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SUSY searches for EWK production of Gauginos and Sleptons at CMS

Lesya Shchutka
on behalf of the CMS collaboration

1 Introduction

2 $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$

→ sleptons

with 3ℓ

with $SS2\ell$

→ WZ

with Z -dijets

3 $\tilde{\chi}\tilde{\chi} \rightarrow ZZ$

with $3-4\ell, Z+j$

4 $\tilde{\ell}\tilde{\ell}$

with $OS2\ell$

5 $\tilde{\chi}^\pm \tilde{\chi}^\pm$

with $OS2\ell$

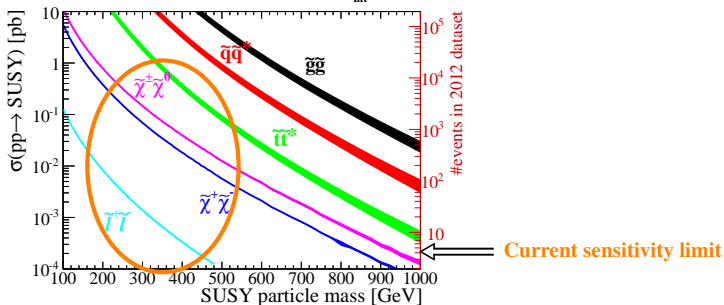
6 Summary

7 Extra material

Electroweak production

- strong SUSY production has large x-sections and spectacular signatures:
 - gluinos probed up to **1.3 TeV**, squarks up to **800 GeV**
 - nothing is found
- high luminosity gives access to rarer SUSY processes: with 19.5/fb dataset can attempt a search of
 - chargino/neutralino up to **800 GeV**
 - sleptons up to **400 GeV**
- need to look as broadly as possible!
- here we present **full dataset** results from **CMS-PAS-SUS-13-006** ← **NEW!**

LPCC SUSY σ WG NLO-NLL $\sqrt{s} = 8$ TeV, $L_{\text{int}} = 19.5 \text{ fb}^{-1}$



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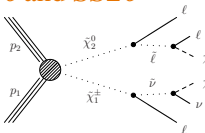
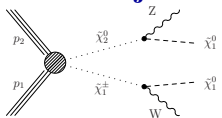
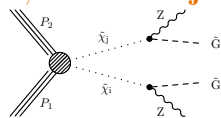
with Z+dijets

3 $\tilde{\chi}\tilde{\chi} \rightarrow ZZ$ with 3-4 ℓ , Z+jj4 $\tilde{\ell}\tilde{\ell}$ with OS2 ℓ 5 $\tilde{\chi}^\pm \tilde{\chi}^\pm$ with OS2 ℓ

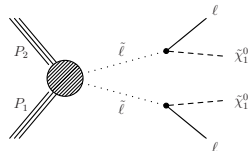
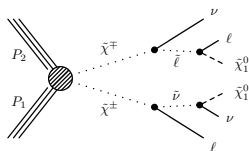
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Overview of the searches

**3 ℓ and SS2 ℓ** **3 ℓ and Z+dijet****3 ℓ , 4 ℓ and Z+dijet**

All analyses are designed exclusive and are therefore subject to statistical combination

opposite-sign 2 ℓ 

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3-leptons: search definition

$\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow$ sleptons

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\rightarrow sleptons

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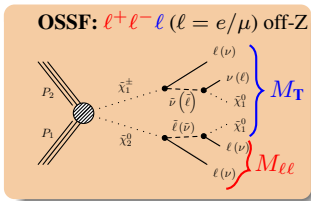
with $OS2\ell$

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Selection:

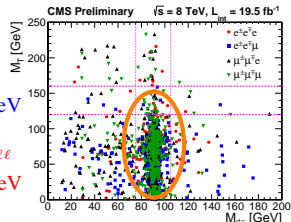
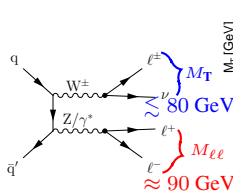
- 3 leptons (up to 1 τ_h)
- b-jet veto
- $M_{\ell\ell} > 12$ GeV
- $E_T^{\text{miss}} > 50$ GeV

Search strategy:

- break into categories by \mathcal{N} (OSSF) and \mathcal{N} (τ)
- form search regions (SR) in $M_{\ell\ell}$, M_T , and E_T^{miss}

