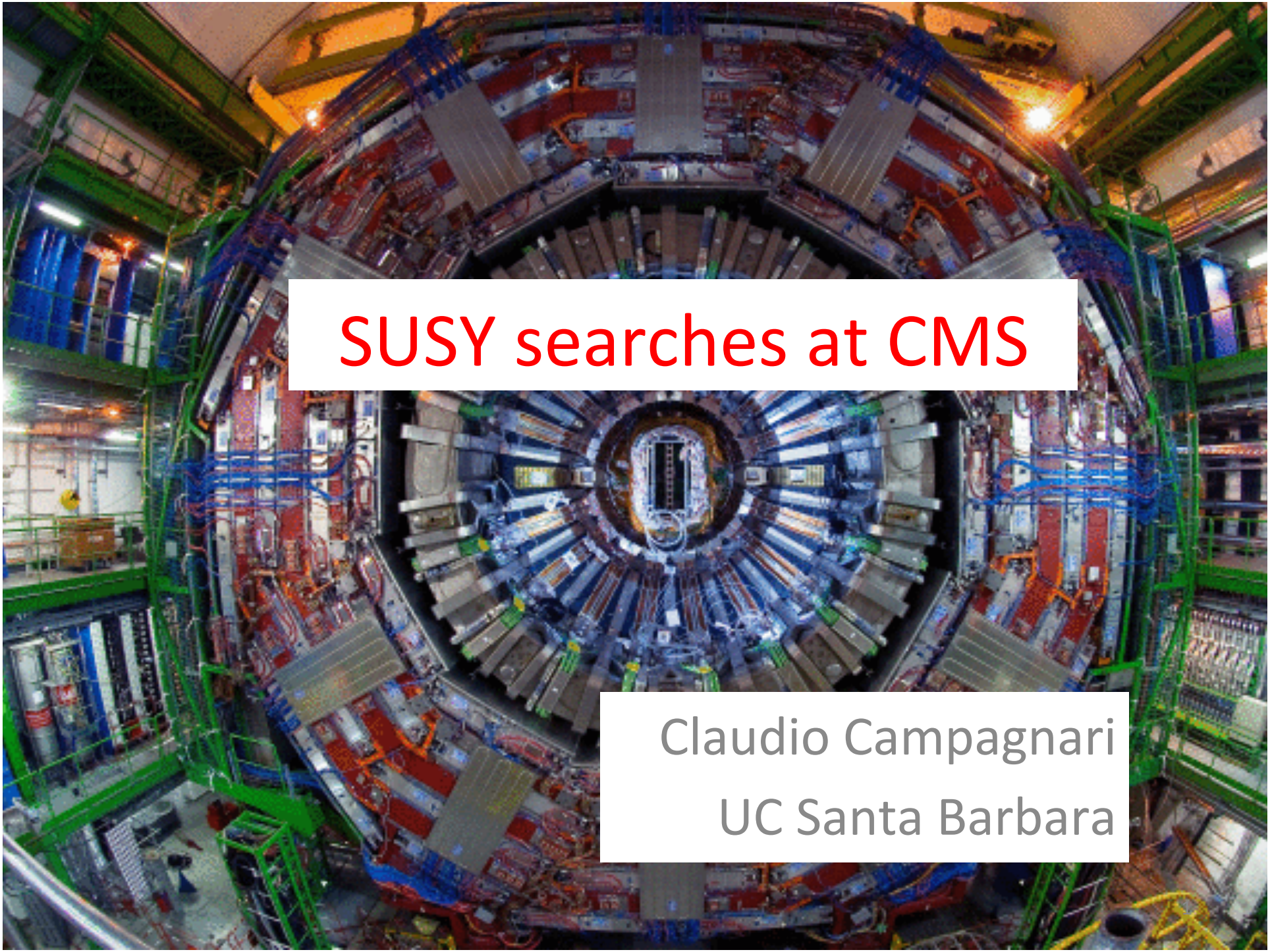


SUSY searches at CMS

Claudio Campagnari

UC Santa Barbara

Outline

- Brief re-cap of 2010-11 results (7 TeV)
- Next frontier (1): Natural SUSY
- Next frontier (2): EWK-ino
- Next frontier (3): compressed spectra
- A few words about RPV SUSY (also Stealth SUSY)
- 8 TeV data, first look
- Communication of results
- Conclusions

SUSY searches at 7 TeV

The initial SUSY program at CMS was designed to be

1. Generic

- Signature based searches not tuned to a particular SUSY model

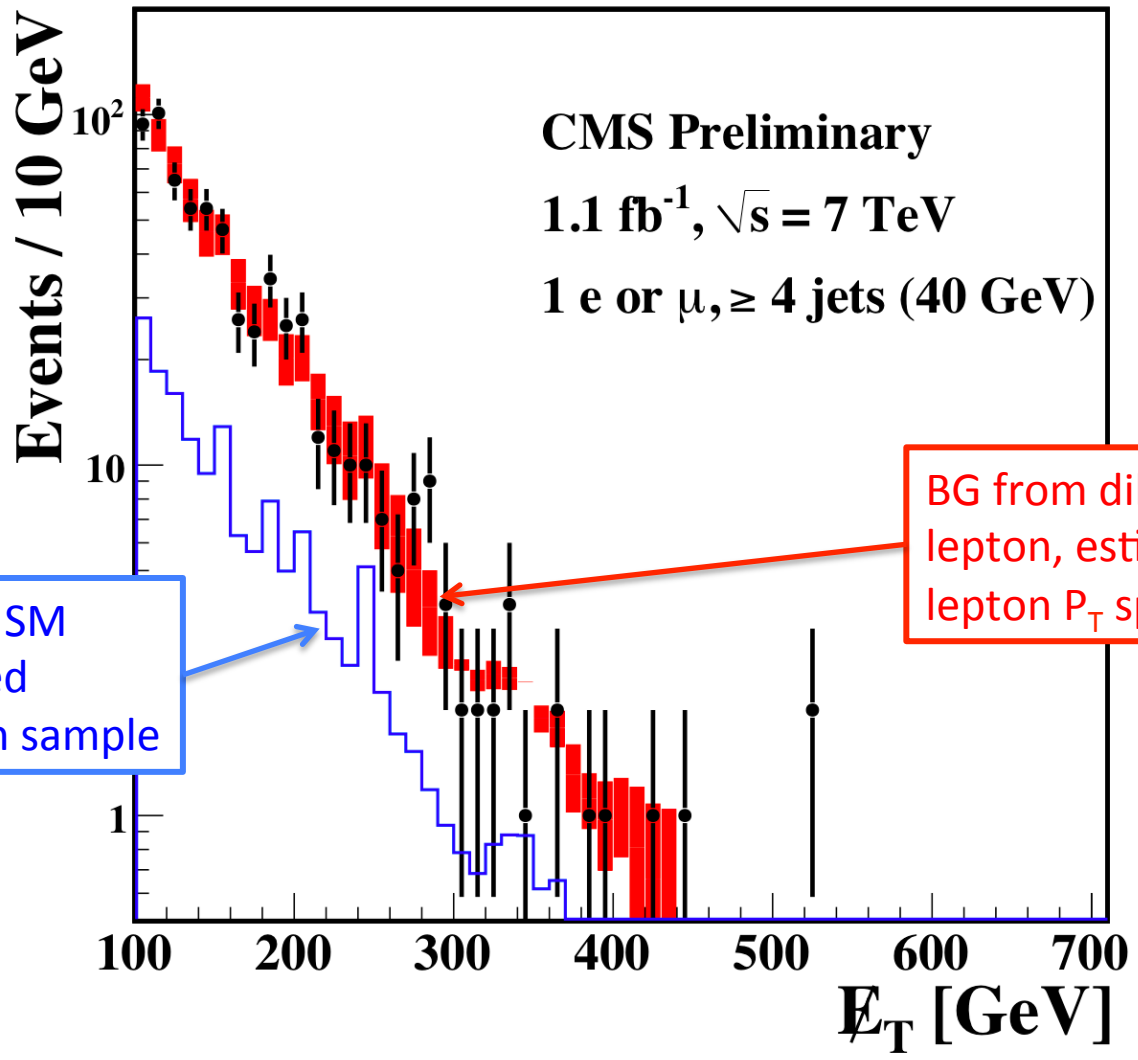
2. Broad

- Cover many possible signatures.
- Use different methods
  - eg: 4 methods/variables for the all hadronic channel (α_T, MHT, MT2, razor)
  - Counting as well as shapes

3. Robust

- As "data driven" and MC-less as possible
  - eg: standard method of normalizing MC to control region and "extrapolate" to signal region is used as little as possible

Example: E_T^{miss} spectrum in single leptons



Contribution from SM dileptons estimated from **data** dilepton sample

BG from dileptons + SM single lepton, estimated from **data** lepton P_T spectrum

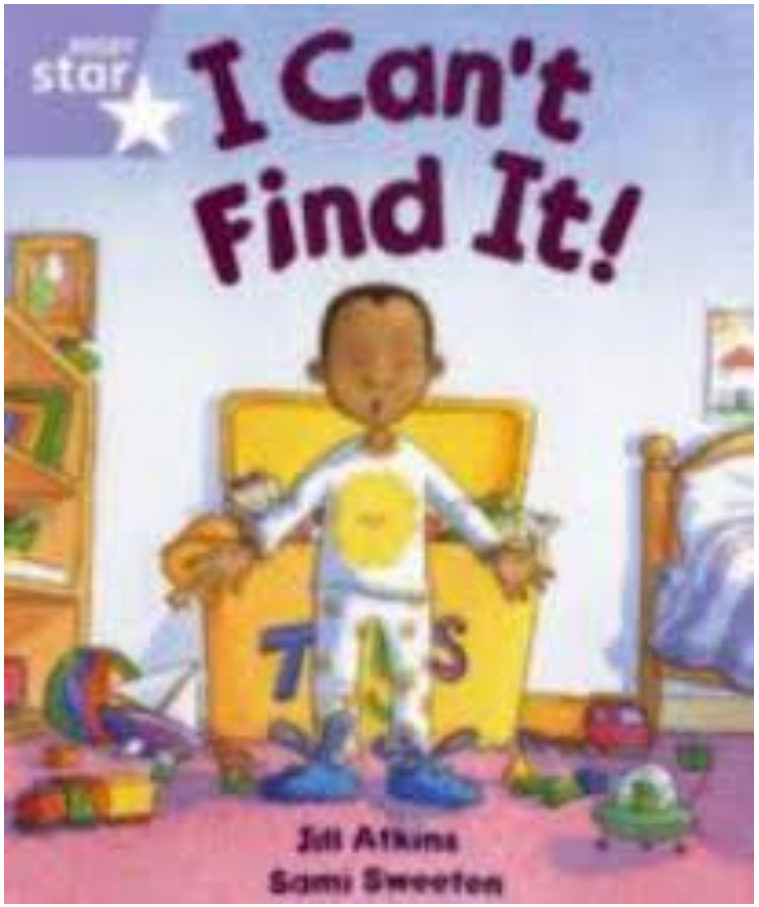
Final states we looked at (all with E_T^{miss})

- Fully hadronic
- 1 lepton
- 2 leptons
  - Same-sign
  - Opposite sign, but not Z
  - Z
- Multileptons
- 1 photon
- 2 photons

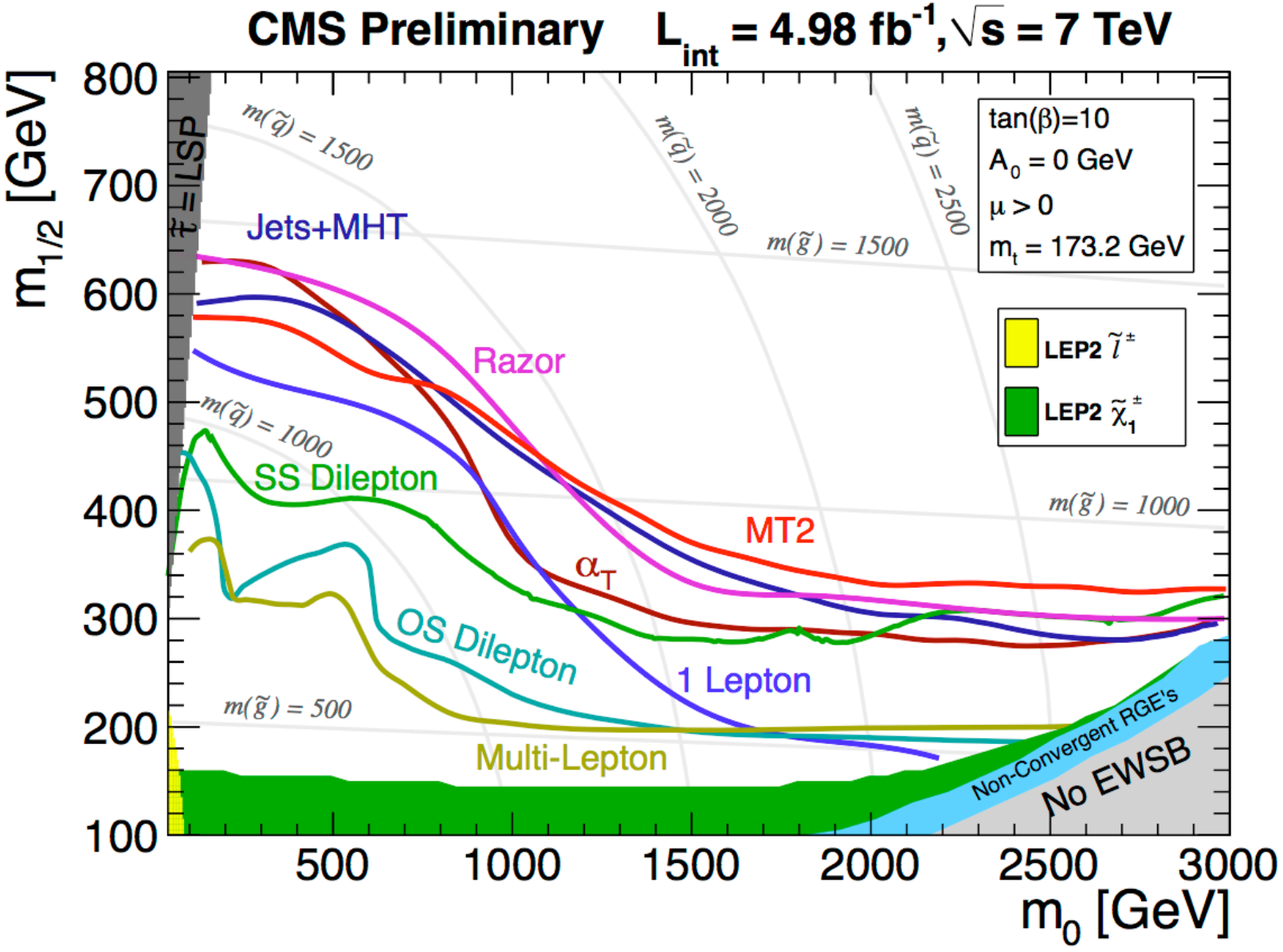
In almost all cases "lepton" also means τ

