SUSY searches in multilepton final states

Nacho Suárez Andrés

Spanish LHC network meeting

8-9 May, 2017

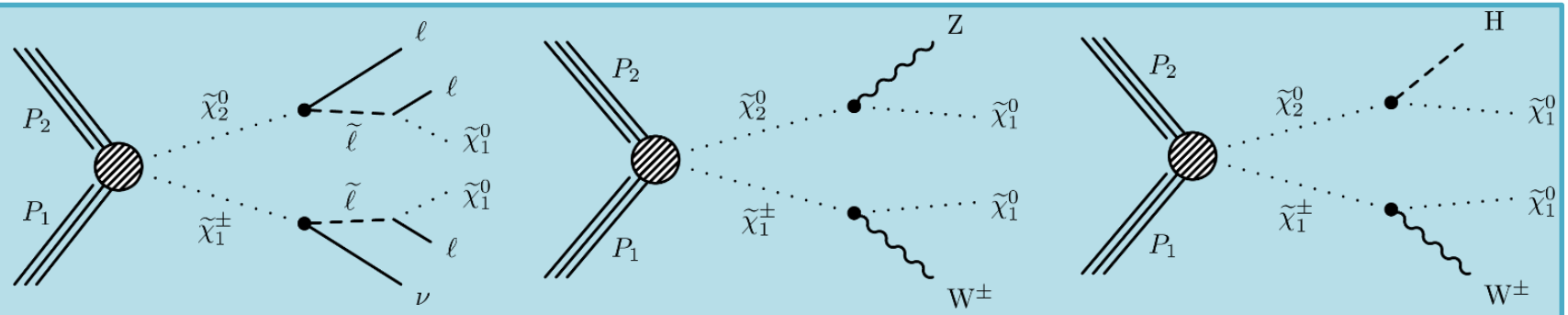
Universidad de Oviedo
Universidá d'Uviéu
University of Oviedo

Outline

- Multileptons, electroweak (SUS-16-039) and strong production (SUS-16-041)

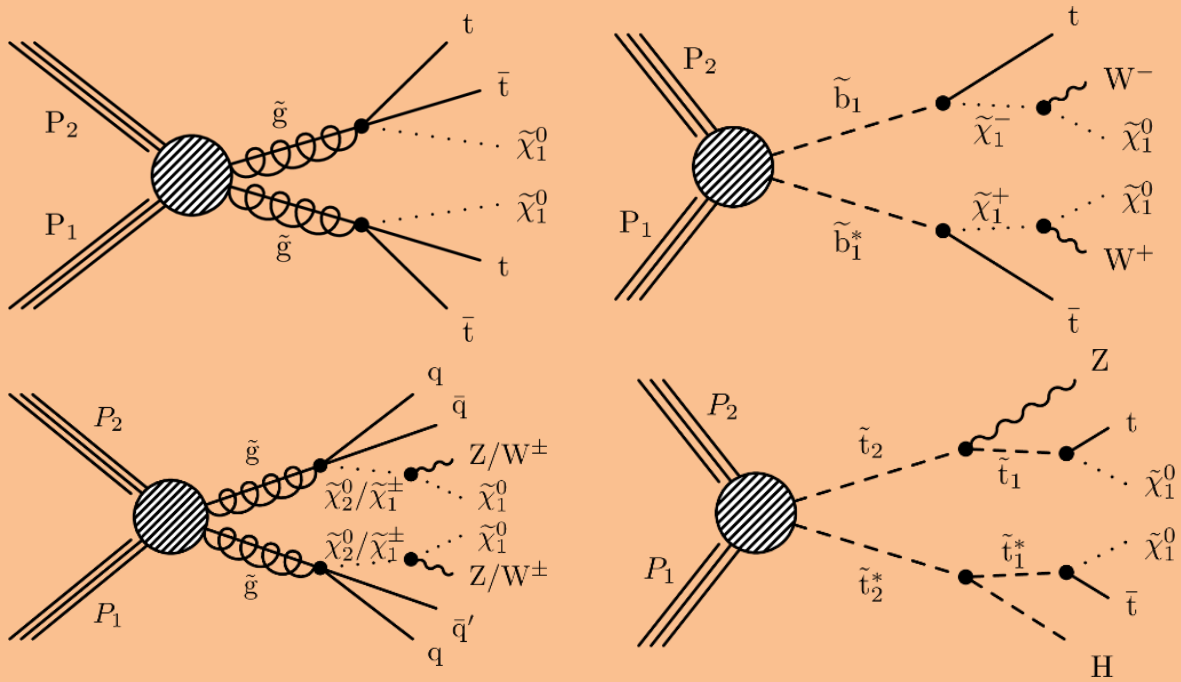
- Two leptons, opposite sign (SUS-16-034)

