Searches for Supersymmetry with the ATLAS detector

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ICNFP 2021

Kolymbari (Greece), August 23, 2021

Introduction

- **SUSY:** Additional symmetry on top of the SM

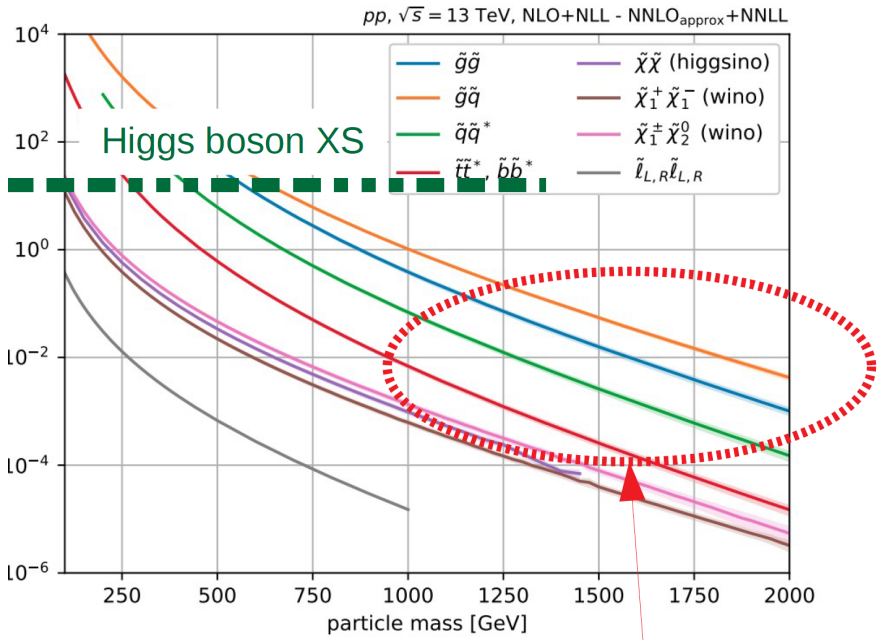
  → *SUSY particles expected to have a mass above 1 TeV*

- LHC is the only place for direct searches for new heavy particles

- ATLAS has a very rich program in SUSY searches

  → *Generally based on final states with jets, E_T^{miss} and high p_T objects.*

SUSYCrossSections



Probing the $>$ 1 TeV regime

Today we will focus on the latest results:

1. Photon + jets + E_T^{miss}: ATLAS-CONF-2021-028
2. Fully Hadronic: ATLAS-CONF-2021-022

Latest results long-lived partices: see Melisa's talk!

Final State: Photon + Jets + E_T^{miss}

ATLAS-CONF-2021-028

Experimental signature: one high p_T photon, many jets and E_T^{miss}

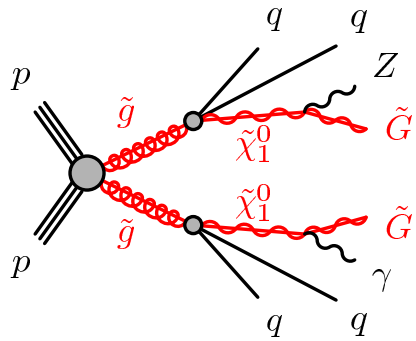
Model interpretation :

- Based on General Gauge Mediation (GGM) models

  → *Allow decoupled mass scales for strongly interacting SUSY particles: NLSP $\tilde{\chi}_0$ has large $\tilde{H}$ or $\tilde{B}$ components*:

  - $\tilde{\chi}_1^0 \to (\gamma/Z)\tilde{G}$
  - $\tilde{\chi}_1^0 \to (\gamma/h)\tilde{G}$

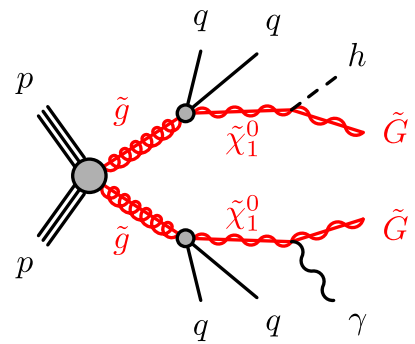
- LSP is the ultra light $\tilde{G}$.
- R-parity is conserved.



γ/Z **model**

Signal Regions: Target different mass splitting

- SRL: $\tilde{g} \gg \tilde{\chi}_1^0$
- SRH: $\tilde{g} \sim \tilde{\chi}_1^0$
- SRM: $\tilde{g} > \tilde{\chi}_1^0$



γ/h **model**

Final State: Photon + Jets + E_T^{miss}

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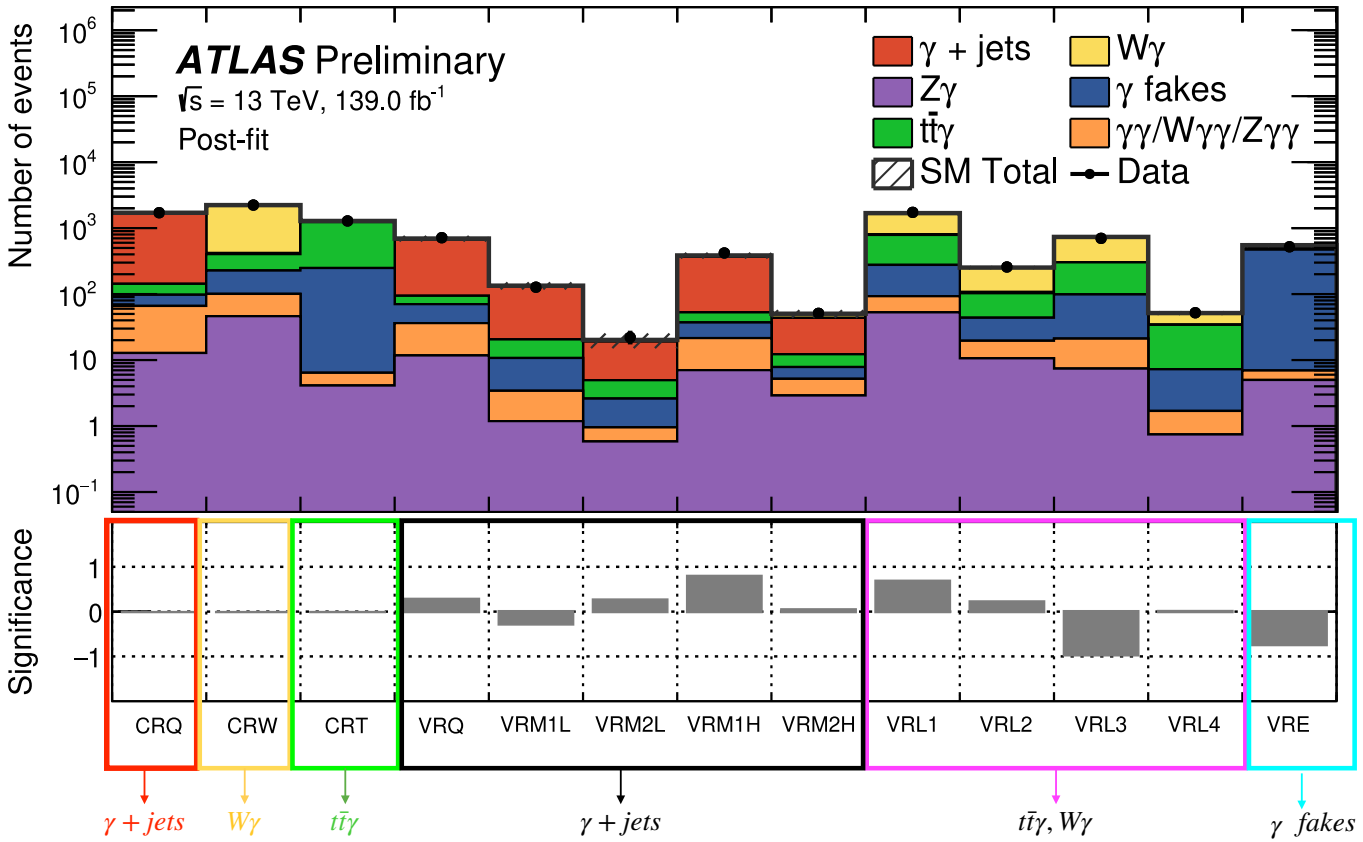
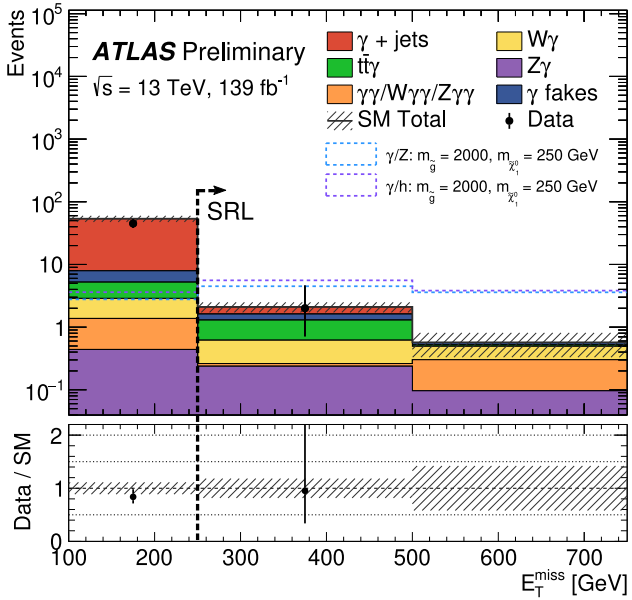
Background estimation:

