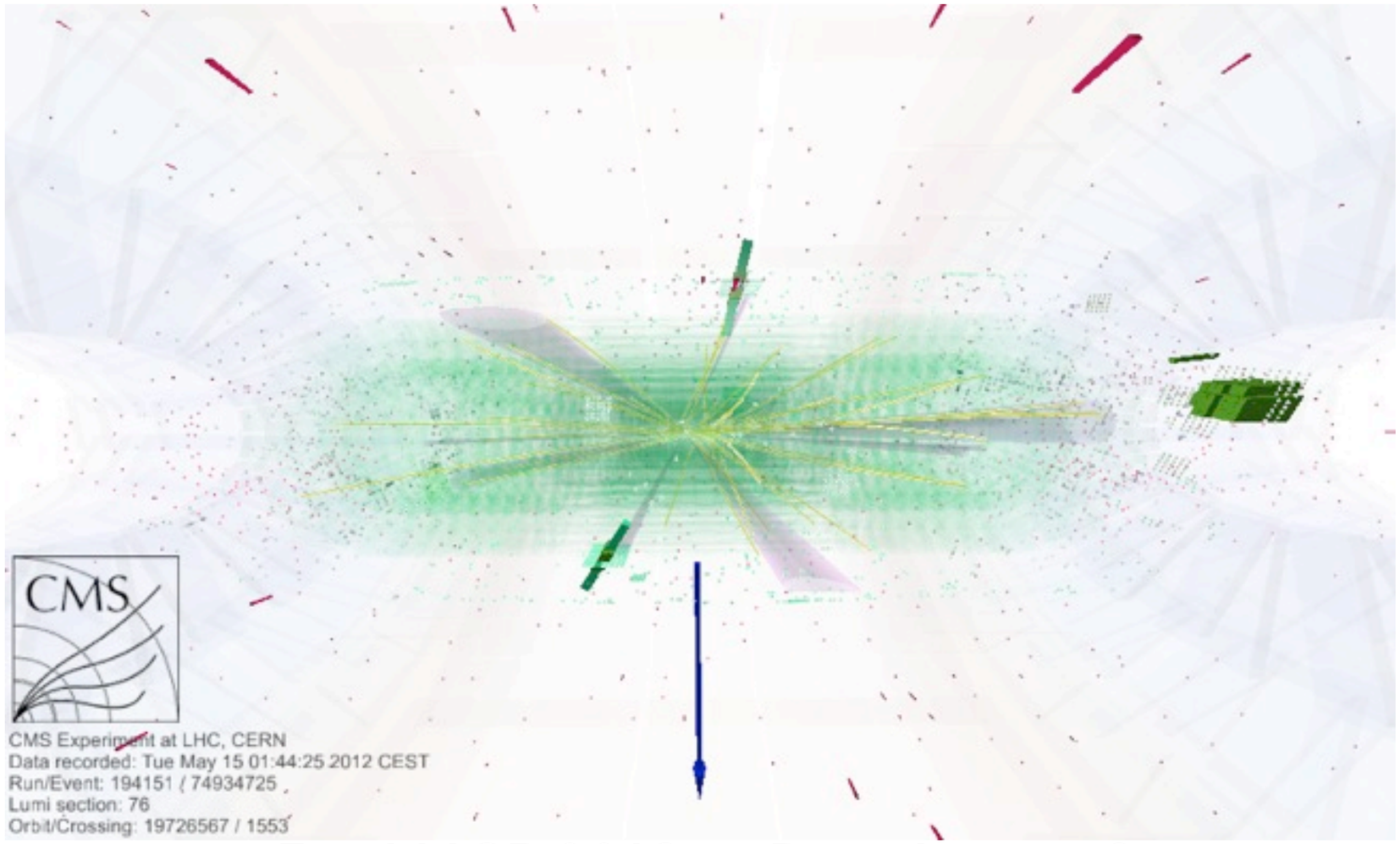
Searches for GMSB scenarios at CMS

Tae Jeong Kim (Korea University)
on behalf of CMS collaboration

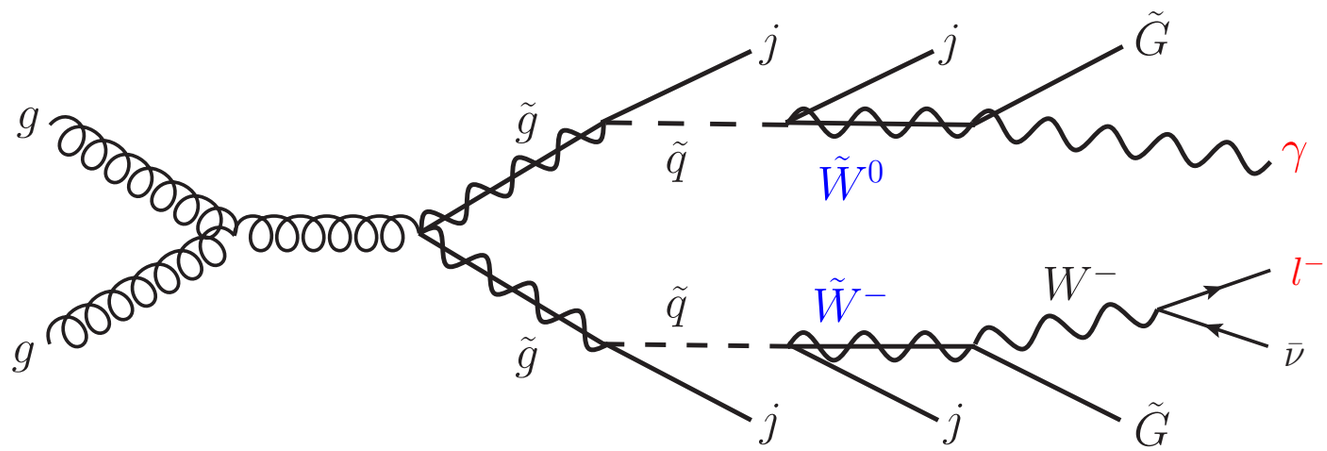


For LHCP 2013 at Barcelona in Spain
17/5/2013

Introduction

General Gauge Mediated Supersymmetry Breaking (GGM/GMSB) arXiv:0801.3278v3

- Stabilize the mass of the SM Higgs boson.
- Drives the grand unification of forces.
- Avoid the large flavor-changing neutral currents.



