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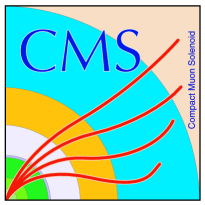

SUSY2014: The 22nd International Conference on
Supersymmetry and Unification of Fundamental Interactions
21–26 July 2014, Manchester, England

Searches for SUSY in Final States with Photons

On Behalf of the CMS Collaboration

22 July 2014

Gail G. Hanson

University of California, Riverside

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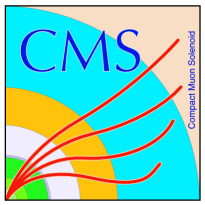
OUTLINE



- Search for SUSY in Two Photon + Jet Events with Razor Variables at 8 TeV – CMS-PAS-SUS-14-008 NEW FOR SUSY2014

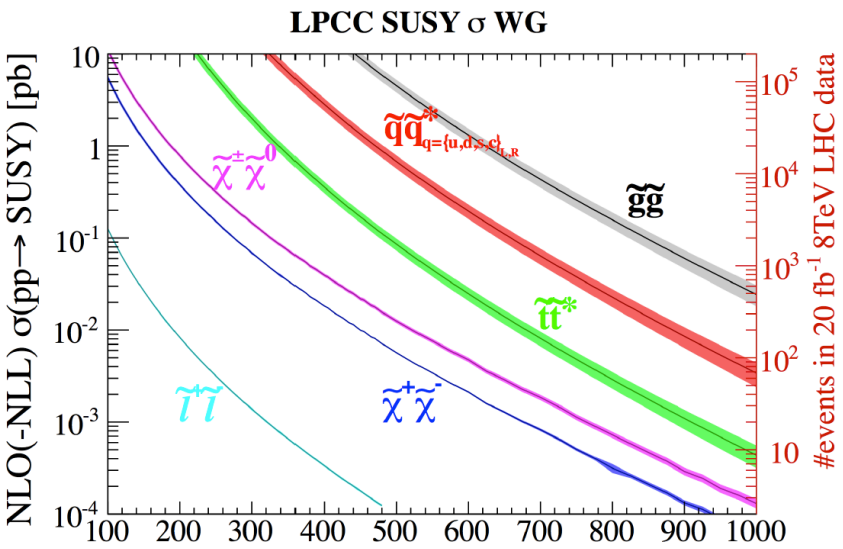
- Search for Top Squark and Higgsino Production Using Diphoton Higgs Boson Decays – CMS-PAS-SUS-13-014, *Phys. Rev. Lett.* **112** (2014) 161802

FIRST PRESENTED AT SUSY2013

- Search for Electroweak Neutralino and Chargino Production in Channels with Higgs, Z, and W Bosons at 8 TeV – CMS-PAS-SUS-14-002

NEW FOR ICHEP2014

SEARCHES FOR STRONG AND ELECTROWEAK SUSY PRODUCTION



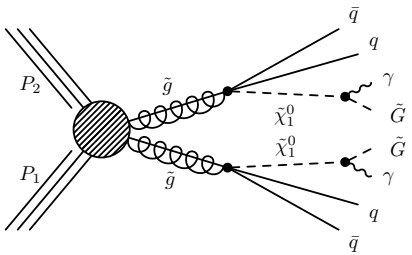
Many searches for strong production of SUSY but with null results

Smaller cross section for electroweak production but different tools

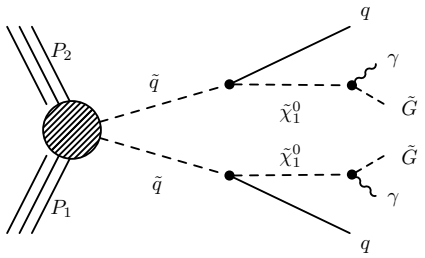
In this presentation will discuss both for final states involving photons

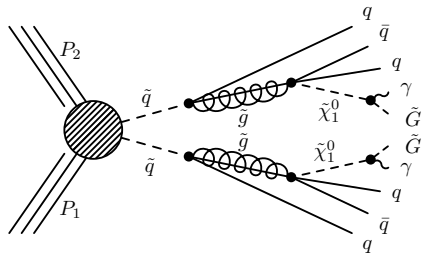
Search for SUSY in Two-Photons + Jet Events with Razor Variables CMS-PAS-SUS-14-008

