Measurement of the inclusive $tt$ production cross section in $pp$ collisions at $\sqrt{s} = 1.96$ TeV with the DØ Detector

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Participant of DZero Collaboration

25th June 2014
Tevatron Collider

$\sqrt{s} = 1.96$ TeV

$p \rightarrow \bar{p}$

Peak luminosities: $3 - 4 \times 10^{32}$ cm$^{-2}$s$^{-1}$

$\sim 10$ fb$^{-1}$/experiment recorded

This measurement: $9.7$ fb$^{-1}$
The DØ Detector

General purpose $4\pi$ detectors:

**Tracker:** Detection and momentum measurement for charged particles

**Calorimeter:** Identification and energy measurement of jets and electrons

**Muon system:** Identification and momentum measurement of muons

Silicon Micro-strip Tracker:
Allows to identify secondary vertices, typical resolutions between 20-40 $\mu$m

Vital for identification of $b$ quarks
Top Pair Introduction

Top quark:
→ $m_t = 173.2 \pm 0.9$ GeV
→ plays special role in EWSB?
→ Lifetime: $\tau \approx 5 \times 10^{-25}$ s $\ll \Gamma_{QCD}$

Strong interaction: Top pairs

Weak interaction: Top decay
$t \rightarrow W+b \sim 100\%$

Top Pair Branching Fractions

Samples are classified according to W-decay: dilepton ($\ell \ell$), lepton+jets ($\ell + $jets), all jets

Tevatron vs. LHC:
(1.96 TeV 7 TeV)

qq $\sim 85\%$  
approx. opposite at LHC

gg $\sim 15\%$
Motivation

- **Goal:** inclusive $\bar{t}t$ cross section measurement in the lepton+jets channel with **reduced systematic uncertainties**

- Combination with dilepton channel

- Previous DØ results ($5.3 \text{ fb}^{-1}$) precision:
  
  - lepton+jets $\sim 9.1\%$
  - dilepton $\sim 11.5\%$
  - Combination $\sim 8\%$

- Top mass extraction
- Measurement of W+jets $k$-factor
- Precision tests of perturbative QCD

**Theory prediction of $\sigma(t\bar{t})$:** (Czakon, et al.)

- $\sim 3.5\%$ for Tevatron 1.96 TeV
- $\sim 4.4\%$ (4.2%) for LHC 7 (8) TeV

Precision is a real **challenge to experiments**
Selection in lepton+jets channel

<table>
<thead>
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• + additional quality cuts
## Selection in lepton+jets channel

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- + additional quality cuts
- at least 2 jets identified
Selection in lepton+jets channel

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- Selection takes into account background from other physics processes and instrumental sources, e.g.

- Multi jet, $W+$heavy flavor ($Whf$) and $W+$light flavor ($Wlf$) contributions are derived from data
Selection in lepton+jets channel

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+ additional quality cuts

Channels definition due to number of jets originated from b-quark ('b-tagged')

Data sample in $\ell$+jets is splitted into 16 separate channels:

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**MVA output distribution**

- **Multi-Variate Analysis** (MVA) of variables allowing to distinguish b-jets and light jets, e.g. secondary vertices, track impact parameter, etc., provides an output distribution

- **MVA output** – probability discriminant of **b-jet identification** technique

- Shape is **different** in each background source to some extent

Subm. to NIM [arxiv:1312.7623]
Cross section measurement

- **Cross section** $\sigma$ measured as:

$$\sigma = \frac{N}{\epsilon \cdot L \cdot BR},$$

$N$ – number of signal events, $L$ – integral luminosity, $\epsilon$ – signal efficiency and acceptance, $BR$ – branching ratio

- **Nuisance parameter fit** of MC to Data performed with "D0 Collie" package
- **Simultaneous** fit of signal and background 2D-MVA distributions in 16 channels
- Treatment of more than 30 systematic uncertainty sources
MVA output before fitting

- Projection of 2D-distribution towards axis of maximum MVA
- Normalization is slightly wrong
MVA output after fitting

- Projection of 2D-distribution towards axis of maximum MVA
- Better post-fit description of Data

