Search for SUSY in events with one lepton, jets and MET in CMS at √s=13 TeV

Artur Apresyan

on behalf of CMS Collaboration

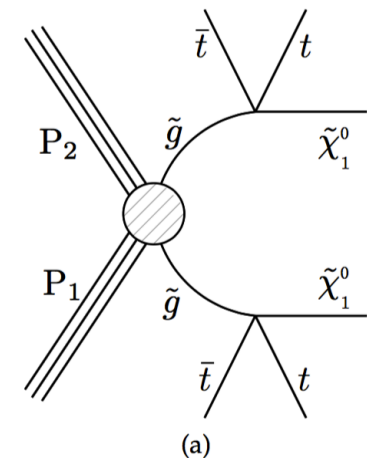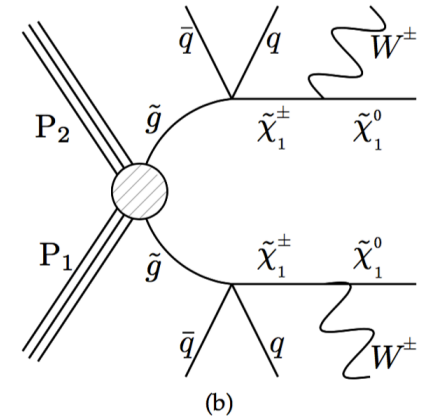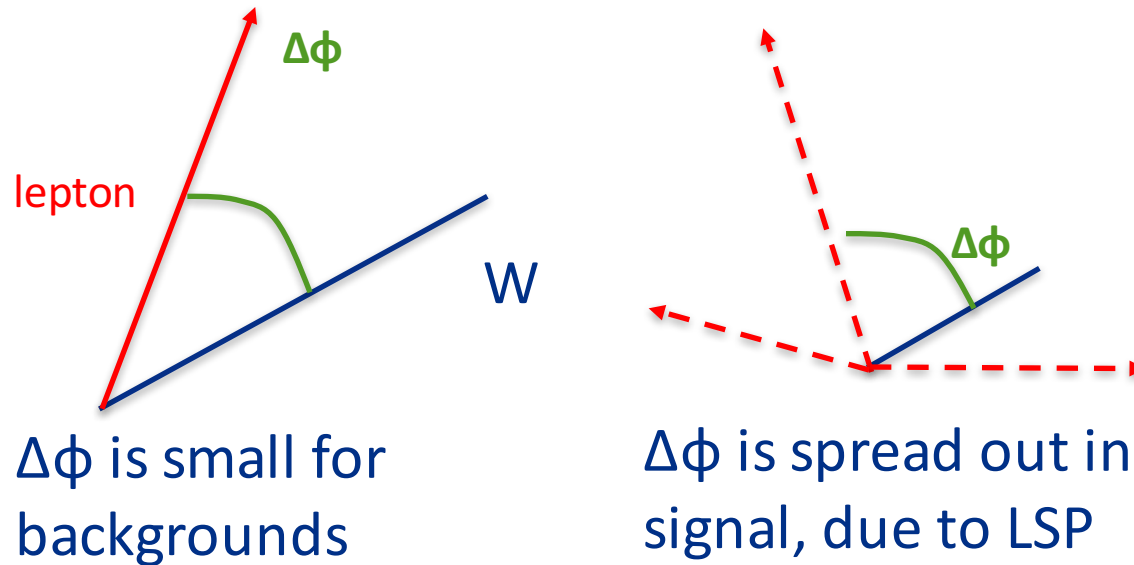38th International Conference on High Energy Physics

04/09/2016

Searches with one lepton in final state

- Sensitivity to production of gluinos, stops and EWK SUSY

- Presence of a well identified lepton helps to reduce hadronic backgrounds
  - Main backgrounds: ttbar and W+jets, QCD

- Signatures with multiple tops: large fraction of signals have ≥1 lepton
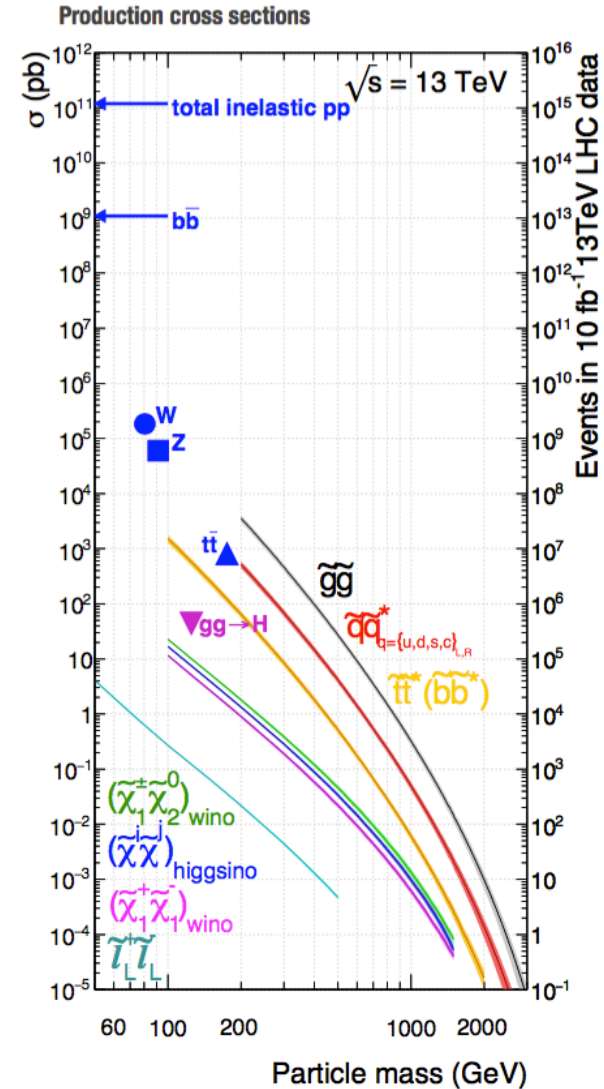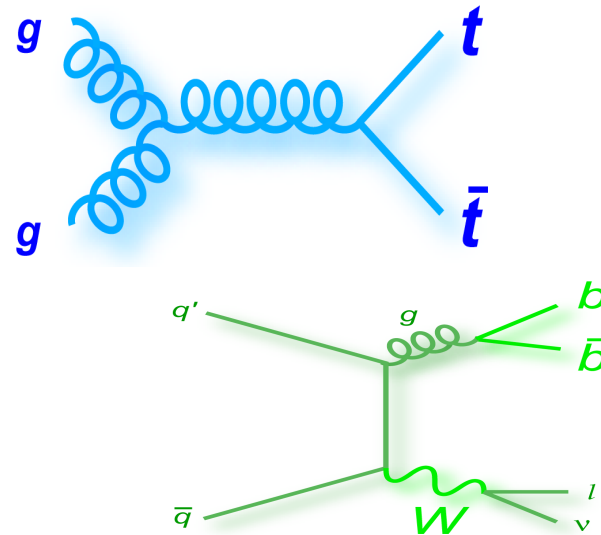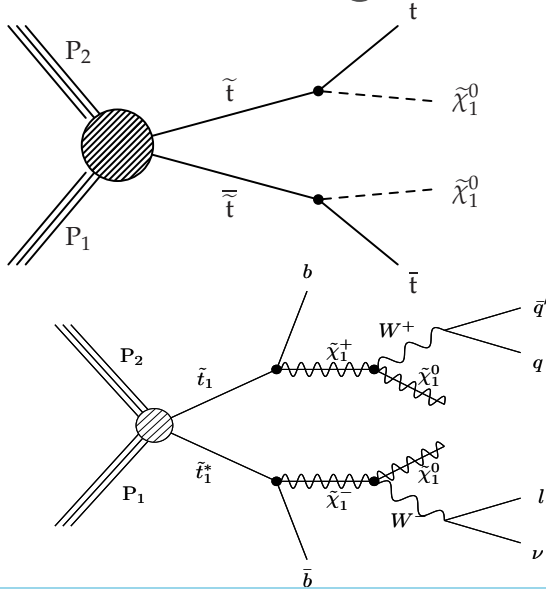
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Gluino search with 1-lepton

