Worldwide Study of the Physics and Detectors for Future Linear e^+e^- Colliders

Measurement of Chargino Mass in $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\tau}^+\nu + \tilde{\tau}^-\nu$ at Future Linear Colliders

Yukihiro Kato,[(a)] **Mihoko M. Nojiri,**[(b)]
Keisuke Fujii,[(c)] **and Teruki Kamon**[(d)]

[a] *Kinki University,* [b] *Kyoto University,* [c] *KEK,*
[d] *Texas A&M University*

OUTLINE

Introduction

Event Selection

Event Acceptance

Determination of Chargino Mass: L Design

Determination of Chargino Mass: L vs S

Summary

• SUSY Analysis Steps

E_{cm}	Signal	BG
350 GeV (100 fb^{-1})	$\tilde{\tau}_1^+\tilde{\tau}_1^- \to \tau^+\tilde{\chi}_1^0\tau^-\tilde{\chi}_1^0$	$W^+W^- \to \tau^+\nu\tau^-\nu$ (↘ by polarized e^- beam)
$\tilde{\tau}_1^\pm$, $\tilde{\chi}_1^0$	$152.7 \pm 4.1, \quad 86.8 \pm 3.0$ GeV$/c^2$	
↓		
400-500 GeV (200 fb^{-1})	$\tilde{\chi}_1^+\tilde{\chi}_1^- \to \tilde{\tau}_1^+\tilde{\tau}_1^-$	$W^+W^- \to \tau^+\nu\tau^-\nu$ (↘ by polarized e^- beam) $\tilde{\tau}_1^+\tilde{\tau}_1^- \to \tau^+\tilde{\chi}_1^0\tau^-\tilde{\chi}_1^0$
$\tilde{\chi}_1^\pm$		
↓		
1-1.5 TeV		
$\tilde{q}$, $\tilde{\ell}/\tilde{\nu}$		
↓		
$\mu^+\mu^-$ Collider ?		

Event Selection

- **Analysis tools:**

  Event generator: BASES/SPRING

  Hadronization: LUND 7.4

  Detector simulation: L (JLC) toy simulation

- **Selection criteria:**

  (a) Two good jets with $E(j) \geq 5$ GeV

  $N(good\ track) \geq 1$ with $p_T \geq 0.1$ GeV/c

  JADE algorithm (Y-cut value ≥ 0.0025)

  (b) Acceptance for jets: $-Q_j \cdot p_z(j)/E(j) < 0.8$

  (c) $M(j) \leq 3$ GeV/c^2 (tracks)

