Cosmologically Interesting(?) Studies of Chargino and Neutralino Production in the Focus Point Region

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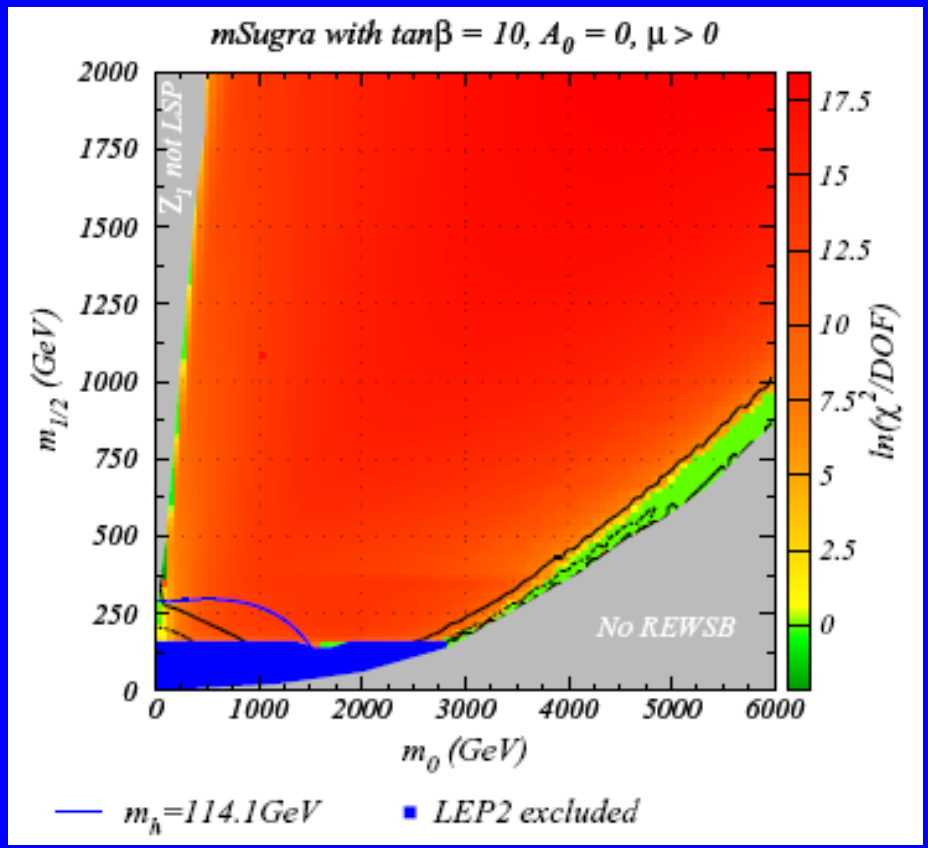
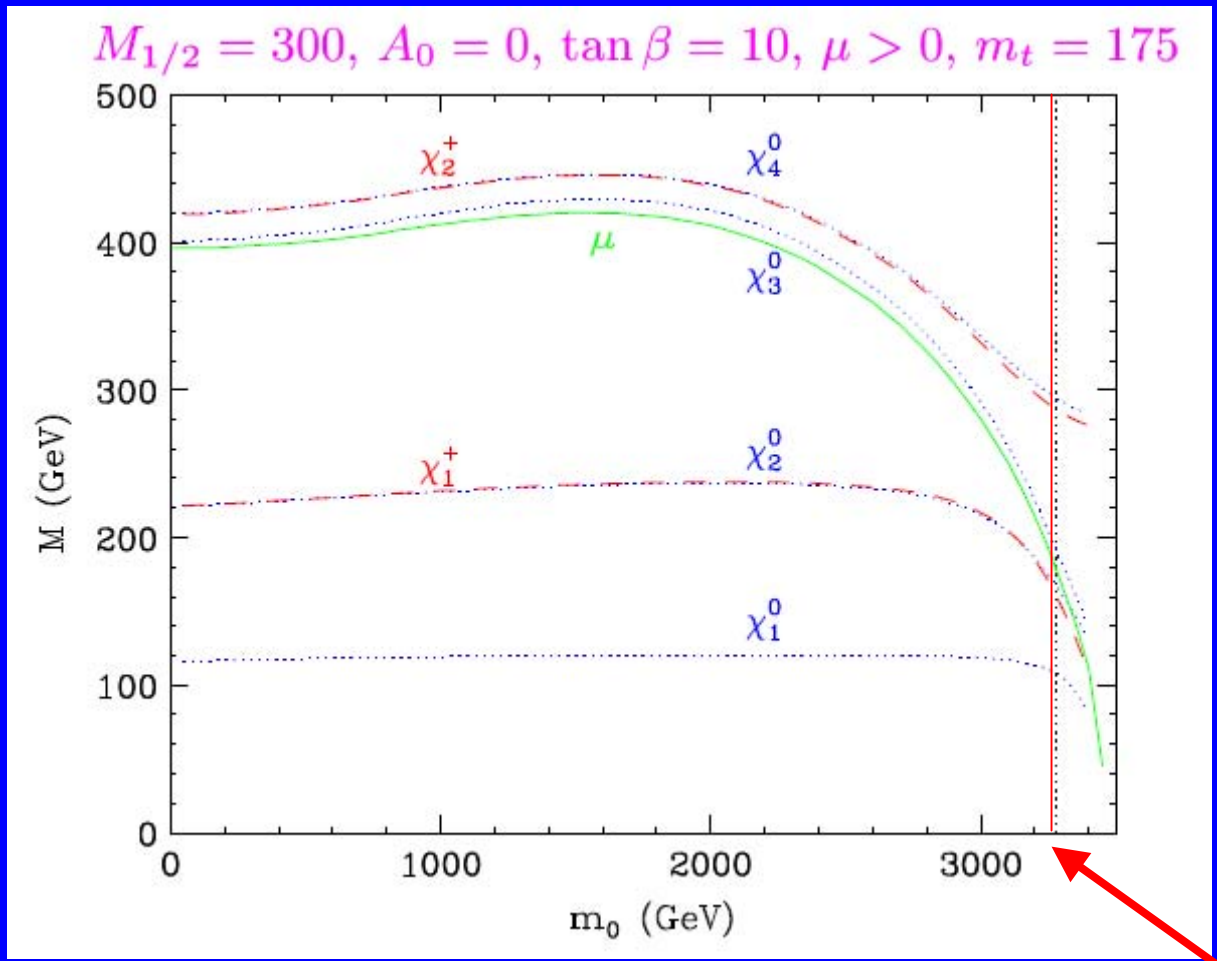
Introduction



Baer et al.

