Search for Chargino Neutralino production at CMS

04. December 2012

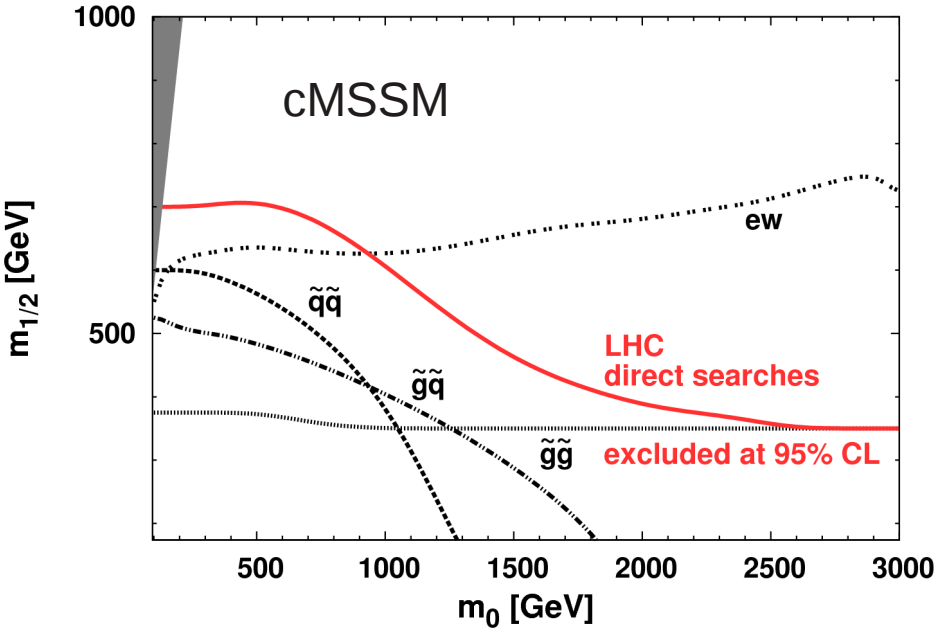
Wim de Boer, Felix Frensch, Christian Lüdtke, Martin Niegel, Fedor Ratnikov, Artur Speiser, Daniel Tröndle, **Stefan Wayand**, Florian Weiser
KIT, Fakultät für Physik, Institut für Experimentelle Kernphysik

Outline

- Logic
- EWKino signatures
- Object definitions
- 3 lepton analysis
- 2l OS+ 2jets analysis
- Results and interpretation

Logic

- SUSY production at LCH is dominated by strongly produced SUSY particles



- Red line LHC exclusion curve
- Dashed lines expected exclusion for a fixed cross section
  - gluinio gluino production $\tilde{g}\,\tilde{g}$
  - gluino squark production $\tilde{g}\,\tilde{q}$
  - squark squark prodcution $\tilde{q}\,\tilde{q}$
  - electroweak production ew

- Electroweakly produced SUSY particles need luminosity
- Use simplified models to quantize EWKino results

EWKino – Signatures

- 4 leptons:

  $pp \to \tilde{\chi}_2 \tilde{\chi}_3 \to Z\,\tilde{\chi}_1\, Z\,\tilde{\chi}_1 \to l^{\pm}\, l^{\mp}\, l^{\pm}\, l^{\mp} + MET$

  - MET, invMass

- 3 leptons:

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  $pp \to \tilde{\chi}_2 \tilde{\chi}_1^{\pm} \to l\,\tilde{l}\, l\,\tilde{\nu} \to l^{\pm}\, l^{\mp}\, l^{\pm} + MET$

  - MT, MET, invMass

- 2 leptons opposite sign same flavor (OSSF) + 2 Jets:

  $pp \to \tilde{\chi}_2 \tilde{\chi}_3 \to Z\,\tilde{\chi}_1\, Z\,\tilde{\chi}_1 \to l^{\pm}\, l^{\mp}\, j^{\pm}\, j^{\mp} + MET$

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  - MET, invMass

- 2 leptons same sign (SS):

  $pp \to \tilde{\chi}_2 \tilde{\chi}_1^{\pm} \to l\,\tilde{l}\, l\,\tilde{\nu} \to l^{\pm}\, \cancel{l^{\mp}}\, l^{\pm} + MET$

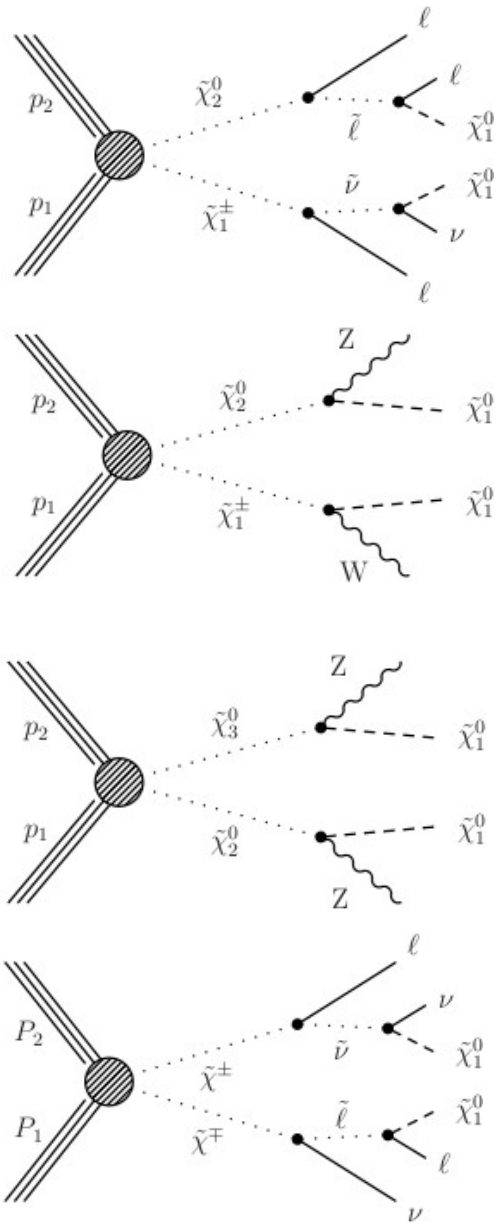
  - MET

- 2 leptons opposite sign (OS):

  $pp \to \tilde{\chi}_1^{\pm}\, \tilde{\chi}_1^{\pm} \to l\,\tilde{\nu}\,\nu\,\tilde{l} \to l^{\pm}\, l^{\mp} + MET$

  - MCT

Single PAS (CMS PAS SUS-12-022) including five exclusive Analysis targeting EWK SUSY production



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  - MET, invMass

Largest S/B, discussed in this presentation

  - MET

- 2 leptons opposite sign (OS):

  $pp \to \tilde{\chi}_1^{\pm} \tilde{\chi}_1^{\pm} \to l\,\tilde{\nu}\,\nu\,\tilde{l} \to l^{\pm} l^{\mp} + MET$

