

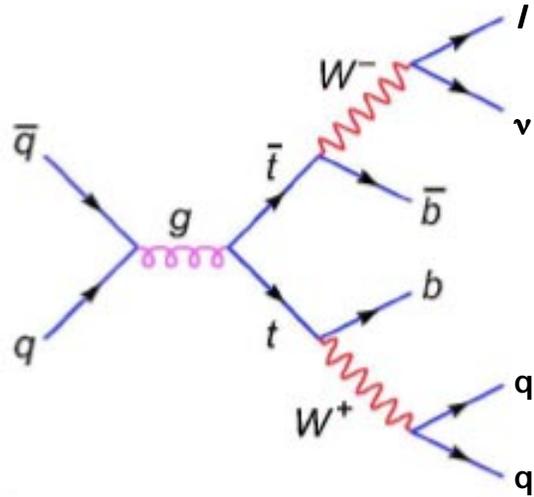
# QCD NLO Issues and Top Mass Measurement

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Fermilab  
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with G. Bruhn, D. Rainwater, T. Stelzer,  
W.J. Stirling

# Top mass reconstruction at the Tevatron



Best: Lepton plus jets;  
one top fully reconstructed.

## Run II:

- Better statistics
- **New:** Jet energy scale coming under control  
Use  $W$  mass constraint *in* top events (**danger!**)
- Systematics will now be dominated by gluon radiation  
(= extra jets, really):

$qq \rightarrow ttg$

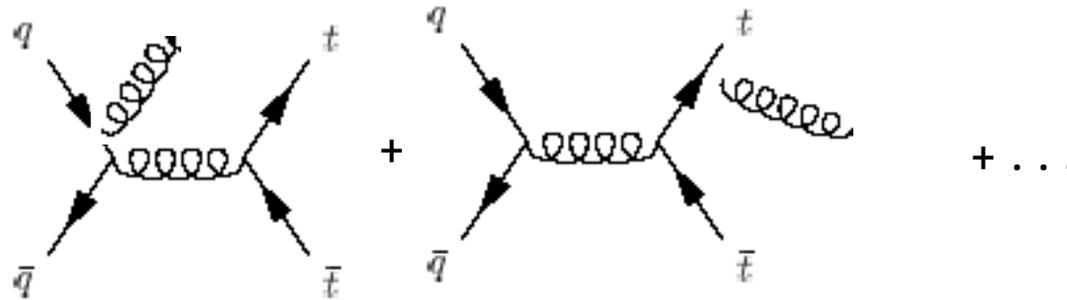
$gg \rightarrow ttg$

$qg \rightarrow ttq$

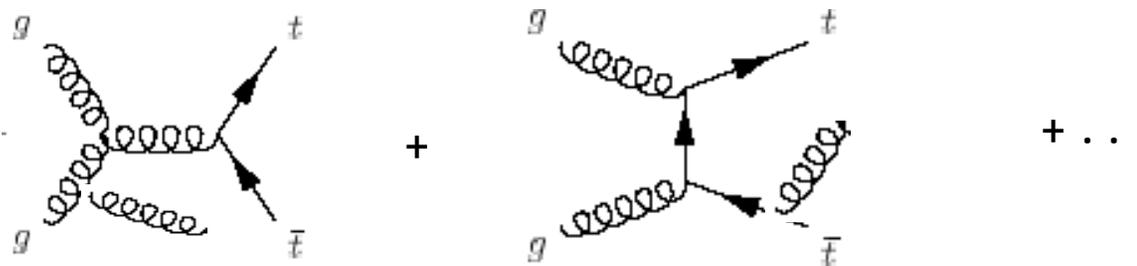
(+ radiative decays)

# t tbar j production at the Tevatron

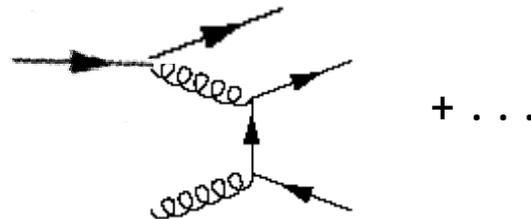
- qq -> ttg:



- gg -> ttg:



- qg -> ttq:

