

A study of topological vertexing for heavy quark tagging

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(Many thanks to discussion with
D.Jackson and J.Jaros)

Introduction

- Bunch of studies for vertex detector (VTX) configuration has been done.
i.e. $r_{\text{inner}} = 1.0$ cm feasibility
However most of study is based on technical side (background, etc...).
- We need to discuss the VTX configuration in terms of physics impact.

Physics opened with VTX

- The strongest particle ID device.
b-jet, c-jet and anti-b/c tag
- Secondary (tertiary) vertex reconstruction.

Important to b-jet, c-jet and anti-b/c tag

Vertex charge $\rightarrow$ quark direction

Higgs study (see J. Brau's talk)

Top study (see M. Iwasaki's talk)

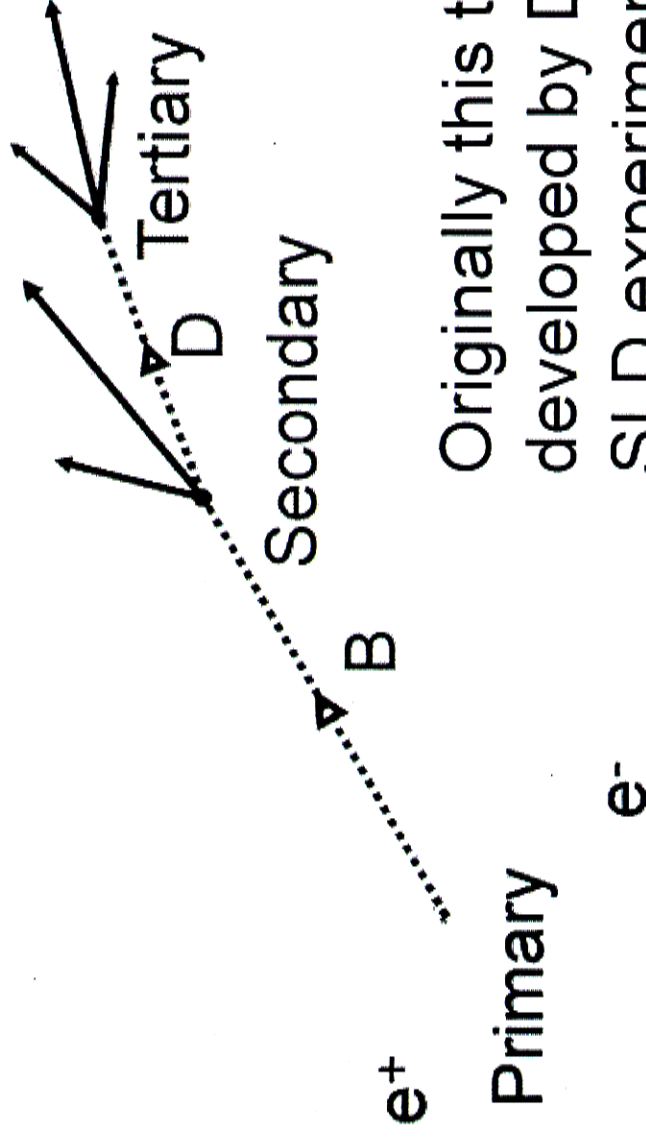
LCD fast simulation

- The simulation is based on Root + C++.
- Tracks are smeared with their error matrices.
- The error matrix is given by look-up table method based on momentum and $\cos\theta$.
- The error matrix includes off-diagonal elements (by B. Schumm)

Contents of this talk

- LCD fast simulation
- Topological vertexing and mass tag technique.
- $R_{in}=1\text{cm}$ and $R_{in}=2\text{cm}$ VTX configuration
impact parameter resolution
reconstructed primary vertex resolution
b-tag, c-tag and anti-b/c tag
- Top analysis (by M.Iwasaki)
- Summary

Topological Vertexing

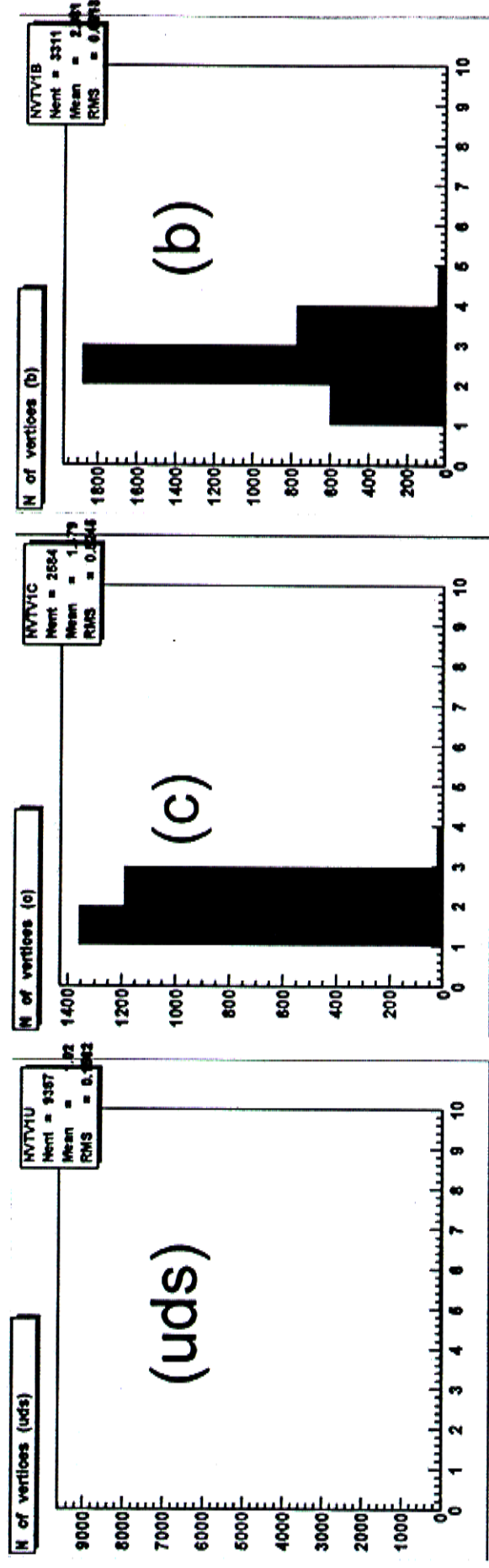


Originally this technique is developed by D.Jackson at the SLD experiment.

D.J.Jackson NIM A388, 247 (1997)

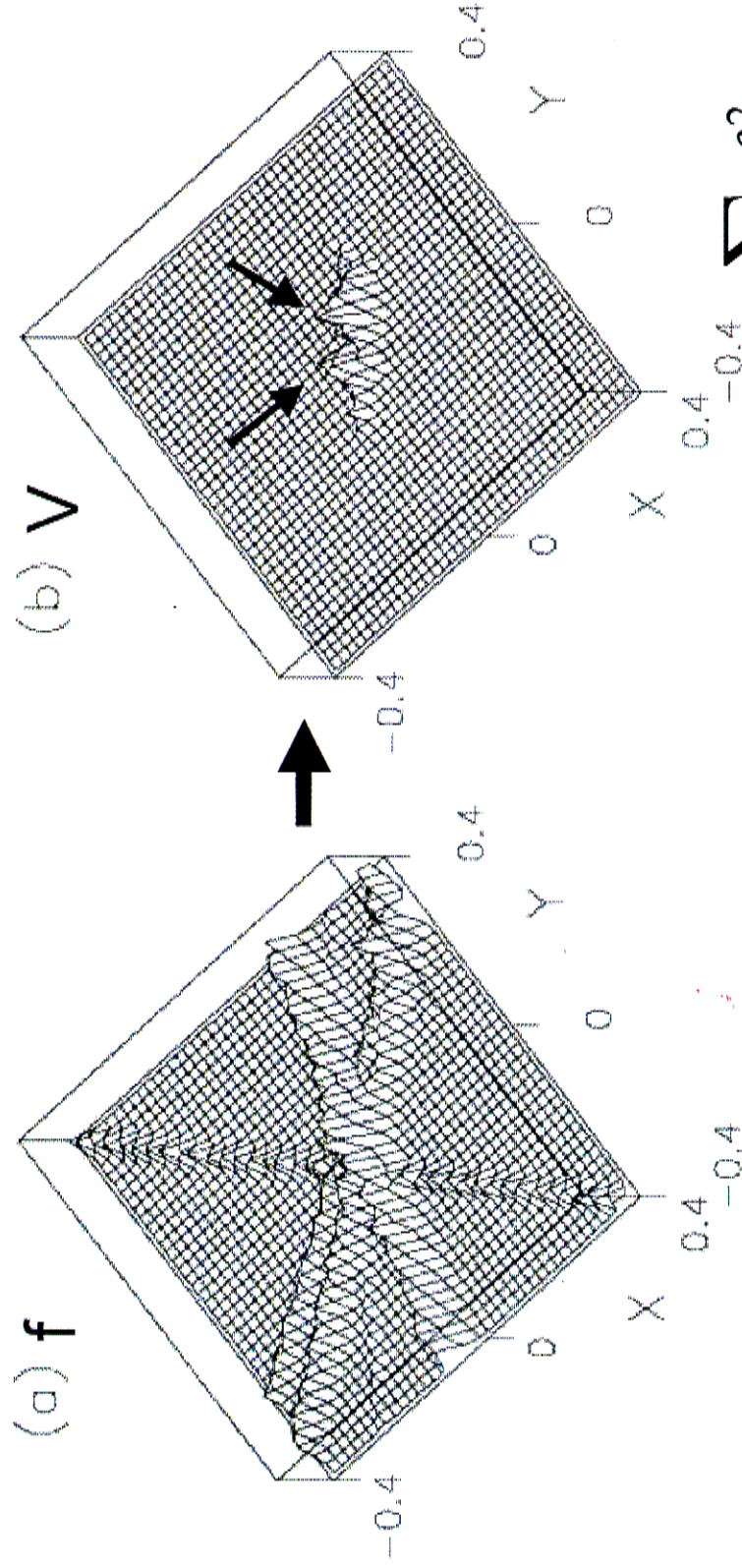
The aim of this vertexing is to fully reconstruct B decay chain.

