

Searches for supersymmetric particles with prompt decays with the ATLAS detector

FLERA RIZATDINOVA ON BEHALF OF THE ATLAS COLLABORATION

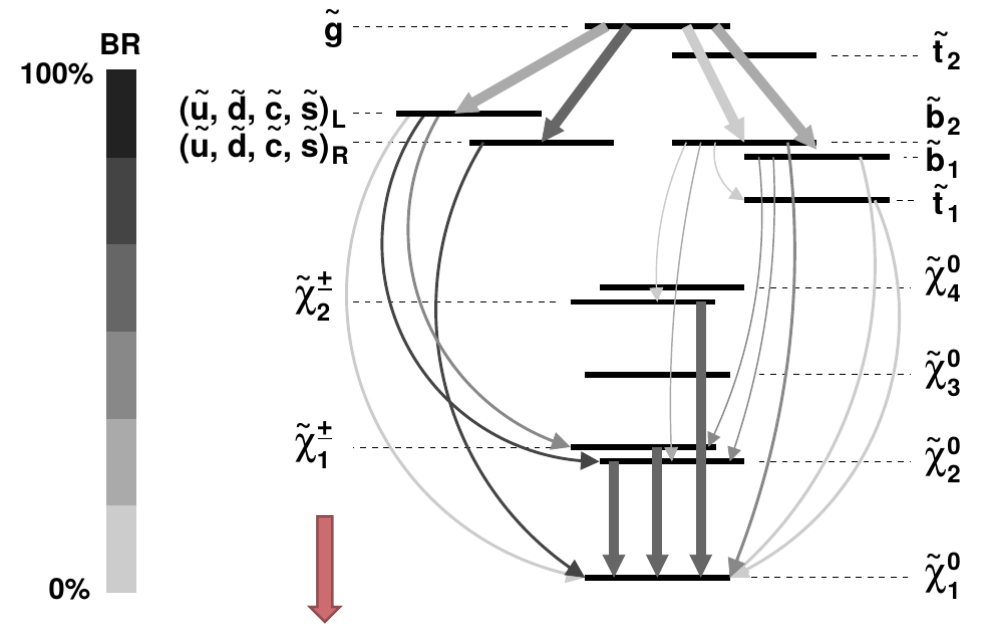
Introduction

- Supersymmetry: a set of theories that predict existence of boson (fermion) partners for existing fermion (boson) particles of the Standard Model
 - Offers a mechanism to stabilize the Higgs boson mass
 - Offers gauge coupling unification
- Several Higgs bosons in the theory in addition to the SM boson, both neutral and charged
 - neutral higgsinos and neutral EW gauginos mix to form neutralinos
 - charged higgsinos and charged EW gauginos mix to form charginos
- If R-parity $R=(-1)^{3(B-L)+2S}$ is conserved, the lightest neutral SUSY particle (LSP) can't decay, making it a dark matter candidate

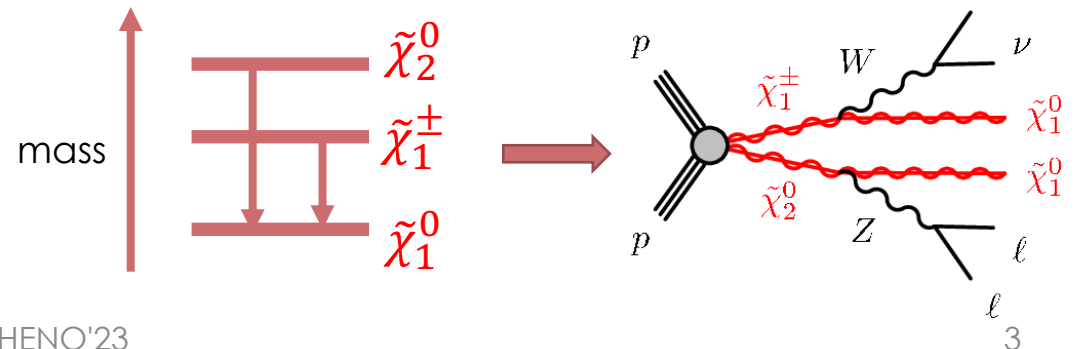
Simplified SUSY models

- Too many model parameters (124 in MSSM) – what to search for?
- The approach: make assumptions to reduce the parameter space (down to 3 - 4 parameters) and focus on specific decay chains
 - Pro: easier to make searches orthogonal, to combine, and to re-interpret
 - Con: almost guaranteed not to be what is realized in nature

Full model



Simplified model



Ways to look for SUSY signals

- Kinematics of events
 - large missing momentum: sensitive to RPC scenarios with LSP in the final state that escape detection
 - large event energy scale
 - characteristic event energy structure (invariant masses, angles)
- Specific event features
 - multiple heavy flavor jets in the final state
 - long-lived objects (for some parameter regions in models such as GMSB or RPV) – not covered in this talk

Latest ATLAS SUSY results

- Reviewed in this presentation:

- charginos/neutralinos in $2l+2j$
- squarks/gluinos in $2l+2j$
- charginos/neutralinos in $SS/3L$
- squarks/gluinos in $SS/3L$
- higgsino pair production in $b\bar{b}\gamma\gamma$
- gluinos in events with multiple b-jets



[arXiv:2204.13072](#)

[ATLAS-CONF-2022-057](#)

[ATLAS-CONF-2023-017](#)

