CHARGINO AND NEUTRALINO SEARCH WITH L3 DETECTOR AT LEP

Plan of talk

MSSM

Production and decay

Analysis

Results

Conclusions

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MSSM FRAMEWORK

MSSM PARAMETERS

M_1 M_2 M_3	Gaugino masses
μ	Higgs mass parameter
$\tan\beta$	$\langle H_2^0 \rangle / \langle H_1^0 \rangle$
m_A	Mass of CP odd Higgs (A)
$M_{\tilde{l}}$ $M_{\tilde{q}}$	Slepton and squark masses
$A_{\tilde{l}}$ $A_{\tilde{q}}$	Trilinear couplings

Constrained MSSM

Unification of gaugino masses	M_2
Unification of scalar masses	m_o
Unification of trilinear couplings	A_o

m-SUGRA incorporates electroweak symmetry breaking

Only sign(μ) is free

R -PARITY

$R = (-1)^{3B + L + 2S}$

B = baryon number

L = lepton number

S = spin

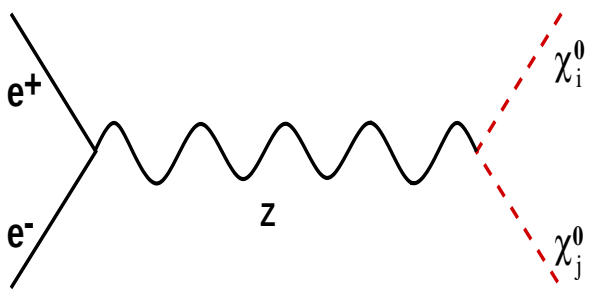
- **R-PARITY CONSERVATION ASSUMED**

  - ▷ **SPARTICLES ARE PAIR PRODUCED**
  - ▷ **ALL SPARTICLES DECAY INTO LSP**
  - ▷ **LSP IS STABLE**

- **LIGHTEST NEUTRALINO (χ_1^0) IS LSP**
  weakly interacting , escapes detection
  giving $\not{E}$ signature

Production at LEP

$$\sigma = \sigma\,(M_2, \mu, \tan\beta, m_0)$$



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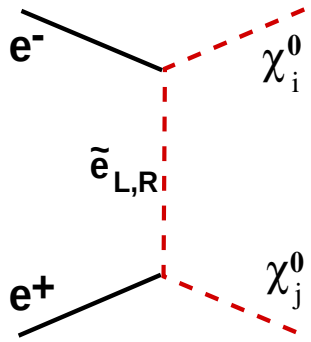
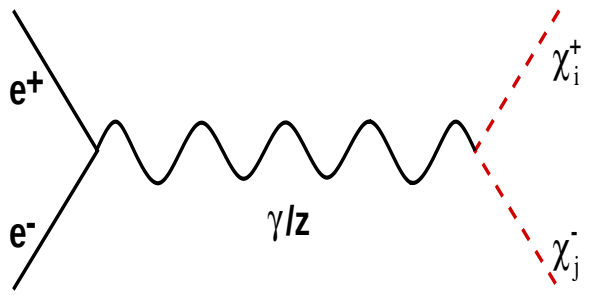


Important when neutralino is higgsino-like

Important for light scalar



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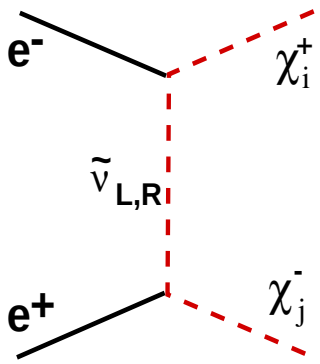


HIGGSINO REGION

($M_2 >> |\mu|$)

no t channel

GAUGINO REGION

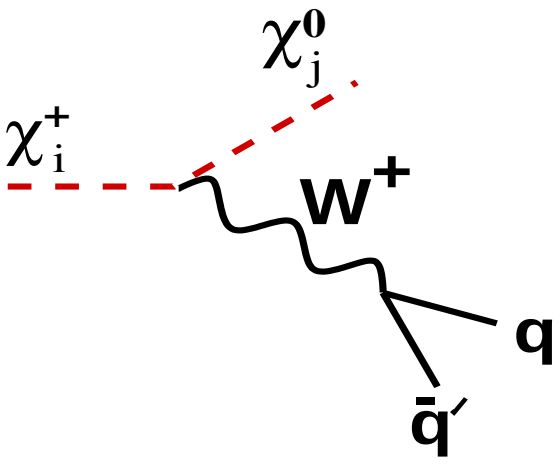
($M_2 << |\mu|$)

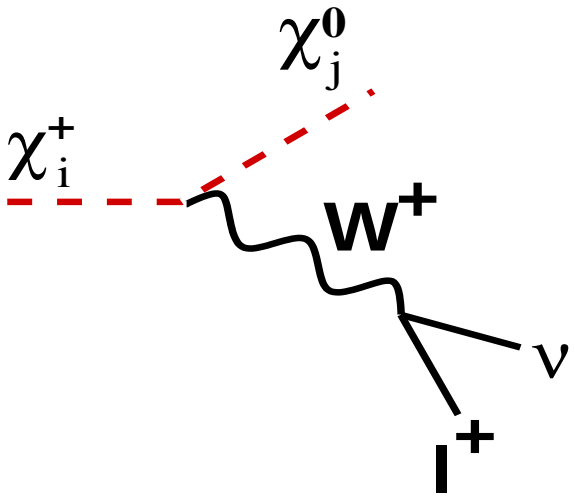
t channel important for small m_0

(indirect limit from slepton searches)

