Chargino-Neutralino production: ISAJET+PYTHIA Checks

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- This search will be an important use of the lepton+track triggers
- Start by recreating results from CDF note 4807
- Compare latest version of ISAJET with older versions and PYTHIA
- 1000 events: chargino-neutralino with all decays
  - Send through CDF SIM, production (4.5.2), evt-ntuplizer
  - Add tau (evt-ntuple) information as soon as possible
    (or switch to std. ntuple ...)

Appendix from CDF 4807

Table 6: Cross check of Table 1 using ISAJET 7.37.

(ISAJET 7.37)	(1)	(1a)	(1b)	(2)	(2a)	(3)	(3a)
m_0	100	100	300	400	150	100	70
$m_{1/2}$	200	150	150	200	150	150	150
A_0	0	0	0	0	0	0	0
$\tan\beta$	2	2	2	35	35	10	10
$sgn(\mu)$	+1	+1	+1	+1	+1	+1	+1
Mass (GeV/c^2)							
$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$	144/146	98/102	106/108	150/150	105/106	102/104	102/104
$\tilde{\chi}_1^0$	77	52	56	80	58	56	56
$\tilde{e}_R/\tilde{\tau}_1$	131/130	121/120	307/307	410/351	167/114	124/116	101/92
$\tilde{g}/\tilde{q}$	535/476	419/379	431/464	556/608	420/392	422/380	421/375
$\tilde{b}_1$	442	351	405	494	315	351	346
$\tilde{t}_1$	309	233	264	423	278	268	265
h	91	87	89	113	110	109	109
Branching Ratio (%)							
$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 e^\pm \nu$	7.0	15.4	11.3	10.4	7.5	15.4	0.5
$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 \tau^\pm \nu$	7.0	15.4	11.3	10.6	42.4	19.8	0.5
$\tilde{\chi}_1^\pm \to \tilde{\tau}_1^\pm \nu$	56.4	0.0	0.0	0.0	0.0	0.0	97.9
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 e^+ e^-$	0.1	17.1	2.5	1.7	0.3	8.8	0.0
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tau^+ \tau^-$	0.1	18.4	2.8	3.0	73.6	31.4	0.0
$\tilde{\chi}_2^0 \to \tilde{e}_R{}^\pm e^\mp$	29.7	0.0	0.0	0.0	0.0	0.0	1.9
$\tilde{\chi}_2^0 \to \tilde{\tau}_1^\pm \tau^\mp$	39.6	0.0	0.0	0.0	0.0	0.0	95.6
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 b\bar{b}$	0.0	2.0	27.8	25.2	14.4	5.8	0.0
Trilepton Branching Ratio (%)							
$\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \to$							
$\ell\ell\ell + X$	8.3	10.5	1.1	0.71	0.09	5.4	0.04
$\tau\ell\ell + X$	37.8	5.3	0.57	0.36	0.25	3.5	3.74
$\ell\tau\tau + X$	5.6	5.7	0.62	0.63	11.0	9.7	0.96
$\tau\tau\tau + X$	25.2	2.8	0.32	0.32	31.2	6.2	94.1

CDF 4807 TABLE 1

Table 1: Examples of mSUGRA points for the $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ search. The $\tilde{q}$ mass is the average of the 1st and 2nd generation squark masses. The cross sections are obtained at $\sqrt{s} = 2.0$ TeV using CTEQ3L [12] parton distribution functions.

