SUSY fits at the LHC

Michael Krämer (RWTH Aachen)

Work done in collaboration with P. Bechtle, J. Conley, K. Desch, H. Dreiner, L. Glaser, J. Lindert, B. O'Leary, C. Robens, B. Sarrazin, J.Tattersall and P. Wienemann.

See arXiv:1003.2648, arXiv:1102.4693, arXiv:1105.5398, and arXiv:1110.1287.

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From the motivation for a recent SUSY meeting at ICL:

The non-observation of SUSY-like signatures in the first fb^{-1} collected by ATLAS and CMS is in tension with the expected ranges of the parameters of constrained SUSY models like the CMSSM/mSUGRA or non-universal Higgs models. If no evidence of a missing energy signature is found by the end of the run year 2011, these constrained models will essentially be ruled out, while a very large volume of the parameter space of simple SUSY will be excluded.

SUSY searches: past, present, future

- past: EWK & flavour observables, collider limits, $\Omega_{\rm DM}$
- present: $\oplus$ LHC SUSY and Higgs exclusions
- future: $\oplus$ LHC discoveries...

SUSY searches: past, present, future

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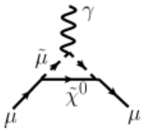
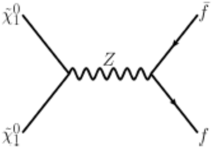
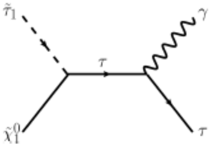
There is a wealth of precision measurements
from B/K physics, $(g-2)$, astrophysics (DM) and collider limits
which show sensitivity to supersymmetry, in particular

- $(g-2)_\mu$



- DM relic abundance

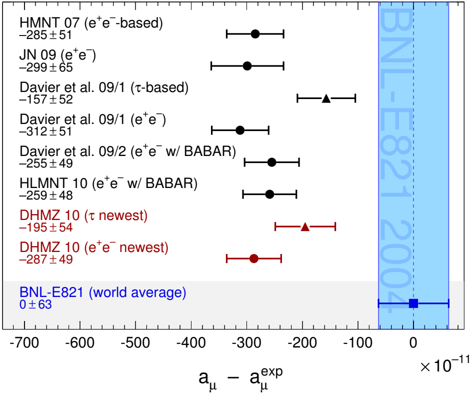




Indirect SUSY searches: $(g-2)_\mu$

3.6/2.4σ discrepancy between experimental data and SM prediction

Davier, Hoecker, Malaescu, Zhang, arXiv:1010.4180v1



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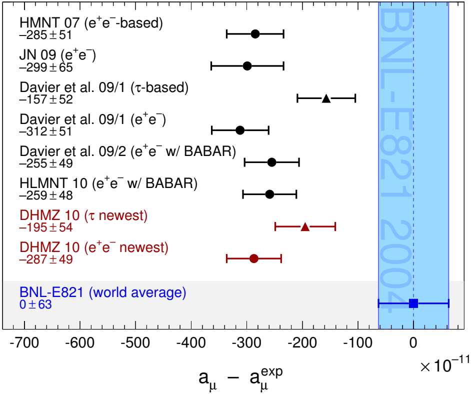
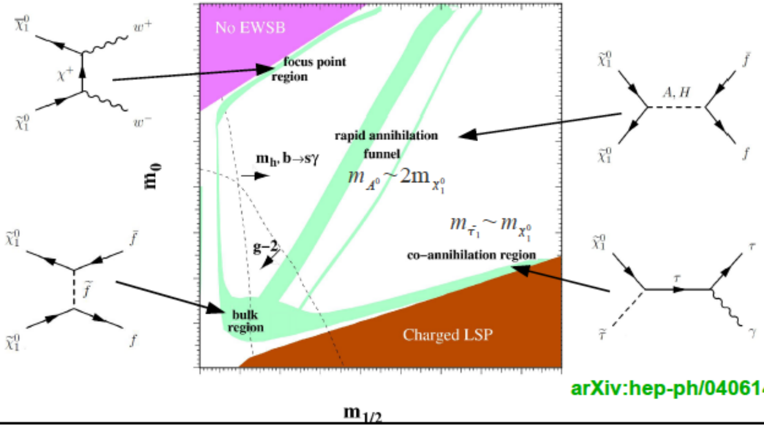


→ SUSY loops: $a_\mu^{\text{SUSY}} \sim \text{sgn}(\mu) \tan\beta \, M_{\text{SUSY}}^{-2}$

Dark matter relic abundance $\Omega_{\rm DM}$

$\Omega_{\rm DM}$ is too large for large parts of the CMSSM parameter space, special annihilation mechanisms are needed



arXiv:hep-ph/0406147

SUSY framework: the constrained MSSM

Indirect SUSY searches are often interpreted in the constrained MSSM, where the breaking is universal at the GUT scale

- universal scalar masses: $M_{\tilde{Q}}^2$, $M_{\tilde{U}}^2$, $M_{\tilde{D}}^2$, $M_{\tilde{L}}^2$, $M_{\tilde{E}}^2 \rightarrow M_0^2$ at M_{GUT}
- universal gaugino masses: M_1, M_2, $M_3 \rightarrow M_{1/2}$ at M_{GUT}
- universal trilinear couplings $A_{ij}^e, A_{ij}^d, A_{ij}^u \rightarrow A \cdot h_{ij}^e, A \cdot h_{ij}^d, A \cdot h_{ij}^u$ at M_{GUT}

In addition we have $\tan\beta$, and we fix $\mathrm{sign}(\mu) = +$

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- universal gaugino masses: M_1, M_2, $M_3 \to M_{1/2}$ at $M_{\rm GUT}$
- universal trilinear couplings $A^e_{ij}, A^d_{ij}, A^u_{ij} \to A \cdot h^e_{ij}, A \cdot h^d_{ij}, A \cdot h^u_{ij}$ at $M_{\rm GUT}$

In addition we have $\tan\beta$, and we fix $\mathrm{sign}(\mu) = +$

In the CMSSM the sparticle masses are strongly correlated, e.g.

$$M_{\tilde{g}} \simeq 3M_{\tilde{\chi}^\pm} \simeq 3M_{\tilde{\chi}^0_2} \simeq 6M_{\tilde{\chi}^0_1}$$

and

$$\begin{aligned} m^2_{\tilde{u}_L} &\simeq M^2_0 + 6.3\, M^2_{1/2} + D_{\tilde{u}_L} \\ m^2_{\tilde{e}_L} &\simeq M^2_0 + 0.5\, M^2_{1/2} + D_{\tilde{e}_L} \end{aligned}$$

where $D_{\tilde{f}_L} = M^2_Z \cos(2\beta)(T_{3_f} - Q_f \sin(2\theta_W))$

The Fittino CMSSM fits

- For the calculation of non-LHC observables we have used
  - the spectrum generator `SPheno`;
  - the `Mastercode` compilation for $(g-2)_\mu$, flavour and electroweak precision observables;
  - `MicrOMEGAs` for the DM relic densities;
  - `HiggsBounds` for the Higgs limits.

- We require that $\tilde{\chi}^0_1$ is the LSP.

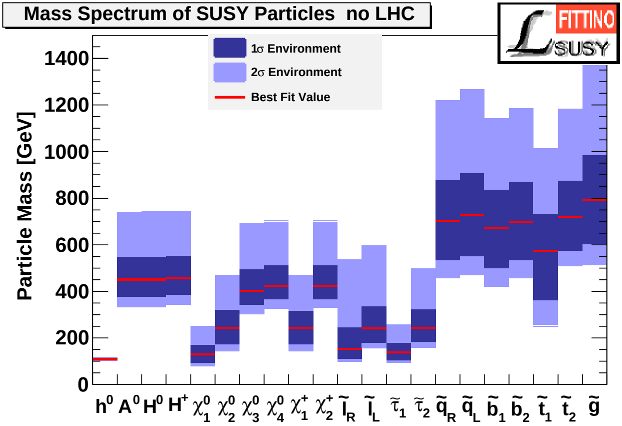
- We then calculate and minimize

$$\chi^2 = (\vec{O}_{\mathrm{obs}} - \vec{O}_{\mathrm{th}}(\vec{P}))^T \,\mathrm{cov}_M^{-1}(\vec{O}_{\mathrm{obs}} - \vec{O}_{\mathrm{th}}(\vec{P})) + \mathrm{limits}$$

  for each point $\vec{P}$ in the CMSSM parameter space using the `Fittino` package.

The Fittino CMSSM fits

Our best fit point without LHC exclusions. . .