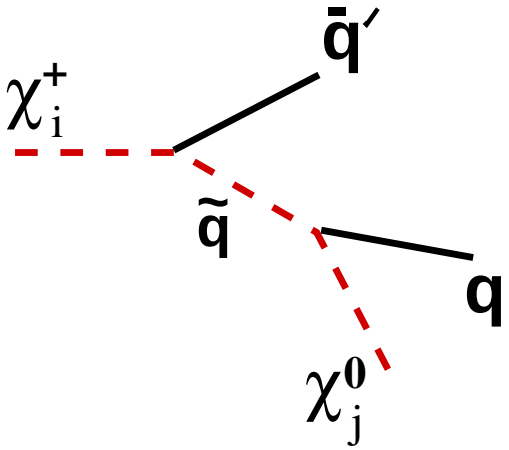
Decay of Chargino and Neutralino

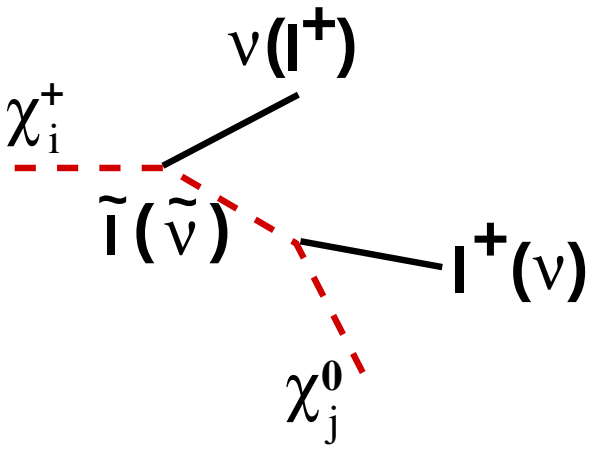
Chargino





dominant at large m_0





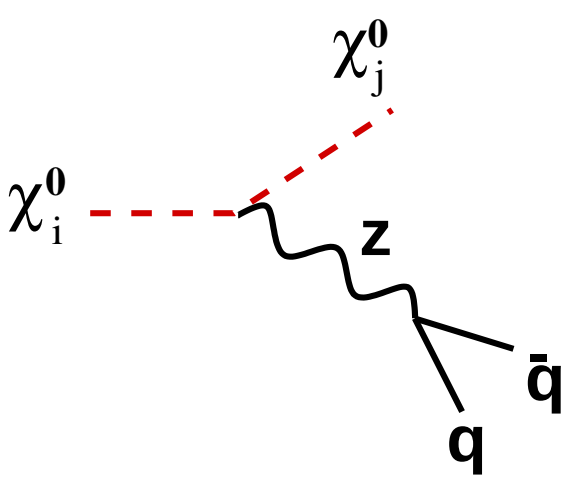
contribute at small m_0

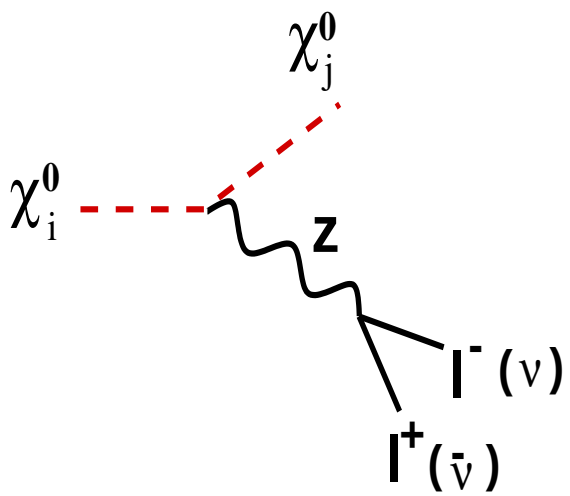
Hadronic

Leptonic

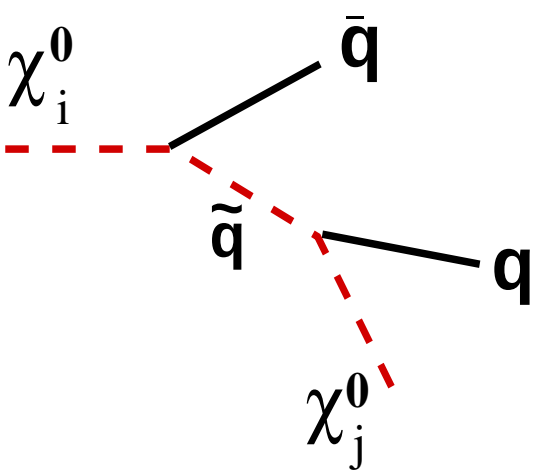
Decay of Chargino and Neutralino

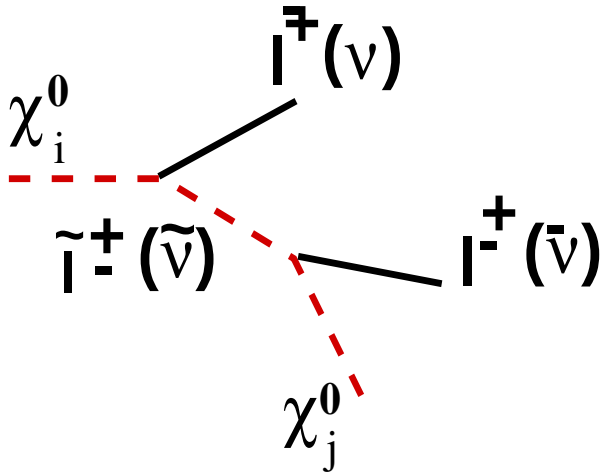
Neutralino





dominant at large m_0





contribute at small m_0

Hadronic

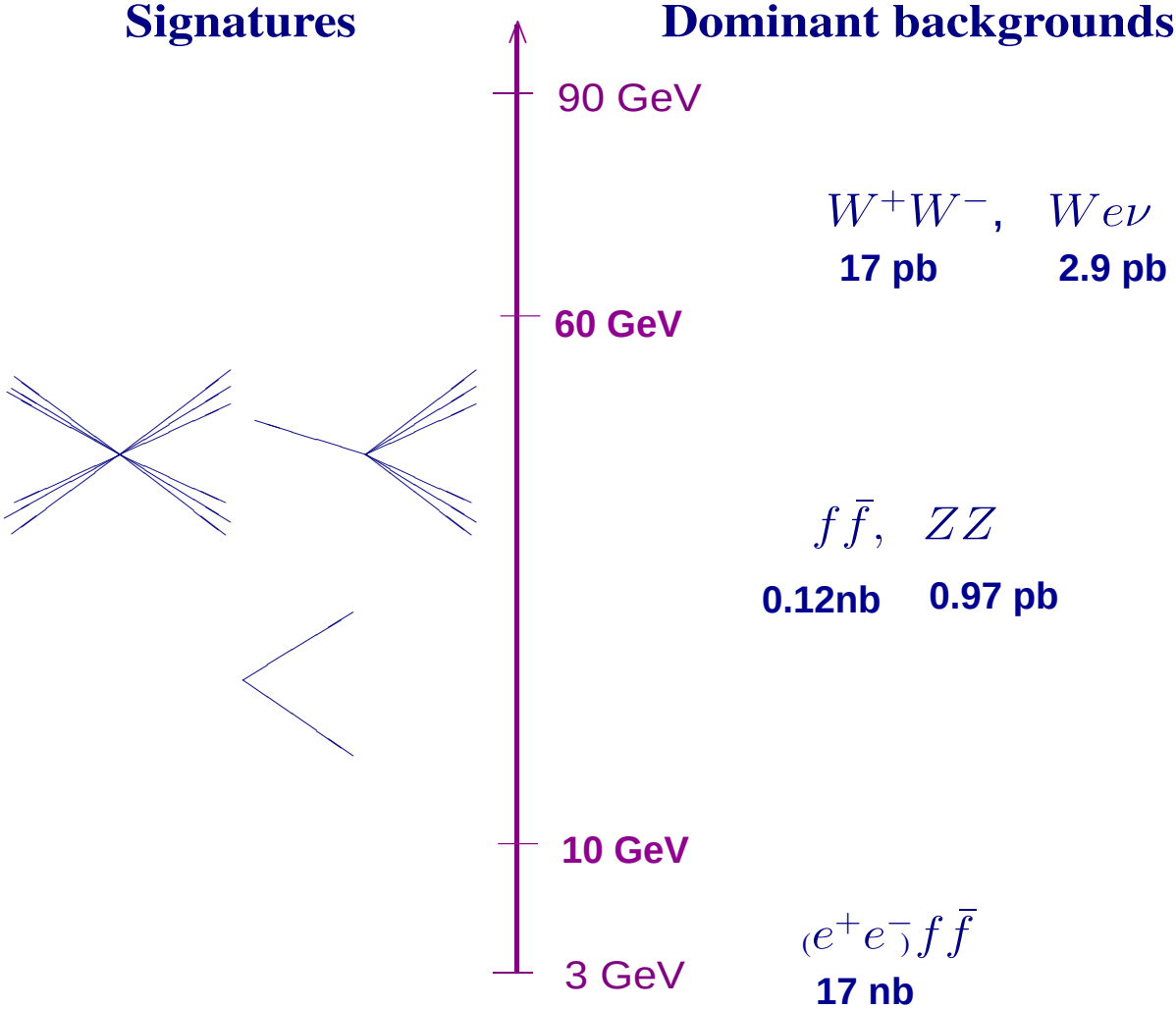
Leptonic

Search Strategies

Δ M = $M_{\tilde{\chi}}$ - M_{LSP} $\Longrightarrow$ Visible energy

Different analysis for different Δ M regions

