Search for third generation squarks at CMS

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(CERN)

on behalf of the CMS collaboration

Introduction

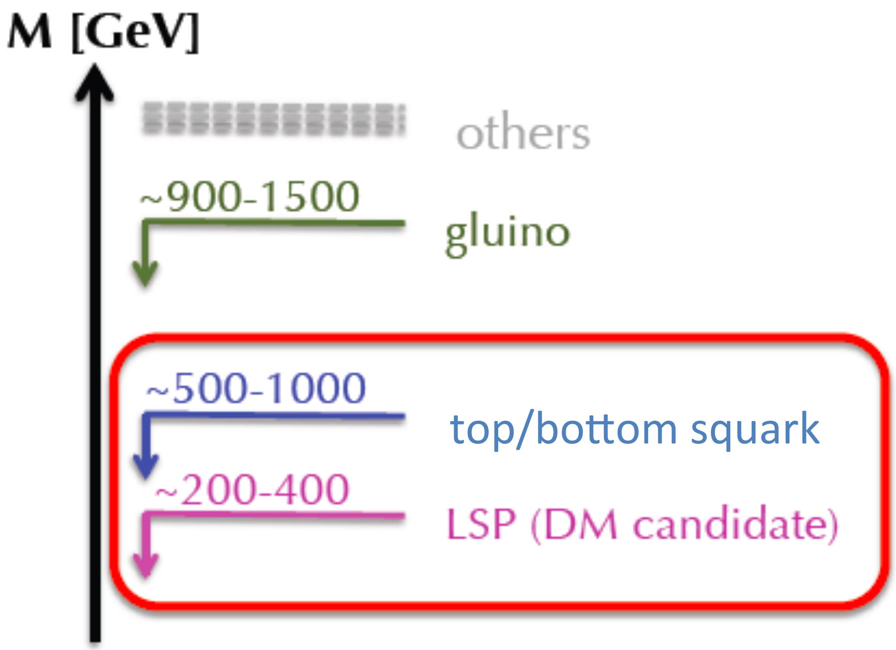
The existence of dark matter (DM) is overwhelming but its properties are unknown.

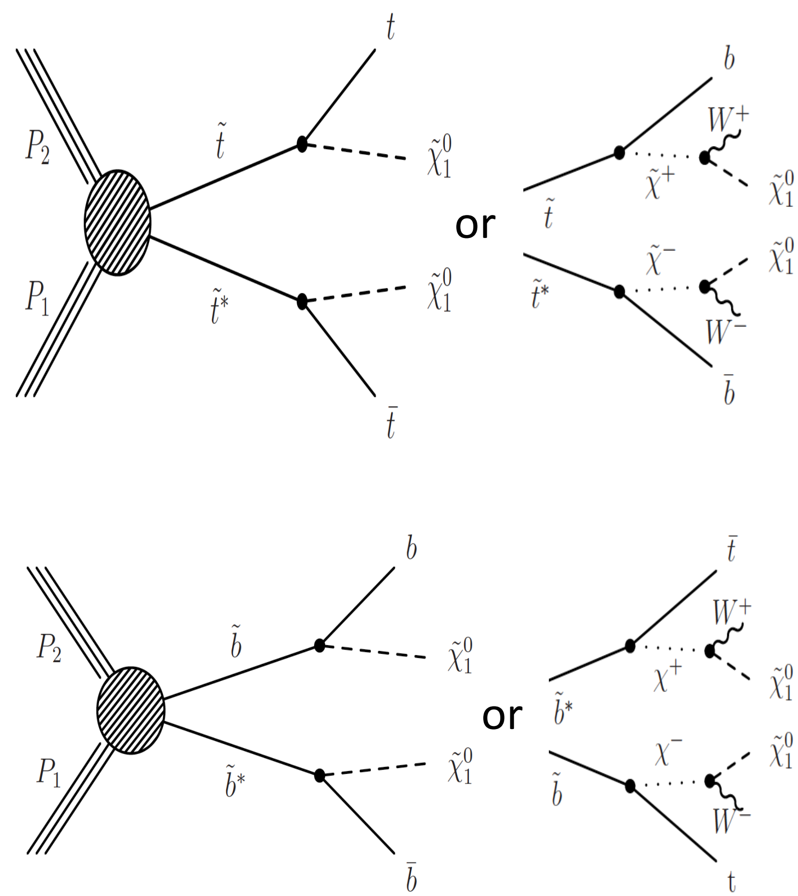
→ This motivates us to search for DM candidate in colliders produced in cascade of the others particles.

The Higgs boson with a mass of 125 GeV exists. The EWK breaking mechanism gives a special role to the particles of the third generation.

→This motivates us to search for third generation partners.

Stop/sbottom production

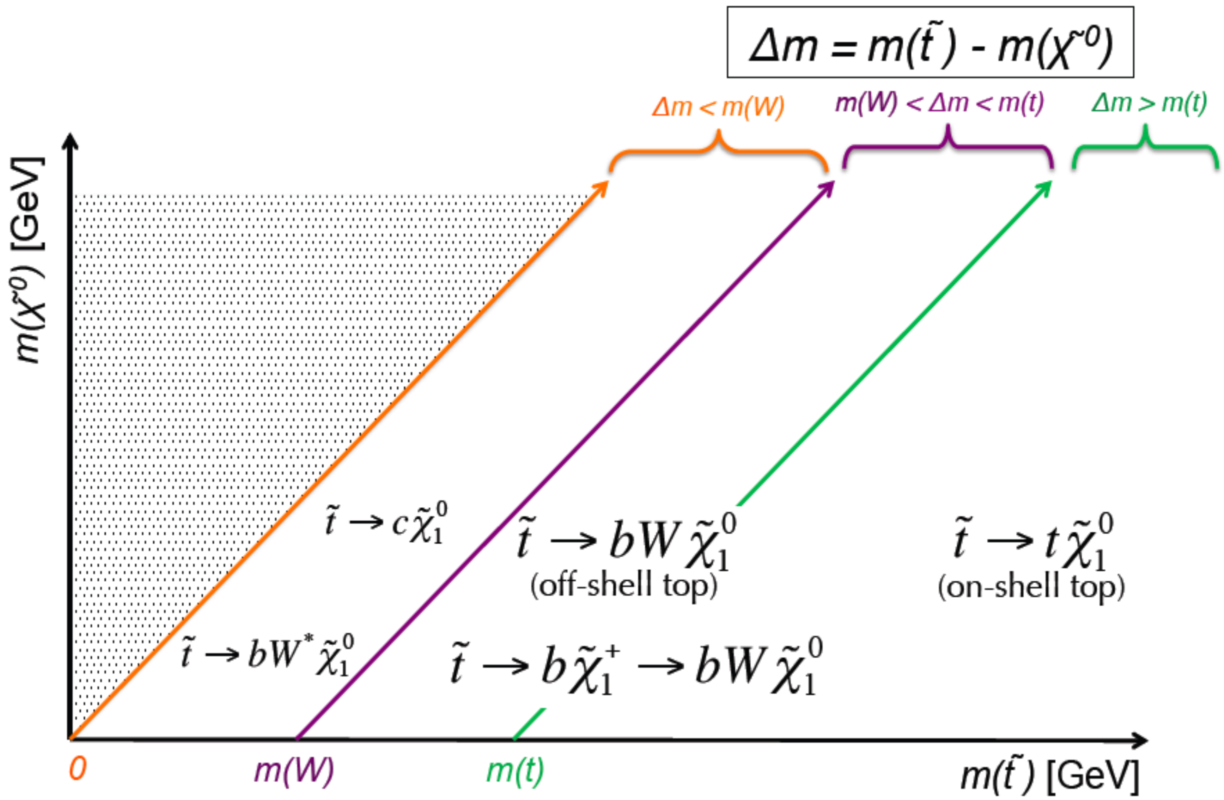




Typical cross section stop/sbottom:
2 pb @ 300 GeV
0.025 pb @ 600 GeV

SM TTbar ~ 230 pb-1

Top Squark decays



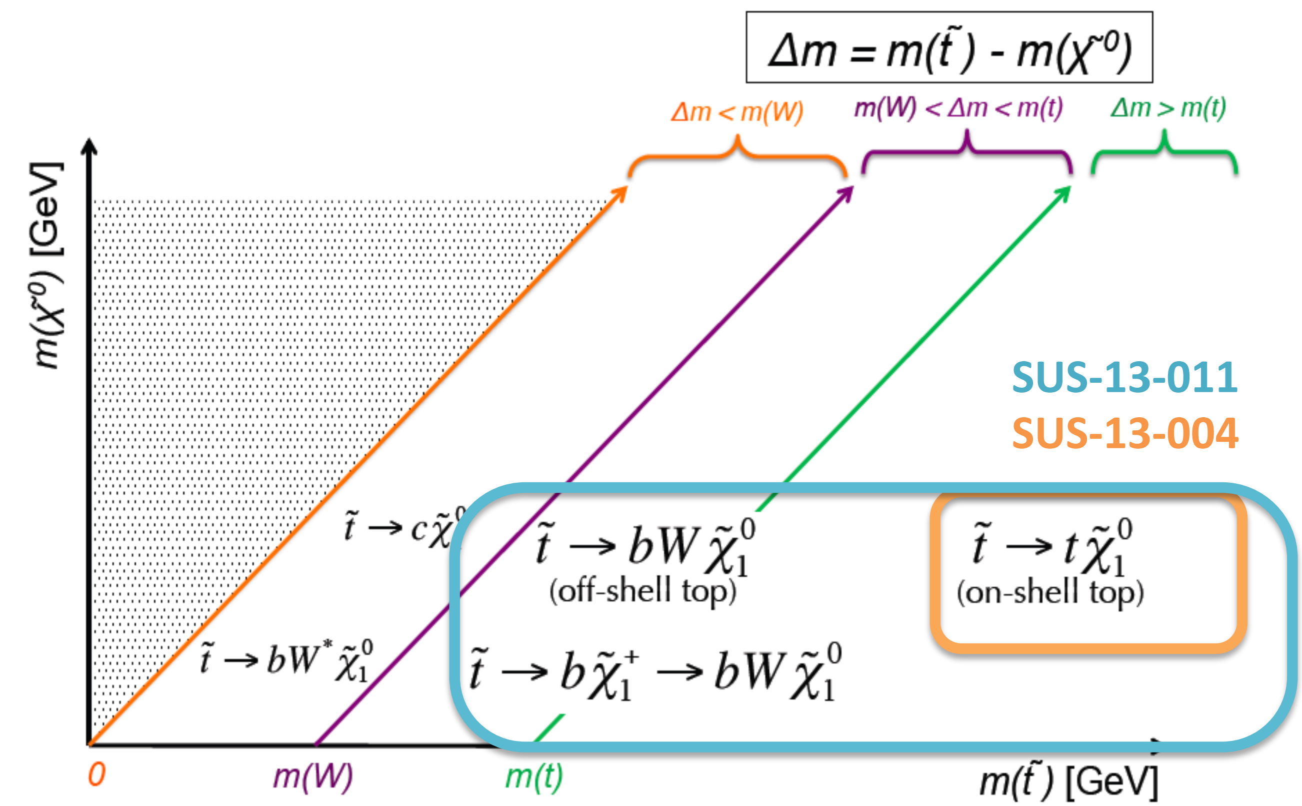
No single signature dominates:

fully hadronic (many bkg but largest BR)

semi-leptonic (clean and moderate BR)

Opposite-sign dileptons (very clean, low BR)

Top Squark decays



SUS-13-011 **(1 e/mu):** *http://arxiv.org/abs/1308.1586*

Discriminating variables: MET,MT(l/met)

