Searches for strong production of supersymmetric particles with the ATLAS detector

Phenomenology 2020 Symposium, 4-6 May 2020

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For the ATLAS Collaboration

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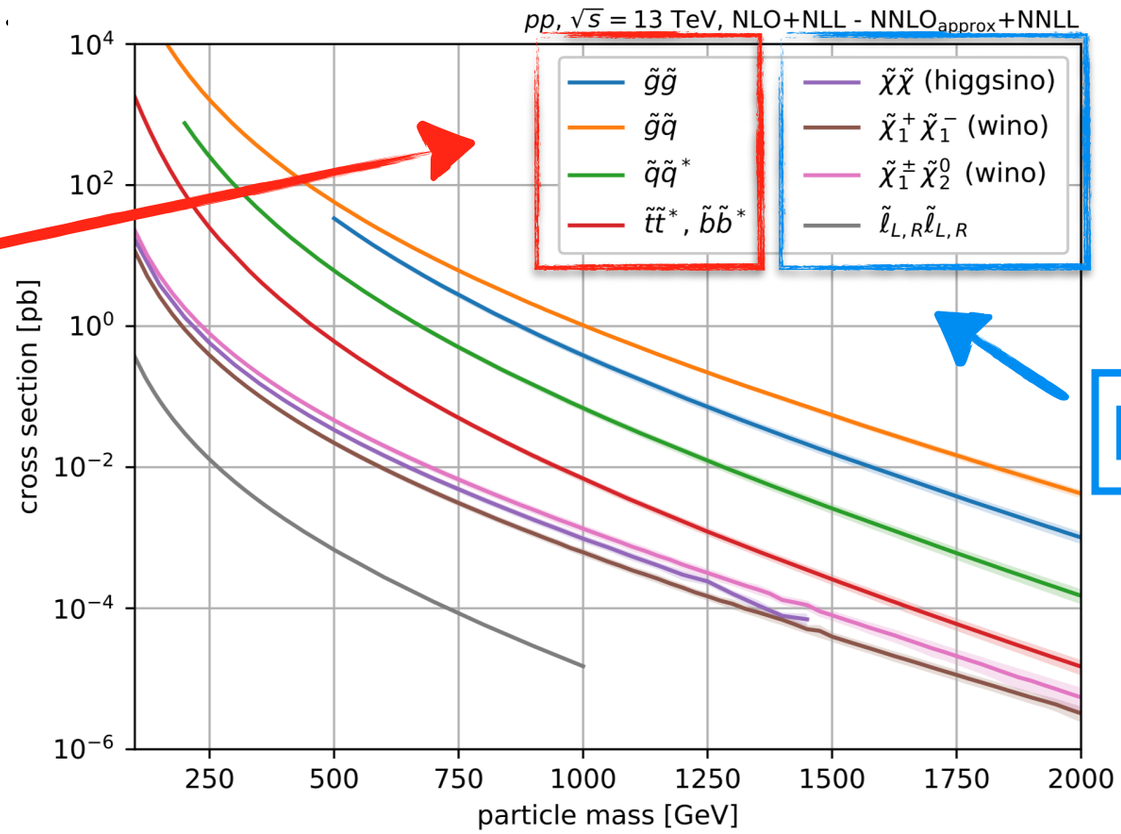
Introduction

- Supersymmetry (SUSY) predicts the existence of a **massive particle sector** allowing to solve different open questions of physics.
- Strongly-interacting SUSY particles (squarks and gluinos) have **larger production cross-sections than EW SUSY partners**.
- If SUSY solves the Higgs hierarchy mass problem (natural SUSY), **gluinos and stops must have small masses**.

Stops and gluinos expected to be observed first at ATLAS.

- Electro-weak (EW) ATLAS searches covered in the talk by Jason Oliver later today (14:45 EDT).

Strong SUSY



EW SUSY

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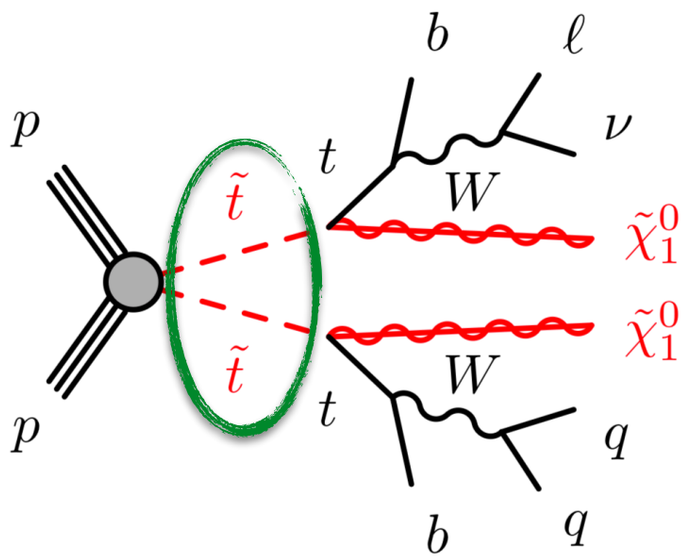
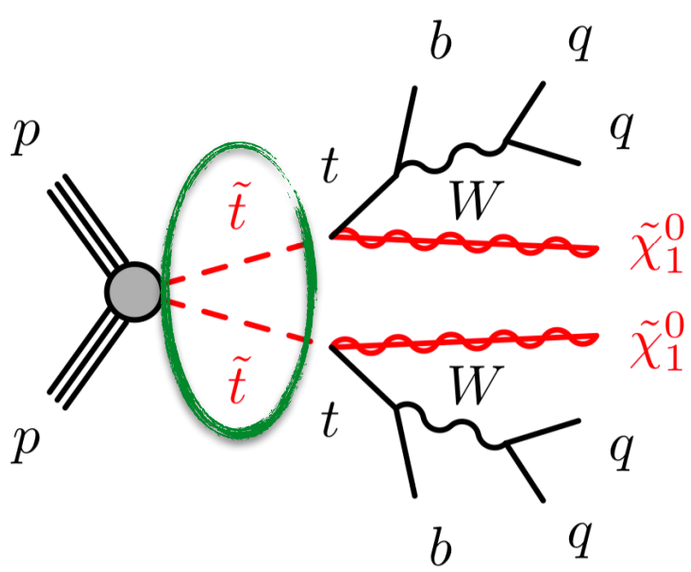
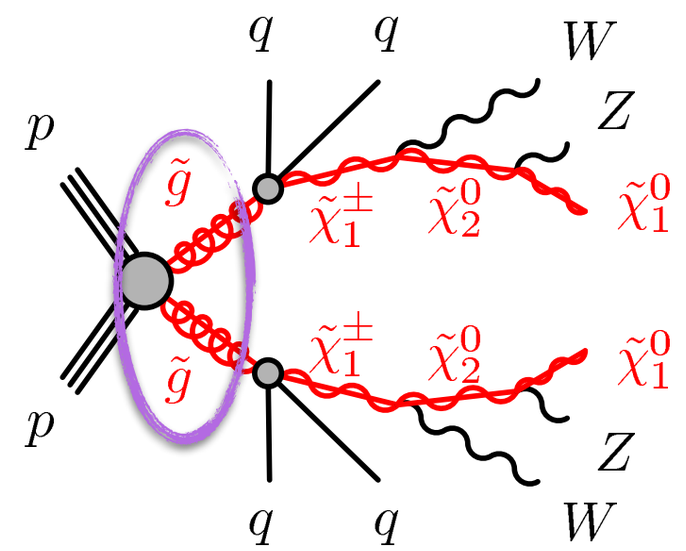
New ATLAS results (139 fb^{-1})

[ATLAS- CONF-2020-003]	[arXiv:2004.14060]	[ATLAS- CONF-2020-002]
		
Signature: • **One lepton** • ≥ 1 b-tagged jet or soft b-object • $N_{jets} \geq 4$ • **Large MET**	Signature: • **Zero leptons** • ≥ 1 b-tagged jet or soft b-object • $N_{jets} \geq 4$ • **Large MET**	Signature: • **Zero leptons** • **Large jet multiplicities** (8-12 jets) • Moderate MET

Searching for stops in zero and one lepton signatures using the complete ATLAS Run 2 dataset (139 fb^{-1})

ATLAS-CONF-2020-003
arXiv:2004.14060

ATLAS stop searches

Status and phenomenology

Searches for strong production of SUSY particles with the ATLAS detector
PHENO2020 [4-6 May 2020]

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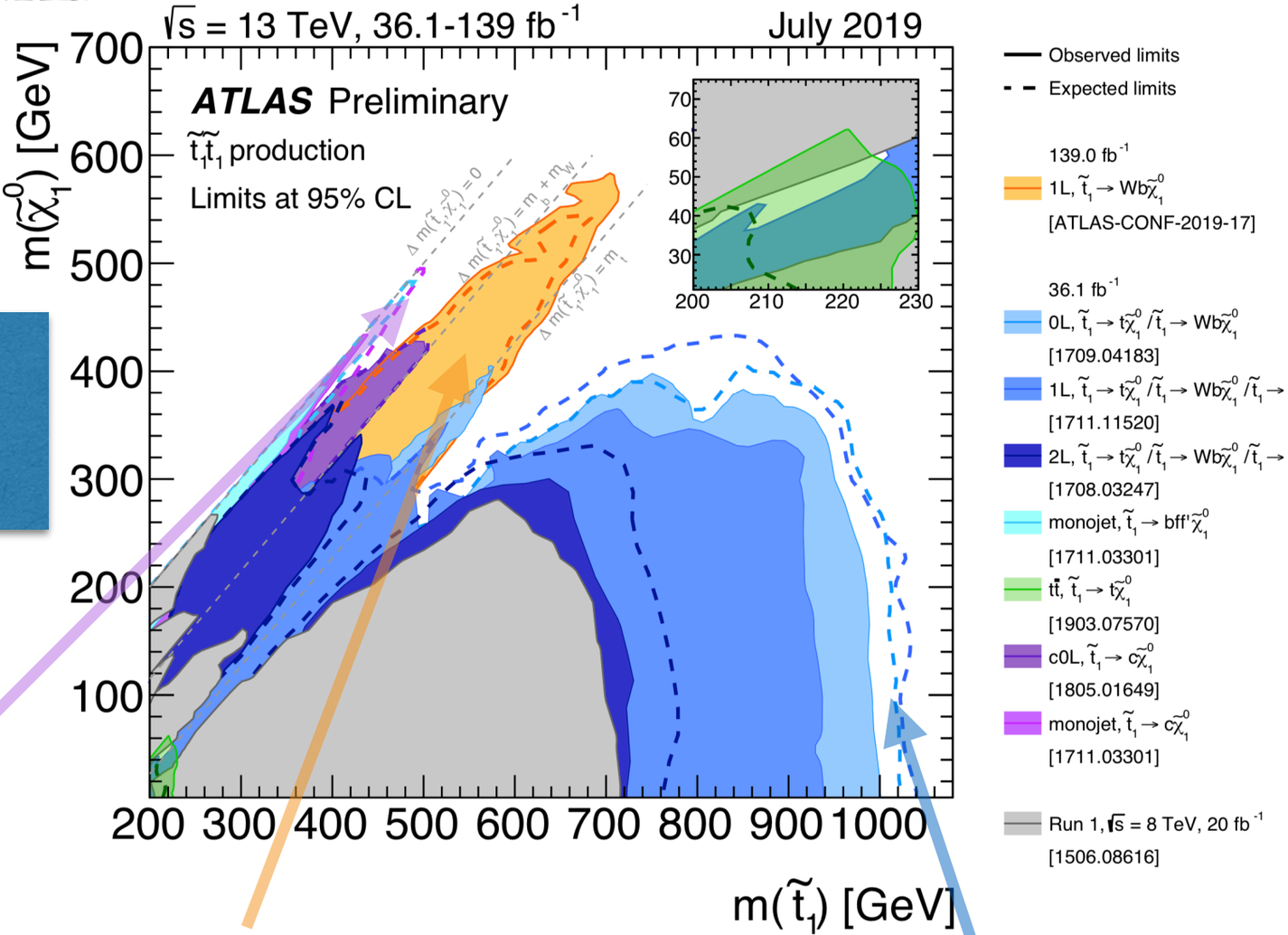
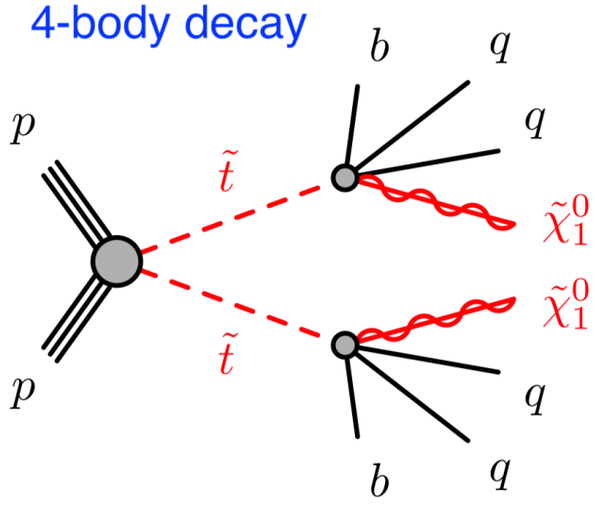
Status before this talk