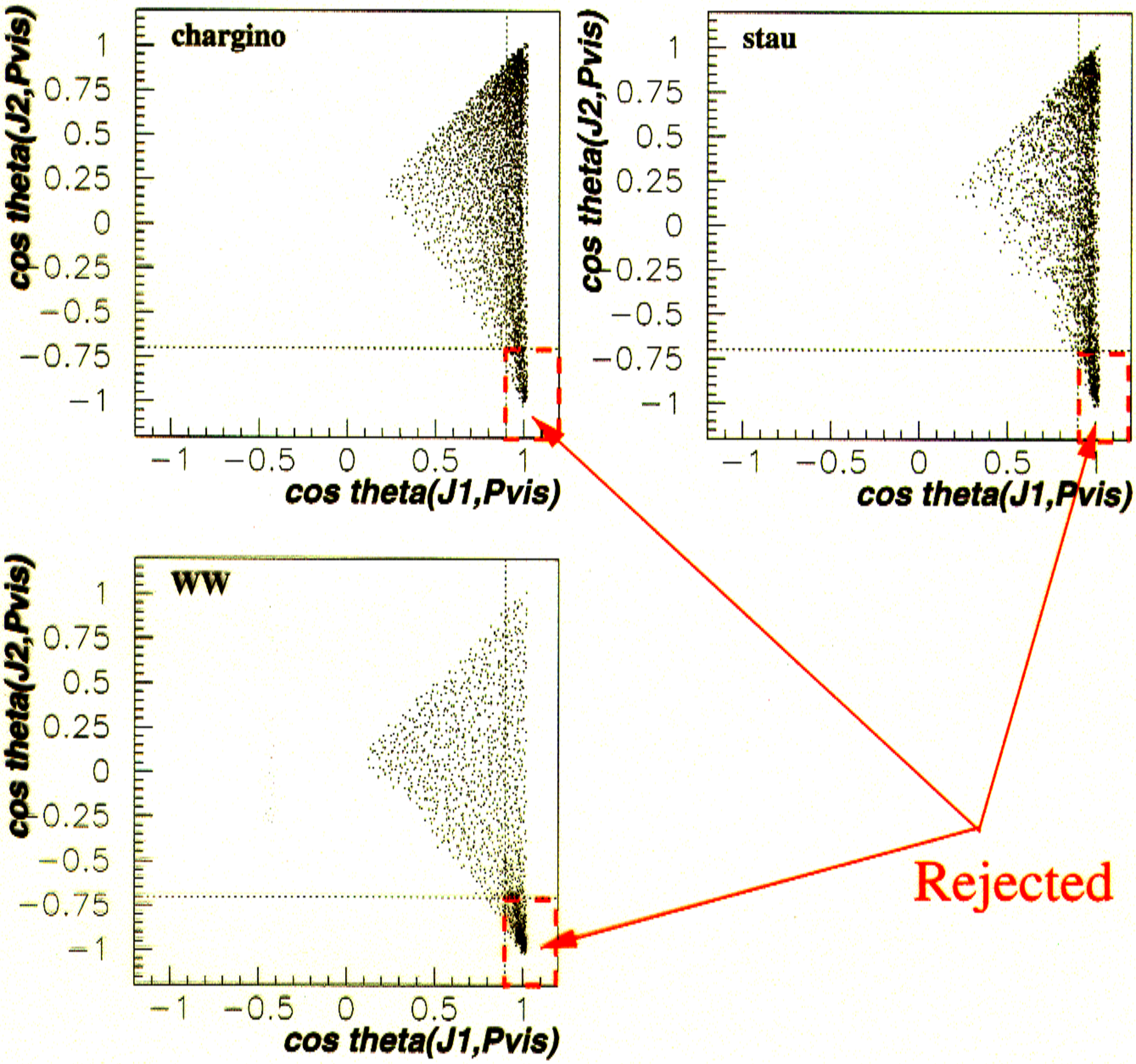
  (d) Missing p_T ($\not{p}_T$) ≥ 20 GeV/c (tracks + γ)

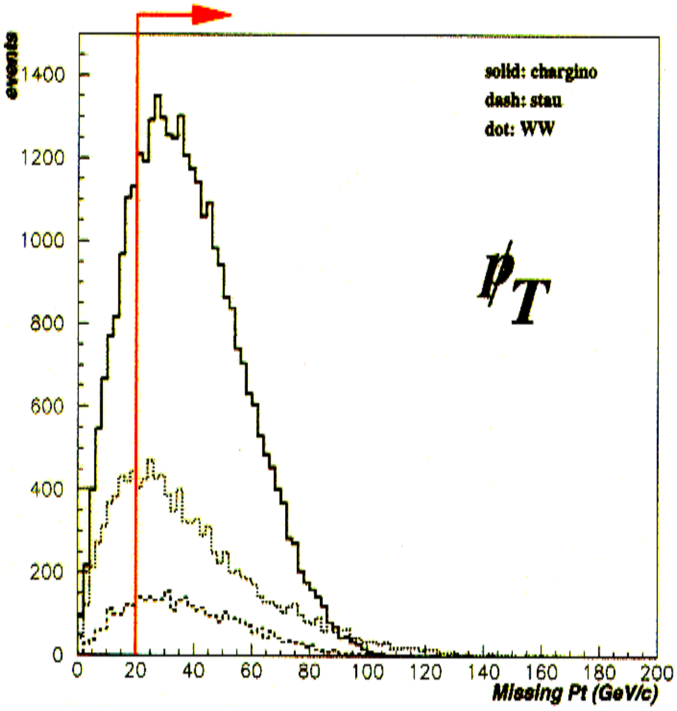
  to reduce $e^+e^- \to \overbrace{(e^+e^-)}^{forward} \tau^+\tau^-$

