Study of top-quark production and decay vertices with LCD fast simulation

10/26/2000

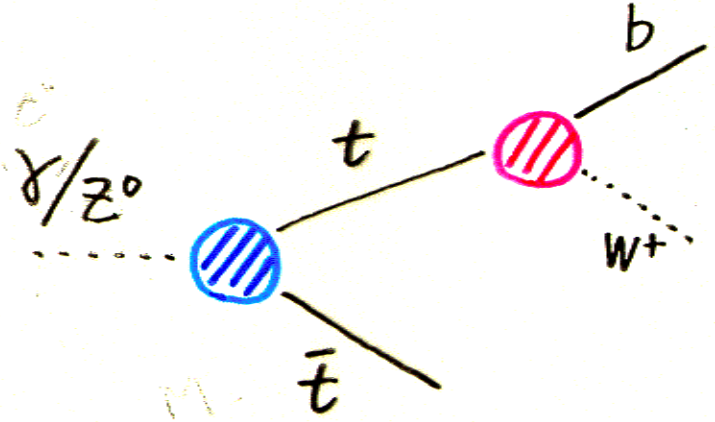
M. Iwasaki
University of Oregon

Top-quark anomalous coupling analysis

Top-quark decays before forming a hadron

→ Top spin information is transferred to its daughters

can probe the Form Factors with their angular distributions



: Form Factors

Form Factors at $t \to bW$ vertex :

$$iM = \frac{ig}{\sqrt{2}}\left\{\gamma^\mu\left[F_{1L}^W P_L + F_{1R}^W P_R\right] + \frac{i\sigma^{\mu\nu}q_\nu}{2m_t}\left[F_{2L}^W P_R + F_{2R}^W P_L\right]\right\}$$

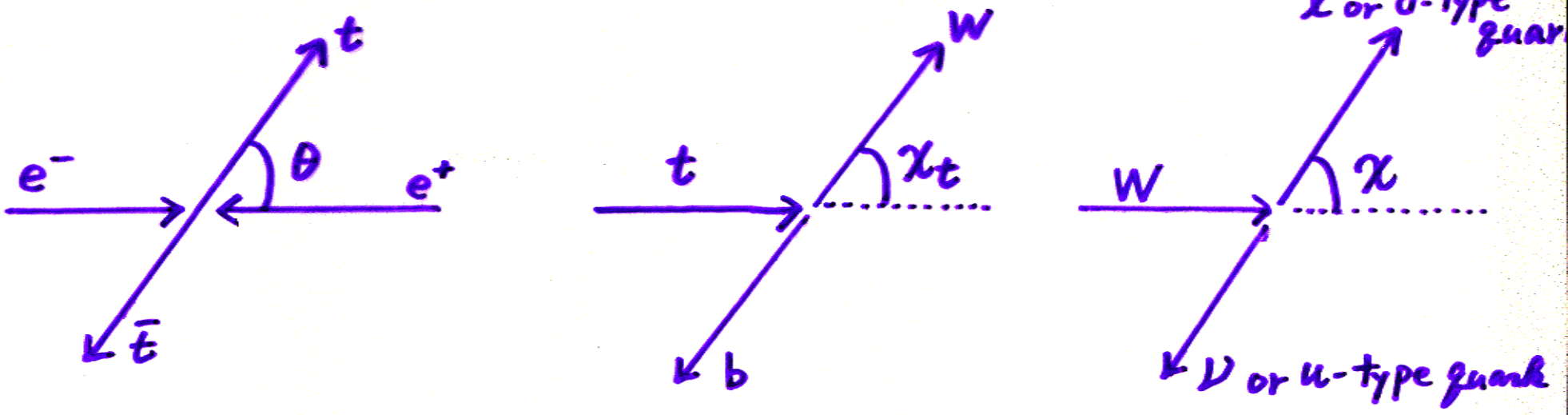
SM: $F_{1L}^W = 1$, $F_{1R}^W = 0$, $F_{2L}^W = 0$, $F_{2R}^W = 0$

Form Factors at $\gamma/Z^0 \to t\bar{t}$:

$$iM = \left\{\gamma^\mu\left[F_{1V} + F_{1A}\gamma_5\right] + \frac{i\sigma^{\mu\nu}q_\nu}{2m_t}\left[F_{2V} + F_{2A}\gamma_5\right]\right\}$$

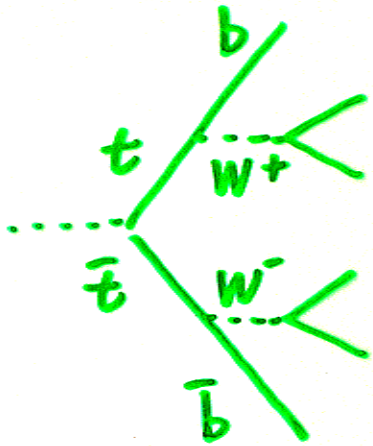
	F_{1V}	F_{1A}	F_{2V}	F_{2A}
SM (Z)	$\frac{\frac{1}{4}-\frac{2}{3}\sin^2\theta_W}{\sin\theta_W\cos\theta_W}$	$\frac{-\frac{1}{4}}{\sin\theta_W\cos\theta_W}$	0	0
(γ)	$\frac{2}{3}$	0	0	0

Here we use the angles:



Key

- good angular resolution
- We need to know
  1) which one is t or $\bar{t}$?
  2) which one is ℓ (or d-type quark) or ν (or u-type quark) in W decay ?



Signal of $t\bar{t}$ production

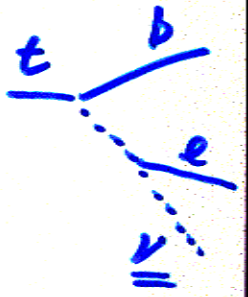
... 2b and 2W

1) 2 leptons + 2 jets

can ID $t/\bar{t}$, ℓ in both W decays, but cannot determine $t/\bar{t}$ direction (because of 2ν)

2) 1 lepton + 4 jets

can ID $t/\bar{t}$, ℓ in one W-decay, but it may difficult to determine t-direction



3) 6 jets

can reconstruct all final 6 fermion directions

but how to know $t/\bar{t}$ and d-type quark in W decay ?