  - MCT

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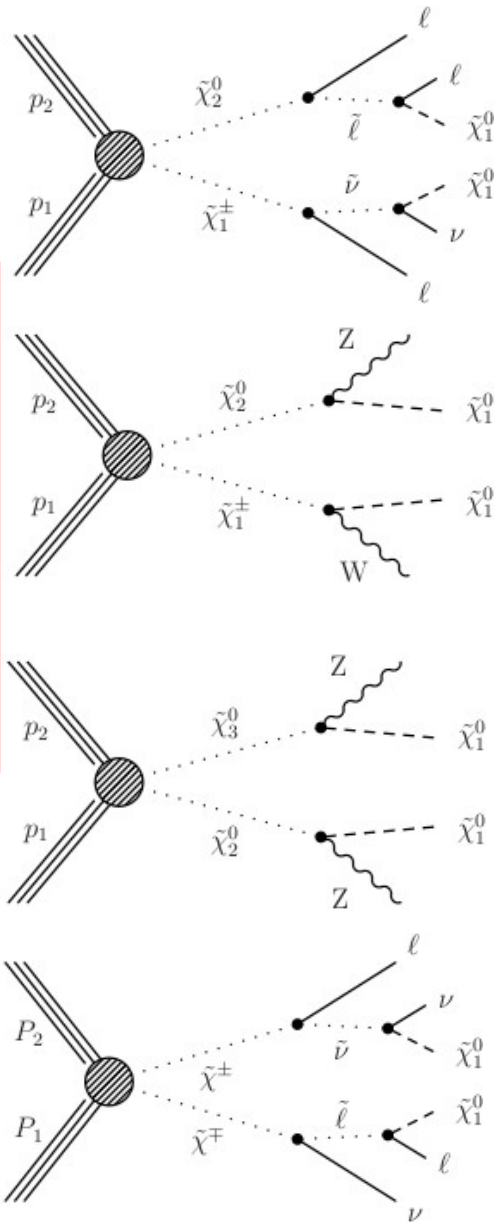
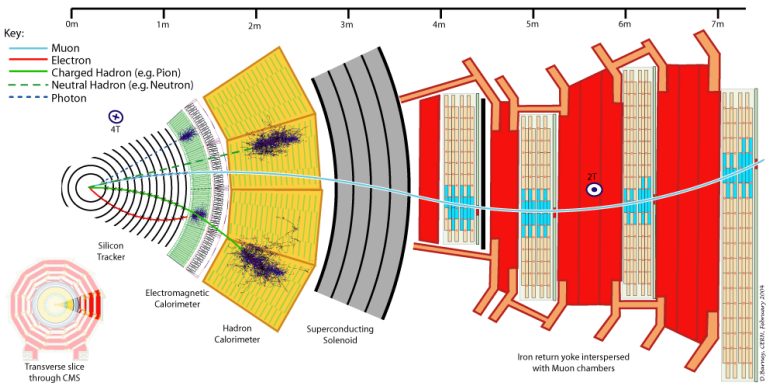
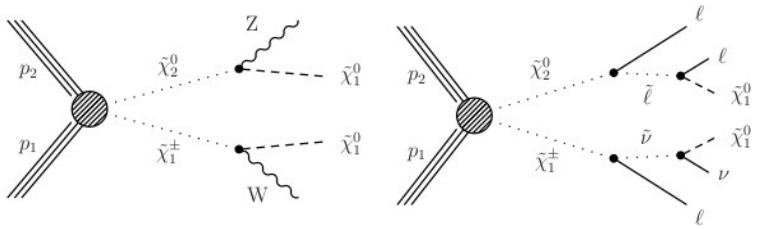


CMS is excellent for Multilepton Searches

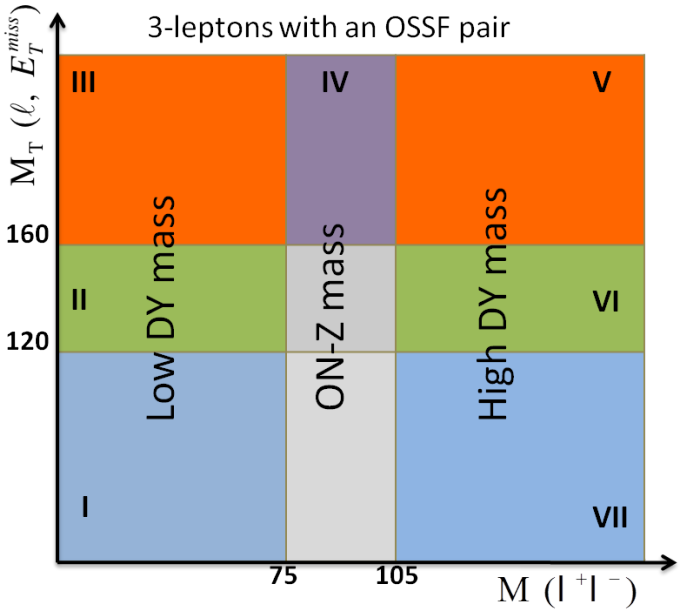
- Trigger:
  - Dilepton Trigger (ε ~ 90%)
    - First lepton Pt > 20 GeV
    - Second lepton Pt >10 GeV
- Lepton ID's
  - Electrons (ε ~ 90%) and Muons (ε > 90%)
    [https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults]
    - Pt > 10 GeV
    - |eta| < 2.4
    - (rel) Particle Flow isolation < 0.15
  - Hadronic Taus τ (ε ~ 50%) [arXiv:1109.6034]
    - Pt > 20 GeV
    - |eta| < 2.3
- Jets and MET:
  [https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults]
  - Particle Flow Jets with Pt > 30 GeV
    - Use CSV b-tag [arXiv:1211.4462]
  - Particle Flow MET

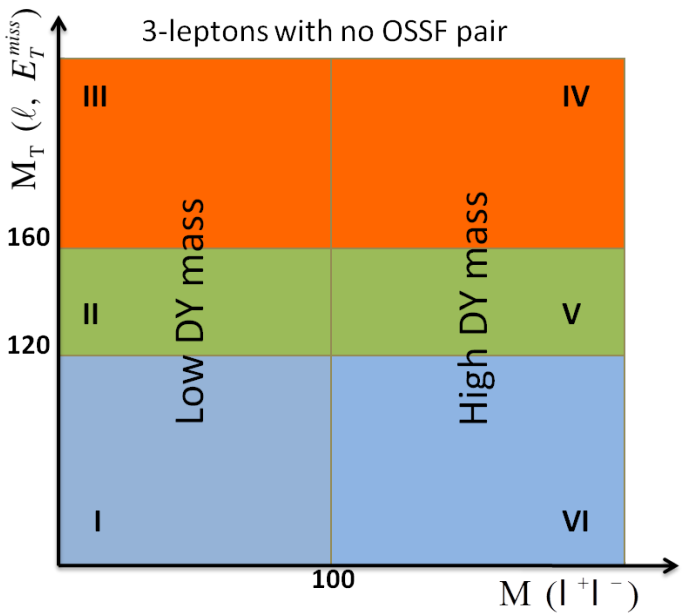


3 Lepton Search Region



Use 3D binning to optimize separation between signal and background: MET, MT and dilepton mass





Also MET binning in each region:[50,100],[100,150],[150,200],[200,∞]

