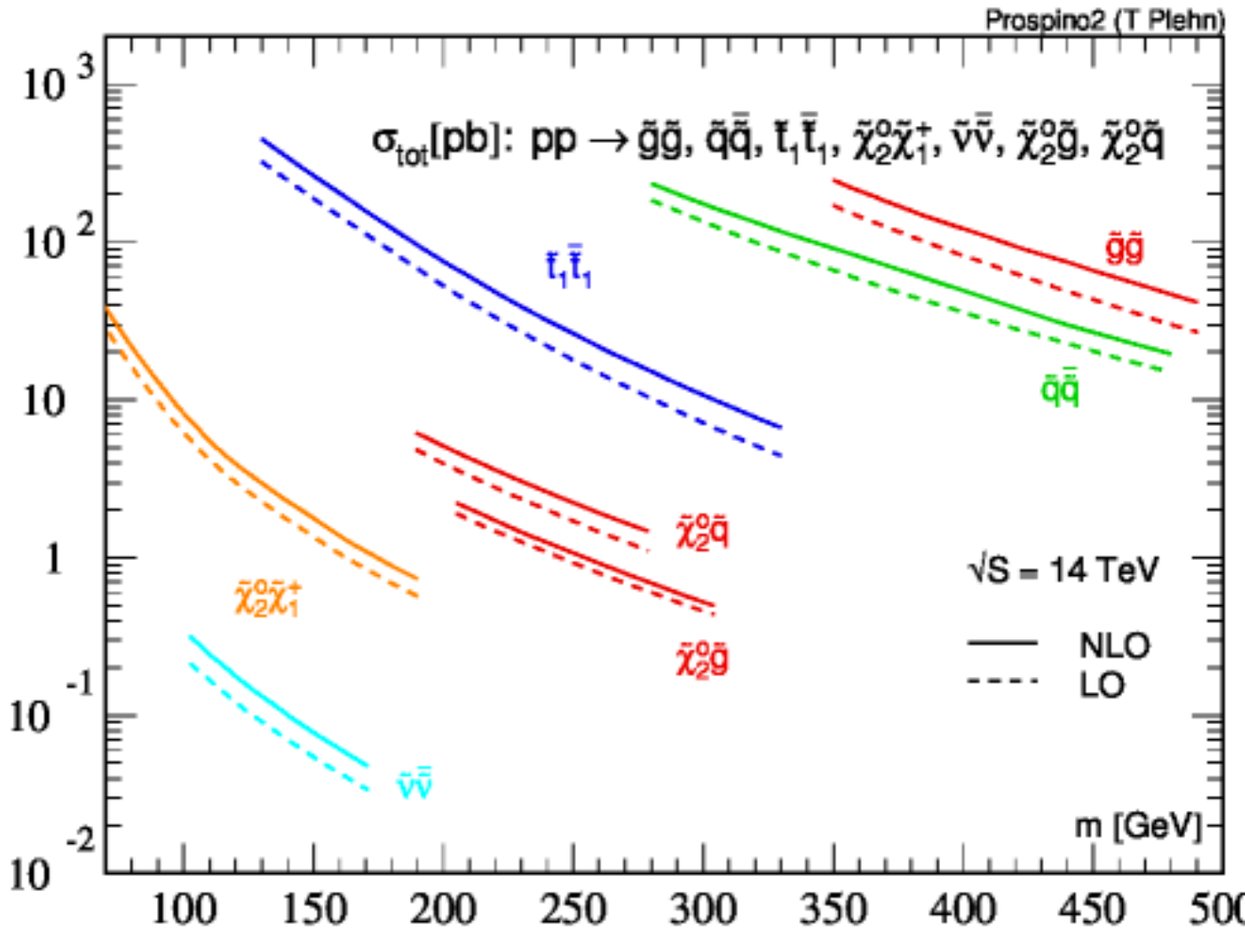
Searches for Strong Supersymmetry

By: Scarlet Norberg (UPRM) on behalf of the ATLAS and CMS Experiments

Rencontres de Moriond 2021: Electroweak Interactions & Unified Theories, 21-27 Mar 2021

Introduction

- Strong SUSY could be one of the dominant SUSY processes at the LHC
- Stop and sbottom ideal because not to heavy/massive, most sensitive channel - if backgrounds are well understood
- Even with the strong limits we have set there are still models and phase space to explore
- SUSY searches are expanding
  - By optimization on search regions and backgrounds
  - Machine learning is used not only for objects such as tops but also backgrounds and even signal extraction



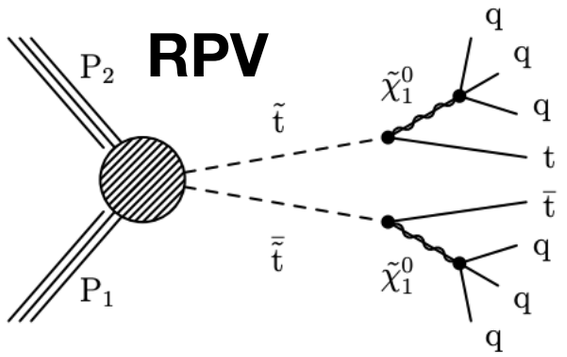
New Results

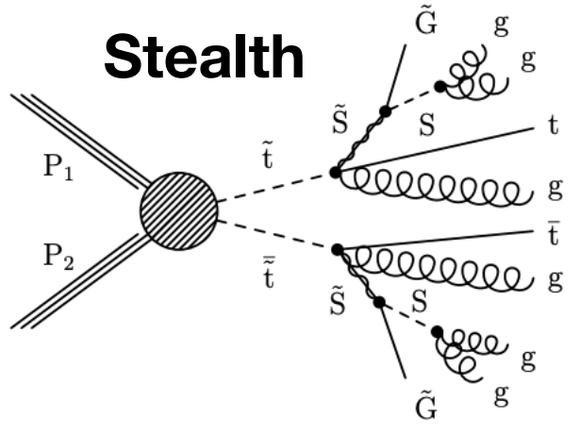
- Search for RPV/Stealth stop (arXiv:2102.06976) CMS
- RPV 1 Lepton + Jets (ATLAS-CONF-2021-007) ATLAS
  - Talking about the EWK component Otilia Ducu
- Stop in an all hadronic state (arXiv:2103.01290) CMS
- Stop Combination (CMS-PAS-SUS-20-002) CMS
  - For corridor results refer to Emmanouil (Manos) Vourliotis's talk
  - Also most stringent tt+DM limits
- b jets + MET (arXiv:2101.12527) ATLAS
  - For DM results see Juliette Alimena's talk
- Final states with tau leptons, b-jets (ATLAS-CONF-2021-008) ATLAS

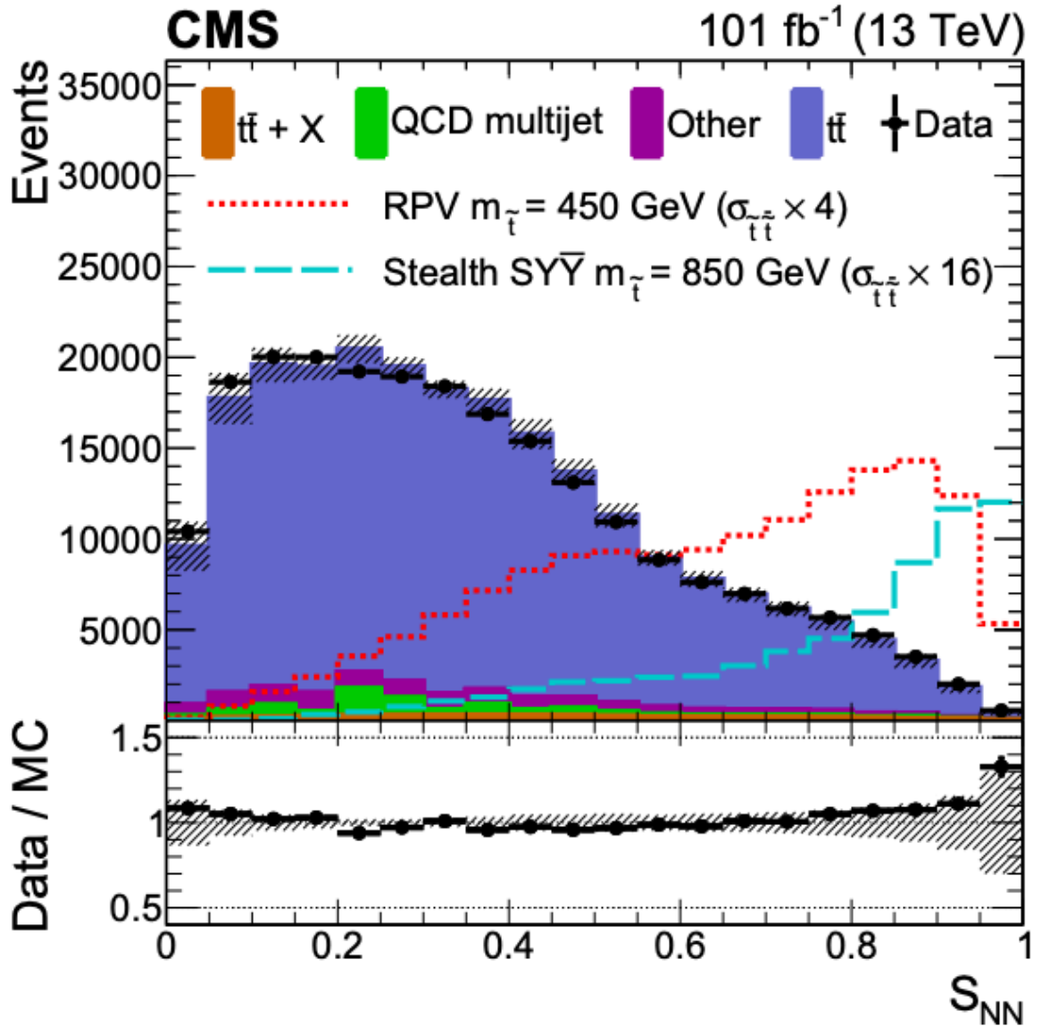
Search for RPV/Stealth stop (1)

