

Constraining composite Higgs models with LHC data

Manuel Kunkel

Uni Würzburg

(Re)interpretation of the LHC results for new physics

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- ▶ A composite Higgs provides a solution to the naturalness problem
- ▶ There are specific candidates for realistic composite Higgs models based on an underlying fermionic description [Ferretti et al 1610.06591](#)
- ▶ Generate large top mass via partial compositeness \Rightarrow top partners T, B
- ▶ Contain extended scalar sector, e.g. electroweak scalars S^{++}, S^+, S^0

$$S^{++}, S^+, S^0$$

Decays:

$$S^{++} \rightarrow W^+ W^+$$

$$S^+ \rightarrow W^+ \gamma, W^+ Z$$

$$S^0 \rightarrow W^+ W^-, \gamma\gamma, \gamma Z, ZZ$$

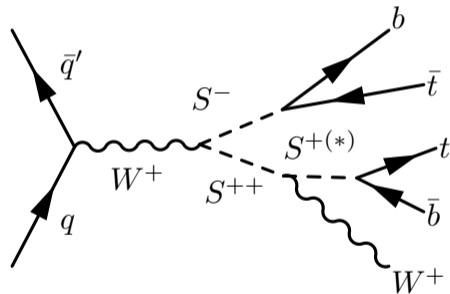
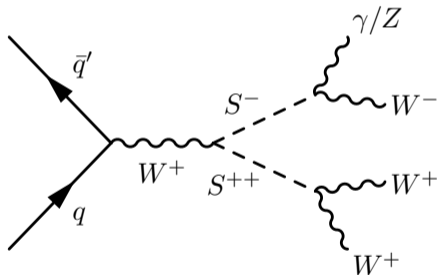
“fermiophobic scenario”

$$S^{++} \rightarrow W^+ t\bar{b}$$

$$S^+ \rightarrow t\bar{b}$$

$$S^0 \rightarrow t\bar{t}, b\bar{b}$$

“fermiophilic scenario”

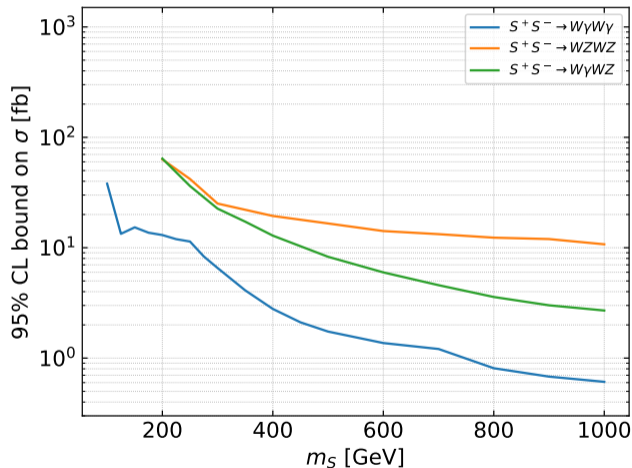




- ▶ Generate events with MadGraph5_aMC@NLO at NLO in QCD
- ▶ Run events against all searches/measurements implemented in
 - ▶ MadAnalysis5 v1.9.60
 - ▶ CheckMATE v2.0.34
 - ▶ Rivet v3.1.5/Contur v2.2.1

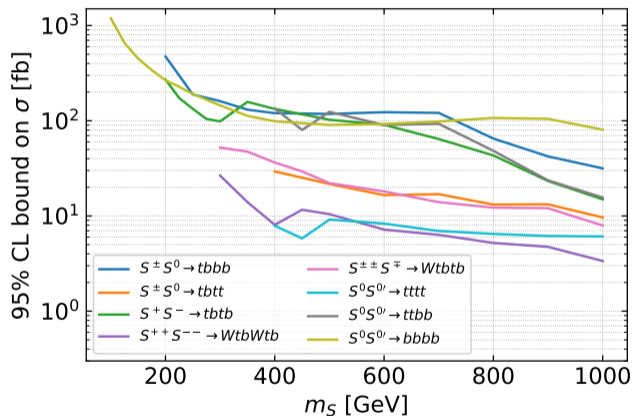
and calculate cross section σ_{95} needed to exclude the events at 95% CL

