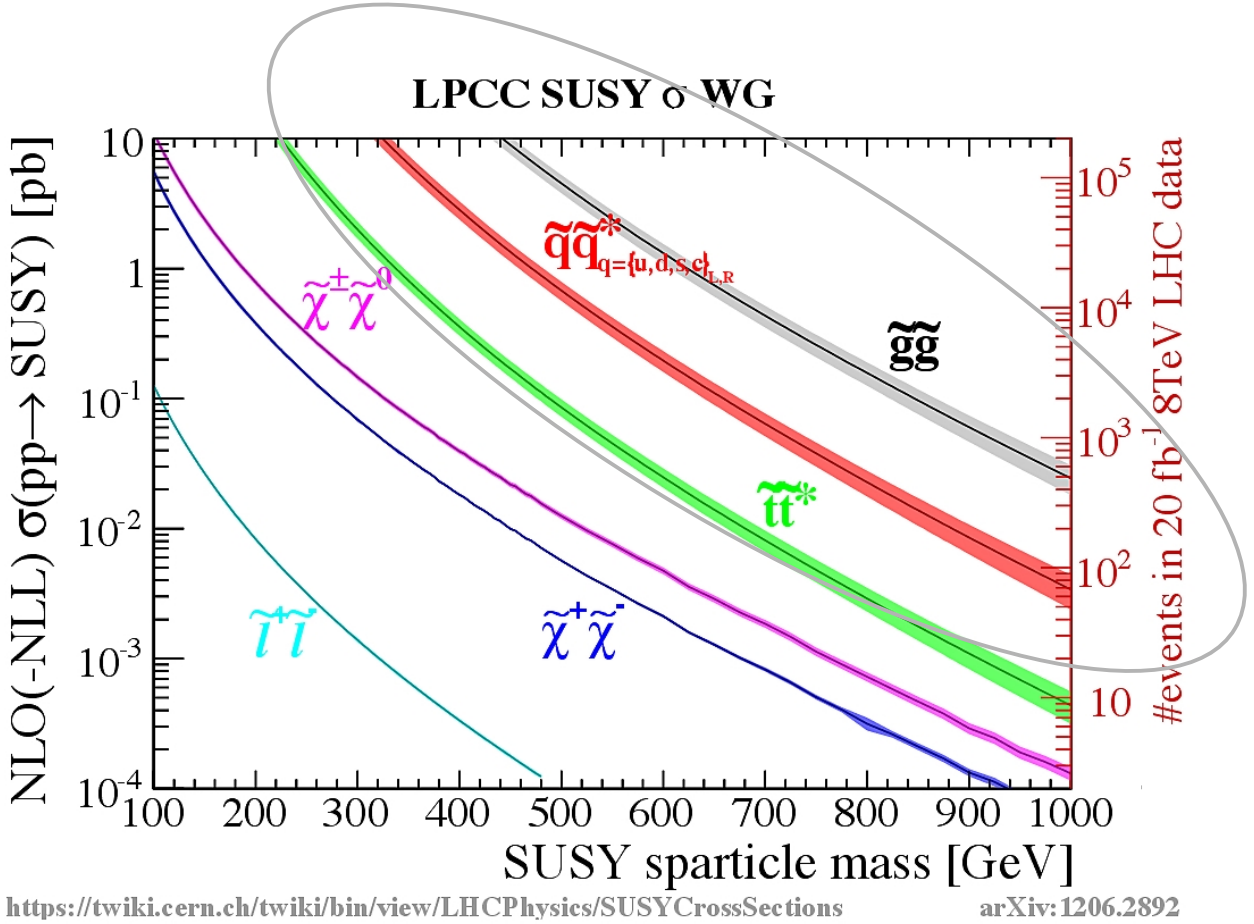
Search for electroweak SUSY production at CMS

Hamed BAKHSHIANSOHI (IPM,Iran)
on behalf of the CMS collaboration

DIS2014
Warsaw, Poland

Introduction and Motivation

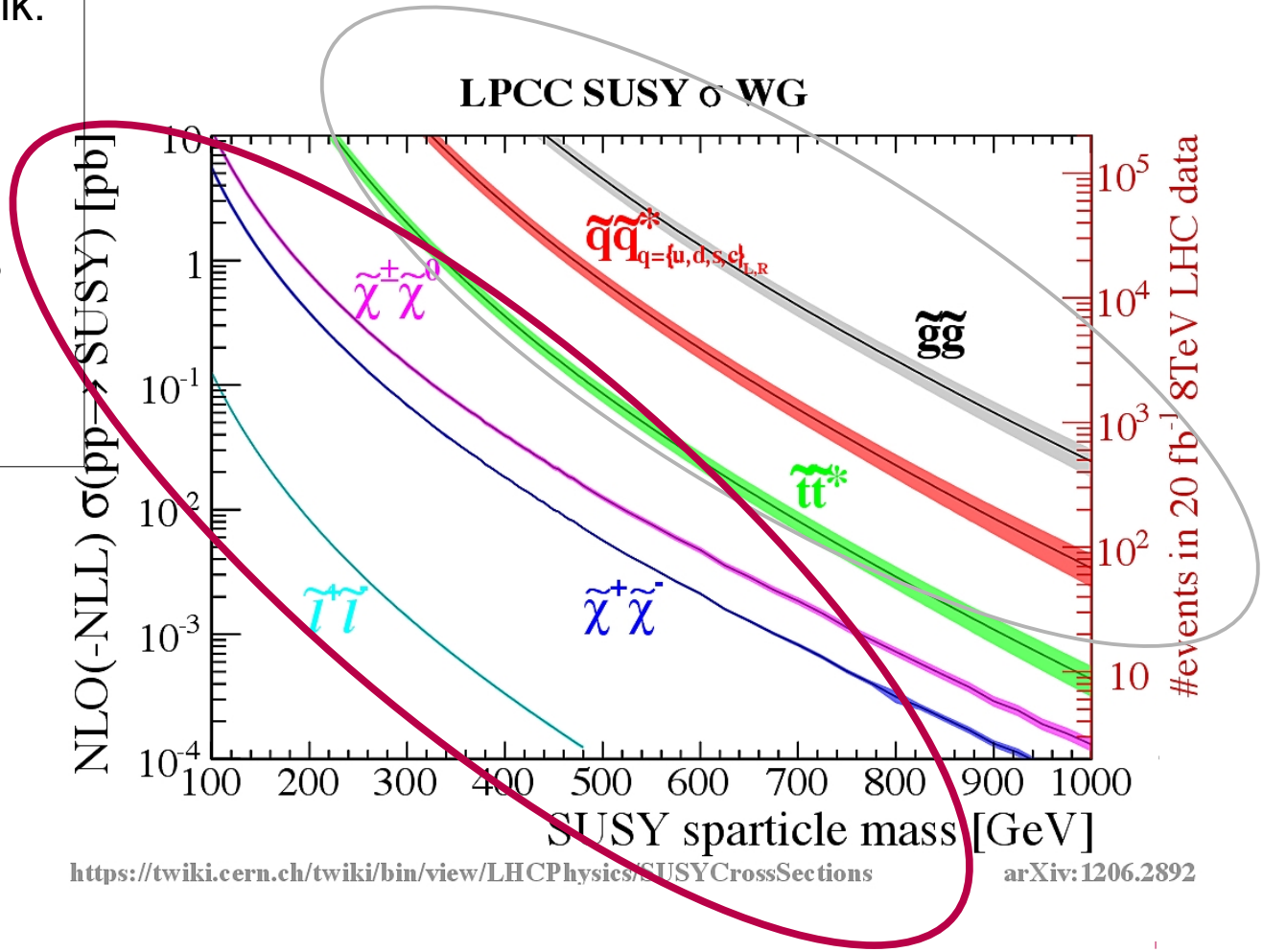


Introduction and Motivation

Subject of this talk:

[very] Low cross sections

Clear Signatures

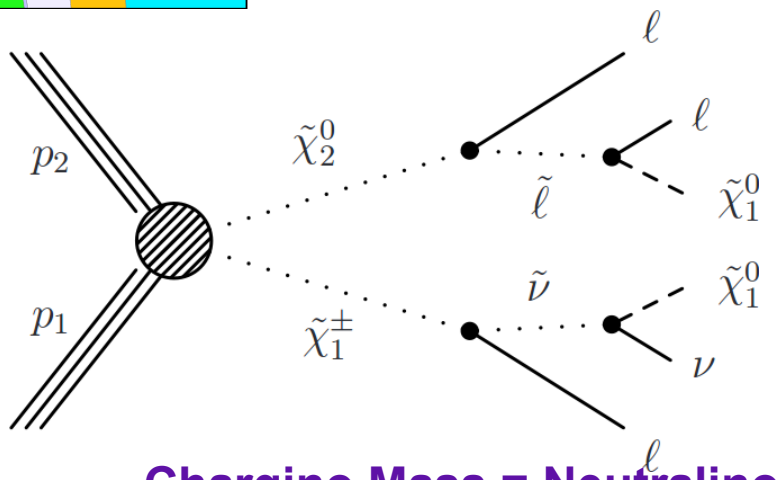


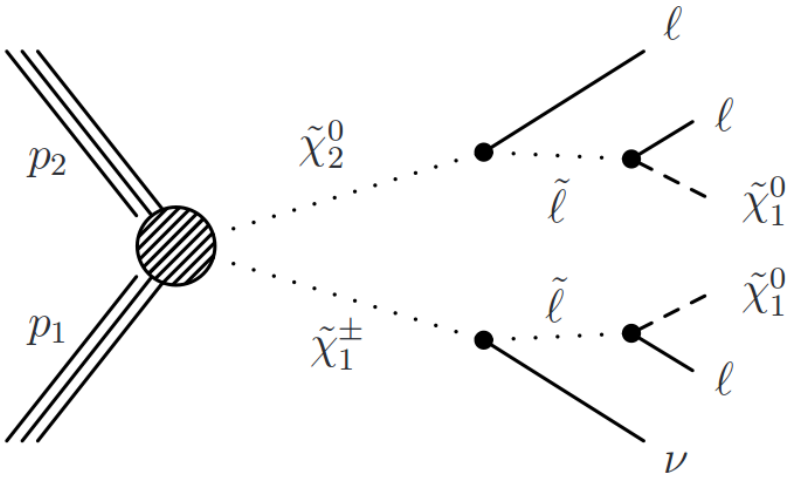
Bibliography

- **CMS-SUS-13-006** : Search for electroweak production of charginos, neutralinos, and sleptons using *leptonic final states* in pp collisions at 8 TeV
- **CMS-SUS-13-017** : Search for electroweak production of charginos and neutralinos in final states with *a Higgs boson* in pp collisions at 8 TeV
- **CMS-SUS-13-022** : Search for electroweak production of higgsinos in channels with *two Higgs bosons decaying to b quarks* in pp collisions at 8 TeV

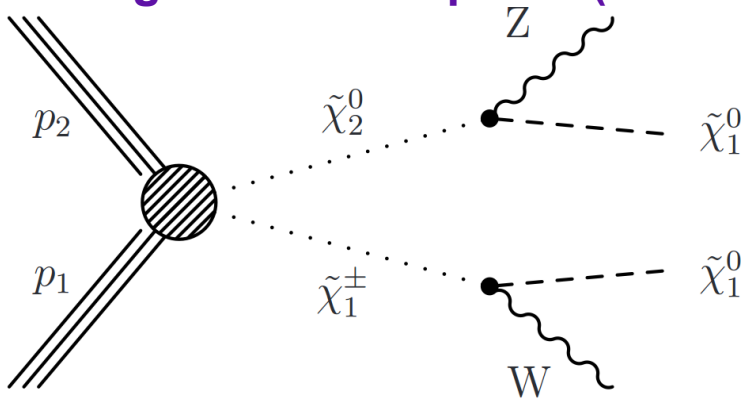
Chargino-Neutralino production

Chargino-Neutralino decay modes



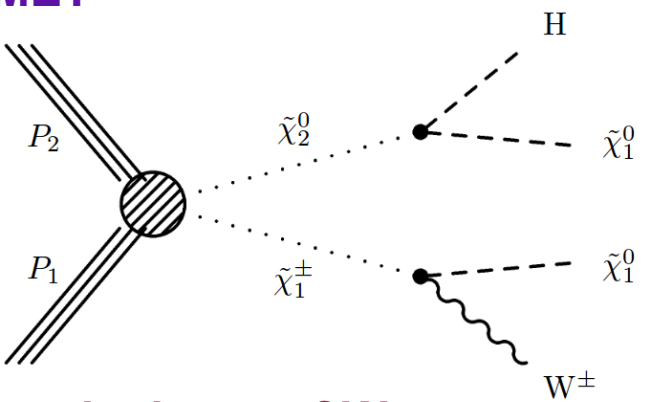


Chargino Mass = Neutralino Mass
Slepton mass = LSP Mass + K(Chargino Mass – LSP Mass)
Signature : 3 Leptons (2 SS Leptons) + MET



