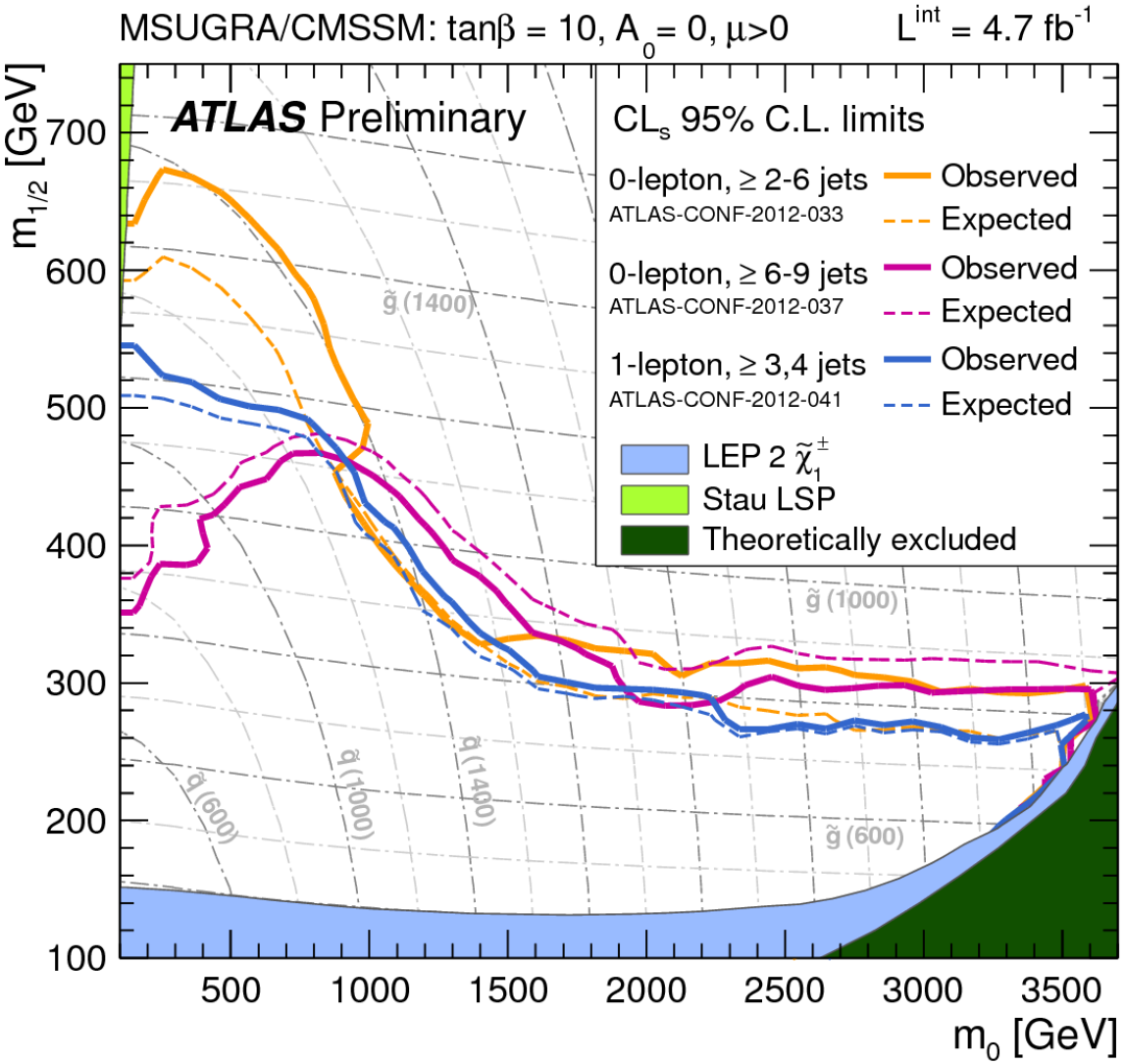
SUSY confronts LHC results –

LHC results confront SUSY?