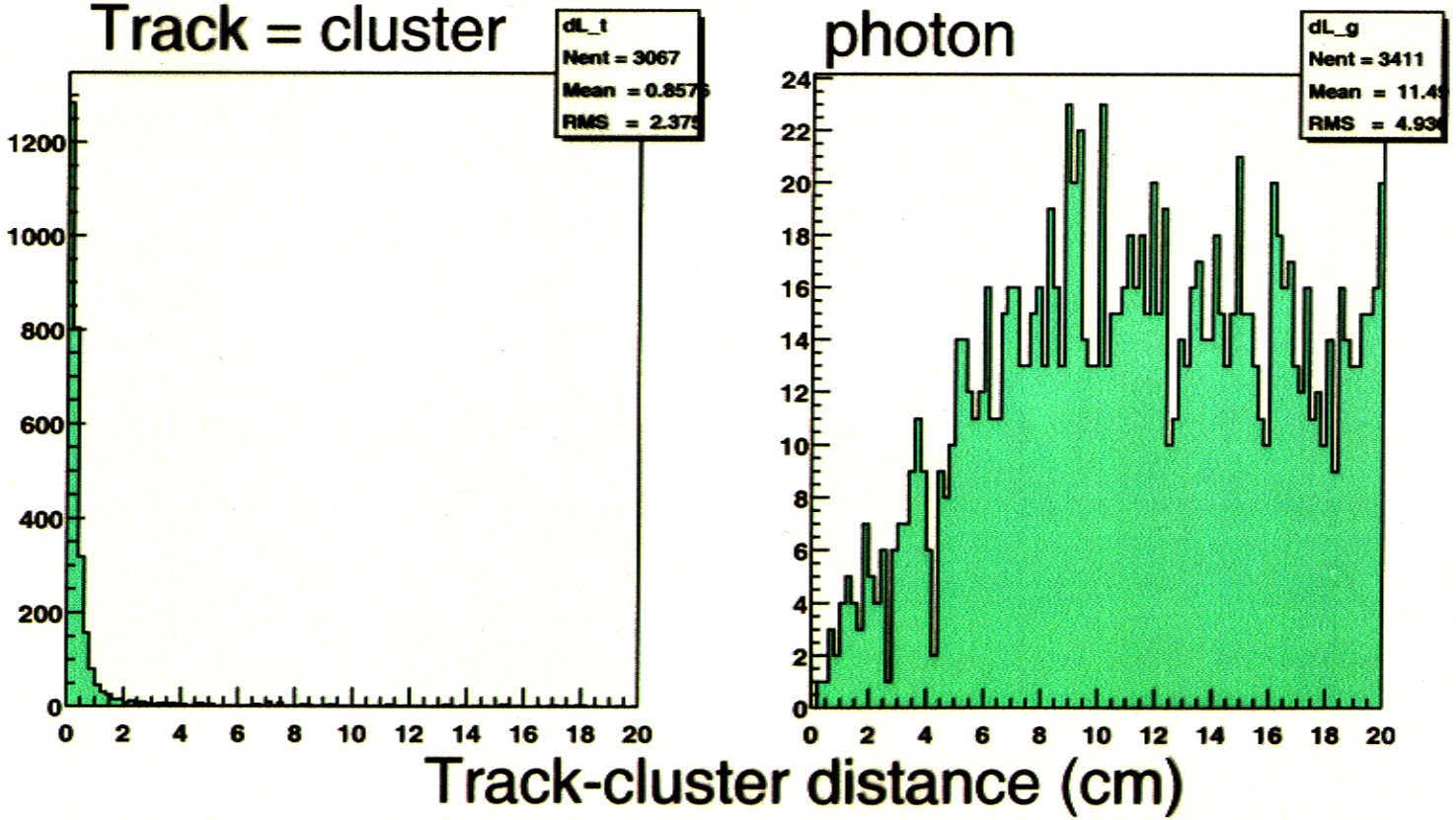
1) $t\bar{t} \rightarrow$ 4jets + 1 lepton analysis

use 60,000 $t\bar{t}$ events (Pandora-Pythia)

$m_t = 175$ GeV, $P_e = -0.8$

Reconstruct 4jets by Jet-clustering

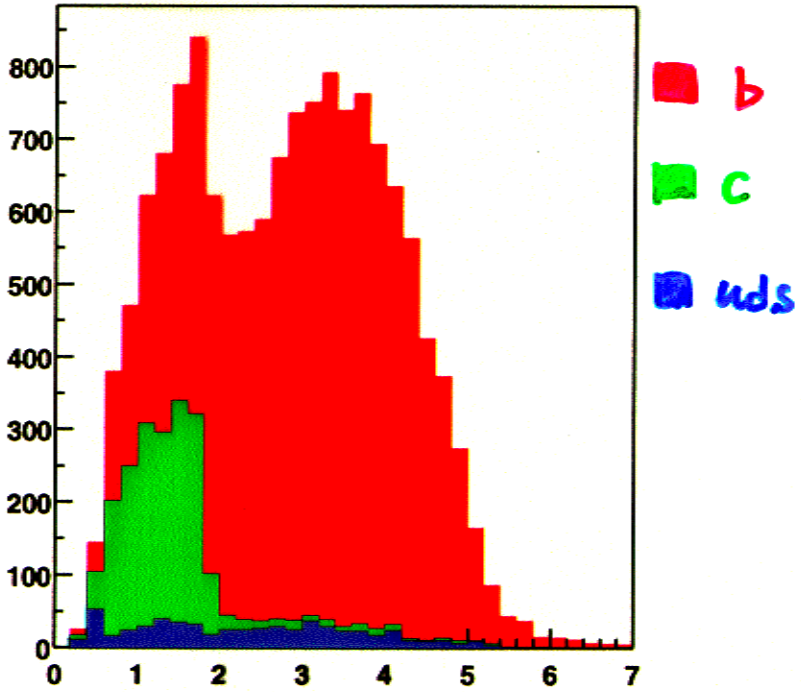
... We use energy flow objects (reject charged clusters)



Track-cluster cut .. 4cm { Neutral ε 97%
Charged rejection 93%

Flavor-tag

b-quark

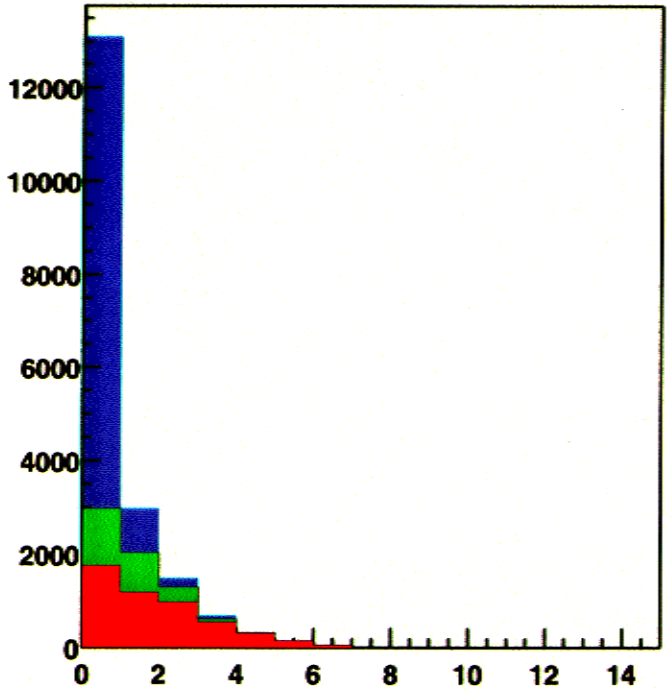


P_T corrected mass(GeV)