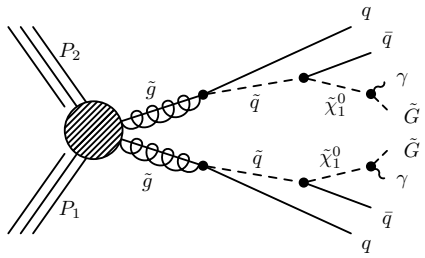
NEW



Simplified Model T5gg







General Gauge Mediation GGM

ANALYSIS

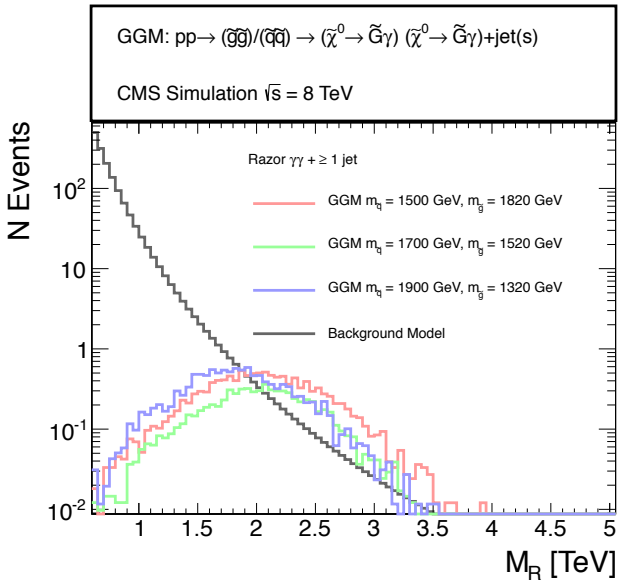
- Two photons: isolated, cluster shape, $|\eta| < 2.5$, $p_T > 30, 22$ GeV
- One or more jets with $p_T > 40$ GeV, $|\eta| < 2.5$
- Event is divided into two "megajets" selected as the pair with the smallest sum of squared invariant masses

Razor Variables

$$M_R \equiv \sqrt{\left(\left|\vec{p}_{j1}\right| + \left|\vec{p}_{j2}\right|\right)^2 - \left(p_z^{j1} + p_z^{j2}\right)^2}$$

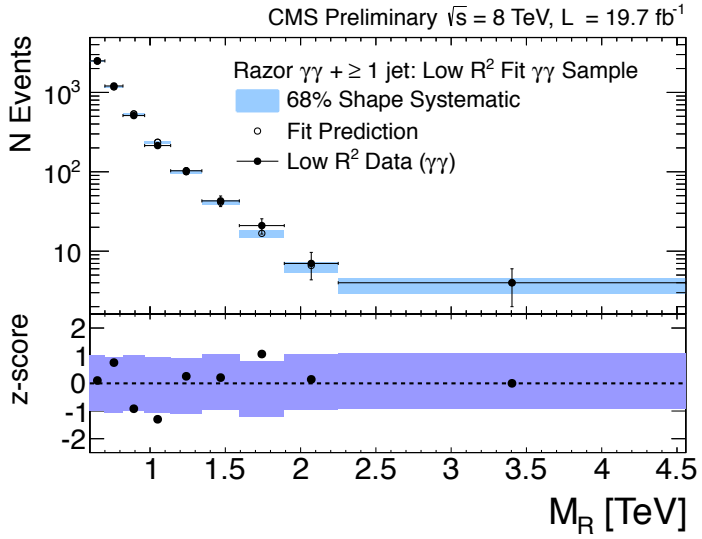
$$M_T^R \equiv \sqrt{\frac{E_T^{miss}\left(p_T^{j1} + p_T^{j2}\right) - \vec{E}_T^{miss} \cdot \left(\vec{p}_T^{j1} + \vec{p}_T^{j2}\right)}{2}}$$

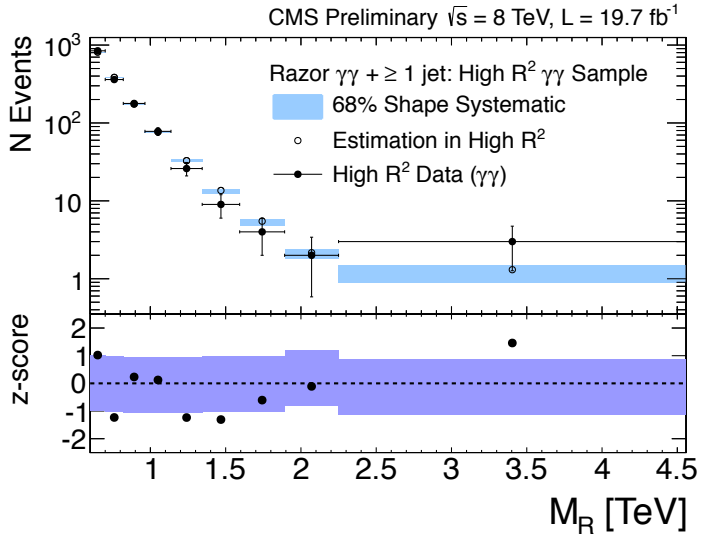
$$R \equiv \frac{M_T^R}{M_R}$$



- Signal region: $M_R > 600$ GeV and $R^2 > 0.02$
- Control region: $M_R > 600$ GeV and $0.01 < R^2 < 0.02$ (signal contamination < 10%) used to fit data for M_R shape
- Photons that fail the cluster shape or isolation requirements are used as a cross check of the background method

