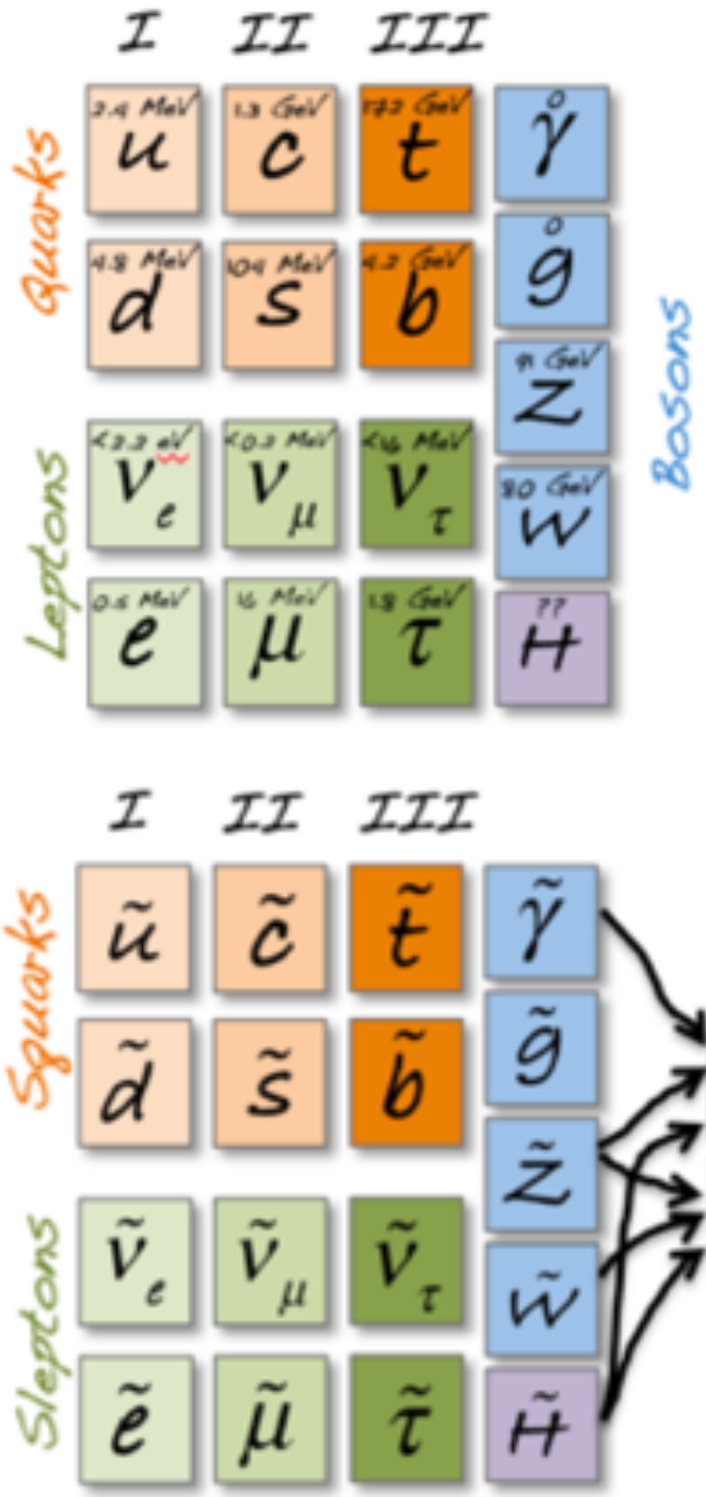
EPS-HEP
5-12 July 2017

Searches for direct pair production of third generation squarks in final states with leptons with the ATLAS detector

Priscilla Pani (CERN) on behalf of the ATLAS Collaboration

Introduction and motivations



S. Amoroso (Moriond 2017)

- ★ Stops and sbottoms are key ingredients for SUSY and hierarchy problem solutions
- ★ **Focus** of this talk: stop searches with leptons and gauginos in the final state.
- ★ **Question to be answered:** is the stop phase space really well excluded for realistic models?

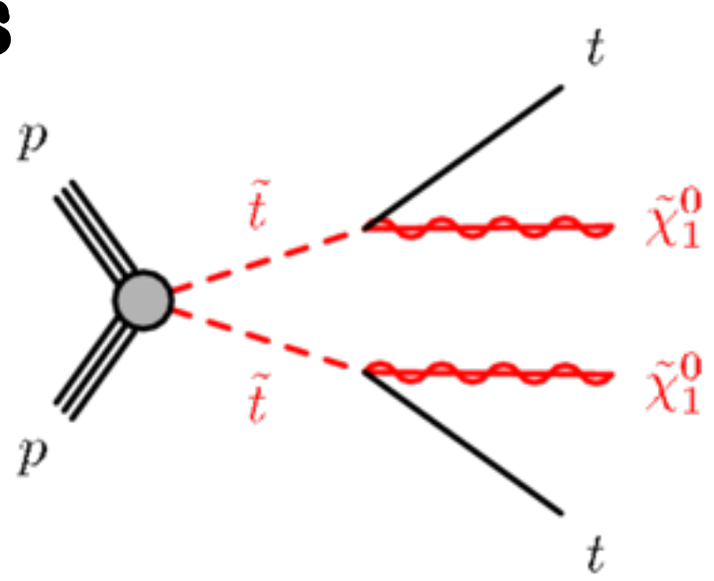
Outlook of the ATLAS stop searches

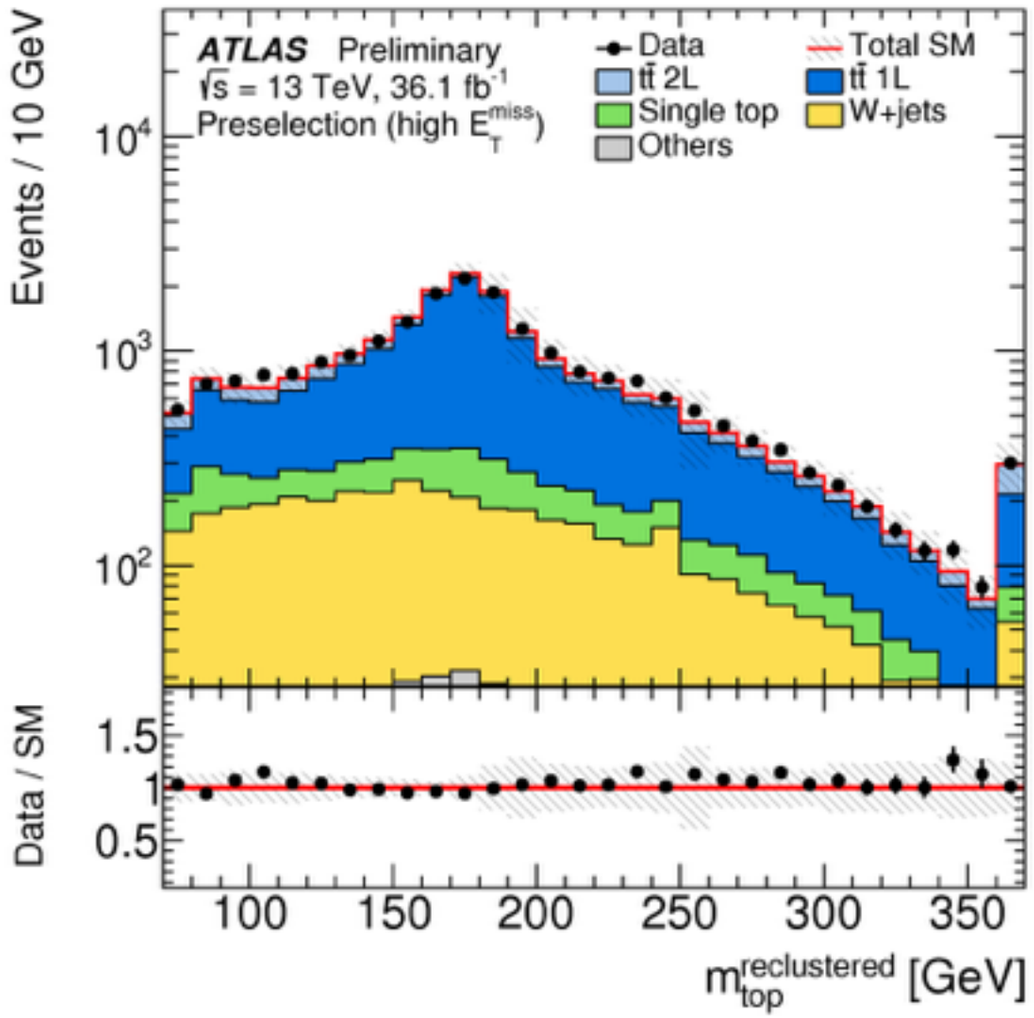
Short Name	Reference	Target	Strategy
stop1L	ATLAS-CONF-2017-037	$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^{\pm}$ / $t\chi_1^0$ / $t\chi_2^0$ $\tilde{t}_1 \rightarrow bff'\tilde{\chi}_1^0$ / $bW^{\pm}\tilde{\chi}_1^0$	BDTs, multi-bin fits, multiple SR
stop2L	ATLAS-CONF-2017-034	$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^{\pm}$ / $t\chi_1^0$ / $t\chi_2^0$ $\tilde{t}_1 \rightarrow bff'\tilde{\chi}_1^0$ / $bW^{\pm}\tilde{\chi}_1^0$	multi-bin fits, multiple SR
stopZ/h	arXiv: 1706.03986	$\tilde{t}_1 \rightarrow t\tilde{\chi}_2^0$ $\tilde{t}_2 \rightarrow \tilde{t}_1 h$ / $\tilde{t}_1 Z$	multiple single-bin SRs
RPV 1L	arXiv: 1704.08493	$\tilde{t}_1 \rightarrow t\chi_1^0$ / $t\chi_2^0$ $\tilde{\chi}_{1,2}^0 \rightarrow tbs$ / sbb	multi-bin fits
RPV b-l	ATLAS-CONF-2017-036	$\tilde{t}_1 \rightarrow b\ell$	multiple single-bin SRs