Heidi Rzehak

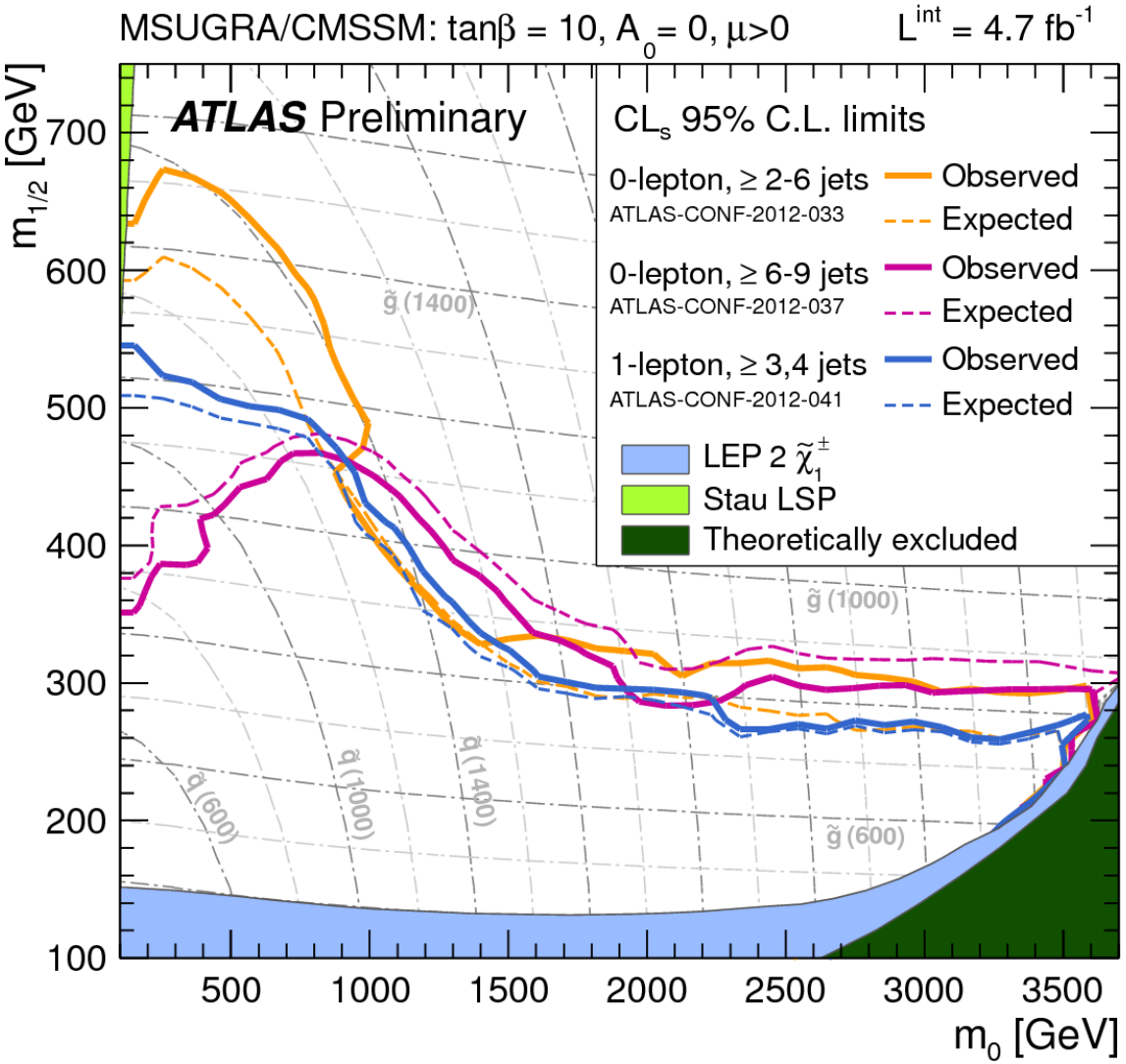
Rencontres de Blois, 29 May 2012

LHC results



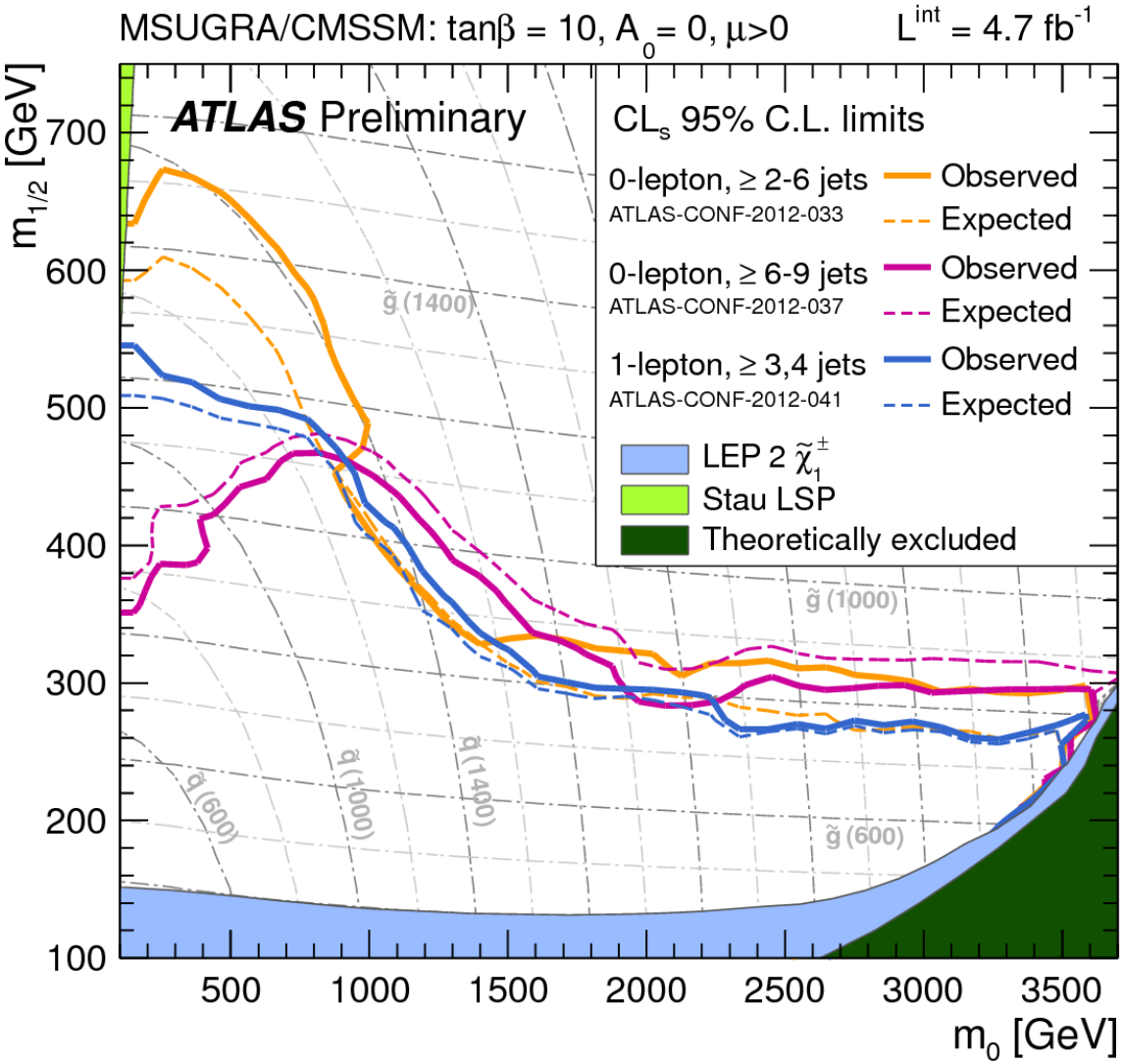
Large parts of parameter space already excluded!

LHC results



Is SUSY killed?

LHC results



Or is SUSY only hiding?

Status

Limits shown on previous slides are for the CMSSM:

CMSSM = (Very) Constrained MSSM

Limits for 1st, 2nd generation of squarks and gluino: strong $\gtrsim$ 1 TeV

Still possible (not complete):

- 1st, 2nd generation of squarks and gluino: heavy

  3rd generation of squarks: relatively light

  Charginos, neutralinos and sleptons: relatively light
- Compressed SUSY spectra
- Limits also change if squarks are non-degenerate

  (see A. Weiler's talk)

Status

Limits shown on previous slides are for the CMSSM:

CMSSM = (Very) Constrained MSSM

Limits for 1st, 2nd generation of squarks and gluino: strong $\gtrsim$ 1 TeV

Still possible (not complete):