Signatures **Dominant backgrounds**



W^+W^-, $We\nu$

17 pb 2.9 pb

$f\bar{f}$, ZZ

0.12nb 0.97 pb

$(e^+e^-)f\bar{f}$

17 nb

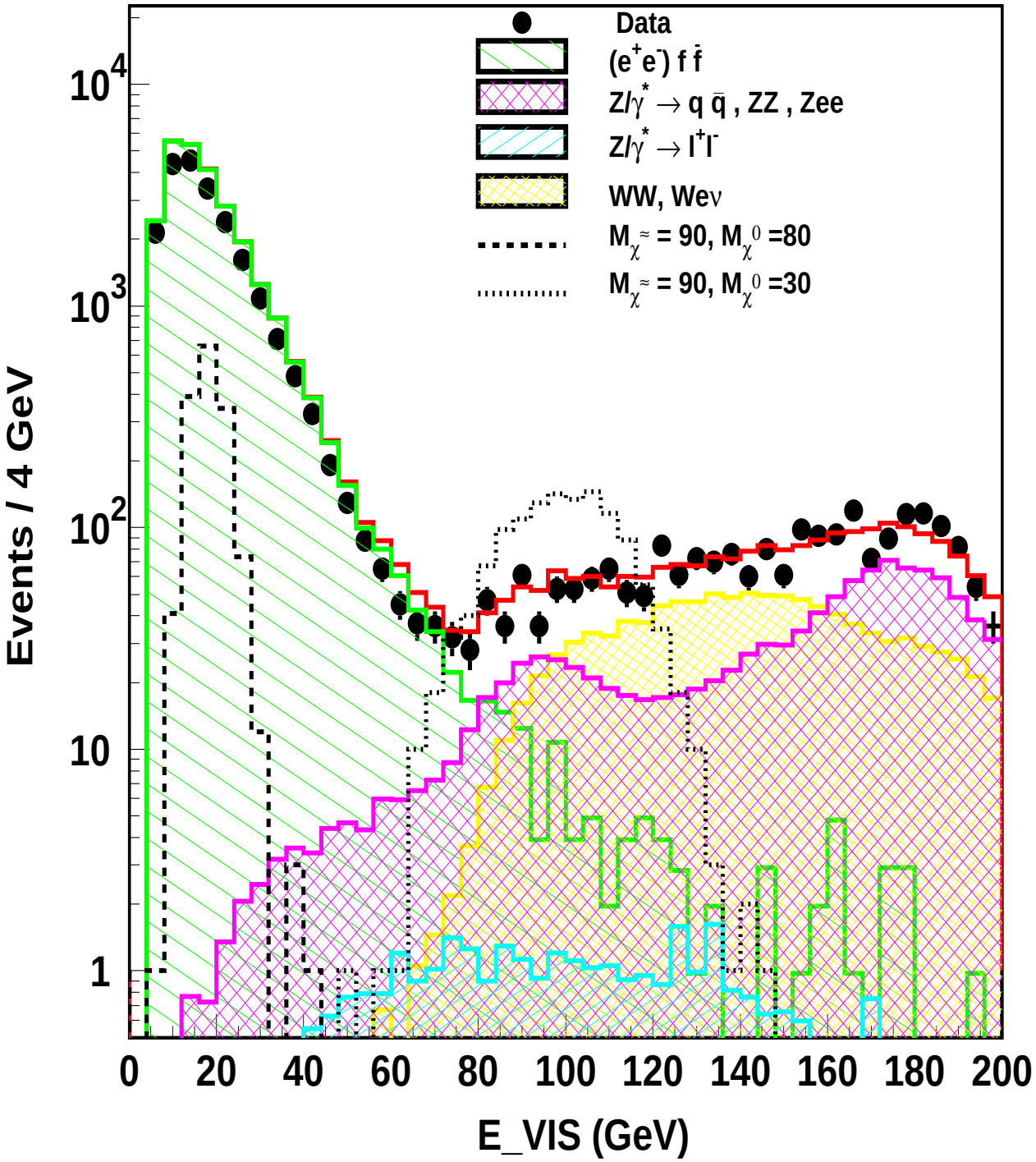
CASCADE DECAYS:

$\chi^0_{3,4} \rightarrow \chi^+_1 f\bar{f}'$ or $\chi^+_1 \rightarrow \chi^0_{2,3} f\bar{f}$ ► MANY JETS/LEPTONS

EACH SEARCH OPTIMISED FOR Δ M RANGES 3-5 GeV, 5-10 GeV, 20-30 GeV, 60-80GeV. TO MAXIMISE SIGNAL/BACKGROUND

BEST COMBINATION USED TO GET HIGHEST SENSITIVITY

189 GeV data (Jets + $\not\!\!E$ preselection)



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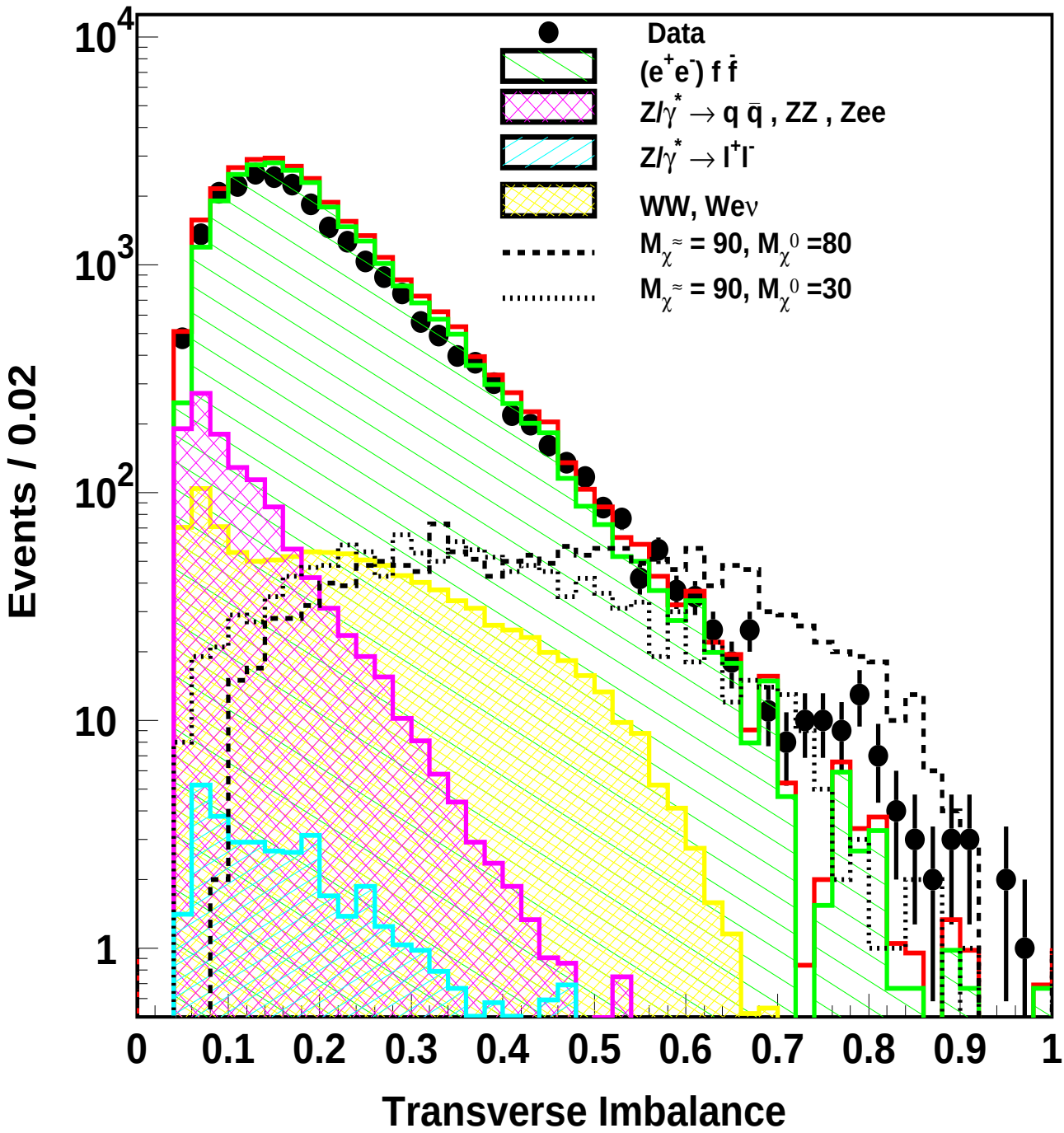
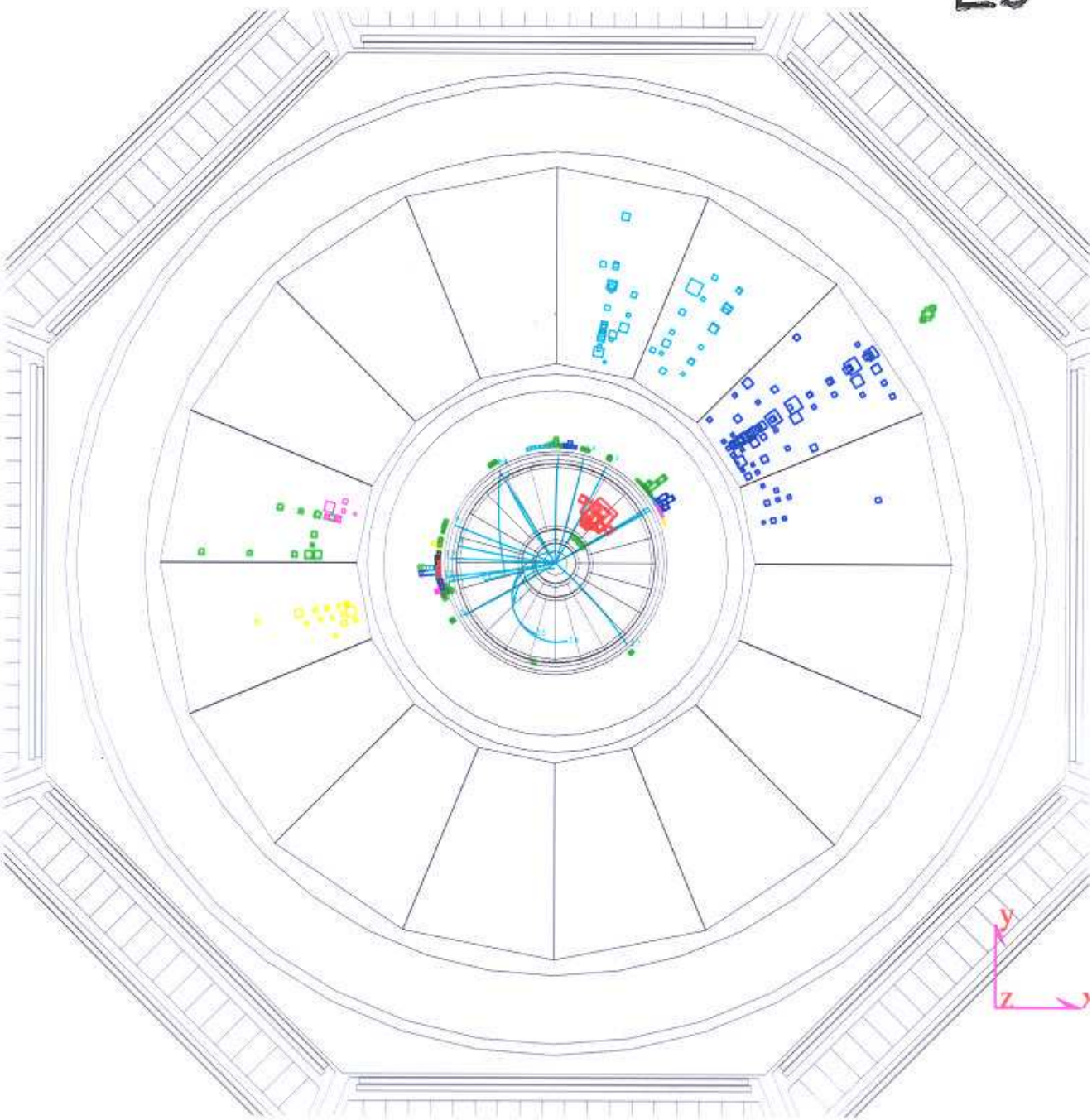


