Search for $\tilde{\chi}_1^{\pm}$ mass degenerate with the $\tilde{\chi}_1^0$ at LEP

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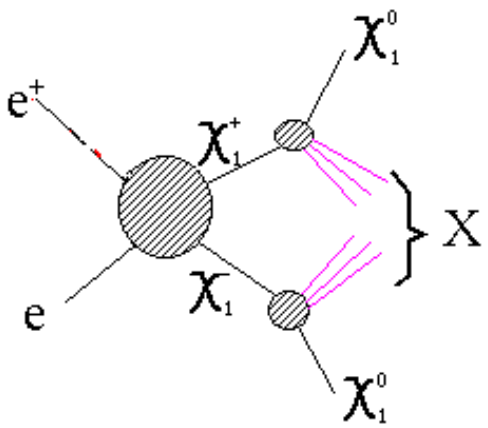
Lake Louise Winter Institute, February 20-26 2000

Standard $\tilde{\chi}_1^{\pm}$ search



R-parity conserved $\Longrightarrow \not{E}$

Standard search done by the 4 LEP experiments

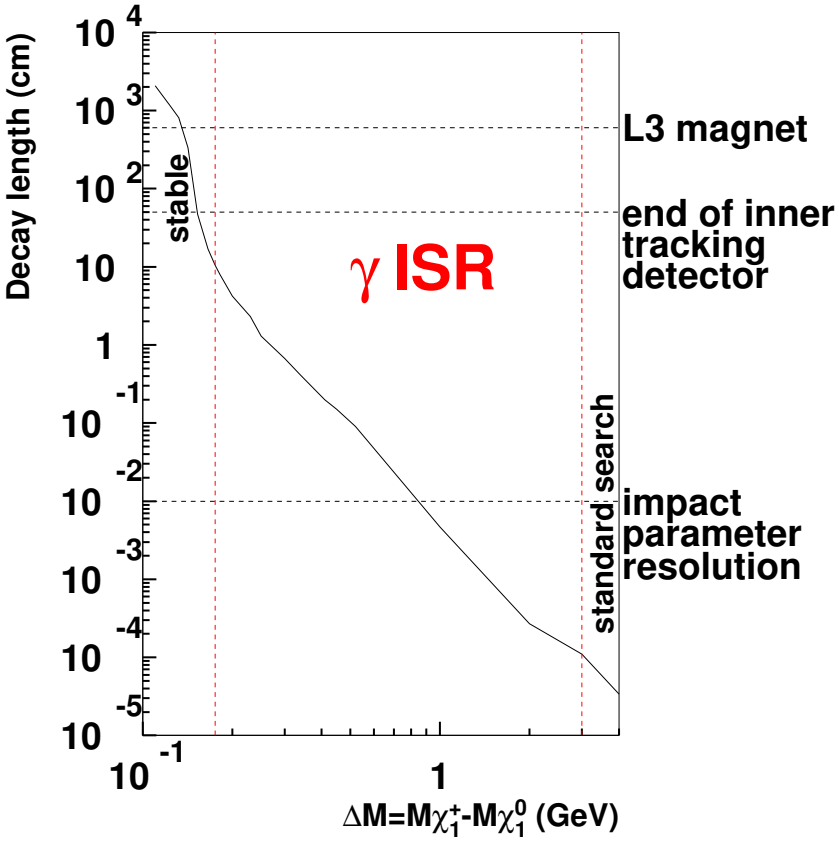
Efficiency ~ 0 for $\mathbf{\Delta M} = M_{\tilde{\chi}_1^{\pm}} - M_{\tilde{\chi}_1^0} \lesssim \mathbf{3\ GeV}$

Non gaugino mass universality at GUT scale can lead in natural way to small $\mathbf{\Delta M}$

$\longrightarrow$ need new approach

Phenomenology is different for heavy and light squarks and sleptons
Unless mentioned, all squarks and sleptons are assumed to be heavy.

Decay length



Long lived $\tilde{\chi}_1^{\pm}$: search for heavy charged stable particles

Ask for 2 highly ionizing tracks

Done by the 4 LEP experiments

DELPHI uses also kinks analyses (search for particles decaying in the tracking chamber)