  $\theta_e \simeq 100$ mrad $\leftrightarrow$ $\not{p}_T \geq 20$ GeV/c

  (e) $\cos\theta(J_1, P_{vis}) \leq 0.9$ or $\cos\theta(J_2, P_{vis}) \geq -0.7$

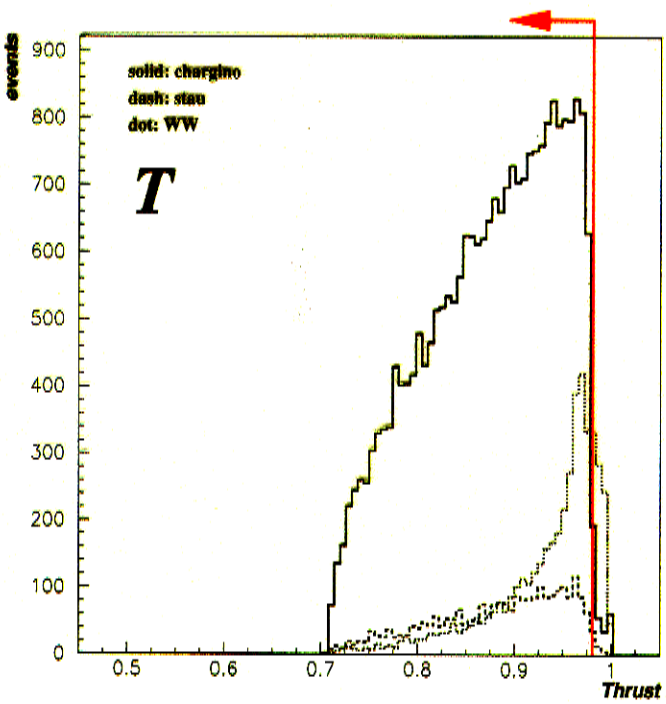
  (f) Thrust ≤ 0.98 & Acoplanarity angle $\geq 30°$

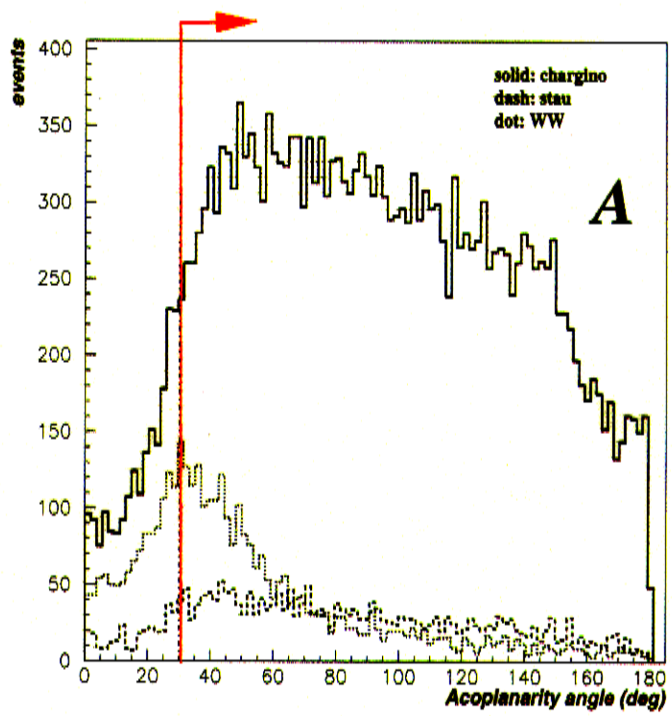

chargino
stau
WW
cos theta(J2,Pvis)
cos theta(J1,Pvis)
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1
-0.5
0
0.5
1
Rejected



$\cos\theta\ (J_i\ ,\ P_{vis}\ )$

See next page....