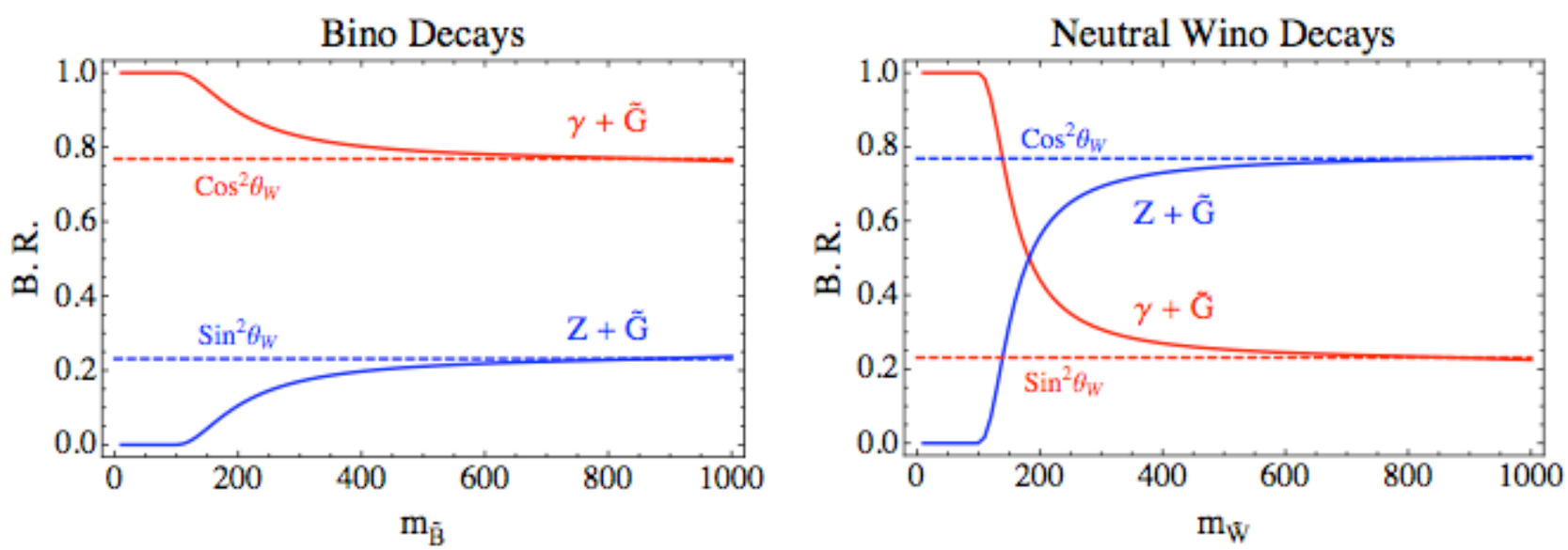
- Gravitino is the lightest SUSY particle (LSP).
- The lightest neutralino is the next-to-lightest-superpartner (NLSP).
- Final signature is determined by the nature of the NLSP.

- We scanned following parameters (Simplified Model)
  - Squark mass
  - Gluino mass
  - Neutralino (the NLSP) mixture : binos, winos, higgsinos

Neutralino branching ratio

NLSP type	$\gamma + 2$ jets $+ E_T^{miss}$	$\gamma\gamma +$ jet $+ E_T^{miss}$
Bino	jets $+ \tilde{\chi}_1^0\tilde{\chi}_1^0 \to$ jets $+ \gamma + Z + \tilde{G}\tilde{G}$	jets $+ \tilde{\chi}_1^0\tilde{\chi}_1^0 \to$ jets $+ \gamma\gamma + \tilde{G}\tilde{G}$
Wino	jets $+ \tilde{\chi}_1^0\tilde{\chi}_1^0 \to$ jets $+ \gamma + Z + \tilde{G}\tilde{G}$ jets $+ \tilde{\chi}_1^0\tilde{\chi}_1^\pm \to$ jets $+ \gamma + W^\pm + \tilde{G}\tilde{G}$	jets $+ \tilde{\chi}_1^0\tilde{\chi}_1^0 \to$ jets $+ \gamma\gamma + \tilde{G}\tilde{G}$

J. Ruderman, D. Shih; hep-ph:1103.6083



- Bino-like neutralino : decays dominantly into a gravitino and photon.
- Wino-like neutralino :
  - the netural decays dominantly into a gravitino and a Z.
  - splitting charged and neutral wino is small : charged wino becomes co-NLSP.
  - charged wino directly decays a gravitino and a W as an additional contribution.

Overview

- Photon final states. (Bino-like or Wino-like neutralino)
  - Single and Di-photon + MET at 8 TeV
  - Gamma-jet balancing (JGB) - single photon at 7 TeV
  - Stealth SUSY - low MET at 7 TeV

- Tau final states (Charged NLSP)
  - Single and double tau analysis at 7 TeV

- Di-lepton final states
  - Z+MET+jets search at 8 TeV
  - See the Marc Dunser's talk, "*SUSY searches for EWK production of Gauginos and Sleptons at the LHC*"

