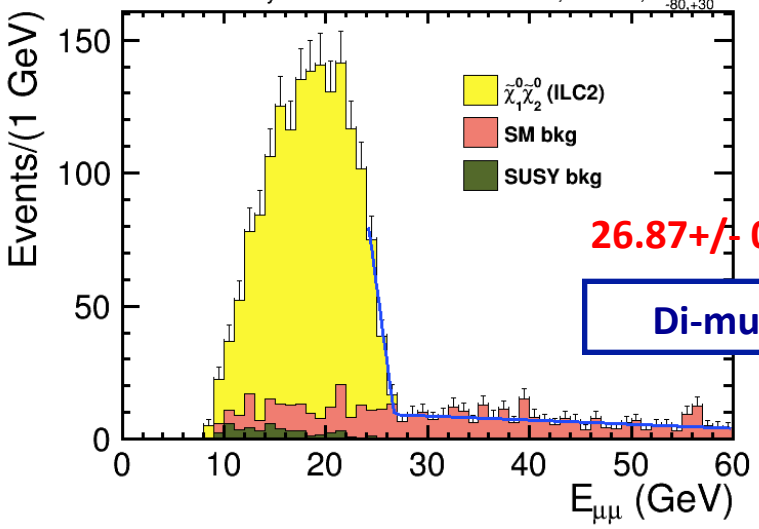
Neutralino mixed production with leptonic decay

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

ILC2, μμ

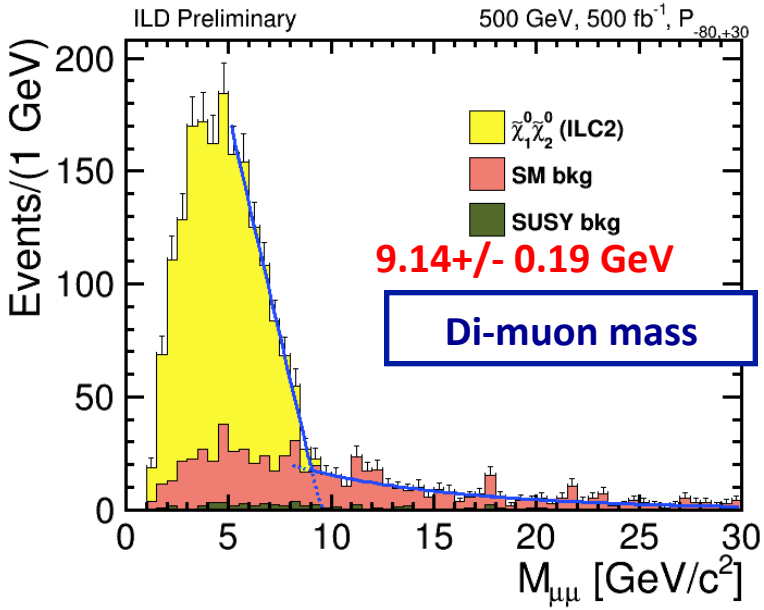
Edge precisions assuming 500 fb^{-1}
0.5-1 %, for Eμμ , 2-2.5% for Mμμ

(Pe-,Pe+) = (-0.8, +0.3)



26.87+/- 0.17 GeV

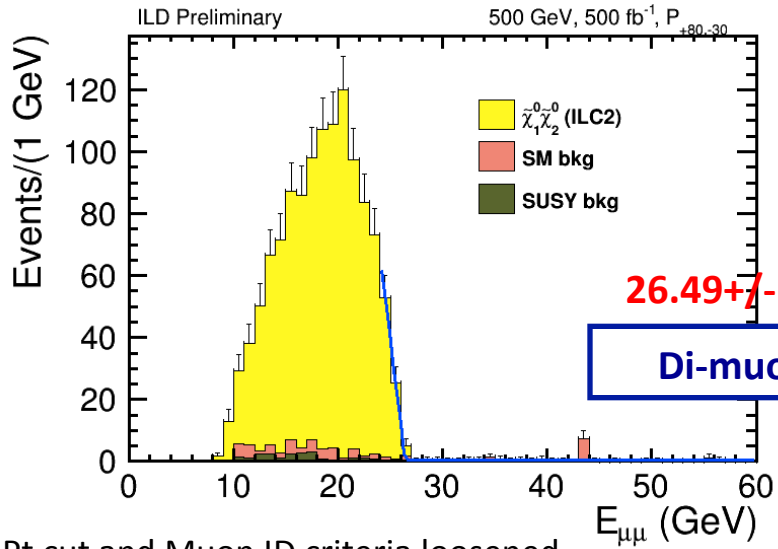
Di-muon energy



9.14+/- 0.19 GeV

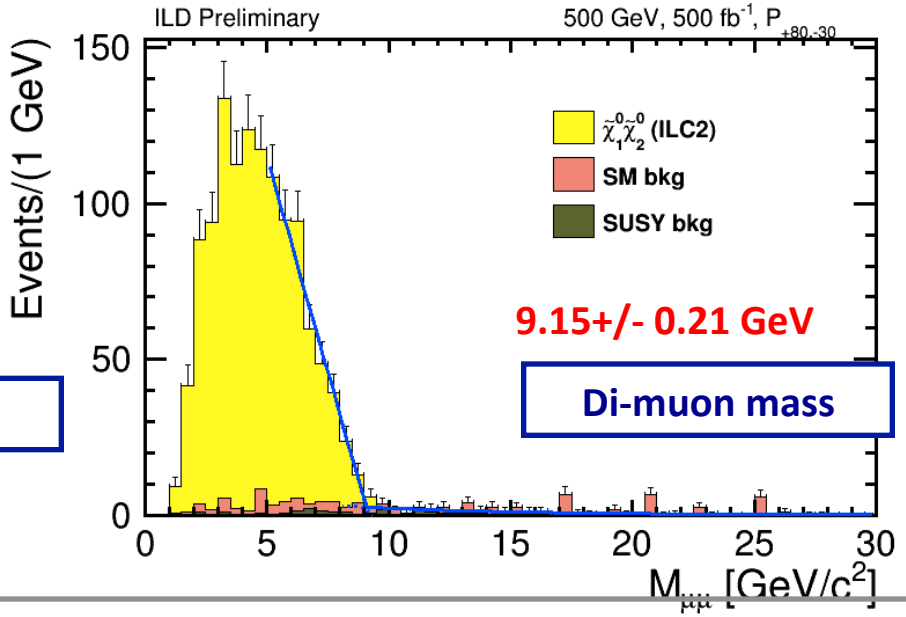
Di-muon mass

(Pe-,Pe+) = (+0.8, -0.3)



26.49+/- 0.22 GeV

Di-muon energy



9.15+/- 0.21 GeV

Di-muon mass

Pt cut and Muon ID criteria loosened
Other selection same as ILC1

Theoretical values: E_max = 26.85 GeV ΔM = 9.7 GeV

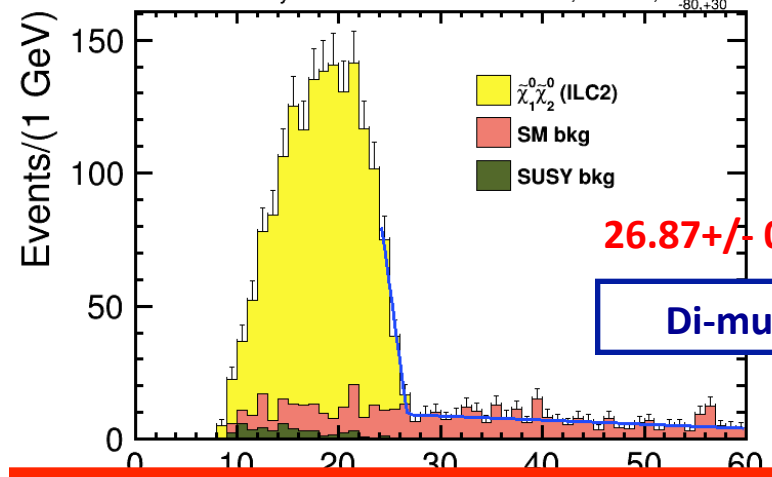
Neutralino mixed production with leptonic decay

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

ILC2, μμ

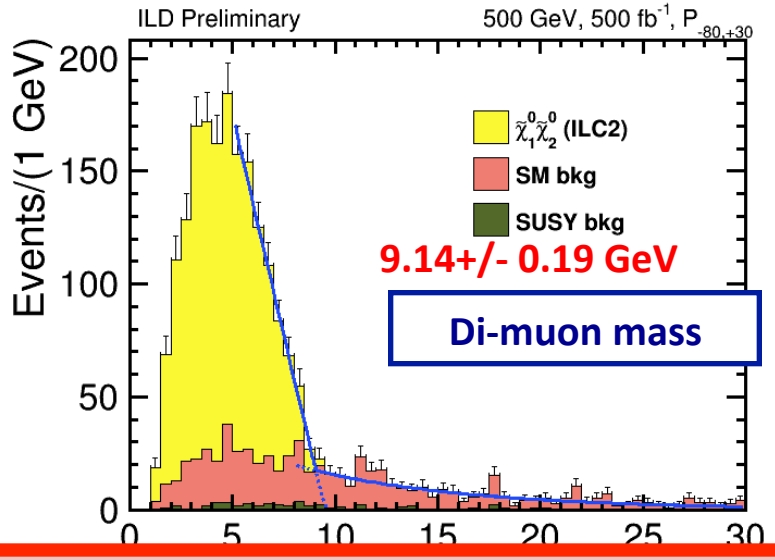
Edge precisions assuming 500 fb^{-1}
0.5-1 %, for Eμμ , 2-2.5% for Mμμ

(Pe-,Pe+) = (-0.8, +0.3)



26.87+/- 0.17 GeV

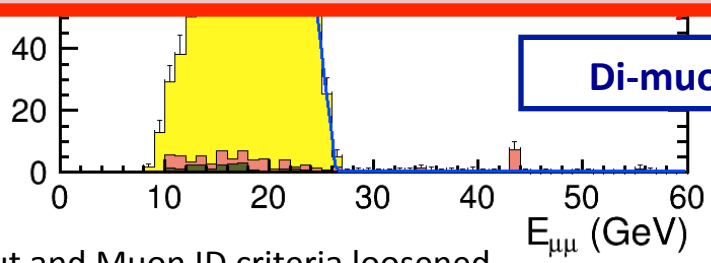
Di-muon energy



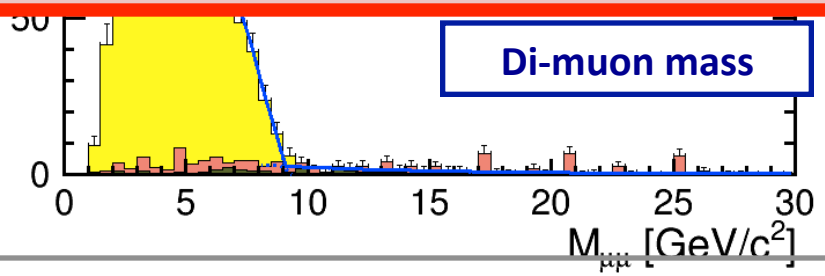
9.14+/- 0.19 GeV

Di-muon mass

- After loosened μ selection criteria (ratio of E_calorimeter over P_tot), μ statistics increased ➔ now precision of E_μ μ is slightly better for ILC2 (may also benefit from steeper slope of signal distribution)
- Plan to optimize μ selection for ILC1 as well, after LCWS2016



Di-muon energy



Di-muon mass

Pt cut and Muon ID criteria loosened
Other selection same as ILC1

Theoretical values: E_max = 26.85 GeV ΔM = 9.7 GeV

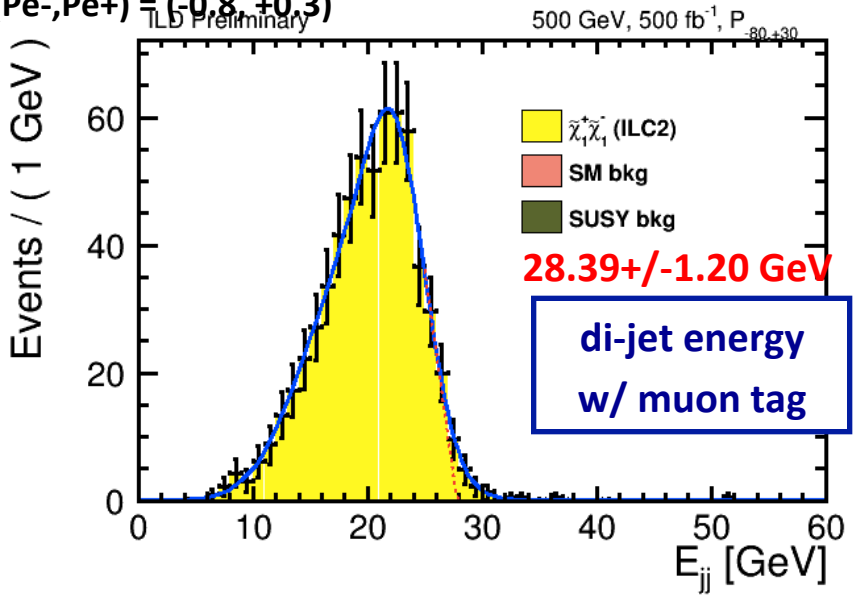
Chargino pair production with semileptonic decay

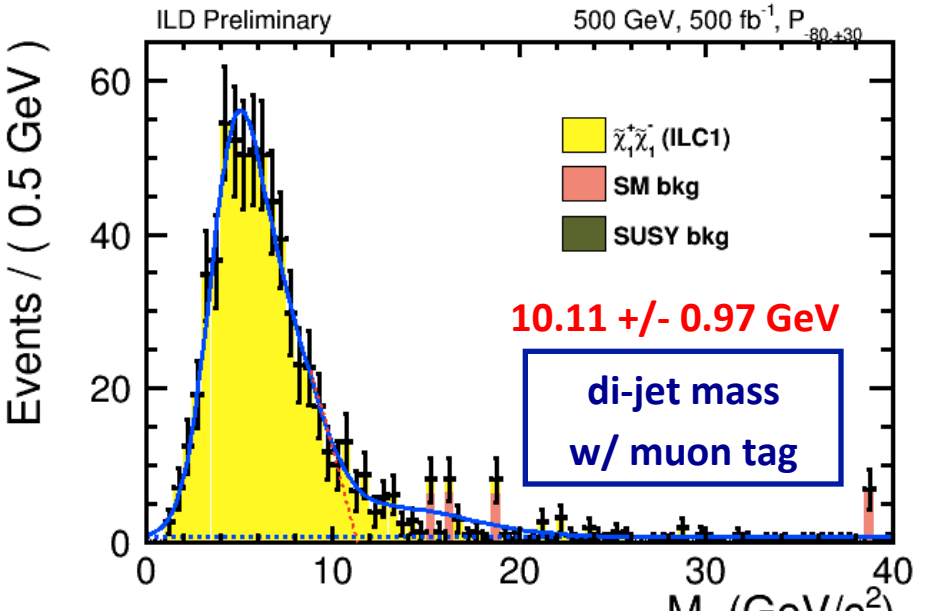
$$e^+e^- \to \tilde{\chi}_1^+ \tilde{\chi}_1^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 qq'\ell\nu$$

ILC2 μ-tag

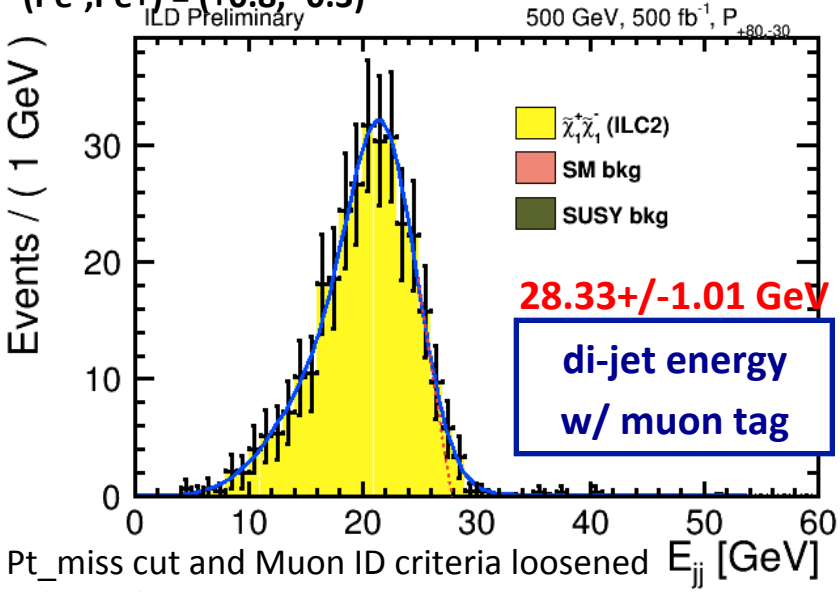
Edge precisions assuming 500 fb^{-1}
~4%, for Ejj , 7-9% for Mjj

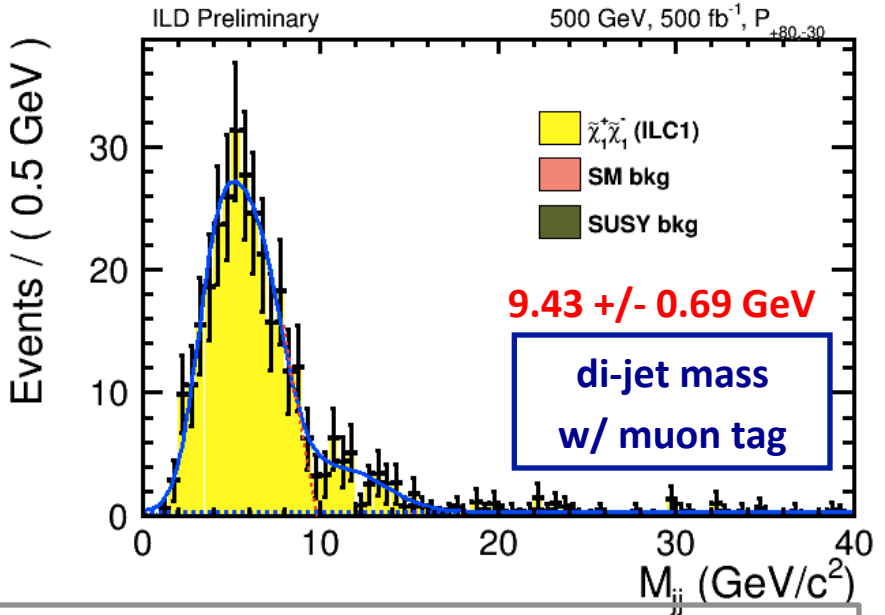
(Pe-,Pe+) = (-0.8, +0.3)





(Pe-,Pe+) = (+0.8, -0.3)





