Enhanced Tau Lepton Signatures at LHC in Constrained Supersymmetric Seesaw Scenarios

Kenji Kadota

Michigan Center for Theoretical Physics

Based on the work
K.K. &Jing Shao(PRD80(2009), 0910.5517[hep-ph]),
(K.K. and Keith Olive(PRD80(2009), 0909.3075[hep-ph])
K.K., K. Olive and L. Velasco-Sevilla (PRD79(09) 0902.2510[hep-ph]))

Outline

1) Motivation

2) Model

3) Enhanced tau signals

4) Results

Kenji Kadota
Pheno10

Enhanced Tau Signals at LHC

Motivation

- Model: Constrained Supersymmetric Seesaw

  CMSSM+a right-handed neutrino N_3 (GUT scale mass)

  Universal boundary conditions.

  Q: Does a heavy N affect collider signals?

- The main result:

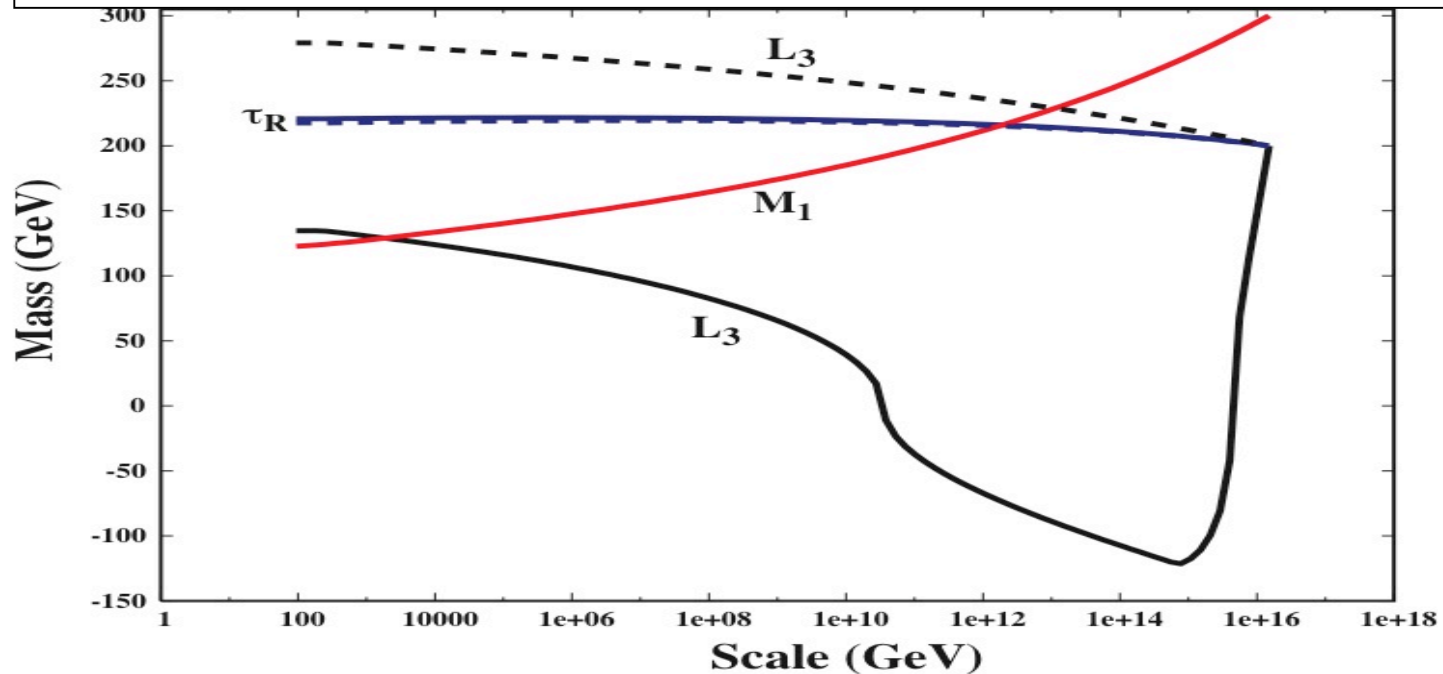 A large number of 3 or more hadronic tau events