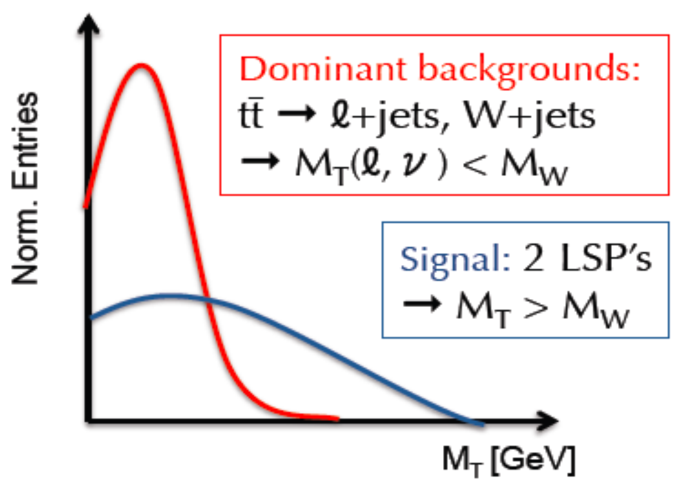
SUS-13-004 **(0 lepton /1 e/mu):**

Discriminating variables: razor

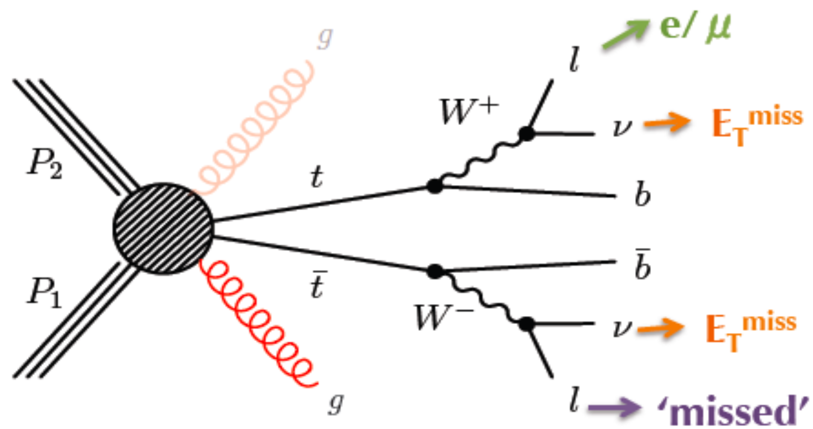
SUS-13-011
http://arxiv.org/abs/1308.1586

SUS-13-011

- **Event pre-selection**
  - 1 high p_T isolated e or μ
  - ≥ 4 jets with ≥ 1 b-jet
  - Veto events with a second lepton
  - Moderate E_T^{miss}
- **Search in M_T tail**
  $M_T(\ell, E_T^{miss}) >> M_W$



- **Main backgrounds**
  - $t\bar{t} \rightarrow \ell\ell$ dominant in M_T tail



  - Single lepton backgrounds:
    $t\bar{t} \rightarrow \ell$+jets & single top s/t-channel (1ℓ top), W+jets
  - Rare processes:
    mainly $t\bar{t}$+W/Z/γ, tW

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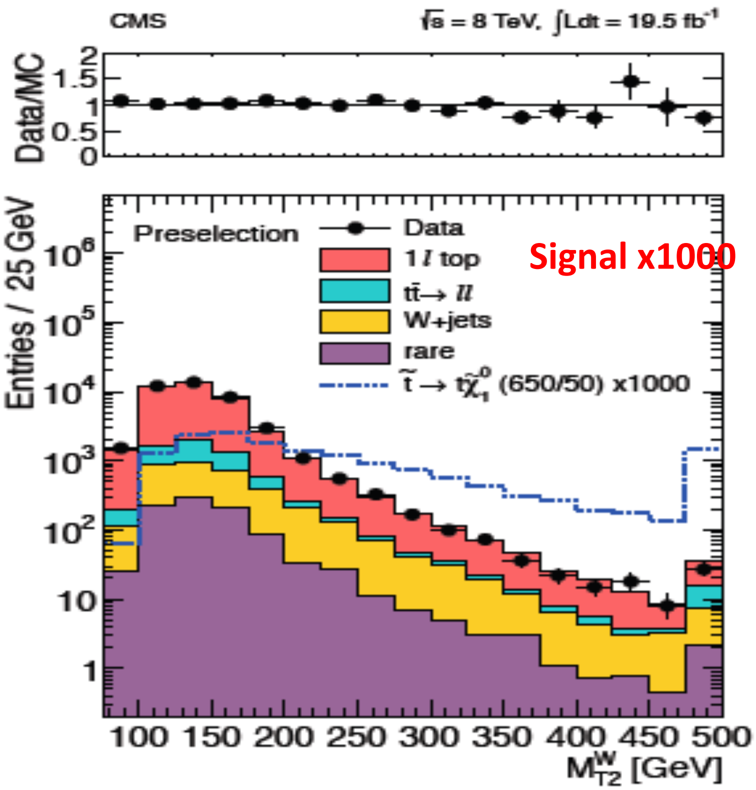
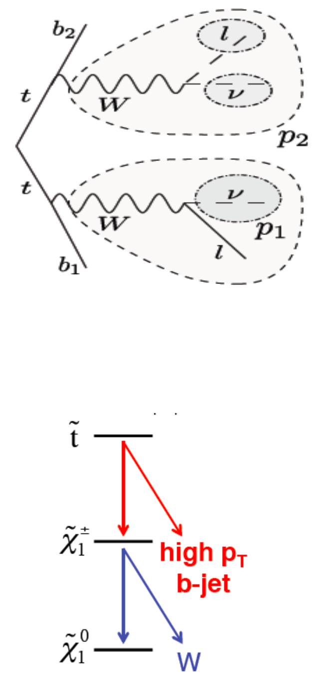
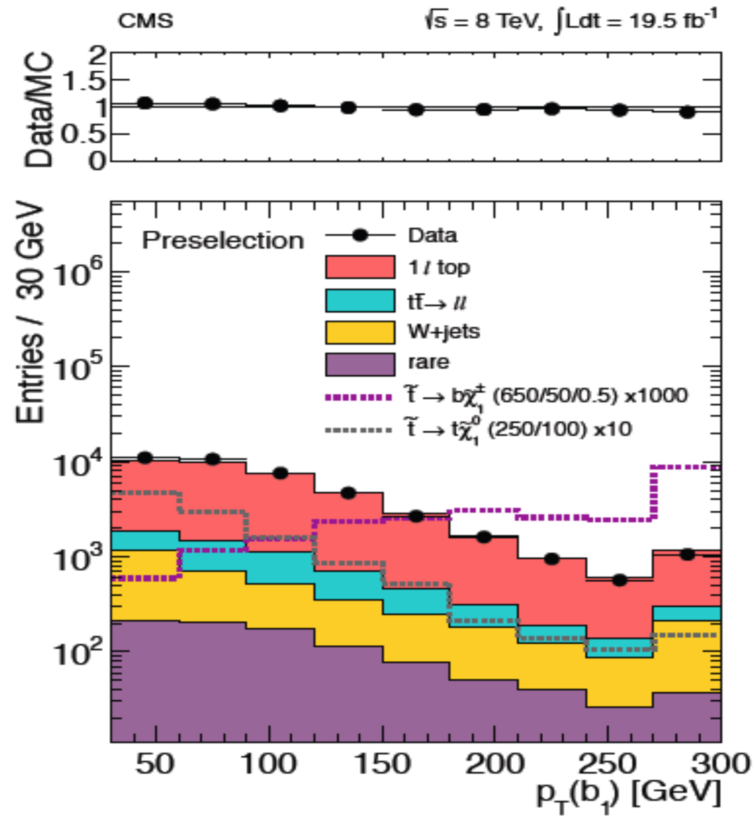
http://arxiv.org/abs/1308.1586

Discriminating variables

Comparison data vs. MC of the kinematic distributions after event preselection, shows that the MC model well the data.







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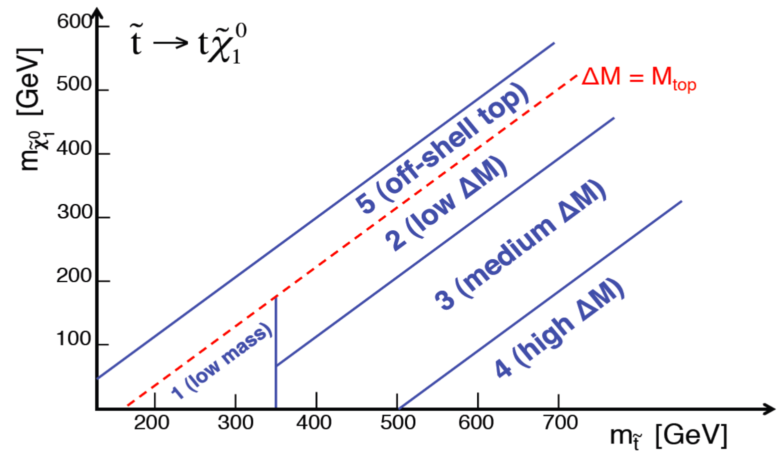
Discriminating variables

Different signal regions target different decay modes and a range of signal kinematics.

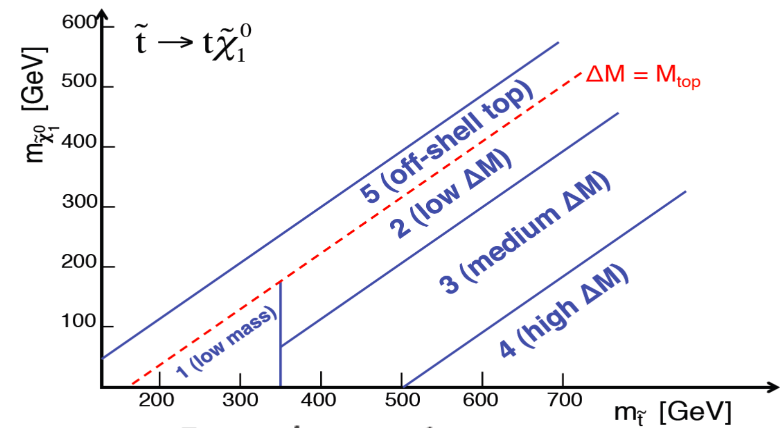
DBT and **cut based** analysis in place

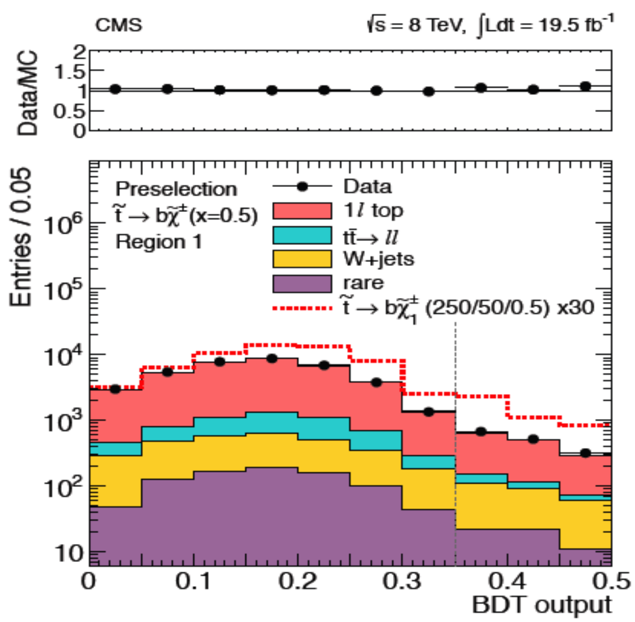


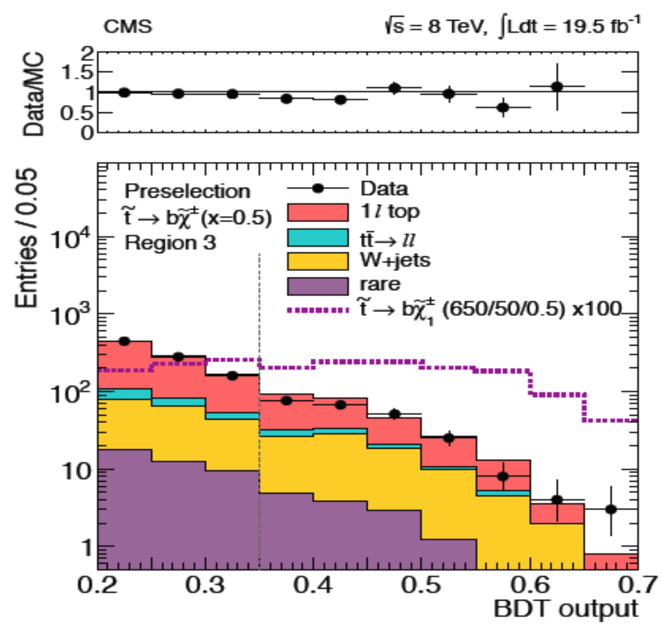
	$\tilde{t} \to t\tilde{\chi}_1^0$			$\tilde{t} \to b\tilde{\chi}_1^+$		
		cut-based			cut-based	
Selection	BDT	Low ΔM	High ΔM	BDT	Low ΔM	High ΔM
E_T^{miss}(GeV)	yes	$>$ 150, 200, 250, 300	$>$ 150, 200, 250, 300	yes	$>$ 100, 150, 200, 250	$>$ 100, 150, 200, 250
M_{T2}^W (GeV)	yes		$>$ 200	yes		$>$ 200
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-jet p_T (GeV)	(off-shell top)			yes		$>$ 100
$\Delta R(\ell$,leading b-jet)				yes		
lepton p_T				(off shell W)		

Discriminating variables

Different signal regions target different decay modes and a range of signal kinematics.
BDT and **cut based** analysis performed.







