Chargino production studies at ILC

- Introduction
- Tools and conditions
- SUSY parameters space
- Cross section results
- Comparison to extrapolated limits
- Conclusions

Introduction

Aim of the study:

- Compute lighter chargino pair production cross sections in a wide SUSY parameter space (only using MSSM as model)
- Determine case with lowest production cross sections
- Compare to cross section detection limits extrapolated from LEP results (in the worst scenario)

Charginos

- Mass eingenstates resulting from mixing of fermionic superpartners of W boson (Wino) and charged Higgs bosons (Higgsinos)
- There are two charginos. The ligher one denoted as X_1^{+-}
- Produced (in e^+e^- collisions) via Z/ɣ annihilation in the s-channel and sneutrino interchange in the t-channel

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Tools and conditions

Conditions

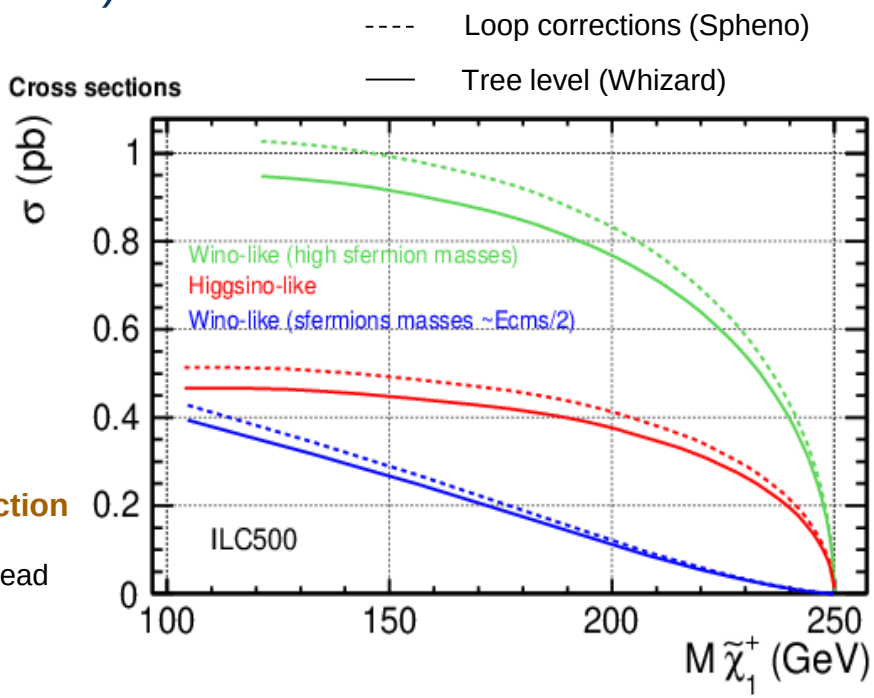
- SUSY parameters varied:
  - M2, μ, tanβ, sneutrino masses
- Polarization (e^-_L 80%, e^+_R 30%)
- ISR
- Beam spectrum (ILC Technical Report)
- Beam energy 500 GeV (250GeV to cross check)

Tools and conditions

Tools

- SPheno: Mass spectrum calculator
  - MSSM as model
  - SUSY parameters as input

- Whizard: Cross section calculator (tree-level)
  - e^+e^- collisions
  - ILC settings, ISR, polarization, beam spectrum
  - mass spectrum (from Spheno)



Effect of loop corrections in chargino cross section

No polarization, no ISR, no beam spread

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SUSY parameters space

- No relation between SUSY parameters assumed
- M2 and μ scanned for simulating chargino masses up to kinematic limit.

  Cross section studies divided in three scenarios:

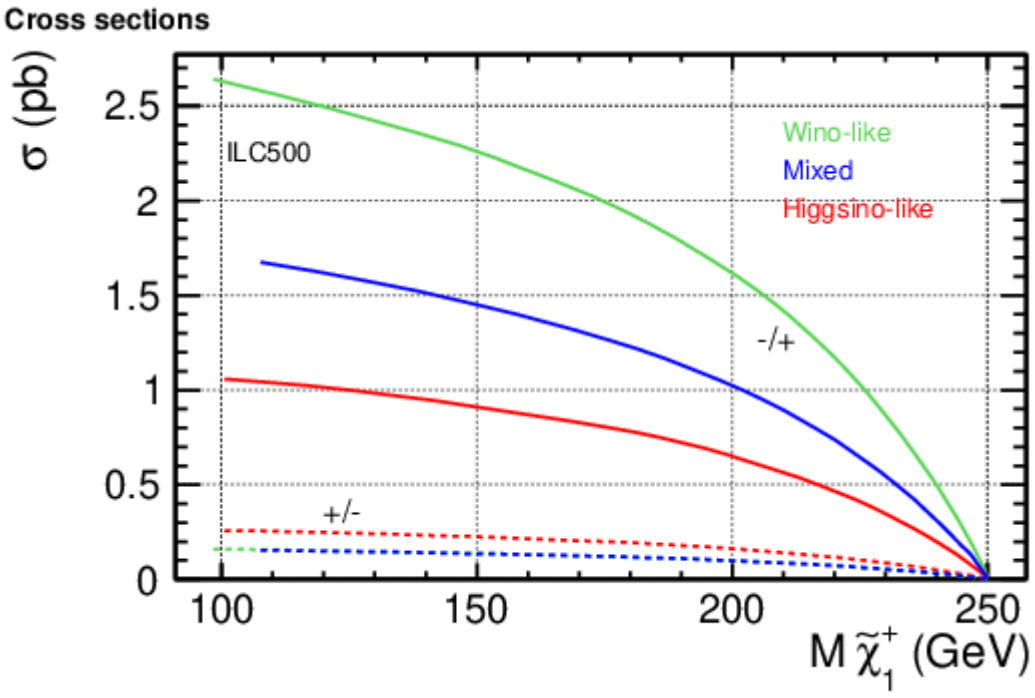
  - Higgsino-like charginos (M2 >> μ)
  - Wino-like charginos (M2 << μ)
  - Mixed chargino (M2 = μ)

  always with M2>0, μ>0.
- tanβ fixed to 10 (changes not affecting results)
- sneutrino masses scanned for analyzing the effect in the three scenarios studied.