Most of these searches have a version with b-tags

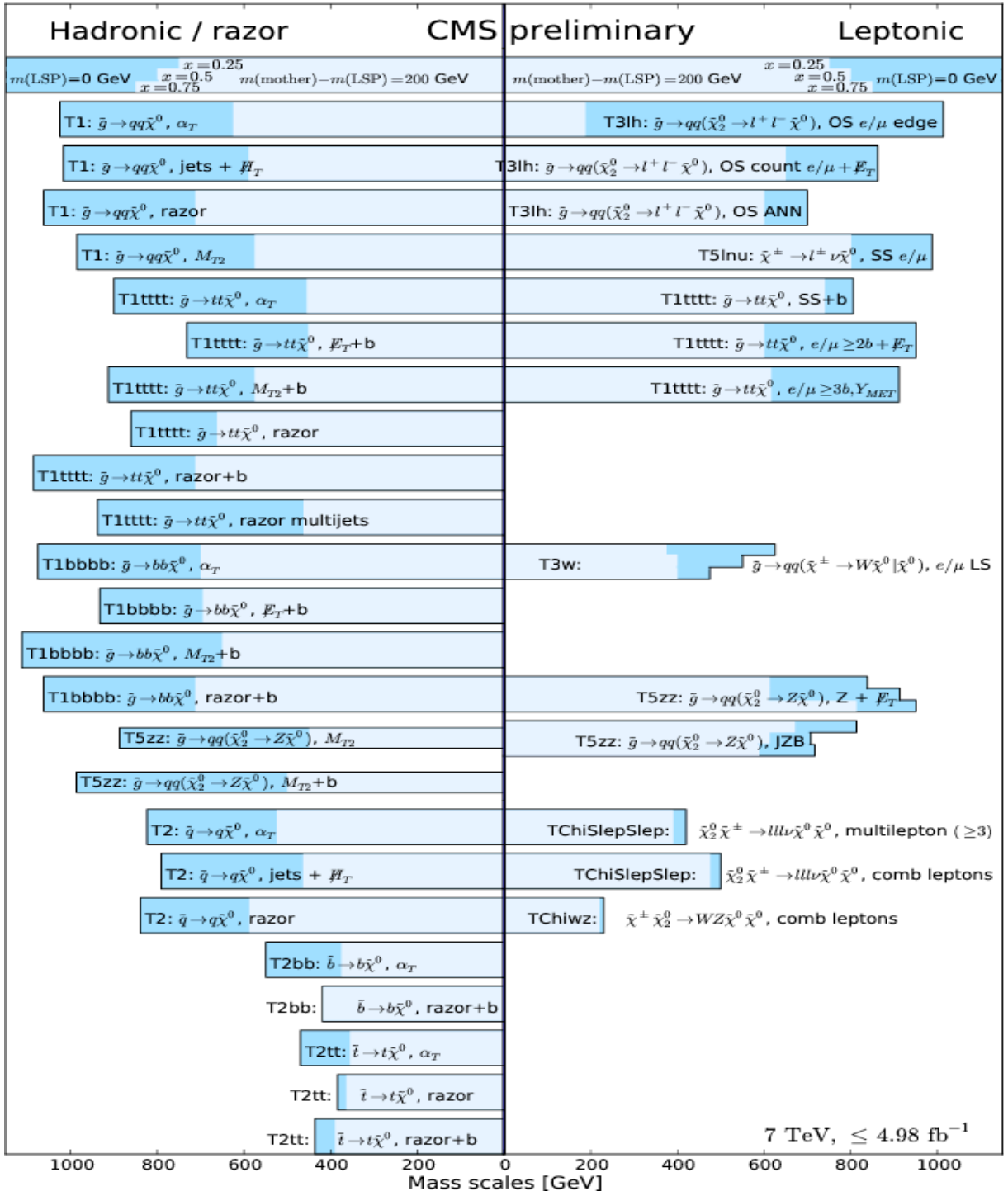
We find no excess of events over the SM



CMSSM interpretation



SMS interpretation



The next frontier (1): "Natural SUSY"

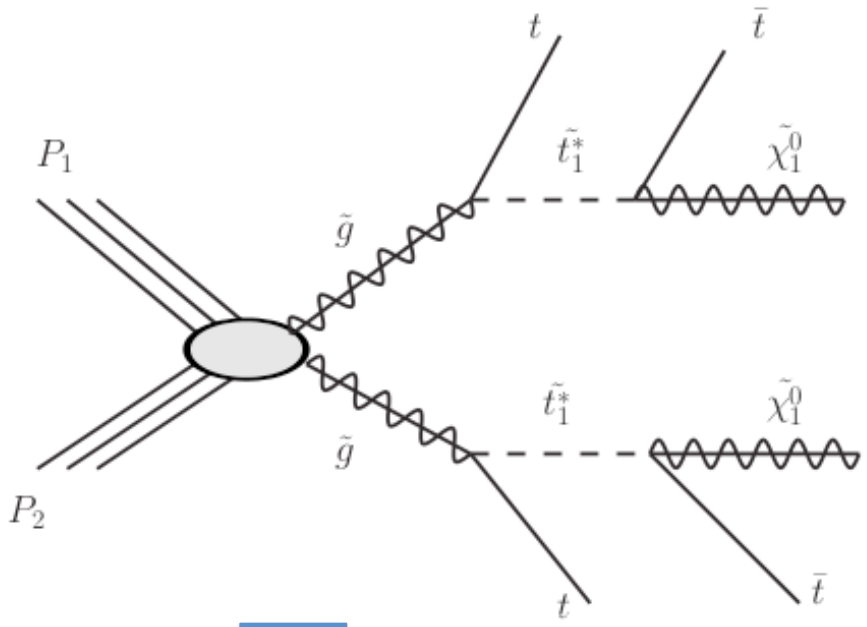
- CMS & ATLAS searches have excluded light squarks and gluinos up to ~ 1 TeV
- But are generally not as sensitive to 3rd generation squarks
- Relatively light stops are needed for naturalness
  - Gluino cannot be too heavy either

Stop is the *flavour du jour* at the CERN cafeteria

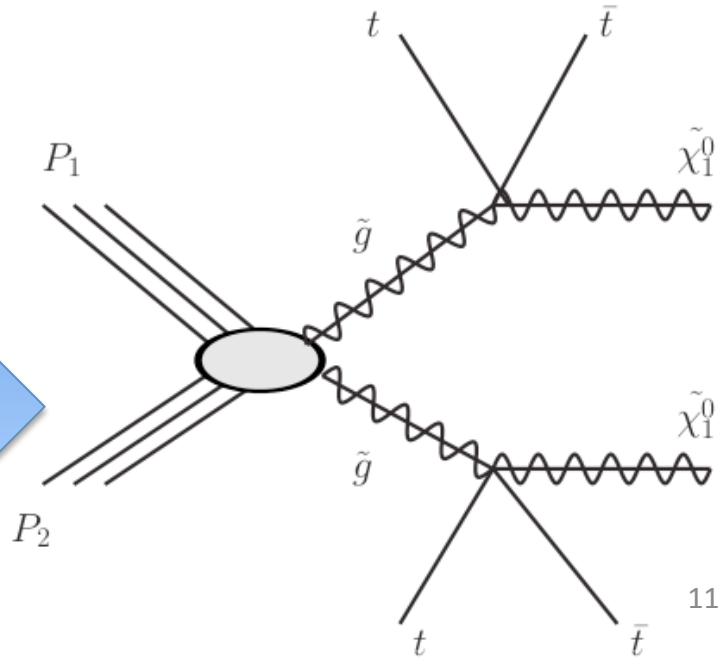
Looking for natural SUSY

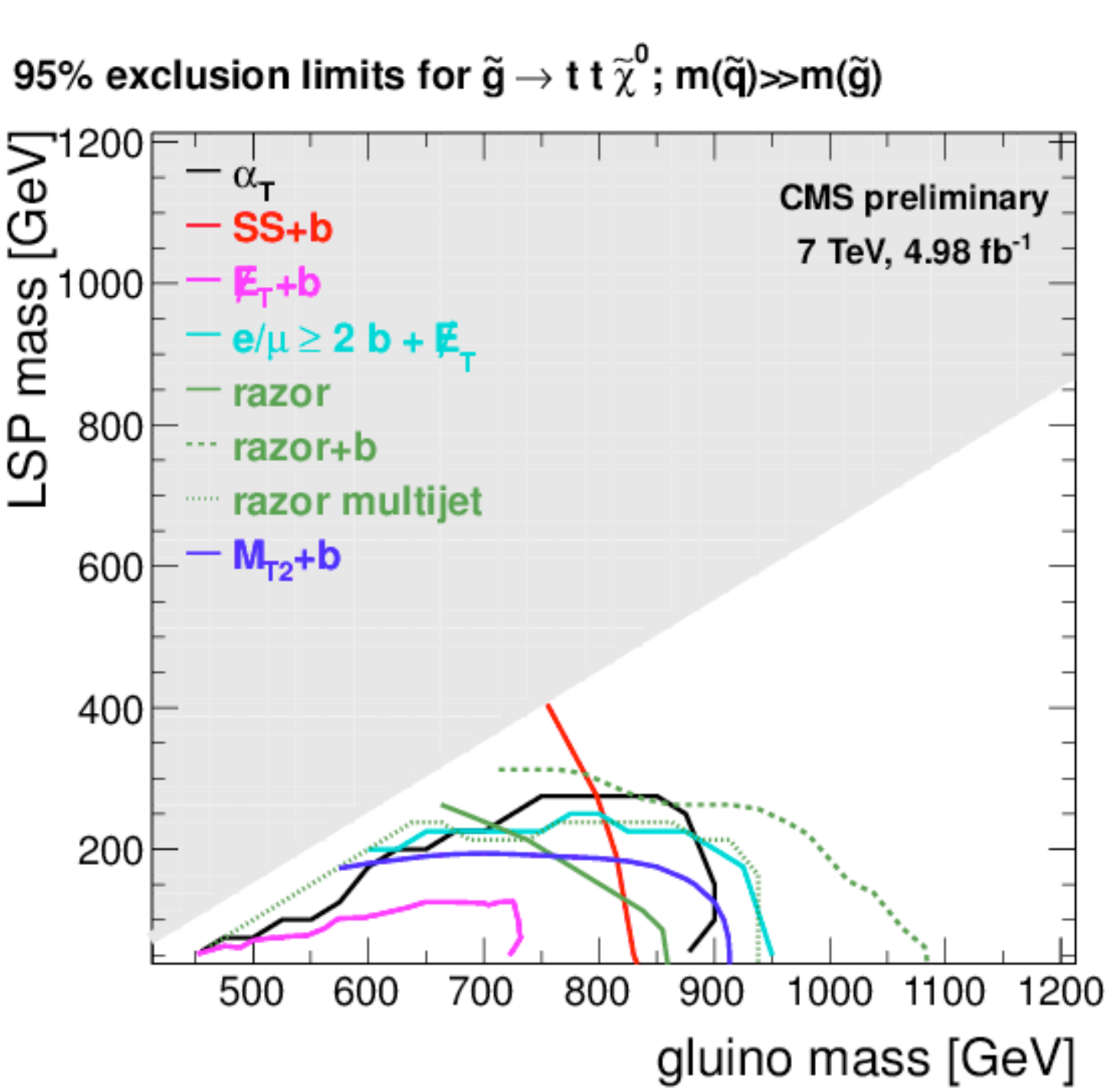
- Search for stops and sbottoms in gluino decays
  - Because in natural SUSY the gluino cannot be too heavy
  - Because if the other squarks are very heavy, then the gluino will decay into sbottoms and stops with high BR
- Search for stop and sbottom pair production
  - To close the loophole that the "gluino is too heavy"
- Existing "generic" searches can be re-interpreted in this context
  - There is sensitivity!
- New targeted searches are being developed for pair production
  - A change of modus operandi at CMS….no real results yet