arXiv:2102.06976

- Search for pair production of scalar top quarks decaying to a top quark and light-flavor jets in 1l final state,
- RPV model no MET requirement because the LSP particle decays to SM particles
- Stealth small amount of MET and LSP is stable
- Categories based on the events Njets and S_{NN} score of the NN
- NN training used makes the S_{NN} independent from the Njets observable



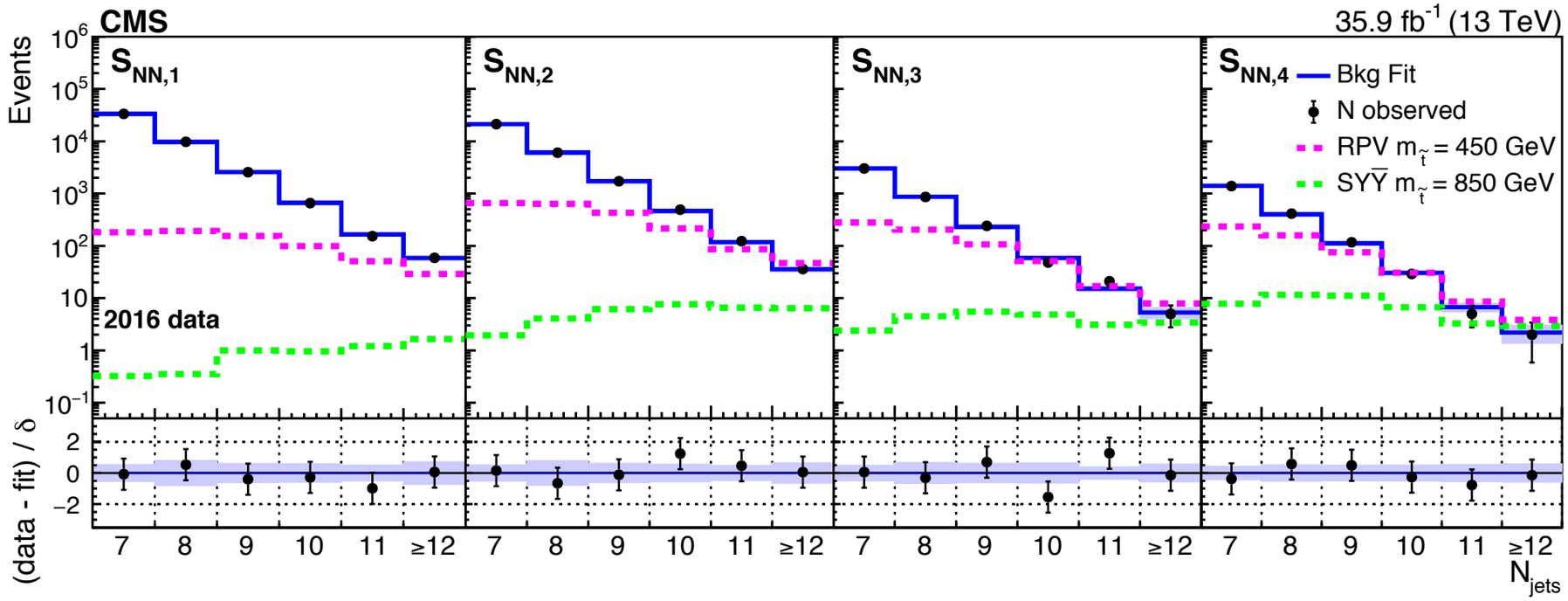




Search for RPV/Stealth stop (2)

