
SUSY effects in B-decays

YETI'06

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Outline

- Classification of B-decays
- Supersymmetric effects
- An example
- Conclusions

Classification of B-decays

There are three types of B-decays^a

- B-decays originate at tree level
- B-decays originate at tree level but polluted by loop contributions (penguins)
- B-decays originate only at loop level

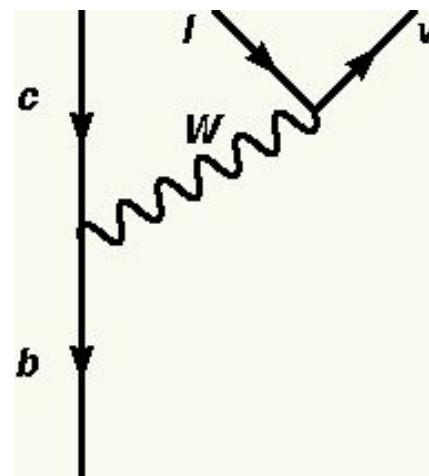
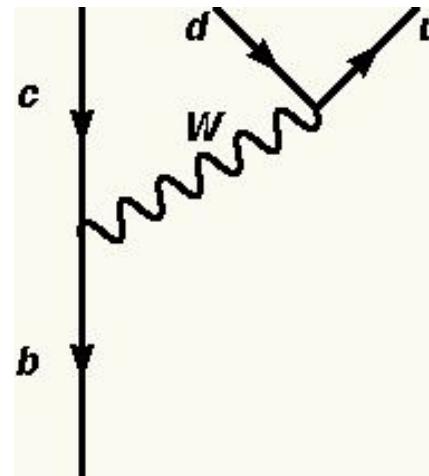
^aPDG Conventions: $B = \bar{b}d$, $B_s = \bar{b}s$, $B^+ = \bar{b}u$, $D^0 = \bar{u}c$, $K^+ = \bar{s}u$, $K = \bar{s}d$, $\pi = (\bar{u}u, \bar{d}d)$, $\phi = \bar{s}s$, $J/\Psi = \bar{c}c$

B-decays

Trees (CC): $\bar{b} \rightarrow \bar{d} c \bar{u}, \bar{d} u \bar{c}$

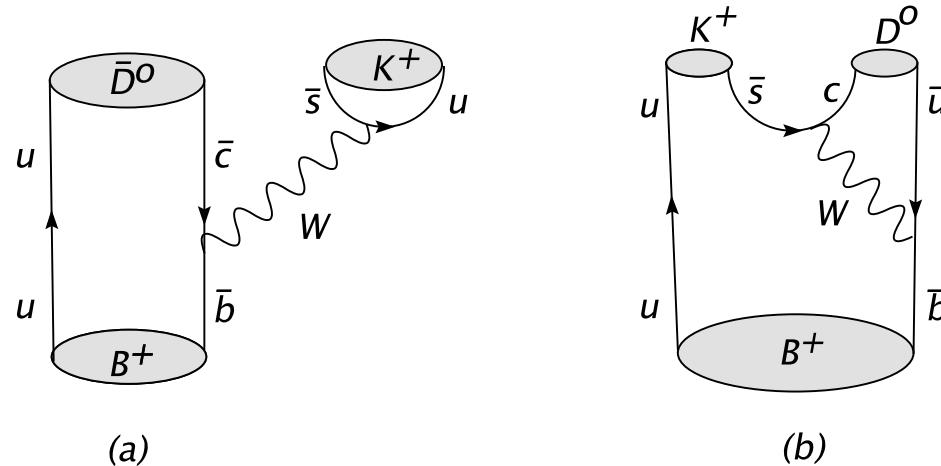
$\bar{b} \rightarrow \bar{s} c \bar{u}, \bar{s} u \bar{c}$

$\bar{b} \rightarrow \bar{u} \nu \bar{l}, \bar{c} \nu \bar{l}$

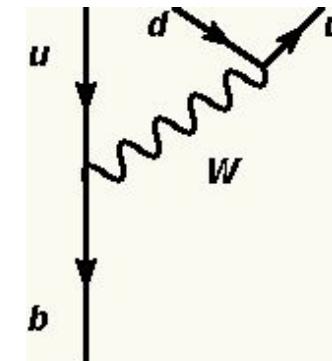


B-decays

LHCb tree example : $B^+ \rightarrow K^+ \bar{D}^0$, $B^+ \rightarrow K^+ D^0$



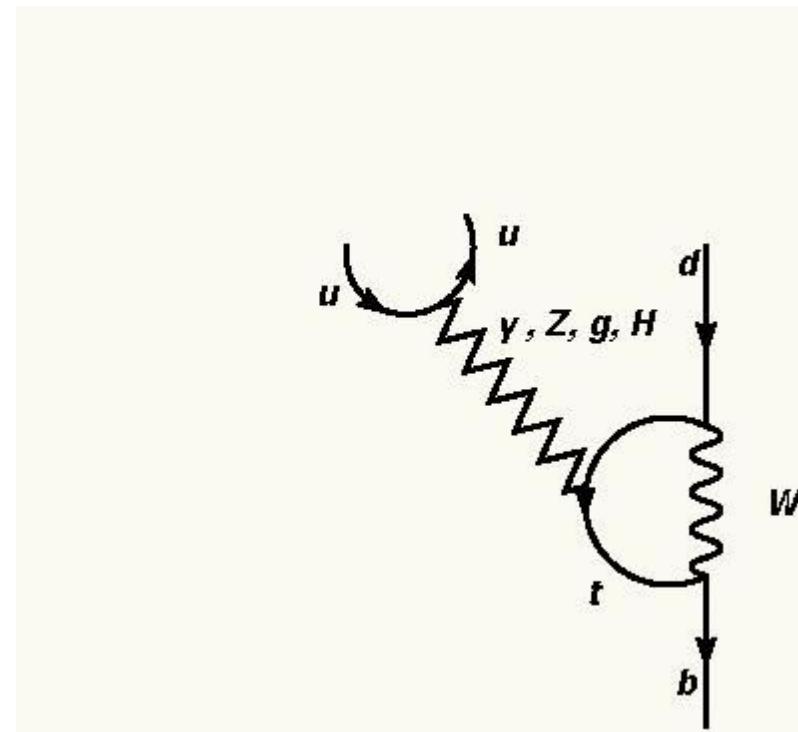
B-decays



Trees(CC) + Penguins(NC):