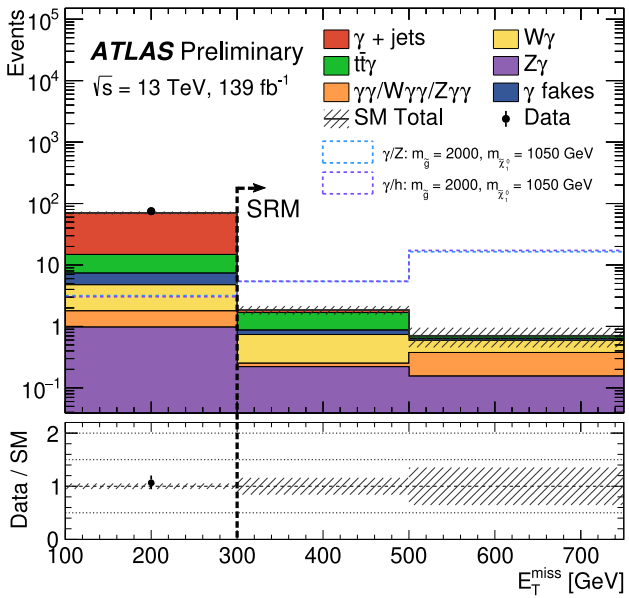
- $W\gamma$, $t\bar{t}\gamma$, γ+jets: *normalised to data in dedicated CRs.*
- $W\gamma\gamma$,$Z\gamma$, $Z\gamma\gamma$, $\gamma\gamma$: *taken from MC.*
- γ fakes: *data-driven techniques used independently for jets and electrons faking photons*

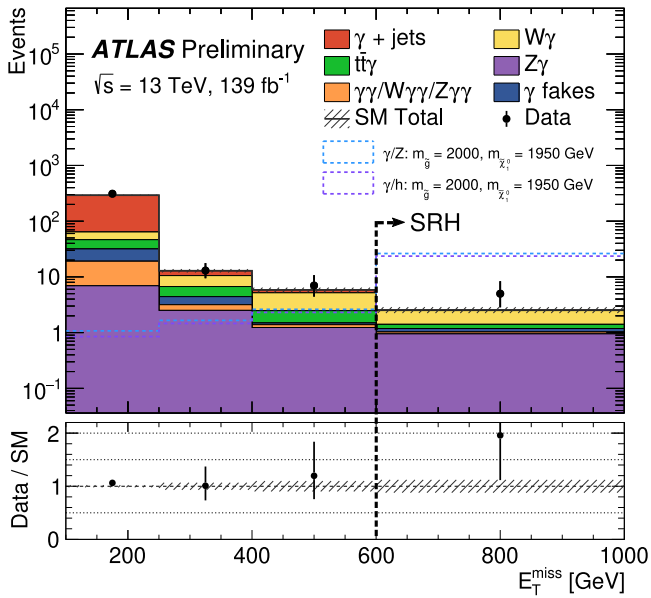


Final State: Photon + Jets + E_T^{miss}

ATLAS-CONF-2021-028







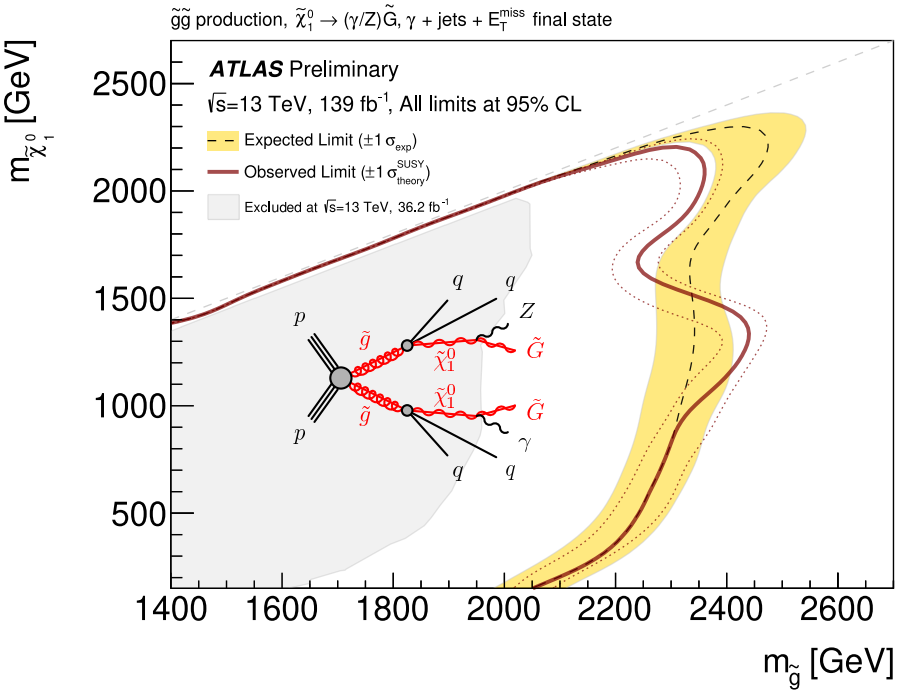
No significant excess above the SM background is observed

Final State: Photon + Jets + E_T^{miss}

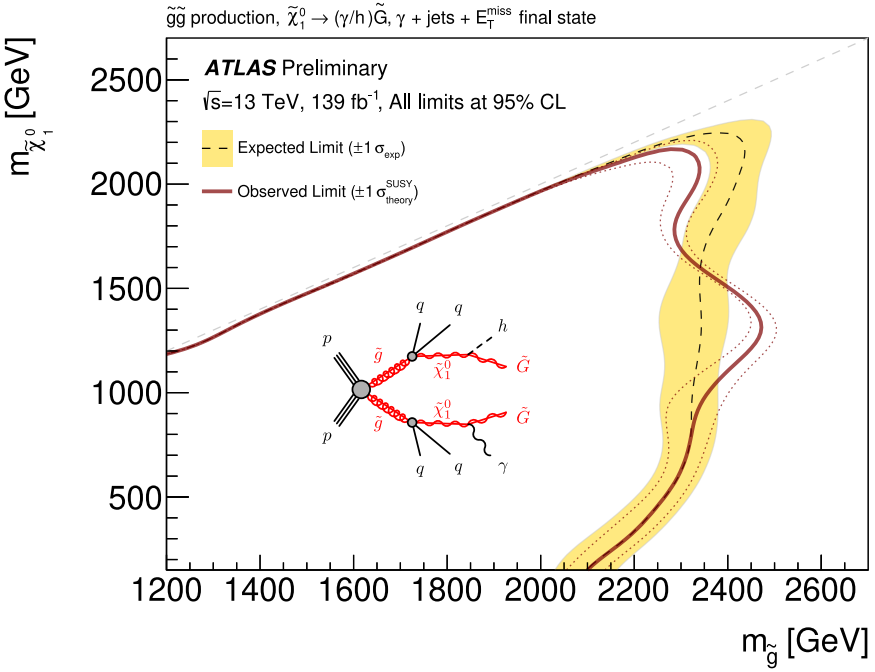
ATLAS-CONF-2021-028

Signal Region	N_{obs}	N_{exp}	$\langle\epsilon\sigma\rangle^{95}_{obs}$ [fb]	$\langle\epsilon\sigma\rangle^{95}_{exp}$ [fb]	S^{95}_{obs}	S^{95}_{exp}	p_0(Z)
SRL	2	2.67 ± 0.75	0.030	$0.034^{+0.019}_{-0.011}$	4.12	$4.7^{+2.6}_{-1.6}$	0.50 (0.00)
SRM	0	2.55 ± 0.64	0.018	$0.032^{+0.018}_{-0.011}$	2.56	$4.4^{+2.5}_{-1.6}$	0.50 (0.00)
SRH	5	2.55 ± 0.44	0.054	$0.034^{+0.019}_{-0.011}$	7.43	$4.7^{+2.6}_{-1.6}$	0.09 (1.36)