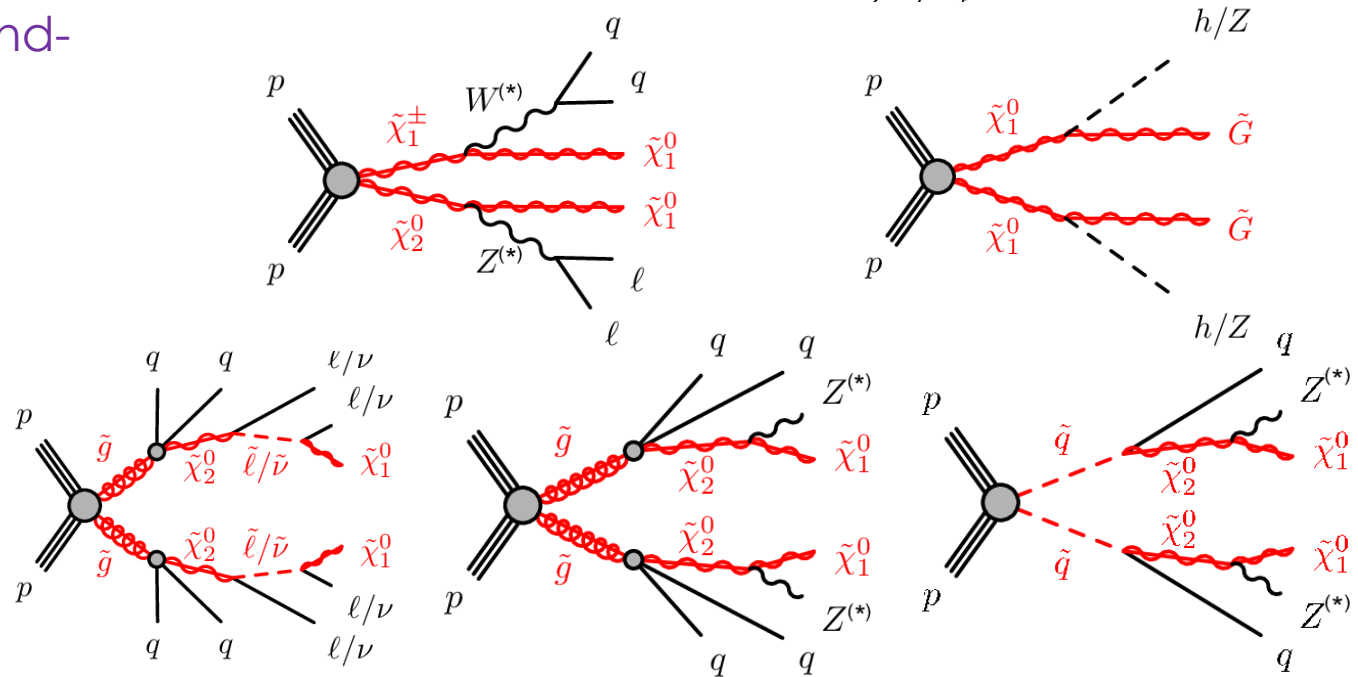
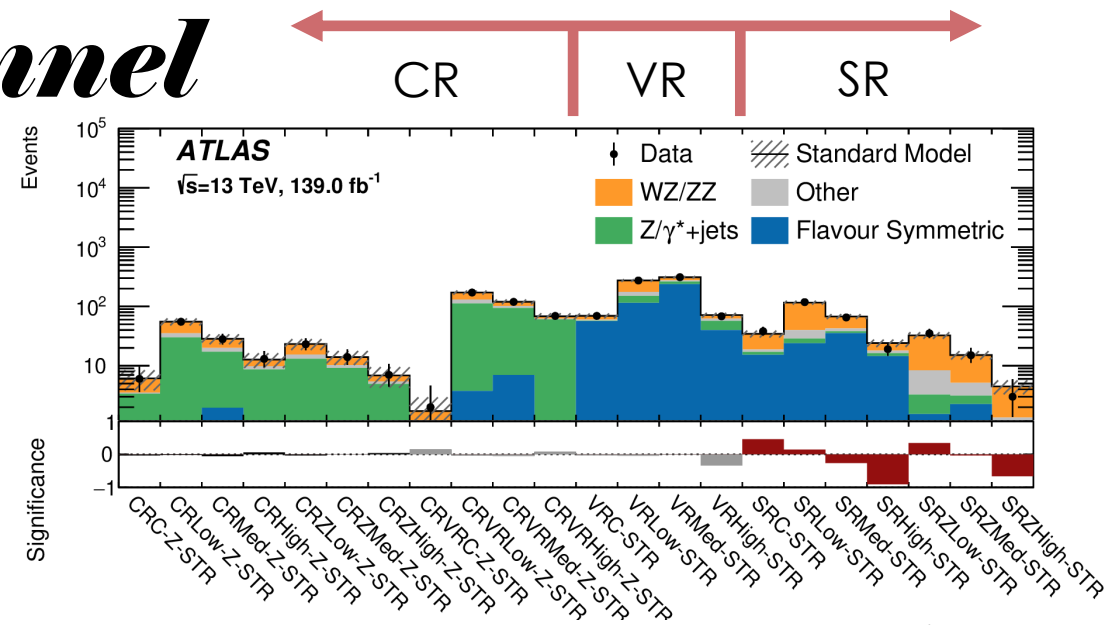
[ATLAS-CONF-2023-009](#)

[arXiv:2211.08028](#)

- Many more results are published or are coming soon!

