Searches for direct pair production of stops and sbottoms with the ATLAS detector

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On behalf of the ATLAS Collaboration

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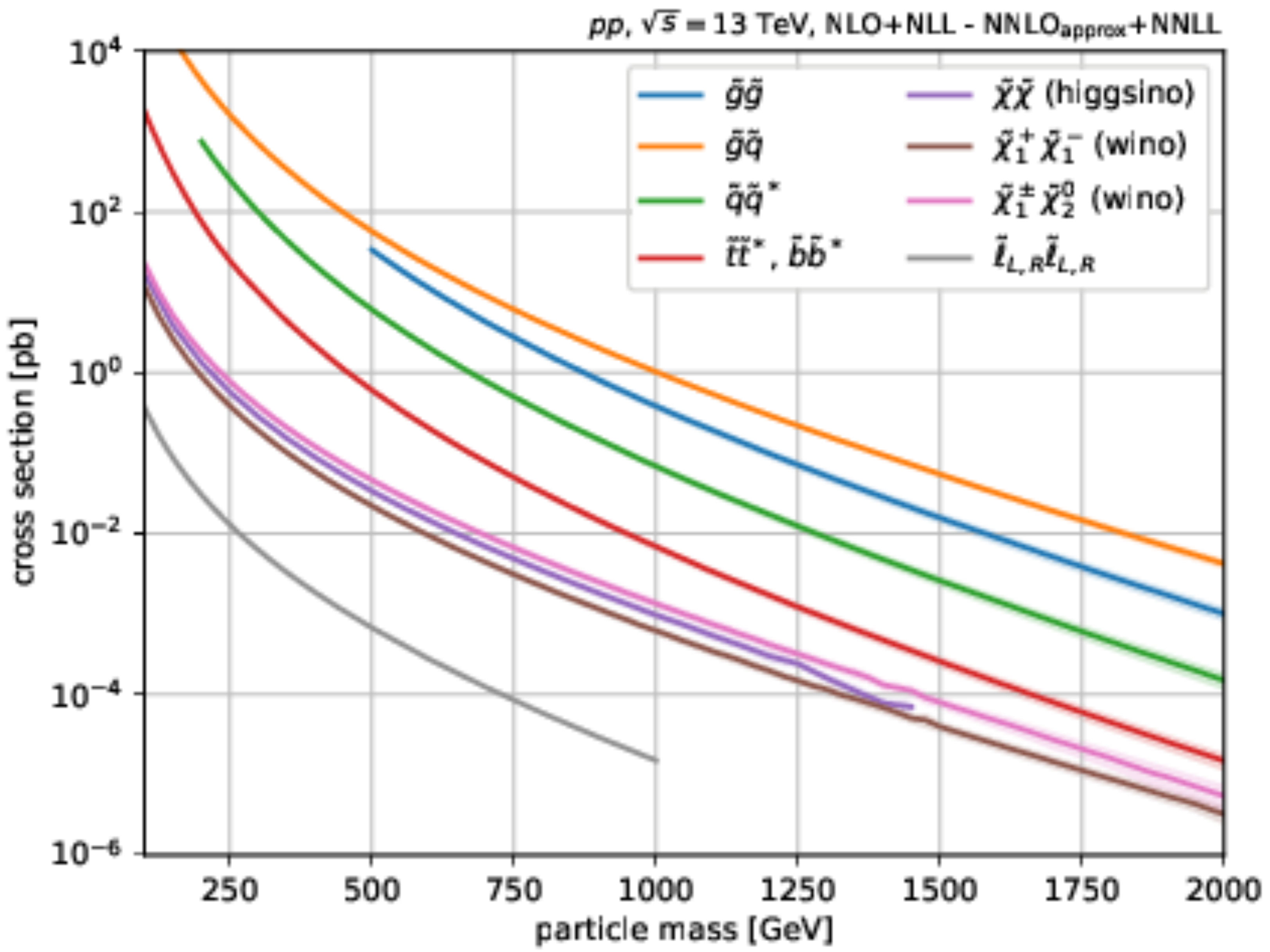
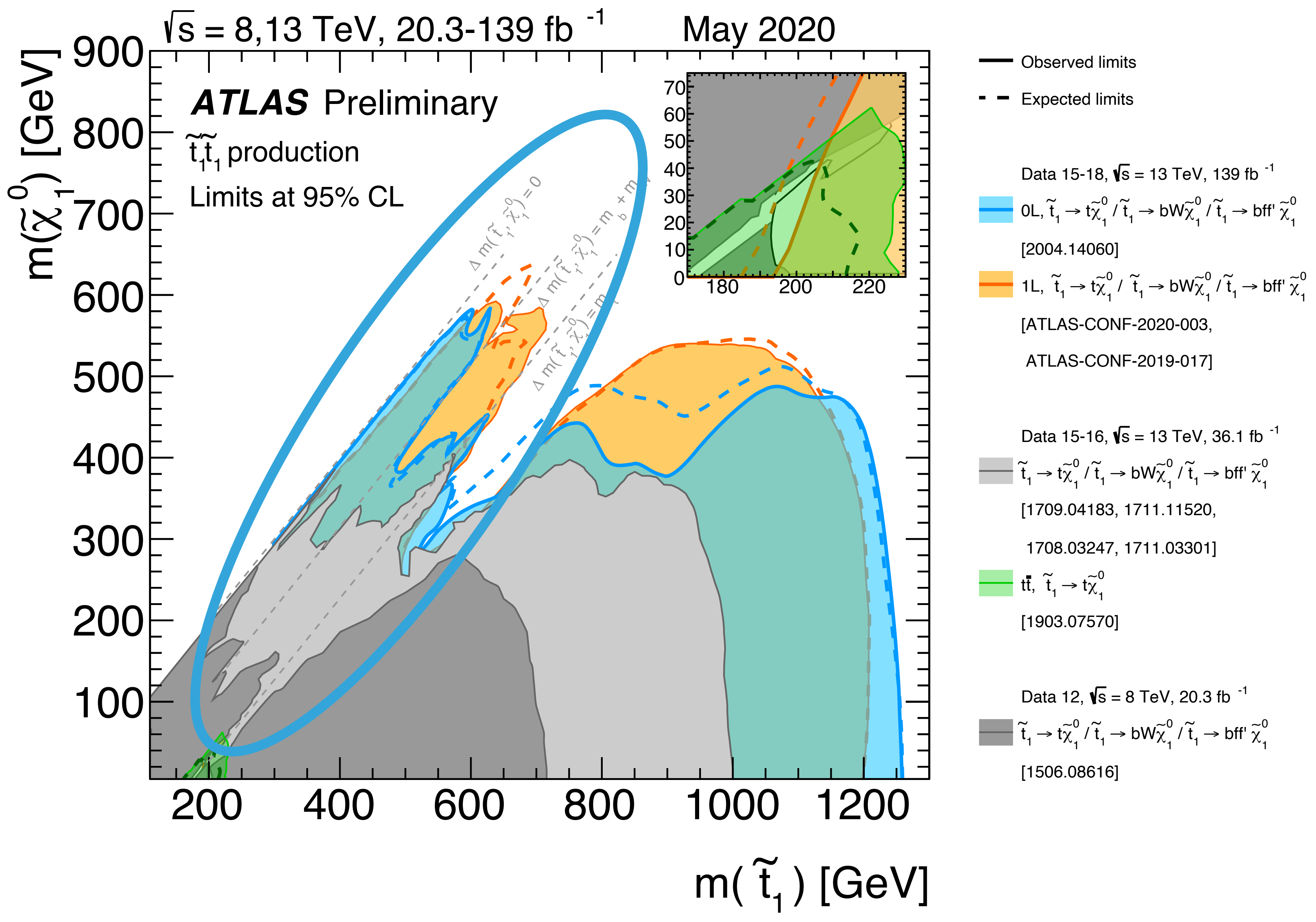
Introduction



[LHC SUSY Cross Section Working Group]



- Supersymmetry predicts the existence of a new family of partner particles to the Standard Model (SM).
- If Natural SUSY exists, then stop particles should have relatively small masses.
- Cross-sections to produce stops and sbottoms typically larger than electroweak SUSY partner particles.
- Will discuss searches for super-partners of third generation particles (sbottom and stop).
  - Wide regions of parameter space have been excluded, need to search more challenging areas.
- Analyses can have interpretations in Dark Matter context.
  - Strong evidence from astrophysical observations for its existence, despite nature and properties of DM remaining largely unknown.

ATLAS-SUSY-2018-12

Search for stop pairs in zero lepton final states

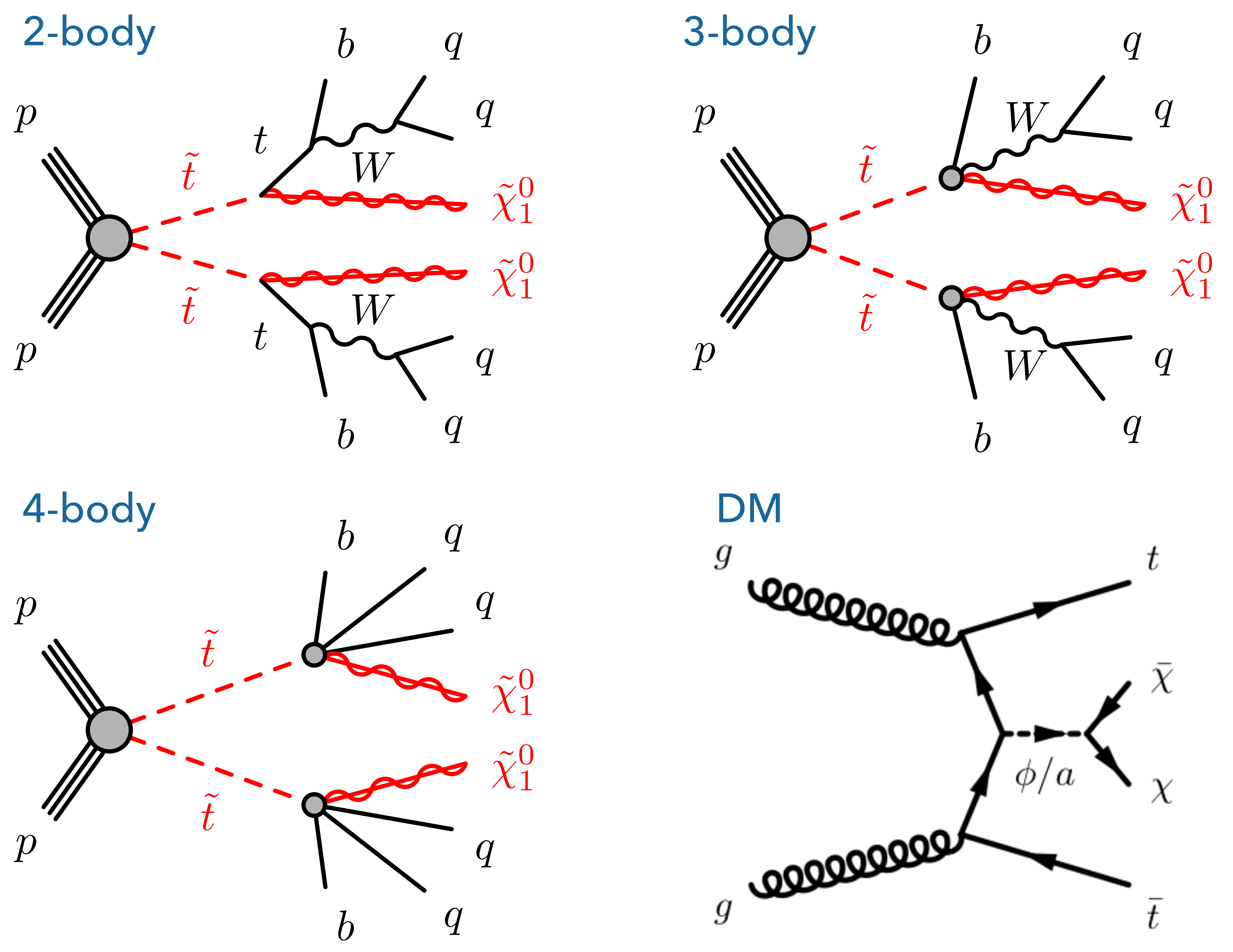
ATLAS-CONF-2020-03

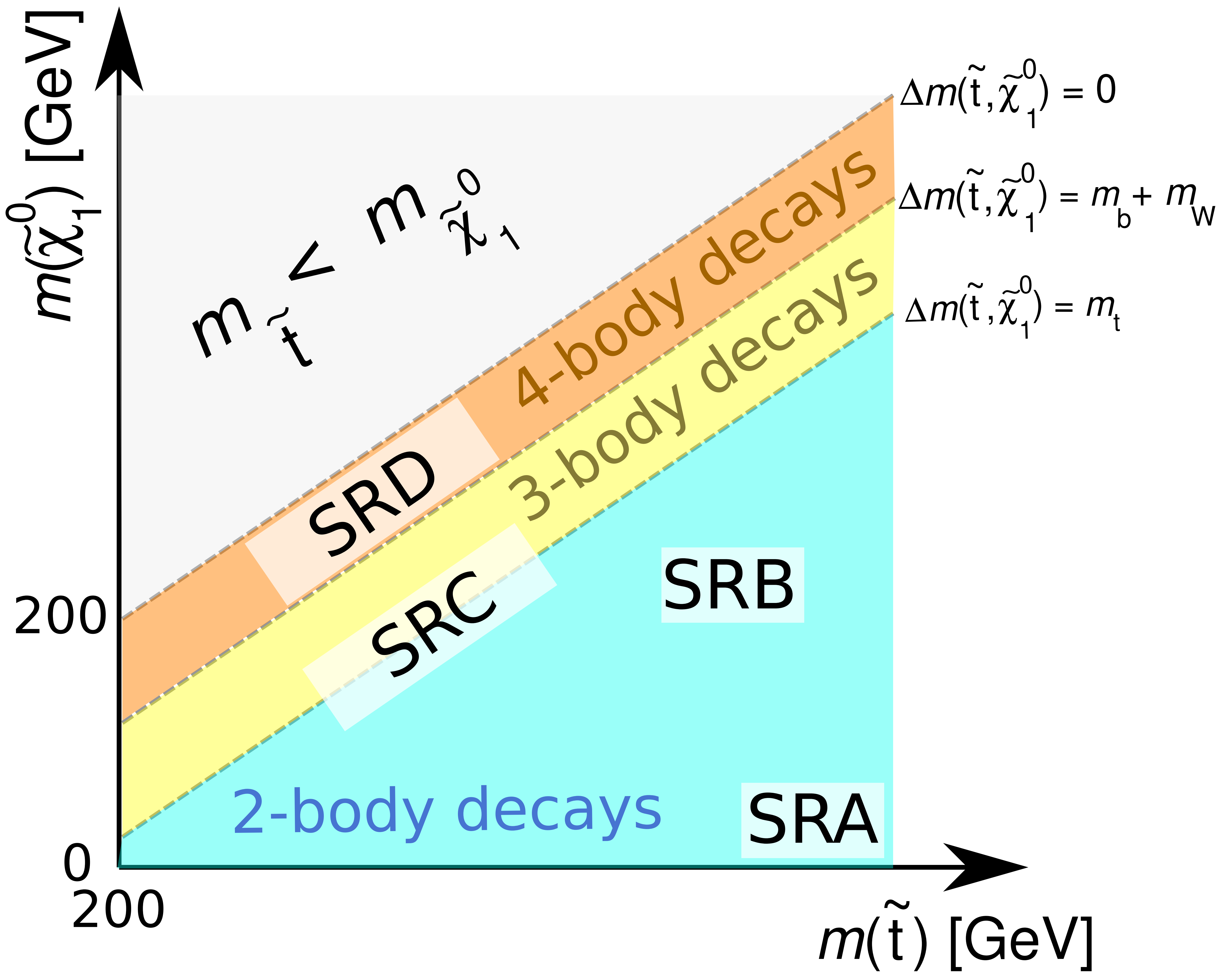
Search for stop pairs in one lepton final states

ATLAS-CONF-2020-046

Search for stop pairs in two lepton final states

Search for stop pairs in 0/1/2 lepton final states

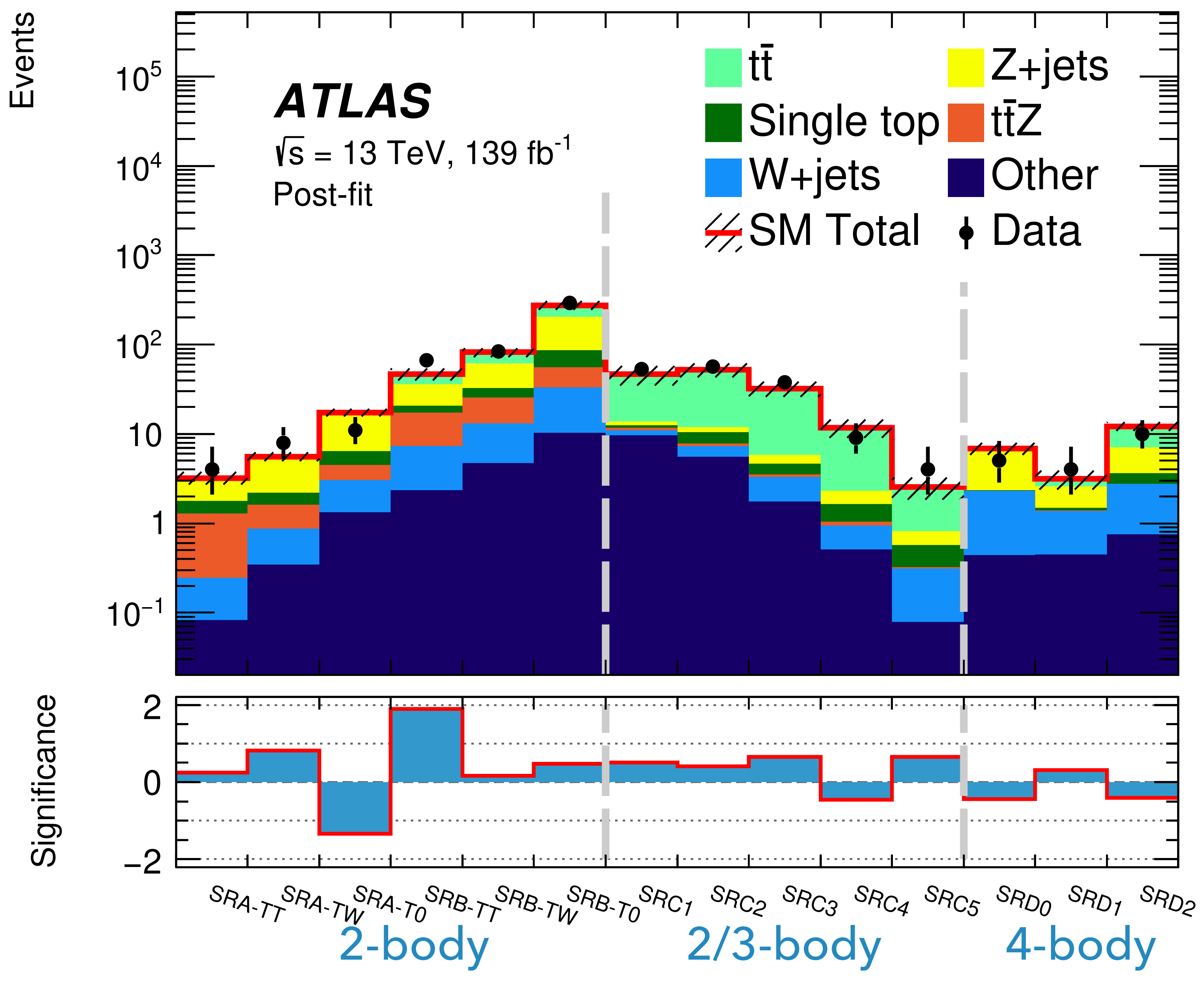




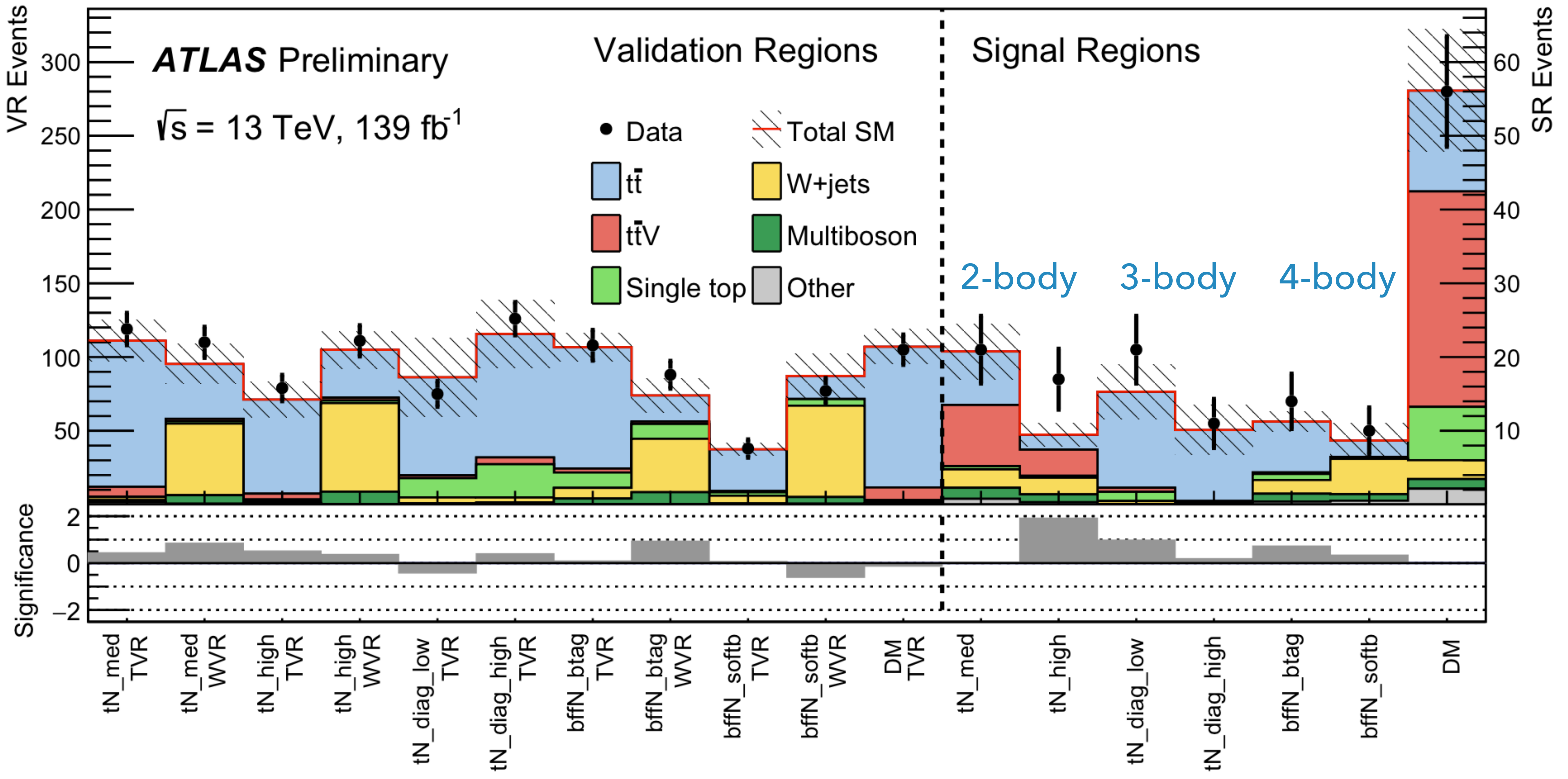
- Analyses use techniques to target different regions of stop-neutralino phase space
  - 2-body decay region with high-mass $\tilde{t}$ pairs leading to large (medium) $\Delta m(\tilde{t},\tilde{\chi}_1^0)$
  - 2-/3-body region where $\Delta m(\tilde{t},\tilde{\chi}_1^0) \sim m_t$
  - Highly compressed 4-body region (new for ATLAS)

Search for stop pairs in 0/1 lepton final states

ATLAS-SUSY-2018-12



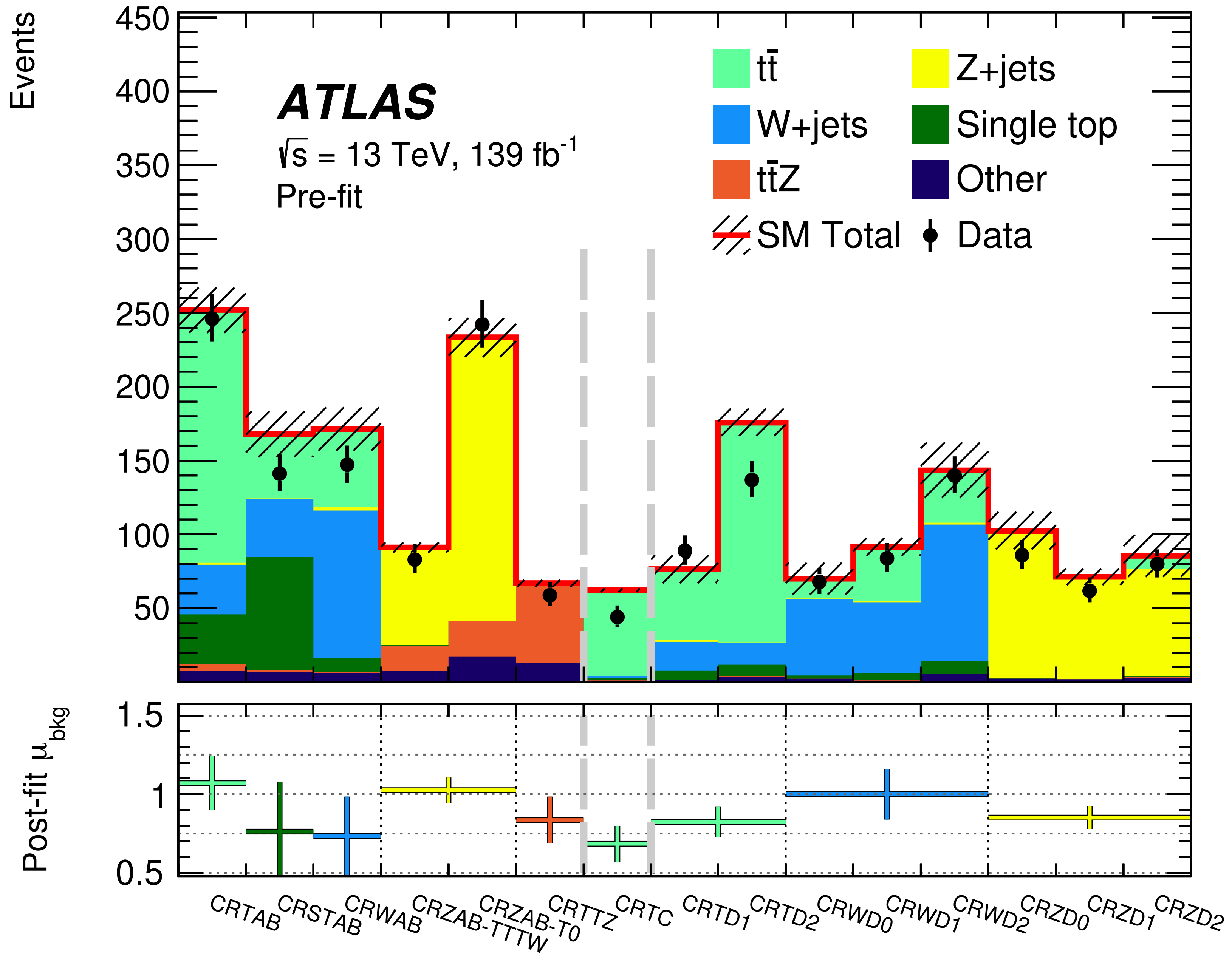
ATLAS-CONF-2020-03



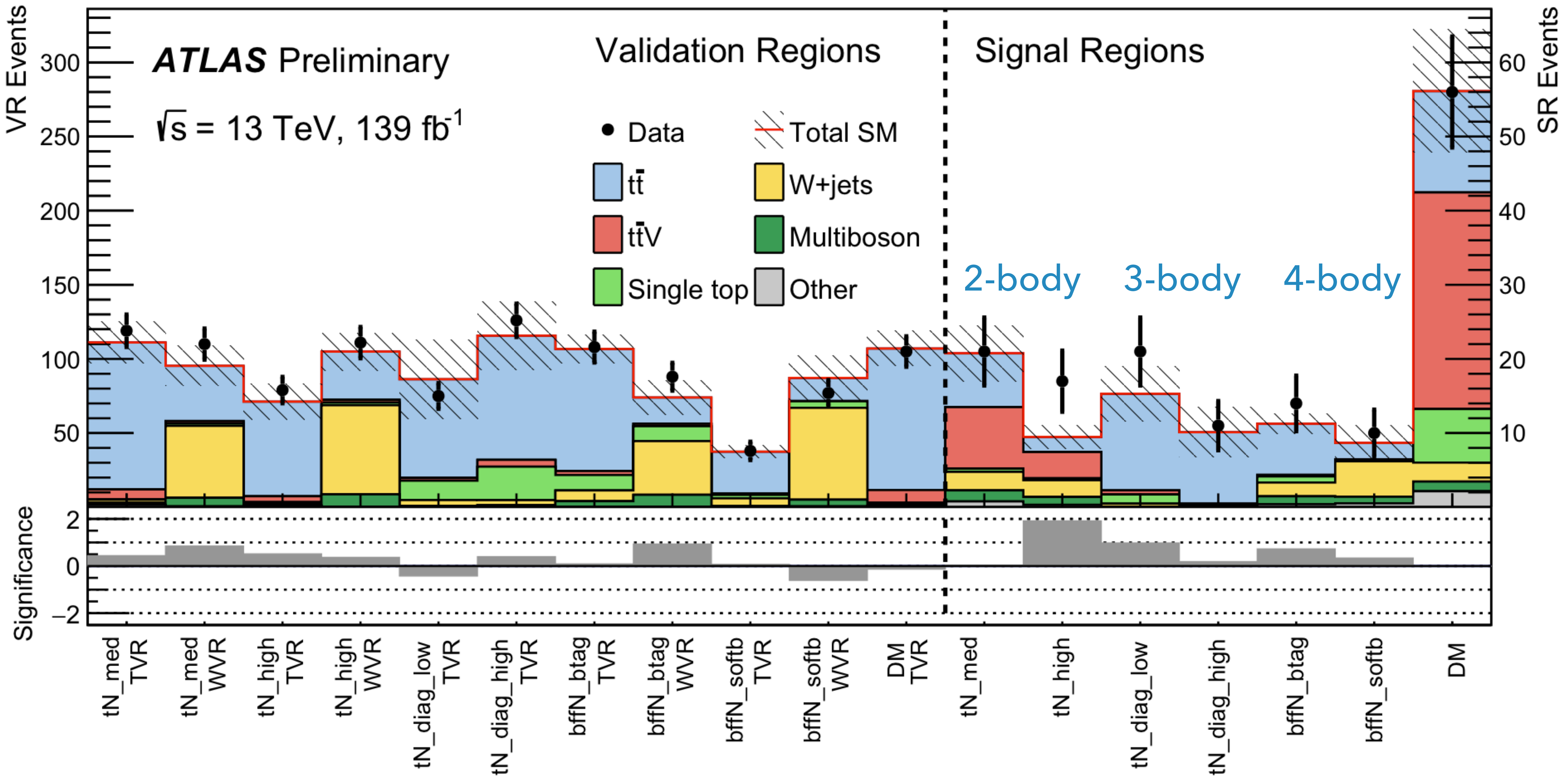
	0 lepton analysis	1 lepton analysis
2-body	reclustered small R jet finding for boosted top production	top reconstruction variables
3-body	recursive jigsaw techniques	ISR jet, MET and other variables
4-body	track-jet based soft b-tagging, with $p_T > 5$ GeV	ISR jet, soft b-tagging
DM	–	$\Delta\varphi(p_T^{miss}, l)$

Search for stop pairs in 0/1 lepton final states

ATLAS-SUSY-2018-12

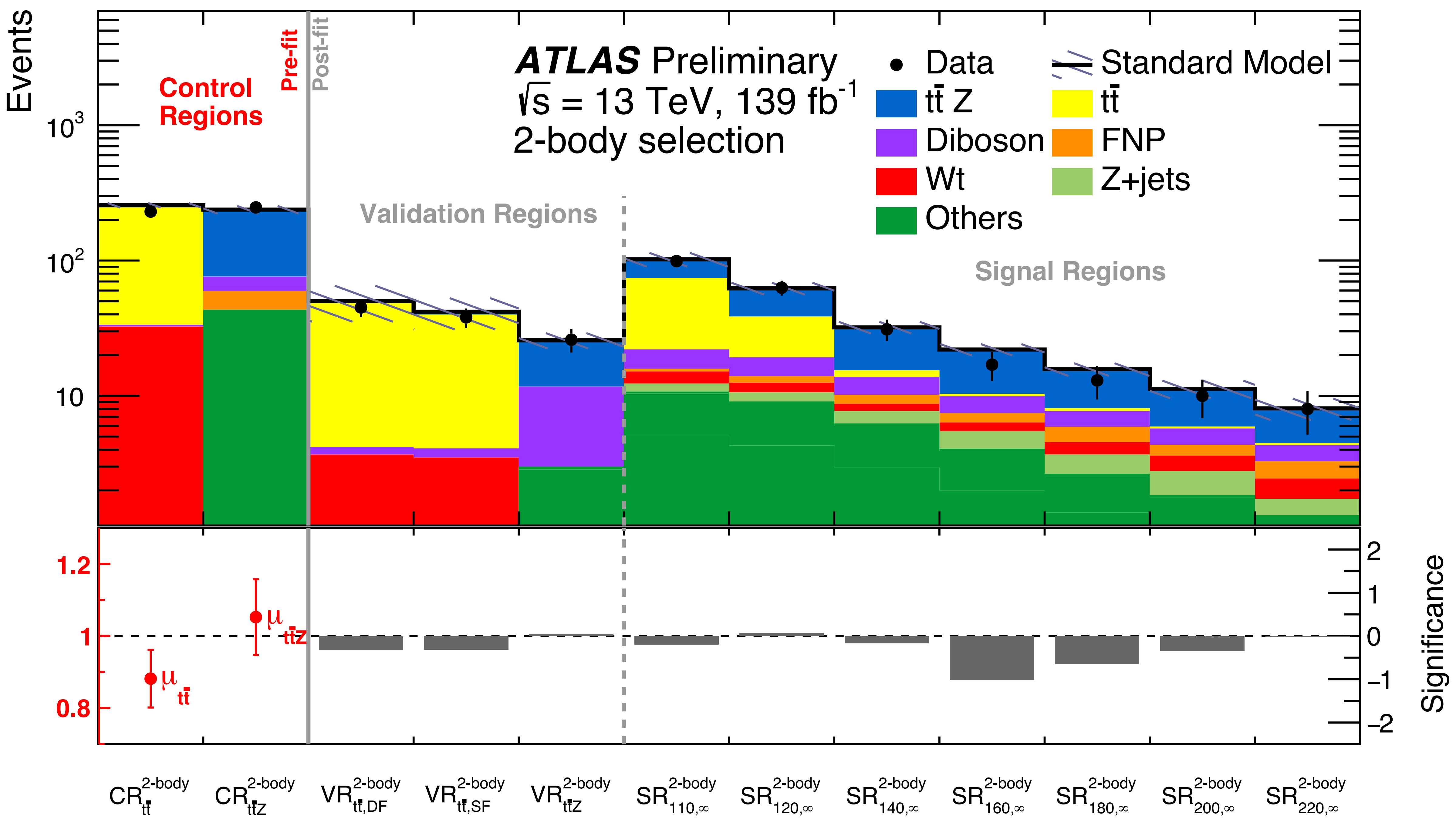


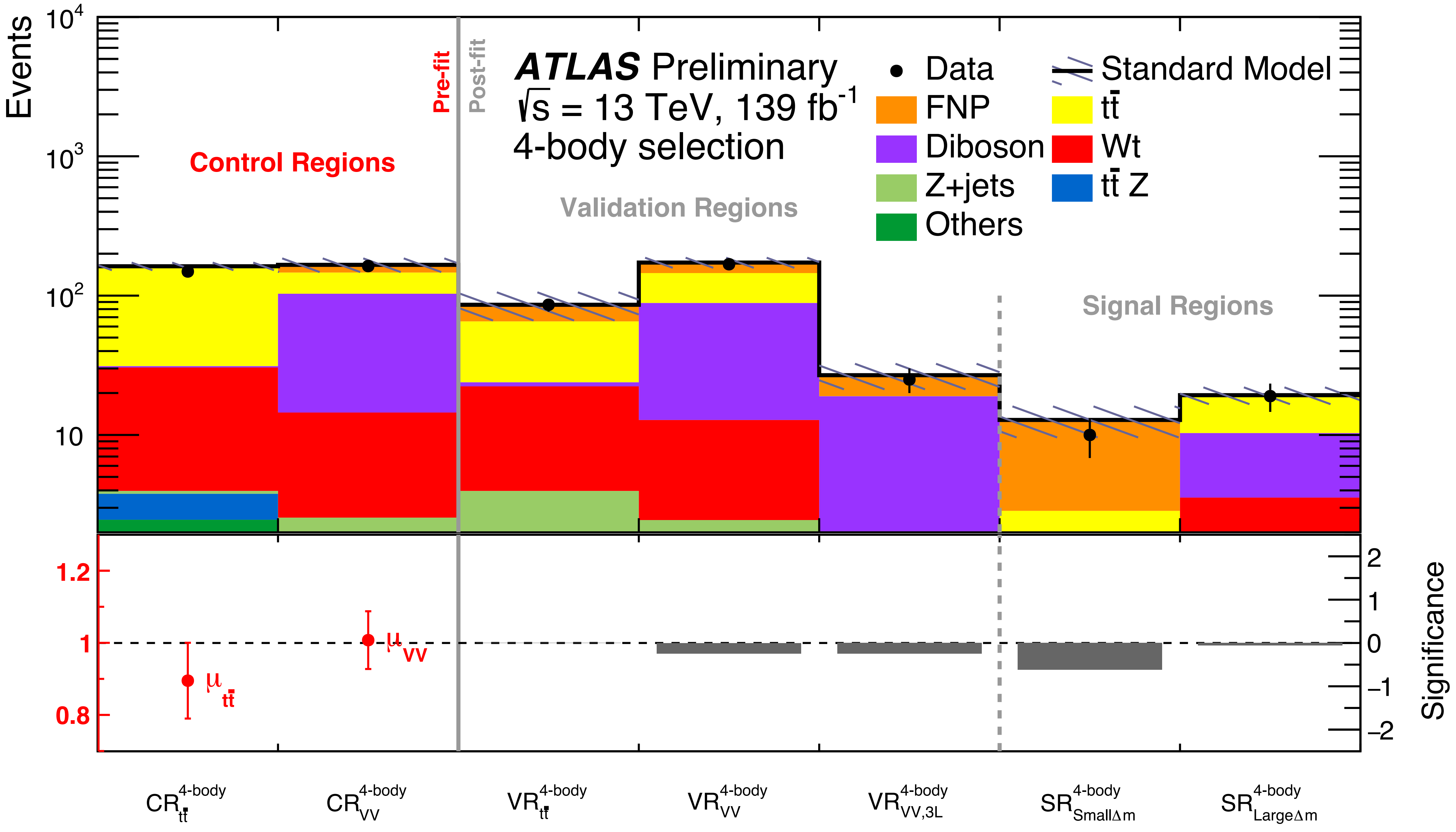
ATLAS-CONF-2020-03



- Backgrounds controlled and estimated using control (CR) and validation (VR) regions.
  - 0-lepton:
    - Z→νν with heavy flavour jets dominates all SR, except SRC which is dominated by top pair production.
    - Other backgrounds include W+Heavy Flavour (HF) jets, single top + W and ttZ production.
  - 1-lepton:
    - Main backgrounds are top pair production, tt̄+V, and W boson production in association with jets.
    - Single top and diboson production are also relevant backgrounds.

