Searches with Jets + missing ET with Leptons @ CMS

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Karlsruhe Institute of Technology

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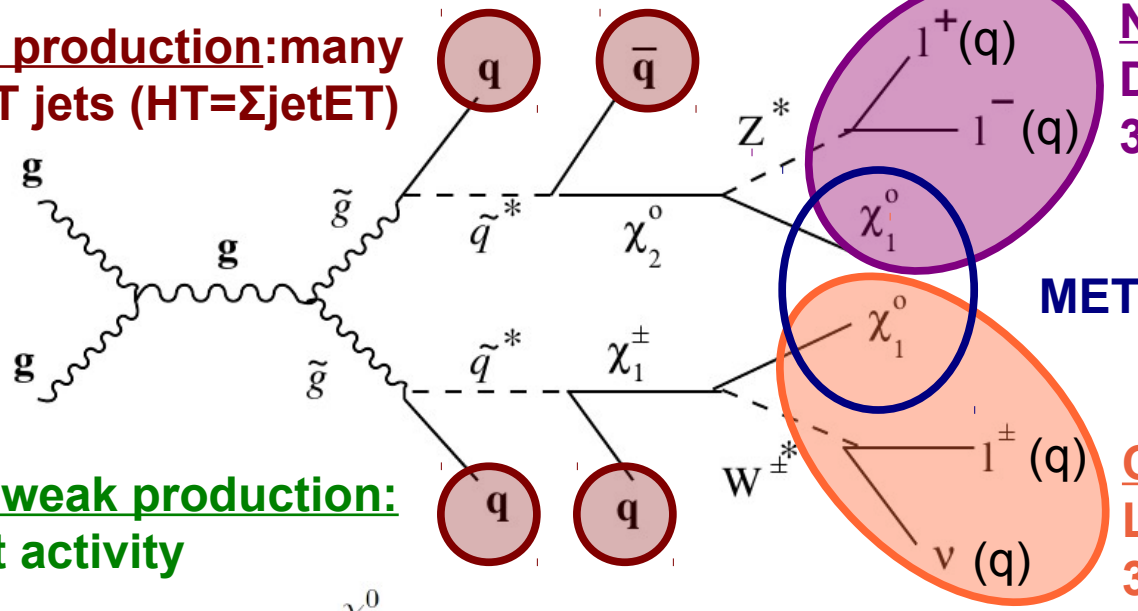
Outline

- Introduction to leptonic SUSY signatures
- CMS strategies for searches with
  - single leptons
  - same sign (SS) dileptons
  - opposite sign (OS) dileptons
  - multileptons
- Interpretation of results

Leptonic SUSY Signatures @ LHC

- SUSY: Leptons arise primarily from Neutralino/Chargino decays
- Neutralino/Charginos either directly produced **(electroweak)** or in cascade decays of squarks/gluinos **(strong production)**

Strong production:many high ET jets (HT=ΣjetET)

