

Is the 125 GeV Higgs the superpartner of a neutrino?

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EPFL (Lausanne) and IFAE (Barcelona)

In collaboration with
Pomarol, Biggio
(arXiv:1211.4526)

Can the Higgs be superpartner of a neutrino?

Yes: same quantum numbers

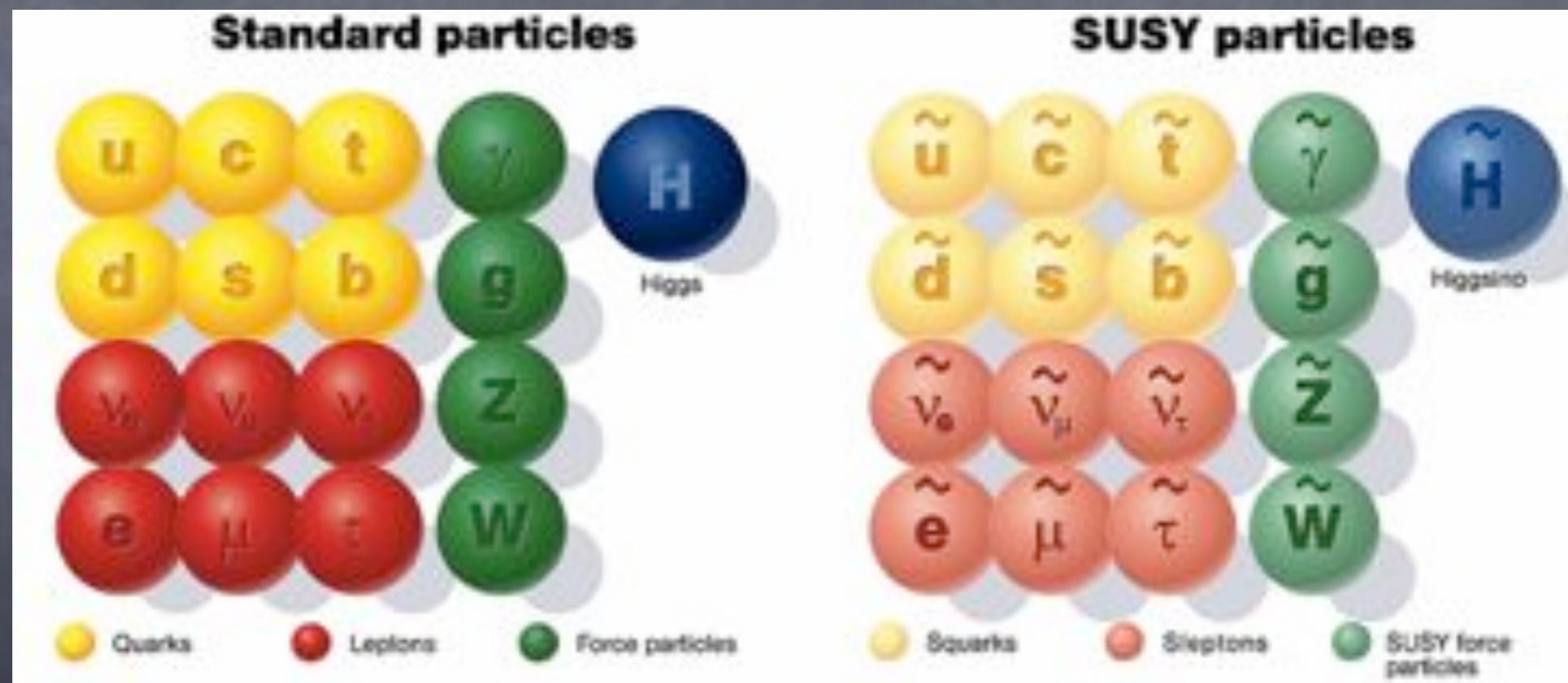
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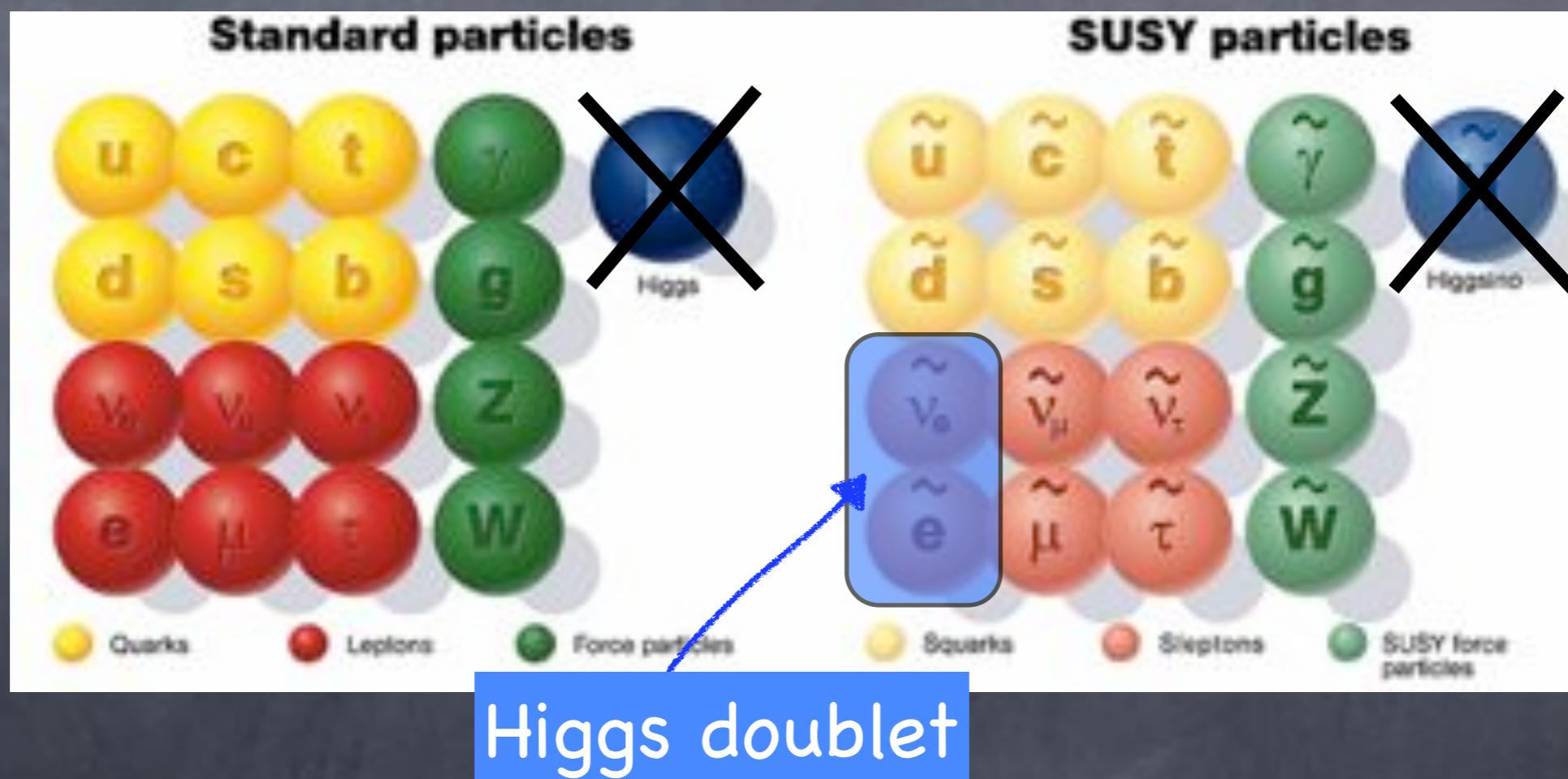
MSSM



