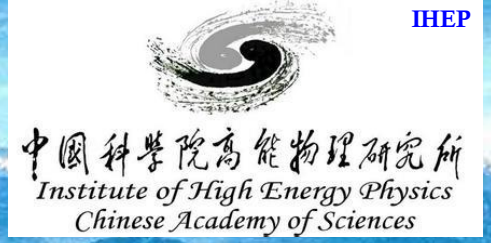
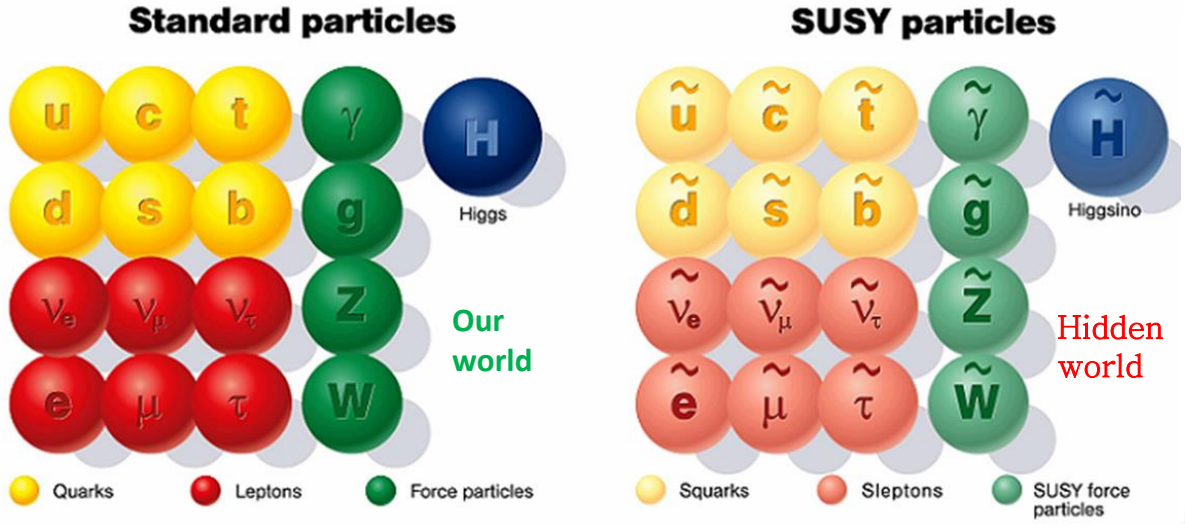


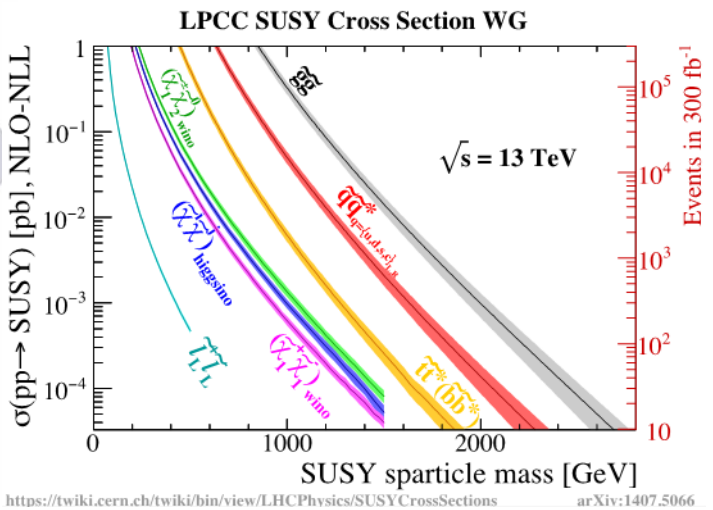
Results of search for SUSY signals with tau leptons in the final states at the LHC

Feng LYU
(IHEP, CAS)

14th Workshop on TeV Physics
Nanjing，20/04/2019

SUSY Introduction





Our world (SM) only 5% of universe, still many many unknown, such as:

Dark matter & dark energy; matter/anti-matter asymmetry; neutrino masses /mixing ; hierarchy problem; gravity in gauge theory and its unification ……

SUSY could be a powerful key to unification and cosmology, the discovery of its "hidden world" can bring a great revolution of modern physics in 21st century

SUSY reveals an unique symmetry relates matter and forces particles (fermions and bosons) together, can deeply solve above current puzzles

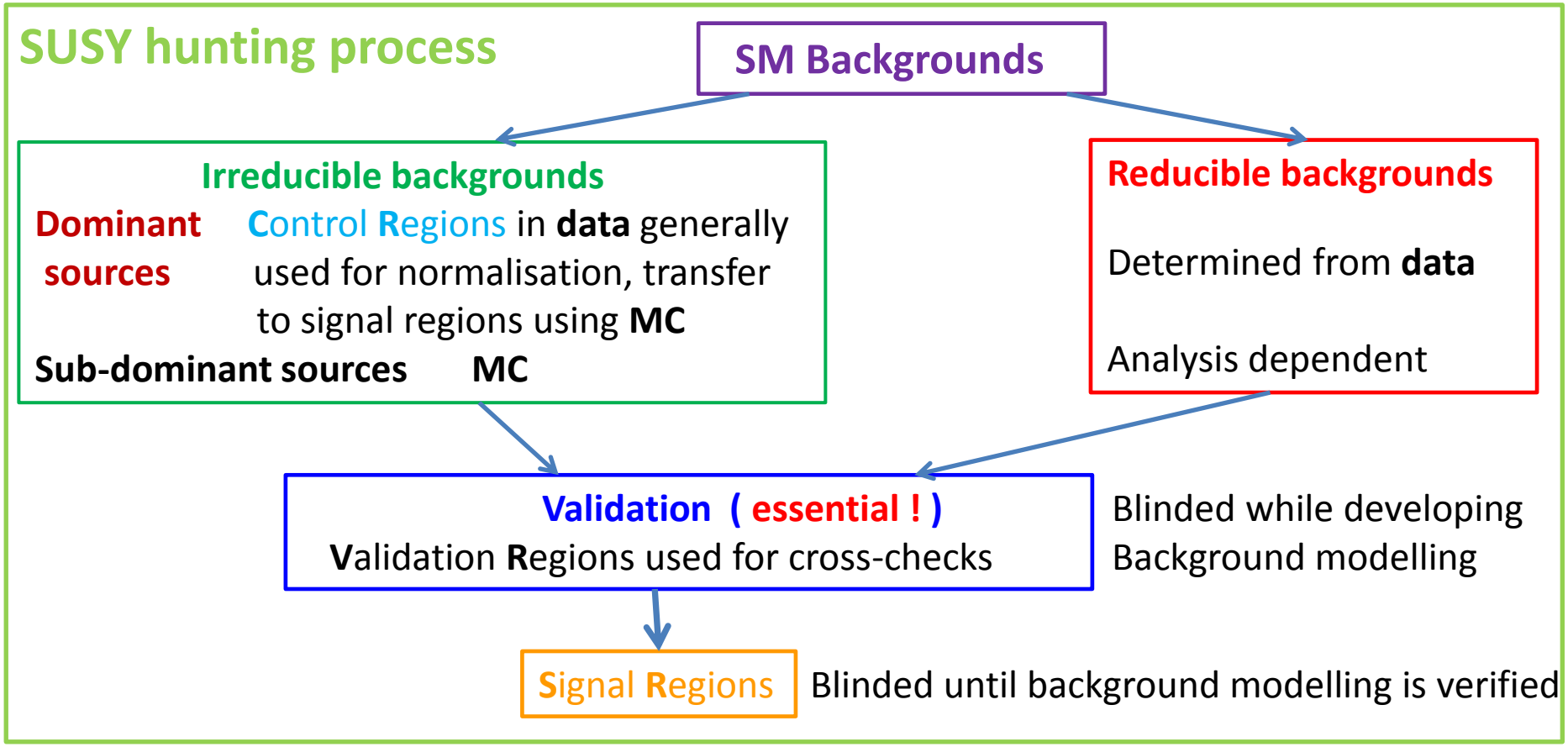
Motivations

Final states with taus are of particular interest in SUSY searches:

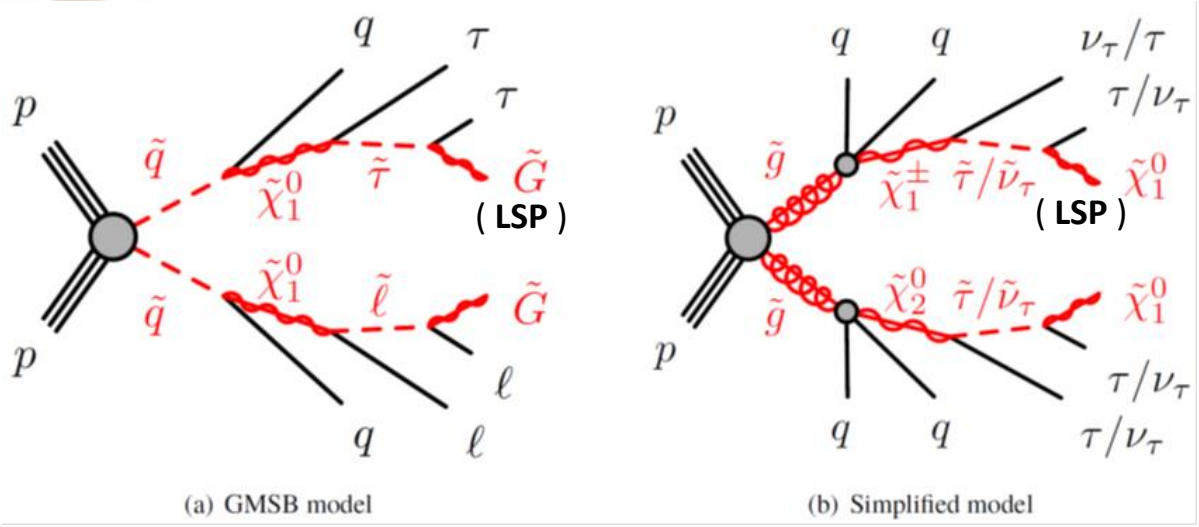
- $\tilde{\tau}$ is a superpartner of the third generation fermion τ and a colorless scalar, intends to be light in SUSY scenarios, lead to τ-riched final states
- Light $\tilde{\tau}$ could expect a Dark Matter relic density consistent with cosmological observations
- Independent studies of τs channels are necessary to investigate the coupling structure of the new physics may be discovered in leptonic final states, especially with regard to lepton universality

SUSY searches at LHC

SM processes are backgrounds for SUSY search, need to carefully understand and accurately model the SM backgrounds, finally to determine SUSY signals' exist by observing significant events excess above SM level in LHC real data



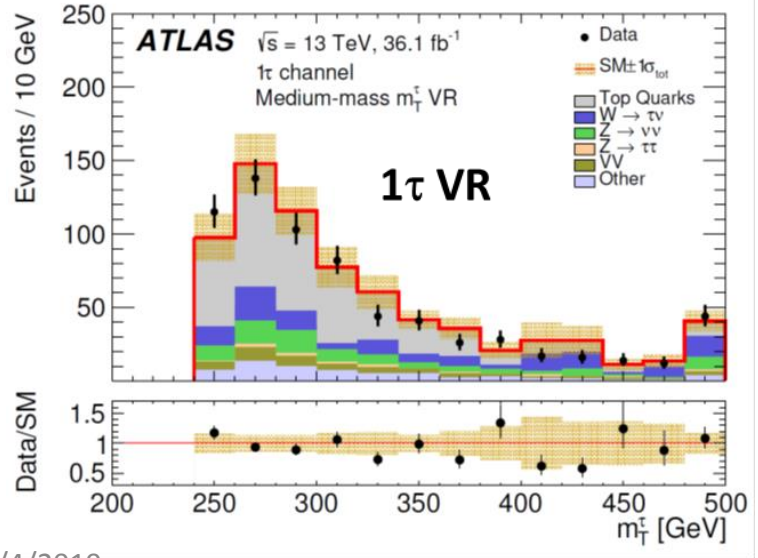
Strong production: 1th/2th squark/gluino pair to taus

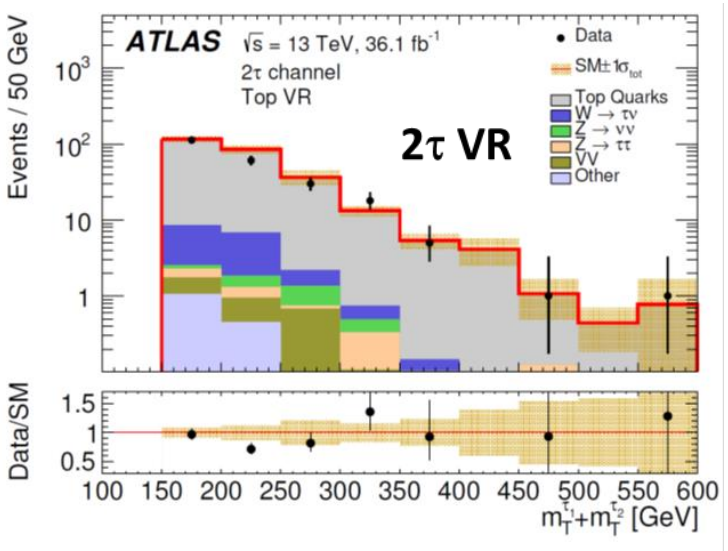


GMSB:
Gauge-**M**ediated **S**upersymmetry **B**reaking scenario, LSP = **G**ravitino

Signal: =1τ_h or ≥2τ_h

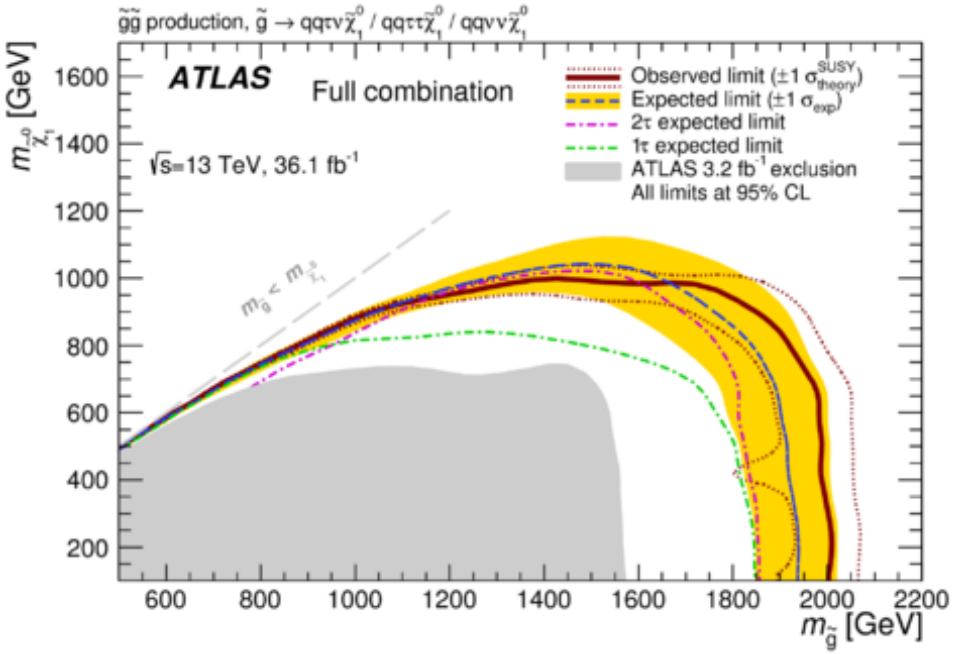
All CR/VR/SR DATA/MC Comparison: well consistent !

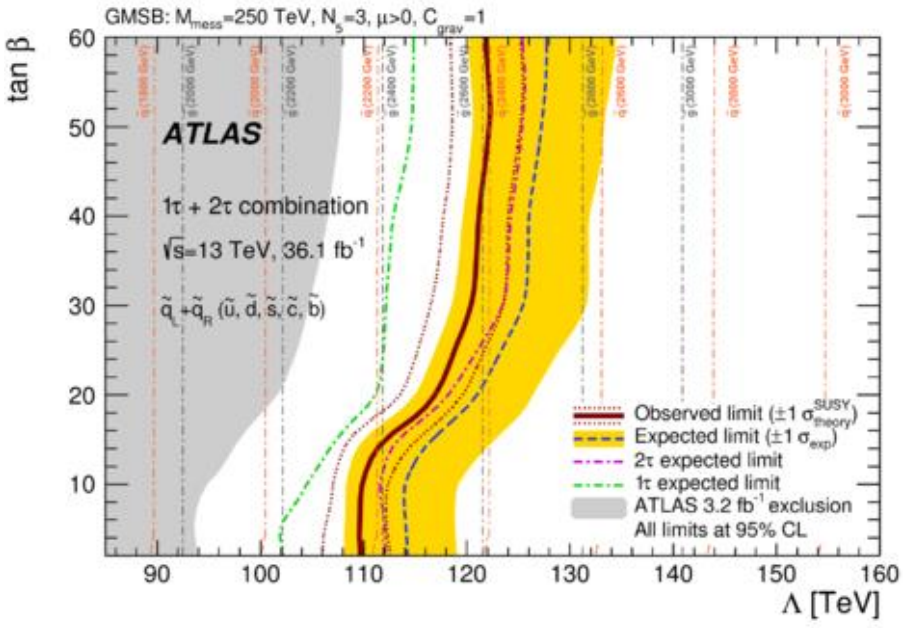




Strong production: 1th/2th squark/gluino pair to taus Result

arXiv:1808.06358





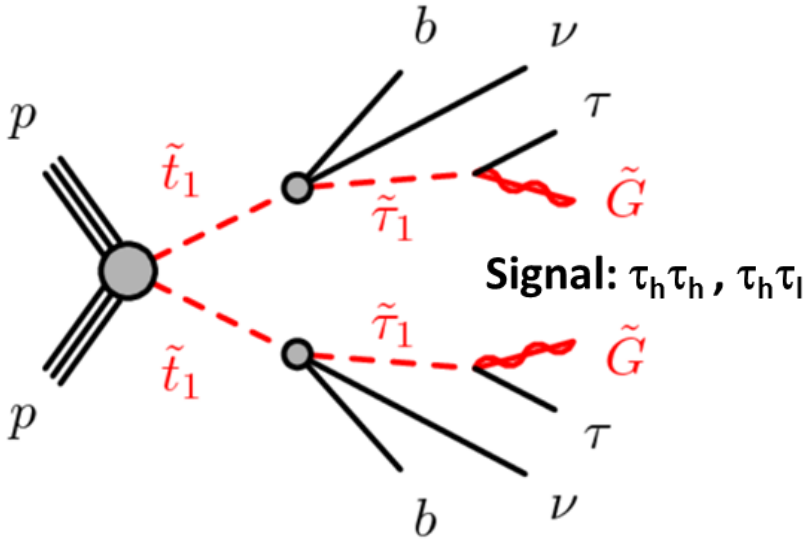
No significant deviation from SM is observed, 95% CL lower limit is set

