Natural SUSY with Light Higgsinos at the ILC

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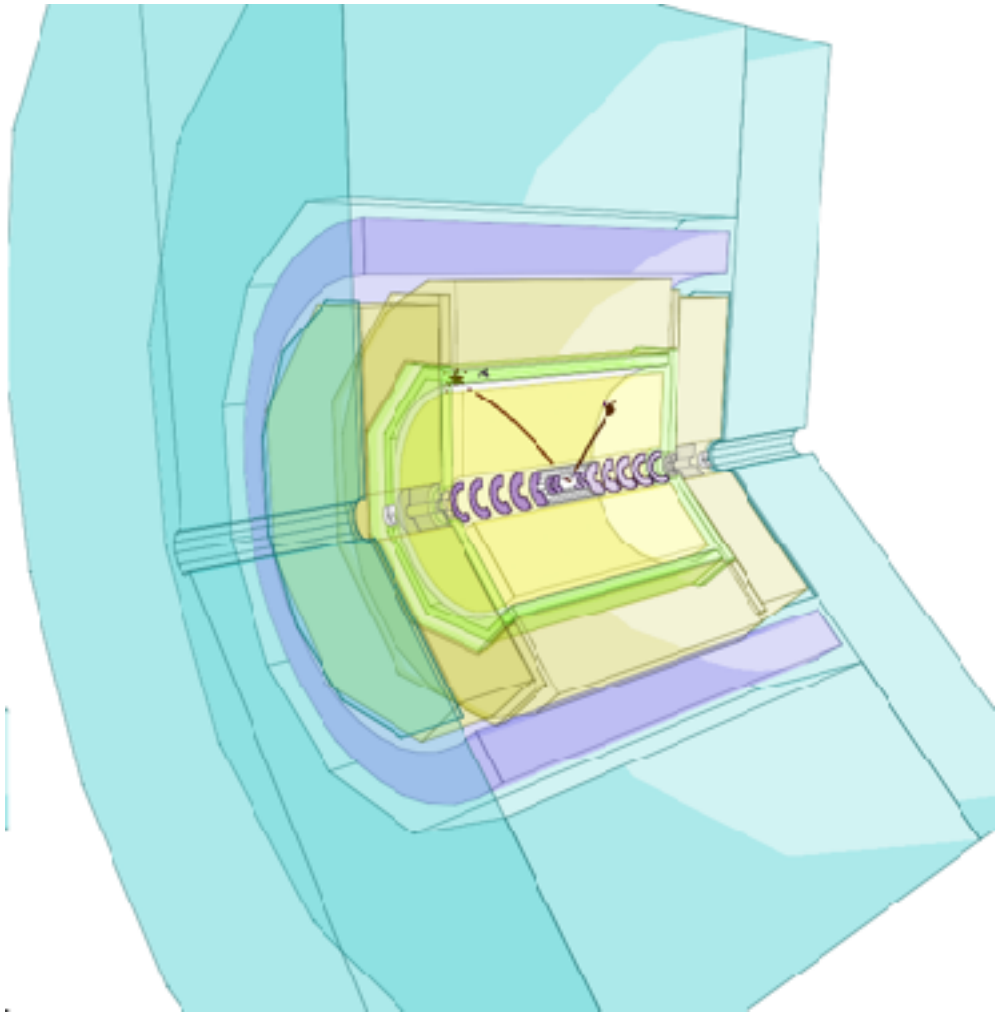

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Most materials are from Tomohiko and Suvi.

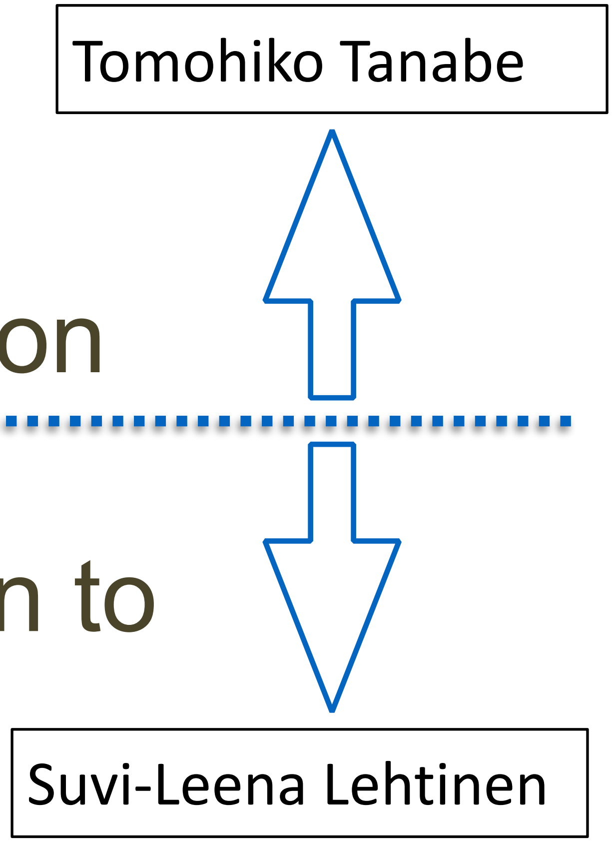
This talk will update one given by Tomohiko in Strasbourg on October 24, 2017.

What's new?

- **More complete BG (missing phase space in low ee-pair invariant mass plugged, 2-photon ae→3f included)**
- **Consistent selection cuts across all benchmarks, final states, and beam polarizations**
- **Global mass fits with improved edge detection**
- **New plots for model parameter extractions using the updated event selection and mass and cross section fit results**

Contents

- **Introduction**
  - Motivation, benchmarks
- **Neutralino channel (N1N2)**
  - Event selection, kinematic edges
- **Chargino channel (C1C1)**
  - Event selection, kinematic edges
- **Results**
  - Mass global fits, Cross section estimation
- **Parameter extraction**
  - Prediction of heavy states, extrapolation to GUT-scale physics
- **Summary**



Introduction

ILC, too, is an energy frontier machine!

It will enter ***uncharted waters of e^+e^- collisions***

Thanks to well-defined initial states,
clean environment w/o QCD BG, and

- ***$>10^3$ higher luminosity than LEP2***
- ***beam polarizations***
- ***much better detectors***

we have ***much better sensitivities to regions with small cross sections and compressed mass spectra, which are challenging for LHC***

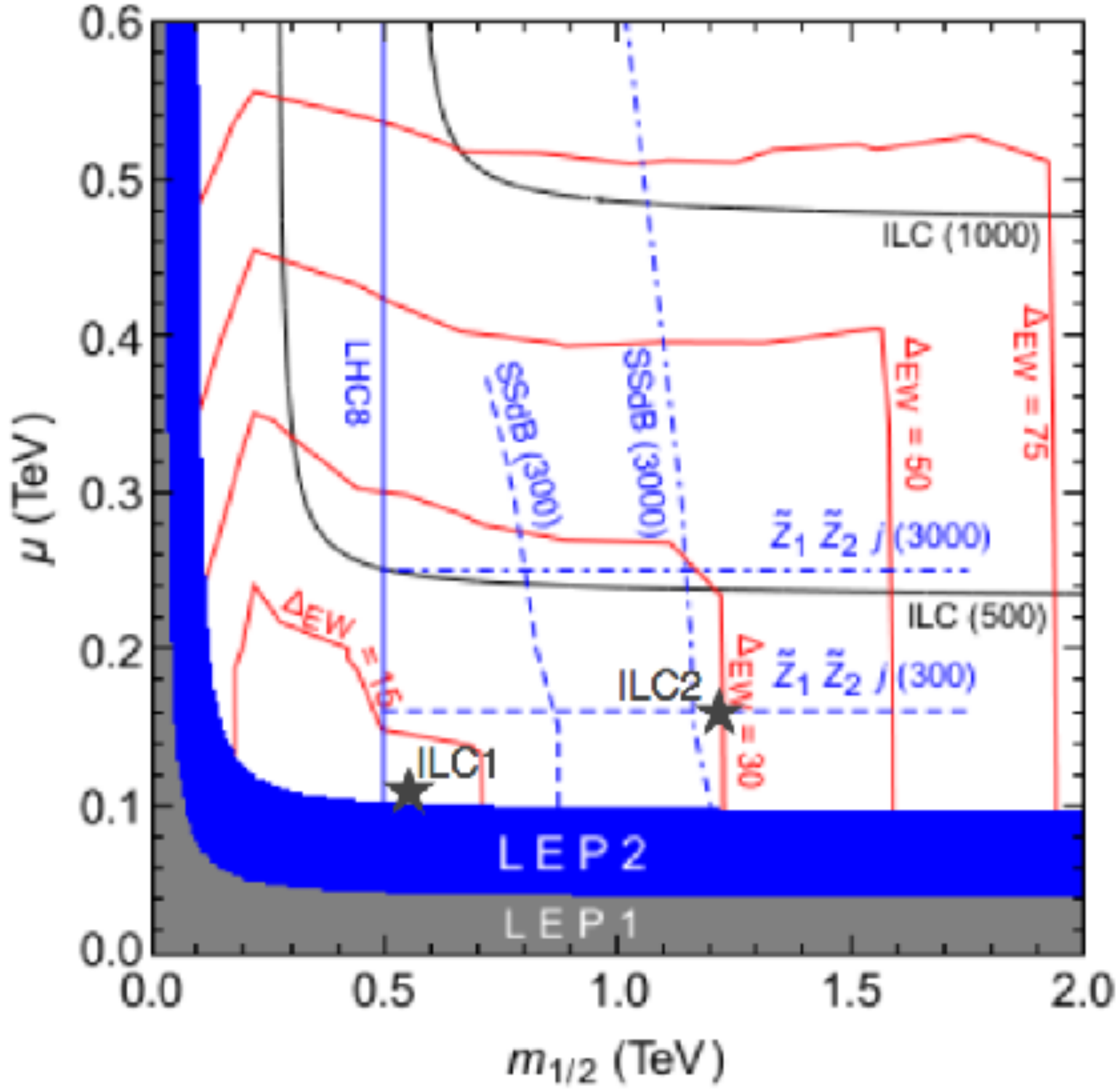
ILC can cover blind spots of LHC!

Why Light Higgsinos?

[arXiv:1212.2655, arXiv:1404.7510]

Radiatively driven Natural SUSY

$$\frac{m_Z^2}{2} = \frac{m_{H_d}^2 - m_{H_u}^2 \tan^2\beta}{\tan^2\beta - 1} - \mu^2$$



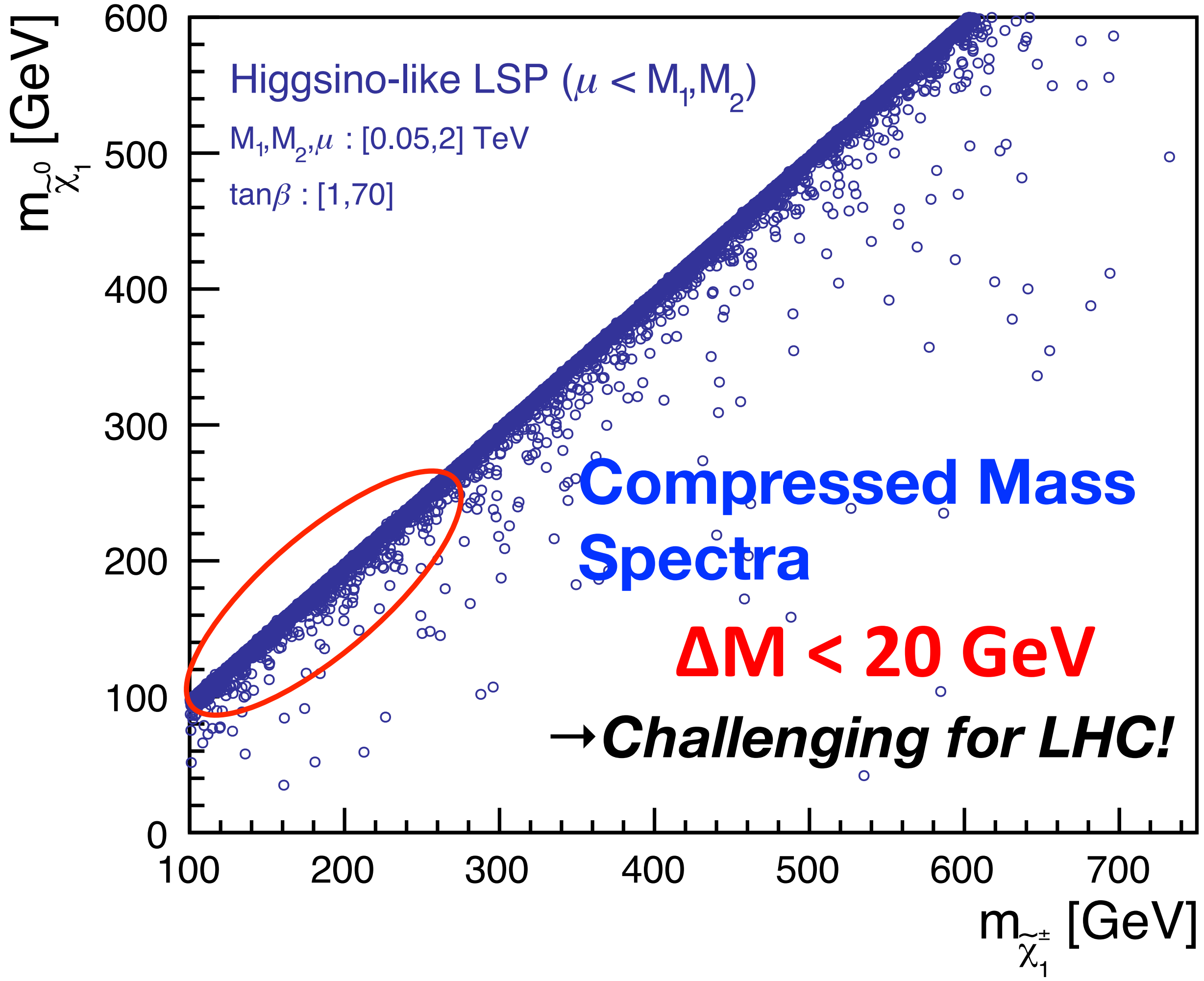
ILC1: ~7% EW fine tuning

ILC2: ~3% EW fine tuning

SUSY is still the best BSM candidate,
if μ is not far above 100 GeV.

μ not far above 100GeV implies

Higgsino-like LSP



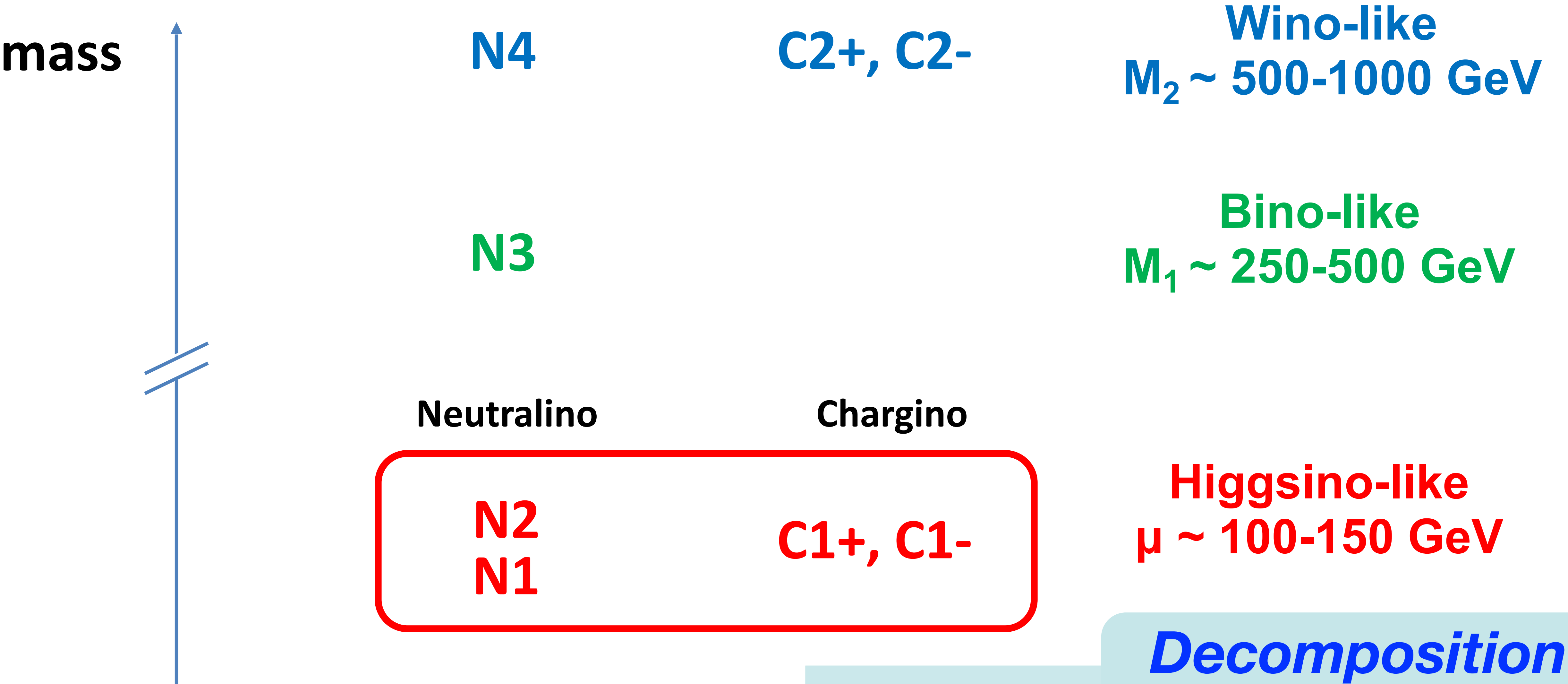
Compressed Mass Spectra

ΔM < 20 GeV

→***Challenging for LHC!***

ILC, including its energy upgrade ~500 GeV, is expected to discover natural SUSY (or finally rule it out).

Typical Natural SUSY Spectrum



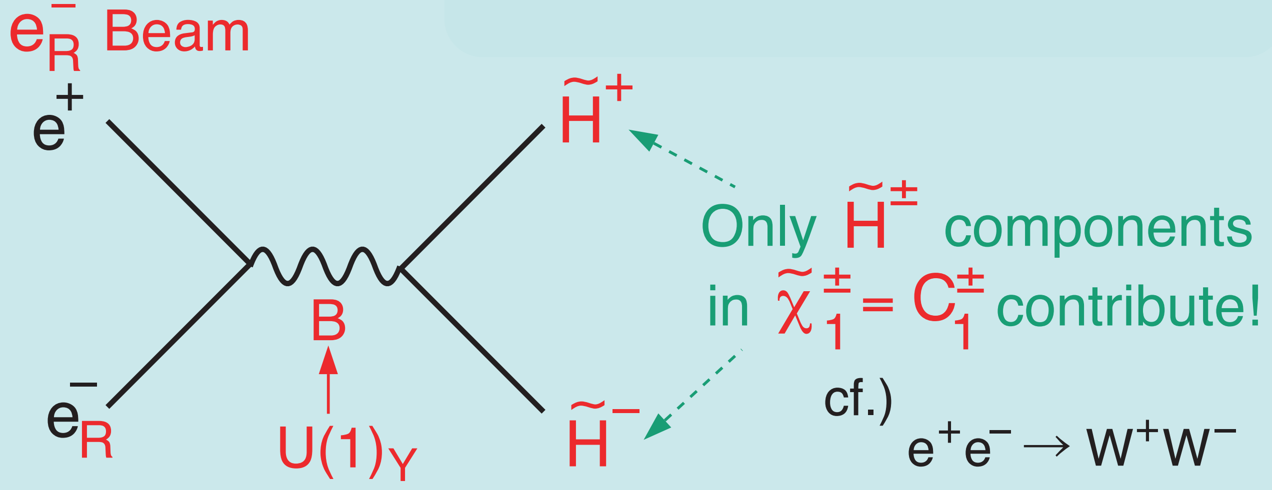
Wino-like
$M_2 \sim$ 500-1000 GeV

Bino-like
$M_1 \sim$ 250-500 GeV

Higgsino-like
$\mu \sim$ 100-150 GeV

Thanks to the small mixings of Higgsino / Bino / Wino,
the Bino & Wino are resolvable from the precision measurements of the polarized cross sections & mass of the lightest Higgsino-like states.