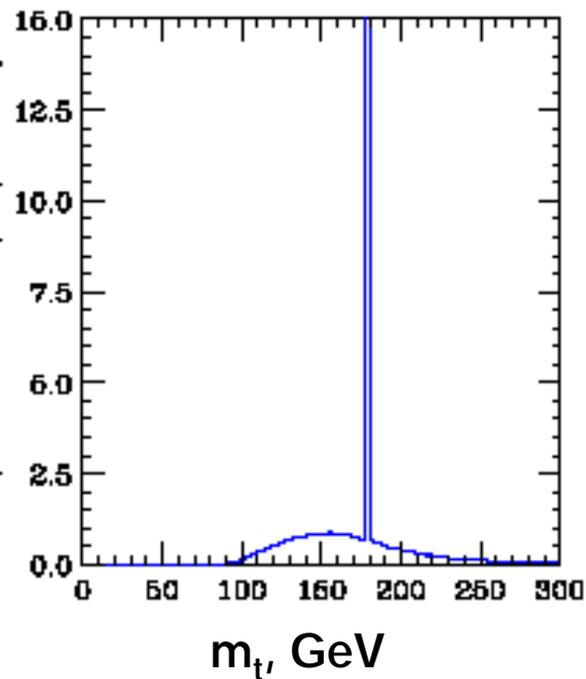


Not always produced in shower Monte Carlos!

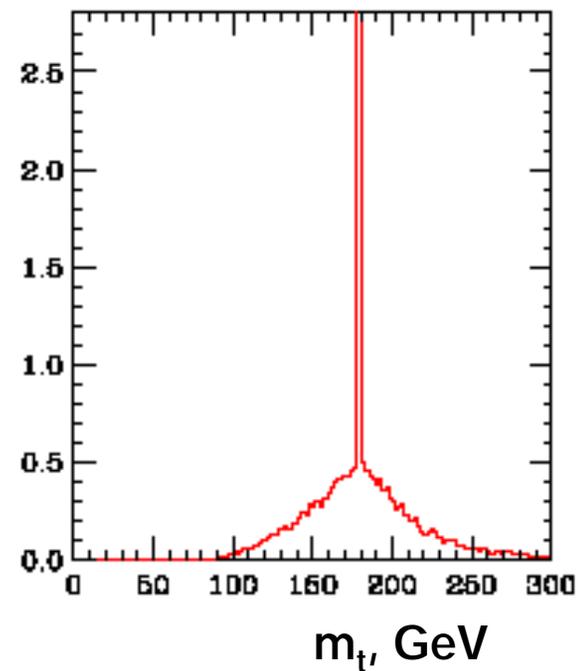
# Mass reconstruction from ttj at the Tevatron

- Madgraph, CTEQ6L pdfs
- **Both b's tagged**,  $p_T(b) > 15$  GeV
- $p_T(l,j) > 20$  GeV,  $\Delta R > 0.4$ ,  $|y_{b,j}| < 2$

