SUSY searches with one or more leptons from ATLAS and CMS

Low p_T lepton final states @13TeV in ATLAS and CMS

Moriond EWK, 17 March 2016

Henning Kirschenmann (CERN)

on behalf of the ATLAS and CMS collaborations

This talk: SUSY searches with one or more leptons

Higher branching ratio ← → Less background

0 leptons

Christopher Young (yesterday)

0-lepton SUSY Searches from ATLAS and CMS

1 lepton

CMS: SUS-15-007 MJ (≥1b)

CMS: SUS-15-006 Δϕ (0b;≥1b) — NEW!

ATLAS: 2015-076 lep,jet,MET hard/soft leptons

2, 3,… leptons

CMS: SUS-15-011 Edge/on-Z

ATLAS: 2015-082 on-Z

CMS: SUS-15-008 Same Sign

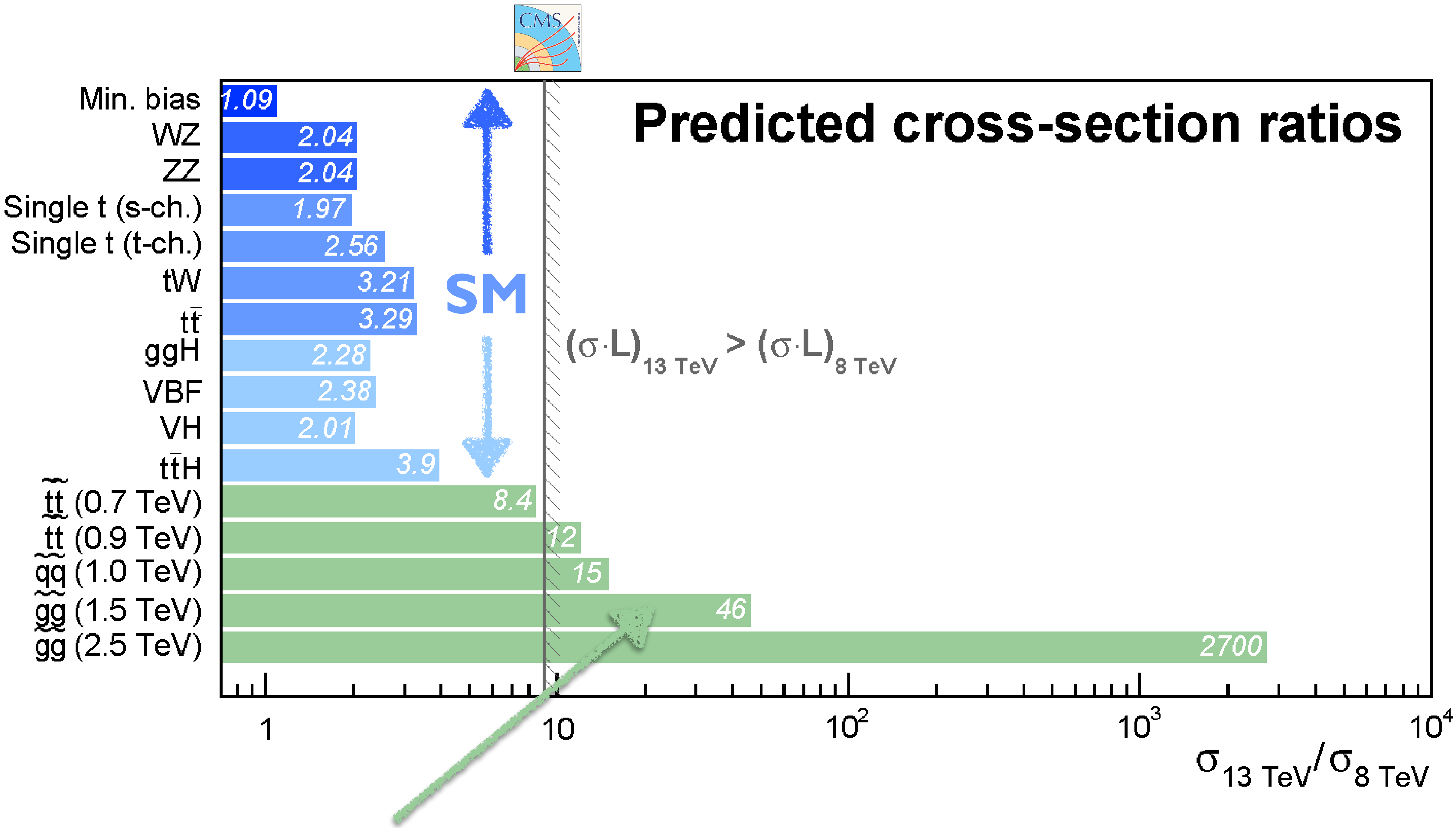
CMS: SUS-16-003 Multileptons — NEW!

ATLAS: 1602.09058 Same Sign Multileptons

Paper submitted

- Interpretation usually done in simplified [SUSY] models
- However, results can be interpreted in non-SUSY models as well

Setting the scene



Early SUSY searches mostly aiming at gluino-induced production: Large cross-section gains w.r.t. 8 TeV

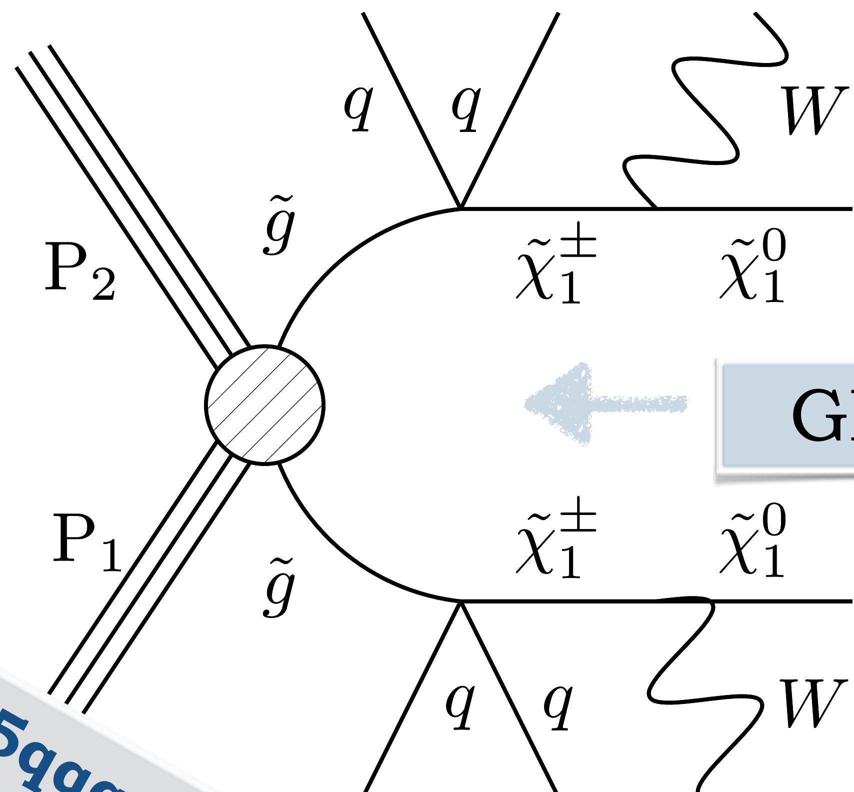
Which signal models?

1 lepton

SUS-15-006
Δϕ (0b)

2015-076
lep,jet,MET
hard/soft
leptons

ATLAS EXPERIMENT

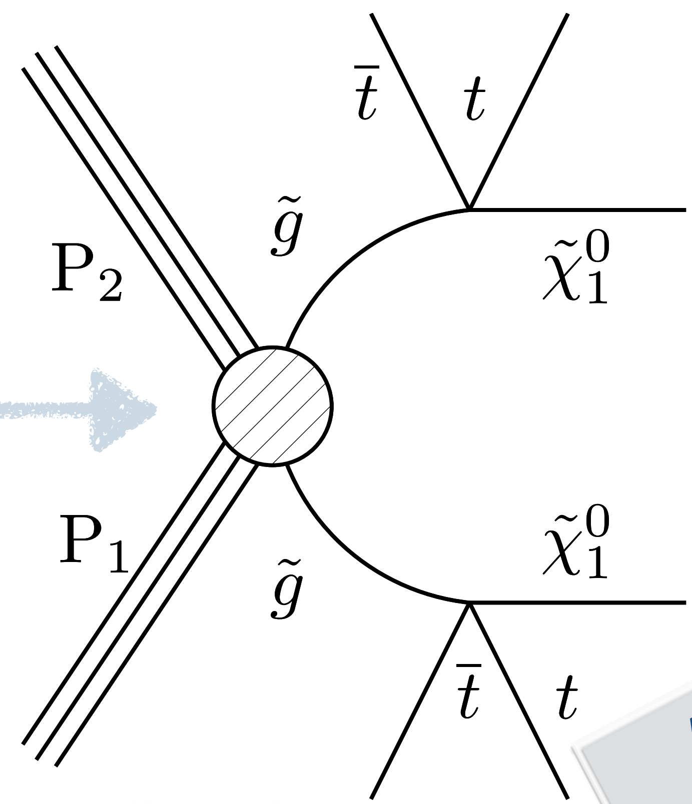


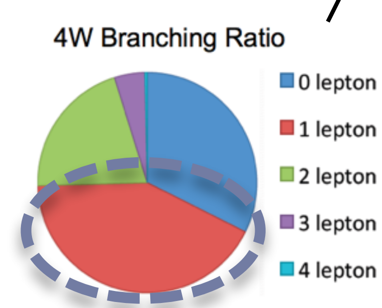
T5qqqqWW
0 b-tag

Gluino-induced

SUS-15-007
MJ (≥1b)

SUS-15-006
Δϕ (≥1b)





T1tttt
High b-tag
multiplicity

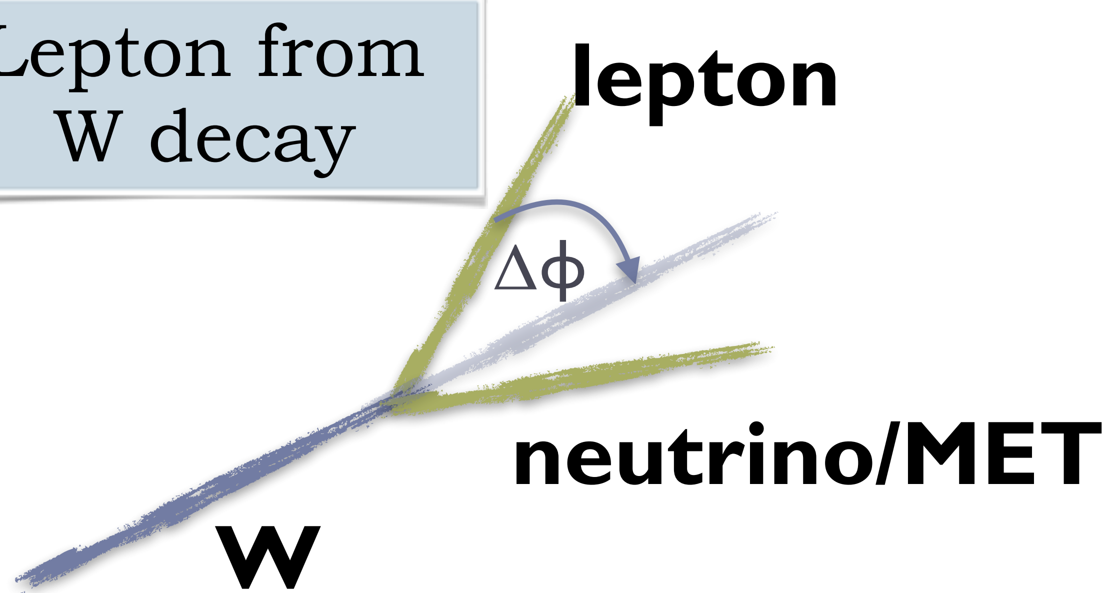
$\Delta\phi$ analysis - new for Moriond:

SUS-15-006
$\Delta\phi$ (0b;≥1b)

Baseline requirements:
- H_T (scalar sum of jet p_T)>500 GeV
- exactly one hard lepton (p_T>25 GeV)
- L_T (scalar sum of p_T(lep) and MET)>250 GeV

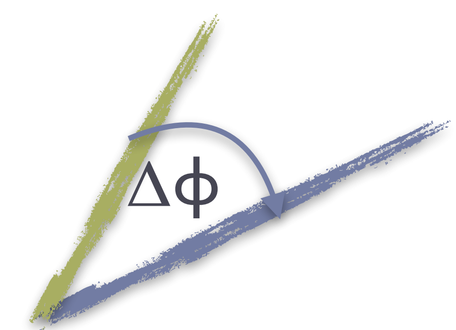
- Analysis binned in #jets, #b-jets, H_T, L_T
- Main discriminating observable: $\Delta\phi$

Lepton from W decay



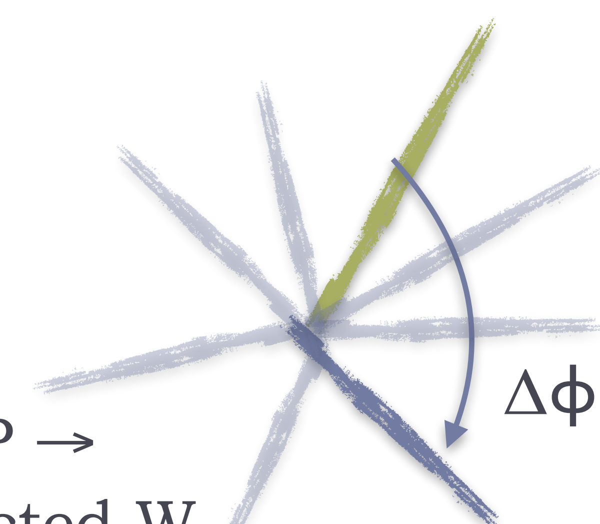
$\Delta\phi$: Angle between lepton and reconstructed W (lepton+MET)

Lepton + MET in SM:



$\Delta\phi$ small (MET≈neutrino)