Decomposition



Only $\tilde{H}^\pm$ components in $\tilde{\chi}_1^\pm = C_1^\pm$ contribute!

cf.) $e^+e^- \to W^+W^-$

$$\tilde{\chi}_1^\pm = \bigcirc \cdot \tilde{W}^\pm + \underset{\langle \tilde{H}^\pm | \tilde{\chi}_1^\pm \rangle}{\underset{\parallel}{\bullet}} \cdot \tilde{H}^\pm$$

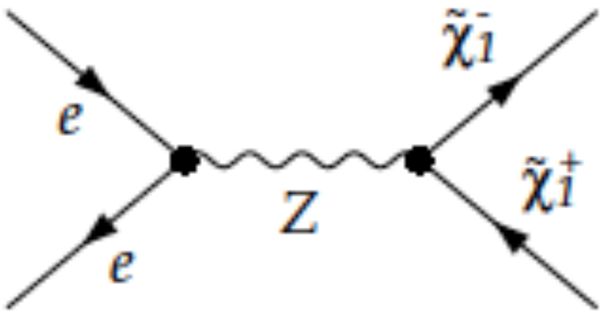
Benchmark Points

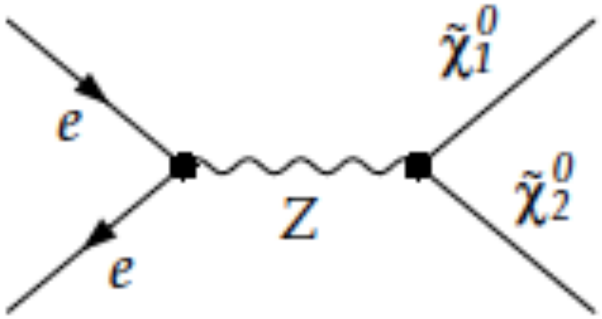
Chargino Pair Production

e+e- → C1+ C1-

Neutralino Mixed Production

e+e- → N1 N2





3 benchmark points with natural higgsinos:

Mass (GeV)	ILC1	ILC2	nGMM1
M(N1)	102.7	148.1	151.4
M(N2)	124.0	157.8	155.8
ΔM(N2,N1)	**21.3**	**9.7**	**4.4**
M(C1)	117.3	158.3	158.7
ΔM(C1,N1)	**14.6**	**10.2**	**7.3**

Cross Section	ILC1	ILC2	nGMM1
C1C1 (e-L, e+R)	1799.9	1530.5	1520.6
C1C1 (e-R, e+L)	334.5	307.2	309.5
N1N2 (e-L, e+R)	490.9	458.9	463.5
N1N2 (e-R, e+L)	378.5	353.8	357.3

*Other SUSY particles are heavy

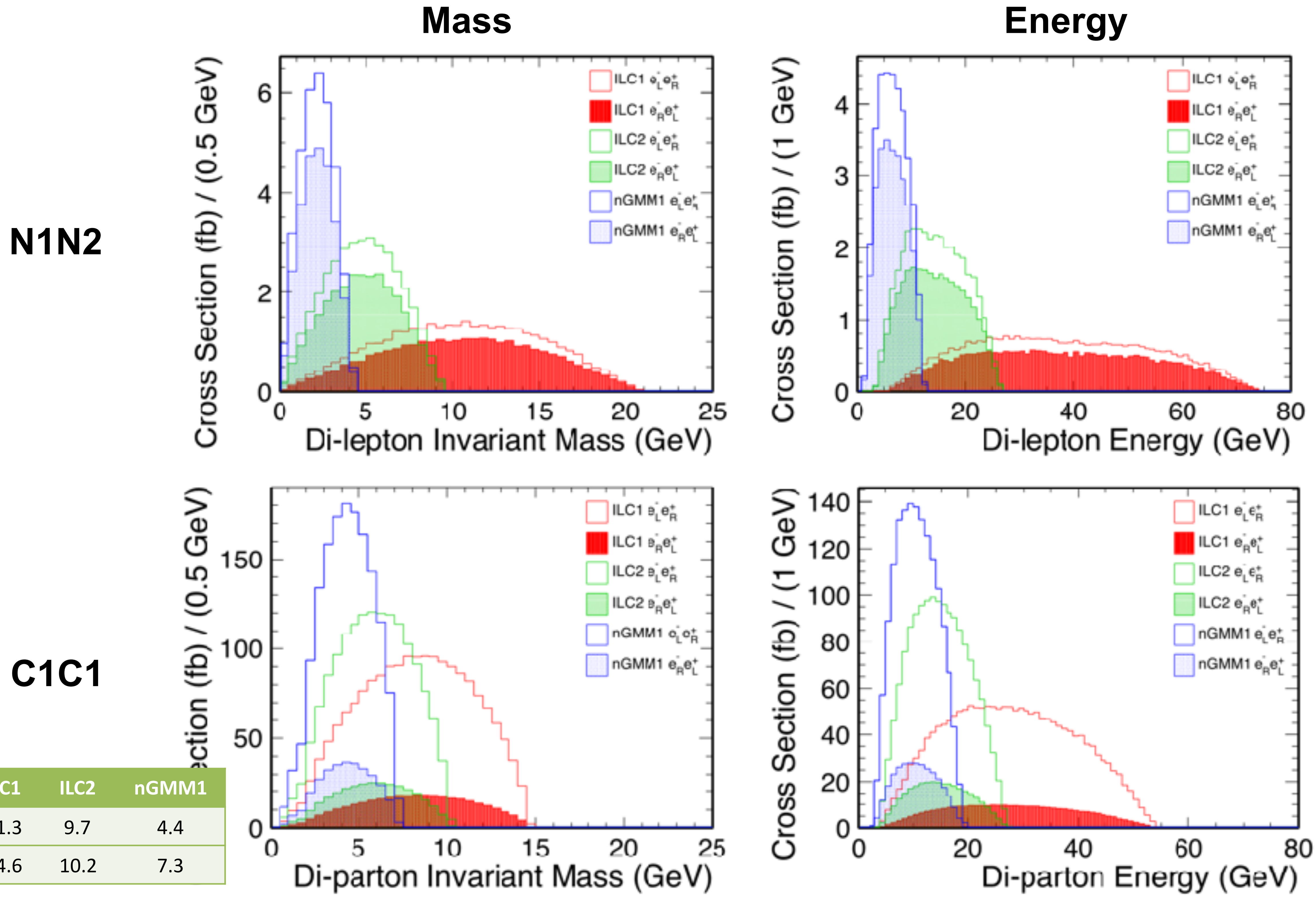
(Assuming discovery)

How well can we reconstruct the masses and cross section?

What are the implications for the precision obtained?

Generator-level Distributions

- **Key observables in this study: di-lepton / di-jet mass and energy.**
- **Their maximum values (edges) can be used to extract the masses.**

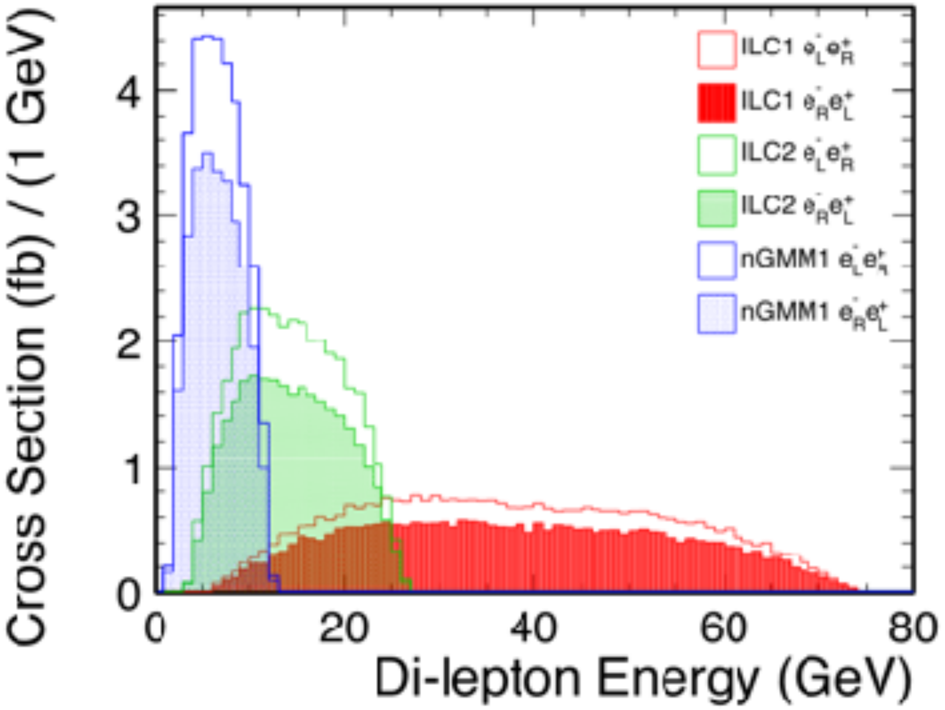


	ILC1	ILC2	nGMM1
ΔM(N2,N1)	21.3	9.7	4.4
ΔM(C1,N1)	14.6	10.2	7.3

Equations

Maximum energy of the di-lepton / di-jet system is given by

$$E^* = \frac{\gamma(1+\beta)}{2}\left(1+\frac{M_1}{M_2}\right)\Delta M$$



where

$$\frac{1}{\gamma} = \sqrt{1-\beta^2} \qquad \frac{1}{\beta} = \sqrt{1+\left(\frac{M_2}{p^*}\right)^2}$$

$$\Delta M = M_2 - M_1$$ (given by ***maximum mass of the di-lepton / di-jet system***)

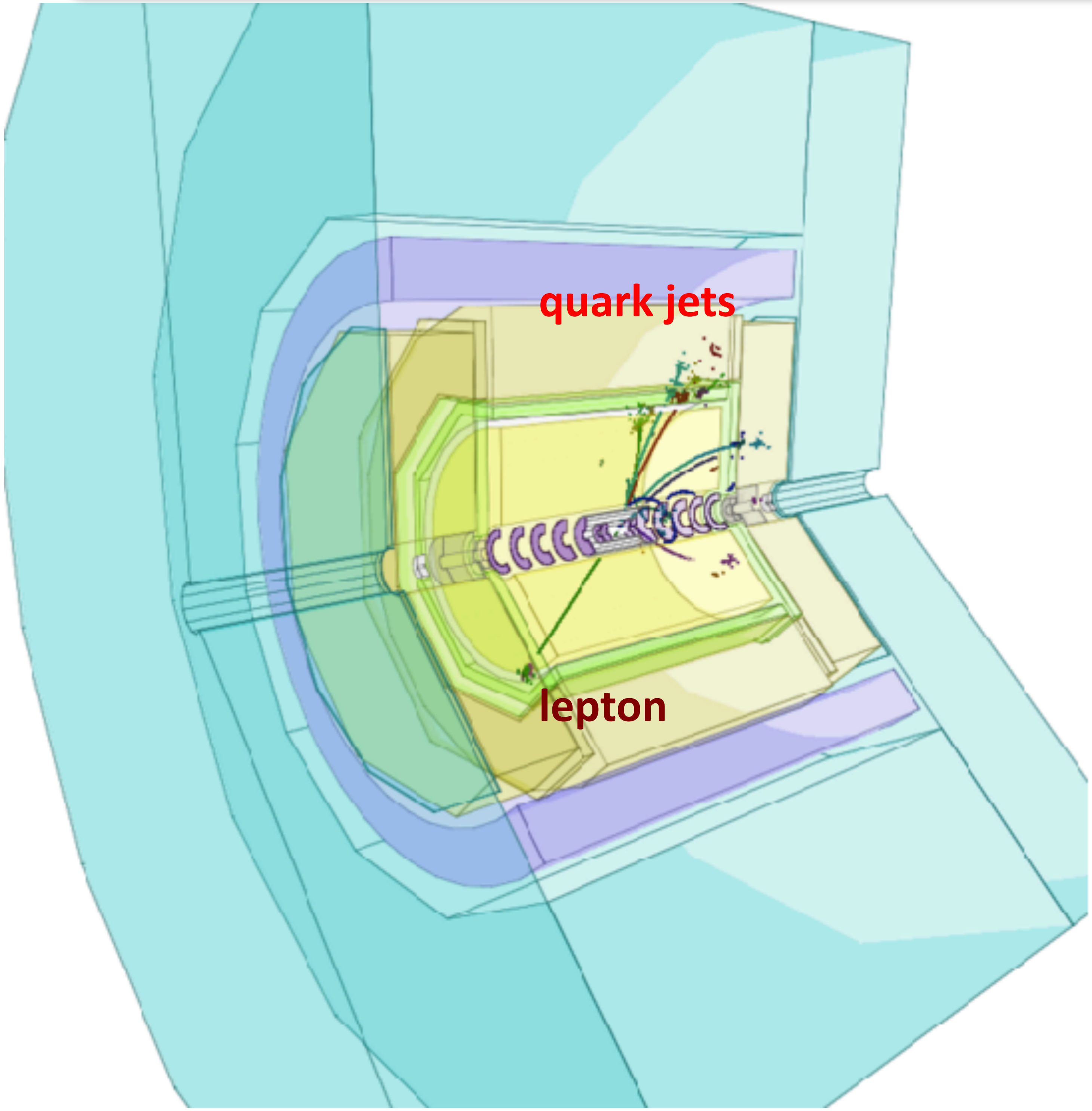
$$p^* = \frac{\sqrt{s}}{2}\sqrt{1-2\left[\left(\frac{M_1}{\sqrt{s}}\right)^2+\left(\frac{M_2}{\sqrt{s}}\right)^2\right]+\left[\left(\frac{M_2}{\sqrt{s}}\right)^2-\left(\frac{M_1}{\sqrt{s}}\right)^2\right]^2}$$

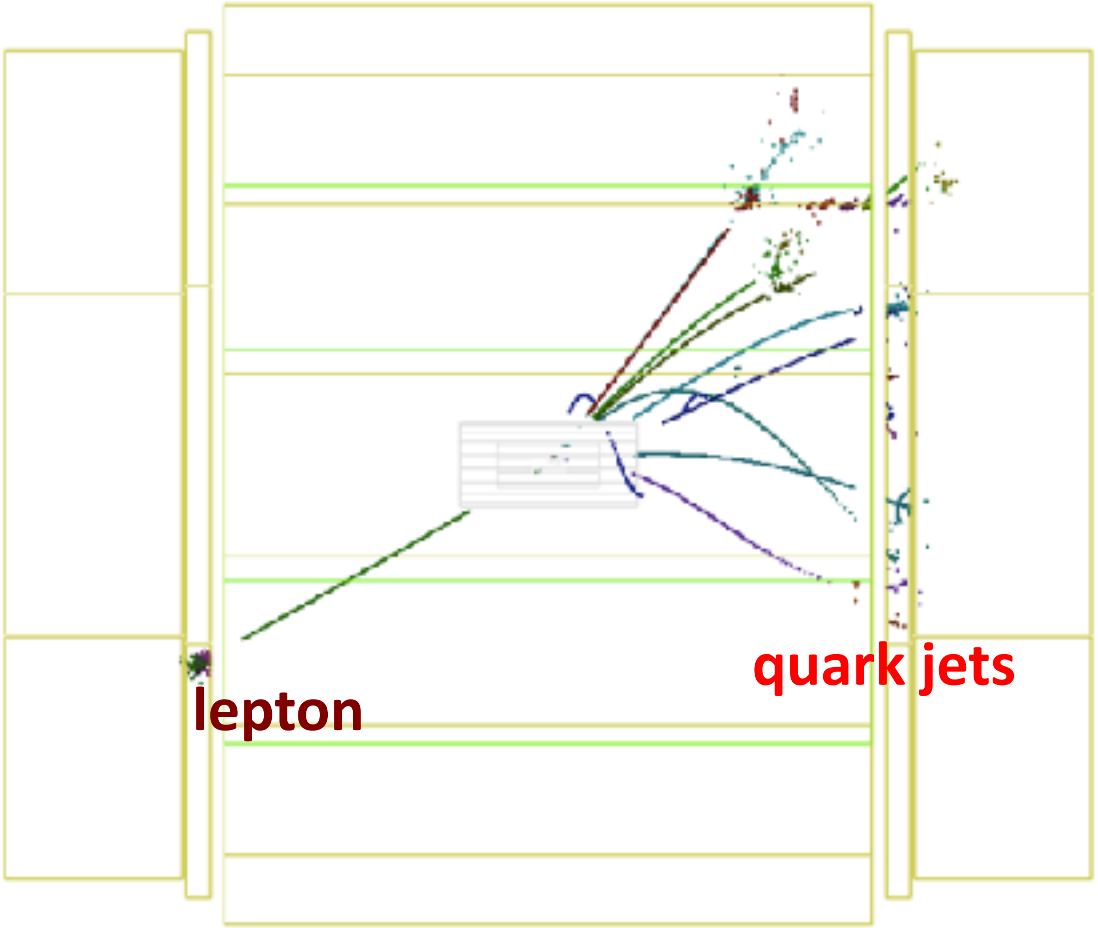
How do these signals look in the detector? (1)

√s =500 GeV

Chargino pair production with semileptonic decay

$$e^+e^- \to \widetilde{\chi}_1^+ \widetilde{\chi}_1^- \to \widetilde{\chi}_1^0 \widetilde{\chi}_1^0 q q' \ell \nu$$