tt + 0j:  $\langle m_t \rangle = 177.8$



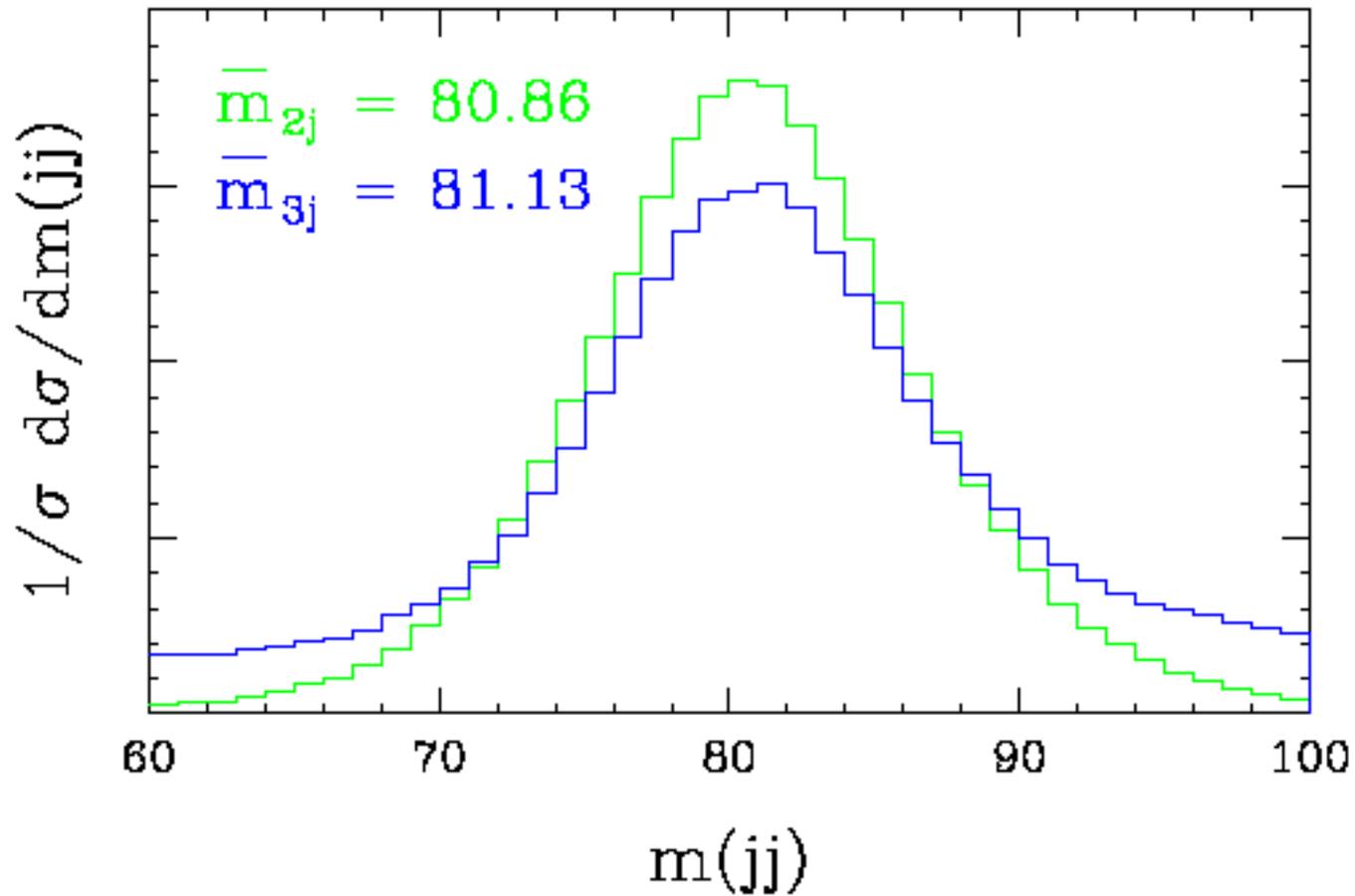
tt + 1j:  $\langle m_t \rangle = 180.7$



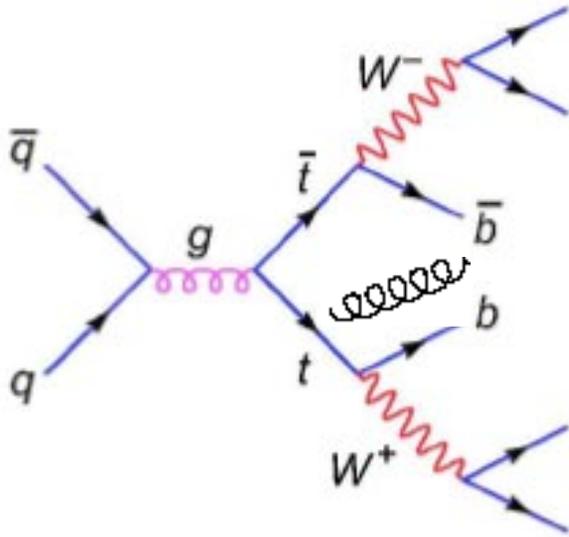
$\Delta m_t = 0.4$  GeV (cross section weighted)

