Sneurino NLSP in νCMSSM

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Based on the work in collaboration with
Keith Olive and Liliana Velasco-Sevilla
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Outline

- Model : νCMSSM
- Motivation: Light left-handed sneutrino
- Results: “Sneutrino Coannihilation region”
- Discussion

Model: νCMSSM

CMSSM(Constrained Minimal Supersymmetric Model)+N

$$W = W_{MSSM} + y_N N L H_u + \frac{1}{2} M_N N N$$

$$m_0, M_{1/2}, A_0, \tan\beta, sign(\mu)$$

$$M_N(Q_{GUT}), m_\nu(Q_{Mz})$$

$$Q_{GUT} \sim 2\times 10^{16} GeV, M_N \sim 10^{15} GeV$$

$$Q < M_N : L \ni -\kappa(LH_u)(LH_u) \Rightarrow m_\nu(Q_{EW}) = \kappa\langle H_u\rangle^2$$

Q: Does a heavy N affect low energy phenomenology?

Effects of heavy N

Gauge unifications, flavor physics

(Hisano et al 96, Casas et al 01,Baer et al 01,Blair et al 01,Dedes 07,Ibarra et al 08,Hirsch et al 08, E.J.Chun et al 08)

Dark Matter

(Petcov et al 04, Calibbi et al 07, Barger et al 08, Gomez et al 09)

Left-handed sneutino NLSP with Neutralino LSP

New: “Sneutrino Coannihlation Region”

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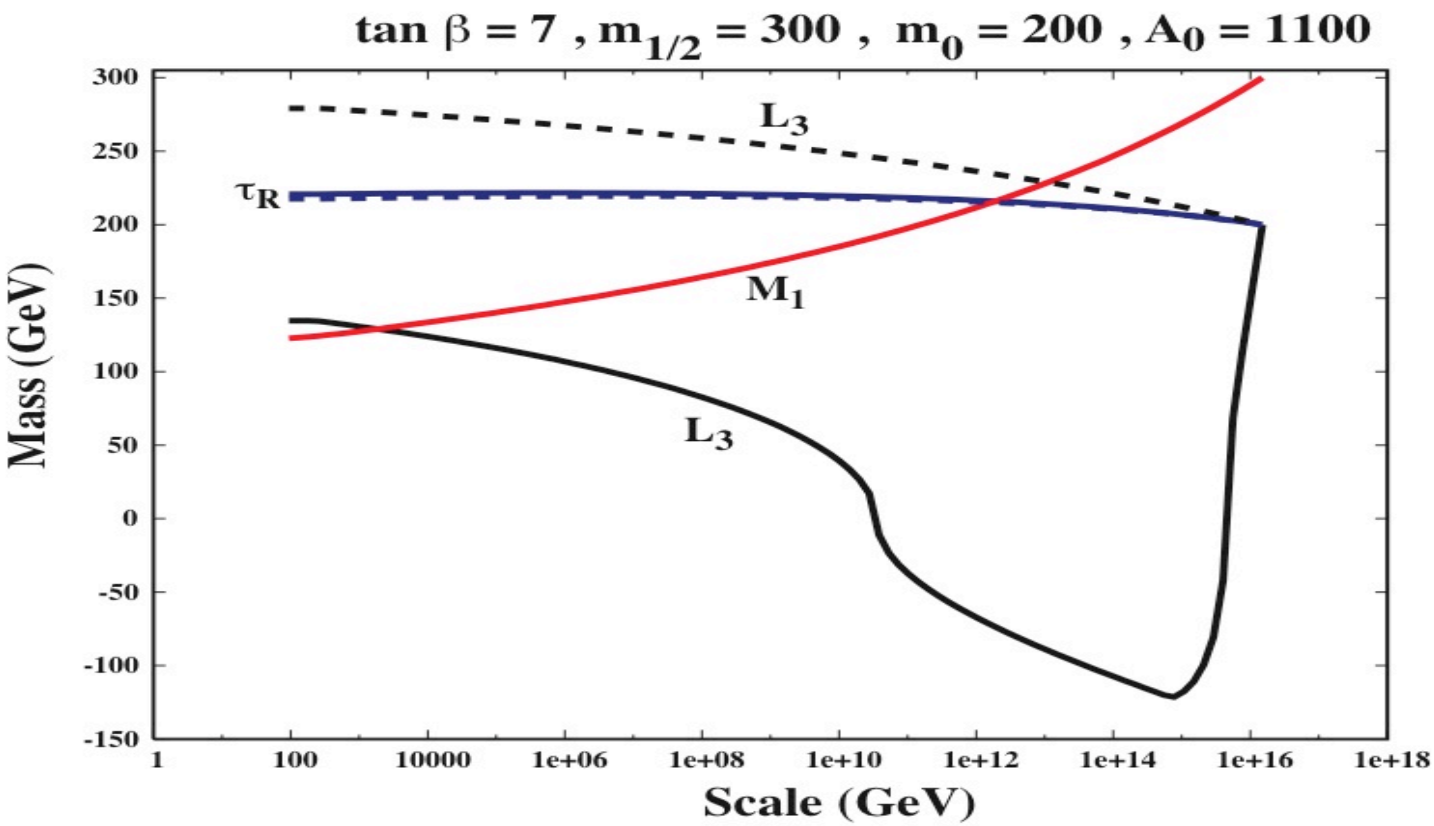
Motivation: Light left-handed sneutrino