Between stable and standard search : search with an ISR photon

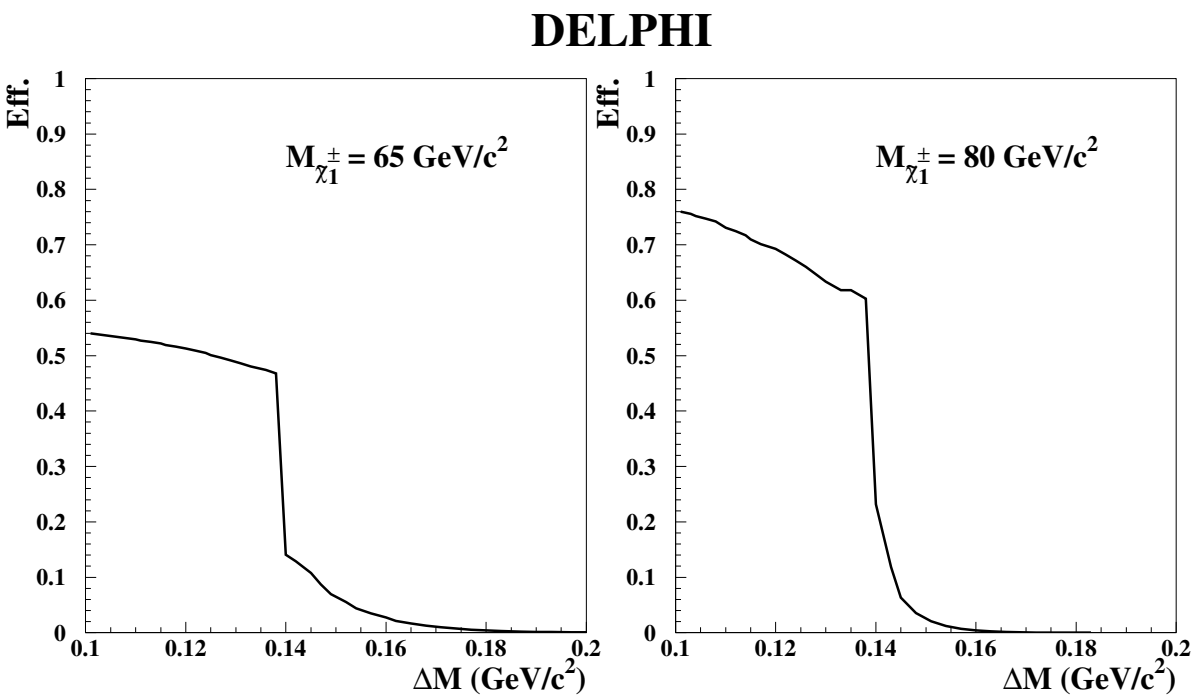
Done by DELPHI and L3

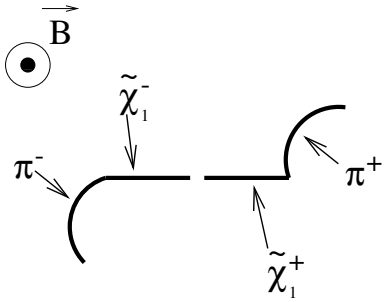
OPAL announces first results for this summer

ALEPH starts analyses with this channel

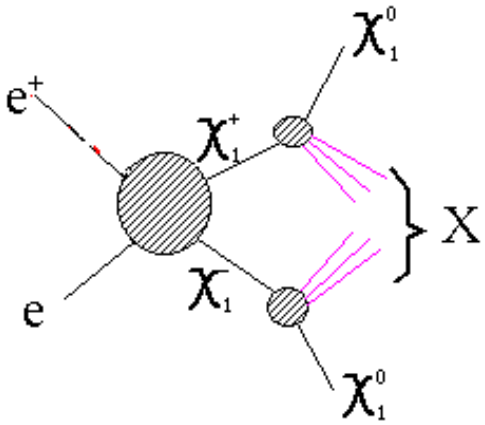
Efficiency

183 GeV

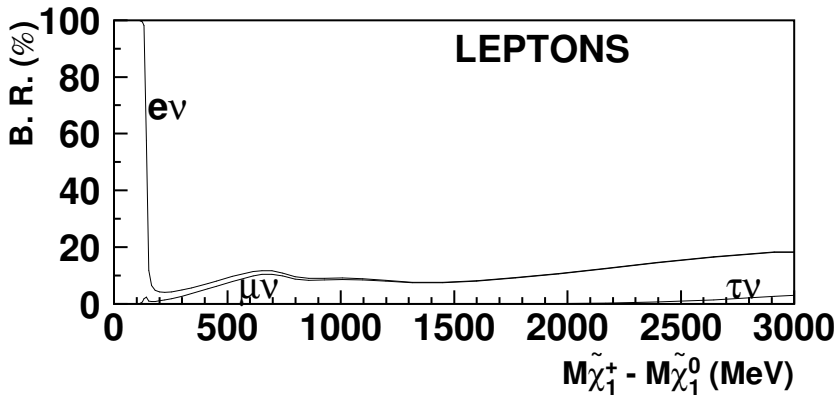


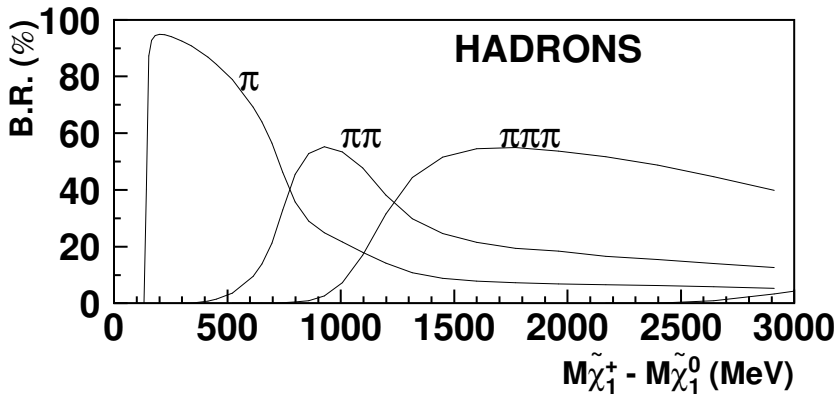


Signal features



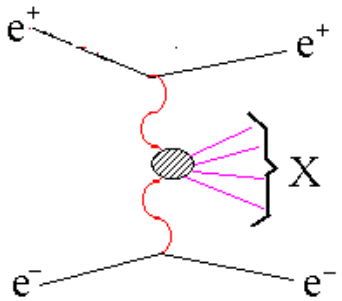
No displaced vertex (short life time)
Small visible energy (small ΔM)
Many pions





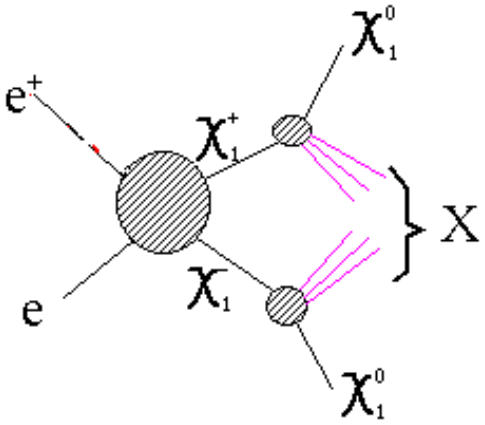
Gunion et al., Phys. Rev. Lett 82 (1999) 3192 - hep-ph/9607421