Pt_miss cut and Muon ID criteria loosened
Other selection same as ILC1

Theoretical values: E_max = 27.66 GeV , ΔM = 9.87 GeV

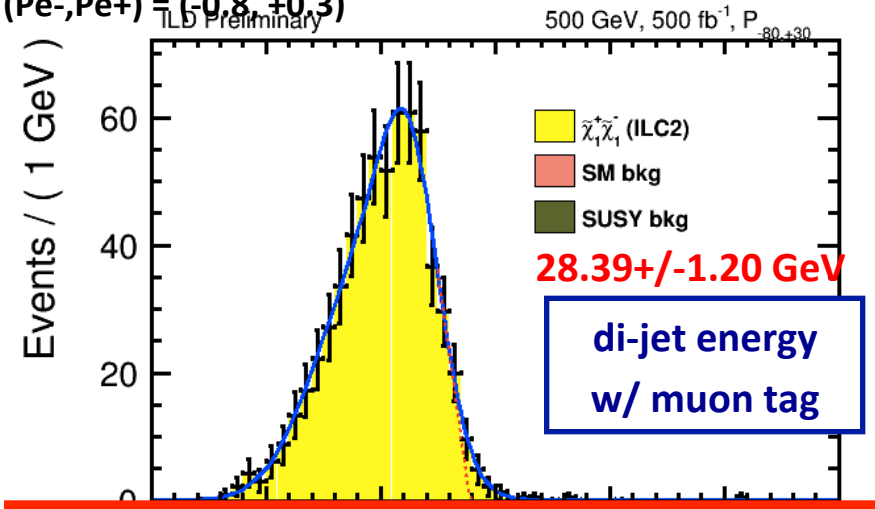
Chargino pair production with semileptonic decay

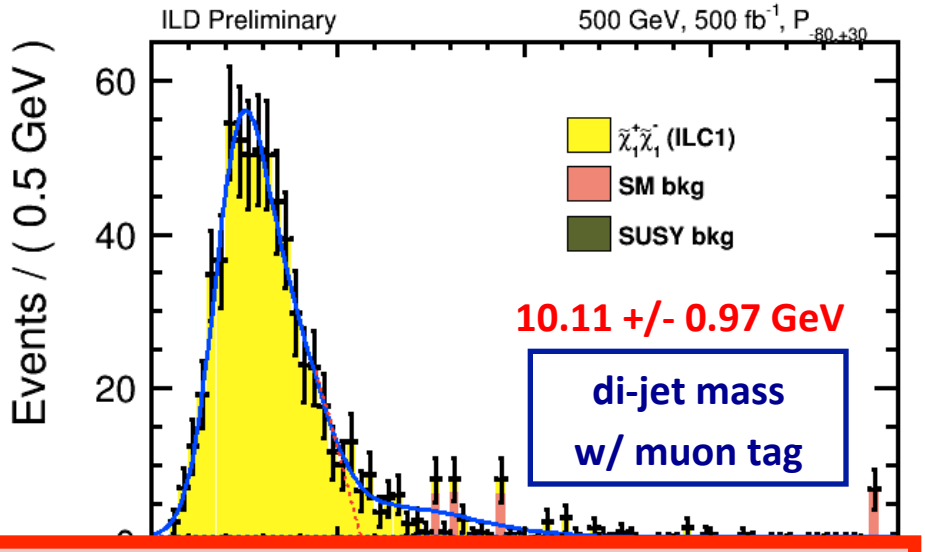
$$e^+e^- \to \tilde{\chi}_1^+ \tilde{\chi}_1^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 qq'\ell\nu$$

ILC2 μ-tag

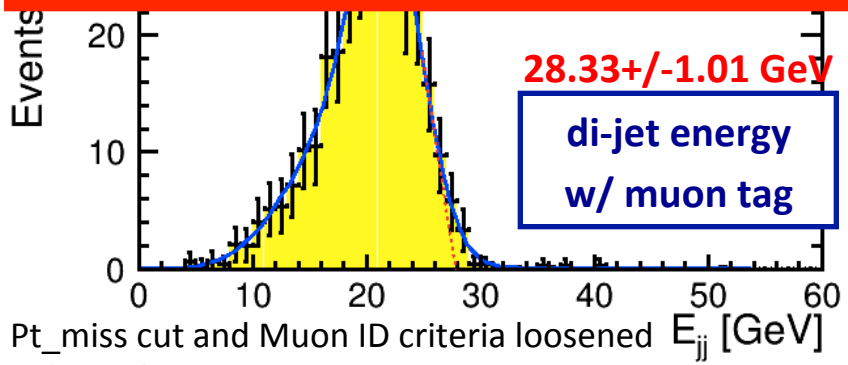
Edge precisions assuming 500 fb^{-1}
～4%, for Ejj , 7-9% for Mjj

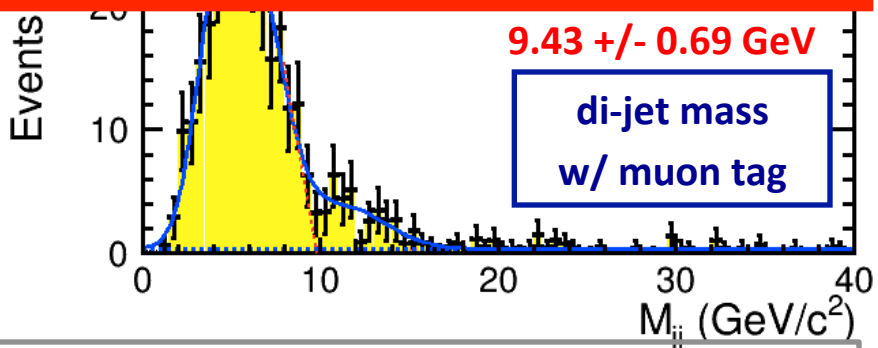
(Pe-,Pe+) = (-0.8, +0.3)





Will think of how to improve statistics for the measurement of these soft particles (in terms of lepton selection method, loosening of cuts, etc…)





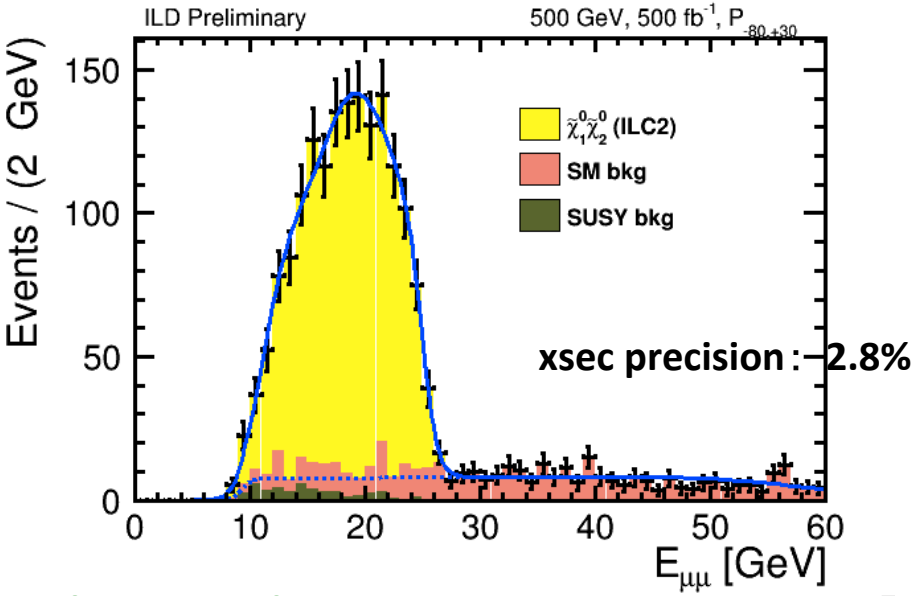
Pt_miss cut and Muon ID criteria loosened
Other selection same as ILC1

Theoretical values: E_max = 27.66 GeV , ΔM = 9.87 GeV

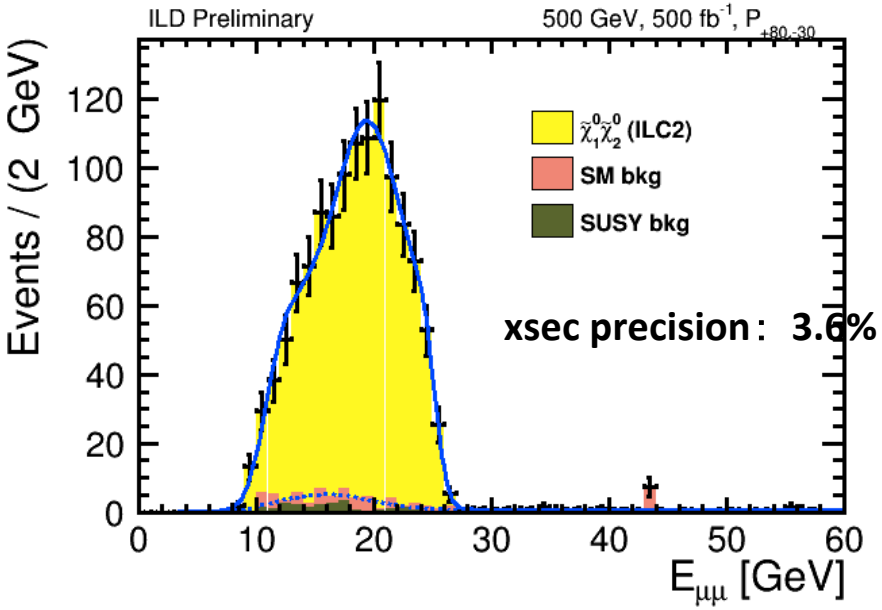
Cross section fits for ILC2

Neutralino: di-muon energy

(Pe-,Pe+) = (-0.8, +0.3)

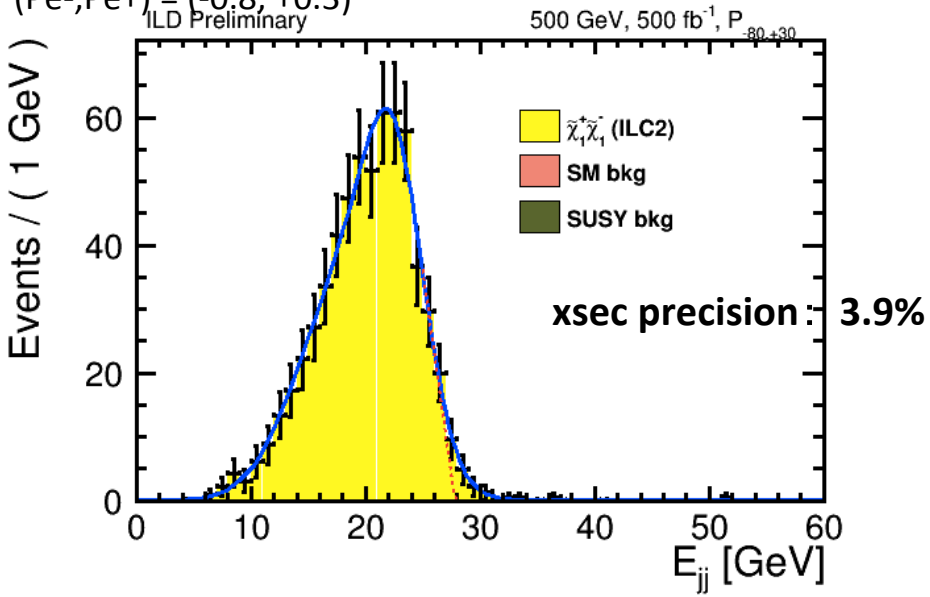


(Pe-,Pe+) = (+0.8, -0.3)

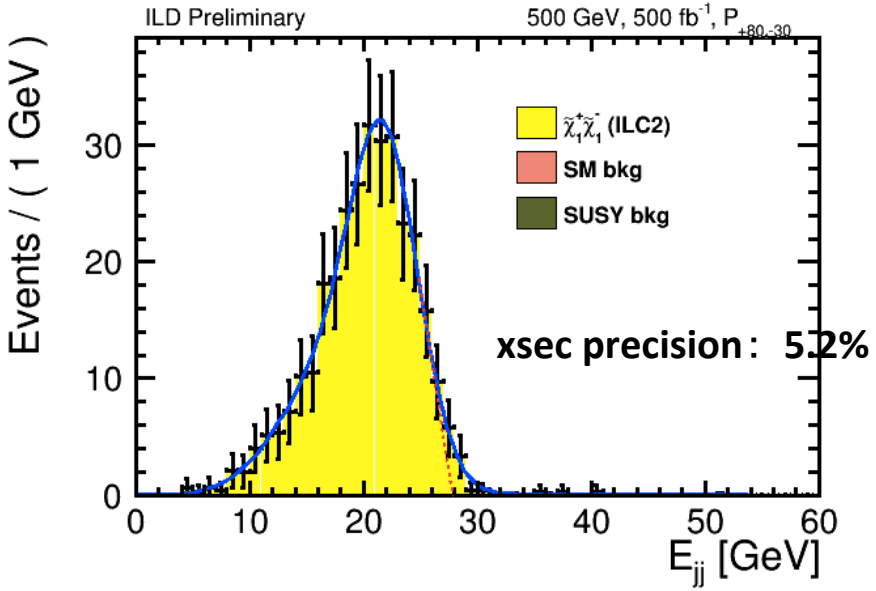


Chargino: di-jet energy

(Pe-,Pe+) = (-0.8, +0.3)



(Pe-,Pe+) = (+0.8, -0.3)



Cross section results

ILC1

channel	Δσ/σ	Δσ/σ
$\chi 01\ \chi 02$	500 fb−1	H20 (1600 fb−1
$\mu\ \mu$, left	3.5%	2.0%
ee, left	3.2%	1.8%
combined	2.3%	1.3%
$\mu\ \mu$, right	2.8%	1.6%
ee, right	2.4%	1.3%
combined	1.8%	1.0%

channel	Δσ/σ	Δσ/σ
$\chi 1+\chi 1-$	500 fb−1	H20 (1600 fb−1)
μ−tag, left	0.9%	0.5%
e−tag, left	0.8%	0.5%
combined	0.6%	0.3%
μ−tag, right	1.8%	1.0%
e−tag, right	1.7%	1.0%
combined	1.2%	0.7%

ILC2

channel	Δσ/σ	Δσ/σ
$\chi 01\ \chi 02$	500 fb−1	H20 (1600 fb−1)
$\mu\ \mu$, left	2.8%	1.6%
$\mu\ \mu$, right	3.6%	2.0%

channel	Δσ/σ	Δσ/σ
$\chi 1+\chi 1-$	500 fb−1	H20 (1600 fb−1)
μ−tag, left	3.9%	2.2%
μ−tag, right	5.2%	2.9%

Higgsino Mass Precisions (combined)

apply χ^2 fit to "observables" (kinematic edges)
(Ell_max, Ejj_max, Mll_max, Mjj_max are functions of Higgsino masses)

Scale results to H20
For each polarization:
- Default : 500 fb^{-1}
- H20: 1600 fb^{-1}

ILC2

Neutralino

μμ channel

channel	M	ΔM	ΔM/M	ΔM/M
χ01 χ02	500 fb−1			H20 (1600 fb−1)
MN1	141.90	1.87	1.3%	0.7%
MN2	151.04	2.00	1.3%	0.7%

Chargino

μ-tag channel

channel	M	ΔM	ΔM/M	ΔM/M
χ1+ χ1−	500 fb−1			H20(1600fb−1)
MN1	140.70	7.44	5.3%	3.0%
MC1	150.36	7.94	5.3%	3.0%

Theoretic values: MN1 = 148.1 GeV MN2 = 157.8 GeV, MC1 = 158.3 GeV

MN1: χ^0_1 mass MN2: χ^0_2 mass MC1: $\chi^\pm_1$ mass

Additional Material

Also analyzing more challenging benchmarks with smaller ΔM

➔ compare precision of SUSY parameter extraction

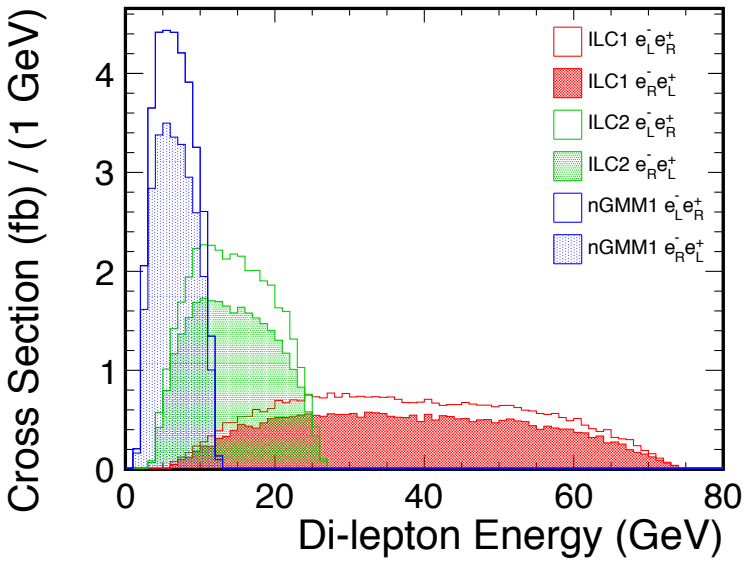
- **Currently working on ILC2**

Despite reduced visible energy, doable without large change in analysis strategies

- **Will show ILC1 & ILC2 results at LCWS2016**

Masses [GeV] from LHA files:

	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 sections [fb] for $\sqrt{s}$=500 GeV with TDR beam parameters , Event Generator: WHIZARD v1.95, DBD setup)

Process (Pe-,Pe+)	ILC1	ILC2	nGMM1
C1C1 (-1,+1)	1799.9	1530.5	1520.6
C1C1 (+1,-1)	334.5	307.2	309.5
N1N2 (-1,+1)	490.9	458.9	463.5
N1N2 (+1,-1)	378.5	353.8	357.3

Efficiency and signal yield

	yield(ILC2)	yield(ILC1)	lepton eff(ILC2	lepton eff (ILC1)
N1N2				
muon,left	2159	1515	63.58	45.44
muon,right	1150	1276		
elec,left	2159	1990	77.29%	79.38%
elec, right	1756	1736		
C1C1				
muon,left	610	14173	84.17%	54.48%
muon,right	313	3466		
elec,left	556	14437	56.16%	51.03%
elec, right	270	3526		

N1N2 efficiency definition:
Muon (similar for electron)
Top: hAnl>GetEntries("leptype==13&&nZmm==2")
Bottom: hGen->GetEntries("nZmm==2”)

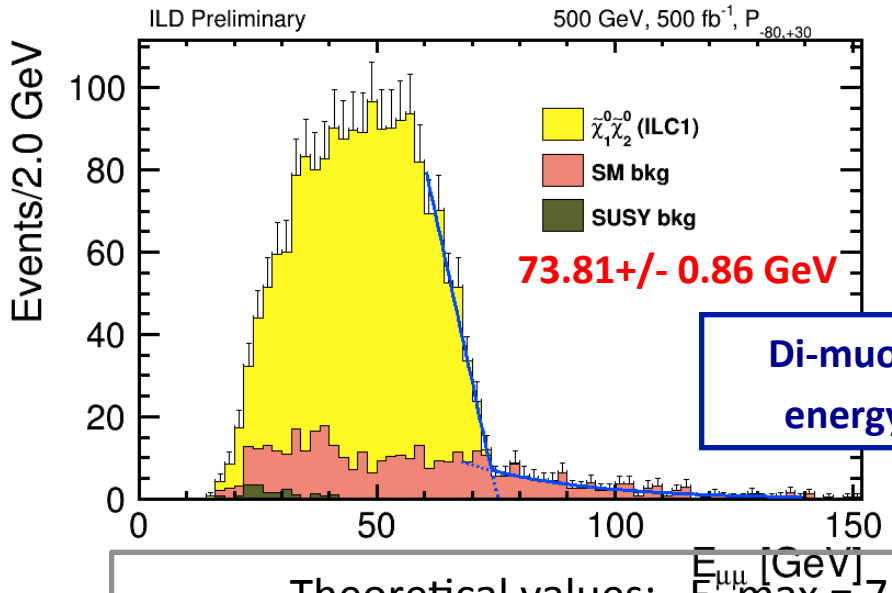
C1C1 efficiency definition:
Muon (similar for electron)
Top: hTr->GetEntries("nWqq==2&&nWmm==1&&abs(PDG)==13&&TagbestlepM==1&&abs(PDGOrig)==1000024")
Bottom: hTr->GetEntries("nWqq==2&&nWmm==1&&abs(PDG)==13&&abs(PDGOrig)==1000024")