Diphoton Razor Results



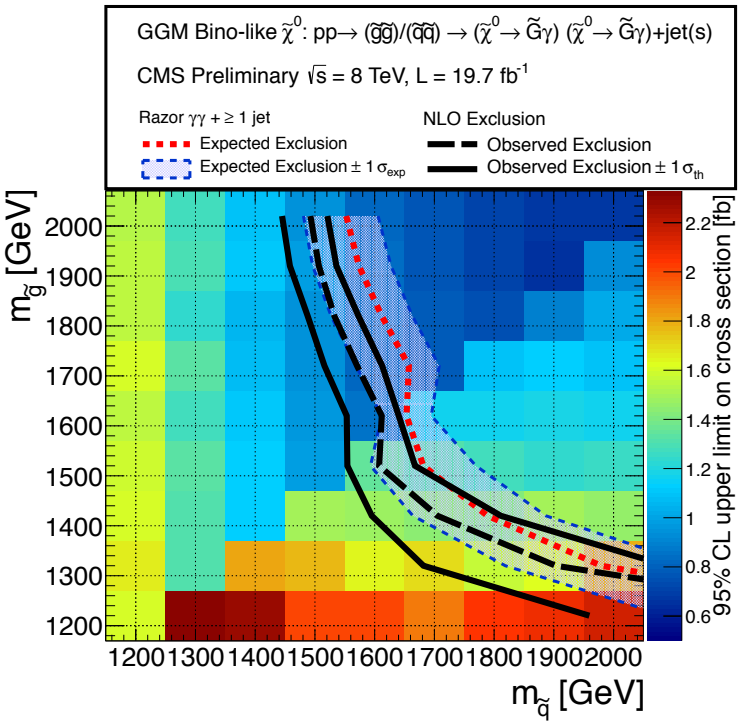


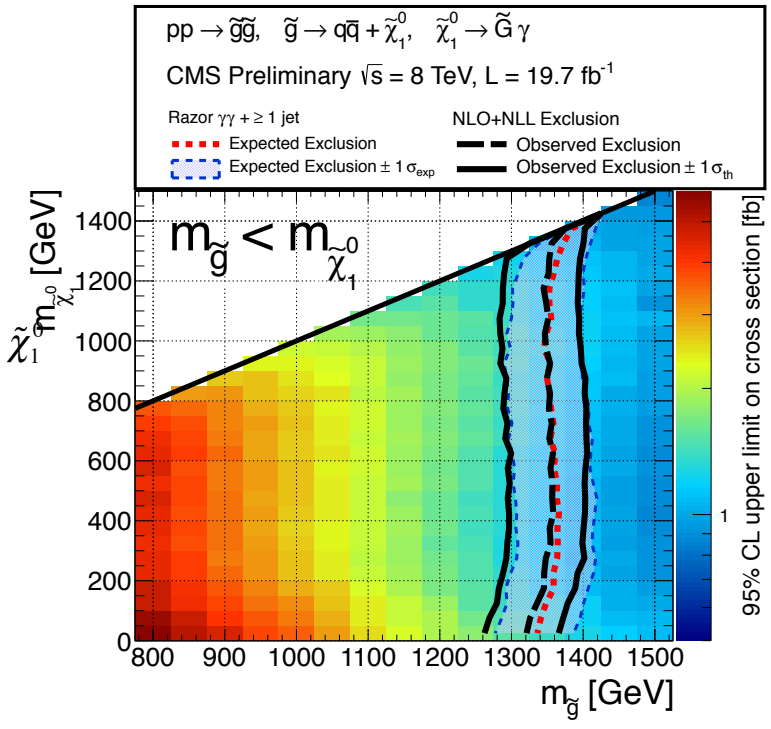
M_R distribution in low R^2 control region

M_R distribution in high R^2 signal region

No evidence for a signal

INTERPRETATION – LIMITS



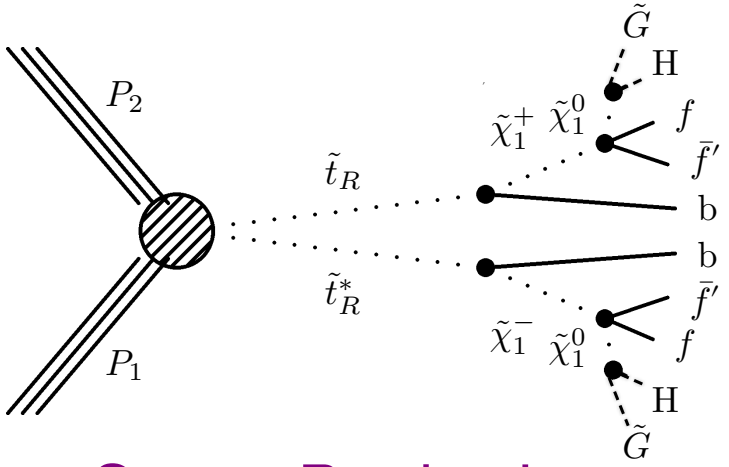


$\tilde{\chi}_1^0$ Mass fixed to 375 GeV

Search for Top Squark and Higgsino Production Using Diphoton Higgs Boson Decays (SUS-13-014), *Phys. Rev. Lett.* **112** (2014) 161802