- 1st, 2nd generation of squarks and gluino: heavy

  3rd generation of squarks: relatively light

  Charginos, neutralinos and sleptons: relatively light

- Compressed SUSY spectra

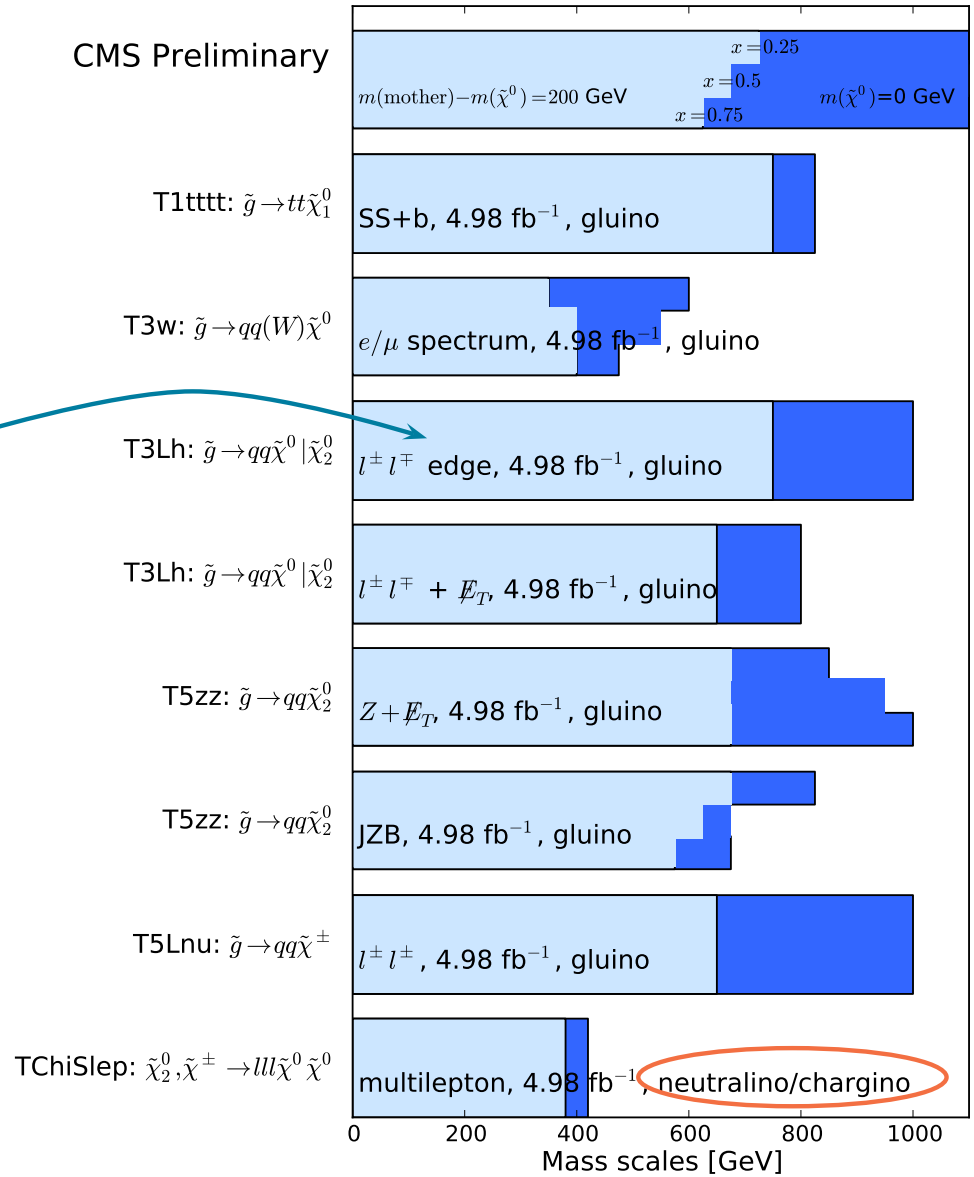
} exp. limits are being set

- Limits also change if squarks are non-degenerate

  (see A. Weiler's talk)

Status

More compressed spectra



Tantalizing hints

Hints for a SM-like Higgs boson with mass of 125 GeV:

$\rightarrow$ Hints for at least one (further) (B)MSSM particle

- Access mainly in $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ \rightarrow \ell\ell\ell\ell$ channel
- No significant access in $H \rightarrow WW^{(*)} \rightarrow \ell\nu\ell\nu$ channel

LHC results
confront SUSY?

SUSY processes as background to $H \to WW$

[Feigl, HR, Zeppenfeld, arXiv:1205.3468]

Scenario:

- Mass hierarchy for stau, light chargino, selectron and smuon:

$$m_{\tilde{\tau}_i} > m_{\chi_1^\pm} > m_{\tilde{e}_i},\ m_{\tilde{\mu}_i}$$

- Lightest neutralino χ_1^0 = Lightest Supersymmetric Particle
- Main decay channel

$$\chi_1^+ \to \tilde{\ell}^+ \nu,\ \ell^+ \tilde{\nu} \to \ell^+ \nu\, \chi_1^0$$

- 1st, 2nd generation of squarks an gluino heavy
- 3rd generation of squarks adjusted for a $\sim$ 125 GeV Higgs boson

Main production processes:

$$q\bar{q} \to \chi_1^+ \chi_1^- \qquad q\bar{q} \to \tilde{\ell}\tilde{\ell} \qquad q\bar{q} \to \chi_1^\pm \chi_2^0$$