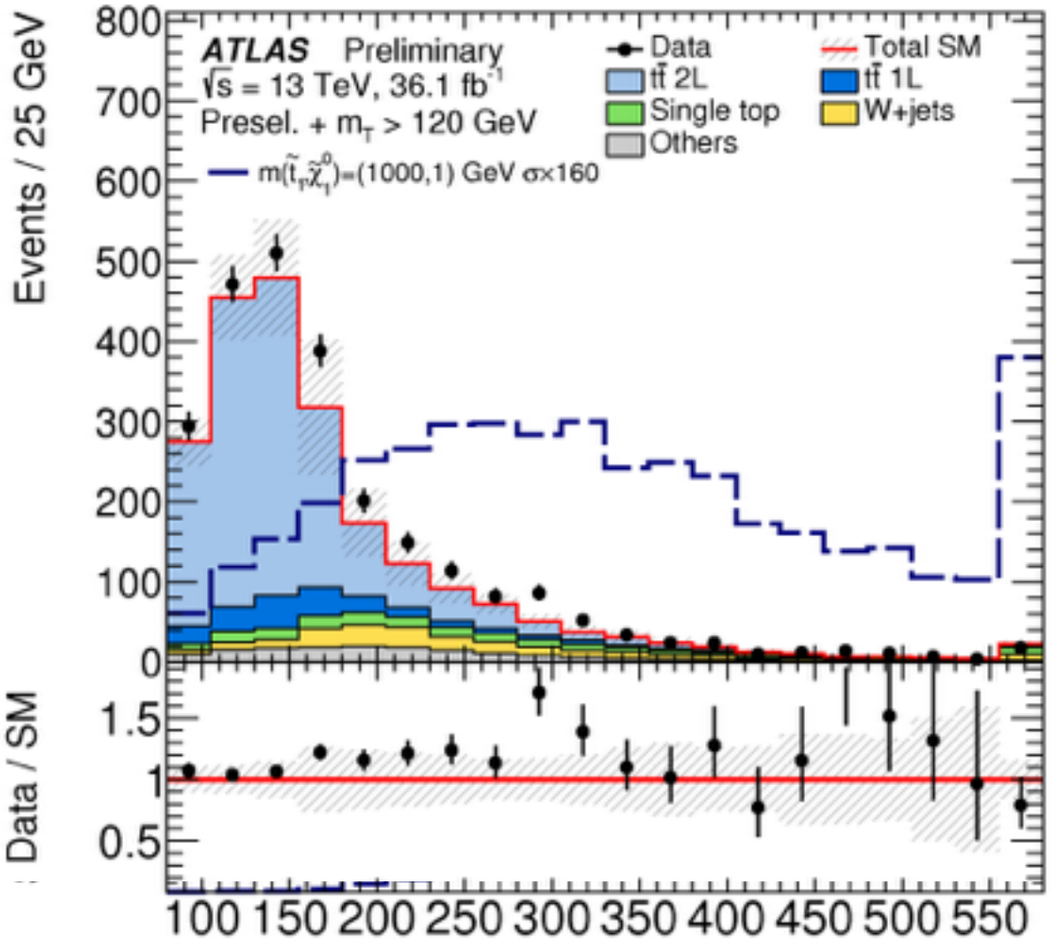
Stop1L in a nutshell

Final state: 1L (soft or hard) + bjets + ETmiss

- ★ Exploit the presence of 1 hadronic and 1 leptonic top decay (large R jet masses)
- ★ asymmetric stranverse mass to suppress di-lepton top in background
- ★ angular correlations between objects to enhance signal discrimination







shape-fits, BDT, cut-and-count

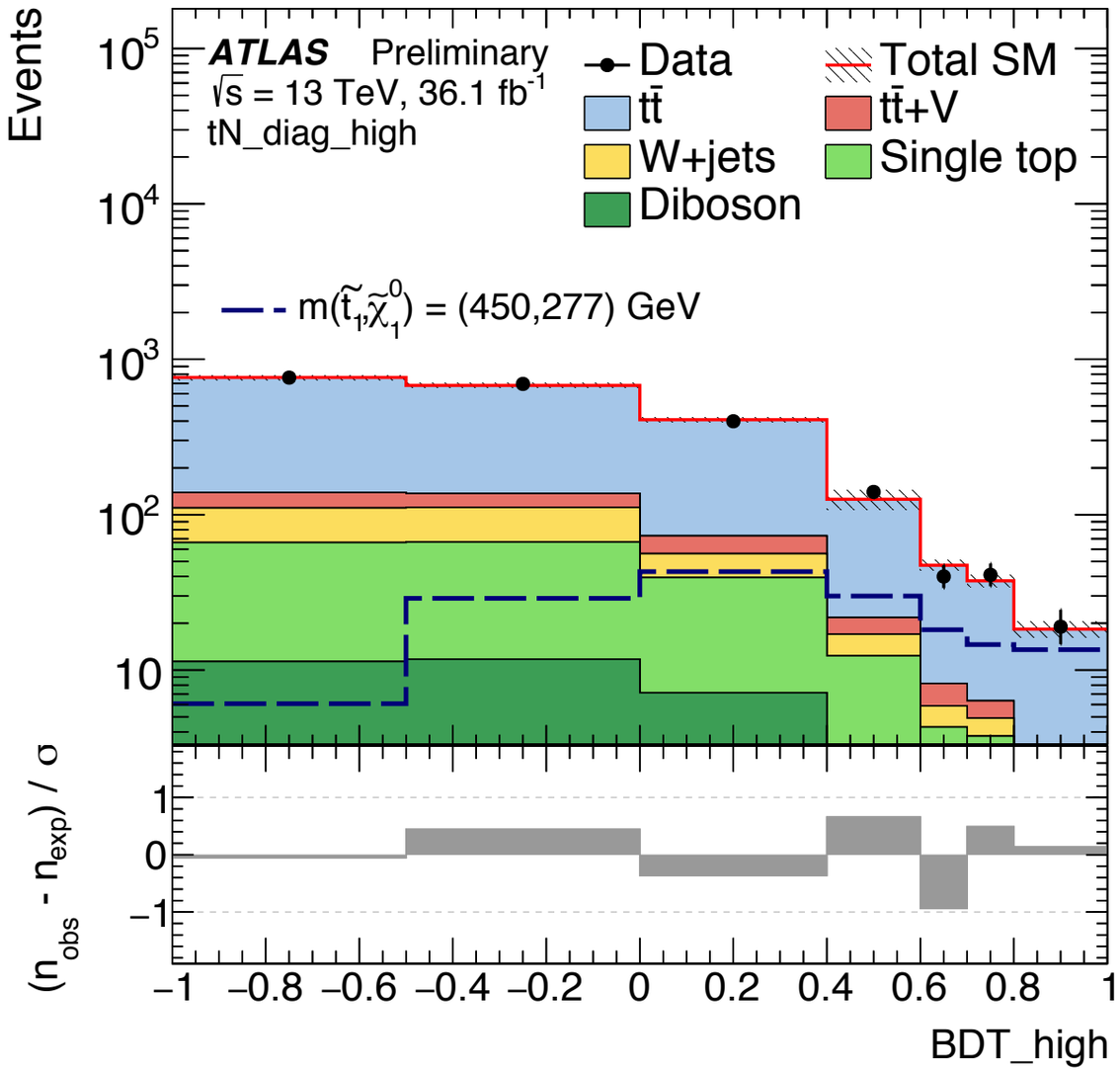
Details of the compressed analysis

tN_diag_low	Pure bino LSP ($\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(190,17)	BDT cut-and-count	7
tN_diag_med	Pure bino LSP ($\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(250,62)	BDT shape-fit	7
tN_diag_high	Pure bino LSP ($\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(450,277)	BDT shape-fit	7

