Current Status of GMSB Searches at CMS

SUSY at the Near Energy Frontier

Fermilab

Peter Thomassen
Rutgers University

November 12, 2013

RUTGERS

Outline

- Introduction
- Recent direct GMSB searches
  - SUS-13-002: co-NLSP, stau-NLSP, Natural Higgsino NLSP
  - SUS-13-014: Natural Higgsino NLSP (diphotons)
  - SUS-13-006: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")
  - SUS-12-018: Photons with MET
- Other GMSB searches
- Conclusions

Motivation

- If SUSY exists, it is broken
- What mechanism breaks it?
  - One option: Gauge-mediated SUSY breaking
  - Additional particle: goldstino = gravitino
- In many GMSB models, all sparticles eventually decay to SM particles + gravitino
- The corresponding signatures are addressed by several CMS searches
- Final state involves
  - MET from the (almost) massless gravitino
  - SM particles from sparticle decays

Motivation

- In this talk, the current status of CMS GMSB searches is presented
- All recent direct searches use 2012 data from pp collisions collected by the CMS detector (8 TeV)
  - Search results are interpreted to obtain limits on GMSB models (assuming R-parity and prompt decays)
  - Further information available at https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS
- Constraints from other searches exist as well (not always interpreted in GMSB scenarios)
  - Only giving a quick overview
  - Further information available at https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO

Outline

- Introduction
- Recent direct GMSB searches
  - SUS-13-002: co-NLSP, stau-NLSP, Natural Higgsino NLSP
  - SUS-13-014: Natural Higgsino NLSP (diphotons)
  - SUS-13-006: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")
  - SUS-12-018: Photons with MET
- Other GMSB searches
- Conclusions

SUS-13-002
Analysis Overview

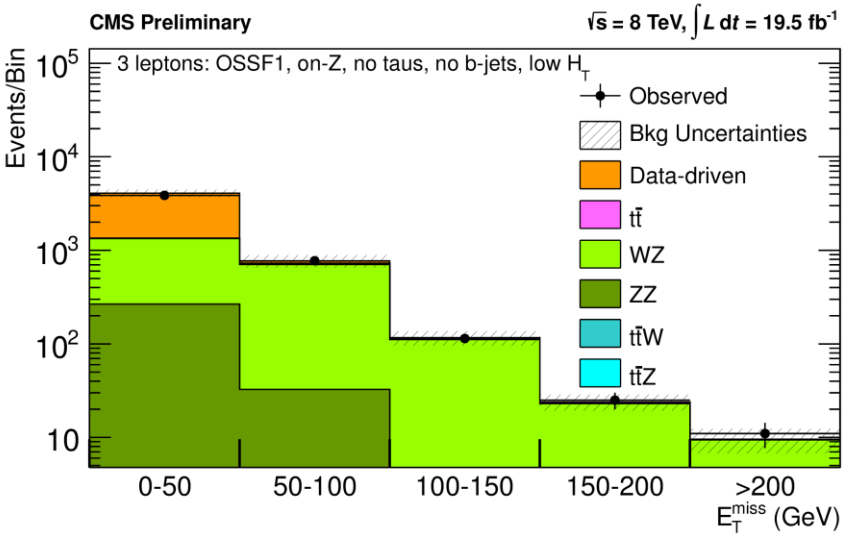
RUTGERS

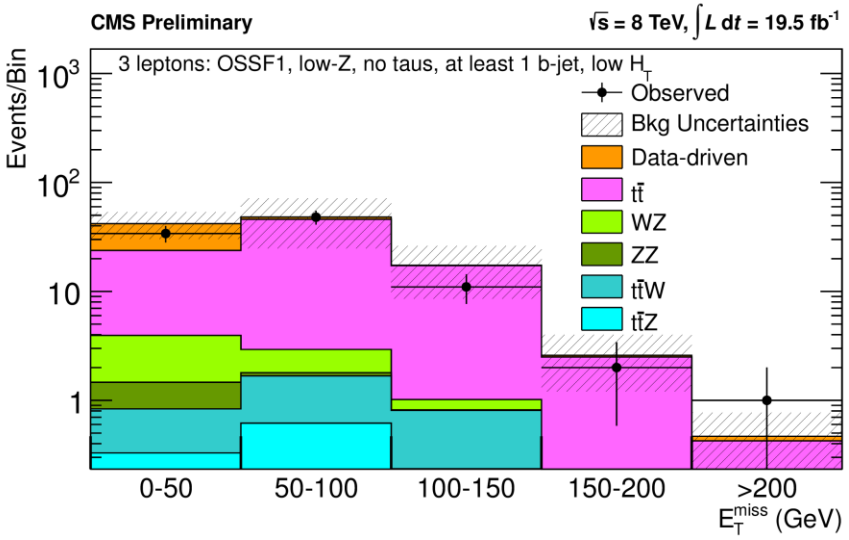
- Inclusive multi-lepton search with full 2012 dataset (19.5/fb)
  - one application: GMSB models
- General idea: Don't cut, but bin in event properties
  - Take advantage of the power of cuts (high S/B), but still make use of the rest of the data
- Bin in number of leptons, hadronic taus, OSSF pairs, dilepton mass, b-tags, MET, H_T (~300 signal regions in total)
- Backgrounds:
  - ttbar, WZ, ZZ – from validated MC simulations
  - Non-prompt leptons from jets – data-driven
  - Asymmetric photon conversions – data-driven
  - Rare backgrounds (ttV, Higgs, …) are estimated from MC
- To compute limits, use most sensitive signal regions
  - They can vary from model to model and also from point to point in the model parameter space

SUS-13-002
Some results (complete tables in backup)

