

Contents

Acknowledgments (Agradecimientos, Ringraziamenti)	iii
Resumen	vii
Resum	ix
Summary	xi
Riassunto	xiii
Contents	xv
List of Figures	xvii
List of Tables	xxiii
1 Introduction	1
1.1 Evolution of Medical Imaging	2
1.1.1 Anatomical Imaging Techniques	3
1.1.1.1 Radiography	3
1.1.1.2 Ultrasonography	4
1.1.1.3 Computed Tomography	5
1.1.1.4 Magnetic Resonance Imaging	5
1.1.2 Molecular Imaging Techniques	6
1.1.2.1 Gamma Camera	7
1.1.2.2 Single Photon Emission Computed Tomography	7
1.1.2.3 Positron Emission Tomography	8
1.1.3 Multimodal Imaging Techniques and Future Trends	10
1.2 Fundamental Physics of PET	11
1.2.1 Interactions of Annihilation Photons	11
1.2.1.1 Radioactive Decay and Emission	11
1.2.1.2 Radiotracers and Diagnostic Tools	12
1.2.2 Scintillation Process	13
1.2.2.1 Photon Production Mechanisms	13
1.2.2.2 Scintillating Materials and Characteristics	15
1.2.2.3 Scintillator Configurations	16
1.2.2.4 Propagation, Reflection and Extraction of Scintillation Photons	18
1.2.2.5 Metascintillator Heterostructures	19

1.3	PET Electronics	22
1.3.1	Photosensitive Detectors	22
1.3.1.1	Photomultiplier Tubes	22
1.3.1.2	Solid-State Photodetectors	23
1.3.1.3	Emerging Photodetection Technologies	26
1.3.2	Front End Readouts for SiPM	27
1.3.2.1	Fundamental Electronic Components	27
1.3.2.2	Single Channel Analog Front-End	29
1.3.2.3	Multi-Channel Systems and Multiplexing	31
1.3.3	Data Acquisition Tools	33
1.4	Signal Processing	35
1.4.1	Signal Extraction	35
1.4.1.1	Signal Features	35
1.4.1.2	Event Filtering and Selection	37
1.4.2	Data Analysis	38
1.4.2.1	3D Positioning Techniques	38
1.4.2.2	Time Walk Corrections	41
1.4.2.3	Kernel Transformation Method	44
2	Objectives & Publications	49
2.1	Exploiting Cherenkov radiation with BGO-based metascintillators	51
2.2	A proof-of-concept of cross-luminescent metascintillators: testing results on a BGO:BaF ₂ metapixel	69
2.3	Comparative Analysis of Data Acquisition Setups for Fast-Timing in ToF-PET Applications	87
3	Discussion & Conclusions	105
	Bibliography	111
	Contributions Published	123
	Participation in Conferences	127