Lepton flavor violation in SUSY decays

Ian Hinchliffe

(see Hinchliffe and Paige hep-ph-001086)

Outline

- Motivation
- Reminder of slepton rates
- One study
- Conclusions

Motivation

- Lepton number is violated (neutrino oscillations)
- Simplest is a see-saw. In SUSY
- $$y^N_{ij} H_2 L_i N_j + N_i M_{ij} N_j + y^E_{ij} E_i L_j H_1 + \mu H_1 H_2$$
- M is large
- Diagonalise charged lepton masses
- 6x6 slepton matrix $$\tilde{\ell}^*_{M\,i} (M^2_{\tilde{\ell}})^{MN}_{ij} \tilde{\ell}_{N\,j} = (\tilde{\ell}^*_{L\,i} \quad \tilde{\ell}^*_{R\,k}) \begin{pmatrix} M^2_{L,\,ij} & M^2_{LR,\,il} \\ M^2_{LR,\,jk} & M^2_{R,\,kl} \end{pmatrix} \begin{pmatrix} \tilde{\ell}_{L\,j} \\ \tilde{\ell}_{R\,l} \end{pmatrix},$$
-

Motivation

$$M^2_{\tilde{l}\tilde{l}} = \begin{bmatrix} M_L^2 + D_L & 0 & 0 & 0 & 0 & 0 \\ 0 & M_L^2 + D_L & M^2_{\mu\tau} & 0 & 0 & 0 \\ 0 & M^2_{\mu\tau} & M^2_{\tau_L} + D_L & 0 & 0 & m_\tau \bar{A}_\tau \\ 0 & 0 & 0 & M_R^2 + D_R & 0 & 0 \\ 0 & 0 & 0 & 0 & M_R^2 + D_R & 0 \\ 0 & 0 & m_\tau \bar{A}_\tau & 0 & 0 & M^2_{\tau_R} + D_R \end{bmatrix}$$

Mixing in left sector

Soft SUSY breaking M_L and M_R dominate

Mixing term $M_{\mu\tau}$

e-μ mixing ignored for now (comment later)