of vertices in a jet



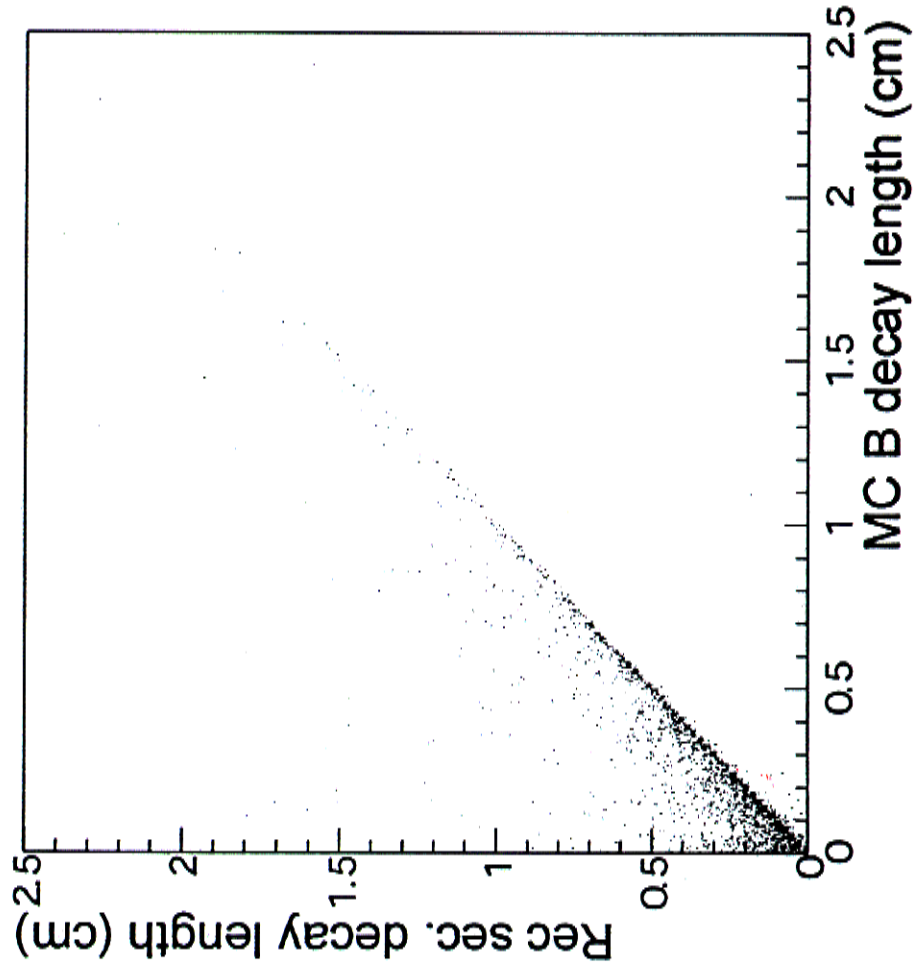
$Z^0 \rightarrow qq$ @ 91.26 GeV with L2($r_{in}=1.0\text{cm}$) tracking configuration

Resolving vertices

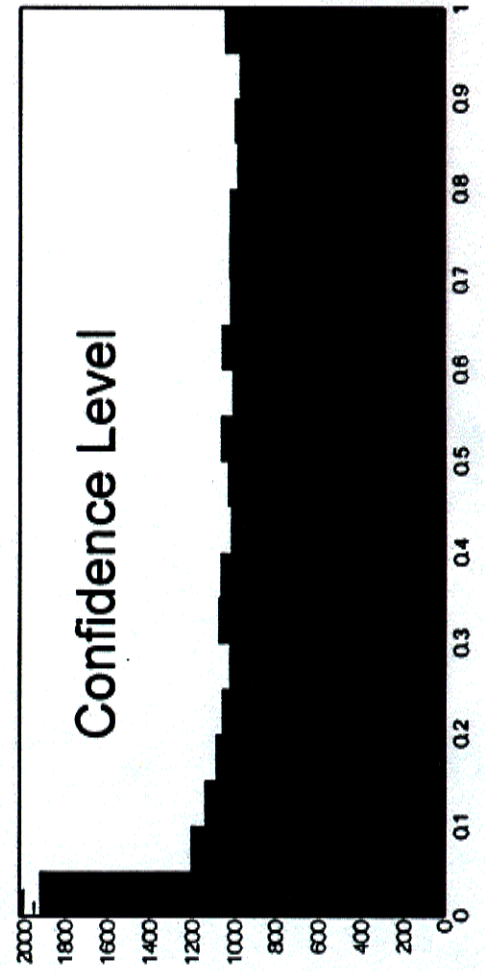
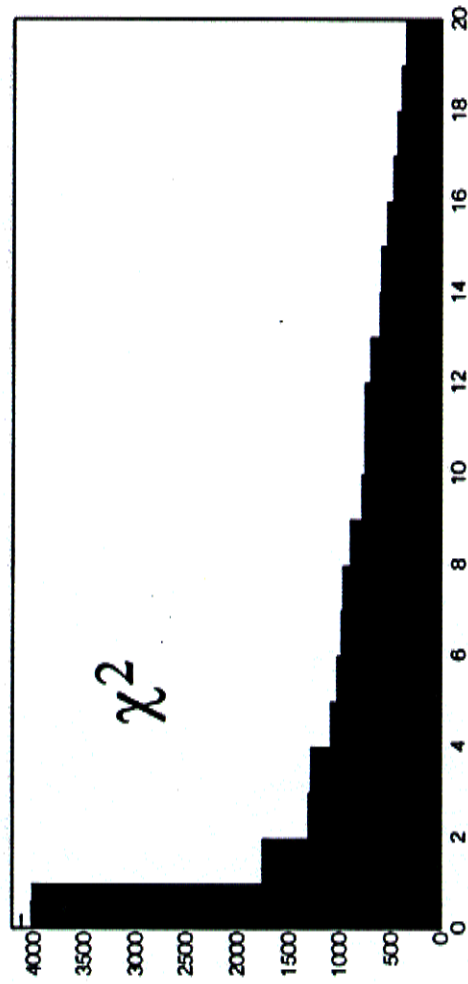


