INCLUSIVE SUSY SEARCHES AT THE LHC USING THE CMS DETECTOR

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Overview

Inclusive searches for supersymmetry

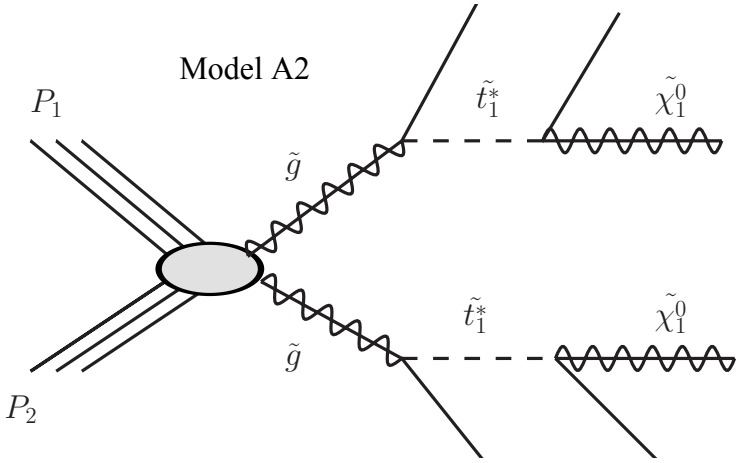
- 3-lepton and ≥ 1 b-tag search, SUS-13-008
- Jets and missing transverse energy search, SUS-13-012

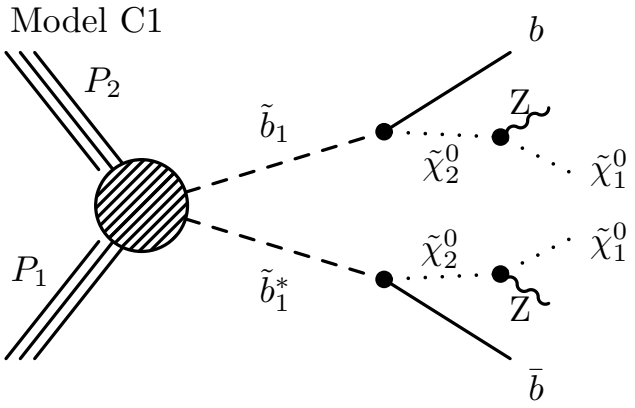
See also other new CMS results:

- Sezen Sekmen, Fri. 18:00 “Search for Natural SUSY with inclusive search strategies at CMS”
- Lesya Shchutska , Fri 18:30, “SUSY searches for EWK production of Gauginos and Sleptons at the LHC”
- Keith Ulmer, Sat. 12:30, “Search for Supersymmetry in the four W and multiple b-quark final state”

Inclusive search for SUSY with multi-leptons plus b

- Generic search, lepton requirement to suppress background
- Targeting possibly light third generation squarks (natural SUSY requires light 3rd generation)





Sensitivity to SUSY scenarios with at least
- Three light isolated leptons (e, μ),
- One b-tagged jet
- Missing transverse energy (MET)
- Hadronic activity

$\sqrt{s}$ = 8 TeV,
19.5 fb^{-1} luminosity (full 2012)

Selection

- 3 leptons with pT > 20, 10, 10 GeV
- $m(l^+l^-) > 12$ GeV
- ≥ 1 b-tagged jet with pT > 30 GeV
- No lepton with ΔR(l, b-jet) < 0.4
- no jet with ΔR(l, jet) < 0.4

29 regions

Variable	Baseline	Search Regions		
Sign/Flavor	3 e/μ	On-Z	Off-Z	
$N_{\text{b-jets}}$	≥ 1	1	2	≥ 3
N_{jets}	≥ 2	2–3	≥ 4	
H_T (GeV)	≥ 60	60–200	≥ 200	
E_T^{miss} (GeV)	≥ 50	50–100	100–200	≥ 200

On-Z: Opposite-sign same-flavor di-lepton mass with m(Z) ± 15 GeV

Off-Z: everything else

HT: scalar sum of jet pT

$$H_T = \sum_i^{jets} \left| \vec{p}_T, i \right|$$

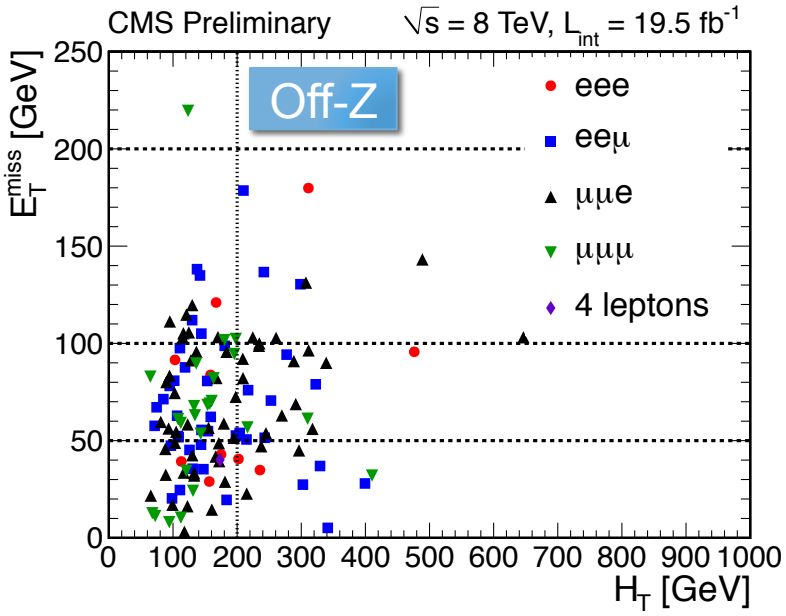
Standard Model background

- Top – anti-top plus boson production: ttW, ttZ, ttWZ
- Single-top plus Z production: tbZ
- Di-boson production: WZ, ZZ
- Triple-boson production, WWW, WWZ, WZZ