BDT output well modelled too.

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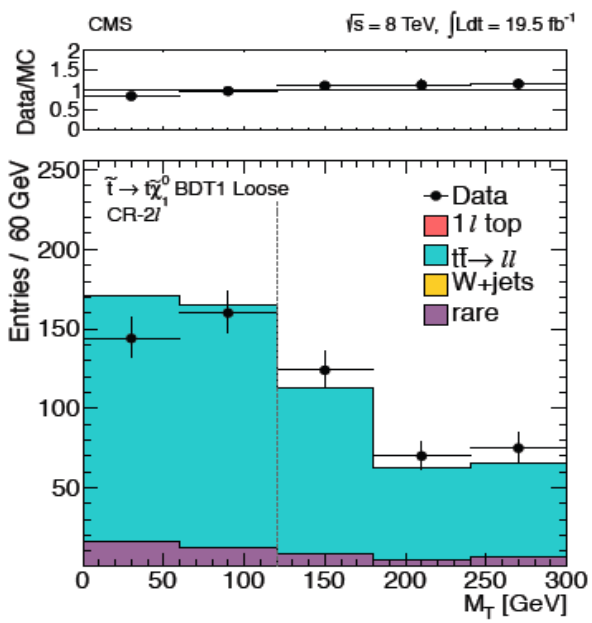
http://arxiv.org/abs/1308.1586

Control region data/MC comparison

Estimate backgrounds from MC → normalized to the MT peak
MT tails validated with control samples → extract scale factor.

2ℓ
tt validation



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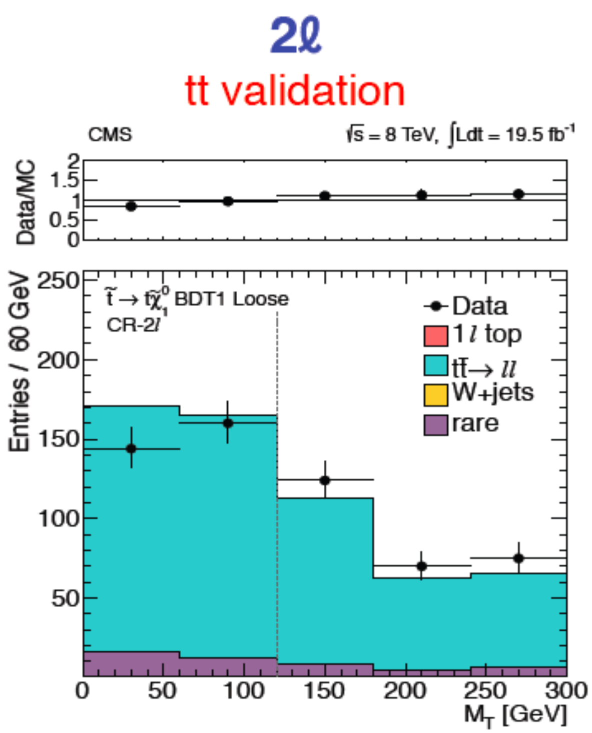

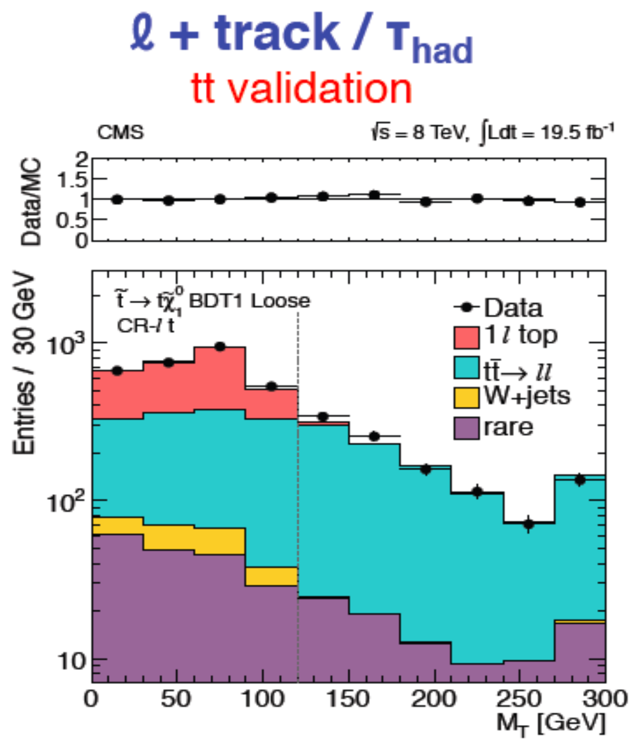

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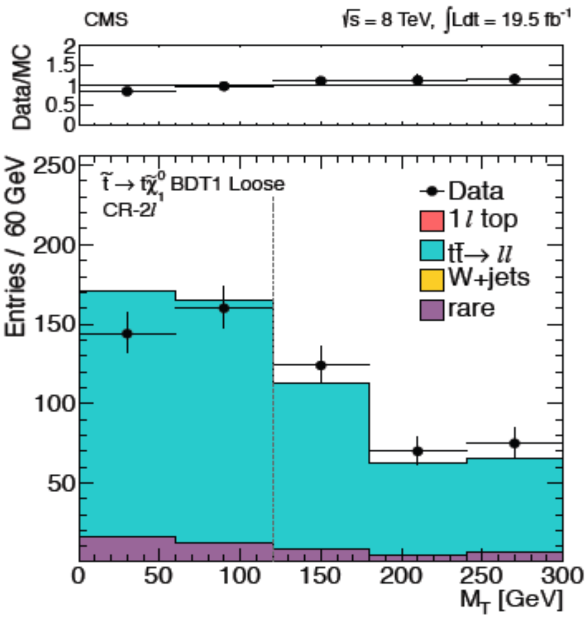
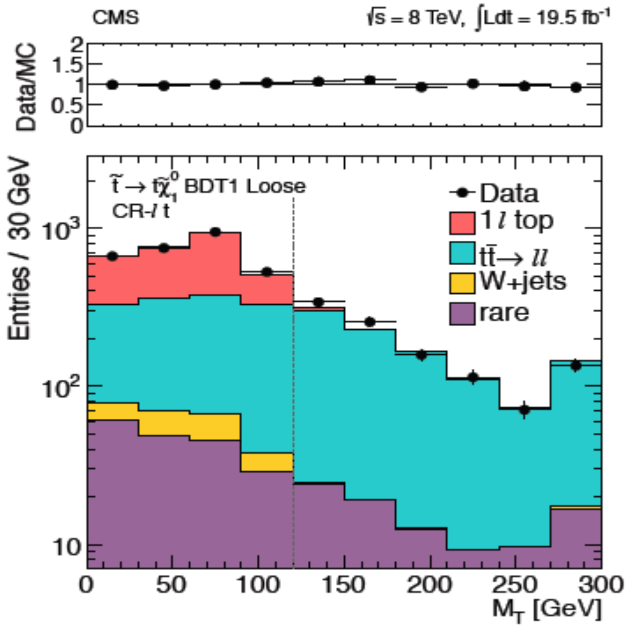


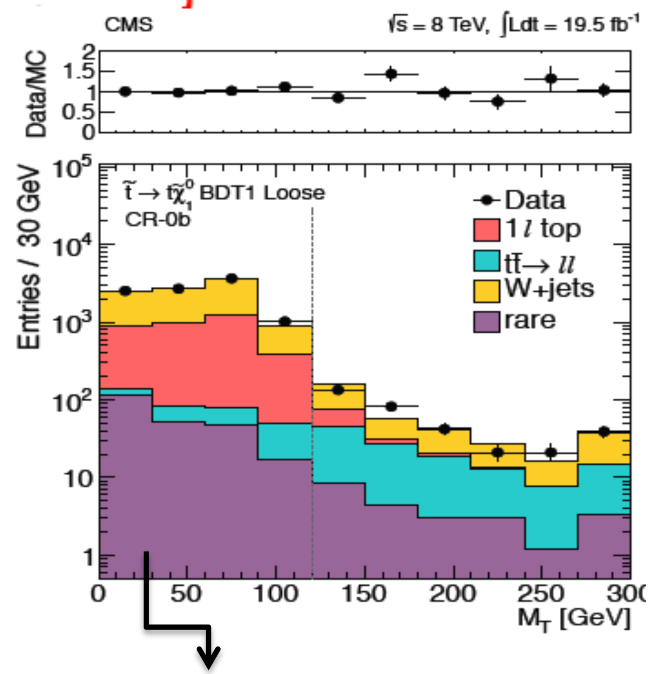
ℓ + track / τ_had

tt validation



b-veto

W+jets validation



Extrapolation for the ttbar 1l

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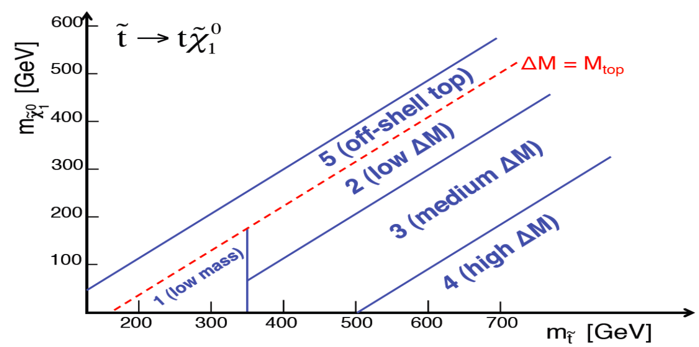
http://arxiv.org/abs/1308.1586

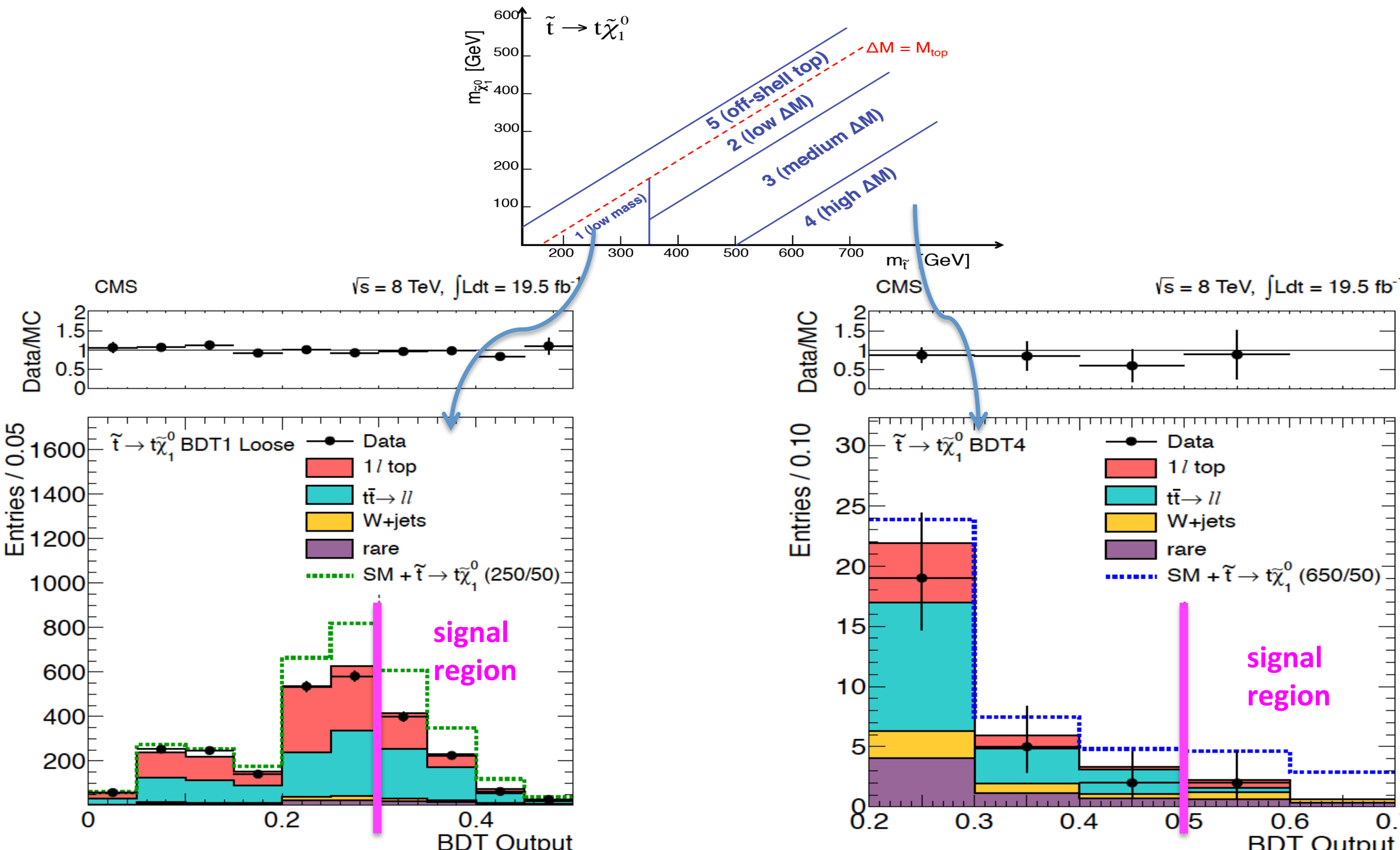
Results

$\tilde{t} \to t\tilde{\chi}_1^0$						
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
$\tilde{t} \to t\tilde{\chi}_1^0$ (250/50)	285 ± 8.5	50 ± 3.5	28 ± 2.6	4.4 ± 1.0	0.3 ± 0.3	34 ± 2.9
$\tilde{t} \to t\tilde{\chi}_1^0$ (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

Data are consistent with the prediction



Results



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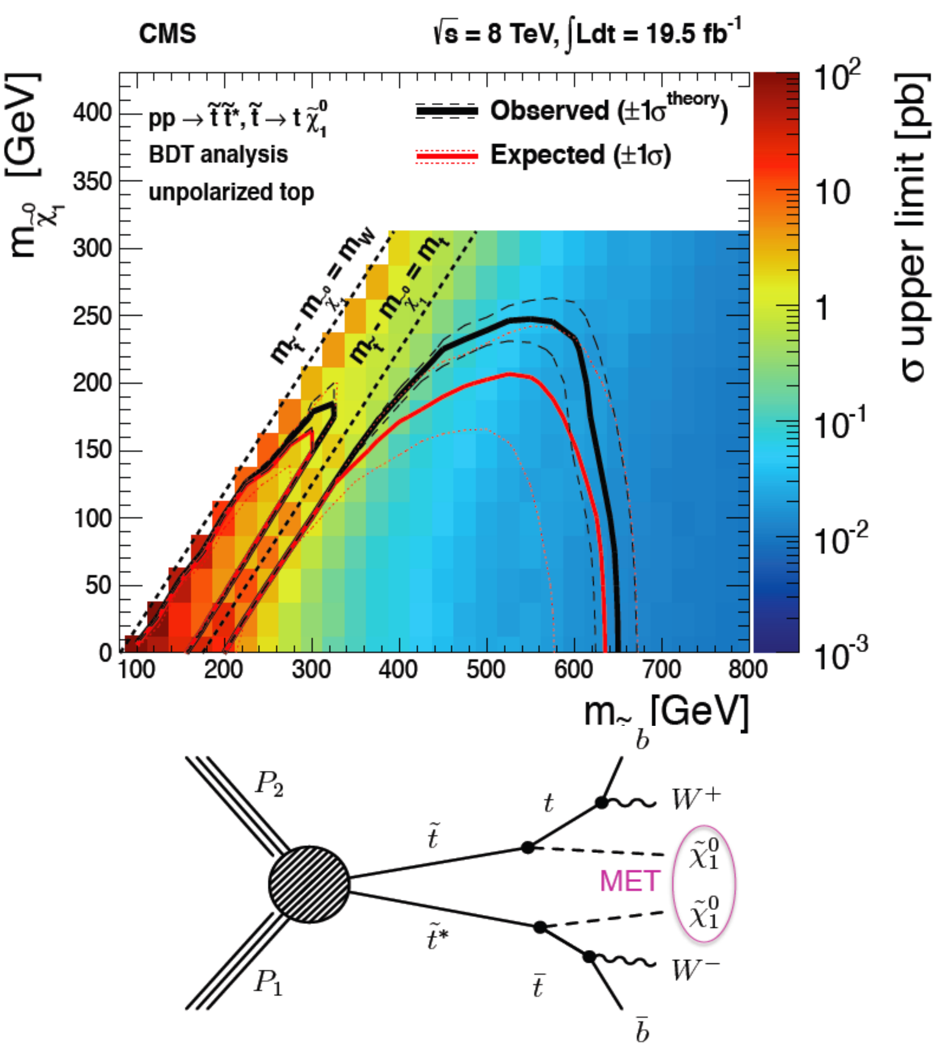
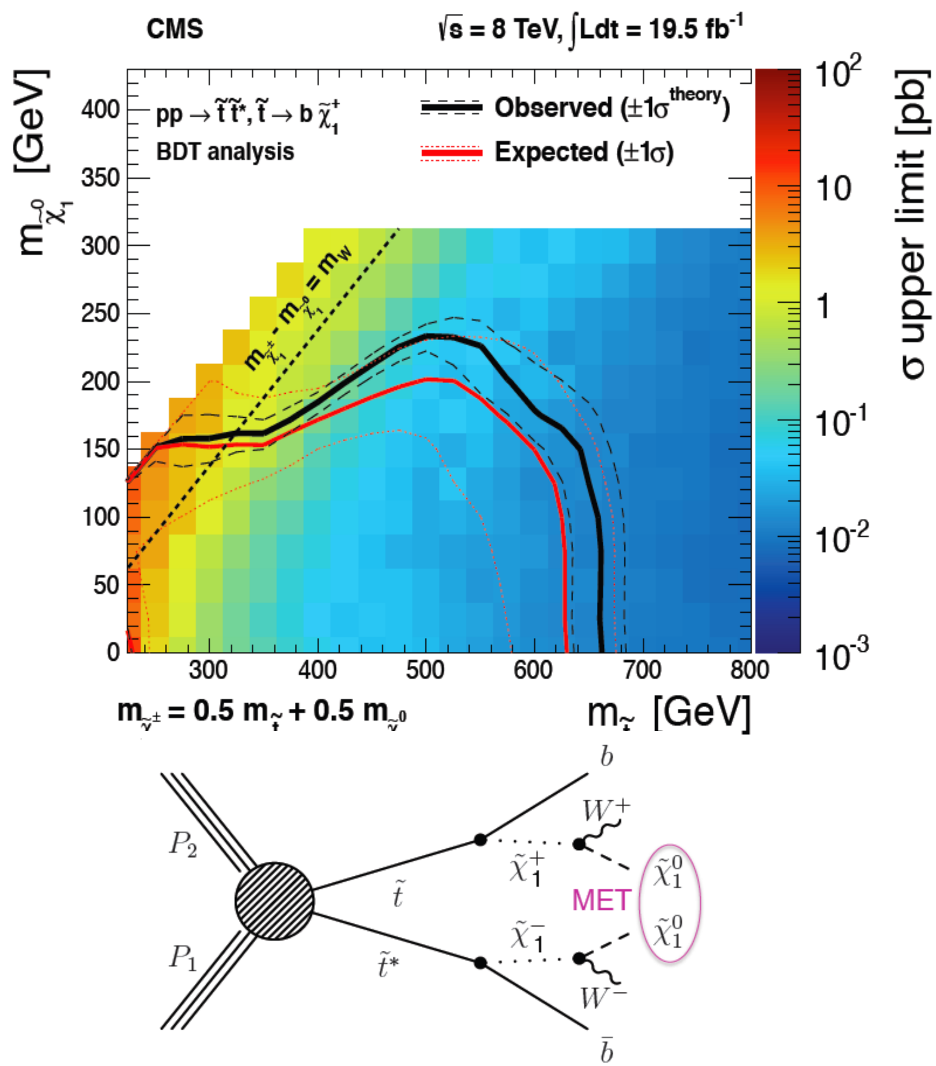
SUS-13-011 interpretation





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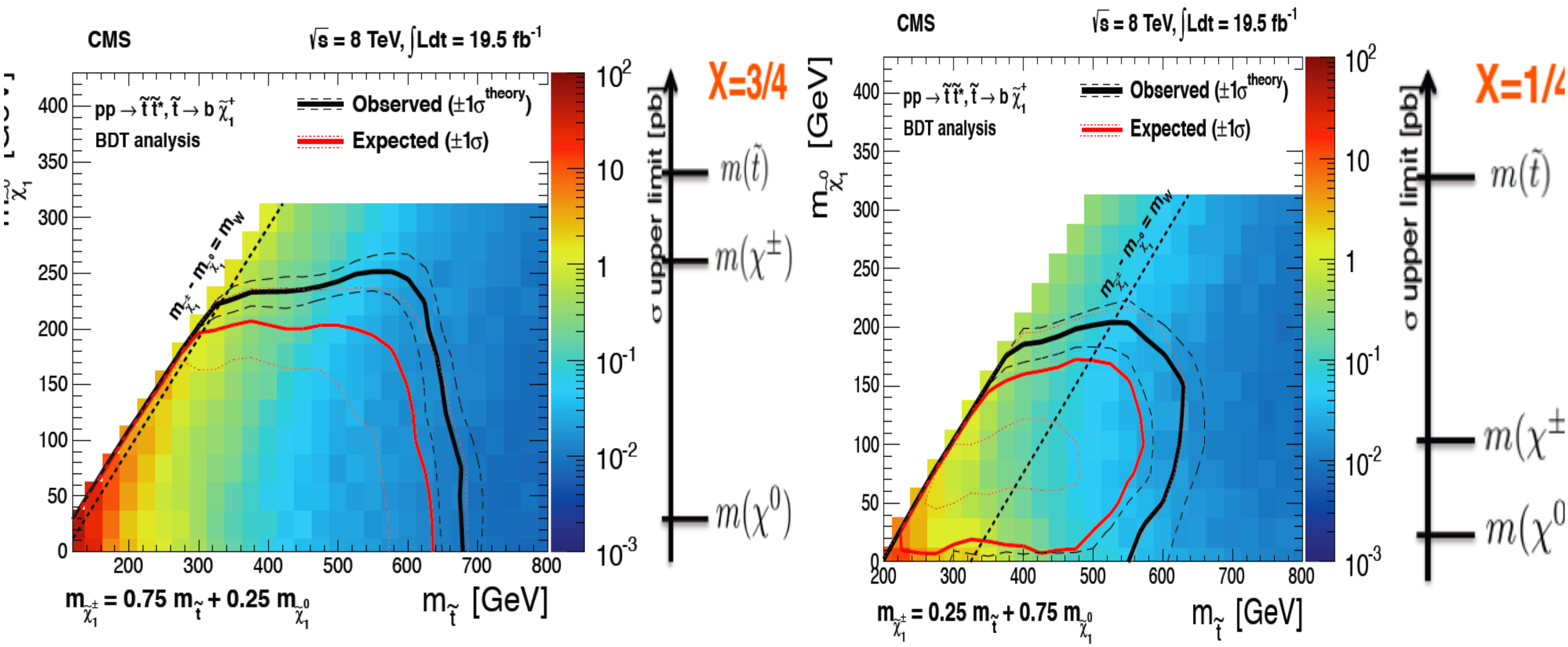
Interpretation of our results (1)

Different mass hierarchies are investigated.



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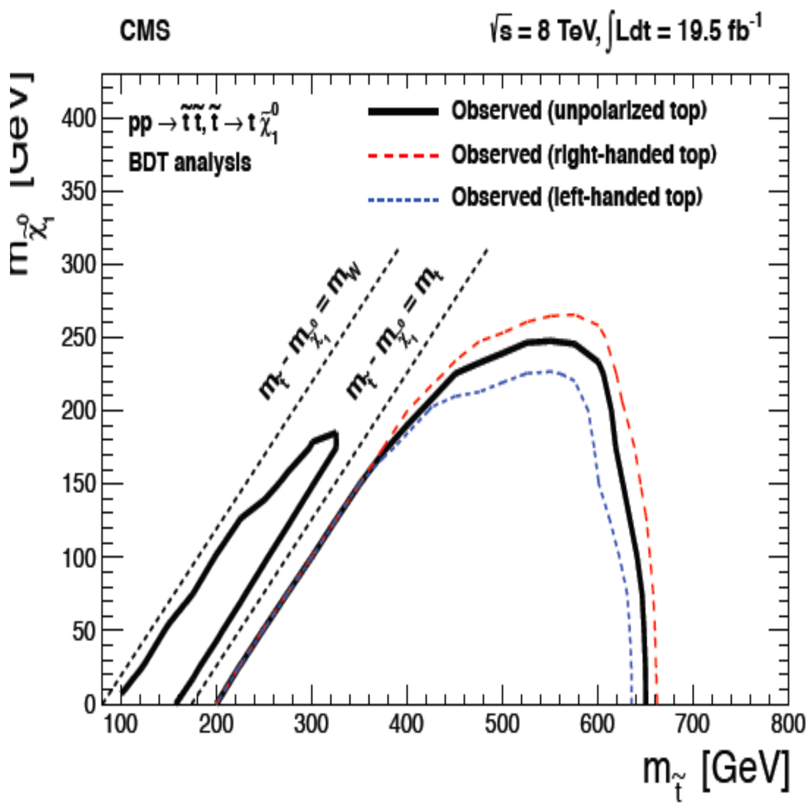
Interpretation of our results (2)

Small variation of the cross section UL for fully left and right handed polarized tops



SUS-13-011
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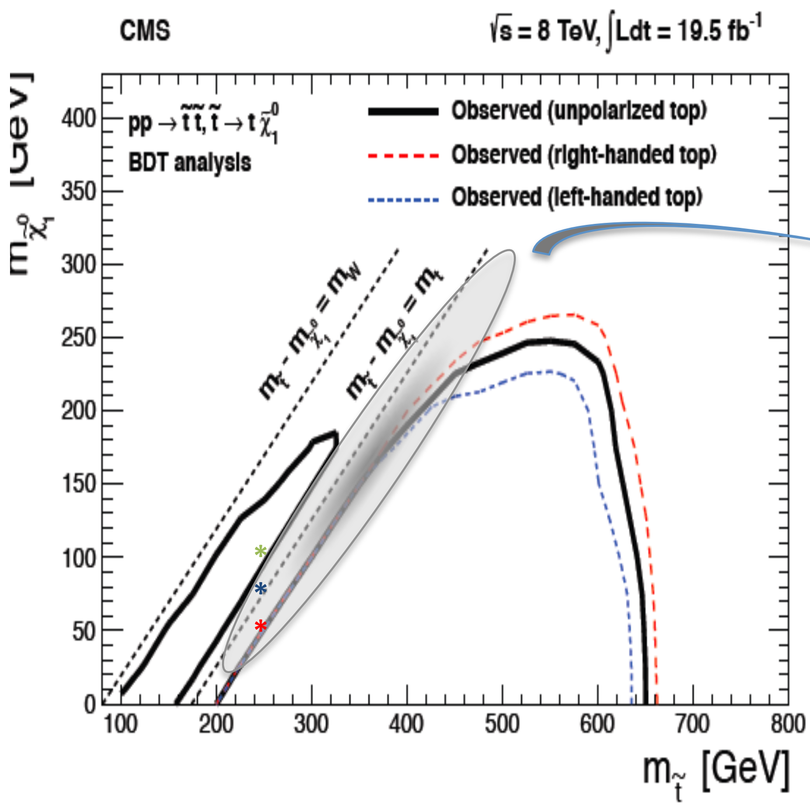
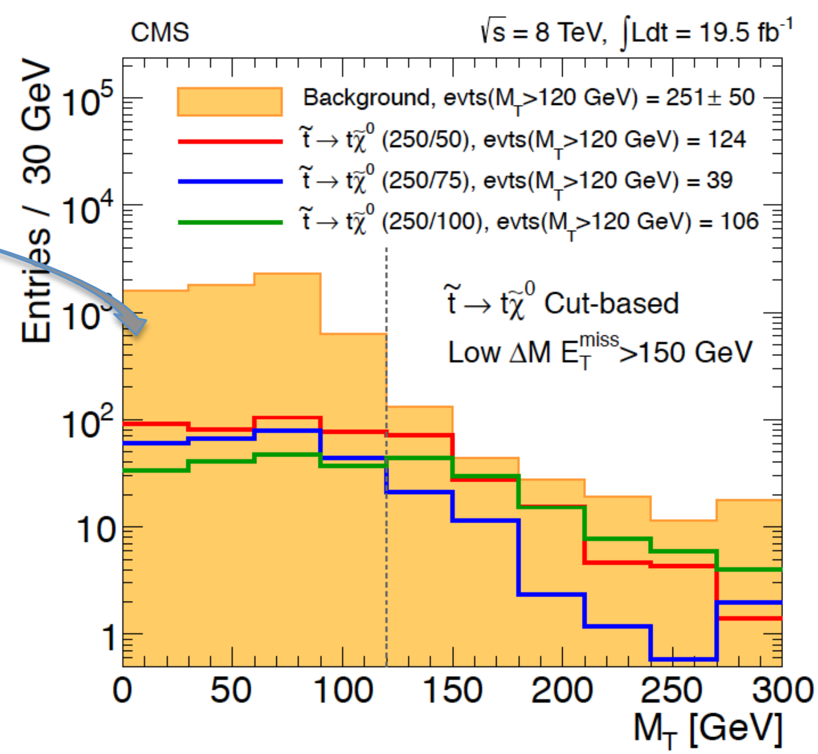


Still some unexplored region: when Δm(stop,LSP)~mTop the MT doesn't have a long tail



SUS-13-004
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS13004

razor

Cluster all objects in one events into two megajets

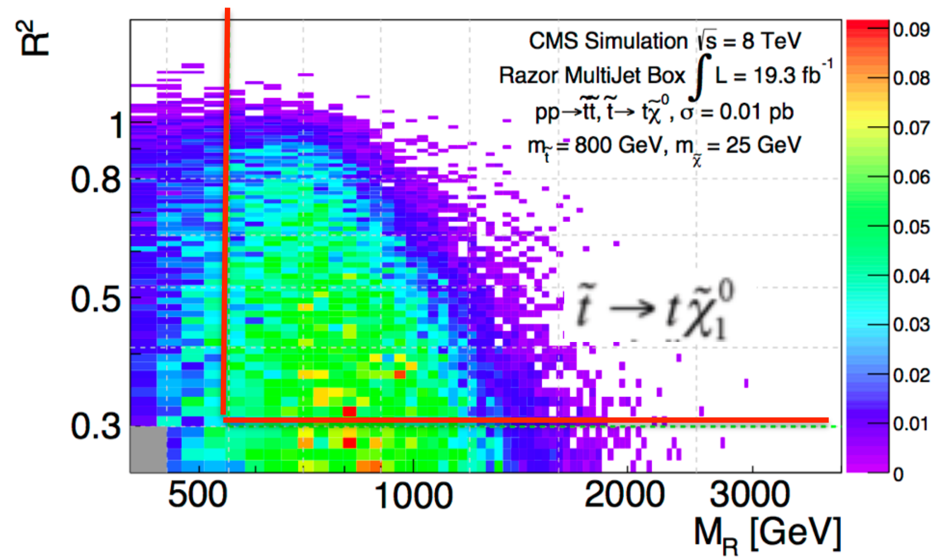
Reduce the pz impact by boosting to the rest frame in two megajets-system

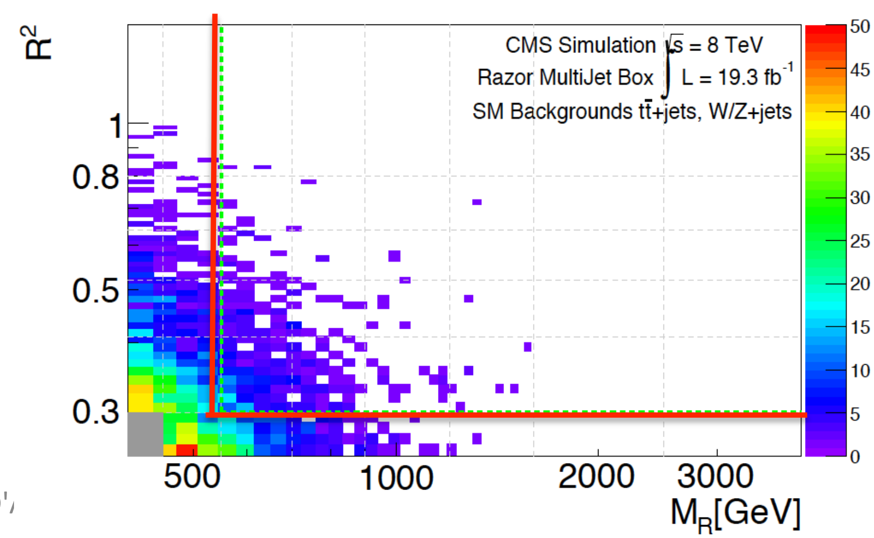
$$M_R \equiv \sqrt{(E_{j_1} + E_{j_2})^2 - (p_z^{j_1} + p_z^{j_2})^2}$$

Divide MET equally for each decay chain

$$M_T^R \equiv \sqrt{\frac{E_T^{miss}(p_T^{j1} + p_T^{j2}) - \vec{E}_T^{miss} \cdot (\vec{p}_T^{j1} + \vec{p}_T^{j2})}{2}}$$