- ▶ Apply to Drell-Yan production $S^{++}S^{--}$, $S^{\pm\pm}S^{\mp\mp}$, S^+S^- , $S^\pm S^0$, $S^0S^{0'}$ with all possible decay channels



Notable searches

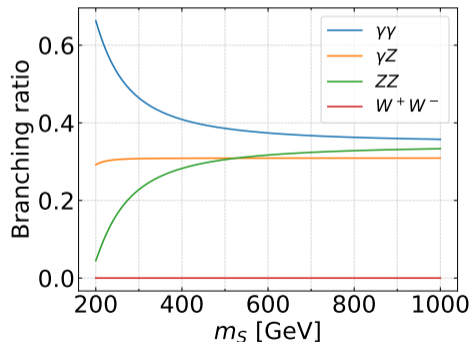
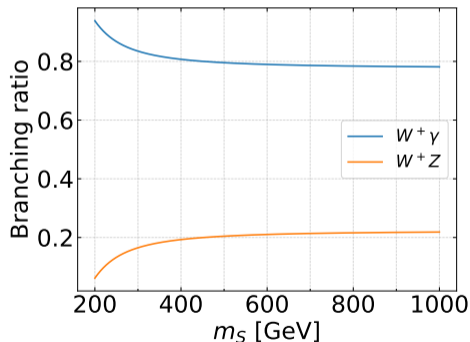
- ▶ CM cms_sus_16_039:
EWino production; ≥ 2 leptons and MET
- ▶ Rivet/Contur:
 $Z(\rightarrow l^+l^-)\gamma$ and
 $Z(\rightarrow \nu\bar{\nu})\gamma$ cross sections
- ▶ CM atlas_1802_03158:
Gauge mediated SUSY
breaking, multiphoton and
jets

