Searches for Electroweak SUSY Production

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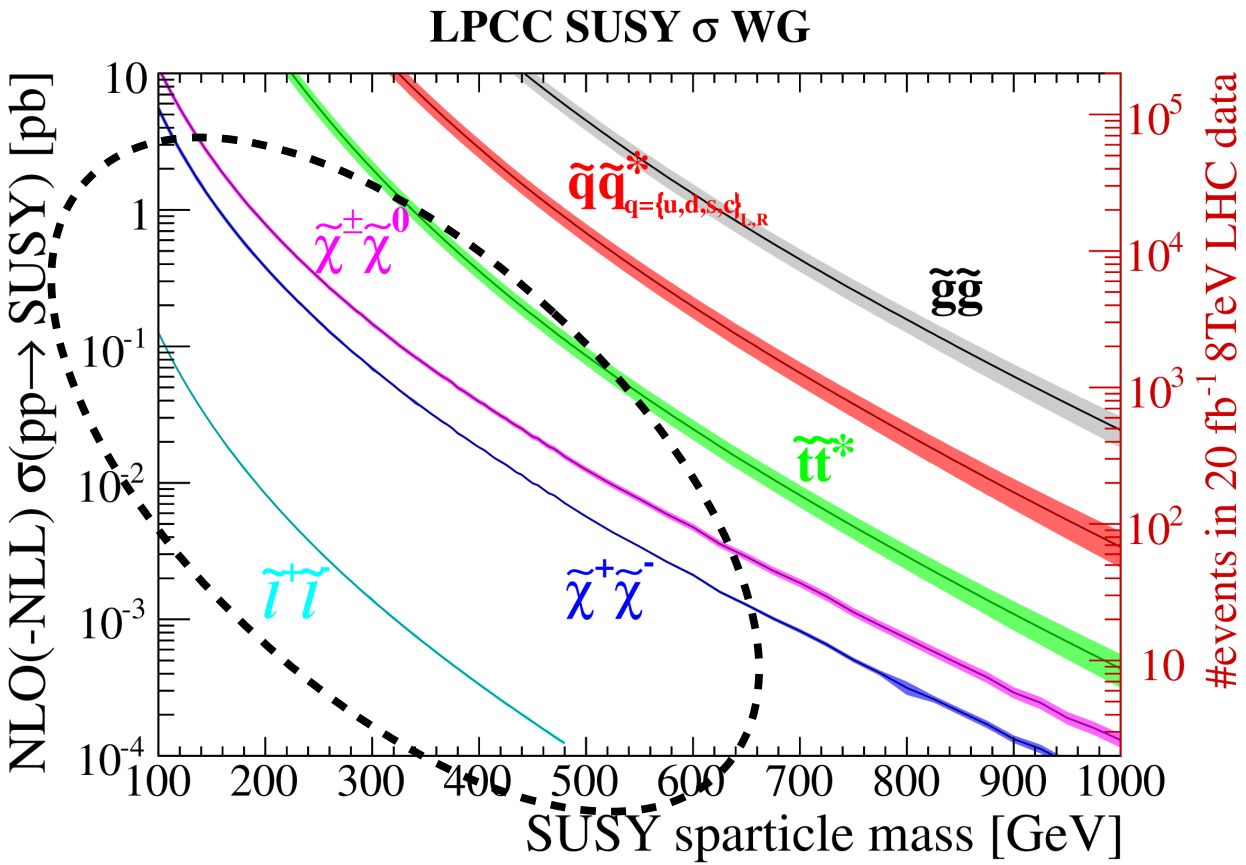
Electroweak SUSY production requires dedicated searches

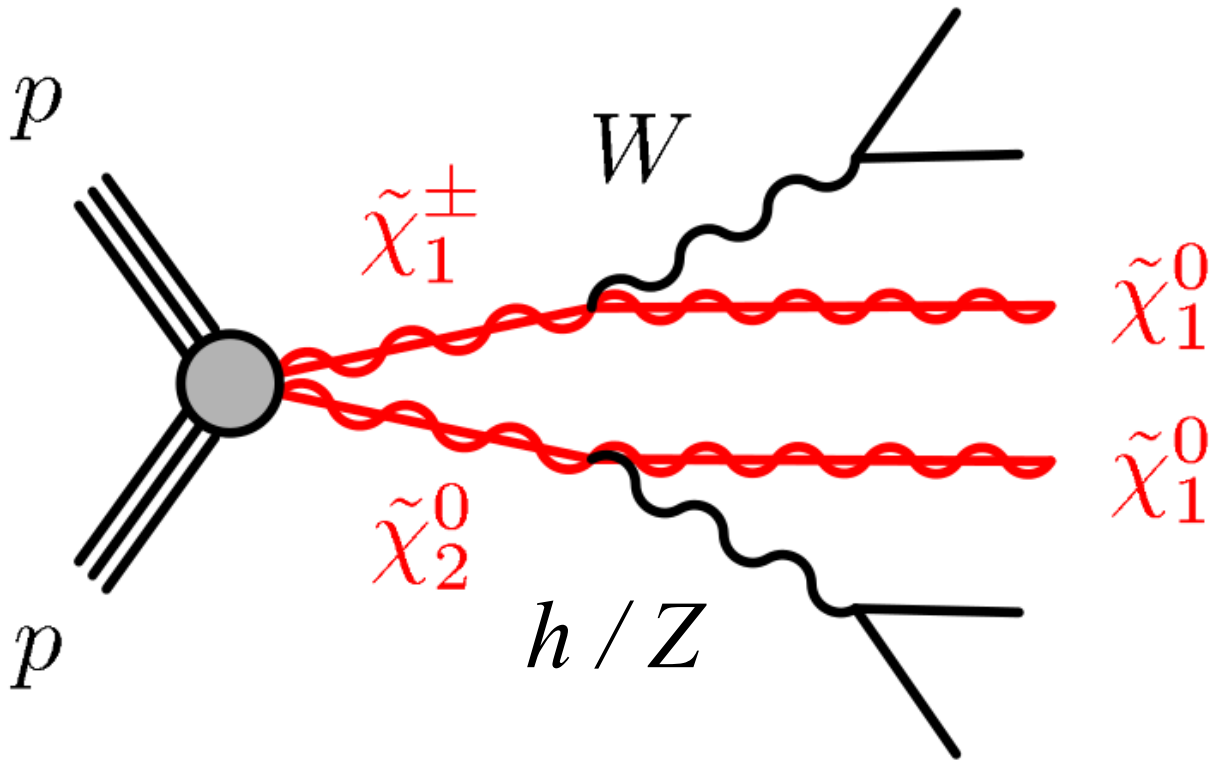
- Inclusive searches have probed strongly interacting SUSY particles up to masses of ~1 TeV
- Electroweak SUSY production has lower σ, probe lower mass



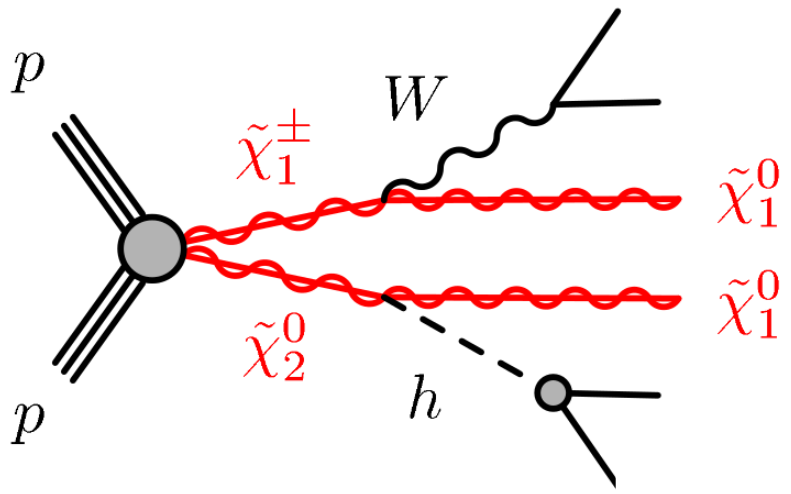
https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections arXiv:1206.2892