Run # 684410 Event # 3479 Total Energy : 119.00 GeV

L3



Transverse Imbalance : .4092		**Longitudinal Imbalance :** .5313
Thrust : .7300	**Major :** .4612	**Minor :** .1199
Event DAQ Time :	*971011 55919*	

DATA SETS

Year(s)	$\sqrt{s}$	$\int \mathcal{L} dt$ /expt	Results
1995	131 GeV	2.8 pb^{-1}	Final
	136 GeV	2.3 pb^{-1}	Final
1996	161 GeV	11.0 pb^{-1}	Final
	172 GeV	10.3 pb^{-1}	Final
1997	183 GeV	55.5 pb^{-1}	Final
1998	189 GeV	176.4 pb^{-1}	Preliminary

RESULTS

Examples:

Chargino @ 189 GeV, L = 176 /pb

	low Δ M	Medium Δ M	High Δ M	.OR.
ε	1-20%	20 - 45 %	3 - 28%	
Exp	8.51	3.69	11.1	22.1
Data	11	7	7	24

183 GeV:

23 expected, 17 observed

161-172 GeV, Chargino + Neutralino:
expected 4.5, observed 5.

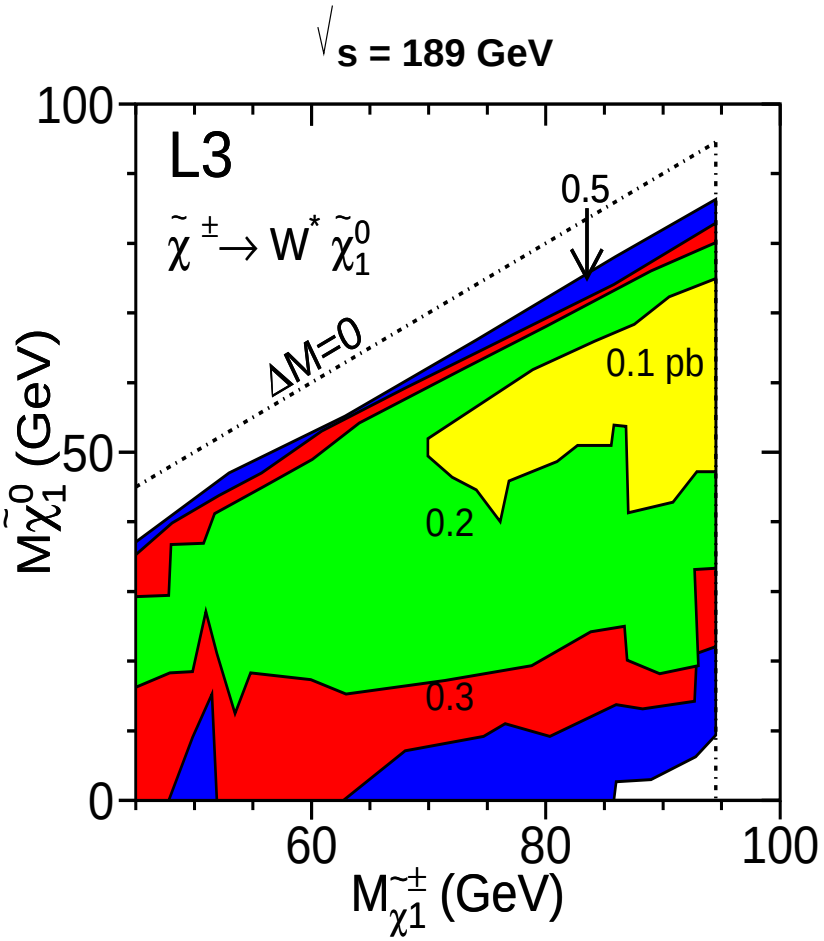
130-140 GeV:

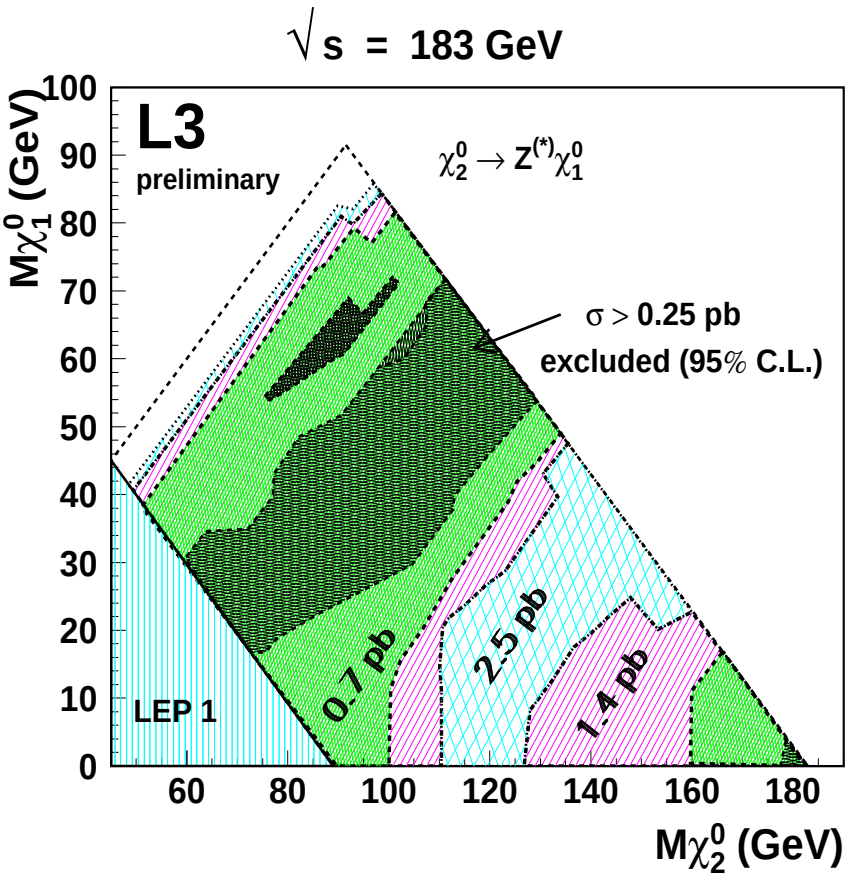
0.9 expected overall, no candidates observed