Outline

1) Motivation

2) Model

3) Enhanced tau signals

4) Results

Model: Light left-handed stau doublet

$$\tilde{\chi}_1^0 : \text{Bino - like.} \quad \tilde{\chi}_2^0 \;\&\; \tilde{\chi}_1^\pm : \text{Wino - like.}$$

$$\text{CMSSM :} \quad \tilde{\tau}_1 \text{ is RH}$$

Drees&Nojiri '92, Baer et al '98, Barger&Kao '99, Lykken&Matchev '00, Hinchliffe&Paige '00, Wells '98, Arnowitt et al '06, Chattopadhyay et al '07, Katz&Tweedie '10 …

$$\text{Seesaw :} \quad \tilde{\tau}_1 \text{ is LH}$$

KK&J. Shao '09, K.K.&K. Olive '09, KK,K.Olive and L. Sevilla '09

Kenji Kadota   Enhanced Tau Signals at LHC
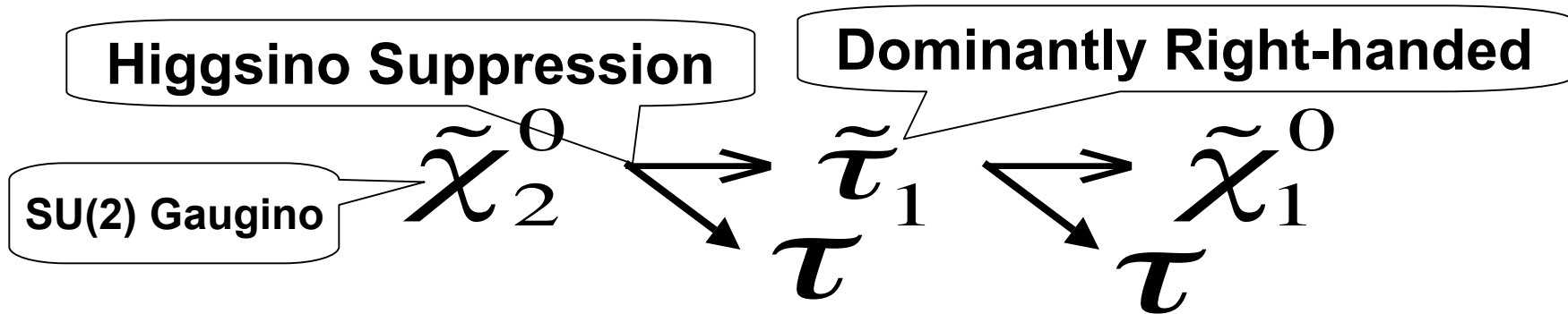Pheno10

Outline

1) Motivation

2) Model
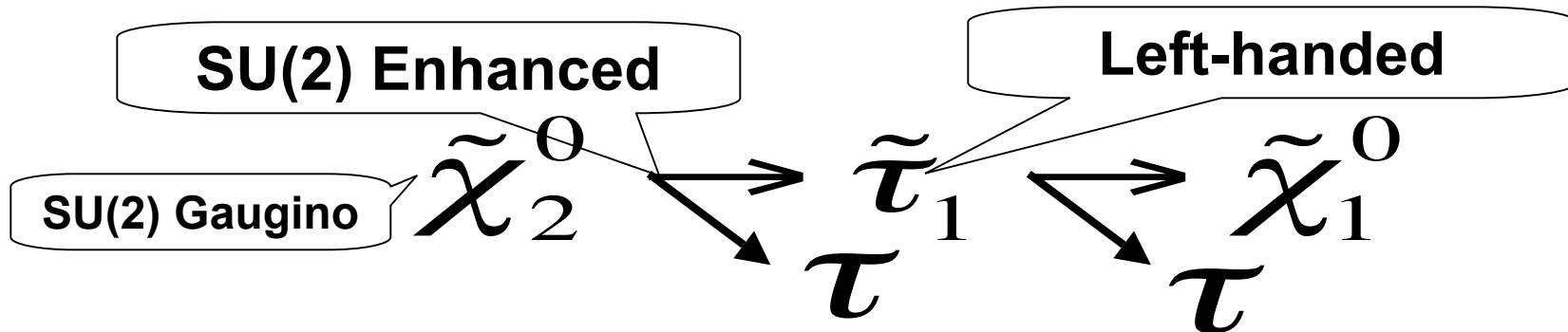
3) Enhanced tau signals

4) Results

Enhanced tau events in light stau doublet scenario

- Previous literature: Light <u>right-handed</u> stau

Large $\tan\beta$ or/and A_0:Kinematically preferable small $m_0, m_{1/2}$ tightly constrained by $Br(b \to s\gamma)$, $Br(Bs \to \mu^+ \mu^-)$ etc.

