CMS SUS-13-011

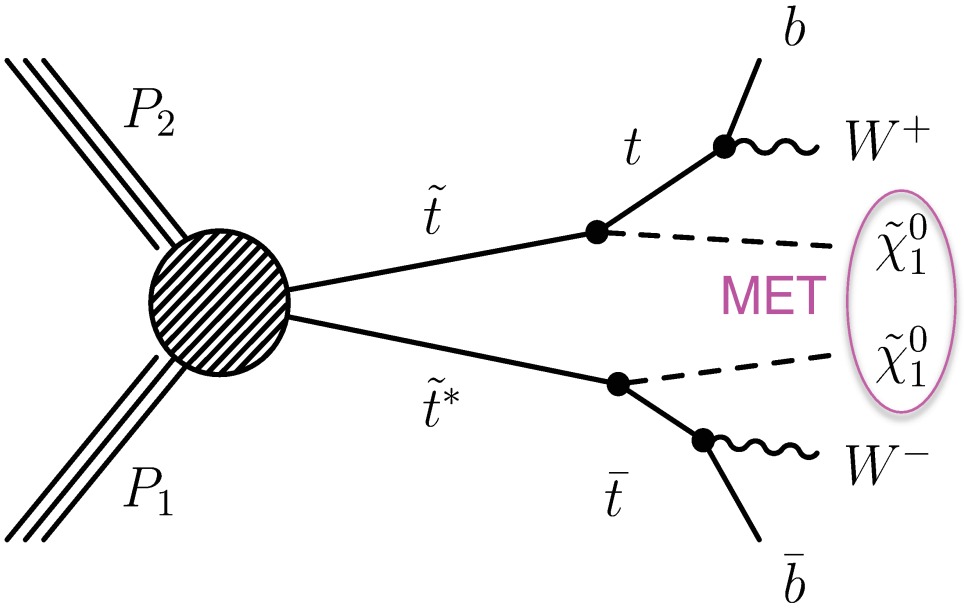
(search for stop pair production on single lepton final states)

Introduction

- The analysis is optimized for two slightly different final states:

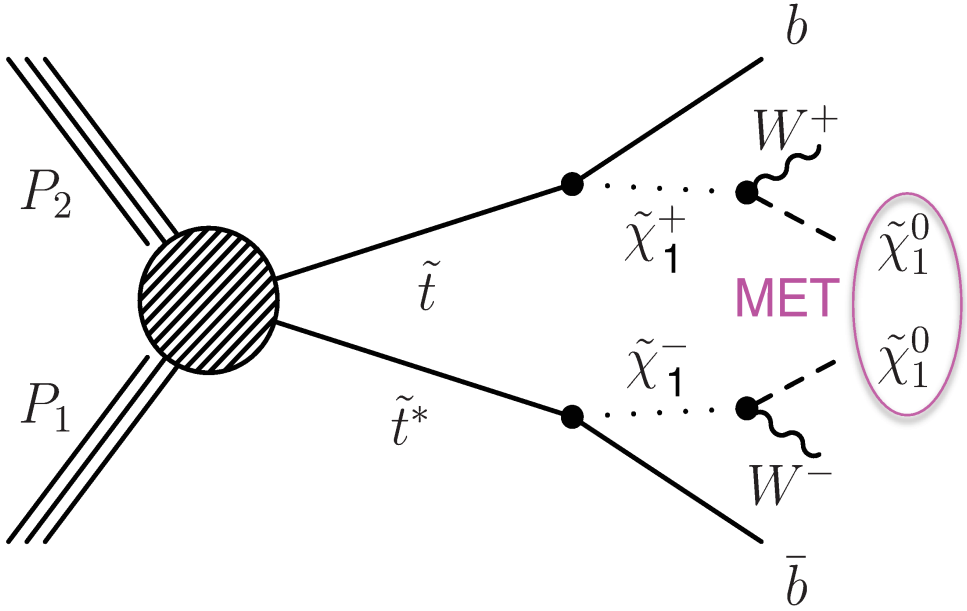
T2tt model

$$\tilde{t}\tilde{t}^{*} \rightarrow t\bar{t}\,\tilde{\chi}_1^0\tilde{\chi}_1^0$$