No Signal ▷ **Upper limit on cross section**

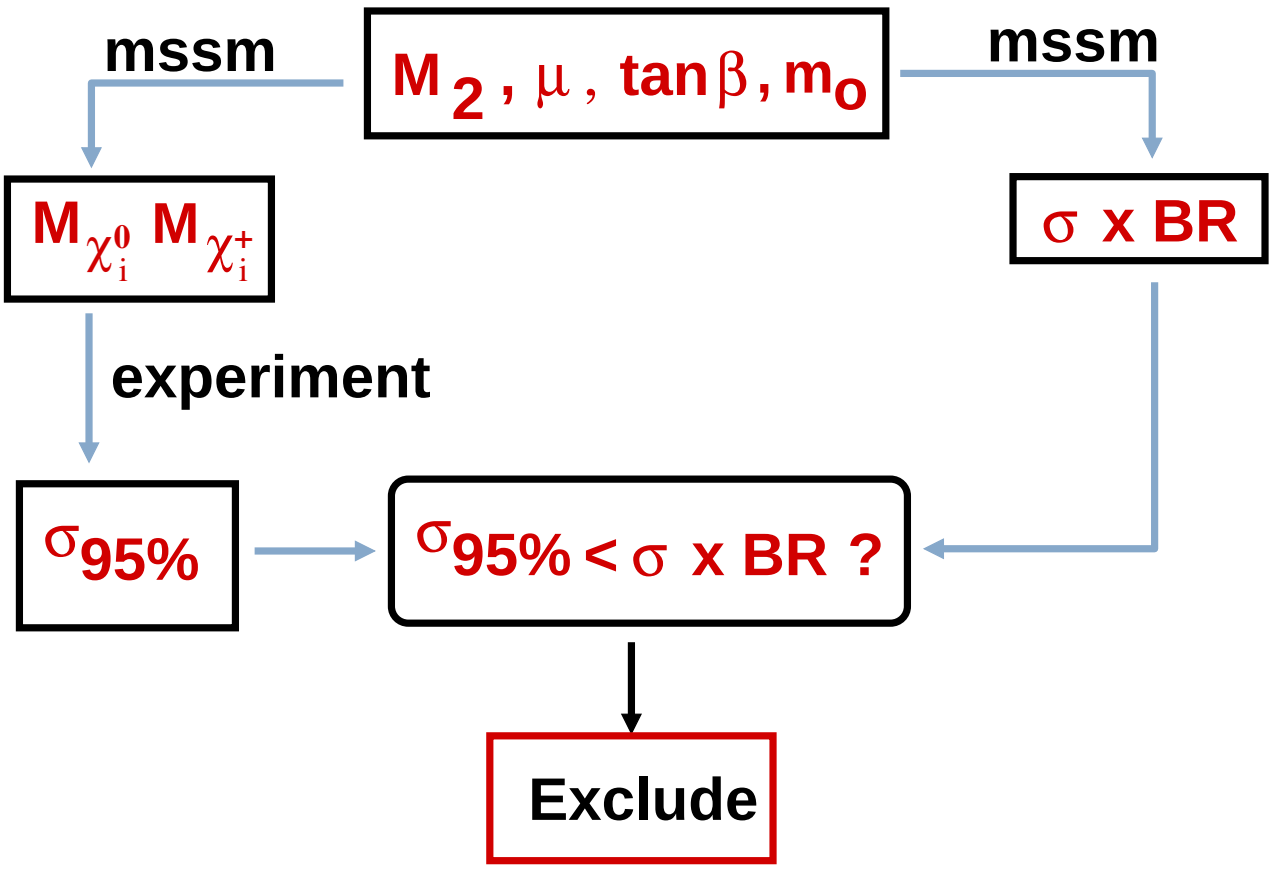
▷ **Exclusion in MSSM parameter space**

▷ **Lower limit on sparticle masses**


√s = 189 GeV
L3
$\tilde{\chi}^{\pm} \rightarrow W^{*} \tilde{\chi}_1^0$
0.5
ΔM=0
0.1 pb
0.2
0.3
100
50
0
60
80
100
$M_{\tilde{\chi}_1^0}$ (GeV)
$M_{\tilde{\chi}_1^{\pm}}$ (GeV)


√s = 183 GeV
L3
preliminary
$\chi_2^0 \rightarrow Z^{(*)}\chi_1^0$
σ > 0.25 pb
excluded (95% C.L.)
LEP 1
0.7 pb
2.5 pb
1.4 pb
100
90
80
70
60
50
40
30
20
10
0
60
80
100
120
140
160
180
$M_{\chi_1^0}$ (GeV)
$M_{\chi_2^0}$ (GeV)

