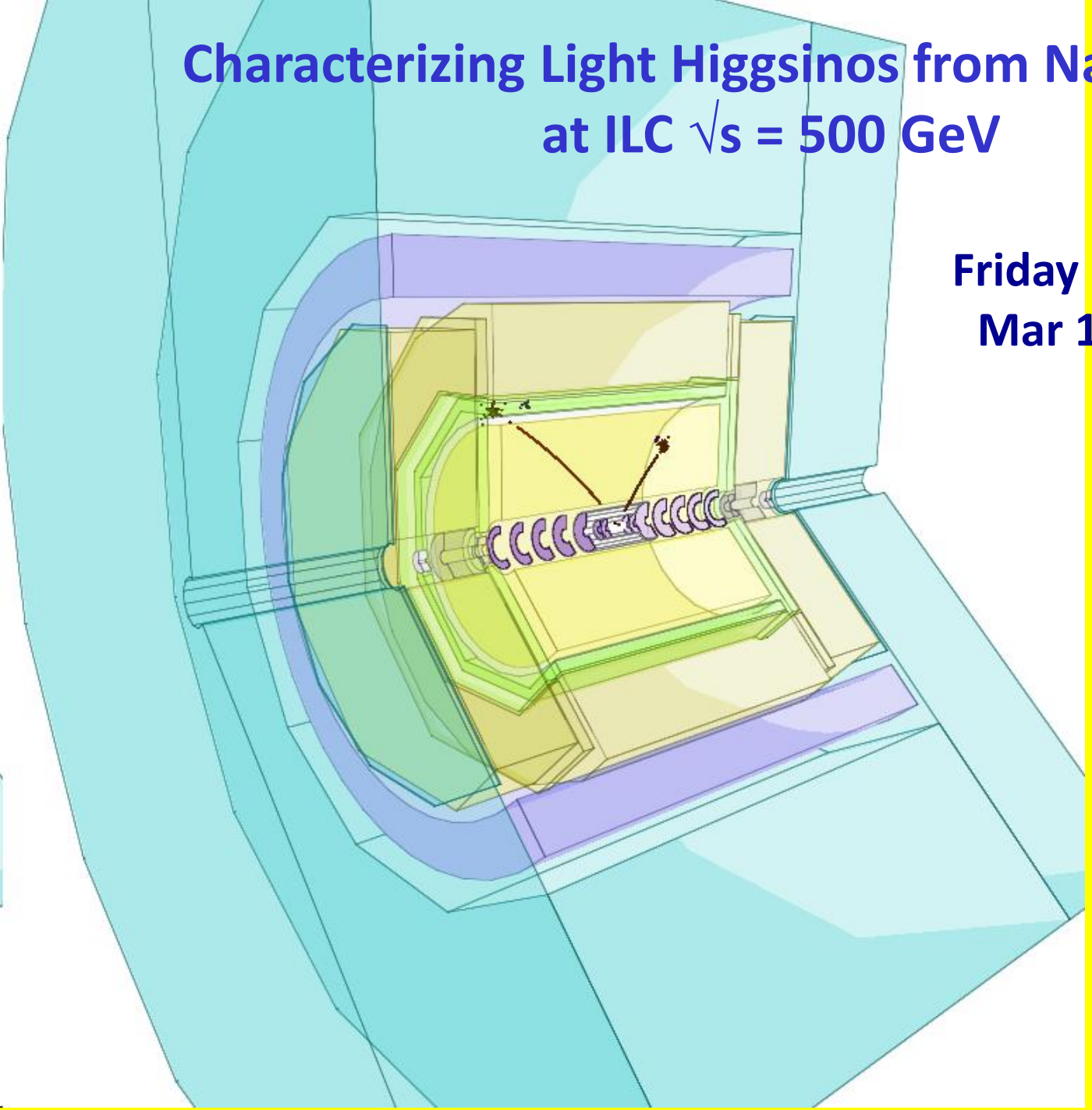
Characterizing Light Higgsinos from Natural SUSY at ILC $\sqrt{s}$ = 500 GeV



Friday Meeting
Mar 10, 2017

Jacqueline Yan (KEK)
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Recent Activities

FINISHED ALL EDGE FITS FOR ALL BENCHMARKS OF N1N2, overlay and non-overlay

（1）Optimized signal selection and cuts

- to **improve significance**
- To **converge to a common set of analysis method** which **works for both overlay and non-overlay** AND hopefully for all benchmarks
- Today will show **preliminary results for neutralino channels with "Marlin reconstruction carried out using the validated v01-16-02"**
- Demonstrated that there are no significant differenced in results no matter using which ILCSoft version (DBD tracking used)

（3）Production of additional aa2f and ae/ea3f bkg SGV samples (Mikael)

Considering legitimate precuts to use in production

These should be mostly gone at the end, but need to confirm (not included in plots shown today)

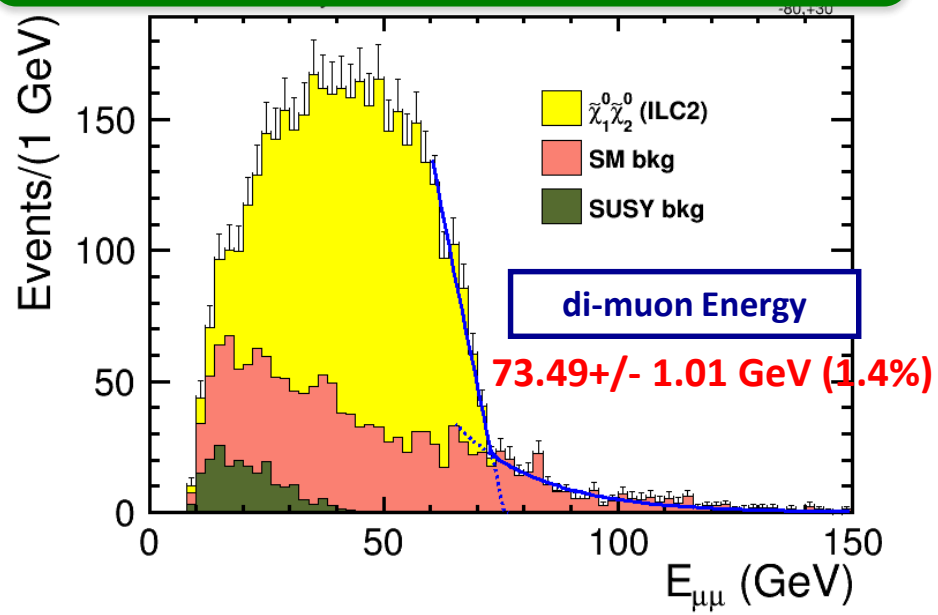
- We are working on a paper which includes results on all 3 benchmarks, and also SUSY parameter extraction and theory

Neutralino mixed production with leptonic decay

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

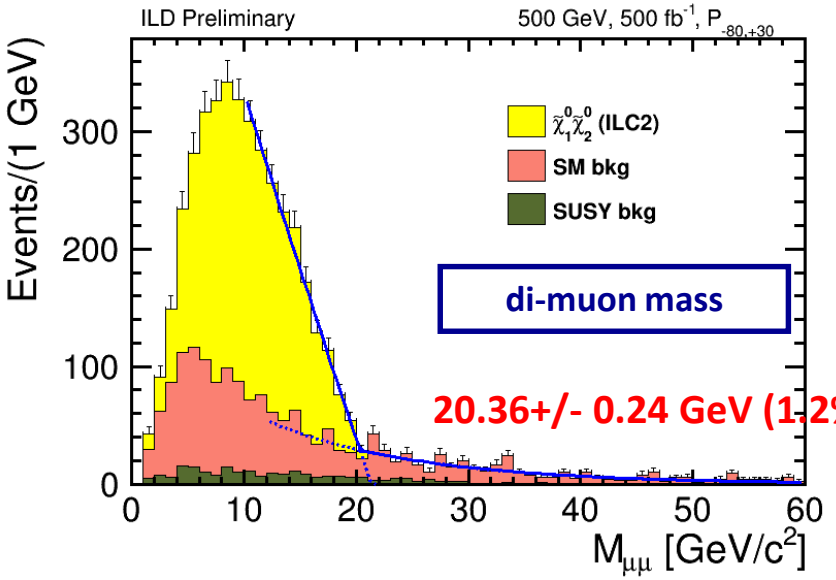
ILC1 @500fb-1 v01-16-02

Without overlay



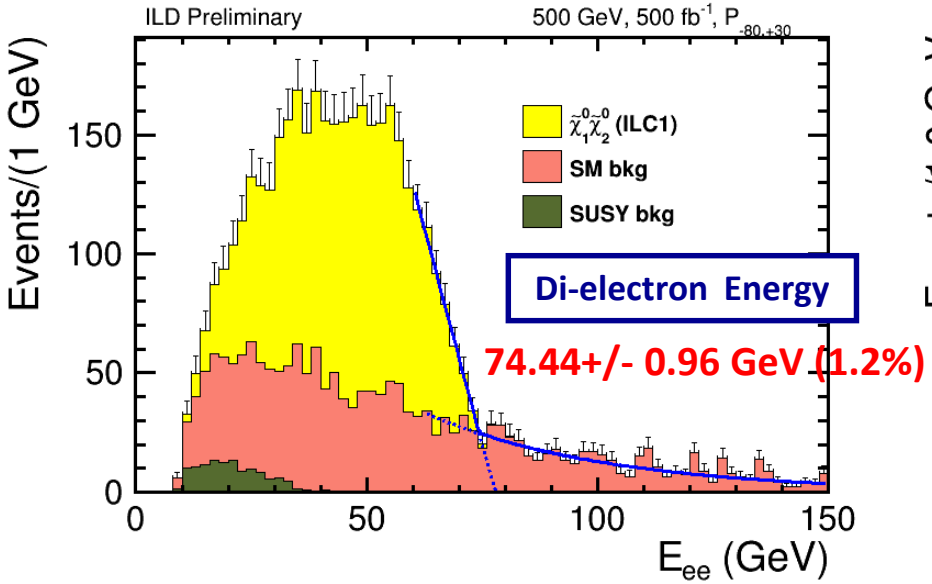
di-muon Energy

73.49+/- 1.01 GeV (1.4%)