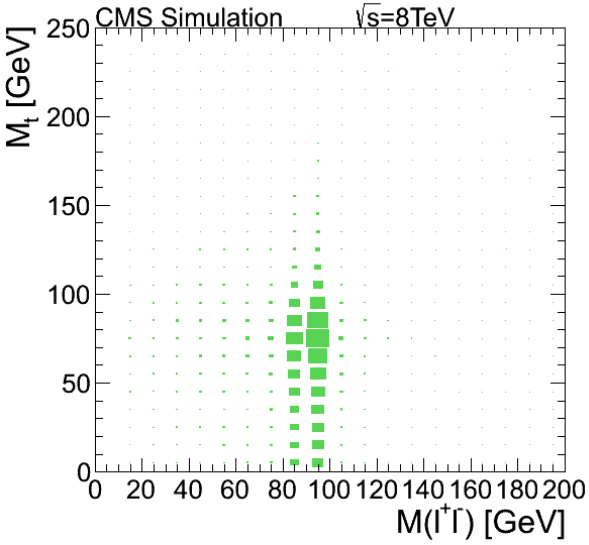
MET<50 GeV used for background methods

b-jet veto to suppress ttbar background

Dominant 3 Lepton Backgrounds

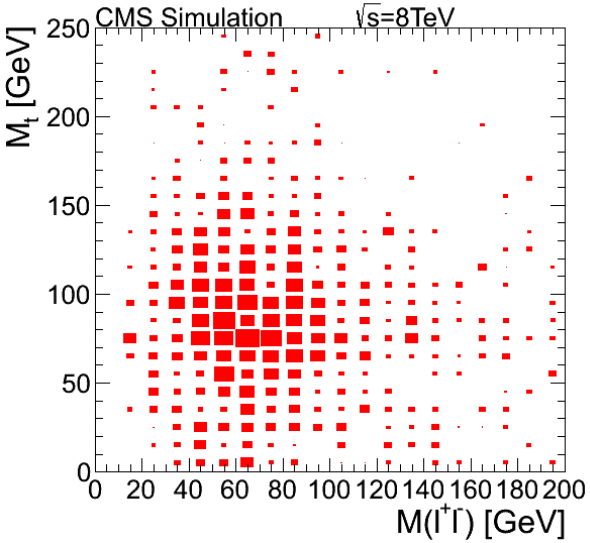
WZ

-suppressed by MT



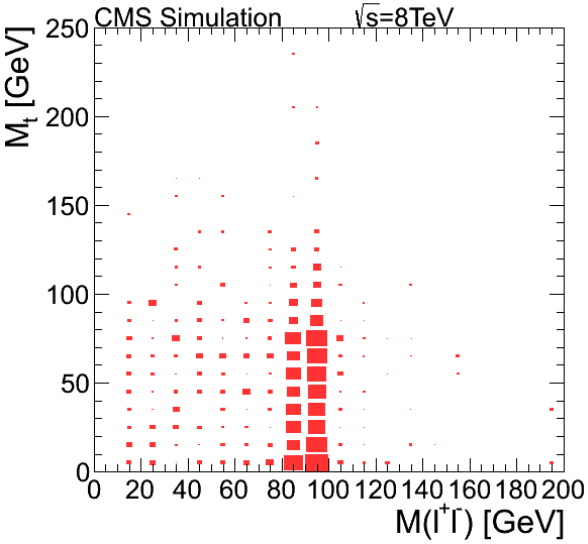
ttbar

-suppressed by b-jet veto



DY

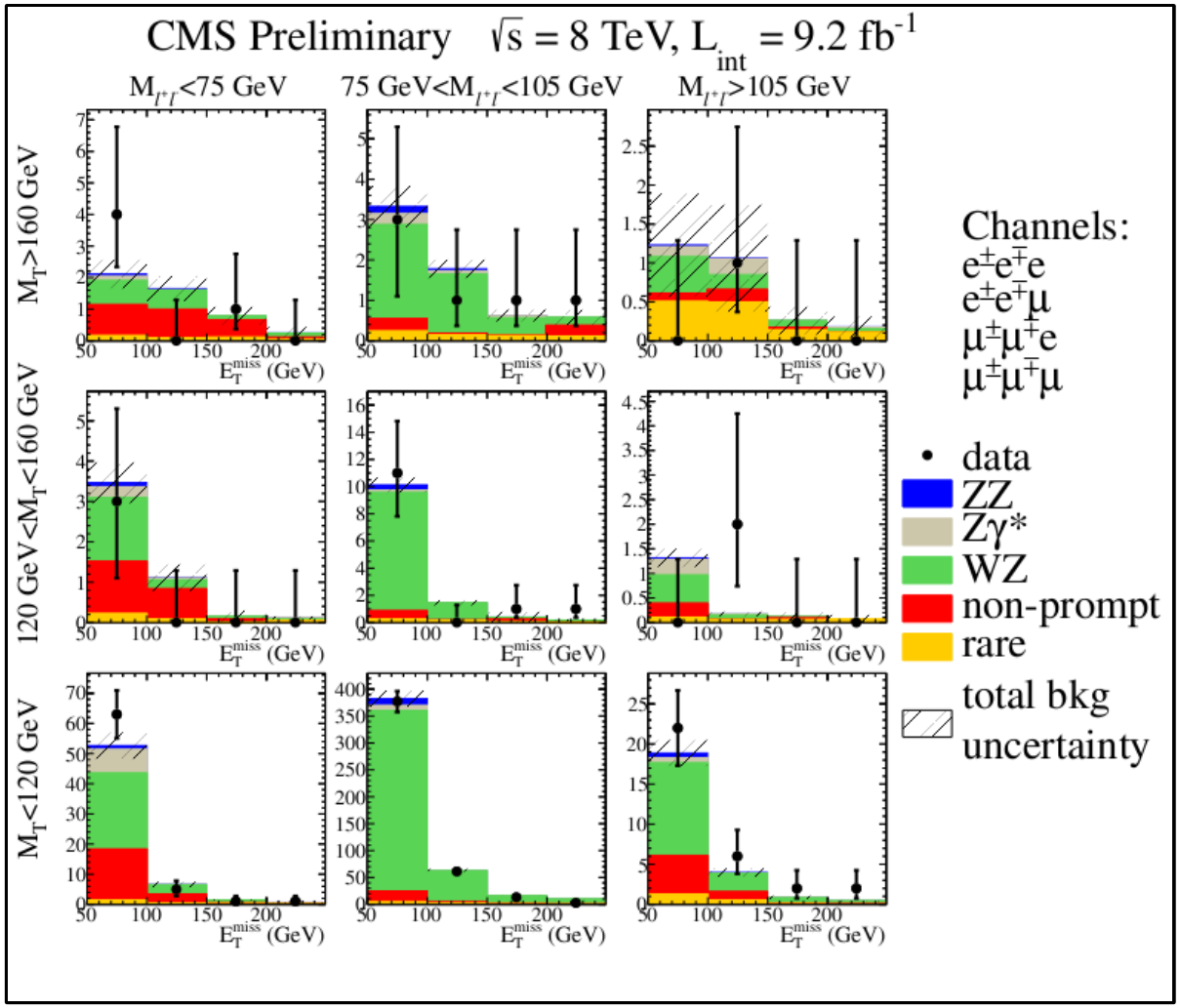
-suppressed by MET and Z-veto



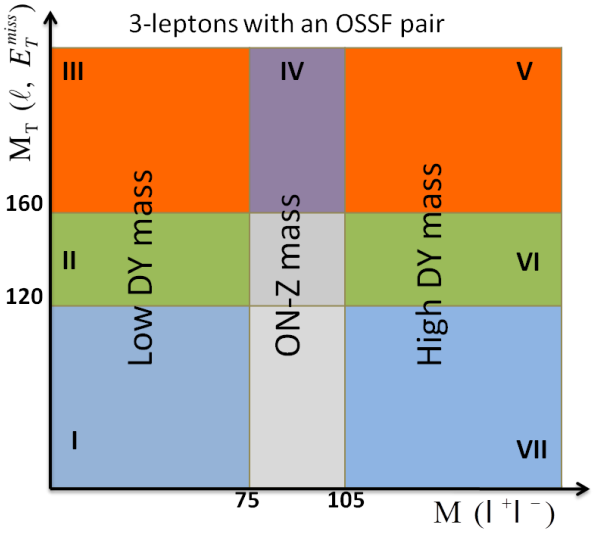
Multiple independent background methods (data-driven)

- WZ:
  - validated MC in control region
- ttbar:
  - Isolation sideband
  - B-tag and probe method
- DY+Fake:
  - Isolation sideband
  - Combined fakeable object method
  - Tight/Loose method

3 Lepton Result



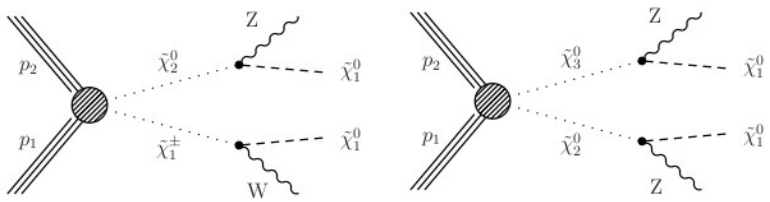
- Left diagrams shows MET distribution in each of the 9 search regions