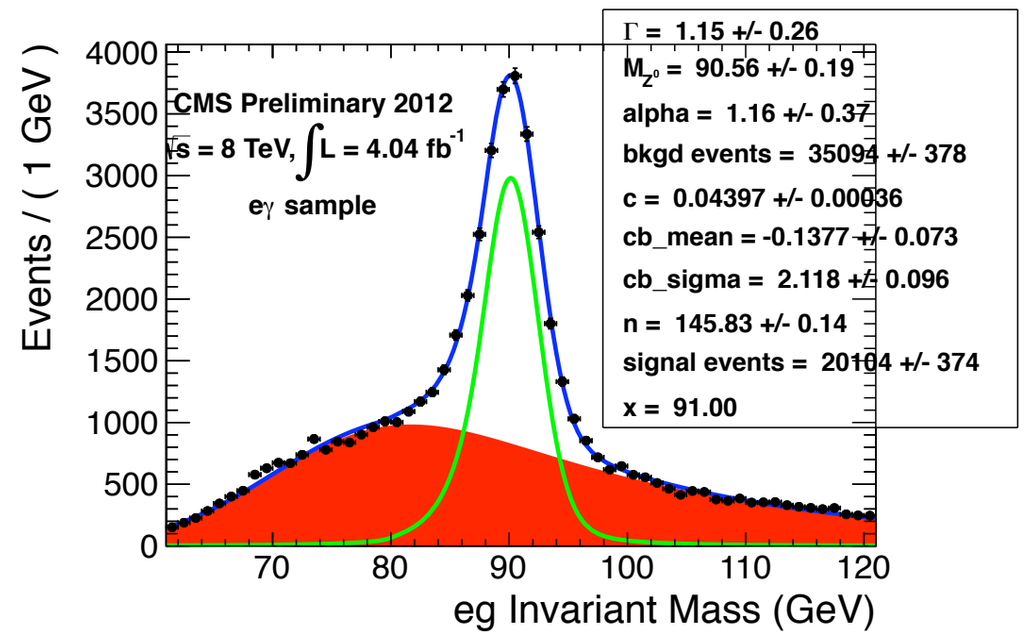
Single and Di-photon + MET SUS-12-018

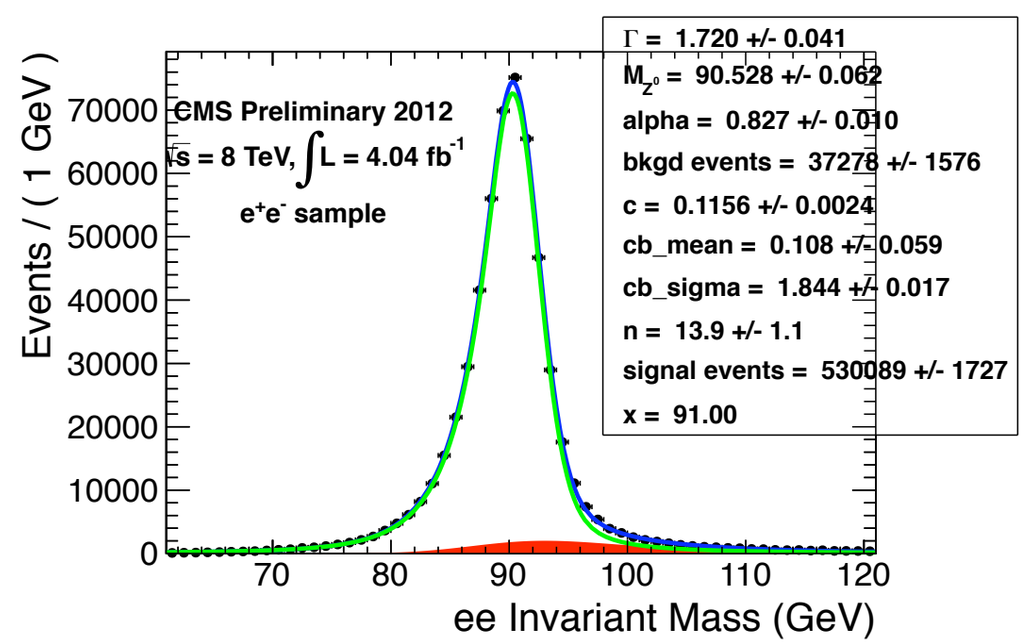
8 TeV with 4 fb^{-1}

- Two final state topologies
  - two (or more) photons with 40 (25) GeV, at least one jet, MET > 50 GeV
  - at least one photon with 80 GeV, at least two jets, MET > 100 GeV

- Photons (thanks to excellent Ecal resolution)
  - Ecal cluster shape matched to photon
  - H/p < 5%
  - pileup corrected Isolation
  - Pixel matching to reject electron

- Data-driven background estimation
  - mis-measurement of MET in QCD process :
    di-photon, photon+jets and multi-jet process
    (jets faking photons)
  - events with true MET in EWK process :
    real or fake photon+W
    (electrons mis-identified as a photon ~ 1%)