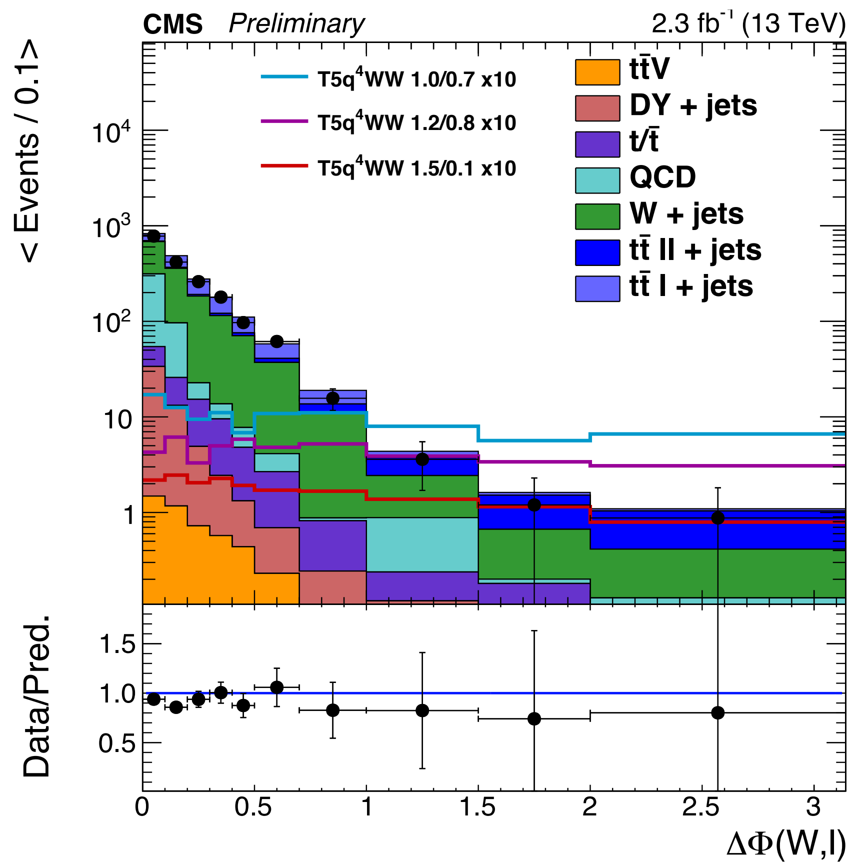
Lepton + MET with SUSY:

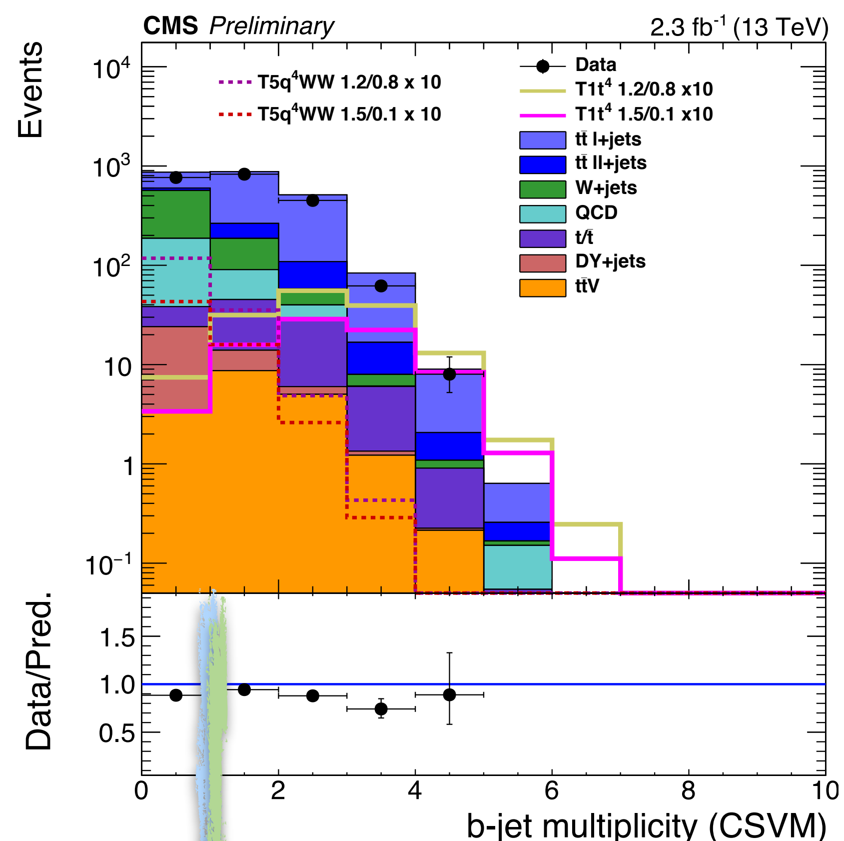


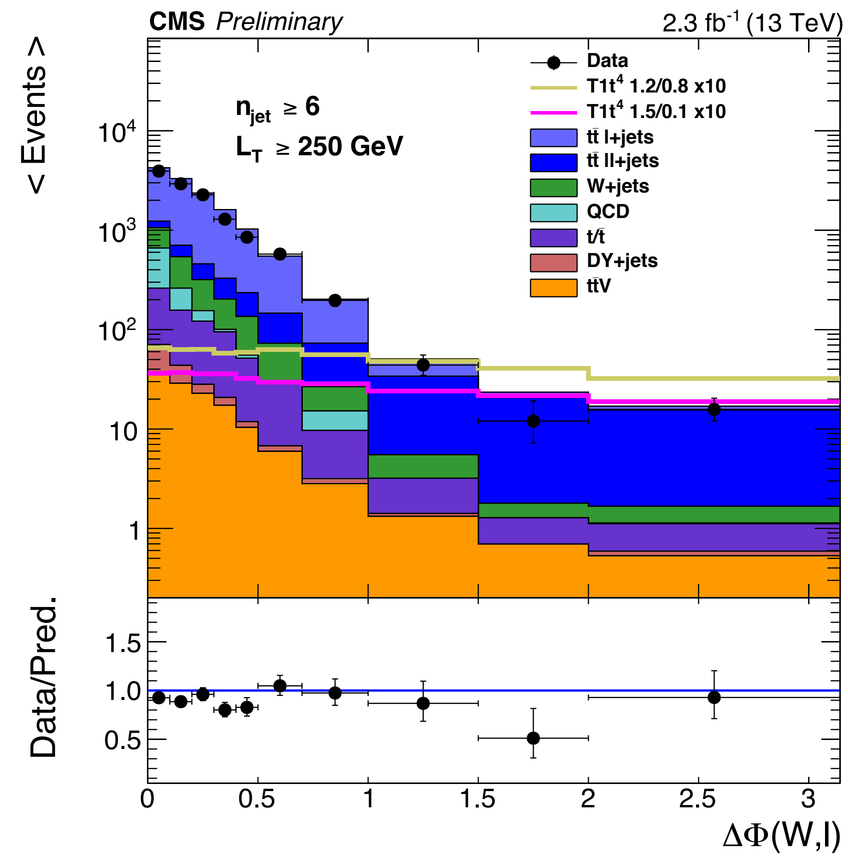
MET (mostly) due to LSP → "randomized" reconstructed W → "randomized" $\Delta\phi$

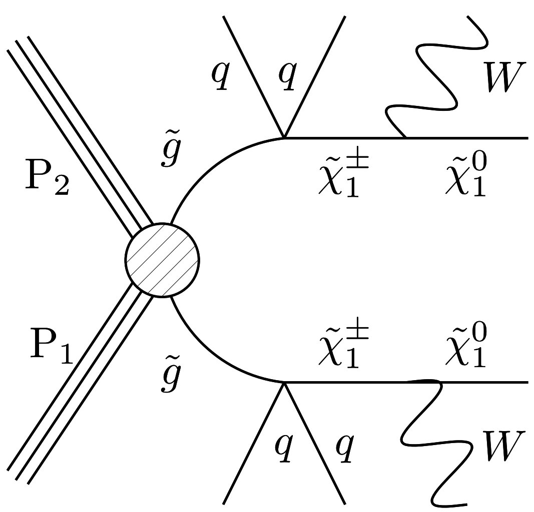
Δϕ - background vs. signal

SUS-15-006
Δϕ (0b;≥1b)







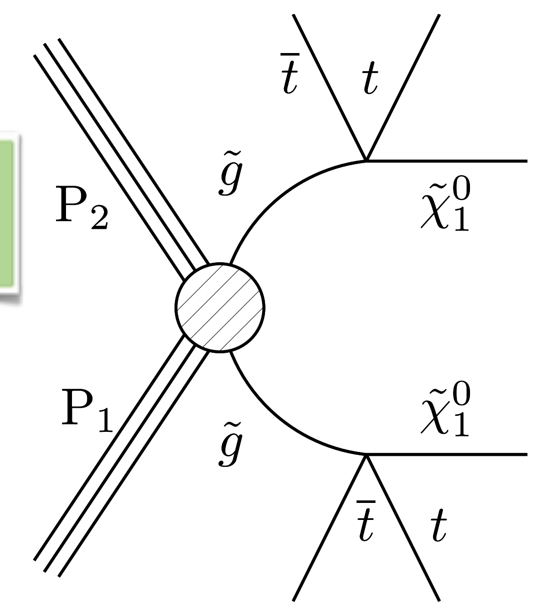


0b

ttbar and W+Jets in signal region

multi-b

ttbar-only in signal region



- Signal regions defined by sliding Δϕ cut (decreasing for high L_T [L_T :scalar sum of p_T(lep) and MET])

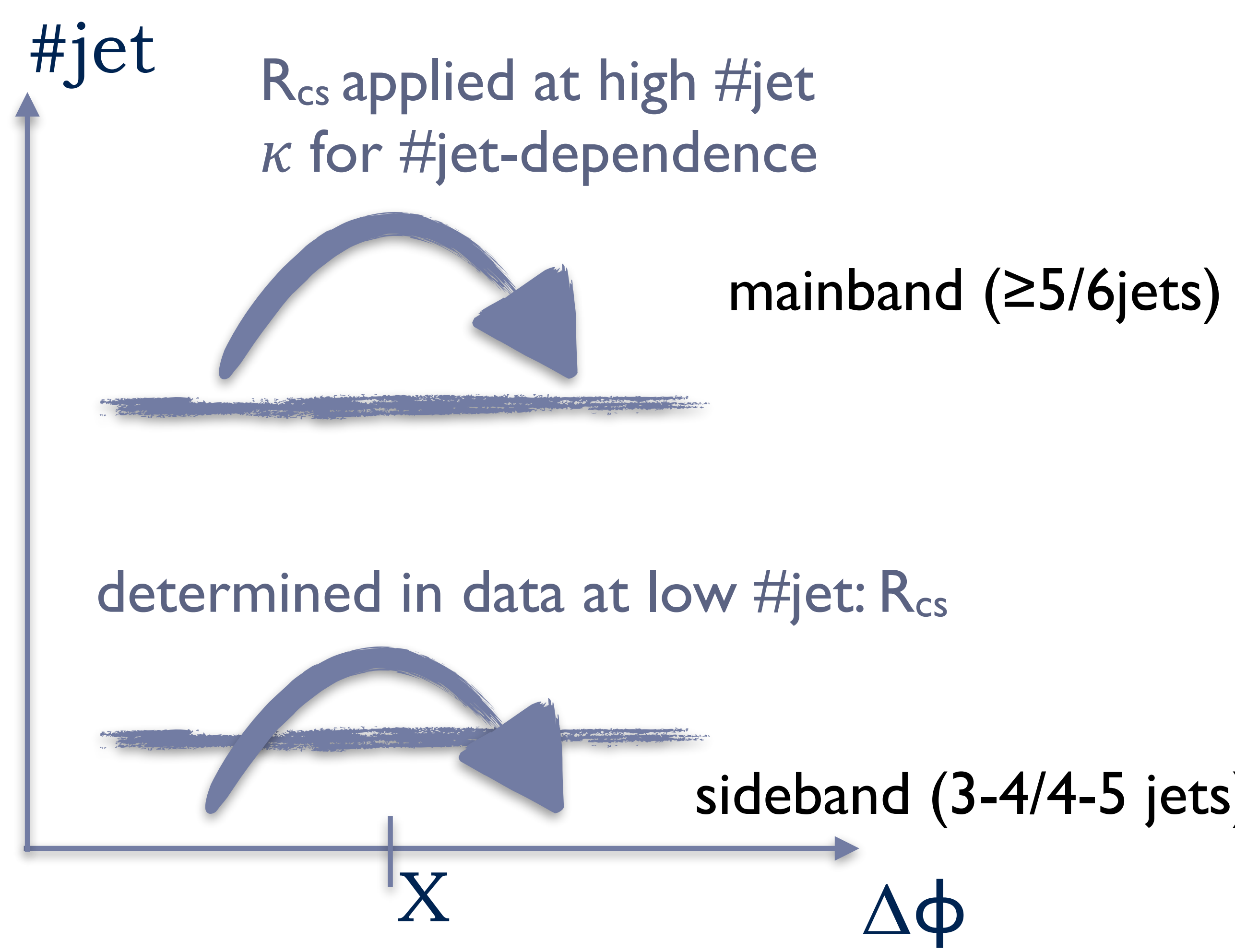
Background estimation

SUS-15-006
$\Delta\phi$ (0b;≥1b)

Analysis	Multi-b analysis		Zero-b analysis	
$n_{\text{b-tag}}$	$n_{\text{b-tag}} = 0$	$n_{\text{b-tag}} \geq 1$	$n_{\text{b-tag}} = 0$	$n_{\text{b-tag}} = 1$
$n_{\text{jet}} = 3$	QCD Fit (el. sample)		$R_{\text{CS}}(\text{W}^{\pm})$ det. (μ sample), QCD Fit (el. sample)	
$n_{\text{jet}} = 4$		R_{CS} det.		$R_{\text{CS}}(\text{t}\bar{\text{t}})$ det.
$n_{\text{jet}} = 5$			MB	
$n_{\text{jet}} \geq 6$		MB		

- Low $\Delta\phi$ (CR) → high $\Delta\phi$ (SR) ratio R_{cs}, determined in low #jet sideband
- 0-b: separate W+jets and tt R_{cs}, fractions determined in data with #b-jet fit
- Multi-b: one R_{cs} for all EWK

- Dominant systematic uncertainty: #jet-extrapolation from dileptonic control sample

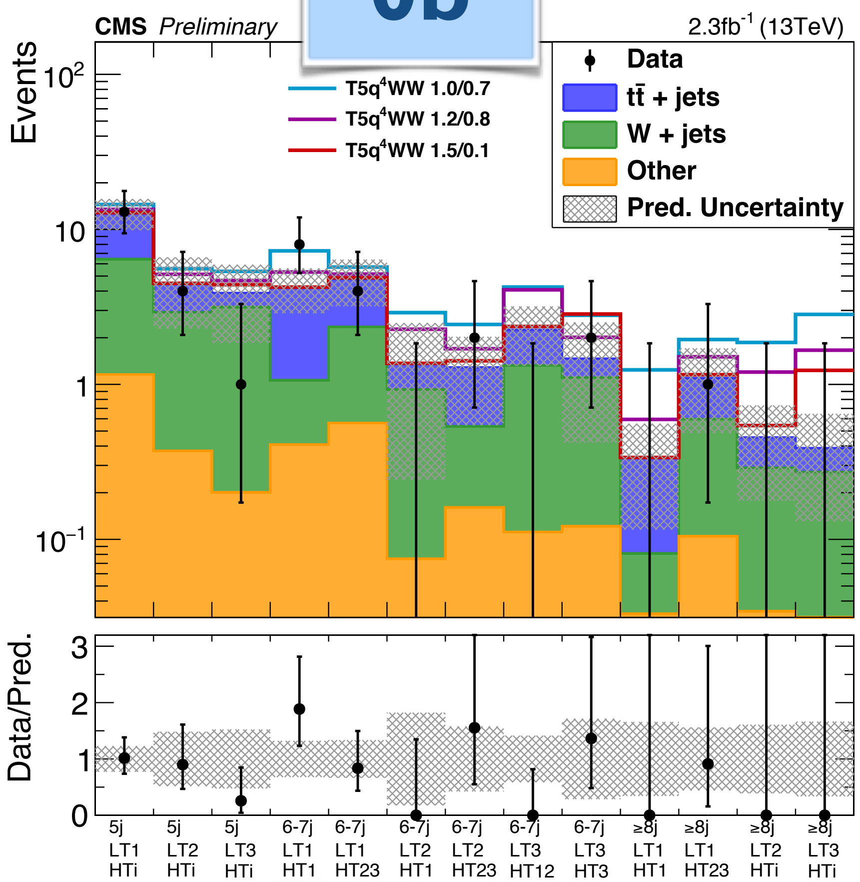


$$R_{\text{CS}}^{\text{MC}} = \frac{N^{\text{all backgrounds except QCD}}(\Delta\Phi > x)}{N^{\text{all backgrounds except QCD}}(\Delta\Phi < x)}$$