(ISAJET 7.44)	(1)	(1a)	(1b)	(2)	(2a)	(3)	(3a)
m_0	100	100	300	400	150	100	70
$m_{1/2}$	200	150	150	200	150	150	150
A_0	0	0	0	0	0	0	0
$\tan\beta$	2	2	2	35	35	10	10
$sgn(\mu)$	+1	+1	+1	+1	+1	+1	+1
Mass (GeV/c^2)							
$\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$	143/145	97/101	107/109	151/152	104/105	100/103	100/102
$\tilde{\chi}_1^0$	76	52	56	80	58	56	56
$\tilde{e}_R/\tilde{\tau}_1$	131/130	121/120	307/307	410/350	167/115	124/116	101/92
$\tilde{g}/\tilde{q}$	510/450	395/354	409/447	531/587	398/369	395/353	394/346
$\tilde{b}_1$	415	324	383	463	288	323	319
$\tilde{t}_1$	287	216	240	395	262	251	248
h	89	85	87	111	108	107	107
Branching Ratio (%)							
$\tilde{\chi}_1^{\pm} \to \tilde{\chi}_1^0 e^{\pm}\nu$	7.9	15.4	11.3	10.4	8.2	15.4	0.1
$\tilde{\chi}_1^{\pm} \to \tilde{\chi}_1^0 \tau^{\pm}\nu$	6.7	14.1	11.2	10.5	36.2	16.0	0.1
$\tilde{\chi}_1^{\pm} \to \tilde{\tau}_1^{\pm}\nu$	50.9	0.0	0.0	0.0	0.0	0.0	96.7
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 e^+e^-$	0.1	17.6	2.7	1.6	0.0	9.4	0.0
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tau^+\tau^-$	0.1	18.8	3.0	3.0	67.1	29.5	0.0
$\tilde{\chi}_2^0 \to \tilde{e}_R{}^{\pm}e^{\mp}$	30.2	0.0	0.0	0.0	0.0	0.0	0.1
$\tilde{\chi}_2^0 \to \tilde{\tau}_1^{\pm}\tau^{\mp}$	38.5	0.0	0.0	0.0	0.0	0.0	97.8
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 b\bar{b}$	0.0	2.1	28.5	26.1	18.8	7.1	0.0
Trilepton Branching Ratio (%)							
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to$							
$\ell\ell\ell + X$	9.6	10.8	1.2	0.67	0.0	5.8	0.0
$\tau\ell\ell + X$	34.9	5.0	0.60	0.34	0.0	3.0	0.19
$\ell\tau\tau + X$	6.1	5.8	0.68	0.62	11.0	9.1	0.20
$\tau\tau\tau + X$	22.2	2.7	0.34	0.32	24.3	4.7	94.7
Cross-section for $p\bar{p} \to \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ (fb)							
	174	932	856	168	694	770	788

20% lower

Mostly small changes

Table 1: Cross check of Table 1 using ISAJET 7.63.

(ISAJET 7.63)	(1)	(1a)	(1b)	(2)	(2a)	(3)	(3a)
m_0	100	100	300	400	150	100	70
$m_{1/2}$	200	150	150	200	150	150	150
A_0	0	0	0	0	0	0	0
$\tan\beta$	2	2	2	35	35	10	10
$sgn(\mu)$	+1	+1	+1	+1	+1	+1	+1
Mass (GeV/c^2)							
$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$	130/133	87/92	96/98	136/137	96/97	92/94	91/94
$\tilde{\chi}_1^0$	72	48	52	76	55	53	53
$\tilde{e}_R/\tilde{\tau}_1$	129/128	119/118	306/306	408/346	166/107	122/114	99/90
$\tilde{g}/\tilde{q}$	484/445	375/350	388/440	505/579	377/367	375/351	373/345
$\tilde{b}_1$	406	317	377	482	304	317	312
$\tilde{t}_1$	283	210	244	397	256	244	239
h	90	85	87	112	108	107	107
Branching Ratio (%)							
$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 e^\pm \nu$	14.8	15.1	11.3	10.5	7.6	15.4	5.3
$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 \tau^\pm \nu$	14.9	15.2	11.3	10.8	42.6	18.1	5.5
$\tilde{\chi}_1^\pm \to \tilde{\tau}_1^\pm \nu$	7.1	—	—	—	—	—	75.5
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 e^+ e^-$	0.4	16.9	2.2	1.7	0.3	9.1	0.6
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tau^+ \tau^-$	0.4	17.8	2.5	3.2	82.4	26.1	0.1
$\tilde{\chi}_2^0 \to \tilde{e}_R{}^\pm e^\mp$	30.2	—	—	—	—	—	—
$\tilde{\chi}_2^0 \to \tilde{\tau}_1^\pm \tau^\mp$	34.0	—	—	—	—	—	96.6
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 b\bar{b}$	0.1	1.8	25.8	19.9	5.1	6.2	0.1
Trilepton Branching Ratio (%)							
$\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \to$							
$\ell\ell\ell + X$	18.1	10.2	1.0	0.7	0.1	5.6	0.1
$\tau\ell\ell + X$	13.4	5.1	0.5	0.4	0.3	3.3	1.0
$\ell\tau\tau + X$	10.2	0.0	0.6	0.7	12.5	8.0	10.3
$\tau\tau\tau + X$	7.6	0.0	0.3	0.3	35.1	4.7	78.3
Cross-section for $p\bar{p} \to \tilde{\chi}_1^\pm \tilde{\chi}_2^0$ (fb)							
Isajet	138	775	666	135	553	629	620
CdfSim(7.51)	134	723	623	120	513	594	617