. . . points to a light sparticle spectrum with $\tilde{m} < 1$ TeV

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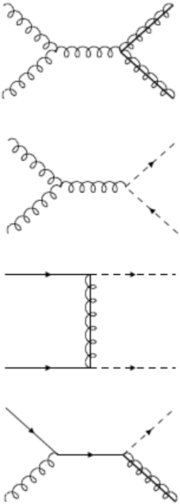
SUSY particles would be produced at the LHC via QCD processes



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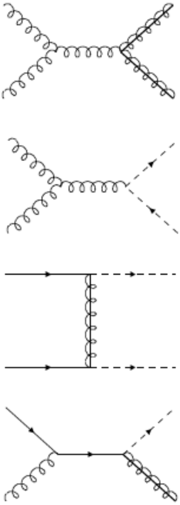
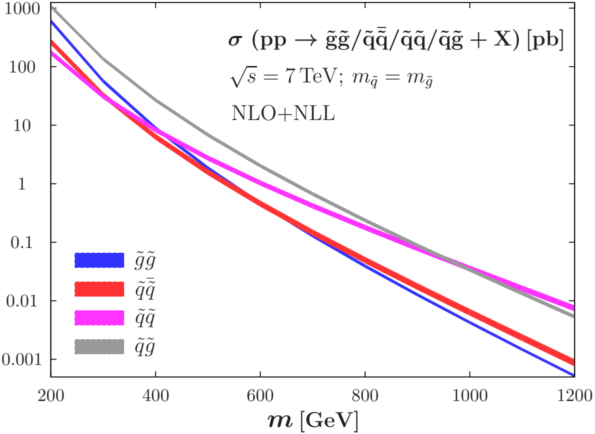


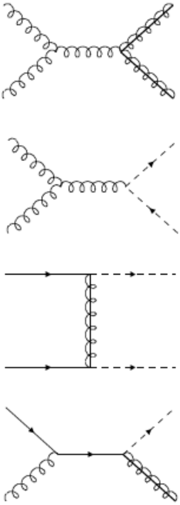
[Beenakker, Brensing, MK, Laenen, Kulesza, Niessen '09]



→ $\sigma \approx 100$ fb for $m \approx 1000$ GeV at $\sqrt{S} = 7$ TeV

SUSY particle production at the LHC

SUSY particles would be produced at the LHC via QCD processes



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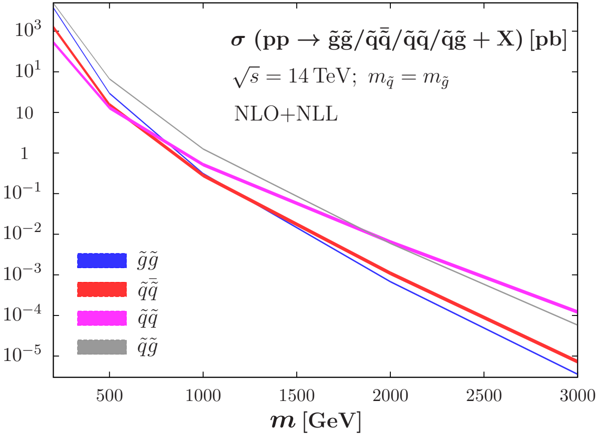
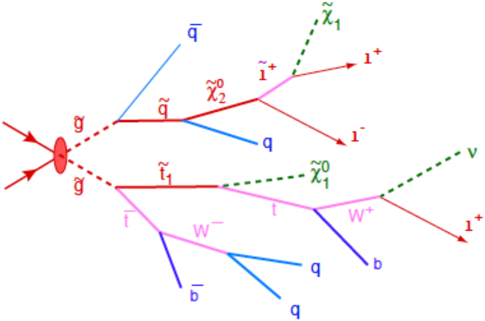


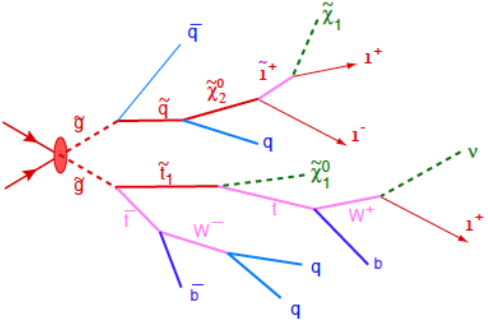
$\to \sigma \approx 2.5$ pb for $m \approx 1000$ GeV at $\sqrt{S} = 14$ TeV

Powerful MSSM signature at the LHC: cascade decays with $E_{\mathrm{T,miss}}$



SUSY searches at hadron colliders

Powerful MSSM signature at the LHC: cascade decays with $E_{\mathrm{T,miss}}$

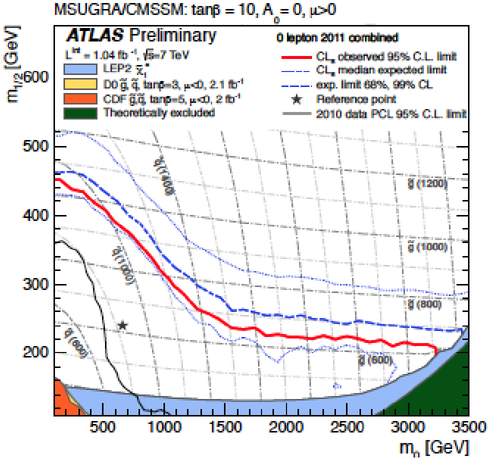


Generic signature for many new physics models which address

- the hierarchy problem
- the origin of dark matter

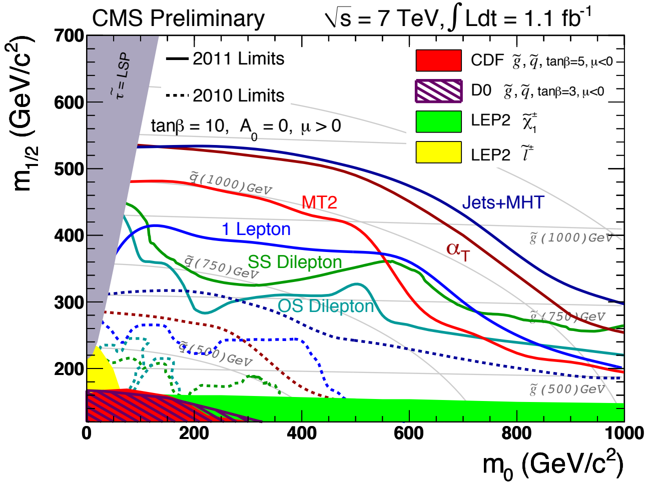
$\rightarrow$ predict spectrum of new particles at the TeV-scale
with weakly interacting & stable particle ($\leftarrow$ discrete parity)

ATLAS limits (1 fb^{-1})



$\rightarrow m_{\tilde{q}} \approx m_{\tilde{g}} \gtrsim 980$ GeV

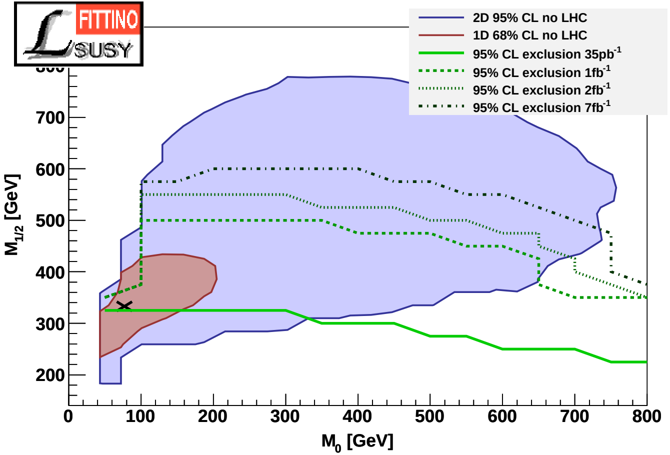
CMS limits $(1\ \mathrm{fb}^{-1})$



$\rightarrow m_{\tilde{q}} \approx m_{\tilde{g}} \gtrsim 1.2$ GeV

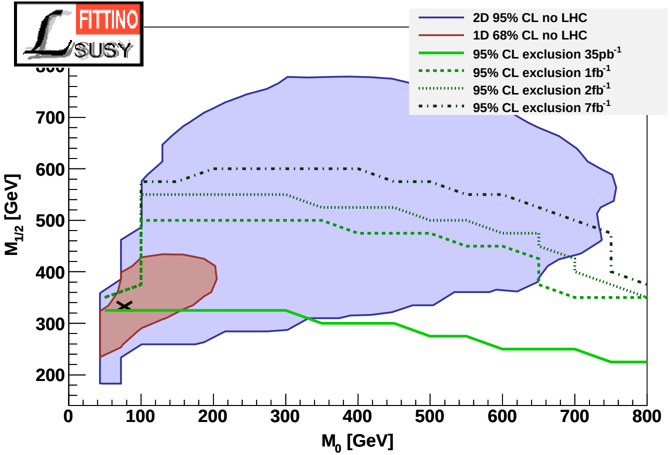
The LHC is probing the preferred region of SUSY parameter space

Bechtle, Desch, Dreiner, MK, O'Leary, Robens, Sarrazin, Wienemann, arXiv:1102.4693 [hep-ph]



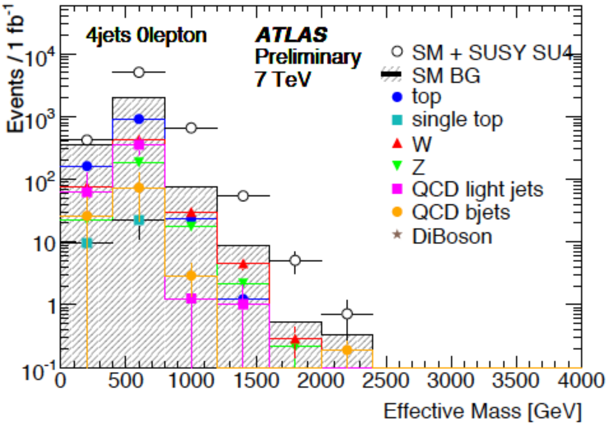
But what if we do not see any SUSY signal at the LHC?