  Effect on cross sections studied for:

  - high sneutrino masses (~1TeV)
  - low sneutrino masses (below/around kinematic limit)

Cross section results



- **Lower cross sections for Higgsino-like**
- **Polarization effects bigger in Wino-like**

- **High sfermions masses**
- **-/+ (e-L 80, e+R 30) vs +/- (e-R 30, e+L 80)**

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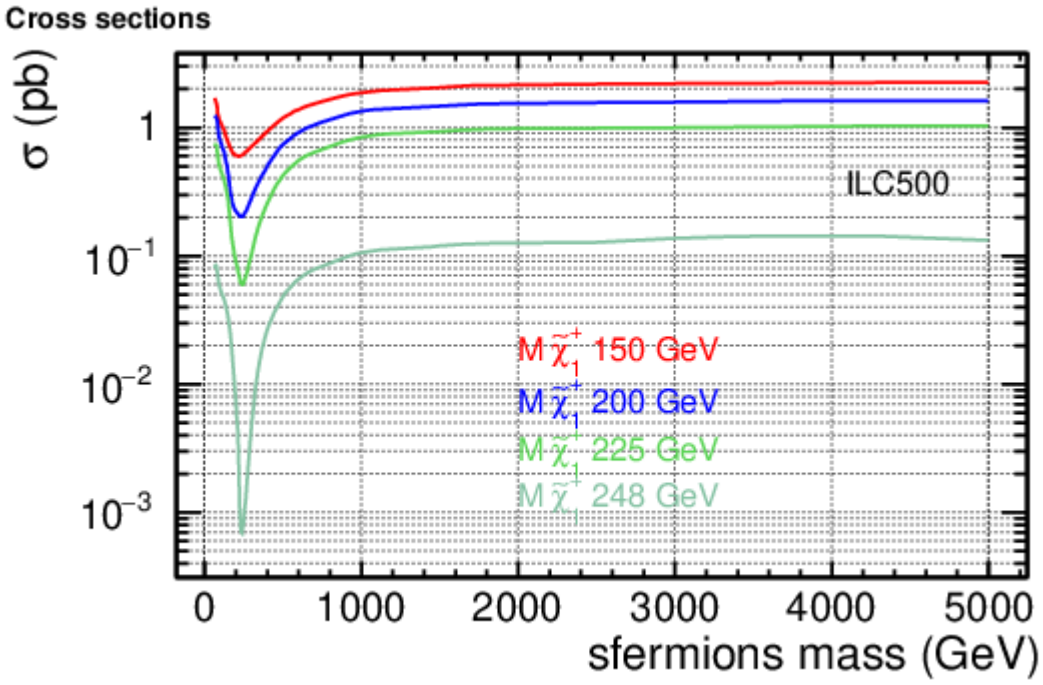
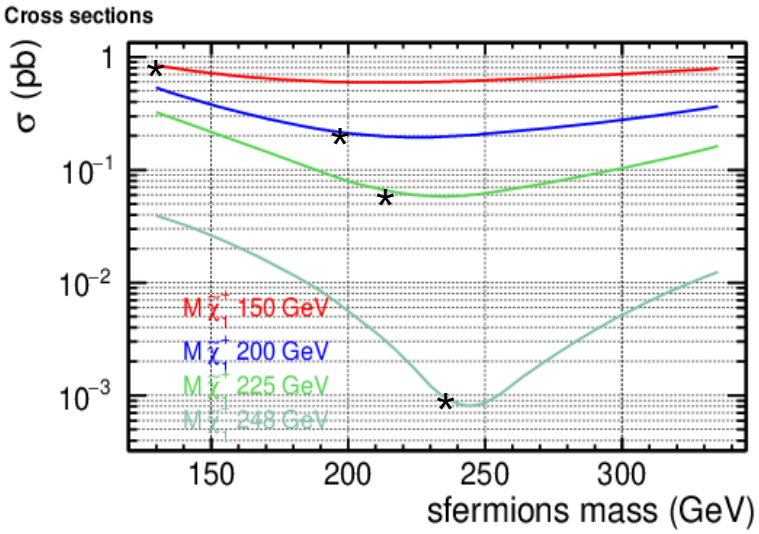
Cross section results

Sfermion masses



Wino-like charginos

- **Affects Wino case via destructive interference of t-channel**
- **No effect on Higgsino due to weakly coupling to sneutrino**



* Limit selectron mass < chi1 mass

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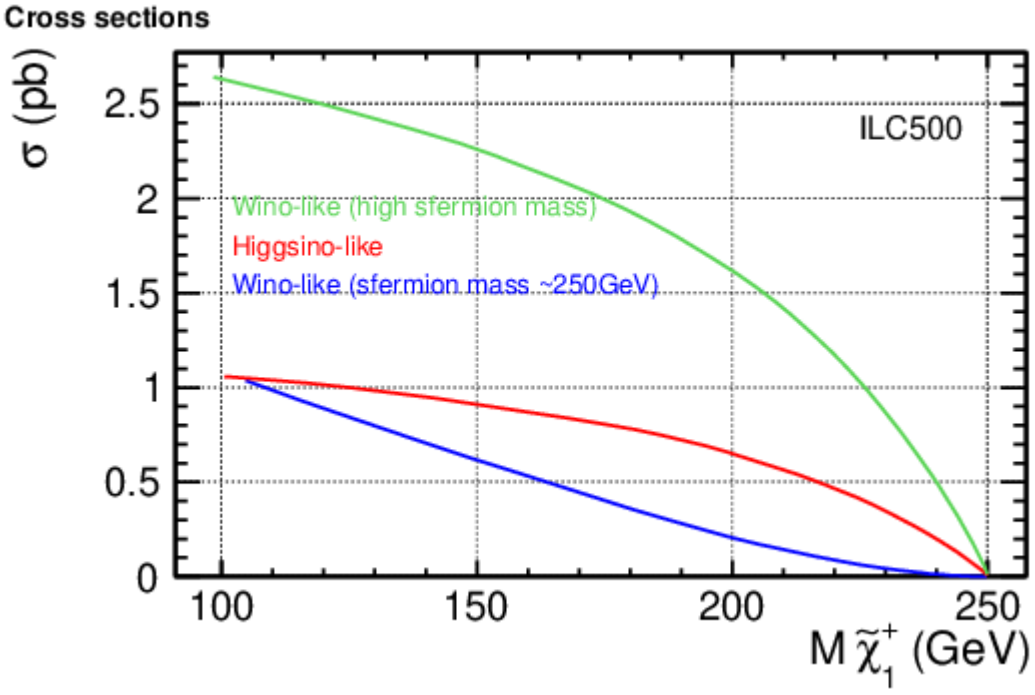
Cross section results