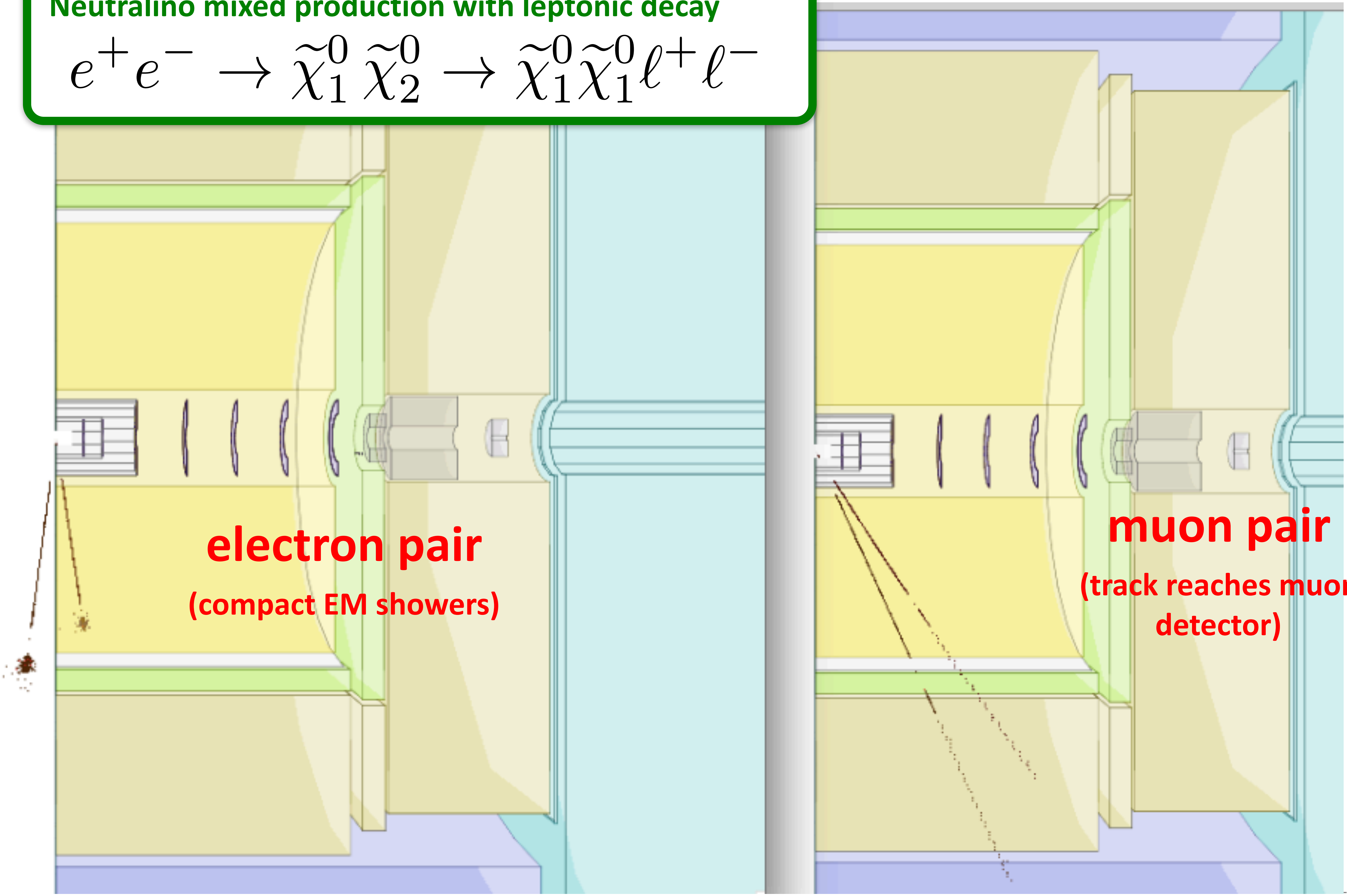


How do these signals look in the detector? (2)

√s =500 GeV

Neutralino mixed production with leptonic decay

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



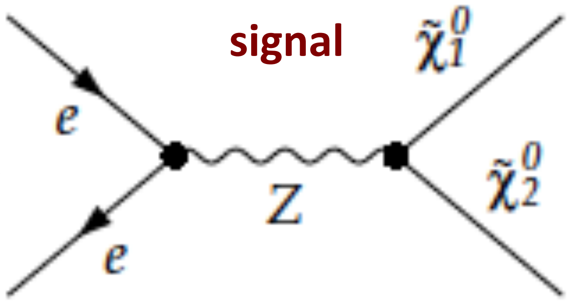
Event Selection

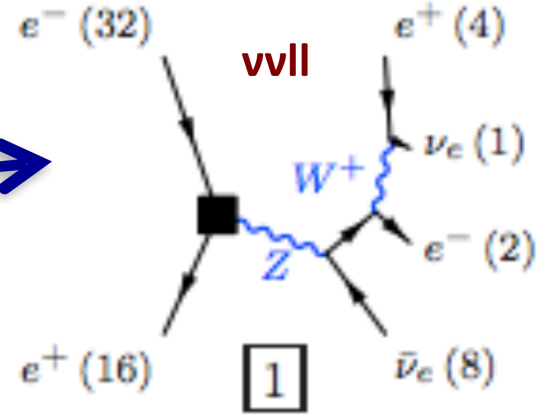
DBD software and samples used

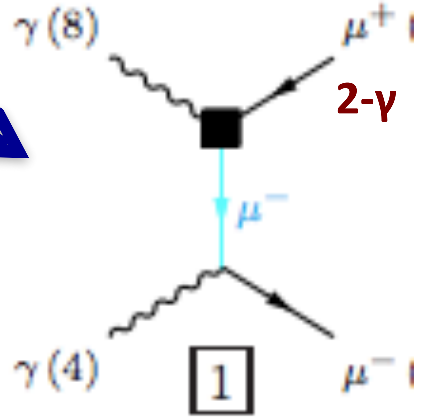
Neutralino mixed production with leptonic decay

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

- Identify **two leptons (ee or μμ)**
- Major residual bkg. are 4f processes accompanied by large missing energy (ννll)
- 2-γ processes removed by BeamCal veto, cuts on lepton track p_T, and coplanarity



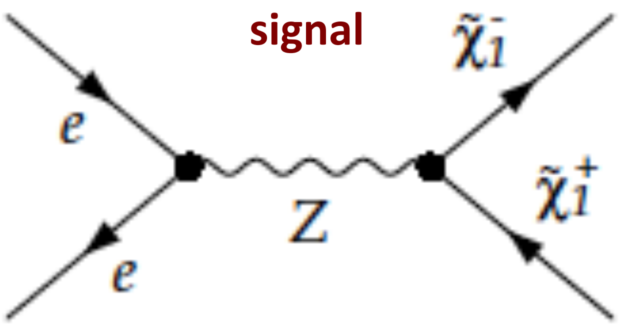




Chargino pair production with semileptonic decay

$$e^+e^- \to \widetilde{\chi}_1^+ \widetilde{\chi}_1^- \to \widetilde{\chi}_1^0\widetilde{\chi}_1^0 qq'\ell\nu$$

- Find an **isolated lepton (e or μ)**
- Reconstruct **two jets** from the rest
- BeamCal veto, cuts on missing p_T, # of tracks, # of leptons, and coplanarity **remove almost all bkg**.



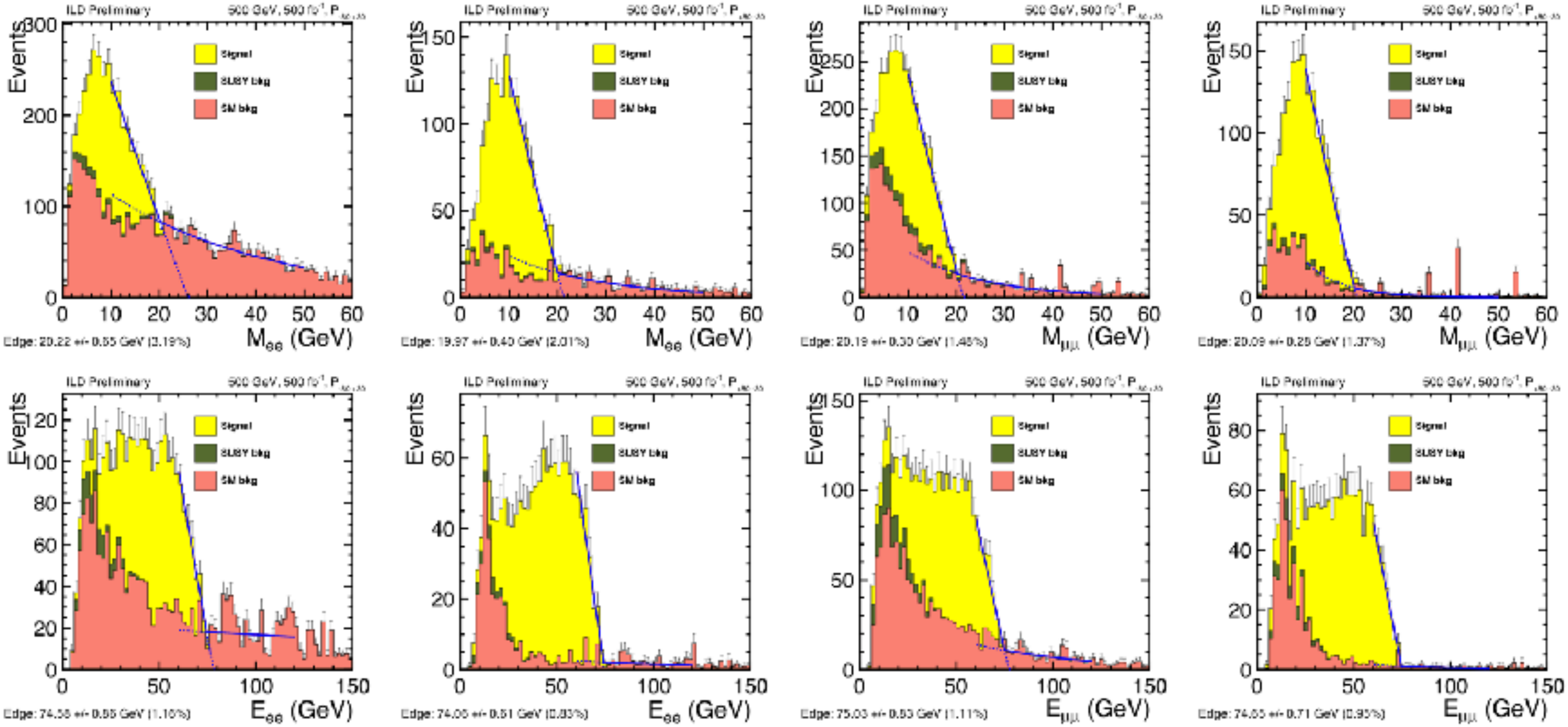
N1N2

Kinematic Edges: ILC1 (N1N2)

ee, (-80,+30) **ee, (+80,-30)** **μμ, (-80,+30)** **μμ, (+80,-30)**

M

E



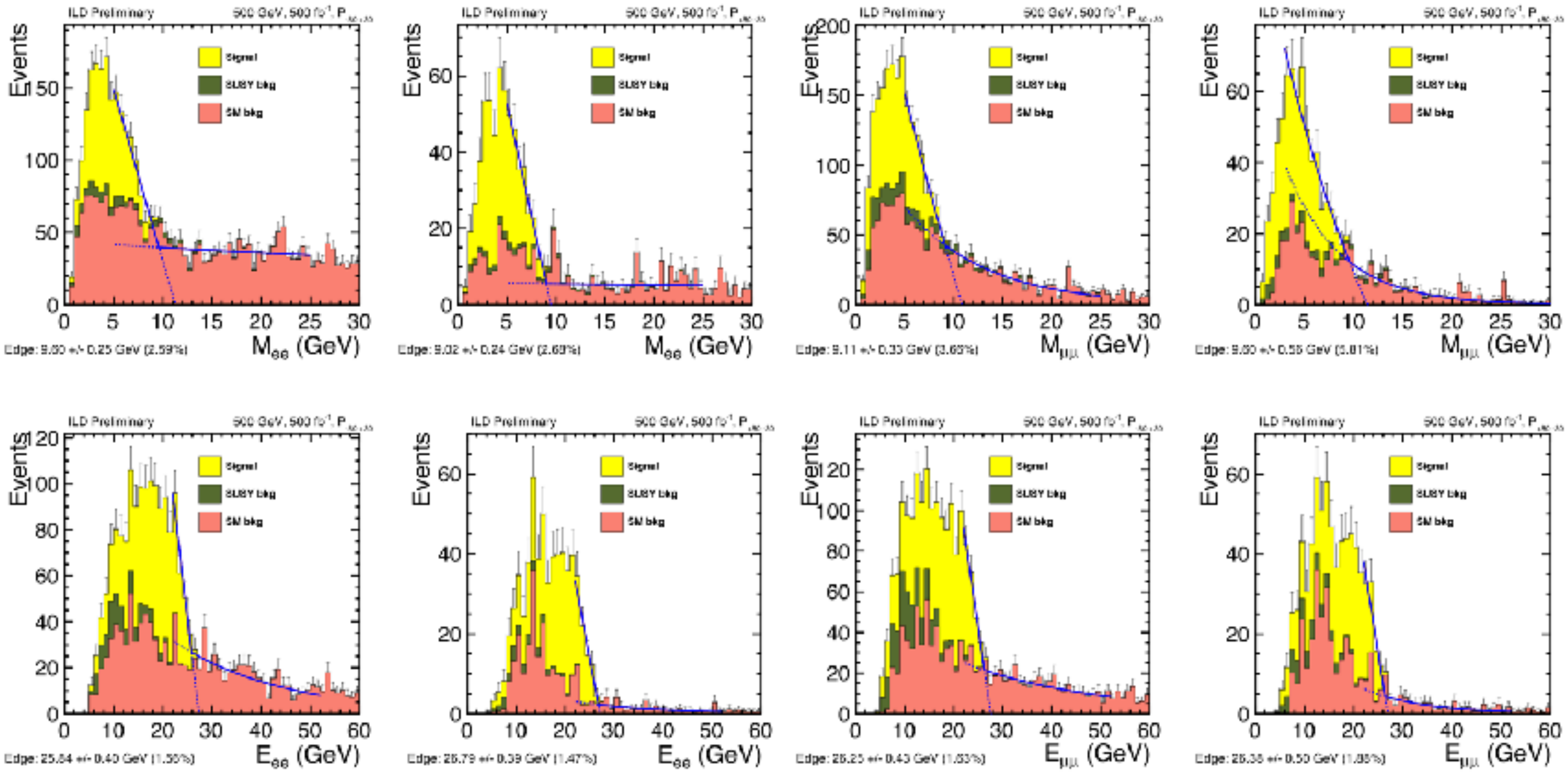
The kinematic edge is modeled as: straight line (signal) + exponential (background). The precision is estimated using toy MC experiments.

Kinematic Edges: ILC2 (N1N2)

ee, (-80,+30) **ee, (+80,-30)** **μμ, (-80,+30)** **μμ, (+80,-30)**

M

E



The kinematic edge is modeled as: straight line (signal) + exponential (background). The precision is estimated using toy MC experiments.

Kinematic Edges: nGMM1 (N1N2)

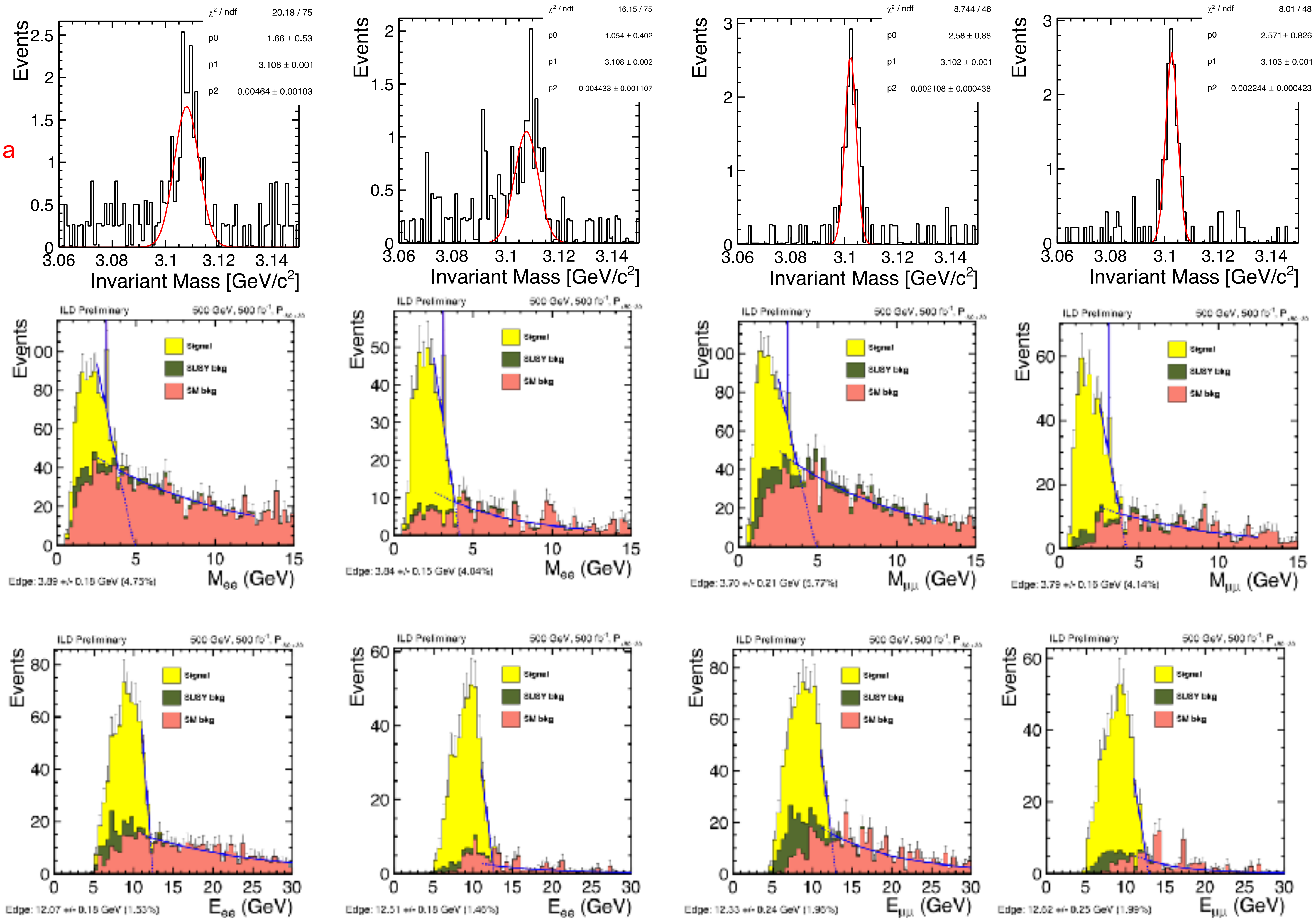
ee, (-80,+30) **ee, (+80,-30)** **μμ, (-80,+30)** **μμ, (+80,-30)**

M(J/ψ)