Model independent limits



γ/Z **model**

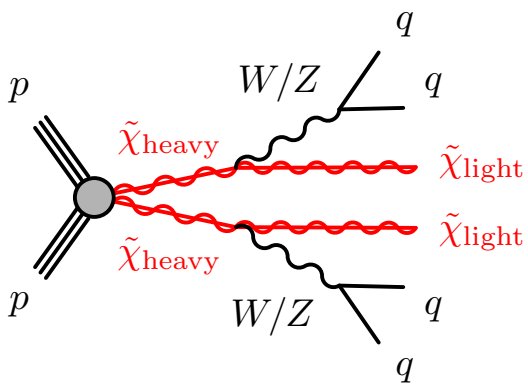


γ/h **model**

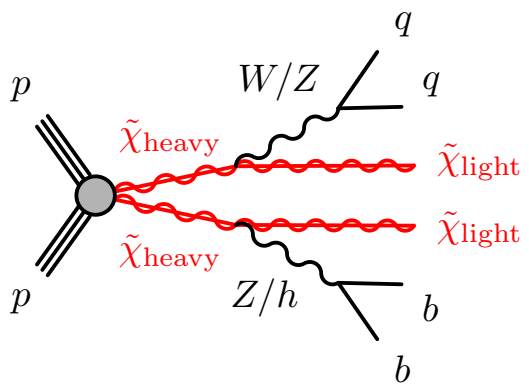
Final State: Fully Hadronic

ATLAS-CONF-2021-022

Experimental signature: 2 boosted hadronically-decaying heavy SM bosons (W, Z, or h)+ $E_{\mathrm{T}}^{\mathrm{miss}}$



Final state: $4Q$



Final state: $2B2Q$

Model interpretation based on 3 scenarios:

1. **A baseline MSSM with $\tilde{B}/\tilde{H}/\tilde{W}$ LSP*** $\rightarrow (\tilde{\chi}_{\mathrm{heavy}}, \tilde{\chi}_{\mathrm{light}}) : (\tilde{W}, \tilde{B}), (\tilde{W}, \tilde{H}), (\tilde{H}, \tilde{B}), (\tilde{H}, \tilde{W})$

   *Typical electroweakino searches at the LHC target only $(\tilde{W}, \tilde{B})$.

2. **GGM/Naturalness-driven $\tilde{G}$ LSP model** $\rightarrow (\tilde{\chi}_{\mathrm{heavy}}, \tilde{\chi}_{\mathrm{light}}) : (\tilde{H}, \tilde{G})$

3. **Naturalness-driven $\tilde{a}$ LSP model** $\rightarrow (\tilde{\chi}_{\mathrm{heavy}}, \tilde{\chi}_{\mathrm{light}}) : (\tilde{H}, \tilde{a})$

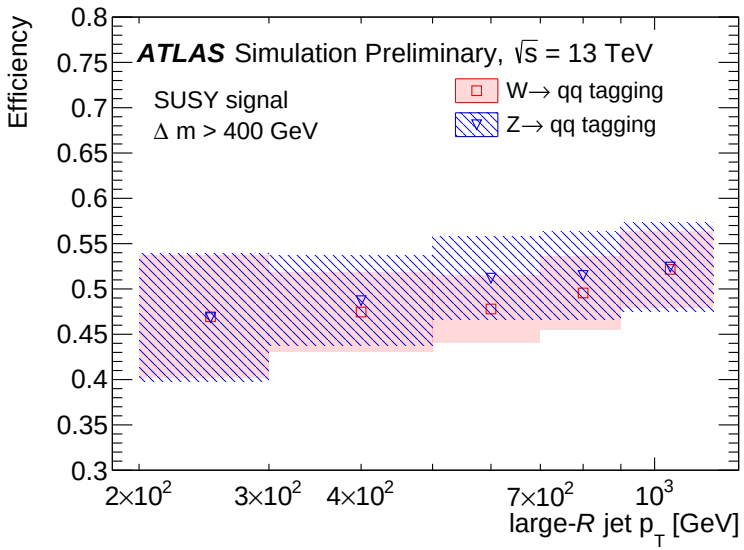
Final State: Fully Hadronic

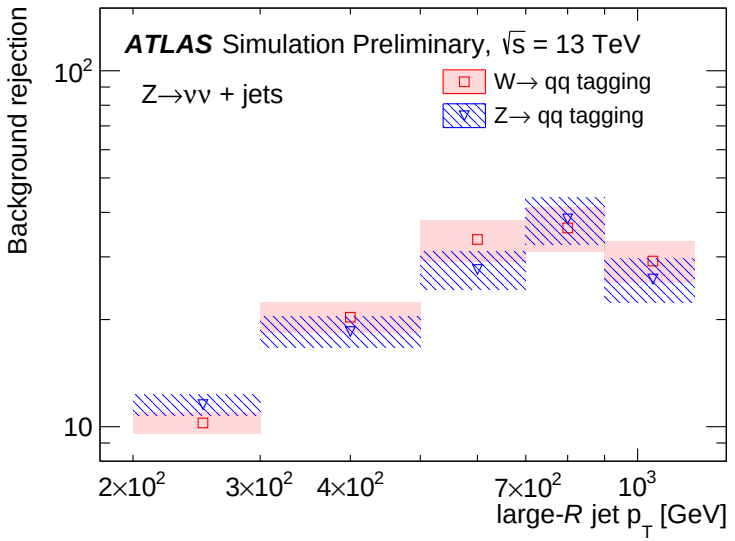
ATLAS-CONF-2021-022

Large-R jets (J) are used to capture two collimated energetic jets from each SM boson decay

"Boson tagging" is used to identify the decays of W, Z, and h:

- $W, Z \to qq$: Use m_J, energy correlation function D_2 and n_{trk}.
- $Z, h \to bb$: Use $m_{J(bb)}$.





Signal Regions: Two categories: 4Q and 2B2Q

→ *Every category splits to target the different final states of the signal processes.*