Stop from gluino decays

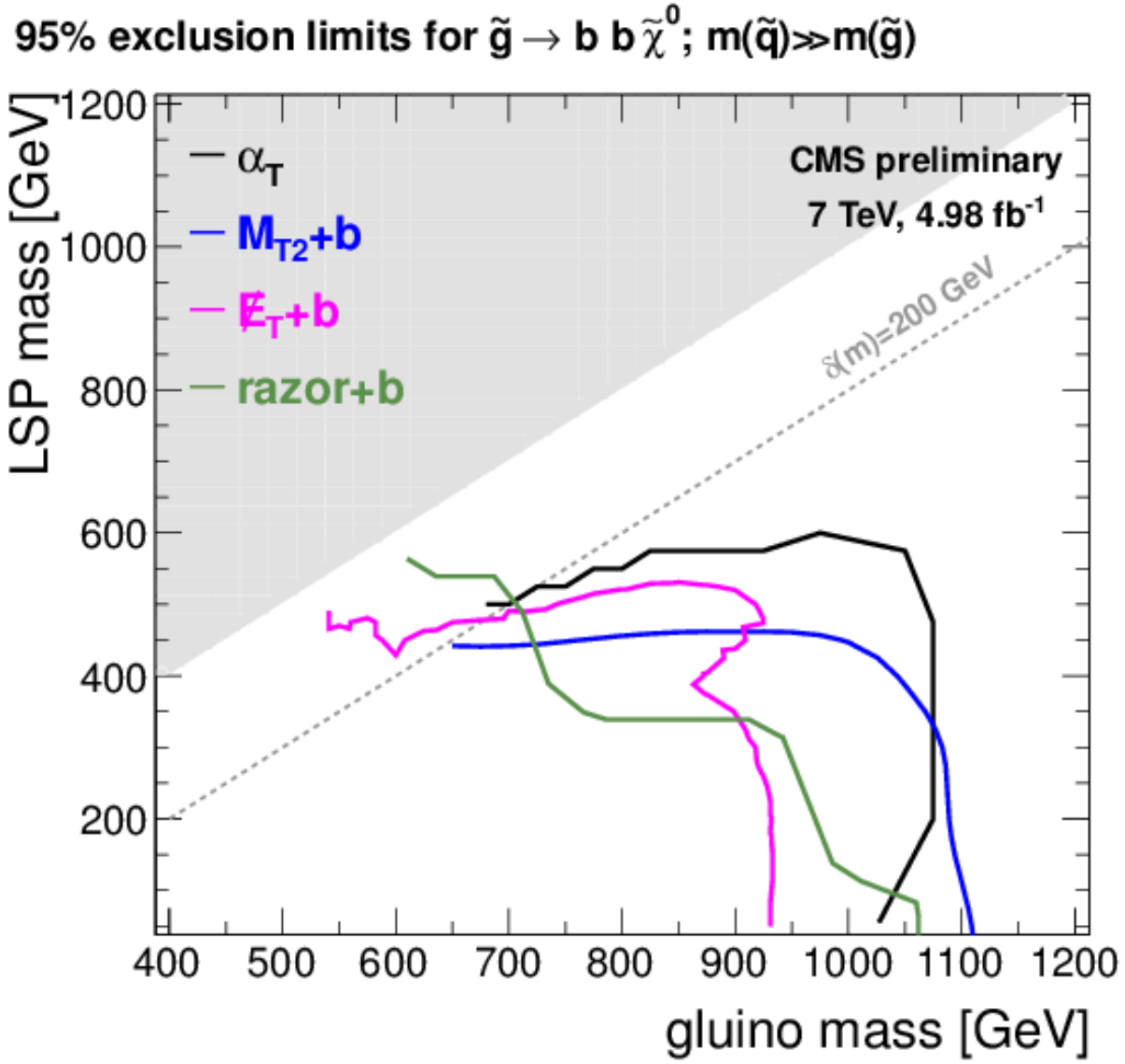


Simplified

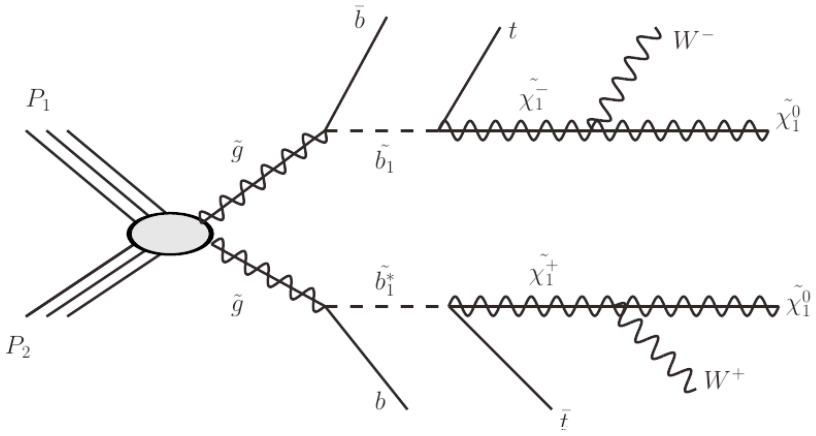



95% exclusion limits for $\tilde{g} \rightarrow t\,t\,\tilde{\chi}^0$; m($\tilde{q}$)>>m($\tilde{g}$)
CMS preliminary
7 TeV, 4.98 fb^{-1}
α_T
SS+b
$\not{E}_T$+b
e/$\mu \geq$ 2 b + $\not{E}_T$
razor
razor+b
razor multijet
M_{T2}+b
LSP mass [GeV]
gluino mass [GeV]
200
400
600
800
1000
1200
500
600
700
800
900
1000
1100
1200