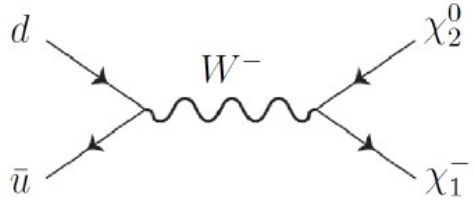


Neutralino decay:
Dilepton + LSP via 3body, slepton, Z or h

MET by LSP's

Chargino decay:
Lepton + υ + LSP via 3body, slepton, W, H+

Electroweak production:
little jet activity

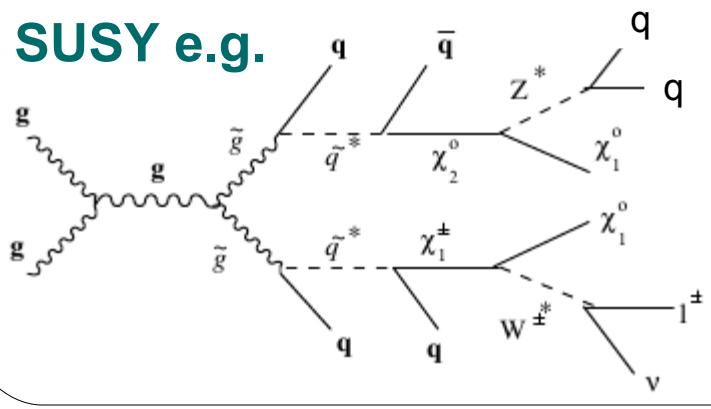


b-jet production can be enhanced

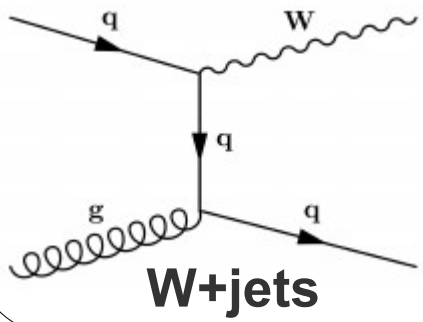
Tau production can be enhanced

Single Lepton SUSY Searches

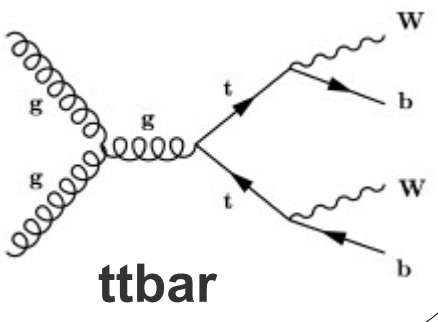
SUSY e.g.



Main SM Backgrounds



W+jets



ttbar

CMS Strategies

CMS SUS-12-010

Chargino production in strong processes selected by HT&MET

Additional variables allow to reduce HT&MET selection:

- **W-polarisation** CMS SUS-11-015
- **enhanced b-production (1,2,3 b-jets)** CMS SUS-11-028
- **Neural Net** CMS SUS-11-026