Stop excluded up to 1 TeV, Neutralino excluded up to 600 GeV

Difficult to target due to low momenta of decay products

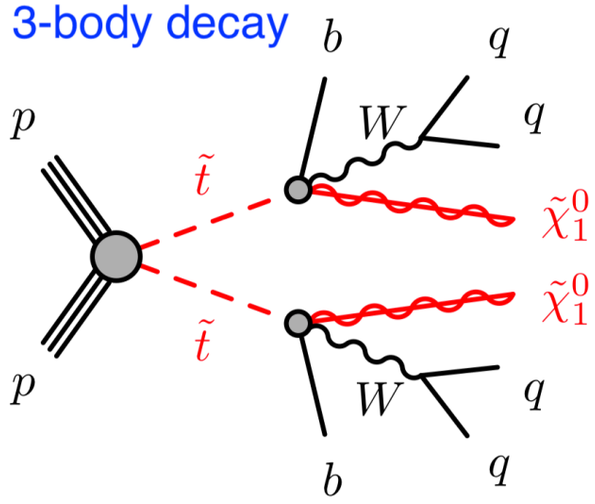


4-body decay



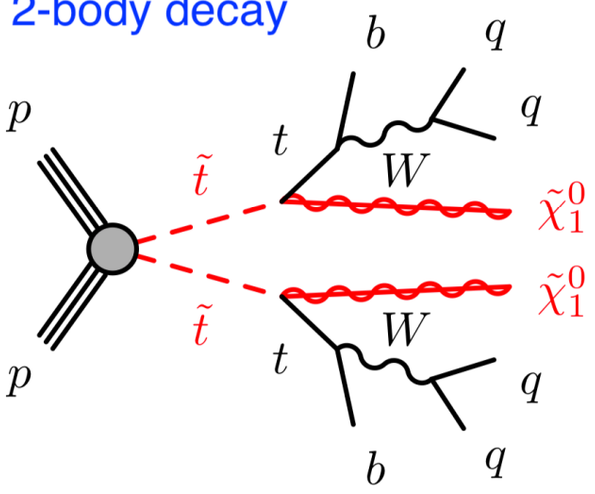
$m_{\tilde{t}} > m_{\tilde{\chi}_1^0}$

3-body decay



$m_{\tilde{t}} \geq m_W + m_b + m_{\tilde{\chi}_1^0}$

2-body decay



$m_{\tilde{t}} > m_t + m_{\tilde{\chi}_1^0}$

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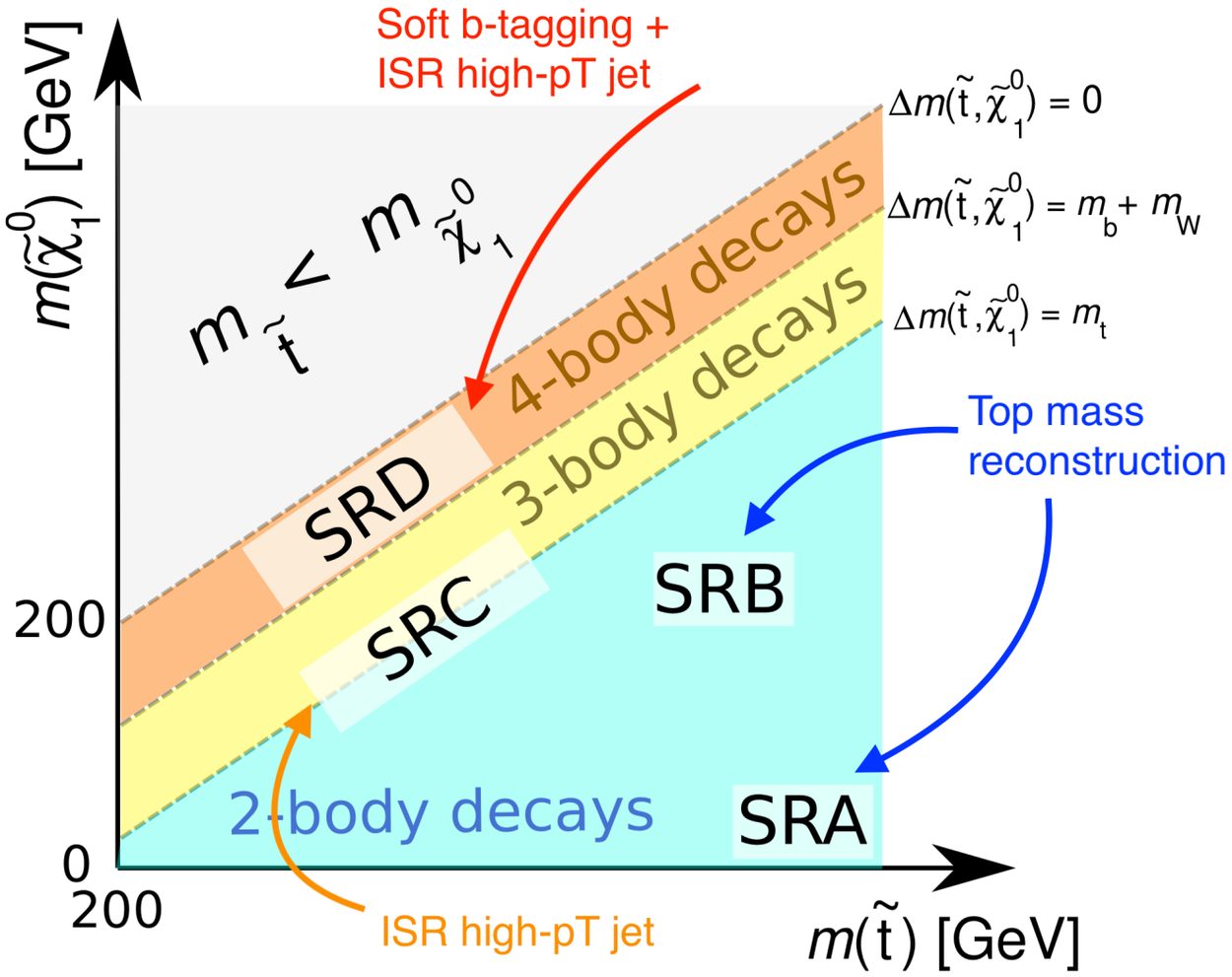
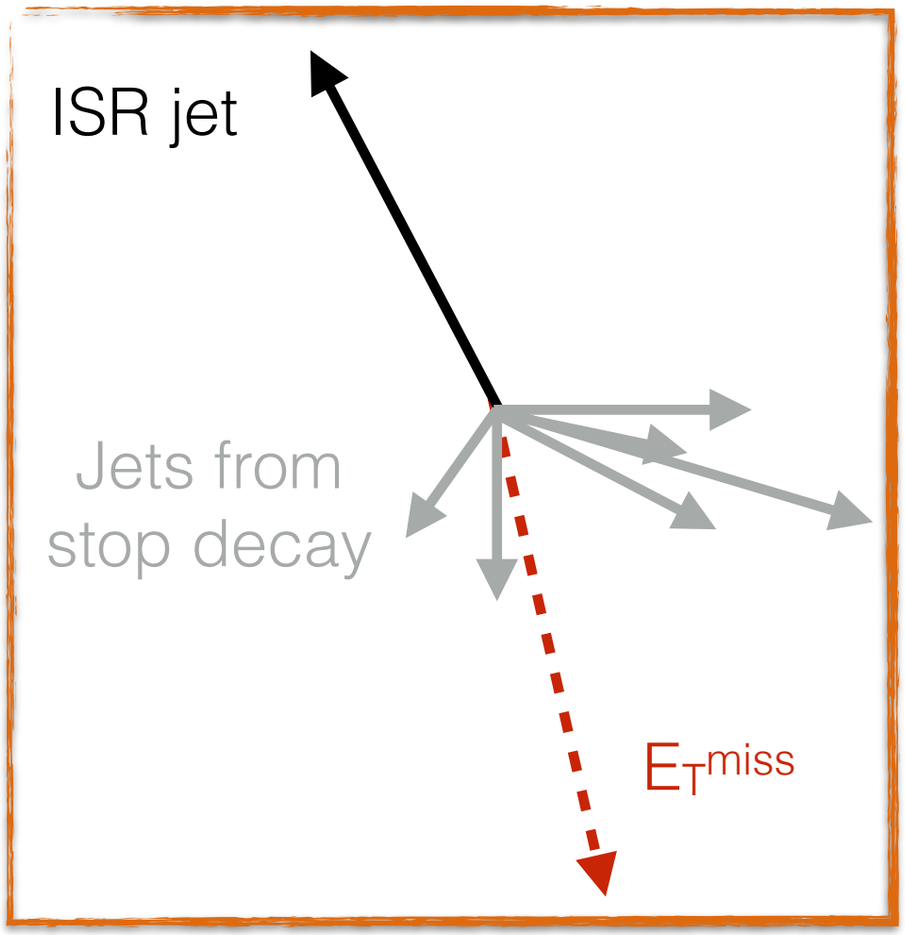
Search for stop pairs with 0 leptons

arXiv:2004.14060 (link)

- Search for stop-pairs in events with **zero leptons** (i.e. electrons and muons) and large Missing Transverse Momentum (E_T^{miss} > 250 GeV).
- **Four different sets of Signal Regions (SRA-D)** targeting different portions of the decay phase space.
- New Run 2 analysis improved with **new reconstruction techniques:** soft b-hadron tagging (b-jets down to $p_T \geq$ 5 GeV) and boosted top reconstruction.





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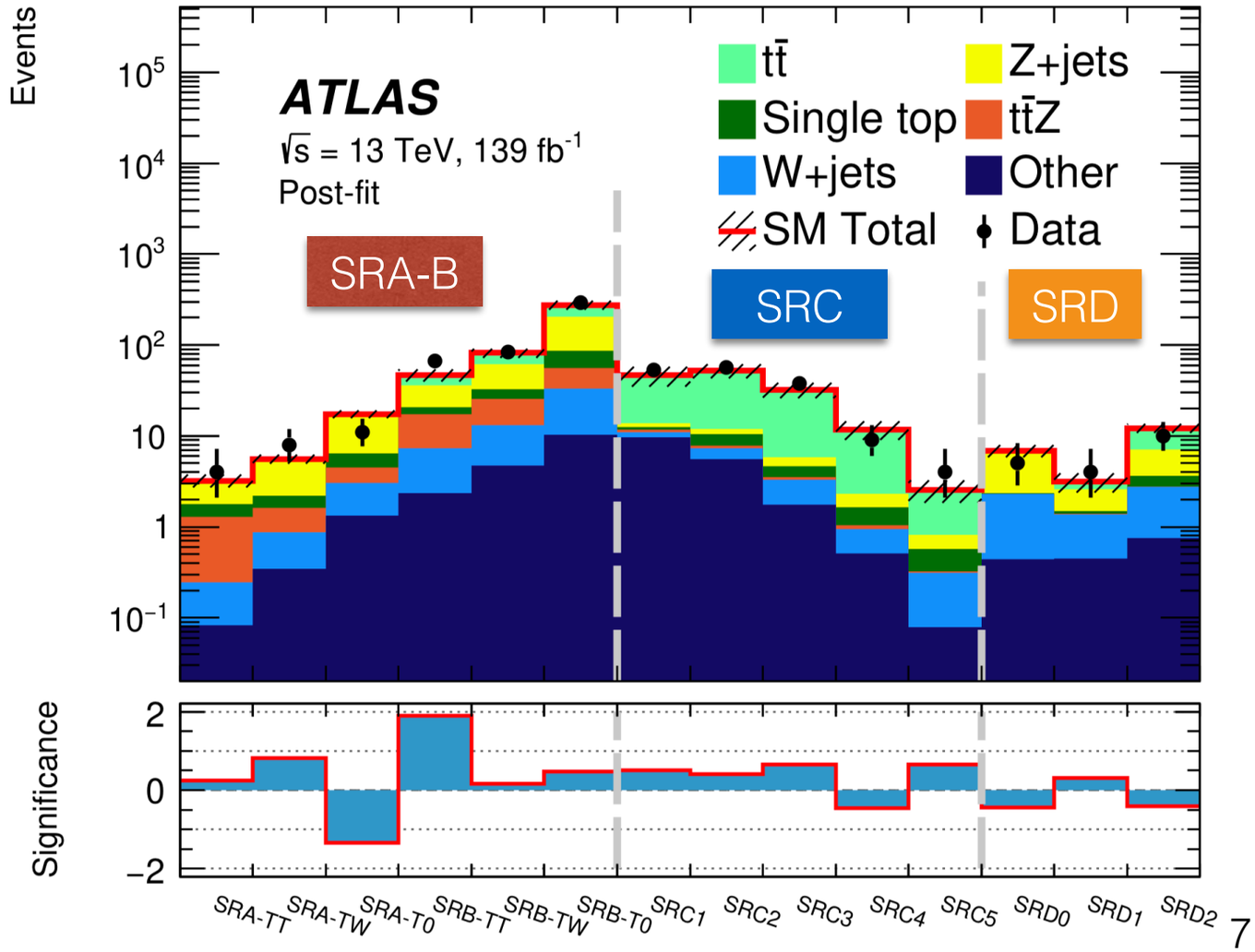
Search for stop pairs with 0 leptons

Results

- **Signal regions A-D further binned** in order to enhance sensitivity to different decay kinematics (14 SRs in total).
- **Backgrounds corrected and assessed** using dedicated orthogonal Control and Validation Regions.

No significant excess has been found

Largest deviation at 2σ significance in SRB-TT



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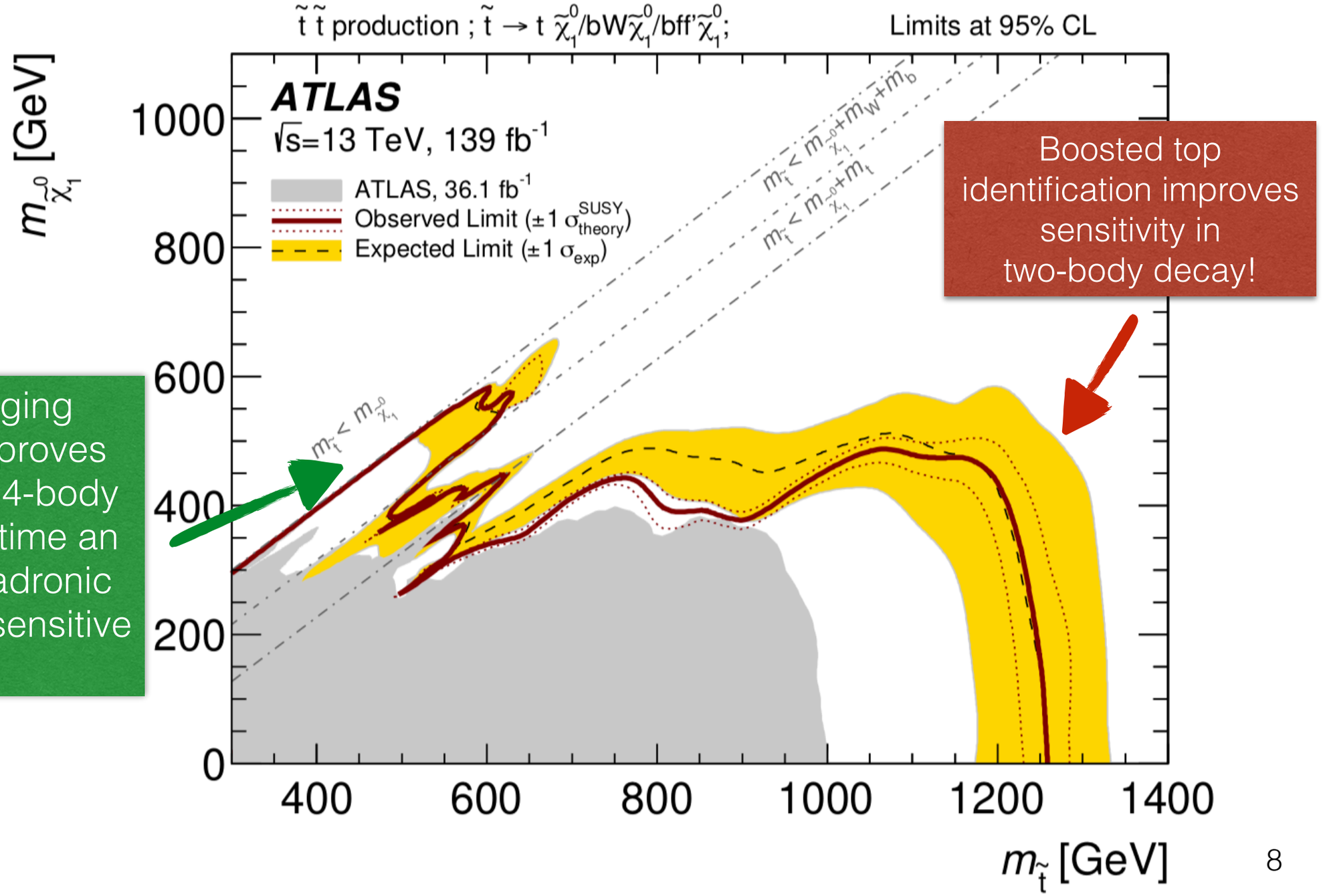
Search for stop pairs with 0 leptons

Exclusion limits

New 95% CL exclusion limits have been set.