T2bw model

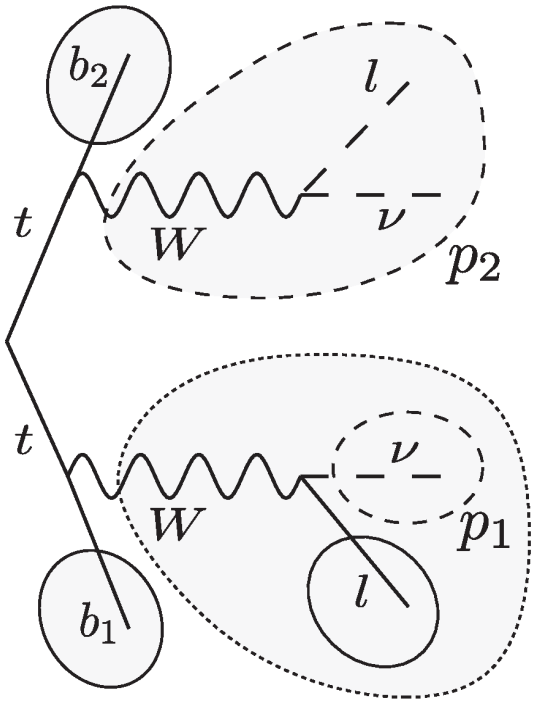
$$\tilde{t}\tilde{t}^{*} \rightarrow b\bar{b}\,\tilde{\chi}_1^+\tilde{\chi}_1^- \rightarrow b\bar{b}W^+W^-\,\tilde{\chi}_1^0\tilde{\chi}_1^0$$

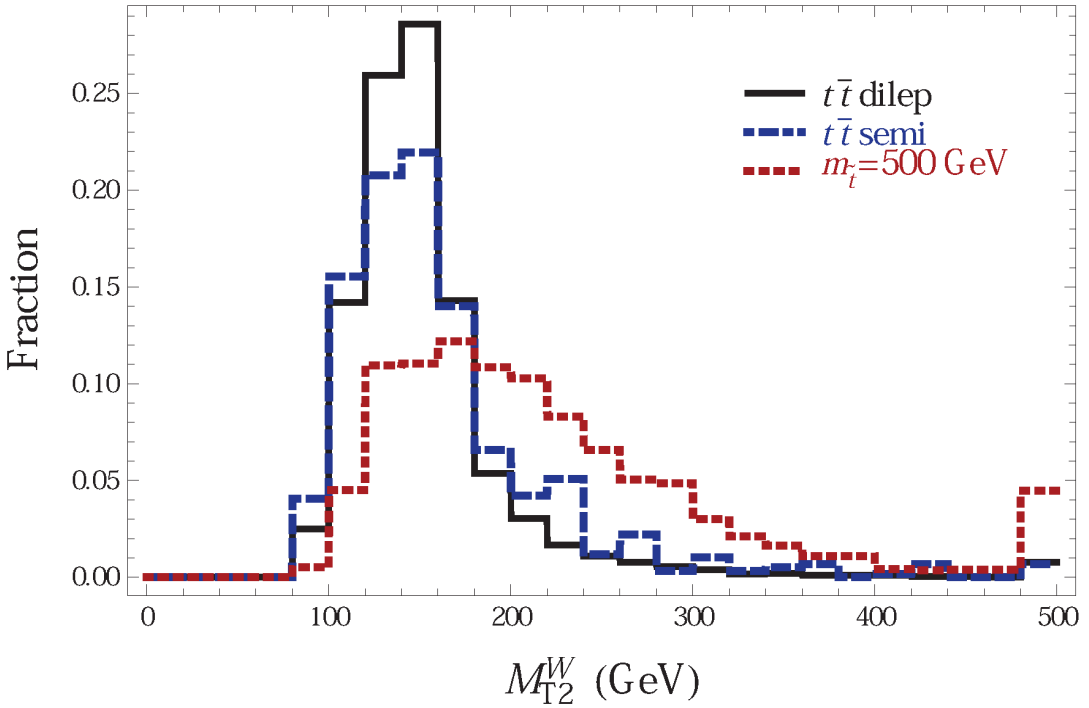


The “MT2W” variable

This variable has been proposed in: arXiv:1203.4813 [hep-ph]

$$M_{T2}^{W} = \min\left\{ m_y \text{ consistent with: } \left[\begin{array}{r} \vec{p}_1^{\,T} + \vec{p}_2^{\,T} = \vec{E}_T^{\,\text{miss}}\,,\ p_1^2 = 0\,,\ (p_1 + p_\ell)^2 = p_2^2 = M_W^2\,, \\ (p_1 + p_\ell + p_{b_1})^2 = (p_2 + p_{b_2})^2 = m_y^2 \end{array} \right] \right\}$$