# W Mass reconstruction in ttj at the Tevatron

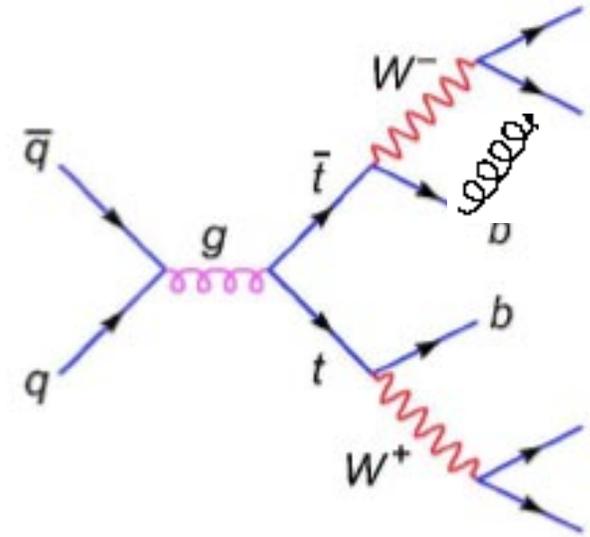
- Highest  $p_T$  non-b jet pair
- Cuts as above



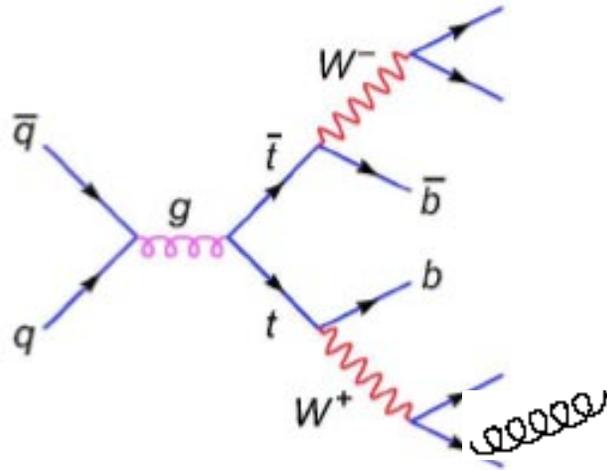
# Top also decays radiatively!