$$M_N = 10^{15} GeV,$$
$$m_\nu = 0.05 eV,$$
$$y_N(Q_{GUT}) \sim 2.5,$$
$$y_N(M_N) \sim 1.8$$

Light left-handed sneutrino doesn't occur in CMSSM

Left-handed sneutino NLSP with Neutralino LSP in νCMSSM

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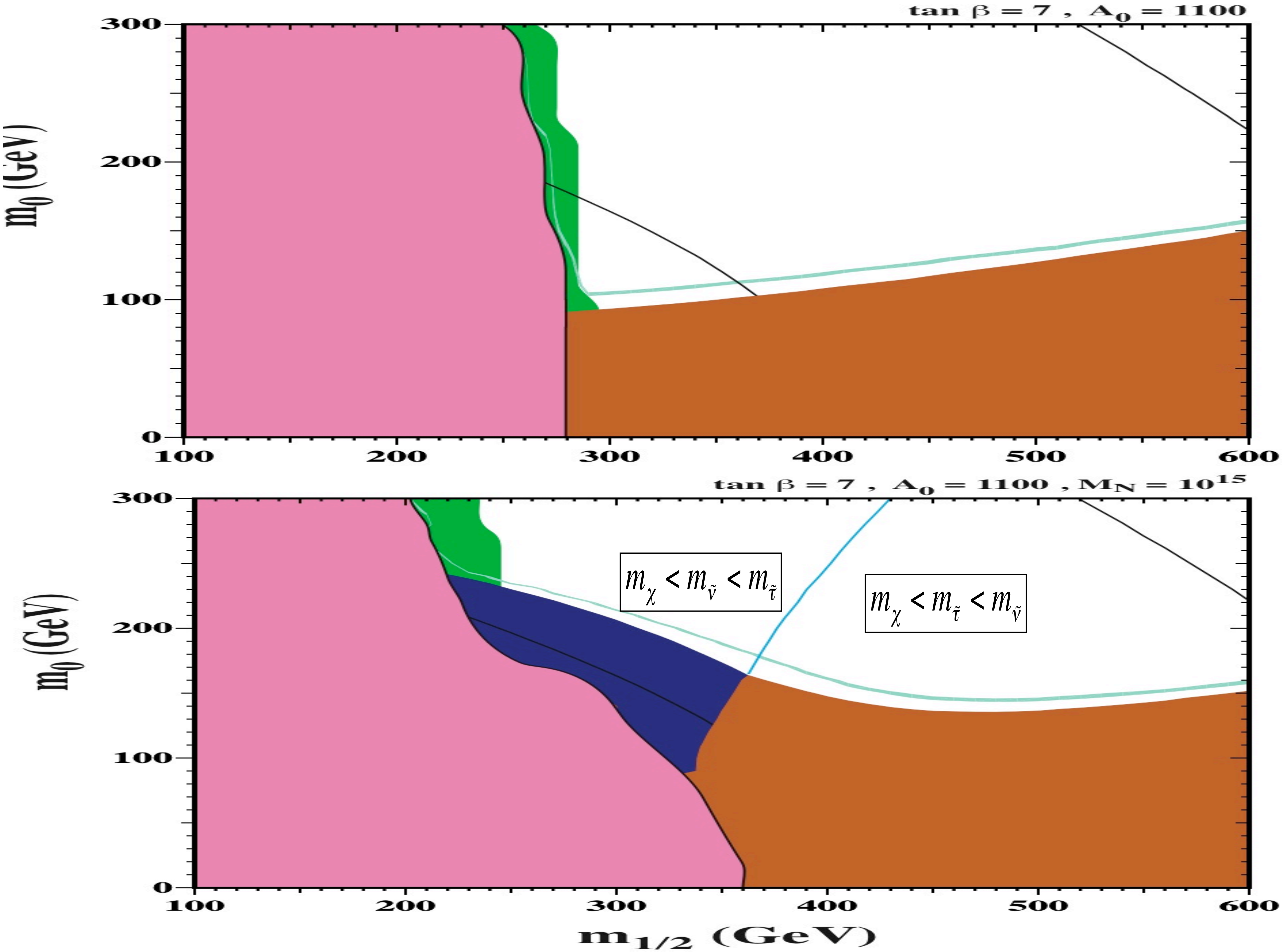
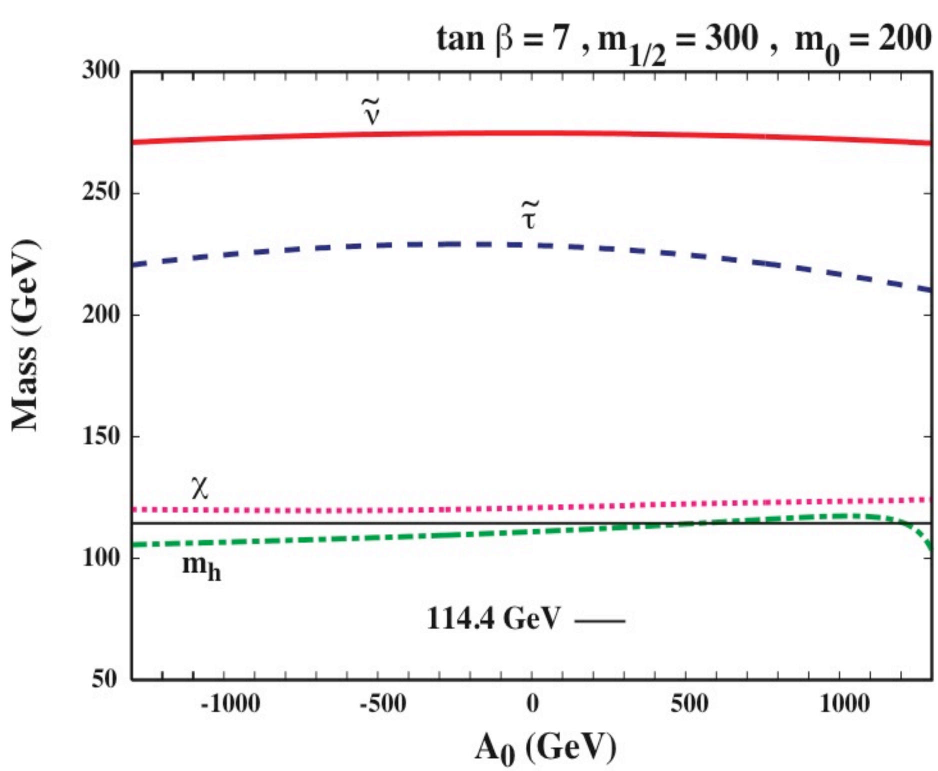

tan β = 7 , A0 = 1100
m0 (GeV)
300
200
100
0
100
200
300
400
500
600
tan β = 7 , A0 = 1100 , MN = 10^15
m_χ < m_ν̃ < m_τ̃
m_χ < m_τ̃ < m_ν̃
m1/2 (GeV)