Neutralino mixed production with leptonic decay

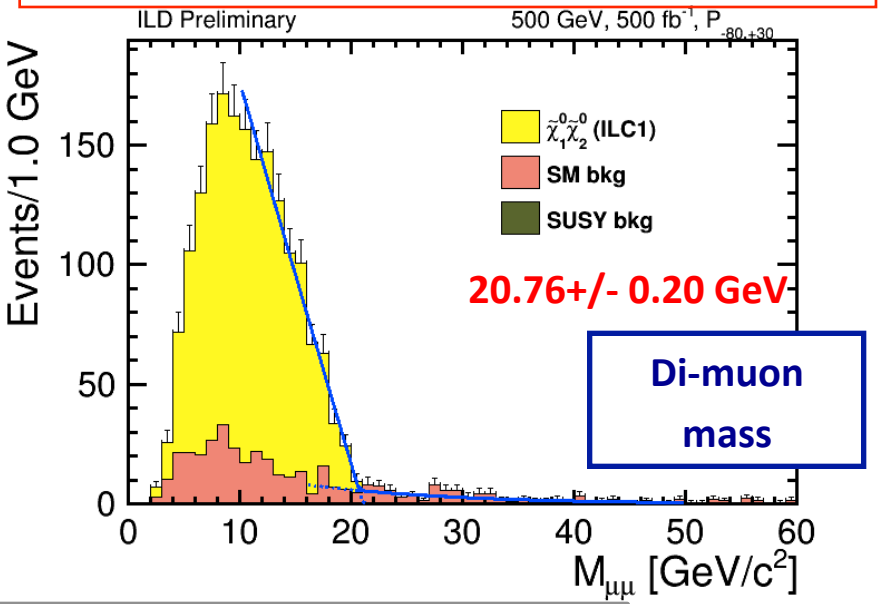
$$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$

Left Polarization **(Pe-,Pe+) = (-0.8, +0.3)**

Edge precisions ~1 %, assuming 500 fb^-1

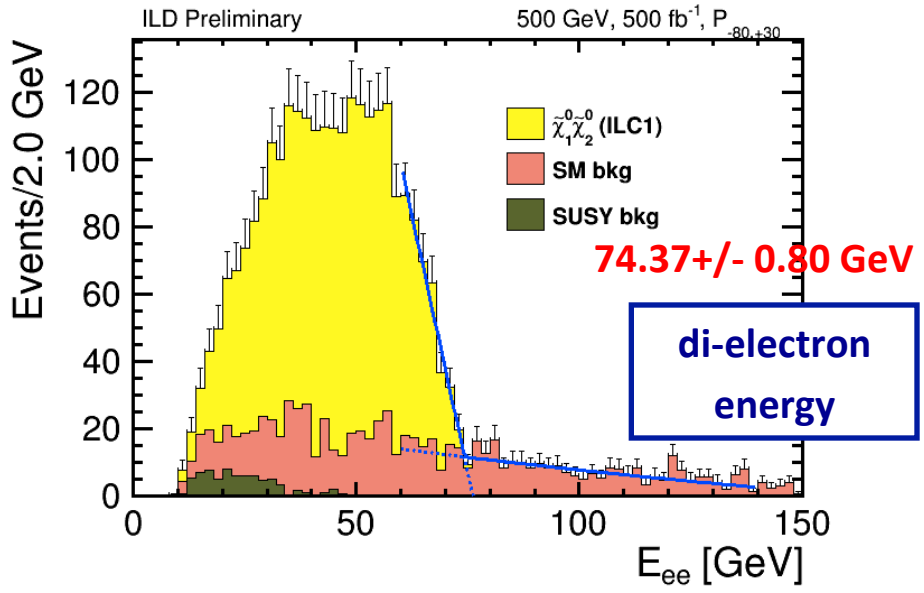


Di-muon energy

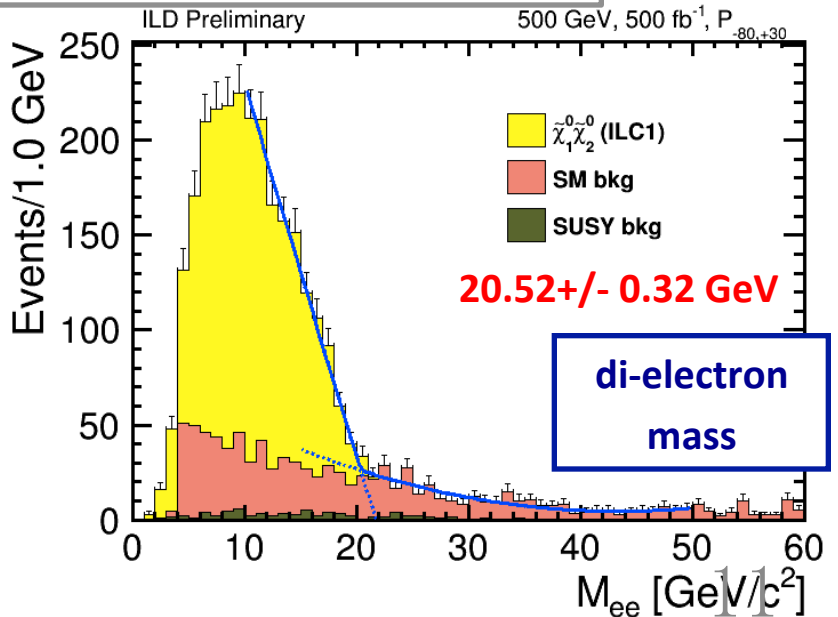


Di-muon mass

Theoretical values: E_max = 74.93 GeV ΔM = 21.28 GeV



di-electron energy



di-electron mass

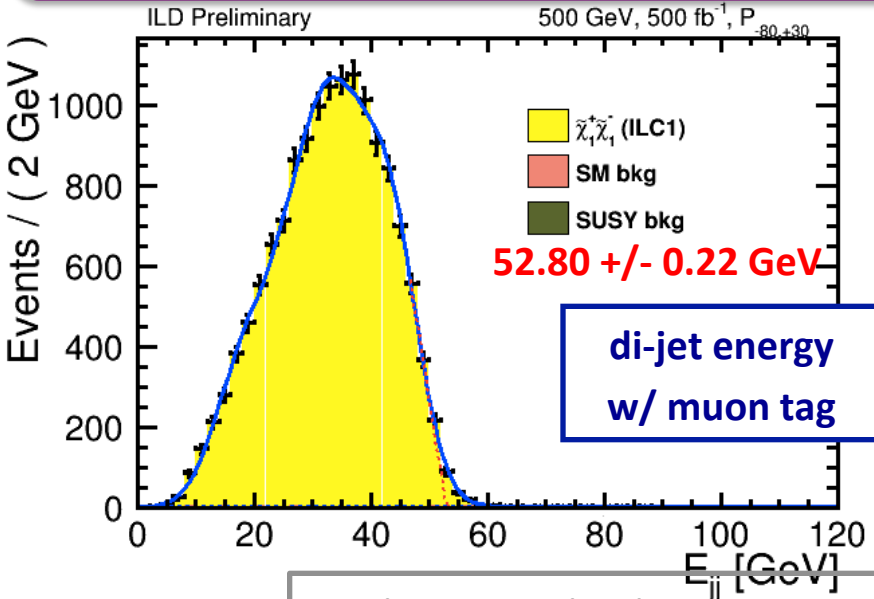
Chargino pair production with semileptonic decay

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

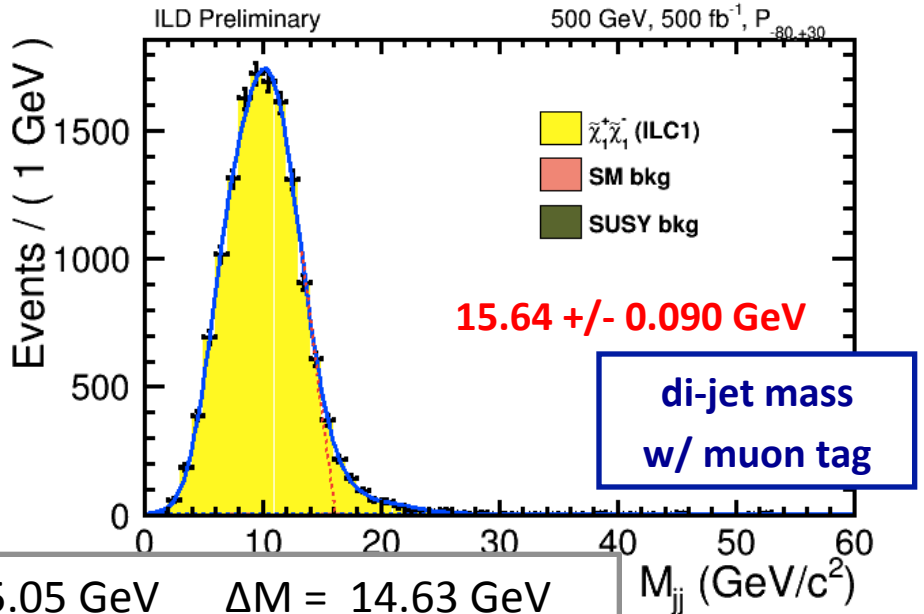
Left Polarization (Pe-,Pe+) = (-0.8, +0.3)

Edge precisions ~0.5 %, assuming 500 fb^-1

Almost all bkg rejected

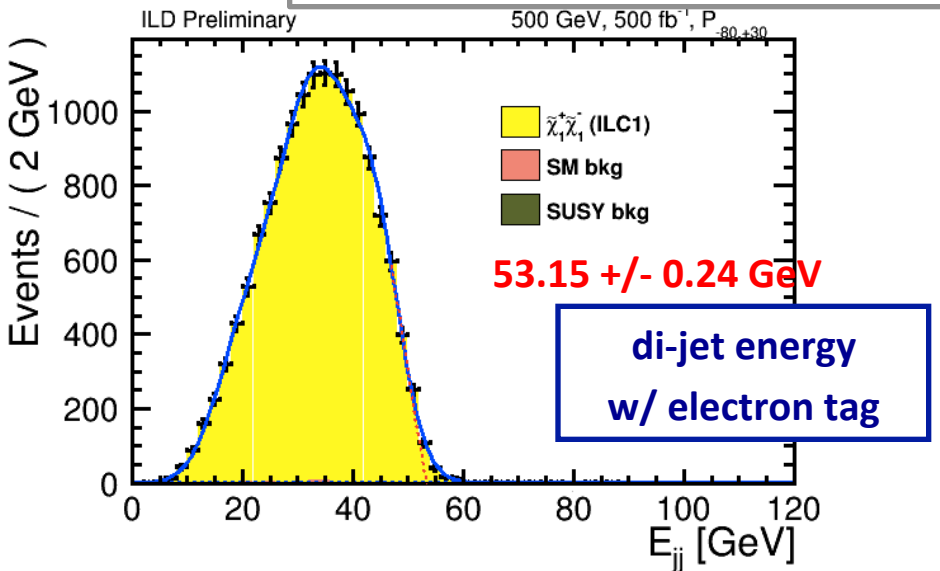


di-jet energy w/ muon tag

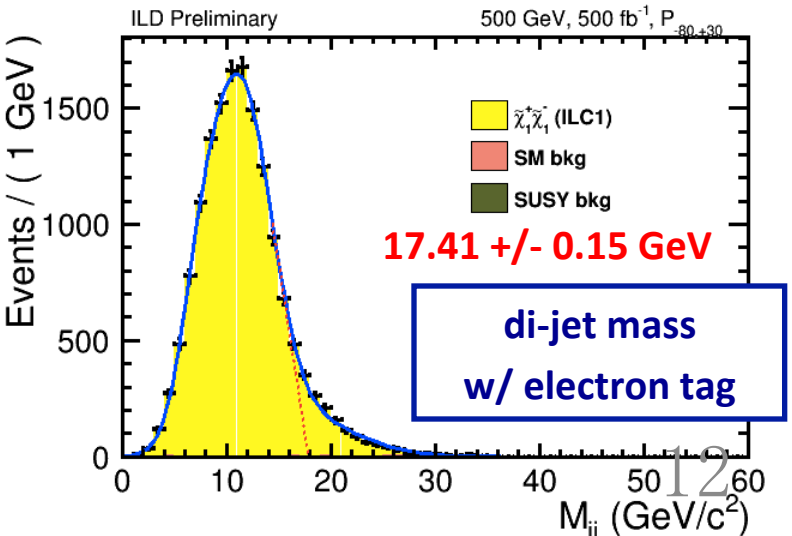


di-jet mass w/ muon tag

Theoretical values: E_max = 55.05 GeV ΔM = 14.63 GeV



di-jet energy w/ electron tag

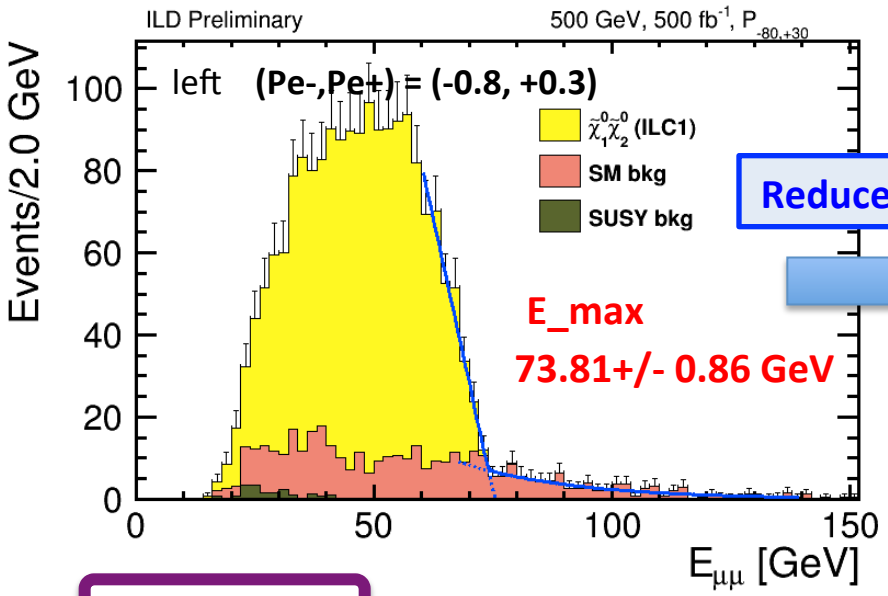


di-jet mass w/ electron tag

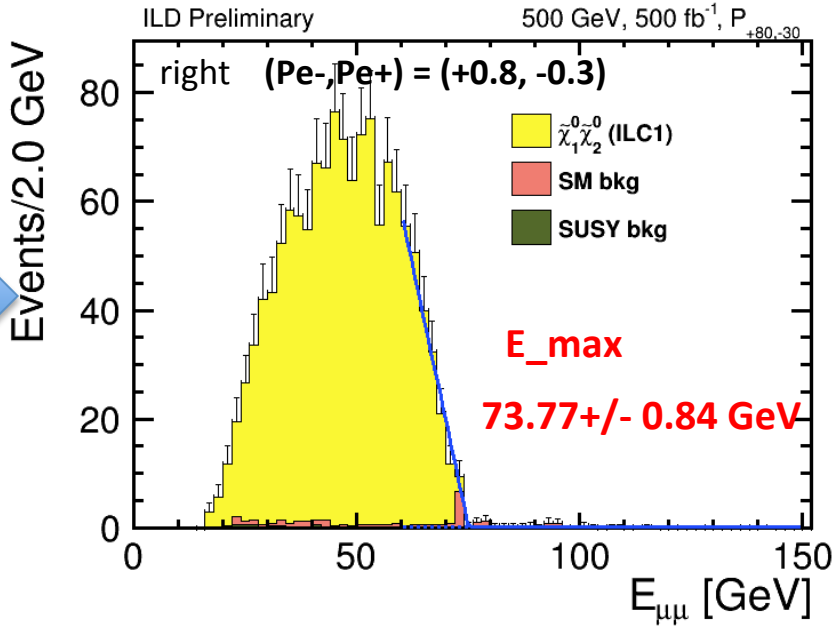
Left polarization vs right polarization

L=500 fb-1

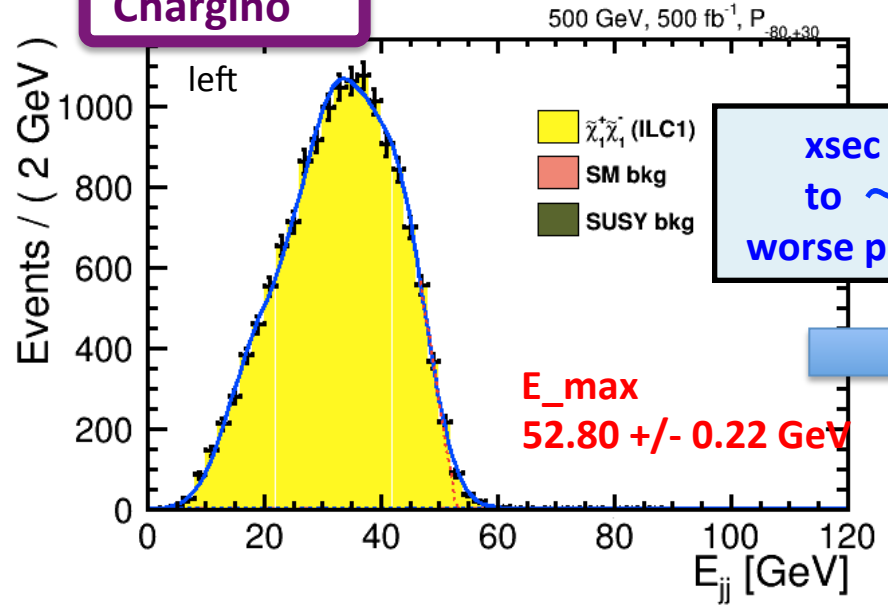
Neutralino



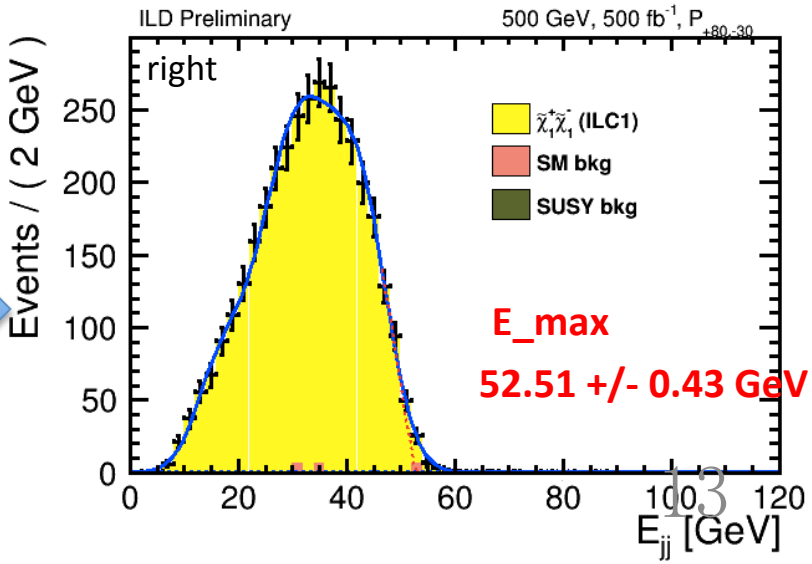
Reduced BKG



Chargino



xsec falls to ~1/5 worse precision



Higgsino Mass Precisions (combined)

apply χ^2 fit to "observables" (kinematic edges)