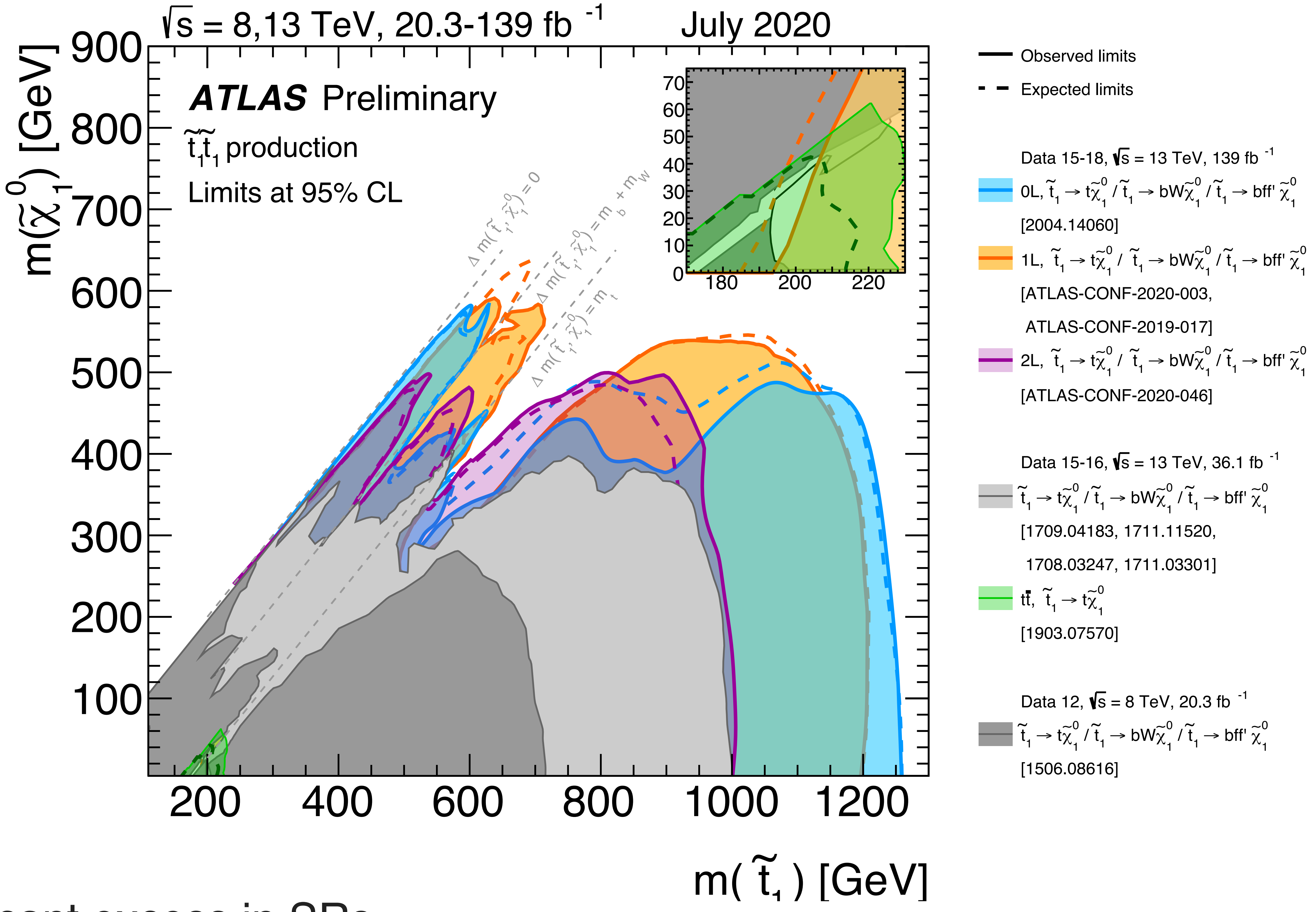
Search for stop pairs in two lepton final states



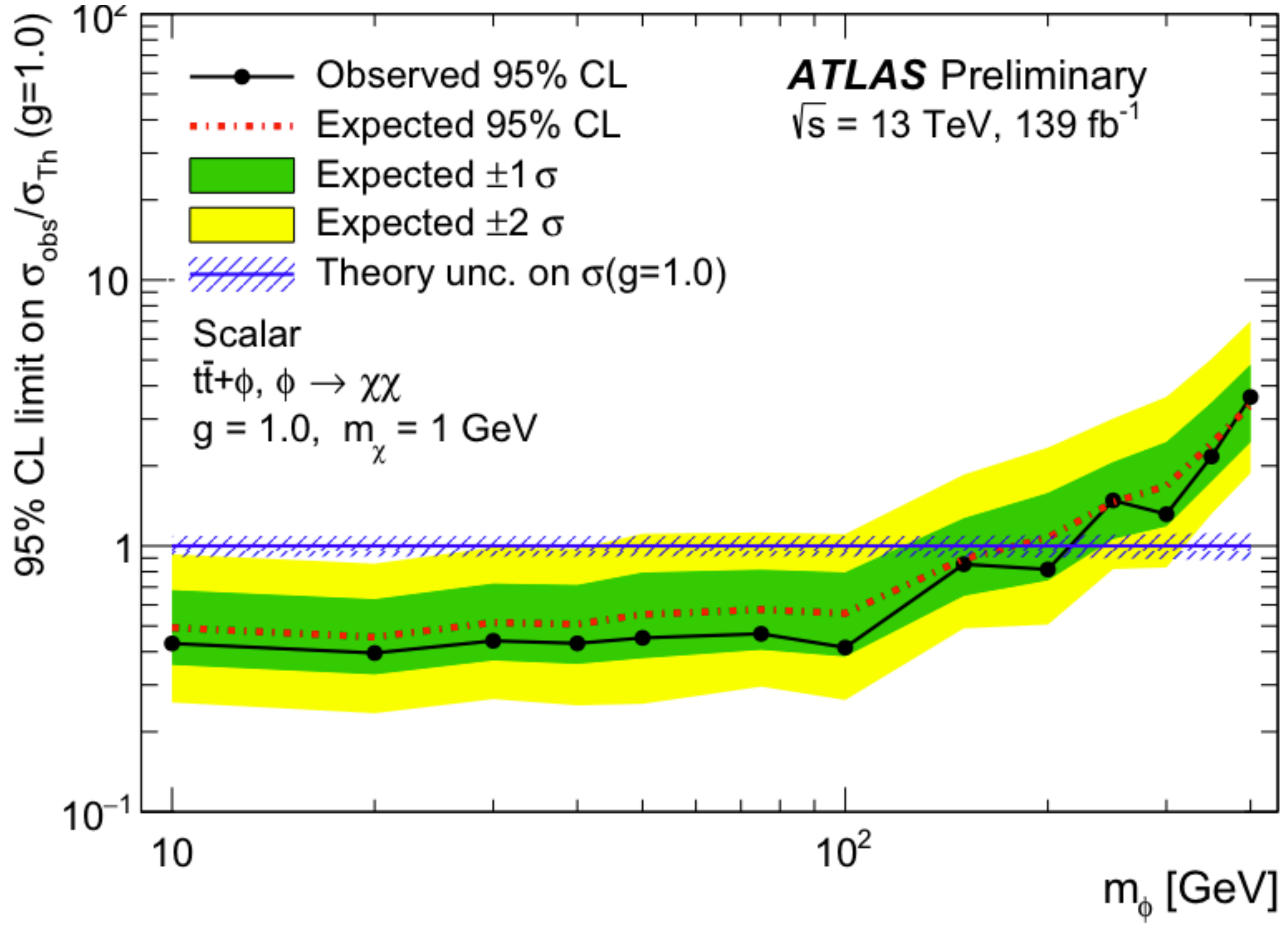


- SRs targeting the different 2-/3-/4-body regions.
- Events are required to have exactly two OS leptons, with min$_{m_{\ell\ell}}$ > 20 GeV (10 GeV) in the two- and three-body (four-body) selections and events in the 2- & 3-body with same flavour (SF) lepton pairs with $|m_{\ell\ell}| > 20$ GeV . E_T^{miss} significance variable gives improvement in sensitivity.
  - Different N$_{\text{jets}}$ and N$_{\text{b-jet}}$ multiplicities required in the different regions, include ISR jet for 4-body region.
  - Other variables include stransverse mass, ratios of E_T^{miss} and pT of leading leptons and jets, and razor variables amongst others.
- Major backgrounds include tt̄, tt̄Z and diboson, as well as those with fake/non-prompt lepton (FNP).
  - Estimated with dedicated control and validation regions.

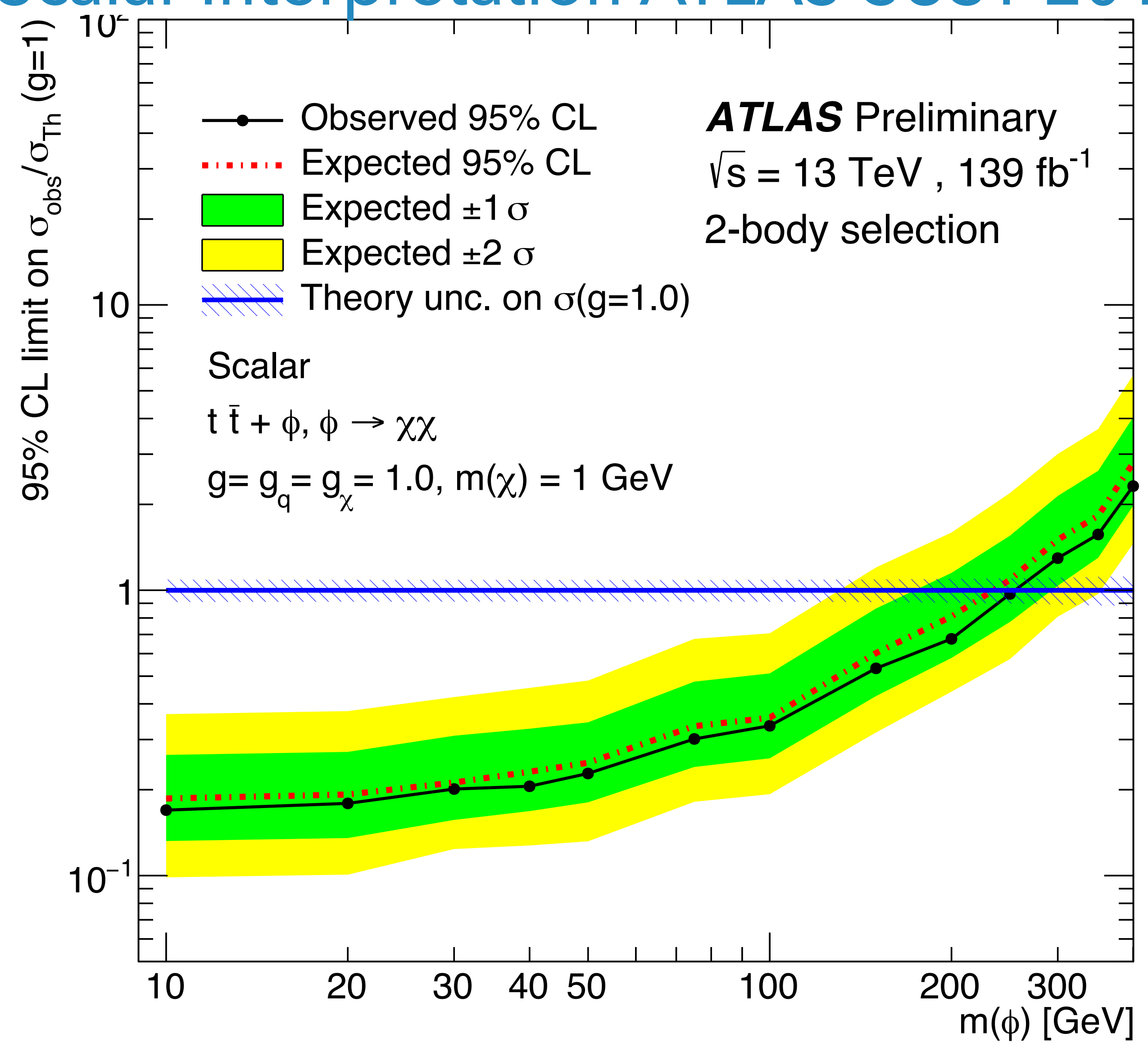
Search for stop pairs in 0/1/2 lepton final states



DM Scalar Interpretation ATLAS-CONF-2020-03



DM Scalar Interpretation ATLAS-SUSY-2018-08

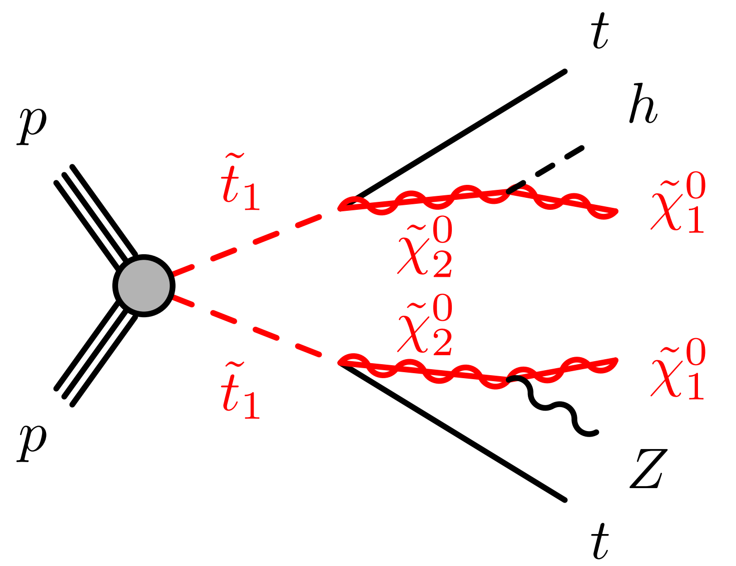


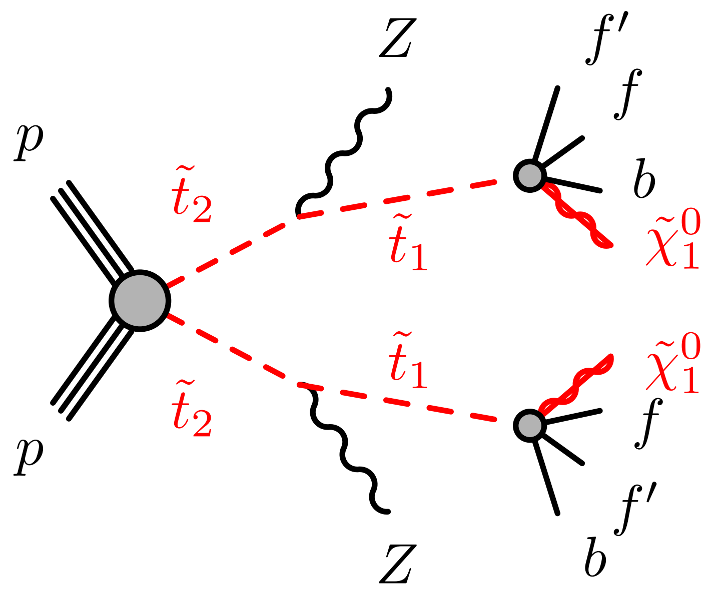
- No significant excess in SRs.
- Stop limits set in the $\tilde{t} - \tilde{\chi}^1_0$ mass plane
  - $\tilde{t}_1$ masses up to about 1.25 TeV excluded for massless $\tilde{\chi}^0_1$.
  - $\tilde{t}_1$ masses up to 550 (430) GeV excluded in region where $m_{\tilde{t}_1} - m_{\tilde{\chi}^0_1} \sim m_t(m_W)$.
  - $\tilde{t}_1$ masses up to 640 GeV excluded in region where $m_{\tilde{t}_1} - m_{\tilde{\chi}^0_1} = 60$ GeV.
- Scalar (pseudo-scalar) mediator masses are excluded up to about 250 (300) GeV for g = 1.

ATLAS-SUSY-2018-21

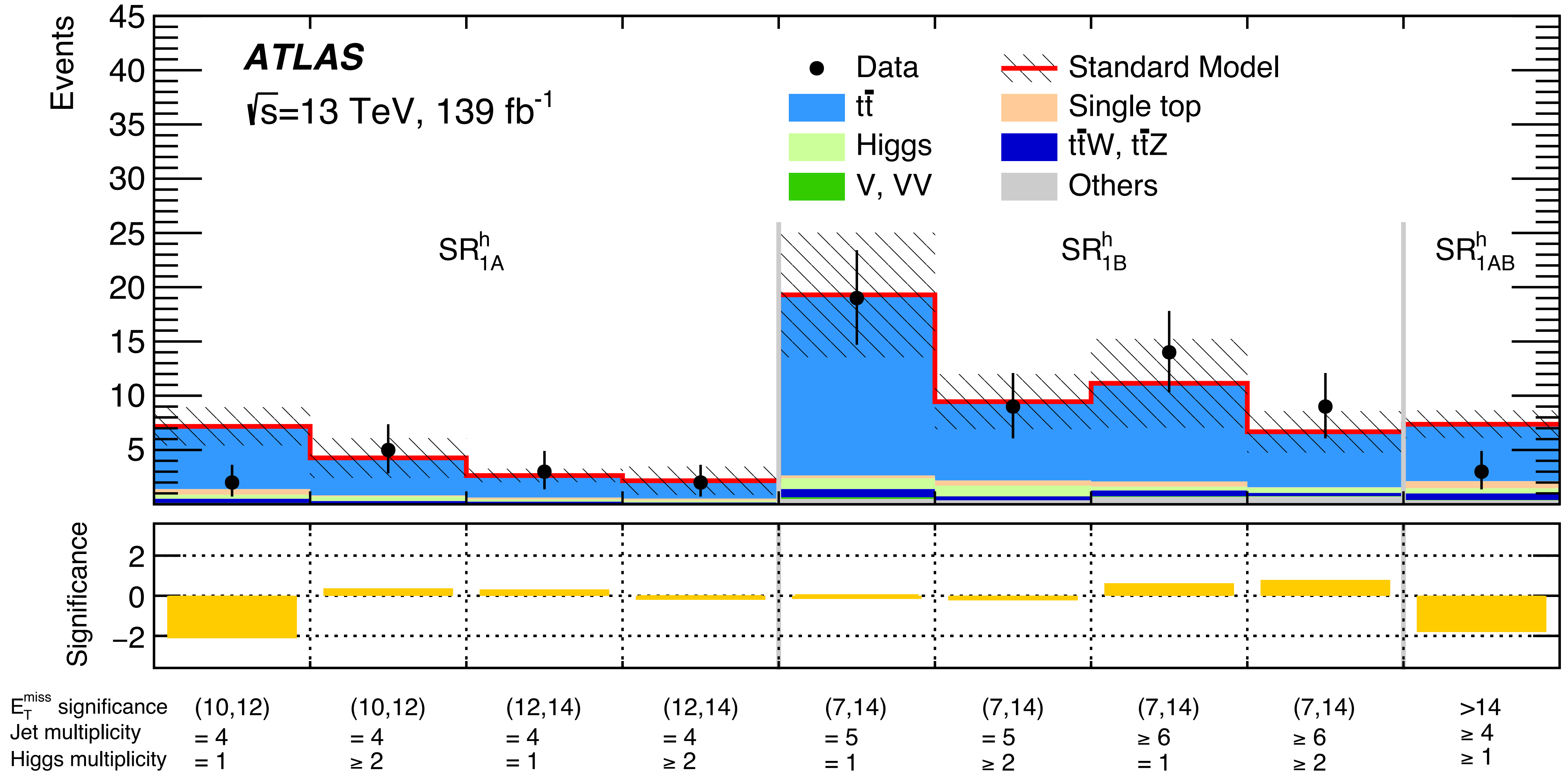
Search for stop pairs in Z and Higgs final states

Search for stop pairs in Z and Higgs final states



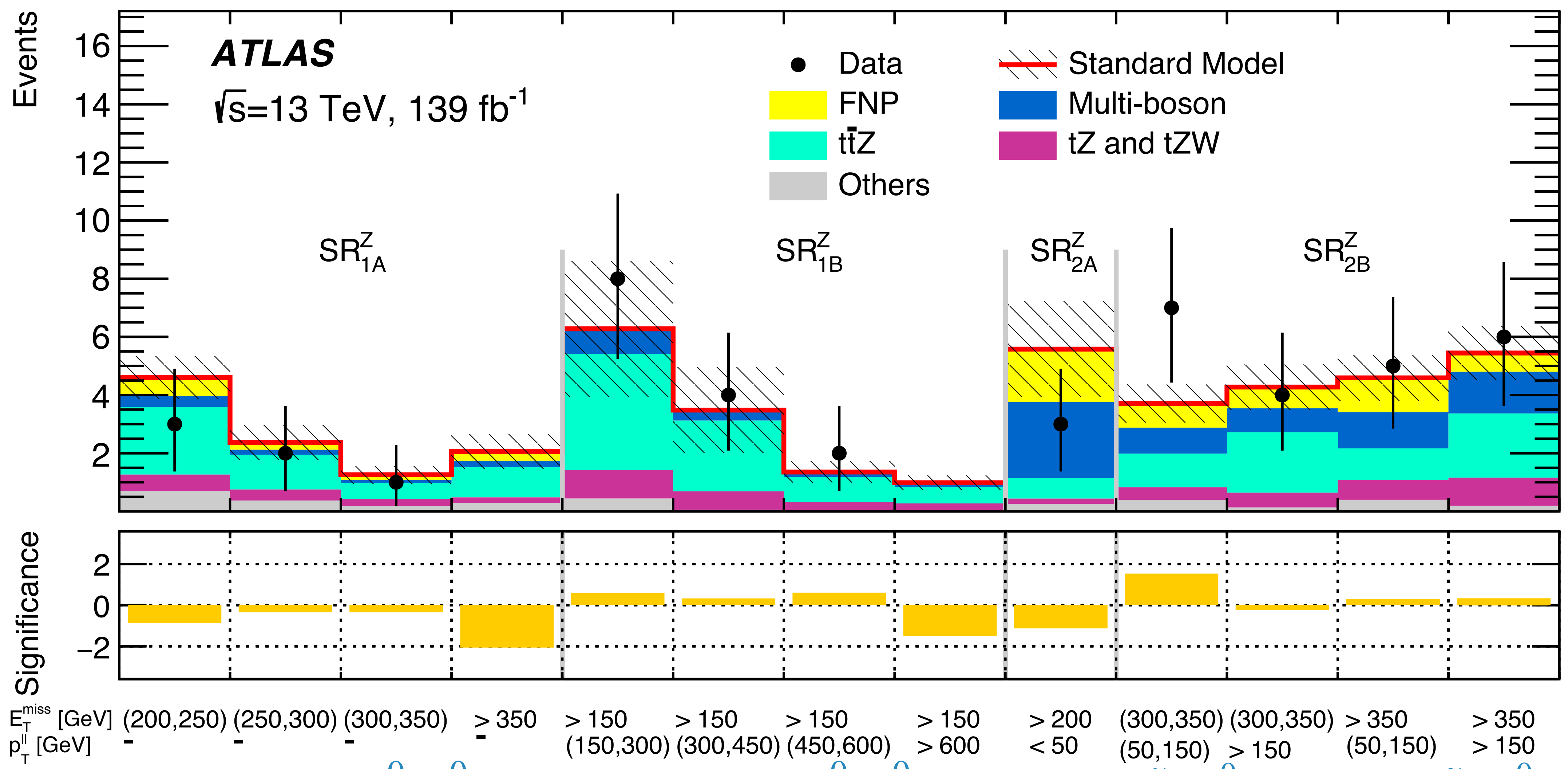


1L Selection



small $\Delta(\tilde{\chi}_2^0, \tilde{\chi}_1^0)$ large $\Delta(\tilde{\chi}_2^0, \tilde{\chi}_1^0)$

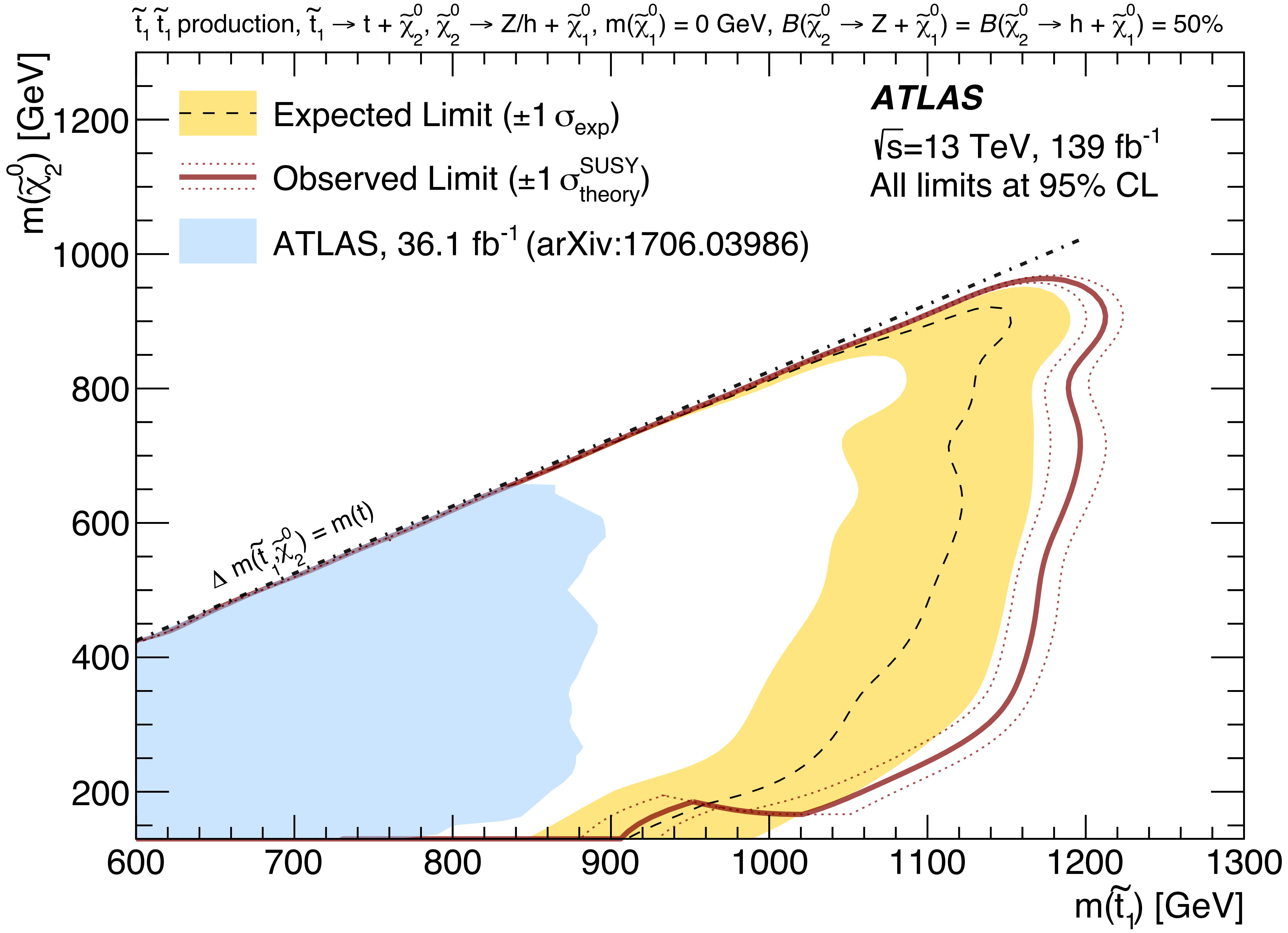
3L Selection

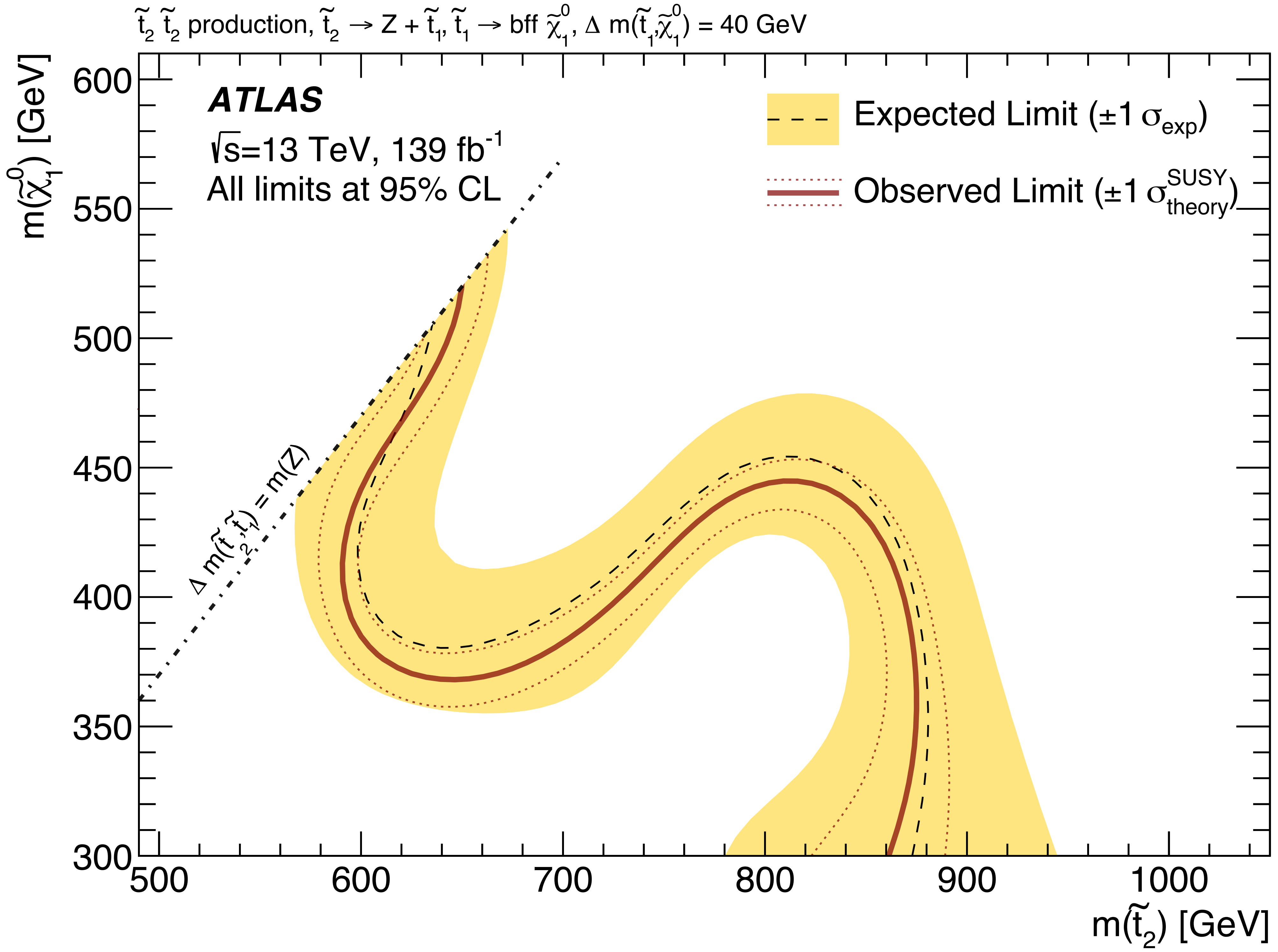


large $\Delta(\tilde{\chi}_2^0, \tilde{\chi}_1^0)$ small $\Delta(\tilde{\chi}_2^0, \tilde{\chi}_1^0)$ small $\Delta(\tilde{t}_2, \tilde{\chi}_1^0)$ large $\Delta(\tilde{t}_2, \tilde{\chi}_1^0)$

- Search for stops, with decay to Higgs and Z boson, or 2 Z bosons.
  - 1L analysis requires one H→bb candidate, $N_{b\text{-jets}} \geq 4$, $N_{jets} \geq 4(6)$, $m_T > 150$ & METSig>7(12).
  - 3L analysis requires a SFOS lepton pair with $|m - m_Z| < 15$ GeV. SRs defined based on $N_{b\text{-jets}}$, leading lepton p_T, leading b-tagged jet p_T, p_T of dilepton pair and stransverse mass (using SFOS lepton pair and third lepton as visible particles.

