# CLIC SUSY Discovery Reach at 3 TeV

OUTLINE

- Introduction pMSSM11 benchmark points
- Mass spectrum for BMP1 and BMP2
- SUSY production cross section
- $\tilde{\chi}_1 \pm$ (4J or eμ) and $\tilde{\chi}_3^0$ (4J) searches
- $\tilde{\chi}_2^0$ and $\tilde{q}$ (2J) searches

# Introduction

Assess the reach for some SUSY particles at CLIC for two different compositions of the $\tilde{\chi}_1^0$ corresponding to two benchmark points resulting from a fit of The pMSSM11 model to non accelerator data and accelerator data

Ref: “The likelihood analysis of the pMSSM11 in Light of LHC 13-TeV Data ” E. Bagnaschi, … J.R. Ellis, … G. Weiglein (arXiv:1710.11091) .

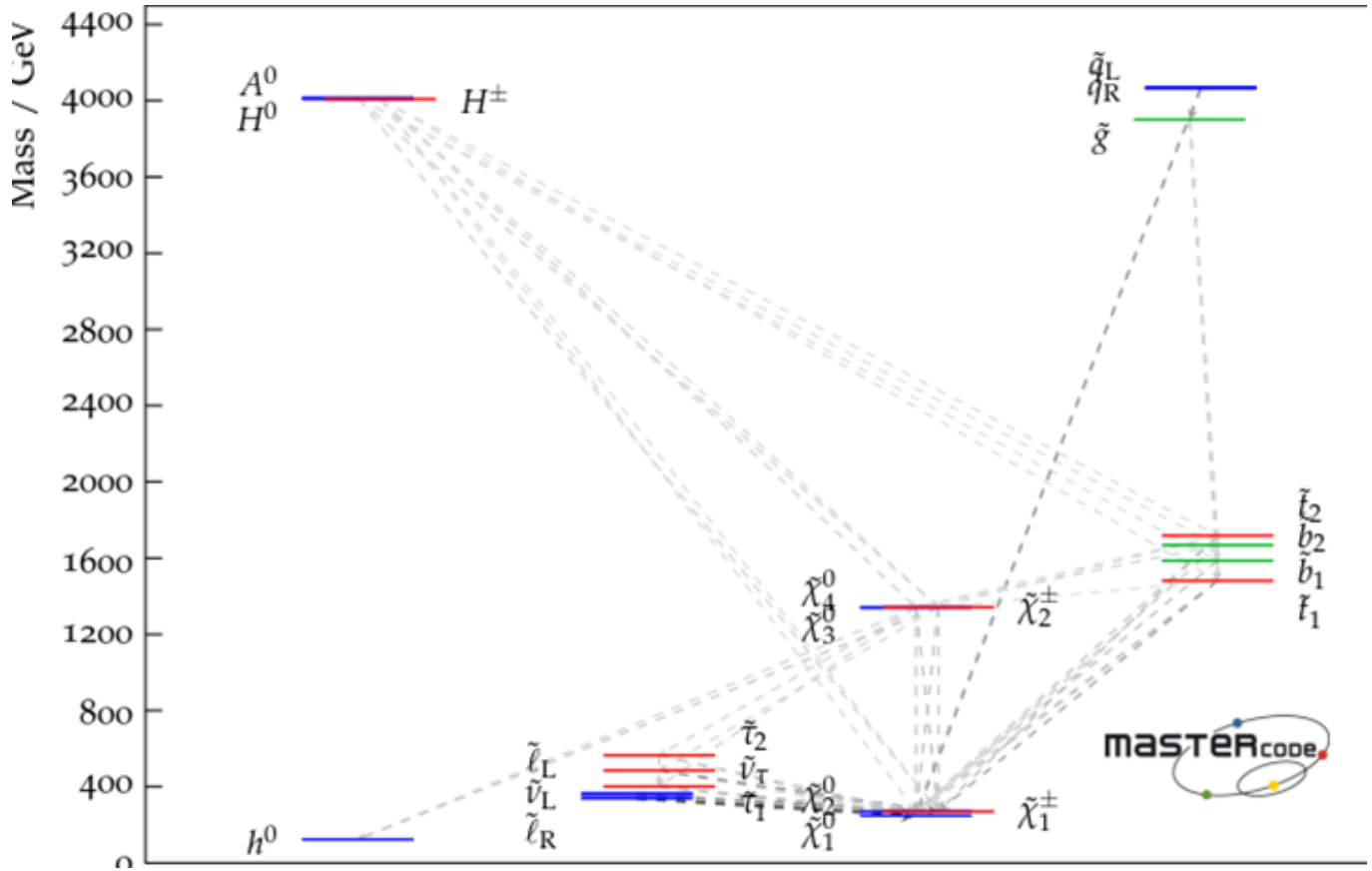
As the fit includes LHC data these points are not excluded by LHC.