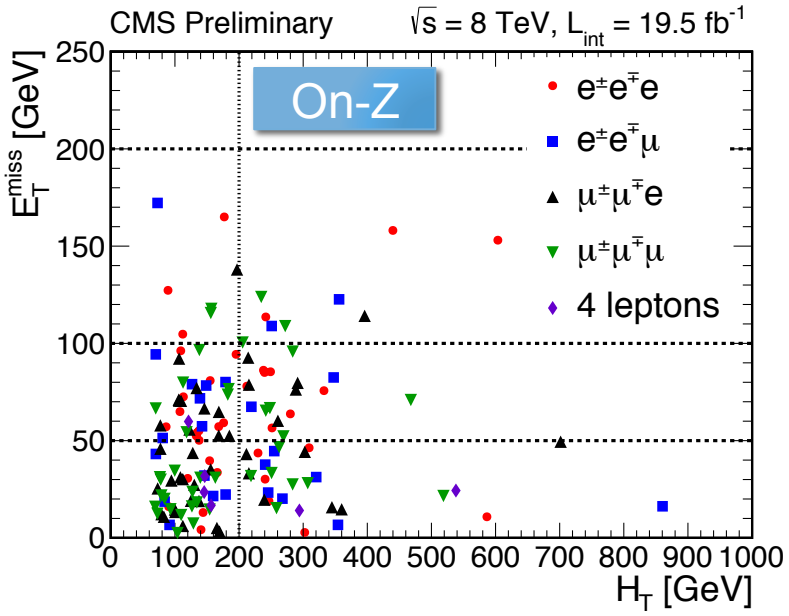
} Monte Carlo simulation

- Non-prompt lepton (e.g. from b-decays)

} Data side-band



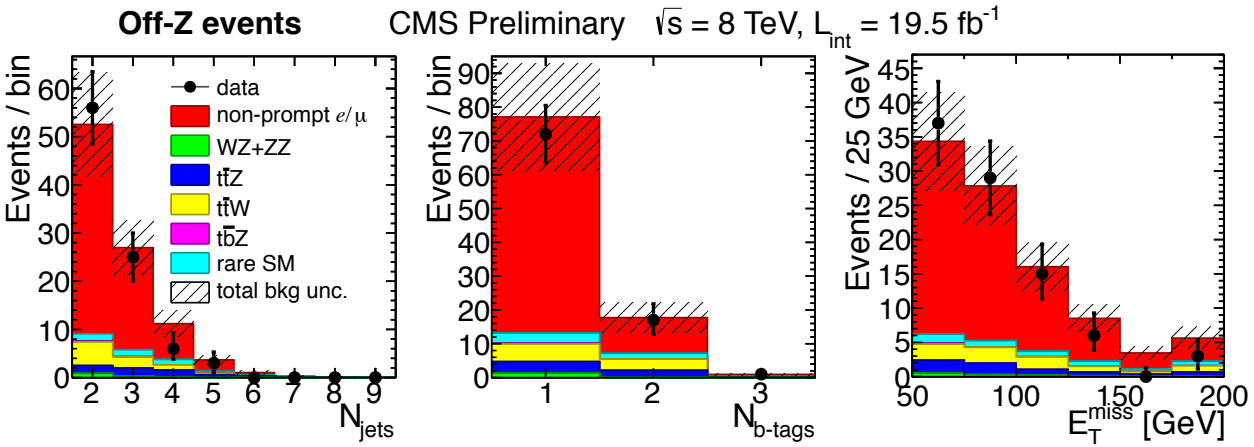
90 events

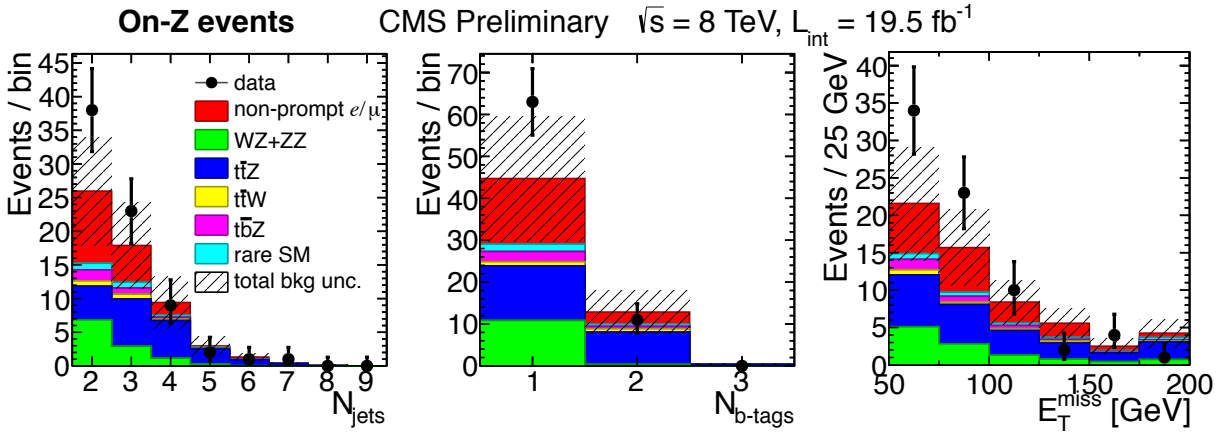


73 events

Results

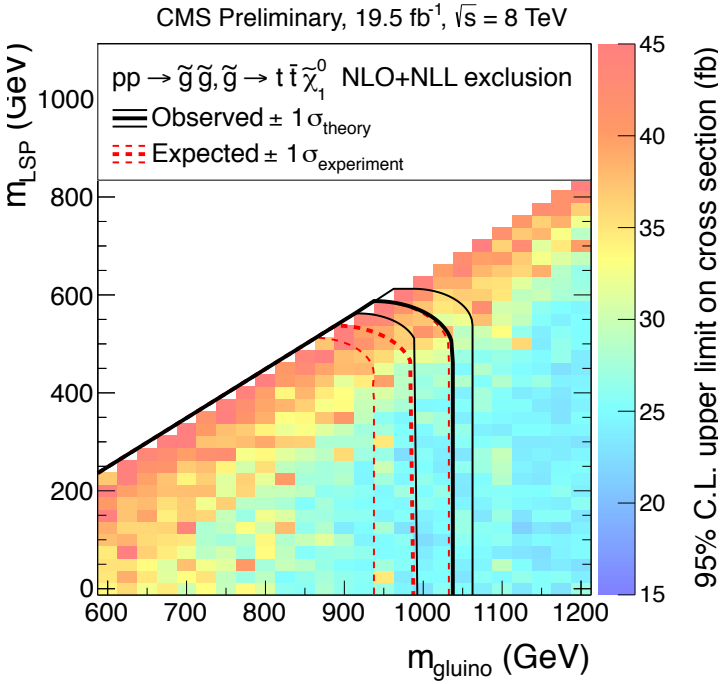
- Non-prompt lepton background dominant – this is extracted from data
- Simultaneous multi-bin fit to obtain final cross-section limits
- Lepton reconstruction and isolation efficiency uncertainties measured in data control sample on the Z peak