- SUSY models have good dark matter candidates
- WMAP $\Omega_h h^2$ limits relic densities
- mSUGRA generally has too much Dark Matter
- Focus Point one parameter set consistent with WMAP
  - higgsino admixture in LSP allows efficient annihilation

LCC2 Focus Point Spectrum



- Scalars are very heavy
- χ_1^0 is the LSP
- Charginos and neutralinos approach degeneracy
- 2 charginos & 3 neutralinos accessible at LC500

LCC2

LCC2 Focus Point Region

mSUGRA parameters:

m_0=3280 GeV

$m_{\frac{1}{2}}$=300 GeV

μ>0

A_0=0

tan β=10

	$\tilde{b}^0$	$\tilde{w}^0$	$\tilde{h}_1^0$	$\tilde{h}_2^0$
$\tilde{\chi}_1^0$	68%	4%	8%	20%
$\tilde{\chi}_2^0$	30%	25%	21%	24%
$\tilde{\chi}_3^0$	1%	1%	52%	46%
$\tilde{\chi}_4^0$	2%	70%	19%	9%

- Scalars are heavy m~2-3 TeV
  - except light higgs
- Lightest Neutralino is LSP = DM
  - has significant higgsino component for efficient annihilation
- $M\chi_i^0$ ={108,166,190,294}
- $M\chi_i^{\pm}$ = {159,287}

LCC2 Focus Point Region

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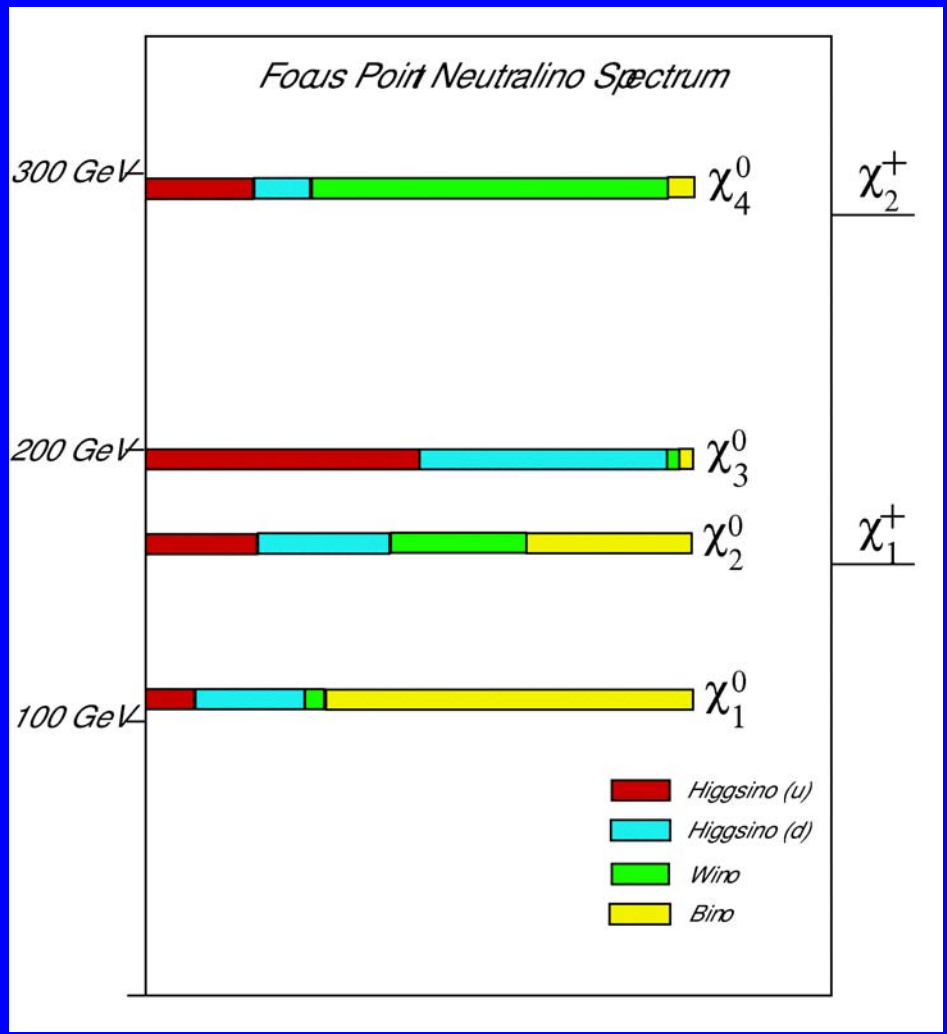
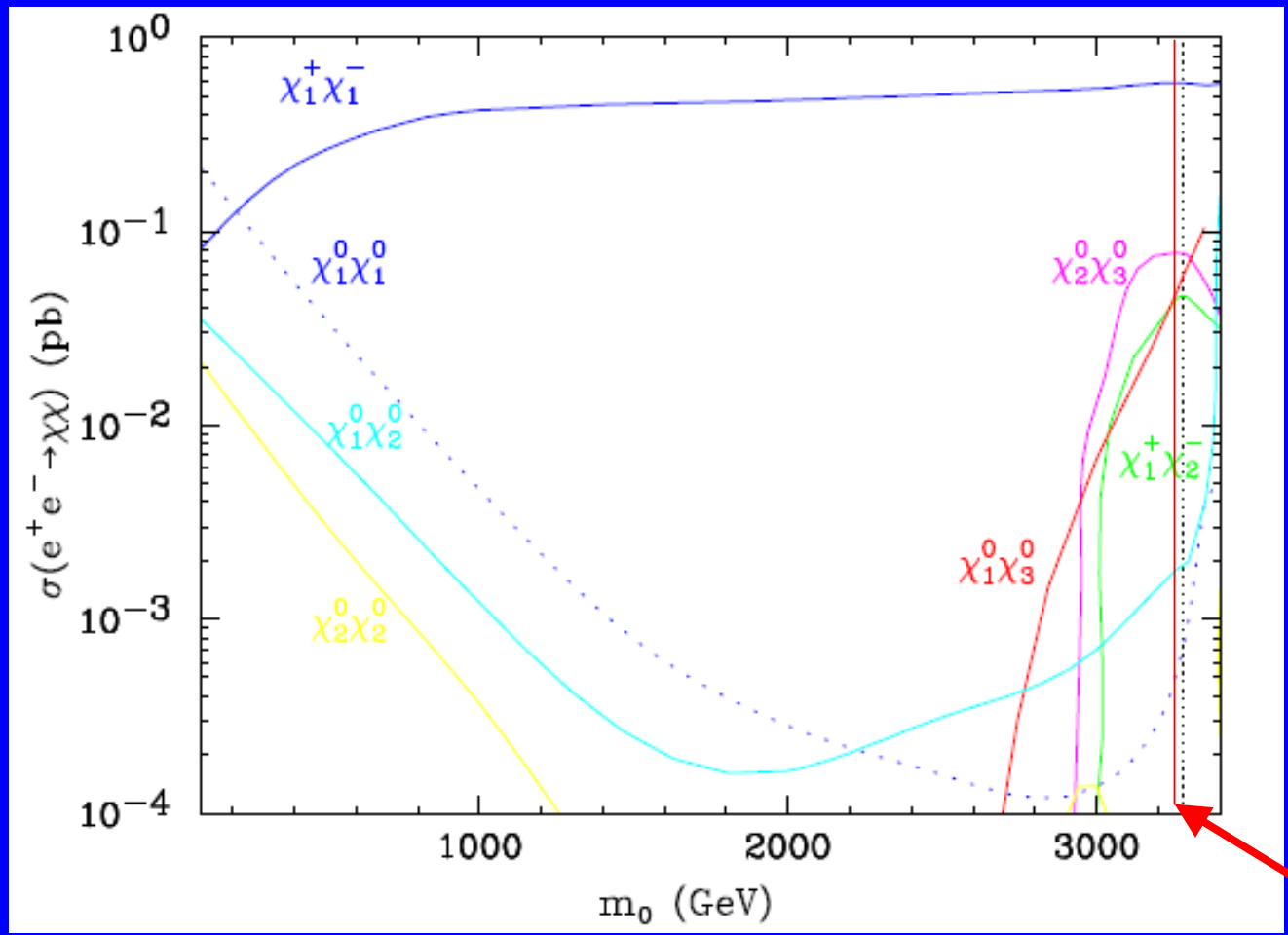


