

PARTICLES

SPARTICLES

Searching for Strong and Third Generation SUSY

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On behalf of the CMS and ATLAS Collaborations

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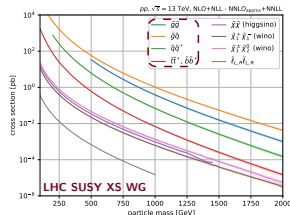
Introduction

Supersymmetry Highlights

- Mitigates the hierarchy problem by stabilizing corrections to the Higgs's mass.
- Lightest supersymmetric partner could be particle dark matter candidate.

Strong and Third Generation

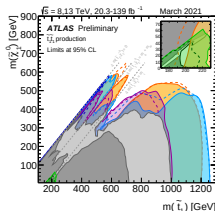
- Squark, gluinos have large production cross section $\rightarrow$ inviting for searches at the LHC.
- Decays can yield numerous final states with unique combinations of many particles.



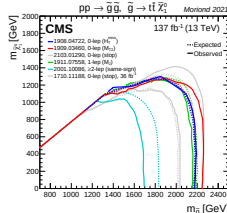
The Campaign

- CMS and ATLAS provide a “strong” campaign searching for evidence of SUSY via strong and third generation production using the full LHC Run2 data set.

Limits on top squarks



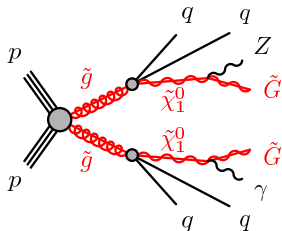
Limits on gluinos



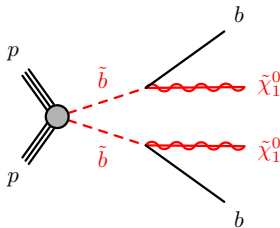
A Collage of Searches

Results highlighted in this talk

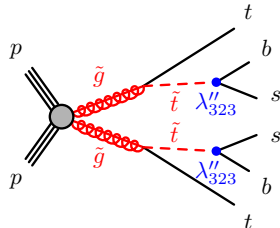
Gauge mediated supersymmetry breaking ATLAS-CONF-2021-028 ☞



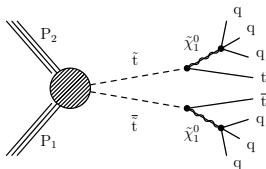
sbottom production JHEP05 (2021) 093 ☞



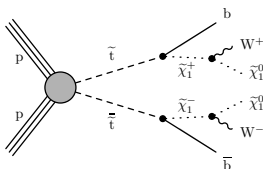
RPV SUSY with gluino production arXiv:2106.09609 ☞



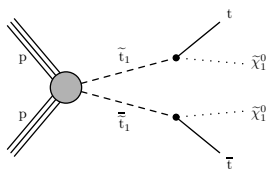
Stealth/RPV SUSY with stop production PhysRevD.104.032006 ☞



Fully hadronic stop decays arXiv:2103.01290 ☞



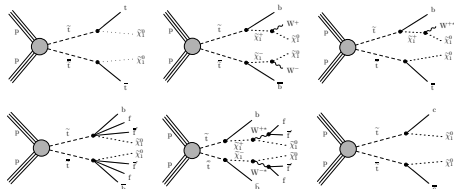
0L, 1L, and 2L stop decays arXiv:2107.10892 ☞



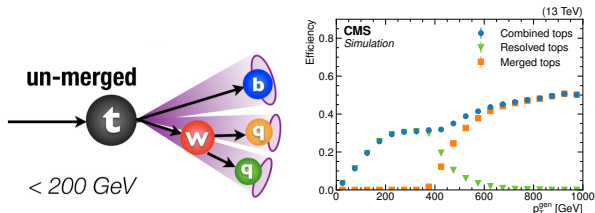
Direct Stop Quark Production (Fully Hadronic Decay)

- Largest branching fraction is the all hadronic decay channel.
- **Makes use DNNs for identifying both tops and Ws in final state.**
- Final states categorized by mass difference between stop and neutralino (Δm).

Top squark decay modes under consideration



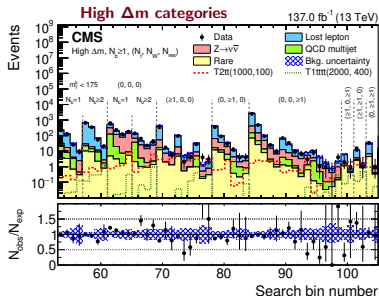
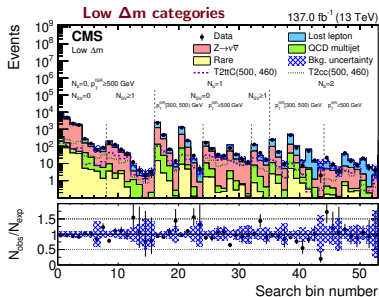
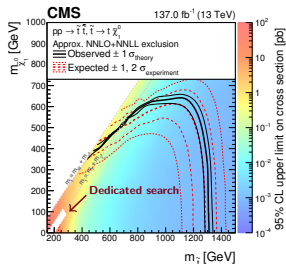
Dedicated DNN-based taggers allow for top tagging in resolved (un-merged) and merged scenarios.