Higgsino Suppression

Dominantly Right-handed

SU(2) Gaugino

$$\tilde{\chi}^0_2 \Rightarrow \tilde{\tau}_1 \Rightarrow \tilde{\chi}^0_1$$
$$\tau \qquad \tau$$

- This talk: Light <u>left-handed</u> stau

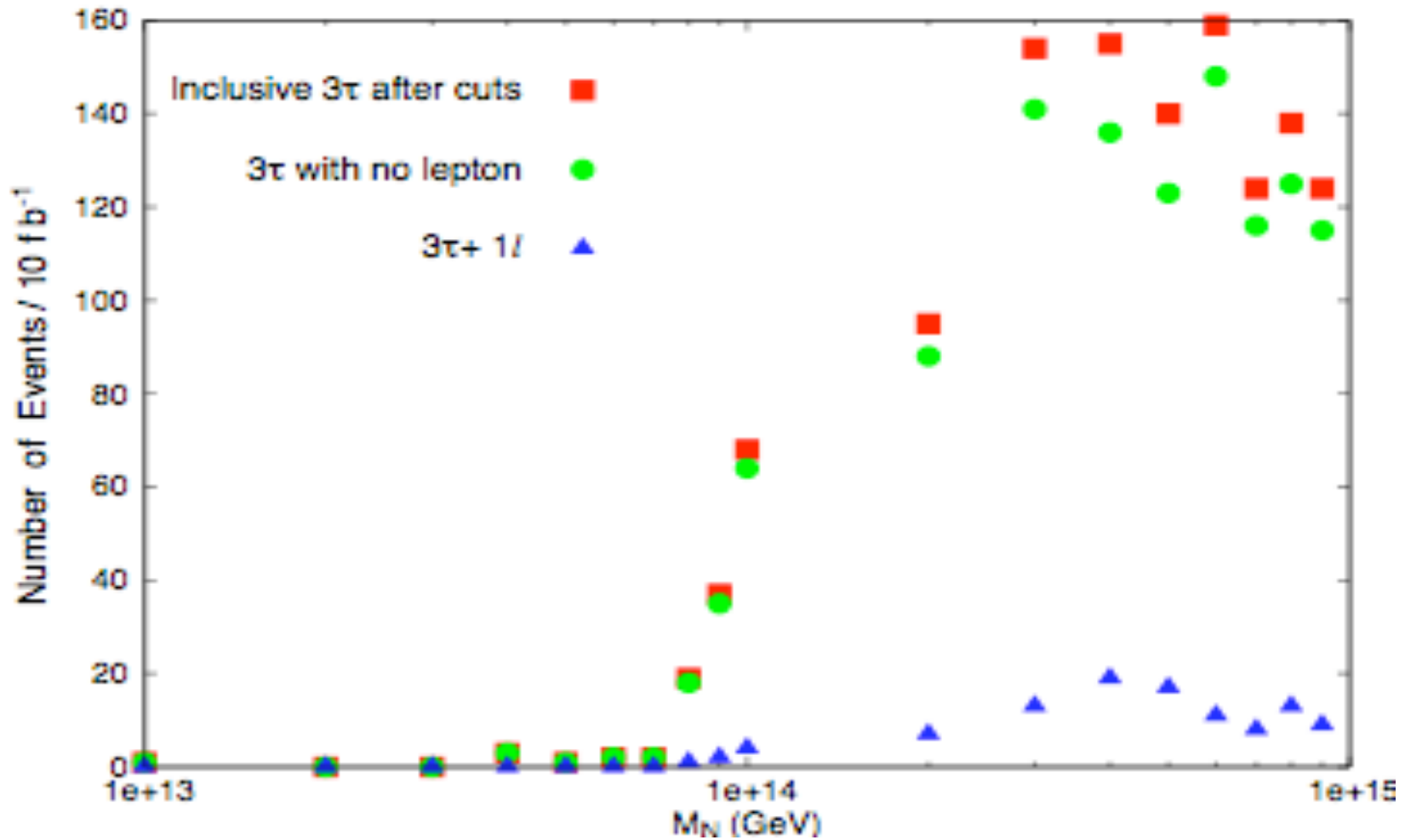Kinematically preferable small $m_0, m_{1/2}$ (Sneutrino Co-annihilation region)

