New Parameter Space for Light Higgs Decays in the R Parity Violating MSSM

RPV Operators

$$
\begin{aligned}
W \quad &\supset \quad \mu_i L_i \bar{H} + \lambda_{ijk} L_i L_j E^c_k + \lambda'_{ijk} L_i Q_j D^c_k \\
&+ \quad \lambda''_{ijk} U^c_i D^c_j D^c_k,
\end{aligned}
$$

LSP may now decay to SM fields

- Higgs may decay to LSP pair which decays through RPV to multiple SM particles
- Non standard Higgs decays may have been missed at LEP
- If Higgs decays dominantly to new missed signals Higgs mass bound may be relaxed

Find parameter Space for LSPs Bellow Half Higgs mass

Throw out gaugino mass unification

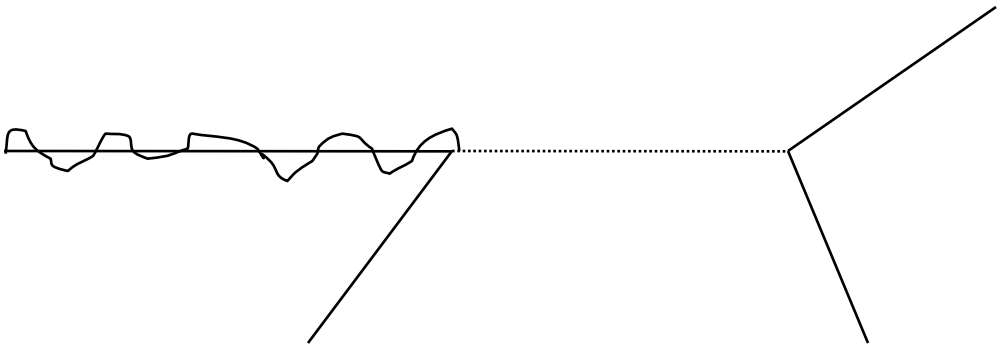
Decouple third generation scalars from Z

General Constraints for Higgs decays

- LSP lighter than half Higgs mass
- Beats bbar by factor of 5
- chargino mass constraint 102.7GeV
- Z width
- b to s gamma

