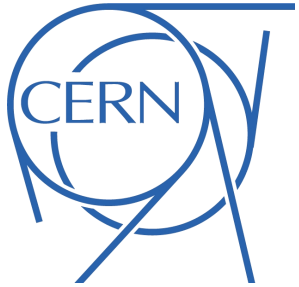


CMS SUSY results

Markus Stoye, CERN
On behalf of the CMS Collaboration

Aspen "Higgs quo vadis"

A·S·P·E·N
Center for Physics

Content

- Natural SUSY (3rd generation)
- EWKinos
- Long-lived sparticles
- “classical” squark&gluinos

Focus new and 8 TeV results

Natural SUSY searches

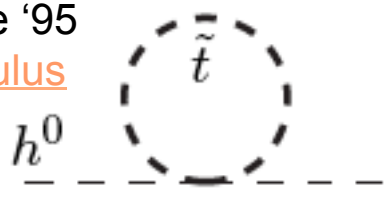
Natural SUSY

SUSY with potentially > TeV 1st squarks generation, but lighter 3rd generation (max mixing)

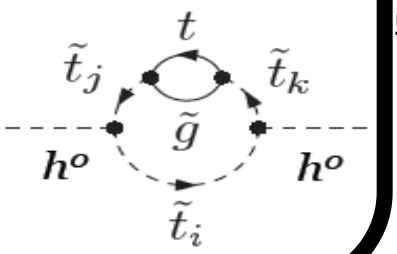
For 10% tuning:

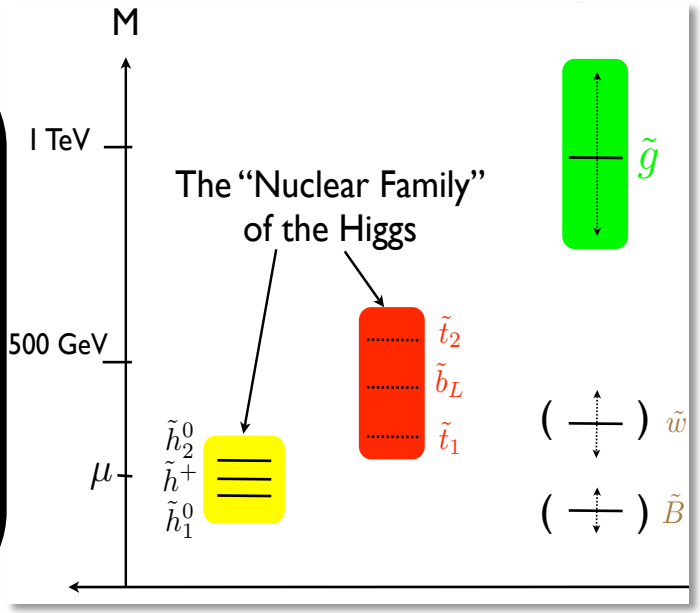
Giudice '95
Dimopulus

one loop: stops<600GeV



two loops: gluinos<1400GeV

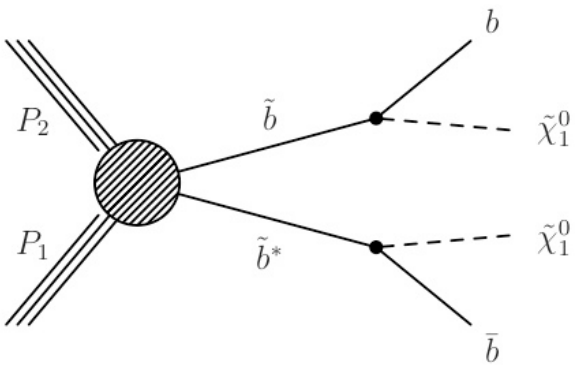


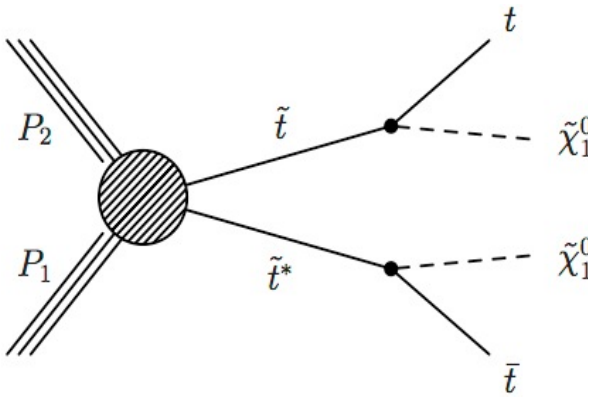


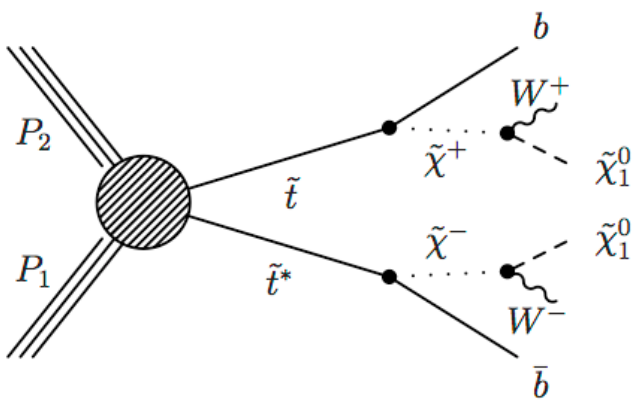
- "Natural" 3rd gen. squarks&gluinos would be produced of LHC

➢ Still need to find them

Direct 3rd generation







2 b + MET ($P_T(\chi^0+\chi^0)$)

2 b + 2 W + MET

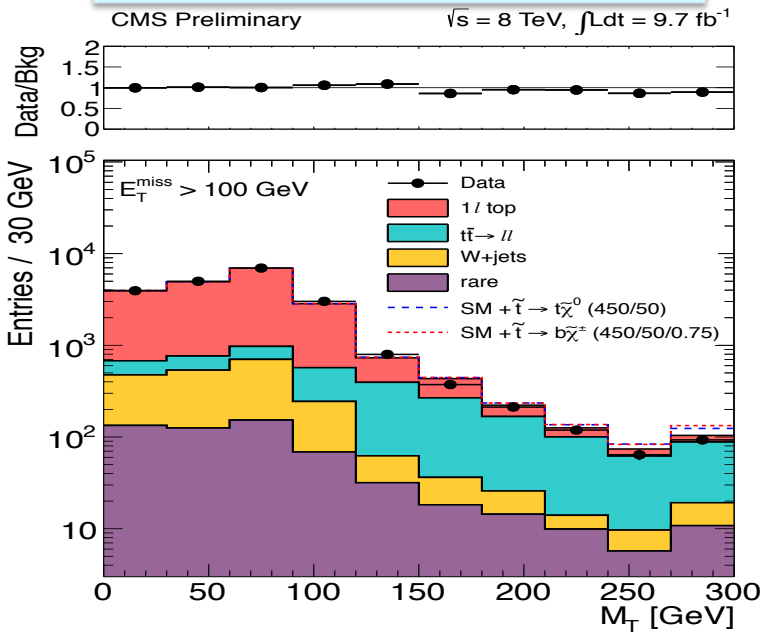
- Significant background expected (tt, ..)
- Background predictions need to be precise!

