Search for $\bar{t}t \rightarrow \not{E}_T + \text{jets}$ at CDF-II

Giorgio Cortiana,
University of Padova and INFN

Outline:
- Introduction: CDF/top properties
- $\sigma_{tt}$ results from CDF
- The MET+jets analysis
  - Background estimate
  - Kinematical sel. optimization
- Preliminary results

Pisa, July 12th 2005
CDF is a multi purpose detector built to study $\bar{p}p$ interaction. Inside a multi wire drift tracking chamber a 7-layers silicon vertex detector (SVX II) is crucial to detect secondary vertices from heavy flavor decays. Outside the tracking systems, energy measurements are provided by electromagnetic and hadronic calorimeters. Finally drift-tube chambers and scintillators for muon detection cover the outer region of the detector.
Introduction: top pairs production

- Top quark production:
  - $q - \bar{q}$ through strong interaction: $\approx 85\%$
  - $g - g$ through strong interaction: $\approx 15\%$

One top pair each $\sim 10^{10}$ inelastic collisions at $\sqrt{s} = 1.96$ TeV

Standard Model

Tevatron Pair Production Through Strong Interaction

$\sigma(t\bar{t}) = 6.7^{+0.7}_{-0.9}$ pb

Cacciari et al., JHEP 0404, 068 (2004)
Introduction: decays

Different decay signatures arise accordingly to $W$ bosons decay, being $BR(t \rightarrow Wb) \sim 1$. 

$Pisa, July 12^{th} 2005$
Introduction

Top pairs are produced rarely, but in general provides clean handles allowing their separation from backgrounds:

- for leptonically decaying Ws signal events contain high-PT lepton/ high MET
  - Possibility of triggering and/or selecting high purity samples.
- each top pair decay mode contains nominally 2 b-quark jets
  - b-quark jets can be identified on the basis of b-properties: decays/lifetimes.

Final states:

- **Dileptons**: BR = 11% (ee/eμ/μμ only = 8%) cleanest sample, lowest statistics
- **Lepton+Jets**: BR = 44% (e/μ + jets = 29%) golden channel w/ high statistics and reasonable S/B
- **All-Hadronic**: BR = 44%, most challenging channel w/ high statistics but large backgrounds
b-jets identification

**SECondary VerTeX (SecVtx) tagging:**
tracks with significant IP are used in an iterative fit to identify the secondary vertex inside the jet.

Efficiency drops at low jet Et and high rapidity but is 45-50% for ttbar central b-jets.
Mistag rates are kept typically at 1-2% (tight SecVtx).

Tight and Loose tagging options to retain signal in double tag searches.
Other B-Tagging Algorithms

2\textsuperscript{nd}ary Vertex Tag
- Displaced vertex reconstruction with silicon detector:
- B hadrons travel $\sim$3mm before decay w/ large track multiplicity

Soft Muon Tag
- Look for relatively low momentum $\mu$ in or near the jets that result from semileptonic decays of B hadrons
- $b \rightarrow \ell \nu c$ (BR $\sim$ 20%)
- $b \rightarrow c \rightarrow \ell \nu s$ (BR $\sim$ 20%)

Jet Probability Tag
- Determine probability for jet to originate from $b$ or $c$ or light quarks based on signed impact par distribution of all tracks in the jet

Top Event Tag Efficiency
- 2\textsuperscript{nd}ary Vertex Tag: 58-63%
- Soft Muon Tag: 15%
- Jet Probability Tag: 57%

False Tag Rate (QCD jets)
- 2\textsuperscript{nd}ary Vertex Tag: 0.8%
- Soft Muon Tag: 3.6%
- Jet Probability Tag: 1.2%
\[ \sigma_{tt} \text{ results:} \]

- Global fit to isolated high \( P_T \) dilepton data (\( ee/e\mu/\mu\mu \)) in \( N_{jet} \) – MET plane
- Fit data to shapes from templates from SM processes
  - Signal(s) floating in fit: \( tt, WW, Z \to \tau\tau \)
  - Backgrounds fixed in fit: \( WZ, ZZ, Z \to ee, Z \to \mu\mu, bb, W\gamma, W+jets \)

- Independent of b-tag.
- Select events with 1 e or \( \mu \), MET and \( \geq 3 \) jets
- Neural Net: Aplanarity, Max-Jet-Rapidity, Min-Dijet-Separation, \( H_T \), \( \Sigma_{jet(3,4,5)}E_T, \Sigma P_z/\Sigma E_t \), Min-Dijet-Mass