Leptonic decay of Z
Leptonic and Hadrnoic decays of W

3Leptons / 2Leptons & 2Jets + MET

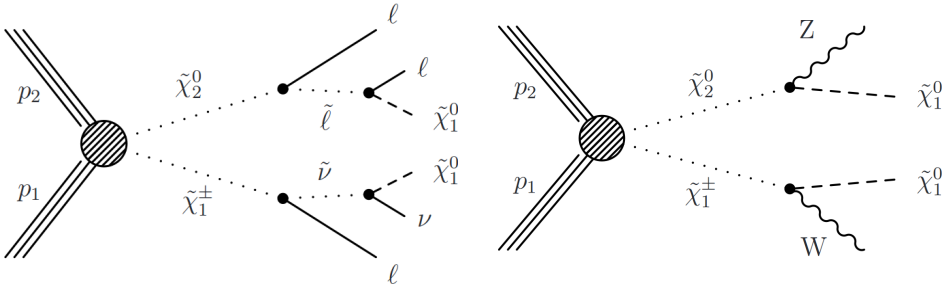


Leptonic decay of W
Higgs decay :
- **bb, W(lnu)W(jj), WW/tautau/ZZ**

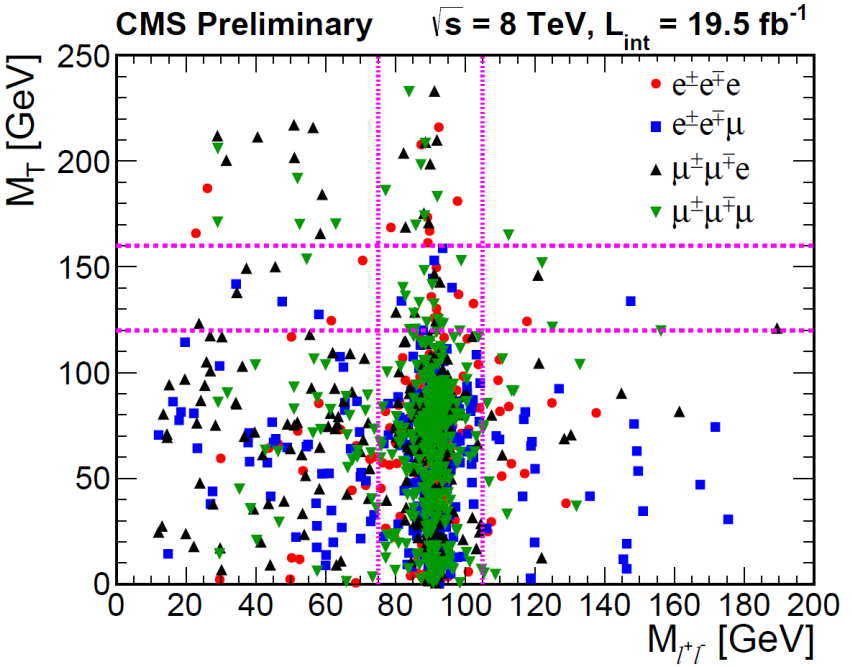
1Lepton, SS Leptons, > 2 leptons

Chargino-Neutralino

3Leptons + MET



- Selection
  - Exactly 3 leptons, up to one hadronic tau
  - MET > 50 GeV (Suppress Z+Jets)
  - b-veto (Suppress ttbar)
  - Classify events based on lepton flavours, M(ll), Transverse mass, MET
- Main Backgrounds
  - WZ : MC (with data-driven MET correction)
  - ttbar+fake : data-driven fake rate method



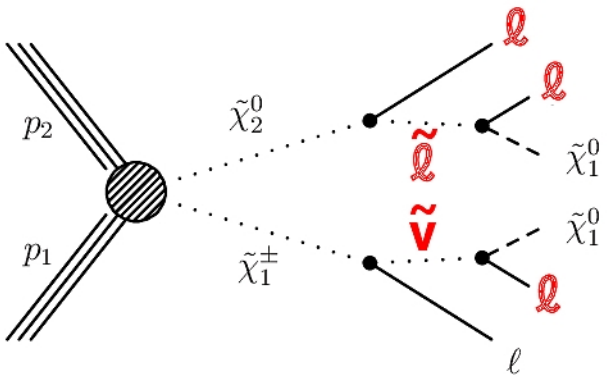
Lepton Falvour Categories
- 3l, OSSF Pair
- 3l, No OSSF Pair
- SS 2l + one hadronic tau
- OS 2l + one hadronic tau

Chargino-Neutralino

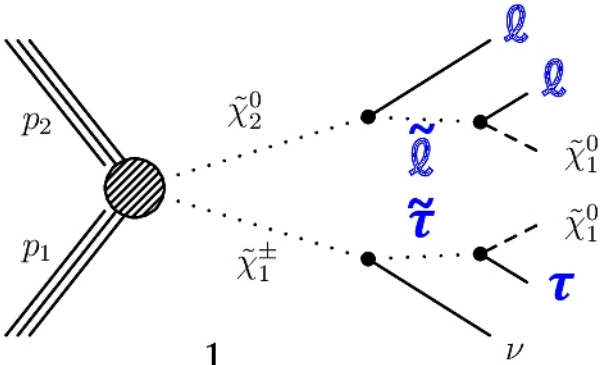
3Leptons + MET : Limits

Data consistent with BKG over range of kinematic regions and lepton categories :

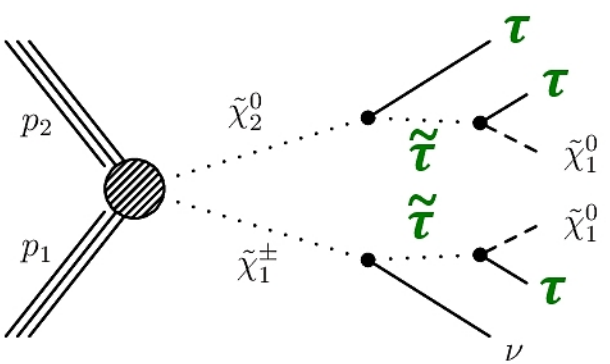
"flavor-democratic" (3ℓ)
light ($\tilde{\ell}_L$,$\tilde{\nu}_L$)



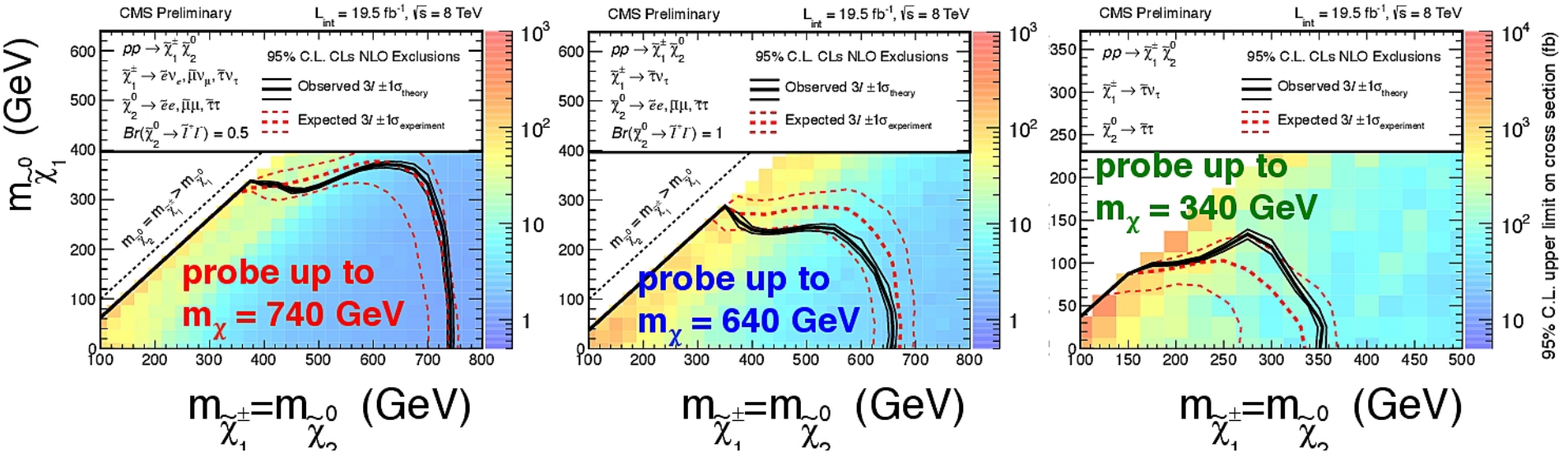
"tau-enriched" (2ℓ+τ)
light $\tilde{\ell}_R$, small tan β



"tau-dominated" (3τ)
light $\tilde{\ell}_R$, high tan β



$$m_{\ell} = \frac{1}{2}(m_{\tilde{\chi}_1^{\pm}} + m_{\tilde{\chi}_1^0})$$

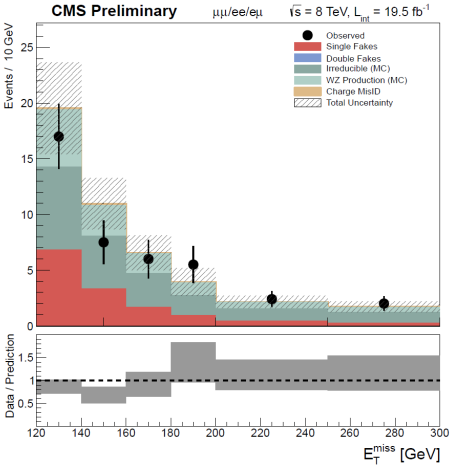


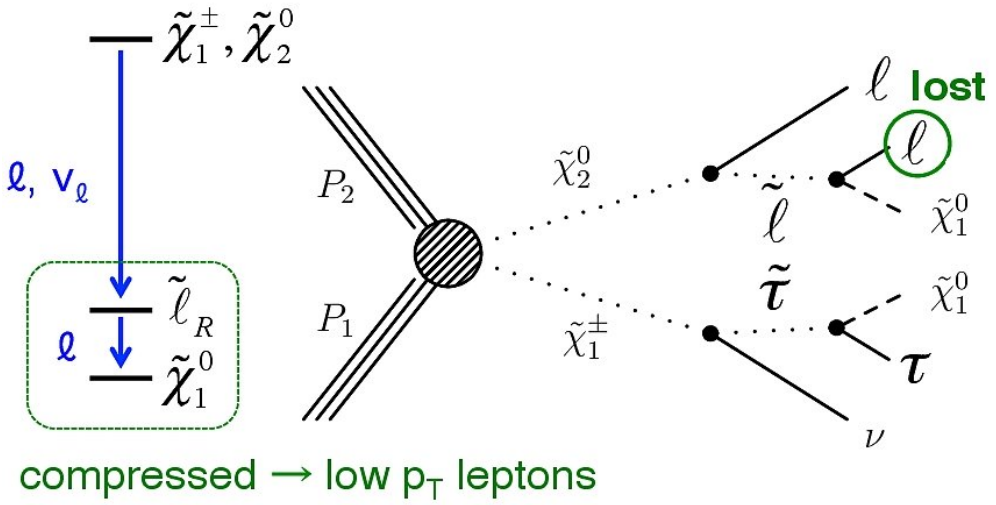
Chargino-Neutralino

SS Dilepton + MET

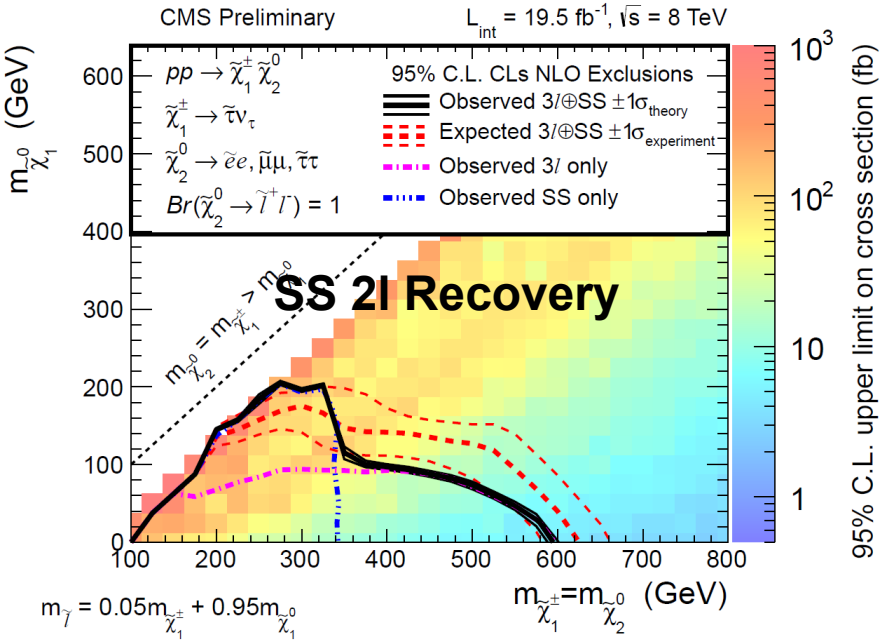
Event Selection:

- Exactly two high Pt SS e/mu leptons
- 2 Signal Regions :
  - 120 < MET < 200 , At most 2 jets, No b-jets
  - MET > 200 GeV



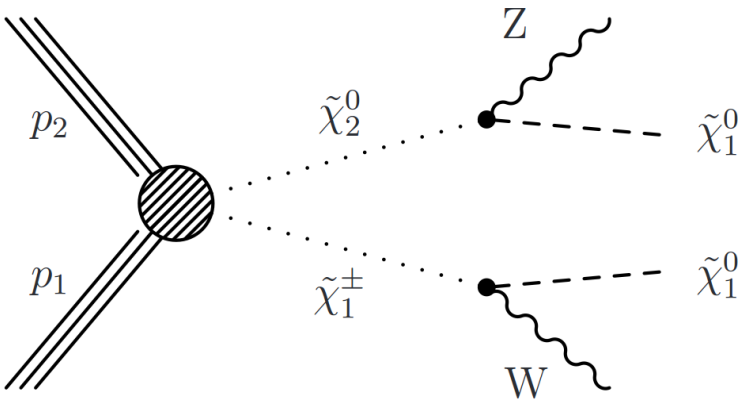


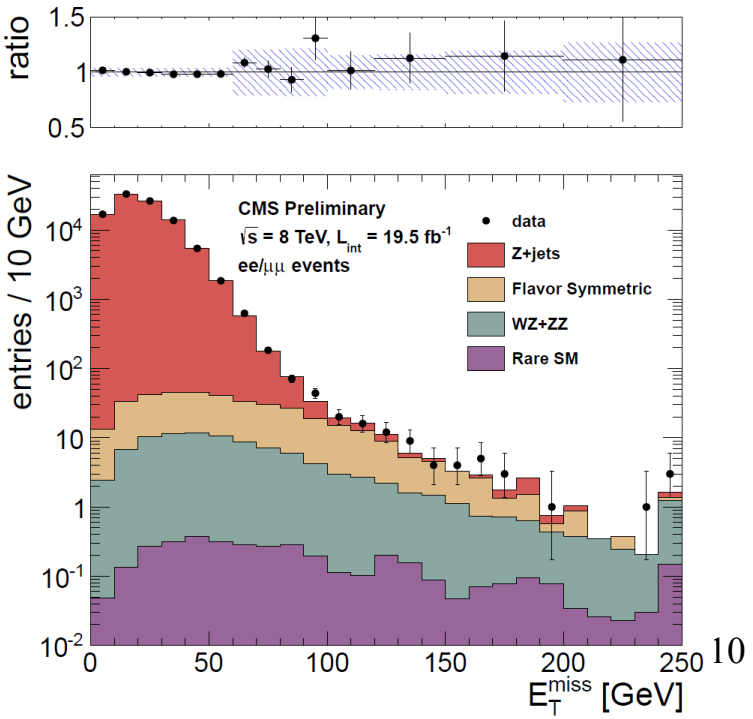
compressed → low p_T leptons



Chargino-Neutralino
Z+W+MET

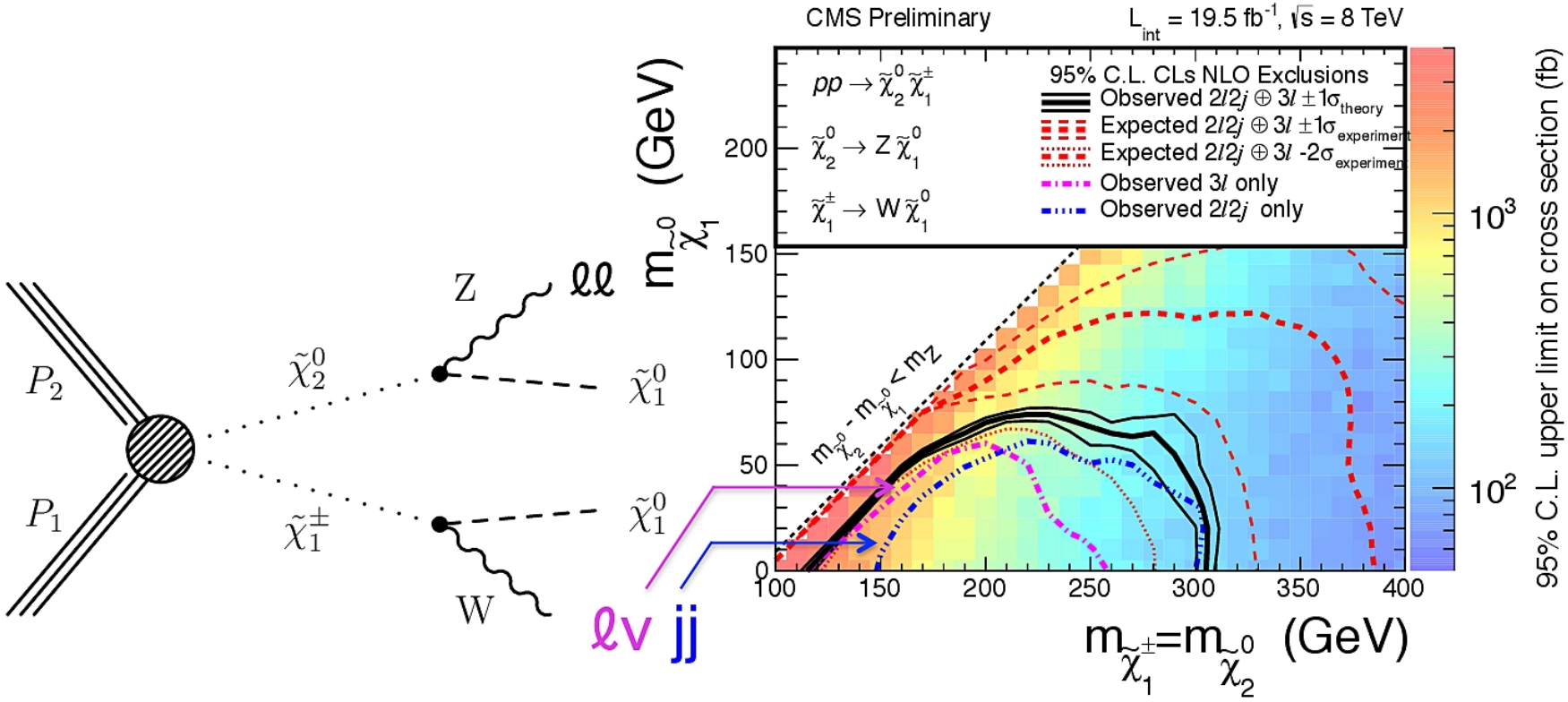
- Event Selection
  - Z → ll candidate
  - MET > 80 GeV
  - 2Jets with Mjj ~ W/Z mass
  - b-veto (to supress ttbar)
- Backgrounds
  - Z+Jets : Fake MET is modeled using photon+jets events
  - ttbar : estimated using e/mu control sample
- No excess is observed





Chargino-Neutralino

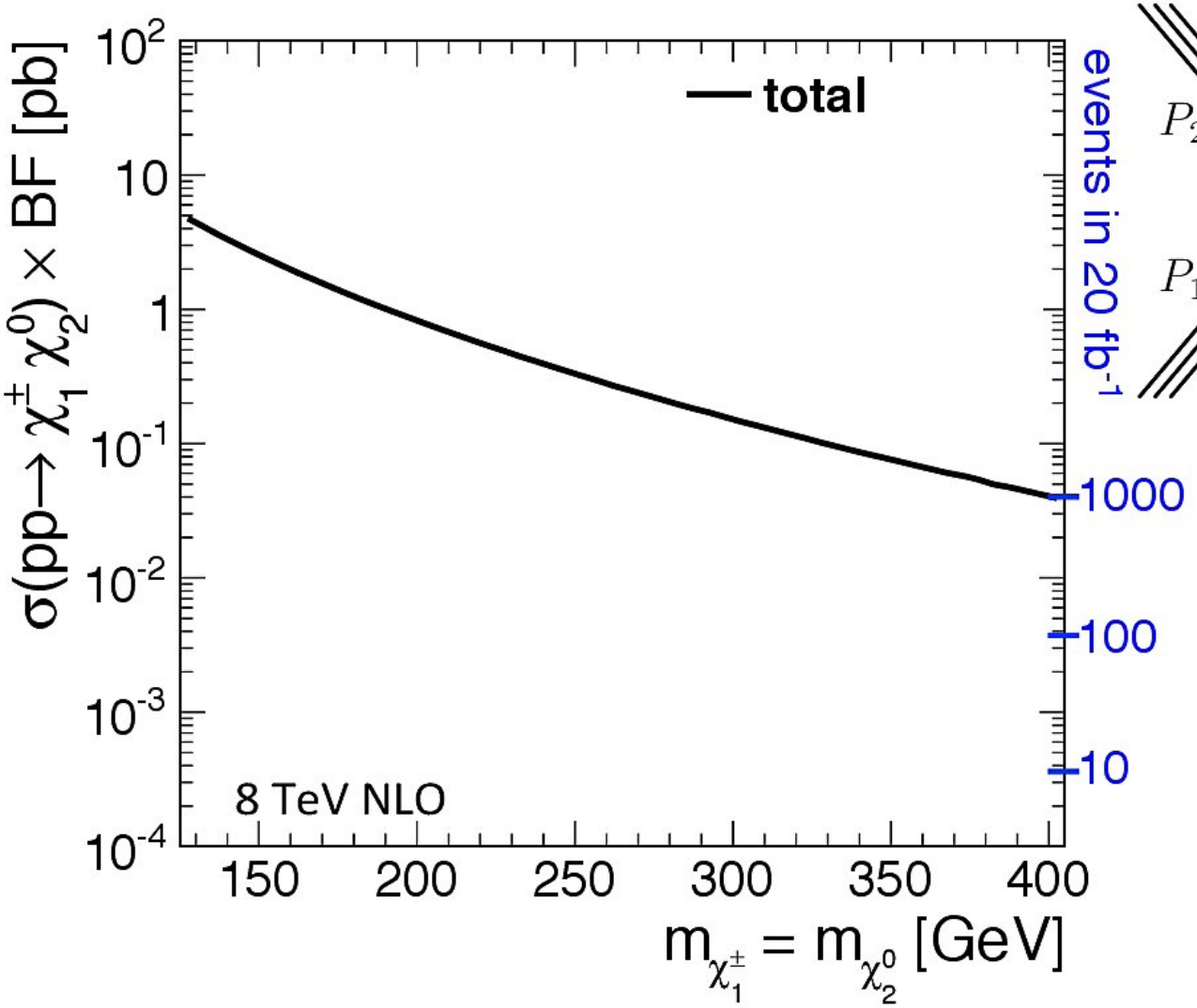
Z+W+MET : Limits

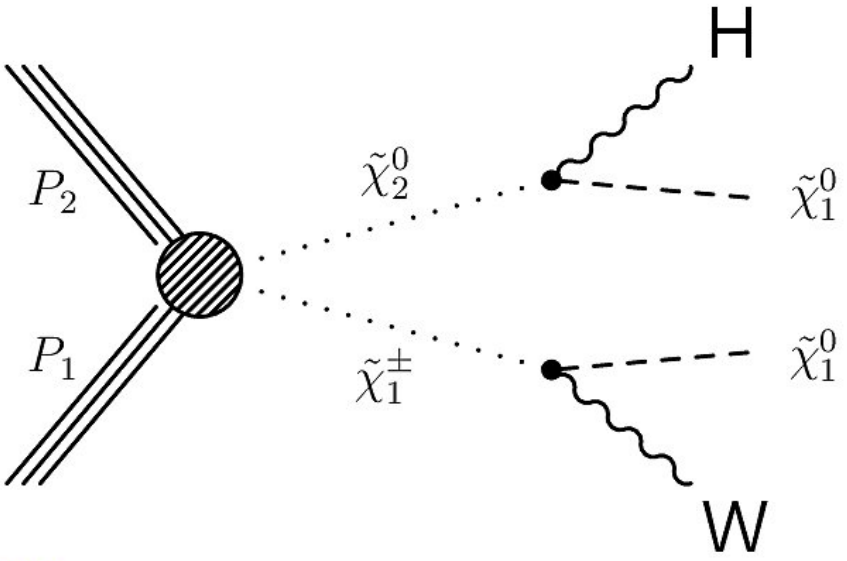


- Results based on **Z(ll)W(jj)** and **3l** searches
  - Complementarity: improvement from combination