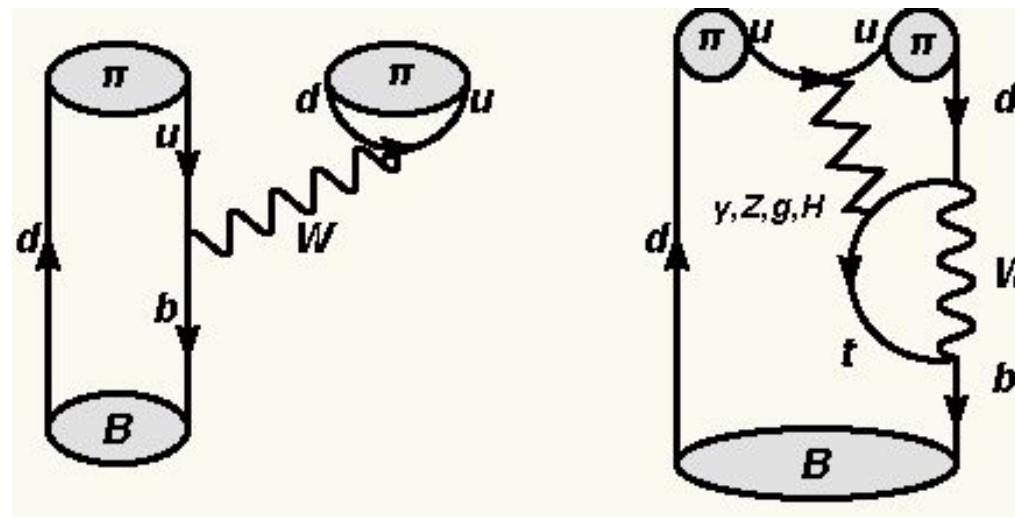
$$\bar{b} \rightarrow \bar{d} u \bar{u}, \bar{d} c \bar{c}$$

$$\bar{b} \rightarrow \bar{s} u \bar{u}, \bar{s} c \bar{c}$$



B-decays

B-factories Tree+Penguin example : $B \rightarrow \pi^+ \pi^-$



B-decays

Pure Penguins (NC):

$$\bar{b} \rightarrow \bar{d} d \bar{d}, \bar{d} s \bar{s}$$

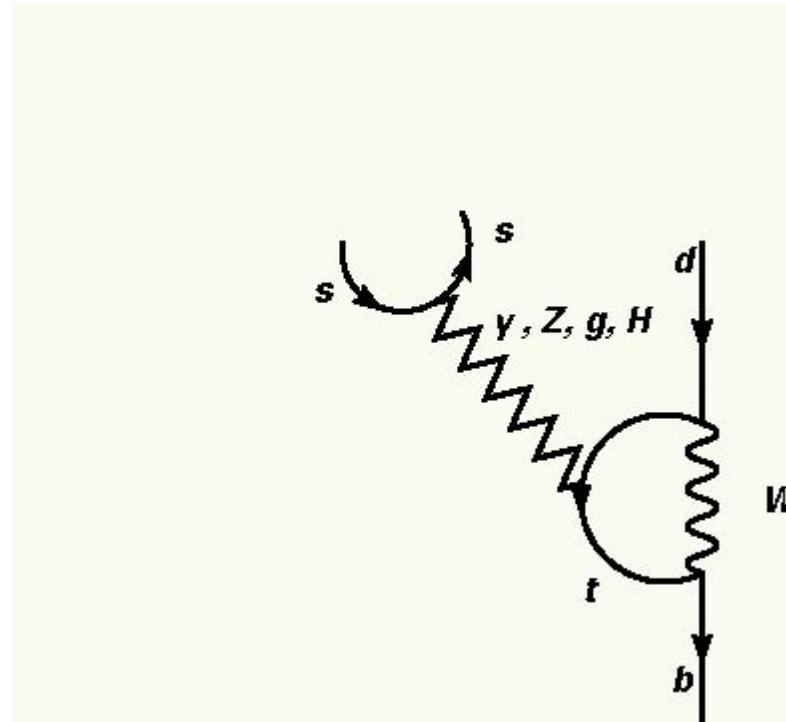
$$\bar{b} \rightarrow \bar{s} d \bar{d}, \bar{s} s \bar{s}$$

$$\bar{b} \rightarrow \bar{d} l \bar{l}, \bar{d} \nu \bar{\nu}$$

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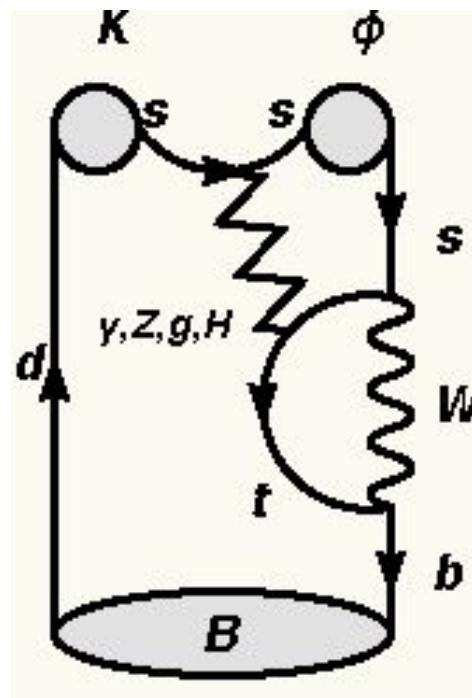
Exclusive Penguins :

$$B \rightarrow l \bar{l}, \nu \bar{\nu}$$



B-decays

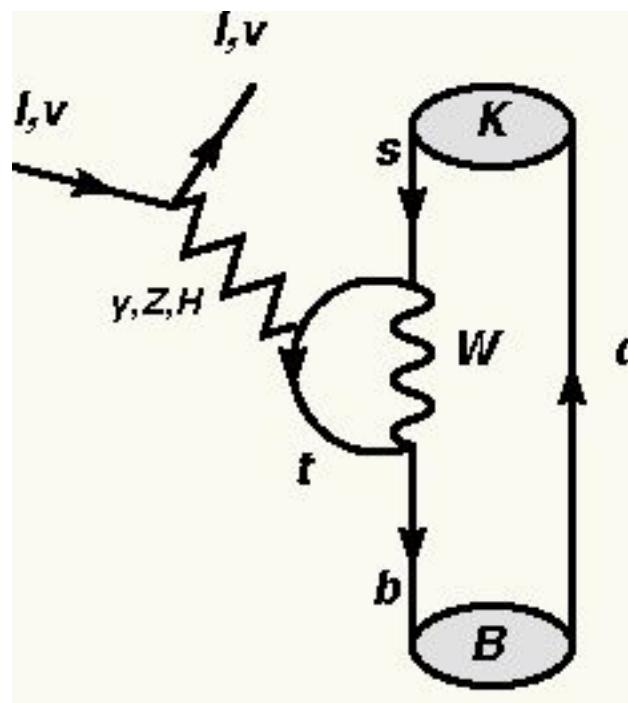
B-factories pure Penguin example 1: $B \rightarrow \phi K$