Sfermion masses



Lower efficiencies reached in Wino-like case with sfermions masses close to kinematic limit

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Comparison to extrapolated limits

Combined LEP chargino studies

- Data taken at up to ~208 GeV center-of-mass energy, accumulated luminosity ~800 pb^{-1}
- No signal found, limits derived at 95%CL in the context of MSSM (R parity conservation) focused in the region with small DM = $M(X_1^{+-}) – M(LSP)$
- Two cases considered:
  - Higgsino-like
  - Wino-like (high sfermion masses)
- Three topologies for the analysis of chargino decays:
  - prompt decays into leptons, leptons + jets, jets via W* (DM > 3GeV)
  - soft decays with a ISR requested on trigger (π mass < DM < 3GeV)
  - events with tracks displaying kinks, impact parameters offset or heavy stable charged particles (DM < π mass)

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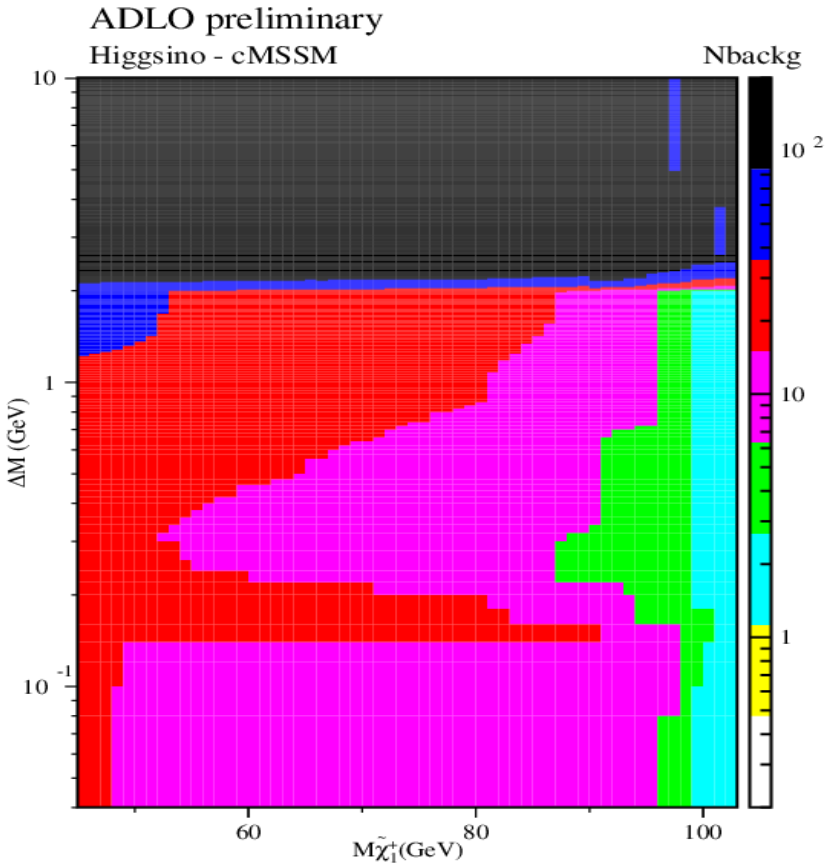
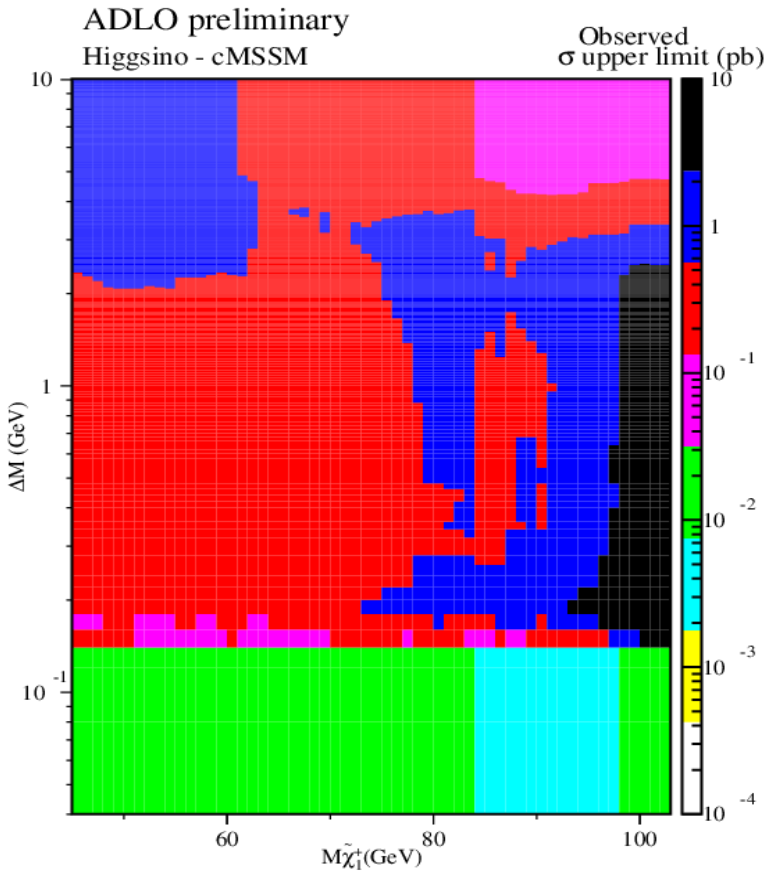
Comparison to extrapolated limits