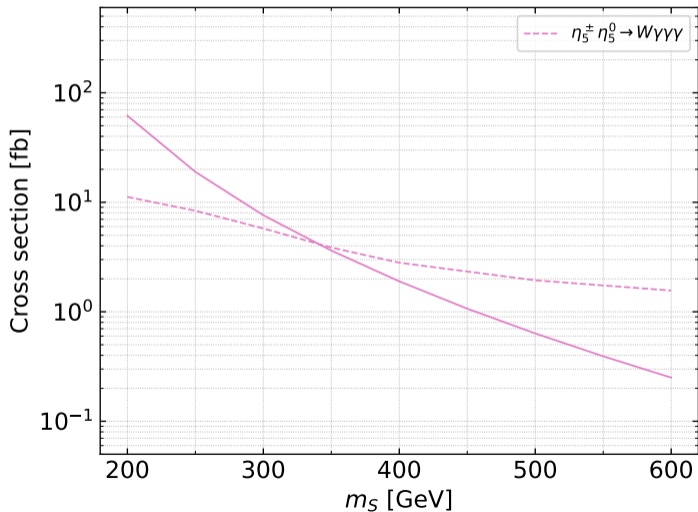


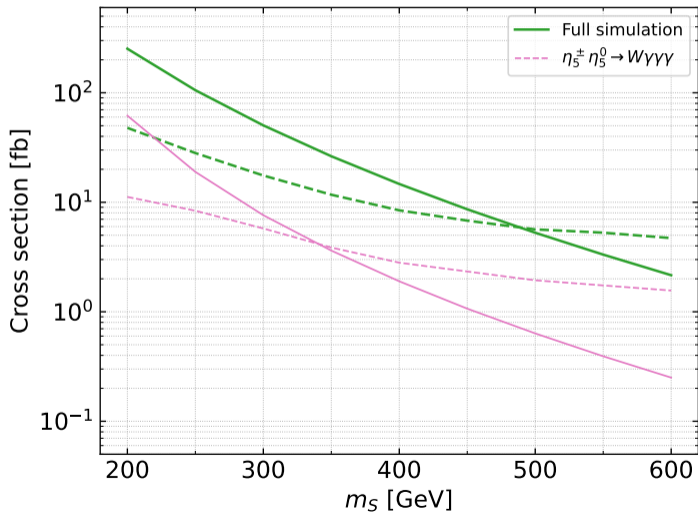
Notable searches

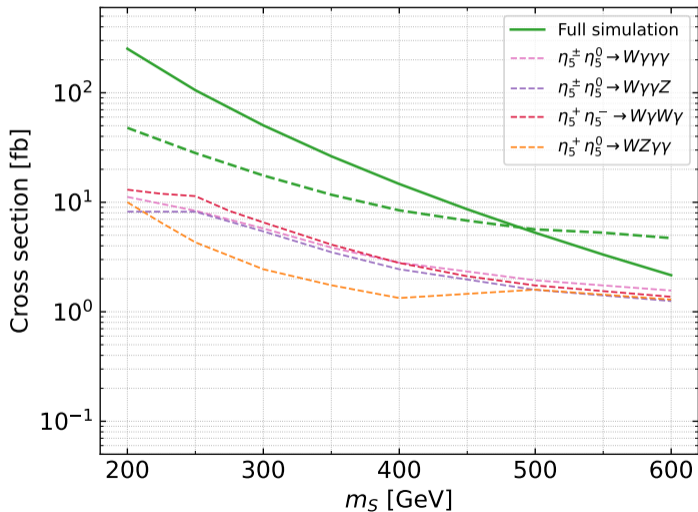
- ▶ CM atlas_2106_09609: RPV SUSY w/ many jets, ≥ 1 leptons and 0 or ≥ 3 b-jets
- ▶ CM atlas_1807_07447: General search for new phenomena

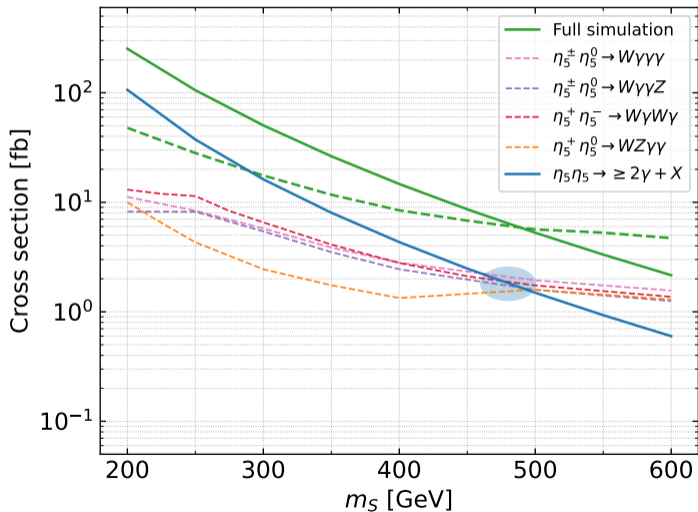
$$\eta_5 = (\eta_5^{++}, \eta_5^+, \eta_5^0, \eta_5^-, \eta_5^{--}), \quad \eta_3 = (\eta_3^+, \eta_3^0, \eta_3^-), \quad \eta_1^0$$