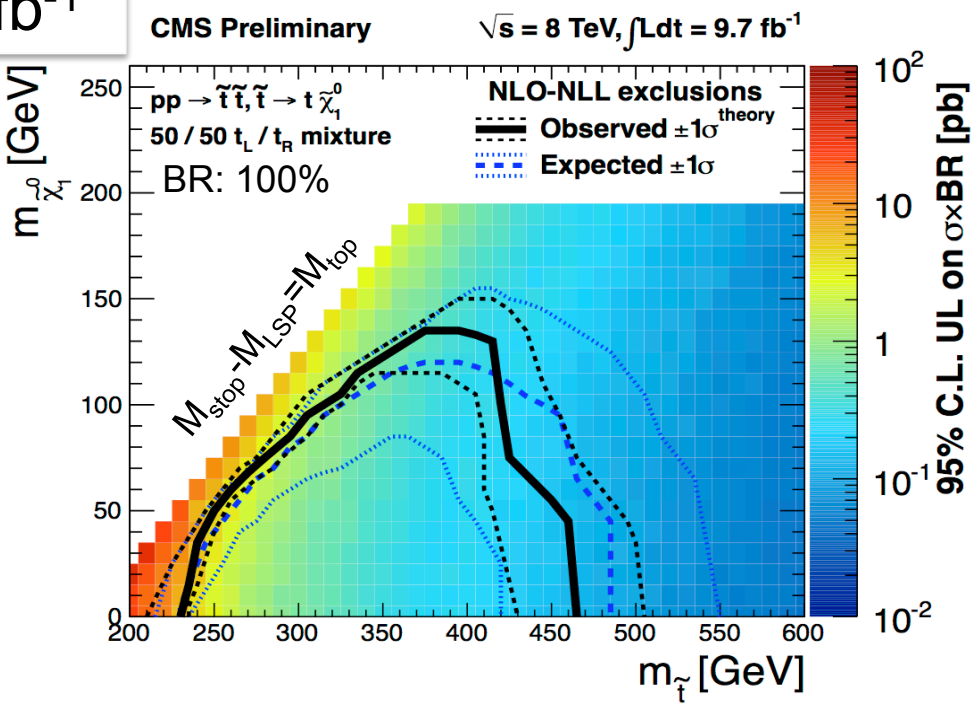
One lepton (2b,2W,MET interpretations)

SUS-12-023, 9.7fb^{-1}

Selection:

- $N_{btag} \geq 1$
- $N_{jet} \geq 4$
- $M_T > 120$ GeV
- MET>150 GeV
- + further MET and MT signal regions



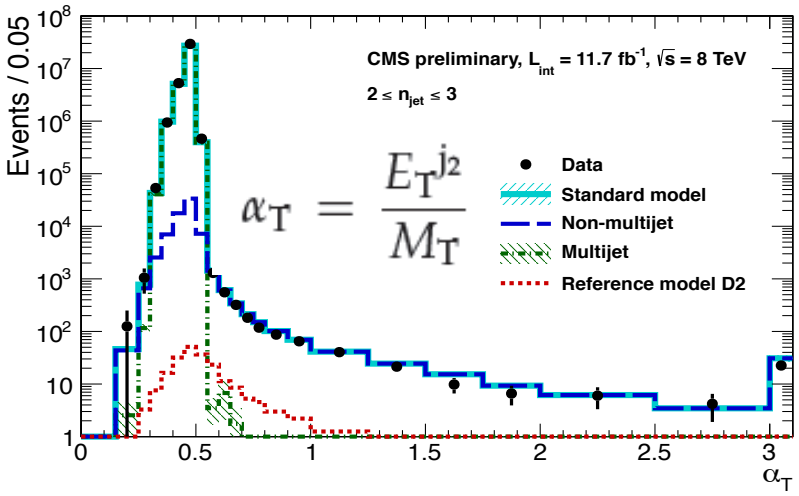


- Diagonal = Compressed spectra: LSP mass ~ stop-top mass leads to small MET!
- stop mass <400 GeV for LSP<100

Hadronic α_T search (two b + MET interpretation)

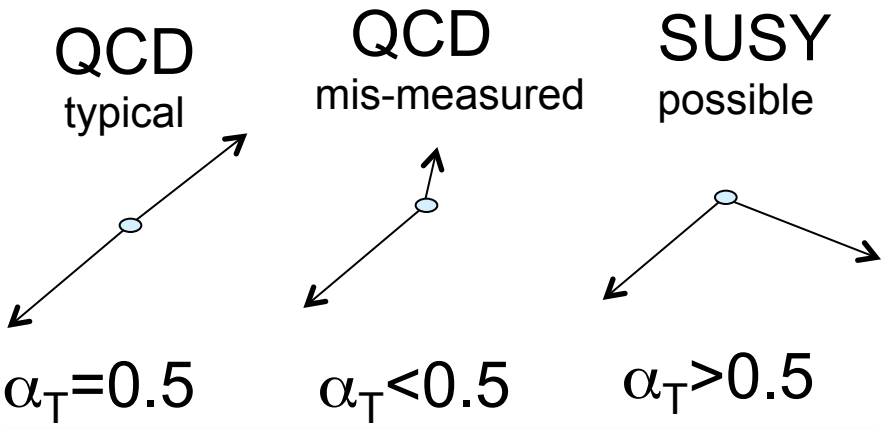
SUS-12-028, 11.7fb^{-1}

arXiv:1303.2985

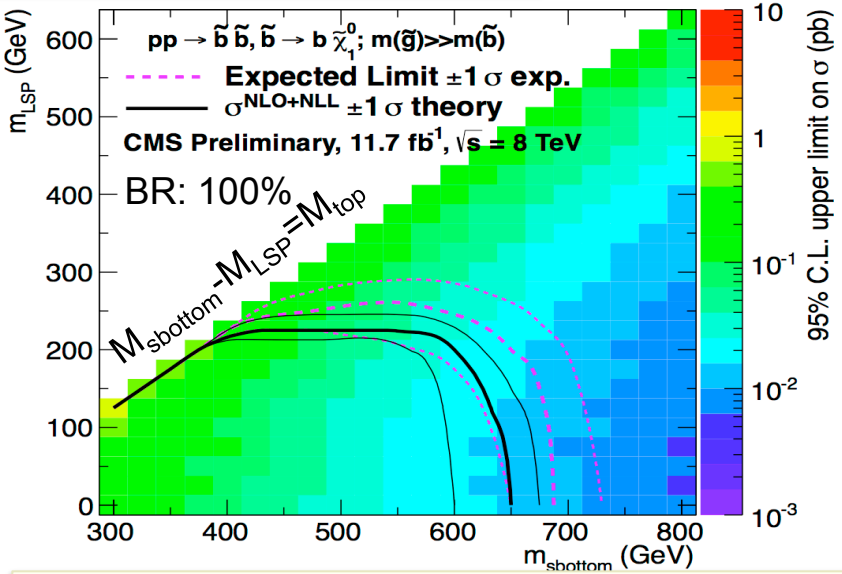


Selection:

- $H_T=\Sigma P_T$(jets): bins
- N_{bjets} bins: [0,1,2,3≥4]
- α_T>0.55
- $2 \le N_{jet} \le 3$ and $4 \le N_{jet}$



Adding angles of jets make α_T very robust against mismeasurements



sbottom mass <600 GeV for LSP<200 GeV

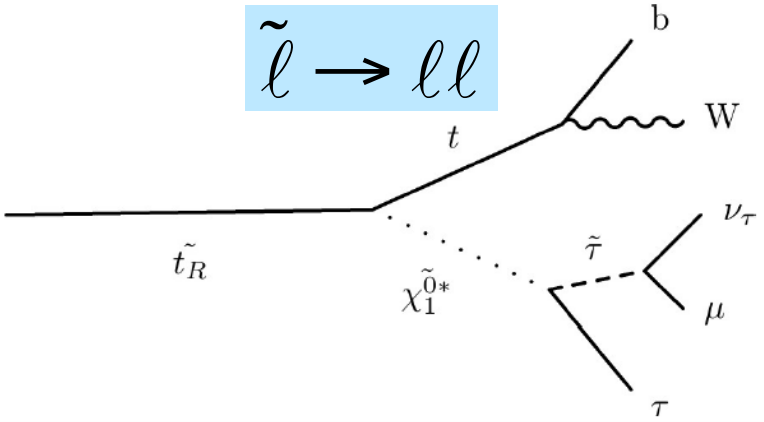
Direct 3rd generation with RPV

RPV SUSY without MET from LSP

- Typically difficult to find!

SUS-003-13 19.4 fb^{-1} NEW

$$W_{RPV} = \lambda_{ijk} L^i L^j \bar{E}^k + \lambda'_{ijk} L^i Q^j \bar{D}^k + \lambda''_{ijk} \bar{U}^i \bar{D}^j \bar{D}^k + \epsilon_i L_i H_2$$



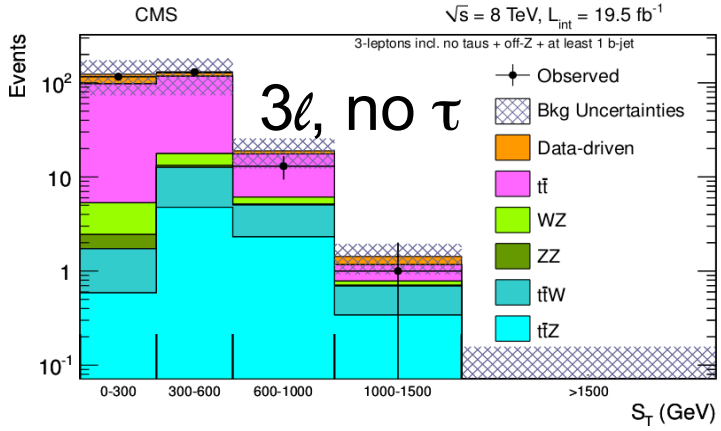
Quite spectacular:

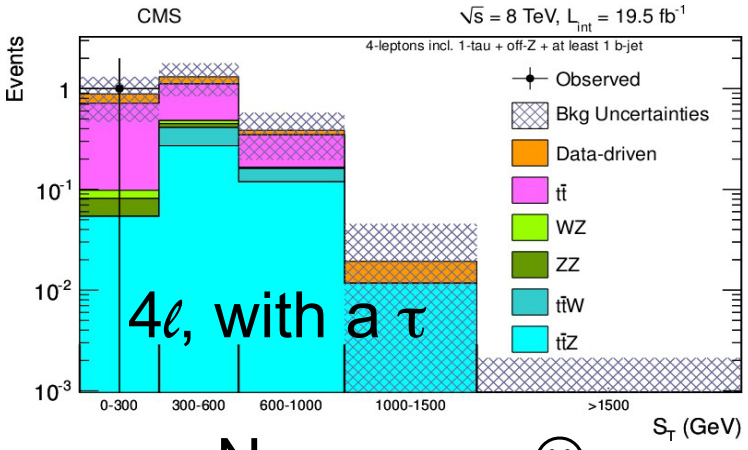
- Two extra charged leptons in stop decay
- Look for many leptons+b

Selection:

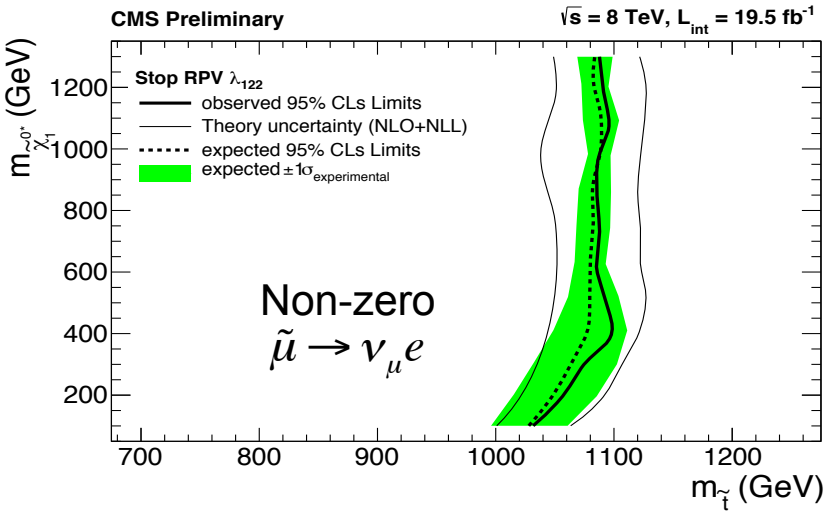
- isolated leptons (e,μ,τ)=3,≥4
- N_{btag}≥1
- Mass cut to remove Z,J/ψ candidates
- S_T=MET+H_T+Σ$P_T(\ell)$, bins: [300,600,1000,>1500] GeV

