

# Contents

Abstract	VII
Resum	IX
Resumen	XI
1 KM3NeT: telescopio de neutrinos en las profundidades del Mar Mediterráneo	1
1.1 Proyecto KM3NeT	2
1.1.1 La detección de un neutrino	2
1.1.2 El detector	4
1.1.3 Otros telescopios submarinos	8
1.2 Sistema de Posicionamiento	10
1.2.1 Las propiedades del entorno	10
1.2.2 El Sistema de Posicionamiento Acústico (APS)	12
1.2.3 El Sistema de Referencia de Actitud y Rumbo (AHRS)	12
1.3 Detección Acústica de Neutrinos	13
1.3.1 Pulso bipolar	14
1.3.2 Calibración y detección	15

I	KM3NeT Positioning System	17
2	The Acoustic Positioning System (APS) of KM3NeT	19
2.1	Acoustic system sensors and operation	20
2.1.1	Acoustic Beacons (ABs)	21
2.1.2	Digital Acoustic Receivers (DARs)	22
2.1.3	The Acoustic Data Filter (ADF)	24
2.2	AB production and characterization in laboratory	28
2.2.1	Ultrasound transducer	28
2.2.2	AB characterization	30
2.3	AB placement studies	42
2.3.1	Autonomous AB location. ORCA006 case	43
2.3.2	Triggered AB location proposal	44
2.4	Performance operational in situ	46
2.4.1	Received Voltage Response of DARs	47
2.4.2	AB emitted Sound Pressure Level	48
2.4.3	Auto system self-calibration	49
2.5	Monitoring the Digital Optical Modules positions	49
3	The Detection Unit Line Fit	55
3.1	The Attitude and Heading Reference System (AHRS) of KM3NeT	56
3.1.1	AHRS using Compass and Tilt meter to produce the YPR data	56
3.1.2	The AHRS matrix for YPR data analysis	59
3.1.3	Positioning DOMs from YPR data	62
3.2	The Mechanical Model (MM) for KM3NeT	64
3.2.1	Mechanical equations for the model	67
3.2.2	DOMs position estimation from sea current properties	72
3.3	MM application to the reconstruction: the DU Line Fit	74
3.3.1	TILT analysis	75
3.3.2	POS analysis	76
3.3.3	Mechanical reconstruction	77

II Acoustic Signal Analysis for Unknown Sources. Studies for Acoustic Neutrino Detection	85
4 Full Acoustic Calibration of Underwater Neutrino Telescopes	87
4.1 Using the Parametric Effect to Reproduce the Acoustic Neutrino Signature . . .	89
4.1.1 The Acoustic Neutrino Signature. . . . .	89
4.1.2 The Acoustic Parametric Effect. . . . .	91
4.2 Acoustic Calibration of Underwater Neutrino Telescopes. . . . .	93
4.2.1 The full calibration for KM3NeT. . . . .	93
4.2.2 The compact array transducer prototype: the bipolar pulse emitter . . . . .	94
4.2.3 1st step: Linear Emission for Frequency Response Calibration. . . . .	96
4.2.4 2nd step: Long Parametric Signal Emission for Directivity Calibration . . . . .	96
4.2.5 3rd step: Bipolar Parametric Signal Emission for Acoustic Neutrino Detection Calibration. . . . .	103
5 Proposal of a Trigger for Acoustic Neutrino Detection	111
5.1 Analysis technique: the spectrogram . . . . .	112
5.2 The raw acoustic data. . . . .	114
5.2.1 Noise in the data . . . . .	114
5.2.2 Data selection for the experiment . . . . .	117
5.3 The detector procedure. . . . .	120
5.3.1 Evaluation . . . . .	121
5.3.2 Configuration. . . . .	121
5.4 Trigger proposal to implement in KM3NeT . . . . .	124
5.5 Results. . . . .	125
5.5.1 BP events and BP candidates. . . . .	125
5.5.2 TP and FP example detections. . . . .	129
Conclusions	137
Bibliography	144
Acronyms	152