J/ψ masses are a bit off: will be investigated

M

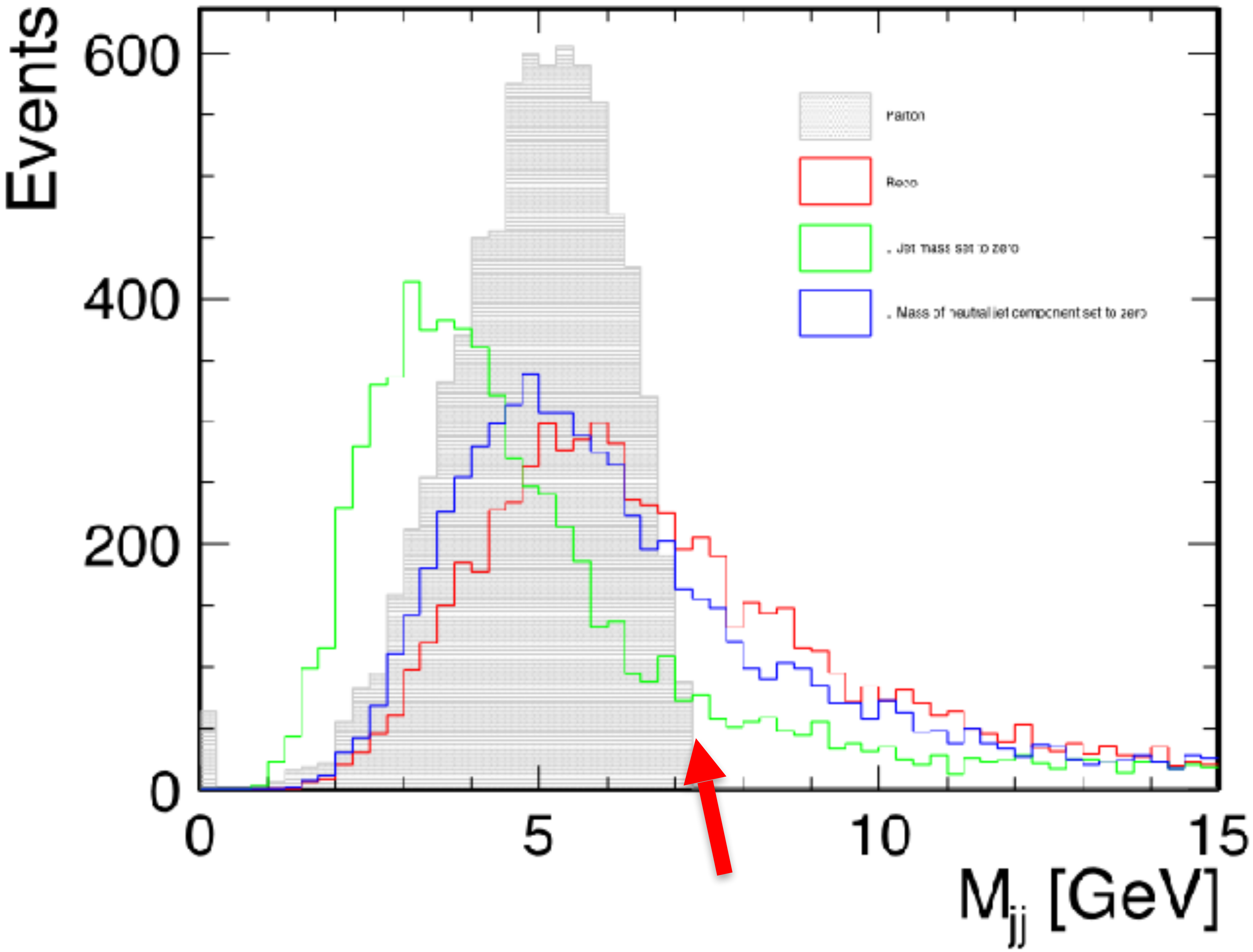
E



C1C1

Di-jet Reconstruction

- Naïve reconstruction of di-jet mass suffers from heavy tail
- Dominant effect: neutral reconstruction **(NOT detector resolution)**
- Set only the neutral component of the jet to have zero mass → improves core reconstruction but the tail remains
- Set jet mass to zero → overcompensation in the core but reproduces the edge → used in this study.

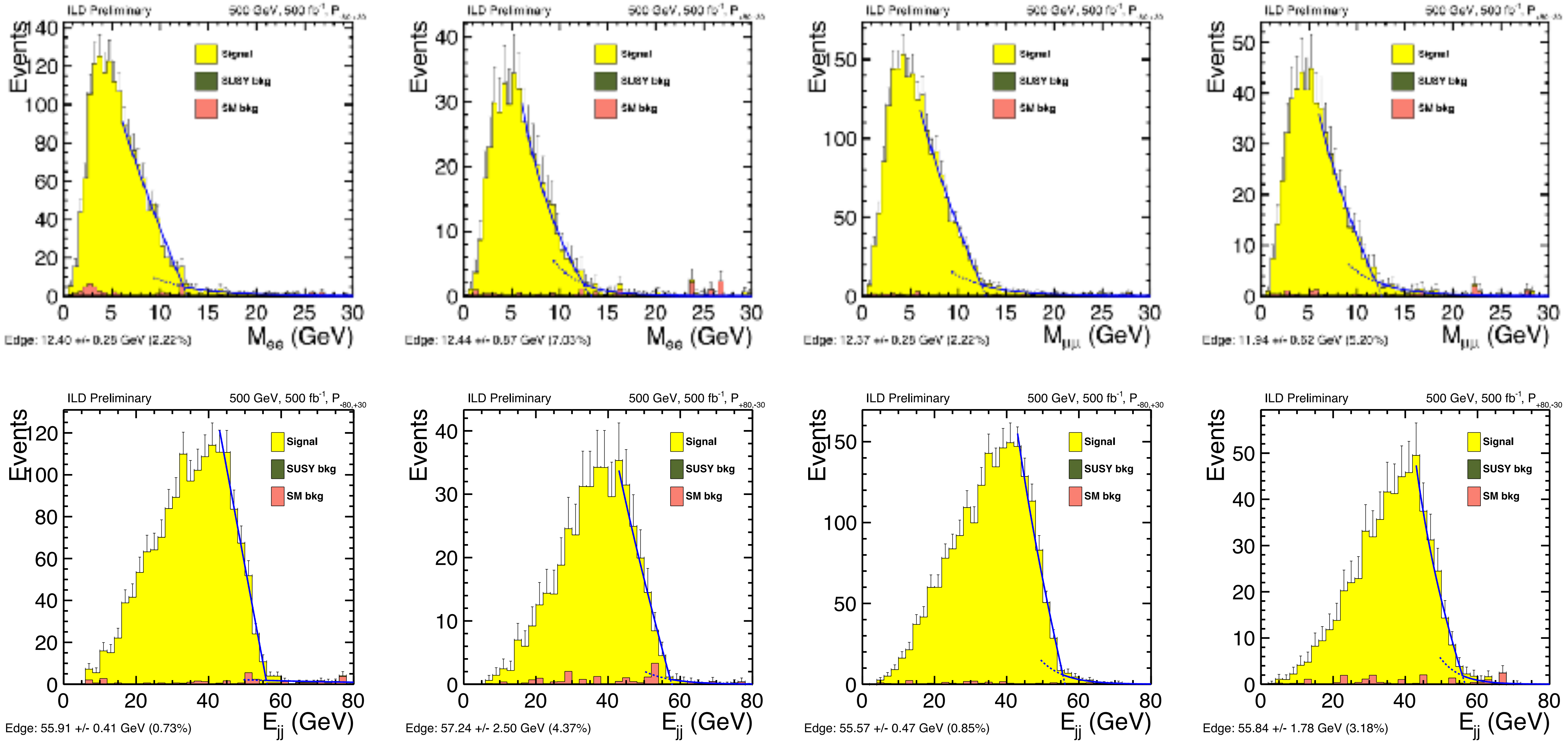


Kinematic Edges: ILC1 (C1C1)

l=e, (-80,+30) **l=e, (+80,-30)** **l=μ, (-80,+30)** **l=μ, (+80,-30)**

M

E

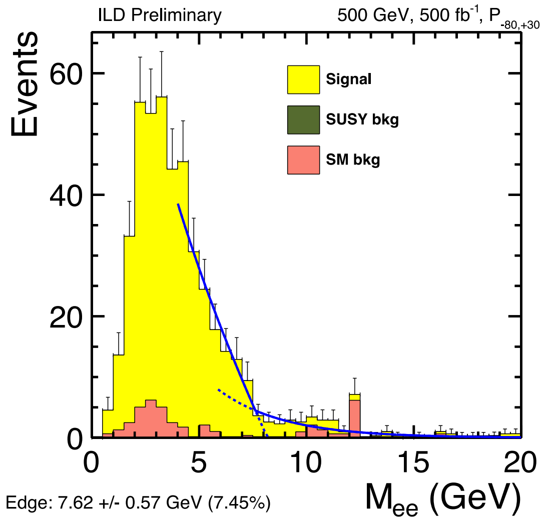


- The core is model with a straight line, while the tail is model with an exponential. The intersection is extract as the edge. The precision is estimated using toy MC experiments.
- A shift in the extract value (bias) is seen. This is correct by a scaling factor.

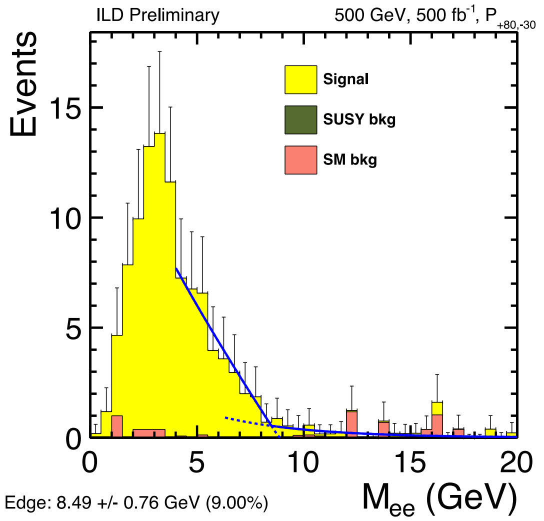
Kinematic Edges: ILC2 (C1C1)

l=e, (-80,+30) **l=e, (+80,-30)** **l=μ, (-80,+30)** **l=μ, (+80,-30)**

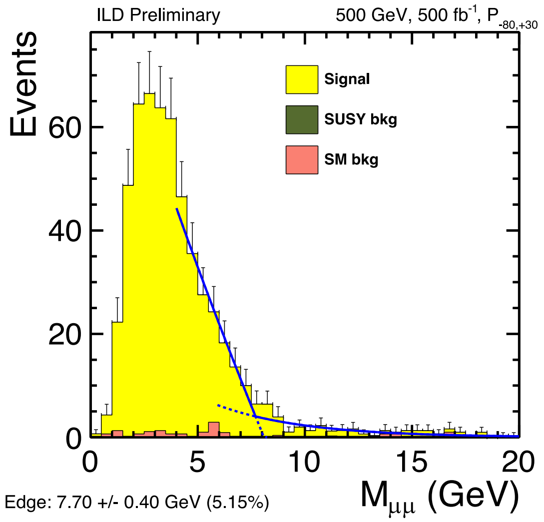
M



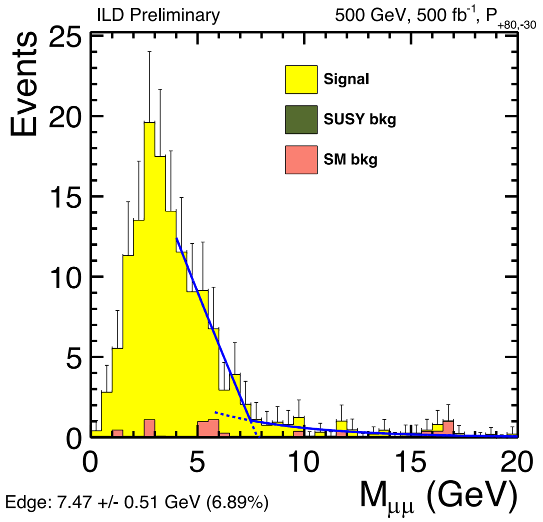
Edge: 7.62 +/- 0.57 GeV (7.45%)



Edge: 8.49 +/- 0.76 GeV (9.00%)

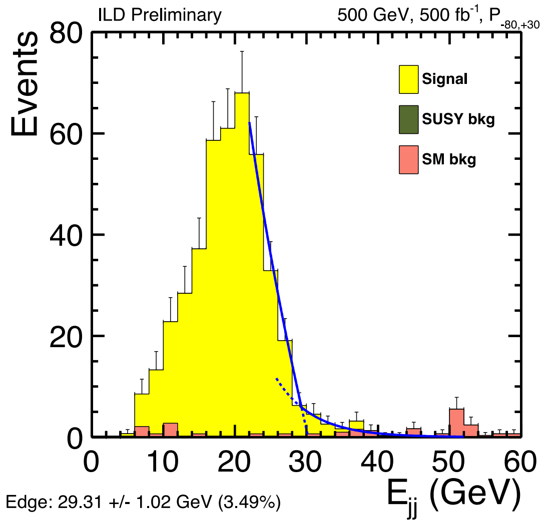


Edge: 7.70 +/- 0.40 GeV (5.15%)

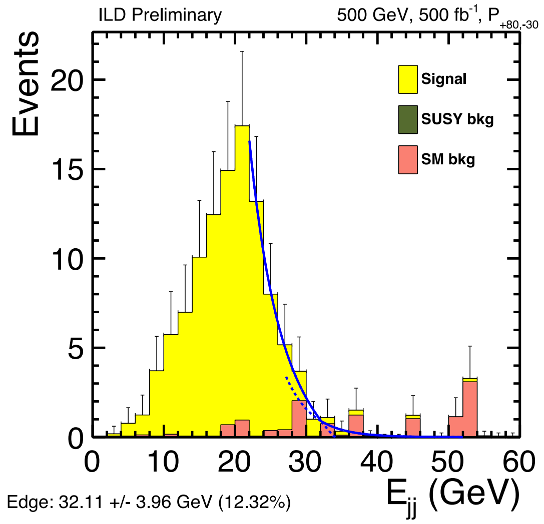


Edge: 7.47 +/- 0.51 GeV (6.89%)

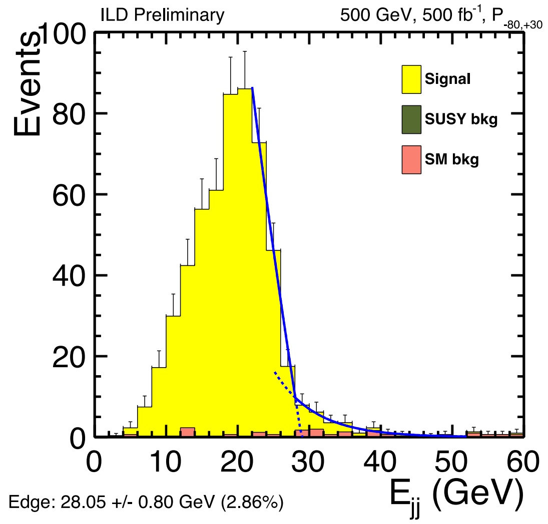
E



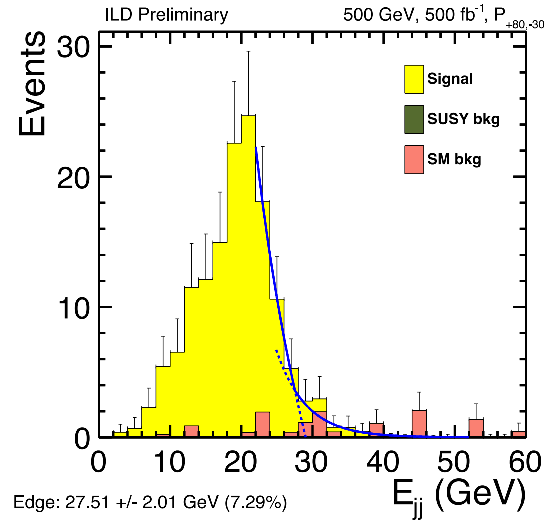
Edge: 29.31 +/- 1.02 GeV (3.49%)



Edge: 32.11 +/- 3.96 GeV (12.32%)



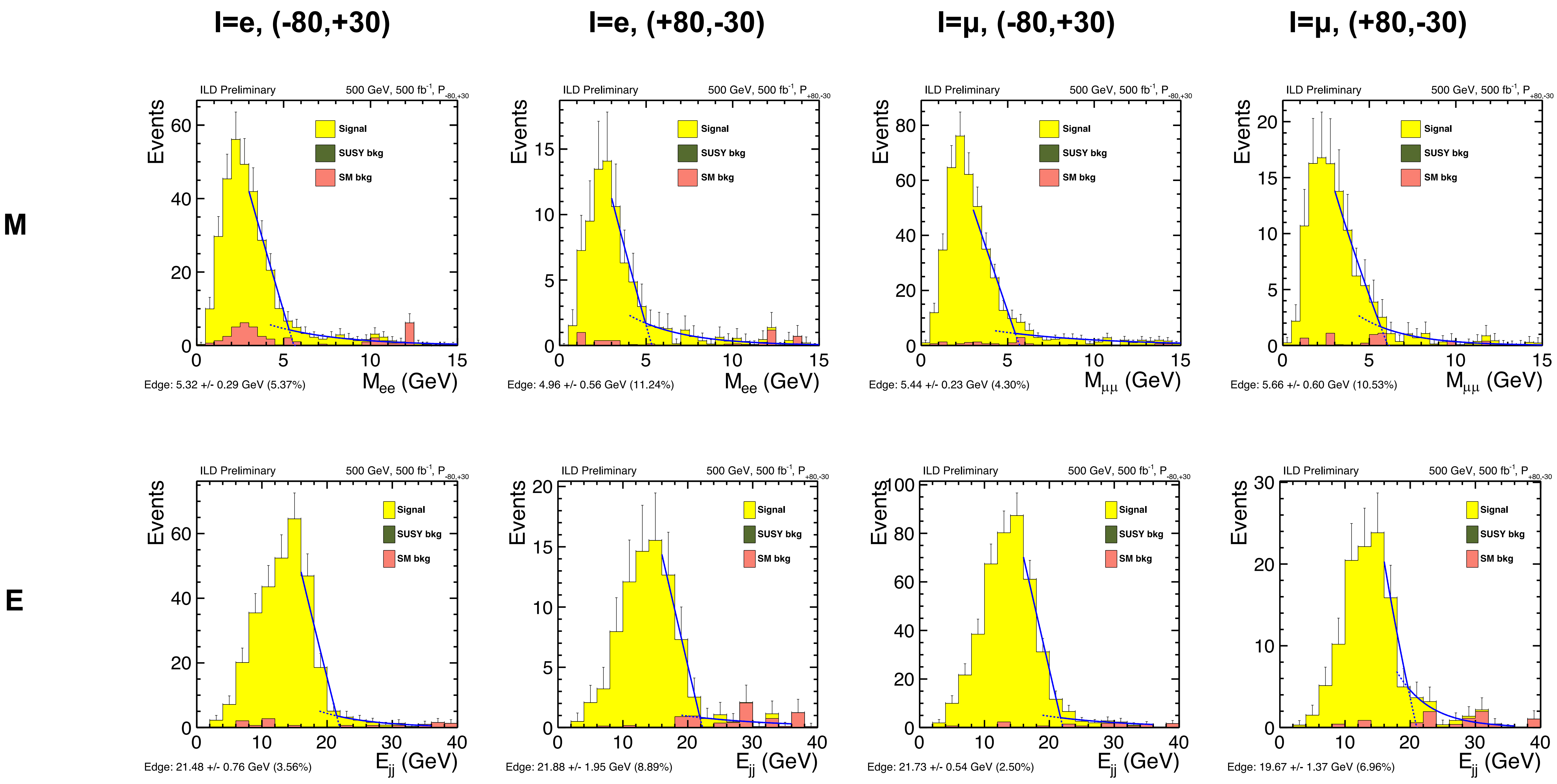
Edge: 28.05 +/- 0.80 GeV (2.86%)



Edge: 27.51 +/- 2.01 GeV (7.29%)

- The core is model with a straight line, while the tail is model with an exponential. The intersection is extract as the edge. The precision is estimated using toy MC experiments.
- A shift in the extract value (bias) is seen. This is correct by a scaling factor.

