Université Mohammed V-Agdal RABAT

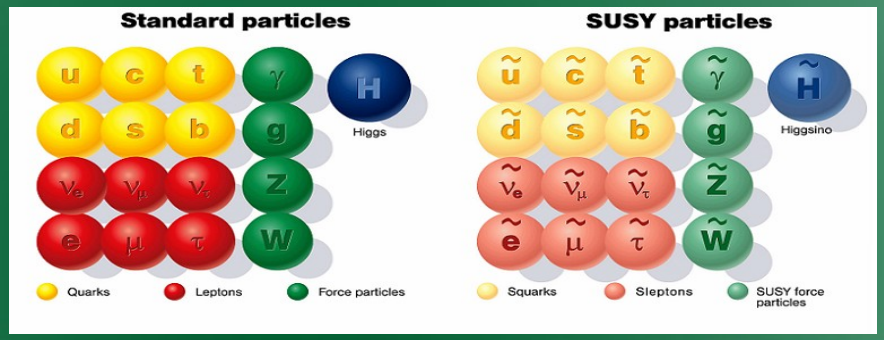
Search for Supersymmetry in events with a Z boson and large MET

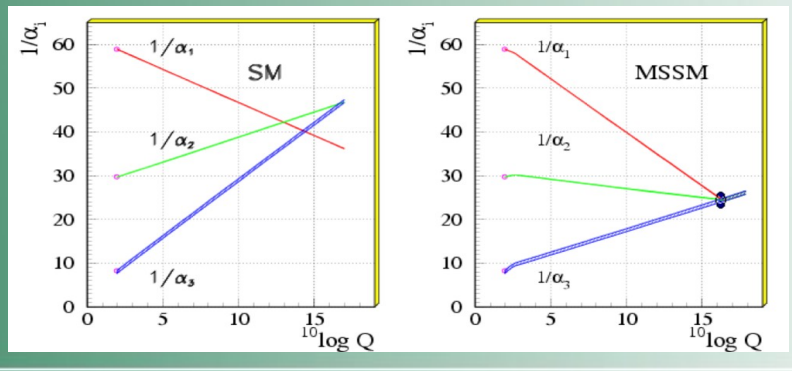
Supersymmetry

=>SUSY is an extension of the SM that try to solve it's problems

all SM particles have SUSY-partners with spin difference of ±1/2

- Theoretical motivation
  - Higgs mass stabilization against loop corrections (fine-tuning problem)
  - unification of gauge couplings at single scale
  - dark matter candidate: Lightest supersymmetric particle (LSP)





R-parity

- R-parity: $R = (-1)^{3(B-L)+2s}$ $\rightarrow R = \begin{cases} +1, \text{ for SM particles} \\ -1, \text{ for superpartners} \end{cases}$

L-number violating terms

$$W_{\not{R}p} = \lambda_{ijk}\hat{L}_i\hat{L}_j\hat{E}^C_k + \lambda'_{ijk}\hat{L}_i\hat{Q}_j\hat{D}^C_k + \epsilon_i\hat{L}_i\hat{H}_u + \lambda''_{ijk}\hat{U}^C_i\hat{D}^C_j\hat{D}^C_k$$

bilinear terms

B-number violating terms

- R-parity conservation hinted but not required by proton stability

Theoretical models

- There is many SUSY models the Simplest is MinimalSupersymetricSM (MSSM) has > 100 parameters

→ different models

Gravity mediated (SUGRA)

Gauge mediated (GMSB)

Minimal Supersymmetric Standard Model (MSSM)

…

GUT scale unification → few free parameters

Searches for R-parity violating SUSY

Bilinear RPV: theoretical motivation

Bilinear RPV

Connexion with neutralino Physics

EW symmetry is broken by Higgs and sneutrino vev's

neutrinos mix with neutralinos → 7 × 7 mixing matrix

a "low-scale" seesaw mechanism renders neutrinos massive

RPV through bilinear terms

bRPV introduces nine additional parameters to the free parameters in R-parity conserving mSUGRA

Valle, Hirsch, Porod, Diaz *et al.*

Bilinear RPV: signatures in colliders

- bRPV couplings can be embedded in any supersymmetric scenario:
  - MSSM, SUGRA, AMSB, …
- Almost same event as in RPC SUSY except that (N)LSP decays at end of SUSY cascade
- Common features among SUSY scenarios
  - LSP lifetime may be long ($c\tau \sim 1$ – 100 mm)
    → search for displaced vertices
  - many **leptons** and **taus** in final state
    → **1-, 2-** or **multilepton** analyses relevant
  - large **MET** due to copious neutrino production
    → conventional MET-based searches applicable to bRPV SUSY