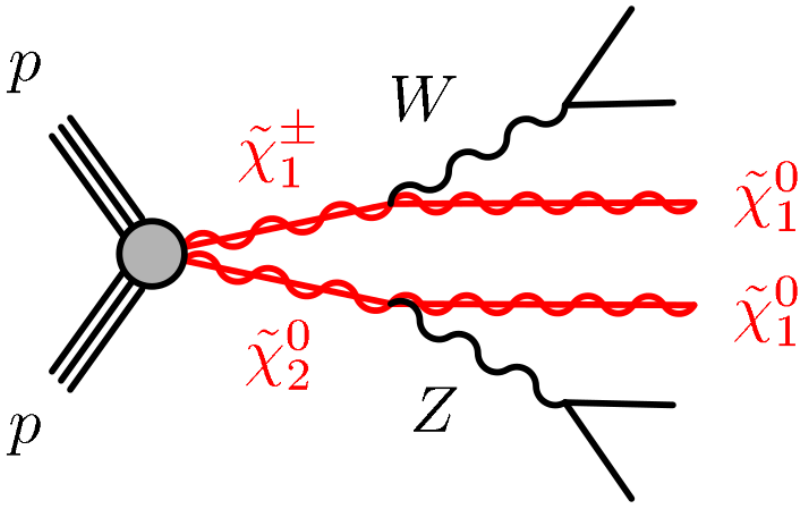
This talk: focus on $\chi^{\pm}\chi^{0}$ production, with largest electroweak cross section

- Direct decays to W and h/Z + LSP, if sleptons are heavy



Use a broad program of searches to maximize coverage of final states



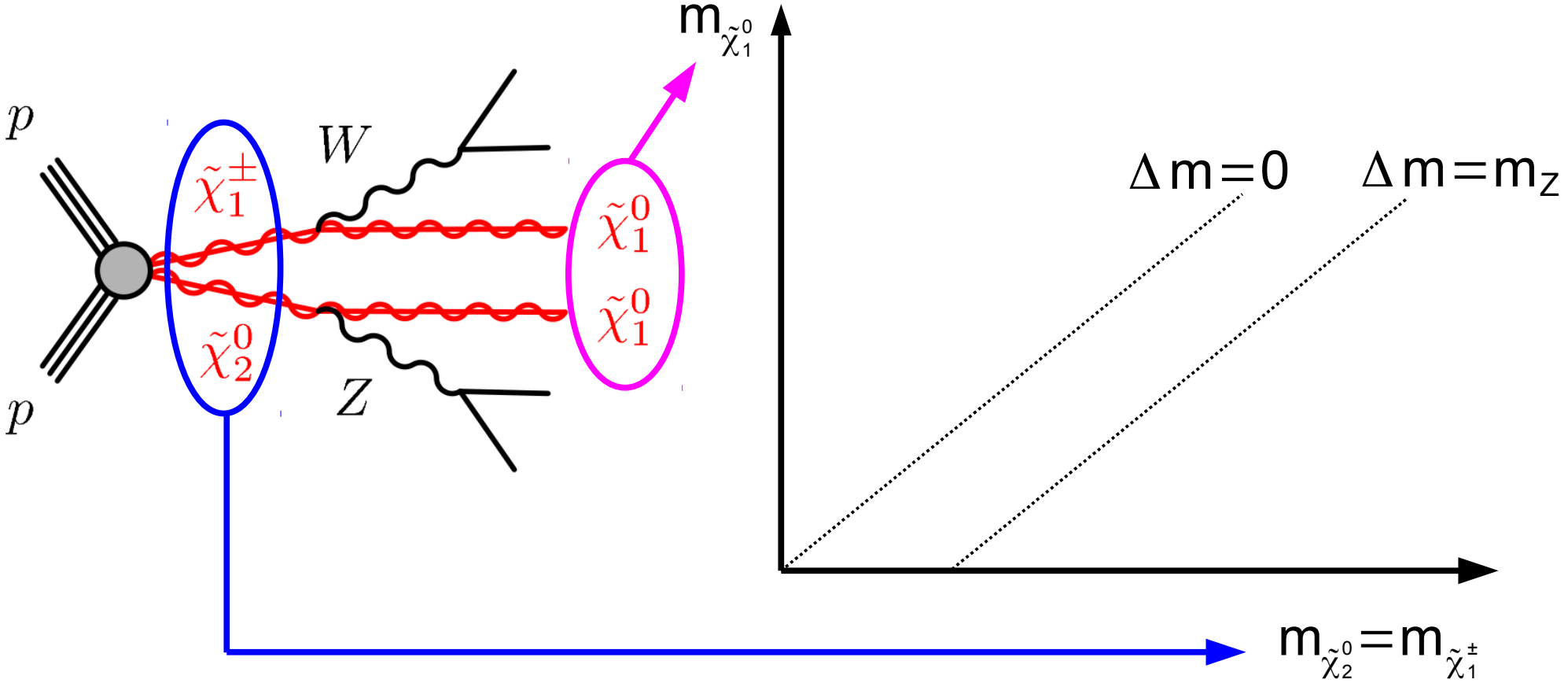


1ℓ+bb: W(ℓν)h(bb)
1ℓ+γγ: W(ℓν)h(γγ)
SS 2ℓ: W($\ell^{\pm}$ν)h, h → W($\ell^{\pm}$ν)W(jj)
≥3ℓ: W(ℓν)h(WW,ZZ,ττ)

3ℓ: W(ℓν)Z(ℓℓ)
OS 2ℓ+jj: W(jj)Z(ℓℓ)

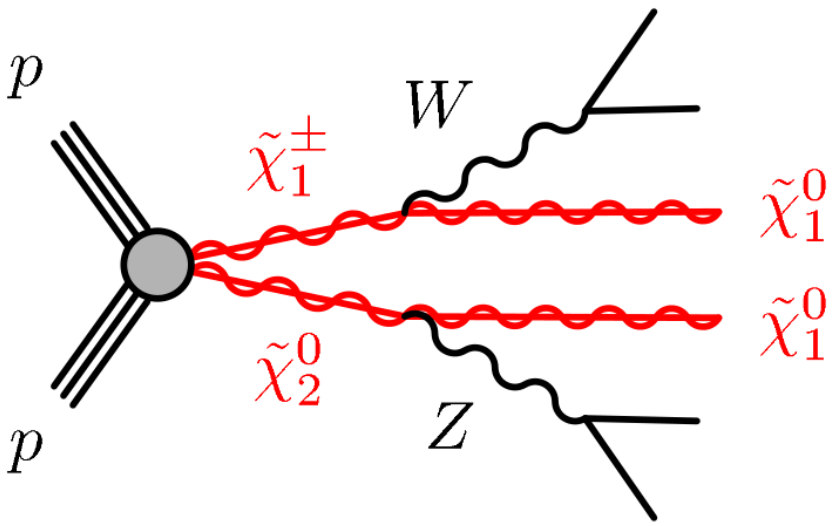
Results are interpreted using Simplified Models