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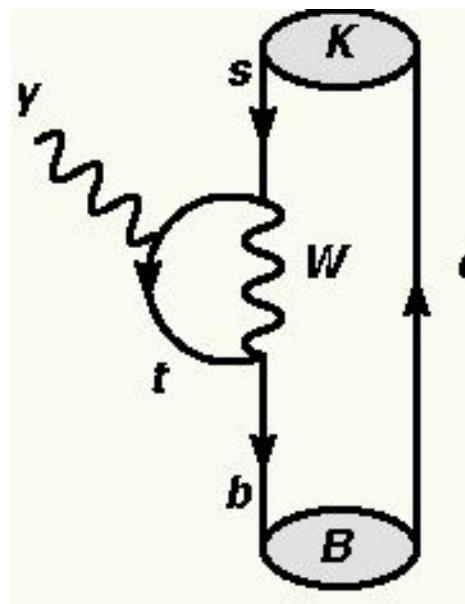
LHCb, B-factories pure Penguin example 2:

$$B \rightarrow K l \bar{l}, K \nu \bar{\nu}$$



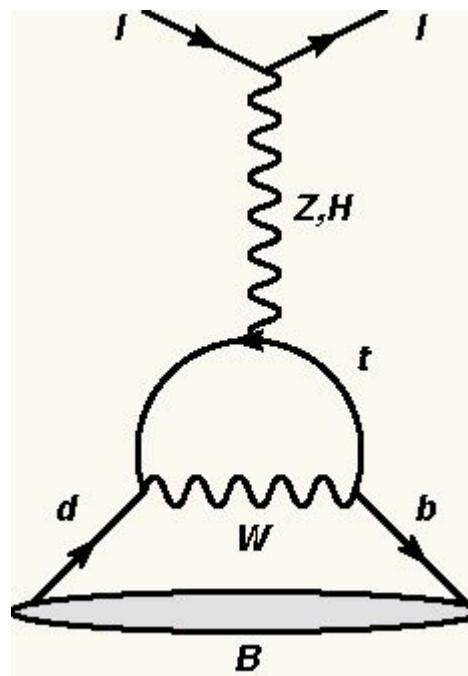
B-decays

B-factories pure Penguin example 3: $B \rightarrow K\gamma$



B-decays

Tevatron, LHC, B-factories pure Exclusive Penguin
example 4: $B \rightarrow l\bar{l}$



SUSY effects

Summary of SUSY effects in B-decays:

- Tree level flavour changing processes if allow for lepton number violation

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- penguins compete with SUSY penguins (penguinos?)
- Higgs penguins are important – they are enhanced by $\tan^2 \beta$

SUSY effects

Recipe: In a specific SM process :

1. Add the effects of one extra Higgs doublet

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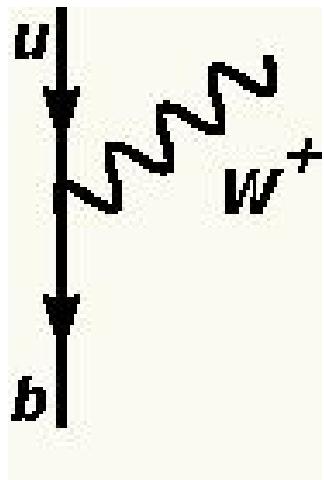
SUSY effects

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SUSY effects

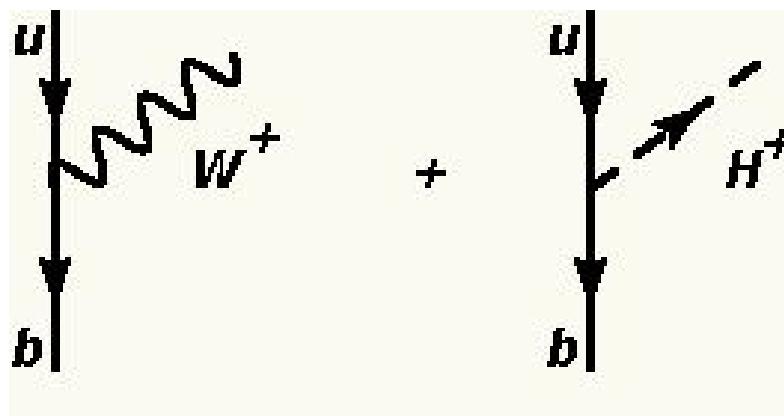
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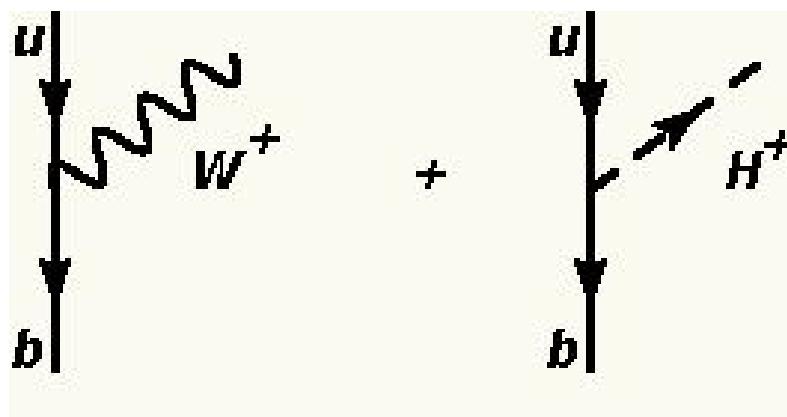
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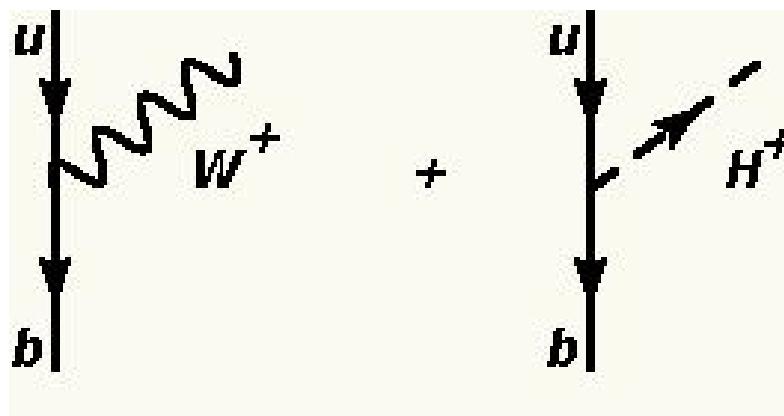
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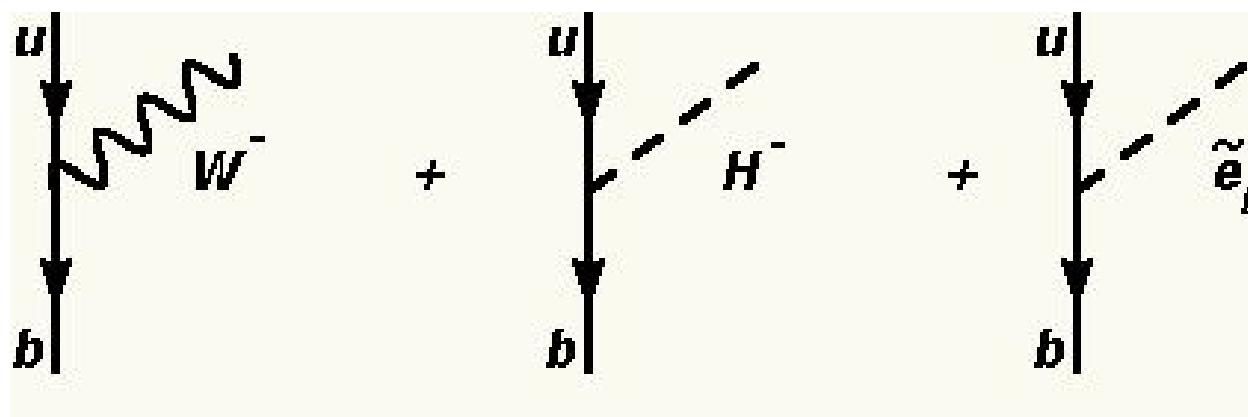