Standard Model Backgrounds:

1 **WZ** (irreducible, dominant):



- corrected MC: calibrate using Z+jets data

2 **Rare processes** (ZZ/ttV/VVV and Higgs!): MC simulations and NLO x-sections

3 **Non-prompt/misID leptons** ($t\bar{t}$, DY+jets): data-driven techniques

4 **Z γ (*) conversion**: data-driven (from $\ell^+ \ell^- \gamma$)

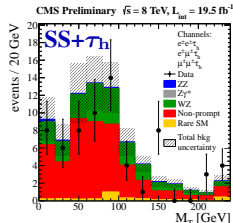
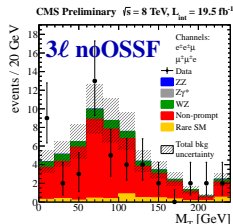
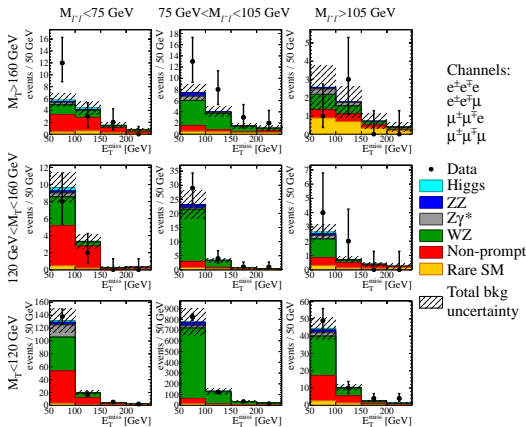


3-leptons: Results

$\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow$ sleptons

Data is in agreement with the expected SM background

3 ℓ OSSF CMS Preliminary $\sqrt{s} = 8$ TeV, $L_{\text{int}} = 19.5 \text{ fb}^{-1}$



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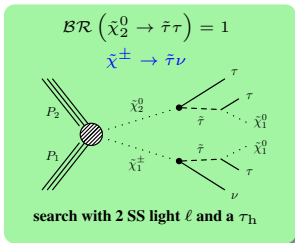
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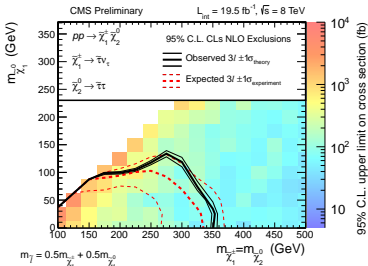
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● $(\tilde{\ell}_L, \tilde{\nu}_L)$ heavy and decoupled from $\tilde{\ell}_R$



“ τ -dominated”



Sensitivity is reduced significantly:

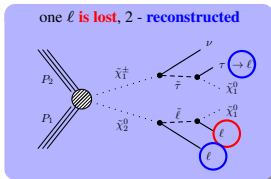
- acceptance suffers from τ BR:
 $2\tau \rightarrow e, \mu$ and $\tau \rightarrow$ hadrons



2 Same-Sign leptons (e/μ)

$\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow$ sleptons \rightarrow sleptons

“Compressed spectra”

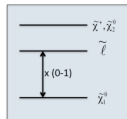


Search strategy:

- aim to recover sensitivity in compressed spectra
- 3^{rd} lepton ($e/\mu/\tau$) veto \implies exclusive wrt 3ℓ search
- search in $E_T^{\text{miss}} \in [120, 200]$ GeV, $N_{\text{jets}} < 3$, $N_{\text{b-jets}} = 0$ and $E_T^{\text{miss}} > 200$ GeV

SM backgrounds: similar to 3ℓ

$$m_{\tilde{\ell}} = m_{\tilde{\chi}_1^0} + \alpha (m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0})$$



$$\alpha = 0.05 \implies m_{\tilde{\ell}} \approx m_{\tilde{\chi}_1^0}$$

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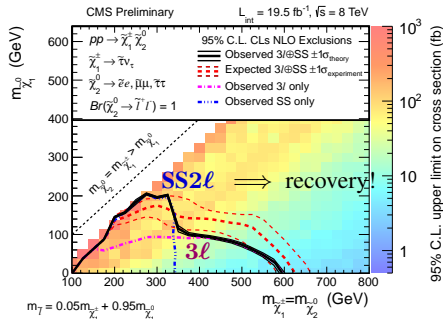
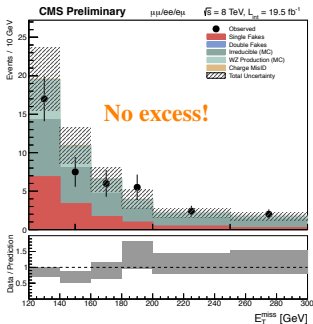
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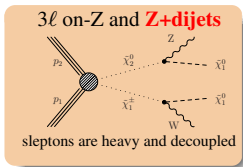
7 Extra material