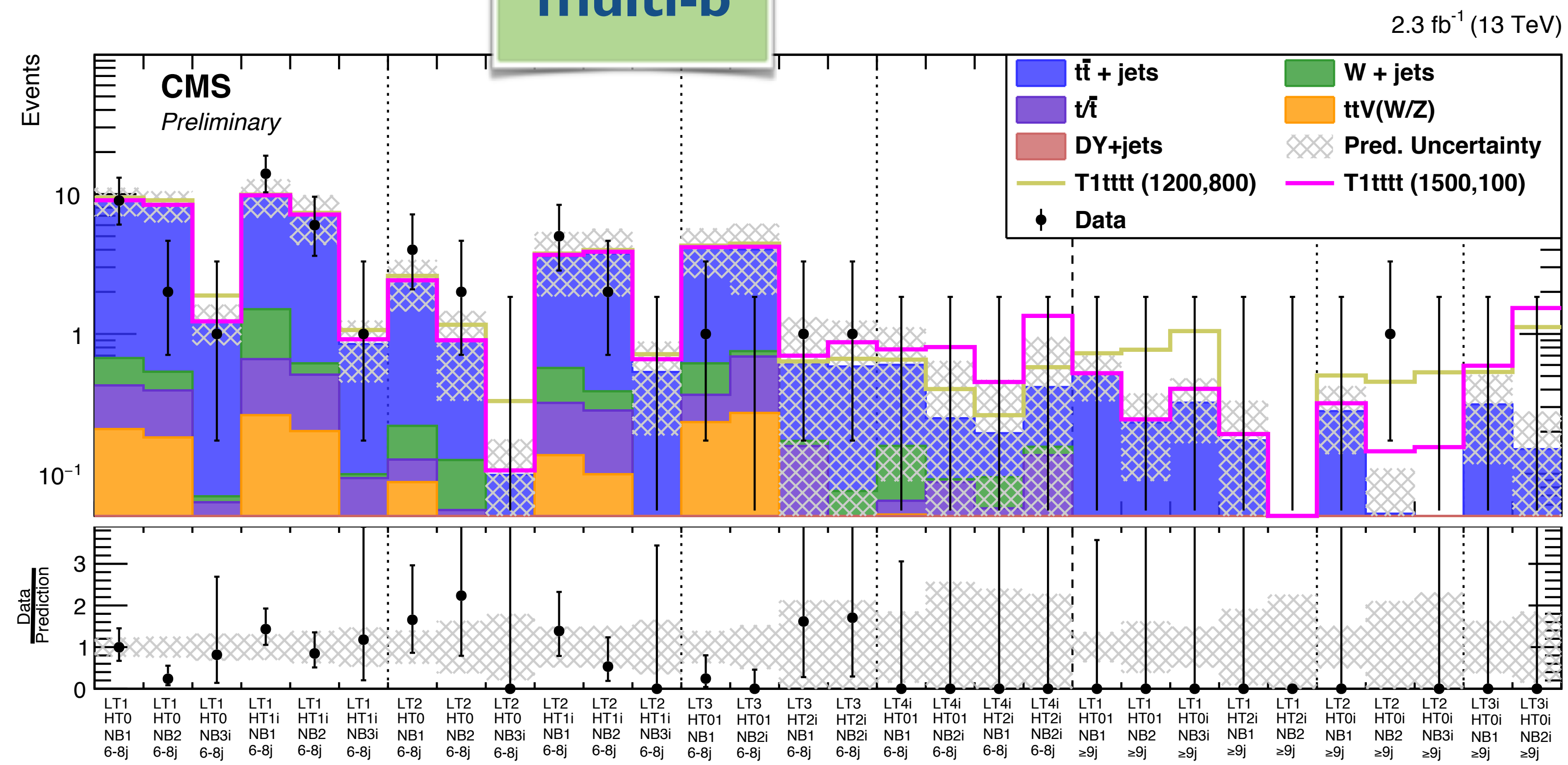
Prediction/Observation

SUS-15-006
Δϕ (0b;≥1b)

0b



multi-b



#jet[6,7]:15/16/10/5 #jet≥8:2.3/1/5.6/2.7 pred/obs./T5q4WW(1.0/0.7)/T5q4WW(1.2/0.8)

Background predictions and observations agree:
Putting limits in

T5qqqqWW 2015-076 lep,jet,MET ATLAS EXPERIMENT and T1tttt

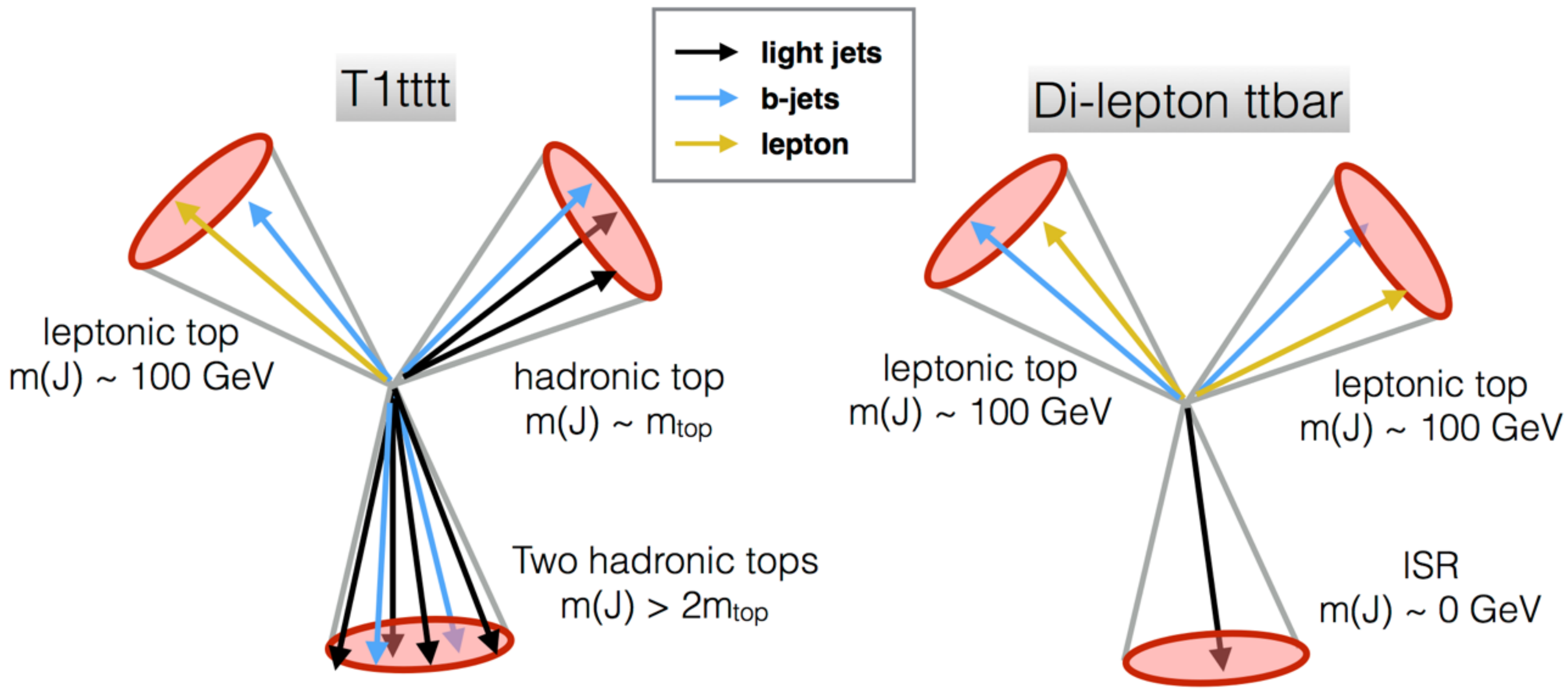
SUS-15-007
MJ (≥1b)

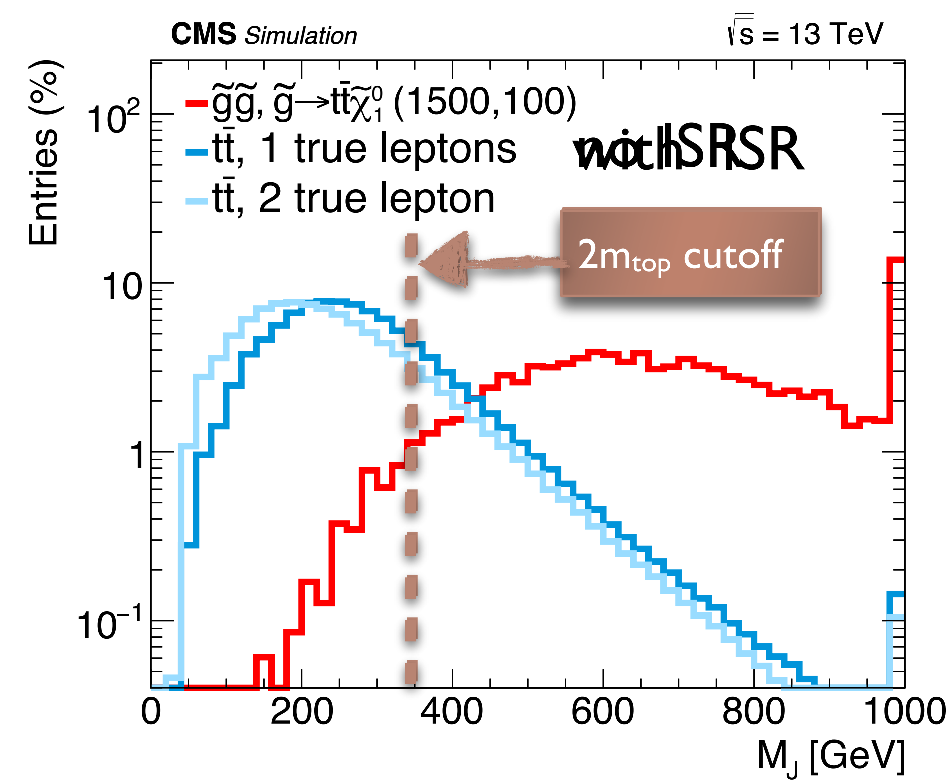
2, 3,… leptons

M_J analysis

SUS-15-007
MJ (≥1b)

- Main discriminating observables: m_T and M_J
- m_T: transverse mass of lepton and MET; suppresses 1L-ttbar; 2L-ttbar remains
- M_J : Scalar sum of the masses of large-R jets (*)
- $M_J = \sum_{J_i=\text{large}-R\text{ jets}} m(J_i)$ J_i clustered with R=1.2 from AK4PF-jets and leptons





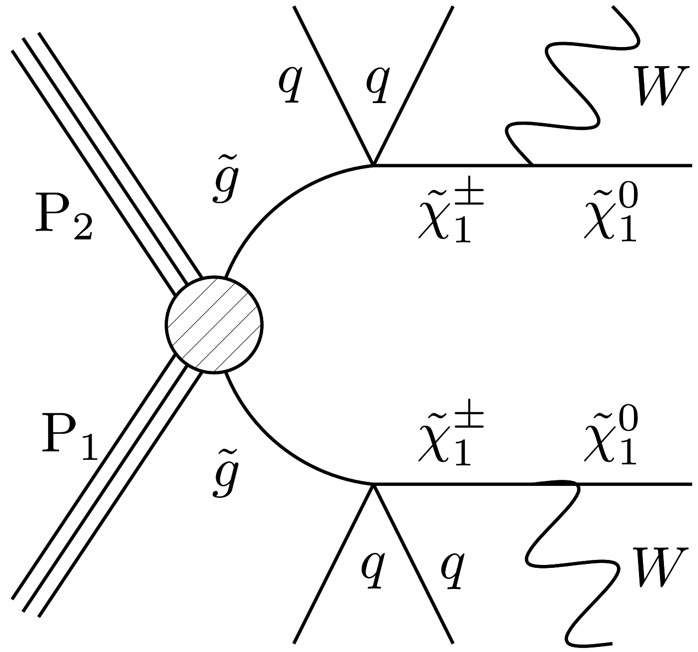
$$\hat{N}^{Data}_{R4,MET,N_{jets},N_b} = \underbrace{N^{Data}_{R2,MET,N_{jets},N_b}\left(\frac{N_{R3}}{N_{R1}}\right)^{Data}_{MET,N_b}}_{\text{ABCD Prediction (Data)}} \times \underbrace{\left(\frac{N_{R4}}{N_{R2}}\right)^{MC}_{MET,N_{jets},Nb}\cdot\left(\frac{N_{R1}}{N_{R3}}\right)^{MC}_{MET,N_b}}_{\kappa\text{ factor (MC)}}$$

- m_T and M_J ~uncorrelated
- ABCD-method in bins of MET, #jets, #b-jets, differences corrected using MC

