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Bennett Magy
$T \rightarrow Wb \text{ @13 TeV}$

**Background Samples:**
- $t\bar{t}$
- $W + \text{jets}$
- $Z + \text{jets}$
- Singletop

**Signal Samples:**
- 700 GeV
- 900 GeV
- 1100 GeV
Neutrinos can't be detected by the ATLAS detector, but we can still piece them back together.
Reconstruction Equations

\begin{align*}
\mu &= \frac{M_W^2}{2} + p_{x,\nu} p_{x,l} + p_{y,\nu} p_{y,l} \\
a &= \frac{\mu p_{z,l}}{E_l^2 - p_{z,l}^2} \\
b &= \frac{E_l^2 E_{T,\text{miss}}^2 - \mu^2}{E_l^2 - p_{z,l}^2} \\
p_{z,\nu} &= a \pm \sqrt{a^2 - b}
\end{align*}

With MET, MET Phi, lepton information and what we know about the W boson, reconstruct the undetected Neutrino.

Currently analyzing six different methods to handle the case where the neutrino solution(s) is/are complex.

Compare how their reconstructions compare with truth
Reconstruction Methods

“Real Only”: $p_{z,\nu} = \text{Re}(a \pm \sqrt{a^2 - b})$

“Colinear”: $\eta_\nu = \eta_l \mid \phi_\nu = \phi_l$

“modColinear”: $\eta_\nu = \eta_l \mid \phi_\nu = \phi_{\text{miss}}$

“TMinuit”: Scale back $E_{T,\text{miss}}$ with TMinuit. The goal is to minimize difference between reconstructed $M_W$ and standard $M_W$.

“Rotation”: Rotate $\phi_{\text{miss}}$ until the solution is real.

“scaleMET”: Scale back $E_{T,\text{miss}}$ until the solution is real.
Neutrino Pt Distribution

\[ \sqrt{s} = 13 \text{ TeV}, \, 20.3 \text{ fb}^{-1} \]

+ jets

**Resolution**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reco</td>
<td>3.68</td>
<td>62.98</td>
</tr>
<tr>
<td>scaleMET</td>
<td>3.68</td>
<td>62.98</td>
</tr>
<tr>
<td>TMinuit</td>
<td>12.31</td>
<td>85.75</td>
</tr>
</tbody>
</table>
Neutrino Energy Distribution

\[ \sqrt{s} = 13 \text{ TeV}, \ 20.3 \text{ fb}^{-1} \]

\( l + \text{jets} \)

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Reco</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>scaleMET</td>
<td>27.65</td>
<td>197.74</td>
<td></td>
</tr>
<tr>
<td>TMinuit</td>
<td>-10.21</td>
<td>152.19</td>
<td></td>
</tr>
</tbody>
</table>

\( \text{ATLAS Internal} \)
Conclusions

• TMinuit and scaleMET are the best reconstruction methods
• Neither clearly superior with respect to distance from truth
• Choose TMinuit since it is a faster method
Cut Optimization

How do we choose our events?

Goal is to create “Signal Region”:
- Signal: $T\bar{T}$ events
- Background: non-$T\bar{T}$ events that pass selection.
- Make sure background doesn’t drown out signal

Maximize Significance

Minimize Statistical Uncertainty

$$\Sigma^2 = \frac{Y_s^2}{Y_s + Y_B}$$  
(Significance Eqn)
8 TeV Cuts

Table 3: Summary of event selection requirements for this analysis.

<table>
<thead>
<tr>
<th>Selection</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preselection</td>
<td>One electron or muon</td>
</tr>
<tr>
<td></td>
<td>$E_T^{\text{miss}} &gt; 20$ GeV, $E_T^{\text{miss}} + m_T &gt; 60$ GeV</td>
</tr>
<tr>
<td></td>
<td>$\geq 4$ jets, $\geq 1$ $b$-tagged jets</td>
</tr>
<tr>
<td>loose selection</td>
<td>Preselection</td>
</tr>
<tr>
<td></td>
<td>$\geq 1$ $W_{\text{had}}$ candidates</td>
</tr>
<tr>
<td></td>
<td>$H_T &gt; 800$ GeV</td>
</tr>
<tr>
<td></td>
<td>$p_T(b_1) &gt; 160$ GeV, $p_T(b_2) &gt; 110$ GeV (type I) or $p_T(b_2) &gt; 80$ GeV (type II)</td>
</tr>
<tr>
<td></td>
<td>$\Delta R(\ell, \nu) &lt; 0.8$ (type I) or $\Delta R(\ell, \nu) &lt; 1.2$ (type II)</td>
</tr>
<tr>
<td>tight selection</td>
<td>loose selection</td>
</tr>
<tr>
<td></td>
<td>min($\Delta R(\ell, b_{1,2})$) &gt; 1.4, min($\Delta R(W_{\text{had}}, b_{1,2})$) &gt; 1.4</td>
</tr>
<tr>
<td></td>
<td>$\Delta R(b_1, b_2) &gt; 1.0$ (type I) or $\Delta R(b_1, b_2) &gt; 0.8$ (type II)</td>
</tr>
<tr>
<td></td>
<td>$</td>
</tr>
</tbody>
</table>
Linear Method

- “N-1” approach, perform all cuts except for the one being plotted
- Analyze significance curve
TMVA Method

- Optimize several different cuts at once.
- Iterates through different levels of signal efficiency and measures significance.
Significance Plots

Cut efficiencies and optimal cut value

**900 GeV**

Cut values for requested signal efficiency: 0.92
Corresponding background efficiency : 0.132506
Transformation applied to input variables : None

Cut [0]: 0.0478034 < \text{DeltaR\_lepnu} <= 3.03565
Cut [1]: 698542 < \text{HT} <= 1.61862e+10
Cut [2]: 55725.3 < \text{bjet\_pt}[0] <= 1.64192e+06
Cut [3]: 13795.2 < \text{bjet\_pt}[1] <= 1.22079e+06

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Cut efficiencies and optimal cut value

**700 GeV**

Cut values for requested signal efficiency: 0.91
Corresponding background efficiency : 0.219705
Transformation applied to input variables : None

Cut [0]: 0.0557273 < \text{DeltaR\_lepnu} <= 3.06343
Cut [1]: 626159 < \text{HT} <= 1.63625e+07
Cut [2]: 34421 < \text{bjet\_pt}[0] <= 1.44751e+06
Cut [3]: 18377.4 < \text{bjet\_pt}[1] <= 1.00036e+06
Cut Results: $H_T \rightarrow 1400 \text{ GeV}$

**ATLAS Internal**

$\sqrt{s} = 13 \text{ TeV}, 20.3 \text{ fb}^{-1}$

$l+\text{jets}$

8 TeV Cuts

$\Sigma = 10.1$

HT Tightened

$\Sigma = 11.3$
Cut Results: TMVA Selection

ATLAS Internal
\( \sqrt{s} = 13 \text{ TeV}, 20.3 \text{ fb}^{-1} \)
l+jets

8 TeV Cuts
\( \Sigma = 10.1 \)

ATLAS Internal
\( \sqrt{s} = 13 \text{ TeV}, 20.3 \text{ fb}^{-1} \)
l+jets

TMVA Cuts
\( \Sigma = 15.5 \)
Cuts Comparison

HT Tightened
\[ \Sigma = 11.3 \]

TMVA Cuts
\[ \Sigma = 15.5 \]
TMVA Selection on 700 GeV

**ATLAS Internal**
\[ \sqrt{s} = 13 \text{ TeV}, \ 20.3 \text{ fb}^{-1} \]
\( \ell + \text{jets} \)

8 TeV Cuts
\[ \Sigma = 8.5 \]

**ATLAS Internal**
\[ \sqrt{s} = 13 \text{ TeV}, \ 20.3 \text{ fb}^{-1} \]
\( \ell + \text{jets} \)

TMVA Cuts
\[ \Sigma = 30.7 (!) \]
PyDataMC
ROOT ntuple → json → Matplotlib Plots
Now available at:
/afs/cern.ch/work/b/bmagy/public/PyDataMC
Cultural Activities
Special Thanks

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