Bechtle, Desch, Dreiner, MK, O'Leary, Robens, Sarrazin, Wienemann, arXiv:1102.4693 [hep-ph]



We have considered the SUSY search in the 4 jets + $E_{T,\mathrm{miss}}$ signature with $M_{\mathrm{eff}} = \sum_i p_{T,i} + E_{T,\mathrm{miss}}$:

ATL-PHYS-PUB-2010-10



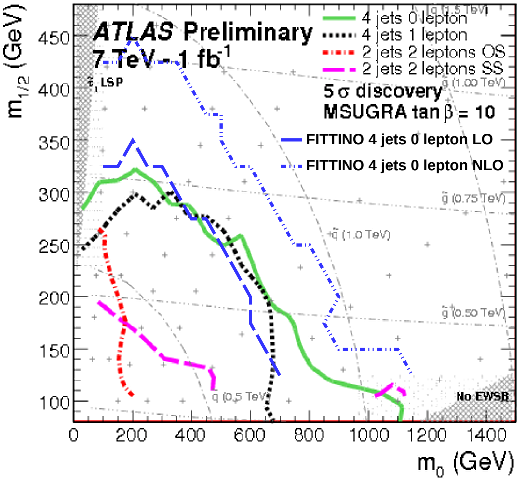
Direct SUSY searches at the LHC: expected limits

- We have calculated the CMSSM signal for a grid in $(m_0, m_{1/2})$ using
  - the spectrum generator `SPheno`;
  - the MC generator `Herwig++`;
  - NLO+NLL K-factors;
  - the fast detector simulation `Delphes`.

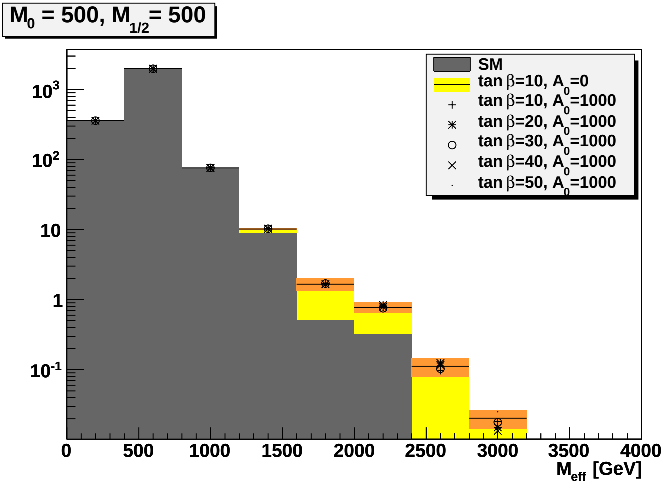
- We consider ten bins in the range $0 < M_{\mathrm{eff}} < 4$ TeV and calculate the χ^2 from the number of signal and background events in each bin of the M_{eff} distribution.

- The SM background is taken from the ATLAS simulation. We assign 30% systematic uncertainty to the SUSY signal cross-section, and 20% systematic uncertainty to the background.

We find good agreement with the ATLAS simulation:

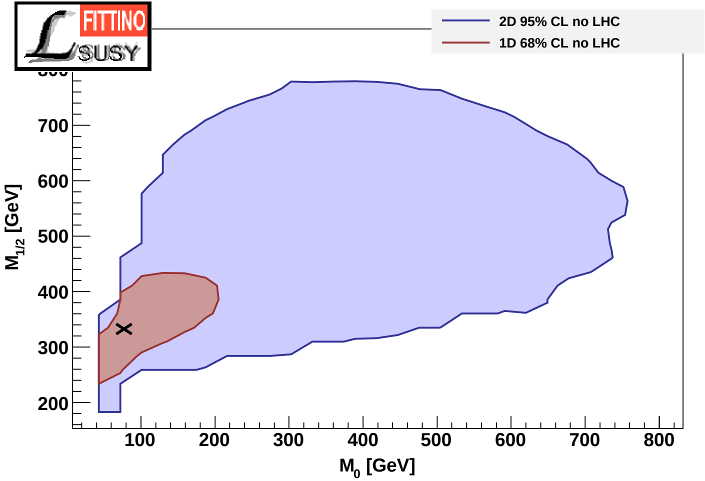


The 4 jets $+E_{T,\mathrm{miss}}$ signature is rather independent of $\tan\beta$ and A_0:



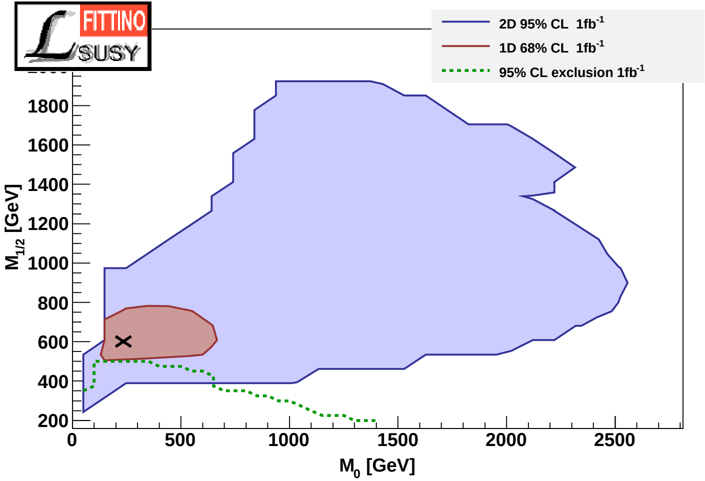
Global SUSY fits with projected LHC exclusions: results

Low-energy observables, DM, no LHC exclusions

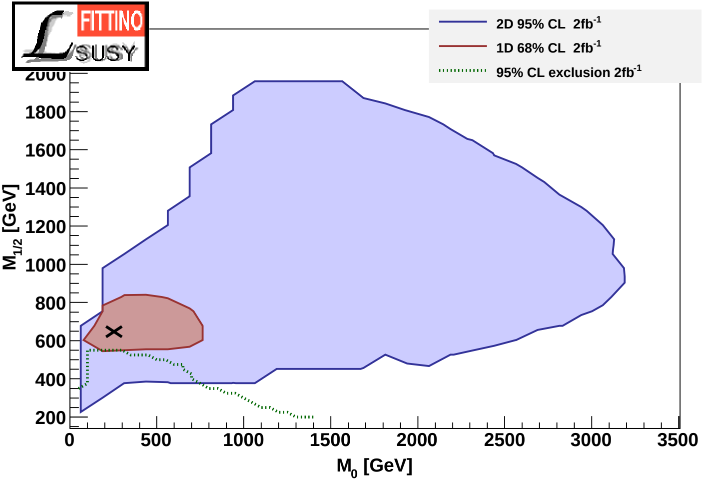


Global SUSY fits with projected LHC exclusions: results

Low-energy observables, DM and LHC exclusions with 1 fb^{-1}

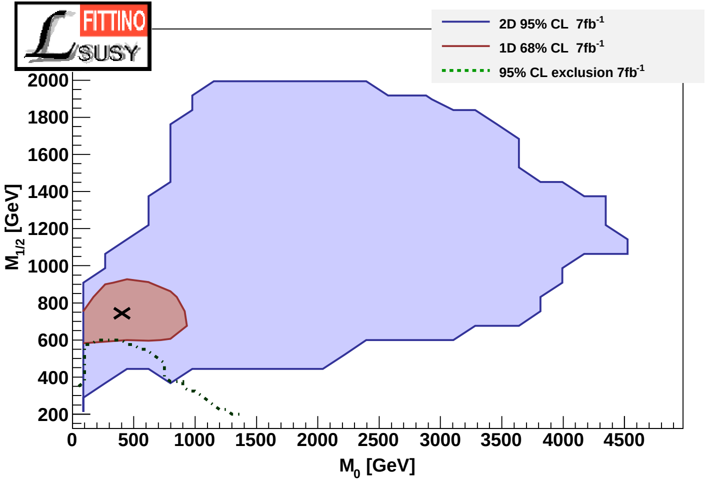


Low-energy observables, DM and LHC exclusions with 2 fb^{-1}



Global SUSY fits with projected LHC exclusions: results

Low-energy observables, DM and LHC exclusions with 7 fb^{-1}



Global SUSY fits with projected LHC exclusions: is there a tension?