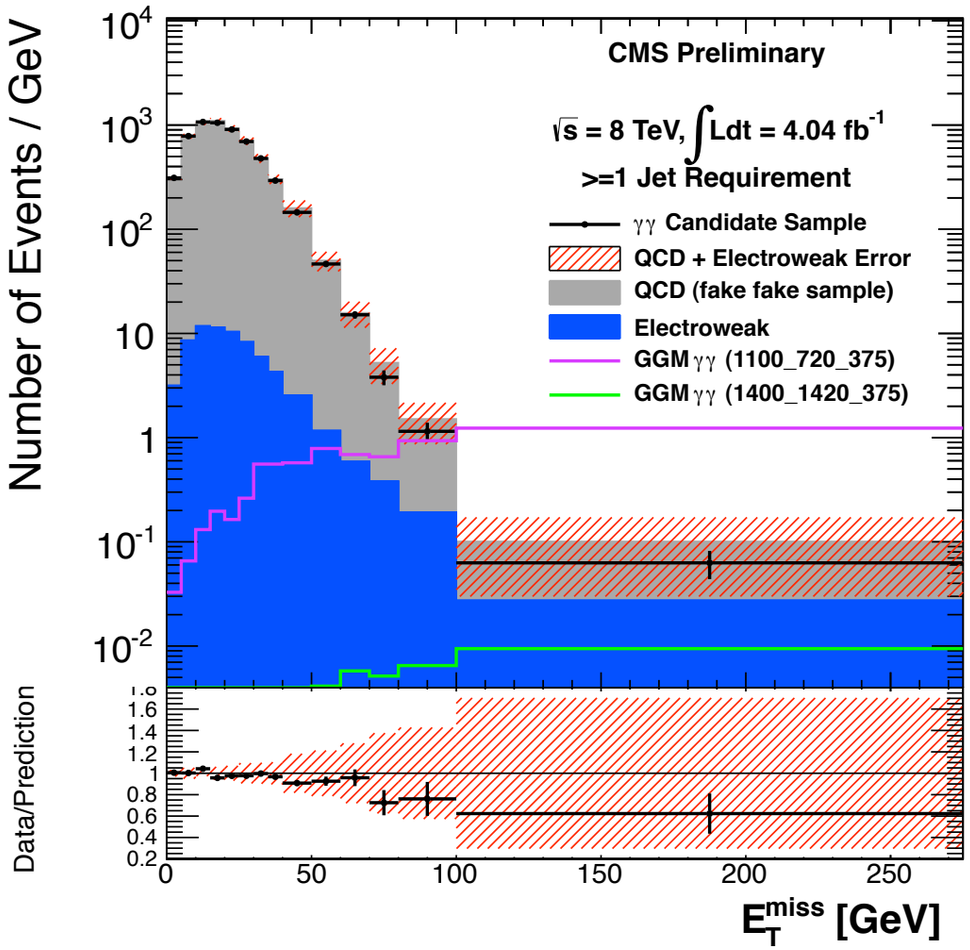




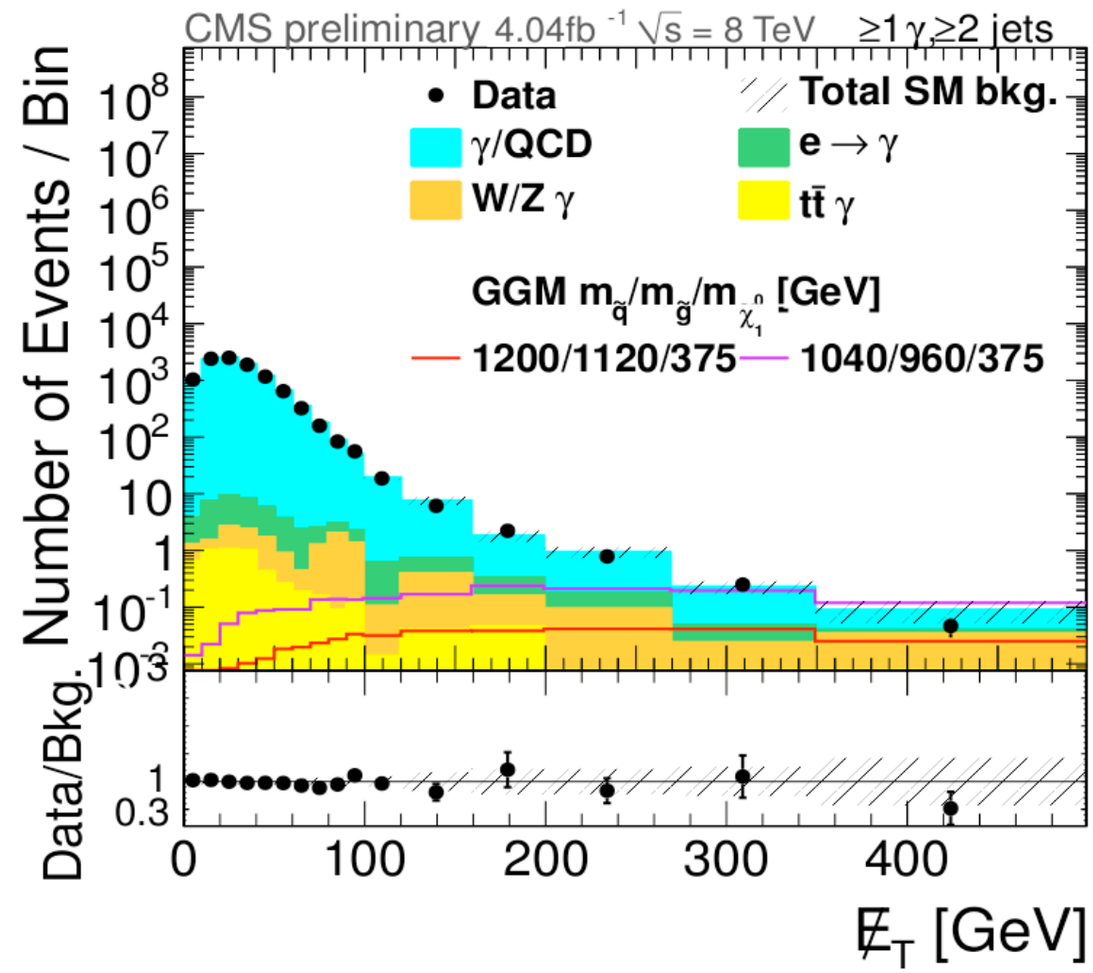
Single and Di-photon + MET SUS-12-018

8 TeV with 4 fb^{-1}

Di-photon



Single-photon



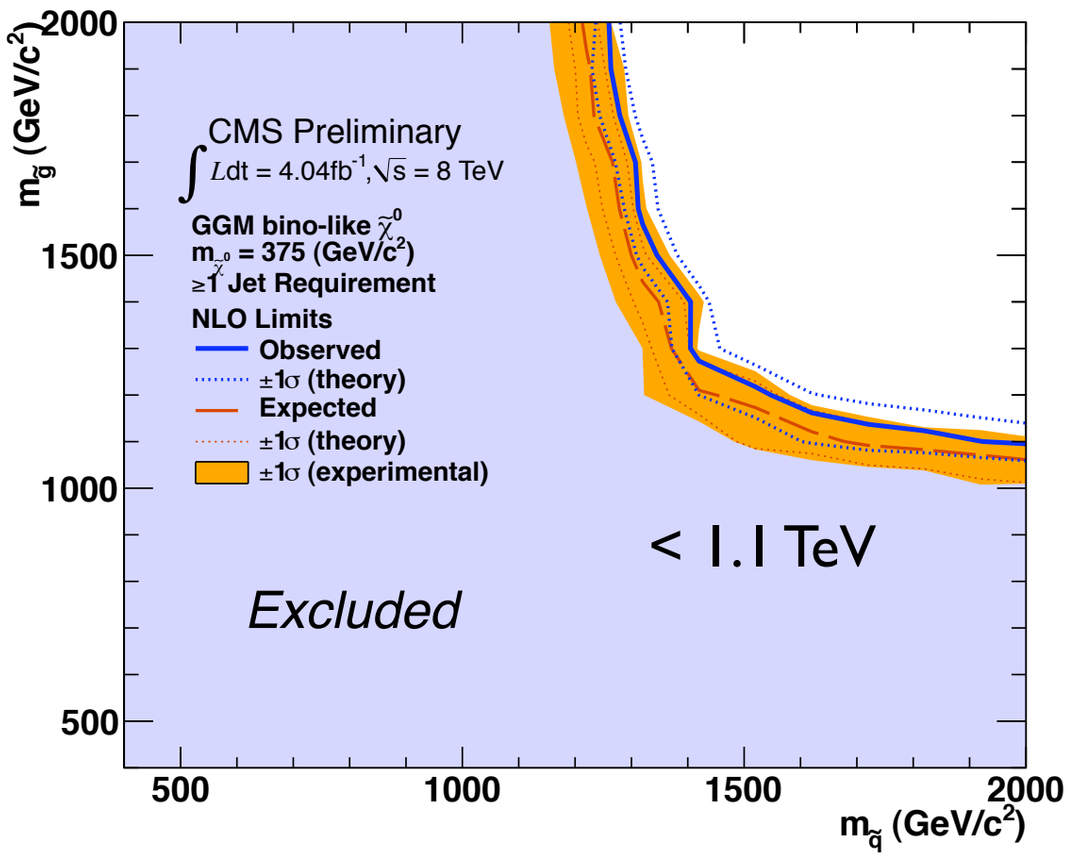
- MET > 50 GeV
- MET > 100 GeV
- Limits are calculated in six distinct bins above MET requirement.