First shown at SUSY2013

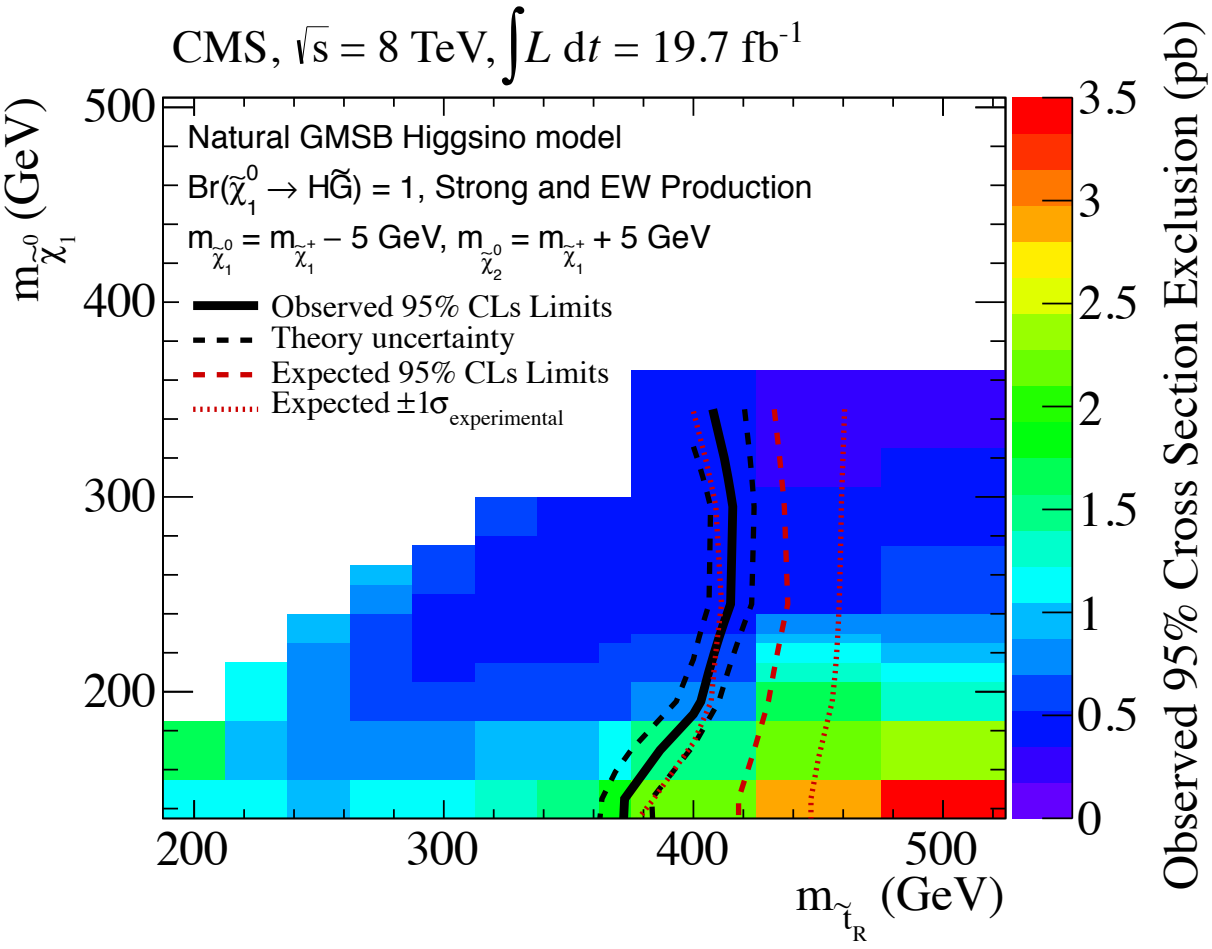
- Search for "natural" SUSY using GMSB
- First CMS "Higgs tagging" to search for SUSY



Strong Production

The Higgs boson is reconstructed via the diphoton decay.
Two b quarks are also present either from decay of the other Higgs or from the top squark decay.
Events are also characterized by missing transverse energy.

Limits for Stop Quark and Higgsino Masses



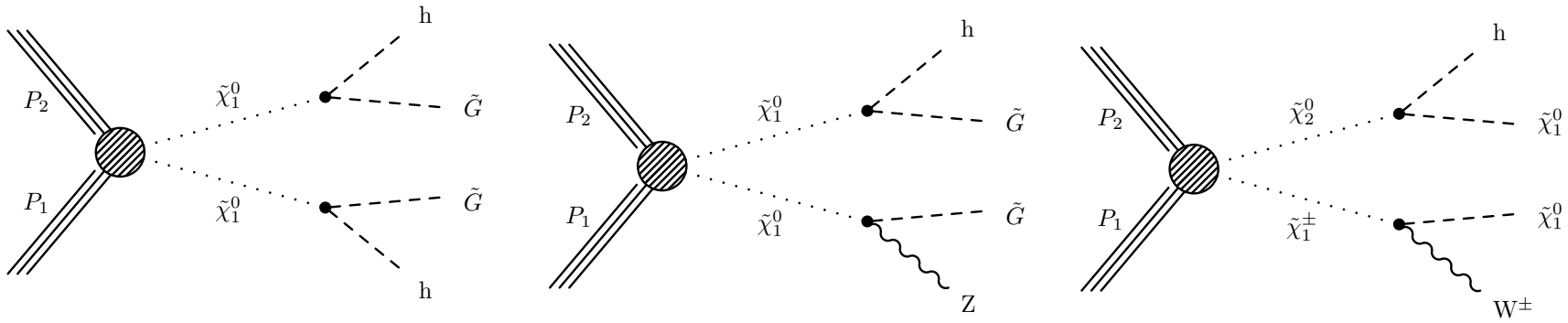
Search for Electroweak Neutralino and Chargino Production in Channels with Higgs, Z, and W Bosons

CMS-PAS-SUS-14-002

NEW FOR ICHEP2014

hh and hZ production through GMSB model with lightest neutralino $\tilde{\chi}_1^0$ NLSP and nearly massless gravitino LSP.

hW production through chargino-neutralino pair creation. $\tilde{\chi}_1^0$ is massive LSP.