Multileptons: EWK & strong SUSY



charginos, neutralinos, sleptons…

gluinos, stop, sbottom…



Two multileptonic searches

Number of leptons	Categories
2	Same-sign
3	0 τ: nOSSF = 0, > 0
	1 τ: SS+τ, nOSSF=1, nOSOF=1
	2 τ
4	0 τ: nOSSF ≤ 1, nOSSF = 2
	1 τ
	2 τ: nOSSF ≤ 1, nOSSF = 2

Additional requirements:

- $E_{\mathrm{T}}^{\mathrm{miss}}$
- Veto event with b-tagged jets

Categorize depending on:

- $M_{\ell\ell}$
- $E_{\mathrm{T}}^{\mathrm{miss}}$
- M_T
- M_{T2}
- $p_{\mathrm{T}}^{\ell\ell}$ (2LSS)

CMS-PAS-SUS-16-039

Number of leptons	Categories
≥ 3	Off-Z, On-Z

Additional requirements:

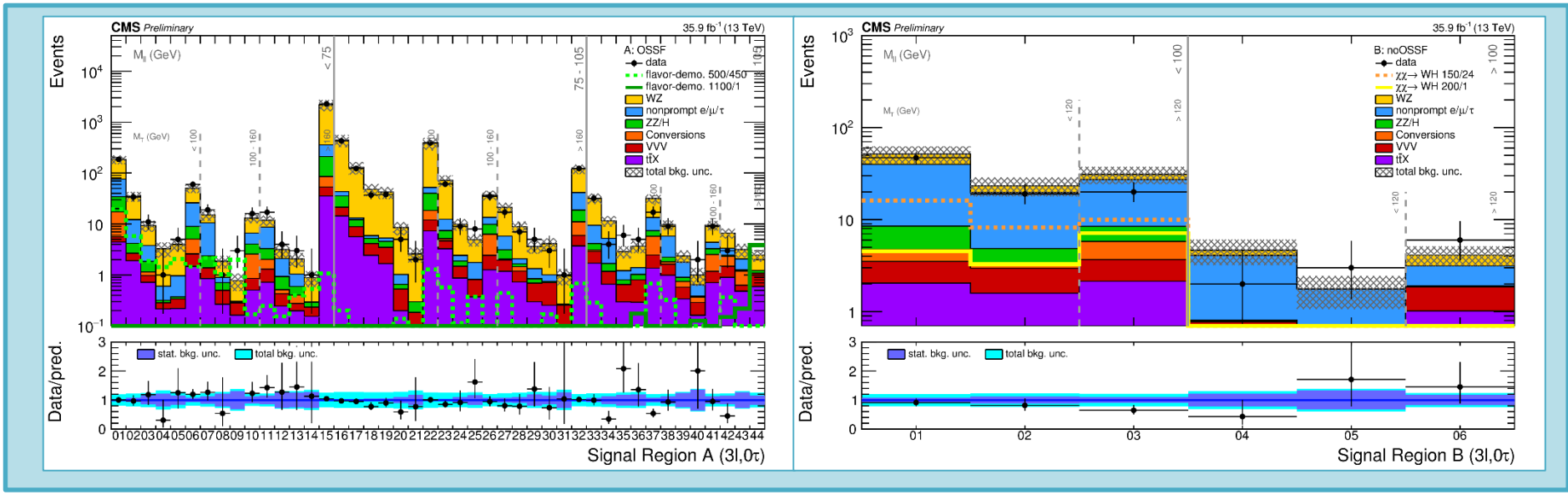
- $E_{\mathrm{T}}^{\mathrm{miss}}$
- $N_{\mathrm{jets}} \geq 2$