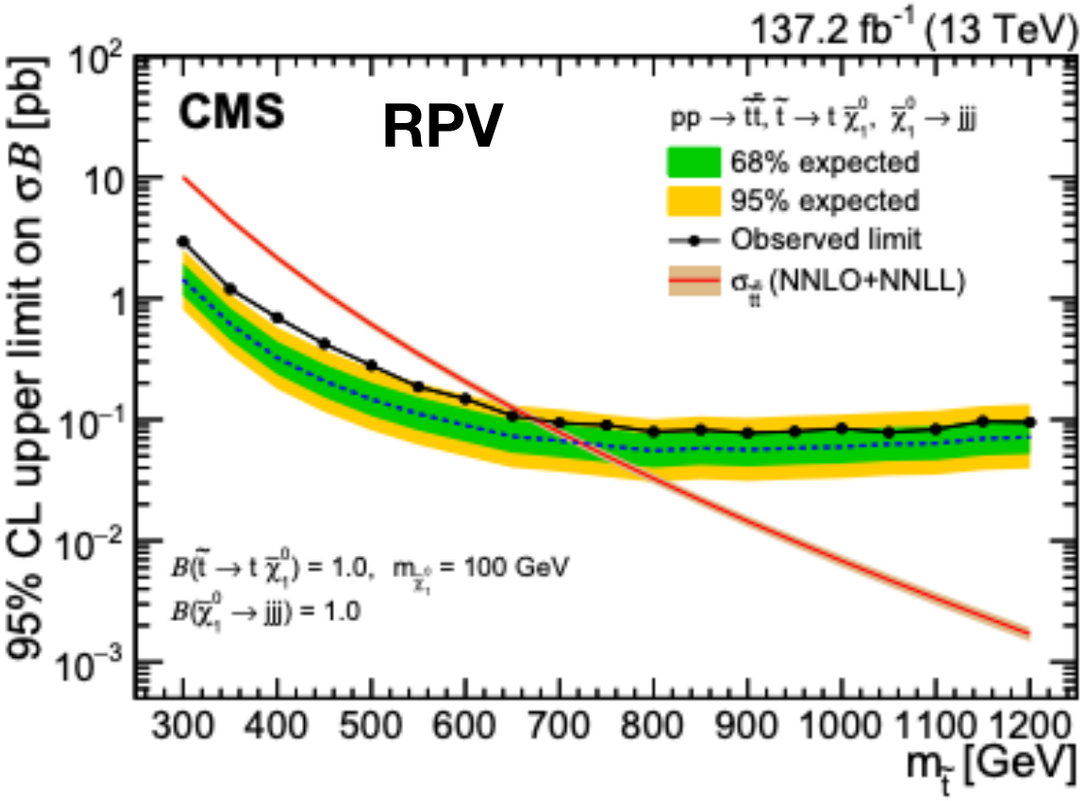
arXiv:2102.06976

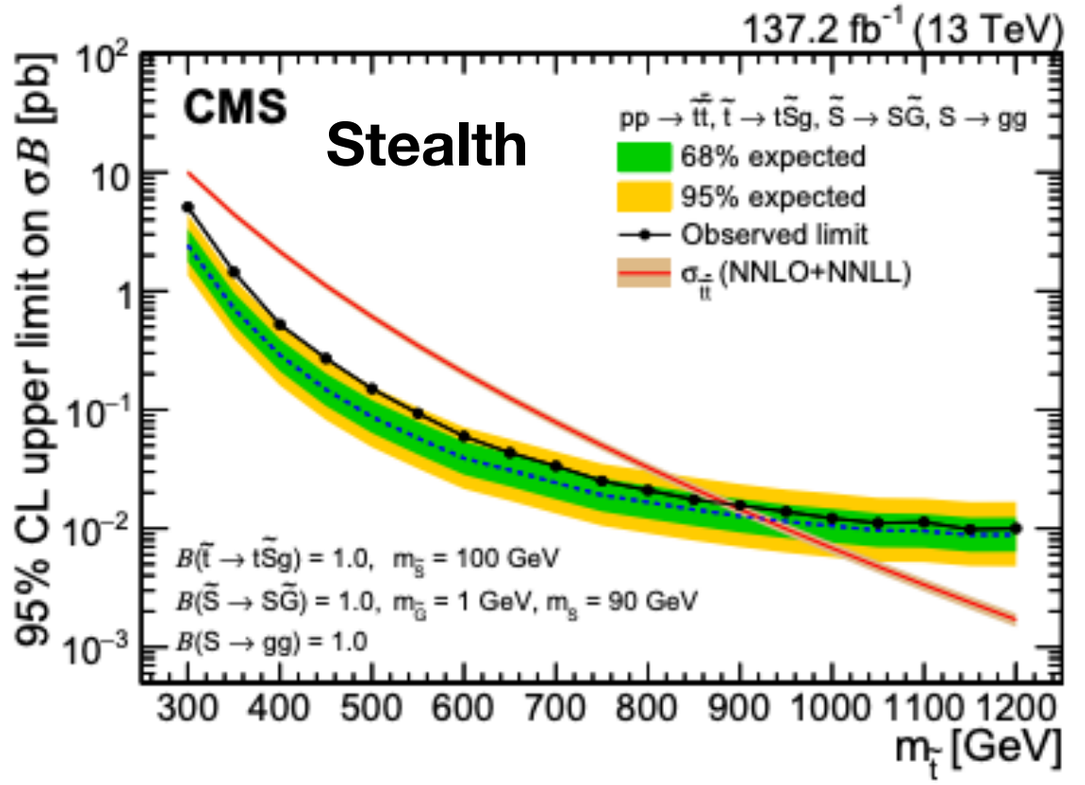
- Main backgrounds are ttbar, minor backgrounds like QCD, W+jets and other single top contributions
- ttbar background:
  - Estimated using a fit function with three free parameters
  - Events are binned in 4 S_{NN} categories
  - Where the nJet shape is assumed/required to be the same by correlating the three free parameters



Search for RPV/Stealth stop (3)

arXiv:2102.06976



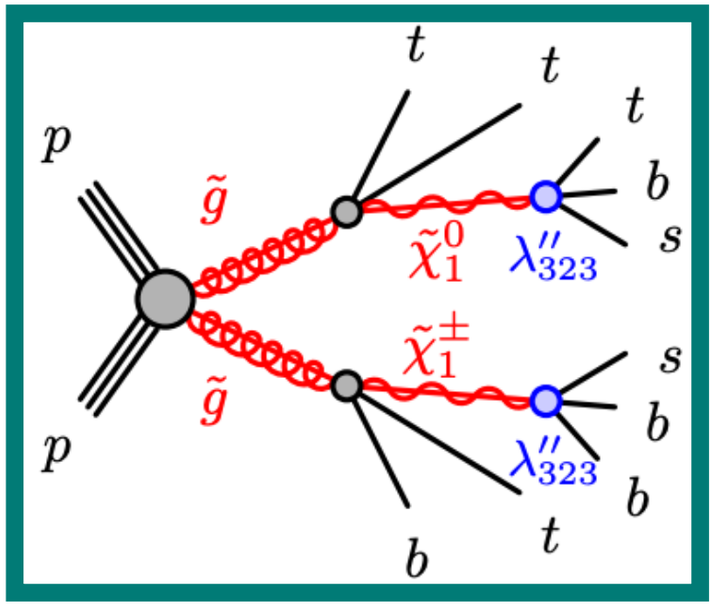


- RPV SUSY
  - Exclusion limits top squark up to 675 GeV
- Stealth SUSY
  - Exclusion limits on top squark up to ~900 GeV

RPV 1 Lepton + Jets

ATLAS-CONF-2021-007

- Search for RPV decays in final states with at least one lepton, many jets, no requirement on MET
- Jet counting is targeting the strong production part
- Split in two categories according to the lepton content, and further categorized in regions based on the jet multiplicity and b-jet multiplicity
- The jet multiplicity is binned from a minimum of four jets to a maximum number that depends on the p_T threshold and the lepton category