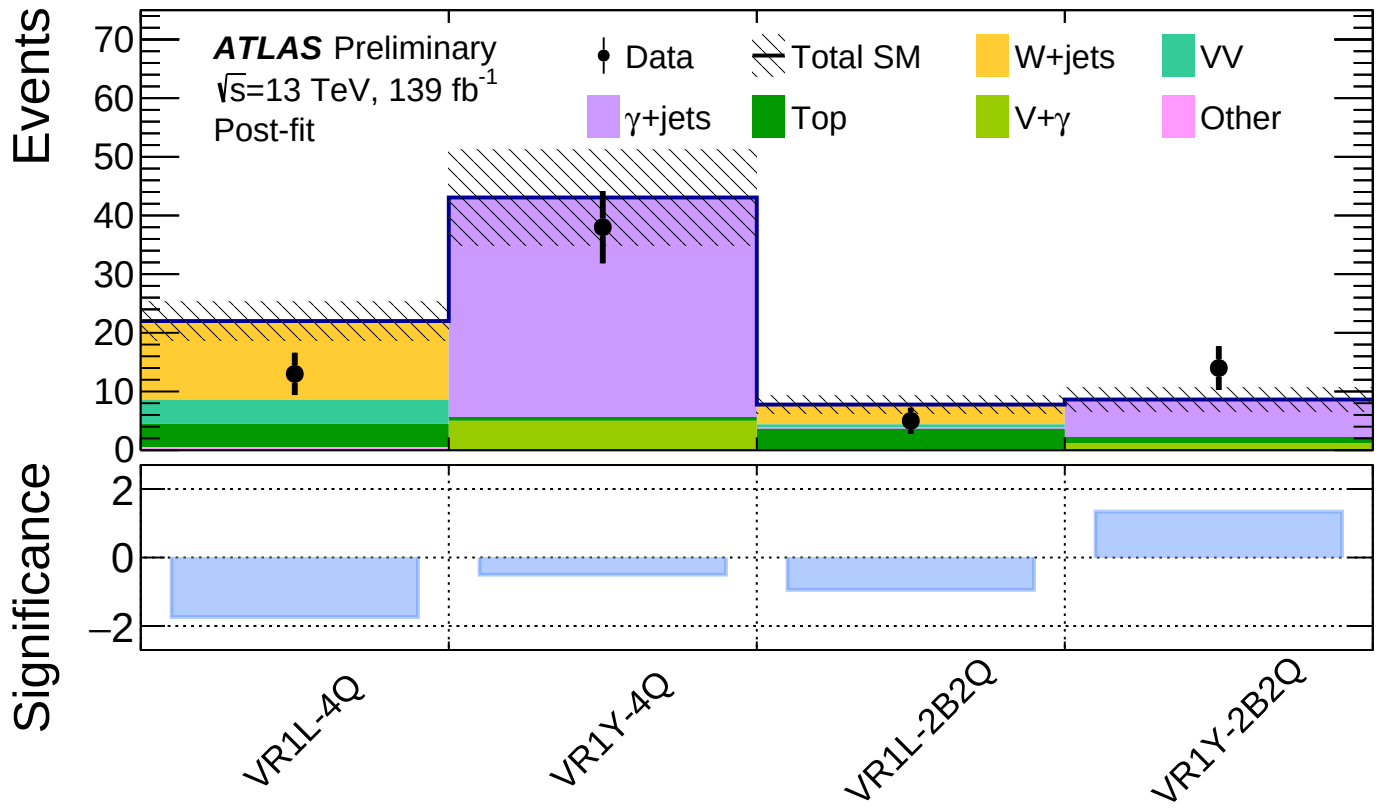
Final State: Fully Hadronic

ATLAS-CONF-2021-022

Background estimation:

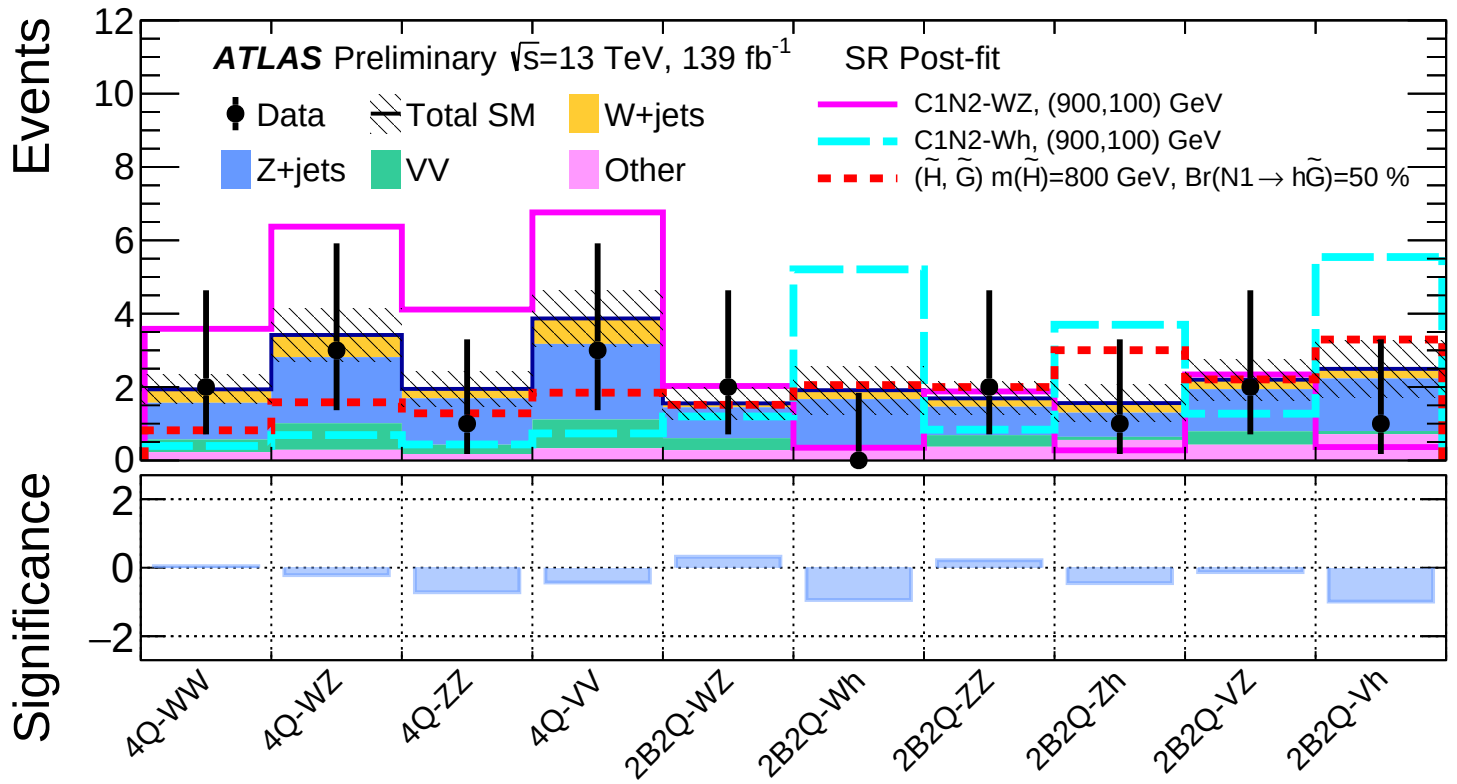
- **Irreducible:** VVV, ttX $\rightarrow$ taken from MC.
- **Reducible:** Mainly from $Z(\nu\nu)$+jets, $W(\ell\nu)$+jets $\rightarrow$ Normalised in a CR with no lepton (0L)

  $\rightarrow$ *Validation done in regions with one lepton (1L) or one photon (1Y)*



Final State: Fully Hadronic

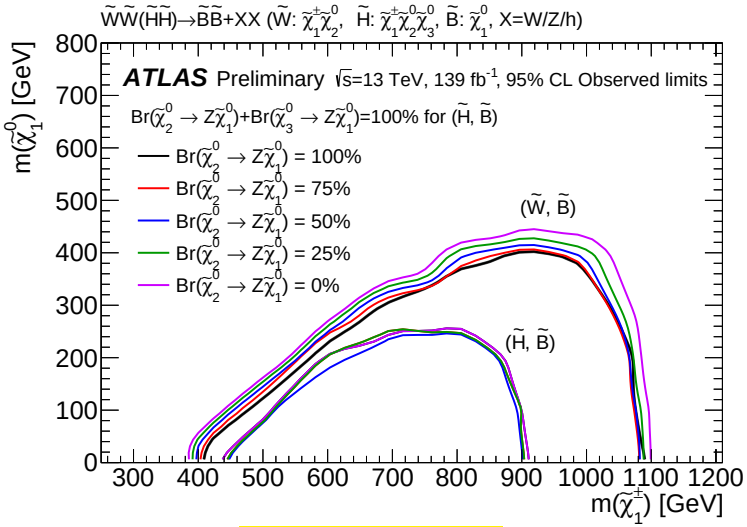
ATLAS-CONF-2021-022



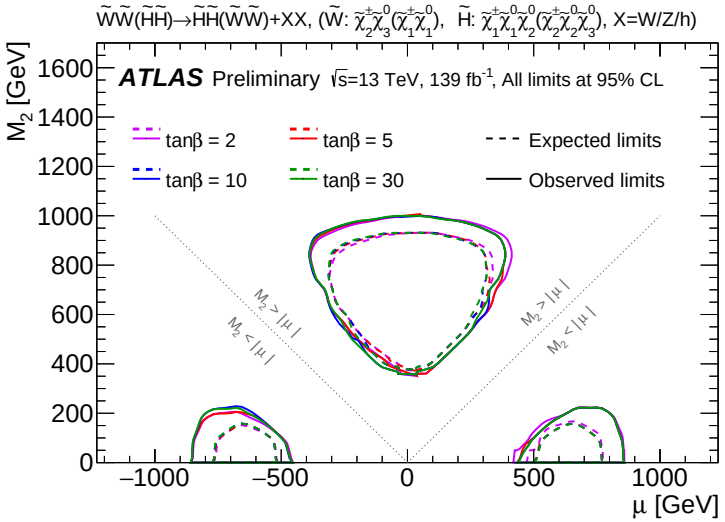
No significance excess above SM background is observed

Exclusion limits: $(\tilde{W}, \tilde{B}), (\tilde{H}, \tilde{B}), (\tilde{W}, \tilde{H}), (\tilde{H}, \tilde{W})$

