

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/beck00PSLA.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 T_EX e L^AT_EX)

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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
L ₁	Level One
HLT	High Level Trigger
L ₁ Calo	L1 Calorimeter Trigger
L ₁ Topo	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
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+NNL	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

Part I

INTRODUCTION

Part II

THEORY AND MOTIVATION

THEORY

1.1 THE STANDARD MODEL

1.2 OPEN QUESTIONS

1.3 SUPERSYMMETRY

LONG LIVED PARTICLES

2.1 MOTIVATION

2.2 BASICS

Part III

EXPERIMENT

PARTICLE ACCELERATORS

3.1 ACCELERATOR THEORY

3.2 THE LARGE HADRON COLLIDER

THE ATLAS DETECTOR

4.1 GENERAL OVERVIEW

4.2 INNER DETECTOR

4.3 CALORIMETERS

4.4 MUON SPECTROMETER

4.5 MAGNET SYSTEMS

DATA ACQUISITION

5.1 OVERVIEW

5.2 GENERAL CHALLENGES

5.3 CHALLENGES FOR LONG LIVED PARTICLES

5.4 THE FAST TRACKER

5.5 FAST TRACKER APPLICATIONS FOR LONG LIVED PARTICLES AND FUTURE PROSPECTS

EVENT RECONSTRUCTION

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 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, an identification step 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 ($|d_0| < 10\text{mm}$). 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 an 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*

6.3 MUONS

6.3.1 *Standard Reconstruction and Identification*

6.3.2 *Modifications*

Part IV

SEARCH FOR DISPLACED LEPTONS

ANALYSIS STRATEGY

7.1 TARGET MODELS AND SIGNAL REGIONS

7.2 OVERVIEW OF BACKGROUNDS

7.3 SIGNAL, CONTROL, AND VALIDATION REGIONS

EVENT SELECTION

8.1 DATASETS

8.1.1 *Recorded Data Streams*

8.1.2 *Trigger Strategy*

8.1.3 *Monte Carlo Samples*

8.2 ELECTRON SELECTION

8.2.1 *Quality Requiremens*

8.2.2 *Efficiency*

8.3 MUON SELECTION

8.3.1 *Quality Requirements*

8.3.2 *Efficiency*

8.4 FINAL EVENT SELECTION

BACKGROUNDS

9.1 FAKES

9.1.1 *Electrons*

9.1.1.1 *Identification*

9.1.1.2 *Systematic Uncertainties*

9.1.2 *Muons*

9.1.2.1 *Identification*

9.1.2.2 *Systematic Uncertainties*

9.2 COSMICS

9.2.1 *Identification*

9.2.2 *Cosmic Events*

9.2.3 *Systematic Uncertainties*

9.3 OTHER BACKGROUNDS

9.3.1 *Heavy Flavor*

9.3.2 *Conversions*

9.3.3 *Material Interactions*

SYSTEMATICS

10.1 MONTE CARLO SYSTEMATICS

10.2 COSMIC MUON IDENTIFICATION

10.3 ELECTRON RECONSTRUCTION

10.4 TRIGGER EFFICIENCY

RESULTS.TEX

11.1 SIGNAL YIELD

11.2 INTERPRETATION

11.3 FUTURE PROSPECTS

Part V

CONCLUSIONS

Part VI

APPENDIX

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.

Chicago, IL, July, 2020

Lesya Horyn

COLOPHON

This document was typeset using the typographical look-and-feel classicthesis developed by André Miede. The style was inspired by Robert Bringhurst's seminal book on typography "*The Elements of Typographic Style*". classicthesis is available for both L^AT_EX and L^YX:

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

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<http://postcards.miede.de/>

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