Table 1: Pythia (6.203) and Isajet (7.63) Comparison

	P 1	I 1	P 1a	I 1a	P 1b	I 1b	P 2	I 2	P 2a	I 2a	P 3	I 3	P 3a	I 3a
m_0	100	100	100	100	300	300	400	400	150	150	100	100	70	70
$m_{1/2}$	200	200	150	150	150	150	200	200	150	150	150	150	150	150
A_0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$\tan\beta$	2	2	2	2	2	2	35	35	35	35	10	10	10	10
$sgn(\mu)$	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Mass (GeV/c^2)														
$\tilde{\chi}_1^\pm$	130	130	87	87	95	96	136	136	95	96	91	92	91	91
$\tilde{\chi}_2^0$	133	133	92	92	98	98	137	137	97	97	94	94	94	94
$\tilde{\chi}_1^0$	72	72	48	48	52	52	76	76	55	55	53	53	53	53
$\tilde{e}_R$	129	129	119	119	306	306	408	408	166	166	122	122	99	99
$\tilde{\tau}_1$	128	128	118	118	306	306	346	346	109	107	114	114	89	90
$\tilde{g}$	484	484	374	375	388	388	505	505	377	377	375	375	373	373
$\tilde{q}$	445	445	350	350	440	440	579	579	367	367	351	351	345	345
$\tilde{b}_1$	406	406	317	317	377	377	476	482	293	304	315	317	310	312
$\tilde{t}_1$	280	283	209	210	242	244	397	397	256	256	244	244	240	239
h	86	90	82	85	84	87	110	112	107	108	106	107	106	107
Branching Ratio (%)														
$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 e^\pm \nu$	14.7	14.8	14.8	15.1	11.2	11.3	10.5	10.5	11.3	7.6	15.0	15.4	5.1	5.3
$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 \tau^\pm \nu$	16.0	14.9	16.0	15.2	11.3	11.3	10.5	10.8	13.8	42.6	19.4	18.1	13.1	5.5
$\tilde{\chi}_1^\pm \to \tilde{\tau}_1^\pm \nu$	5.8	7.1	—	—	—	—	—	—	—	—	—	—	68.7	75.5
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 e^+ e^-$	0.4	0.4	15.3	16.9	1.9	2.2	1.7	1.7	1.1	0.3	8.5	9.1	0.5	0.6
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tau^+ \tau^-$	0.4	0.4	16.1	17.8	1.9	2.5	1.5	3.2	29.2	82.4	13.8	26.1	0.5	0.1
$\tilde{\chi}_2^0 \to \tilde{e}_R{}^\pm e^\mp$	29.0	30.2	—	—	—	—	—	—	—	—	—	—	—	—
$\tilde{\chi}_2^0 \to \tilde{\tau}_1^\pm \tau^\mp$	35.8	34.0	—	—	—	—	—	—	—	—	—	—	95.2	96.6
$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 b\bar{b}$	0.1	0.1	1.9	1.8	27.4	25.8	19.4	19.9	16.2	5.1	7.1	6.2	0.1	0.1
Trilepton Branching Ratio (%) $\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \to$														
$\ell\ell\ell + X$	17.3	18.1	9.1	10.2	0.9	1.0	0.7	0.7	0.5	0.1	5.1	5.6	0.1	0.1
$\tau\ell\ell + X$	12.8	13.4	4.9	5.1	0.4	0.5	0.4	0.4	0.3	0.3	3.3	3.3	0.8	1.0
$\ell\tau\tau + X$	10.6	10.2	4.8	0.0	0.4	0.6	0.3	0.7	6.6	12.5	4.1	8.0	9.8	10.3
$\tau\tau\tau + X$	7.9	7.6	2.6	0.0	0.2	0.3	0.2	0.3	4.0	35.1	2.7	4.7	78.3	78.3