Searches in $2l+2j$ channel

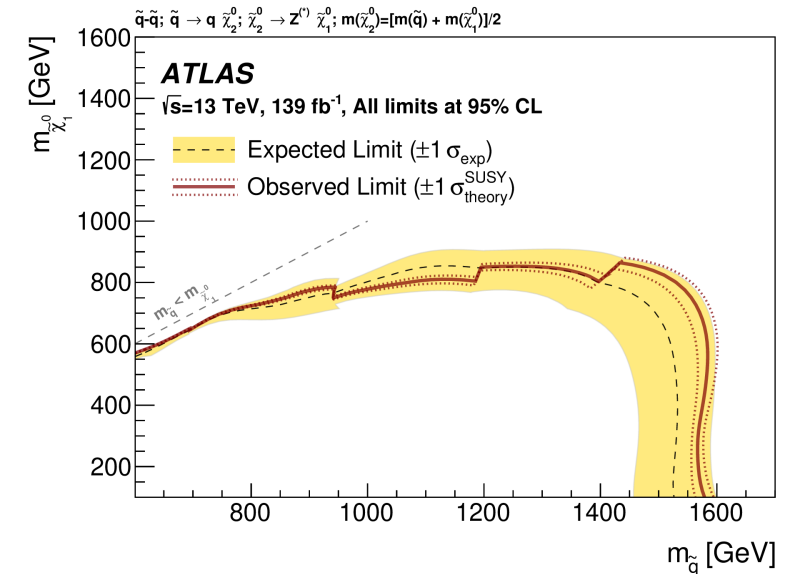
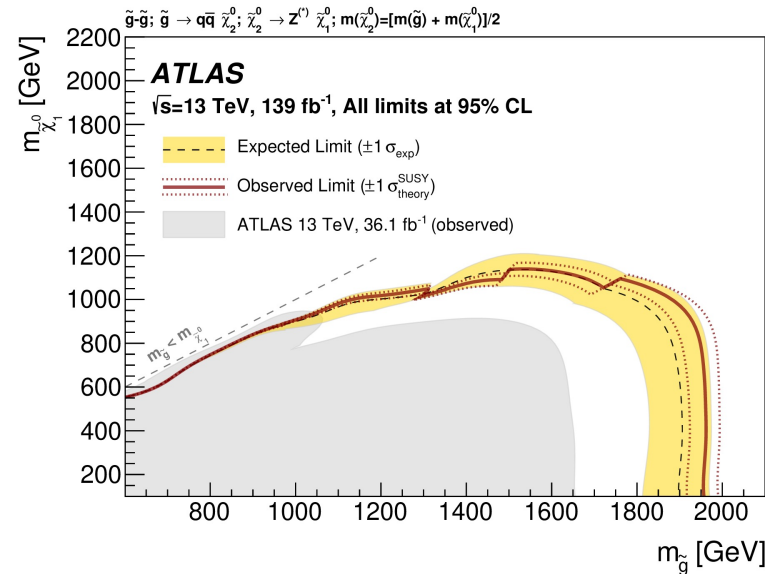
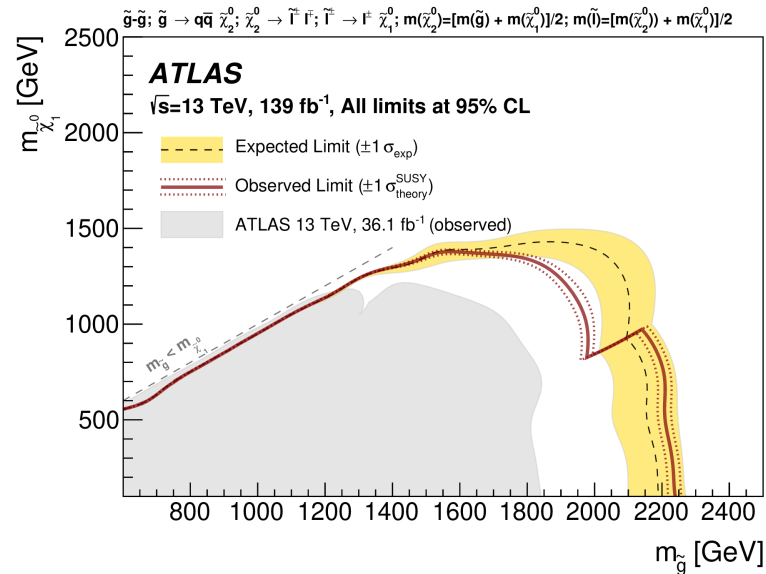
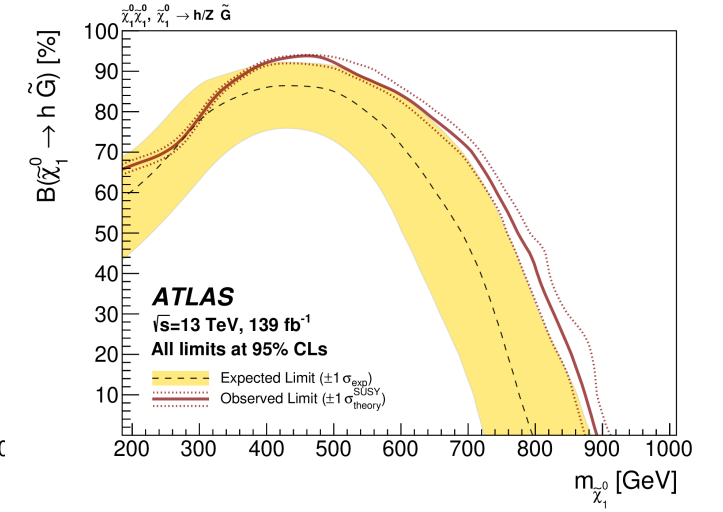
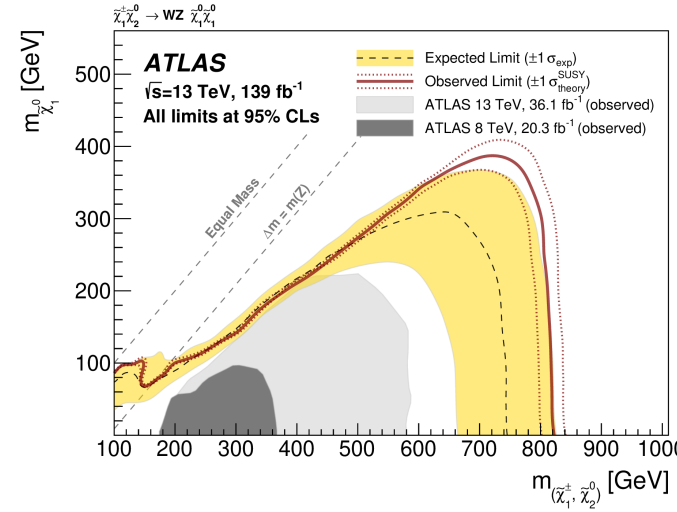
- Searching for EW production of charginos / neutralinos and for strong production of squarks/gluinos in events with two OS leptons, ≥ 2 jets and MET
- EW:
 - recursive-jigsaw reconstruction or cut-and-count
 - Models: C1N2, GMSB
- Strong:
 - Cut-and-count
 - Models: gluino-slepton, gluino- Z^* , squark- Z^*



[arXiv:2204.13072](https://arxiv.org/abs/2204.13072)

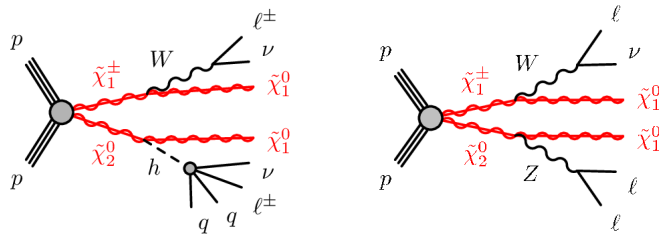
2l+2j: results

- EW: exclude electroweakinos up to 900 GeV
- Strong: Exclude masses up to 1550 GeV for squarks and 2250 GeV for gluinos



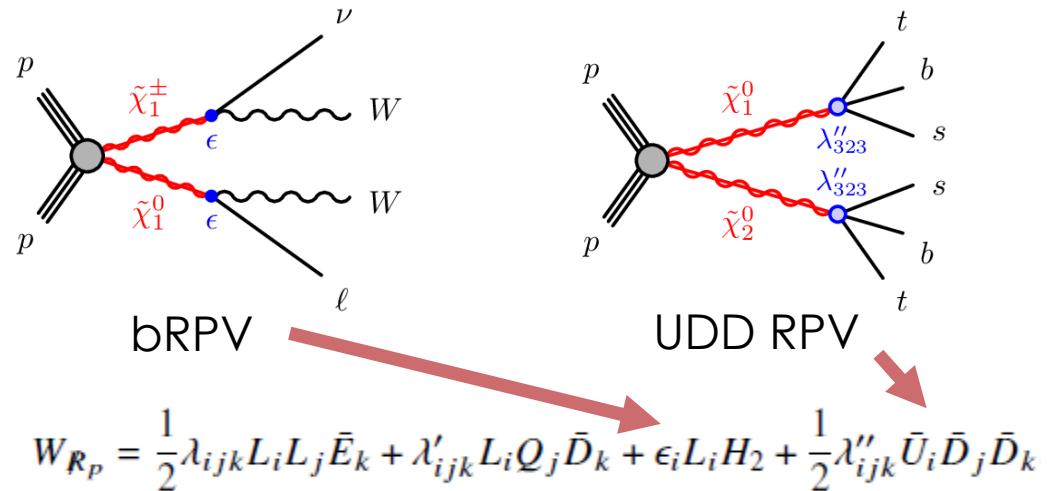
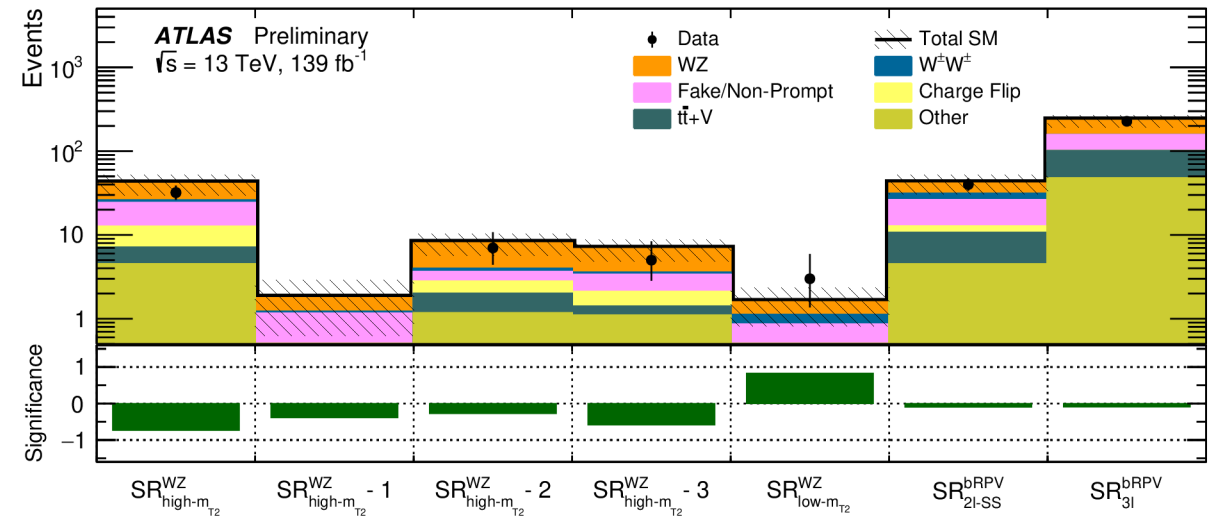
EW SS/3L

