

# List of figures

## CHAPTER 2

Fig. 2.1: Atomic structure of SrTiO <sub>3</sub> at RT. The sizes of the spheres representing the atoms are arbitrary and are not related to atomic radii. ....	12
Fig. 2.2: Atomic arrangements for the <100>, <110> and <111> axial directions in SrTiO <sub>3</sub> . The arrangements shown on the left are end views of the channels, and the letters refer to the individual rows shown on the right. ....	12
Fig. 2.3: Ordering of oxygen vacancies in SrFeO <sub>2.875</sub> (=Sr <sub>8</sub> Fe <sub>8</sub> O <sub>23</sub> ). Fe ions are located in both square pyramids and in octahedral. ....	15
Fig. 2.4: Schematic electronic structures for TiO <sub>6</sub> octahedron of a typical SrTiO <sub>3</sub> oxide with <i>d<sub>0</sub></i> electronic configuration for the Ti ion. ....	17
Fig. 2.5: (a) Picture of an early furnace used by Verneuil to synthesise rubies using the Verneuil process schematized in (b). ....	22

## CHAPTER 3

Fig. 3.1: Sketch and photo of the <i>Danfysik</i> ion implanter installed at ITN ion beam laboratory, from [5]. ....	38
Fig. 3.2: Sketch of radioactive nuclide production in a uranium target irradiated with protons. ....	39
Fig. 3.3: Overview of CERN accelerators and ISOLDE hall with General Purpose Separator (GPS) with its three different beam lines (CBL, GLM and GHM). Implantation chambers in the end of the GLM and GHM beam lines, from [6]. ....	40
Fig. 3.4: Implantation chambers at GLM (left) and LA2 (right) ISOLDE beam lines. ....	42
Fig. 3.5: The basic principle of PIXE. ....	49
Fig. 3.6: Field dependence of magnetization (a) and thermal variation of the magnetic susceptibility (b) for a diamagnetic material. ....	53
Fig. 3.7: (a) Paramagnetic free atoms under zero applied field. (b) Field dependence of magnetization and (c) thermal variation of magnetic susceptibility according Curie law for a paramagnet of non-interacting spins. ....	54
Fig. 3.8: Brillouin curves for ideal paramagnets with various <i>S</i> values are shown. Magnetization normalized to saturation magnetization is plotted against <i>H/T</i> . Systems with high <i>S</i> values saturate more quickly in response to increasing magnetic field than those with low values of <i>S</i> . ....	55
Fig. 3.9: Magnetization curve of a demagnetised material or initial magnetisation curve (full line). Hysteresis loop (dashed line) of a ferromagnetic material showing the coercive field, <i>H<sub>C</sub></i> , and remnant magnetisation, <i>M<sub>r</sub></i> . ....	56
Fig. 3.10: The basic principle of SQUID. ....	58

Fig. 3.11: SQUID assembly (a) and sample rod (b) sketch illustrating sample mounting details	59
Fig. 3.12: Schematic illustration of the effect of the EFG on the intermediate energy level ( $I = 5/2$ ) of the cascade. The EFG causes the energy to split into three (doubly degenerate) levels depending on the quantum number for the $z$ component of the nuclear angular momentum, $m$ .	61
Fig. 3.13: Simplified schematic of the principle of the PAC experiment illustrated with a setup of 3 detectors but typical setups have 4 or 6 detectors. For each pair of detectors, the probability of detecting the second $\gamma$ -ray at the angle $\theta$ is detected as a function of the time elapsed between the two $\gamma$ -rays.	65
Fig.3.14: From left to right decay scheme of $^{111}\text{Ag}$ and $^{111m}\text{Cd}$ showing the cascades used in the perturbed angular correlation experiments.	69
Fig. 3.15: Photos of the 4 (a) and 6 (b) detector $\gamma\text{-}\gamma$ PAC spectrometers. The 6-detector spectrometer is equipped with a refrigerator/furnace that can be mounted in the centre of the detectors as shown in the figure.	70
Figure 3.16: Schematic illustration of the basic principle of the electron emission channelling technique.	72
Figure 3.17: The bottom half of the figure shows the starting point of the theoretical model, where an incoming plane wave impinges on a crystal. The upper half shows the approximations that have been made: the wave functions inside and outside the crystal are split up into a longitudinal and a transverse component. Due to the continuum and the small angle approximations, the transverse wave function inside the crystal can be expanded into 2D Bloch waves. (From [31]).	74
Fig. 3.18: Schematics illustrating the sample mounted in a goniometer, in this case a 2-axis goniometer with two rotational degrees and one translational degree of freedom. It can be oriented with respect to the detector by changing the polar angle $J$ and the azimuthal angle $j$ of rotation, and by moving it up and down along $z$ . The square shaped detector of size $l \times l$ is positioned at a distance $D$ from the sample, which determines the angular range $\theta$ of the measured pattern.	84
Fig. 3.19: (a) Design of new detector chamber. (b): Photo of the whole setup. The goniometer that holds the sample is seen on top of the setup, placing the sample at the center of the vacuum chamber. The new detector chamber is connected via the tube visible in the center of the photograph. The detector can be sealed from the rest of the chamber, e. g. during sample annealing, by means of the vacuum valve	85
Fig. 3.20: Cross-section (a) and planar (b) schematic views of the cooling system. (c): Photo of the cooling system surrounding the backplane side of the detector.	86