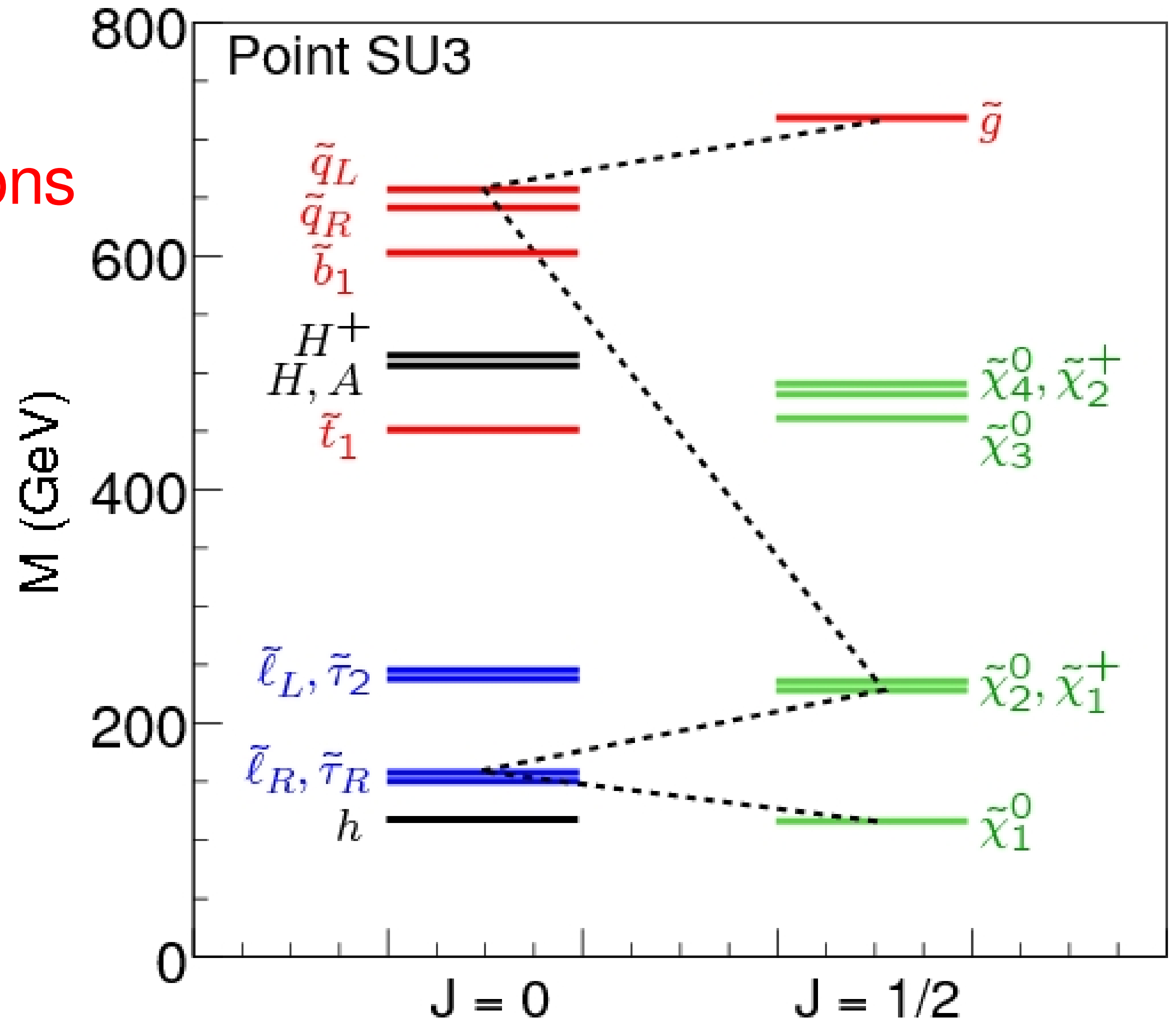
Motivation

- How big is $M_{\mu\tau}$
- If scalar masses diagonal at high scale, radiative corrections give $M^2_{ij} \sim M^2 (y_N y^*_N)_{ij}$
- Details depend on neutrino mixing
- Parametrize by $\delta = M^2_{ij} / M^2_L$