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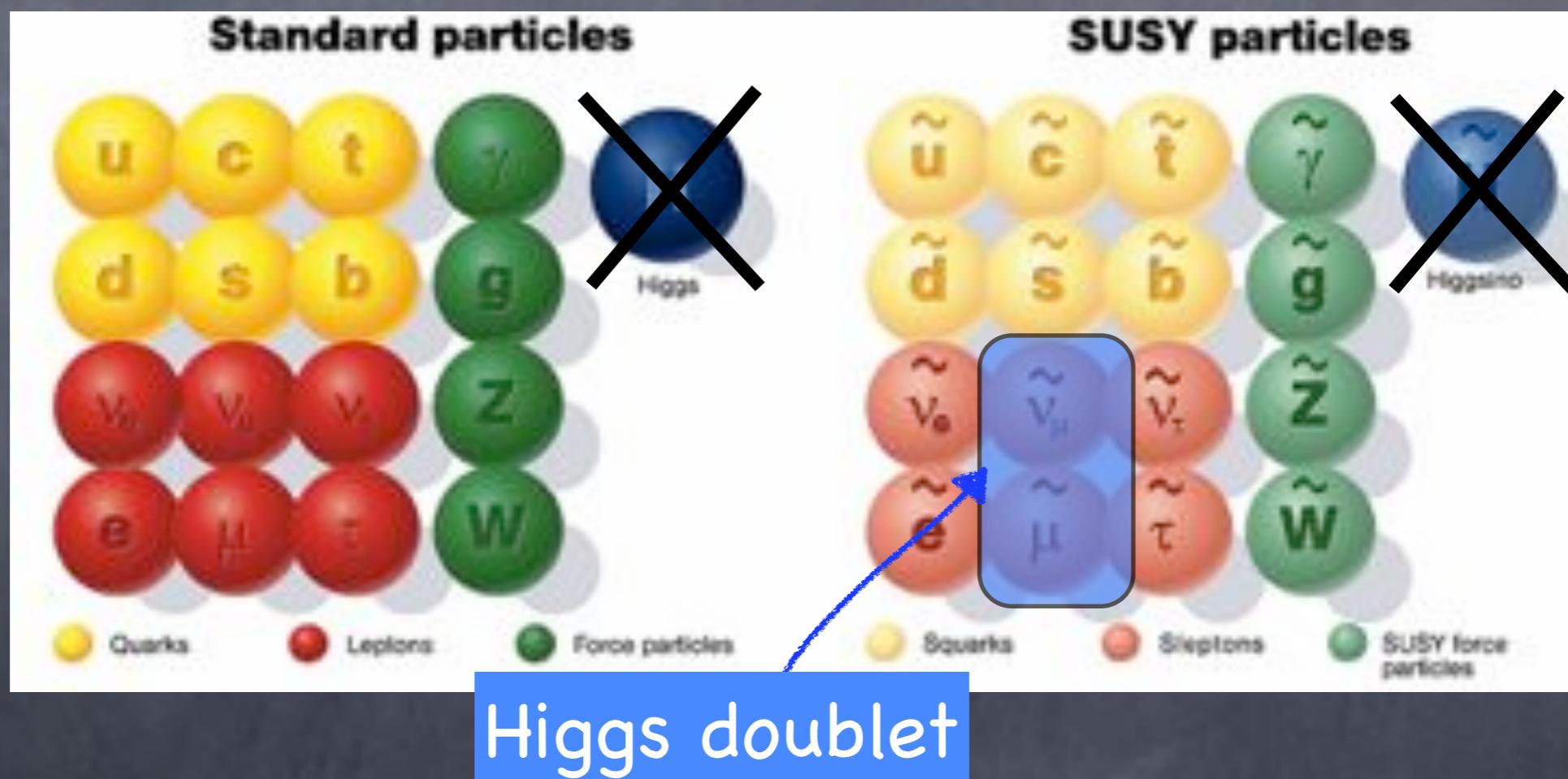
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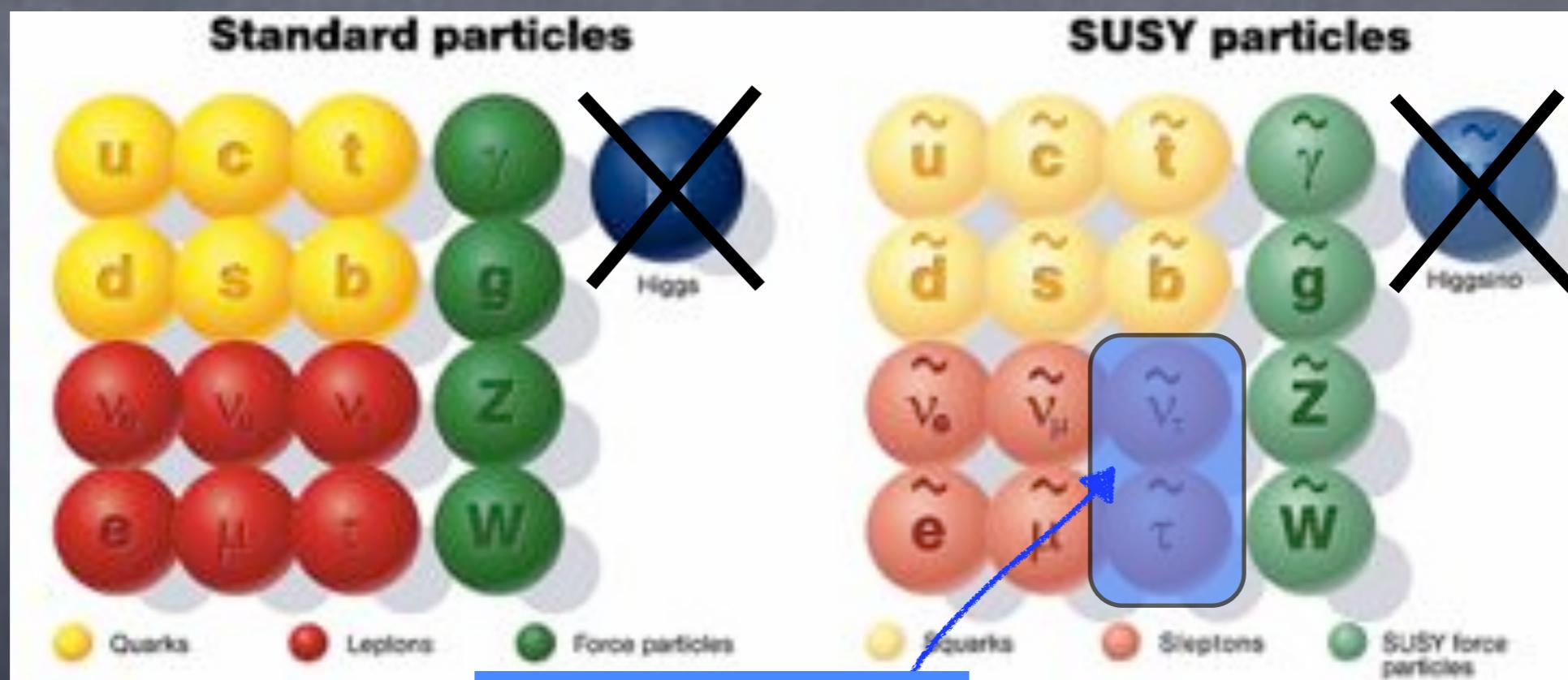
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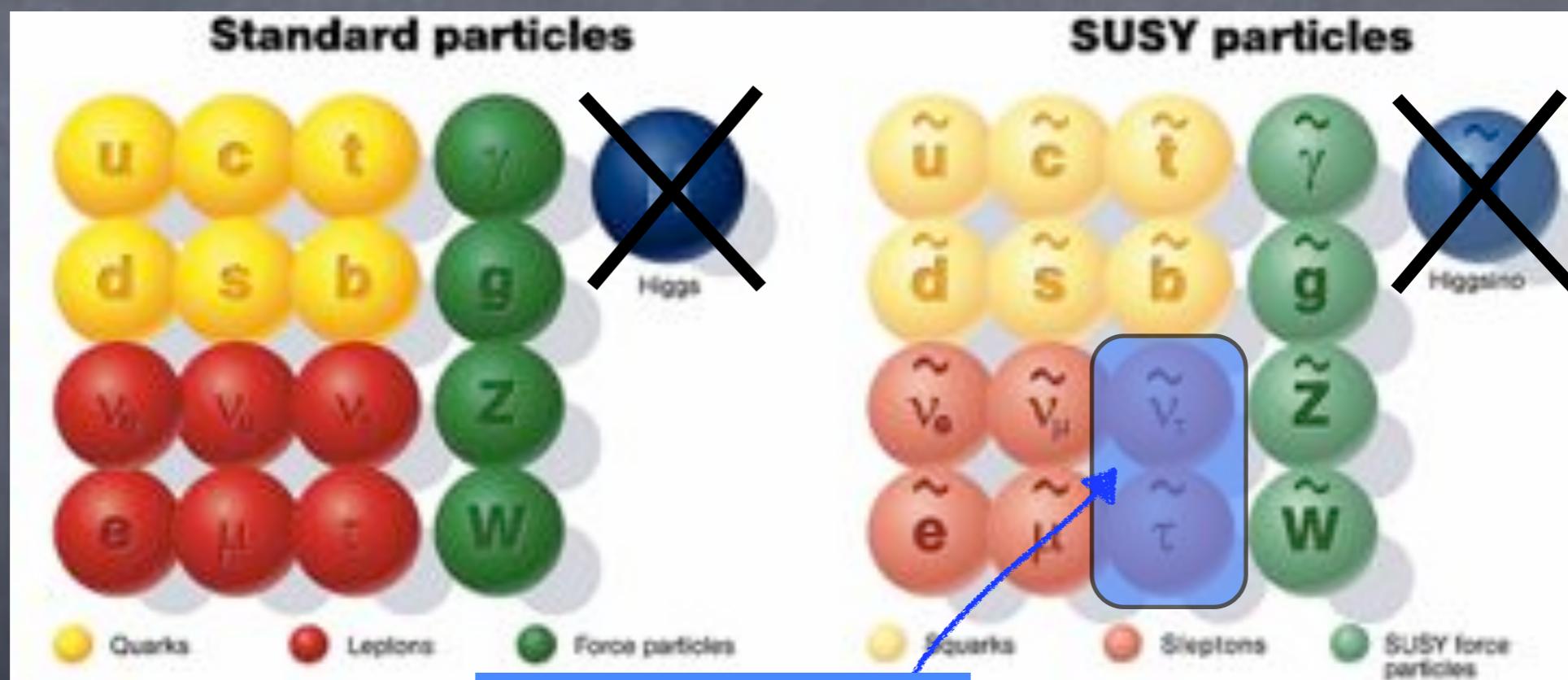


Possibility here:

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Is the Higgs the first SUSY particle discovered?

What if Higgs is the superpartner of the neutrino?

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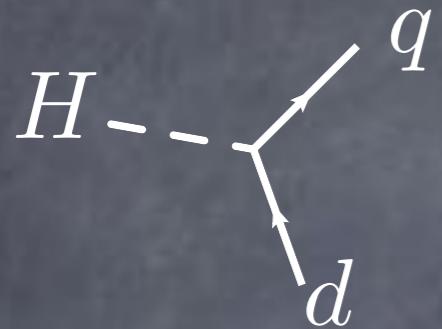
Graham G Ross

Grand Unified Theories

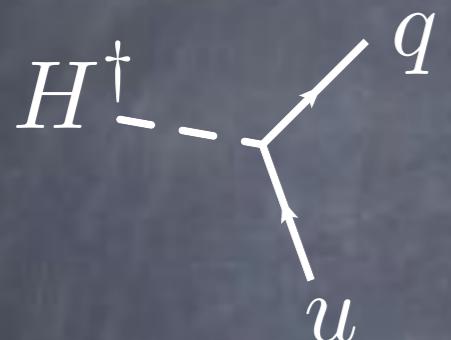
Chapter 9

An obvious possibility is to identify the Higgs SU(2) doublet as a partner of a lepton doublet. However, this is not possible, for such an assignment in supersymmetry does not give an acceptable pattern of fermion masses. The reason is that supersymmetry restricts the possible forms of Yukawa couplings

Yukawa Couplings

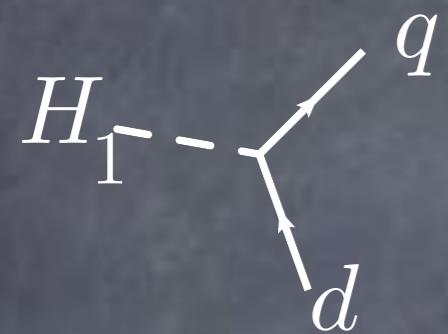


✓ Can be supersymmetrized

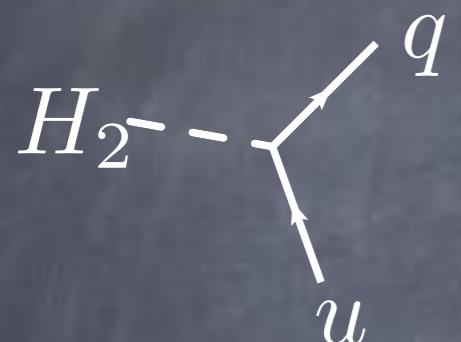


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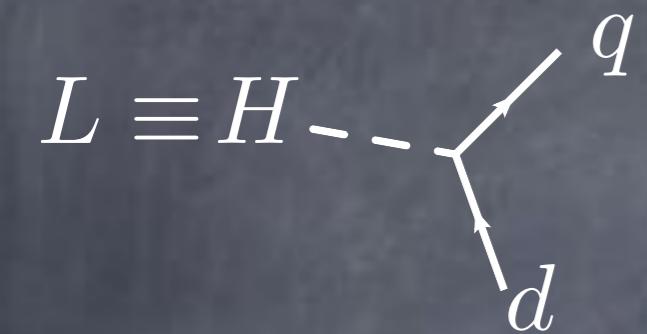


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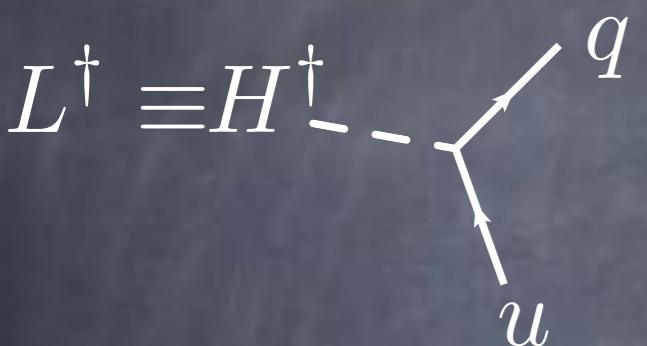


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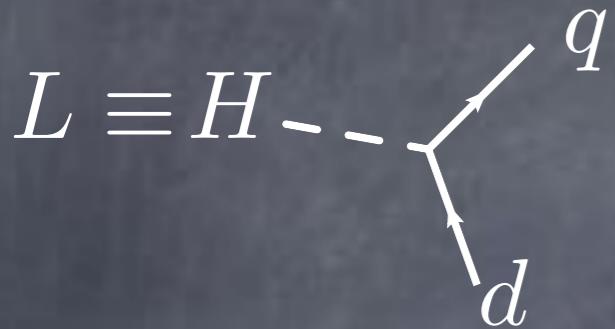


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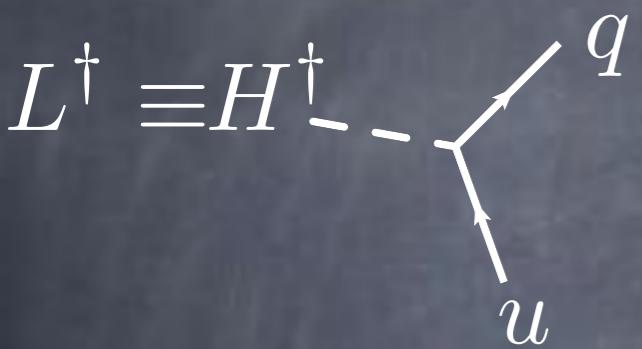