Low efficiency in π mass < DM < 3 GeV region due to ISR trigger requirement

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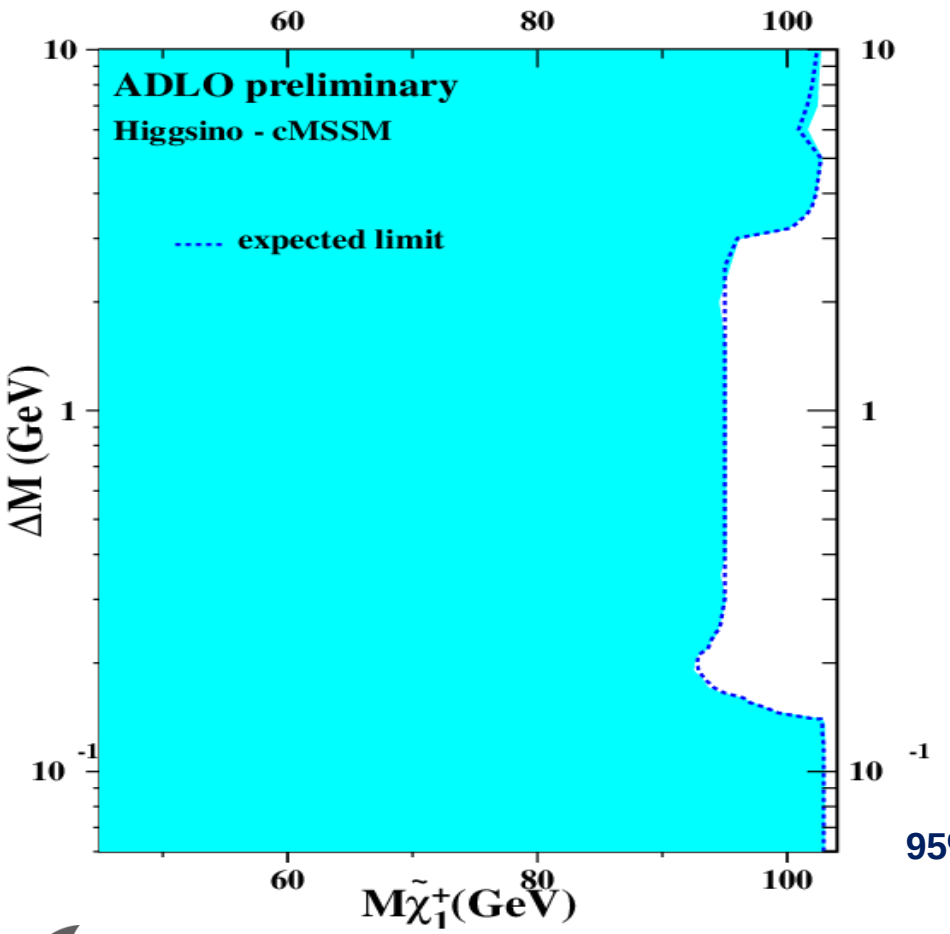
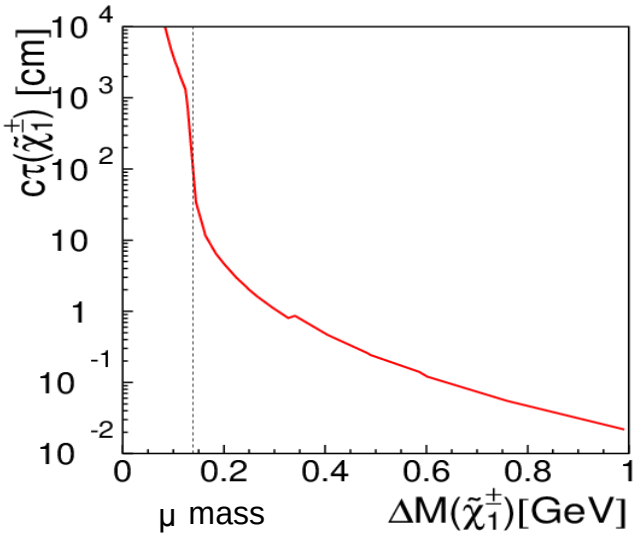
Comparison to extrapolated limits



95% CL

- ISR trigger request in soft events decrease detection efficiency by two orders of magnitude
- DM below pion mass increase abruptly decay length and therefore detection efficiency



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Comparison to extrapolated limits

Extrapolation of cross section limits

- **Worst case limit: region π mass < DM < 3GeV**
- **Gain comparing to DM > 3GeV region**
- **Assume same signal/background ratio and detection efficiencies**
- **Extrapolation based only on increase of luminosity (1.6 ab^{-1} ILC500, P(e^-L 80%,e^+R 30%)). Scaled using 1/sqrt(L) dependency**

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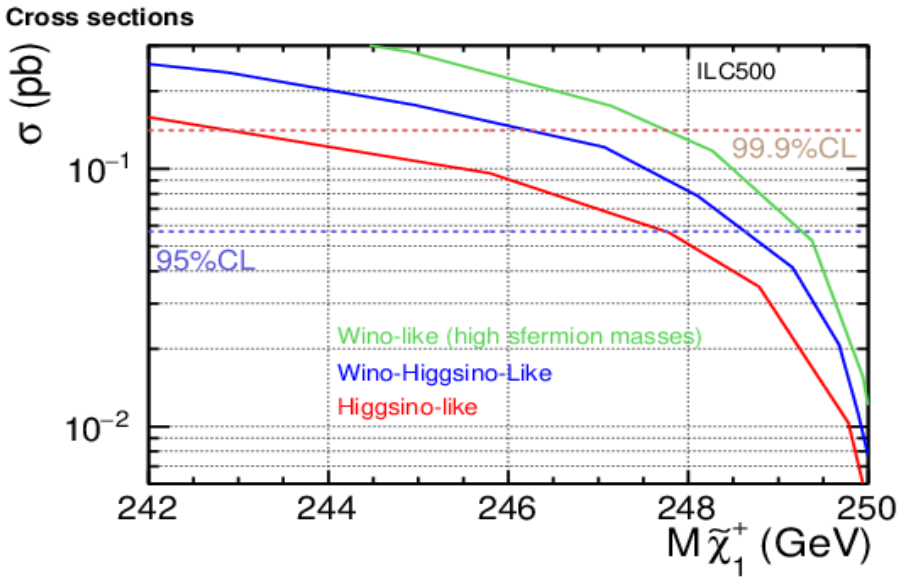
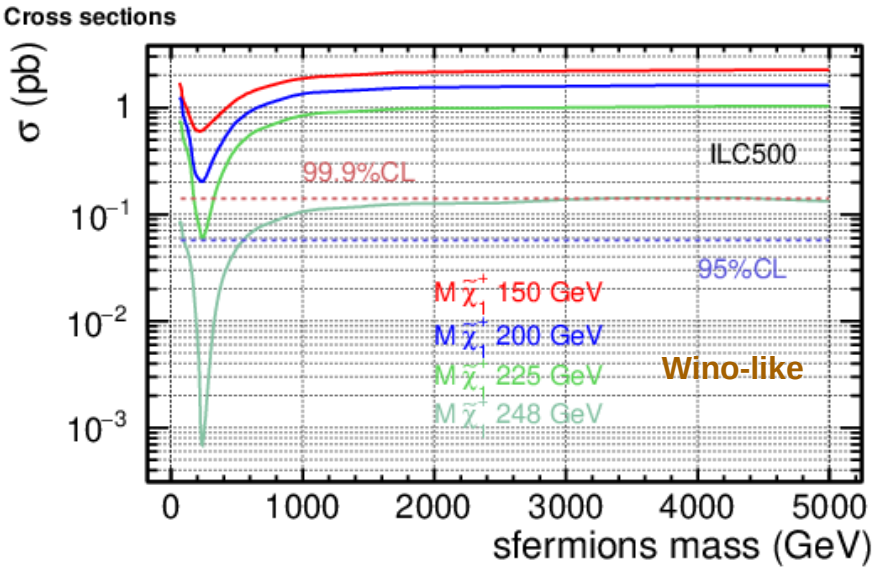
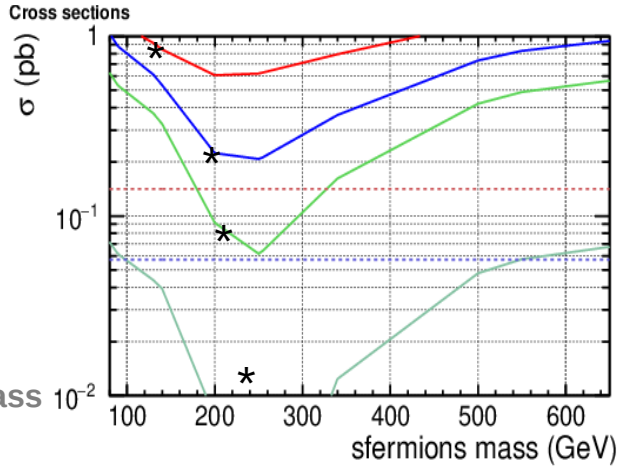
Comparison to extrapolated limits