Boosted top identification improves sensitivity in two-body decay!

Soft b-tagging largely improves sensitivity in 4-body decay! First time an ATLAS all-hadronic search is so sensitive here!

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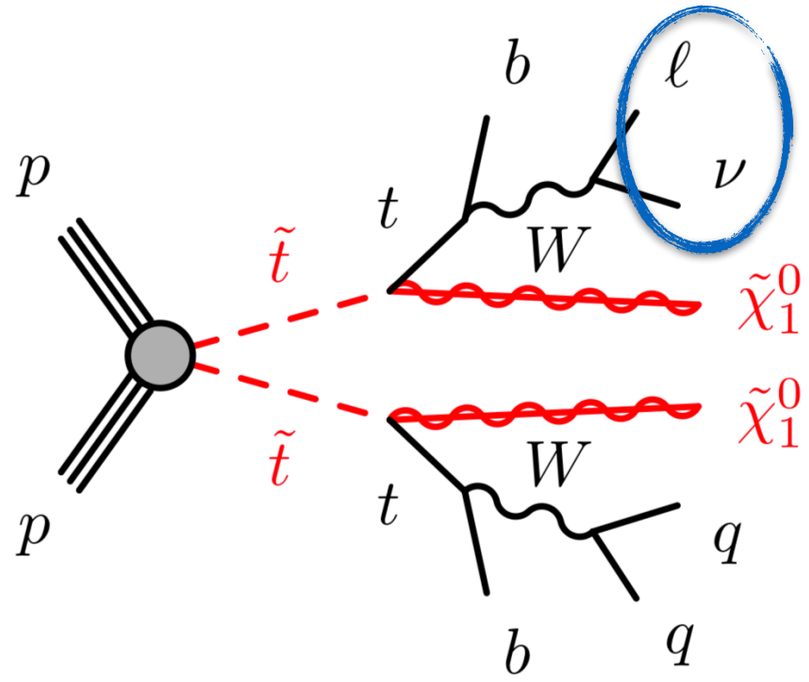
Search for stop pairs with 1 lepton

ATLAS-CONF-2020-003 (link)

- Search for stop-pairs in events with one lepton (electron or muon) and large Missing Transverse Momentum (MET).
- **6 Signal Regions in total targeting two-body and four-body decays.**
- Three-body decay previously addressed with 139 fb^{-1} statistics in a dedicated 1 lepton search ATLAS-CONF-2019-017.



Signal Regions	Target	Requirements on
tN_med, tN_high	**two-body decay**, high $\tilde{t},\tilde{\chi}$ mass splitting	**1 hard-lepton**, $N_{jets} \geq 4$, $N_{b\text{-jets}} \geq 1$, m_T, E_T^{miss}, **top reconstruction variables**, and others
tN_diag_low, tN_diag_high	**two-body decay**, low $\tilde{t},\tilde{\chi}$ mass splitting (diagonal region)	**1 hard-lepton**, $N_{jets} \geq 5$, **ISR jet** $N_{b\text{-jets}} \geq 2$, m_T, E_T^{miss}, and others
bffN_btag, bffN_softb	**4-body decay**	**1 soft lepton**, $N_{jets} \geq 1,2$, $N_{b\text{-jets}} \geq 0,1$, E_T^{miss} b-tagging, **ISR jet**, **soft b-tagging**

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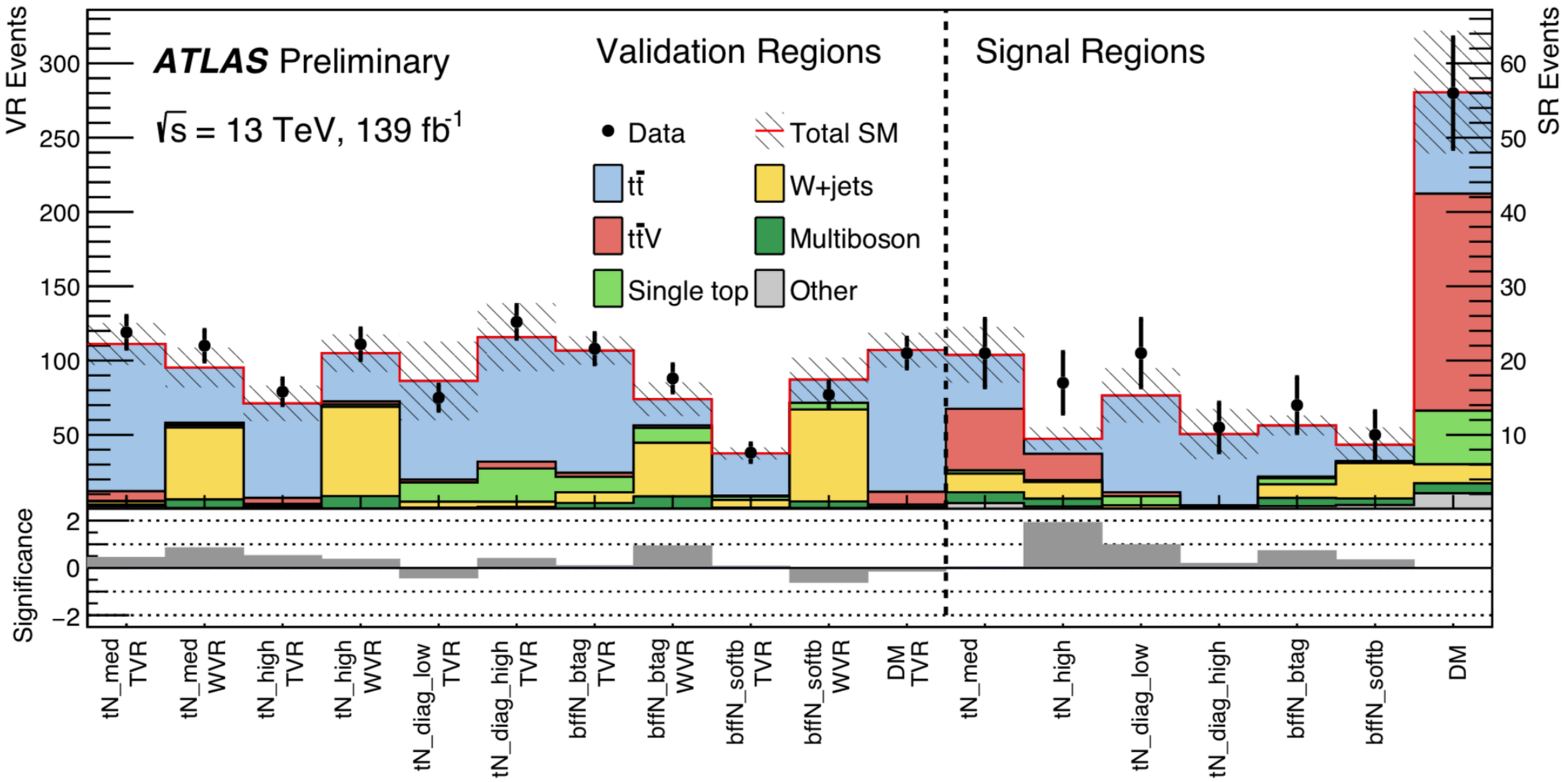
Search for stop pairs with 1 lepton

Results

- Background corrected and assessed using dedicated Control and Validation Regions.
- **No significant deviation observed** with respect to the SM prediction.



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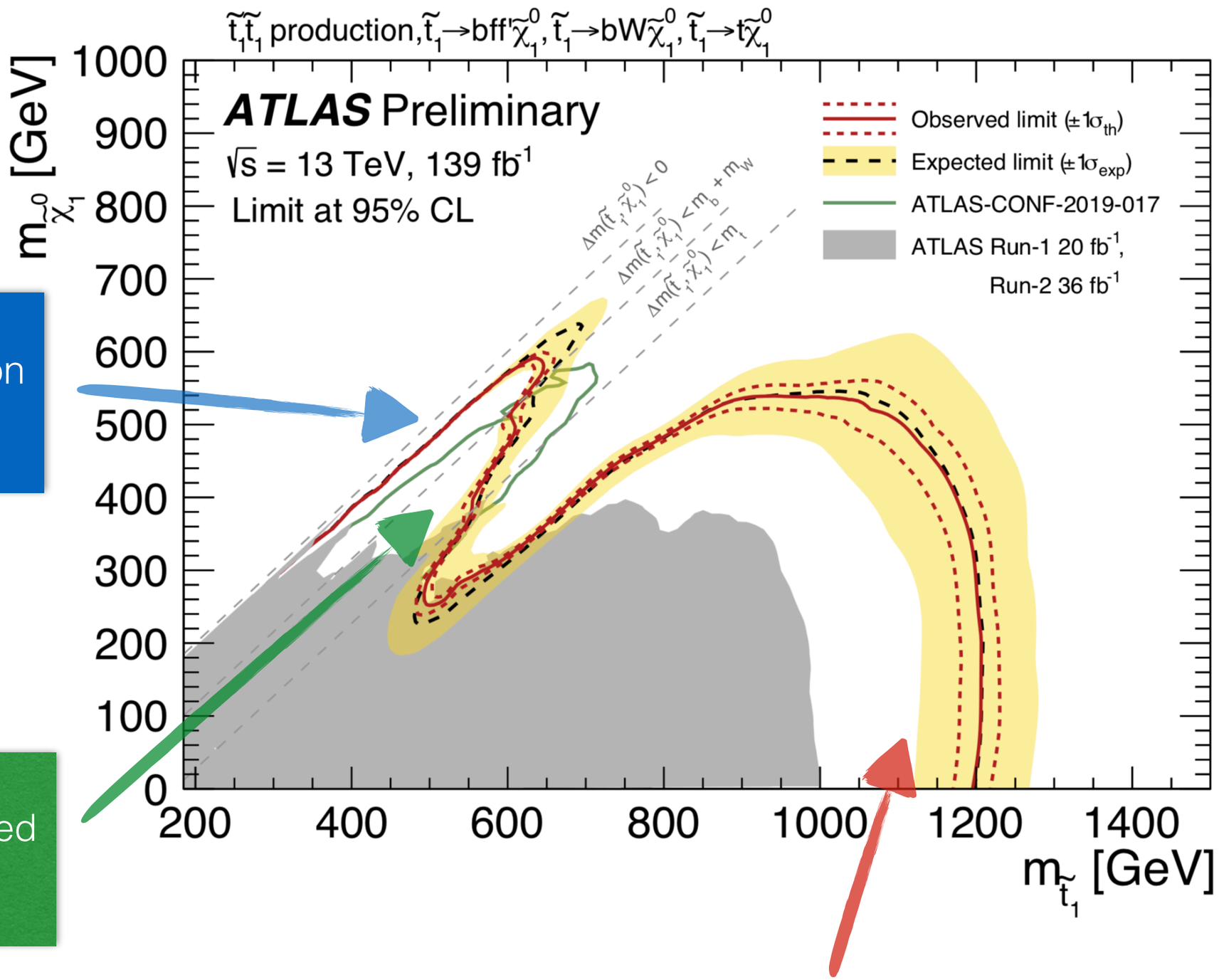
Search for stop pairs with 1 lepton

Exclusion limits

Soft b-tagging improves exclusion limits also with 1 lepton.



Best sensitivity to 3-body decay provided by dedicated 1 lepton analysis

Stop mass limit improved by ~200 GeV

Search for gluino pairs using the complete ATLAS Run 2 dataset (139 fb^{-1})

ATLAS-CONF-2020-002

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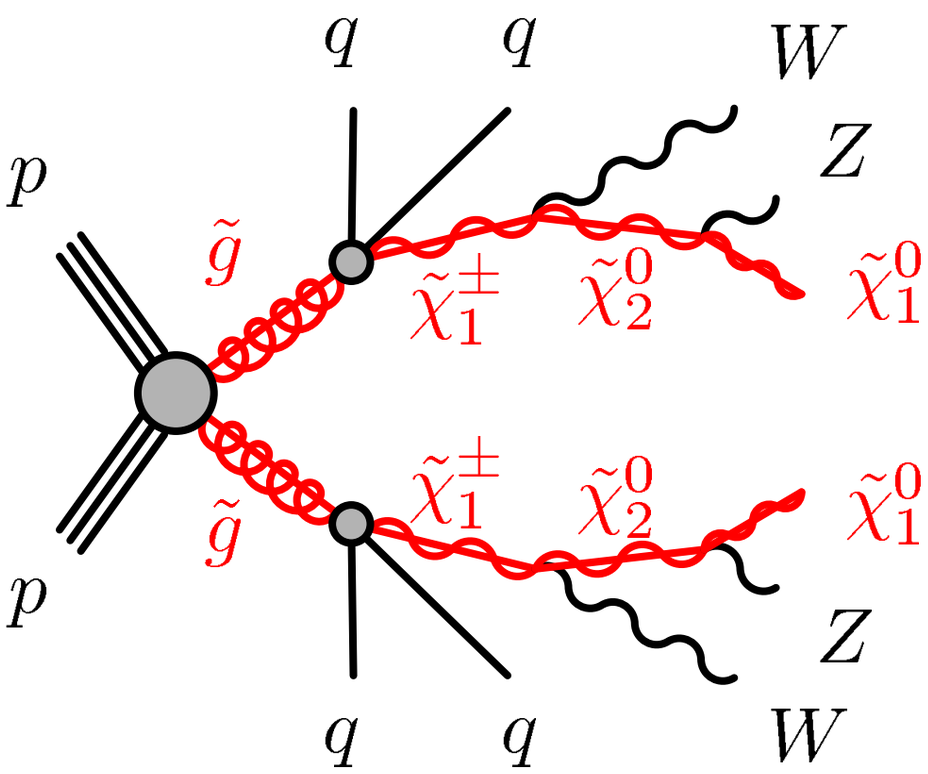
Multijets zero lepton analysis

ATLAS-CONF-2020-002 (link)

- Gluinos typically decays trough **longer decay chains** than stops.
- Signature: **zero leptons** (electrons and muons), **large jet multiplicities** (8-12 jets) and moderate MET.
- Additional requirements on b-jet multiplicities and boosted variables.