Chargino-Neutralino

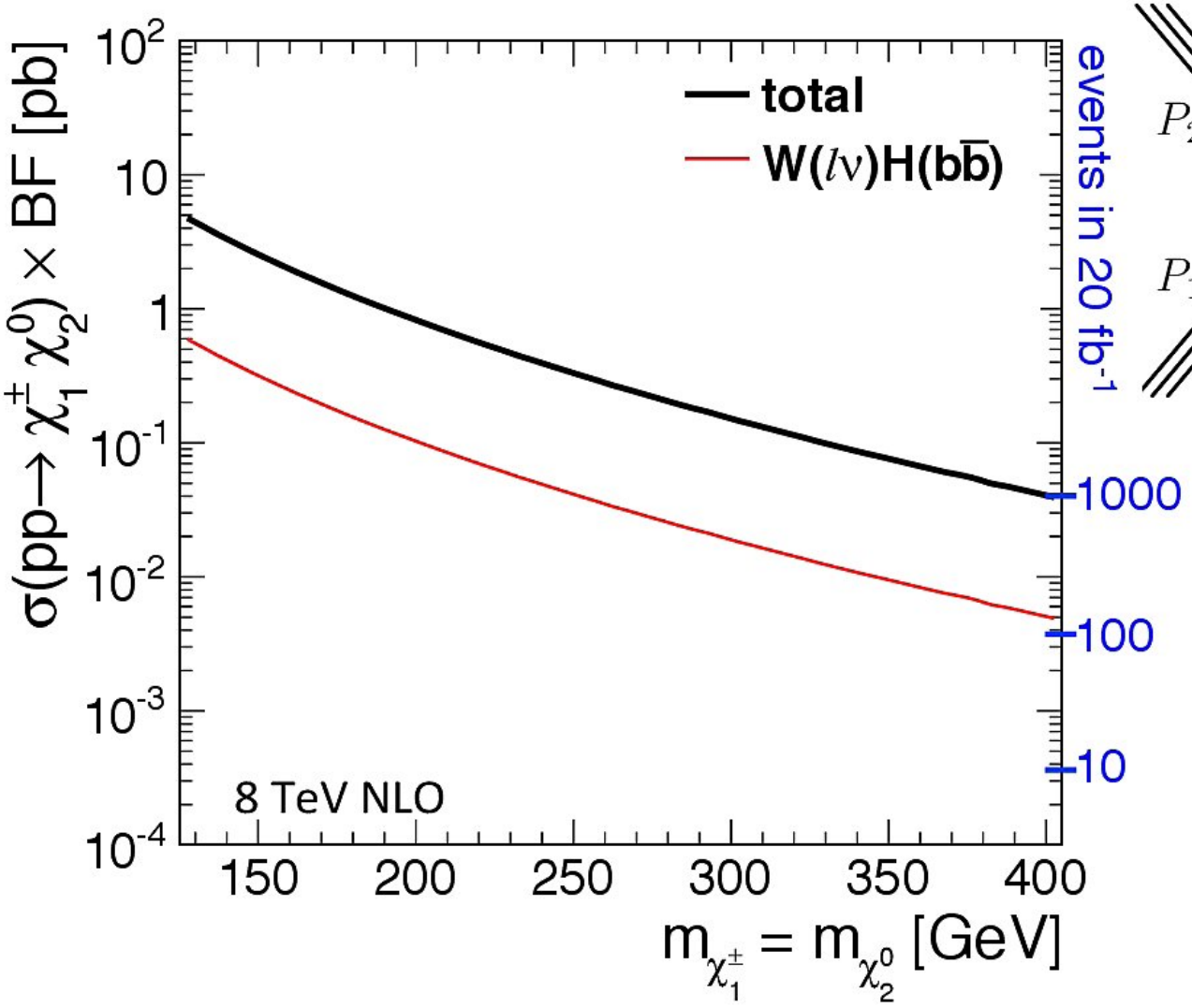
H+W+MET

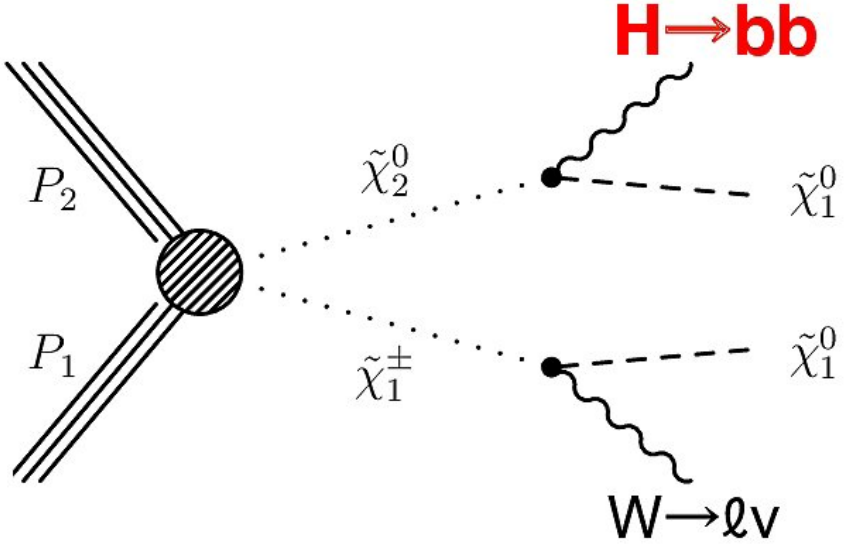




Chargino-Neutralino

H+W+MET

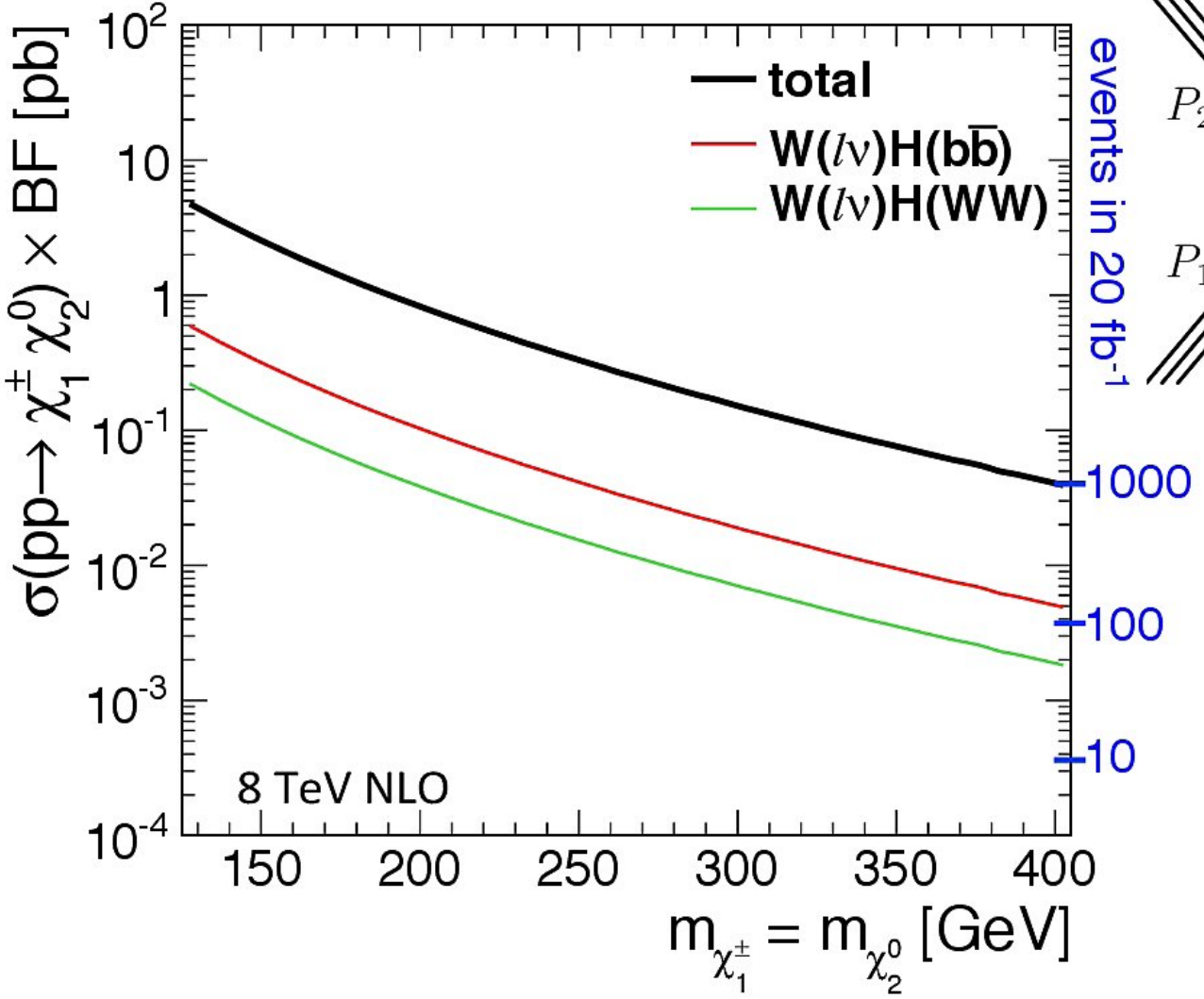


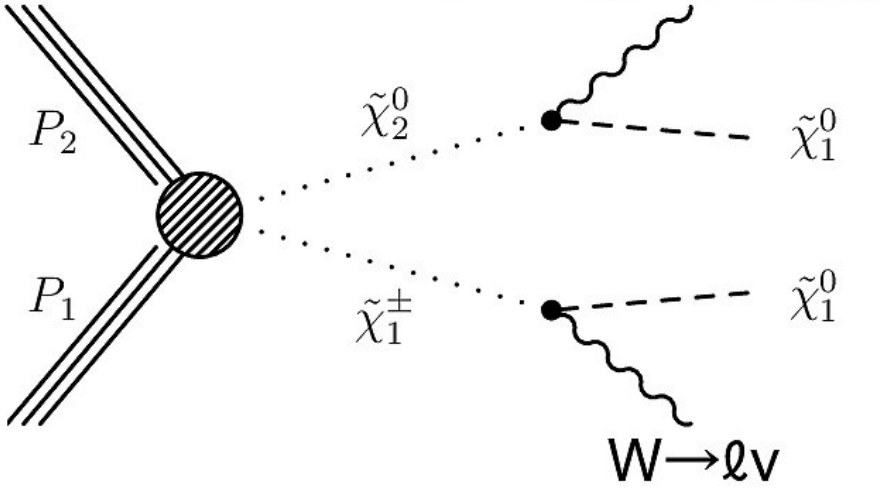


- 1ℓ

Chargino-Neutralino

H+W+MET

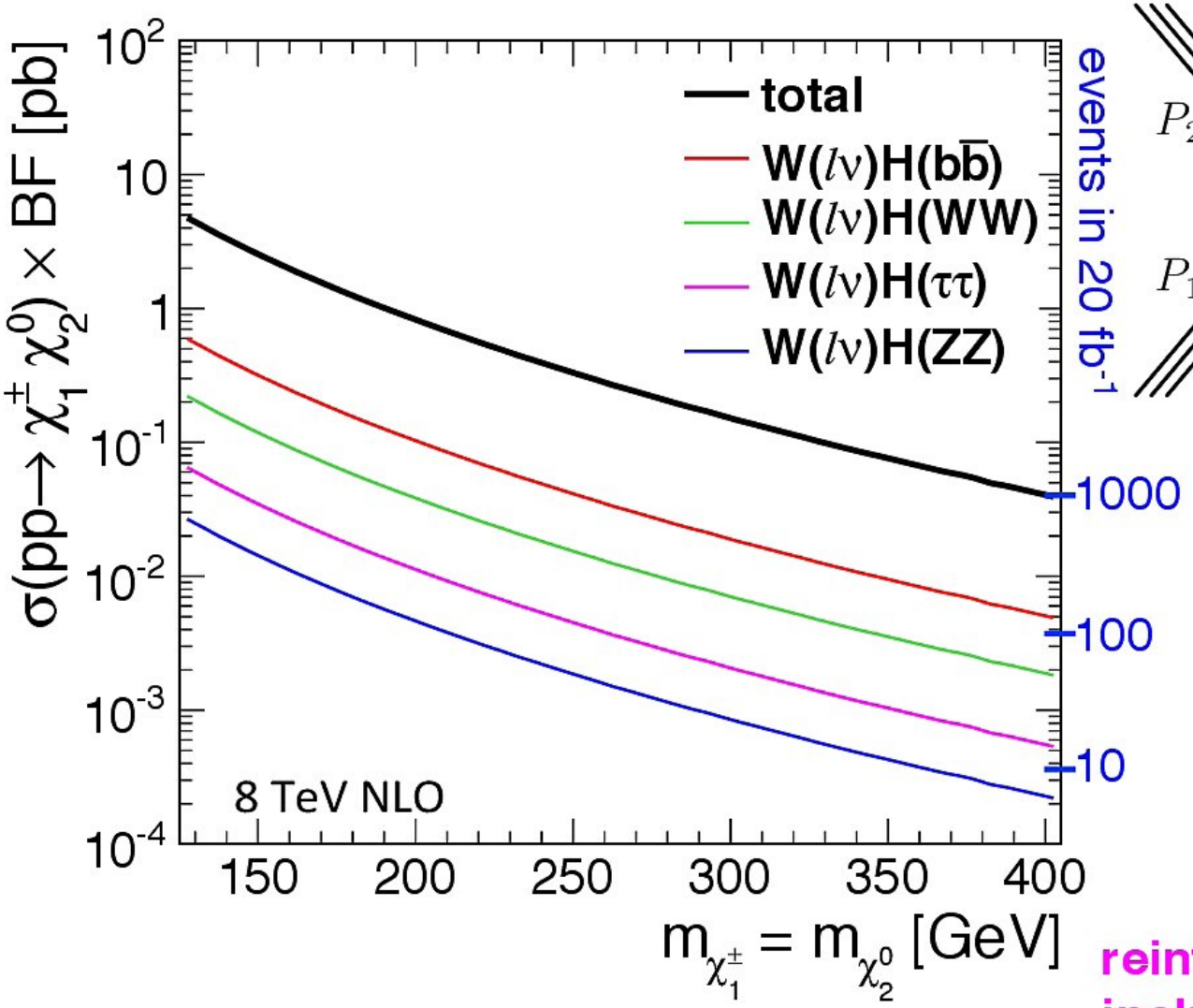




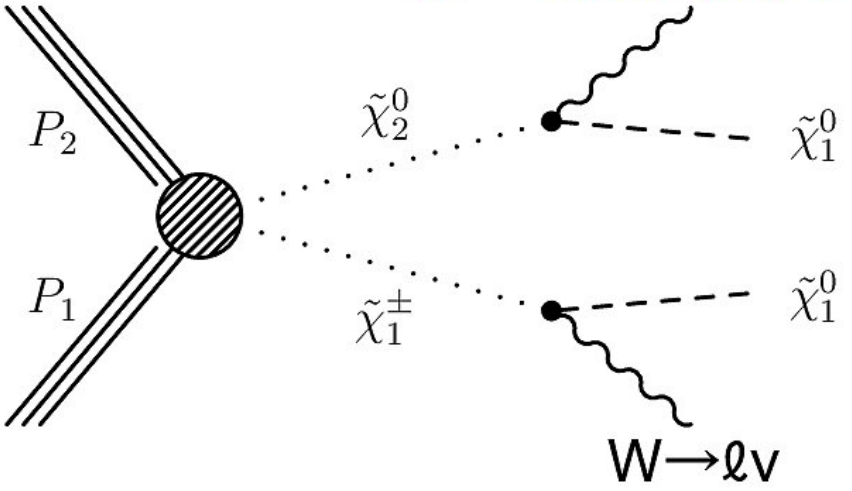
- 1ℓ
- SS 2ℓ

Chargino-Neutralino

H+W+MET



H→WW/ττ/ZZ



- 1ℓ
- SS 2ℓ
- ≥3ℓ

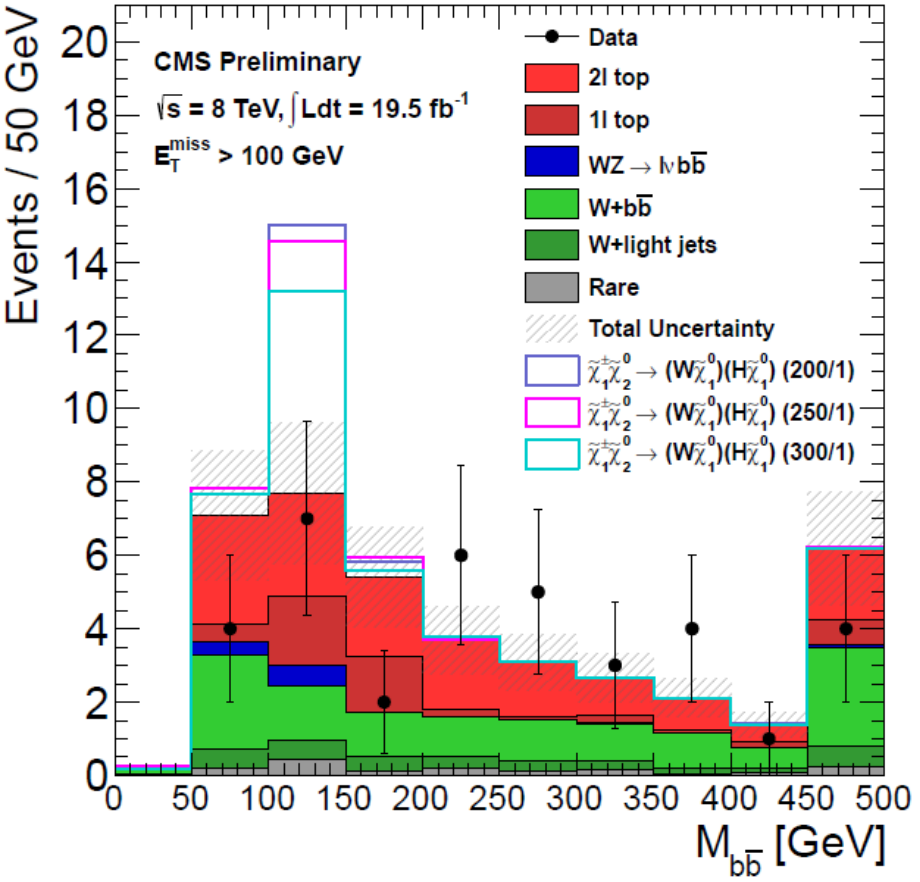
exclusive: combine to improve sensitivity

reinterpretation of SUS-13-002 inclusive multilepton SUSY search

Chargino-Neutralino