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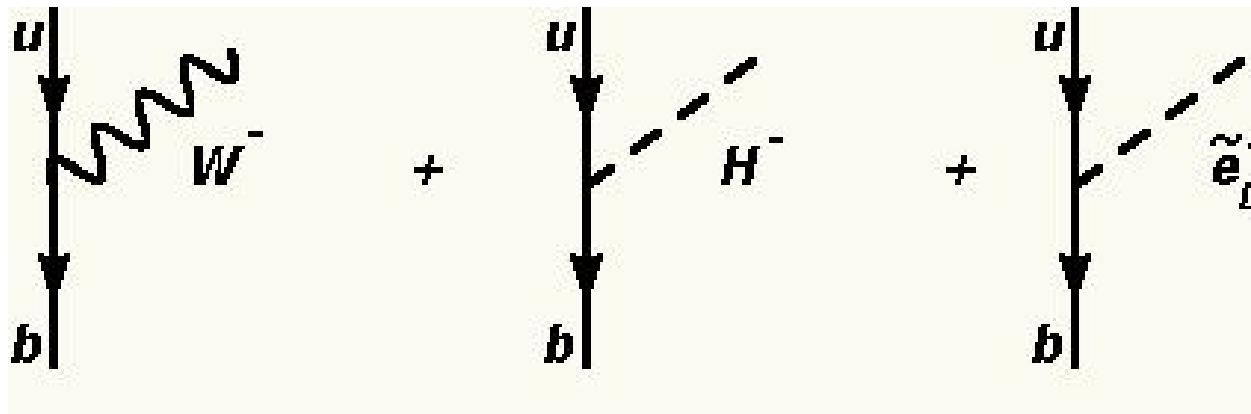
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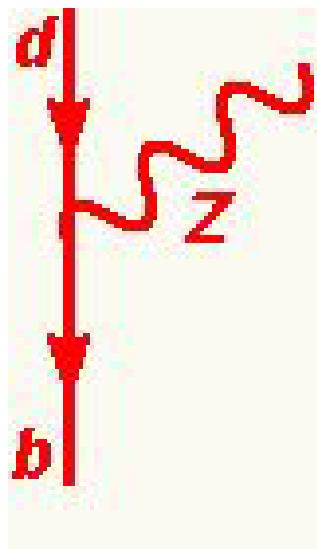
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$$\propto g_w \quad g_w m_f \begin{cases} \tan \beta \\ \cot \beta \end{cases} \lambda'$$

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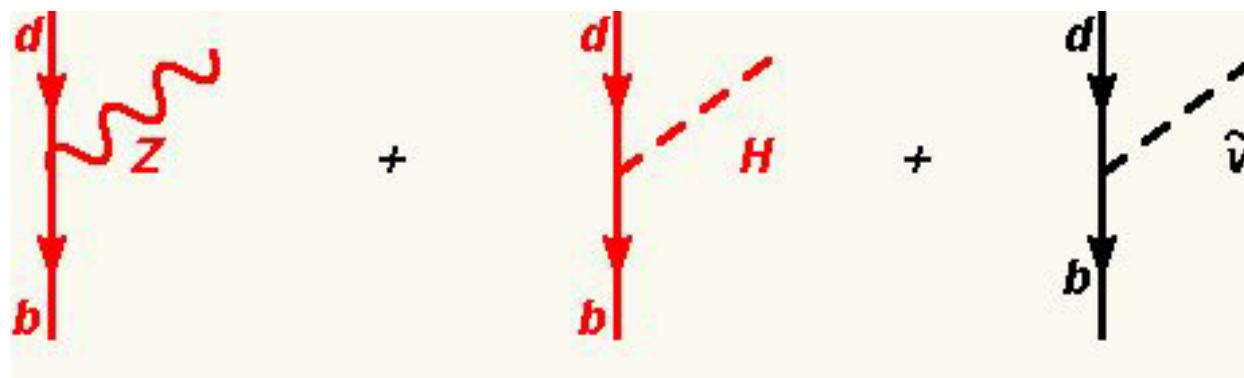