$$R \equiv \frac{M_T^R}{M_R}$$



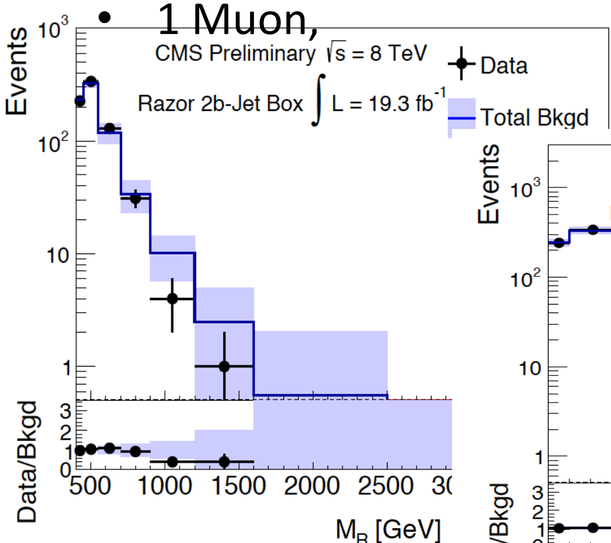


SUS-13-004
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS13004

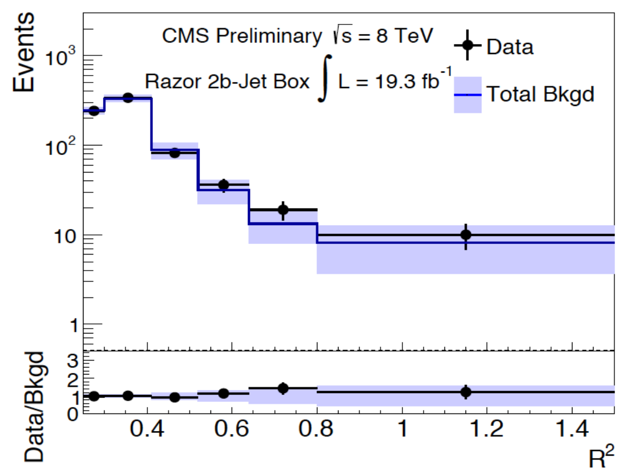
razor

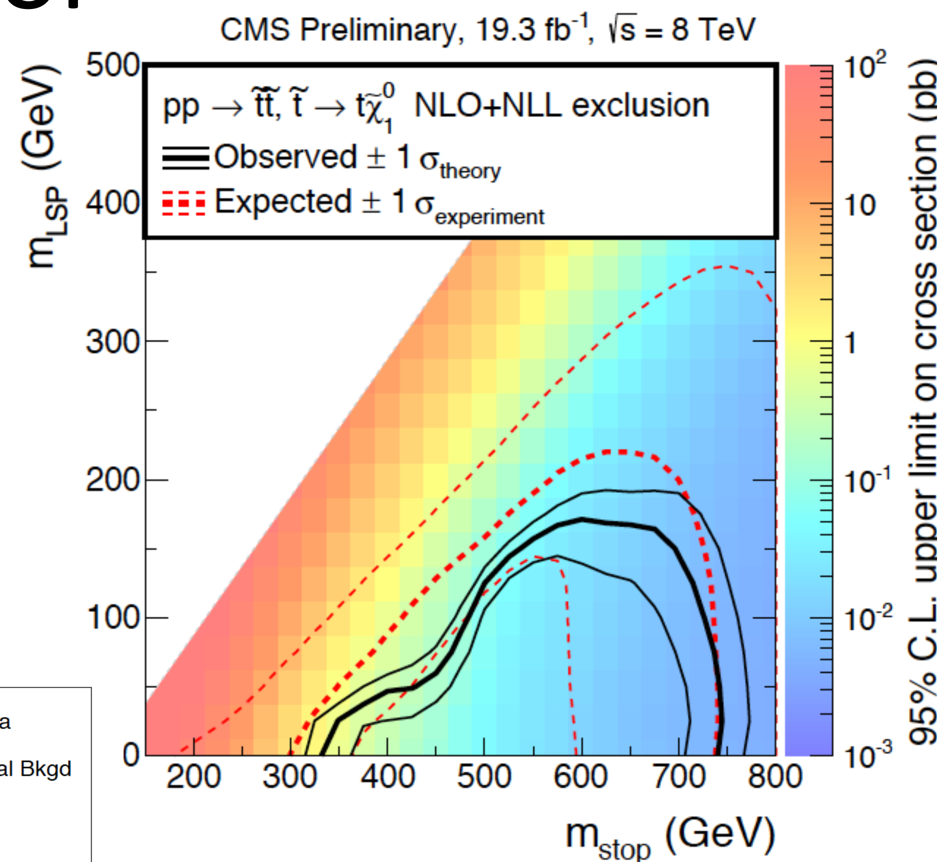
Events are classified in exclusive categories and the R^2 and M_R distribution are simultaneously fitted in each of them.
For the stop searches, the most sensitive categories are

- 0 lepton, >=1b , >=4 jets
- 0 lepton, >=2b
- 1 Muon,



Here 1d projection

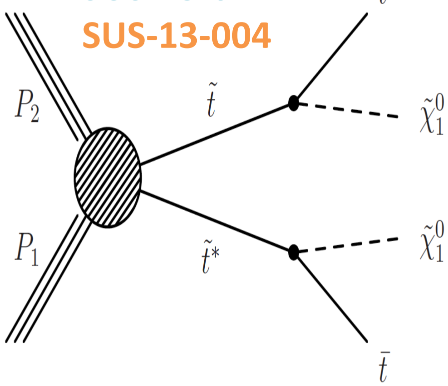


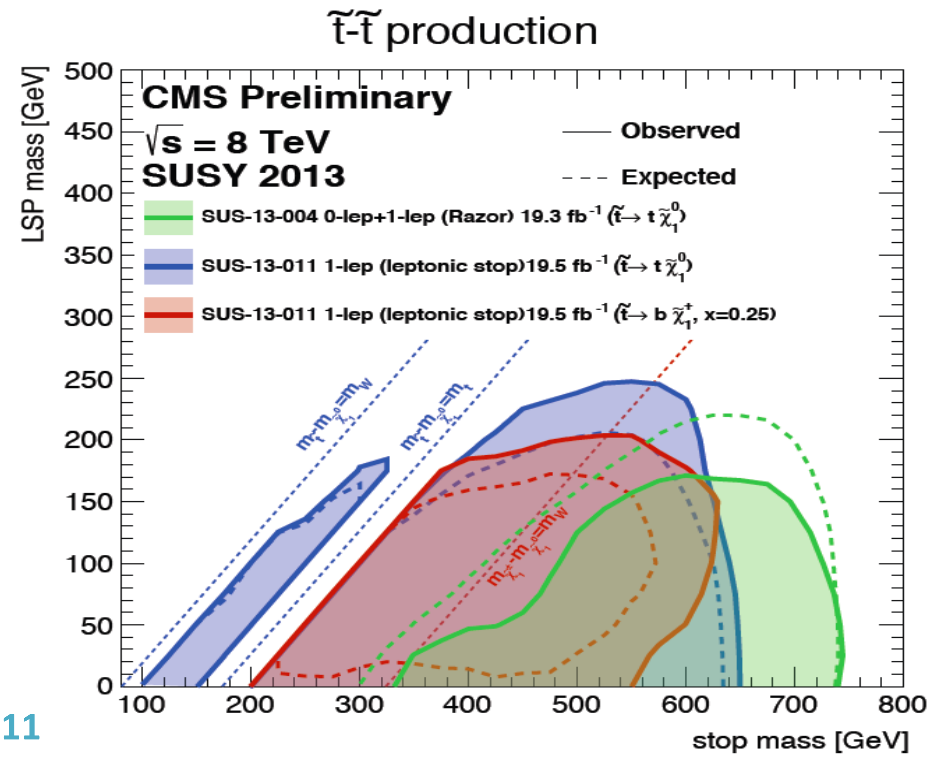


See more details in J.Thompson talk

summary direct stop production

SUS-13-011
SUS-13-004





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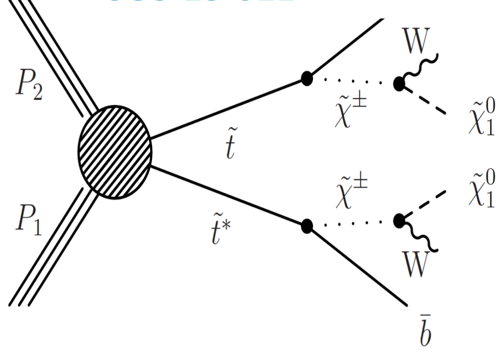
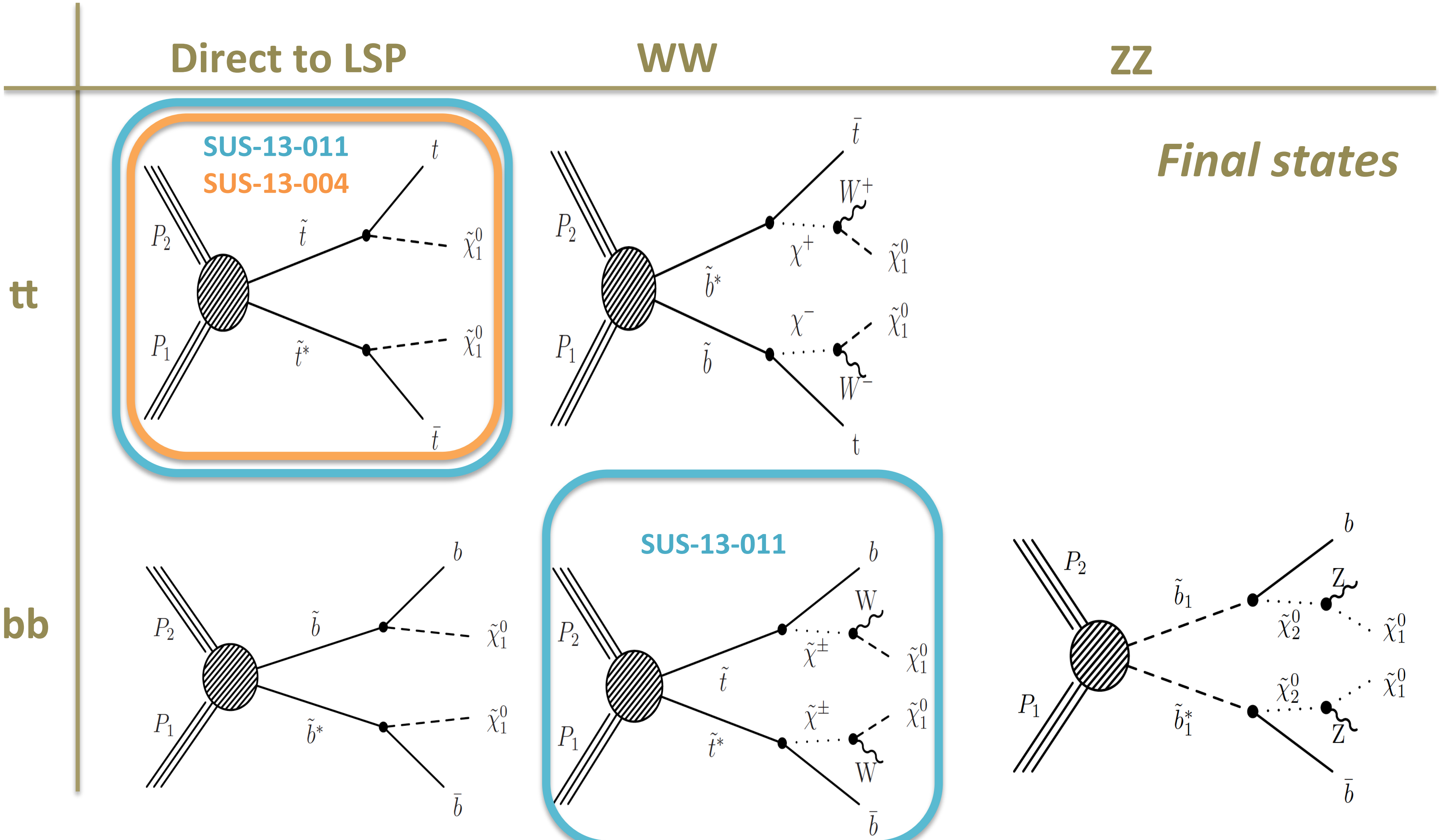