Gauge-mediated supersymmetry breaking

In GMSB models , SUSY breaking is propagated to the visible sector via SM-like $SU(3) \times SU(2) \times U(1)$ gauge boson and gaugino

Advantage of the models relative to the minimal supergravity and anomaly-mediated SUSY breaking models is that scalars with the same gauge quantum numbers, but different flavors, have identical soft SUSY breaking masses

the gravitino (˜G) is the LSP (in general m(˜G 84) ≪ 1 keV), which escapes detection, leading to missing transverse momentum

bRPV in Z+missE analysis

In this analysis we look for supersymmetry in events characterized by a Z boson that decays to an electron or a muon pair, large missing transverse energy (ETmiss) and jets. Such a final state is motivated by various SUSY models where at least one superpartner decays preferably to a Z boson.

Analysis overview

Signal regions

Table 1: Signal region definition.

Variable	SR1	SR2	SR3
E_T^{miss}	> 225 GeV	> 150 GeV	
N_{jets}	> 1	> 3	
p_T^{jet}	> 30 GeV	> 30 GeV	
H_T	> 600 GeV	> 900 GeV	

Background determination

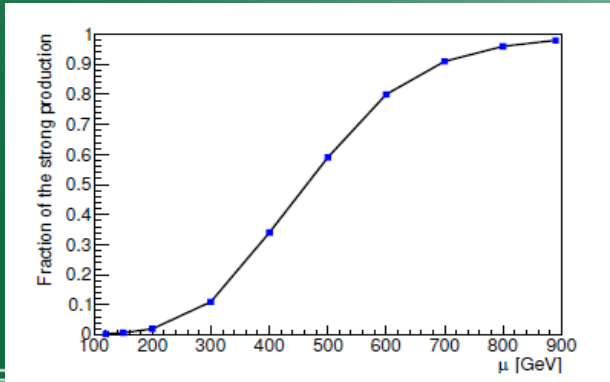
Table 2: Control region definition.

Variable	CR1	CR2
E_T^{miss}	> GeV	> GeV
N_{jets}	>	>
H_T	> GeV	> GeV

General gauge mediation signal samples

Parameters	M_1	M_2	$\tan\beta$	$c\tau_{NLSP}$	μ	$m(\tilde{g})$
Values	1 TeV	1 TeV	1.5	0.1 mm	vary	vary
Values	1 TeV	1 TeV	30	0.1 mm	vary	vary

The fraction of the ˜g˜g processes as function of μ for GGM grid models characterised by the
following parameters: M1 = 1 TeV, M2 = 1 TeV, m(˜g) = 900 GeV, tan β = 1.5.