(Ell_max, Ejj_max, Mll_max, Mjj_max are functions of Higgsino masses)

Neutralino

4 channels (mm, ee, left, right)

N1N2	MN1	ΔMN1/MN1	MN2	ΔMN2/MN2
	102.54	0.758%	123.36	0.688%
H20		0.424%		0.385%

Chargino

4 channels (m tag, e tag, left, right)

C1C1	MN1	ΔMN1/MN1	MC1	ΔMC1/MC1
	116.60	0.447%	132.79	0.435%
H20		0.250%		0.243%

ALL

8 channels (m, e, left, right, N1N2, C1C1)

	MN1	ΔMN1/MN1	MN2	ΔMN2/MN2	MC1	ΔMC1/MC1
	110.56	0.405%	130.90	0.372%	126.09	0.396%
H20		0.226%		0.208%		0.221%

Scale results to H20

For each polarization:

- Default : 500 fb^{-1}
- H20: 1600 fb^{-1}

Theoretic values: MN1 = 102.70 GeV MN2 = 123.98 GeV, MC1 = 117.33 GeV

MN1: χ^0_1 mass MN2: χ^0_2 mass MC1: $\chi^\pm_1$ mass

- **combined statistical mass precision ~ 0.2% (H20)**
- Dominated by precision of chargino channel (higher cross section)

- Neutralino results consistent with theoretic values
- Chargino results deviated due to jet energy resolution

- H20: 1600 fb^{-1}

H20		0.424%		0.385%		

Chargino

4 channels (m tag, e tag, left, right)

C1C1	MN1	ΔMN1/MN1	MC1	ΔMC1/MC1
	116.60	0.447%	132.79	0.435%
H20		0.250%		0.243%

8 channels (m, e, left, right, N1N2, C1C1)

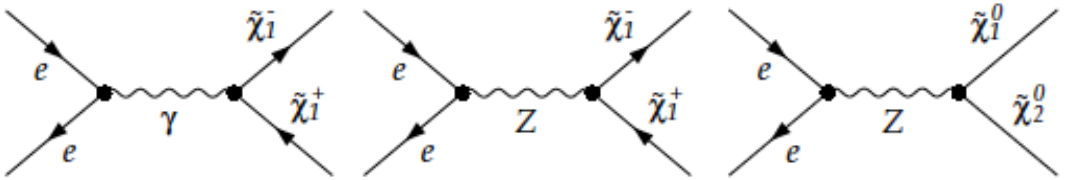
ALL

	MN1	ΔMN1/MN1	MN2	ΔMN2/MN2	MC1	ΔMC1/MC1
	110.56	0.405%	130.90	0.372%	126.09	0.396%
H20		0.226%		0.208%		0.221%

Theoretic values: MN1 = 102.70 GeV MN2 = 123.98 GeV, MC1 = 117.33 GeV

MN1: χ^0_1 mass MN2: χ^0_2 mass MC1: $\chi^\pm_1$ mass

Benchmarks in this Study



RNS model (Radiatively-driven natural SUSY)

- **4 light Higgsinos:** $\tilde{\chi}_1^0$ (LSP) $\tilde{\chi}_2^0$ $\tilde{\chi}_1^+$ $\tilde{\chi}_1^-$

- **ΔM approximately complies with naturalness** (ISR tag not needed)

This study: **√s = 500 GeV**
Full detector simulation

process	σ_{ILC1}	σ_{ILC2}
$e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-$,left	1800.8	1530.5
$e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-$,right	334.8	307.2
$e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_2^0$,left	491.4	458.9
$e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_2^0$,right	379.8	353.8

BR	ILC1	ILC2
$BR(\tilde{\chi}_1^+ \to \tilde{\chi}_1^0 qq)$	67%	67%
$BR(\tilde{\chi}_1^+ \to \tilde{\chi}_1^0 l\nu)$	22%	22%
$BR(\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 qq)$	58%	63%
$BR(\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 l\nu)$	7.4%	8.0%

NUHM2 model parameters [arXiv:1404.7510]

Benchmark	ILC1	ILC2
M_0 [GeV]	7025	5000
$M_{1/2}$ [GeV]	568.3	1200
A_0 [GeV]	-10427	-8000
tanβ	10	15
μ [GeV]	115	150
M_A [GeV]	1000	1000
$M(\chi_1^0)$ [GeV]	102.7	148.1
$M(\chi_1^\pm)$ [GeV]	117.3	158.3
$M(\chi_2^0)$ [GeV]	124.0	157.8
$M(\chi_3^0)$ [GeV]	267.0	538.8

ΔM : 15-20 GeV **ΔM～ 10 GeV**

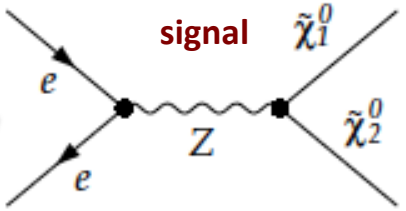
Defined at GUT scale ,
Defined at weak scale **Observables**

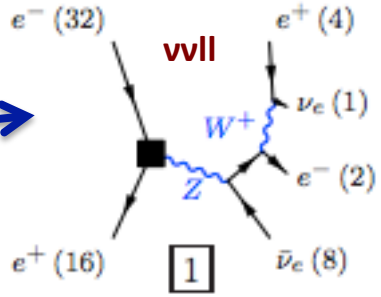
Event Selection

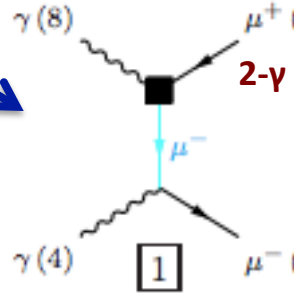
Neutralino mixed production with leptonic decay

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

- Reconstruct **two leptons (ee or μμ) which originate from Z* emission in decay of χ_2^0 to χ_1^0**
- Major residual bkg. are 4f processes accompanied by large missing energy (vvll)
- 2-γ processes are removed by BeamCal veto, cuts on lepton track p_T, and coplanarity





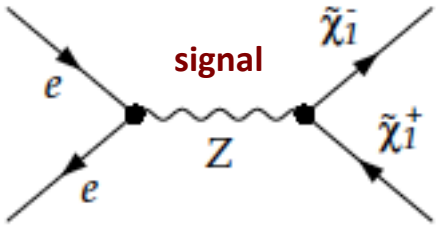


Chargino pair production with semileptonic decay

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

- Reconstruct **two jets which originate from W* emission in decay of $\chi_1^\pm$ to χ_1^0**
- Use lepton (e or μ) from the other chargino as tag
- BeamCal veto, cuts on missing p_T, # of tracks, # of leptons, and coplanarity remove almost all bkg.

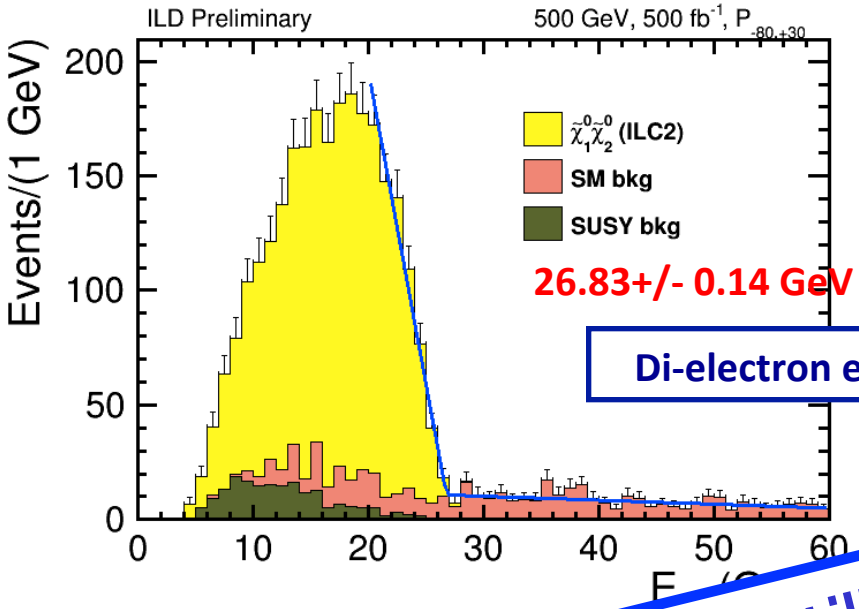
(signal significance > 100)



Neutralino mixed production with leptonic decay

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

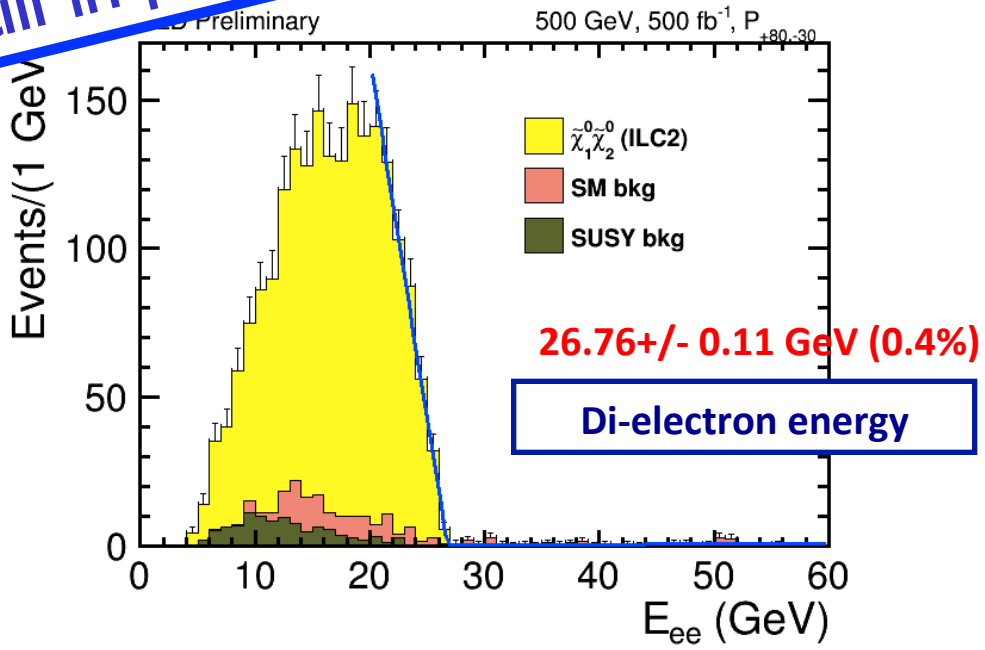
ILC2, ee



26.83+/- 0.14 GeV (0.5%)

Di-electron energy

Electron channels still in progress (checking)



26.76+/- 0.11 GeV (0.4%)

Di-electron energy

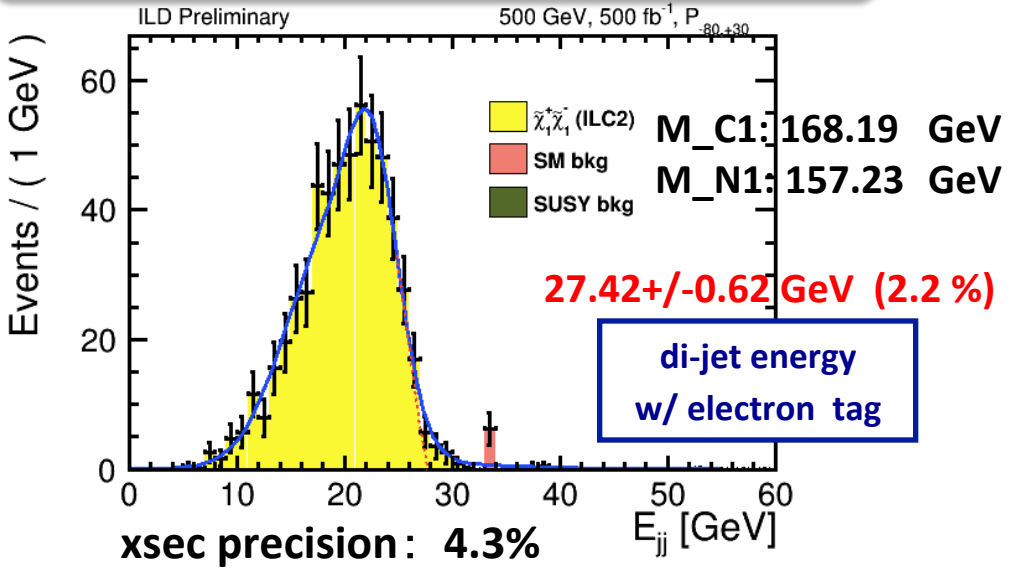
Chargino pair production with semileptonic decay

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

ILC2 e-tag

All ILC1 cuts applied, with exception of
- Pt_mis cut loosened from 10 → 7 GeV
- Muon ID criteria loosened

(Pe-,Pe+) = (-0.8, +0.3)

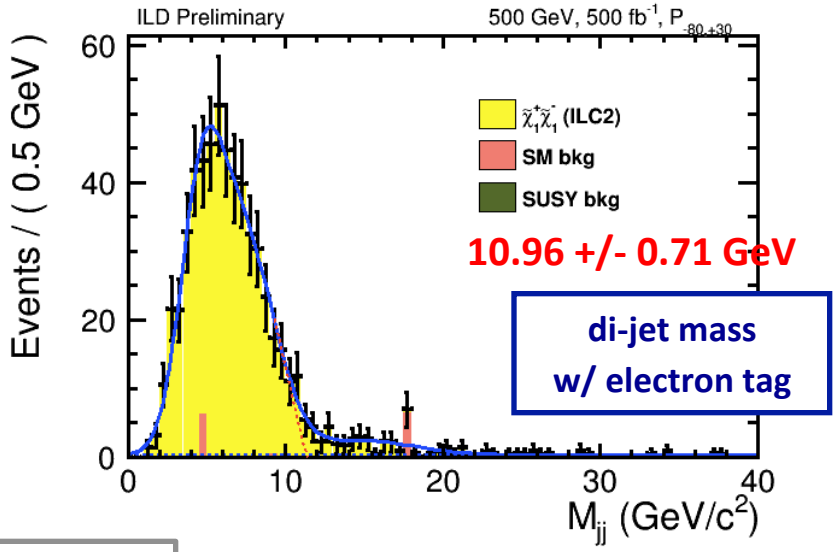


M_C1: 168.19 GeV
M_N1: 157.23 GeV

27.42+/-0.62 GeV (2.2 %)

di-jet energy w/ electron tag

xsec precision : 4.3%

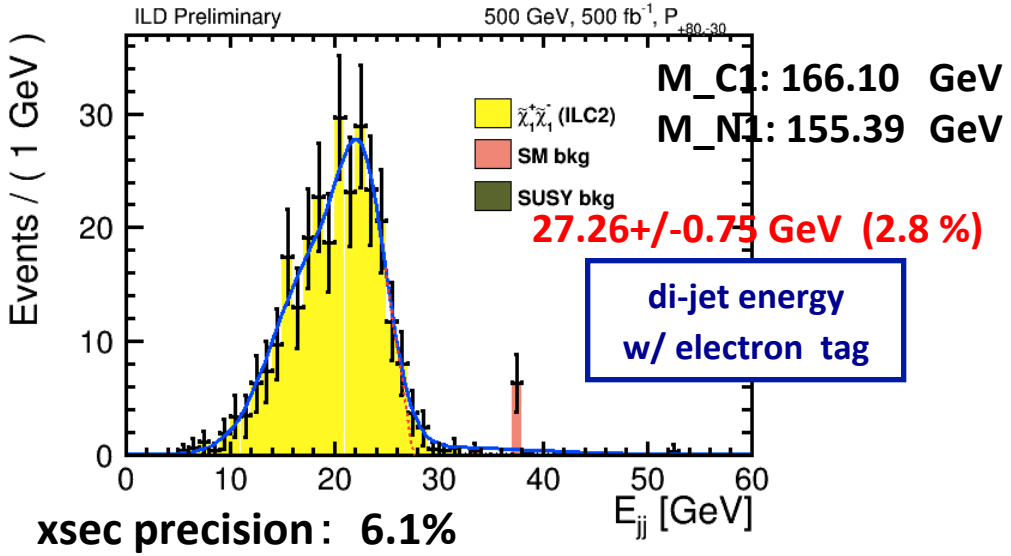


10.96 +/- 0.71 GeV

di-jet mass w/ electron tag

Theoretical values: E_max = 27.66 GeV , ΔM = 9.87 GeV
M_C1: 158.3 GeV, M_N1: 148.1 GeV

(Pe-,Pe+) = (+0.8, -0.3)

