Effective Supersymmetry at the LHC

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SUSY 10 - August 26th, 2010

H. Baer, S. Kraml, A. Lessa, S. Sekmen and X. Tata
Effective Supersymmetry at the LHC.
arXiv:1007.3897

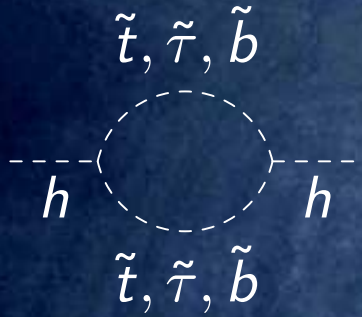
Outline

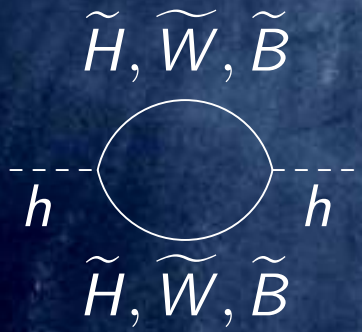
- Effective Supersymmetry
- Motivation
- Parameter Space
- Markov Chain MC
- Phenomenology

- Conclusions

Motivation

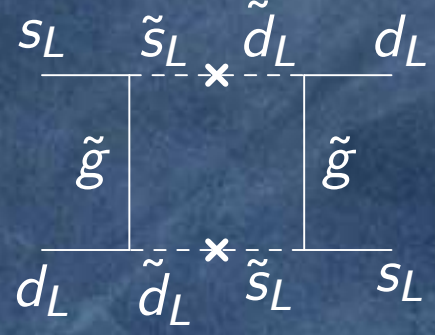
- Hierarchy Problem:

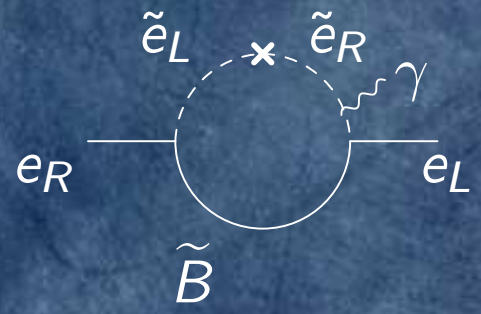




$$m_{\tilde{t},\tilde{\tau},\tilde{b}} \lesssim \text{few TeV}$$
$$m_{\widetilde{H},\widetilde{B},\widetilde{W}} \lesssim \text{few TeV}$$

- Flavor/CP Problems:





$$m_{\tilde{q},\tilde{l}}(1,2) \gtrsim \text{10-100 TeV}$$

ESUSY

- At the weak scale:

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\begin{aligned}
m_{\tilde{t},\tilde{\tau},\tilde{b}} &\lesssim \text{1-5 TeV} \\
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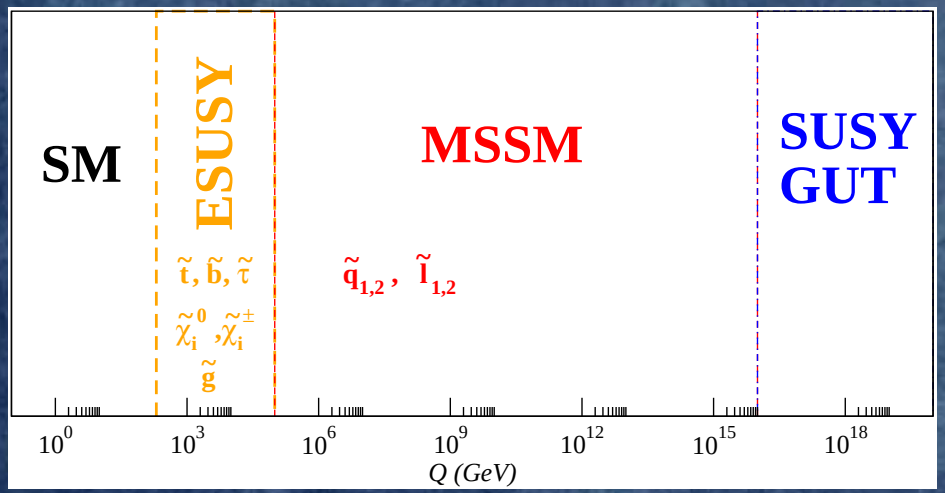