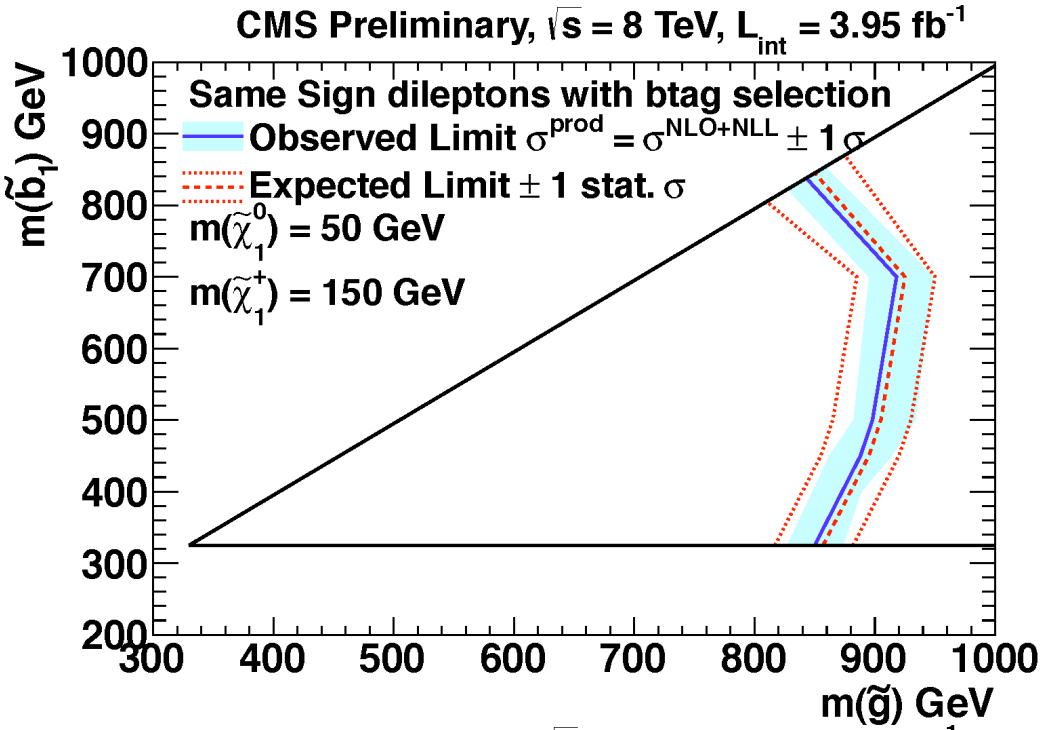
Same as previous page, but for sbottoms

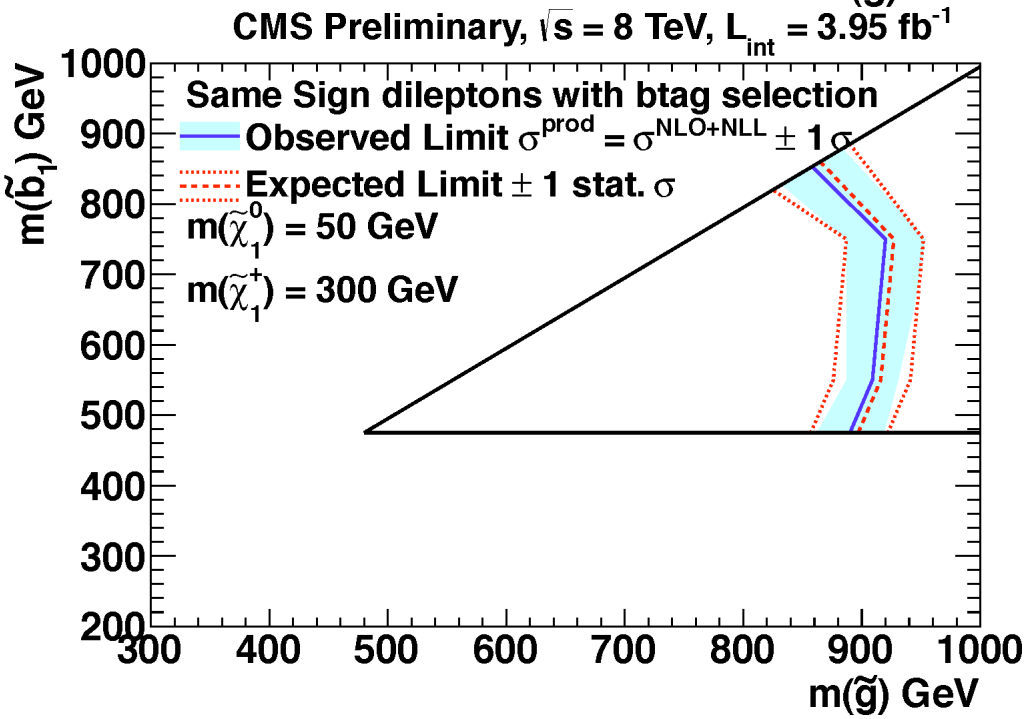


Sbottoms from gluinos again, but different sbottom decay mode

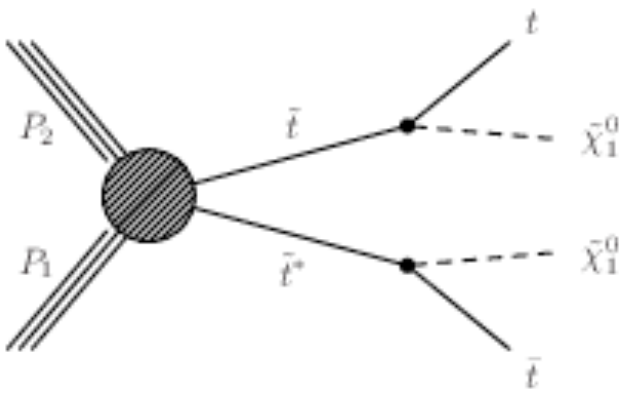


Early 8 TeV result

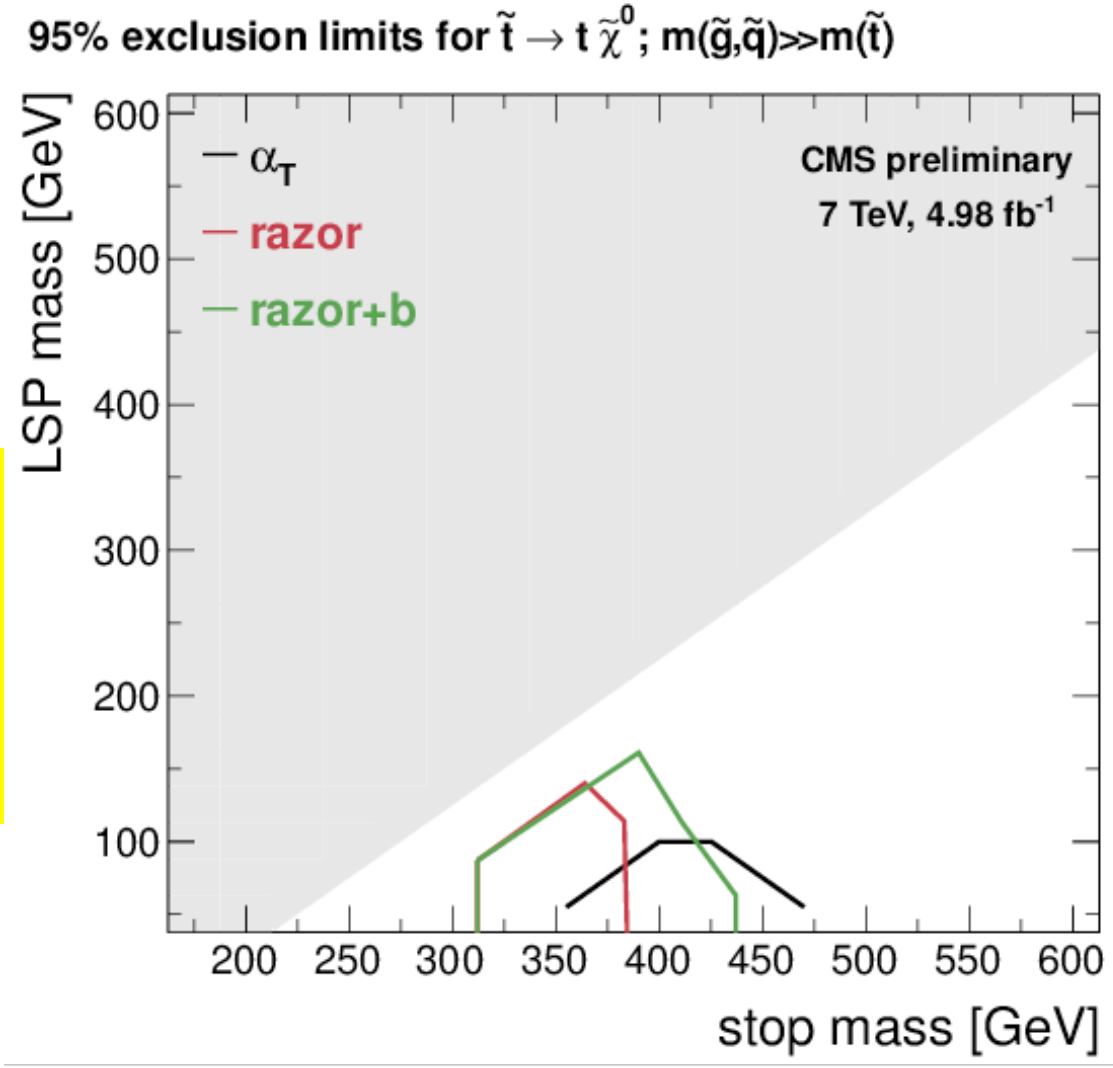




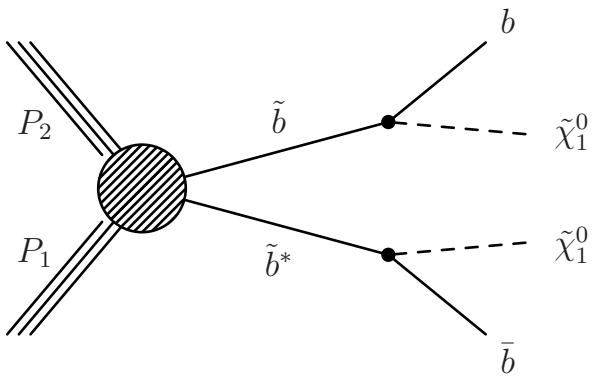
Stop Pair Production

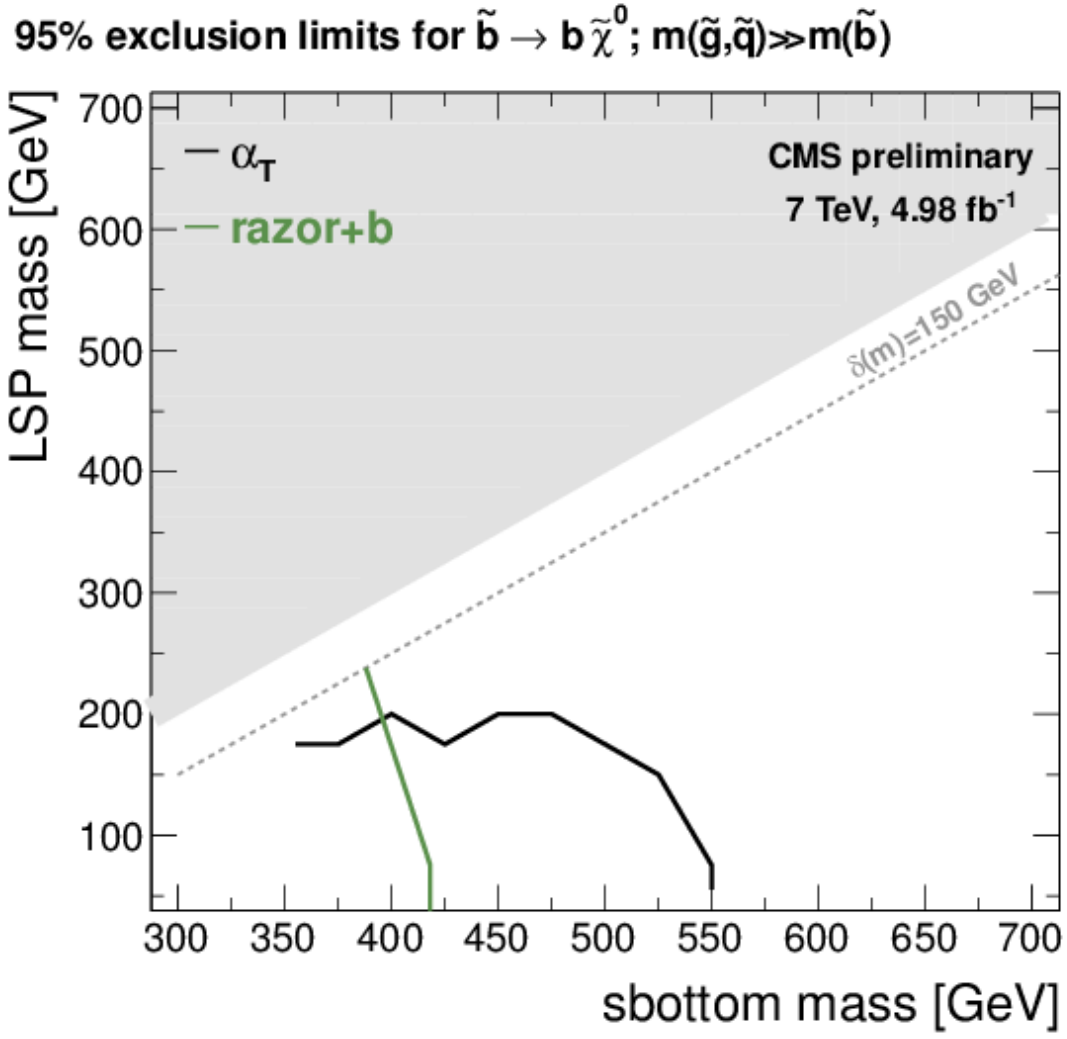


More dedicated searches in the works

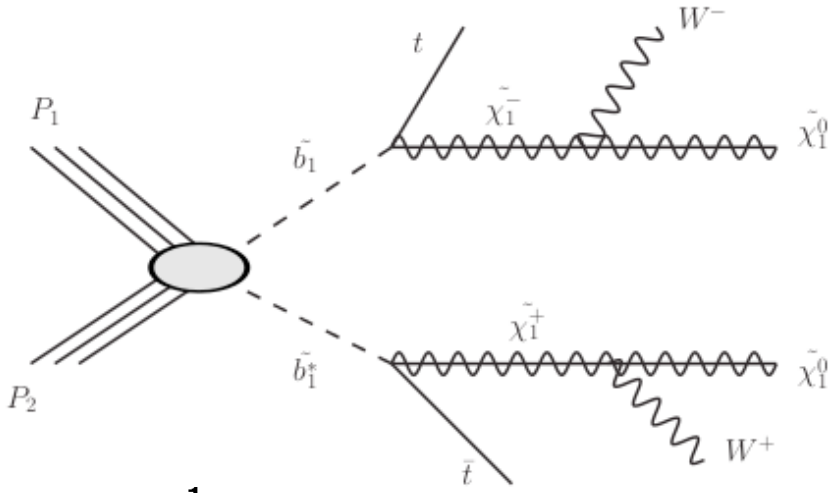


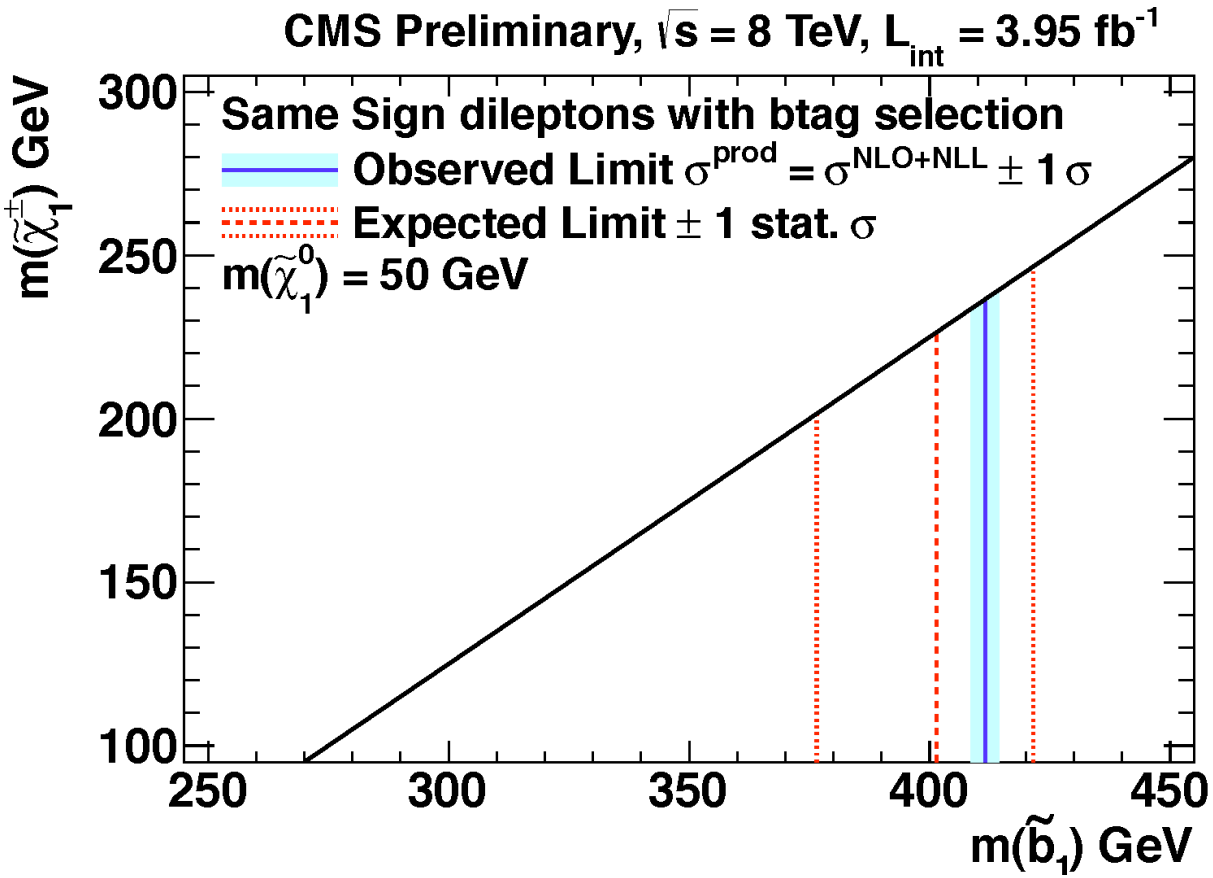
Sbottom pair production (1)





Sbottom pair production (2)

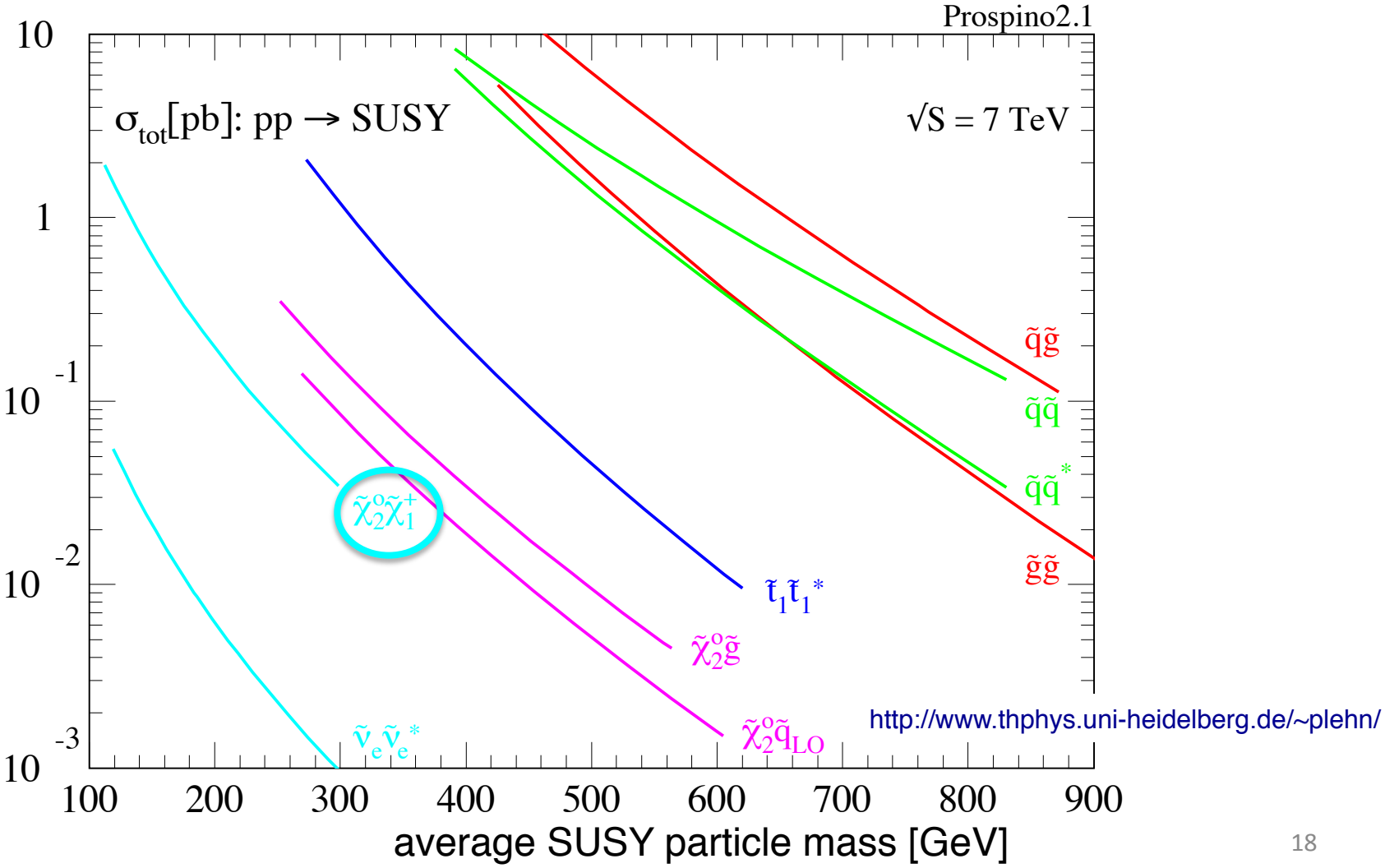




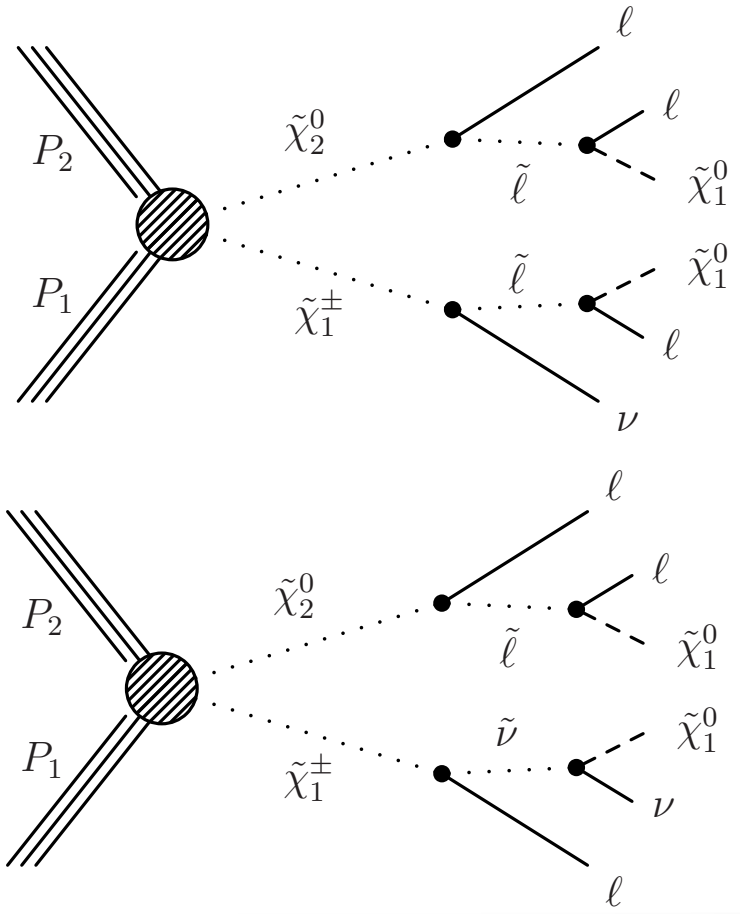
Early 8 TeV result

The next frontier (2): EWK production

High Luminosity → begin to be sensitive to EWK production

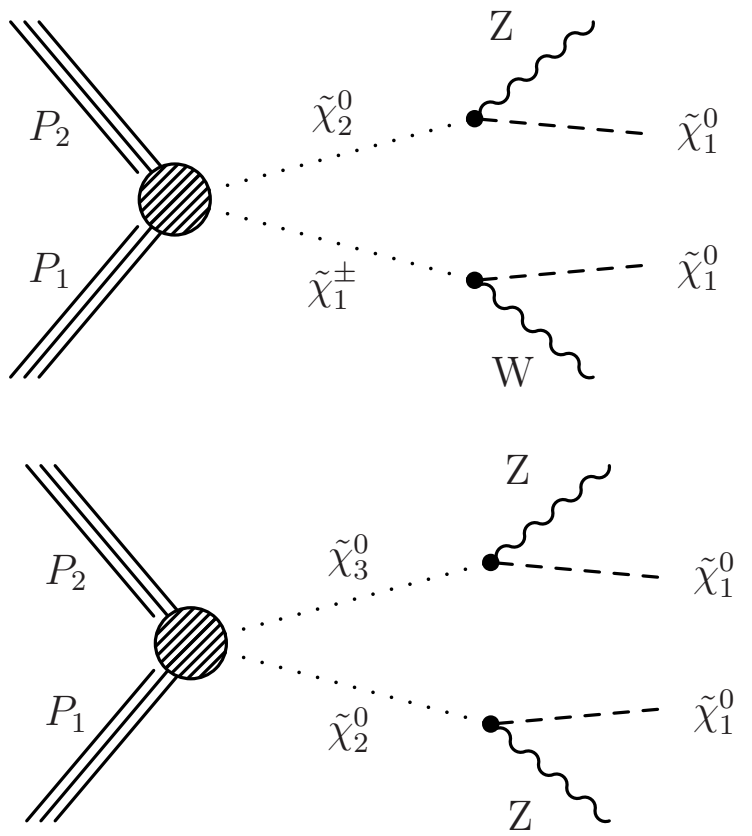


Models with decays into sleptons



- Trilepton + MET final states
- Same-sign dileptons to increase eff.