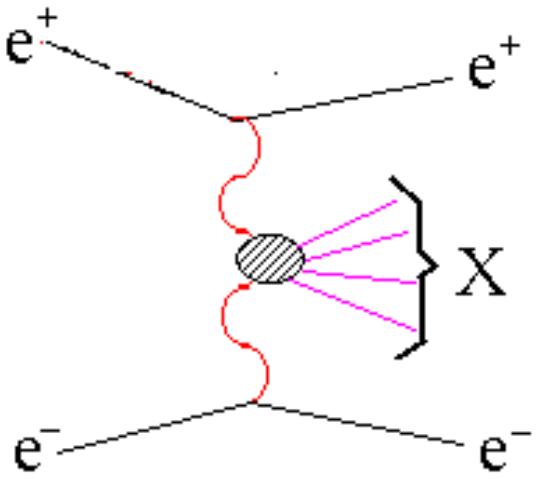
very similar to



Two-photon rejection

VS





$\sigma \sim 1 - 10\text{pb}$

$\sigma \sim 10^6$ pb

A photon with a transverse energy high enough can deflect an electron in the detector thus separating signal and background

$$E_{T\gamma} \geq 2E_{\text{beam}} \frac{\sin\theta_d}{1+\sin\theta_d}$$

with

$\theta_d \sim 2^\circ$ minimum detection angle for electrons

$+$: Easier to trigger with a high energy photon

$-$: No Monte Carlo describes completely two-photon interactions with ISR

Preselection

1 photon

E_T cut,
isolated in a 15° (L3) or 30° (DELPHI) cone
Recoil mass$> \mathbf{2M}_{\tilde{\chi}_1^\pm}$

$\tilde{\chi}_1^\pm$ decay products

$$E_{calorimeters} - E_\gamma \; < \; 12 \text{ GeV} \quad \text{L3}$$
$$< \; \mathbf{0.06}\sqrt{s} \quad \text{DELPHI}$$

at least 2 tracks

Not too many tracks or energy deposits in calorimeters

Two-photon rejection

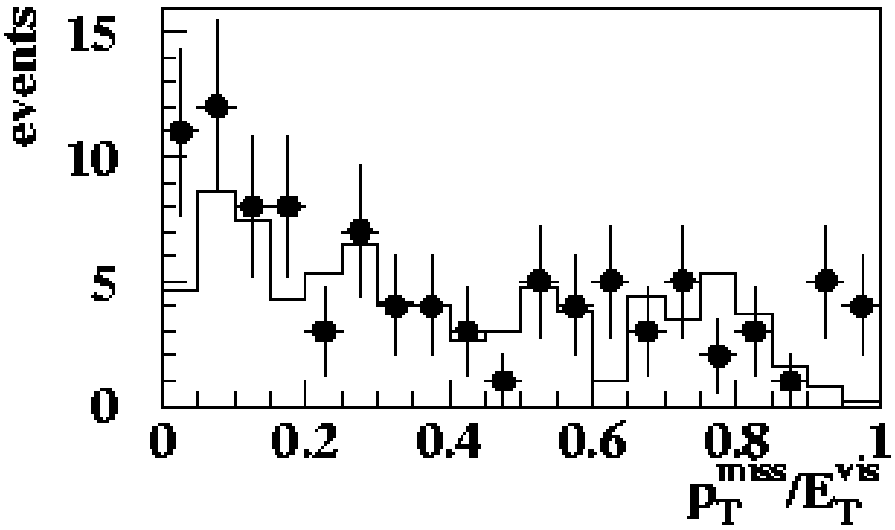
No energy deposit at small angle

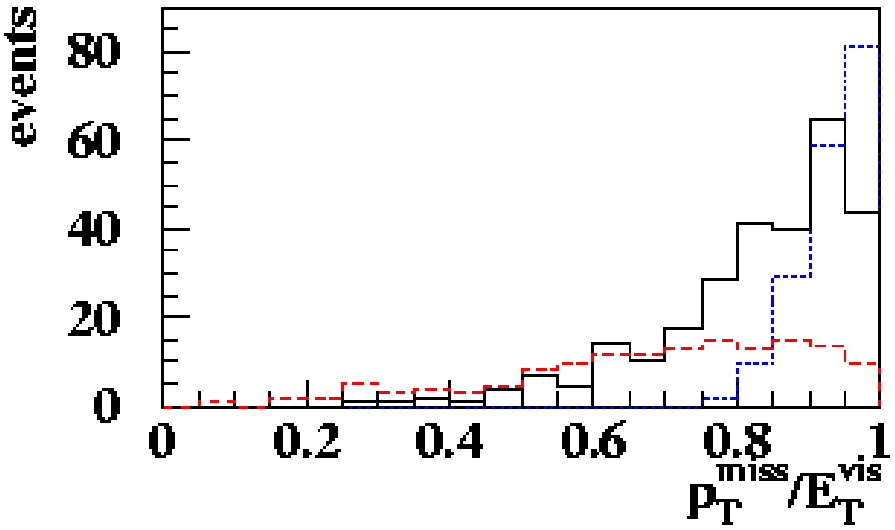
Specific cut $\frac{E_{Tvis}}{E_{vis}} > \mathbf{0.1}$ L3