For the two benchmark points the composition is such that Ω is compatible with the relic density constraints.

# BMP1 Spectrum and $\tilde{\chi}_1^0$ composition

Benchmark point 1 (BMP1): Neutralino composition:

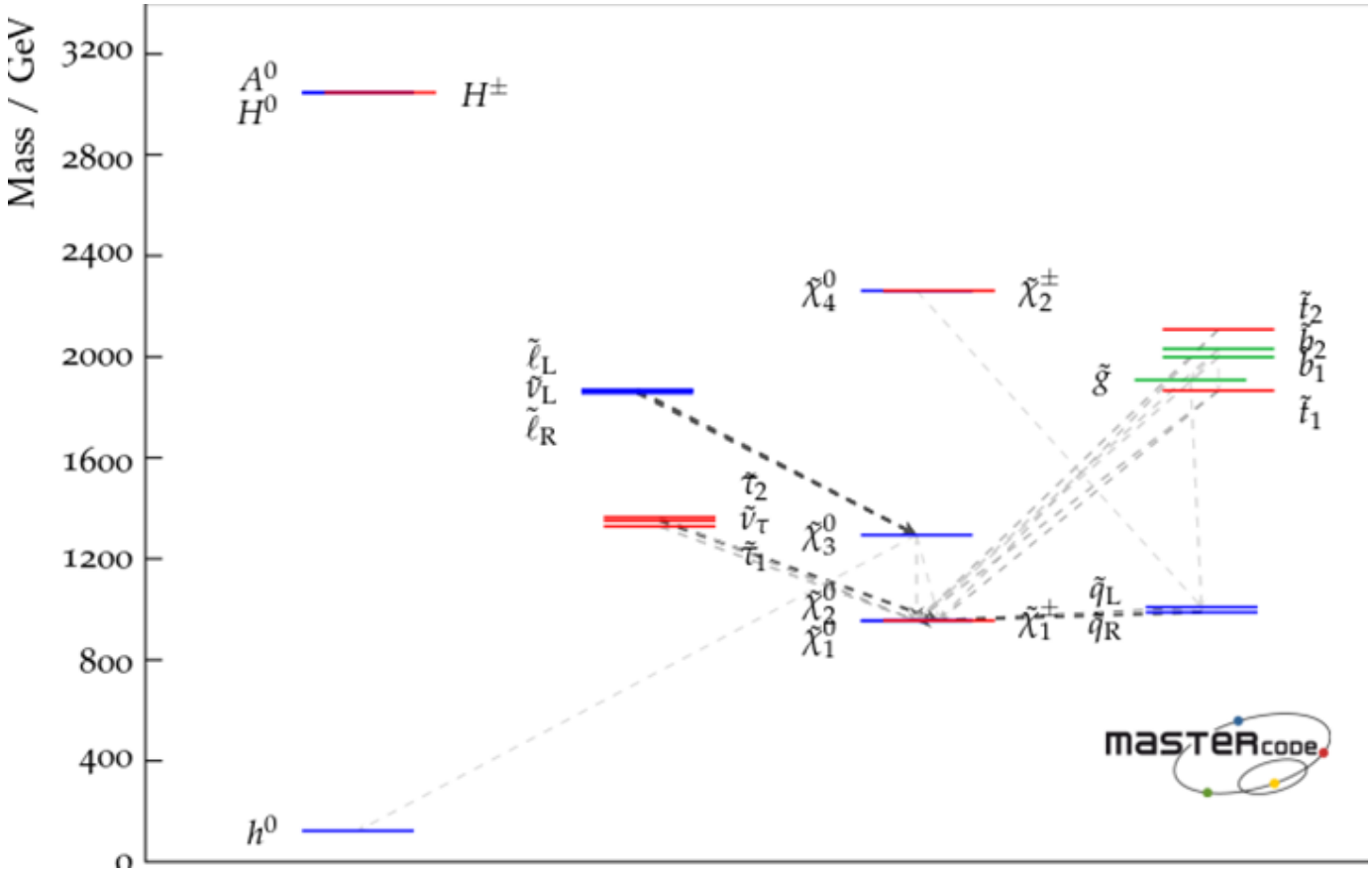
~o1 = 0.999*bino -0.028*wino +0.036*higgsino1 -0.008*higgsino2