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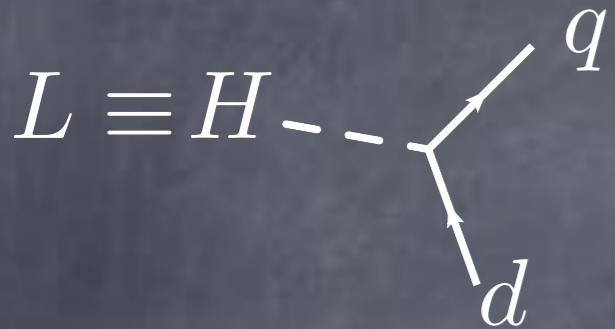


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Up-sector Yukawa must come from ~~SUSY~~

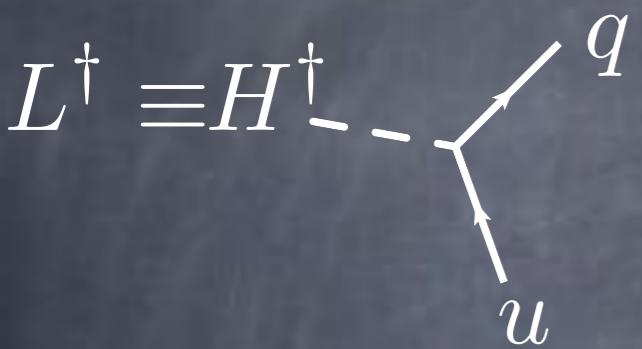
(Can arise from Heavy MSSM-like Higgses, not accessible at LHC)

Frugiuele, Gregoire, Kumar, Ponton, Bertuzzo '11-'12

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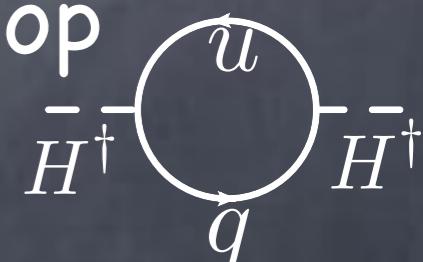


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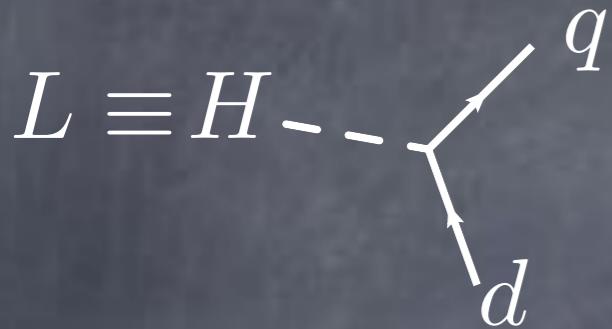
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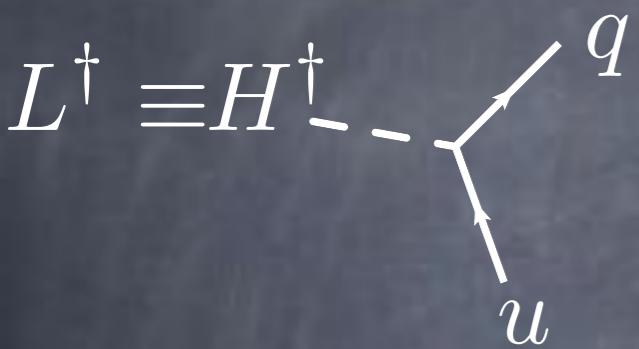
→ Surprisingly Higgs mass still protected at one-loop



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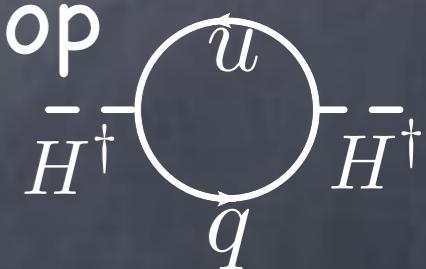


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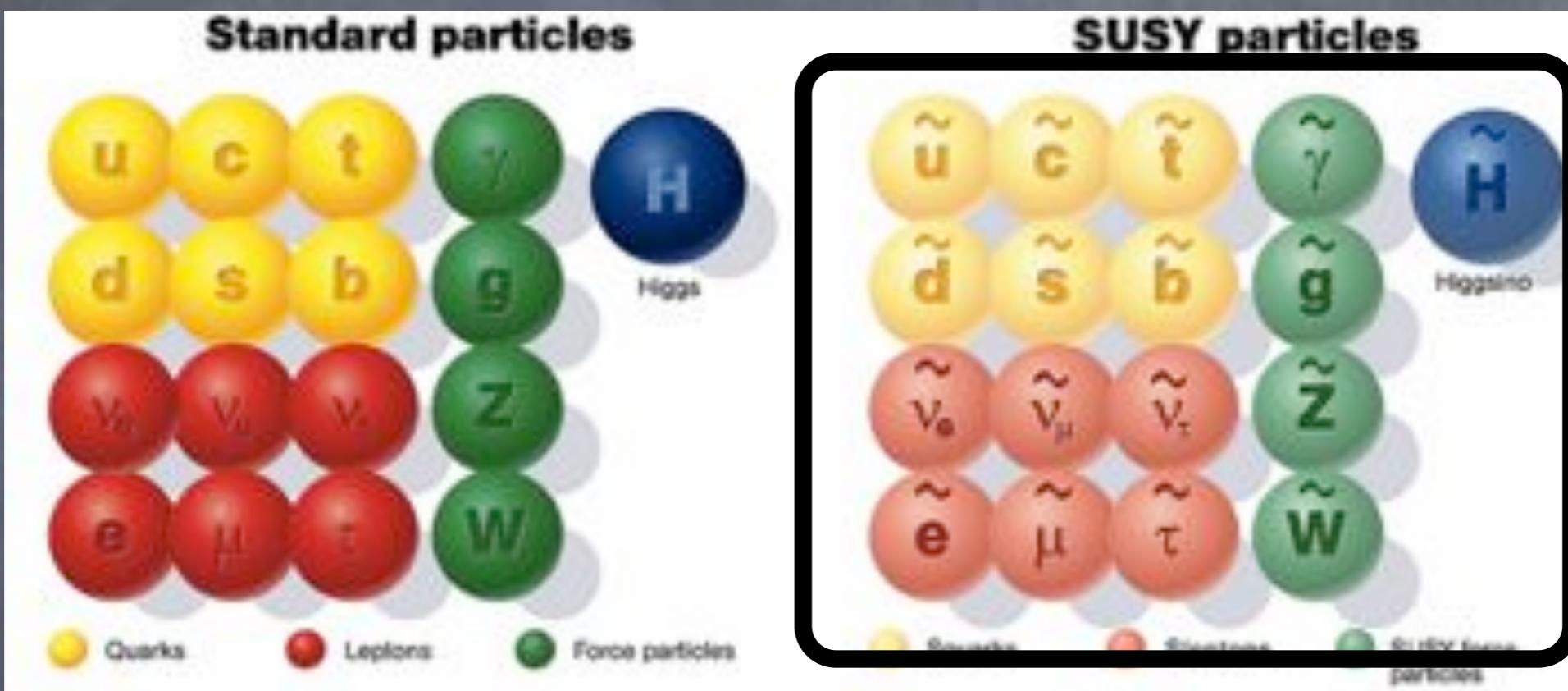


→ Notice that a 125 GeV Higgs also needs
a “quartic coupling” from SUSY breaking!

$$(125\text{GeV})^2 \lesssim m_Z^2 + \delta m^2 \xrightarrow{\sim} (86\text{GeV})^2$$

MSSM: R-Parity

In the MSSM, we need an R-parity:

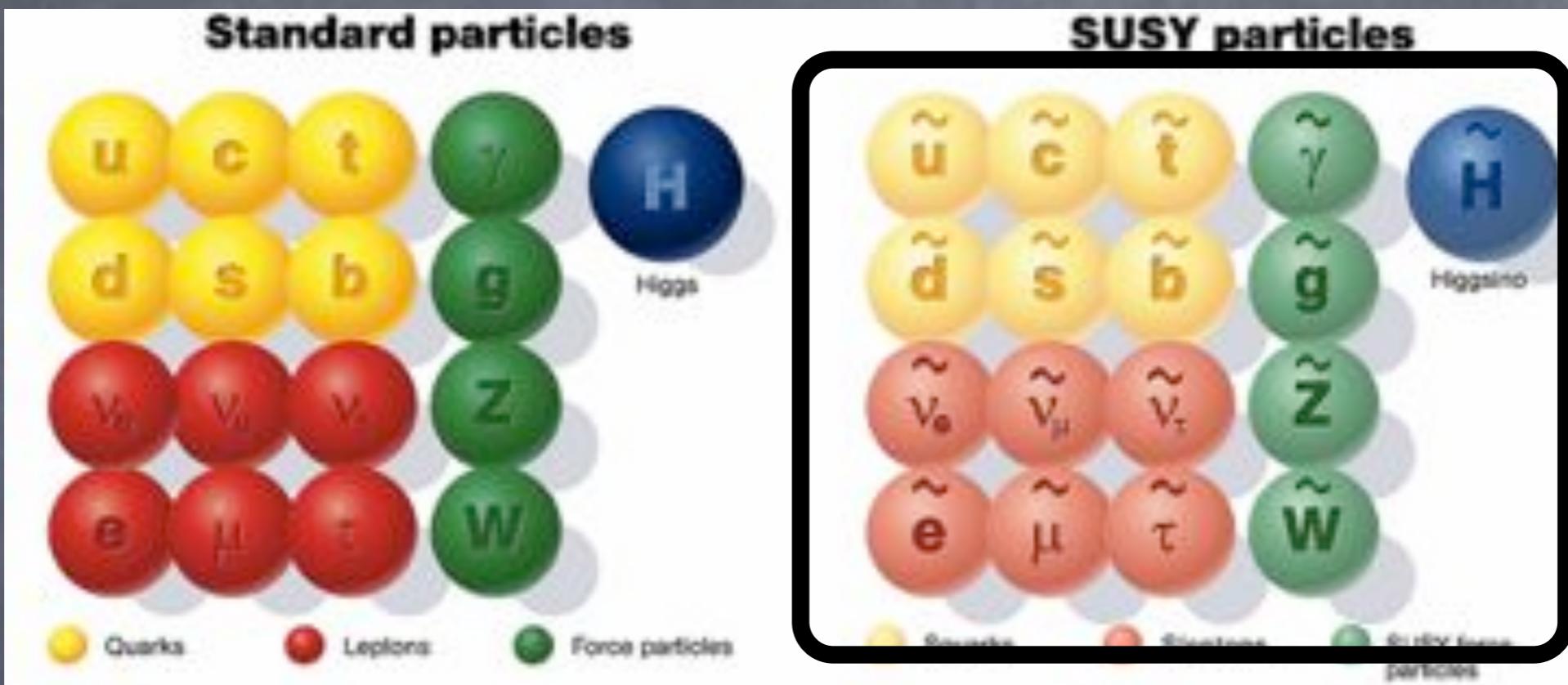


R=1

R=-1

MSSM: R-Parity

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R=1

... with important implications
for phenomenology

R=-1

\tilde{g}



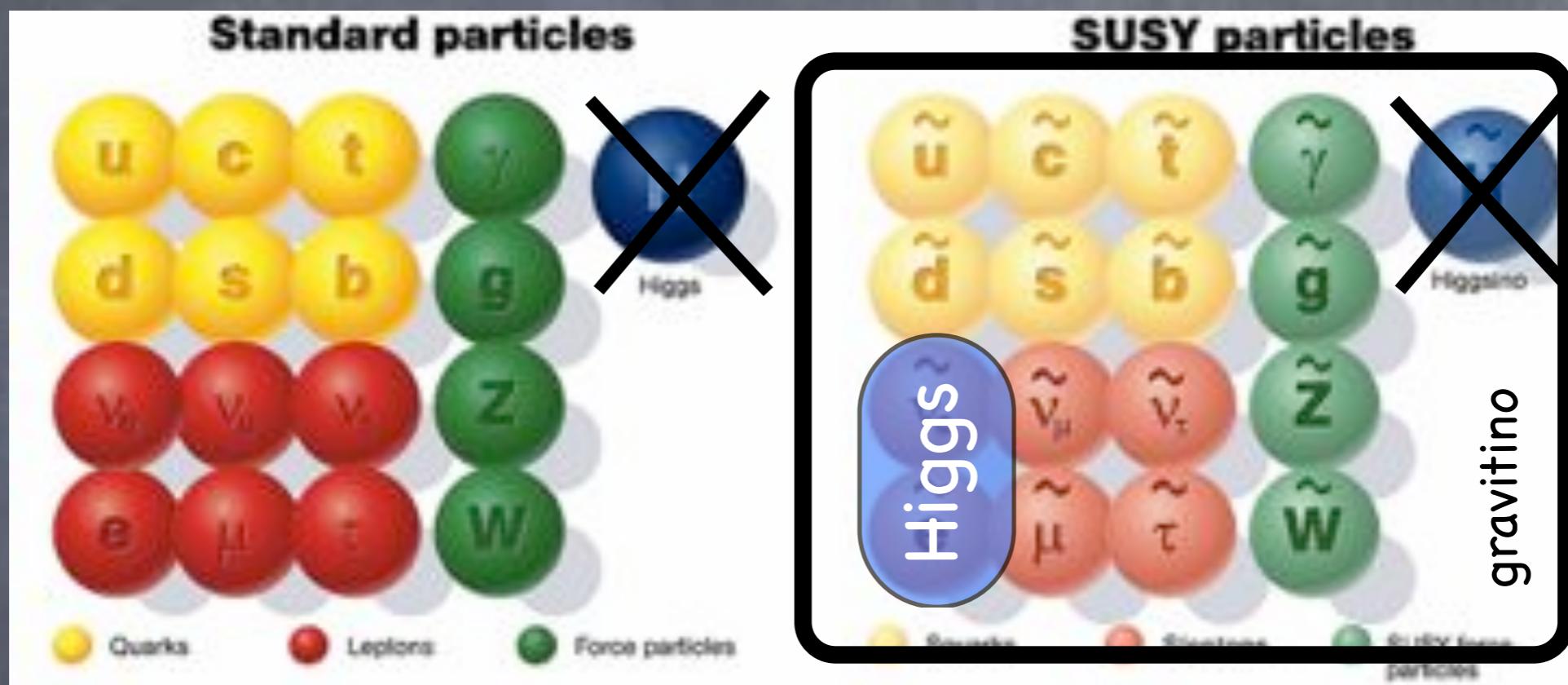
\tilde{t}



\tilde{h}

MET

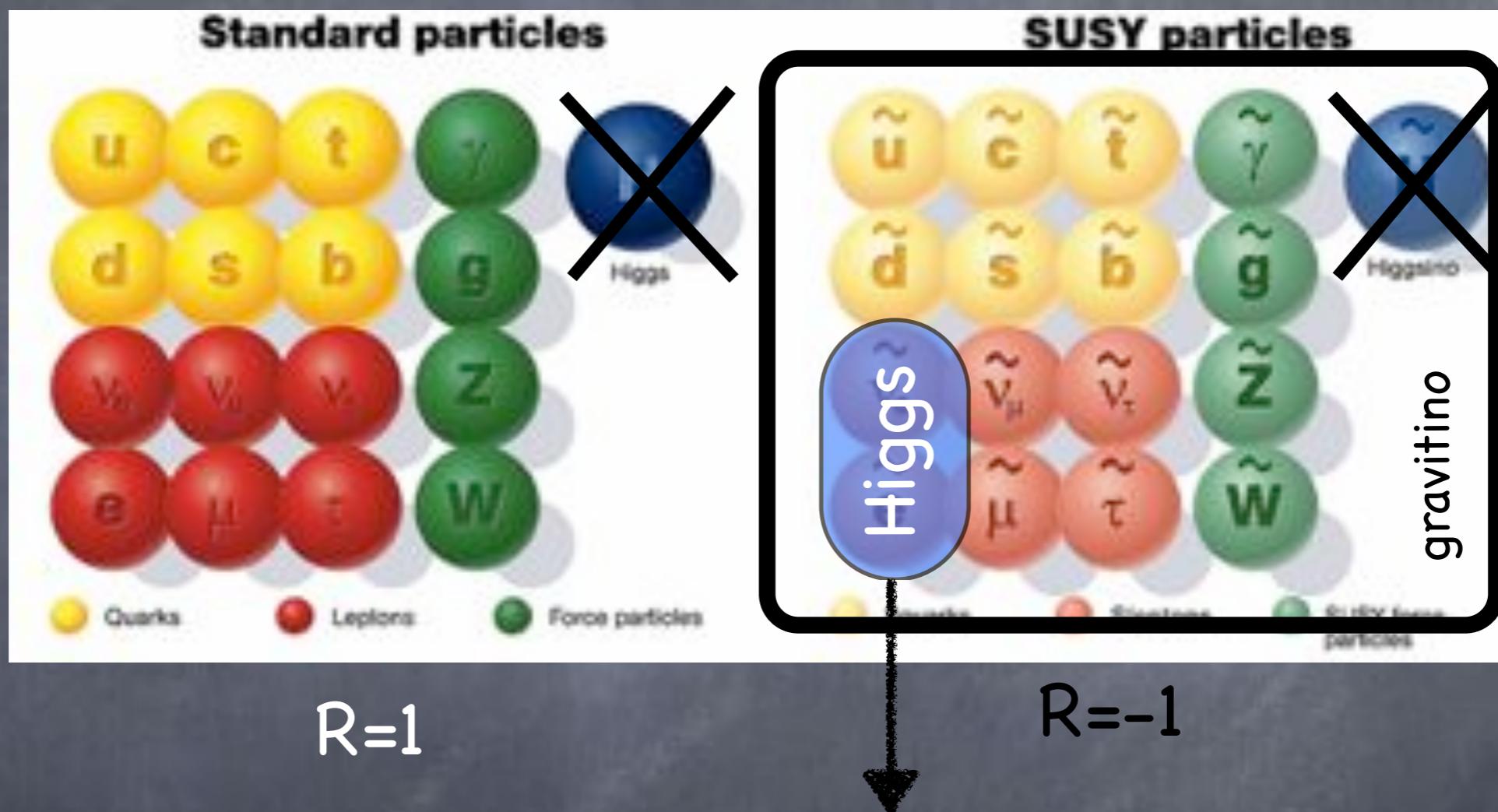
Higgs as slepton: R-parity?



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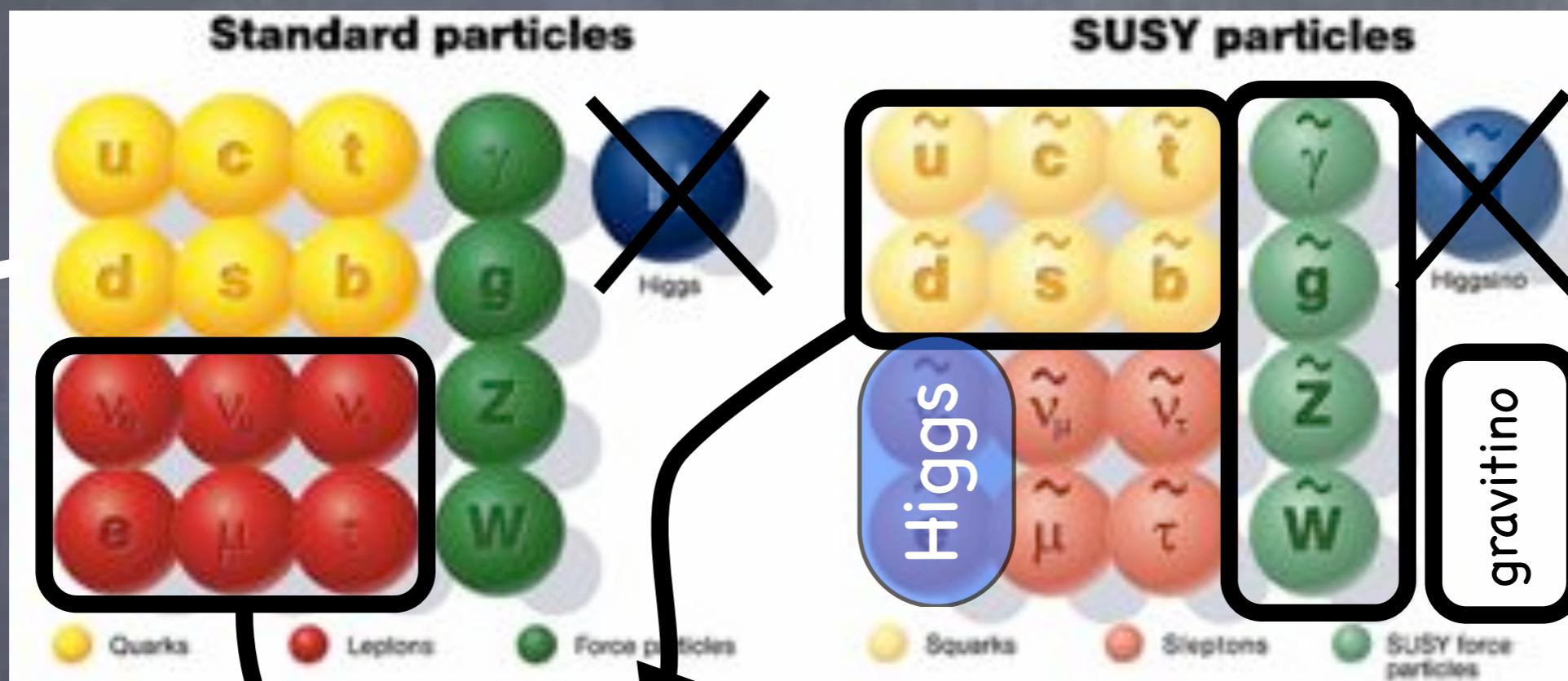


Higgs VEV breaks it!

- Proton decay...
- Need a new version of R-parity!

Higgs as slepton: R-Symmetry

Example:

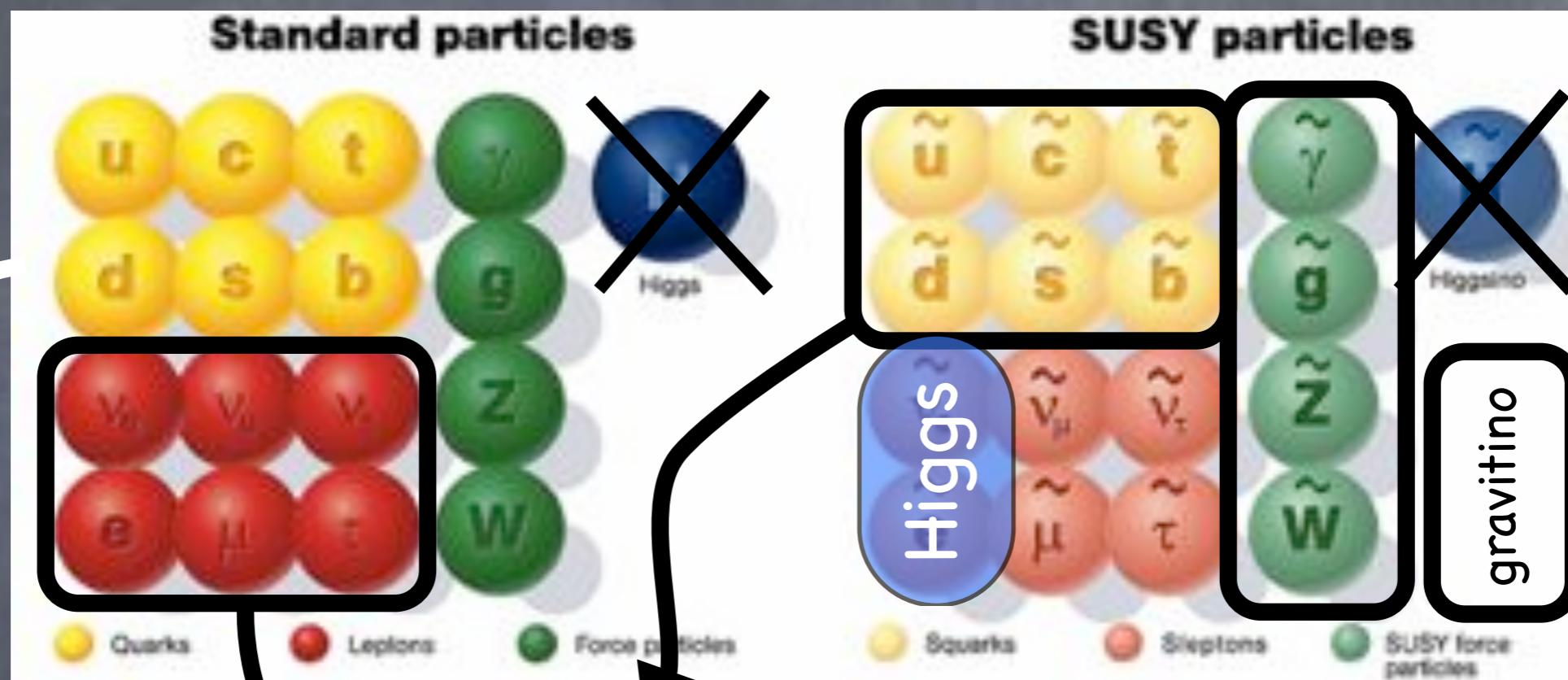


R-charge = 0

R-charge = 1

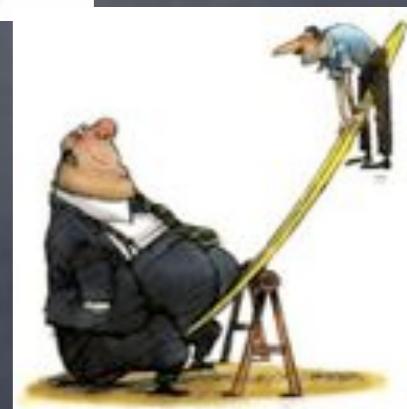
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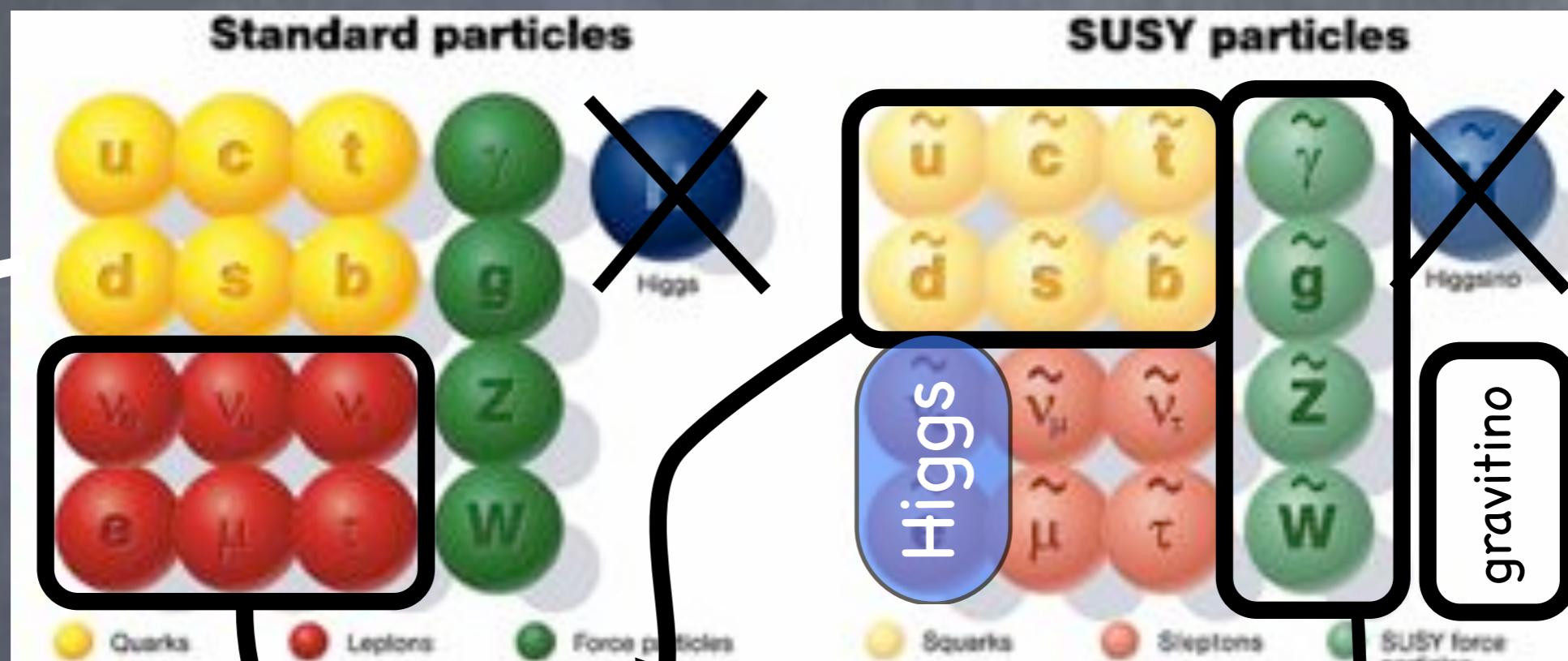
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→ Neutrino masses: - must be charged
- R must be a symmetry (not a parity)

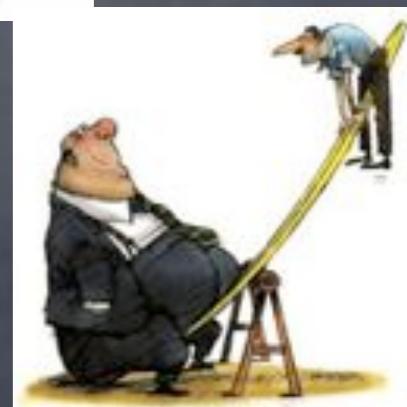
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Example:



R-charge = 0

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- Neutrino masses:
 - must be charged
 - R must be a symmetry (not a parity)
- Gauginos: Majorana masses forbidden, must get Dirac masses by marrying other states

Implications

- Gauginos have Dirac-type masses: different phenomenology
(no same-sign dileptons)

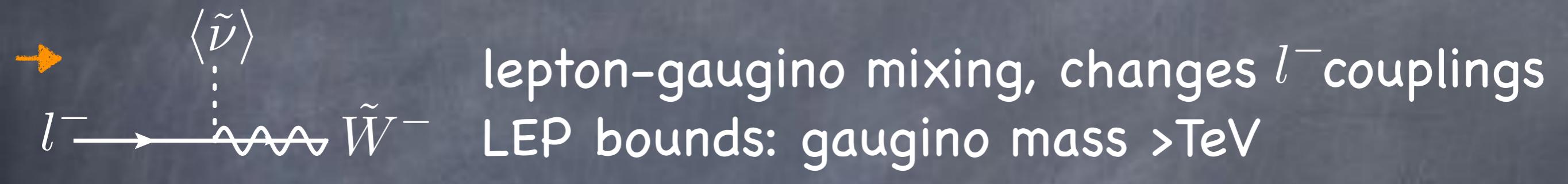
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-  lepton-gaugino mixing, changes l^- -couplings
LEP bounds: gaugino mass >TeV

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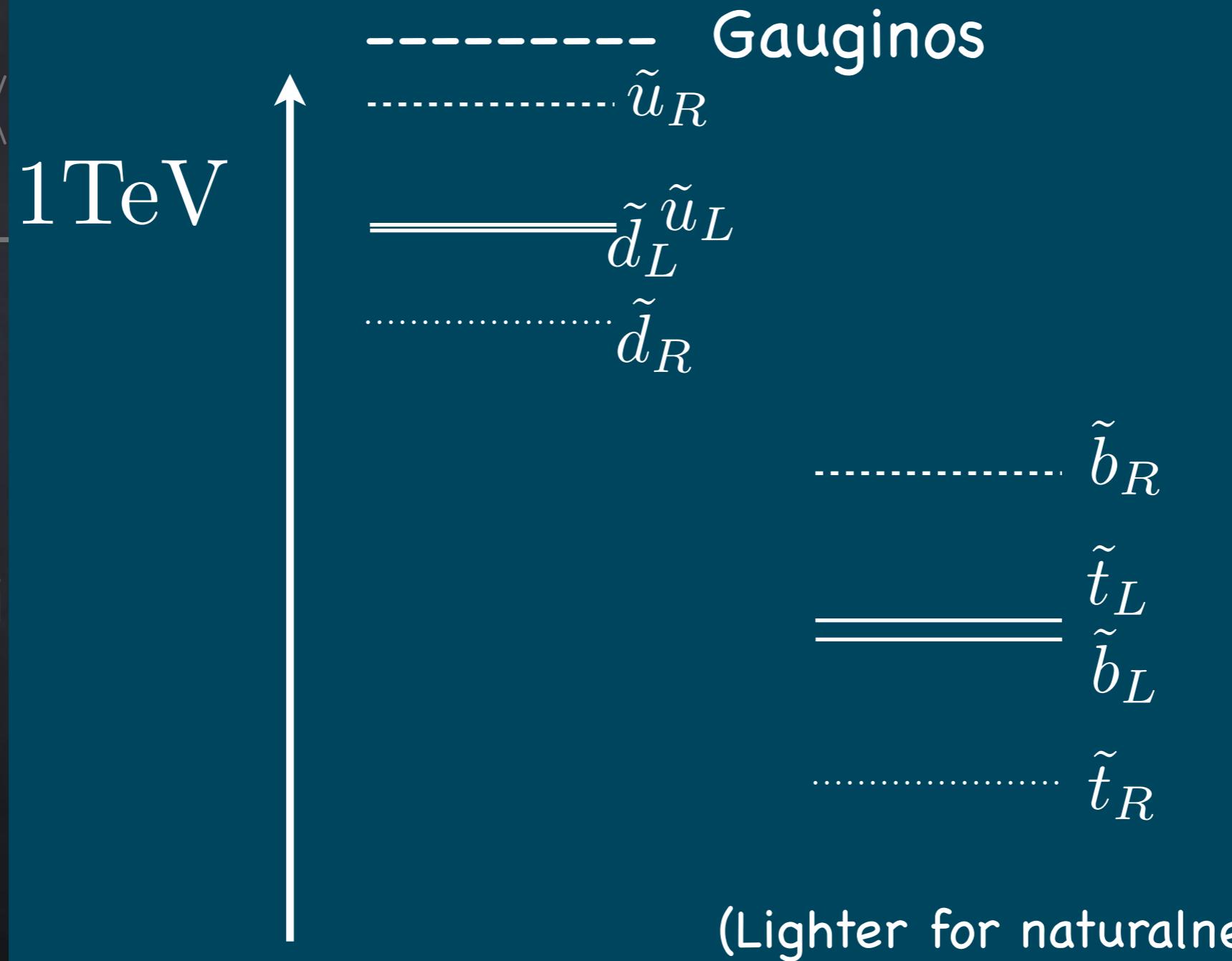