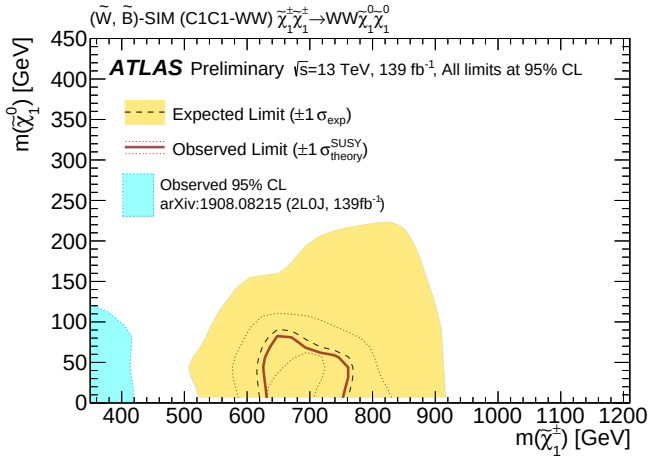
ATLAS-CONF-2021-022



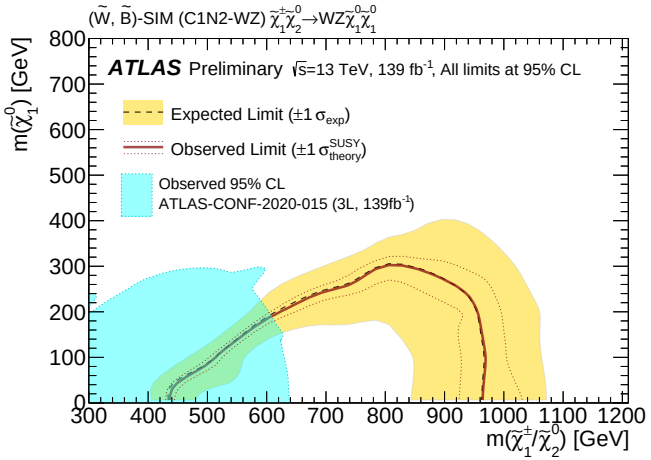
$(\tilde{W}, \tilde{B}), (\tilde{H}, \tilde{B})$



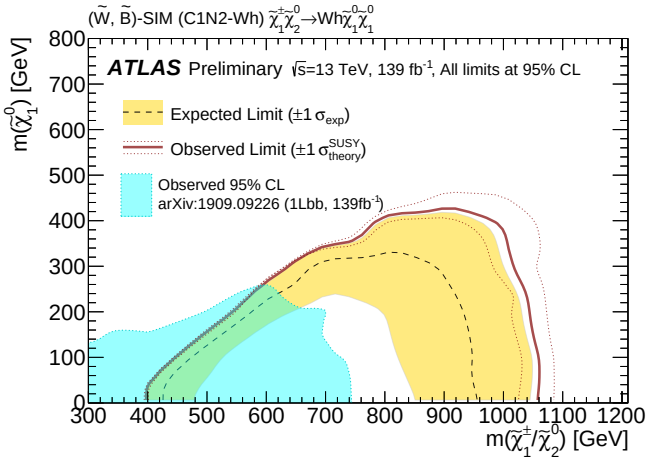
$(\tilde{W}, \tilde{H}), (\tilde{H}, \tilde{W})$



$(\tilde{W}, \tilde{B})$-**SIM model: C1C1-***WW*



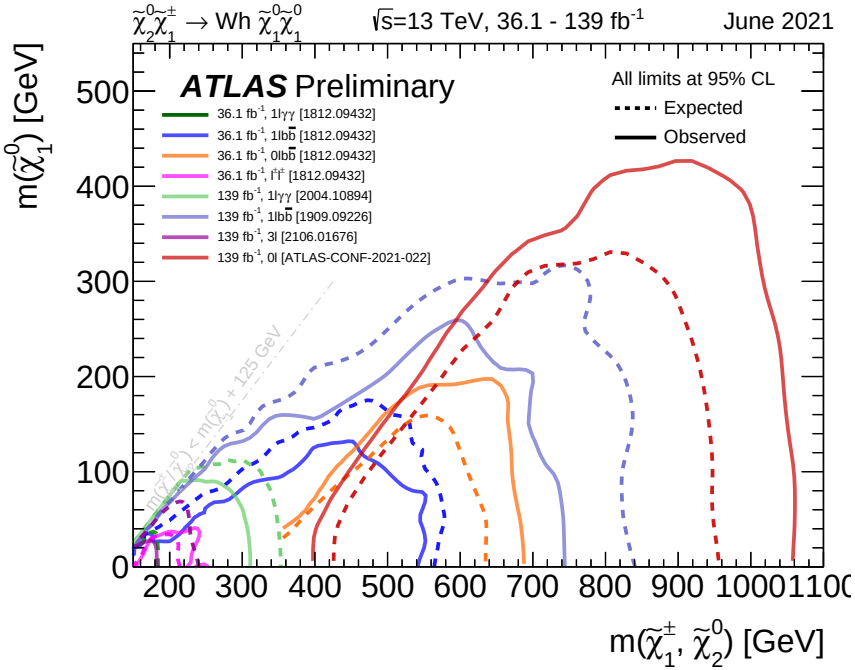
$(\tilde{W}, \tilde{B})$-**SIM model: C1N2-***WZ*