$\rightarrow$ LEOs prefer low mass scales (for non-coloured sector)

$\rightarrow$ LHC prefers high mass scales (for coloured sector)

Is there a tension building up?

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$\rightarrow$ LHC prefers high mass scales (for coloured sector)

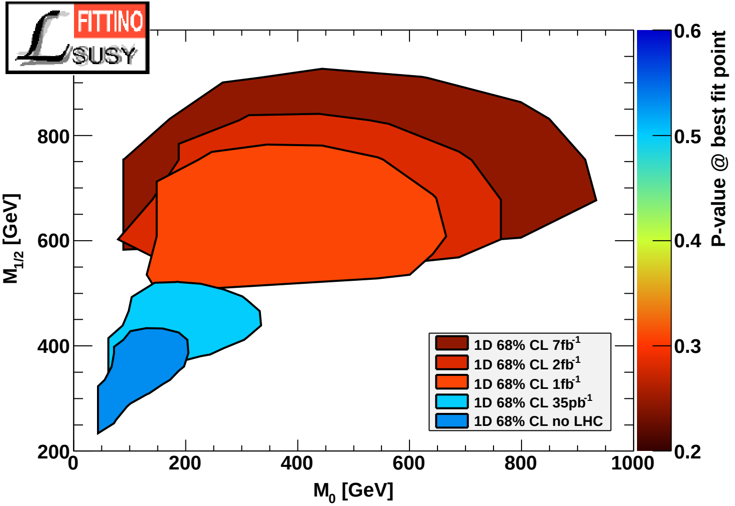
Is there a tension building up?

Let us look at the best fit points:

	M_0	$M_{1/2}$	A_0	$\tan\beta$	χ^2/ndf
no LHC	77^{+114}_{-31}	333^{+89}_{-87}	426^{+70}_{-735}	13^{+10}_{-8}	19/20
35 pb^{-1}	126^{+189}_{-54}	400^{+109}_{-40}	724^{+722}_{-780}	17^{+14}_{-9}	20/21
1 fb^{-1}	235^{+389}_{-103}	601^{+148}_{-63}	627^{+1249}_{-717}	31^{+19}_{-18}	24/21
2 fb^{-1}	254^{+456}_{-128}	647^{+157}_{-74}	771^{+1254}_{-879}	30^{+20}_{-19}	24/21
7 fb^{-1}	403^{+436}_{-281}	744^{+142}_{-150}	781^{+1474}_{-918}	43^{+11}_{-33}	25/21

$\rightarrow$ even the CMSSM would "survive" the 2011/2012 LHC run

Global SUSY fits with projected LHC exclusions: is there a tension?



Why do $\tan\beta$ and $M_{1/2}$ move to larger values?

- mainly due to $a_\mu^{\mathrm{SUSY}} \sim \mathrm{sgn}(\mu)\,\tan\beta\, M_{\mathrm{SUSY}}^{-2}$ and Ω_{DM}

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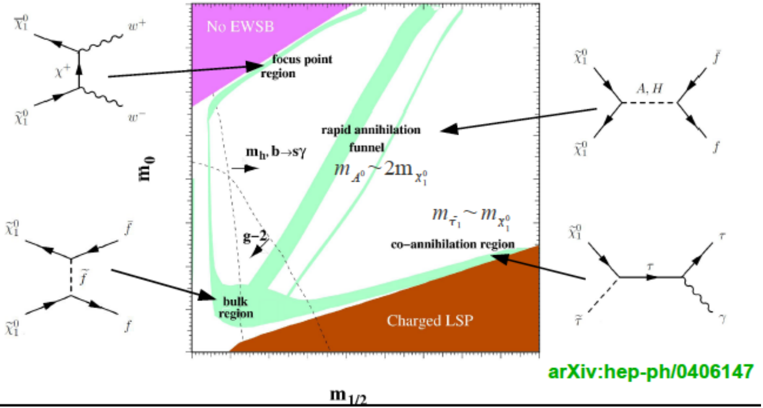
- mainly due to $a_\mu^{\mathrm{SUSY}} \sim \mathrm{sgn}(\mu)\tan\beta\, M_{\mathrm{SUSY}}^{-2}$ and Ω_{DM}
- Ω_{DM} is too large for large parts of the CMSSM parameter space, special annihilation mechanisms are needed



arXiv:hep-ph/0406147

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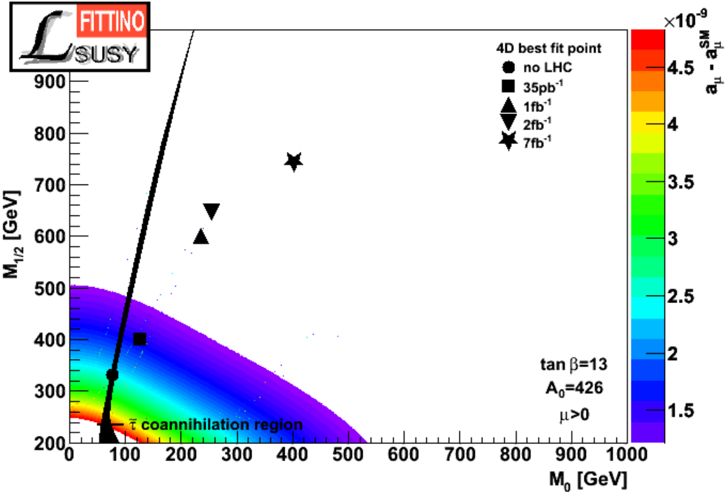

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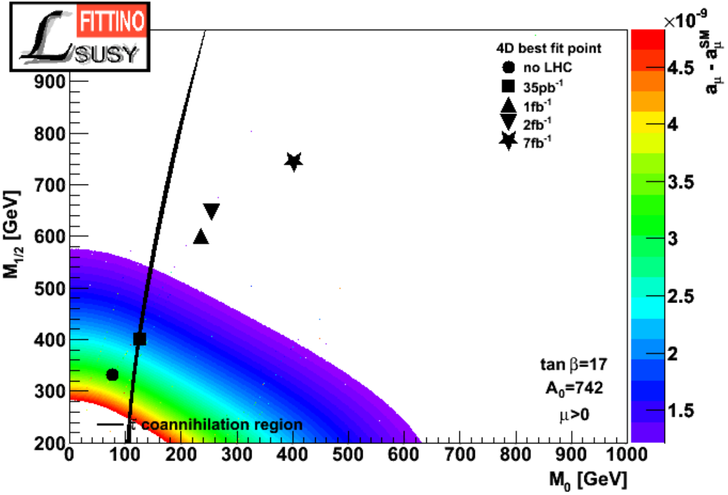

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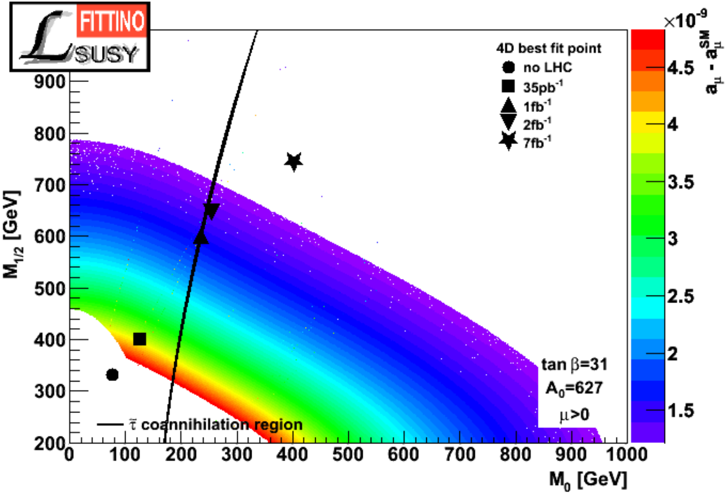

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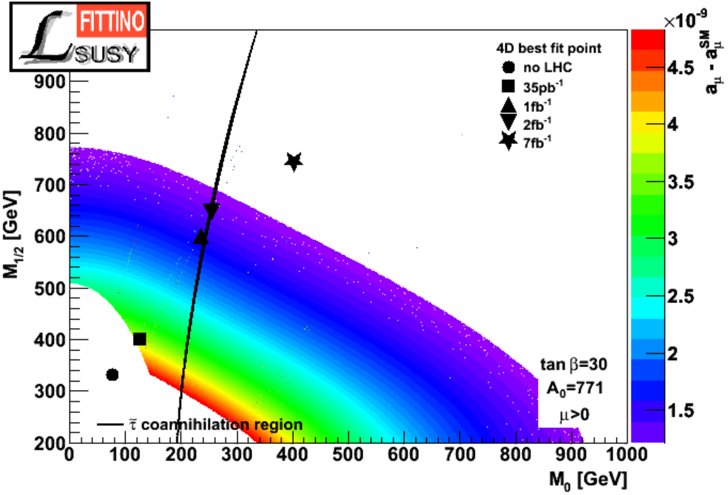