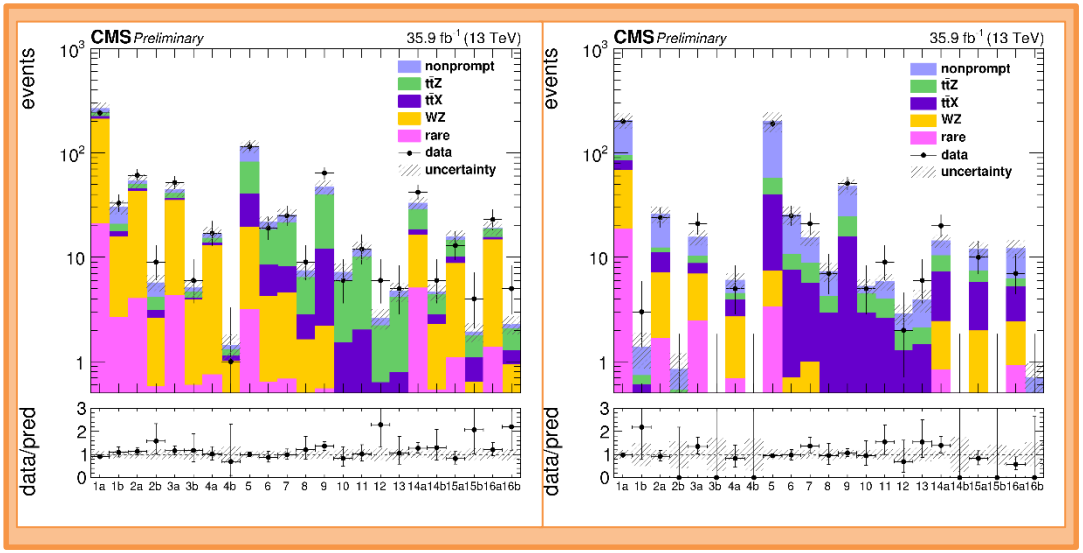
Categorize depending on:

- $N_{\mathrm{b\ jets}}$
- $E_{\mathrm{T}}^{\mathrm{miss}}$
- H_{T}
- M_{T}

CMS-PAS-SUS-16-041

Some of our search regions

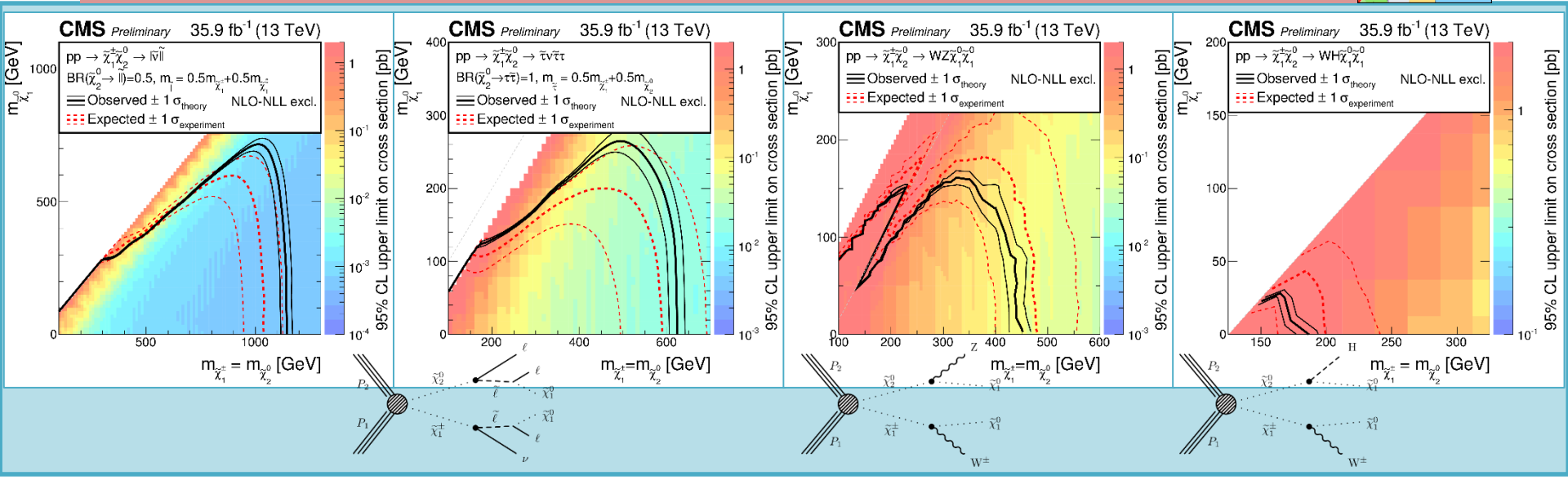


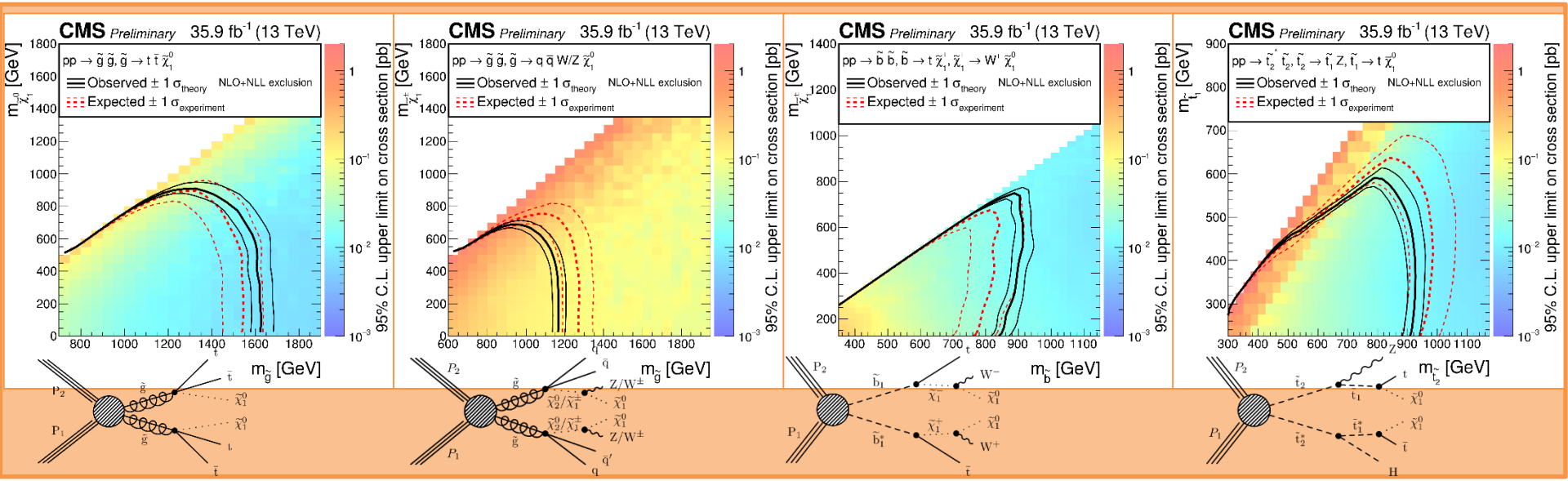


We must have a really good understanding of our backgrounds:

- WZ, $t\bar{t}Z$: control regions for validating normalization and shape
- Nonprompt/misID leptons: data-driven estimation