- Searching for EW production of charginos / neutralinos in events with at least two same sign leptons or exactly three leptons
- Models: direct chargino/neutralino production with Wh/WZ intermediate states, generic RPV
- Main BG: WZ, WW (irreducible), Vjj, tt, instrumental



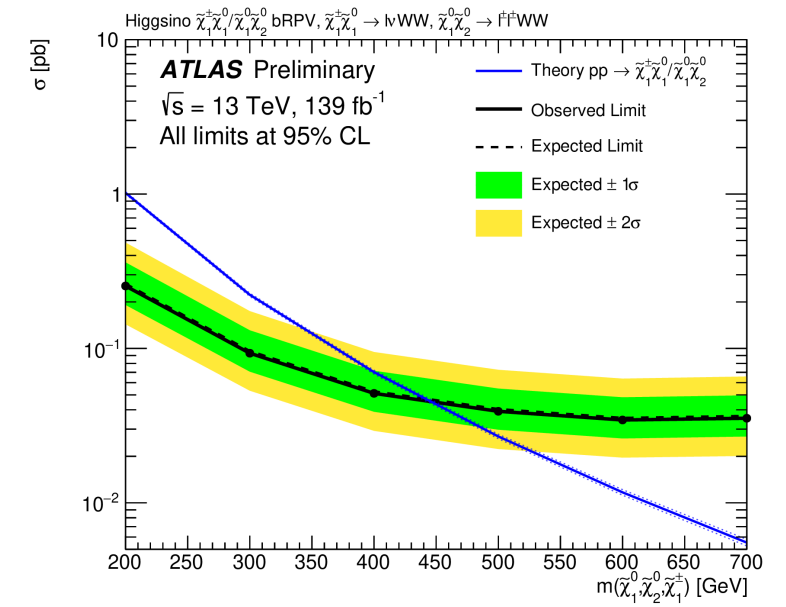
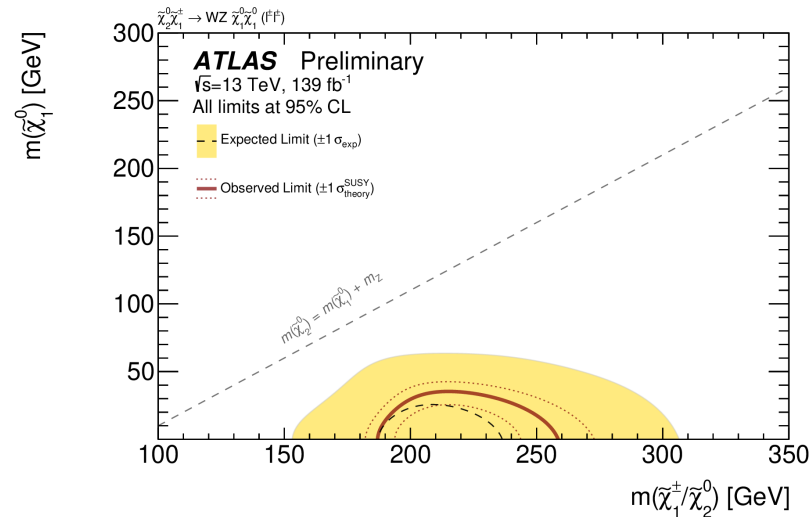
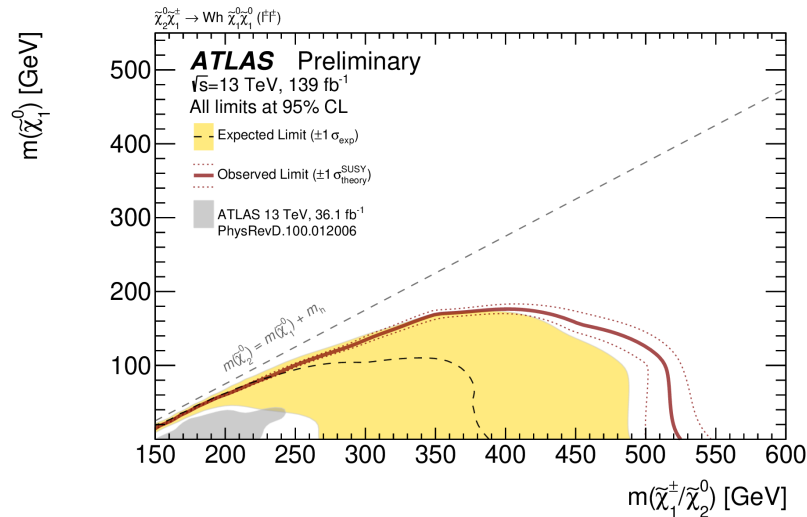
RPC simplified models

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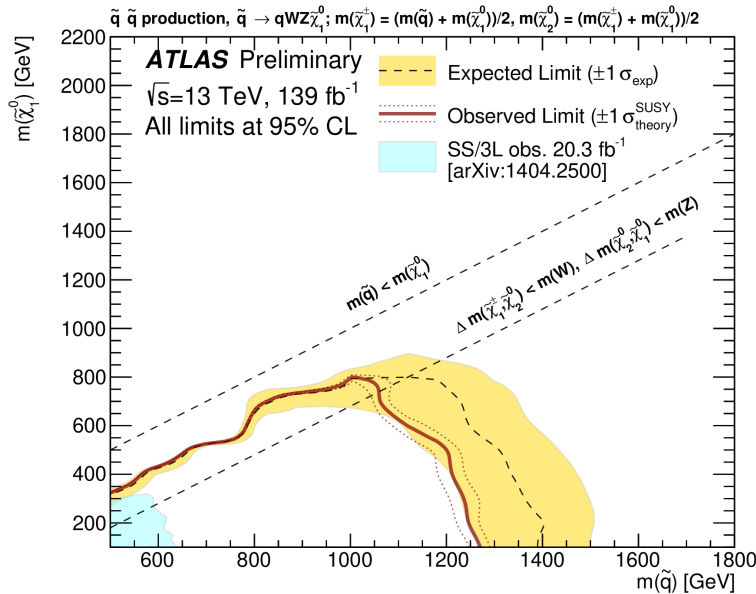
EW SS/3L: results