Channels Used

- Channels used for hh: ($\gamma\gamma$)($b\bar{b}$), ($b\bar{b}$)($b\bar{b}$), ($\gamma\gamma$)(leptons), (leptons)(leptons)
- Channels used for hZ: ($\gamma\gamma$)(2 jets), ($\gamma\gamma$)(leptons), ($b\bar{b}$)(leptons), (leptons)(leptons)
- Channels used for hW: ($\gamma\gamma$)(2 jets), ($\gamma\gamma$)(leptons), ($b\bar{b}$)(leptons),(leptons)(leptons)

Leptonic channels will be covered in another talk

$h \rightarrow \gamma\gamma$ Reconstruction

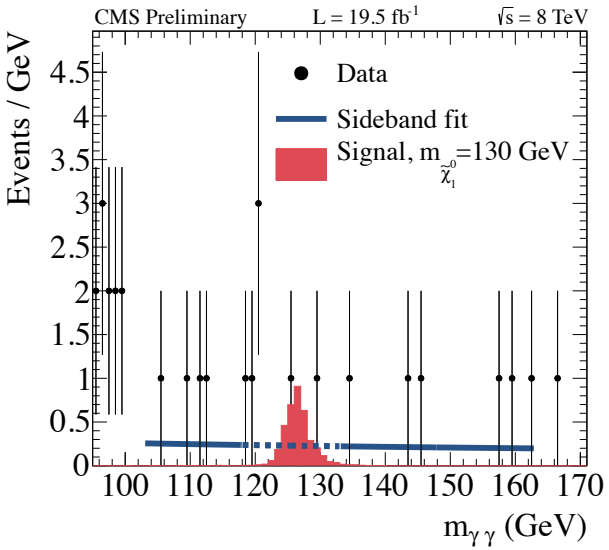
- Two photons: isolated, cluster shape, $|\eta| < 1.44$, $p_T > 40, 25$ GeV
- h candidate is formed from two highest p_T photons in the event
- Diphoton invariant mass $m_{\gamma\gamma}$ is required to be within Higgs boson mass region $120 < m_{\gamma\gamma} < 131$ GeV
- $m_{\gamma\gamma}$ sidebands defined by $103 \leq m_{\gamma\gamma} \leq 118$ GeV and $133 \leq m_{\gamma\gamma} \leq 163$ GeV are used to determine background from data

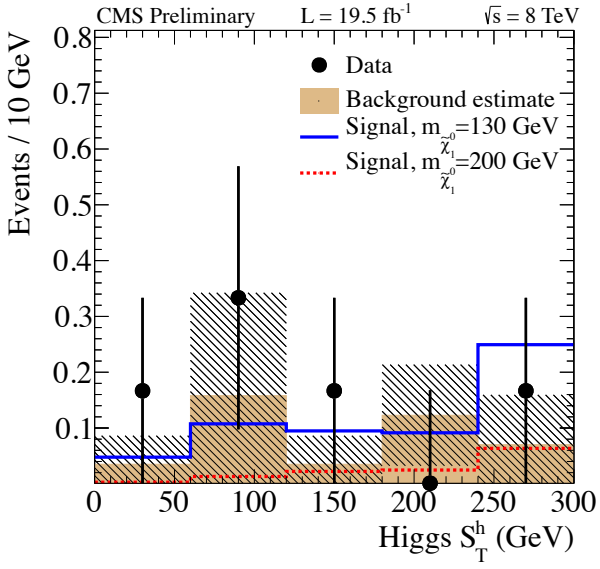
$h \to b\bar{b}$ Reconstruction

- b jets identified using combined secondary vertex algorithm (CSV): displaced secondary vertices, tracks with large impact parameters, kinematic variables. Three operating points (efficiency, misidentification probability) for jets with $p_T > 60$ GeV:
  - "loose" (83%, 10%)
  - "medium" (70%, 1.5%)
  - "tight" (55%, 0.1%)

h(γγ)h(bb̄) Channel

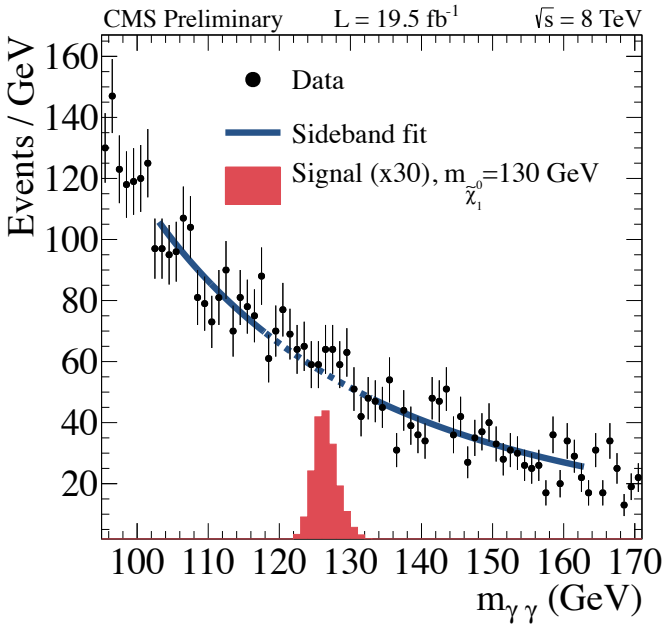
- Exactly two tagged b jets
- Invariant mass of the two b jets between 95 and 155 GeV
- No identified isolated electron or muon candidates
- S_T^h, the scalar sum of the *p*T's of the two Higgs candidates, is the discriminating variable