$$V = \sum f - \frac{\sum f^2}{\sum f}$$

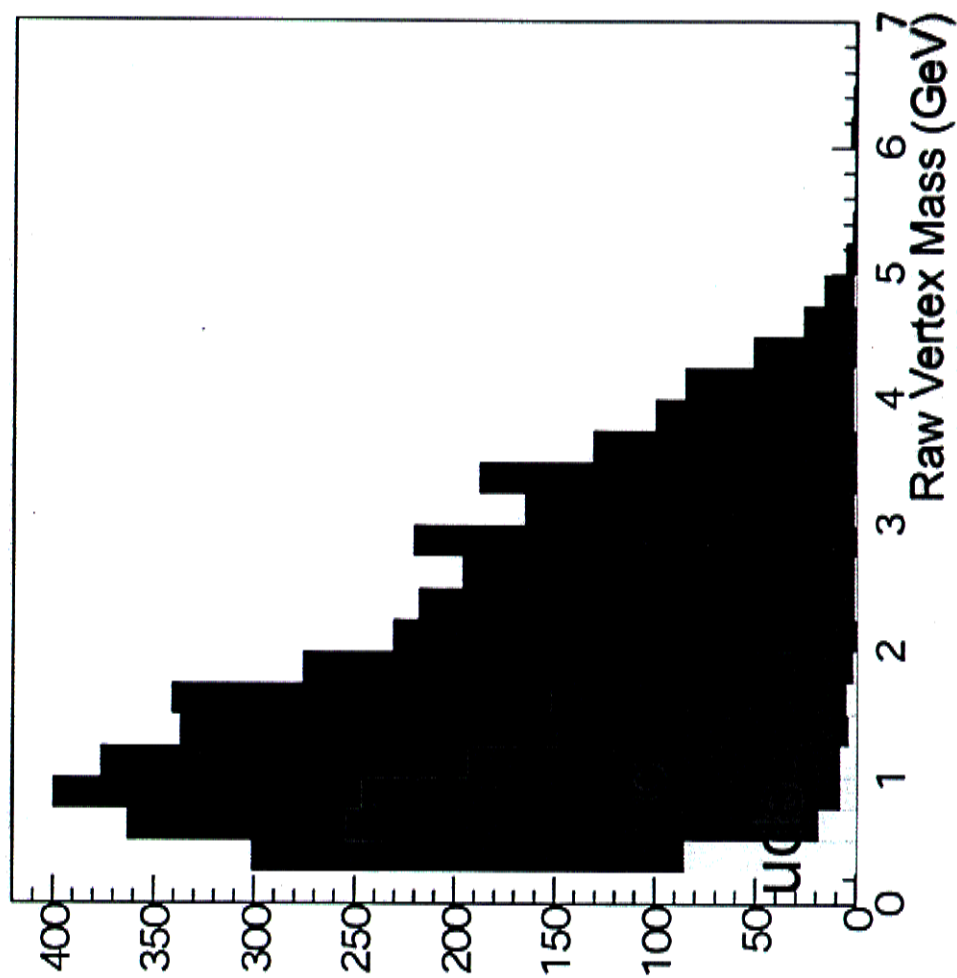
MC B decay length vs. reconstructed decay length



Confidence Level

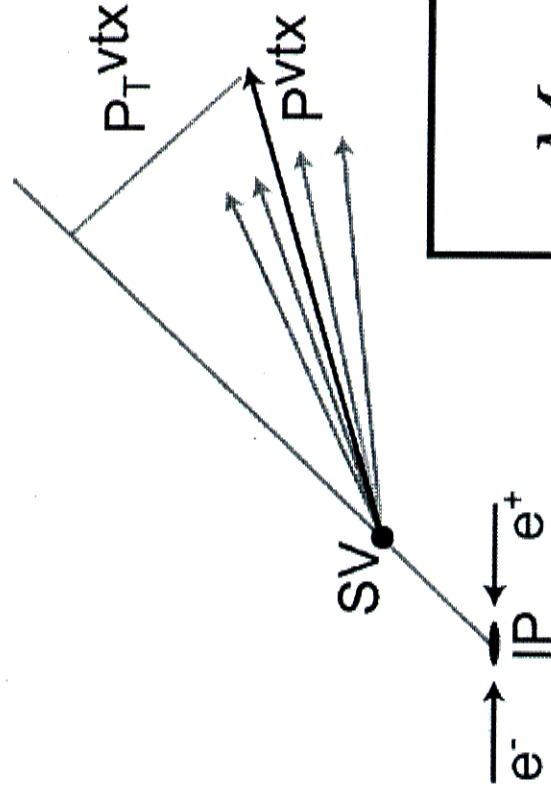


Vertex mass



P_T corrected vertex mass

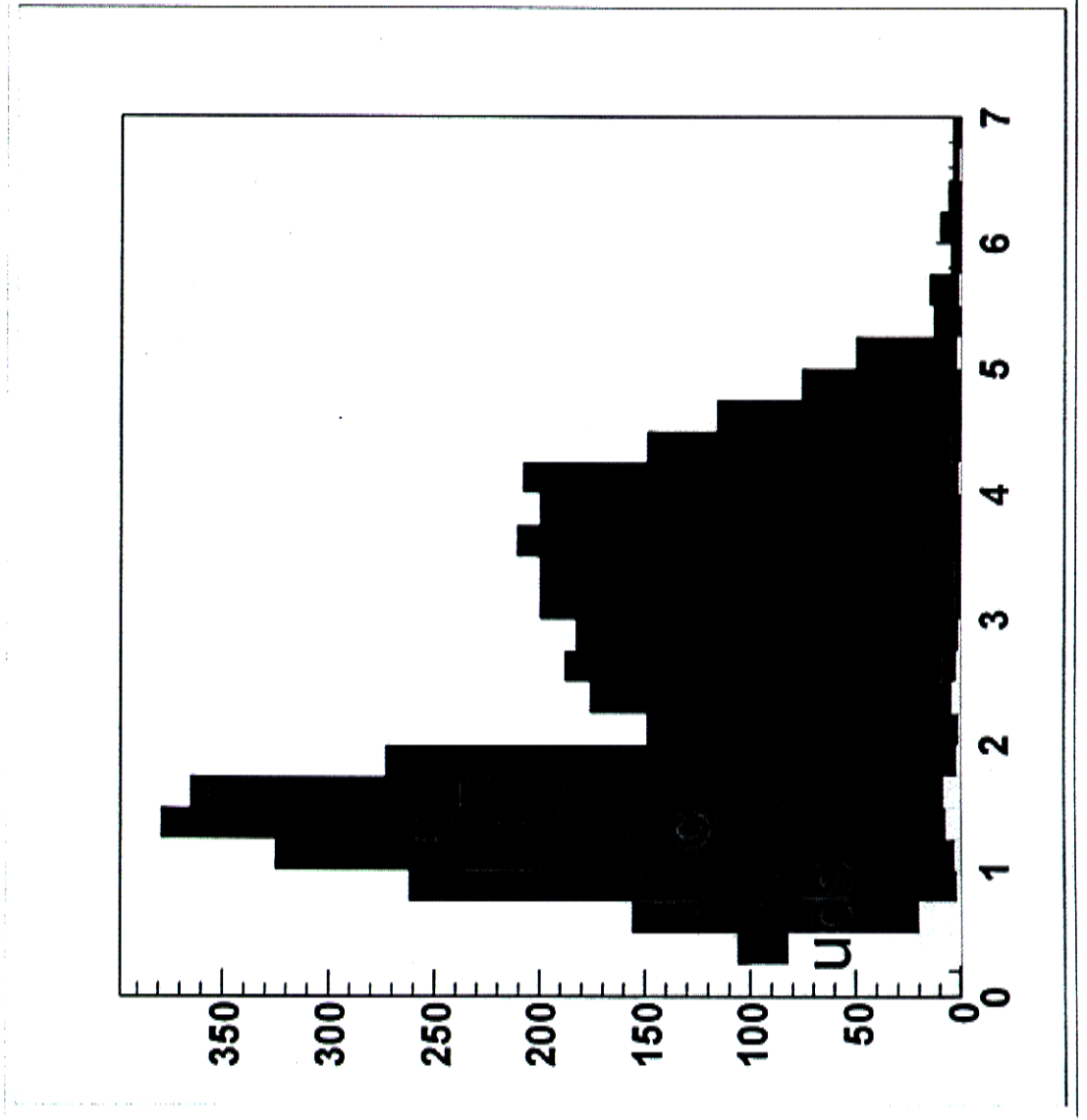
- Applying a kinematic correction to the M_{vtx} to recover neutral particle effect:



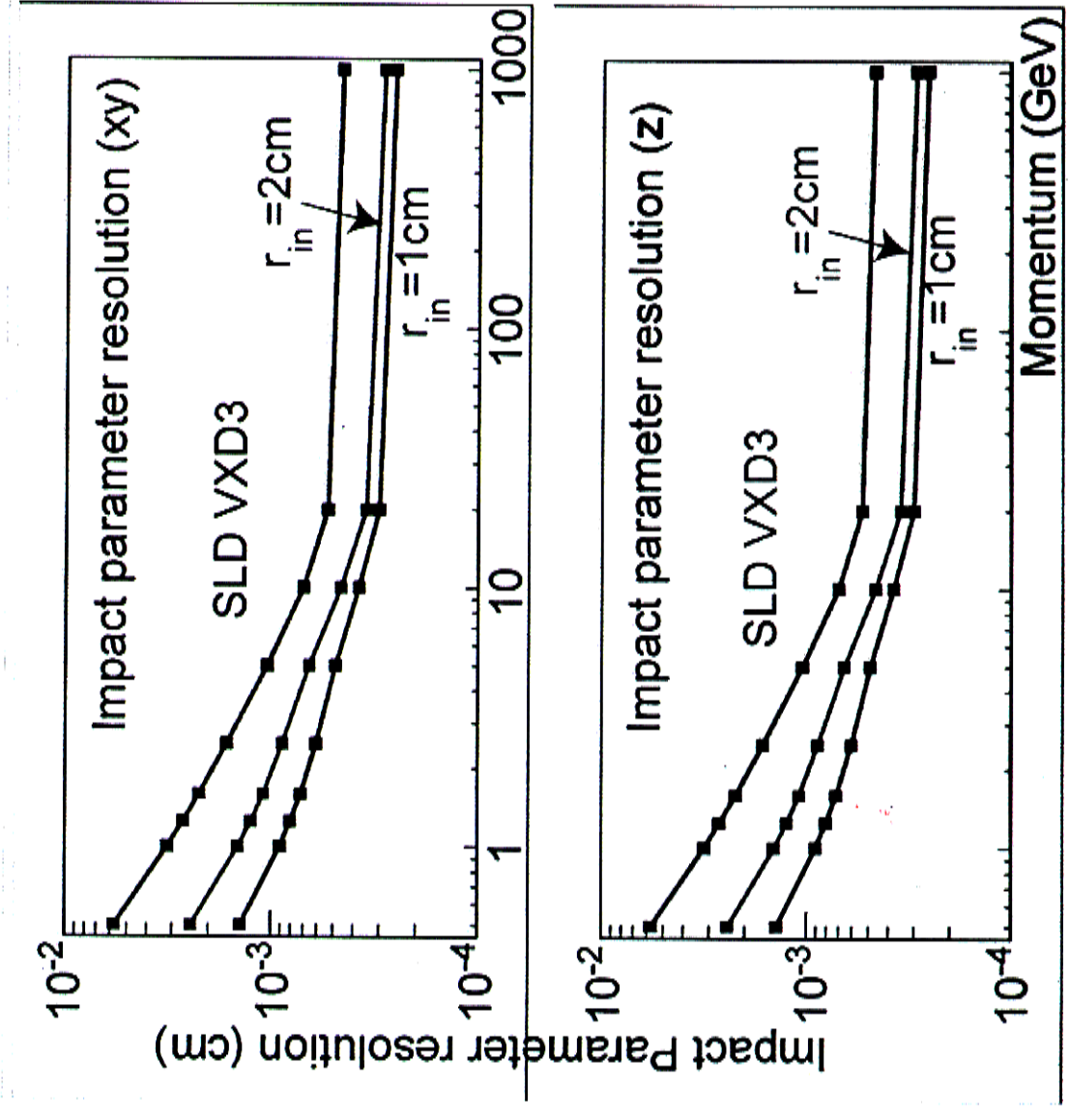
$$M_{P_T} = \sqrt{M_{\text{vtx}}^2 + |P_T^{\text{vtx}}|^2} + |P_T^{\text{vtx}}|$$

SLD collaboration PRL 80, 660 (1998)