P_T corrected mass > 1.8 GeV

$\varepsilon_b = 62\%$ $\pi_b = 94\%$

uds-quarks

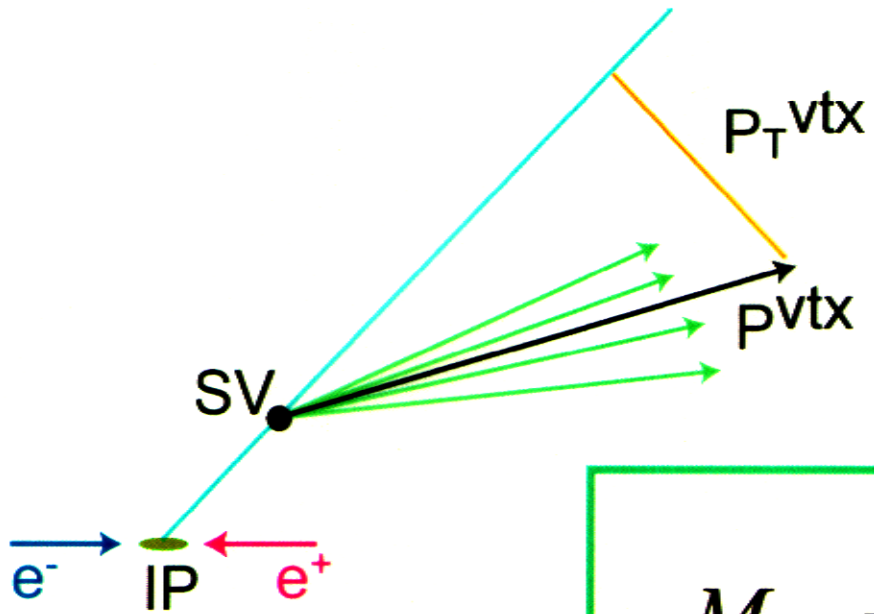


# of significant tracks in jet

$N_{sig} = 0$

$\varepsilon_{uds} = 86\%$ $\pi_{uds} = 77\%$

P_T corrected vertex mass

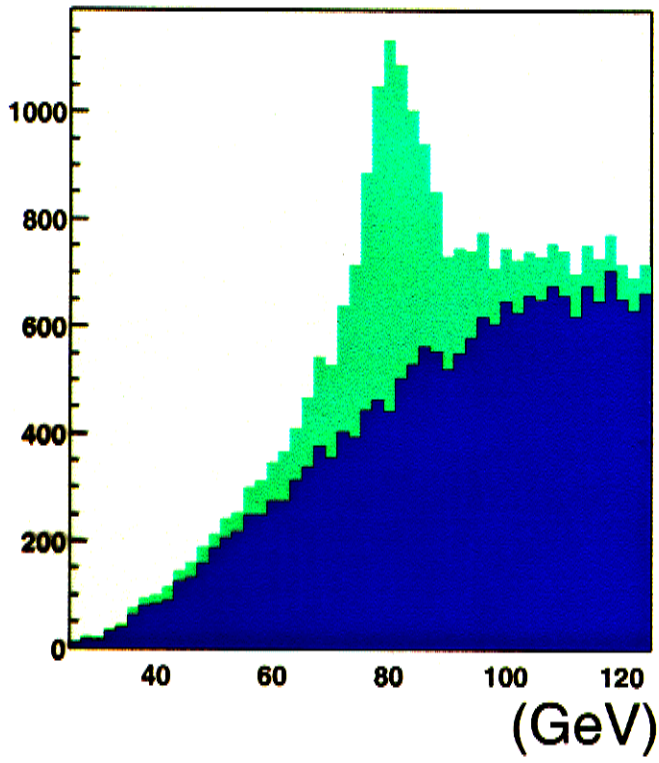


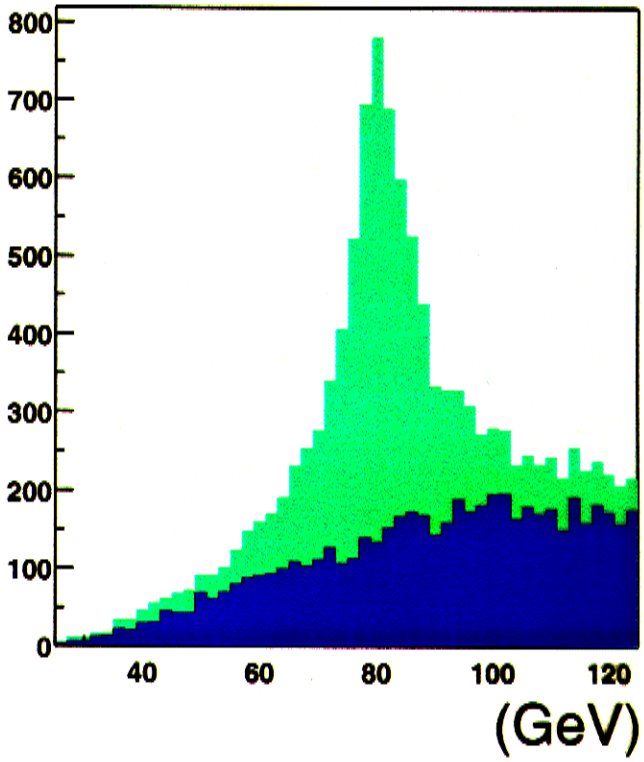
- Applying a kinematic correction to the M_{vtx} to recover neutral particle effect:

$$M_{P_T} = \sqrt{M_{VTX}^2 + \left|P_T^{VTX}\right|^2} + \left|P_T^{VTX}\right|$$