- In RPC with Wh (WZ), exclude winos up to 525 (260) GeV for a bino of vanishing mass
- Exclude higgsino up to 440 GeV in RPV with bilinear terms

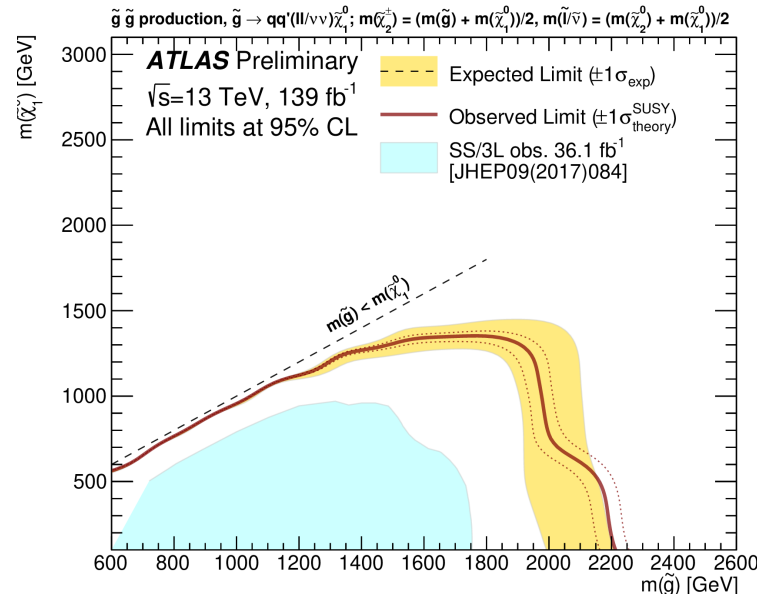


Strong SS/3L: results

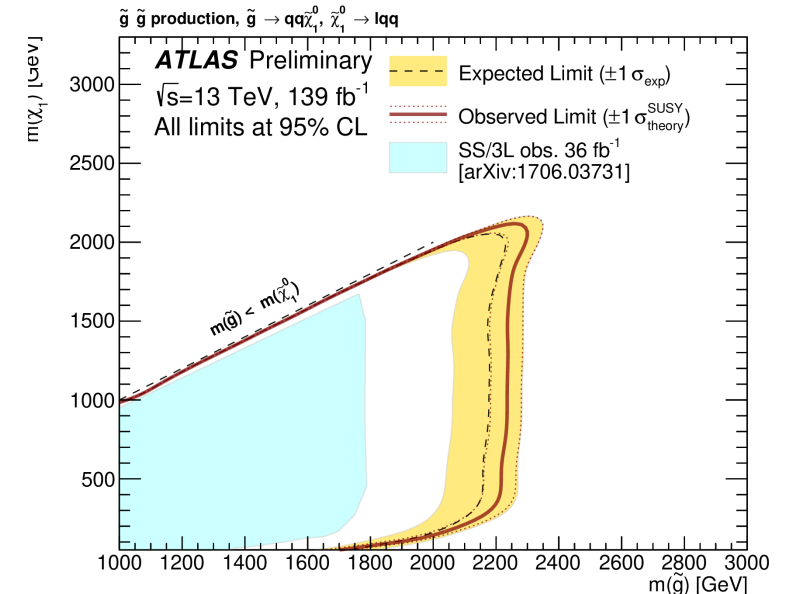
- In models with gluino (squark) production, gluino (squark) masses are excluded up to 2.2 (1.7) TeV at 95% C.L.



$$\tilde{q} \rightarrow q' W Z \tilde{\chi}_1^0$$



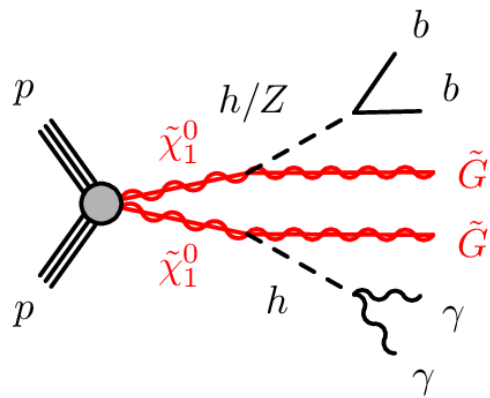
$$\tilde{g} \rightarrow q \bar{q} (ll/\nu\nu) \tilde{\chi}_1^0$$



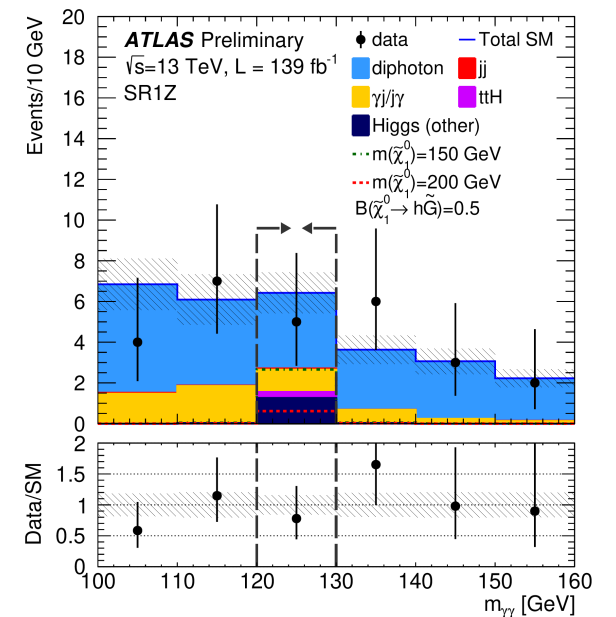
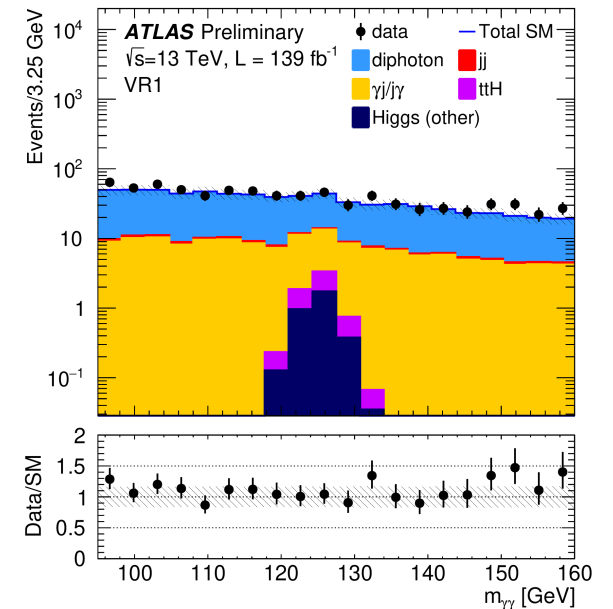
$$\tilde{g} \rightarrow q \bar{q} \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow l q q$$