Pair Production Cross Sections



At LCC2

- $\chi_1^+\chi_1^-$
- $\chi_1^+\chi_2^-$
- $\chi_1^0\chi_3^0$
- $\chi_2^0\chi_3^0$

Decays

- Chargino/Neutralino decays to χ_1^0 (LSP)
  - three-body decays
    - $\chi_1^+ \rightarrow \chi_1^0 jj$, $\chi_1^0 \ell\nu$ (W*)
    - $\chi_{2,3}^0 \rightarrow \chi_1^0 jj$, $\chi_1^0 \ell\ell$ (Z*)
  - Z and W-like Branching ratios
- Signatures
  - $\chi_1^+\chi_1^-$: 4j, **2j+ℓ**
  - $\chi_1^0\chi_3^0$: **2j, 2ℓ**
  - $\chi_2^0\chi_3^0$: **2j+2l**, 4ℓ, 4j
  - $\chi_1^+\chi_2^-$: 6j, 4j+2l (W,Z)

In the focus point region the LC has access to the heavier neutralinos and charginos.
It may be possible to see these signals and measure masses, and the higgsino admixture to LSP.

Preliminary Results of Study

- Isajet 7.69
- LCD Root Fast MC
  - SD Mar01
- 250 fb^{-1} at 500 GeV
  - unpolarized beams
  - beam/bremsstrahlung
- Looking for signals
  - $\chi_1^+\chi_1^-$ (2j + ℓ)
  - $\chi_1^0\chi_3^0$ (2j ; 2ℓ)
  - $\chi_2^0\chi_3^0$ (2j + 2ℓ)

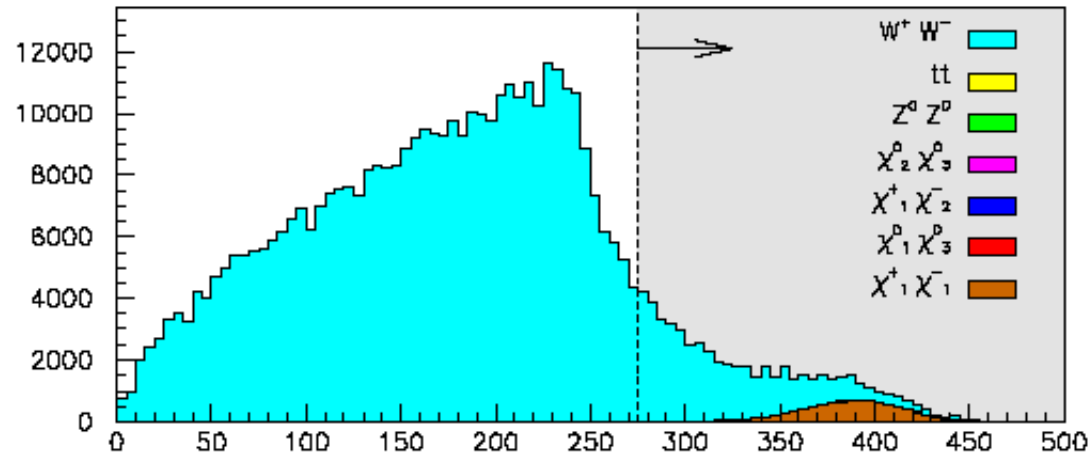
SUSY samples:

- $\chi_1^+\chi_1^-$
- $\chi_1^+\chi_2^-$
- $\chi_1^0\chi_3^0$
- $\chi_2^0\chi_3^0$

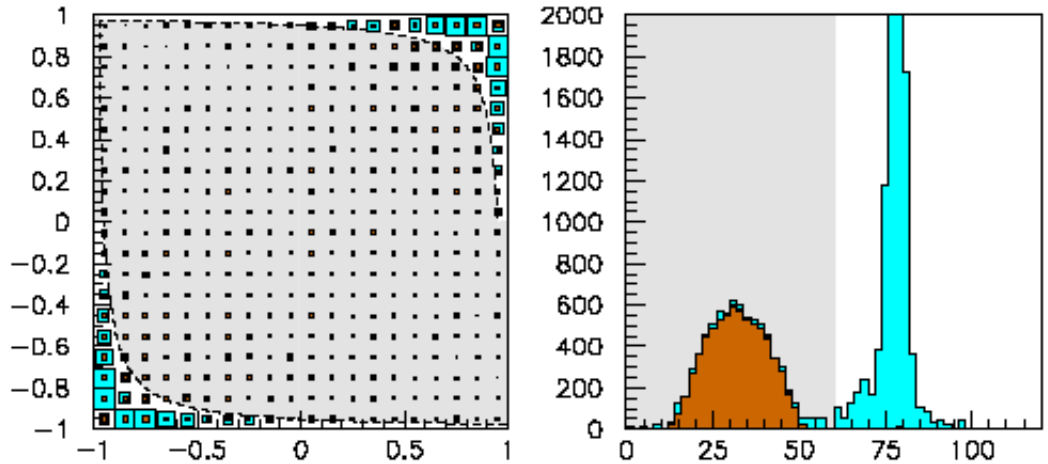
SM backgrounds:

- $W^+ W^-$
- t tbar
- $Z^0 Z^0$

$e^+e^- \rightarrow \chi_1^+\chi_1^- \rightarrow \chi_1^0 jj \chi_1^0 \ell\nu$



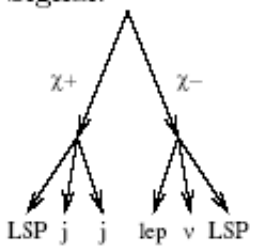
Missing energy in 2−jet, 1−lepton events