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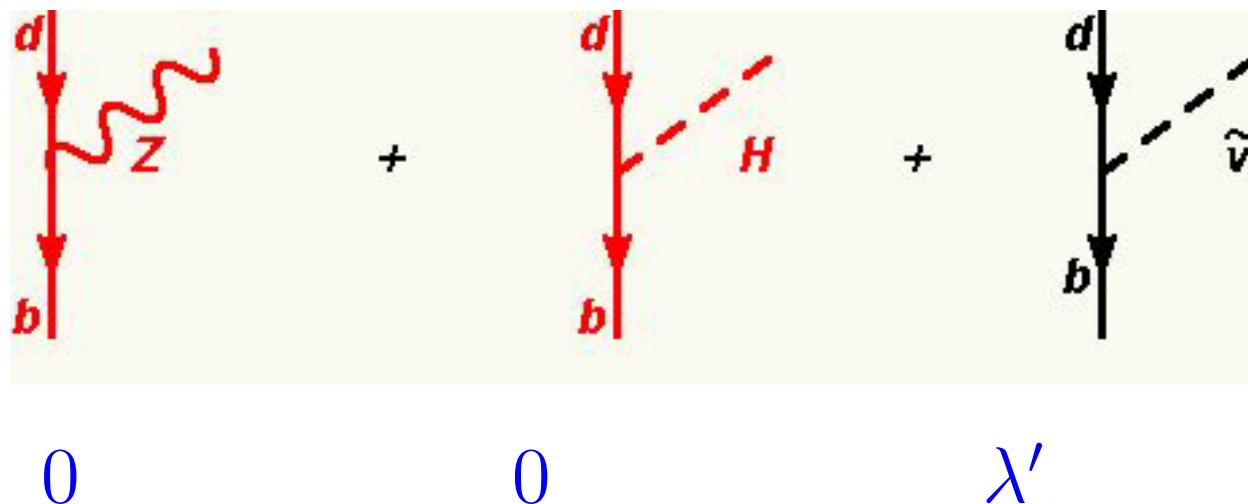
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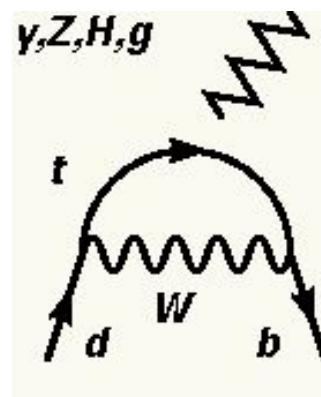
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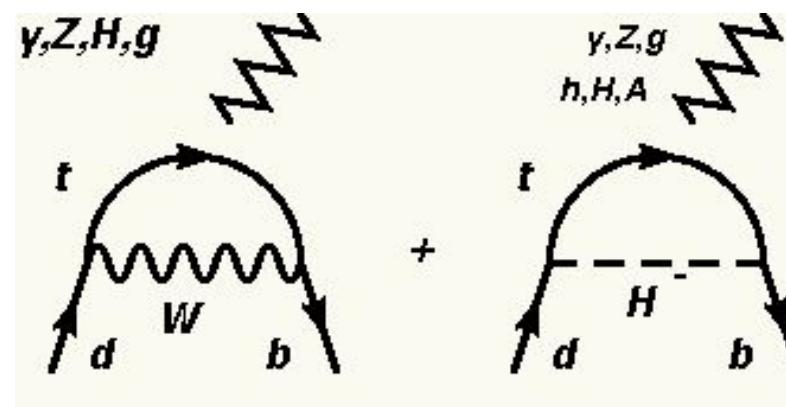
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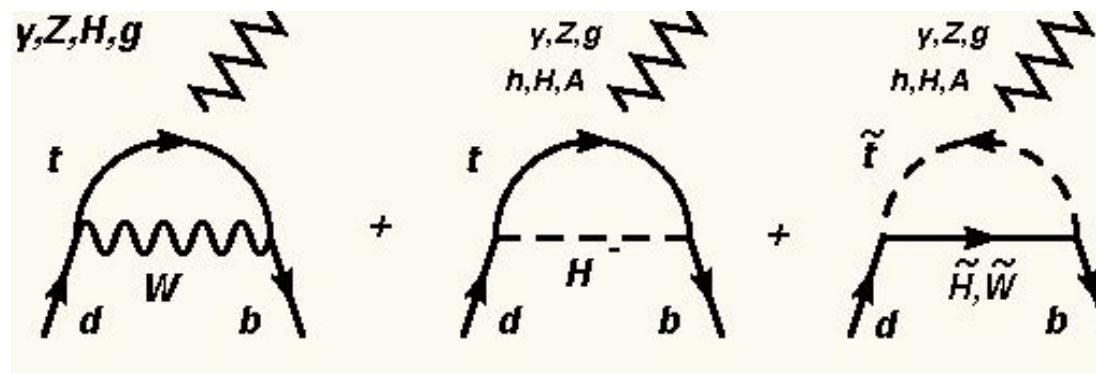
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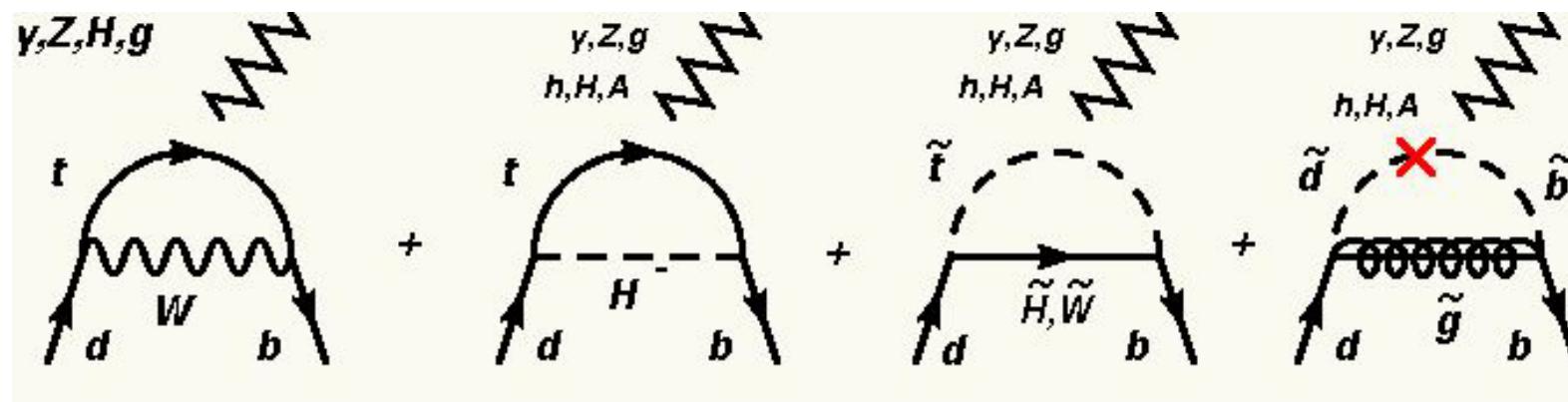
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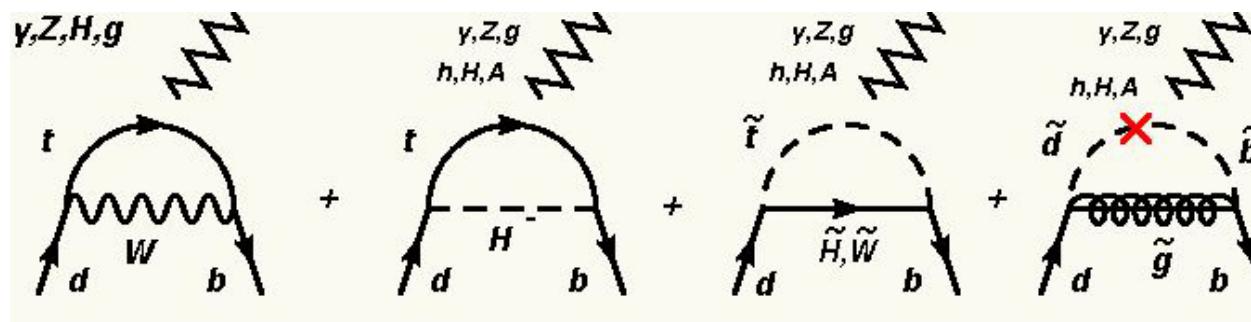