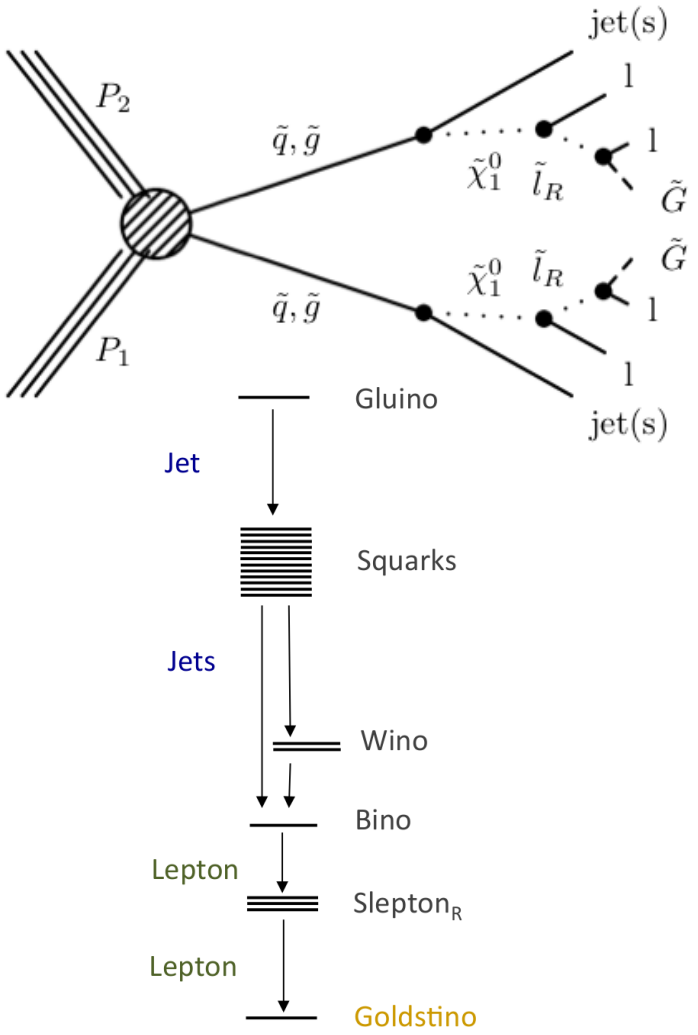
RUTGERS

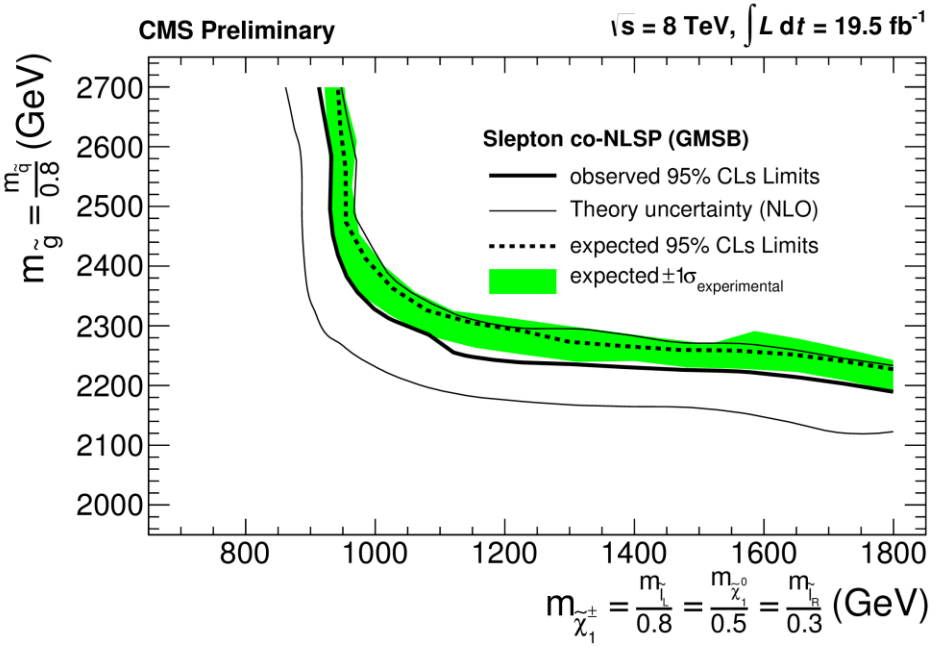
Selection 3 Lepton Results		E_T^{miss}	$N(\tau_h)=0$, $N_{b-jets}=0$ obs	$N(\tau_h)=0$, $N_{b-jets}=0$ exp	$N(\tau_h)=1$, $N_{b-jets}=0$ obs	$N(\tau_h)=1$, $N_{b-jets}=0$ exp	$N(\tau_h)=0$, $N_{b-jets}\geq 1$ obs	$N(\tau_h)=0$, $N_{b-jets}\geq 1$ exp	$N(\tau_h)=1$, $N_{b-jets}\geq 1$ obs	$N(\tau_h)=1$, $N_{b-jets}\geq 1$ exp
OSSF0 $H_T < 200$	NA	(100,∞)	7	11 ± 4.9	101	111 ± 54	13	10 ± 5.3	87	119 ± 61
OSSF0 $H_T < 200$	NA	(50,100)	35	38 ± 15	406	402 ± 152	29	26 ± 13	269	298 ± 151
OSSF0 $H_T < 200$	NA	(0,50)	53	51 ± 11	910	1035 ± 255	29	23 ± 10	237	240 ± 113
OSSF1 $H_T < 200$	above-Z	(100,∞)	18	13 ± 3.5	25	38 ± 18	10	6.5 ± 2.9	24	35 ± 18
OSSF1 $H_T < 200$	below-Z	(100,∞)	21	24 ± 9	41	50 ± 25	14	20 ± 10	42	54 ± 28
OSSF1 $H_T < 200$	on-Z	(100,∞)l	150	152 ± 26	39	48 ± 13	15	14 ± 4.8	19	23 ± 11
OSSF1 $H_T < 200$	above-Z	(50,100)	50	46 ± 9.7	169	139 ± 48	20	18 ± 8	85	93 ± 47
OSSF1 $H_T < 200$	below-Z	(50,100)	142	125 ± 27	353	355 ± 92	48	48 ± 23	140	133 ± 68
OSSF1 $H_T < 200$	on-Z	(50,100)	*773	777 ± 116	1276	1154 ± 306	56	47 ± 13	81	75 ± 32
OSSF1 $H_T < 200$	above-Z	(0,50)	178	196 ± 35	1676	1882 ± 540	17	18 ± 6.7	115	94 ± 42
OSSF1 $H_T < 200$	below-Z	(0,50)	510	547 ± 87	9939	8980 ± 2660	34	42 ± 11	226	228 ± 63
OSSF1 $H_T < 200$	on-Z	(0,50)	*3869	4105 ± 666	*50188	50162 ± 14984	*148	156 ± 24	906	925 ± 263





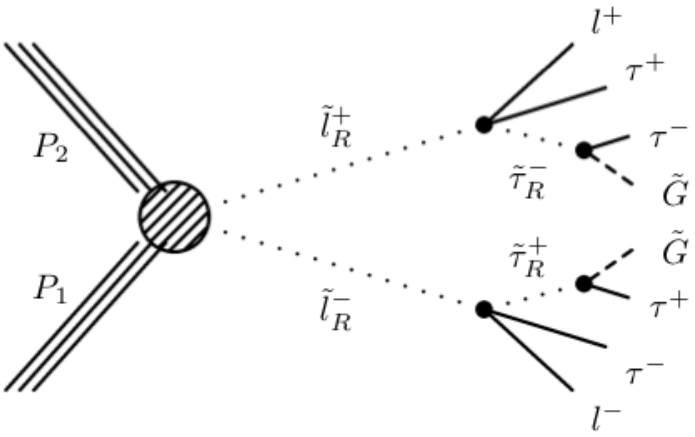
SUS-13-002
Interpretation: GMSB slepton co-NLSP

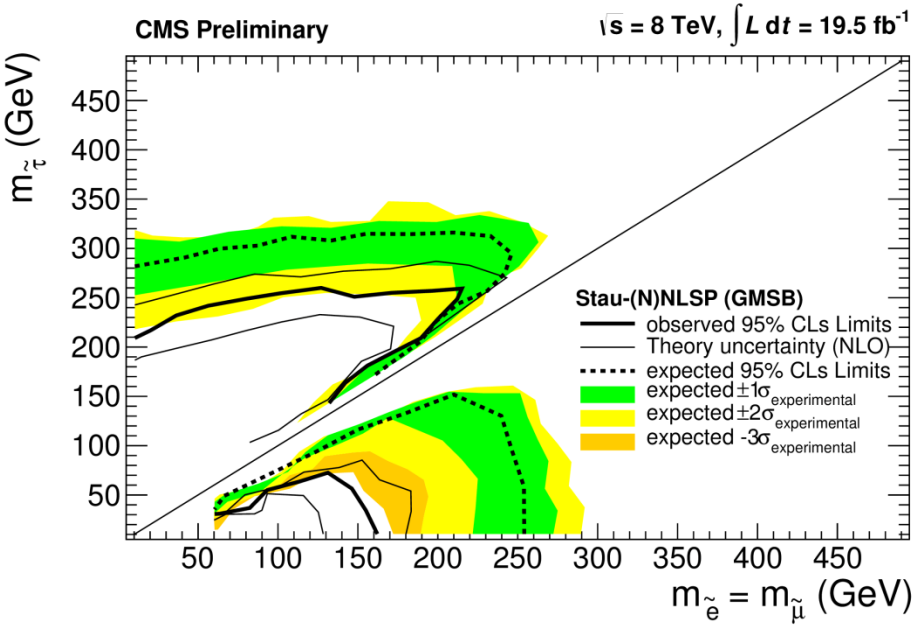


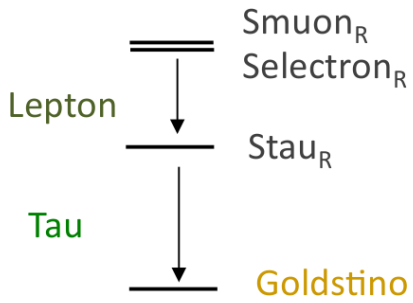


- Both strong and weak production of a wide spectrum of sparticles
  - Cascade decays to gravitino
- Produces up to 4 leptons
- Good agreement with expectation

SUS-13-002
Interpretation: stau-(N)NLSP

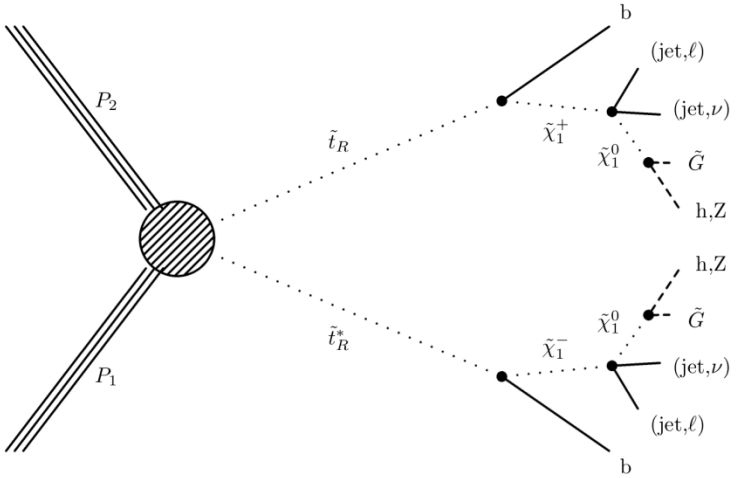


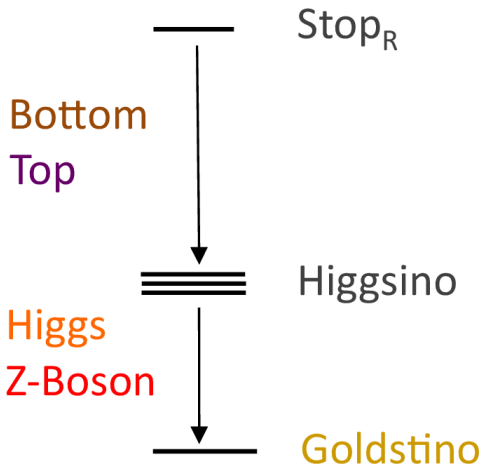




- Direct slepton production
- Produces up to 6 leptons
- Discrepancy is driven by 4L incl. τ_{had}, 1OSSF off Z, no b-tag, H_T < 200 GeV in several MET bins
  - Details in the backup slides

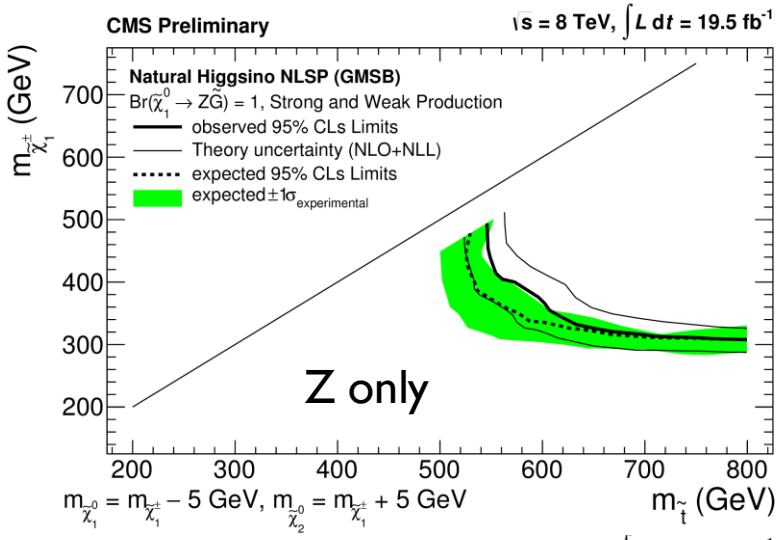
SUS-13-002
Interpretation: Natural Higgsino NLSP

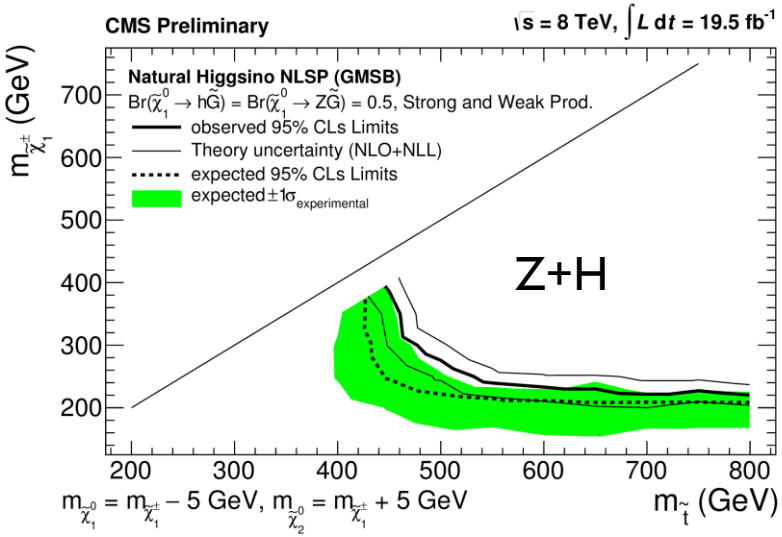


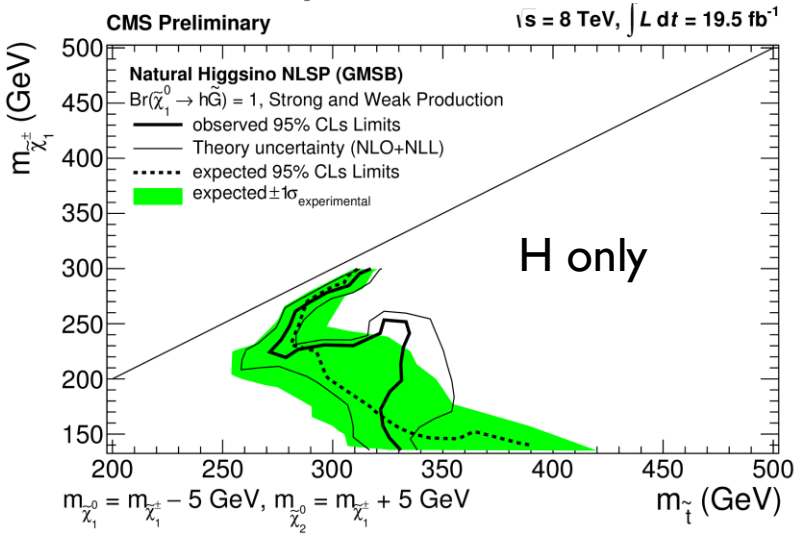


- Production of charginos and neutralinos (higgsinos) either directly or through stop decays
  - Both strong and weak production
  - Higgsinos nearly degenerate
- Light neutralinos decay to goldstino + Z or H
- Many variations of stop and higgsino masses possible
- Scanning Higgsino BRs as well

SUS-13-002
Interpretation: Natural Higgsino NLSP







- Probing the stop–higgsino mass plane
- Three example branching ratios
  - Not very sensitive in HH mode
- Overall good agreement with expectations

Outline

- Introduction
- Recent direct GMSB searches
  - SUS-13-002: co-NLSP, stau-NLSP, Natural Higgsino NLSP
  - SUS-13-014: Natural Higgsino NLSP (diphotons)
  - SUS-13-006: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")
  - SUS-12-018: Photons with MET
- Other GMSB searches
- Conclusions

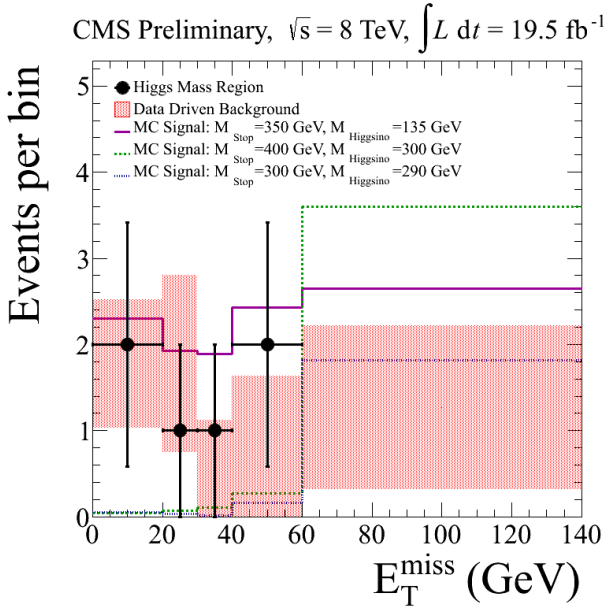
SUS-13-014
Analysis Overview

RUTGERS

- Targeted at probing the Natural Higgsino NLSP model with BR($\chi^0 \rightarrow$ HG) = 100% where one H $\rightarrow \gamma\gamma$ using the full CMS 2012 dataset (19.5/fb)
- Search strategy:
  - Require at least two b-tags
  - Categorize events into three signal regions:
    - Exactly two b-tags with m_{bb} consistent with m_H (120–131 GeV)
    - Exactly two b-tags with m_{bb} inconsistent with m_H
    - Three or more b-tags (no mass requirement) to catch strong production

SUS-13-014
Analysis Overview

- Backgrounds:
  - QCD with $\gamma\gamma$bb or γbb + jets
    - Fit using power law function for $m_{\gamma\gamma}$ between 103 and 163 GeV (signal region excluded)
  - Other backgrounds negligible

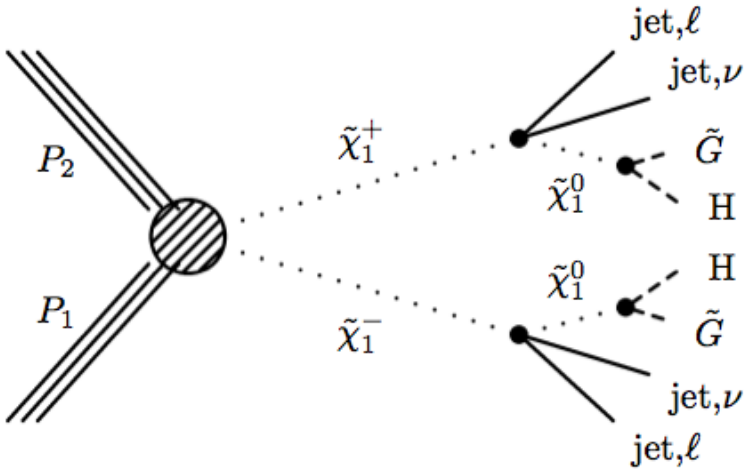


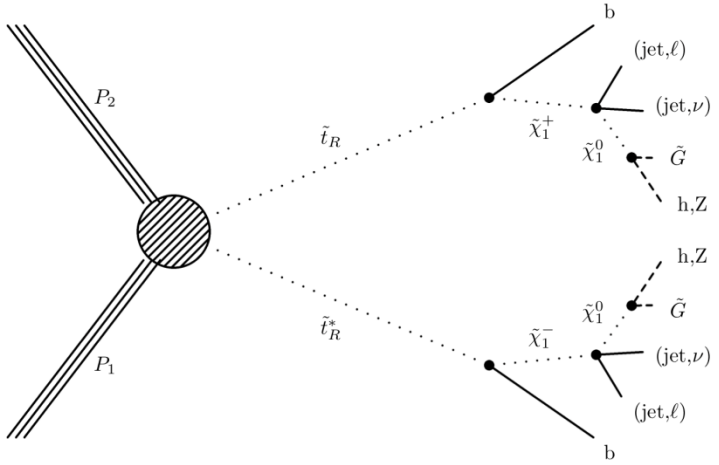
- Results

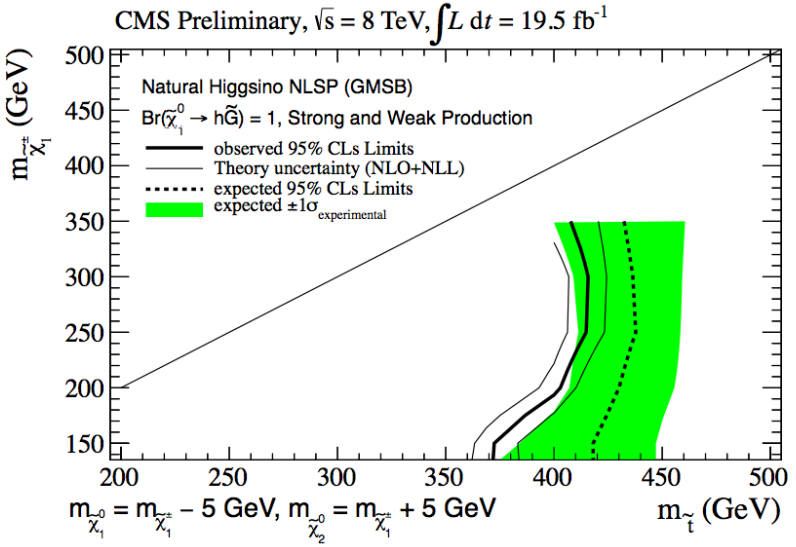
	2 b-jets on h mass		2 b-jets off h mass		3+ b-jet		Total	
E_T^{miss} (GeV)	Data	Bkg	Data	Bkg	Data	Bkg	Data	Bkg
0-20	3	5.0 ± 1.3	15	11.0 ± 1.8	2	1.77 ± 0.73	20	18.1 ± 2.3
20-30	2	3.4 ± 1.3	4	7.9 ± 1.7	1	1.8 ± 1.1	7	13.1 ± 2.0
30-40	0	1.39 ± 0.71	5	6.3 ± 1.3	1	0.73 ± 0.84	6	8.7 ± 2.0
40-60	1	0.58 ± 0.68	7	2.2 ± 1.7	2	0.73 ± 0.84	10	3.8 ± 1.6
60+	1	0.19 ± 0.28	2	1.35 ± 0.73	0	1.3 ± 1.0	3	2.8 ± 1.0

- Overall, observation agrees with background expectations

SUS-13-014
Interpretation: Natural Higgsino NLSP







- Same topology as in SUS-13-002
- Diphotons give more powerful exclusion than multileptons
- Observed limit between 360 and 410 GeV on stop mass

Outline

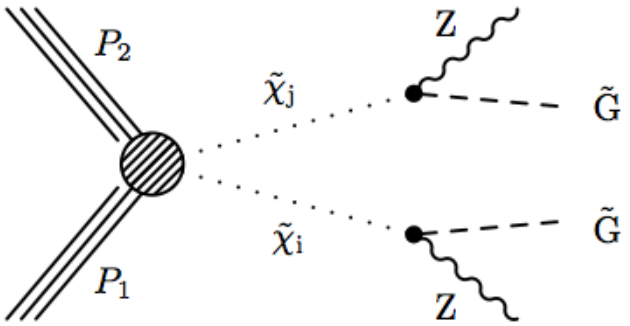
- Introduction
- Recent direct GMSB searches
  - SUS-13-002: co-NLSP, stau-NLSP, Natural Higgsino NLSP
  - SUS-13-014: Natural Higgsino NLSP (diphotons)
  - SUS-13-006: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")
  - SUS-12-018: Photons with MET
- Other GMSB searches
- Conclusions

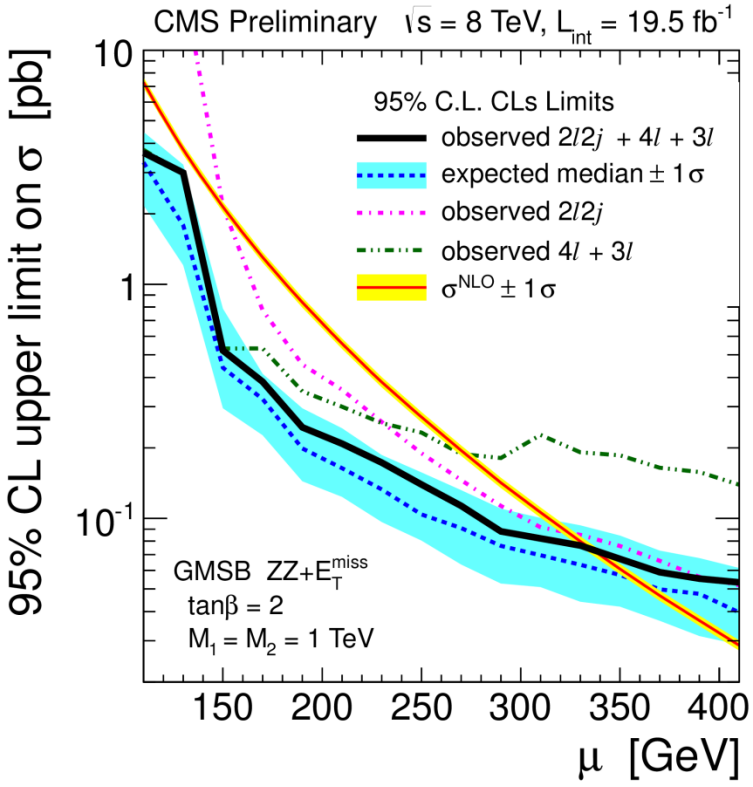
SUS-13-006
Analysis Overview

RUTGERS

- Targeting electroweak production of charginos, neutralinos, and sleptons using the full 2012 CMS dataset (19.5/fb)
- Final states relevant for GMSB model ($\chi^0\chi^0 \rightarrow$ ZZ+GG):
  - Exactly 3 leptons
  - Exactly 4 leptons
  - OSSF dileptons + 2 jets
- Backgrounds:
  - WZ and ZZ from Monte Carlo simulation
  - Fakes from jets using data-driven techniques
- More details and results is Lesya Shchutska's talk on electroweak SUSY searches

SUS-13-006
Interpretation: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")





- Direct neutralino production
  - Neutralinos and charginos nearly degenerate; $m_\chi \approx \mu$
- Produces 2, 3 or 4 leptons depending on Z decay mode
- Exclusion up to 330 GeV in agreement with expectation

Outline

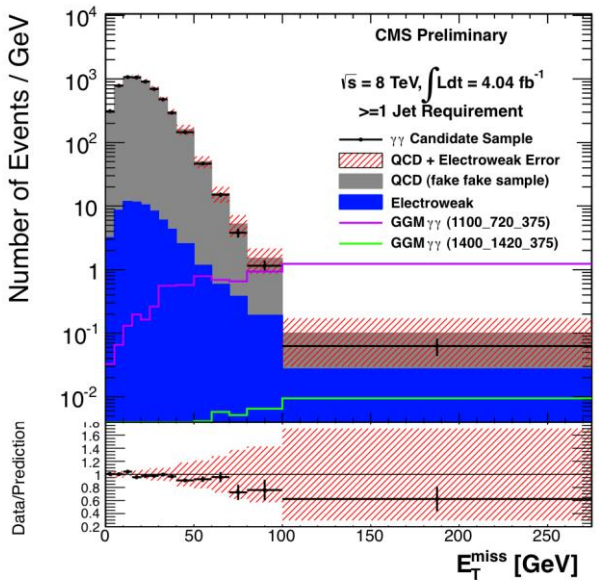
- Introduction
- Recent direct GMSB searches
  - SUS-13-002: co-NLSP, stau-NLSP, Natural Higgsino NLSP
  - SUS-13-014: Natural Higgsino NLSP (diphotons)
  - SUS-13-006: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")
  - SUS-12-018: Photons with MET
- Other GMSB searches
- Conclusions

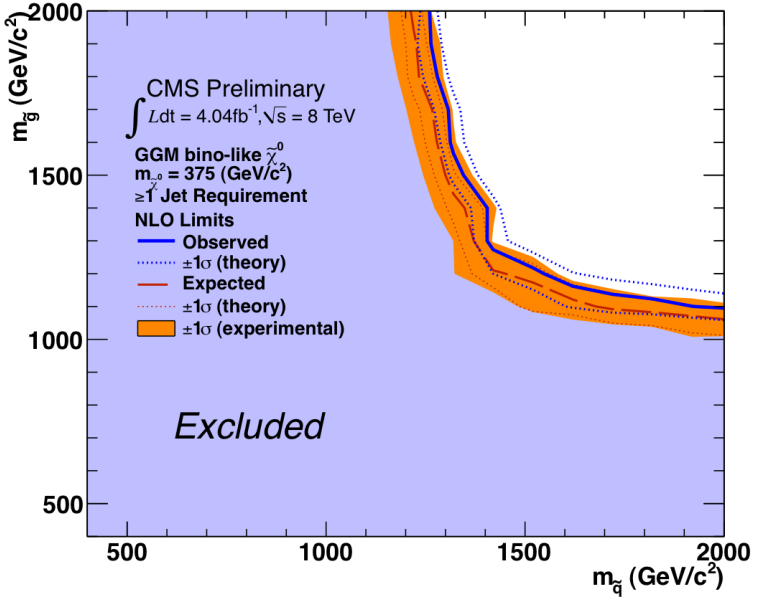
SUS-12-018
Analysis Overview

RUTGERS

- Aims at a general GMSB model using 4.04/fb of CMS 2012 data
  - Strong pair production of sparticles decaying to neutralinos / charginos (NLSPs)
- Signal regions:
  - If the neutralino is bino-like, it decays predominantly to a photon and the gravitino LSP
    - Two photons in the final state + MET from the gravitinos
  - If the neutralino is wino-like, the photonic decay is suppressed by the preference for decays to Z + gravitino (chargino:W + gravitino)
    - Single photon + MET and additional jets in the final state
- Dominant Backgrounds:
  - Mismeasured MET in QCD (direct diphoton, photon + jets, …)
  - Events with true MET from $\gamma + W \rightarrow \gamma e \nu$ with misidentified electron

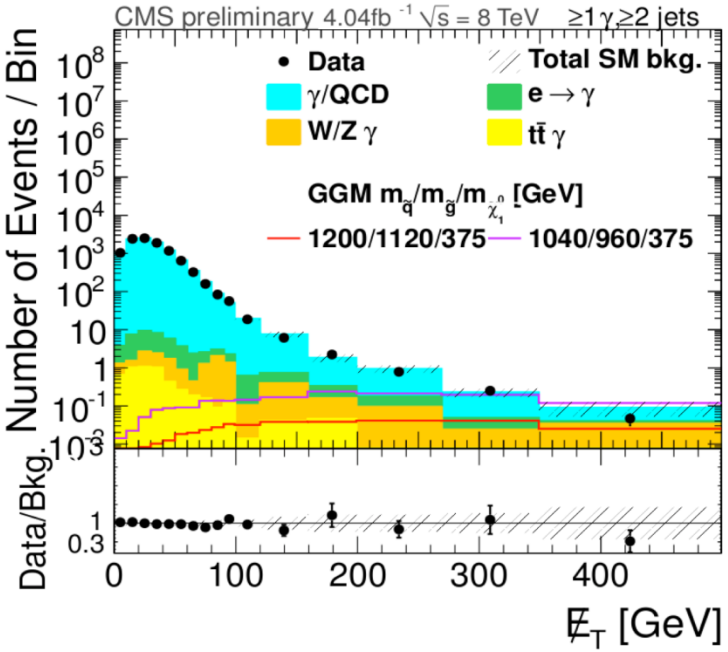
SUS-12-018
Interpretation: Bino-like scenario

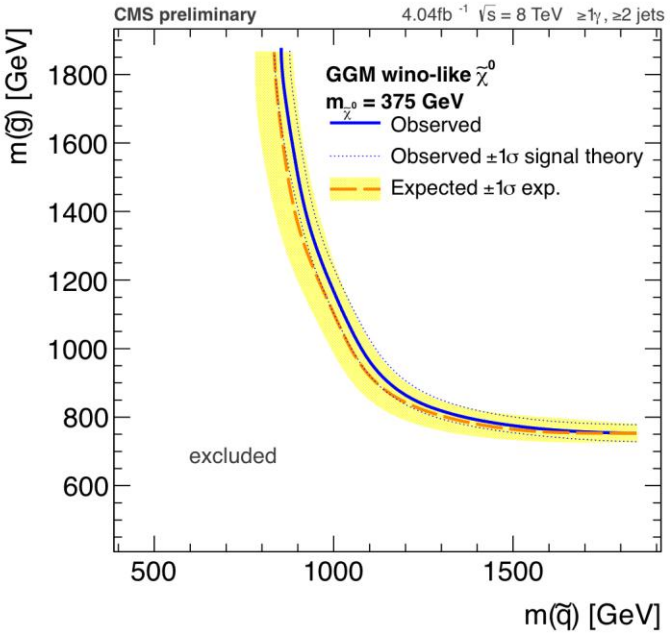




- Diphoton analysis
  - Selection: ≥ 2 photons with E_T > 40 (25) GeV, MET > 50 GeV, 1 jet
  - Neutralino at 375 GeV, other sparticles decoupled
  - Exclusion below m_{squark} = 1200 GeV and m_{gluino} = 1100 GeV in agreement with expectation

SUS-12-018
Interpretation: Wino-like scenario





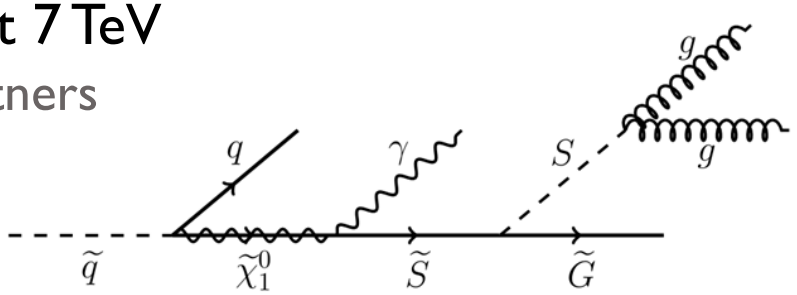
- Single photon analysis
  - Selection: E_T > 80 GeV, MET > 100 GeV, 2 jets, H_T > 450 GeV
  - Neutralino at 375 GeV, other sparticles decoupled
  - Exclusion below m_{squark} = 850 GeV and m_{gluino} = 750 GeV in agreement with expectation

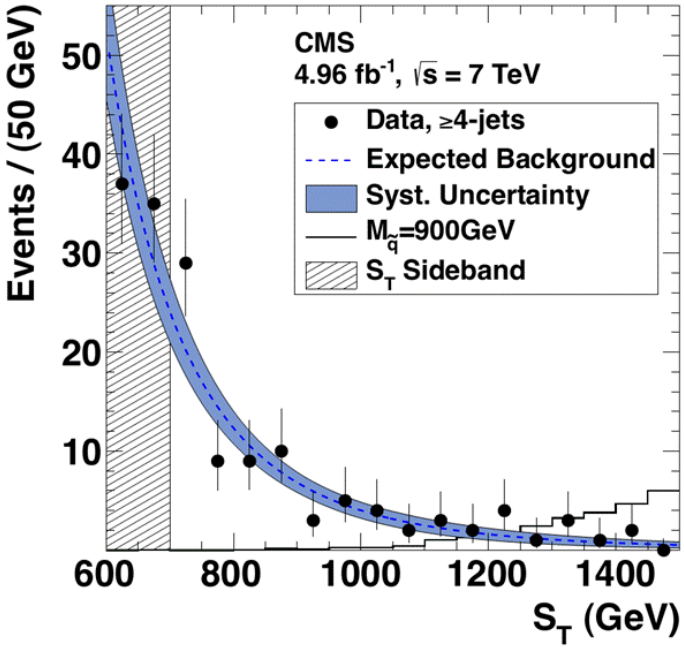
Outline

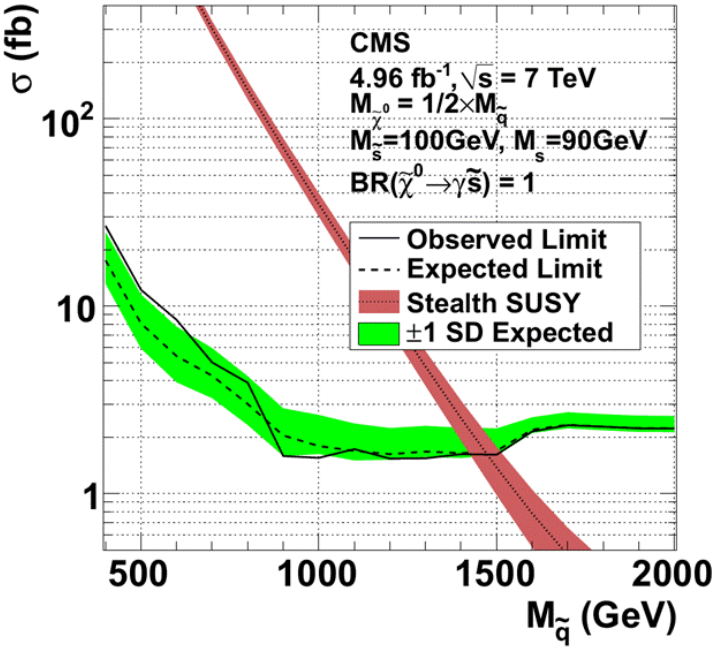
- Introduction
- Recent direct GMSB searches
  - SUS-13-002: co-NLSP, stau-NLSP, Natural Higgsino NLSP
  - SUS-13-014: Natural Higgsino NLSP (diphotons)
  - SUS-13-006: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")
  - SUS-12-018: Photons with MET
- Other GMSB searches
- Conclusions

Other GMSB searches
SUS-12-014: Stealth SUSY

- Stealth SUSY search with 4.96/fb at 7 TeV
  - nearly degenerate stealth superpartners so that the gravitino is very soft
  - m_{gluino} = 1500 GeV
- Require 2 photons and ≥ 4 jets
- Excluding squark masses below 1430 GeV