or

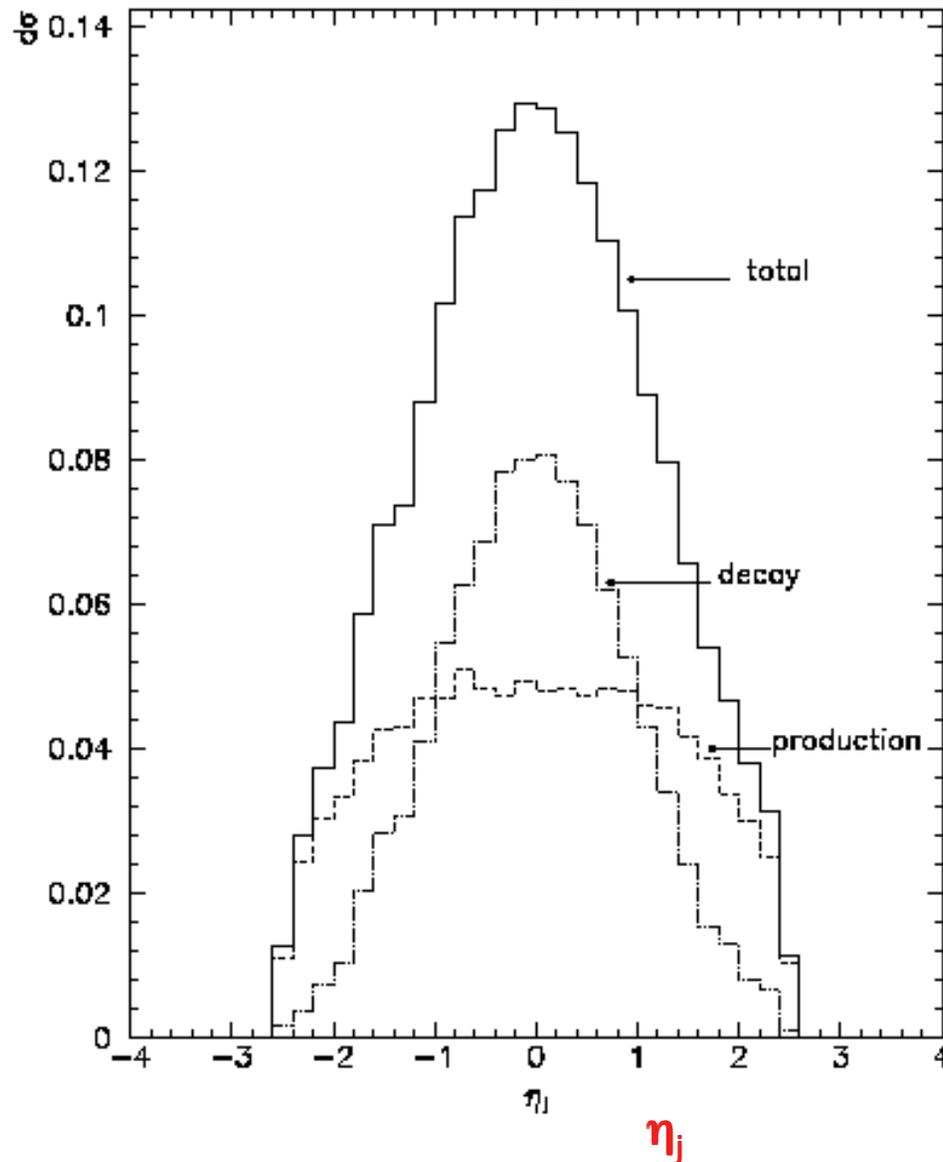


or



## Top also decays radiatively, cont.

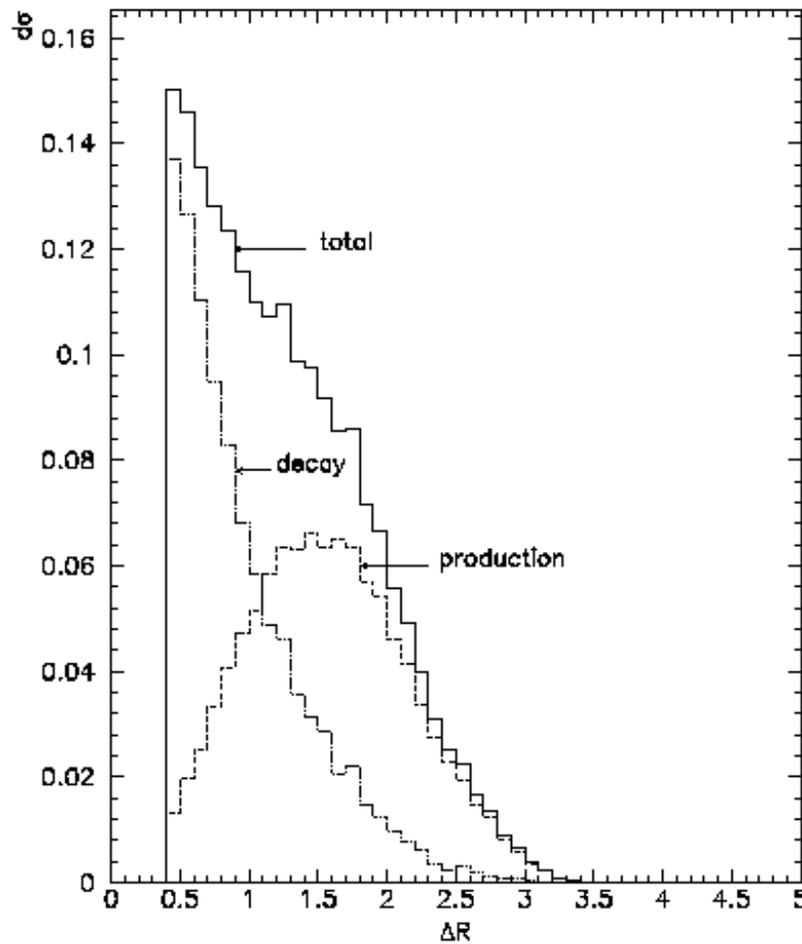
LHO, Stelzer, Stirling, PRD 1995:



- Tevatron (run I),  
**dilepton mode:**  
radiation from  $t$ ,  $t\bar{t}$ ,  $b$ ,  
 $b\bar{b}$  only
- Approx. half of extra  
jets come from decays!
- Production-stage rad.  
~flat in rapidity
- Decay-stage rad.  
central

## Top also decays radiatively, cont.

- Production/decay stage fraction very sensitive to cuts:

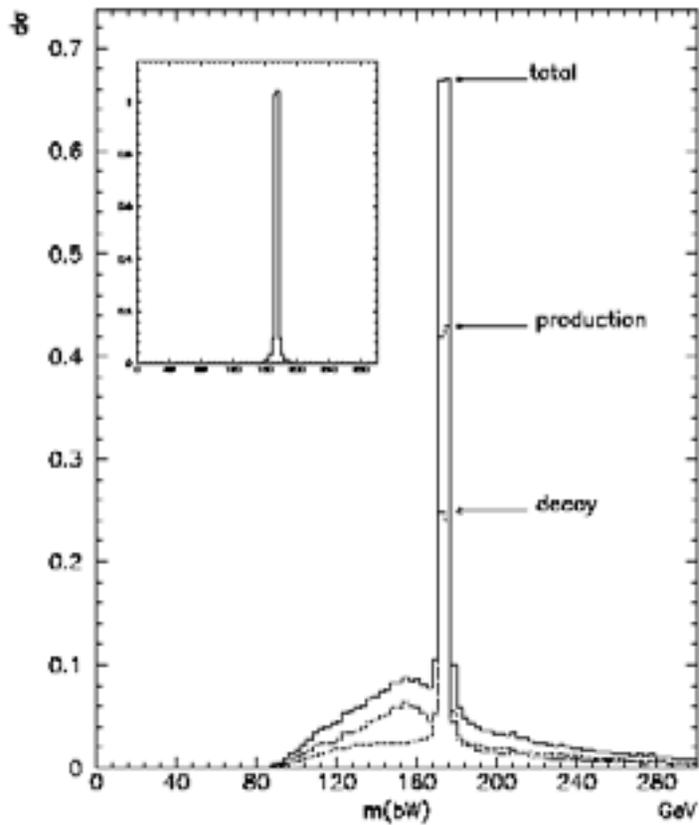


$\Delta R(b,j)$

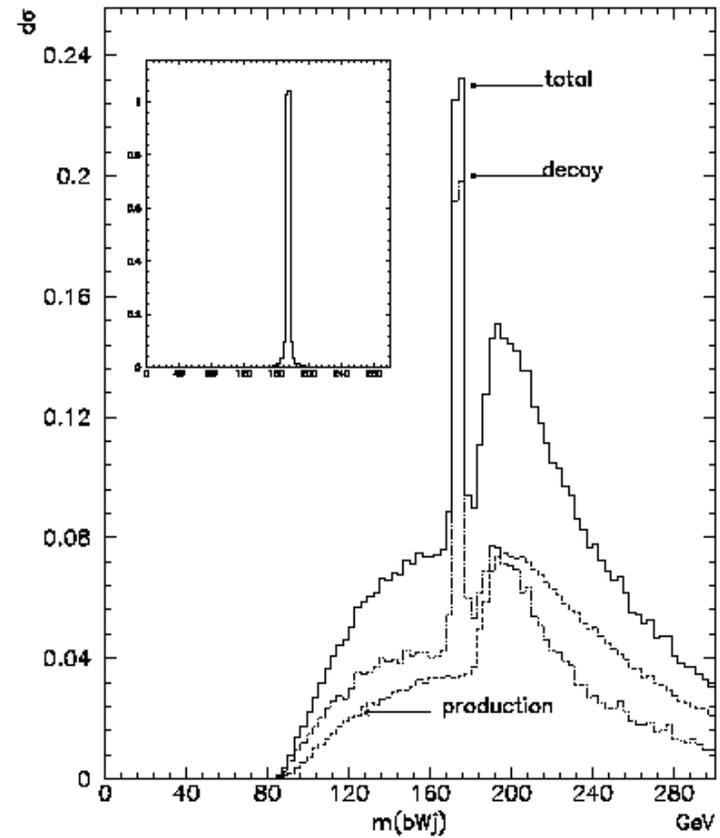
## Top also decays radiatively, cont.

