Single top production in ppbar collisions at $\sqrt{s} = 1.96$ TeV with the DØ detector

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Single top quark production

- Key to understanding electroweak interactions of top
  - Direct measurement of CKM matrix element $|V_{tb}|$
- Small signal, large backgrounds
  - Requires detailed understanding of entire detector
  - Multivariate analyses to isolate signal
- Sensitive probe to many new physics models

\[ \sigma_t = 2 \text{ pb} \]

\[ \sigma_s = 1 \text{ pb} \]
Lepton+jets final state

QCD multijets
- Model using data
- Normalize to data

W+jets: Wjj, Wcj, Wcc, Wbb
- Model using Alpgen
- Correct kinematics to data
- Normalize to data

Top quark pairs
- Model using Alpgen
- Normalize to resum.

Small contributions from Z+jets, dibosons
Background modeling

DØ Preliminary, 5.4 fb⁻¹

W+jets cross-check sample
DØ Preliminary, 5.4 fb⁻¹

top pair cross-check sample
DØ Preliminary, 5.4 fb⁻¹
Multivariate analysis

• Several filters combined in one BNN

- Boosted decision trees
- Bayesian neural networks
- Neuro evolution

DØ Preliminary, 5.4 fb$^{-1}$
Cross section measurement

- Bayesian statistical analysis

- Dominant systematic uncertainties:
  - JES, JER,
  - b-tagging efficiency,
  - W + heavy jets normalization

DØ Preliminary, 5.4 fb⁻¹
CKM matrix element $V_{tb}$

- Single top cross section $\propto |V_{tb}|^2$
- Assume
  - SM top quark decay: $|V_{td}|^2 + |V_{ts}|^2 \ll |V_{tb}|^2$
  - Pure V-A and CP conserving $W_{tb}$ vertex
- No assumption on number of families or unitarity
s-channel analysis

- Train MVA filters for s-channel signal
  - Include t-channel as background
- No evidence for s-channel yet
  - Significance ~ 2 SD
t-channel analysis

- Separate t-channel from backgrounds and from s-channel
- MVA discriminant
  - Combination of BDT, BNN, NEAT
t-channel signal region

- Figure (a): Histogram showing $H_T$ vs. $t$-channel signal region with data points and various signal regions.
- Figure (b): Histogram showing top quark mass vs. $t$-channel signal region with data points and various signal regions.
- Figure (c): Histogram showing $Q(\text{lepton}) \times \eta(\text{light-quark jet})$ vs. $t$-channel signal region with data points and various signal regions.
- Figure (d): Histogram showing top quark spin correlation vs. $t$-channel signal region with data points and various signal regions.
t-channel result

- t-channel measurement from integration over 2D posterior
  - no assumption about s-channel XS
  - $\sigma_{t\text{-channel}} = 2.90 \pm 0.59$ pb
  - $\sigma_{s\text{-channel}} = 0.98 \pm 0.62$ pb

Observed significance > 5 SD
Top quark width

- t-channel cross section to measure top quark partial width
- combine with $B(t \rightarrow Wb)$ measurement to get total width

Measurement with 2.3 fb$^{-1}$

Total top width:

$$\Gamma_t = 1.99^{+0.69}_{-0.55} \text{ GeV}$$

Top lifetime:

$$\tau_t = (3.3^{+1.3}_{-0.9}) \times 10^{-25} \text{ s}$$

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Search for W' boson

- Explore simultaneously left-handed and right-handed couplings
- 95% CL limits:
  - $M_{W'} > 863$ GeV (L only)
  - $M_{W'} > 885$ GeV (R, $M_{W'} < m_{nR}$)
  - $M_{W'} > 890$ GeV (R, $M_{W'} > m_{nR}$)
  - $M_{W'} > 916$ GeV (L+R)
FCNC in single top

- same final state as t-channel single top
- different kinematics → multivariate filter

Limit on tgu and tgc couplings:

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<thead>
<tr>
<th></th>
<th>tgu</th>
<th>tgc</th>
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<tbody>
<tr>
<td>Cross section</td>
<td>0.20 pb</td>
<td>0.27 pb</td>
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<tr>
<td>$\kappa_{tgf}/\Lambda$</td>
<td>0.013 TeV$^{-1}$</td>
<td>0.057 TeV$^{-1}$</td>
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<tr>
<td>$B(t \to qg)$</td>
<td>$2.0 \times 10^{-4}$</td>
<td>$3.9 \times 10^{-3}$</td>
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Summary

- Updated single top results from DØ with 5.4 fb\(^{-1}\) of Tevatron data
- combined s+t measurement
  - 95\% CL limit |V\(_{tb}\)| > 0.79
- t-channel observed at 5 SD
  - \(\sigma_{t\text{-channel}} = 2.90 \pm 0.59\) pb
- Limits on new physics with 2.3 fb\(^{-1}\)
  - For W’ boson with SM-like and non-SM couplings
  - FCNC couplings of top to up and charm quarks