Search for stop pairs in Z and Higgs final states



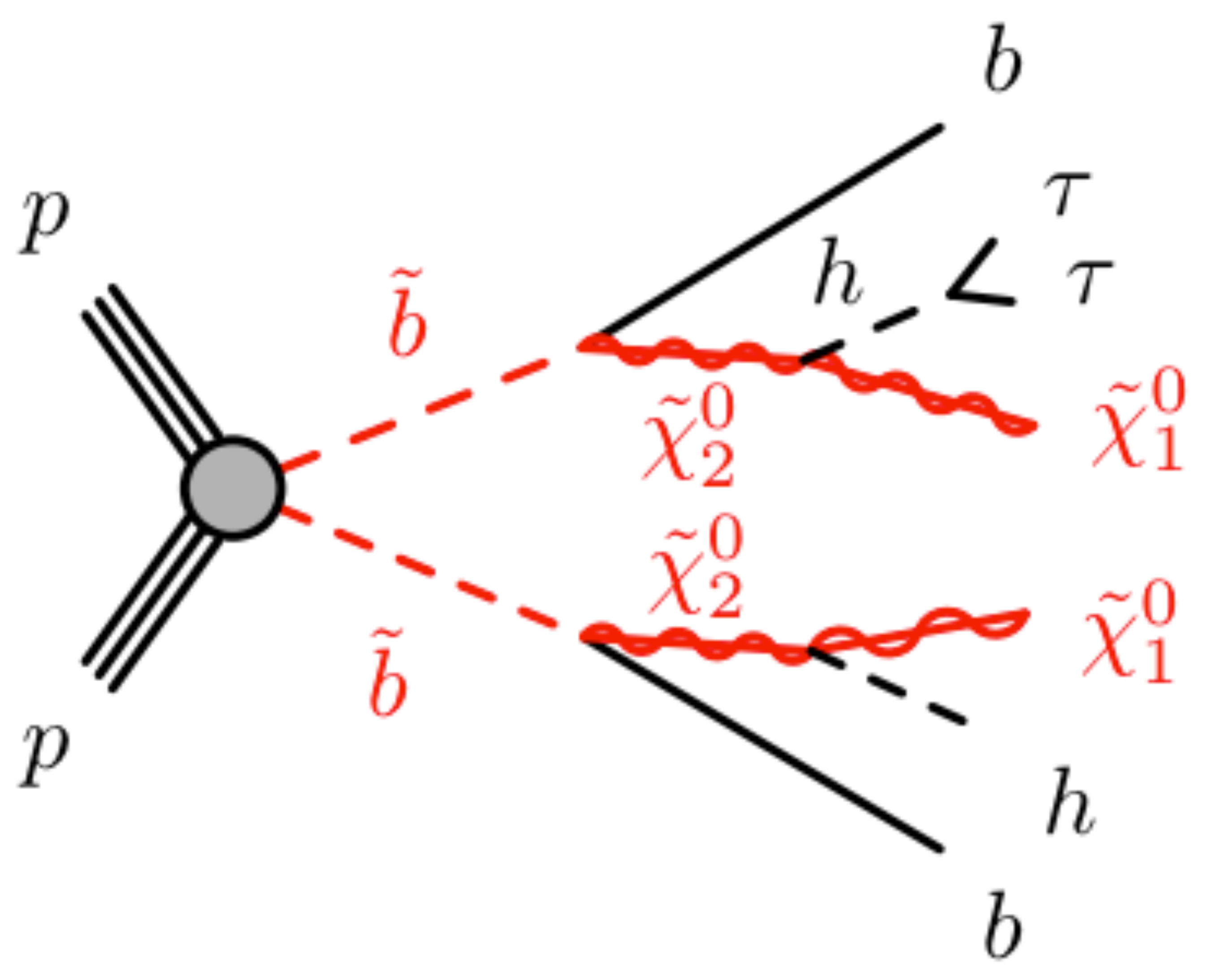


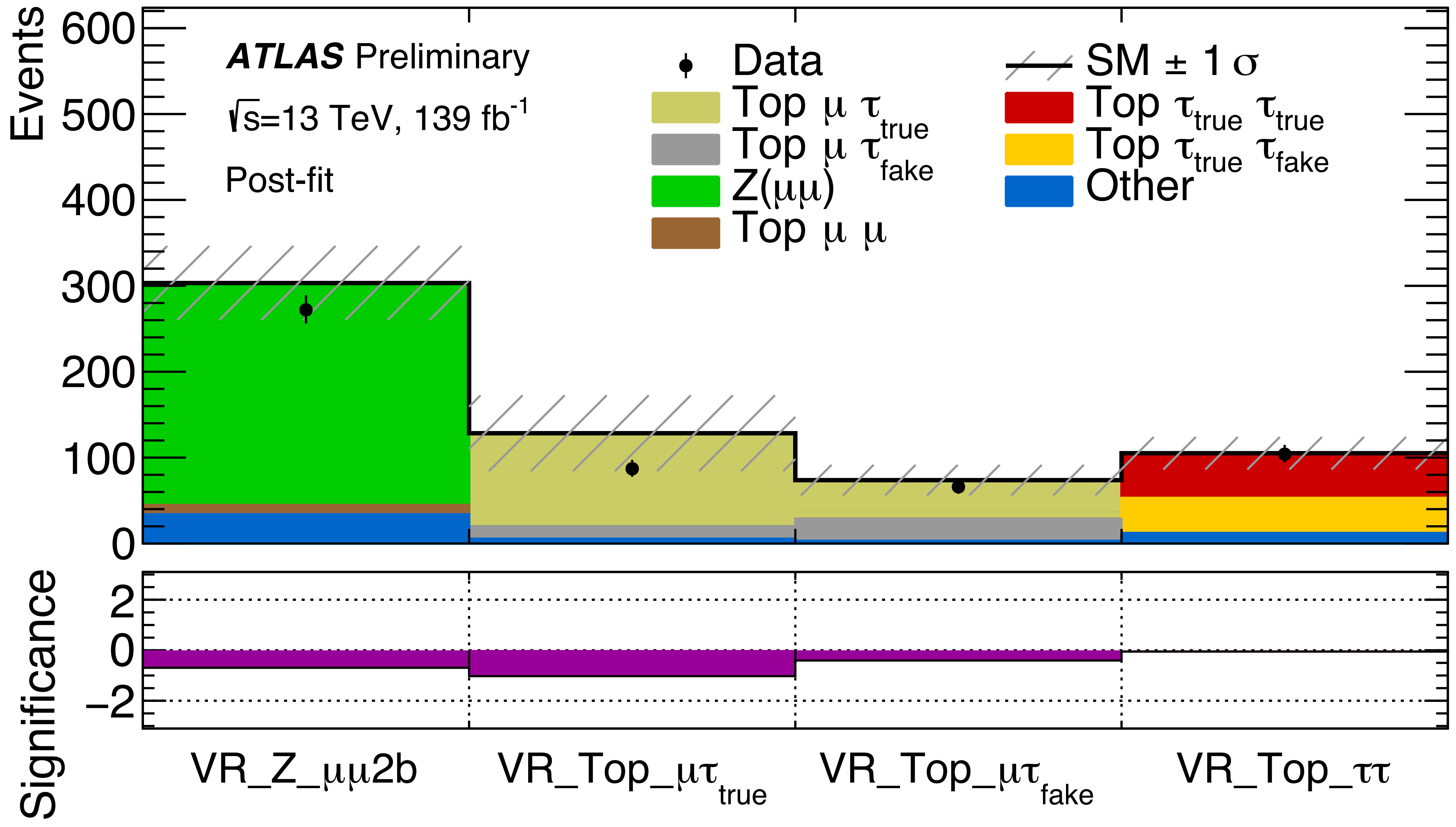
- Main backgrounds sources are tt+HF and ttZ. WZ, hadrons faking leptons and non-prompt leptons from tt are also relevant.
  - Backgrounds are constrained via CRs in the fit.
- Analysis excludes:
  - $\tilde{t}_1$ masses up to around 900 GeV for massless $\tilde{\chi}_2^0$ and,
  - $\tilde{t}_2$ up to around 875 GeV for massless $\tilde{\chi}_1^0$.

ATLAS-CONF-2020-031

Search for sbottom pairs in final states with hadronic taus

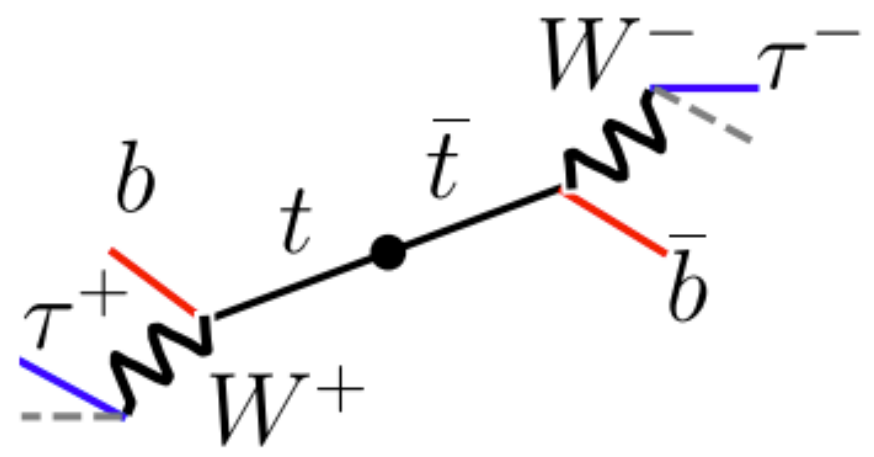
Search for sbottom pairs in final states with taus

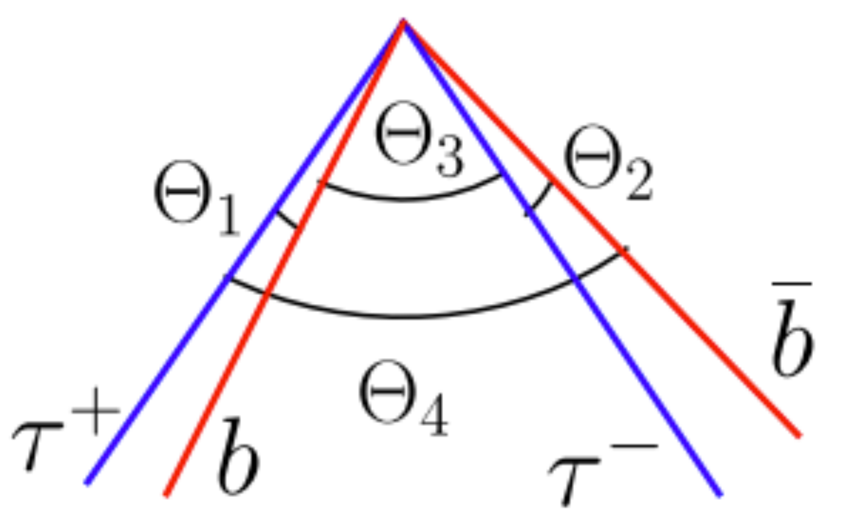


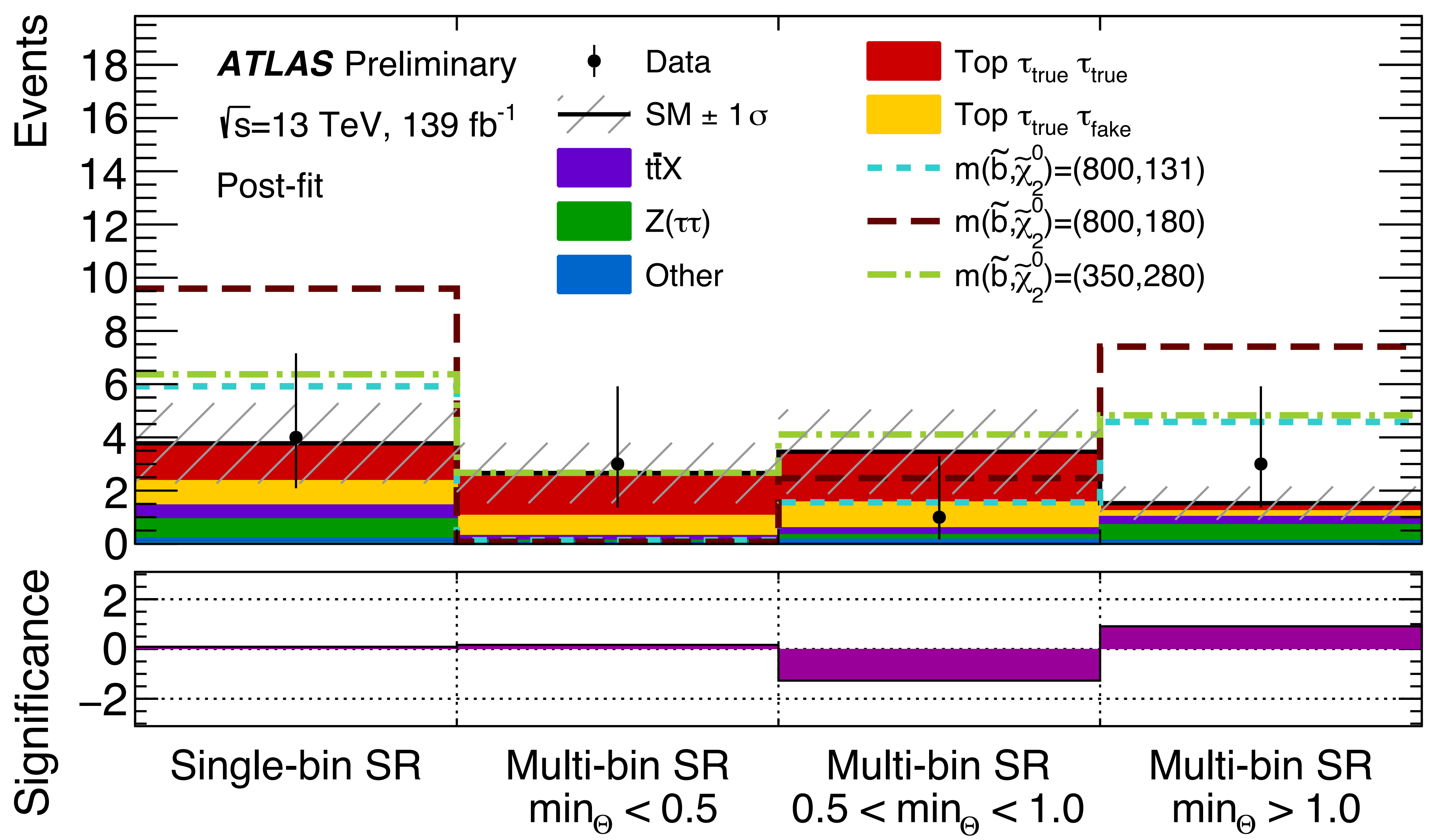


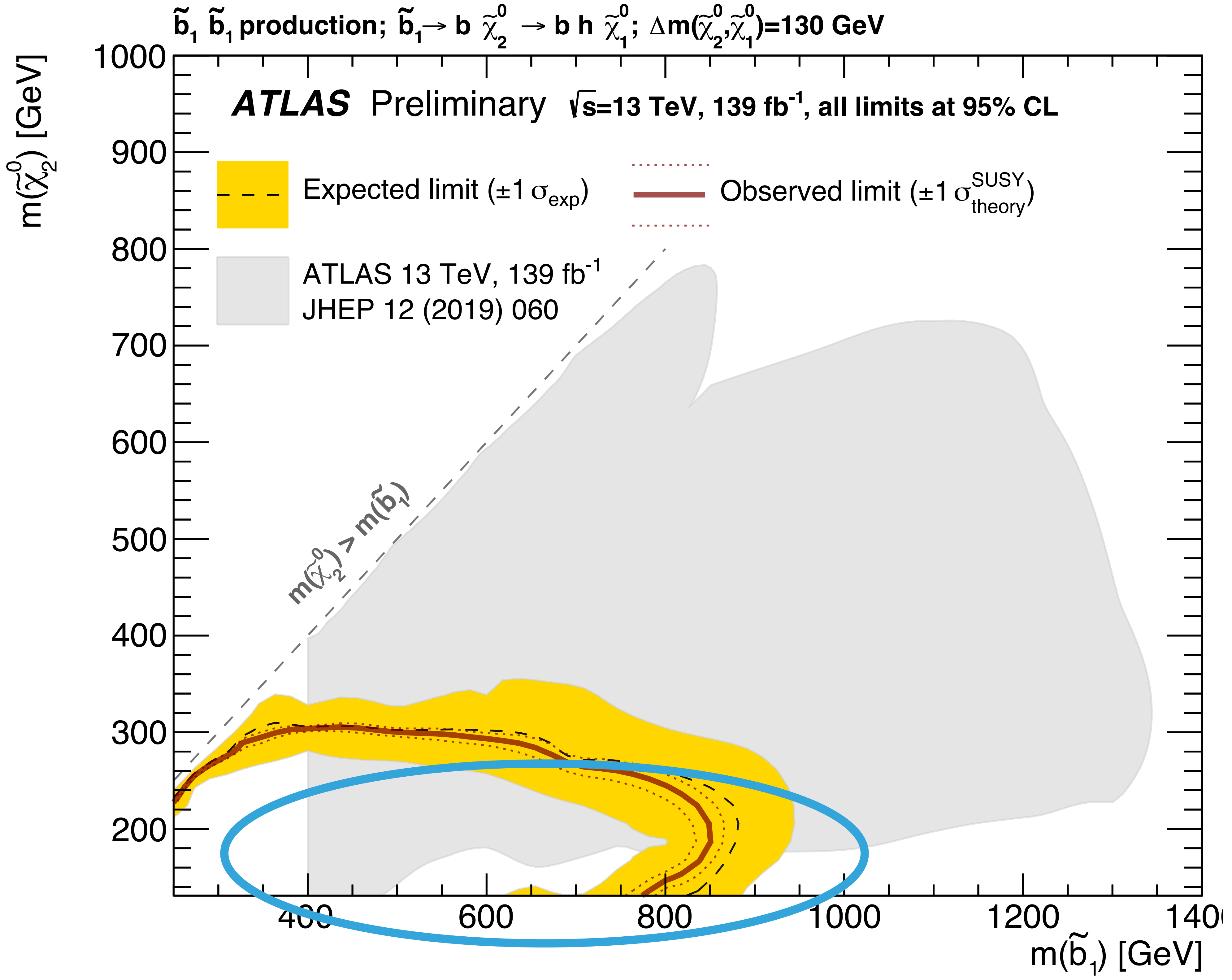
- Simplified SUSY model assuming $\tilde{b} \rightarrow b\tilde{\chi}_2^0 \rightarrow bh\tilde{\chi}_1^0$, where at least one Higgs boson decays to a pair of taus.
- Analysis has unique sensitivity at low $\tilde{\chi}_2^0$ masses due to presence of hadronically decaying taus that mitigate the SM background, and the presence of associated tau neutrinos that add to the E_T^{miss} originating from the $\tilde{\chi}_1^0$.
- SRs require $N_{b\text{-jets}} \geq 2$, ≥ 2 hadronic taus with OS and visible mass [55,120] and large E_T^{miss}. Key variables include stransverse mass m_{T2}, H_T and $\min_\Theta$, amongst other variables.
- Largest background contributions from $t\bar{t}$ and single top processes, and $Z \rightarrow \tau\tau$ produced in association with b-jets. Subdominant contributions arise from $t\bar{t}X$ processes.
  - top and Z backgrounds constrained using dedicated CRs.
  - Use muons instead of true taus to increase statistics in limited phase space.

Search for sbottom pairs in final states with taus







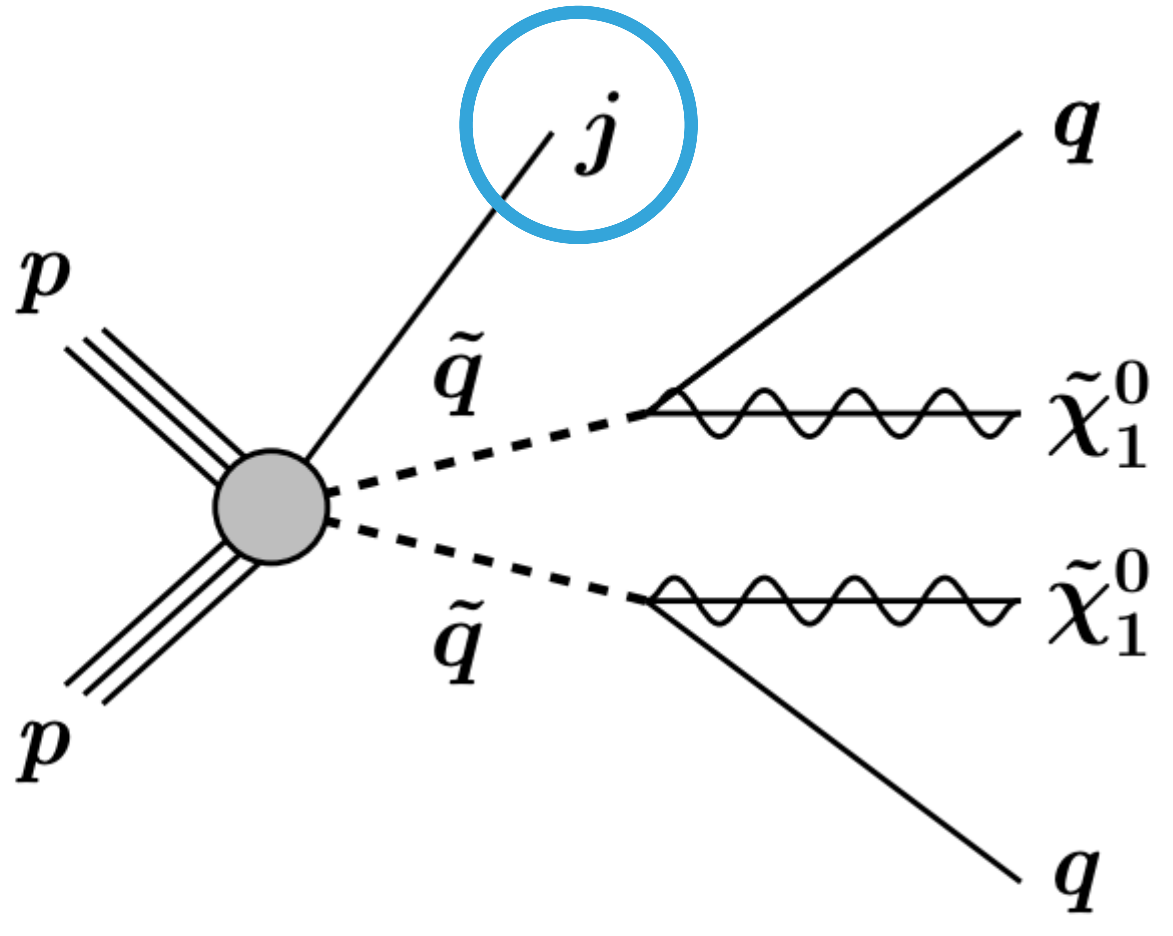


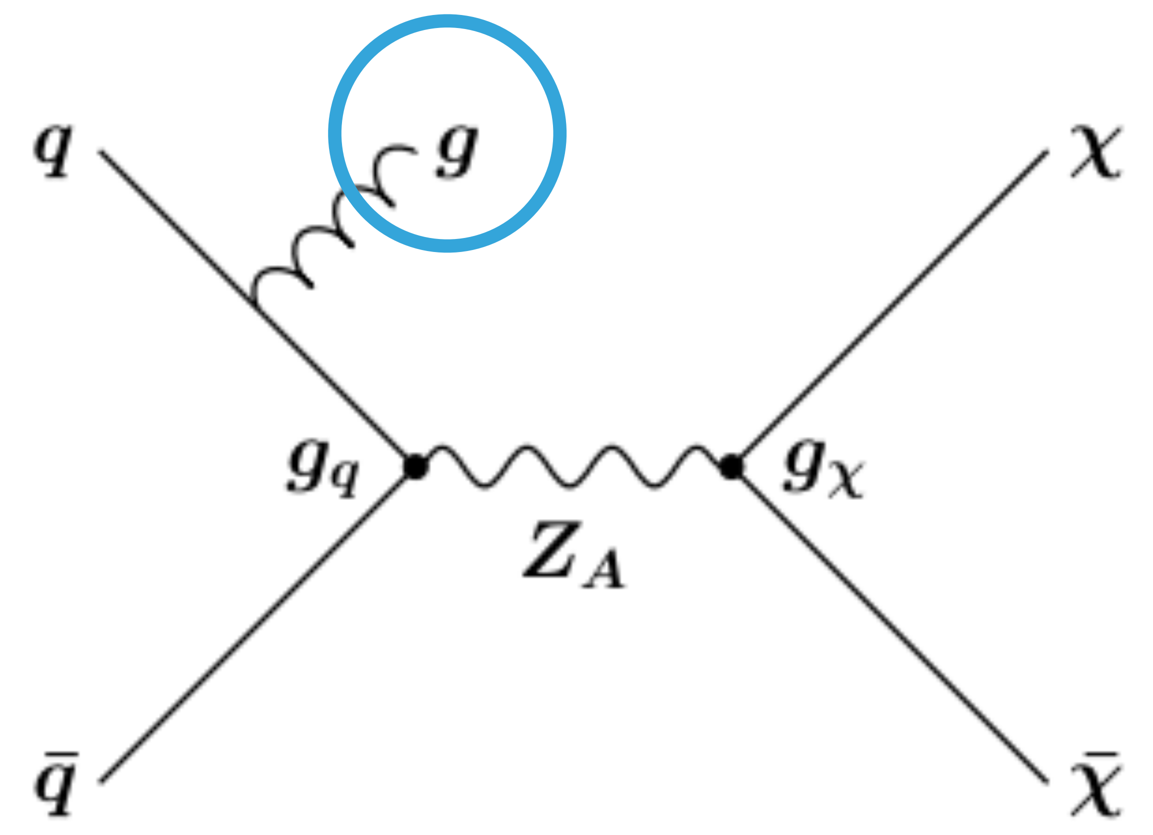
- Multi-bin SR is binned in $\min_\Theta$ (minimum angle between tau and b-jet) to exploit difference in sources:
  - For signal events, angle between b-jet and tau lepton pair increases with $\tilde{b}$ mass, and so does $\min_\Theta$.
  - For tt background, b-jet and tau originate from same top resulting in relatively low values.
  - For Z(ττ)+b$\bar{b}$ with highly boosted Z, tau pair recoils against b-jets, leading to large values.
- No significant excesses observed in SRs.
- $\tilde{b}_1$ masses up to 850 GeV are excluded.

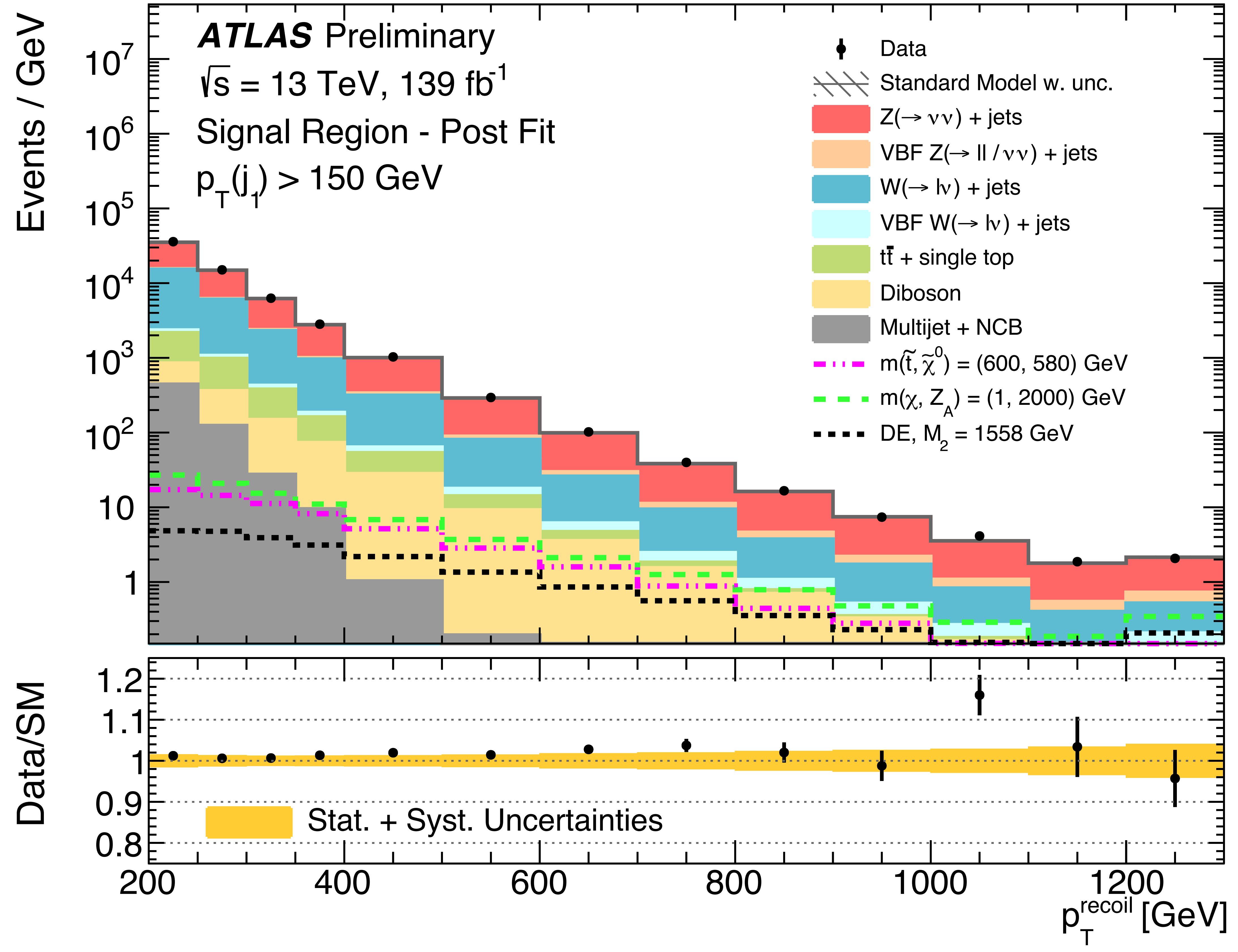
ATLAS-CONF-2020-048

Search for new physics in final states with an energetic jet and large missing transverse momentum

Mono-jet + MET analysis





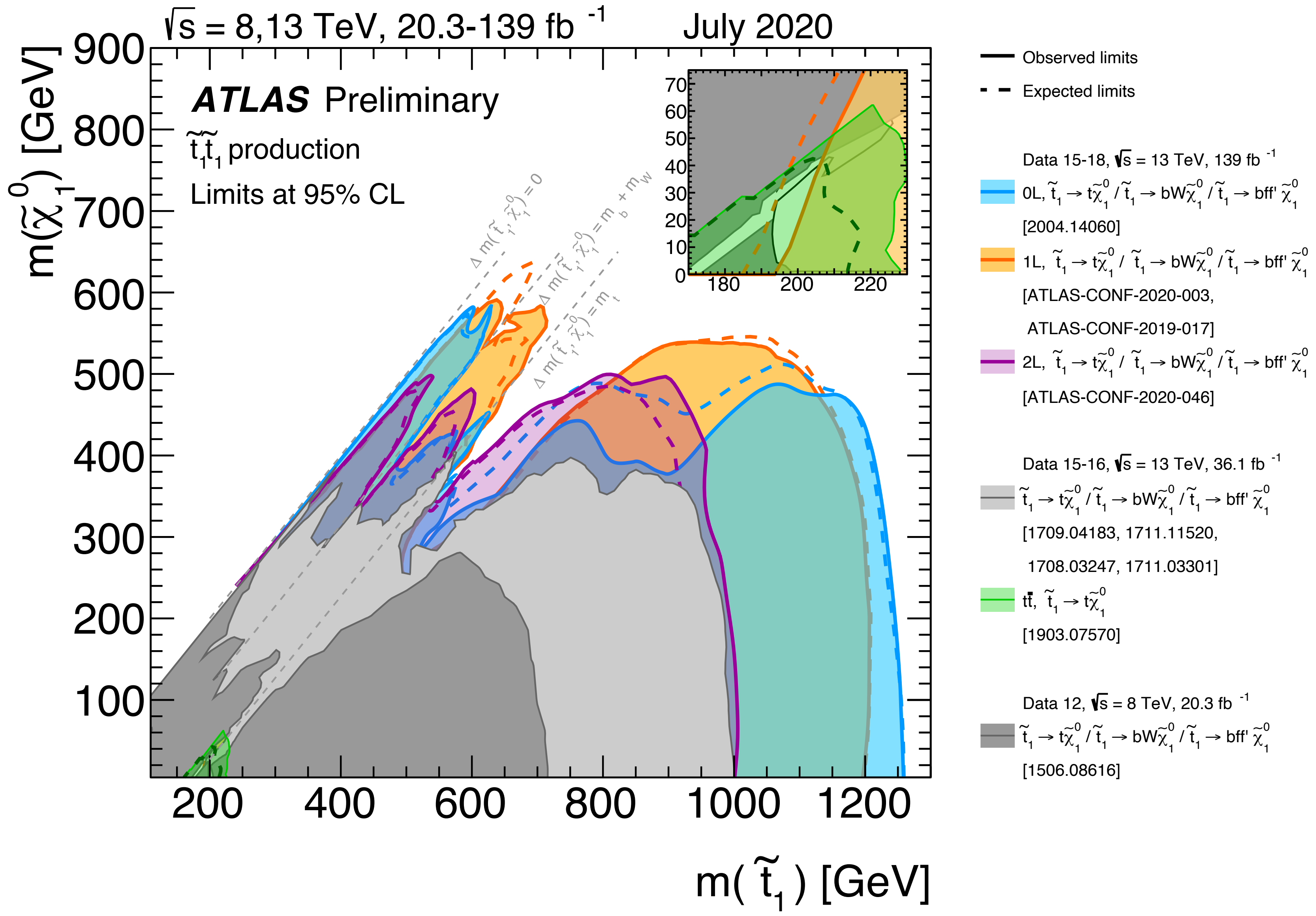


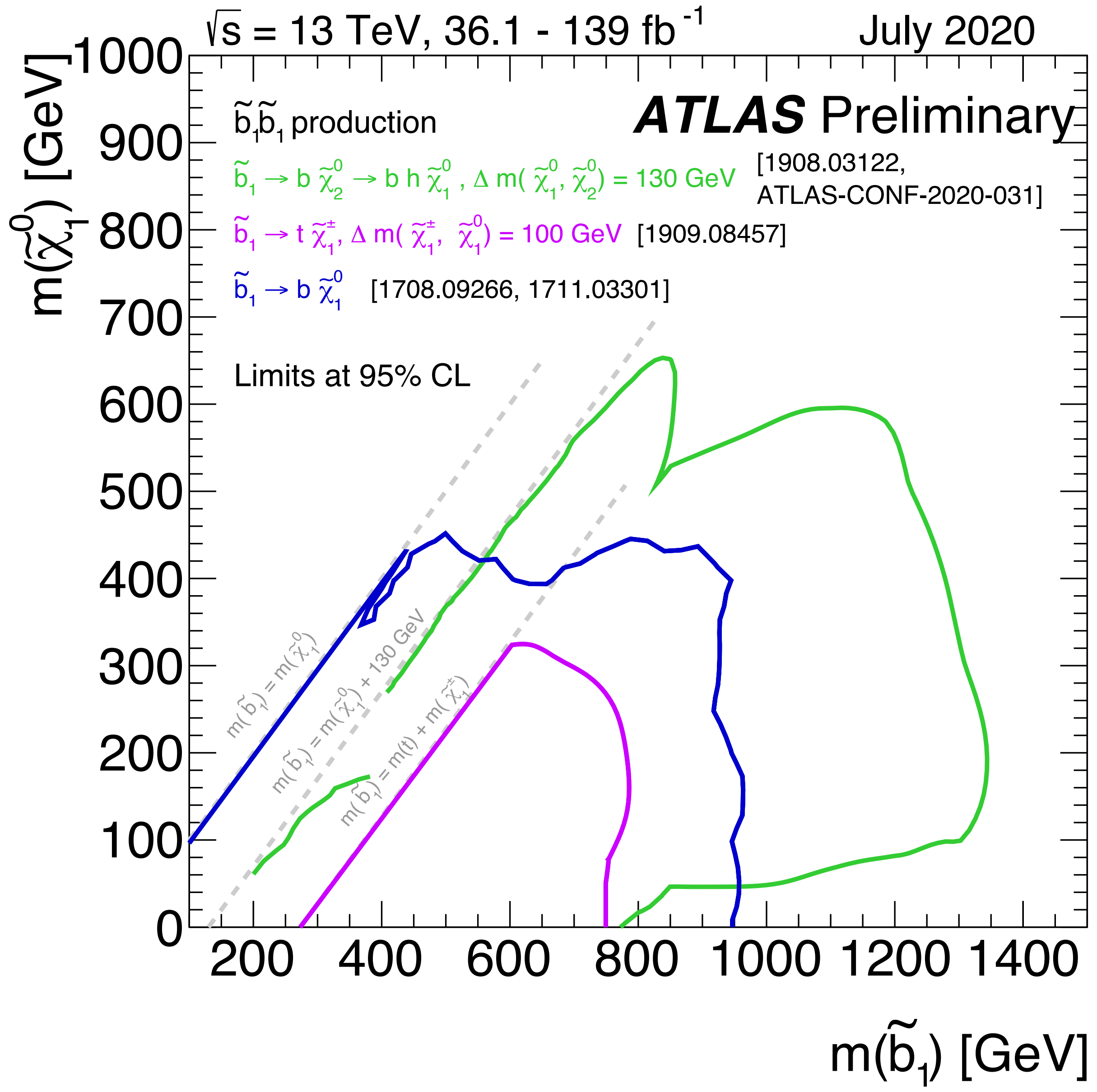
- Inclusive signature sensitive to a wide range of New Physics theories, including compressed SUSY and DM.
- Select events with an **energetic ISR jet** and large E_T^{miss}, with up to 3 other jets vetoing all other particles.
- SR divided into bins in E_T^{miss} and search for an excess.
- Dominant backgrounds from Z(vv)+jets and W(lv)+jets. Top processes also relevant.
  - Control regions for V+jets processes and top processes.