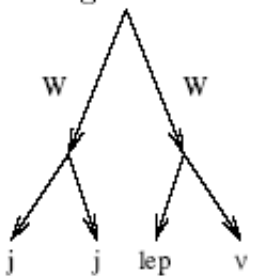
Cosine of jets with missE cut

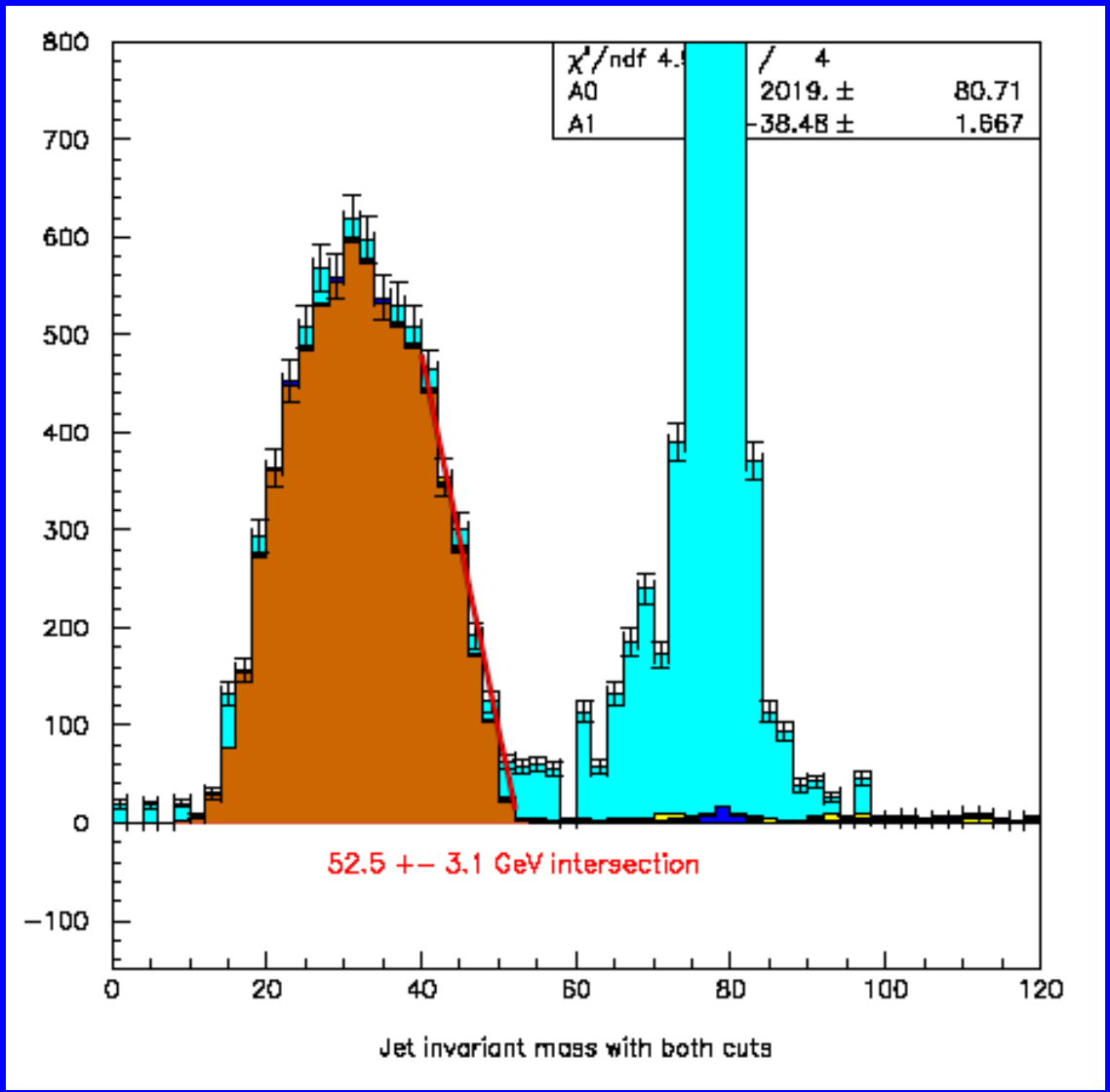
Jet invariant mass with both cuts

Signal:



Background:



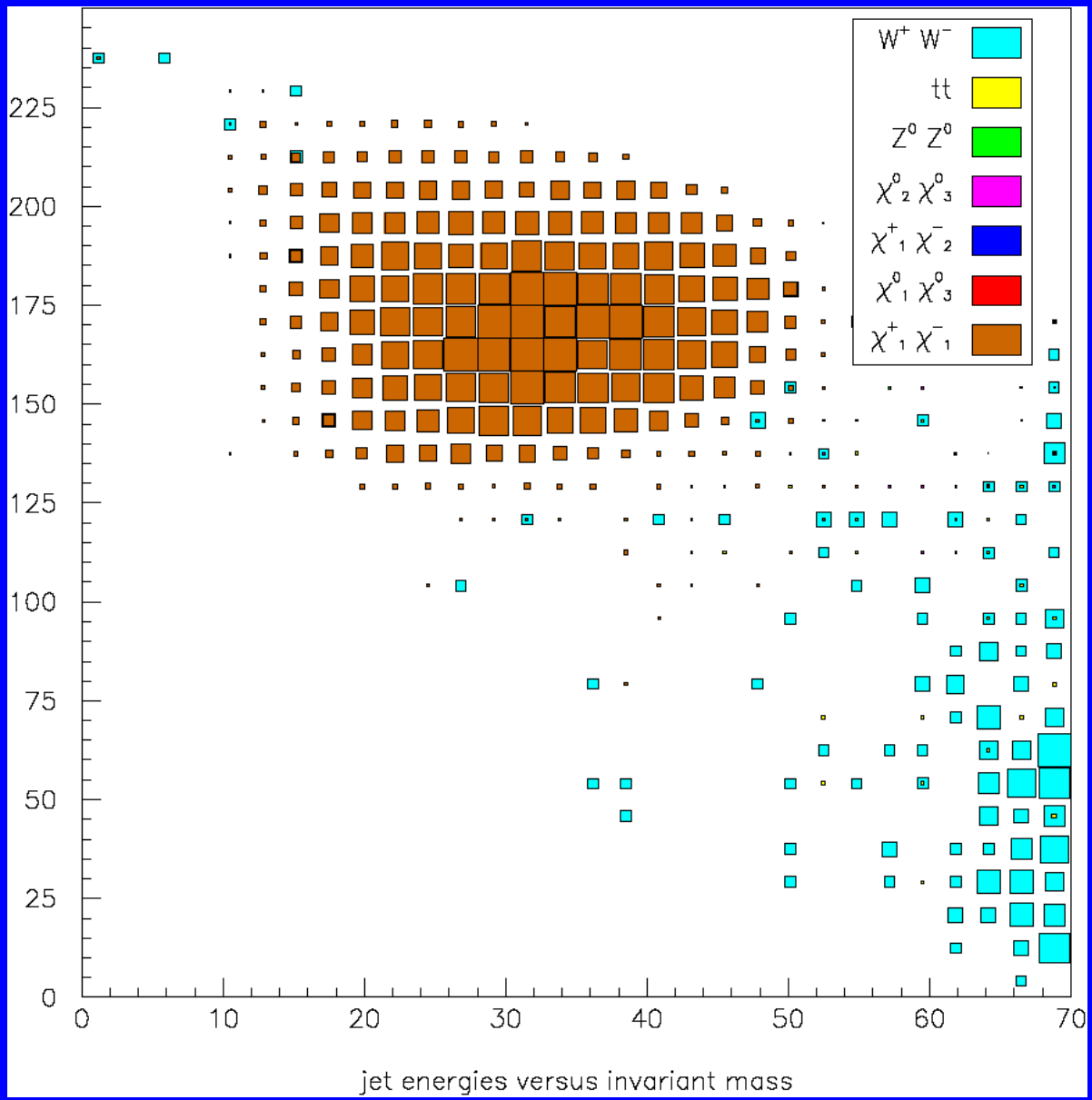


- Clear signal seen
- Can fit M(jj) for endpoint

$\Delta M = M\chi_1^+ - M\chi_1^0$

$= 52$ GeV

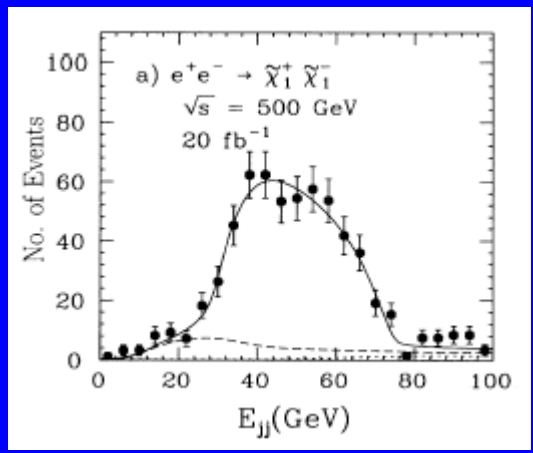
- Analysis to be optimized

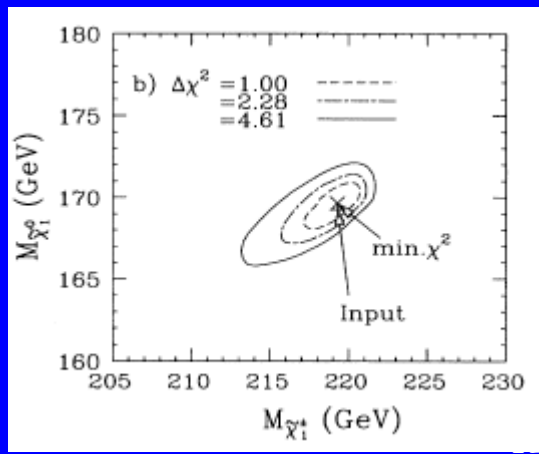


Fit to E_{jj} will give both masses

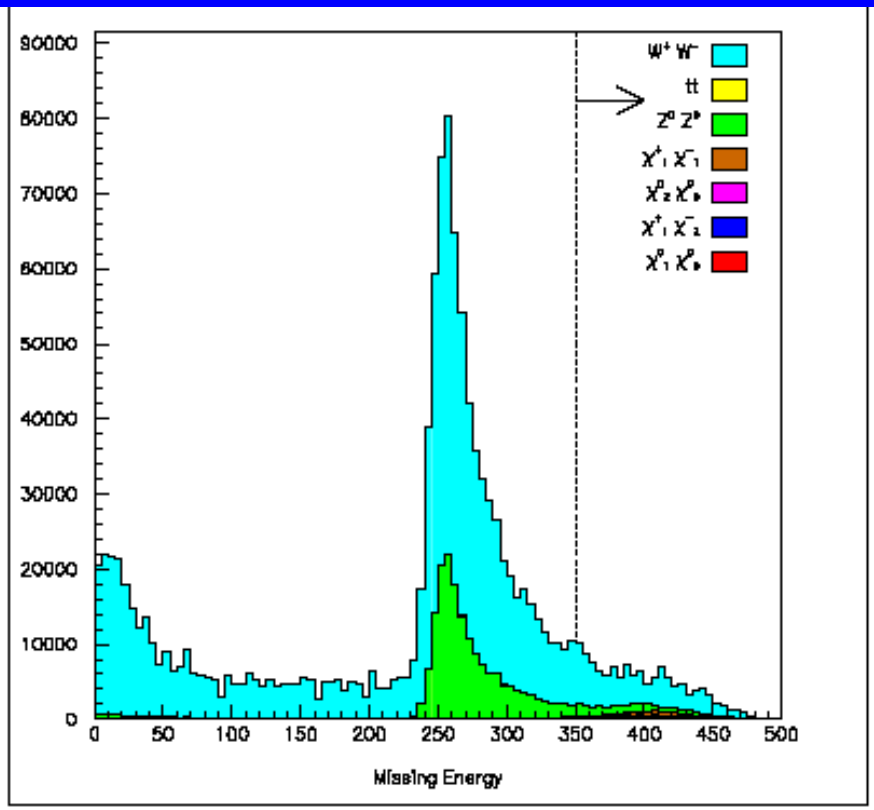
Tsukamoto et al

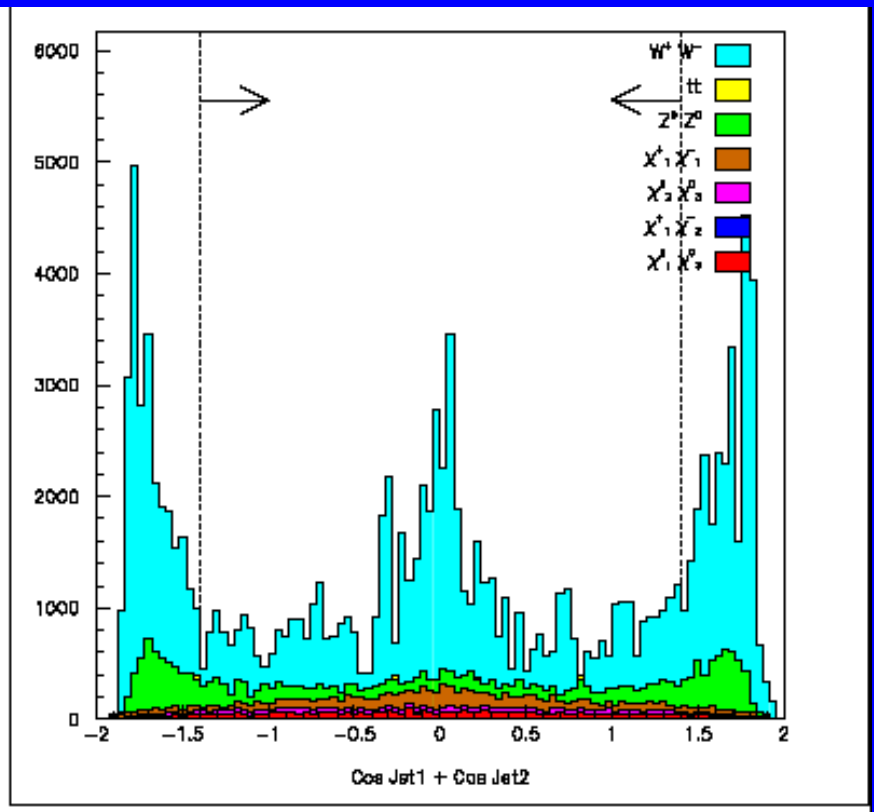
PRD 51 3153 (1995)