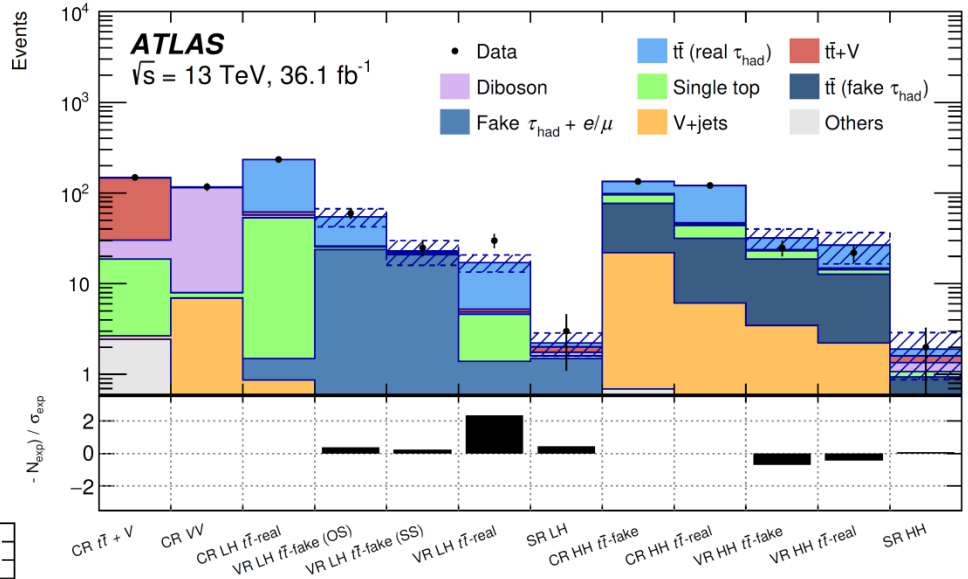
Exclusion: Gluino masses up to 2000 GeV for low values of the mass of the **L**ightest **S**upersymmetric **P**article (LSP); while LSP masses up to 1000 GeV for gluino masses around 1400 GeV in the simplified model

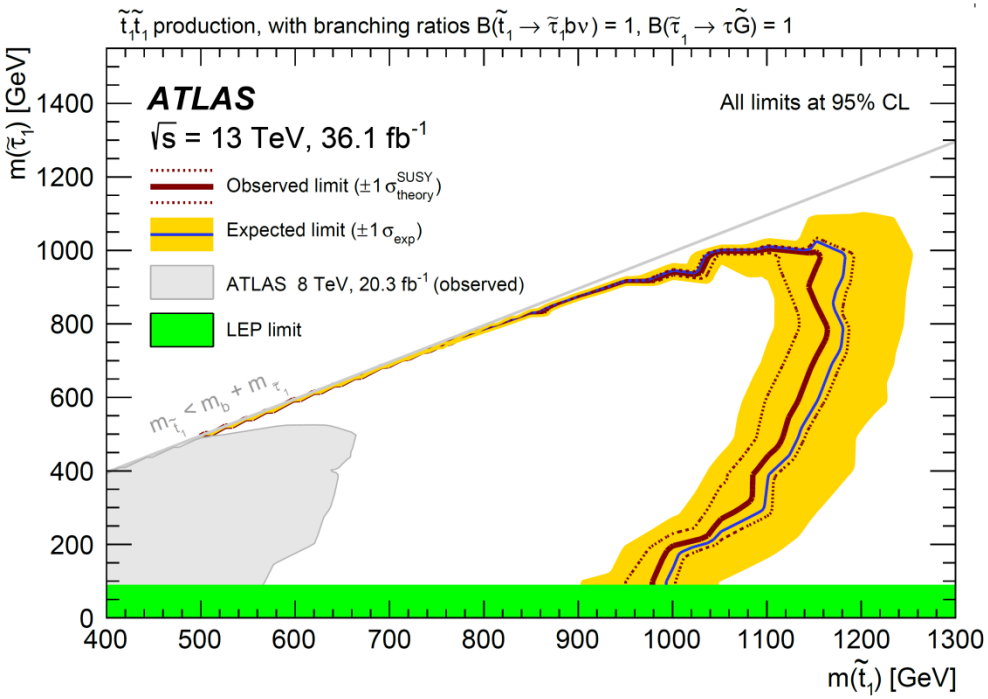
Exclusion: Values of the supersymmetry-breaking scale $\Lambda < 110$ TeV for all values of tanβ in the range $2 \leq \tan\beta \leq 60$, and $\Lambda < 120$ TeV for $\tan\beta > 30$ in the GMSB model

Strong production: stop pair to taus

PRD 98 (2018) 032008







No significant deviation from SM is observed, 95% CL lower limit is set

Exclusion: $m(\tilde{t}_1)$ up to 1.16 TeV

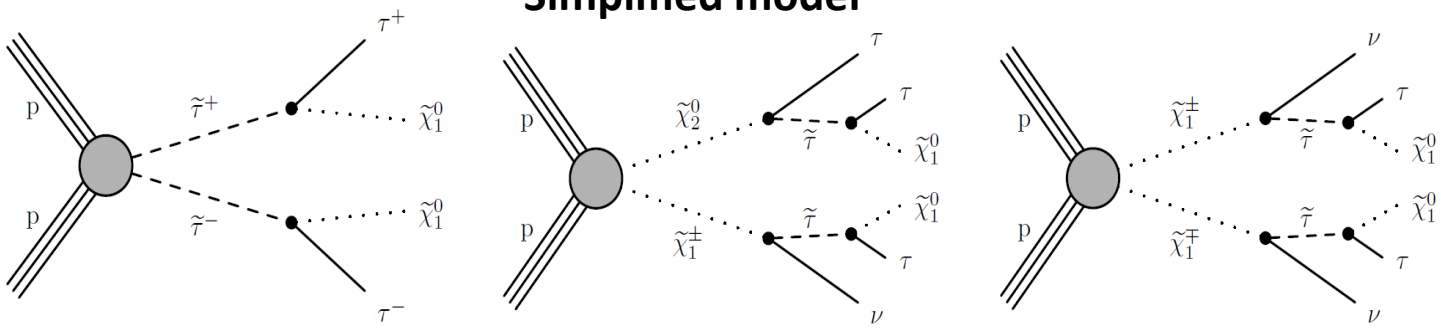
$m(\tilde{\tau}_1)$ up to 1.00 TeV

In **simplified model** of supersymmetry with a nearly massless gravitino

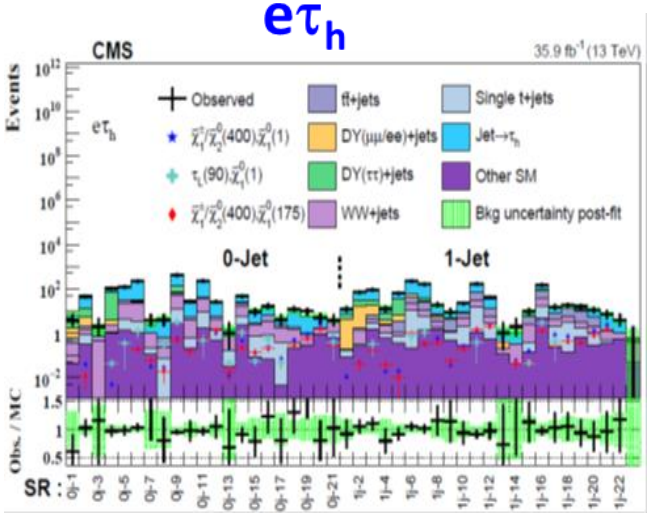
Electroweak: Direct/indirect staus (up to 2τ)

