

Validation of the MadAnalysis 5 implementation of CMS-PAS-SUS-16-052

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The analysis CMS-PAS-SUS-16-052 searches for new physics in a compressed spectrum with a single lepton + missing energy final state. The primary target is stop-pair production followed by $\tilde{t} \rightarrow bf f' \chi_1^0$, *i.e.* the T2tt topology in the CMS simplified-model nomenclature. The dataset used corresponds to a total integrated luminosity of $\mathcal{L} = 36 \text{ fb}^{-1}$ at $\sqrt{s} = 13 \text{ TeV}$.

CMS provides cut flows corresponding to two benchmark points for the T2tt simplified model, one with $(m_{\tilde{t}}, m_{\tilde{\chi}_1^0}) = (500, 470) \text{ GeV}$, and one with $(m_{\tilde{g}}, m_{\tilde{\chi}_1^0}) = (375, 365) \text{ GeV}$.

The following comments and remarks are pertinent to this analysis,

- The stop quark pair production cross section used was from the official web page, <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections13TeVstopsbottom> and corresponds to a cross section of 0.51pb for a stop quark mass of 500 GeV at 13 TeV center of mass energy. Note that the uncertainty of the cross section as quoted in the web page is 10%.
- Stop quarks were pair produced with up to two hard radiation in the final state using MadGraph5, and subsequent showering and hadronization was performed with PYTHIA8 with merging parameter set to $m_{\tilde{t}_1}/4$
- The following cut flow numbers were obtained as tabulated in Table ??, and was compared with the official numbers provided in the webpage for this analysis.
- It was not entirely clear from the paper whether the T2tt topology specified has an intermediate chargino state as described in the paper. The events are simulated without this and the results matched.
- The lepton efficiencies were collected from the webpage <https://twiki.cern.ch/twiki/bin/view/CMSPublic/SUSMoriond20170bjectsEfficiency> corresponding to SUS-16-048 to take into account soft leptons. This is just parametrized in the delphes card.

Table 1: Summary of yields for the $\tilde{t}_1 \rightarrow b f f' \tilde{\chi}_1^0$ model for two benchmark points with $m_{\tilde{t}_1} = 500, 375$ GeV, as compared to official CMS results given on <http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/SUS-16-052/index.html>. The uncertainties given for the CMS event numbers are statistical only.

| cut | $m_{\tilde{t}_1, \tilde{\chi}_1^0} = 500, 470$ GeV | | $m_{\tilde{t}_1, \tilde{\chi}_1^0} = 375, 365$ GeV | |
|--|--|-------------|--|-------------|
| | CMS result | MA 5 result | CMS result | MA 5 result |
| All signal Regions | | | | |
| $H_T + p_T(ISR) > 100 + E_T^{\text{miss}} > 200$ GeV | 656.3 | 678.3 | 933.7 | 945.9 |
| + $\Delta\phi(j_1, j_2)$ | 606.4 | 592.1 | 872.8 | 881.4 |
| + $N(\text{hard jet}) \leq 2$ | 454.3 | 461.8 | 662.5 | 678.8 |
| + $N(\tau = 0) + N(l \geq 1) + N(l \text{ with } p_T > 20) \leq 2$ | 327.3 | 352.4 | 371.6 | 382.4 |
| + $p_T(l) < 30$ | 313.7 | 332.8 | 368.6 | 374.2 |
| Common to SR1 | | | | |
| + $N_b = 0$ | 274.9 | 268.4 | 333.6 | 348.8 |
| + $C_{T1} > 300$ | 154.2 | 148.8 | 192 | 196.2 |
| + $\eta_l \leq 1.5$ | 138 | 141.4 | 174 | 178.4 |
| SR1ax | 16.5 | 19.8 | 32.2 | 37.4 |
| SR1aY | 16.3 | 19.2 | 38.8 | 43.6 |
| SR1bX | 9.3 | 13.2 | 5.7 | 7.4 |
| SR1bY | 8.4 | 10.1 | 6.6 | 8.0 |
| SR1cX | 14.7 | 16.2 | 2.0 | 2.8 |
| SR1cX | 19.7 | 22.8 | 3.6 | 4.2 |
| Common to SR2 | | | | |
| + $N_b(\text{hard}) = 0 + N_b(\text{soft}) = 1$ | 19.7 | 22.6 | 13.9 | 16.2 |
| + $C_{T2} > 300$ | 10.7 | 13.2 | 7.4 | 8.9 |
| SR2aX | 1.1 | 1.8 | 1.1 | 1.6 |
| SR2aY | 1.4 | 1.8 | 1.2 | 1.5 |
| SR2bX | 0.7 | 1.1 | 0.4 | 0.6 |
| SR2bY | 0.5 | 0.7 | 0.6 | 0.8 |
| SR2cX | 1.3 | 1.7 | 0.2 | 0.5 |
| SR2cY | 1.8 | 2.2 | 0.5 | 0.7 |