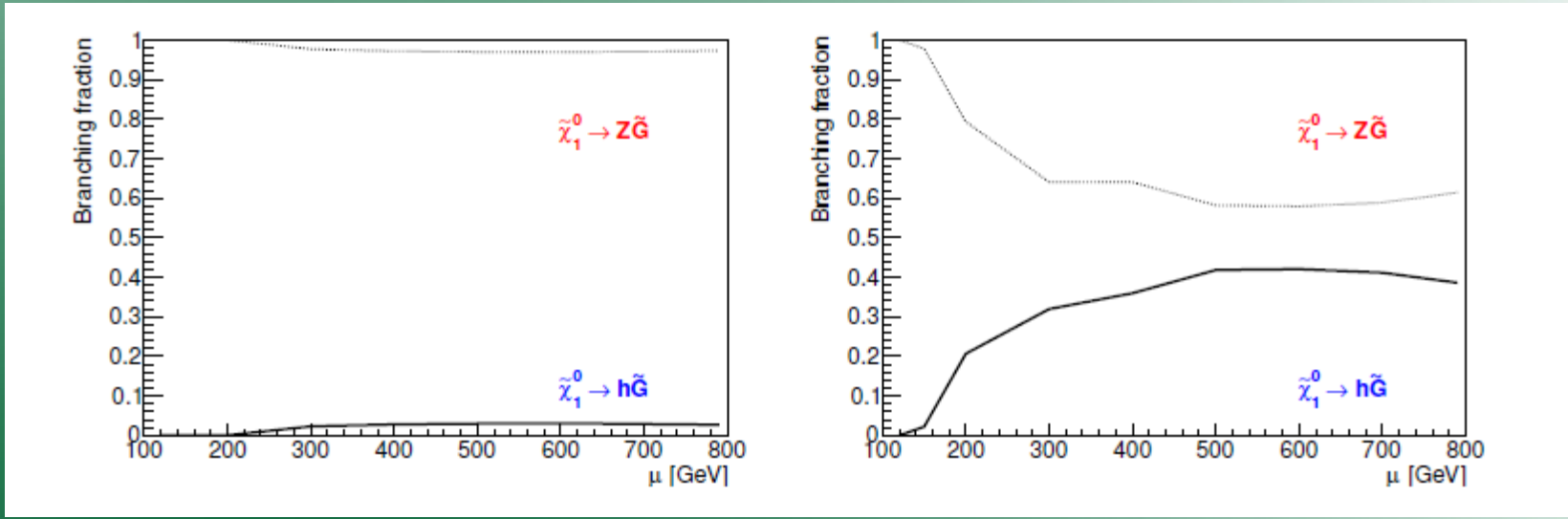


Figure 2: The branching fraction for $\tilde{\chi}_1^0 \to h\tilde{G}$ and $\tilde{\chi}_1^0 \to Z\tilde{G}$ processes as function of μ for GGM grid models characterised by the following parameters: $M_1 = 1$ TeV, $M_2 = 1$ TeV, $m(\tilde{g}) = 800$ GeV, $\tan\beta = 1.5$ (left), $\tan\beta = 30$ (right).

Bilinear RPV signal samples :

The mSUGRA parameters in this analysis are defined as follows:

- $400\ \text{GeV} \leq m_0 \leq 2200\ \text{GeV}$
- $250\ \text{GeV} \leq m_{1/2} \leq 800\ \text{GeV}$
- $A_0 = -2m_0$
- $\tan\beta = 30$
- $\text{sgn}(\mu) = +1$

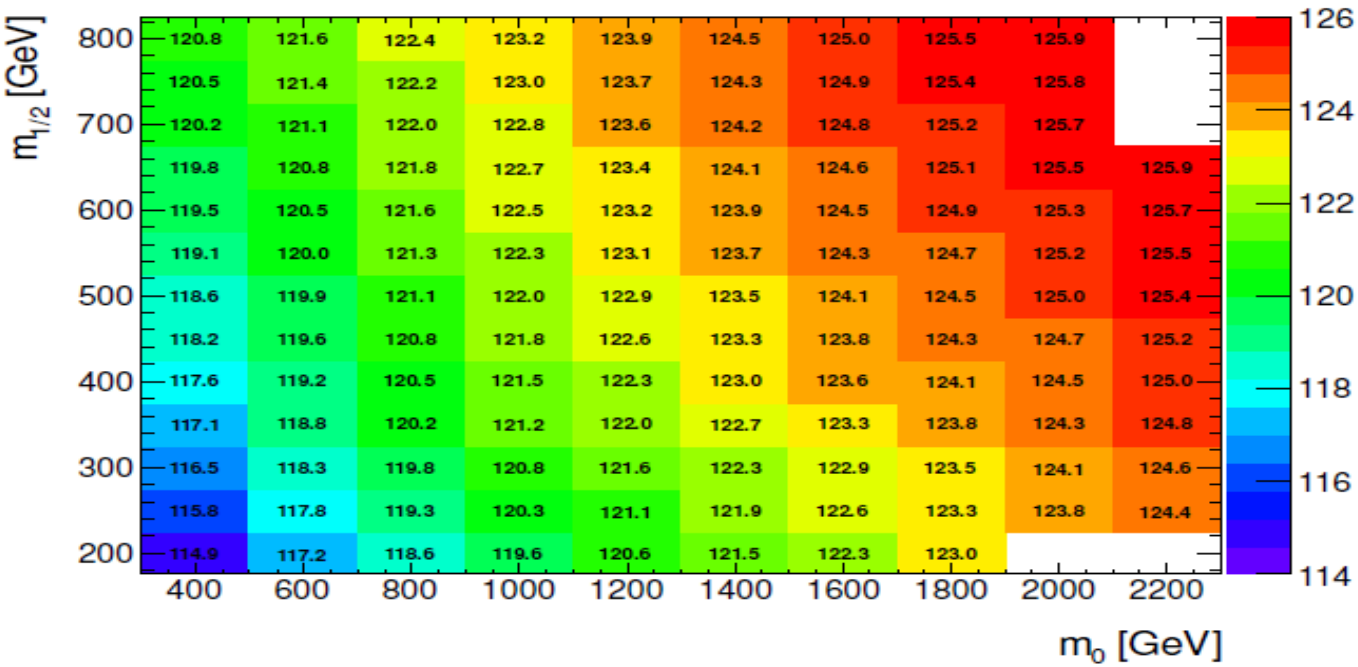


Figure 3: Higgs masses in GeV for all bRPV signal points considered.

THANK YOU