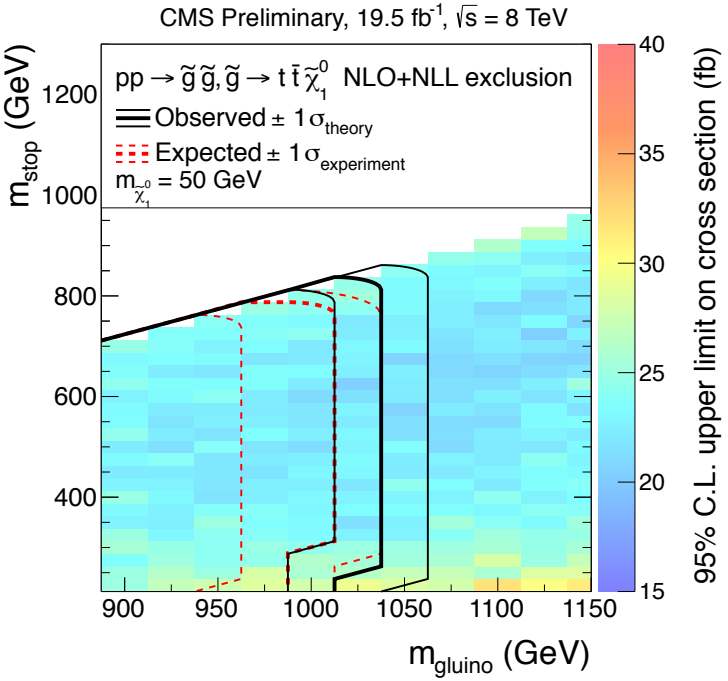


Source	Uncertainty, %
Luminosity	4.4
Modeling of lepton reconstruction, ID, I_{rel} based on Z-events	12
Jet energy scale	5–15
Unclustered energy and lepton effects on $E_{\mathrm{T}}^{\mathrm{miss}}$	5
Modeling of b-jet multiplicity	5–20
Trigger	5
Total systematic uncertainty	15–30

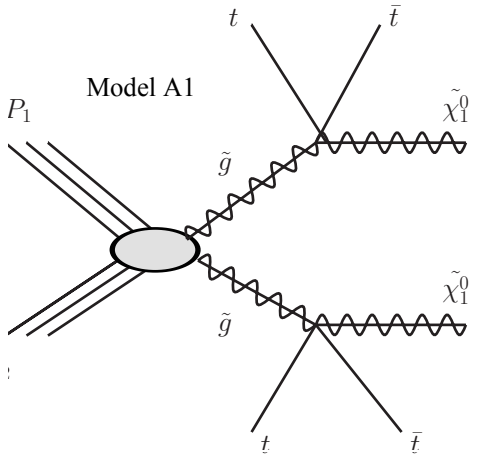
Cross section limit and interpretation in simplified model spectra (SMS)

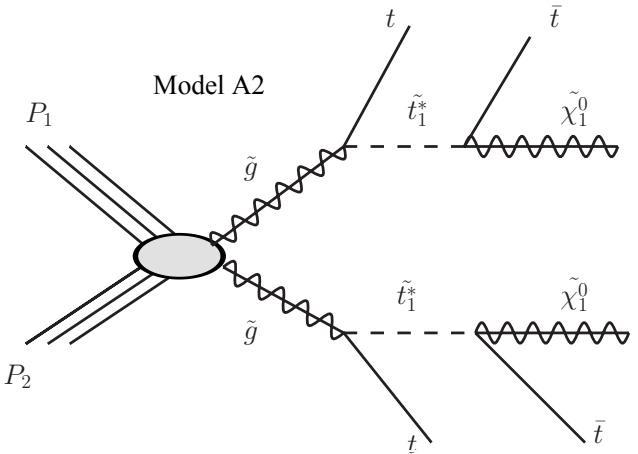


Off-shell stop



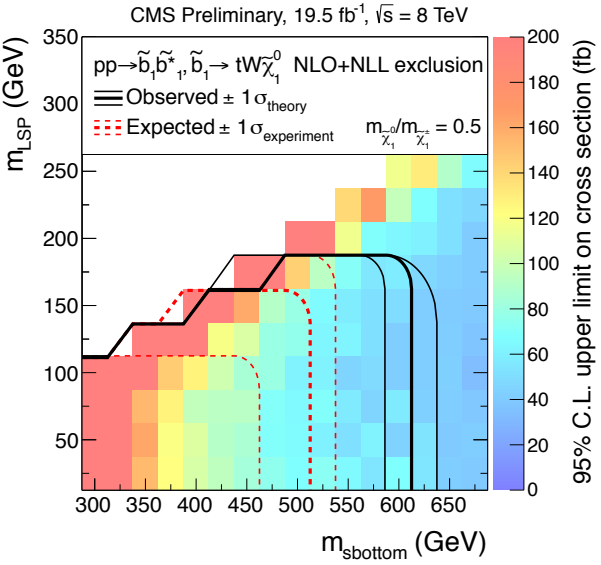
m(neutralino 1) = 50 GeV



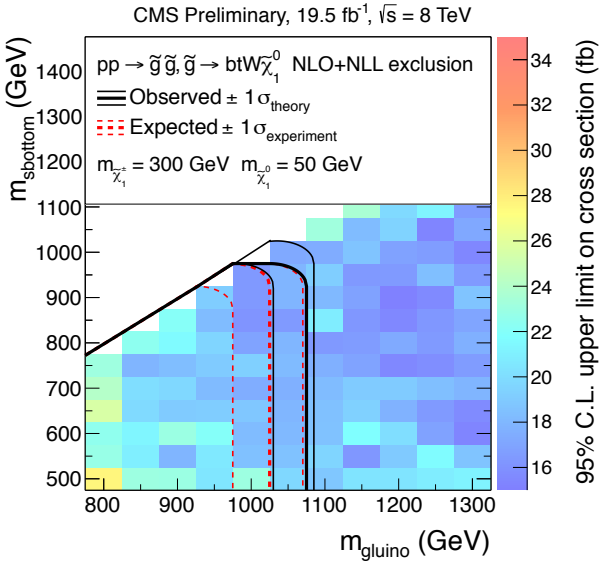


Cross section limit and interpretation in SMS

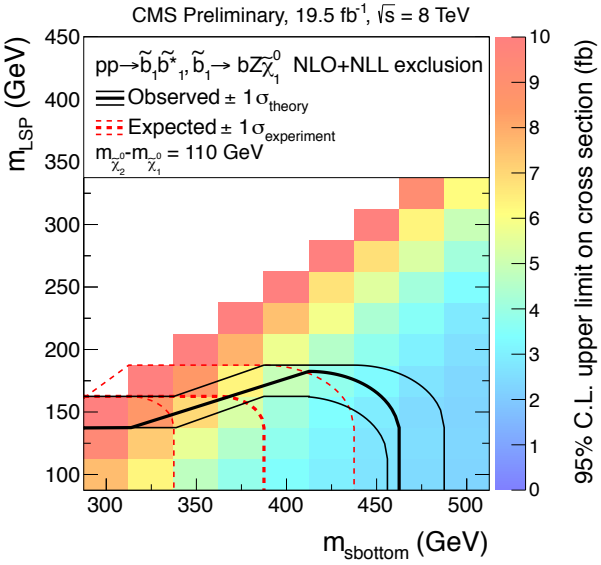
m(LSP) – m(sbottom)