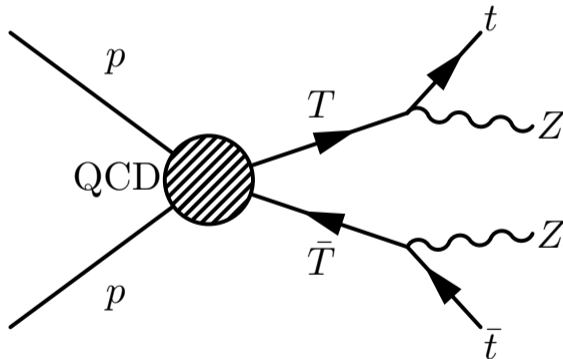




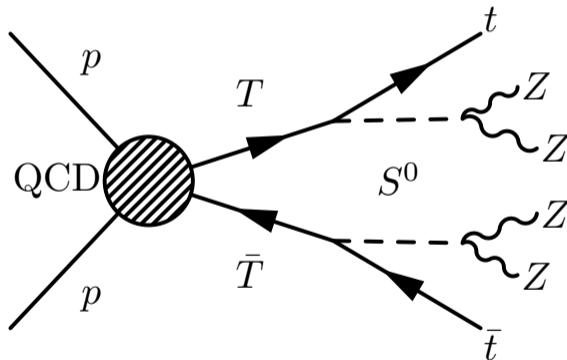




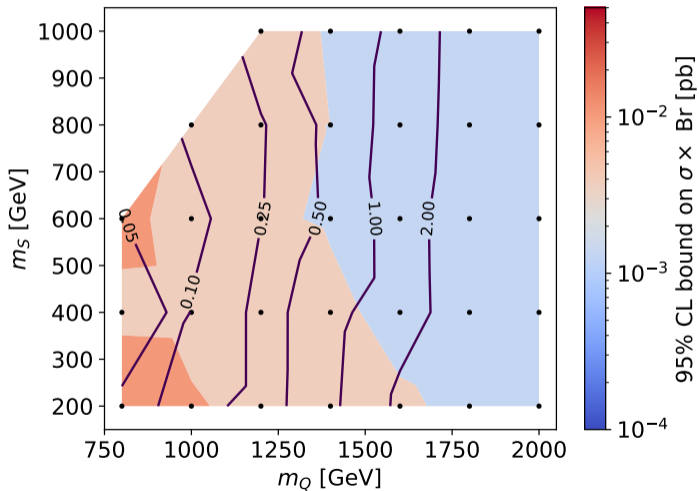
$$pp \rightarrow T\bar{T} \rightarrow tZ\bar{t}Z$$



$$pp \rightarrow T\bar{T} \rightarrow tS^0 \bar{t}S^0 \rightarrow tZZ \bar{t}ZZ$$



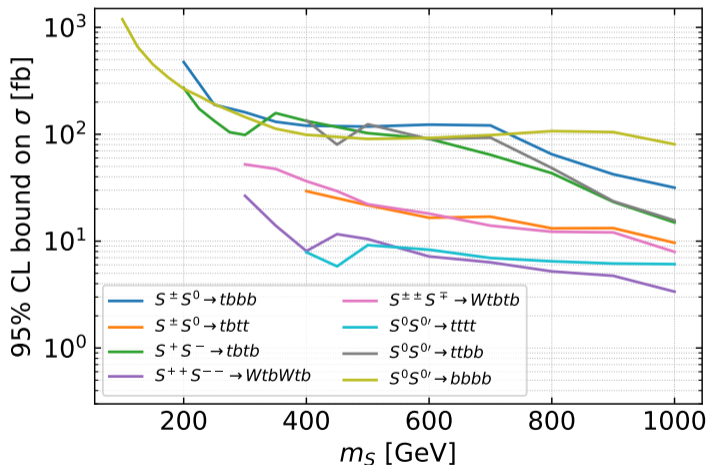
$$pp \rightarrow T\bar{T} \rightarrow tS^0 \bar{t}S^0 \rightarrow tZZ \bar{t}ZZ$$