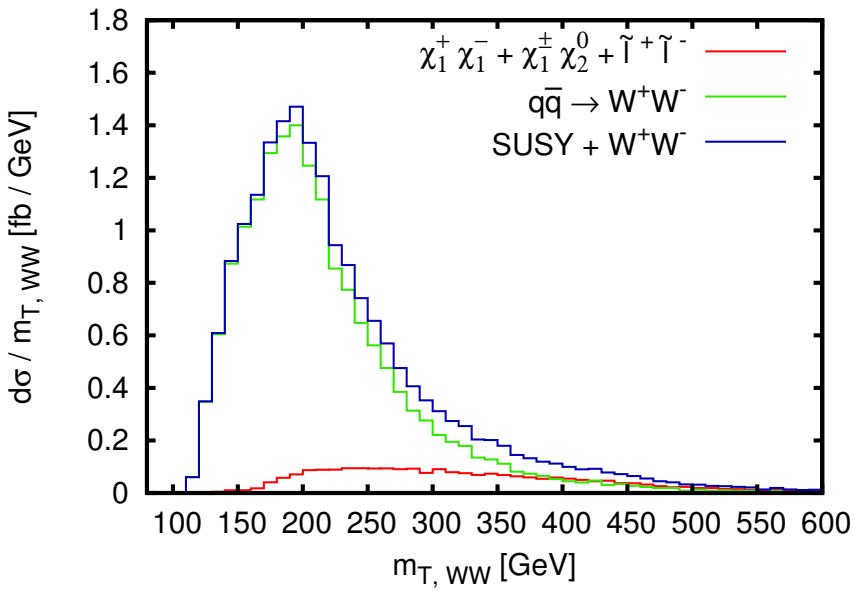
First scenario:

$m_{\chi_1^\pm} \approx 260$ GeV, $m_{\tilde{\ell}} \approx 140$ GeV, $m_{\chi_1^0} \approx 100$ GeV

Cuts largely taken from ATLAS-CONF-2012-012

Transverse WW mass distributions (control region):

$$m_{T,WW} = \sqrt{(E_T^{\ell\ell} - |\mathbf{p}_T^{\text{miss}}|)^2 - (\mathbf{p}_T^{\ell\ell} - \mathbf{p}_T^{\text{miss}})^2}$$



Doubling WW background for $m_{T,WW} \gtrsim 350$ GeV: would be observable:

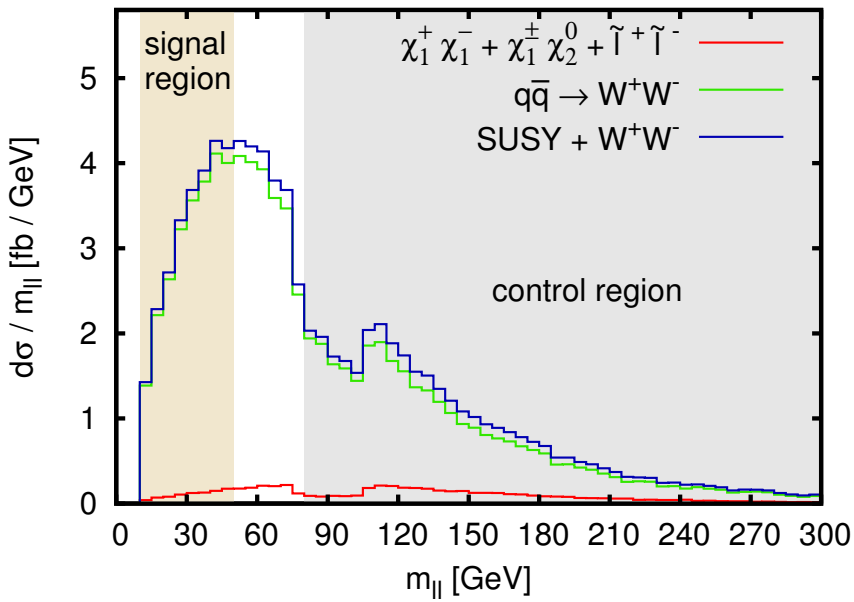
no access seen:

ruled out

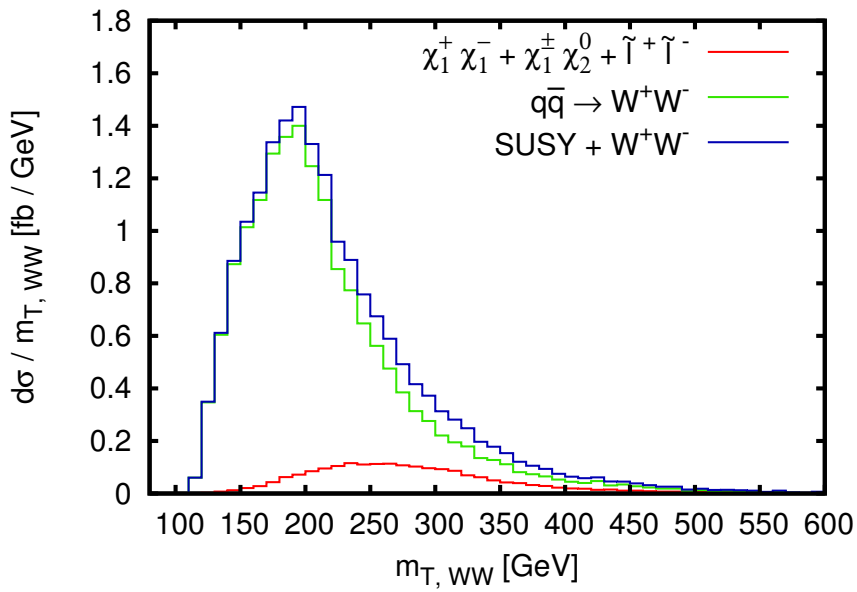
Second scenario

$m_{\chi_1^\pm} \approx 260$ GeV, $m_{\tilde{\ell}} \approx 195$ GeV, $m_{\chi_1^0} \approx 124$ GeV

Dilepton mass distributions



Transverse WW mass distributions (control region)



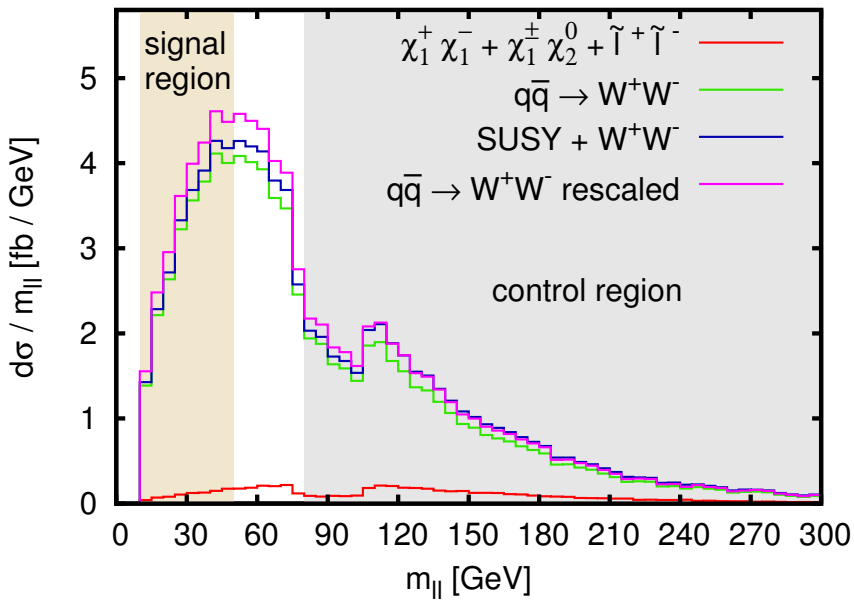
Data driven background estimate: $N^{B\text{ackground}}_{S\text{ignal}} = \underbrace{\frac{N^{WW}_{S,MC}}{N^{WW}_{C,MC}}}_{=\alpha} N^{B}_{C\text{ontrol}}$