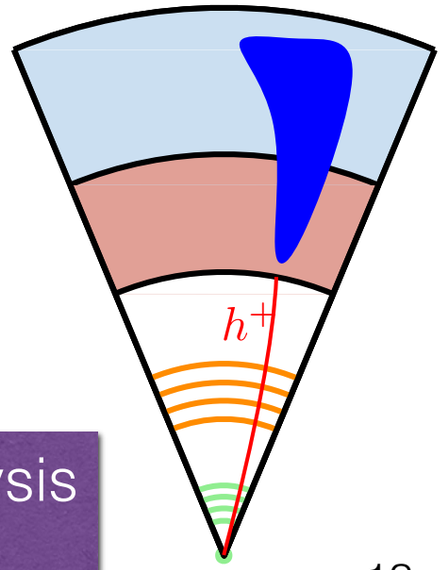
$$M_{\mathrm{J}}^{\Sigma} = \sum m_j^{R=1.0}$$

- **New reconstruction techniques:** Particle Flow jet/MET reconstruction (arXiv:1703.10485, ATLAS-CONF-2018-023) and object-based MET significance (ATLAS-CONF-2018-038).

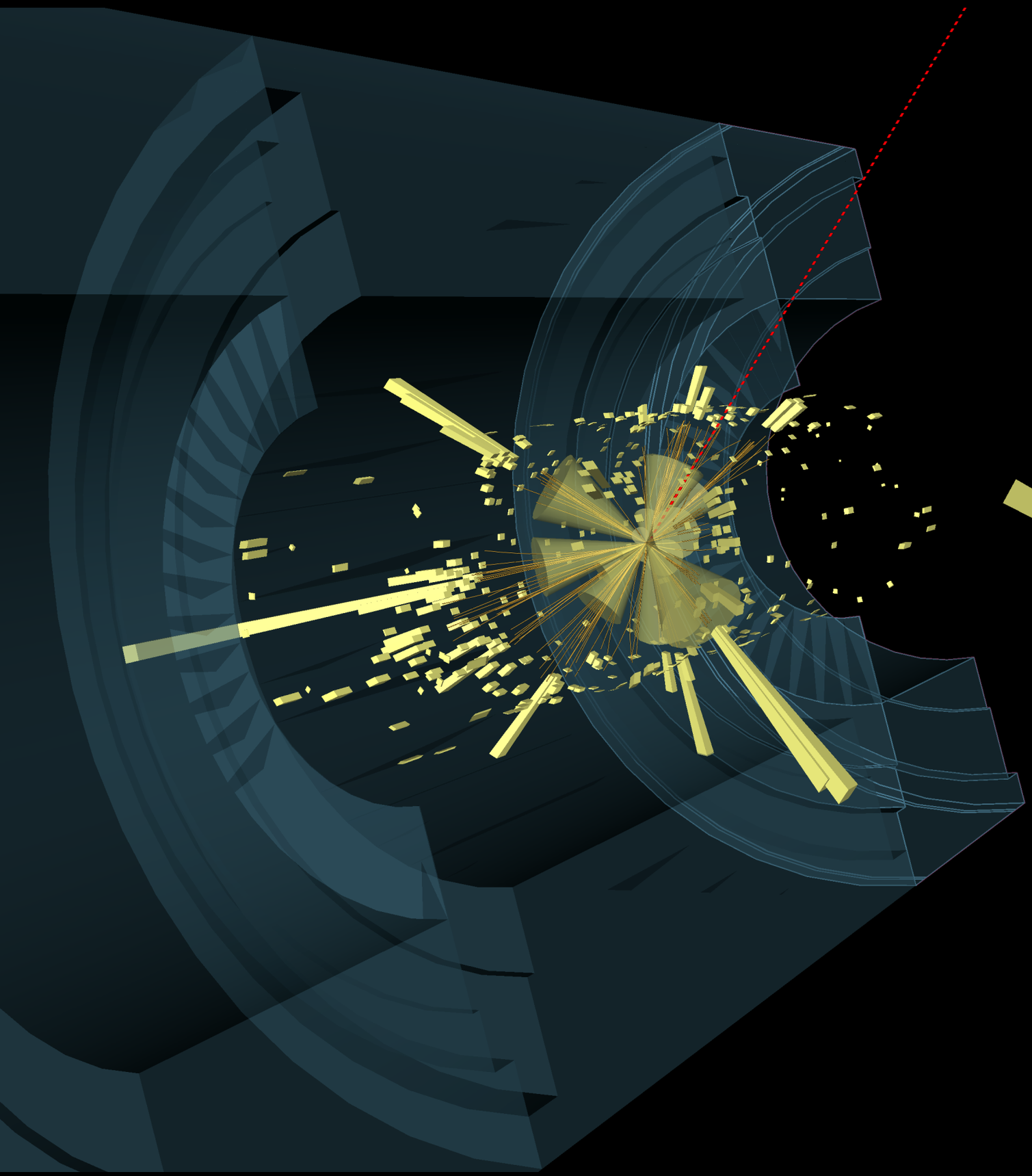


Particle Flow reconstruction

- Combination of tracker and calorimeter information.
- **Optimal jet and MET reconstruction precision**.

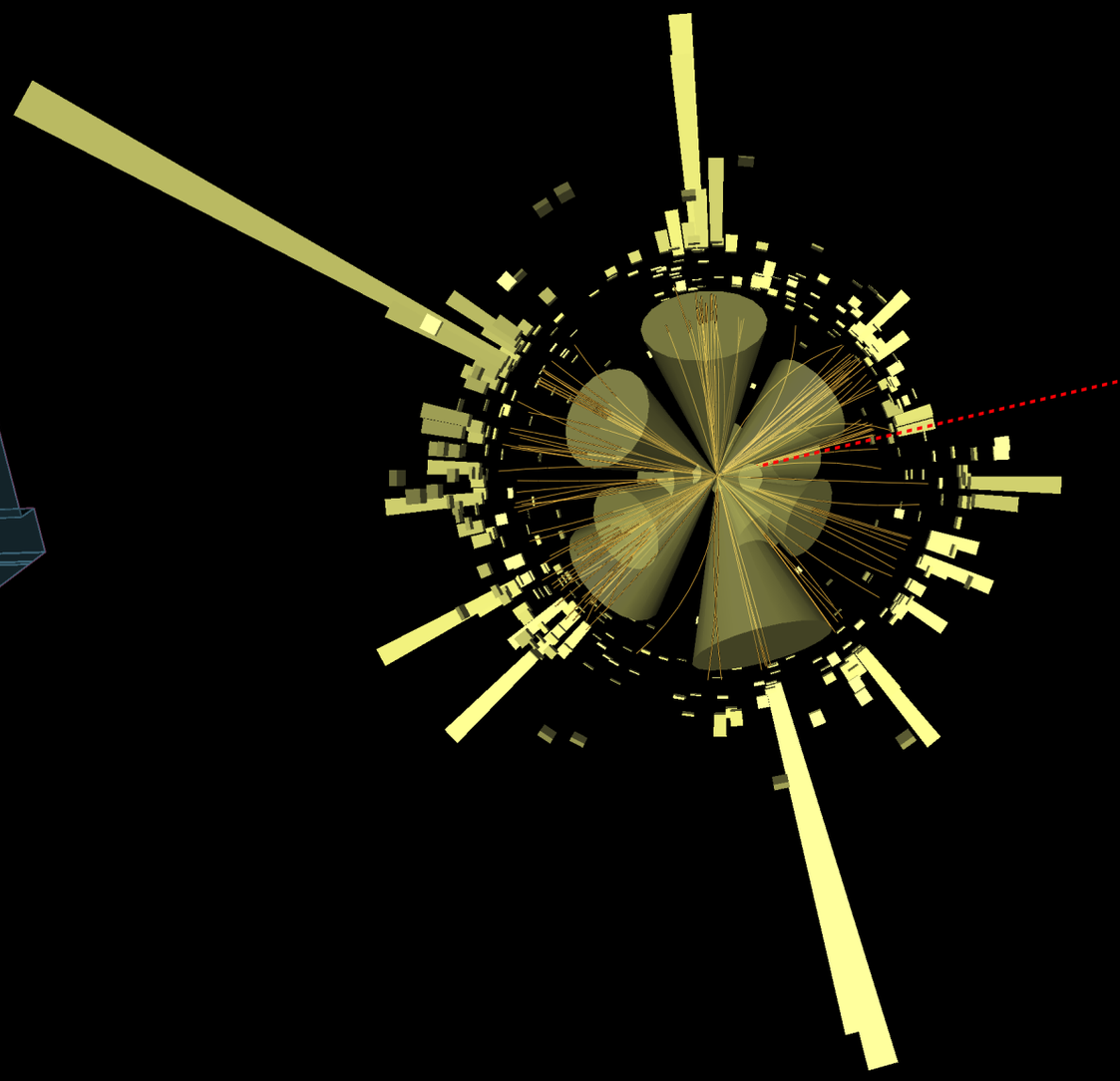


First ATLAS SUSY analysis to use Particle Flow!



ATLAS EXPERIMENT

Run: 311287
Event: 2323168151
2016-10-23 14:56:09 CEST



Events with spectacularly high jet multiplicity (16 Particle Flow jets) in SRs!

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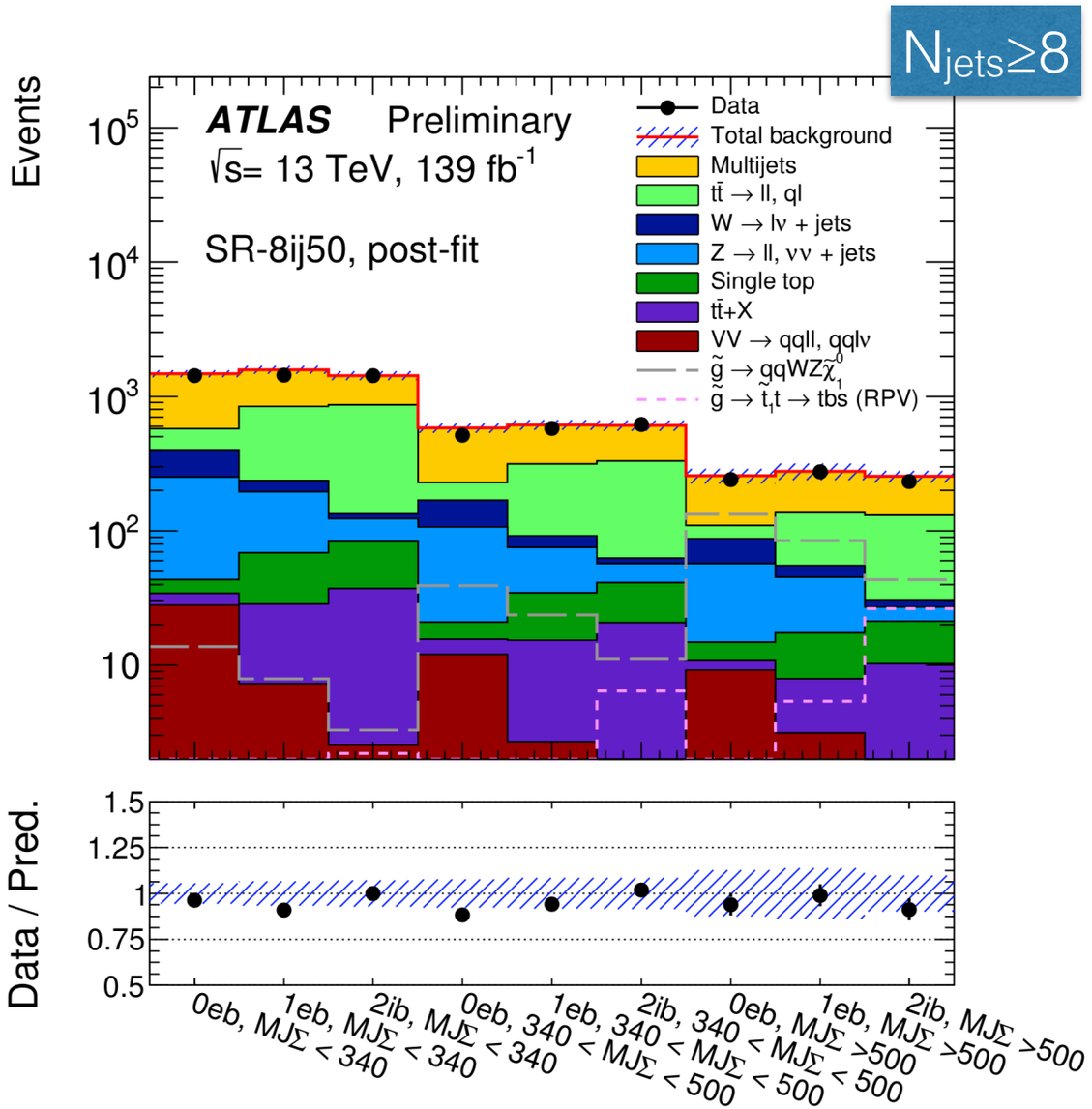
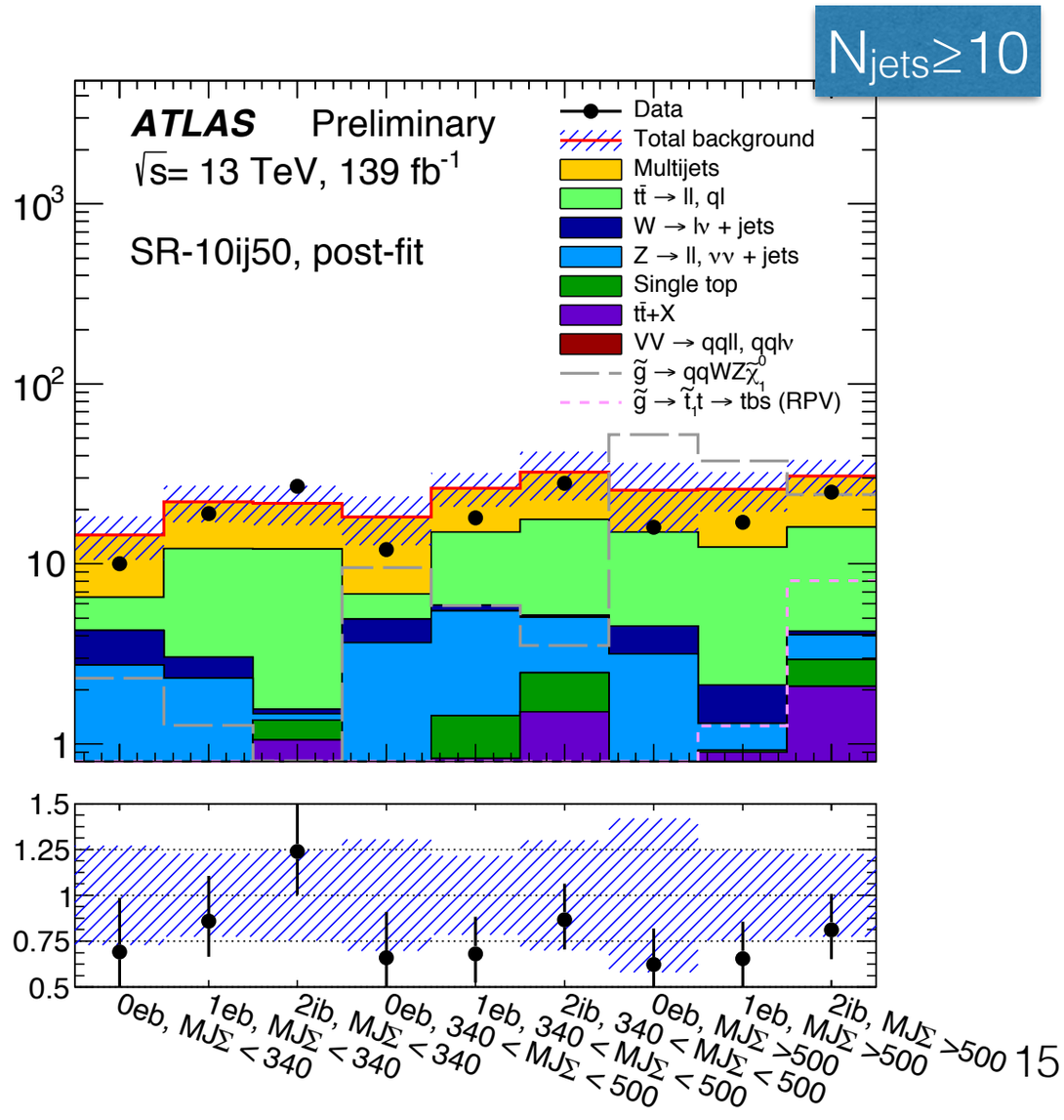
Multijets zero lepton analysis

Results

- **No excess** found above the SM prediction.
- **Multijet background** (dominant background) **reduced up to 30%** (SR dependent) thanks to Particle Flow MET reconstruction.