$\frac{P_{Tmis}}{E_{Tvis}} > \mathbf{0.4}$ DELPHI

$\frac{P_{Tmis}}{E_{Tvis}}$

DELPHI E_{cms}=189 GeV





Selections

3 selections

low ΔM	very low ΔM	ultra low ΔM
$\Delta M \sim 3$ GeV	$\Delta M \sim 1$ GeV	$\Delta M \sim 300$ MeV

When ΔM $\searrow$:

Event Multiplicity $\searrow$

$E_{calorimeters} - E_{\gamma}$ $\searrow$

Cut on $\frac{E_{Tvis}}{E_{vis}}$ or $\frac{P_{Tmis}}{E_{Tvis}}$ $\nearrow$

low and very low ΔM:

Low energy tracks coming from the interaction point

ultra low ΔM:

Tracks with high impact parameter are allowed.
For L3 also high energy tracks are allowed (kinks)

Preliminary results

L3				
selection	low ΔM	very low ΔM	ultra low ΔM	OR
189 GeV(176 pb^{-1})	6/2.3	1/1.1	1/0.9	8/3.1
192-202 GeV(232 pb^{-1})	8/2.9	4/1.5	2/1.4	9/3.8
All (408 pb^{-1})	14/5.2	5/2.6	3/2.3	17/6.8

No two-photon background

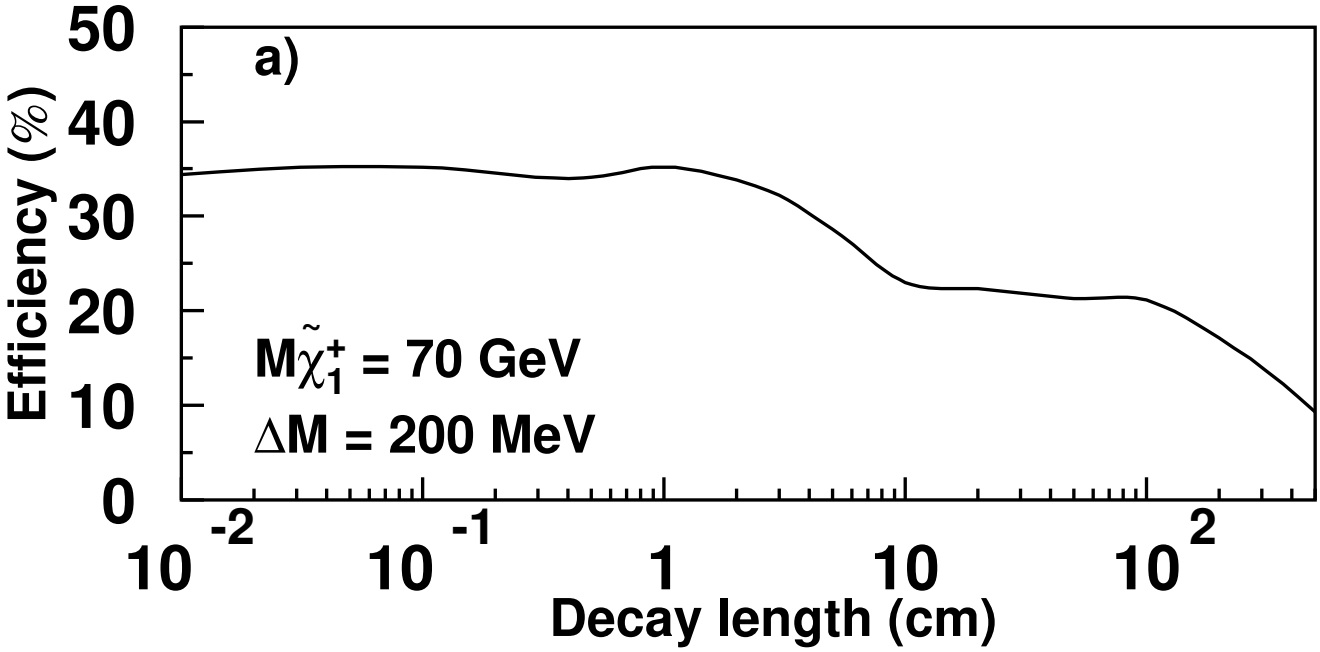
DELPHI	
selection	OR
130-183 GeV(81.3 pb^{-1})	5/2.8
189 GeV(152.9 pb^{-1})	8/5.5
All (234.2 pb^{-1})	13/8.3