$EW\cdot bb\gamma\gamma$

- Searching for pair production of higgsinos in events with two photons and two b-jets
- 139/fb, cut-and-count
- Models: gauge-mediated SUSY
- Backgrounds: non-resonant di-photons and γ +jet, determined with data-driven method (sidebands)

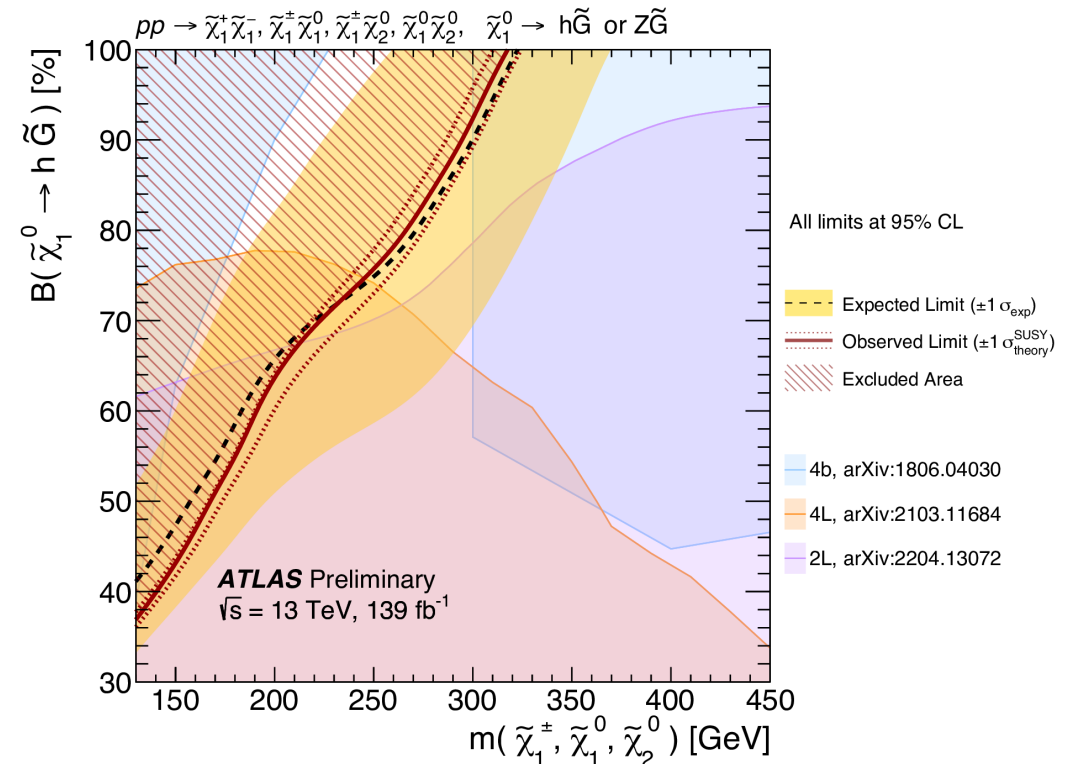
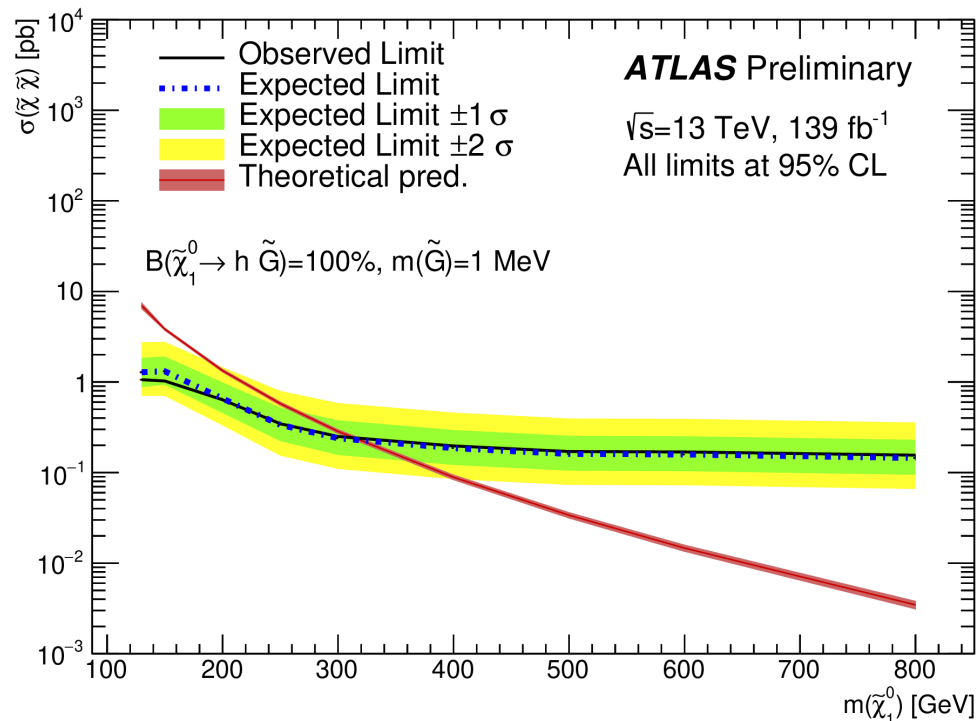