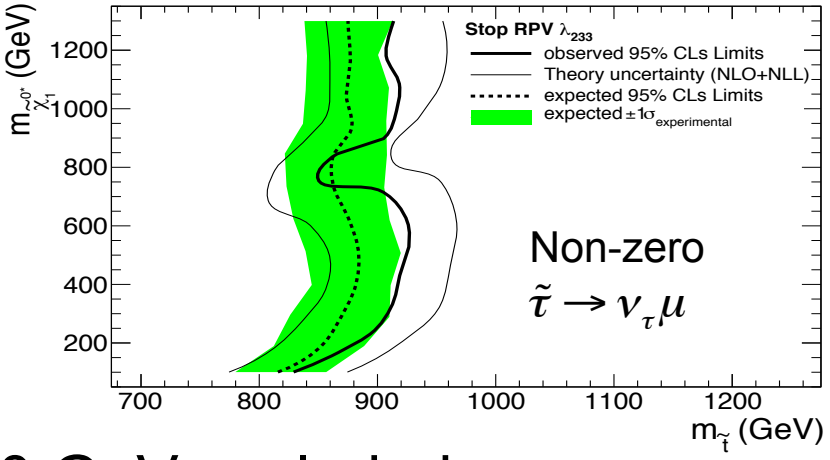
Direct 3rd generation with RPV





No excess ☹

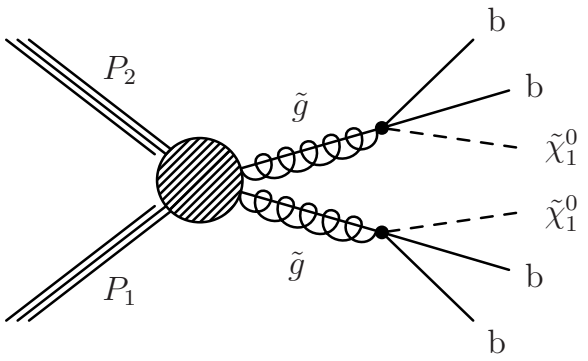




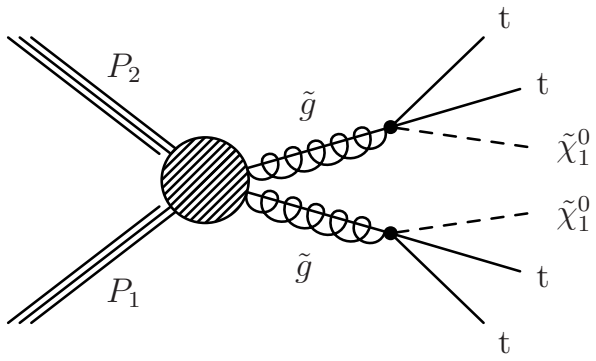
- Stop mass ≤ 850 GeV excluded
- Further RPV non-zero couplings tested

Gluino induced natural SUSY searches

"Light" gluinos will decay into the 3rd generation



4b, MET



4b, MET,4W (many jets and leptons)

- **Spectacular signal** events and tiny background
- Expect sensitivity to compressed spectra of 3rd gen squarks and χ^0 mass (Energy from gluino to stop+top mass gap)

Hadronic search

Selection:

- No isolated leptons
- $N_{jets} \geq 3$
- N_{btags} (binned) [1,2, ≥3]
- MET (binned)
- H_T=(binned)
- $\Delta\hat{\phi} = \min(\Delta\phi^i(jet^i, MET)/\sigma^i_{\Delta\phi}) > 4.$

SUS-12-024 19.4 fb^{-1} NEW

Bin	H_T (GeV)	E_T^{miss} (GeV)
1	400 – 500 (HT1)	125 – 150 (MET1)
2	500 – 800 (HT2)	150 – 250 (MET2)
3	800 – 1000 (HT3)	250 – 350 (MET3)
4	> 1000 (HT4)	> 350 (MET4)

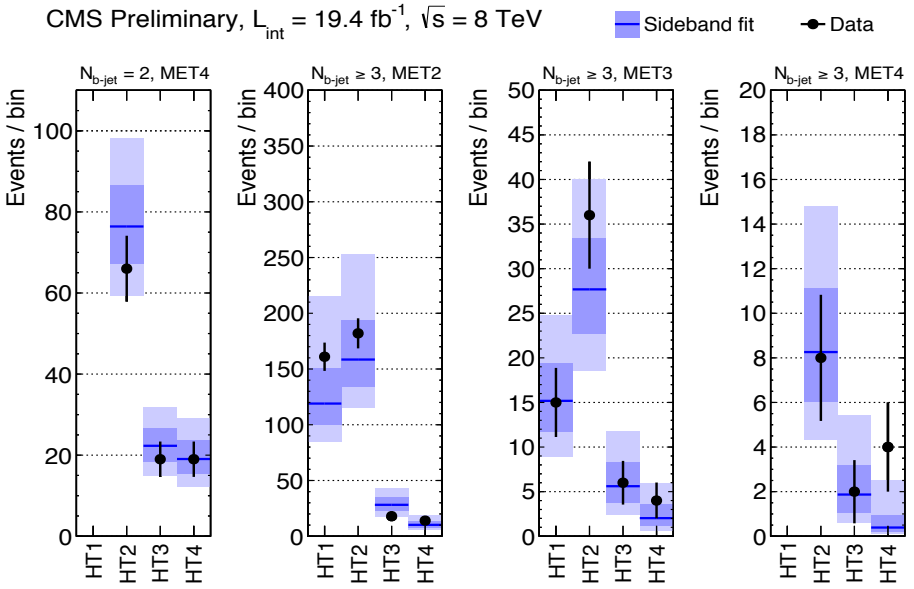
Control samples for background shape (in 3D(MET,H_T,N_{btags})):

- One-leptonic (M_T<100 GeV) for top backgrounds
- Z->μμ&Z->*ee* for Z->νν
- Inverted Δϕ for QCD

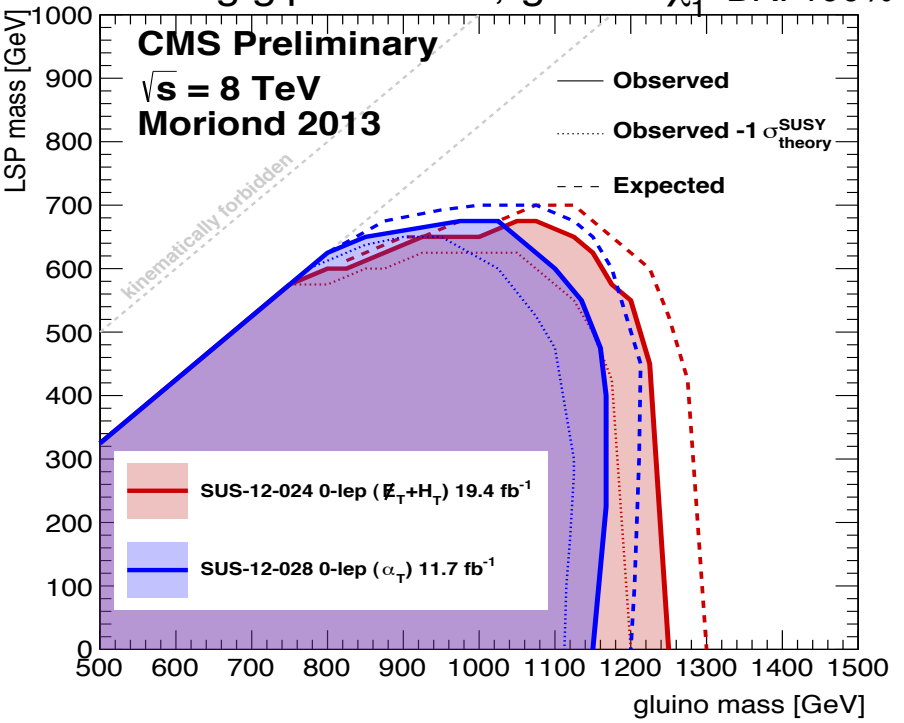
Shape corrections from control to signal region from MC

Four b-quarks + MET interpretation

Prediction and observation



No excess ☹



Red: hadronic MET&H_T search, previous slide (19.4 fb^{-1})