H+W+MET

1 lepton + bb

- Selection
  - Exactly on high pt lepton
  - Exactly 2 jets, both b-tagged
  - Cuts on MET and MT
- Backgrounds from MC
- Search for a peak in M_{bb}
  - No evidence for a peak is found

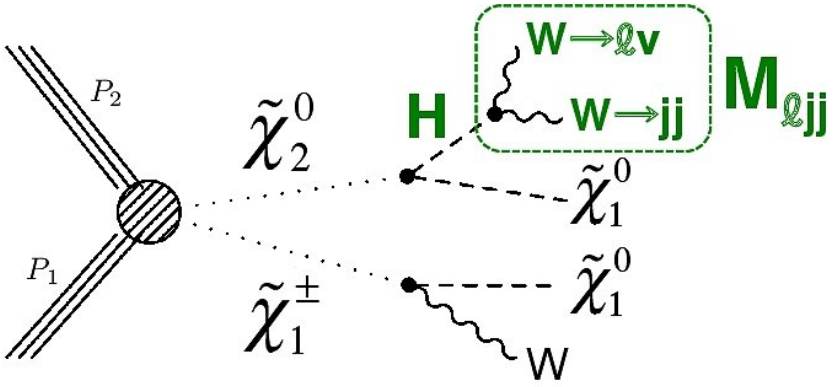


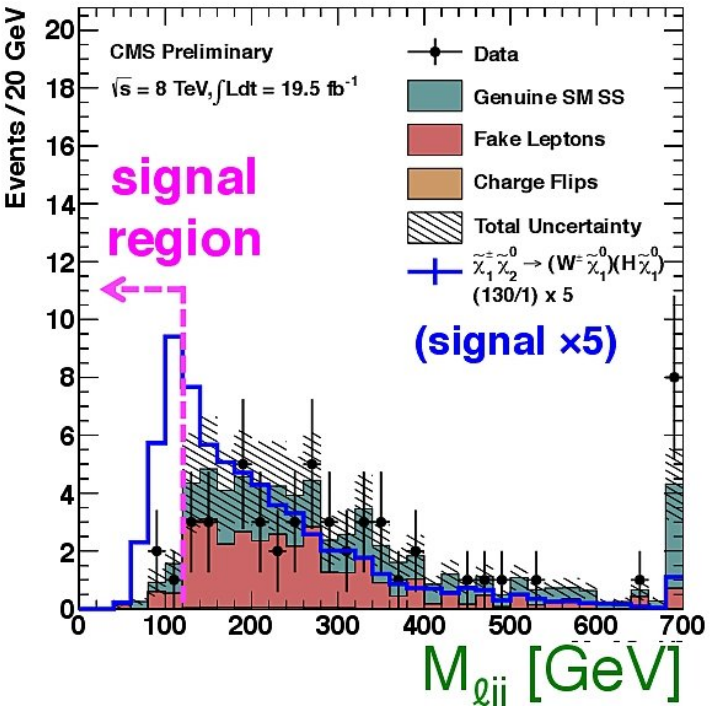
Chargino-Neutralino

H+W+MET

SS Dileptons + Jets + MET

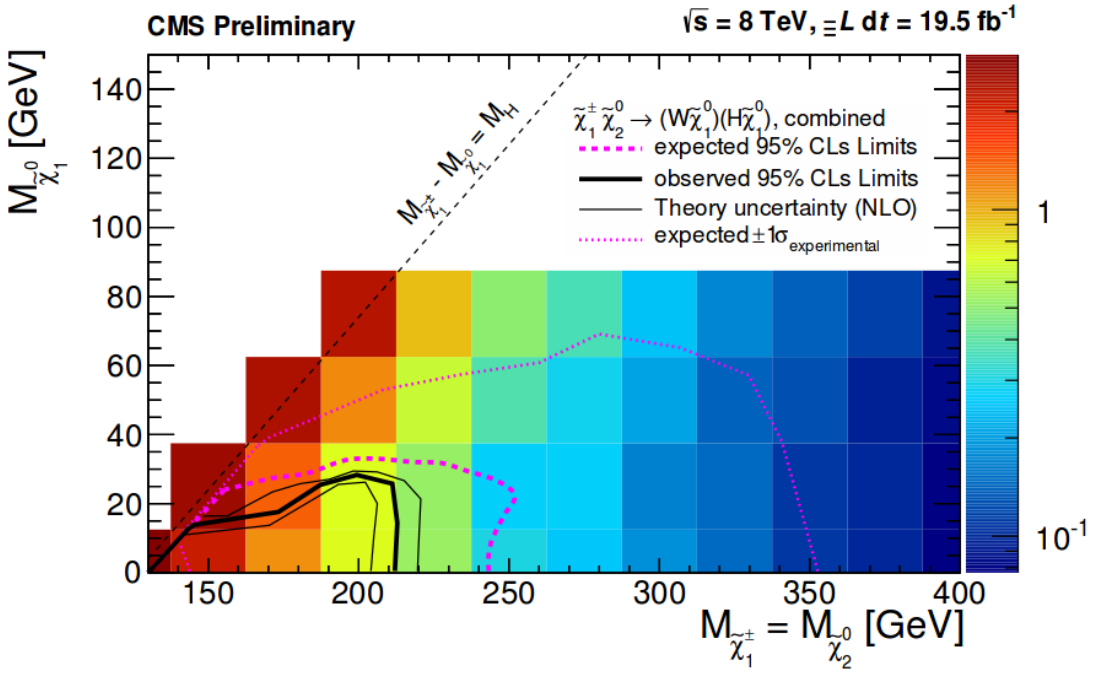
- Selection
  - Exactly two SS e/mu
  - 2/3 jets, b-veto
  - Moderate MET
- Data-driven fake lepton estimate
- Prompt SS 2l bkg from MC
- Search for a bump in M_{ljj}
  - No evidence for a peak is found