m(sbottom) – m(gluino)



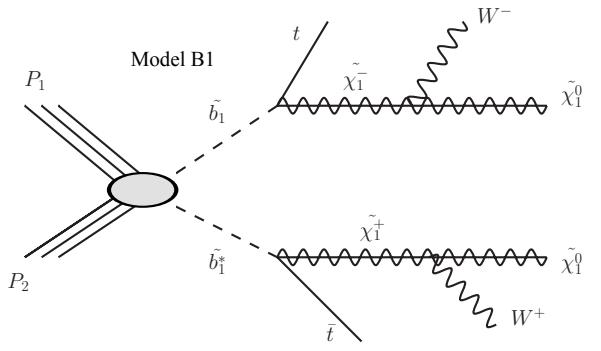
m(LSP) – m(sbottom)

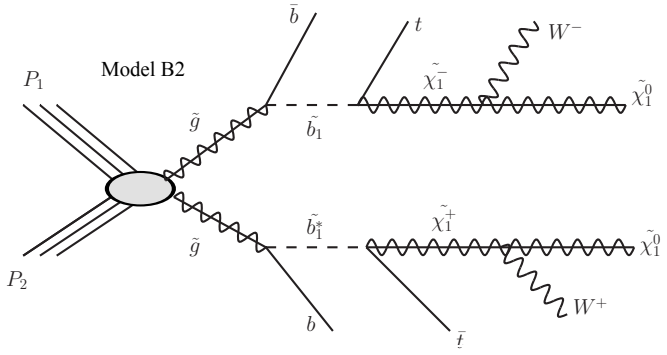


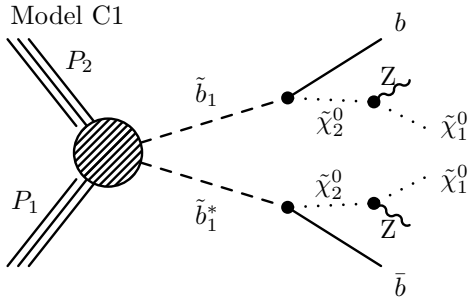
$m(\chi^{\pm}) / m(\chi^{0}) = 0.5$

$M(\chi^{\pm}_1) = 300$ GeV

$M(\chi^{0}_2) - M(\chi^{0}_1) = 110$ GeV



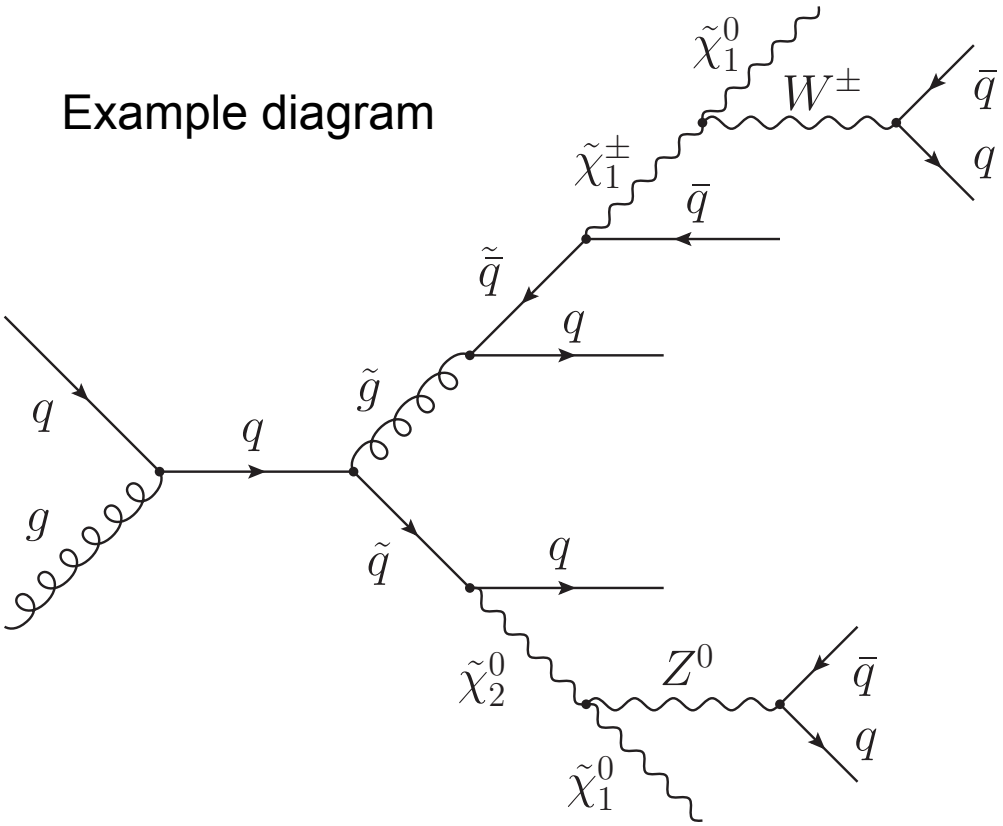




Inclusive search for SUSY in the MET and jets final state

New!