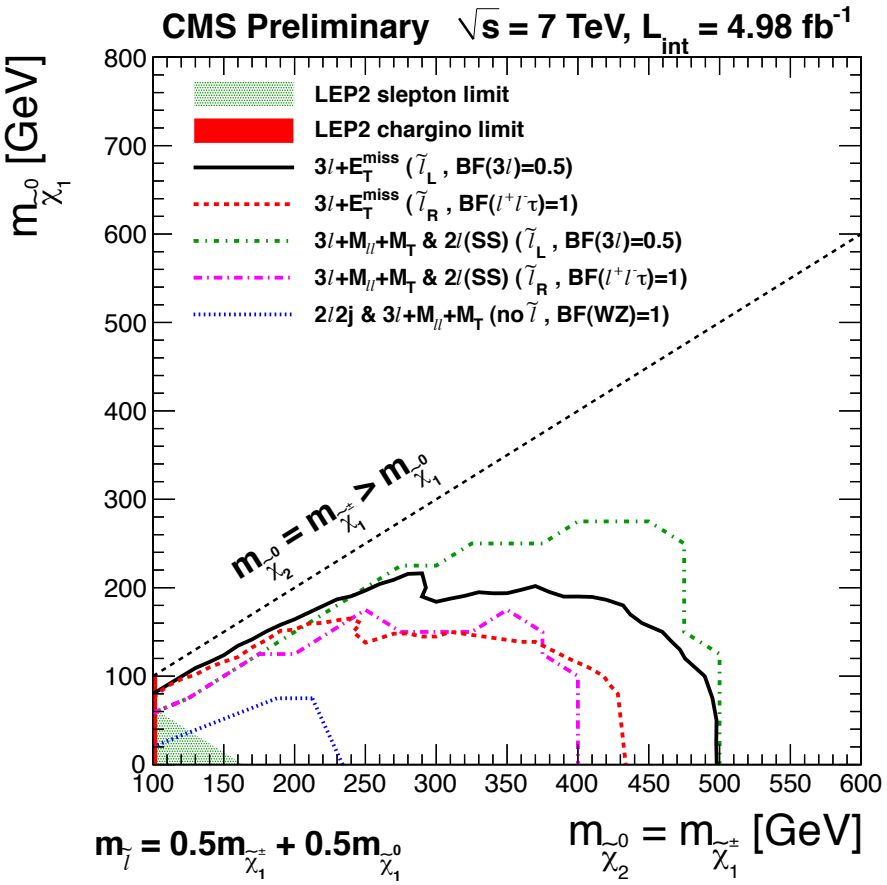
Models with decays into W and Z



- Z→ℓℓ + ℓ + MET
- Z→ℓℓ + W/Z→jet-jet + MET
- Four leptons

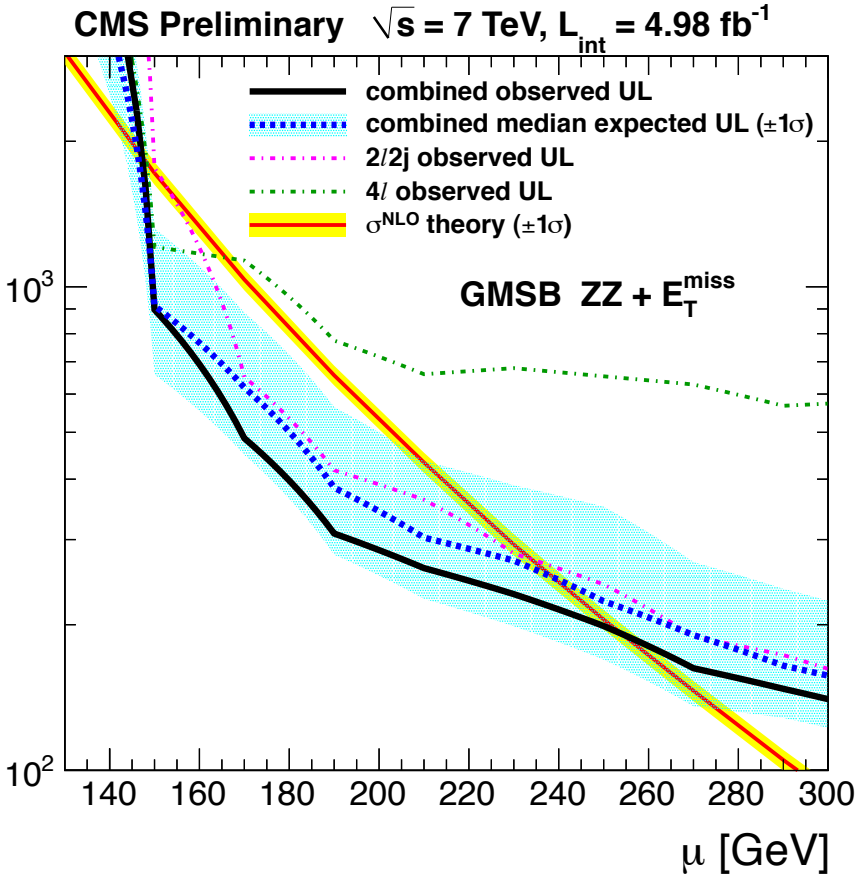
Note: $\chi^+\chi^-$ final state not probed yet

$\chi+\chi^0$ Limits



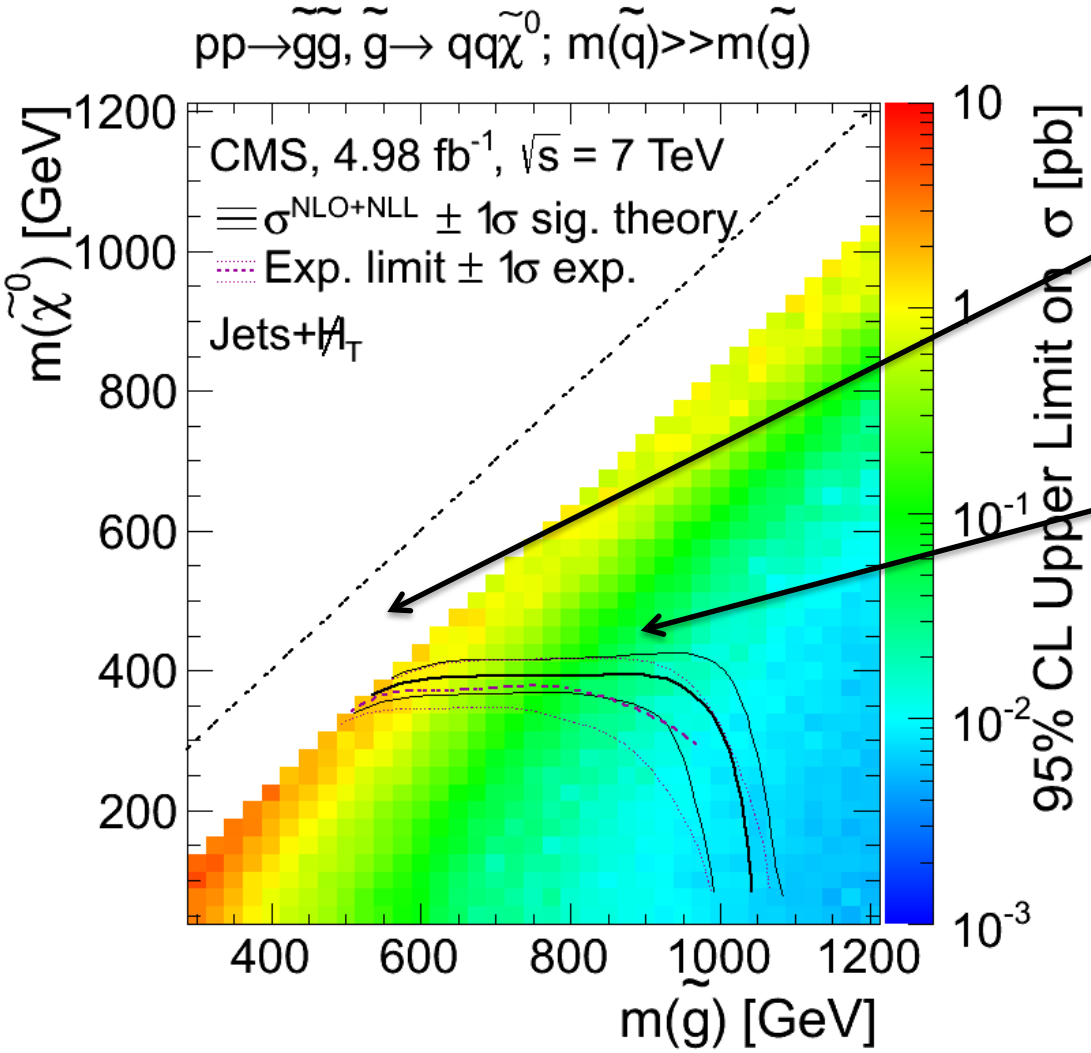
New 7 TeV result

Limits in GMSB model with high rate of ZZ+MET



[1] K. Matchev and S. Thomas, http://prd.aps.org/abstract/PRD/v62/i7/e077702
[2] P. Meade, M. Reece, and D. Shih http://www.springerlink.com/content/yg780th511075556/?MUD=MP
[3] J. Ruderman and D. Shih http://arxiv.org/abs/1103.6083

Next Frontier (3) : compressed spectra



This area is (conservatively?) not probed until the production details are better understood

Sensitivity turns over as spectrum becomes compressed

Compressed spectra…what's coming

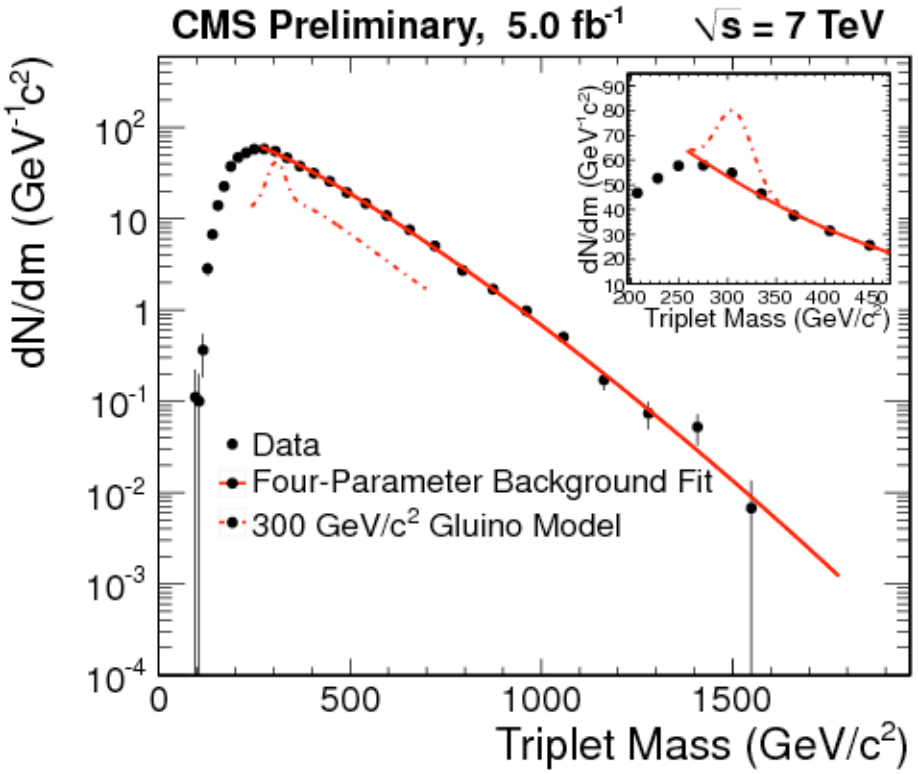
- New analysis techniques under development

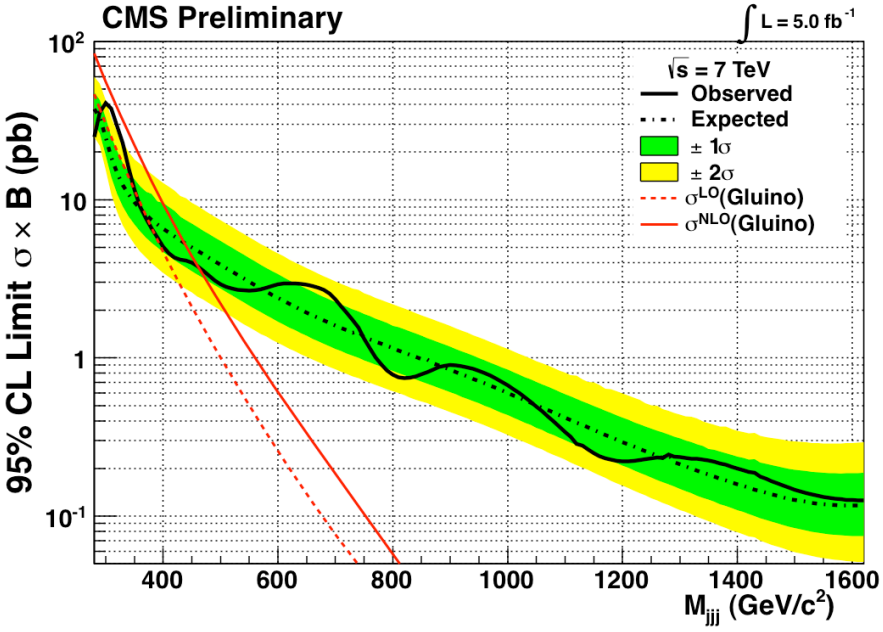
- "Parked" triggers
  - Lower thresholds on MET and jets
  - To be processed at the end of 2012

What about RPV SUSY?

- Not studied in a great deal of detail
- Lots of possibilities
- However: many of the "exotica" searches are de-facto sensitive to RPV signatures
  - Because they tend to look at high mass scales
  - Example: 3rd generation leptoquark search interpreted as stop search in RPV SUSY (EXO-12-002)
- Same-sign SUSY dilepton searches are also sensitive
  - Because the E_T^{miss} requirements are quite loose
- A systematic characterization is missing
  - Is it even possible?