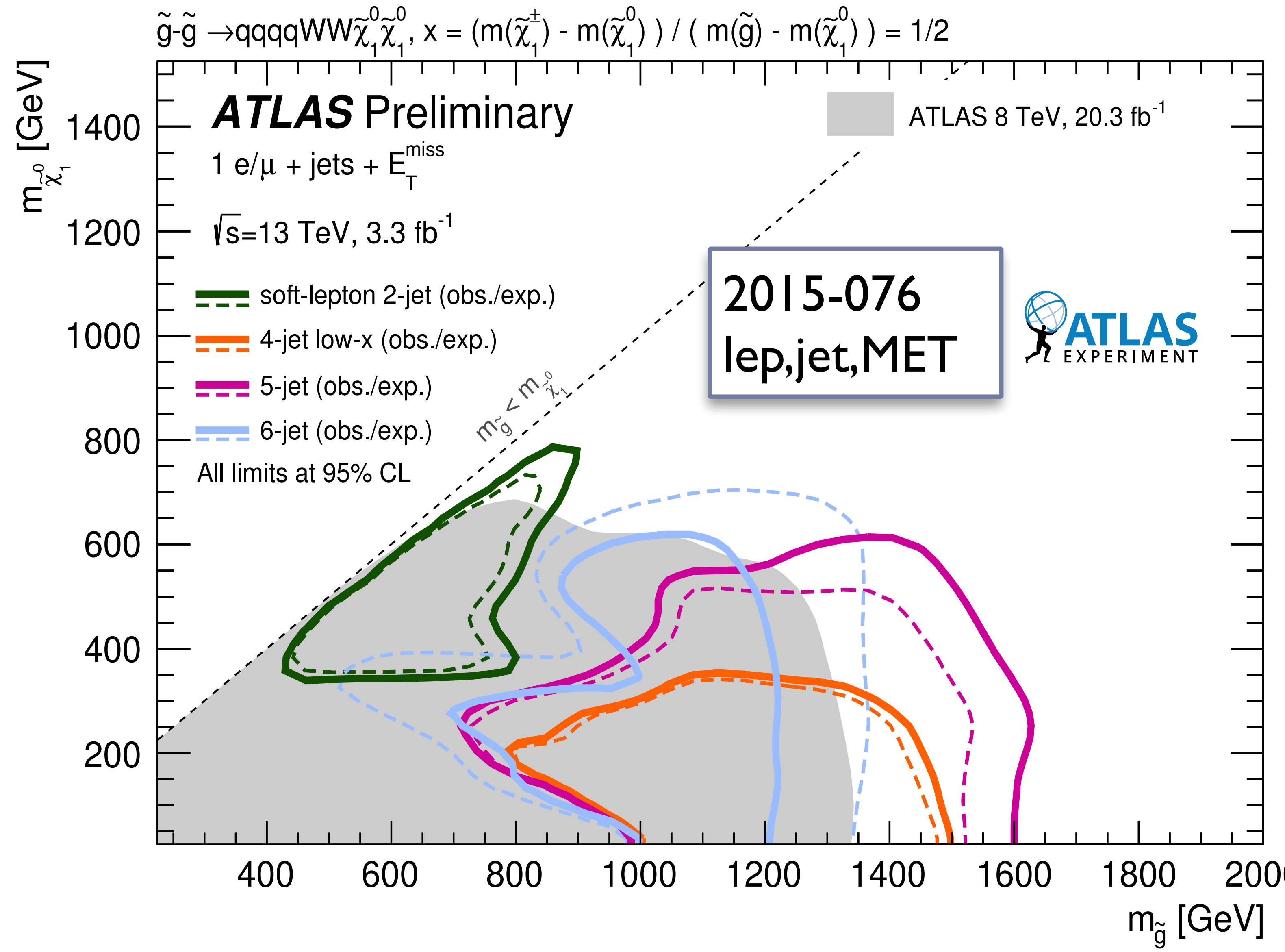
(*) a la Phys.Rev. D85 (2012) 055029

1 lepton, jets, MET

2015-076
lep,jet,MET

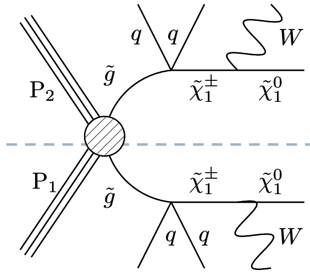


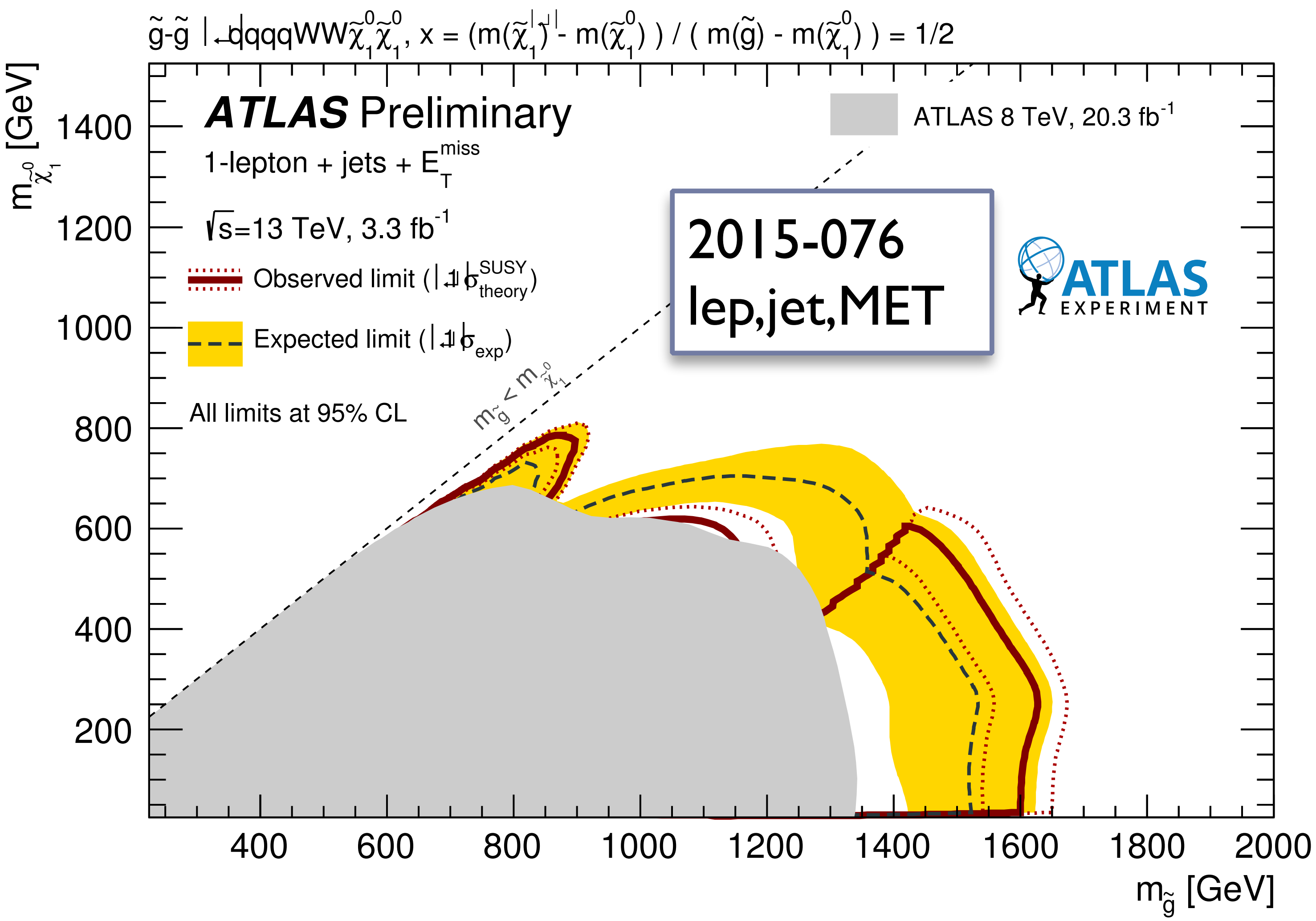
- Main backgrounds: ttbar and W+jets - normalize the MC in control regions
- Small backgrounds from MC
- Signal regions for high m_T and high MET

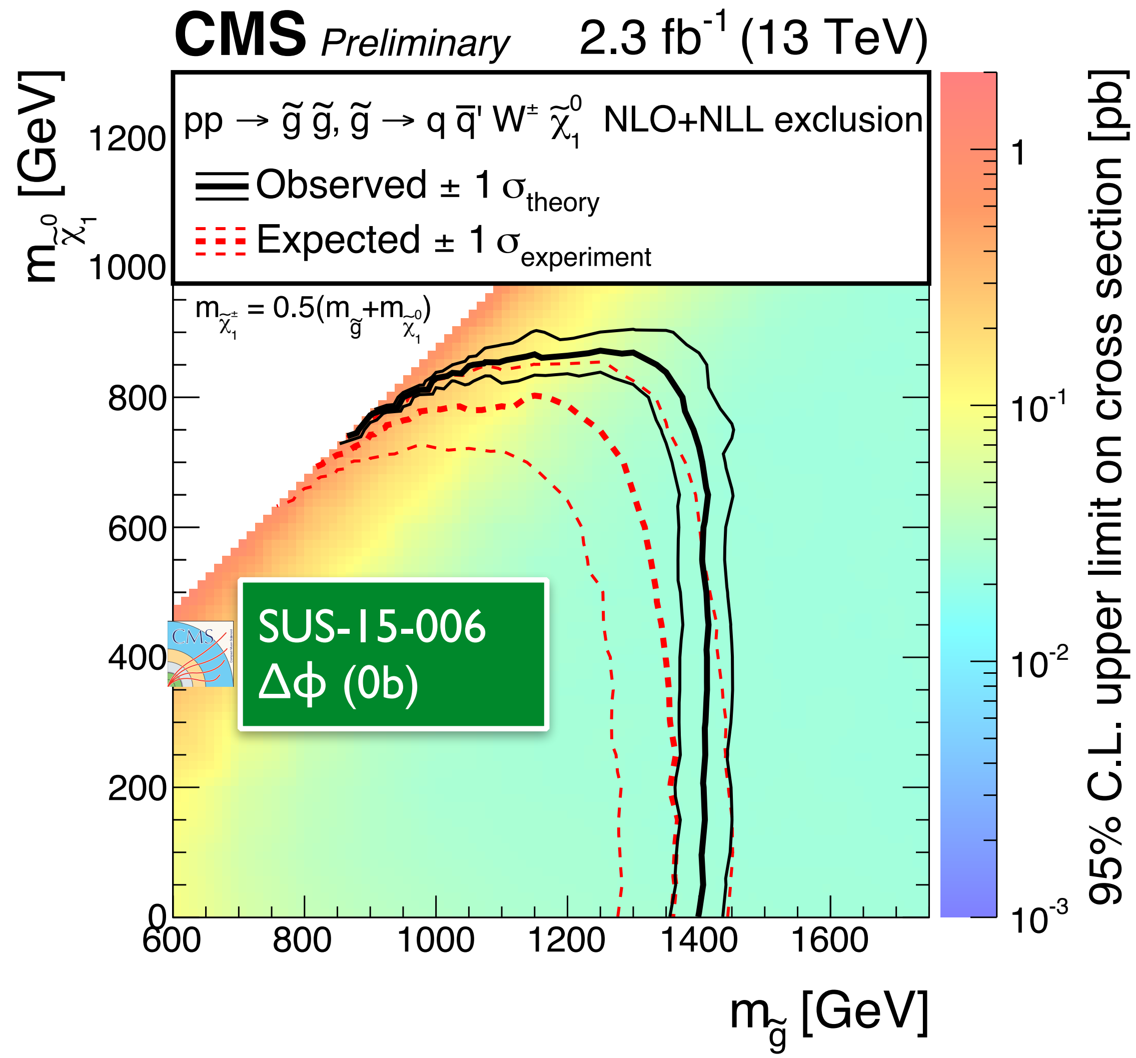


- **Hard lepton**: target large mass splittings between gluino, chargino, neutralino with hard leptons and jets
- **Soft lepton**: target small mass splittings between gluino, chargino, neutralino

Limits (T5qqqqWW)





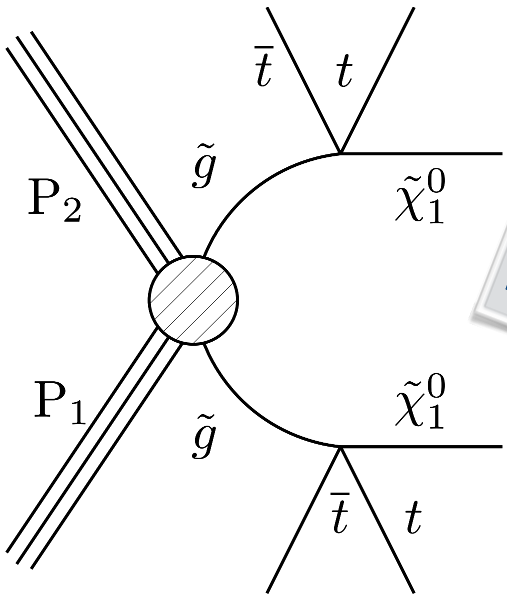


- expected limit well above 8 TeV
- slight excess in 6-jet region/ muon channel (see previous slide)

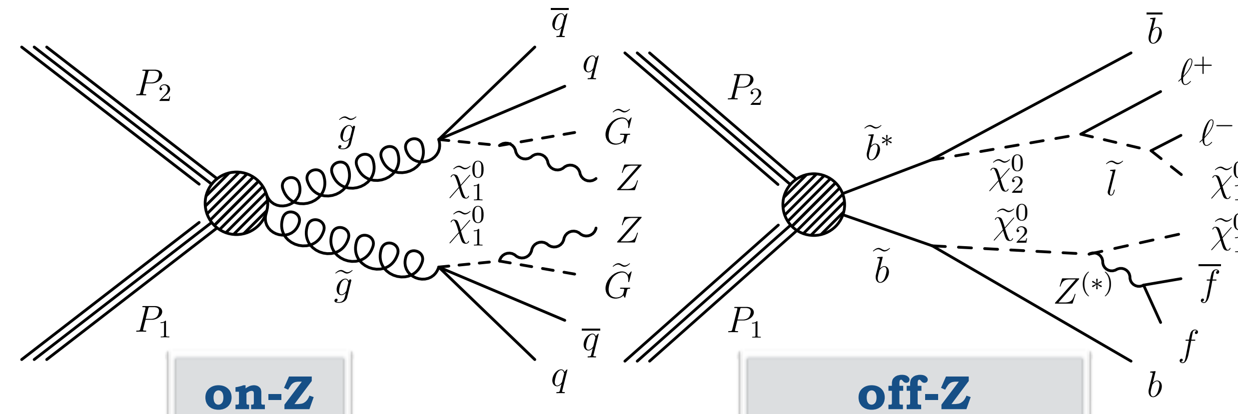
- only consider 0-b jet case
- stringent limits for high neutralino masses

Which signal models?