- Use dedicated trigger: 4 jets with \( E_T>15 \text{ GeV and } \Sigma E_t^{\text{event}}>125 \text{ GeV} \)
- \( 6 \text{ – } 8 \) jets, and \( \geq 1 \) b-tag (vtx tag)

- 1 isolated high-\( P_T \) e or \( \mu \) (\( E_T(P_T)>20 \text{ GeV} \))
- Missing \( E_T > 20 \text{ GeV} \), for escaping \( \nu \)
- \( \geq 3 \) jets (\( E_T>15 \text{ GeV} \)) with \( \geq 1 \) b-tags (2\text{ndary vertex tagger})

- \( \geq 3 \) jets with \( \geq 1 \) b-tags
- Fit leading jet \( E_T \) distribution in data to templates

- In events with 1 e or \( \mu \), MET and \( \geq 3 \) jets require \( \geq 1 \) b-tag (b-tag: \( \text{JetProb} \))
- \( H_T>200 \text{ GeV} \)

- In events with 1 e or \( \mu \), MET and \( \geq 3 \) jets require \( \geq 1 \) b-tag (b-tag: \( \text{soft muon tag} \))
- Reduce background by \( H_T>200 \text{ GeV} \)
$E_T$+jets analysis:

Rather than lepton identification,

The MET + jets analysis concentrates mainly in the selection of events with high and significant missing $E_T$.

- MET+jets decays were not studied yet, give us the possibility to add a new piece of knowledge in the top physics sector.
- Show large acceptance w.r.t. to tau+jets decays
  - taus are reconstructed as jet-like objects: more challenging signature compared to e/µ.
- Large background: QCD, EWK+HF

- need an optimized kinematical + topology selection
- need b-jet identification to increase S/N ratio. (SecVTX)

- b-jet identification rates are different on ttbar and background processes: can distinguish the two components:
  - B-tag rate parametrizations
  - Tagging matrix
Datasets & Method

Datasets and trigger:

**TOP_MULTI_JET dataset** up to Aug 2004: 311 pb$^{-1}$.

- **L1**: ≥1 cal. tower with $E_T \geq 10$ GeV;
- **L2**: ≥4 cal. clusters with $E_T \geq 15$ GeV, $\Sigma E_T \geq 125$ GeV;
- **L3**: ≥4 jets, $R=0.4$, $E_T \geq 10$ GeV

**MC**: (167 fb$^{-1}$), Pythia ttbar, $M_{top} = 178$ GeV

**High missing Et Selection?**

- Yes: MET+jets analysis
  - $ttbar \rightarrow bl\nu bbarjj$
  - Method-I approach + ad hoc Kinematical selection
  - $ttbar$ cross section measurements in Missing $E_T$ + multi-jet final states
- No: All-Had analysis
  - $ttbar \rightarrow bjj bbarjj$
  - **Method 1**: positive tagging matrix approach to predict the absolute amount of background
  - Kinematical Selection + ≥ 1 SECVTX positive tagged jet.
Tagging rate dependences observed in 3-jet data events will be then used to predict the number of tagged jets at higher jet-multiplicities and on kinematically selected data samples.

The choice of the set of variables used for the tagging rate parametrization need to be able to track possible sample composition changes introduced by different kinematical selections.

b-jet identification rates are different on \( tt\bar{t} \) and background processes: can distinguish the two components:

Look at the B-tag rates directly from TOP_MULTI_JET data
Use 3 (\( E_T > 15 \) GeV, \( |\eta|<2.0 \)) jet events: \( F_{\text{top}} = 2 \times 10^{-5} \)
Take the vars by which the tag-rate mainly depends to construct a matrix

<table>
<thead>
<tr>
<th>Number of events</th>
<th>3 jets</th>
<th>( \epsilon_{Tag}^{ave} )</th>
<th>4 jets</th>
<th>( \epsilon_{Tag}^{ave} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>multijet data</td>
<td>879,187</td>
<td>6.5 %</td>
<td>1,553,525</td>
<td>8.7 %</td>
</tr>
<tr>
<td>expected inclusive ( tt )</td>
<td>16.88</td>
<td>58.2 %</td>
<td>182.92</td>
<td>74.3 %</td>
</tr>
<tr>
<td>multijet data, ( E_T/\sqrt{\Sigma E_T} \geq 4 )</td>
<td>2,317</td>
<td>10.8 %</td>
<td>2,412</td>
<td>16.6 %</td>
</tr>
<tr>
<td>expected inclusive ( tt ), ( E_T/\sqrt{\Sigma E_T} \geq 4 )</td>
<td>6.54</td>
<td>59.3 %</td>
<td>56.92</td>
<td>77.3 %</td>
</tr>
</tbody>
</table>

Note:

Tagging rate dependences observed in 3-jet data events will be then used to predict the number of tagged jets at higher jet-multiplicities and on kinematically selected data samples.