Also single tau production studied CMS SUS-12-008

CMS SUS-12-010

Single Lepton SUSY Search: HT&MET

Strategy

>3 jets, high HT und high MET

- MET> 150,250,350,450,550 GeV
- HT> 500,750,1000 GeV

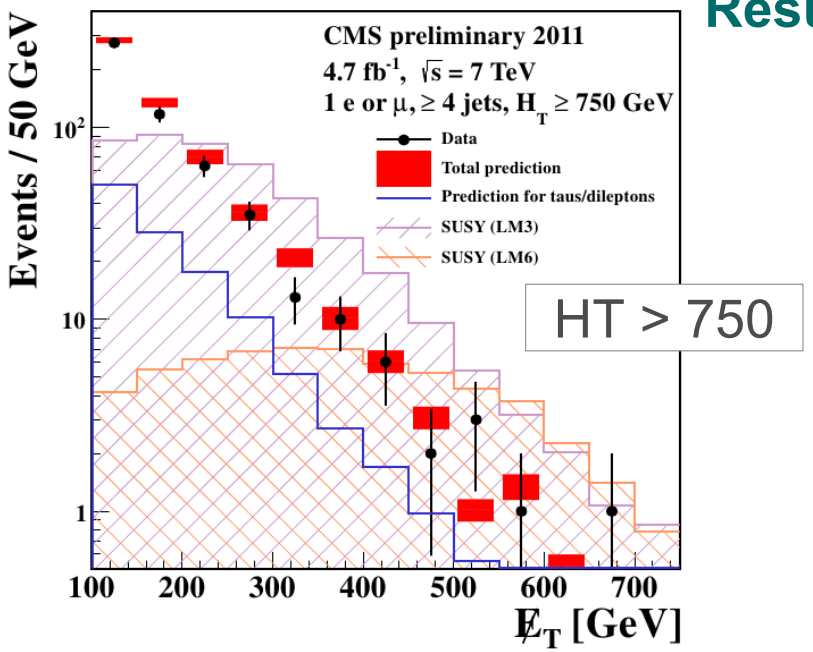
Wjets/ttbar bkg estimation

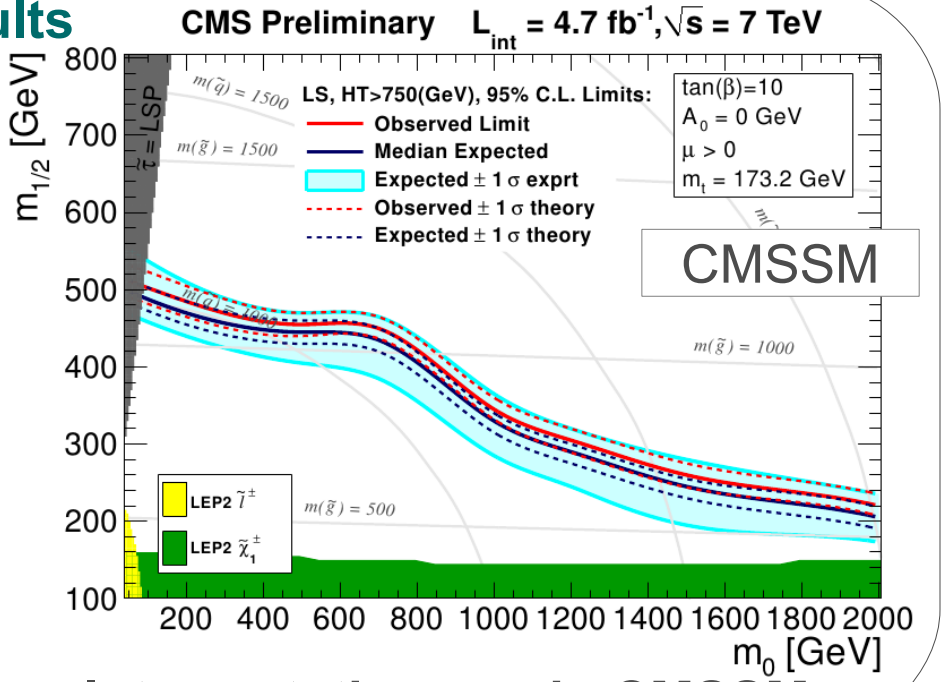
- MET by Neutrino from W-decay

→ Lepton & MET coupled

- **Use measured lepton spectrum to describe MET spectrum**

Results



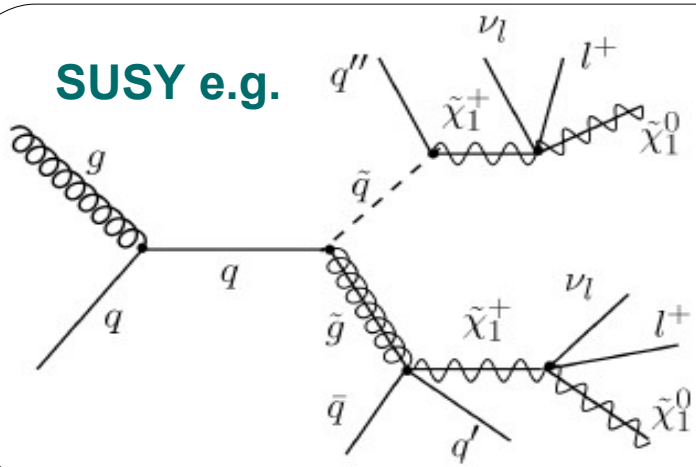


Data agrees well with SM pred. → Interpretation e.g. in CMSSM

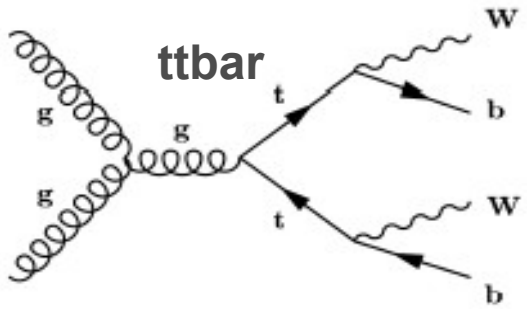
Same Sign Dilepton SUSY Searches

- Search for same sign di-chargino production in strong processes
- Two CMS strategies:
  - jets+MET — CMS SUS-11-010
  - b-jets +MET — CMS SUS-11-020
- Pro: Small SM bkg

SUSY e.g.