A. Cohen, D. Kaplan and A. Nelson, *Phys.Lett.B 388 (1996), 588*

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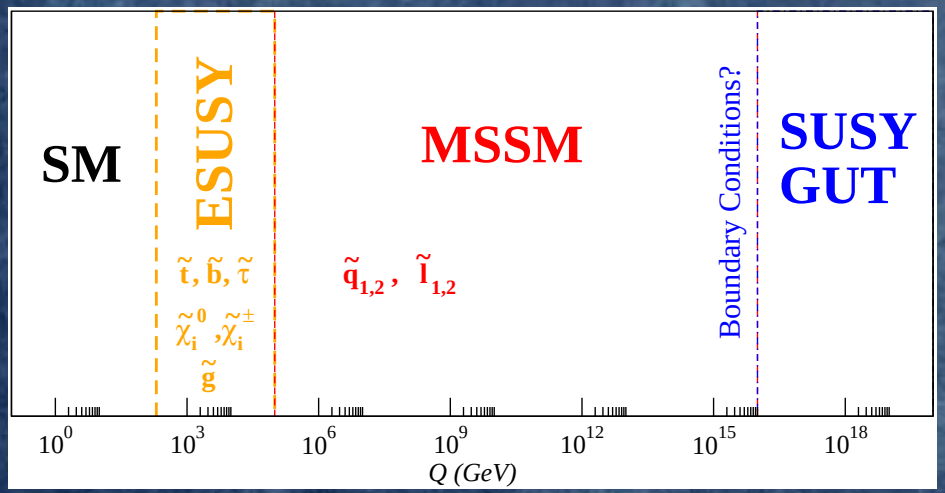

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- Which GUT scale physics generates ESUSY at M_W?

ESUSY - Parameter Space

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  - $m_0(1,2,3), m_{H_{u,d}}, M_{1,2,3}$

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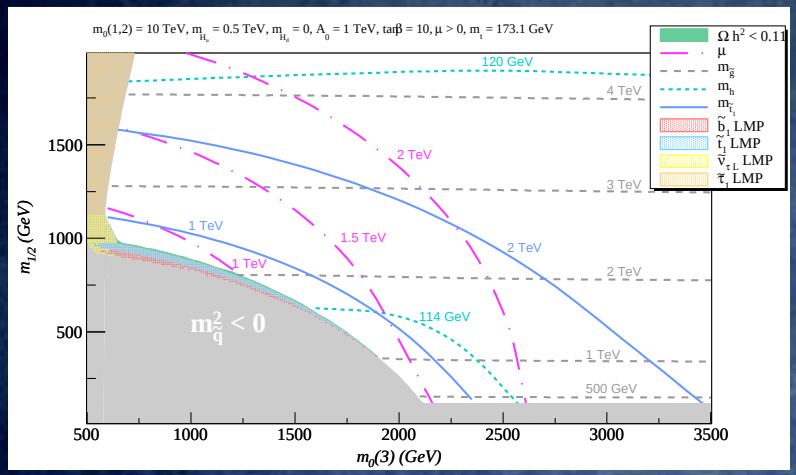
- RGE Schematics:

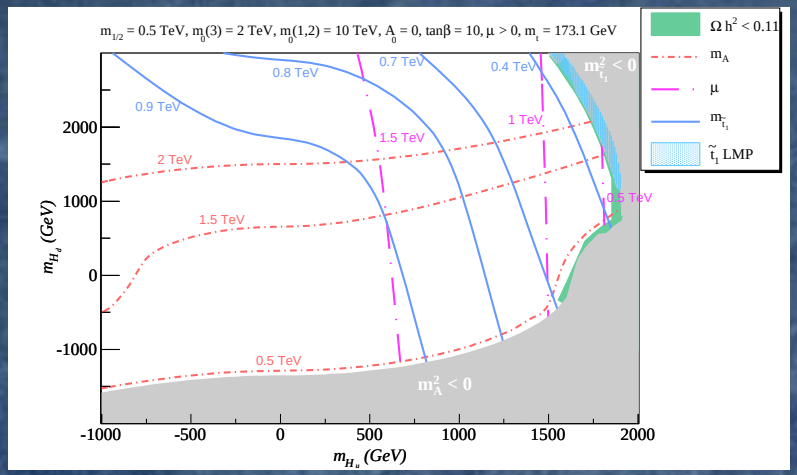
$$\begin{array}{ccccc} & & \uparrow & \downarrow & \downarrow \\ \frac{dm^2_{Q_3}}{dt} & \sim & -\alpha_s M_3^2 + f_t^2 m^2_{Q_3} & + \boldsymbol{\alpha_s^2 m^2_{Q_{1,2}}} & + \ldots \\ \frac{dm^2_{H_u}}{dt} & \sim & +f_t^2 m^2_{Q_3} & + \ldots & \\ & & \downarrow & & \end{array}$$