The code used by CMS to compute it is publicly available at:
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS13011#Code

Trigger and common selection

- Single lepton triggers:
  - e: p_T > 30 GeV (ε: 85-97%),
  - μ: p_T > 25 GeV (ε: 80-95%)
- Isolation: if the sum of the p_T of the particles within a cone of $\Delta R = 0.3$, is $p_{T,sum} > \min(5\ \text{GeV}, 0.15\ p_{T,lep})$, the lepton is discarded. Isolation efficiency: 84% for electrons, 91% for muons.
- Veto on a second lepton with p_T > 5 GeV;
- Isolated track veto: reject events with an isolated track (with charge opposite to that of the candidate lepton, with p_T > 10 GeV);
- Hadronic τ veto: reject event, if it has a jet with p_T > 20 GeV, consistent with a hadronic τ. Isolation criteria: consider only charged particles, in a cone of $\Delta R = 0.4$. Reject if $p_{T,sum} > \alpha\ p_{T,lep}$, ($\alpha$ = 0.1 for tracks, 0.2 for leptons).

Common selection

- The event must contain at least 4 (anti-kt, R = 0.5) jets with p_T > 30 GeV, $|\eta|$ < 2.4;
- At least one jet is required to be consistent with a b-jet (CSVM tagger, ε ~70%, fake rate for light quarks ~1%, for c ~10%);
- MET > 100 GeV;
- MT > 120 GeV.
- “Topological variables”:
  - min$\Delta\phi$: minimum $\Delta\phi$ between MET and the two leading jets in the event;
  - HT_{ratio}: fraction of the total HT lying in the same hemisphere of the MET vector;

Hadronic top candidate

- For the on-shell top final state search, a χ^2 is built, to constrain three of the jets in the event to be consistent with a hadronic top decay:

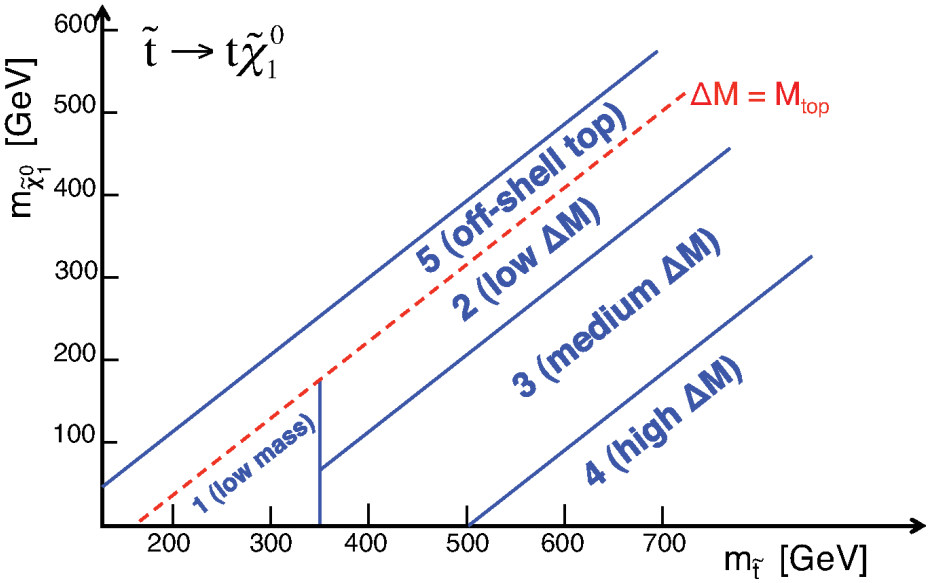
$$\chi^2 = \frac{(M_{j_1 j_2 j_3} - M_{\mathrm{top}})^2}{\sigma^2_{j_1 j_2 j_3}} + \frac{(M_{j_1 j_2} - M_{\mathrm{W}})^2}{\sigma^2_{j_1 j_2}}$$