$\Delta m \equiv m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$

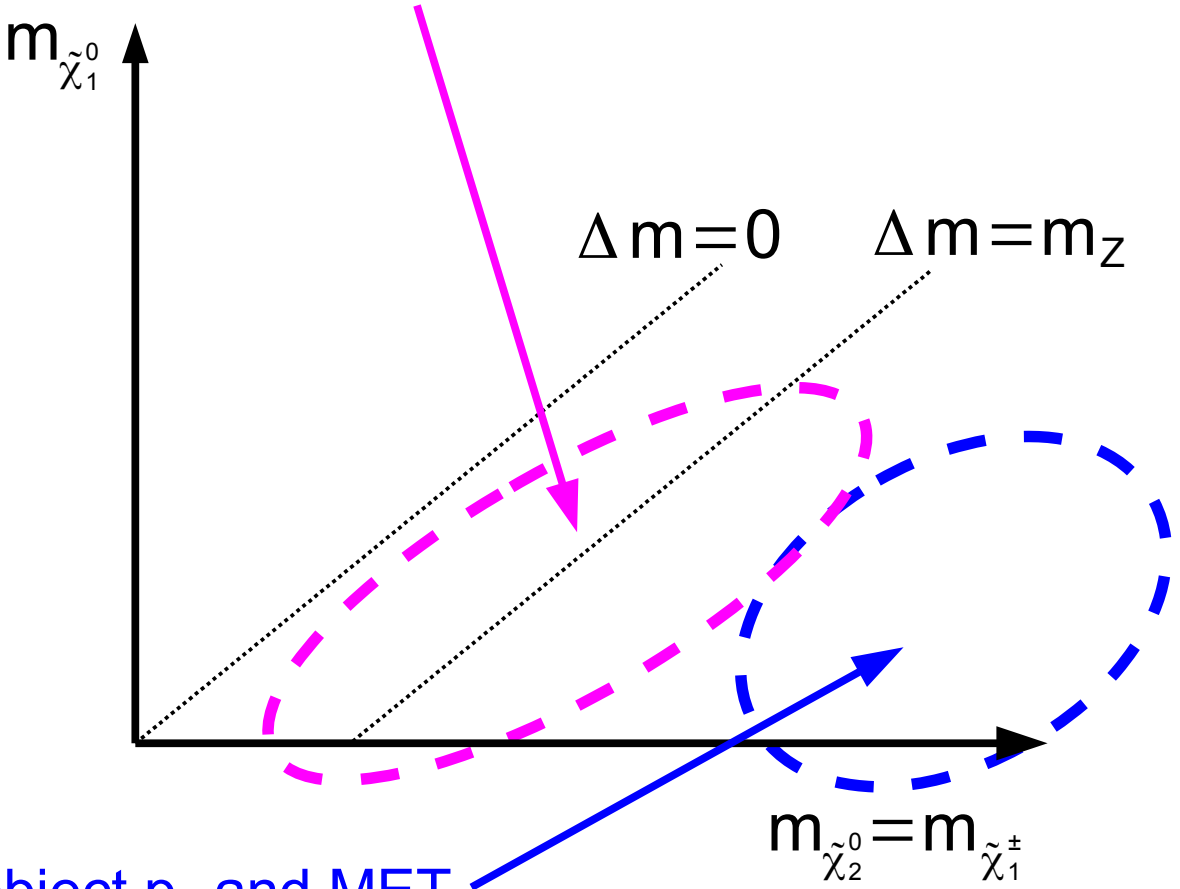


Different final states provide complementary model coverage

$\Delta m \equiv m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$



Small Δm: lower object p_T and MET, multilepton channels dominate

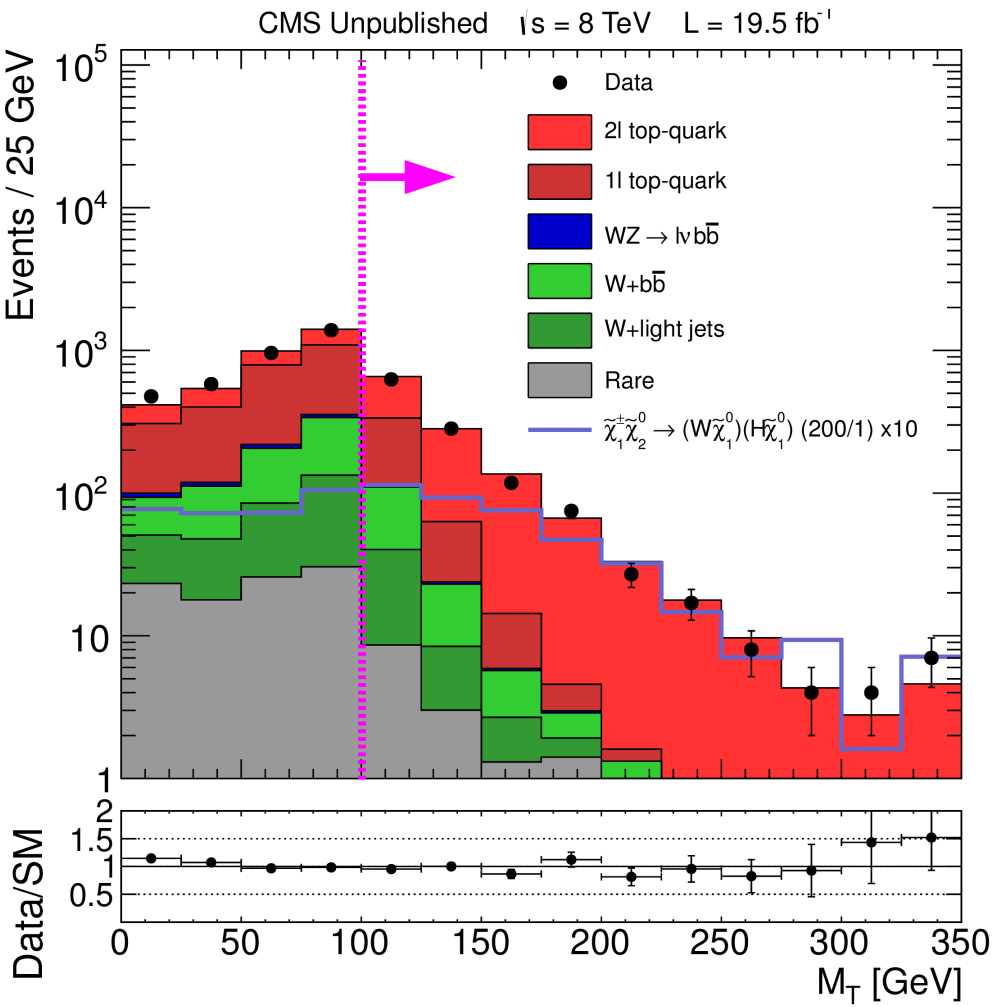


Large Δm: higher object p_T and MET, lepton+hadron channels contribute/dominate

1ℓ+bb search gives the best sensitivity for the Wh+MET topology at large Δm

- Exactly 1ℓ (e,μ) and 2 b-jets
  - p_T(e/μ) > 30/25 GeV
  - p_T(jet) > 50/30 GeV
  - Look for resonance in M(bb)

- Main backgrounds: ttbar, W+jets, WZ
  - Suppress using kinematic variables to exploit extra MET in signal
  - M_T, M_{T2}^{bl}, also MET
  - Model mainly using MC with corrections from data control regions