Fig. 3.21: Photo of the SINTEF wafer containing Si pad detectors, (b) scheme of the EC pad detector layout and (c) corner of a pad detector showing the guard ring structure and its bonding pad. ....	87
Fig. 3.22: Schematic layout of the readout cycle on the position sensitive pad detector, from ref. [40]. ....	89
<b>CHAPTER 4</b>	
Fig. 4.1: Normalized EC yield $\chi_{\max}$ measured along the major crystallographic directions of SrTiO <sub>3</sub> following SrTiO <sub>3</sub> implantation with $2.5 \times 10^{13}$ (a) and $8 \times 10^{14}$ <sup>89</sup> Sr at/cm <sup>2</sup> (b) and as a function of annealing temperature. ....	100
Fig. 4.2: Angular distributions of $\beta$ particles emitted from <sup>89</sup> Sr in SrTiO <sub>3</sub> around the (a) <100> and (b) <211> axes following RT implantation of the highest dose sample. The best fits of the simulated patterns to the experimental ones are shown in (c)–(d). ....	103
Fig. 4.3: Angle dependent $\beta$ emission yields from implanted <sup>89</sup> Sr in SrTiO <sub>3</sub> to a fluence of $2.5 \times 10^{13}$ following 1050 °C annealing around the (a) <100>, (b) <110>, (c) <211>, (d) <411> and (e) <111> axes. Best fits (f)–(j) of simulated channelling patterns for S <sub>Sr</sub> sites to experimental yield. ....	104
Fig. 4.4: Angle dependent $\beta$ emission yields from implanted <sup>89</sup> Sr in SrTiO <sub>3</sub> to a fluence of $8 \times 10^{14}$ following 1300 °C annealing around the (a) <100>, (b) <111>, (c) <211> and (d) <110> axes. Best fits (e)–(h) of simulated channelling patterns for S <sub>Sr</sub> sites to experimental yield. ....	104
Fig. 4.5: <i>Smoothing</i> distribution width sigma taken to obtain the simulated $\beta$ angular distributions giving the best fits for each axis for the high fluence sample following <sup>89</sup> Sr implantation and annealing up to 1300 °C. ....	106
Fig. 4.6: Substitutional fraction of <sup>89</sup> Sr at Sr- sites for low and high fluence (i.e. LF and HF) samples deduced from a fit to (a) theoretical simulations including the broadening due to mosaicity and (b) theoretical emission yields assuming a perfect crystal. as a function of annealing temperature for low- and high- fluence <sup>89</sup> Sr-implanted samples. The fraction ration for each set of theoretical fits as a function of annealing temperature is displayed in (c). Squared and circled symbols refer to high- and low- fluence samples, respectively. ....	108
Fig. 4.7: One dimensional <i>rms</i> displacements perpendicular to the channelling axes, measured as a function of annealing temperature for low- (a) and high- (b) fluence samples. The dashed and dotted lines correspond to the vibration amplitude of Sr and Ti in SrTiO <sub>3</sub> , $u_1(\text{Sr}) = 0.077 \text{ \AA}$ and $u_2(\text{Ti}) = 0.06 \text{ \AA}$ . ....	109
Fig. 4.8: RBS/C spectra of a virgin SrTiO <sub>3</sub> sample (blue) and of two 900 °C annealed <sup>56</sup> Fe-implanted samples to $1 \times 10^{15}$ (green) and $5 \times 10^{15}$ (red) at/cm <sup>2</sup> along three axes: (a) <100>, (b) <111> and (c) <110>. Inset plots are RBS/C spectra of both <sup>56</sup> Fe-implanted samples measured in the as implanted state along the same three axes. ....	111