Single and Di-photon + MET SUS-12-018

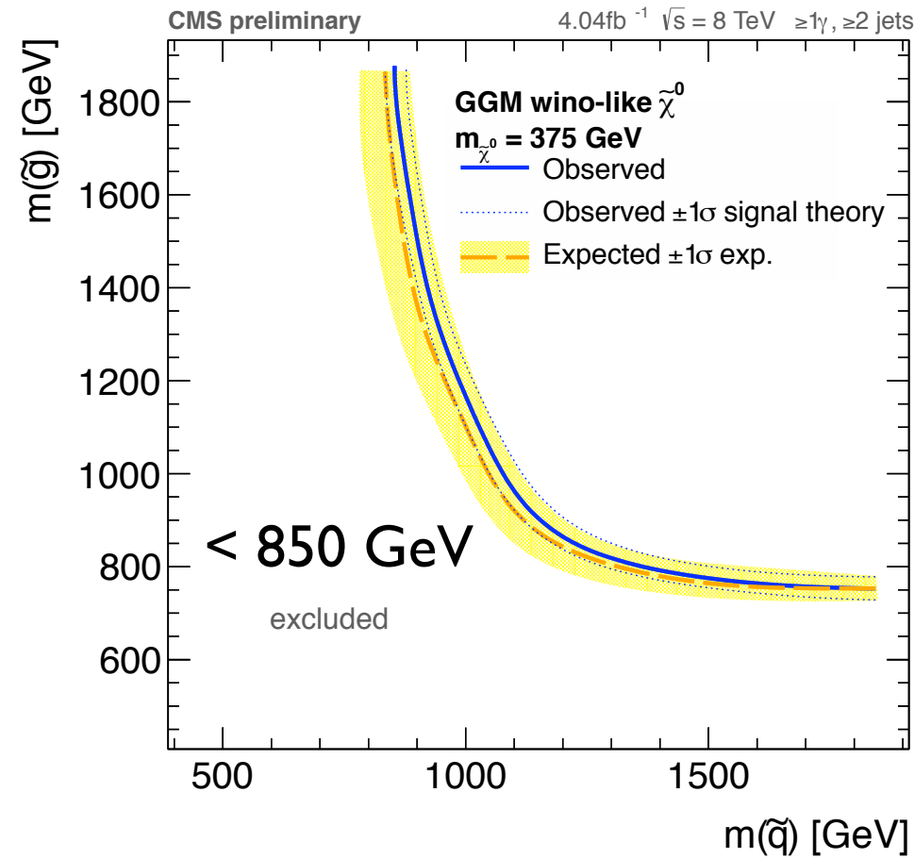
8 TeV with 4 fb^{-1}

Fixed the neutralino mass = 375 GeV

Di-photon : Bino-like



Single-photon : Wino-like



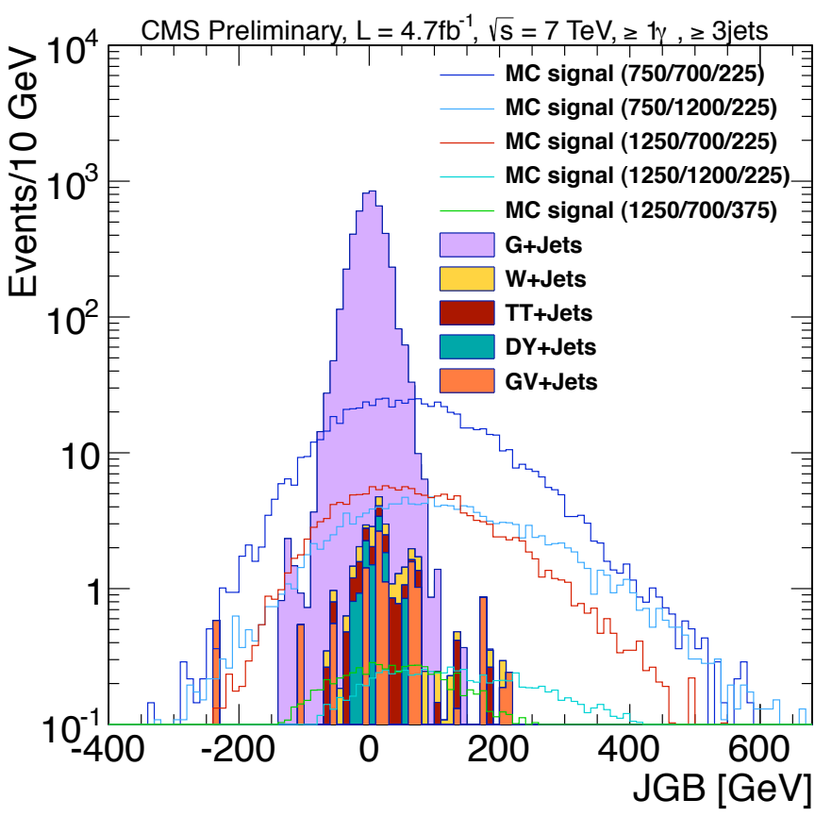
- Extended the limit with respect to previous analysis at 7 TeV.
  - by 100 GeV in the bino-like and 50 GeV in the wino-like scenario.
- Bino-like scenario is sensitive in di-photon
- Wino-like scenario is sensitive in single-photon

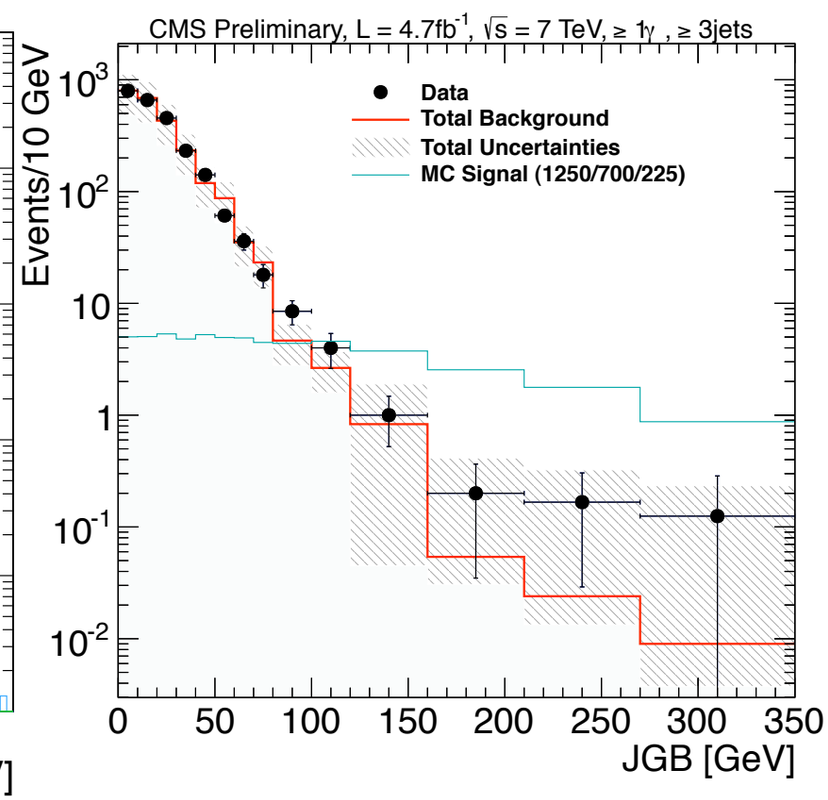
Jet-gamma balance method

SUS-12-013

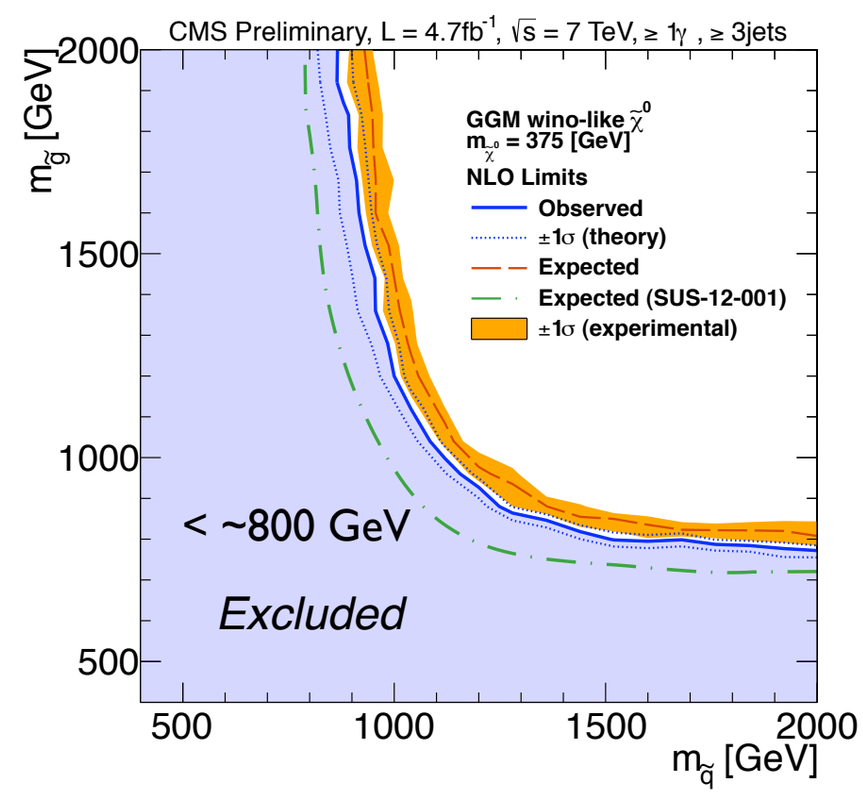
7 TeV with 4.7 fb^{-1}

- Event selection
  - >= 1 photon with p_T > 80 GeV, |η| < 1.4442
  - >= 3 jets p_T >100 GeV, |η|<2.6, dR(jet, γ) >0.4, HT > 460 GeV
- Jet Gamma Balancing $JGB = |\sum \overrightarrow{p_T, jets}| - |\overrightarrow{p_T, \gamma}| = |\overrightarrow{E_T^{miss}} + \overrightarrow{p_T, \gamma}| - |\overrightarrow{p_T, \gamma}|$
  - SUSY cascade decay→A high positive value of JGB.
  - Photons from PV are kinematically balanced→ JGB close to 0.
- Sensitive to Wino-like scenario





