Searches for supersymmetry via strong production in events with one or more leptons at CMS

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on behalf of the CMS Collaboration

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Introduction

LHC and CMS performed very well last year

- 35.9 fb^{-1} for us to analyze

A lot of work by many people to present 2016 SUSY results at Moriond

- Most are currently being turned into papers

Leptonic final states of particular interest:

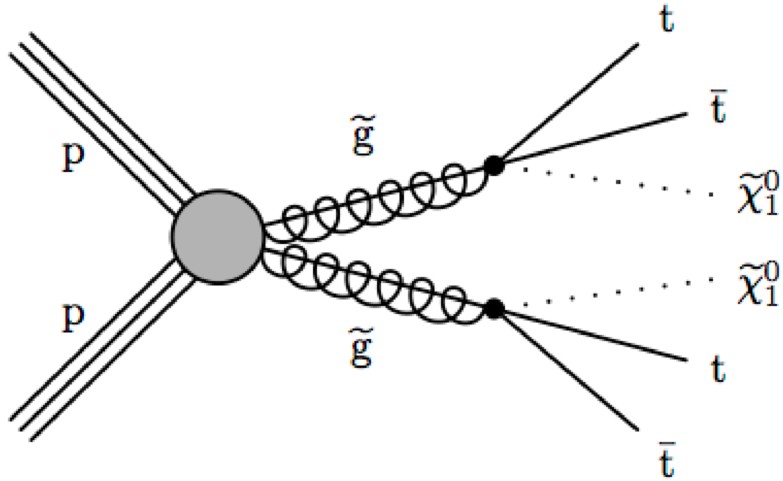
- Light stops in "natural" SUSY models + flavor conservation → top quarks → leptons
- EWK models : Weak mass limits, difficult to discover in hadronic final states
- Measuring electrons and muons is relatively easy
- QCD background is strongly suppressed
- Remaining background processes well understood, can often be estimated from data

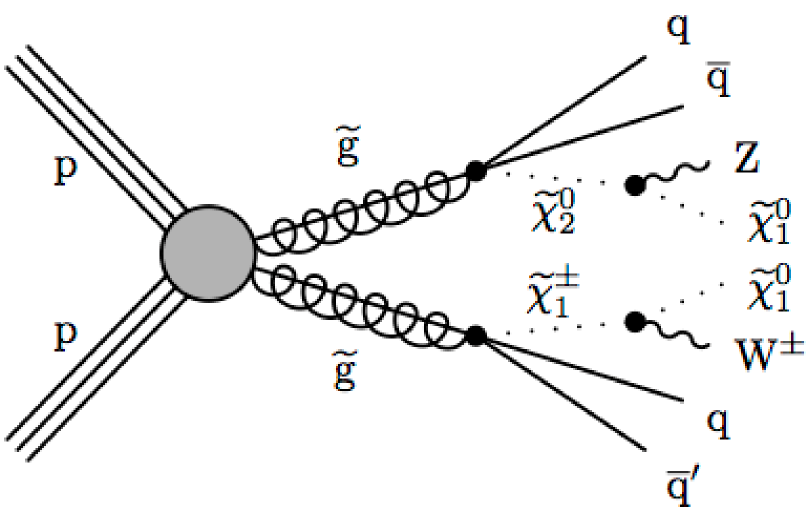
Talks on leptonic CMS SUSY searches:

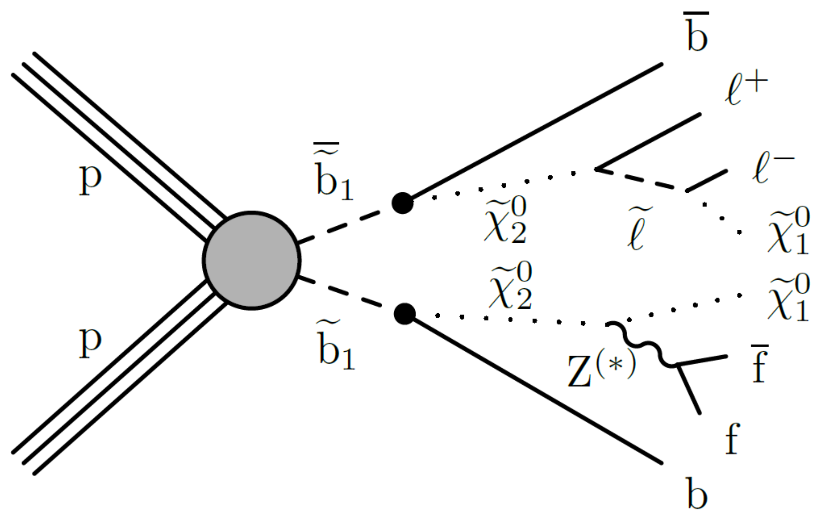
- This talk: Strongly produced SUSY models
- Constantin's talk later: Compressed spectra and decays via Higgs bosons
- Indara's talk later: Third generation squarks
- Miaoyuan's talk tomorrow: EWK produced SUSY

Strongly produced leptonic final states

- Strong SUSY production and R-parity conservation $\rightarrow$ jets and p_{T}^{miss}
- Single/uncorrelated leptons from W boson decays
- Correlated lepton signatures from Z boson or sleptons in decay chain
- Only electrons and muons considered here







Covered analyses

Single lepton searches (1ℓ large jets, 1ℓ $\Delta\phi$):

CMS-SUS-16-037: Search for supersymmetry in pp collisions at $\sqrt{s} = 13$ TeV in the single-lepton final state using the sum of masses of large-radius jets arXiv:1705.04673

CMS-PAS-SUS-16-042: Search for supersymmetry in events with one lepton and multiple jets in proton-proton collisions at $\sqrt{s} = 13$ TeV with 2016 data

Dilepton searches (OS, LS):

CMS-PAS-SUS-16-034: Search for new phenomena in final states with two opposite-sign, same-flavor leptons, jets, and missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV

CMS-SUS-16-035: Search for physics beyond the standard model in events with two leptons of same sign, missing transverse momentum, and jets in proton-proton collisions at $\sqrt{s} = 13$ TeV. arXiv:1704.07323

Multilepton search:

CMS-PAS-SUS-16-041: Search for new physics in events with multileptons and jets in $35.9\ \mathrm{fb}^{-1}$ of proton-proton collision data at $\sqrt{s} = 13$ TeV

Single lepton search with large jets

Search for supersymmetry in pp collisions at $\sqrt{s} = 13$ TeV in the single-lepton final state using the sum of masses of large-radius jets

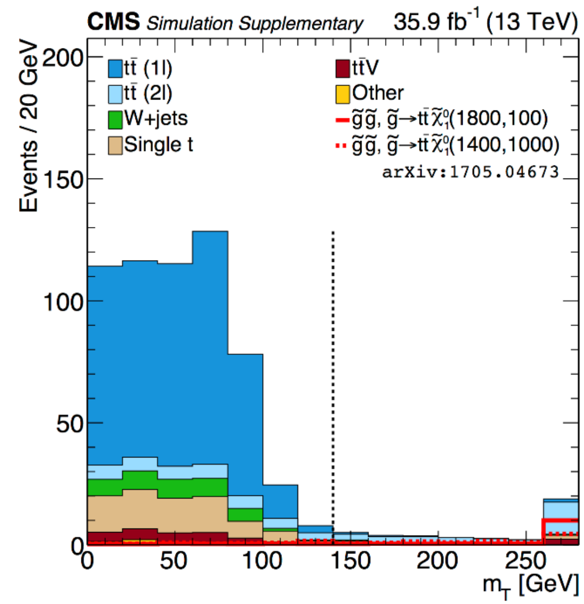
(CMS-SUS-16-037)

arXiv:1705.04673

1ℓ large jets: Background estimation

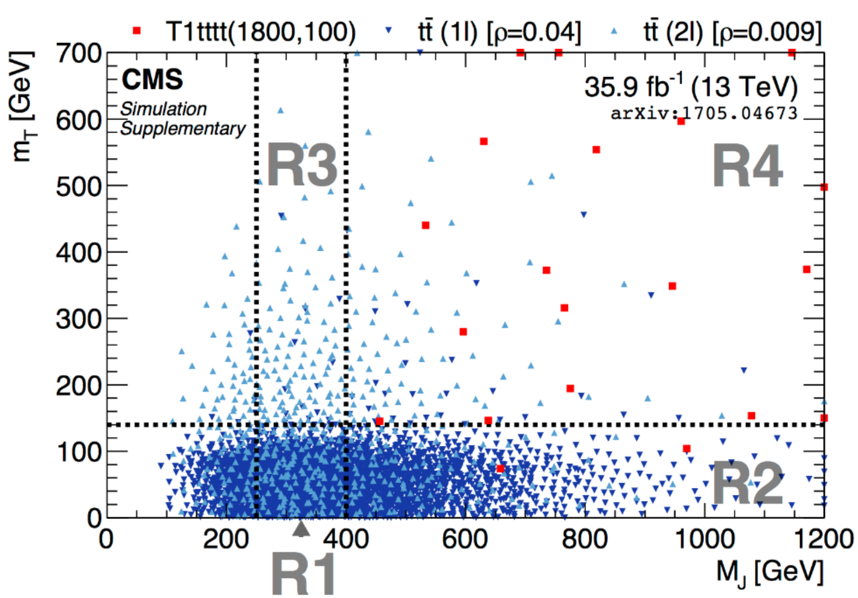
Observables and selection:

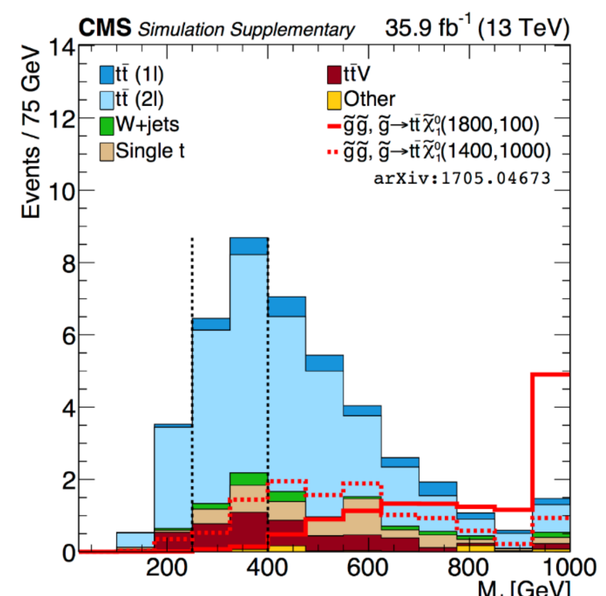
- Selection: $(H_T + p_T^{\ell}) > 500$ GeV, $p_T^{miss} > 200$ GeV, 6+ jets, 1+ b-jets
- m_T to supress semileptonic $t\bar{t}$
- Recluster jets and leptons to large jets (R=1.4 cone)
- M_J = Scalar sum of masses of large jets



Background estimation:

- $N_{R4} = \kappa \frac{N_{R2}}{N_{R1}} N_{R3}$
- κ: MC corrections for residual m_T-M_J correlations
- Fit in R1-3 for background prediction and global fit on all regions for interpretation

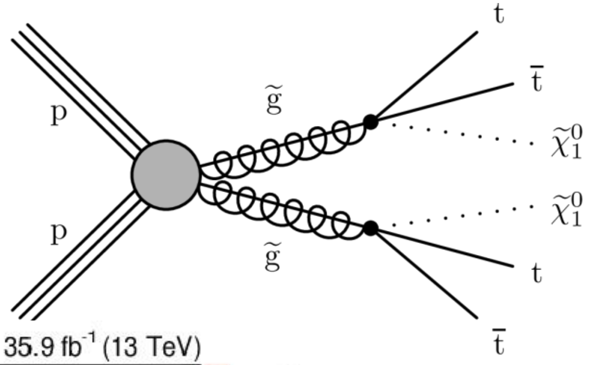


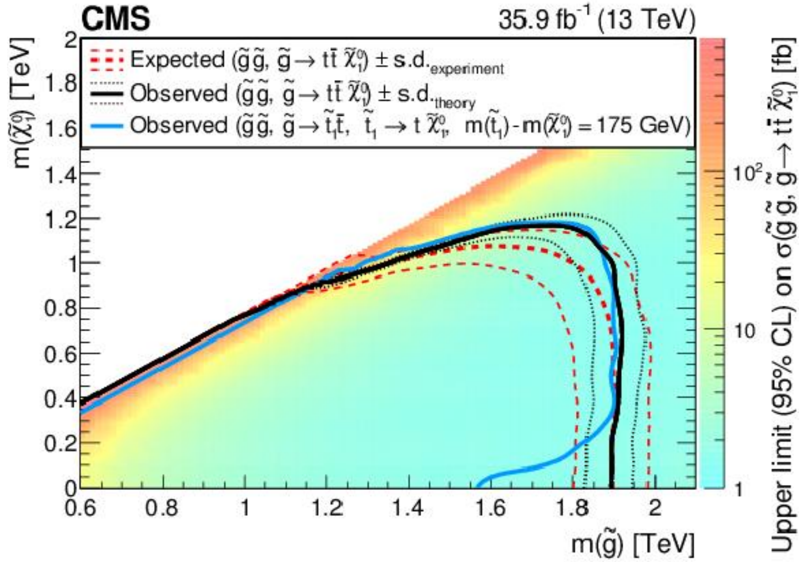


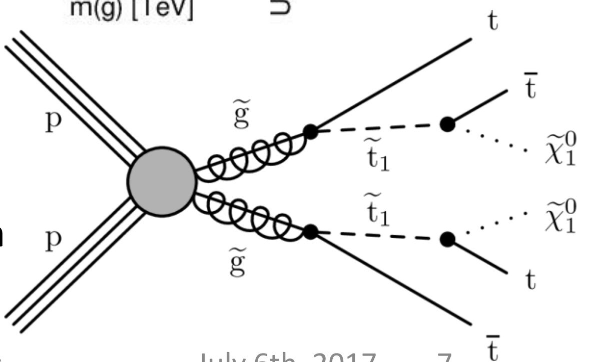
1ℓ large jets: Results and interpretation

N_{jets}	N_b	NC	C	κ	Pred.	Obs.
			$200 < p_T^{miss} \leq 350$ GeV			
6-8	1	0.4	1.9	1.2 ± 0.2	85 ± 14	106
6-8	2	0.6	3.0	1.2 ± 0.2	55.1 ± 9.3	75
6-8	≥ 3	0.6	2.2	1.5 ± 0.2	16.4 ± 3.0	16
≥ 9	1	0.2	1.6	1.0 ± 0.2	6.5 ± 1.5	11
≥ 9	2	0.3	2.1	1.2 ± 0.3	7.6 ± 1.9	11
≥ 9	≥ 3	0.4	3.1	1.4 ± 0.3	2.3 ± 0.7	2
			$350 < p_T^{miss} \leq 500$ GeV			
6-8	1	0.7	1.1	1.0 ± 0.3	17.4 ± 6.6	25
6-8	2	0.9	1.3	1.1 ± 0.4	13.7 ± 5.3	10
6-8	≥ 3	0.8	0.9	1.3 ± 0.4	3.8 ± 1.6	1
≥ 9	1	0.3	1.0	1.1 ± 0.4	1.3 ± 0.6	2
≥ 9	2	0.5	1.1	0.8 ± 0.3	1.6 ± 0.8	2
≥ 9	≥ 3	0.7	2.1	1.2 ± 0.5	0.6 ± 0.4	0
			$p_T^{miss} > 500$ GeV			
6-8	1	2.5	0.6	1.0 ± 0.3	1.9 ± 1.5	8
6-8	2	3.6	1.0	1.0 ± 0.4	0.9 ± 0.7	4
6-8	≥ 3	3.2	0.4	1.5 ± 0.6	0.4 ± 0.4	1
≥ 9	1	1.0	0.7	1.0 ± 0.4	0.2 ± 0.2	2
≥ 9	2	1.8	1.2	1.0 ± 0.4	0.1 ± 0.1	0
≥ 9	≥ 3	2.3	1.7	3.1 ± 1.5	0.1 ± 0.1	0

Example points (T1tttt):
NC: 1800, 100
C: 1400, 1000







- Yields in R1 and R3 not split by (b-) jet multiplicity
  → Results in each p_T^{miss} region correlated
- Agreement within 2 σ in single bins and combined p_T^{miss} >500 GeV bin
- Gluino masses up to 1.9 TeV excluded

Single lepton search with $\Delta\phi$

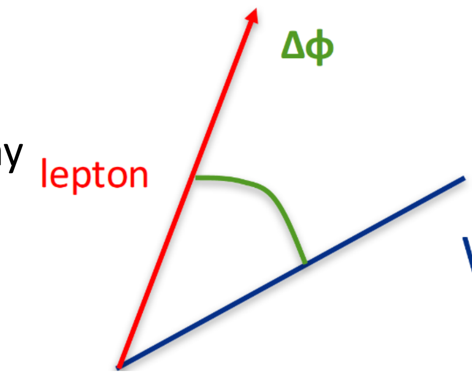
Search for supersymmetry in events with one lepton and multiple jets in proton-proton collisions at $\sqrt{s} = 13$ TeV with 2016 data

(CMS-PAS-SUS-16-042)

1ℓ Δϕ: Background estimation

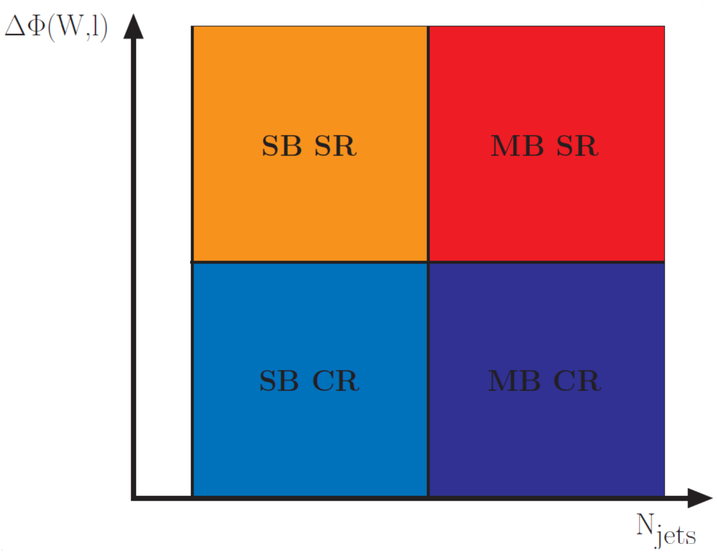
Observables and selection:

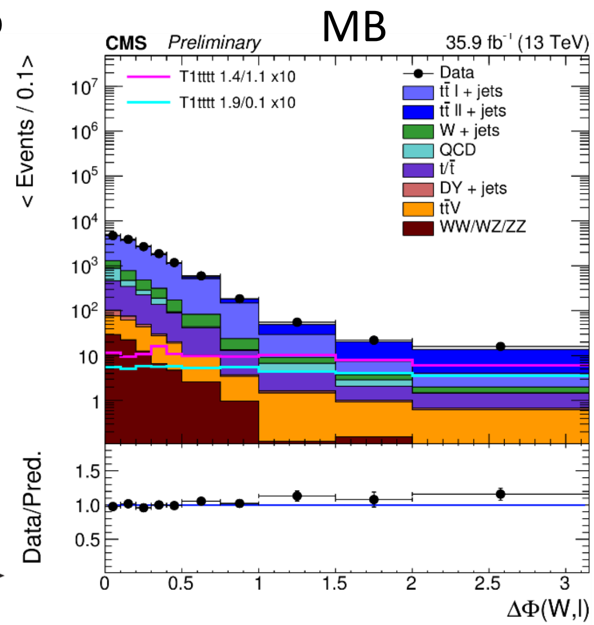
- Selection: $L_T = p_T^{miss} + p_T^{\ell} > 250$ GeV, 5+ jets, $H_T > 500$ GeV
- Main backgrounds W+jets and semileptonic tt̄ → lepton from W decay
  → small Δϕ between lepton and W boson candidate

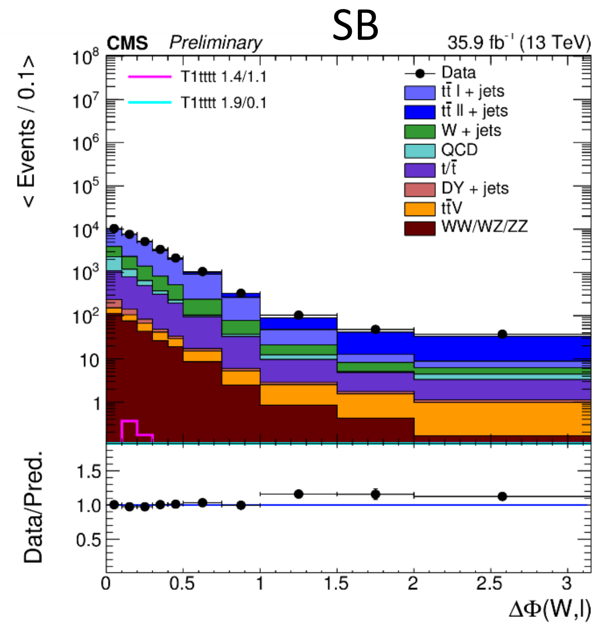


Background estimation:

- $N_{MB}^{SR} = \kappa \frac{N_{SB}^{SR}}{N_{SB}^{CR} - N_{QCD,SB}^{CR}} N_{MB}^{CR}$
- κ: MC corr. for differences in (b-) jet multiplicity between side band (SB) and main band (MB)
- Search performed in b-tagged (tt̄ dominated) and b-veto (W+jets and tt̄) regions
- QCD est. from tight-to-loose ratio

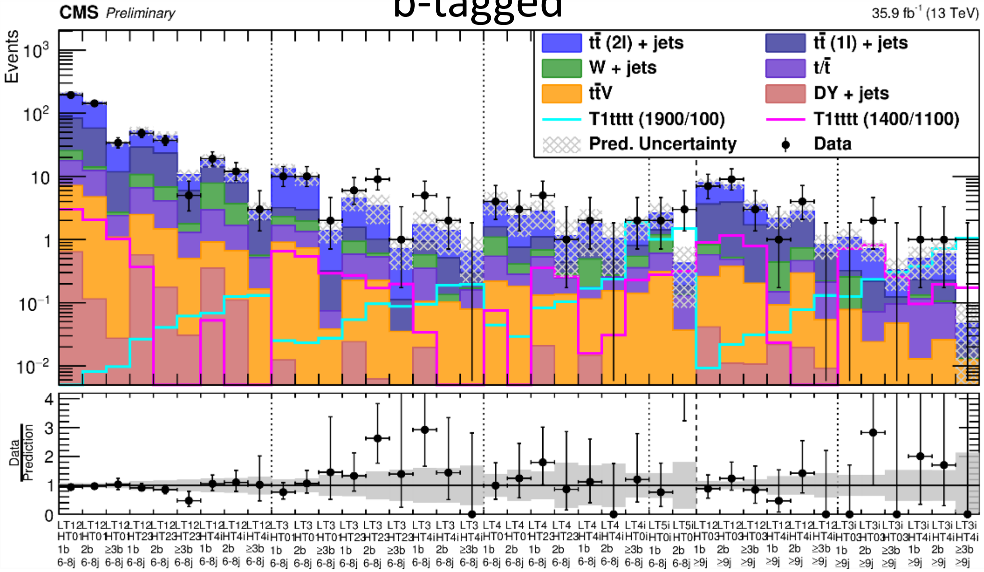


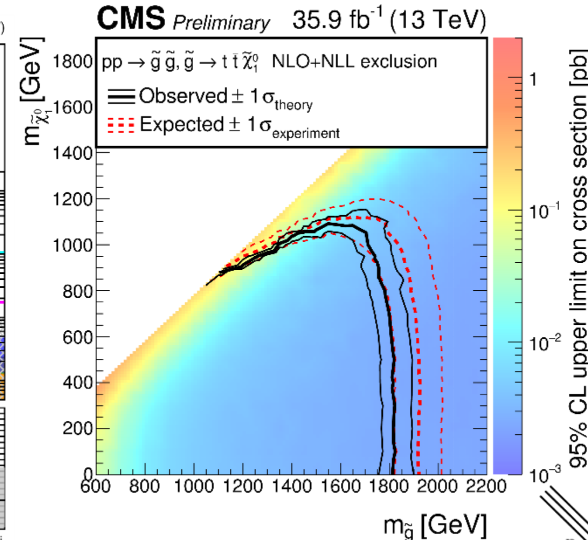


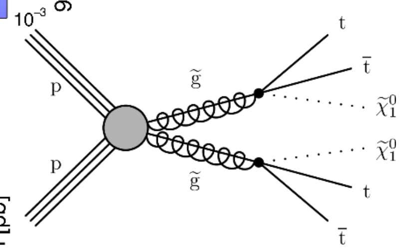


1ℓ Δϕ: Results and interpretation

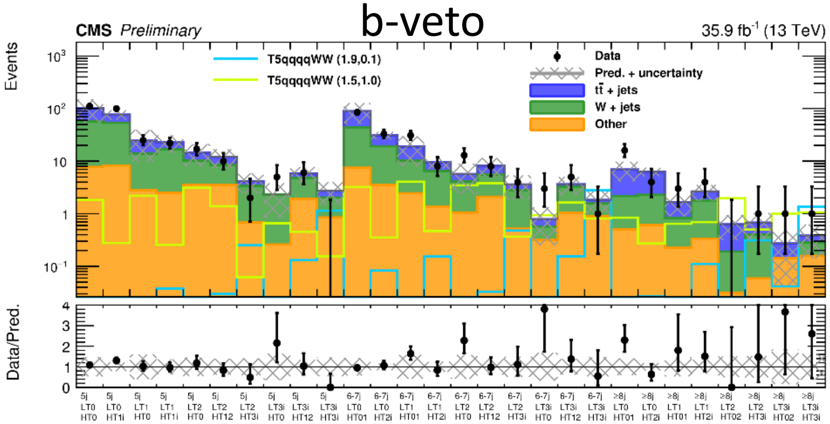
b-tagged

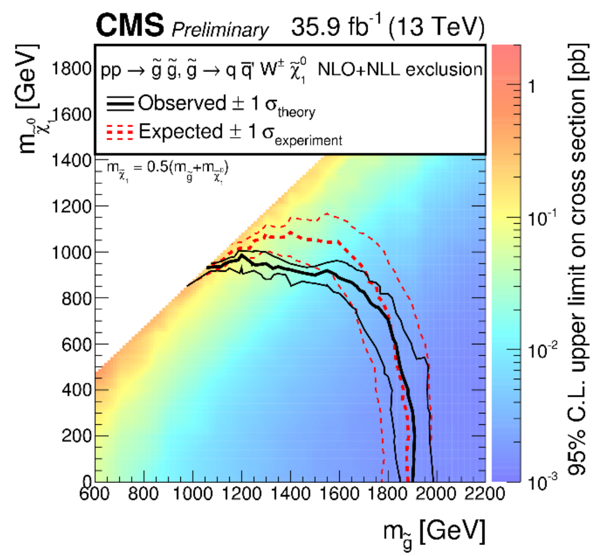


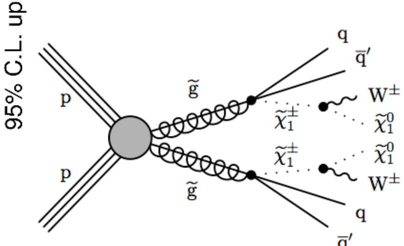




b-veto







- Binning in jet multiplicity, L_T, and H_T
- No significant deviation observed
- Gluino masses up to 1.8-1.9 TeV excluded

Opposite-sign, same-flavor dilepton search

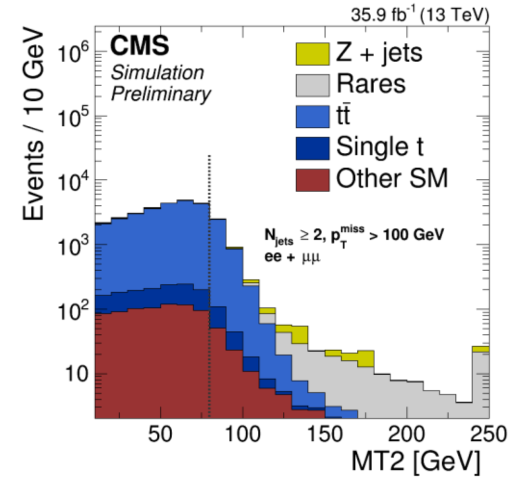
Search for new phenomena in final states with two opposite-sign, same-flavor leptons, jets, and missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV

(CMS-PAS-SUS-16-034)

OS: Background estimation

Search strategies and selection:

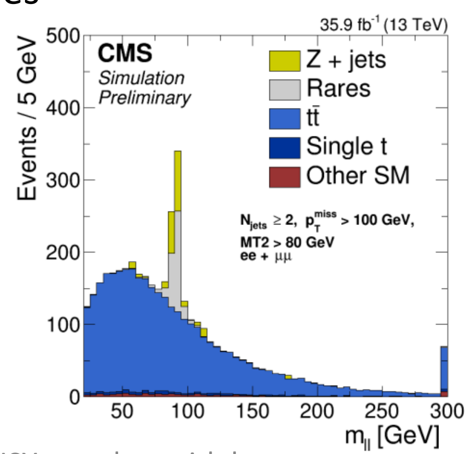
- Selection: $p_T^{miss} > 100$ (150) GeV, 2+ jets
- $M_{T2} > 80$ GeV to supress most of the dominant $t\bar{t}$ background
- Resonant contribution on the Z peak ($|m_{\ell\ell} - m_Z| < 5$ GeV):
  - Binning in (b-) jet multiplicity and p_T^{miss}
- Edge like feature in $m_{\ell\ell}$ outside the Z window:
  - Kinematic fit to search for edge shaped feature in full mass range
  - Counting experiment in mass and $t\bar{t}$ likelihood bins

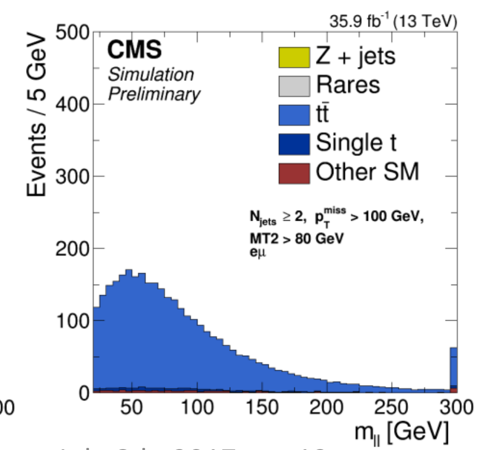


$$M_{T2} = \min_{\vec{p}_T^{miss(1)} + \vec{p}_T^{miss(2)} = \vec{p}_T^{miss}} \left[\max\left(m_T^{(1)}, m_T^{(2)}\right)\right]$$

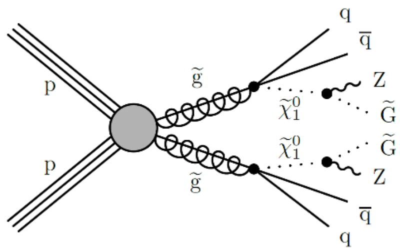
Background estimation:

- Flavor-symmetric background:
  - From $e\mu$ control region
  - Corrected by $R_{SF/DF}$ for differences in efficiencies
- Z+jets background
  - No neutrinos, p_T^{miss} from mismeasured jets
  - Estimated with p_T^{miss} templates from γ+jets sample
- Rare backgrounds (Z+ν)
  - From MC
  - WZ, ZZ, and $t\bar{t}Z$ validated in control regions



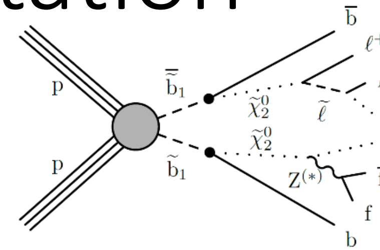


OS: Results and interpretation



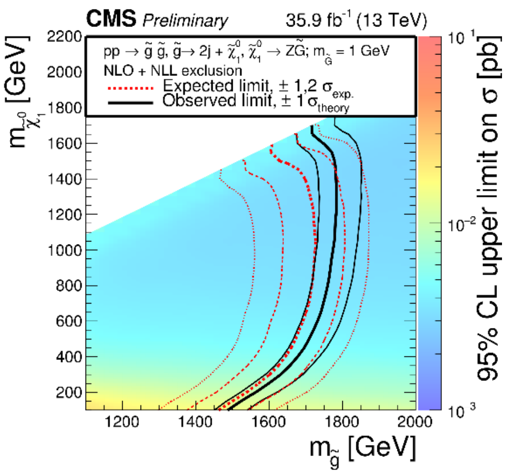
on-Z:

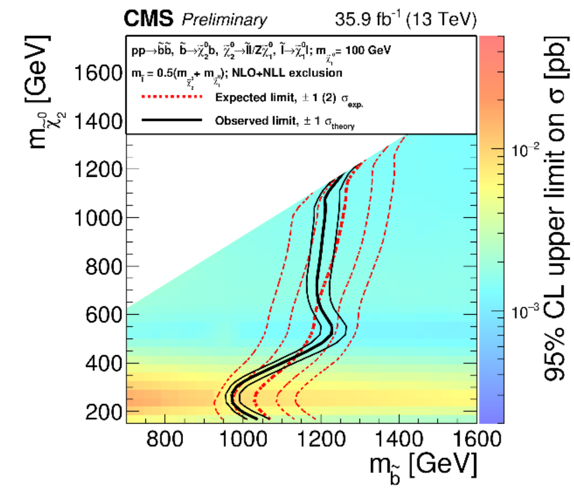
- No significant deviation
- Limits on GMSB gluino pair production model up to 1.8 TeV

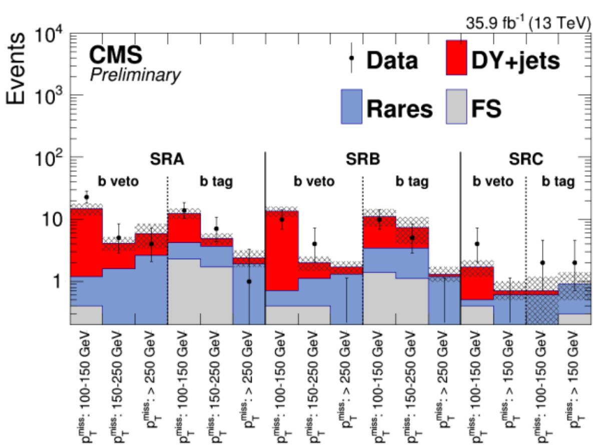


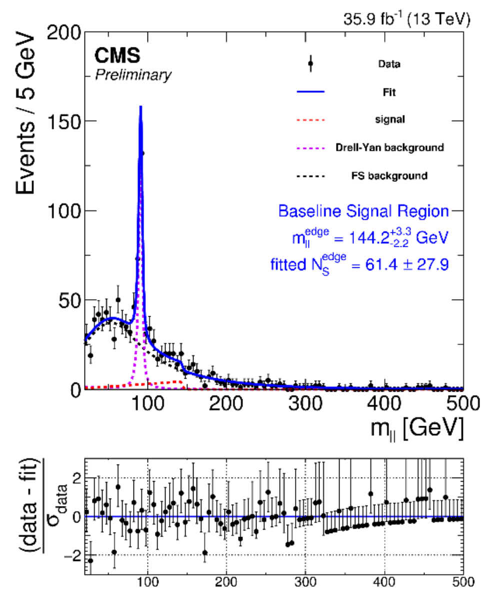
off-Z:

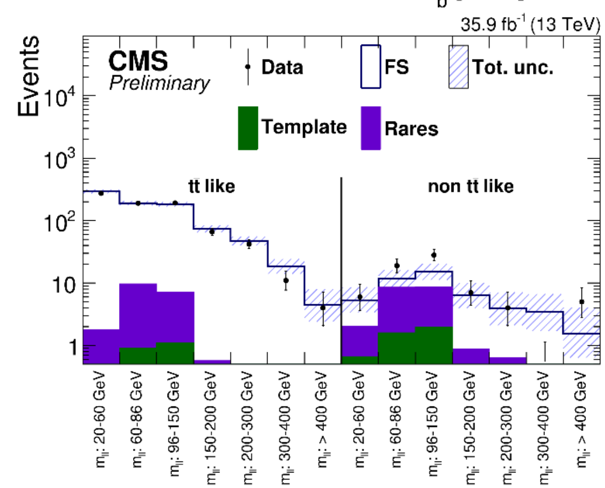
- 2σ deviation in non $t\bar{t}$ like, $m_{\ell\ell}$ 96-150 GeV bin
- Best fit at 144 GeV (61 ± 28 ev.)
- Sbottom limits up to 1.2 TeV
- Limit contour reflects mass binning











Like-sign dilepton search

Search for physics beyond the standard model in events with two leptons of same sign, missing transverse momentum, and jets in proton-proton collisions at $\sqrt{s} = 13$ TeV

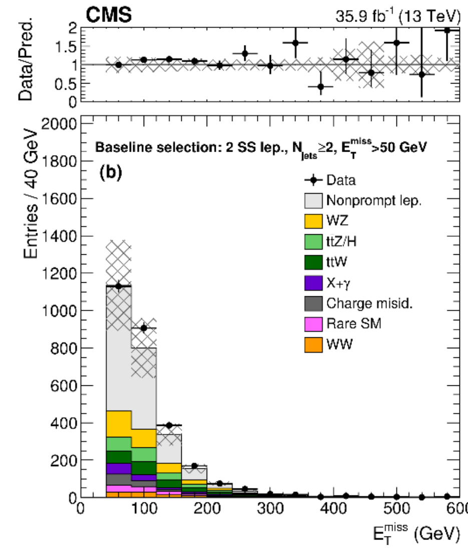
(CMS-SUS-16-035)

arXiv:1704.07323

LS: Background estimation

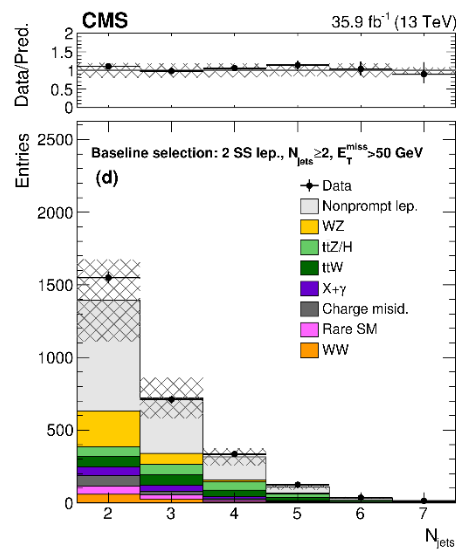
Selection:

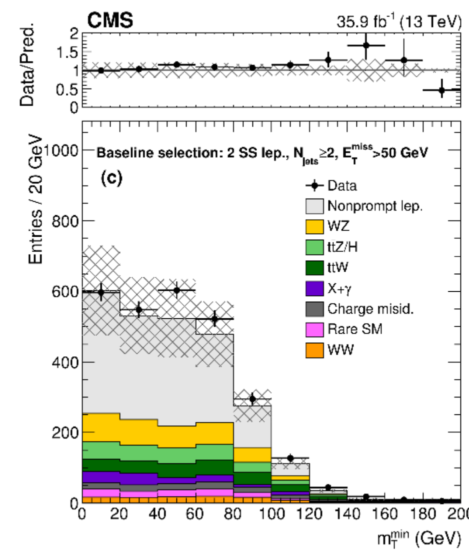
- 1+ LS lepton pair ($m_{\ell\ell} > 8$ GeV), 2+ jets, $p_T^{miss} > 50$ GeV
- Veto if additional loose lepton can be used for an OS pair with $m_{\ell\ell} < 12$ GeV or $|m_{\ell\ell} - m_Z| < 15$ GeV
- Further binning in lepton p_T, (b-) jet multiplicity, H_T, p_T^{miss}, m_T^{min} and split into ++ and -- lepton pairs



Background estimation:

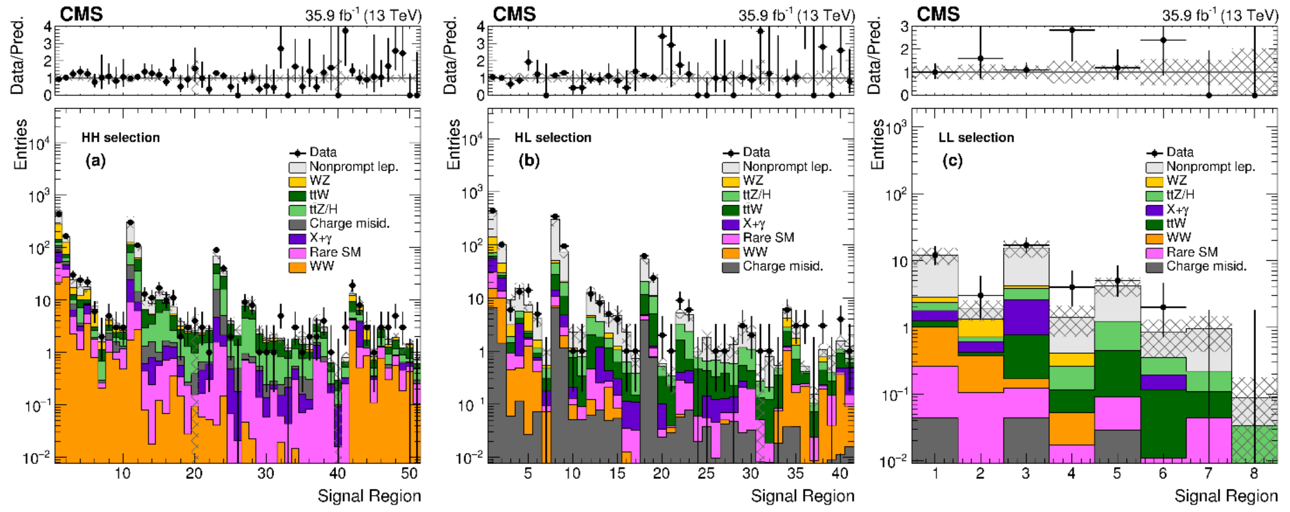
- Non-prompt leptons:
  - Tight-to-loose ratio from control region
- Rare SM processes with prompt LS pairs:
  - From MC
  - WZ and $t\bar{t}Z$ validated in control regions
- Charge-misidentificatied electrons:
  - Misidentification rate taken from MC
  - Validated in control region and applied to OS data

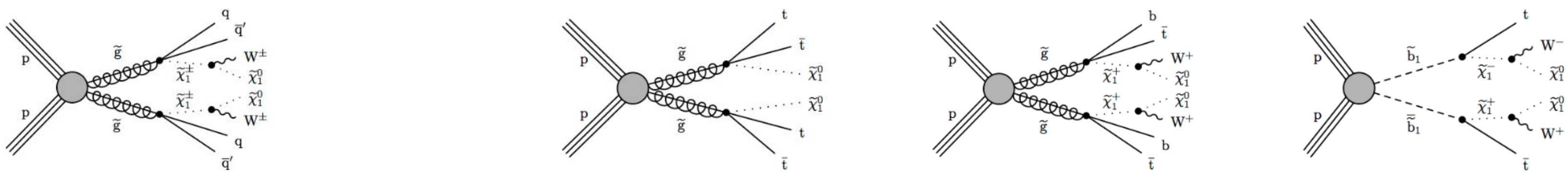


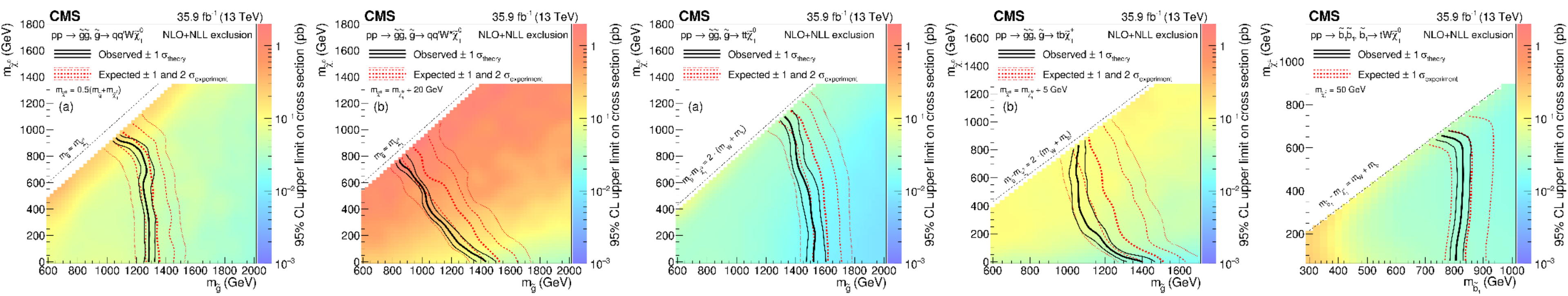


LS: Results and interpretation

- No significant deviation in any of the SRs
- Interpretet in a variety of SUSY models
- Several compressed spectra
- Further interpretations include (pseudo-)scalar boson production and model independent upper limits







Multilepton search

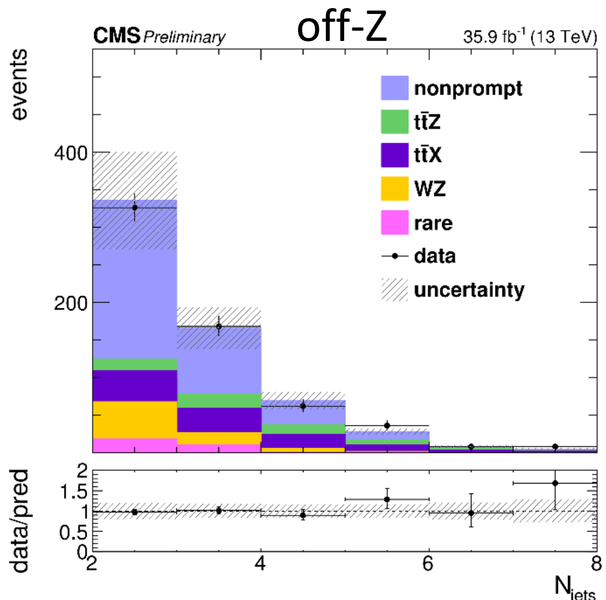
Search for new physics in events with multileptons and jets in 35.9 fb^{-1} of proton-proton collision data at $\sqrt{s} = 13$ TeV

(CMS-PAS-SUS-16-041)

Multilepton: Background estimation

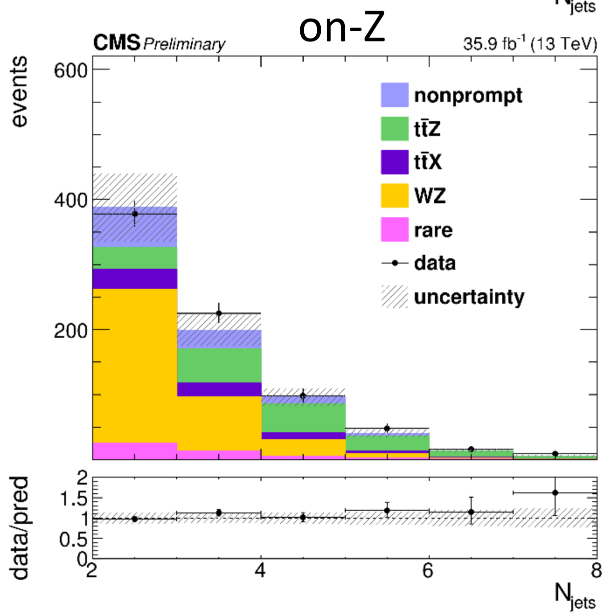
Selection:

- 3+ leptons, $m_{\ell\ell} > 12$ GeV for OSSF pairs,
  2+ jets, $p_{\mathrm{T}}^{miss} > 50$ GeV
- On-Z regions:
  - OSSF pair with $|m_{\ell\ell} - m_Z| < 15$ GeV
- Binning in (b-) jet multiplicity, H_{T}, p_{T}^{miss}, $m_{\ell\ell}$ and m_{T}



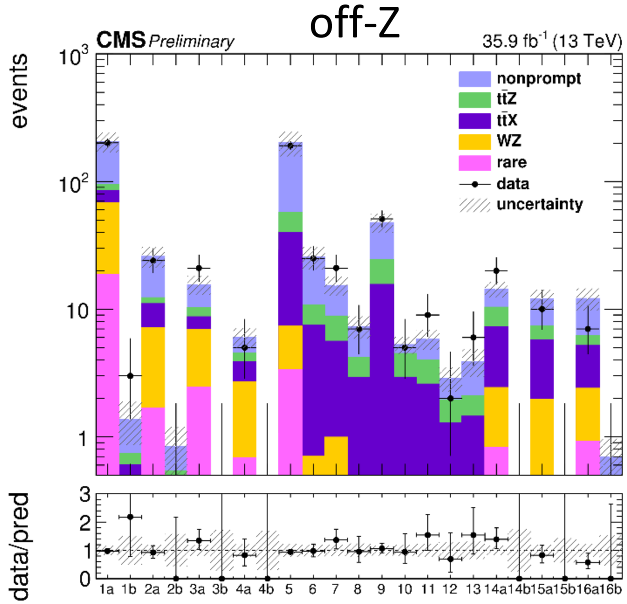
Background estimation:

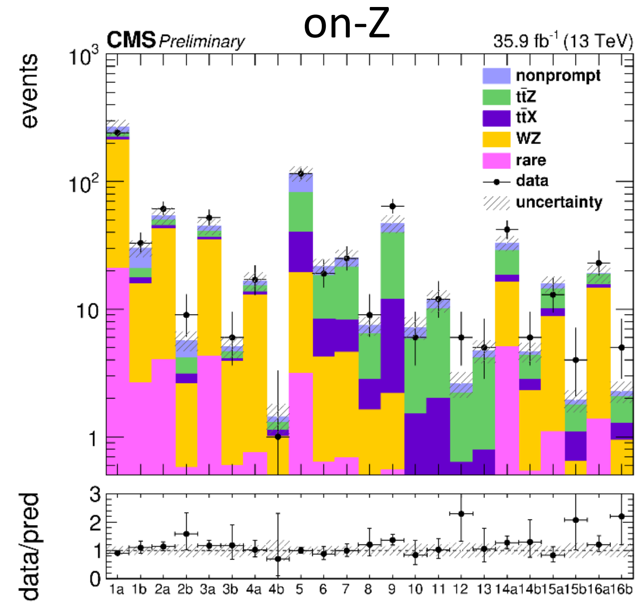
- Non-prompt leptons:
  - Dominant in off-Z regions
  - Tight-to-loose ratio from control region
- Remaining backgrounds:
  - From MC
  - WZ and tt̄Z validated in control regions

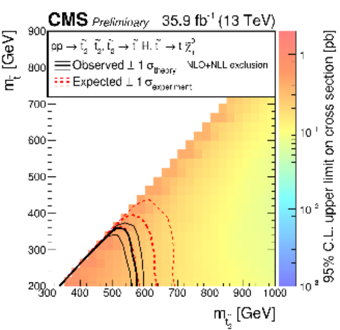


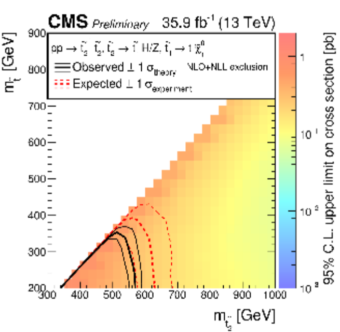
Multilepton: Results and interpretation

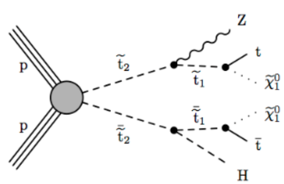
- No significant deviation in any of the SRs
- Interpretet in a variety of SUSY models
- Different branching fractions tested

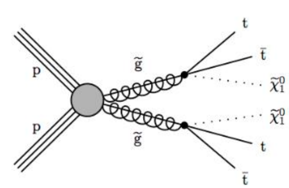


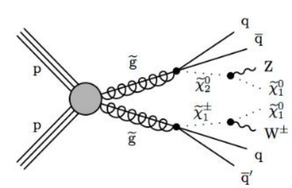


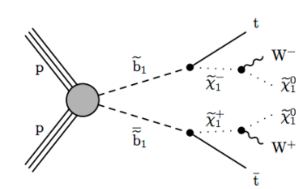


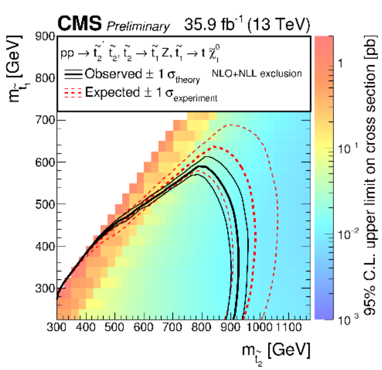


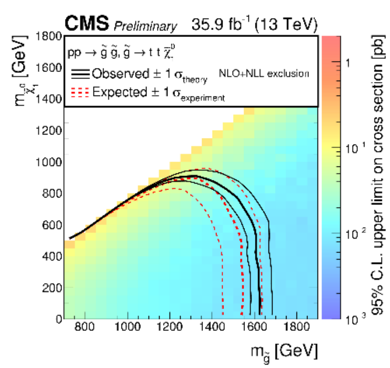


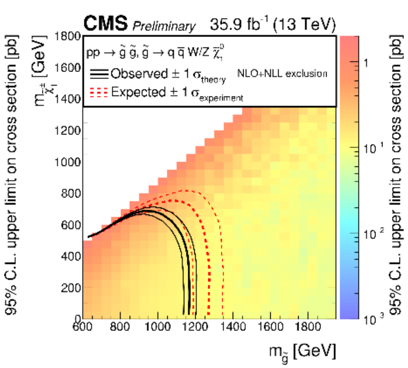


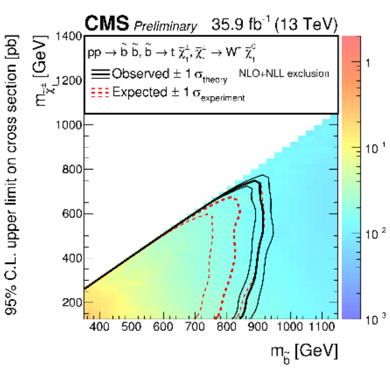












Summary

- LHC and CMS performed extremely well in 2016
- CMS presented lots of (leptonic) SUSY searches at Moriond
- Several already published as papers, many more to follow
- Unfortunately, no sign for SUSY in any of the leptonic searches for strongly produced SUSY
- Time for easy limit extension in simple final states is likely over
- Might need to focus on more complex scenarios or those we lacked statistics for (compressed spectra, EWK models, boosted topologies, RPV ...)
- Results on some of these scenarios later on or tomorrow

Extras

- Signal region definitions
- Numerical results
- Additional interpretations

1ℓ $\Delta\phi$: b-tagged results

n_{jet}	n_{b}	L_{T} [GeV]	H_{T} [GeV]	Bin name	Expected signal T1tttt $m_{\tilde{g}}/m_{\tilde{\chi}^0}$ [TeV] (1.9,0.1)	(1.4,1.1)	Predicted background	Observed
[6, 8]	= 1	[250, 450]	[500, 1000]	NB1, LT12, HT01	< 0.01	3.02 ± 0.24	206 ± 12 ± 9.4	194
			[1000, 1500]	NB1, LT12, HT23	0.03 ± 0.01	0.37 ± 0.08	53 ± 7.4 ± 3.6	48
			≥ 1500	NB1, LT12, HT4i	0.07 ± 0.01	0.05 ± 0.03	18 ± 4.2 ± 0.5	19
		[450, 600]	[500, 1000]	NB1, LT3, HT01	0.03 ± 0.01	0.66 ± 0.11	13 ± 2.5 ± 0.9	10
			[1000, 1500]	NB1, LT3, HT23	0.05 ± 0.01	0.27 ± 0.07	4.5 ± 1.7 ± 0.3	6
			≥ 1500	NB1, LT3, HT4i	0.09 ± 0.01	0.03 ± 0.02	1.7 ± 1.0 ± 0.3	5
		[600, 750]	[500, 1000]	NB1, LT4, HT01	0.04 ± 0.01	0.08 ± 0.04	4.0 ± 1.5 ± 0.5	4
			[1000, 1500]	NB1, LT4, HT23	0.08 ± 0.01	0.35 ± 0.08	2.8 ± 1.3 ± 0.2	5
			≥ 1500	NB1, LT4, HT4i	0.17 ± 0.02	0.02 ± 0.02	1.8 ± 1.2 ± 0.2	2
		≥ 750	≥ 500	NB1, LT5i, HT0i	1.01 ± 0.04	0.28 ± 0.07	2.6 ± 1.1 ± 0.2	2
	= 2	[250, 450]	[500, 1000]	NB2, LT12, HT01	0.01 ± 0.01	2.06 ± 0.20	147 ± 9.4 ± 5.5	143
			[1000, 1500]	NB2, LT12, HT23	0.04 ± 0.01	< 0.01	44 ± 7.3 ± 1.7	37
			≥ 1500	NB2, LT12, HT4i	0.13 ± 0.01	< 0.01	11 ± 2.7 ± 0.7	12
		[450, 600]	[500, 1000]	NB2, LT3, HT01	0.02 ± 0.01	0.54 ± 0.10	9.4 ± 2.1 ± 0.8	10
			[1000, 1500]	NB2, LT3, HT23	0.10 ± 0.01	0.17 ± 0.06	3.4 ± 1.7 ± 0.2	9
			≥ 1500	NB2, LT3, HT4i	0.19 ± 0.02	< 0.01	1.4 ± 0.8 ± 0.2	2
		[600, 750]	[500, 1000]	NB2, LT4, HT01	0.03 ± 0.01	< 0.01	2.4 ± 1.2 ± 0.4	3
			[1000, 1500]	NB2, LT4, HT23	0.10 ± 0.01	0.26 ± 0.07	1.2 ± 0.9 ± 0.2	1
			≥ 1500	NB2, LT4, HT4i	0.24 ± 0.02	0.03 ± 0.02	1.1 ± 0.8 ± 0.2	0
		≥ 750	≥ 500	NB2, LT5i, HT0i	1.50 ± 0.05	0.32 ± 0.08	0.42 ± 0.34 ± 0.05	3
	≥ 3	[250, 450]	[500, 1000]	NB3i, LT12, HT01	0.01 ± 0.01	1.03 ± 0.14	33 ± 2.9 ± 1.5	34
			[1000, 1500]	NB3i, LT12, HT23	0.06 ± 0.01	< 0.01	11 ± 2.0 ± 0.5	5
			≥ 1500	NB3i, LT12, HT4i	0.13 ± 0.01	< 0.01	2.9 ± 0.9 ± 0.3	3
		[450, 600]	[500, 1000]	NB3i, LT3, HT01	0.03 ± 0.01	0.29 ± 0.07	1.4 ± 0.5 ± 0.2	2
			[1000, 1500]	NB3i, LT3, HT23	0.09 ± 0.01	0.20 ± 0.06	0.72 ± 0.38 ± 0.07	1
			≥ 1500	NB3i, LT3, HT4i	0.20 ± 0.02	< 0.01	0.66 ± 0.44 ± 0.07	0
		≥ 600	≥ 500	NB3i, LT4i, HT0i	1.85 ± 0.05	0.23 ± 0.06	1.7 ± 0.7 ± 0.2	2
≥ 9	= 1	[250, 450]	[500, 1500]	NB1, LT12, HT03	0.01 ± 0.01	0.90 ± 0.12	7.9 ± 0.9 ± 0.7	7
			≥ 1500	NB1, LT12, HT4i	0.03 ± 0.01	0.02 ± 0.02	2.2 ± 0.7 ± 0.2	1
		≥ 450	[500, 1500]	NB1, LT3i, HT03	0.13 ± 0.01	0.72 ± 0.11	1.1 ± 0.4 ± 0.2	0
			≥ 1500	NB1, LT3i, HT4i	0.38 ± 0.02	0.10 ± 0.04	0.50 ± 0.26 ± 0.06	1
	= 2	[250, 450]	[500, 1500]	NB2, LT12, HT03	0.02 ± 0.01	1.15 ± 0.14	7.3 ± 0.8 ± 0.5	9
			≥ 1500	NB2, LT12, HT4i	0.08 ± 0.01	< 0.01	2.8 ± 0.8 ± 0.3	4
		≥ 450	[500, 1500]	NB2, LT3i, HT03	0.23 ± 0.02	0.83 ± 0.12	0.71 ± 0.24 ± 0.09	2
			≥ 1500	NB2, LT3i, HT4i	0.72 ± 0.03	0.20 ± 0.05	0.59 ± 0.30 ± 0.07	1
	≥ 3	[250, 450]	[500, 1500]	NB3i, LT12, HT03	0.03 ± 0.01	0.79 ± 0.11	3.6 ± 0.6 ± 0.3	3
			≥ 1500	NB3i, LT12, HT4i	0.13 ± 0.01	< 0.01	0.83 ± 0.34 ± 0.07	0
		≥ 450	[500, 1500]	NB3i, LT3i, HT03	0.31 ± 0.02	0.26 ± 0.06	0.33 ± 0.16 ± 0.07	0
			≥ 1500	NB3i, LT3i, HT4i	1.04 ± 0.04	0.17 ± 0.05	0.05 ± 0.05 ± 0.01	0

1ℓ $\Delta\phi$: b-veto results

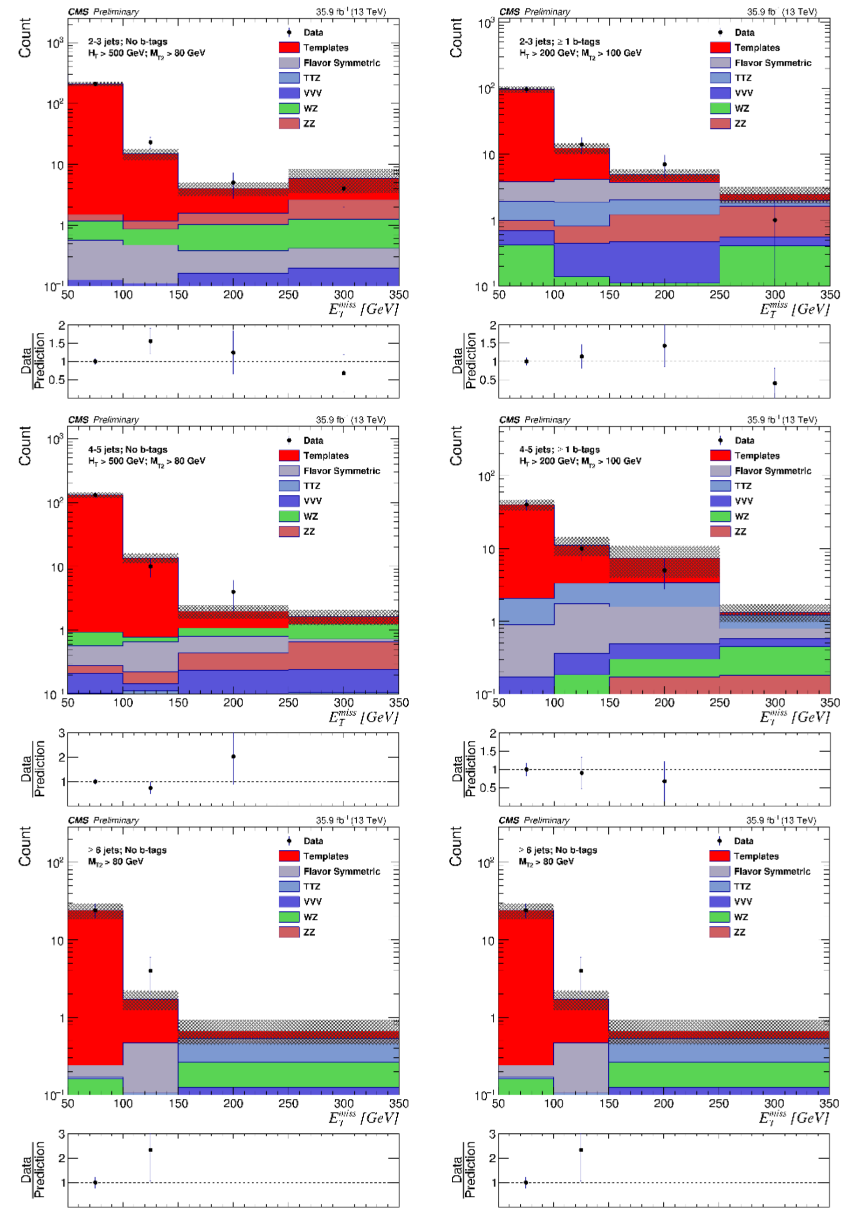
n_{jet}	L_T [GeV]	H_T [GeV]	Bin name	Signal T5qqqqWW $m_{\tilde{g}}/m_{\tilde{\chi}^0}$ [TeV] (1.5/1.0)	Signal T5qqqqWW $m_{\tilde{g}}/m_{\tilde{\chi}^0}$ [TeV] (1.9/0.1)	Predicted background	Observed
5	[250, 350]	[500, 750]	LT0, HT0	1.82 ± 0.29	< 0.01	101.91 ± 47.55	111
		≥ 750	LT0, HT1i	0.21 ± 0.09	0.01 ± 0.01	76.73 ± 16.19	100
	[350, 450]	[500, 750]	LT1, HT0	2.25 ± 0.32	< 0.01	24.43 ± 14.78	25
		≥ 750	LT1, HT1i	0.29 ± 0.11	0.04 ± 0.01	22.78 ± 8.29	22
	[450, 650]	[500, 750]	LT2, HT0	3.02 ± 0.37	< 0.01	14.46 ± 6.5	17
		[750, 1250]	LT2, HT12	1.4 ± 0.25	0.04 ± 0.02	12.13 ± 4.68	10
		≥ 1250	LT2, HT3i	0.08 ± 0.06	0.25 ± 0.04	4.15 ± 1.72	2
	≥ 650	[500, 750]	LT3i, HT0	0.74 ± 0.18	0.01 ± 0.01	2.32 ± 1.49	5
		[750, 1250]	LT3i, HT12	0.49 ± 0.15	0.12 ± 0.03	5.79 ± 1.96	6
		≥ 1250	LT3i, HT3i	0.14 ± 0.07	1.15 ± 0.08	2.74 ± 1.26	0
[6, 7]	[250, 350]	[500, 1000]	LT0, HT01	3.02 ± 0.36	< 0.01	89.32 ± 38.21	85
		≥ 1000	LT0, HT2i	0.31 ± 0.1	0.09 ± 0.02	30.94 ± 5.08	33
	[350, 450]	[500, 1000]	LT1, HT01	4.13 ± 0.41	0.01 ± 0.01	18.91 ± 10.89	31
		≥ 1000	LT1, HT2i	0.52 ± 0.14	0.14 ± 0.03	9.51 ± 2.34	8
	[450, 650]	[500, 750]	LT2, HT0	3.63 ± 0.39	< 0.01	5.71 ± 3.31	13
		[750, 1250]	LT2, HT12	3.79 ± 0.39	0.03 ± 0.01	8.21 ± 3.15	8
		≥ 1250	LT2, HT3i	0.36 ± 0.12	0.47 ± 0.05	3.61 ± 1.78	4
	≥ 650	[500, 750]	LT3i, HT0	0.89 ± 0.19	< 0.01	0.79 ± 0.53	3
		[750, 1250]	LT3i, HT12	1.77 ± 0.26	0.15 ± 0.03	3.63 ± 1.37	5
		≥ 1250	LT3i, HT3i	0.83 ± 0.18	2.83 ± 0.12	1.83 ± 0.86	1
≥ 8	[250, 350]	[500, 1000]	LT0, HT01	0.88 ± 0.18	< 0.01	6.96 ± 2.83	16
		≥ 1000	LT0, HT2i	0.26 ± 0.09	0.03 ± 0.01	6.32 ± 1.17	4
	[350, 450]	[500, 1000]	LT1, HT01	0.55 ± 0.14	< 0.01	1.67 ± 0.77	3
		≥ 1000	LT1, HT2i	0.72 ± 0.15	0.11 ± 0.02	2.65 ± 0.89	4
	[450, 650]	[500, 1250]	LT2, HT02	2.07 ± 0.26	0.01 ± 0.01	0.63 ± 0.32	0
		≥ 1250	LT2, HT3i	0.45 ± 0.12	0.3 ± 0.04	0.68 ± 0.35	1
	≥ 650	[500, 1250]	LT3i, HT02	0.97 ± 0.18	0.04 ± 0.01	0.27 ± 0.23	1
		≥ 1250	LT3i, HT3i	1.12 ± 0.18	1.37 ± 0.08	0.38 ± 0.24	1

OS: Signal region definitions

Strong on-Z Signal Regions					
Region	N_{jets}	$N_{b\text{-}jets}$	H_T	$M_{T2}(\ell\ell)$	E_T^{miss} binning [GeV]
SRA b-veto	2–3	= 0	> 500 GeV	> 80 GeV	[100,150,250,∞]
SRB b-veto	4–5	= 0	> 500 GeV	> 80 GeV	[100,150,250,∞]
SRC b-veto	≥ 6	= 0	-	> 80 GeV	[100,150,∞]
SRA b-tag	2–3	≥ 1	> 200 GeV	> 100 GeV	[100,150,250,∞]
SRB b-tag	4–5	≥ 1	> 200 GeV	> 100 GeV	[100,150,250,∞]
SRC b-tag	≥ 6	≥ 1	-	> 100 GeV	[100,150,∞]
Electroweak on-Z Signal Regions					
Region	N_{jets}	$N_{b\text{-}jets}$	dijet mass	M_{T2}	E_T^{miss} binning [GeV]
VZ	≥ 2	= 0	$m_{jj} < 110$ GeV	$M_{T2}(\ell\ell) > 80$ GeV	[100,150,250,350,∞]
HZ	≥ 2	= 2	$m_{bb} < 150$ GeV	$M_{T2}(\ell b \ell b) > 200$ GeV	[100,150,250,∞]
Edge Signal Regions					
Region	N_{jets}	E_T^{miss}	$M_{T2}(\ell\ell)$	$t\bar{t}$ likelihood	$m_{\ell\ell}$ binning [GeV]
Edge Fit	≥ 2	> 150 GeV	> 80 GeV	-	> 20
$t\bar{t}$ like	≥ 2	> 150 GeV	> 80 GeV	< 21	[20,60,86],[96,150,200,300,400,∞]
non-$t\bar{t}$ like	≥ 2	> 150 GeV	> 80 GeV	> 21	[20,60,86],[96,150,200,300,400,∞]

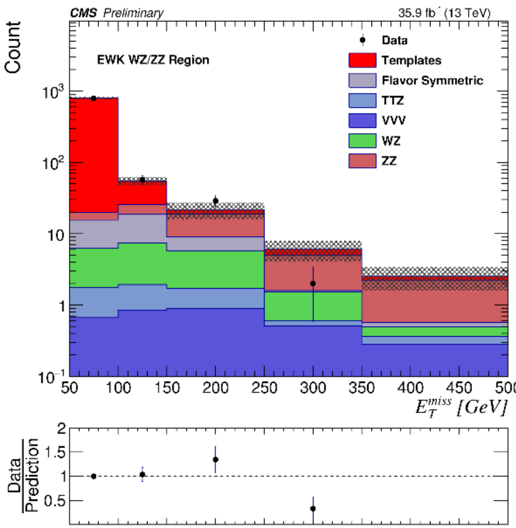
OS: On-Z results

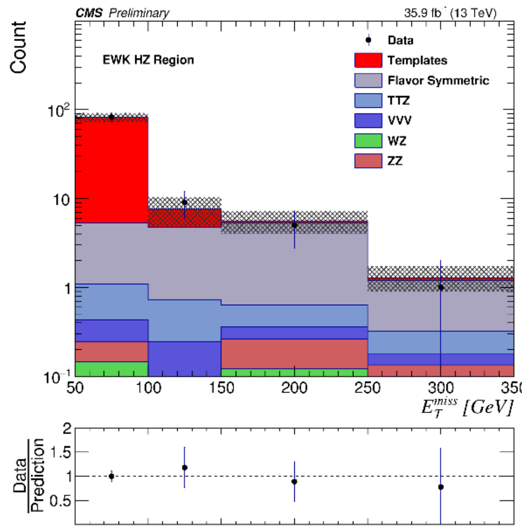
SRA	E_T^{miss} [GeV]	50-100	100-150	150-250	250+
	Template	208.5±16.1	13.6±3.1	2.5±0.9	3.3±2.4
	FS	$0.4^{+0.3}_{-0.2}$	$0.4^{+0.3}_{-0.2}$	$0.2^{+0.2}_{-0.1}$	$0.2^{+0.2}_{-0.1}$
	Rares	1.1±0.4	0.8±0.3	1.4±0.4	2.4±0.8
	Sum	210.0±16.1	14.8±3.2	4.0±1.0	5.9±2.5
	Data	210	23	5	4
SRAb	E_T^{miss} [GeV]	50-100	100-150	150-250	250+
	Template	92.2±10.4	8.2±2.1	1.2±0.5	0.5±0.3
	FS	1.9±0.7	2.3±0.8	$1.7^{+0.7}_{-0.6}$	$0.1^{+0.2}_{-0.1}$
	Rares	1.9±0.4	1.9±0.4	2.0±0.5	1.8±0.6
	Sum	96.0±10.4	12.4±2.3	4.9±1.0	2.5±0.7
	Data	96	14	7	1
SRB	E_T^{miss} [GeV]	50-100	100-150	150-250	250+
	Template	130.1±12.8	12.8±2.3	0.9±0.3	0.4±0.2
	FS	0.3±0.2	$0.4^{+0.3}_{-0.2}$	$0.4^{+0.3}_{-0.2}$	$0.1^{+0.2}_{-0.1}$
	Rares	0.6±0.2	0.3±0.1	0.7±0.2	1.2±0.4
	Sum	131.0±12.8	13.6±2.4	2.0±0.5	$1.6^{+0.5}_{-0.4}$
	Data	131	10	4	0
SRBb	E_T^{miss} [GeV]	50-100	100-150	150-250	250+
	Template	37.9±6.7	7.7±3.1	4.0±3.3	0.1±0.1
	FS	$0.7^{+0.4}_{-0.3}$	$1.4^{+0.6}_{-0.5}$	$1.1^{+0.5}_{-0.4}$	$0.2^{+0.2}_{-0.1}$
	Rares	1.3±0.4	2.0±0.5	2.3±0.6	1.0±0.3
	Sum	40.0±6.8	11.1±3.2	7.4±3.4	$1.3^{+0.4}_{-0.3}$
	Data	40	10	5	0
SRC	E_T^{miss} [GeV]	50-100	100-150	150+	
	Template	23.8±5.5	1.2±0.4	0.1±0.1	
	FS	$0.1^{+0.2}_{-0.1}$	$0.4^{+0.3}_{-0.2}$	$0.1^{+0.2}_{-0.1}$	
	Rares	0.2±0.1	0.1±0.1	0.5±0.2	
	Sum	24.0±5.5	1.7±0.5	$0.7^{+0.3}_{-0.2}$	
	Data	24	4	0	
SRCb	E_T^{miss} [GeV]	50-100	100-150	150+	
	Template	9.9±3.7	0.1±0.5	0.0±0.3	
	FS	$0.1^{+0.2}_{-0.1}$	$0.0^{+0.1}_{-0.0}$	0.3±0.2	
	Rares	0.0±0.1	0.6±0.2	0.6±0.2	
	Sum	10.0±3.7	0.8±0.5	$0.9^{+0.5}_{-0.4}$	
	Data	10	2	2	

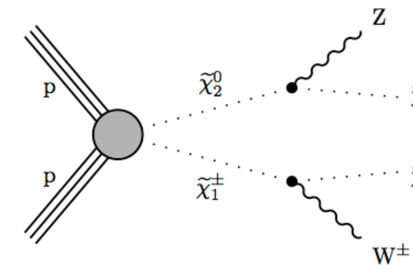


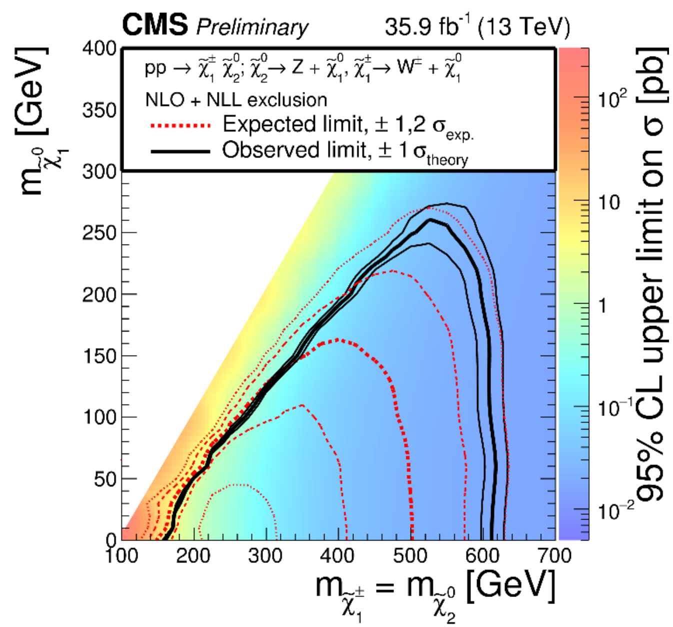
- Template prediction normalized in 1st bin
- No significant deviation

OS: Electroweak results & interpretation









WZ/ZZ	E_T^{miss} [GeV]	50-100	100-150	150-250	250-350	350+
	Template	773.2±31.9	29.3±4.4	2.9±2.1	1.0±0.7	0.3±0.3
	FS	9.4±3.0	11.1±3.6	3.2±1.1	$0.1^{+0.2}_{-0.1}$	$0.1^{+0.2}_{-0.1}$
	Rares	10.4±2.6	14.5±4.0	15.5±5.1	5.0±1.8	2.2±0.9
	Sum	793.0±32.2	54.9±7.0	21.6±5.6	6.0±1.9	2.5±0.9
	Data	793	57	29	2	0
HZ	E_T^{miss} [GeV]	50-100	100-150	150-250	250+	
	Template	76.7±9.4	2.9±2.4	0.3±0.2	0.1±0.1	
	FS	4.2±1.4	4.0±1.4	4.7±1.6	0.9±0.4	
	Rares	1.1±0.3	0.7±0.2	0.6±0.2	0.3±0.1	
	Sum	82.0±9.5	7.6±2.8	5.6±1.6	1.3±0.4	
	Data	82	9	5	1	

- Template prediction normalized in 1st bin
- No significant deviation
- Highest bins in WZ/ZZ region causes limits to be stronger than expected

OS: $t\bar{t}$ likelihood discriminator

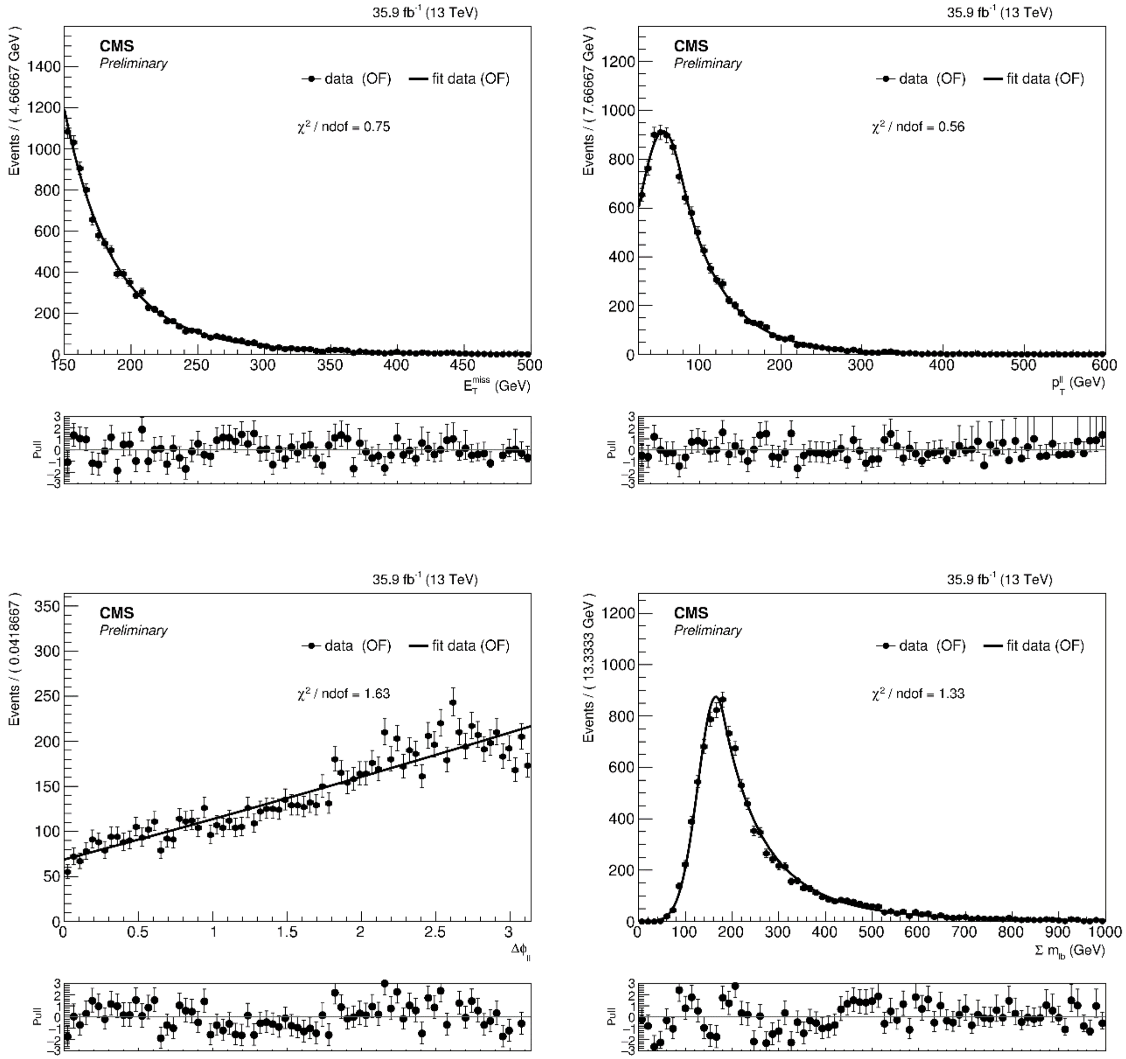
Construct likelihood out of four variables that are characteristic for dileptonic $t\bar{t}$:

- p_{T}^{miss}
- Dilepton p_{T}
- $\Delta\phi(\ell\ell)$
- sum of $m_{\ell b}$'s ($m_{\ell j}$'s if < 2 b-jets)

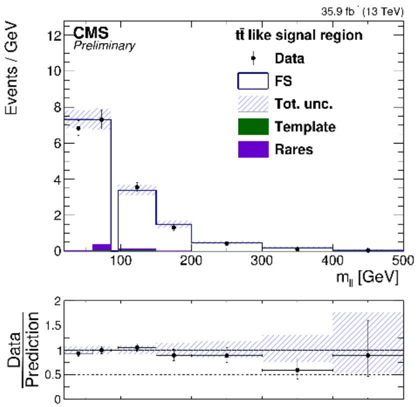
Evaluate shapes in DF data

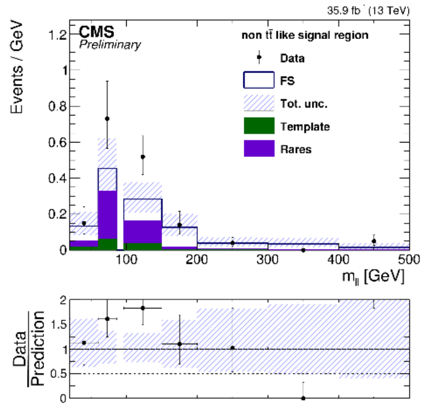
Cross check with $t\bar{t}$ MC

Choose arbitrary 95%/5% bins

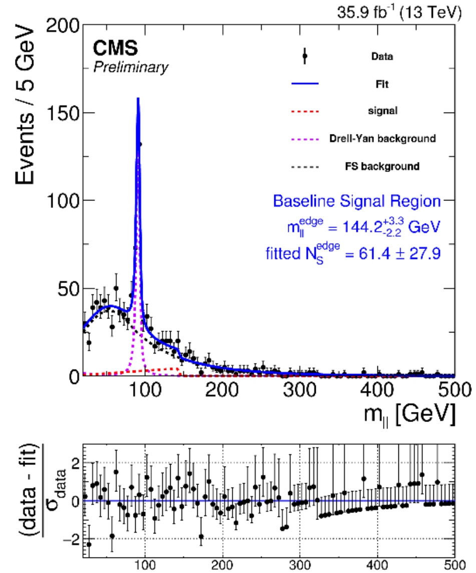


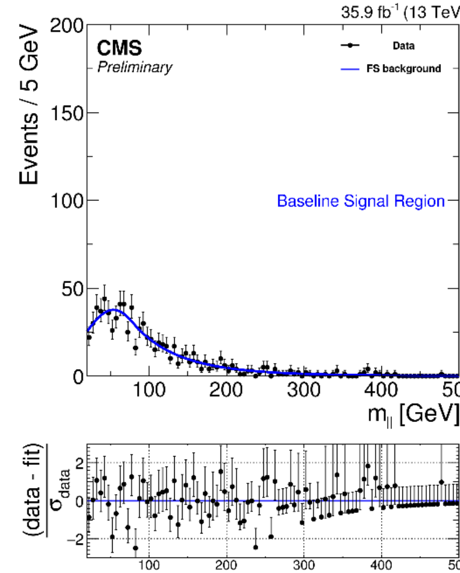
OS: Off-Z results





Mass range [GeV]	FS	Template	Rares	Sum	Observed
$t\bar{t}$ like					
20-60	$290.9^{+20.7}_{-19.7}$	0.4±0.3	1.4±0.5	$292.7^{+20.7}_{-19.7}$	273
60-86	$180.5^{+15.7}_{-14.7}$	0.9±0.7	8.8±3.4	$190.1^{+16.1}_{-15.1}$	190
96-150	$175.5^{+15.4}_{-14.4}$	1.1±0.9	6.0±2.4	$182.7^{+15.7}_{-14.6}$	192
150-200	$73.3^{+10.4}_{-9.2}$	0.1±0.1	0.4±0.2	$73.9^{+10.4}_{-9.2}$	66
200-300	$46.9^{+8.4}_{-7.3}$	0.1±0.1	0.3±0.1	$47.3^{+8.4}_{-7.3}$	42
300-400	$18.5^{+5.7}_{-4.5}$	0.0±0.0	0.0±0.0	$18.6^{+5.7}_{-4.5}$	11
>400	$4.3^{+3.4}_{-2.1}$	0.0±0.0	0.1±0.0	$4.5^{+3.4}_{-2.1}$	4
non-$t\bar{t}$ like					
20-60	$3.3^{+3.2}_{-1.8}$	0.7±0.5	1.4±0.5	$5.3^{+3.3}_{-1.9}$	6
60-86	$3.3^{+3.2}_{-1.8}$	1.6±1.3	6.9±2.7	$11.8^{+4.4}_{-3.5}$	19
96-150	$6.6^{+3.9}_{-2.6}$	1.9±1.5	6.8±2.7	$15.3^{+5.0}_{-4.1}$	28
150-200	$5.5^{+3.7}_{-2.4}$	0.2±0.3	0.7±0.3	$6.4^{+3.7}_{-2.4}$	7
200-300	$3.3^{+3.2}_{-1.8}$	0.2±0.2	0.5±0.2	$3.9^{+3.2}_{-1.8}$	4
300-400	$3.3^{+3.2}_{-1.8}$	0.1±0.1	0.2±0.1	$3.5^{+3.2}_{-1.8}$	0
>400	$1.1^{+2.5}_{-0.9}$	0.1±0.1	0.4±0.2	$1.6^{+2.5}_{-0.9}$	5
Super signal regions (non-$t\bar{t}$ like)					
20-86	$6.5^{+3.9}_{-2.6}$	2.3±1.5	8.3±3.2	$17.1^{+5.3}_{-4.4}$	25
>96	$19.6^{+5.8}_{-4.6}$	2.4±1.6	8.5±3.4	$30.6^{+7.0}_{-6.0}$	44





Drell–Yan	191 ± 19
OF yield	768 ± 24
$R_{SF/OF}$	1.07 ± 0.03
Signal events	61.4 ± 27.9
$m_{\ell\ell}^{edge}$	$144.2^{+3.3}_{-2.2}$ GeV
Local significance	2.3 σ
Global significance	1.5 σ

LS: Signal regions

Signal regions split according to lepton p_T:

- Both > 25 GeV → HH
- One 10—25 GeV → HL
- Both 10—25 GeV → LL

HH

N_b	m_T^{min} (GeV)	E_T^{miss} (GeV)	N_{jets}	$H_T < 300$ GeV	$H_T \in [300, 1125]$ GeV	$H_T \in [1125, 1300]$ GeV	$H_T \in [1300, 1600]$ GeV	$H_T > 1600$ GeV
0	<120	50 – 200	2-4	SR1	SR2	SR46 (++) / SR47 (--)	SR48 (++) / SR49 (--)	SR50 (++) / SR51 (--)
			≥5	SR3	SR4			
		200 – 300	2-4		SR5 (++) / SR6 (--)			
			≥5		SR7			
	>120	50 – 200	2-4		SR8 (++) / SR9 (--)			
			≥5		SR10			
		200 – 300	2-4					
			≥5					
1	<120	50 – 200	2-4	SR11	SR12			
			≥5	SR13 (++) / SR14 (--)	SR15 (++) / SR16 (--)			
		200 – 300	2-4		SR17 (++) / SR18 (--)			
			≥5		SR19			
	>120	50 – 200	2-4		SR20 (++) / SR21 (--)			
			≥5		SR22			
		200 – 300	2-4					
			≥5					
2	<120	50 – 200	2-4	SR23	SR24			
			≥5	SR25 (++) / SR26 (--)	SR27 (++) / SR28 (--)			
		200 – 300	2-4		SR29 (++) / SR30 (--)			
			≥5		SR31			
	>120	50 – 200	2-4		SR32 (++) / SR33 (--)			
			≥5		SR34			
		200 – 300	2-4					
			≥5					
≥3	<120	50 – 200	≥2	SR35 (++) / SR36 (--)	SR37 (++) / SR38 (--)			
		200 – 300			SR39			
	>120	50 – 300	≥2	SR40	SR41			
inclusive	inclusive	300 – 500	≥2	—	SR42 (++) / SR43 (--)			
		>500		—	SR44 (++) / SR45 (--)			

HL

N_b	m_T^{min} (GeV)	E_T^{miss} (GeV)	N_{jets}	$H_T < 300$ GeV	$H_T \in [300, 1125]$ GeV	$H_T \in [1125, 1300]$ GeV	$H_T > 1300$ GeV
0	<120	50 – 200	2-4	SR1	SR2	SR38 (++) / SR39 (--)	SR40 (++) / SR41 (--)
			≥5	SR3	SR4		
		200 – 300	2-4		SR5 (++) / SR6 (--)		
			≥5		SR7		
1	<120	50 – 200	2-4	SR8	SR9		
			≥5	SR10 (++) / SR11 (--)	SR12 (++) / SR13 (--)		
		200 – 300	2-4		SR14 (++) / SR15 (--)		
			≥5		SR16 (++) / SR17 (--)		
2	<120	50 – 200	2-4	SR18	SR19		
			≥5	SR20 (++) / SR21 (--)	SR22 (++) / SR23 (--)		
		200 – 300	2-4		SR24 (++) / SR25 (--)		
			≥5		SR26		
≥3	<120	50 – 200	≥2	SR27 (++) / SR28 (--)	SR29 (++) / SR30 (--)		
		200 – 300			SR31		
inclusive	>120	50 – 300	≥2	SR32	SR33		
inclusive	inclusive	300 – 500	≥2	—	SR34 (++) / SR35 (--)		
		>500		—	SR36 (++) / SR37 (--)		

LL

N_b	m_T^{min} (GeV)	H_T (GeV)	$E_T^{miss} \in [50, 200]$ GeV	$E_T^{miss} > 200$ GeV
0	<120	>300	SR1	SR2
1			SR3	SR4
2			SR5	SR6
≥3			SR7	
Inclusive	>120		SR8	

LS: Results

	HH regions		HL regions		LL regions	
	Expected SM	Observed	Expected SM	Observed	Expected SM	Observed
SR1	468 ± 98	435	419 ± 100	442	12.0 ± 3.9	12
SR2	162 ± 25	166	100 ± 20	101	1.88 ± 0.62	3
SR3	24.4 ± 5.4	30	9.2 ± 2.4	6	15.5 ± 4.7	17
SR4	17.6 ± 3.0	24	15.0 ± 4.5	13	1.42 ± 0.69	4
SR5	17.8 ± 3.9	22	7.3 ± 1.5	14	4.2 ± 1.4	5
SR6	7.8 ± 1.5	6	4.1 ± 1.2	5	0.84 ± 0.48	2
SR7	1.96 ± 0.47	2	1.01 ± 0.28	0	0.95 ± 0.52	0
SR8	4.58 ± 0.81	5	300 ± 82	346	0.09 ± 0.07	0
SR9	3.63 ± 0.75	3	73 ± 17	95		
SR10	2.82 ± 0.56	3	2.30 ± 0.61	1		
SR11	313 ± 87	304	2.24 ± 0.87	1		
SR12	104 ± 20	111	12.8 ± 3.3	12		
SR13	9.5 ± 1.9	13	8.9 ± 2.3	8		
SR14	8.7 ± 2.0	11	4.5 ± 1.3	5		
SR15	14.4 ± 2.9	17	4.7 ± 1.6	4		
SR16	12.7 ± 2.6	10	2.3 ± 1.1	1		
SR17	7.3 ± 1.2	11	0.73 ± 0.29	1		
SR18	3.92 ± 0.79	2	54 ± 12	62		
SR19	3.26 ± 0.74	3	23.7 ± 4.9	24		
SR20	2.6 ± 2.7	4	0.59 ± 0.17	2		
SR21	3.02 ± 0.75	3	0.34 ± 0.20	1		
SR22	2.80 ± 0.57	1	5.2 ± 1.2	9		
SR23	70 ± 12	90	4.9 ± 1.4	6		
SR24	35.7 ± 5.9	40	0.97 ± 0.27	0		
SR25	3.99 ± 0.73	2	1.79 ± 0.74	0		
SR26	2.68 ± 0.80	0	1.01 ± 0.27	1		
SR27	9.7 ± 1.8	9	1.03 ± 0.44	1		
SR28	7.9 ± 2.5	8	1.33 ± 0.61	0		
SR29	2.78 ± 0.58	1	2.89 ± 0.99	3		
SR30	1.86 ± 0.38	1	2.24 ± 0.79	2		
SR31	2.20 ± 0.54	1	0.27 ± 0.30	1		
SR32	1.85 ± 0.39	5	0.79 ± 0.33	1		
SR33	1.20 ± 0.32	0	0.53 ± 0.13	0		
SR34	1.81 ± 0.42	3	6.3 ± 1.3	6		
SR35	1.98 ± 0.61	1	2.92 ± 0.87	3		
SR36	1.43 ± 0.37	2	0.51 ± 0.15	3		
SR37	4.2 ± 1.3	2	0.15 ± 0.07	0		
SR38	3.04 ± 0.68	4	1.07 ± 0.33	3		
SR39	0.63 ± 0.17	1	0.81 ± 0.47	0		
SR40	0.29 ± 0.34	0	1.54 ± 0.50	4		
SR41	0.80 ± 0.22	3	1.23 ± 0.53	1		
SR42	13.4 ± 1.9	19				
SR43	8.0 ± 3.0	8				
SR44	3.33 ± 0.74	3				
SR45	0.94 ± 0.26	1				
SR46	2.92 ± 0.50	3				
SR47	1.78 ± 0.42	3				
SR48	1.95 ± 0.39	5				
SR49	1.23 ± 0.30	3				
SR50	1.46 ± 0.31	0				
SR51	0.74 ± 0.18	0				