Event Acceptance

MC Pt. #3 (SUGRA)

$P(e^-) = -0.9$	$\tilde{\chi}_1^+\tilde{\chi}_1^-$	$\tilde{\tau}^+\tilde{\tau}^-$	W^+W^-	$\gamma\gamma$	$\frac{N_S}{\sqrt{N_B}}$
σ [fb]	305	30	256	56.2 pb	18
$N(j) \geq 2$	0.849	0.866	0.793	0.976	
Jet acceptance	0.581	0.625	0.233	0.039	53
$M(j) \leq 3$ GeV	0.538	0.596	0.227	0.039	
$\not{p}_T \geq 20$ GeV/c	0.427	0.467	0.168	5.0×10^{-4}	
$\cos\theta(J_i, P_{vis})$	0.403	0.426	0.090	3.0×10^{-4}	239
Thrust (T)	0.399	0.420	0.075	2.9×10^{-4}	
Acoplanarity (A)	0.365	0.369	0.053	4.1×10^{-5}	
N_{event} (200 fb^{-1})	22,265	2,214	2,714	460	303

Event Acceptance (cont'd)

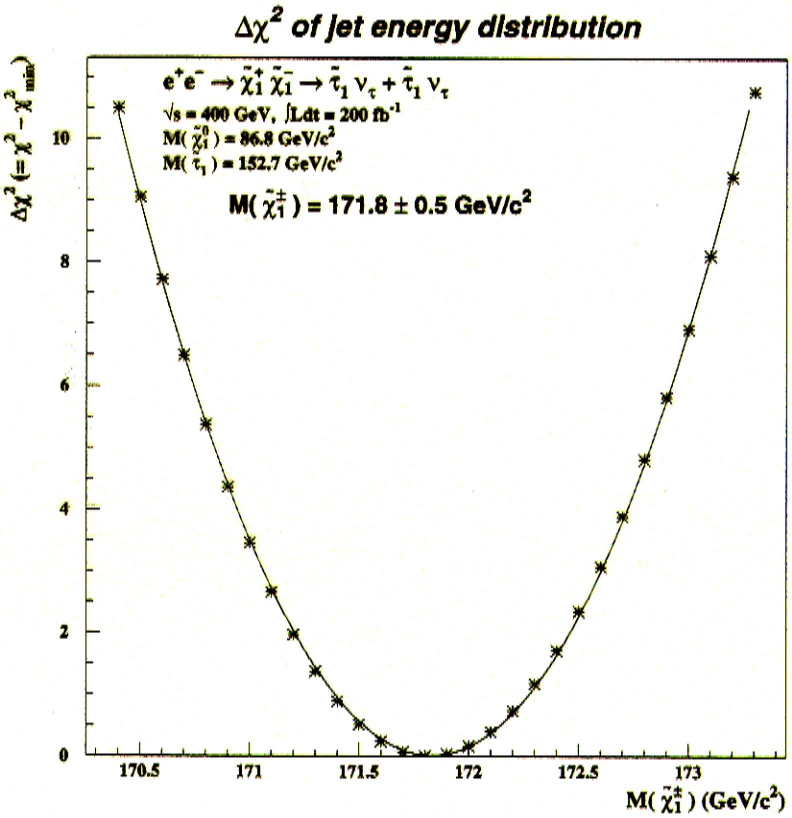
MC Pt.	σ (fb)	$M(\tilde{\chi}_1^\pm)$	$M(\tilde{\tau})$	$M(\tilde{\chi}_1^0)$	$\Delta M(\tilde{\chi}_1^\pm, \tilde{\chi}_1^0)$	ϵ (%)
1.	486	157.5	152.7	86.8	5	36
2.	440	162.5	152.7	86.8	10	36
3.	305	172.5	152.7	86.8	20	37
4.	111	192.5	152.7	86.8	40	38

↑ Very weak dependence on $M(\tilde{\chi}_1^\pm)$

- **Case A: $\tilde{\tau}_1$ and $\tilde{\chi}_1^0$ masses are fixed.**

Input (GeV/c^2)	*Output* (GeV/c^2)	$O-I$	$\frac{O-I}{\sigma}$
157.5	156.3±0.3	-1.2	-4.0
162.5	162.4±0.5	-0.1	-0.2
172.5	171.8±0.5	-0.7	-1.4
182.5	181.1±0.6	-1.4	-2.3
192.5	190.5±0.5	-2.0	-4.0

Example of the χ^2 Distribution:



- **Case B: $M(\tilde{\chi}_1^{\pm}) = 172.5$ GeV$/c^2$ (fixed)**

$M(\tilde{\tau}_1)$	$M(\tilde{\chi}_1^0)$
152.7 (nominal)	86.8 (nominal)
↓	↓
−4.1, 0, +4.1	−3.0, 0, +3.0