Fig. 4.9: 2 MeV He <sup>+</sup> RBS/C minimum yield $\chi_{\min}(\text{Sr})$ along $\langle 100 \rangle$ , $\langle 111 \rangle$ and $\langle 110 \rangle$ directions as a function of Fe- implanted sample fluence measured in the as implanted state (a) and after 900°C annealing (b). .....	114
Fig. 4.10: PAC anisotropy ratio R(t) of the 96.7-245.4 keV gamma cascade (a) and its Fourier transform (b) obtained from the <sup>111</sup> Ag/ <sup>111</sup> Cd:SrTiO <sub>3</sub> system annealed at 900°C, with the $\langle 100 \rangle$ axis in detector plane at 45° with detectors. The thicker solid line on the R(t) and Fourier spectra represents the theoretical fit. ....	117
Fig. 4.11: Time dependent anisotropy of the 151-245 keV $\gamma$ - $\gamma$ of <sup>111m</sup> Cd( <sup>111</sup> Cd) in 2%Nb-doped SrTiO <sub>3</sub> as implanted (a) and after annealing the sample for 20 min at 720 °C (b) and 1000 °C (c). It is also shown the anisotropy function of <sup>111m</sup> Cd( <sup>111</sup> Cd) $\gamma$ cascade in undoped SrTiO <sub>3</sub> after annealing the sample for 20 min at 1000 °C (d). ....	120
<b>CHAPTER 5</b>	
Fig. 5.1: Angular distributions of $\beta$ particles emitted from <sup>111</sup> Ag in SrTiO <sub>3</sub> around the $\langle 100 \rangle$ (a), $\langle 111 \rangle$ (b), $\langle 211 \rangle$ (c) and $\langle 110 \rangle$ (d) directions following RT implantation of <sup>111</sup> Ag and annealing for 10 min at 900 °C. The best fits of the simulated patterns to the experimental ones are shown in (e)–(h). ....	129
Fig. 5.2: Substitutional fractions of Ag occupying Sr, Ti and octahedral interstitial sites and their <i>rms</i> displacements perpendicular to $\langle 111 \rangle$ , $\langle 100 \rangle$ , $\langle 110 \rangle$ and $\langle 211 \rangle$ axial directions as a function of annealing temperature in vacuum for 10 min. The dotted and dashed lines represent the RT Sr and Ti vibration amplitudes, respectively. ....	130
Fig. 5.3: Angular distributions of the $\beta$ particles emitted from <sup>115</sup> Cd in SrTiO <sub>3</sub> around the (a) $\langle 100 \rangle$ , (b) $\langle 110 \rangle$ , (c) $\langle 211 \rangle$ and (d) $\langle 111 \rangle$ directions following annealing at 800°C. The best fits for each direction are shown from figure (f) to (h). ....	132
Fig. 5.4: Fraction of Cd atoms at S <sub>Sr</sub> and S <sub>Ti</sub> sites (a) and their <i>rms</i> displacements (b) perpendicular to $\langle 100 \rangle$ , $\langle 111 \rangle$ , $\langle 211 \rangle$ , $\langle 110 \rangle$ and $\langle 411 \rangle$ directions; following 10 min vacuum annealing at 800 °C. The dashed and dotted lines represent the room-temperature Sr and Ti vibration amplitudes. ....	133
Fig. 5.5: Adopted level scheme for the internal conversion decay of <sup>117m</sup> Sn. ....	135
Fig. 5.6: Simulated electron emission yields from <sup>117m</sup> Sn in SrTiO <sub>3</sub> around the $\langle 100 \rangle$ , $\langle 110 \rangle$ , $\langle 211 \rangle$ and $\langle 411 \rangle$ axes considering full substitutionality of Sn atoms at Sr-, (a)-(d), and Ti-, (e)-(h), sites. ....	136
Fig. 5.7: (a)-(e) Electron emission patterns for $\langle 100 \rangle$ , $\langle 110 \rangle$ , $\langle 211 \rangle$ , $\langle 411 \rangle$ and $\langle 111 \rangle$ axes measured after annealing at 900 °C. Panels (f)–(j) represent the best two-fraction fit of theoretical patterns to the experimental data. ....	137
Fig. 5.8: Fractions of (a) <sup>117m</sup> Sn atoms on Sr- and Ti- sites and (b) their <i>rms</i> displacements perpendicular to the indicated crystal axes for the complete annealing sequence. RT <i>rms</i> displacements of Sr and Ti atoms are $u_1(\text{Sr}) = 0.077 \text{ \AA}$ and $u_1(\text{Ti}) = 0.061 \text{ \AA}$ . ....	138