- Each entry of the MET distribution is taken as independent channel
- Therefore 36 channels for this topology



No significant excess (all channels in backup)

2 Leptons Opposite Sign Same Flavor + 2 Jets

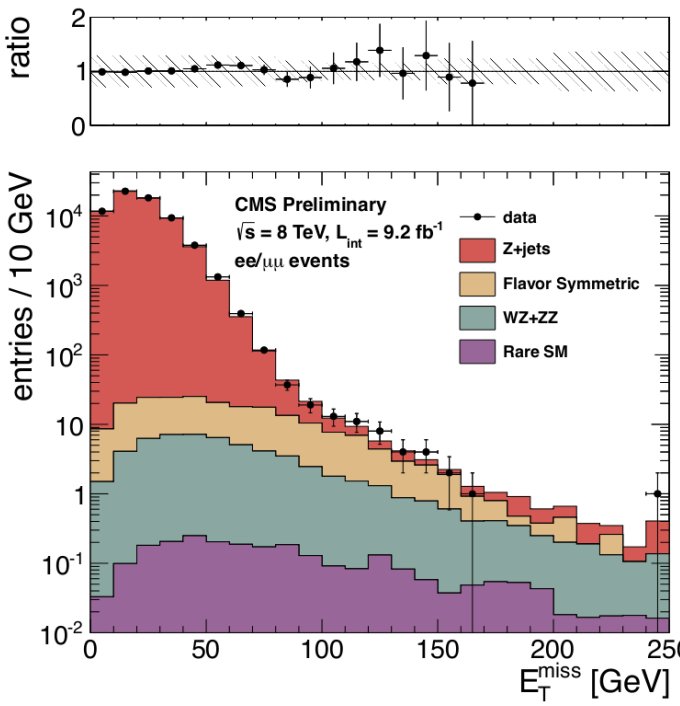
Brief introduction



- Major Background ttbar, DY+jets, WZ+ZZ:
  - ttbar ->use flavor symmetry (e mu sample)
  - DY+jets use gamma+jets for the MET shape
  - WZ+ZZ validated MC

  Data driven background predictions
- Search region:
  - Veto on events without Z-Candidate (75 GeV < invM(ll) < 105 GeV) (suppress ttbar)
  - Veto on events with b-jets (suppress ttbar)
  - Invariant JetJet Mass has to be in W/Z range (70 GeV < invM(jj) < 111 GeV)
  - Result binned in MET [0-30-60-80-100-120-150-200-inf] where low MET bins are control regions