Mono-jet + MET analysis

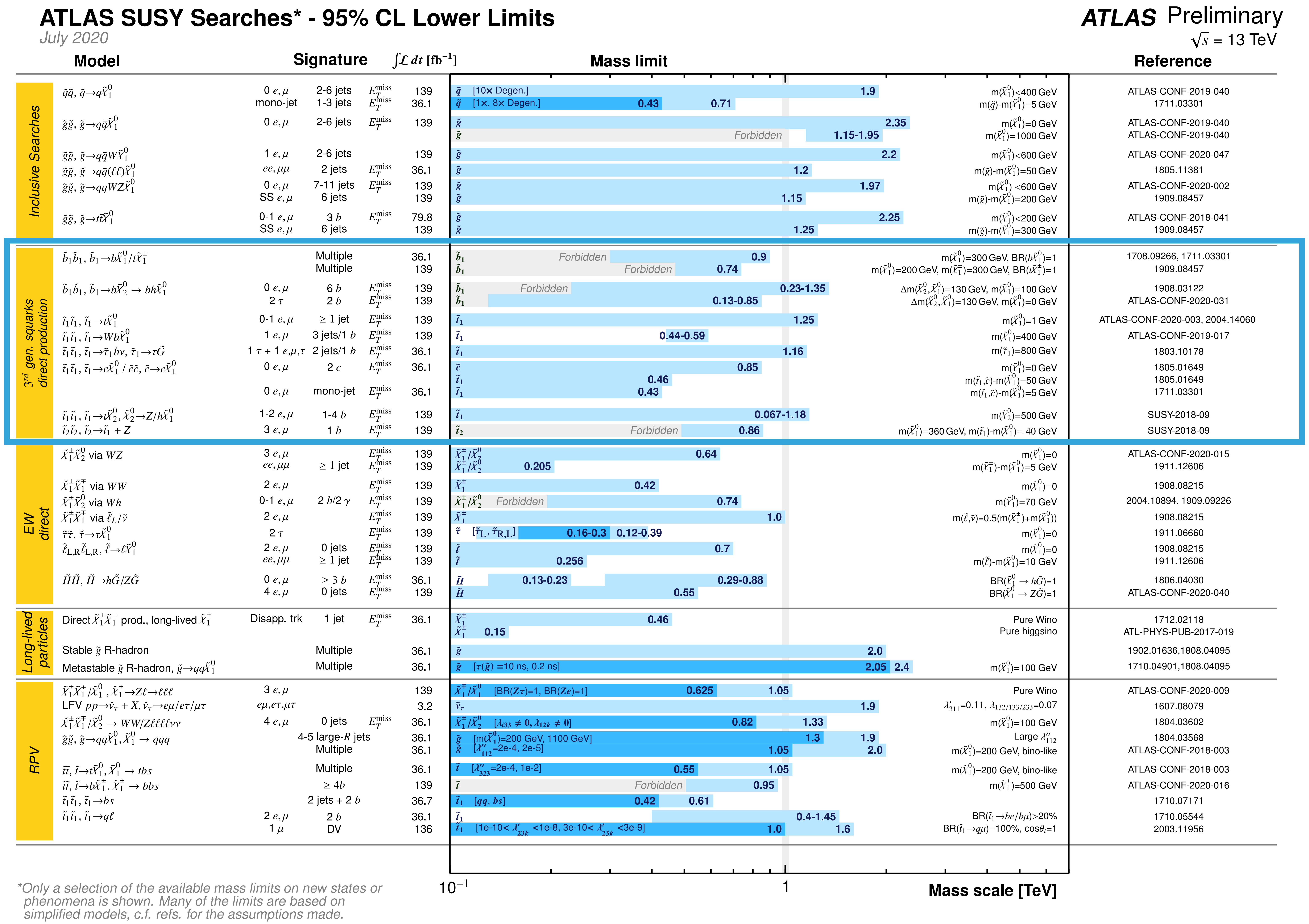
- No significant excesses observed.
- For $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} \sim m_b$ stop masses up to 520 GeV are excluded.
- For $m_{\tilde{b}_1} - m_{\tilde{\chi}_1^0} \sim m_b$ sbottom masses up to 520 GeV are excluded.
- In simplified models for WIMP-pair production in the s-channel, with Dirac fermions as dark-matter candidates, an axial-vector mediator with masses above 2 TeV is excluded for very light WIMPs and coupling values $g_q = 1/4$ and $g_X = 1$.

Current Summaries





ATLAS Summaries



Conclusions

- Natural Supersymmetry as an extension to the SM still eludes us.
- However starting to search in more challenging areas of the phase space or more exotic decay signatures requiring new and interesting analysis techniques
  - Soft b-tagging, large R jet reclustering, etc.
- Stop 0/1/2 lepton analysis:
  - Constrain stop mass to below 1.25 TeV for small $\tilde{\chi}_1^0$.
  - Constrain stop mass to about 600 GeV in the highly compressed region.
- Stop production in Z/h final states constrain $\tilde{t}_1$ masses up to around 900 GeV for massless $\tilde{\chi}_2^0$.
- Sbottom analysis with hadronic taus excludes $\tilde{b}_1$ masses up to 850 GeV are excluded.
- Mono-jet plus MET analysis excludes stop masses up to 520 GeV for $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} \sim m_b$ and sbottom masses up to 520 GeV for $m_{\tilde{b}_1} - m_{\tilde{\chi}_1^0} \sim m_b$.

Related Talks

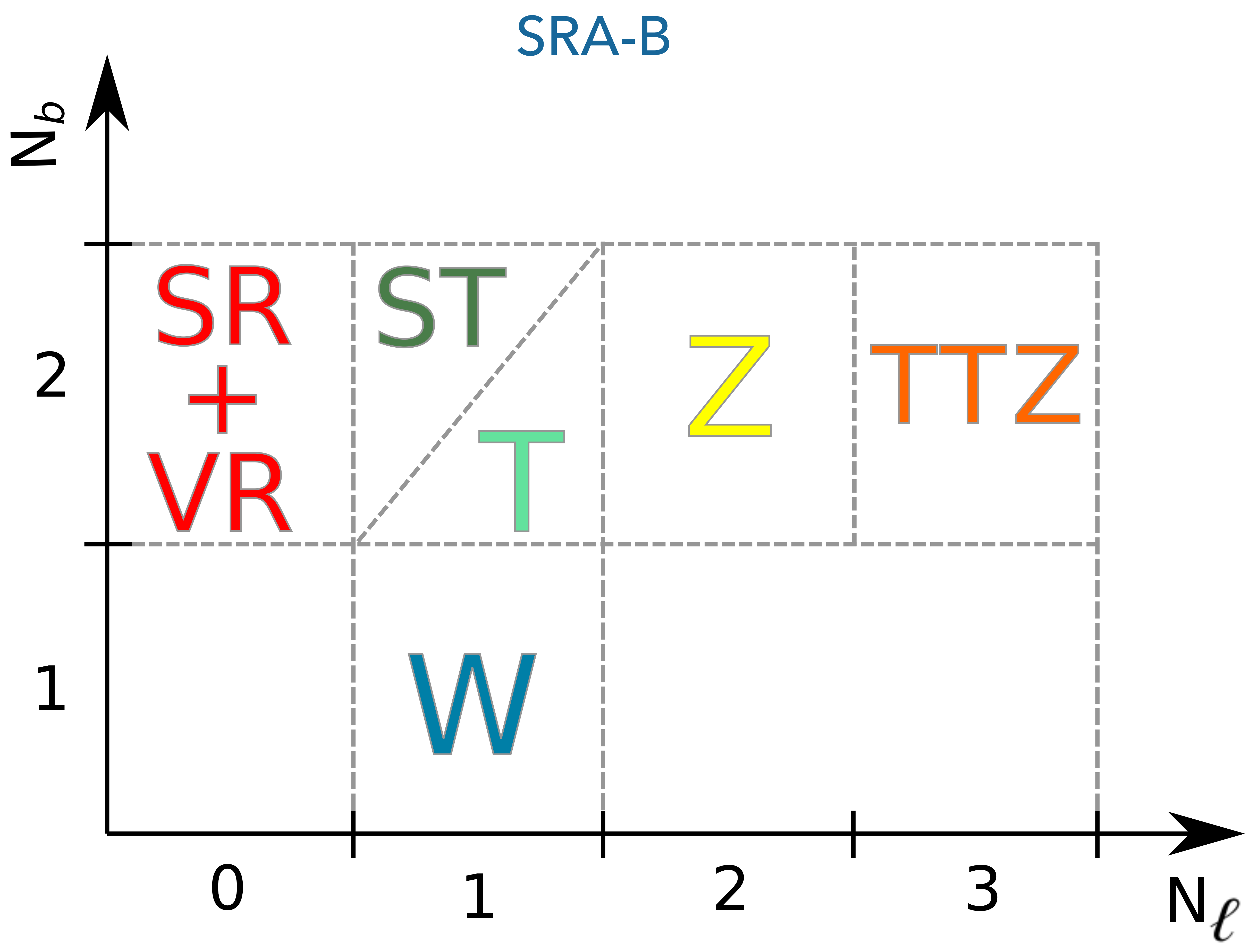
- Searching outside the box for supersymmetry: beyond the cut-and-count in ATLAS analyses — Frederik Ruehr
- Reconstruction techniques in supersymmetry searches with soft objects in the ATLAS experiment — Shion Chen
- Searches for SUSY with long-lived particles in ATLAS — Tova Ray Holmes
- R-parity violating SUSY searches in ATLAS — Johannes Josef Junggeburth
- Dark Matter searches with the ATLAS detector — Ben Carlson

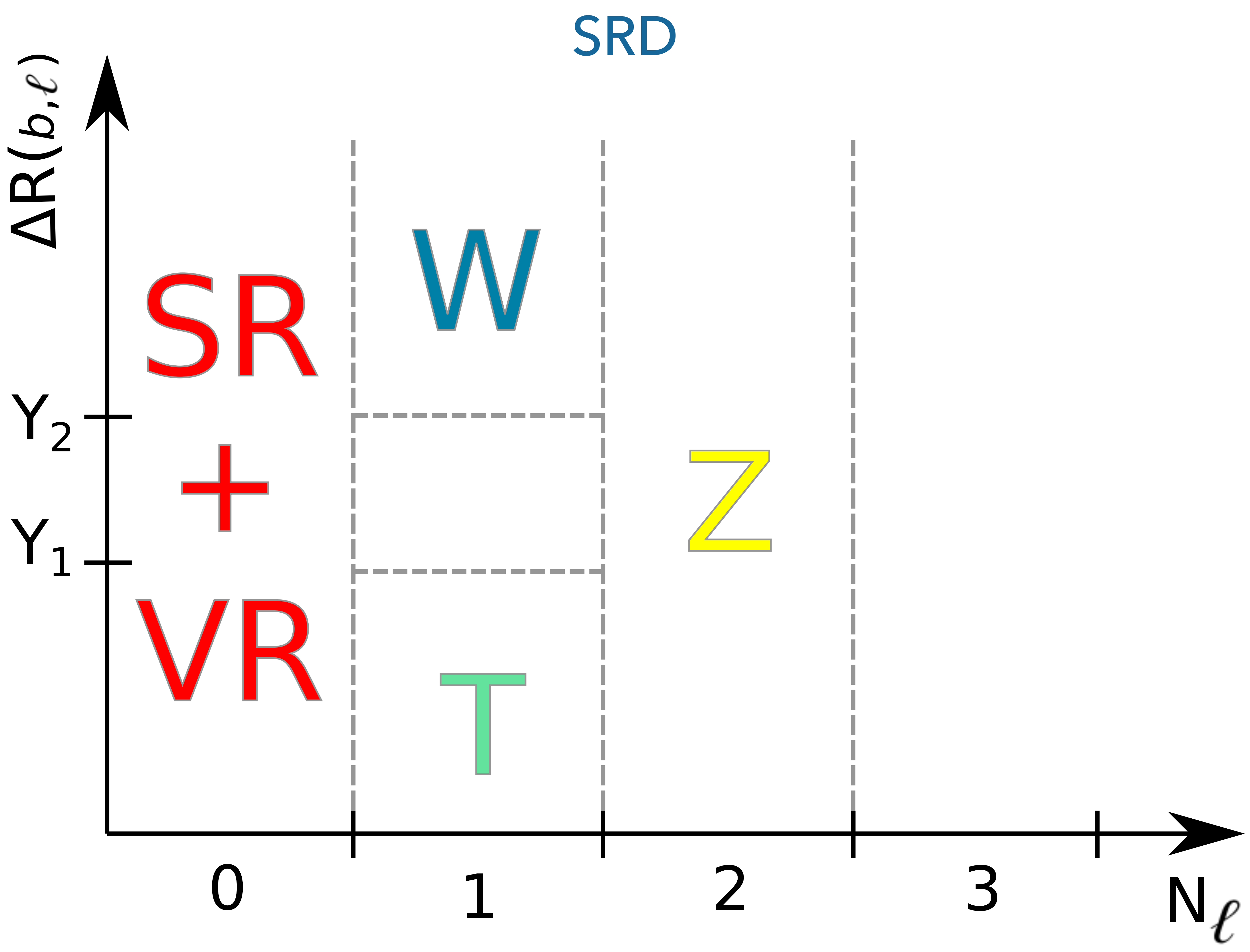
BACKUP

ATLAS-SUSY-2018-12

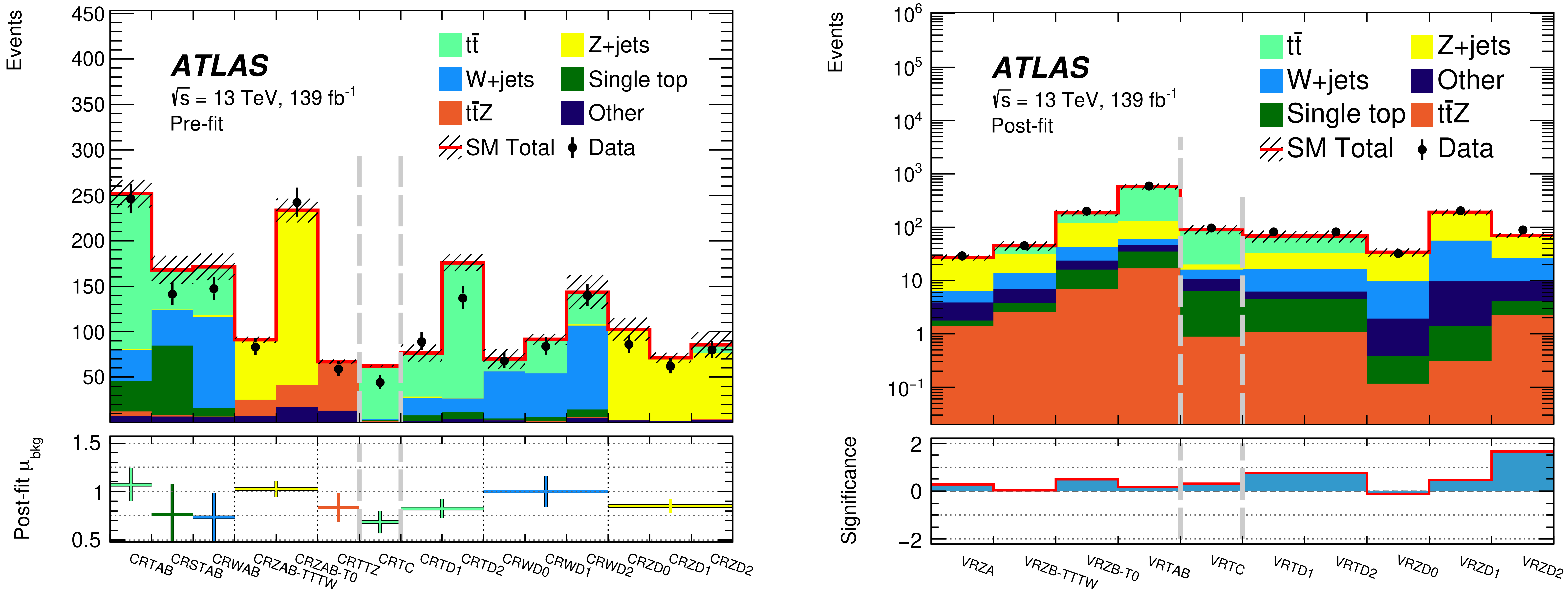
Search for stop pairs in zero lepton final states

Search for stop pairs in zero lepton final states





Search for stop pairs in zero lepton final states



Search for stop pairs in zero lepton final states

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					
$\left\|\Delta\phi_{\min}\left(\mathbf{p}_{\mathrm{T},1-4}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\|$	> 0.4					
N_{b}	≥ 2					
$m_{\mathrm{T}}^{b,\min}$	> 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			–		
$j_{1}^{R=1.2}(b)$	✓			–		
$j_{2}^{R=1.2}(b)$	✓	–				
$\Delta R\left(b_{1}, b_{2}\right)$	> 1.0	–		> 1.4		
$m_{\mathrm{T}}^{b,\max}$	–			> 200 GeV		
$\mathcal{S}$	> 25			> 14		
m_{T2,χ^2}	> 450 GeV			< 450 GeV		

Search for stop pairs in zero lepton final states

Variable/SR	SRC1	SRC2	SRC3	SRC4	SRC5
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				
N_b	≥ 2				
$E_{\mathrm{T}}^{\mathrm{miss,track}}$	> 30 GeV				
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}trk\right)\right\|$	$< \pi/3$				
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T},1-2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\|$	> 0.4				
$N_{\mathrm{j}}^{\mathrm{S}}$	≥ 4				
N_b^{S}	≥ 2				
$p_{\mathrm{T}}^{\mathrm{ISR}}$	> 400 GeV				
$p_{\mathrm{T},1}^{\mathrm{S},b}$	> 50 GeV				
$p_{\mathrm{T},4}^{\mathrm{S}}$	> 50 GeV				
m_{S}	> 400 GeV				
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{ISR}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\|$	> 3.0				
R_{ISR}	0.30–0.40	0.40–0.50	0.50–0.60	0.60–0.70	> 0.70

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		
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\|$	> 2.4		
$E_{\mathrm{T}}^{\mathrm{miss,track}}$	> 30 GeV		
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}trk\right)\right\|$	$< \pi/3$		
N_b^{track}	≥ 1		–
$\left\|\Delta\phi_{\min}\left(\mathbf{p}_{\mathrm{T},1-4}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\|$	> 0.4	–	
$\|\eta_1^{b,\mathrm{track}}\|$	< 1.2	–	
$\max\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T}}^{b^{\mathrm{track}}}\right)\right\|$	> 2.2	–	
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T},1}^{b^{\mathrm{track}}}, \mathbf{p}_{\mathrm{T},2}^{b^{\mathrm{track}}}\right)\right\|$	< 2.5	–	
$p_{\mathrm{T},1}^{b,\mathrm{track}}$	< 50 GeV	> 10 GeV	–
$p_{\mathrm{T},1}^{\mathrm{track}}$	–	< 40 GeV	–
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T},1-4}^{\mathrm{j}^{\mathrm{track}}}, \mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}\right)\right\|$	–	> 1.2	–
$\|\eta_1^b\|$	–	< 1.6	–
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T},1}^{b}\right)\right\|$	–	> 2.2	
$\|\eta_2^b\|$	–		< 1.2
$p_{\mathrm{T},1}^{b}$	–		< 175 GeV
$\left\|\Delta\phi\left(\mathbf{p}_{\mathrm{T}}^{\mathrm{j}^{\mathrm{ISR}}}, \mathbf{p}_{\mathrm{T},2}^{b}\right)\right\|$	–		> 1.6
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 26\sqrt{\mathrm{GeV}}$	$> 22\sqrt{\mathrm{GeV}}$	

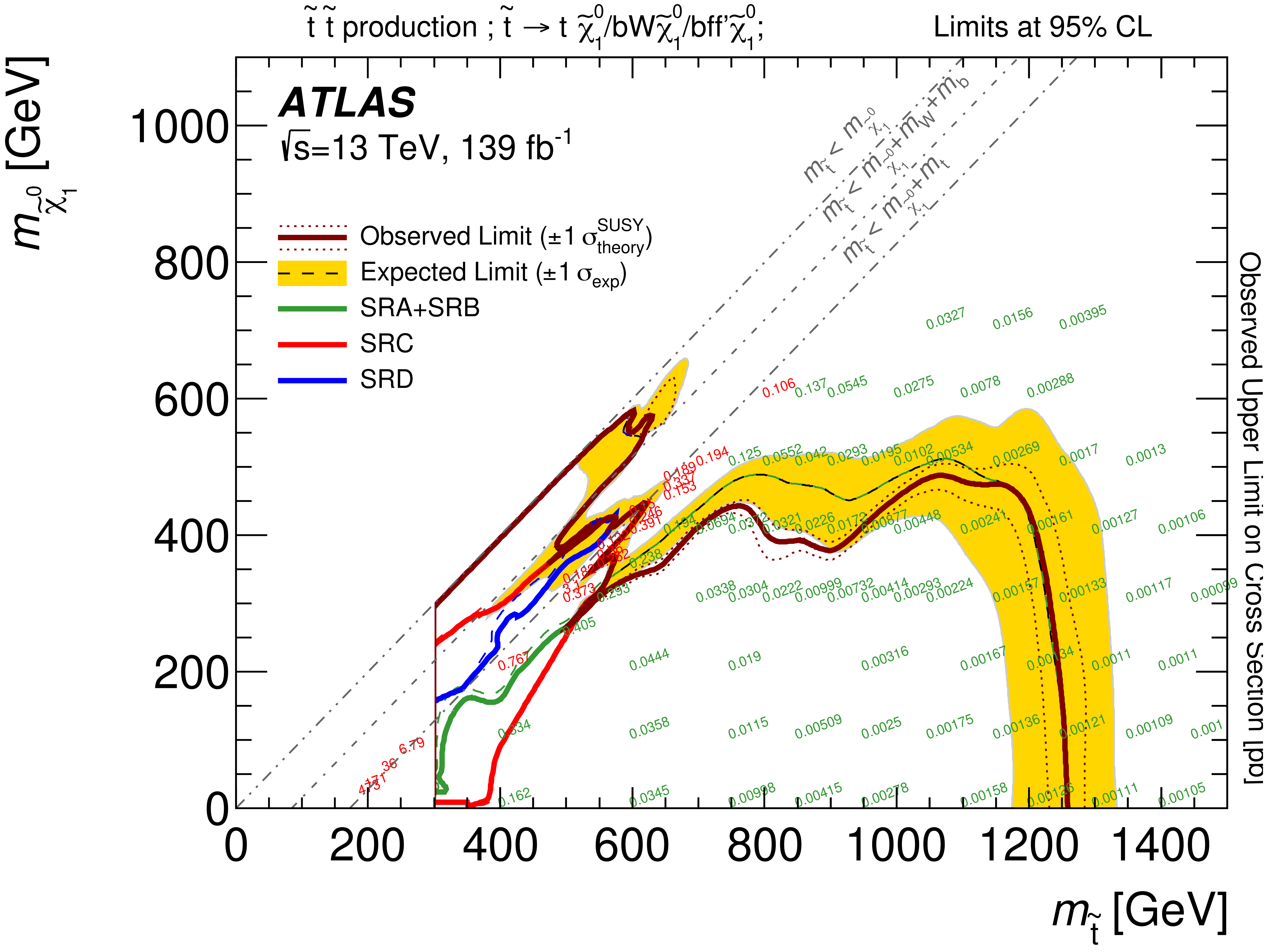
Search for stop pairs in zero lepton final states

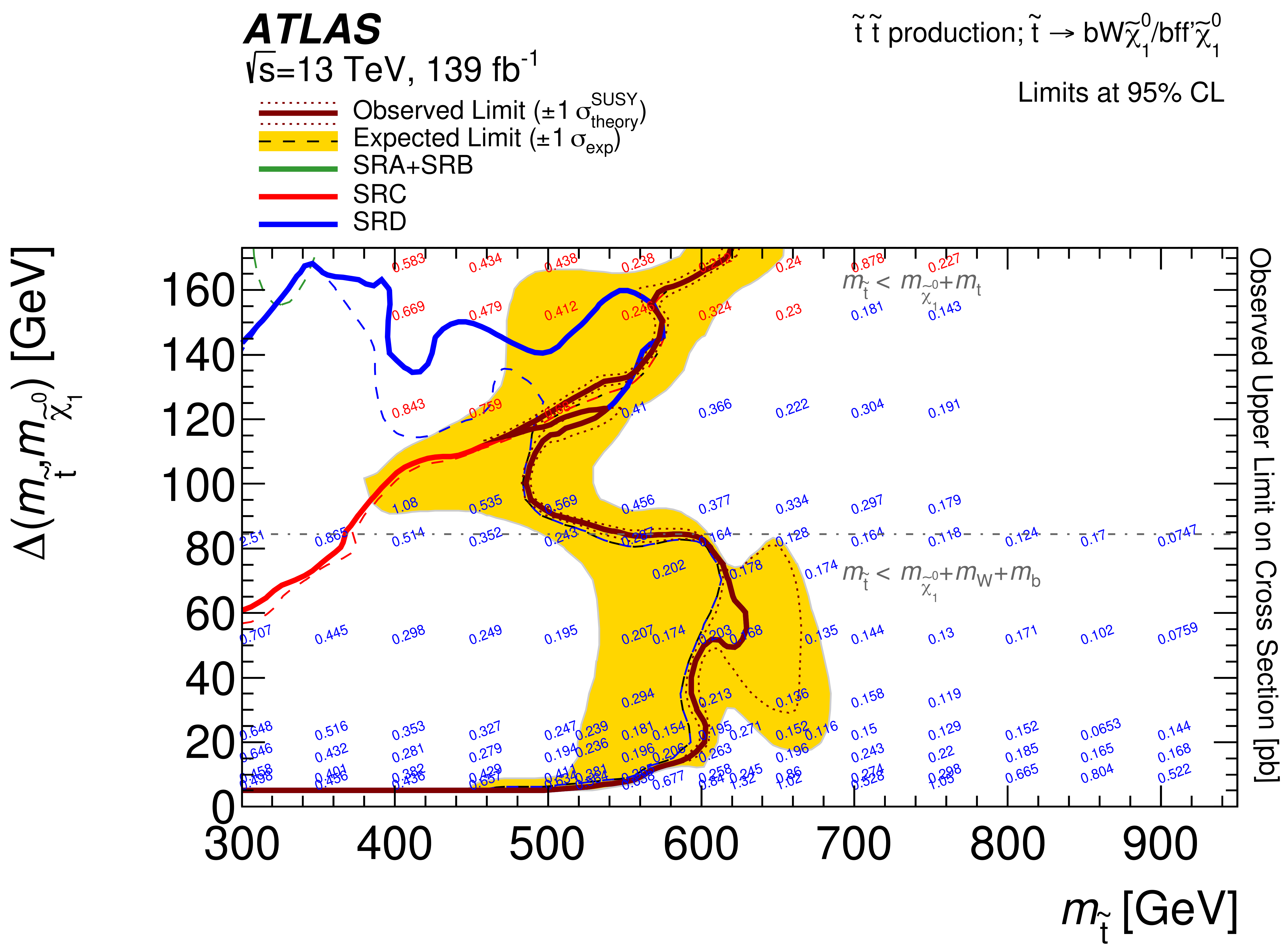
	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Total syst. unc.	15	12	10	14	9	9
$t\bar{t}$ theory	2	2	1	11	6	4
Single-top theory	7	5	4	1	<1	1
$t\bar{t}Z$ theory	3	<1	<1	<1	<1	<1
Z theory	<1	<1	1	<1	<1	<1
$\mu_{t\bar{t}}$	<1	<1	<1	4	4	4
$\mu_{t\bar{t}+Z}$	6	2	2	4	3	1
μ_Z	3	5	5	3	3	3
μ_W	2	3	3	4	4	3
$\mu_{\text{single top}}$	6	4	5	3	4	5
JER	7	3	2	6	2	3
JES	4	4	2	2	<1	<1
b-tagging	5	3	3	2	1	2
$E_{\text{T}}^{\text{miss}}$ soft term	2	1	1	<1	<1	<1
MC statistics	7	7	5	3	3	2

Search for stop pairs in zero lepton final states

	SRC1	SRC2	SRC3	SRC4	SRC5	SRD0	SRD1	SRD2
Total syst. unc.	25	18	20	27	27	18	31	12
$t\bar{t}$ theory	20	11	12	16	21	4	9	5
Single-top theory	<1	<1	<1	<1	<1	<1	4	2
Z theory	<1	<1	1	2	4	7	3	2
W theory	<1	<1	1	2	3	<1	<1	<1
$\mu_{t\bar{t}}$	12	13	14	14	11	<1	2	5
μ_Z	<1	<1	<1	<1	<1	5	3	2
μ_W	<1	<1	<1	<1	<1	4	5	3
JER	5	<1	8	15	7	8	18	4
JES	<1	1	<1	4	6	1	4	2
b-tagging	2	2	2	2	2	3	5	7
Track-jet flavour	<1	<1	<1	<1	<1	4	7	<1
Track-jet flavour (low p_{T})	<1	<1	<1	<1	<1	7	4	1
$E_{\mathrm{T}}^{\mathrm{miss}}$ soft term	<1	<1	<1	<1	3	<1	<1	<1
Pile-up	<1	<1	<1	1	<1	2	12	<1
MC statistics	3	2	3	4	6	11	17	5

Search for stop pairs in zero lepton final states





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Search for stop pairs in one lepton final states

Search for stop pairs in one lepton final states

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)
$E_{\mathrm{T}}^{\text{miss}}$	[GeV]	¿ 230	¿ 520
$E_{\mathrm{T},\perp}^{\text{miss}}$	[GeV]	¿ 400	-
$H_{\mathrm{T,sig}}^{\text{miss}}$		¿ 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 $E_{\mathrm{T}}^{\text{miss}}$ and m_{T} in tN_med	
		$E_{\mathrm{T}}^{\text{miss}} \in [230, 400]$, $m_{\mathrm{T}} > 220$	
		$E_{\mathrm{T}}^{\text{miss}} \in [400, 500]$, $m_{\mathrm{T}} > 220$	
Bin boundaries	[GeV]	$E_{\mathrm{T}}^{\text{miss}} \in [500, 600]$, $m_{\mathrm{T}} \in [220, 380]$	
		$E_{\mathrm{T}}^{\text{miss}} \in [500, 600]$, $m_{\mathrm{T}} > 380$	
		$E_{\mathrm{T}}^{\text{miss}} > 600$, $m_{\mathrm{T}} \in [220, 380]$	
		$E_{\mathrm{T}}^{\text{miss}} > 600$, $m_{\mathrm{T}} > 380$	

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
$E_{\mathrm{T}}^{\text{miss}}$	[GeV]	–	> 400
m_{T2}	[GeV]	–	< 360
$\Delta m_{\mathrm{T}}^{\alpha}$	[GeV]	> 40	–
$\Delta m_{\mathrm{T}}^{\text{dyn}}$	[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 in one lepton final states

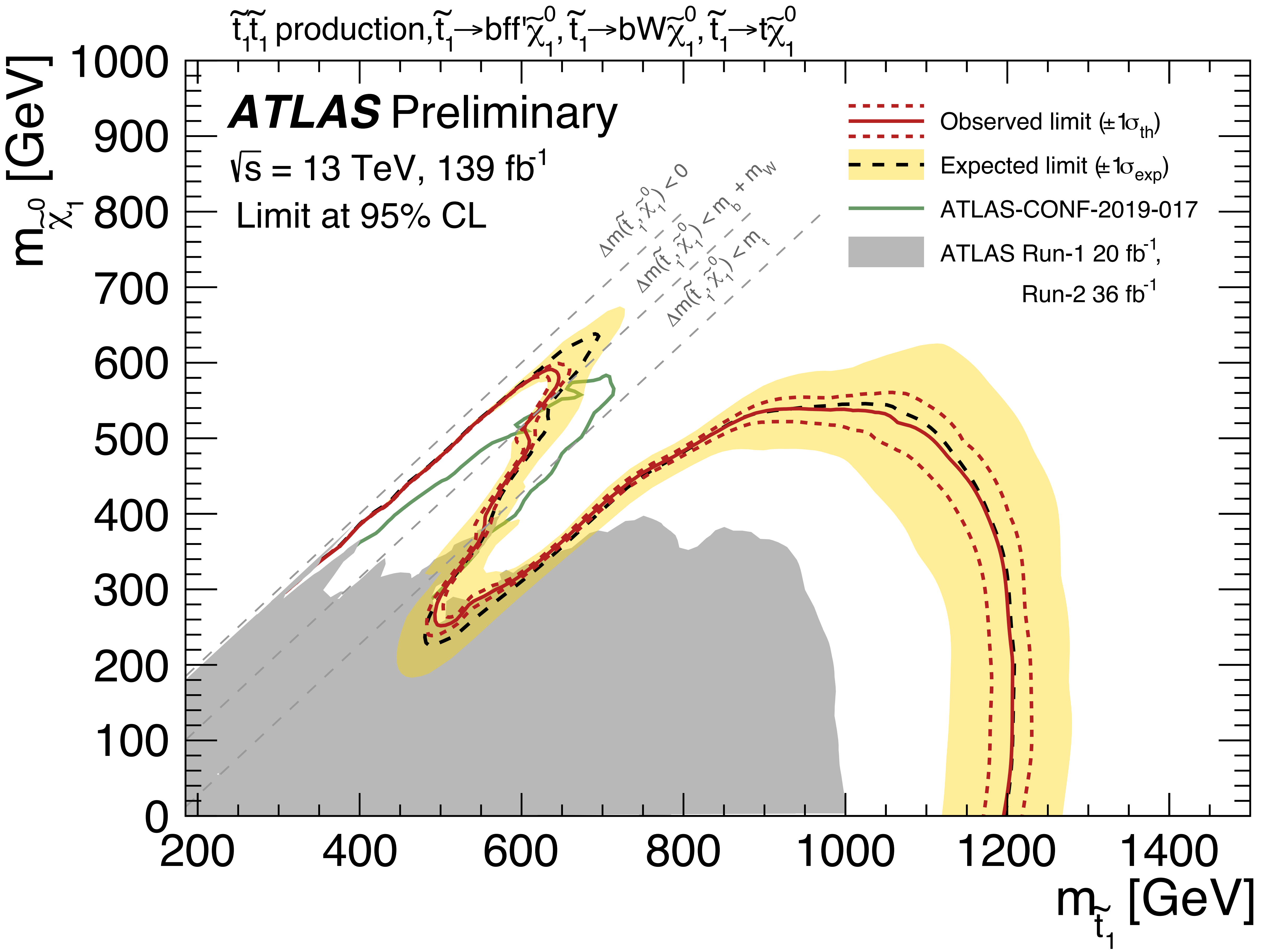
Selection		bffN_softb	bffN_btag
Preselection		soft-lepton preselection	
N_{jet}		≥ 1	≥ 2
Jet p_{T}	[GeV]	> 200	
$N_{b\text{-jet}}$		=0	≥ 1
b-jet p_{T}	[GeV]	–	< 50
N_{SV}		≥ 1	–
m_{T}	[GeV]	> 90	
$E_{\text{T}}^{\text{miss}}$	[GeV]	> 250	–
$\Delta\phi(\vec{p}_{\text{T}}^{\text{miss}}, \ell)$	[rad]	< 2.0	–
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]		$\{0, 0.8, 1.5\}$

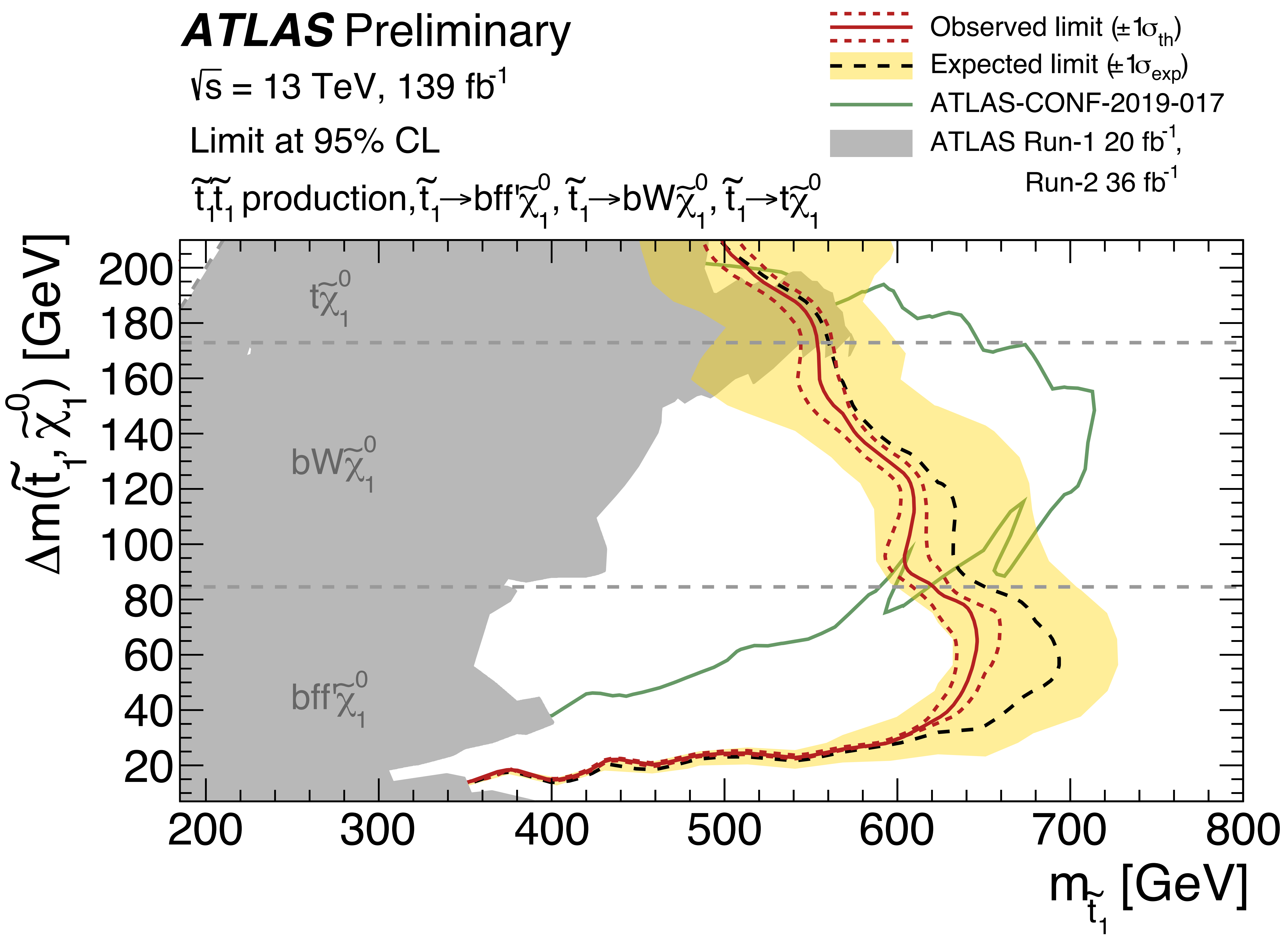
Selection		DM_scalar	DM_pseudo
Preselection		hard-lepton preselection	
N_{jet}, $N_{b\text{-jet}}$		$\geq (4, 2)$	
Jet p_{T}	[GeV]	¿ (80, 60, 30, 25)	
b-tagged jet p_{T}	[GeV]	¿ (80, 25)	
$E_{\text{T}}^{\text{miss}}$	[GeV]	¿ 230	
$H_{\text{T,sig}}^{\text{miss}}$		¿ 15	
m_{T}	[GeV]	¿ 180	
topness		¿ 8	
$m_{\text{top}}^{\text{reclustered}}$	[GeV]	¿ 150	
$\Delta\phi(\text{jet}_i, \vec{p}_{\text{T}}^{\text{miss}})$, $i \in [1, 4]$	[rad]	> 0.9	
$\Delta\phi(\vec{p}_{\text{T}}^{\text{miss}}, \ell)$	[rad]	> 1.1	> 1.5
Exclusion technique		Based on shape fit in $\Delta\phi(\vec{p}_{\text{T}}^{\text{miss}}, \ell)$	
Bin boundaries in $\Delta\phi(\vec{p}_{\text{T}}^{\text{miss}}, \ell)$		$\{1.1, 1.5, 2.0, 2.5, \pi\}$	