- No trilinears: No LR-mixing in the squark sector

$$m_{\tilde{b}_L}^2 = m_{\tilde{t}_L}^2 - m_t^2 + m_b^2$$

Implications

Typical Spectrum



No Higgsinos
menology
(dileptons)
couplings

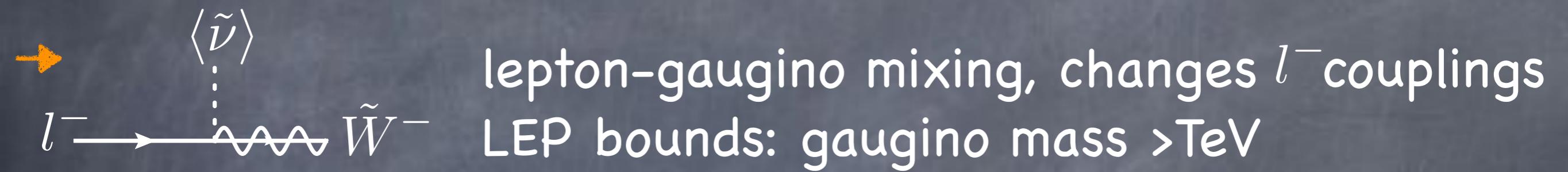
→ Gauginos

→ $l^- \rightarrow$

→ No tri

Implications

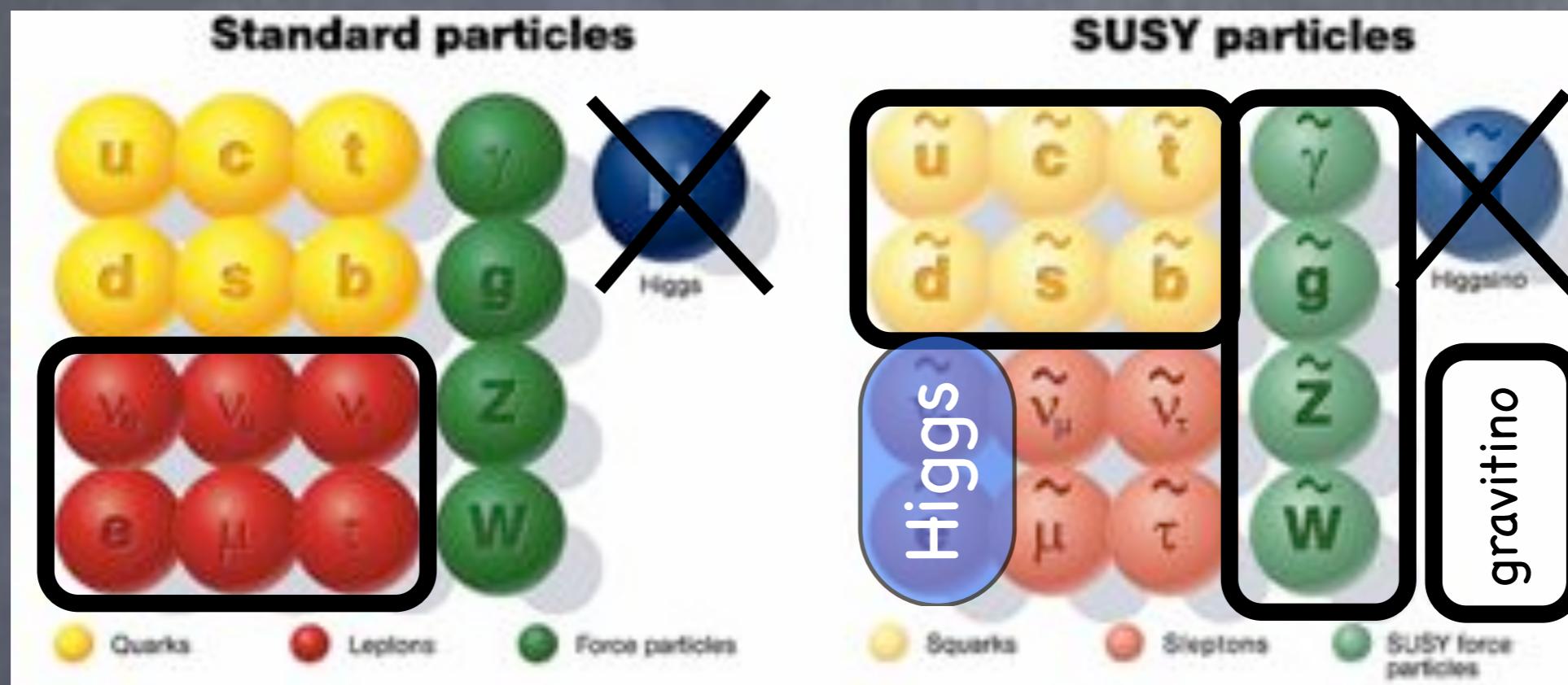
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$$m_{\tilde{b}_L}^2 = m_{\tilde{t}_L}^2 - m_t^2 + m_b^2$$
- No ordinary R-parity: Squarks can decay to quarks+lepton

Higgs as slepton: R-Symmetry

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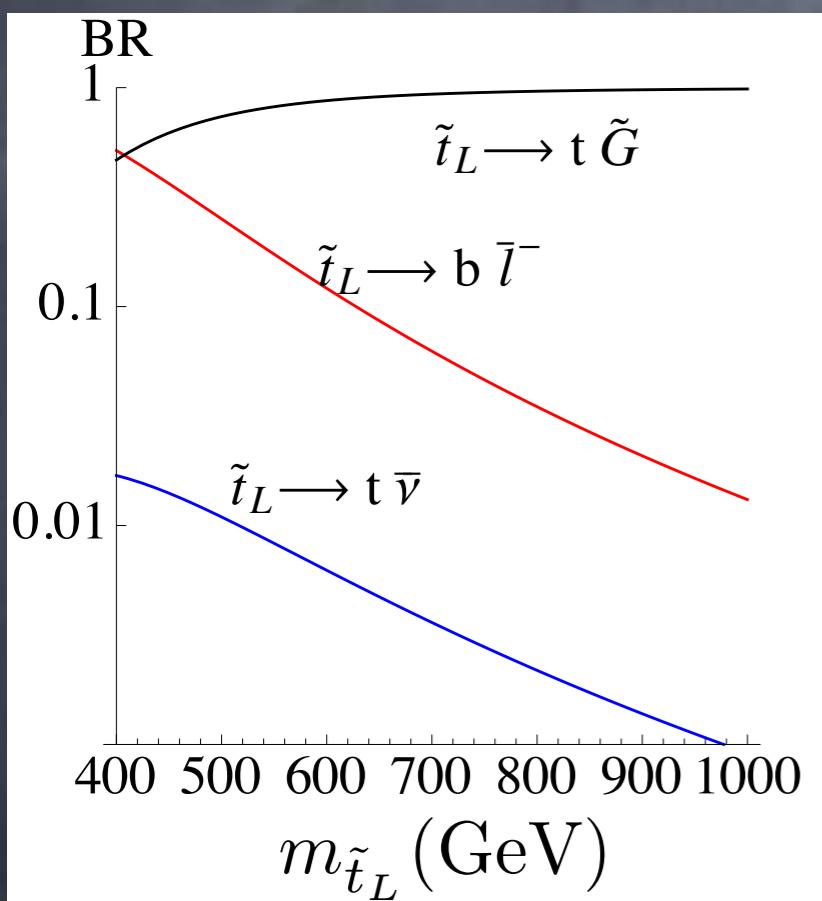


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Signatures: 3rd family squarks

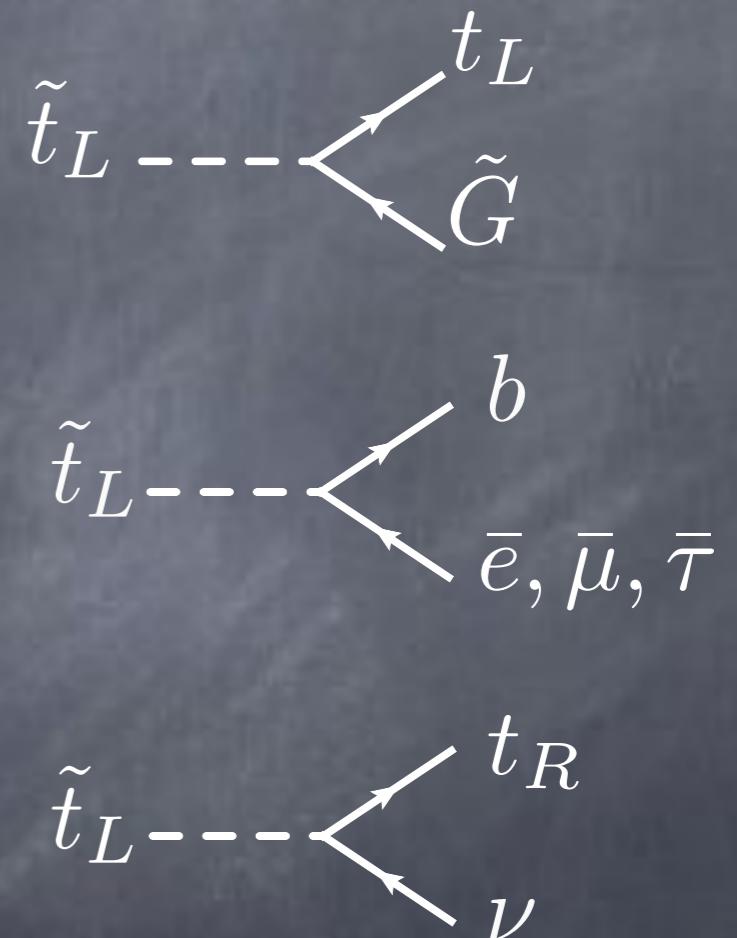
Typical LHC signatures: No E_T , but leptons in final state!



→ SUSY signal

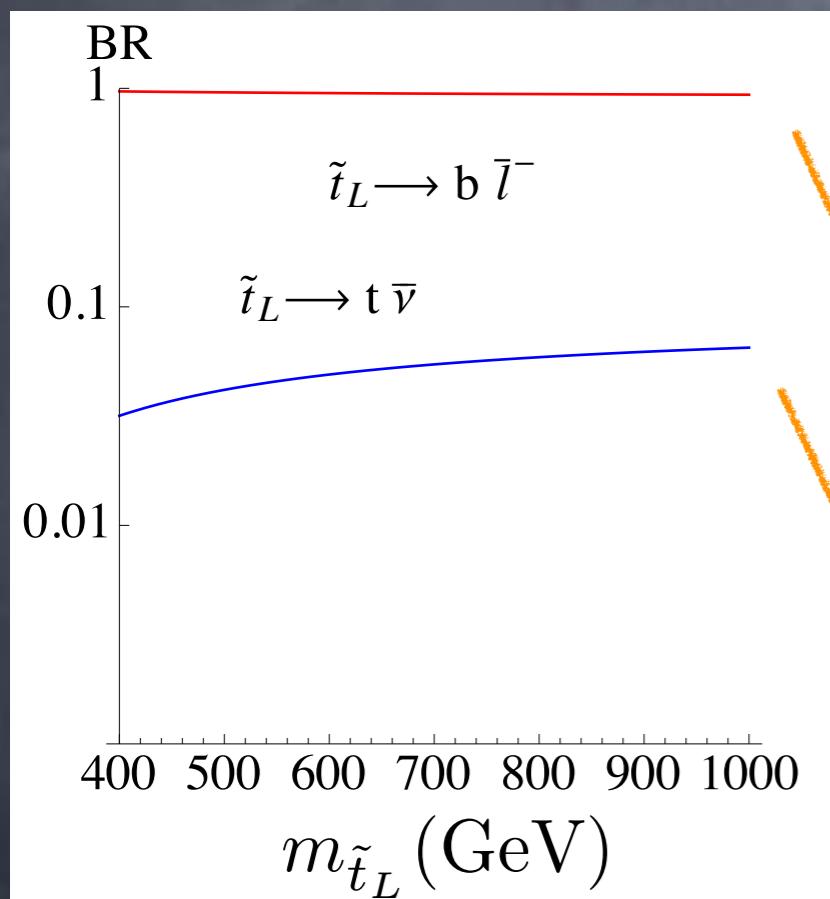
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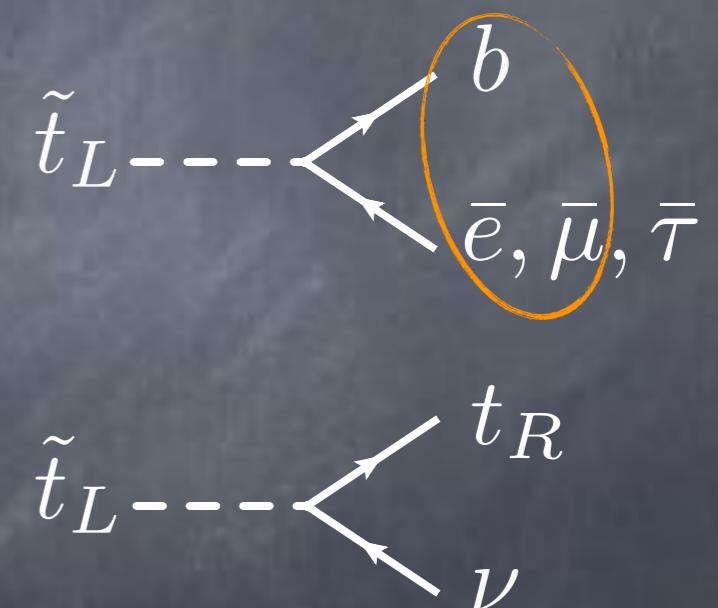