# BMP2 Spectrum and $\tilde{\chi}_1^0$ composition

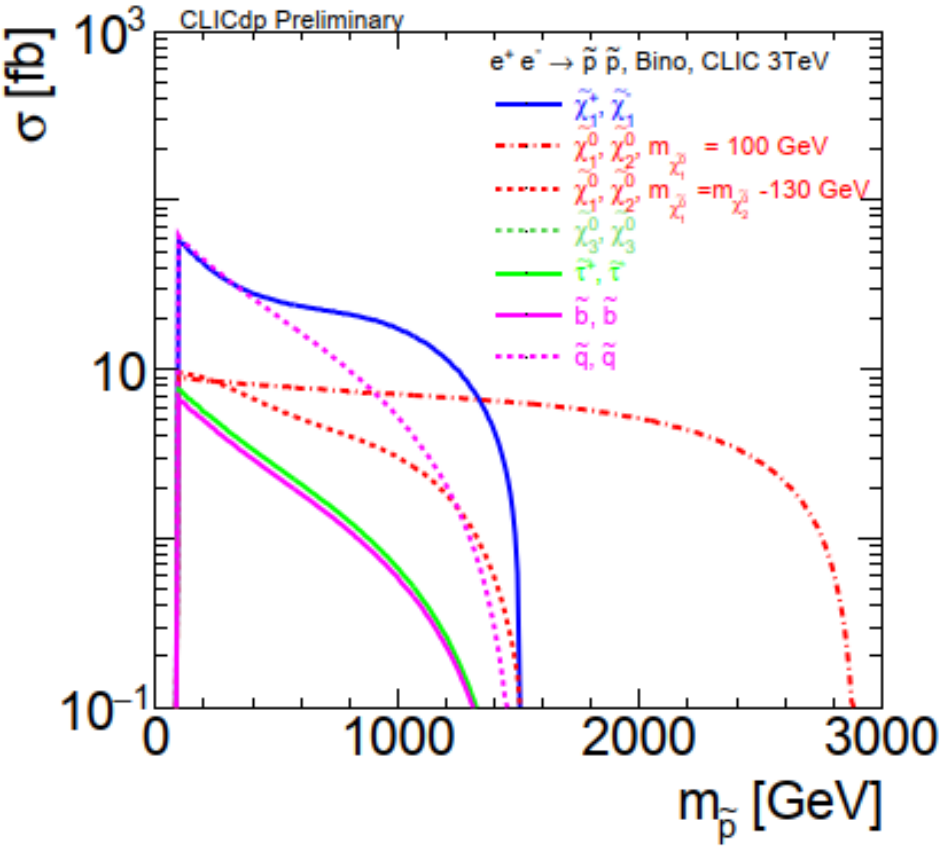
Benchmark point 2 (BMP2): Neutralino composition:

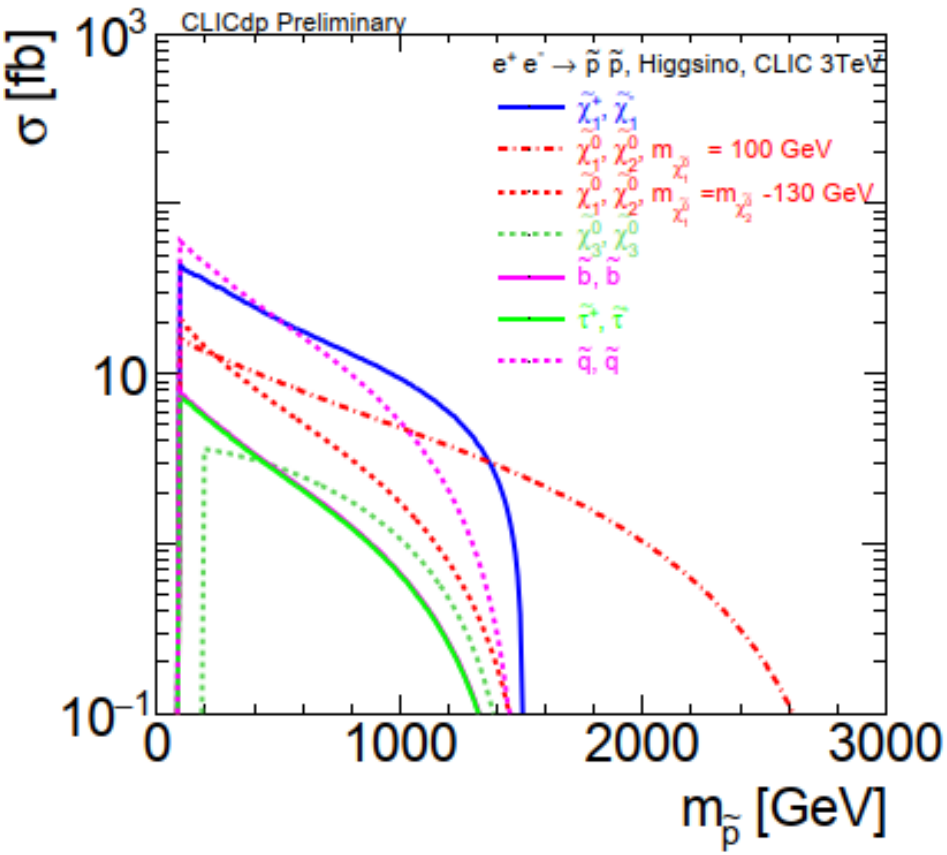
~o1 = 0.096*bino +0.018*wino -0.704*higgsino1 +0.703*higgsino2