- Main backgrounds from ttbar and W+jets
- Exploit the difference in W decay kinematics

Δφ is small for backgrounds

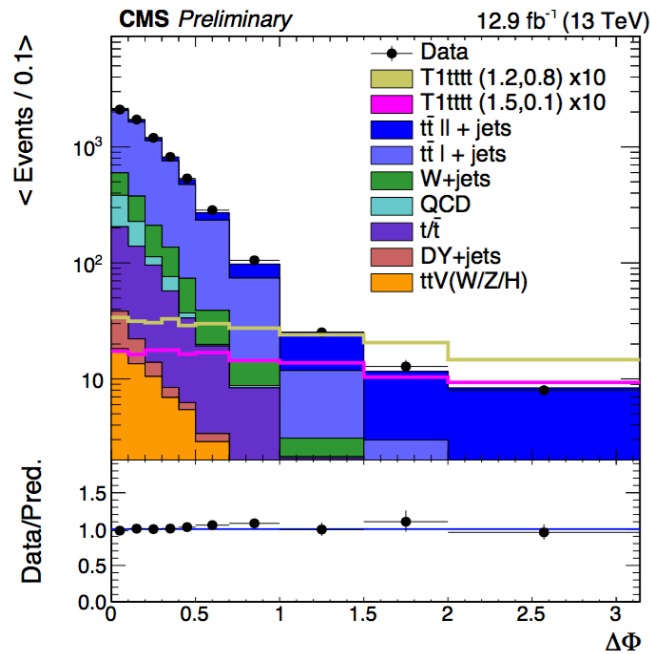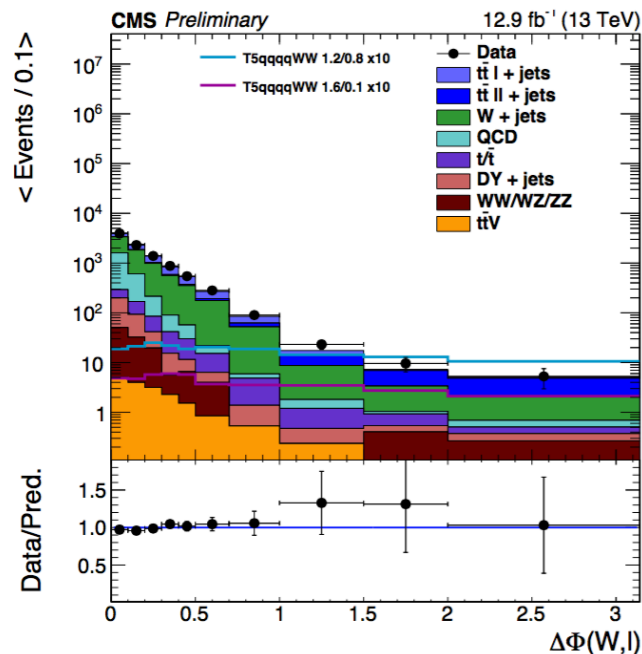Δφ is spread out in signal, due to LSP

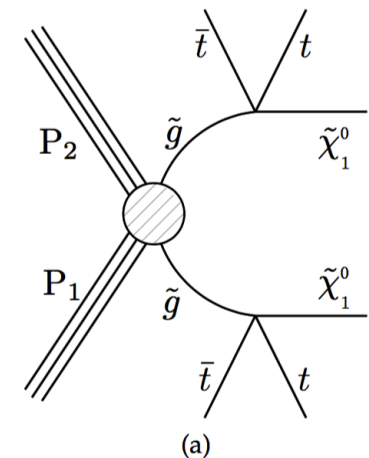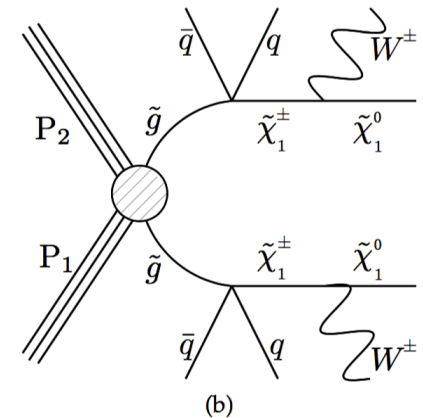A. Apresyan | ICHEP 2016

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Gluino search with 1-lepton

- Main backgrounds from ttbar and W+jets
- Exploit the difference in W decay kinematics

Events with many b-jets

Events with 0 b-jets

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Event selections
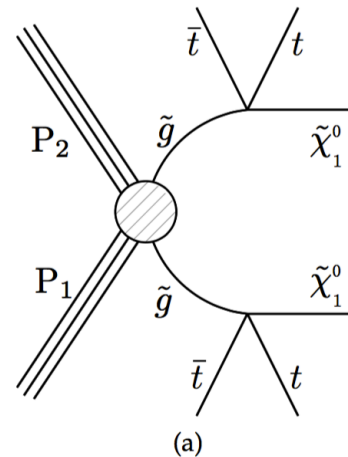
- Event selection:
  - Exactly 1 electron or muon $p_T > 25$ GeV
  - ≥ 5 (0-b) or ≥ 6 (multi-b) anit-k_t jets
  - $H_T > 500$ GeV; $L_T > 250$ GeV

- Signal regions defined by sliding $\Delta\phi$ cut: $\Delta\phi > 0.5, 0.75, 1.0$
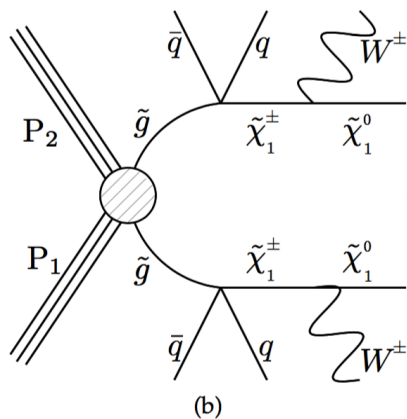
0-b,
Less jets,
SR binned in
LT, HT, Δφ
Bkgd: ttbar
and W+Jets