BDT inputs

Recursive Jigsaw variables

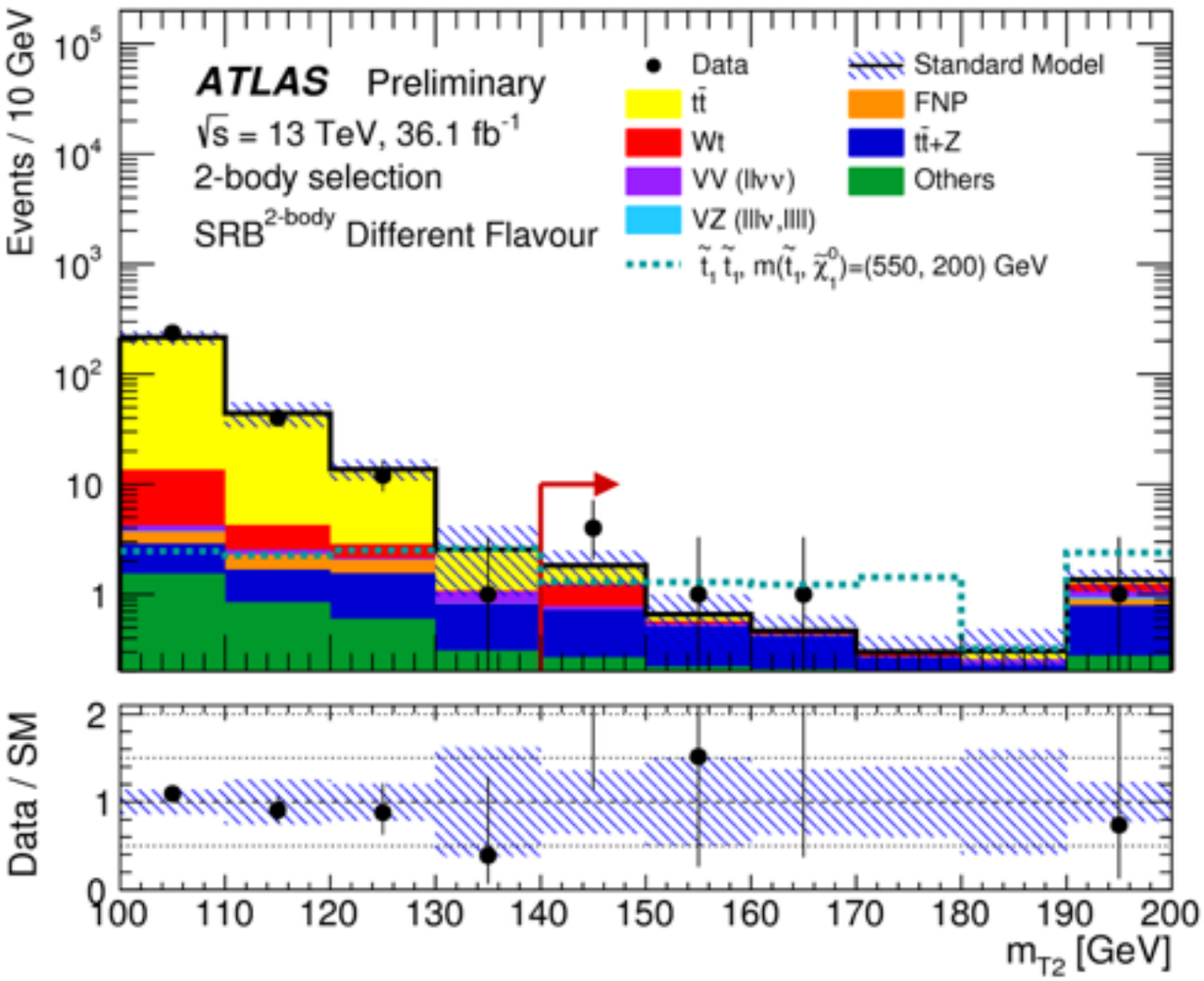
$\tilde{t}_1 \rightarrow t\chi_1^0$

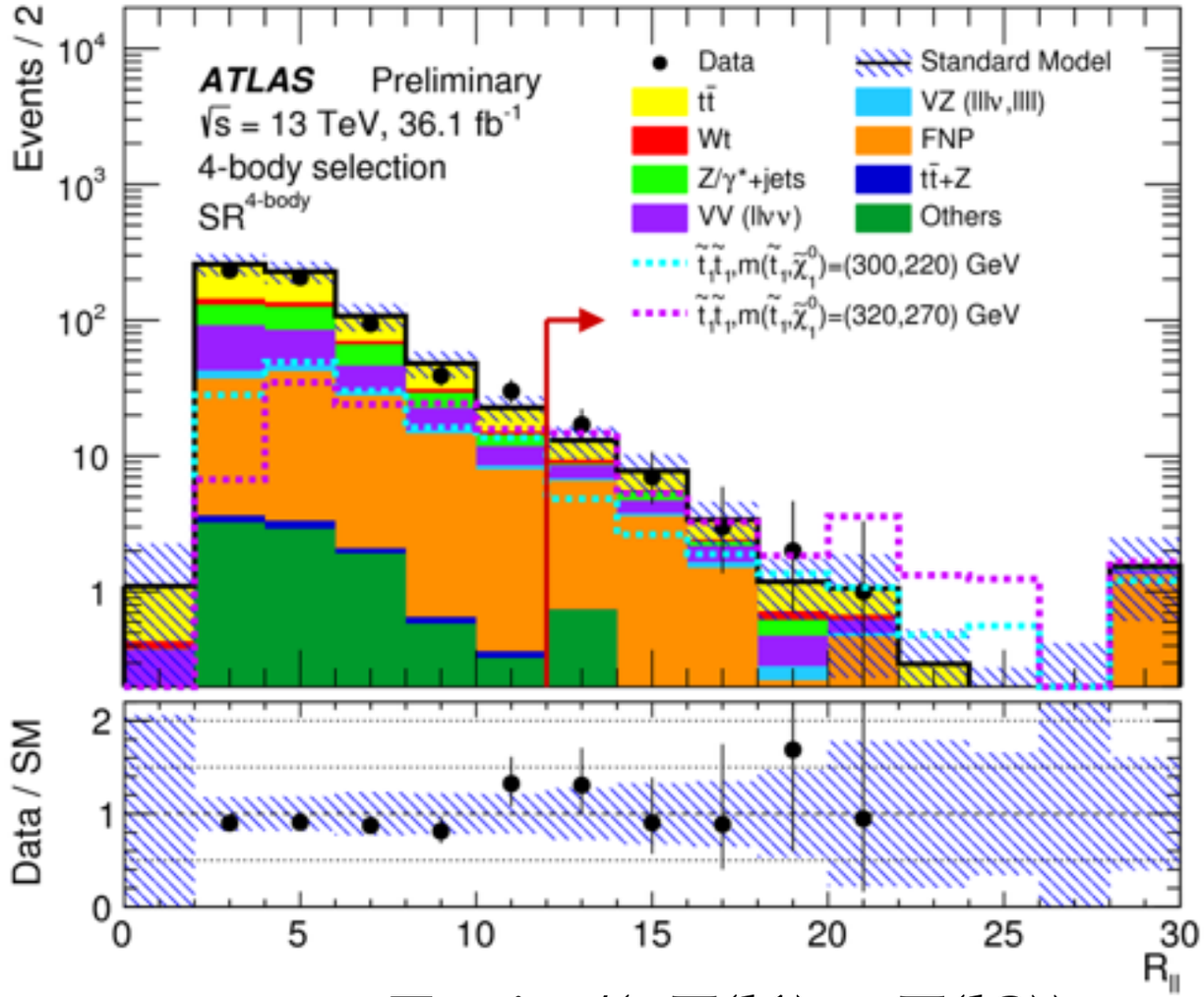


Stop2L in a nutshell

Final state: 2L (soft or hard) + ETmiss

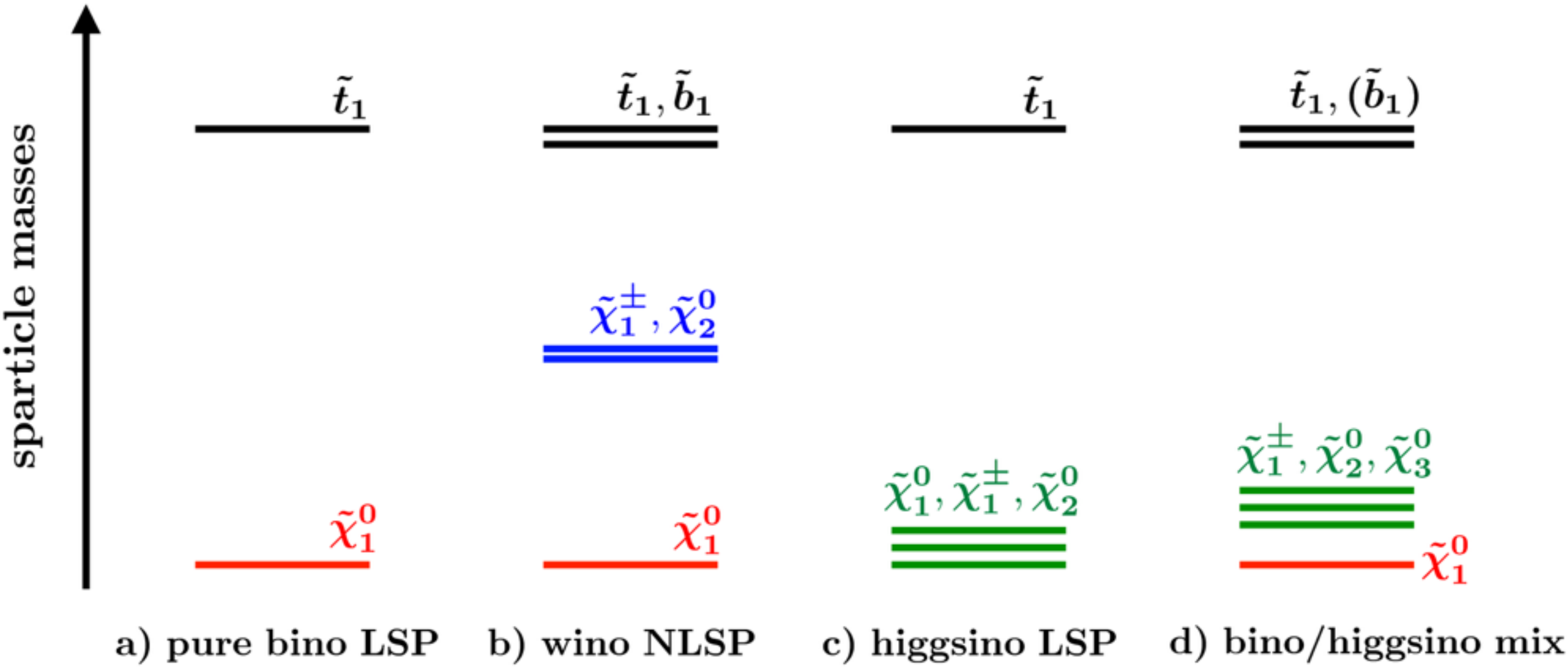
- ★ Exploit kinematic end-point of stranverse mass $\tilde{t}_1 \rightarrow t\chi_1^0$
- ★ jigsaw analysis for $\tilde{t}_1 \rightarrow bW^{\pm}\tilde{\chi}_1^0$
- ★ Ratios of E_T^{miss} and pTs to enhance soft topologies $\tilde{t}_1 \rightarrow bff'\tilde{\chi}_1^0$





$E_T^{miss}/(pT(l1)+pT(l2))$

RPC quasi-simplified models



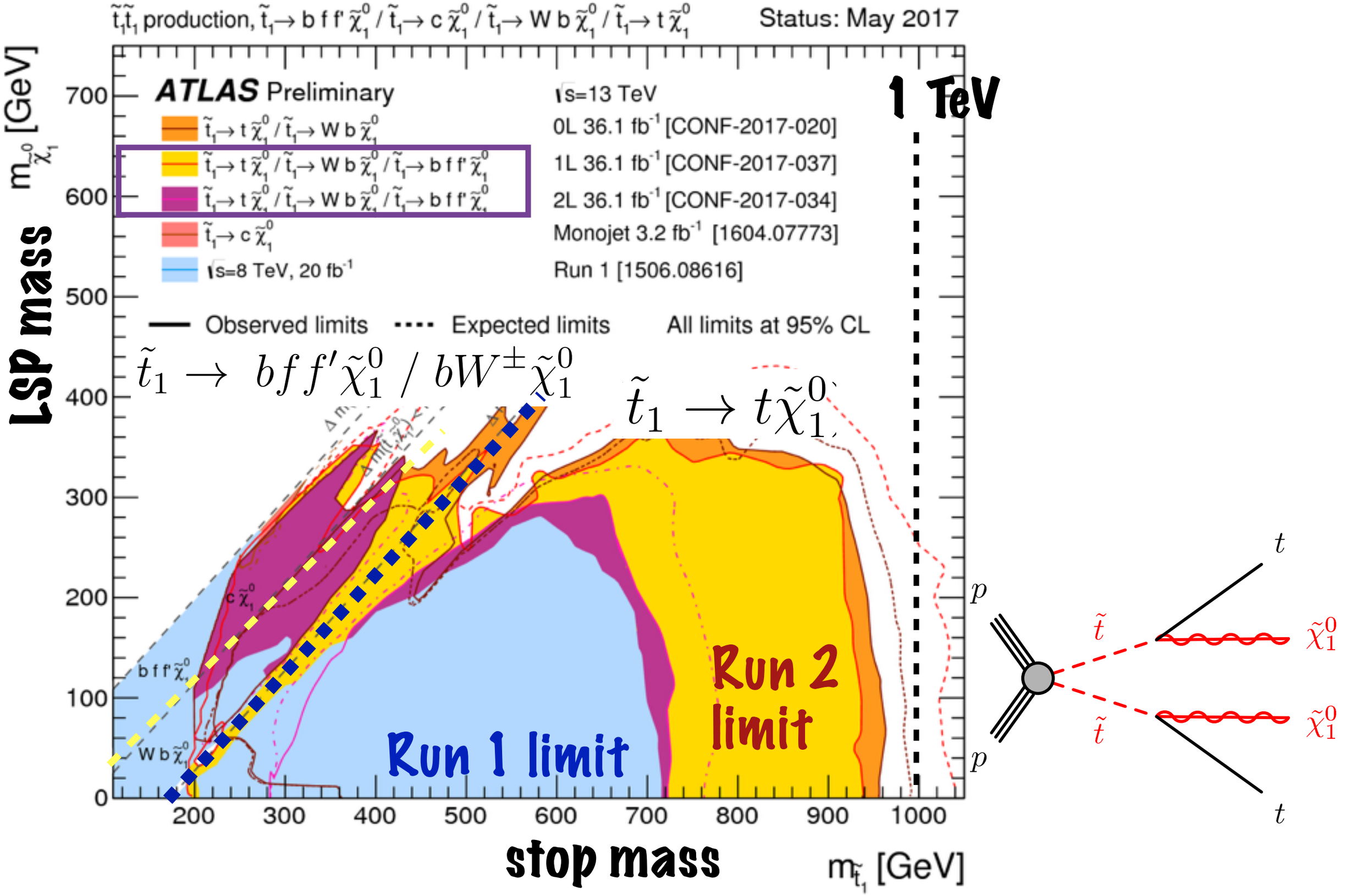
a) pure bino LSP b) wino NLSP c) higgsino LSP d) bino/higgsino mix