After preselection

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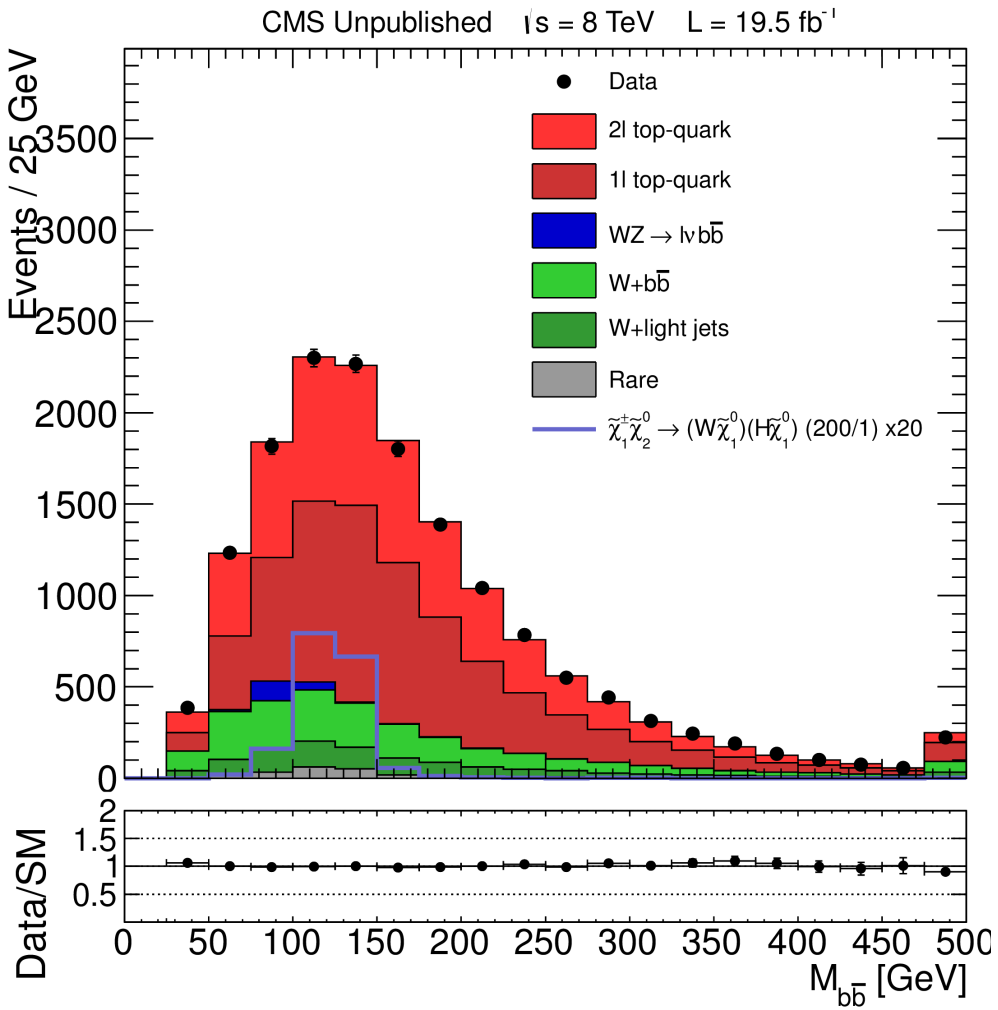
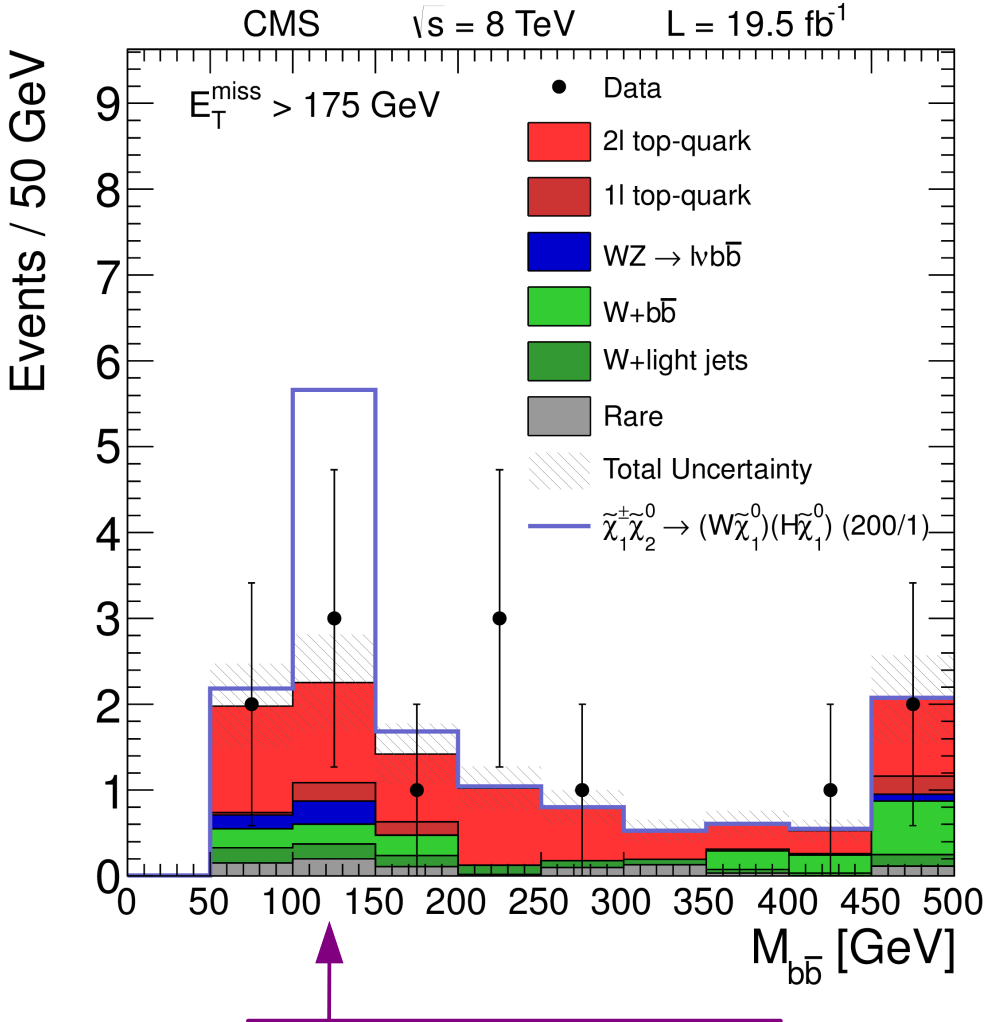
Observe good modeling of M(bb), no excess in signal regions



After preselection



Tightest signal region

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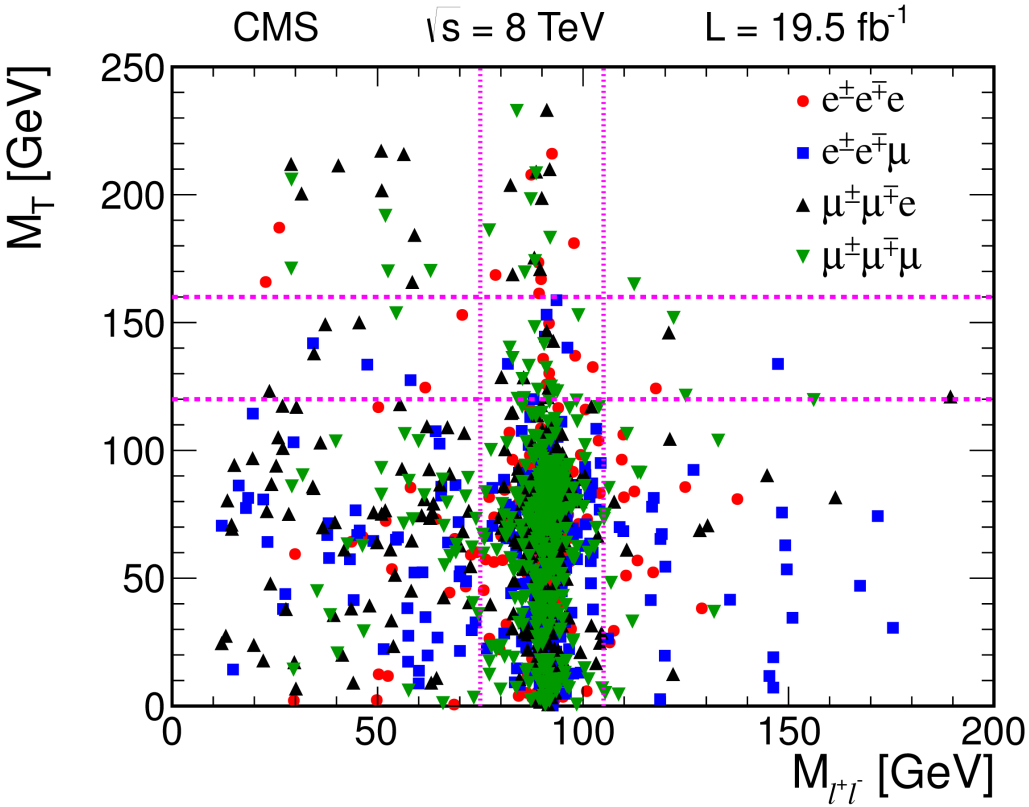
3ℓ search gives the best sensitivity for the WZ+MET topology