Search for stop pairs in one lepton final states

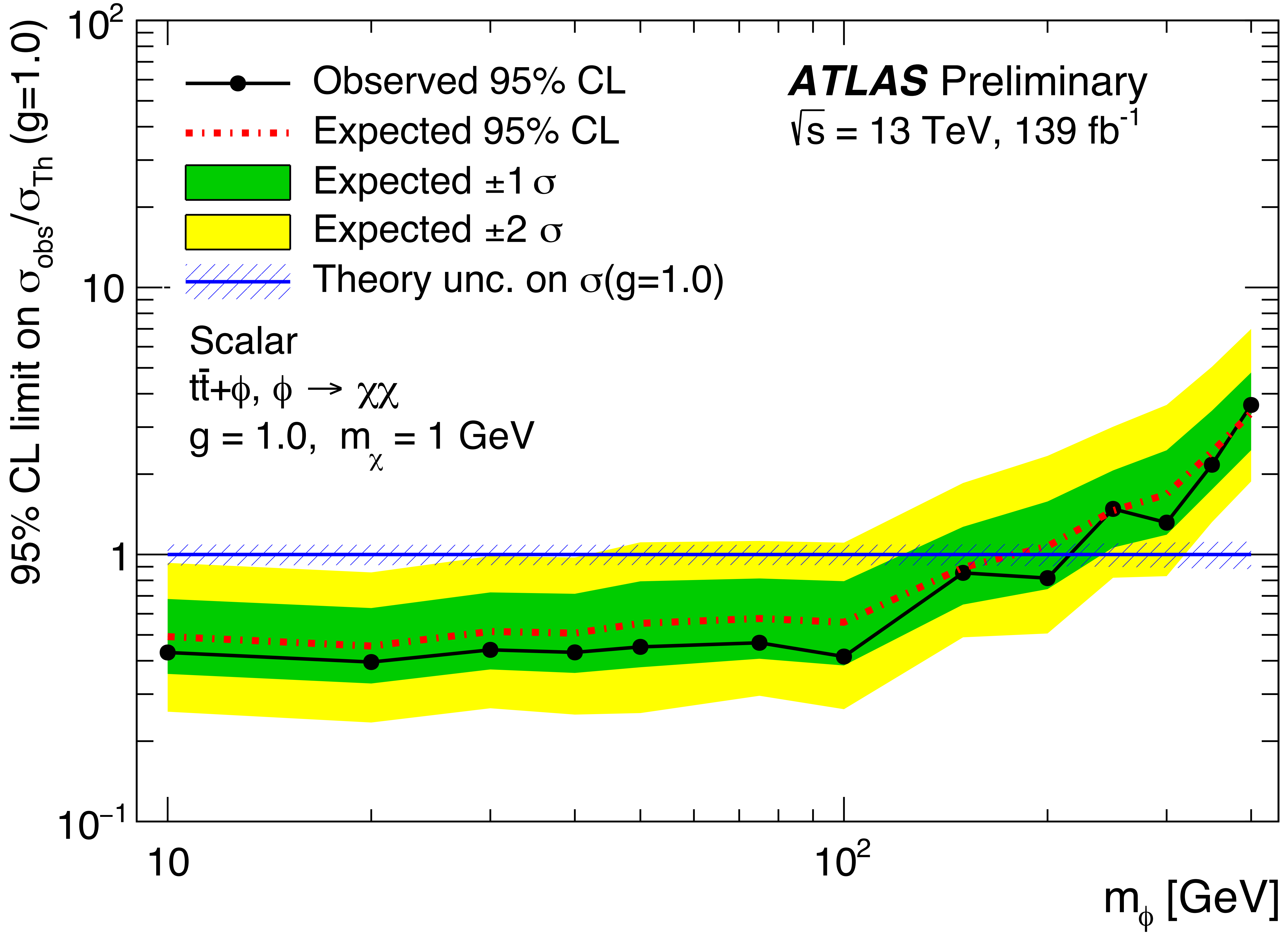
Selection		hard-lepton	soft-lepton
Trigger		$E_{\mathrm{T}}^{\mathrm{miss}}$ trigger	
Data quality		jet cleaning, primary vertex	
Second-lepton veto		no additional baseline leptons	
Number of leptons, tightness		= 1 'loose' lepton	= 1 'tight' lepton
Lepton p_{T}	[GeV]	> 25	$> 4(4.5)$ for $\mu(e)$
Number 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	–

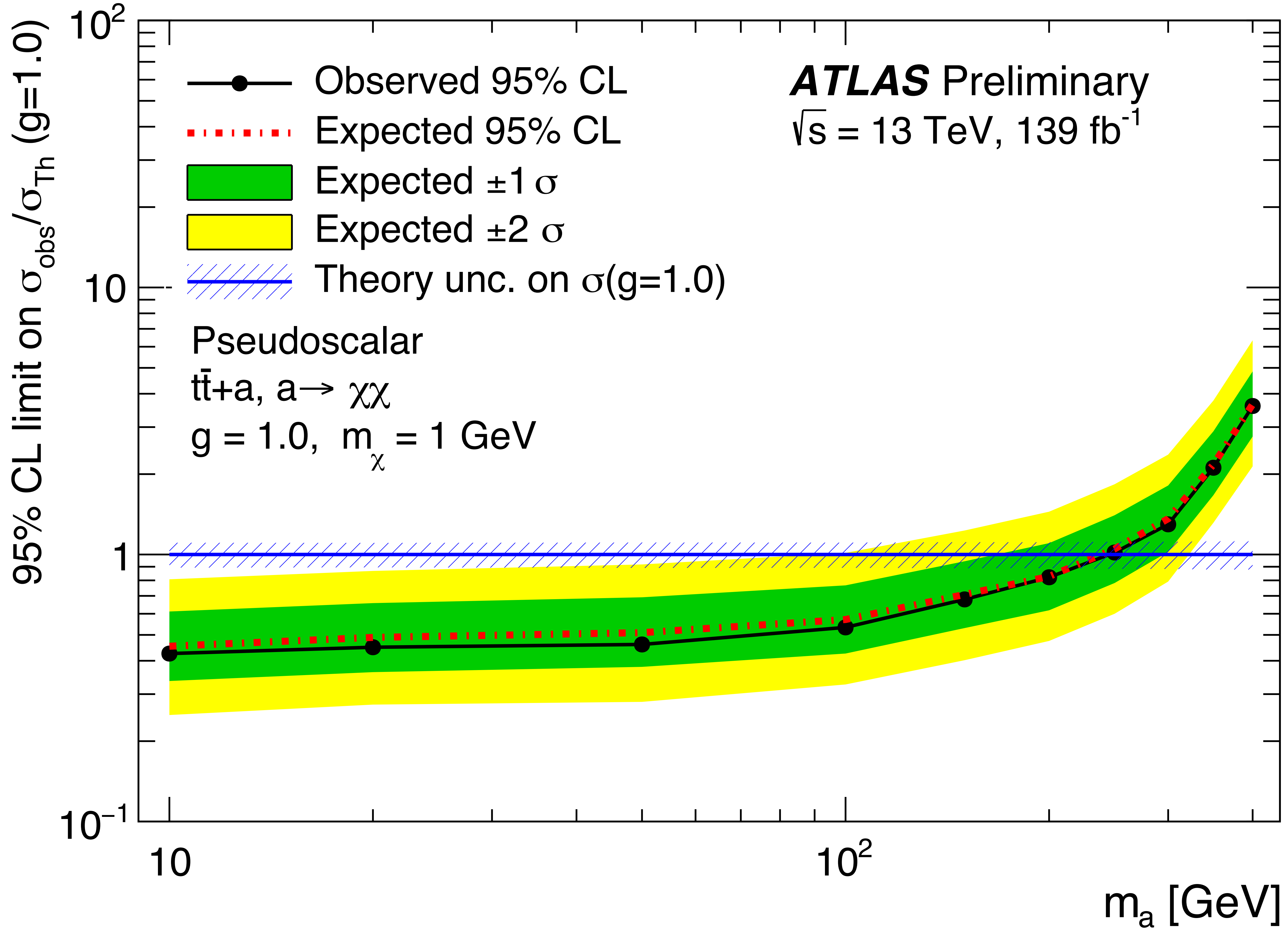
Search for stop pairs in one lepton final states





Search for stop pairs in one lepton final states





ATLAS-CONF-2020-046

Search for stop pairs in two lepton final states

Search for stop pairs in two lepton final states

	$SR^{2\text{-body}}$	
Leptons flavour	DF	SF
$p_T(\ell_1)$ [GeV]	> 25	
$p_T(\ell_2)$ [GeV]	> 20	
$m_{\ell\ell}$ [GeV]	> 20	
$\lvert m_{\ell\ell} - m_Z \rvert$ [GeV]	–	> 20
$n_{b\text{-jets}}$	≥ 1	
$\Delta\phi_{\text{boost}}$ [rad]	< 1.5	
E_T^{miss} significance	> 12	
$m_{T2}^{\ell\ell}$ [GeV]	> 110	

	$SR_W^{3\text{-body}}$		$SR_t^{3\text{-body}}$	
Leptons flavour	DF	SF	DF	SF
$p_T(\ell_1)$ [GeV]	> 25		> 25	
$p_T(\ell_2)$ [GeV]	> 20		> 20	
$m_{\ell\ell}$ [GeV]	> 20		> 20	
$\lvert m_{\ell\ell} - m_Z \rvert$ [GeV]	–	> 20	–	> 20
$n_{b\text{-jets}}$	$= 0$		≥ 1	
$\Delta\phi_\beta^R$ [rad]	> 2.3		> 2.3	
E_T^{miss} significance	> 12		> 12	
$1/\gamma_{R+1}$	> 0.7		> 0.7	
R_{p_T}	> 0.78		> 0.70	
M_Δ^R [GeV]	> 105		> 120	

	$SR^{4\text{-body}}_{\text{Small}\,\Delta m}$	$SR^{4\text{-body}}_{\text{Large}\,\Delta m}$
$p_T(\ell_1)$ [GeV]	$[4.5(4),\ 25]$ $e(\mu)$	< 100
$p_T(\ell_2)$ [GeV]	$[4.5(4),\ 10]$ $e(\mu)$	$[10,\ 50]$
$m_{\ell\ell}$ [GeV]	> 10	
$p_T(j_1)$ [GeV]	> 150	
$\min \Delta R_{\ell_2, j_i}$	> 1	
E_T^{miss} significance	> 10	
$p_{T,\text{boost}}^{\ell\ell}$ [GeV]	> 280	
E_T^{miss} [GeV]	> 400	
$R_{2\ell}$	> 25	> 13
$R_{2\ell 4j}$	> 0.44	> 0.38

Search for stop pairs in two lepton final states

Signal Region	$\text{SR-SF}^{\text{2-body}}_{[110,120)}$	$\text{SR-SF}^{\text{2-body}}_{[120,140)}$	$\text{SR-SF}^{\text{2-body}}_{[140,160)}$	$\text{SR-SF}^{\text{2-body}}_{[160,180)}$	$\text{SR-SF}^{\text{2-body}}_{[180,220)}$	$\text{SR-SF}^{\text{2-body}}_{[220,\infty)}$
Total SM background uncertainty	19%	20%	17%	15%	15%	20%
VV theoretical uncertainties	–	2.4%	3.5%	4.9%	4.4%	7.1%
$t\bar{t}$ theoretical uncertainties	10%	11%	6.2%	–	1.7%	2.7%
$t\bar{t}Z$ theoretical uncertainties	1.0%	2.2%	4.2%	5.2%	5.0%	11%
$t\bar{t}$-Wt interference	–	–	–	–	1.0%	5.7%
Other theoretical uncertainties	1.0%	1.4%	2.7%	2.5%	2.6%	1.9%
MC statistical uncertainty	5.1%	5.4%	7.0%	7.7%	9.9%	8.7%
$t\bar{t}$ normalization	7.6%	4.8%	1.0%	–	–	–
$t\bar{t}Z$ normalization	1.1%	3.2%	5.6%	7.2%	6.4%	4.8%
Jet energy scale	11%	6.7%	9.6%	2.0%	3.4%	2.0%
Jet energy resolution	3.6%	13%	7.0%	6.1%	3.6%	7.7%
$E_{\text{T}}^{\text{miss}}$ modelling	2.9%	3.6%	1.0%	4.1%	2.7%	1.2%
Lepton modelling	3.6%	1.8%	1.8%	3.8%	3.7%	6.4%
Flavor tagging	1.0%	1.0%	1.0%	2.6%	3.0%	2.4%
Pile-up reweighting and JVT	–	1.4%	1.0%	1.0%	1.7%	–
Fake and non-prompt leptons	–	–	1.1%	–	2.8%	4.3%

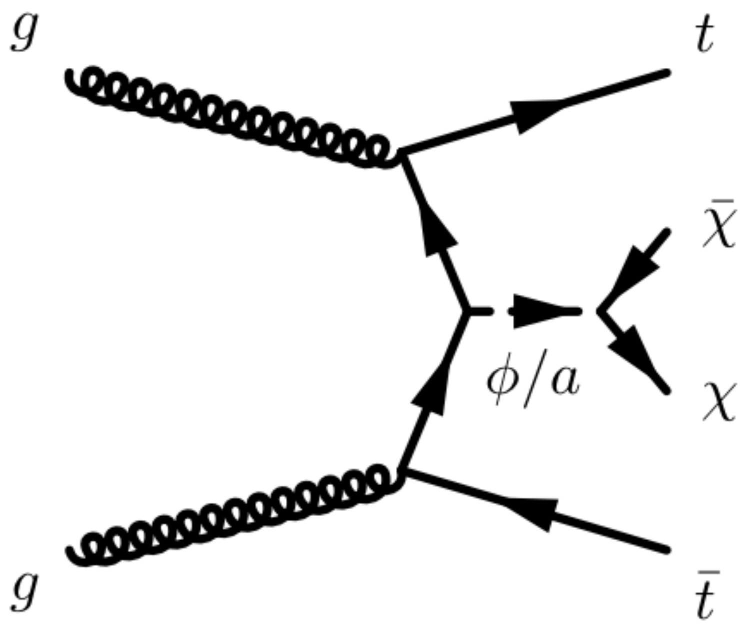
Search for stop pairs in two lepton final states

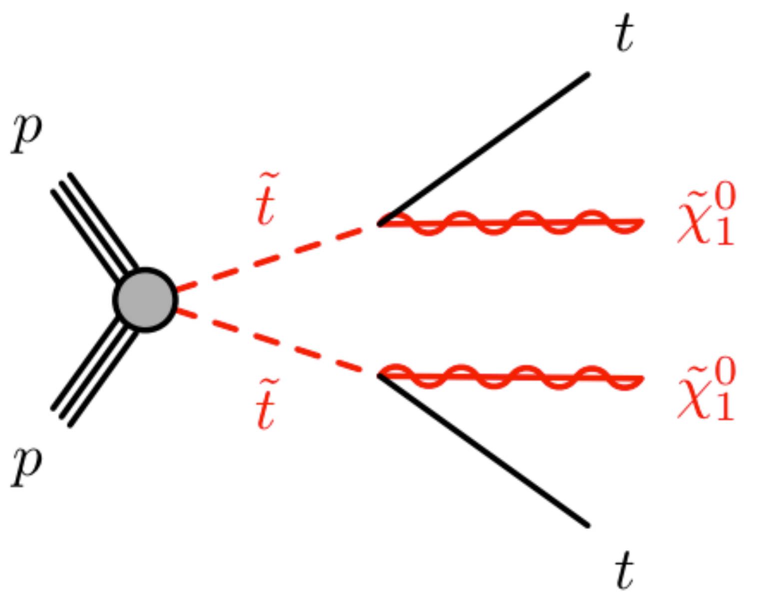
Signal Region	$\text{SR-DF}^{\text{2-body}}_{[110,120)}$	$\text{SR-DF}^{\text{2-body}}_{[120,140)}$	$\text{SR-DF}^{\text{2-body}}_{[140,160)}$	$\text{SR-DF}^{\text{2-body}}_{[160,180)}$	$\text{SR-DF}^{\text{2-body}}_{[180,220)}$	$\text{SR-DF}^{\text{2-body}}_{[220,\infty)}$
Total SM background uncertainty	20%	20%	15%	16%	14%	21%
VV theoretical uncertainties	1.0%	1.3%	2.6%	1.0%	2.0%	1.8%
$t\bar{t}$ theoretical uncertainties	9.6%	12%	7.6%	–	3.1%	–
$t\bar{t}Z$ theoretical uncertainties	1.2%	2.0%	5.3%	6.6%	5.7%	16%
$t\bar{t}$-Wt interference	–	–	–	–	–	–
Other theoretical uncertainties	1.0%	1.2%	2.8%	3.2%	2.7%	3.3%
MC statistical uncertainty	4.7%	5.0%	6.9%	8.2%	7.7%	6.6%
$t\bar{t}$ normalization	7.2%	5.6%	1.2%	–	–	–
$t\bar{t}Z$ normalization	1.4%	2.8%	6.9%	9.1%	7.3%	7.2%
Jet energy scale	8.5%	10%	2.5%	6.1%	1.0%	2.6%
Jet energy resolution	13%	6.6%	6.2%	4.3%	5.3%	2.0%
$E_{\text{T}}^{\text{miss}}$ modelling	3.5%	6.1%	1.0%	2.2%	2.2%	1.0%
Lepton modelling	1.5%	1.1%	1.6%	1.3%	1.3%	1.0%
Flavor tagging	1.0%	1.0%	1.3%	2.0%	1.0%	1.0%
Pile-up reweighting and JVT	–	1.6%	1.0%	–	1.0%	–
Fake and non-prompt leptons	–	3.5%	–	–	7.1%	13%

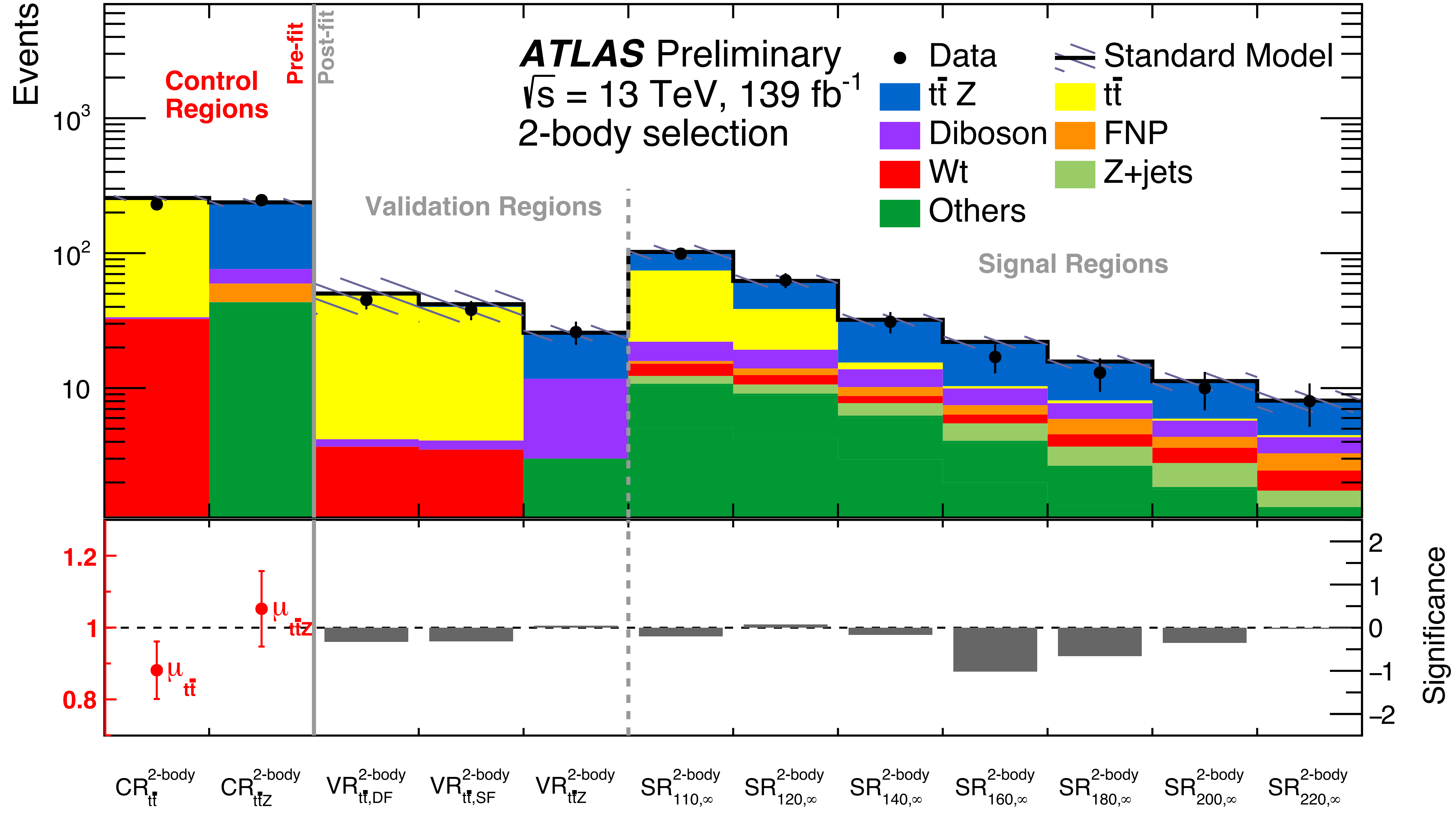
Search for stop pairs in two lepton final states

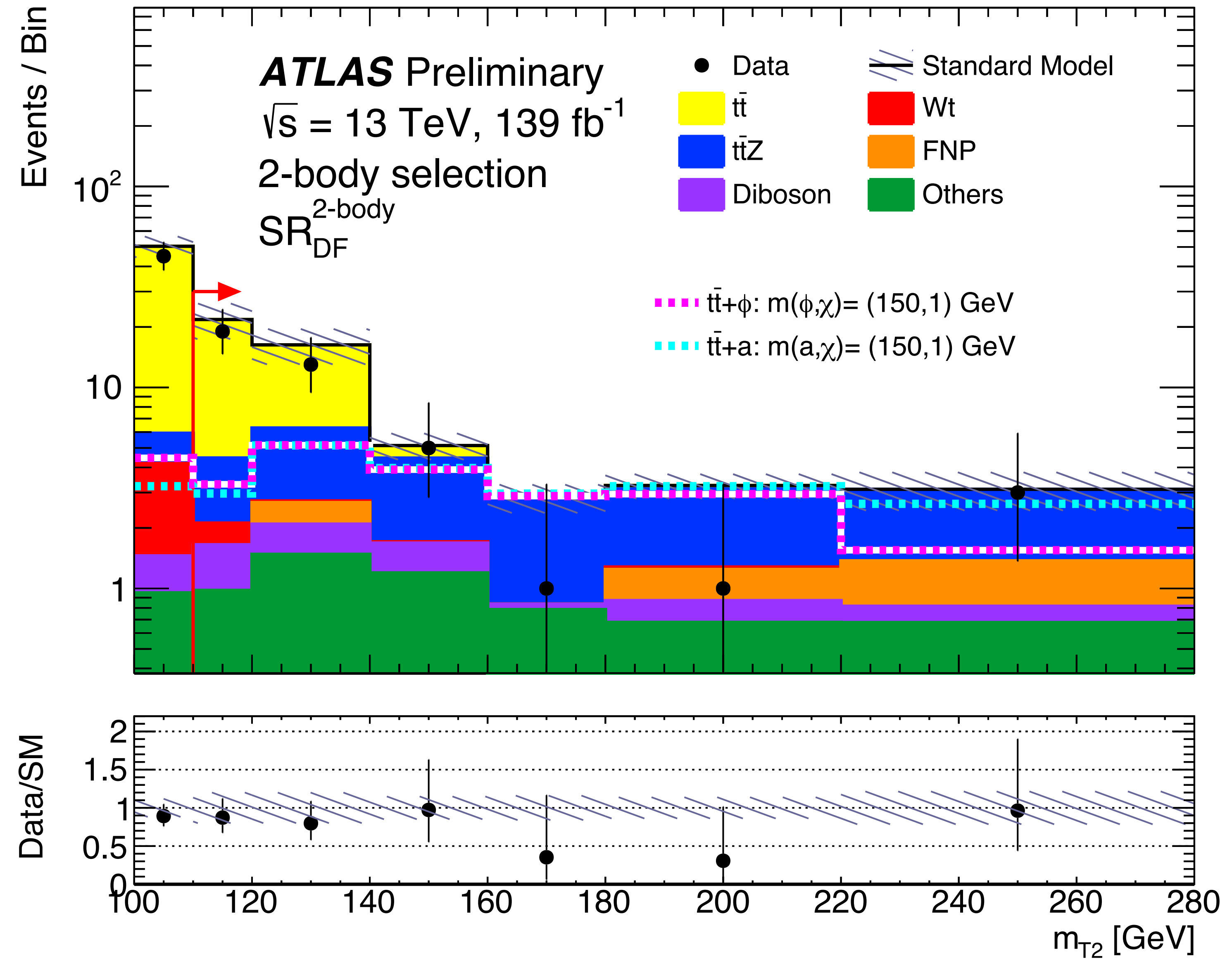
Signal Region	SR-DF$_W^{\text{3-body}}$	SR-SF$_W^{\text{3-body}}$	SR-DF$_t^{\text{3-body}}$	SR-SF$_t^{\text{3-body}}$	SR$_{\text{Small}\,\Delta m}^{\text{4-body}}$	SR$_{\text{Large}\,\Delta m}^{\text{4-body}}$
Total SM background uncertainty	18%	26%	18%	22%	25%	14%
VV theoretical uncertainties	8.0%	10%	1.0%	1.5%	3.6%	4.9%
$t\bar{t}$ theoretical uncertainties	8.2%	6.6%	14%	8.6%	1.0%	6.3%
$t\bar{t}Z$ theoretical uncertainties	–	–	1.2%	2.0%	–	–
$t\bar{t}$-Wt interference	–	1.0%	–	1.1%	–	2.4%
Other theoretical uncertainties	–	–	1.4%	1.6%	–	–
MC statistical uncertainty	5.8%	7.4%	5.6%	6.7%	3.3%	2.7%
VV normalization	15%	20%	1.0%	2.0%	2.8%	8.6%
$t\bar{t}$ normalization	2.3%	1.9%	4.9%	3.3%	1.0%	6.1%
$t\bar{t}Z$ normalization	–	–	4.1%	4.5%	–	–
Jet energy scale	5.5%	3.7%	3.8%	4.1%	1.0%	3.2%
Jet energy resolution	2.3%	11%	9.0%	18%	1.3%	3.5%
Lepton modelling	1.3%	2.0%	1.0%	2.5%	1.3%	3.3%
$E_{\text{T}}^{\text{miss}}$ modelling	1.1%	2.2%	3.0%	1.8%	–	1.0%
Flavor tagging	3.1%	2.9%	1.6%	1.0%	–	1.3%
Pile-up reweighting and JVT	1.0%	1.0%	–	–	1.0%	–
Fake and non-prompt leptons	1.7%	–	–	4.6%	25%	–

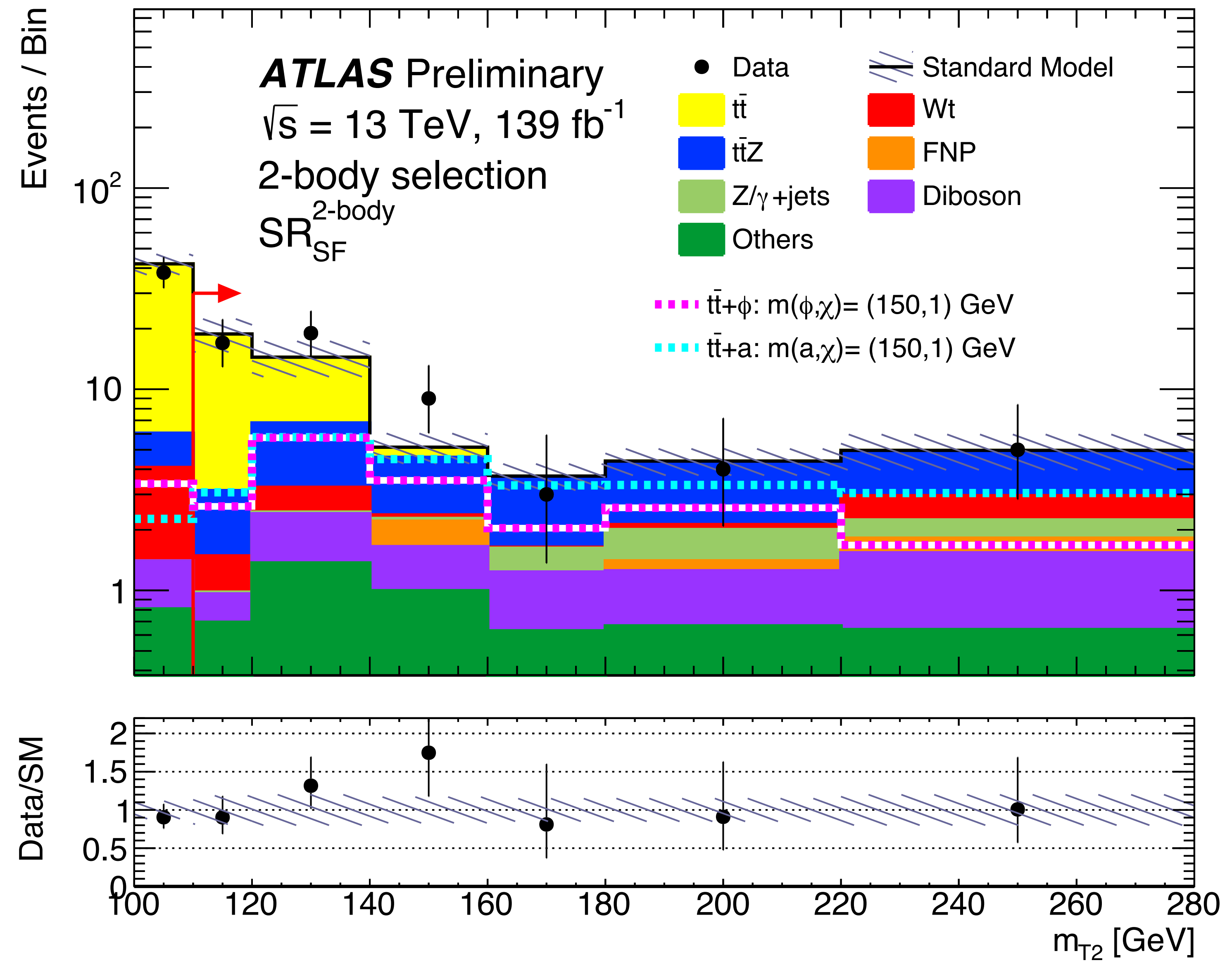
Search for stop pairs in two lepton final states