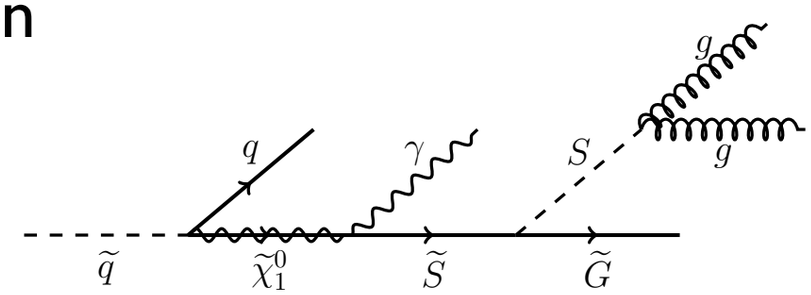
Wino-like



Stealth SUSY : low MET PLB 719 (2013) 42

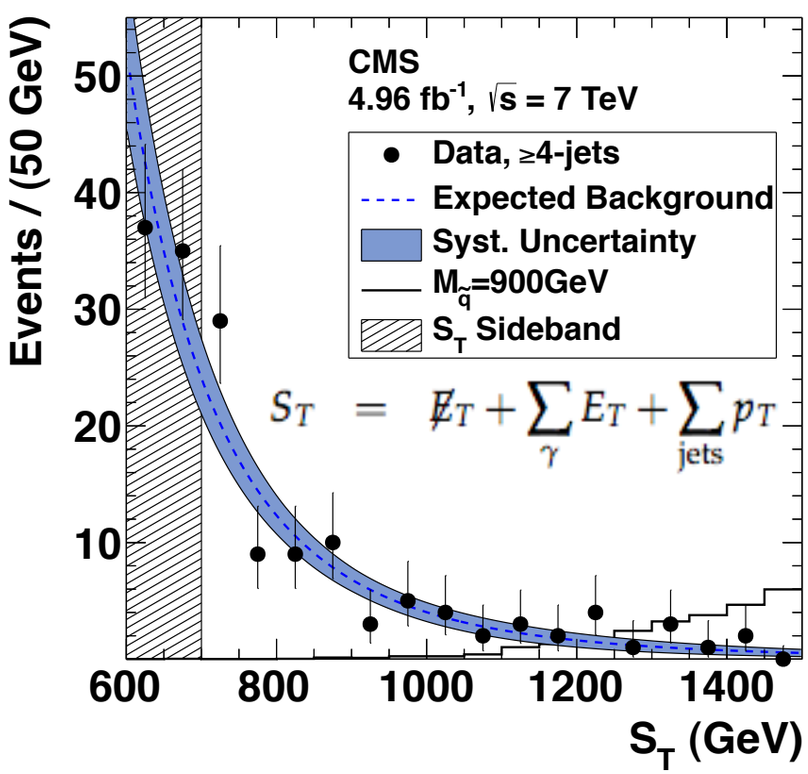
7 TeV with 5 fb^{-1}

- Motivation
  - The simplest Stealth SUSY : introduce additional hidden sector SUSY particle (LHSP) at the weak scale.
  - LHSP (singlino) decays to SM partner and LSP.
  - Near mass degeneracy →for the LSP with low MET.

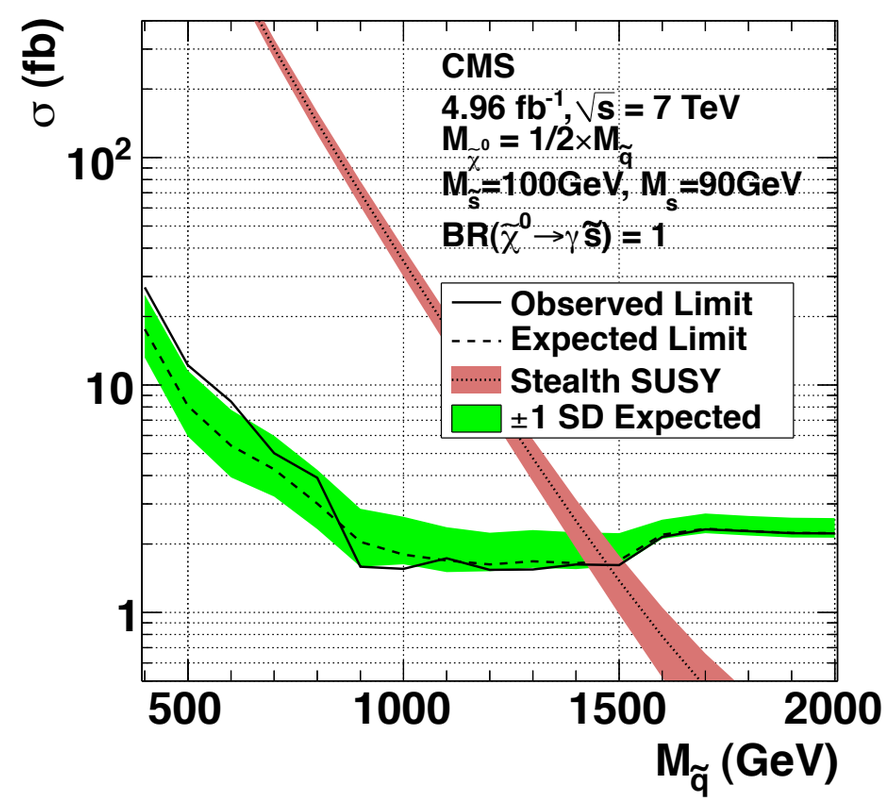


$$m_{\tilde{S}} - m_S \ll m_{\tilde{S}}$$

- Background estimation from data
  - S_T shape is from jet multiplicity side-bands. (2 jets or 3 jets)
- Set the CL_S limit in two bins (4 jets and >= 5 jets)



Bino-like : excluded < ~1430 GeV

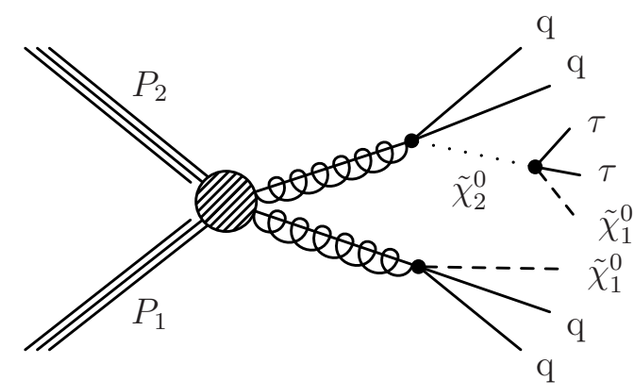


GMSB in tau decay

arXiv:1301.3792

- 7 TeV with 5 fb-1

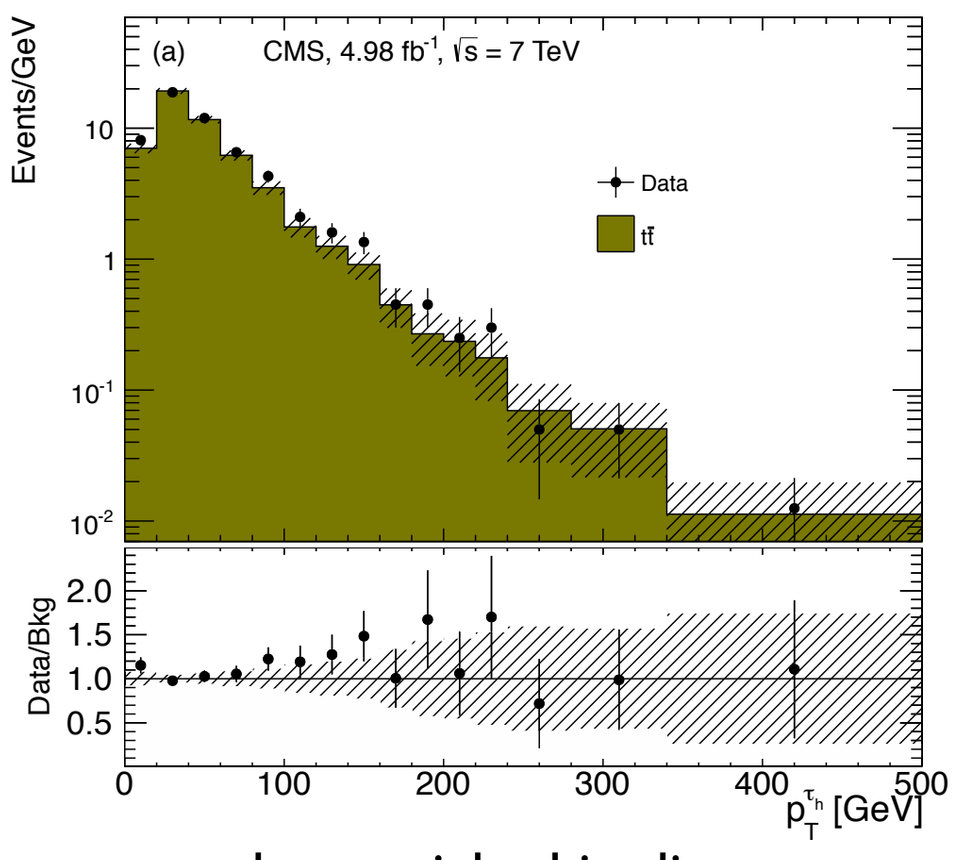
- Interpreted with GMSB model where stau is the charged NLSP which decays to a τ and a gravitino.
- The rate of misidentification as τ_h from data : 1-2%



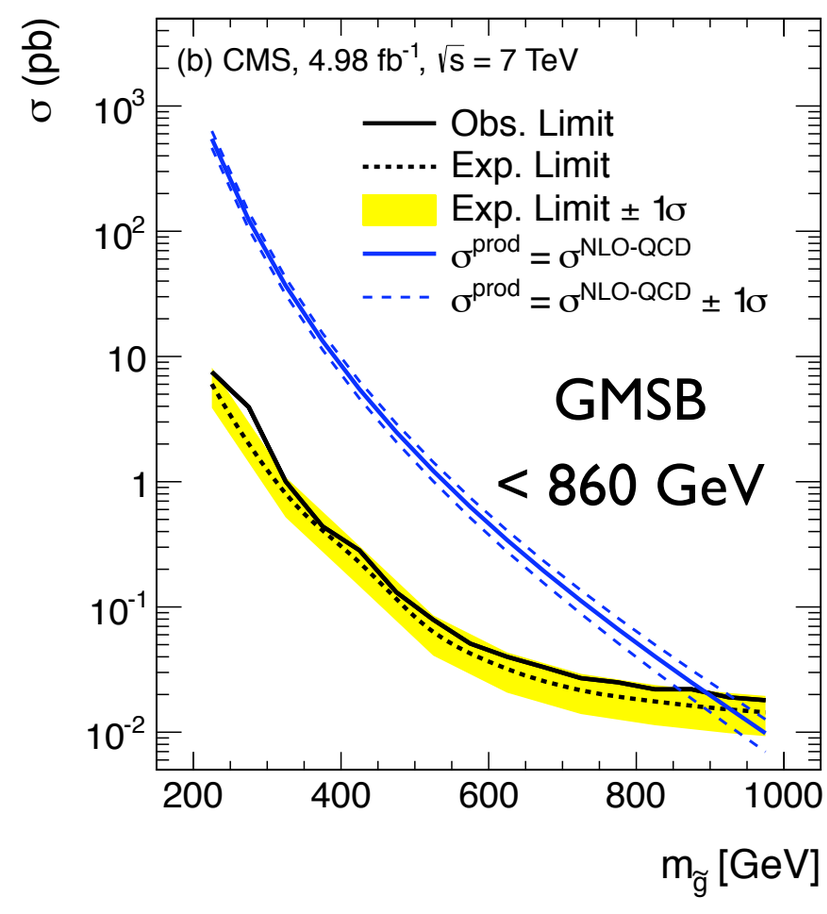
T3tauh in SMS (similar to GMSB)

$$\tilde{\chi}_2^0 \to \tau\tilde{\tau} \to \tau\tau\tilde{G}$$

- Di-tau final state result is interpreted in the context of GMSB assuming 100% branching ratio to tautau.