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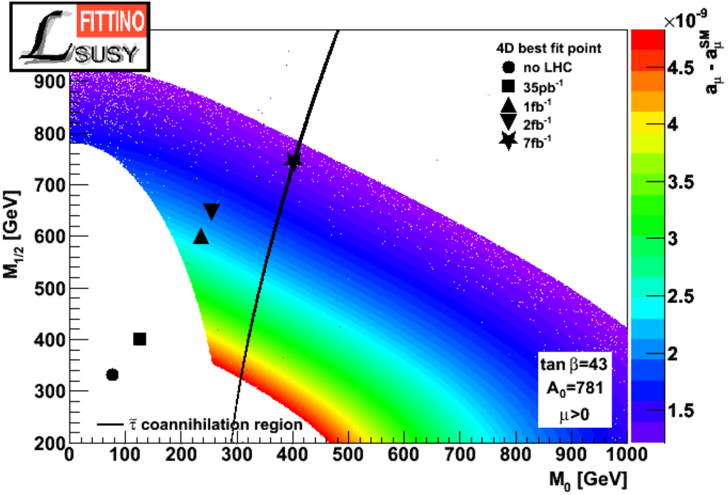
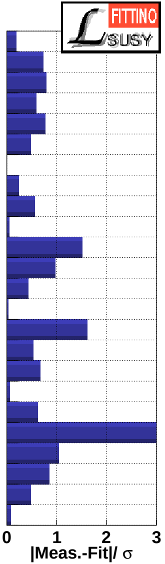


no LHC

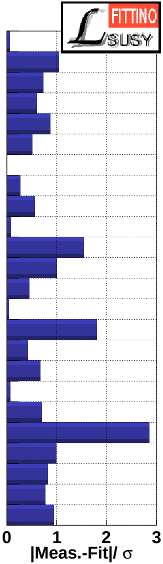
$\Omega_{CDM}h^2$	0.1099 ± 0.0135	0.1125
$a_\mu - a_\mu^{SM}$	$(30.2 \pm 9.0) \times 10^{-10}$	24.0×10^{-10}
$C(\epsilon_K)$	0.92 ± 0.14	1.03
$\overline{BR}(K \to l\nu)$	1.008 ± 0.014	1.000
$\overline{BR}(b \to s\gamma)$	1.117 ± 0.122	1.022
$\overline{BR}(b \to \tau\nu)$	1.15 ± 0.40	0.96
$\overline{BR}(B_s \to X_s ll)$	0.99 ± 0.32	0.99
$\overline{\Delta m}_{Bs}$	1.11 ± 0.32	1.03
$\overline{\Delta m}_{Bs}/\overline{\Delta m}_{Bd}$	1.09 ± 0.16	1.00
Γ_Z [MeV]	2495.2 ± 2.5	2495.3
σ^0_{had} [nb]	41.540 ± 0.037	41.484
R^0_l	20.767 ± 0.025	20.743
R^0_b	0.21629 ± 0.00066	0.21601
R^0_c	0.1721 ± 0.0030	0.1722
A_l	0.1513 ± 0.0021	0.1482
A_τ	0.1465 ± 0.0032	0.1482
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
$A^{0,l}_{FB}$	0.0171 ± 0.0010	0.0165
$A^{0,b}_{FB}$	0.0992 ± 0.0016	0.1039
$A^{0,c}_{FB}$	0.0707 ± 0.0035	0.0743
$\sin^2\theta^l_{eff}$	0.2324 ± 0.0012	0.2314
m_W [GeV]	80.398 ± 0.027	80.385
m_h [GeV] >	114.3	113.4



Global SUSY fits with projected LHC exclusions: individual pulls

$35\ pb^{-1}$

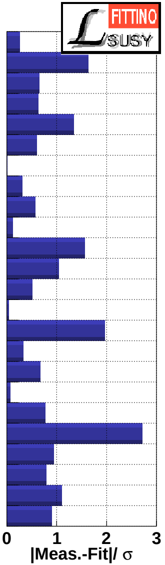
$\Omega_{CDM}h^2$	0.1099 ± 0.0135	0.1107
$a_\mu - a_\mu^{SM}$	$(30.2 \pm 9.0) \times 10^{-10}$	21.4×10^{-10}
$C(\epsilon_K)$	0.92 ± 0.14	1.02
$\overline{BR}(K \to l\nu)$	1.008 ± 0.014	1.000
$\overline{BR}(b \to s\gamma)$	1.117 ± 0.122	1.009
$\overline{BR}(b \to \tau\nu)$	1.15 ± 0.40	0.945
$\overline{BR}(B_s \to X_s ll)$	0.99 ± 0.32	0.99
$\overline{\Delta m}_{Bs}$	1.11 ± 0.32	1.02
$\overline{\Delta m}_{Bs}/\overline{\Delta m}_{Bd}$	1.09 ± 0.16	1.00
Γ_Z [MeV]	2495.2 ± 2.5	2495.0
σ^0_{had} [nb]	41.540 ± 0.037	41.483
R^0_l	20.767 ± 0.025	20.743
R^0_b	0.21629 ± 0.00066	0.21600
R^0_c	0.1721 ± 0.0030	0.1722
A_l	0.1513 ± 0.0021	0.1479
A_τ	0.1465 ± 0.0032	0.1479
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
$A^{0,l}_{FB}$	0.0171 ± 0.0010	0.0164
$A^{0,b}_{FB}$	0.0992 ± 0.0016	0.1037
$A^{0,c}_{FB}$	0.0707 ± 0.0035	0.0741
$\sin^2\theta^l_{eff}$	0.2324 ± 0.0012	0.2314
m_W [GeV]	80.398 ± 0.027	80.377
LHC		



Global SUSY fits with projected LHC exclusions: individual pulls

1 fb^{-1}

$\Omega_{CDM}h^2$	0.1099 ± 0.0135	0.1063
$a_\mu - a_\mu^{SM}$	$(30.2 \pm 9.0) \times 10^{-10}$	26.3×10^{-10}
$C(\epsilon_K)$	0.92 ± 0.14	1.01
$\overline{BR}(K \to l\nu)$	1.008 ± 0.014	0.999
$\overline{BR}(b \to s\gamma)$	1.117 ± 0.122	0.952
$\overline{BR}(b \to \tau\nu)$	1.15 ± 0.40	0.91
$\overline{BR}(B_s \to X_s ll)$	0.99 ± 0.32	0.99
$\overline{\Delta m}_{Bs}$	1.11 ± 0.32	1.01
$\overline{\Delta m}_{Bs}/\overline{\Delta m}_{Bd}$	1.09 ± 0.16	1.00
Γ_Z [MeV]	2495.2 ± 2.5	2494.9
σ^0_{had} [nb]	41.540 ± 0.037	41.482
R^0_l	20.767 ± 0.025	20.741
R^0_b	0.21629 ± 0.00066	0.21596
R^0_c	0.1721 ± 0.0030	0.1722
A_l	0.1513 ± 0.0021	0.1476
A_τ	0.1465 ± 0.0032	0.1476
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
$A^{0,l}_{FB}$	0.0171 ± 0.0010	0.0163
$A^{0,b}_{FB}$	0.0992 ± 0.0016	0.1035
$A^{0,c}_{FB}$	0.0707 ± 0.0035	0.0739
$\sin^2\theta^l_{eff}$	0.2324 ± 0.0012	0.2315
m_W [GeV]	80.398 ± 0.027	80.368
LHC		



Global SUSY fits with projected LHC exclusions: individual pulls

2 fb^{-1}

$\Omega_{CDM}h^2$	0.1099 ± 0.0135	0.1134
$a_\mu - a_\mu^{SM}$	$(30.2 \pm 9.0) \times 10^{-10}$	13.7×10^{-10}
$C(\epsilon_K)$	0.92 ± 0.14	1.01
$\overline{BR}(K \to l\nu)$	1.008 ± 0.014	0.999
$\overline{BR}(b \to s\gamma)$	1.117 ± 0.122	0.971
$\overline{BR}(b \to \tau\nu)$	1.15 ± 0.40	0.913
$\overline{BR}(B_s \to X_s ll)$	0.99 ± 0.32	1.00
$\overline{\Delta m}_{Bs}$	1.11 ± 0.32	1.01
$\overline{\Delta m}_{Bs}/\overline{\Delta m}_{Bd}$	1.09 ± 0.16	1.00
Γ_Z [MeV]	2495.2 ± 2.5	2494.4
σ^0_{had} [nb]	41.540 ± 0.037	41.482
R^0_l	20.767 ± 0.025	20.741
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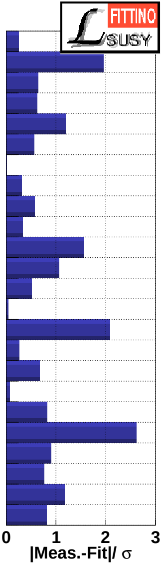
$\sin^2\theta^l_{eff}$	0.2324 ± 0.0012	0.2315
m_W [GeV]	80.398 ± 0.027	80.366
LHC		