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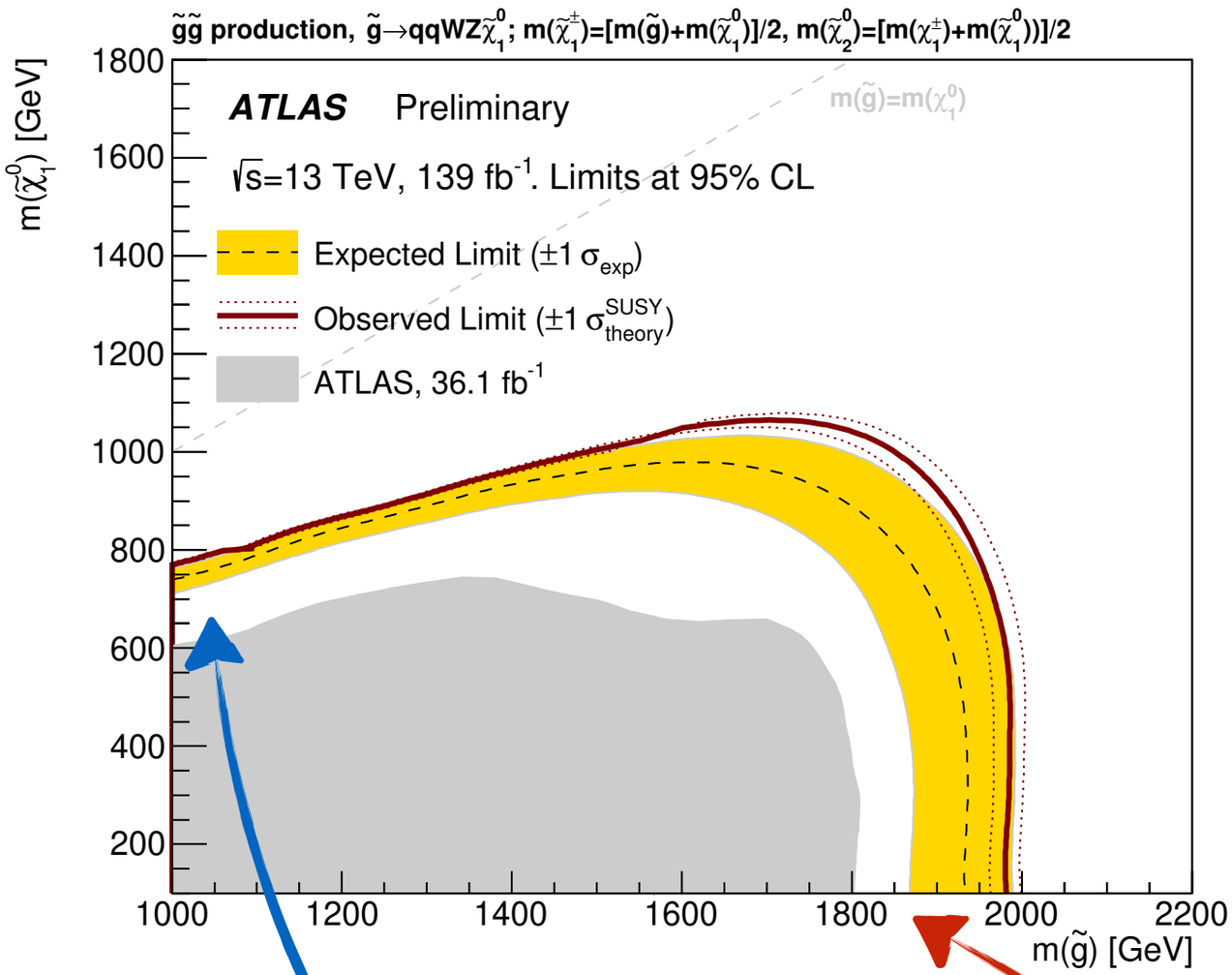
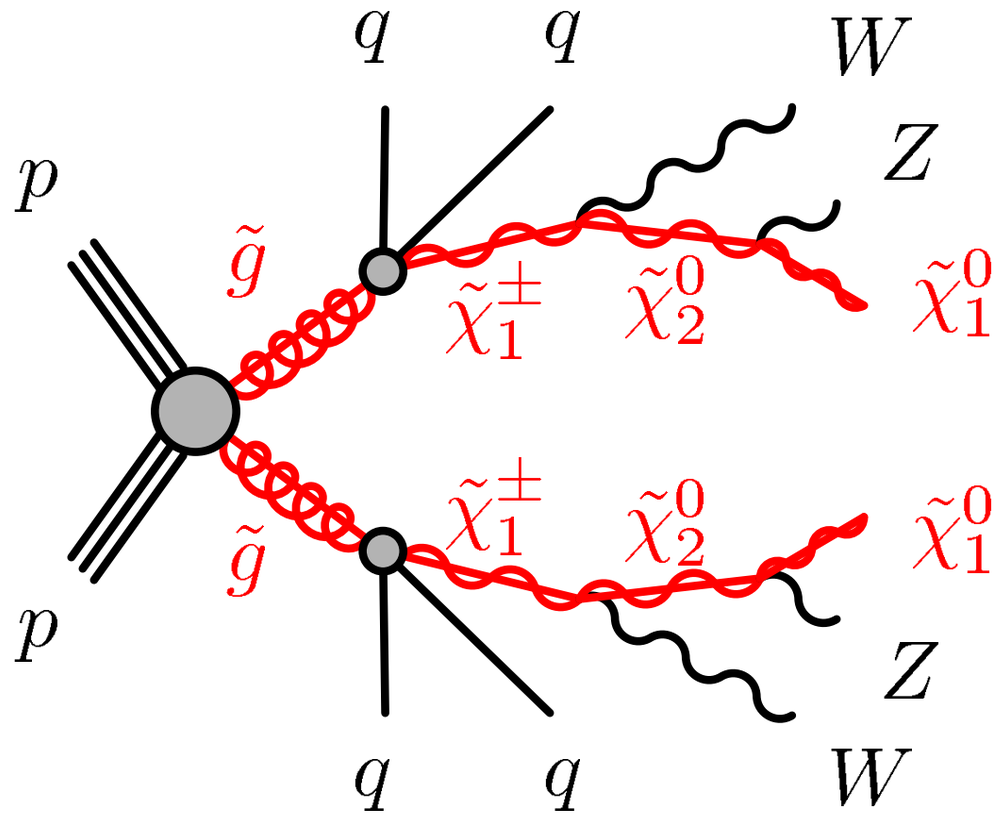
Multijets zero lepton analysis

Exclusion limits



Two-step gluino model



Neutralino mass excluded up to 1 TeV

Gluino mass excluded up to 2 TeV

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Summary

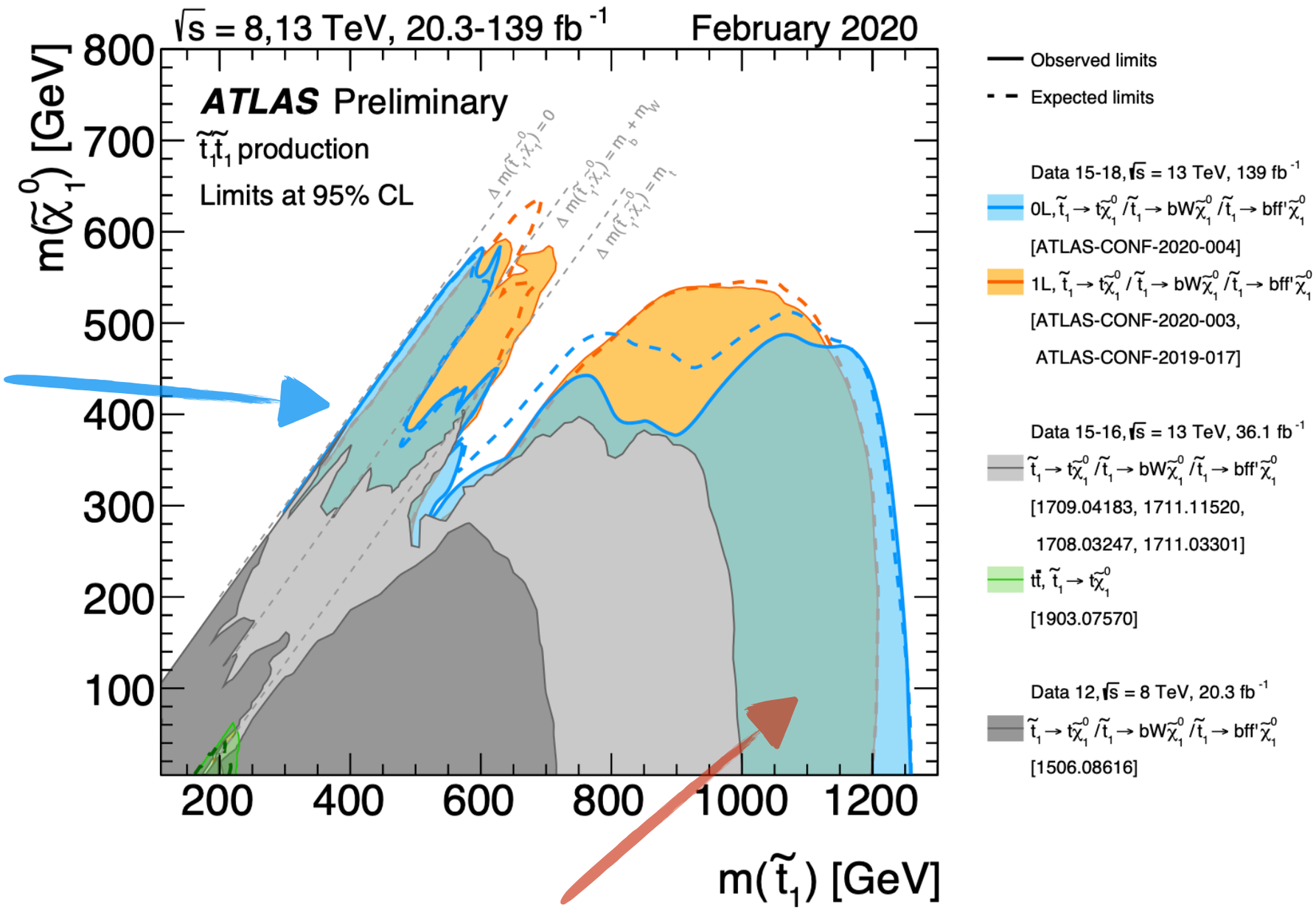
- Summarised recent results obtained by the ATLAS strong SUSY searches using the complete Run 2 dataset.
- **No excess** above the SM has been found. **Exclusion limits have been extended** by these analysis on stops (up to 1.25 TeV), gluinos (up to 2 TeV), and LSP masses.
- **Enhanced sensitivity achieved** using **improved offline reconstruction** (Particle Flow jets/MET, soft-b tagging, etc.).
- The search for SUSY continues at ATLAS. More results will follow up soon!

Stay tuned!