Signal: 2τ

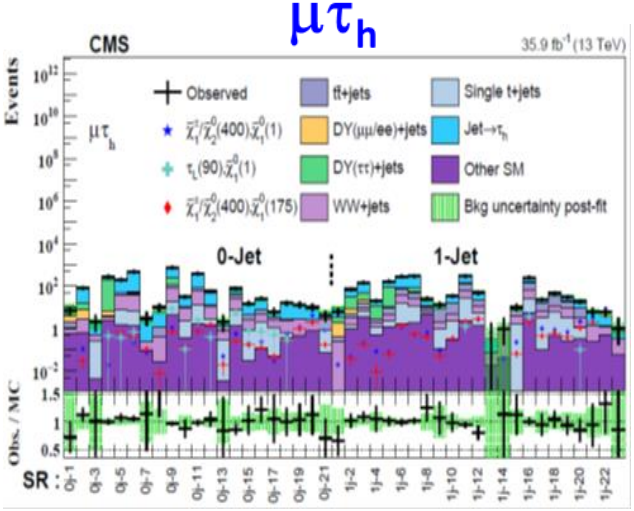
Simplified model



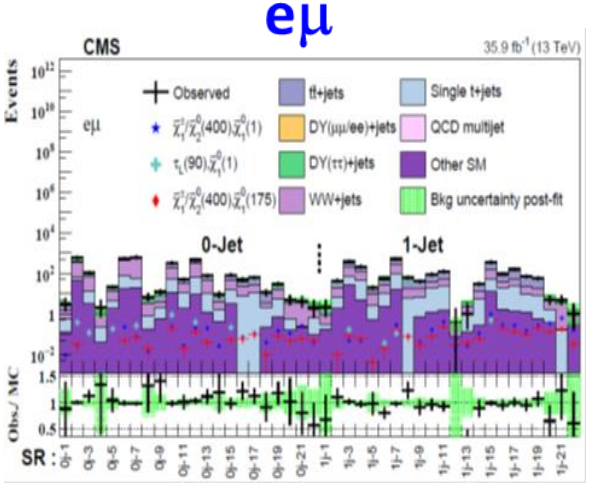
$e\tau_h$



$\mu\tau_h$



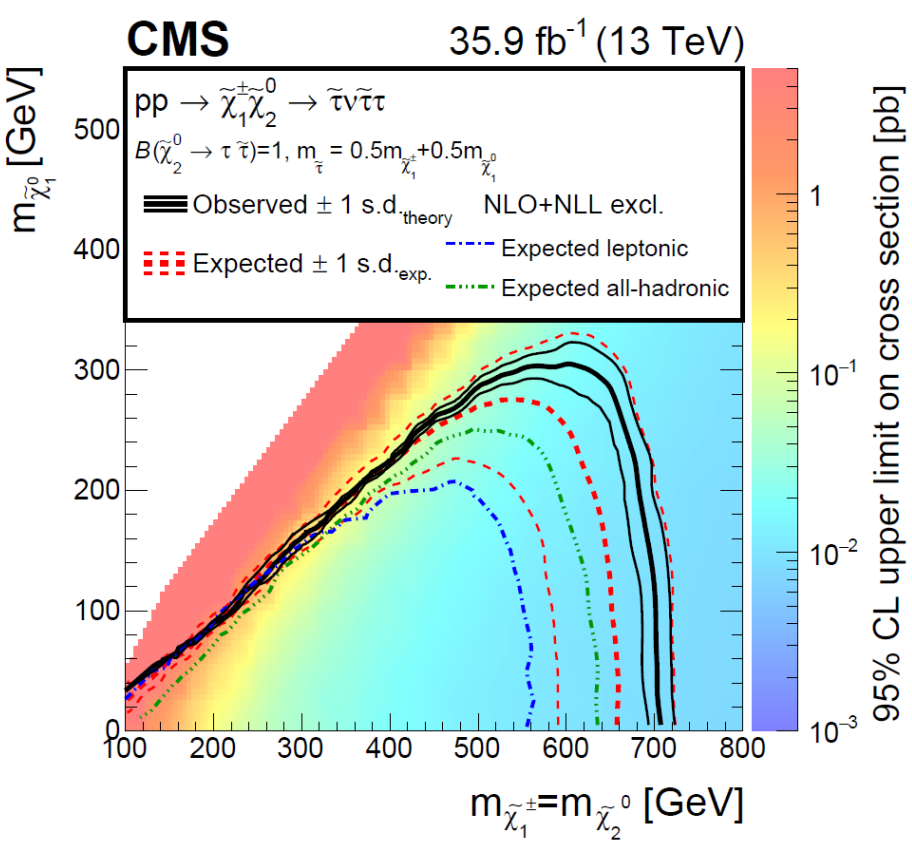
$e\mu$

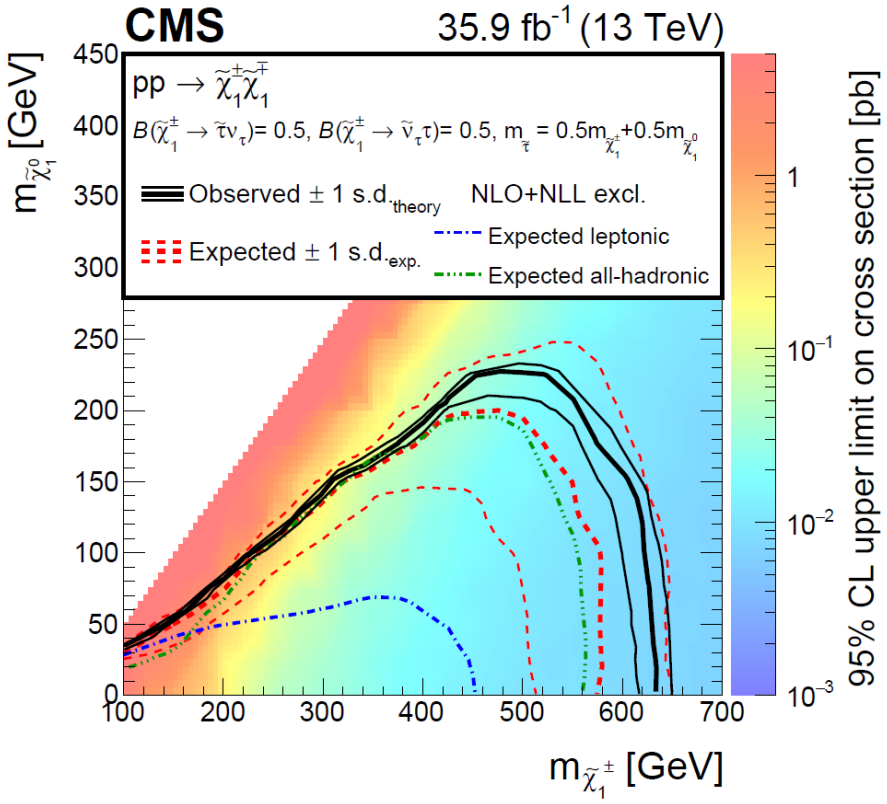


No significant events excess above SM level in all Signal Regions used for the final signal extraction

Direct/indirect staus Result

arXiv:1807.02048 (to JHEP)

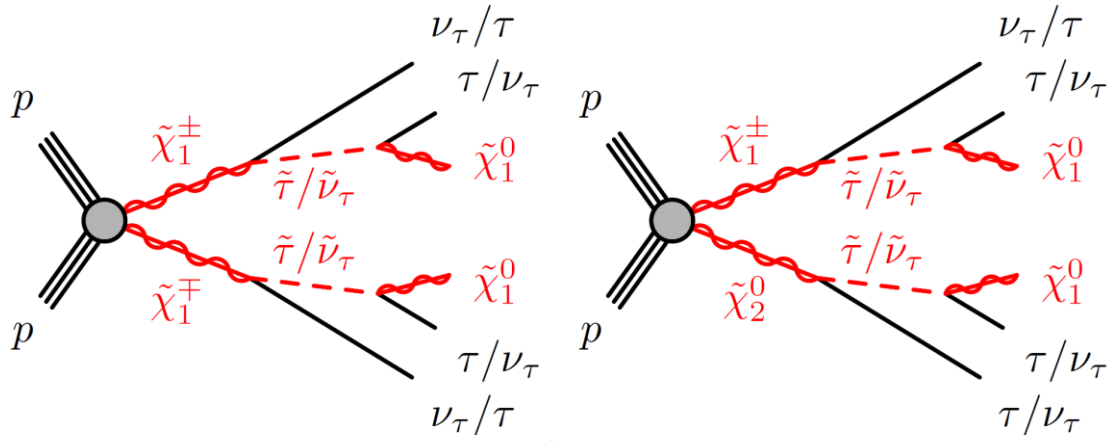




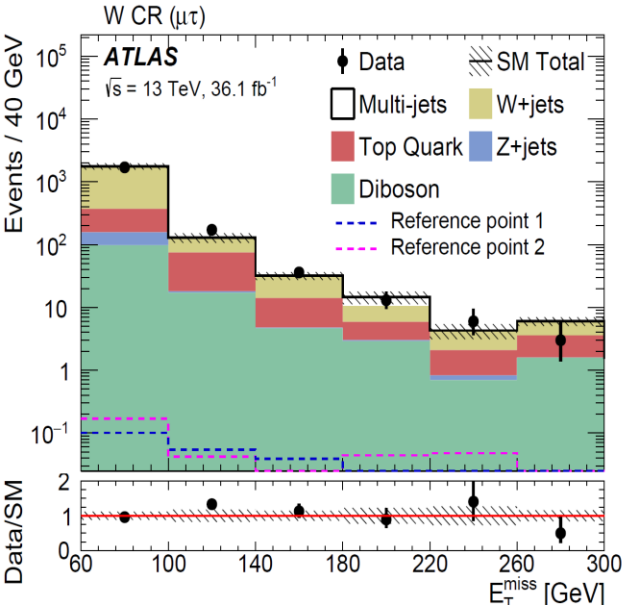
Exclusion limits in the simplified model are set of indirect stau production to taus, range up to 710 and 630 GeV