Phenomenology

Direct production of sleptons is small

Background difficult



Exploit cascade decays from squarks/gluinos

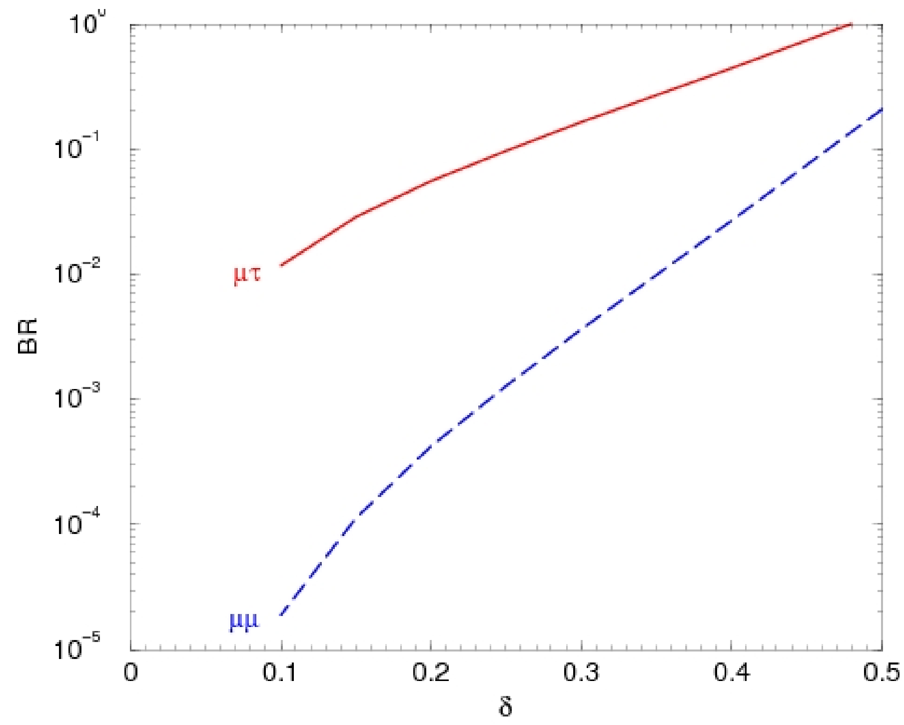
Phenomenology

Flavor mixing in left sector, therefore

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

Hence

$$\chi^0_2 \Rightarrow \mu\tau\chi^0_1,\ \mu\mu\chi^0_1$$



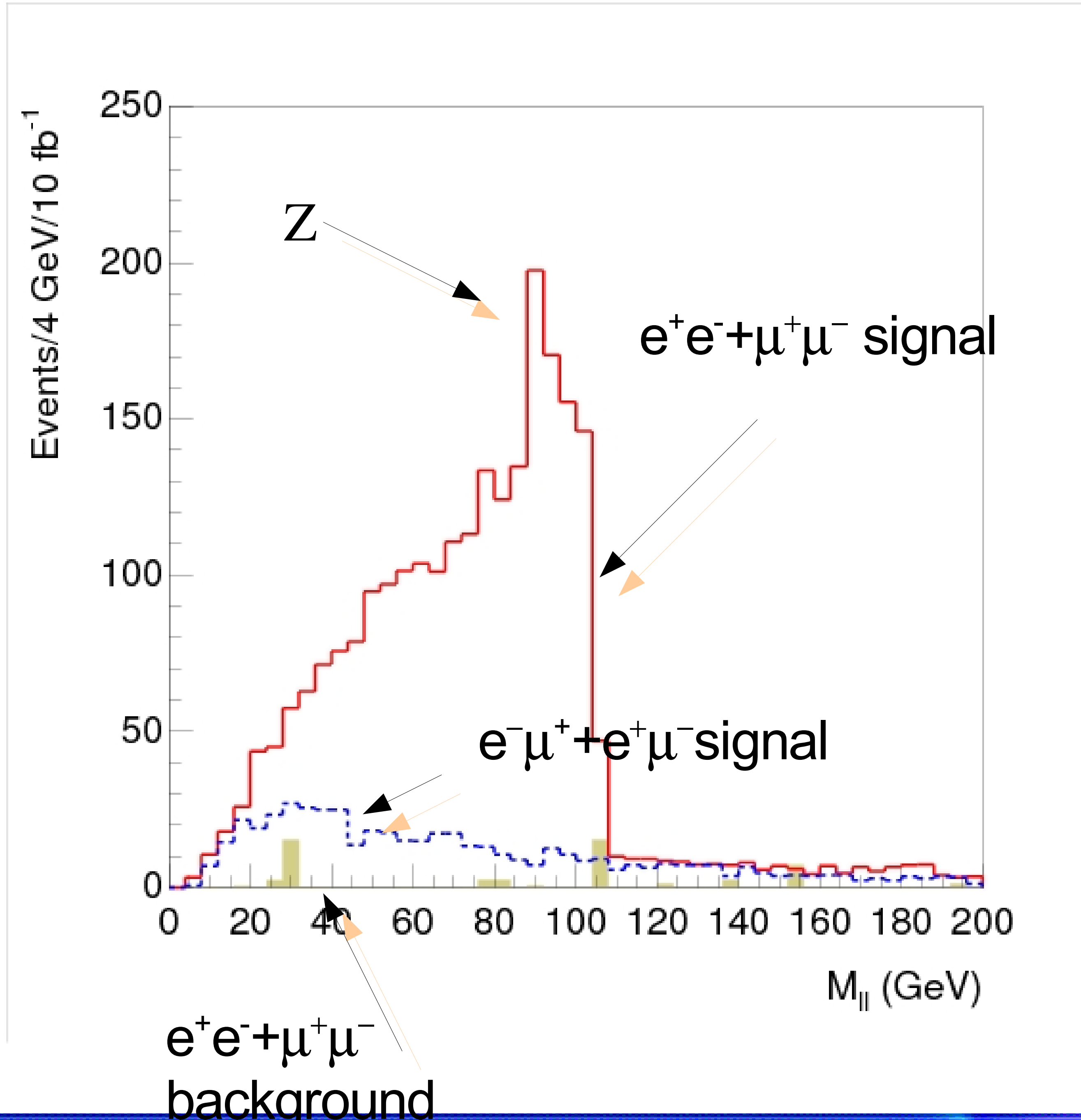
μμ unobservable

Study of one case

- SUGRA m_0=100, $m_{1/2}$=300,tanβ=10,A=300
- 600K events, corresponds to 25fb^{-1}
- Standard SUSY selection

