PROCEEDINGS OF SCIENCE

SUSY searches in hadronic final states at CMS

Tribeni Mishra on behalf of the CMS Collaboration

National Institute of Science Education and Research, India

E-mail: tribeni.mishra@niser.ac.in

Most recent results from the CMS experiment are presented for searches for supersymmetry with decays to hadronic final states. The searches use proton-proton collision data with a luminosity of up to 137 fb^{-1} recorded by the CMS detector at a center of mass energy of 13 TeV during the LHC Run2.

The Tenth Annual Conference on Large Hadron Collider Physics - LHCP2022
16-20 May 2022
online

https://pos.sissa.it/

PoS(LHCP2022)268

1. Introduction

The Standard Model (SM) of particle physics predicts a wide range of phenomena with a high level of precision. Nonetheless, it does leave many questions unanswered, such as why the Higgs mass is observed to be at 125 GeV, whether a framework exists for unifying all the particle interactions, whether a dark matter candidate exists, and many more. Supersymmetry (SUSY) is a favoured extension of the SM which provides a suitable and elegant explanation to resolve several problems of the SM. The main difficulty in SUSY searches arises from the low SUSY production cross-section. However, SUSY searches in hadronic final state are essential search channels for new physics because of the abundance of jets and the missing transverse energy (p_T^{miss}) in the final states. Many analyses are performed within CMS, targeting different decay topologies and final state signatures. Due to space constraints, we provide a review of the two most recent CMS searches, i.e., searches for top squarks and searches for charginos or neutralinos with fully hadronic final states. We use proton-proton collision events at $\sqrt{s}$ = 13 TeV collected by the CMS detector in 2016–2018, corresponding to an integrated luminosity of 137 fb^{-1}.

2. Top squark searches

This analysis discusses a search for direct and gluino mediated top squark pair production in a final state with jets from hadronisation of quarks, and large p_T^{miss} from lightest neutralinos ($\tilde{\chi}_1^0$). The event diagrams for direct top squark and direct gluino pair production are shown in Figure 1.

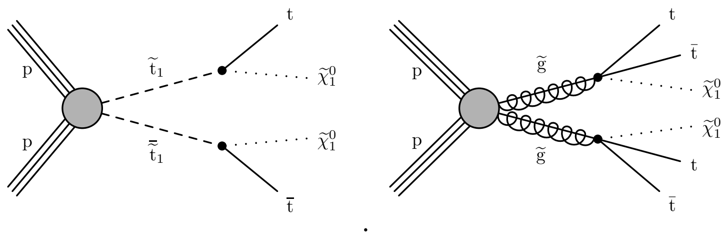

Figure 1: Diagrams displaying the event topologies of direct top squark pair production, T2tt (left), and direct gluino pair production, T1tttt (right) [2]

Sensitivity to the final states expected from these models is enhanced by the application of top quark and W boson taggers. Depending on the specific details of the SUSY model and the mass hierarchy of the SUSY particles, the top squark decays in a variety of modes. In particular, the mass difference, $\triangle$m between the top squark $\tilde{t}$ and the LSP has a large impact on the decay modes of the top squark. Two search regions (SRs) are designed which are sensitive to different signal models corresponding to the low and high $\triangle$m. The contributions of the major backgrounds are estimated using data-driven methods. The total predicted background yields in every bin is compared against observed data in the SR, as shown in Figure 2.

3. Charginos/neutralinos searches

This analysis searches for direct pair production of chargino-chargino and chargino-neutralino in a final state containing large p_T^{miss} from $\tilde{\chi}_1^0$ and hadronically decaying boson pairs WW, WZ,