Reconstructed W with 2 jets

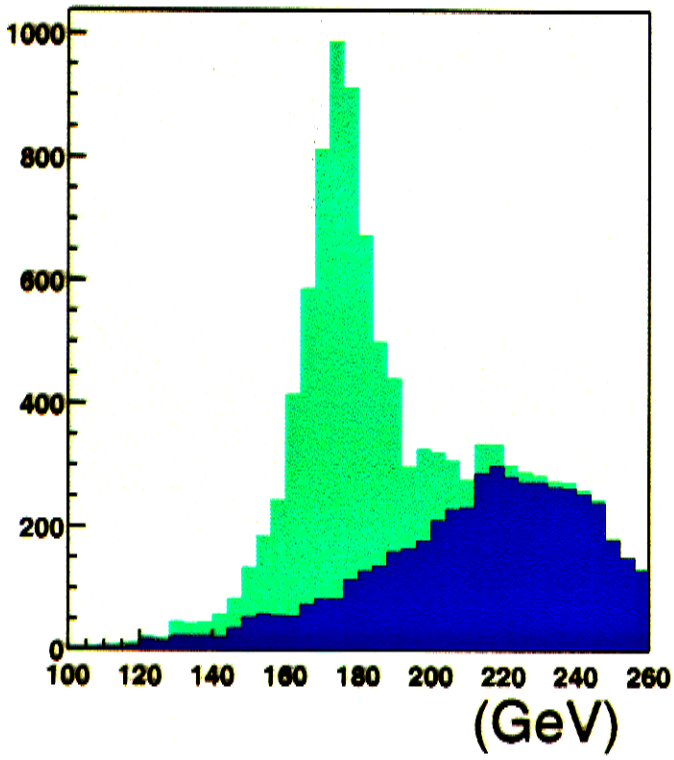
With flavor-tag

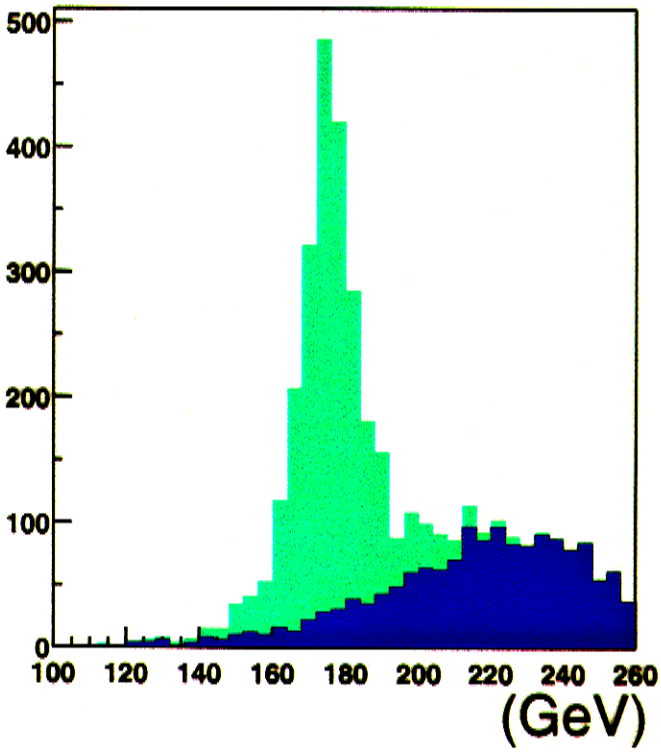




Reconstructed top with 3 jets

With flavor-tag

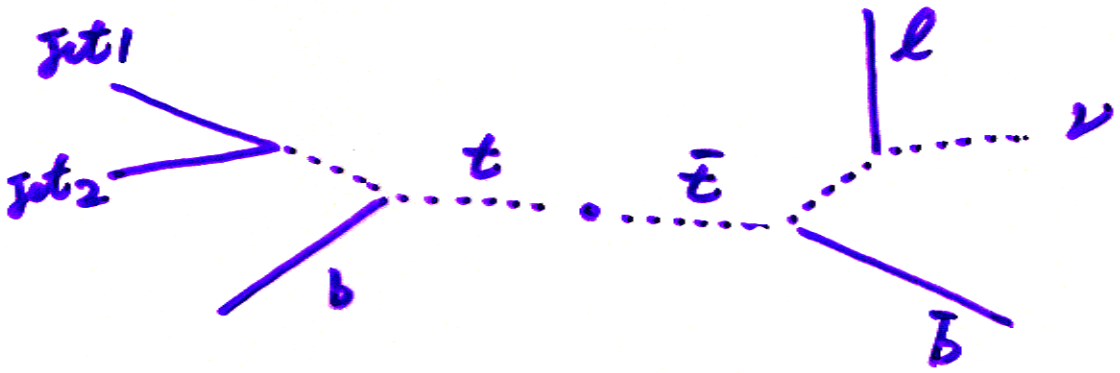




$e^+e^- \rightarrow t\bar{t}$	60000 Events	
4jets+1lepton	17343	
(e or μ)		b-tag
Reconstructed top candidates	5121	2095
True top signal	4366 (85%)	1894 (90%)
Correct b assign	2930 (57%)	1871 (89%)
Top mass resolution	12GeV	9GeV (Xjet cut 0.9-1.1)
		8GeV (Xjet cut 0.95-1.1) →lose 36%ε