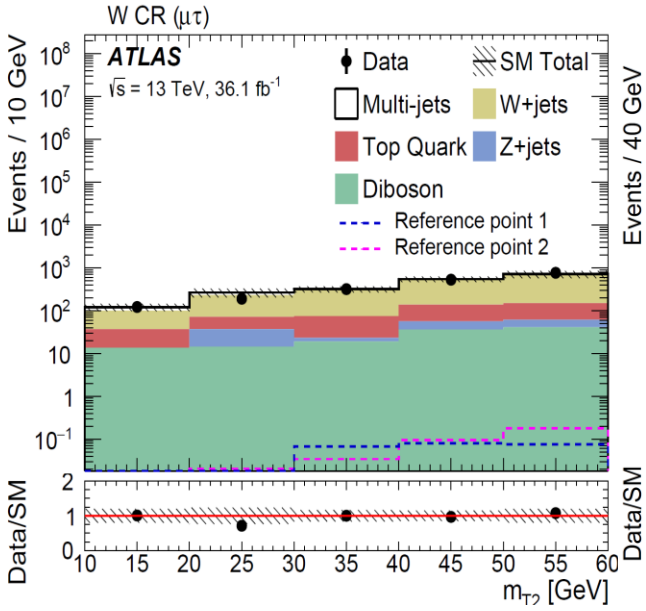
Direct staus gives a purely left-handed 90 GeV $\tilde{\tau}$ decaying to a ~0 GeV neutralino, correspond to 1.26 times expected production cross section in simplified model

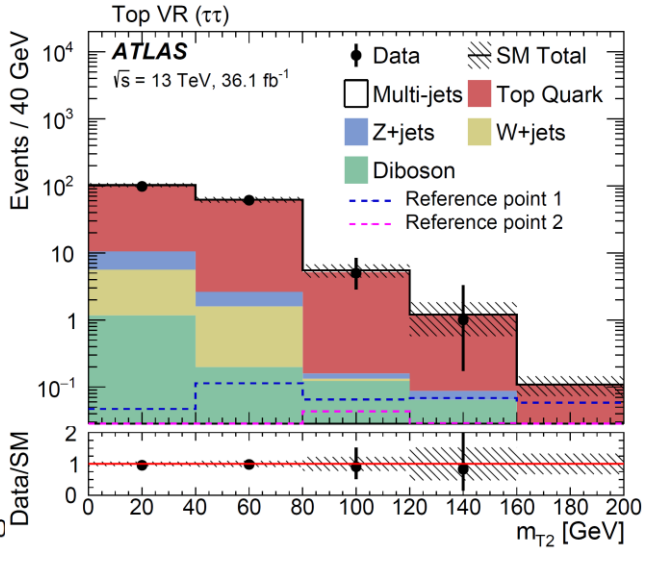
Indirect stau to taus



Signal: $\geq 2\tau_h$







All Contral/Validation Regions DATA/MC Comparison are Consistent !

Indirect stau to taus Result

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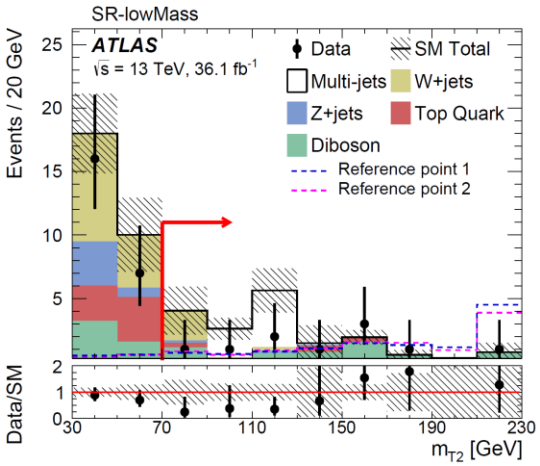
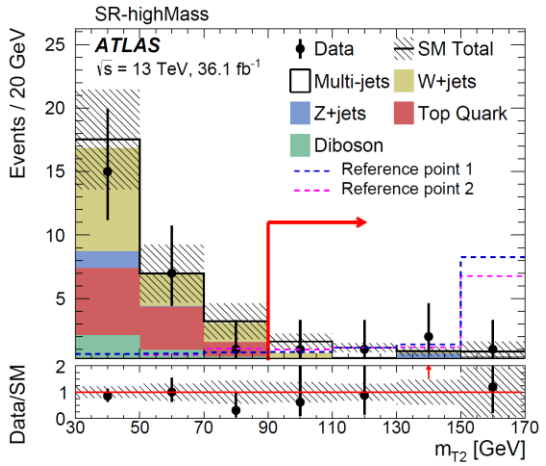
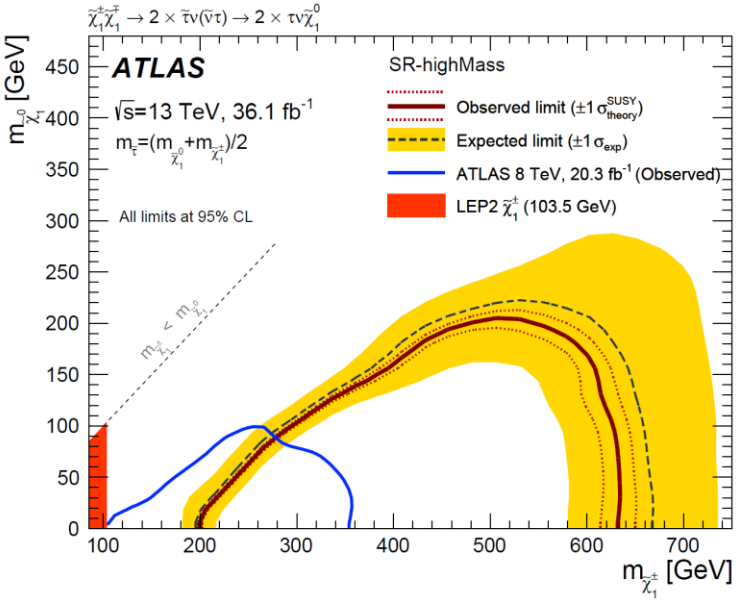
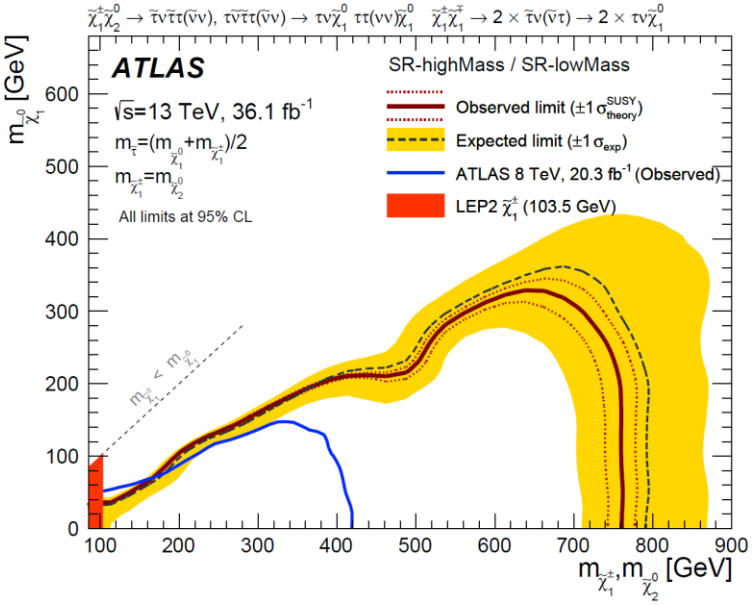








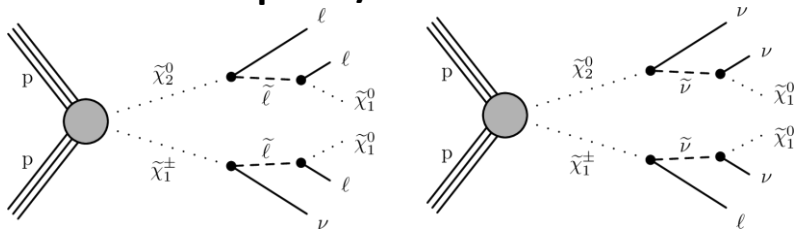
No significant deviation from SM is observed, 95% CL lower limit is set

Chargino mass up to 630GeV , direct production of $\tilde{x}_1^+\tilde{x}_1^-$ for a massless $\tilde{x}_1^0$

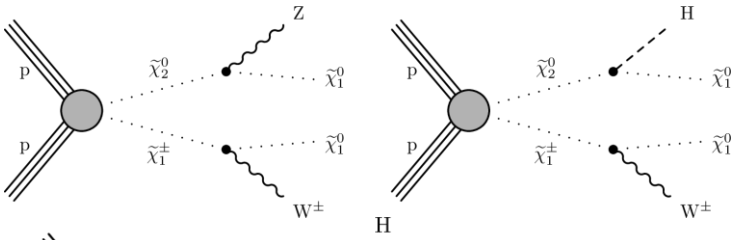
Common $\tilde{x}_1^\pm$ and $\tilde{x}_2^0$ masses up to 760 GeV , $\tilde{x}_1^+\tilde{x}_2^0$ and $\tilde{x}_1^+\tilde{x}_1^-$ assuming a massless $\tilde{x}_1^0$