Gaugino 3 body decay

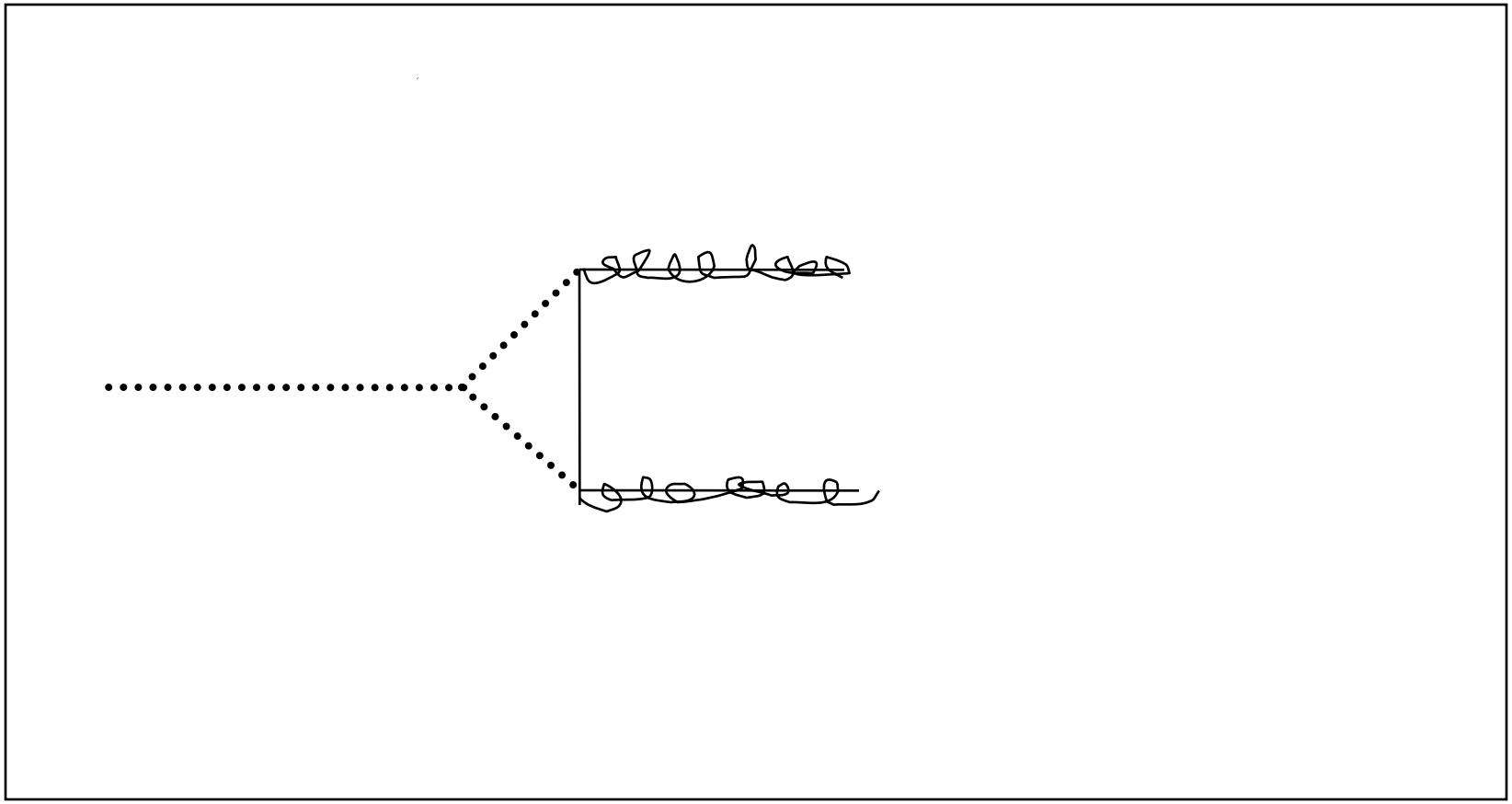
May decay with displaced vertex



Neutralino LSP

- Existing RPV bounds on neutralinos most come from assuming gaugino mass unification
- Chargino mass bound 102.7GeV means neutralino can’t be much below 40 GeV.

Gluino LSP



- RPV decays of Gluino not well studied
- Lower limit of light gluinos from running of alpha strong 6.5 GeV
- Sufficiently decoupled from Z at LEP

- LLE 2 tau plus missing energy
- LQD 2 quarks plus missing energy, or tau
- UDD three quarks

Scalar Decoupling

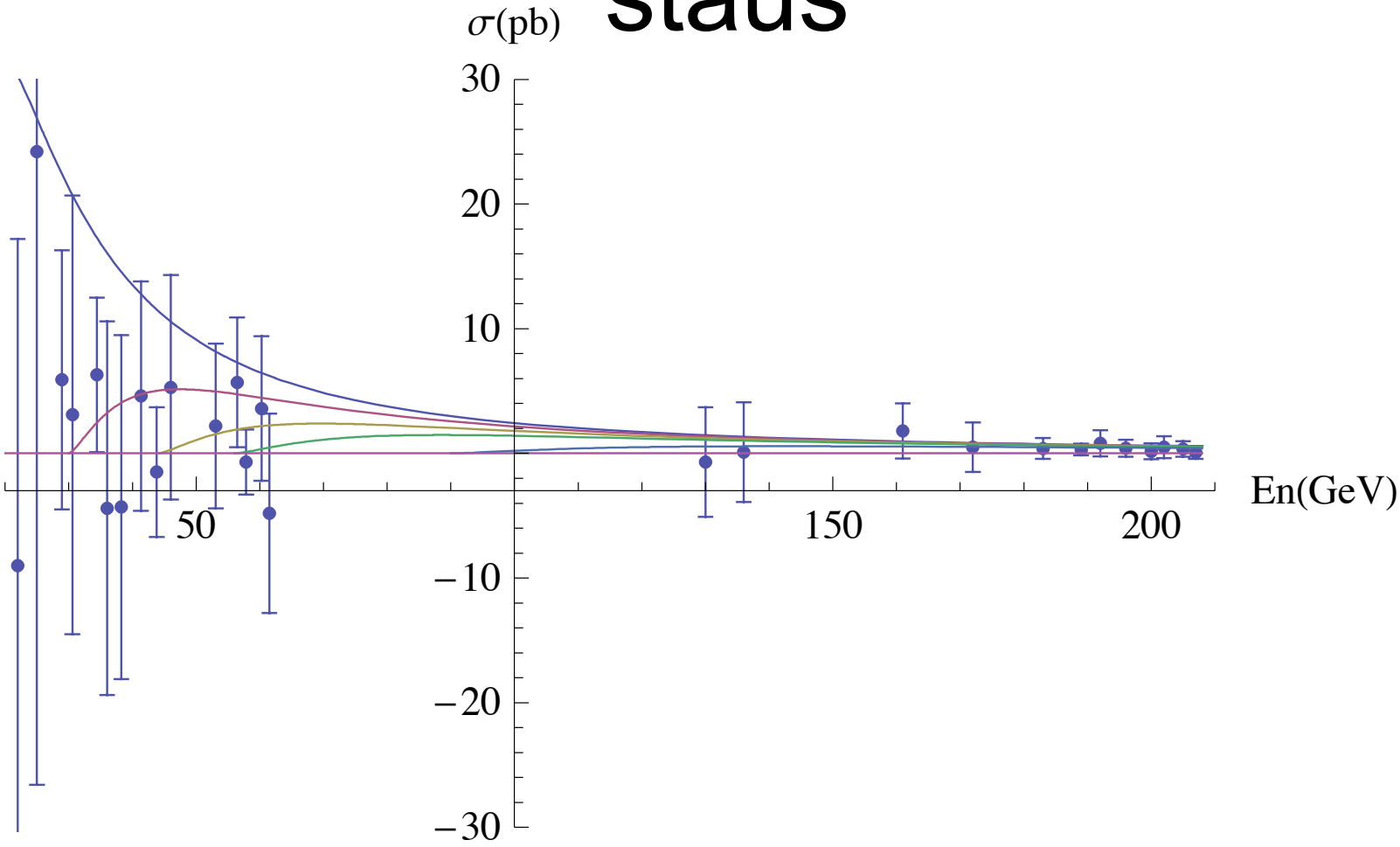
- Third generation scalars left-right eigenstates may be heavily Mixed
- Off diagonal terms in mass matrix go like $m_s(A-\mu\tan\beta)$
- Mixing angle is