# SUSY Cross Sections at CLIC

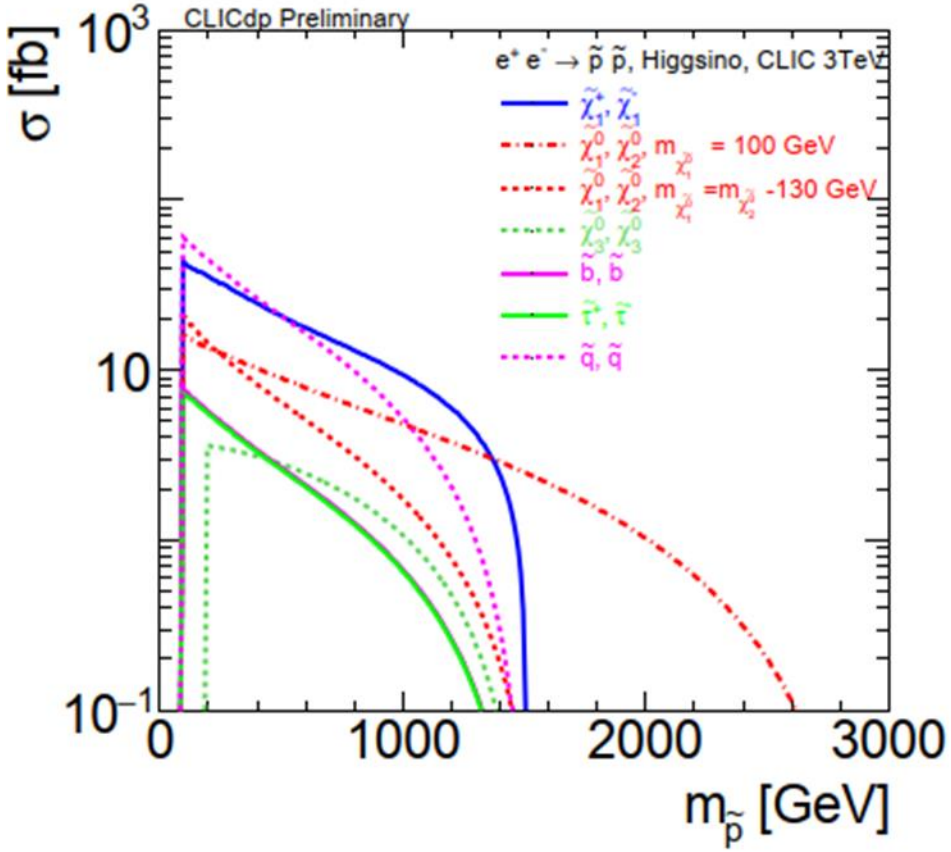
SUSY production cross section for BMP1 (Bino) and BMP2 (Higgsino).