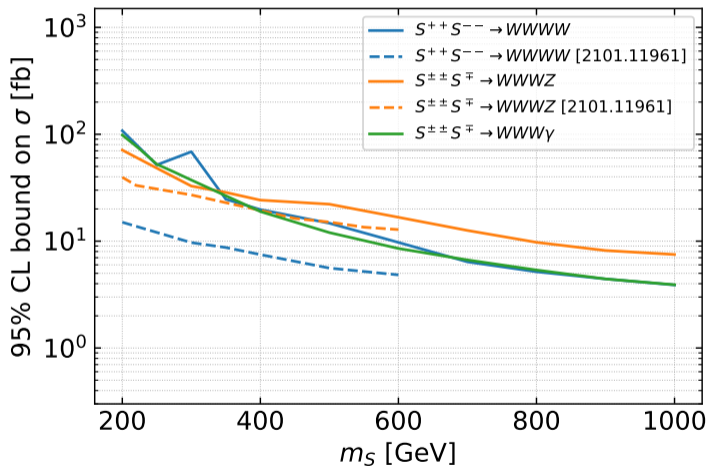


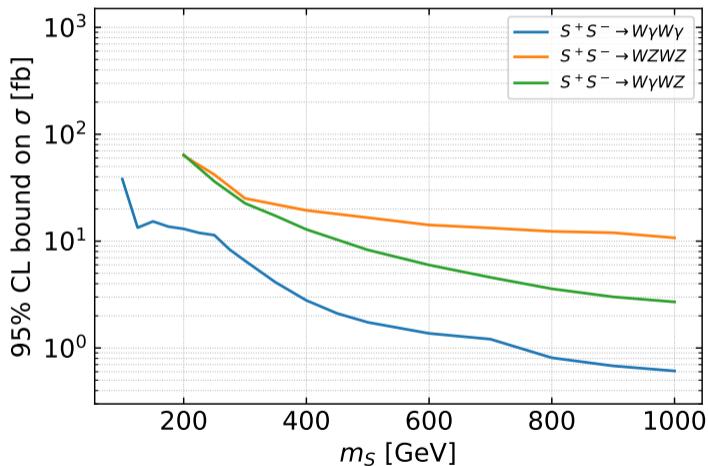
- ▶ Composite Higgs models predict experimentally unprobed signatures
- ▶ Simplified model bounds can be applied to a variety of models with little effort
- ▶ Strength of bounds relative to full simulation depends on processes
- ▶ Biggest limitation: bounds only from searches that have been implemented in recasting tools

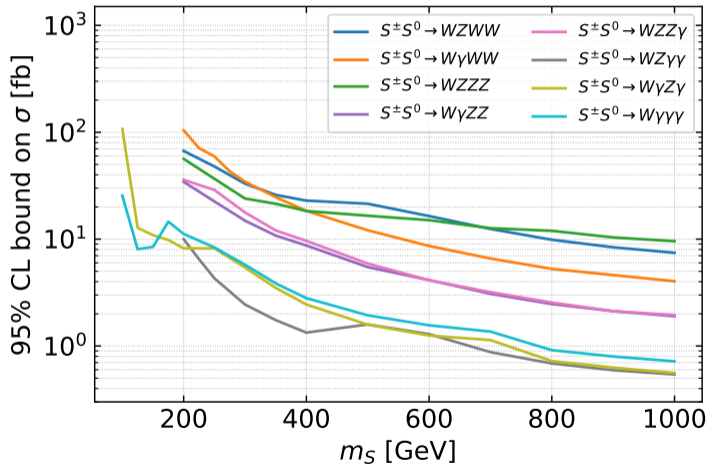
Details: JHEP 12 (2022) 087 and <https://github.com/manuelkunkel/scalarbounds>