$\mathcal{BR}(\tilde{t}_1 \to t\tilde{\chi}_1^0) = 100\%$

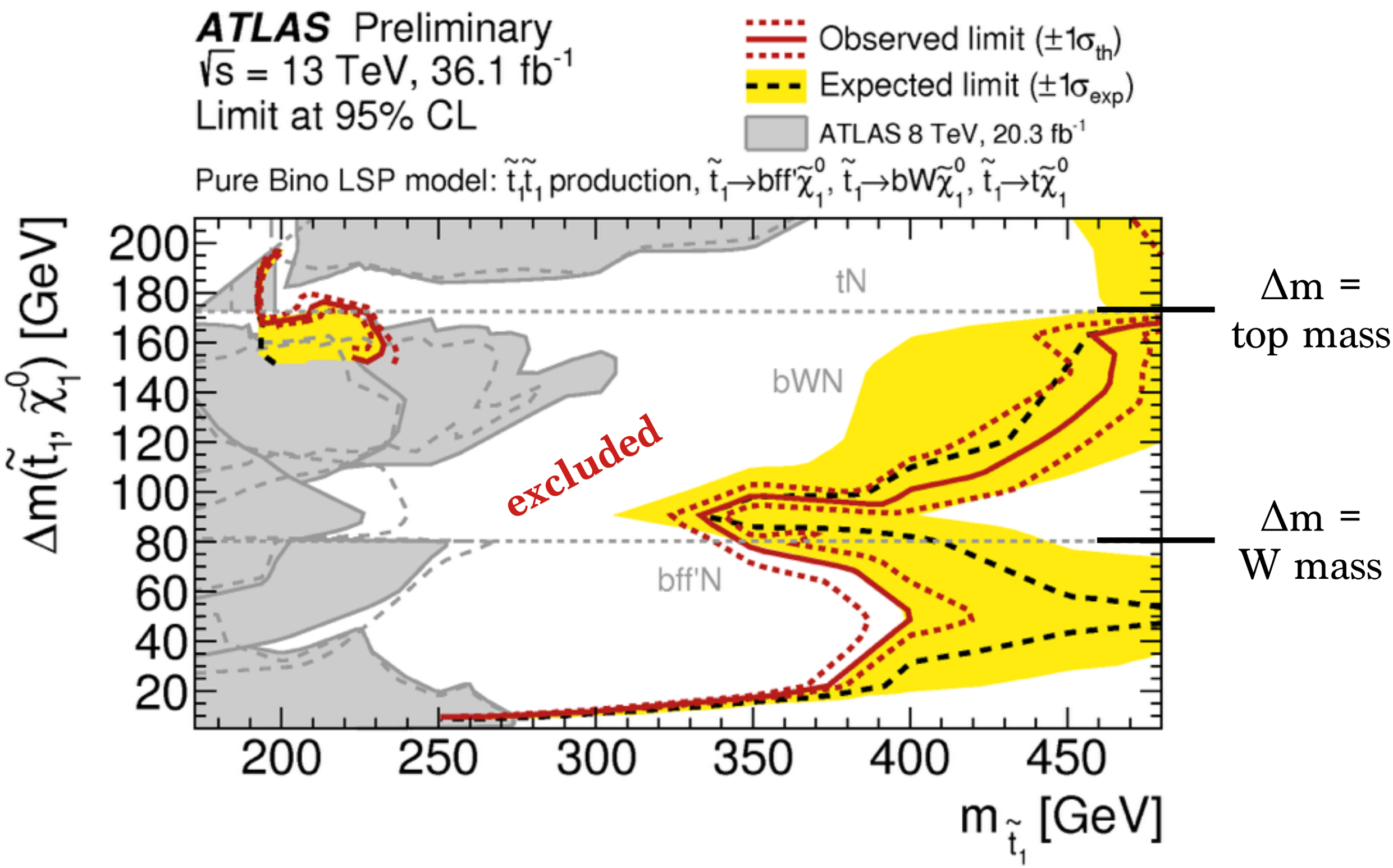
"standard" simplified model

more complex chains than Run 1 benchmarks (pMSSM inspired)

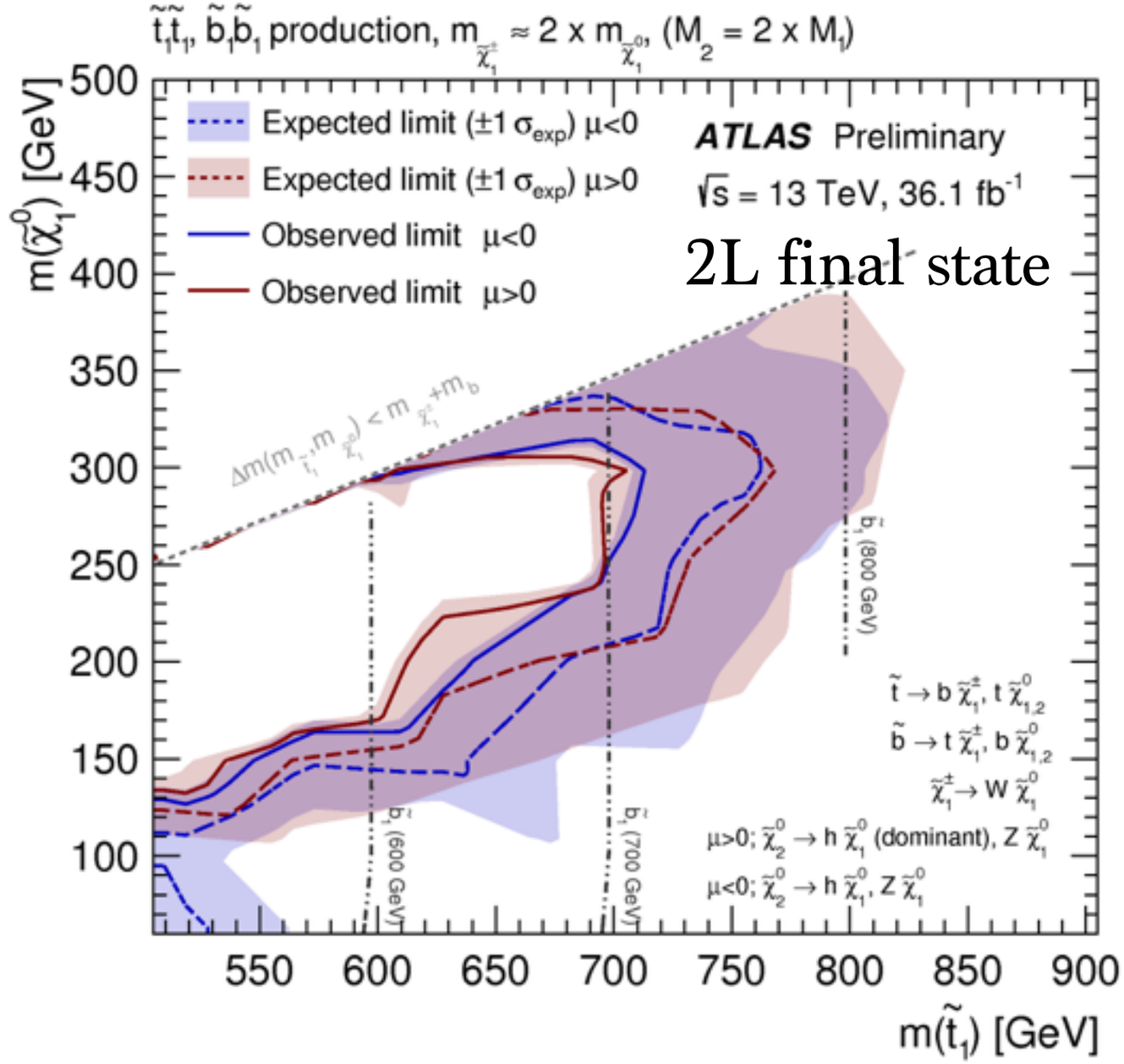
Scenario a) Bino-LSP



Results along the diagonal



Scenario b) Wino N-LSP



$$\tilde{t}_1 \to b\tilde{\chi}_1^\pm \;/\; t\chi_1^0 \;/\; t\chi_2^0$$

$\tilde{t}_1, \tilde{b}_1$

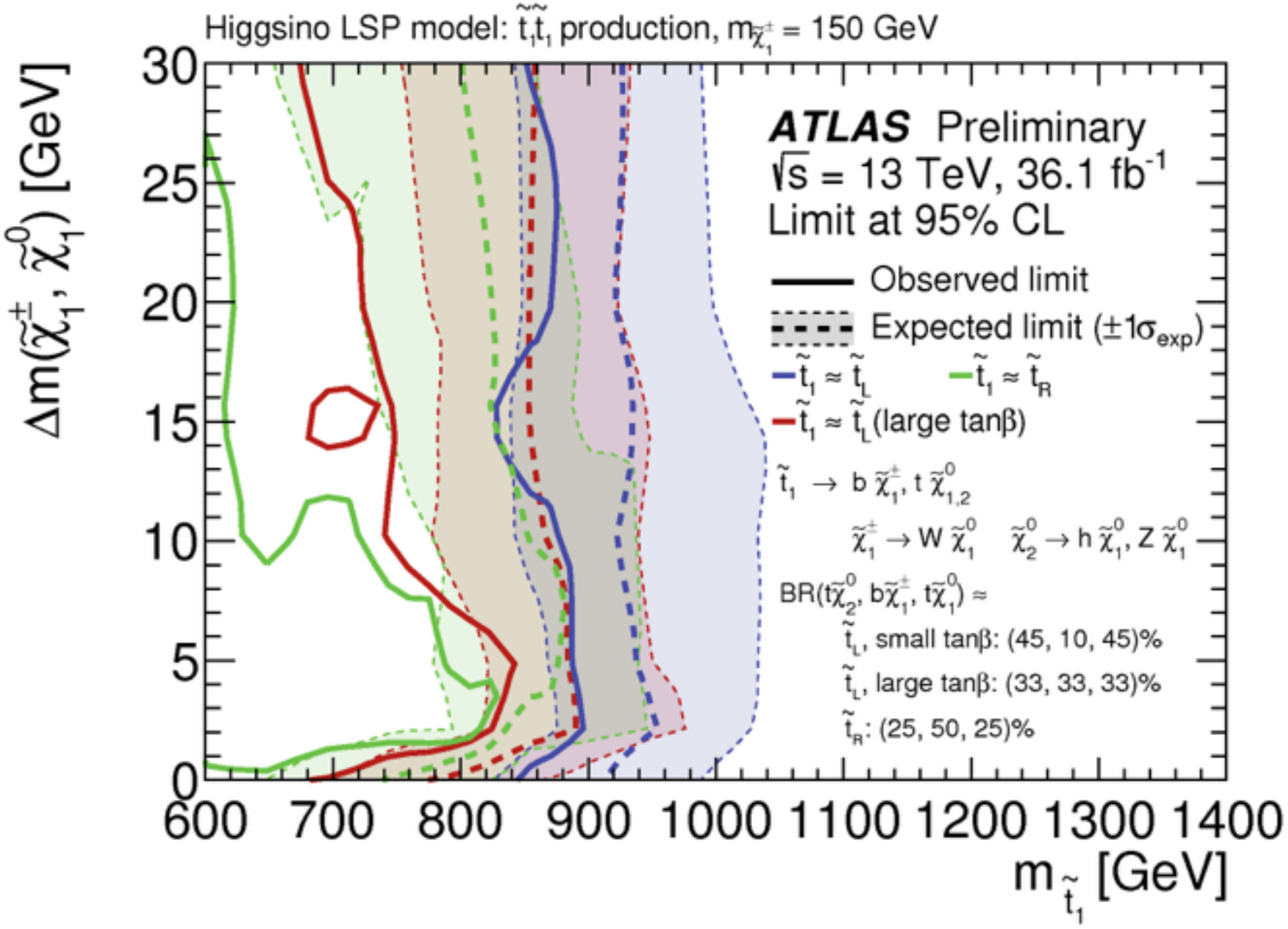
$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$

$\tilde{\chi}_1^0$

b) wino NLSP

Parameter	M1, M2	M3	Iμl	tan β	Ms	Xt
Value	M2=2*M1	2.2 TeV	high	20	1.2 TeV	Xt=Ms*√6