Main SM background



Prompt + Fake Lepton

Further SM bkg: Prompt-Prompt

Di-boson production: $q\bar{q} \to WZ, ZZ$

Double "W-sstrahlung": $qq \to q'q'W^{\pm}W^{\pm}$

Double-parton scattering: $2 \times (qq \to W^{\pm})$

Tri-Boson production: $q\bar{q} \to WWW, WWZ, WZZ, ZZZ$

Top-Antitop+Boson production: $q\bar{q}' \to t\bar{t}\,W, t\bar{t}\,Z$

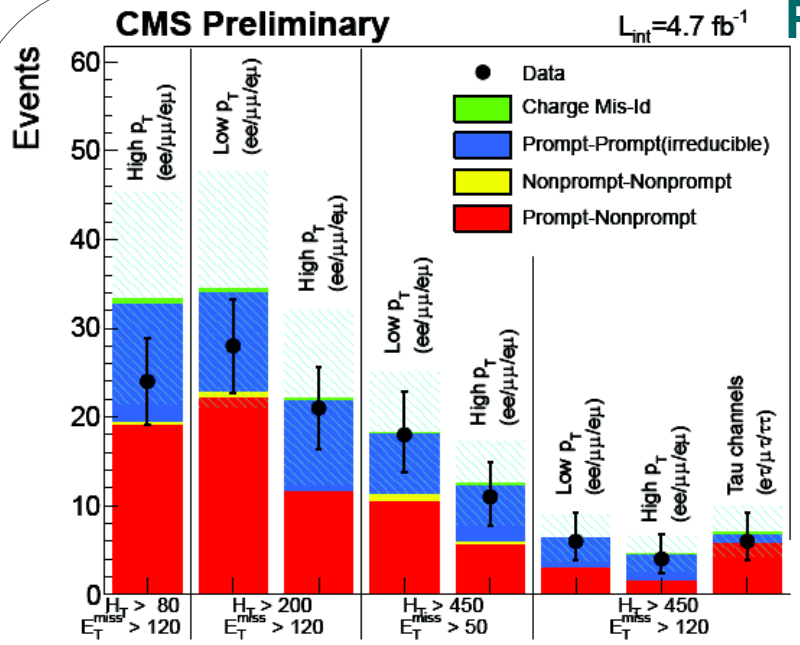
+ Additional: Fake-Fake, $\ell^+\ell^-$ mit Charge-MisID

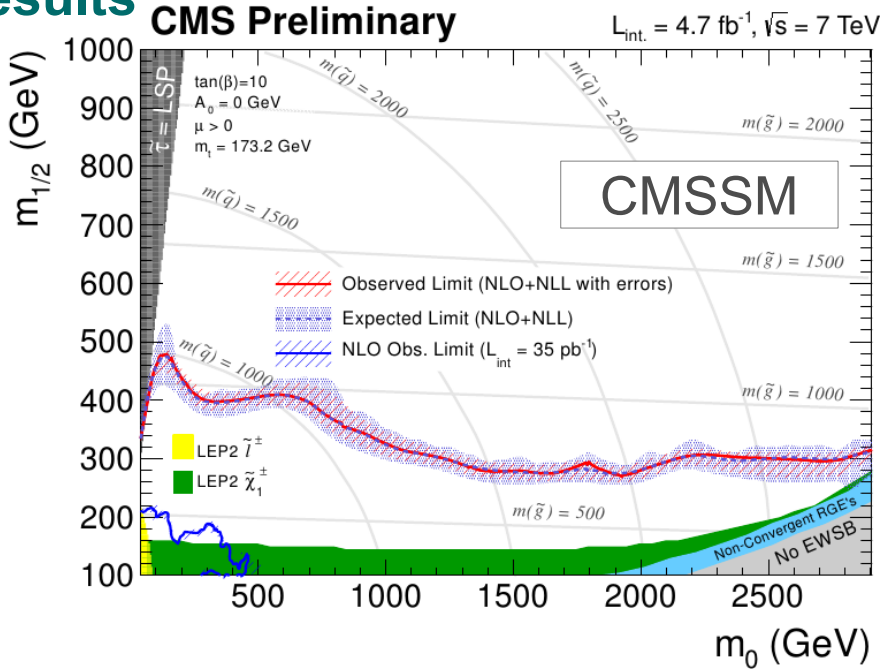
CMS SUS-11-010

Same Sign Dilepton SUSY Search: jets+MET

- Small SM bkg allows for high PT,HT,MET selection efficiency
- e,μ,τ final states with different PT and HT&MET requirements used