The signal contamination needs to be as low as possible in the sample used to parametrize the tagging rates in order to avoid biases in the background estimate.
MET *cos Δφ(MET,jet): has a consistent correlation with heavy flavor component of the sample and allows to distinguish met origins in relation to geometrical properties:

- Instrumental MET due to energy mismeasurements is generally oriented along jets.
- Physics produced MET can be correlated or uncorrelated with jet direction:
  - b-quarks semileptonic decays produce missing E_T along the jet.
  - W→lν + jets processes yield missing E_T pointing away from jets.
The main tagging rate dependences were identified w.r.t.:

- jet $E_T$
- jet $N_{TRK}$
- $\text{Met} \times \cos \Delta\phi(\text{met,jet})$

**Background estimate – cont’d**

3-d ($E_T, N_{TRK}, \text{Met}_{PRJ}$) Positive Tagging Matrix constructed on 3 ($E_T > 15$ GeV, $|\eta| < 2.0$) jet data events. Use it to extrapolate the tag rate to higher jet multiplicities.

Asymmetric distribution due to different concurring processes, HF+jets EWK+jets allows to track sample composition changes with MET.

The matrix bins are chosen to best fit the tagging dependences and to avoid low stats/undefined bins:

- 3 $E_T$ bins: $15 \div 40$, $40 \div 70$, $\geq 70$, GeV;
- 11 $N_{TRK}$ bins: $2 \div 12$;
- 10 $\text{Met}_{PRJ}$ bins: $\leq -40$, $-40 \div -20$, $-20 \div -10$, $-10 \div 0$, $0 \div 10$, $10 \div 20$, $20 \div 30$, $30 \div 40$, $\geq 40$, GeV.
Mtx Check #1:

Extrapolate the tag rate from 3 jet to higher jet multiplicity events, before kinematical selection.

The agreement between observed and matrix-predicted positive tagged jet is good for all jet multiplicities.

<table>
<thead>
<tr>
<th>N jet</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nevts</td>
<td>879,187</td>
<td>1,553,525</td>
<td>859,543</td>
<td>284,062</td>
<td>68,628</td>
<td>13,237</td>
</tr>
<tr>
<td>N tgbj jets</td>
<td>1,781,645</td>
<td>4,197,888</td>
<td>2,877,148</td>
<td>1,134,089</td>
<td>318,410</td>
<td>69,966</td>
</tr>
<tr>
<td>Obs + tags</td>
<td>57,314</td>
<td>135,056</td>
<td>87,332</td>
<td>32,914</td>
<td>8,992</td>
<td>1,914</td>
</tr>
<tr>
<td>Exp + tags</td>
<td>57,314 ± 233</td>
<td>133,275 ± 546</td>
<td>87,156 ± 370</td>
<td>33,184 ± 149</td>
<td>9,147 ± 43</td>
<td>2,000 ± 10</td>
</tr>
</tbody>
</table>

Total observed + tags: 323,522
Total expected + tags: 322,076 ± 717
Optimize the kinematical selection in order to minimize the relative statistical error on xsec using both the expected amount of tags for inclusive ttbar and background (from matrix).

Optimization procedure:
- Start by selecting ≥4 jets (matrix is computed with =3 jet events)
- Scan different sets of requirements (metsig, A, minΔφ(met,jet))
- Calculate the amount of expected bkg tags for a given cut set
- Instead of $N_{obs}^{tag}$ use $N_{mc}^{tag} + N_{exp}^{tag}$

Choose the set of cuts that minimizes the expected (stat. only) relative error on xsec

$\sigma_{ttbar} = \frac{N_{obs}^{tag} - N_{exp}^{tag}}{\epsilon_{kin} \cdot \epsilon_{tag}^{ave} \cdot L}$