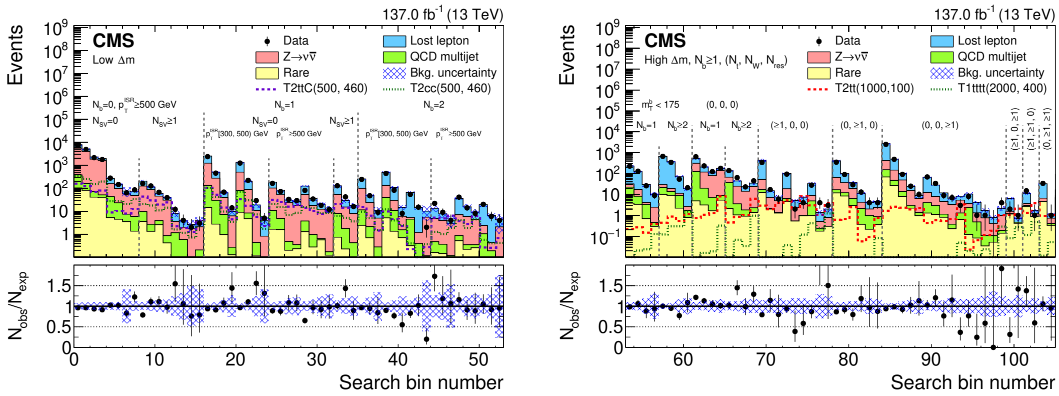

Figure 2: Observed numbers of events and SM background predictions in the low $\triangle$m SR (left), and the high $\triangle$m SR (right).

and WH, where H is the Higgs boson. Figure 3 depicts the event diagrams. We consider simplified models in which the charginos ($\tilde{\chi}_1^{\pm}$) and the next-to-lightest neutralino ($\tilde{\chi}_2^0$) are assumed to be the mass-degenerate next-to-lightest supersymmetric particles (NLSPs) and $\tilde{\chi}_1^0$ is assumed to be the lightest supersymmetric particle (LSP). Four SRs are defined based on the number of b-tagged jets

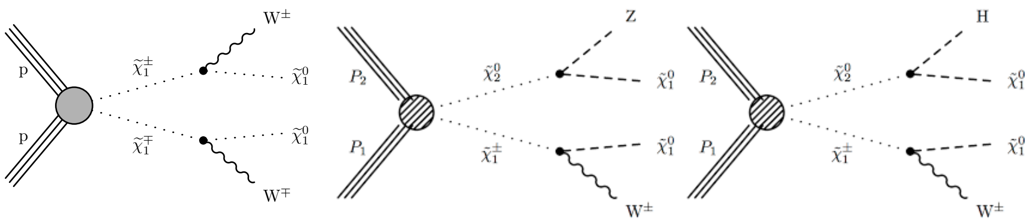

Figure 3: Diagrams for the production of $\tilde{\chi}_1^{\pm}$ $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^{\pm}$ $\tilde{\chi}_2^0$ with the $\tilde{\chi}_1^{\pm}$ decaying to a W boson and the LSP, TChiWW (left) and the $\tilde{\chi}_2^0$ decaying to either a Z boson, TChiWZ (middle) or a Higgs boson, TChiWH (right) and the LSP [3]

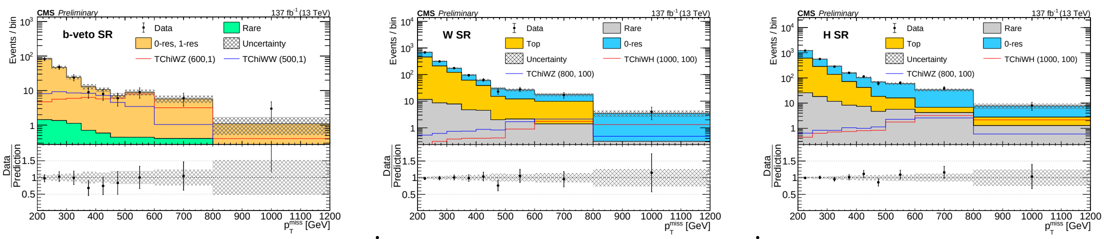

Figure 4: Observed numbers of events and SM background predictions in the b-veto SR (left), the W SR (middle), and the H SR (right).

and the W and H boson candidates and p_T^{miss}. Top backgrounds ($t\bar{t}$, single top) are estimated using the transfer factor method. Non-resonant backgrounds (W$\rightarrow$ $\ell\nu$, Z$\rightarrow$ $\nu\nu$, QCD) are estimated by inverting the tagging requirements while the rare backgrounds (triboson, ZH, ttW ttZ) are taken directly from simulation. All the predicted backgrounds are added together and compared against observed data in the SR, as shown in Figure 4.