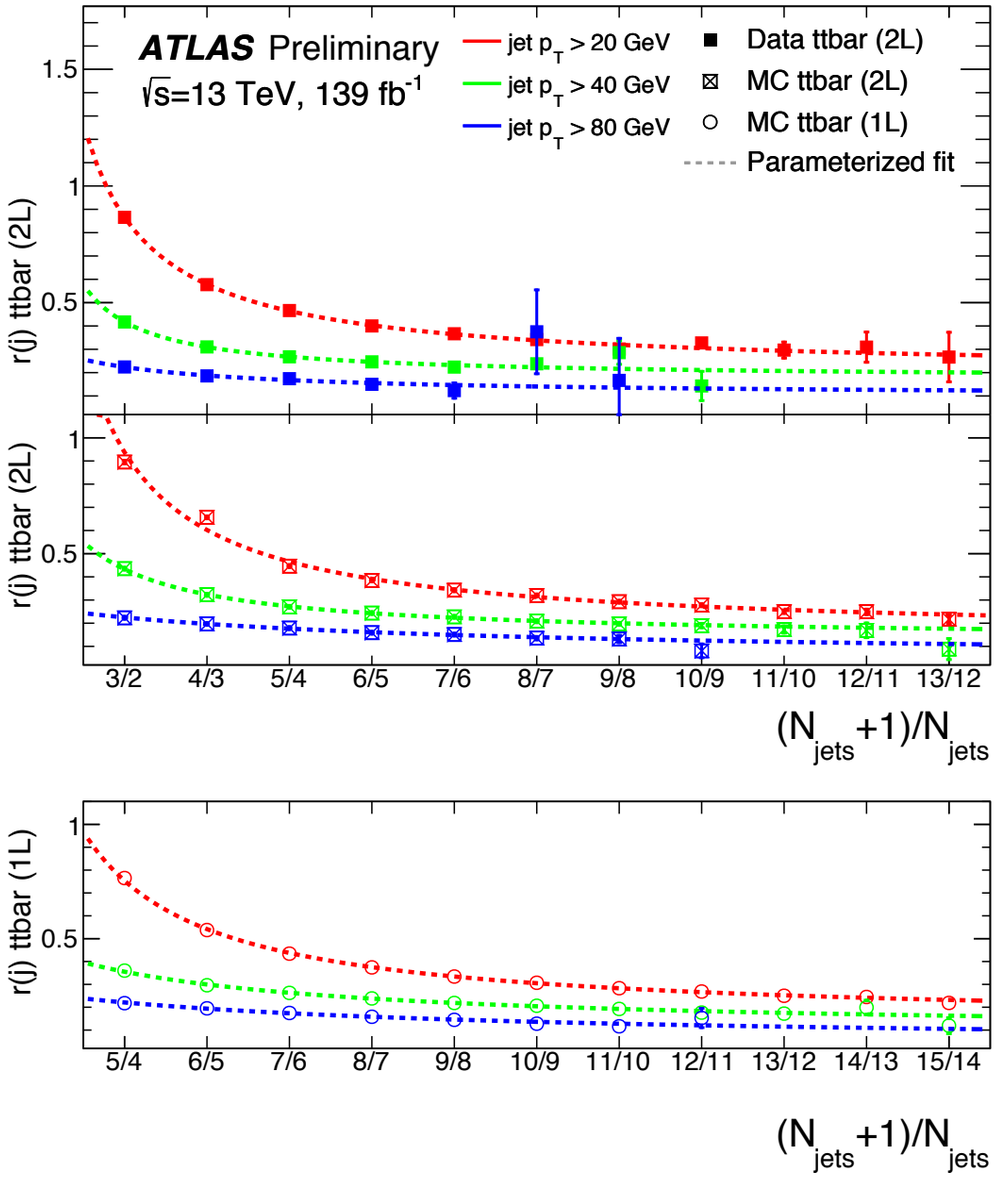


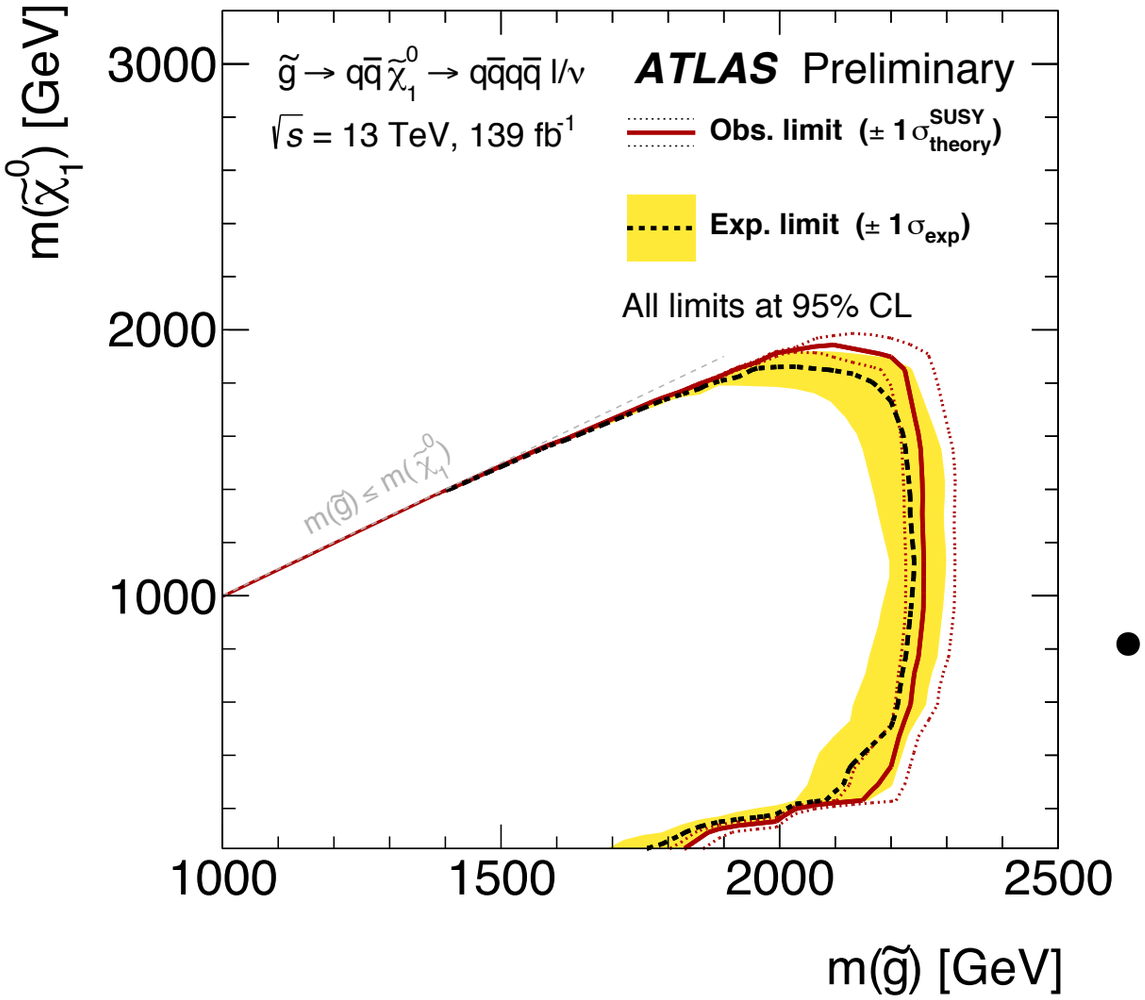
- Dominant background processes are ttbar+jets and W/Z+jets in the 1l category, and ttbarW , ttbar with a misidentified lepton, and diboson production in the 2l same charge category.

RPV 1 Lepton + Jets

ATLAS-CONF-2021-007

- Backgrounds estimated from the data by extrapolating the jet and b-jet multiplicity distributions extracted at moderate jet multiplicities, to the high jet multiplicities of the search regions.



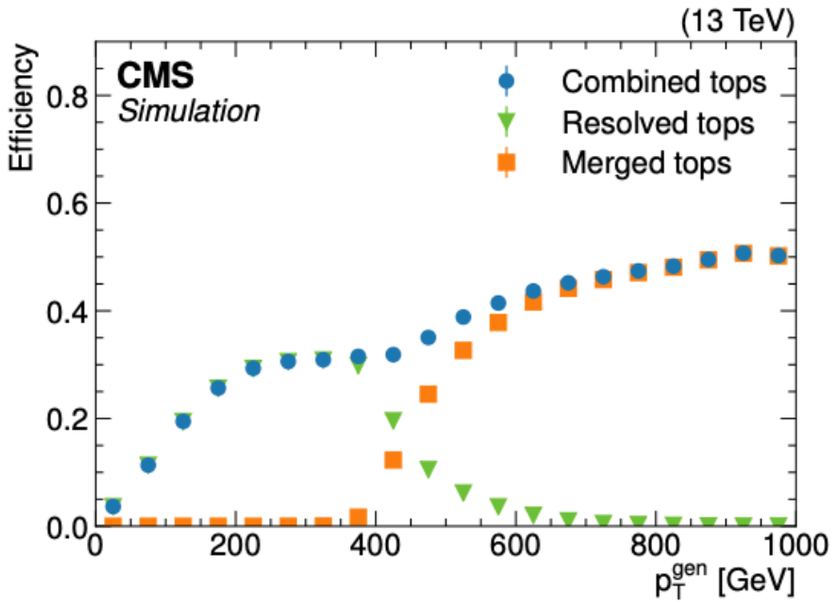


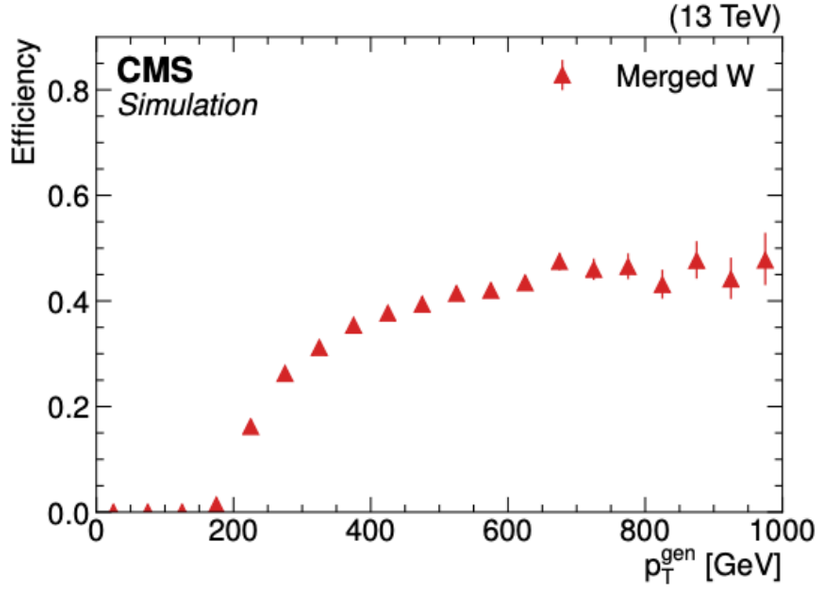
- Gluino masses up to 2.4 TeV are excluded for high LSP masses, and up to 2 TeV for low LSP masses.

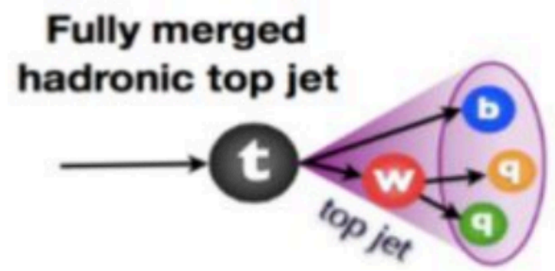
Stop all Hadronic

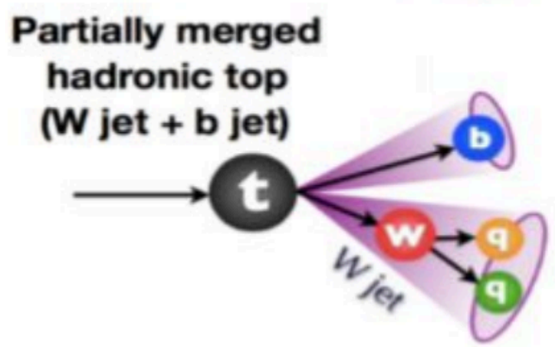
arXiv:2103.01290

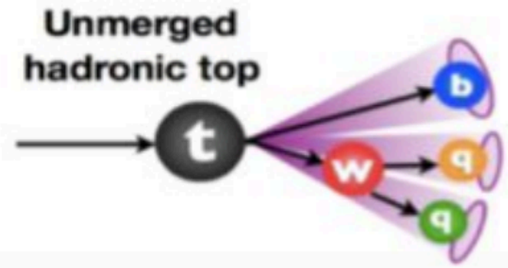
- DeepAK8 and DeepResolved algorithms are used to tag tops



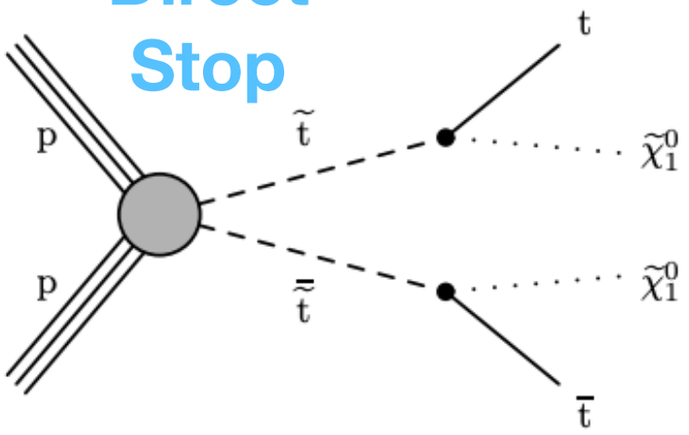




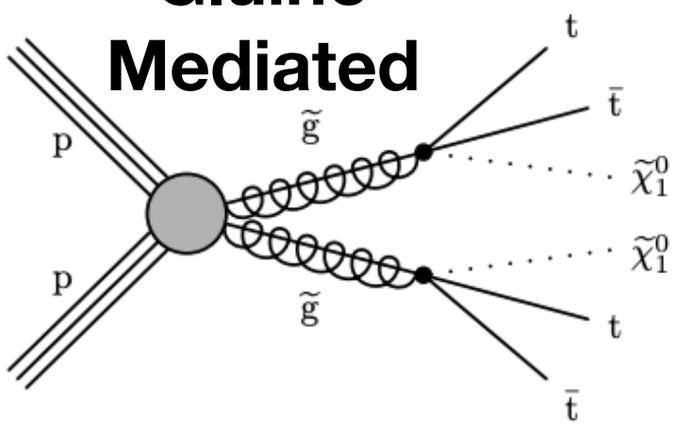




Direct Stop



Gluino Mediated

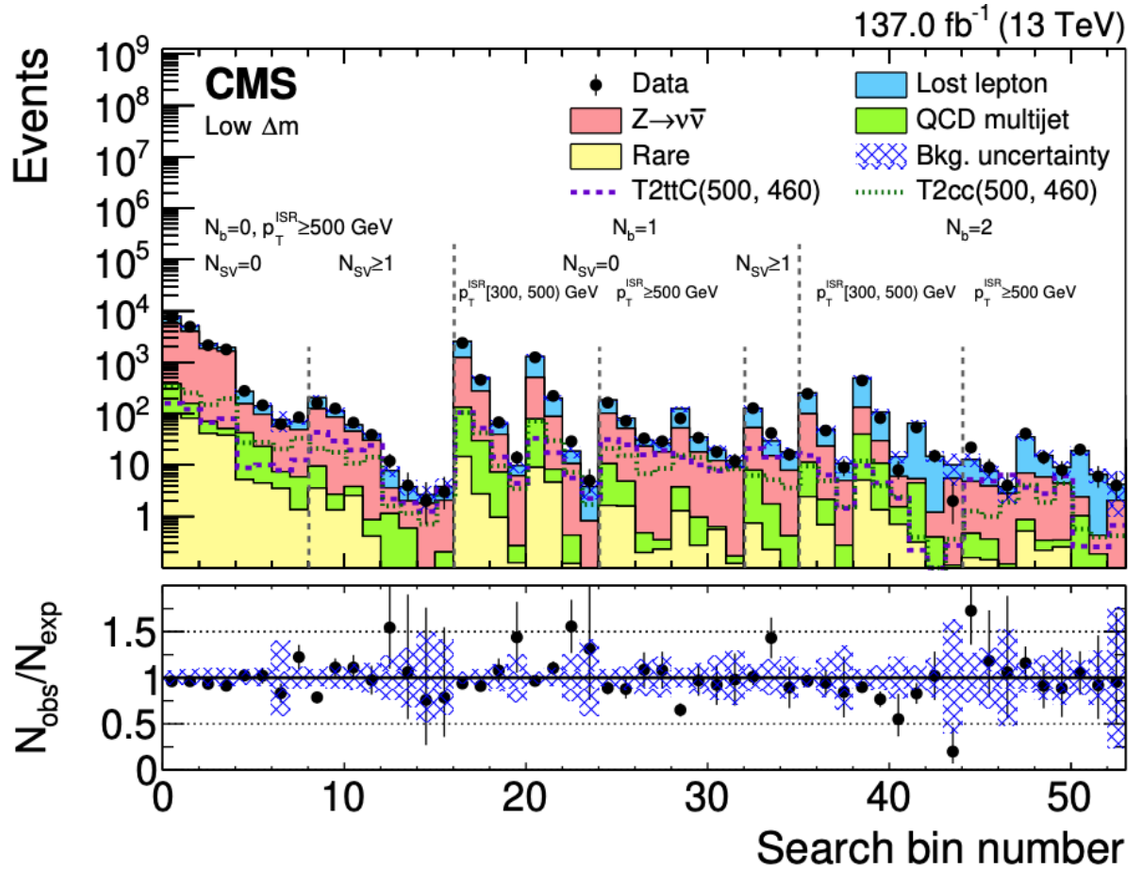


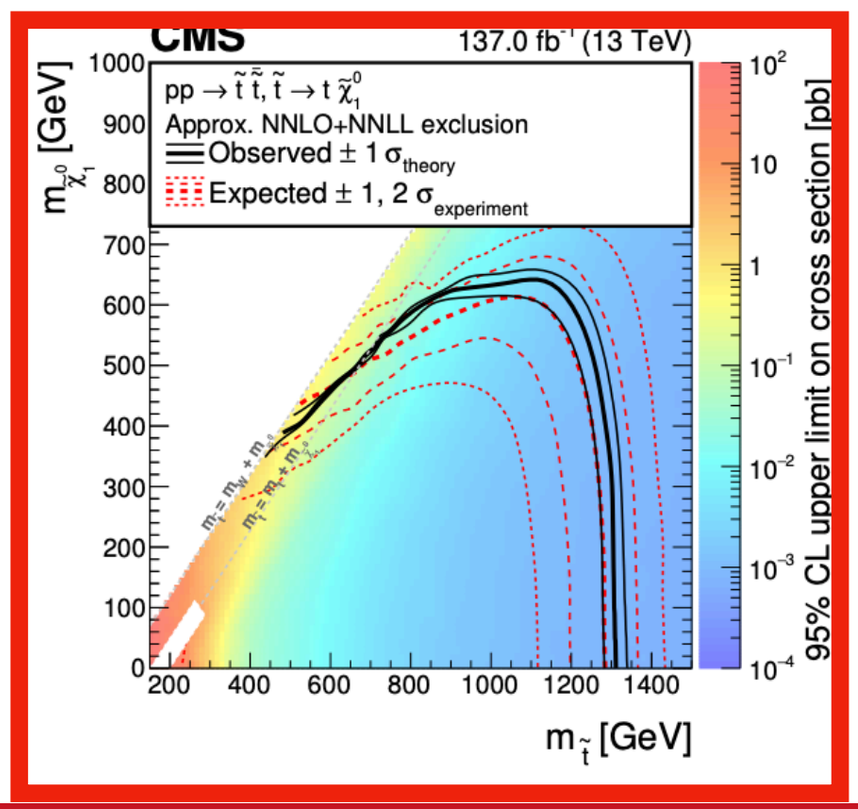
- Also a soft b tagging algorithm used to increase signal sensitivity

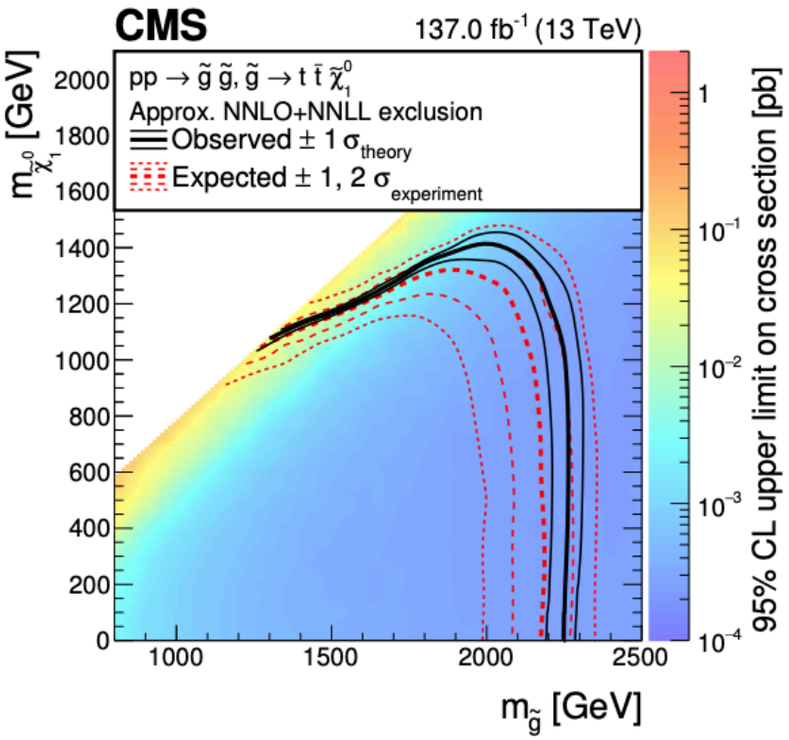
Stop all Hadronic Cont.

arXiv:2103.01290

- Backgrounds: $W \rightarrow l\nu$, $Z \rightarrow \nu\nu$, QCD
- Low mass(m_T^b < 175 GeV) and high mass (m_T^b> 175 GeV) search regions used
- Direct Stop squark mass exclusion up to 1310 GeV
- Gluino-mediated top squark exclusions up to 2260 GeV