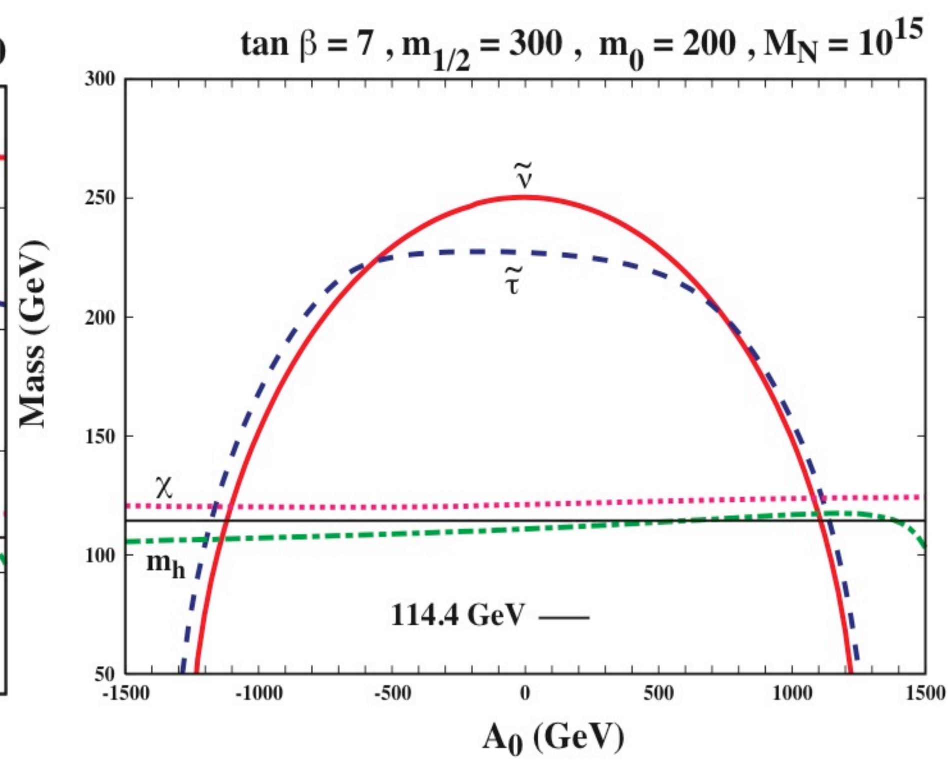
Parameter Choice for sneutrino NLSP

$$\frac{d}{dt} m_{L3}^2 = \frac{1}{8\pi^2} y_N^2 X_N + \ldots$$

$$X_N = m_{L3}^2 + m_N^2 + m_{Hu}^2 + A_N^2$$

Small m_0 Large A_0 Small $M_{1/2}$ Moderate $\tan\beta$





Discussion

- Sneutrino NLSP with neutralino LSP
  "Sneutrino coannihilation region"
- Collider signature of sneutrino NLSP with neutralino LSP

$$q\overline{q} \rightarrow Z \rightarrow \tilde{\nu}\tilde{\nu}^{*}, q\overline{q'} \rightarrow W \rightarrow \tilde{\nu}\tilde{l}^{*}$$

$$e^{+}e^{-} \rightarrow \tilde{\chi}_{1}^{+}\tilde{\chi}_{1}^{-} \rightarrow \tilde{\nu}\tilde{\nu}^{*} l^{-} l^{+}$$

(Kalinowski et al'08)