Postfit: RunII V CJetDef Central ejets inc1Tag Medium 2DFit 4jb

WORK IN PROGRESS
e+jets, 4 jets, ≥ 1 b-tags

1115 Data
854.52 tbarlj
24.14 tbarll
0.45 ZZ
2.07 WZ
7.30 WW
12.38 tbq
5.53 tb
1.65 ZlllTauTau
1.91 ZlllEE
0.92 ZlllNuTau
2.94 ZlllNuNu
1.25 ZlllTab
3.77 Zlllbb
38.79 Wbb
38.11 Wcc
40.60 Wlp
48.85 QCD
76.90 Wcc+Wbb
153.76 otherMC
KS Test: 0.16
Dominant sources for $\ell$+jets signal

Channel: e+jets, 4 jets, $\geq$ 1 b-tags – projections towards mva_max

Signal Prefit AH_vs_AP_hadro Shape: RunII e+jets inc1Tag Medium 2DFit 4jb MAX

- AH_vs_AP_hadro UP Avg=0.23 Int=894.59
- AH_vs_AP_hadro DOWN Avg=0.23 Int=606.66
Nominal Int=750.64

Parton showering

Signal Prefit MH_vs_AH_signal Shape: RunII e+jets inc1Tag Medium 2DFit 4jb MAX

- MH_vs_AH_signal UP Avg=0.12 Int=649.57
- MH_vs_AH_signal DOWN Avg=0.12 Int=815.70
Nominal Int=750.64

Alternative signal

Signal Prefit bTag Shape: RunII e+jets inc1Tag Medium 2DFit 4jb MAX

- bTag UP Avg=0.02 Int=785.65
- bTag DOWN Avg=0.02 Int=717.58
Nominal Int=750.64

b-tagging

Signal Prefit PDF Shape: RunII e+jets inc1Tag Medium 2DFit 4jb MAX

- PDF UP Avg=0.11 Int=835.22
- PDF DOWN Avg=0.11 Int=666.10
Nominal Int=750.64

PDF
### Measured $\tilde{t}\tilde{t}$ cross section

<table>
<thead>
<tr>
<th>Channel</th>
<th>$\sigma(\tilde{t}\tilde{t})$, pb</th>
<th>Precision, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>lepton+jets</td>
<td>$6.95 \pm 0.14$ (stat.) $\pm 0.65$ (syst.)</td>
<td>$9.6$</td>
</tr>
<tr>
<td>dilepton</td>
<td>$7.64 \pm 0.34$ (stat.) $\pm 1.48$ (syst.)</td>
<td>$19.9$</td>
</tr>
<tr>
<td><strong>combination</strong></td>
<td>$7.33 \pm 0.13$ (stat.) $\pm 0.42$ (syst.)</td>
<td>$6.0$</td>
</tr>
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About **25 %** improvement in comparison with a previous DØ result (5.3 fb$^{-1}$) with precision of 8% !

Theory prediction: $7.16$ pb $\pm 3.5$ %

Top Mass Extraction

- Cross section measurement performed at different top mass points with common procedure (slightly changed nominal method)

- Simultaneous fit of experimental and theory curves

\[ m_{\text{top}} = 167.02^{+4.16}_{-4.24} \, \text{GeV} \]
Conclusions

- 2D Fit provides reduction of overall systematic uncertainty
- Best behavior of systematic uncertainties using separate individual channels for the fitting
- Combination result: $\sigma_{t\bar{t}} = 7.33 \pm 0.44 \text{ pb}$ (precision $\sim 6.0\%$)!
- Extracted top mass: $m_{top} = 167.02^{+4.16}_{-4.24} \text{ GeV}$

NOT FINAL RESULTS AND WORK IS IN PROGRESS
Conclusions

- 2D Fit provides reduction of overall systematic uncertainty
- Best behavior of systematic uncertainties using separate individual channels for the fitting
- Combination result: $\sigma_{t\bar{t}} = 7.33 \pm 0.44 \text{ pb}$ (precision $\sim 6.0\%$!)
- Extracted top mass: $m_{\text{top}} = 167.02^{+4.16}_{-4.24} \text{ GeV}$

NOT FINAL RESULTS AND WORK IS IN PROGRESS

THANKS FOR ATTENTION!

e-mail: savitsky@fnal.gov, mykola.savitsky@gmail.com
Backup
Selection in lepton+jets channel

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- + additional quality cuts
- Channels definition due to number of jets originated from $b$ quark ('$b$-tagged')

One of the most important experimental techniques “$b$-tagging”:

$b$-quarks hadronize before decaying into a $c$-quark:
- Long-lived $B$ hadrons decay some mm away
- Multi-Variate Analysis technique