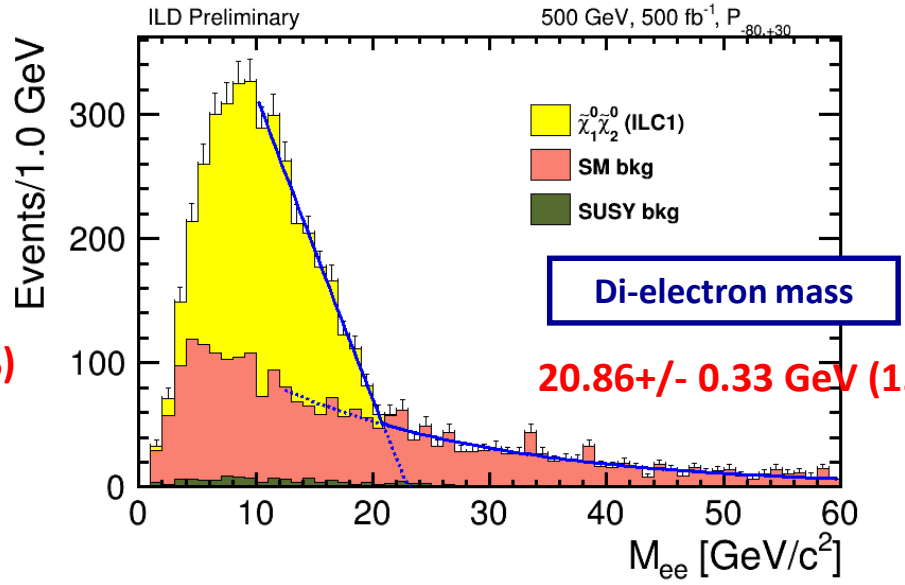
di-muon mass

20.36+/- 0.24 GeV (1.2%)



Di-electron Energy

74.44+/- 0.96 GeV (1.2%)



Di-electron mass

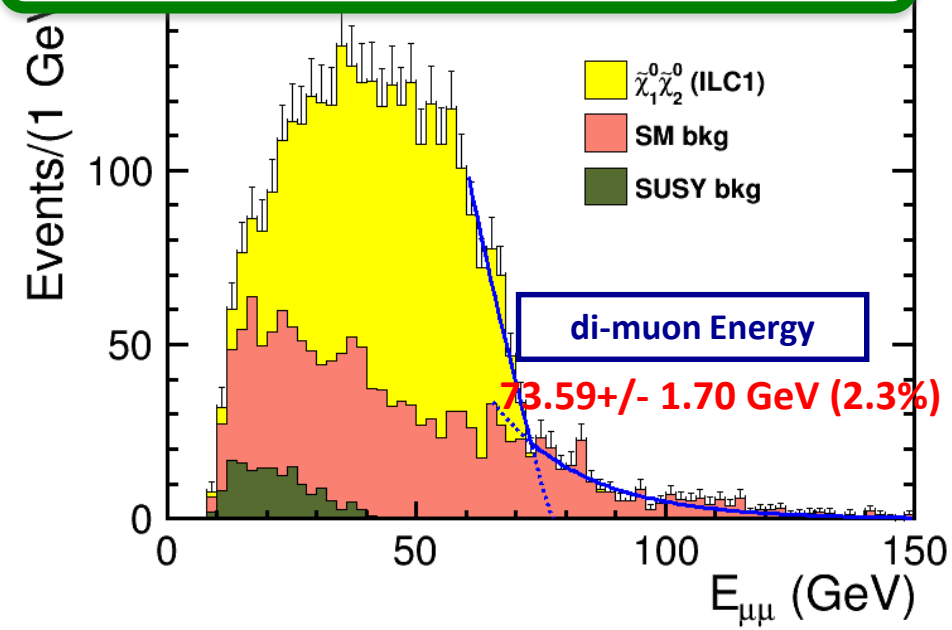
20.86+/- 0.33 GeV (1.6

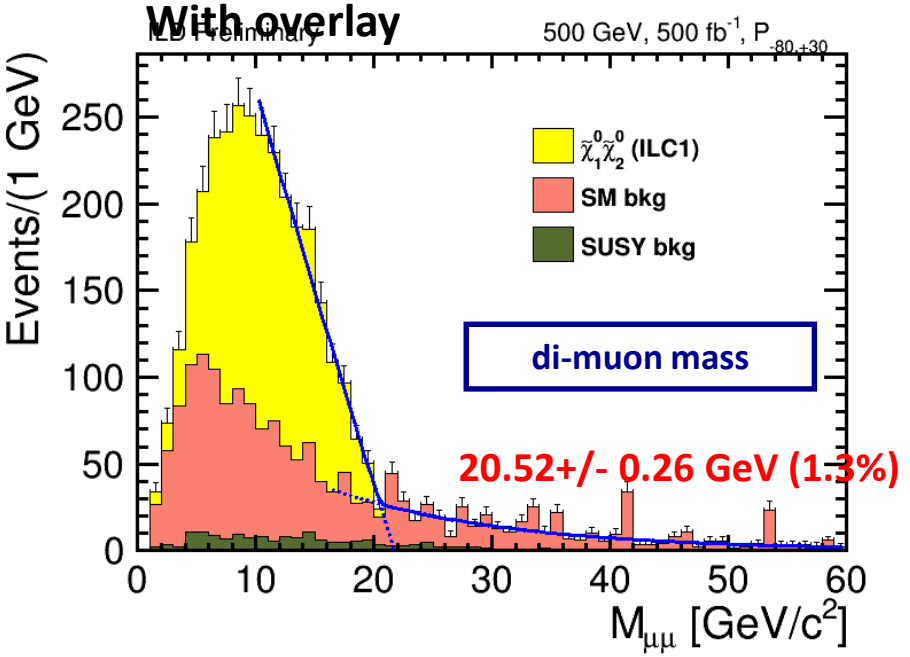
Neutralino mixed production with leptonic decay

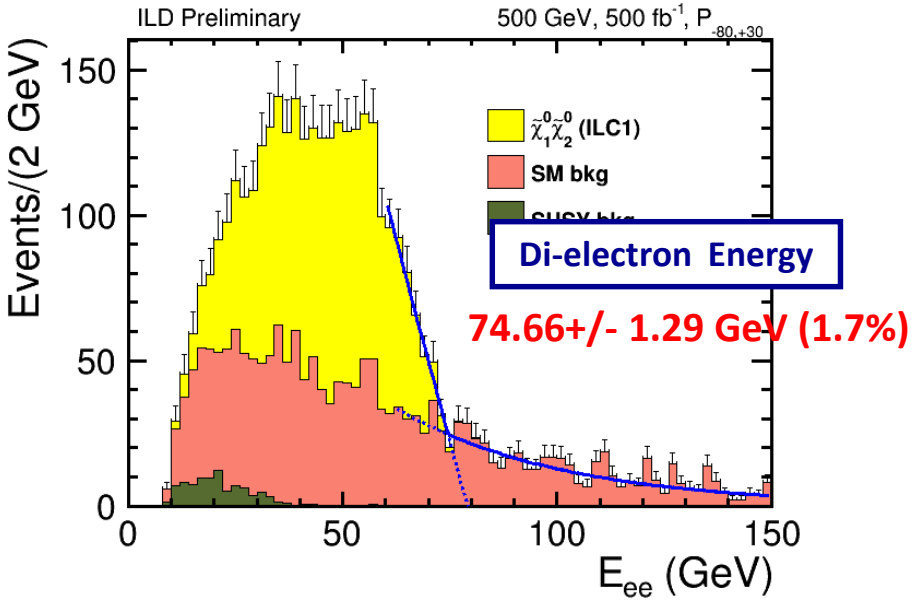
$$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$