- Add in extra jet or not?

Without:



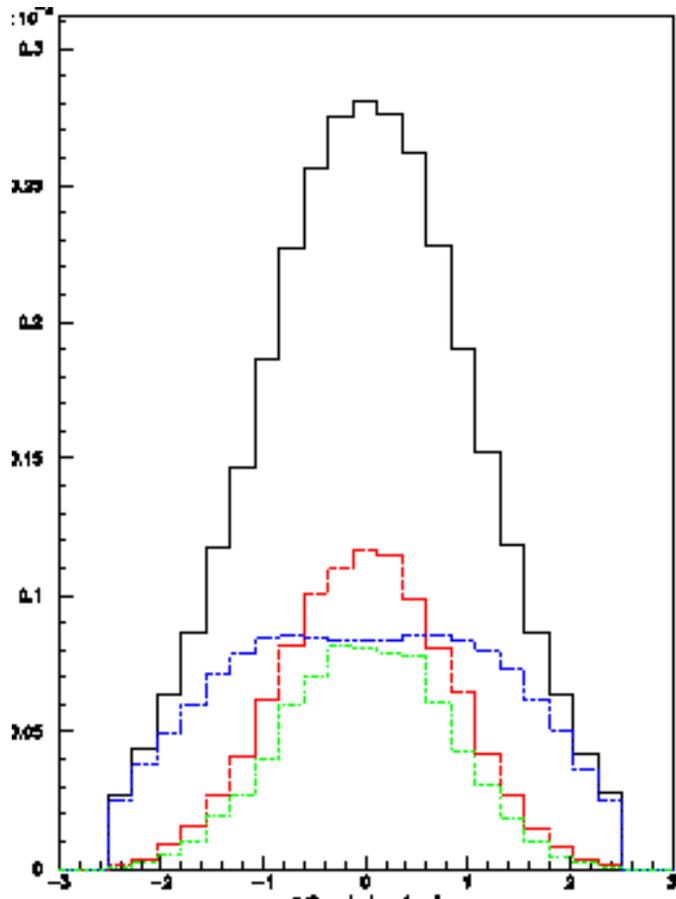
With:



... and that's with no radiation from hadronic W decay!