Direct Stop Squark Production (Fully Hadronic)

► Phase space divided into numerous search regions.

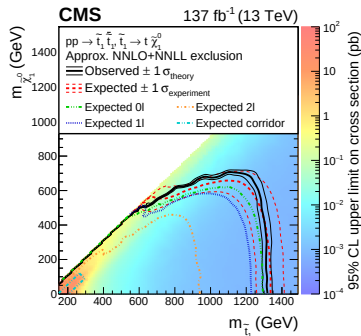
▼ Top squark mass excluded up to 1350 GeV for some range of LSP mass.



Stop Quark Search, Combined Channels

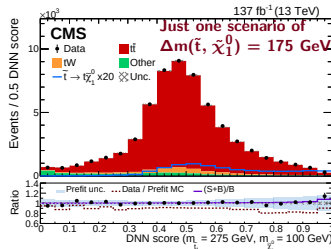
Examining All Final States

- Brings together three orthogonal final states/analyses: 0L, 1L, and 2L.
- Gives more power in the overall exclusion limits on the stop and neutralino mass.



Dedicated Top Corridor Search

- A DNN is used for discriminating stop decays from $t\bar{t}$ final states where $\Delta m(\tilde{t}_1, \tilde{\chi}_1^0) = m_{\text{top}}$.
- Fitting to the output discriminant shape used to deduce presence of signal.
- Corridor space is excluded at 95% confidence.

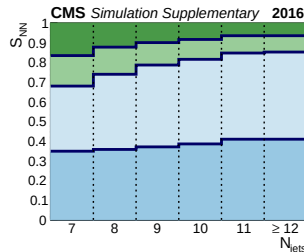
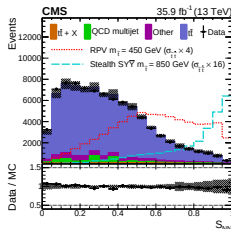
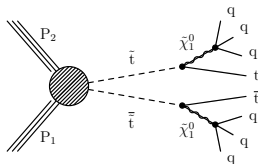


RPV/Stealth SUSY with Stop Quarks

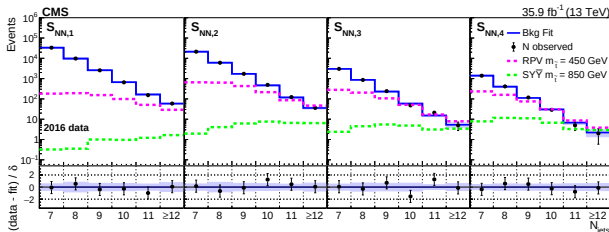
R-parity violation with stop decay via off-shell squark (UDD coupling).

Signal and background discriminated via “ N_{jets} -agnostic” NN

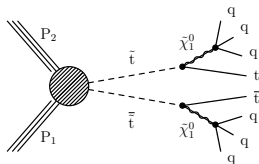
Events are grouped by NN score (S_{NN}) and N_{jets} .



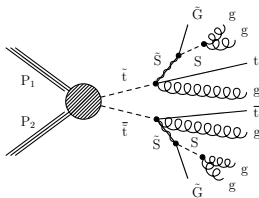
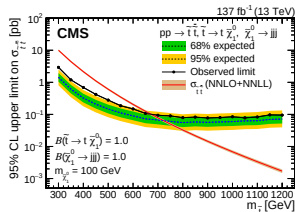
► A simultaneous fit is performed on the 24 $N_{\text{jets}}-S_{\text{NN}}$ bins where $t\bar{t}$ N_{jets} shape constrained to be same in all S_{NN} bins.



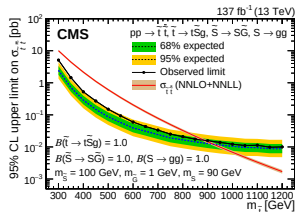
RPV/Stealth SUSY with Stop Quarks



► For the **RPV model**, exclusion limits on the stop mass extend to 670 GeV.

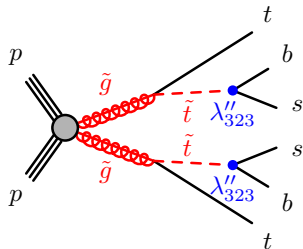


► For the **Stealth model**, exclusion limits on stop mass go out to ~ 900 GeV



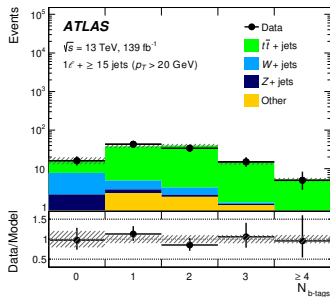
RPV SUSY with Gluinos

- Explores R-parity violation in gluino and stop decays via a B(L)-violating coupling.
- Many SM objects in final state: several tops, multiple light flavor quarks, and/or leptons.
- For strong production, events are grouped/counted by N_{jets} and $N_{b \text{ jets}}$, properties of jet scaling used to constrain background at high N_{jets} .
- Multi-bin design allows for a general overall search.

