Search for top-squark pair production in the semi-leptonic final state with the ATLAS detector

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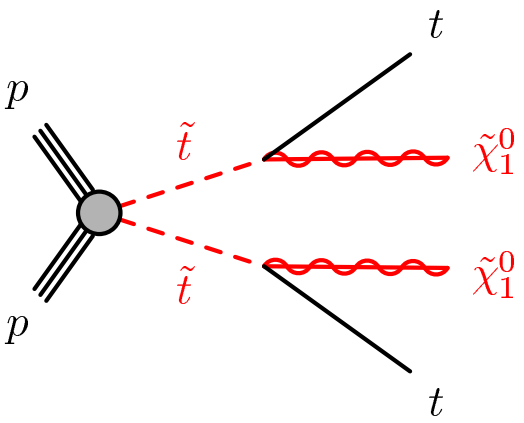
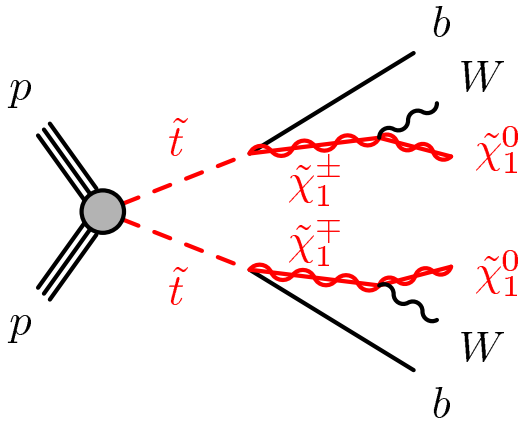
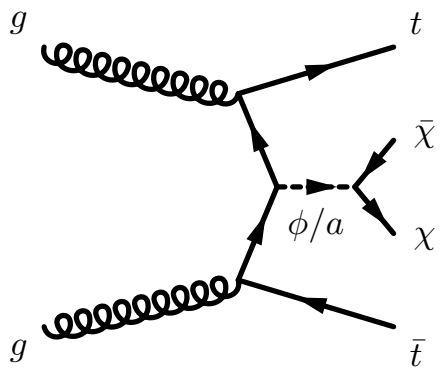
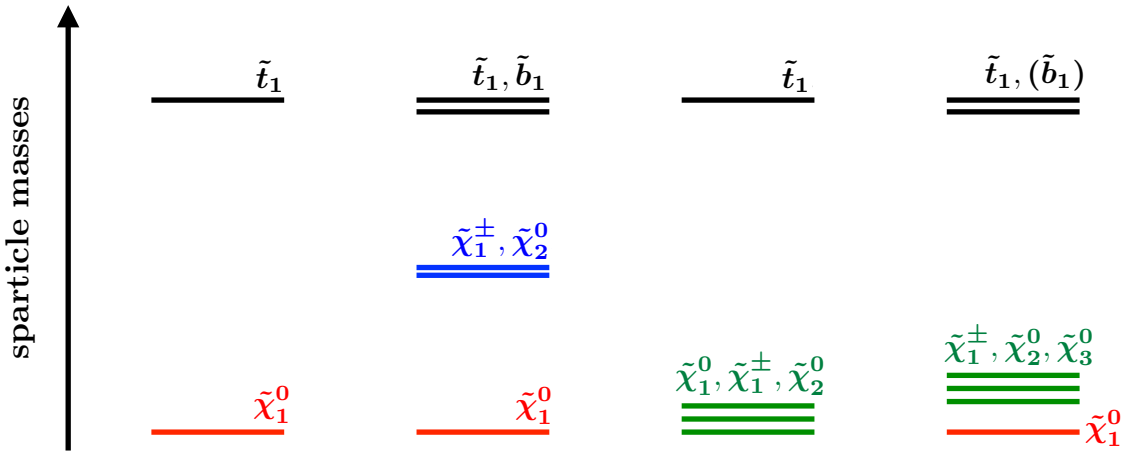
Signal Models



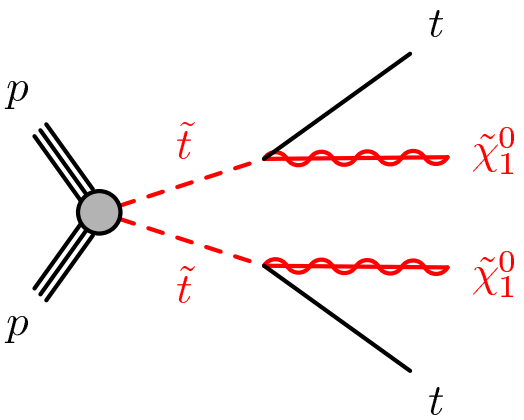


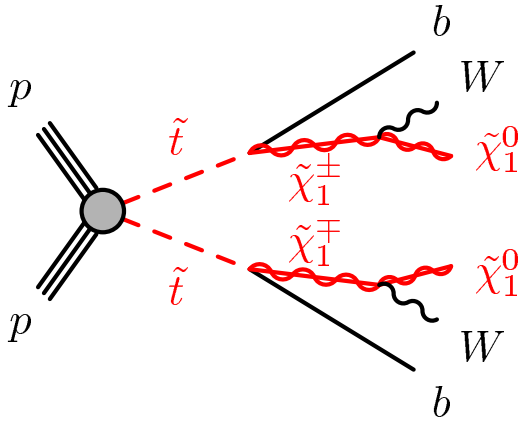


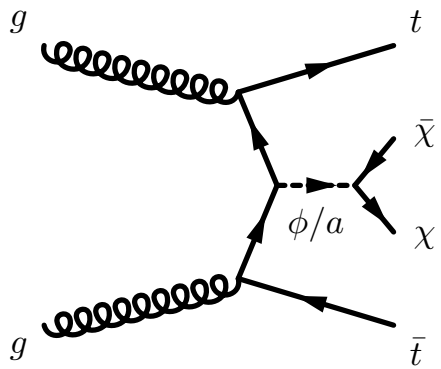


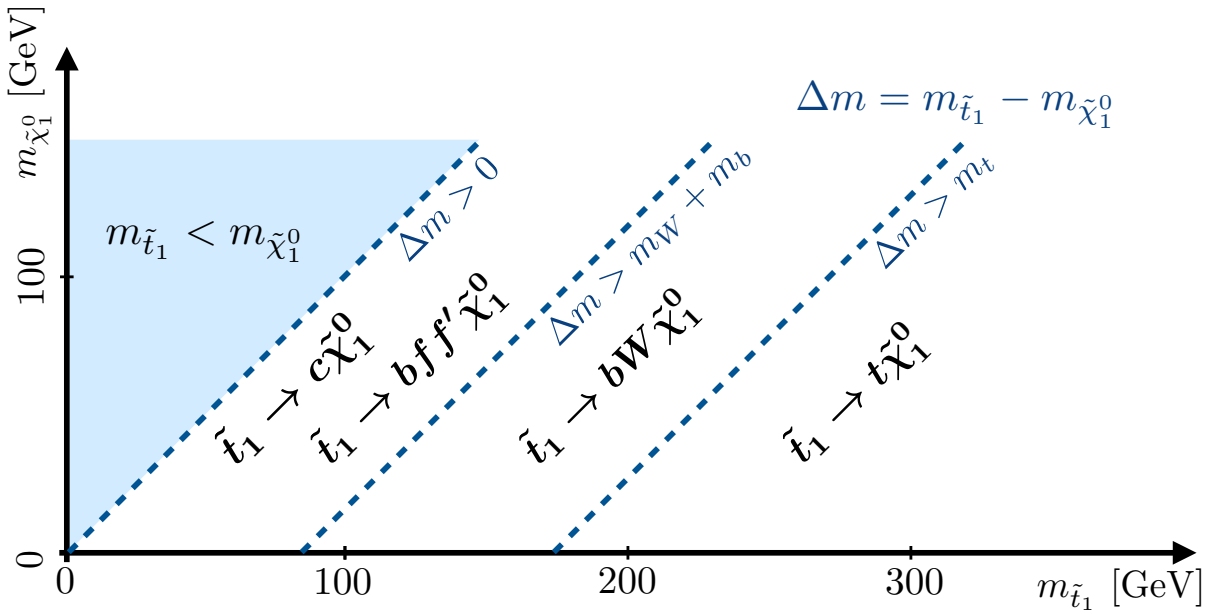
a) pure bino LSP b) wino NLSP c) higgsino LSP d) bino/higgsino mix