  - ≥ 4 jets with $p_{T,1} > 100\,\mathrm{GeV}$ and $p_{T,2,3,4} > 50\,\mathrm{GeV}$;
  - $M_{\mathrm{eff}} \equiv \not{E}_T + p_{T,1} + p_{T,2} + p_{T,3} + p_{T,4} > 800\,\mathrm{GeV}$;
  - $\not{E}_T > 0.2 M_{\mathrm{eff}}$;

Then view dilepton invariant mass

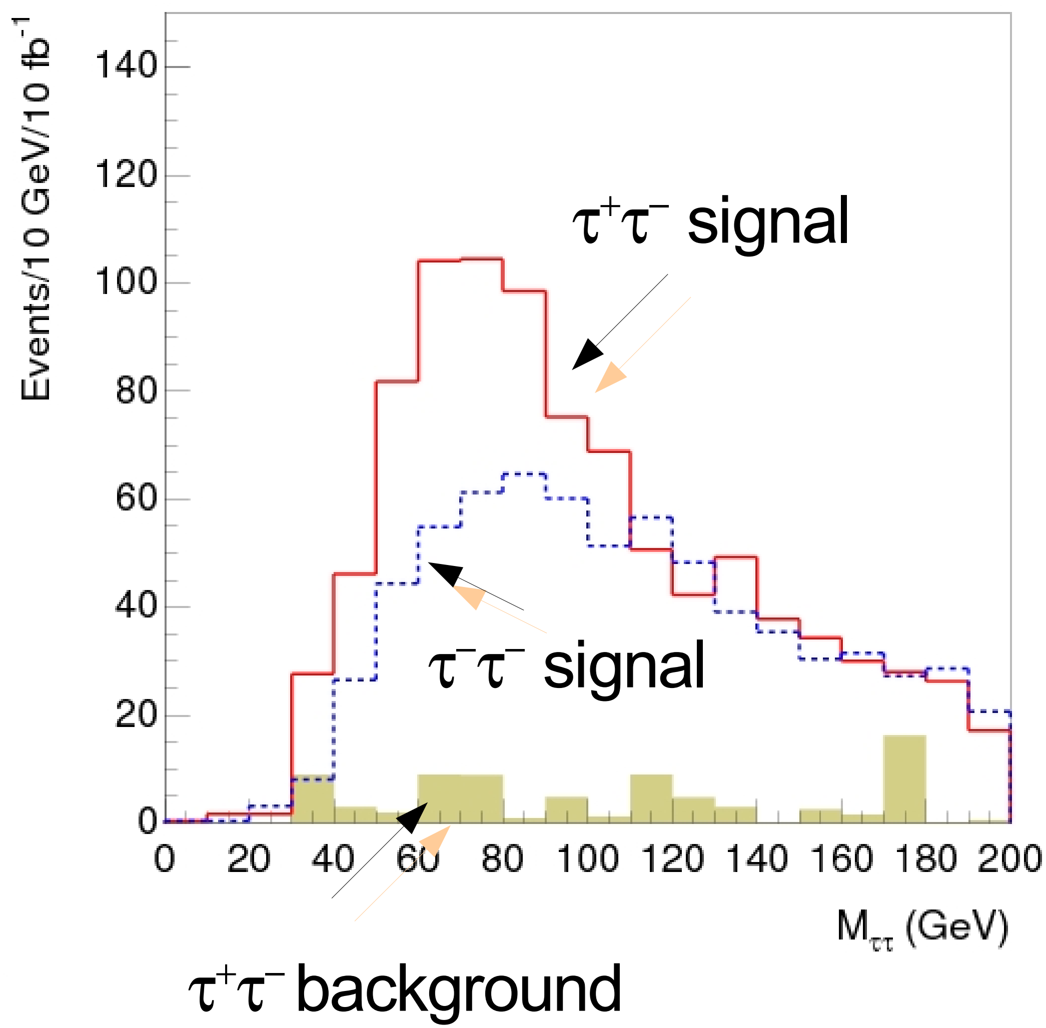

Events/4 GeV/10 fb^{-1}
250
200
150
100
50
0
0 20 40 60 80 100 120 140 160 180 200
M_{ll} (GeV)
Z
$e^+e^-+\mu^+\mu^-$ signal
$e^-\mu^++e^+\mu^-$signal
$e^+e^-+\mu^+\mu^-$
background