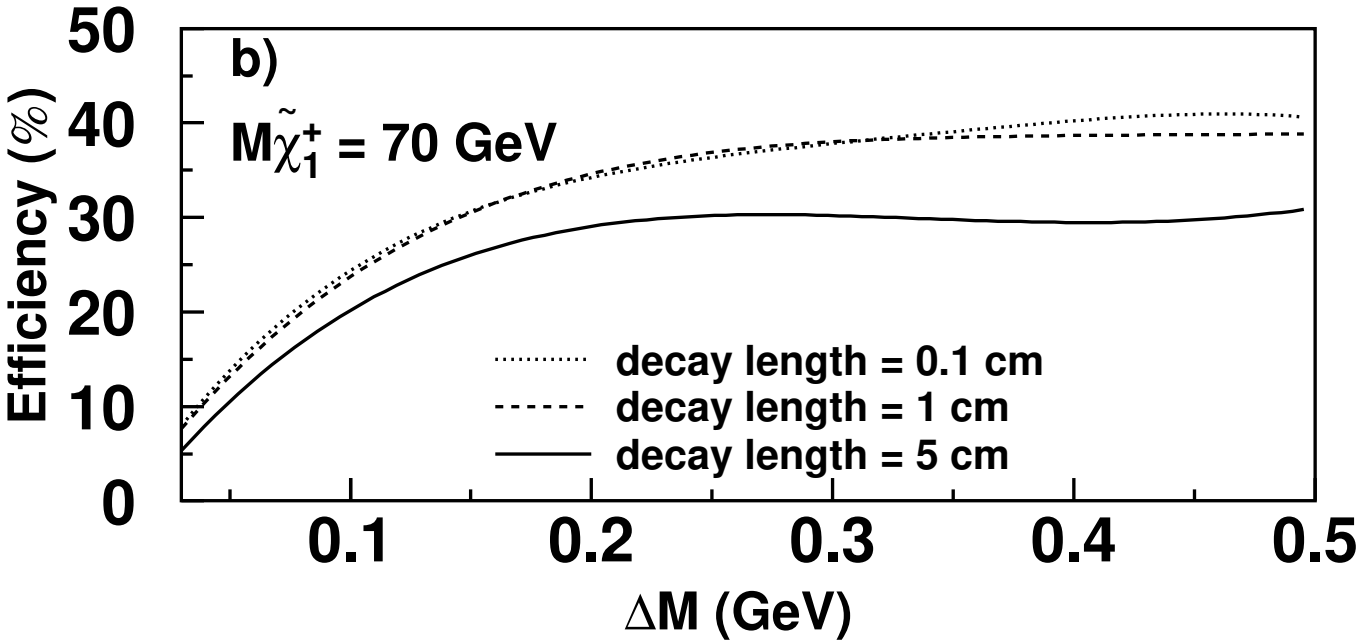
No complete phase space for two-photon background and some without ISR

Selection efficiency

Efficiency for events with $E_\gamma > 4$ GeV and $\Theta_\gamma > 10°$

L3 189 GeV



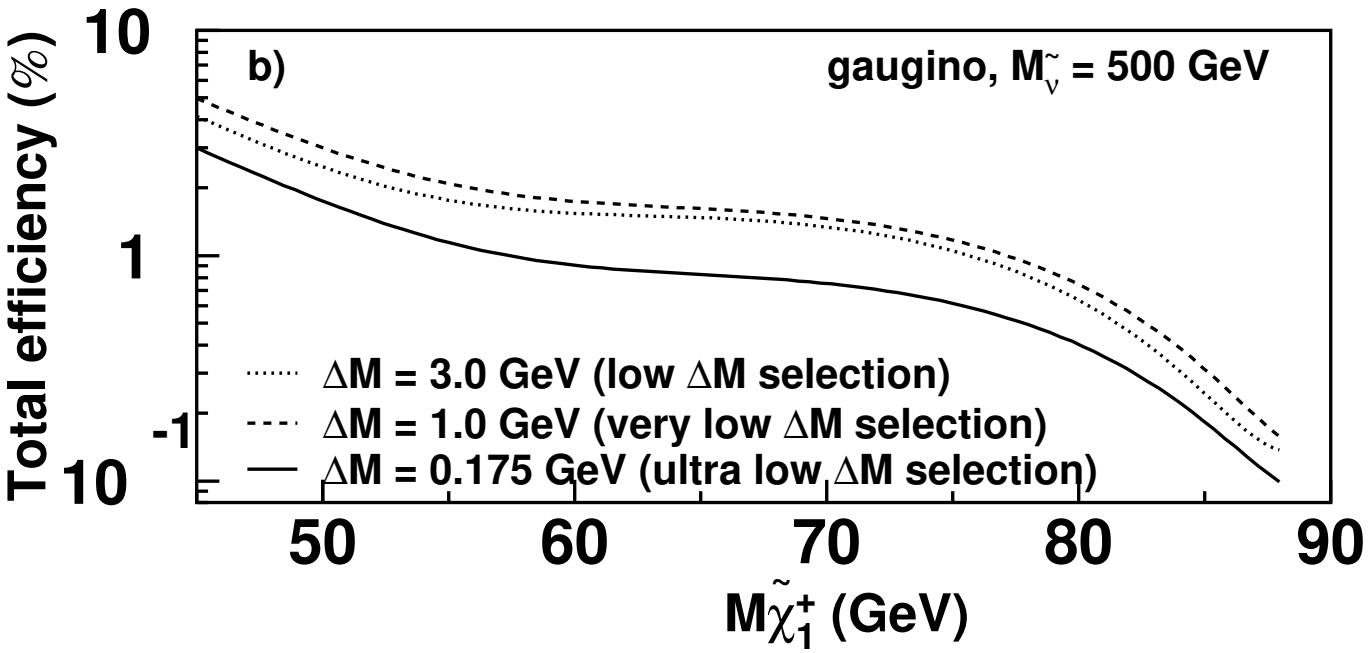


Efficiency

Global efficiency on $e^+e^- \to \chi_1^+\chi_1^-$ including ISR γ
to compare with other analyses