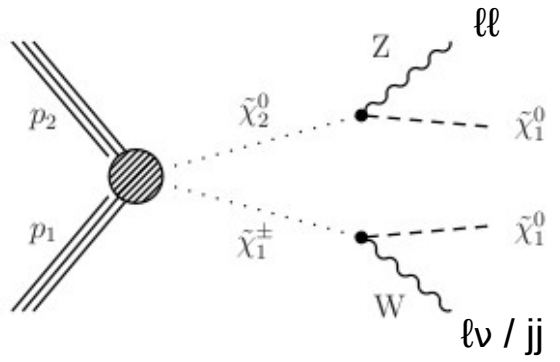
Result

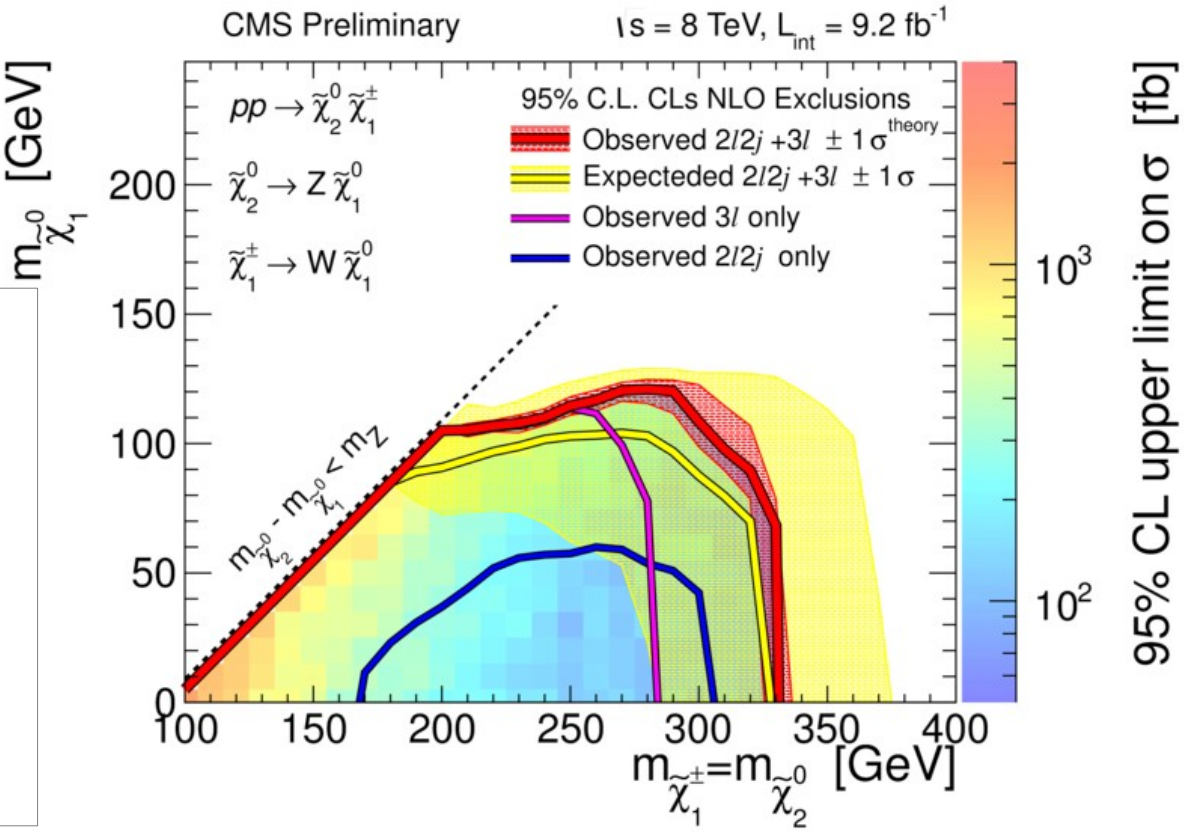


SMS Interpretations into TChiWZ

- Used Channels:
  - 108 channels 3 lepton
  - 8 channels 2 lepton+2 jet

One simplified model (SMS):
TChiWZ





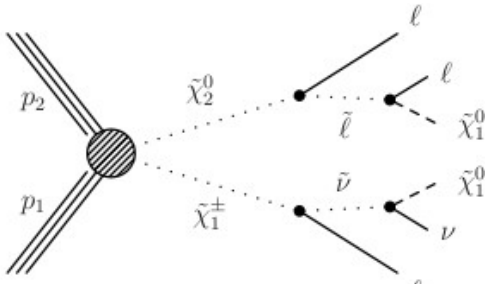
- Results for Z(ℓℓ)V(jj) search, 3ℓ search, and combination
- Z(ℓℓ)W(jj) has better sensitivity at high mass,
- 3ℓ has better sensitivity at low mass

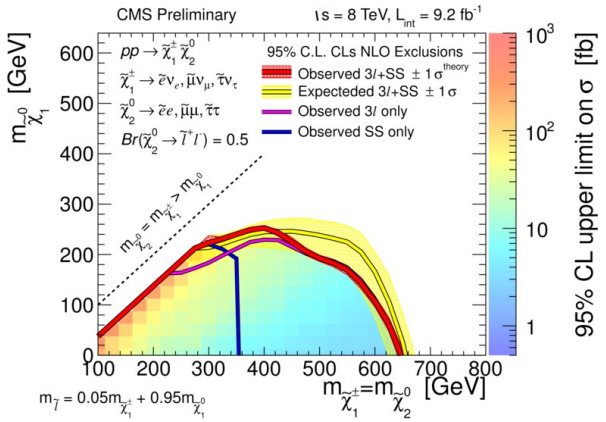
} **complementarity**

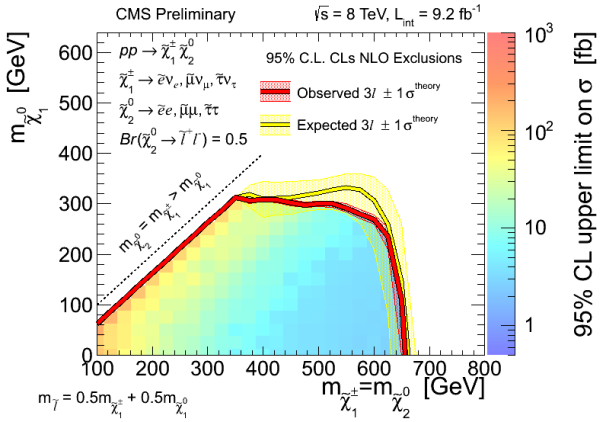
- Full exclusive -> combination limit better

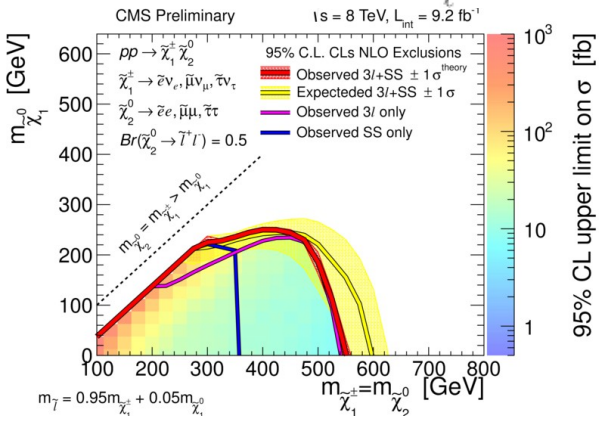
Other Interpretations

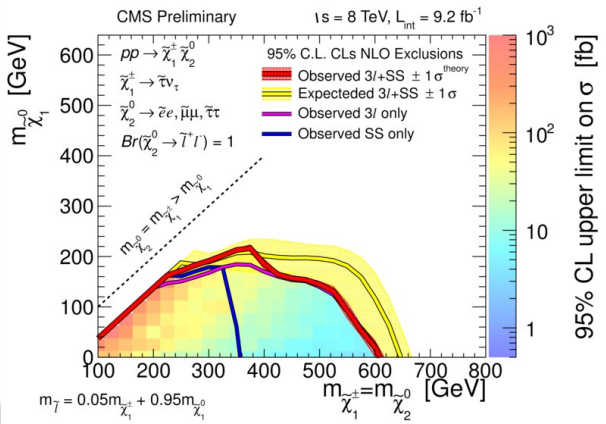
- There are many SMS under discussion.
- On this slide interpretation into TChiSlepSnu is shown

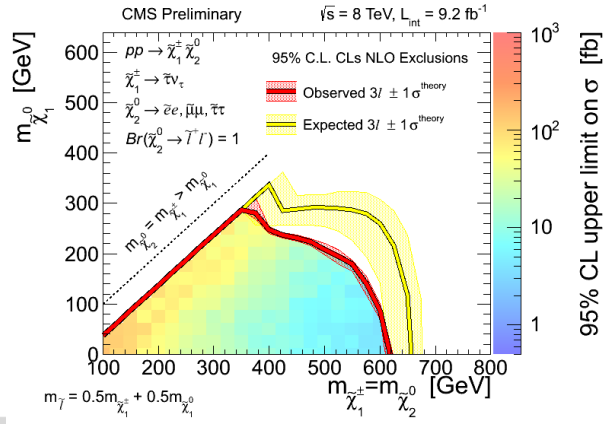


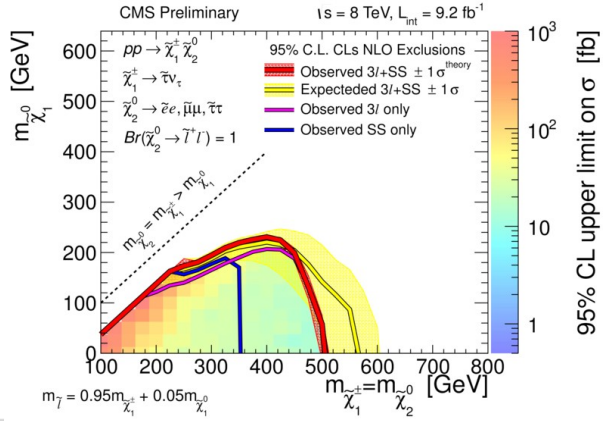












Conclusion

- CMS is an excellent detector for searching in channels with leptons
- No significant deviation from Background prediction can be observed
- Typical limits on chargino masses 300-600 GeV
- Results published in
  - CMS-PAS-SUS-12-022