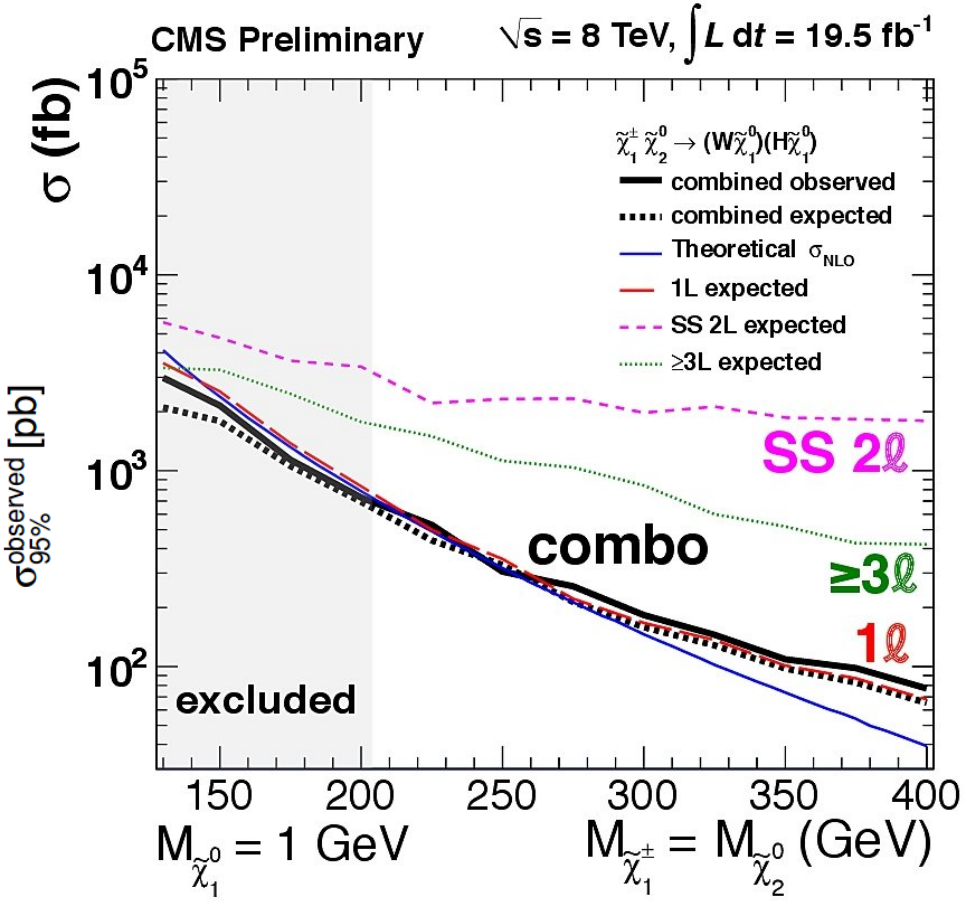




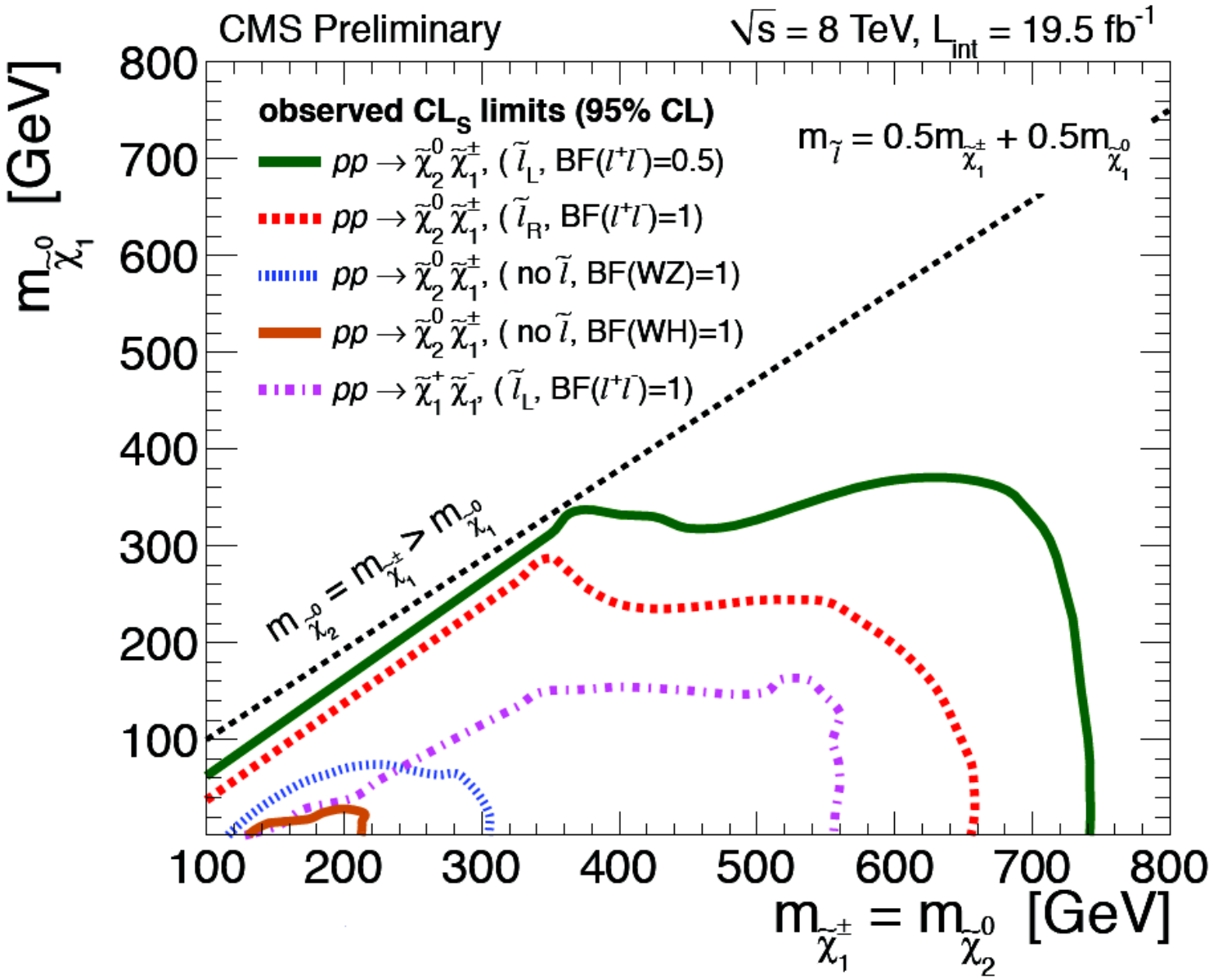
Chargino-Neutralino
H+W+MET

- 1lepton : best at large chargino mass
  - SS 2l and >2l contributes at low chargino mass
- Combined 3 channels :
  probe up to chargino mass ~ 200 GeV



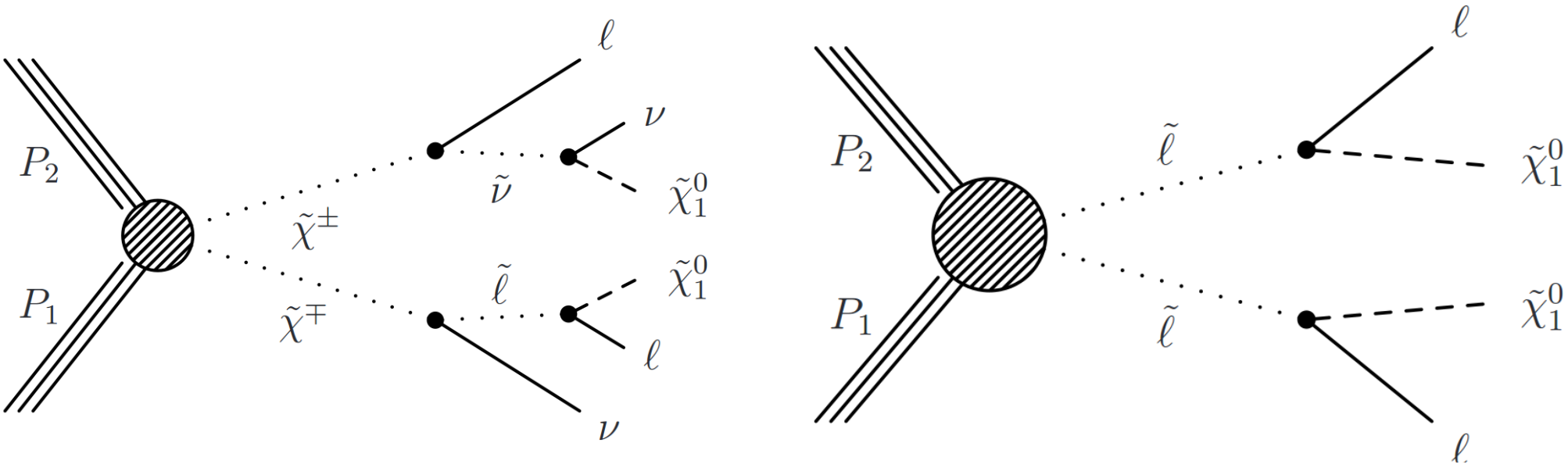


Chargino-Neutralino SUMMARY



Chargino-Chargino & Slepton-SLepton

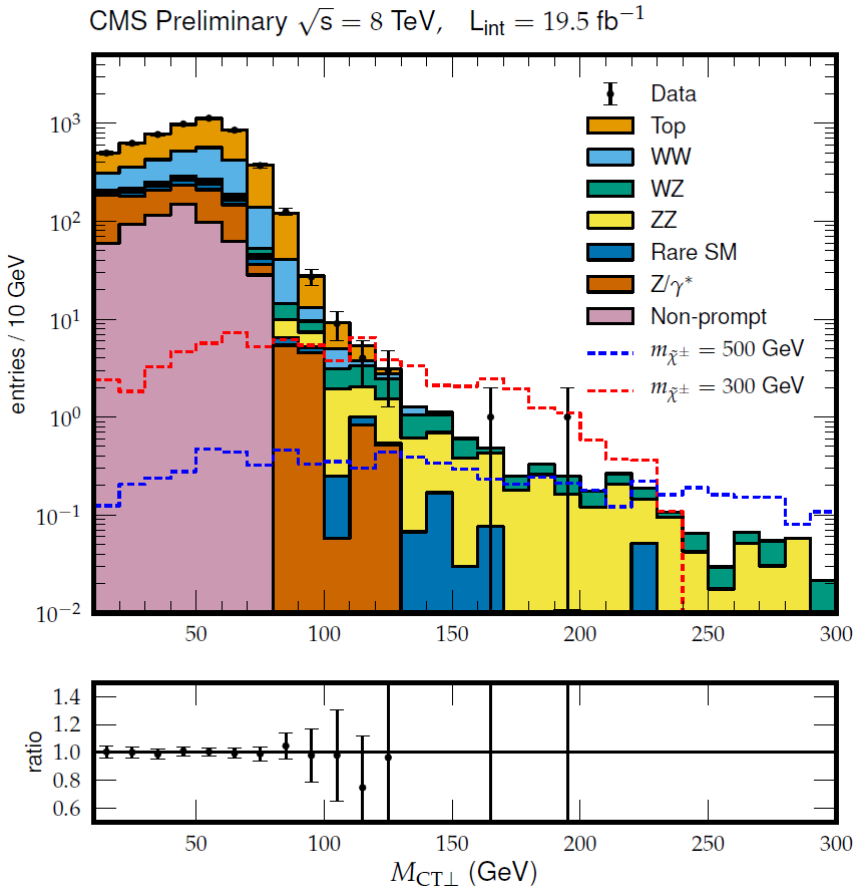
Chargino-Chargino & Slepton-SLepton



Signature : 2 OS leptons + MET

Chargino-Chargino & Slepton-SLepton

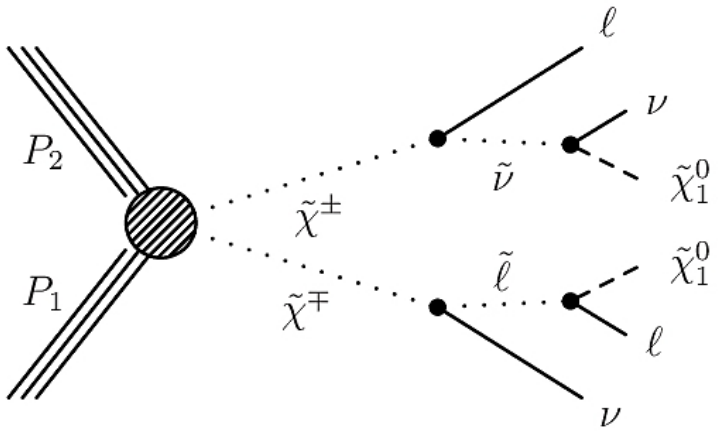
Selection

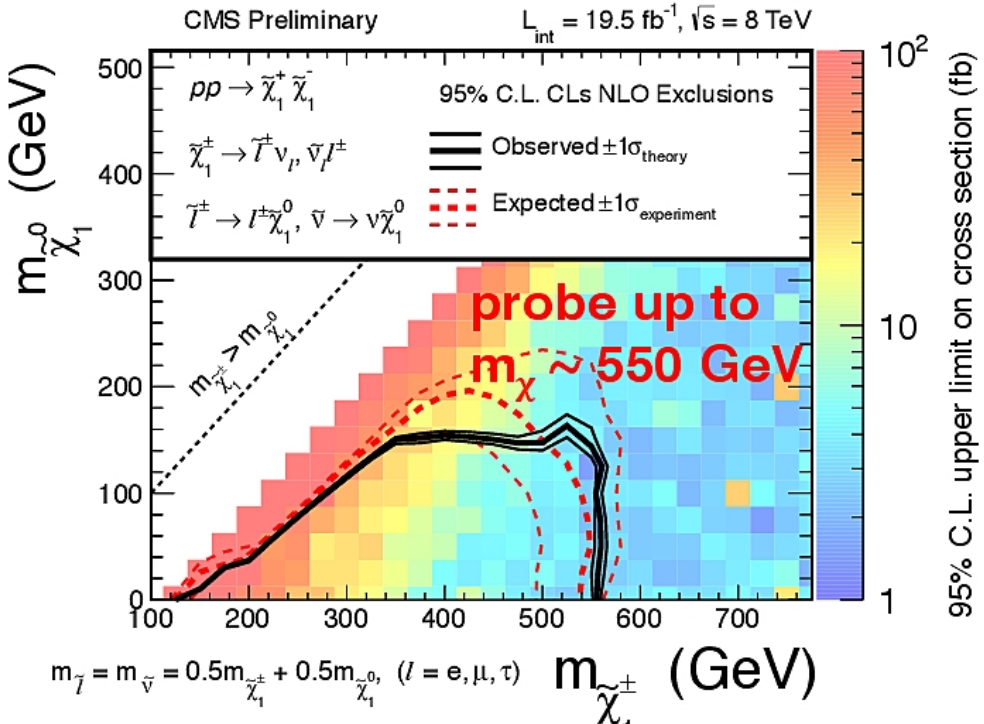


- Event Selection
  - 2 high Pt OS e/mu leptons with Z-veto
  - b-veto, moderate MET cut
- $M_{CT\perp}$:Kinematic Reconstruction
  - Separate WW backgrounds
  - Fitted using data driven templates and MC
  - Data agrees well with prediction