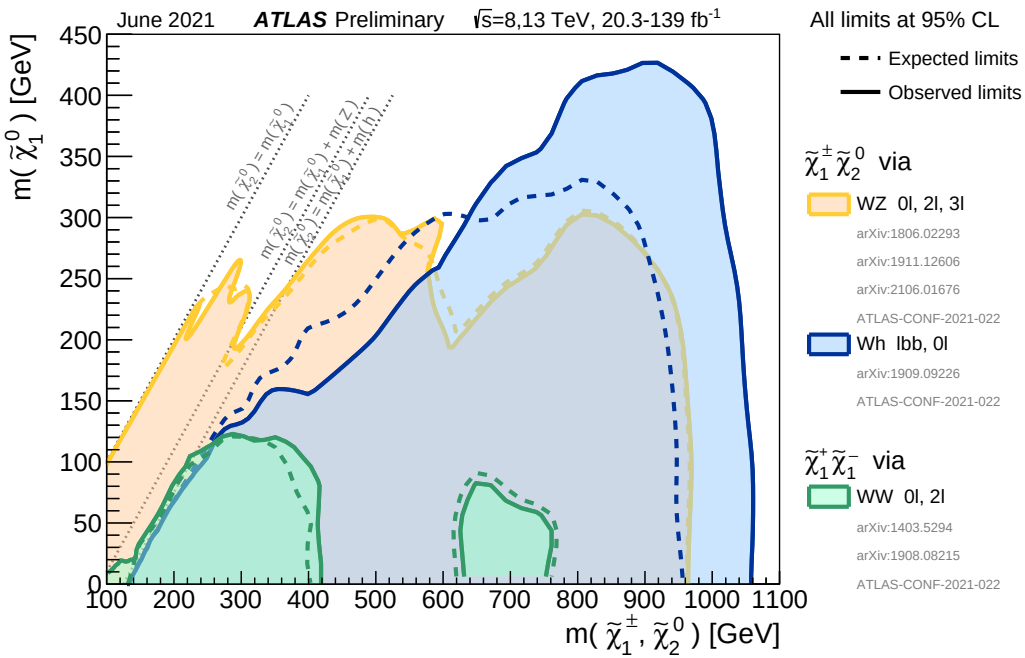


$(\tilde{W}, \tilde{B})$-**SIM model: C1N2-***Wh*

Exclusion limits: comparison with other searches

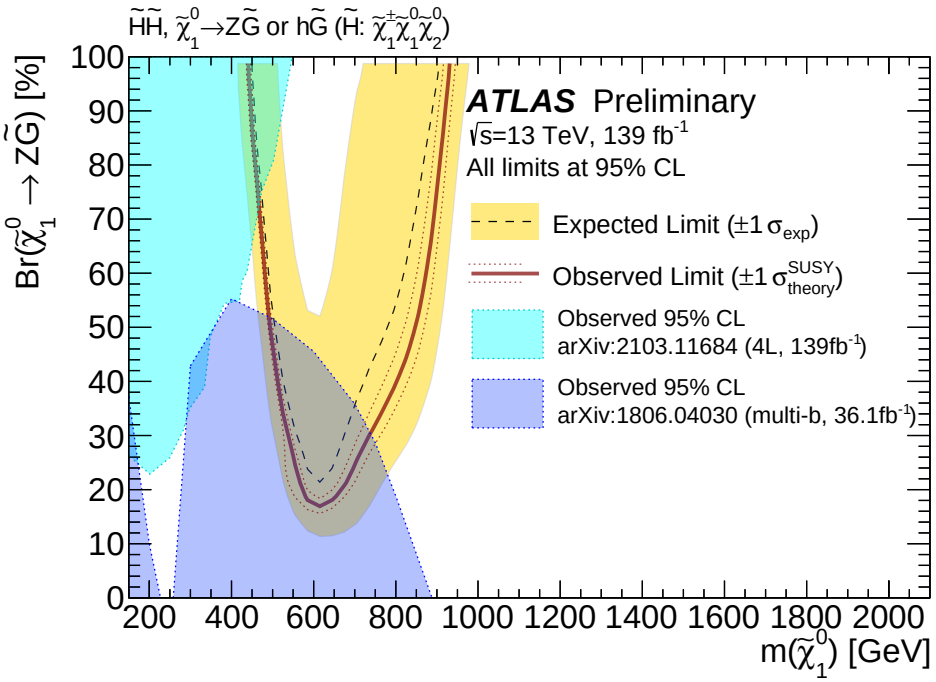
ATL-PHYS-PUB-2021-019



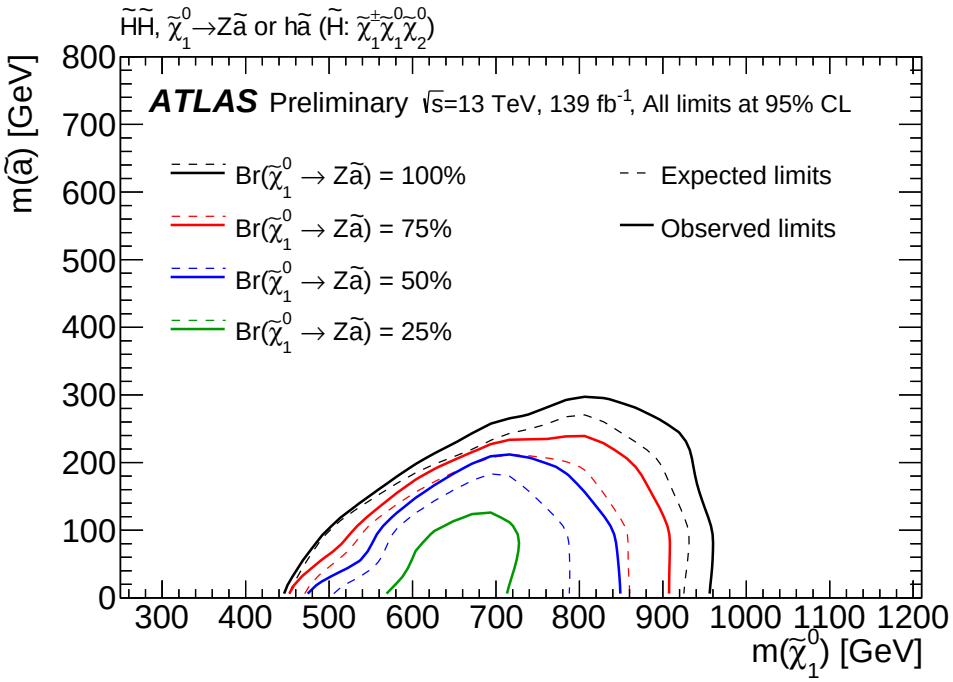


Exclusion limits: $(\tilde{H}, \tilde{G}), (\tilde{H}, \tilde{a})$

ATLAS-CONF-2021-022



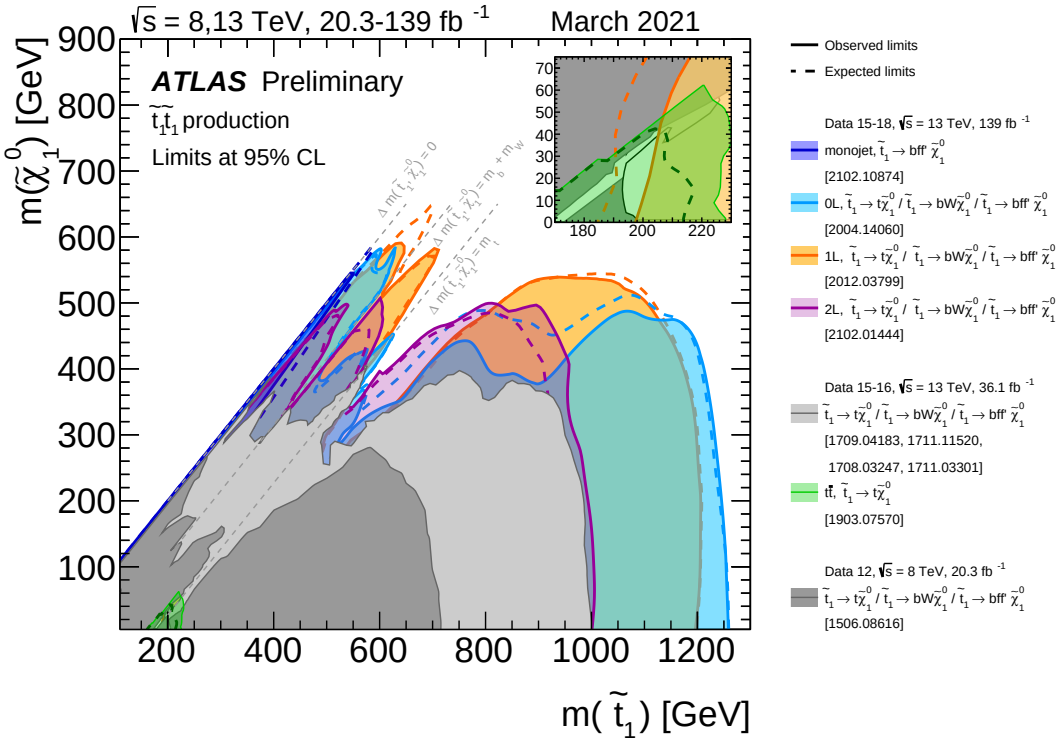
$(\tilde{H}, \tilde{G})$