Gauginos to 3/4 L (up to 2τ_h)

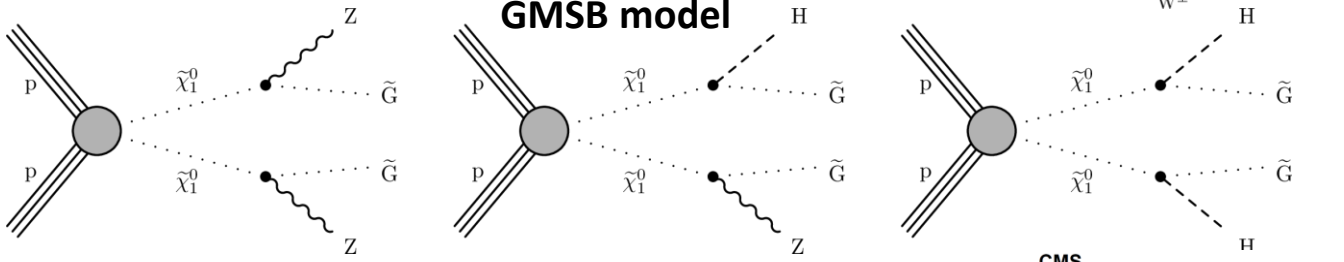
Via sleptons/sneutrinos

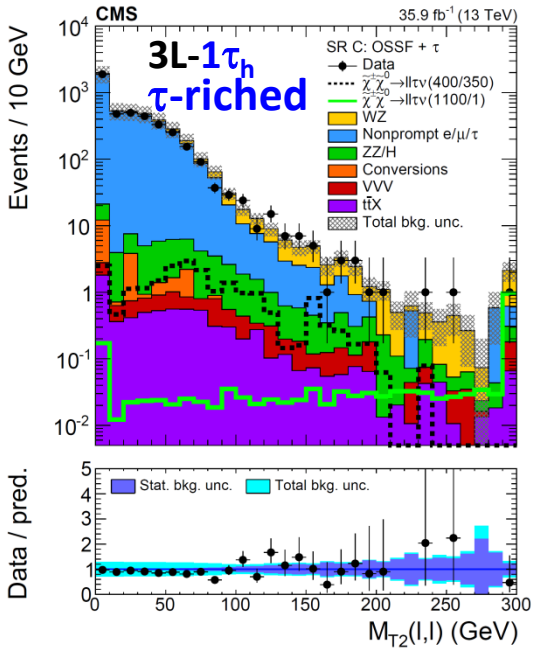


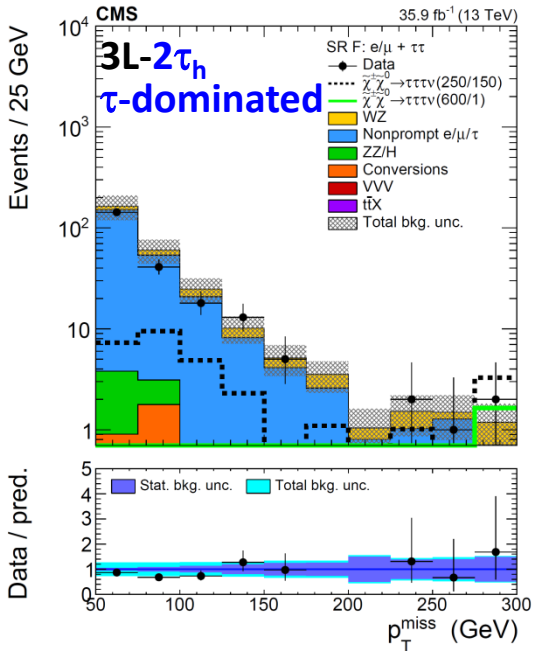
Direct decay to LSP

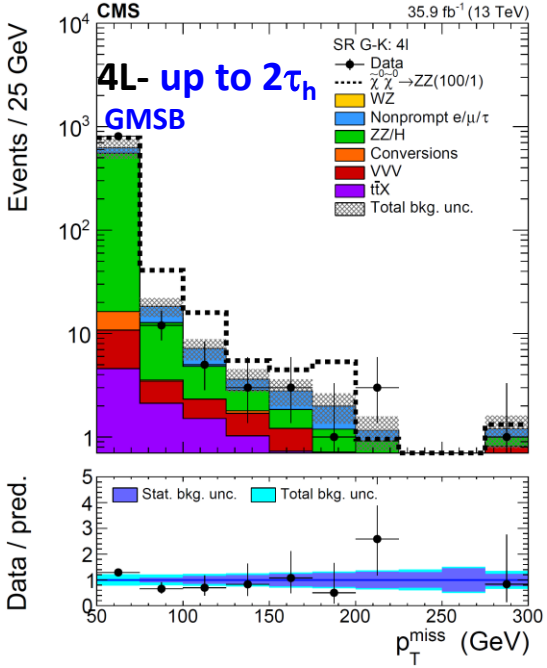


GMSB model



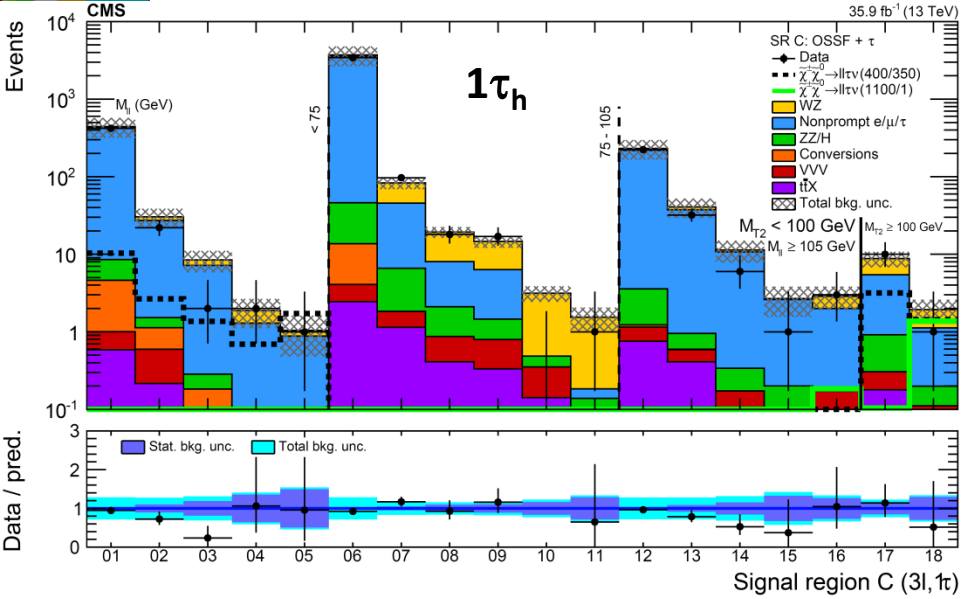


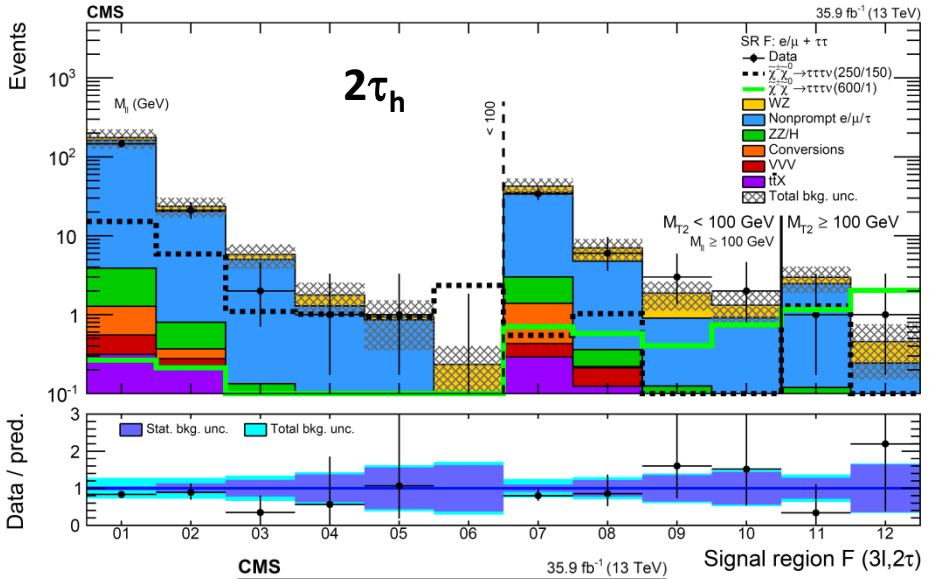


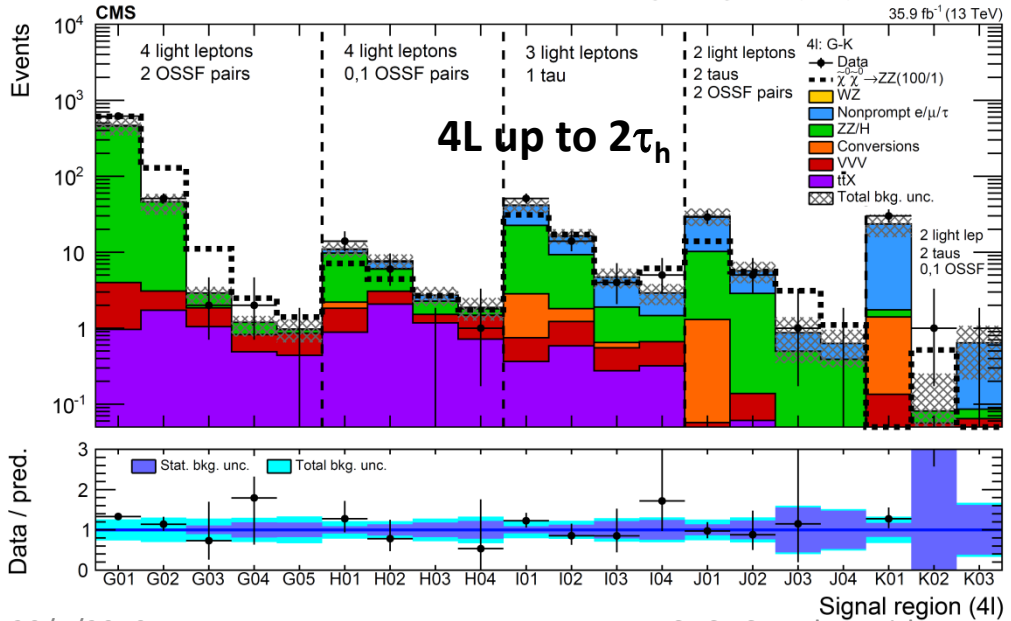


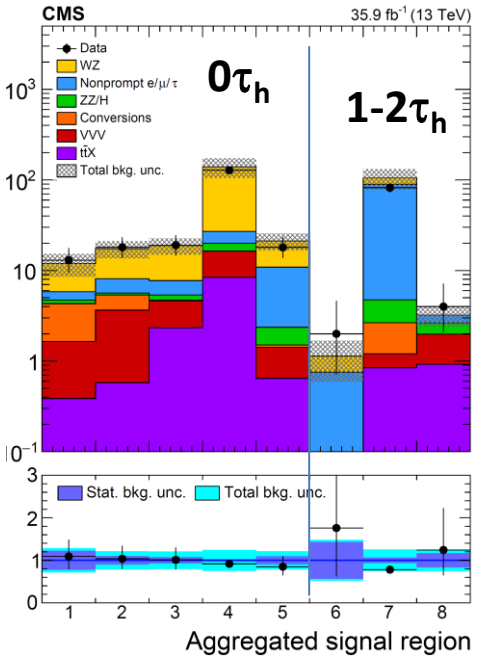
In all Signal Regions: no significant events excess observed above SM level

Gauginos to 3/4 L, up to 2τ_h