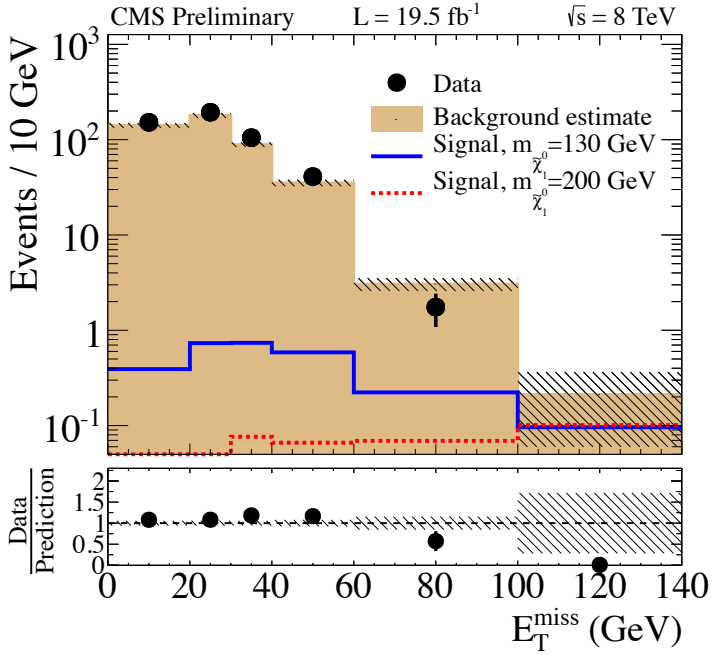




hZ and hW $\rightarrow \gamma\gamma$ + 2 jets

- Similar to h($\gamma\gamma$)h($b\bar{b}$)
- Z or W formed from two jets with dijet mass between 70 and 110 GeV
- E_T^{miss} is the discriminating variable rather than S_T^h





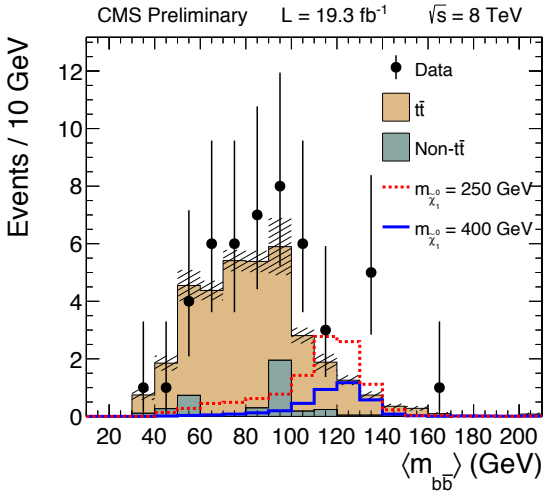
Already public in February 2014

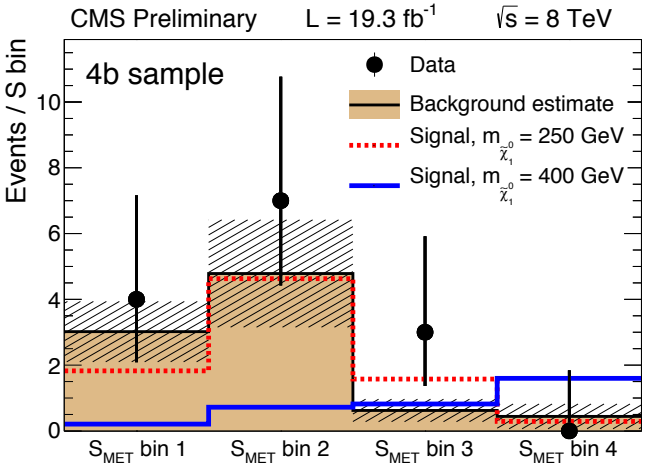
$h(b\bar{b})\,h(b\bar{b})$ Channel

With a branching fraction of ≈ 0.56 $h \to b\bar{b}$ decays represent the most likely decay mode

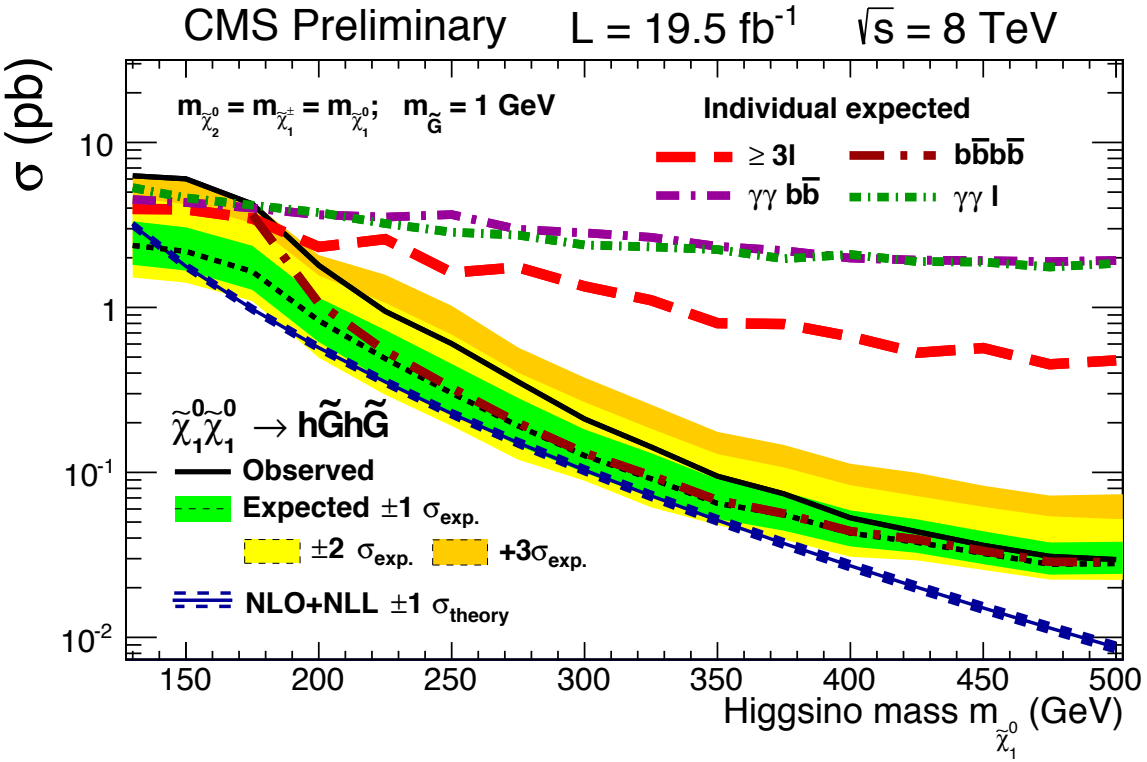
All jets must satisfy $p_T > 20$ GeV, $|\eta| < 2.4$

