

Contents

Introduction	1
I Introduction to the high energy neutrino world	5
1 High energy neutrinos in astroparticle physics	7
1.1 Introduction	7
1.2 Cosmic rays	8
1.2.1 Acceleration mechanism	10
1.3 Neutrino astronomy	11
1.3.1 Hadronic production mechanisms of high energy neutrinos	11
1.4 Neutrino sources	12
1.4.1 Galactic sources	13
1.4.2 Extra-Galactic sources	14
1.4.3 Atmospheric neutrinos	16
1.5 Neutrino propagation	16
1.5.1 High Energy Neutrino interactions with matter	17
1.5.2 Neutrino oscillation	19
2 Neutrino telescopes	21
2.1 Neutrino detection principle	21
2.2 Cherenkov radiation	21
2.3 Background	22
2.3.1 Atmospheric muons and neutrinos	22
2.3.2 Optical background	24
2.4 Number of optical sensors in a neutrino telescope	27
2.5 Water and ice properties	28
2.6 Operating neutrino telescopes	29
3 ANTARES	33
3.1 The ANTARES neutrino telescope	33
3.2 Detector structure	33
3.2.1 The lines	34

3.2.2	The Storeys	35
3.2.3	The Optical Module	35
3.2.4	The Junction Box and the electro-optical cable	37
3.3	Water properties	37
3.3.1	Light transmission	38
3.3.2	Optical background	38
3.3.3	Biofouling and sedimentation	38
3.4	Detector calibration	39
3.4.1	Time calibration	39
3.4.2	Charge calibration	40
3.4.3	Position calibration	41
3.5	Data acquisition system	42
3.5.1	Data taking	43
4	KM3NeT	45
4.1	KM3NeT	45
4.1.1	KM3NeT/ARCA: Astroparticle Research with Cosmics in the Abyss	46
4.1.2	KM3NeT/ORCA: Oscillation Research with Cosmics in the Abyss	46
4.2	Digital Optical Module	48
4.3	Detection Units	50
4.4	Positioning system	53
4.5	Time calibration	55
4.6	Data acquisition	56
II	Analysis of KM3NeT compass data	57
5	Calibration, monitoring and position reconstruction using KM3NeT compass data	59
5.1	AHRS: Attitude Heading Reference System	60
5.2	Calibration of the compass and tilt board	61
5.2.1	Calibration in different environment	62
5.3	Monitoring compass data	64
5.3.1	Low sea current period	64
5.3.2	Strong sea current study	65
5.4	Detection Unit Line fit	69
5.4.1	Application of the Detection Line Fit Model using compass data	71

III Dark Matter searches towards the Sun with ANTARES**77**

6	Dark Matter phenomenology	79
6.1	Introduction to the Dark Matter problem	79
6.2	Evidences of existence of Dark Matter	80
6.2.1	The Galactic scale	81
6.2.2	Gravitational lensing	83
6.2.3	The Cosmological scale	84
6.3	Dark Matter candidates	87
6.3.1	Baryonic candidates	89
6.3.2	Non-Baryonic candidates	90
6.4	Weakly Interactive Massive Particles	91
6.5	Detection of Dark Matter	92
6.5.1	Dark Matter at colliders	92
6.5.2	Direct detection	93
6.5.3	Indirect detection	94
6.6	Dark Matter using neutrinos	96
6.7	Dark Matter from the Sun	100
6.7.1	Capture rate in the Sun	101
6.7.2	Neutrino spectra	101
7	Inputs for ANTARES data analysis	105
7.1	Monte Carlo simulations	105
7.1.1	Atmospheric muons	107
7.1.2	Neutrinos	107
7.1.3	Particle and light propagation	107
7.1.4	Data acquisition simulations	108
7.2	Reconstruction strategies	108
7.2.1	AAFIt	109
7.2.2	BBFit	110
7.3	Data set and pre-selection cuts used in this work	111
7.4	Moving sources	113
7.4.1	Conversions of the celestial coordinates	115
7.4.2	Sun path	116
8	Analysis and Results	125
8.1	Binned analysis strategy	125
8.2	Acceptance	126
8.2.1	Effective areas	126
8.3	Evaluation of the backgrounds	127
8.4	Sensitivity estimation	129
8.4.1	Choice of the best cut	130
8.5	Systematic uncertainties	134

8.6	Unblinding	135
8.6.1	Neutrino flux upper limits	137
8.7	Cross section	139
8.7.1	Comparison with previous publication	139
8.8	Comparison with other experiments	141
Summary and Conclusions		149
Resumen y Conclusiones		151
A Compasses		153
A.1	Additional plot for low sea current velocity period and the two period of strong sea current	154
A.2	Additional plot for Period 2	155
B Compass calibration		181
B.1	Calibration	181
C Tables		185
C.1	Tables with expected events	185
List of Acronyms		189
Bibliography		191