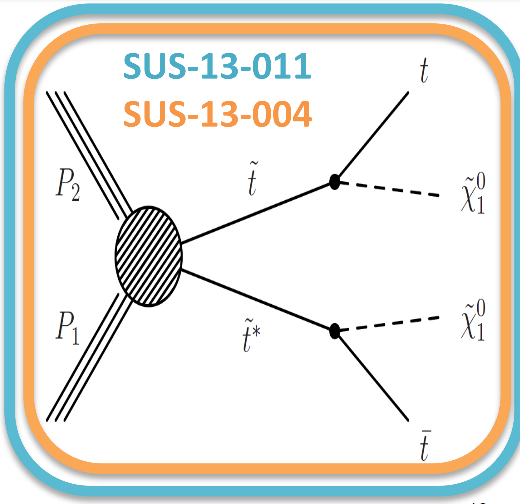
Other possibilities covered too

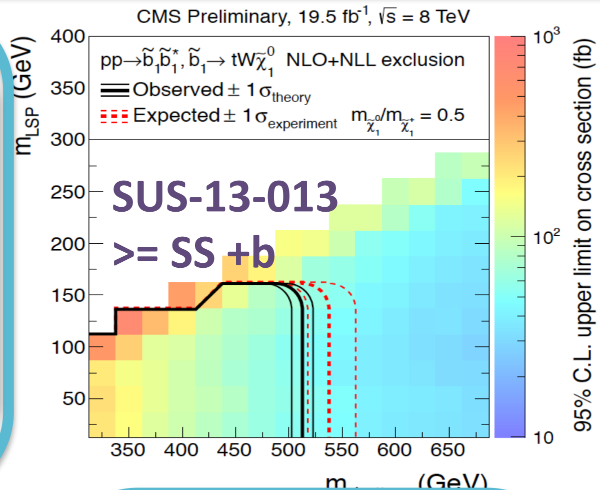


Other possibilities covered too

	Direct to LSP	WW	ZZ

tt

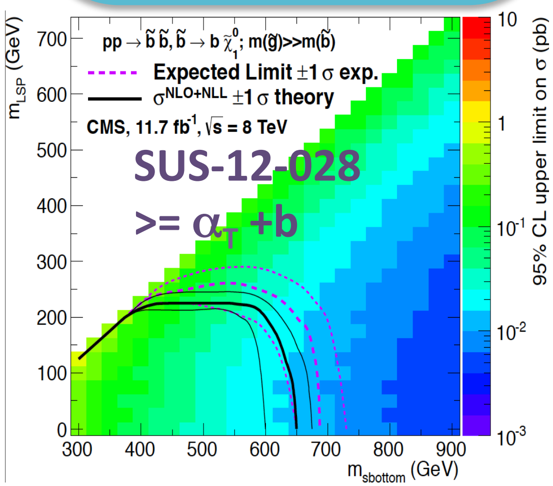


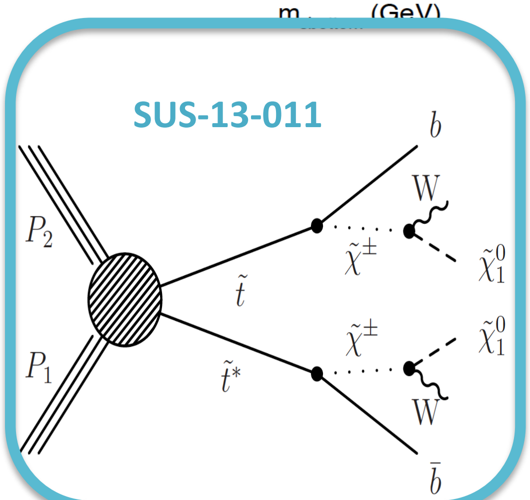


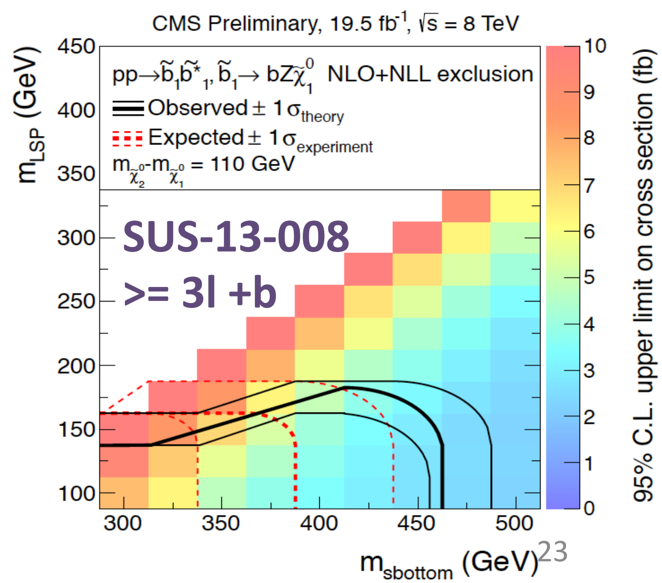
Final states

See
SUS-13-028 J.Thompson
SUS-13-013 M.Buchmann
SUS-13-008 A.Gozzellino

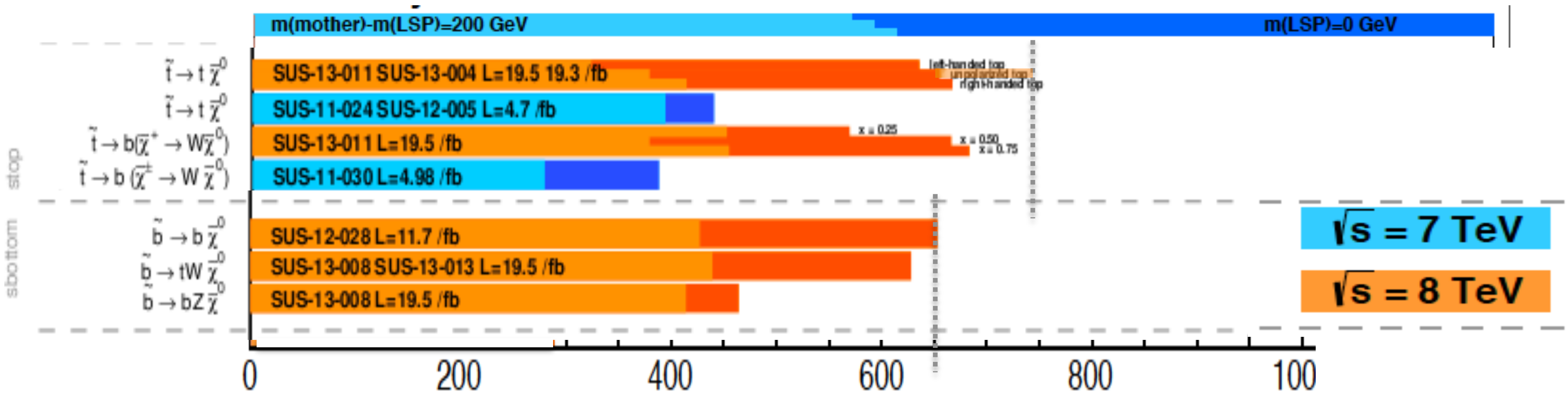
bb







Summary and conclusions



- Dedicated searches for the 3rd generation squarks started at 7 TeV with 5 fb^{-1} .

- Progressively covering more phase space at 8 TeV.
  - Covered different decay modes with different signatures.
  - More updates coming soon.

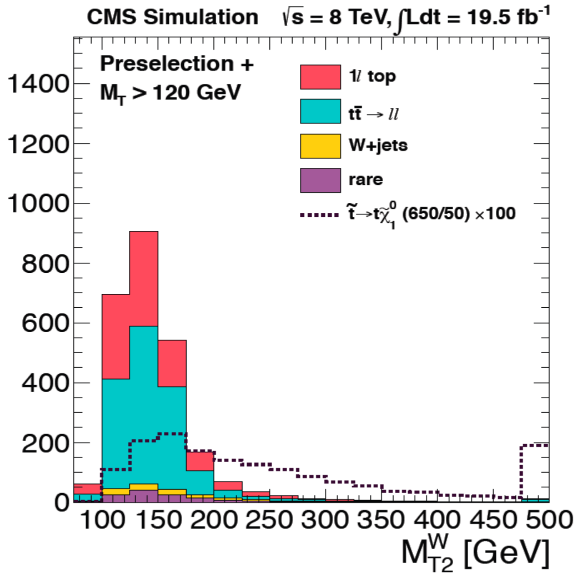
- Looking forward to the 14 TeV run.