  $\mathrm{Sin}2\theta=2m_sA/(ms_1^2-ms_2^2)$ and

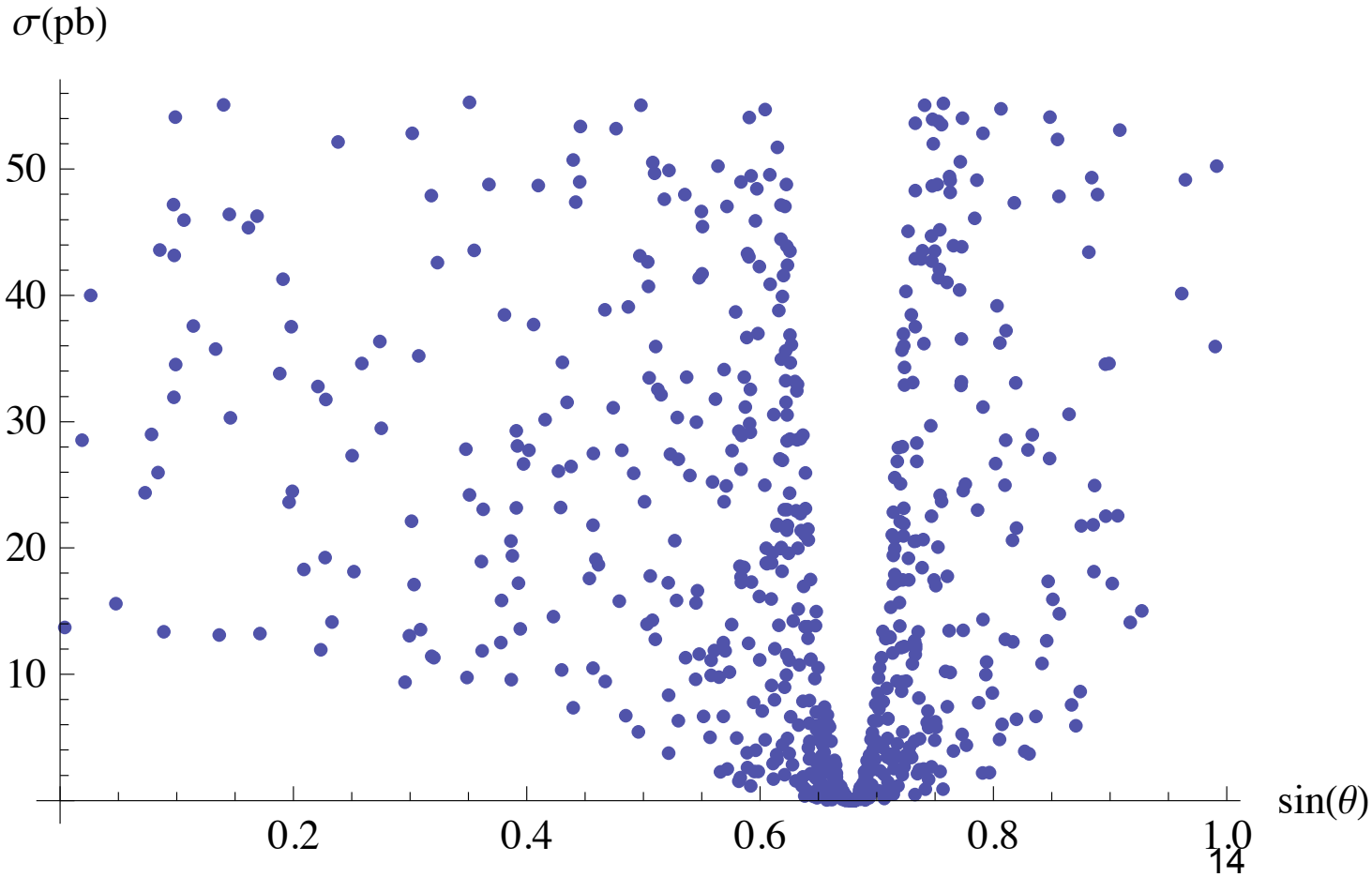
  $g_Z=g(I_3\sin^2\theta_w-Q\sin^2\theta)$