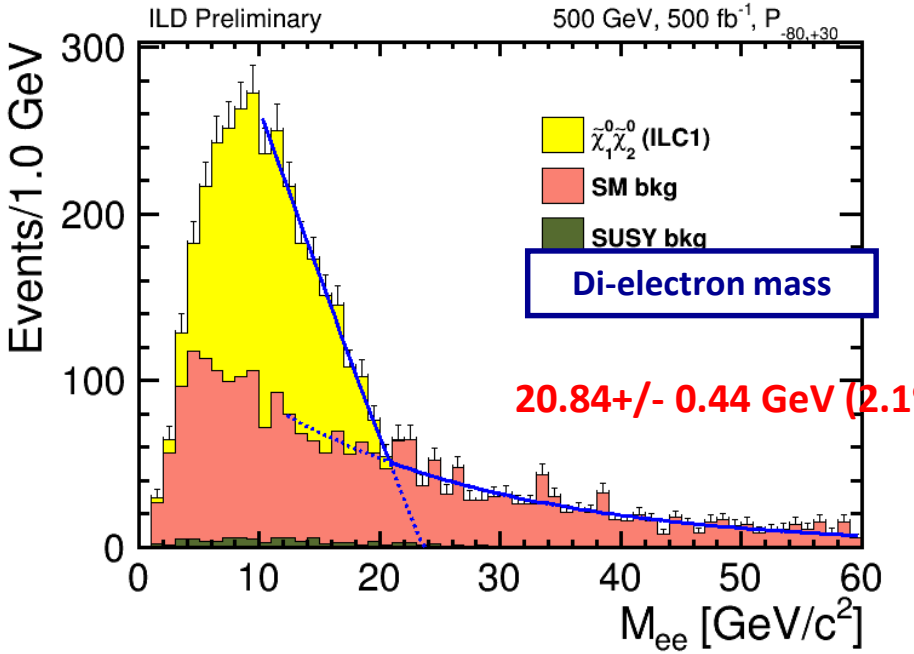
ILC1 @500fb-1 v01-16-02

With overlay







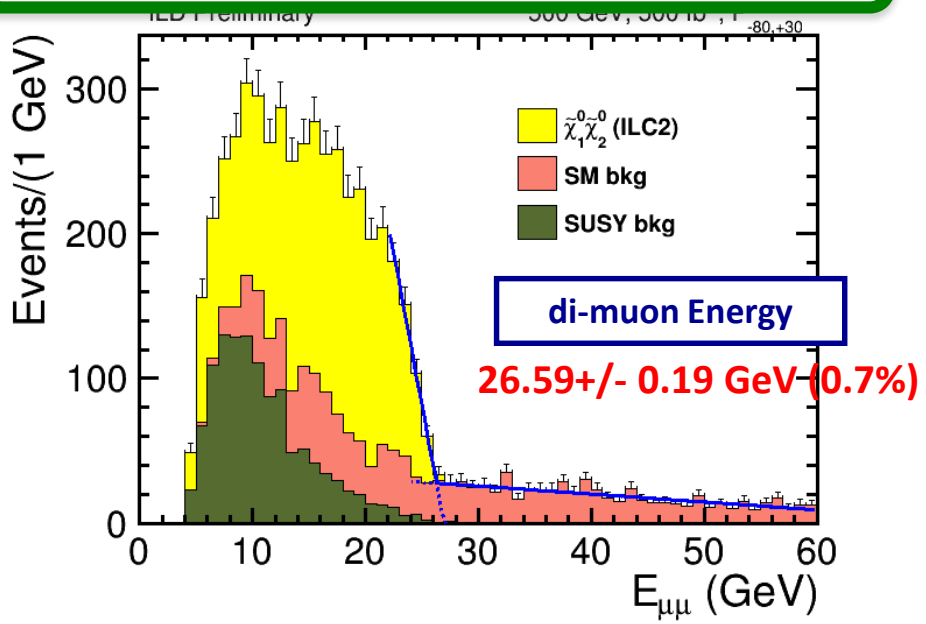


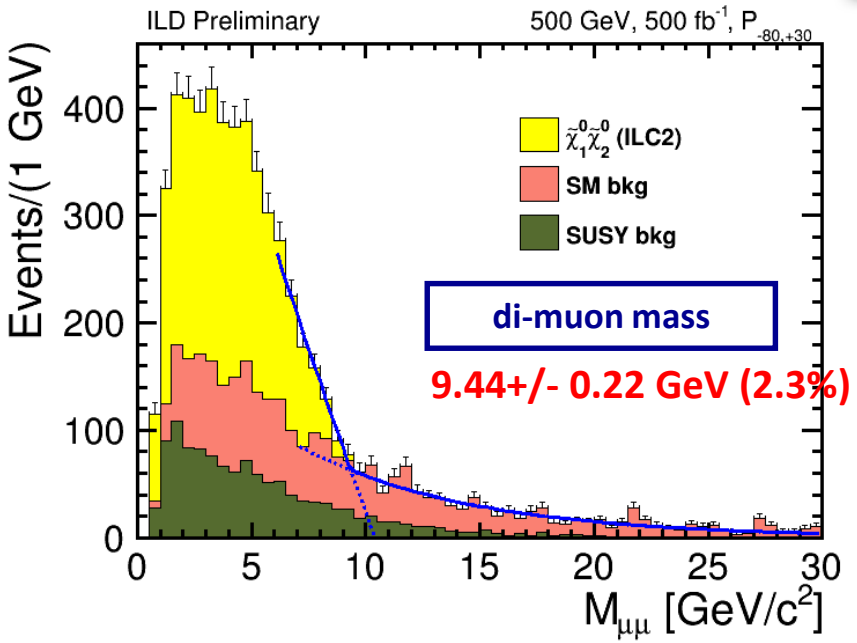
Neutralino mixed production with leptonic decay

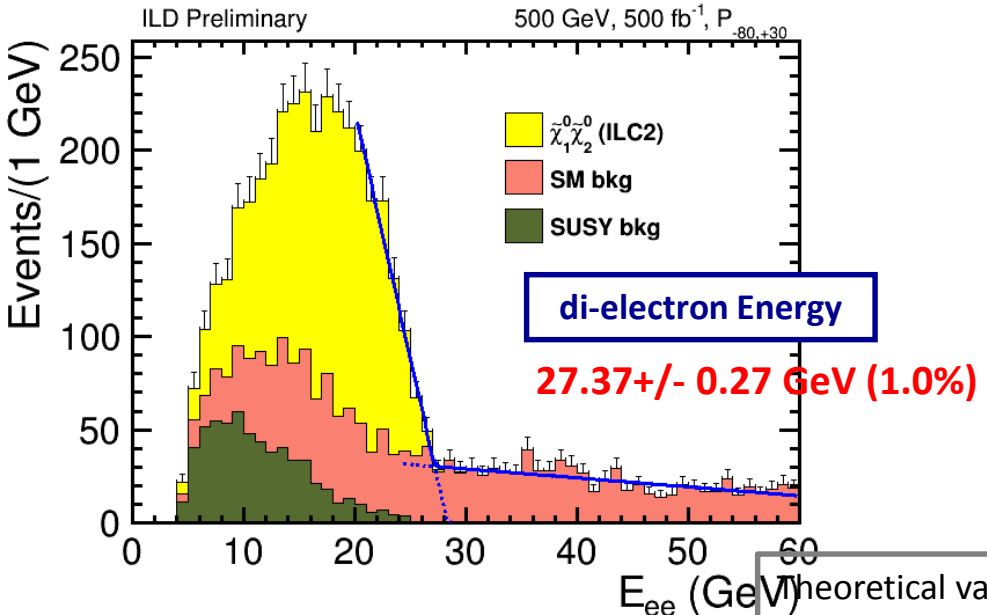
$$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$