ttbar enriched in di-tau

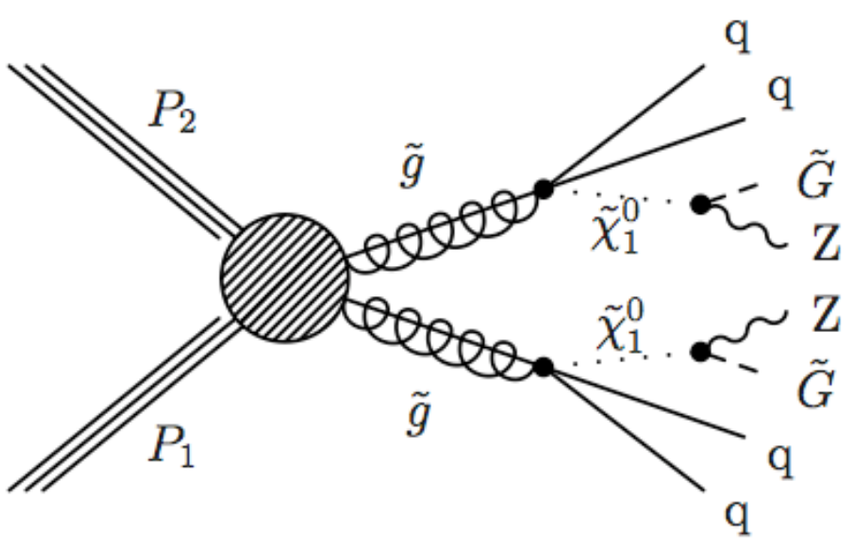


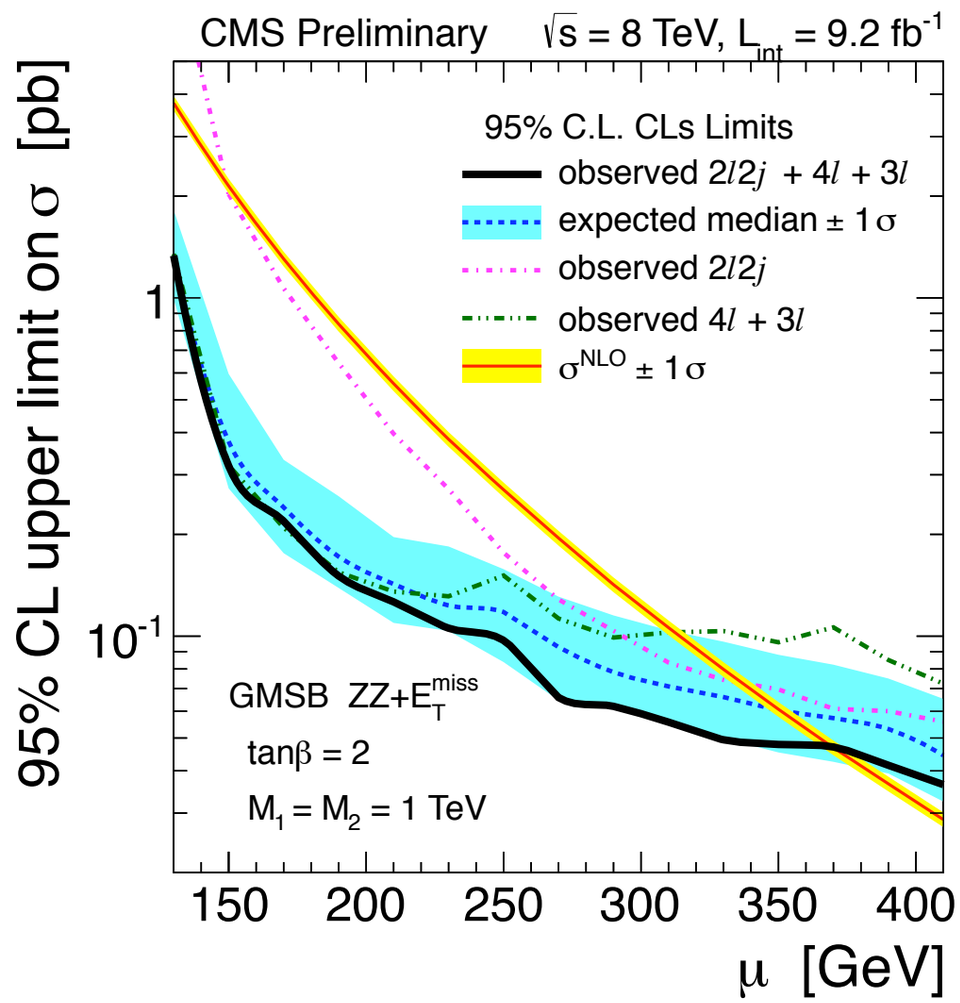
Dilepton : Z+jets+MET

SUS-12-022

8 TeV with 9.2 fb^{-1}

- EWK production
- Dilepton final states.
- See the Marc Dunser's talk, "*SUSY searches for EWK production of Gauginos and Sleptons at the LHC*"





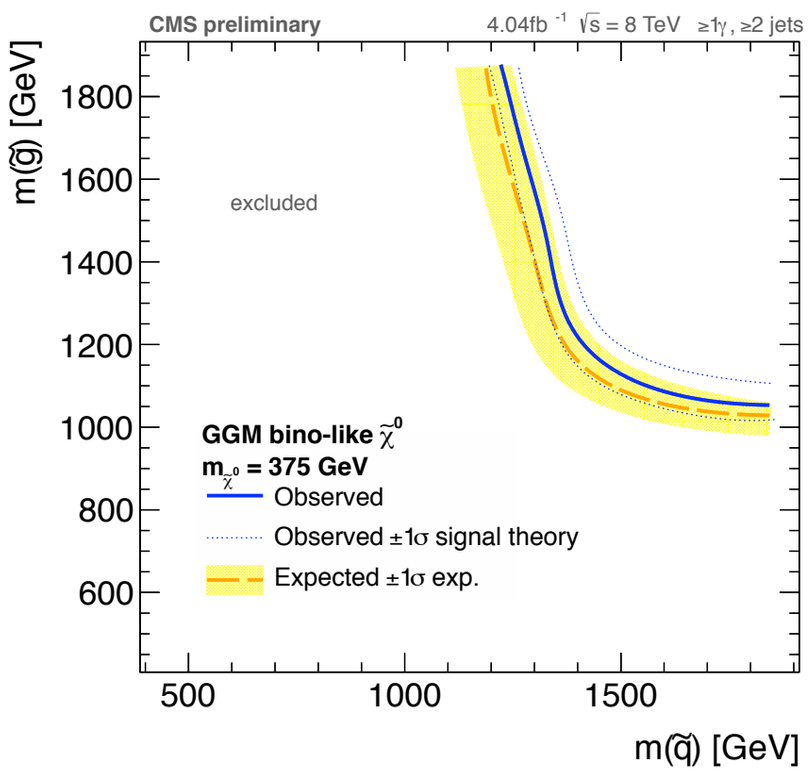
Conclusion

- gluino and squark mass < ~1.1 TeV excluded for bino-like NLSP.
- gluino and squark mass < ~850 GeV excluded for wino-like NLSP.
- low MET or lepton final states has been explored in GMSB.
- SUSY (in GMSB) is excluded more if it is strongly produced.
- Updating with full data with lepton(+photons), sensitive to EWK production.
- More searches coming for the higgsino-like neutralino.

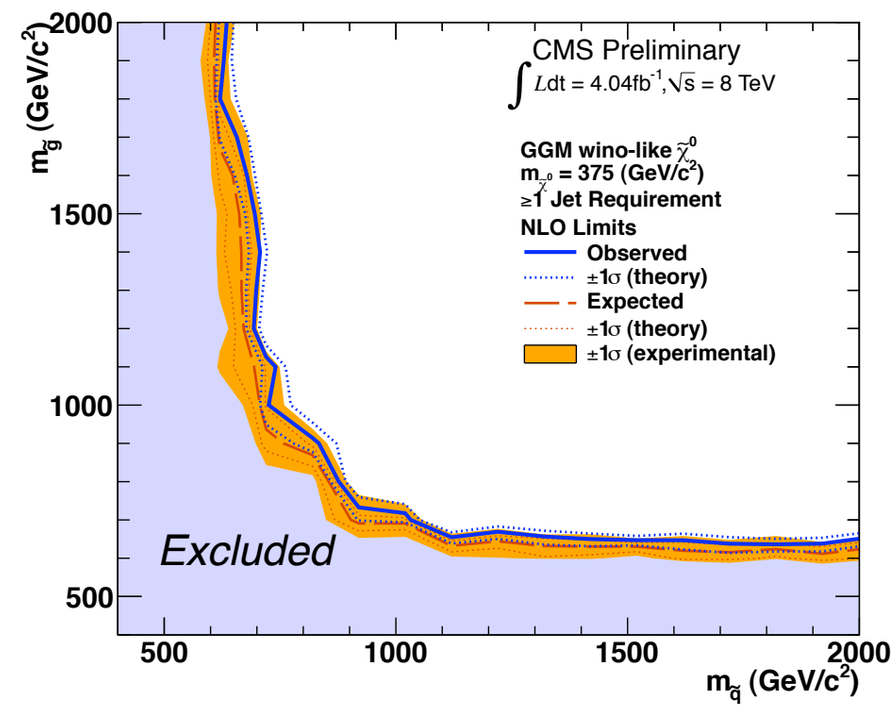
Single and Di-photon + MET SUS-12-018

Other interpretations

- Single-photon : Bino-like



- Di-photon : Wino-like



- Bino-like scenario is less sensitive in single-photon.
- Wino-like scenario is less sensitive in di-photon.

- Further interpretations : JHEP03 (2013) 111 at 7 TeV
  - gluino-bino and gluino-wino mass planes (fixed squark mass 2500 GeV)
  - SMS $\Upsilon\Upsilon \rightarrow \Upsilon\Upsilon$ and $\Upsilon\Upsilon \rightarrow \Upsilon W$
  - Unified extra dimensions

Lepton+photon

7 TeV (PLB 716, 260–284)

- Jet-Z Balancing method or MET template