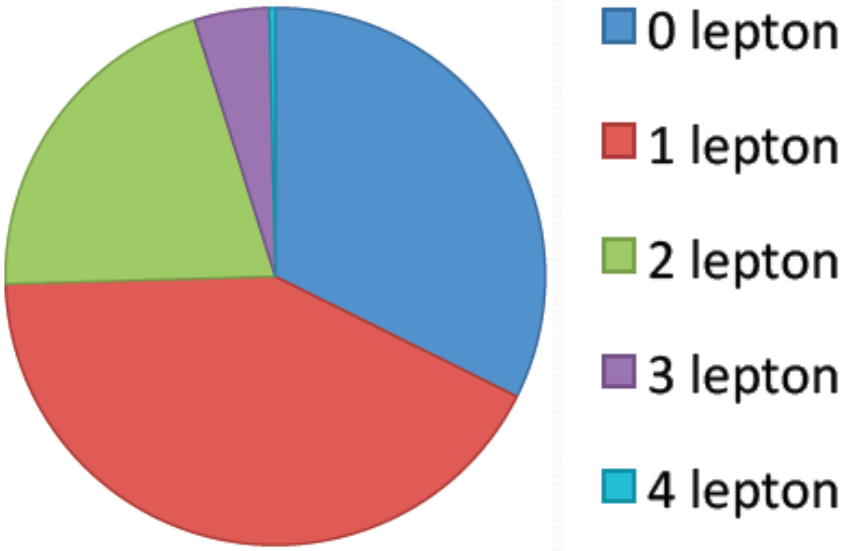
Blue: hadronic α_T & H_T search (11.7fb^{-1})

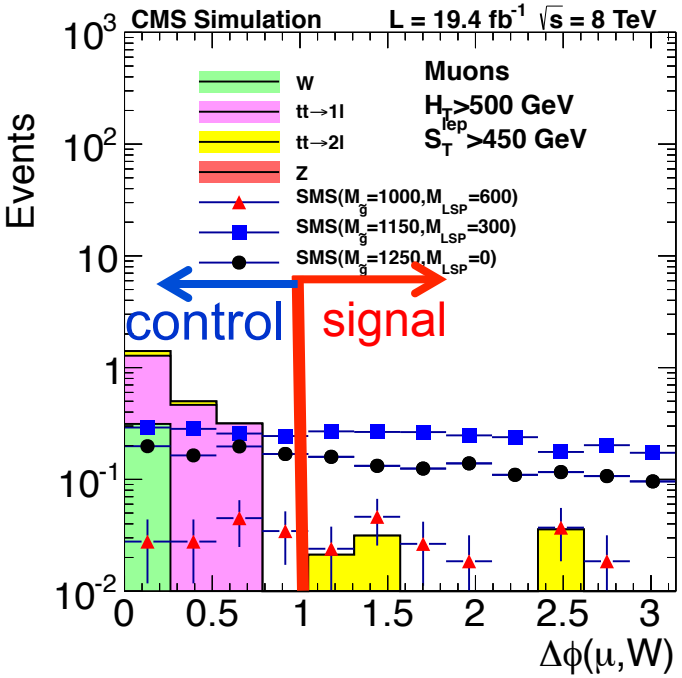
- Excluded gluino mass of 1200 GeV and LSP mass of 600 GeV

One Lepton search

SUS-13-007 19.4 fb^{-1} NEW

4W Branching Ratio





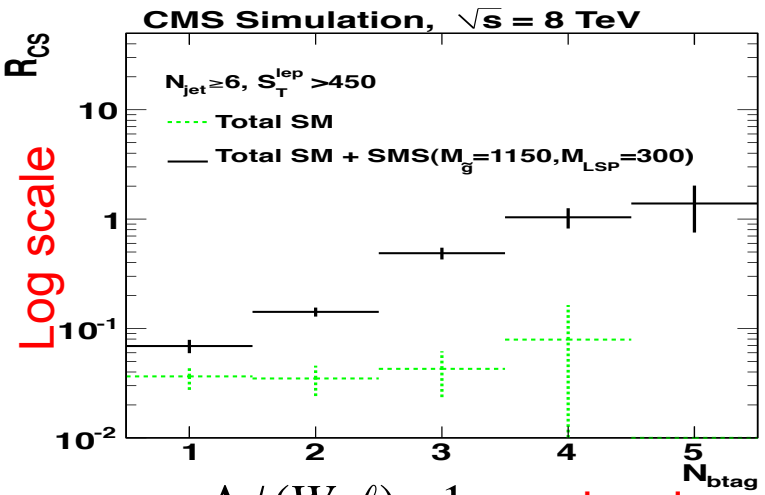
One lepton channel has largest BR

For semi-leptonic tt lepton aligned to a boosted W. (cut $\Delta\phi(W,\ell)$ at 1)

One lepton search

Selection:

- Exactly one isolated lepton
- $\Delta\phi(\ell,W)>1$
- **$N_{jets}\geq 6$**
- N_{btags} (binned) [=2, ≥3]
- $S_T^{lep}=MET+P_T(\ell)$ (binned) [250,350,450>] GeV
- $H_T>500$ GeV



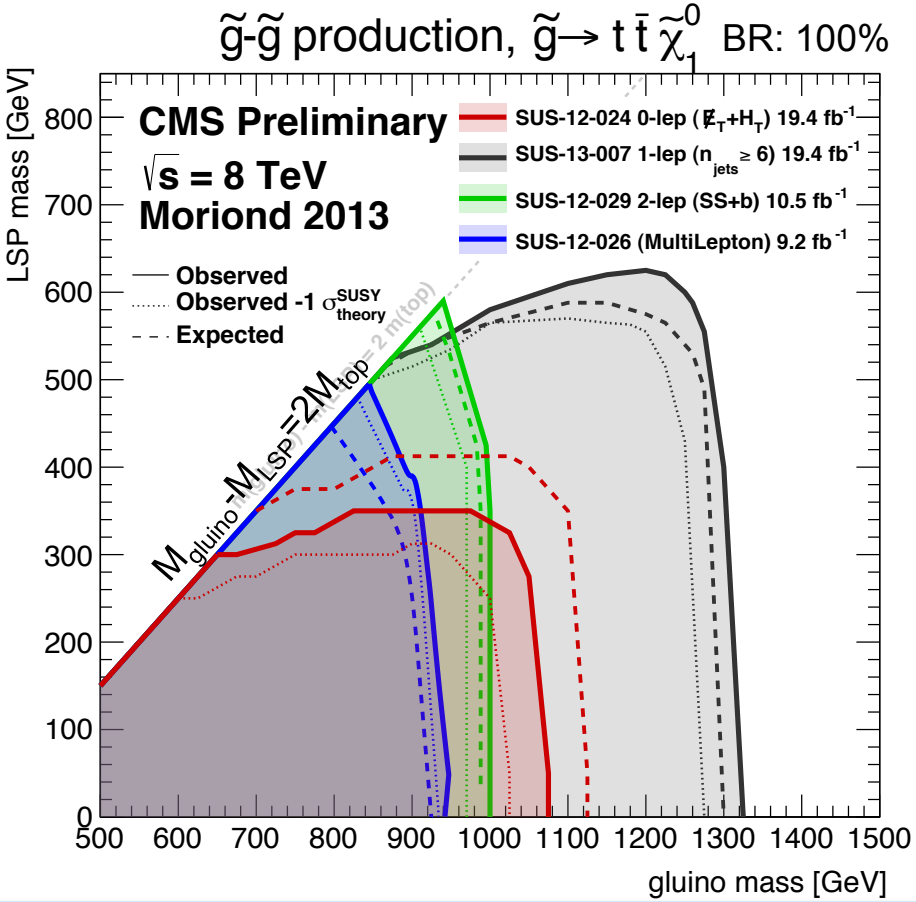
$$R_{CS} = \frac{\Delta\phi(W,\ell)>1}{\Delta\phi(W,\ell)<1} = \frac{\text{signal}}{\text{control}}$$