Subm. to NIM [arxiv:1312.7623]
Top Mass Extraction

- Cross section measurement performed at different top mass points with common procedure
- Simultaneous fit of experimental and theory curves

\[ m_{\text{top}} = 167.02^{+4.16}_{-4.24} \text{ GeV} \]
Fitting procedure

- Nuisance parameter fit performed with "D0 Collie" package
- Input: 20-binned histograms of MVA output (distributions from "0" to "1")
- Jet with second highest MVA output is considered (mva_next) in addition to jet with highest MVA output (mva_max) in same event (2D fit in ℓ+jets channel)
- Data sample in ℓ+jets is splitted into 16 separate channels:

<table>
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<th>mu+jets</th>
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<td>0 b-tags</td>
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</tbody>
</table>

which are fitted simultaneously.

- Fitting in dilepton: 1D highest MVA (43 bins) and 4 channels – EMMU 1 jet, EMMU ≥ 2 jets, DIEM ≥ 2 jets, DIMU ≥ 2 jets
- Combination: 20 channels are fitted and correlation of systematic uncertainties taken into account
Measurement strategy

- Counting method using $b$-ID for cross section measurement shows large dependency on $W+$jets Scale Factors, while precision is lower.
- To constrain systematic uncertainties use a simultaneous fit of $Whf$, $Wlp$ contributions and $t\bar{t}$ cross section in lepton+jets channel.
- A nuisance parameter fit method takes shapes of systematic uncertainties into account.

Data sample and selection

- **Data sample**: Tevatron RunII (9.7 fb$^{-1}$)
- **Applied selection**: follows DØ “Measurement of differential $t\bar{t}$ production cross sections in pp collisions” subm. to PRD [arxiv:1401.5785]
Considered systematic uncertainties in combination

<table>
<thead>
<tr>
<th>Shape dependent systematic uncertainty:</th>
<th>Shape dependent systematic uncertainty:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepton identification</td>
<td>PDF</td>
</tr>
<tr>
<td>Jet energy resolution</td>
<td>b-fragmentation</td>
</tr>
<tr>
<td>Jet energy scale</td>
<td>Luminosity reweighting</td>
</tr>
<tr>
<td><strong>b-tagging uncertainty</strong></td>
<td>Top mass uncertainty</td>
</tr>
<tr>
<td>c-tag uncertainty</td>
<td>ISR/FSR</td>
</tr>
<tr>
<td>l-tag uncertainty</td>
<td>Alternative signal model</td>
</tr>
<tr>
<td>Taggability uncertainty</td>
<td>Parton showering model</td>
</tr>
<tr>
<td>Vertex confirmation</td>
<td>Jet identification</td>
</tr>
<tr>
<td>MC statistics in lepton+jets</td>
<td>MC statistics in dilepton</td>
</tr>
<tr>
<td>Z vertex reweighting</td>
<td>Jet response correction</td>
</tr>
<tr>
<td>Z/W pT reweighting and PV SF</td>
<td>Color Reconnection</td>
</tr>
<tr>
<td><strong>Flat systematic uncertainty</strong></td>
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</tr>
<tr>
<td>Trigger efficiency</td>
<td>W+jets heavy flavor SF (2, 3, 4, 5 jet bins)</td>
</tr>
<tr>
<td>Luminosity</td>
<td>W+jets light parton SF (2, 3, 4, 5 jet bins)</td>
</tr>
<tr>
<td>MC branching ratios uncertainty</td>
<td>Muon ID, track and isolation</td>
</tr>
<tr>
<td>Fake and True lepton rate</td>
<td>Data quality</td>
</tr>
<tr>
<td>MC background cross section</td>
<td>dZ (lepton, PV)</td>
</tr>
<tr>
<td>Opposite charge</td>
<td>Lepton momentum and energy scale</td>
</tr>
</tbody>
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Red – dominant
1D MVA output distribution

Channel: electron+muon, $\geq 2$ jets, $\geq 0$ b-tags
Sample composition in $\ell$+jets channel

- "2 jet" events – largely dominated by $W$+jets contribution, while other jet bins (jb) by $t\bar{t}$ signal
- Events with $\geq 1$ b-tags dominated by $t\bar{t}$ signal and Whf+jets (inc1Tag sample), while events with exactly 0 b-tags by Wlf+jets (0Tag sample). Later: beforeTag = 0Tag + inc1Tag ($\geq 0$ b-tags)
MVA output after fitting in combination