Kinematic Edges: nGMM1 (C1C1)



Edge: 5.32 +/- 0.29 GeV (5.37%)

Edge: 4.96 +/- 0.56 GeV (11.24%)

Edge: 5.44 +/- 0.23 GeV (4.30%)

Edge: 5.66 +/- 0.60 GeV (10.53%)

Edge: 21.48 +/- 0.76 GeV (3.56%)

Edge: 21.88 +/- 1.95 GeV (8.89%)

Edge: 21.73 +/- 0.54 GeV (2.50%)

Edge: 19.67 +/- 1.37 GeV (6.96%)

- The core is model with a straight line, while the tail is model with an exponential. The intersection is extract as the edge. The precision is estimated using toy MC experiments.
- A shift in the extract value (bias) is seen. This is correct by a scaling factor.

Results

Mass Extraction

- *3 masses as fitted values* **which are used to compute the two observables: di-lepton/di-jet invariant mass and maximum energy**
- ***16 measurements: {N1N2,C1C1} x {e,mu} x {E,M} x {2 polarizations}***
- **Least-squares fit assuming Gaussian errors and independent measurements**
- **Calibration applied to M_{jj} edge: assume uncertainty scales linearly and without additional error**

√s=500 GeV L=500 fb-1	M(N1)	M(N2)	M(C1)
ILC1	102.6 ± 0.85 GeV (0.84%)	123.7 ± 0.99 GeV (0.80%)	117.2 ± 0.95 GeV (0.81%)
ILC2	148.2 ± 1.9 (1.31%)	157.9 ± 2.1 (1.31%)	158.5 ± 2.1 (1.30%)
nGMM1	151.0 ± 2.6 (1.72%)	155.3 ± 2.7 (1.72%)	158.4 ± 2.7 (1.68%)

Percent-level precision for neutralino and chargino masses.
(*Sub-percent expected for H-20 luminosities.*)
Event selection dedicated to each benchmark will improve the precision.

Cross Section

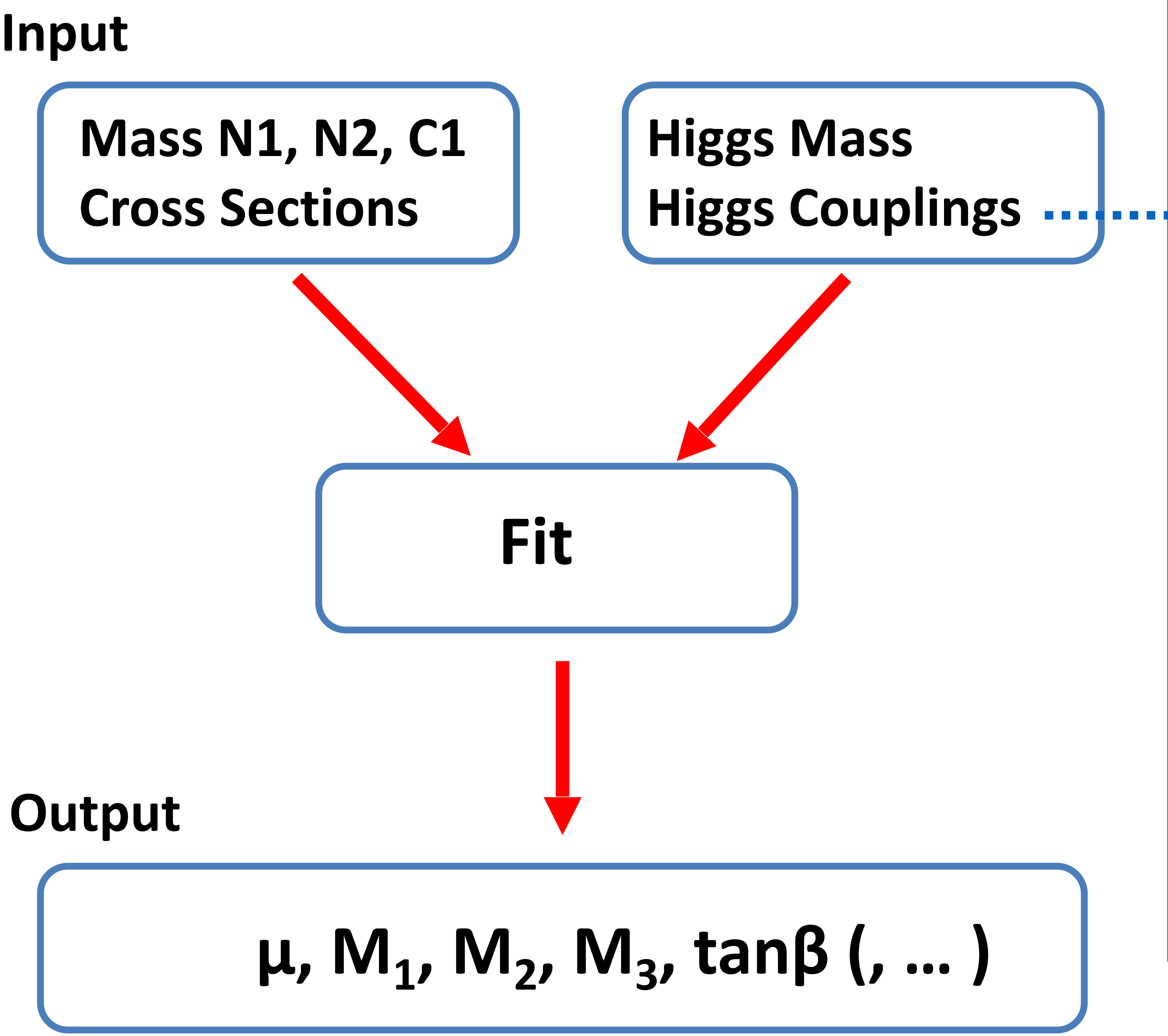
- *Event counting within optimized mass window*
  - N1N2:
    - ILC1: [0, 20] GeV
    - ILC2: [0, 9] GeV
    - nGMM1: [0, 3.5] GeV
  - C1C1: use all selected events
- Cross section significance computed via S/√(S+B) for each channel, combined via squared-sums → converted to statistical uncertainty

√s=500 GeV L=500 fb-1	Δσ/σ (N1N2)	Δσ/σ (C1C1)
ILC1	1.73%	1.51%
ILC2	2.90%	2.99%
nGMM1	3.03%	3.46%

A few percent precision for neutralino and chargino cross sections.
(*Percent-level expected for H-20 luminosities*.)
Event selection dedicated to each benchmark will improve the precision.

Parameter Extraction

SUSY Parameter Fit



Input

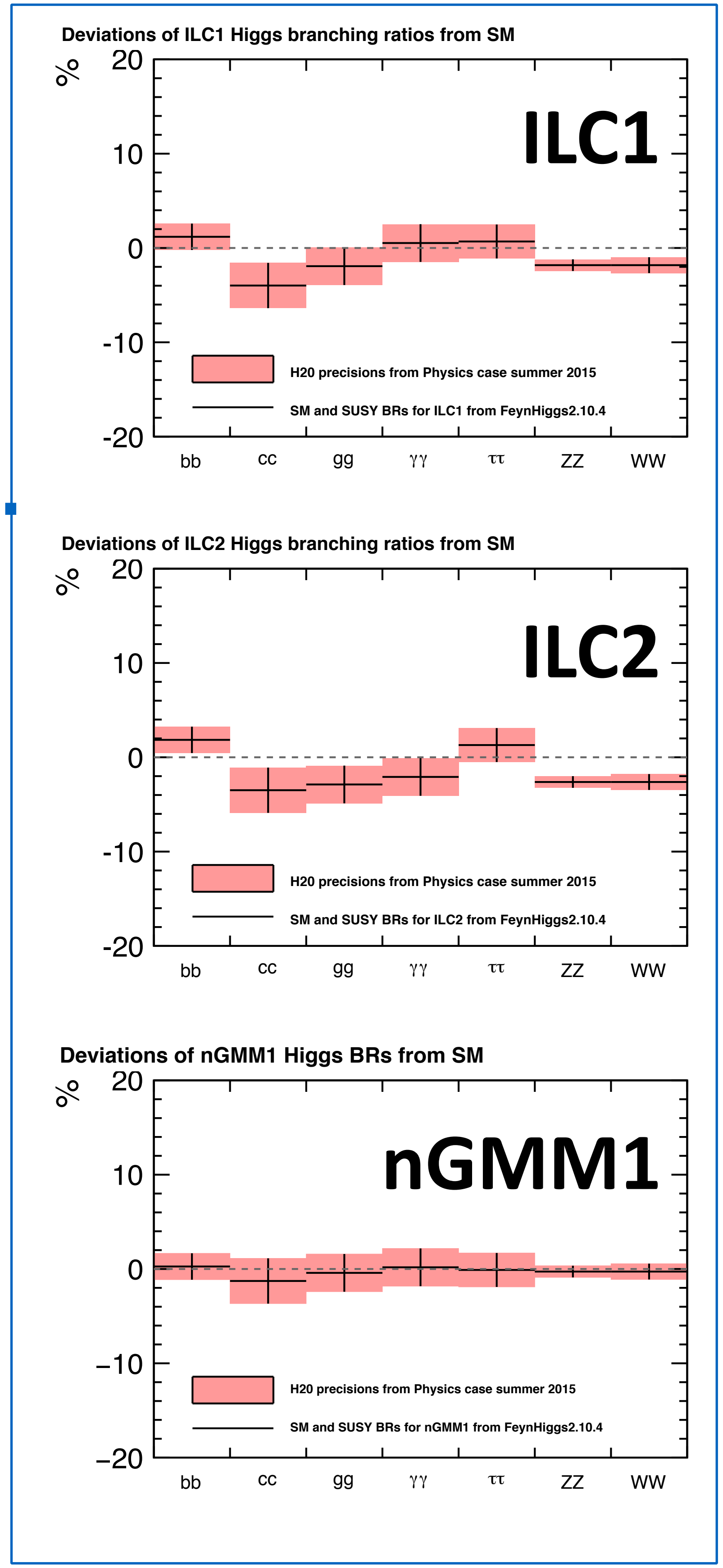
Mass N1, N2, C1
Cross Sections

Higgs Mass
Higgs Couplings

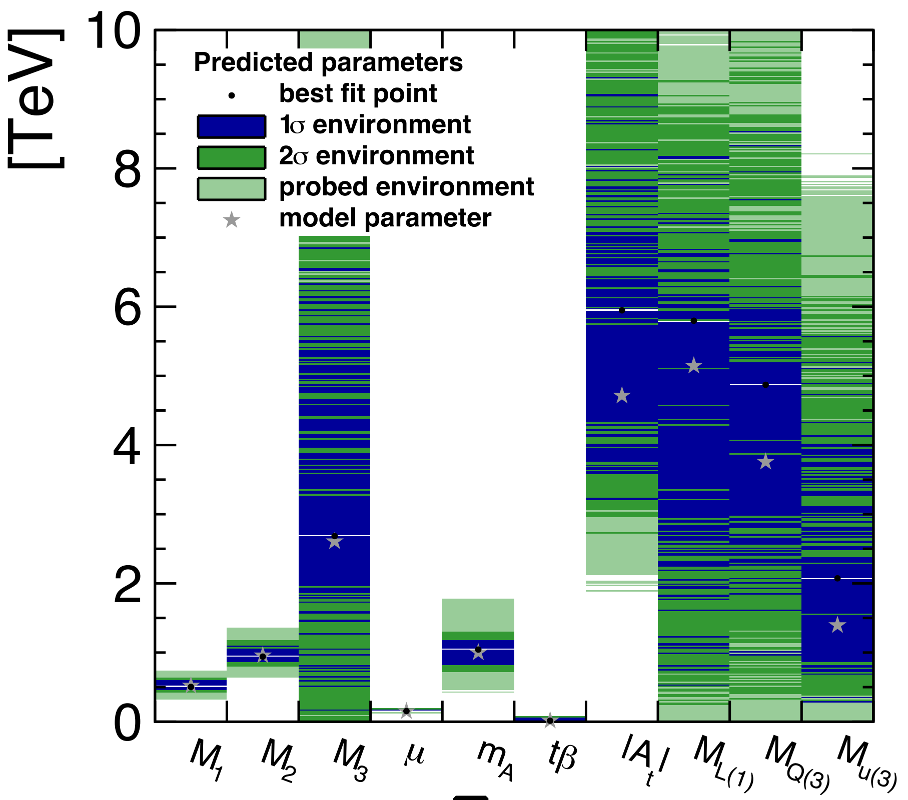
Fit

Output

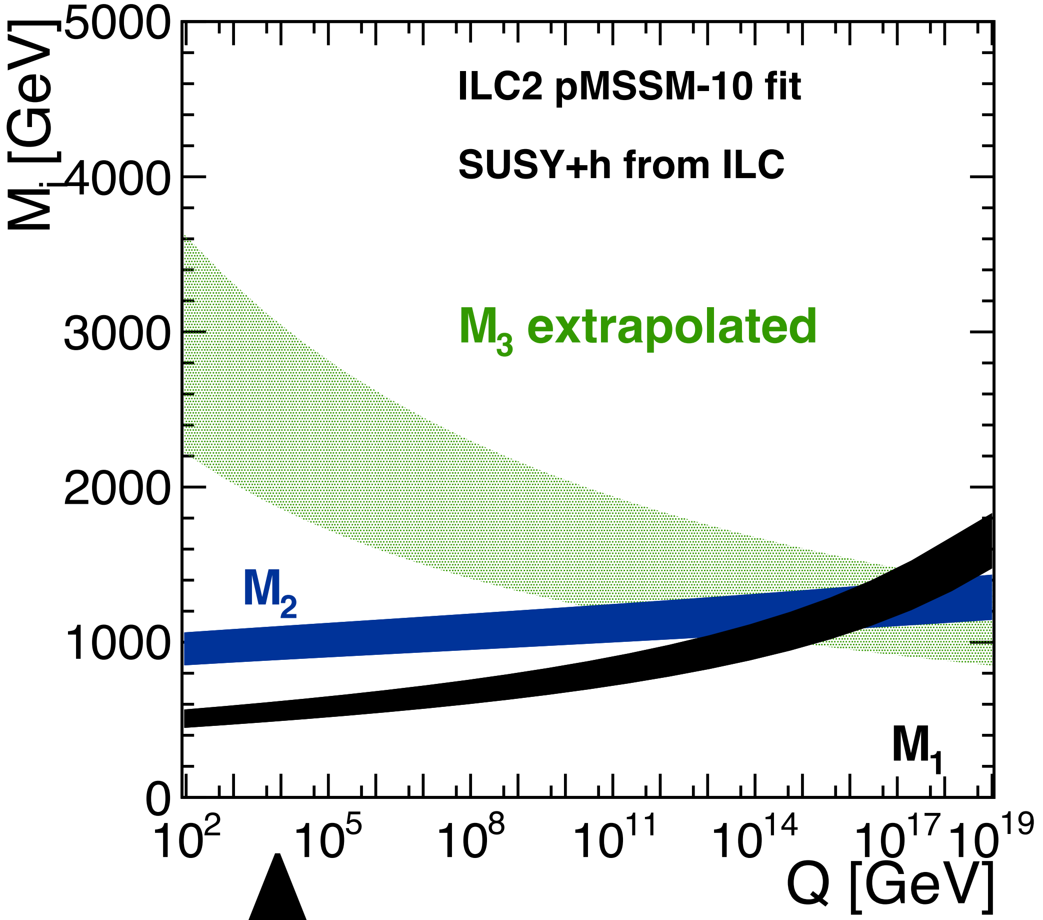
μ, M_1, M_2, M_3, $\tan\beta$ (, …)



Example: ILC2: *10-parameter* Fit (H20)

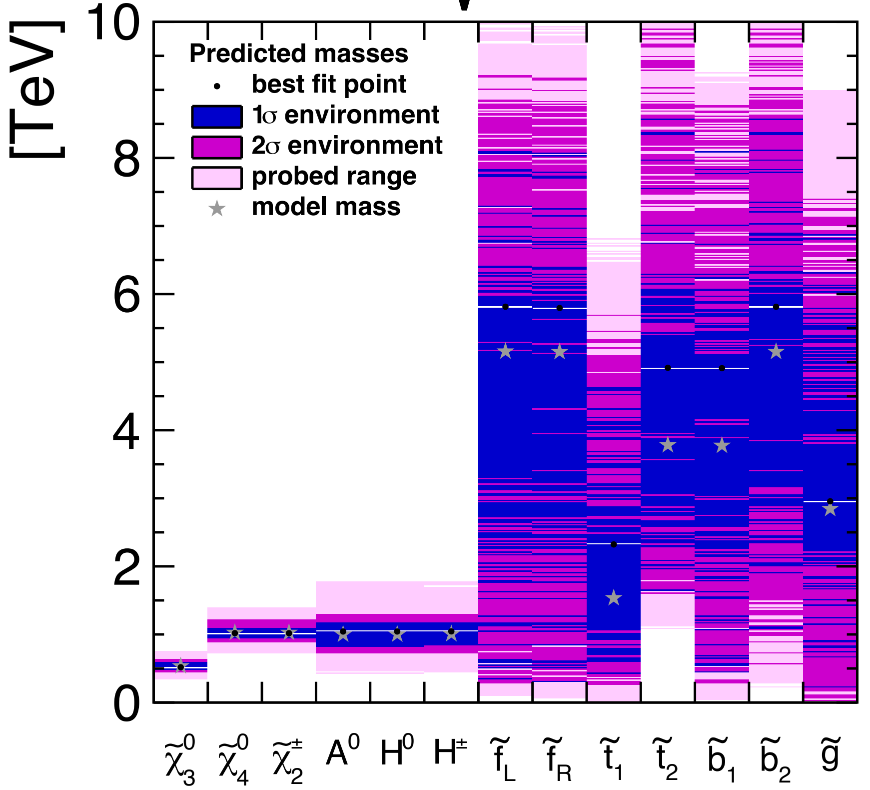


Assuming GUT relation, predict M3 at the EW scale



Or, if a gluino found at LHC, we can test Gaugino mass unification

Prediction of heavy states



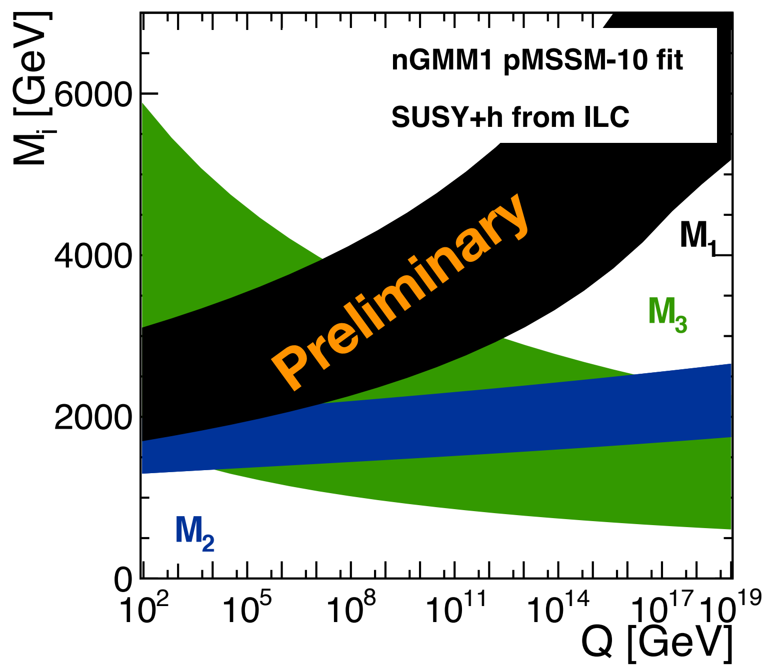
N2, N4, C2 masses to ~10%
A, H, H+/- masses to ~20%

Sets the target for ILC E-upgrade

Upper limit on stop, other sfermions and gluino

Sets the Energy for next machine?