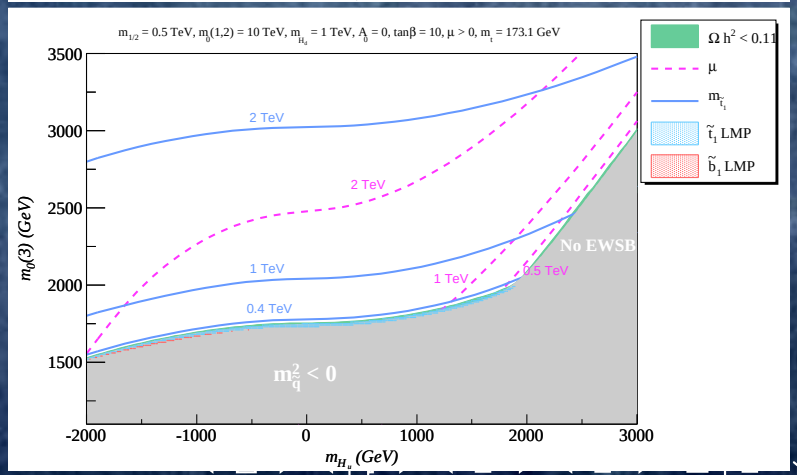
$$\mu^2(M_W) \sim -m^2_{H_u}(M_W)$$

ESUSY - Parameter Space

- $m_0(1,2), m_0(3), m_{1/2}, m_{H_u}, m_{H_d}, A_0, \tan\beta, sign(\mu)$







- $m^2_{\tilde{t}} > 0 \rightarrow$ lower bound on $m_{1/2}, m_0(3)$
- $\mu^2 > 0 \rightarrow$ upper bound on m_{H_u}
- $m^2_A > 0 \rightarrow$ lower bound on m_{H_d}

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  - Observables: $b \to s\gamma$, $B_s \to \mu^+\mu^-$, $B^- \to \tau\nu_\tau$, m_t, m_h

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$$L_{\widetilde{M}}(m_0(1,2)) = \frac{1}{1+\exp((10-m_0(1,2))/1.7\ \mathrm{TeV})} \quad \Rightarrow \quad m_0(1,2) \gtrsim 10\ \mathrm{TeV}$$

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$$L_{M_{eff}}(m_X) = \frac{1}{1+\exp((m_X-1\ \mathrm{TeV})/170\ \mathrm{GeV})} \quad \Rightarrow \quad m_X \lesssim 1\ \mathrm{TeV}$$

$X = \tilde{\chi}_1^+,\ \tilde{\chi}_2^+,\ \tilde{t}_1,\ \tilde{t}_2,\ \tilde{b}_1$

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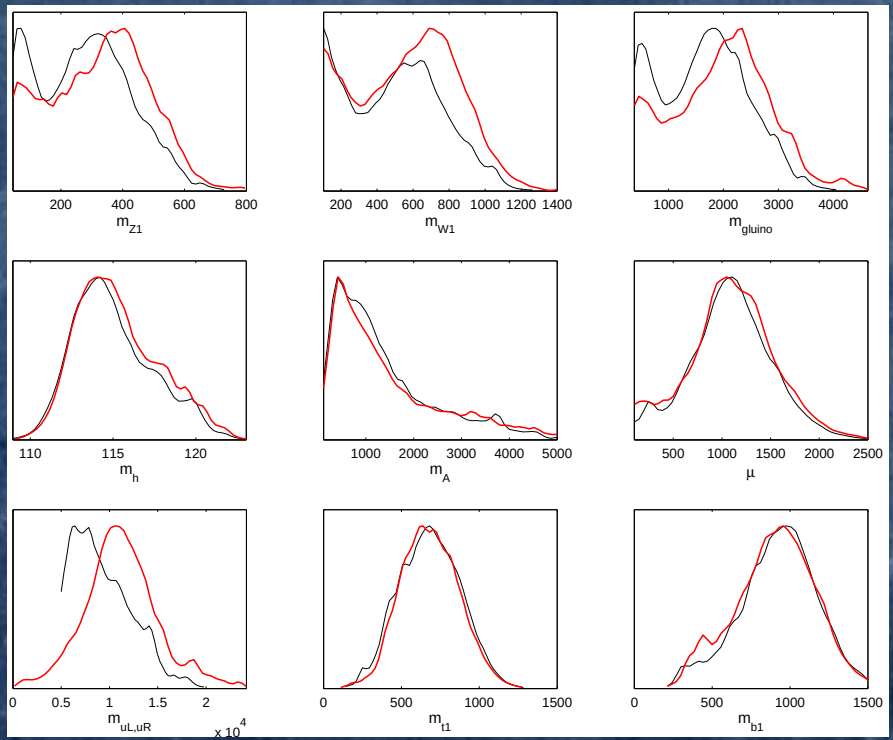
- MCMC Results:
  - PPDs for ESUSY masses:



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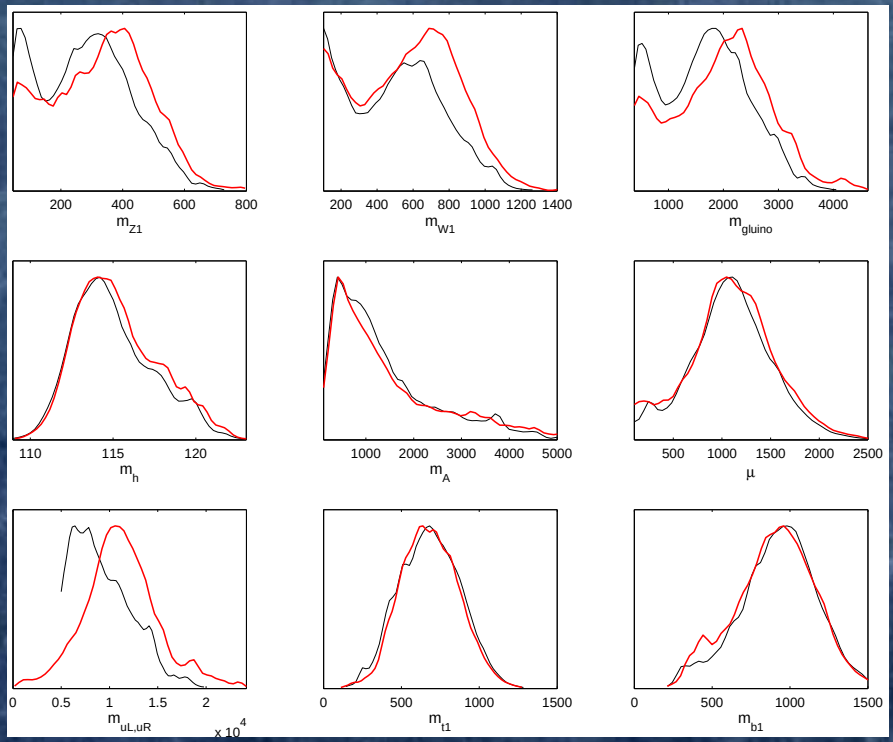

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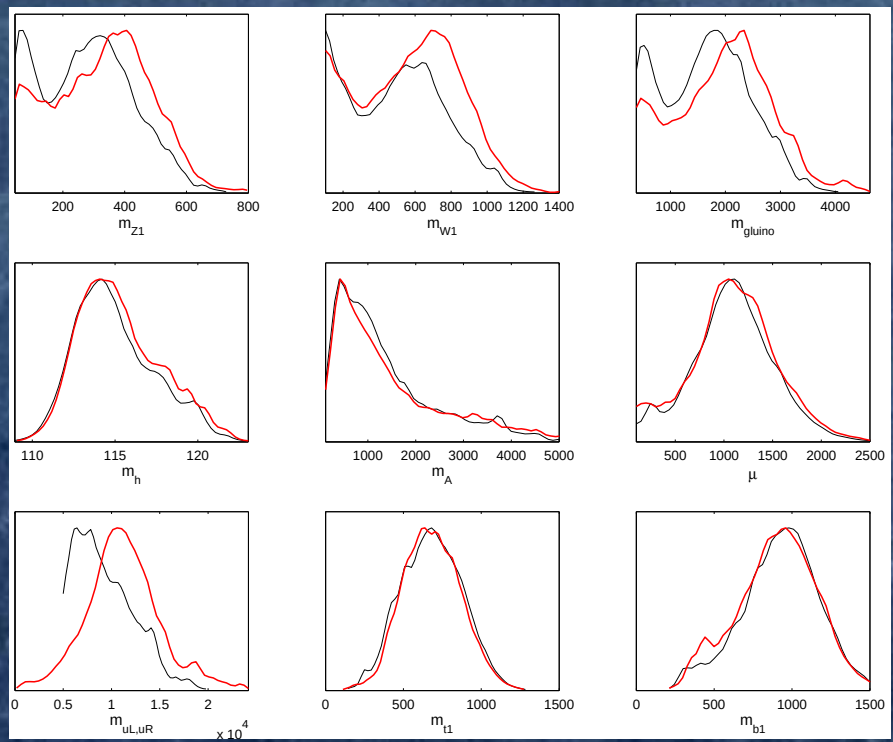