Postfit: RunII VCJetDef Central e+jets inc1Tag Medium 2DFit 4jb

- 1115 Data
- 854.52 tbarbar
- 24.14 tbarbar
- 0.45 ZZ
- 2.07 WZ
- 7.30 WW
- 12.38 tbg
- 5.92 tt
- 2.65 ZipTauTau
- 1.91 ZipEE
- 2.94 ZccEE
- 12.55 ZbbTauTau
- 2.77 ZbbEE
- 36.79 Wbb
- 38.11 Wcc
- 40.70 Wlp
- 48.85 QCD
- 76.90 Wcc+Wbb
- 153.76 otherMC

KS Test: 0.16

- Data/MC - Prefit
- Data/MC - Postfit
- Syst.Unc. - Prefit
- Syst.Unc. - Postfit

mva_max output

Postfit: RunII VCJetDef Central e+jets inc1Tag Medium 2DFit 4jb

- 1115 Data
- 854.52 tbarbar
- 24.14 tbarbar
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- 48.85 QCD
- 76.90 Wcc+Wbb
- 153.76 otherMC

KS Test: 0.37

- Data/MC - Prefit
- Data/MC - Postfit
- Syst.Unc. - Prefit
- Syst.Unc. - Postfit

mva_next output

Postfit: RunII VCJetTCS10 Central mu+jets inc1Tag Medium 2DFit 3jb

- 1667 Data
- 724.38 tbarbar
- 96.80 tbarbar
- 1.55 ZZ
- 9.17 WZ
- 29.96 WW
- 40.99 tbg
- 24.67 tb
- 7.37 ZipTauTau
- 18.16 ZipMuMu
- 3.32 ZccTauTau
- 17.53 ZccMuMu
- 3.57 ZbbTauTau
- 22.84 ZbbMuMu
- 186.02 Wbb
- 164.13 Wcc
- 277.36 Wlp
- 73.86 QCD
- 356.15 Wcc+Wbb
- 627.64 otherMC

KS Test: 0.87

- Data/MC - Prefit
- Data/MC - Postfit
- Syst.Unc. - Prefit
- Syst.Unc. - Postfit

mva_max output

Postfit: RunII Central EMMU_2jet

- 465 Data
- 341.11 tbarbar
- 32.16 Fake bckg
- 16.71 Dibosons
- 81.98 Zll

KS Test: 0.46

- Data/MC - Prefit
- Data/MC - Postfit
- Syst.Unc. - Prefit
- Syst.Unc. - Postfit

mva_max output
e+jets, ≥ 4 jets, ≥ 0 b-tags control plots

Here:
≥ 4 jets in event
Expected $\sigma(\bar{t}t) = 7.48$ pb

Leading Jet

Next-to-Leading Jet

Electron

\[ p_T (GeV) \]
e+μ, $\geq 2$ jets, $\geq 0$ b-tags control plots
Three iterations procedure based on TFractioFitter was introduced

Step A: The fit of the ttbar signal and Whf contribution to data in each run period, while keeping all other MC contributions (including multijet and Wlp) constant.
Step B: The fit of the ttbar signal and Wlp contributions to data, while keeping all other MC contributions constant, including Whf contribution scaled with HF SF obtained after previous step in each run period.
Step C: The Wlp contribution was scaled with SFs derived at step “B” and remained constrained with all other MC contributions, while performing the fit of ttbar signal and initial unscaled Whf contribution to data.
### W+jets SF uncertainty

#### inc1Tag

<table>
<thead>
<tr>
<th>run period</th>
<th>HF SF$_{im}$</th>
<th>$k_{Wlp}$</th>
<th>$k_{W_{cc}+W_{bb}}$</th>
<th>$k_{t\bar{t}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run IIa</td>
<td>1.00 ± 0.13</td>
<td>1.18 ± 0.13</td>
<td>0.82 ± 0.13</td>
<td>0.98 ± 0.10</td>
</tr>
<tr>
<td>Run IIb1</td>
<td>0.91 ± 0.13</td>
<td>1.30 ± 0.13</td>
<td>0.65 ± 0.13</td>
<td>1.06 ± 0.10</td>
</tr>
<tr>
<td>Run IIb2</td>
<td>0.98 ± 0.08</td>
<td>1.10 ± 0.08</td>
<td>0.91 ± 0.08</td>
<td>1.00 ± 0.06</td>
</tr>
<tr>
<td>Run IIb34</td>
<td>0.89 ± 0.06</td>
<td>1.14 ± 0.06</td>
<td>0.78 ± 0.06</td>
<td>1.09 ± 0.05</td>
</tr>
<tr>
<td>Run IIb</td>
<td>0.92 ± 0.05</td>
<td>1.15 ± 0.05</td>
<td>0.81 ± 0.05</td>
<td>1.05 ± 0.04</td>
</tr>
<tr>
<td>Run II</td>
<td>0.92 ± 0.04</td>
<td>1.15 ± 0.04</td>
<td>0.81 ± 0.04</td>
<td>1.05 ± 0.04</td>
</tr>
<tr>
<td>$SF_{avg}$</td>
<td></td>
<td>1.15</td>
<td>0.81</td>
<td></td>
</tr>
</tbody>
</table>

