PHD Day at CPPM

EXDO

Electron Reconstruction Efficiency
And Top Yukawa Coupling Measurement
Using ttH Events
With Two Same Sign Leptons In ATLAS

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Overview





T&P method using $Z \rightarrow ee$

Need a sample enriched in well **isolated** electrons $\rightarrow \mathbb{Z} \rightarrow ee$ Standard Model processes

> Data driven measurements are needed for % or sub-% level accuracy \rightarrow T&P method!



Tag electron : impose very strict selection criteria to suppress QCD background.

Probe electron : used for the measurement, and selected with loose requirements

Require tag-probe invariant mass to be close to Z mass \rightarrow reject SM processes with non-isolated electrons.

Using electrons with $|\eta| < 2.47$ (20 bins); 15 GeV (10 bins).

Reconstruction Efficiency: Introduction

- Electron reconstruction efficiency is defined as the efficiency of reconstructing and matching a good quality track to the electron cluster.
- A good track quality requires the object to have at least 1 pixel hit and 7 silicon hits.



N/B: Number of reconstructed/background probes.

PassTQ/FailTQ: Pass/Fail track quality requirements

Ph: Number of Photons.

<u>Challenge</u>: Background estimation in 200 η/p_{T} bins!

Reconstruction Efficiency: Background (1/2)



pt>=30 GeV: !2 loose & topoetcone40 / p_T > 0.05

Reconstruction Efficiency: Background (2/2)



Photon Background: Fit 3rd order polynomial.

Reconstruction Efficiency: Systematics

72 (3 \times 3 \times 2 \times 4) variations are used for data, 9 (3 \times 3) for MC

- **3 Tag identification variations :** LH Tight,LH Medium & topoetcone40 < 5 GeV or LH tight & topoetcone40 < 5 GeV.
- 3 invariant mass windows :

[80,100] GeV . [75,105] GeV or [70,110] GeV.

• 2 electron bkgd. template variations:

	Variation 1	Variation 2
pT<30 GeV	!2 loose & topoetcone 30 $/p_{_T} > 0.02$ $120~{\rm GeV} < {\rm m}_{_{\rm ee}} < 250~{\rm GeV}$!2 loose & topoetcone 30 $/{\rm p_{_T}} > 0.02$ $60~{\rm GeV} < m_{_{\rm ee}} < 70~{\rm GeV}$
p T >= 30 GeV	!2 loose & topoetcone 40 $/p_{_T} > 0.05$ $120~{\rm GeV} < {\rm m}_{_{ee}} < 250~{\rm GeV}$! 2 loose & topoetcone 40 $/p_{_{\rm T}} > 0.20$ $120~{\rm GeV} < {\rm m}_{_{\rm ee}}~< 250~{\rm GeV}$

• 4 photon background configurations (GeV):

 $\{\![70,\!80];\![100,\!110]\},\,\{\![60.80];\![100,\!120]\},\!\{\![50.80];\![100,\!130]\},\!\{\![55,\!70];\![110,\!125]\}$

Reconstruction Efficiency: Measurements (1/2)

2015 measurements (3.3 fb^{-1})



2012 measurements

50

60

- → Measurements performed in 200 bins projected along pt/eta.
- \rightarrow Very similar to the 2012 measurements except in the crack region.

80

70

E_T [GeV]

Reconstruction Efficiency: Measurements (2/2)



Reco Scale Factor

- > SF are consistent with 1 in most bins.
- stat errors are dominating almost in all bins.

Typical errors:

> 0.1- 1.3% (0.0-0.6%) stat (sys.) errors at E_T >25 GeV and 0.3- 2.7% (0.1-3.7) at low E_T .



in $E_{T} \sim 15 - 30$ GeV statistical uncertainties could be reduced by analyses using toys.



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Reconstruction Efficiency: Conclusion

Electron reconstruction efficiency measurements with **2015 full dataset using ~3.3/fb** released for physics analysis.