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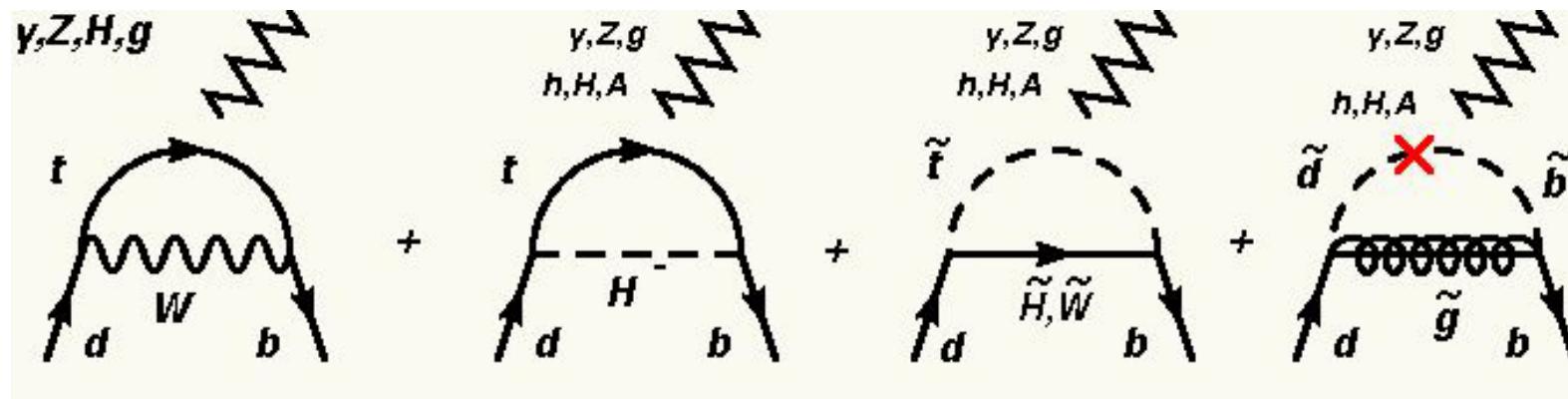
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$$\gamma, Z, g : \quad 1$$

$$\tan \beta$$

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$$\frac{\delta m_{\tilde{b}\tilde{d}}^2}{m_{SUSY}^2} \tan \beta$$

$$h, H, A : \quad 1$$

$$\tan \beta$$

$$\tan^2 \beta$$

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An example

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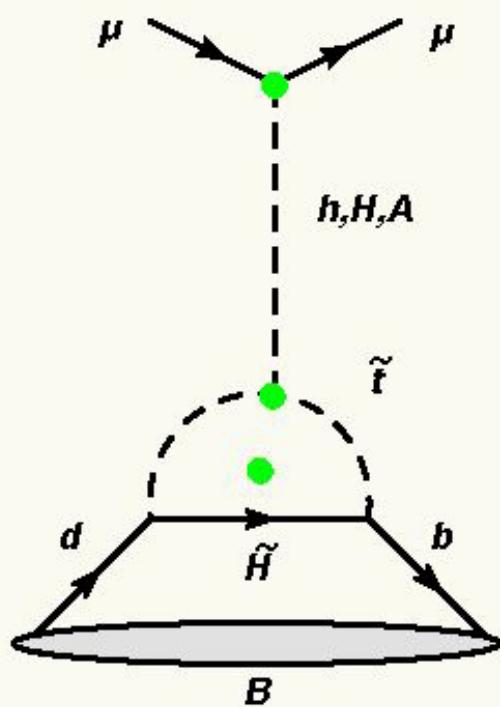
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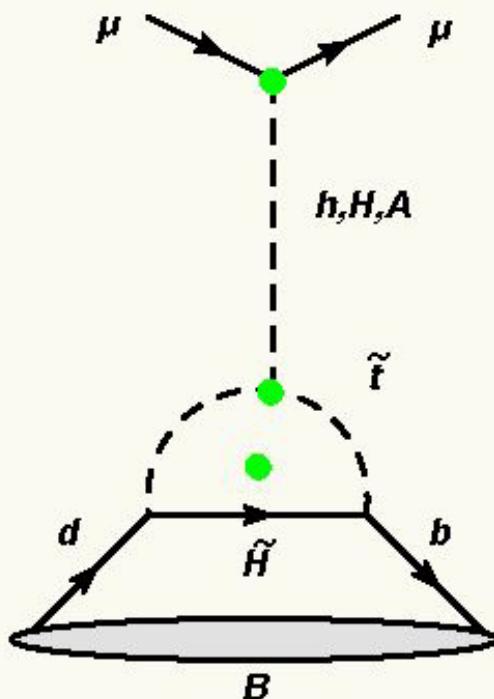
Q: What are the SUSY effects?

An example



- Amplitude
 $\sim \tan^3 \beta / M_A^2$

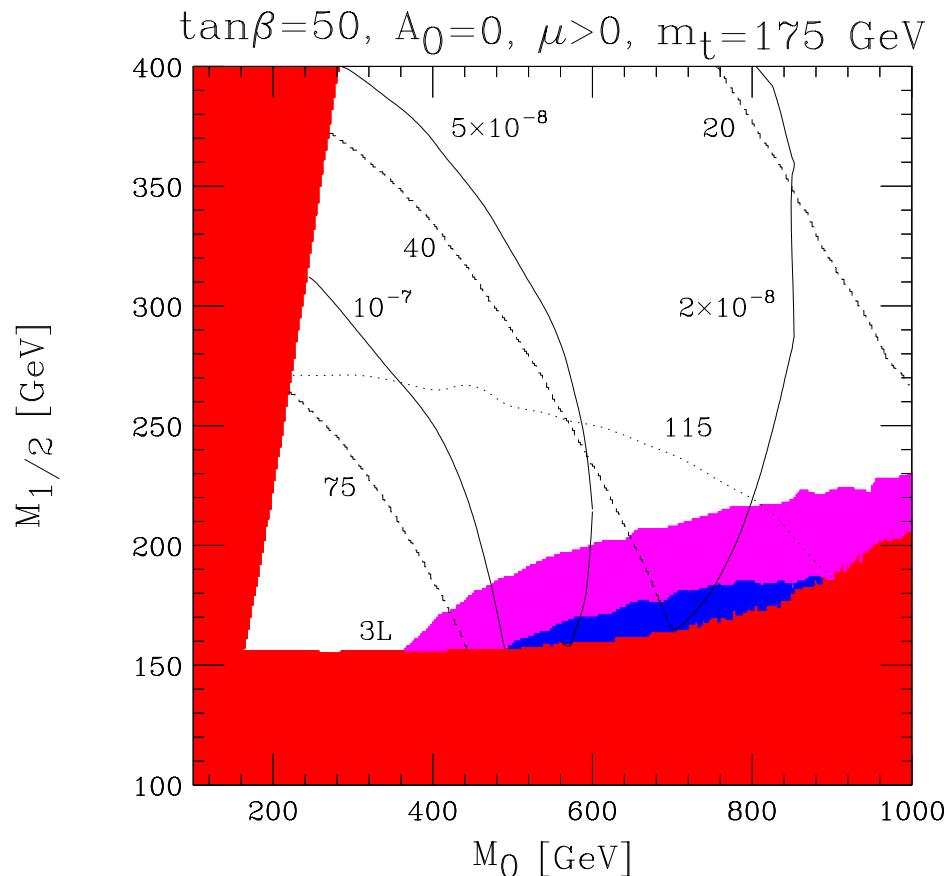
An example



- Amplitude
 $\sim \tan^3 \beta / M_A^2$
- SUSY loop fairly insensitive to heavy spectrum