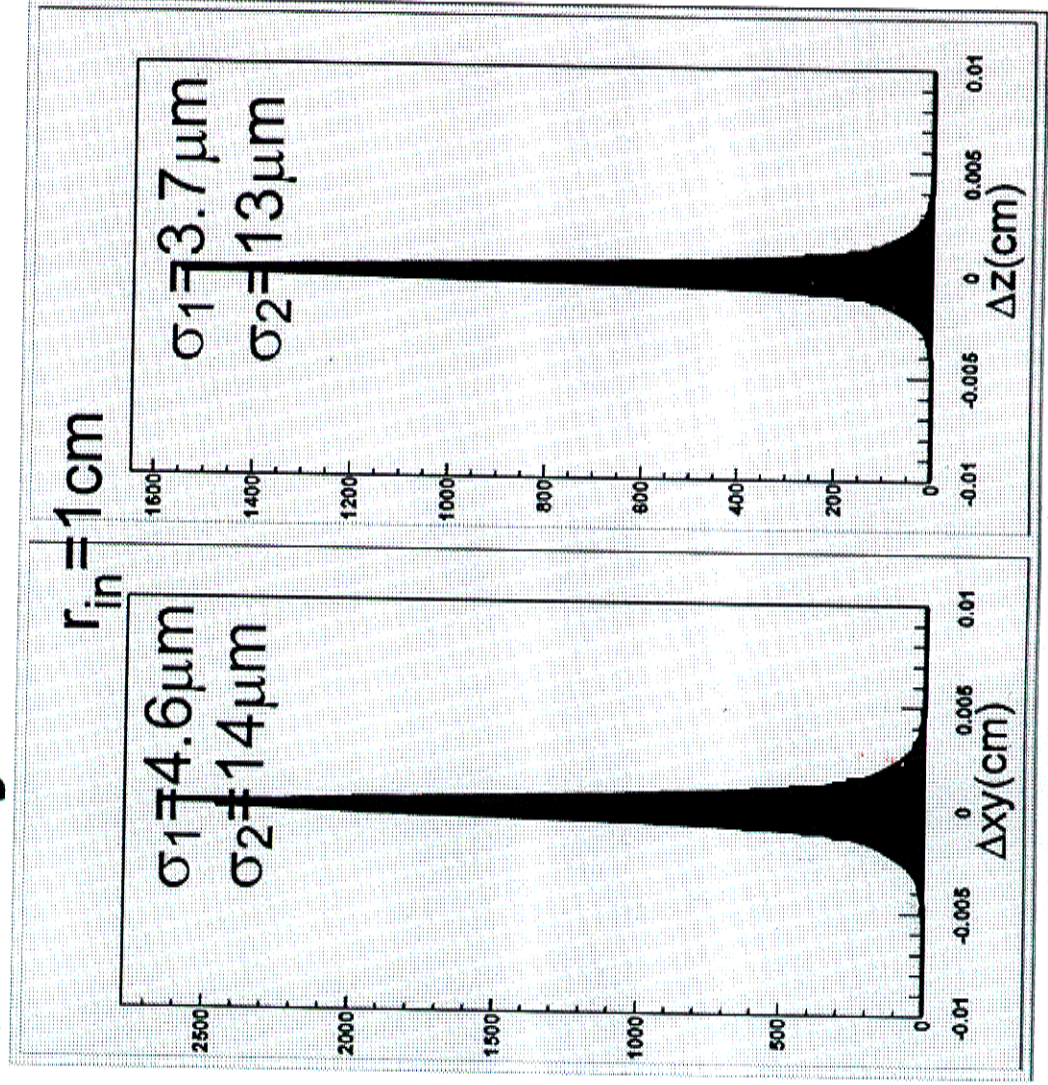
P_T corrected vertex mass



Impact parameter resolution



Primary vertex resolution

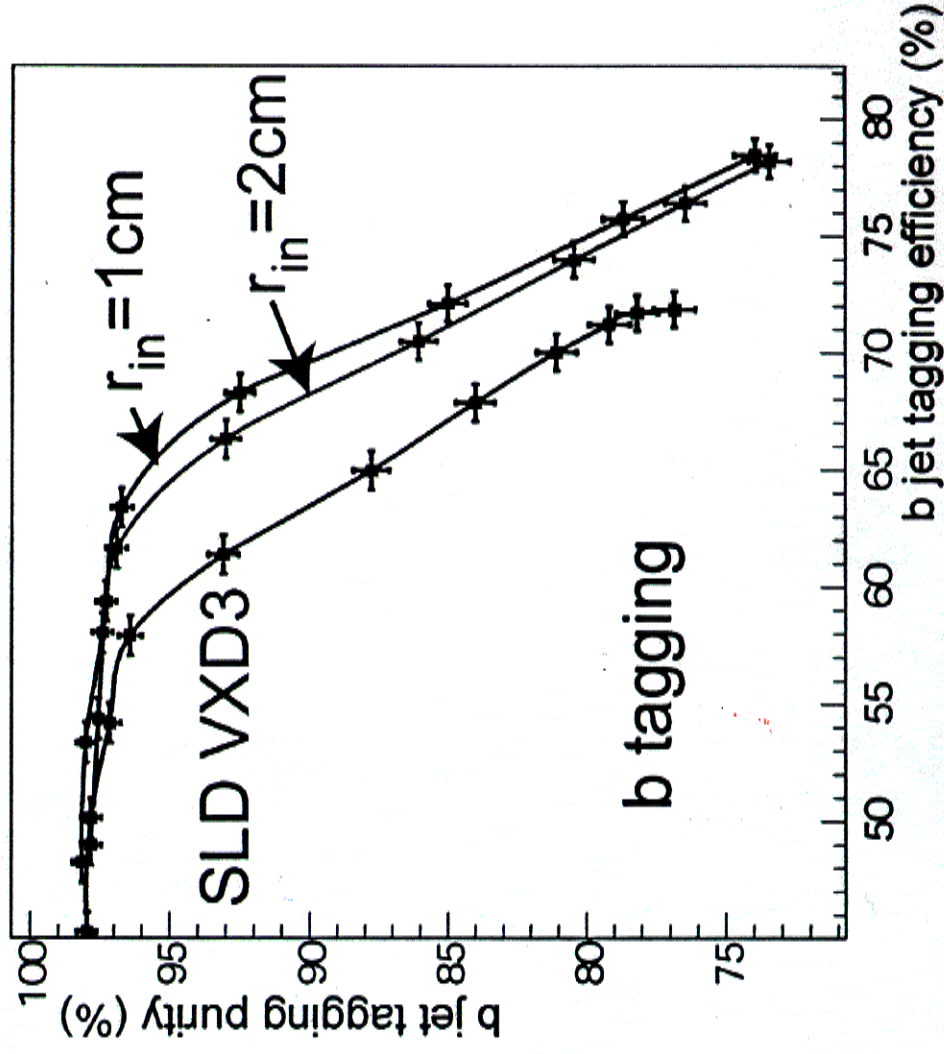


$$r_{in} = 2 \text{ cm}$$

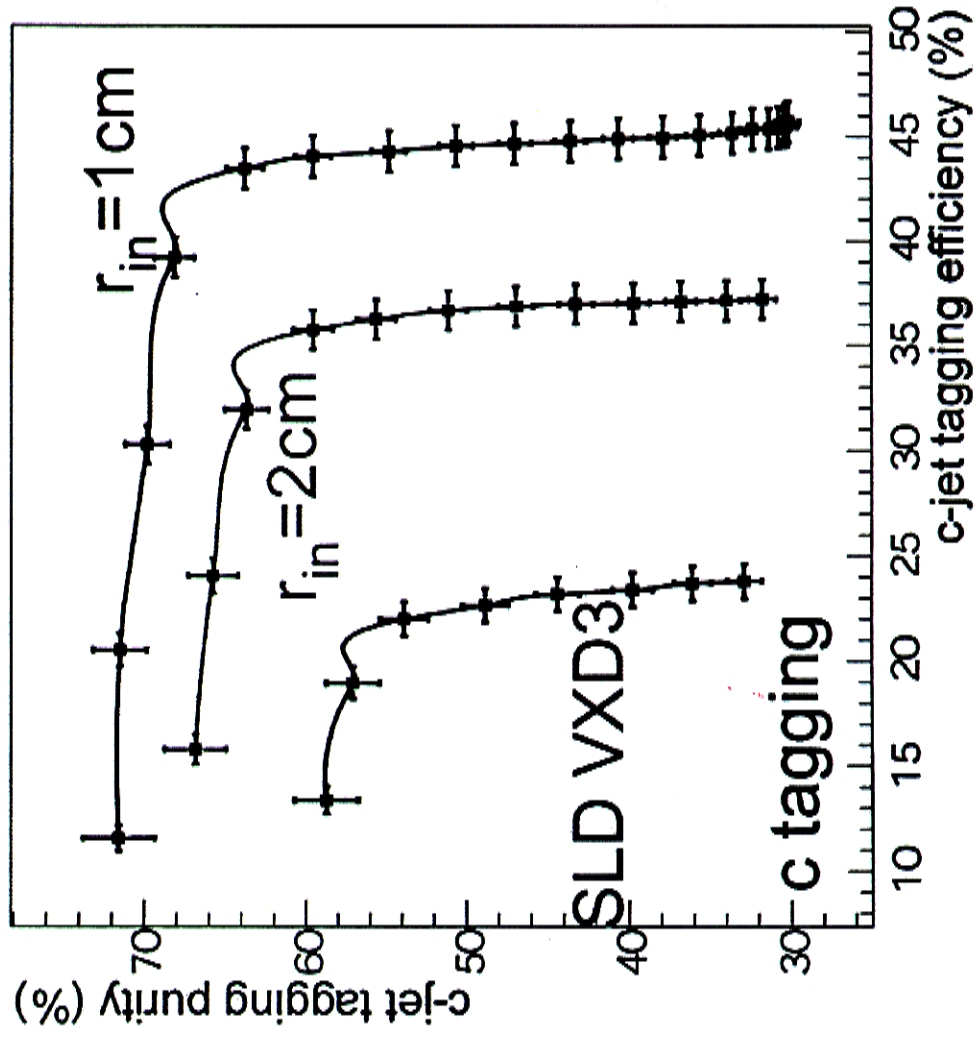
$$\sigma_{xy} = 6.9 \mu\text{m}$$

$$\sigma_z = 5.2 \mu\text{m}$$

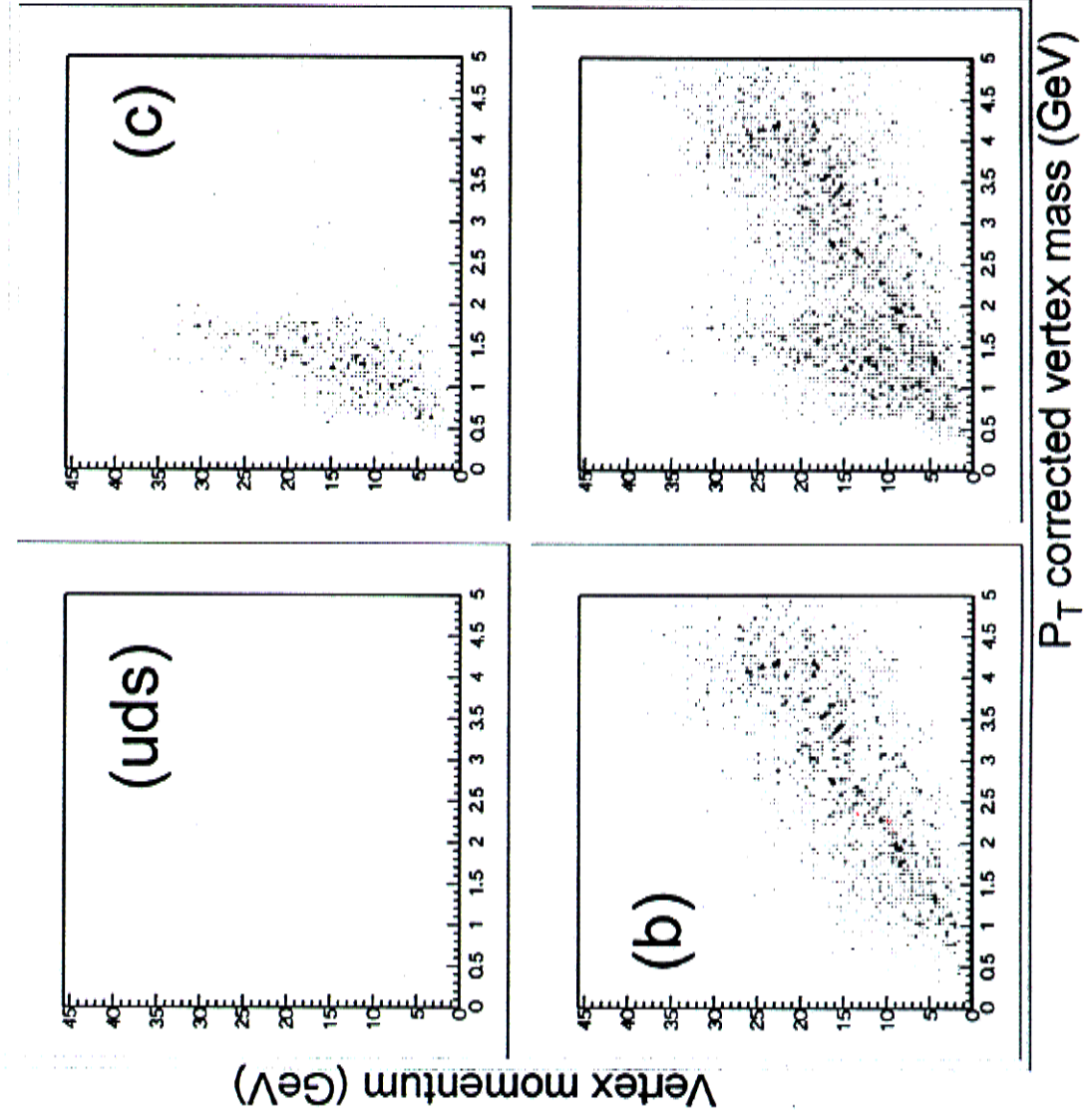
B tag efficiency vs. purity



C tag efficiency vs. purity



Charm jet tagging



Heavy quark tagging performance

For $r_{in}=1\text{cm}$ VTX:

$\varepsilon=63\%$ and $\Pi=97\%$ for b-tag

$\varepsilon=32\%$ and $\Pi=83\%$ for c-tag

$\varepsilon=78\%$ and $\Pi=91\%$ for uds-tag

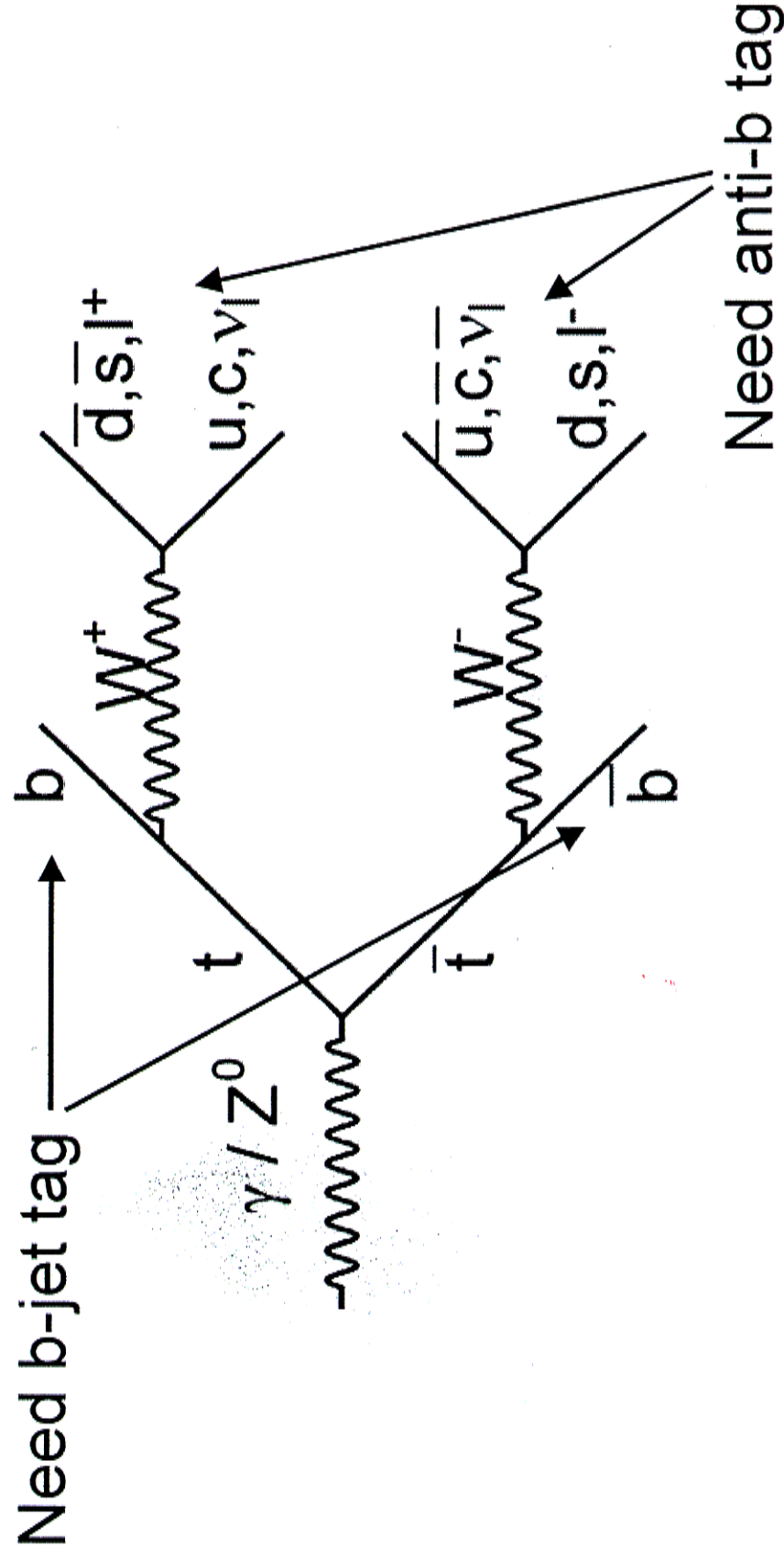
For $r_{in}=2\text{cm}$ VTX:

$\varepsilon=62\%$ and $\Pi=97\%$ for b-tag

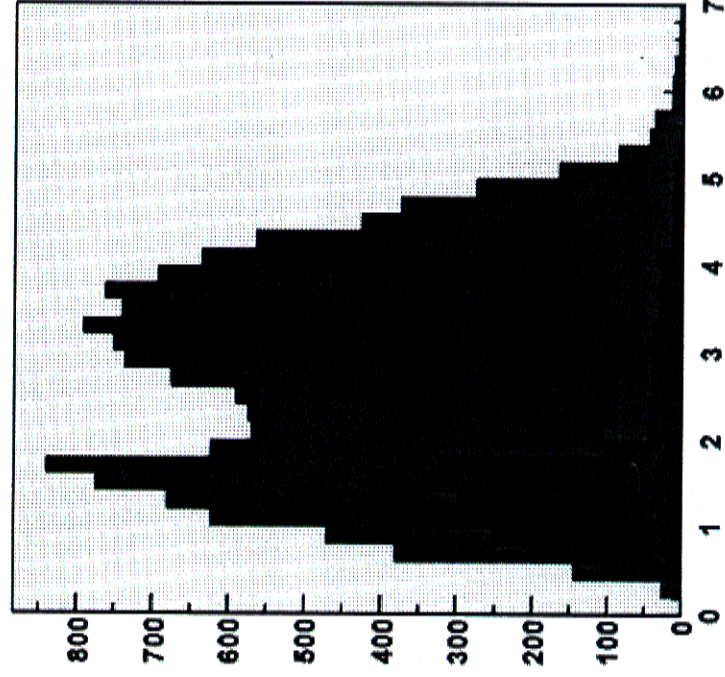
$\varepsilon=27\%$ and $\Pi=80\%$ for c-tag