		S_T^{lep} [GeV]	control reg. data	prediction	observation
N_b=2	Muons	[250,350]	141	$6.00 \pm 2.40\ (2.23)$	9
		[350,450]	24	$1.37 \pm 1.19\ (1.12)$	2
		>450	9	$0.0 \pm 0.66\ (0.66)$	0
	Electr.	[250,350]	112	$3.83 \pm 1.84\ (1.75)$	9
		[350,450]	28	$2.74 \pm 2.02\ (1.86)$	2
		>450	9	$0.0 \pm 0.42\ (0.42)$	0
$N_b \geq 3$	Muons	[250,350]	28	$1.92 \pm 0.95\ (0.84)$	0
		[350,450]	13	$0.57 \pm 0.58\ (0.52)$	0
		>450	2	$0.0 \pm 0.22\ (0.22)$	0
	Electr.	[250,350]	45	$1.89 \pm 1.03\ (0.94)$	4
		[350,450]	7	$0.85 \pm 0.80\ (0.70)$	0
		>450	0	$0.0 \pm 0.08\ (0.08)$	0

- $\Delta\phi(W,\ell)$ shape (R_{CS}) similar for 1,2, and ≥3 btags
- Used for main data-driven background estimate
- No excess found ☹

Four tops + Met interpretation

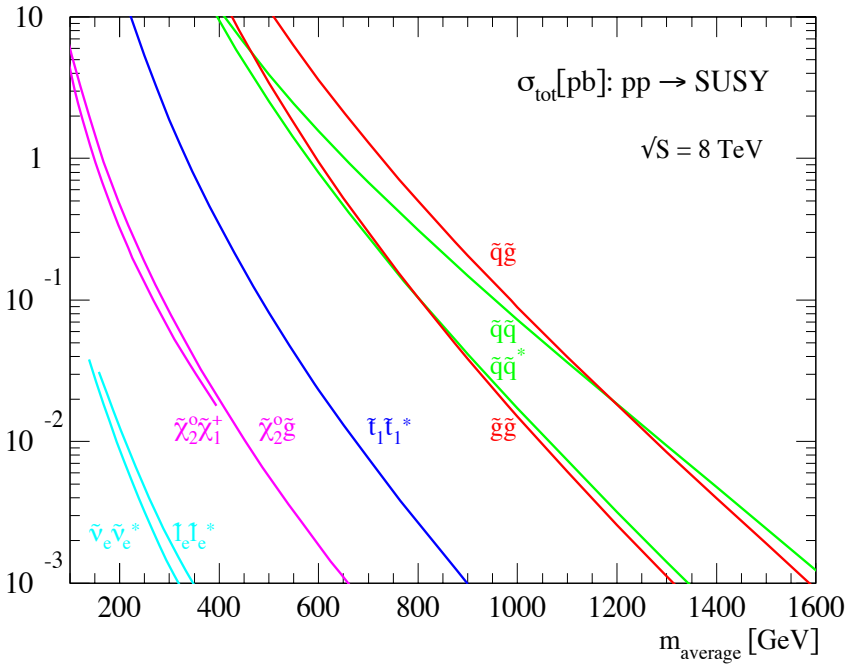
- Black: one lepton search 19.4 fb^{-1}
- Red: Hadronic search (19.4 fb^{-1})
- Green: SS dileptonic search, **very sensitive** if LSP and gluino masses compressed; little MET required (10.5 fb^{-1})
- Blue: ≥3 leptons (9.2 fb^{-1})

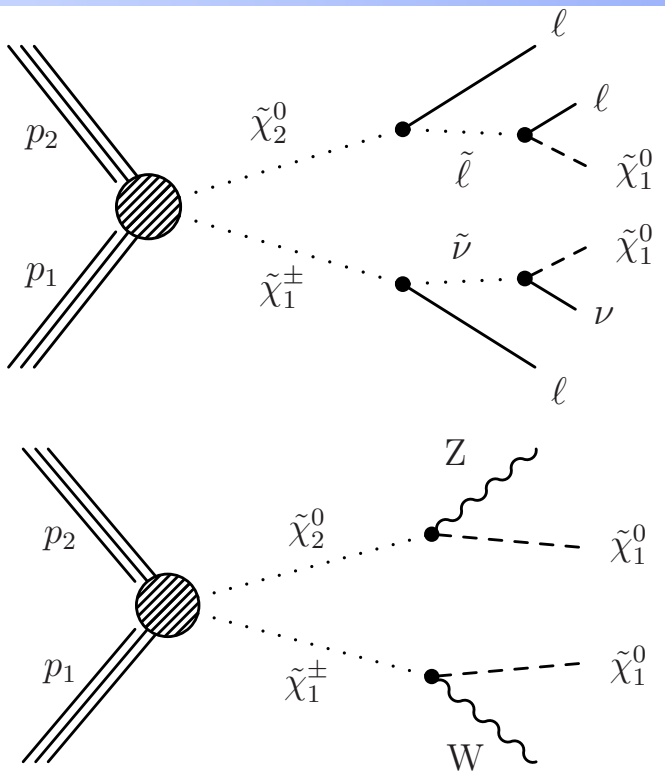


- Excluded gluino mass of 1300 GeV and LSP mass of 550 GeV

EWKino searches

Electroweakinos





- Small production cross-section
- Spectacular signature with many leptons (bosons) and MET
- Interesting for natural SUSY and split SUSY