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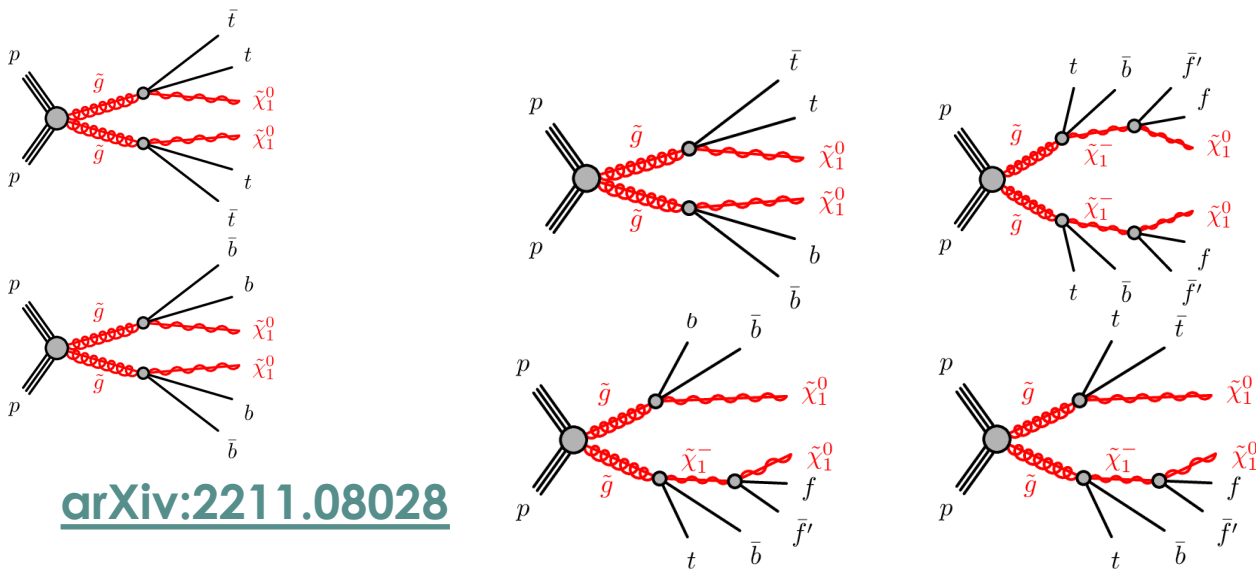
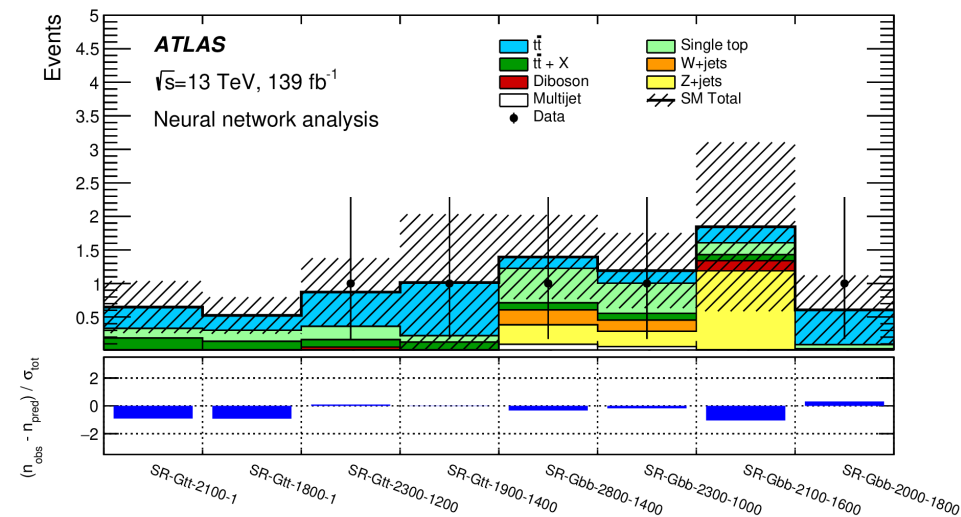
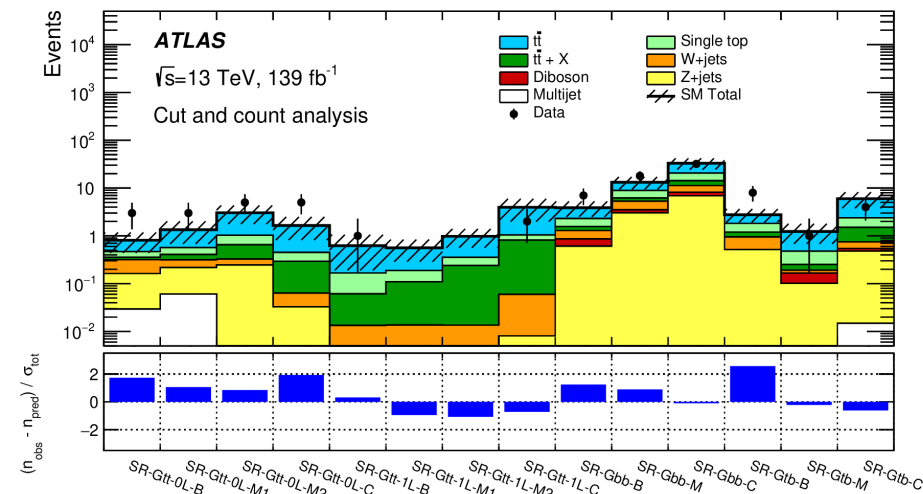
EW $b\bar{b}\gamma\gamma$: results

- Exclude masses up to 320(130) GeV for $B(\tilde{\chi}_1^0 \rightarrow h\tilde{G})=100(36) \%$



Strong multi-b

- Searching for production of gluinos in events with ≥ 3 b-tagged jets, 0/1 lepton and MET
- 139/fb, cut-and-count and NN
- Simplified models with gluino decays via off-shell stops to neutralino or higgsino-like chargino+neutralino
- Backgrounds: $t\bar{t}$, Z+jets, instrumental



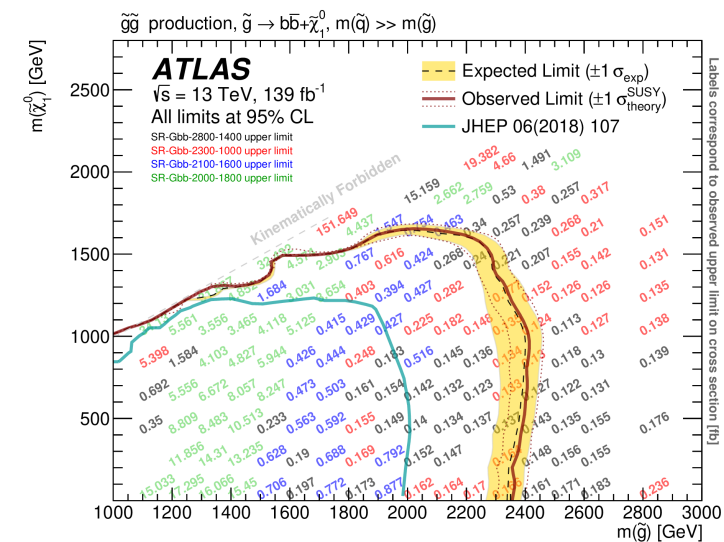
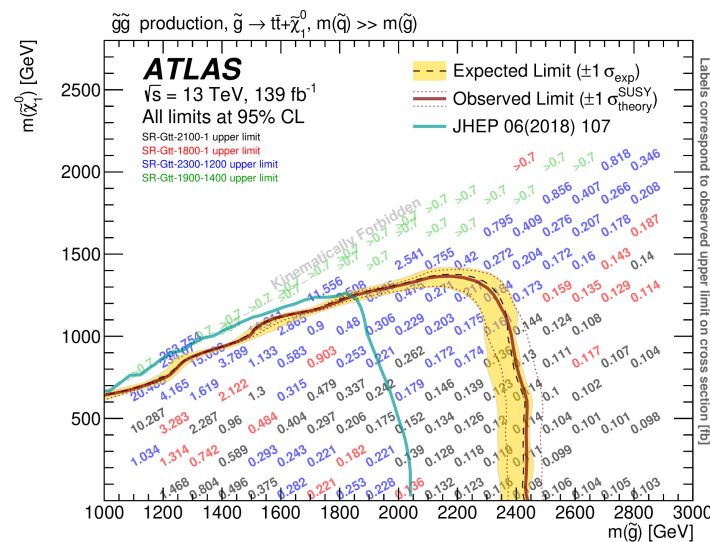
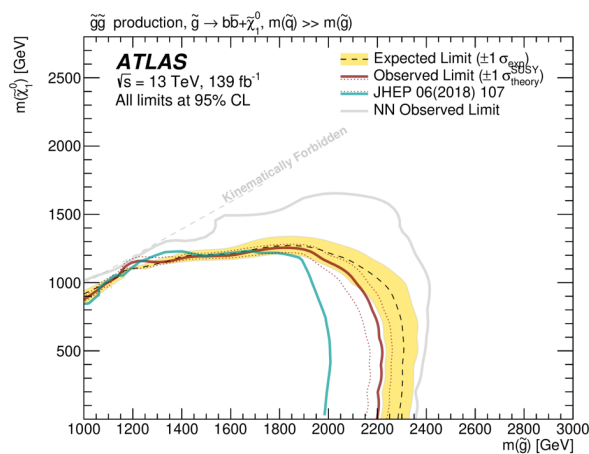
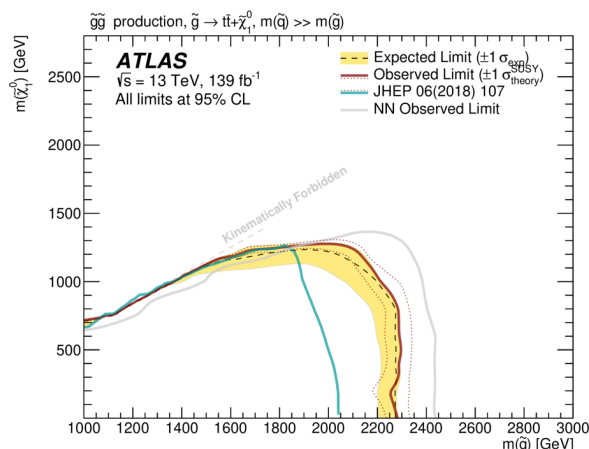
[arXiv:2211.08028](https://arxiv.org/abs/2211.08028)