Example diagram



$\sqrt{s}$ = 8 TeV,
19.5 fb^{-1} luminosity
(full 2012)

- Dominant squark and gluino pair/ associated production
- Stable neutralino LSP

Final state

- MHT
  missing transverse Energy

$$\not{H}_T = \left| -\sum_i^{jets} \vec{p}_T,i \right|$$

- Jets
  - High multiplicity or
  - High H_T (scalar sum jet p_T)

$$H_T = \sum_i^{jets} \left| \vec{p}_T,i \right|$$

➔ Very little model assumptions

Selection

- 3 jets pT > 50 GeV, $|\eta| < 2.5$
- $\Delta\Phi(\text{MHT}, \text{jets}_{1,2,3}) > 0.5, 0.3, 0.3$
- Veto events with isolated e, μ with $p_T > 10$ GeV

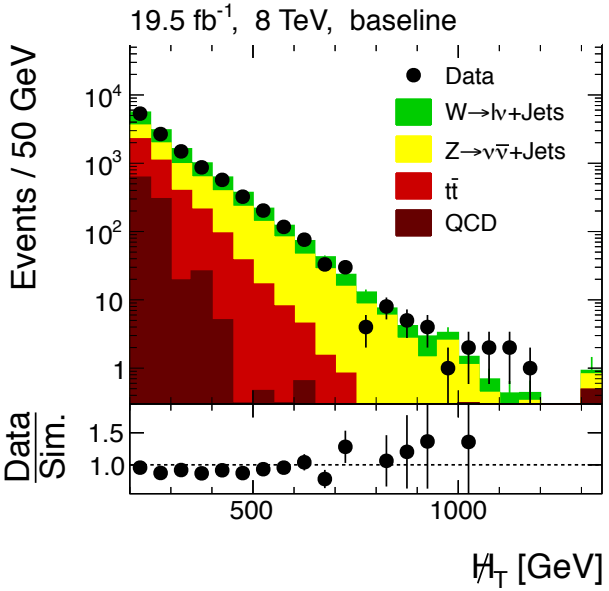
Variable	baseline	36 signal search regions				
Jet-multiplicity	3 -	3 - 5	6 - 7	8 -		
HT [GeV]	500 -	500-800	800-1000	1000-1250	1250-1500	1500 -
MHT [GeV]	200 -	200-300	300-450	450-600	600 -	

Backgrounds

- QCD multi-jet production
  MHT from jet resolution and mis-measurements
- W/tt➔(e/μ)+jets
  Lepton is not reconstructed
- Z➔νν
- W+jets➔τ+jets

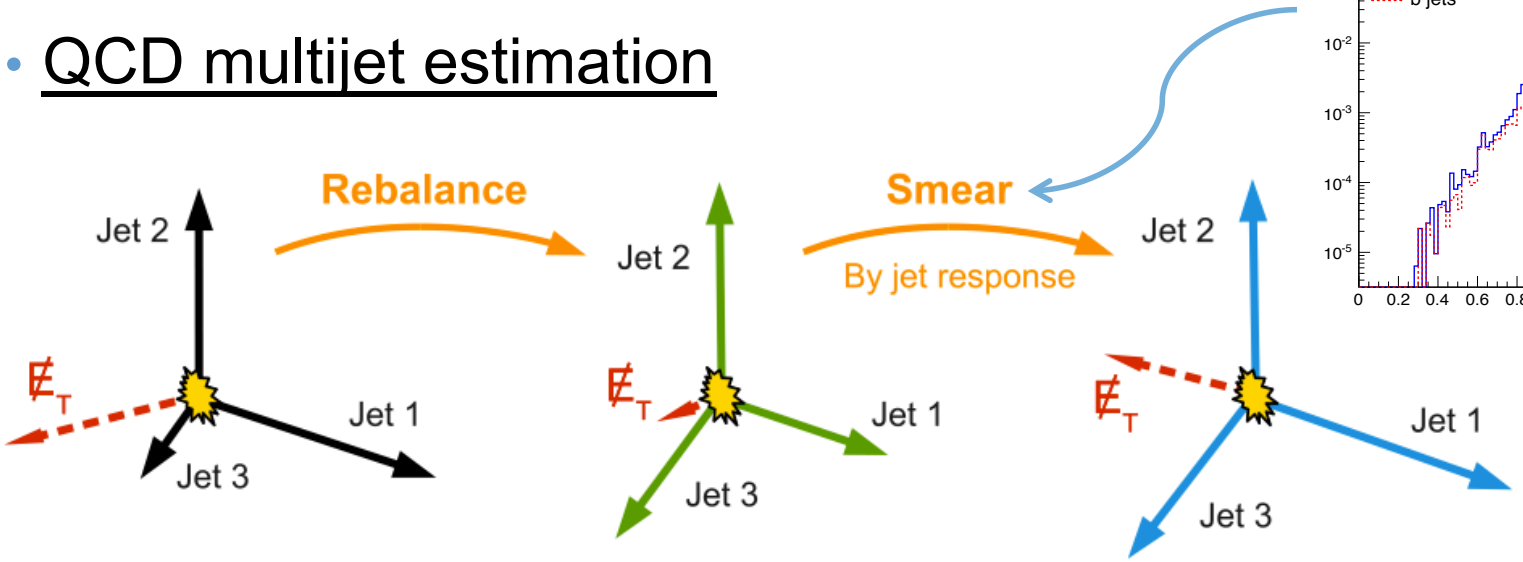
➔ All are estimated using data-driven methods

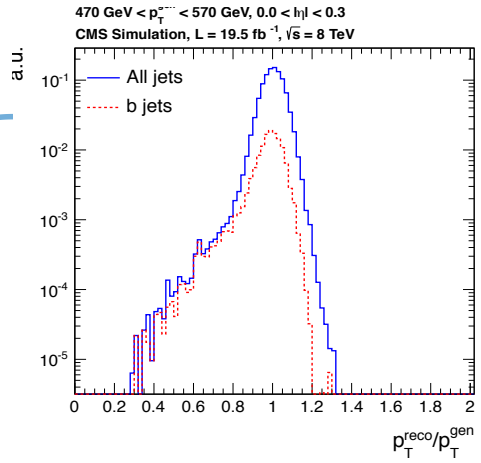
Baseline selection:



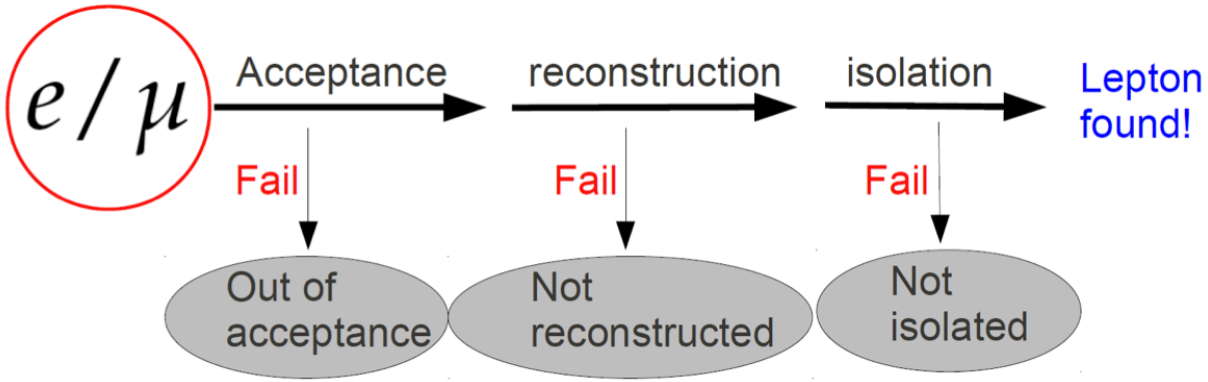
Background estimation

- QCD multijet estimation





- tt/W ➔ (e/μ) + jets, where the lepton is lost



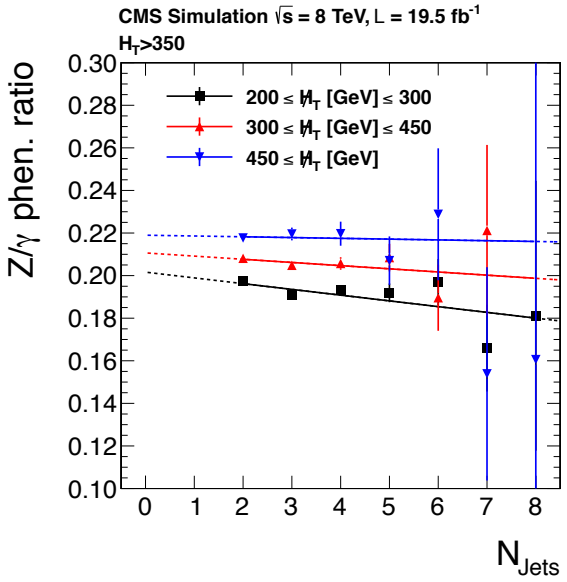
➔ Signal selection (lepton-veto)

➔ Control sample (isolated muon)

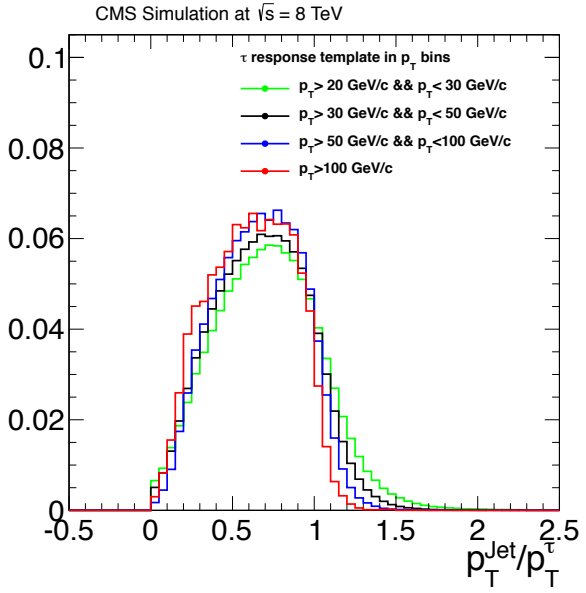
Weighted according to lepton acceptance, isolation, and recon-struction efficiencies

Background estimation

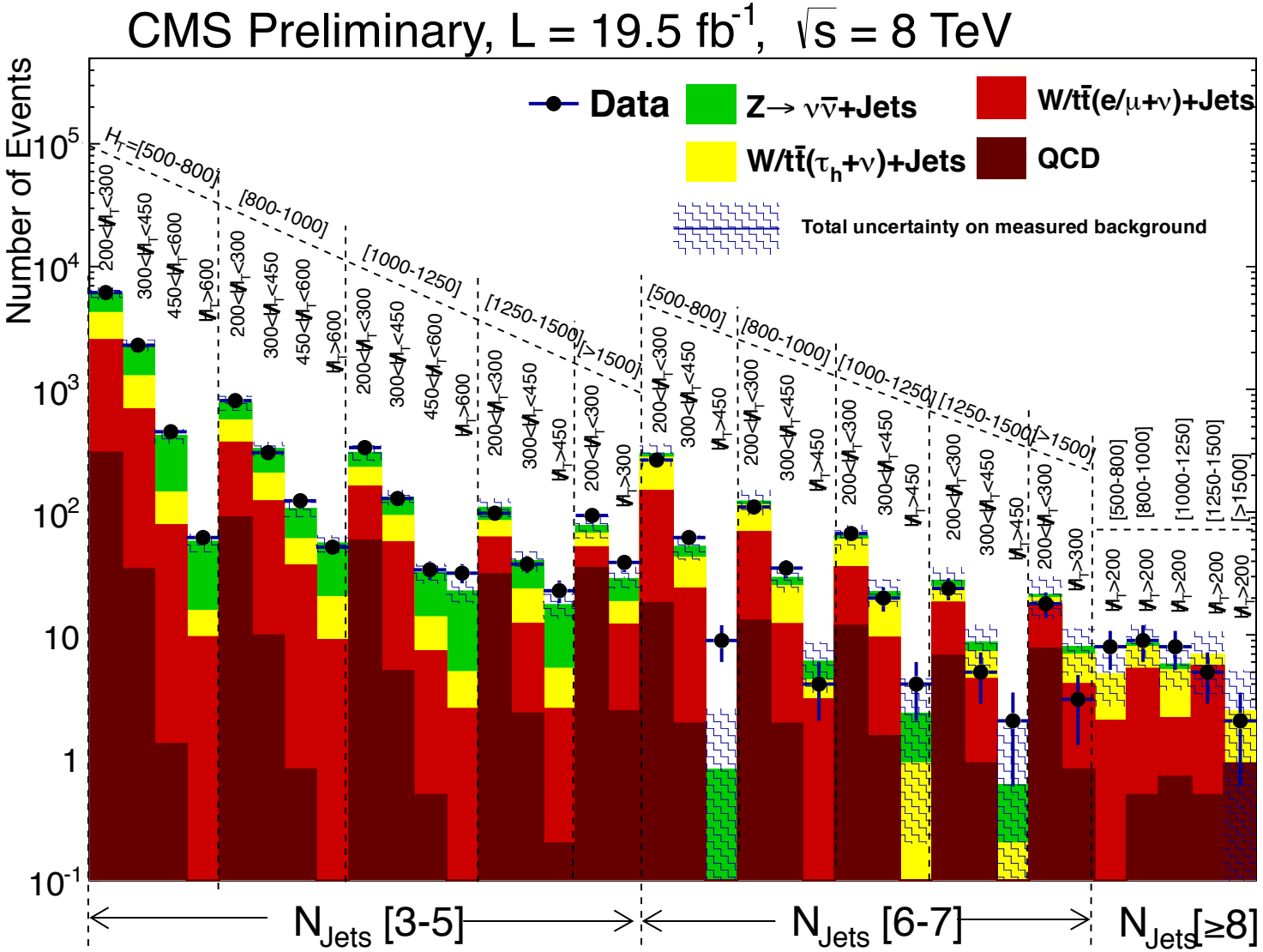
- Z ➔νν from γ+jets
  - Z/γ similar at high boson pT
  - Replace γ with MET
  - Correct Z/γ ratio using simulation
  - Apply γ acceptance & efficiency corrections