Taus

- Leptonic decays are useless (may not have come from tau)
- Must use hadronic decays
- Identify taus from hadronic decays: low multiplicty low mass jets.
- Can measure sign
- Look at tau pairs first

Visible hadronic decay products only

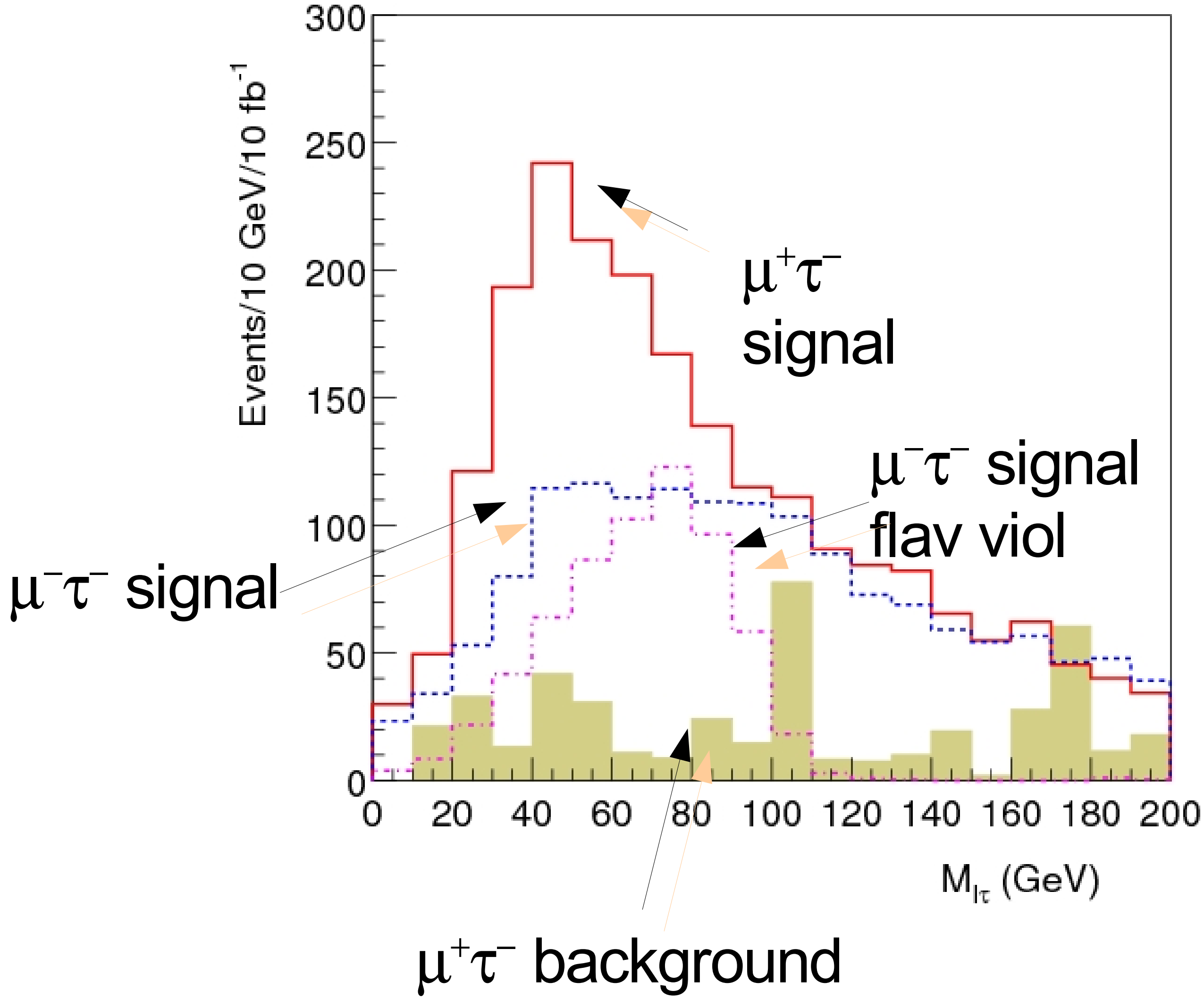
Peak smeared and shifted due to tau neutrinos lost