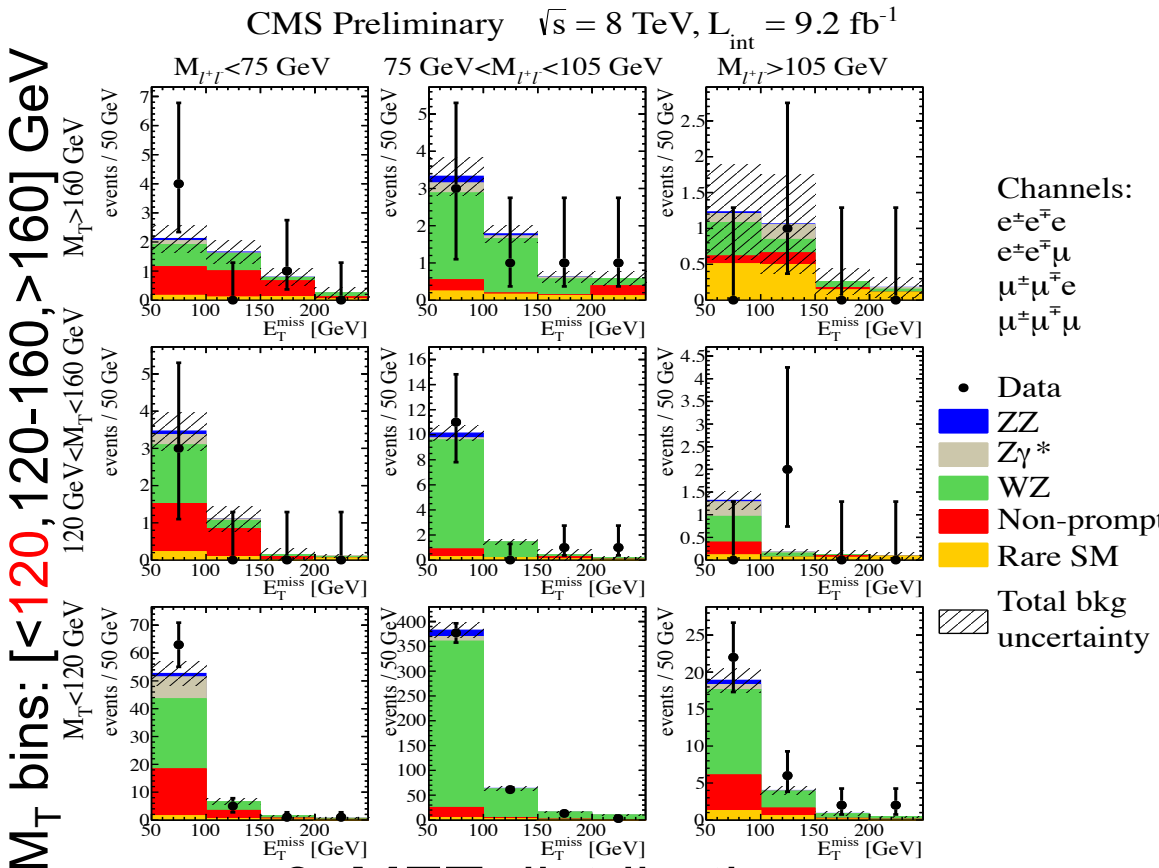
Electroweakinos

SUS-12-022, 9.2fb^{-1}

Selection 3 ℓ:
- 3D bins in MET,M(ℓ^-,ℓ^+), M_T
- MET>50 GeV
- b veto

Selection 2 ℓ :
- SS lepton (3rd lep veto)
- SRI: MET>200 GeV
- SRII: MET>120 GeV,$N_{jets}\leq 2$, b veto
- SRIII: MET>120, $N_{jets}=0$