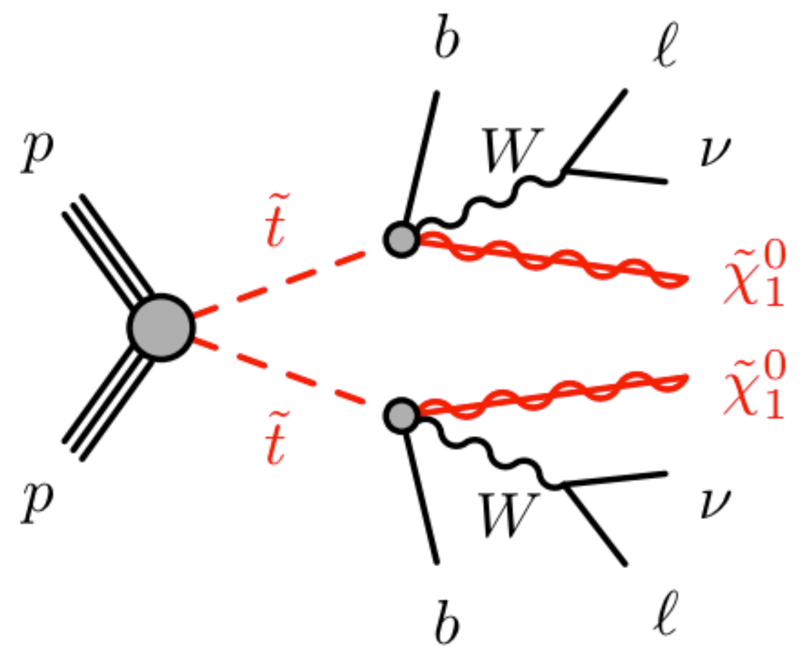


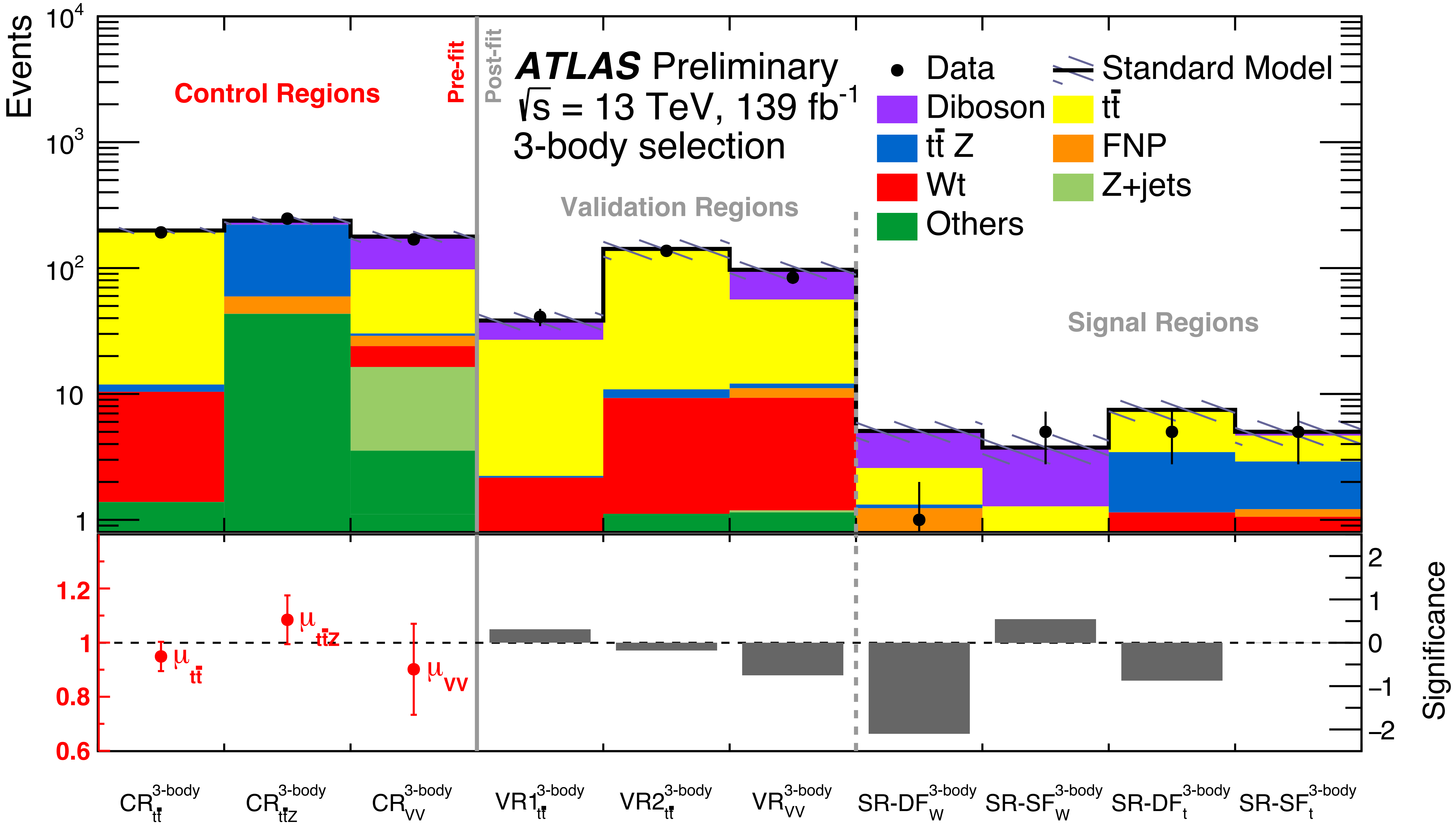


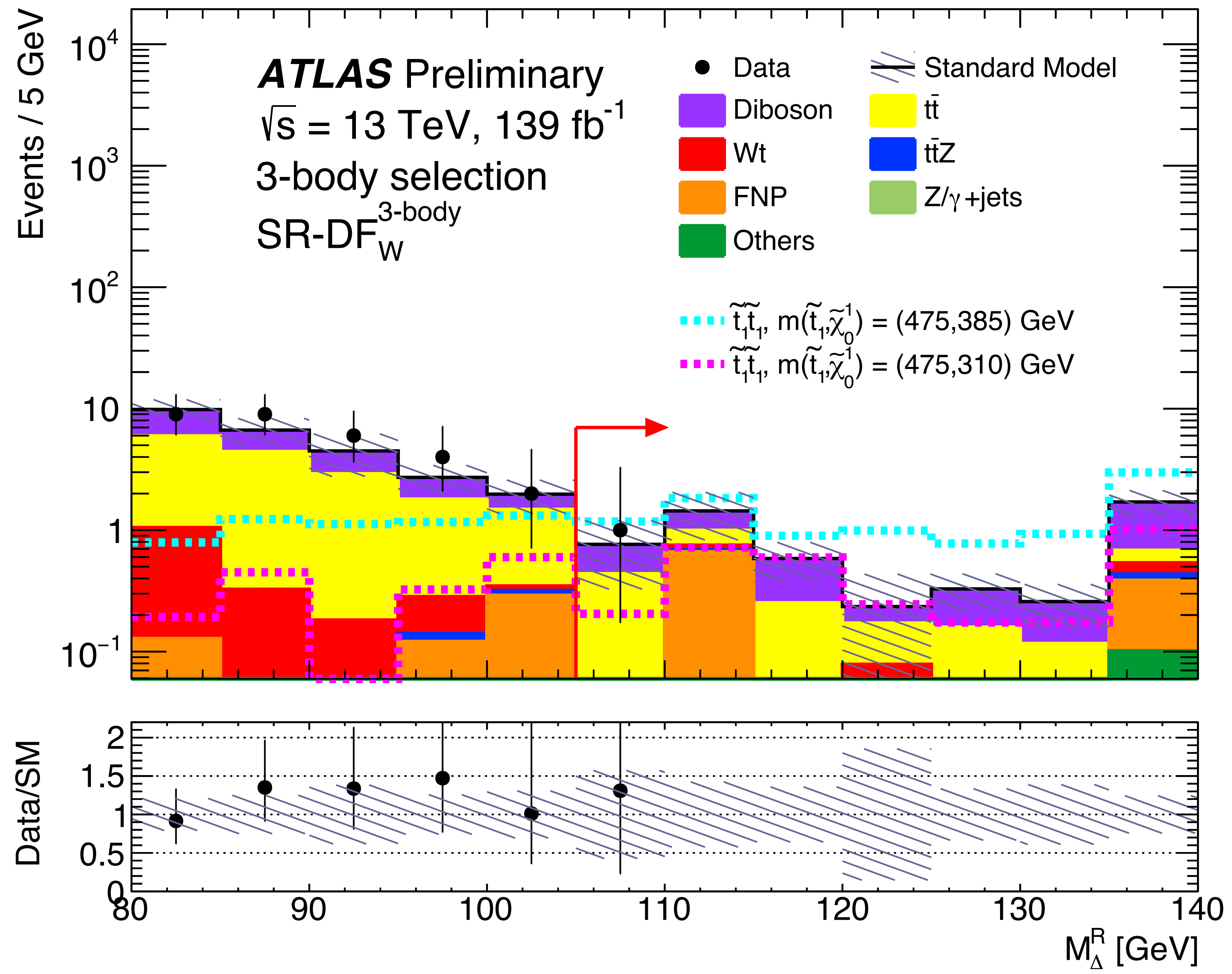


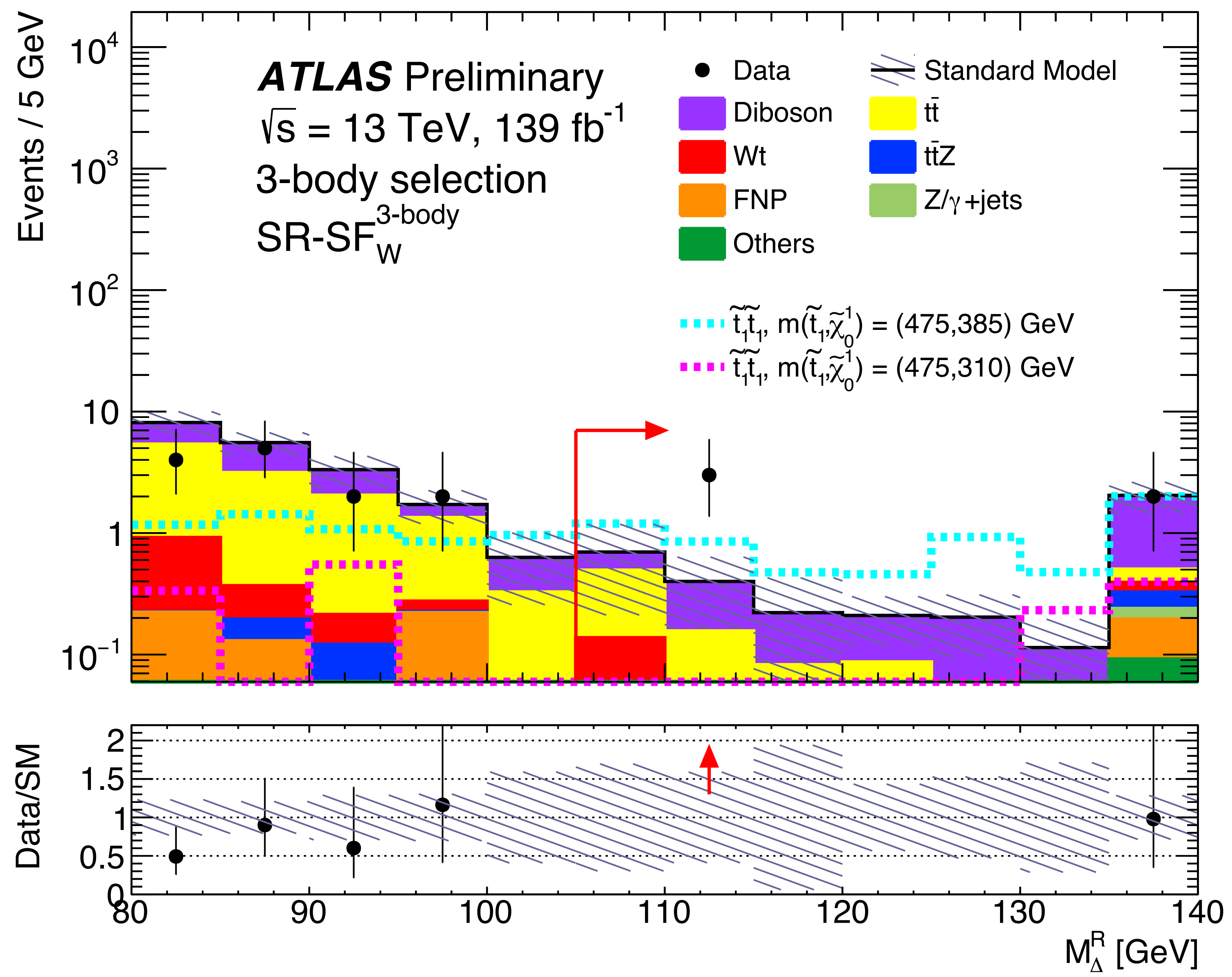


Search for stop pairs in two lepton final states

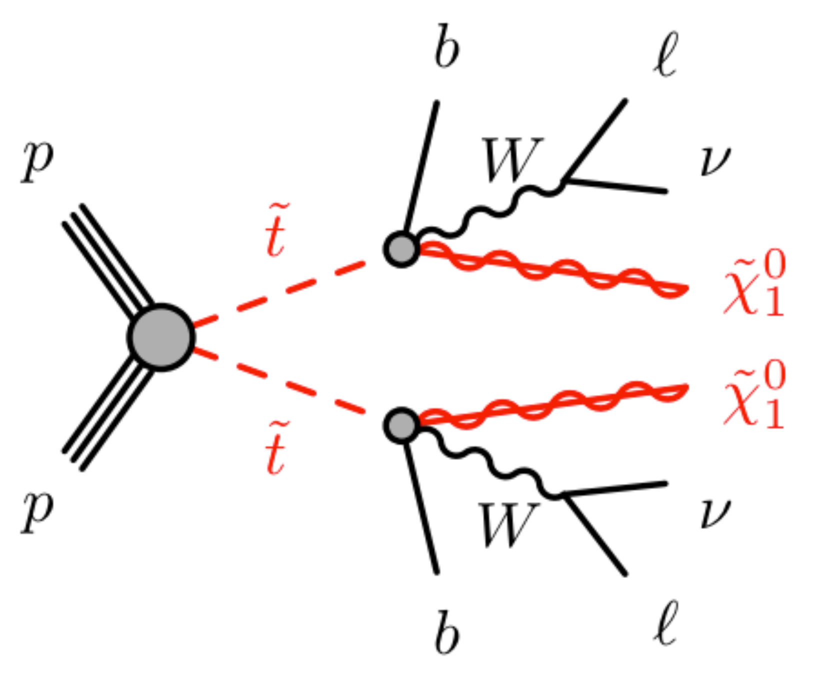


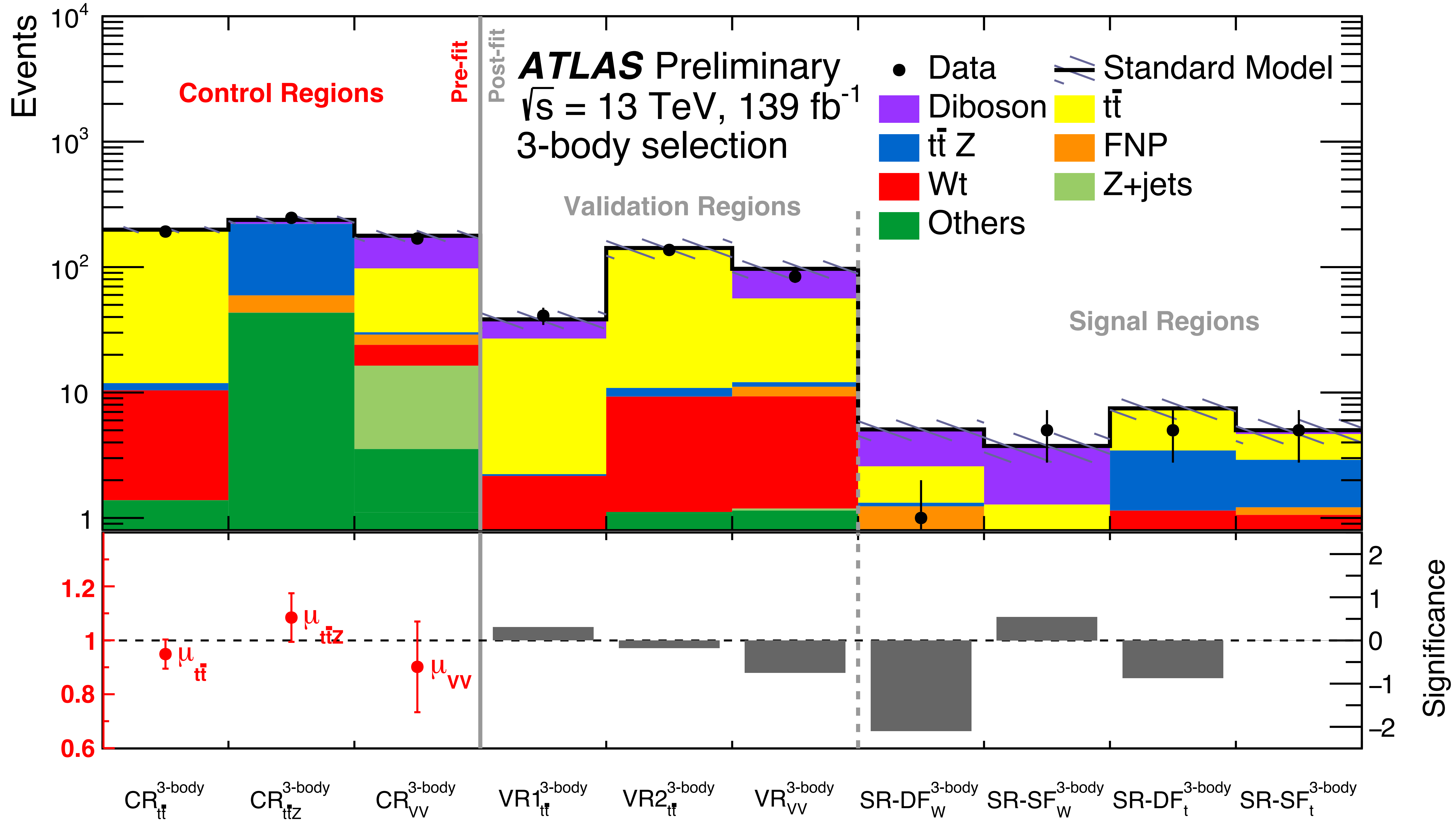


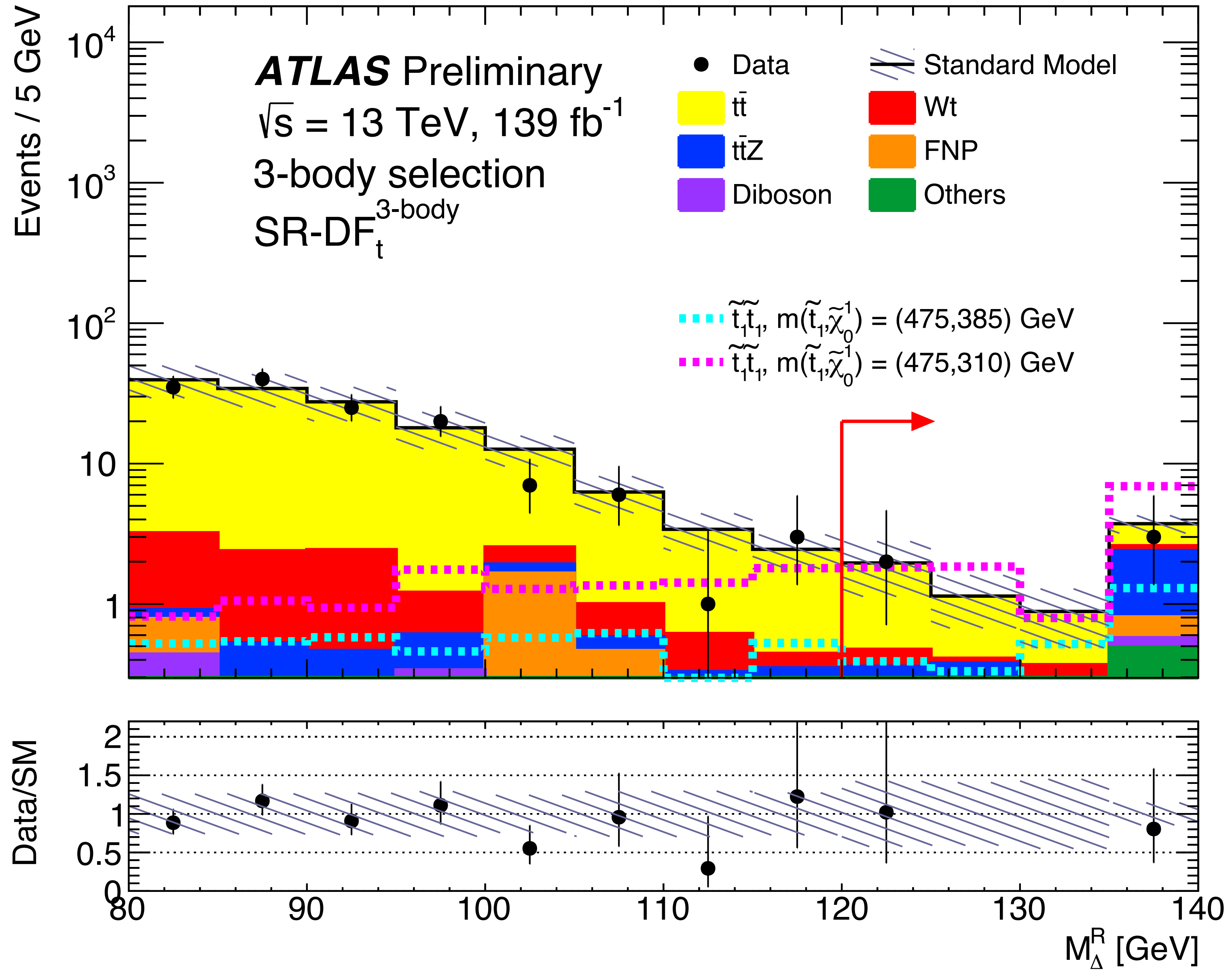


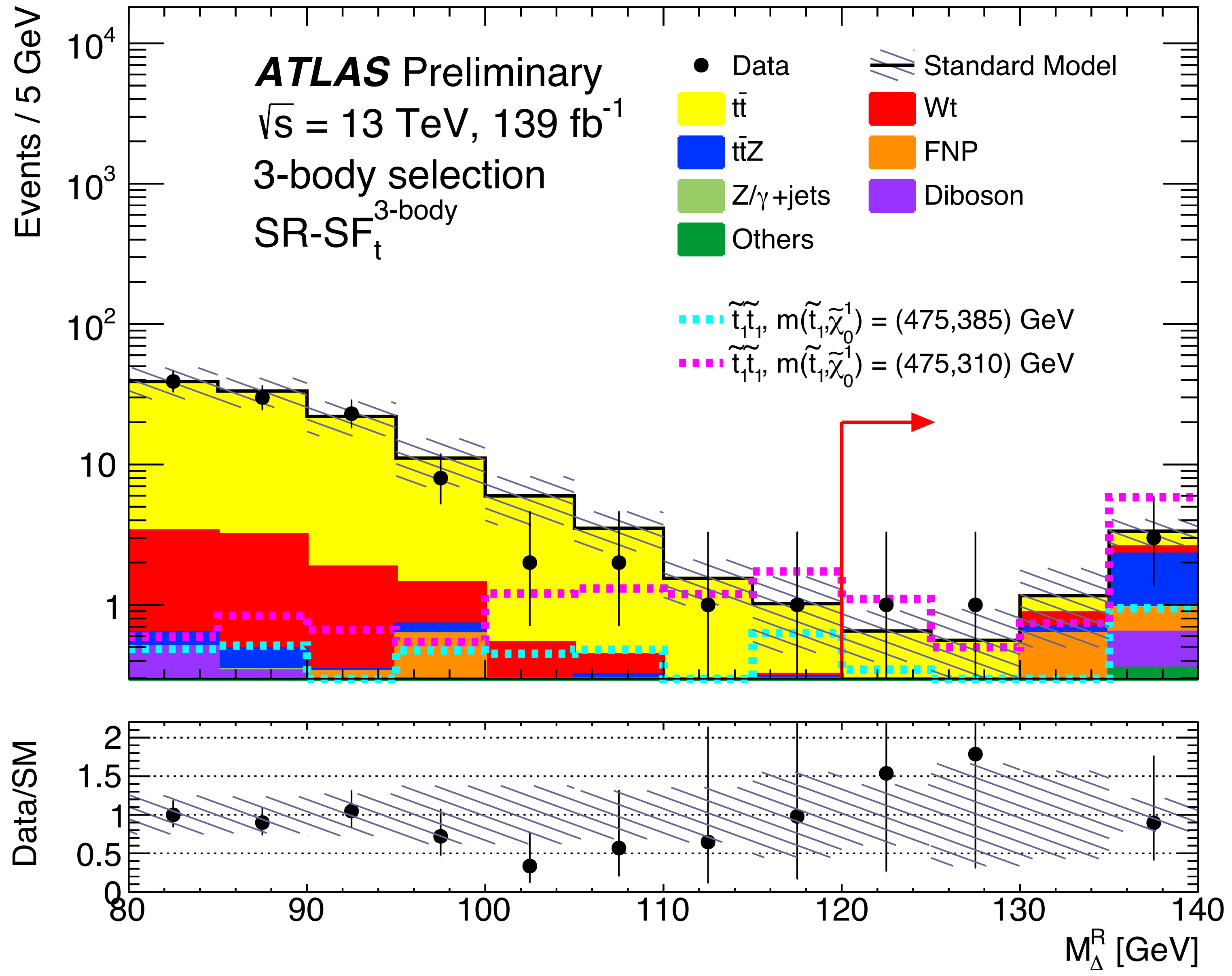


Search for stop pairs in two lepton final states

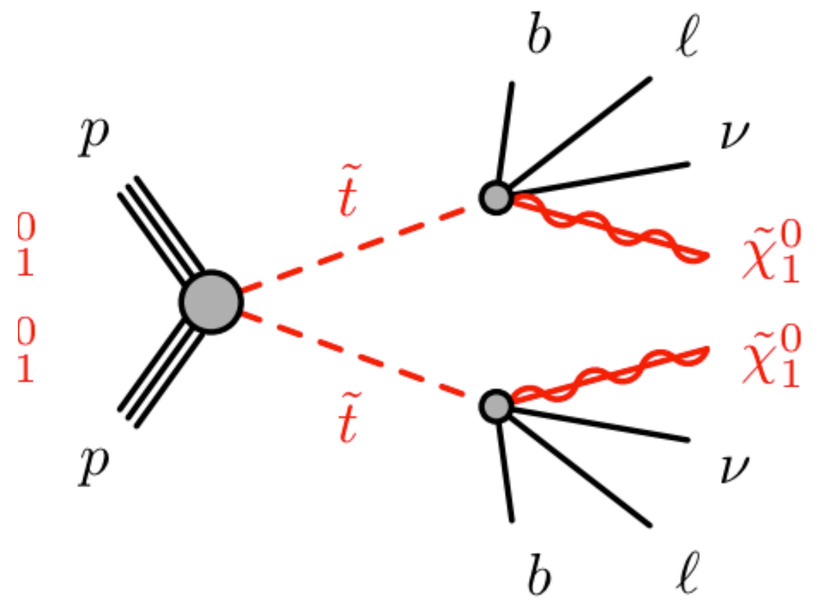


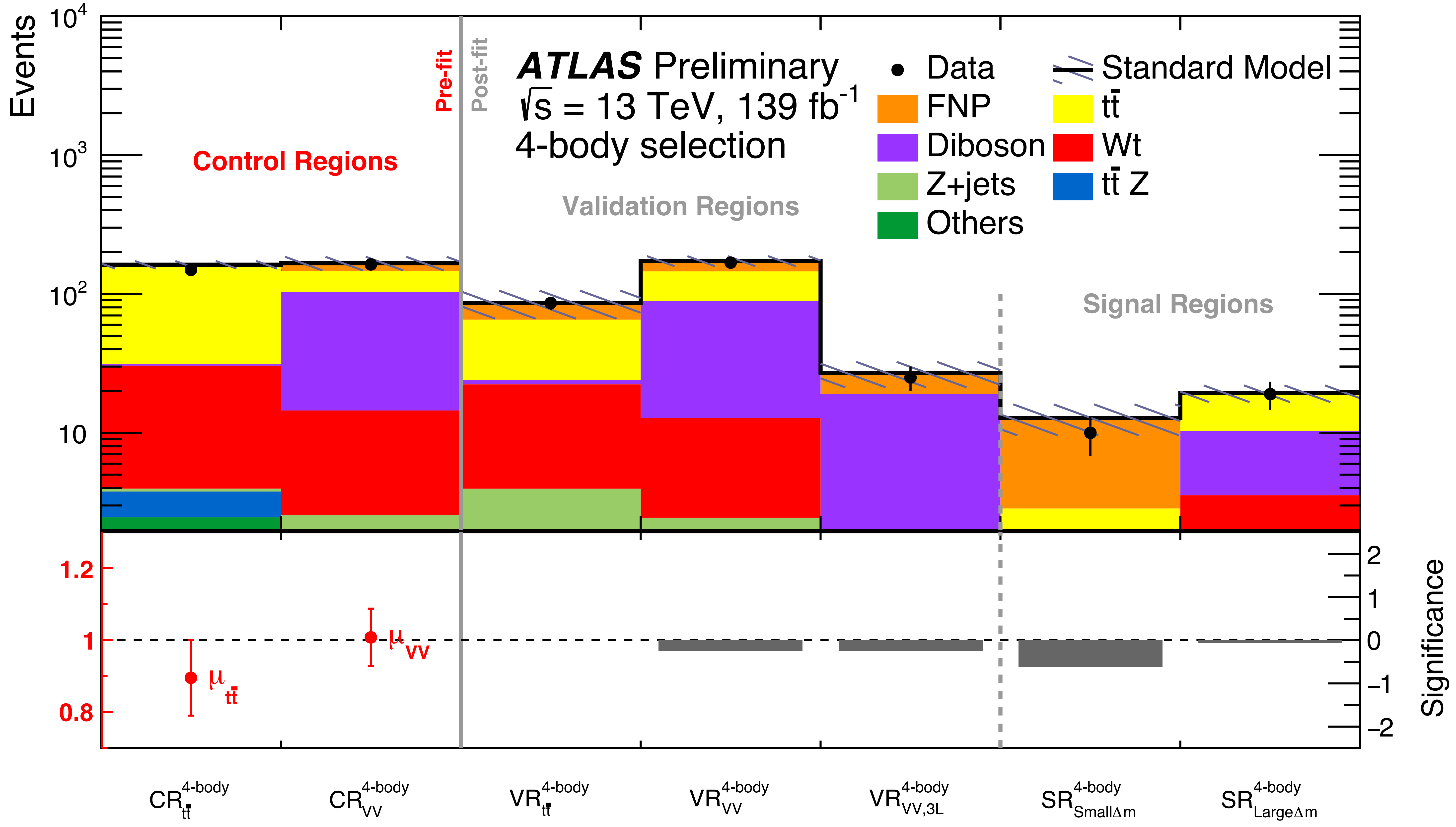


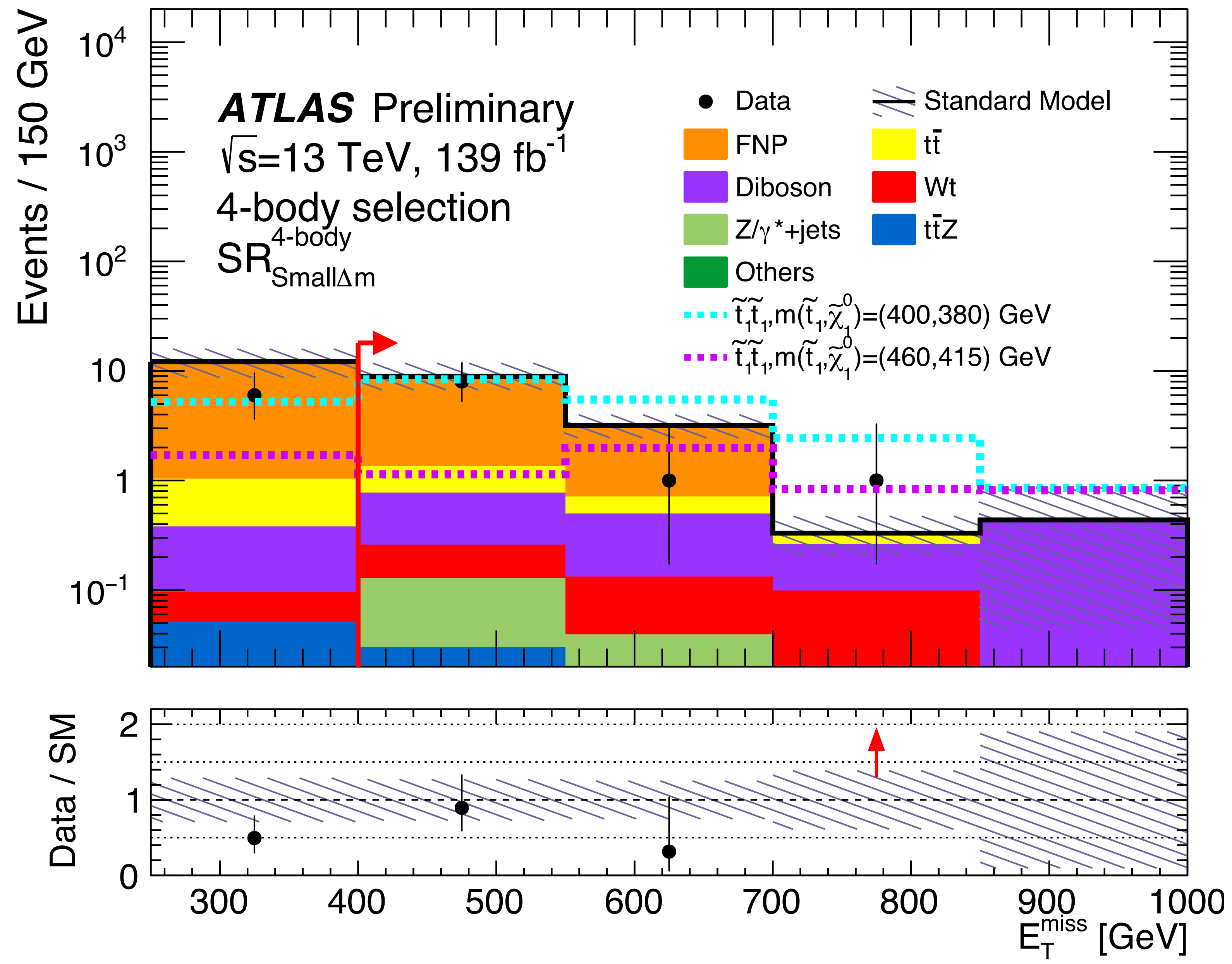


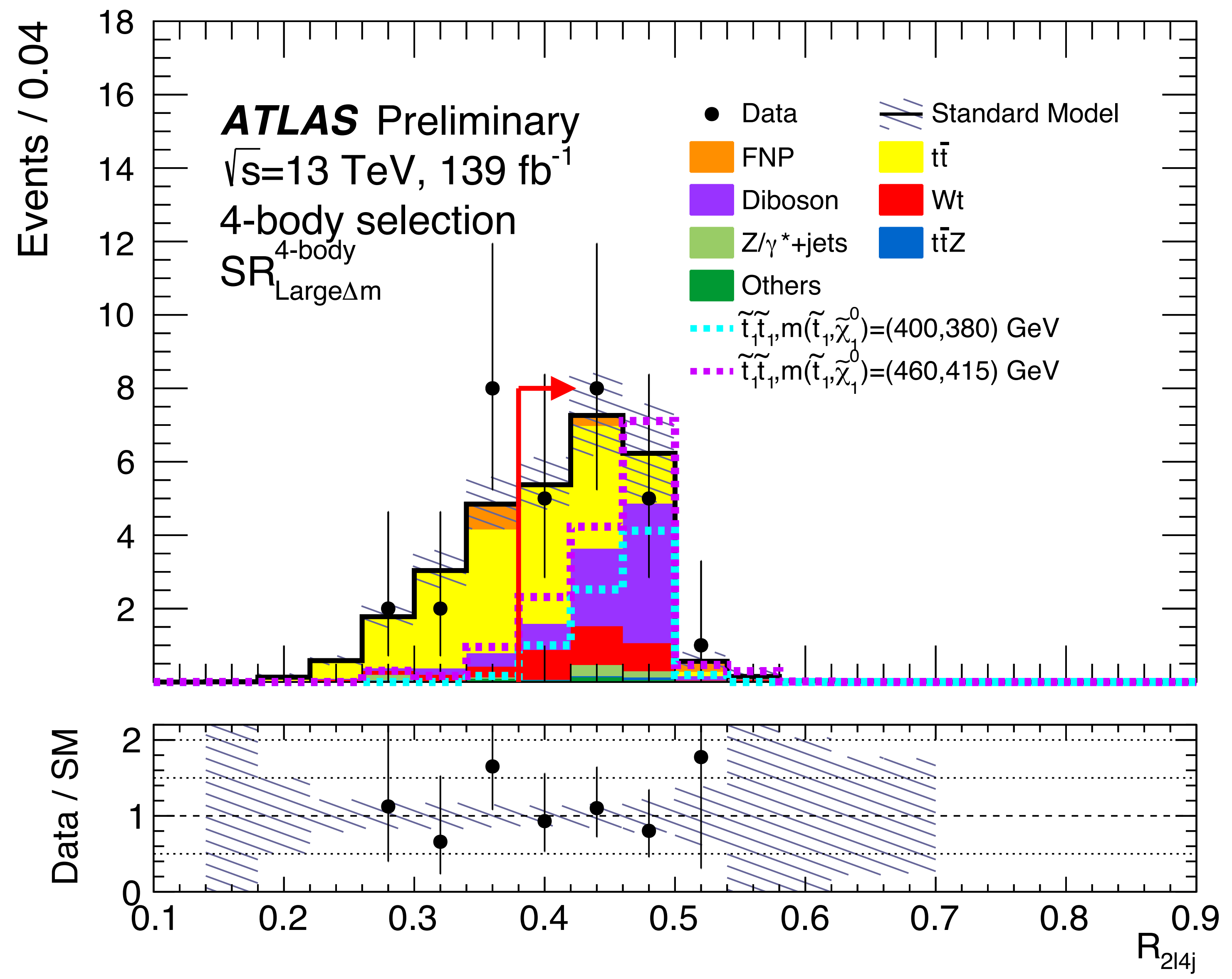


Search for stop pairs in two lepton final states

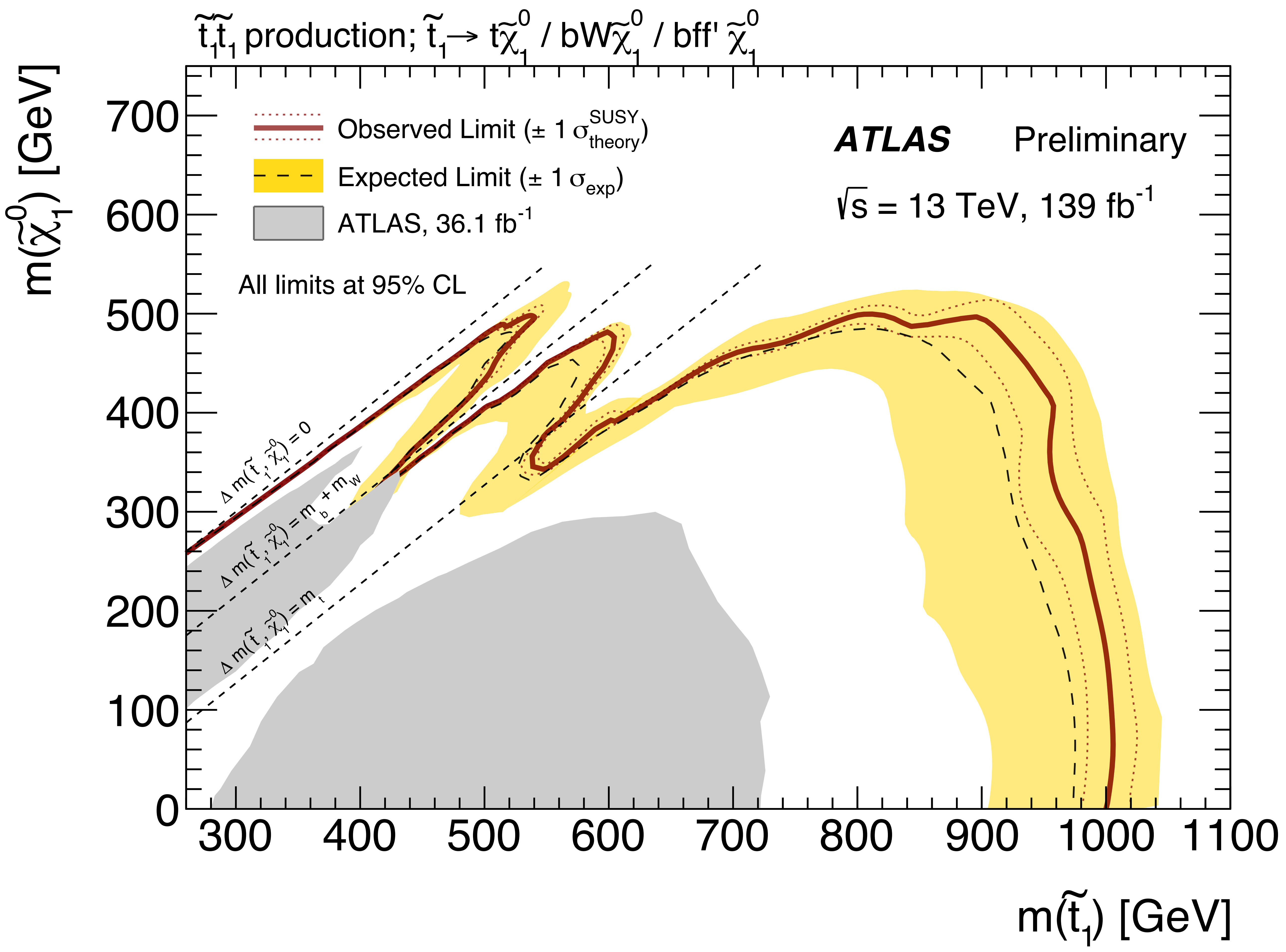






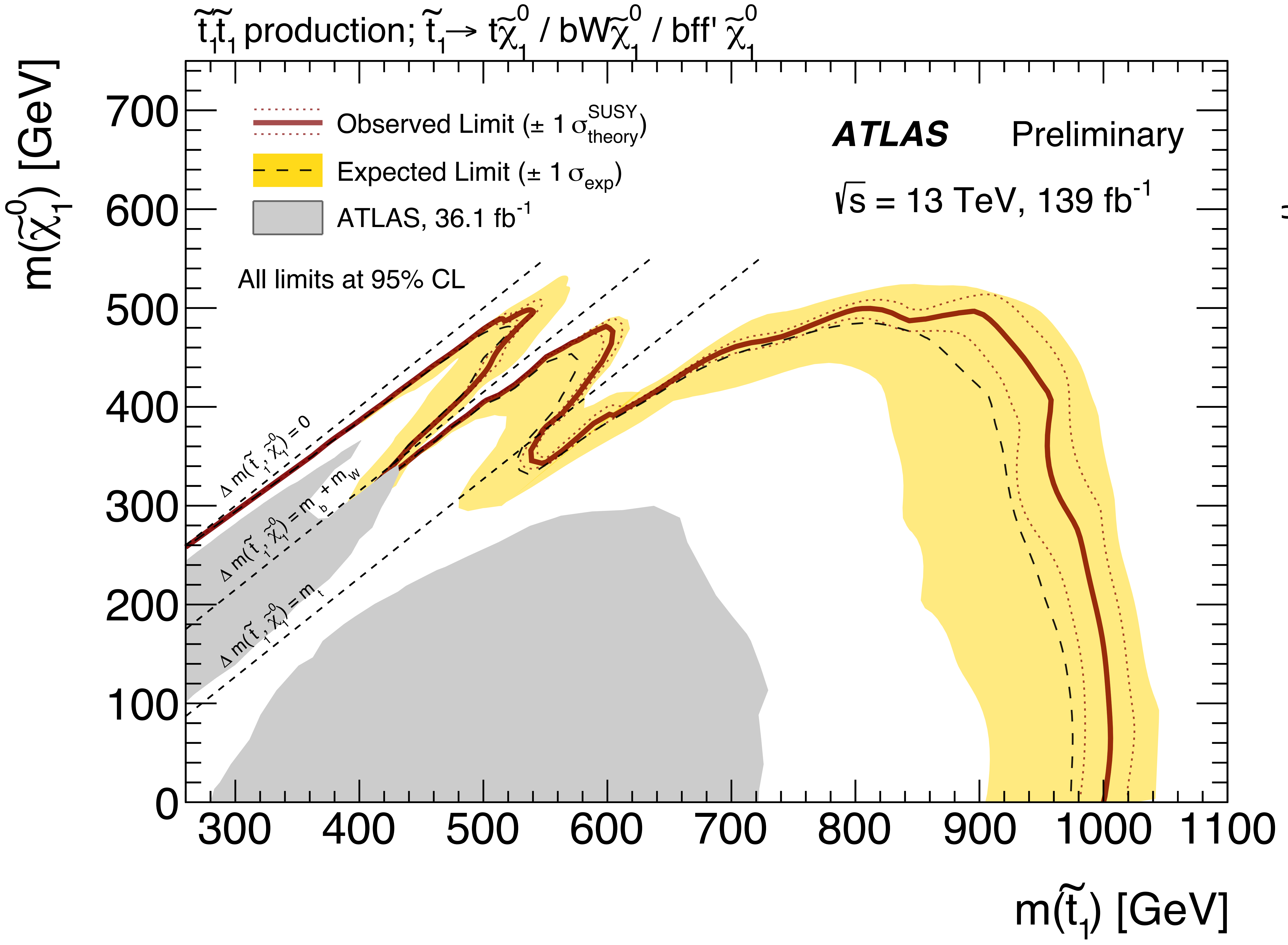


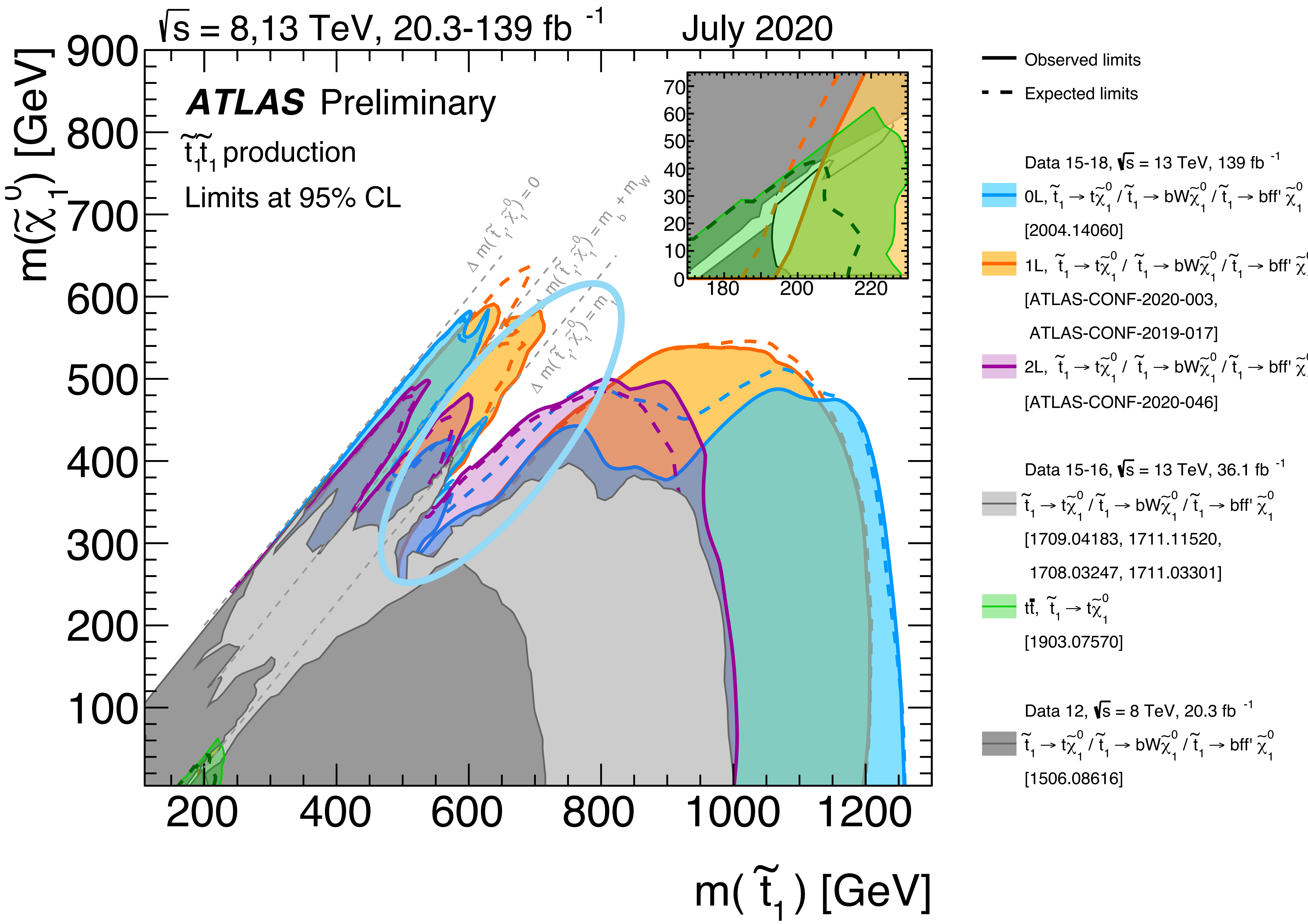
Search for stop pairs in two lepton final states



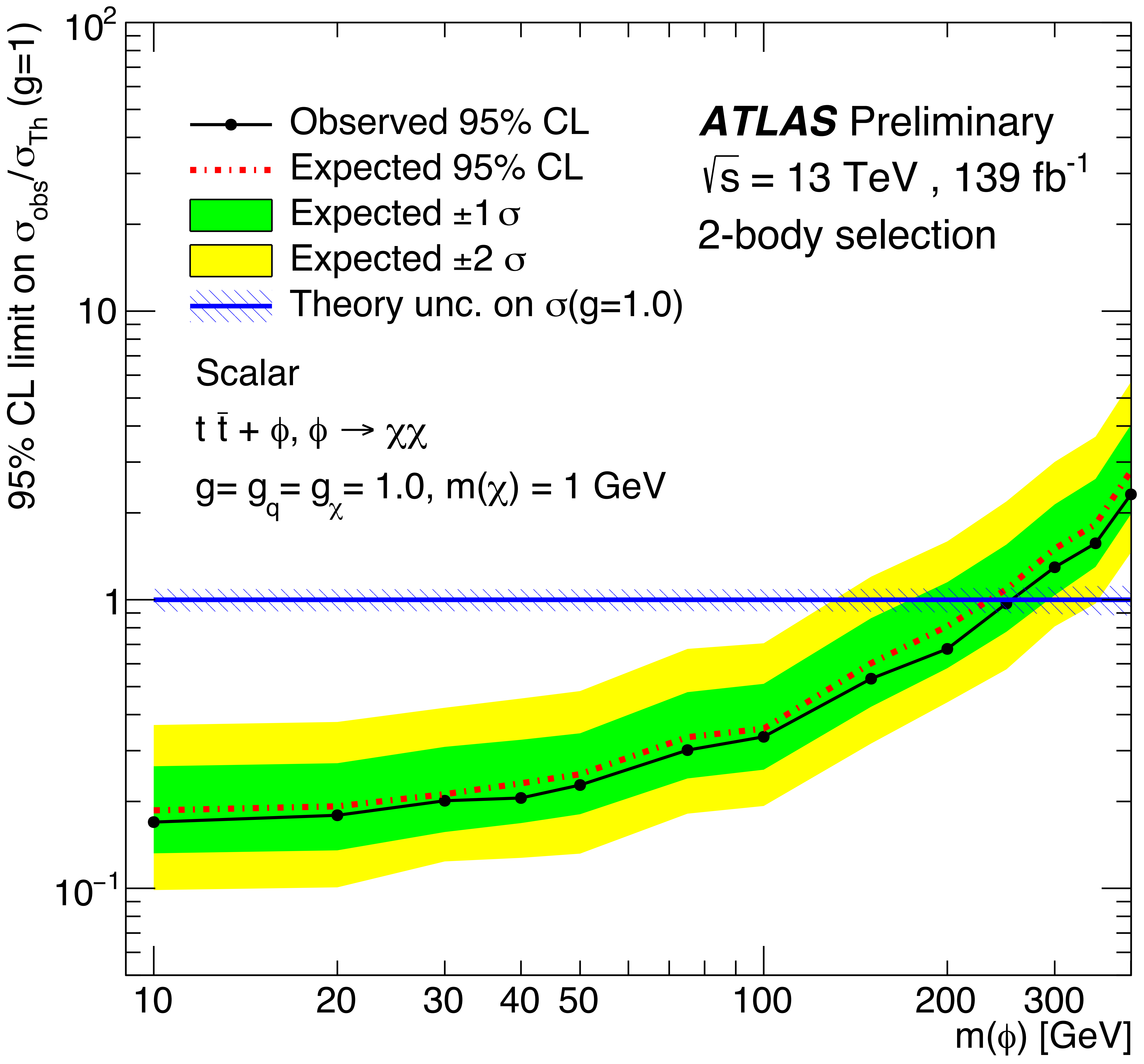
Selection	Signal Region	σ_{vis} [fb]	S^{95}_{obs}	S^{95}_{exp}	$p(s=0)$
Two-body	$\text{SR}^{\text{2-body}}_{110,\infty}$	0.21	29.3	31^{+11}_{-8}	0.5
	$\text{SR}^{\text{2-body}}_{120,\infty}$	0.15	21.4	21^{+8}_{-6}	0.40
	$\text{SR}^{\text{2-body}}_{140,\infty}$	0.10	13.2	14^{+5}_{-4}	0.5
	$\text{SR}^{\text{2-body}}_{160,\infty}$	0.06	8.2	$11^{+5}_{-3.0}$	0.5
	$\text{SR}^{\text{2-body}}_{180,\infty}$	0.06	7.9	$9.6^{+3.8}_{-2.8}$	0.5
	$\text{SR}^{\text{2-body}}_{200,\infty}$	0.06	7.6	$8.4^{+3.6}_{-2.3}$	0.5
	$\text{SR}^{\text{2-body}}_{220,\infty}$	0.05	7.6	$7.5^{+3.1}_{-2.0}$	0.5
Three-body	$\text{SR-DF}^{\text{3-body}}_{W}$	0.023	3.2	$5.7^{+2.3}_{-1.5}$	0.5
	$\text{SR-SF}^{\text{3-body}}_{W}$	0.05	7.0	$5.6^{+2.3}_{-1.5}$	0.27
	$\text{SR-DF}^{\text{3-body}}_{t}$	0.04	5.5	$6.9^{+2.9}_{-1.9}$	0.5
	$\text{SR-SF}^{\text{3-body}}_{t}$	0.04	6.3	$6.1^{+2.6}_{-1.6}$	0.5
Four-body	$\text{SR}^{\text{4-body}}_{\text{Small}\,\Delta m}$	0.06	8.2	$9.6^{+3.8}_{-2.5}$	0.5
	$\text{SR}^{\text{4-body}}_{\text{Large}\,\Delta m}$	0.08	11.1	$11.1^{+4.5}_{-3.0}$	0.5

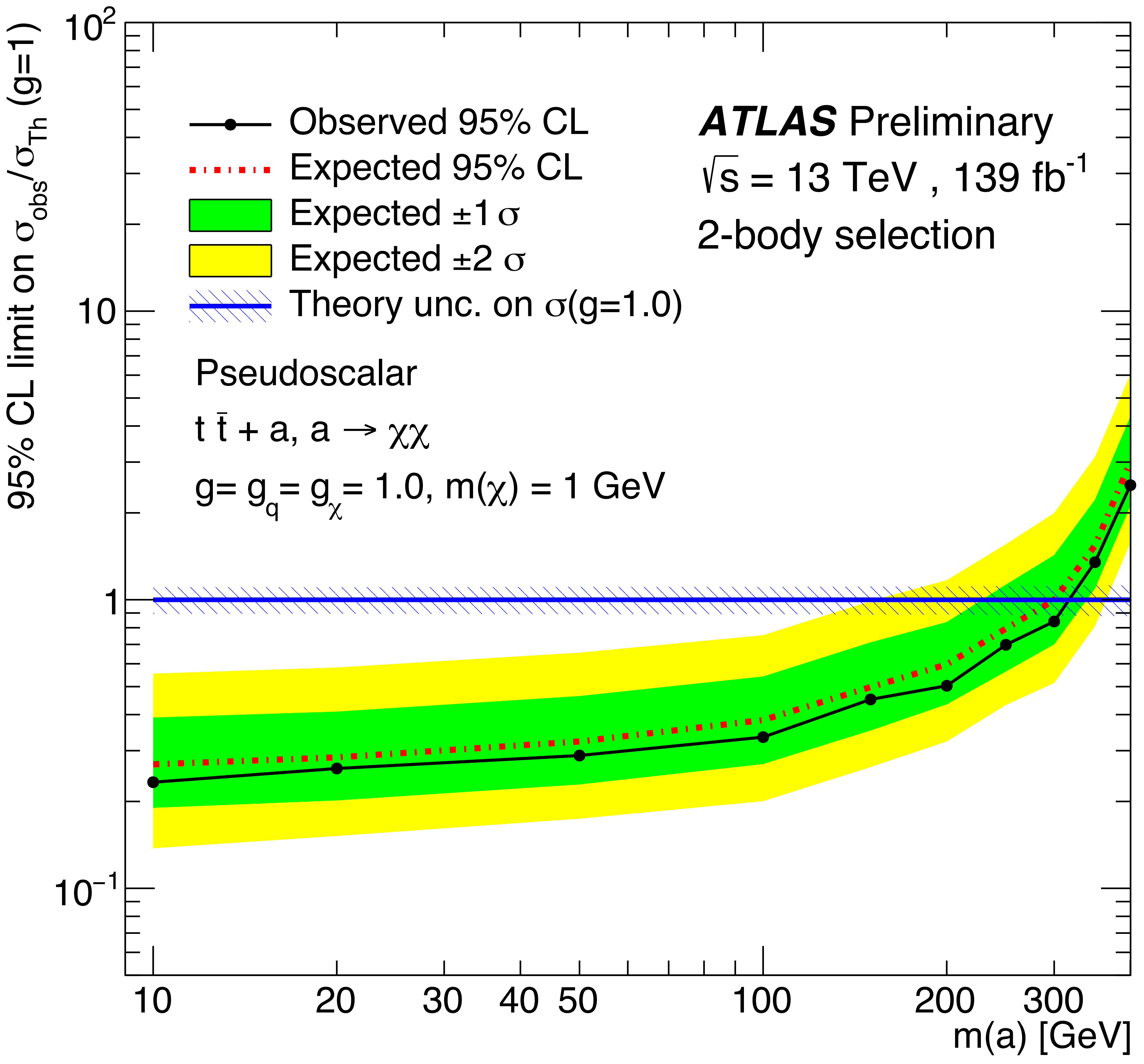