Distinguish different SUSY breaking scenarios



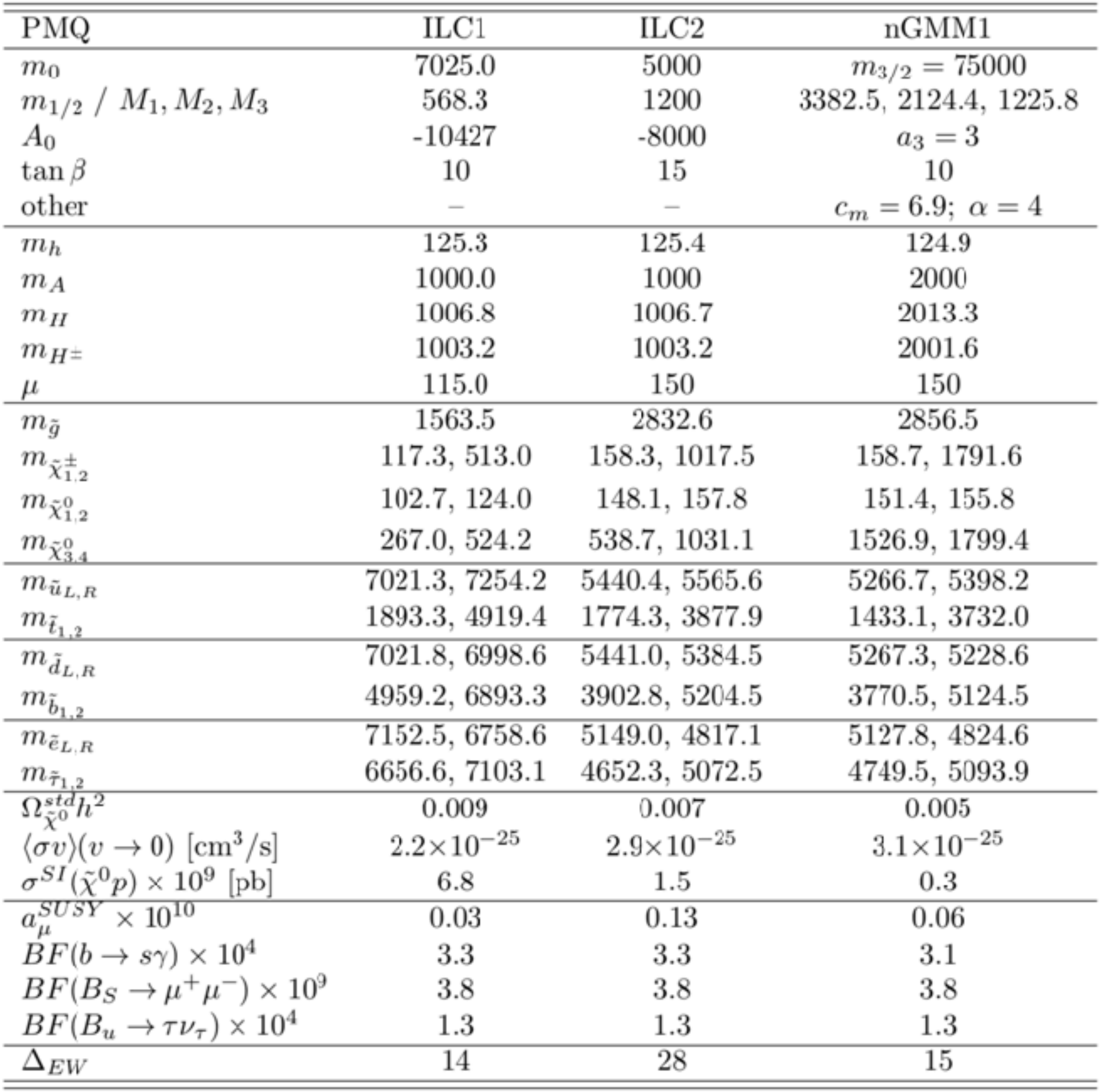
Can exclude standard GUT-scale unification

nGMM1

Summary

- ILC, too, is an energy frontier machine. It will enter uncharged waters fo e^+e^- collisions.
- With beam polarizations, 10^3 higher luminosity, and much better detectors, ILC can find new particles hiding in the LHC’s blind spot.
- Natural SUSY is viable and very well-motivated, and hence one of the most attractive scenarios of BSM physics.
- It predicts light Higgsinos which are compressed. The ILC, including its update, can probe these Higgsinos, and, if discovered, measure their masses & cross sections at percent level with the “full” dataset.
- These precise measurements allow us to predict the heavy states and to extract the underlying model parameters.
- Test of GUT-scale physics is possible, including the distinction of various scenarios such as gaugino mass unification vs. mirage/string-like unification.
- The predicted mass range of the heavy states sets the target energy for the ILC upgrade and new machines.

Backup



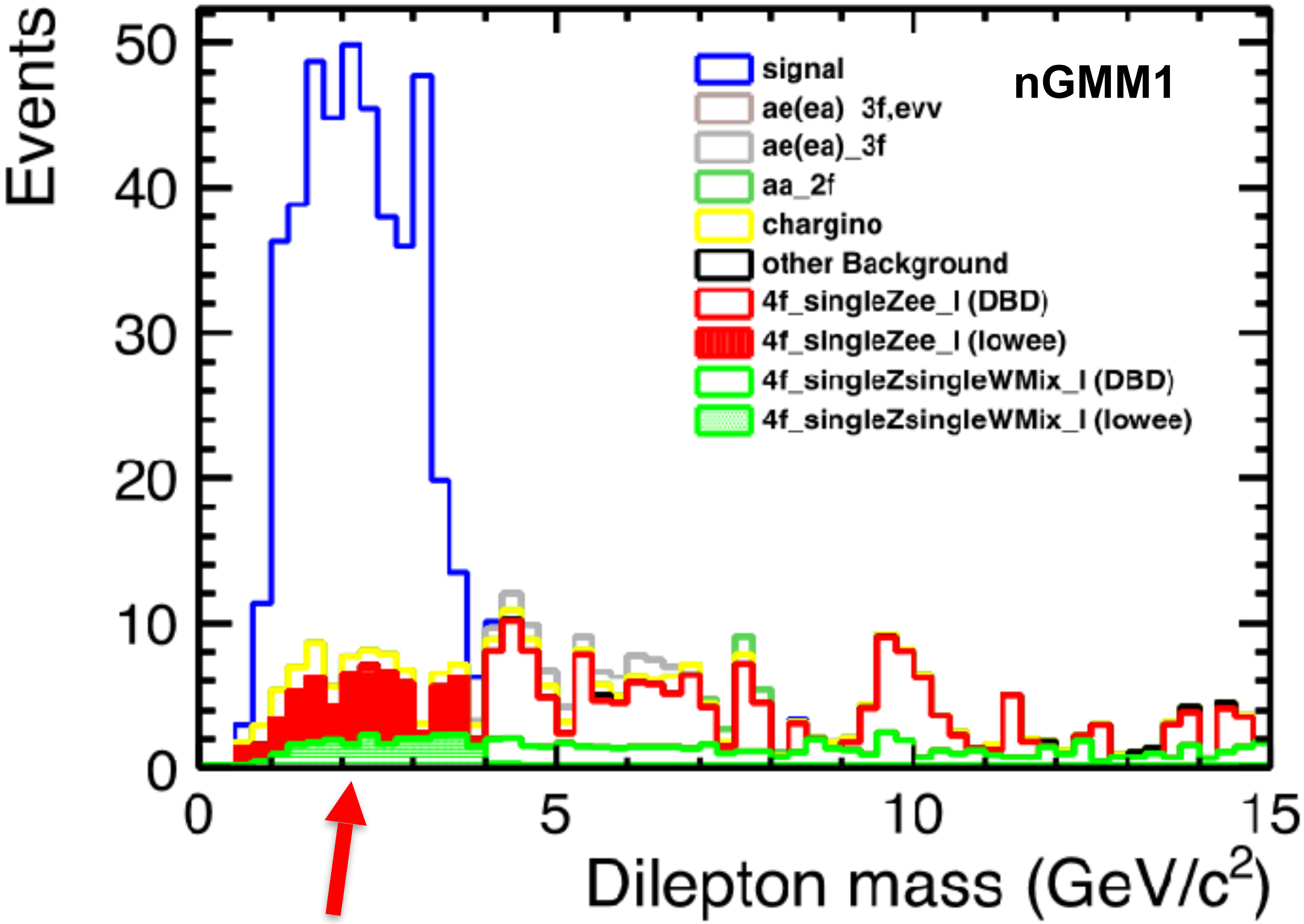
PMQ	ILC1	ILC2	nGMM1
m_0	7025.0	5000	$m_{3/2} = 75000$
$m_{1/2}$ / M_1, M_2, M_3	568.3	1200	3382.5, 2124.4, 1225.8
A_0	-10427	-8000	$a_3 = 3$
$\tan\beta$	10	15	10
other	–	–	$c_m = 6.9;\ \alpha = 4$
m_h	125.3	125.4	124.9
m_A	1000.0	1000	2000
m_H	1006.8	1006.7	2013.3
$m_{H^\pm}$	1003.2	1003.2	2001.6
μ	115.0	150	150
$m_{\tilde g}$	1563.5	2832.6	2856.5
$m_{\tilde\chi^\pm_{1,2}}$	117.3, 513.0	158.3, 1017.5	158.7, 1791.6
$m_{\tilde\chi^0_{1,2}}$	102.7, 124.0	148.1, 157.8	151.4, 155.8
$m_{\tilde\chi^0_{3,4}}$	267.0, 524.2	538.7, 1031.1	1526.9, 1799.4
$m_{\tilde u_{L,R}}$	7021.3, 7254.2	5440.4, 5565.6	5266.7, 5398.2
$m_{\tilde t_{1,2}}$	1893.3, 4919.4	1774.3, 3877.9	1433.1, 3732.0
$m_{\tilde d_{L,R}}$	7021.8, 6998.6	5441.0, 5384.5	5267.3, 5228.6
$m_{\tilde b_{1,2}}$	4959.2, 6893.3	3902.8, 5204.5	3770.5, 5124.5
$m_{\tilde e_{L,R}}$	7152.5, 6758.6	5149.0, 4817.1	5127.8, 4824.6
$m_{\tilde\tau_{1,2}}$	6656.6, 7103.1	4652.3, 5072.5	4749.5, 5093.9
$\Omega^{std}_{\tilde\chi^0}h^2$	0.009	0.007	0.005
$\langle\sigma v\rangle(v\to 0)$ [cm^3/s]	2.2×10^{-25}	2.9×10^{-25}	3.1×10^{-25}
$\sigma^{SI}(\tilde\chi^0 p)\times 10^9$ [pb]	6.8	1.5	0.3
$a_\mu^{SUSY}\times 10^{10}$	0.03	0.13	0.06
$BF(b\to s\gamma)\times 10^4$	3.3	3.3	3.1
$BF(B_S\to\mu^+\mu^-)\times 10^9$	3.8	3.8	3.8
$BF(B_u\to\tau\nu_\tau)\times 10^4$	1.3	1.3	1.3
Δ_{EW}	14	28	15

Table 1: Input parameters and mass spectrum and rates for benchmark points ILC1, ILC2 and nGMM1. All masses and dimensionful parameters are in GeV units. All values have been obtained with Isasugra. The nGMM1 benchmark has parameters $\alpha = 4$ and $m_{3/2} = 75$ TeV with $c_m = 6.9$ and $a_3 = 3$.

Missing Phase Space

Previously missing phase space in 4-fermion backgrounds (due to generator-level cut) is now supplemented by including additional samples (full/fast)

[Thanks to H. Ono, A. Miyamoto, M. Berggren]



Event Selection (N1N2)

1. Pair of isolated leptons (e or μ) **[preselelection]**
2. Visible Energy in the event < 25 GeV
3. Missing Energy in the event 300 GeV
4. Missing |cosθ| <0.98
5. No BeamCal hits
6. # of tracks with pT>2 GeV = 2
7. Lepton pT > 2.3 GeV, |cosθ|<0.95
8. di-lepton coplanarity < 0.8
9. di-lepton |cosθ|<0.98
10. **di-lepton mass cuts for di-lepton energy measurement (process-dependent)**

Consistent across all benchmarks (ILC1/ILC2/nGMM1) **[except #10]**, final states (e/mu), and beam polarizations.

Event Selection (C1C1)

1. One isolated lepton (e or μ) **[preselelection]**
2. No BeamCal hits
3. **Lepton pT > 5 GeV (suppress two-photon background)**
4. **# of tracks in event >= 4 (suppress ae_3f background)**
5. Missing Energy > 400 GeV
6. Missing |cosθ| <0.99
7. Visible Energy < 80 GeV
8. Each jet|cosθ|<0.98
9. di-jet coplanarity < 1.0
10. Angle between lepton and dijet system |cosθ|< 0.2

Consistent across all benchmarks (ILC1/ILC2/nGMM1), final states (e/mu), and beam polarizations.

The event selection is much tighter compared to previous results. This is to ensure the removal of the 2-photon and ae_3f backgrounds.

SUSY Parameter Fit: Details

Chi-square (χ^2) from experimental observables and theory predictions

→Uncertainty taken from experimental observables

Find SUSY parameters that minimize χ^2

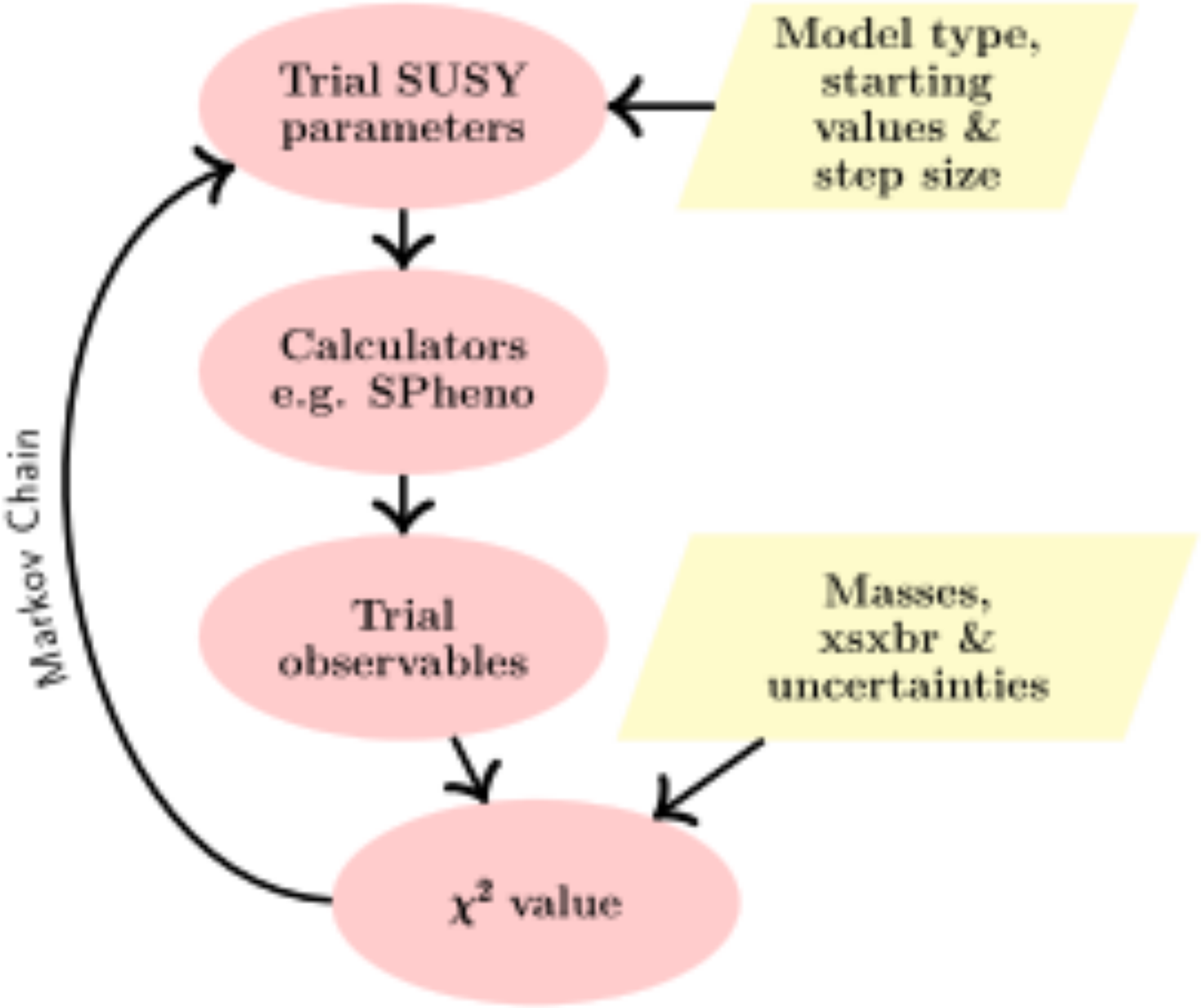
The range of values $\Delta\chi^2 = [0,1]$ gives the uncertainty