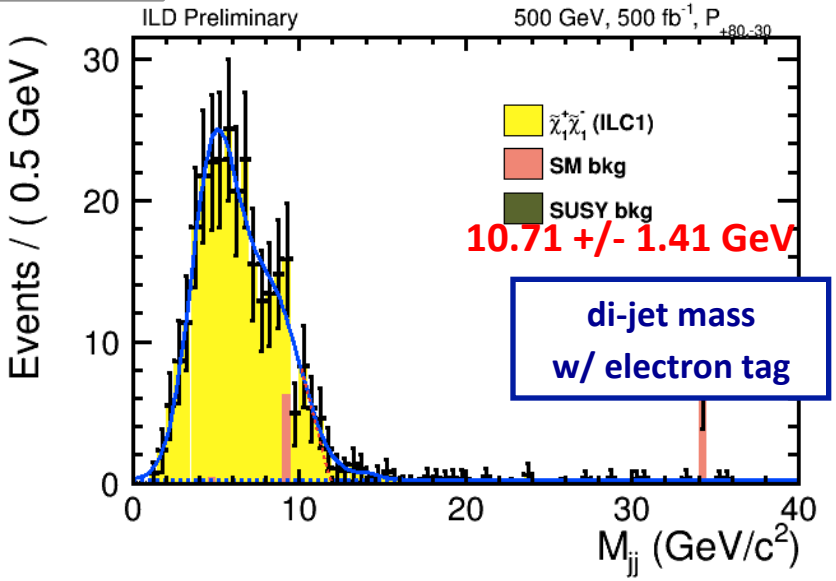


M_C1: 166.10 GeV
M_N1: 155.39 GeV

27.26+/-0.75 GeV (2.8 %)

di-jet energy w/ electron tag

xsec precision : 6.1%

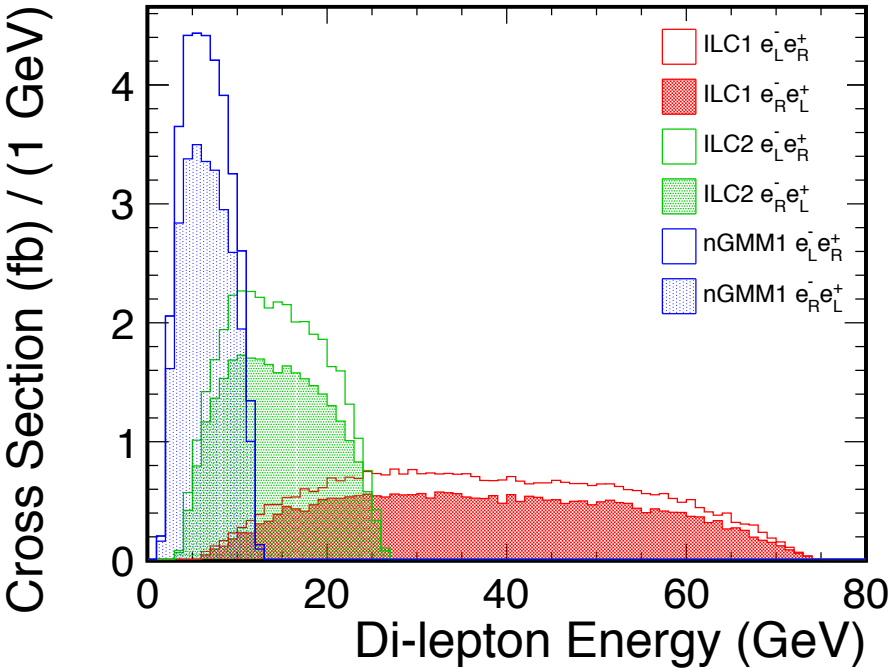


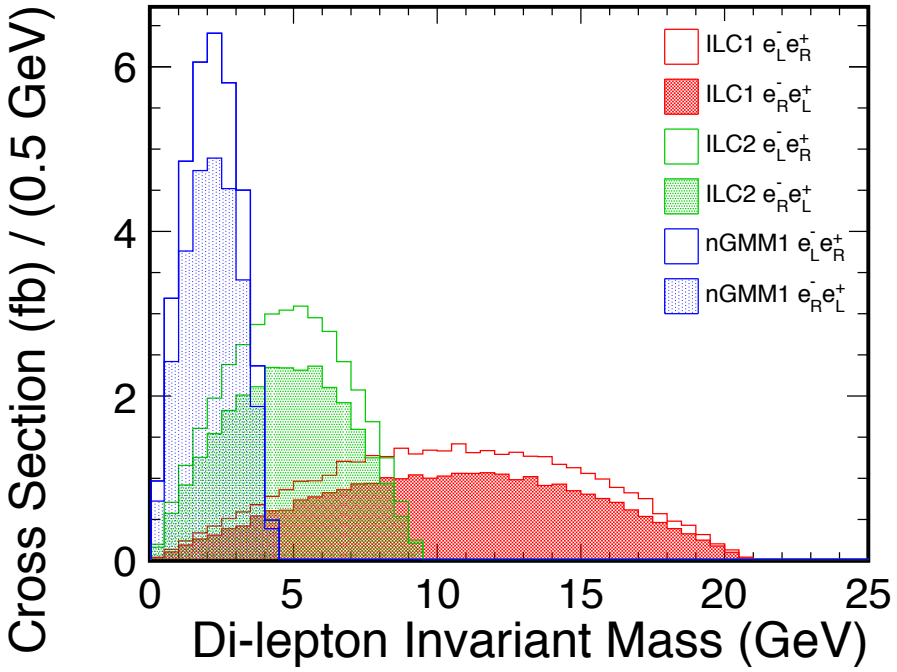
10.71 +/- 1.41 GeV

di-jet mass w/ electron tag

WHIZARD-level distributions

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

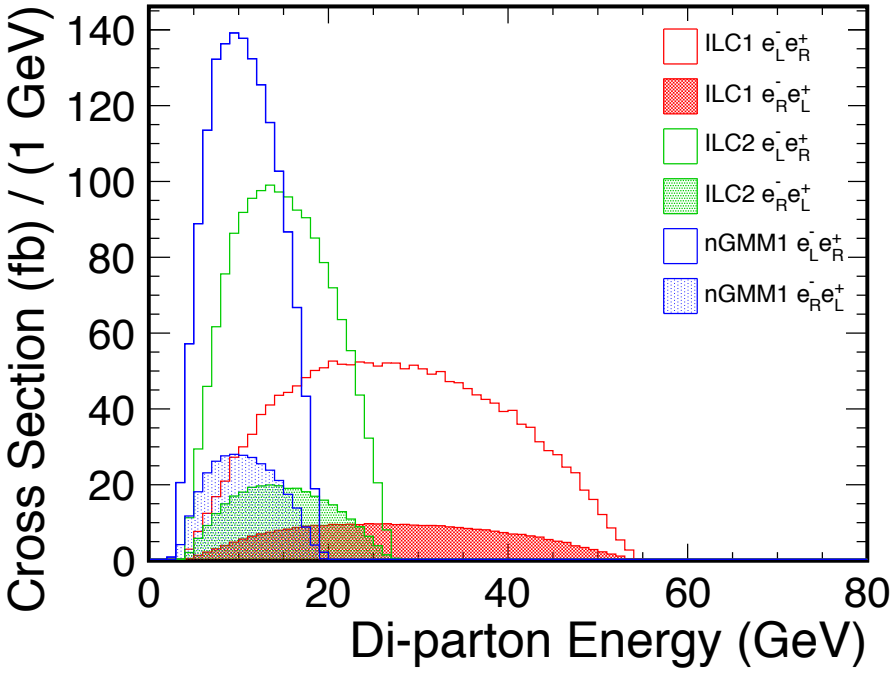


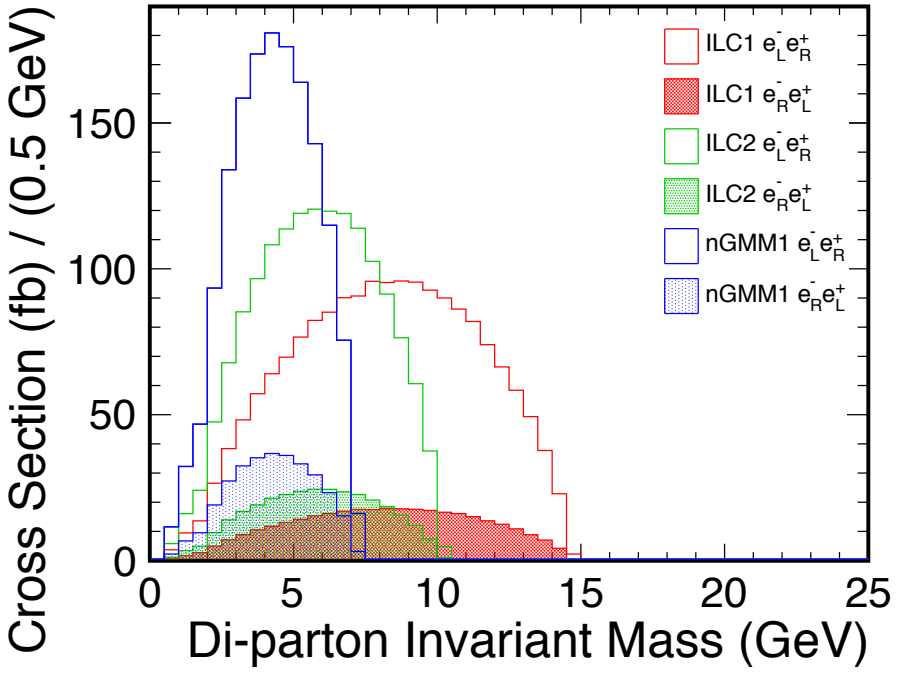


	ILC1	ILC2	nGMM1
ΔM(N2,N1)	21.3	9.7	4.4

WHIZARD-level distributions

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



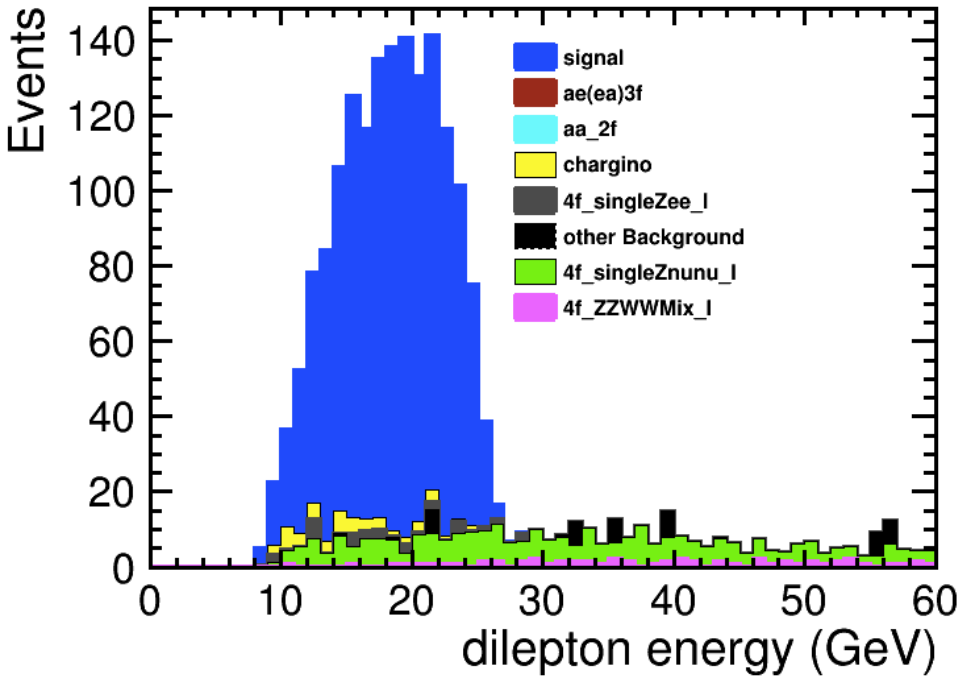


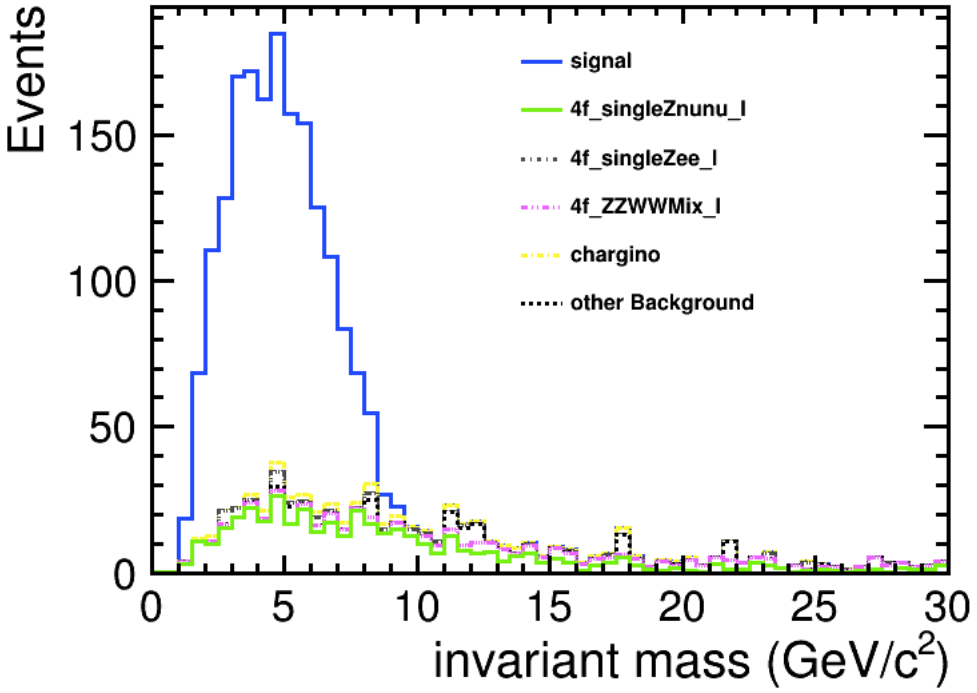
	ILC1	ILC2	nGMM1
ΔM(C1,N1)	14.6	10.2	7.3

Xsec fits for ILC2 N1N2

Neutralino mixed production with leptonic decay

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



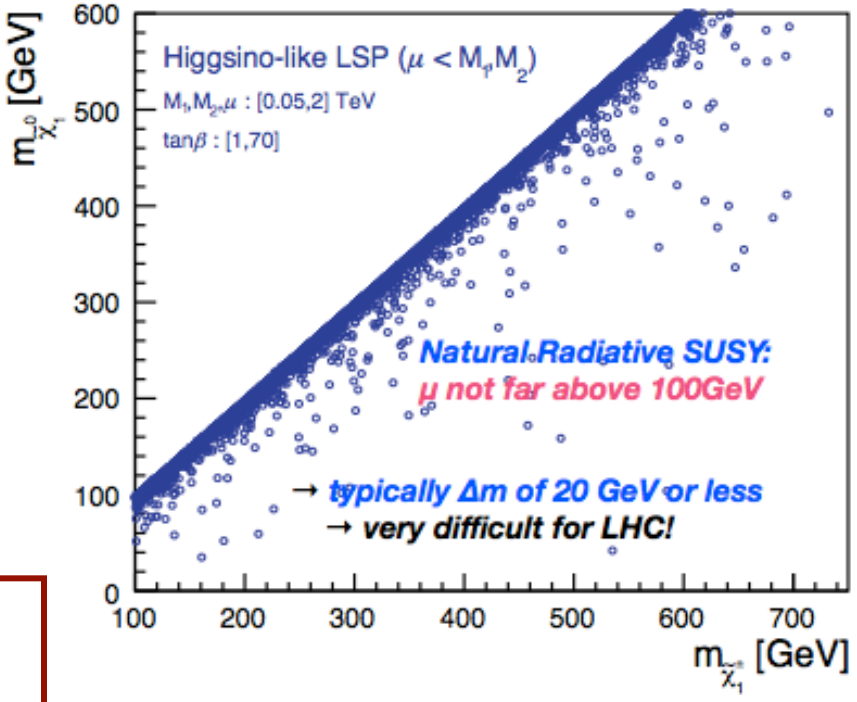


Motivation for Searching Light Higgsinos with Small ΔM

❖ From experimental point of view:

- LHC already excluded large regions with large ΔM = M(NLSP) – M(LSP)
- Remaining region with compressed spectrum
  very small visible energy release,
  near impossible to probe at LHC

➔ **ILC is essential**



❖ From theoretical point of view:

Compressed Higgsino spectra related to naturalness [e.g. arXiv:1212.2655, arXiv:1404.7510]

$$\frac{M_Z^2}{2} = \frac{m_{H_d}^2 + \Sigma_d^d - (m_{H_u}^2 + \Sigma_u^u)\tan^2\beta}{\tan^2\beta - 1} - \mu^2$$

- To maintain **small electroweak fine tuning ΔEW (<∼3%)**, all contributions on right-hand-side should be comparable to M(Z) ➔ requires **μ ∼ 100–300 GeV**

  top and bottom squarks in the few TeV regime, gluino mass 2–4 TeV,
  1st, 2nd generation squarks and sleptons in the 5–30 TeV regime

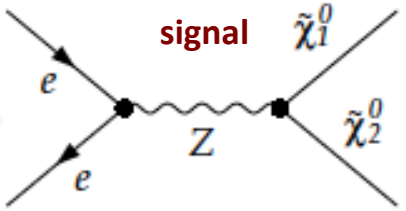
- μ feeds mass to both SM (W, Z, h) and SUSY particles (Higgsinos)
- Higgsino masses not too far from masses of W, Z, h (∼100 GeV)

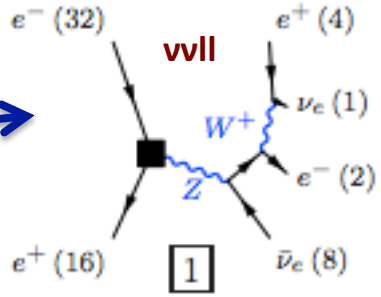
Event Selection

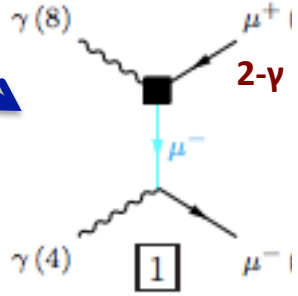
Neutralino mixed production with leptonic decay

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

- Reconstruct **two leptons (ee or μμ) which originate from Z* emission in decay of χ_2^0 to χ_1^0**
- Major residual bkg. are 4f processes accompanied by large missing energy (vvll)
- 2-γ processes are removed by BeamCal veto, cuts on lepton track p_T, and coplanarity



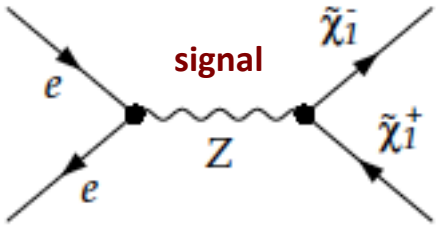




Chargino pair production with semileptonic decay

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

- Reconstruct **two jets which originate from W* emission in decay of $\chi_1^\pm$ to χ_1^0**
- Use lepton (e or μ) from the other chargino as tag
- BeamCal veto, cuts on missing p_T, # of tracks, # of leptons, and coplanarity remove almost all bkg.