Results





Data agrees well with SM pred. → Interpretation e.g. in CMSSM

Opposite Sign Dilepton SUSY Searches

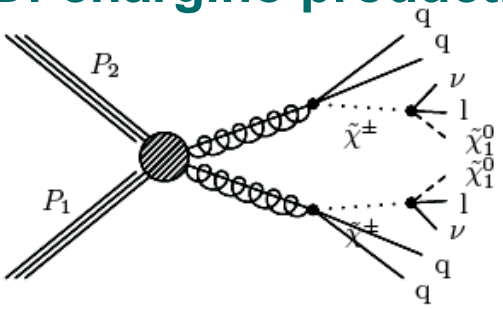
Main SM Background
- Z+jets & ttbar

- jets+MET+(Taus)
- Neural Net

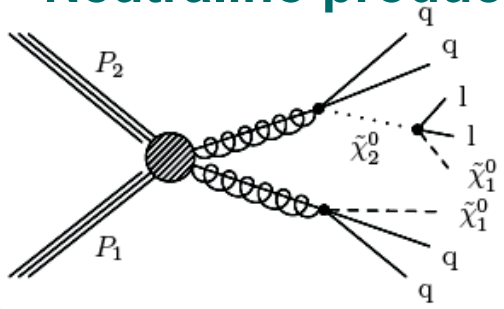
CMS SUS-11-011
CMS SUS-12-004
CMS SUS-11-019

Strategies:

Di-chargino production



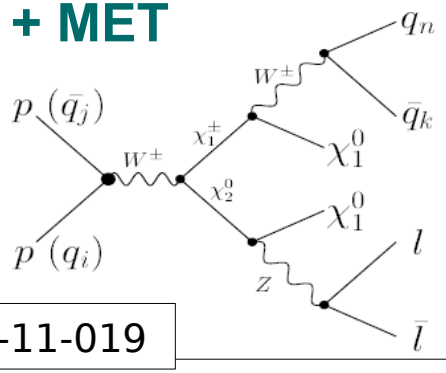
Neutralino production



- M($\ell^+\ell$)-Shape

CMS SUS-11-011

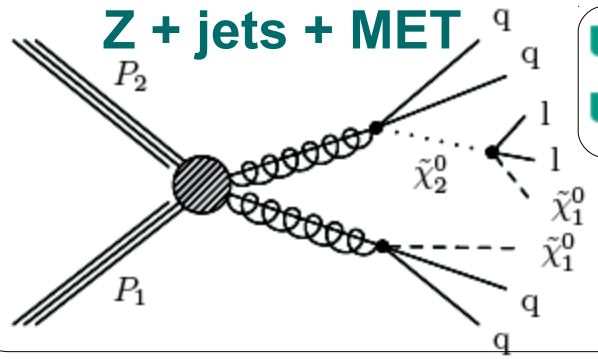
Z + W + MET



CMS SUS-11-019

CMS SUS-11-021

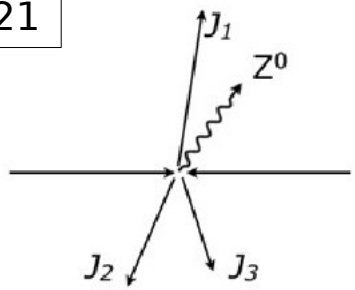
Z + jets + MET



- jets+MET
- JZB

CMS SUS-11-021

Opposite Sign Dilepton SUSY Search: JZB



Strategy

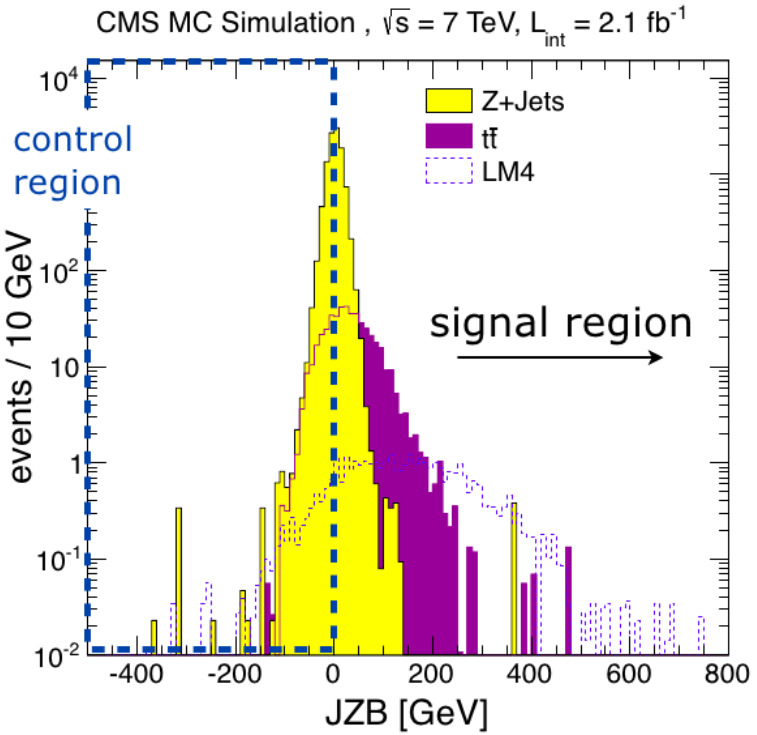
Search for SUSY in $Z \rightarrow \ell^+\ell^-$ + ≥3 jets

