Electrons in Dense Environments

Christopher Lawrence Davou
Supervisor: Associate Prof. Deepak Kar

School of Physics and Institute for Collider Particle Physics
University of the Witwatersrand

lawrence.davou.christopher@cern.ch

Presented at the 2020 HEPP Workshop

January 29, 2020
- Introduction
- Challenges with the boosted regime
- Samples and quantities used in electron identification
- Brief description
- Plots of ID variables for electron close to jet and isolated electron
- Electron in jet variables in ΔR 0.4 with profile
- Table showing ID variables, $\chi^2$, difference and remark
- Summary
Introduction

- Electron and jet reconstruction
- The boosted regime

**Figure:** Our model

Cases where this is common

- Top-antitop pair production
- Semi-leptonic decay
- Boosted heavy neutrino analysis
Challenges with the boosted Regime

- Generally poor signal efficiency

**Figure:** Signal efficiency for muons and electrons

This is from current heavy boosted neutrino analysis

https://cds.cern.ch/record/2266957
Challenges with the boosted Regime cont.

**Figure:** Top left and right: Isolated and electron in jet ID efficiency in $E_T$. Bottom left and right: Isolated and electron close to jet ID efficiency in $\eta$. 

Isolated electron efficiency vs $E_T$

Electron in jet efficiency vs $E_T$

Isolated electron efficiency vs $\eta$

Electron in jet efficiency vs $\eta$
Challenges with the boosted Regime cont.

Figure: Efficiency for electron in jet for different likelihoods
**Samples and Quantities used in electron identification**

### Signal and standard Sample
- This is a 3TeV $w_R$ decaying into a boosted neutrino and a lepton with the boosted neutrino decaying into $q\bar{q}l$.
- This is a $Z\rightarrow ee$ sample

### Quantities used in electron identification
- Hadronic leakage ($R_{\text{had}}$)
- Second layer of Electromagnetic (EM) calorimeter ($R_\eta, w_{\eta 2}, R_\phi$)
- Third layer of EM calorimeter ($f_3$).
- First layer of EM calorimeter ($f_1, E_{\text{ratio}}, w_{\text{tots1}}$).
- Track condition ($d_0, |d_0/\sigma(d_0)|, \Delta p/p, n_{\text{Blayer}}, n_{\text{pixel}}, n_{\text{Si}}$).
- Track-cluster matching ($\Delta \eta 1, \Delta \phi_{\text{rescaled2}}, E/P$).
- Transition radiation tracker ($\text{eprobabilityHT}$).
Brief description

- $R_\eta$, $R_\phi$, $w_\eta$, $w_{tots1}$ are the energy widths variables that distinguish narrow electron showers from diffuse hadronic showers.
- $f_1$, $f_3$, $R_{had}$ and $E_{ratio}$ are the energy ratio variables.
- $\Delta \eta 1$, $\Delta \phi_{rescaled2}$ and $E/p$ are the track-cluster match variables.
- $d_0$, $|d_0/\sigma(d_0)|$, $\Delta p/p$, $n_{Blayer}$, $n_{pixel}$, $n_{Si}$ are the track conditions.
- eProbabilityHT is the likelihood probability based on information from the transition radiation tracker.
Plots of ID variables for electron close to jet and isolated electron

Figure: Width variables
Plots of ID variables for electron close to jet and isolated electron cont.

Figure: Energy ratio variables
Electron in jet ID variables in $\Delta R$ 0.4 with profile

Top: ID variables. Bottom: Profile plots

ATLAS Simulation work in Progress

Events

$\phi$ $\eta$

$R_{\phi}$ Profile vs $\Delta R$($el,jet$)

$R_{\eta}$ Profile vs $\Delta R$($el,jet$)

$w_{\eta_1}$ Profile vs $\Delta R$($el,jet$)

$w_{\eta_2}$ Profile vs $\Delta R$($el,jet$)

$R_{\eta}$ for sig electron in $\Delta R$ 0.2 and $\Delta R$ 0.2-0.4

$R_{\phi}$ for sig electron in $\Delta R$ 0.2 and $\Delta R$ 0.2-0.4

$w_{\eta_1}$ for sig electron in $\Delta R$ 0.2-0.4 and $\Delta R$ 0.2-0.4

$w_{\eta_2}$ for sig electron in $\Delta R$ 0.2-0.4 and $\Delta R$ 0.2-0.4

Electrons close to Jets

January 29, 2020
Electron in jet ID variables in $\Delta R \ 0.4$ with profile cont.

Top: ID variables. Bottom: Profile plots

- $f_1$ for sig electron in $\Delta R \ 0.0\ 2$ and $\Delta R \ 0.2\ -\ 0.4$
- $f_2$ for sig electron in $\Delta R \ 0.0\ 2$ and $\Delta R \ 0.2\ -\ 0.4$
- $R_{el}$ for sig electron in $\Delta R \ 0.0\ 2$ and $\Delta R \ 0.2\ -\ 0.4$
- $E_{ratio}$ for sig electron in $\Delta R \ 0.0\ 2$ and $\Delta R \ 0.2\ -\ 0.4$

$E_\gamma$ for sig electron in $\Delta R \ 0.2\ -\ 0.4$...
Table: 1 showing ID variables, their $\chi^2$, their difference and those chosen.

| ID variables        | $\chi^2$    | $|X(\Delta R < 0.2) - X(\Delta R[0.2,0.4])|$ | New ID? |
|---------------------|-------------|---------------------------------|---------|
| $R_{\text{had}}$   | 842.8764    | 0.00285                         | No      |
| $R_\eta$           | 1229.1245   | 0.00675                         | No      |
| $\Delta \eta_1$    | 303.6312    | 0.00002                         | Yes     |
| $w_{\eta_2}$       | 714.4455    | 0.00015                         | No      |
| $f_1$               | 949.0093    | 0.01692                         | No      |
| $R_\phi$           | 750.2240    | 0.00264                         | No      |
| $f_3$               | 456.7543    | 0.00093                         | Yes     |
| $\Delta p/p$       | 148.3094    | 0.00101                         | Yes     |
| $\Delta \phi_{\text{rescaled}2}$ | 387.9096 | 0.00007 | Yes |
| $d_0/\sigma(d_0)$  | 105.4380    | 0.05418                         | Yes     |
| $d_0$              | 105.2062    | 0.00055                         | Yes     |
| $E/p$              | 281.6260    | 0.06753                         | Yes     |
| $w_{\text{tots}1}$ | 383.8977    | 0.04604                         | Yes     |
| $E_{\text{ratio}}$ | 605.3296    | 0.00615                         | No      |
Summary

- We have seen from the studies how the effect of nearby hadronic activity affects the standard ID variables used in electron reconstruction.
- We have also seen the effect of the standard electron ID on the efficiency of electron in jet.
- We will use our chosen ID variables that are specific for electrons in jets to build an ID.
- We will test the performance of this new ID against nearby hadronic activity and also test its signal efficiency/background rejection.
- At the moment we are tuning this electron in jet ID.

Acknowledgement: This work is based on the research supported by the National Research Foundation of South Africa (NRF) in conjunction with The World Academy of Science (TWAS) Grant number 1106886 and Ref No: SFH170530235137, without which this study might not have been possible.