SU(2) Enhanced

Left-handed

SU(2) Gaugino

$$\tilde{\chi}^0_2 \Rightarrow \tilde{\tau}_1 \Rightarrow \tilde{\chi}^0_1$$
$$\tau \qquad \tau$$

Kenji Kadota
Pheno10

Enhanced Tau Signals at LHC

Outline

1) Motivation

2) Model

3) Enhanced tau signals

4) Results

Figure axes: Number of Events / 10 f b⁻¹ (y-axis, rendered as $\text{Number of Events} / 10\ \text{f b}^{-1}$) versus M_N (GeV) (x-axis).

Legend:
- Inclusive 3τ after cuts ■
- 3τ with no lepton ●
- $3\tau + 1l$ ▲

138 3-tau events for constrained seesaw @ $M_N = 8 \times 10^{14}$ GeV.
1 3-tau event for CMSSM

Kenji Kadota   Enhanced Tau Signals at LHC
Pheno10

Conclusion

Enhanced Tau Lepton Signatures in
Constrained Supersymmetric Seesaw Scenarios

- Production and decay of weak gauginos

  could signal the deviations from SM

  e.g. Enhanced tau events
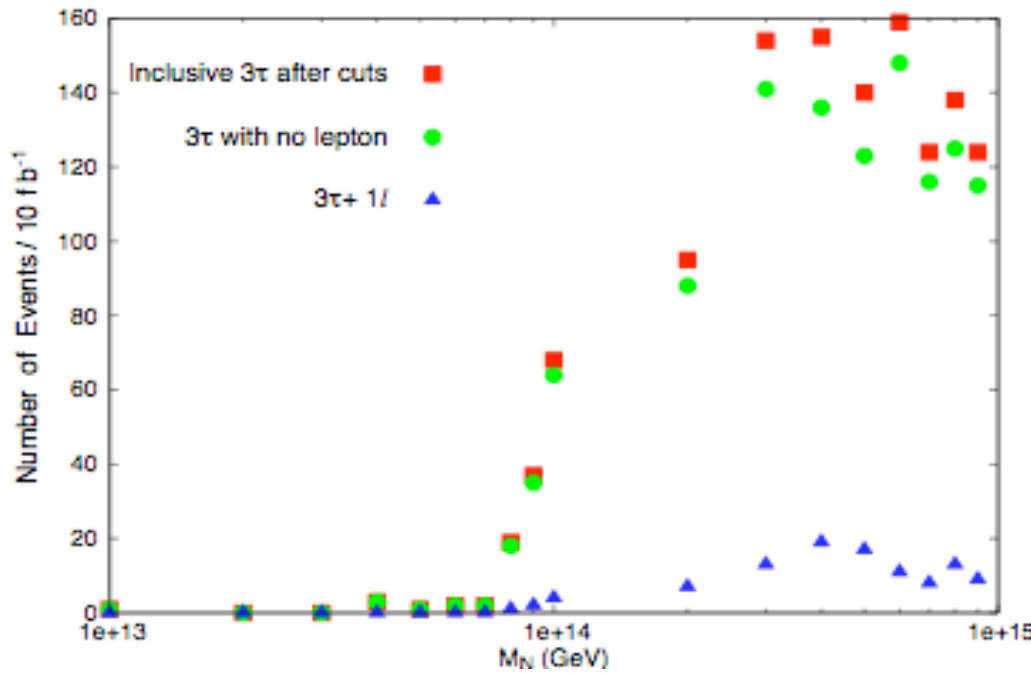
   (could be related to finite neutrino masses)

- Simple cuts:

1) Four jets with pt>50GeV with the leading jets pt>100GeV

2) MET>max(0.2Meff,100GeV)

3) Leptons (e,μ) pt>20GeV and $|\eta|$<2.5

4) Hadronically decaying taus pt>20GeV,
 $|\eta|$<2.5. Tau efficiency factor ε_τ=0.4.