Many b-jets,
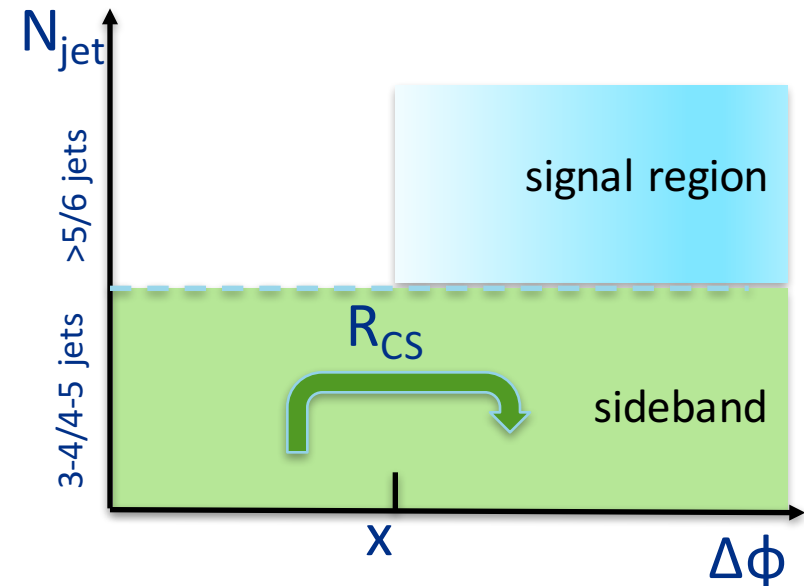Many jets,
SR binned in
LT, HT, Δφ
Bkgd: mostly
ttbar

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ttbar and W+jets backgrounds

- Use low Δφ regions to derive translation factors
  - Translation factors R_{CS} derived in low N_{jet} sidebands

$$R_{CS} = \frac{N^{\text{All backgrounds except QCD}}(\Delta\phi > x)}{N^{\text{All backgrounds except QCD}}(\Delta\phi < x)}$$

- **Multi-b** SR: one R_{CS} for all EWK backgrounds

- **0-b SR**: R_{CS} derived separately for W+jets and ttbar: fit N_b shape

- Extrapolation from low to high N_{jet} obtained from MC

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ttbar and W+jets backgrounds

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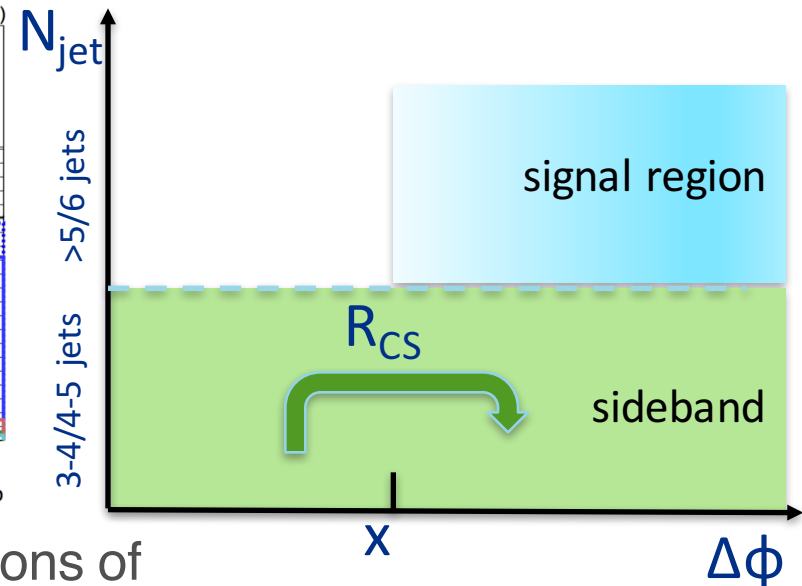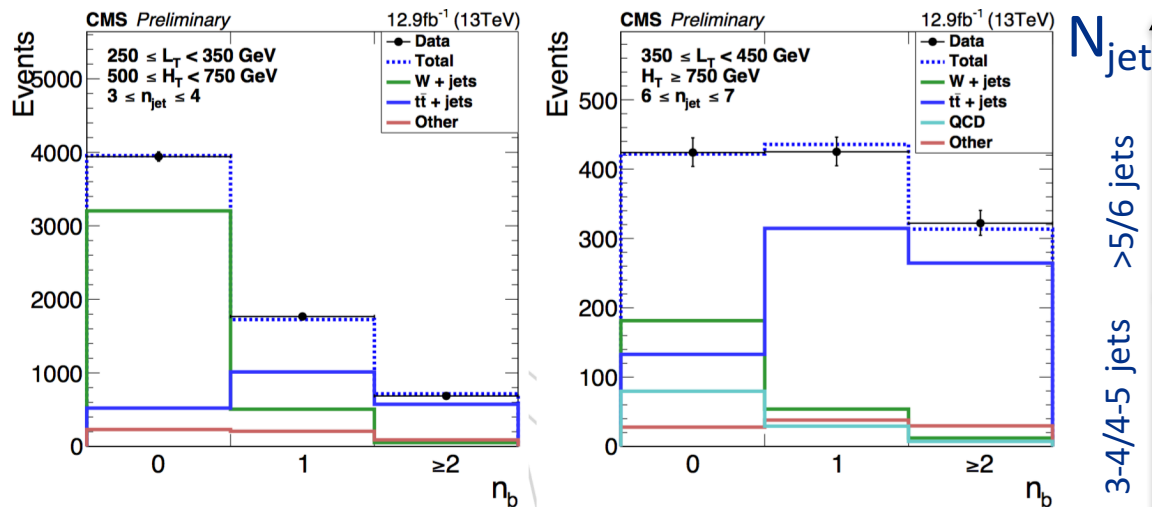