↘ ↙

9 combinations

↓

templates

↓

$M(\tilde{\tau}_1)$	$M(\tilde{\chi}_1^0)$	Outputs	
−	0	175.4±0.5	+3.6
0	0	171.8±0.5	
+	0	166.7±0.5	−5.1
0	−	167.0±0.5	−4.8
0	0	171.8±0.5	
0	+	174.9±0.5	+3.1
−	+	178.4±0.5	+6.6
−	−	170.6±0.5	
+	+	169.0±0.5	
+	−	162.0±1.0	-9.8

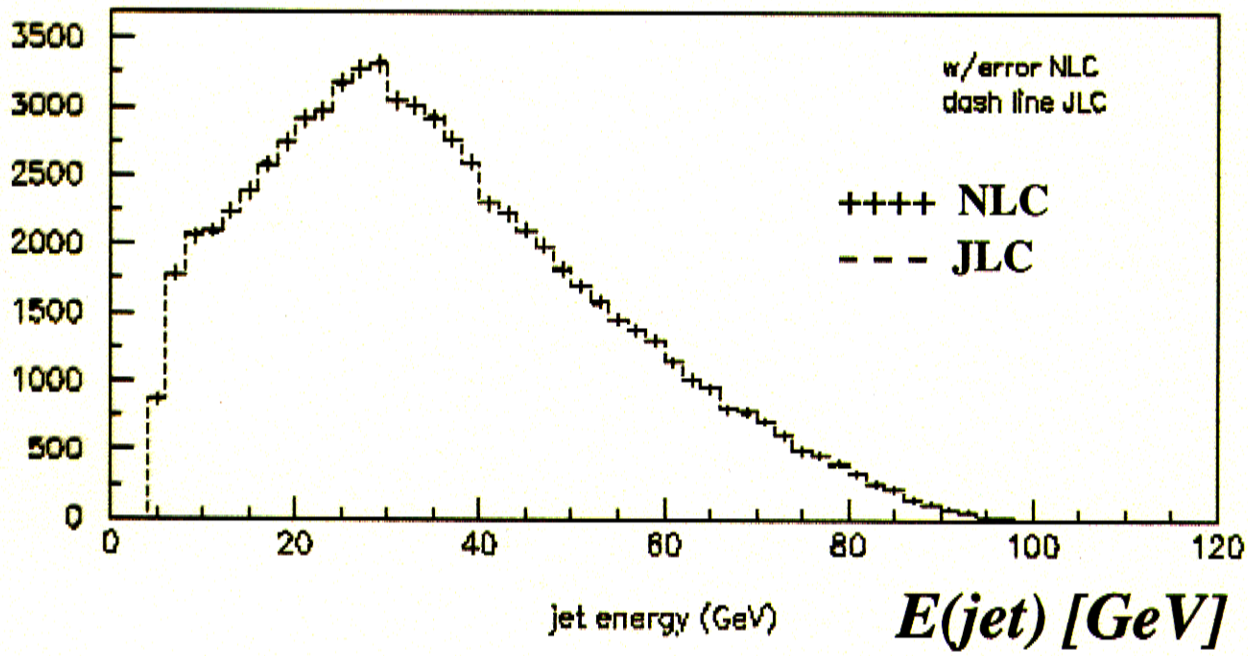
Determination of Chargino Mass: L vs S

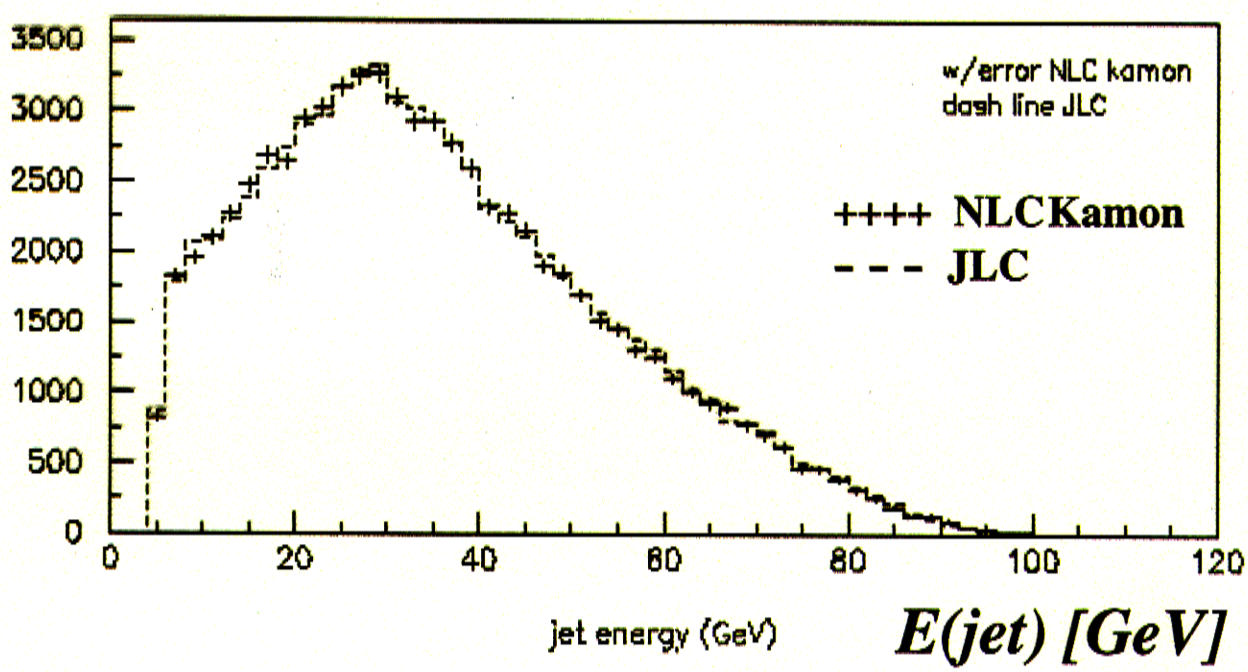
- **Calorimeter resolutiuons:**