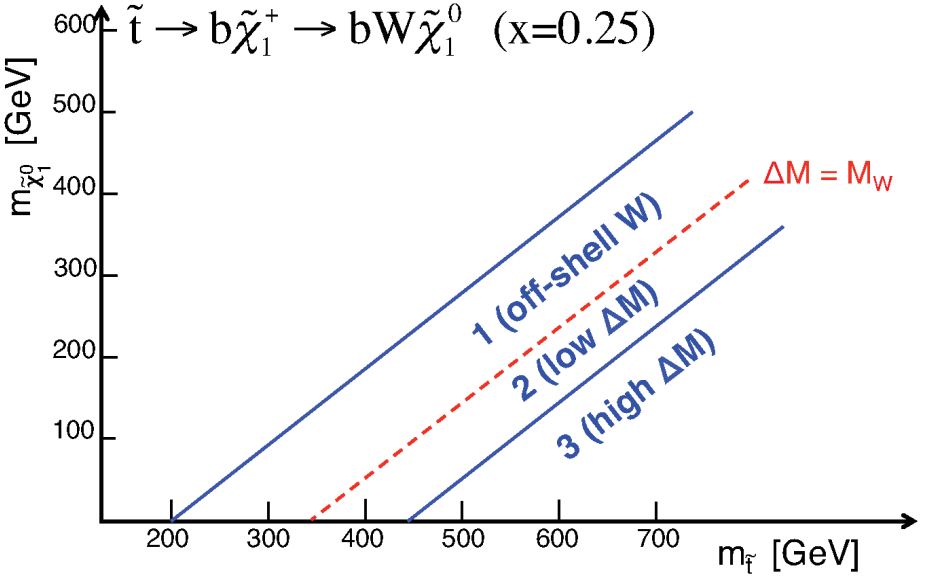
- The b-tagging information is appropriately taken into account when assigning jets in the computation of the χ^2.