$\varepsilon=78\%$ and $\Pi=90\%$ for uds-tag

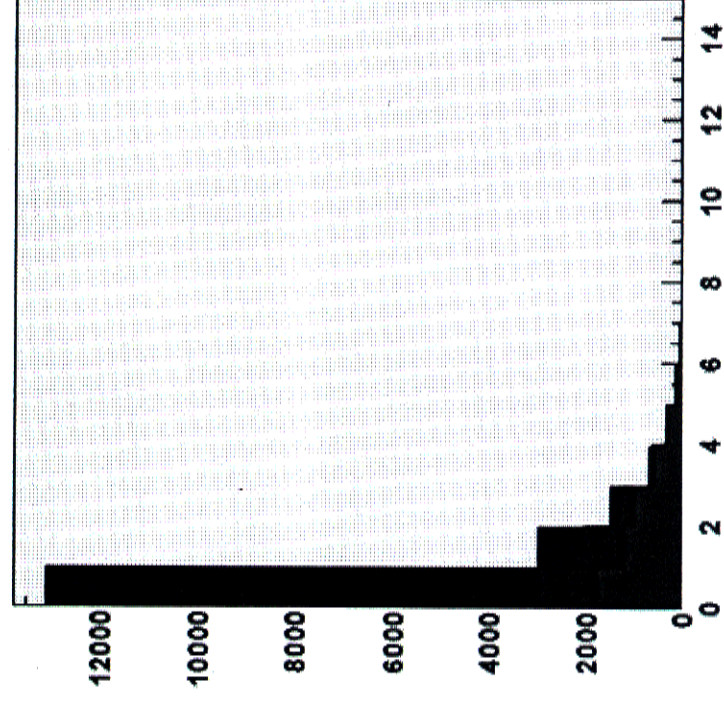
Top quark reconstruction



b/uds-jet tagging at $t\bar{t}$ events



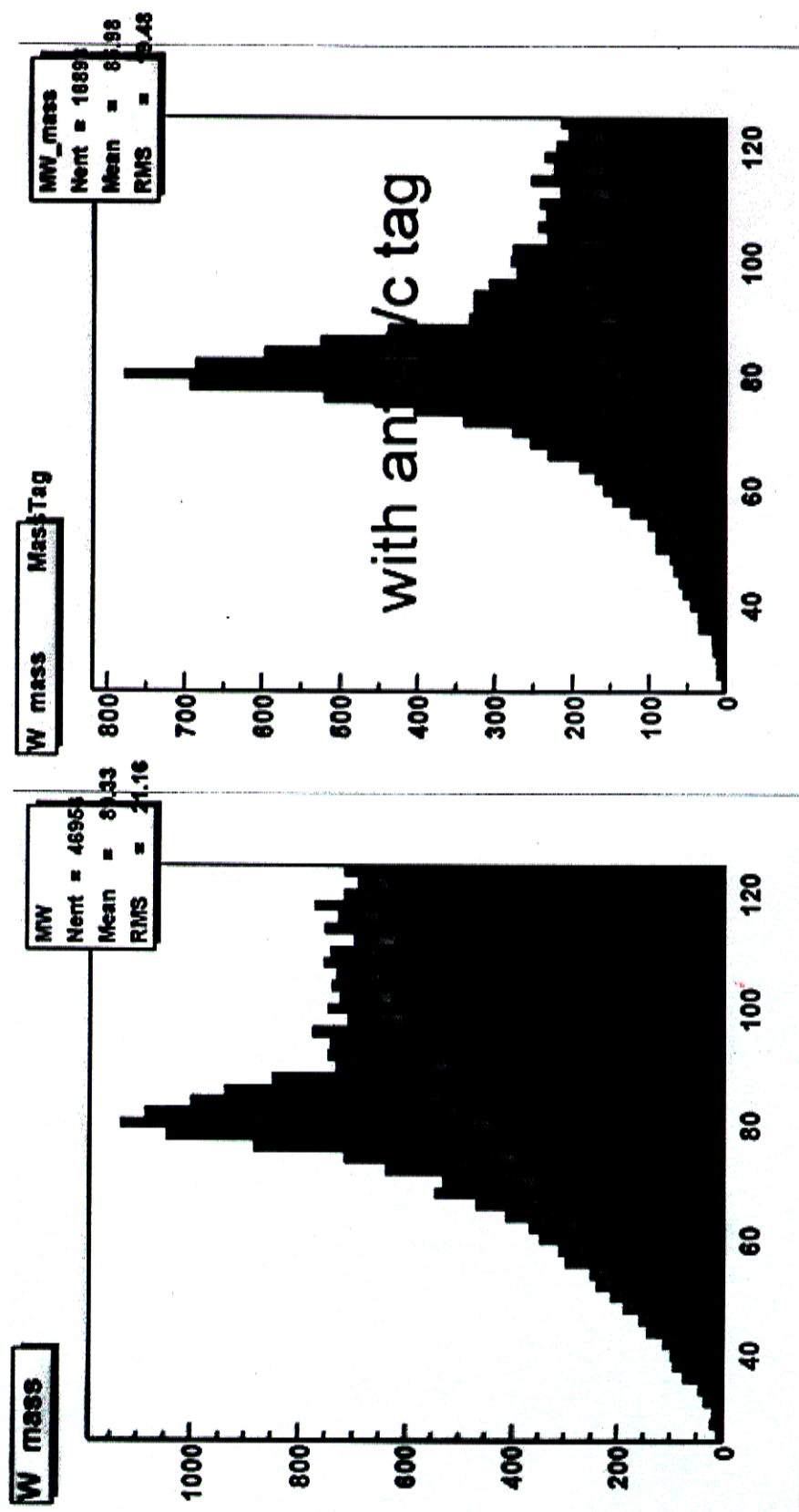
$$\varepsilon_b = 62\% \quad \Pi_b = 94\%$$



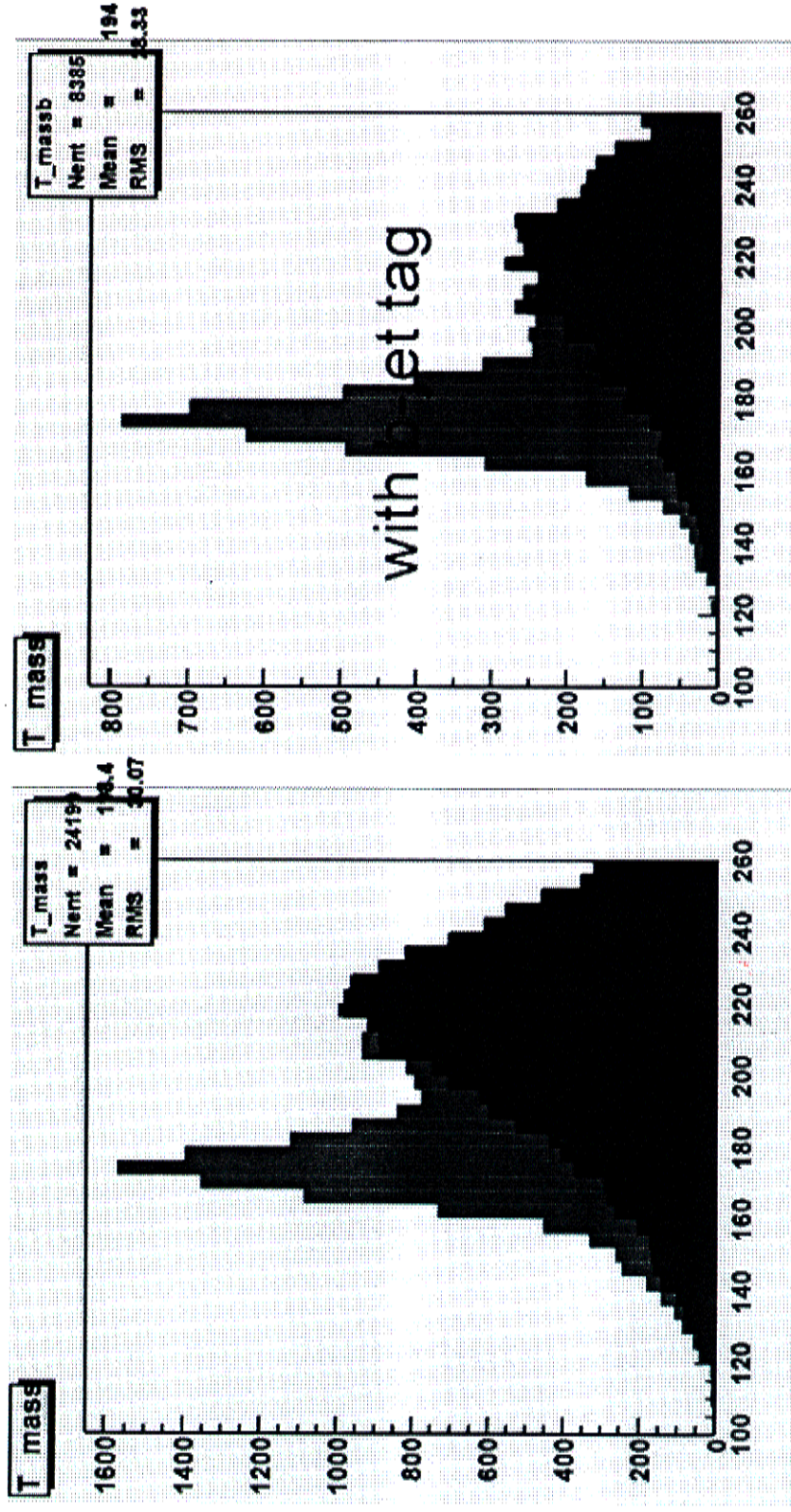
P_T corrected mass(GeV) # of significant tracks in jet

$$\varepsilon_{uds} = 86\% \quad \Pi_{uds} = 77\%$$

W mass reconstruction (top 4jet+1)