- Template fit to N_b to extract relative fractions of tt and W+jets

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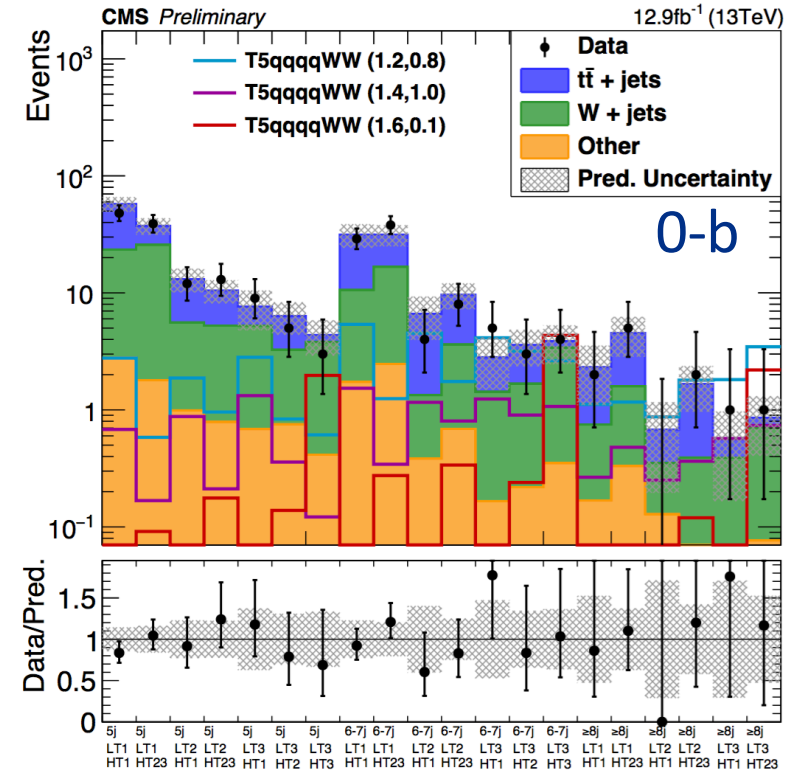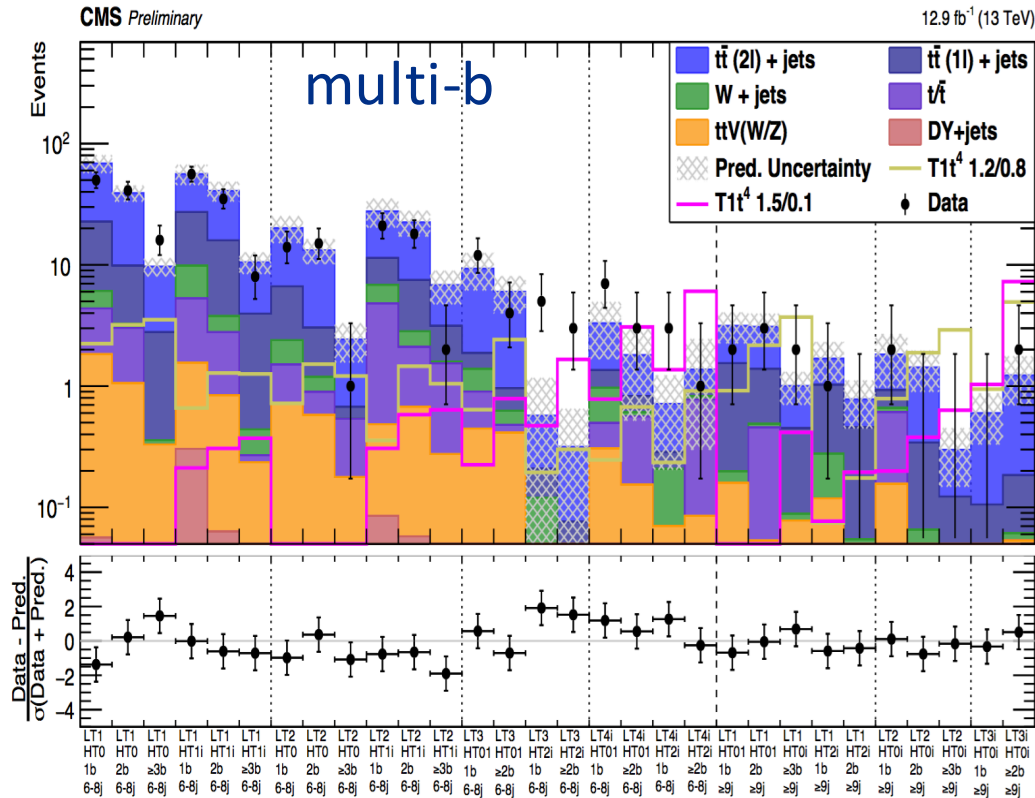
Results

- No significant deviations from data observed in the signal regions

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Results

- Exclude gluino masses
  - T1tttt: up to 1.65 TeV for neutralino masses ≤ 900 GeV
  - T5qqqqWW: up to 1.6 TeV for neutralino masses ≤ 600 GeV

RPV gluino search in 0- and 1-leptons

- Search for new physics with a high N_{jets} and N_b signature
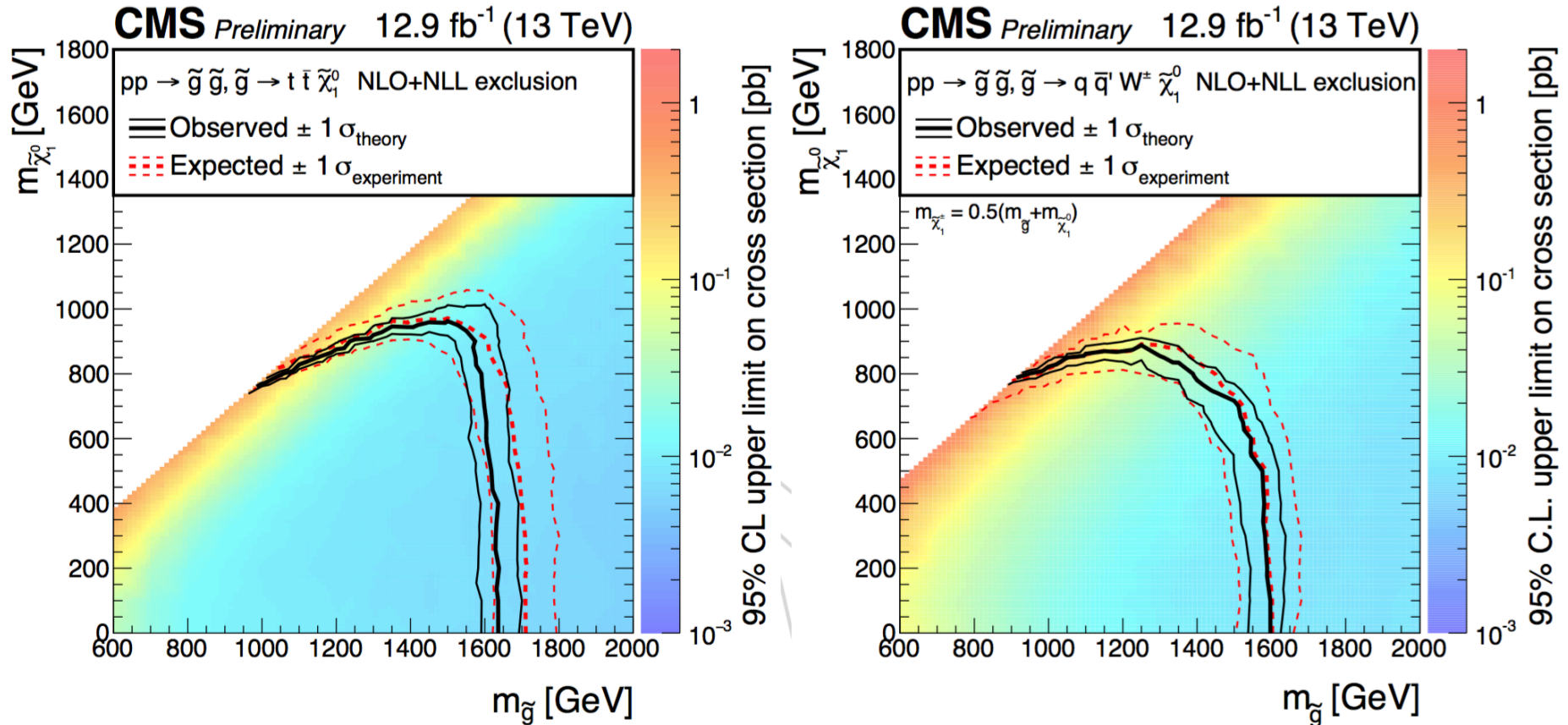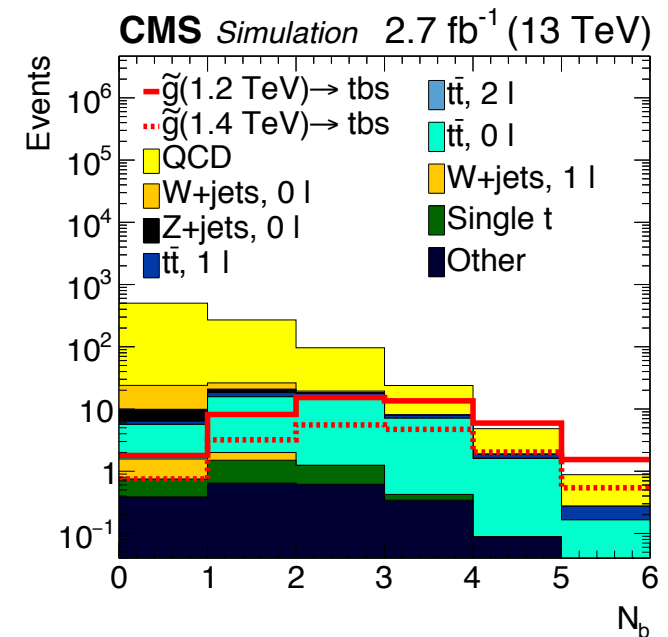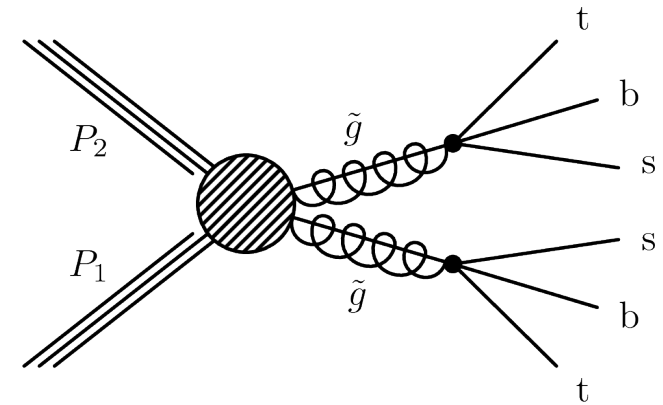 - 0 and 1 lepton final state
  - No MET requirement
  - Main backgrounds: QCD and ttbar