Global SUSY fits with projected LHC exclusions: individual pulls

$7\ fb^{-1}$

$\Omega_{CDM}h^2$	0.1099 ± 0.0135	0.1095
$a_\mu - a_\mu^{SM}$	$(30.2 \pm 9.0) \times 10^{-10}$	13.3×10^{-10}
$C(\epsilon_K)$	0.92 ± 0.14	1.01
$\overline{BR}(K \to l\nu)$	1.008 ± 0.014	0.999
$\overline{BR}(b \to s\gamma)$	1.117 ± 0.122	0.948
$\overline{BR}(b \to \tau\nu)$	1.15 ± 0.40	0.854
$\overline{BR}(B_s \to X_s ll)$	0.99 ± 0.32	1.00
$\overline{\Delta m}_{Bs}$	1.11 ± 0.32	1.00
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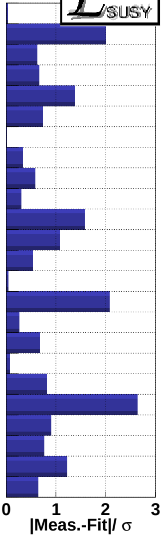
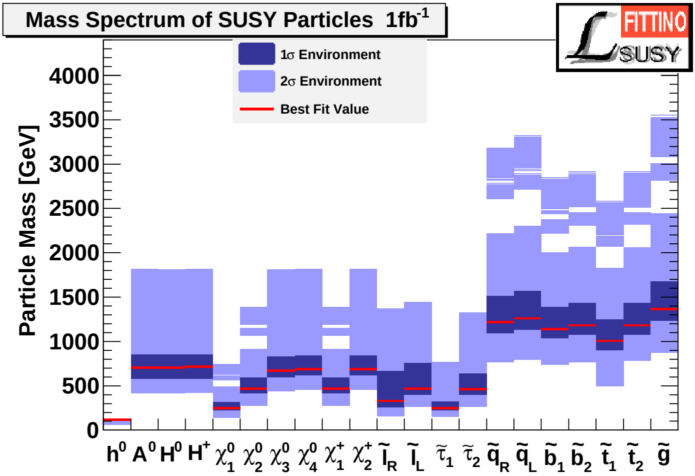


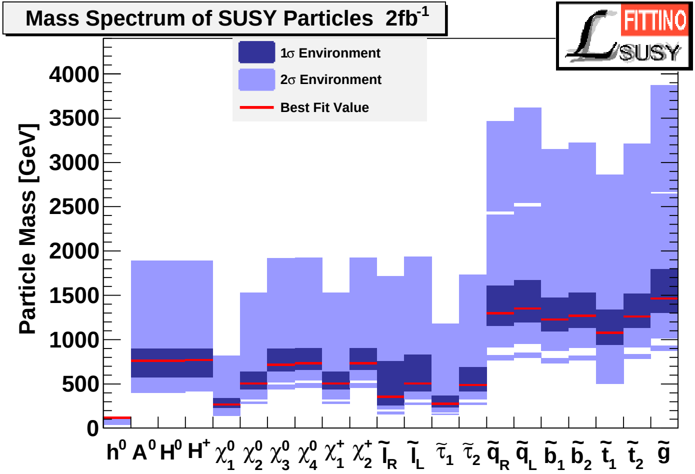
Global SUSY fits with projected LHC exclusions: mass spectrum

Low-energy observables, DM and LHC exclusions with 1 fb^{-1}



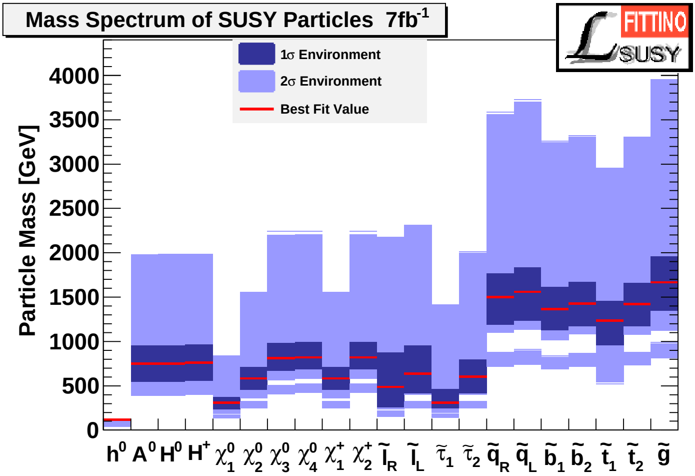
Global SUSY fits with projected LHC exclusions: mass spectrum

Low-energy observables, DM and LHC exclusions with 2 fb^{-1}



Global SUSY fits with projected LHC exclusions: mass spectrum

Low-energy observables, DM and LHC exclusions with 7 fb^{-1}

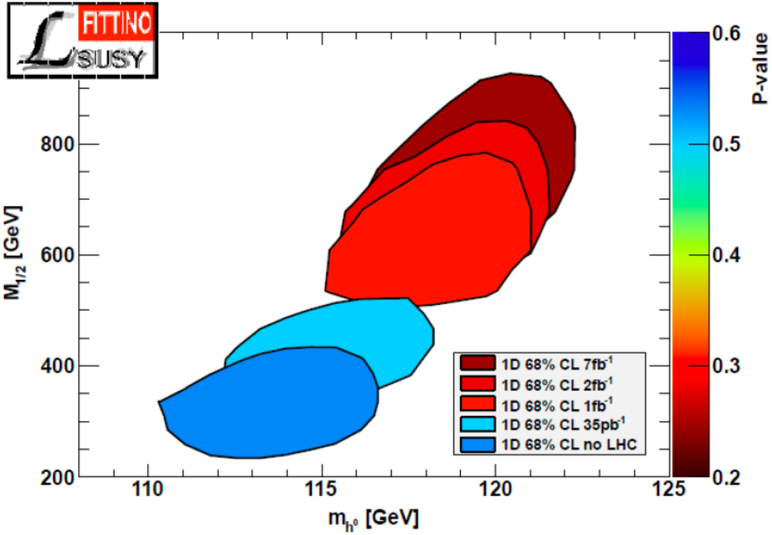


What is the role of the Higgs sector?

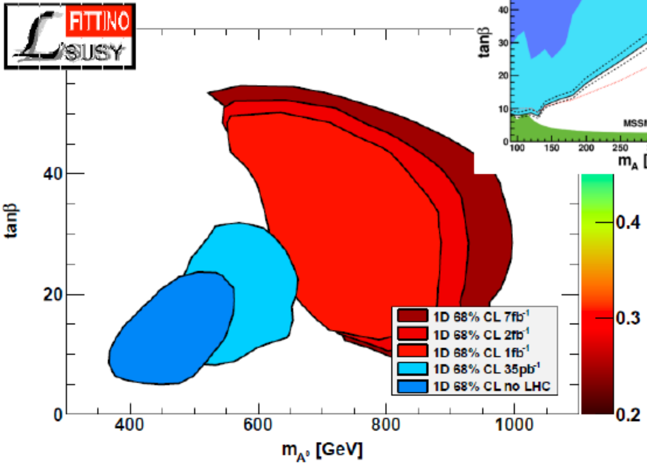
A few comments:

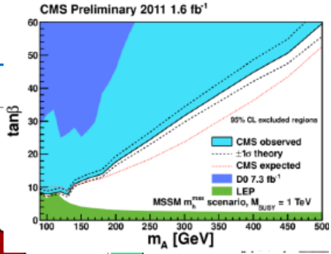
- the Higgs sector is strongly constrained in the CMSSM;
- in our CMSSM fits, the light Higgs is very SM-like, and the heavy Higgses are beyond current (future?) reach;

What is the role of the Higgs sector?



Higgs sector in CMSSM fit





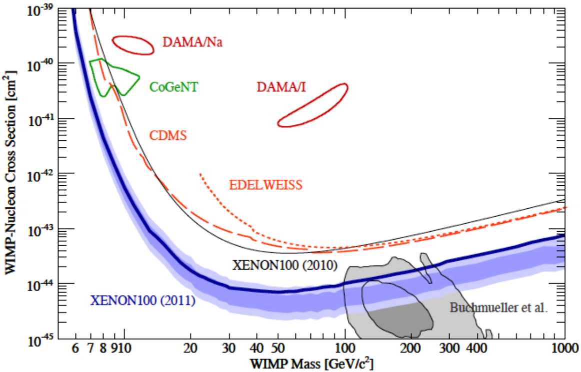
What is the role of the Higgs sector?