5/8/2023

F. Rizatdinova, PHENO'23

Strong multi-b: results

- Gluino masses less than 2.44 TeV (2.35 TeV) are excluded at 95% CL for a massless $\tilde{\chi}_0^1$ in simplified Gtt (Gbb) models

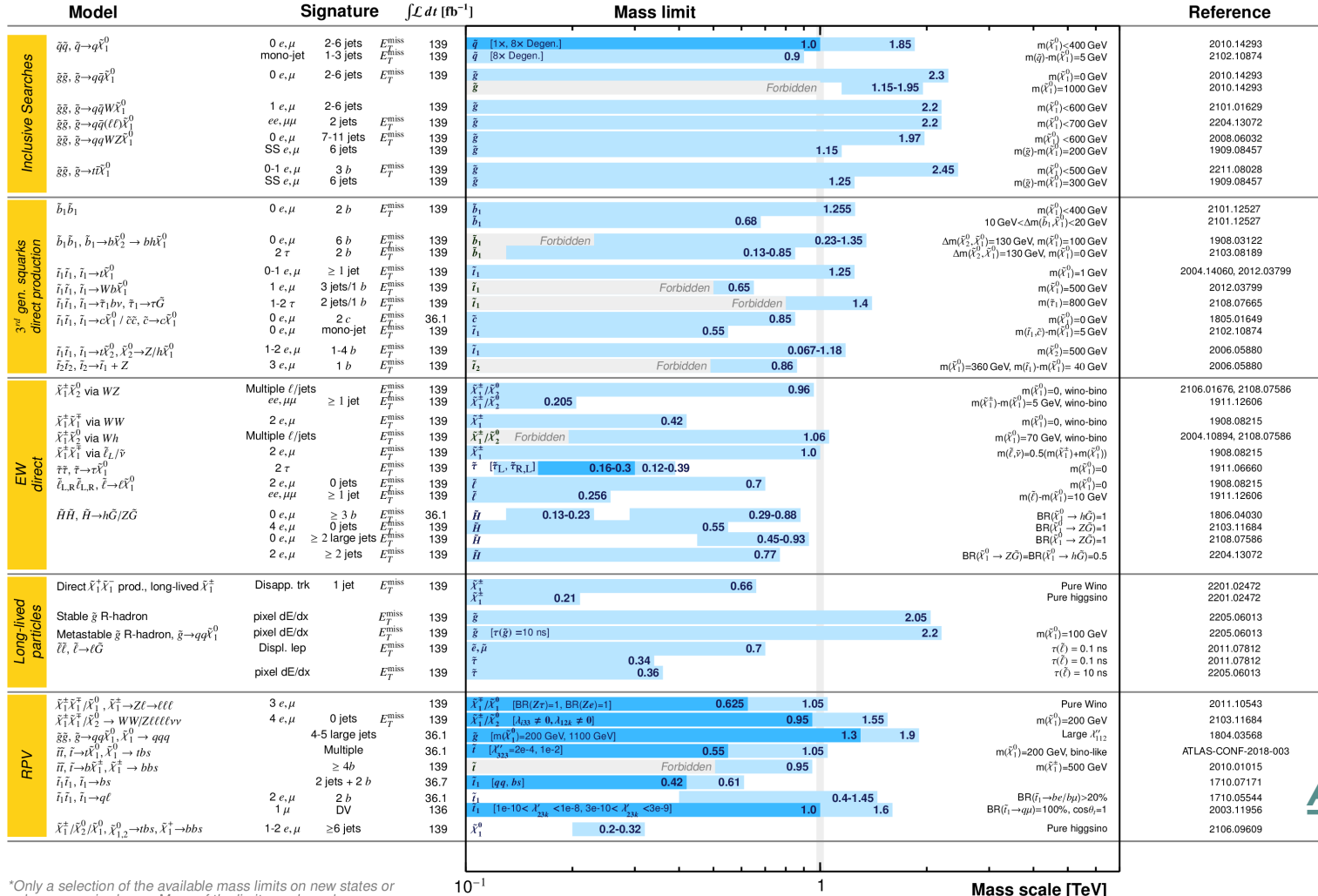


EW multi-b (higgsino pair production in gauge-mediated SUSY) is coming soon!

A snapshot of SUSY results at ATLAS

ATLAS SUSY Searches* - 95% CL Lower Limits
March 2023

ATLAS Preliminary
 $\sqrt{s} = 13$ TeV



ATL-PHYS-PUB-2023-005

5/8/2023

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

Conclusion

- ATLAS has an extensive SUSY search program
 - various original analyses
 - expanding coverage thanks to reinterpretation of existing results
- Identifying uncovered areas and looking for new ways to explore the SUSY parameter space
- A lot of interesting results are obtained with Run 2 data, more to come
- Looking forward to taking more data with Run 3 that recently started

Thank you!

And special thanks to:

Conference Organizing Committee



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The ATLAS Collaboration

