

SEARCH FOR $t\bar{t}Z' \rightarrow t\bar{t}t\bar{t}$ PRODUCTION IN THE MULTILEPTON FINAL STATE IN
 pp COLLISIONS AT $\sqrt{s} = 13$ AND 13.6 TEV WITH THE ATLAS DETECTOR

By

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A DISSERTATION

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for the degree of

Physics — Doctor of Philosophy
Computational Mathematics, Science and Engineering — Dual Major

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ABSTRACT

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I dedicate this work to the Opossum and his noble pursuit of snacks.

ACKNOWLEDGMENTS

Una Salus Victis Nullam Sperare Salutem.

PREFACE

This is my preface. remarks remarks remarks

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KEY TO ABBREVIATIONS

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1.1 Motivation

1.2 Analysis strategy

1.2.1 Profile likelihood fit

1.2.2 Analysis regions

Chapter 2. Theoretical Overview

2.1 The Standard Model

2.1.1 Formalism

2.1.2 Four-top quarks production

[observation paper results]

2.1.3 Shortcomings

2.2 Beyond the Standard Model

2.2.1 Hypothetical top-philic gauge bosons

Chapter 3. LHC & the ATLAS Experiment

3.1 The Large Hadron Collider

[History of accelerators, leading into LHC + aim of LHC]

3.1.1 Overview

[Basic info: location, size, main working mechanism, main detectors, main physics done]

3.1.2 Collider physics

[pp collision, pdf, cross section, luminosity]

3.1.3 Operations

[particle productions, runs & data collected, timeline + HL-LHC]

3.2 The ATLAS detector

[History, goals, coordinate system]

- 3.2.1 Inner detector
- 3.2.2 Calorimeter systems
- 3.2.3 Muon spectrometer
- 3.2.4 Forward detectors
- 3.2.5 Magnetic systems
- 3.2.6 Trigger & data acquisition

Chapter 4. Data & Simulated Samples

4.1 Data samples

[trigger selection] [other cuts made] [luminosity]

4.2 Monte Carlo samples

4.2.1 Simulation

[geant4, madgraph, pdf set, etc.]

4.2.2 Signal samples

4.2.3 Background samples

Chapter 5. Particle Reconstruction & Identification

5.1 Object reconstruction

5.1.1 Vertex & track reconstruction

5.1.2 Jets

5.1.3 Electrons

[isolation criteria along with muon]

5.1.4 Muons

5.1.5 Missing transverse momentum

5.1.6 Topological clustering

5.1.7 Pile-up & overlap removal

5.2 Particle identification

b-tagging

[details about optimization work & b-tagging calibration work]

Chapter 6. Event Selection

[event selection criteria]

6.1 Object definition

[lepton pt cut study here]

6.2 Background estimation

6.2.1 Fake & non-prompt leptons

6.2.2 Irreducible background

6.3 Analysis regions

6.3.1 Control regions

$t\bar{t}W$ CRs

6.3.2 Signal regions

[include blinding strategy]

6.3.3 Validation region

6.4 Signal extraction

SM MVA

BSM MVA

Chapter 7. Systematic Uncertainties

7.1 Experimental uncertainties

7.2 Modeling uncertainties

7.2.1 Signal modeling uncertainties

7.2.2 Background modeling uncertainties

Chapter 8. Results

8.1 Likelihood fit

8.2 Limits

8.3 Interpretation

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APPENDIX A. Statistical analysis

A.1 Statistical inference

A.2 Hypothesis testing

A.3 χ^2 template fitting