Checked these strong cuts sufficiently reduce the backgrounds (ZZ, WZ, Z+Jets,WW,tt, QCD jets) to be negligible for 3 and 4 tau events for our study

- Jet rejection factor(function of ε_τ and jet Et):

300 for 20GeV<Et<30GeV

500 for 30<Et<60GeV

1000 for 60<Et<100GeV

3000 for 100GeV<Et

- Tau reconstruction/identification
- E.g. to be tested by ~100/pb of LHC data for multi jet backgrouds

Tau Decay

- 35% leptonically with two neutrinos
- 65% hadronically with one (50%) or three (15%) charged particles

- Low multiplicity and high collimation

Top plot axes: Number of Events / 10 fb^{-1} (y-axis), M_N (GeV) (x-axis)

Legend:
- Inclusive 3τ after cuts ■
- 3τ with no lepton ●
- 3τ + 1l ▲

Bottom plot axes: Mass (GeV) (y-axis), M_N (GeV) (x-axis)

Legend:
- $\tilde{v}_\tau$ ------
- $\tilde{\tau}_1$ ——
- χ_1^+ ——
- χ_1^0 ········

138 3-tau events for constrained seesaw @ $M_N = 8 \times 10^{14}$ GeV.
1 3-tau event for CMSSM for 10/fb

(sigma(tot)=50pb,
m0=180GeV, m12=250GeV,tanb=7)

	Seesaw	CMSSM
3 tau:	138	1
2 tau+1L:	521	5
1 tau+ 2L:	468	14
3L:	109	73
for 10/fb		
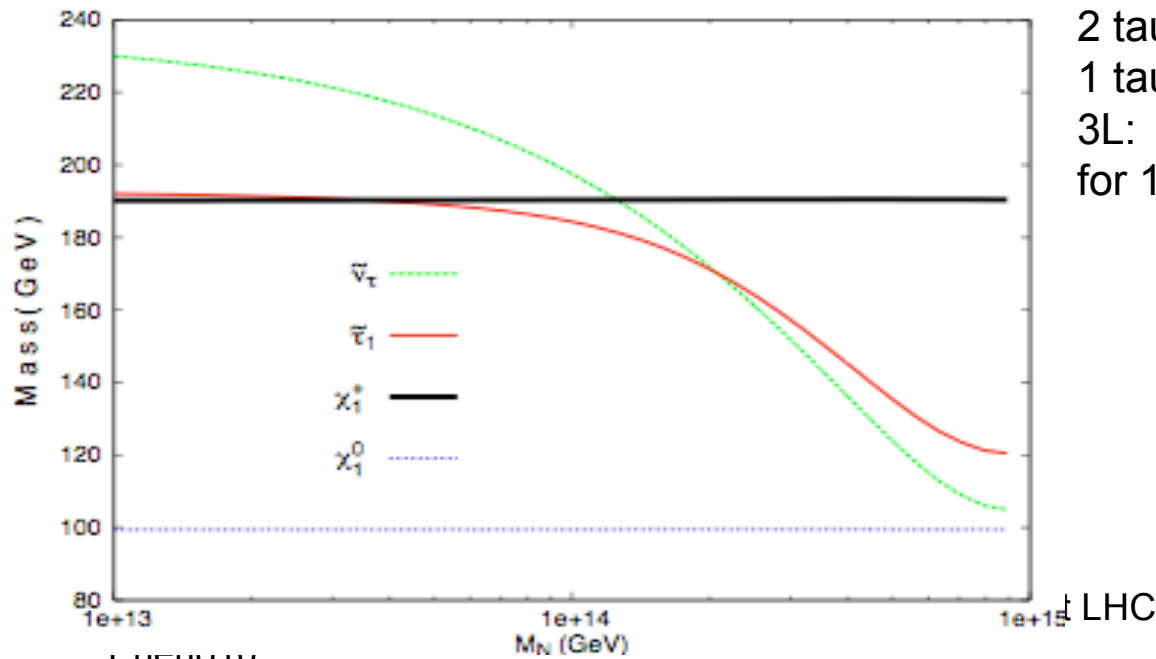
LHC

Model: Constrained Seesaw

CMSSM(Constrained Minimal Supersymmetric Model)+N

$$W = W_{MSSM} + y_N NLH_u + \frac{1}{2} M_N NN$$

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

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

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

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

Q: Does a heavy N affect collider signals?