The biggest variations of SFs from corresponding SF$_{avg}$ values given in table among different run periods are considered as limit for flat systematic uncertainties of W+jets SF:

- For **inc1Tag**:  
  \[ \sigma_{Wcc+Wbb} = +9.9\% , -15.8\% \]  
  \[ \sigma_{Wlp} = +14.8\% , -4.9\% \]

- For **beforeTag**:  
  \[ \sigma_{Wcc+Wbb} = +16.8\% , -23.3\% \]  
  \[ \sigma_{Wlp} = +3.5\% , -1.8\% \]

In order to decrease syst. uncertainty due to W+jets SF and easily distinguish Whf and Wlp MC in different jet bins, it was decided to continue analysis with **0Tag and inc1Tag** samples, instead of beforeTag.
MC generator related uncertainties

- Large systematic uncertainty from comparing different MCs:
  - Alpgen+Herwig vs Alpgen+Pythia ↔ hadronization
  - MC@NLO+Herwig vs Alpgen+Herwig ↔ signal model (higher orders)
  - Alpgen+Pythia vs MC@NLO+Herwig ↔ signal model (previously used)

- MC for signal in lepton+jets and dilepton inclusive xsec measurement analysis: Alpgen+Pythia

- For 4th jet bin in ljets channel: AH has 20 % higher efficiency than AP
  MH has 11 % higher efficiency than AP

- For EMMU dilepton channel: AH has 21 % lower efficiency than AP
  MH has 15 % higher efficiency than AP

- Plots on next slides for lepton+jets: reconstruction level
The signal and hadronization uncertainties are currently under investigation in order to improve/reduce them.
Sample: RunII, ejets channel, inc2jb
Generator LVL $p_T^{(ttbar)}$ before re-weighting

Sample: RunII, ejets channel, 4jb

- Re-weighting of $p_T^{(ttbar)}$ in AH to AP
- Filled with variables from true LVL
- AH and MH normalized to AP
- Fit function: $f(x) = a_0 + a_1 x + a_2 x^2 + \frac{a_3}{x} + \frac{a_4}{x^2}$, for $x < 3.75$ GeV: $f(x) = \frac{\text{bin}_1 + \text{bin}_2}{2}$
Generator LVL $p_T^{(ttbar)}$ after re-weighting

Sample: RunII, ejets channel, 4jb

- Re-weighted $p_T^{(ttbar)}$ is propagated through reconstruction again
- Filled with variables from true LVL
- AH and MH normalized to AP
- Improvement for hadronization uncertainty, while signal modeling uncertainty getting worse
Reconstruction LVL plots before re-weighting

Sample: RunII, ejets channel, 4jb

- Distributions on reconstruction level filled with variables from *hitfit*
Reconstruction LVL plots after re-weighting

Sample: RunII, ejets channel, 4jb

- Distributions on reconstruction level are filled with variables from hitfit
- It seems that there is no dependency of MC efficiency from shape of the $p_T^{(ttbar)}$ distribution
- Changes in MVA plot are negligible → no sense in usage of re-weighted $p_T^{(ttbar)}$ distributions
Generator LVL distributions
Sample: RunII, ejets channel, 4jb

- **Idea**: constrain MC with usage of latest differential cross section measurement.
Jet $p_T$ control plots: RunII, ejets channel, beforeTag, 4jb

- Softest jet fails to pass selection criteria of 40 GeV in ~80% events in comparison with 20 GeV cut → loss ~80% of events

