

Contents

1	Introduction and Theoretical Framework	1
1.1	The Standard Model	2
1.1.1	Building the Standard Model	4
1.1.2	Quantum Chromodynamics	5
1.1.3	Electroweak Theory	6
1.1.4	Spontaneous Symmetry Breaking	9
1.1.5	Quark Mixing and CKM Matrix	12
1.1.6	Experimental Successes of the Standard Model	13
1.1.7	Shortcomings of the Standard Model	14
1.2	Beyond the Standard Model	19
1.2.1	Quark Singlet Model	19
1.2.2	Two-Higgs Doublet Model	19
1.2.3	Supersymmetry	20
1.3	Flavor-Changing Neutral Current Interactions	22
1.3.1	FCNC Interactions in the SM	22
1.3.2	One-Loop FCNC Diagrams	23
1.3.3	FCNC Interactions in Light Quarks	24
1.4	Top FCNC Interactions	25
1.4.1	Top FCNC Interactions in the SM	26
1.4.2	Top FCNC Interactions Beyond the SM	28
1.5	Top Quark Production and Decay at the LHC	29
1.5.1	Top Quark Production and Decay Within the SM	29
1.5.2	FCNC-Mediated Top Quark Production and Decay	32
	References	34
2	The ATLAS Experiment at the Large Hadron Collider	37
2.1	The Large Hadron Collider	37
2.2	The ATLAS Experiment	41
2.2.1	Coordinate System	43
2.2.2	Magnet System	45
2.2.3	Inner Detector	46

2.2.4	Calorimeters	48
2.2.5	Muon Spectrometer	52
2.2.6	Forward Subdetectors and Luminosity Measurement. . .	54
2.2.7	Trigger and Data Acquisition System	55
2.2.8	Data Quality	57
	References.	58
3	Event Simulation	59
3.1	Simulation of pp Collisions	59
3.1.1	Factorization Theorem.	60
3.1.2	Fixed Order QCD: Matrix Elements	61
3.1.3	Parton Shower.	63
3.1.4	Matrix Element and Parton Shower Matching.	64
3.1.5	Hadronization	64
3.1.6	Underlying Event	66
3.1.7	Pile-Up	66
3.2	Monte Carlo Generators	67
3.2.1	General Purpose Generators	67
3.2.2	Multi-leg Leading-Order Generators	67
3.2.3	NLO Generators	67
3.3	ATLAS Detector Simulation.	68
3.4	Monte Carlo Simulation Corrections.	69
	References.	70
4	Event Reconstruction	73
4.1	Tracks.	73
4.2	Primary Vertices.	76
4.3	Leptons.	77
4.3.1	Electrons	77
4.3.2	Muons.	81
4.4	Jets	83
4.4.1	Cluster Formation	84
4.4.2	Jet-Finding Algorithm.	86
4.4.3	Jet Calibration.	87
4.4.4	Jet Cleaning	91
4.4.5	Jet Vertex Fraction	93
4.5	b -tagging	93
4.5.1	b -tagging Algorithms	95
4.5.2	b -tagging Calibration.	98
4.6	Missing Transverse Momentum	99
	References.	100
5	Event Samples and Preselection	103
5.1	Data Sample.	103
5.2	Event Preselection	104

5.3	Signal and Background Modeling	105
5.3.1	$t\bar{t}$ +jets Background	106
5.3.2	W/Z +jets Background	112
5.3.3	Other Simulated Backgrounds	114
5.3.4	Multijet Background	115
5.3.5	Signal Modeling	116
5.4	Tag Rate Function Method	117
5.5	Data-to-Monte Carlo Comparison	120
	References	122
6	Analysis Strategy	125
6.1	Event Categorization	125
6.2	Discriminating Variable	130
6.2.1	Signal Probability	132
6.2.2	Background Probability	136
6.2.3	PDF Smoothing	138
6.2.4	Final Discriminant	139
	Reference	142
7	Systematic Uncertainties	143
7.1	Luminosity	146
7.2	Objects Definitions	146
7.2.1	Lepton Reconstruction, Identification and Trigger	146
7.2.2	Lepton Momentum Scale and Resolution	146
7.2.3	Jet Reconstruction Efficiency	147
7.2.4	Jet Vertex Fraction Efficiency	147
7.2.5	Jet Energy Scale	147
7.2.6	Jet Energy Resolution	148
7.2.7	Missing Transverse Momentum	149
7.2.8	b -tagging	149
7.3	Background Modeling	150
7.3.1	$t\bar{t}$ +jets Modeling	150
7.3.2	W/Z +jets Modeling	155
7.3.3	Other Physics Backgrounds	156
7.3.4	Multijet Background	157
7.4	Signal Modeling	158
	References	158
8	Statistical Analysis	161
8.1	Hypothesis Testing	161
8.2	CL_s Method	163
8.3	Likelihood Function and Profile Likelihood Ratio	164
8.4	Approximation for the Profile Likelihood Ratio	166
	References	167

9	Results	169
9.1	Search for $t\bar{t} \rightarrow WbHq, H \rightarrow b\bar{b}$	169
9.1.1	Discussion of the Fit	176
9.1.2	Limits on $\text{BR}(t \rightarrow Hq)$	181
9.2	Combination with Other ATLAS Searches	181
9.2.1	$H \rightarrow \gamma\gamma$	182
9.2.2	$H \rightarrow W^+W^-, \tau^+\tau^-$	183
9.2.3	ATLAS Combined Results	185
	References	190
10	Prospects	193
10.1	Statistical Uncertainty	193
10.2	Systematic Uncertainties	193
10.3	Event Categorization	195
10.4	Discriminating Variable	196
10.4.1	Pseudo-Continuous b -tagging Term	197
10.4.2	Jet Charge Information	198
	References	202
11	Summary	205
	Appendix A: Signal Modeling	207
	Appendix B: Tag Rate Function Validation	213
	Appendix C: Data-to-MC Comparisons	221
	Appendix D: Pre- and Post-fit Distributions for the Search	231
	Appendix E: Fit Validation	237
	Appendix F: Expected Sensitivity Studies	241

Search for Flavor-Changing Neutral Current Top Quark
Decays $t \rightarrow Hq$, with $H \rightarrow b\bar{b}$, in pp Collisions at $\sqrt{s} = 8$
TeV with the ATLAS Detector

Tsiskaridze, S.

2017, XVII, 242 p. 133 illus., 95 illus. in color.,

Hardcover

ISBN: 978-3-319-63413-5