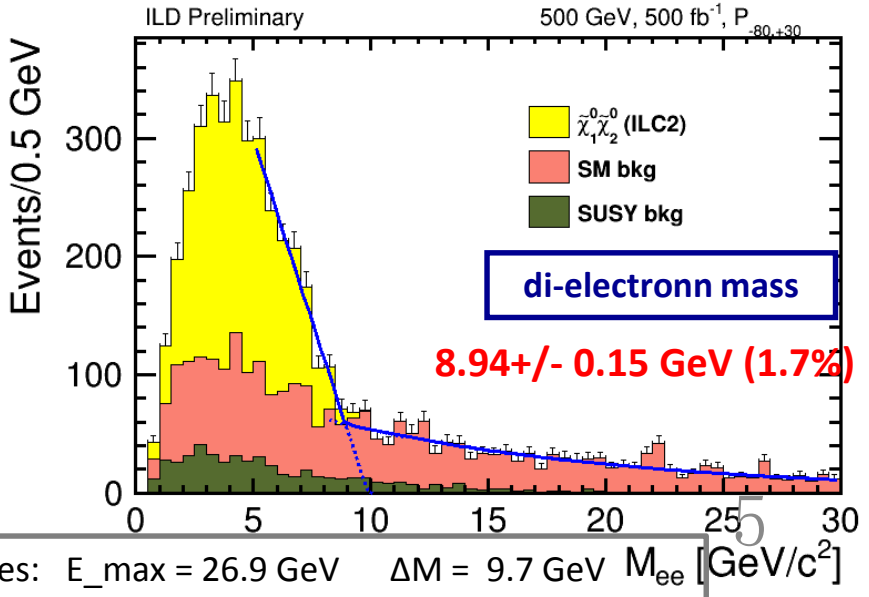
ILC2 @500fb-1 v01-16-02

Without overlay









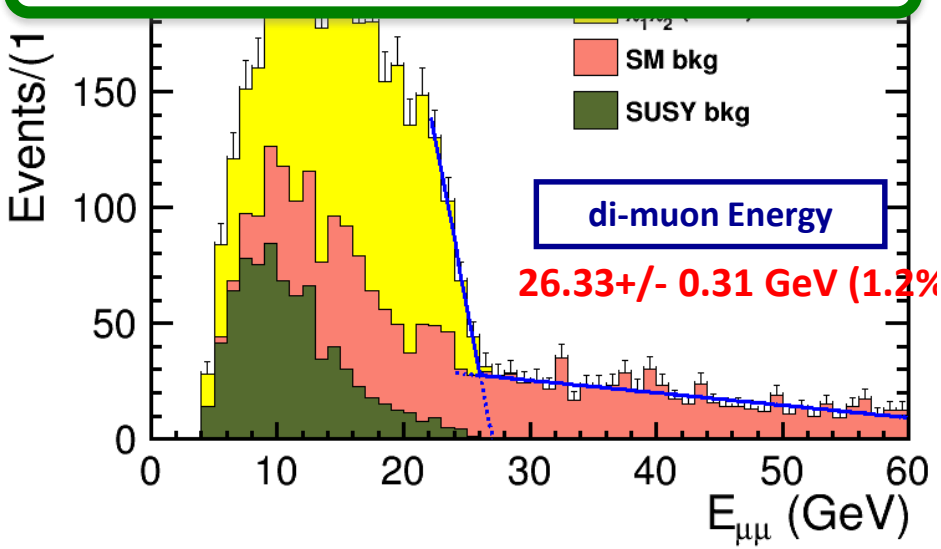
Theoretical values: E_max = 26.9 GeV ΔM = 9.7 GeV

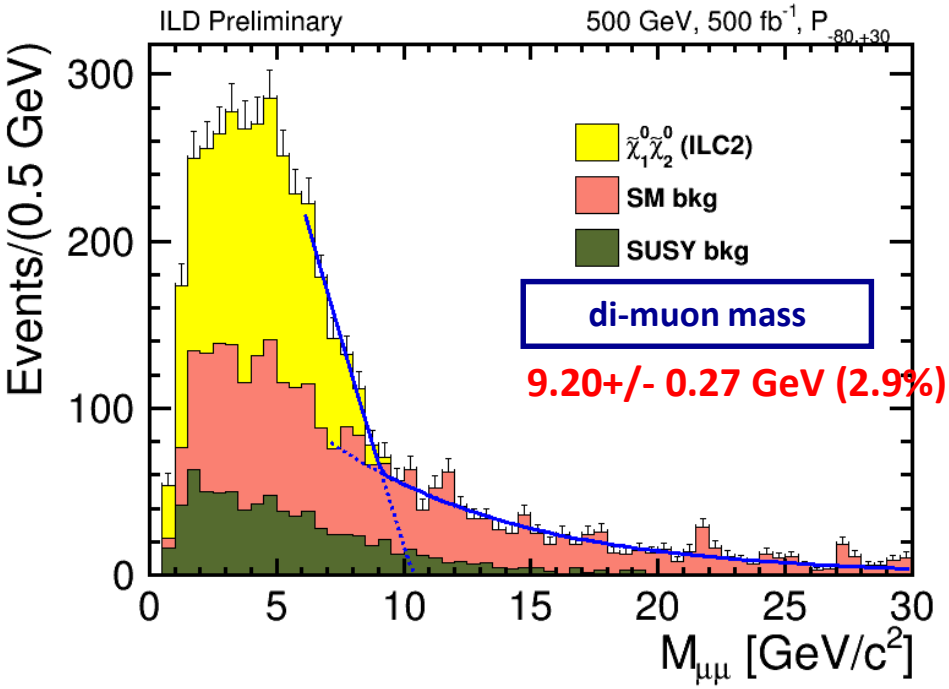
Neutralino mixed production with leptonic decay

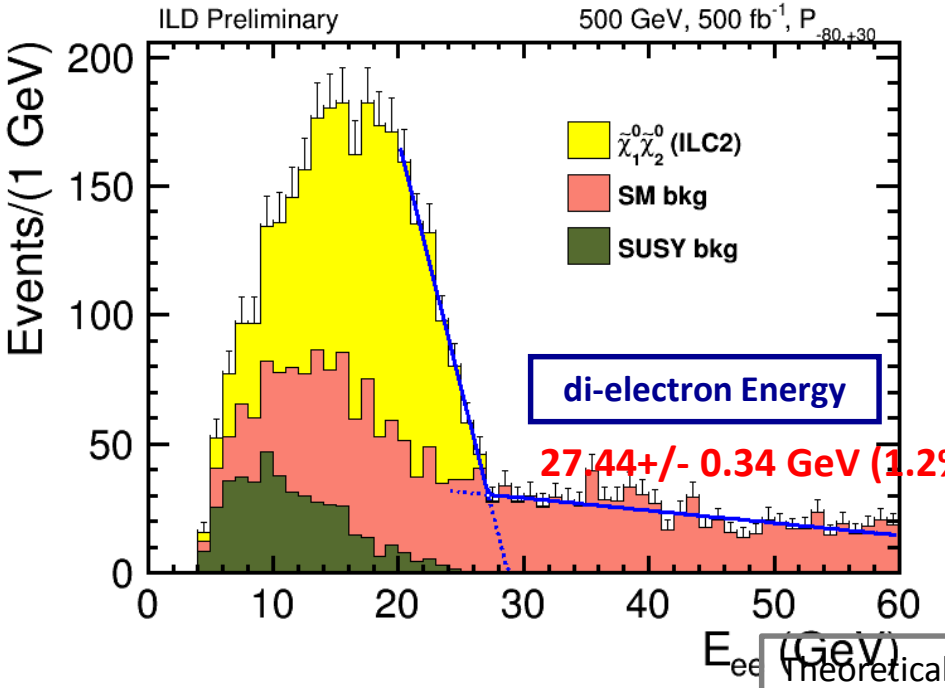
$$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$

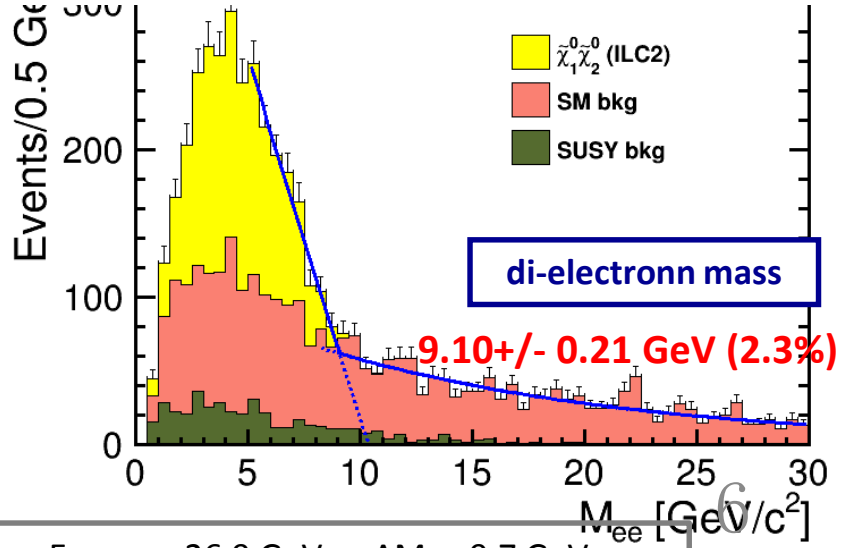
ILC2 @500fb-1 v01-16-02

Without overlay









Theoretical values: E_max = 26.9 GeV ΔM = 9.7 GeV

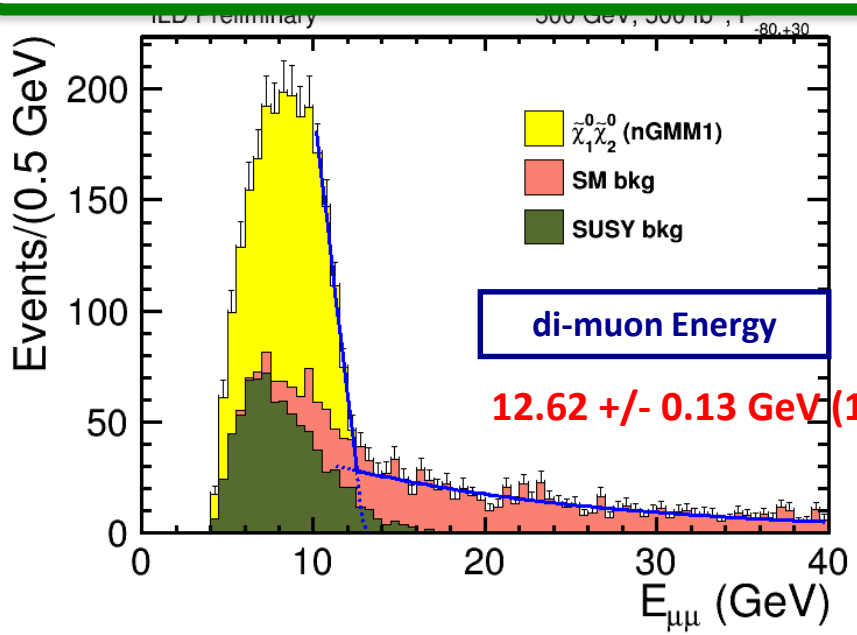
Neutralino mixed production with leptonic decay