Interpretations



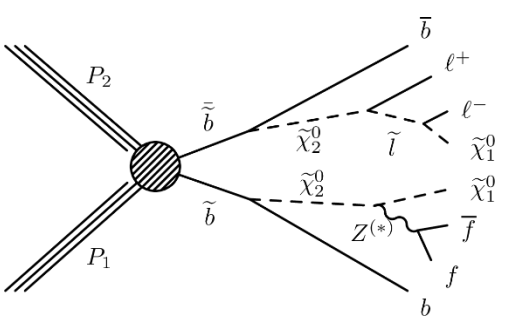


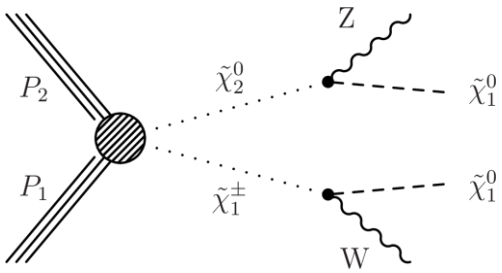
2L OS

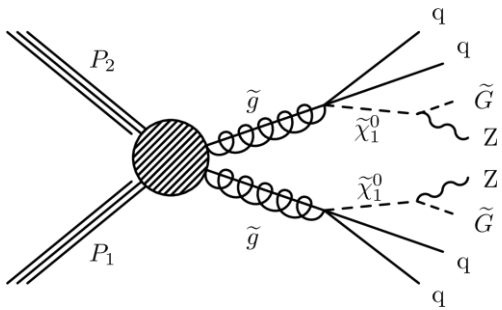
Strong on-Z Signal Regions					
Region	N_{jets}	$N_{\text{b-jets}}$	H_T	$M_{T2}(\ell\ell)$	E_T^{miss} binning [GeV]
SRA b-veto	2–3	= 0	> 500 GeV	> 80 GeV	[100,150,250,∞]
SRB b-veto	4–5	= 0	> 500 GeV	> 80 GeV	[100,150,250,∞]
SRC b-veto	≥ 6	= 0	-	> 80 GeV	[100,150,∞]
SRA b-tag	2–3	≥ 1	> 200 GeV	> 100 GeV	[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}	$N_{\text{b-jets}}$	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,∞]

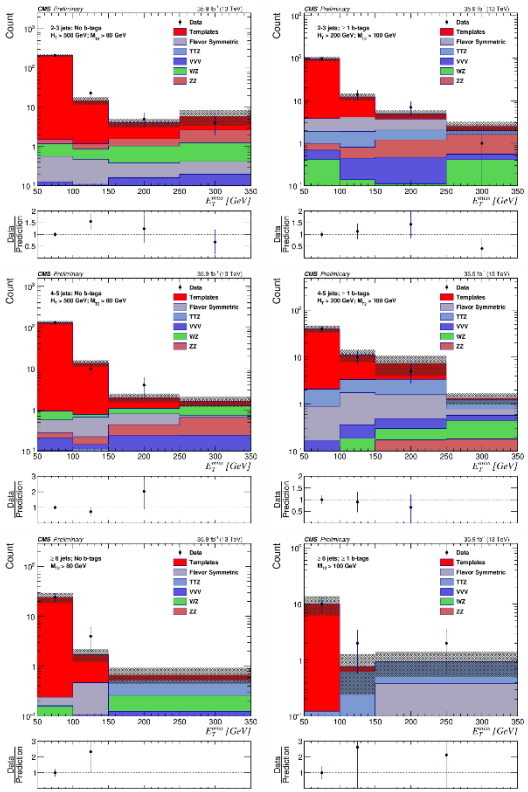
Edge Signal Regions					
Region	N_{jets}	E_T^{miss}	$M_{T2}(\ell\ell)$	$t\bar{t}$ likelihood	$m_{\ell\ell}$ binning [GeV]
Edge Fit	≥ 2	> 150 GeV	> 80 GeV	-	> 20
$t\bar{t}$ like	≥ 2	> 150 GeV	> 80 GeV	< 21	[20,60,86],[96,150,200,300,400,∞]
non-$t\bar{t}$ like	≥ 2	> 150 GeV	> 80 GeV	> 21	[20,60,86],[96,150,200,300,400,∞]