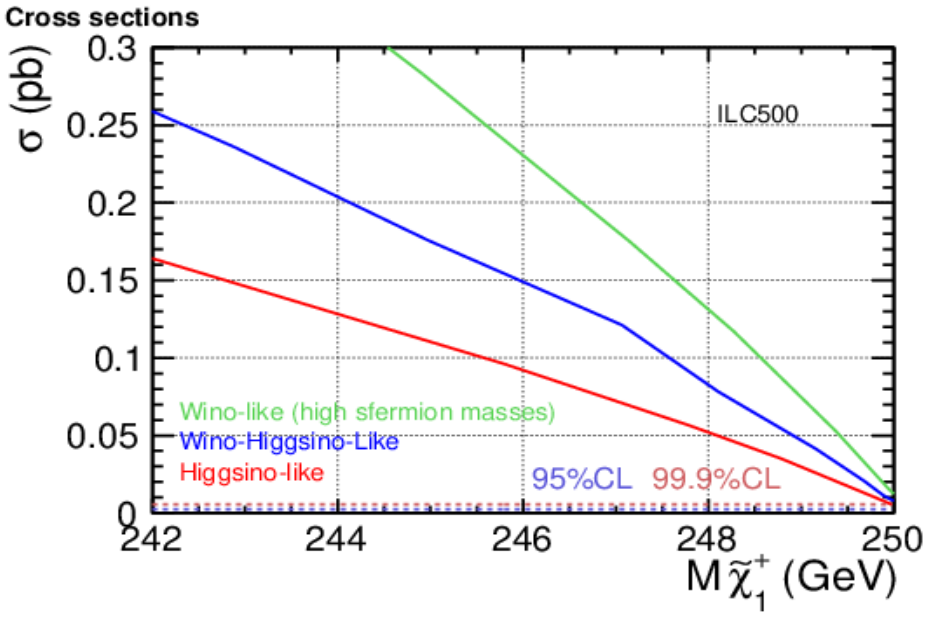


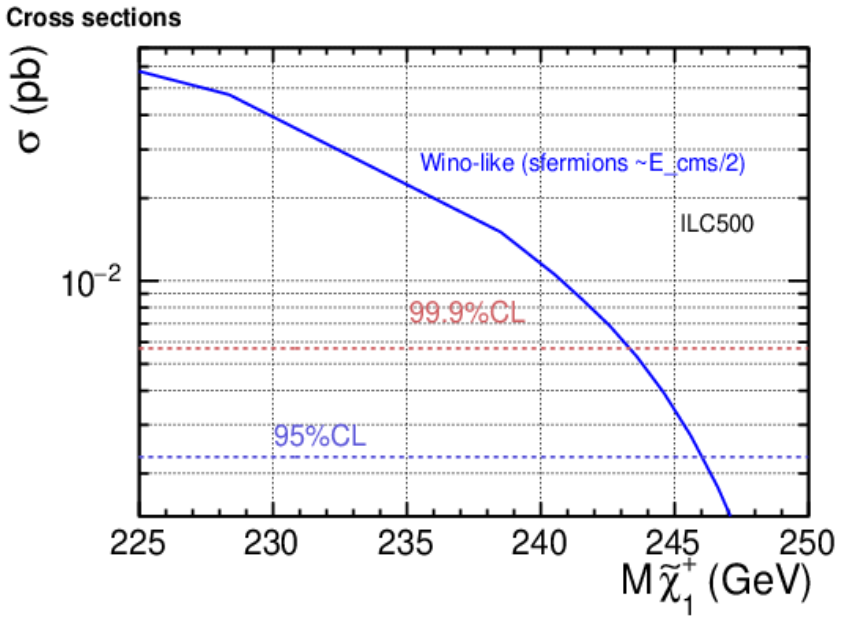


Comparison in the very worst scenario and without ILC improvements corrections

* Limit selectron mass < chi1 mass

Comparison to extrapolated limits





Comparison in the region DM > 3 GeV