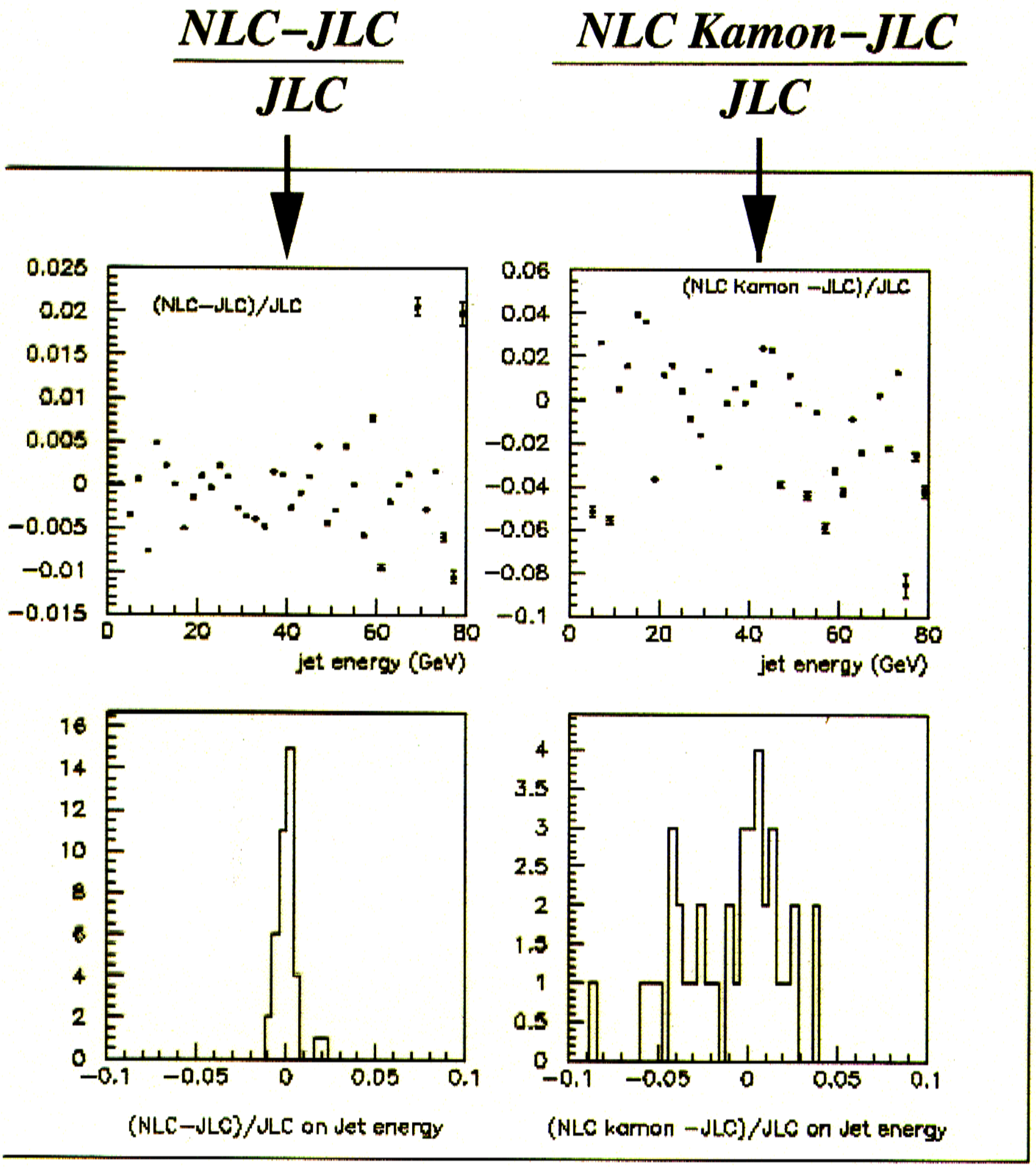
	EM	HAD
JLC (L)	$15\%/\sqrt{E} \oplus 1\%$	$40\%/\sqrt{E} \oplus 2\%$
NLC (S)	$12\%/\sqrt{E} \oplus 1\%$	$50\%/\sqrt{E} \oplus 2\%$
NLCkamon	$20\%/\sqrt{E} \oplus 1\%$	$80\%/\sqrt{E} \oplus 2\%$