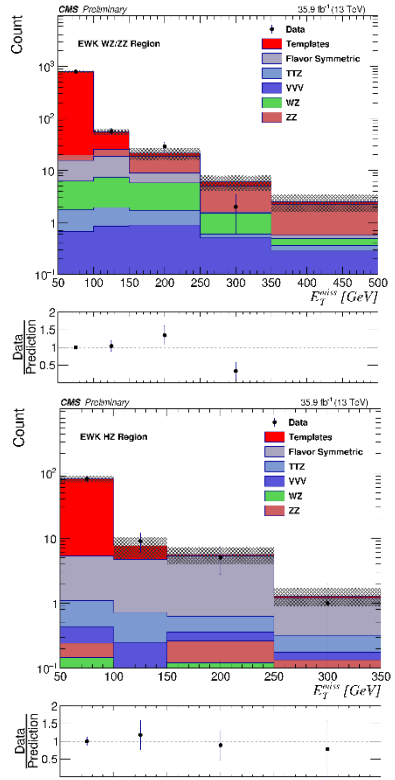


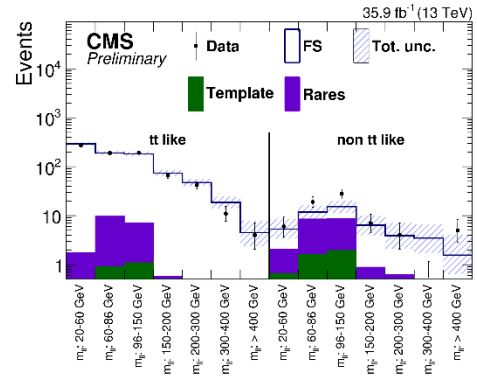


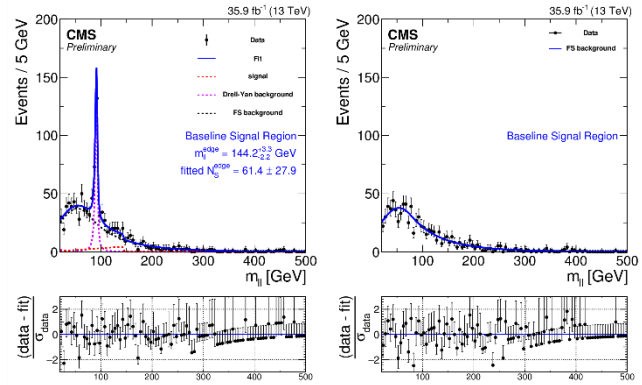


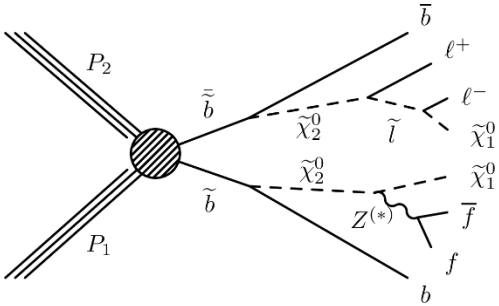
2L OS

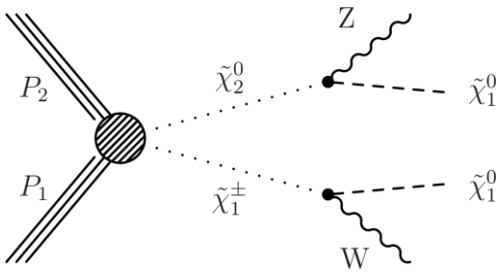


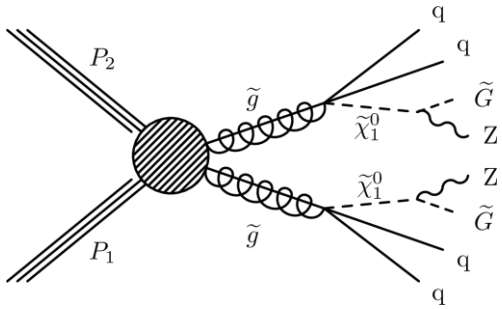

CMS Preliminary
35.9 fb^{-1} (13 TeV)
EWK WZ/ZZ Region
EWK HZ Region
Data
Templates
Flavor Symmetric
TTZ
VVV
WZ
ZZ
Count
Data / Prediction
E_T^{miss} [GeV]


35.9 fb^{-1} (13 TeV)
CMS
Preliminary
Data
FS
Tot. unc.
Template
Rares
tt like
non tt like
Events
m_{ll}: 20-60 GeV
m_{ll}: 60-86 GeV
m_{ll}: 96-150 GeV
m_{ll}: 150-200 GeV
m_{ll}: 200-300 GeV
m_{ll}: 300-400 GeV
m_{ll}: > 400 GeV