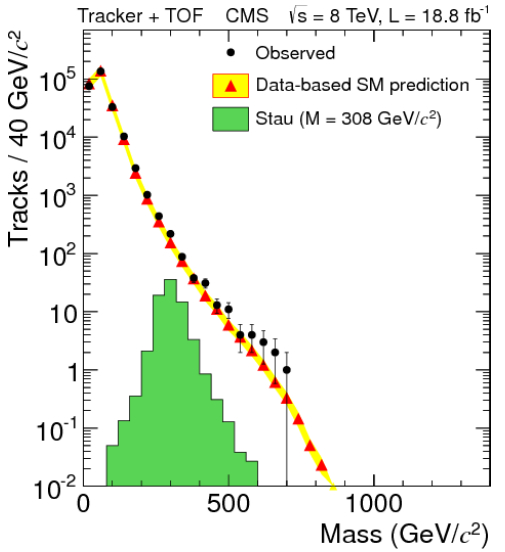


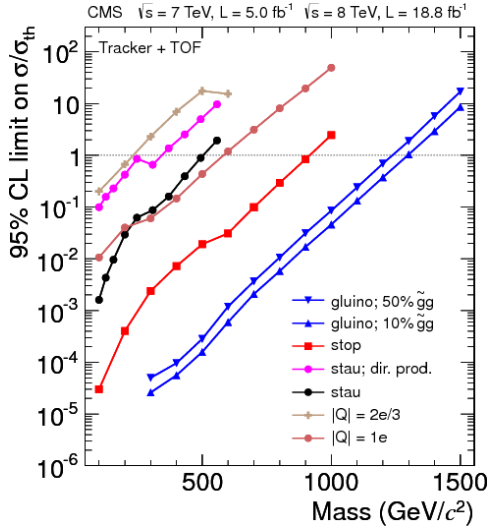




Other GMSB searches
EXO-12-026: HSCP stau GMSB

- Search for heavy stable charged particles, interpreted in terms of a GMSB scenario with 5.0/fb at 7 TeV and 18.8/fb at 8 TeV
  - Assuming detector-stable stau
  - Require tracks that are reconstructed in the tracker and in the muon system
  - Apply cuts on $1/\beta$ and ionization discriminators
- Probing stau masses up to 500 (339) GeV for direct+indirect (direct only) production
  - in agreement with expectations





Other GMSB searches
Exotic searches placing constraints

RUTGERS

- Some exotic searches place constraints on GMSB
  - EXO-12-038
    - Search for displaced dijets; strongly constrains many models with long-lived particles including GMSB
  - EXO-11-067
    - Search for displaced photon + MET (using conversion pointing)
  - EXO-11-035
    - Search for displaced photon + MET (using photon timing)
- More information in the backup and at https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO

Outline

- Introduction
- Recent direct GMSB searches
  - SUS-13-002: co-NLSP, stau-NLSP, Natural Higgsino NLSP
  - SUS-13-014: Natural Higgsino NLSP (diphotons)
  - SUS-13-006: $\chi^0\chi^0 \rightarrow$ ZZ+GG ("TChiZZ")
  - SUS-12-018: Photons with MET
- Other GMSB searches
- Conclusions

Conclusion

- Many interesting GMSB searches in CMS
- Observations mostly in agreement with expectations
  - The results are interpreted in several GMSB scenarios to set limits on the model parameters
- Highlights:
  - Multi-lepton search with high sensitivity to a variety of models
  - Photon searches complement the leptonic searches
  - Photons also sensitive to wino-ness of the NLSP
  - Further constraints from stealth and exotic searches
- Looking forward to extended experimental reach in 2015

Extra Slides

SUS-13-002
3-lepton results

RUTGERS

Selection 3 Lepton Results		E_T^{miss}	$N(\tau_h)=0$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=0$, $N_{b-jets}\geq 1$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}\geq 1$ obs	exp
OSSF0 $H_T > 200$	NA	(100,∞)	5	3.7 ± 1.6	35	33 ± 14	1	5.5 ± 2.2	47	61 ± 30
OSSF0 $H_T > 200$	NA	(50,100)	3	3.5 ± 1.4	34	36 ± 16	8	7.7 ± 2.7	82	91 ± 46
OSSF0 $H_T > 200$	NA	(0,50)	4	2.1 ± 0.8	25	25 ± 9.7	1	3.6 ± 1.5	52	59 ± 29
OSSF1 $H_T > 200$	above-Z	(100,∞)	5	3.6 ± 1.2	2	10 ± 4.8	3	4.7 ± 1.6	19	22 ± 11
OSSF1 $H_T > 200$	below-Z	(100,∞)	7	9.7 ± 3.3	18	14 ± 6.4	8	9.1 ± 3.4	21	23 ± 11
OSSF1 $H_T > 200$	on-Z	(100,∞)	39	61 ± 23	17	15 ± 4.9	9	14 ± 4.4	10	12 ± 5.8
OSSF1 $H_T > 200$	above-Z	(50,100)	4	5 ± 1.6	14	11 ± 5.2	6	6.8 ± 2.4	32	30 ± 15
OSSF1 $H_T > 200$	below-Z	(50,100)	10	11 ± 3.8	24	19 ± 6.4	10	9.9 ± 3.7	25	32 ± 16
OSSF1 $H_T > 200$	on-Z	(50,100)	78	80 ± 32	70	50 ± 11	22	22 ± 6.3	36	24 ± 9.8
OSSF1 $H_T > 200$	above-Z	(0,50)	3	7.3 ± 2	41	33 ± 8.7	4	5.3 ± 1.5	15	23 ± 11
OSSF1 $H_T > 200$	below-Z	(0,50)	26	25 ± 6.8	110	86 ± 23	5	10 ± 2.5	24	26 ± 11
OSSF1 $H_T > 200$	on-Z	(0,50)	*135	127 ± 41	542	543 ± 159	31	32 ± 6.5	86	75 ± 19

Selection 3 Lepton Results		E_T^{miss}	$N(\tau_h)=0$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=0$, $N_{b-jets}\geq 1$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}\geq 1$ obs	exp
OSSF0 $H_T < 200$	NA	(100,∞)	7	11 ± 4.9	101	111 ± 54	13	10 ± 5.3	87	119 ± 61
OSSF0 $H_T < 200$	NA	(50,100)	35	38 ± 15	406	402 ± 152	29	26 ± 13	269	298 ± 151
OSSF0 $H_T < 200$	NA	(0,50)	53	51 ± 11	910	1035 ± 255	29	23 ± 10	237	240 ± 113
OSSF1 $H_T < 200$	above-Z	(100,∞)	18	13 ± 3.5	25	38 ± 18	10	6.5 ± 2.9	24	35 ± 18
OSSF1 $H_T < 200$	below-Z	(100,∞)	21	24 ± 9	41	50 ± 25	14	20 ± 10	42	54 ± 28
OSSF1 $H_T < 200$	on-Z	(100,∞)l	150	152 ± 26	39	48 ± 13	15	14 ± 4.8	19	23 ± 11
OSSF1 $H_T < 200$	above-Z	(50,100)	50	46 ± 9.7	169	139 ± 48	20	18 ± 8	85	93 ± 47
OSSF1 $H_T < 200$	below-Z	(50,100)	142	125 ± 27	353	355 ± 92	48	48 ± 23	140	133 ± 68
OSSF1 $H_T < 200$	on-Z	(50,100)	*773	777 ± 116	1276	1154 ± 306	56	47 ± 13	81	75 ± 32
OSSF1 $H_T < 200$	above-Z	(0,50)	178	196 ± 35	1676	1882 ± 540	17	18 ± 6.7	115	94 ± 42
OSSF1 $H_T < 200$	below-Z	(0,50)	510	547 ± 87	9939	8980 ± 2660	34	42 ± 11	226	228 ± 63
OSSF1 $H_T < 200$	on-Z	(0,50)	*3869	4105 ± 666	*50188	50162 ± 14984	*148	156 ± 24	906	925 ± 263