Comments

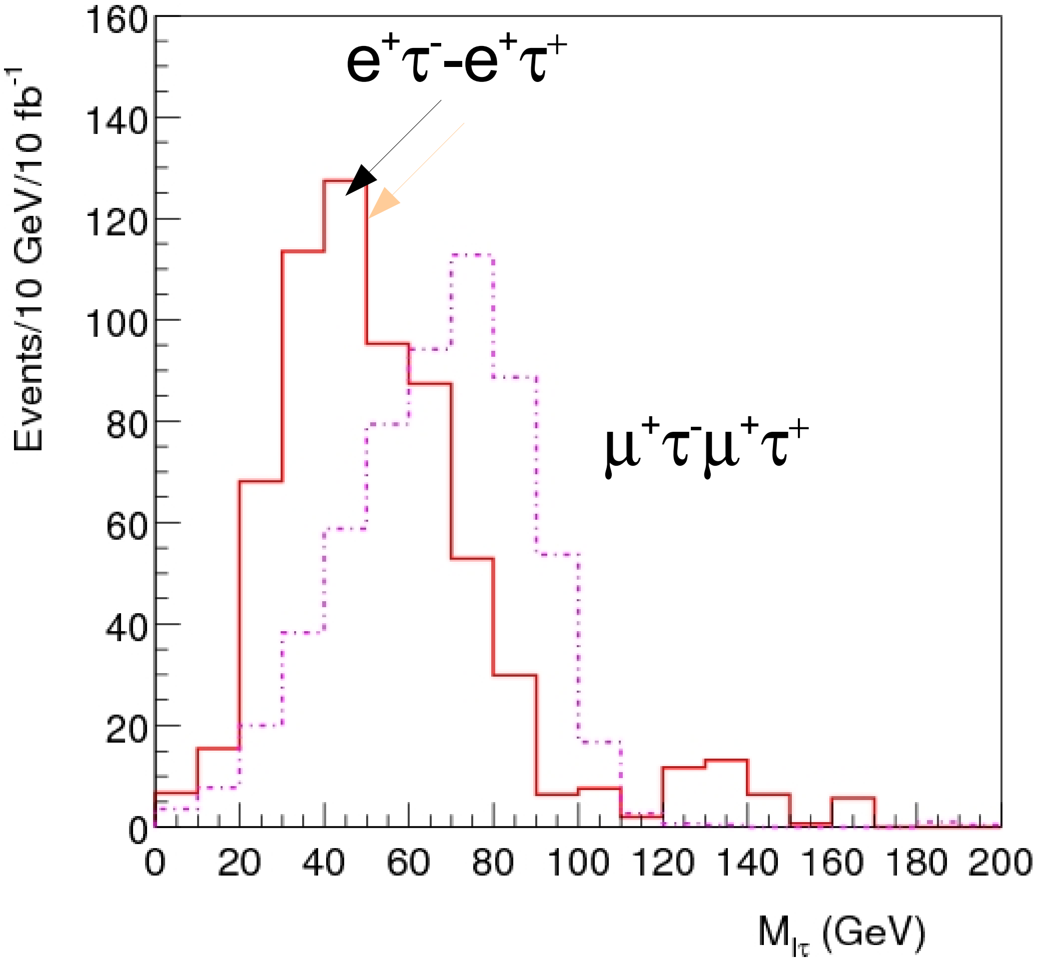
- Same sign comes from chargino decays
- Now three sources of $\mu\tau$
- τ pairs from χ^0_2 with one decay to μ and one hadronic
- $\tau\ \tau$ from chargino (same and opposite sign)
- Lepton flavor violation decay of χ^0_2
- Must disentangle these
- Note Lepton flavor violation give differant rate for $e\tau$ and $\mu\tau$