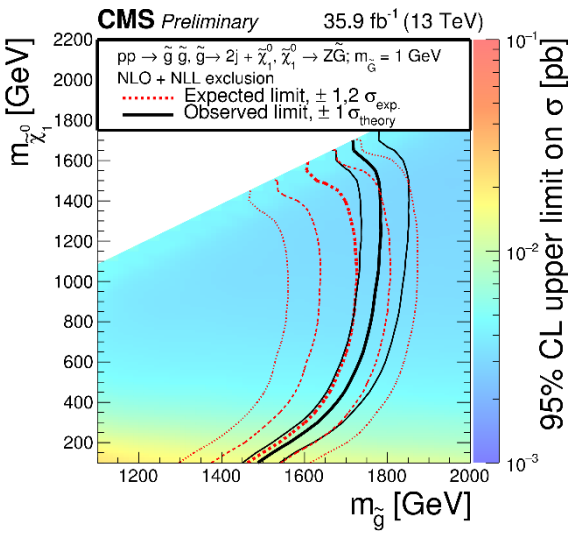

35.9 fb^{-1} (13 TeV)
CMS
Preliminary
Events / 5 GeV
Data
Fit
signal
Drell-Yan background
FS background
Baseline Signal Region
m_{ll}^{edge} = 144.2$^{+3.3}_{-2.2}$ GeV
fitted N_S^{edge} = 61.4 ± 27.9
m_{ll} [GeV]
(data - fit) / σ_{data}

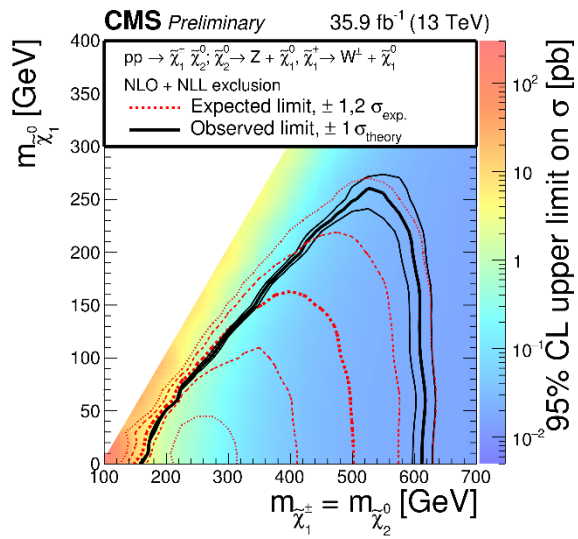

P_2
P_1
$\tilde{\bar{b}}$
$\tilde{b}$
$\tilde{\chi}_2^0$
$\tilde{l}$
ℓ^+
ℓ^-
$\tilde{\chi}_1^0$
$Z^{(*)}$
$\bar{f}$
f
$\bar{b}$
b