- Require 3ℓ, at most 1 τ_h
  - p_T(e/μ) > 10 GeV
  - p_T > 20 GeV for τ_h, lead e/μ
  - Veto on b-jets with p_T > 30 GeV
  - Bins: M($\ell^{\pm}\ell^{\mp}$), M_T, MET, N(τ_h)
  - M($\ell^{\pm}\ell^{\mp}$) binning targets on- and off-shell Z bosons
- Main backgrounds: WZ, ttbar with non-prompt ℓ
  - Use MC with data-based corrections for WZ
  - Data-driven fake rate method for non-prompt ℓ



Signal regions with OSSF ee or μμ pair, third lepton e or μ

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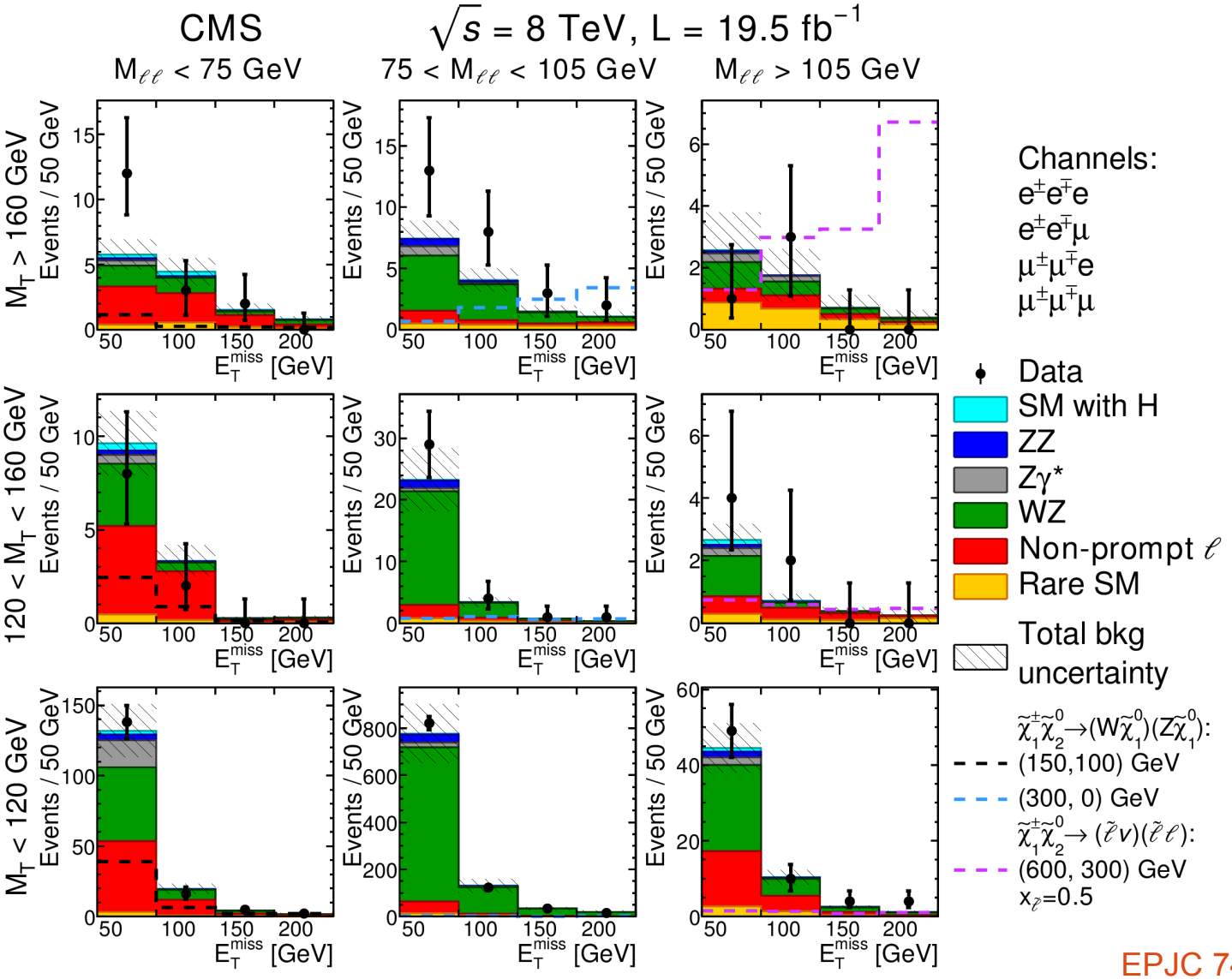
Observe overall agreement, slight excesses below and on-Z at high M_T



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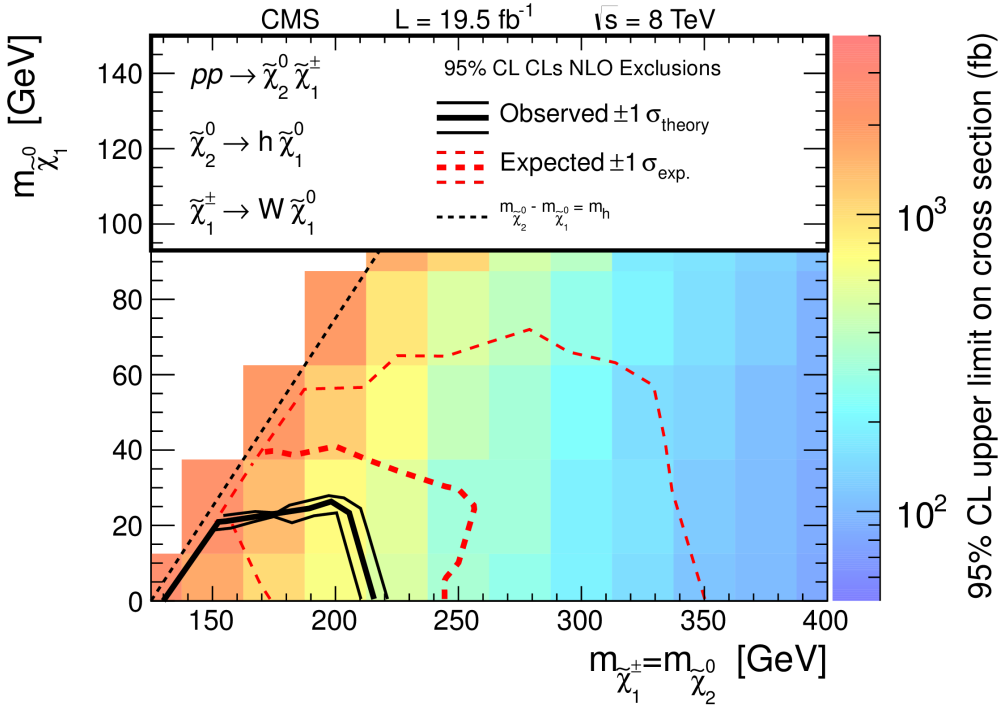
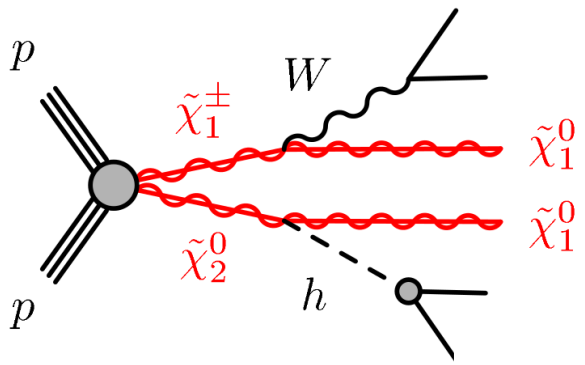
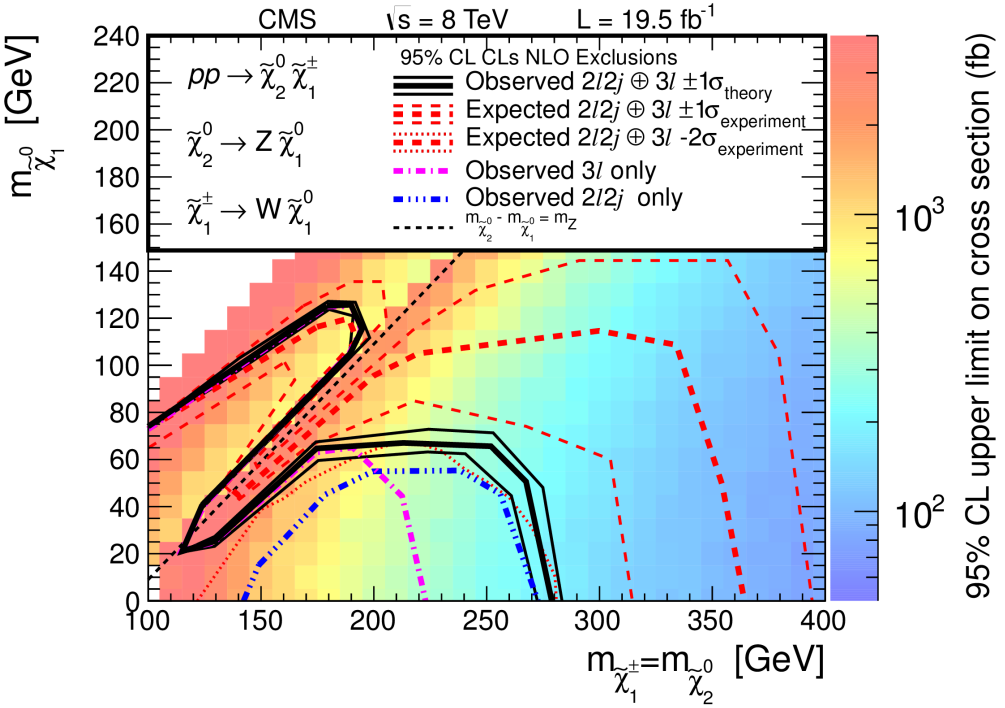
Signal regions with OSSF ee or μμ pair, third lepton e or μ

