Search for Gluino-Mediated Stop Pair Production in Events with b-jets and Large Missing Transverse Momentum

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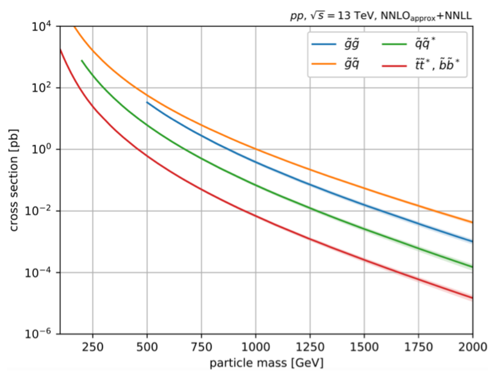
Abstract:
A search for supersymmetry involving the pair production of gluions decaying via stop quarks into the lightest neutralino $\tilde{\chi}_1^0$ is reported. It uses LHC proton-proton collision data at the center-of-mass energy $\sqrt{s} = 13\ TeV$ with an integrated luminosity of $79.8\ fb^{-1}$ collected with the ATLAS detector in 2015-2017. The search is performed in events containing large missing transverse momentum and several energetic jets, at least three of which must be identified as originating from b-quarks. The analysis is done in two final states, one of which is required to have at least 1 lepton, and the second one is required the veto on leptons. Limits are set on the gluino and neutralino masses assuming a simplified signal model. Neutralino masses greater than $800\ GeV$ are excluded while gluino masses above $2.2\ TeV$ excluded at the 95% confidence level.

Motivation for SUSY

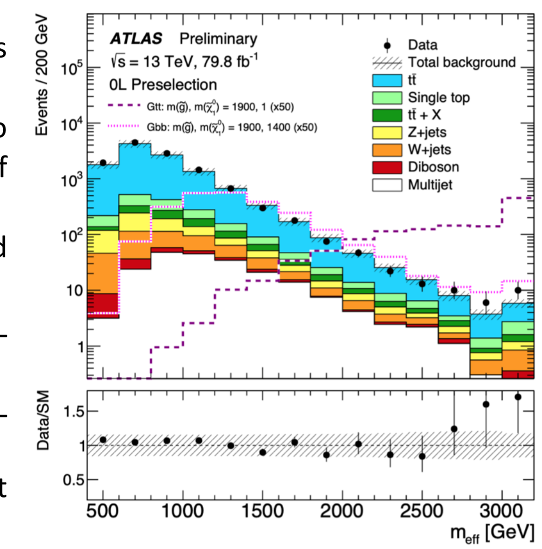
Supersymmetry is a generalization of space-time symmetry that predicts new fermionic partners for bosons and vice versa. Some of the open question of the Standard Model solved by SUSY are:
- The dark matter candidate – LSP.
- Hierarchy problem.
- Standard Model gauge coupling unification.

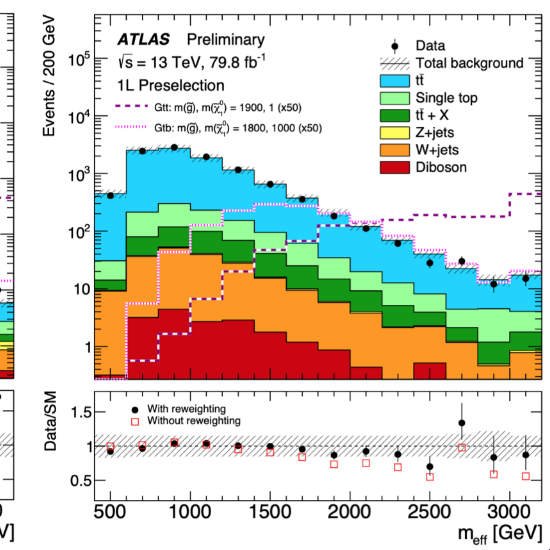


Gluinos are motivated by naturalness to have a mass around the TeV scale in order to limit their contributions to the radiative corrections to the top squarks masses. Gluinos are expected to be pair-produced with a high cross-section at the LHC, thus the search for gluino production with decays via top and the 3rd generation squarks is highly motivated at the LHC.