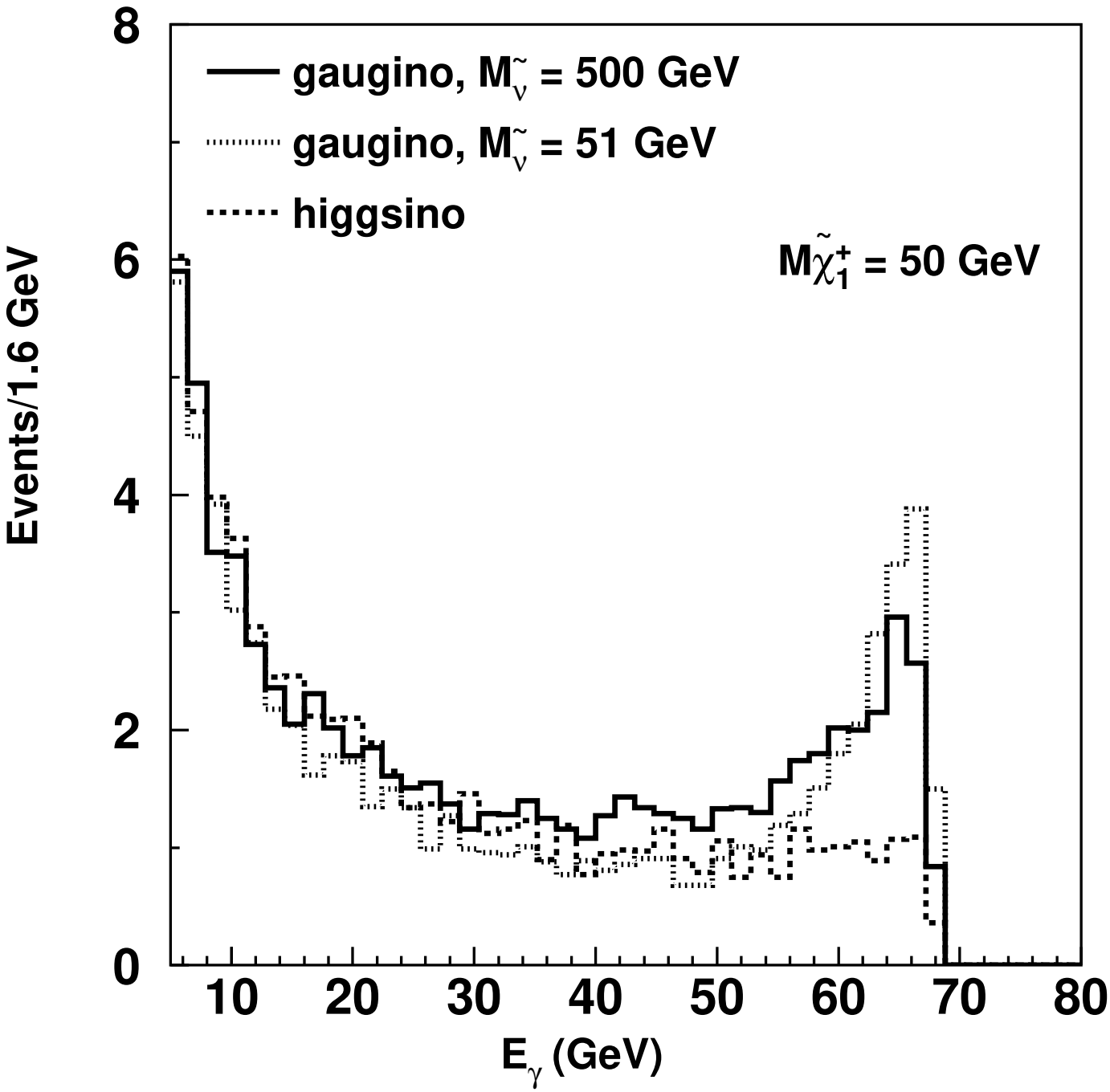
$\Longrightarrow$ efficiency ~ 1 %

L3 189 GeV



Dominated by ISR spectrum

ISR spectrum



Exclusion in $M_{\tilde{\chi}_1^\pm} - \Delta$M plane

Standard search
gives cross section upper limit as a function of
$M_{\tilde{\chi}_1^\pm}$ and ΔM

ISR search
gives cross section upper limit as a function of
$M_{\tilde{\chi}_1^\pm}$, ΔM and decay length

Stable search
gives cross section upper limit as a function of
$M_{\tilde{\chi}_1^\pm}$ and decay length

Evolution of decay length with ΔM depends on SUSY parameters

To exclude in the $(M_{\tilde{\chi}_1^\pm}, \Delta\text{M})$ plane, one has to choose a relation between ΔM and decay length

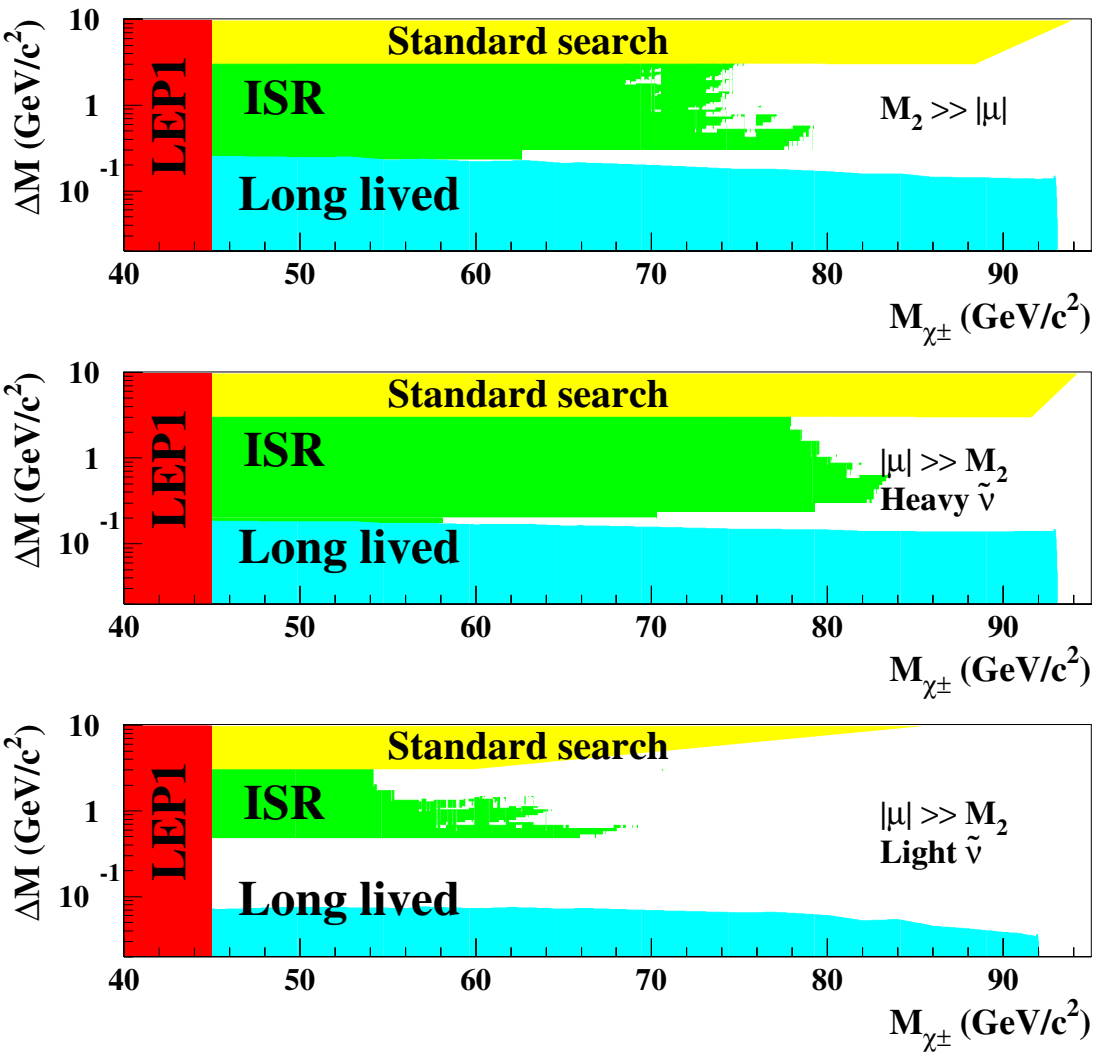
Smaller decay length gives smaller $\tilde{\chi}_1^\pm$ mass limit at intersection between Stable and ISR searches.