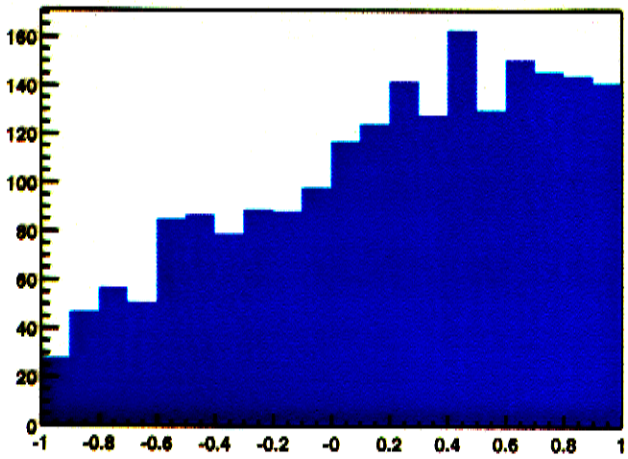
After reconstruct 1 top-quark

We get opposite top-quark 4-vector

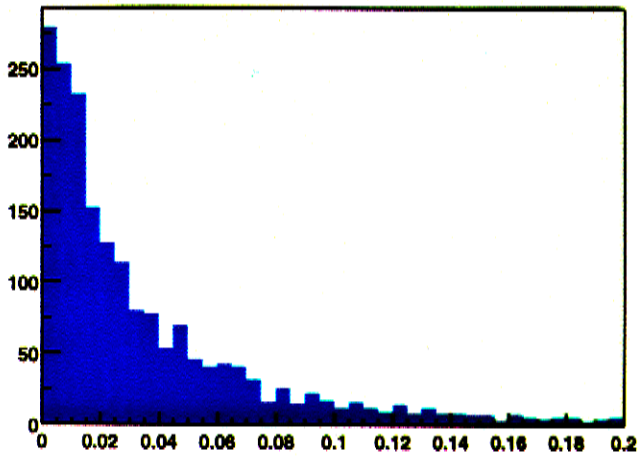


(t-quark direction → opposite to the reconstructed t

W direction → opposite to b-quark at top CM

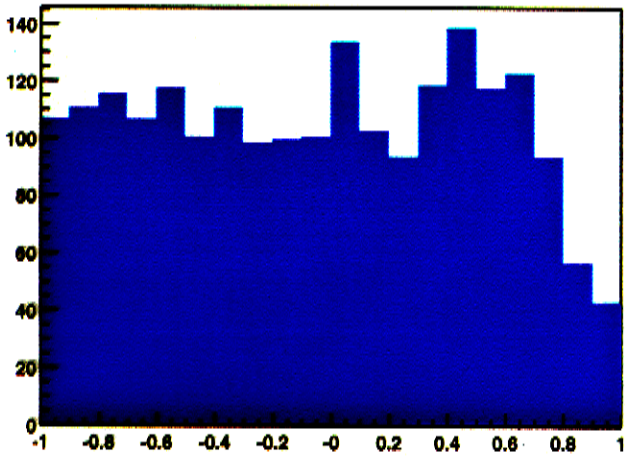


$\cos\theta$

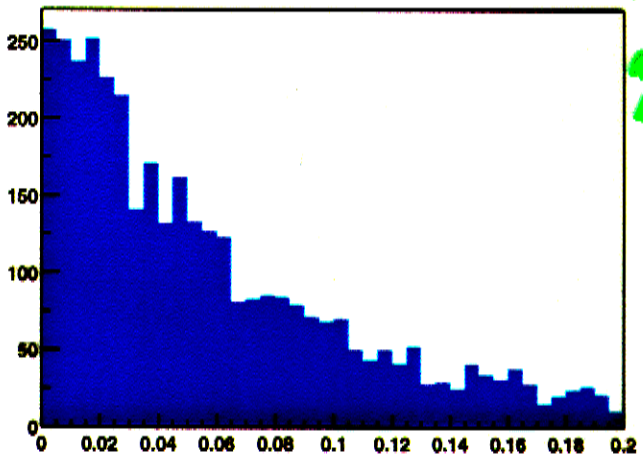


$\Delta\theta$ $(\theta - \theta_{gen})$

$\Delta\theta = 36$ mrad (~30 mrad generator level analysis & 2 Sigma cuts)

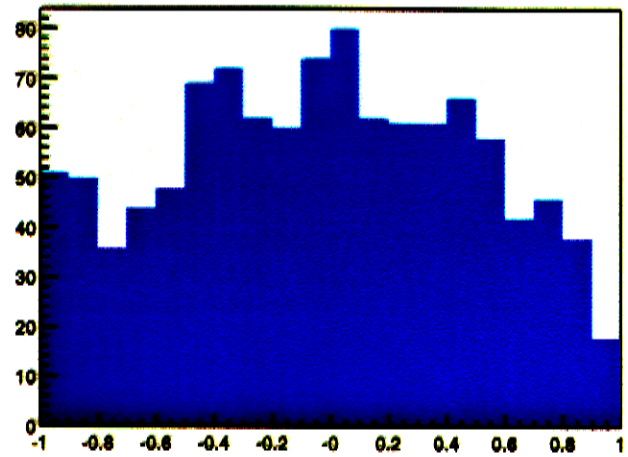


$\cos\chi_t$

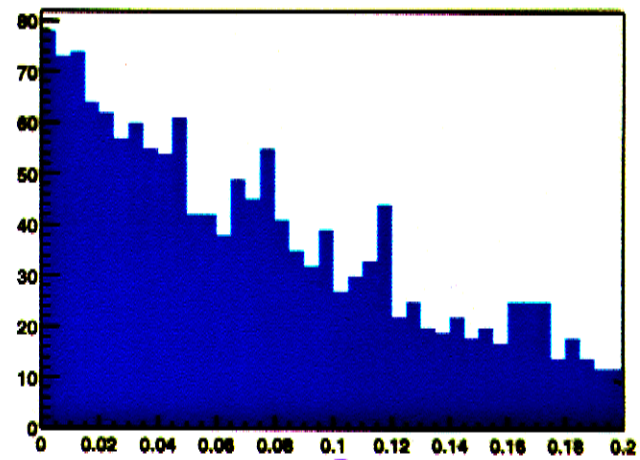


$\Delta\chi_t$

$\Delta\chi_t = 73$ mrad (~40)



$\cos\chi$



$\Delta\chi$

$\Delta\chi = 104$ mrad (~50)

Sensitivity to the couplings

In order to measure the coupling, we use

1) $F_{2V}^{\gamma,Z}$ → $t\bar{t}$ total cross section

2) $F_{1V}^{\gamma,Z}$ → L/R asymmetry

3) $F_{1A}^{\gamma,Z}$ → $\cos\theta$ asymmetry

---

1) We need { cut efficiency
Acceptance correction
BG fraction } ... under study

2) Not yet..

3)

	SM	$80fb^{-1}$, $P_e=-0.8$
F_{1A}^{γ}	0	0.045 ± 0.024 (BG fraction not included)
F_{1A}^{Z}	1 (normalized)	1.00 ± 0.038

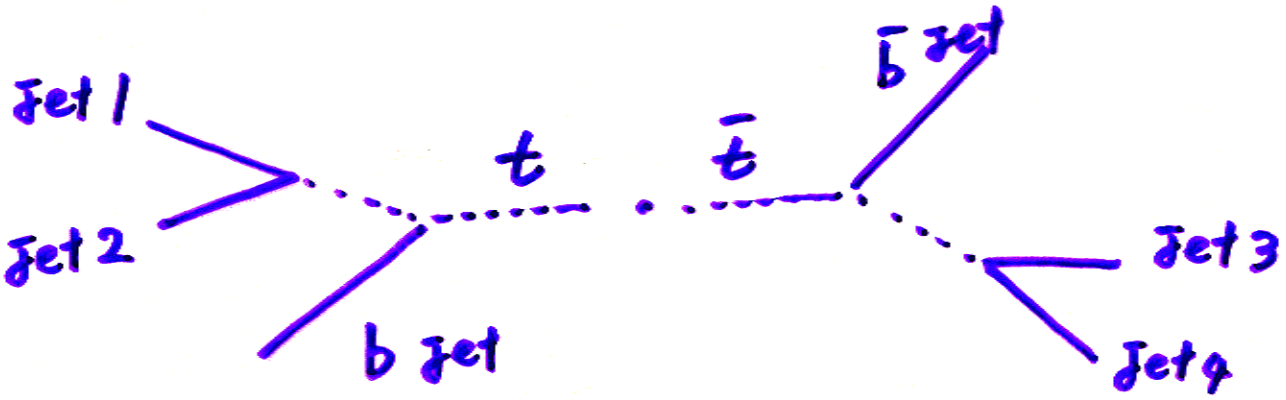
Very preliminary

Calorimeter granularity effect

Granularity =	20 mrad	30 mrad
$\Delta\theta$	36.4±1.4 mrad	41.2±1.6 mrad
$\Delta\chi_t$	72.6±1.0 mrad	80.9±1.2 mrad
$\Delta\chi$	103.5±2.9 mrad	111.6±4.6 mrad