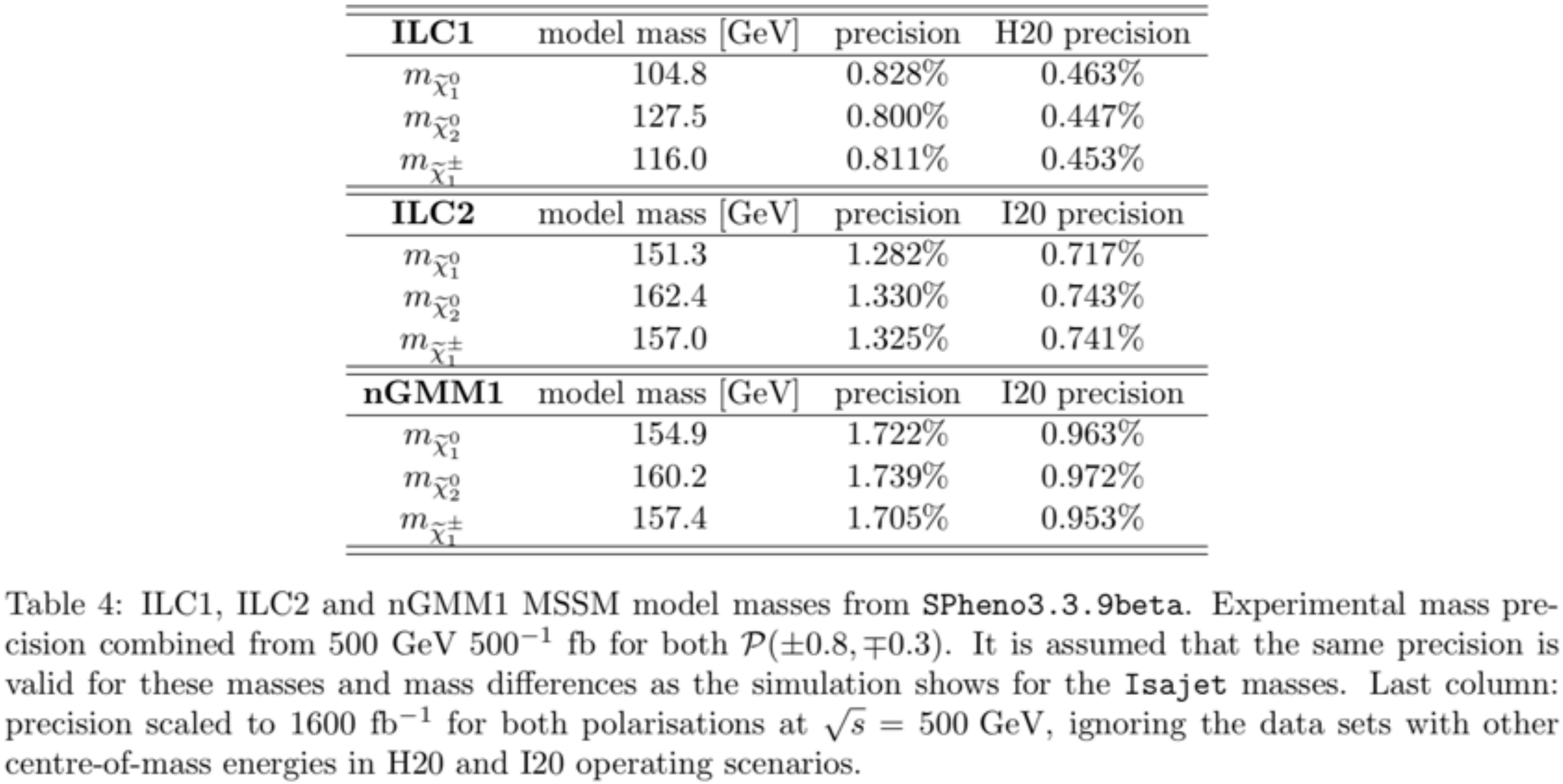
Fittino minimises

$$\chi^2 = \left(\frac{\mathcal{O}(ILC)-\mathcal{O}(theory)}{\Delta\mathcal{O}(ILC)}\right)^2$$

(arXiv:hep-ph/0412012)

SPheno 3.3.9beta,
FeynHiggs2.10.2 for Higgs,
MicrOMEGAs and
AstroFit for DM





ILC1	model mass [GeV]	precision	H20 precision
$m_{\tilde{\chi}_1^0}$	104.8	0.828%	0.463%
$m_{\tilde{\chi}_2^0}$	127.5	0.800%	0.447%
$m_{\tilde{\chi}_1^\pm}$	116.0	0.811%	0.453%

ILC2	model mass [GeV]	precision	I20 precision
$m_{\tilde{\chi}_1^0}$	151.3	1.282%	0.717%
$m_{\tilde{\chi}_2^0}$	162.4	1.330%	0.743%
$m_{\tilde{\chi}_1^\pm}$	157.0	1.325%	0.741%

nGMM1	model mass [GeV]	precision	I20 precision
$m_{\tilde{\chi}_1^0}$	154.9	1.722%	0.963%
$m_{\tilde{\chi}_2^0}$	160.2	1.739%	0.972%
$m_{\tilde{\chi}_1^\pm}$	157.4	1.705%	0.953%

Table 4: ILC1, ILC2 and nGMM1 MSSM model masses from `SPheno3.3.9beta`. Experimental mass precision combined from 500 GeV 500^{-1} fb for both $\mathcal{P}(\pm 0.8, \mp 0.3)$. It is assumed that the same precision is valid for these masses and mass differences as the simulation shows for the `Isajet` masses. Last column: precision scaled to 1600 fb^{-1} for both polarisations at $\sqrt{s} = 500$ GeV, ignoring the data sets with other centre-of-mass energies in H20 and I20 operating scenarios.

ILC1 $\Delta(\sigma \times BR)[\%]$	$\sqrt{s} = 500$ GeV $\mathcal{L} = 500$ fb^{-1}	$\sqrt{s} = 500$ GeV $\mathcal{L} = 1600$ fb^{-1}	$\sqrt{s} = 250$ GeV $\mathcal{L} = 1350$ fb^{-1}	$\sqrt{s} = 350$ GeV $\mathcal{L} = 135$ fb^{-1}
$LR\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 ee)$	3.80	2.12	1.65	5.36
$LR\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \mu\mu)$	3.42	1.91	1.48	4.82
$LR\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qqe\nu_e)$	2.59	1.45	1.20	3.74
$LR\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qq\mu\nu_\mu)$	2.27	1.27	1.05	3.28
$\Delta(\sigma \times BR)[\%]$	$\mathcal{L} = 500$ fb^{-1}	$\mathcal{L} = 1600$ fb^{-1}	$\mathcal{L} = 450$ fb^{-1}	$\mathcal{L} = 45$ fb^{-1}
$RL\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 ee)$	3.38	1.89	2.56	8.29
$RL\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \mu\mu)$	3.33	1.86	2.52	8.17
$RL\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qqe\nu_e)$	4.94	2.76	4.28	12.70
$RL\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qq\mu\nu_\mu)$	4.30	2.40	3.73	11.05

Table 5: ILC1: Simulation results for experimental precisions. Scaled precisions for the various centre of mass energies and the two polarisations. LR refers to the beam polarisation $\mathcal{P} = (-80\%, +30\%)$ and RL refers to $\mathcal{P} = (+80\%, -30\%)$.

ILC2 $\Delta(\sigma \times BR)[\%]$	$\sqrt{s} = 500$ GeV $\mathcal{L} = 500$ fb^{-1}	$\sqrt{s} = 500$ GeV $\mathcal{L} = 1600$ fb^{-1}	$\sqrt{s} = 250$ GeV $\mathcal{L} = 337.5$ fb^{-1}	$\sqrt{s} = 350$ GeV $\mathcal{L} = 1147.5$fb^{-1}
$LR\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 ee)$	5.52	3.09	–	3.30
$LR\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \mu\mu)$	5.04	2.82	–	3.01
$LR\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qqe\nu_e)$	5.17	2.89	–	3.17
$LR\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qq\mu\nu_\mu)$	4.39	2.45	–	2.70
$\Delta(\sigma \times BR)[\%]$	$\mathcal{L} = 500$ fb^{-1}	$\mathcal{L} = 1600$ fb^{-1}	$\mathcal{L} = 112.5$ fb^{-1}	$\mathcal{L} = 382.5$ fb^{-1}
$RL\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 ee)$	6.54	3.66	–	3.93
$RL\ \sigma(\tilde{\chi}_2^0\tilde{\chi}_1^0 \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \mu\mu)$	6.50	3.63	–	3.91
$RL\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qqe\nu_e)$	10.30	5.76	–	6.49
$RL\ \sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 qq\mu\nu_\mu)$	8.84	4.94	–	5.57

Table 6: ILC2: Simulation results for experimental precisions. Scaled precisions for the various centre of mass energies and the two polarisations. LR refers to the beam polarisation $\mathcal{P} = (-80\%, +30\%)$ and RL refers to $\mathcal{P} = (+80\%, -30\%)$.

nGMM1 $\Delta(\sigma \times BR)[\%]$	$\sqrt{s} = 500$ GeV $\mathcal{L} = 500$ fb^{-1}	$\sqrt{s} = 500$ GeV $\mathcal{L} = 1600$ fb^{-1}	$\sqrt{s} = 250$ GeV $\mathcal{L} = 337.5$ fb^{-1}	$\sqrt{s} = 350$ GeV $\mathcal{L} = 1147.5$ fb^{-1}
$LR\ \sigma(\tilde{\chi}^0_2\tilde{\chi}^0_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 ee)$	6.81	3.81	–	4.11
$LR\ \sigma(\tilde{\chi}^0_2\tilde{\chi}^0_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 \mu\mu)$	6.21	3.47	–	3.74
$LR\ \sigma(\tilde{\chi}^+_1\tilde{\chi}^-_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 qqe\nu_e)$	6.20	3.47	–	3.83
$LR\ \sigma(\tilde{\chi}^+_1\tilde{\chi}^-_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 qq\mu\nu_\mu)$	4.99	2.79	–	3.08
$\Delta(\sigma \times BR)[\%]$	$\mathcal{L} = 500$ fb^{-1}	$\mathcal{L} = 1600$ fb^{-1}	$\mathcal{L} = 112.5$ fb^{-1}	$\mathcal{L} = 382.5$ fb^{-1}
$RL\ \sigma(\tilde{\chi}^0_2\tilde{\chi}^0_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 ee)$	5.88	3.29	–	3.56
$RL\ \sigma(\tilde{\chi}^0_2\tilde{\chi}^0_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 \mu\mu)$	5.55	3.10	–	3.36
$RL\ \sigma(\tilde{\chi}^+_1\tilde{\chi}^-_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 qqe\nu_e)$	11.70	6.54	–	7.41
$RL\ \sigma(\tilde{\chi}^+_1\tilde{\chi}^-_1 \to \tilde{\chi}^0_1\tilde{\chi}^0_1 qq\mu\nu_\mu)$	9.90	5.53	–	6.27

Table 7: nGMM1: Simulation results on experimental precisions. Scaled precisions for the various centre of mass energies and the two polarisations. LR refers to the beam polarisation $\mathcal{P} = (-80\%, +30\%)$ and RL refers to $\mathcal{P} = (+80\%, -30\%)$.

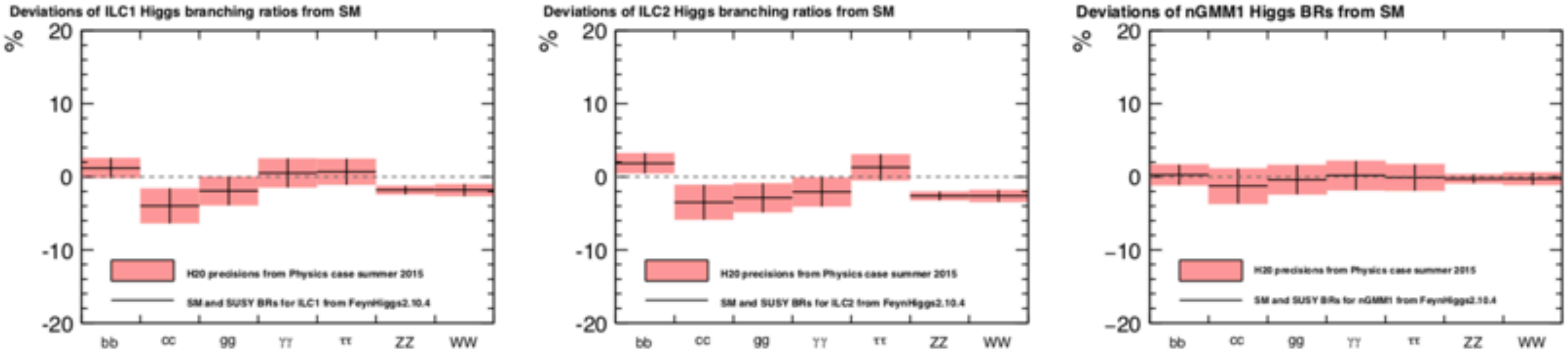
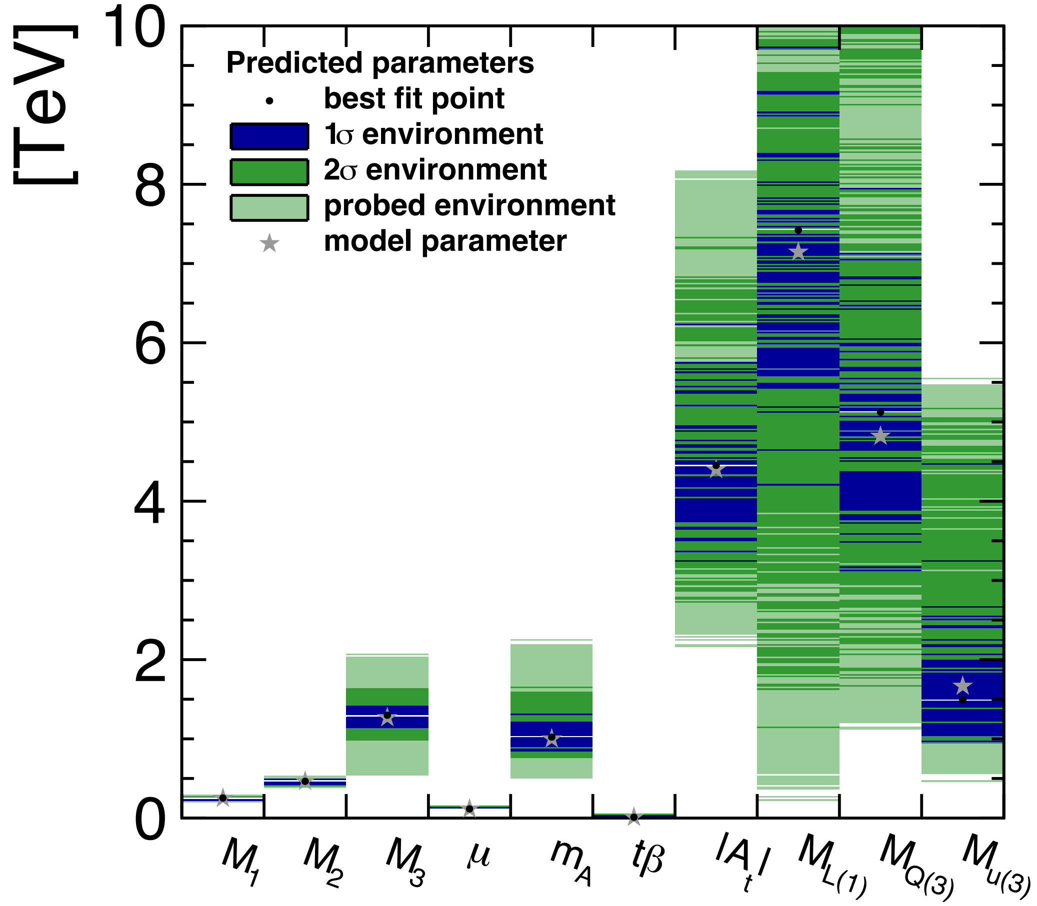
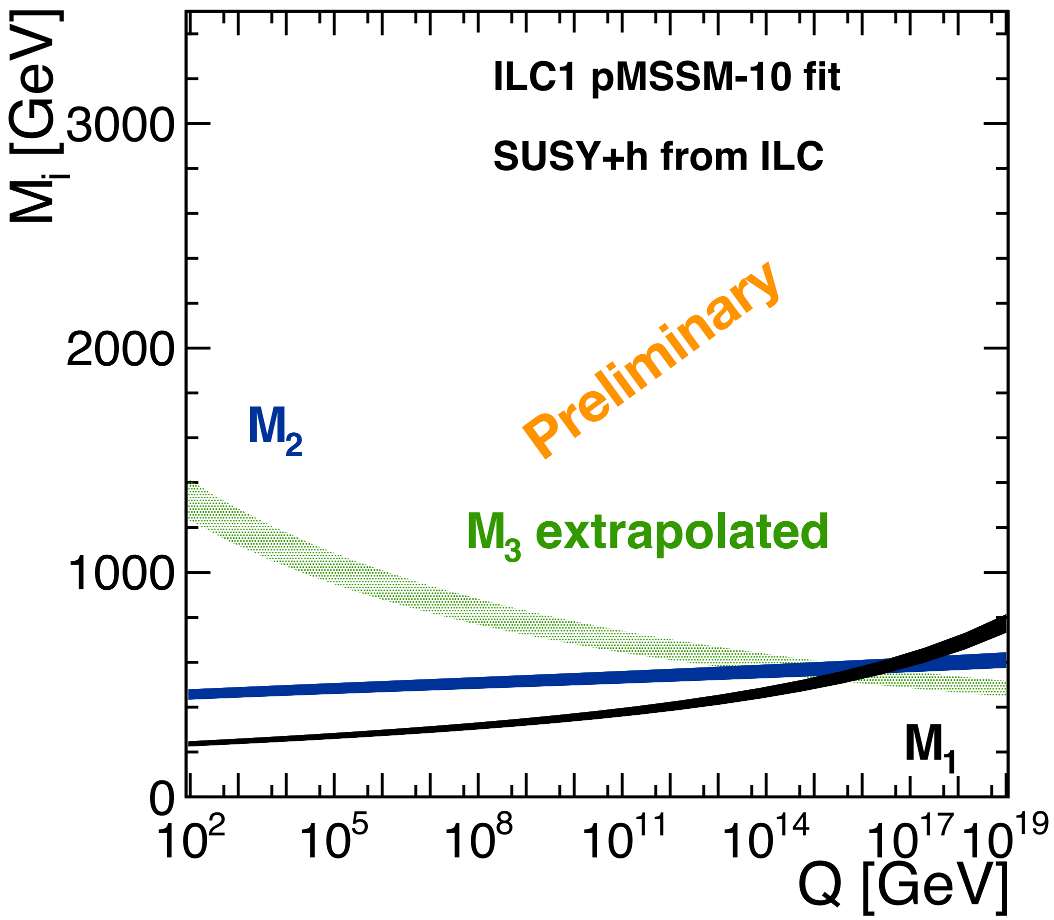
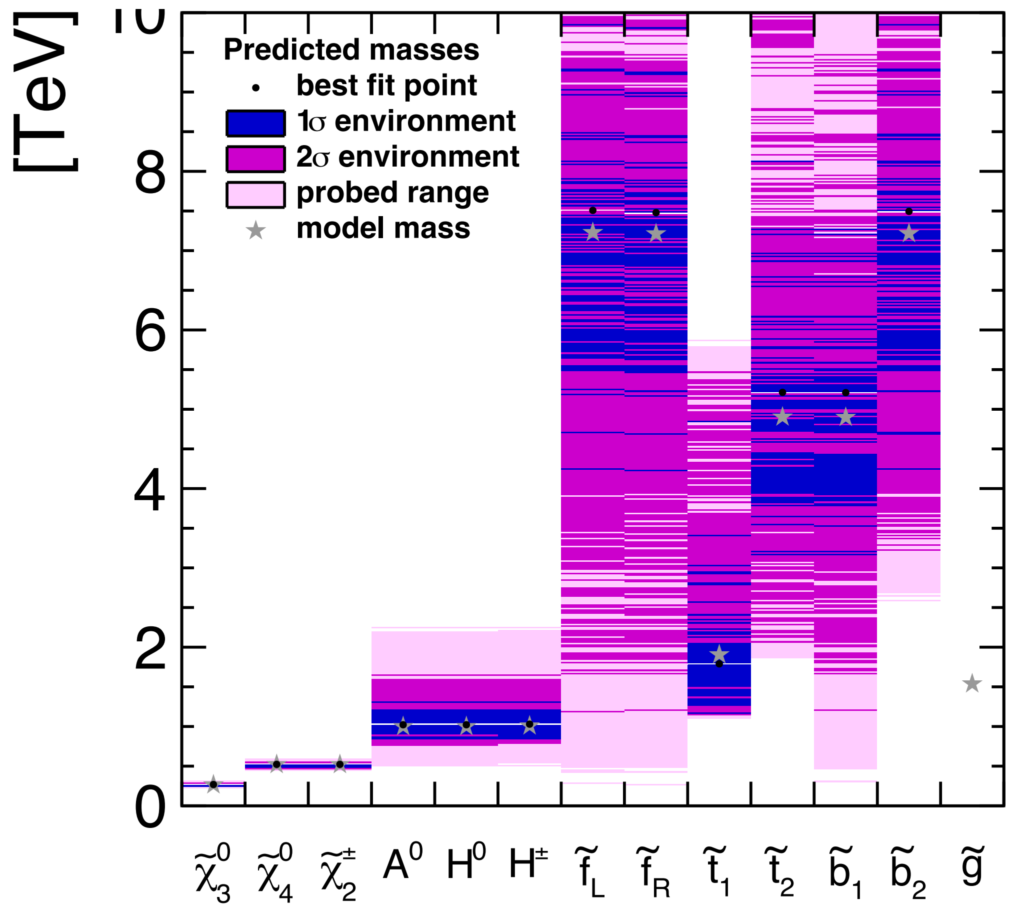