Use balance of jets & Z boson

$$JZB = \left|\Sigma_{jets} \vec{p_T}\right| - \left|\vec{p_T}(Z^0)\right|$$

(≡ MET + additional sign)

- **SM: Z+jets**
  - no genuine MET
  - MET by mismeasured jets
  - → MET direction independend on Z
  - → JZB equally distributed around 0
- **SUSY:**
  - MET by LSP
  - LSP & Z origin from same decay
  - → MET & Z in same direction
  - → JZB mostly positiv

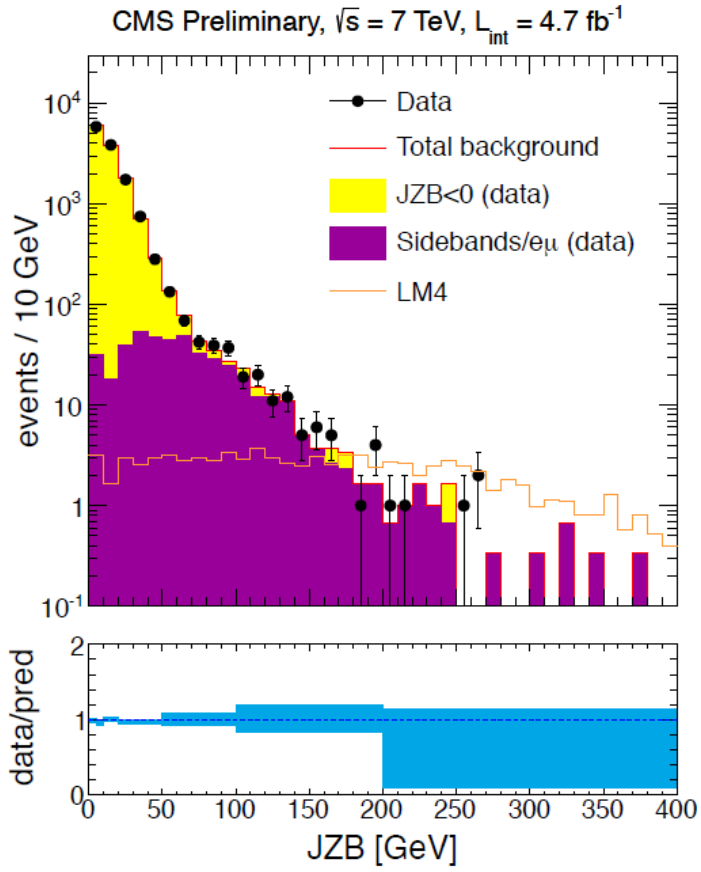