~10% effect

2) $t\bar{t} \rightarrow 6$ jets analysis



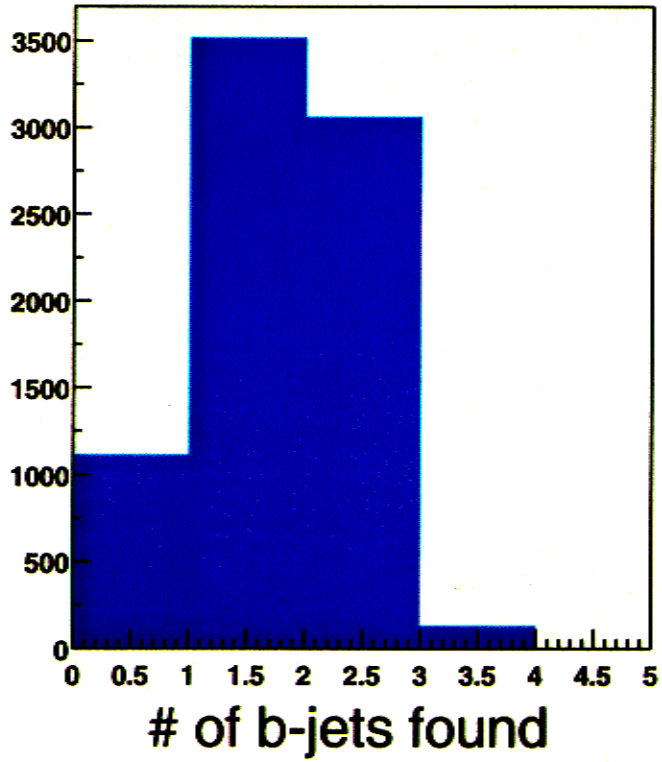
In this analysis we know all final 6 fermion directions

... But, how to know t or $\bar{t}$

u-type quark or d-type ?

$t\bar{t}$ → 6 Jet reconstruction

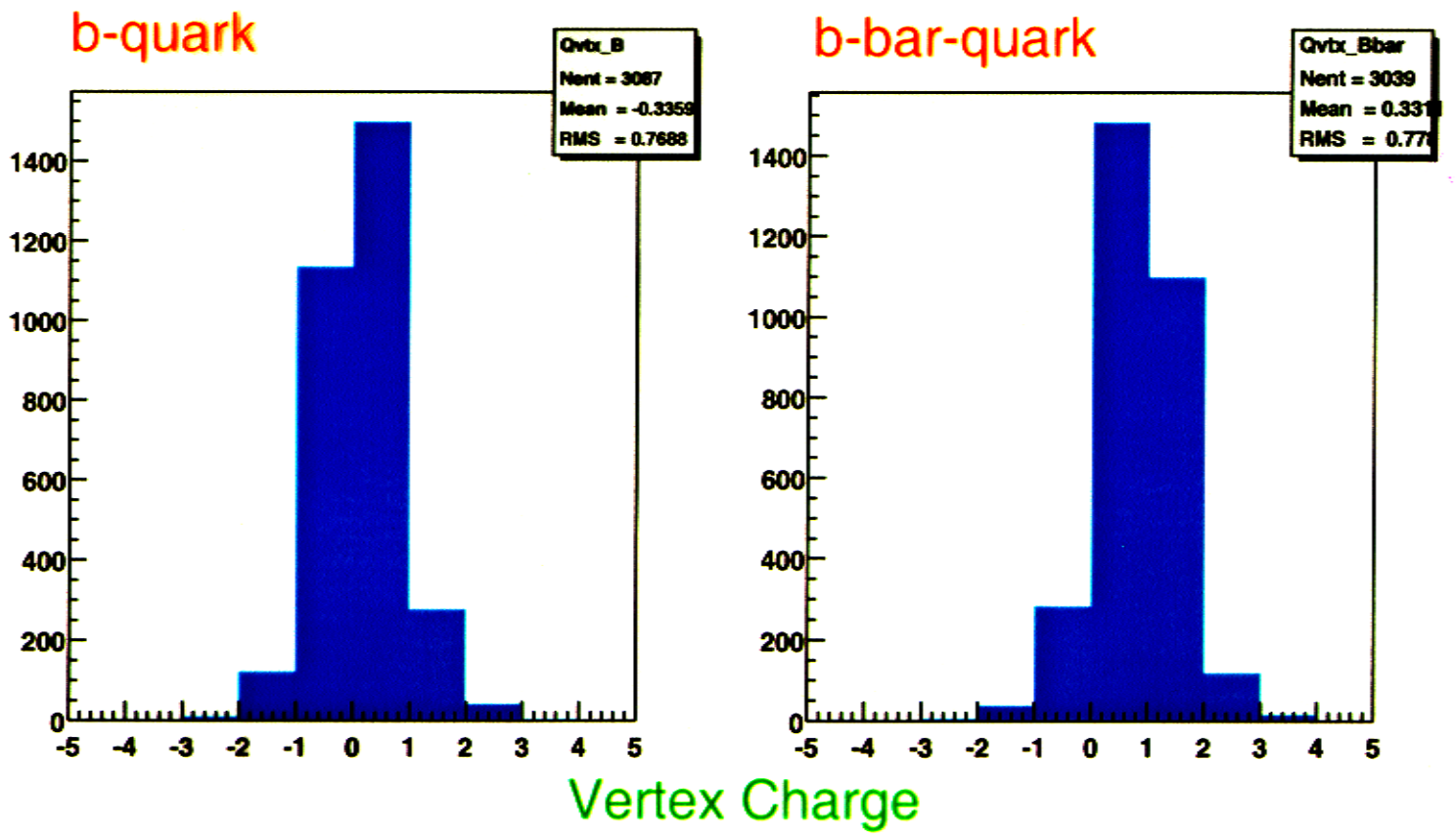
- Reconstruct 6 jets by clustering
- Using Mass-tag method, we tag 2 b-jets