An example

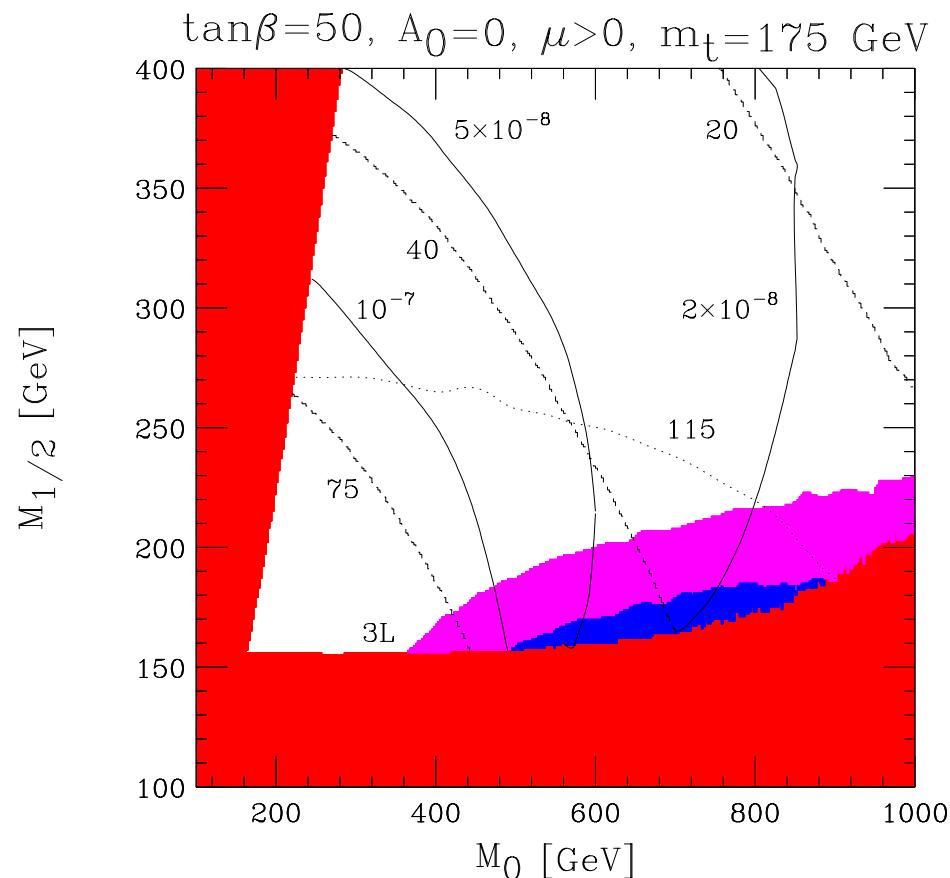
A.D, H. Dreiner, U. Nierste, P. Richardson, hep-ph/0207026