SUS-13-002
4-lepton results

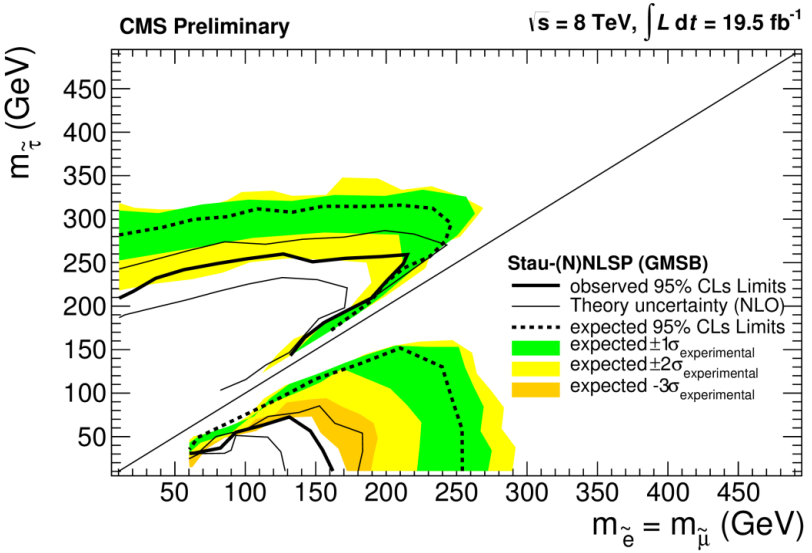
RUTGERS

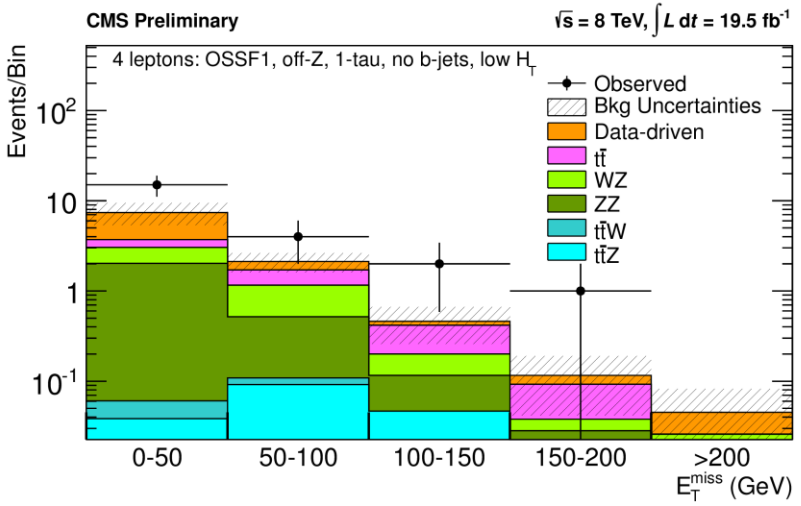
Selection 4 Lepton Results		E_T^{miss}	$N(\tau_h)=0$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=0$, $N_{b-jets}\geq 1$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}\geq 1$ obs	exp
OSSF0 $H_T < 200$	NA	(100,∞)	0	0.11 ± 0.08	0	0.17 ± 0.1	0	0.03 ± 0.04	0	0.04 ± 0.04
OSSF0 $H_T < 200$	NA	(50,100)	0	0.01 ± 0.03	2	0.7 ± 0.33	0	$0.0^{+0.02}_{-0.00}$	0	0.28 ± 0.16
OSSF0 $H_T < 200$	NA	(0,50)	0	0.01 ± 0.02	1	0.7 ± 0.3	0	0.001 ± 0.02	0	0.13 ± 0.08
OSSF1 $H_T < 200$	off-Z	(100,∞)	0	0.06 ± 0.04	3	0.6 ± 0.24	0	0.02 ± 0.04	0	0.32 ± 0.2
OSSF1 $H_T < 200$	on-Z	(100,∞)	1	0.5 ± 0.18	2	2.5 ± 0.5	1	0.38 ± 0.2	0	0.21 ± 0.1
OSSF1 $H_T < 200$	off-Z	(50,100)	0	0.18 ± 0.06	4	2.1 ± 0.5	0	0.16 ± 0.08	1	0.45 ± 0.24
OSSF1 $H_T < 200$	on-Z	(50,100)	2	1.2 ± 0.34	9	9.6 ± 1.6	2	0.42 ± 0.23	0	0.5 ± 0.16
OSSF1 $H_T < 200$	off-Z	(0,50)	2	0.46 ± 0.18	15	7.5 ± 2	0	0.09 ± 0.06	0	0.7 ± 0.31
OSSF1 $H_T < 200$	on-Z	(0,50)	4	3 ± 0.8	41	40 ± 10	1	0.31 ± 0.15	2	1.5 ± 0.47
OSSF2 $H_T < 200$	off-Z	(100,∞)	0	0.04 ± 0.03	-	-	0	0.05 ± 0.04	-	-
OSSF2 $H_T < 200$	on-Z	(100,∞)	0	0.34 ± 0.15	-	-	0	0.46 ± 0.25	-	-
OSSF2 $H_T < 200$	off-Z	(50,100)	2	0.18 ± 0.13	-	-	0	0.02 ± 0.03	-	-
OSSF2 $H_T < 200$	on-Z	(50,100)	4	3.9 ± 2.5	-	-	0	0.5 ± 0.21	-	-
OSSF2 $H_T < 200$	off-Z	(0,50)	7	8.9 ± 2.4	-	-	1	0.23 ± 0.09	-	-
OSSF2 $H_T < 200$	on-Z	(0,50)	*156	159 ± 34	-	-	4	2.9 ± 0.8	-	-

Selection 4 Lepton Results		E_T^{miss}	$N(\tau_h)=0$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}=0$ obs	exp	$N(\tau_h)=0$, $N_{b-jets}\geq 1$ obs	exp	$N(\tau_h)=1$, $N_{b-jets}\geq 1$ obs	exp
OSSF0 $H_T > 200$	NA	(100,∞)	0	0.01 ± 0.03	0	0.01 ± 0.06	0	0.02 ± 0.04	0	0.11 ± 0.08
OSSF0 $H_T > 200$	NA	(50,100)	0	$0.0^{+0.02}_{-0.00}$	0	0.01 ± 0.06	0	$0.0^{+0.03}_{-0.00}$	0	0.12 ± 0.07
OSSF0 $H_T > 200$	NA	(0,50)	0	1e-05 $\pm$ 0.02	0	0.07 ± 0.1	0	$0.0^{+0.02}_{-0.00}$	0	0.02 ± 0.02
OSSF1 $H_T > 200$	off-Z	(100,∞)	0	0.005 ± 0.02	1	0.25 ± 0.11	0	0.13 ± 0.08	0	0.12 ± 0.12
OSSF1 $H_T > 200$	on-Z	(100,∞)	1	0.1 ± 0.06	0	0.5 ± 0.27	0	0.42 ± 0.22	0	0.42 ± 0.19
OSSF1 $H_T > 200$	off-Z	(50,100)	0	0.07 ± 0.06	1	0.29 ± 0.13	0	0.04 ± 0.04	0	0.23 ± 0.13
OSSF1 $H_T > 200$	on-Z	(50,100)	0	0.23 ± 0.11	1	0.7 ± 0.31	0	0.23 ± 0.13	1	0.34 ± 0.16
OSSF1 $H_T > 200$	off-Z	(0,50)	0	0.02 ± 0.03	0	0.27 ± 0.12	0	0.03 ± 0.04	0	0.31 ± 0.15
OSSF1 $H_T > 200$	on-Z	(0,50)	0	0.2 ± 0.08	0	1.3 ± 0.47	0	0.06 ± 0.04	1	0.49 ± 0.19
OSSF2 $H_T > 200$	off-Z	(100,∞)	0	0.01 ± 0.02	-	-	0	0.01 ± 0.06	-	-
OSSF2 $H_T > 200$	on-Z	(100,∞)	1	0.15 ± 0.16	-	-	0	0.34 ± 0.18	-	-
OSSF2 $H_T > 200$	off-Z	(50,100)	0	0.03 ± 0.02	-	-	0	0.13 ± 0.09	-	-
OSSF2 $H_T > 200$	on-Z	(50,100)	0	0.8 ± 0.4	-	-	0	0.36 ± 0.19	-	-
OSSF2 $H_T > 200$	off-Z	(0,50)	1	0.27 ± 0.13	-	-	0	0.08 ± 0.05	-	-
OSSF2 $H_T > 200$	on-Z	(0,50)	5	7.4 ± 3.5	-	-	2	0.8 ± 0.4	-	-

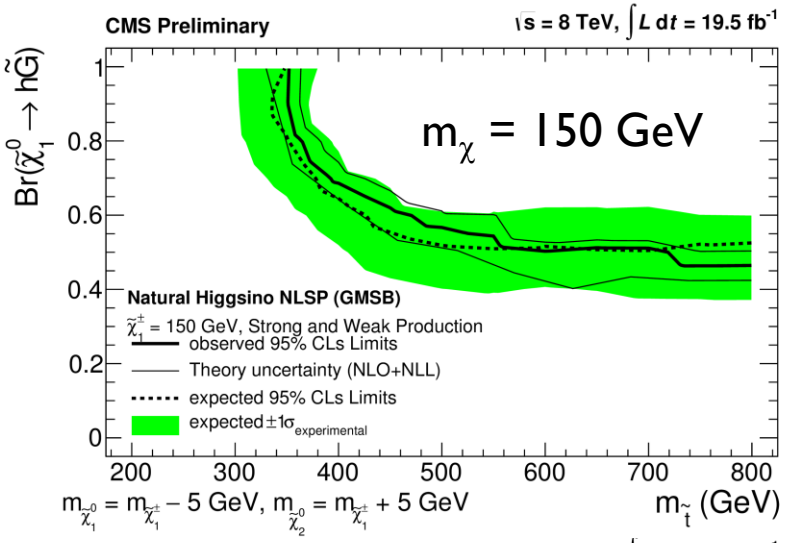
SUS-13-002
Excess in stau-NLSP scenario

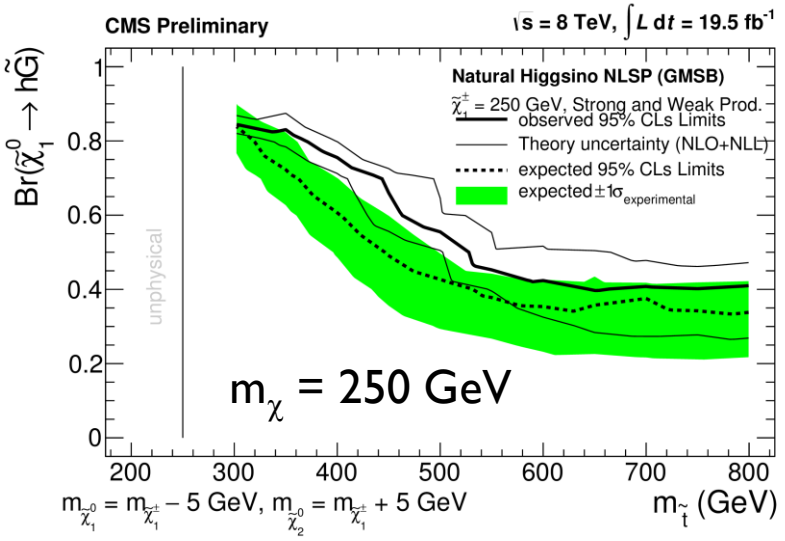
- Reminder: The channels used for the limit calculation are picked based on sensitivity
- Below the diagonal, channels with 4 leptons including a τ_{had} but without an on-Z pair, with low H_T and 0 b-tags are sensitive
- The probability for the distribution sum (expected 10 ± 2.4) to fluctuate to 22 is about 1%
  - Taking into account trial factors for 64 such distributions, the chance rises to 50%
- Alternatively, the joint probability to observe an excess at least this large in three individual bins in one of the 64 distributions is 5%