## Top also decays radiatively, cont.

- Now add radiation from hadronic W decay: **lepton+jets**

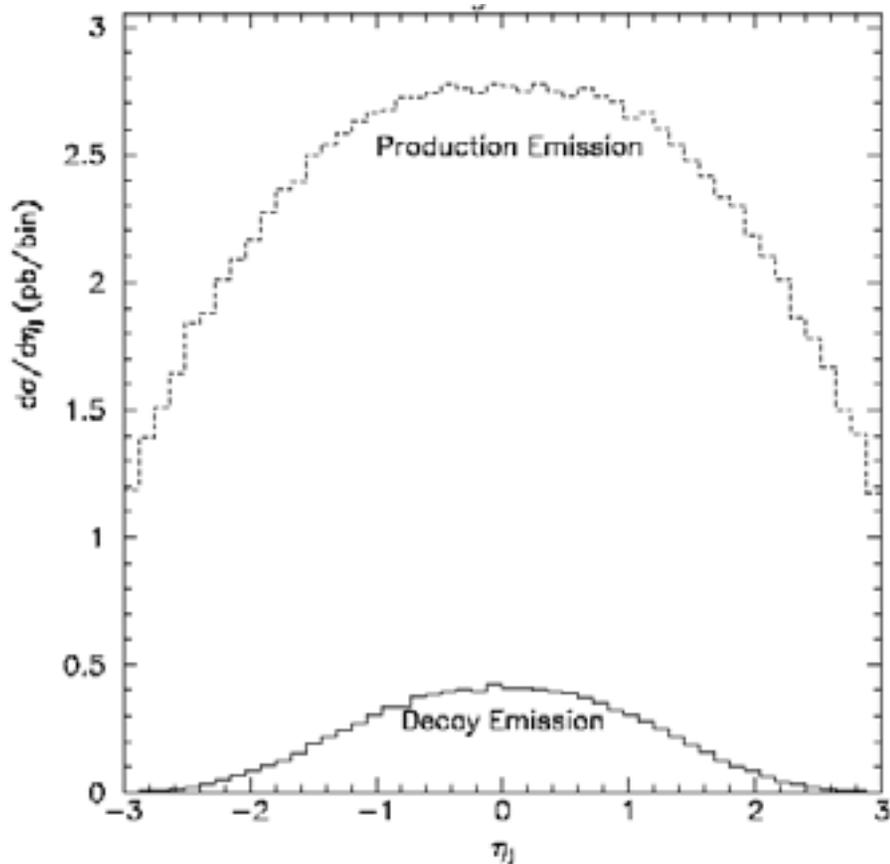


$\eta_j$

- Radiation from **single** hadronically decaying W comparable to total decay radiation from t, tbar, b, bbar!
- Similar rapidity distributions in all decay-stage radiation

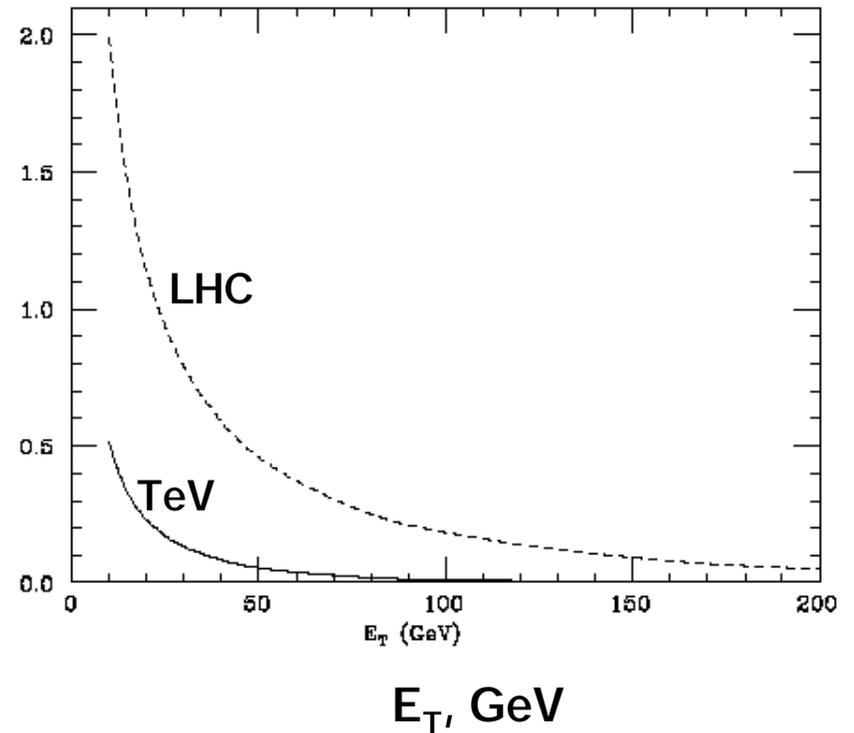
# What about the LHC?

- Most radiation in production:



- And lots of it!

$$\frac{\sigma}{\sigma_0} = \frac{\sigma(ttj, E_T^j \geq E_T \text{ cut})}{\sigma(tt)}$$



LHO, Stelzer, Stirling, PRD 1997

## Forward-Backward Asymmetry in $t\bar{t}j$

M. Bowen, S. Ellis, D. Rainwater, hep-ph/0509267

- QCD higher-order effects induce a forward-backward asymmetry in  $t\bar{t}$  production at Tevatron.
- Asymmetry is **different** in the inclusive, 0j and 1j exclusive samples.
- Pythia does not reproduce this asymmetry, since it does not have the quantum corrections in its matrix elements.
- Pythia does have its own asymmetries from long-distance QCD modeling.
- The asymmetry should be observable if they get enough luminosity (4-8 fb<sup>-1</sup>).

# Conclusions

- Many top events have extra jets, which complicate mass reconstruction
- Wrong combinations
- Jet energy scale from  $W$  reconstruction
- Radiative decays matter at Tevatron
- LHC has much more production-stage radiation
- QCD generates top asymmetry at NLO in SM