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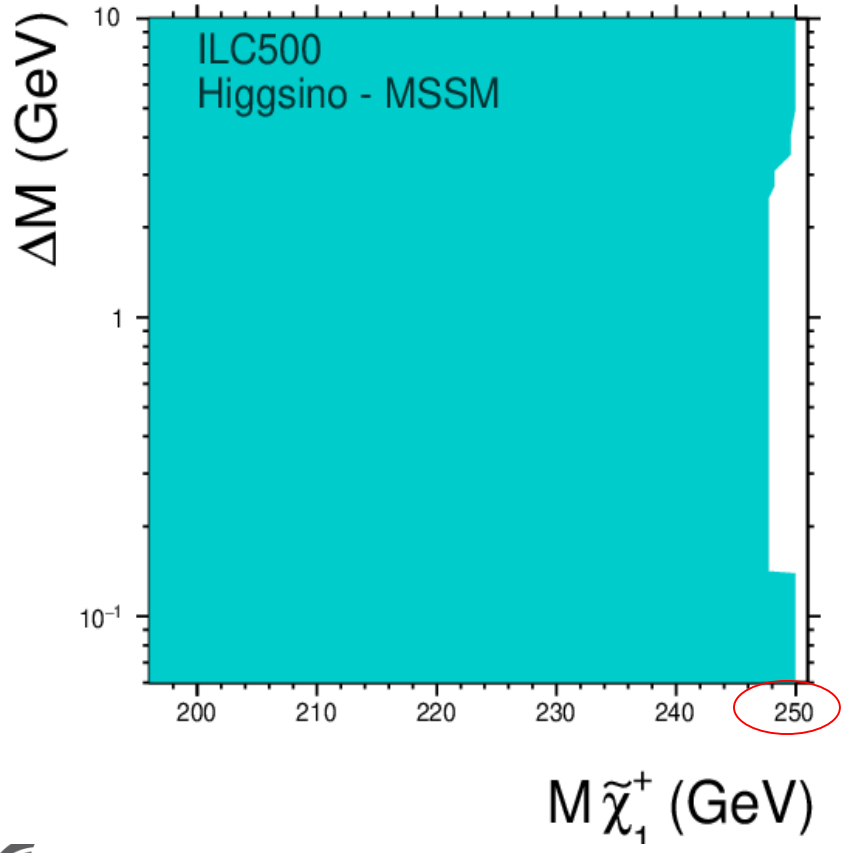
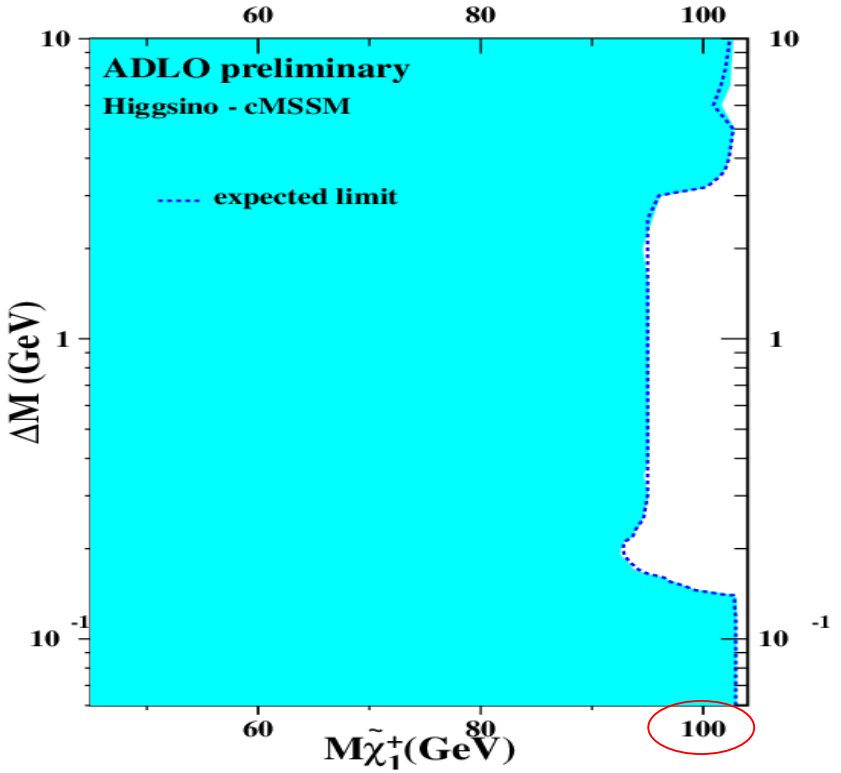
Comparison to extrapolated limits

Mass limits - Higgsino





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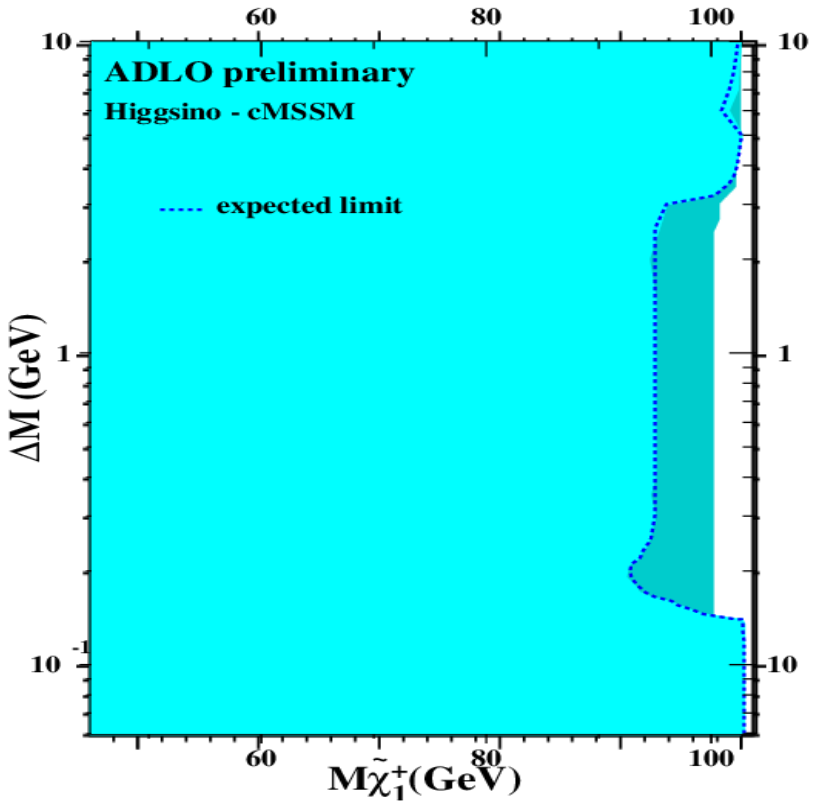
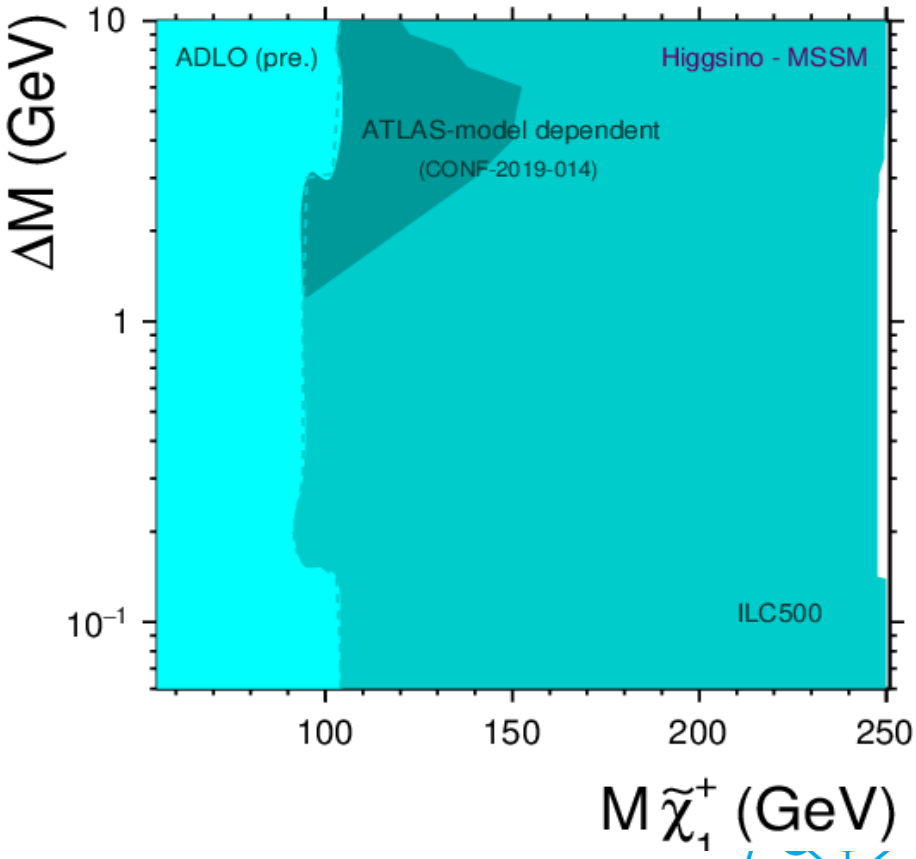
Comparison to extrapolated limits