Search for stop pairs in two lepton final states





Search for stop pairs in two lepton final states





ATLAS-SUSY-2018-21

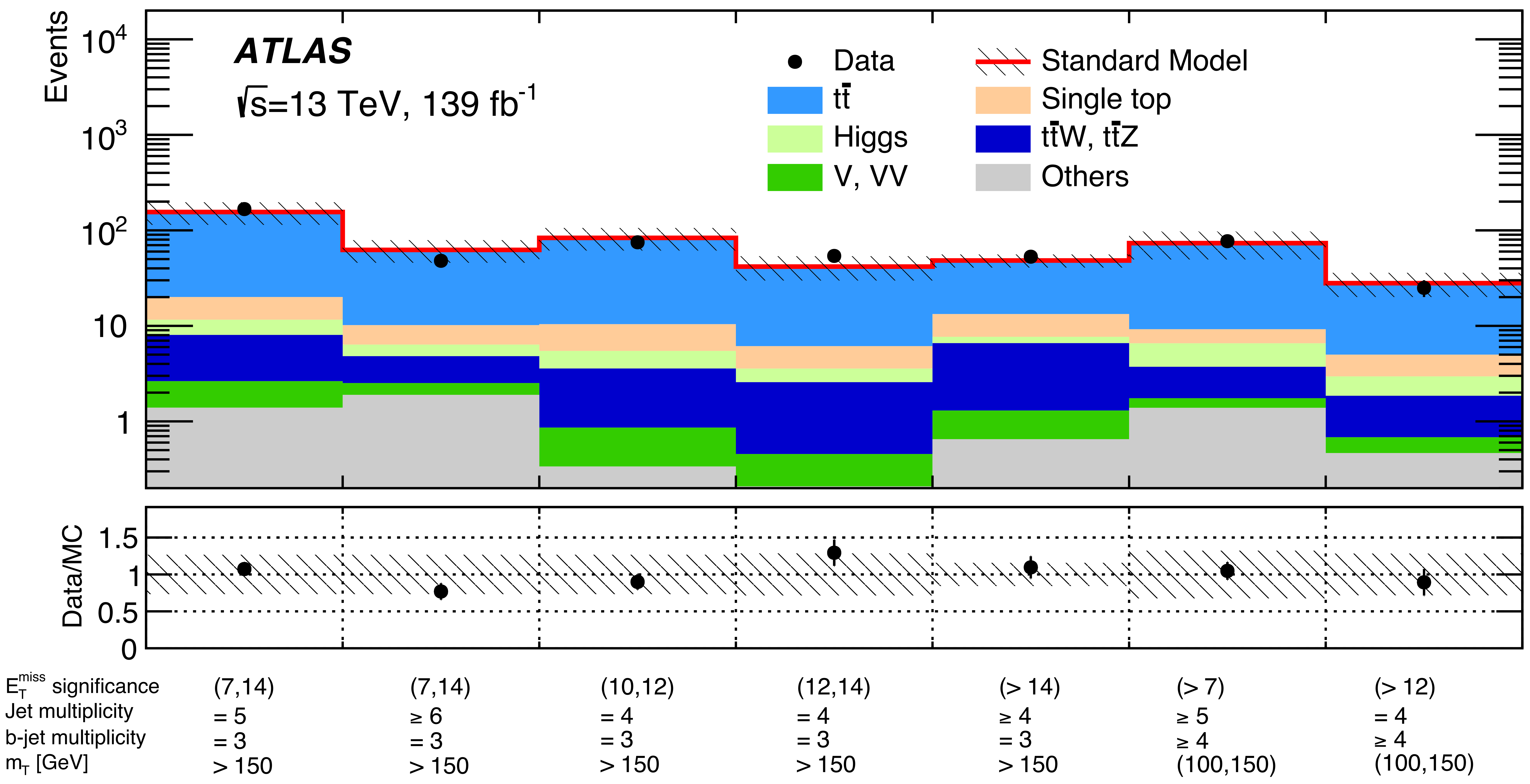
Search for stop pairs in Higgs final states

Search for stop pairs in Higgs final states

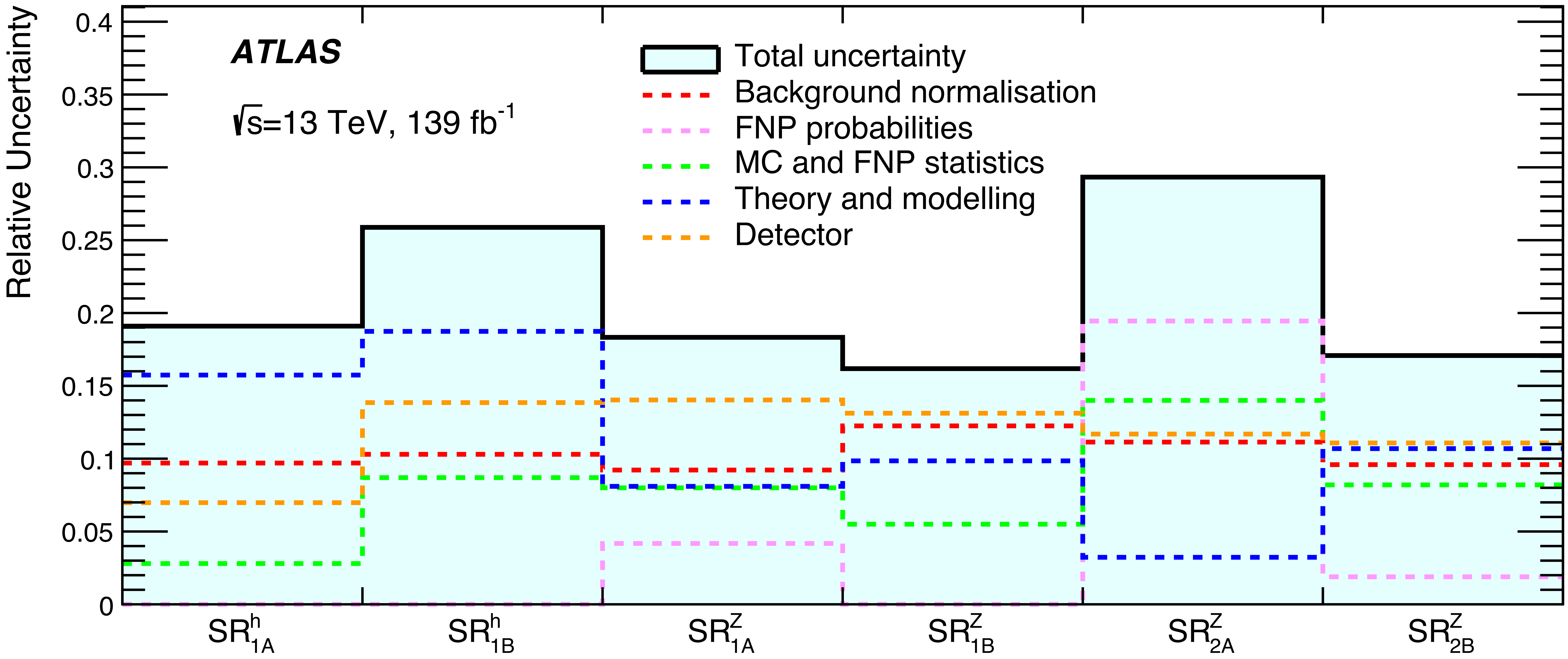
Requirement / Region	SR^{Z}_{1A}	SR^{Z}_{1B}	SR^{Z}_{2A}	SR^{Z}_{2B}
Number of signal leptons		≥ 3		
Number of SF-OS pairs		≥ 1		
Leading lepton p_{T} [GeV]		> 40		
Subleading lepton p_{T} [GeV]		> 20		
$\lvert m_{\ell\ell}^{\text{SF-OS}} - m_Z \rvert$ [GeV]		< 15		
Third leading lepton p_{T} [GeV]	> 20	> 20	< 20	< 60
n_{jets} ($p_{\mathrm{T}} > 30$ GeV)	≥ 4	≥ 5	≥ 3	≥ 3
$n_{b\text{-tagged jets}}$ ($p_{\mathrm{T}} > 30$ GeV)	≥ 1	≥ 1	–	≥ 1
Leading jet p_{T} [GeV]	–	–	> 150	–
Leading b-tagged jet p_{T} [GeV]	–	> 100	–	–
$E_{\mathrm{T}}^{\text{miss}}$ [GeV]	> 250	> 150	> 200	> 350
$p_{\mathrm{T}}^{\ell\ell}$ [GeV]	–	> 150	< 50	> 150
$m_{\mathrm{T2}}^{3\ell}$ [GeV]	> 100	–	–	–

Requirement / Region	SR^{h}_{1A}	SR^{h}_{1B}
Number of signal leptons	1	
$n_{h\text{-cand}}$	≥ 1	
$n_{b\text{-tagged jets}}$ ($p_{\mathrm{T}} > 30$ GeV)	≥ 4	
n_{jets} ($p_{\mathrm{T}} > 60$ GeV)	≥ 4	≥ 6
m_{T} [GeV]	> 150	> 150
$\mathcal{S}$	> 12	> 7

Search for stop pairs in Higgs final states



Search for stop pairs in Higgs final states



ATLAS-CONF-2020-031

Search for sbottom pairs in final states with hadronic taus

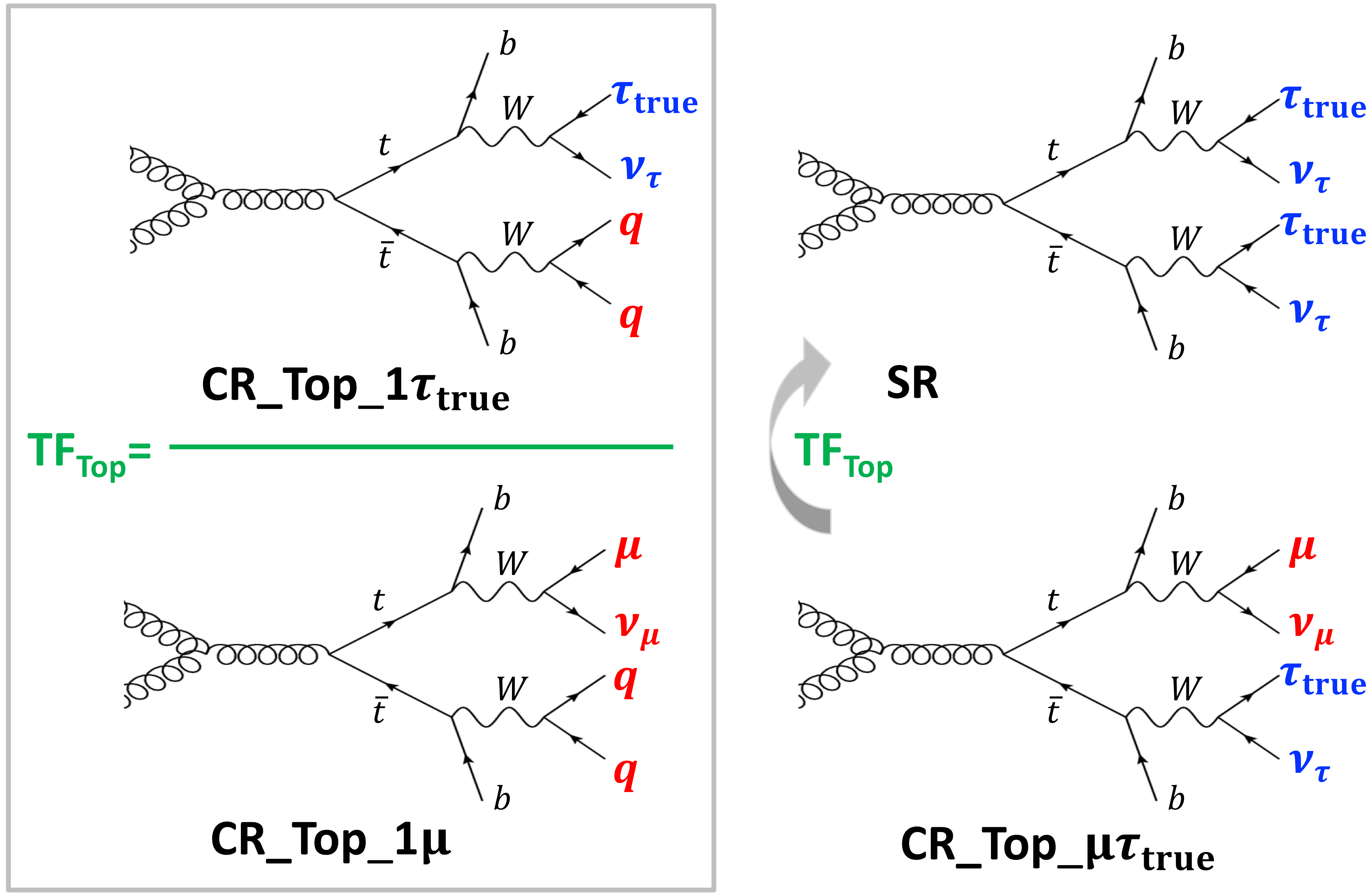
Search for sbottom pairs in final states with taus

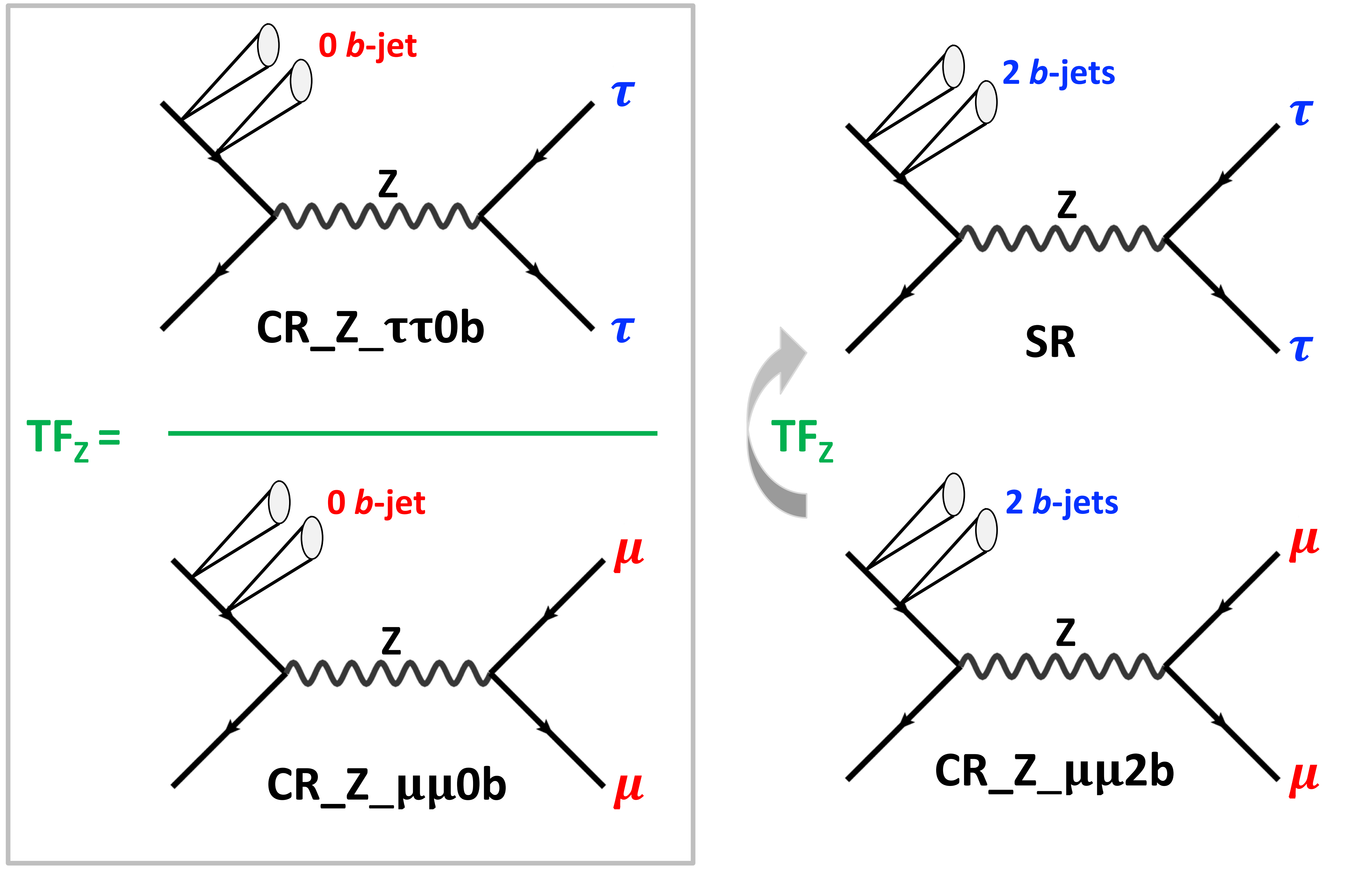
Common Preselection

$N_\tau + N_\mu$	≥ 1		
N_{jets}	≥ 3		
$p_{\text{T}}(\text{jet}_1)$	> 140 GeV		
$p_{\text{T}}(\text{jet}_2)$	> 100 GeV		
$\Delta\phi(\text{jet}_{1,2}, \vec{p}_{\text{T}}^{\text{miss}})$	> 0.5		
$N_{b\text{-jets}}$	≥ 2		
$p_{\text{T}}(b\text{-jet}_1)$	> 100 GeV		
Trigger	$E_{\text{T}}^{\text{miss}} + b$-jet	OR	$E_{\text{T}}^{\text{miss}}$
$E_{\text{T}}^{\text{miss}}$	> 160 GeV		> 200 GeV