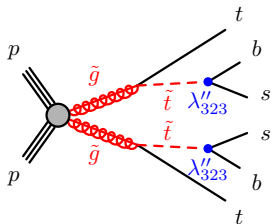


Data-driven background estimation lets search extend to very high jet multiplicities !

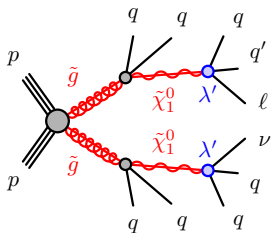
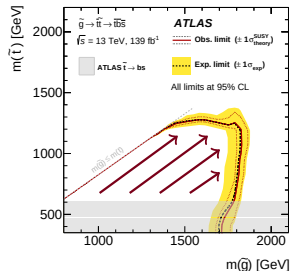
► E.g. Analysis bin requiring at least 15 jets in the event.



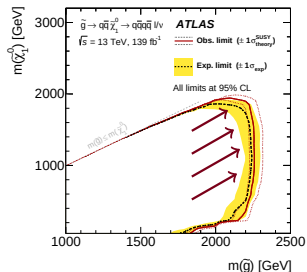
RPV SUSY with Gluinos



► In the tbs final state, exclusion limits extend beyond 1600 GeV for some region of LSP mass.

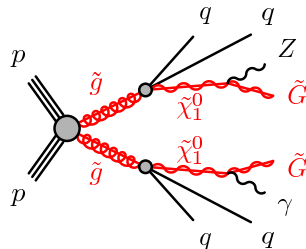


► Exclusion limits are even more impressive in the leptonic final state.

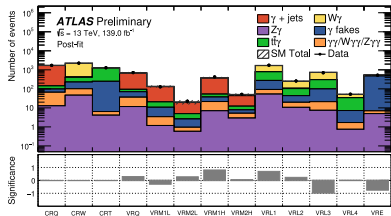


Gluino Production/Decay Under GMSB

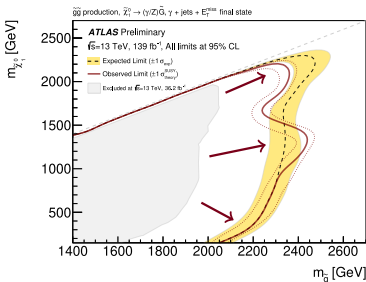
- With Gauge Mediated Symmetry Breaking, NLSP is mixture of bino and higgsino and is able to couple to γ , Z , and h .
- Final state is then: several jets + bosons + p_T^{miss} .
- Events categorized by mass splitting between gluino and neutralino.



Data agree with background-only hypothesis.

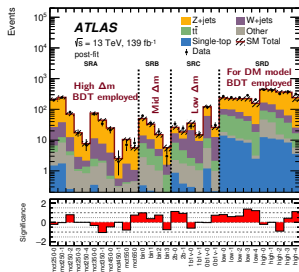
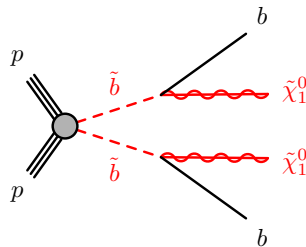


Nice gains in exclusion limits over previous analysis

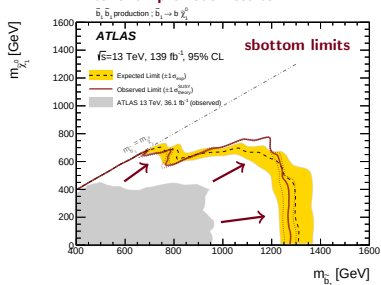


Sbottom Production and Decay to b Quarks

- Looking for the pair production of sbottoms decaying to b quarks and neutralinos.
- Improves upon earlier, similar searches with more data and newer techniques.
- Optimized search regions/selection techniques for $\Delta m(\tilde{b}, \tilde{\chi}_1^0)$ and utilize a BDT.
- Dedicated algorithm for very low p_T b jet efficiency.
- Also interprets results for third gen. leptoquarks.

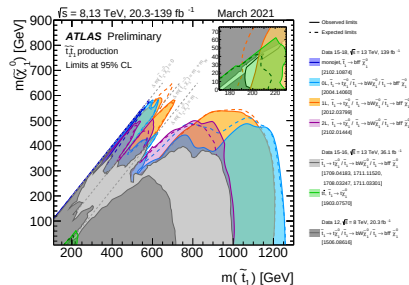


Again, noticeable improvement in exclusion limits over previous results

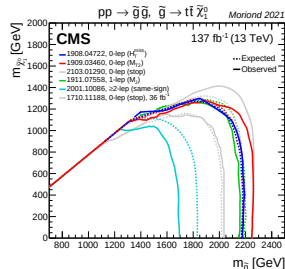


Summary

- The CMS and ATLAS Collaborations have a healthy program dedicated to searches for SUSY in strong and third generation production modes.



- New analysis techniques continue to be deployed for optimizing signal efficiency, enhancing discrimination between signal and background, etc.
- The search continues !**



BACKUP