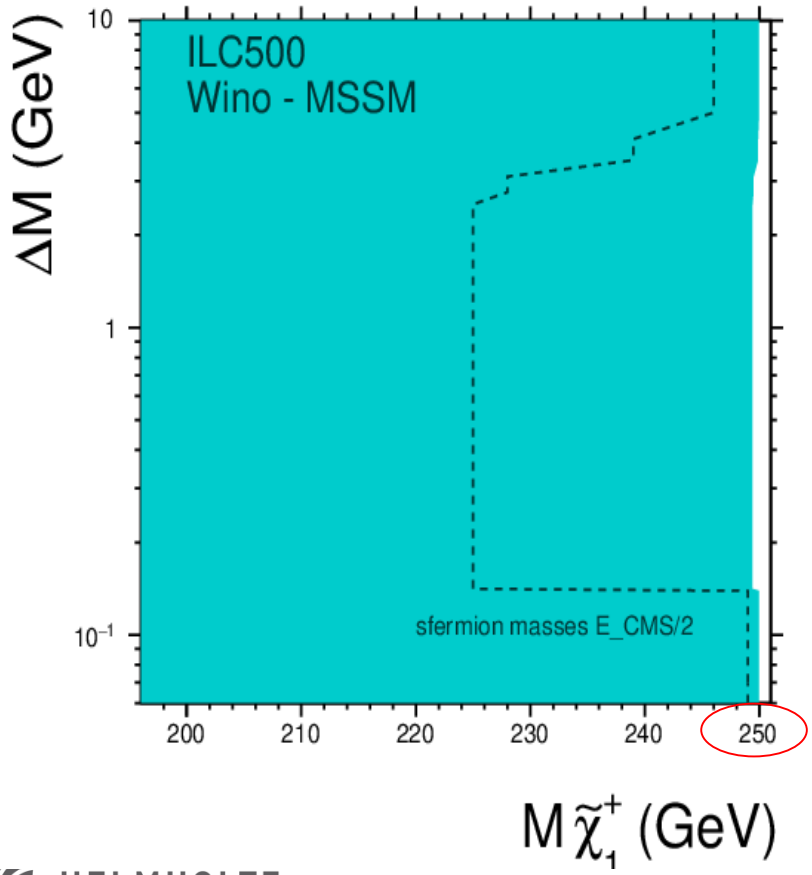
Mass limits - Higgsino

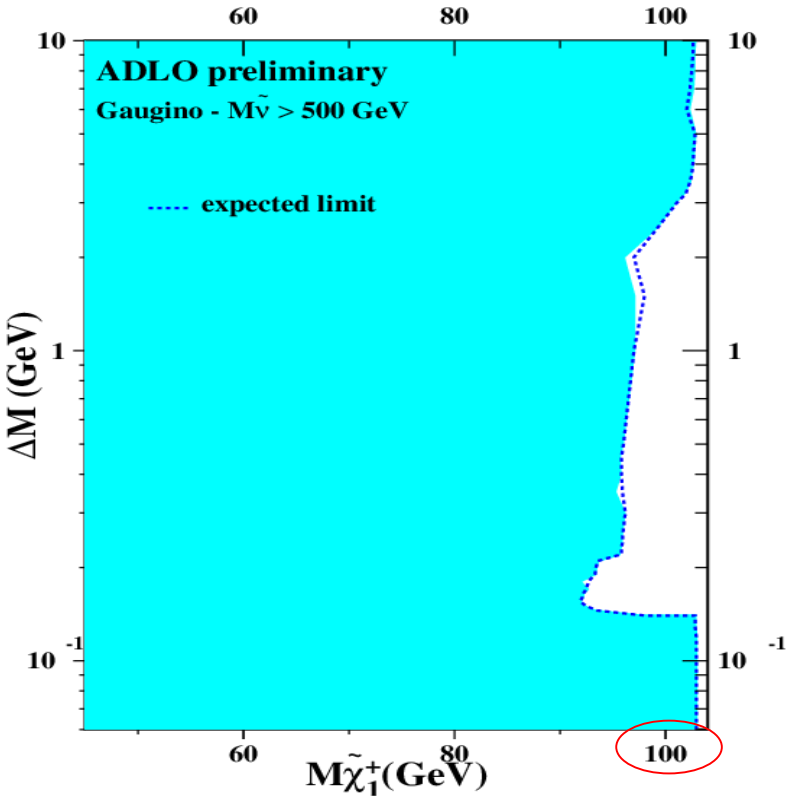




Comparison to extrapolated limits

Mass limits - Wino





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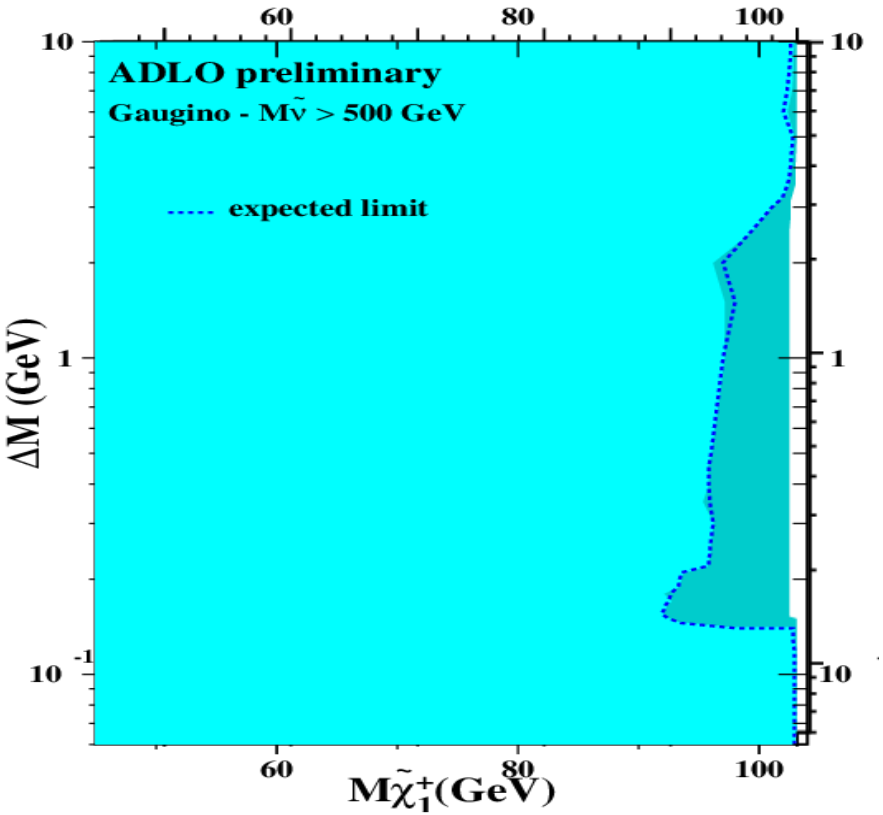
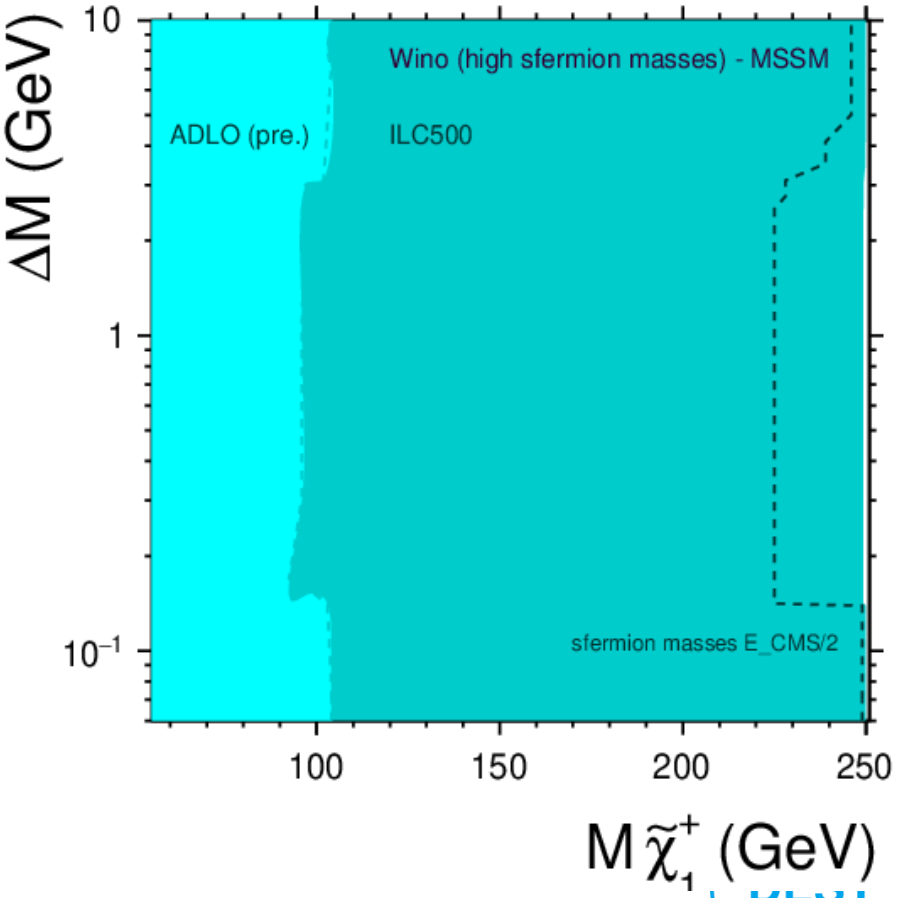
Comparison to extrapolated limits

Mass limits - Wino





Comparison to extrapolated limits

Improvements at the ILC

- Polarization (increases signal/background ratio)
- No trigger (increases detection efficiency and allows ‘redundant’ analysis) but …
  ISR needed for gamma-gamma background suppression
- Smaller beam size (increases detection efficiency by releasing ISR requests -> observation of decay length for soft events)

General comments

- Loop corrections are not included (increase chargino pair production cross sections)
- Low sfermions masses not taken into account in LEP analysis:
  - if sfermions masses are below the chargino ones they could be detected and/or could improve chargino detection efficiency favoring leptonic decays
  - if sfermions masses go below neutralino_0, they will be the LSP and the relevant DM will be (mass s_nue – mass chi1+)

  The drop in cross section due to sfermions masses depends on the beam energy, can be shifted.
- ISR request close to kinematic limits could cause unknown effects

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Conclusions

- Chargino production cross sections computed within a wide SUSY parameter space only using MSSM as model
- Lowest cross sections configuration compared to worst limit case: soft event decays
- Room to improvement at ILC:
  - Polarization
  - No trigger
  - Smaller beam size
- Cross section computed at tree-level (loop cross sections are higher)
- Low sfermion masses were compared but they would introduce new studies:
  - sfermions discovery
  - effect on chargino branching ratios
  - sfermions as LSP

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