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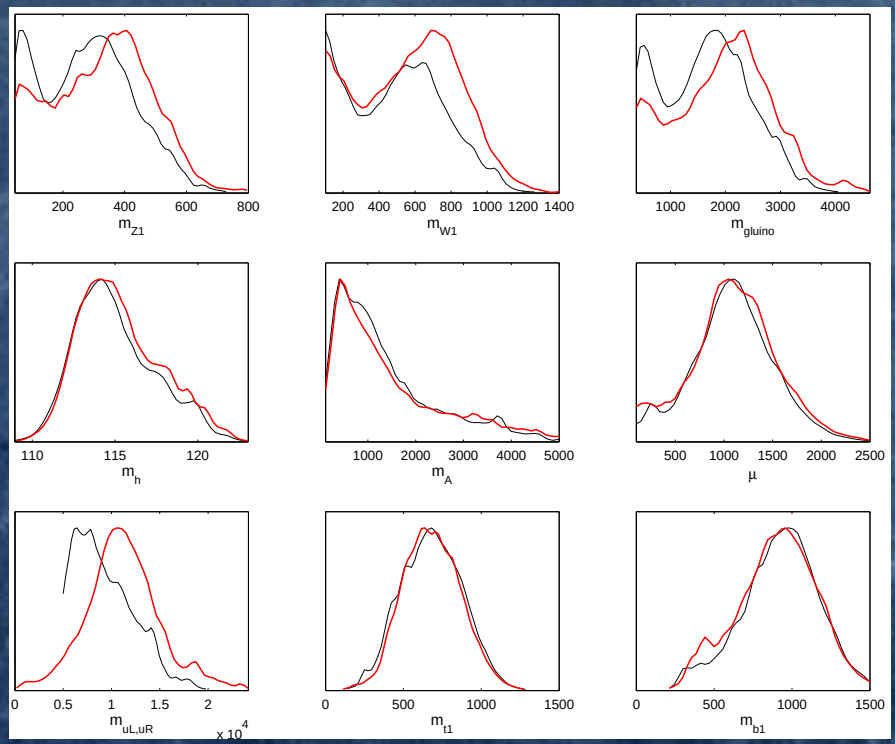
- $m_{\tilde{q}_{1,2}} \lesssim 20\ \text{TeV}$
  $(L_{M_{eff}})$



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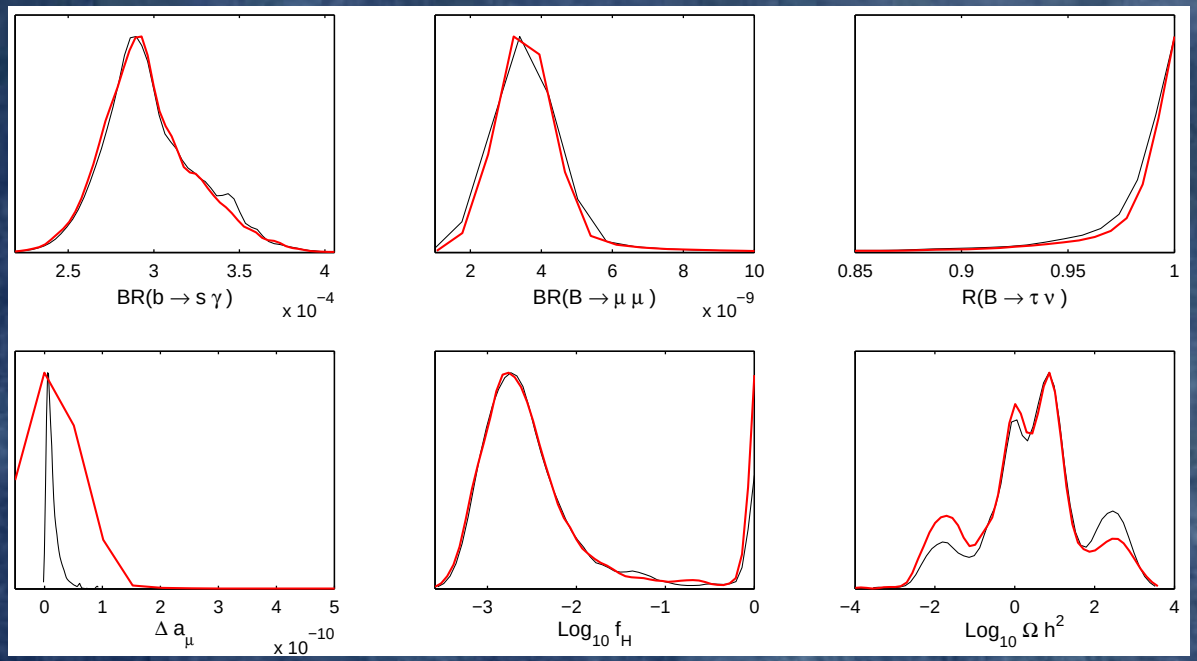

