

# Contents

<b>1</b>	<b>Introduction and Theoretical Background</b> . . . . .	1
1.1	Standard Model and the Higgs . . . . .	1
1.2	Standard Model Predictions . . . . .	5
1.3	The Higgs Boson at the LHC . . . . .	8
1.4	Conclusion . . . . .	9
	References . . . . .	9
<b>2</b>	<b>The Large Hadron Collider</b> . . . . .	11
2.1	Overview . . . . .	11
2.2	The 2010–2012 LHC Data-Sets . . . . .	12
	References . . . . .	14
<b>3</b>	<b>The ATLAS Experiment</b> . . . . .	15
3.1	Overview . . . . .	15
3.2	The Inner Detector . . . . .	17
3.3	The Calorimeter System . . . . .	19
3.4	The Muon Spectrometer . . . . .	21
3.5	Conclusion . . . . .	22
	References . . . . .	22
<b>4</b>	<b>Reconstruction and Commissioning</b> . . . . .	25
4.1	Particle Reconstruction . . . . .	25
4.2	Trigger . . . . .	31
4.3	Pile-Up . . . . .	32
4.4	Commissioning . . . . .	33
4.5	Conclusion . . . . .	34
	References . . . . .	34

<b>5</b>	<b>Detector Alignment</b> . . . . .	37
5.1	Introduction to Detector Alignment . . . . .	37
5.2	Track-Based Alignment . . . . .	41
5.2.1	Mathematical Formalism . . . . .	44
5.2.2	Matrix Inversion . . . . .	46
5.2.3	Weak Modes . . . . .	48
5.3	Alignment Validation . . . . .	52
5.4	ATLAS Inner Detector Alignment . . . . .	53
	References . . . . .	61
<b>6</b>	<b>TRT Alignment</b> . . . . .	63
6.1	TRT Construction . . . . .	63
6.2	TRT Alignment Levels . . . . .	67
6.3	L1 Barrel Alignment . . . . .	69
6.4	L1 End-Cap Alignment . . . . .	72
6.5	L2 Barrel Alignment . . . . .	73
6.5.1	L2 Barrel Alignment Using TRT Stand-Alone Tracks . . . . .	75
6.5.2	L2 Barrel Alignment Using Combined ID Tracks . . . . .	78
6.5.3	Difference in L2 Alignment Constants . . . . .	79
6.5.4	Barrel A/C Side Differences: “The $\phi$ Structure” . . . . .	82
6.6	L2 End-Cap Alignment . . . . .	85
6.6.1	L2 End-Cap Alignment with Cosmic-Ray Data . . . . .	85
6.6.2	L2 End-Cap Alignment with Collision Data . . . . .	86
6.7	Evidence for End-Cap Wheel Distortions . . . . .	89
6.8	Wire-Level End-Cap Alignment . . . . .	91
6.9	Wire-Level Barrel Alignment . . . . .	94
6.10	End-Cap Alignment Along Z . . . . .	95
6.11	Conclusion . . . . .	100
	References . . . . .	100
<b>7</b>	<b>Electron Identification</b> . . . . .	101
7.1	Electron Reconstruction . . . . .	101
7.2	Discriminating Variables for Electron Identification . . . . .	106
7.3	Electron Operating Points . . . . .	113
7.3.1	The IsEM Menu . . . . .	113
7.3.2	Data-Driven IsEM Optimization . . . . .	115
7.3.3	The IsEM++ Menu . . . . .	119
7.3.4	Coping with High Luminosity Running Conditions in the 2012 Data Taking . . . . .	121
7.3.5	The Future of Electron Identification . . . . .	125
7.4	Conclusion . . . . .	126
	References . . . . .	127