Signal Models

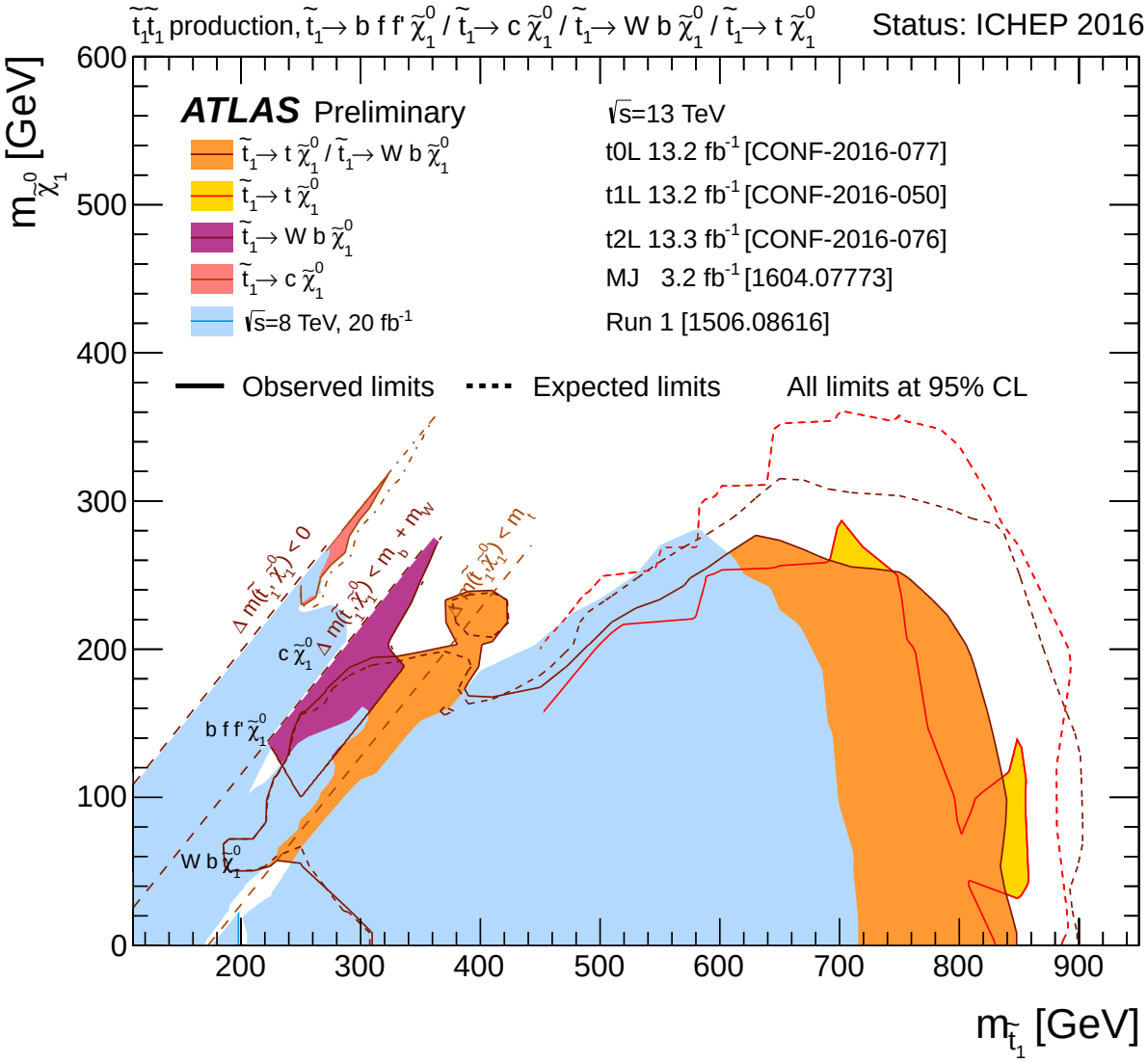




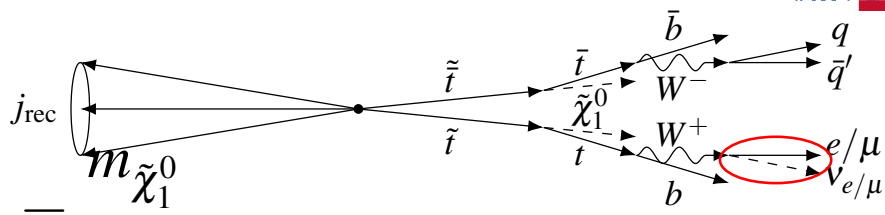




Signal Models



tN-Diagonal: Neutrino Reconstruction



$$\alpha = \frac{m_{\tilde{\chi}_1^0}}{m_{\tilde{\chi}_1^0} + m_{t_{\mathrm{had}}}} = \frac{m_{\tilde{\chi}_1^0}}{m_{\tilde{t}}}$$

$$p_{x/y}\left(\nu^{\alpha}\right) = (1-\alpha)\, E_{\mathrm{T}_{x/y}}^{\mathrm{miss}} - \alpha\left(t_{\mathrm{had}_{x/y}} + t_{\mathrm{lep}_{x,y}}^{\mathrm{vis}}\right)$$

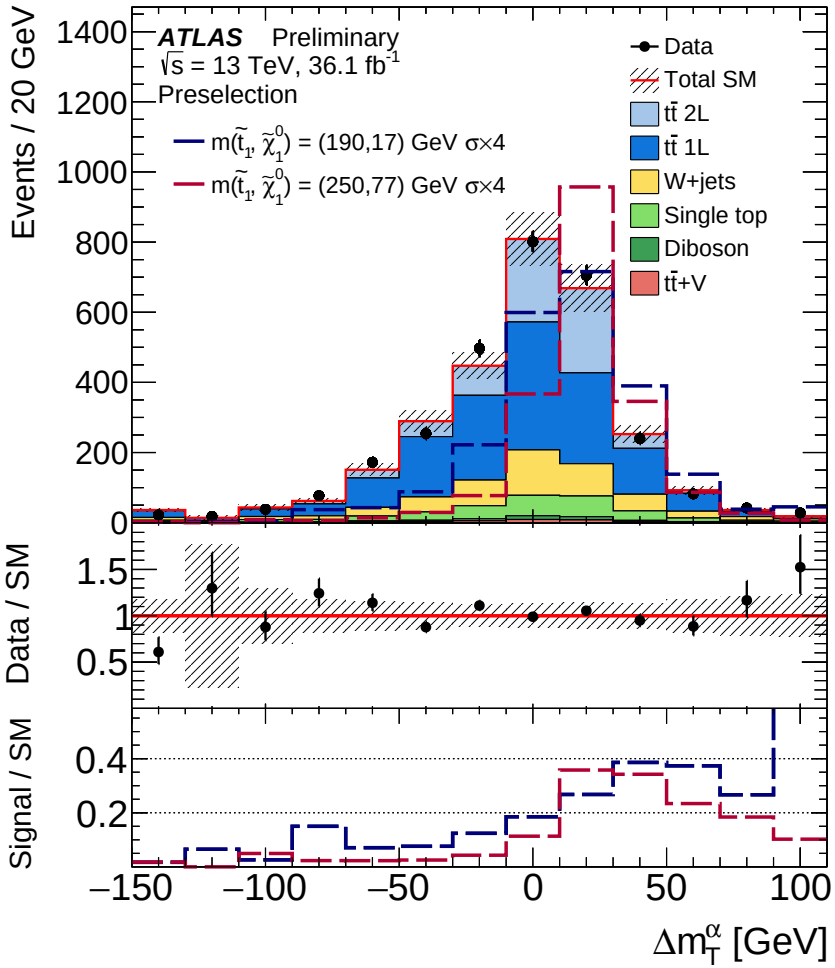
With that define following variables:

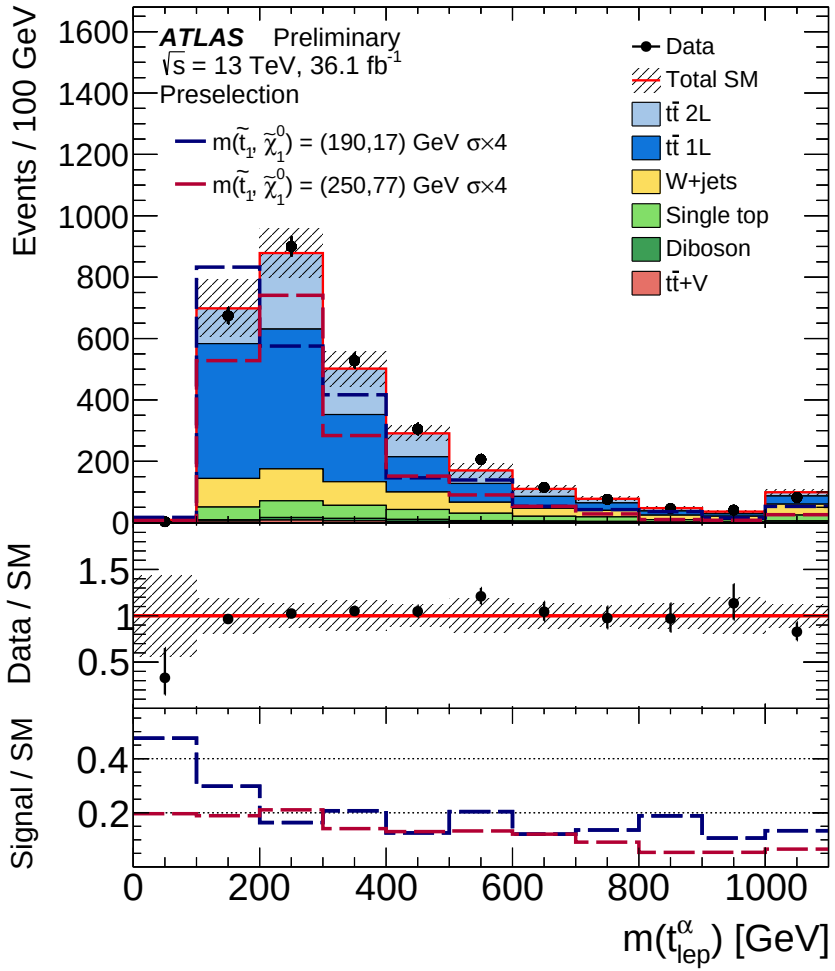
$$m_{\mathrm{T}} = \sqrt{1 - 2p_{\mathrm{T}}^{l} E_{\mathrm{T}}^{\mathrm{miss}} \cos\Delta\phi\left(l, E_{\mathrm{T}}^{\mathrm{miss}}\right)}$$

$$m_{\mathrm{T}}^{\alpha} = \sqrt{1 - 2p_{\mathrm{T}}^{l} p_{\mathrm{T}}\left(\nu^{\alpha}\right) \cos\Delta\phi\left(l, \nu^{\alpha}\right)}$$

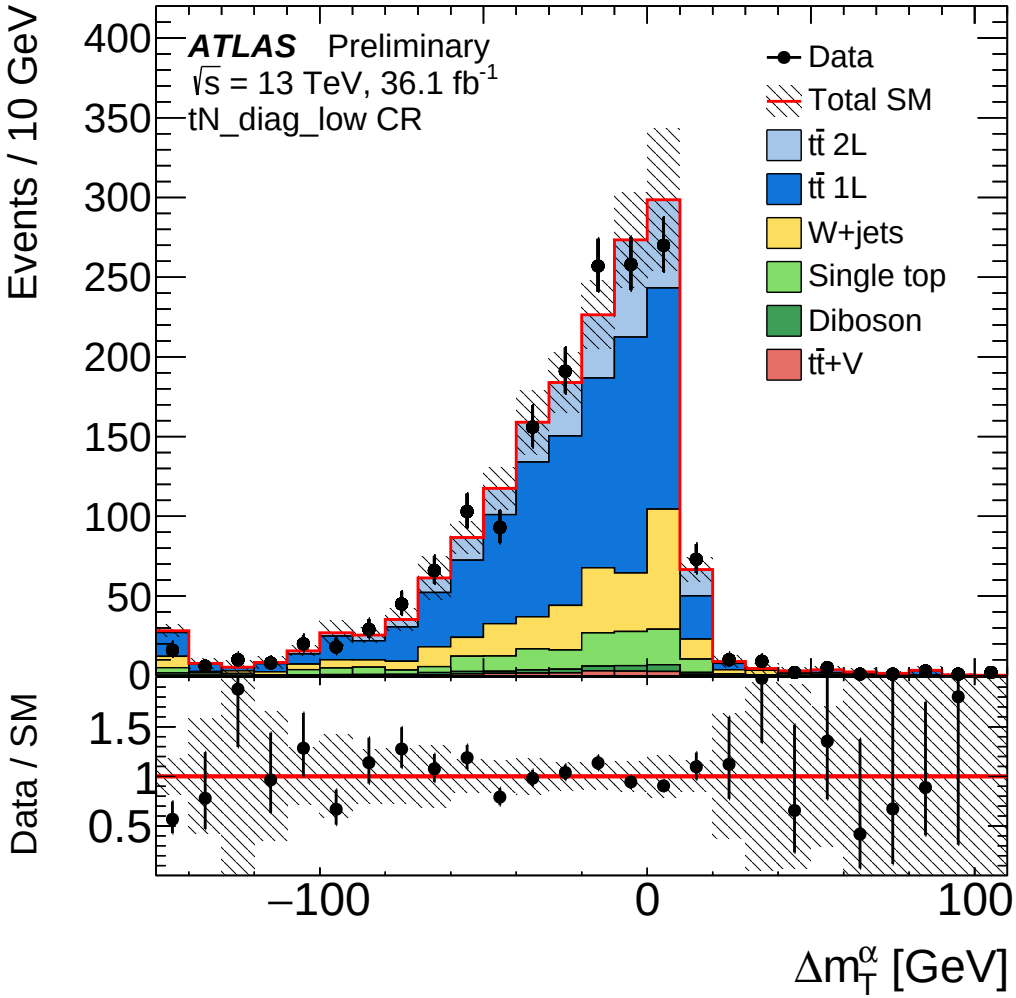
$$\Delta m_{\mathrm{T}}^{\alpha} = m_{\mathrm{T}} - m_{\mathrm{T}}^{\alpha}$$

tN-Diagonal: Neutrino Reconstruction

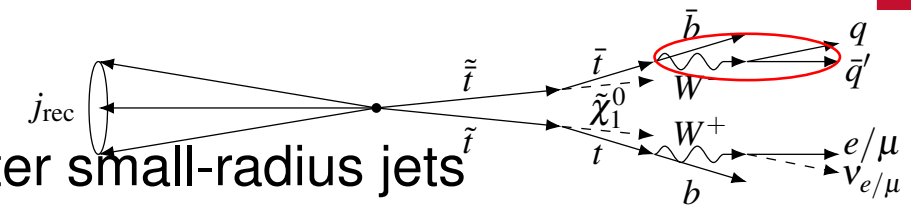




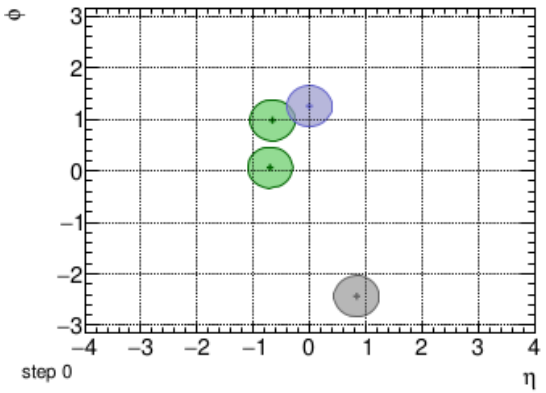
tN-Diagonal: Neutrino Reconstruction



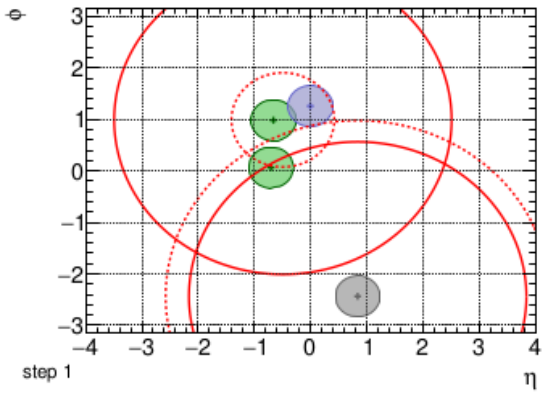
DM: Top/W Reconstruction by Reclustering



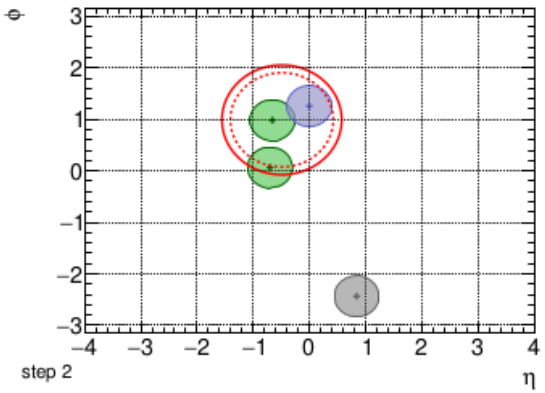
- Tops with significant boost: Recluster small-radius jets to anti-$k_{\mathrm{T}}^{3.0}$ jets
  $\rightarrow$ Advantage: Calibrated objects
- Shrink jet iteratively to 'optimal' radius $R_i = 2m/p_{\mathrm{T}}$
- Mass of reclustered jet is taken as topquark or W-boson mass



(a) All jets in the event.