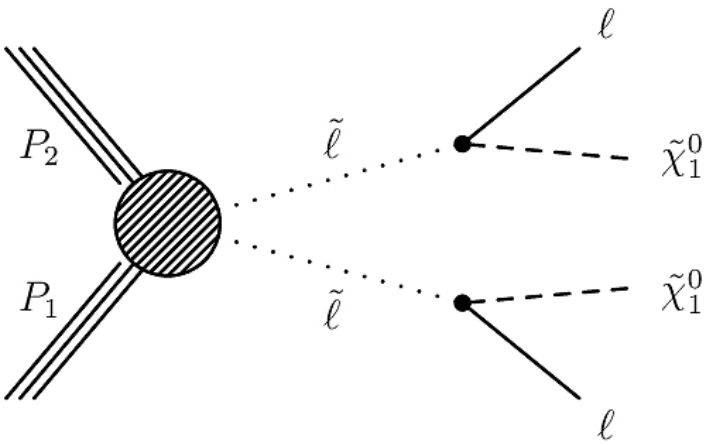
Chargino-Chargino & Slepton-SLepton Results

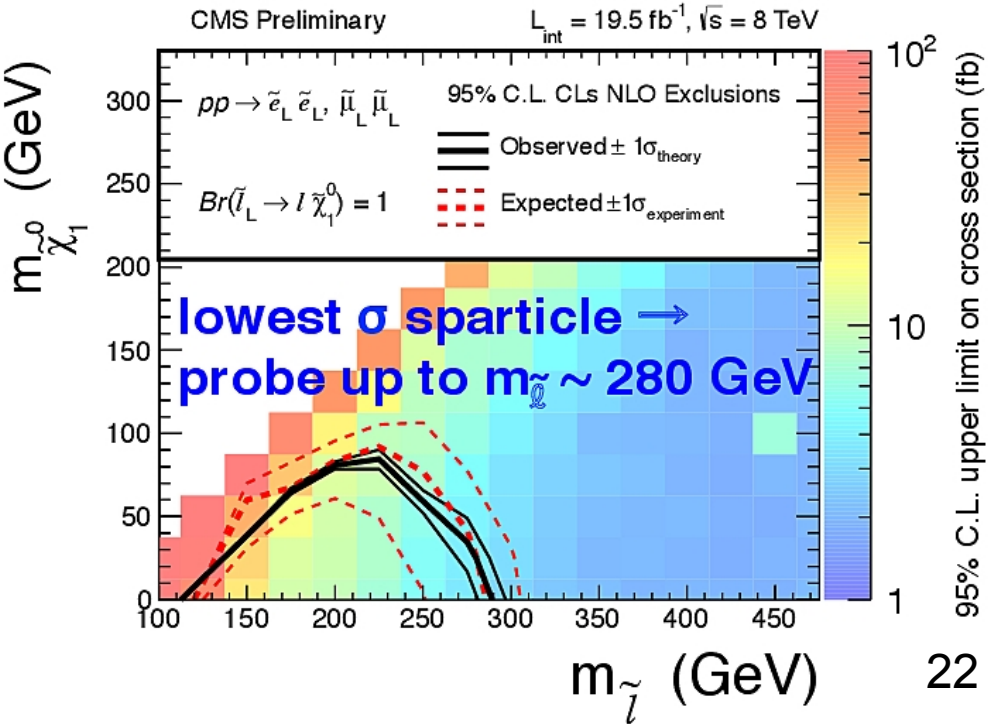
Use ee+μμ and eμ lepton pairs





Use ee+μμ lepton pairs only

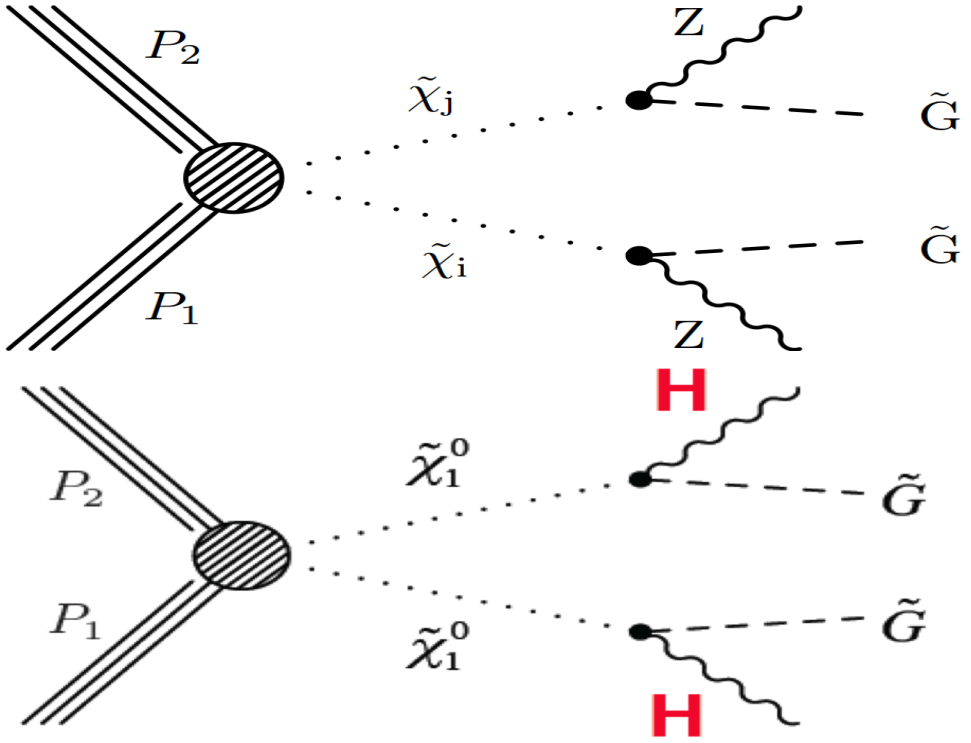




Neutralino-Neutralino

Neutralino-Neutralino decay modes

- R-parity-conserving gauge-mediated SUSY-breaking (GMSB) models are considered
  - Gravitino is a nearly massless LSP
- $X^0_{1,2}$ and $X^{\pm}_0$ are approximately mass-degenerate
- $X^0_2 / X^{\pm}_0 \rightarrow X^0_1$ + low pt standard model particle