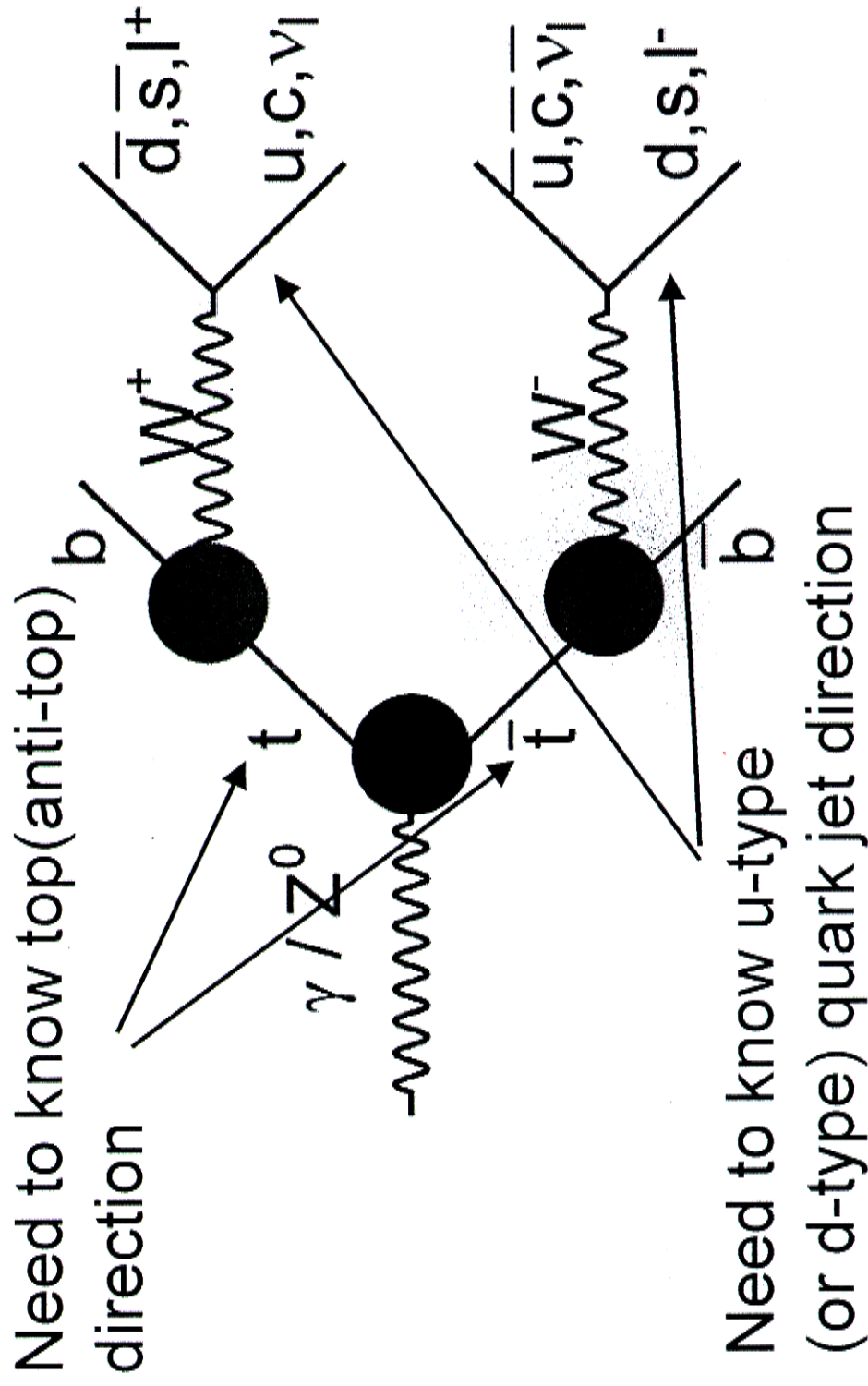


Top mass reconstruction (6jet)

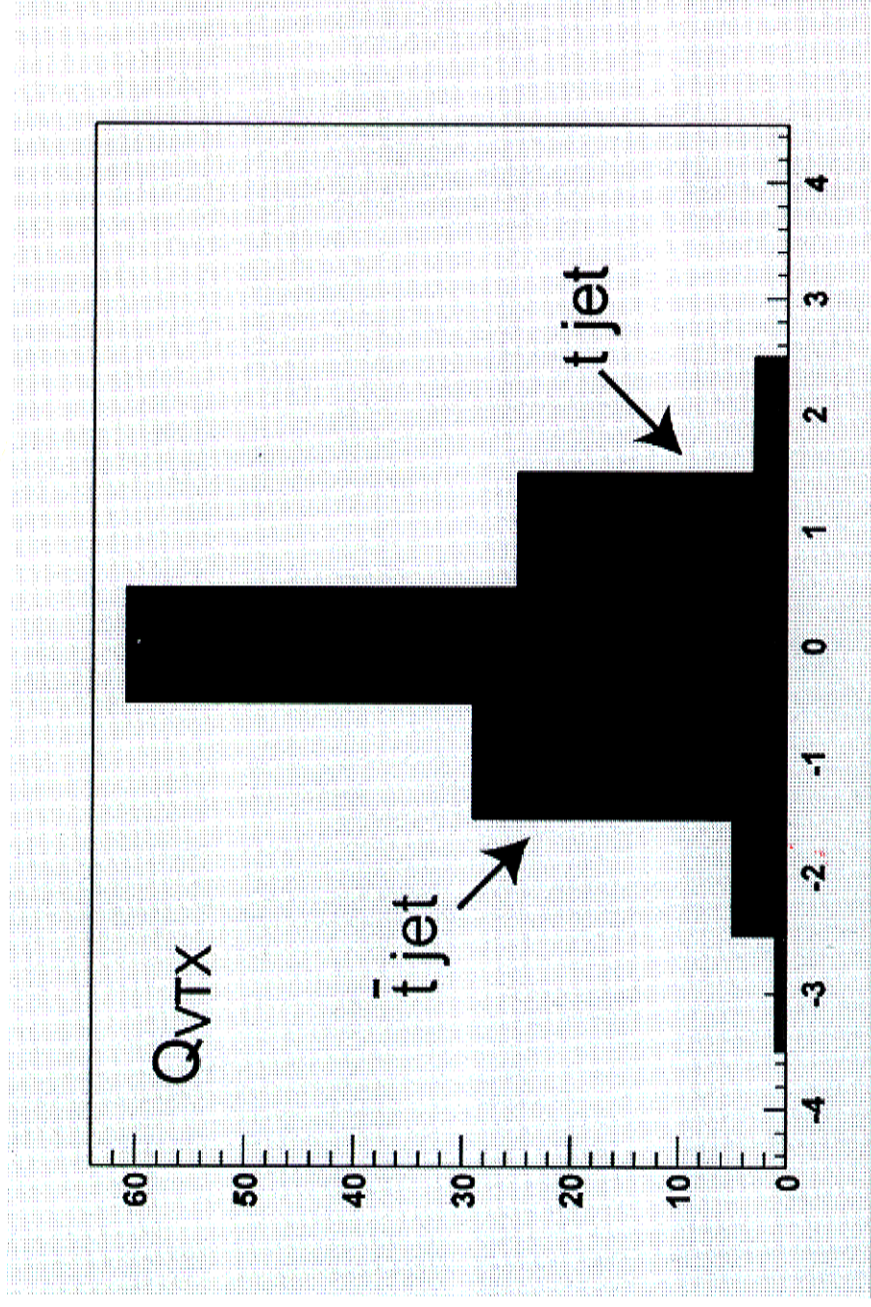


Reconstruction efficiency 6% difference between $r_{\text{in}}=1\text{cm}$ and 2cm

Anomalous top quark couplings



Vertex charge



Correct top(or anti-top)-quark tagging is $\sim 80\%$

Top analysis summary (6jet)

- Top quark reconstruction
 - $r_{in}=1\text{cm}$: # of rec. top=1802(1483 corr.)
 - $r_{in}=2\text{cm}$: # of rec. top=1704(1395 corr.)
 - 6% difference
 - Anomalous top couplings (c-tag in W)
 - $r_{in}=1\text{cm}$: # of rec. top=484(471 corr.)
 - $r_{in}=2\text{cm}$: # of rec. top=380(368 corr.)
 - 20% difference
- Qvtx: same perform. for (anti-)top direction

Summary

- We have developed fast simulation code to optimize the detector design for a future linear collider and first look results with topological vertexing technique are presented.
- The two VTX configurations ($r_{in}=1\text{cm}$ and 2cm) do not show significant difference for b-jet tagging but c-jet tagging.
- Excellent VTX with secondary (tertiary) vertex reconstruction opens new physics ability.