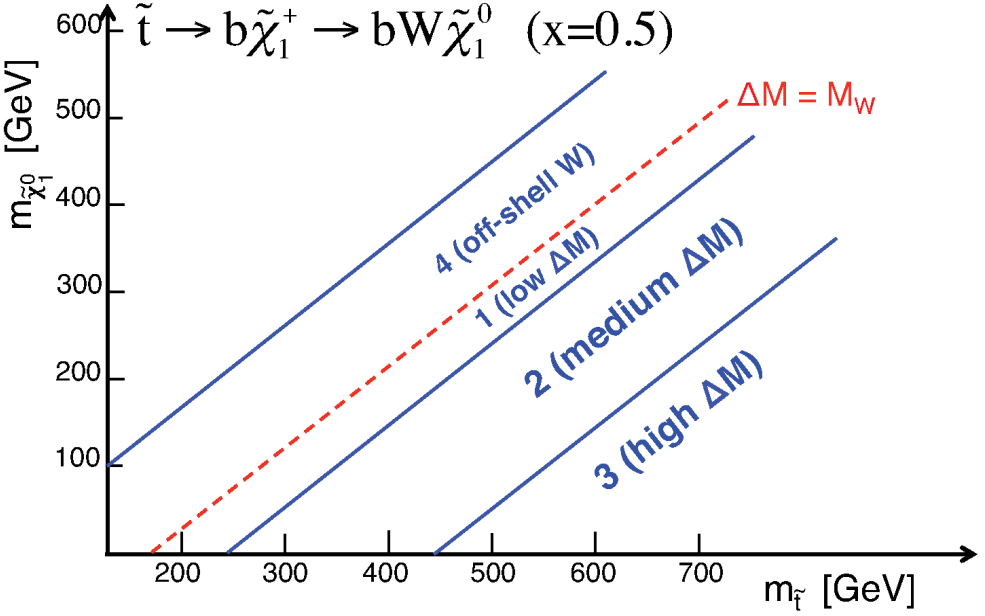
Summary of the selections

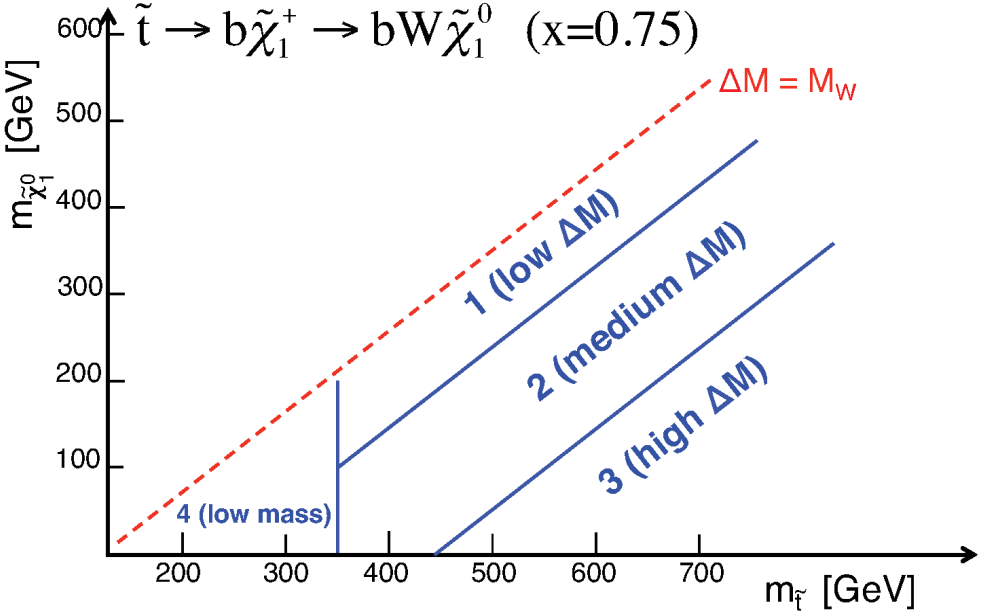
	$\tilde{t} \to t\tilde{\chi}_1^0$			$\tilde{t} \to b\tilde{\chi}^+$		
		Cut-based			Cut-based	
Selection	BDT	Low ΔM	High ΔM	BDT	Low ΔM	High ΔM
E_T^{miss} (GeV)	yes	$>$ 150, 200, 250, 300	$>$ 150, 200, 250, 300	yes	$>$ 100, 150, 200, 250	$>$ 100, 150, 200, 250
M_{T2}^W (GeV)	yes		$>$200	yes		$>$200
min $\Delta\phi$	yes	$>$0.8	$>$0.8	yes	$>$0.8	$>$0.8
H_T^{ratio}	yes			yes		
Hadronic top χ^2	(on-shell top)	$<$5	$<$5			
Leading b-tagged jet p_T (GeV)	(off-shell top)			yes		$>$100
$\Delta R(\ell$,leading b-tagged jet)				yes		
Lepton p_T (GeV)				(off shell W)		

BDT signal regions









Results tables (1)

BDT on-shell top

$\widetilde{t} \to t\widetilde{\chi}_1^0$

Sample	BDT1–Loose	BDT1–Tight	BDT2	BDT3	BDT4	BDT5
$t\bar{t} \to \ell\ell$	438 ± 37	68 ± 11	46 ± 10	5 ± 2	0.3 ± 0.3	48 ± 13
1ℓ top	251 ± 93	37 ± 17	22 ± 12	4 ± 3	0.8 ± 0.9	30 ± 12
$W + jets$	27 ± 7	7 ± 2	6 ± 2	2 ± 1	0.8 ± 0.3	5 ± 2
Rare	47 ± 23	11 ± 6	10 ± 5	3 ± 1	1.0 ± 0.5	4 ± 2
Total	763 ± 102	124 ± 21	85 ± 16	13 ± 4	2.9 ± 1.1	87 ± 18
Data	728	104	56	8	2	76
$\widetilde{t} \to t\widetilde{\chi}_1^0$ (250/50)	285 ± 8.5	50 ± 3.5	28 ± 2.6	4.4 ± 1.0	0.3 ± 0.3	34 ± 2.9
$\widetilde{t} \to t\widetilde{\chi}_1^0$ (650/50)	12 ± 0.2	7.2 ± 0.2	9.8 ± 0.2	6.5 ± 0.2	4.3 ± 0.1	2.9 ± 0.1

Results tables (2)

