SEARCH FOR DISPLACED LEPTONS IN THE ATLAS DETECTOR

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Ohana means family.
Family means nobody gets left behind, or forgotten.

— Lilo & Stitch

Dedicated to the loving memory of Rudolf Miede.

1939 – 2005

ABSTRACT

Short summary of the contents... a great guide by Kent Beck how to write good abstracts can be found here:

https://plg.uwaterloo.ca/~migod/research/beckOOPSLA.html

PUBLICATIONS

Some ideas and figures have appeared previously in the following publications:

Put your publications from the thesis here. The packages `multibib` or `bibtopic` etc. can be used to handle multiple different bibliographies in your document.

We have seen that computer programming is an art,
because it applies accumulated knowledge to the world,
because it requires skill and ingenuity, and especially
because it produces objects of beauty.

— Donald E. Knuth [1]

ACKNOWLEDGEMENTS

Put your acknowledgements here.

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1 Members of GuIT (Gruppo Italiano Utilizzatori di TeX e LaTeX)

CONTENTS

LISTINGS

ACRONYMS

IBL Insertable B-Layer

MS Muon Spectrometer

ID Inner Detector

SCT Silicon Microstrip Tracker

TRT Transition Radiation Tracker

ToT Time Over Threshold

MDT Monitored Drift Tube

CSC Cathode-Strip Chamber

RPC Resistive Plate Chamber

TGC Thin Gap Chamber

L1 Level One

HLT High Level Trigger

L1Calo L1 Calorimeter Trigger

L1Topo L1 Topological Trigger

CTP Central Trigger Processor

TTC Trigger Timing and Control

ROB Read Out Board

RoI Region of Interest

LHC Large Hadron Collider

LEP Large Electron-Positron

SPS Super Proton Synchrotron

ATLAS A Toroidal LHC Apparatus

CMS Compact Muon Solenoid

ALICE A Large Ion Collider Experiment

LHCb Large Hadron Collider beauty

RF Radiofrequency

PSB Proton Synchrotron Booster

PS Proton Synchrotron

OR Overlap Removal

EM Electromagnetic

CB Combined

LRT Large Radius Tracking

MC Monte Carlo simulation

SM Standard Model

BSM Beyond the Standard Model

SUSY Supersymmetry

QCD Quantum Chromodynamics

PDF Parton Distribution Function

DM Dark Matter

LO Leading Order

NLO Next to Leading Order

NLO+NLL Next-to-Leading-Logarithmic Accuracy

SUSY Supersymmetry

MSSM Minimal Supersymmetric Standard Model

LSP Lightest Supersymmetric Particle

AOD Analysis Object Data

dAOD derived AOD

SR Signal Region

VR Validation Region

CR Control Region

FS Flavor Symmetric

CL Confidence Level

HL-LHC High Luminosity Large Hadron Collider

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INTRODUCTION

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Event reconstruction is the process by which detector signals are turned into objects that can be used for physics analysis. This is a complex process that requires a great deal of focused effort by the A Toroidal LHC Apparatus (ATLAS) collaboration. First, digital signals from the detector are collected into tracks and clusters, then they are combined to form first-stage physics objects. Then, a identification steps is performed, where quality requirements are placed on the first-stage objects to classify them into particles like electrons, muons, and jets that can be used in physics analyses.

These algorithms are centrally developed by the collaboration and designed to reconstruct and identify prompt objects ($|d_0| < 10|$mm). This section describes this process for objects which are relevant to this analysis, as well as the changes to these algorithms that we have implemented to be able to study displaced objects. Other objects, such as jets, taus, and missing transverse energy, are also reconstructed in this analysis, though the final event selection remains agnostic to their existence or quality, but does perform a overlap removal process to ensure that the same particle is not accidentally reconstructed as two different objects.

Reconstruction of tracks, including modifications to reconstruct tracks with high impact parameter, is described in Section 6.1. Electron and muon reconstruction, as well as their modifications, are described in Section 6.2 and Section 6.3, respectively.

6.1 TRACK RECONSTRUCTION

6.1.1 *Primary Vertex Identification*

6.1.2 *Large Radius Tracking*

6.2 ELECTRONS

6.2.1 *Standard Reconstruction and Identification*

6.2.2 *Modifications*

To be able to reconstruct electrons with high impact parameter, several changes needed to be made to the reconstruction and identification algorithms.

First, the reconstruction algorithm needed to be changed to allow tracks with a high d_0 to be extrapolated to clusters, and remove a requirement on pixel hits, and instead only require a total number of silicon hits. The reconstruction is then run on the track collection including Large Radius Tracking (LRT) tracks.

At the identification stage, we remove variables concerned with d_0 from the likelihood consideration, but do not retrain the likelihood itself. We also remove the cut on the number of silicon hits on top of that made at the reconstruction stage.

After these modifications, we introduce many fake electrons, primarily resulting from a fake LRT track being associated to an Electromagnetic (EM) cluster from a photon. The most powerful discriminator is the consistency in the p_T as measured by the track and the cluster. Furthermore, we require the primary track to be good quality, with $\chi^2 < 2$ and $n_{holes} <$??.

6.3 MUONS

6.3.1 *Standard Reconstruction and Identification*

Muons are reconstructed by combining independently reconstructed tracks in the Muon Spectrometer (MS) and the Inner Detector (ID). Combined (CB) muon tracks are generally seeded from the MS, then extrapolated inward and matched to an ID track. Then, at the identification stage, quality requirements are imposed on the combined tracks to reduce improve the purity of the muon collection. For this analysis, the muon reconstruction remains unchanged, while changes are made at the identification stage.

6.3.1.1 *Muon Track Reconstruction*

6.3.1.2 *Muon Identification*

This analysis uses the default muon working point for ATLAS analyses, called a *medium* muon. This working point places a requirement on the number of ID and MS hits that comprise the track to ensure a robust momentum measurement. At least 1 pixel hit, at least 5 Silicon Microstrip Tracker (SCT) hits, and at least 10% of the Transition Radiation Tracker (TRT) hits associated to the object are included in the final fit are required. It also requires there to be fewer than 3 holes in the silicon tracking layers, where holes are defined as a lack of hit from a sensor traversed by the track. Furthermore, MS track must have at least 3 hits in at least 2 Monitored Drift Tube (MDT) layers. In the crack region $|\eta| < 0.1$, MS tracks with at least three hits in only one MDT layer are allowed provided there are no holes in the track. Finally, a loose requirement is placed on the consistency between the MS and ID tracks. Namely, the *q/p significance*, the difference betweeen the charge and momentum ratio in the ID and MS divided by their uncertanities summed in quadrature, is required to be less than 7.

6.3.2 *Modifications*

For this analysis, muons are reconstructed after LRT is performed and the reconstruction and identification efficiency is quite high. Furthermore, we remove the requirement that the ID track has at least one pixel hit, further improving the efficiency at high d_0. The effect of these improvements is show in fig

This modification of the muon identification increases the fake rate of muons, so again we impose quality requirements that are independent of displacement. Primarily, we require the muon to have at least two precision hits and require the $\chi^2_{CB}/N_{DoF} < 3$. The χ^2_{CB} requirement is, in effect, a requirement on the consistnecy of the p_T of the two tracks.

6.4 isolation

In this analysis, both muons and electrons are required to be isolated to reduce background from heavy flavor decays.

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BIBLIOGRAPHY

[1] Donald E. Knuth. "Computer Programming as an Art." In: *Communications of the ACM* 17.12 (1974), pp. 667–673.

DECLARATION

Put your declaration here.

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Lesya Horyn

colophon

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https://bitbucket.org/amiede/classicthesis/

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