

Contents

1	Introduction	1
1.1	The Standard Model	1
1.1.1	Electroweak Interaction	5
1.1.2	The Spontaneous Symmetry Breaking	8
1.1.3	Quantum-Chromo Dynamics (QCD)	11
1.1.4	Test of the SM	12
1.1.5	Problems of the SM	14
1.2	Supersymmetry	15
1.2.1	Minimum Supersymmetric Standard Model (MSSM)	17
1.2.2	R-Parity	22
1.2.3	SUSY Breaking	22
1.2.4	The MSSM Higgs Sector	23
1.2.5	SUSY Spectrum	24
1.2.6	Natural SUSY Versus 125 GeV Higgs Boson	28
1.3	Productions and Decay Modes of SUSY Particles at the LHC	31
1.4	Current Status of SUSY Searches	34
1.4.1	Search for Direct Chargino Pair Production at the LEP	36
1.4.2	Search for Direct Production of Electroweak Gauginos at the LHC	36
1.4.3	Search for Scalar Top Quark Pair Production at the LHC	37
1.5	Target Event Topology of This Work	41
	References	43
2	The LHC and the ATLAS Experiment	49
2.1	The Large Hadron Collider	49
2.2	The ATLAS Detector	52
2.2.1	Inner Detector	54
2.2.2	Calorimetry	59

2.2.3	Muon Spectrometer	67
2.2.4	Trigger and Data Acquisition System	71
	References	75
3	Data and Monte Carlo Simulation	77
3.1	The ATLAS pp Collisions Data in 2012	77
3.1.1	Data Processing and Online Calibration	77
3.1.2	Luminosity Measurement	78
3.1.3	Trigger Efficiency Measurement	78
3.2	Monte Carlo Simulation	81
3.2.1	Parton Distribution Function (PDF)	81
3.2.2	The Standard Model Backgrounds	84
3.2.3	Signals	85
3.2.4	Overlap Removal Between Diagrams by Matrix Element and Parton Shower	88
3.2.5	Detector Simulation	88
3.2.6	Pileup Re-Weighting	89
	References	89
4	Particle Reconstruction	93
4.1	Track and Vertex Reconstruction	93
4.1.1	Track Reconstruction	93
4.1.2	Vertex Reconstruction	95
4.1.3	Impact Parameter Resolution	96
4.2	Electron Reconstruction	96
4.2.1	Cluster Reconstruction at the EM Calorimeter	97
4.2.2	Track Matching	97
4.2.3	Energy Calibration	98
4.2.4	Electron Identification	100
4.2.5	Reconstruction and Identification Efficiency	100
4.3	Muon Reconstruction	103
4.3.1	Standalone Muon Reconstruction	103
4.3.2	Combined Muon Reconstruction	103
4.3.3	Segment-Tagged Muon Reconstruction	103
4.3.4	Muon Momentum Scale and Resolution	104
4.3.5	Muon Identification	106
4.3.6	Reconstruction and Identification Efficiency	106
4.4	Lepton Isolation	107
4.5	Jet Reconstruction	109
4.5.1	Calorimeter Clustering Criteria	109
4.5.2	Anti- k_T Algorithm	109
4.5.3	Pileup Subtraction	110
4.5.4	Jet Energy Scale (JES) and Resolution Calibration	111

4.5.5	Jet Vertex Fraction (JVF)	113
4.5.6	Jet Identification	115
4.5.7	Flavor Tagging	116
4.6	Missing Transverse Energy Reconstruction	119
	References	120
5	Event Selections	123
5.1	Preselection.	123
5.2	Target Signal Topology	125
5.3	Tools for Signal Discrimination.	126
5.4	Optimization of Signal Regions.	129
5.4.1	Small ΔM Channel	129
5.4.2	Moderate ΔM Channel	133
5.4.3	Combination of Two Channels	136
	References	137
6	Background Estimation	139
6.1	Overview	139
6.2	Maximum Likelihood Fit	140
6.3	Systematic Uncertainties	142
6.3.1	Experimental Sources.	142
6.3.2	Theoretical Sources	144
6.3.3	Systematic Uncertainty on the Signal	146
6.3.4	Application of the Systematic Uncertainty	146
6.4	Mis-identified Lepton Estimation	148
6.4.1	Matrix Method	149
6.4.2	Measurement of Isolation Efficiency for Real Leptons	150
6.4.3	Estimation of Isolation Efficiency for Fake Leptons	150
6.5	Control Region and Validation Region Definitions.	151
6.6	Validation of the Estimated Background.	155
6.6.1	Validation for Mis-identified Lepton Background	155
6.6.2	Validation for MC Samples with Loose Selection	156
6.6.3	Validation in CRs and VRs	159
	References	164
7	Results	167
7.1	Observations in Signal Regions	167
7.1.1	Small ΔM Channel	167
7.1.2	Moderate ΔM Channel	170
7.2	Model-Independent Upper Limit	172
7.2.1	Profile-Likelihood Method	173
7.2.2	Limits on the Signal Hypotheses	177

7.3	Model-Dependent Limits	177
7.3.1	CLs Method	177
7.3.2	Limits on Stop Pair Production Models	179
7.3.3	Comparison with Other ATLAS Stop Analyses	183
	References	185
8	Conclusions	187
	Appendix A: Impact of $t\bar{t}$ Re-Weighting.	189
	Appendix B: Cut-Flow Chart	193
	Appendix C: Signal Leaks to Control Regions	199
	Appendix D: Impact of Additional Uncertainty on ϵ_{fake}	201
	Appendix E: Confirmation of Statistical Approximations	203
	Appendix F: Combination of Sub-channels for the Exclusion Limit Setting	205
	Appendix G: Improvements on the ATLAS Muon Trigger System	209
	Curriculum Vitae	223

Search for Scalar Top Quarks and Higgsino-Like
Neutralinos

SUSY Hunting With a "Soft" Lepton at the LHC

Nobe, T.

2016, XII, 224 p. 122 illus., 19 illus. in color., Hardcover

ISBN: 978-981-10-0001-0