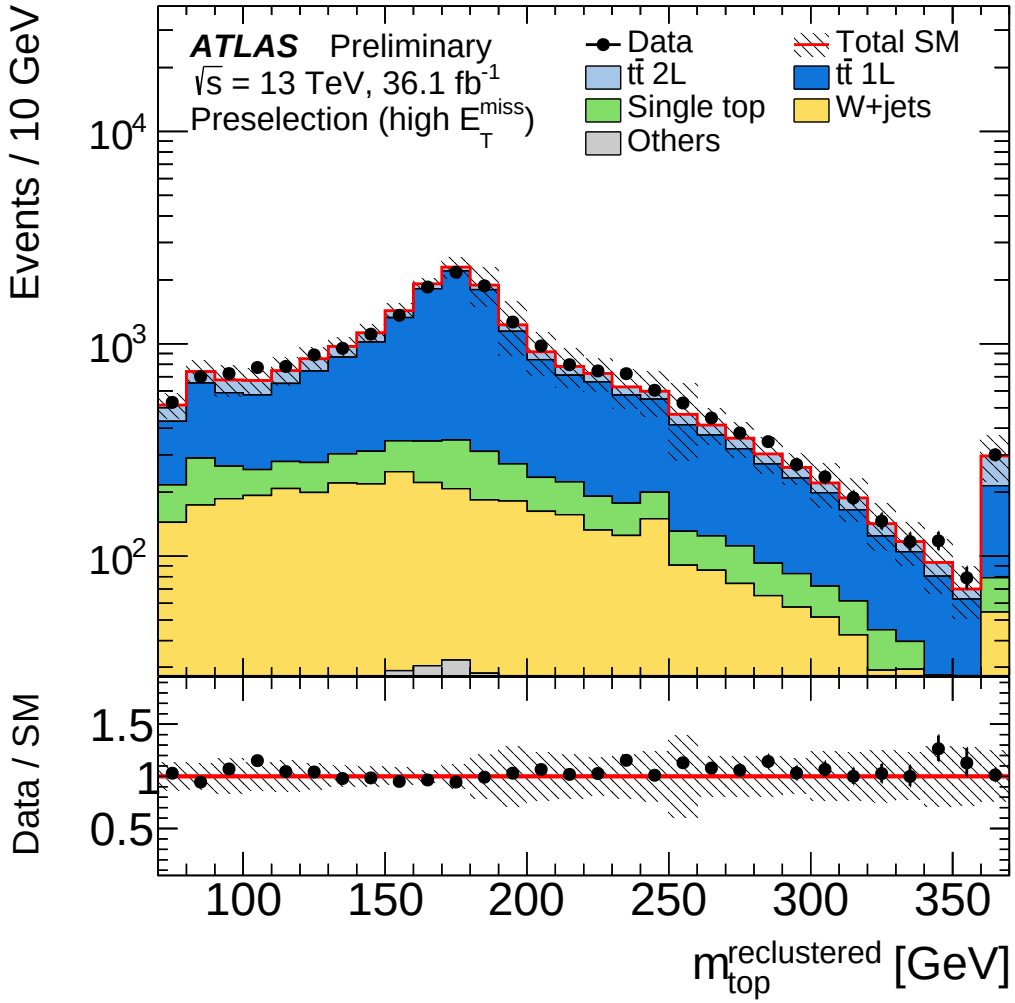


(b) Initial clustering with $R_0 = 3.0$, yielding two candidate objects.



(c) Final step of the algorithm, with one candidate shrunk to fit the p_{T} and the other one discarded.

DM: Top/*W* Reconstruction by Reclustering



Stransverse Mass

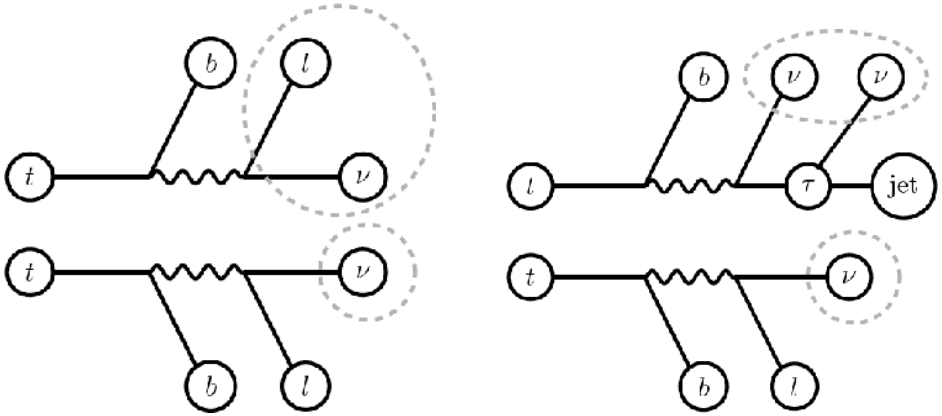
- Generalisation of m_{T}

$$m_{\mathrm{T}i}^2 = \left(\sqrt{p_{\mathrm{T}i}^2 + m_{pi}^2} + \sqrt{q_{\mathrm{T}i}^2 + m_{qi}^2} \right)^2 - \left(p_{\mathrm{T}i} + q_{\mathrm{T}i} \right)^2$$

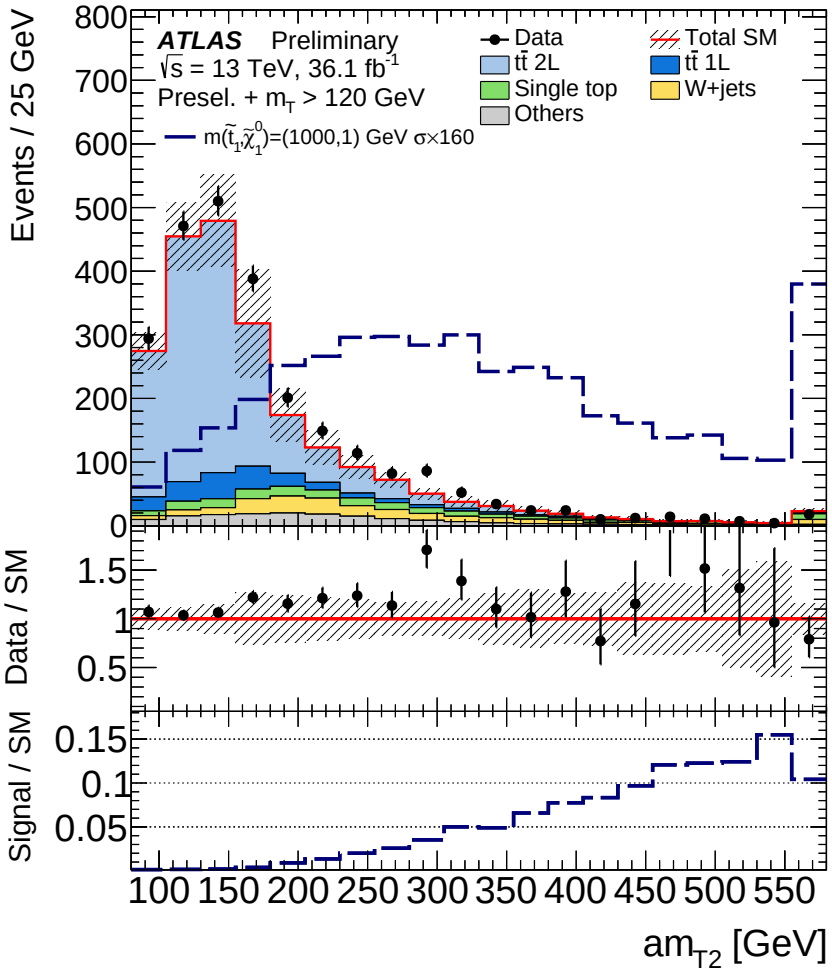
- Targets decay topologies with two branches ($i = a, b$) with each measured (p_i) and unmeasured (q_i) momenta
- Defined as

$$m_{T2} \equiv \min_{q_{\mathrm{T}a} + q_{\mathrm{T}b} = p_{\mathrm{T}}^{\mathrm{miss}}} \left(\max \left(m_{\mathrm{T}a}, m_{\mathrm{T}b} \right) \right)$$