2, 3,… leptons



T1tttt High b-tag multiplicity



on-Z GMSB

off-Z slepton-edge

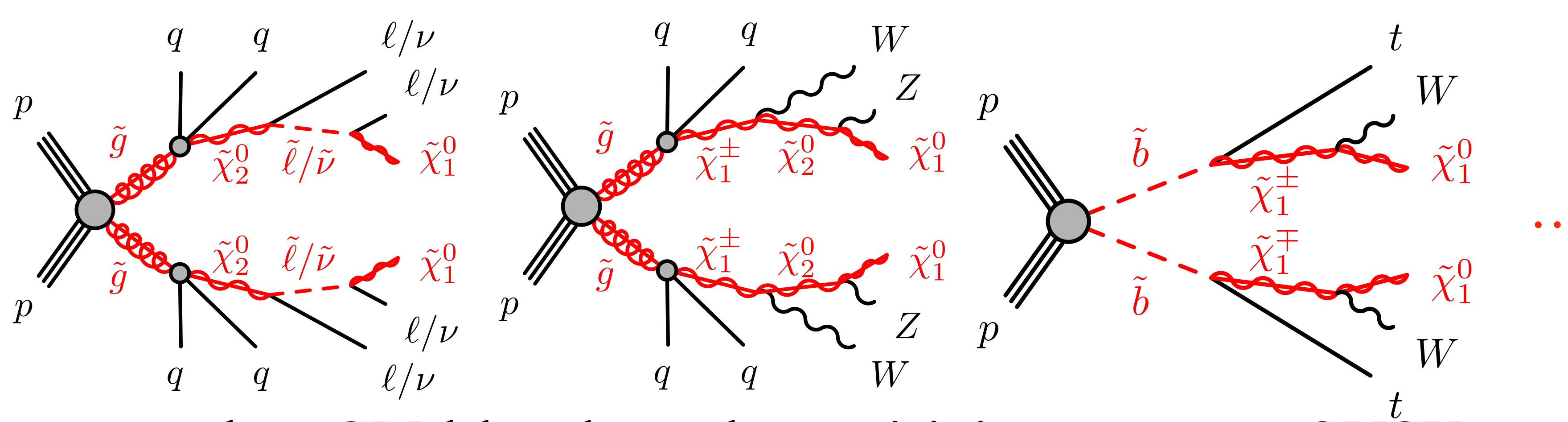
SUS-15-011 Edge/on-Z

2015-082 on-Z

1602.09058 Same Sign Multileptons

SUS-15-008 Same Sign

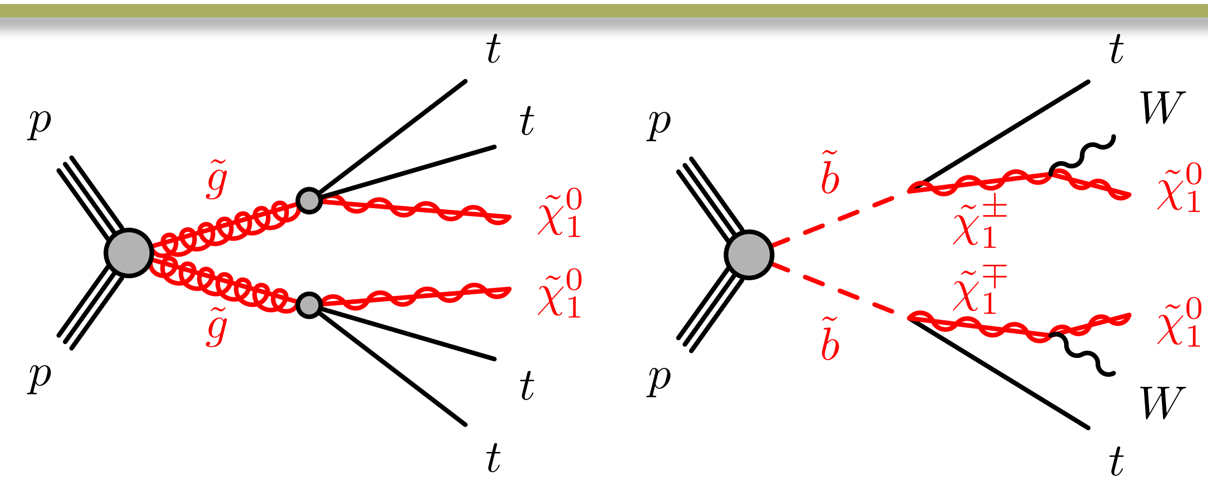
SUS-16-003 Multileptons



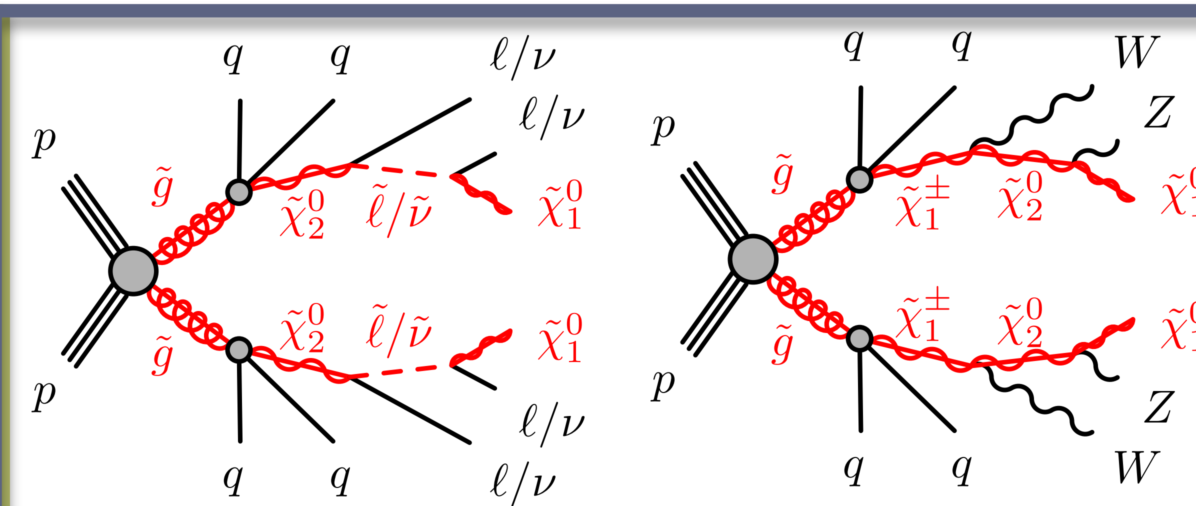
- very low SM bkg, broad sensitivity to many SUSY scenarios with leptons in the decay chain, key is to suppress the low reducible backgrounds

Same-sign 2L/multileptons

1602.09058
Same Sign - Multileptons



- Light third generation → 2 signal regions with b-jet requirement



- Gluino pairs → light quarks → 2 signal regions with b-jet veto

Signal region	$N_{\text{lept}}^{\text{signal}}$	N_{bjets}^{20}	N_{jets}^{50}	$E_{\text{T}}^{\text{miss}}$ [GeV]	m_{eff} [GeV]
SR0b3j	≥ 3	$=0$	≥ 3	>200	>550
SR0b5j	≥ 2	$=0$	≥ 5	>125	>650
SR1b	≥ 2	≥ 1	≥ 4	>150	>550
SR3b	≥ 2	≥ 3	-	>125	>650

- Signal regions requiring two same sign (or ≥3) leptons and jets; varying requirements on #(b)-jets; MET; $m_{\text{eff}}^{\text{inc}} = p_T^{\ell} + \sum_{j=1}^{N_{\text{jet}}} p_{T,j} + E_T^{\text{miss}}$

Treatment of backgrounds

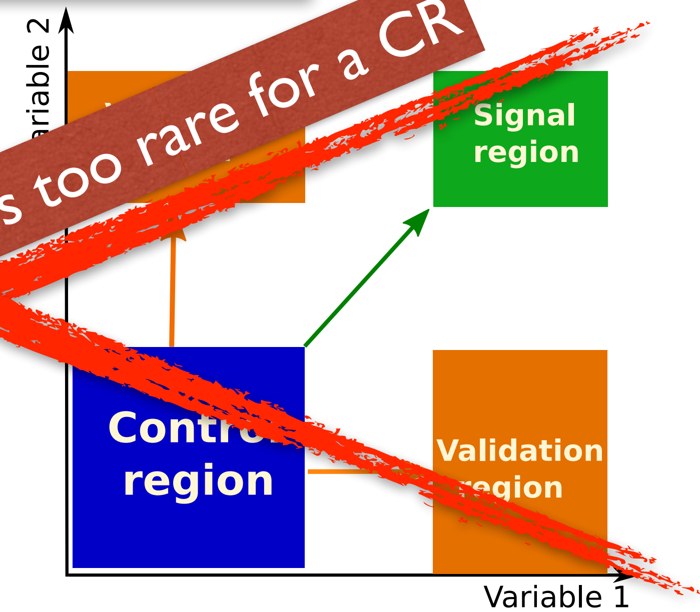
1602.09058
Same Sign - Multileptons

ATLAS EXPERIMENT

Irreducible

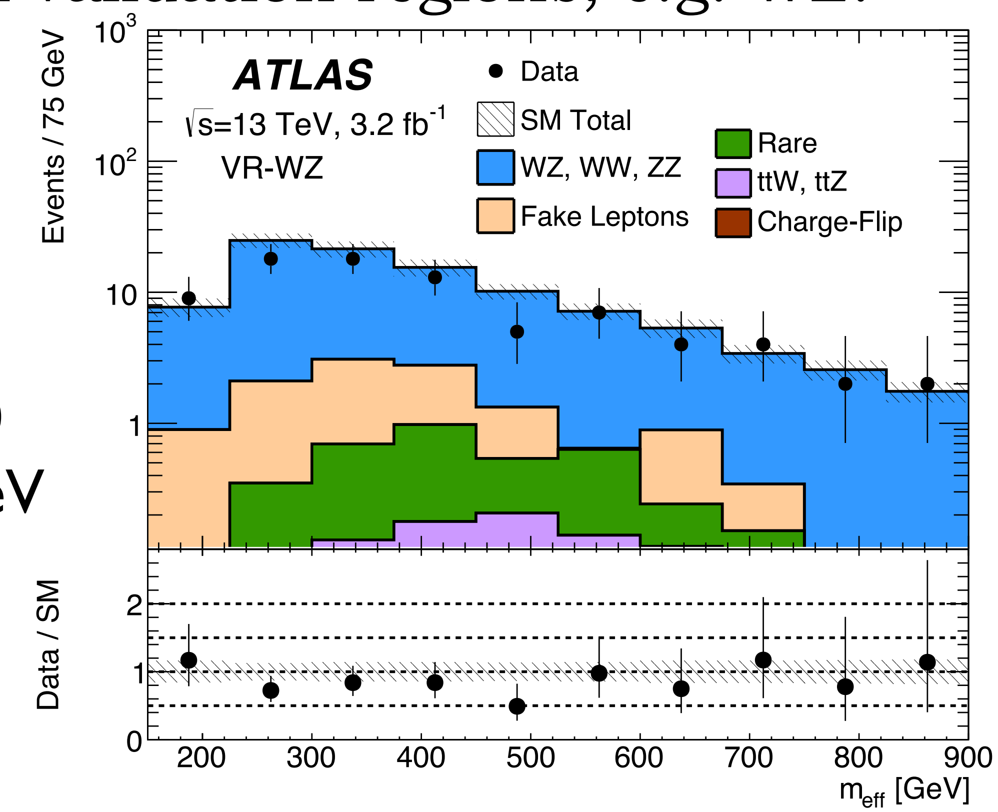
- ~~Irreducible/dominant: Renormalize MC to data in control region, check extrapolation in validation regions~~

Irreducible backgrounds too rare for a CR



- Irreducible/rare SM backgrounds: TTV, VV, VVV from MC
  - check in validation regions, e.g. WZ:

#lep: 3
#b-jet: 0
#jet: 1-3
MET: 30-200
p_T^{lep3}>30 GeV



Reducible

Data-driven estimates

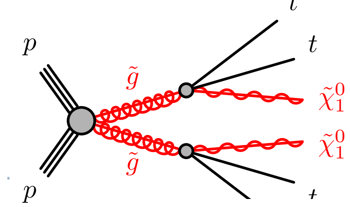
Fake+non-prompt leptons:
- from misidentified jets
- heavy flavour decay
- γ conversion

→ loose-to-tight matrix method

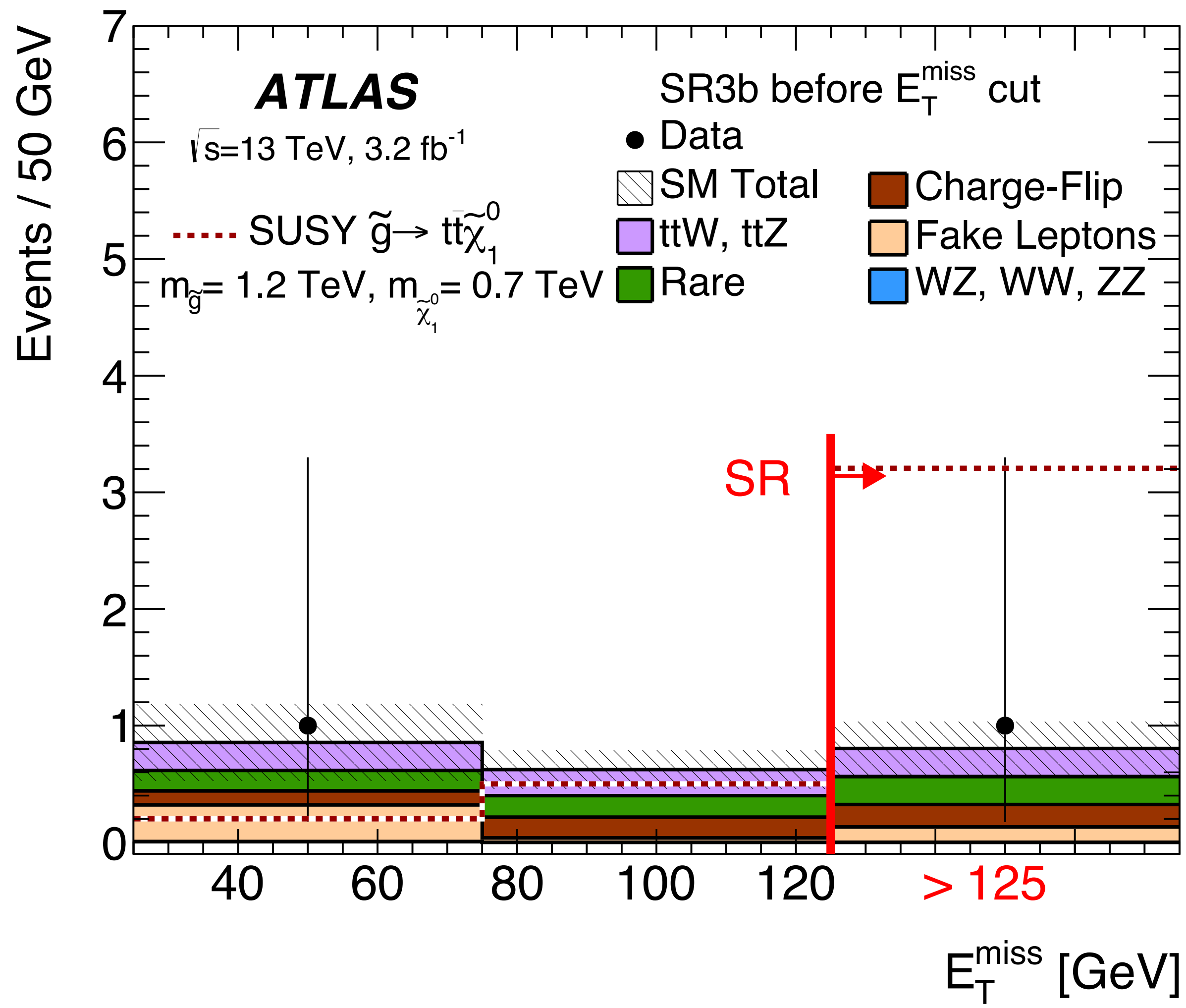
- input from CRs:
  - prompt efficiency
  - fake rate