- Exactly 4 or exactly 5 jets, with $p_T > 50$ GeV for two highest p_T jets
- E_T^{miss} significance $S_{MET} > 30$
- No isolated charged particles
- Reject fake E_T^{miss} with $\Delta\phi_{min}$ cut between E_T^{miss} vector and jets



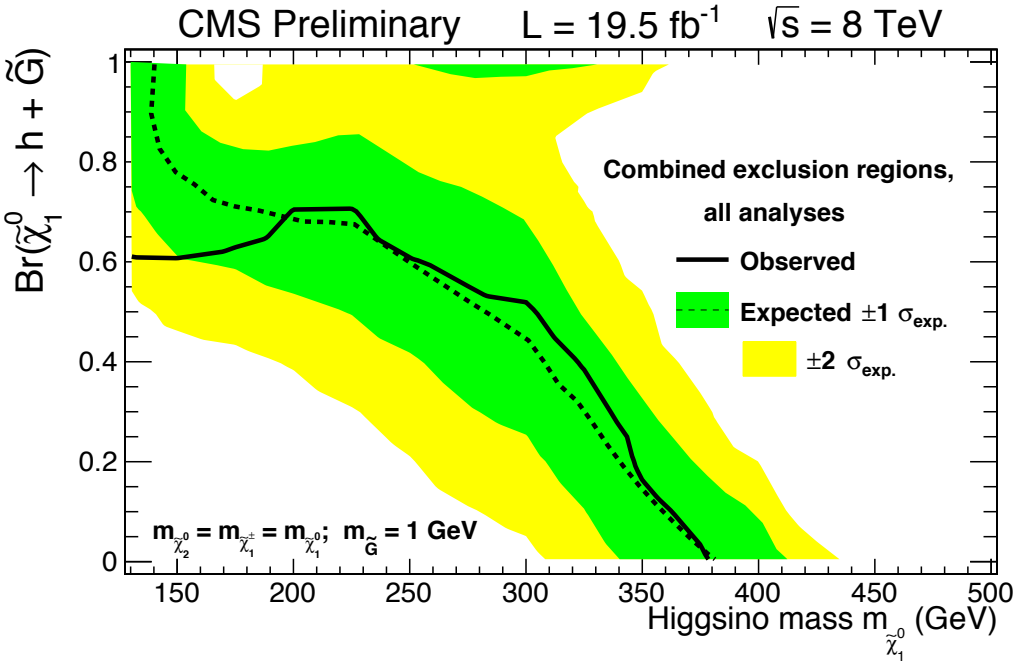


hh GMSB Higgsino Interpretation



- 4 b channel is most sensitive for higgsino mass > 200 GeV.
- Observed limit deviates from expected for higgsino mass less than about 170 GeV due to excess in multi-lepton channel