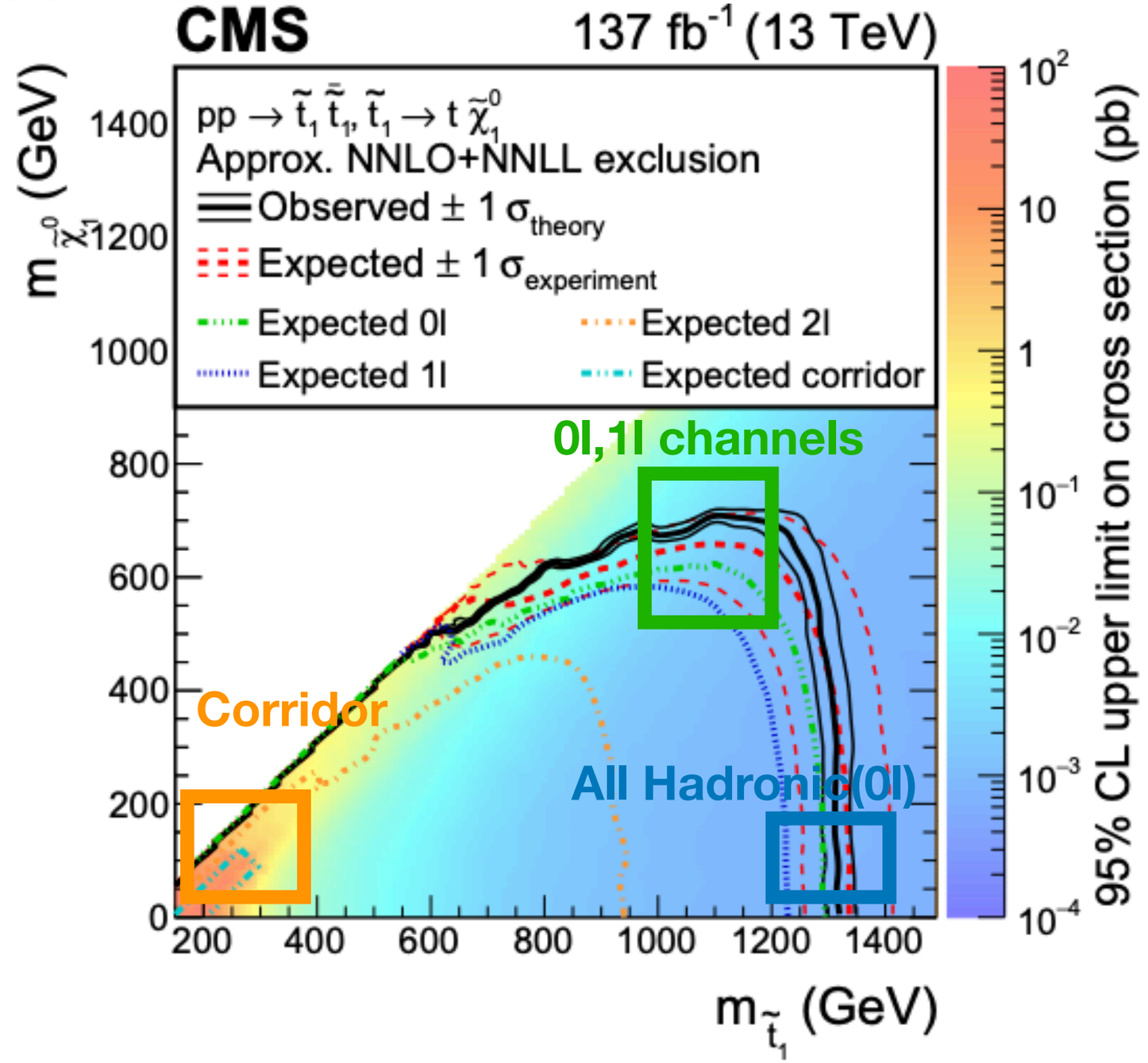




Stop Combination

CMS-PAS-SUS-20-002

- Three stop analyses targeting different final states designed to be mutually exclusive: all hadronic, 1l, 2l
- All hadronic and 1l analyzes uses a novel DNN to tag tops
- Corridor region is discussed in Manos's Talk



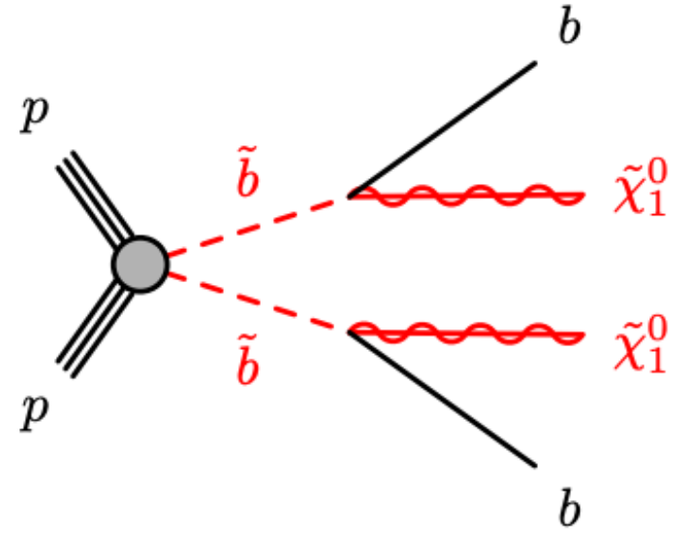
arXiv:2103.01290, arXiv:1912.08887v2, arXiv:2008.05936v2

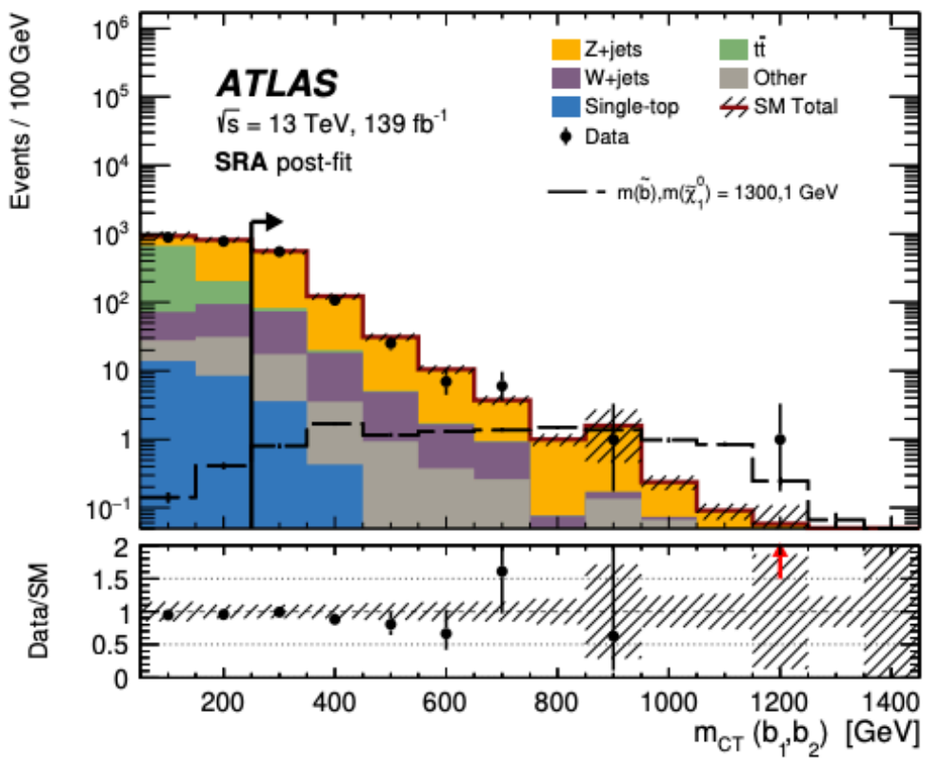
- Top squark mass exclusion of 1150 GeV for an LSP mass of 700 GeV
- Top squark mass exclusion of 1325 GeV

b jets + MET

arXiv:2101.12527v1

- Decay of a pair-produced supersymmetric bottom squark into a bottom quark and a stable neutralino
- Three search regions used
  - SRA targets large values of Δm and has basic MET and lepton selections
  - SRB is designed to be optimal for 50 GeV $<\Delta m<$ 200 GeV, and uses a BDT
  - SRC targets signals with $\Delta m<$ 50 GeV, and exploits the information from the soft b tagger