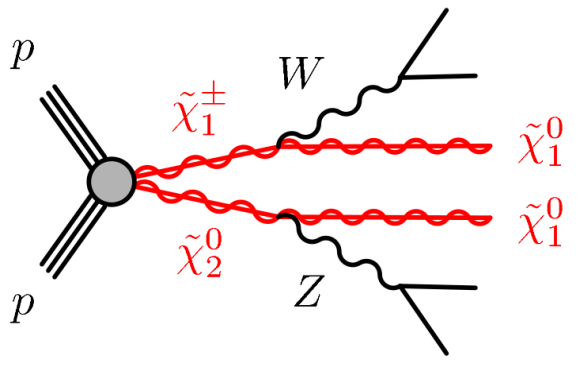
Probe $\chi^{\pm}\chi^{0}$ production up to 210-270 GeV in M($\chi^{\pm}$)





arXiv:1409.3168





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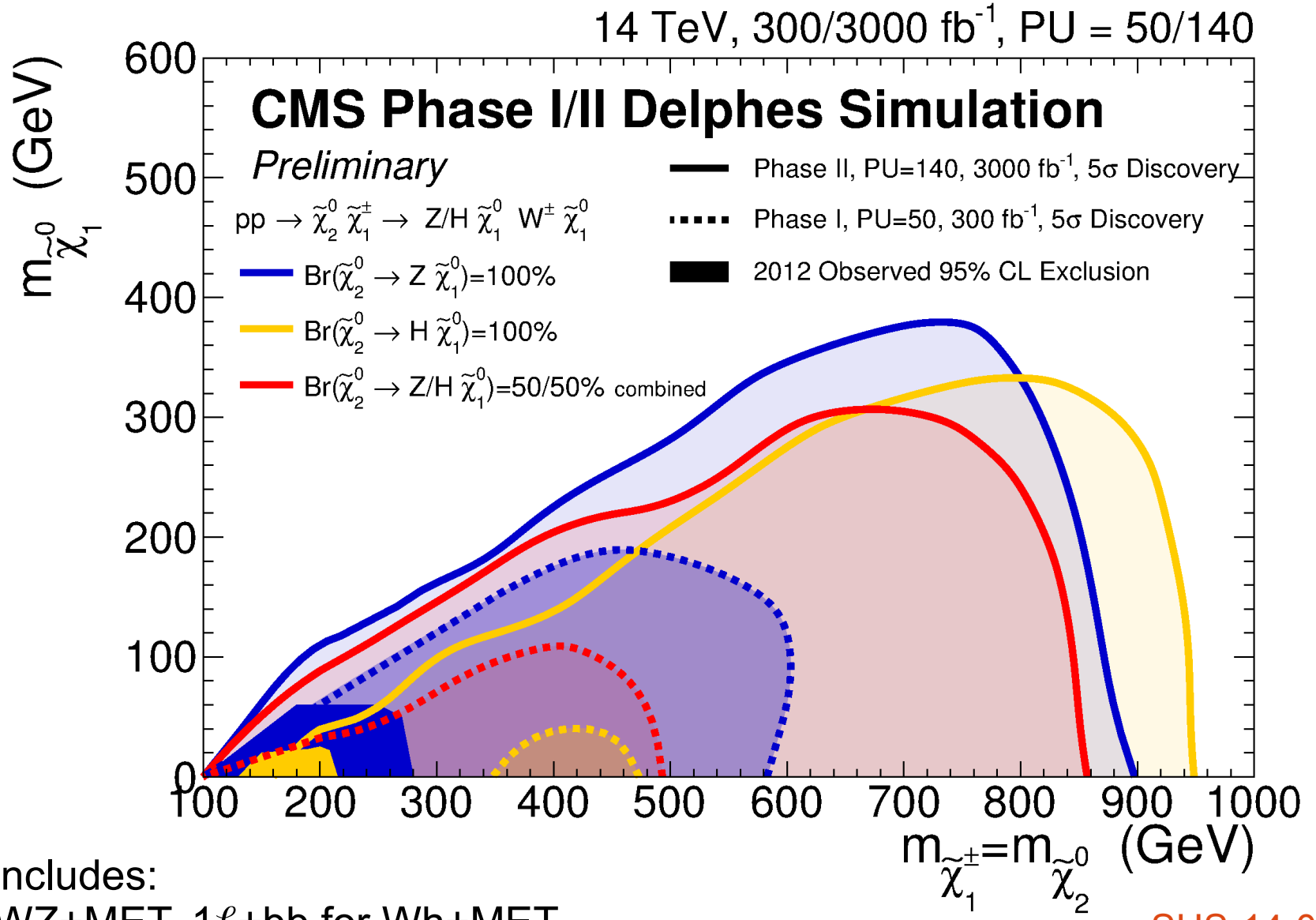
These searches will benefit greatly from more lumi in Run 2 and HL-LHC



* only includes:
3ℓ for WZ+MET, 1ℓ+bb for Wh+MET

SUS-14-012

Conclusions

- Broad program of complementary searches at 8 TeV to cover different decays of electroweak SUSY partners
  - Many more than could be covered here

- No significant excesses observed so far
- Probe $\chi^{\pm}\chi^{0}$ production up to 210-270 GeV in M($\chi^{\pm}$), depending on scenario assumed