Z($\ell\ell$) + dijets

Selection: Z($ee/\mu\mu$), two jets with $M_{jj} \in [70, 100]$ GeV, b-veto, 3rd lepton ($e/\mu/\tau$) veto

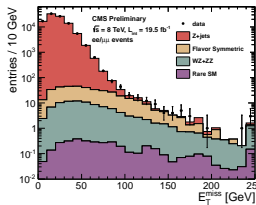
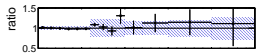


Search strategy

- bins in E_T^{miss} : 80–100–120–150–200... GeV

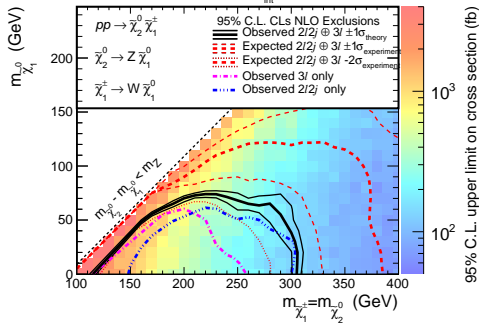
SM backgrounds

- Z+jets** from γ +jets in data
- flavor-symmetric** from $e\mu$ in data
- diboson** and **rare SM** from MC



CMS Preliminary

$L_{\text{int}} = 19.5 \text{ fb}^{-1}$, $\sqrt{s} = 8 \text{ TeV}$



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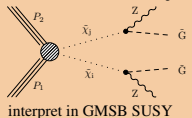
with OS2 ℓ

5 $\tilde{\chi}^\pm \tilde{\chi}^\pm$

with OS2 ℓ

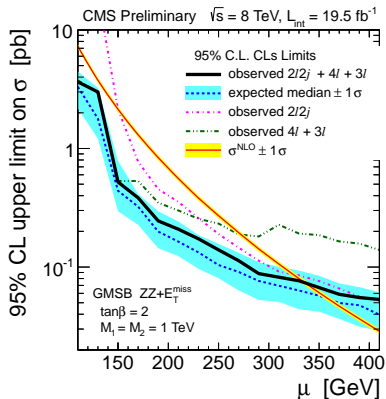
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3-4 ℓ and Z($\ell\ell$) + dijets4 ℓ on-Z, 3 ℓ and Z+dijets

Selection: 4 ℓ including Z($e\bar{e}/\mu\bar{\mu}$)
SM Backgrounds: as in 3 ℓ

E_T^{miss} (GeV)	Observed	Total Bkg
1 OSSF, 0 τ		
0-30	1	2.3 ± 0.6
30-50	3	1.2 ± 0.3
50-100	2	1.5 ± 0.4
> 100	2	0.8 ± 0.3
1 OSSF, 1 τ		
0-30	33	25 ± 12
30-50	11	11 ± 3.1
50-100	9	9.3 ± 1.9
> 100	2	2.9 ± 0.6
2 OSSF, 0 τ		
0-30	142	149 ± 46
30-50	25	28 ± 11
50-100	4	4.5 ± 2.7
> 100	1	0.8 ± 0.3



The region $\mu < 330 \text{ GeV}$ is excluded at 95% confidence level.

