Table des matières

Introduction **17**

1 The ATLAS Upgrade project **19**

1.1 The Inner detector 19

1.2 The calorimeters and Muon Chambers 19

1.3 THe SLHC project 19

1.3.1 Phase 1 : The Insertable b-layer (IBL) 19

1.3.2 Phase 2 : Upgrade for high luminosity 19

2 Principles of Silicon pixel sensors **21**

2.1 The p-n junction 21

2.2 Radiation detection 21

2.3 The Hybrid Planar Pixel Sensor 21

2.4 Radiation damage in Silicon sensors 21

2.5 Other Silicon sensors 21

3 TCAD Simulation models and experimental validation **23**

3.1 Principles of TCAD simulation 23

3.1.1 The physics models 23

3.1.2 Boundary conditions 23

3.1.3 Process simulation 23

3.1.4 Device simulation 23
3.2 The Multi-Guard Ring structure 24
3.2.1 Principles of guard ring structures 24
3.2.2 Optimization of guard ring structures for radiation hardness 24
3.2.3 Study of guard ring structure in slim edges planar pixel sensors . . . 24
3.3 The charge amplification mechanism in highly irradiated silicon sensors . . . 24
3.4 Experimental validation 24
3.4.1 Doping profile measurements 24
3.4.2 Guard Ring measurements 24
3.4.3 Current versus Bias characteristics 24
3.4.4 Depletion Potential measurements 24
3.4.5 Experimental evidence of the charge amplification mechanism . . . 24

4 From TCAD simulation and experimental data to digitization 25
4.1 Monte Carlo charge transport simulation 25
4.2 Planar pixel sensor digitization 25
4.2.1 Implementation in GEANT4 simulation of the FEI3 and FEI4 digitization 25
4.3 Test beam validation of TCAD simulation 25
4.3.1 Validation of the digitization model 25
4.3.2 Edge effects 25
4.3.3 Charge amplification 25

5 Physics motivations 27
5.1 $H->\tau\tau$ phenomenology 27
5.2 IBL Simulation 27
5.2.1 Thinning effects 27

5.2.2 Slim edges effects 27

6 Perspective for future Radiation-Hard Silicon Planar Pixel sensors 29

6.1 3D electronics front-end read-out 29

6.2 Charge amplification pixel structures 29

Conclusion 33

Bibliographie 33

Annexes 39

A Doping profile measurements 39

B Clean room experimental setup 41

C The ALLPix Simulation Software 43

Glossaire 45