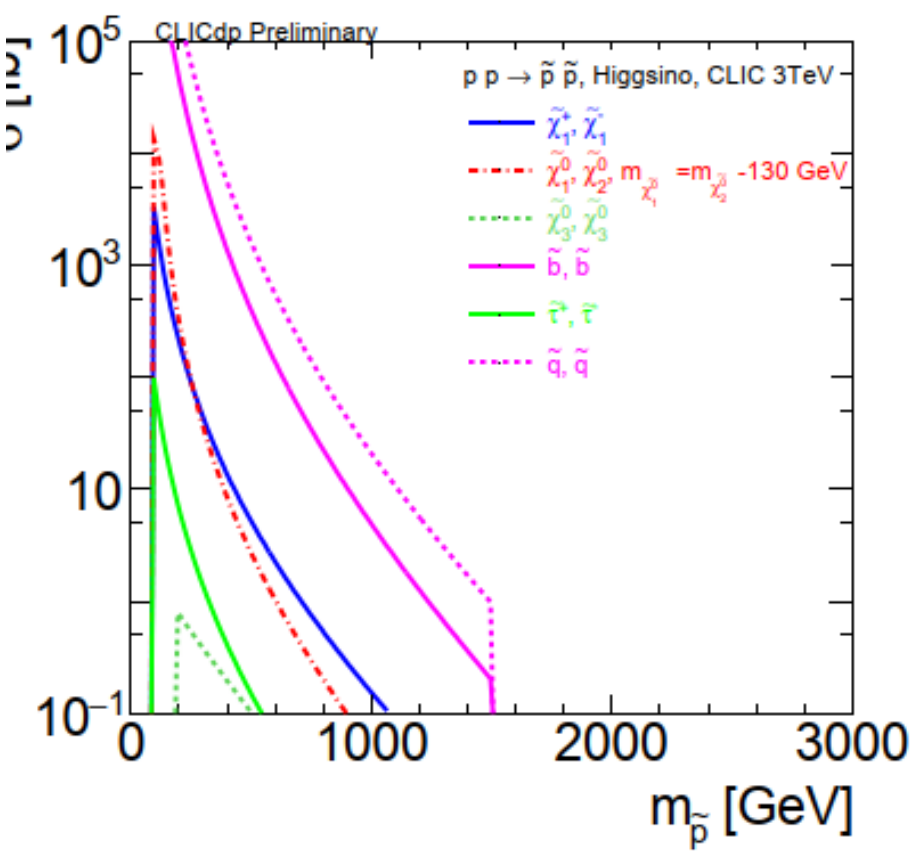


# SUSY Cross Sections at CLIC and LHC

SUSY production cross section for BMP2 (Higgsino) at CLIC and LHC.



# $\tilde{\chi}_1^{\pm}$ Search

$e^+ e^- \rightarrow \tilde{\chi}_1^+ \tilde{\chi}_1^-$

Only the decay $\tilde{\chi}_1^{\pm} \rightarrow \tilde{\chi}_1^0 W^{\pm}$ is considered for the analysis with a branching ratio of 100%.

Two W decay channels are considered:

- for $m(\tilde{\chi}_1^{\pm}) - m(\tilde{\chi}_1^0) > 90$ GeV the 4J final state selection is used.
  $W^+W^- \rightarrow q\bar{q}\,q\bar{q}$ ; branching ratio = 49%
- for $5 \text{ GeV} < m(\tilde{\chi}_1^{\pm}) - m(\tilde{\chi}_1^0) < 90$ GeV the e μ final state is used
  $W^+ W^- \rightarrow e^- \mu^+ \nu \bar{\nu}$ and $e^+ \mu^- \nu \nu$ ; branching ratio = 2%

# W→4J Background Cross Sections

| Process | σ[fb] | Events for ∫L=1 ab<br>For BDT Train and Test |
|---|---|---|
| $e^+ e^- \to q \bar{q} q \bar{q}$ | $5.5\ 10^2$ | $1.1\ 10^6$ |
| $e^+ e^- \to q \bar{q} q \bar{q}\ \nu \bar{\nu}$ | $7.2\ 10^1$ | $1.5\ 10^5$ |
| $e^+ e^- \to q \bar{q} q \bar{q}\ l\ l$ | $1.7\ 10^2$ | $3.4\ 10^5$ |
| $e^+ e^- \to q \bar{q}\ q \bar{q}\ l\ \nu$ | $1.0\ 10^2$ | $2.0\ 10^5$ |

Cross sections of the main backgrounds for the 4J final state and number of events used for the analysis.
The events are from the samples used for the Higgs analysis