Standard Model Background

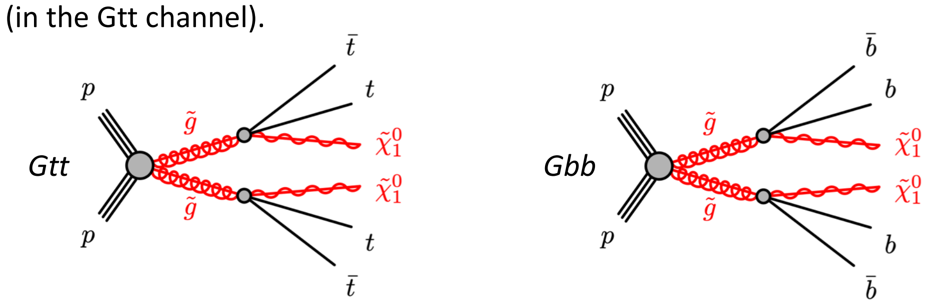
Background estimation was validated in so-called preselection regions using Data where signal events are not expected:
- To increase sensitivity, the analysis in *Gtt* channel was divided to zero (0L) and non-zero (1L) leptons channels depending on the presence of leptons in the final state.
- Dominant background is $t\bar{t}$ production. It was evaluated using MC and Data. All other backgrounds, except ACD, are estimated using MC.
- QCD background was estimated using Data-driven method for the 0L channel.
- Kinematic reweighing was implemented with respect to H_T^{had} in the 1L channel to correct miss-modeling in p_T variables
- The largest experimental uncertainties were: jet energy scale, jet energy resolution, b-tagging efficiency.





Decay topologies for the strong multi-b Simplified Models

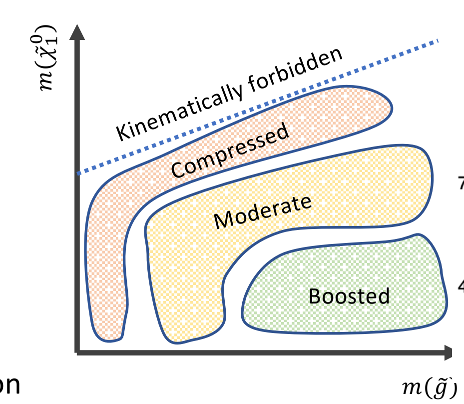
Final states for both Gtt and Gbb channels have at least four b-jets origination from top quark or gluino decays, large missing transverse momenta (E_T^{miss}) due to two escaping neutralinos ($\tilde{\chi}_1^0$) and potentially $1-2$ isolated charged leptons due to boson decay (in the Gtt channel).

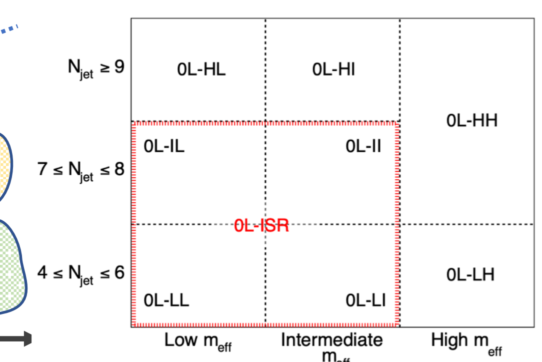


Definitions of Regions

Cut-and-count analysis:
- Partially overlapping single-bin signal regions.
- Optimized to maximize the expected discovery power.

Multi-bin analysis:
- Orthogonal bins in $\{N_{jets}, N_l, m_{eff}\}$ phace space.
- Optimized to maximize exclusion limits on the target signal.