- am_{T2} and m_{T2}^{τ}

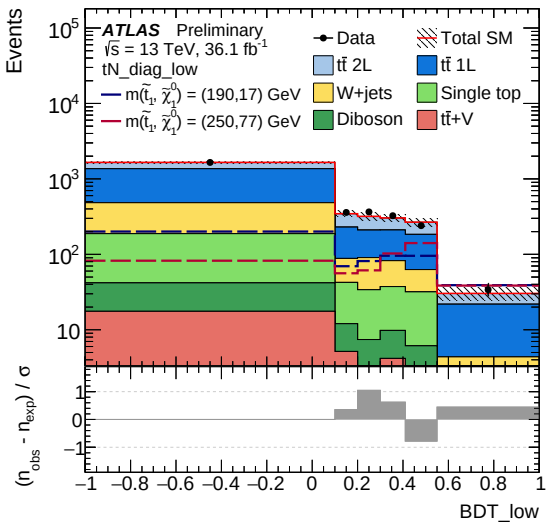


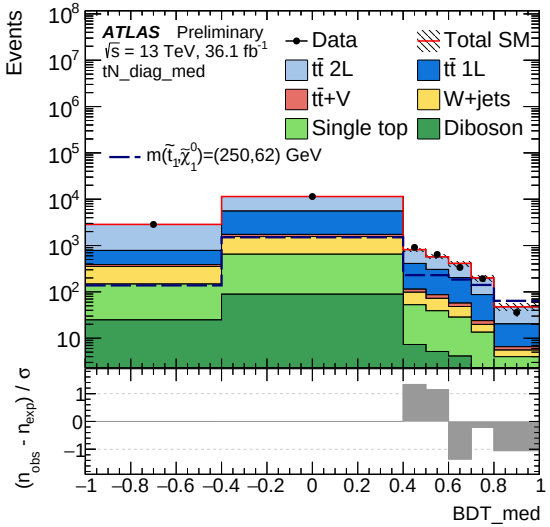
Stransverse Mass

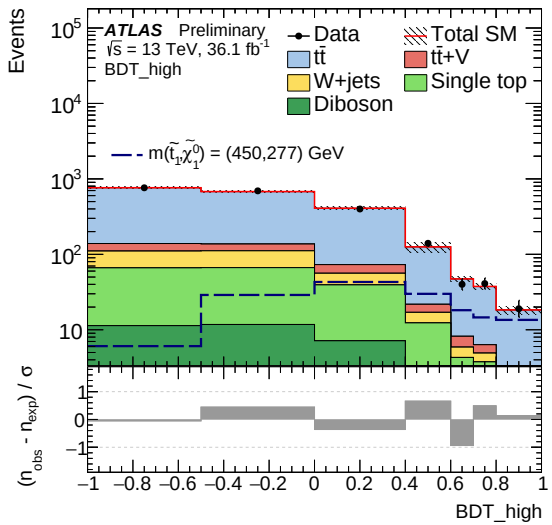


Results: *tN*-Diagonal

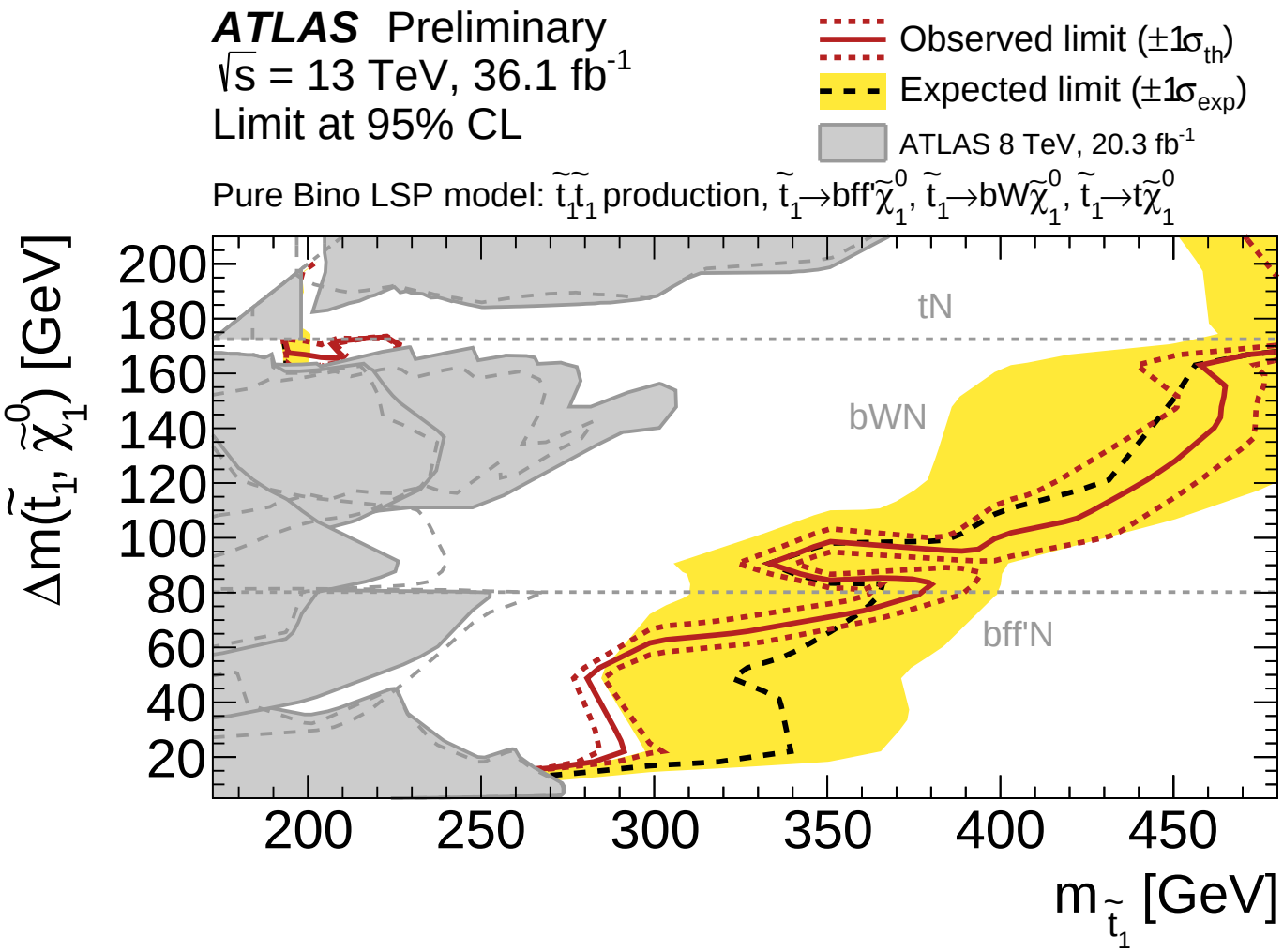
Train three different BDTs for different benchmark scenarios:



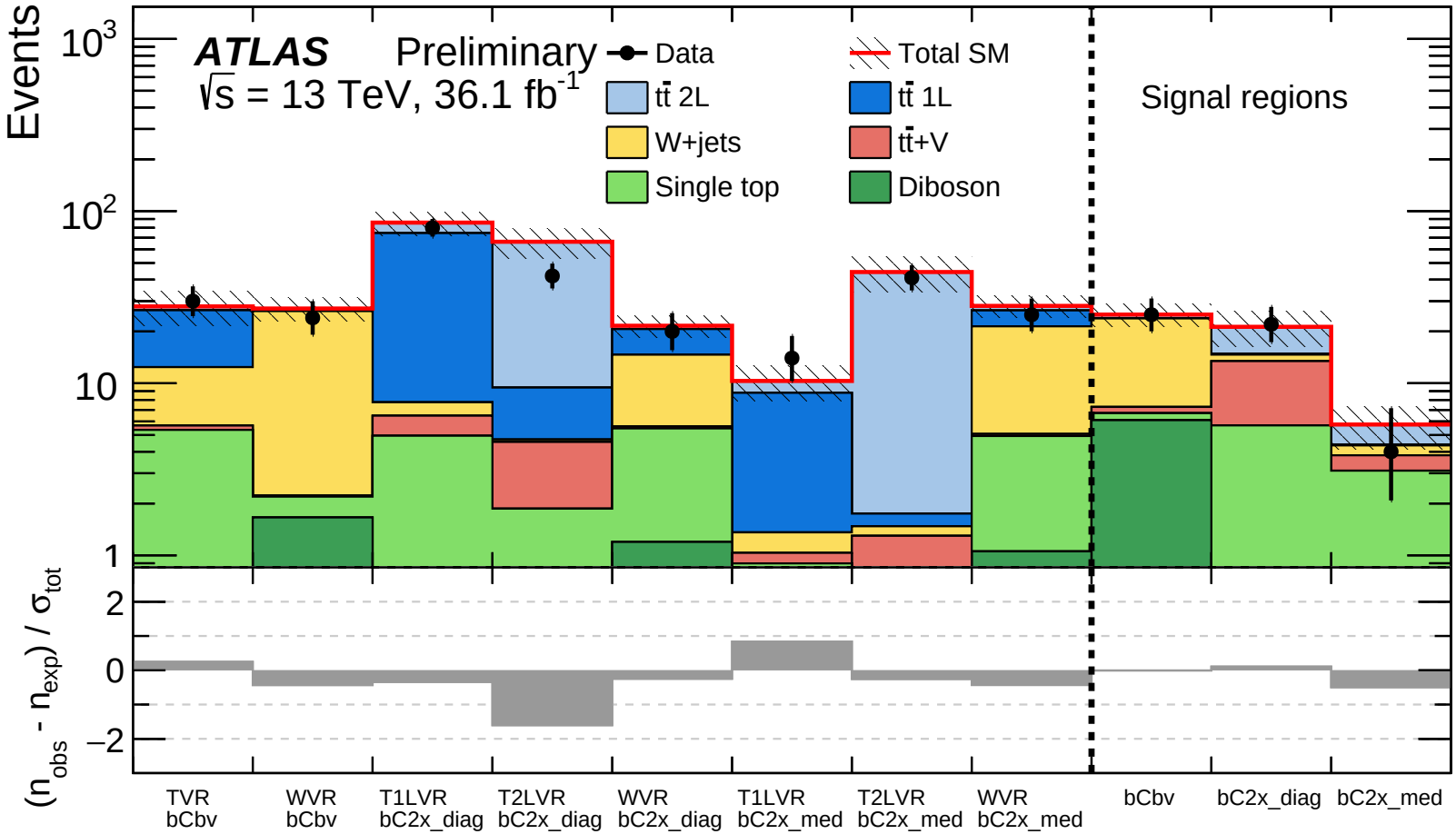




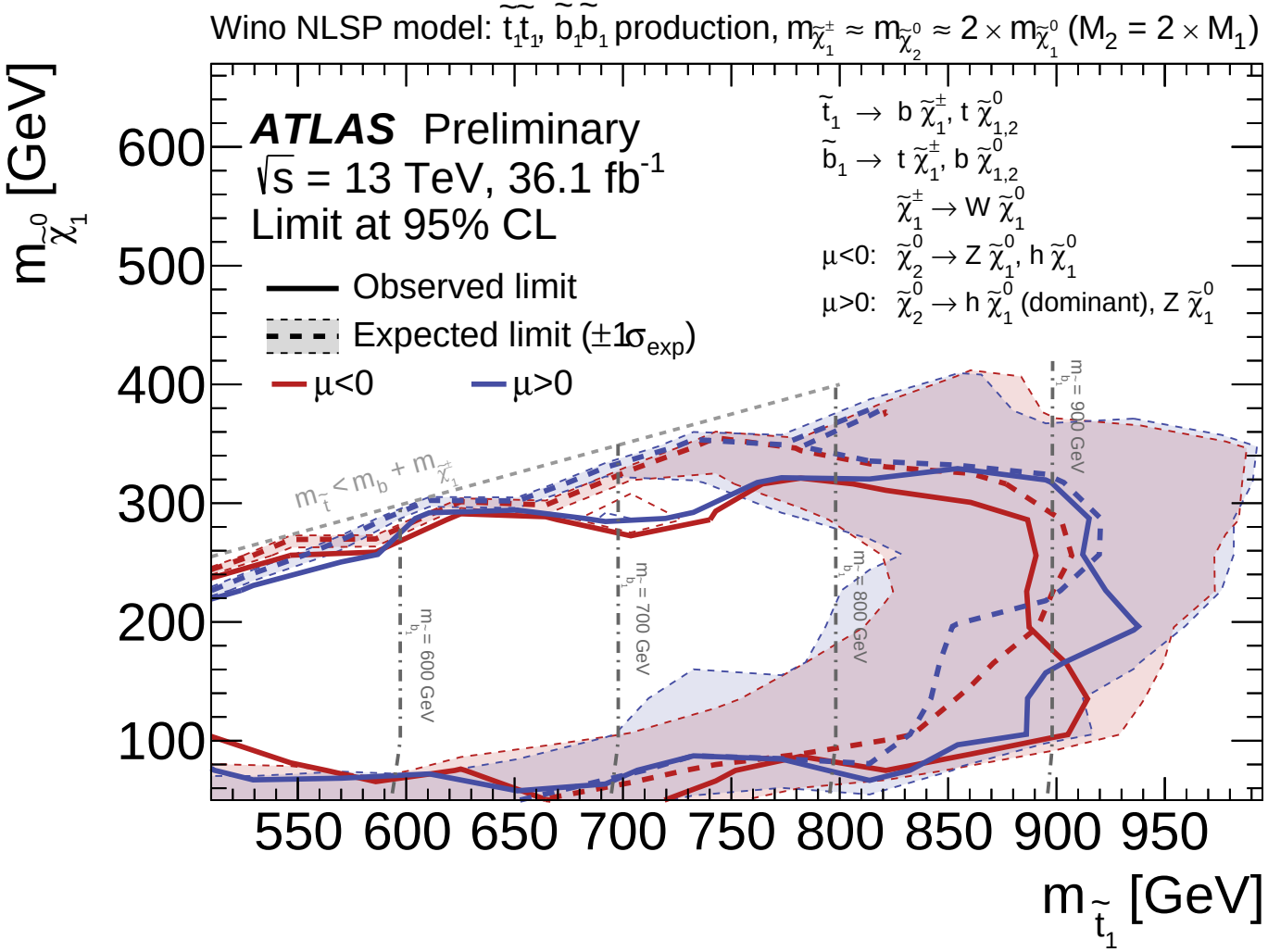
Results: *tN*-Diagonal



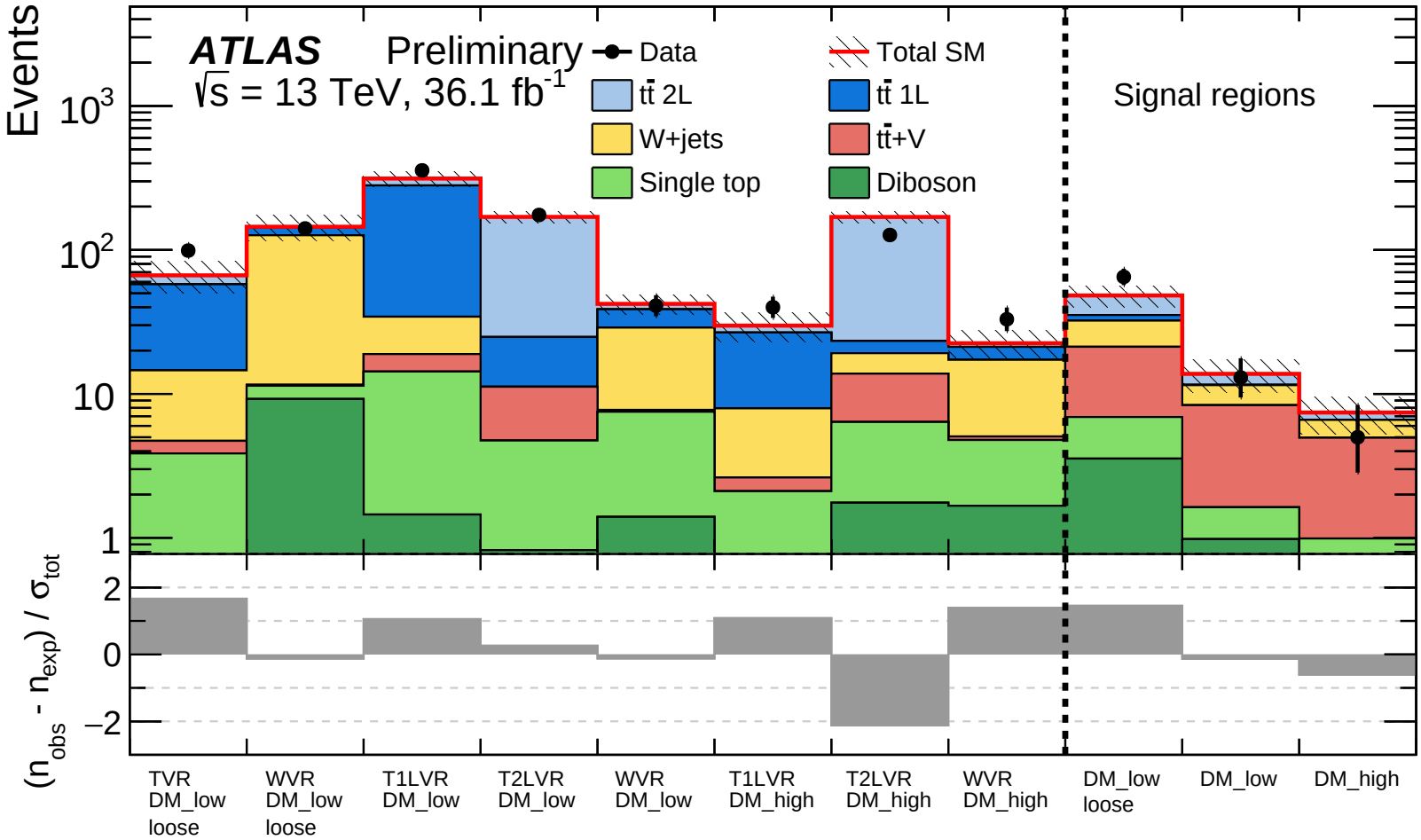
Results: Wino NLSP



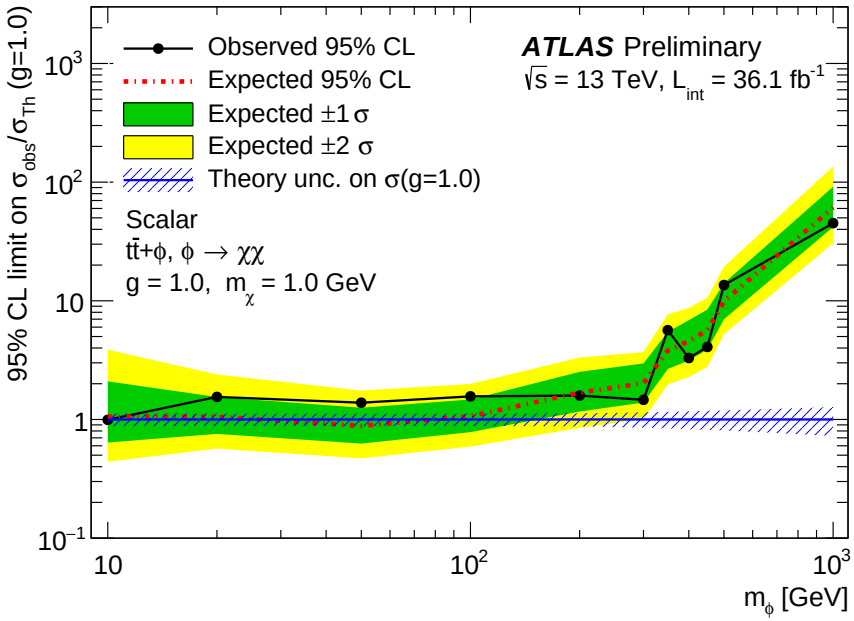
Results: Wino NLSP

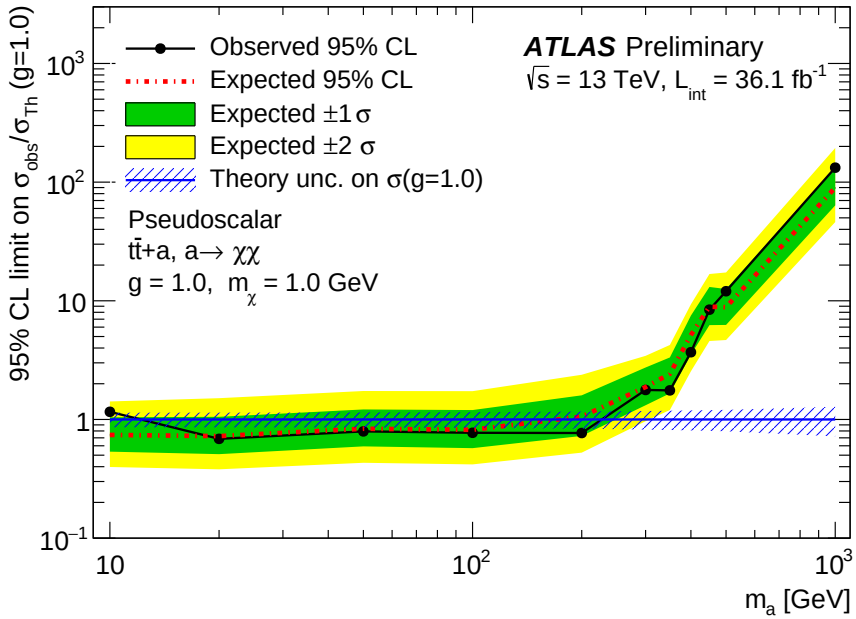


Results: Dark Matter



Results: Dark Matter





Summary

- Presented selection of discriminating variables
- No significant excess observed
- Exclusion limits for bino LSP and wino NLSP scenarios were set
- Exclusion limits on σ for (pseudo-)scalar mediator decaying into dark matter particles were set

$\rightarrow$ Publication: ATLAS-CONF-2017-037

Backup

Preselections

Selection	**high-$E_{\mathrm{T}}^{\mathrm{miss}}$**	**low-$E_{\mathrm{T}}^{\mathrm{miss}}$**	**soft-lepton**
Trigger	$E_{\mathrm{T}}^{\mathrm{miss}}$ triggers only	$E_{\mathrm{T}}^{\mathrm{miss}}$ and lepton triggers	$E_{\mathrm{T}}^{\mathrm{miss}}$ triggers only
Data quality	jet cleaning, primary vertex		
Second lepton veto	no additional baseline leptons		
Number of leptons, tightness	= 1 'loose' lepton	= 1 'tight' lepton	= 1 'tight' lepton
Lepton p_{T} [GeV]	≥ 25	≥ 27	≥ 4
Number of (jets, b-tags)	$(\geq 2, \geq 0)$	$(\geq 4, \geq 1)$	$(\geq 2, \geq 1)$
Jet p_{T} [GeV]	$> (25,\ 25)$	$> (50,\ 25,\ 25,\ 25)$	$> (25,\ 25)$
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 230	> 100	> 230
m_{T} [GeV]	> 30	> 90	–

tN-Diagonal Selections

Variable	tN_diag_low	tN_diag_med	tN_diag_high
Preselection	low-$E_{\mathrm{T}}^{\mathrm{miss}}$	low-$E_{\mathrm{T}}^{\mathrm{miss}}$	high-$E_{\mathrm{T}}^{\mathrm{miss}}$
Number of (jets, b-tags)	$(\geq 4, \geq 1)$	$(\geq 4, \geq 1)$	$(\geq 5, \geq 1)$
Jet p_{T} [GeV]	$> (120,\ 25,\ 25,\ 25)$	$> (100,\ 50,\ 25,\ 25)$	$> (25,\ 25,\ 25,\ 25,\ 25)$
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 100	> 120	> 230
m_{T} [GeV]	> 90	> 120	> 120
R_{ISR}	–	–	¿ 0.4
$p_{\mathrm{T}}(t\bar{t})$ [GeV]	> 400	–	–
$\lvert\Delta\phi(l, t\bar{t})\rvert$	> 1.0	–	–
$\lvert\Delta\phi(j_{1,2}, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert$	> 0.4	> 0.4	–
m_{T2}^{τ} based τ-veto [GeV]	–	> 80	–
BDT score	BDT_low ≥ 0.55	BDT_med ≥ 0.4	BDT_high≥ 0.6
Exclusion technique	cut-and-count	shape-fit in BDT score	shape-fit in BDT score
Bin boundaries	–	$[0.4, 0.5, 0.6, 0.7, 0.8, 1.0]$	$[0.6, 0.7, 0.8, 1.0]$

Wino NLSP Selections

Signal region	bC2x_diag	bC2x_med	bCbv
Preselection		high-$E_{\mathrm{T}}^{\mathrm{miss}}$ preselection	
Number of (jets, b-tags)	$(\geq 4, \geq 2)$	$(\geq 4, \geq 2)$	$(\geq 2, = 0)$
Jet p_{T} [GeV]	$> (75,\ 75,\ 75,\ 30)$	$> (200,\ 140,\ 25,\ 25)$	$> (120,\ 80)$
b-tagged jet p_{T} [GeV]	$> (30,\ 30)$	$> (140,\ 140)$	–
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 230	> 230	> 360
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 13	> 10	> 16
m_{T} [GeV]	> 180	> 120	> 200
am_{T2} [GeV]	> 175	> 300	–
$\lvert\Delta\phi(\mathrm{jet}_i, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert (i = 1)$	> 0.7	> 0.9	> 2.0
$\lvert\Delta\phi(\mathrm{jet}_i, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert (i = 2)$	> 0.7	> 0.9	> 0.8
$m_W^{\mathrm{reclustered}}$ [GeV]	> 50	> 50	$[70, 100]$
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, \ell)$	–	–	> 1.2
$\lvert\Delta\phi(j_{1,2}, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert$		> 0.4	
m_{T2}^{τ} based τ-veto [GeV]	> 80	> 80	–
exclusion technique	cut-and-count	cut-and-count	cut-and-count

DM Selections

Signal region	DM_low_loose	DM_low	DM_high
Preselection		high-$E_{\mathrm{T}}^{\mathrm{miss}}$ preselection	
Number of (jets, b-tags)	$(\geq 4, \geq 1)$	$(\geq 4, \geq 1)$	$(\geq 4, \geq 1)$
Jet p_{T} [GeV]	$> (60,\ 60,\ 40,\ 25)$	$> (120,\ 85,\ 65,\ 25)$	$> (125,\ 75,\ 65,\ 25)$
b-tagged jet p_{T} [GeV]	–	> 60	–
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 300	> 320	> 380
m_{T} [GeV]	> 120	> 170	> 225
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 14	> 14	–
am_{T2} [GeV]	> 140	> 160	> 190
$m_{\mathrm{top}}^{\mathrm{reclustered}}$ [GeV]	–	> 130	> 130
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, \ell)$	> 0.8	> 1.2	> 1.2
$\lvert\Delta\phi(\mathrm{jet}_i, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert$	> 1.4	> 1.0	> 1.0
$\lvert\Delta\phi(j_{1,2}, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert$		> 0.4	
m_{T2}^{τ} based τ-veto [GeV]		> 80	
exclusion technique	cut-and-count	cut-and-count	cut-and-count

Results

Signal region	tN_high	tN_med	tN_diag_high	tN_diag_med	tN_diag_low	bWN	bffN
Observed	8	50	6	115	34	68	70
Total background	3.8 ± 1.0	36.3 ± 6.6	7.4 ± 1.6	115 ± 31	30.3 ± 5.9	71 ± 16	60.5 ± 6.1
$t\bar{t}$ 2ℓ	0.51 ± 0.18	12.1 ± 2.9	6.51 ± 0.87	65.1 ± 9.4	8.5 ± 2.3	65 ± 16	25.5 ± 5.5
$t\bar{t}$ 1ℓ	0.020 ± 0.001	0.19 ± 0.05	-	35.0 ± 8.9	17.5 ± 4.1	-	-
$t\bar{t} + W/Z$	1.86 ± 0.90	14.2 ± 5.5	0.23 ± 0.08	2.5 ± 1.6	0.34 ± 0.20	1.7 ± 1.7	0.35 ± 0.06
Single top	0.13 ± 0.10	3.5 ± 1.2	0.54 ± 0.21	8.1 ± 1.1	2.3 ± 1.2	$1.9^{+2.0}_{-1.9}$	10.3 ± 4.4
W+jets	0.88 ± 0.24	4.3 ± 1.1	0.09 ± 0.08	3.8 ± 1.9	$1.7^{+2.0}_{-1.7}$	1.41 ± 0.88	19.6 ± 4.9
Diboson	0.42 ± 0.16	2.08 ± 0.70	0.07 ± 0.02	$0.69^{+0.73}_{-0.69}$	$0.07^{+0.24}_{-0.07}$	0.89 ± 0.28	2.72 ± 0.99
Z+jets	-	-	-	-	-	-	1.9 ± 1.8
$t\bar{t}$ 2ℓ NF	1.01 ± 0.15	0.96 ± 0.13	1.05 ± 0.06	1.16 ± 0.16	0.85 ± 0.10	1.04 ± 0.07	-
$t\bar{t}$ 1ℓ NF	0.97 ± 0.08	1.05 ± 0.09	-	1.16 ± 0.28	0.85 ± 0.10	1.04 ± 0.07	0.73 ± 0.11
$t\bar{t} + W/Z$ NF	1.11 ± 0.35	1.13 ± 0.32	-	-	-	-	-
Single top NF	0.64 ± 0.37	1.19 ± 0.37	-	-	-	-	-
W+jets NF	0.82 ± 0.17	0.85 ± 0.18	-	-	-	-	1.19 ± 0.26
p_0 (σ)	0.05 (1.6)	0.07 (1.4)	0.5 (0)	0.5 (0)	0.33 (0.46)	0.5 (0)	0.17 (0.95)
$N^{\text{limit}}_{\text{non-SM}}$ exp.	5.8	19	6.1	58	19	33	21
$N^{\text{limit}}_{\text{non-SM}}$ obs.	10	31	7.2	58	17	31	28

Results

Signal region	DM_high	DM_low	DM_low_loose	bC2x_diag	bC2x_med	bCbv	bCsoft_diag	bCsoft_med	bCsoft_high
Observed	5	13	65	22	4	25	33	19	2
Total background	7.4 ± 2.1	13.8 ± 3.6	48.3 ± 8.2	21.3 ± 5.0	5.8 ± 1.6	25.1 ± 3.8	24.7 ± 3.1	13.7 ± 2.1	1.8 ± 0.3
$t\bar{t}$ 2ℓ	0.82 ± 0.27	2.21 ± 0.58	16.0 ± 5.7	6.4 ± 2.4	1.36 ± 0.49	1.25 ± 0.65	10.3 ± 2.4	4.9 ± 1.5	0.36 ± 0.15
$t\bar{t}$ 1ℓ	0.0 ± 0.0	0.07 ± 0.03	-	0.28 ± 0.18	$0.04^{+0.13}_{-0.04}$	-	-	-	-
$t\bar{t} + W/Z$	4.0 ± 2.0	6.7 ± 3.2	14.3 ± 5.9	7.8 ± 3.3	0.71 ± 0.38	0.58 ± 0.16	0.14 ± 0.06	0.44 ± 0.10	0.05 ± 0.02
Single top	0.33 ± 0.16	0.65 ± 0.57	3.4 ± 1.3	5.5 ± 2.4	3.0 ± 1.5	0.60 ± 0.54	3.5 ± 1.5	1.6 ± 0.5	0.23 ± 0.11
W+jets	1.64 ± 0.53	3.2 ± 1.3	11.0 ± 2.8	1.22 ± 0.35	0.54 ± 0.14	16.5 ± 3.1	8.0 ± 2.0	6.4 ± 2.0	1.06 ± 0.24
Diboson	0.66 ± 0.21	0.98 ± 0.33	3.6 ± 1.3	0.23 ± 0.08	0.07 ± 0.04	6.1 ± 2.0	2.21 ± 0.93	0.31 ± 0.16	0.04 ± 0.01
Z+jets	-	-	-	-	-	-	0.60 ± 0.55	0.17 ± 0.16	0.04 ± 0.04
$t\bar{t}$ 2ℓ NF	1.19 ± 0.13	1.06 ± 0.12	1.13 ± 0.21	1.28 ± 0.17	1.58 ± 0.22	0.78 ± 0.28	0.73 ± 0.11	0.92 ± 0.07	0.93 ± 0.16
$t\bar{t}$ 1ℓ NF	1.08 ± 0.14	0.95 ± 0.04	1.13 ± 0.21	0.96 ± 0.08	0.75 ± 0.15	0.78 ± 0.28	0.73 ± 0.11	0.92 ± 0.07	0.93 ± 0.16
$t\bar{t} + W/Z$ NF	0.98 ± 0.38	1.06 ± 0.38	1.10 ± 0.32	1.18 ± 0.39	0.95 ± 0.52	-	-	-	-
Single top NF	0.94 ± 0.37	1.05 ± 0.35	1.22 ± 0.27	1.59 ± 0.45	1.17 ± 0.37	-	-	0.47 ± 0.14	0.37 ± 0.15
W+jets NF	1.08 ± 0.21	1.04 ± 0.18	0.93 ± 0.10	0.80 ± 0.24	1.11 ± 0.25	1.07 ± 0.09	1.19 ± 0.26	1.35 ± 0.24	1.11 ± 0.19
p_0 (σ)	0.5 (-)	0.5 (-)	0.07 (1.5)	0.45 (0.11)	0.5 (-)	0.5 (-)	0.25 (0.68)	0.12 (1.17)	0.44 (0.16)
$N^{\text{limit}}_{\text{non-SM}}$ exp.	7.2	11	23	14	6.4	13	13	9.6	4.1
$N^{\text{limit}}_{\text{non-SM}}$ obs.	5.7	10	37	14	5.2	13	20	14	4.3