- Sneutrino NLSP with Gravitino LSP

$$\Omega_{G} h^{2} = \frac{m_{G}}{m_{\tilde{\nu}}} \Omega_{\tilde{\nu}} h^{2} + \Omega_{G}^{T} h^{2} \Rightarrow \Omega_{\tilde{\nu}} h^{2} \leq 0.1$$

(Covi et al'07, Ellis et al '08)

Also talks by Anibal Medina and Terrance Figy

Process	500 GeV	σ [fb], presel.	σ^{cut} [fb]
Signal	$ee \to e\mu\bar{\nu}_e\nu_\mu\tilde{\chi}_1^0\tilde{\chi}_1^0$	3.940(8)	1.639(3)
SUSY τ Bkgd.	$ee \to \tau\tau\tilde{\chi}_1^0\tilde{\chi}_1^0 \to e\mu\tilde{\chi}_1^0\tilde{\chi}_1^0 4\nu$	4.107(7)	0.978(2)
SUSY $\tau\nu$ Bkgd.	$ee \to \tau\tau\tilde{\chi}_1^0\tilde{\chi}_1^0 2\nu \to e\mu\tilde{\chi}_1^0\tilde{\chi}_1^0 6\nu$	3.245(10)	0.818(3)
SUSY τe Bkgd.	$ee \to e\tau\bar{\nu}_e\nu_\tau\tilde{\chi}_1^0\tilde{\chi}_1^0 \to e\mu\tilde{\chi}_1^0\tilde{\chi}_1^0 4\nu$	3.691(9)	1.102(8)
SUSY $\tau\mu$ Bkgd.	$ee \to \mu\tau\nu_\mu\bar{\nu}_\tau\tilde{\chi}_1^0\tilde{\chi}_1^0 \to e\mu\tilde{\chi}_1^0\tilde{\chi}_1^0 4\nu$	2.617(10)	0.966(8)
SM WW Bkgd.	$ee \to e\mu 2\nu$	152.42(25)	0.736(2)
SM $e\tau$ Bkgd.	$ee \to e\tau 2\nu \to e\mu 4\nu$	26.522(12)	0.317(1)
SM $\mu\tau$ Bkgd.	$ee \to \mu\tau 2\nu \to e\mu 4\nu$	15.569(54)	0.174(1)
SM ν Bkgd.	$ee \to e\mu 4\nu$	0.145(1)	0.016(3)
SM τ Bkgd.	$ee \to \tau\tau \to e\mu 4\nu$	32.679(98)	< 0.001
SM $\tau\nu$ Bkgd.	$ee \to \tau\tau 2\nu \to e\mu 6\nu$	3.852(10)	0.335(9)
SM $\gamma \to \tau$ Bkgd.	$\gamma^*\gamma^* \to \tau\tau \to e\mu 2\nu$	21392(70)	0.273(2)
SM $\gamma \to c$ Bkgd.	$\gamma^*\gamma^* \to c\bar{c} \to e\mu jj 2\nu$	1089(4)	< 0.001
SM $\gamma \to W$ Bkgd.	$\gamma^*\gamma^* \to WW \to e\mu 2\nu$	1.094(6)	0.079(1)
SM $\gamma \to \tau\nu_\tau$ Bkgd.	$\gamma^*\gamma^* \to \tau\tau 2\nu \to e\mu 8\nu$	0.077(1)	< 0.001
SM $\gamma \to \ell\tau$ Bkgd.	$\gamma^*\gamma^* \to (e,\mu)\tau 2\nu \to e\mu 4\nu$	0.404(2)	0.055(2)

Table 1: Cross sections for all signal and background processes for an ILC energy of 500 GeV. ISR and beamstrahlung are always included. Note that the final states e always means electron and μ always anti-muon. For more details about the processes confer the text. The "presel." column always includes a 5° cut for the final electron to cut out collinear regions, and for the γ-induced processes a 1° cut for particles vanishing in the beampipe. The last column shows cross sections after the cuts discussed in Sec. 3. In parentheses are the WHIZARD integration errors.

ILC, SUSY processes appear to have a generic cascade chain structure, but due to their production being electroweak, a lot more interference among different chains is possible