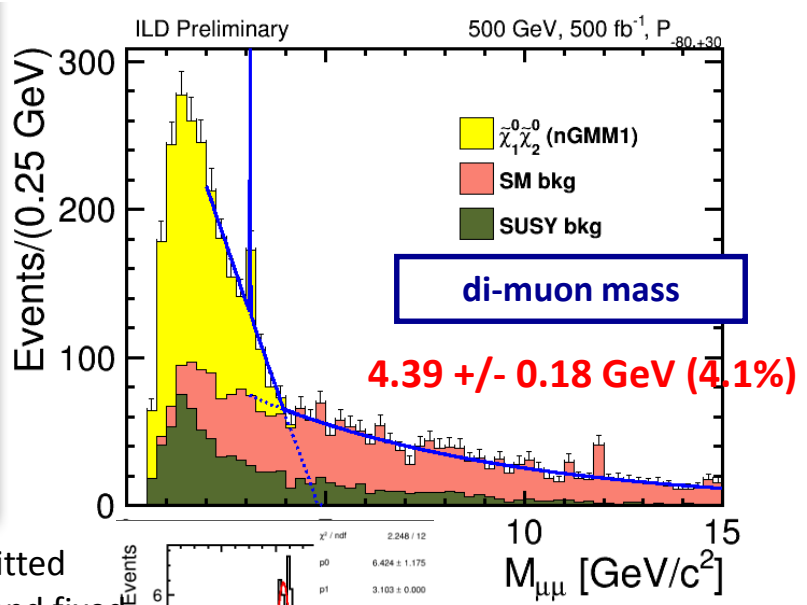
$$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$

Mirage Mediation @500fb-1

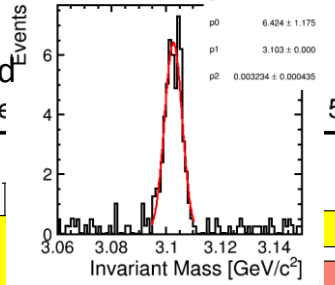
v01-16-02

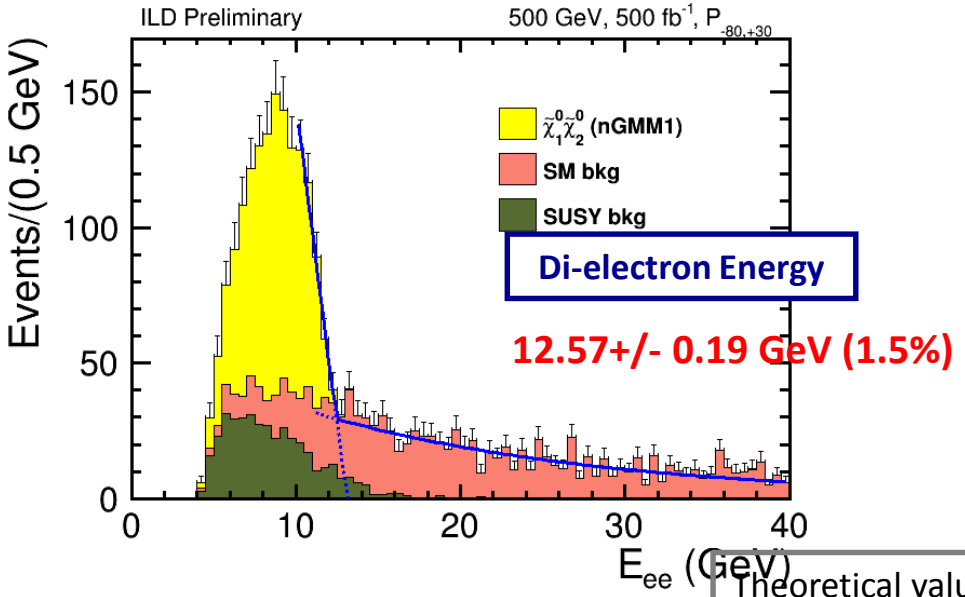
Without overlay





J/Psi peak fitted separately and fixed

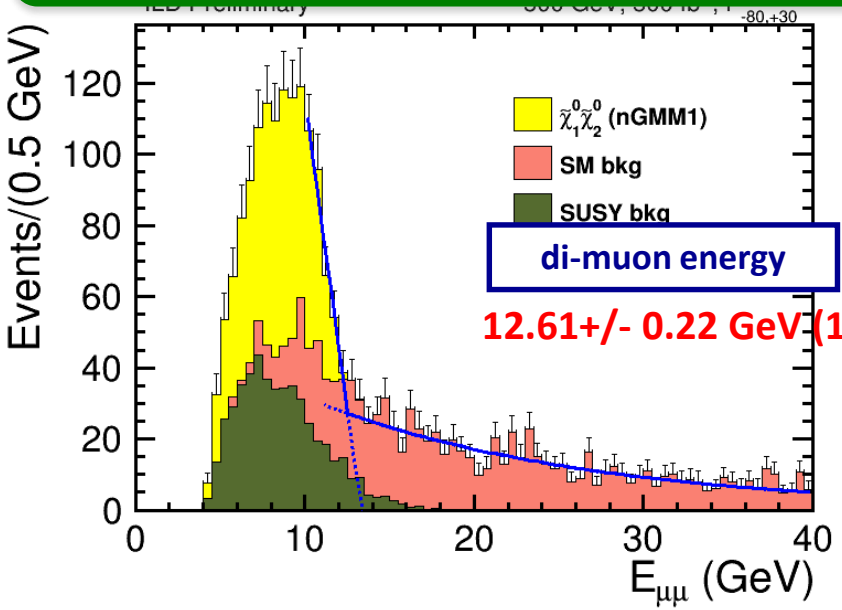




Theoretical values: E_max = 12.5 GeV ΔM = 4.3 GeV

Neutralino mixed production with leptonic decay

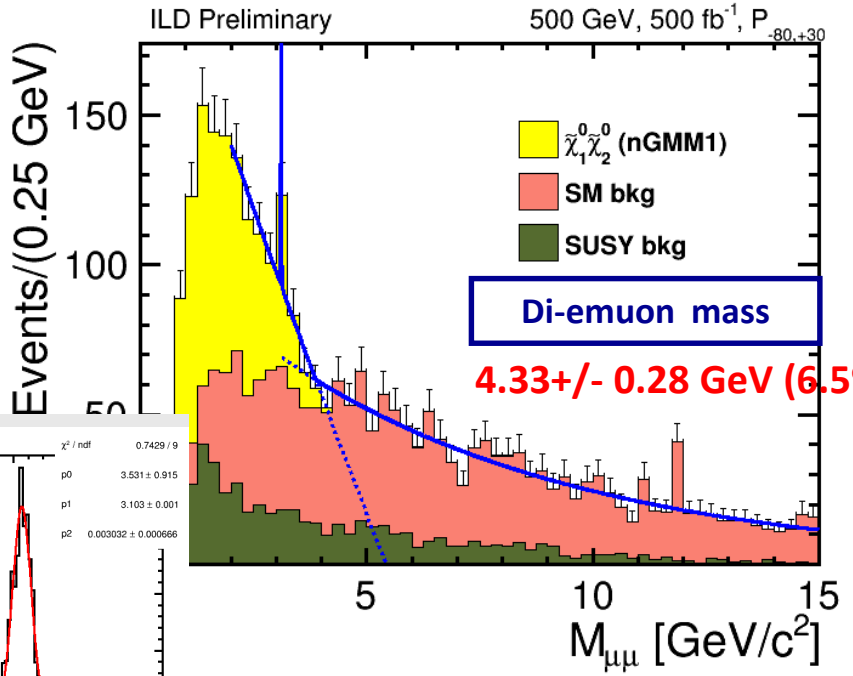
$$e^+e^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$



di-muon energy

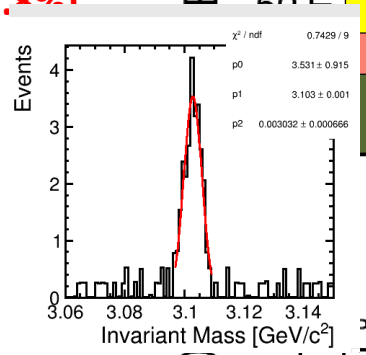
12.61+/- 0.22 GeV (1.8%)