Select the event
# of b-jet = 2

Using Vertex charge of b-jet,

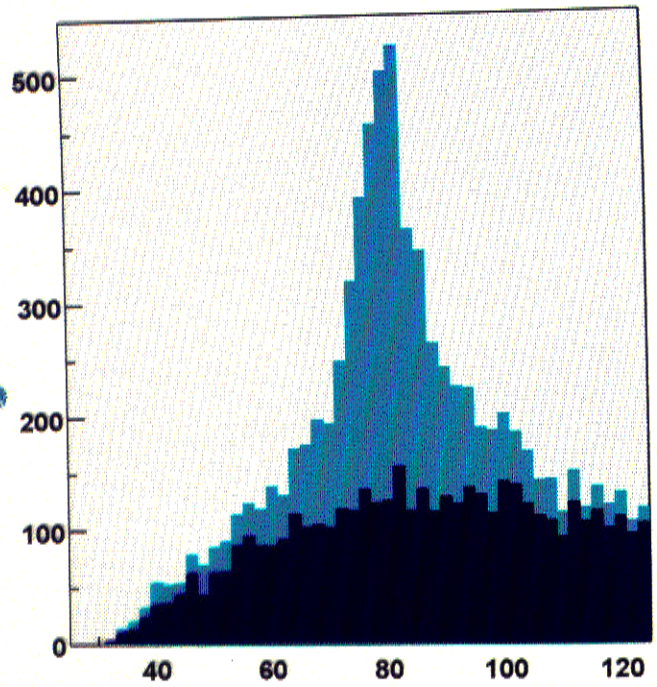
We know b or $\bar{b}$ → t or $\bar{t}$



Require at least 1 b jet has Vertex Charge $\neq 0$

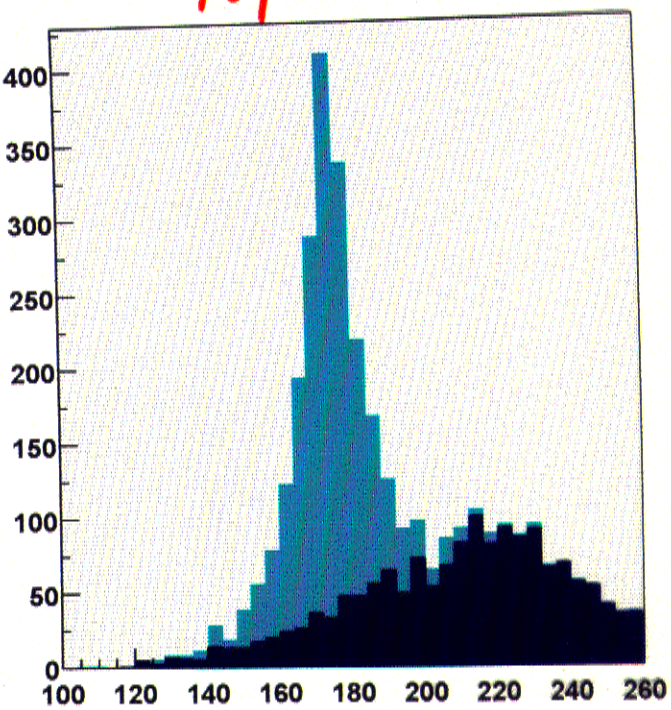
→ We can determine t or $\bar{t}$ with purity 80%
efficiency 40%

Reconstructed W

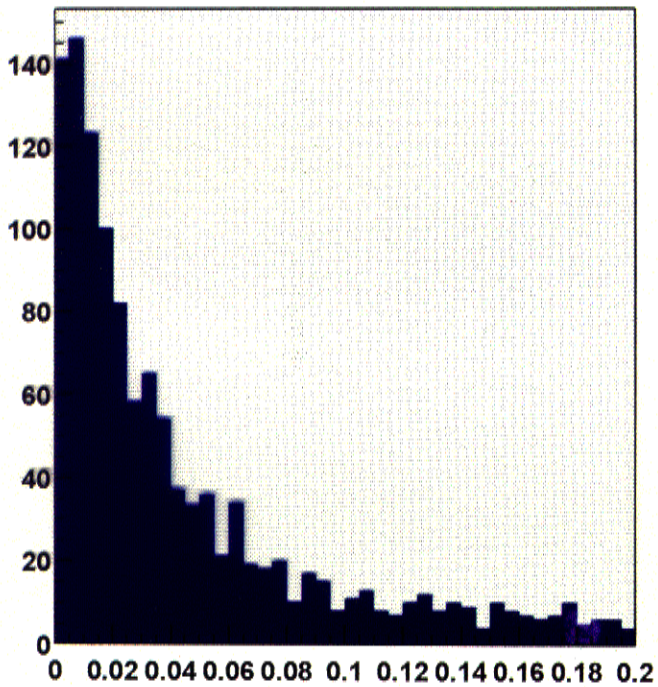


Mass (2 jets)

Top



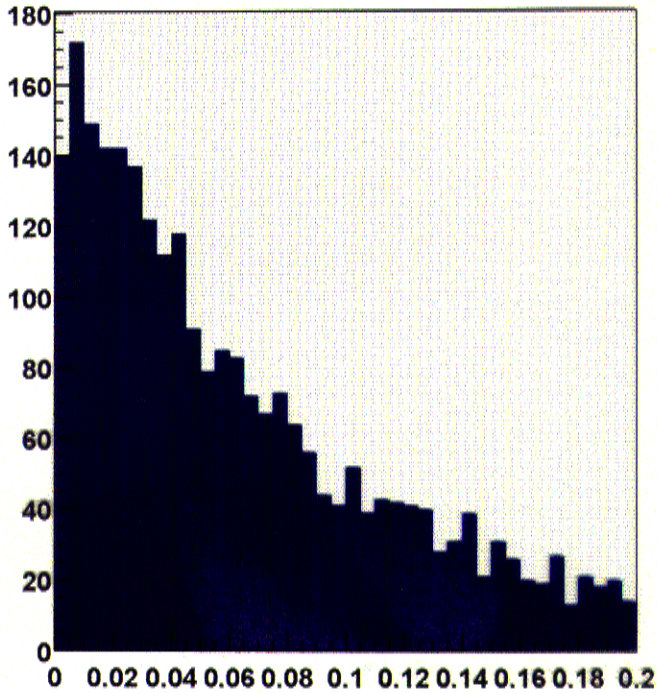
Mass (3 jets)



$\Delta\theta$

$\Delta\theta$ = 40 mrad

(36 : 4 jets + lepton)