Neutralino mixed production with leptonic decay

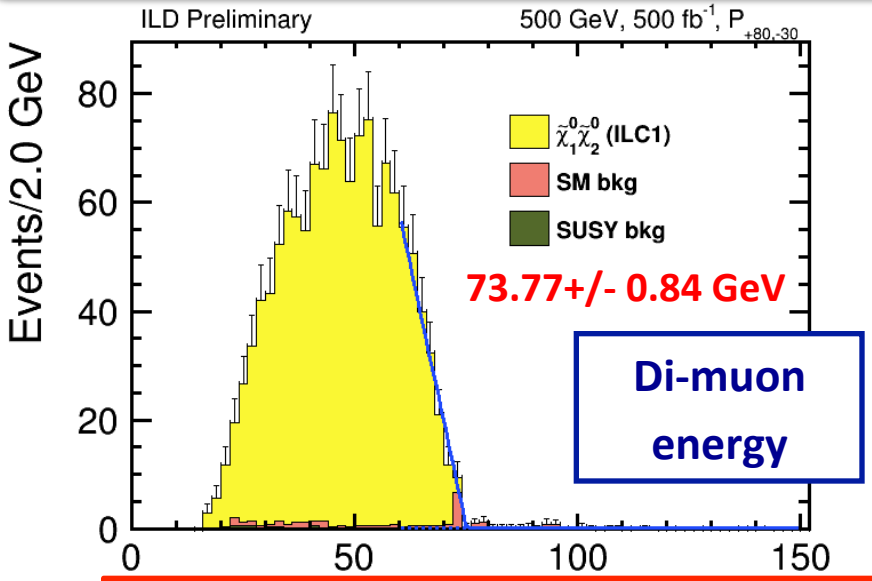
$$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$

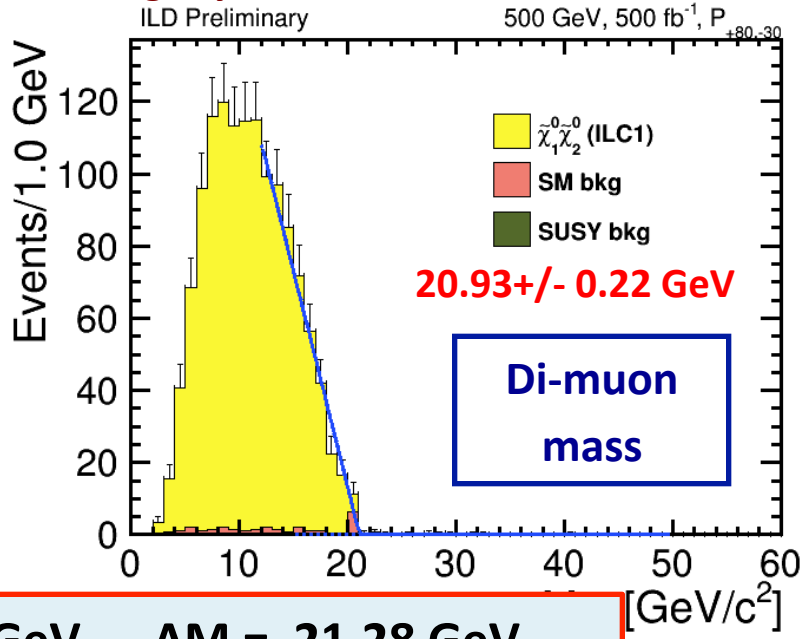
Right Polarization (Pe-,Pe+) = (+0.8, -0.3)

Much less bkg

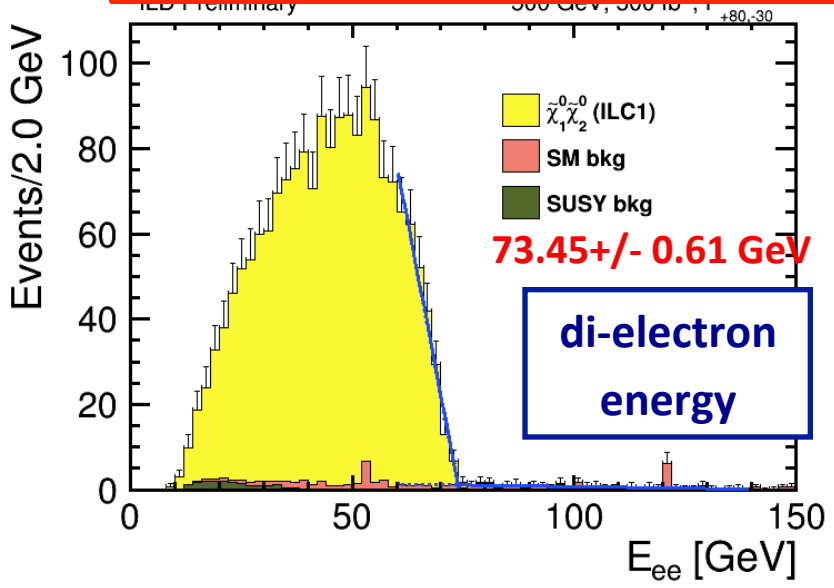
Precision slightly better

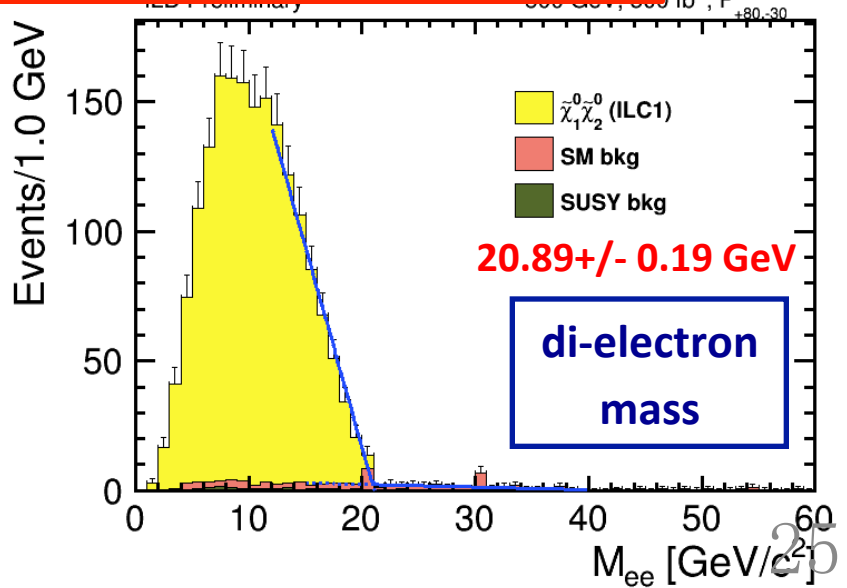
Edge precision < ~ 1 %





Theoretical values: E_max = 74.93 GeV ΔM = 21.28 GeV



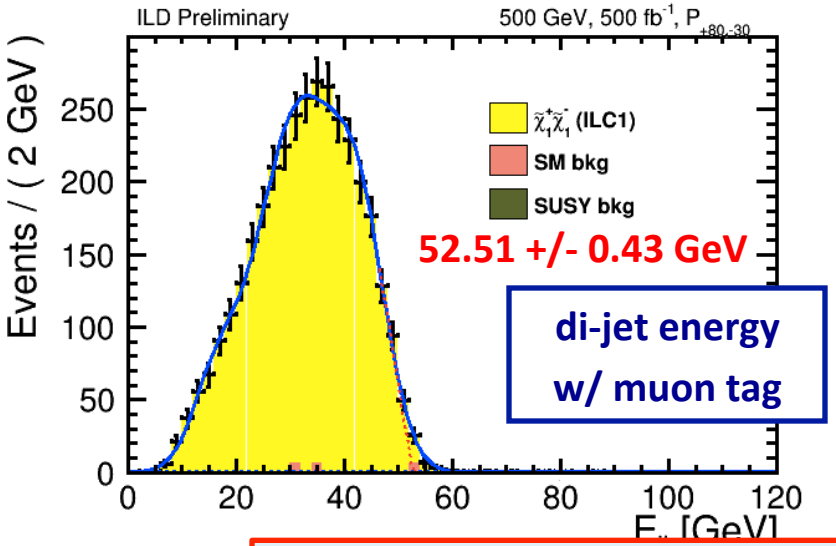


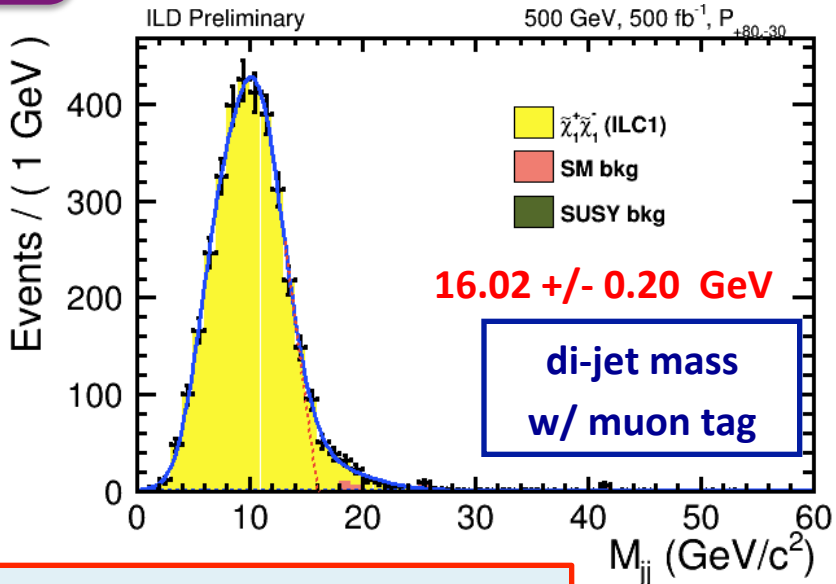
Chargino pair production with semileptonic decay

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

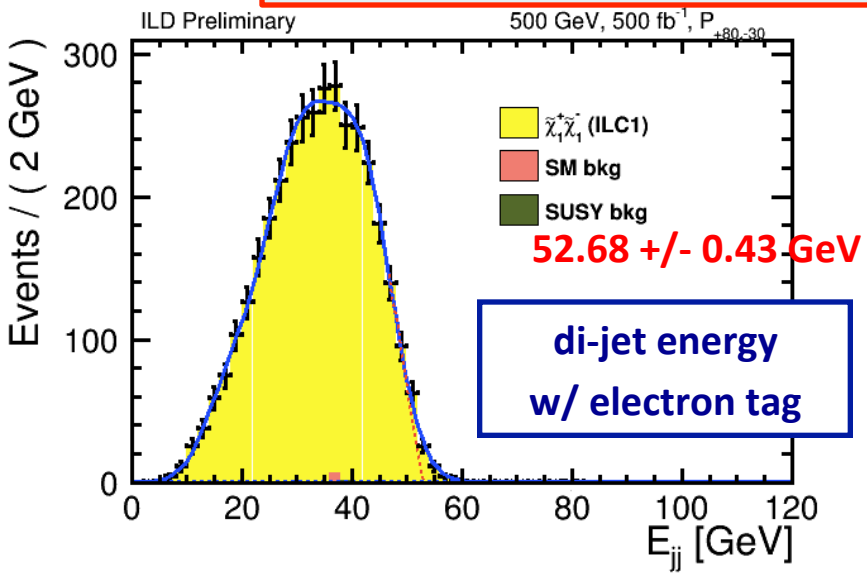
right Polarization(Pe-,Pe+) = (+0.8, -0.3)

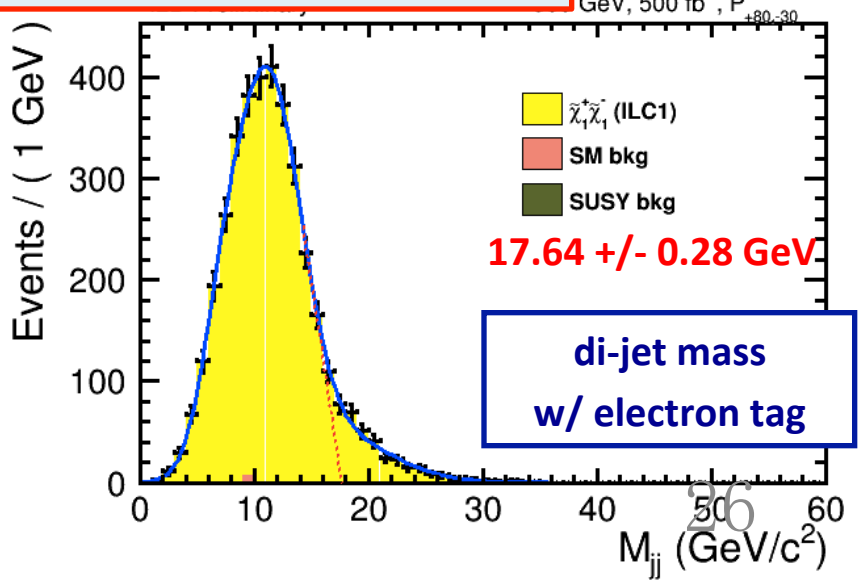
Cross section ~ 1/5 of left polarization





Theoretical values: E_max = 55.05 GeV ΔM = 14.63 GeV

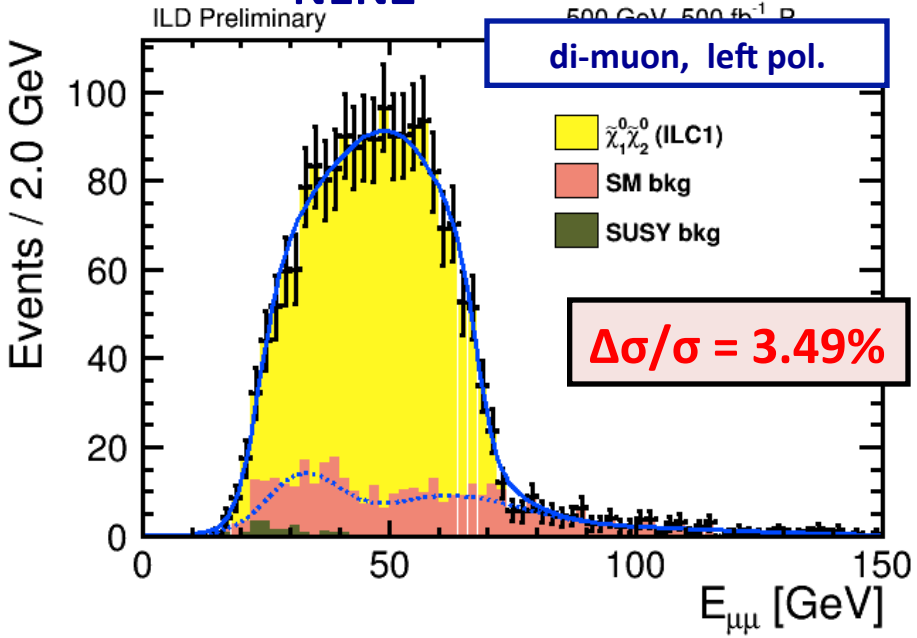


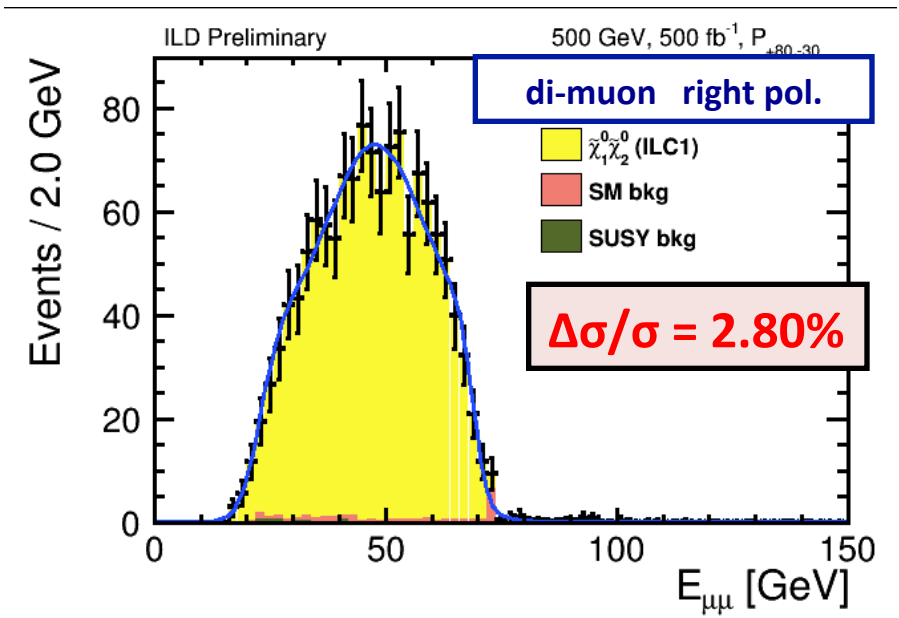


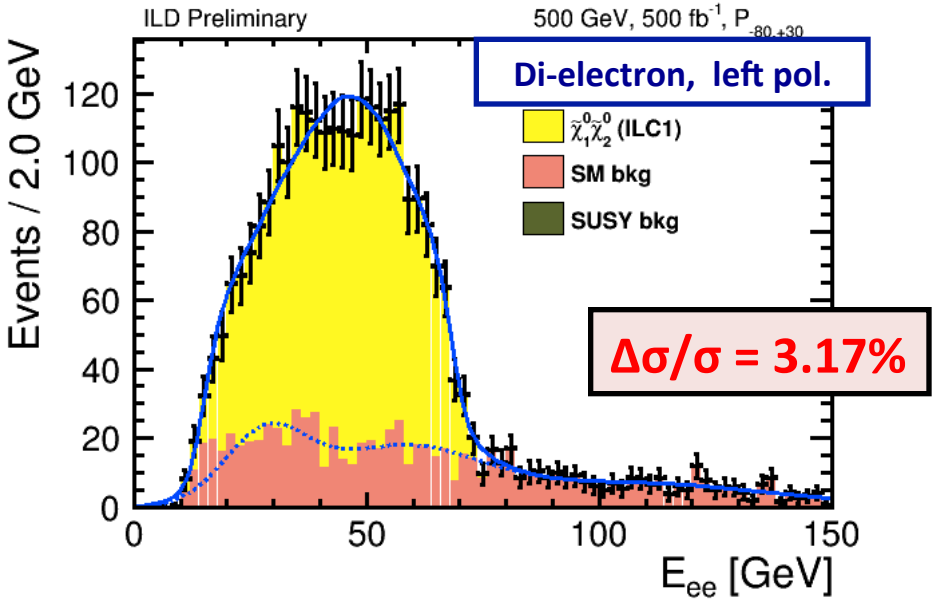
Extraction of Cross Section

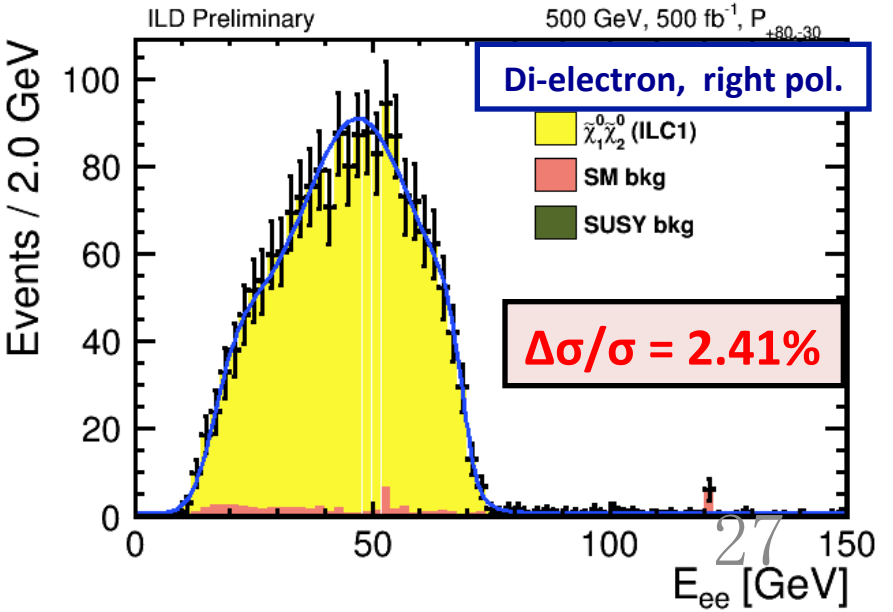
N1N2

Uncertainty of right pol is about 3 / 4 of left pol
dependent on statistics (evaluated using Toy MC)