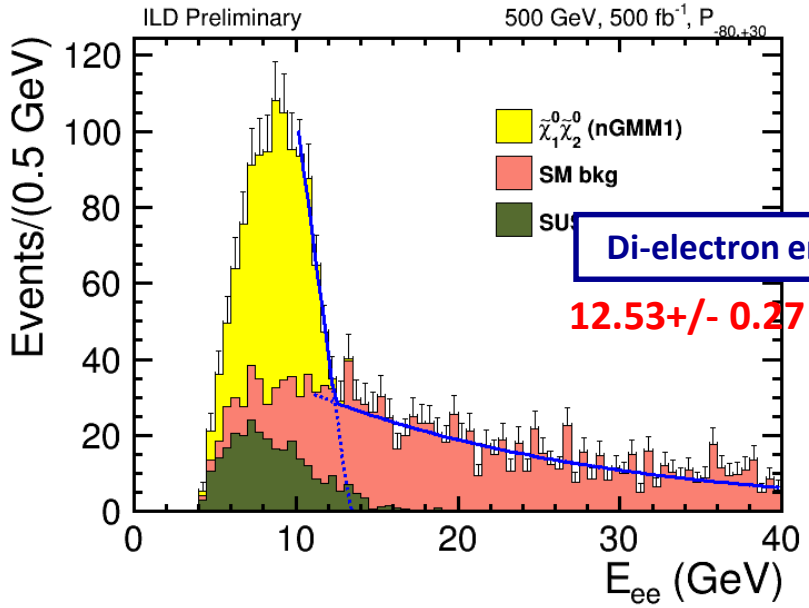
Mirage v01-16-02 **With overlay**



Di-emuon mass

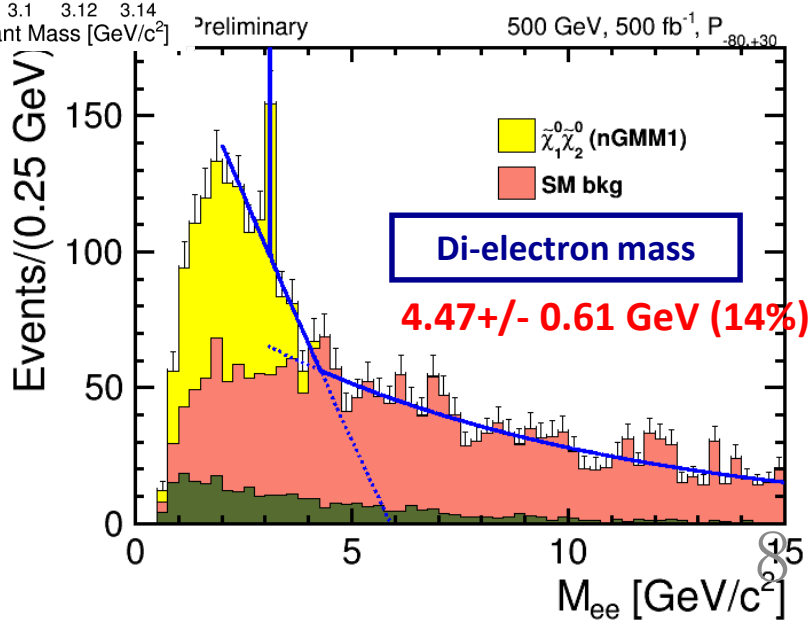
4.33+/- 0.28 GeV (6.5%)





Di-electron energy

12.53+/- 0.27 GeV (2.1%)

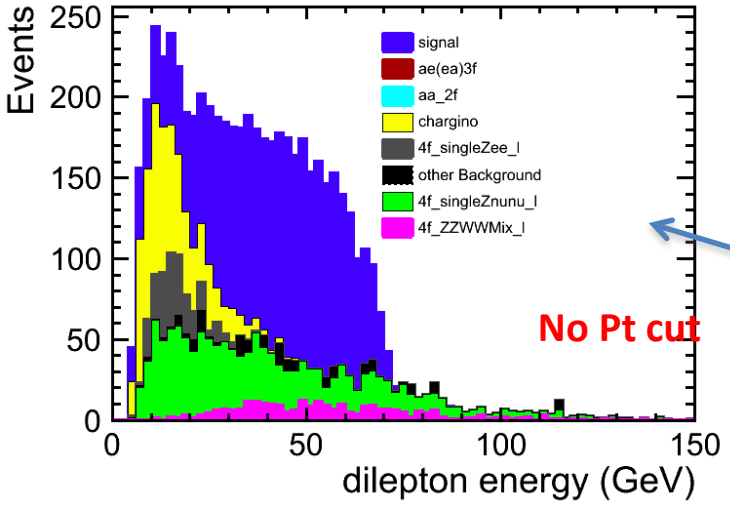


Di-electron mass

4.47+/- 0.61 GeV (14%)

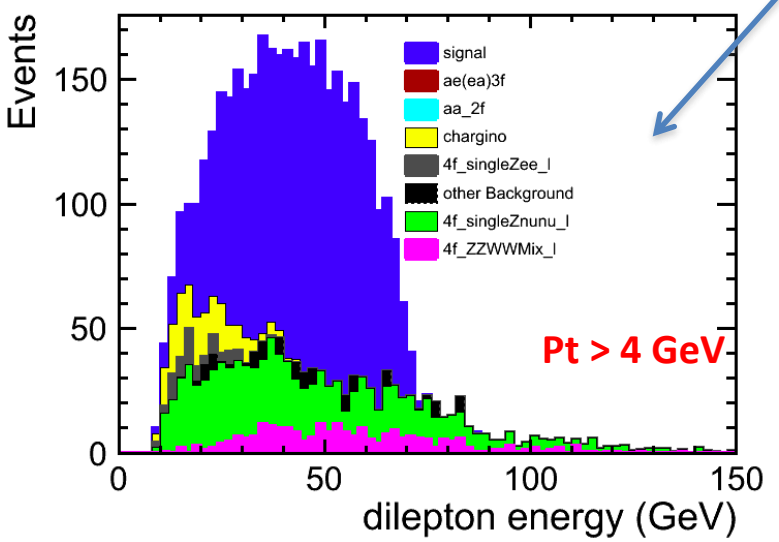
Pt cut or not ?

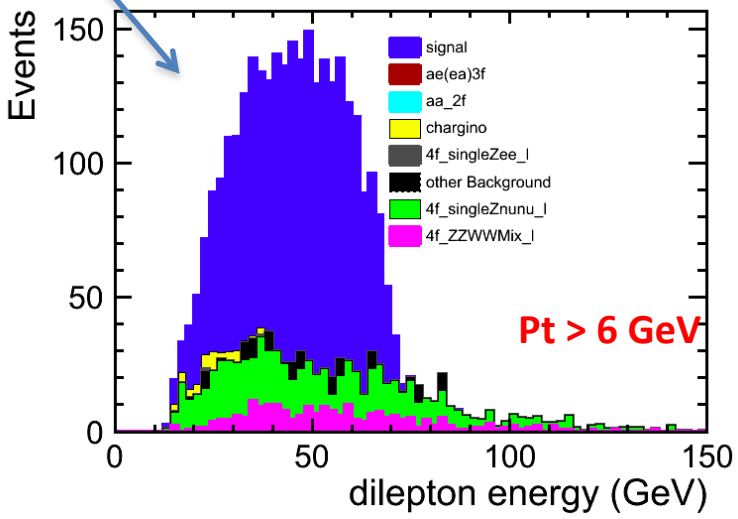
- have one set of cuts for “discovery” (loose cuts, no Pt cut) which applies to all benchmarks
- **Then a tighter set of cuts for “precision measurement” optimized for each benchmark**
- **Different cuts for kinematic edge extraction and cross section measurement**



ILC1, N1N2, no overlay

di-muon energy





Summary

- **made progress in analysis of benchmarks with smaller ΔM**
- **Optimized analysis methods for neutralino analysis with works well for both "overlay" and "no-overlay"** in signal samples, and for all three benchmarks