- It was assumed measurements of Z width and R ruled out sparticles below half of the Z mass
- With Z decoupling contributions to R come only from photons
- Sbottom and stau may be lighter than half of the Higgs mass

data and theory predictions for staus



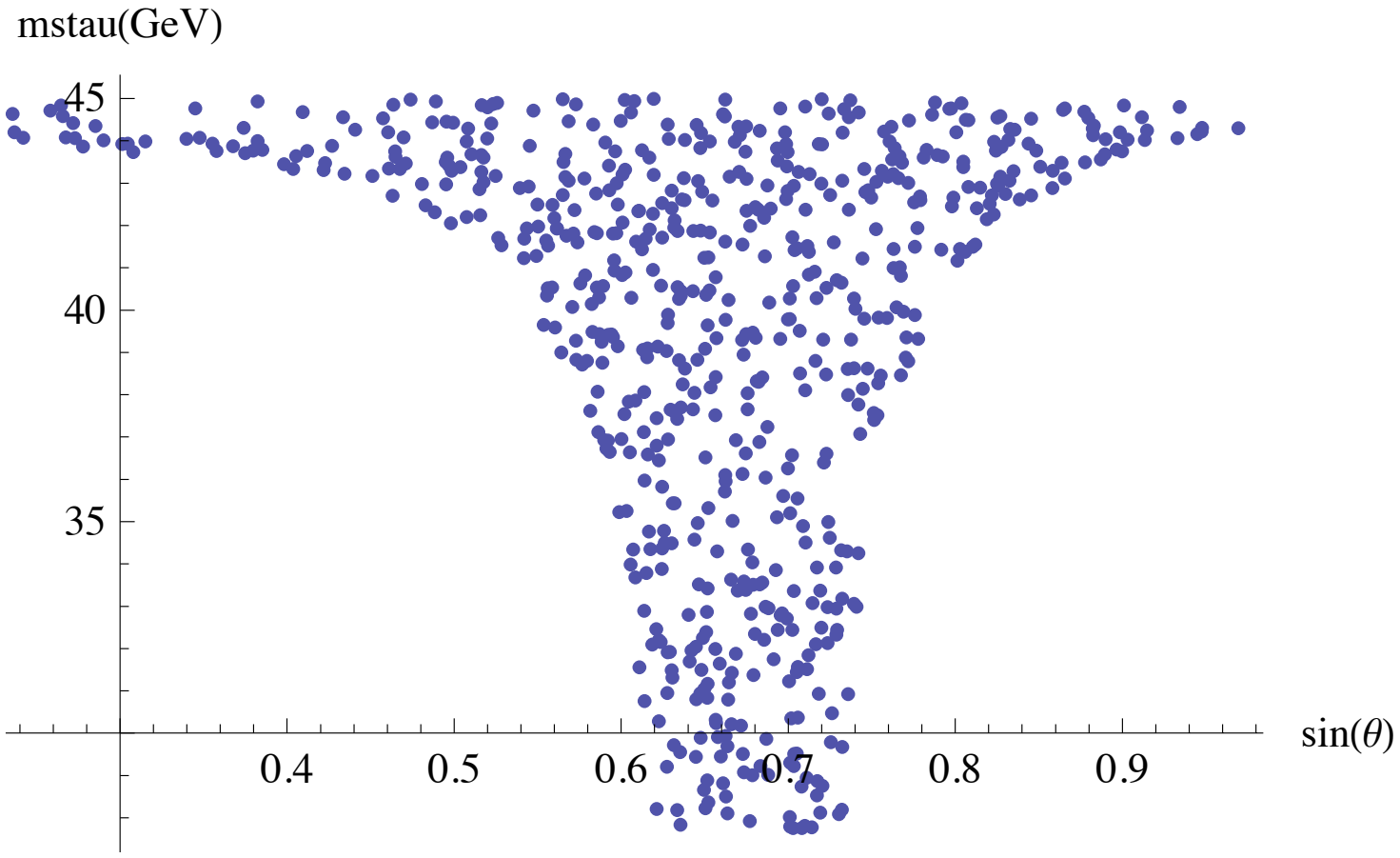
hadron production vs mixing angle for 27 GeV stau