Metsig = met/$\sqrt{\Sigma E_T}$, A=3/2Q_1, Q_1 is the smallest eigenvector of the sphericity tensor; Apla values are in the range [0, 0.5], extremes are reached for opposite jets and evenly distributed jets.
Kinematical Selection

Ordering the scanned sets by increasing expected relative error on the cross section measurement we end up with the following:

\[ \text{[Mets, } A, m\Delta\phi] \]

<table>
<thead>
<tr>
<th>cut set</th>
<th>( MC_{\text{inc}} )</th>
<th>( MJ_{\text{inc}} )</th>
<th>( MC_{\text{tag}} )</th>
<th>( BKG_{\text{tag}} )</th>
<th>( S/\sqrt{N} )</th>
<th>( \text{relative error} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.00</td>
<td>0.00</td>
<td>0.40</td>
<td>93</td>
<td>597</td>
<td>73</td>
</tr>
<tr>
<td>2</td>
<td>4.00</td>
<td>0.00</td>
<td>0.50</td>
<td>82</td>
<td>461</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>4.00</td>
<td>0.01</td>
<td>0.40</td>
<td>90</td>
<td>549</td>
<td>71</td>
</tr>
<tr>
<td>4</td>
<td>4.00</td>
<td>0.01</td>
<td>0.50</td>
<td>80</td>
<td>426</td>
<td>63</td>
</tr>
<tr>
<td>5</td>
<td>4.00</td>
<td>0.02</td>
<td>0.40</td>
<td>85</td>
<td>494</td>
<td>68</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

The set:

- \( N \text{ jets}(E_T \geq 15 \text{ GeV}; |\eta| < 2.0) \geq 4 \)
- \( E'_T / \sqrt{\sum E_T} \geq 4.00 \text{ GeV}^{1/2} \)
- \( \min \Delta\phi(\text{met, jet}) \geq 0.4 \text{ rad} \)

promises a relative statistical uncertainty of 17.5% and provides a pre-tagging S/N~0.18.

*Pisa, July 12th 2005*
Kinematical Selection

- N jets($E_T \geq 15$ GeV; $|\eta| < 2.0$) $\geq 4$
- $\Delta \phi(\text{met}, \text{jet}) \geq 0.4$ rad
- $\frac{E_T}{\sqrt{\sum E_T}} \geq 4.00$

### before tagging

<table>
<thead>
<tr>
<th>N evt</th>
<th>$MC_{(\tau+\text{jets})}$</th>
<th>$MC_{\text{Incl.}}$</th>
<th>MJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>149,323</td>
<td>1,021,924</td>
<td>4,249,644</td>
</tr>
<tr>
<td>Prereq</td>
<td>74,904</td>
<td>558,528</td>
<td>3,897,755</td>
</tr>
<tr>
<td>$N_{\text{jet}} \geq 4$</td>
<td>72,708</td>
<td>549,138</td>
<td>2,781,788</td>
</tr>
<tr>
<td>$\frac{E_T}{\sqrt{\sum E_T}} \geq 4$</td>
<td>29,830</td>
<td>78,145</td>
<td>3,996</td>
</tr>
<tr>
<td>min $\Delta \phi(\text{met}, \text{jets}) &gt; 0.4$</td>
<td>19,079</td>
<td>49,848</td>
<td>597</td>
</tr>
</tbody>
</table>

in 311 pb$^{-1}$:
- S/N $\tau + \text{jets}$: $\frac{N_{\tau}^{\text{mc}}}{(N_{\text{obs}}^{\text{data}} - N_{\text{mc}}^{\text{incl}})} = 0.07$
- S/N Inclusive: $\frac{N_{\text{mc}}^{\text{incl}}}{(N_{\text{obs}}^{\text{data}} - N_{\text{mc}}^{\text{incl}})} = 0.18$

### after tagging

| min $\Delta \phi(\text{met}, \text{jets}) \geq 0.4$ | 19,079 | 49,848 | 597 |
| > 1 tag | 11,666 | 30,410 | 106 |

in 311 pb$^{-1}$:
- S/N $\tau + \text{jets}$: $\frac{N_{\tau}^{\text{mc}}}{(N_{\text{obs}}^{\text{data}} - N_{\text{mc}}^{\text{incl}})} = 0.44$
- S/N Inclusive: $\frac{N_{\text{mc}}^{\text{incl}}}{(N_{\text{obs}}^{\text{data}} - N_{\text{mc}}^{\text{incl}})} = 1.14$

- $\sim 1/3$ of the total acceptance is provided by the tau+jets exclusive $t\bar{t}$ decay channel;

- the remaining $\sim 2/3$ come from $e/\mu + \text{jets}$ $t\bar{t}$ events failing the tight lepton identification requirements

Pisa, July 12th 2005

Giorgio Cortiana
The matrix performs well in the control samples, the discrepancies in terms of the ratio obs/exp tags being are limited at 10% (even lower folding the ratio with the number of events populating each jet multiplicity).
Kin sel + ≥1 tag Sample:

Once we feel confident about our matrix parametrization we can look at its prediction in the data sample after kinematical selection and compare it with SecVtx tagged data.