  ➔ **improvement in significance**

- Currently obtainable statistical precisions for (no overlay): **Assuming H20**

  Mass : **< ～ 0.5% (ILC1, ILC2)** **<～1.5% (nGMM1)**

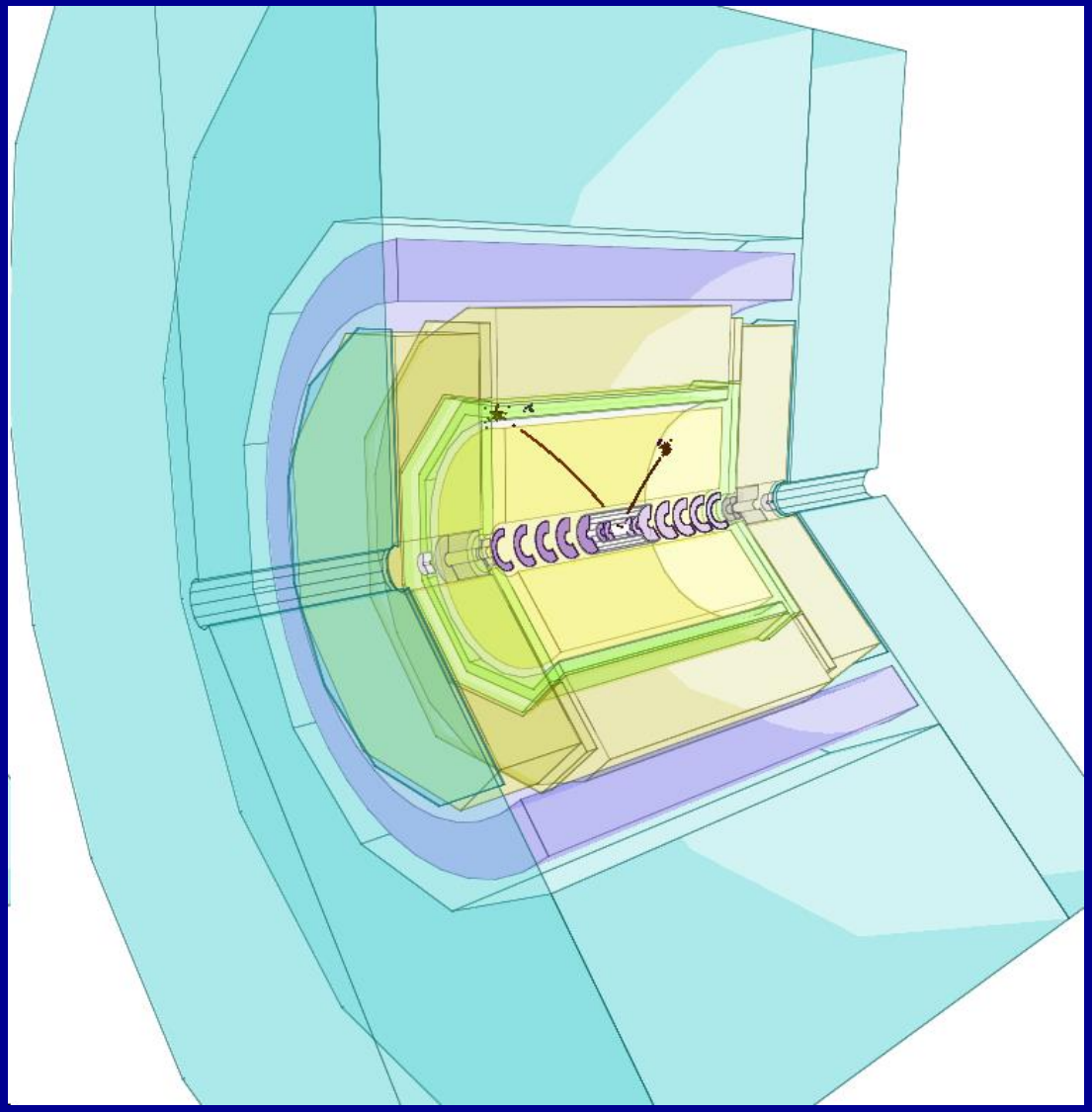
  Cross section : **1−2% (ILC1, ILC2)**

- Showed no difference in final results regardless of ILCSoft version (results today shown using v01-16-02, which is validated and consistent with SM bkg)

Plans

- re-optimize analysis methods for chargino analysis, also to accommodate all scenarios
- Implement SGV samples when ready → reconfirm they are removed by current cuts
- Work on paper
- Consider contribution from Higgsino analysis to staging scenario (next talk)

Backup



Optimization in signal selection and Pt cut

<Goal> **Converge to a set which can give good significance for both "with" and "without" overlay, and works for all scenarios of ΔM**

Change#1: definition of "# of charged tracks",

OLD: no Pt requirement : this led to under-estimation of bkg (which has overlay)

NEW: **require Pt>2 GeV**

Change#2: isolated lepton selection and removal of extra Pt cuts
in order to recover signal efficiency for case of "overlay in signal sample"

OLD: Leptons chosen without Pt requirement

ILC2: Pt cut 4 GeV/2 GeV for mm/ee , Mirage: Pt cut 2.2 GeV for mm and ee

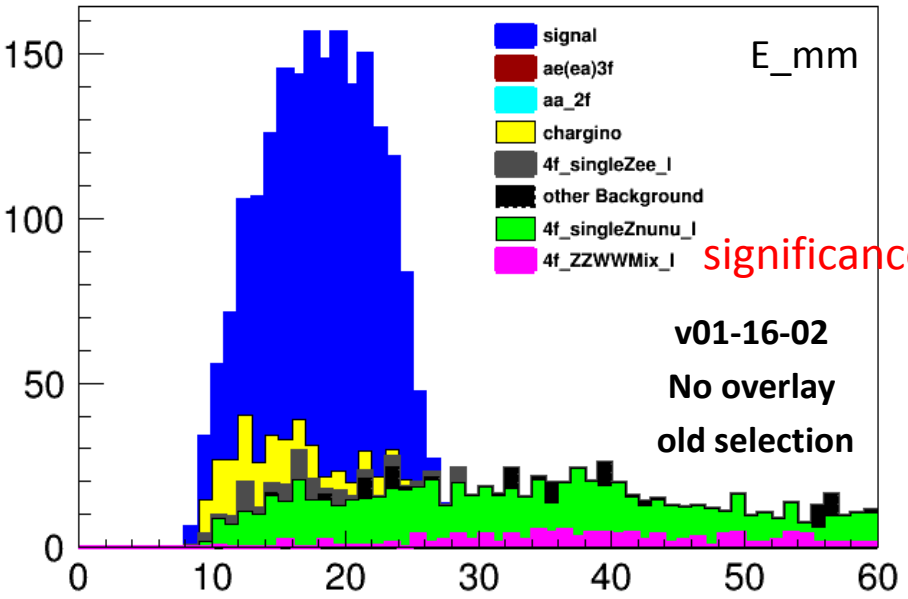
NEW: only choose from leptons with Pt>2GeV (in lepton selection processor)

Remove Pt cut from following analysis cuts

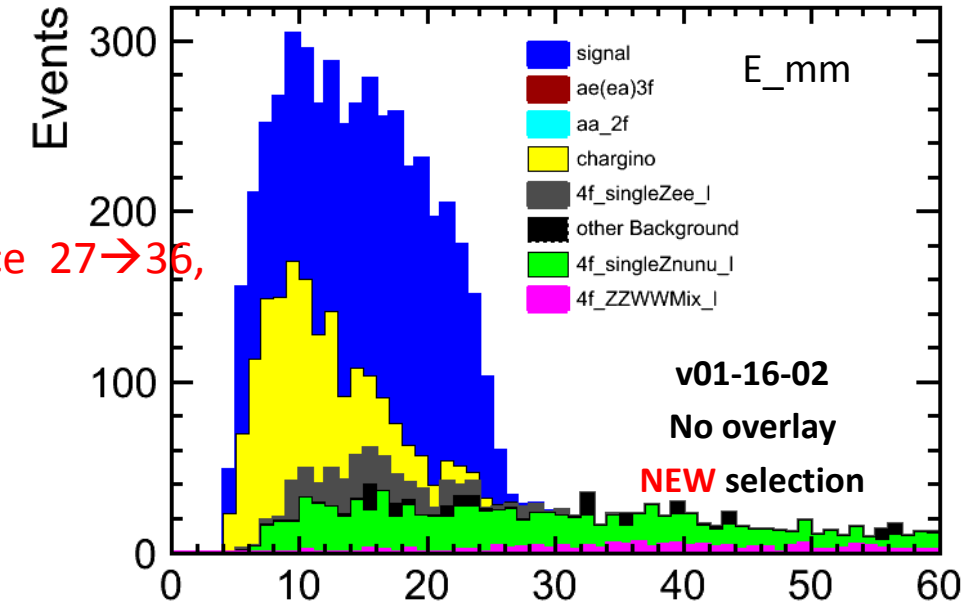
In the next page, comparisons will be shown for Change#2