A few more comments:

- the Higgs sector is strongly constrained in the CMSSM;
- in our CMSSM fits, the light Higgs is very SM-like, and the heavy Higgses are beyond current (future?) reach;
- the exclusion of a Higgs with $m_h \lesssim 140$ GeV would probably be the only way to exclude the MSSM;
- SM Higgs searches may, however, not be sufficient to exclude a light MSSM Higgs, e.g. because of invisible decays $h \to \tilde{\chi}\tilde{\chi}$;
- the Higgs sector will play a crucial role for the assessment of SUSY in the near future!

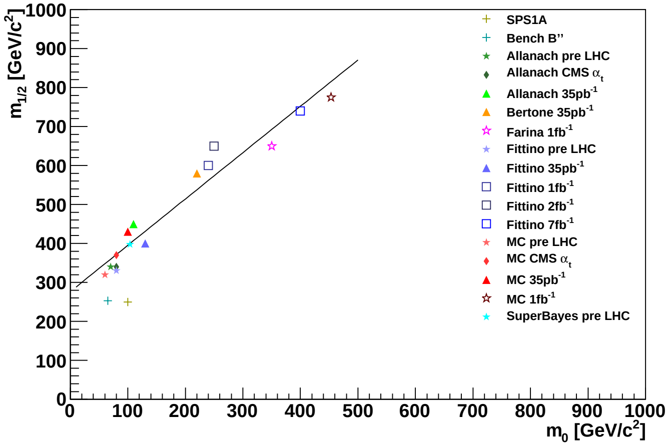
Future SUSY searches beyond MET

- flavour constraints, *e.g.* $B_s \to \mu\mu$ (LHCb)
- direct dark matter searches (see e.g. Aprile et al: arXiv:1104.2549)



Comparison of global CMSSM fits with and without LHC exclusions

There has been a lot of activity recently (see e.g. arXiv:1109.3859v1)



→ there is less agreement after the inclusion of LHC limits

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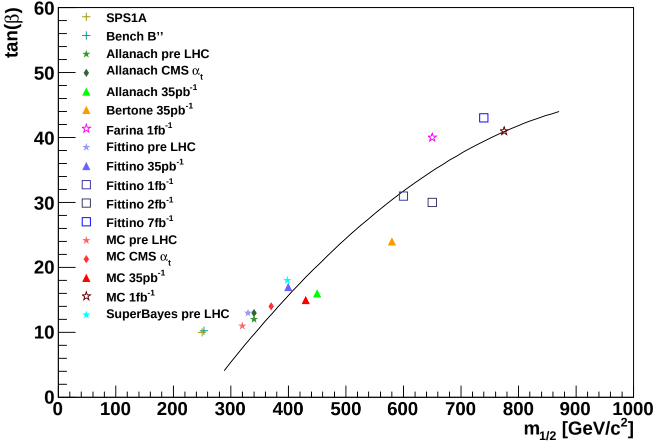

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Global SUSY fits: the χ^2 of the LHC exclusions

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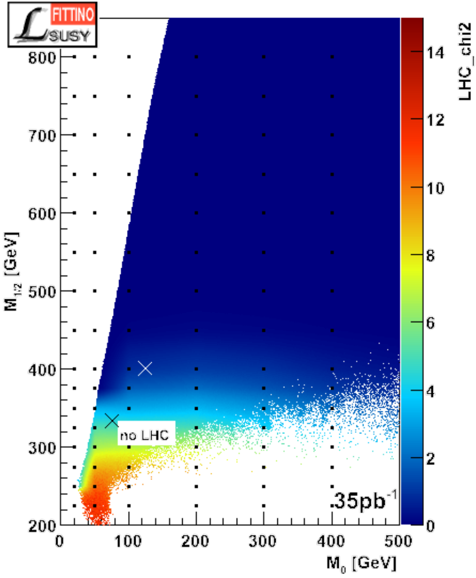
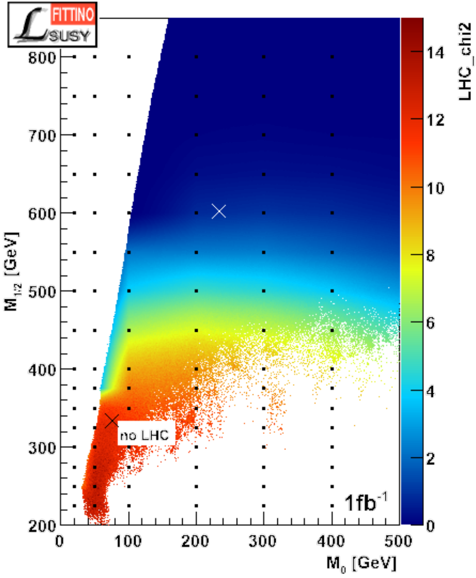


Global SUSY fits: the χ^2 of the LHC exclusions



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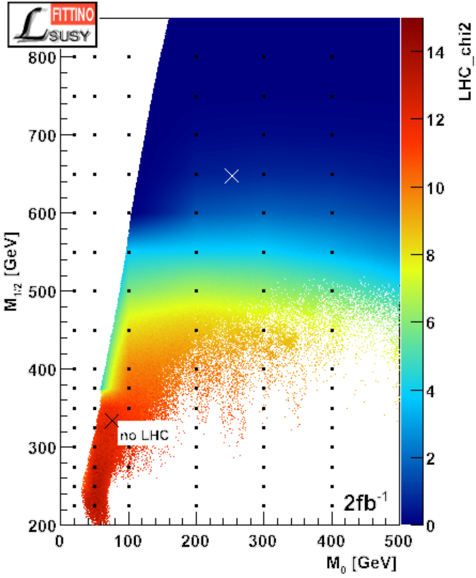

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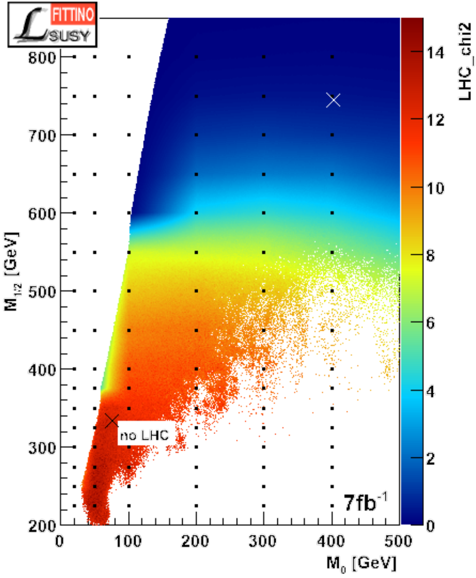
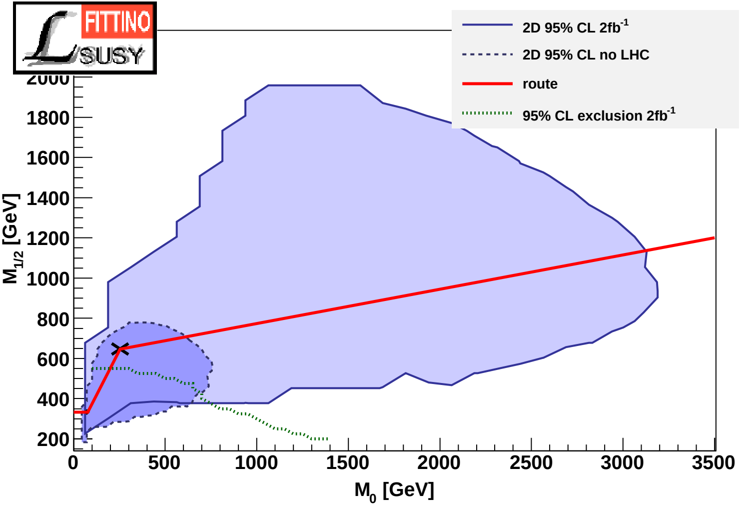


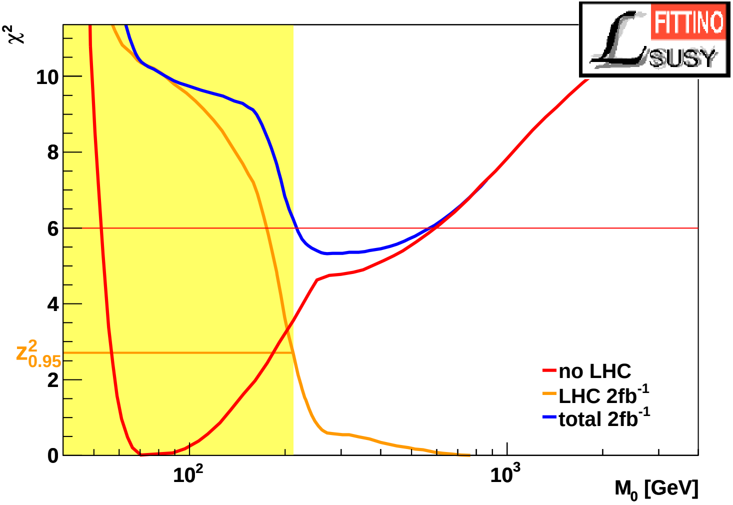
Global SUSY fits: the χ^2 of the LHC exclusions