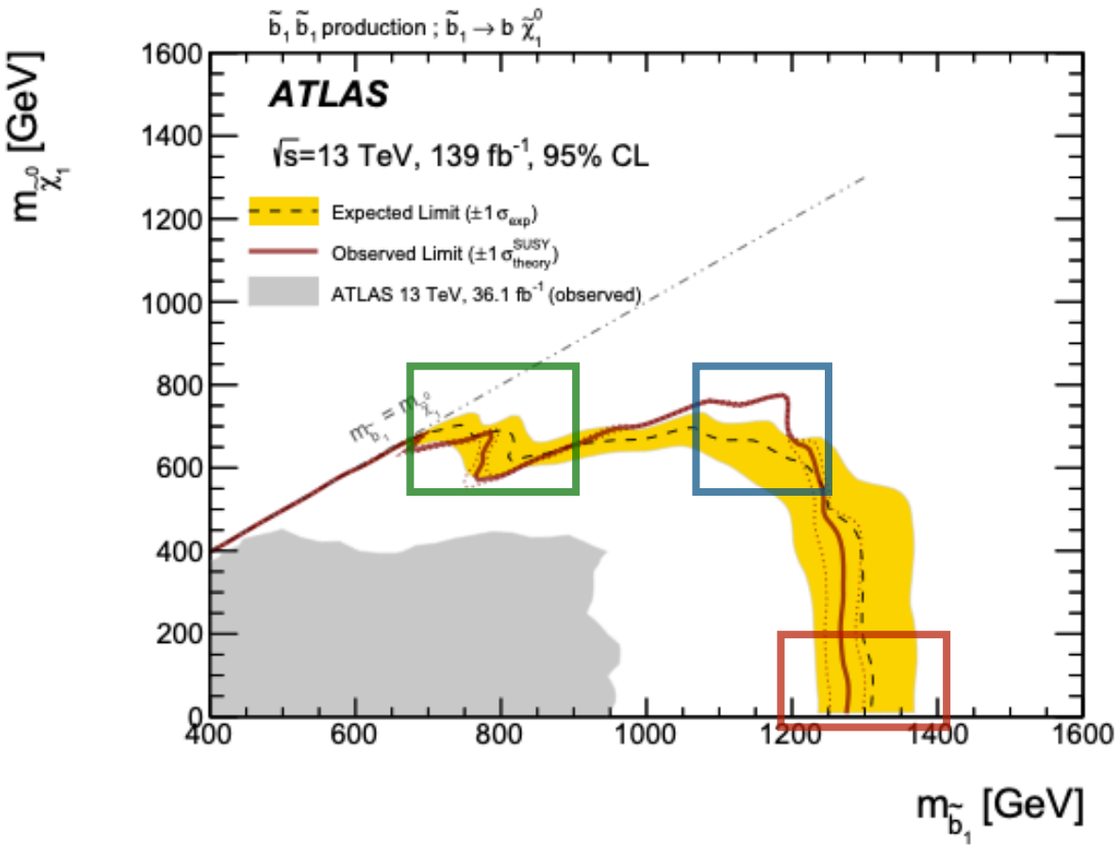




b jets + MET Cont.

arXiv:2101.12527v1

- Backgrounds considered in this analysis are: Z + jets production; W+ jets production; ttbar pair production; single-top-quark production; ttbar production in association with electroweak or Higgs bosons (ttbar + X); and diboson production (WW, $Z\,Z$, ZW, ZH and WH).
- Bottom squark masses up to 1270 GeV are excluded for massless LSP, dedicated low-p_T SV tagger (soft b-tagger) allows to exclude sbottom masses up to 660 GeV for mass differences of 10 GeV between sbottom and neturalino

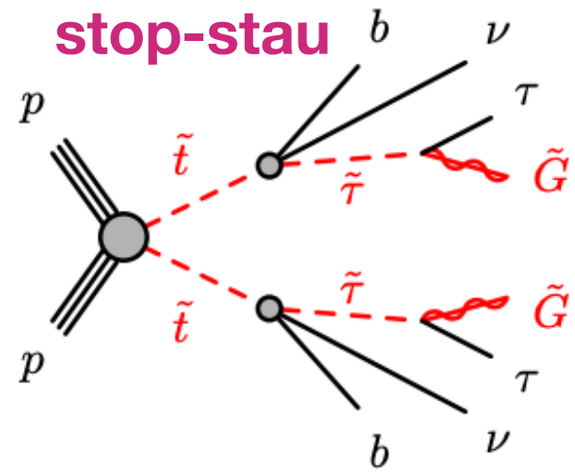


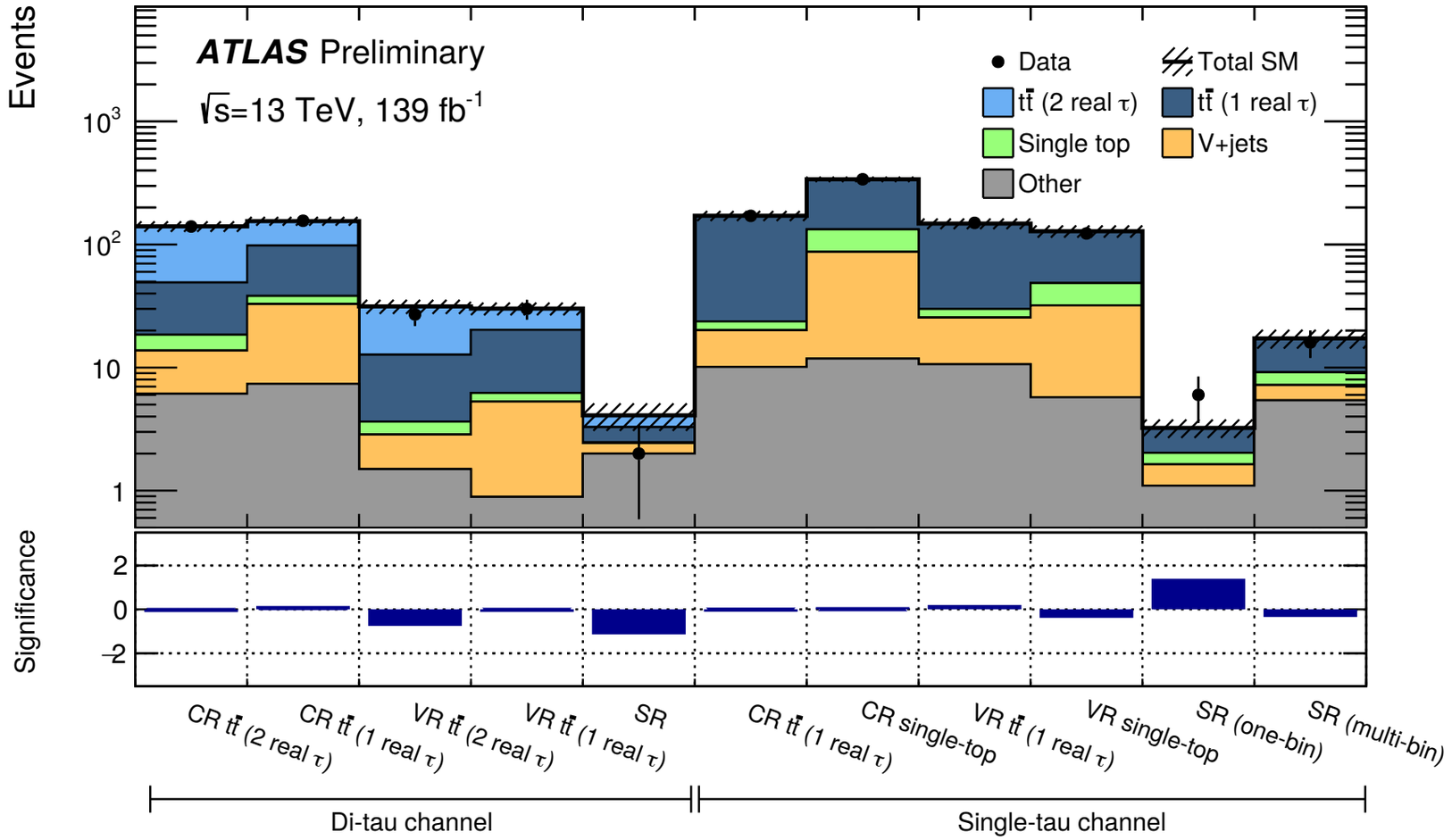
SRC SRB SRA

Final states with tau leptons, b-jets(1)

ATLAS-CONF-2021-008

- stop-stau:
  - supersymmetric partner states of the third-generation SM particles a three-body decay proceeding through an off-shell chargino $\tilde{t}_1 \rightarrow b\tilde{\tau}_1\nu\tau$ followed by $\tilde{\tau}_1 \rightarrow \tau$ hadronically decaying tau leptons
- There are two search regions: single tau(NEW), ditau