KS = 0.244 $S_W = 1.328$

KS = 0.020 $S_W = 1.328$

KS = 0.027 $S_W = 1.328$

KS = 0.130 $S_W = 1.328$
Cut on jet $p_T$ dependency

Sample: RunII, ejets channel, 4jb

- Here reconstruction level plots are given
- Searching for events, where all jets have $p_T > 20$ GeV (nominal cut)
Cut on jet $p_T$ dependency

Sample: RunII, ejets channel, 4jb

- Here reconstruction level plots are given
- Searching for events, where all jets have $p_T > 25$ GeV
- There is no improvement for hadronization and signal modeling uncertainties
- Some loss in statistics
Cut on jet $p_T$ dependency
Sample: RunII, ejets channel, 4jb

- Here reconstruction level plots are given
- Searching for events, where all jets have $p_T > 40$ GeV
- There is no improvement for hadronization and signal modeling uncertainties
- Significant loss in statistics \(\rightarrow\) cut on $p_T$ of jets will remain at 20 GeV
Data integrity uncertainty

Sample: TopTree13 (QCD`11), RunII, Medium WP, inc1Tag, VCJetDef
Channel: ejets, inc2jb

- For mujets: 
  - with bad events – 6606
  - without bad events - 6482
  - Loss: 1.9 %
Taggability uncertainty

Sample: TopTree13 (QCD`11), RunII, Medium WP, beforeTag, VCJetDef
Channel: ejets, 3jb - NOM

WORK IN PROGRESS
Taggability uncertainty

Sample: TopTree13 (QCD`11), RunII, Medium WP, beforeTag, VCJetDef
Channel: ejets, 3jb - UP

WORK IN PROGRESS
Taggability uncertainty

Sample: TopTree13 (QCD`11), RunII, Medium WP, beforeTag, VCJetDef
Channel: ejets, 3jb - DOWN

WORK IN PROGRESS
## Flat systematic uncertainties

<table>
<thead>
<tr>
<th>Flat systematic uncertainty:</th>
<th>+1 sigma</th>
<th>-1 sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MC background cross section</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z+jets</td>
<td>+0.250</td>
<td>+0.250</td>
</tr>
<tr>
<td>Diboson</td>
<td>+0.070</td>
<td>-0.070</td>
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<tr>
<td>Single top</td>
<td>+0.126</td>
<td>-0.126</td>
</tr>
<tr>
<td><strong>Fake and True lepton rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eps_QCD in ejets</td>
<td>+0.03</td>
<td>-0.03</td>
</tr>
<tr>
<td>eps_QCD in mujets</td>
<td>+0.222</td>
<td>-0.222</td>
</tr>
<tr>
<td>eps_sig in ejets</td>
<td>+0.03</td>
<td>-0.03</td>
</tr>
<tr>
<td>eps_sig in mujets</td>
<td>+0.017</td>
<td>-0.017</td>
</tr>
<tr>
<td><strong>MC signal and background branching ratio</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ttbar-&gt;$ljets$ (signal)</td>
<td>+0.008</td>
<td>-0.008</td>
</tr>
<tr>
<td>ttbar-&gt;$dilepton$ (background)</td>
<td>+0.017</td>
<td>-0.017</td>
</tr>
</tbody>
</table>
## Flat systematic uncertainties

<table>
<thead>
<tr>
<th>Flat systematic uncertainty:</th>
<th>+1 sigma</th>
<th>-1 sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger efficiency</td>
<td>+0.05</td>
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<tr>
<td>Luminosity</td>
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<tr>
<td>Muon ID</td>
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<tr>
<td>Muon track</td>
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<td>-0.01</td>
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<tr>
<td>Muon isolation</td>
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<td>-0.005</td>
</tr>
<tr>
<td>Data Quality</td>
<td>+0.019</td>
<td>-0.019</td>
</tr>
</tbody>
</table>