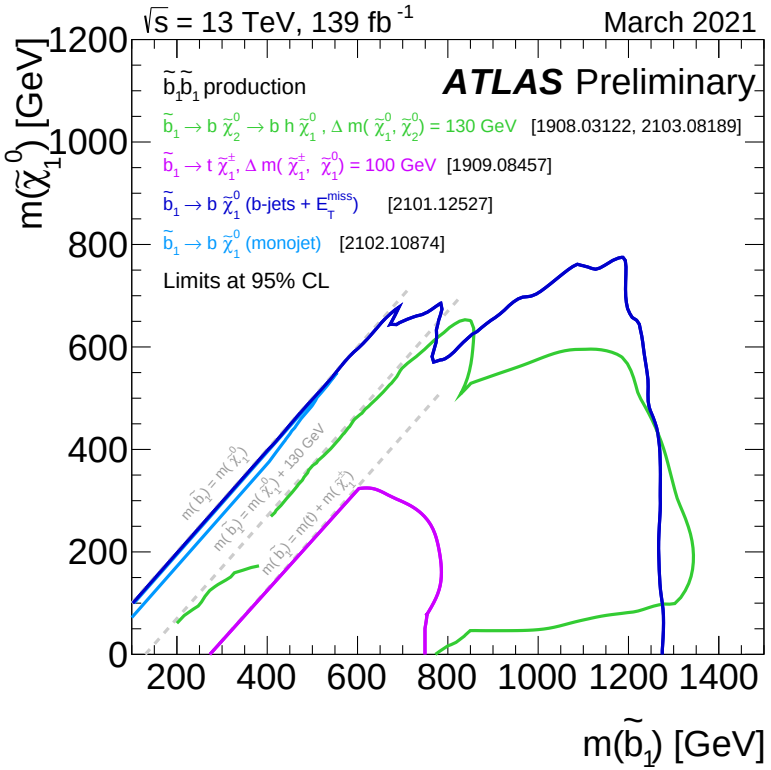


$(\tilde{H}, \tilde{a})$

Searches for $\tilde{t}_1$ and $\tilde{b}_1$

ATL-PHYS-PUB-2021-019





Searches for $\tilde{g}$ and $\tilde{q}$

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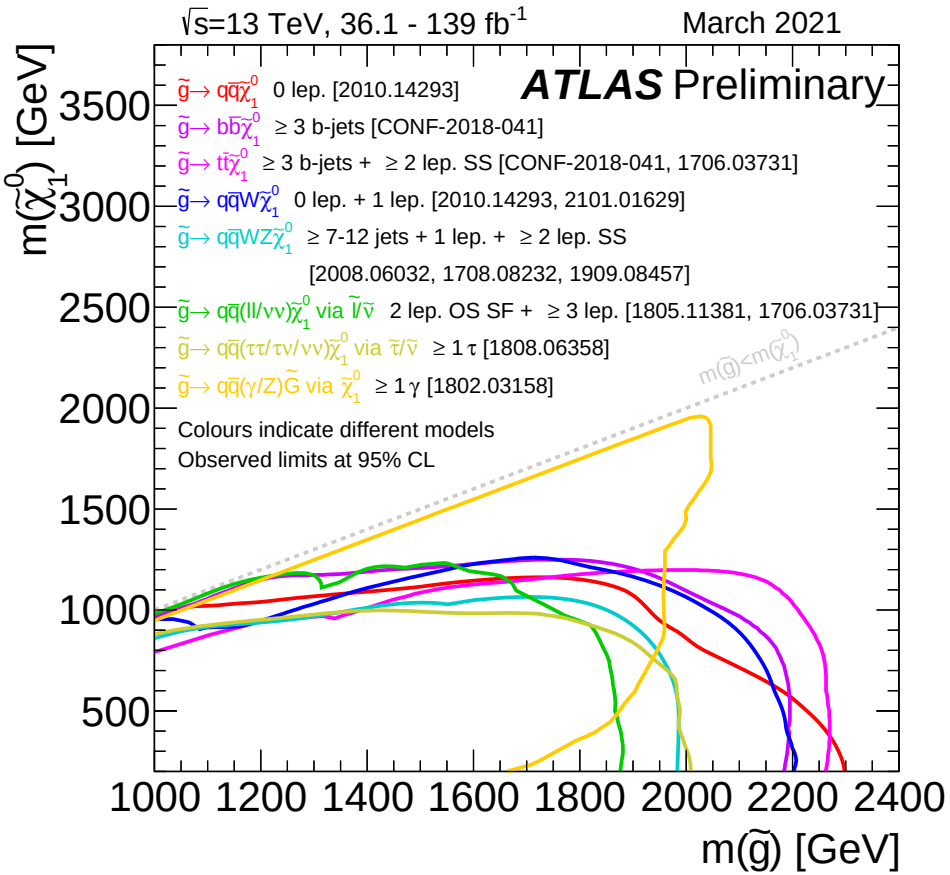

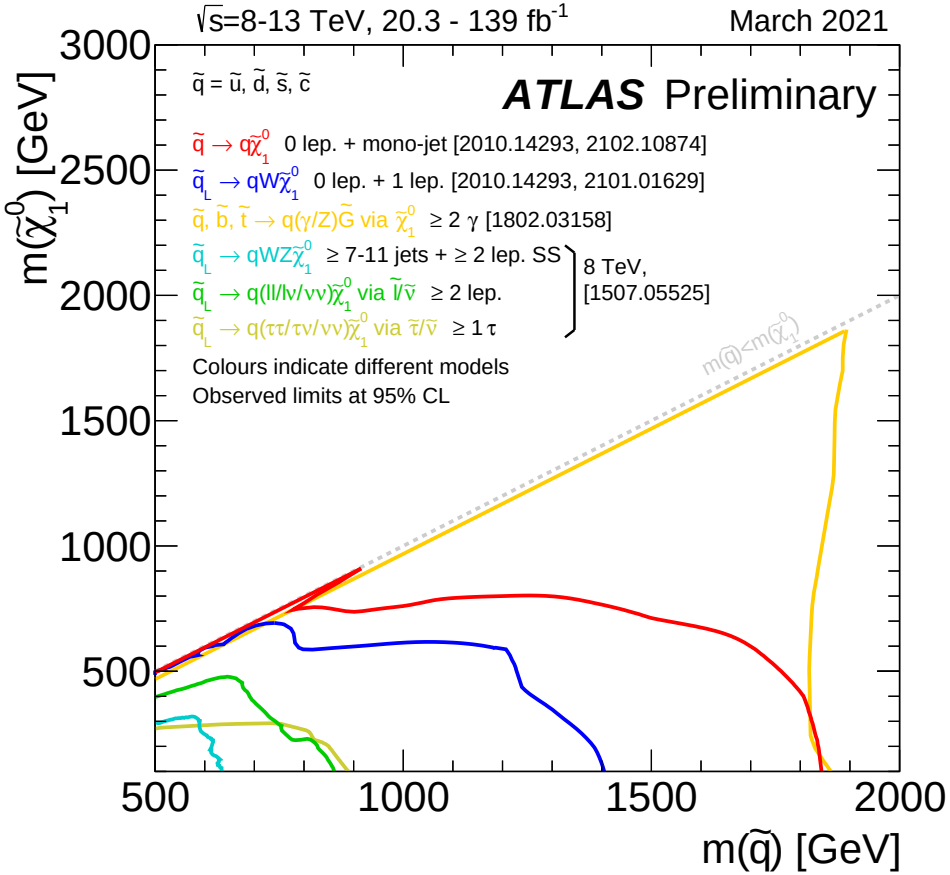

RPV searches

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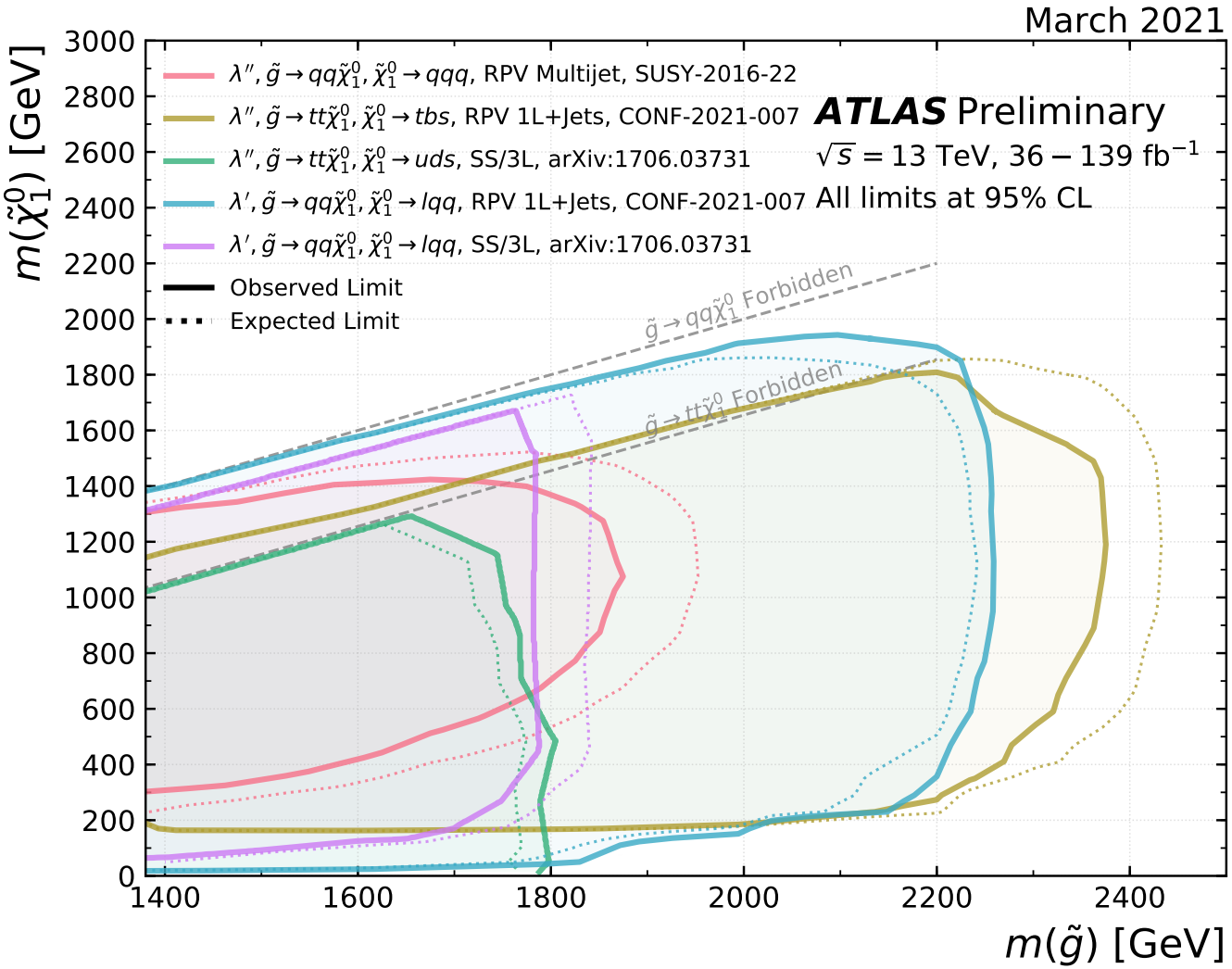