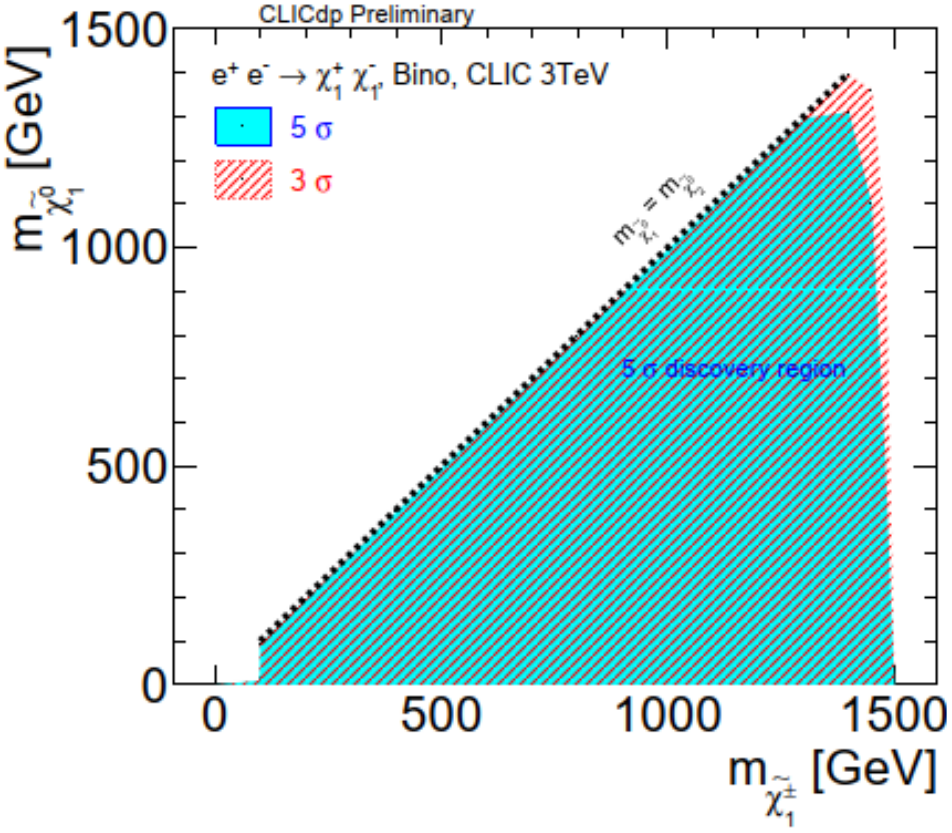
# W→e μ Background Cross Sections

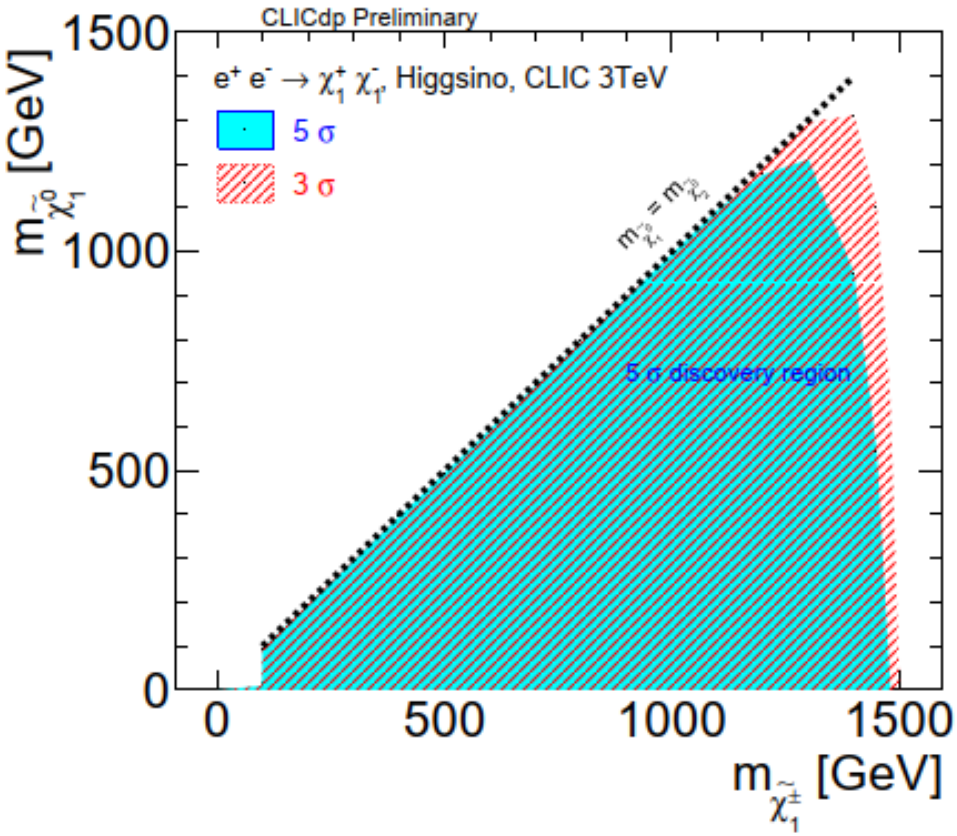
| Process | σ[fb] | Events for ∫L=1 ab<br>For BDT Train and Test |
|---|---|---|
| $e\,\gamma \rightarrow e^- \mu^+ \mu^-$ | $2.3\ 10^2$ | $4.6\ 10^5$ |
| $e^+ e^- \rightarrow e^- \mu^+ e^+ \mu^-$ | $2.0\ 10^1$ | $4.0\ 10^4$ |
| $e^+ e^- \rightarrow e^- \nu \mu^+ \nu$ | $5.5\ 10^1$ | $1.1\ 10^5$ |
| $e^+ e^- \rightarrow \tau^+ \tau^- \rightarrow e^- \nu \mu^+ \nu$ | 1.4 | 5000 |