4. Results

No statistically significant excess of events is observed in the data with respect to the expectation from the SM in both top squark and charginos/neutralinos searches, as shown in Figures 2 and 4. The likelihood fit to the data based on SUSY signal strength, the signal uncertainties, the predicted SM background contributions and the uncertainties in these backgrounds are used to evaluate upper limits on the production cross section of various signal scenarios. Figure 5 shows the 95%

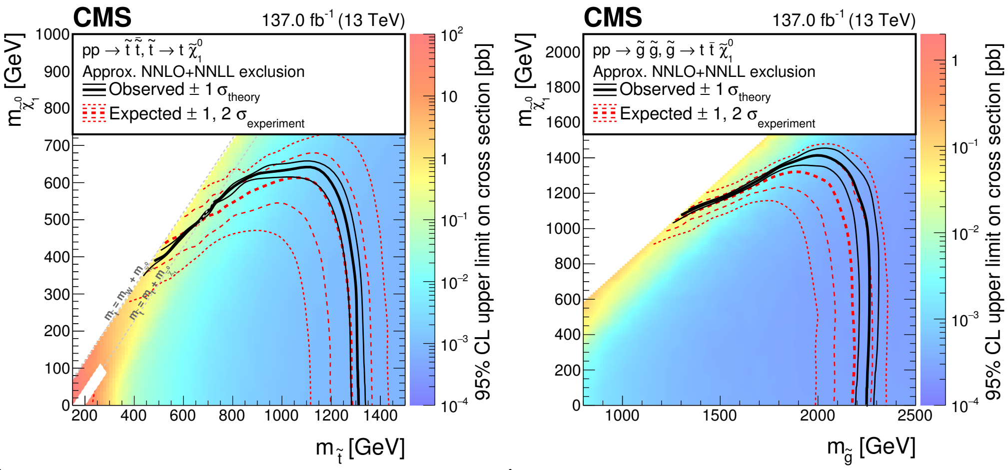

Figure 5: Observed and expected upper limits on the production cross sections at 95% CL for T2tt (left) and T1tttt (right).

Confidence Level (CL) upper limits on the production cross section for two signal scenarios, where stop mass is excluded up to 1310 GeV and gluino mass is excluded up to 2260 GeV for nearly massless neutralinos. For models of direct top squark production, the results obtained in this analysis are the most stringent constraints to date.

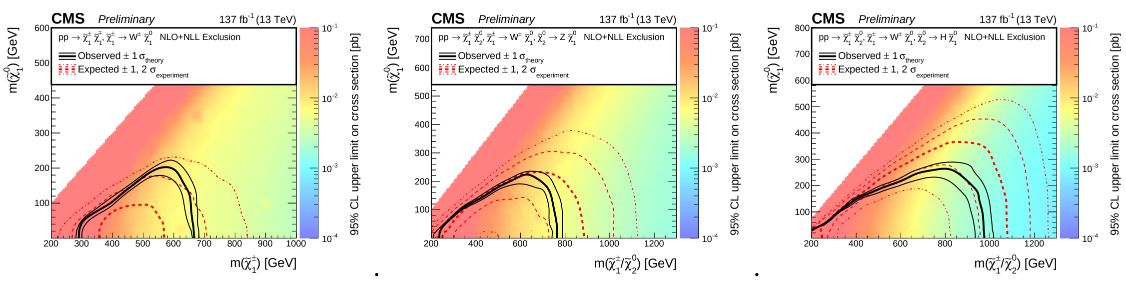

Figure 6: Observed and expected upper limits on the production cross sections at 95% CL for TChiWW (left), TChiWZ (middle), and TChiWH (right).

For signals with WW, WZ, or WH boson pairs, the NLSP mass exclusion limit for low-mass LSPs extends up to 670, 760, and 970 GeV, respectively, as shown in Figure 6. These mass exclusions significantly improve on those achieved by searches using leptonic probes of SUSY for high NLSP masses.

References

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