Here: $N_C^B = N_C^{WW} + N_C^{\text{SUSY}}$

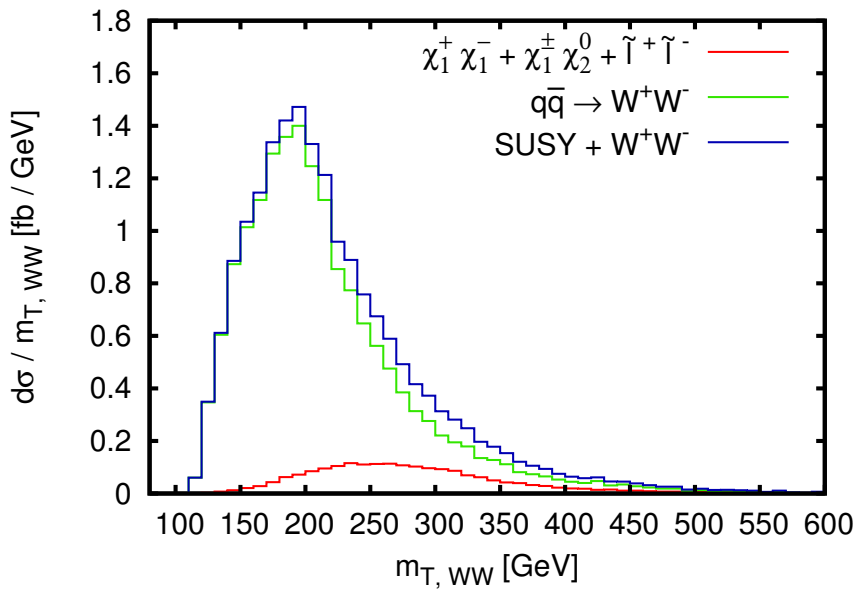
Second scenario

$m_{\chi_1^\pm} \approx 260$ GeV, $m_{\tilde{\ell}} \approx 195$ GeV, $m_{\chi_1^0} \approx 124$ GeV

Dilepton mass distributions



Transverse WW mass distributions (control region)



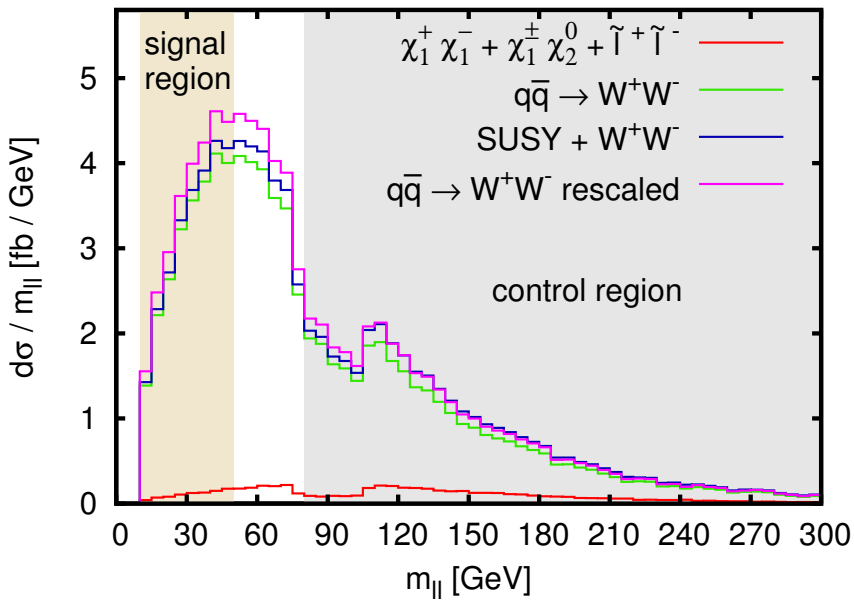
rescaled: WW distribution $\cdot \frac{\sigma_C^{WW} + \sigma^{SUSY}}{\sigma_C^{WW}}$

$\Rightarrow$ Enhancement of background in signal region

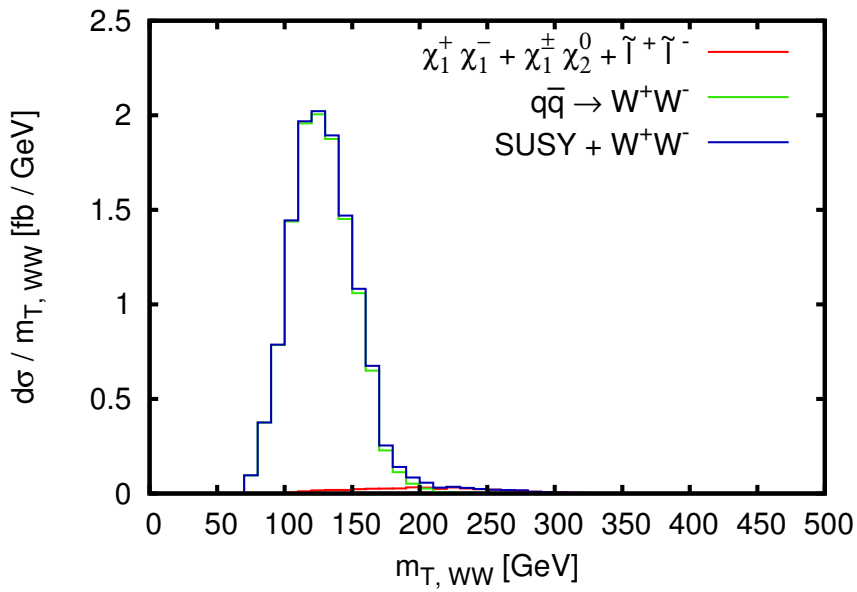
Second scenario

$m_{\chi_1^\pm} \approx 260$ GeV, $m_{\tilde{\ell}} \approx 195$ GeV, $m_{\chi_1^0} \approx 124$ GeV