Let us look at the χ^2 of the LHC exclusions along the red line:



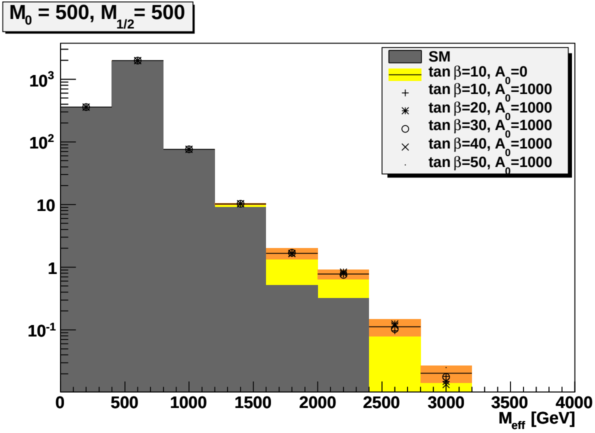
Global SUSY fits: the χ^2 of the LHC exclusions

We find a non-trivial shape of the LHC χ^2:



Global SUSY fits: the χ^2 of the LHC exclusions

When we vary m_0 and $m_{1/2}$, both the SUSY rate as well as the shape of the $M_{\rm eff}$ distribution change; SUSY signals with larger rate may become more background-like and thus harder to observe.



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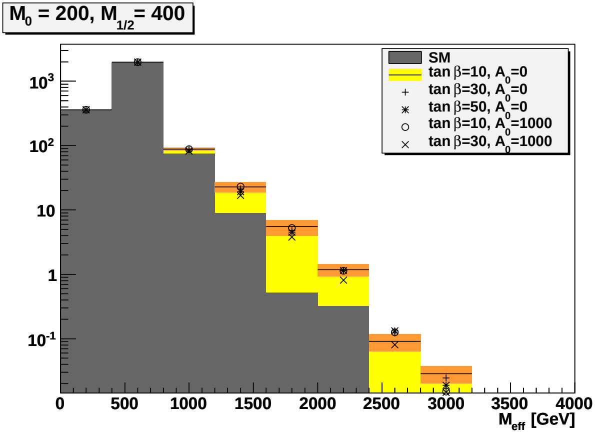

Comparison of global CMSSM fits with LHC exclusions

- There is too wide a spread in global CMSSM fits with LHC exclusions.

  The different groups use different

  - LHC signatures;
  - levels of sophistication in the implementation of LHC limits.

  We should compare the LHC χ^2 maps between the different groups and identify problematic regions.

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  The different groups use different

  - LHC signatures;
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  We should compare the LHC χ^2 maps between the different groups and identify problematic regions.

- How can we optimize the LHC sensitivity?

  We observe

  - a reduced sensitivity when going from our analysis based on the M_{eff} distribution to the more recent analysis of ATLAS-CONF-2011-086 (prel.);
  - limitations of the sensitivity due to the systematic uncertainties of signal and background.

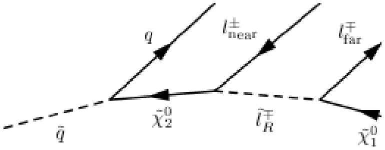
  We should compare the impact of different analyses (M_{eff}, α_{T} etc.) on global SUSY fits and include a combination of various LHC constraints.

SUSY searches: past, present, future

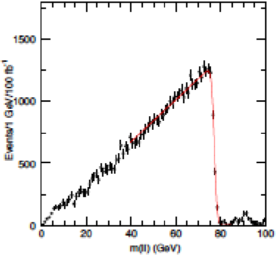
- past: EWK & flavour observables, collider limits, $\Omega_{\rm DM}$
- present: $\oplus$ LHC SUSY and Higgs exclusions
- future: $\oplus$ LHC discoveries...

SUSY parameter determination at the LHC

Mass measurements from cascade decays, e.g.



Allanach et al.



→ kinematic endpoints sensitive to masses:

$$
\begin{aligned}
(m^2_{ll})^{\max} &= (m^2_{\tilde{\chi}^0_2} - m^2_{\tilde{l}_R})(m^2_{\tilde{l}_R} - m^2_{\tilde{\chi}^0_1})/m^2_{\tilde{l}_R} \\
(m^2_{qll})^{\max} &= (m^2_{\tilde{q}_L} - m^2_{\tilde{\chi}^0_2})(m^2_{\tilde{\chi}^0_2} - m^2_{\tilde{\chi}^0_1})/m^2_{\tilde{\chi}^0_2} \\
(m^2_{ql,\min})^{\max} &= (m^2_{\tilde{q}_L} - m^2_{\tilde{\chi}^0_2})(m^2_{\tilde{\chi}^0_2} - m^2_{\tilde{l}_R})/m^2_{\tilde{\chi}^0_2} \\
(m^2_{ql,\max})^{\max} &= (m^2_{\tilde{q}_L} - m^2_{\tilde{\chi}^0_2})(m^2_{\tilde{l}_R} - m^2_{\tilde{\chi}^0_1})/m^2_{\tilde{l}_R}
\end{aligned}
$$

SUSY parameter determination with cross sections

How well could we do at 7 TeV and 1 fb^{-1}? [Dreiner, MK, Lindert, O'Leary]

[cf. Baer et al., Altunkaynak et al., . . .]

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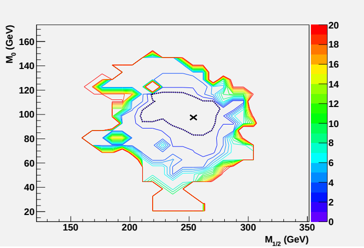

SPS1a with 4 kinematic edges only

→ no stable fit

→ add cross sections:
sensitive to masses and spins

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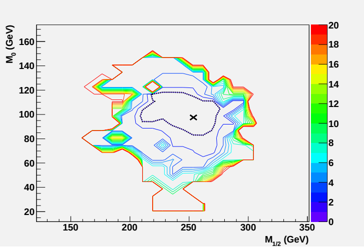

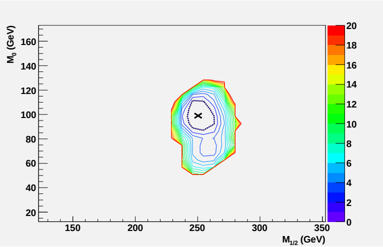

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kinematic edges $\oplus$ cross sections

$$\rightarrow m_0 = 99 \pm 9 \text{ GeV}$$

$$m_{1/2} = 250 \pm 7 \text{ GeV}$$

$$\tan\beta = 11 \pm 6$$

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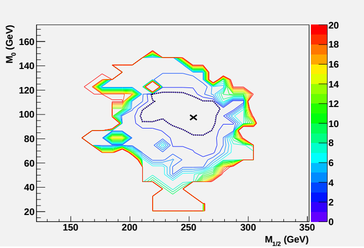

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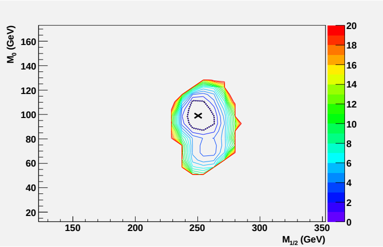

kinematic edges ⊕ cross sections

$$\rightarrow m_0 = 99 \pm 9 \text{ GeV}$$
$$m_{1/2} = 250 \pm 7 \text{ GeV}$$
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→ cross sections are crucial to determine BSM parameters

SUSY parameter determination with cross sections

Beyond mSUGRA: explore mirage mediation models

[Choi, Nilles, Falkowski, Ratz, Loewen and many others]

→ characteristic pattern of soft SUSY-breaking terms

$M_1 : M_2 : M_3 \simeq (1 + 0.66\alpha) : (2 + 0.2\alpha) : (6 - 1.8\alpha)$

→ relative size of modulus and anomaly mediation controlled by α

How well can we determine α from future LHC data?

SUSY parameter determination with cross sections

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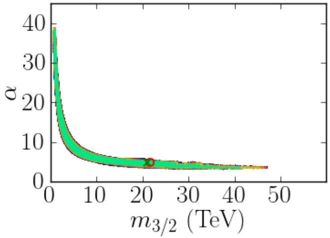
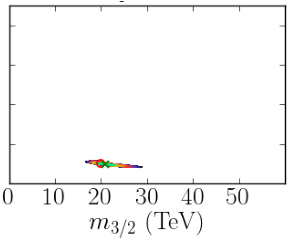
Assume LHC @ 14 TeV with 1 fb^{-1}

[Conley, Dreiner, Glaser, MK, Tattersall]



kinematic edges only



kinematic edges ⊕ cross sections

$\rightarrow \alpha = 5 \pm 0.3$

backup