Aggregate inclusive signal regions

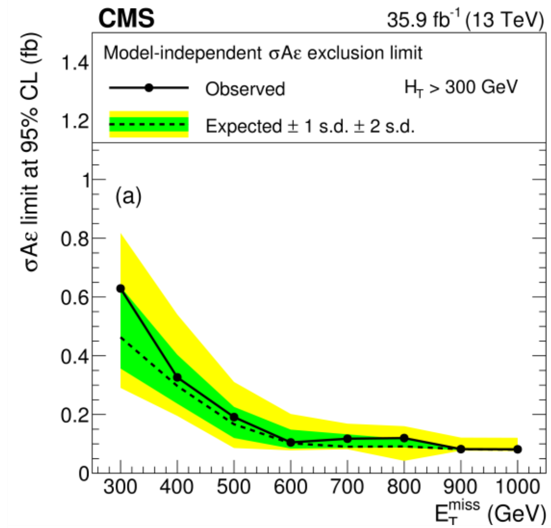
SR	Leptons	N_{jets}	N_{b}	H_{T} (GeV)	$E_{\text{T}}^{\text{miss}}$ (GeV)	$m_{\text{T}}^{\text{min}}$ (GeV)	SM expected	Observed	$N_{\text{obs,UL}}^{95\%\text{CL}}$
InSR1	HH	≥2	0	≥1200	≥50	—	4.00 ± 0.79	10	12.35
InSR2		≥2	≥2	≥1100	≥50	—	3.63 ± 0.71	4	5.64
InSR3		≥2	0	—	≥450	—	3.72 ± 0.83	4	5.62
InSR4		≥2	≥2	—	≥300	—	3.32 ± 0.81	6	8.08
InSR5		≥2	0	—	≥250	≥120	1.68 ± 0.44	2	4.46
InSR6		≥2	≥2	—	≥150	≥120	3.82 ± 0.76	7	9.06
InSR7		≥2	0	≥900	≥200	—	5.6 ± 1.1	10	10.98
InSR8		≥2	≥2	≥900	≥200	—	5.8 ± 1.3	9	9.77
InSR9		≥7	—	—	≥50	—	10.1 ± 2.7	9	7.39
InSR10		≥4	—	—	≥50	≥120	15.2 ± 3.5	22	16.73
InSR11		≥2	≥3	—	≥50	—	13.3 ± 3.4	17	13.63
InSR12		≥2	0	≥700	≥50	—	3.6 ± 2.5	3	4.91
InSR13	LL	≥2	—	—	≥200	—	4.9 ± 2.9	10	11.76
InSR14		≥5	—	—	≥50	—	7.3 ± 5.5	6	6.37
InSR15		≥2	≥3	—	≥50	—	1.06 ± 0.99	0	2.31

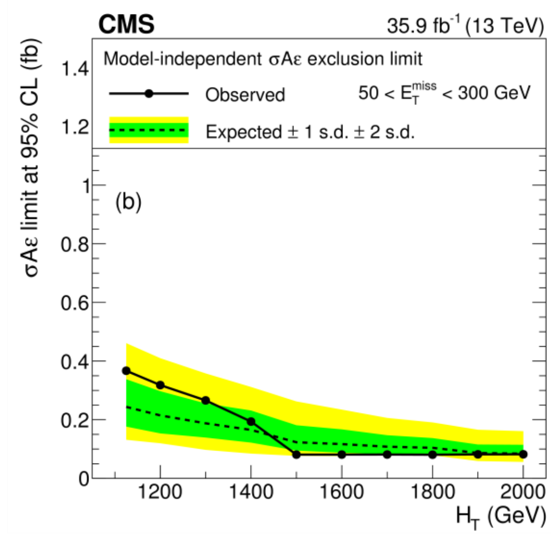
Aggregate exclusive signal regions

SR	Leptons	N_{jets}	N_{b}	$E_{\text{T}}^{\text{miss}}$ (GeV)	H_{T} (GeV)	$m_{\text{T}}^{\text{min}}$ (GeV)	SM expected	Observed
ExSR1	HH	≥2	0	50–300	<1125	<120 for $H_{\text{T}} > 300$	700 ± 130	685
ExSR2		≥2	0	50–300	300–1125	≥120	11.0 ± 2.2	11
ExSR3		≥2	1	50–300	<1125	<120 for $H_{\text{T}} > 300$	477 ± 120	482
ExSR4		≥2	1	50–300	300–1125	≥120	8.4 ± 3.5	8
ExSR5		≥2	2	50–300	<1125	<120 for $H_{\text{T}} > 300$	137 ± 25	152
ExSR6		≥2	2	50–300	300–1125	≥120	4.9 ± 1.2	8
ExSR7		≥2	≥3	50–300	<1125	<120 for $H_{\text{T}} > 300$	11.6 ± 3.1	10
ExSR8		≥2	≥3	50–300	300–1125	≥120	0.8 ± 0.24	3
ExSR9		≥2	—	≥300	≥300	—	25.7 ± 5.4	31
ExSR10		≥2	—	50–300	≥1125	—	10.1 ± 2.2	14
ExSR11	HL	≥2	—	50–300	<1125	<120	1070 ± 250	1167
ExSR12		≥2	—	50–300	<1125	≥120	1.33 ± 0.46	1
ExSR13		≥2	—	≥300	≥300	—	9.9 ± 2.5	12
ExSR14		≥2	—	50–300	≥1125	—	4.7 ± 1.8	8
ExSR15	LL	≥2	—	≥50	≥300	—	37 ± 12	43

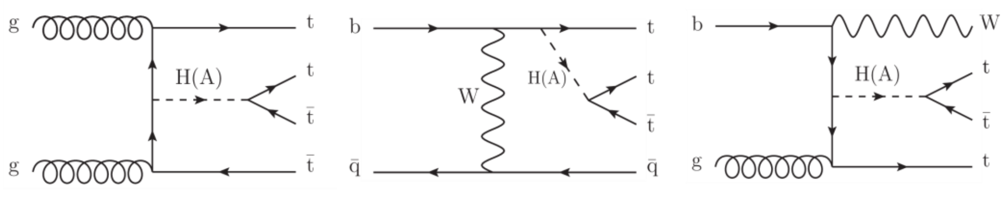
LS: Additional interpretations

Model independent limits

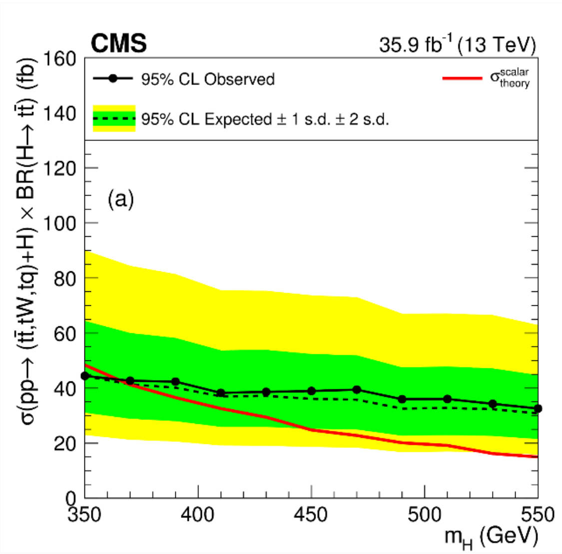


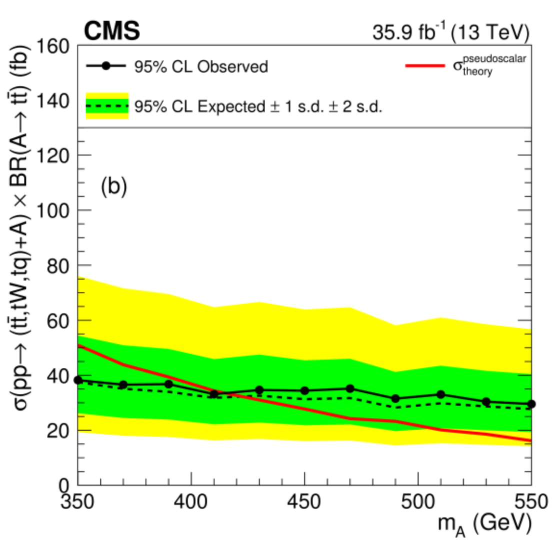


(pseudo-) scalar boson production in association with top quarks



(a) $t\bar{t}H$ (b) tHq (c) tHW





Multilepton: Results

Off-Z signal regions

b-tags	H_T (GeV)	E_T^{miss} (GeV)	M_T (GeV)	Expected	Observed	SR
0 b-tags	60-400	50-150	< 120	$206 \pm 6 \pm 35$	201	SR1a
			≥ 120	$1.4 \pm 0.5 \pm 0.2$	3	SR1b
		150-300	< 120	$25.9 \pm 2.1 \pm 4.3$	24	SR2a
			≥ 120	$0.84 \pm 0.34 \pm 0.12$	0	SR2b
	400-600	50-150	< 120	$15.6 \pm 1.6 \pm 2.1$	21	SR3a
			≥ 120	$0.19 \pm 0.09 \pm 0.02$	0	SR3b
		150-300	< 120	$6.0 \pm 0.8 \pm 0.7$	5	SR4a
			≥ 120	$0.19 \pm 0.09 \pm 0.04$	0	SR4b
1 b-tags	60-400	50-150	inclusive	$202 \pm 6 \pm 44$	191	SR5
		150-300		$25.6 \pm 1.9 \pm 4.6$	25	SR6
	400-600	50-150		$15.4 \pm 1.3 \pm 2.2$	21	SR7
		150-300		$7.3 \pm 1 \pm 1.1$	7	SR8
2 b-tags	60-400	50-150	inclusive	$47.7 \pm 2.8 \pm 7.6$	51	SR9
		150-300		$5.3 \pm 0.5 \pm 0.6$	5	SR10
	400-600	50-150		$5.8 \pm 0.7 \pm 0.8$	9	SR11
		150-300		$2.9 \pm 0.5 \pm 0.4$	2	SR12
≥ 3 b-tags	60-600	50-300	inclusive	$3.9 \pm 0.7 \pm 0.6$	6	SR13
inclusive	≥ 600	50-150	< 120	$14.4 \pm 1.2 \pm 1.6$	20	SR14a
			≥ 120	$0.28 \pm 0.14 \pm 0.04$	0	SR14b
		150-300	< 120	$12.1 \pm 1.4 \pm 1.6$	10	SR15a
			≥ 120	$0.40 \pm 0.12 \pm 0.05$	0	SR15b
	≥ 60	≥ 300	< 120	$12.1 \pm 1.5 \pm 1.9$	7	SR16a
			≥ 120	$0.70 \pm 0.25 \pm 0.11$	0	SR16b

On-Z signal regions

b-tags	H_T (GeV)	E_T^{miss} (GeV)	M_T (GeV)	Expected	Observed	SR
0 b-tags	60-400	50-150	< 120	$266 \pm 5 \pm 39$	241	SR1a
			≥ 120	$30 \pm 2 \pm 4$	33	SR1b
		150-300	< 120	$53.8 \pm 2.2 \pm 8$	61	SR2a
			≥ 120	$5.69 \pm 0.76 \pm 0.69$	9	SR2b
	400-600	50-150	< 120	$44.6 \pm 1.9 \pm 6.5$	52	SR3a
			≥ 120	$5.1 \pm 0.6 \pm 0.7$	6	SR3b
		150-300	< 120	$16.6 \pm 1.3 \pm 2.5$	17	SR4a
			≥ 120	$1.43 \pm 0.33 \pm 0.2$	1	SR4b
1 b-tags	60-400	50-150	inclusive	$115.70 \pm 3.50 \pm 15.23$	115	SR5
		150-300		$21.7 \pm 1.2 \pm 2.8$	19	SR6
	400-600	50-150		$25.2 \pm 1.2 \pm 3.6$	25	SR7
		150-300		$7.5 \pm 0.8 \pm 1$	9	SR8
2 b-tags	60-400	50-150	inclusive	$47 \pm 1.6 \pm 7.4$	64	SR9
		150-300		$7.2 \pm 0.8 \pm 1.2$	6	SR10
	400-600	50-150		$11.7 \pm 1 \pm 2.1$	12	SR11
		150-300		$2.6 \pm 0.4 \pm 0.4$	6	SR12
≥ 3 b-tags	60-600	50-300	inclusive	$4.7 \pm 0.5 \pm 0.9$	5	SR13
inclusive	≥ 600	50-150	< 120	$33 \pm 2 \pm 4$	42	SR14a
			≥ 120	$4.6 \pm 0.6 \pm 0.6$	6	SR14b
		150-300	< 120	$15.8 \pm 1.2 \pm 2$	13	SR15a
			≥ 120	$1.9 \pm 0.3 \pm 0.2$	4	SR15b
	≥ 60	≥ 300	< 120	$19.1 \pm 1.1 \pm 2.8$	23	SR16a
			≥ 120	$2.28 \pm 0.35 \pm 0.26$	5	SR16b