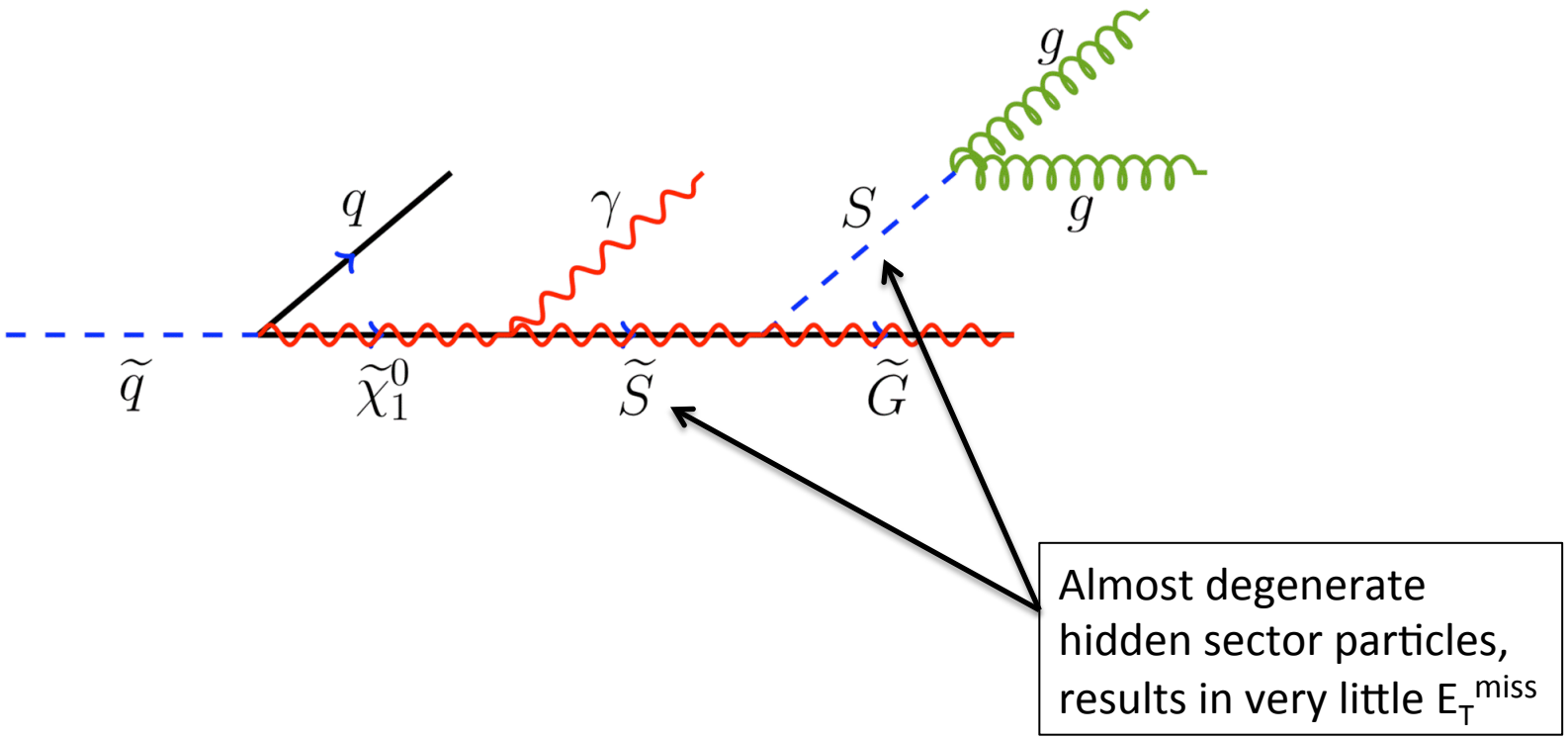
An RPV example: gluino→3 quarks



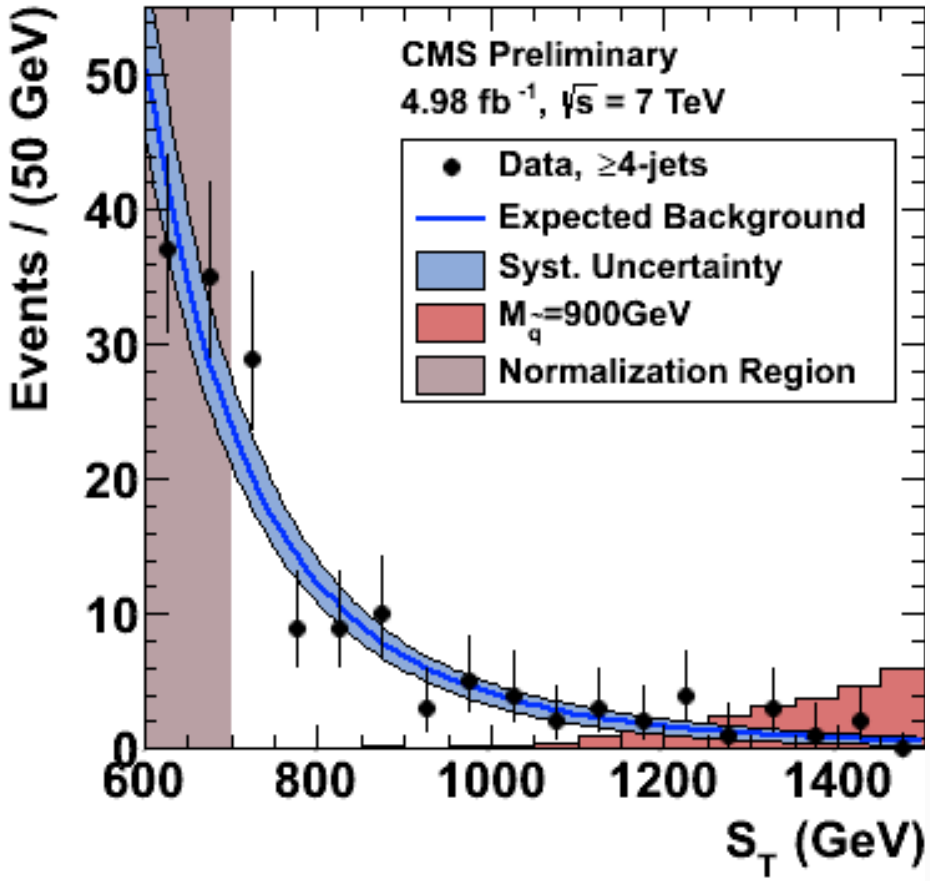


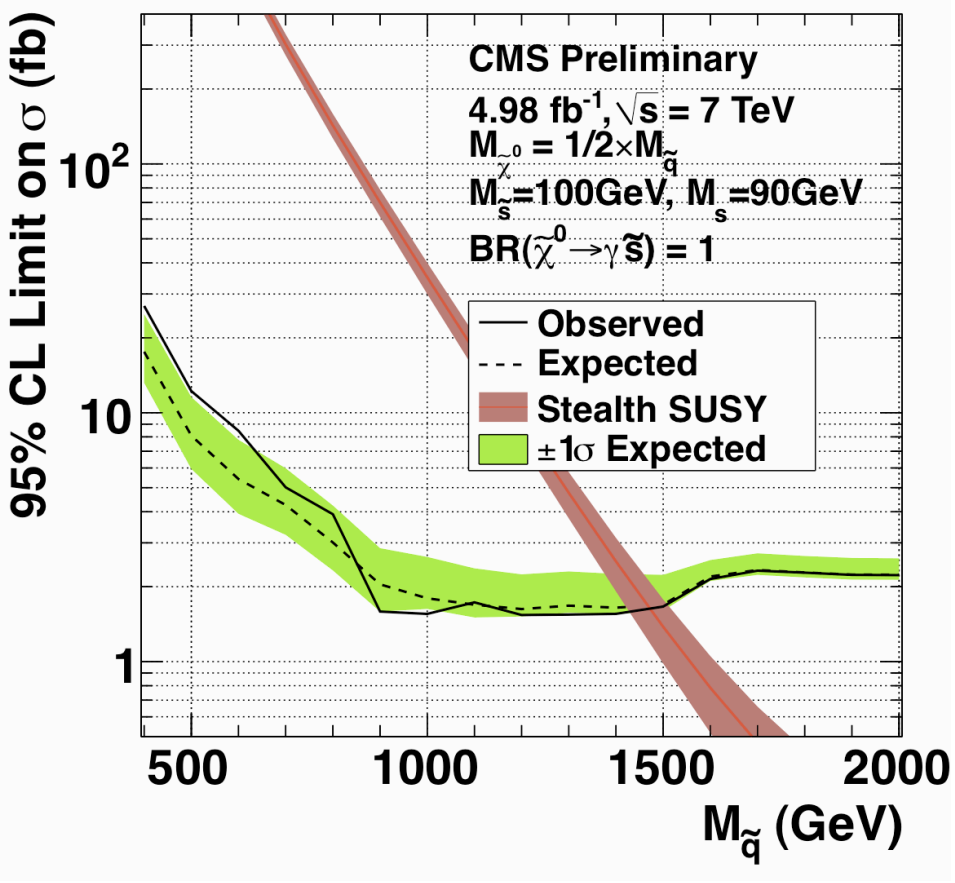
Exclude gluino masses below 460 GeV (assuming 100% BR into three jets)

Stealth SUSY



- Two photons and at least 4 jets
- First search of this kind
- Signal is excess of high $S_T = H_T + E_t^{miss} + \Sigma P_T(\gamma)$
  - This is a variable that is sensitive to high mass scales



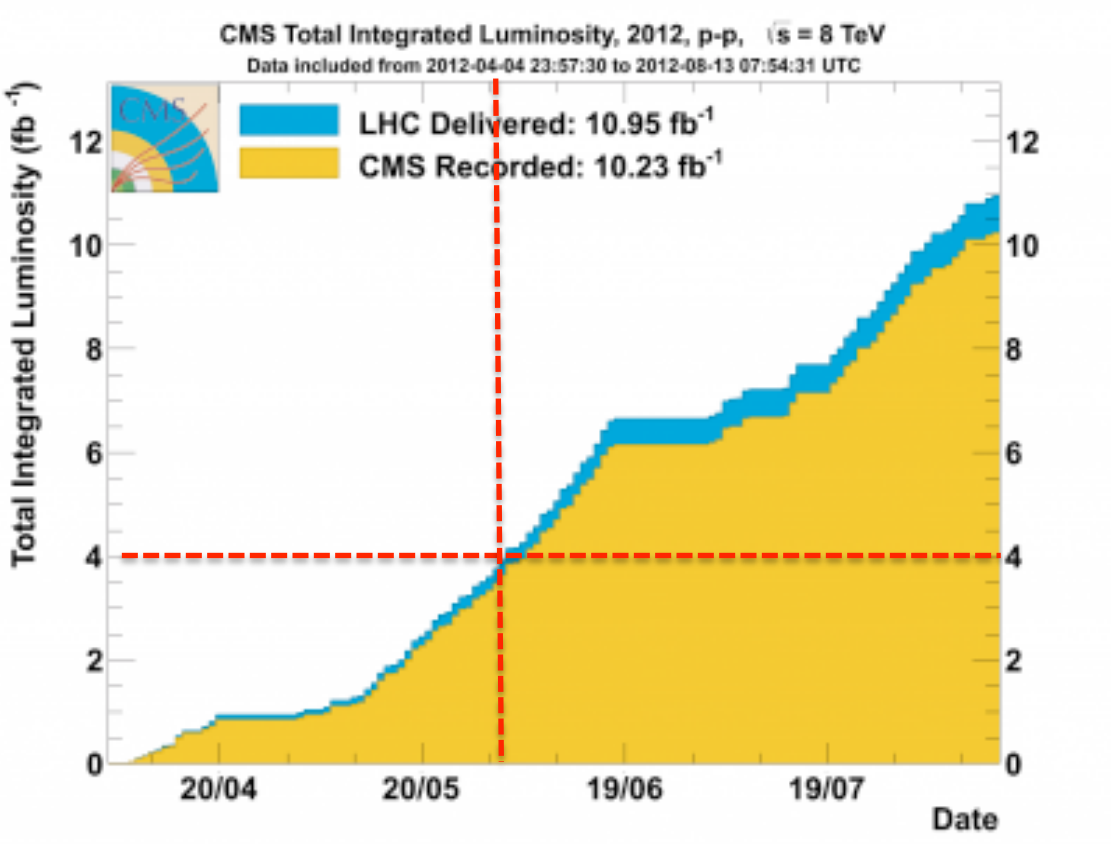


Exclude squark masses below 1430 GeV

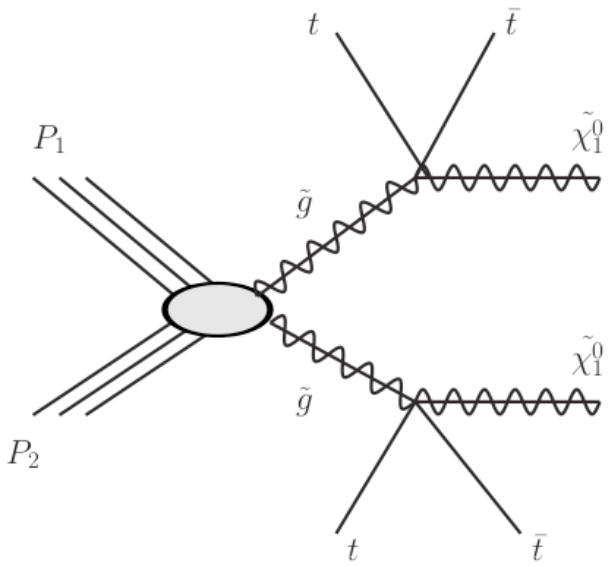
8 TeV data

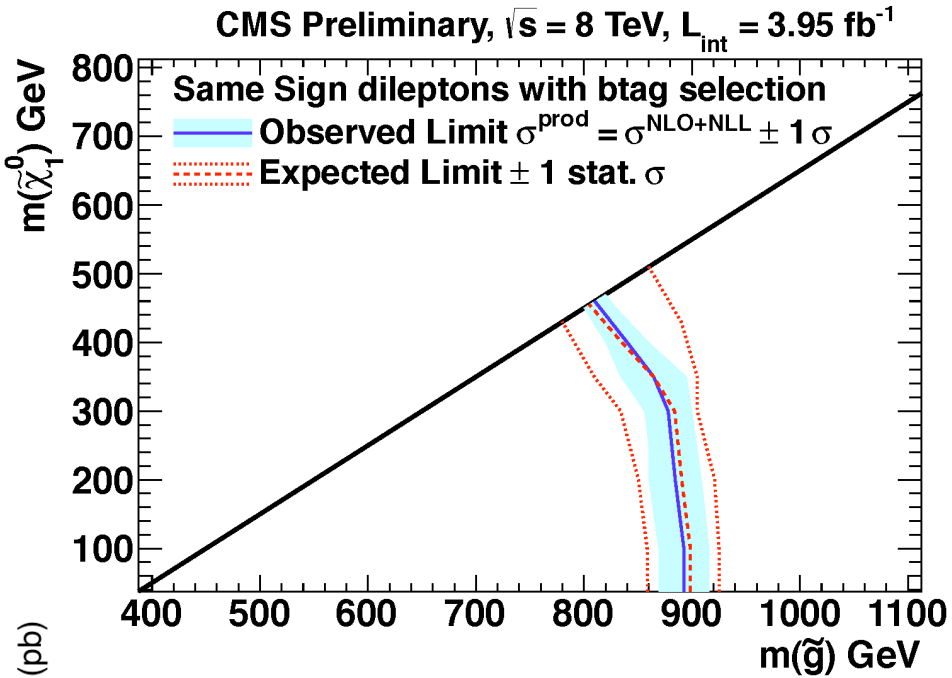
A few searches updated with ~ 4 fb^{-1} @ 8 TeV