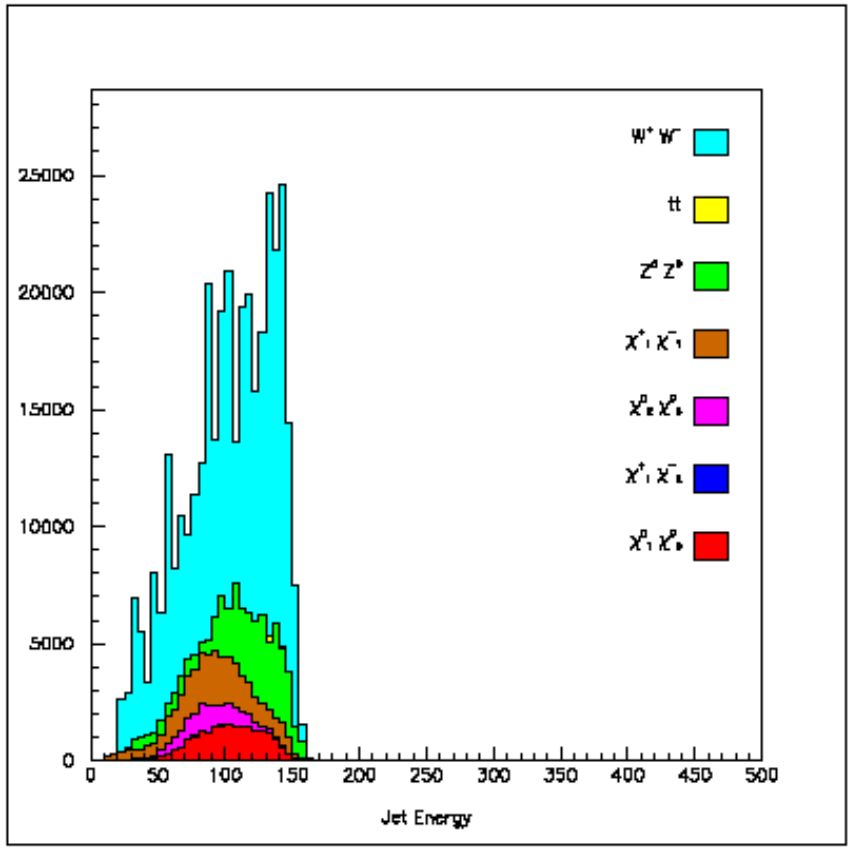


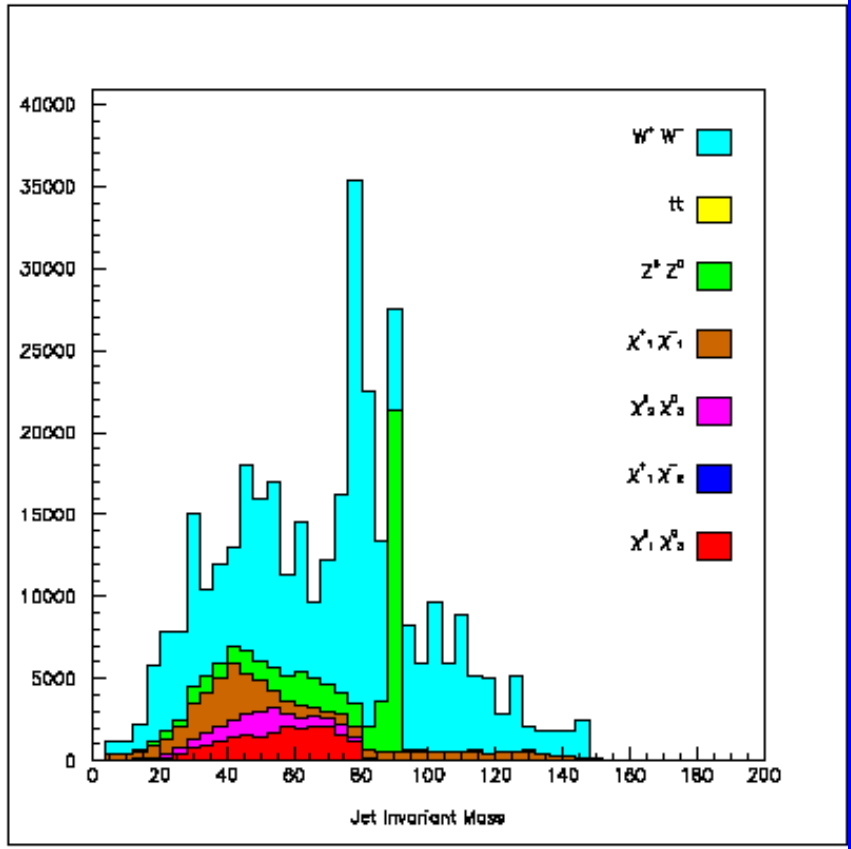
$e^+e^- \rightarrow \chi_1^0\chi_3^0 \rightarrow \chi_1^0\chi_1^0 jj$