Cross sections of the main backgrounds for the e μ final state search and number of events used for the analysis.
The events were generated using Whizard2

# $\tilde{\chi}_1^{\pm}$ Results

5 σ and 3 σ regions in the plane ($m\tilde{\chi}_1^{\circ}$ , $m\tilde{\chi}_1^{\pm}$) for Bino and Higgsino. $\tilde{\chi}_1^{\pm}$ observation difficult for $m\tilde{\chi}_1^{\pm} - m\tilde{\chi}_1^{0} < 5$GeV. For $m\tilde{\chi}_1^{\pm} - m\tilde{\chi}_1^{0} > 5$GeV the $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^{0}$ masses can be determined using the W energy



# $\tilde{\chi}_3^0$ Search

$e^+ e^- \rightarrow \tilde{\chi}_3^0 \tilde{\chi}_3^0$

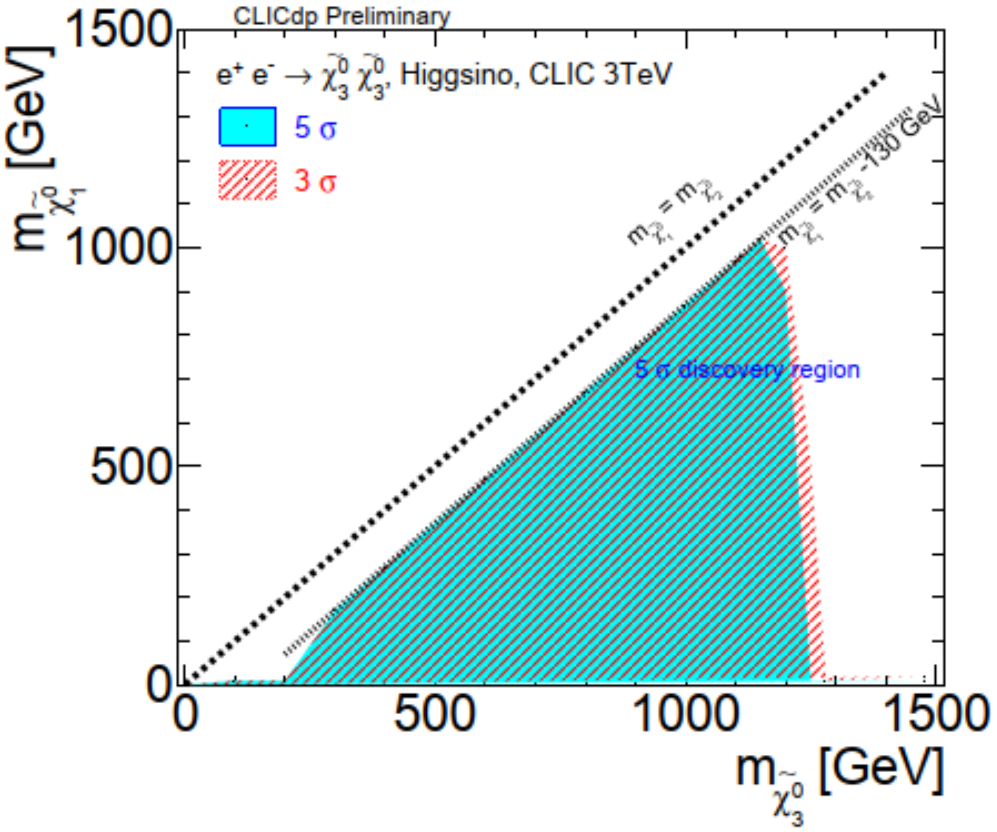
Only the $\tilde{\chi}_3^0 \rightarrow \tilde{\chi}_1^0$ h decay channels is considered for the analysis with a branching ratio of 100%.