Scenario c) Higgsino LSP



$\tilde{t}_1$

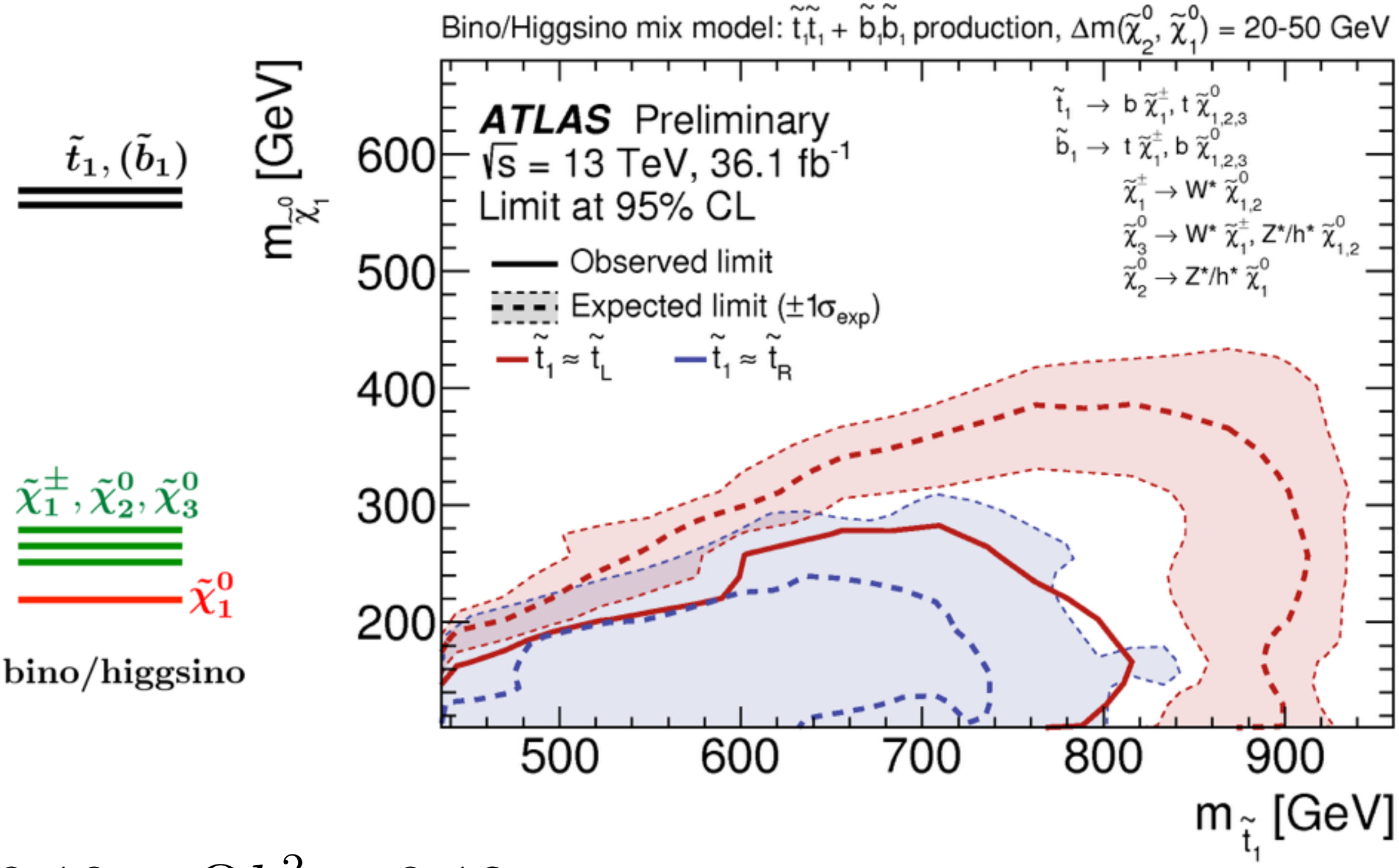
$\tilde{\chi}_1^0, \tilde{\chi}_1^\pm, \tilde{\chi}_2^0$

c) higgsino LSP

soft 1L final states

Parameter	$m(\chi_1^\pm)$	$\Delta m(\chi_2^0\text{-}\chi_1^0)$	lμl
Value	150 GeV	$2\Delta m(\chi_1^\pm\text{-}\chi_1^0)$	low

Scenario d) Well tempered grid



$\tilde{t}_1, (\tilde{b}_1)$

$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0, \tilde{\chi}_3^0$

$\tilde{\chi}_1^0$

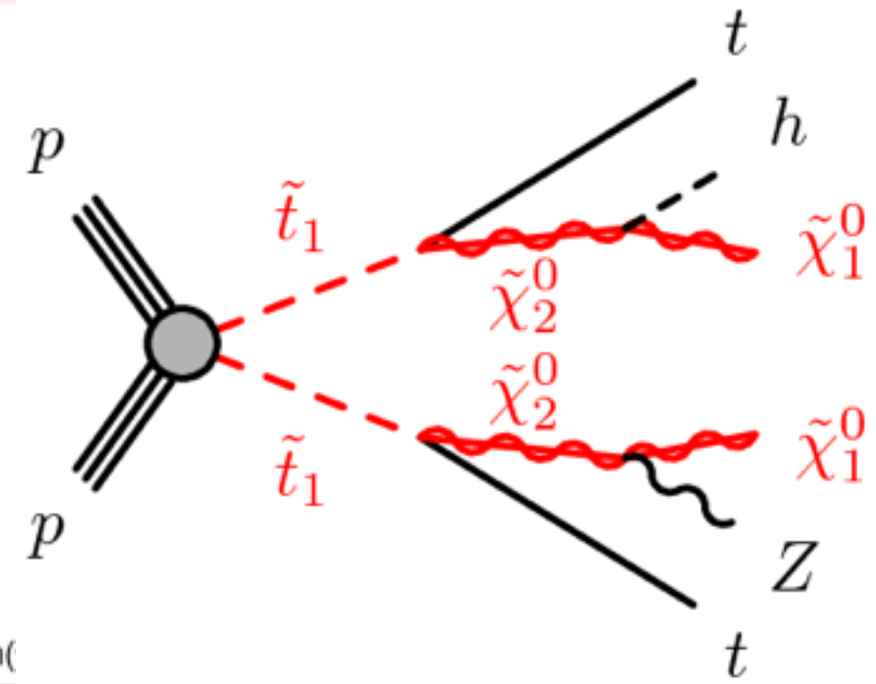
d) bino/higgsino

$0.10 < \Omega h^2 < 0.12$

1L final states

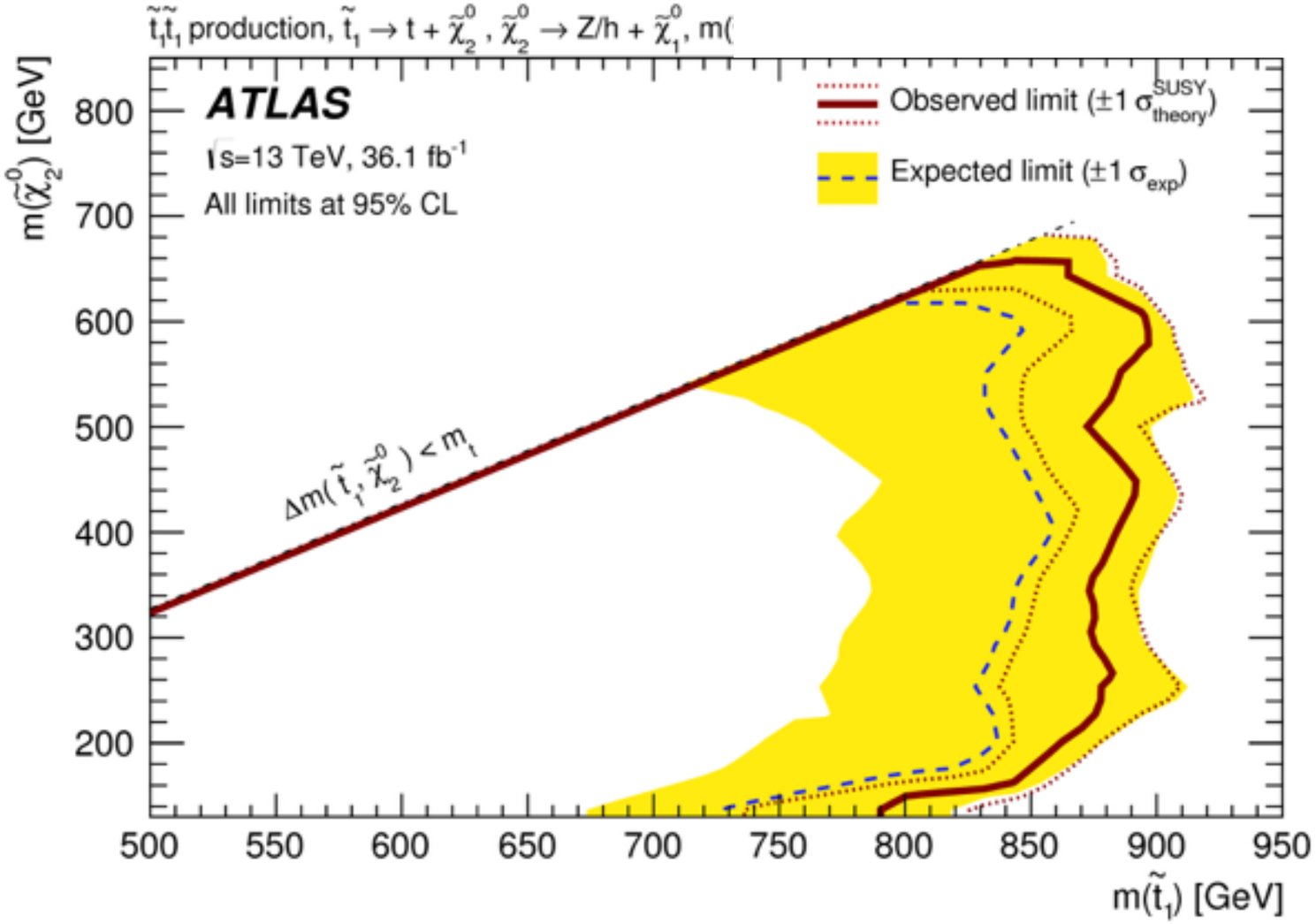
Searches with higgs and Z

★ Simplified model targeting χ_2 decaying via Higgs or Z-boson.