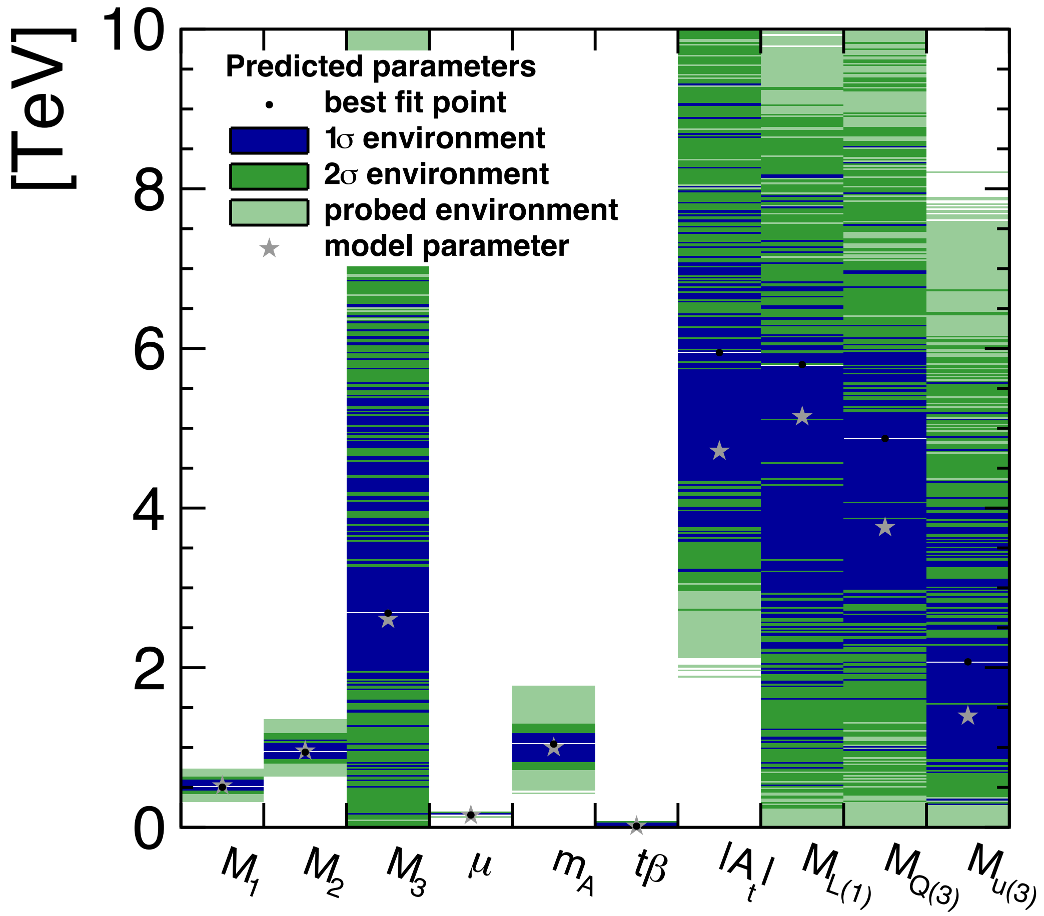
Figure 6: Deviations of the branching fractions of the SUSY light Higgs from the Standard Model expectations in ILC1, ILC2 and nGMM1.

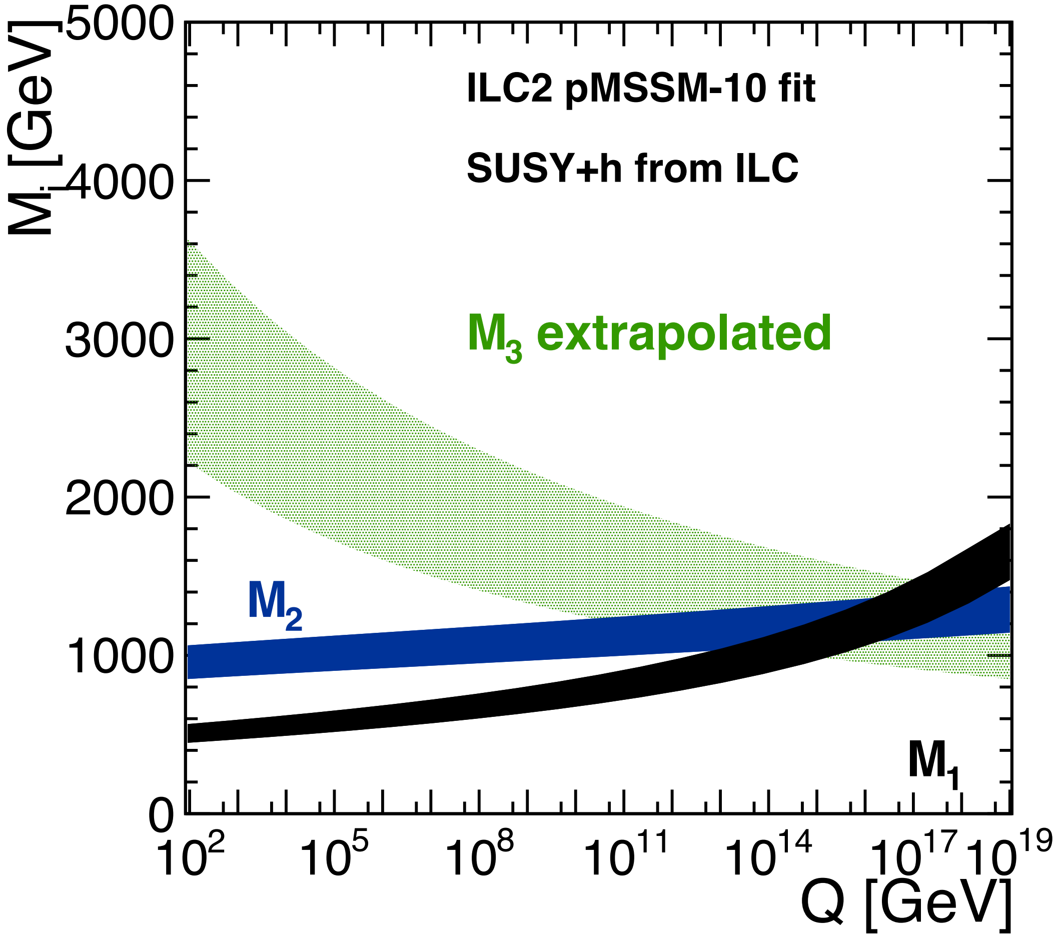


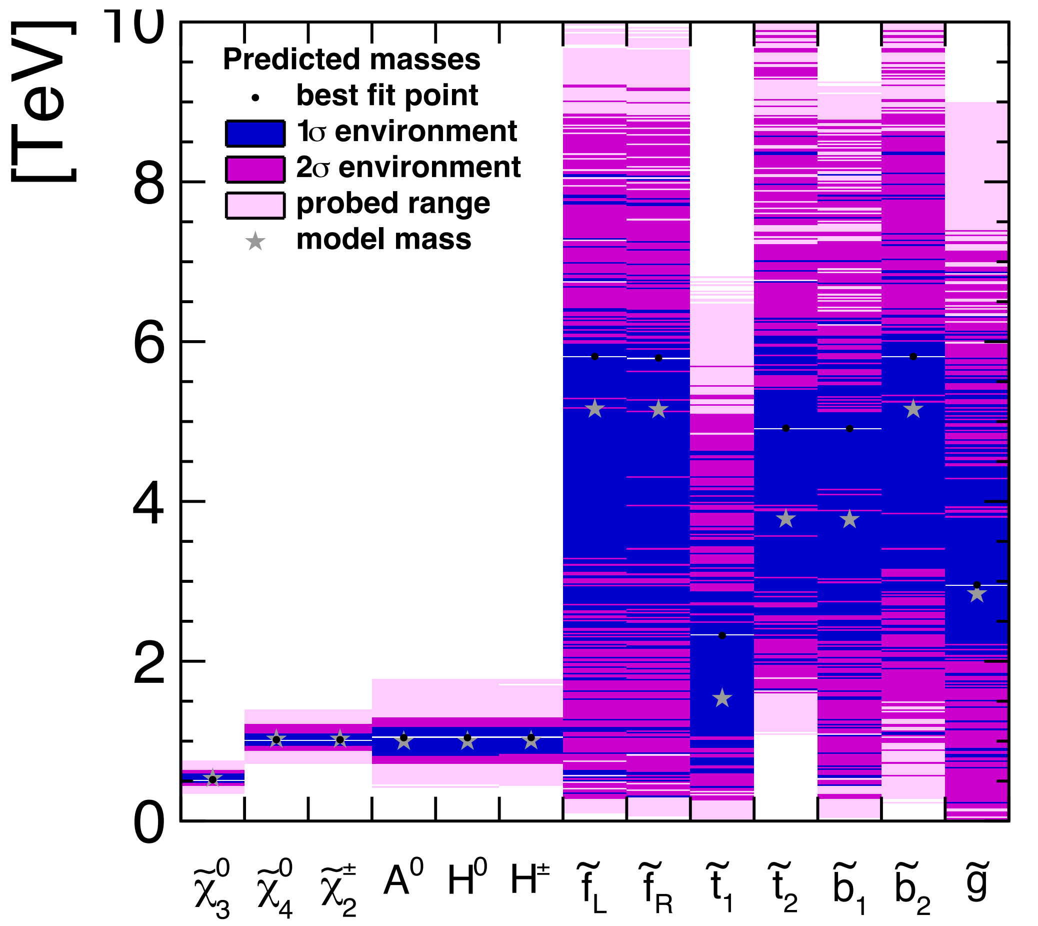




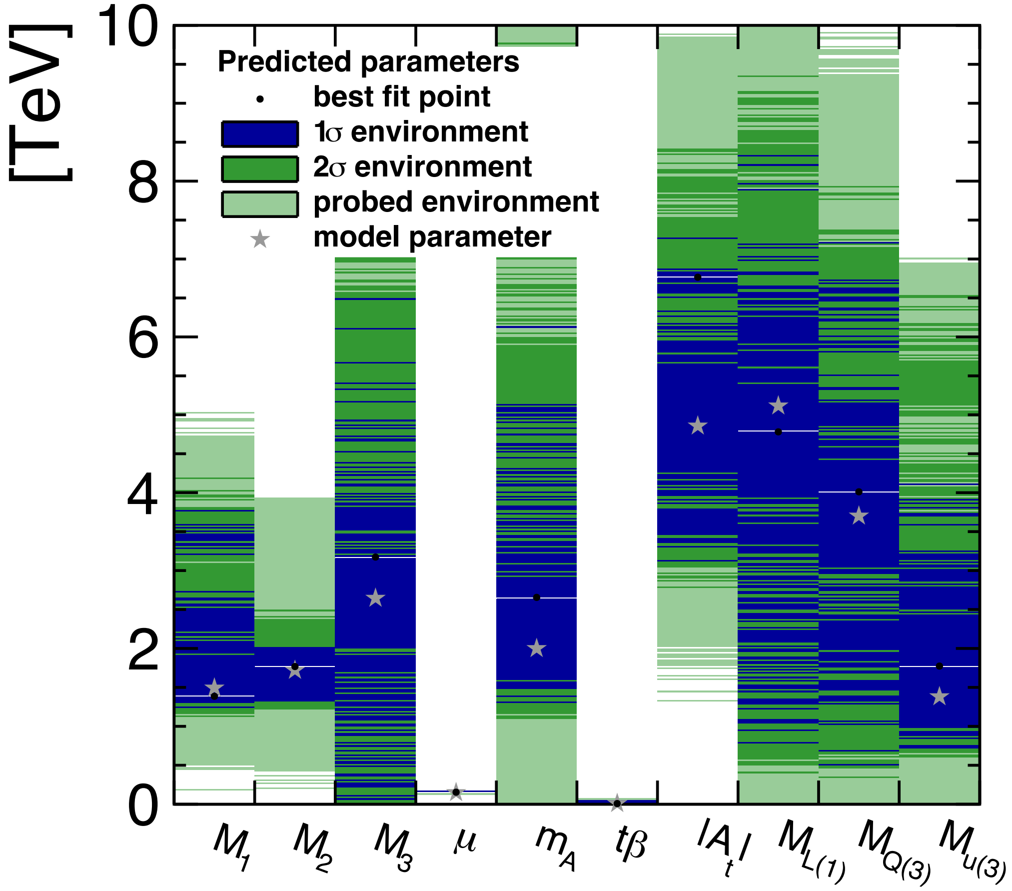
Example: ILC1: *10-parameter* Fit (H20)

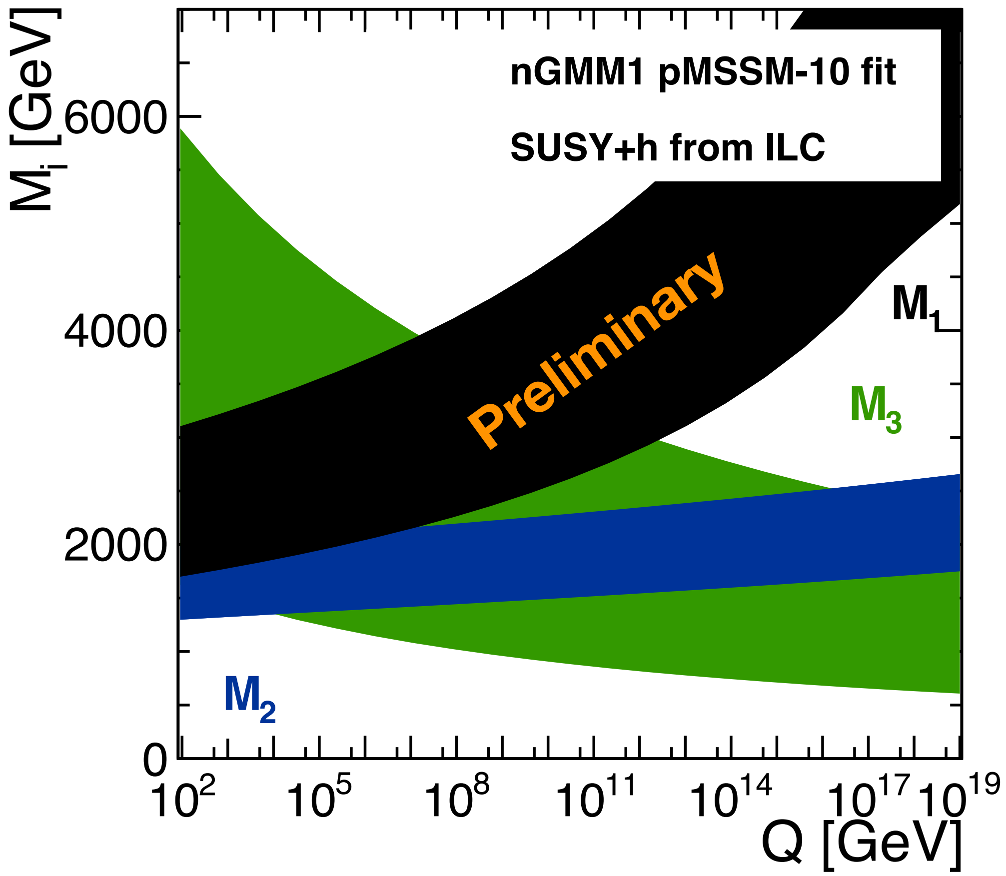


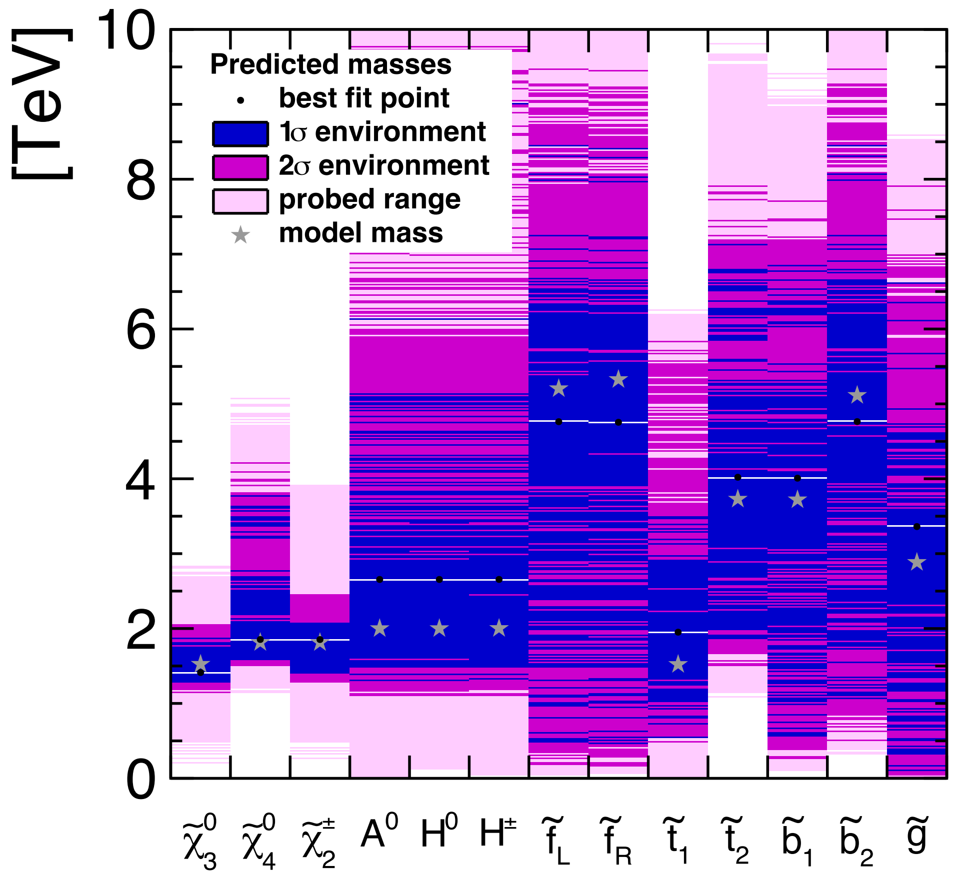




Example: ILC2:
***10-parameter* Fit (H20)**







Example: nGMM1:
***10-parameter* Fit (H20)**