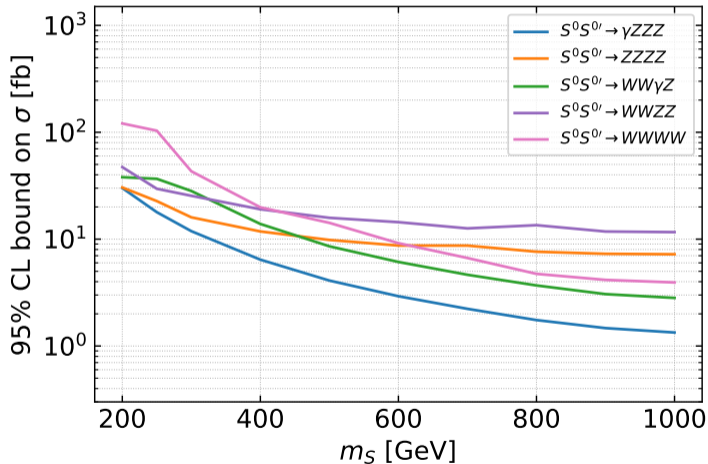
Further results

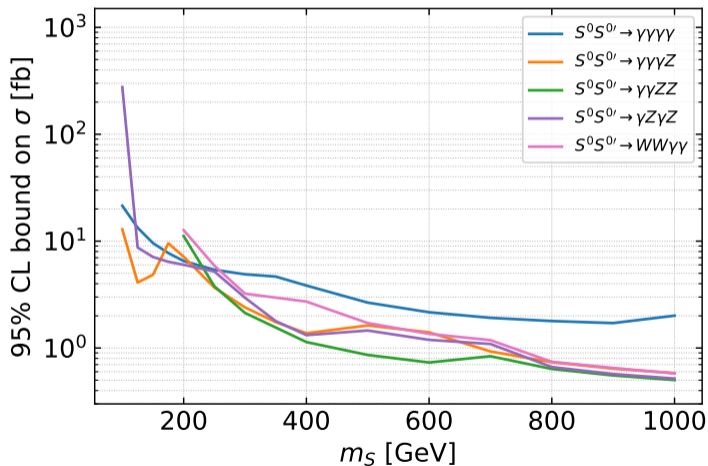




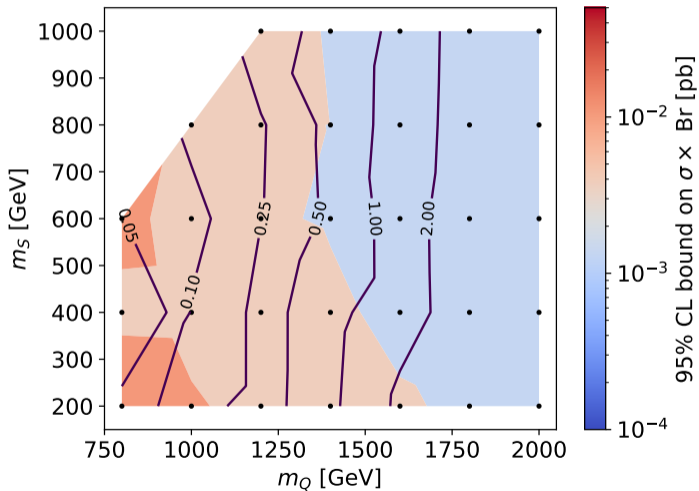




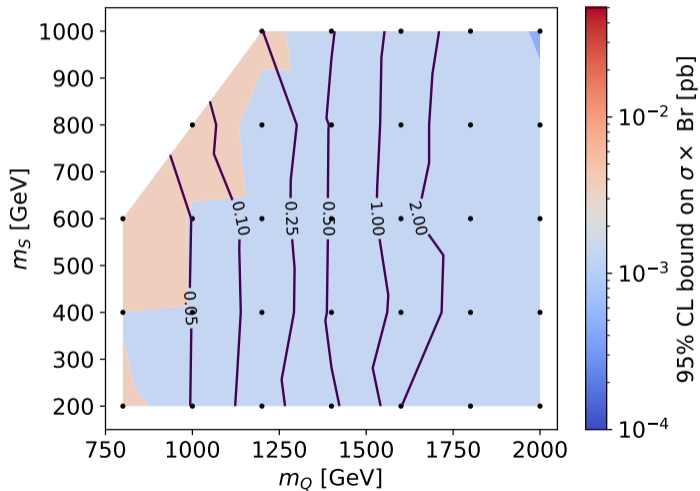




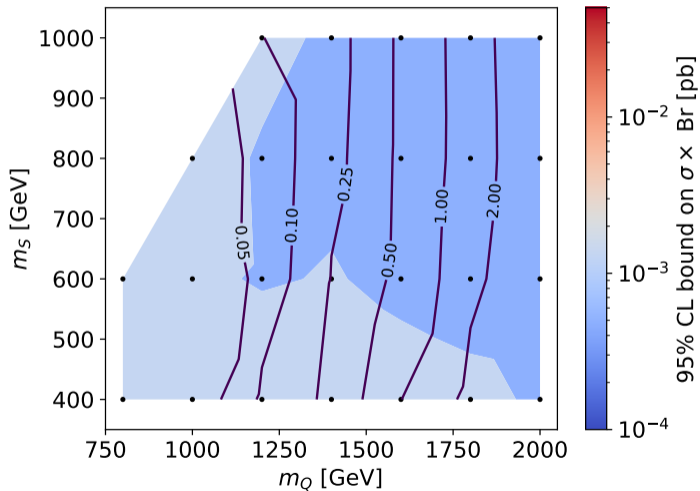
VLQs: $T\bar{T} \rightarrow tS^0\bar{t}S^0 \rightarrow tZZ\bar{t}ZZ$



$$\text{VLQs: } T\bar{T} \rightarrow tS^0\bar{t}S^0 \rightarrow t\gamma\gamma\bar{t}\gamma\gamma$$



VLQs: $T\bar{T} \rightarrow tS^0\bar{t}S^0 \rightarrow t\bar{t}\bar{t}\bar{t}\bar{t}\bar{t}$



VLQs: $T\bar{T} \rightarrow bS^+ \bar{b}S^- \rightarrow bt\bar{b}\bar{b}\bar{t}b$