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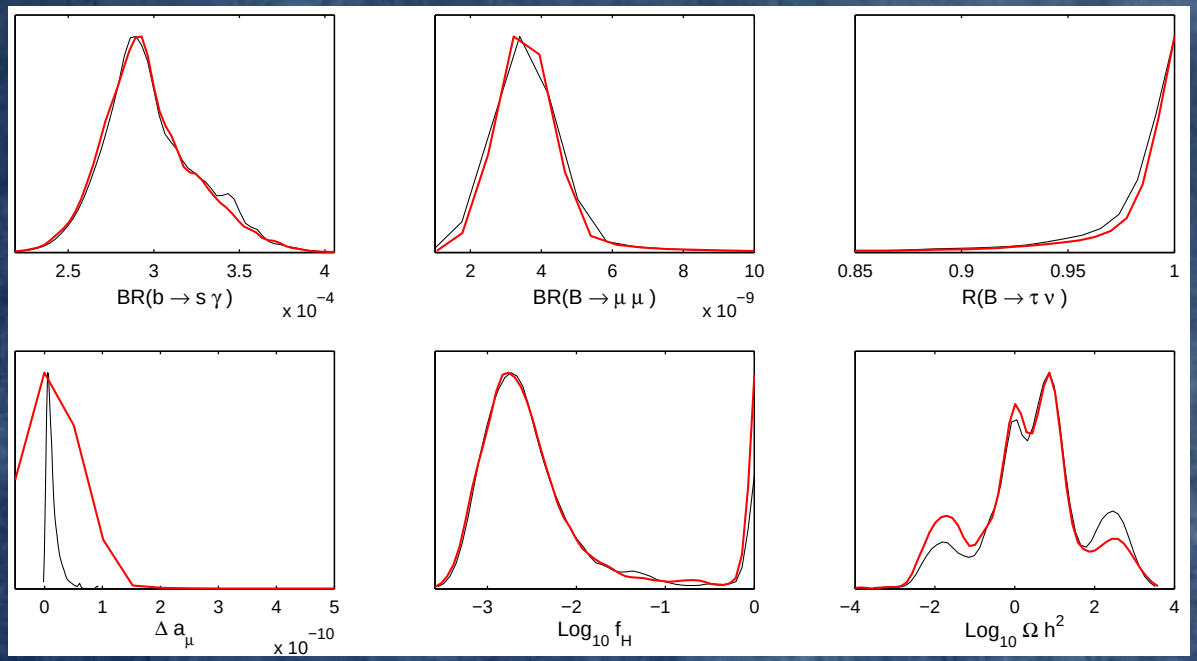
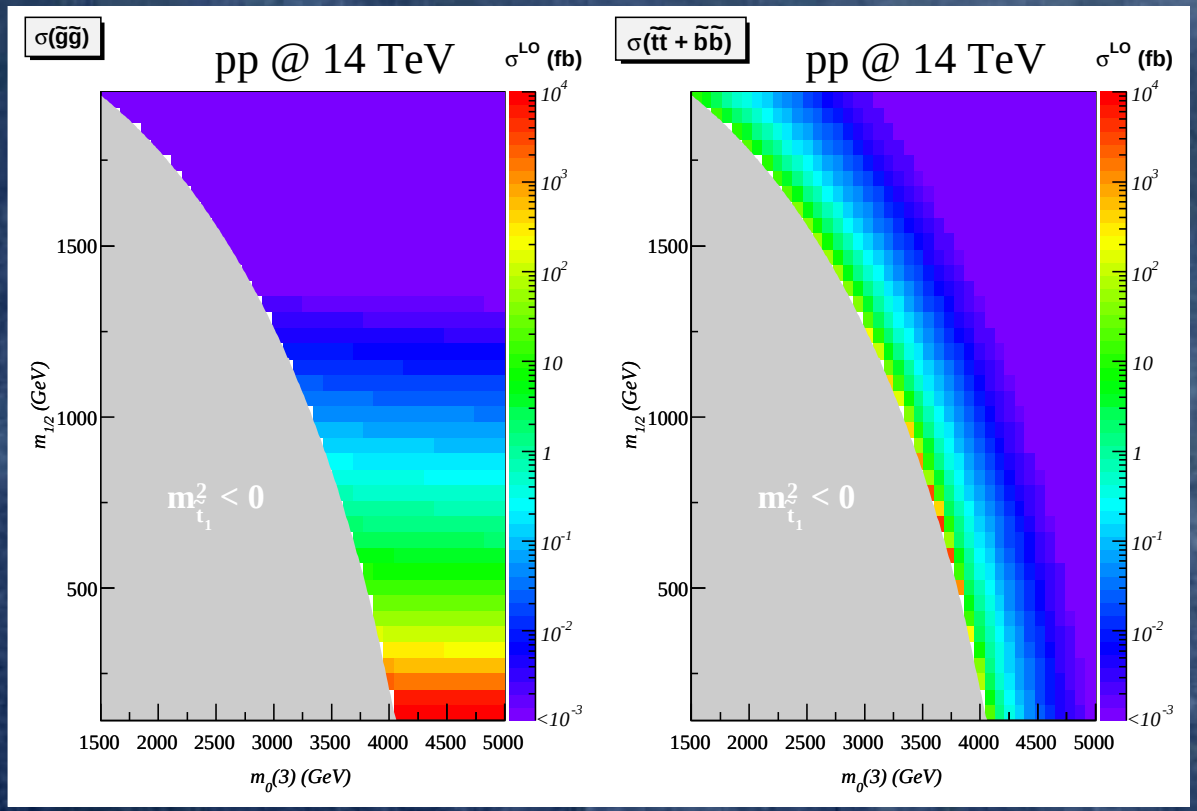