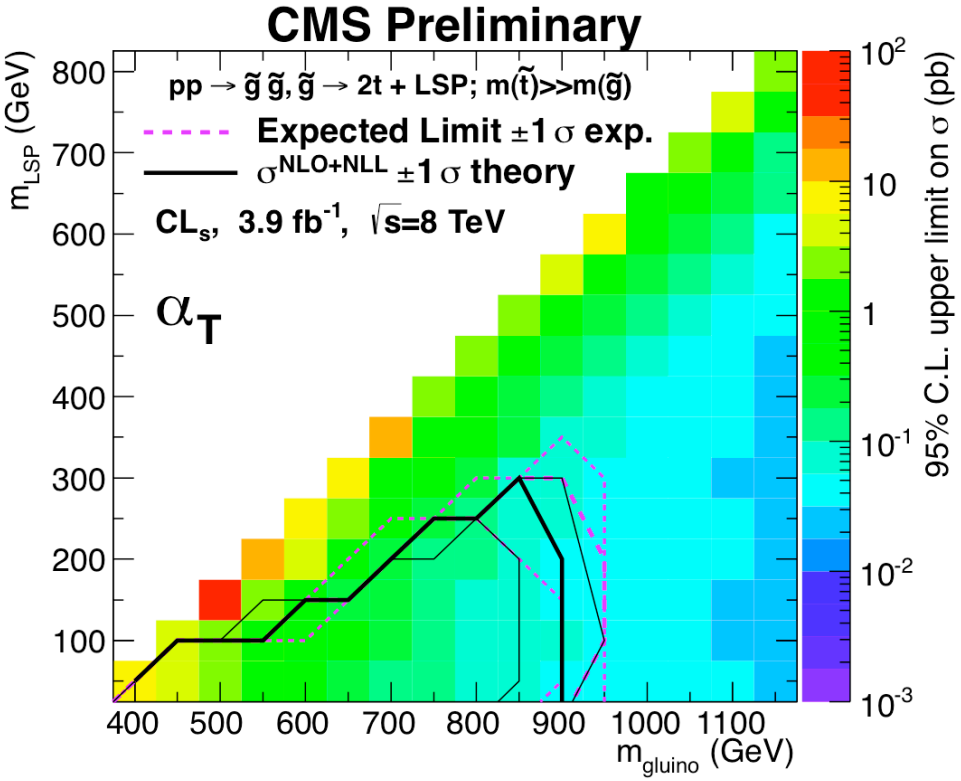
- Hadronic α_T
- Same-sign dileptons with b-tags
- Photon(s) + MET



Unfortunately, no excess to report







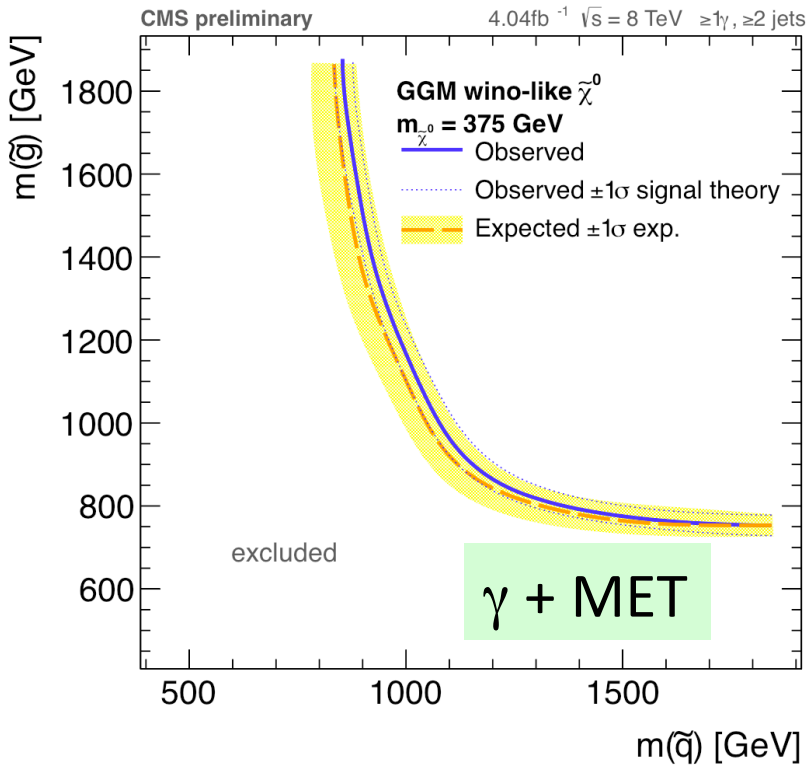
Extend the gluino exclusion in these scenarios which are interesting because of naturalness by ~ 60 GeV

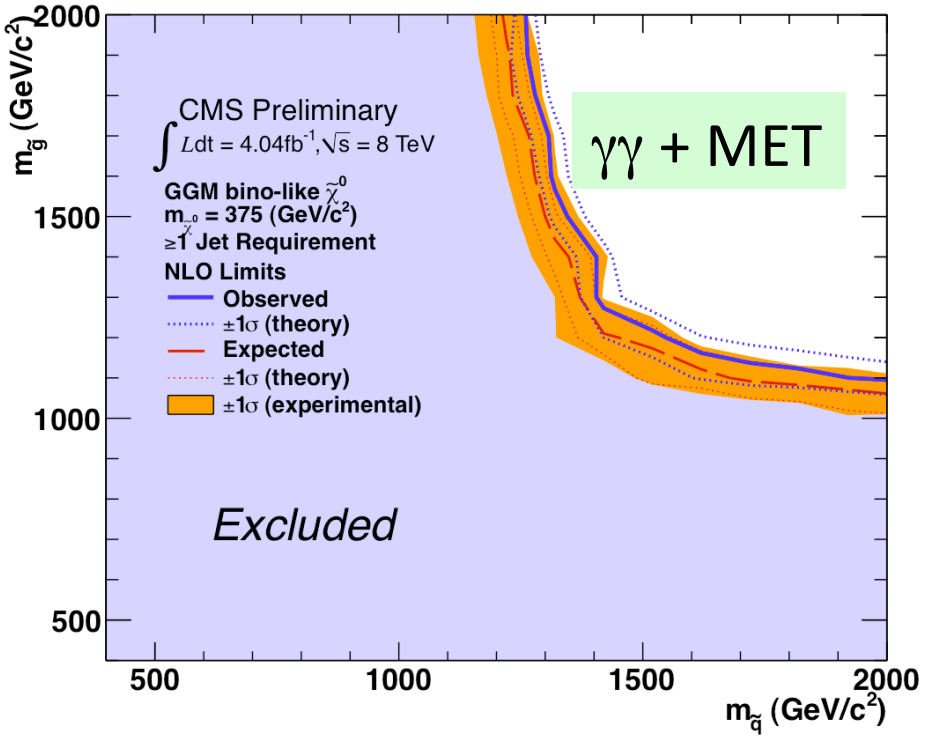
Early 8 TeV results

Gauge-mediated SUSY breaking scenarios

Early 8 TeV results

Depending on the nature of χ^0, single or double photon final states can dominate





Communication of Results (1)

- Three years ago many were hoping (dreaming?) that at SUSY12 we would be basking in the glory of the discovery of SUSY
- And we would be having spirited discussions on how to disentangle the SUSY spectrum
  - *LHC Inverse Problem* anyone?
- Alas, it's *limits-all-the-time*

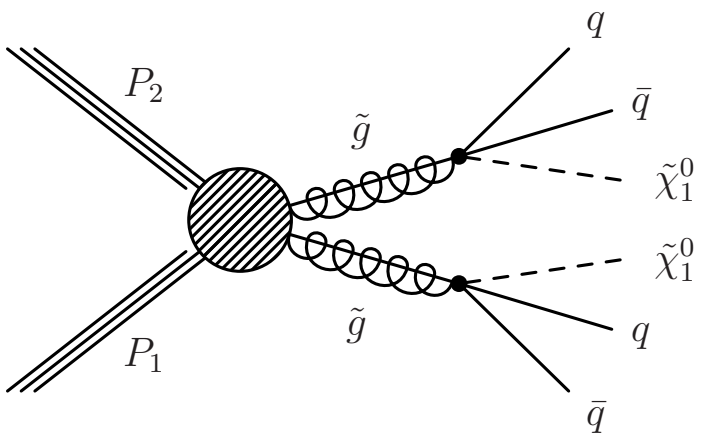
Communications of Results (2)

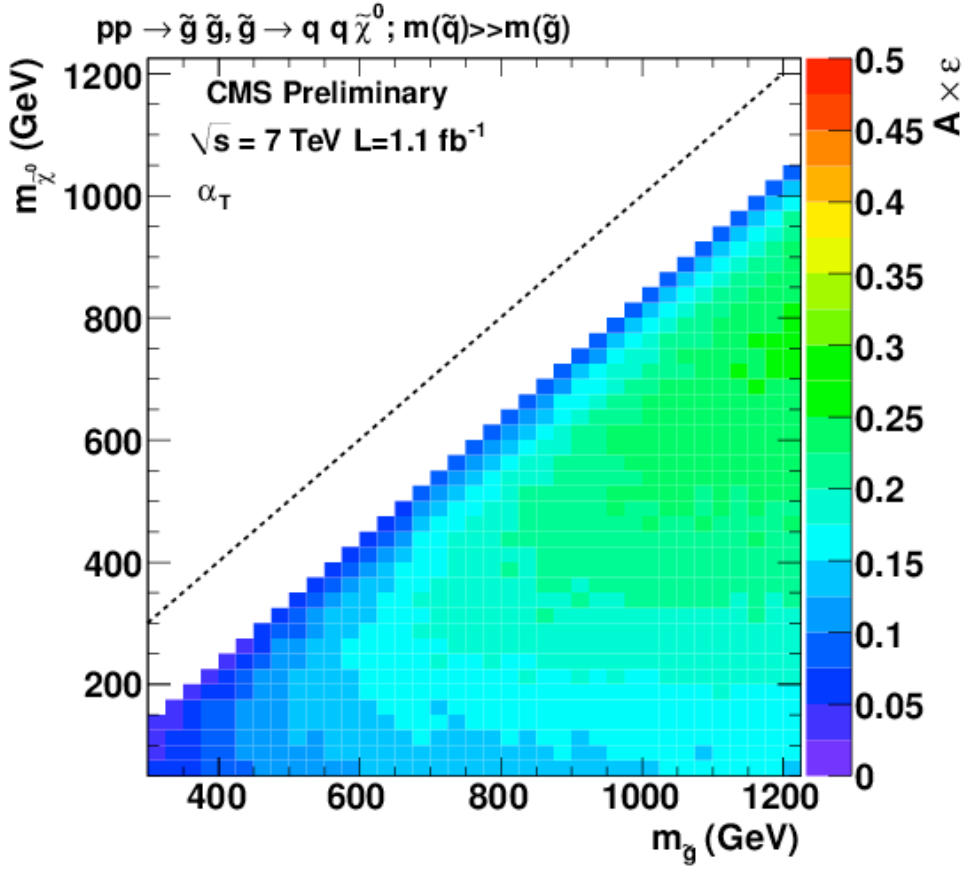
- We make many pretty colorful plots….
- There have been many discussions on how to make our results as useful as possible for the community
  - Some quite ambitious
- At CMS we pursue two complementary relatively simple avenues

Avenue 1: SMS efficiency maps

Can be used by a phenomenologist to "calibrate" a "simple" MC

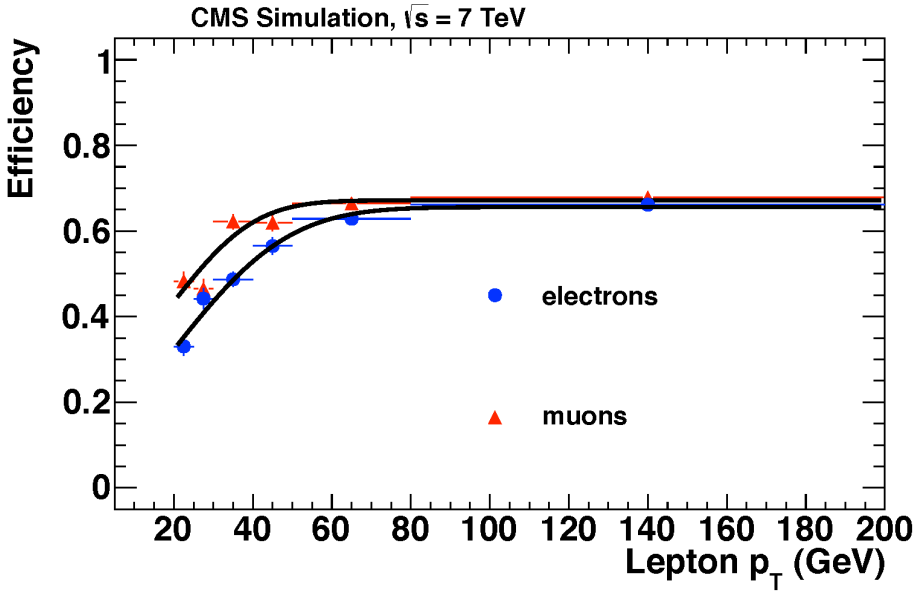
Example efficiency map for α_T
search for well defined Simplified Model

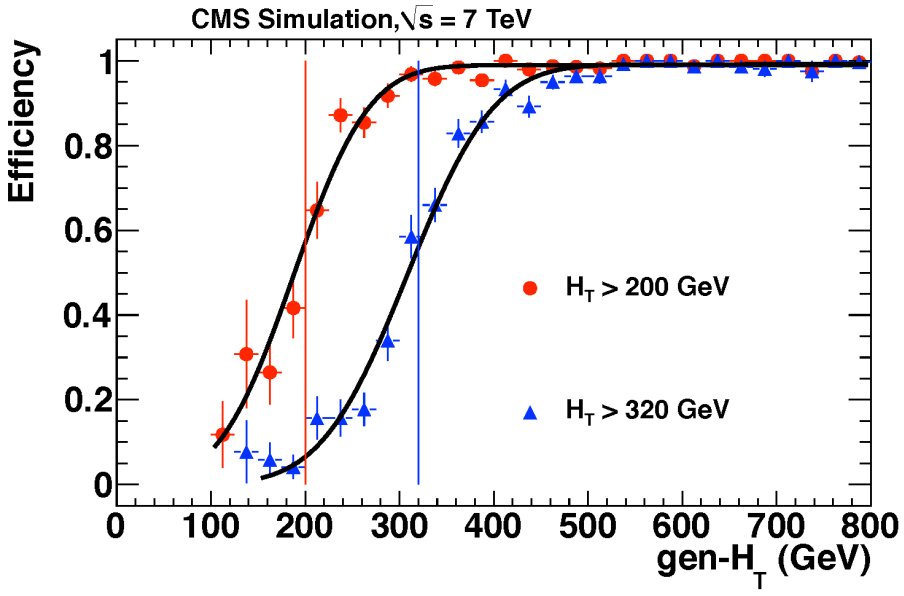




Avenue 2: Provide efficiency and turn on curves

To be used by phenomenologist to “build” a “simple” MC





Example from SameSign dilepton analysis: lepton efficiencies and H_T turn-on curves