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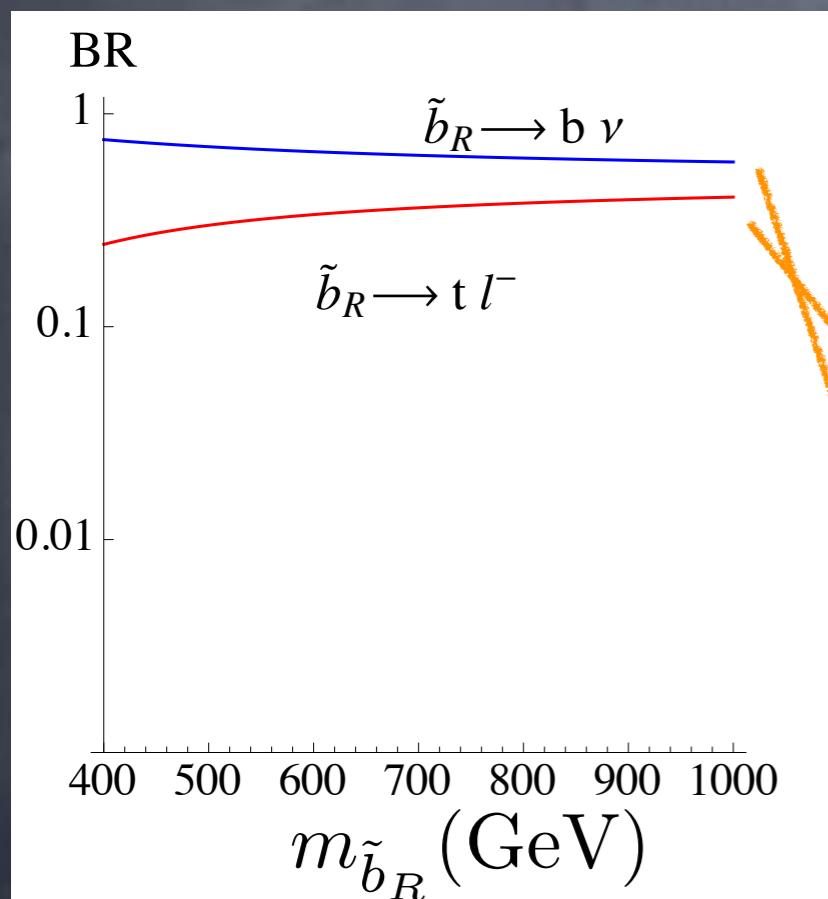


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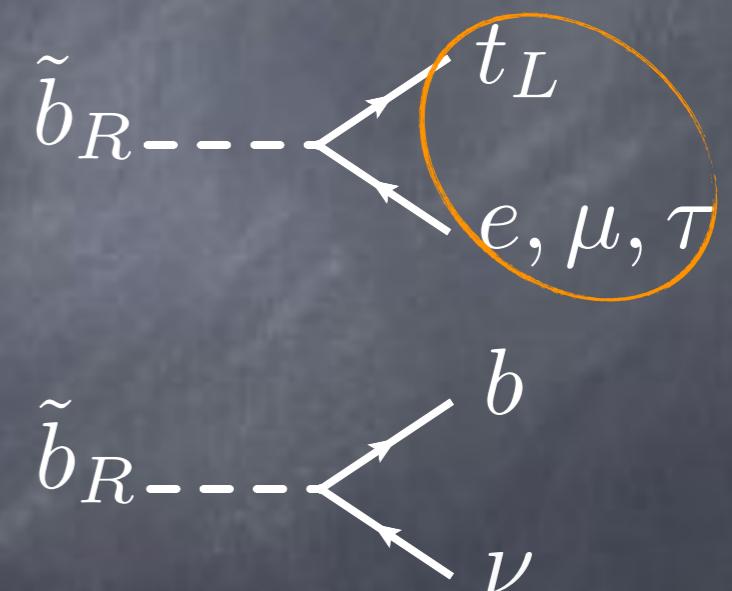
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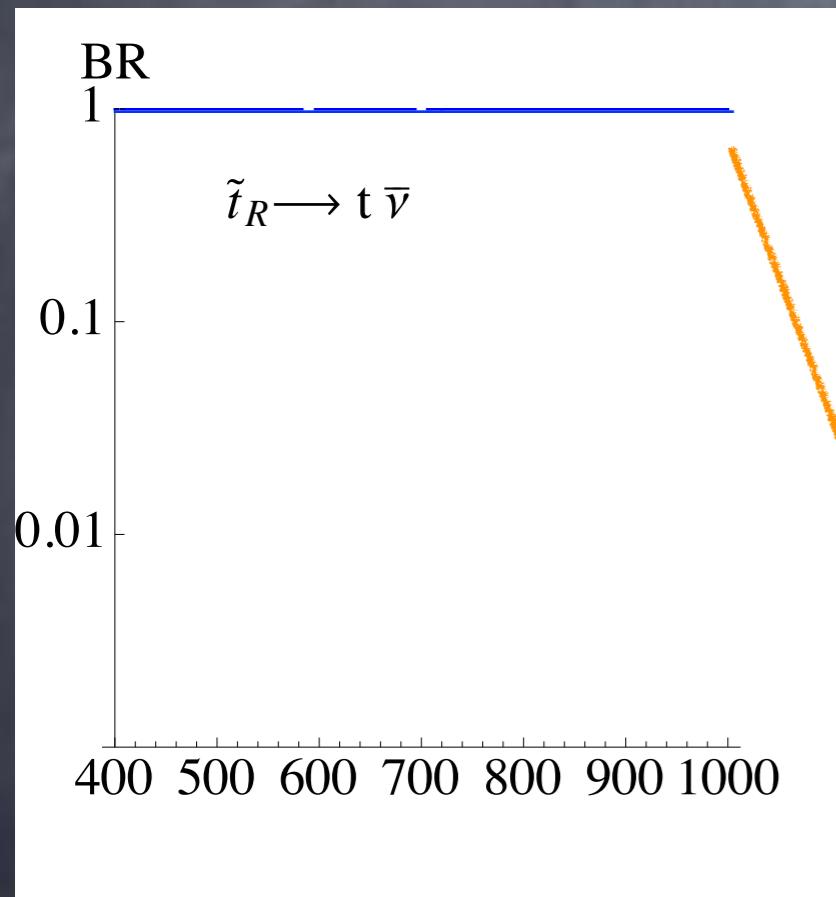
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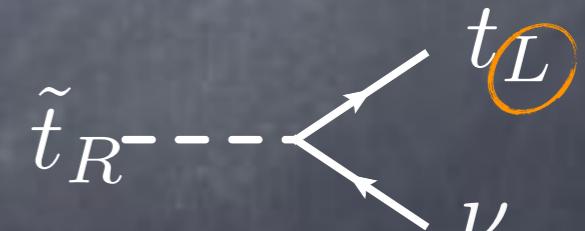
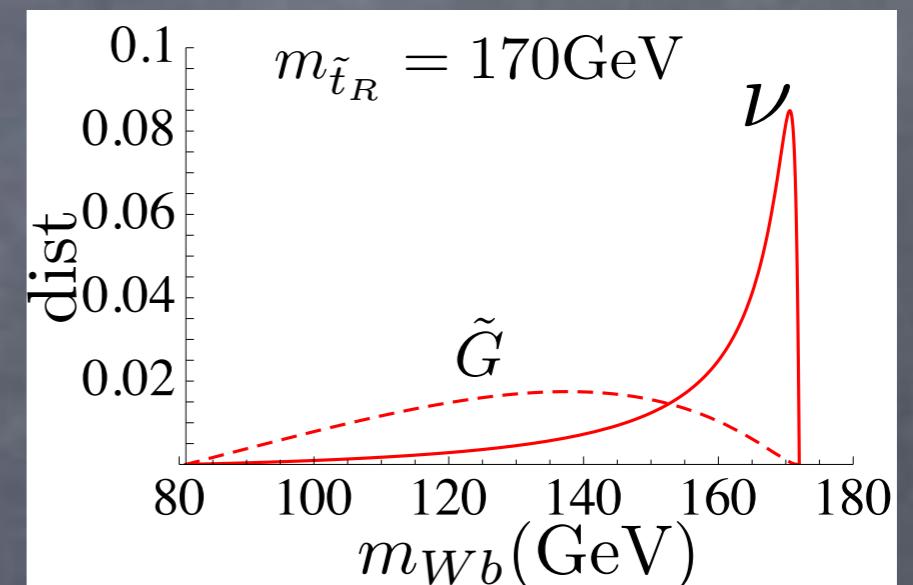


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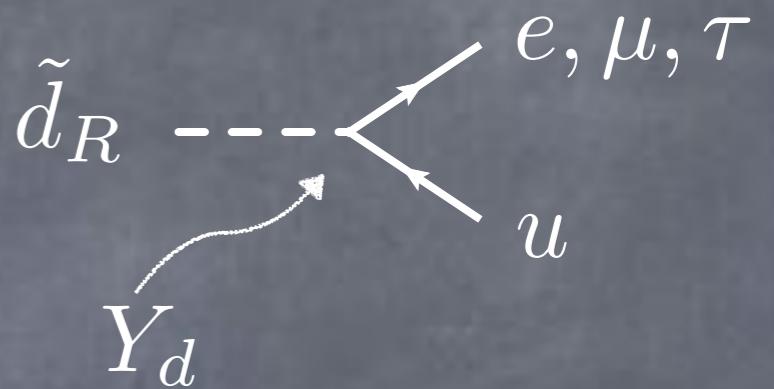


SUSY signal
(but different helicity)
 $\tilde{t}_R \rightarrow \tilde{G} t_R$



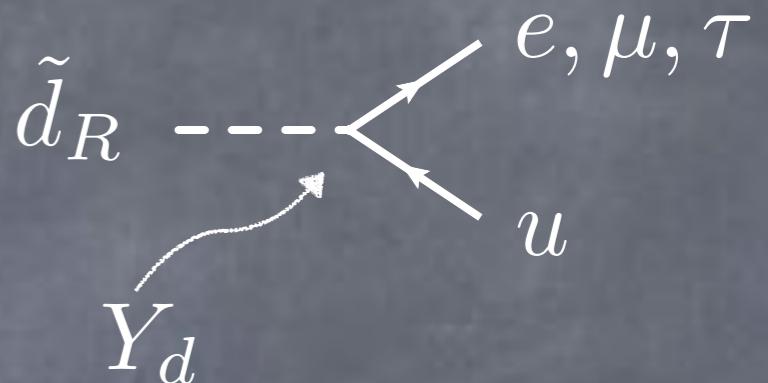
Signatures: 1st/2nd family squarks

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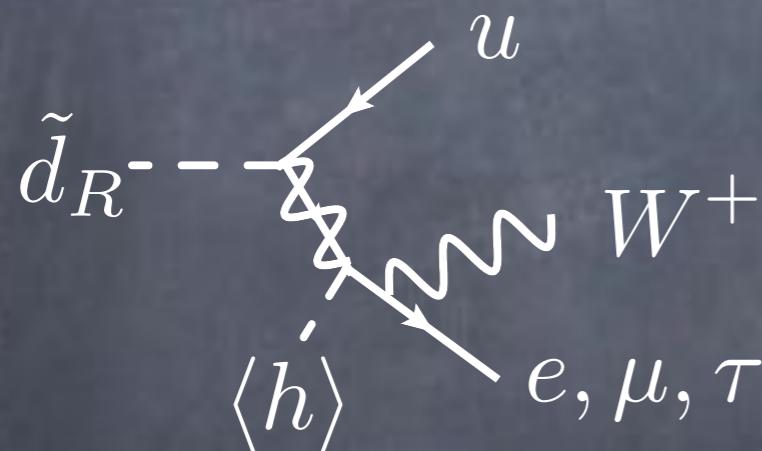