- Many of these searches were just beginning to have sensitivity with 20 fb^{-1}
- Accumulating more luminosity at 13 TeV will greatly extend our discovery reach

Bonus Slides

3ℓ Search: Yields

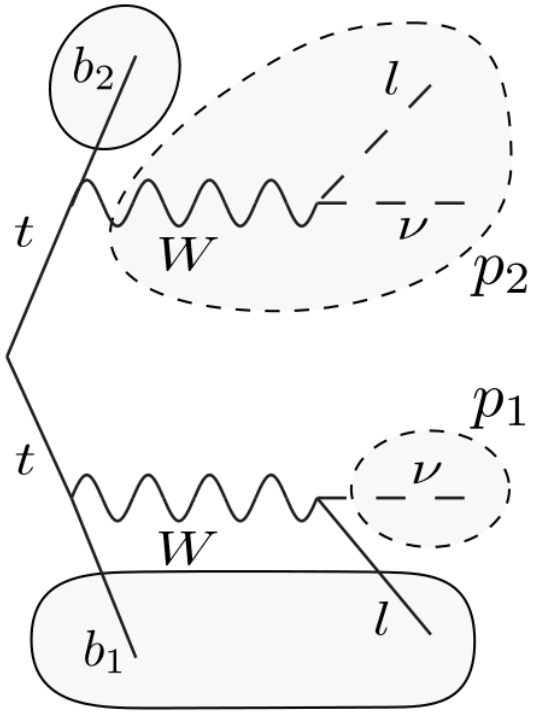
- Yields for 3ℓ events with an OSSF ee or μμ pair, where the third lepton is e or μ

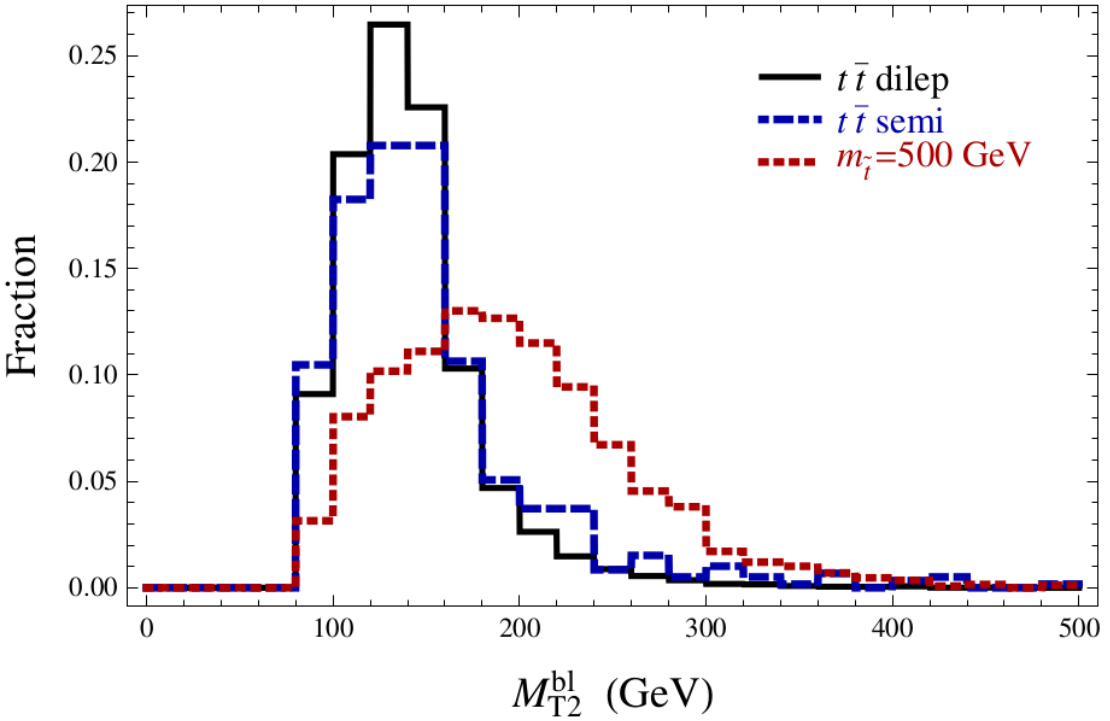
M_T (GeV)	E_T^{miss} (GeV)	$M_{\ell\ell} < 75$ GeV		$75 < M_{\ell\ell} < 105$ GeV		$M_{\ell\ell} > 105$ GeV	
		Total bkg	Observed	Total bkg	Observed	Total bkg	Observed
>160	50–100	5.8 ± 1.1	12	7.5 ± 1.4	13	2.6 ± 1.2	1
	100–150	4.5 ± 1.1	3	4.0 ± 1.0	8	1.8 ± 0.9	3
	150–200	1.5 ± 0.4	2	1.5 ± 0.5	3	0.7 ± 0.4	0
	>200	0.81 ± 0.21	0	1.1 ± 0.4	2	0.40 ± 0.24	0
120–160	50–100	9.6 ± 1.7	8	23 ± 5	29	2.7 ± 0.5	4
	100–150	3.3 ± 0.8	2	3.4 ± 0.7	4	0.71 ± 0.22	2
	150–200	0.26 ± 0.10	0	0.72 ± 0.19	1	0.38 ± 0.14	0
	>200	0.29 ± 0.11	0	0.36 ± 0.12	1	0.24 ± 0.20	0
0–120	50–100	132 ± 19	138	776 ± 125	821	45 ± 7	49
	100–150	20 ± 4	16	131 ± 30	123	10.0 ± 1.9	10
	150–200	4.0 ± 0.8	5	34 ± 8	34	2.5 ± 0.5	4
	>200	1.9 ± 0.4	2	21 ± 7	14	1.2 ± 0.3	4

M_{T2}^{bl} Variable

- Variation of M_{T2} variable for 1ℓ analyses targeting ttbar $\rightarrow \ell\ell$ bg
- Combines visible leptons and b-jets, endpoint at M(top)

$$M_{T2}^{b\ell} = \min \left\{ \bigcup_{\vec{p}_1^T + \vec{p}_2^T = \vec{E}_T^{\text{miss}}} \max\left[M_T(\vec{p}_{b_1} + \vec{p}_\ell, \vec{p}_1^T), M_T(\vec{p}_{b_2}, \vec{p}_2^T) \right] \right\}$$