SM bkg prediction

- Z+jets by negative JZB
- ttbar by same sign events

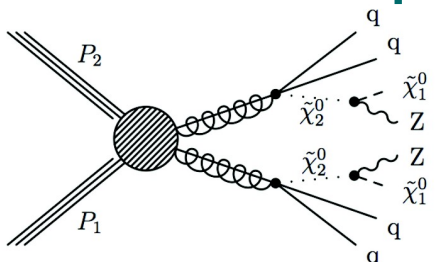
Opposite Sign Dilepton SUSY Search: JZB

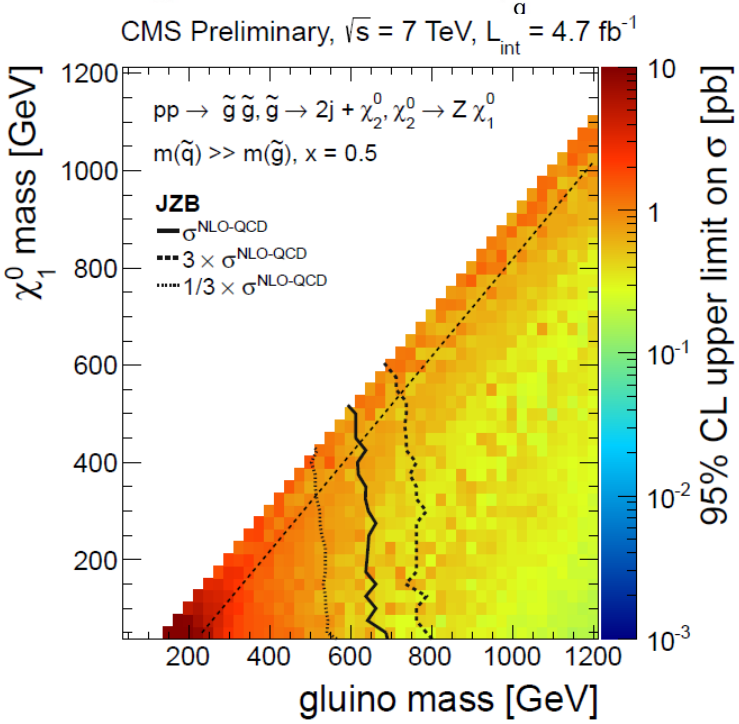
Results



Good Data-SM agreement

Simplified Model Interpretation

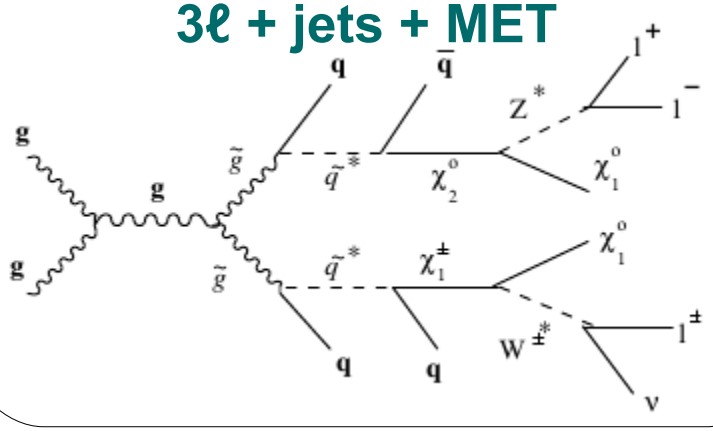




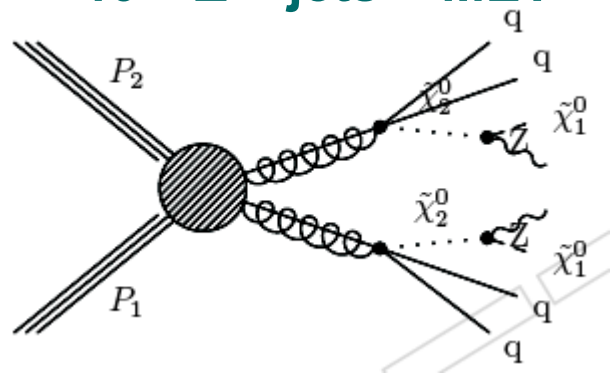
Multilepton SUSY Search

Multiple production mechanism e.g.:

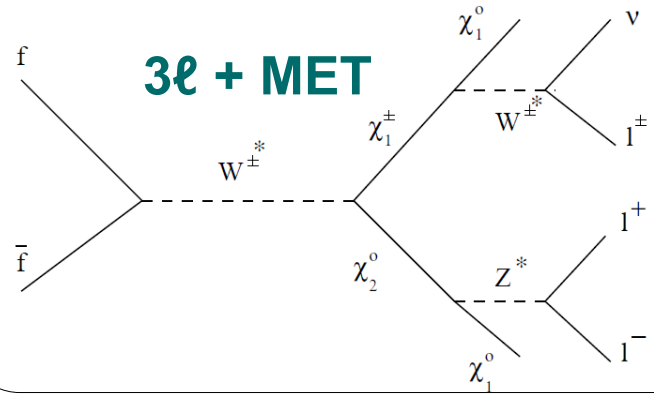
3ℓ + jets + MET



4ℓ + Z + jets + MET



3ℓ + MET



- 3ℓ + Z + MET
- 3ℓ + Z + jets + MET
- 4ℓ + jets + MET
- 4ℓ + Z + MET

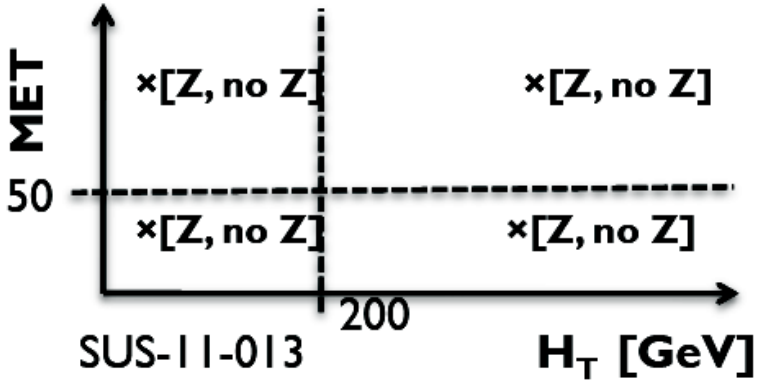
Main SM background

- Prompt: ZZ, ZW
- Fake: Z+jets & ttbar

Multilepton SUSY Search

Strategy: inklusive search

- Use ≥3 leptons (up to 2 τ's)
- Reject J/Ψ,ϒ: M($\ell^+\ell$) > 12GeV
- Sensitivity to diff. models
  - EW, strong, w/o Z, 3ℓ, 4ℓ,...
- Split multilepton events by:



+ Charge und NTaus

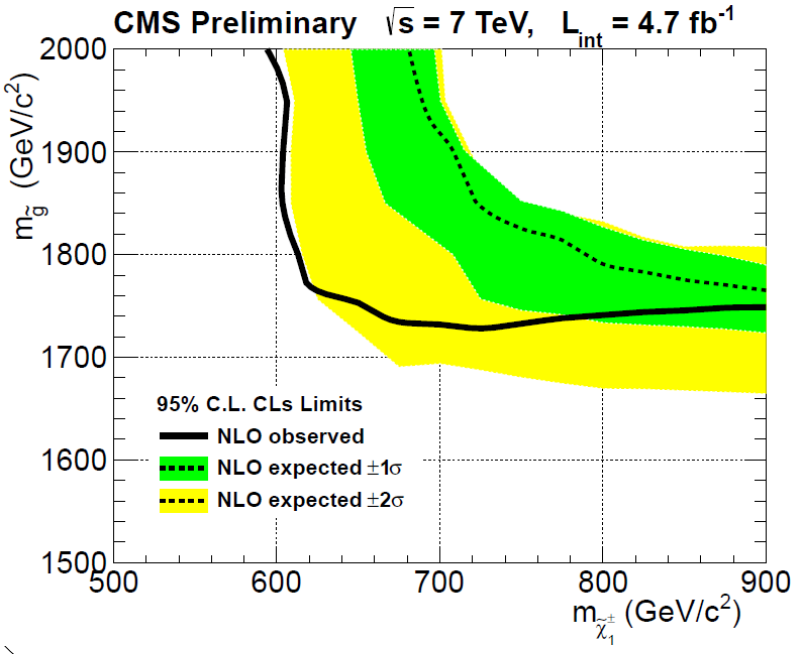
Results

Data compatible with SM

Interpretation e.g. in GMSM

- Slepton co-NLSP scenario
- Gravitino=LSP
- Sleptons=NLSP

$$\chi^0 \rightarrow \tilde{\ell}^{\pm}\ell^{\mp} \quad \tilde{\ell} \rightarrow \tilde{G}\ell$$



Summary and Conclusion

- Strategies and results of various CMS SUSY searches with leptons with single, dilepton and multilepton final states have been presented
- Most analyses have already produced updated results with the full 2011 dataset (L~5fb-1)
- Observations agree with standard model prediction
- Results have been interpreted in various SUSY scenarios (CMSSM, GMSM) and simplified models
- Exclusion limits produced in summer (~2fb-1) have been further extended

CMS SUSY results:
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS