Singlet Scalar Model Benchmarks for Di-Scalar Production

Shekhar Adhikari,[1,*] Ian M. Lewis,[1,†] and Matthew Sullivan[1,‡]

[1]*Department of Physics and Astronomy,*

University of Kansas, Lawrence, Kansas 66045 U.S.A.

One of the most important processes to be studied at the LHC and future colliders is double Higgs production. This process is sensitive to the shape of the scalar potential, and hence the source of electroweak symmetry breaking. Any change in the scalar potential away from Standard Model expectations will change double Higgs rates.

Some of the simplest extensions of the Standard Model are the addition of either a real or a complex scalar singlet, which at the renormalizable level only change the scalar potential. Beyond their simplicity, these models can also provide a strong first order electroweak phase transition necessary for electroweak baryogenesis [1–5]. Hence, these are good benchmark models with which to compare searches at the LHC and future colliders.

These simple extensions can drastically change double Higgs phenomenology. In both the real and complex scalar singlet extensions, if kinematically allowed, it is possible to resonantly produce double Higgs. In the complex singlet model, there are two additional scalars. Hence, it is also possible to resonantly produce a Higgs with a new scalar or to have double production of the new scalars.

We propose to extend our previous work [6, 7] to produce benchmark points for double scalar production at the LHC and future colliders. We will maximize the branching ratios into the various resonant di-scalar final states in both the real singlet and complex singlet models. No additional symmetry, such as a Z_2, will be applied and the most general scalar potentials will be assumed. These points will incorporate future projections of limits on the mixing angle between the Standard Model Higgs and other scalars.

*Electronic address: s869a465@ku.edu

†Electronic address: ian.lewis@ku.edu

‡Electronic address: mattsullivan14916@gmail.com

[1] J. Choi and R. R. Volkas, *Real Higgs singlet and the electroweak phase transition in the Standard Model*, *Phys. Lett.* **B317** (1993) 385–391, arXiv:hep-ph/9308234 [hep-ph].

[2] S. Profumo, M. J. Ramsey-Musolf, and G. Shaughnessy, *Singlet Higgs phenomenology and the electroweak phase transition*, *JHEP* **08** (2007) 010, arXiv:0705.2425 [hep-ph].

[3] J. R. Espinosa, T. Konstandin, and F. Riva, *Strong Electroweak Phase Transitions in the Standard Model with a Singlet*, *Nucl. Phys.* **B854** (2012) 592–630, arXiv:1107.5441 [hep-ph].

[4] D. Curtin, P. Meade, and C.-T. Yu, *Testing Electroweak Baryogenesis with Future Colliders*, *JHEP* **11** (2014) 127, arXiv:1409.0005 [hep-ph].

[5] C.-Y. Chen, J. Kozaczuk, and I. M. Lewis, *Non-resonant Collider Signatures of a Singlet-Driven Electroweak Phase Transition*, *JHEP* **08** (2017) 096, arXiv:1704.05844 [hep-ph].

[6] I. M. Lewis and M. Sullivan, *Benchmarks for Double Higgs Production in the Singlet Extended Standard Model at the LHC*, *Phys. Rev.* **D96** no. 3, (2017) 035037, arXiv:1701.08774 [hep-ph].

[7] S. Dawson and M. Sullivan, *Enhanced di-Higgs boson production in the complex Higgs singlet model*, *Phys. Rev. D* **97** no. 1, (2018) 015022, arXiv:1711.06683 [hep-ph].