Note peaks in differant places



δ=0.25

Sign subracted removes SM background, CHARGINO but NOT LEPTON FLAVOR VIOLATION

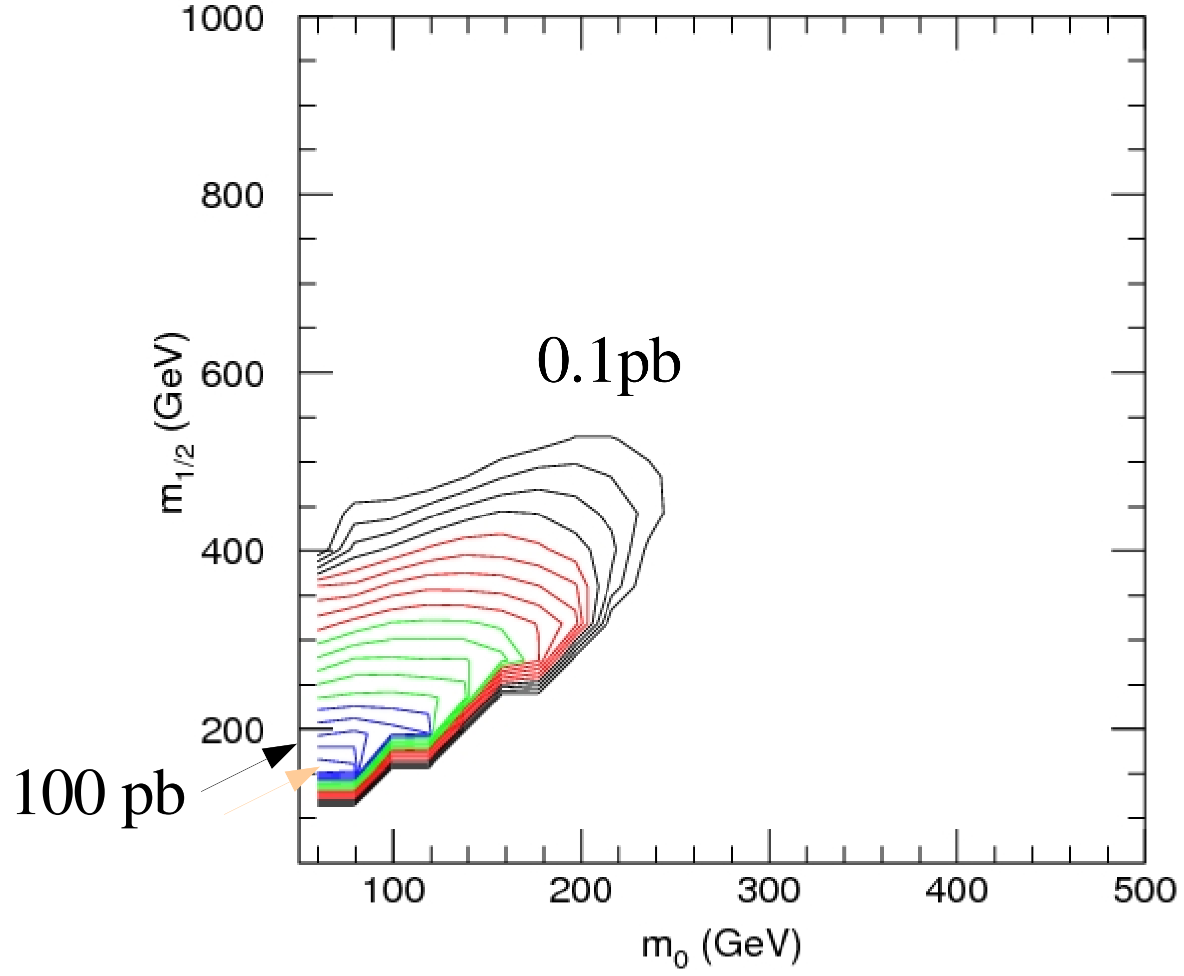


Sensitivity

- For this case 30 fb^{-1} implies 5σ with δ=0.1
- Approx same as BR(τ=>$\gamma\mu$)=10^{-9}
- Results very sensitive to masses of all sparticles
- Can estimate sensitivity in SUGRA for rate for stau prod.
- Need a cascade decay: true if $m_{1/2}$>m_0
- Rates can be estimated

Sensitivity

Stau rates



Conclusions

- Results here are with parametrized detector response; taus are hard so need to reevaluate with full simulation or (better) data
- Sensitivity may be better than (τ=>$\gamma\mu$) from W=>$\tau\nu$
- Limits will be very difficult to interpret!
- Same conclusions for eτ: eμ is easier (clean endpoint)
- See also Carvalho et al hep-ph/0206148,Deppisch et al hep-ph./0401243, Bartl et al hep-ph/0510074