Top Pair Production Measurements at $s^{1/2} = 2$ TeV

- The newest quark
  - What are modes of production and decay?
  - What are the final state kinematics?
  - Is it really a la Electroweak theory?

- A very large mass...
  - ...and a suspicious Yukawa coupling $\sim 1$

- Need to convincingly find top with understood backgrounds
  - Then can measure it's mass and other properties

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Production and Signatures

- Even though the top mass is high, pair production wins over single top because it occurs strongly: 85% qqbar, 15% gluon fusion @ LO
  - Theoretical cross section @ 1.8 TeV = 5.2 pb
    @ 1.96 TeV = 6.7 pb +/- 0.42 pb
  - Expect a 30% cross-section increase

- Final states dictated by W decays:
  - All-jets (background: QCD)
  - Single lepton (background: W+jets, QCD)
  - Dilepton (background: Z/g, WW, W+jets)
  - Keep track of $\tau \rightarrow e, \mu$

\[ \sigma(tt) = \frac{N_{obs} - N_{bkg}}{A \int L dt} \]
Lepton+Track - CDF

- Avoid full inefficiency of lepton identification
- In 360 pb$^{-1}$
  - 46 observed, $14.6 \pm 3.6$ background

$$\sigma_{tt} = 9.9 \pm 2.1{(\text{stat})} \pm 1.3{(\text{syst})} \pm 0.6{(\text{lum})} \text{ pb}$$

m$_t$ = 178 GeV

1 lepton, 1 track
2 jets
Etmiss

Event count per jet bin

Leading Lepton Transverse Momentum

Missing Transverse Energy
Dilepton - DØ

- Kinematics-based selection
- 13 evts, background $3.2 \pm 0.7$
  \[ \sigma_{tt} = 8.6^{+3.2}_{-2.7} \text{(stat)} \pm 1.1 \text{(sys)} \pm 0.6 \text{pb (230 pb}^{-1} \text{ PLB)} \]
- 28 evts, background $6.8+2.6-1.8$
  \[ \sigma_{tt} = 8.6^{+2.3}_{-2.0} \text{(stat)}^{+1.2}_{-1.0} \text{(sys)} \pm 0.6 \text{pb (370 pb}^{-1} \text{ prelim.)} \]

\[ m_t = 175 \text{ GeV} \]
b-TAGGING

- Secondary vertex tagging
  - Find primary vertex for event
  - Reconstruct vertex from tracks in jet
    - Select jets with positive tags
    - based on decay length significance
  - CDF has new tagger, more efficient

- Jet probability tagging
  - Know track resolutions
  - Calculate probability that tracks in jet originate from event primary vertex
  - Select jets with low probability
**Single lepton - DØ**

- In 230 pb$^{-1}$
  \[ \sigma_{tt} = 6.7^{+1.4}_{-1.3} (stat)^{+1.6}_{-1.1} (sys) \pm 0.4(lum) \text{ pb (PLB, topo.)} \]
  \[ \sigma_{tt} = 8.6^{+1.6}_{-1.5} (stat + sys) \pm 0.6(lum) \text{ pb (PLB, b - tag)} \]

- 370 pb$^{-1}$ (prelim.)
  \[ \sigma_{tt} = 8.1^{+1.3}_{-1.2} (stat + sys) \pm 0.5(lum) \text{ pb (prelim, b - tag)} \]
Single Lepton - CDF

- jet probability tag
  - Look at single, double tags
  - $P_{jet} < 1\%, 5\%$
  - Very consistent results
    - More top needed

$$\sigma_{tt} = 8.9 \pm 1.0 (stat) \pm 1.1 (sys) \text{ pb (prelim, jet prob.)}$$

- SecVtx tag $\sigma_{tt} = 8.9 \pm 0.9 (stat) ^{+1.2}_{-0.9} (sys) \text{ pb (prelim, sec. vtx.)}$

- Two taggers
- Compatible results

$m_t = 178 \text{ GeV}$

318 pb$^{-1}$
**MULTI-JETS**

- No required leptons, need to tag b-jets
- All-jets

$$\sigma_{tt} = 7.5^{+3.7}_{-2.8} (stat + sys) \text{ pb (CDF prelim, 311pb}^{-1})$$

$$\sigma_{tt} = 5.2^{+2.6}_{-2.5} (stat)^{+1.5}_{-1.0} (sys) \pm 0.3(lum)\text{ pb (D0 prelim, 350 pb}^{-1})$$

- MEt + jets

Enhance $W \rightarrow \tau \nu$

$$\sigma_{tt} = 5.9^{+1.8}_{-1.6} (stat + sys) \text{ pb (CDF prelim, 311pb}^{-1})$$
# Breakdown of Uncertainties

- **Systematic uncertainties**
  - beginning to dominate lepton+jets
  - Significant fraction of dilepton, multijet channel results

<table>
<thead>
<tr>
<th>Source</th>
<th>D0 dilepton</th>
<th>D0 l+jets/2nd vtx</th>
<th>CDF l+jets/2nd vtx</th>
<th>CDF l+jets/jet prob tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tagging</td>
<td>–</td>
<td>0.4 pb</td>
<td>5.2%</td>
<td>7.2%</td>
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<tr>
<td>Lepton ID/isolation</td>
<td>0.4 pb</td>
<td>–</td>
<td>5.0%</td>
<td>4.9%</td>
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<tr>
<td>Jet energy scale</td>
<td>0.5 pb</td>
<td>0.2 pb</td>
<td>4.3%</td>
<td>4.2%</td>
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<tr>
<td>Background model</td>
<td>–</td>
<td>0.4 pb</td>
<td>4.4%</td>
<td>–</td>
</tr>
<tr>
<td>Jet ID/reconstruction</td>
<td>+0.5 - 0.4 pb</td>
<td>0.2 pb</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>triggering</td>
<td>+0.7 - 0.4 pb</td>
<td>0.3 pb</td>
<td>–</td>
<td>–</td>
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</tbody>
</table>
Summary Results

- Have gone from ~200 pb-1 to almost 400 pb-1 in current analyses

DØ Run II Preliminary

<table>
<thead>
<tr>
<th>Process</th>
<th>#σ(pp → t¯t) (pb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dilepton (topological) L=230 pb⁻¹</td>
<td>7.0 ± 2.4 ± 1.6 ± 0.4</td>
</tr>
<tr>
<td>#jets (topological) L=230 pb⁻¹</td>
<td>6.3 ± 0.8 ± 0.9 ± 0.4</td>
</tr>
<tr>
<td>combined (topological) L=230 pb⁻¹</td>
<td>5.3 ± 3.3 ± 1.3 ± 0.3</td>
</tr>
<tr>
<td>dilepton (topological) NEW L=370 pb⁻¹</td>
<td>8.9 ± 0.9 ± 1.1 ± 0.5</td>
</tr>
<tr>
<td>#jets (topological) NEW L=370 pb⁻¹</td>
<td>6.1 ± 1.2 ± 1.3 ± 0.4</td>
</tr>
<tr>
<td>all hadronic</td>
<td>8.0 ± 1.7 ± 3.3 ± 0.5</td>
</tr>
</tbody>
</table>

10/27/05

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