■ Solid :
 $\mathcal{B}(B_s \rightarrow \mu^+ \mu^-)$

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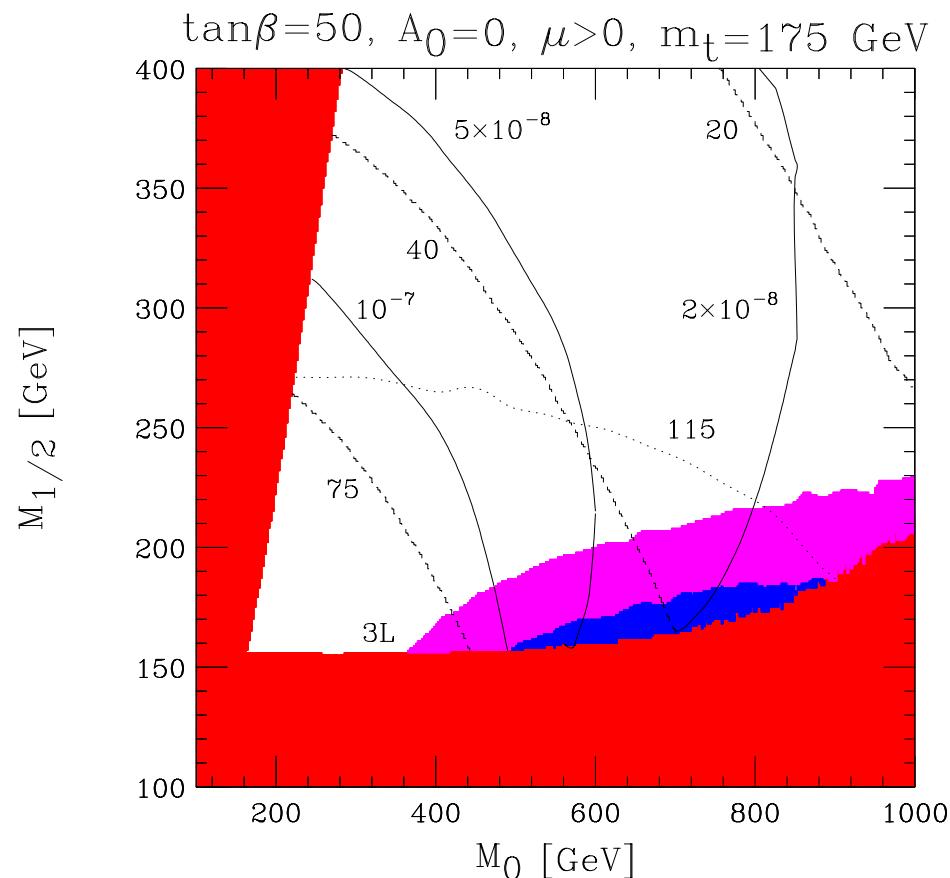
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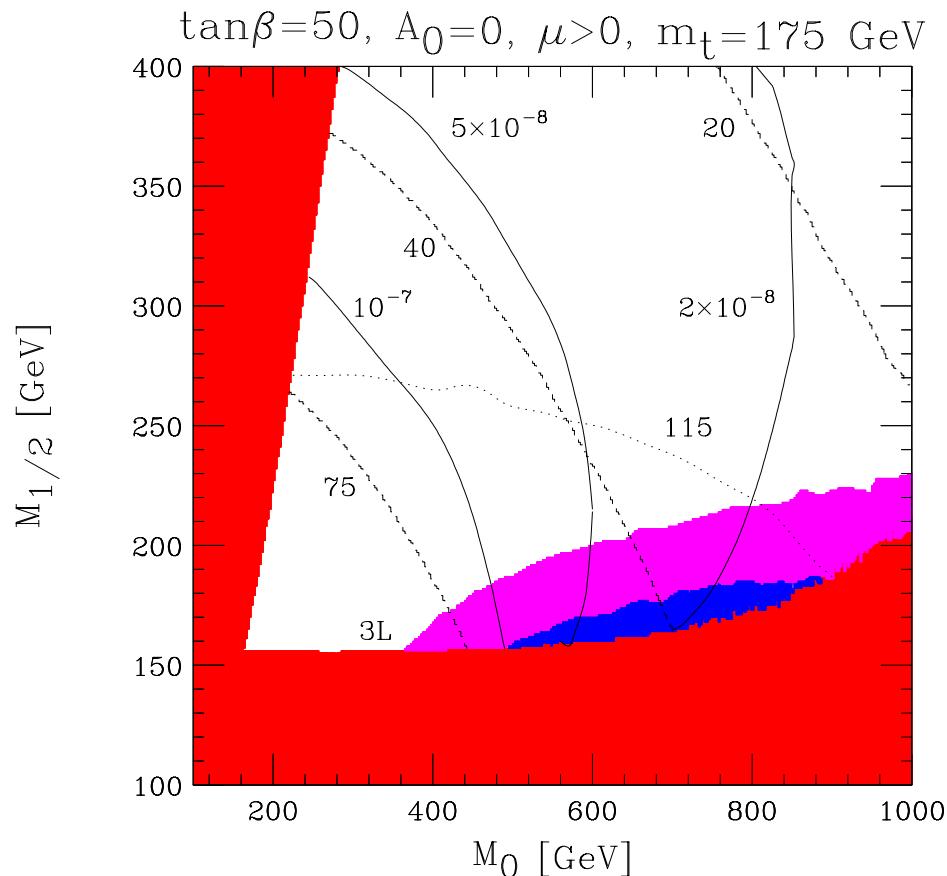
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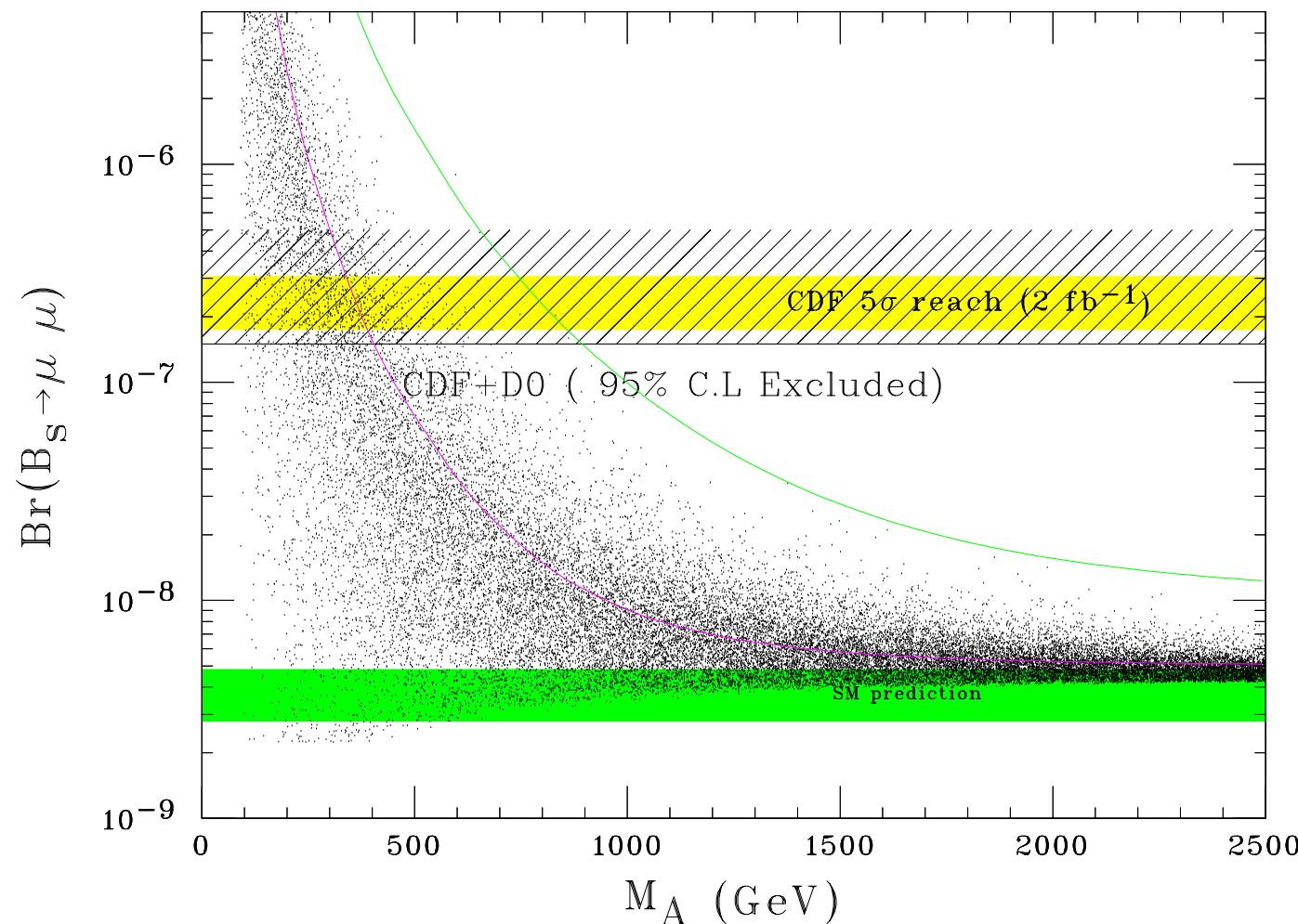
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- Solid : $\mathcal{B}(B_s \rightarrow \mu^+ \mu^-)$
- dashed: $(g-2)$ in 10^{-10} units
- dotted: light Higgs mass prediction
- filled areas : trilepton searches at Tevatron

An example

A.D, T. Huffman, hep-ph/0407285



Conclusions

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- SUSY effects trigger new decays
- SUSY effects originate at the squark (unknown) sector
- SUSY effects originate when you allow for Lepton number violation
- if no effects appear in B-decays there must be an “organizing principle” behind this fact: Heavy superpartners? Degeneracy of squarks? Alignment ?

References

1. SUSY effects : SLAC report for Super-B factory,
hep-ph/0503261
2. General flavour physics : A. Buras, 9806471
3. Higgs penguin : hep-ph/0309233
4. Effective Theories, P. Ball, YETI'06
5. Exp status for $B_s \rightarrow \mu^+ \mu^-$, M. Schmitt YETI'06