FROM CDF 4807

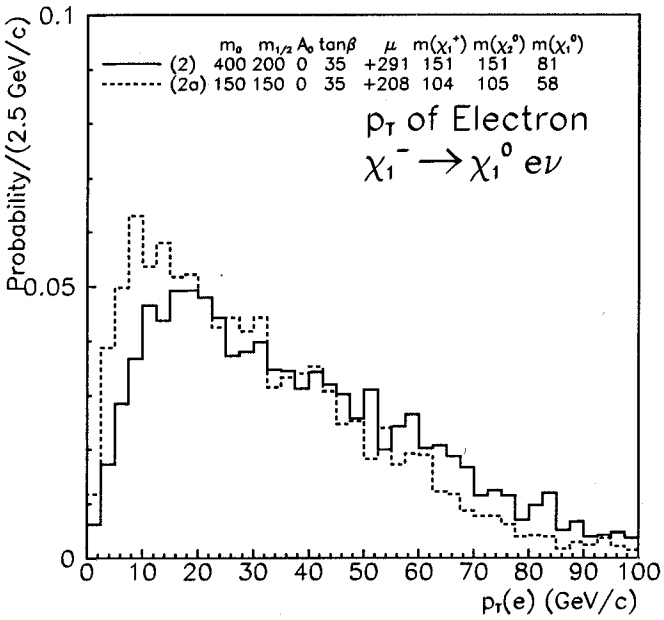


Figure 1: p_T distribution of electrons from $\tilde{\chi}_1^{\pm} \to e\nu\tilde{\chi}_1^0$ in $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to e\tau\tau + X$ events. No cut on η is applied.

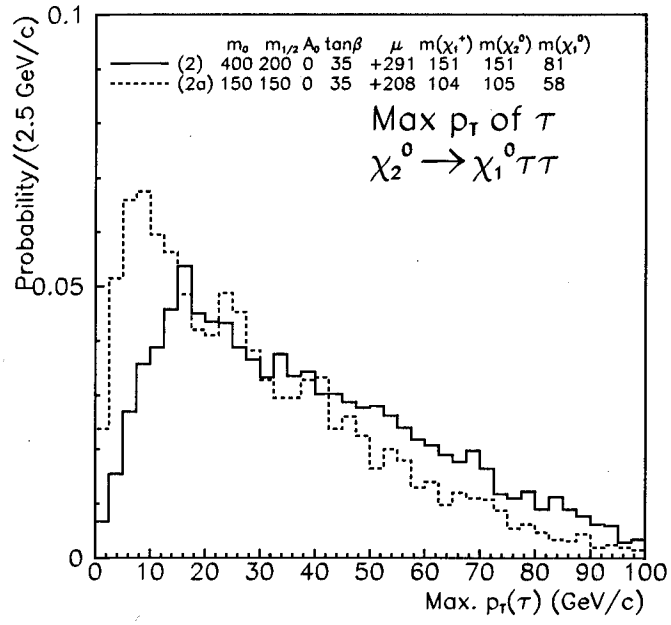


Figure 2: p_T distribution of leading τ's from $\tilde{\chi}_2^0 \to \tau\tau\tilde{\chi}_1^0$ in $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to e\tau\tau + X$ events. No cut on η is applied.