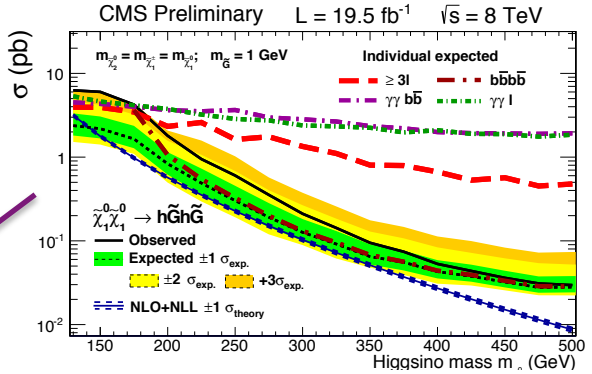
hh and hZ GMSB Interpretation

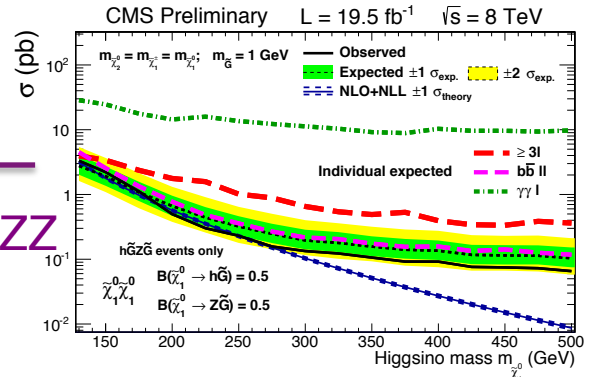


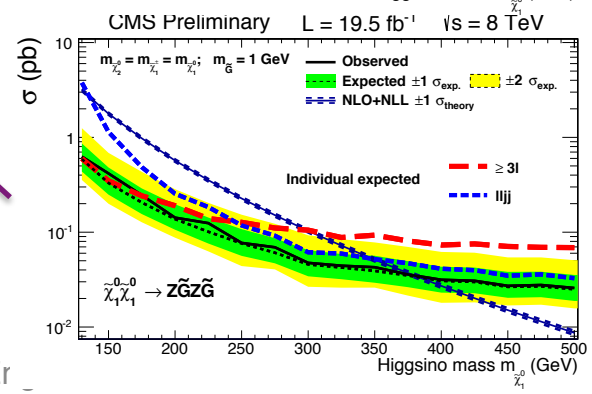
hh

hh, hZ, ZZ

ZZ

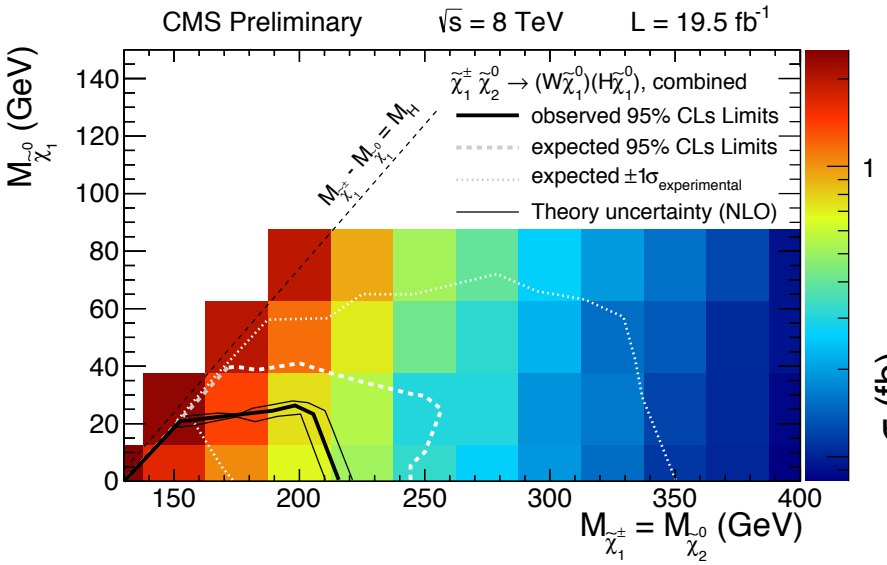


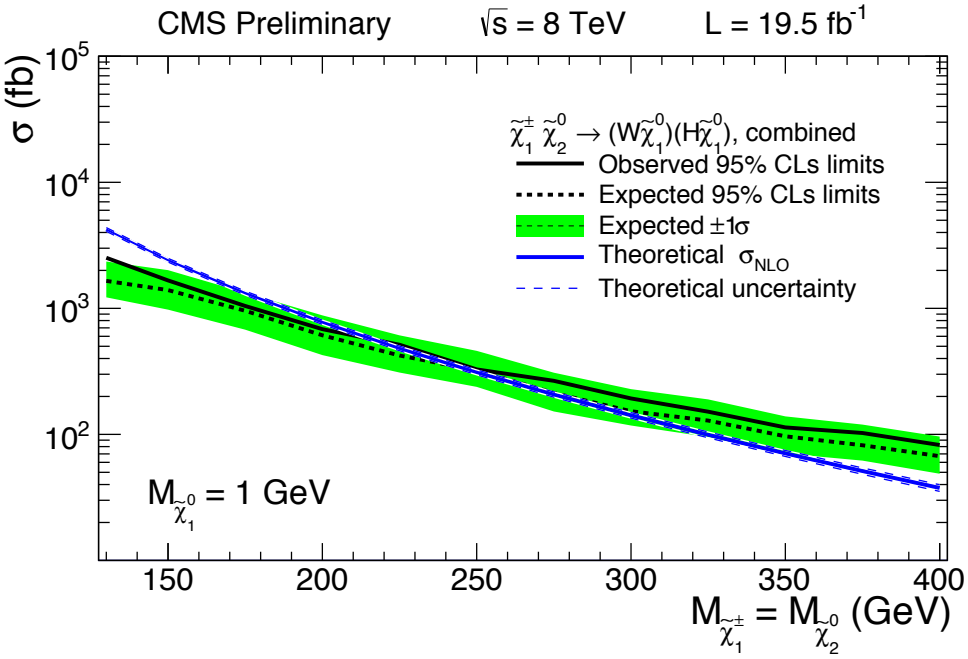




(Leptonic channels also used)

hW Electroweak Chargino-Neutralino Pair Production Interpretation





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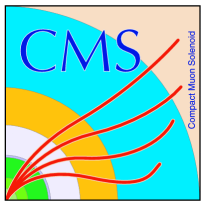
Combined Chargino-Neutralino Limits



- More sensitivity when lepton channels are included – see presentation by Santiago Folgueras on Friday!

CONCLUSIONS

- New diphoton search using razor variables, interpreted in T5gg as well as GGM
- First Higgs tagging in search for stop and higgsino (shown at SUSY2013)
- Electroweak production with Higgs tagging with photons and b's

No SUSY yet, but we are looking forward to 13 TeV data with higher cross sections in 2015!

THANK YOU FOR YOUR ATTENTION!