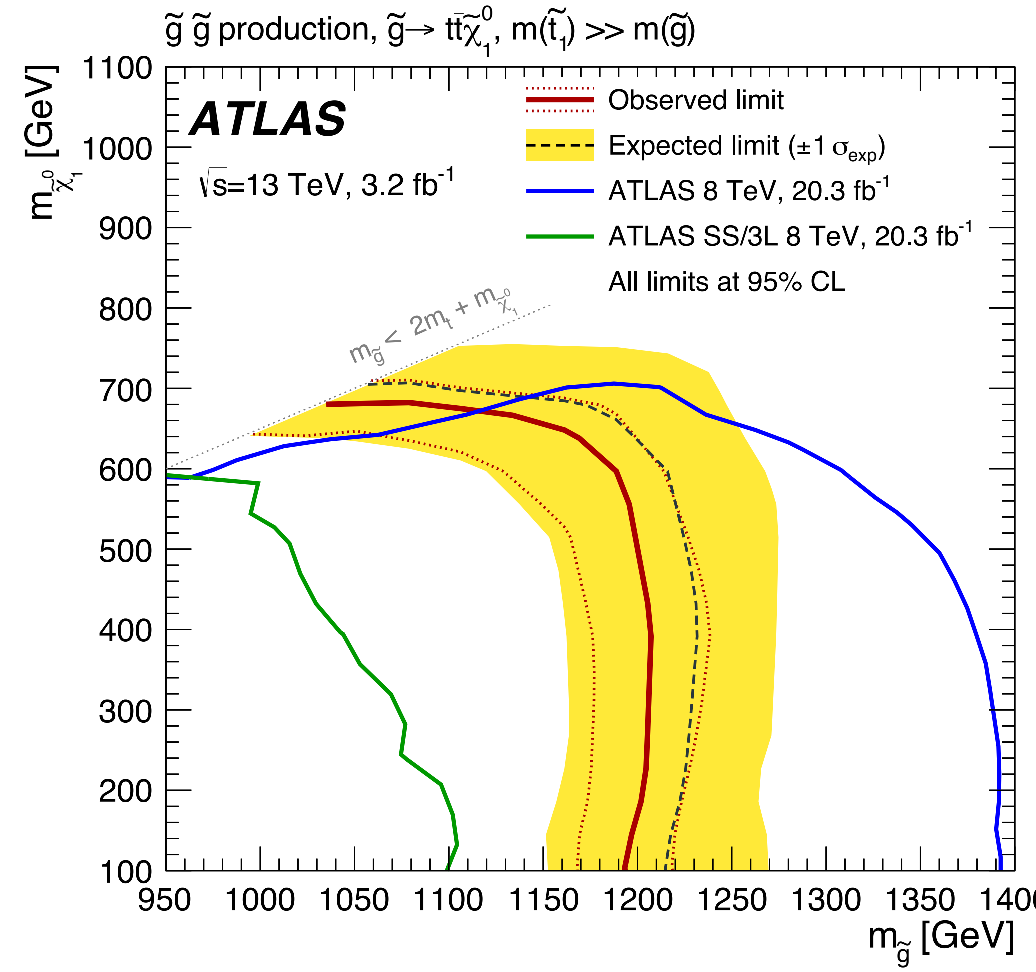
Charge flipping for electrons
- from hard bremsstrahlung γ conversion
- flip rate measured in DY CR
- apply it in 2L OS SR to get 2L SS background

Same-sign 2L (T1tttt)

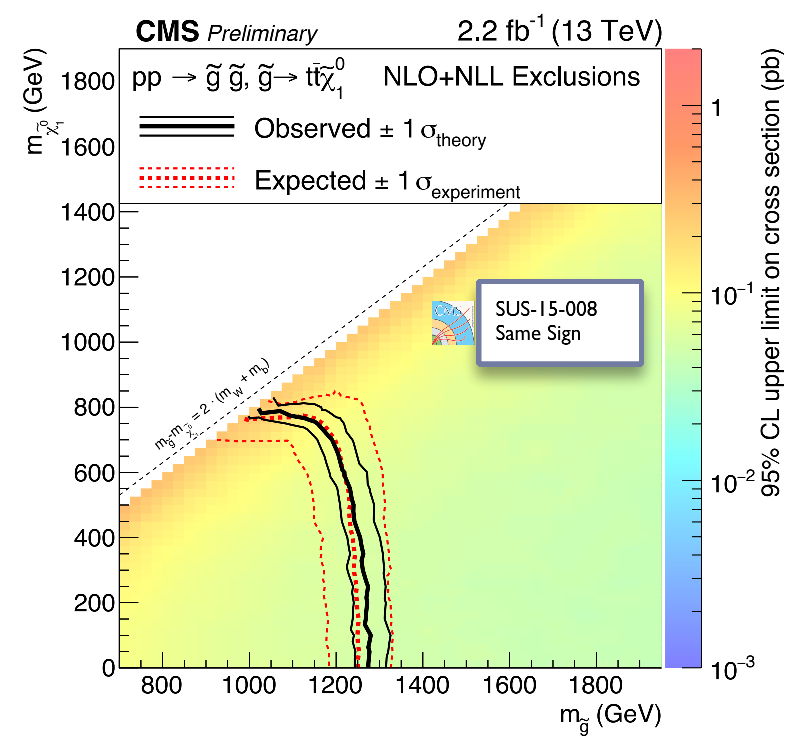


1602.09058
Same Sign - Multileptons





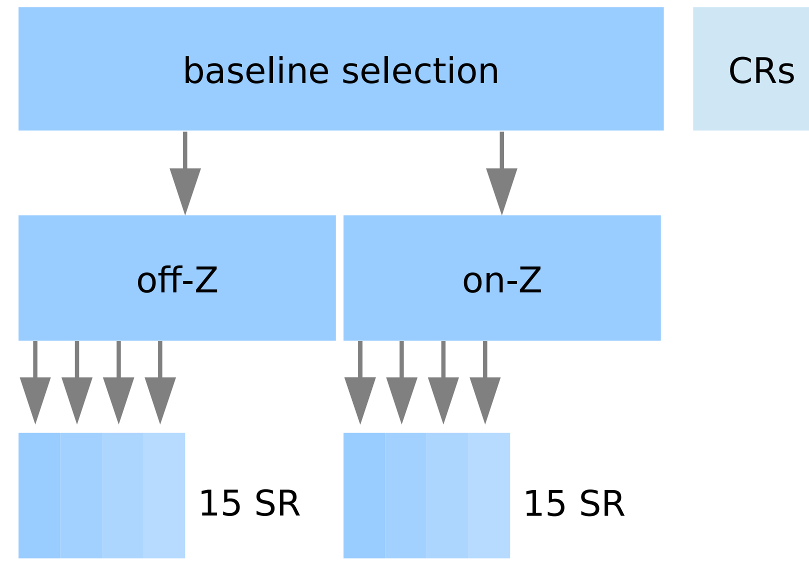
- Reaching around 1200 GeV in gluino mass, surpassing 8 TeV combined limit in compressed region
- Comparable reach by multi-bin CMS analysis

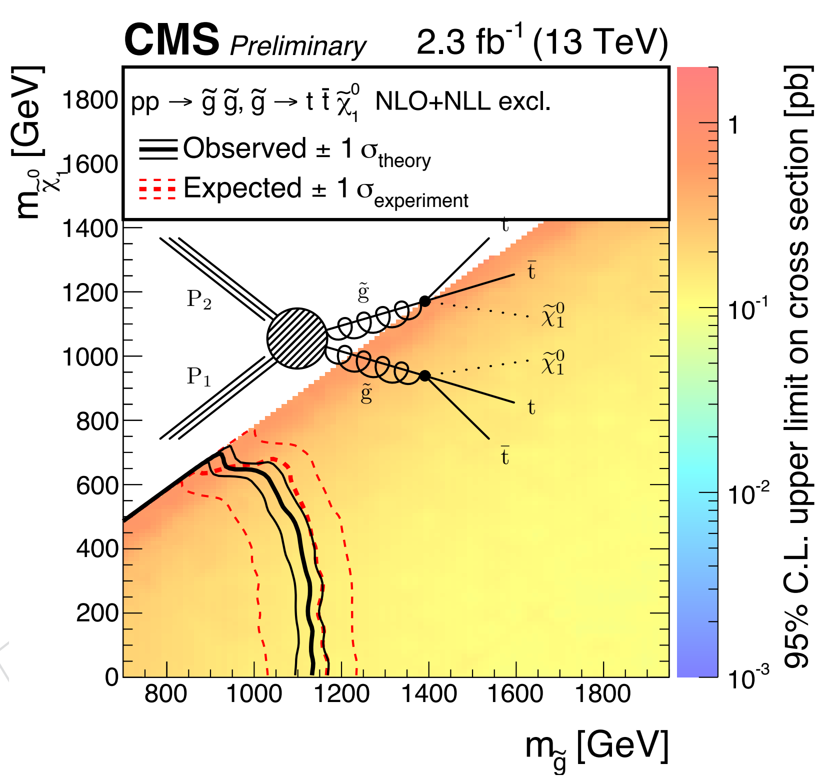


Multileptons

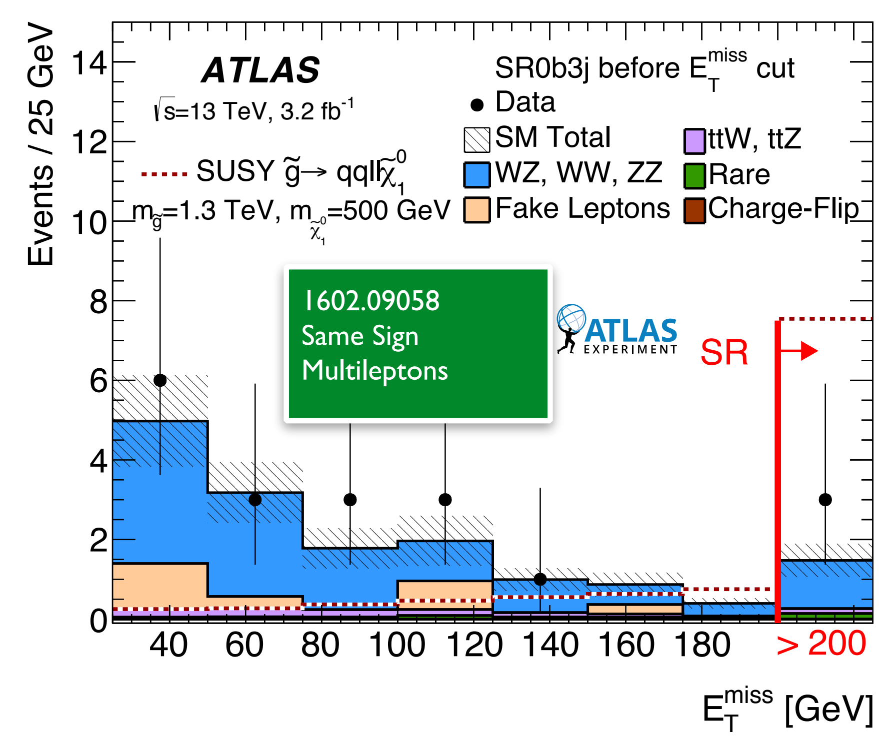
SUS-16-003
Multileptons

- Targeting ~same signals as same-sign analyses
  - categorise events based on #b-jets, HT, MET, on-Z/ other lepton pairs
- Baseline selection: ≥3 well identified leptons, passing p_T > 20,15,10 GeV
  - m_{llossf} > 12 GeV → reject low mass DY
  - #jets ≥ 2 → reject DY, WZ
  - MET > 50 GeV → reject DY



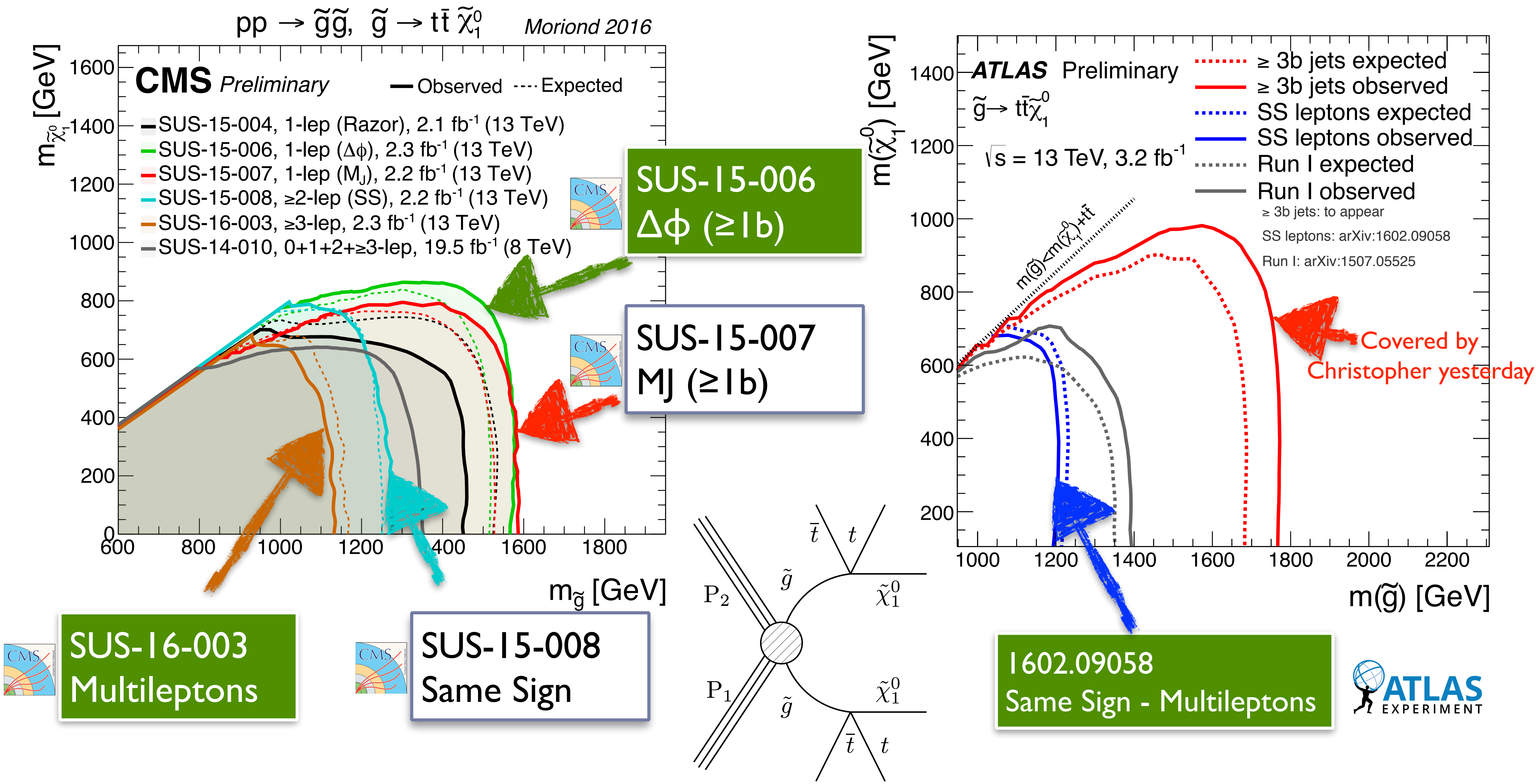


- No excess in CMS multi-bin analysis
- No excess in ATLAS search region



1602.09058
Same Sign
Multileptons

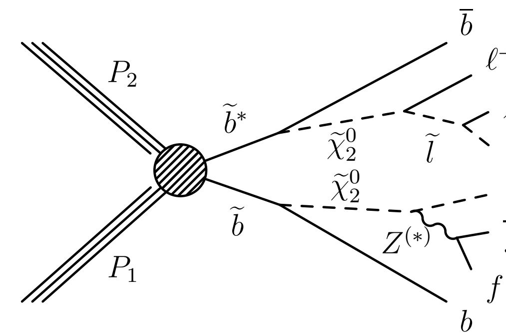
Limits T1tttt

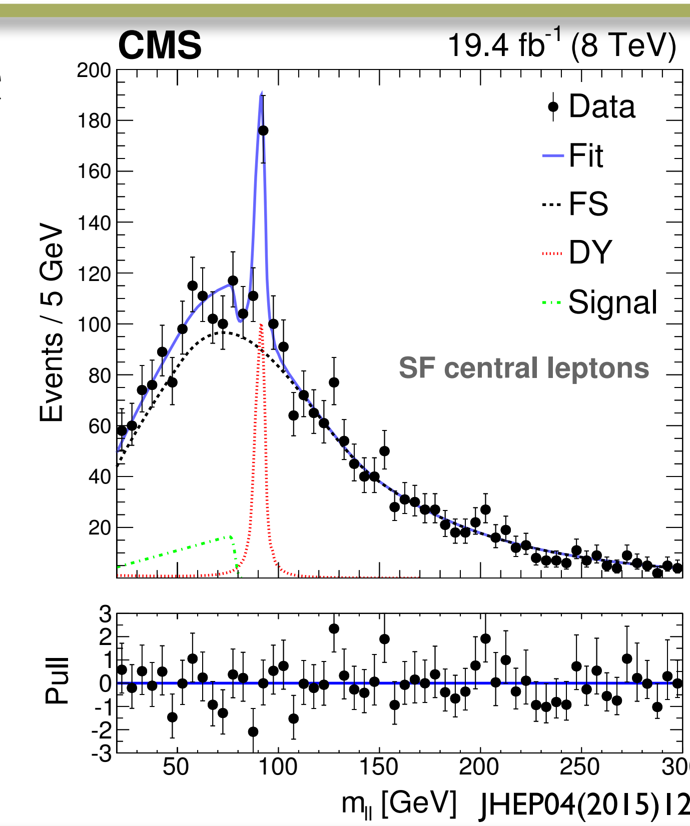


- Putting limits in the neutralino/gluino mass plane
- 1-lep analyses exceed 8 TeV 0…n-lep limit by ≥200 GeV (CMS)/≥300 GeV (ATLAS) in gluino mass