- tt/W ➔ τ(➔hadrons) + jets
  - Isolated μ control sample
  - μ replaced by tau response according to template (each μ sampled 100 times)
  - μ trigger, acceptance, efficiency, and branching ratio μ / ν corrections

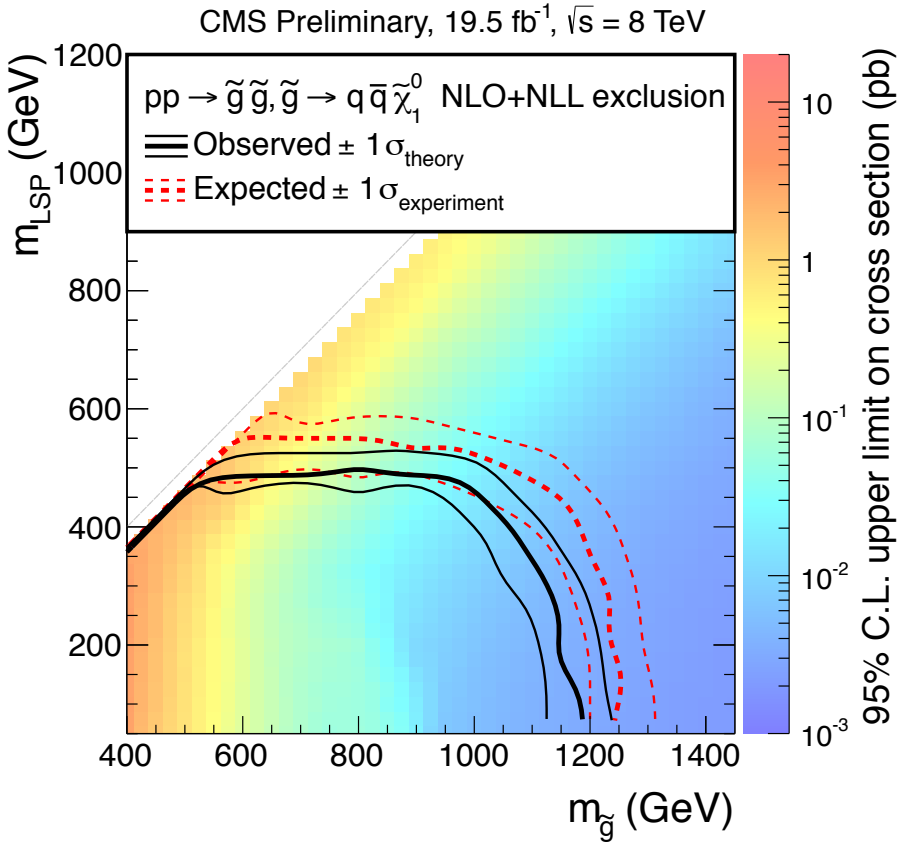


Results of the Jets plus MET search



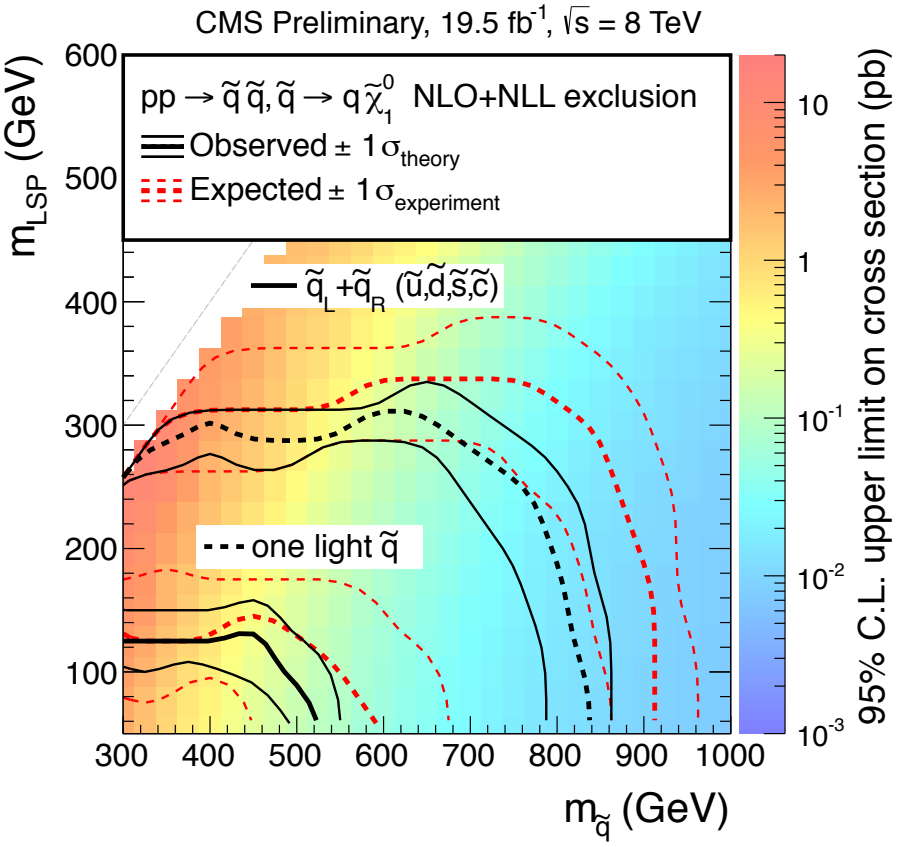
Cross section limit and Interpretation in SMS