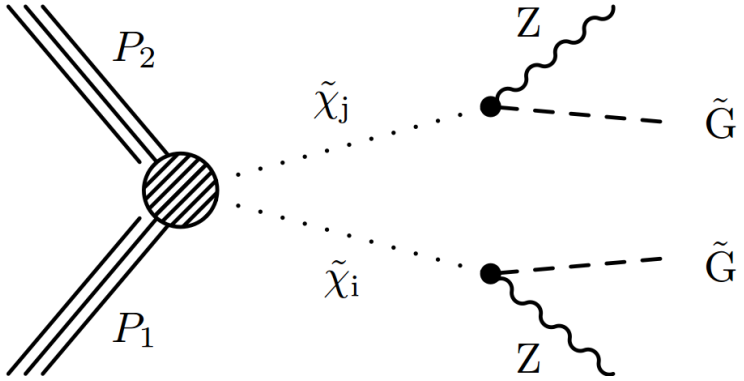


- 4 leptons
- 3 leptons
- 2 leptons + 2 jets

- 4 b-jets : ✓ NEW
- Higgs decays to gauge bosons (photon, W, Z) : under study

Neutralino-Neutralino

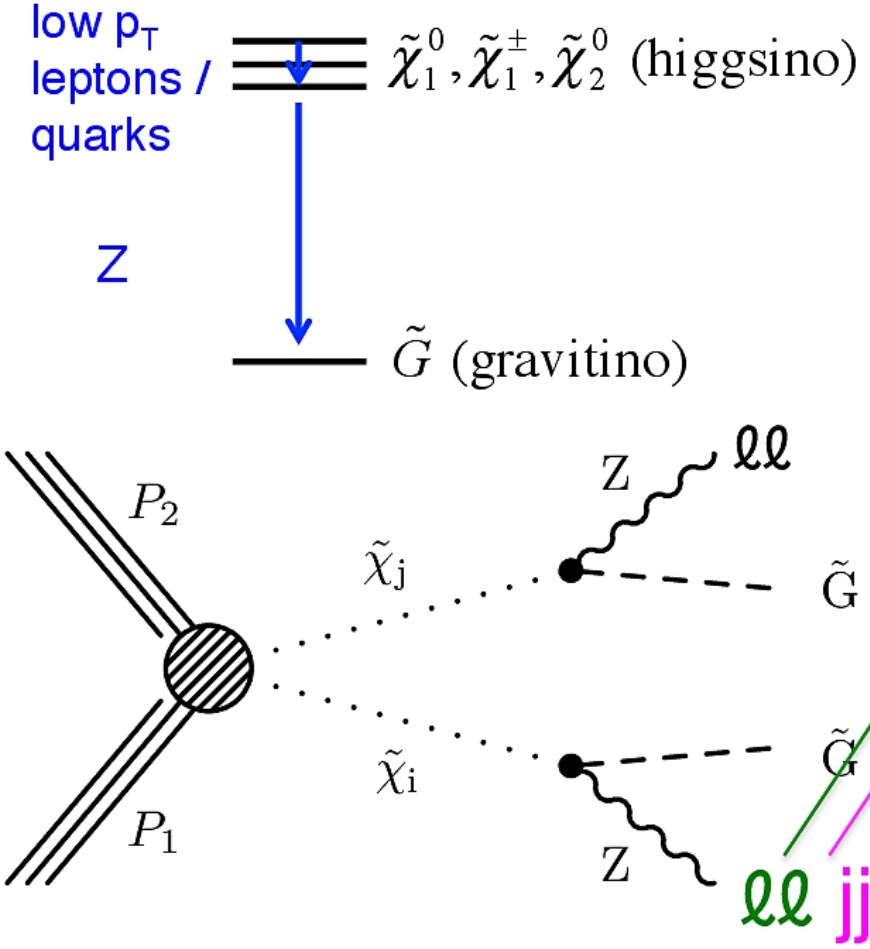
Z+Z+MET

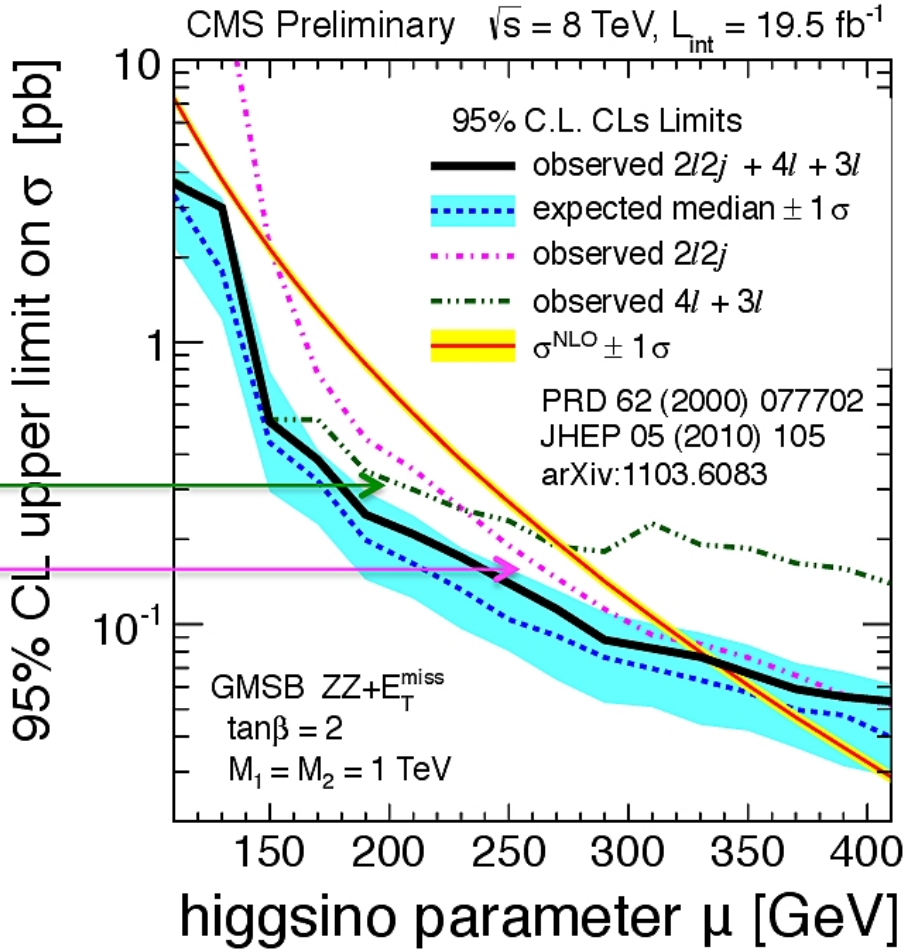


E_T^{miss} (GeV)	Observed	Total Bkg
1 OSSF, 0 τ		
0–30	1	2.3 ± 0.6
30–50	3	1.2 ± 0.3
50–100	2	1.5 ± 0.4
> 100	2	0.8 ± 0.3
1 OSSF, 1 τ		
0–30	33	25 ± 12
30–50	11	11 ± 3.1
50–100	9	9.3 ± 1.9
> 100	2	2.9 ± 0.6
2 OSSF, 0 τ		
0–30	142	149 ± 46
30–50	25	28 ± 11
50–100	4	4.5 ± 2.7
> 100	1	0.8 ± 0.3

- Event Selection
  - 4 leptons (up to one hadronic tau)
  - Classify events by #OSSF pairs, #hadronic taus, MET
- Main Background
  - ZZ : estimated from MC, with data-driven MET corrections
- Results
  - No sign of new physics

Neutralino-Neutralino
Z+Z+MET (Results)

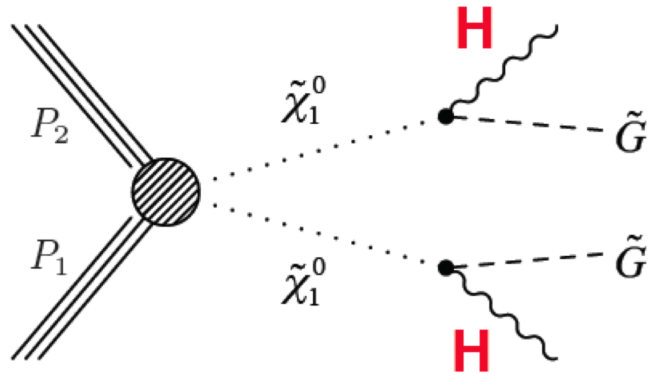


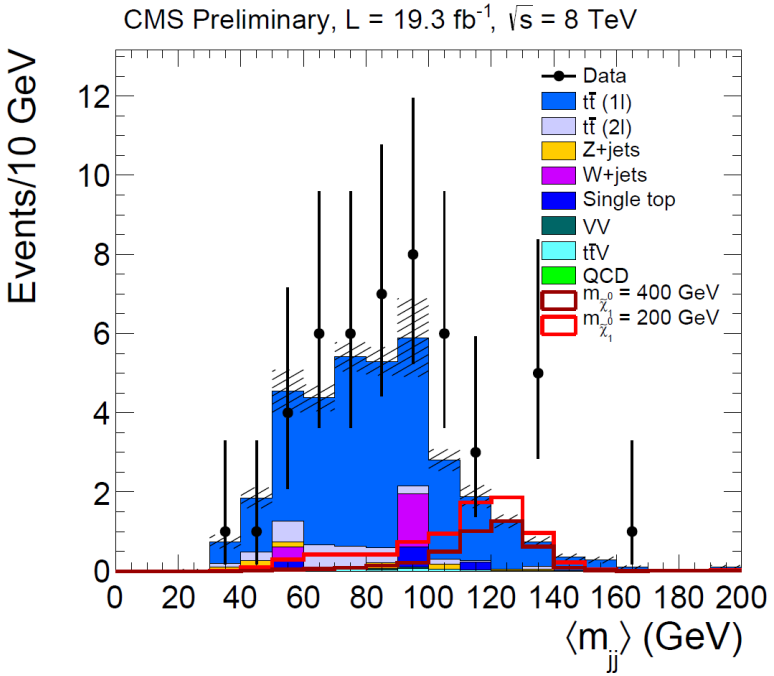


- Results based on **Z(ℓℓ)V(jj) , 3ℓ+4ℓ**, and combination
  - Combination of complementary channels → **exclude μ 110-330 GeV**

Neutralino-Neutralino

H+H+MET (4b)



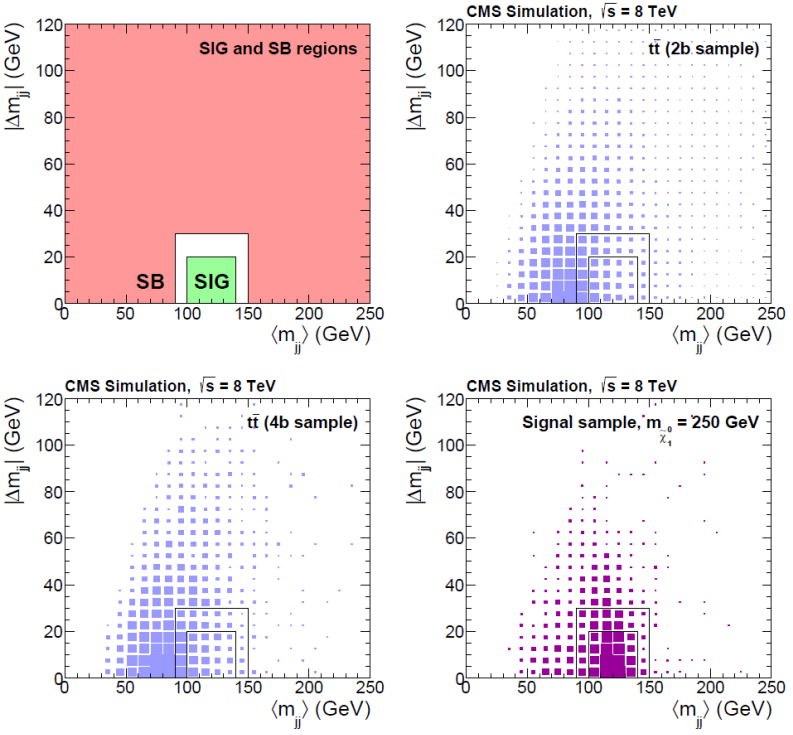


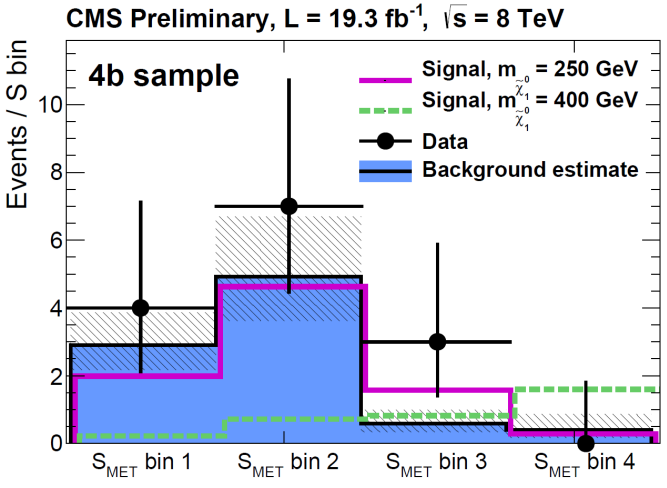
- Event Selection
  - 4/5 Jets, at least 3 b's
  - Moderate MET cut
  - Cut on Dphi of MET and Jets to eliminate QCD and ttbar
- HH Reconstruction
  - $|\Delta m_{jj}| \equiv |m_{jj,1} - m_{jj,2}|$ is minimized
  - $|\Delta m_{jj}| < 20\,\mathrm{GeV}$
  - $100 < \langle m_{jj} \rangle < 140\,\mathrm{GeV}$

Neutralino-Neutralino H+H+MET (4b)

NEW

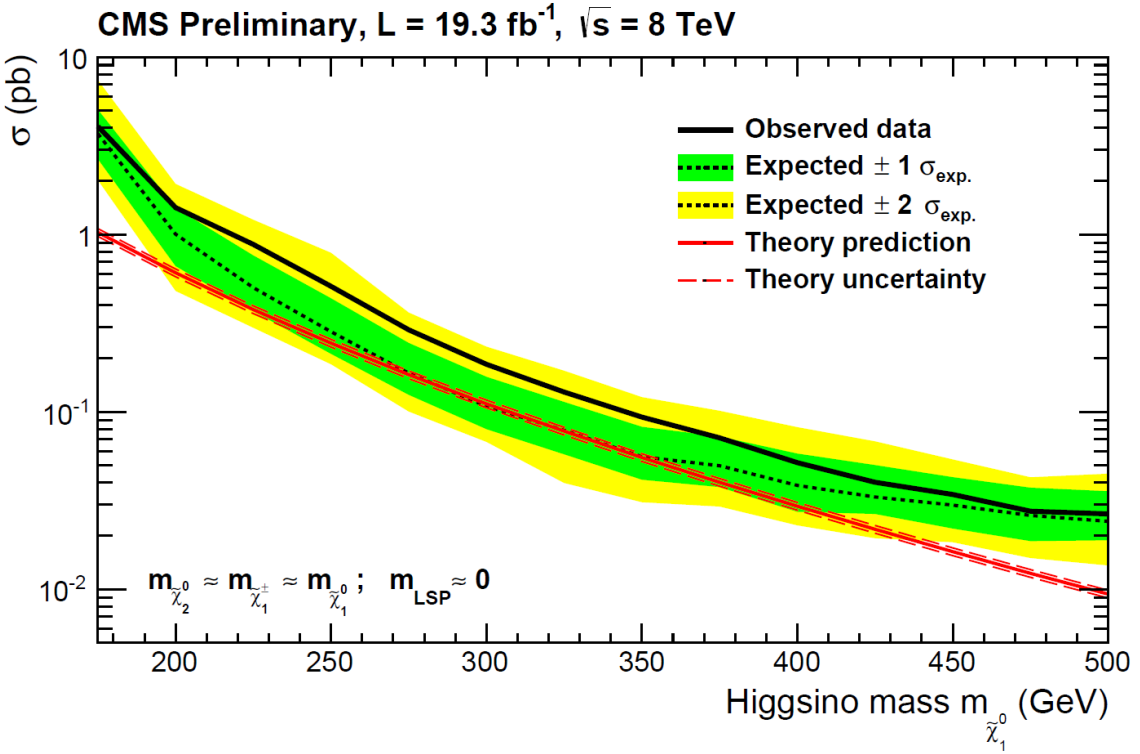
- Background estimation
  - $\langle m_{jj} \rangle$ and $|\Delta m_{jj}|$ are used to define signal and background regions
  - #Signal and background for different #b's are illustrated
  - #background can be estimated using an ABCD method
- Results
  - Binning vs. MET
  - No sign of new physics is observed



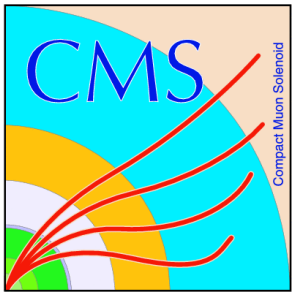


Neutralino-Neutralino

H+H+MET (4b)



- For higgsino masses between ~ 270 and 350 GeV, the expected cross section upper limits reach the level of the expected production cross section.
- Because of a slight excess in the observed number of events compared to the estimated background, we are unable to exclude the signal model for any value of higgsino mass.



Summary and Conclusion

- A wide range of searches for electroweak SUSY production is performed with full 8 TeV dataset
- Different decay scenarios are considered :
  - 1,2,3,4 leptons
  - 2leptons + 2jets
  - 4b
- The results are interpreted in various simplified models spectra
- No sign of new physics is observed