The small width of the Higgs boson makes its decay uniquely sensitive to the existence of light hidden sectors. We assess the potential of an exotic Higgs decay search for $h \rightarrow 2X \rightarrow b\bar{b}\mu\mu$ to constrain theories with light CP-even and CP-odd singlet scalars. This decay arises naturally in many scenarios, such as the Standard Model augmented with a singlet, the two-Higgs-doublet model with a singlet (2HDM+S) – which includes the Next-to-Minimal Supersymmetric Standard Model (NMSSM) – and in hidden valley models. The $2b2\mu$ channel may represent the best discovery avenue for many models. It has competitive reach, and is less reliant on low- p_T b - and τ -reconstruction compared to other channels like $4b$, 4τ , and $2\tau2\mu$. We analyze the sensitivity of a $2b2\mu$ search for the 8 and 14 TeV LHC, including the HL-LHC and find that $\text{Br}(h \rightarrow 2X \rightarrow 2b2\mu)$ can be constrained at the few $\times 10^{-5}$ level at the HL-LHC.

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