EXTRACTING THE LIMITS



Search for lowest $M_{\chi_1^0}$ that has not been excluded

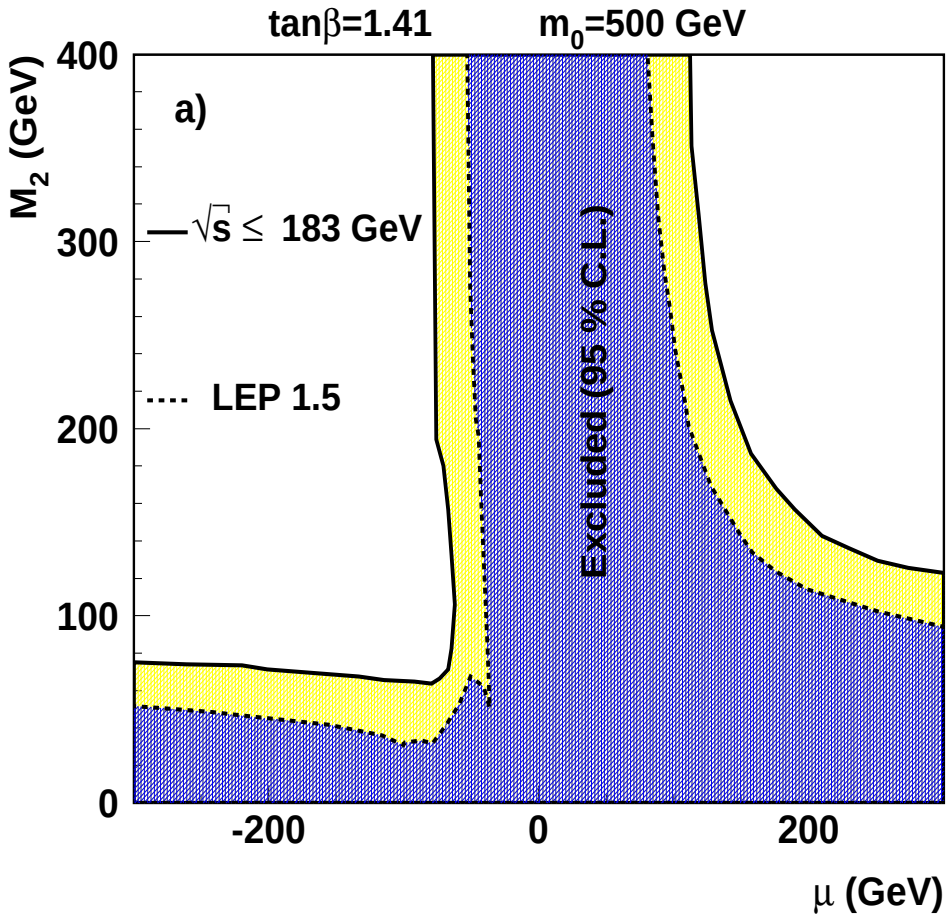
► Indirect limit on LSP mass

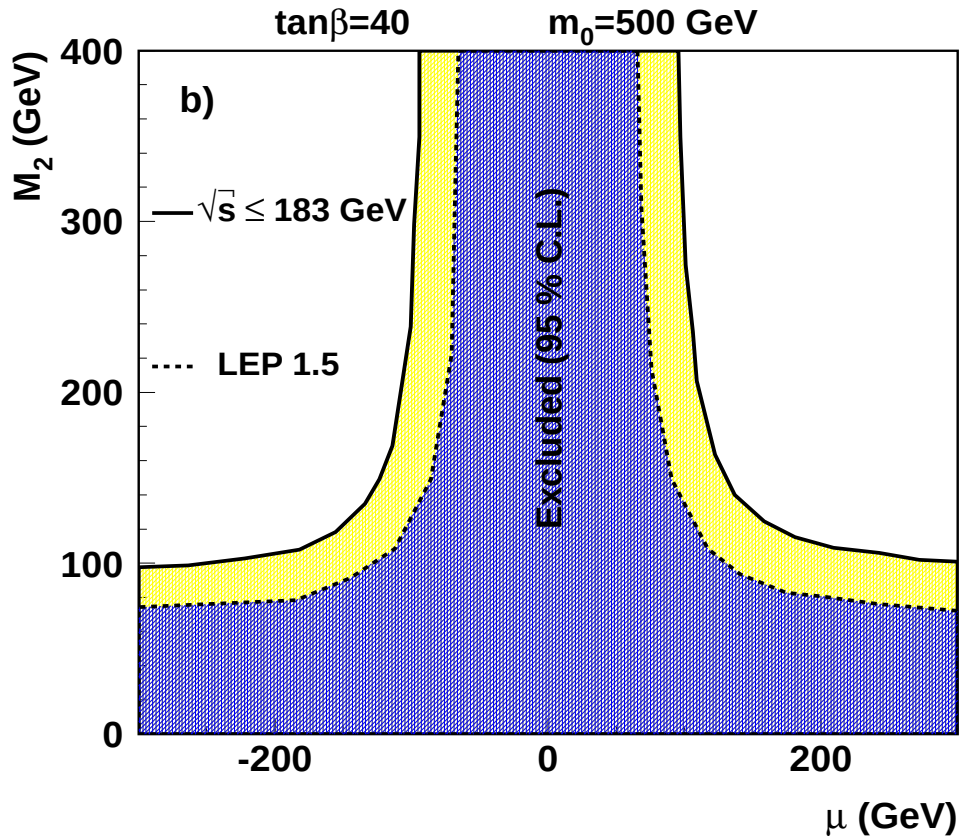
Parameter space scanned:

$0 \leqslant M_2 \leqslant 2000$ GeV $10 \leqslant m_o \leqslant 500$ GeV

$1 \leqslant \tan\beta \leqslant 60$ $-2000 \leqslant \mu \leqslant 2000$ GeV

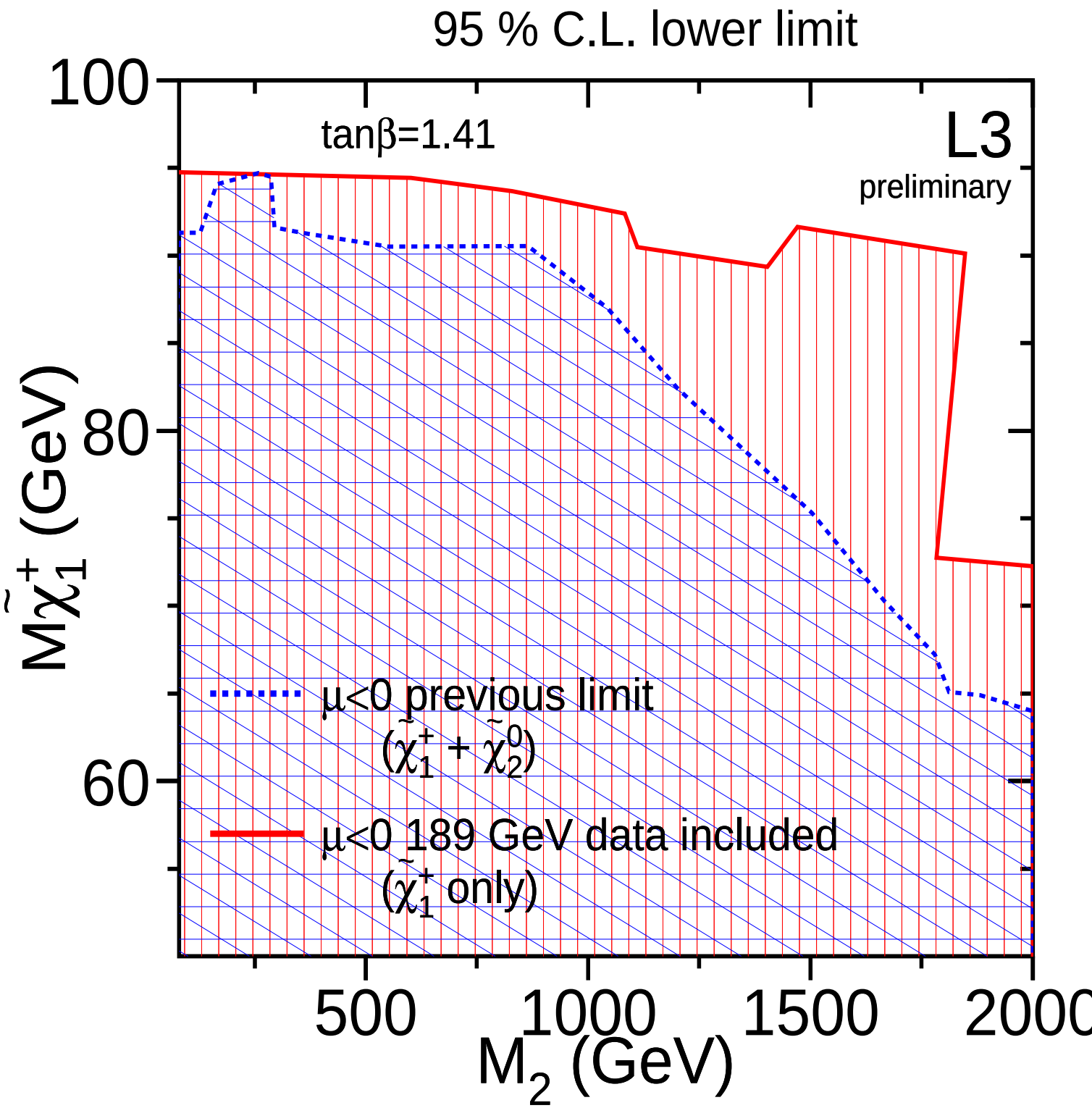
CM energy upto 183 GeV

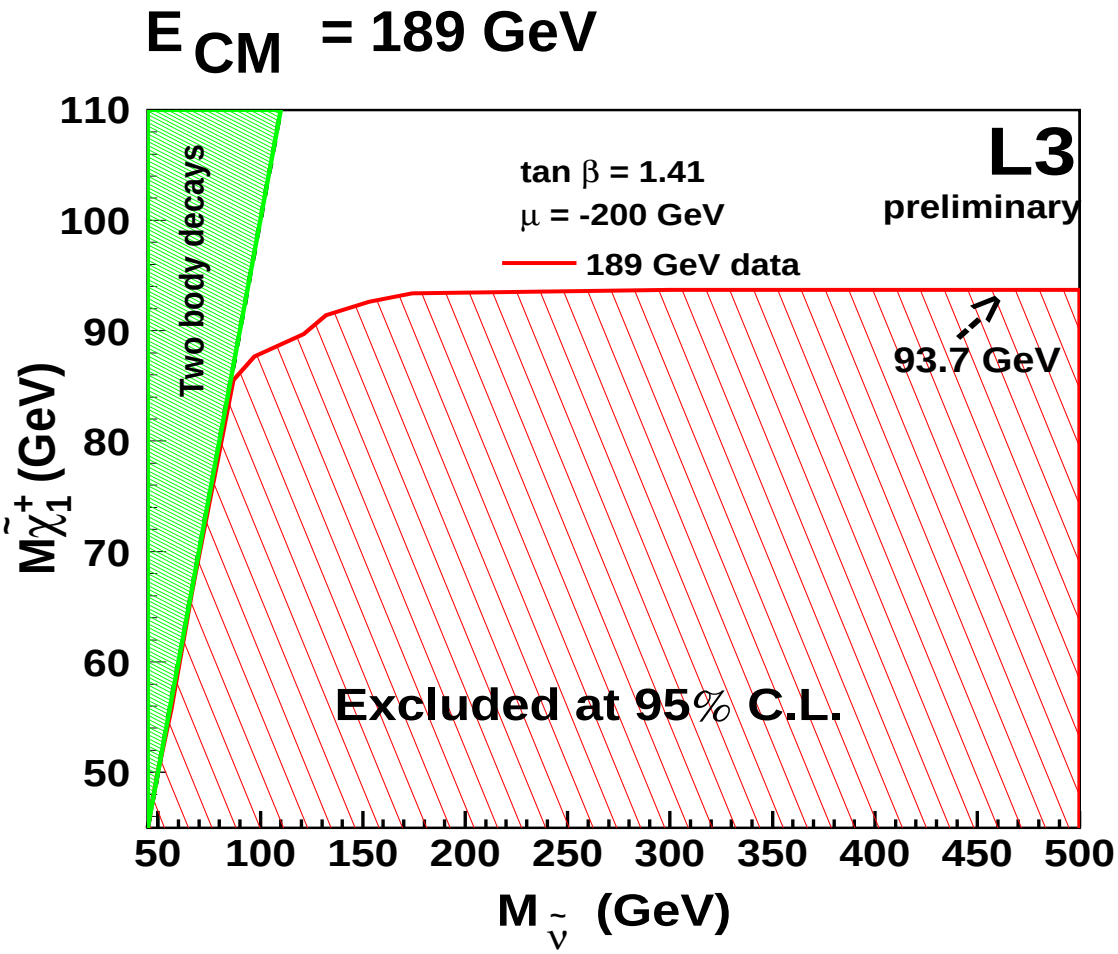




Higgsino Region

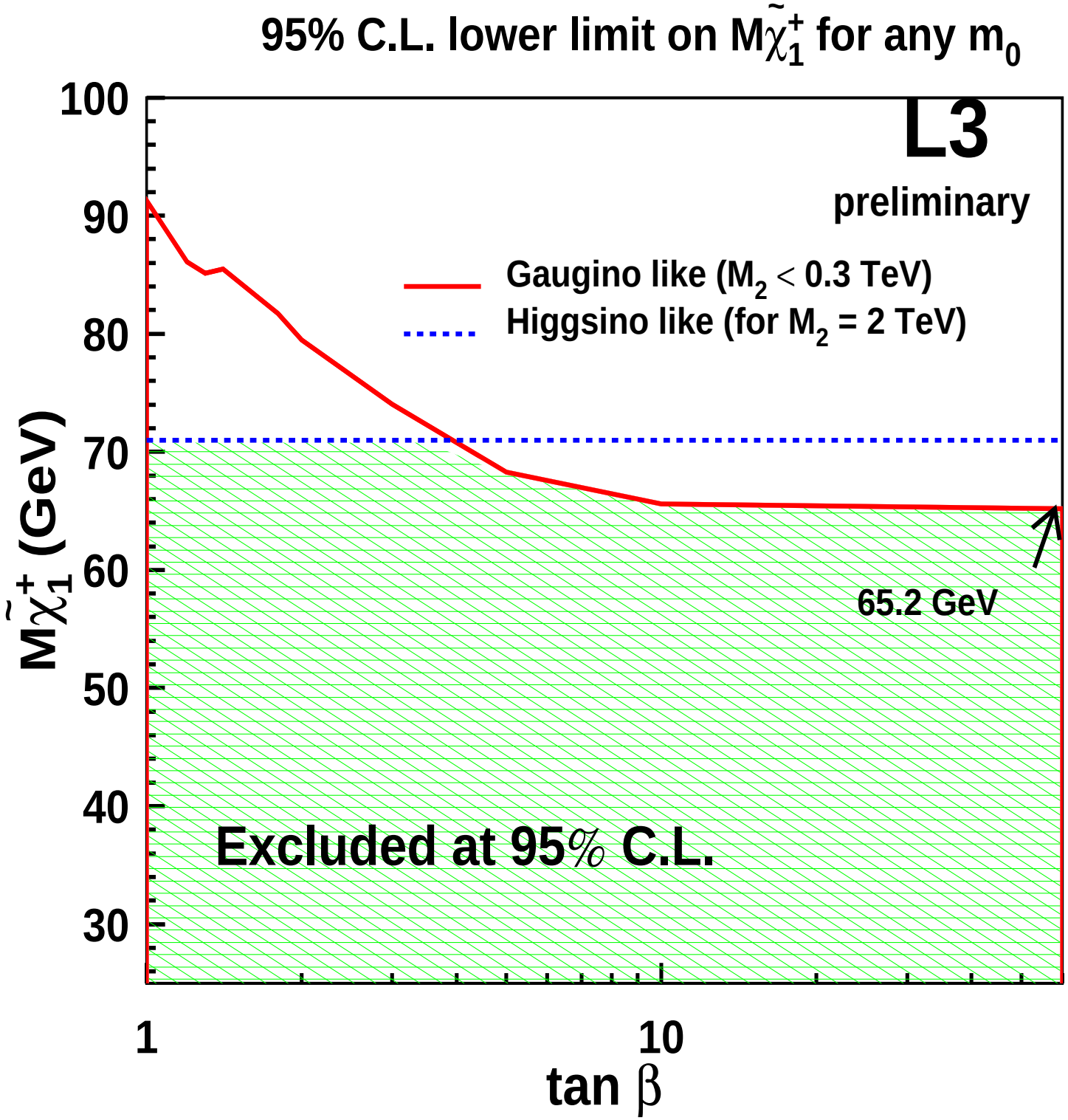
CM energy upto 189 GeV





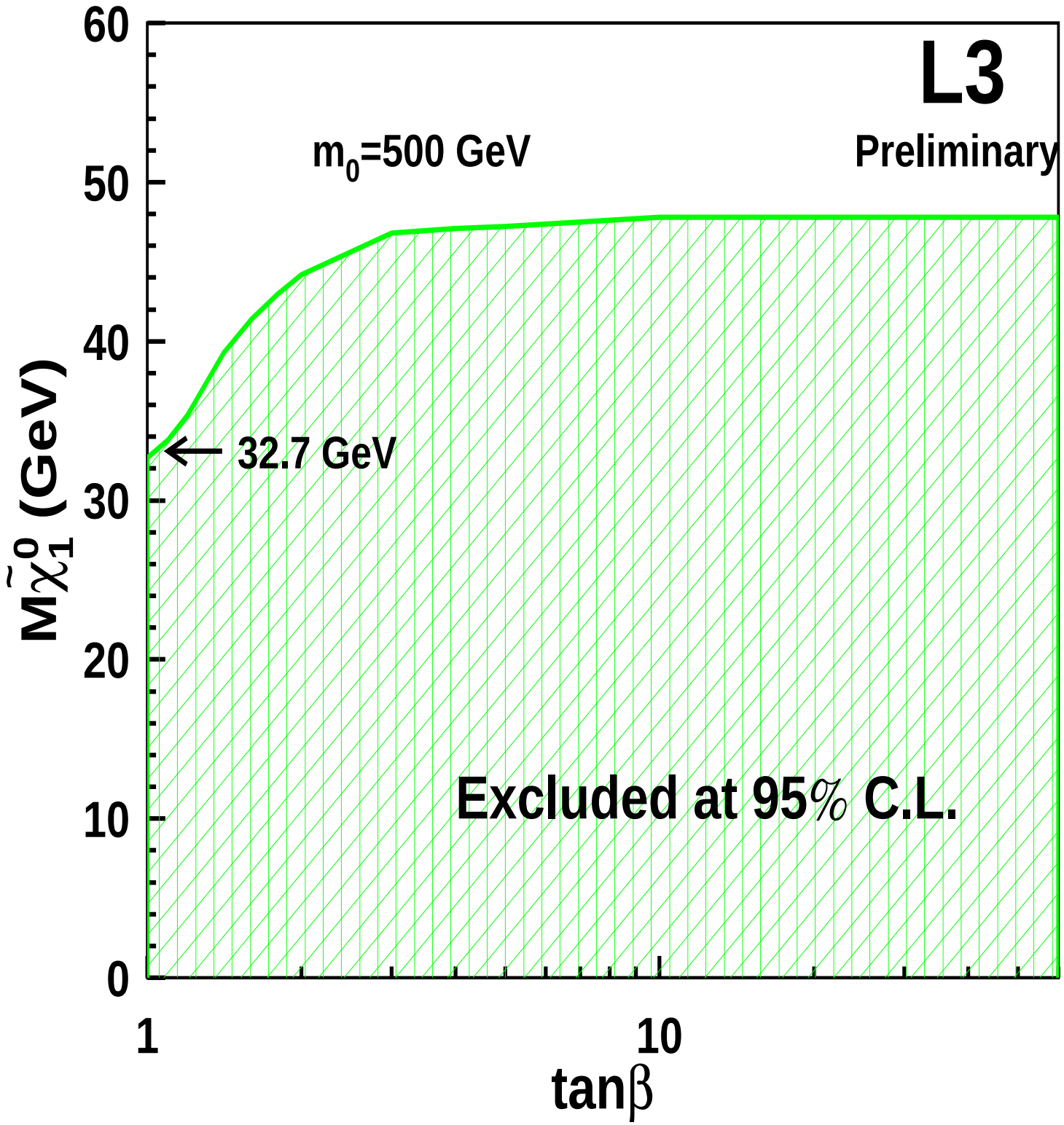
Lower limit on chargino mass as a function of $M_{\tilde{\nu}}$ (Gaugino Region)