Dilepton mass distributions



Transverse WW mass distributions (signal region)



$m_{T,WW}$ distribution of SUSY processes slightly different in signal region:

Tail for large $m_{T,WW}$: invisible at the moment

Correction factor

Background estimate:

$$N_S^{\text{norm}} = \alpha(N_C^{WW} + N_C^{\text{SUSY}})$$

True number of events:

$$N_S^{\text{true}} = N_S^{WW} + N_S^{\text{SUSY}}$$

Correction factor:

$$C = \frac{N_S^{\text{true}}}{N_S^{\text{norm}}} = 0.924$$

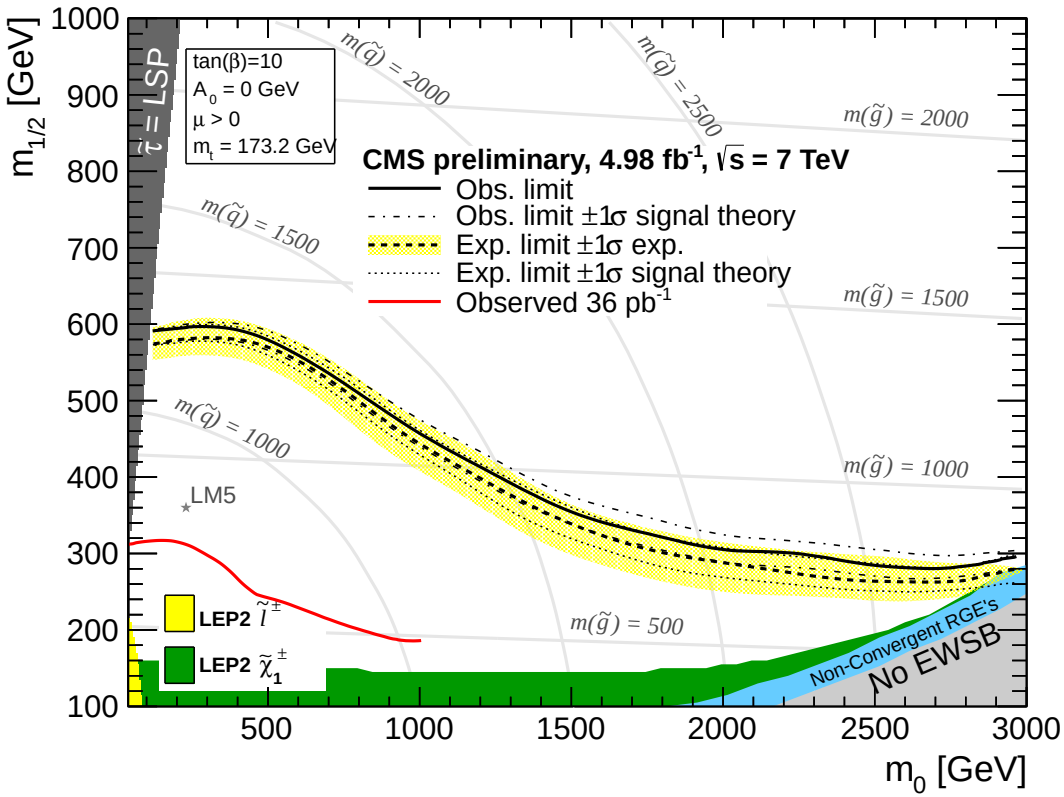
With additional cut of $0.75 \cdot m_h < m_T < m_H$:

$$C = 0.897$$

Conclusion

- Many LHC results already!
- Hope for more (not only exclusions...)!
- LHC results are constraining
  SUSY model parameter space
- Still possible:
  Data driven background method might lead
  to an overestimation due to SUSY processes

LHC results


tan(β)=10
A0 = 0 GeV
μ > 0
mt = 173.2 GeV
CMS preliminary, 4.98 fb-1, √s = 7 TeV
Obs. limit
Obs. limit ±1σ signal theory
Exp. limit ±1σ exp.
Exp. limit ±1σ signal theory
Observed 36 pb-1
m(q̃) = 2000
m(q̃) = 2500
m(q̃) = 1500
m(q̃) = 1000
m(g̃) = 2000
m(g̃) = 1500
m(g̃) = 1000
m(g̃) = 500
LM5
LEP2 l̃±
LEP2 χ̃1±
Non-Convergent RGE's
No EWSB
τ̃ = LSP
m1/2 [GeV]
m0 [GeV]
100
200
300
400
500
600
700
800
900
1000
500
1000
1500
2000
2500
3000