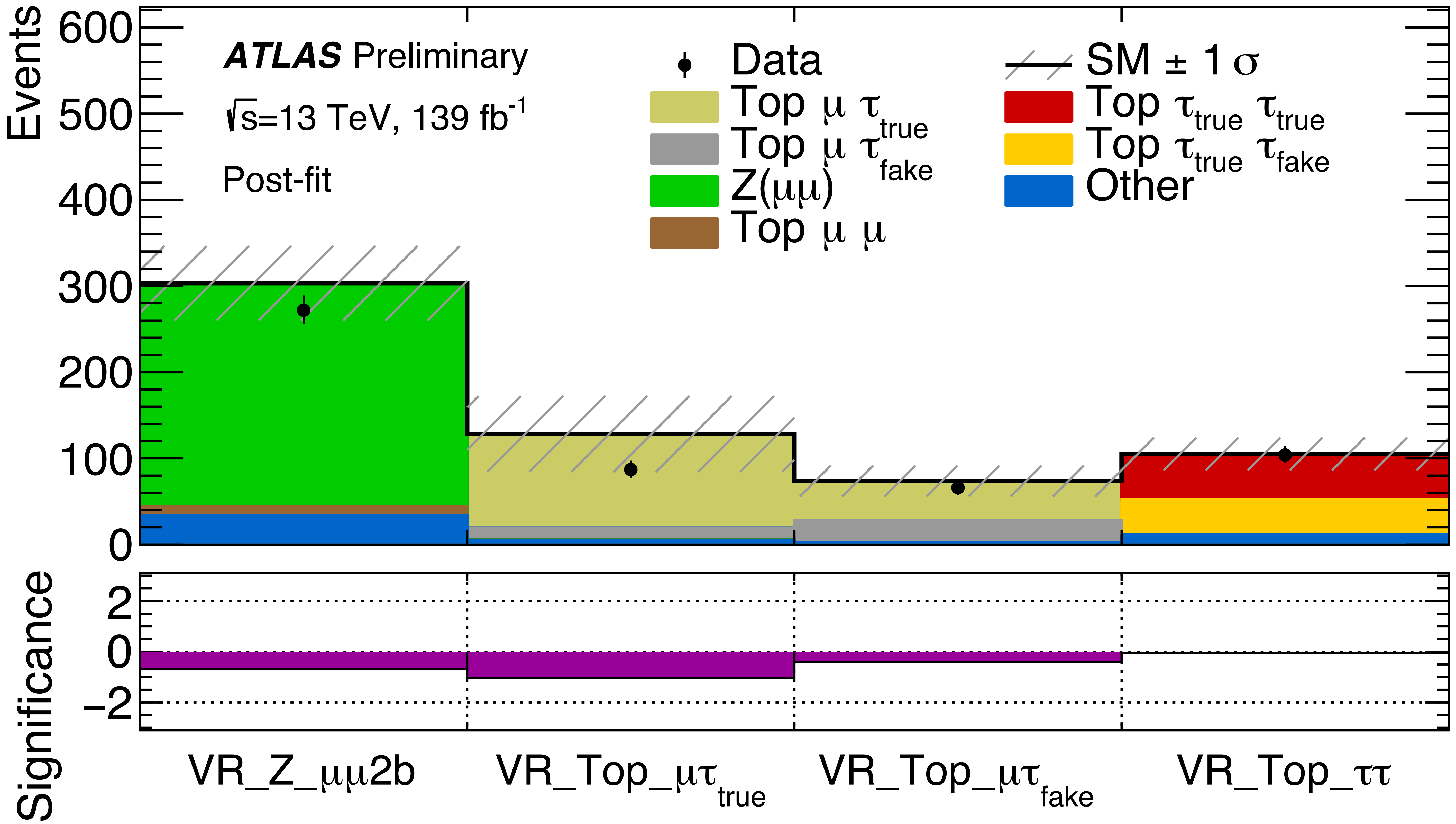
Common SR requirements		
N_μ	0	
N_τ	≥ 2	
$\text{OS}(\tau_1, \tau_2)$	yes	
$m(\tau_1, \tau_2)$	$[55, 120]$ GeV	
m_{T2}	> 140 GeV	
H_{T}	> 1100 GeV	
	Single-bin SR	Multi-bin SR
$\min_\Theta$	> 0.6	3 bins: < 0.5, $[0.5, 1.0]$, > 1.0

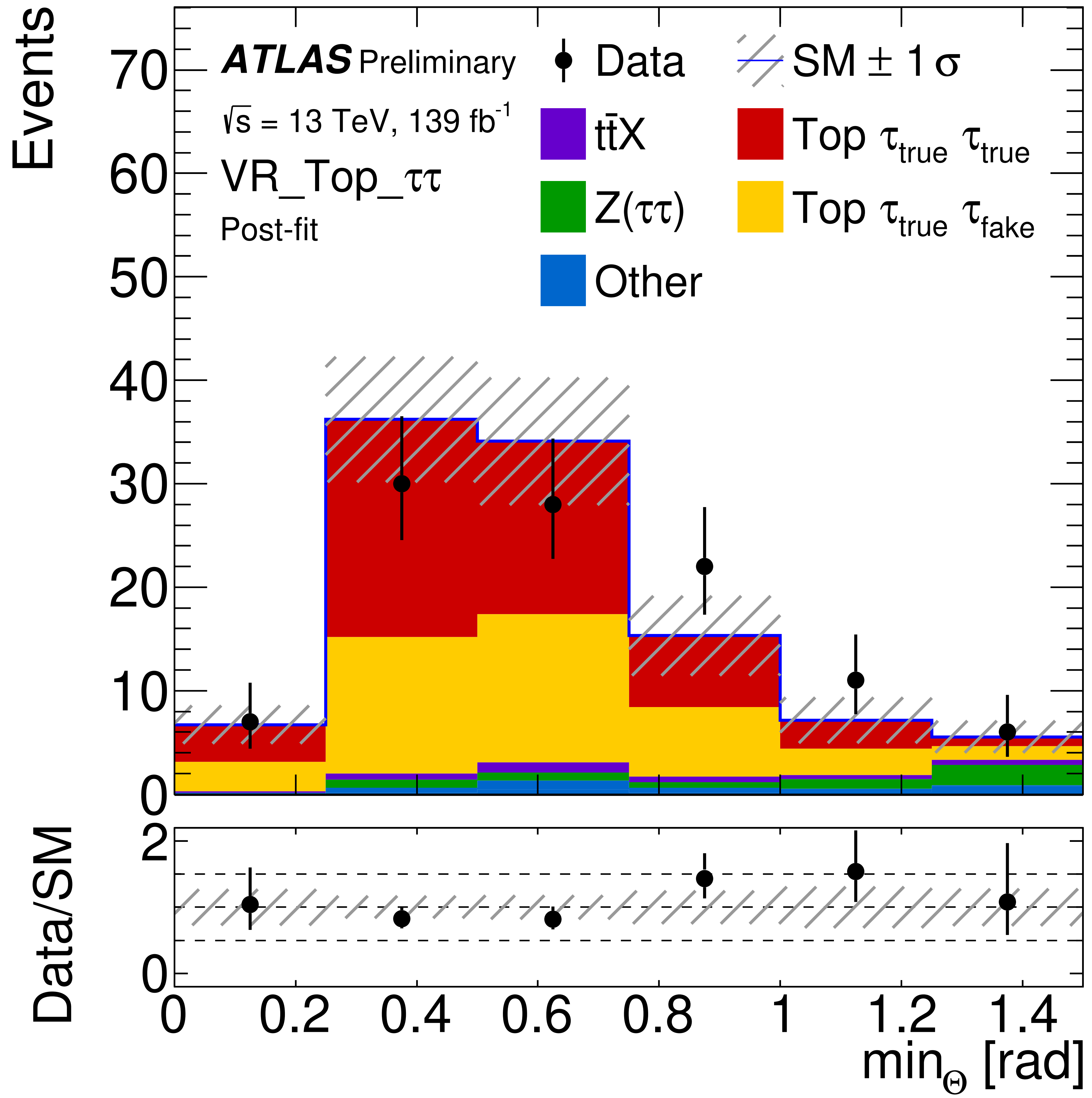
Search for sbottom pairs in final states with taus





Search for sbottom pairs in final states with taus





Search for sbottom pairs in final states with taus

Uncertainty	Single-bin SR	Multi-bin SR		
		$\min_\Theta < 0.5$	$0.5 < \min_\Theta < 1.0$	$\min_\Theta > 1.0$
Generator modeling	37%	42%	44%	27%
Normalization / transfer factors	15%	11%	12%	18%
JER and JES	12%	5.1%	9.8%	22%
Tau leptons	8.3%	3.5%	2.3%	15%
MC statistical uncertainty	6.9%	6.8%	7.2%	11%
Flavor tagging	3.8%	1.0%	1.8%	5.4%
Other	2.9%	1.3%	1.8%	6.6%
Total	40%	43%	46%	41%

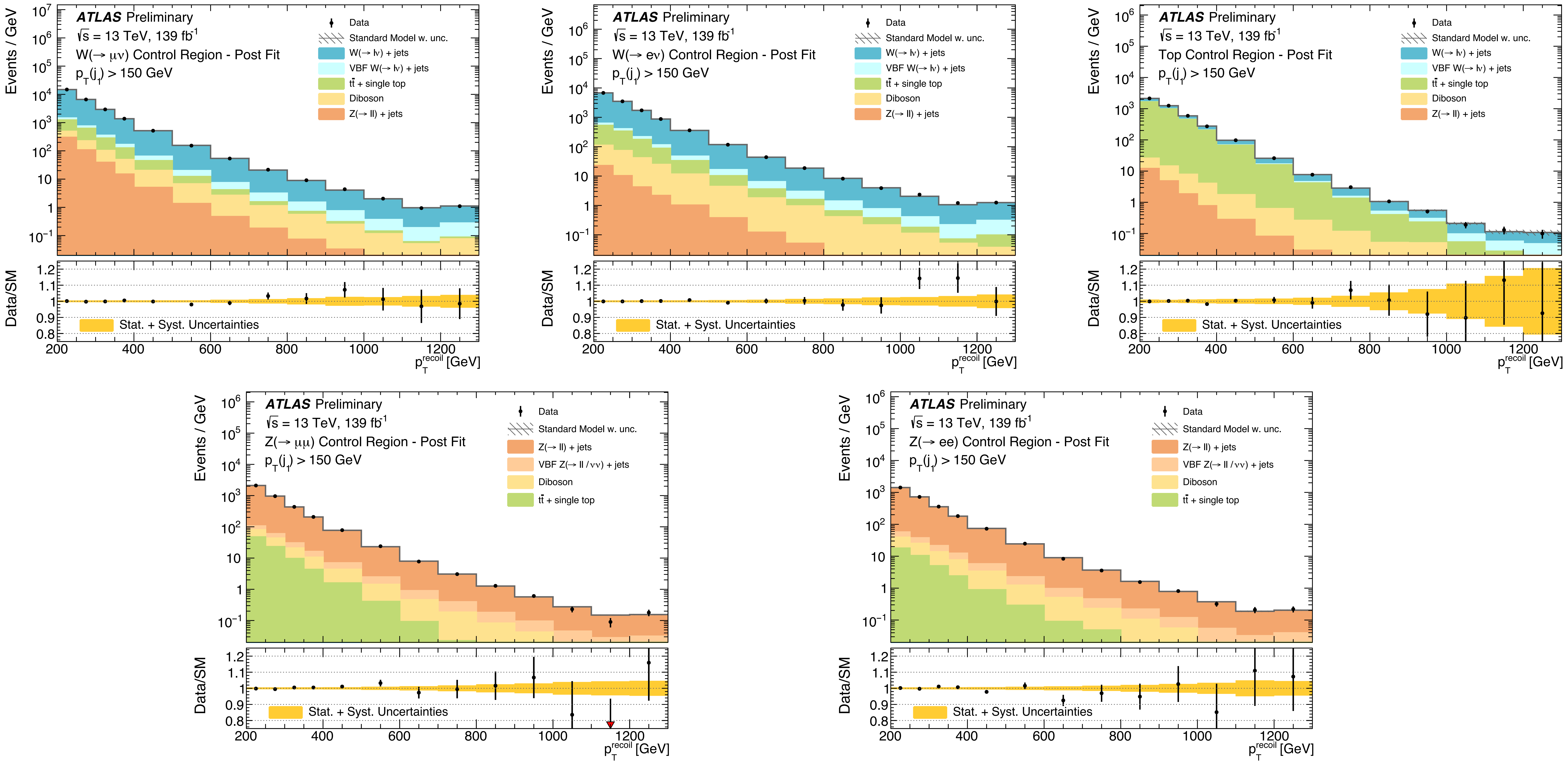
ATLAS-CONF-2020-048

Search for new physics in final states with an energetic jet and large missing transverse momentum

Mono-jet + MET analysis

Requirement	SR	$W \to \mu\nu$	$Z \to \mu\mu$	$W \to e\nu$	$Z \to ee$	top
primary vertex	at least one with ≥ 2 associated tracks with $p_T > 500$ MeV					
trigger	E_T^{miss}			single-electron		E_T^{miss}, single-electron
p_T^{recoil} cut	$E_T^{miss} > 200$ GeV	$\lvert \mathbf{p}_T^{miss} + \mathbf{p}_T(\mu)\rvert > 200$ GeV	$\lvert \mathbf{p}_T^{miss} + \mathbf{p}_T(\mu\mu)\rvert > 200$ GeV	$\lvert \mathbf{p}_T^{miss} + \mathbf{p}_T(e)\rvert > 200$ GeV	$\lvert \mathbf{p}_T^{miss} + \mathbf{p}_T(ee)\rvert > 200$ GeV	$\lvert \mathbf{p}_T^{miss} + \mathbf{p}_T(\mu)\rvert > 200$ GeV or $\lvert \mathbf{p}_T^{miss} + \mathbf{p}_T(e)\rvert > 200$ GeV
jets	up to 4 with $p_T > 30$ GeV, $\lvert\eta\rvert < 2.8$					
$\lvert\Delta\phi(\text{jets}, \mathbf{p}_T^{miss})\rvert$	> 0.4 (> 0.6 if 200 GeV $< E_T^{miss} \leq 250$ GeV)					
leading jet	$p_T > 150$ GeV, $\lvert\eta\rvert < 2.4$, $f_{ch}/f_{max} > 0.1$					
b-jets	any	none	any	none	any	at least one
electrons or muons	none	exactly one muon, with $p_T > 10$ GeV, $30 < m_T < 100$ GeV; no electron	exactly two muons, with $p_T > 10$ GeV, $66 < m_{\mu\mu} < 116$ GeV; no electron	exactly one electron, tight, with $p_T > 30$ GeV, $\lvert\eta\rvert \notin (1.37, 1.52)$, tight isolation, $30 < m_T < 100$ GeV; no muon	exactly two electrons, with $p_T > 30$ GeV, $66 < m_{ee} < 116$ GeV; no muon	as for $W \to \mu\nu$ or as for $W \to e\nu$
τ-leptons	none					
photons	none					

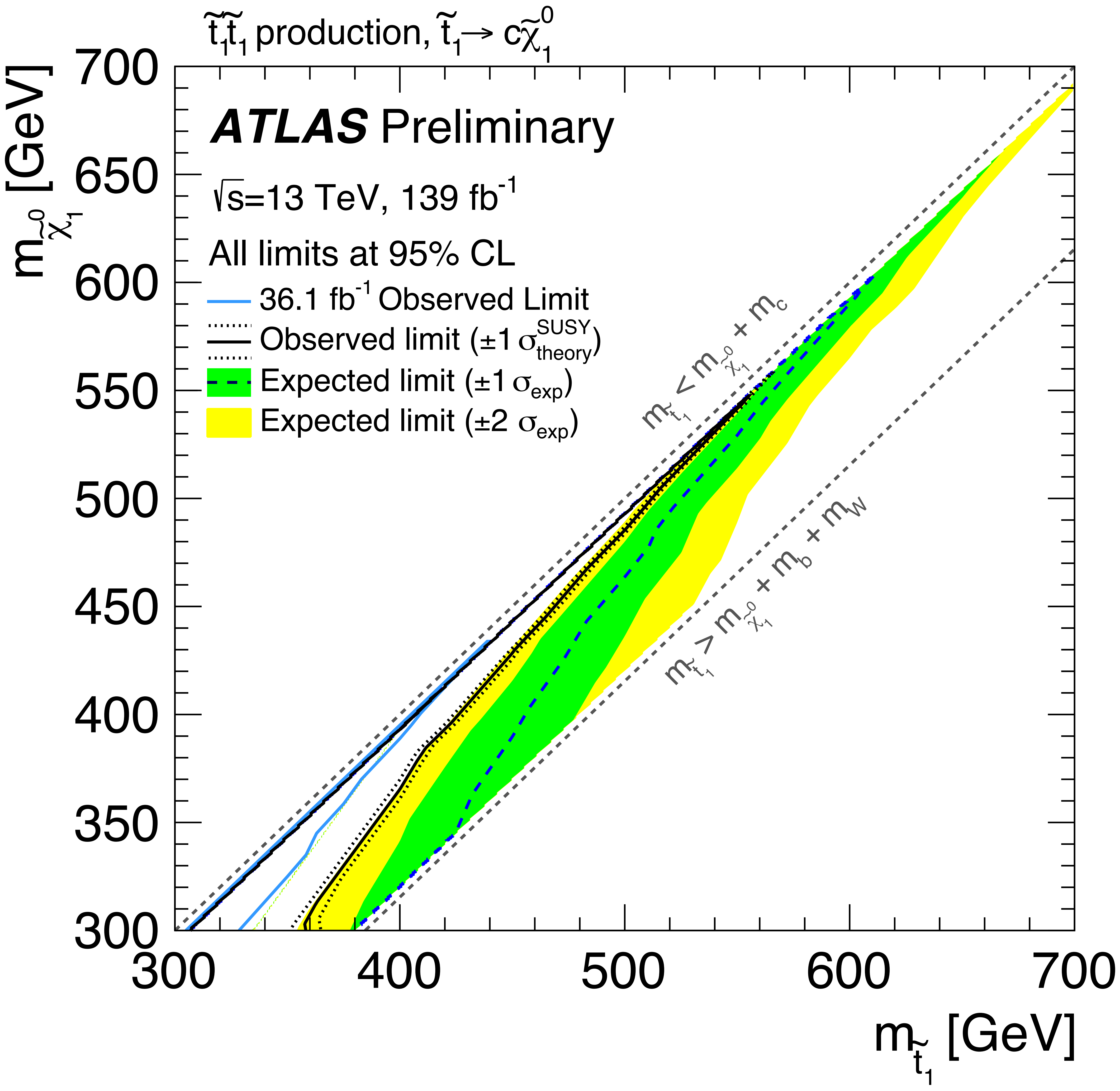
Mono-jet + MET analysis

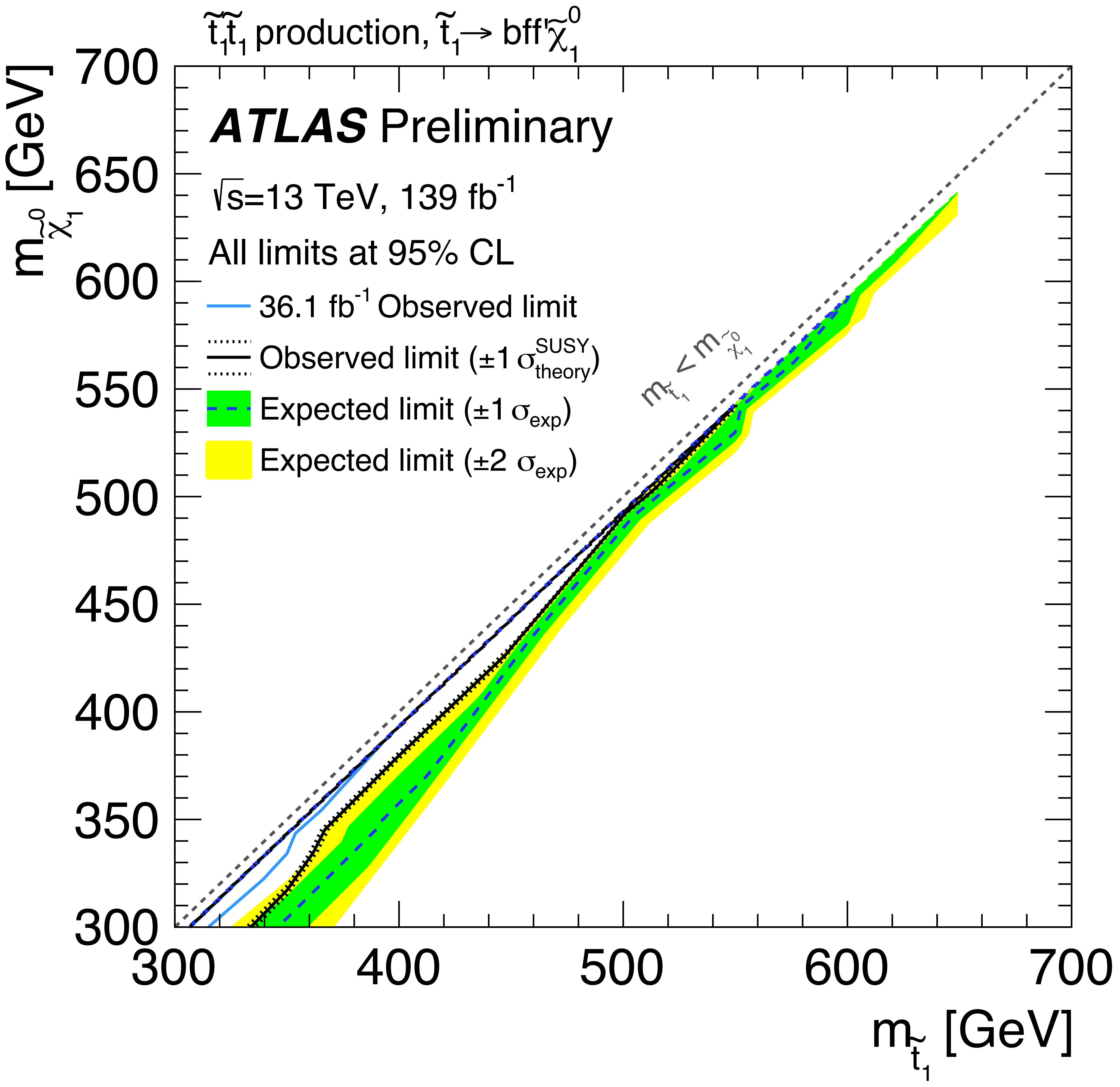


Mono-jet + MET analysis

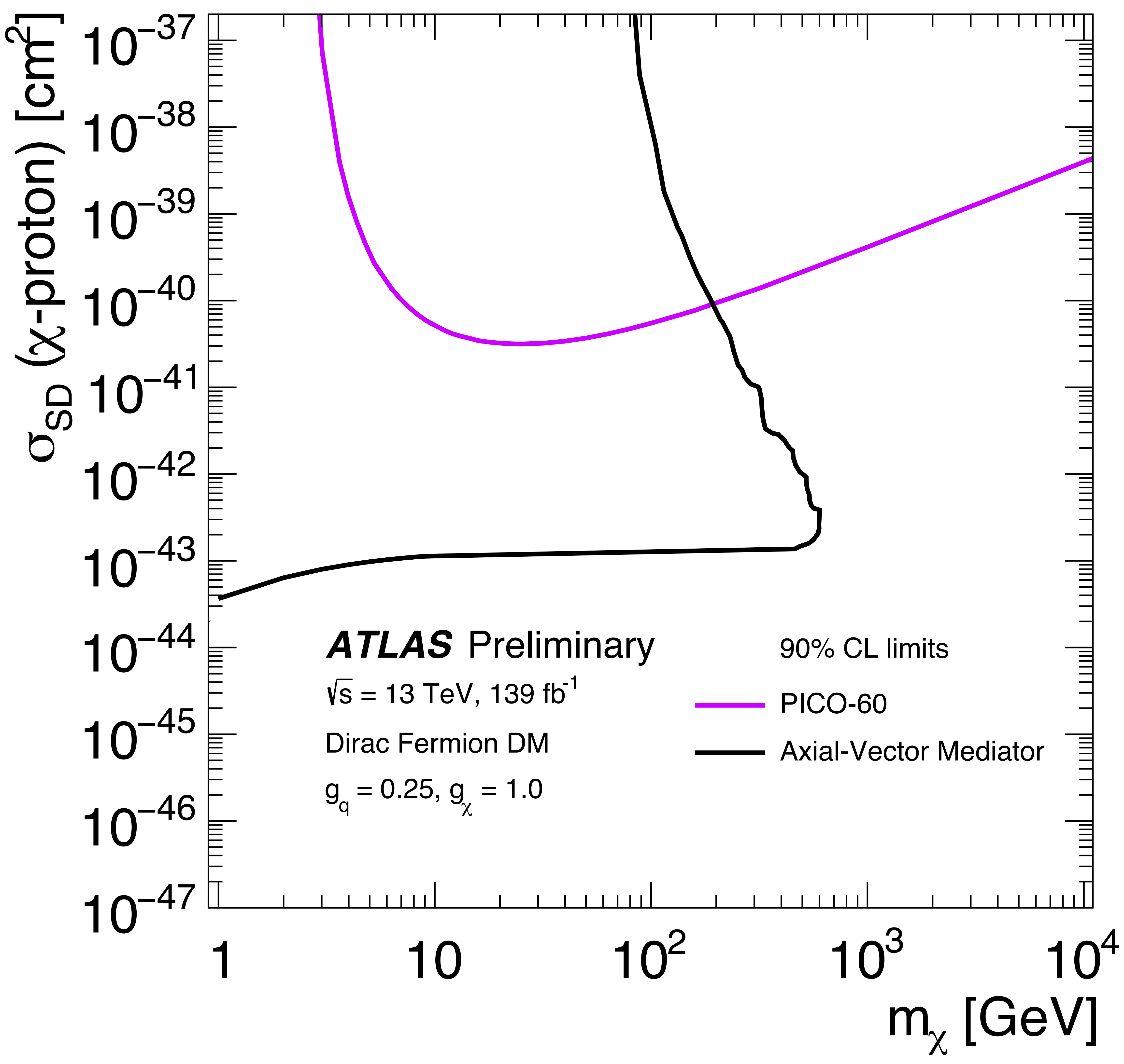
Selection	$\langle\sigma\rangle^{95}_{obs}$ [fb]	S^{95}_{obs}	S^{95}_{exp}
$p_T^{recoil} > 200$ GeV	861	119653	86000^{+27000}_{-24000}
$p_T^{recoil} > 250$ GeV	350	48636	35600^{+12700}_{-10000}
$p_T^{recoil} > 300$ GeV	156	21624	15500^{+6000}_{-4300}
$p_T^{recoil} > 350$ GeV	87	12066	8200^{+3100}_{-2300}
$p_T^{recoil} > 400$ GeV	52	7285	4700^{+1800}_{-1300}
$p_T^{recoil} > 500$ GeV	21	2903	1910^{+720}_{-530}
$p_T^{recoil} > 600$ GeV	10	1421	930^{+350}_{-260}
$p_T^{recoil} > 700$ GeV	4.2	578	480^{+180}_{-130}
$p_T^{recoil} > 800$ GeV	2.1	296	267^{+100}_{-75}
$p_T^{recoil} > 900$ GeV	1.2	165	161^{+62}_{-45}
$p_T^{recoil} > 1000$ GeV	1.3	189	113^{+43}_{-31}
$p_T^{recoil} > 1100$ GeV	0.5	73	71^{+27}_{-20}
$p_T^{recoil} > 1200$ GeV	0.3	39	47^{+19}_{-13}

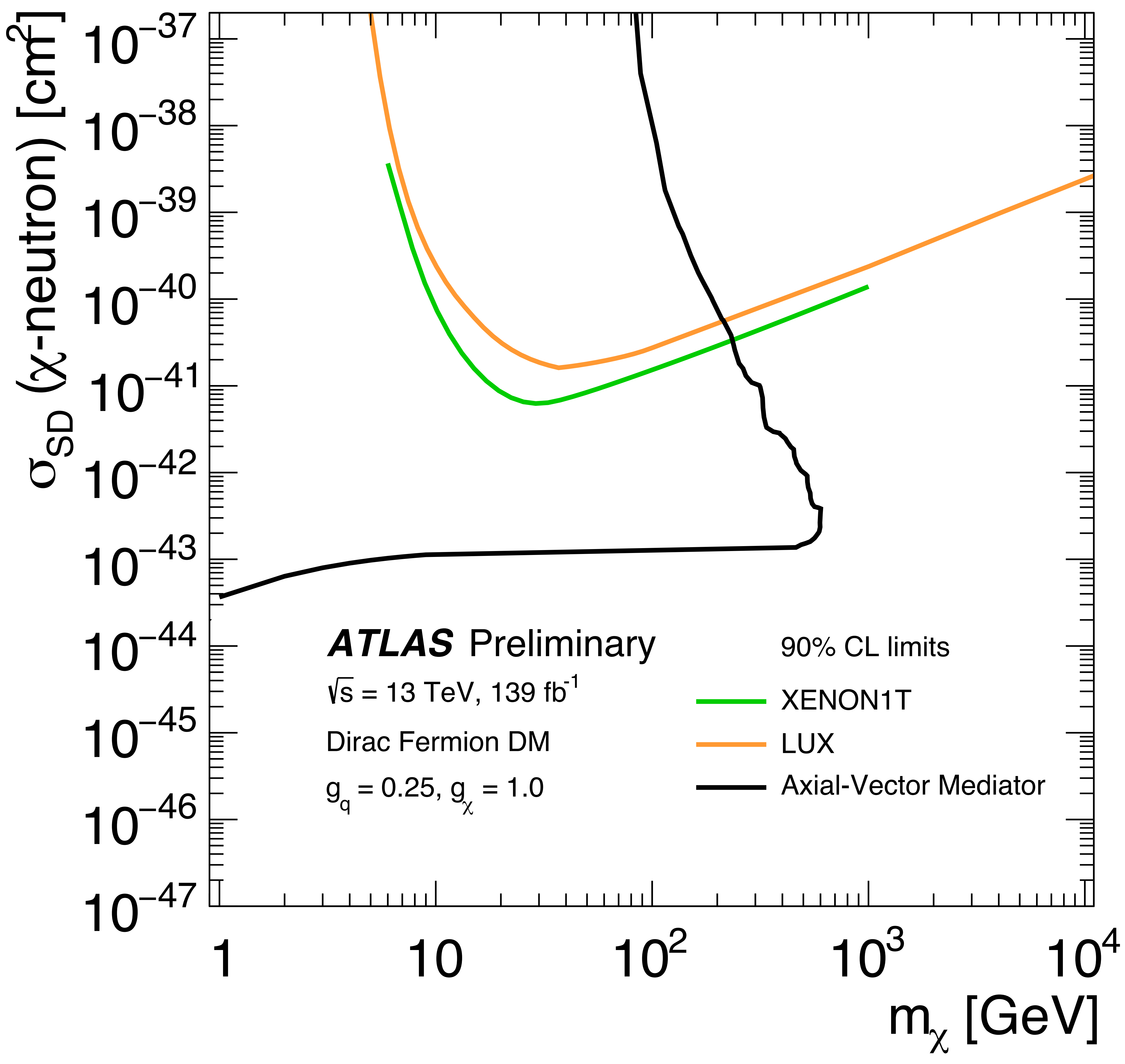
Mono-jet + MET analysis



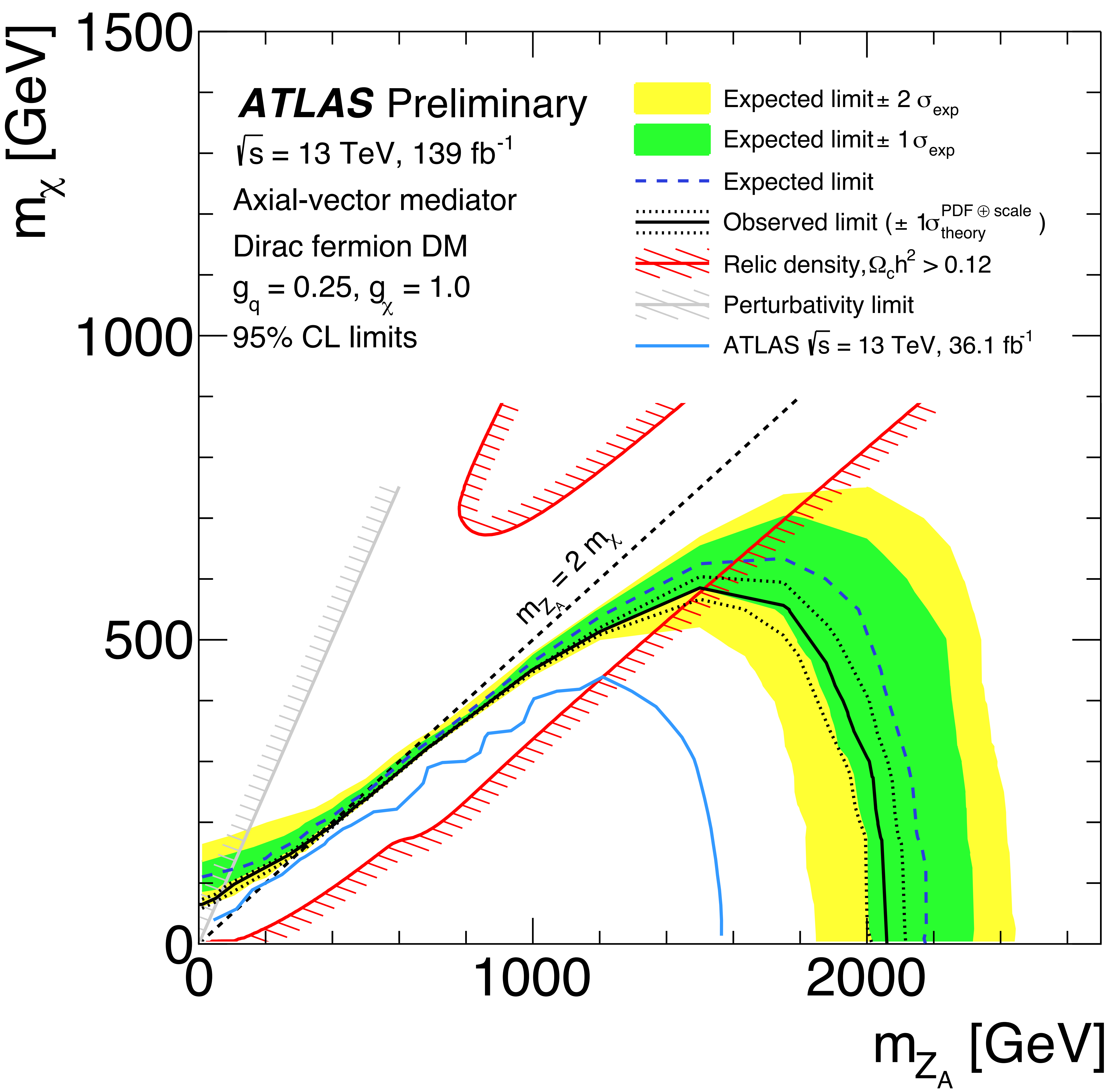


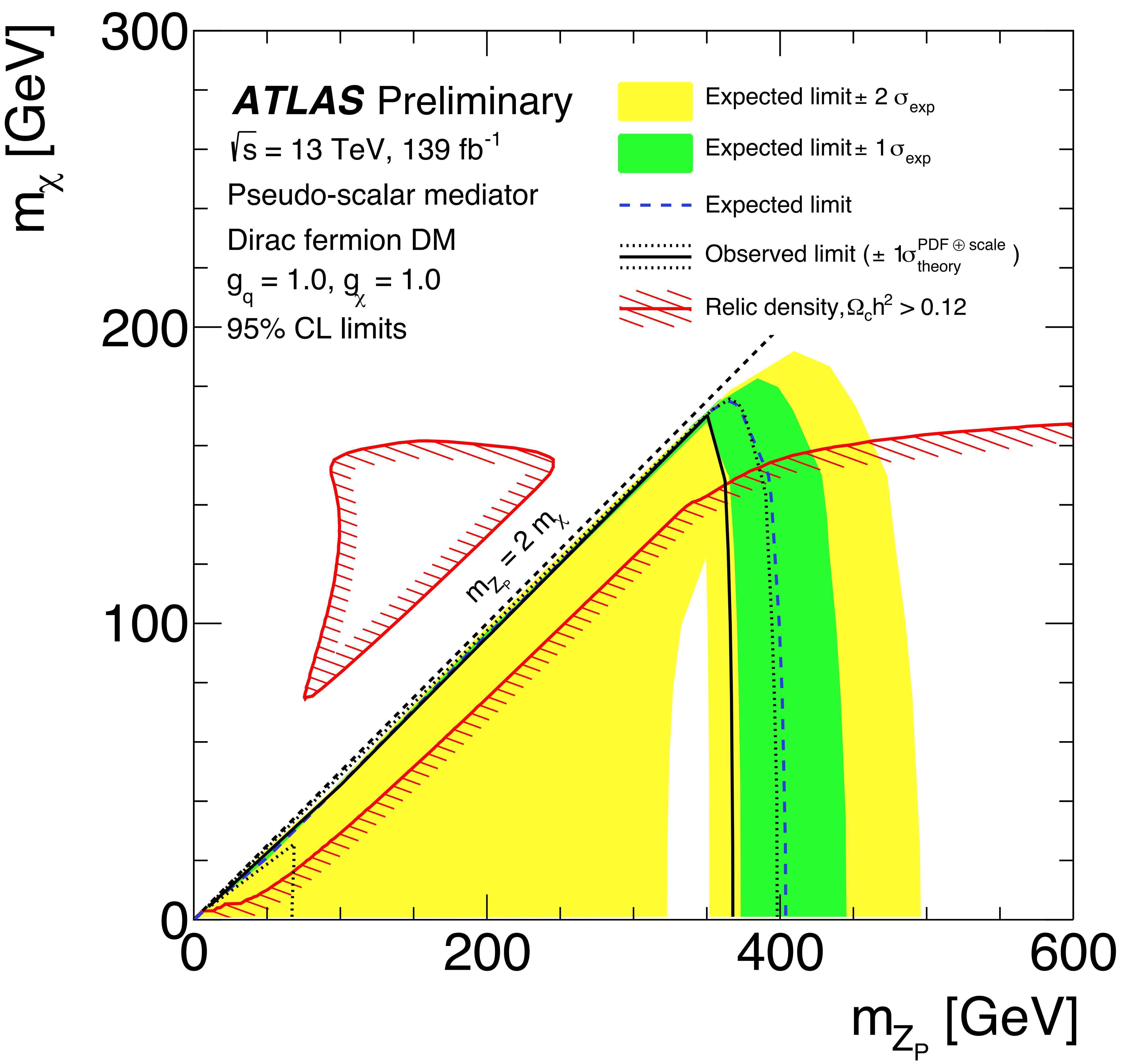
Mono-jet + MET analysis





Mono-jet + MET analysis





Mono-jet + MET analysis