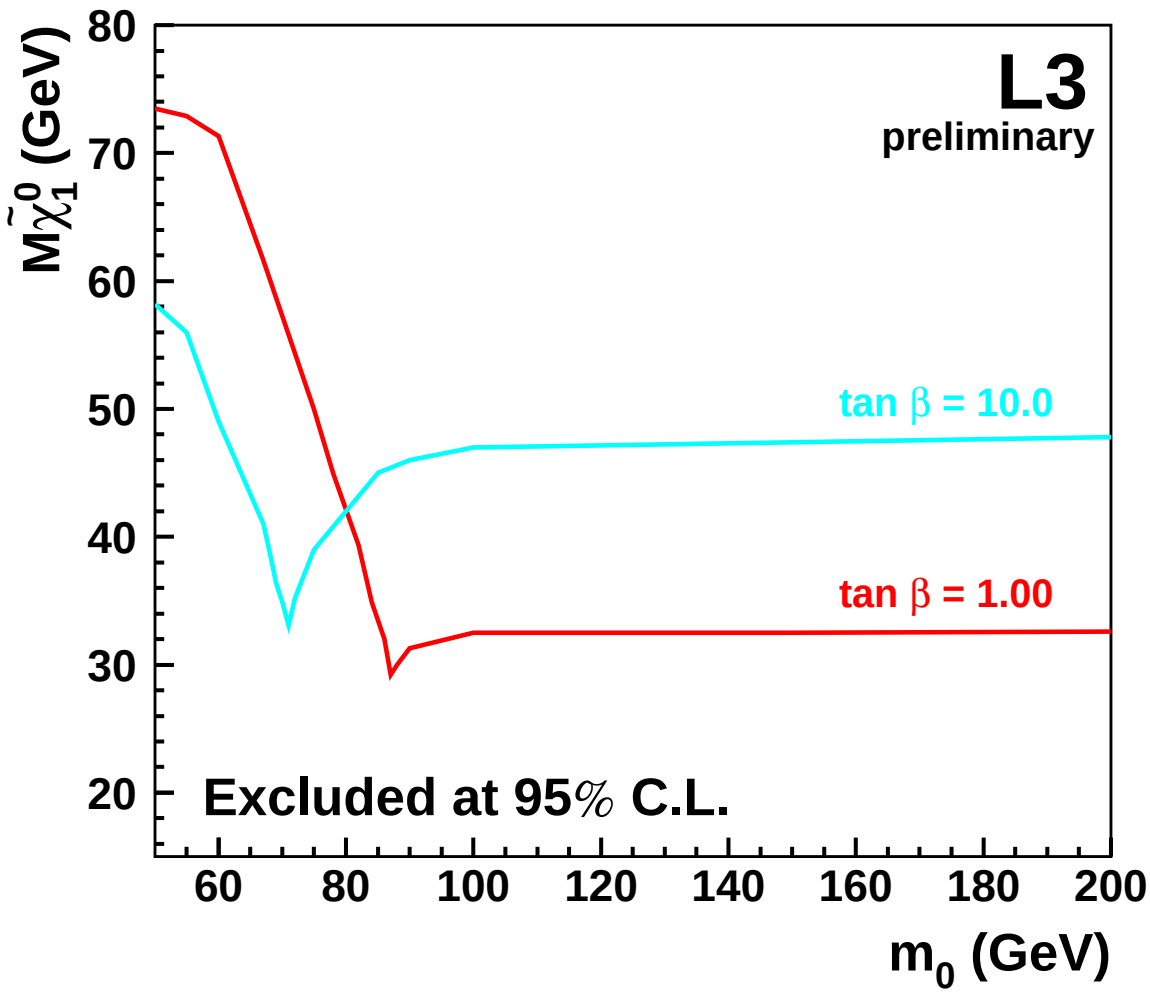
Upto CM energy 189 GeV

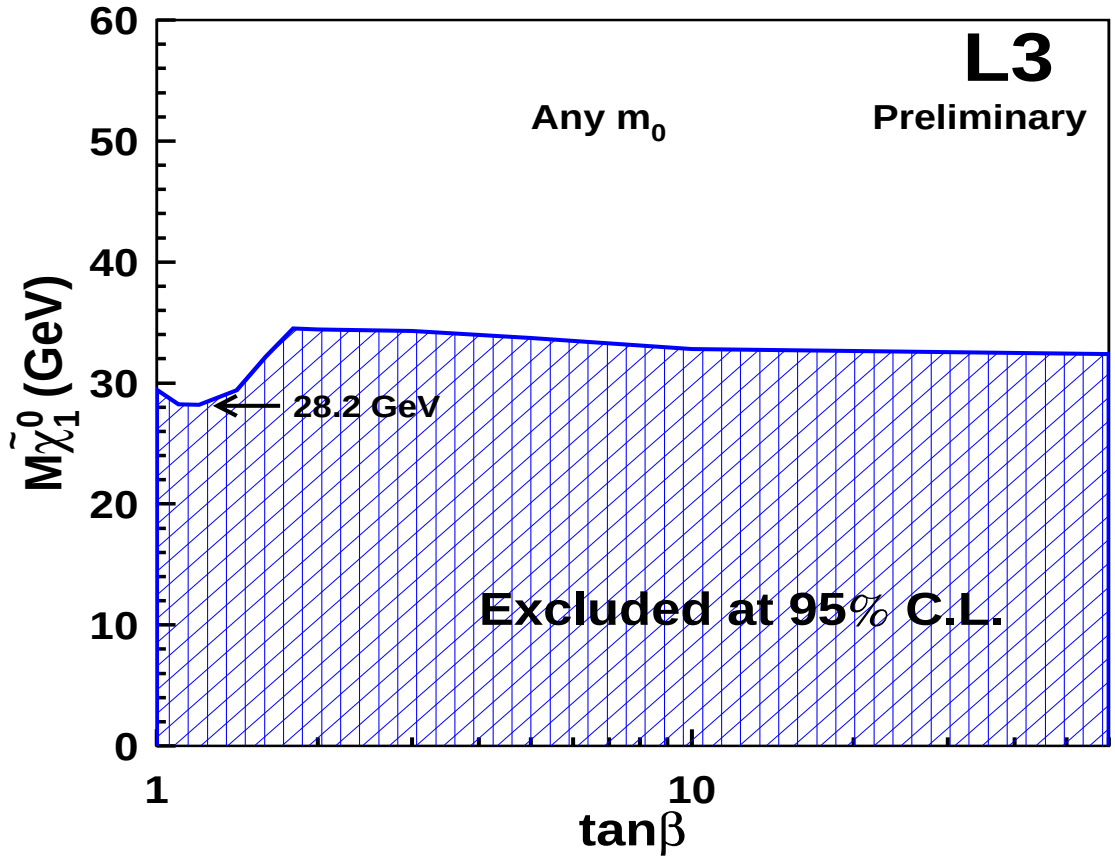


Indirect limit on LSP mass

(upto CM energy 189 GeV)




L3
preliminary
$M\tilde{\chi}_1^0$ (GeV)
80
70
60
50
40
30
20
tan β = 10.0
tan β = 1.00
Excluded at 95% C.L.
60
80
100
120
140
160
180
200
m_0 (GeV)


L3
Preliminary
Any m_0
$M\tilde{\chi}_1^0$ (GeV)
60
50
40
30
20
10
0
28.2 GeV
Excluded at 95% C.L.
1
10
tanβ

CONCLUSIONS AND PERSPECTIVES

At LEP pair production of charginos and neutralinos with all possible decays investigated

NO EVIDENCE

➤ **MSSM parameter space more constrained**

- **Lower limit on LSP mass 28.2 GeV**
- **Lower limit on lightest chargino mass 65.2 GeV for $\tan\beta > 1$ and any m_o**
- **Lightest chargino has been excluded upto the kinematic limit in most of the parameter space**

LEP200 will allow to probe
chargino upto 100 GeV and LSP upto 40 GeV