- higgsino χ_1^0: low μ-$m_{\tilde{t}}$ region
- $\Delta a_\mu^{exp} \sim 30 \times 10^{-10}$

ESUSY - Phenomenology

- LHC14 cross-sections:



$m_0(1,2) = 20$ TeV, $m_{H_{u,d}} = 1$ TeV

ESUSY - Phenomenology

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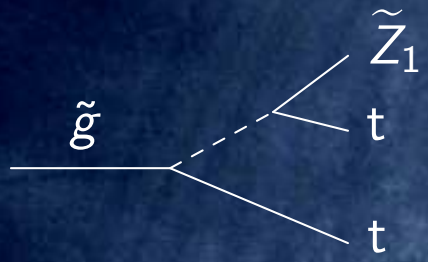
- Light Gluino:



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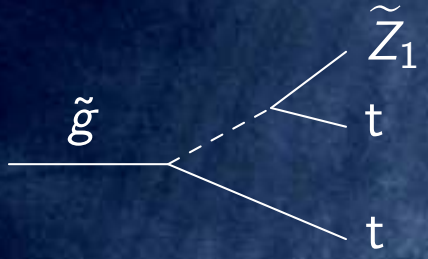

- Heavy Gluino:

Multi-b jets

$\not{E}_T$ + *leptons*

Soft jets and/or leptons

(if $m_{\tilde{t}_1} \sim m_{\widetilde{Z}_1}$)

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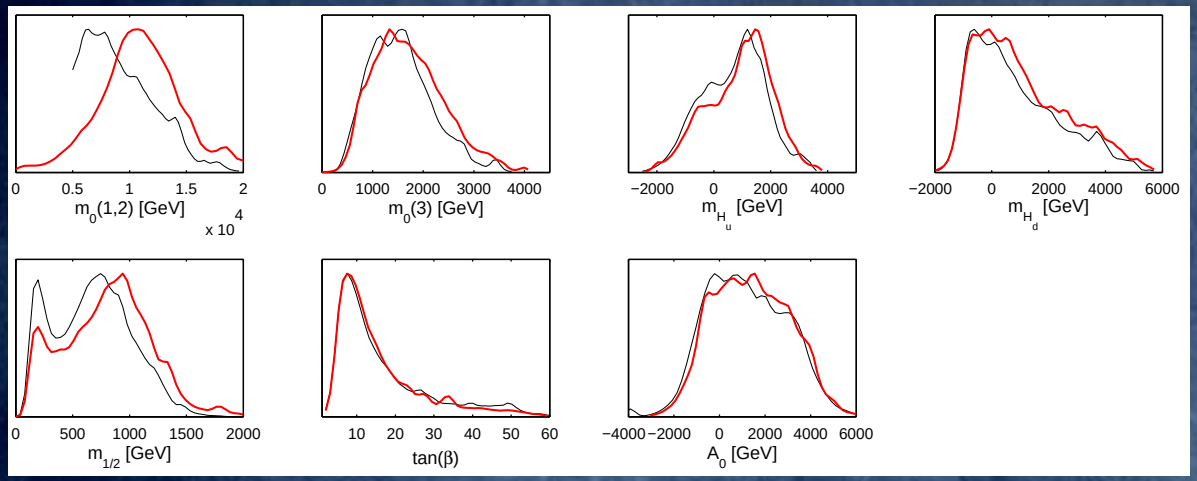
  - ...but scenarios with degenerate $\tilde{t} - \widetilde{Z}_1$ can produce a soft $\not{E}_T$ spectrum
  - ...stops, sbottoms and staus can also be the LSP $\rightarrow$ very distinct signatures

Danke!