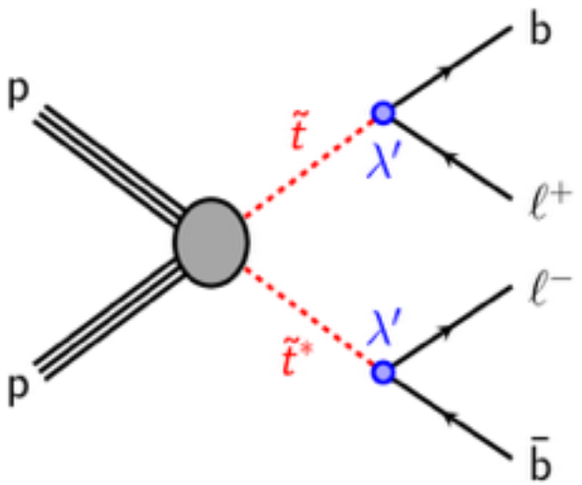
★ Final states:
- 3L + 1b
- 1L + 4b

★ Backgrounds:
- ttZ in 3L+1b
- ttbar in 1L+4b



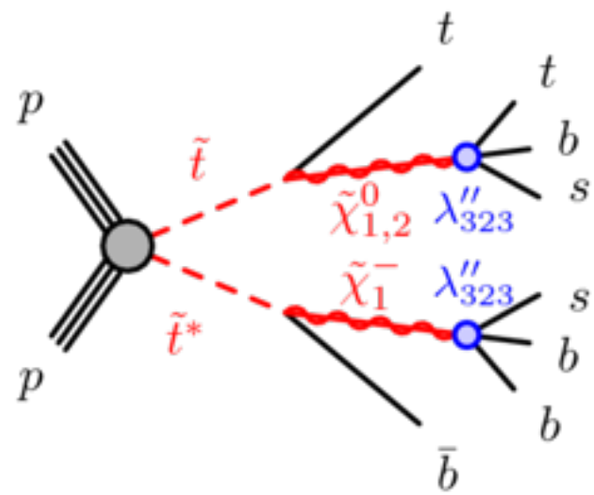
RPV third generation summary

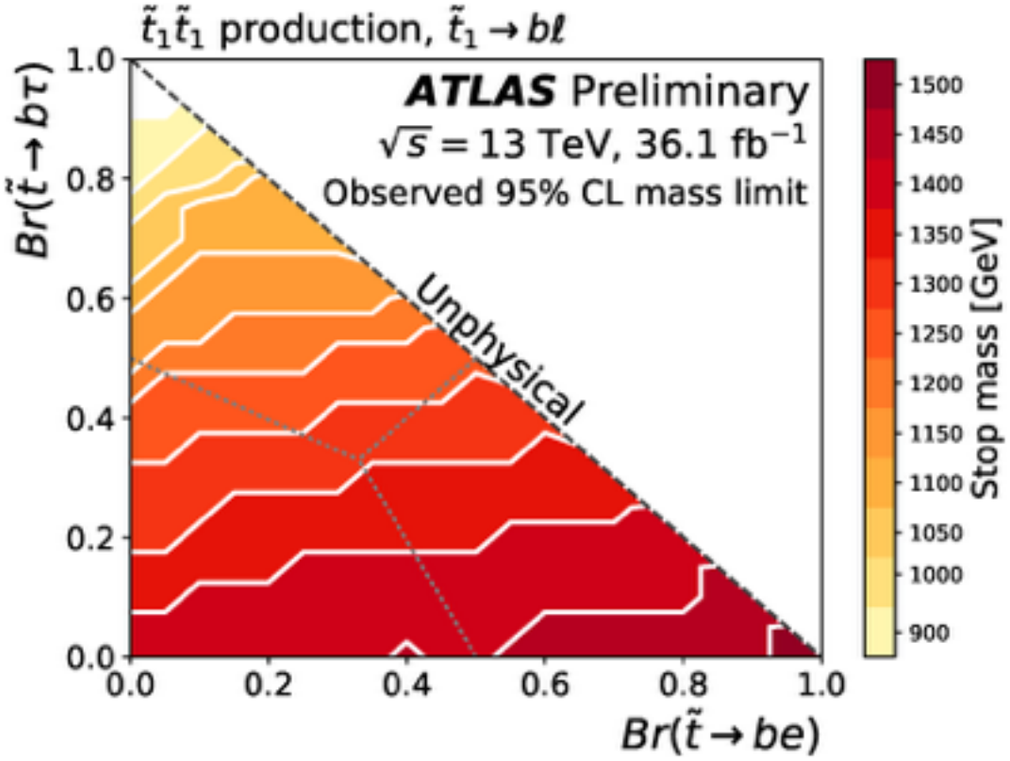
★ Multiple analyses dedicated to RPV in the 3rd generation sector:

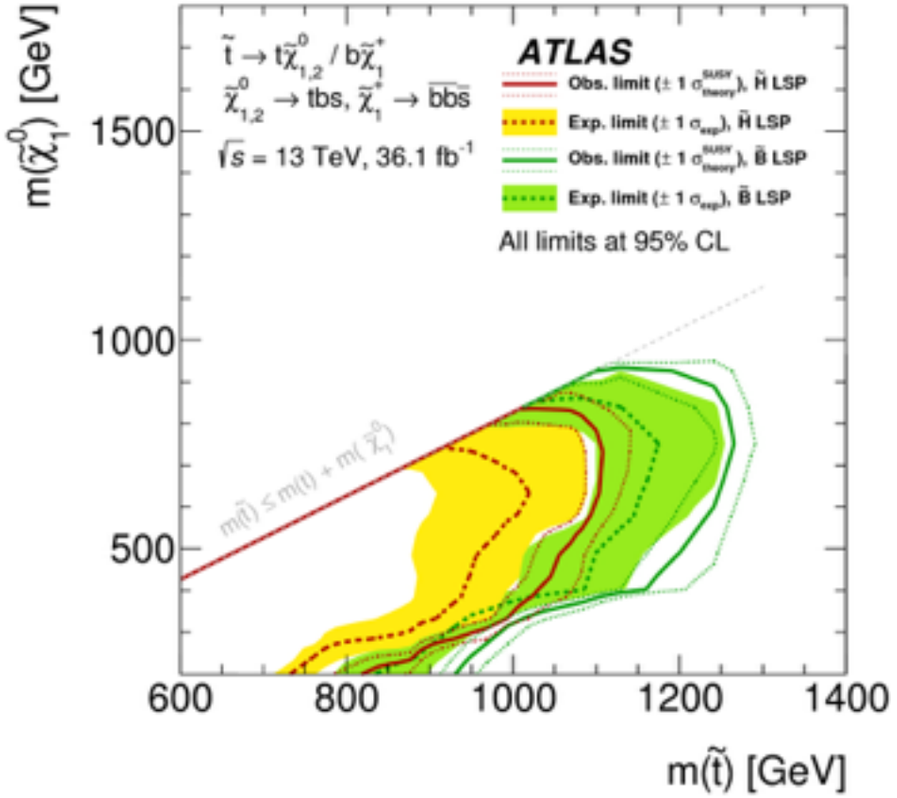


2b2l final states

1L final states



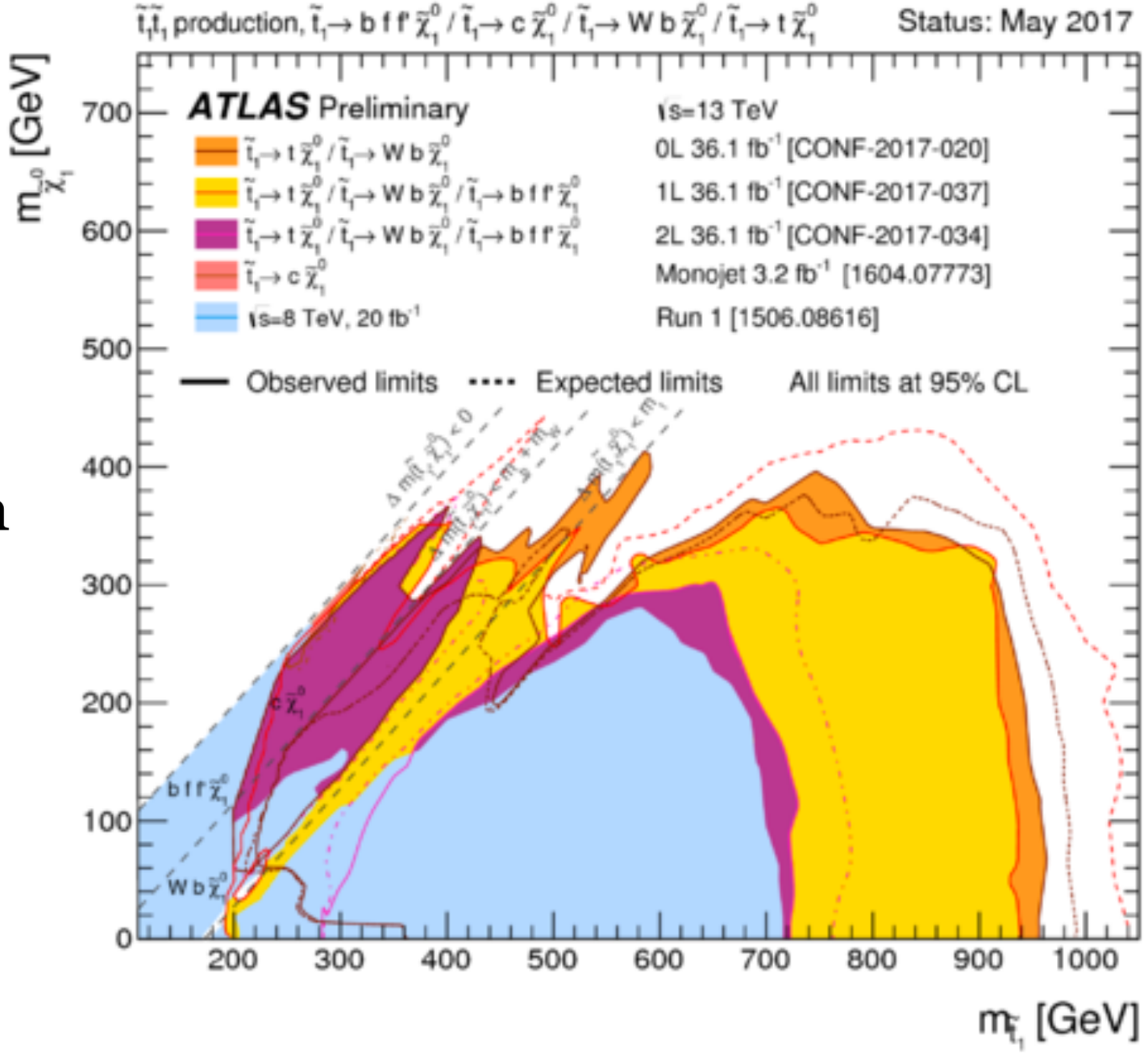




details in S. Mehlhase's talk on Friday!

Conclusions and final remarks

- ★ Many new results from ATLAS for 3rd generation squark searches based on full 2015+2016 data (36 fb-1)
- ★ No significant excess found. Limits are significantly improved with respect to previous results
- ★ Stringent limits obtained in pMSSM inspired models, yet some part of the parameter space is still uncovered.



Backup

Details of the compressed analysis (I)

tN_diag_low	Pure bino LSP ($\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(190,17)	BDT cut-and-count	7
tN_diag_med	Pure bino LSP ($\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(250,62)	BDT shape-fit	7
tN_diag_high	Pure bino LSP ($\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(450,277)	BDT shape-fit	7

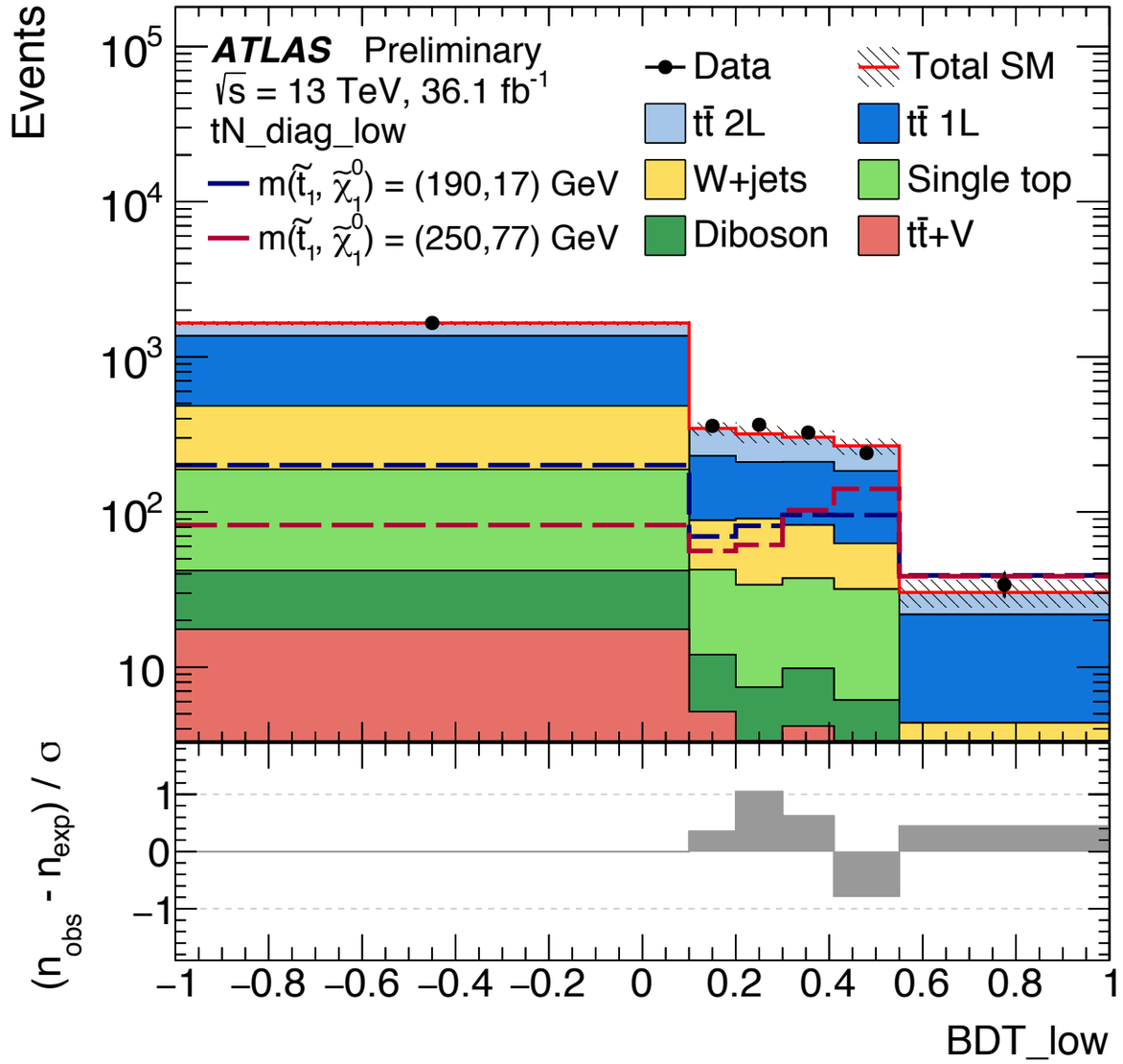
BDT inputs

$\Delta m_{\mathrm{T}}^{\alpha}$(SM, signal)