When $M_{\tilde{\nu}_e} \lesssim M_{\tilde{\chi}_1^\pm}$, $\tilde{\chi}_1^\pm$ are short lived and $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ cross section is smaller

Mass exclusion DELPHI

$\sqrt{s} = 130 - 189$ GeV

DELPHI (Preliminary)



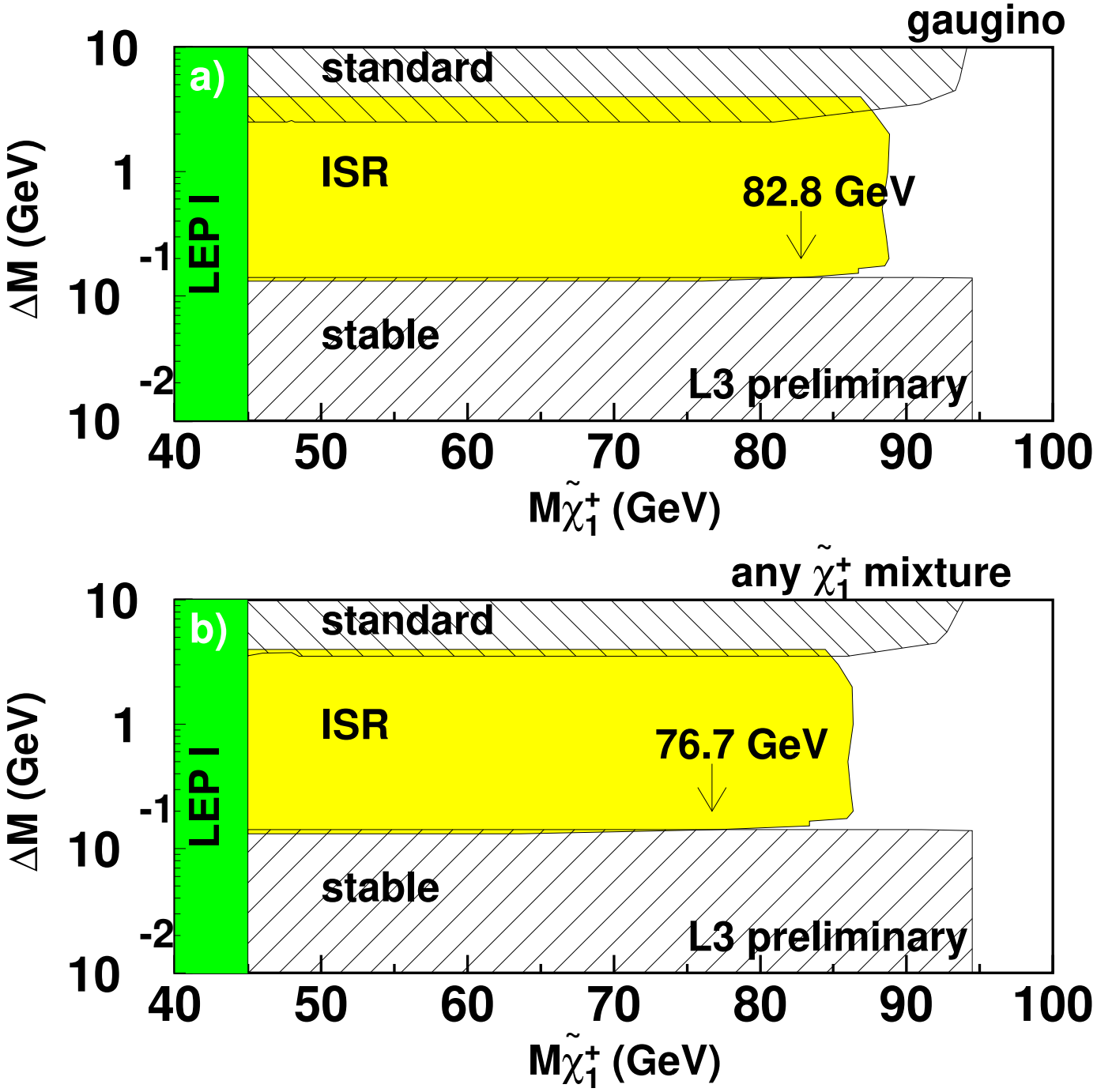
ISR and long lived analyses combined for heavy $\tilde{\nu}$ scenario