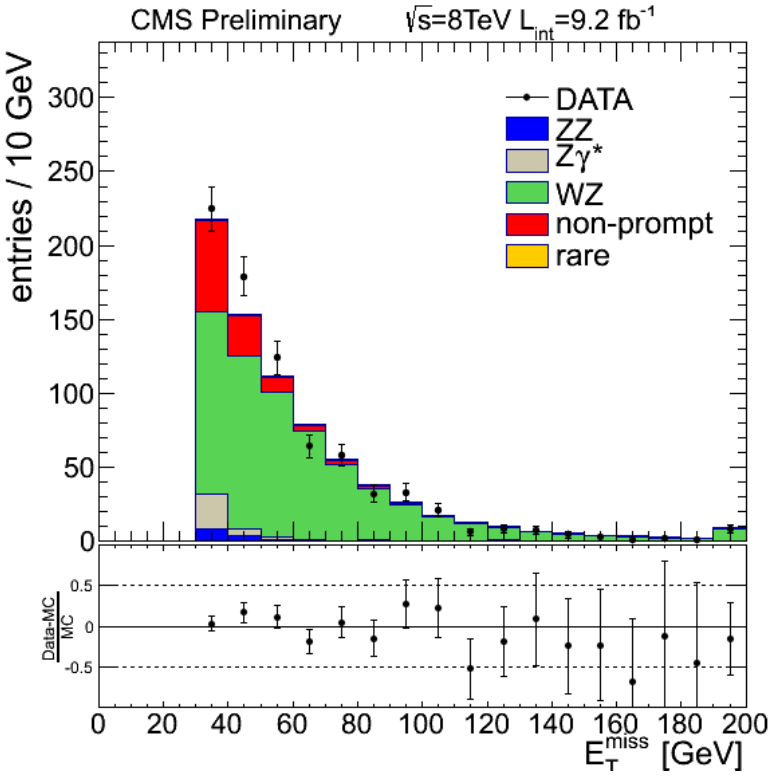
Thank You

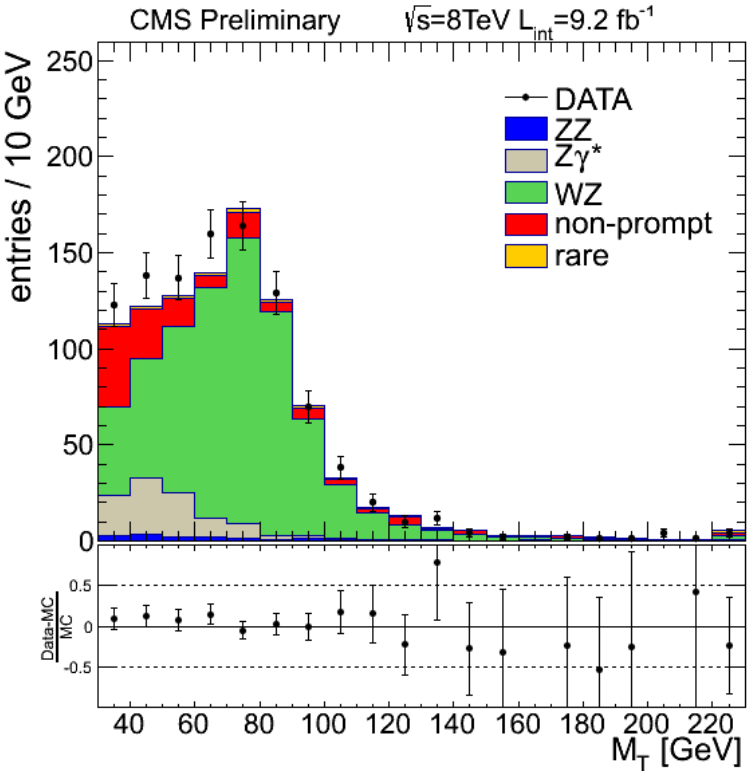
- Plots are from:
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS12022