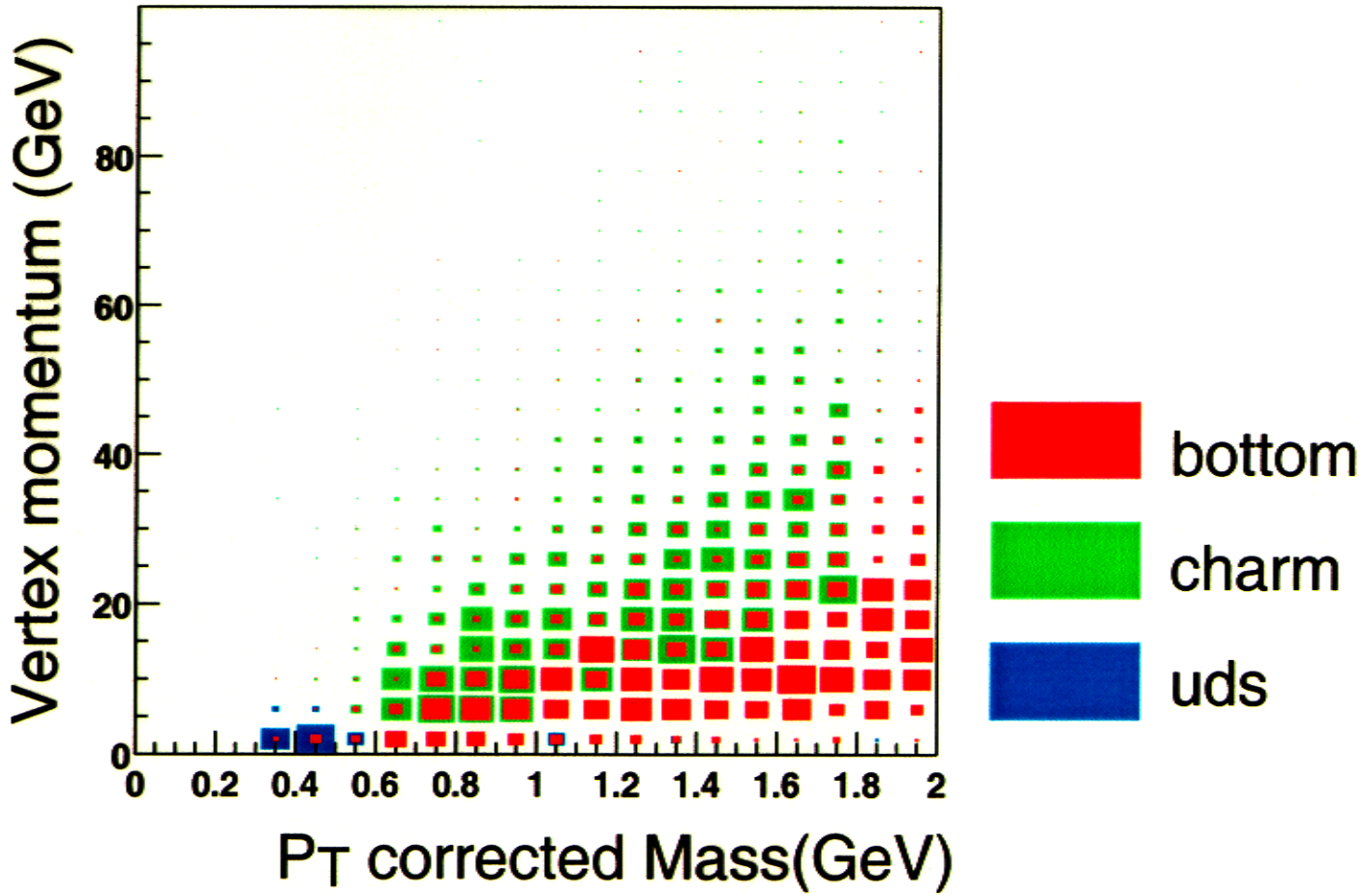
$\Delta\chi_t$

$\Delta\chi_t$ = 83 mrad

(73)

Can we tag $W \to q\bar{q}'$?

... Using the P_T corrected mass + Vertex momentum we can tag c-quark.



$\varepsilon_c = 28\%$ $\pi_c = 69\%$

Apply c-tag to reconstructed W

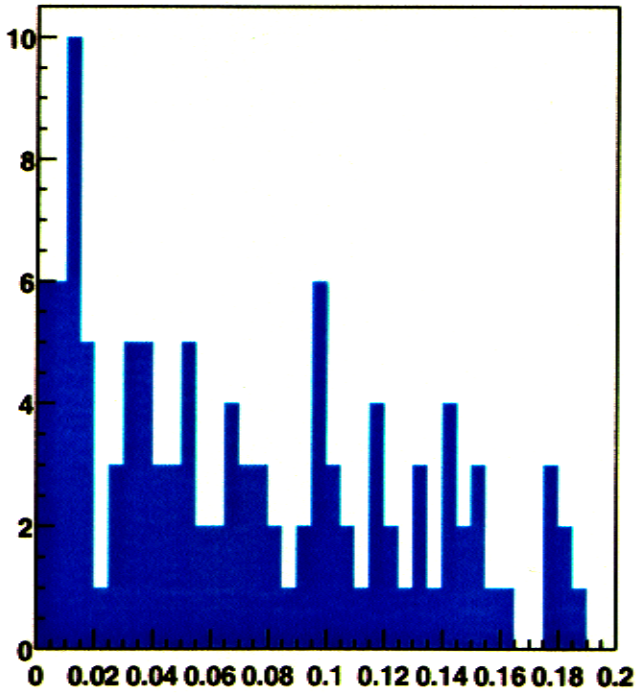
In the reconstructed W
we can tag c-quark with

$\varepsilon = 27\%$

$\pi_L = 97\%$

↓

Because we ID W already.
(no b BG)



$\Delta\chi$

$\Delta\chi = 95$ mrad

(104 mrad in 4jet+l)

In the $t\bar{t} \rightarrow 6$ jets analysis

- b/c-tagging
- Charge tagging

are important

→depend on vertex detector performance

	# of to reconstructed	# of c tagged in W
VXD R_{inner} =1cm	1802(1483 correct)	484 (471 correct)
=2cm	1704(1395 correct)	380 (368 correct)
	↓	↓
	6% difference	20% difference

Vertex detector is important!

Summary

We have studied top-quark reconstruction with LCD Fast Simulator

1) tt → 4 jets + lepton

- Flavor-tag is effective to reconstruct W & Top
- Calorimeter granularity 20mrad → 30mrad

  .. 10% effect in decay angle resolution
- We need more detail study for coupling measurements

2) tt → 6 jets

- Using Vertex-charge of b-jet, we can tag the charge of Top-quark with 80% purity
- Vertex detector is important to tag c-quark in W-decay

  Rinner = 1cm →2cm .. 20% effect