Backup

Updated summary of stop searches

Significant improvements in 3- and 4-body regions

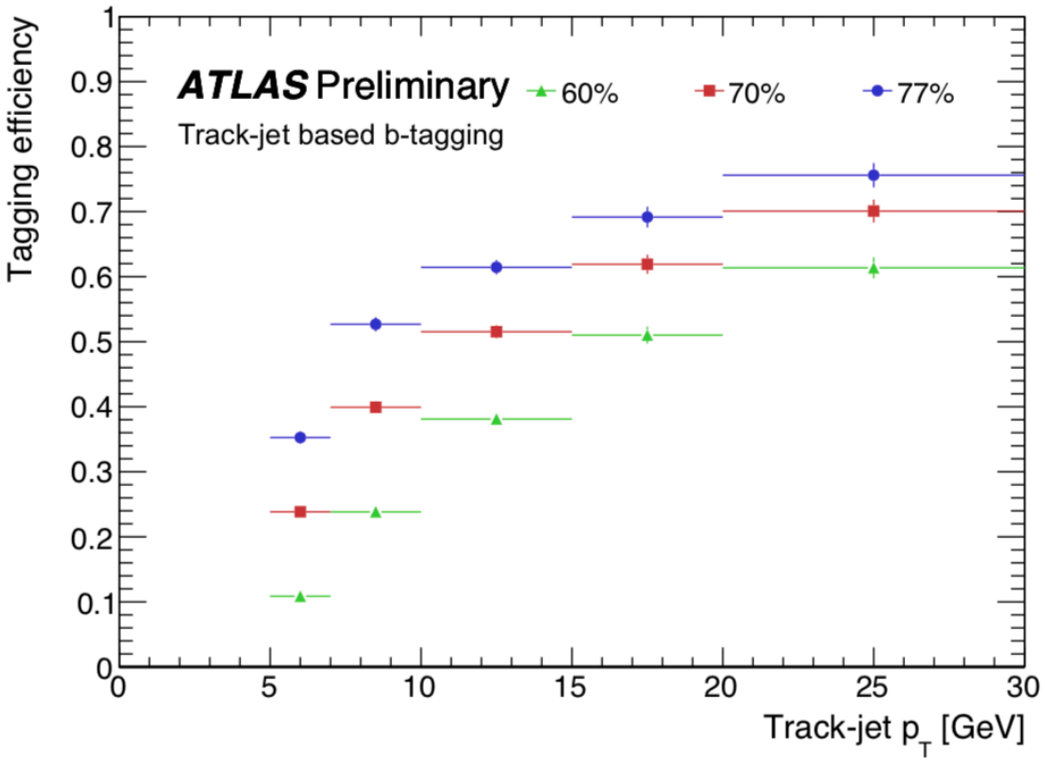


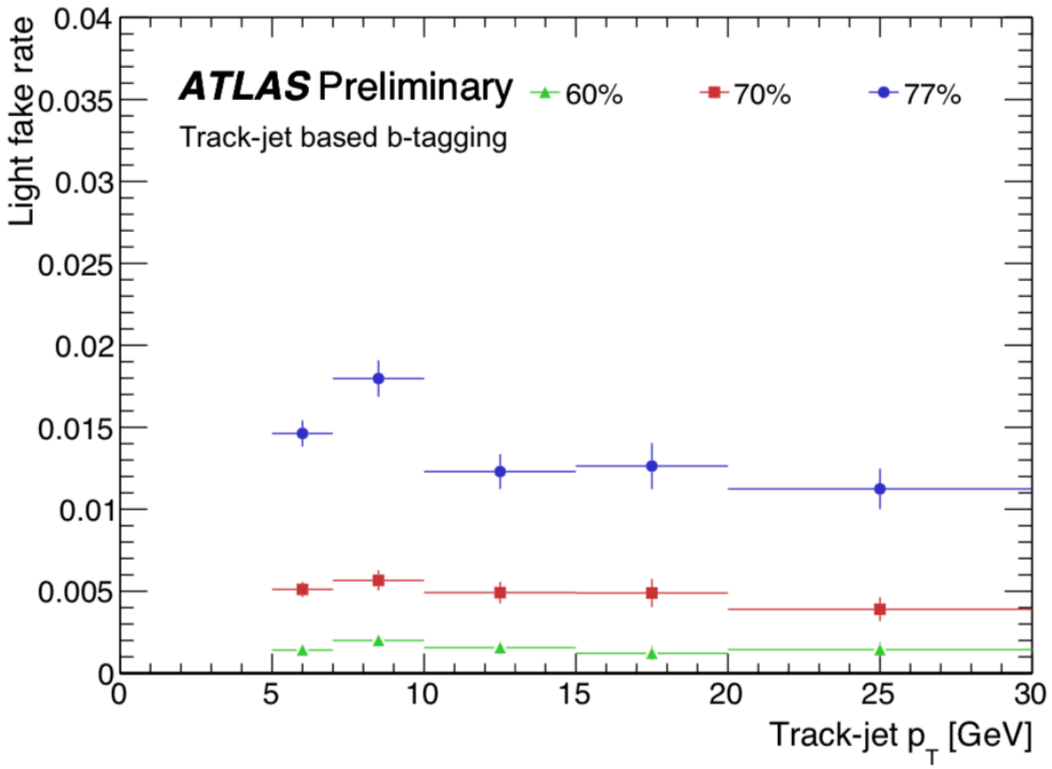
Limits on stop mass improved by ~250 GeV

Soft b-hadron tagging

ATLAS-CONF-2019-027

In order to identify low p_{T} b–hadrons that are not captured by jets passing the $p_{\mathrm{T}} > 20$ GeV requirement, "track jets" are reconstructed from inner detector tracks using the anti-k_t algorithm with radius parameter $R = 0.4$. Tracks considered for inclusion in track jets are required to have $p_{\mathrm{T}} > 500$ MeV, $|\eta| < 2.5$, at least seven hits in the silicon microstrip and pixel detectors, no more than one hit shared by multiple tracks in the pixel detector, no more than one missing hit in the pixel detector, and no more than two missing hits in the silicon microstrip detector. Additional requirements on the longitudinal impact parameter projected along the beam direction ($|z_0 \sin(\theta)| < 3$ mm) reduce the pileup contributions and improve the efficiency in selecting tracks from the hard-scatter vertex. Track jets are required to have $p_{\mathrm{T}} > 5$ GeV, more than one track, $|\eta| < 2.5$, and not overlap with the leading non-b–tagged jet in the event ($\Delta R > 0.4$). The standard b–tagging algorithm is employed on track jets [107] and a tighter selection requirement is applied with respect to regular jets, due to the larger amount of background at low p_{T}. The average identification efficiency of jets containing b–hadrons is 70% as determined in simulated $t\bar{t}$ events. Using the same simulated sample, a rejection factor of approximately 200 (10) is reached for jets initiated by light quarks and gluons (charm quarks).





Search for stop pairs with 0 leptons

Definitions of SRA-B

Table 2: Selection criteria for SRA and SRB. Each signal region is separated into three categories based on reconstructed top candidate masses. A dash indicates that no selection is applied.

Variable/SR	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Trigger	$E_{\mathrm{T}}^{\mathrm{miss}}$					
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 250 GeV					
N_{ℓ}	exactly 0					
N_{j}	≥ 4					
$p_{\mathrm{T},2}$	> 80 GeV					
$p_{\mathrm{T},4}$	> 40 GeV					
$\lvert\Delta\phi_{\mathrm{min}}\left(\mathbf{p}_{\mathrm{T},1-4}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\rvert$	> 0.4					
N_b	≥ 2					
$m_{\mathrm{T}}^{b,\mathrm{min}}$	> 200 GeV					
τ-veto	✓					
$m_1^{R=1.2}$	> 120 GeV					
$m_2^{R=1.2}$	> 120 GeV	$60 - 120$ GeV	< 60 GeV	> 120 GeV	$60 - 120$ GeV	< 60 GeV
$m_1^{R=0.8}$	> 60 GeV			–		
$j_1^{R=1.2}(b)$	✓			–		
$j_2^{R=1.2}(b)$	✓	–				
$\Delta R\,(b_1, b_2)$	> 1.0	–		> 1.4		
$m_{\mathrm{T}}^{b,\mathrm{max}}$	–			> 200 GeV		
$\mathcal{S}$	> 25			> 14		
m_{T2,χ^2}	> 450 GeV			< 450 GeV		

Search for stop pairs with 0 leptons

Definitions of SRC

Table 3: Selection criteria for SRC. The signal regions are separated into five categories based on ranges of R_{ISR}.

Variable/SR	**SRC1**	**SRC2**	**SRC3**	**SRC4**	**SRC5**
Trigger	$E_{\mathrm{T}}^{\mathrm{miss}}$				
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 250 GeV				
N_{ℓ}	exactly 0				
$\mathrm{N_j}$	≥ 4				
$p_{\mathrm{T},2}$	> 80 GeV				
$p_{\mathrm{T},4}$	> 40 GeV				
N_b	≥ 2				
$E_{\mathrm{T}}^{\mathrm{miss,track}}$	> 30 GeV				
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss,track}}\right)\right\rvert$	$< \pi/3$				
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T},1-2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\rvert$	> 0.4				
$\mathrm{N_j^S}$	≥ 4				
$p_{\mathrm{T}}^{\mathrm{ISR}}$	> 400 GeV				
$p_{\mathrm{T},1}^{\mathrm{S},b}$	> 50 GeV				
$p_{\mathrm{T},4}^{\mathrm{S}}$	> 50 GeV				
m_{S}	> 400 GeV				
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{ISR}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\rvert$	> 3.0				
R_{ISR}	$0.30 - 0.40$	$0.40 - 0.50$	$0.50 - 0.60$	$0.60 - 0.70$	> 0.70

$$R_{\mathrm{ISR}} \equiv \frac{E_{\mathrm{T}}^{\mathrm{miss}}}{p_{\mathrm{T}}^{\mathrm{ISR}}} \sim \frac{m_{\tilde{\chi}_1^0}}{m_{\tilde{t}}}.$$

Search for stop pairs with 0 leptons

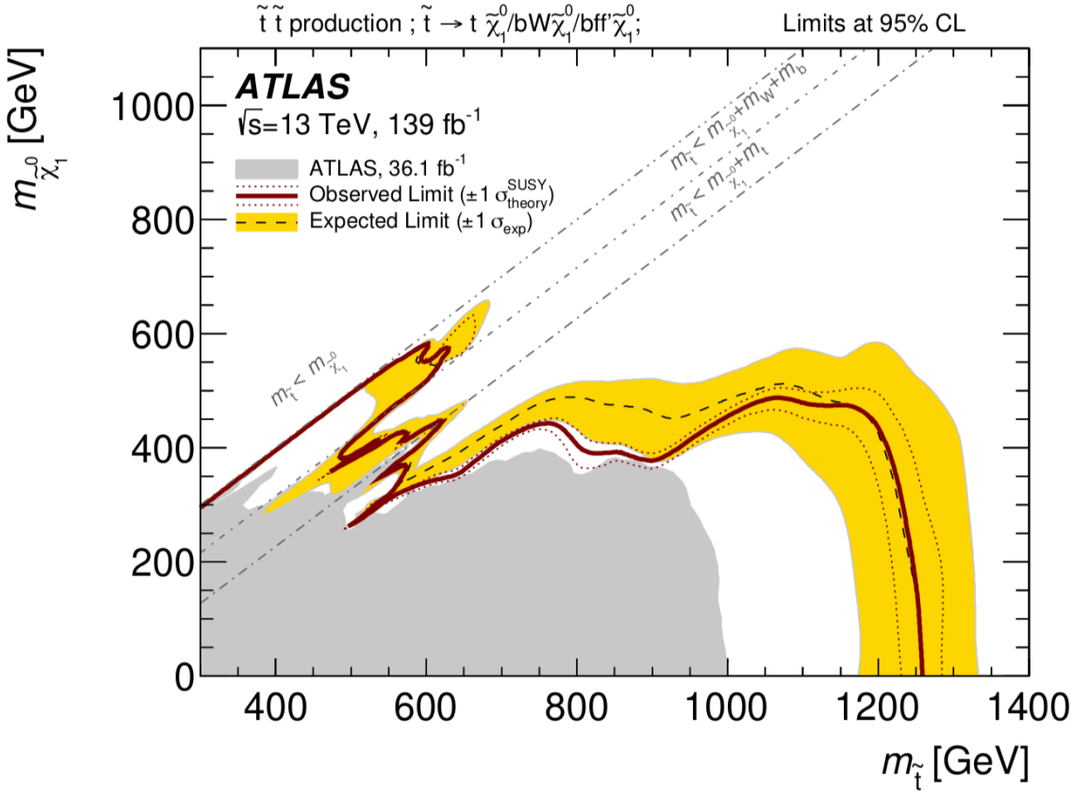
Definitions of SRD

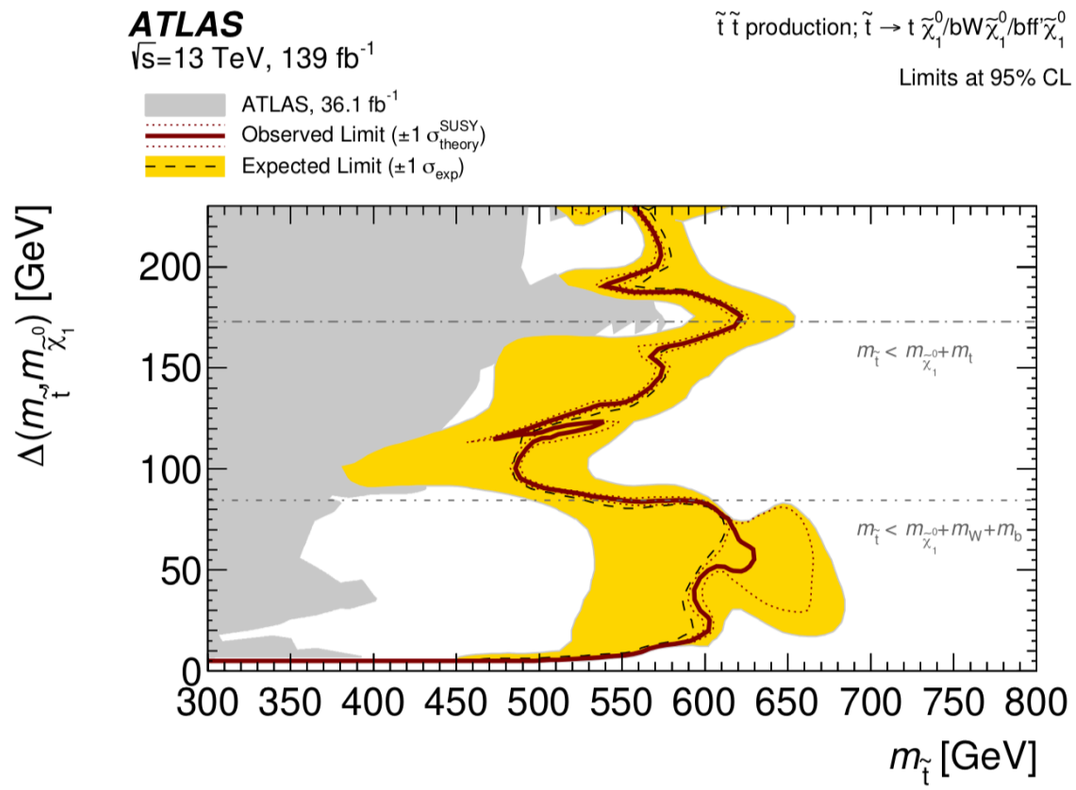
Table 4: Signal region selections for SRD. Variables involving track jets are denoted with the label "track". A dash indicates that no selection is applied.

Variable/SR	**SRD0**	**SRD1**	**SRD2**
Trigger	$E_{\mathrm{T}}^{\mathrm{miss}}$		
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 250 GeV		
N_{ℓ}	exactly 0		
N_{b}	exactly 0	exactly 1	≥ 2
$p_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}$	> 250 GeV		
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\rvert$	> 2.4		
$E_{\mathrm{T}}^{\mathrm{miss,track}}$	> 30 GeV		
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss,track}}\right)\right\rvert$	$< \pi/3$		
$\mathrm{N}_{b}^{\mathrm{track}}$	≥ 1		–
$\left\lvert\Delta\phi_{\mathrm{min}}\left(\mathbf{p}_{\mathrm{T},1-4}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\rvert$	> 0.4	–	
$\lvert\eta_{1}^{b,\mathrm{track}}\rvert$	< 1.2	–	
$\max\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T}}^{b^{\mathrm{track}}}\right)\right\rvert$	> 2.2	–	
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T},1}^{b^{\mathrm{track}}}, \mathbf{p}_{\mathrm{T},2}^{b^{\mathrm{track}}}\right)\right\rvert$	< 2.5	–	
$p_{\mathrm{T},1}^{b,\mathrm{track}}$	< 50 GeV	> 10 GeV	–
$p_{\mathrm{T},1}^{\mathrm{track}}$	–	< 40 GeV	–
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T},1-4}^{\mathrm{j}^{\mathrm{track}}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}\right)\right\rvert$	–	> 1.2	–
$\lvert\eta_{1}^{b}\rvert$	–	< 1.6	–
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T},1}^{b}\right)\right\rvert$	–	> 2.2	
$\lvert\eta_{2}^{b}\rvert$	–		< 1.2
$p_{\mathrm{T},1}^{b}$	–		< 175 GeV
$\left\lvert\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T},2}^{b}\right)\right\rvert$	–		> 1.6
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 26\sqrt{\mathrm{GeV}}$	$> 22\sqrt{\mathrm{GeV}}$	

Search for stop pairs with 0 leptons

Exclusion limits





Search for stop pairs with 1 lepton

Preselections

Table 3: Preselection criteria used for the hard lepton signal regions (left) and the soft lepton signal regions (right).