$M_{\tilde{\chi}_1^\pm} > 62.4$ GeV higgsino-like $\tilde{\chi}_1^\pm$

$M_{\tilde{\chi}_1^\pm} > 59.8$ GeV any field content

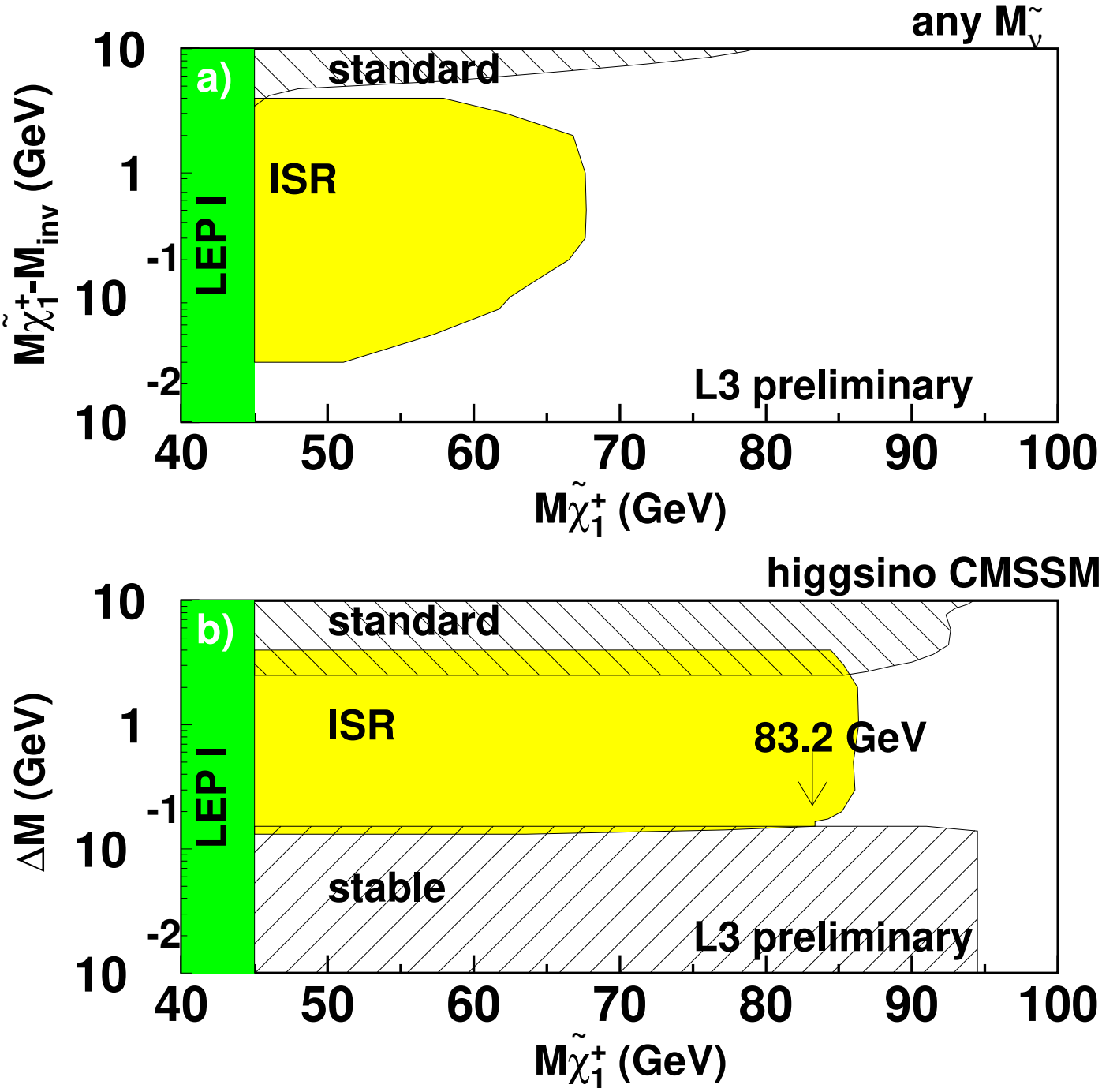
Mass exclusion L3 (I)

$$\sqrt{s} = 189 - 202 \text{ GeV}$$



Mass exclusion L3 (II)

$$\sqrt{s} = 189 - 202 \text{ GeV}$$



Conclusion

Direct search of $\tilde{\chi}_1^{\pm}$with any $\Delta M = M_{\tilde{\chi}_1^{\pm}} - M_{\tilde{\chi}_1^0}$ and new analyse for ΔM less than few GeV

3 selections needed

ΔM_A	$>$	ΔM_B	$>$	ΔM_C
Standard $\not{E}$		ISR γ		Long lived

Difficult for Tevatron
At RUN II with 30 fb^{-1}, $\tilde{\chi}_1^{\pm}$ mass limit < 60 GeV
(see hep-ph/9906270)

$\tilde{\chi}_1^{\pm}$ mass exclusion above 80 GeV is achieved at LEP for $\tilde{\nu}_e$ and $\tilde{e}^{\pm}$ heavy