For GMSB SUSY at CMS see Christian Autermann's poster

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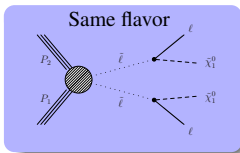
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Non-resonant OS dileptons: SF

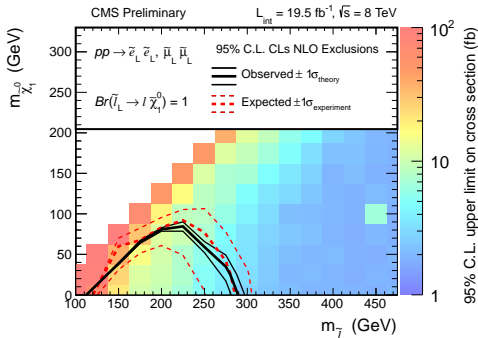
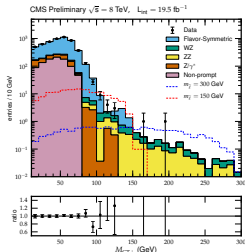


Selection: 2ℓ (e/μ) off-Z, b-veto, $E_T^{\text{miss}} > 60$ GeV
Strategy: employ shape of $M_{CT\perp}$ variable:

- has an endpoint for processes with $WW \rightarrow \ell\nu\ell\nu$: $\sim M_W$
- SUSY processes have flat distribution
- construct $M_{CT\perp}$ templates:
 - fit the data in $10 < M_{CT\perp} < 120$ GeV
 - perform search in $M_{CT\perp} > 120$ GeV

SM backgrounds fitted with $M_{CT\perp}$ templates obtained for:

- **Flavor-Symmetric** from opposite flavor control sample
- **Non-FS diboson** from MC
- **non-prompt** from CS in data
- **Z/γ^*** from corrected MC



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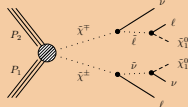
6 Summary

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Non-resonant OS dileptons: SF and OF

 $\tilde{\chi}^\pm \tilde{\chi}^\pm$

Opposite and same flavor



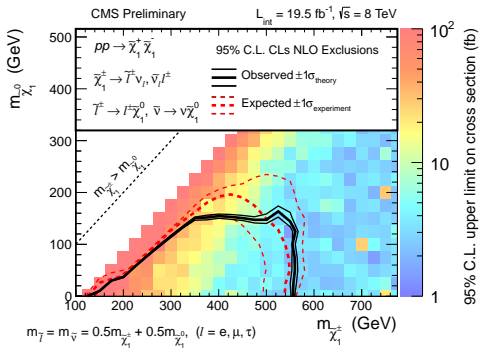
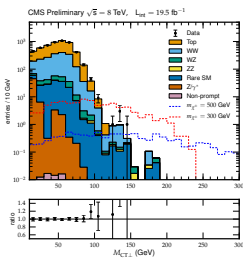
Selection: 2ℓ (e/μ) off-Z, b-veto, $E_T^{\text{miss}} > 60$ GeV

Strategy:

- can have both **same flavor** and **opposite flavor**
- do not rely on OF control sample \implies employ b-tag CS
- use $M_{CT\perp}$ templates

SM backgrounds fitted with $M_{CT\perp}$ templates obtained for:

- **Top** from b-tag CS in data
- **non-prompt** from CS in data
- **Z/ γ^*** from corrected MC
- **diboson** and **rare SM** from MC



$$m_{\tilde{\nu}} = m_{\tilde{\nu}} = 0.5m_{\tilde{\chi}_1^\pm} + 0.5m_{\tilde{\chi}_1^0}, \quad (l = e, \mu, \tau)$$

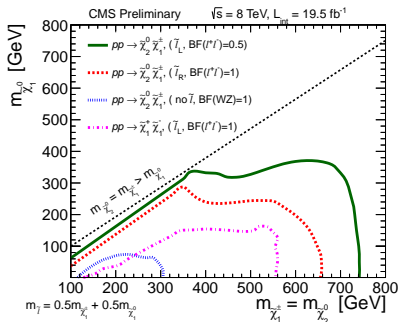
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Summary



New Results!

- Performed a wide range of searches for electroweak SUSY production with full 8 TeV dataset



- tailored a complementary set of analyses to target various scenarios:
 - 3 l , 4 l , SS2 l , OS2 l , Z+dijet
- no significant excess observed
- interpreted results in various simplified models spectra
- probe SUSY masses up to **740 GeV** in the most optimistic scenario
- reach up to **300 GeV** in more challenging cases

For more information:

- twiki of CMS-PAS-SUS-13-006

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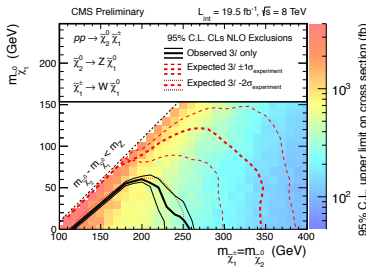
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Extra material (links)