Backup

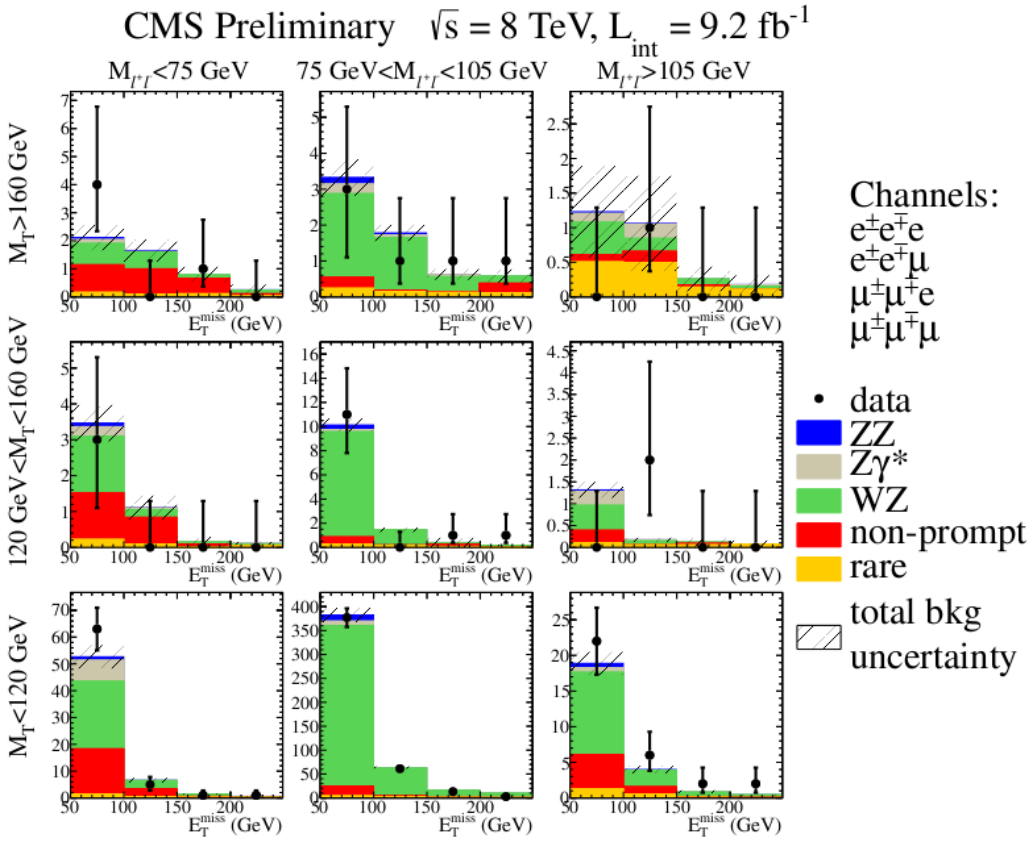
3 leptons WZ Control

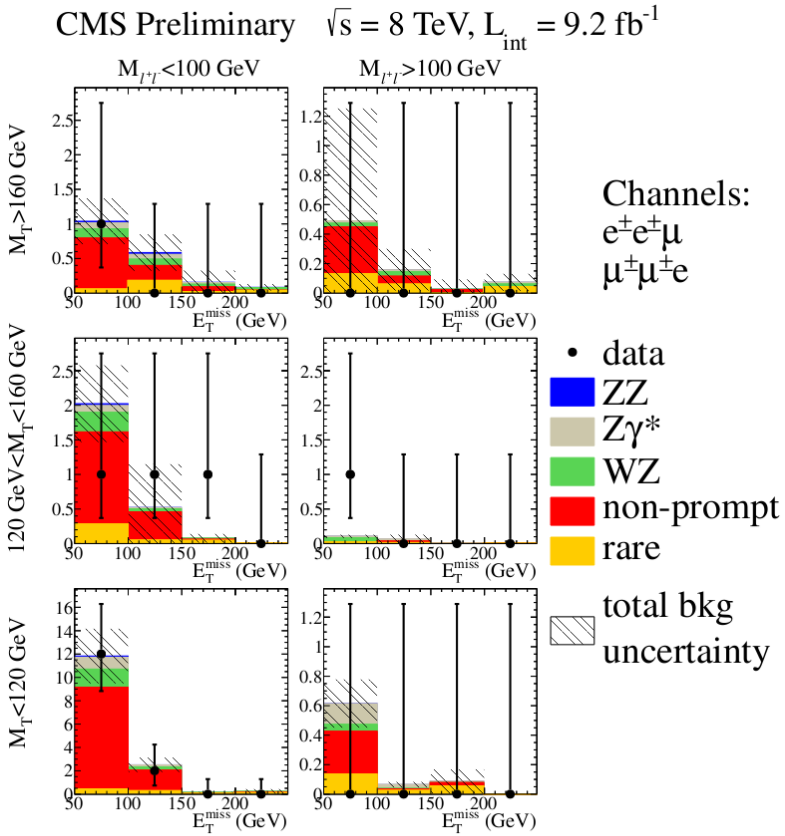
- ONZ
- MET > 30 GeV
- MT > 20 GeV



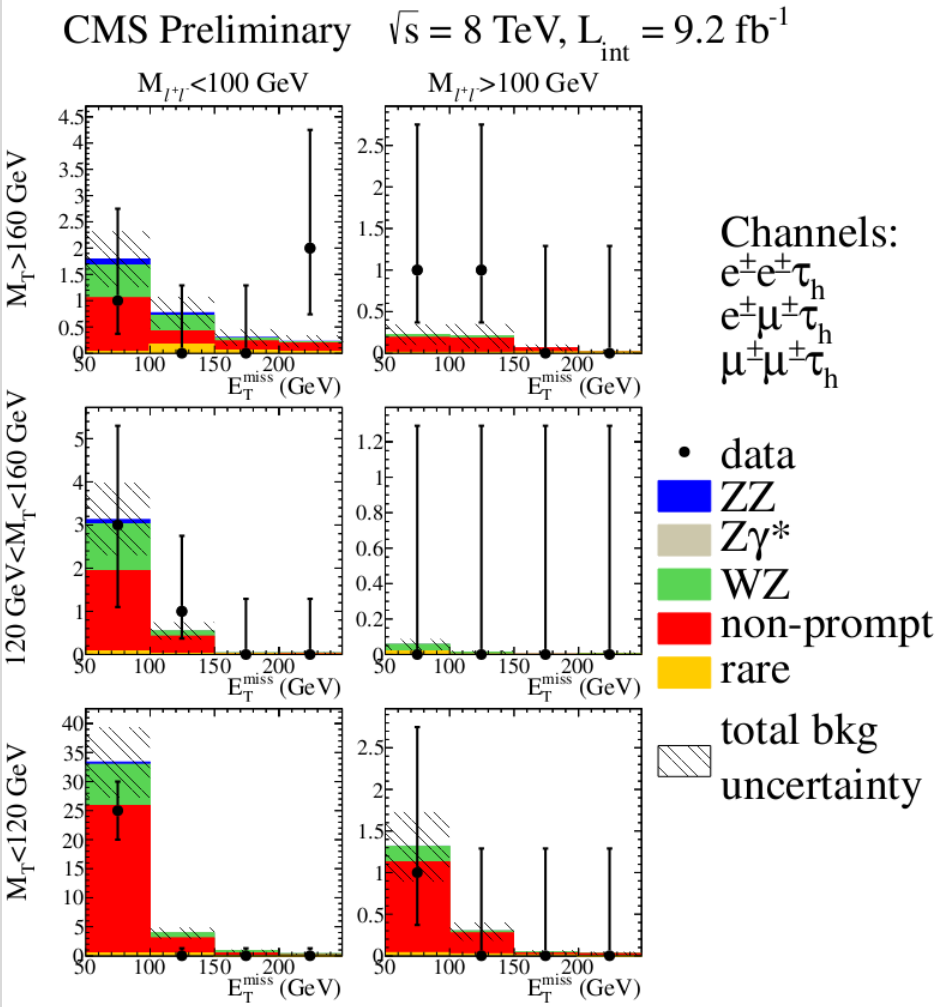


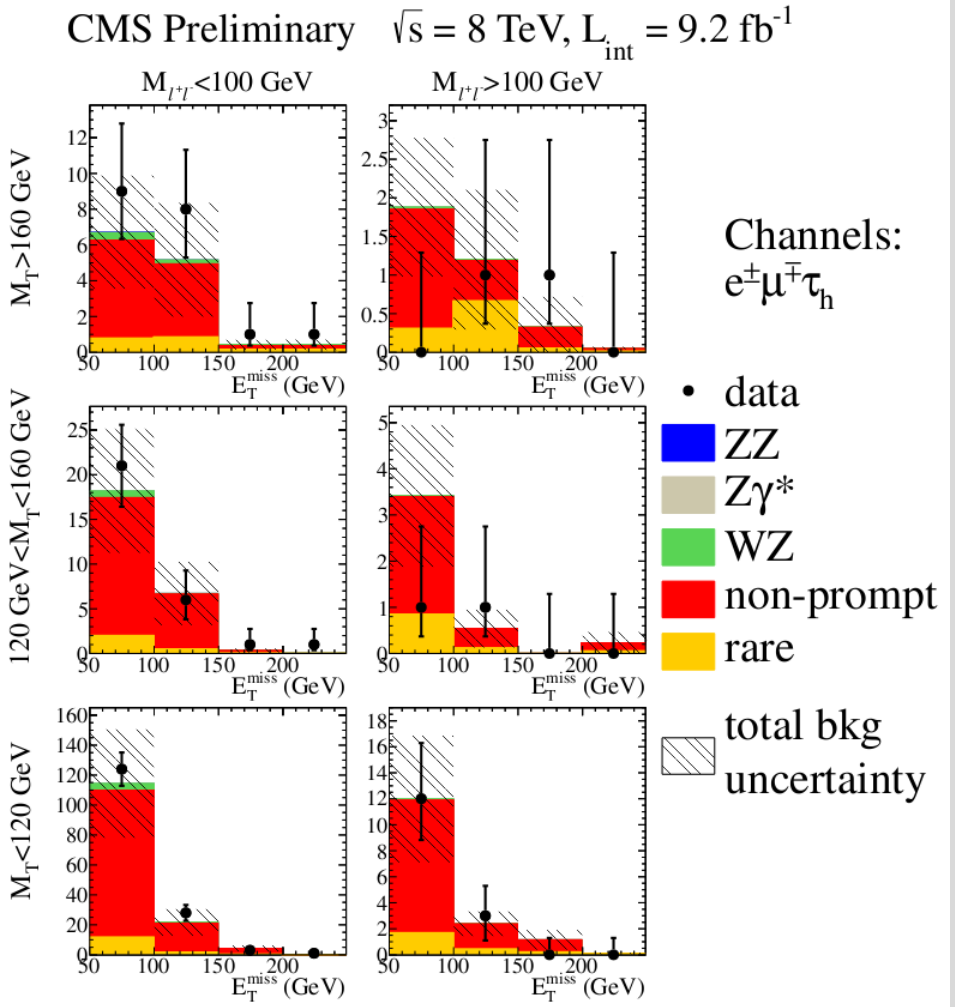
3 leptons Results





3 leptons Results



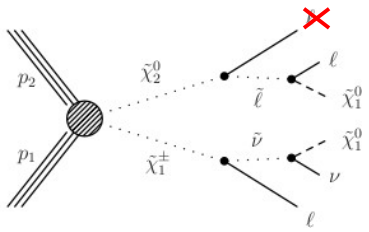


2 leptons oposite sign same flavor + 2 Jets

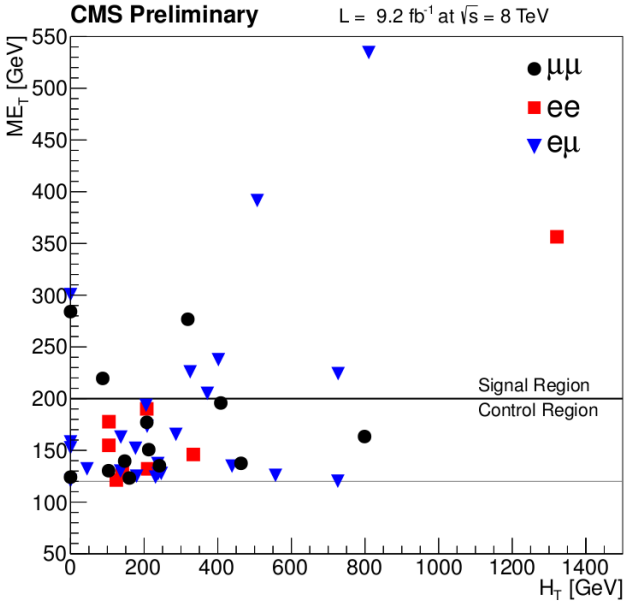
	E_T^{miss} 0–30 GeV	E_T^{miss} 30–60 GeV	E_T^{miss} 60–80 GeV	E_T^{miss} 80–100 GeV
Z + jets bkg	52823 ± 15847	14015 ± 4205	433 ± 130	40.9 ± 12.4
FS bkg	41.3 ± 7.2	49.5 ± 8.6	26.4 ± 4.7	17.9 ± 3.3
WZ bkg	9.5 ± 6.6	15.9 ± 11.2	6.6 ± 4.7	3.9 ± 2.7
ZZ bkg	2.1 ± 1.0	4.1 ± 2.1	2.2 ± 1.1	1.8 ± 0.9
rare SM bkg	0.3 ± 0.2	0.7 ± 0.3	0.4 ± 0.2	0.3 ± 0.2
total bkg	52876 ± 15847	14085 ± 4205	468 ± 130	64.7 ± 13.2
data	52485	14476	510	56

	E_T^{miss} 100–120 GeV	E_T^{miss} 120–150 GeV	E_T^{miss} 150–200 GeV	$E_T^{miss} > 200$ GeV
Z + jets bkg	7.0 ± 2.2	3.1 ± 0.9	1.6 ± 0.5	0.8 ± 0.3
FS bkg	11.3 ± 2.2	6.9 ± 1.5	2.4 ± 1.1	0.4 ± 0.3
WZ bkg	2.1 ± 1.5	1.6 ± 1.1	1.0 ± 0.7	0.5 ± 0.5
ZZ bkg	1.0 ± 0.5	1.1 ± 0.6	0.8 ± 0.4	0.7 ± 0.7