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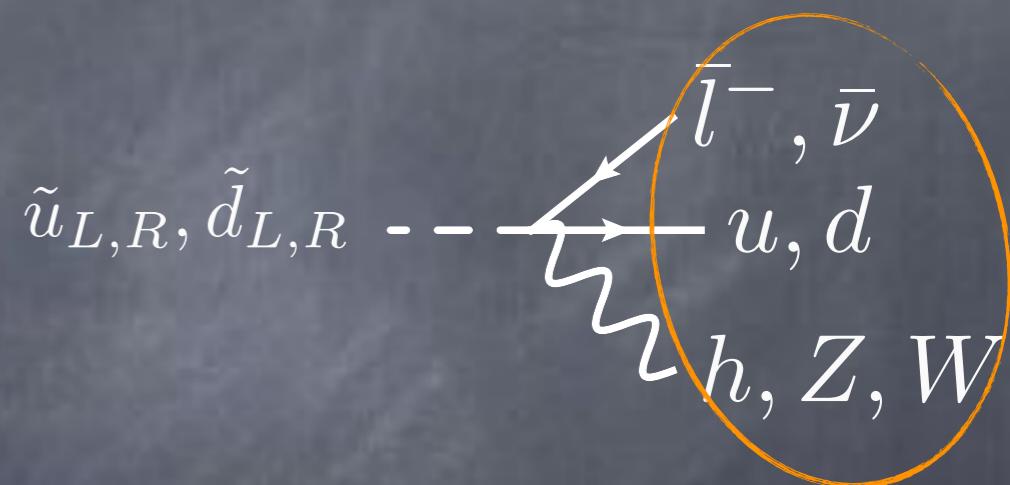
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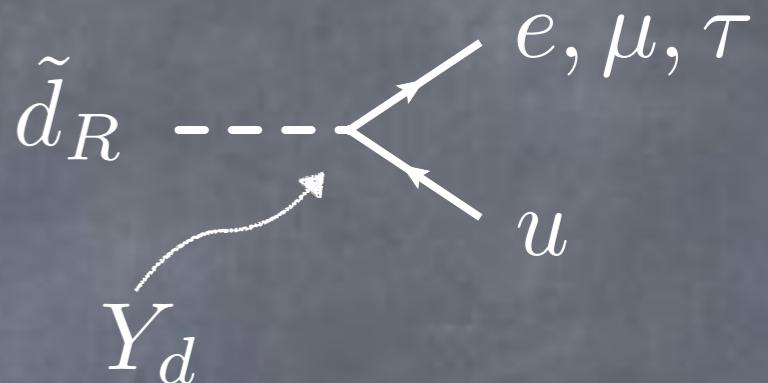


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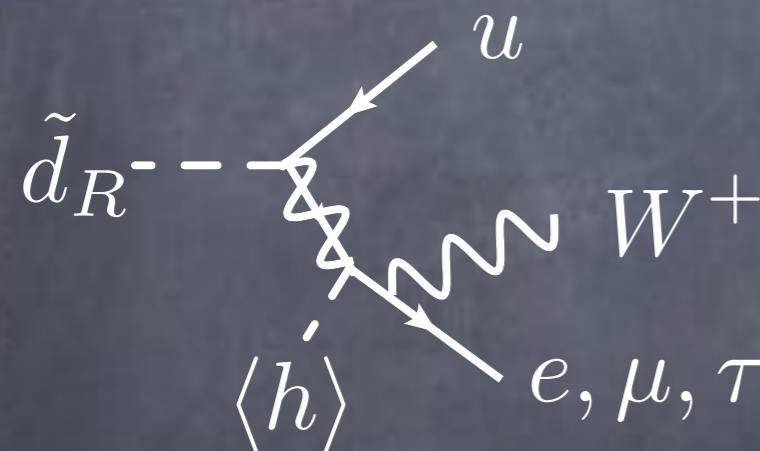


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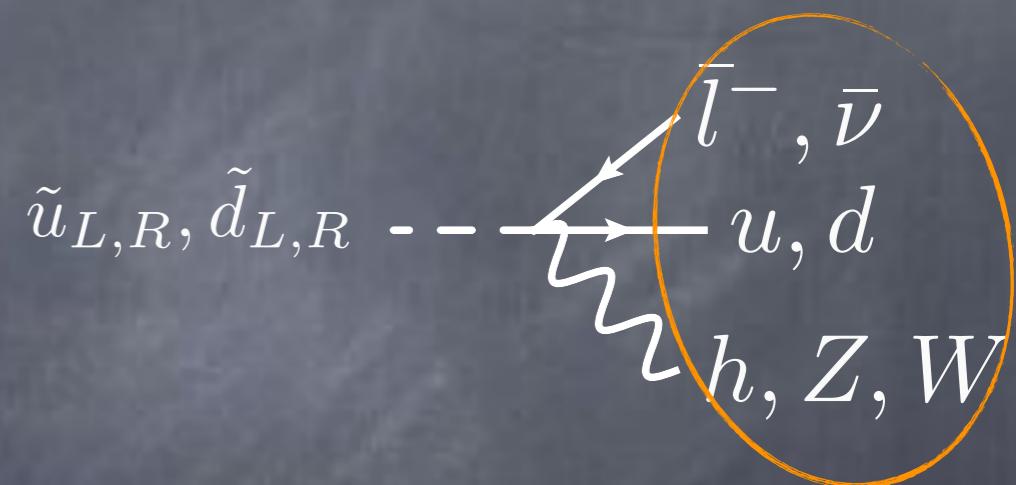
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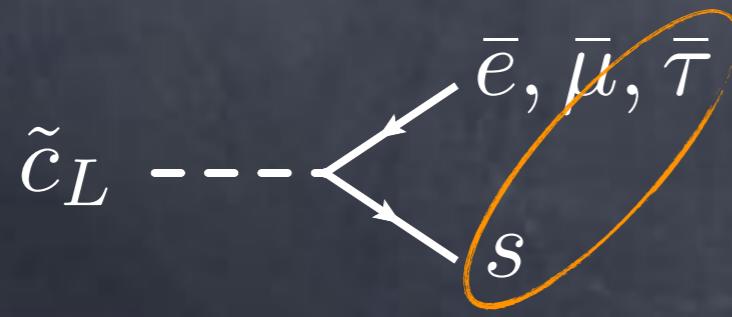
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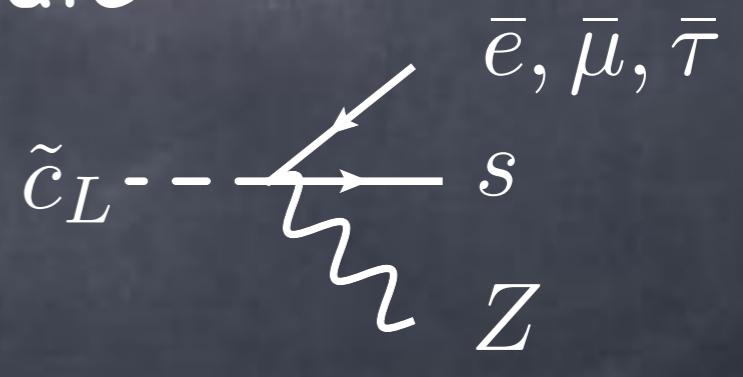
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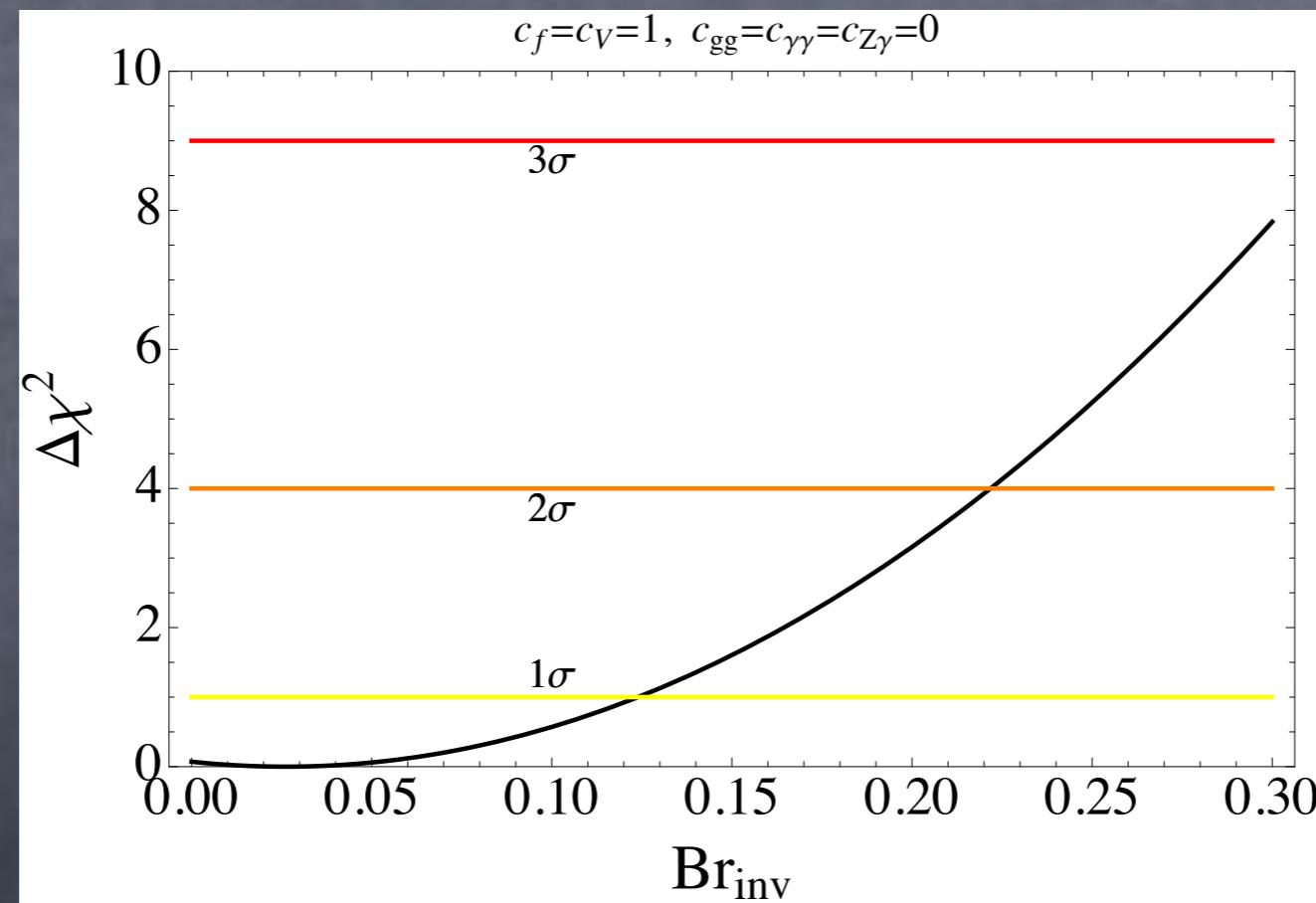
$$(m \lesssim 500 \text{ GeV})$$



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Signatures: Higgs sector

Higgs sector: Invisible decay $h \rightarrow \nu + \tilde{G}$ with $\text{BR}_{\text{inv}} \lesssim 10\%$



Conclusions

- ⦿ SUSY is a general framework with diverse realizations
- ⦿ Discovery of 125 GeV Higgs has changed perspective on SUSY: Hard breaking needed / MSSM unnatural

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- ⦿ SUSY is a general framework with diverse realizations
- ⦿ Discovery of 125 GeV Higgs has changed perspective on SUSY: Hard breaking needed / MSSM unnatural
- ⦿ Higgs could be the first SUSY partner discovered (same quantum numbers as sneutrino):
 - Squarks decay into quarks and leptons, or into 3-body
 - If gravitino is light, small invisible Higgs BR expected
 - Dedicated study allows to distinguish from other models