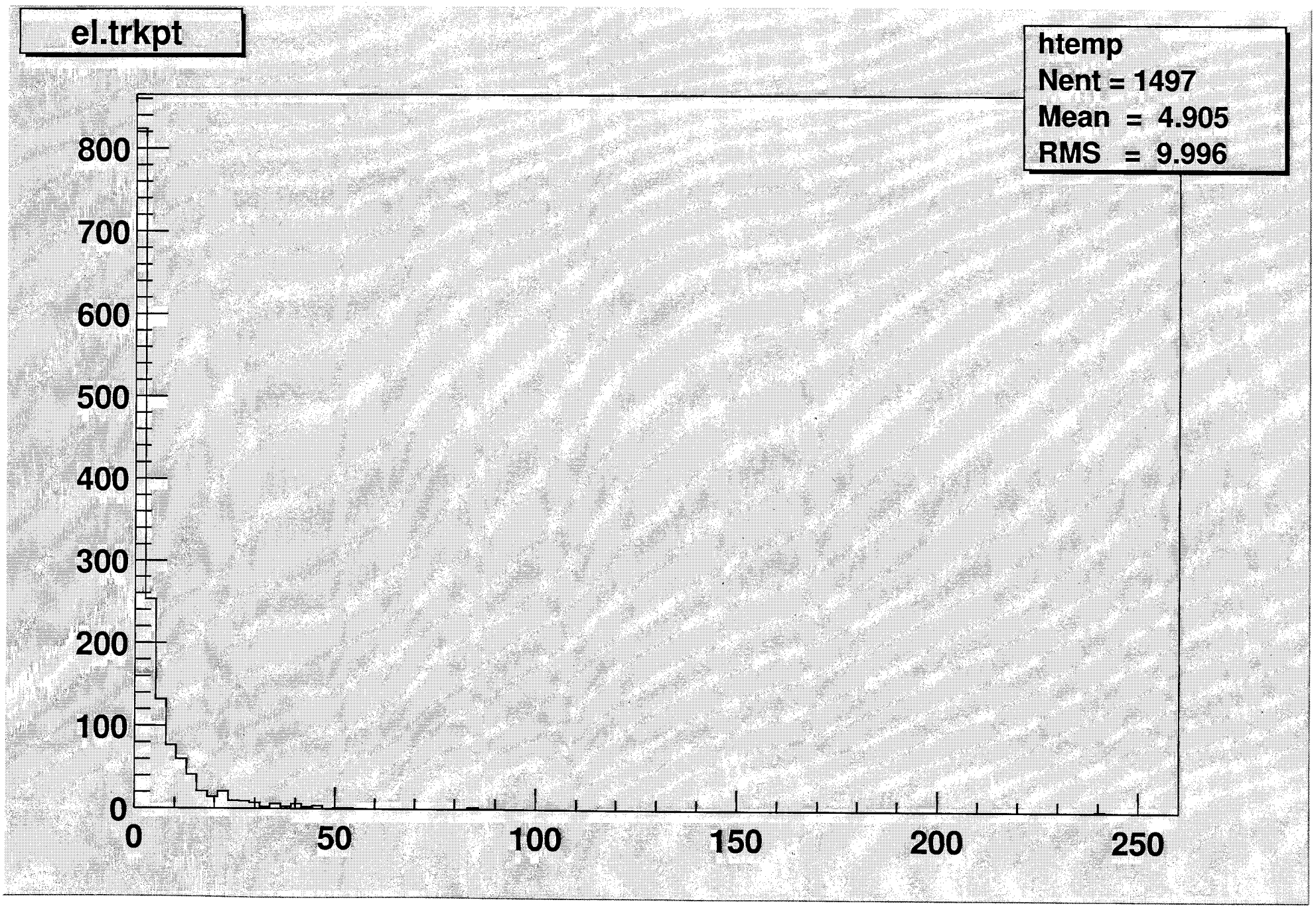
by requiring $p_T(\ell_{1,2}) > 10$, 5 GeV/c, $E_T^{\rm vis}(\tau) > 15$ GeV, and $\not{E}_T > 15$ GeV, or $p_T(\ell_{1,2}) > 5$, 5 GeV/c, $E_T^{\rm vis}(\tau) > 15$ GeV, and $\not{E}_T > 35$ GeV. The result is that there is no reach beyond LEP II.

Figures 1 and 2 show p_T distributions of electrons from $\tilde{\chi}_1^{\pm} \to e\nu\tilde{\chi}_1^0$ and one of two τ's with larger p_T from $\tilde{\chi}_2^0 \to \tau\tau\tilde{\chi}_1^0$, respectively, in $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to e\tau\tau + X$ events for Points (2) and (2a) generated by using ISAJET 7.44 [11]. Figures 3 and 4 show corresponding η distributions. For electrons and τ's in the central region ($|\eta| < 0.9$), a cut of $p_T > 10$ GeV/c accepts $> 80\%$ of $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to e\tau\tau + X$ events. Our goal is thus to design a lepton-track trigger with $E_T(e) \simeq$ 5–10 GeV and $p_T(\tau) \simeq$ 5–15 GeV/c.