rare SM bkg	0.2 ± 0.1	0.3 ± 0.1	0.2 ± 0.1	0.2 ± 0.2
total bkg	21.7 ± 3.5	13.0 ± 2.2	6.1 ± 1.5	2.5 ± 0.9
data	24	16	3	1

2 leptons same sign (SS)

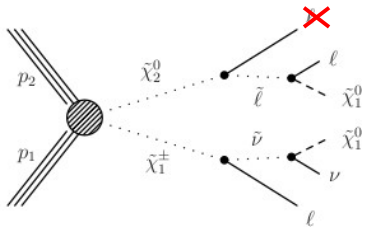


- Major Background WZ, fakes, misidentified sign:
  - WZ validate MC in control region (inverted Z-veto)
  - Fakes determine fake rate in side-band
  - Misidentified sign (electrons), determine in Z-> ee and apply on 2l OS sample
- Search region:
  - Require Z-veto
  - 3 lepton veto
  - MET >200



Data and prediction agrees well → Set limits on SMS

2 leptons same sign (SS)



	$120<E_T^{miss}<200$ GeV $N_{jets} \leq 2$, $N_{bjets} = 0$	$120<E_T^{miss}<200$ GeV $N_{jets} \leq 2$, $N_{bjets} = 0$ 3^{rd} lepton veto	$E_T^{miss}>200$ GeV	$E_T^{miss}>200$ GeV 3^{rd} lepton veto
Double Fakes	0.05 ± 0.05	0.02 ± 0.04	-0.01 ± 0.02	0.01 ± 0.02
Single Fakes	5.59 ± 4.50	1.31 ± 1.38	3.45 ± 1.90	0.66 ± 0.78
Charge MisID	0.42 ± 0.03	0.40 ± 0.03	0.14 ± 0.01	0.13 ± 0.01
Rare SM	4.99 ± 2.64	4.26 ± 2.30	4.70 ± 2.50	4.26 ± 2.30
WZ Prod.	8.35 ± 1.65	6.18 ± 1.25	2.66 ± 0.54	2.13 ± 0.44
Total Bkg	22.40 ± 5.45	12.16 ± 2.88	10.95 ± 3.16	7.20 ± 2.44
Data	14	11	11	7

SMS interpretations