Opposite sign dilepton searches (8 TeV)

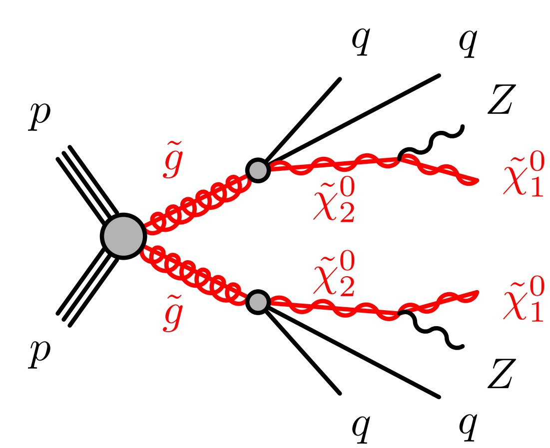
- CMS observed a 2.6σ deviation in the off-Z region at 8 TeV
  - off-Z: Off-shell Z-boson or slepton decays lead to a characteristic edge  shape in m_{ll}

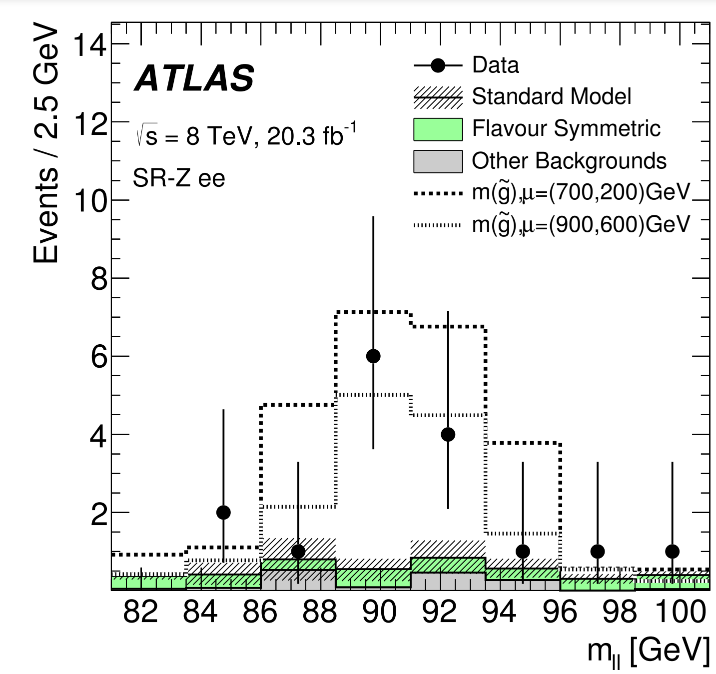




JHEP04(2015)124

- ATLAS reported 3σ in the on-Z region at 8 TeV
  - Large neutralino-mass difference → more on-Z events





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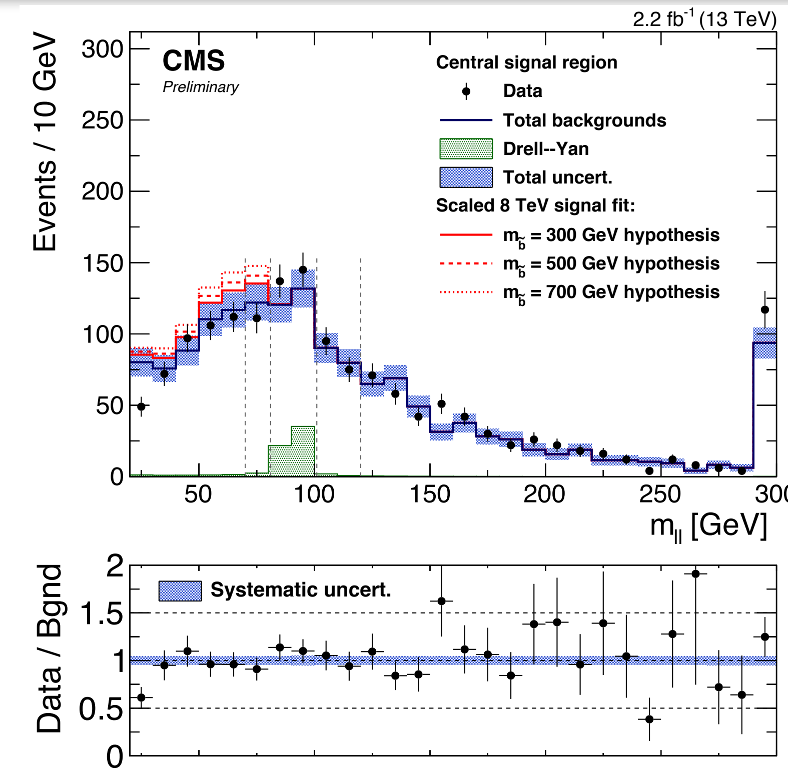
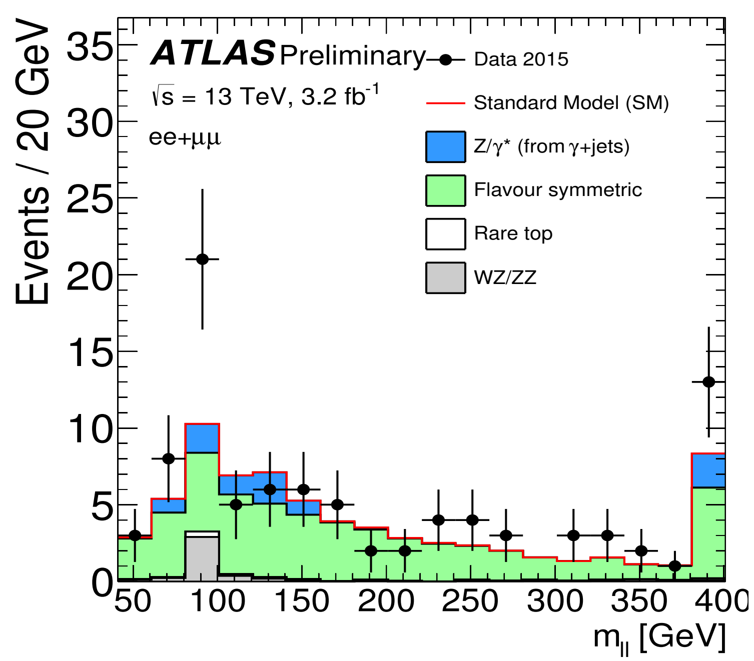
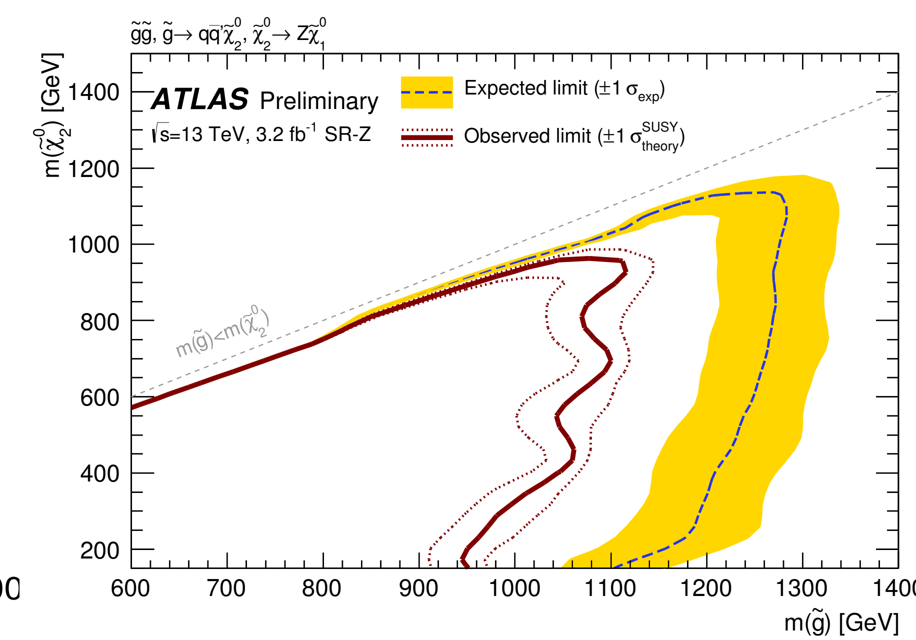
OS dilepton searches (13 TeV)

- CMS: Revisited off-Z excess of 8 TeV analysis
  - SUSY interpretation of 8 TeV excess disfavoured in view of 13 TeV data
- Extensions:
  - introduce b-tag exclusive regions
  - add below-Z/above-Z region



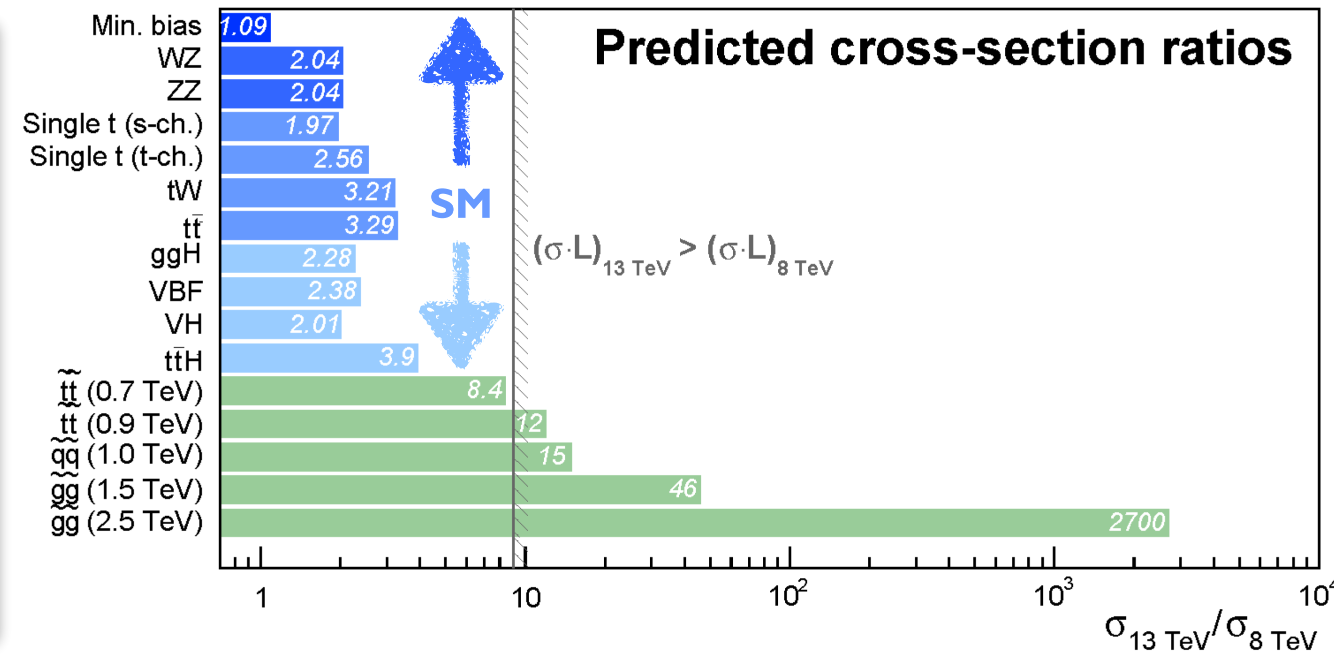
- ATLAS: Excess reestablished at 13 TeV
- CMS: No excess in “a la ATLAS” signal region pred./obs.: 12/12
- Revisiting with more data this summer…



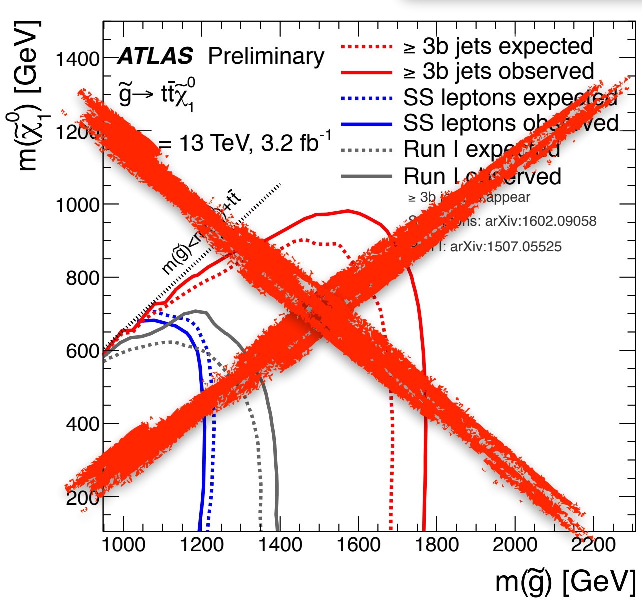


Conclusions

- First round of 13 TeV excitement with Jamboree results in December + Moriond
- Pushed limits beyond 8 TeV results by 200-300 GeV up to m($\tilde{g}$) ≳1700 GeV for T1tttt. No huge surprises, yet.