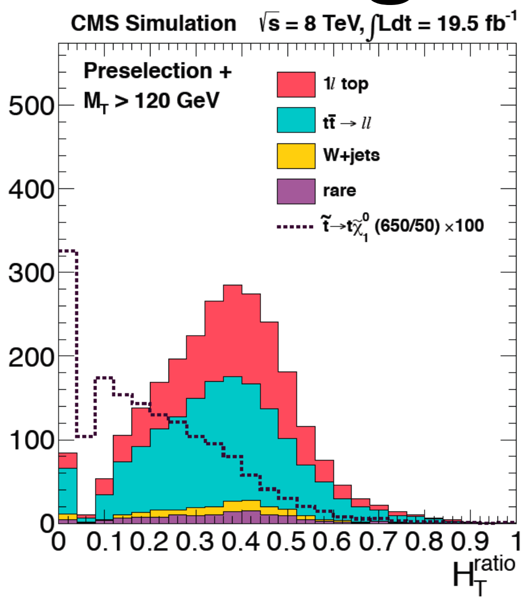
backup

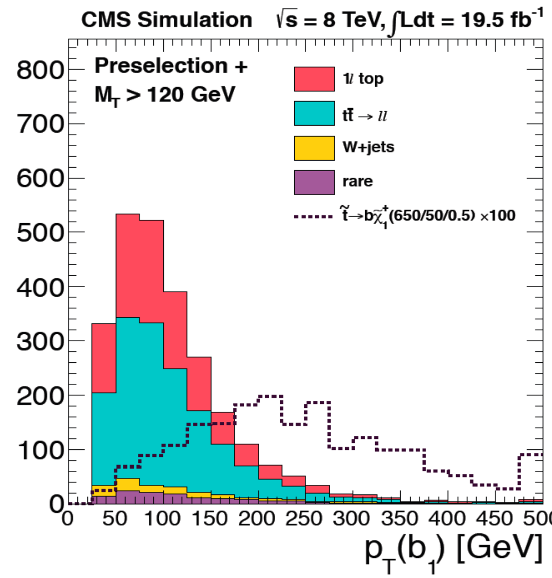
SUS-13-011

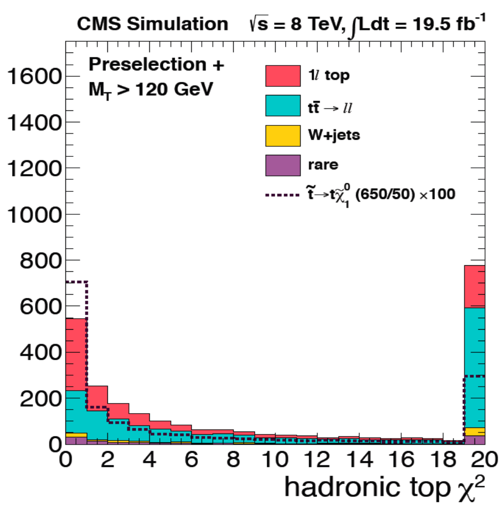
http://arxiv.org/abs/1308.1586

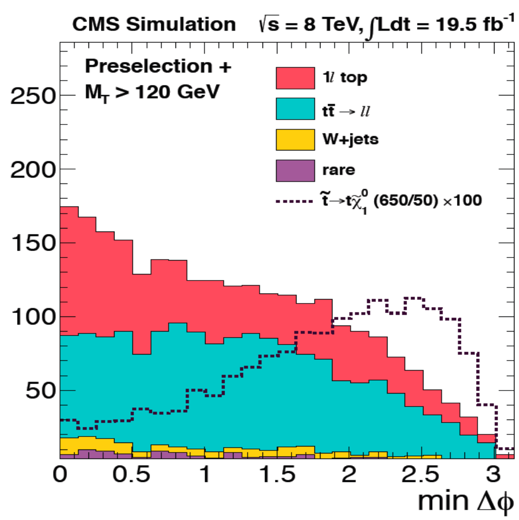
Discriminating variables

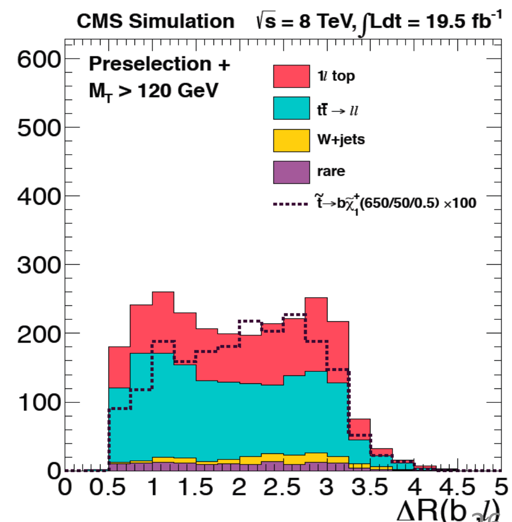








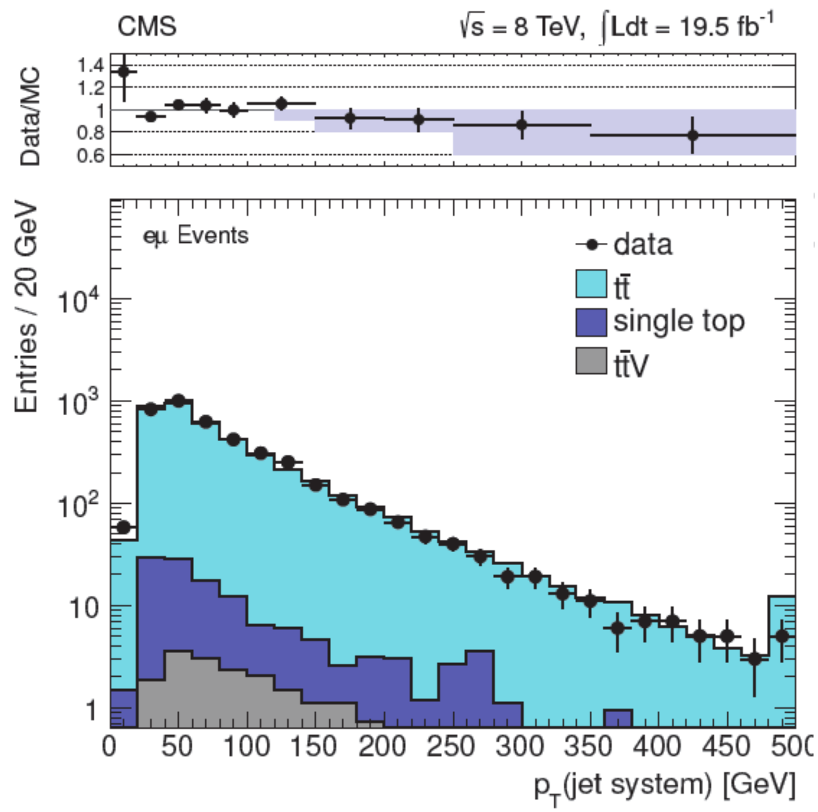




SUS-13-011
http://arxiv.org/abs/1308.1586

Interpretation of our results

Investigated DATA/MC comparison for the ttbar recoil system.
The signal acceptance are corrected.



SUS-13-011
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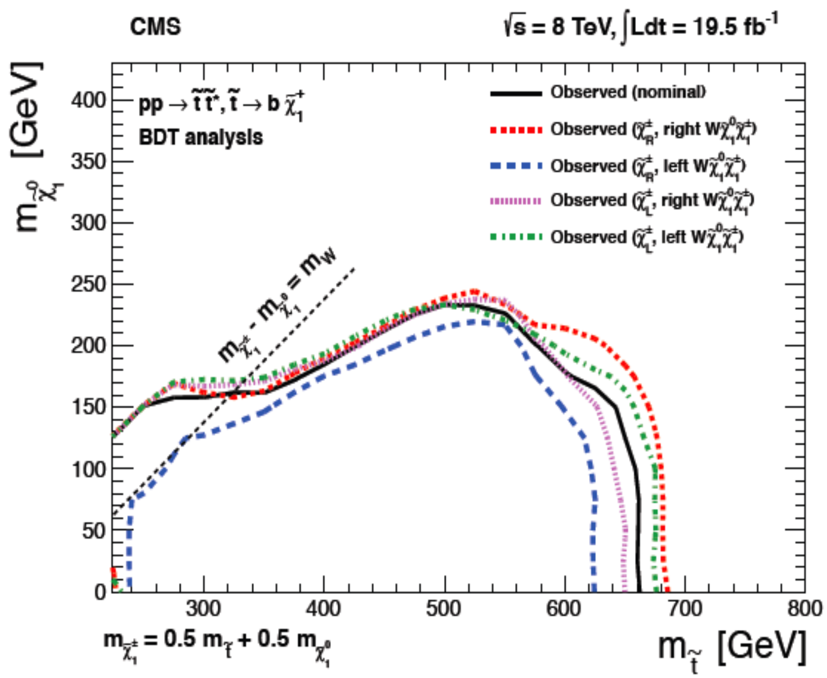
More on polarization

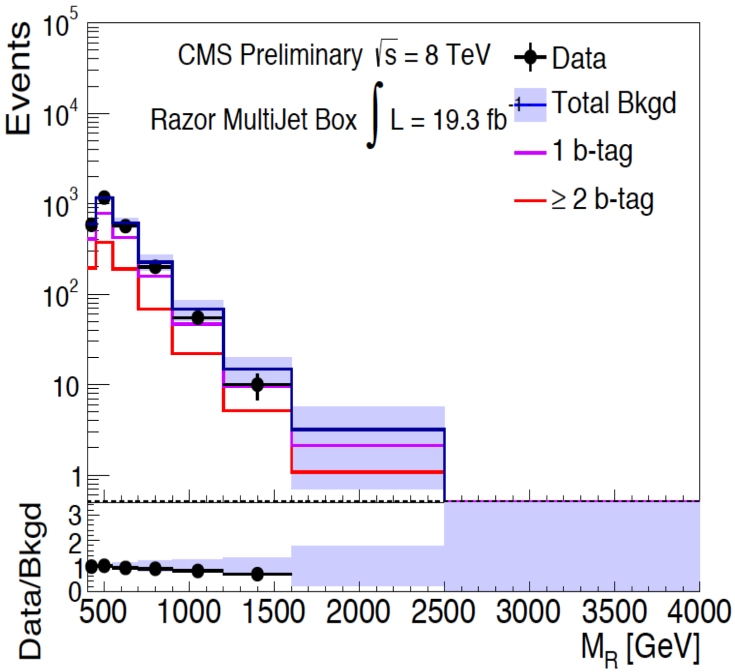
Top polarization in stop decay depends on left/right stop mixing and the LSP composition.
The top polarization to left-handed and right handed scenario has impact on the lepton p_T and M_T .

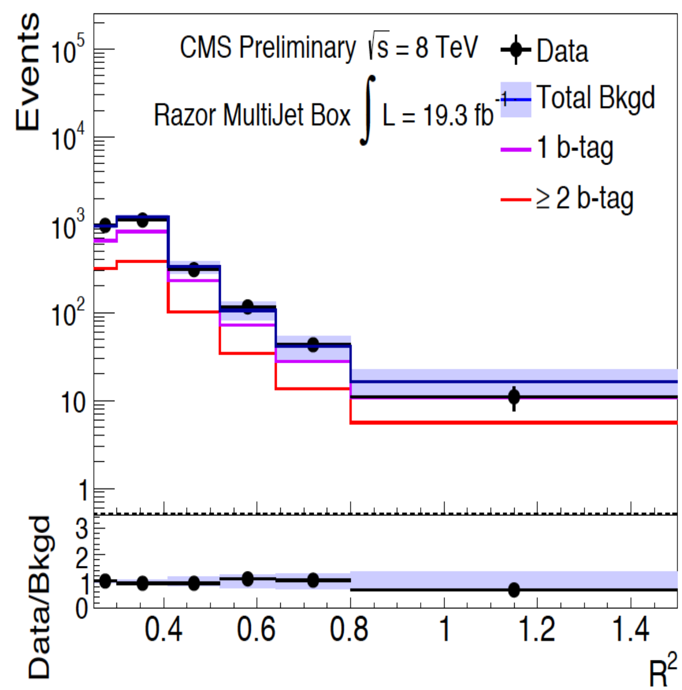


SUS-13-004
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS13004

RAZOR

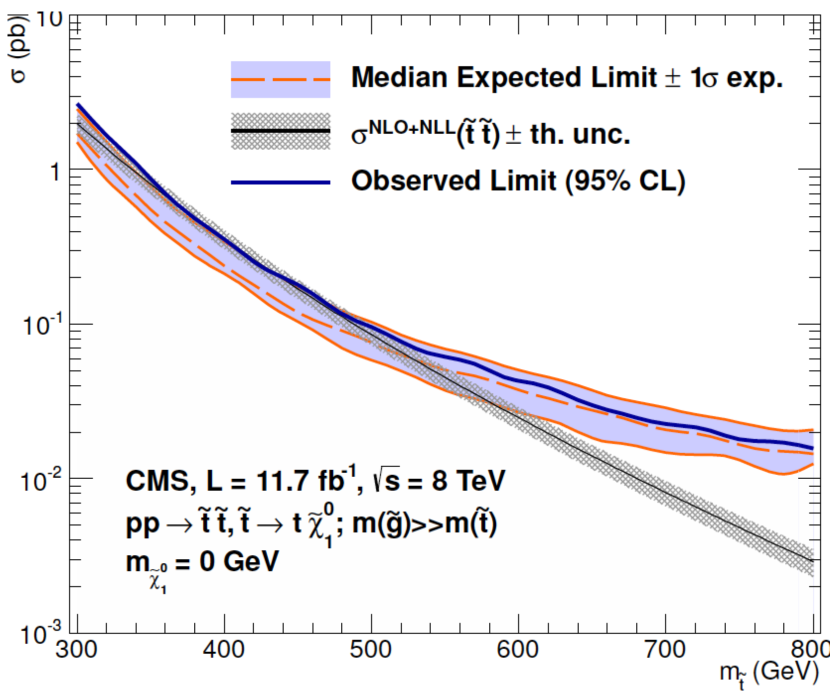
SUS-13-004





Other stops bounds

SUS-12-028 - alphaT

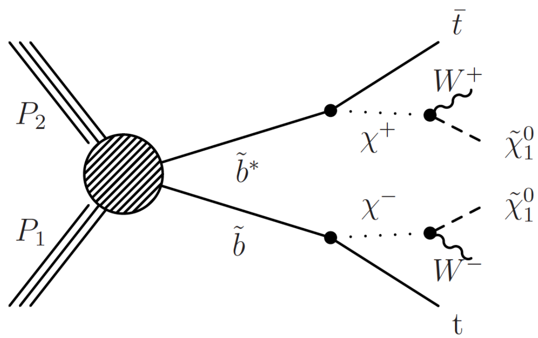


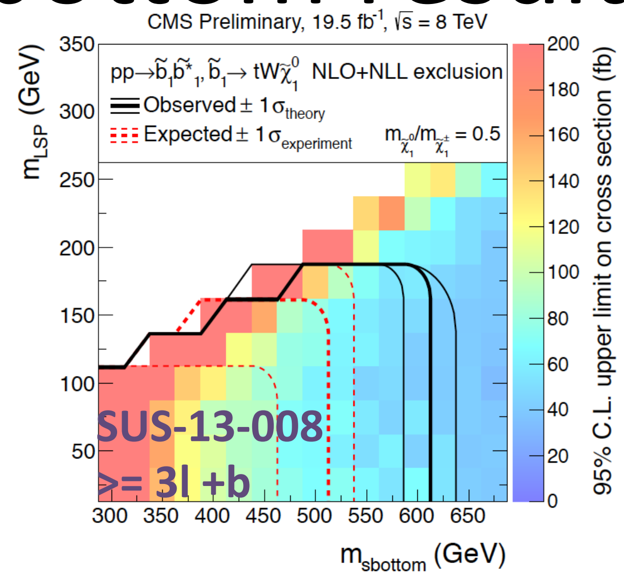
SUS-13-013/SUS-13-008

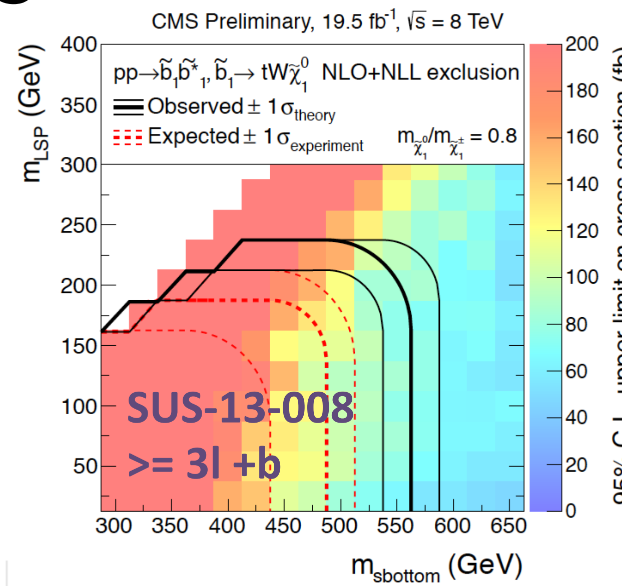
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS13013

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS13008

Sbottom results







Different mass hierarchies .

Different signatures investigated too.