All SF are close to 1.

Results presented in e/gamma workshop from 9-13 November.

Conf. note by Moriond 2016.

Multilepton ttH Analysis



Objective: Direct measurement of top Yukawa coupling at Run2 in the t t⁻ H channel with two same-sign leptons.

To Do:

- Measure fake lepton background using matrix method.
- Signal region optimization.

Target:

- ICHEP Conference $2016 \rightarrow \text{conf. Note.}$
- Moriond $2017 \rightarrow \text{paper}$.



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Importance of the leptons for LHC physics

Electron marker of interest in the harsh pp collision hadronic environment -> Identifying electrons is crucial for many physics analyses in LHC experiment.

- Clear experimental signature.
- Cross Section $\geq 10^{-6}\sigma(QCD)$.
 - -> Very useful to define triggers
- Tag processes of high interest :
 - Z/W physics : Z(+jets) / W(+jets)/ Dibosons.
 - Top physics : tt(+jets) , single top.
 - Higgs : H -> ZZ*-> 4l / H > WW* -> 2l2v.
 - New physics : SUSY / exotic.



CERN Accelerator Complex



LHC Experiment



LHC accelerator:

- § 27 km circumference: ring of superconducting magnets.
- \$ 96 ton of 1.9K(-271.3 °C) liquid helium to cool the magnet.
- § 100m depth.
- § 10000 magnets installation (2005-2007).
- § 120 MW electric consummation.
- § Pressure: 10 times more pressed than the moon.
- § 3.5 Billion Euros
- § Each proton beam: 2808 bunches, each bunch: 10^11 protons

<u>6 Detectors</u>: ATLAS, CMS, LHCb, ALICE, LHCf and TOTEM

- § Proton-Proton collision at 13TeV (June 2015), 8/7TeV(2010-2012).
- § Collision every 50ns.
- 600 million particle collisions per second. 1billion events/s \rightarrow 100 events are selected by the trigger system.

<u>Goals:</u>

§ Higgs boson discovery.

§ Search for New physics such as: SUSY and extra dimensions.

§ Matter-antimatter asymmetry...

ATLAS Detector

The remarkable discovery of the Higgs boson in the experimentally harsh LHC environment would not have been possible without the deep understanding of the detector performance and optimisation of the reconstruction and identification algorithms.



EM Calorimeter at ATLAS

Large shower shapes for the charged particles at the passage through the calorimeter



Accordion geometry : a full coverage and a very good uniformity in ϕ

Object Reconstruction at ATLAS



An object is reconstructed using energy deposits in the calorimeter (clusters), and/or tracks that provide information on the particle's origin and direction (its momentum).

ATLAS Sub-Detectors

Tracker

Determine trajectories of charged particles

Electromagnetic Calorimeter

Hadronic Calorimeter Measure energies of detectable particles

(except muons)

Muon System

Detect & measure muons

Electron Reconstruction at ATLAS

$\mathbf{Z} \rightarrow \mathbf{ee} \ \mathbf{candidate}$





An electron is reconstructed using energy deposits in the calorimeter (clusters), matched with tracks that provide information on the particle's origin and direction (its momentum).





Electron Reconstruction

Both charged particles and photons deposit energy in the Electromagnetic Calorimeter detector.

How could we distinguish between electron and other particles?



<u>Step 1</u> : Identification of Seed-clusters (energy clusters in a fixed $\Delta \Phi$ and $\Delta \eta$ window).

<u>Step 2</u> : Association of a track with the cluster.

- found track :
- -> electron
- No track found:
- -> photon

<u>Step 3</u> : Computation of the final physical parameters ex : 4 momentum / charge etc ...

Improvement In Electron Reconstruction

2012 New Algorithm! Gaussian Sum Filter (GSF)

- improved track-cluster matching.
- Recovered efficiency losses due to electrons undergoing bremsstrahlung.





Electron reconstruction efficiency has increased by roughly 5%.