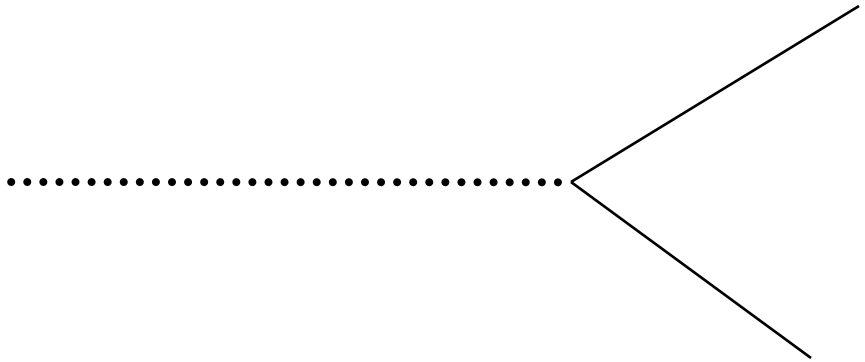
- Fit for light stau surpasses SM fit at 22 GeV.

- Fit for light stau is within 2 sigma of data for staus above 27GeV

Stau mass vs allowed mixing angle



2 body decays of scalars



- LLE stau plus missing energy
- LQD 2 quarks or quark plus lepton
- UDD two quarks

Higgs decays

LSP	LLE	LQD	UDD
χ_0	$4\tau+2\nu$	4b/4c+2ν, 2b+2c+2ν, 2b+2c+2τ,3b+c+τ+ν, b+3c+τ+ν	2b+2c+2q
g	-	4b/4c+2ν, 2b+2c+2ν, 2b+2c+2τ,3b+c+τ+ν, b+3c+τ+ν	2b+2c+2q
b	-	2b+2ν, 2c+2τ, b+c+ν+τ	2c+2q
τ	2τ+2ν	2b+2c	-

Table 2: Higgs decay signals for all possible LSPs and RPV operators

Constraining searches

LSP	Signature	Mass Bound	Search
χ_0	$4q + 2\nu$	105 GeV	WW^* with invisible Z decay
$\tilde{g}$	$4q + 2\nu$	105 GeV	WW^* with invisible Z decay
$\tilde{b}$	$2q + 2\nu$	103 GeV	SUSY squark search
-	$2b + 2\nu$	111 GeV	SUSY squark search
-	$4q$	105 GeV	WW^* with invisible Z decay
$\tilde{\tau}$	$\tau\overline{\tau} + 2\nu$	104 GeV	WW^*
-	$l\bar{l} + 2\nu$	104 GeV	WW^*
-	4q	105 GeV	WW^* with invisible Z decay

Conclusions

- RPV MSSM has parameter space for light LSPs which may be decay products of Higgs
- Possibility open for over a dozen strange Higgs decay signals
- In many cases new signals mean relaxed lower mass bounds for Higgs