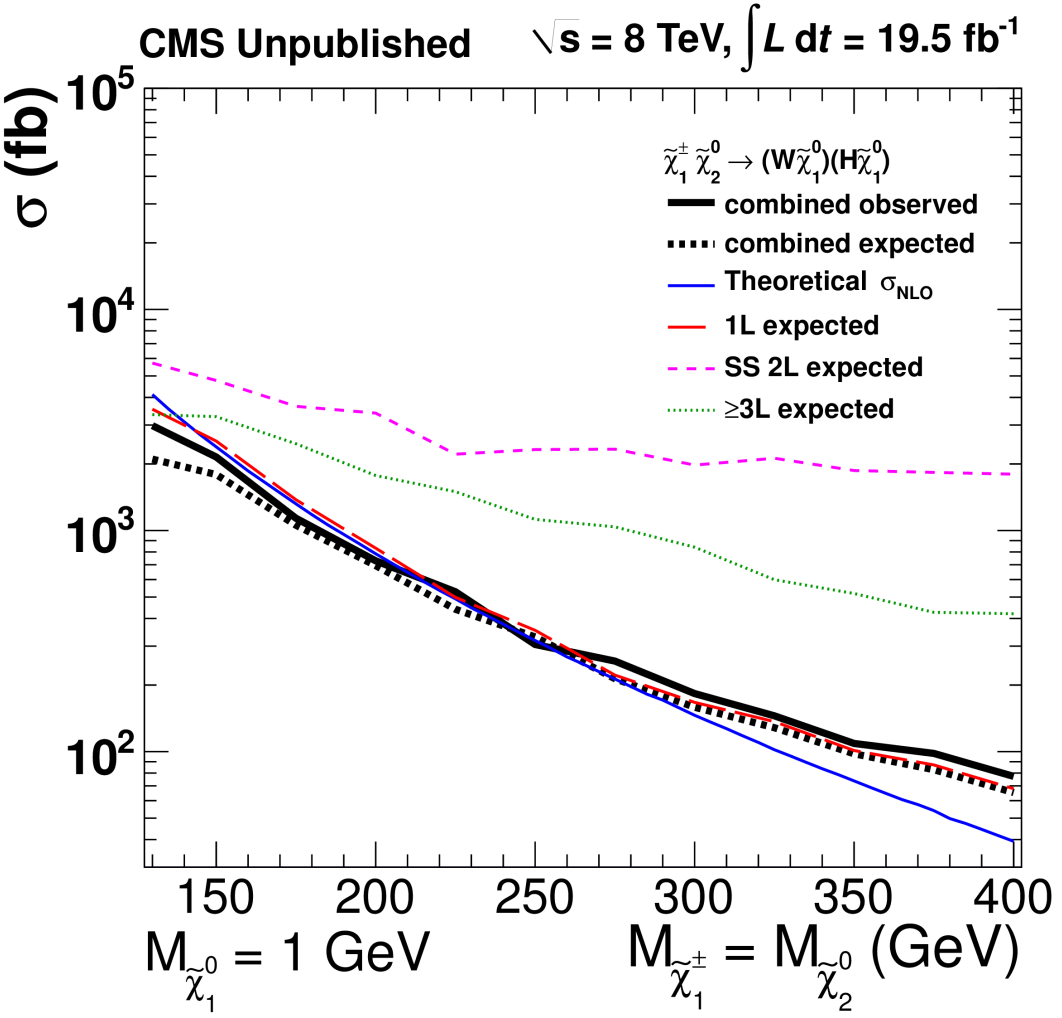


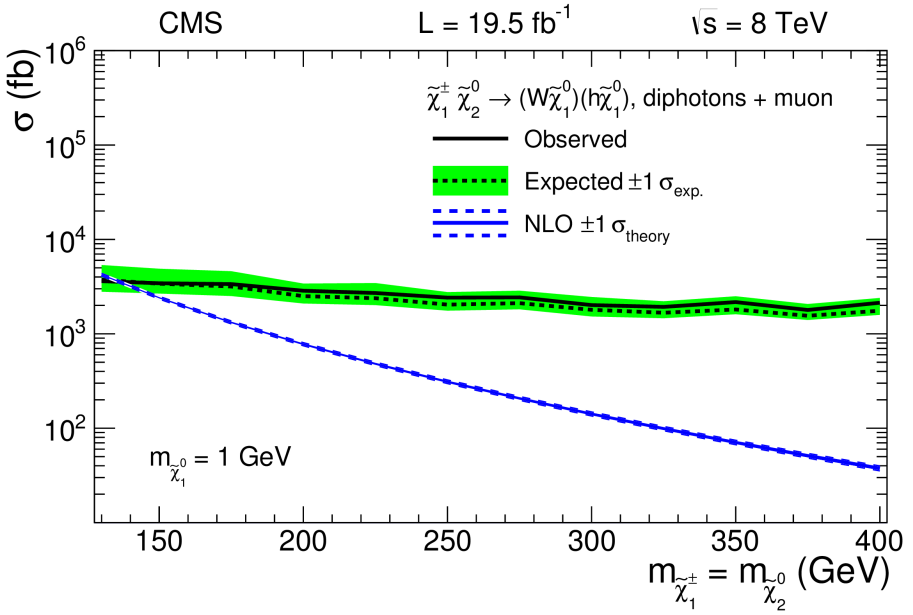
Bai et al, JHEP 1207 (2012) 110

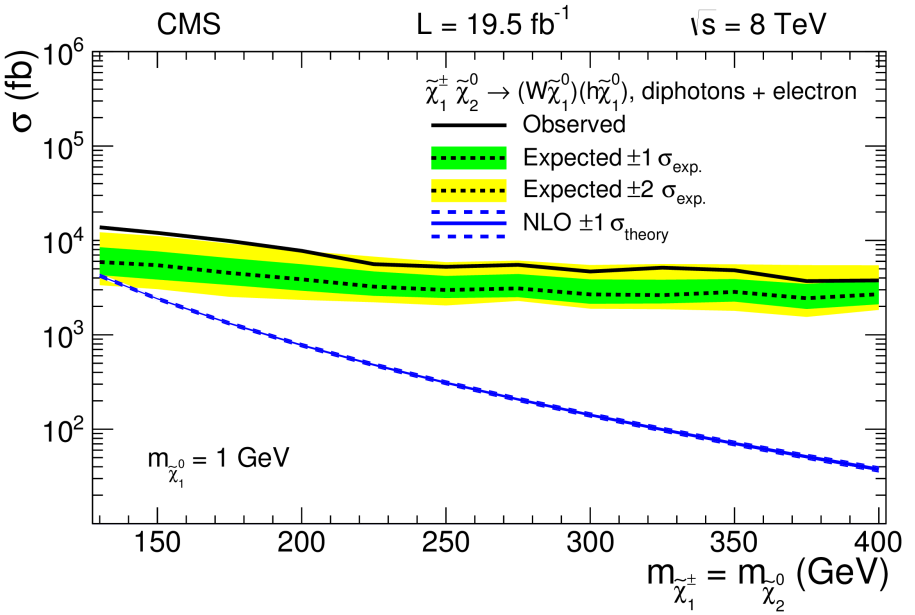
1ℓ+bb Search: Yields

Sample	$E_T^{miss} > 100$ GeV	$E_T^{miss} > 125$ GeV	$E_T^{miss} > 150$ GeV	$E_T^{miss} > 175$ GeV
Dilepton top-quark	2.8 ± 1.2	2.3 ± 1.0	1.7 ± 0.7	1.2 ± 0.5
Single-lepton top-quark	1.8 ± 1.1	0.9 ± 0.6	0.5 ± 0.3	0.2 ± 0.2
$WZ \to \ell\nu b\bar{b}$	0.6 ± 0.2	0.4 ± 0.2	0.3 ± 0.1	0.3 ± 0.1
$W + b\bar{b}$	1.5 ± 0.9	1.0 ± 0.7	0.9 ± 0.6	0.2 ± 0.3
W + light-flavor jets	0.5 ± 0.2	0.3 ± 0.1	0.2 ± 0.1	0.2 ± 0.1
Rare	0.4 ± 0.2	0.3 ± 0.2	0.3 ± 0.2	0.2 ± 0.1
Total background	7.7 ± 1.9	5.4 ± 1.3	3.8 ± 1.0	2.3 ± 0.6
Data	7	6	3	3
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to (W\tilde{\chi}_1^0)(H\tilde{\chi}_1^0)$ (130/1)	9.0 ± 1.2	7.5 ± 1.0	6.0 ± 0.8	4.5 ± 0.6
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to (W\tilde{\chi}_1^0)(H\tilde{\chi}_1^0)$ (150/1)	7.2 ± 1.0	6.1 ± 0.9	5.0 ± 0.7	3.5 ± 0.5
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to (W\tilde{\chi}_1^0)(H\tilde{\chi}_1^0)$ (200/1)	7.0 ± 0.9	5.8 ± 0.8	4.7 ± 0.7	3.4 ± 0.5
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to (W\tilde{\chi}_1^0)(H\tilde{\chi}_1^0)$ (300/1)	5.2 ± 0.7	4.9 ± 0.7	4.4 ± 0.6	3.9 ± 0.5
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to (W\tilde{\chi}_1^0)(H\tilde{\chi}_1^0)$ (400/1)	3.2 ± 0.4	3.0 ± 0.4	2.8 ± 0.4	2.5 ± 0.3

Wh+MET: Combination







A natural model with W+h/Z+MET