<b>8</b>	<b>WW Physics</b> . . . . .	129
8.1	Introduction and Motivation . . . . .	129
8.2	Signature and Event Selection . . . . .	133
8.3	Background Estimation . . . . .	139
8.3.1	Drell-Yan Background. . . . .	140
8.3.2	Top Background. . . . .	142
8.3.3	$W$ +jet Background . . . . .	143
8.3.4	Di-boson Background . . . . .	144
8.4	Separating SM $WW$ from $H \rightarrow WW^{(*)}$ . . . . .	145
8.5	Conclusion. . . . .	149
	References. . . . .	149
<b>9</b>	<b>The Fake Factor Method</b> . . . . .	151
9.1	Introduction . . . . .	151
9.2	Fake Factor Method . . . . .	154
9.2.1	Motivation of Fake Factor Method . . . . .	158
9.3	Application of the Fake Factor Method to Di-Lepton Events . . . . .	162
9.3.1	Denominator Definitions . . . . .	163
9.3.2	Fake Factor Measurement . . . . .	167
9.3.3	Fake Factor Systematics . . . . .	174
9.3.4	Background Prediction . . . . .	181
9.3.5	Data-Driven Validation of the Background Modeling. . . . .	189
9.4	Extension of the Fake Factor Method for Multiple Sources of Background . . . . .	193
9.4.1	Bias from Multiple Sources of Background . . . . .	193
9.4.2	Extending the Fake Factors Method to Account for Multiple Sources of Background . . . . .	196
9.4.3	Bias in Extended Method. . . . .	200
9.4.4	Application to Electron Heavy-Flavor Fakes. . . . .	202
9.5	Conclusion. . . . .	208
	References. . . . .	209
<b>10</b>	<b>WW Cross Section Measurement</b> . . . . .	211
10.1	Analysis Overview . . . . .	211
10.2	Data Set and MC Samples . . . . .	212
10.3	Event Selection. . . . .	213
10.4	Background Estimation . . . . .	217
10.4.1	$Z/\gamma^*$ Background . . . . .	218
10.4.2	Top Background. . . . .	220
10.4.3	$W$ +jet Background . . . . .	221
10.4.4	Di-boson Background . . . . .	223
10.5	$WW$ Acceptance . . . . .	224

10.6	Results . . . . .	225
10.7	Conclusion. . . . .	226
	References. . . . .	226
<b>11</b>	<b>Search for <math>H \rightarrow WW^{(*)}</math></b> . . . . .	229
11.1	Analysis Overview . . . . .	229
11.2	Data Sets and MC Samples . . . . .	231
11.3	Event Selection. . . . .	232
	11.3.1 0-Jet Analysis. . . . .	237
	11.3.2 1-Jet Analysis. . . . .	241
	11.3.3 2-Jet Analysis. . . . .	243
11.4	Background Estimation . . . . .	247
	11.4.1 Standard Model $WW$ Background . . . . .	247
	11.4.2 Top Background. . . . .	254
	11.4.3 $Z/\gamma^*$ Background . . . . .	256
	11.4.4 $W$ +jet Background . . . . .	256
	11.4.5 Di-boson Background . . . . .	259
11.5	Systematics . . . . .	259
11.6	Statistical Model. . . . .	262
11.7	Results . . . . .	264
	11.7.1 Results of the 2011 Analysis . . . . .	264
	11.7.2 Results of the 2012 Analysis . . . . .	265
	11.7.3 Combined Results. . . . .	267
11.8	Conclusion. . . . .	269
	References. . . . .	269
<b>12</b>	<b>Combined Higgs Results</b> . . . . .	271
12.1	Overview of Other Higgs Searches at ATLAS . . . . .	271
	12.1.1 $H \rightarrow ZZ^{(*)} \rightarrow llll$ . . . . .	271
	12.1.2 $H \rightarrow \gamma\gamma$ . . . . .	274
	12.1.3 $H \rightarrow WW^{(*)}$ . . . . .	277
12.2	Higgs Combination . . . . .	280
12.3	Results . . . . .	282
12.4	Conclusions . . . . .	285
	References. . . . .	285
	<b>Appendix A: Alignment Toy</b> . . . . .	287
	<b>Appendix B: Fake Factor Derivations.</b> . . . . .	297



<http://www.springer.com/978-3-319-10343-3>

The Road to Discovery

Detector Alignment, Electron Identification, Particle  
Misidentification, WW Physics, and the Discovery of the  
Higgs Boson

Alison, J.

2015, XXII, 302 p. 223 illus., 99 illus. in color., Hardcover

ISBN: 978-3-319-10343-3