- $N \text{ jets}(E_T^{L5} \geq 15; |\eta| < 2.0) \geq 3$
- $E_T' / \sqrt{\sum E_T} \geq 4.00$
- $\text{min} \Delta\phi(\text{met,jet}) \geq 0.4 \text{ rad}$

Matrix-based background prediction is corrected with an iterative procedure to account for the ttbar presence in the pre-tag sample.

The excess is well consistent w.r.t. MC+BKG expectations in all jet bins!
We can cross-check the excess we attribute to ttbar production by looking to kinematical variables. In particular we can use the positive tagging matrix to extract background shapes.

Then fit data distribution after kin sel + ≥1 tag to the sum of:

- Inclusive ttbar template
- Matrix extracted bkg template

And extract the relative fractions of signal and background in the data

\[ L = -2 \cdot \sum_{i=1}^{N_{bins}} N_i \cdot \log(F) - F \]

\[ F = f_b B_i + (1 - f_b) S_i \]

Used binned likelihood fits: and checked the fitting procedure by pseudoexperiments.
We then fitted several other event and/or jet variables with the same technique.

Anyway, most of them are correlated with each other. For this reason we chose one event-variable and one jet-variable for our estimation.

*We chose among the vars the ones on which the PE return on average the lowest error on the fitted fraction.*

*From data fits:* we found a ttbar fraction consistent with that calculated by the counting method.
- Systematic Uncertainties -

<table>
<thead>
<tr>
<th>Source</th>
<th>Method</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \epsilon_{\text{kin}} ) systematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigger simulation</td>
<td>turn-on curves</td>
<td>14.8 %</td>
</tr>
<tr>
<td>Generator dependence</td>
<td>(</td>
<td>\epsilon_{\text{PYTHIA}} - \epsilon_{\text{HERWIG}}</td>
</tr>
<tr>
<td>PDFs</td>
<td>( \epsilon_{\text{PYTHIA}} )</td>
<td></td>
</tr>
<tr>
<td>ISR/FSR</td>
<td>MC reweighting</td>
<td>1.6 %</td>
</tr>
<tr>
<td>Jet Corrections</td>
<td>samples comparison</td>
<td>2.0 %</td>
</tr>
<tr>
<td></td>
<td>(</td>
<td>\epsilon_{\text{jetcorr},+1\sigma} - \epsilon_{\text{jetcorr},-1\sigma}</td>
</tr>
<tr>
<td>( \epsilon_{\text{tag}} ) systematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SecVtX scale factor</td>
<td>(</td>
<td>\epsilon_{\text{tag},+1\sigma} - \epsilon_{\text{tag},-1\sigma}</td>
</tr>
<tr>
<td>Tagging matrix systematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data control samples</td>
<td>( N_{\text{obs}} / N_{\text{exp}} )</td>
<td>10.0 %</td>
</tr>
<tr>
<td>Luminosity systematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luminosity measurement</td>
<td></td>
<td>6.0 %</td>
</tr>
</tbody>
</table>
The final sample kin sel + ≥1 tag consists of 106 events for a total of $N_{\text{obs}} = 127$ positive tagged jets.

From tagging matrix prediction we expect $N_{\text{exp}} = 67.4 \pm 7.2$ tags.

We need to correct the tagging matrix prediction in order to account for the ttbar presence in the pre-tagging sample by using an iterative method:

$$N'_{\text{exp}} = N_{\text{exp}} \exp \left( \frac{N_{\text{evt}} - N_{\text{ttbar}}}{N_{\text{evt}}} \right) = N_{\text{exp}} \frac{N_{\text{obs}} - N_{\text{exp}}}{\mathcal{E}_{\text{tag}} N_{\text{evt}}}$$

The procedure stops when $|N_{\text{exp}}' - N_{\text{exp}}| < 1\%$.

10.0 tags out of 67.4 are attributed in this way to the ttbar presence in the pre-tagging sample.

$N_{\text{exp}}' = 57.4 \pm 8.1$ is the corrected background amount to be used for a cross section measurement.
We have all the ingredients to compute the $t\bar{t}$ production measurement.

We used a likelihood maximization:

$$\mathcal{L} = \epsilon \cdot \frac{(L - L_0)^2}{2\sigma_L^2} \cdot \epsilon \cdot \frac{(\epsilon_{\text{kin}} - \epsilon_{\text{kin}}')^2}{2\sigma_{\epsilon_{\text{kin}}}^2} \cdot \epsilon \cdot \frac{(\epsilon_{\text{tag}} - \epsilon_{\text{tag}}')^2}{2\sigma_{\epsilon_{\text{tag}}}^2} \cdot \epsilon \cdot \frac{(N_{\text{exp}}' - N_{\text{exp}})^2}{2\sigma_{N_{\text{exp}}'}^2}$$

$$\cdot \frac{(\sigma_L \cdot \epsilon_{\text{kin}} \cdot \epsilon_{\text{tag}} \cdot L + N_{\text{exp}}') N_{\text{obs}}!}{N_{\text{obs}}^!} \cdot e^{- (\sigma_L \cdot \epsilon_{\text{kin}} \cdot \epsilon_{\text{tag}} \cdot L + N_{\text{exp}}')}$$

$\sigma_{t\bar{t}} = 5.9 \pm 1.2 \text{ (stat)} ^{+1.4}_{-1.0} \text{ (syst)} \text{ pb}$

$= 5.9 ^{+1.8}_{-1.6} \text{ pb.}$
Cross section vs Top Mass

The Top mass used to generate our base Monte Carlo sample was set to 178 GeV/c².

We used different other MC signal sample to evaluate the kinematical selection and cross section dependence on $M_{\text{TOP}}$.
We wanted to the $t\bar{t}$bar MET+jets signal from multijet triggered data in the sample after kin sel + ≥ 1 SecVtx tag.

We set up positive tagging matrix in which the tagging rate were parametrized as a function of jet $E_T$, $N_{TRK}$ and $MET_{PRJ}$. We demonstrated its capabilities to predict the amount of background tags in a given data sample with an uncertainty of 10%.

We optimized the kinematical selection using the matrix predicted background information by minimizing the expected statistical uncertainty in a xsec measurement. We ended up with a selection showing acceptance for tau+jets and $e/\mu$+jets events not selected by other TOP analyses.

By using tag counting and kinematical distribution fits, 50% of the final sample was attributed to inclusive $t\bar{t}$bar production.

The total systematic uncertainty estimated to be 22%, and was found to be mainly driven by trigger simulation systematics.

As a final result we found:

$$\sigma_{t\bar{t}bar} = 5.9 \pm 1.2 \text{ (stat)} \pm 1.4 \text{ (syst)} \text{ pb}$$

$$= 5.9 +1.8 -1.6 \text{ pb.}$$
What’s next?

- We isolated a **new ttbar sample** with a good S/N.
- The signal comes in with different decay modes, \( e/\mu/\tau + \text{jets} \). **It will be an interesting game to separate them**, in particular to distinguish taus from the other lepton categories. We already have the recipe/instruments to set up the standard tau-id but the efficiency is too low within the sample statistics.
  - The main idea is that we just need to tag one of the jets to be different from the other (for \( e/\tau \)) and look for isolated muon track.
    - A combined likelihood will maybe help
- Need to think about **Top Mass measurement** method, w/ or w/o loose lepton identification.
- Lots of work is ahead, but things appear promising.
Backup Slides
Jets at the TeVatron

Jets are complicated objects measured with a calorimeter and defined by algorithm.

- Complex detector properties:
  - Energy response could be non-linear
  - There are non-instrumented regions
  - Larger particle shower widths worse energy measurement
  - Jet may not contain low energy deposition

- Algorithms have complex behavior:
  - Might not capture all particles
  - Low energy jets might not be possible to define
  - Algorithm must handle merging and splitting of jets

- Complex underlying physics:
  - Events contain spectator interactions
  - Partons radiate initial and final state gluons
  - Might contain energy from different ppbar interactions
  - There are different types of jets: light quarks, gluons, b/c/τ

Need to correct for detector, algorithm and physics effects to obtain the true energy of the jets:
Jet Energy Scale (JES)