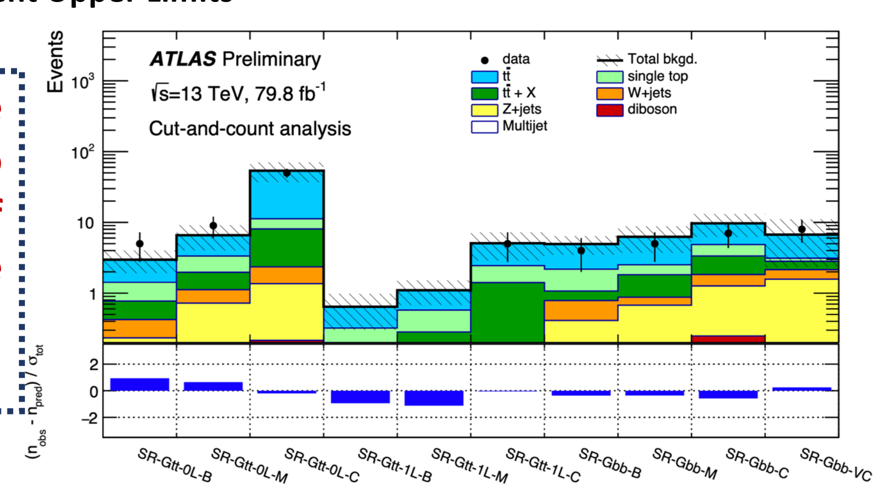


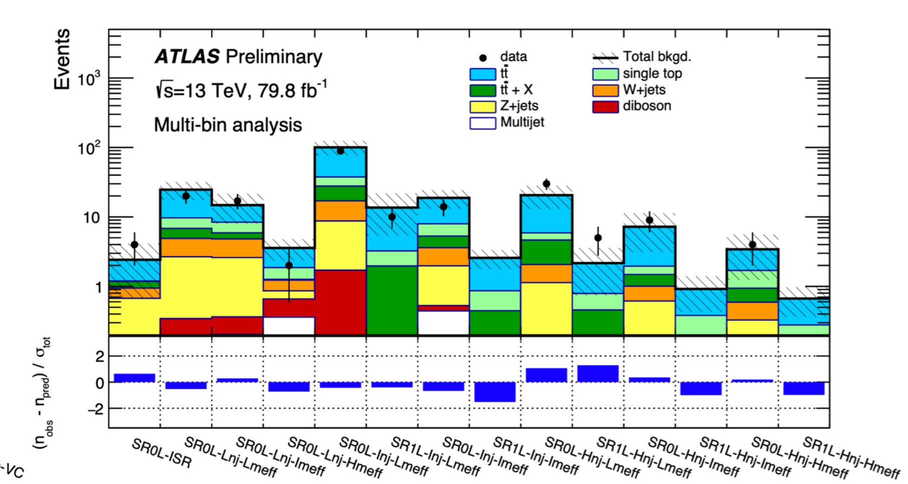
Analysis Strategy

- Control Regions (CR) are used to derive normalization factors for $t\bar{t}$ background.
- The normalization factor are verified using Validation Regions (VR) and extrapolated to Signal Regions.
- Signal Regions (SR) are designed to maximize sensitivity to the signal.
- The analysis is looking for excess of Data over the background prediction in SRs.

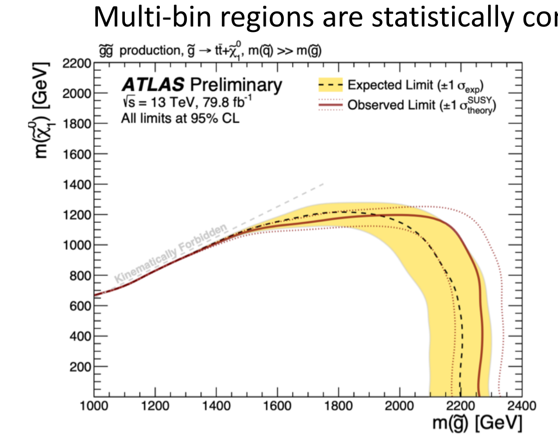
Results and Model Dependent Upper Limits

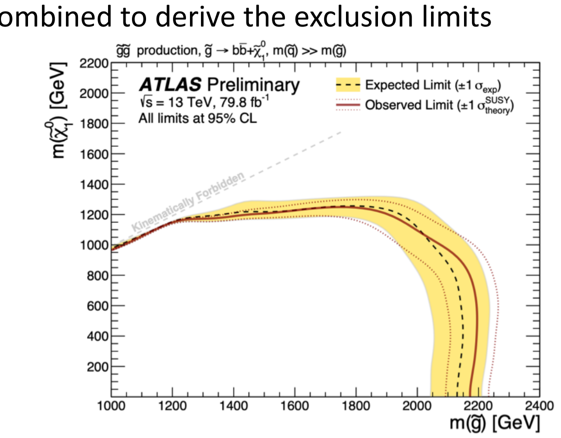
After unblinding the Signal Regions, no significant excess of data above the predicted background is observed.





Multi-bin regions are statistically combined to derive the exclusion limits





The observed exclusion limits are: up to $\sim 1.2\ TeV$ in $m(\tilde{\chi}_1^0)$
And up to $\sim 2.250/2.180\ TeV$ in $m(\tilde{g})$ in *Gtt/Gbb* channel.

Reference: ATLAS-CONF-2018-041, arXiv:1711.01901