- Benchmark model is RPV SUSY with gluino→tbs
  - Using 2.7 fb-1 of 2015 data

- Search for excess in N_b distribution
  - Fit N_b distribution in bins of N_j and M_J

CMS *Simulation* 2.7 fb^{-1} (13 TeV)

Legend:
- $\tilde{g}(1.2\ \mathrm{TeV}) \to$ tbs
- $\tilde{g}(1.4\ \mathrm{TeV}) \to$ tbs
- QCD
- W+jets, 0 l
- Z+jets, 0 l
- t$\bar{t}$, 1 l
- t$\bar{t}$, 2 l
- t$\bar{t}$, 0 l
- W+jets, 1 l
- Single t
- Other

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Event selections

- 0 or 1 lepton with $P_T > 20$ GeV

- ≥ 4 Jets with $P_T > 30$ GeV; $N_b \geq 1$

- $H_T > 1500$ GeV (1200 GeV) for 0-lepton (1-lepton) selection

- $M_J > 500$ GeV; M_J is re-clustered from R=0.4 anti-k_t jets

- Data sample split into control and signal regions based on N_j, N_b, and M_J

N_{lep}	M_J [GeV]	N_{jet}			
		$4-5$	$6-7$	$8-9$	≥ 10
0	$500-800$	CR	CR	SR	SR
	> 800	CR	CR	SR	SR
1	$500-800$	CR	SR	SR	
	> 800	CR	SR	SR	

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QCD background estimation

- Flavor composition of QCD events may not be well-modeled

  – Template fit to b-tag discriminant shape

  – Reweight MC with fractions obtained from the fit

- Vary the fit range; and fit in sideband to assess systematic uncertainty
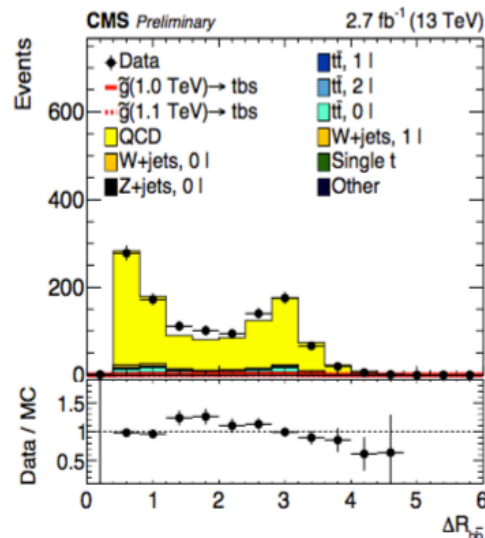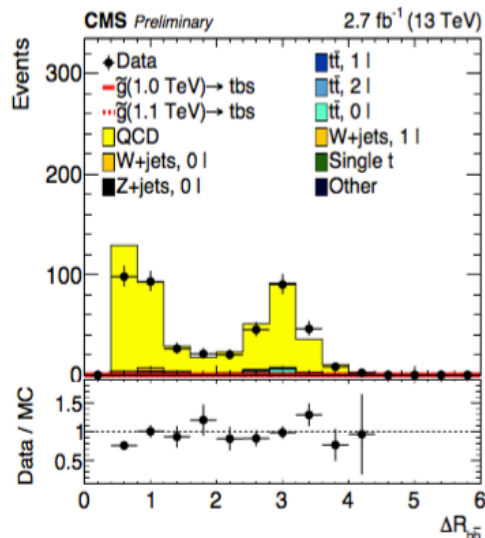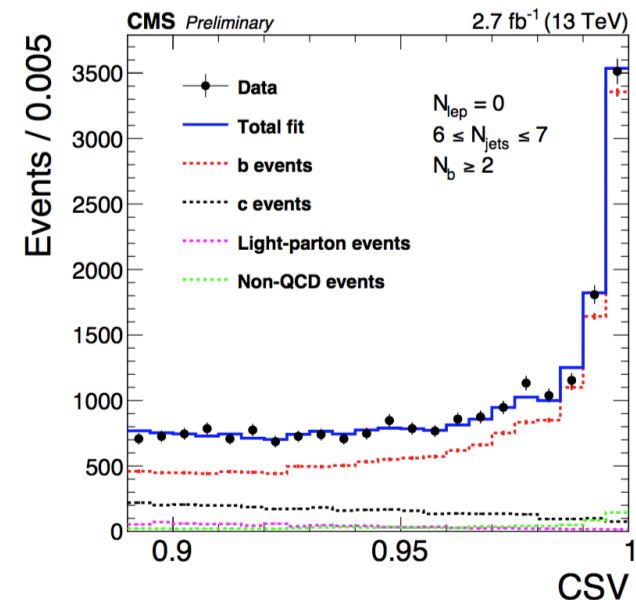
- Measure the uncertainty from gluon splitting mis-modeling