The search is done in the region where $m\tilde{\chi}_2 - m\tilde{\chi}_1^0 > mh$ and assuming a branching ratio $h \rightarrow b\bar{b}$ of 60%

As it is a 4 jet final state the backgrounds are the same as for the $\tilde{\chi}_1^\pm$ analysis.

# $\tilde{\chi}_3^0$ Results

5 σ and 3 σ regions in the plane ($m\tilde{\chi}_1^\circ$ , $m\tilde{\chi}_3^0$ )
The Higgsino $\tilde{\chi}_3^0$ can be observed at CLIC; the $\tilde{\chi}_3^0$ and $\tilde{\chi}_1^0$ masses can be determined using the higgs energy distribution.



# $\tilde{\chi}_2^0$ and $\tilde{q}$ Searches

$e^+ e^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0$

Only the $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0$ h decay channels is considered for the analysis with a branching ratio of 100%.

The search is done in the region where $m\tilde{\chi}_2 - m\tilde{\chi}_1^0 > mh$ and assuming a branching ratio $h \rightarrow b\bar{b}$ of 60%

$e^+ e^- \rightarrow \tilde{q}\,\tilde{q}$

Only the $\tilde{q} \rightarrow \tilde{\chi}_1^0$ q decay channel is considered for the analysis. with a branching ratio of 100%.

The search is done in the region where $m\tilde{q} - m\tilde{\chi}_1^0 > 50$ GeV and assuming a branching ratio $\tilde{q} \rightarrow \tilde{\chi}_1^0$ q of 100%

$e^+ e^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0$ h and $e^+ e^- \rightarrow \tilde{q}\,\tilde{q} \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0$ q $\bar{q}$ are 2 jets final state events. The SM model backgrounds are shown on next slide.

# $\tilde{\chi}_2^0$ and $\tilde{q}$ Background Cross Sections

| Process | PtqQ>1 GeV MqQ>1 GeV σ[fb] | PtqQ>20 GeV MqQ>100 GeV σ[fb] | Events for ∫L=500 fb With Lumi factors 1, 0.8, 0.75 |
|---|---|---|---|
| $\gamma\gamma \to q\bar{q}$ | $5.4\ 10^6$ | 1100 (MqQ>100) | $4.1\ 10^5$ |
| $e^\pm\gamma \to e^\pm q\bar{q}$ (γ) | $1.9\ 10^6$ | 2500 | $1.0\ 10^6$ |
| $e^\pm\gamma \to \nu q\bar{q}$ (γ) | $4.5\ 10^4$ | 1080 | $4.4\ 10^5$ |
| $e^+e^- \to e^\pm \nu q\bar{q}$ (γ) | $7.5\ 10^4$ | 380 | $2.0\ 10^5$ |
| $e^+e^- \to q\bar{q}\nu\bar{\nu}$ (γ) | $1.4\ 10^3$ | 71 | $3.5\ 10^4$ |
| $e^+e^- \to e^+e^- q\bar{q}$ (γ) | $6.5\ 10^5$ | 450 | $2.2\ 10^5$ |
| $e^+e^- \to q\bar{q}$ (γ) | 385 | 60 | $3.0\ 10^4$ |
| $e^+e^- \to h\nu\nu$ (γ) | 410 | No cut | $2.1\ 10^5$ |

2 jet final state SM background cross sections

# Results

5 σ and 3 σ regions in the plane ($m\tilde{\chi}_1^0$ , $m\tilde{\chi}_2^0$) and ($m\tilde{\chi}_1^\circ$ , $m\tilde{q}$ ).
The $\tilde{q}$ and $\tilde{\chi}_2^\circ$ can be observed at CLIC; the $\tilde{q}$ and $\tilde{\chi}_2^\circ$ masses can be determined using the quark and h energy distributions respectively.