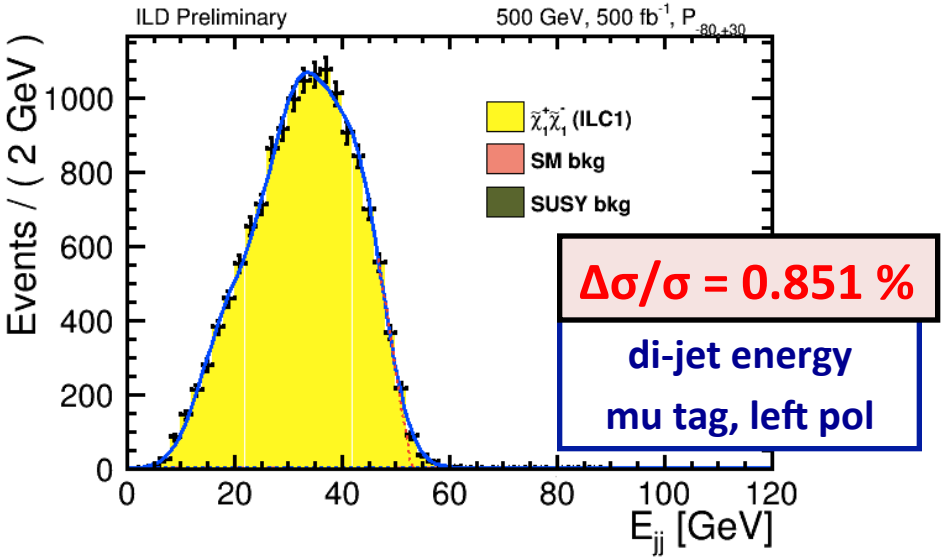


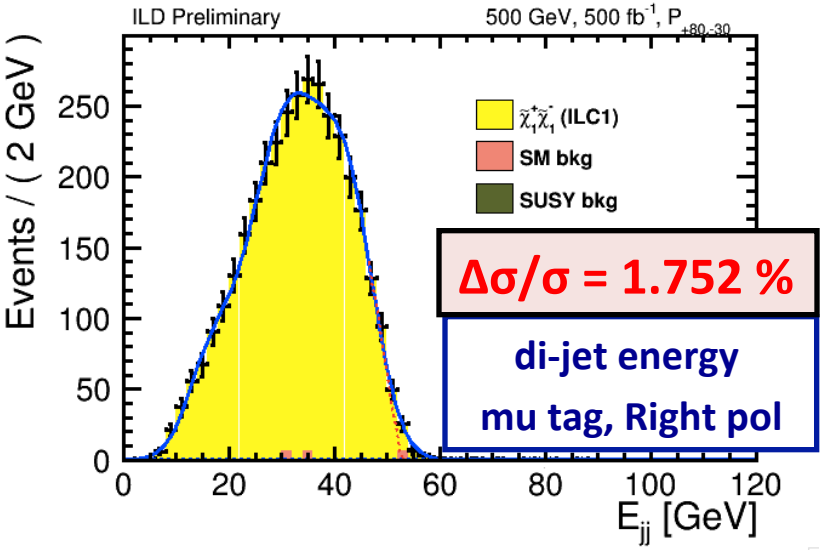


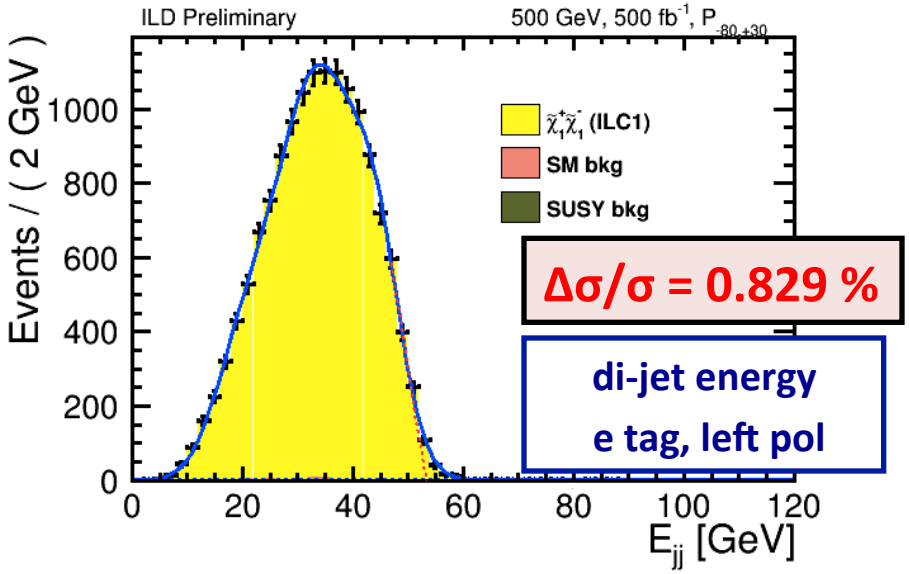
Extraction of Cross Section

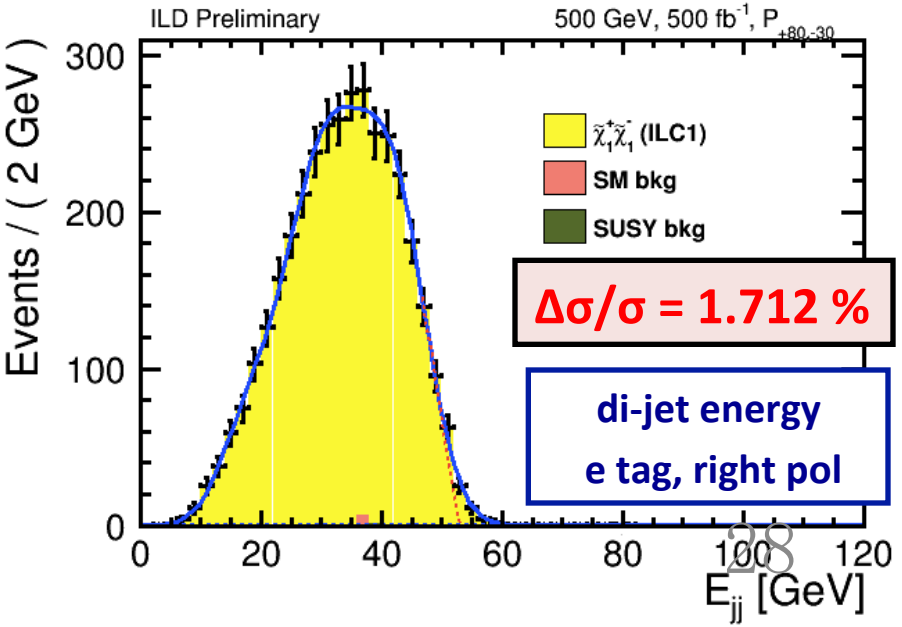
C1C1

- Left pol has x2 better precision
- dependent on statistics









ILC2 Cut Table: N1N2 left polarization, mumu

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	Ch	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	906.095	26.0064	264326	3.0012e+06	280.839	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	1.35308e+06	8300	2.28257e+07	1.06721e+08	622651	622651	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	453047	13003.2	1.32163e+08	1.5006e+09	140420	140420	3.62473
Cut0	:	2.1489e+06	6.05387e+06	2.42023e+06	4.22121e+06	3.19932e+06	1.845e+09	131918	0	4.85045e+07	1.91168e+09	50331.3	50331.3	1.15113
Cut1	:	198750	808.428	204261	484.857	0	8.71657e+08	4252.83	0	2.19281e+07	8.93994e+08	6375.79	6375.79	0.213238
Cut2	:	187868	611.818	118065	204.663	0	5.41902e+06	4225.91	0	965354	6.69535e+06	6338.25	6338.25	2.44837
Cut3	:	179334	0.752646	80930.8	13.3301	0	3.32467e+06	1156.26	0	524259	4.11037e+06	1641.33	1641.33	0.809412
Cut4	:	122636	0.752646	47735.1	0.373803	0	2.14954e+06	1146.58	0	289298	2.61035e+06	1639.23	1639.23	1.01427
Cut5	:	5926.63	0.376323	6831.94	0.373803	0	24449.2	49.8356	0	67640.5	104899	1464.62	1464.62	4.49087
Cut6	:	5050.14	0.376323	2765.5	0	0	19882.9	49.8173	0	20471.5	48220.3	1463.03	1463.03	6.56368
Cut7	:	12.8732	0	1217.26	0	0	99.0678	49.8173	0	349.268	1728.29	1463.03	1463.03	25.8981
Cut8	:	0	0	1164.09	0	0	33.6364	49.3397	0	121.364	1368.43	1452.39	1452.39	27.3462
Cut9	:	0	0	813.454	0	0	33.6364	49.3397	0	121.364	1017.79	1452.39	1452.39	29.2226
Cut10	:	0	0	520.768	0	0	0	47.6307	0	113.864	682.264	1452.39	1452.39	31.4355

ILC2 Cut Table: N1N2 right polarization, mumu

Polarization: (e-,e+) = (+0.8,-0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	Ch	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	5960.13	11663.4	7482.28	2943.64	741.331	2.6771e+06	233.28	26.0064	255791	2.96194e+06	223.035	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	1.35308e+06	8300	2.28257e+07	1.06721e+08	622651	622651	
Expected	:	2.98006e+06	5.83168e+06	3.74114e+06	1.47182e+06	370665	1.33855e+09	116640	13003.2	1.27896e+08	1.48097e+09	111517	111517	2.
Cut0	:	1.90282e+06	3.36716e+06	1.71042e+06	935367	275567	1.845e+09	68230.8	0	4.82243e+07	1.90148e+09	40214.2	40214.2	0.922206
Cut1	:	155831	731.52	152570	481.142	0	8.71657e+08	2212.32	0	2.19218e+07	8.93891e+08	5157.25	5157.25	0.172494
Cut2	:	147362	588.141	67418.6	161.676	0	5.41902e+06	2198.83	0	962865	6.59961e+06	5125.45	5125.45	1.99436
Cut3	:	139500	12.5799	36595.1	13.2896	0	3.32467e+06	571.971	0	522469	4.02383e+06	1303.49	1303.49	0.649705
Cut4	:	98183	12.5799	21306.4	6.24784	0	2.14954e+06	564.997	0	286895	2.5565e+06	1300.3	1300.3	0.813039
Cut5	:	4821.3	6.28997	5094.61	6.24784	0	24449.2	23.3857	0	67420.9	101822	1163.47	1163.47	3.62549
Cut6	:	4118.03	6.28997	1031.78	0	0	19882.9	23.0801	0	20482.2	45544.3	1163.37	1163.37	5.383
Cut7	:	0.770192	0	200.774	0	0	99.0678	23.0801	0	410.06	733.752	1163.37	1163.37	26.7098
Cut8	:	0	0	155.016	0	0	33.6364	22.1379	0	142.529	353.32	1150.5	1150.5	29.6681
Cut9	:	0	0	108.715	0	0	33.6364	22.1379	0	142.529	307.019	1150.5	1150.5	30.1357
Cut10	:	0	0	75.9479	0	0	0	21.7311	0	130.029	227.708	1150.5	1150.5	30.9906

ILC1 Cut Table: N1N2 left polarization, mumu

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	Ch	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	1065.17	26.0064	261580	2.99861e+06	300.791	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	2.33207e+06	8300	2.26291e+07	1.07503e+08	1.0963e+06	1.0963e+06	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	532585	13003.2	1.3079e+08	1.49931e+09	150395	150395	3.8839
Cut0	:	1.84022e+06	62768.8	1.46378e+06	1.98579e+06	430258	1.845e+09	6227.38	0	4.83904e+07	1.89918e+09	16478.1	16478.1	0.378114
Cut1	:	185899	0.376323	89936.7	12.9538	0	8.71657e+08	2425.99	0	2.19281e+07	8.93864e+08	2121.19	2121.19	0.0709487
Cut2	:	176420	0.376323	62927.4	12.9538	0	5.41902e+06	2410.6	0	965354	6.62614e+06	2105.07	2105.07	0.817649
Cut3	:	175961	0.376323	54146.6	12.9538	0	1.35498e+06	1985.79	0	295459	1.88255e+06	1804.44	1804.44	1.3145
Cut4	:	120835	0.376323	32485.6	0.373803	0	895478	1950	0	167734	1.21848e+06	1749.98	1749.98	1.5842
Cut5	:	5708.39	0.376323	3408.47	0.373803	0	3496.68	21.7669	0	33867	46503.1	1530.26	1530.26	6.98221
Cut6	:	4935.45	0.376323	1656.45	0	0	2188.4	21.7669	0	4743.09	13545.5	1527.48	1527.48	12.4416
Cut7	:	6.4366	0	795.253	0	0	33.6364	20.6055	0	23	878.932	1520.51	1520.51	31.0408
Cut8	:	0	0	785.559	0	0	33.6364	19.4559	0	9.00002	847.652	1515.69	1515.69	31.1779
Cut9	:	0	0	500.845	0	0	33.6364	19.4559	0	9.00002	562.937	1515.69	1515.69	33.2447
Cut10	:	0	0	374.054	0	0	33.6364	19.4559	0	9.00002	436.147	1515.69	1515.69	34.3075

ILC2 Cut Table: N1N2 left polarization, ee

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	Ch	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	906.095	26.0064	264326	3.0012e+06	280.839	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	1.35308e+06	8300	2.28257e+07	1.06721e+08	622651	622651	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	453047	13003.2	1.32163e+08	1.5006e+09	140420	140420	3.62473
Cut0	:	2.1489e+06	6.05387e+06	2.42023e+06	4.22121e+06	3.19932e+06	1.845e+09	131918	0	4.85045e+07	1.91168e+09	50331.3	50331.3	1.15113
Cut1	:	369688	117.74	199206	211.807	0	9.34249e+08	2966.99	0	1.16828e+07	9.46504e+08	4663.82	4663.82	0.151593
Cut2	:	338190	79.246	130429	148.07	0	5.11411e+06	2950.05	0	648520	6.23443e+06	4633.7	4633.7	1.85511
Cut3	:	331497	0	119800	78.4665	0	5.04102e+06	1678.23	0	635554	6.12962e+06	3077.96	3077.96	1.2429
Cut4	:	126906	0	64248.8	12.5796	0	2.99956e+06	1617.35	0	341129	3.53348e+06	2988.86	2988.86	1.58936
Cut5	:	4416.64	0	10725.2	12.5796	0	47962.8	186.86	0	67884.9	131189	2184.45	2184.45	5.98147
Cut6	:	678.292	0	5960.91	0	0	37247.9	186.842	0	24094.4	68168.4	2182.38	2182.38	8.22804
Cut7	:	31.2224	0	2313.23	0	0	320.312	186.842	0	1640.5	4492.11	2182.38	2182.38	26.713
Cut8	:	13.7132	0	2209.25	0	0	21.8171	181.678	0	1475.5	3901.96	2159.05	2159.05	27.7326
Cut9	:	13.7132	0	1224.07	0	0	21.8171	181.678	0	611.5	2052.78	2159.05	2159.05	33.2681
Cut10	:	6.28661	0	674.558	0	0	4.91819	179.124	0	242.5	1107.39	2159.05	2159.05	37.7768

ILC2 Cut Table: N1N2 right polarization, ee

Polarization: (e-,e+) = (+0.8,-0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	Ch	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	5960.13	11663.4	7482.28	2943.64	741.331	2.6771e+06	233.28	26.0064	255791	2.96194e+06	223.035	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	1.35308e+06	8300	2.28257e+07	1.06721e+08	622651	622651	
Expected	:	2.98006e+06	5.83168e+06	3.74114e+06	1.47182e+06	370665	1.33855e+09	116640	13003.2	1.27896e+08	1.48097e+09	111517	111517	2.8
Cut0	:	1.90282e+06	3.36716e+06	1.71042e+06	935367	275567	1.845e+09	68230.8	0	4.82243e+07	1.90148e+09	40214.2	40214.2	0.922206
Cut1	:	348952	82.2538	136959	254.47	0	9.34249e+08	1537.28	0	1.15785e+07	9.46316e+08	3726.21	3726.21	0.121129
Cut2	:	318859	67.4158	68865.8	158.293	0	5.11411e+06	1528.65	0	576002	6.07959e+06	3701.47	3701.47	1.50074
Cut3	:	312250	0	60446	41.4731	0	5.04102e+06	876.676	0	564326	5.97896e+06	2488.21	2488.21	1.01738
Cut4	:	117226	0	28217	0.752627	0	2.99956e+06	851.716	0	299116	3.44498e+06	2419.18	2419.18	1.30293
Cut5	:	4331.67	0	6379.33	0.752627	0	47962.8	103.15	0	64744.9	123523	1786.5	1786.5	5.04675
Cut6	:	681.173	0	1788.44	0	0	37247.9	102.845	0	21055.4	60875.8	1783.83	1783.83	7.12622
Cut7	:	35.4134	0	407.908	0	0	320.312	102.845	0	479.5	1345.98	1783.83	1783.83	31.8856
Cut8	:	6.27674	0	313.128	0	0	21.8171	101.013	0	244.5	686.735	1766.12	1766.12	35.6603
Cut9	:	6.27674	0	217.76	0	0	21.8171	101.013	0	148.5	495.367	1766.12	1766.12	37.1384
Cut10	:	0.376122	0	151.715	0	0	4.91819	100.556	0	107.5	365.065	1766.12	1766.12	38.2569

ILC1 Cut Table: N1N2 left polarization, ee

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	Ch	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	1065.17	26.0064	261580	2.99861e+06	300.791	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	2.33207e+06	8300	2.26291e+07	1.07503e+08	1.0963e+06	1.0963e+06	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	532585	13003.2	1.3079e+08	1.49931e+09	150395	150395	3.8839
Cut0	:	1.84022e+06	62768.8	1.46378e+06	1.98579e+06	430258	1.845e+09	6227.38	0	4.83904e+07	1.89918e+09	16478.1	16478.1	0.378114
Cut1	:	370709	7.90279	202605	232.557	0	9.34249e+08	3491.12	0	1.15692e+07	9.46396e+08	3829.66	3829.66	0.124487
Cut2	:	339108	7.15014	131982	161.026	0	5.11411e+06	3468.38	0	553509	6.14234e+06	3796.34	3796.34	1.53131
Cut3	:	326820	0	109309	53.7053	0	4.05147e+06	3056.24	0	446325	4.93703e+06	2721.13	2721.13	1.22432
Cut4	:	124943	0	58984.8	6.28981	0	2.54505e+06	2950.29	0	242702	2.97463e+06	2611.06	2611.06	1.51325
Cut5	:	3756.07	0	9005.42	6.28981	0	29306.4	82.7328	0	54031.4	96188.3	2020.56	2020.56	6.44759
Cut6	:	495.138	0	5388.26	0	0	22010.1	82.4337	0	15209	43184.9	2017.23	2017.23	9.48802
Cut7	:	9.70654	0	2064.4	0	0	208.738	77.8352	0	133	2493.68	2007.8	2007.8	29.9256
Cut8	:	1.13998	0	2021.29	0	0	16.8989	75.2367	0	27.5	2142.06	1999.13	1999.13	31.0655
Cut9	:	1.13998	0	1050.45	0	0	16.8989	75.2367	0	27.5	1171.23	1998.89	1998.89	35.5019
Cut10	:	0	0	811.285	0	0	16.8989	75.2367	0	27.5	930.921	1998.89	1998.89	36.9291

