Backgrounds to $t\bar{t}$bar and Heavy Flavor Production Mechanisms

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Outline

- Status of top production x-section using b-tagging
- Backgrounds to $t\bar{t}$bar
- Heavy flavor production mechanisms and review of run 1 results
- Possible course of action
Ttbar production

- $T \rightarrow W b$
- Two b-jets in the final state, b-tag at least one ~45%
- Top signal is extracted as an access over the expected in background in $W+\geq 3$ jets
Before tagging

\[ W^+ \text{ Njets} \]

\[ l+\text{MET} + \text{Njets} \]

\[ \text{ALPGEN fractions} \]

\[ \text{QCD} \]

After tagging

\[ W^+ \text{ Light jets} \]

\[ W^+ \text{ Light jets} \]

\[ \text{Ptag light} \]

\[ \text{Ptag light} \]

\[ \text{Wc} \]

\[ \text{Wc} \]

\[ \text{Wb} \]

\[ \text{Wb} \]

\[ \text{Wcc} \]

\[ \text{Wcc} \]

\[ \text{Wbb} \]

\[ \text{Wbb} \]

\[ \text{Ptag 1c jet} \]

\[ \text{Ptag 1c jet} \]

\[ \text{Ptag 2c jets} \]

\[ \text{Ptag 2c jets} \]

\[ \text{Ptag 2b jets} \]

\[ \text{Ptag 2b jets} \]

\[ \text{Ptag QCD} \]

\[ \text{Ptag QCD} \]

\[ \text{N Bckg tag} \]

ALPGEN fractions were not verified on data yet.
Ttbar production cross section

$$\sigma = 7.4^{+4.4}_{-3.6}^{+2.1}_{-1.8} (\text{stat})^{+0.7}_{-0.7} (\text{lum}) \text{ pb}$$

- Allow 3 or more jets in lepton+jets channel, but apply b-tagging
- First time in DØ use lifetime based b-tagging!
**SM W(Z)+heavy flavor production.**

- **Final state gluon splitting**
  - $q \rightarrow Wb, c$
  - $\bar{q} \rightarrow \bar{Wb}, \bar{c}$

- **Initial state gluon splitting**
  - $g \rightarrow Wb, c$
  - $q \rightarrow \bar{Wb}, \bar{c}$

- **Flavor excitation.**

$sg \rightarrow Wc$ - uncertainty dominated by $s$-quark pdf’s constrained by NuTeV/CCFR data: $sn \rightarrow lc$ (same diagram w/o g, but twisted. 13-15%

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UR D0 group meeting, 08/08/03, R. Demina
QCD Heavy flavor production mechanisms

- Use high statistics QCD samples to calibrated MC prediction for gluon splitting component on data.
- Tag jets using different methods – lifetime or lepton.
- $\Delta\phi$ or $\Delta R$ are typically used to distinguish different mechanisms of h.f. production.
Correlations between h.f. jets.

Use \( \Delta \phi \) between tagged jets to determine the fraction of gluon splitting component after tagging.
Studies of the QCD h.f. production.

Tag both b-jets by muons.
2 muons Pt>3 GeV/c
Use 2D impact parameter fitting to determine b fraction.

\[ \Delta \phi(\mu - \mu), \text{ compared to MNR Prediction.} \]
Published Phys. Rev. D55,2546(1997)
Studies of the QCD h.f. production.

Both jets tagged by lifetime.
\( \Delta \phi \) (JETVTX tags) compared to PYTHIA Prediction.

\[
\frac{\text{data}}{MC}:
\]

\[
F_{\text{direct}} = 1.07 \pm 0.2 \text{(stat)};
\]

\[
F_{\text{flavex.}} = 0.85 \pm 0.55 \text{(stat)};
\]

\[
F_{\text{gsplit}} = 0.96 \pm 0.32 \text{(stat)}.
\]
Studies of the QCD h.f. production.

Later incarnation of tagging
Use c\(\tau\) to distinguish b from c
\(\Delta\phi\) SECVTX tags, compared to HERWIG Prediction.

\[
\begin{align*}
\text{data} : & \\
\frac{MC}{MC} : & \\
F_{\text{direct}} &= 0.82 \pm 0.19 (\text{stat}) ; \\
F_{\text{flavex.}} &= 1.36 \pm 0.42 (\text{stat}) ; \\
F_{\text{gsplit}} &= 0.95 \pm 0.25 (\text{stat}) \pm 0.16 (\text{sys}) .
\end{align*}
\]
Studies of the QCD h.f. production.

$\Delta \phi(\mu - \text{JETPROB tag})$ compared to MNR Prediction. Published
Pt($\mu$) > 9 GeV/c,
Use impact parameter fitting to determine b fraction (40% ) in muon jet, and JETPROB shape fitting on the away jet.
Studies of the QCD h.f. production.

From top x-section paper. 
\( \Delta R \) SECVTX tags, compared to HERWIG Prediction.

\(
\begin{align*}
\text{data} : & \\
\text{MC} : & \\
F_{\text{direct}} &= 0.47 \pm 0.22(\text{stat}); \\
F_{\text{flavex.}} &= 1.37 \pm 0.41(\text{stat}); \\
F_{\text{gsplit}} &= 1.40 \pm 0.19(\text{stat}).
\end{align*}
\)
Studies of the QCD h.f. production.

Data

Herwig MC:
flavor excitation
direct
gluon splitting

$$\Delta\phi(D^*-\text{JETPROB}),$$
compared to HERWIG Prediction.
Select
$$D^*-\rightarrow D0\pi, D0\rightarrow\mu K\nu.$$ 
Pt(\mu)>9GeV/c,
away jet: JetProb<10%.
Sample $90\%$ charm: probe
g$\rightarrow cc$ splitting
Studiests of the QCD h.f. production.
Summary.

We don't know it better than 30-40%, but now we have more data, better tagging tools.
Rick Field’s studies

- A more thorough study was initiated by R. Field
- Looked at the flavor correlation between jets:
  - If one jet is definitely a heavy flavor what is the other one?
- CDF note 5558
Open questions

- Basically all of them
- Overall rate
- Need better precision in fractions
- APPGEN fraction need to be verified on data
- B/c separation
Possible course of action

- **ALPGEN fractions verification**
  - Use dijet data+tagging (CSIP - ready, certified, very simple)
  - Need dijet ALPGEN MC
  - Use mu+jets data - higher b-fraction, two independent taggers (mu+lifetime)
  - Use reconstructed D-states (Burdis, Borisov, Nomerotski)
Jet production

- $\Delta\phi$ - sensitive to different production mechanisms, especially when jets are tagged as heavy flavor

Relative contribution of heavy flavor production mechanisms is known to an unacceptable $>30\%$ accuracy. $W+g(\rightarrow bb, cc)$ - main background to top and Higgs production.
Jet production cross section

- One of the first run 2 physics results
- Dijet mass - new physics probe