In all Signal Regions: no significant events excess observed above SM level

Gauginos to 3/4 L, up to 2τ_h Result

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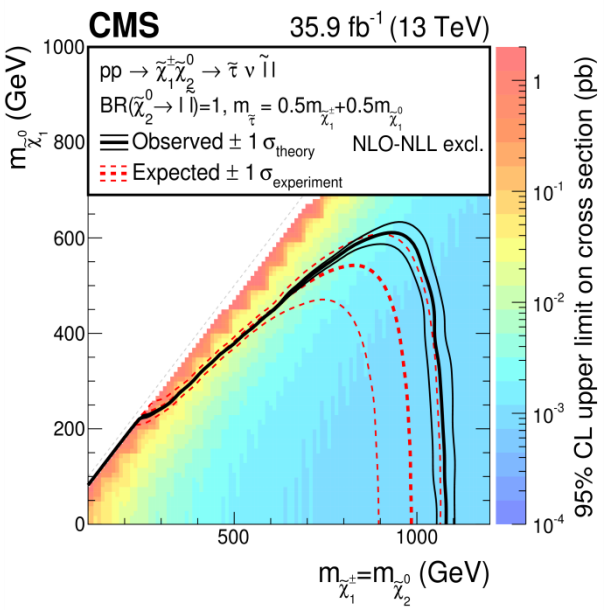
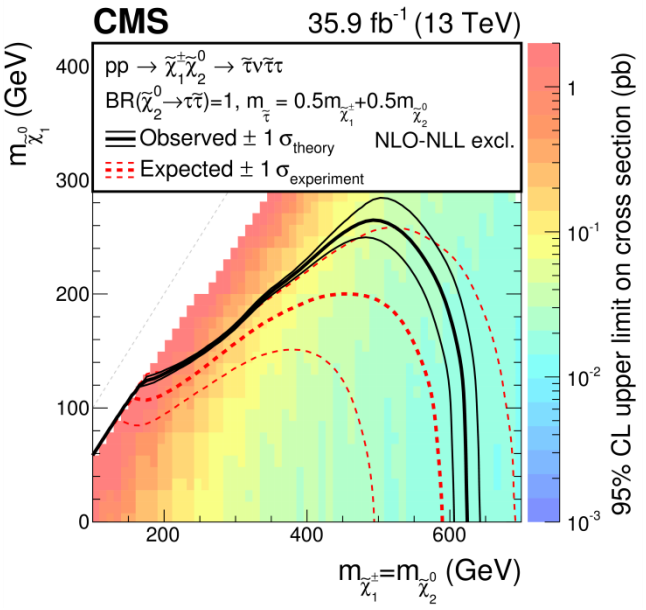
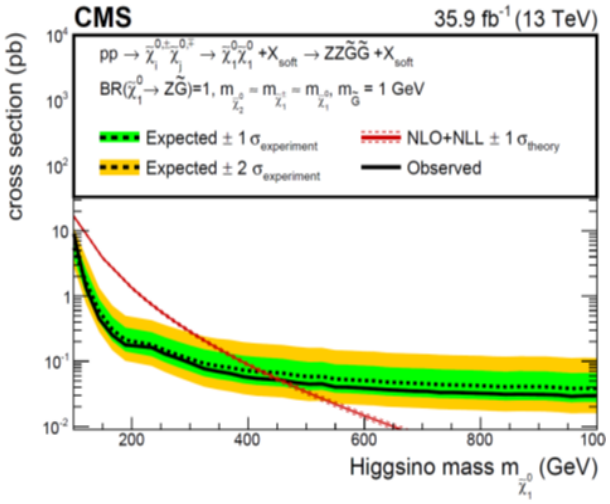


τ-enriched:
exclude charginos and neutralinos up to 1050 GeV



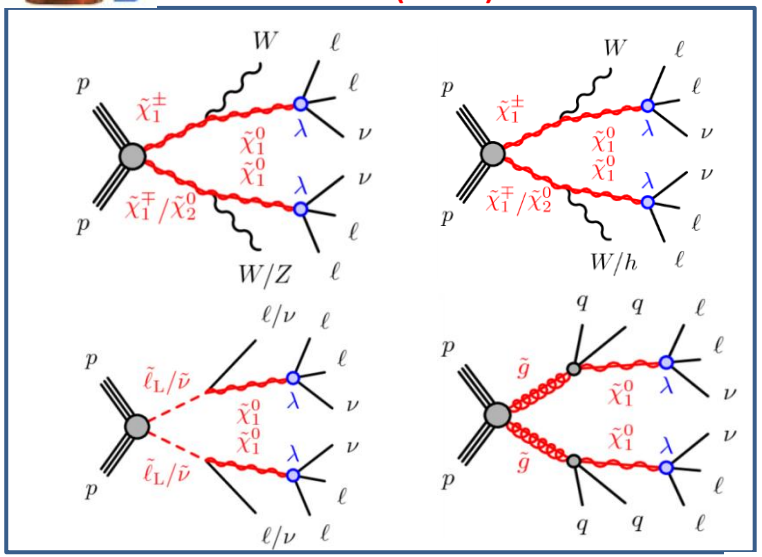
τ-dominated:
exclude chargino and neutralino masses up to 625 GeV



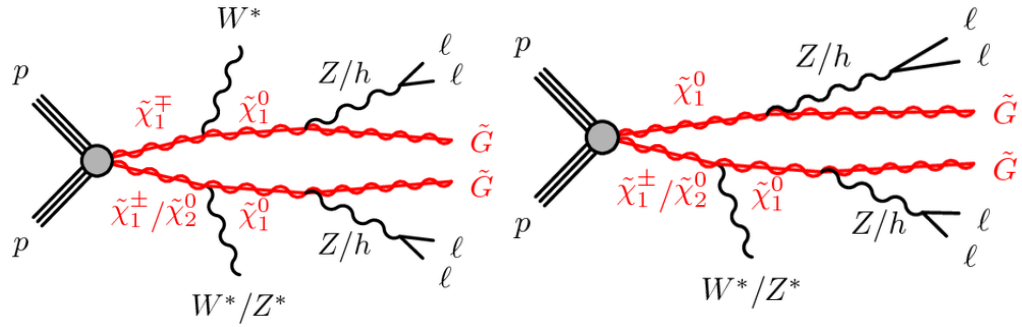
GSMB model :
exclude higgsino masses up to 450 GeV