ILC2 Cut Table: C1C1 left polarization, mu tag

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	280.839	26.0064	261580	2.99783e+06	906.095	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	622651	8300	2.26291e+07	1.05794e+08	1.35308e+06	1.35308e+06	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	140420	13003.2	1.3079e+08	1.49891e+09	453047	453047	11.7001
Cut0	:	2.97791e+06	8.92902e+06	3.0183e+06	6.29276e+06	4.18404e+06	1.34285e+09	0	0	1.23824e+08	1.49208e+09	183479	183479	4.74967
Cut1	:	215888	810057	2.19699e+06	440342	219030	1.18992e+06	0	0	860560	5.93279e+06	14217.9	14217.9	5.83025
Cut2	:	144855	232428	2.19234e+06	418755	62421.7	587577	0	0	639364	4.27774e+06	9309.7	9309.7	4.49631
Cut3	:	19467.9	18229.3	2.08897e+06	69424.5	253.387	116934	0	0	131973	2.44525e+06	3728.56	3728.56	2.38259
Cut4	:	276.316	312.952	2.04942e+06	46427.5	0	760.468	0	0	2331.05	2.09952e+06	1075.35	1075.35	0.741958
Cut5	:	142.317	107.041	2.04899e+06	34910.3	0	195.135	0	0	536.501	2.08488e+06	659.507	659.507	0.456677
Cut6	:	60.1868	9.30082	2.04838e+06	62.8483	0	163.127	0	0	57	2.04874e+06	658.22	658.22	0.459789
Cut7	:	14.0019	0.376323	2.04823e+06	12.5737	0	4.20718	0	0	0	2.04826e+06	657.357	657.357	0.459239
Cut8	:	13.2494	0	2.04823e+06	6.2839	0	4.20718	0	0	0	2.04826e+06	656.934	656.934	0.458944
Cut9	:	13.2494	0	2.04823e+06	6.2839	0	4.20718	0	0	0	2.04826e+06	656.934	656.934	0.458944

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

ILC2 Cut Table: C1C1 right polarization, mu tag

Polarization: (e-,e+) = (+0.8,-0.3)

Reduction Table

Process	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	5960.13	11663.4	7482.28	2943.64	741.331	2.6771e+06	223.035	26.0064	254270	2.96041e+06	233.28	0	
Generated	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	622651	8300	2.26291e+07	1.05794e+08	1.35308e+06	1.35308e+06	
Expected	2.98006e+06	5.83168e+06	3.74114e+06	1.47182e+06	370665	1.33855e+09	111517	13003.2	1.27135e+08	1.4802e+09	116640	116640	3.03158
Cut0	2.63307e+06	5.20654e+06	1.77488e+06	1.37424e+06	358554	1.34285e+09	0	0	1.70482e+08	1.52468e+09	94891.2	94891.2	2.43009
Cut1	176641	533942	1.68588e+06	70585.4	18470.4	1.18992e+06	0	0	1.29565e+06	4.97109e+06	7376.6	7376.6	3.30604
Cut2	116679	149108	1.68477e+06	59829.7	5680	587577	0	0	963034	3.56668e+06	4840.02	4840.02	2.56107
Cut3	15284.8	12303.1	1.67218e+06	11734	46.316	116934	0	0	205874	2.03436e+06	1911.44	1911.44	1.3395
Cut4	223.302	307.027	1.66781e+06	5614.12	0	760.468	0	0	970.673	1.67568e+06	529.063	529.063	0.408642
Cut5	127.565	112.951	1.66772e+06	3147.78	0	195.135	0	0	233.5	1.67154e+06	329.683	329.683	0.254974
Cut6	41.1958	50.6961	1.66765e+06	30.4428	0	163.127	0	0	93	1.66803e+06	329.301	329.301	0.254946
Cut7	19.6352	6.28997	1.66763e+06	0.752273	0	4.20718	0	0	0	1.66767e+06	328.945	328.945	0.254698
Cut8	7.05852	0	1.66763e+06	0.37596	0	4.20718	0	0	0	1.66765e+06	328.92	328.92	0.25468
Cut9	7.05852	0	1.66763e+06	0.37596	0	4.20718	0	0	0	1.66765e+06	328.869	328.869	0.254641
Cut10	0	0	1.66763e+06	0	0	0.999997	0	0	0	1.66764e+06	311.082	311.082	0.240871

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

ILC2 Cut Table: C1C1 left polarization, e tag

Cut10 : 2.04823e+06 1665.15 556.662 0.388663

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	280.839	26.0064	261580	2.99783e+06	906.095	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	622651	8300	2.26291e+07	1.05794e+08	1.35308e+06	1.35308e+06	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	140420	13003.2	1.3079e+08	1.49891e+09	453047	453047	11.7001
Cut0	:	2.97791e+06	8.92902e+06	3.0183e+06	6.29276e+06	4.18404e+06	1.34285e+09	0	0	1.23824e+08	1.49208e+09	183479	183479	4.74967
Cut1	:	265865	230025	2.18272e+06	270277	65378	4.69081e+06	0	0	6.68666e+06	1.43917e+07	8298.58	8298.58	2.18686
Cut2	:	160005	96429.9	2.18134e+06	257536	29874.4	2.96822e+06	0	0	5.74779e+06	1.14412e+07	6558.75	6558.75	1.93848
Cut3	:	24943.3	5657.27	2.06899e+06	46334.9	100.966	693575	0	0	1.80149e+06	4.6411e+06	3108.73	3108.73	1.44254
Cut4	:	382.466	194.352	2.04875e+06	32554.3	0	68667.2	0	0	312067	2.46262e+06	771.343	771.343	0.491452
Cut5	:	335.994	97.7404	2.04847e+06	27340.6	0	50124.8	0	0	265287	2.39165e+06	579.83	579.83	0.374886
Cut6	:	27.3275	6.29023	2.0483e+06	21.1283	0	21643.2	0	0	11707.3	2.0817e+06	579.408	579.408	0.401527
Cut7	:	7.18905	0	2.04823e+06	6.28981	0	0	0	0	0	2.04824e+06	578.967	578.967	0.404484
Cut8	:	7.18905	0	2.04823e+06	0	0	0	0	0	0	2.04823e+06	578.948	578.948	0.404472
Cut9	:	7.18905	0	2.04823e+06	0	0	0	0	0	0	2.04823e+06	578.948	578.948	0.404472

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

ILC2 Cut Table: C1C1 right polarization, e tag

Polarization: (e-,e+) = (+0.8,-0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	5960.13	11663.4	7482.28	2943.64	741.331	2.6771e+06	223.035	26.0064	254270	2.96041e+06	233.28	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	622651	8300	2.26291e+07	1.05794e+08	1.35308e+06	1.35308e+06	
Expected	:	2.98006e+06	5.83168e+06	3.74114e+06	1.47182e+06	370665	1.33855e+09	111517	13003.2	1.27135e+08	1.4802e+09	116640	116640	3.03158
Cut0	:	2.63307e+06	5.20654e+06	1.77488e+06	1.37424e+06	358554	1.34285e+09	0	0	1.70482e+08	1.52468e+09	94891.2	94891.2	2.43009
Cut1	:	243855	151696	1.68048e+06	53021.3	5527.38	4.69081e+06	0	0	8.56541e+06	1.53908e+07	4265.16	4265.16	1.08704
Cut2	:	142563	62978.7	1.68024e+06	43662.7	2700.96	2.96822e+06	0	0	7.49421e+06	1.23946e+07	3351.61	3351.61	0.951872
Cut3	:	22746.5	4149.08	1.66998e+06	9044.84	12.2397	693575	0	0	2.33334e+06	4.73285e+06	1597.22	1597.22	0.73406
Cut4	:	312.69	105.64	1.66771e+06	3634.58	0	68667.2	0	0	206941	1.94737e+06	382.664	382.664	0.274189
Cut5	:	265.245	62.2548	1.66766e+06	2575.44	0	50124.8	0	0	189651	1.91034e+06	286.24	286.24	0.207082
Cut6	:	32.9641	0.376339	1.66765e+06	25.516	0	21643.2	0	0	13499.6	1.70285e+06	286.214	286.214	0.219314
Cut7	:	12.9618	0	1.66763e+06	0.376313	0	0	0	0	0	1.66765e+06	285.883	285.883	0.22136
Cut8	:	12.9618	0	1.66763e+06	0	0	0	0	0	0	1.66765e+06	285.578	285.578	0.221124
Cut9	:	12.9618	0	1.66763e+06	0	0	0	0	0	0	1.66765e+06	285.578	285.578	0.221124

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

ILC1 Cut Table: C1C1 left polarization, mu-tag

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	300.791	26.0064	261580	2.99785e+06	1065.17	0	
Generated	:	949500	2.3467e+06	2.8488e+06	1.9401e+06	704600	7.17376e+07	1.0963e+06	8300	2.26291e+07	1.04261e+08	2.33207e+06	2.33207e+06	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	150395	13003.2	1.3079e+08	1.49892e+09	532585	532585	13.7538
Cut0	:	2.5406e+06	0	3.21083e+06	1.6053e+06	1463	1.34285e+09	6448.59	0	1.23824e+08	1.47404e+09	139638	139638	3.63688
Cut1	:	166279	0	2.05938e+06	12369.8	121.502	1.18992e+06	1135.45	0	860560	4.28976e+06	57982.8	57982.8	27.8078
Cut2	:	116859	0	2.03424e+06	6042.91	32.1319	465397	964.755	0	519208	3.14274e+06	38240.3	38240.3	21.4408
Cut3	:	24514.9	0	1.82201e+06	838.307	0	83683.4	530.5	0	109325	2.04091e+06	26085.4	26085.4	18.1438
Cut4	:	507.2	0	1.75586e+06	541.814	0	554.622	22.288	0	2234.05	1.75972e+06	14611.8	14611.8	10.9695
Cut5	:	345.949	0	1.75524e+06	514.594	0	131.168	0	0	511.501	1.75674e+06	14307.6	14307.6	10.7511
Cut6	:	152.933	0	1.75387e+06	6.28999	0	100.16	0	0	41	1.75417e+06	14295.4	14295.4	10.7497
Cut7	:	20.8147	0	1.75325e+06	0	0	3.20718	0	0	0	1.75327e+06	14230.5	14230.5	10.7039
Cut8	:	20.8147	0	1.75325e+06	0	0	3.20718	0	0	0	1.75327e+06	14229.6	14229.6	10.7032
Cut9	:	20.8147	0	1.75325e+06	0	0	3.20718	0	0	0	1.75327e+06	14180.9	14180.9	10.6667

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

ILC2 Cut Table: C1C1 left polarization, e tag

Cut10 : 2.04823e+06 1665.15 556.662 0.388663

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	280.839	26.0064	261580	2.99783e+06	906.095	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	622651	8300	2.26291e+07	1.05794e+08	1.35308e+06	1.35308e+06	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	140420	13003.2	1.3079e+08	1.49891e+09	453047	453047	11.7001
Cut0	:	2.97791e+06	8.92902e+06	3.0183e+06	6.29276e+06	4.18404e+06	1.34285e+09	0	0	1.23824e+08	1.49208e+09	183479	183479	4.74967
Cut1	:	265865	230025	2.18272e+06	270277	65378	4.69081e+06	0	0	6.68666e+06	1.43917e+07	8298.58	8298.58	2.18686
Cut2	:	160005	96429.9	2.18134e+06	257536	29874.4	2.96822e+06	0	0	5.74779e+06	1.14412e+07	6558.75	6558.75	1.93848
Cut3	:	24943.3	5657.27	2.06899e+06	46334.9	100.966	693575	0	0	1.80149e+06	4.6411e+06	3108.73	3108.73	1.44254
Cut4	:	382.466	194.352	2.04875e+06	32554.3	0	68667.2	0	0	312067	2.46262e+06	771.343	771.343	0.491452
Cut5	:	335.994	97.7404	2.04847e+06	27340.6	0	50124.8	0	0	265287	2.39165e+06	579.83	579.83	0.374886
Cut6	:	27.3275	6.29023	2.0483e+06	21.1283	0	21643.2	0	0	11707.3	2.0817e+06	579.408	579.408	0.401527
Cut7	:	7.18905	0	2.04823e+06	6.28981	0	0	0	0	0	2.04824e+06	578.967	578.967	0.404484
Cut8	:	7.18905	0	2.04823e+06	0	0	0	0	0	0	2.04823e+06	578.948	578.948	0.404472
Cut9	:	7.18905	0	2.04823e+06	0	0	0	0	0	0	2.04823e+06	578.948	578.948	0.404472

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

ILC2 Cut Table: C1C1 right polarization, e tag

Polarization: (e-,e+) = (+0.8,-0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	5960.13	11663.4	7482.28	2943.64	741.331	2.6771e+06	223.035	26.0064	254270	2.96041e+06	233.28	0	
Generated	:	949500	2.3467e+06	5.58174e+06	1.2138e+06	704600	7.17376e+07	622651	8300	2.26291e+07	1.05794e+08	1.35308e+06	1.35308e+06	
Expected	:	2.98006e+06	5.83168e+06	3.74114e+06	1.47182e+06	370665	1.33855e+09	111517	13003.2	1.27135e+08	1.4802e+09	116640	116640	3.03158
Cut0	:	2.63307e+06	5.20654e+06	1.77488e+06	1.37424e+06	358554	1.34285e+09	0	0	1.70482e+08	1.52468e+09	94891.2	94891.2	2.43009
Cut1	:	243855	151696	1.68048e+06	53021.3	5527.38	4.69081e+06	0	0	8.56541e+06	1.53908e+07	4265.16	4265.16	1.08704
Cut2	:	142563	62978.7	1.68024e+06	43662.7	2700.96	2.96822e+06	0	0	7.49421e+06	1.23946e+07	3351.61	3351.61	0.951872
Cut3	:	22746.5	4149.08	1.66998e+06	9044.84	12.2397	693575	0	0	2.33334e+06	4.73285e+06	1597.22	1597.22	0.73406
Cut4	:	312.69	105.64	1.66771e+06	3634.58	0	68667.2	0	0	206941	1.94737e+06	382.664	382.664	0.274189
Cut5	:	265.245	62.2548	1.66766e+06	2575.44	0	50124.8	0	0	189651	1.91034e+06	286.24	286.24	0.207082
Cut6	:	32.9641	0.376339	1.66765e+06	25.516	0	21643.2	0	0	13499.6	1.70285e+06	286.214	286.214	0.219314
Cut7	:	12.9618	0	1.66763e+06	0.376313	0	0	0	0	0	1.66765e+06	285.883	285.883	0.22136
Cut8	:	12.9618	0	1.66763e+06	0	0	0	0	0	0	1.66765e+06	285.578	285.578	0.221124
Cut9	:	12.9618	0	1.66763e+06	0	0	0	0	0	0	1.66765e+06	285.578	285.578	0.221124

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

ILC1 Cut Table: C1C1 left polarization, mu-tag

Polarization: (e-,e+) = (-0.8,+0.3)

Reduction Table

Process	:	2f_l	2f_h	4f_l	4f_sl	4f_h	aa_2f	N1N2	aa_4f	ae3f	BG	Signal	Signf	
Cross Section	:	6773.07	19625.1	10566.2	13232.1	8648.64	2.6771e+06	300.791	26.0064	261580	2.99785e+06	1065.17	0	
Generated	:	949500	2.3467e+06	2.84884e+06	1.9401e+06	704600	7.17376e+07	1.0963e+06	8300	2.26291e+07	1.04261e+08	2.33207e+06	2.33207e+06	
Expected	:	3.38654e+06	9.81253e+06	5.28308e+06	6.61606e+06	4.32432e+06	1.33855e+09	150395	13003.2	1.3079e+08	1.49892e+09	532585	532585	13.7538
Cut0	:	2.5406e+06	0	3.21083e+06	1.6053e+06	1463	1.34285e+09	6448.59	0	1.23824e+08	1.47404e+09	139638	139638	3.63688
Cut1	:	166279	0	2.05938e+06	12369.8	121.502	1.18992e+06	1135.45	0	860560	4.28976e+06	57982.8	57982.8	27.8078
Cut2	:	116859	0	2.03424e+06	6042.91	32.1319	465397	964.755	0	519208	3.14274e+06	38240.3	38240.3	21.4408
Cut3	:	24514.9	0	1.82201e+06	838.307	0	83683.4	530.5	0	109325	2.04091e+06	26085.4	26085.4	18.1438
Cut4	:	507.2	0	1.75586e+06	541.814	0	554.622	22.288	0	2234.05	1.75972e+06	14611.8	14611.8	10.9695
Cut5	:	345.949	0	1.75524e+06	514.594	0	131.168	0	0	511.501	1.75674e+06	14307.6	14307.6	10.7511
Cut6	:	152.933	0	1.75387e+06	6.28999	0	100.16	0	0	41	1.75417e+06	14295.4	14295.4	10.7497
Cut7	:	20.8147	0	1.75325e+06	0	0	3.20718	0	0	0	1.75327e+06	14230.5	14230.5	10.7039
Cut8	:	20.8147	0	1.75325e+06	0	0	3.20718	0	0	0	1.75327e+06	14229.6	14229.6	10.7032
Cut9	:	20.8147	0	1.75325e+06	0	0	3.20718	0	0	0	1.75327e+06	14180.9	14180.9	10.6667

```
if (iZDecayMode == 13) {  //Zmumu mode
  cut1  = "leptype==13&&nLeps1==1&&nBCAL==0";
  cut2 = "Ptmis>7";  // "jet_pt1>2 && jet_pt2>5";//&&Ptmis>10";
  cut3 = "jet_cop<1.0";
  cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  //    cut4 = "abs(jet_costheta1)<0.95&&abs(jet_costheta2)<0.95&&jet_pt1>1 && jet_pt2>1&&nTrack2>1&&(jet_nTrack-nTrack2)>1";
  cut5  = "cosJJlep<0.2&&cosJlep2<0";
  cut6  = "(Evis-Ephotonmax)<60" ;//Evis<40,17
  cut7  = "Emis>400" ;
  cut8 =  "abs(cosmis)<0.98";
  cut9 = "ptjj<50";
  //abs(jet_coll) < 0.98&&ptjj<50";
  //&&(Elep1+Elep2)>35";
  cut10 = "jj_mass < 15";//130
  //cut10 = "jj_e < 230";
```

Mass Precisions（individual channels）

√s = 500 GeV

Convert precisions of kinematic edges to those of Higgsino masses

L = 500 fb^{-1}

MN1: χ^0_1 mass　　MN2: χ^0_2 mass　　MC1: $\chi^\pm_1$ mass

Neutralino: 1 – 2%

polarization		MN1	MN2	ΔMN1	ΔMN1/MN1	ΔMN2	ΔMN2/MN2
left	mm	102.26	123.02	1.77	1.7%	1.76	1.4%
left	ee	100.30	120.81	2.17	2.2%	2.15	1.8%
right	mm	103.06	123.99	1.82	1.8%	1.81	1.5%
right	ee	103.41	124.30	1.44	1.4%	1.43	1.1%

Chargino: left pol is better than 1%

～ 2 times better than right pol

polarzation		MN1	MC1	ΔMN1	ΔMN1/MN1	ΔMC1	ΔMC1/MC1
left	mu tag	113.50	129.14	0.82	0.7%	0.82	0.6%
left	e tag	122.96	140.37	1.19	1.0%	1.18	0.8%
right	mu tag	116.42	132.44	1.76	1.5%	1.75	1.3%
right	e tag	125.34	142.98	2.20	1.8%	2.18	1.5%

Theoretic values MN1 = 102.70 GeV　　MN2 = 123.98 GeV, MC1 = 117.33 GeV