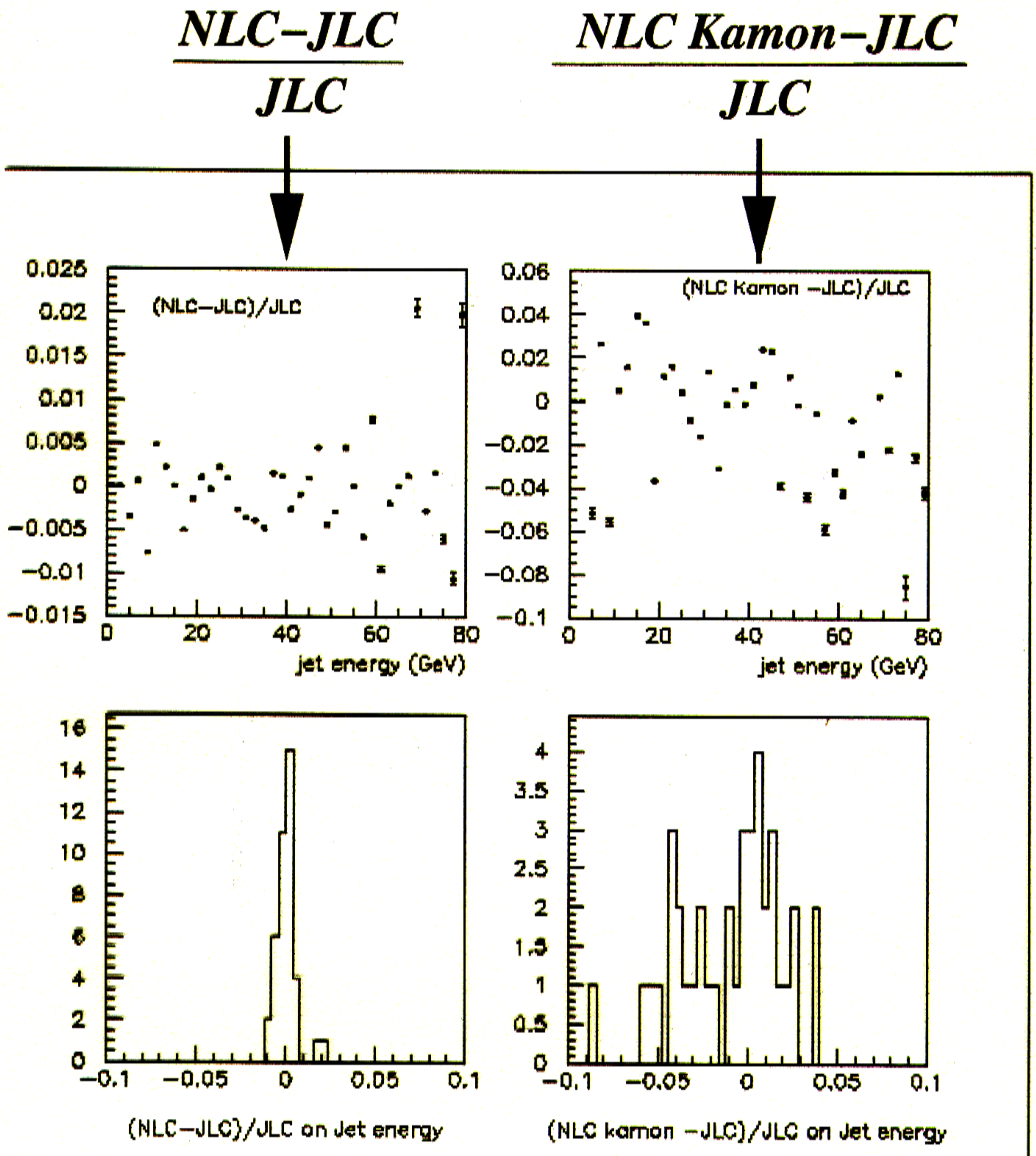
- **$E(jet)$ distributions for MC Pt. #3**

JLC vs NLC vs NLCkamon


3500
3000
2500
2000
1500
1000
500
0
0
20
40
60
80
100
120
w/error NLC
dash line JLC
++++ NLC
- - - JLC
jet energy (GeV)
E(jet) [GeV]


3500
3000
2500
2000
1500
1000
500
0
0
20
40
60
80
100
120
w/error NLC kamon
dash line JLC
++++ NLCKamon
- - - JLC
jet energy (GeV)
E(jet) [GeV]


NLC–JLC / JLC
NLC Kamon–JLC / JLC
(NLC–JLC)/JLC
(NLC Kamon –JLC)/JLC
jet energy (GeV)
jet energy (GeV)
(NLC–JLC)/JLC on Jet energy
(NLC kamon –JLC)/JLC on Jet energy


$\frac{NLC-JLC}{JLC}$
$\frac{NLC\ Kamon-JLC}{JLC}$
(NLC−JLC)/JLC
jet energy (GeV)
(NLC Kamon −JLC)/JLC
jet energy (GeV)
(NLC−JLC)/JLC on Jet energy
(NLC kamon −JLC)/JLC on Jet energy

Summary

- **Chargino decay:** $\tilde{\chi}_1^{\pm} \to \tilde{\tau}_1^{\pm}\nu \to \tau\nu\tilde{\chi}_1^0$

- **SUSY reference (SUGRA) point:**

$$\begin{cases} M(\tilde{\chi}_1^{\pm}) = 172.5 \pm XX \text{ GeV}/c^2 \\ M(\tilde{\tau}_1) = 152.5 \pm 4.1 \\ M(\tilde{\chi}_1^0) = 86.8 \pm 3.0 \end{cases}$$

- **BG:** $\tilde{\tau}_1\tilde{\tau}_1$, W^+W^-, $\gamma\gamma$

- **LC:**

$$\begin{cases} \sqrt{s} = 400 \text{ GeV} \\ \int \mathcal{L}\, dt = 200 \text{ fb}^{-1} \\ P(e^-) = -0.9 \end{cases}$$

- **L and S calorimeter resolutions**

- $XX \simeq 5$ GeV$/c^2$ **for L and S**