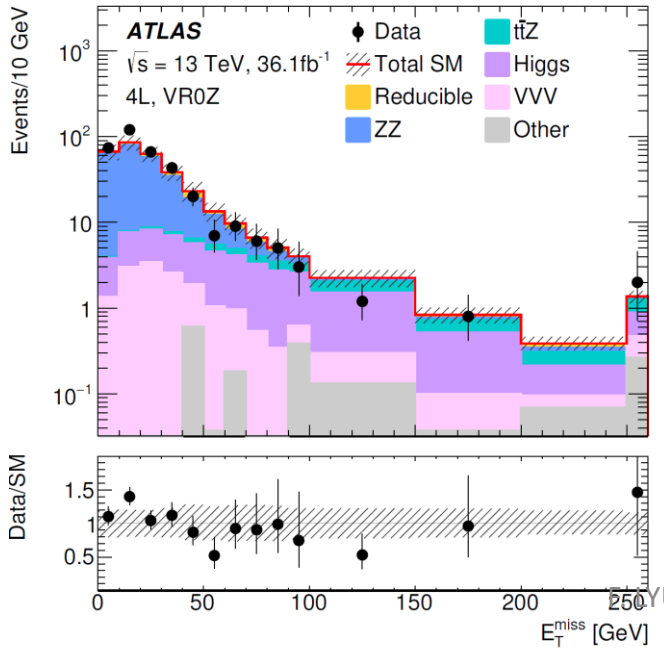
Gauginos RPV & RPC 4L (τ_h up to 2)

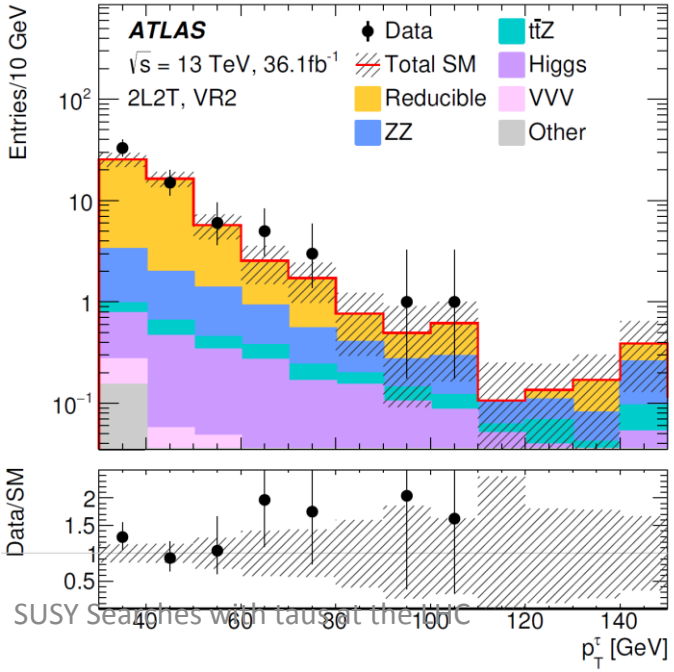
4L+ 2ν (RPV)



4L + 2$\tilde{G}$ (RPC)



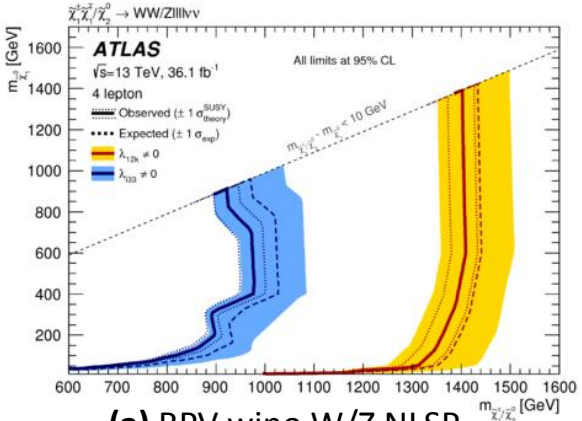




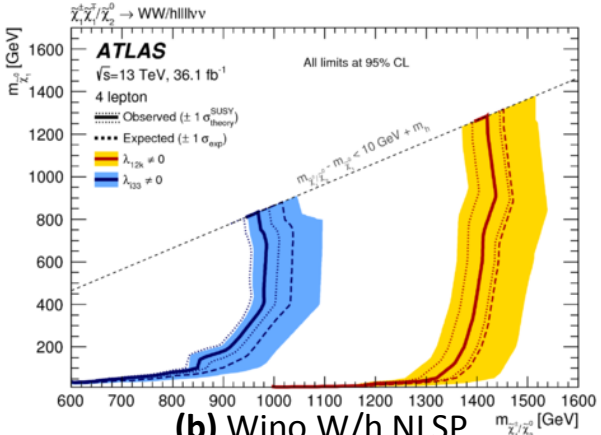
All Validation Regions Data/MC Consistent !

RPV & RPC 4L Result

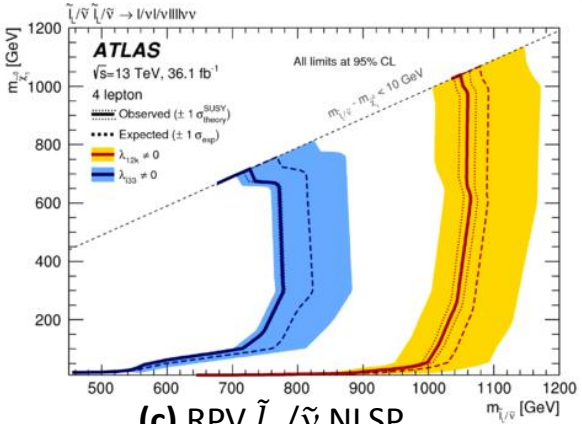
PRD 98 (2018)032009



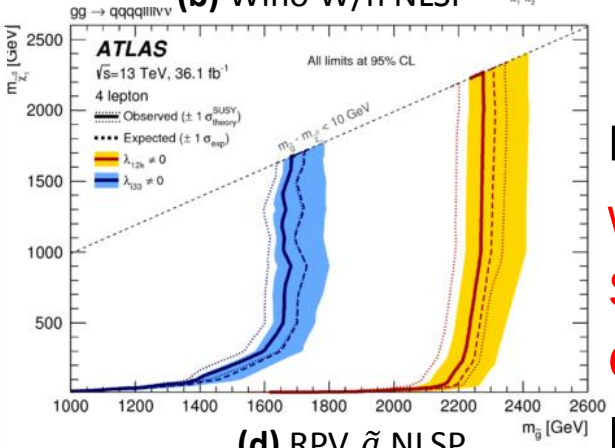
(a) RPV wino W/Z NLSP



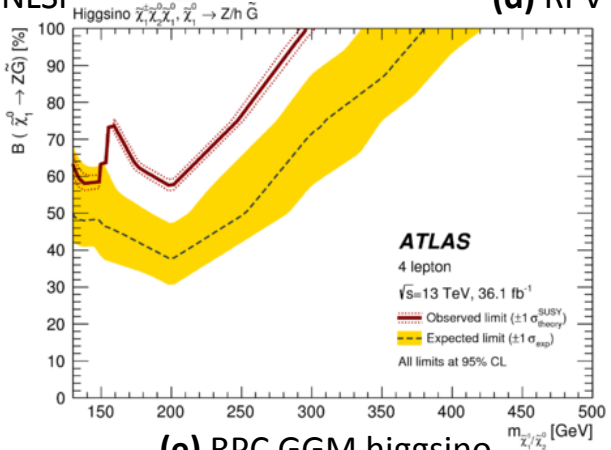
(b) Wino W/h NLSP



(c) RPV $\tilde{l}_L/\tilde{\nu}$ NLSP



(d) RPV $\tilde{g}$ NLSP



(e) RPC GGM higgsino

λ_{12k} (k∈1,2) ≠ 0:

LSP→ee(1/4) + eμ(1/2) + μμ(1/4)

λ_{i33} (i∈1,2) ≠ 0:

LSP→ eτ (1/4) + ττ(1/2) + μτ(1/4)

Masses exclusion:

wino up to1.46 TeV,

Slepton up to 1.06 TeV,

Gluino up to 2.25 TeV

In RPV simplified models with LSP decays to charged leptons

Exclusion: m(Higgsino) up to 295 GeV

In RPC simplified models of **G**eneral **G**auge **M**ediated supersymmetry

Summary

- Six results from ATLAS and CMS with LHC 13TeV ~36 ifb are included
- No significant deviation from SM is observed, 95% CL limits are set
- SUSY masses exclusion limits are set for the various signal scenarios by two kinds of SUSY productions (strong & Electroweak), which remarkably extend the exclusion space of SUSY search

All these results are just based upon 1.2% of LHC planned total luminosity. 140/300/3000 ifb @13/14TeV LHC results will come later ! SUSY still has a lot of space left for search! Keep efforts for SUSY discovery !

Thanks for your attention!