ILC2 : N1N2 left pol, without overlay

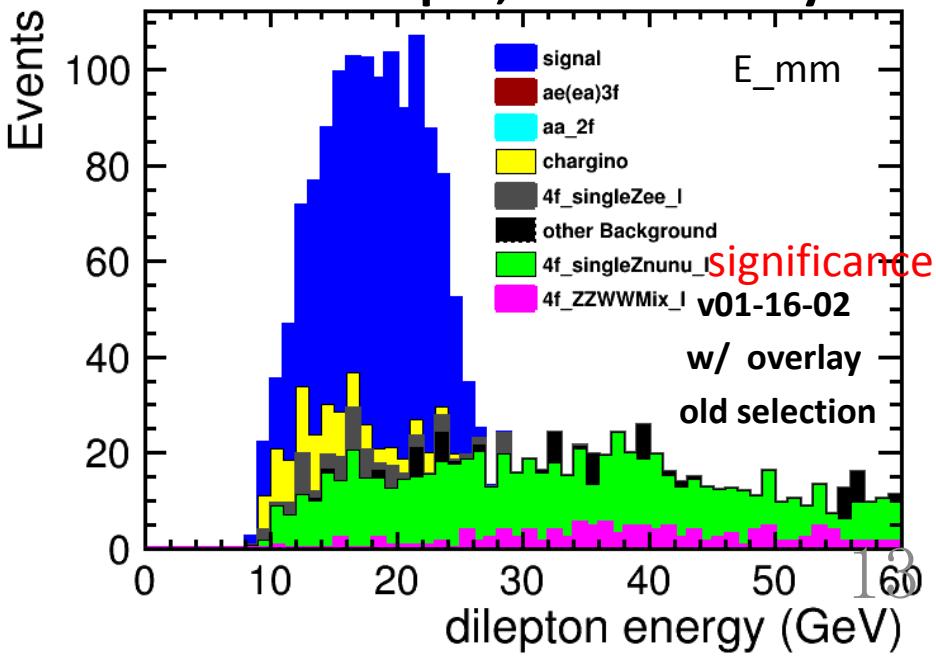
similar improvement in other channels of ILC2 and Mirage



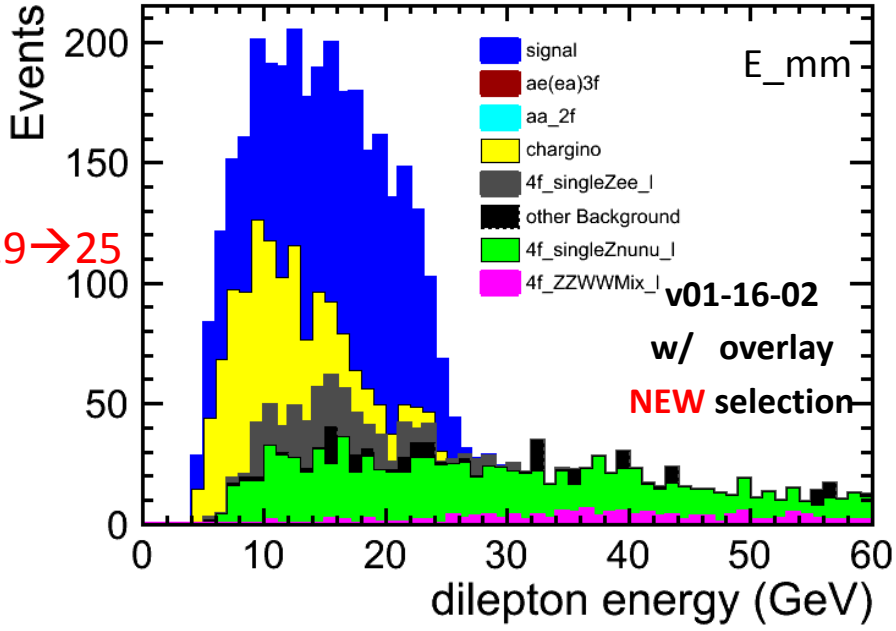
significance 27→36,



ILC2 : N1N2 left pol, with overlay



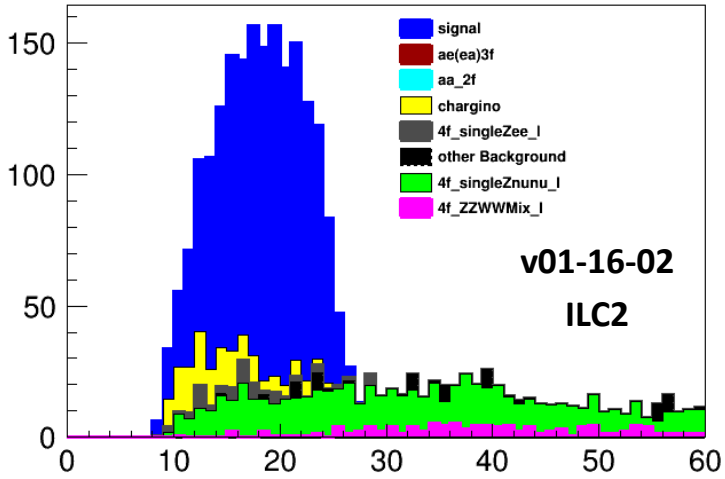
significance 19→25

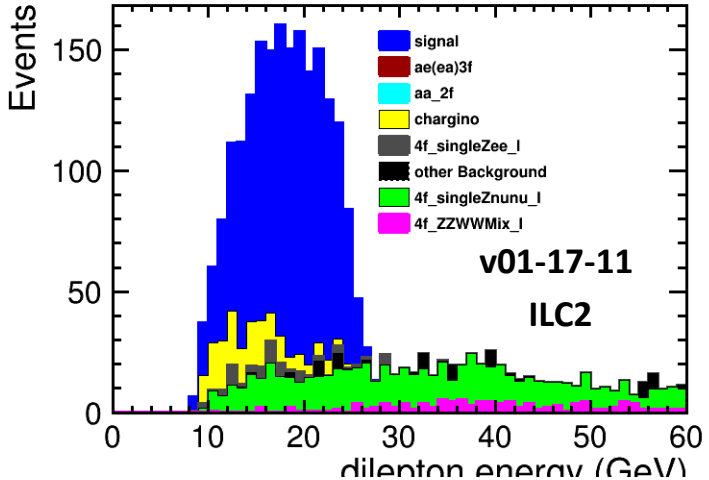


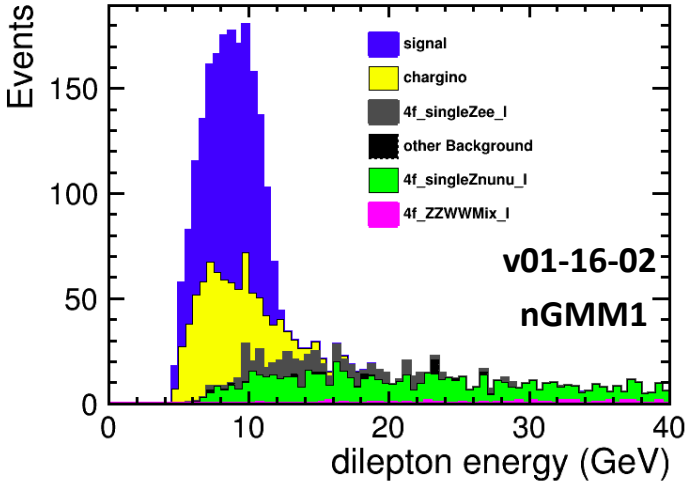
Version comparison

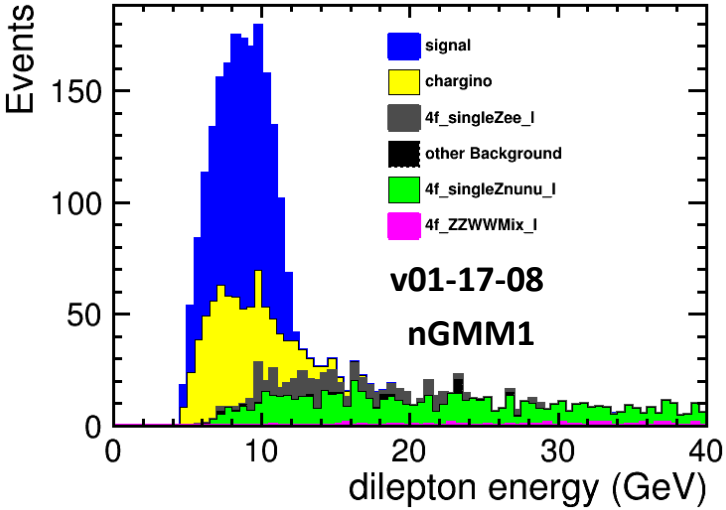
- **final analysis results based on "Marlin reco using the validated v01-16-02" shows no significant difference from other versions, for both ILC2 and Mirage**
- Working with software experts to cross check between versions

Note) these were before recent optimization of selection methods









Cuts for ILC2 N1N2

- **lepton type (μμ or ee)** : the two leptonic channels of N1N2 analysis
- **nTrack = 2** : number of charged tracks
- **no hit in BeamCal** : veto γγ2f BG
- **Pt_lep1,2 > 2 GeV and |cosθlep1,2| < 0.95:**
- **Coplanarity < 1.0 rad** : angle between leptons in x-y plane
- **Evis – Eγmax < 40 GeV** : visible energy (very small for signal)
- **Emis > 300 GeV** : missing energy (very large for signal)
- **|cosθmissing| < 0.98** : θ of missing energy events
- **|cosθZ| < 0.98** : Z* production angle
- **Pt_dl < 80 GeV** : transverse momentum of dilepton
- **Minv<20 GeV** : dilepton invariant mass: determines ΔM

last of all observe distributions of Minv and dilepton energy (E_dl)

Kinematic edge is a function of Higgsino mass and ΔM