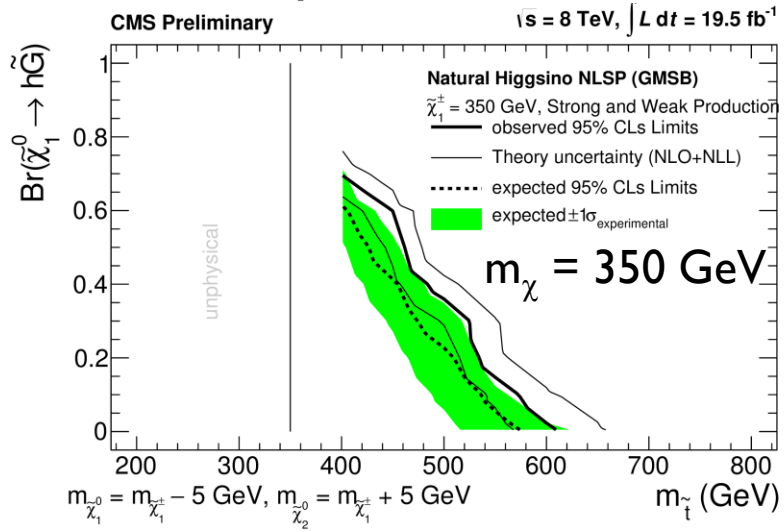




SUS-13-002
Interpretation: Natural Higgsino NLSP



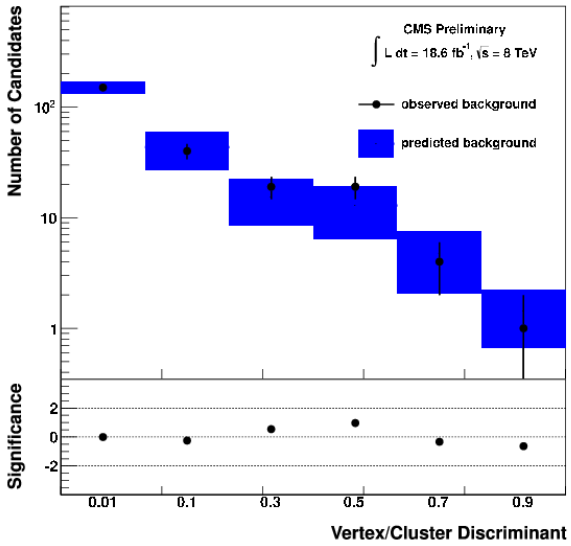


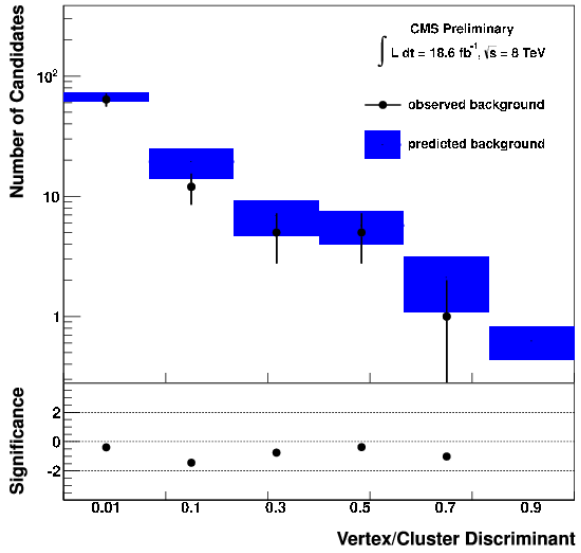


- Fixed higgsino mass
- Probing BRs and stop mass using three example Higgsino masses
- Again, no surprises

EXO-12-038

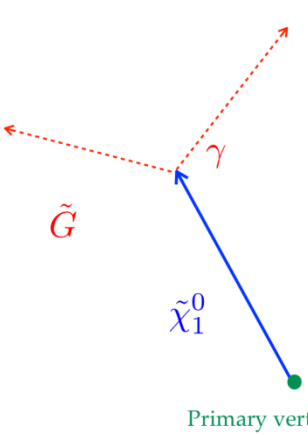
- Search for displaced dijets with 18.6/fb at 8 TeV
  - Two bins in L_{xy}, the distance between the dijet track intersection and the primary vertex (below/above 20cm)
- Results:
  - Below L_{xy} = 20 cm, 2 observed and 1.60 $\pm$ 0.25(stat) $\pm$ 0.51(syst) expected
  - Above L_{xy} = 20 cm, 1 observed and 1.14 $\pm$ 0.15(stat) $\pm$ 0.52(syst) expected
- Strongly constrains many models with long-lived particles including GMSB
- Background control plots below and above L_{xy} = 20 cm:

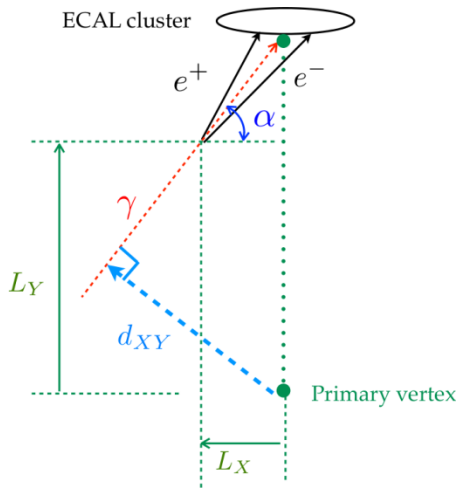


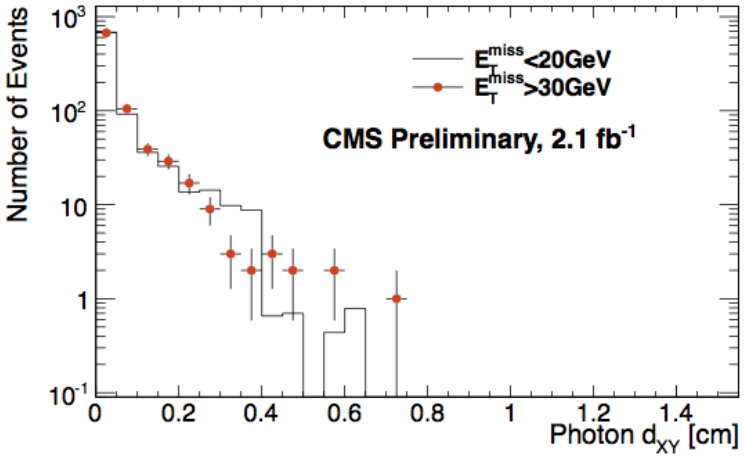


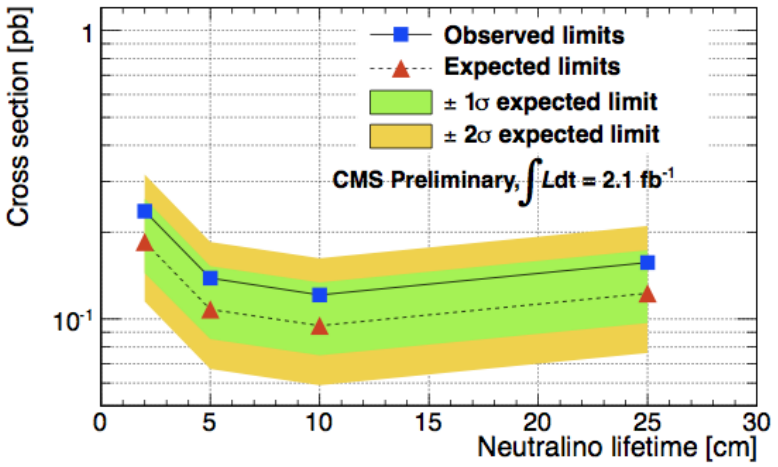
EXO-11-067

- Search for one or more displaced photons with MET using 2.23/fb at 7 TeV
  - Require at least one displaced photon
  - Use conversion pointing to determine impact parameter
- Model: neutralino at 140 GeV decaying to γ + gravitino









EXO-11-035

- Search for one or more displaced photons with MET using 4.9/fb at 7 TeV
  - Requiring at least one displaced photon and 3 or more jets
  - Cut on time of flight and MET
- Assume BR($\chi^0 \rightarrow \gamma G$) = 100%