Cut&count on-shell top

Sample	$E_T^{miss} > 150\,GeV$	$E_T^{miss} > 200\,GeV$	$E_T^{miss} > 250\,GeV$	$E_T^{miss} > 300\,GeV$
		Low ΔM Selection		
$t\bar{t} \to \ell\ell$	131 ± 15	42 ± 7	17 ± 5	5.6 ± 2.5
1ℓ top	94 ± 47	30 ± 19	9 ± 6	3.1 ± 2.4
W + jets	10 ± 3	5 ± 1	2 ± 1	1.0 ± 0.4
Rare	16 ± 8	7 ± 4	4 ± 2	1.8 ± 0.9
Total	251 ± 50	83 ± 21	31 ± 8	11.5 ± 3.6
Data	227	69	21	9
$\tilde{t} \to t\tilde{\chi}_1^0$ (250/50)	108 ± 3.7	32 ± 2.0	12 ± 1.2	5.2 ± 0.8
$\tilde{t} \to t\tilde{\chi}_1^0$ (650/50)	8.0 ± 0.1	7.2 ± 0.1	6.2 ± 0.1	4.9 ± 0.1
		High ΔM Selection		
$t\bar{t} \to \ell\ell$	8 ± 2	5 ± 2	3.2 ± 1.4	1.4 ± 0.9
1ℓ top	13 ± 6	6 ± 4	3.0 ± 2.2	1.4 ± 1.0
W + jets	4 ± 1	2 ± 1	1.5 ± 0.5	0.9 ± 0.3
Rare	4 ± 2	3 ± 1	1.8 ± 0.9	1.0 ± 0.5
Total	29 ± 7	17 ± 5	9.5 ± 2.8	4.7 ± 1.4
Data	23	11	3	2
$\tilde{t} \to t\tilde{\chi}_1^0$ (250/50)	10 ± 1.1	4.6 ± 0.8	2.3 ± 0.5	1.4 ± 0.4
$\tilde{t} \to t\tilde{\chi}_1^0$ (650/50)	4.9 ± 0.1	4.7 ± 0.1	4.3 ± 0.1	3.7 ± 0.1

Results tables (3)

BDT off-shell top

$m_{\chi+} = x\, m_{stop} + (1\text{-}x)\, m_{\chi 0}$

$\tilde{t} \to b\tilde{\chi}^+$ $x = 0.25$

Sample	BDT1	BDT2	BDT3
$t\bar{t} \to \ell\ell$	18 ± 4	2.2 ± 1.3	1.2 ± 1.0
1ℓ top	10 ± 5	4.0 ± 1.8	1.5 ± 0.8
W + jets	3 ± 1	2.0 ± 0.7	0.7 ± 0.3
Rare	4 ± 2	1.6 ± 0.8	1.0 ± 0.5
Total	35 ± 6	9.8 ± 2.4	4.4 ± 1.4
Data	29	7	2
$\tilde{t} \to b\tilde{\chi}^+$ (450/50/0.25)	19 ± 2.9	11 ± 2.2	5.2 ± 1.5
$\tilde{t} \to b\tilde{\chi}^+$ (600/100/0.25)	8.8 ± 0.8	7.5 ± 0.8	5.6 ± 0.7

$\tilde{t} \to b\tilde{\chi}^+$ $x = 0.5$

Sample	BDT1	BDT2–Loose	BDT2–Tight	BDT3	BDT4
$t\bar{t} \to \ell\ell$	40 ± 5	21 ± 4	4 ± 2	6 ± 2	100 ± 16
1ℓ top	24 ± 10	15 ± 7	4 ± 3	4 ± 2	33 ± 12
W + jets	5 ± 1	5 ± 1	2 ± 1	3 ± 1	5 ± 1
Rare	8 ± 4	8 ± 4	3 ± 1	4 ± 2	8 ± 4
Total	77 ± 12	50 ± 9	13 ± 4	17 ± 4	146 ± 21
Data	67	35	12	13	143
$\tilde{t} \to b\tilde{\chi}^+$ (250/50/0.5)	45 ± 7.6	24 ± 5.2	5.7 ± 2.4	5.2 ± 2.6	55 ± 8.1
$\tilde{t} \to b\tilde{\chi}^+$ (650/50/0.5)	3.5 ± 0.4	9.5 ± 0.7	5.6 ± 0.5	8.3 ± 0.6	3.2 ± 0.4

$\tilde{t} \to b\tilde{\chi}^+$ $x = 0.75$

Sample	BDT1	BDT2	BDT3	BDT4
$t\bar{t} \to \ell\ell$	37 ± 5	9 ± 2	3.1 ± 1.3	248 ± 22
1ℓ top	17 ± 9	6 ± 5	1.6 ± 1.6	188 ± 70
W + jets	4 ± 1	4 ± 1	1.6 ± 0.6	22 ± 6
Rare	4 ± 2	4 ± 2	1.8 ± 0.9	20 ± 10
Total	61 ± 10	22 ± 6	8.1 ± 2.3	478 ± 74
Data	50	13	5	440
$\tilde{t} \to b\tilde{\chi}^+$ (250/50/0.75)	115 ± 13	21 ± 5.6	8.0 ± 3.7	518 ± 28
$\tilde{t} \to b\tilde{\chi}^+$ (650/50/0.75)	3.9 ± 0.4	8.4 ± 0.6	6.8 ± 0.6	5.5 ± 0.5

Results tables (4)

Cut&count off-shell top

Sample	$E_T^{miss} > 100$ GeV	$E_T^{miss} > 150$ GeV	$E_T^{miss} > 200$ GeV	$E_T^{miss} > 250$ GeV
		Low ΔM Selection		
$t\bar{t} \to \ell\ell$	875 ± 57	339 ± 23	116 ± 14	40 ± 9
1ℓ top	658 ± 192	145 ± 70	41 ± 24	14 ± 9
W + jets	59 ± 15	21 ± 5	8 ± 2	4 ± 1
Rare	70 ± 35	33 ± 17	16 ± 8	8 ± 4
Total	1662 ± 203	537 ± 75	180 ± 28	66 ± 13
Data	1624	487	151	52
$\tilde{t} \to b\tilde{\chi}^+$ (450/50/0.25)	47 ± 3.3	33 ± 2.7	19 ± 2.0	8.7 ± 1.4
$\tilde{t} \to b\tilde{\chi}^+$ (600/100/0.25)	15 ± 0.7	13 ± 0.7	11 ± 0.6	7.9 ± 0.5
$\tilde{t} \to b\tilde{\chi}^+$ (250/50/0.5)	419 ± 17	157 ± 9.9	52 ± 5.4	21 ± 3.4
$\tilde{t} \to b\tilde{\chi}^+$ (650/50/0.5)	14 ± 0.6	13 ± 0.5	11 ± 0.5	8.4 ± 0.4
$\tilde{t} \to b\tilde{\chi}^+$ (250/50/0.75)	854 ± 26	399 ± 18	144 ± 10	56 ± 6.4
$\tilde{t} \to b\tilde{\chi}^+$ (650/50/0.75)	17 ± 0.7	16 ± 0.6	13 ± 0.6	11 ± 0.5
		High ΔM Selection		
$t\bar{t} \to \ell\ell$	25 ± 5	12 ± 3	7 ± 2	2.9 ± 1.5
1ℓ top	35 ± 10	15 ± 6	6 ± 3	2.7 ± 1.8
W + jets	9 ± 2	5 ± 1	2 ± 1	1.8 ± 0.6
Rare	9 ± 5	7 ± 3	4 ± 2	2.4 ± 1.2
Total	79 ± 12	38 ± 7	19 ± 5	9.9 ± 2.7
Data	90	39	18	5
$\tilde{t} \to b\tilde{\chi}^+$ (450/50/0.25)	30 ± 2.7	23 ± 2.3	15 ± 1.8	7.3 ± 1.3
$\tilde{t} \to b\tilde{\chi}^+$ (600/100/0.25)	11 ± 0.6	9.7 ± 0.6	8.4 ± 0.6	6.1 ± 0.5
$\tilde{t} \to b\tilde{\chi}^+$ (250/50/0.5)	37 ± 4.8	23 ± 3.8	11 ± 2.6	5.0 ± 1.7
$\tilde{t} \to b\tilde{\chi}^+$ (650/50/0.5)	11 ± 0.5	9.8 ± 0.5	8.6 ± 0.4	6.7 ± 0.4
$\tilde{t} \to b\tilde{\chi}^+$ (250/50/0.75)	32 ± 5.2	23 ± 4.4	11 ± 2.9	3.6 ± 1.4
$\tilde{t} \to b\tilde{\chi}^+$ (650/50/0.75)	9.2 ± 0.5	8.4 ± 0.5	7.5 ± 0.4	6.3 ± 0.4