  – Normalize in high ΔR_{bb} region; and measure mis-modeling in low ΔR_{bb}

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Results

- Likelihood template fit of N_b distribution in bins of N_j and M_J

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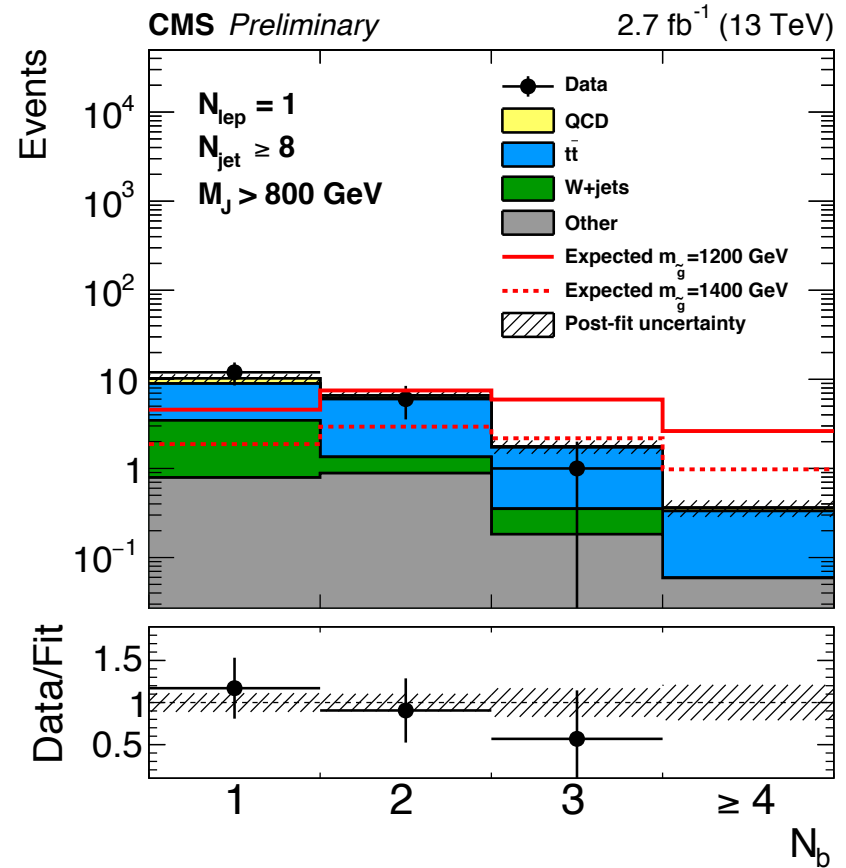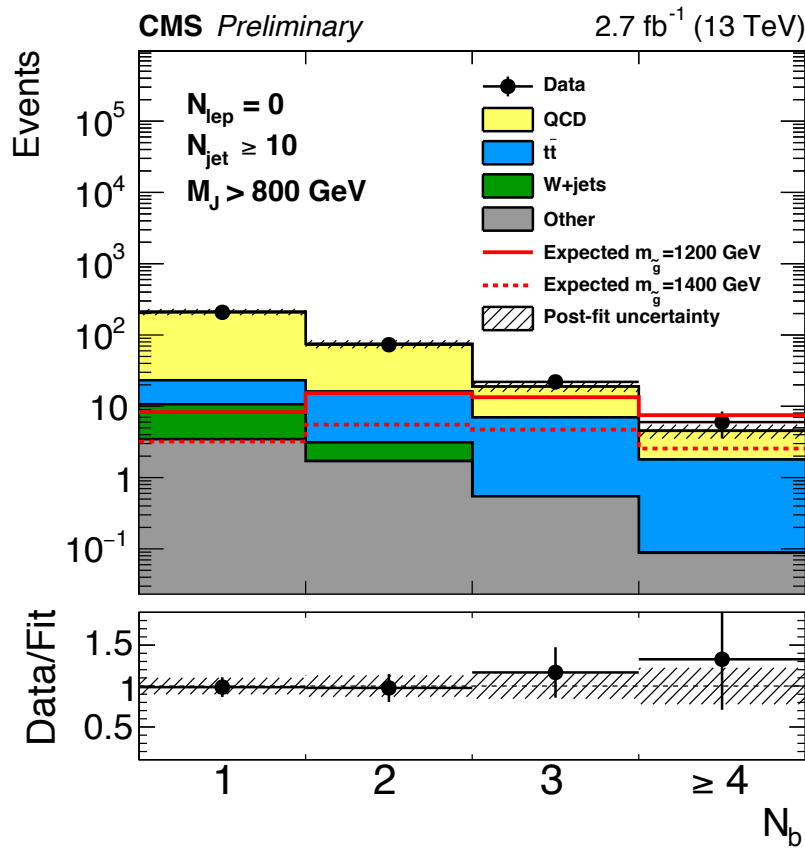
Results
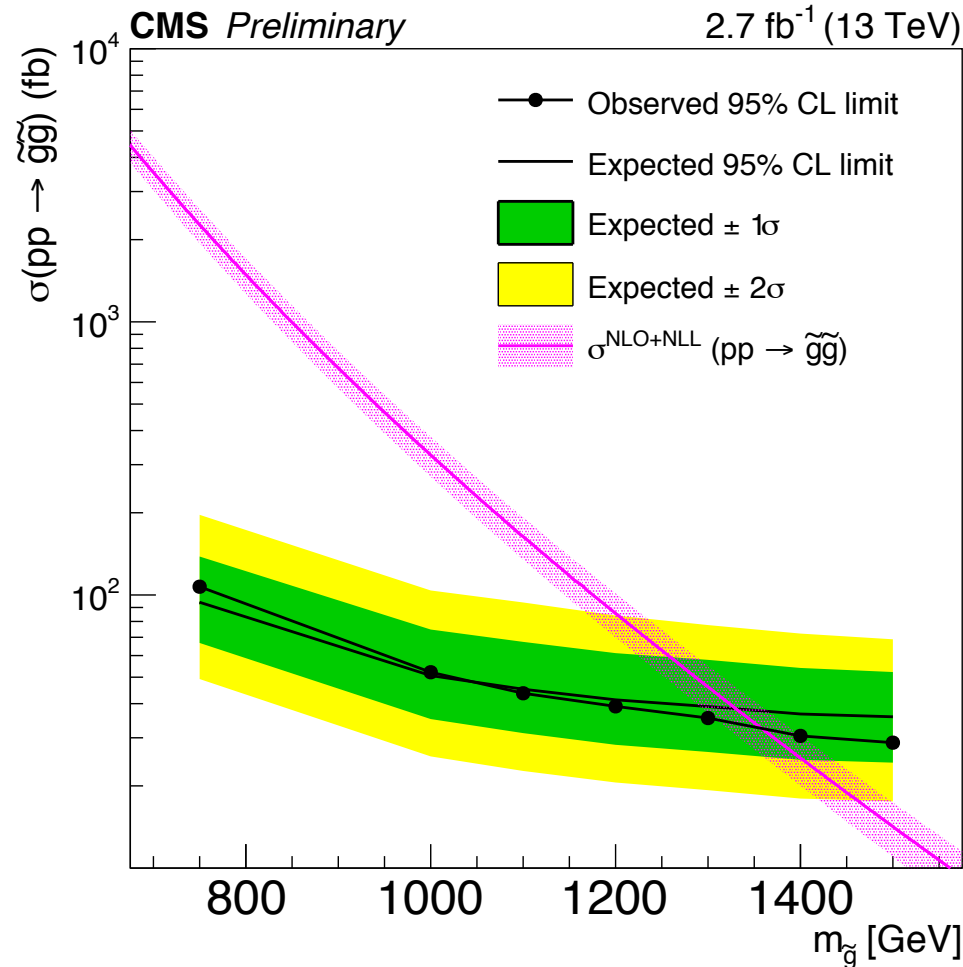
- Data is found to be consistent with background expectation
- Exclude RPV gluino production with masses below 1360 GeV

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EWK SUSY searches

- Chargino-netralino production
  - $\tilde{\chi}_2^0 \to H\tilde{\chi}_1^0$: Higgs boson in the H→bb channel
  - $\tilde{\chi}_1^\pm \to W\tilde{\chi}_1^0$: W boson leptonic decay
- Search performed in M_{bb} distribution
  - Extra MET from signal helps to separate backgrounds
- Main backgrounds: ttbar and W+jets

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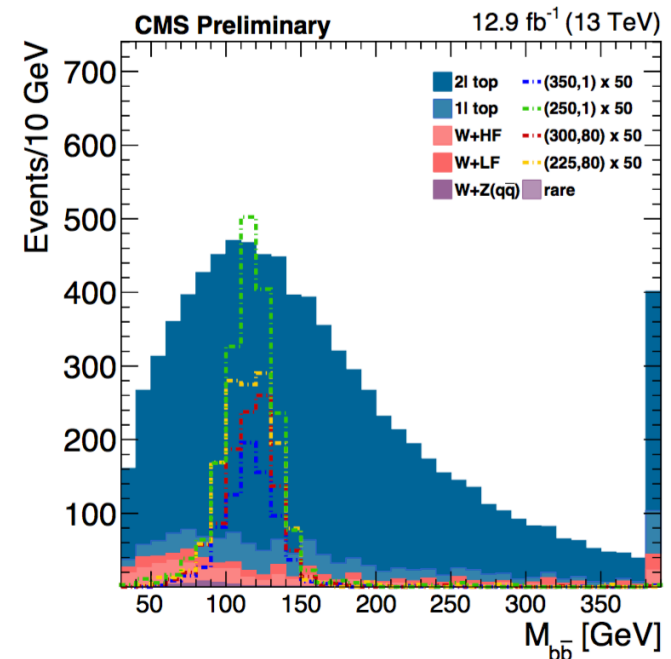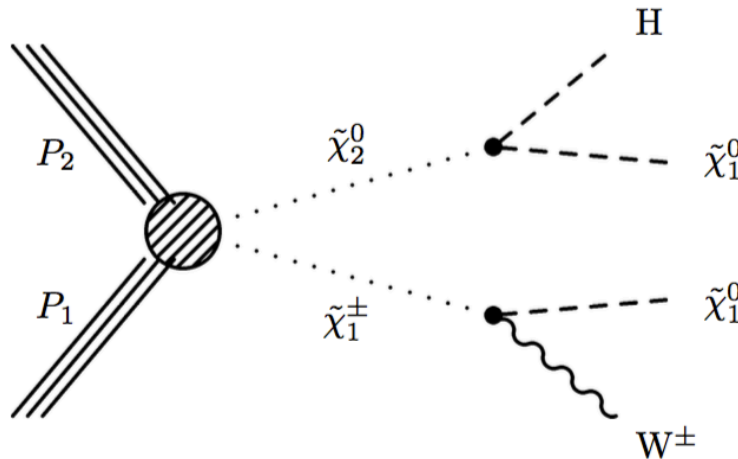
Event selection

- Signal region 90 GeV < M_{bb} < 150 GeV

- Suppress backgrounds
  - Exactly two b-jets,
  - 1-lepton, veto additional leptons
  - MET > 100 GeV, M_T > 150 GeV, M_{CT} > 150 GeV

Validate M_{bb} shape modeling of for 2l top

Validate tail modeling in W+jets
Derive corrections/systematics

Validate tail modeling 2l top
Derive correction/systematics

| Cut	Signal Region	CR2ℓ	CR0b	CRM$b\bar{b}$
N(leptons)	= 1	= 1 or 2	= 1	= 1
Isolated track veto	✓	inverted if 1ℓ	✓	✓
Tau candidate veto	✓	inverted if 1ℓ	✓	✓
N(b-tags), CSVv2M	= 2	= 2	= 0	= 2
$M_{b\bar{b}}$	$\in[90,150]$ GeV	-	$\in[90,150]$ GeV	$\notin[90,150]$ GeV
E_T^{miss}	> 100 GeV	> 100 GeV	> 100 GeV	> 100 GeV
M_T	> 150 GeV	> 50 GeV	> 150 GeV	> 150 GeV
M_{CT}	> 150 GeV	-	> 150 GeV	> 150 GeV

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Background prediction

- Backgrounds estimated with MC simulation,
  - Dilepton top quark: ~90% of total background in SR
  - Subdominant backgrounds: W+light jets, W+HF, W+Z(bb)
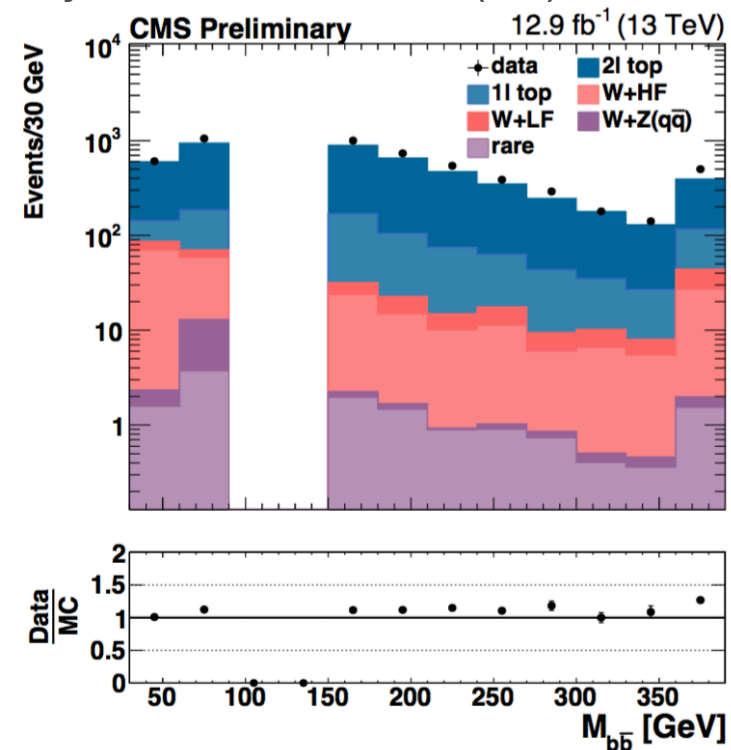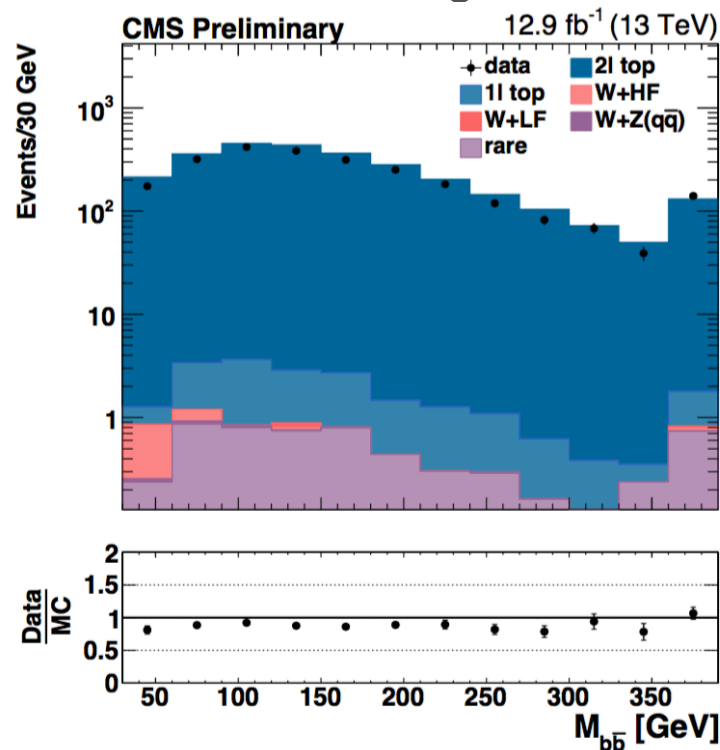
- Good modeling of $M_{b\bar{b}}$ shape near signal region
  - Assign stat error (20%) as systematic on modeling of 2l top

Results
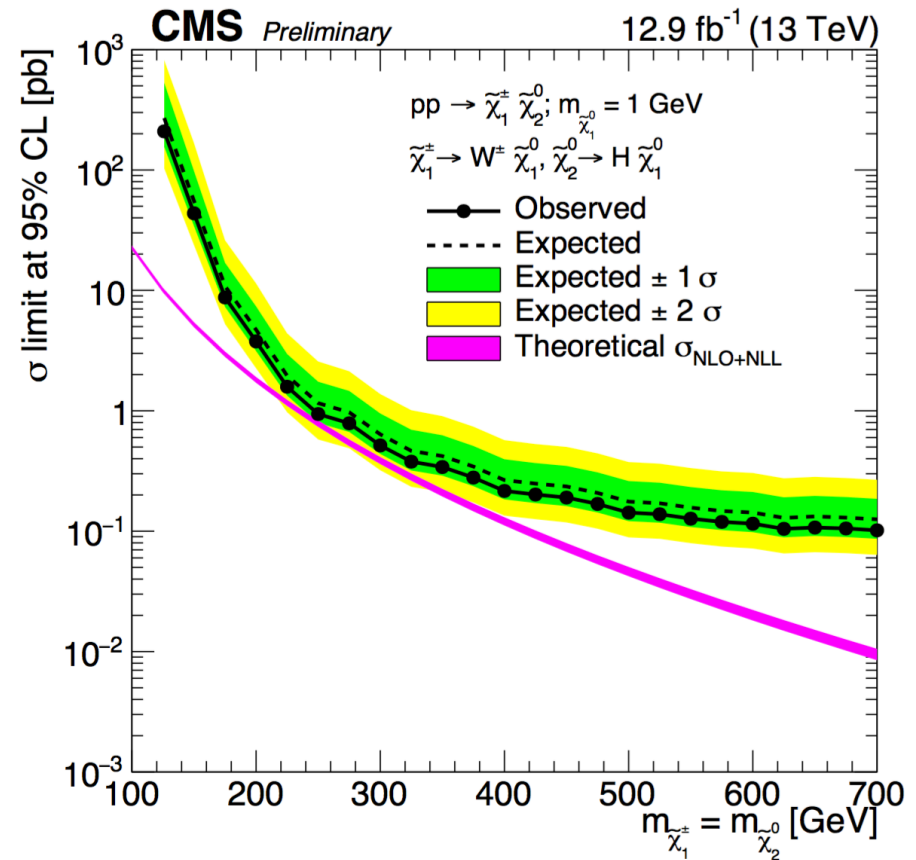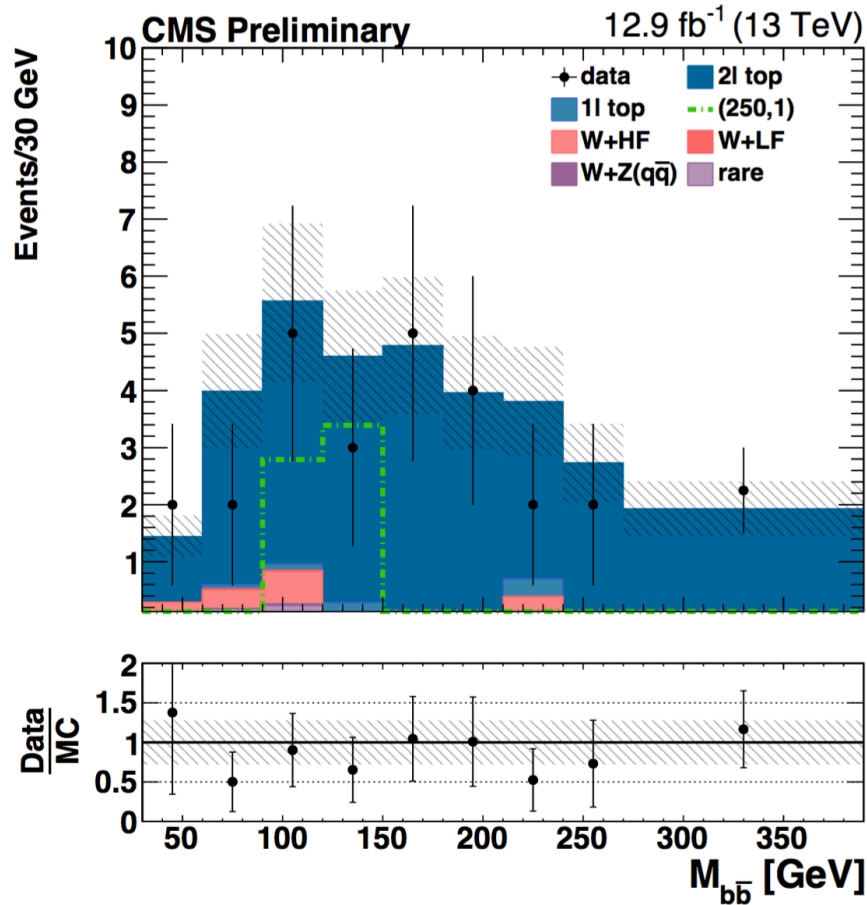
- Data agrees with the prediction in the signal region
- Sensitivity close to exclude the models, σ limits around 1 pb

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Summary

- Searches for SUSY are entering a new era at 13 TeV with large datasets
  - Gluino limits extended ~100 GeV beyond previous searches
  - Nearing sensitivity for EWK SUSY production

- Good modeling of SM backgrounds is observed in a variety of dedicated control regions
  - Robust techniques for SM background estimation

- Many improvements in the analysis techniques, many more results to come with quickly increasing datasets

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