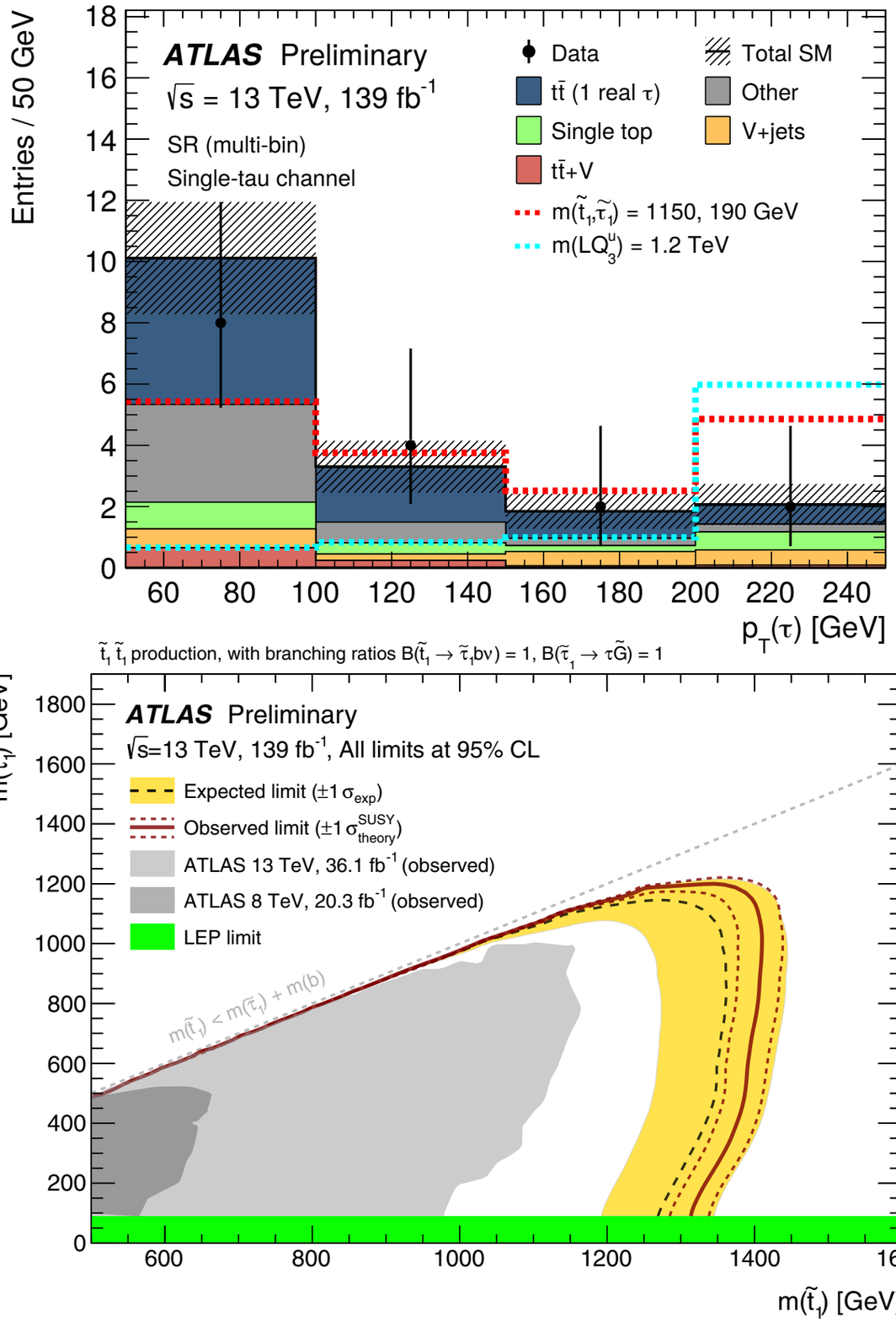


- Also interpreted in leptoquarks(LQ)
  - Single tau SR to target light staus and the LQ model with BR to taus of 0.5

Final states with tau leptons, b-jets(2)

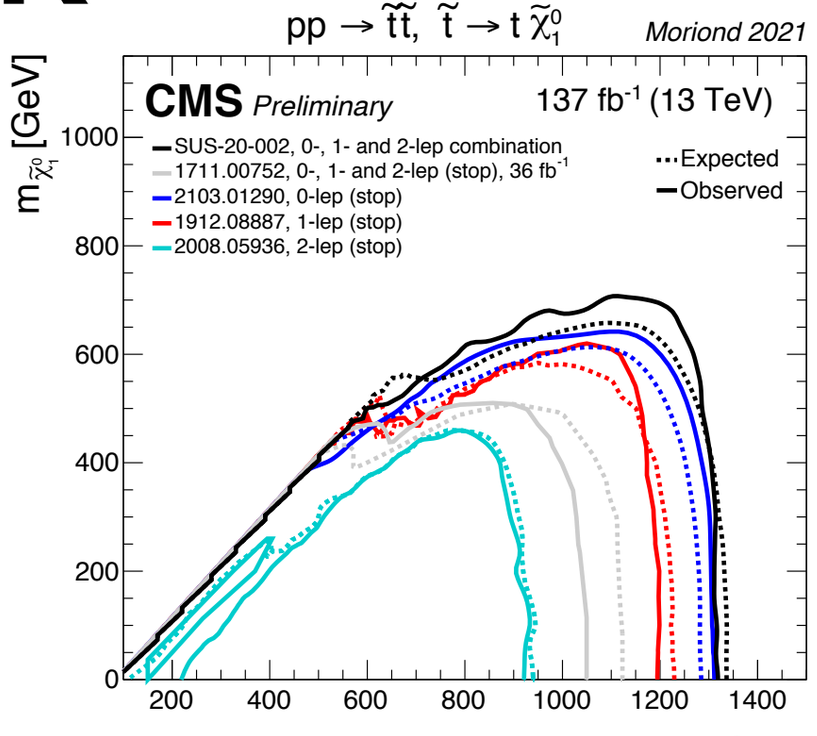
ATLAS-CONF-2021-008

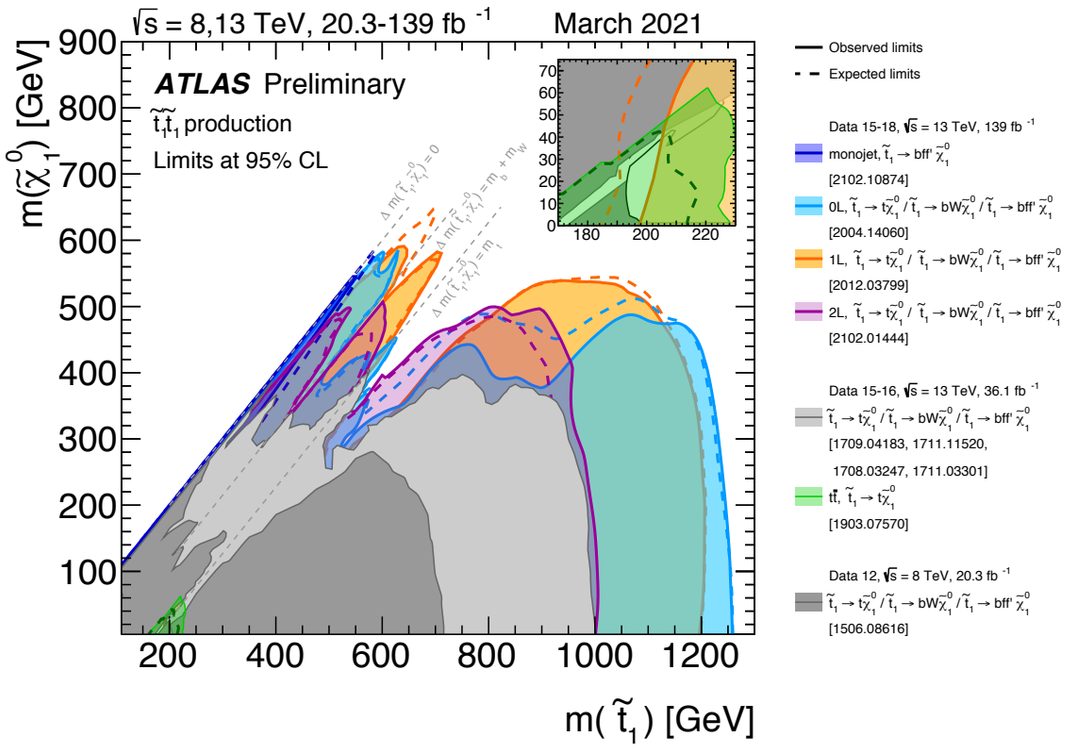
- Ditau is used to understand the region where the mass between the stau and stop are low to modest
- The single-tau channel employs two signal regions and is optimized for large stop stau differences (tau p_T)
- Background dominated by ttbar, and single top and is extracted in a simultaneous maximum-likelihood fit
- 1.4 TeV are excluded for top squarks decaying via tau sleptons into nearly massless gravitinos across a wide range of tau-slepton masses.



Summary & Outlook

- We have already performed many strong SUSY searches for the full run 2
- We incorporated a multitude of machine learning algorithms to help improve our object tagging, understanding of backgrounds or even signal extraction
- Collaborations are moving to focus on more dedicated searches to explore holes in uncovered parameter space.
- Results to come later this year
  - Stay tuned!!





Back Up

Search for displaced leptons

b jets + MET

arXiv:2101.12527v1

- A deviation of the observed limit from the expected one is observed at sbottom , LSP of about (1150 GeV, 700 GeV) (due to a small deficit of events relative to the background prediction in three SRA where the signal contributions from models in this region of the parameter space is found to be significant