$m_{\mathrm{T}}, E_{\mathrm{T}}^{\mathrm{miss}}$

$m(t_{\mathrm{had}}^{\mathrm{ISR}})$ and $m(t_{\mathrm{lep}}^{\alpha})$

$\Delta\varphi$ tt system, lepton, $E_{\mathrm{T}}^{\mathrm{miss}}$



Details of the compressed analysis (II)

tN_diag_low	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(190,17)	BDT cut-and-count	7
tN_diag_med	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(250,62)	BDT shape-fit	7
tN_diag_high	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(450,277)	BDT shape-fit	7

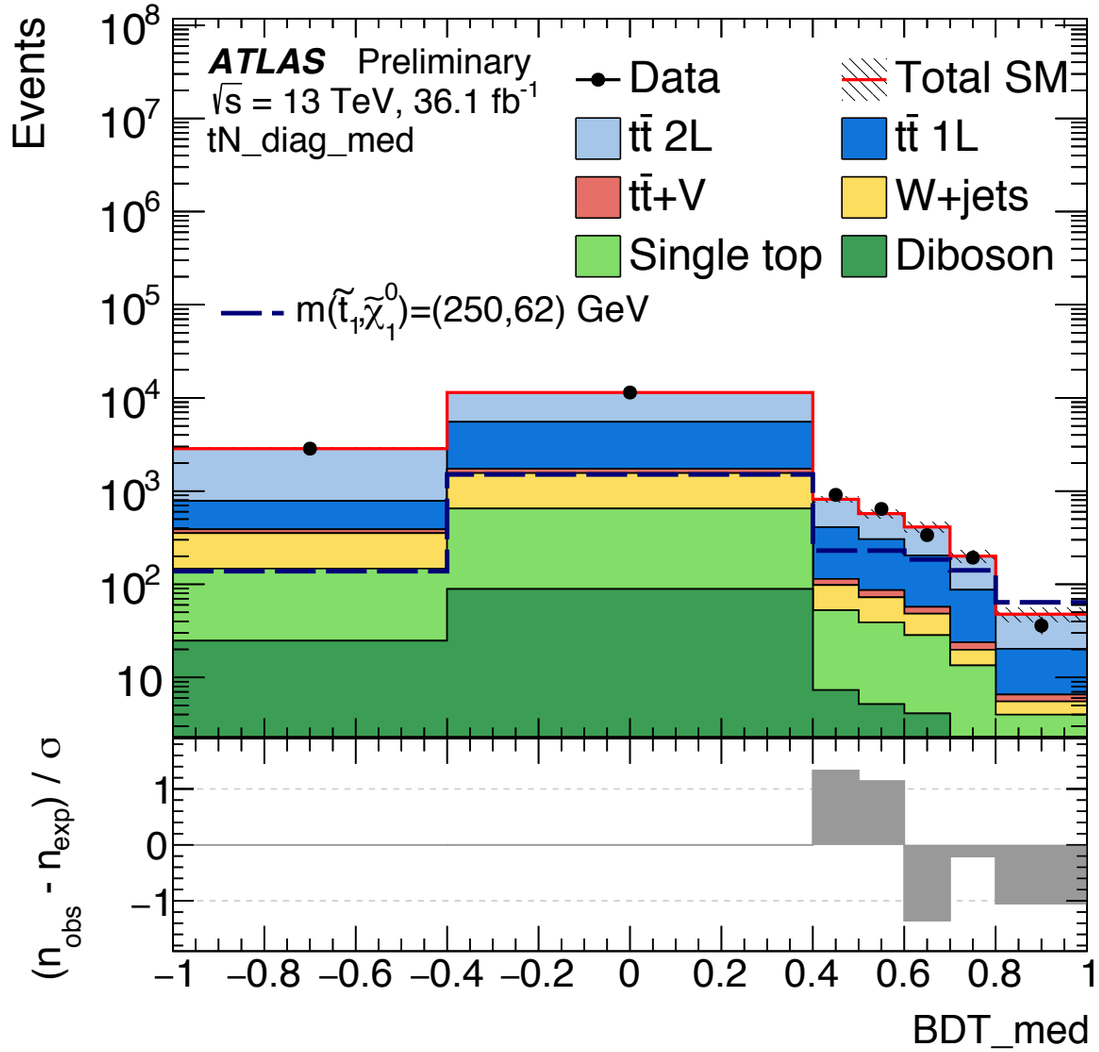
BDT inputs

m_{T}, $E_{\mathrm{T}}^{\mathrm{miss}}$ $H_{\mathrm{T}}^{\mathrm{sig}}$

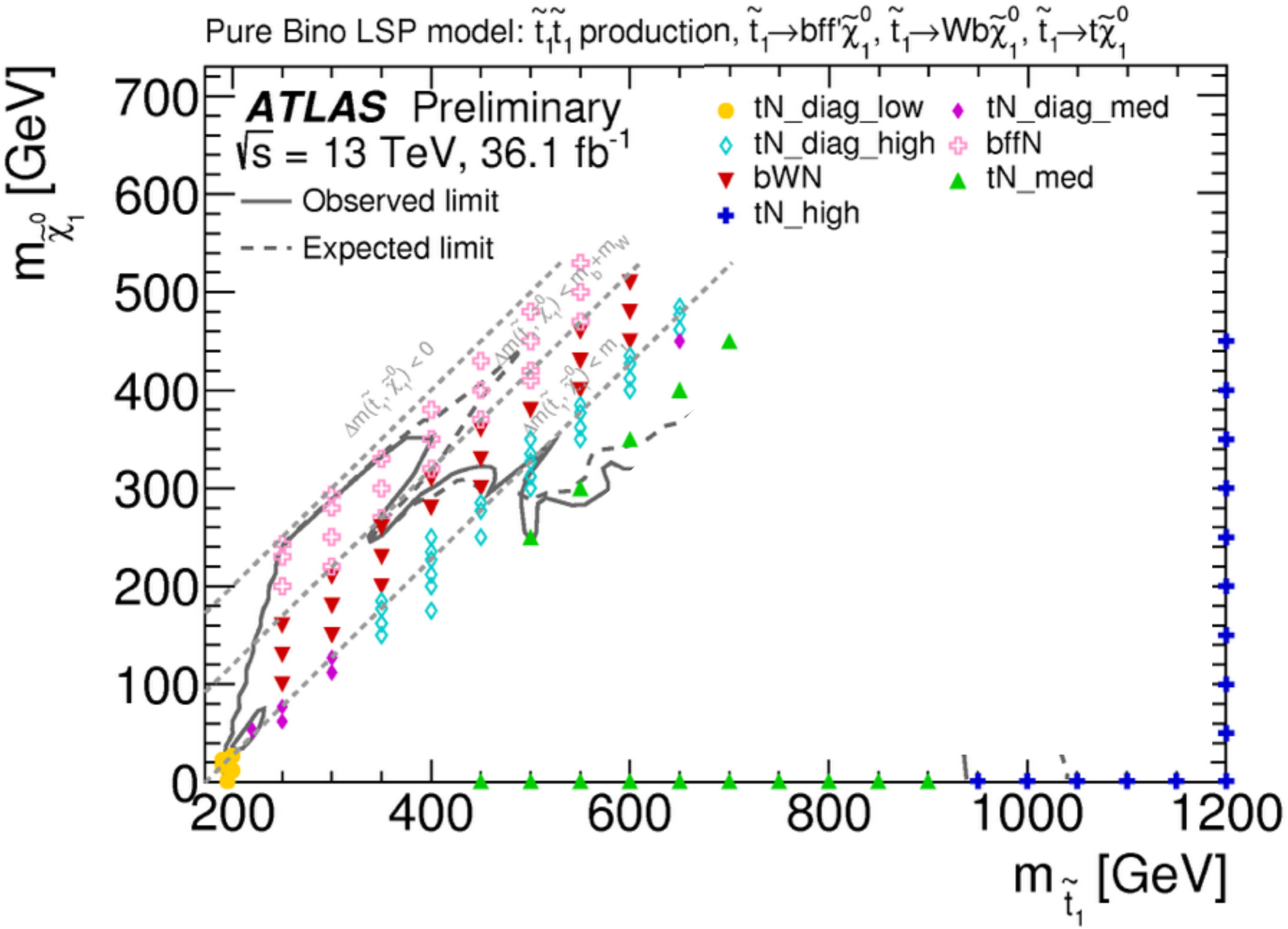
nJets, pT(j3, j4)

$\Delta R(b, \ell)$, m_{top}^{χ}

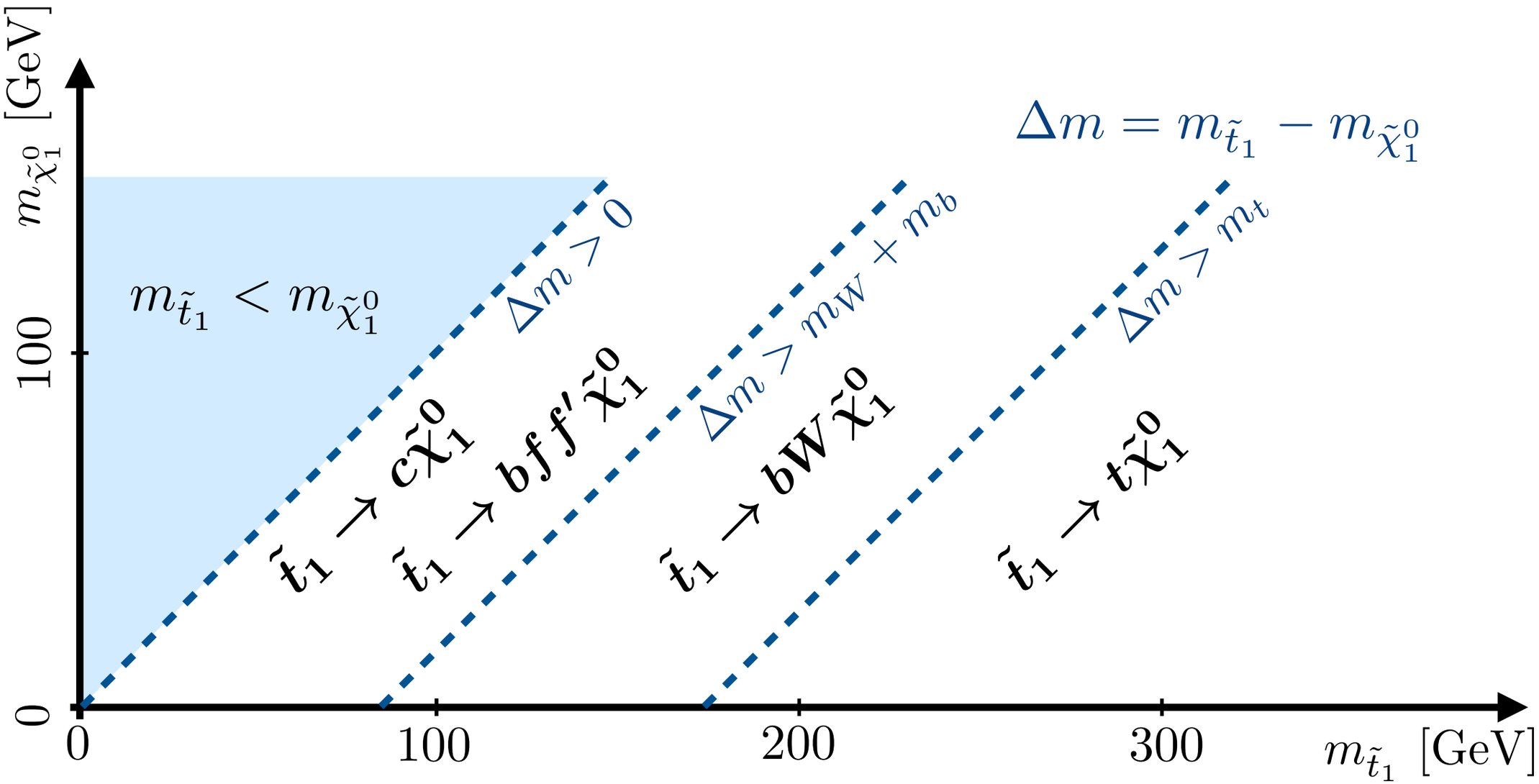
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, t_{\mathrm{had}}^{\chi})$, $\Delta\phi(t_{\mathrm{had}}^{\chi}, t_{\mathrm{lep}}^{\chi})$