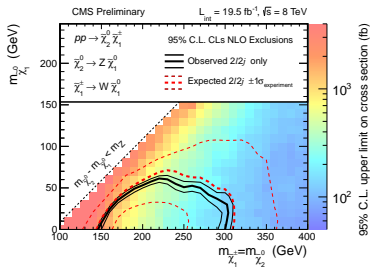
- Summary of CMS Physics results
- CMS SUSY results
 - CMS-PAS-SUS-13-006 (19.5/fb EWKino search)
 - CMS-PAS-SUS-12-022 (9.2/fb EWKino search)



 $8 \tilde{\chi}_1^\pm \tilde{\chi}_1^0 \rightarrow WZ$ 9 More on compressed
 3ℓ and $SS2\ell$ 10 $M_{CT\perp}$ ① 3ℓ 

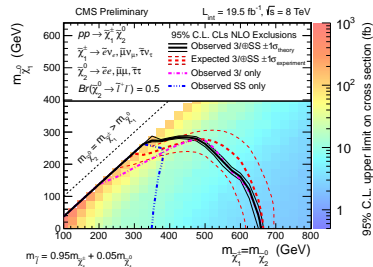
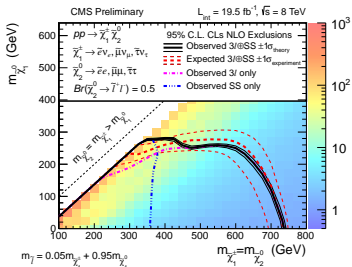
◀ back

② Z+dijets

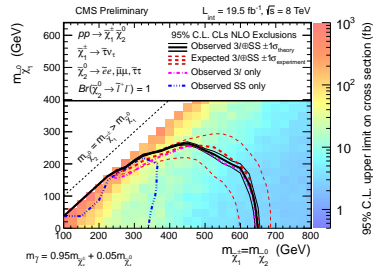
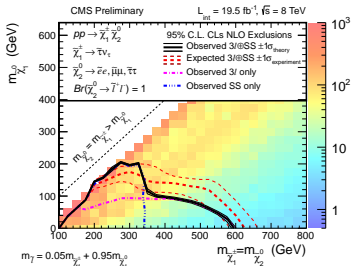


8 $\tilde{\chi}_1^\pm \tilde{\chi}_1^0 \rightarrow WZ$ 9 More on compressed
3 ℓ and SS2 ℓ 10 $M_{CT\perp}$

“Flavor-democratic”



“Tau-enriched”


[◀ back](#)



8 $\bar{\chi}_1^\pm \bar{\chi}_1^0 \rightarrow WZ$

9 More on compressed
3 ℓ and SS2 ℓ

10 $M_{CT\perp}$

● **Konstantin Matchev and Myeonghun Park:**

- Phys. Rev. Lett. 107, 061801 (2011) (hep-ph:0910.1584)

- for $P \rightarrow VC$, where V - a visible particle:

$$M_{CT}^2 = m^2(V_1) + m^2(V_2)$$

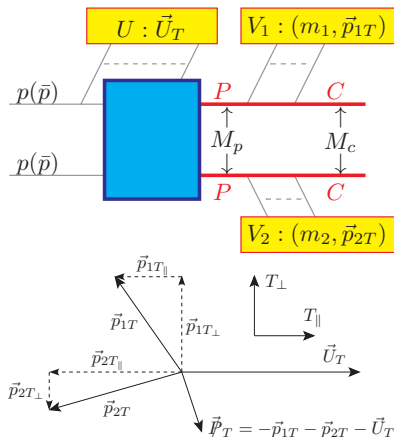
$$+2 \left[E_T(V_1)E_T(V_2) + \mathbf{p}_T(V_1) \cdot \mathbf{p}_T(V_2) \right]$$

- an endpoint:

$$M_{CT}^{\max} = \frac{m^2(P) - m^2(C)}{m(P)}$$

- if PP are not at rest, use E_T and p_T components normal to \vec{U}_T :

$$\vec{U}_T = -\vec{E}_T^{\text{miss}} - \vec{p}_T(V_1) - \vec{p}_T(V_2)$$



◀ back