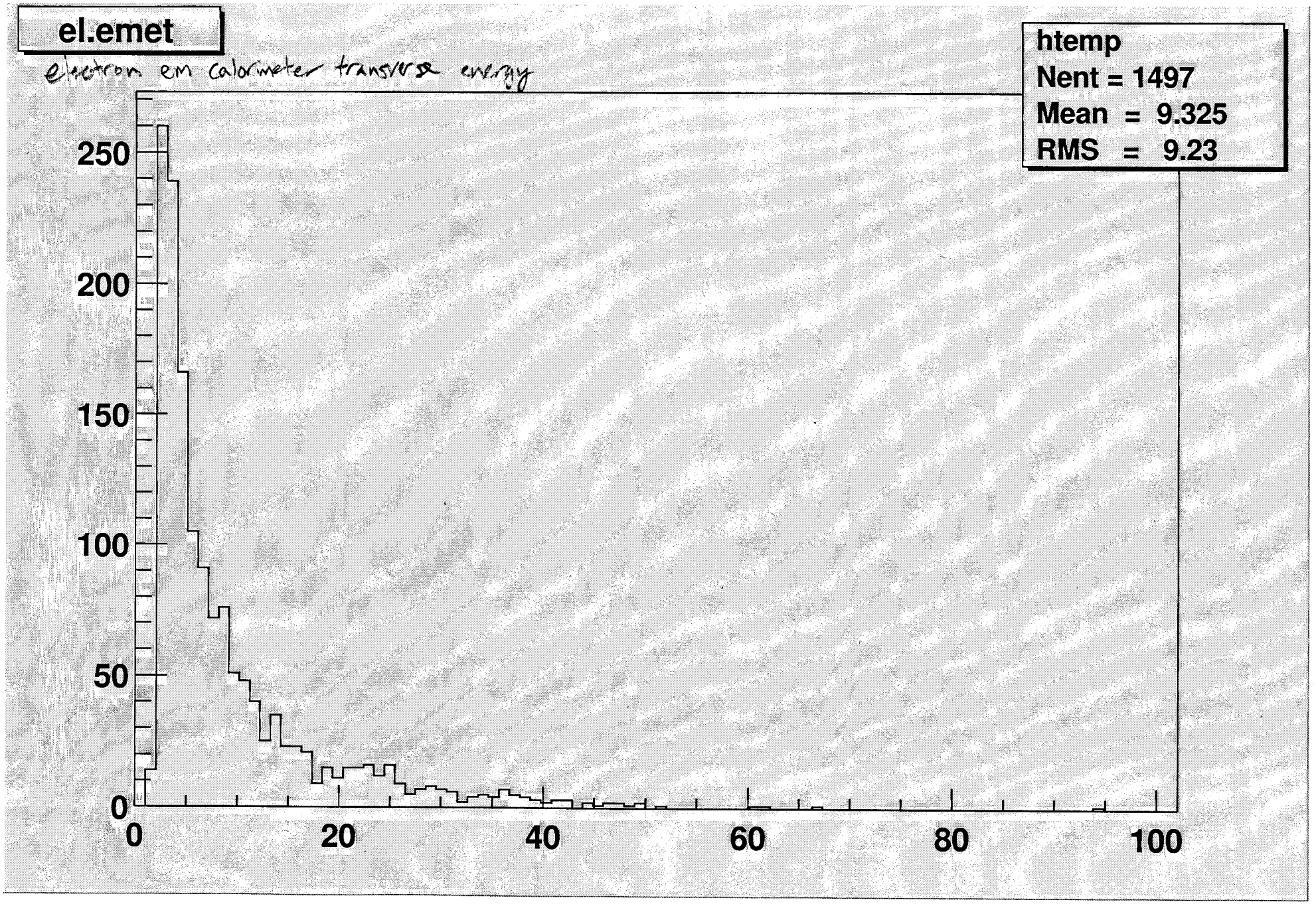
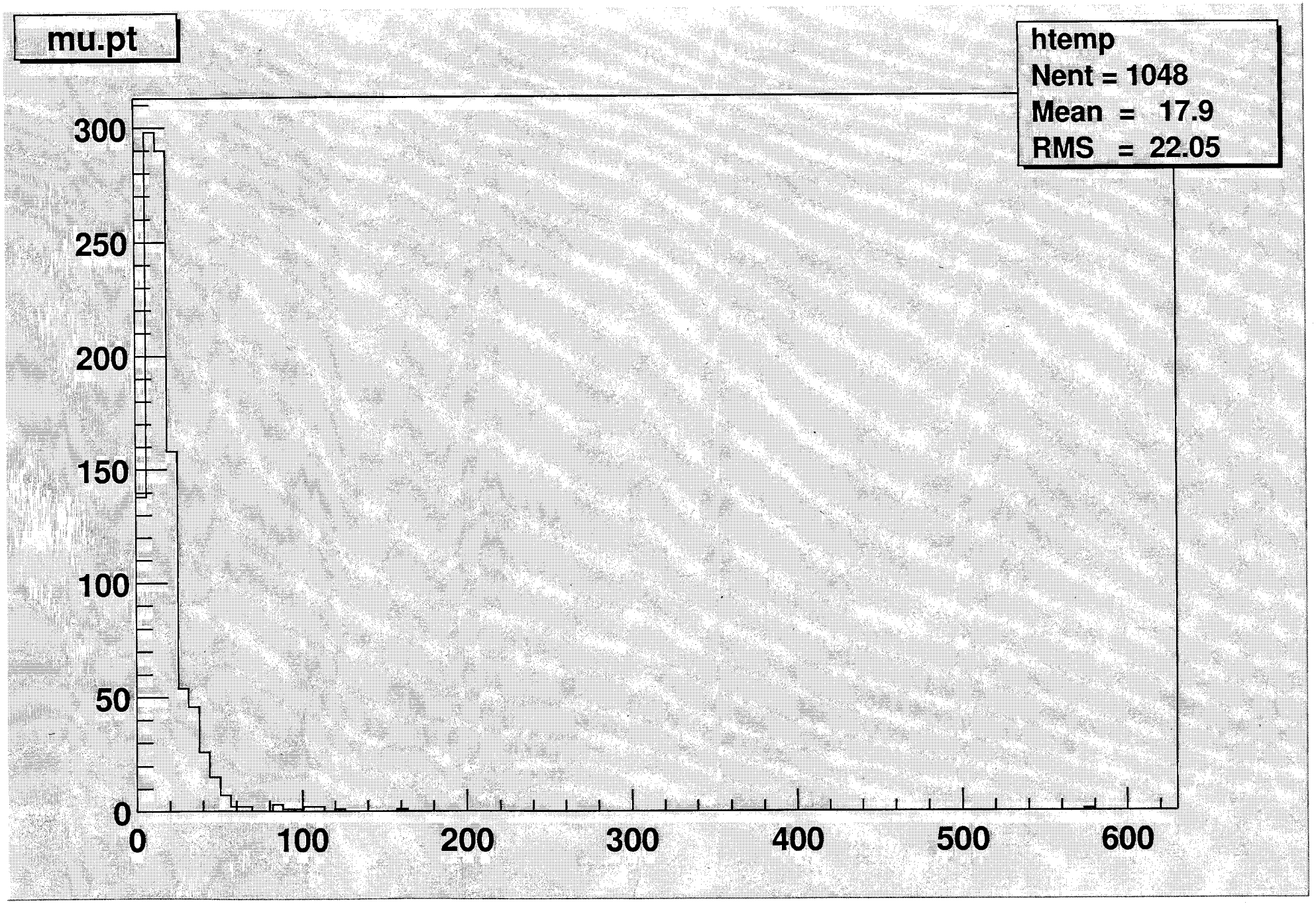
There are physics analyses involving τ's in Run I. Table 2 lists identification cuts for τ's in a search for $t \to H^+b \to \tau\nu b$ [13]. They are designed for high-p_T τ's expected from decays of large mass objects such as W and $H^{\pm}$. Figure 5 shows a distribution of the charged track multiplicity in a 10° cone obtained from large-$\not{E}_T$ plus jet events [14, 15]. Clear excesses of one and three charged particles in the distribution are attributed to $W \to \tau(\to \text{hadrons})\nu$ events. Figure 6 shows the p_T distribution of τ's from Monte Carlo $W \to \tau\nu$ decays. The E_T cuts for the τ objects in these analyses are between 20–30 GeV, which is too high for our SUSY search [4].

There is also a study on a τ trigger for Run II as summarized in Table 3 [16]. The result for ZH^0 ($M_{H^0} = 120$ GeV/c^2) is obtained using SHW [17], a toy detector simulation developed for the SUSY/Higgs workshop. In this study, the SHW code is tuned to give the same event acceptance as in the CDF charged Higgs search [13]. The $W \to \tau\nu$ result

SUGRA point 3a, ISAJET (7.52) + CDFSIM



SUGRA point 3a, ISATET + CDFSIM



SUGRA point 3a, ISAJET + CMSSIM