Signal region distribution



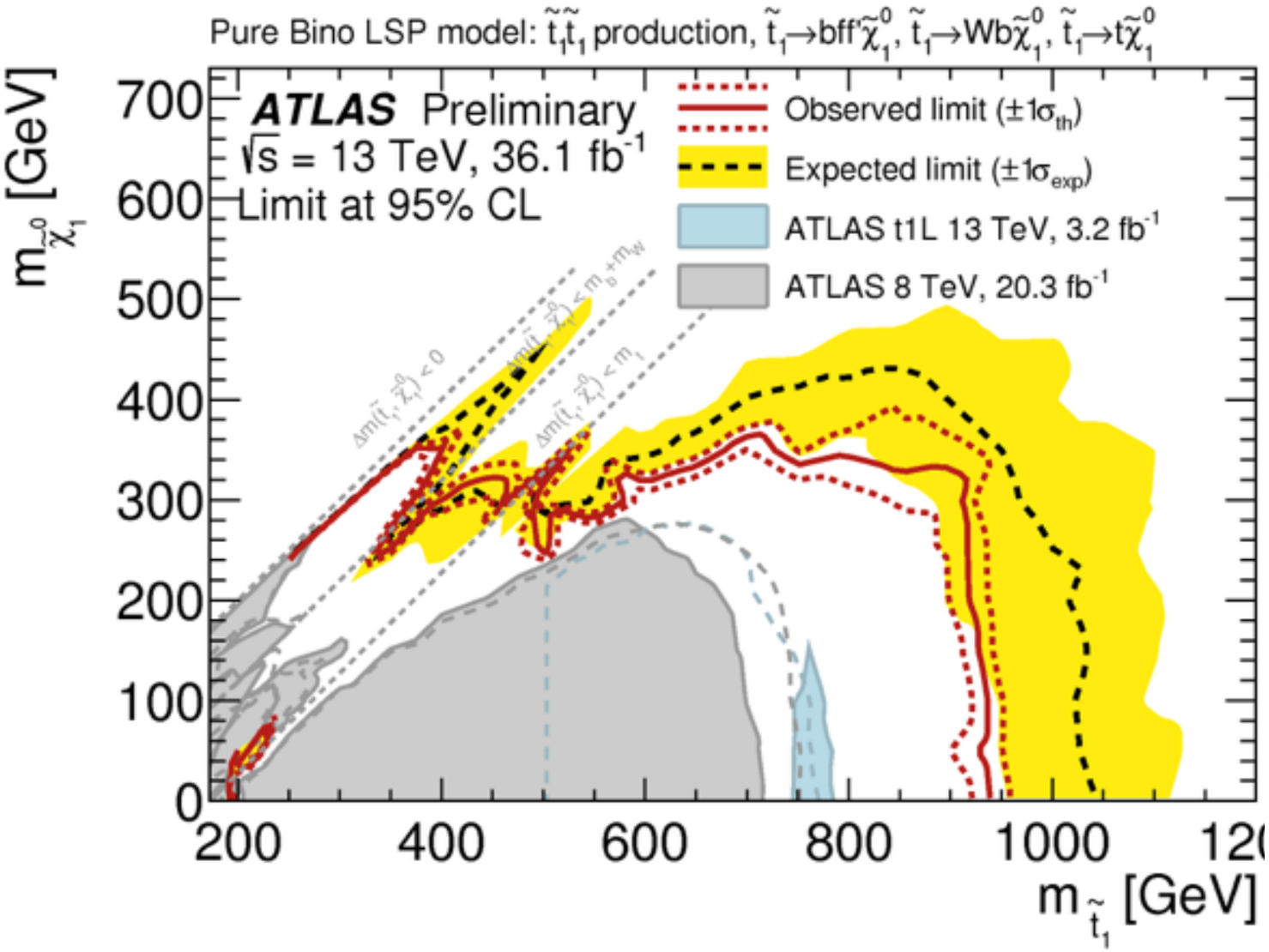
Bino LSP decays

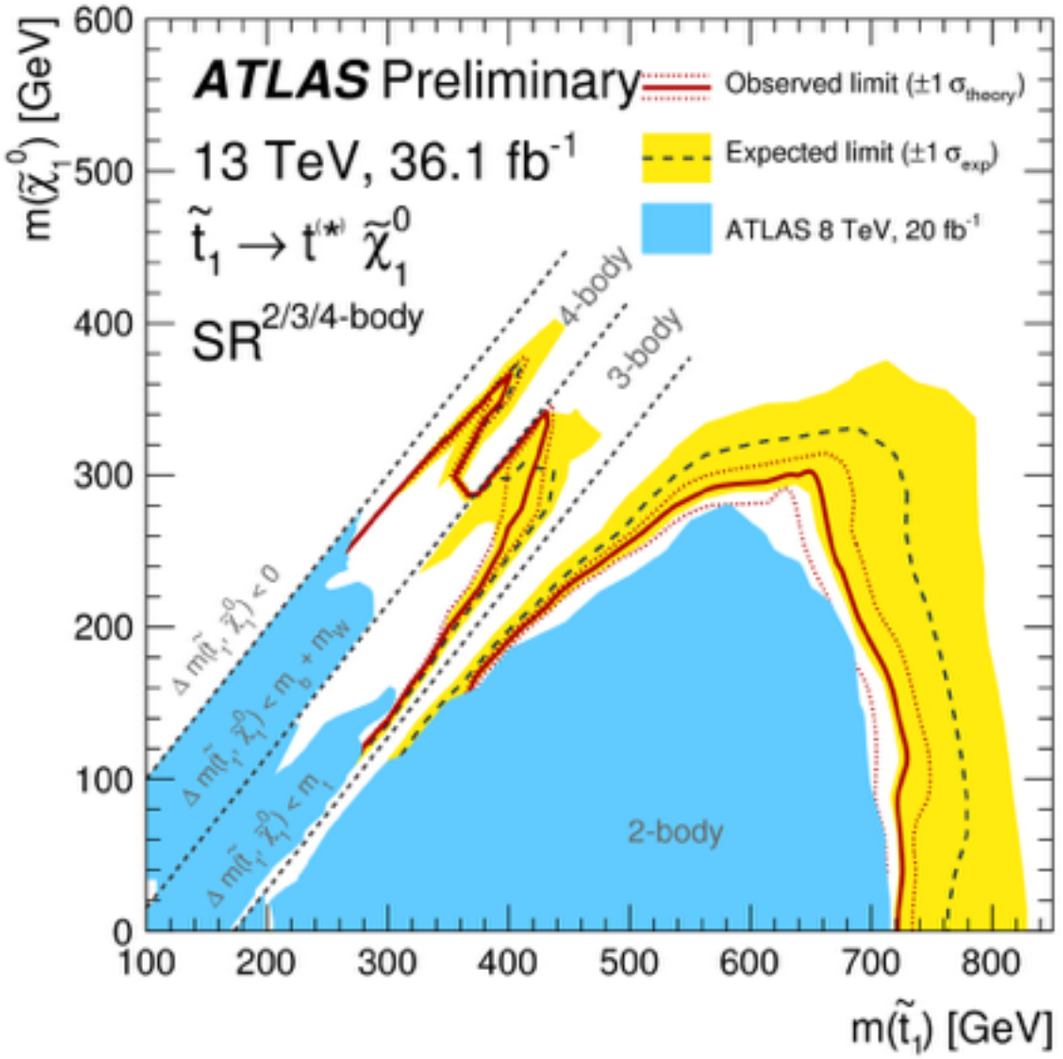


stop1L summary

SR	Signal scenario	benchmark	Exclusion technique	Table
tN_med	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(600,300)	shape-fit ($E_{\mathrm{T}}^{\mathrm{miss}}$)	6
tN_high	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(1000,1)	cut-and-count	6
tN_diag_low	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(190,17)	BDT cut-and-count	7
tN_diag_med	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(250,62)	BDT shape-fit	7
tN_diag_high	Pure bino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(450,277)	BDT shape-fit	7
bWN	Pure bino LSP ($\tilde{t}_1 \to bW\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(350,230)	shape-fit (am_{T2})	8
bffN	Pure bino LSP ($\tilde{t}_1 \to bff'\tilde{\chi}_1^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^0$)=(400,350)	shape-fit ($p_{\mathrm{T}}^{\ell}/E_{\mathrm{T}}^{\mathrm{miss}}$)	8
bC2x_med	Wino NLSP ($\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}, \tilde{t}_1 \to t\tilde{\chi}_2^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$)=(750,300,150)	cut-and-count	9
bC2x_diag	Wino NLSP ($\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}, \tilde{t}_1 \to t\tilde{\chi}_2^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$)=(650,500,250)	cut-and-count	9
bCbv	Wino NLSP ($\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}, \tilde{t}_1 \to t\tilde{\chi}_2^0$)	m($\tilde{t}_1$, $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$)=(700,690,1)	cut-and-count	9
bCsoft_diag	Higgsino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0, \tilde{t}_1 \to t\tilde{\chi}_2^0, \tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$)	m($\tilde{t}_1$, $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$)=(400,355,350)	shape-fit ($p_{\mathrm{T}}^{\ell}/E_{\mathrm{T}}^{\mathrm{miss}}$)	10
bCsoft_med	Higgsino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0, \tilde{t}_1 \to t\tilde{\chi}_2^0, \tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$)	m($\tilde{t}_1$, $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$)=(600,205,200)	shape-fit ($p_{\mathrm{T}}^{\ell}/E_{\mathrm{T}}^{\mathrm{miss}}$)	10
bCsoft_high	Higgsino LSP ($\tilde{t}_1 \to t\tilde{\chi}_1^0, \tilde{t}_1 \to t\tilde{\chi}_2^0, \tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$)	m($\tilde{t}_1$, $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$)=(800,155,150)	shape-fit ($p_{\mathrm{T}}^{\ell}/E_{\mathrm{T}}^{\mathrm{miss}}$)	10
DM_low_loose	spin-0 mediator	m(Φ/a, χ)=(20,1)	cut-and-count	11
DM_low	spin-0 mediator	m(Φ/a, χ)=(20,1)	cut-and-count	11
DM_high	spin-0 mediator	m(Φ/a, χ)=(300,1)	cut-and-count	11

Scenario a) Bino LSP





1L results scenario b)