Feedback by users of these information appreciated

Conclusions

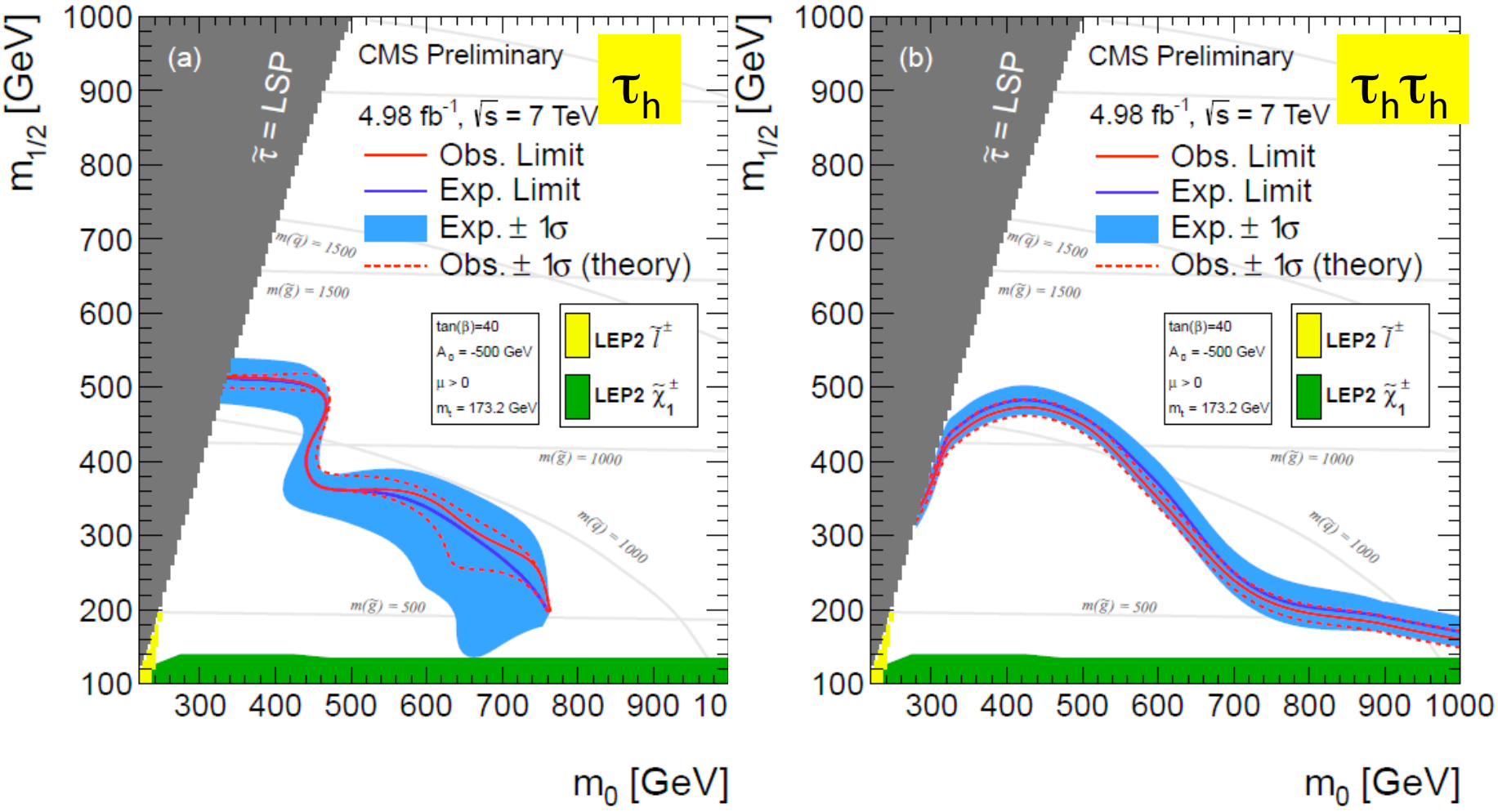
- Probed a wide variety of SUSY-motivated final states
- Nothing found so far, but developed detailed understanding of BG → prerequisite for discovery
- Transitioning to targeted searches optimized for specific, well-motivated models (eg. ewk SUSY, natural SUSY)
- Analyses of 8 TeV data are in progress. Expect ~ 20 fb^{-1} by the end of the year
- Stay tuned

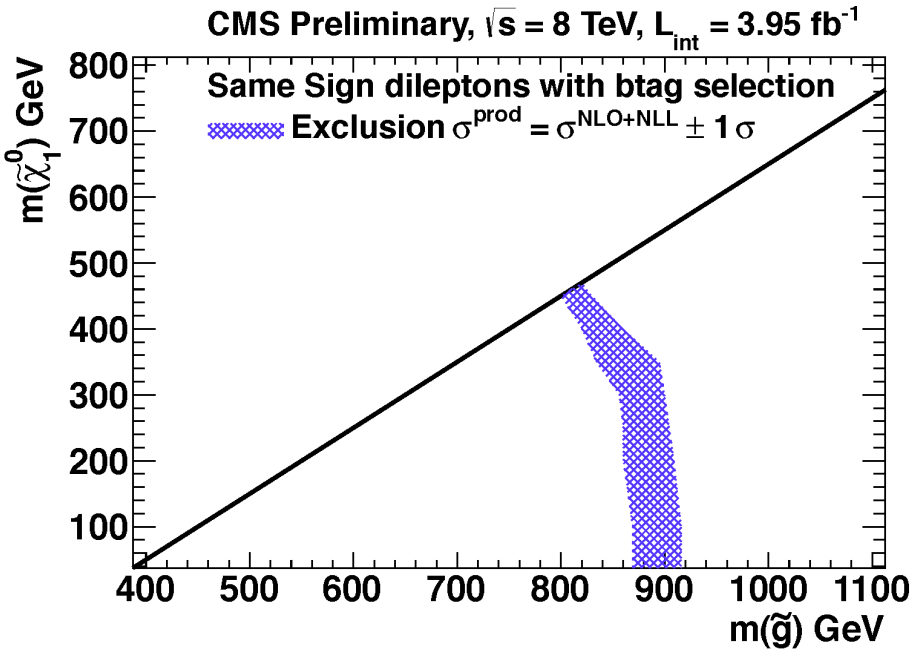
Much more on CMS SUSY results in parallel sessions

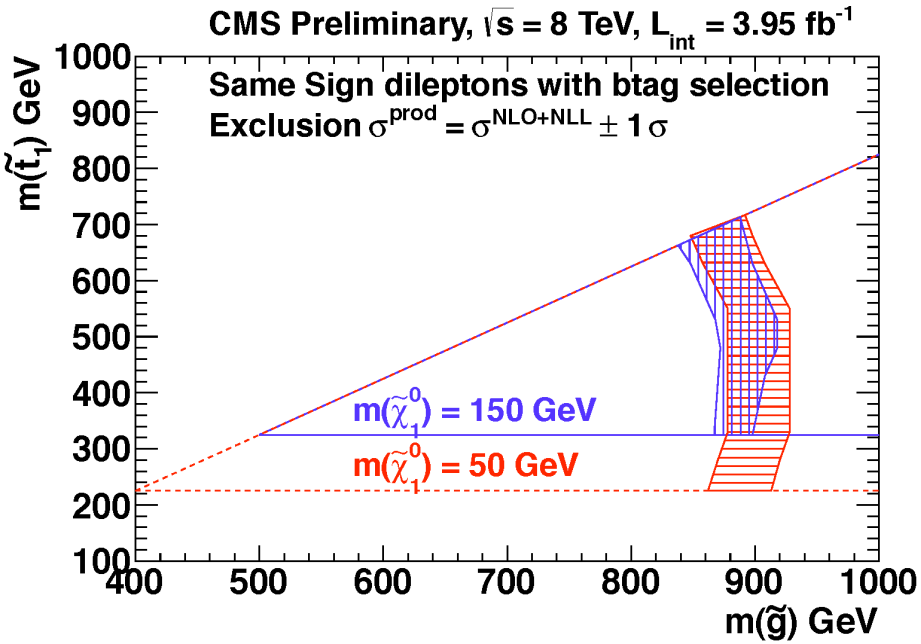
- B. Casal Larana
  - Searches for SUSY in hadronic final states at CMS
- I. Melzer-Pellmann
  - Searches for SUSY in final states with single leptons at CMS
- D. Sprenger
  - Searches for SUSY in events with di-leptons at CMS
- K. Theofilatos
  - Searches for SUSY in final states with photons at CMS
- C. Sanders
  - Searches for SUSY in events with taus at CMS
- W. Waltenberger
  - Interpretations of CMS SUSY analyses in the simplified model space (SMS)
- M. D'Alfonso
  - Searches for top and bottom squarks at CMS
- D. Dobur
  - Search for chargino or neutralino production at CMS
- Y. Chen
  - New results using the razor at the LHC
- A. Bhatti
  - Search for Dark Matter at CMS

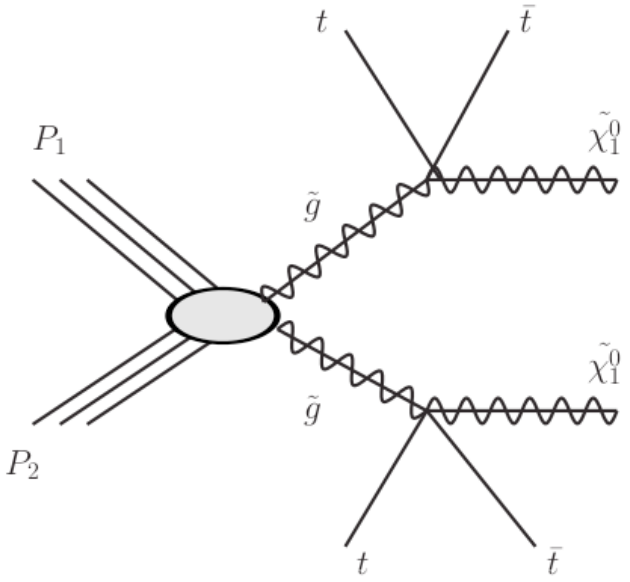
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

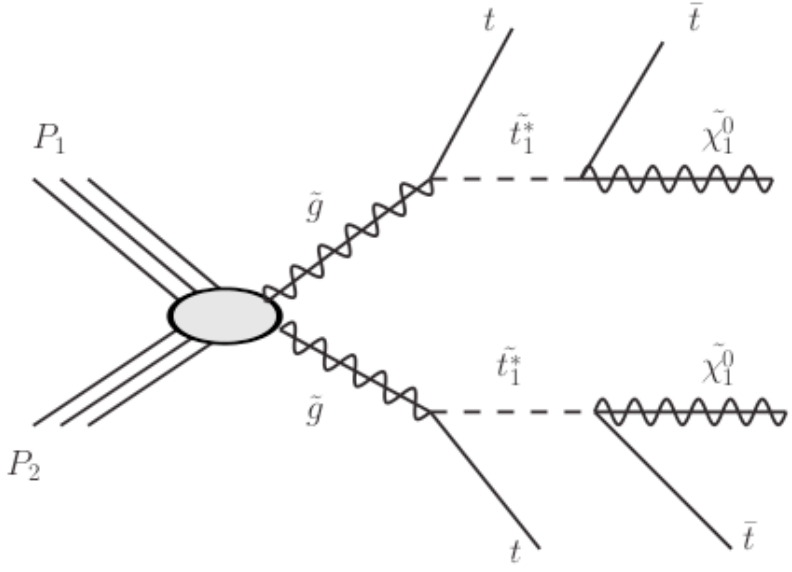
The End


(a)
CMS Preliminary
4.98 fb^{-1}, $\sqrt{s}$ = 7 TeV
τ_h
Obs. Limit
Exp. Limit
Exp. ± 1σ
Obs. ± 1σ (theory)
$\tilde{\tau}$ = LSP
tan(β)=40
A_0 = -500 GeV
μ > 0
m_t = 173.2 GeV
LEP2 $\tilde{l}^{\pm}$
LEP2 $\tilde{\chi}_1^{\pm}$
$m(\tilde{q})$ = 1500
$m(\tilde{g})$ = 1500
$m(\tilde{g})$ = 1000
$m(\tilde{q})$ = 1000
$m(\tilde{g})$ = 500
$m_{1/2}$ [GeV]
m_0 [GeV]
(b)
CMS Preliminary
4.98 fb^{-1}, $\sqrt{s}$ = 7 TeV
$\tau_h\tau_h$
Obs. Limit
Exp. Limit
Exp. ± 1σ
Obs. ± 1σ (theory)
$\tilde{\tau}$ = LSP
tan(β)=40
A_0 = -500 GeV
μ > 0
m_t = 173.2 GeV
LEP2 $\tilde{l}^{\pm}$
LEP2 $\tilde{\chi}_1^{\pm}$
$m(\tilde{q})$ = 1500
$m(\tilde{g})$ = 1500
$m(\tilde{g})$ = 1000
$m(\tilde{q})$ = 1000
$m(\tilde{g})$ = 500
$m_{1/2}$ [GeV]
m_0 [GeV]


CMS Preliminary, √s = 8 TeV, L_int = 3.95 fb^-1
Same Sign dileptons with btag selection
Exclusion σ^prod = σ^NLO+NLL ± 1σ
m(χ̃₁⁰) GeV
m(g̃) GeV


CMS Preliminary, √s = 8 TeV, L_int = 3.95 fb^-1
Same Sign dileptons with btag selection
Exclusion σ^prod = σ^NLO+NLL ± 1σ
m(t̃₁) GeV
m(χ̃₁⁰) = 150 GeV
m(χ̃₁⁰) = 50 GeV
m(g̃) GeV


P_1
P_2
t
$\bar{t}$
$\tilde{g}$
$\tilde{g}$
$\tilde{\chi}_1^0$
$\tilde{\chi}_1^0$
t
$\bar{t}$


P_1
P_2
t
$\bar{t}$
$\tilde{t}_1^*$
$\tilde{t}_1^*$
$\tilde{g}$
$\tilde{g}$
$\tilde{\chi}_1^0$
$\tilde{\chi}_1^0$
t
$\bar{t}$