Selection		**hard-lepton**	**soft-lepton**
Trigger		$E_{\mathrm{T}}^{\mathrm{miss}}$ trigger	
Data quality		jet cleaning, primary vertex	
Second-lepton veto		no additional baseline leptons	
Number of leptons, tightness		= 1 'loose' lepton	= 1 'tight' lepton
Lepton p_{T}	[GeV]	> 25	> 4(4.5) for $\mu(e)$
Number of jets	(jet p_{T})	≥ 4 (25 GeV)	≥ 1 (200 GeV) or ≥ 2 (20 GeV)
$E_{\mathrm{T}}^{\mathrm{miss}}$	[GeV]	> 230	
$\Delta\phi(j_{1,2}, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})$	[rad]	> 0.4	
$N_{b\text{-jet}}$		≥ 1	–
m_{T}	[GeV]	> 30	–
m_{T2}^{τ}	[GeV]	> 80	–

Search for stop pairs with 1 lepton

tN signal regions

Table 4: Event selections defining the signal regions `tN_med` and `tN_high`.

Selection		`tN_med`	`tN_high`
Preselection		hard-lepton preselection	
N_{jet}, $N_{b\text{-jet}}$		$\geq (4, 1)$	$\geq (4, 1)$
Jet p_{T}	[GeV]	$> (100, 90, 70, 50)$	$> (120, 50, 50, 25)$
$E_{\text{T}}^{\text{miss}}$	[GeV]	> 230	> 520
$E_{\text{T},\perp}^{\text{miss}}$	[GeV]	> 400	-
$H_{\text{T,sig}}^{\text{miss}}$		> 16	> 25
m_{T}	[GeV]	> 220	> 380
topness		> 9	> 8
$m_{\text{top}}^{\text{reclustered}}$	[GeV]	> 150	
$\Delta R(b, \ell)$		< 2.8	< 2.6
Exclusion technique		Based on shape-fit in $E_{\text{T}}^{\text{miss}}$ and m_{T} in `tN_med`	
Bin boundaries	[GeV]	$E_{\text{T}}^{\text{miss}} \in [230, 400]$, $m_{\text{T}} > 220$ $E_{\text{T}}^{\text{miss}} \in [400, 500]$, $m_{\text{T}} > 220$ $E_{\text{T}}^{\text{miss}} \in [500, 600]$, $m_{\text{T}} \in [220, 380]$ $E_{\text{T}}^{\text{miss}} \in [500, 600]$, $m_{\text{T}} > 380$ $E_{\text{T}}^{\text{miss}} > 600$, $m_{\text{T}} \in [220, 380]$ $E_{\text{T}}^{\text{miss}} > 600$, $m_{\text{T}} > 380$	

Topness variable: how well an event can be reconstructed under a top hypothesis

$$\mathcal{S}(p_{Wx}, p_{Wy}, p_{Wz}, p_{\nu z}) = \frac{(m_W^2 - p_W^2)^2}{a_W^4} + \frac{(m_t^2 - (p_{b1} + p_\ell + p_\nu)^2)^2}{a_t^4} + \frac{(m_t^2 - (p_{b2} + p_W)^2)^2}{a_t^4} + \frac{(4m_t^2 - (\Sigma_i p_i)^2)^2}{a_{\text{CM}}^4},$$

Search for stop pairs with 1 lepton

tN_diag signal regions

Table 5: Event selections defining the signal regions `tN_diag_low` and `tN_diag_high`.

Selection		`tN_diag_low`	`tN_diag_high`
Preselection		hard-lepton preselection without τ-veto	
N_{jet}, $N_{b\text{-jet}}$		$\geq (4, 1)$	
Jet p_{T}	[GeV]	$> (400, 40, 40, 40)$	
m_{T}	[GeV]	> 150	> 110
$E_{\text{T}}^{\text{miss}}$	[GeV]	–	> 400
m_{T2}	[GeV]	–	< 360
$\Delta m_{\text{T}}^{\alpha}$	[GeV]	> 40	–
$\Delta m_{\text{T}}^{\text{dyn}}$	[GeV]	–	> 60
$m_{\tilde{t}_1}^{\text{lep}}$	[GeV]	< 600	–
$m_{\tilde{\chi}_1^0}^{\text{dyn}}$	[GeV]	> 5	[220, 595]
x_1		–	> -0.2
Exclusion technique		cut-and-count	

Search for stop pairs with 1 lepton

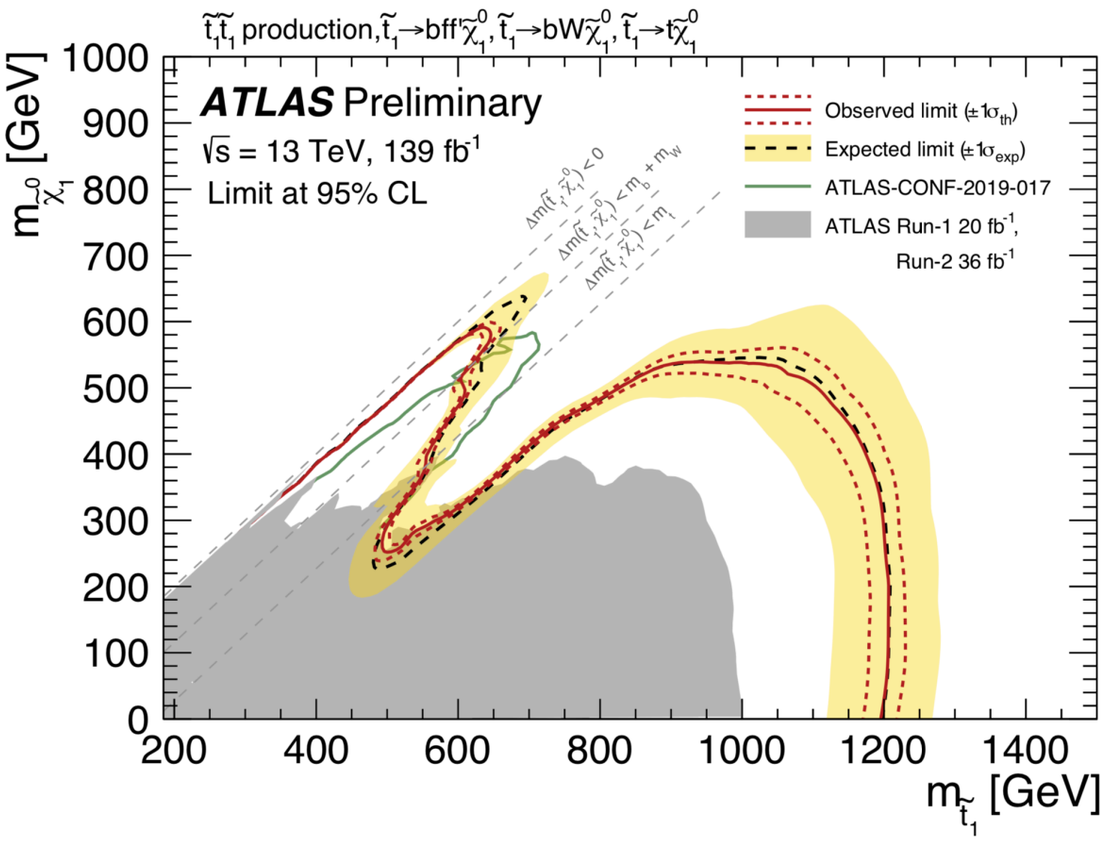
bffN signal regions

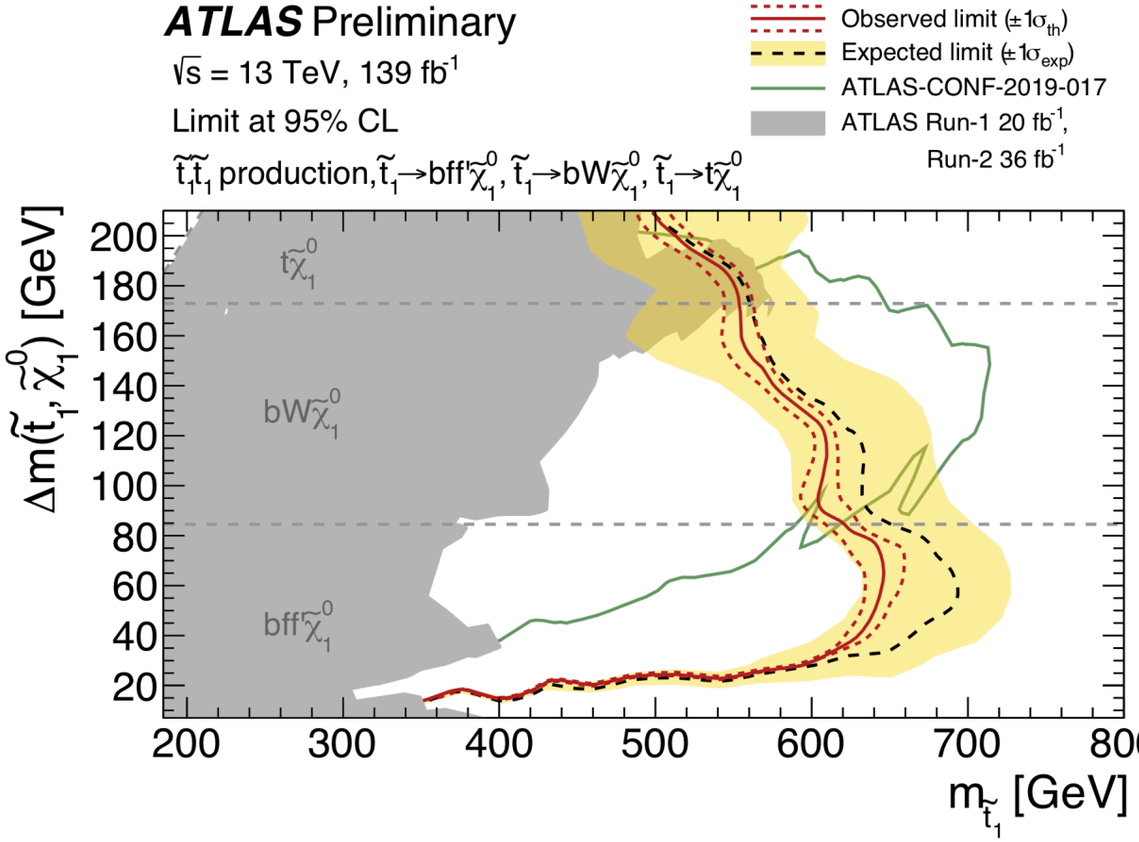
Table 6: Event selections defining the signal regions `bffN_softb` and `bffN_btag`.

Selection		`bffN_softb`	`bffN_btag`
Preselection		soft-lepton preselection	
N_{jet}		≥ 1	≥ 2
Jet p_{T}	[GeV]	> 200	
$N_{b\text{-jet}}$		$=0$	≥ 1
b-jet p_{T}	[GeV]	–	< 50
N_{SV}		≥ 1	–
m_{T}	[GeV]	> 90	
$E_{\text{T}}^{\text{miss}}$	[GeV]	> 250	–
$\Delta\phi(\vec{p}_{\text{T}}^{\text{miss}}, \ell)$	[rad]	< 2.0	–
CT2	[GeV]	–	> 400
$\Delta\phi(p_{\text{T}}^{b-\text{jet}}, \vec{p}_{\text{T}}^{\text{miss}})$	[rad]	–	< 1.5
$p_{\text{T}}^{\ell}/E_{\text{T}}^{\text{miss}}$		< 0.04	< 0.05
Exclusion technique		shape-fit in $p_{\text{T}}^{\ell}/E_{\text{T}}^{\text{miss}}$	shape-fit in $p_{\text{T}}^{\ell}/E_{\text{T}}^{\text{miss}}$ and $\Delta\phi(p_{\text{T}}^{b-\text{jet}}, \vec{p}_{\text{T}}^{\text{miss}})$
Bin boundaries in $p_{\text{T}}^{\ell}/E_{\text{T}}^{\text{miss}}$		$\{0, 0.015, 0.025, 0.04, 0.06, 0.08\}$	$\{0, 0.03, 0.06, 0.1\}$
Bin boundaries in $\Delta\phi(p_{\text{T}}^{b-\text{jet}}, \vec{p}_{\text{T}}^{\text{miss}})$	[rad]		$\{0, 0.8, 1.5\}$

Search for stop pairs with 1 lepton

Exclusion limits





Search for gluino pairs in multi-jet events

Signal region definitions

Signal region	N_{jet}^{50}	$N_{b\text{-jet}}$	M_{J}^{Σ} (GeV)
SR-8ij50 multi-bin	≥8	$= 0,\ = 1,\ \geq 2$	$(0, 340],\ (340, 500],\ (500, \infty)$
SR-9ij50 multi-bin	≥9		
SR-10ij50 multi-bin	≥10		

Table 2: Signal region subdivisions for the multi-bin fit in the {8,9,10}ij50 analysis channels. The selections on these variables apply to the signal regions as well as to the multijet template and validation regions described later in Section 6. For each inclusive jet multiplicity fit, nine regions are generated combining the $N_{b\text{-jet}}$ and M_{J}^{Σ} selections.

Signal region	N_{jet}^{50}	N_{jet}^{80}	$N_{b\text{-jet}}$	M_{J}^{Σ} (GeV)
SR-8ij50-0ib-MJ500	≥8	-	-	≥500
SR-9ij50-0ib-MJ340	≥9	-	-	≥340
SR-10ij50-0ib-MJ340	≥10	-	-	≥340
SR-10ij50-0ib-MJ500	≥10	-	-	≥500
SR-10ij50-1ib-MJ500	≥10	-	≥1	≥500
SR-11ij50	≥11	-	-	-
SR-12ij50-2ib	≥12	-	≥2	-
SR-9ij80	-	≥9	-	-

Table 3: Summary of signal region criteria for single-bin selections. The requirements in multiplicity and M_{J}^{Σ} are inclusive in all cases. A dash ('-') indicates that there is no requirement applied to the corresponding variable. The requirement $\mathcal{S}(E_{\text{T}}^{\text{miss}}) > 5$ is applied to all bins.