Gluino-gluino pair-production



Squark-squark pair-production

- First two squark generations mass degenerate
- Only one accessible squark



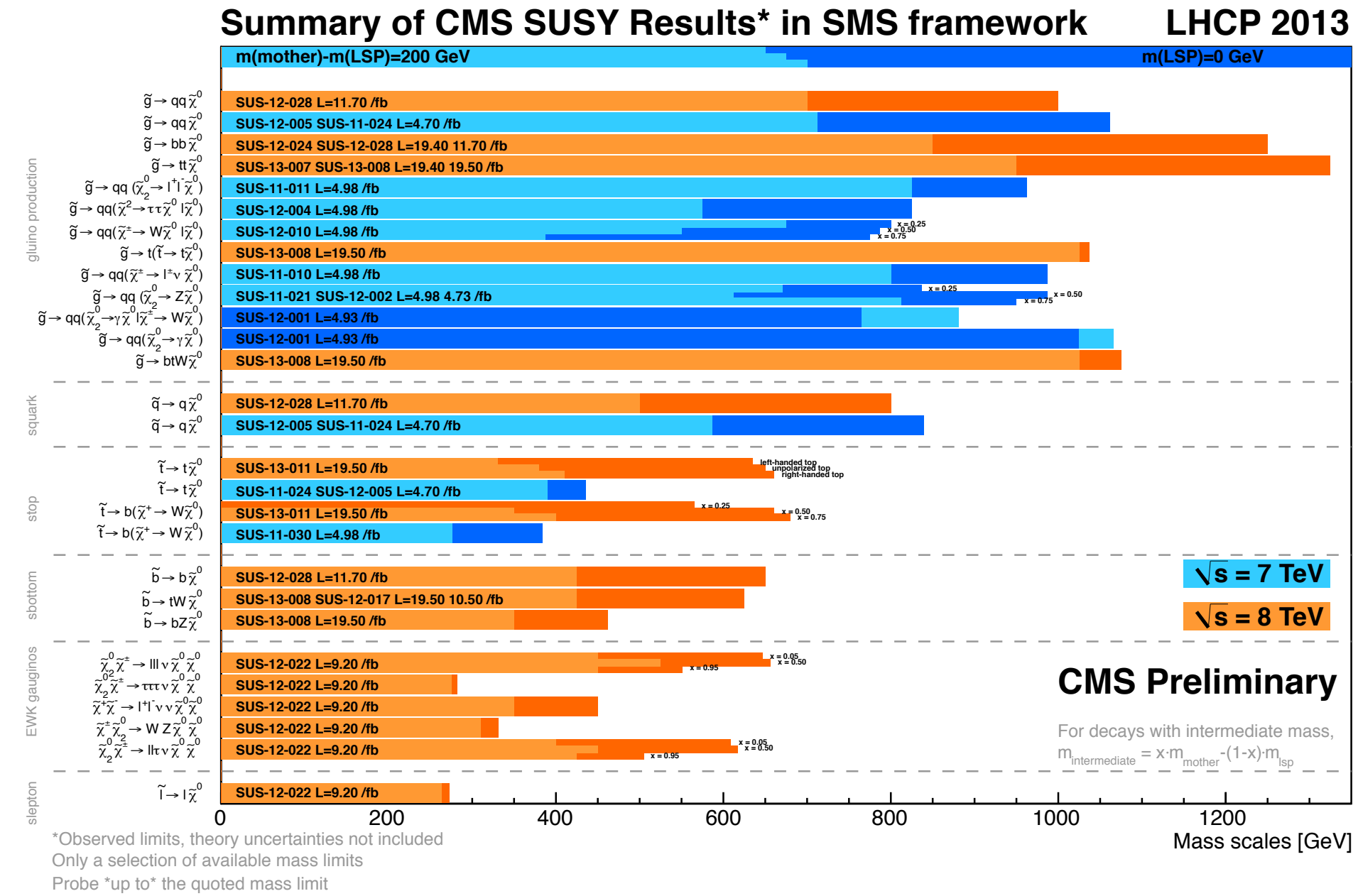
Conclusion

- CMS has searched for New Physics using 19.5 fb^{-1} of 8 TeV data of the full 2012 dataset
  - Multi-lepton search SUS-13-008
  - Jets and missing transverse energy SUS-13-012
- No significant excess has been observed
- CLs limits at 95% C.L. on the signal cross section have been calculated
- Interpretation in various simplified model spectra (SMS)

References

CMS public results: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults

Additional Material


Summary of CMS SUSY Results* in SMS framework
LHCP 2013
m(mother)-m(LSP)=200 GeV
m(LSP)=0 GeV
gluino production
squark
stop
sbottom
EWK gauginos
slepton
SUS-12-028 L=11.70 /fb
SUS-12-005 SUS-11-024 L=4.70 /fb
SUS-12-024 SUS-12-028 L=19.40 11.70 /fb
SUS-13-007 SUS-13-008 L=19.40 19.50 /fb
SUS-11-011 L=4.98 /fb
SUS-12-004 L=4.98 /fb
SUS-12-010 L=4.98 /fb
SUS-13-008 L=19.50 /fb
SUS-11-010 L=4.98 /fb
SUS-11-021 SUS-12-002 L=4.98 4.73 /fb
SUS-12-001 L=4.93 /fb
SUS-12-001 L=4.93 /fb
SUS-13-008 L=19.50 /fb
SUS-12-028 L=11.70 /fb
SUS-12-005 SUS-11-024 L=4.70 /fb
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SUS-12-022 L=9.20 /fb
SUS-12-022 L=9.20 /fb
left-handed top
unpolarized top
right-handed top
x = 0.25
x = 0.50
x = 0.75
0
200
400
600
800
1000
1200
Mass scales [GeV]
√s = 7 TeV
√s = 8 TeV
CMS Preliminary
For decays with intermediate mass,
m_intermediate = x·m_mother -(1-x)·m_lsp
*Observed limits, theory uncertainties not included
Only a selection of available mass limits
Probe *up to* the quoted mass limit

Jets plus MET search bins

36 exclusive search bins			
N_{Jets}	[3,5]	[6,7]	≥8
$H_T(\downarrow)$	$\not{H}_T$	$\not{H}_T$	$\not{H}_T$
[500-800] [800,1000] [1000,1200]	[200,300] [300,450] [450,600] ≥ 600	[200,300] [300,450] ≥ 450	≥ 200
[1200,1500]	[200,300] [300,450] ≥ 450	[200,300] [300,450] ≥ 450	≥ 200
≥ 1500	[200,300] ≥ 300	[200,300] ≥ 300	≥ 200