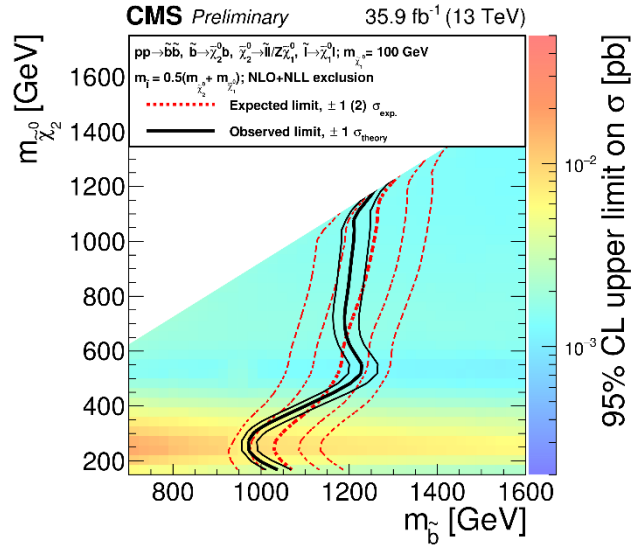

P_2
P_1
$\tilde{\chi}_2^0$
$\tilde{\chi}_1^\pm$
Z
W
$\tilde{\chi}_1^0$

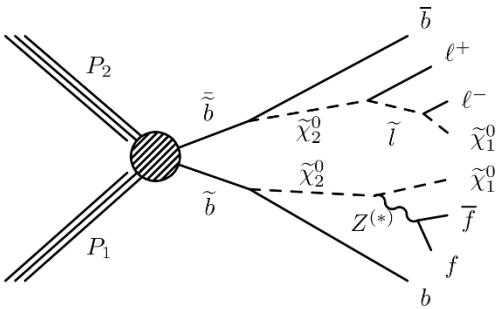

P_2
P_1
$\tilde{g}$
$\tilde{\chi}_1^0$
$\tilde{G}$
Z
q

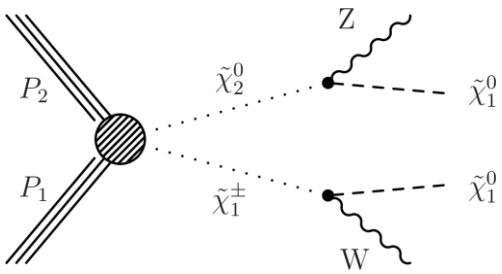
2L OS

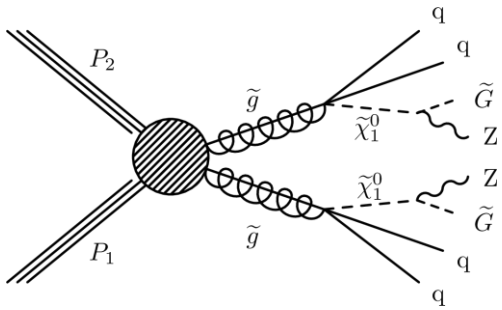

CMS Preliminary
35.9 fb-1 (13 TeV)
pp → g̃ g̃, g̃→ 2j + χ̃01; χ̃01 → ZG̃; mG̃ = 1 GeV
NLO + NLL exclusion
Expected limit, ± 1,2 σexp.
Observed limit, ± 1 σtheory
mχ̃01 [GeV]
mg̃ [GeV]
95% CL upper limit on σ [pb]


CMS Preliminary
35.9 fb-1 (13 TeV)
pp → χ̃±1 χ̃02; χ̃02→ Z + χ̃01, χ̃±1→ W± + χ̃01
NLO + NLL exclusion
Expected limit, ± 1,2 σexp.
Observed limit, ± 1 σtheory
mχ̃01 [GeV]
mχ̃±1 = mχ̃02 [GeV]
95% CL upper limit on σ [pb]


CMS Preliminary
35.9 fb-1 (13 TeV)
pp→b̃b̃, b̃→χ̃02b, χ̃02→l̃l/Zχ̃01, l̃→χ̃01l; mχ̃01= 100 GeV
ml̃ = 0.5(mχ̃02+ mχ̃01); NLO+NLL exclusion
Expected limit, ± 1 (2) σexp.
Observed limit, ± 1 σtheory
mχ̃02 [GeV]
mb̃ [GeV]
95% CL upper limit on σ [pb]


P2
P1
b̃
b̃
χ̃02
χ̃02
l̃
Z(*)
ℓ+
ℓ−
χ̃01
χ̃01
f̄
f
b̄
b


P2
P1
χ̃02
χ̃±1
Z
W
χ̃01
χ̃01

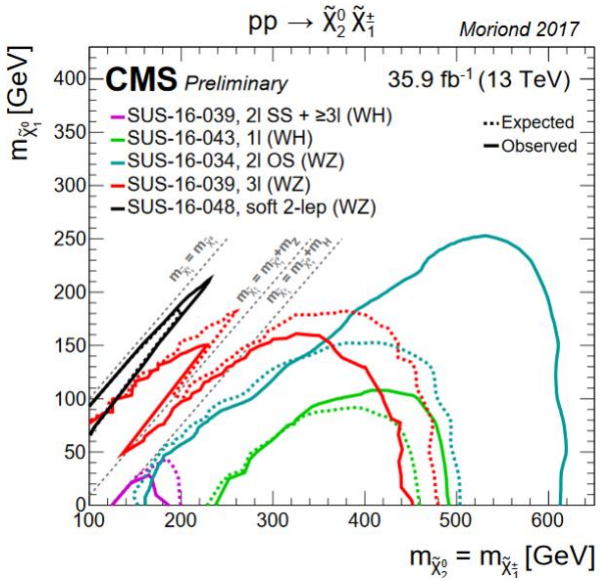

P2
P1
g̃
g̃
χ̃01
χ̃01
Z
Z
G̃
G̃
q
q
q
q

Prospects

Aside from our hard work designing and constantly optimizing our analyses, part of the progress made so far has been due to the impressive increases in energy and luminosity at the LHC.

No big jump in either is expected in the short term.

What is to be done?



Time to study all of our options and keep squeezing our data:

- Combinations of analyses to increase sensitivity?
- Target unexplored areas (WZ-like corridor, very compressed scenarios)?

Backup