Search for gluino pairs in multi-jet events

Control Regions definition

Selection criterion	Selection ranges
Lepton multiplicity	Exactly one signal e or μ remaining after overlap removal
Lepton p_{T}	> 20 GeV
m_{T} $(\ell, E_{\mathrm{T}}^{\mathrm{miss}})$	< 120 GeV
Trigger	Same as signal regions
Jet p_{T}, $\lvert\eta\rvert$	Same as signal regions
N_{jet} (including lepton)	≥ 8, for $N_{\mathrm{jet}}^{50} \geq 8$ signal regions; $\geq (N_{\mathrm{jet}}^{\mathrm{SR}} - 1)$, otherwise
$N_{b\text{-jet}}$	$= 0$ (WCR), ≥ 1 (TCR)
M_{J}^{Σ}	Same as signal regions
$\mathcal{S}(E_{\mathrm{T}}^{\mathrm{miss}})$	Table 6

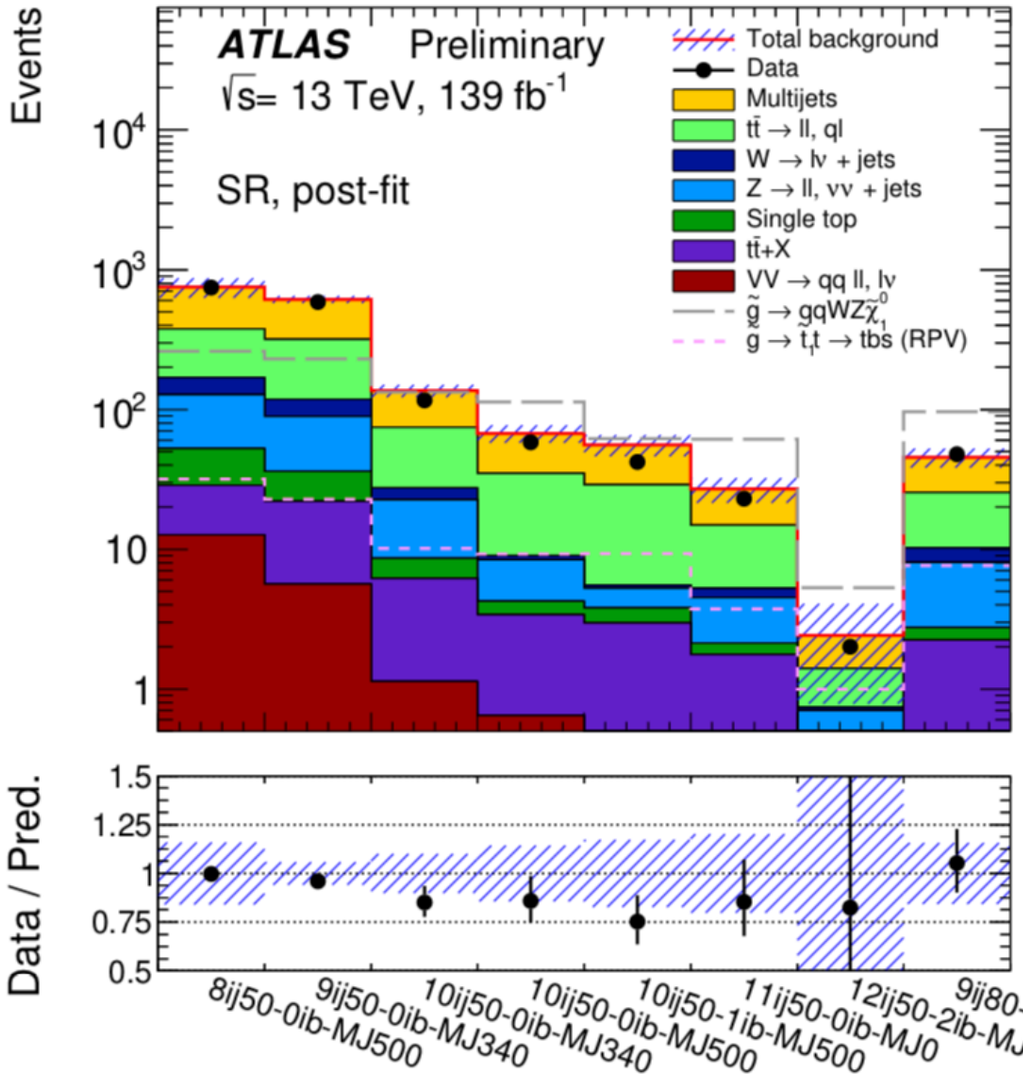
Table 7: Summary of the selections used to define the leptonic control regions.

8, 9, 10ij50 CR definitions	$N_{b\text{-jet}} = 0$	$N_{b\text{-jet}} \geq 1$
$M_{\mathrm{J}}^{\Sigma} \leq 340$ GeV	WCR1	TCR1
340 GeV $< M_{\mathrm{J}}^{\Sigma} \leq 500$ GeV	WCR2	TCR2
$M_{\mathrm{J}}^{\Sigma} > 500$ GeV	WCR3	TCR3

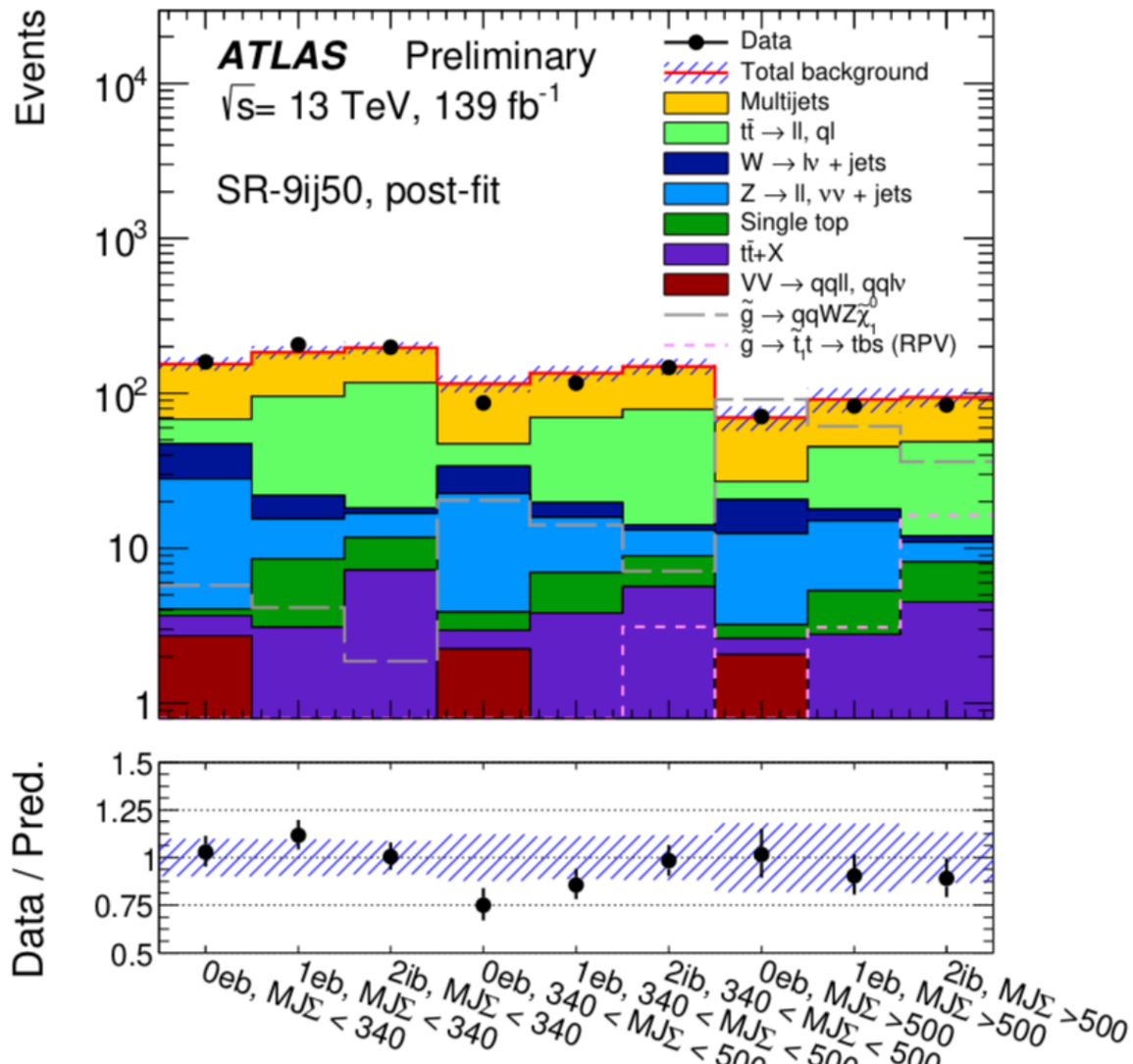
Table 8: Control region subdivisions for the background fits for multi-bin signal selections.

Search for gluino pairs in multi-jet events

Other signal regions



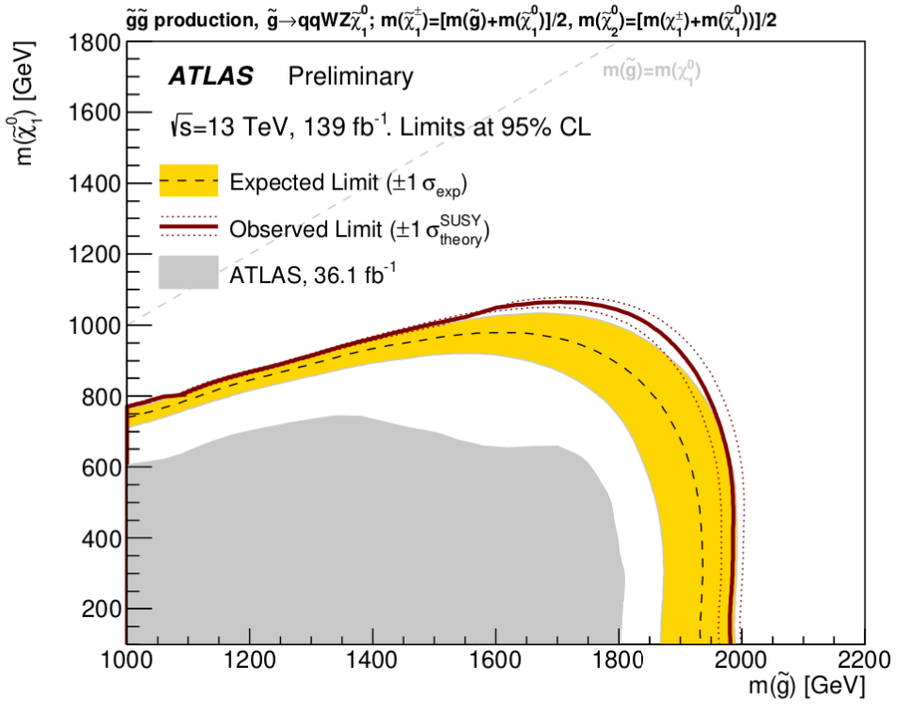
(d) Single-bin summary



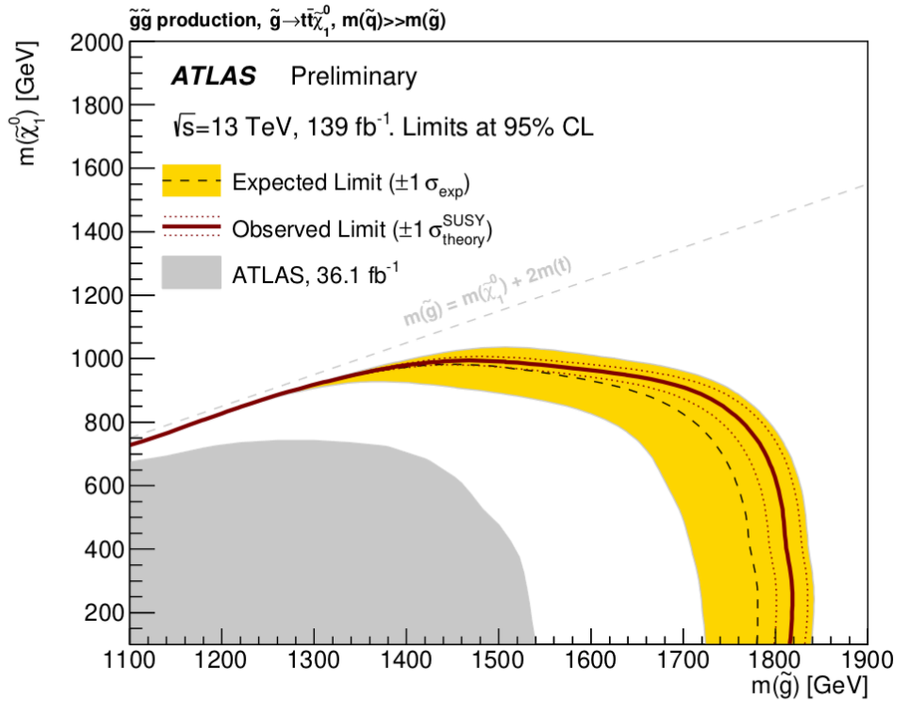
(b) SR-9ij50, multi-bin

Search for gluino pairs in multi-jet events

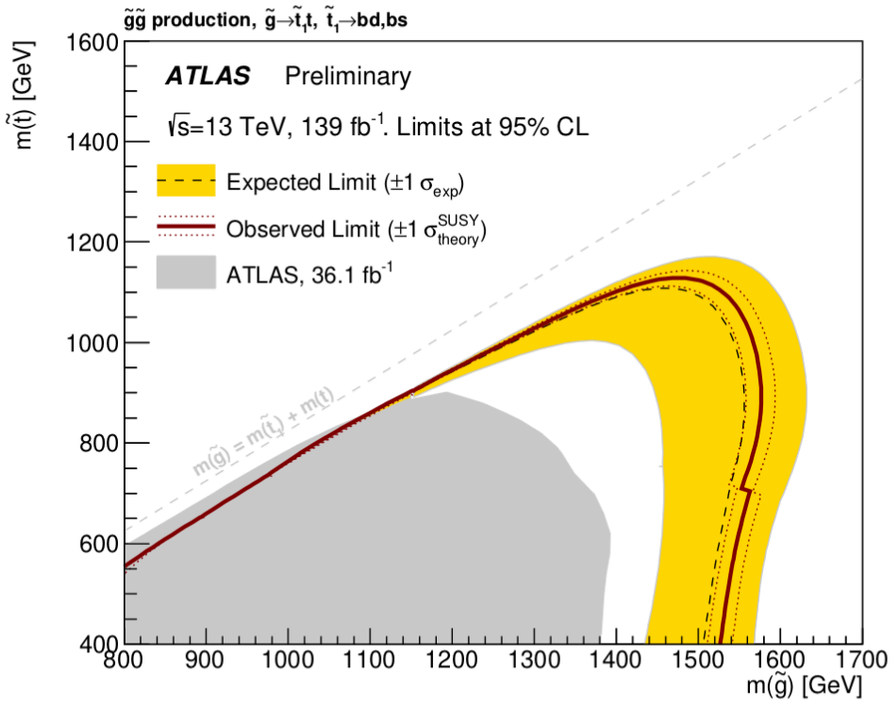
Other exclusion limits



(a) $\tilde{g}$, 2-step cascade



(b) $\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$



(c) RPV $\tilde{g} \rightarrow tbd, tbs$