M($\ell\ell$) bins: [<75, 75-105, >105] GeV

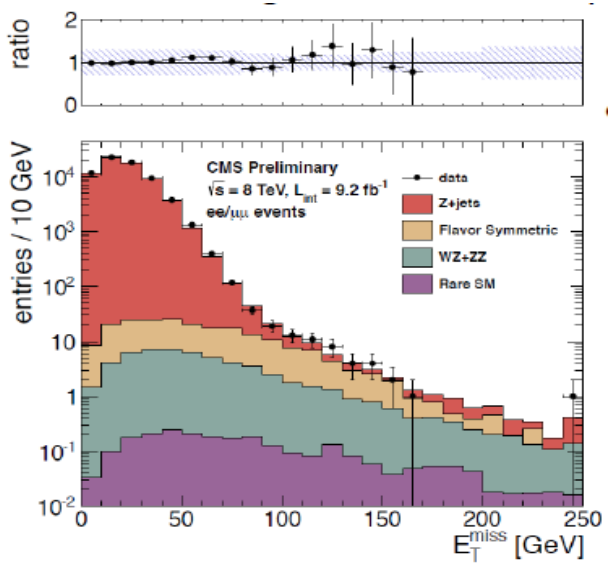


3ℓ MET distributions

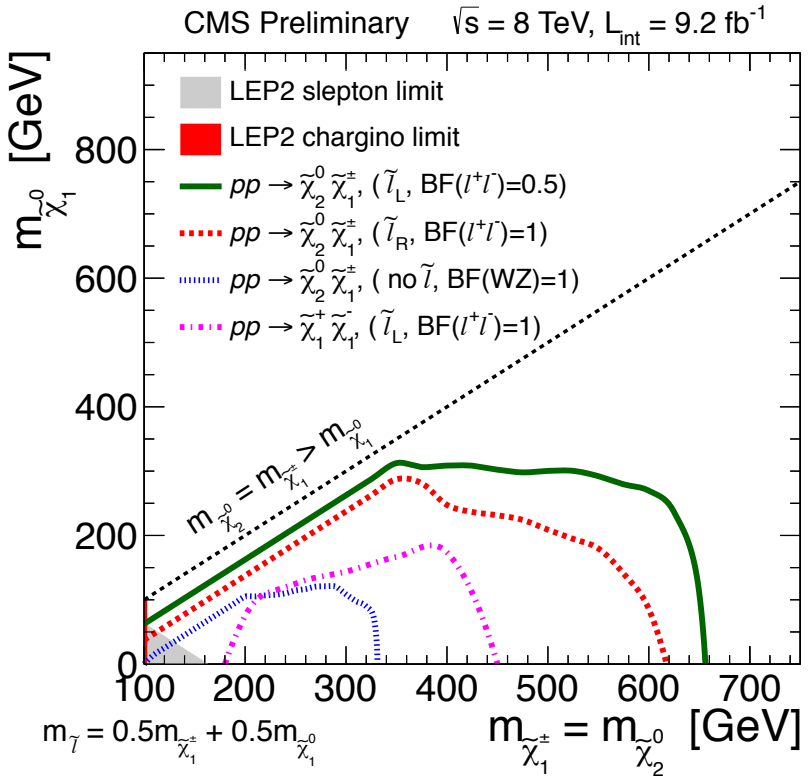
Electroweakinos

Further Selections:
- Z+Jets+MET
- 4 leptons

MET of Z+jet events



SUS-12-022, 9.2fb^{-1}

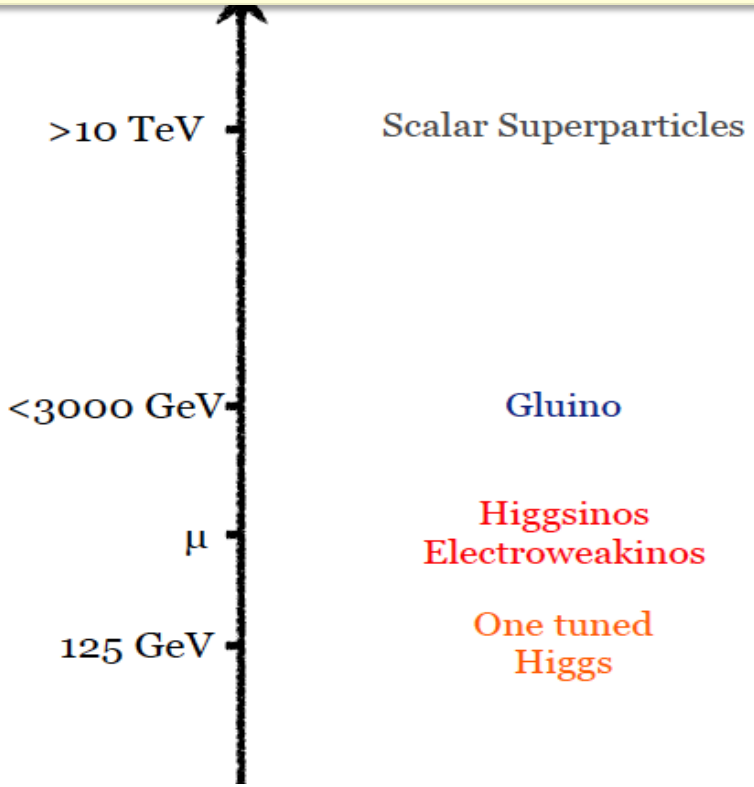


Exclusions for electroweakinos masses several hundred GeV

Long lived sparticles

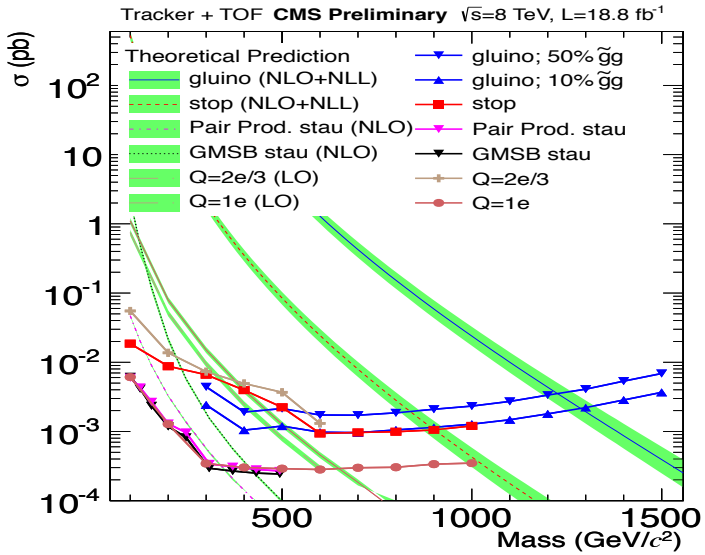
Split SUSY

EXO-012-024 19.4 fb^{-1} NEW



- Preserves successes of Dark Matter and gauge coupling unification

- Gluino long lived (virtual squark) and velocity < c
- Different dE/dx than SM particles in tracker
- Different TOF in the muon system

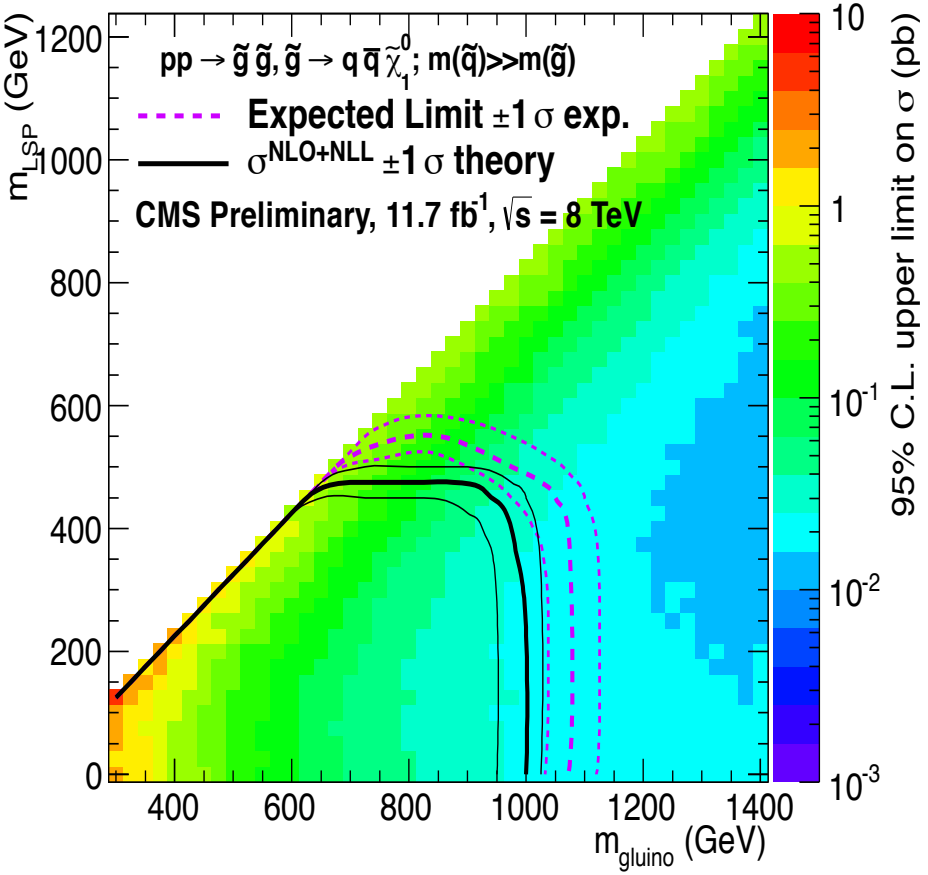


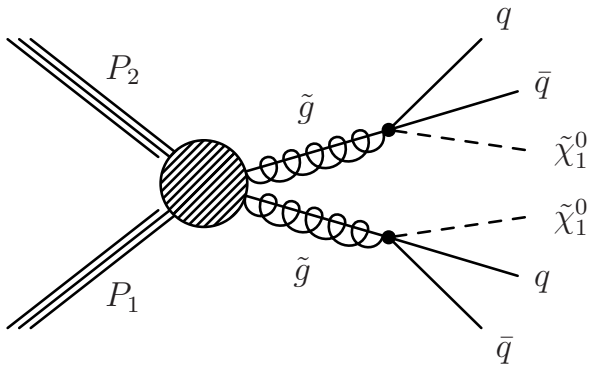
- Gluino (long-lived) > 1.2 TeV
- More in EXO talk

Squarks and gluinos

Gluino to 1st generation

α_T analysis, see earlier slides





- "Classical" searches continued
- Gluino mass SMS limits more conservative than MSSM, as only a single production mechanism is considered

Summary

Natural SUSY:

- Would be produced at LHC, but not yet found.
- Limits get close to 10% tuning (0.6 TeV stop, 1.4 TeV Gluino)
- Compressed spectra or RPV could hide SUSY
  - starting to significantly constrain compressed & RPV as well
- Stay tuned: Further analysis in pipeline for 2013!

EWKinos:

- Exclusions up to several hundred GeV EWKinos

Long lived sparticles:

- Search for long lived gluinos

“Classical” squark-gluino searches:

- Keep searching

Natural SUSY quite constrained, but alive