More Results

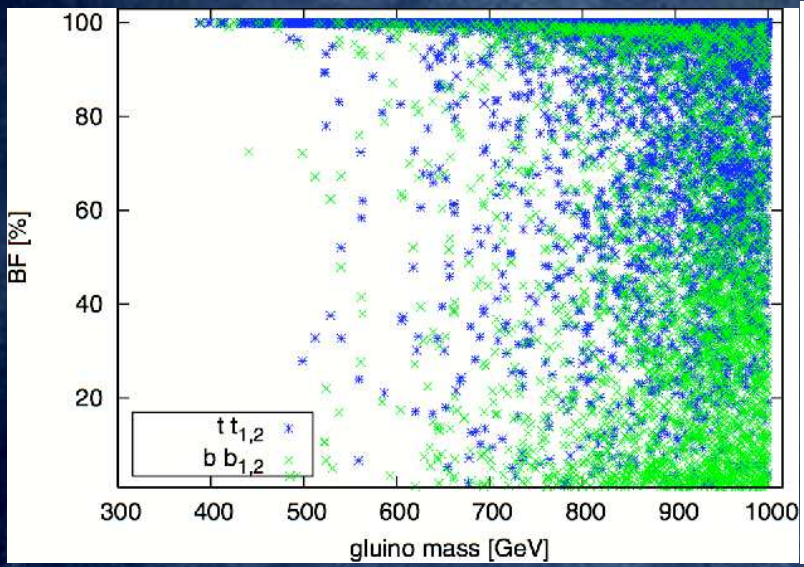


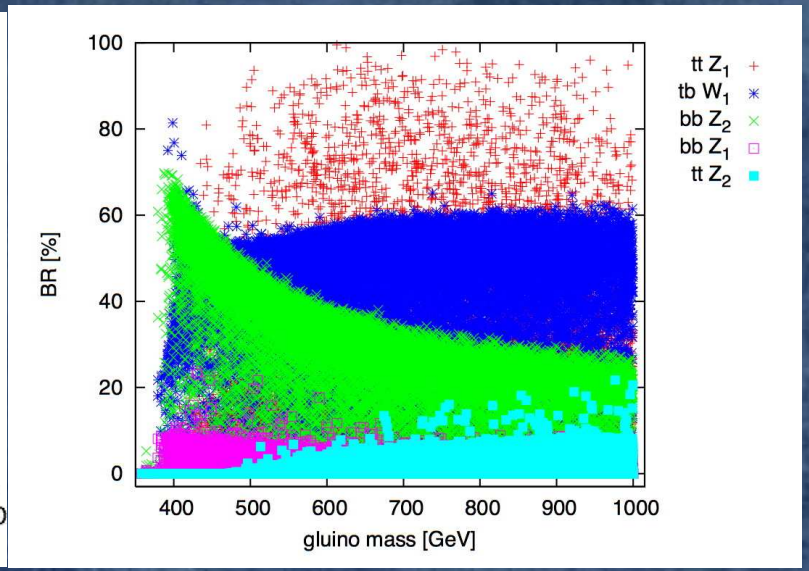
ESUSY - Phenomenology

- What if $\widetilde{Z}_1$ is not the LSP?
- Other interesting signatures:
  - $\tilde{t}$ or $\tilde{b}$ LSP: quasi-stable R-mesons/baryons $\rightarrow$ intermitent charged tracks
  - $\tilde{t}$ or $\tilde{b}$ LSP: quasi-stable R-mesons/baryons $\rightarrow$ "heavy muon"

ESUSY - Phenomenology

- Gluino BFs:





ESUSY - Phenomenology

- Benchmark points:
  - ES1 ($\sigma = 4$ pb)

$m_{\tilde{g}} = 524$ GeV, $m_{\tilde{t}_1} = 656$ GeV, $m_{\tilde{Z}_1} = 69$ GeV, $m_{\tilde{t}_2, \tilde{b}_i, \tilde{\tau}_i} \sim 1 - 2$ TeV

  - ES2 ($\sigma = 0.007$ pb)

$m_{\tilde{g}} = 2.4$ TeV, $m_{\tilde{t}_1} = 612$ GeV, $m_{\tilde{Z}_1} = 441$ GeV, $m_{\tilde{t}_2, \tilde{b}_i, \tilde{\tau}_i} \sim 0.8 - 1.4$ TeV

- LHC7 signal:

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