- Broad set of searches done at 13 TeV by ATLAS and CMS with leptons in the final state
- Detectors and methods in good shape, need more data to make another jump in sensitivity



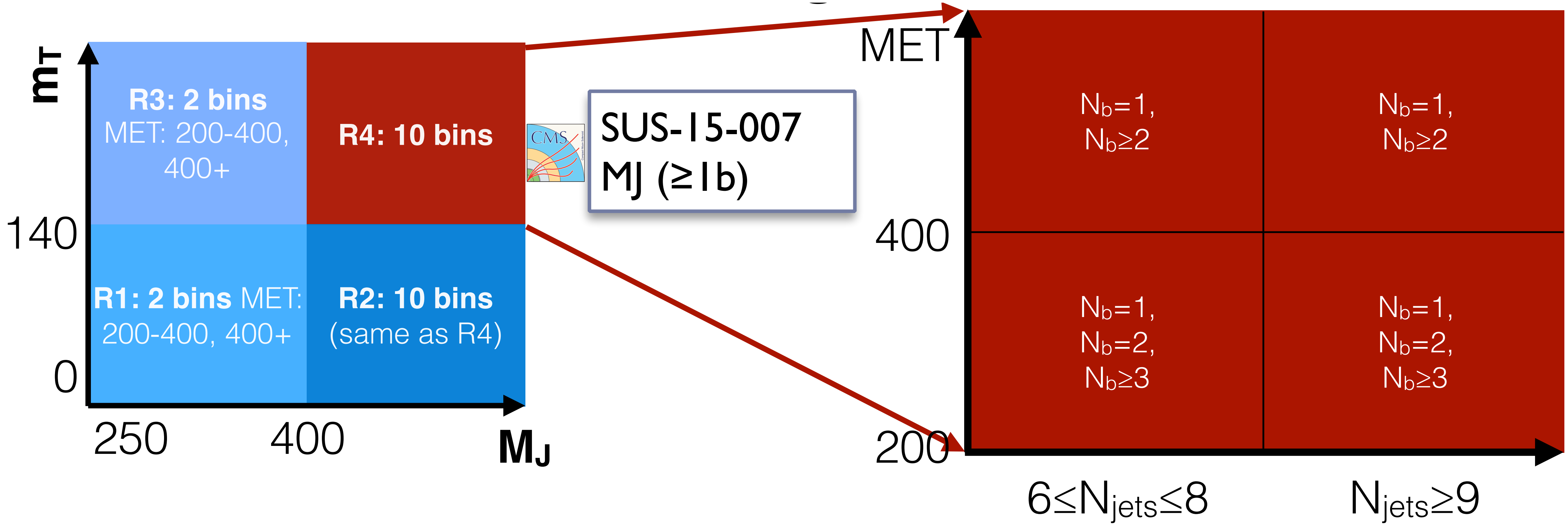
?

- Expecting ~30 fb^{-1} this year (Jörg's talk)
- Hopefully it will not be about setting limits this year…
- … some places to look at first!

- Hopefully the BSM sky clears up this year

Backup

Signal regions CMS (1L)



SUS-15-006
Δϕ (0b, ≥1b)

n_{jet}	$n_{b\text{-}tag}$	L_T [GeV]	H_T [GeV]	$\Delta\Phi$
[6,8]	$=1, =2, \geq 3$	$[250, 350]$	$[500, 750], \geq 750$	1.0
		$[350, 450]$	$[500, 750], \geq 750$	0.75
	$=1, \geq 2$	$[450, 600]$	$[500, 1250], \geq 1250$	
		≥ 600	$[500, 1250], \geq 1250$	0.5
≥ 9	$=1, =2$	$[250, 350]$	$[500, 1250], \geq 1250$	1.0
	≥ 3		≥ 500	
	$=1, =2, \geq 3$	$[350, 450]$	≥ 500	0.75
	$=1, \geq 2$	≥ 450	≥ 500	
5	0	$[250, 350], [350, 450], \geq 450$	≥ 500	1.0
[6,7]		$[250, 350], [350, 450]$	$[500, 750], \geq 750$	
		≥ 450	$[500, 1000], \geq 1000$	0.75
≥ 8		$[250, 350]$	$[500, 750], \geq 750$	1.0
		$[350, 450], \geq 450$	≥ 500	0.75

Signal regions ATLAS (1L)

	2-jet soft-lepton SR	5-jet soft-lepton SR
N_{lep}	= 1	= 1
$p_{\mathrm{T}}^{\ell\, e(\mu)}$ (GeV)	7(6) - 35	7(6) - 35
$p_{\mathrm{T}}^{\ell_2\, e(\mu)}$ (GeV)	< 7(6)	< 7(6)
N_{jet}	≥ 2	≥ 5
$p_{\mathrm{T}}^{\mathrm{jet}}$ (GeV)	> 180, 30	> 200, 200, 200, 30, 30
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	> 530	> 375
m_{T} (GeV)	> 100	-
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}^{\mathrm{incl}}$	> 0.38	-
H_{T} (GeV)	-	> 1100
Jet aplanarity	-	> 0.02

2015-076
lep,jet,MET
hard/soft
leptons

ATLAS EXPERIMENT

	4-jet high-x SR	4-jet low-x SR	5-jet SR	6-jet SR
N_{lep}	= 1	= 1	= 1	= 1
p_{T}^{ℓ} (GeV)	> 35	> 35	> 35	> 35
$p_{\mathrm{T}}^{\ell_2}$ (GeV)	< 10	< 10	< 10	< 10
N_{jet}	≥ 4	≥ 4	≥ 5	≥ 6
$p_{\mathrm{T}}^{\mathrm{jet}}$ (GeV)	> 325, 30,... , 30	> 325, 150,... , 150	> 225, 50,... , 50	> 125, 30,... , 30
$E_{\mathrm{T}}^{\mathrm{miss}}$ (GeV)	> 200	> 200	> 250	> 250
m_{T} (GeV)	> 425	> 125	> 275	> 225
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}^{\mathrm{incl}}$	> 0.3	-	> 0.1	> 0.2
$m_{\mathrm{eff}}^{\mathrm{incl}}$ (GeV)	> 1800	> 2000	> 1800	> 1000
Jet aplanarity	-	> 0.04	> 0.04	> 0.04

Edge signal regions

SUS-15-011
Edge/on-Z

Table 5: Results for the edge-like search in all 30 signal regions. The DY contribution to the total background is given separately in the brackets. All signal regions require $E_T^{miss} > 150$ if $N_{jets} \geq 2$ or $E_T^{miss} > 100$ if $N_{jets} \geq 3$.

		$N_{b\text{-}jets} \geq 0$		$N_{b\text{-}jets} = 0$		$N_{b\text{-}jets} \geq 1$	
	$m_{\ell\ell}$ **range [GeV]**	pred. total (DY)	obs.	pred. total (DY)	obs.	pred. total (DY)	obs.
central	20 - 70	470.9 ± 29.9 (4.6 ± 1.3)	**437**	126.7 ± 12.3 (3.4 ± 1.0)	**132**	344.2 ± 23.9 (1.2 ± 0.3)	**305**
central	70 - 81	132.2 ± 12.6 (2.6 ± 0.7)	**129**	38.2 ± 6.2 (2.0 ± 0.6)	**33**	93.9 ± 10.4 (0.7 ± 0.2)	**96**
central	81 - 101	247.9 ± 17.8 (59.3 ± 7.8)	**271**	93.1 ± 10.5 (44.4 ± 7.6)	**106**	154.8 ± 13.4 (14.9 ± 2.1)	**165**
central	101 - 120	164.7 ± 14.5 (2.0 ± 0.6)	**163**	48.1 ± 7.0 (1.5 ± 0.5)	**42**	116.6 ± 11.8 (0.5 ± 0.1)	**121**
central	> 120	467.8 ± 29.9 (1.5 ± 0.4)	**507**	109.9 ± 11.4 (1.1 ± 0.3)	**141**	357.9 ± 24.6 (0.4 ± 0.1)	**366**
forward	20 - 70	107.6 ± 11.9 (1.5 ± 0.4)	**135**	34.7 ± 6.0 (1.1 ± 0.3)	**45**	72.9 ± 9.4 (0.4 ± 0.1)	**90**
forward	70 - 81	46.6 ± 7.1 (1.2 ± 0.3)	**50**	15.0 ± 3.7 (0.9 ± 0.3)	**14**	31.7 ± 5.7 (0.3 ± 0.1)	**36**
forward	81 - 101	98.9 ± 10.1 (23.1 ± 3.0)	**92**	44.4 ± 5.9 (17.3 ± 2.7)	**40**	54.5 ± 7.5 (5.8 ± 1.2)	**52**
forward	101 - 120	76.7 ± 9.6 (0.9 ± 0.3)	**54**	22.3 ± 4.7 (0.7 ± 0.2)	**19**	54.3 ± 7.8 (0.2 ± 0.1)	**35**
forward	> 120	299.4 ± 25.0 (0.7 ± 0.2)	**298**	84.9 ± 10.3 (0.5 ± 0.2)	**92**	214.5 ± 19.4 (0.2 ± 0.1)	**206**

On-Z signal regions

SUS-15-011
Edge/on-Z

Table 4: Results for the on-Z search, binned in all the variables.

N_{jets}/H_T	N_{b-jets}	E_T^{miss}	predicted	observed
SRA	== 0	100-150	$28.2^{+5.4}_{-4.8}$	**28**
		150-225	$8.7^{+3.2}_{-1.9}$	**6**
		225-300	$3.3^{+2.5}_{-1.0}$	**5**
2- 3 jets		> 300	$1.9^{+1.4}_{-0.7}$	**6**
	≥ 1	100-150	$14.2^{+4.4}_{-3.3}$	**21**
and $H_T > 400$		150-225	$5.8^{+3.4}_{-2.1}$	**6**
		225-300	$5.0^{+3.3}_{-2.0}$	**1**
		> 300	$1.6^{+2.4}_{-0.9}$	**3**
SRB	== 0	100-150	$23.1^{+4.9}_{-3.7}$	**20**
		150-225	$8.2^{+3.4}_{-2.1}$	**10**
		225-300	$0.8^{+1.2}_{-0.2}$	**2**
		> 300	$1.5^{+2.4}_{-0.9}$	**0**
	≥ 1	100-150	$44.6^{+7.7}_{-6.6}$	**43**
≥ 4 jets		150-225	$16.7^{+5.1}_{-3.9}$	**22**
		225-300	$0.6^{+1.2}_{-0.3}$	**3**
		> 300	$1.4^{+2.4}_{-0.9}$	**3**
ATLAS - SR:				
$H_T+p_T^{l_1}+p_T^{l_2} > 600$ GeV	$E_T^{miss} > 225$ GeV	$\Delta\phi_{E_T^{miss},j_1,j_2} > 0.4$	$12.0^{+4.0}_{-2.8}$	**12**

2015-082
on-Z

Region	E_T^{miss} [GeV]	H_T [GeV]	n_{jets}	$m_{\ell\ell}$ [GeV]	**SF/DF**	$\Delta\phi(\text{jet}_{12}, p_T^{miss})$	$m_T(\ell_3, E_T^{miss})$ [GeV]	$n_{b\text{-jets}}$
Signal regions								
SRZ	> 225	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
Control regions								
Z normalisation	< 60	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
CR-FS	> 225	> 600	≥ 2	$61 < m_{\ell\ell} < 121$	DF	> 0.4	-	-
CRT	> 225	> 600	≥ 2	$m_{\ell\ell} \notin [81, 101]$	SF	> 0.4	-	-
Validation regions								
VRZ	< 225	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
VRT	100–200	> 600	≥ 2	$m_{\ell\ell} \notin [81, 101]$	SF	> 0.4	-	-
VRS	100–200	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
VR-FS	100–200	> 600	≥ 2	$61 < m_{\ell\ell} < 121$	DF	> 0.4	-	-
VR-WZ	100–200	-	-	-	3ℓ	-	< 100	0
VR-ZZ	< 100	-	-	-	4ℓ	-	-	0
VR-3L	60–100	> 200	≥ 2	$81 < m_{\ell\ell} < 101$	3ℓ	> 0.4	-	-

Multilepton signal regions

SUS-16-003
Multileptons

Table 1: multilepton signal region definition

N_{jets}	$N_{\text{b jets}}$	E_T^{miss} (GeV)	$60\,\text{GeV} \leq H_T < 400\,\text{GeV}$	$400\,\text{GeV} \leq H_T < 600\,\text{GeV}$	$H_T \geq 600\,\text{GeV}$
≥ 2	0	$50-150$	SR1	SR3	SR14
		$150-300$	SR2	SR4	
	1	$50-150$	SR5	SR7	
		$150-300$	SR6	SR8	
	2	$50-150$	SR9	SR11	
		$150-300$	SR10	SR12	
	≥ 3	$50-300$	SR13		
	inclusive	≥ 300	SR15		

Same-sign signal regions

SUS-15-008
Same Sign

Table 3: Signal region definitions for the HH lepton selection.

$N_{\text{b jets}}$	M_T^{min} (GeV)	E_T^{miss} (GeV)	N_{jets}	$H_T < 300$ GeV	$H_T \in [300, 1125]$ GeV	$H_T > 1125$ GeV
0	< 120	$50-200$	2-4	SR1	SR2	SR32
			5+	SR3	SR4	
		$200-300$	2-4		SR5	
			5+		SR6	
	> 120	$50-200$	2-4		SR7	
			5+		SR8	
		$200-300$	2-4			
			5+			
1	< 120	$50-200$	2-4	SR9	SR10	
			5+	SR11	SR12	
		$200-300$	2-4		SR13	
			5+		SR14	
	> 120	$50-200$	2-4		SR15	
			5+		SR16	
		$200-300$	2-4			
			5+			
2	< 120	$50-200$	2-4	SR17	SR18	
			5+	SR19	SR20	
		$200-300$	2-4		SR21	
			5+		SR22	
	> 120	$50-200$	2-4		SR23	
			5+		SR24	
		$200-300$	2-4			
			5+			
3+	< 120	$50-200$	2+	SR25	SR26	
		$200-300$	2+	SR27	SR28	
	> 120	> 50	2+	SR29	SR30	
inclusive	inclusive	> 300	2+		SR31	

Table 4: Signal region definitions for the HL lepton selection.

$N_{\text{b jets}}$	M_T^{min} (GeV)	E_T^{miss} (GeV)	N_{jets}	$H_T < 300$ GeV	$H_T \in [300, 1125]$ GeV	$H_T > 1125$ GeV
0	< 120	$50-200$	2-4	SR1	SR2	SR26
			5+	SR3	SR4	
		$200-300$	2-4		SR5	
			5+		SR6	
1	< 120	$50-200$	2-4	SR7	SR8	
			5+	SR9	SR10	
		$200-300$	2-4		SR11	
			5+		SR12	
2	< 120	$50-200$	2-4	SR13	SR14	
			5+	SR15	SR16	
		$200-300$	2-4		SR17	
			5+		SR18	
3+	< 120	$50-200$	2+	SR19	SR20	
		$200-300$	2+	SR21	SR22	
inclusive	> 120	$50-300$	2+	SR23	SR24	
inclusive	inclusive	> 300	2+		SR25	

Table 5: Signal region definitions for the LL lepton selection. The $H_T > 300$ GeV requirement is applied in all search regions in this category.

$N_{\text{b jets}}$	M_T^{min} (GeV)	H_T (GeV)	$E_T^{\text{miss}} \in [50-200]$ GeV	$E_T^{\text{miss}} > 200$ GeV
0	< 120	> 300	SR1	SR2
1	< 120		SR3	SR4
2	< 120		SR5	SR6
3+	< 120		SR7	
inclusive	> 120		SR8	