*WORK IN PROGRESS*
## ttbar cross section with 1D and 2D Fit

**Sample:** TopTree13 (QCD'11), RunII, Medium WP

**Fit:** ejets+mujets, 2jb+3jb+4jb

### Table

<table>
<thead>
<tr>
<th>Fit Type</th>
<th>tagBin</th>
<th>XSEC, pb</th>
<th>XSEC Err.</th>
<th>Wlp SF</th>
<th>Wlp Err</th>
<th>Whf SF</th>
<th>Whf Err</th>
<th>Chi2/NDF Prefit</th>
<th>Chi2/NDF Postfit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D max</td>
<td>bT</td>
<td>7.53</td>
<td>5.2 $^{+2.3}_{-4.7}$</td>
<td>1.07</td>
<td>0.05</td>
<td>0.97</td>
<td>0.07</td>
<td>3.44</td>
<td>1.45</td>
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<tr>
<td></td>
<td>i1T</td>
<td>7.99</td>
<td>6.8 $^{+2.3}_{-6.4}$</td>
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<td>0.09</td>
<td>1.00</td>
<td>0.07</td>
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<tr>
<td>1D next</td>
<td>bT</td>
<td>7.55</td>
<td>5.2 $^{+2.5}_{-4.6}$</td>
<td>1.03</td>
<td>0.05</td>
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<td>0.07</td>
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<td>6.4 $^{+2.3}_{-6.1}$</td>
<td>1.23</td>
<td>0.16</td>
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<tr>
<td>1D max+next</td>
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<td>4.3 $^{+2.3}_{-3.6}$</td>
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<td>0.06</td>
<td>2.31</td>
<td>1.41</td>
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<tr>
<td></td>
<td>i1T</td>
<td>7.83</td>
<td>6.1 $^{+2.3}_{-5.6}$</td>
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<td>0.08</td>
<td>1.01</td>
<td>0.07</td>
<td>2.46</td>
<td>1.40</td>
</tr>
</tbody>
</table>

**Remarks:** intermediate result – not full list of systematics was included
max+next fit results are not reliable – double consideration of statistics

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<table>
<thead>
<tr>
<th>2D Fit</th>
<th>tagBin</th>
<th>XSEC, pb</th>
<th>XSEC Err.</th>
<th>Wlp SF</th>
<th>Wlp Err</th>
<th>Whf SF</th>
<th>Whf Err</th>
<th>Chi2/NDF Prefit</th>
<th>Chi2/NDF Postfit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bT</td>
<td>7.49</td>
<td>4.8 $^{+2.3}_{-4.1}$</td>
<td>1.09</td>
<td>0.04</td>
<td>0.98</td>
<td>0.07</td>
<td>1.80</td>
<td>1.56</td>
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<tr>
<td></td>
<td>i1T</td>
<td>7.91</td>
<td>6.5 $^{+2.3}_{-6.0}$</td>
<td>1.32</td>
<td>0.09</td>
<td>1.00</td>
<td>0.07</td>
<td>1.71</td>
<td>1.55</td>
</tr>
</tbody>
</table>

*bT – beforeTag
i1T – inclusive 1Tag*
Multiplicity of $b$-tagged jets

- Past research: DZero Note 6028 - 5.3 fb$^{-1}$
- The samples are split into events with 0, 1 and $\geq 2$ $b$-tagged jets
- The amount of $W$+jets events is normalized to data minus signal and all others sources of background in beforeTag sample
- RunIIb2: $\mathcal{L} = 3.040$ fb$^{-1}$

Sample: RunIIb2, ejets, beforeTag, Medium WP, incjb.

$S_W = 0.931$

Sample: RunIIb2, mujets, beforeTag, Medium WP, incjb.

$S_W = 1.085$
Multiplicity of $b$-tagged jets

- Plots are done for different: run period, lepton type, tag bin, working point, jet bin and their appropriate combinations.
- Scale factor for W+jets varies for different combinations.
- BR ejets $\ell_j = 0.1721$  
  RunIIb2: $\mathcal{L} = 3.040$ fb$^{-1}$
- Cross section:
  $$\sigma_{t\bar{t}, \text{inc}} = \frac{N_{\text{sig}}}{\Delta X \cdot \epsilon \cdot BR \cdot \mathcal{L}}$$
  $$\sigma_{t\bar{t}, \text{exp}} = 7.5 \text{ pb}$$

Sample: RunIIb2, ejets, inc1Tag, Medium WP, incjb.

- $\sigma_{t\bar{t}} = 9.56 \text{ pb}$
- $\sigma_{t\bar{t}} = 7.75 \text{ pb}$
Multiplicity of $b$-tagged jets

- Derived cross sections strongly depends on $v_{jets}$ HF SF.

- BR mujets $l_j = 0.17137$  \( \mathcal{L} = 3.040 \text{ fb}^{-1} \)

- Estimation of systematic uncertainties can be done using nuisance parameter method.

- Information about shape of MVA distribution is lost.

**Sample:** RunIIb2, mujets, inc1Tag, Medium WP, incjb.  **Sample:** RunIIb2, mujets, inc1Tag, Medium WP, 4jbb.