Searches for $\tilde{\mu}$

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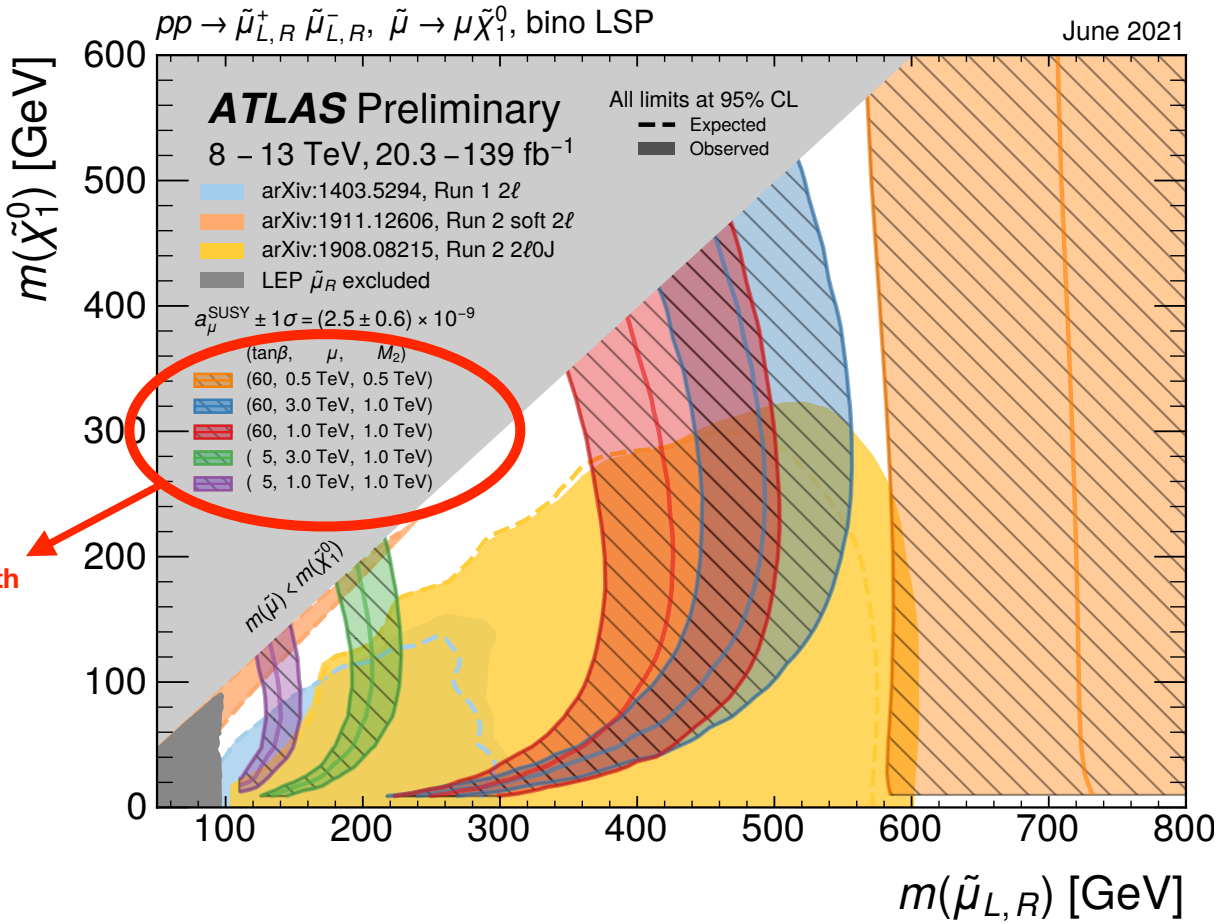
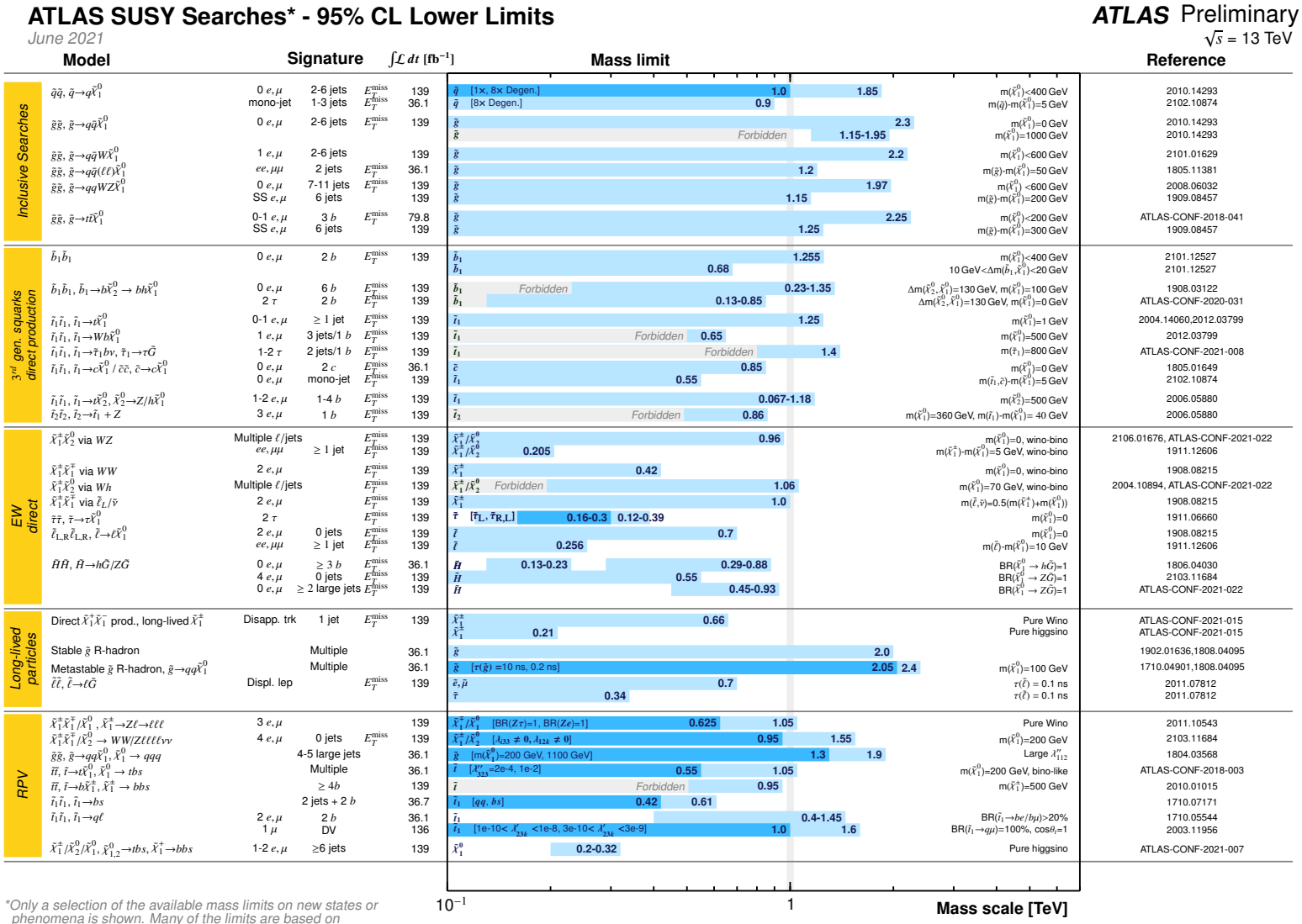


Parameters compatible with the muon g-2 anomaly

ATLAS SUSY Searches



Summary

- ATLAS SUSY searches cover a wide range of scenarios.
- No excess above SM background has been observed.
- Exclusion limits have been set for model dependent and model independent scenarios.
- A good portion of parameter space is still unexplored!

Waiting for more data from the LHC Run 3!

BACKUP