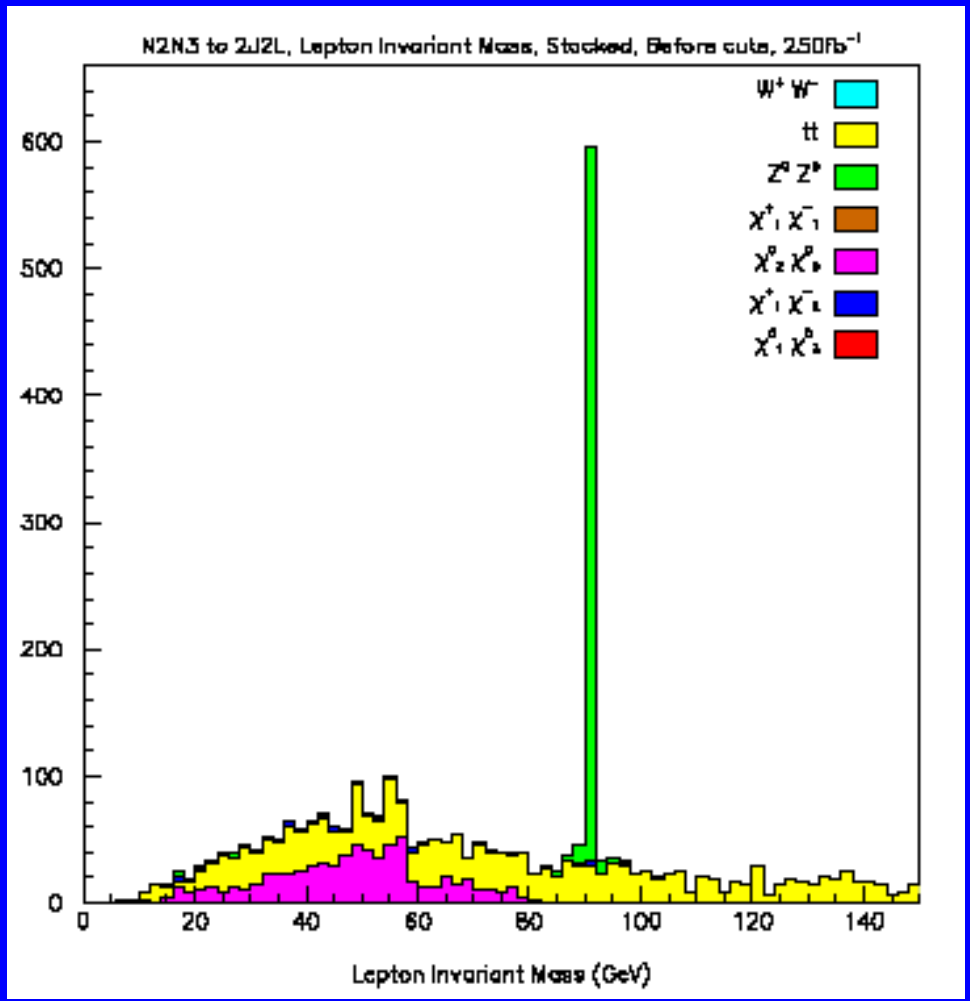
- Minimal cuts: 2 jets, no isolated leptons
- Missing E > 350 GeV; $|\cos\theta_1 + \cos\theta_2| < 1.4$





- SM and SUSY bkgd still large; looking for edge m(jj)
  $\Delta M = M\chi_3^0 - M\chi_1^0 = 82$ GeV
- Try beam polarization and b tag to improve S/B
  - χ_3^0 is mostly higgsino; WW and $\chi_1^+\chi_1^-$ suppressed with b tagging.

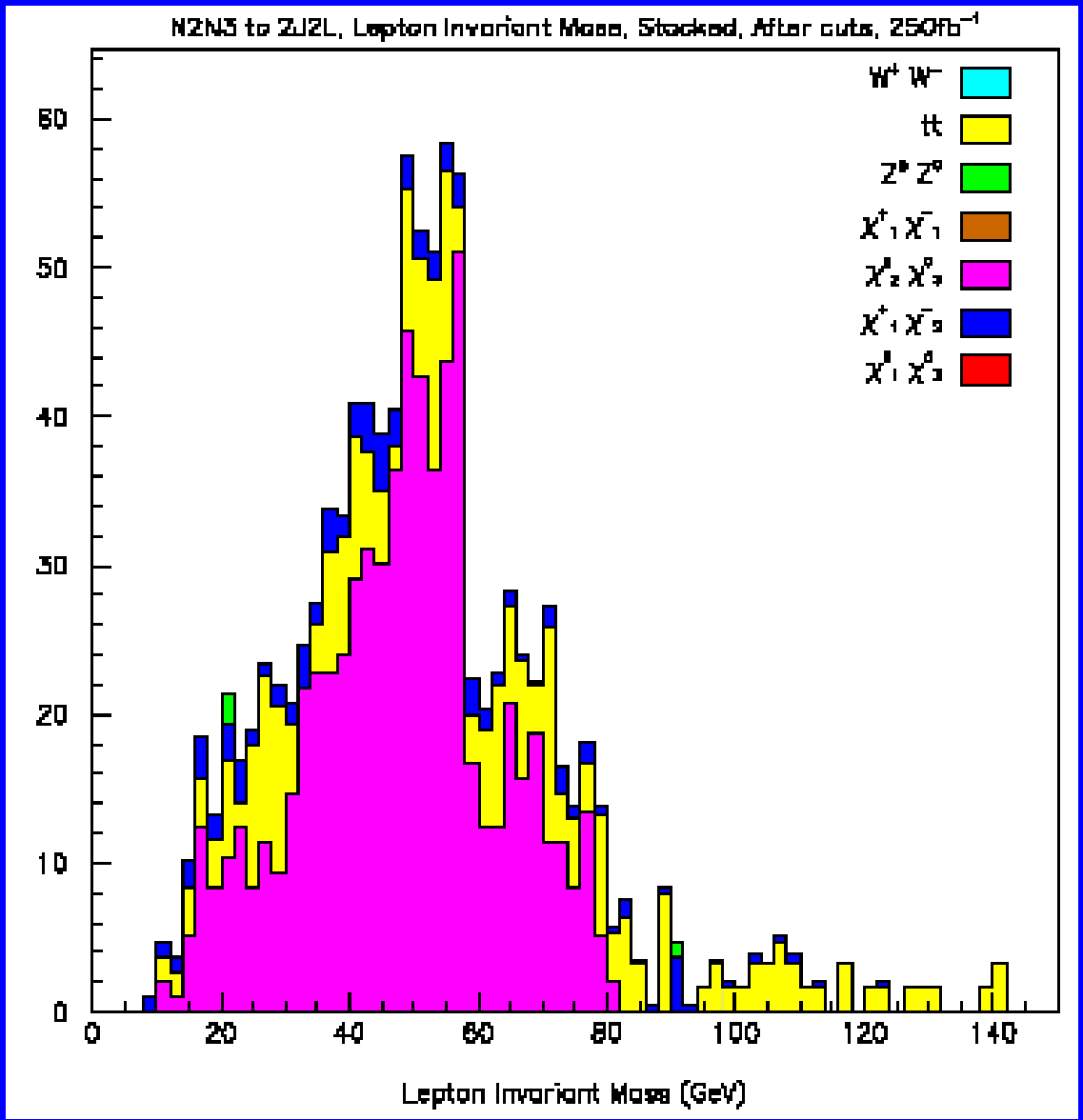
$e^+e^- \rightarrow \chi_2^0\chi_3^0 \rightarrow \chi_1^0\chi_1^0 jj\ell\ell$



- 2 jets + 2 leptons
  - $m(\ell\ell)$ before cuts
- Expect 2 edges
  - $M\chi_3^0 - M\chi_1^0 = 82$ GeV
  - $M\chi_2^0 - M\chi_{10} = 59$ GeV

Cuts to reduce bkgd:

- $E_{miss} > 250$ GeV
- $E_{jj} < 110$ GeV
- $5 < E_\ell < 110$ GeV

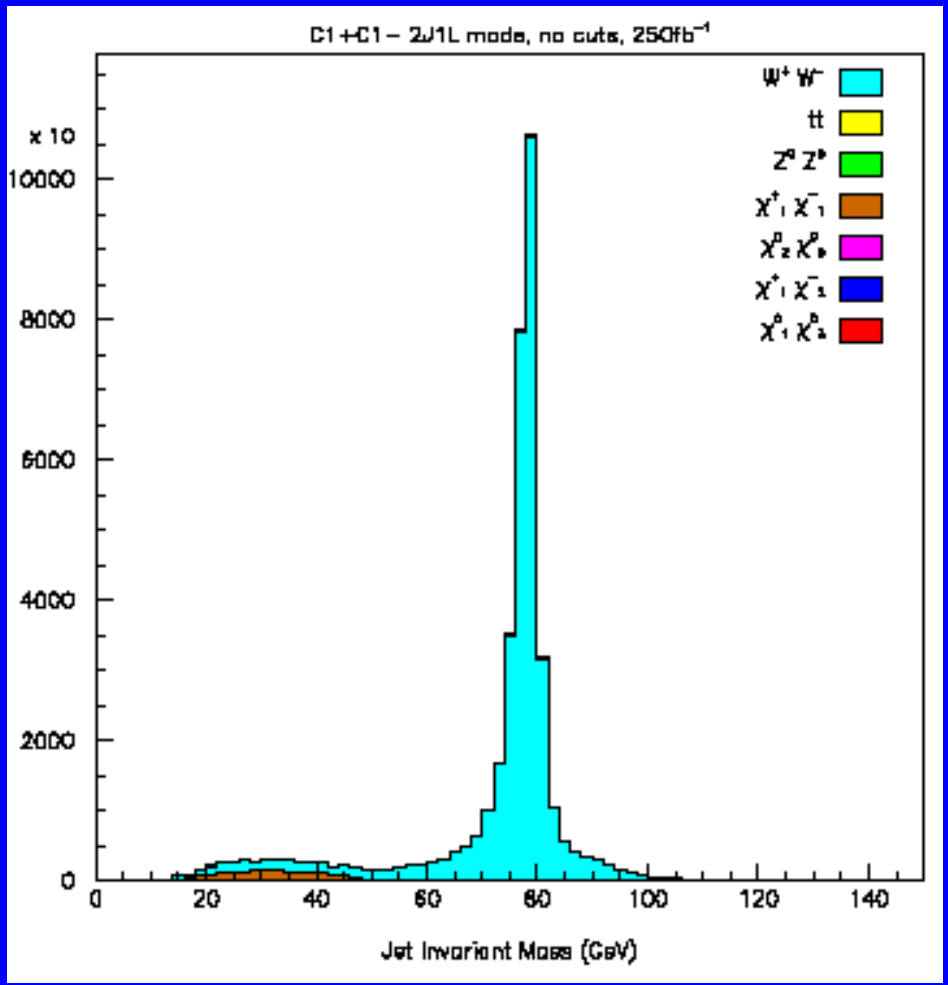


- Good S/B
- Can get two ΔM's from edges
- Spectrum contains more information
- More work needed for estimate of precision

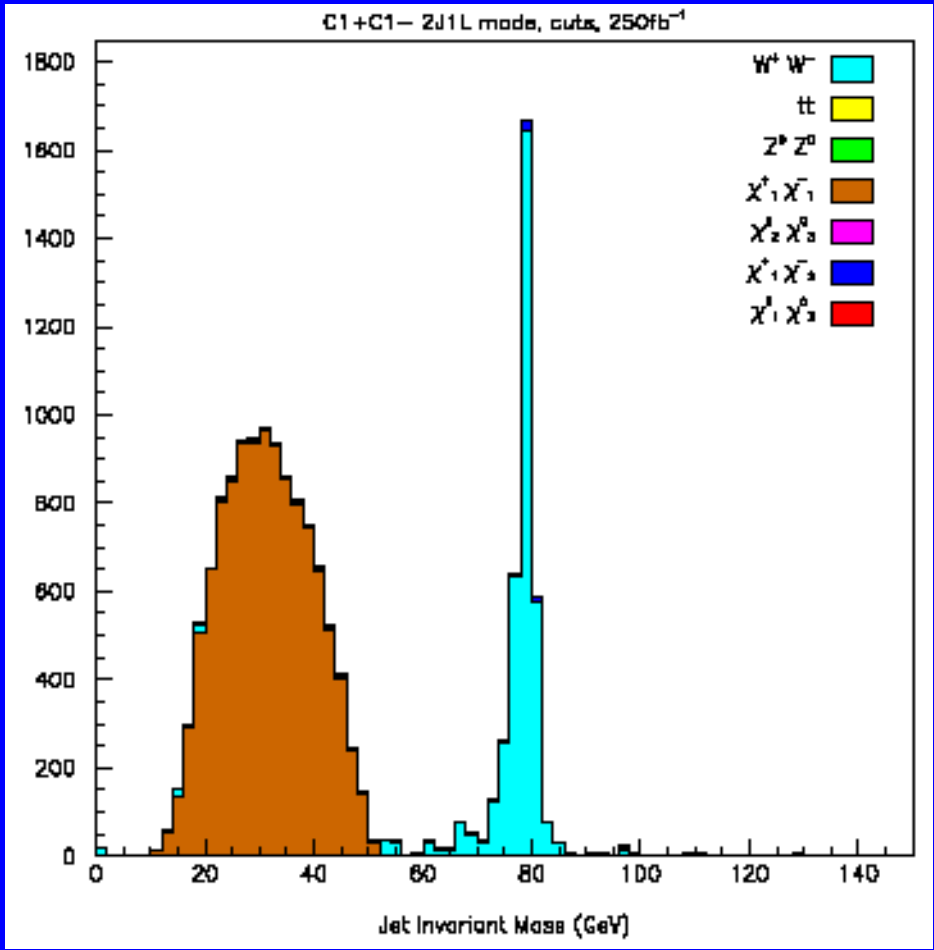
Future Directions

- Continue refining analyses
- Look at other observables
  - cross sections: σ_L, σ_R
  - asymmetries: A_L^{FB}, A_R^{FB}
- Putting things together
  - $M\chi_1^+$, $M\chi_1^0$, $M\chi_2^0$, $M\chi_3^0 \rightarrow M_1$, M_2, μ, tan β
  - Can we achieve precision on SUSY parameters to test focus point? …Maybe.

$e^+e^- \rightarrow \chi_1^+\chi_1^- \rightarrow \chi_1^0 jj \chi_1^0 \ell\nu$



- M(jj) with no cuts
- Expect Endpoint at $\Delta M = M\chi_1^+ - M\chi_1^0 = 52$ GeV
- Cuts
  - $E_{miss} > 300$ GeV
  - $|\cos\theta_j| < 0.8$ (t-channel WW peak)


C1+C1− 2J1L mode, cuts, 250fb⁻¹
1800
1600
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
140
Jet Invariant Mass (GeV)
W⁺ W⁻
tt
Z⁰ Z⁰
χ⁺₁ χ⁻₁
χ⁰₂ χ⁰₃
χ⁺₁ χ⁻₃
χ⁰₁ χ⁰₃