Fig. 5.9: Simulated channeling patterns considering 100% of emitter atoms ( $^{69}\text{Tm}$ ) at substitutional Sr- [(a)-(d)] and Ti- [(e)-(h)] sites. ....	141
Fig 5.10: Experimental (a)-(e) and simulated (f)-(j) electron EC patterns from $^{169}\text{Tm}$ following $^{169}\text{Yb}$ -implanted $\text{SrTiO}_3$ annealing at 865 °C, along several crystal axes. Best fits were obtained considering the implanted atoms amphoteric. ....	141
Fig. 5.11: (a) Substitutional fractions of Tm occupying Sr and Ti sites as a function of annealing temperature in vacuum for 10 min each. (b) <i>rms</i> displacements perpendicular to the channelling axes, measured as a function of the same isochronal annealing temperature. The dashed lines corresponds to the vibration amplitude of Sr and Ti in $\text{SrTiO}_3$ , $u_1(\text{Sr}) = 0.077 \text{ \AA}$ and $u_2(\text{Ti})=0.061 \text{ \AA}$ . ....	143
Fig. 5.12: Angle dependent $\beta$ emission yields from $^{59}\text{Fe}$ in $\text{SrTiO}_3$ around the $\langle 100 \rangle$ (a), $\langle 110 \rangle$ (b), $\langle 211 \rangle$ (c) and $\langle 111 \rangle$ (d) axes. The patterns were recorded after ion implantation at RT. Best fits of simulated channelling patterns for a mixture of $S_{\text{Ti}}$ sites, $S_{\text{Ti}} \rightarrow S_{\text{O}}$ and $S_{\text{O}}$ sites to the experimental yields (e)-(h). ....	147
Fig. 5.13: Angle dependent $\beta$ emission yields from $^{59}\text{Fe}$ in $\text{SrTiO}_3$ around the $\langle 100 \rangle$ (a), $\langle 110 \rangle$ (b), $\langle 211 \rangle$ (c) and $\langle 111 \rangle$ (d) axes. The patterns were recorded after 900°C annealing. Best fits of simulated channelling patterns for a mixture of $S_{\text{Ti}}$ sites, $S_{\text{Ti}} \rightarrow S_{\text{O}}$ and $S_{\text{O}}$ sites to the experimental yields (e)-(h). ....	147
Fig 5.14: Simulated channelling patterns considering 100% of emitter atoms on $S_{\text{Ti}}$ (a)-(d), $S_{\text{Ti}} \rightarrow S_{\text{O}}$ (e)-(h), $S_{\text{Sr}}$ (i)-(l) and octahedral, O, (m)-(p) sites along $\langle 100 \rangle$ , $\langle 110 \rangle$ , $\langle 211 \rangle$ and $\langle 111 \rangle$ axes. The orientation and angular resolution has been chosen so as to match the experimental patterns of Figure 5.13. ....	147
Fig. 5.15: (a) Substitutional fractions of $^{59}\text{Fe}$ atoms occupying Ti substitutional sites and $S_{\text{B}} \rightarrow S_{\text{O}}$ and octahedral interstitial sites. (b) The averaged <i>rms</i> displacements of Fe atoms at Ti and $S_{\text{B}} \rightarrow S_{\text{O}}$ sites perpendicular to $\langle 111 \rangle$ , $\langle 100 \rangle$ , $\langle 110 \rangle$ and $\langle 211 \rangle$ axial directions as a function of annealing temperature are also shown. The dashed lines corresponds to the vibration amplitude of Sr and Ti in $\text{SrTiO}_3$ , $u_1(\text{Sr}) = 0.077 \text{ \AA}$ and $u_2(\text{Ti})=0.061 \text{ \AA}$ . ....	148
Fig. 5.16: Normalized electron EC yield $\chi_{\text{max}}$ measured along the major crystallographic directions of $\times 10^{15}$ (a) and $5 \times 10^{15} \text{ at./cm}^2$ $^{59}\text{Fe}$ -implanted $\text{SrTiO}_3$ samples following their implantation with (a) $1 \times 10^{14}$ and (b) $1.9 \times 10^{14} \text{ }^{59}\text{Fe at./cm}^2$ , as a function of annealing temperature. ....	151
Fig. 5.17: Measured angular distribution of $\beta^-$ emission yield from $^{59}\text{Fe}$ in $5 \times 10^{15} \text{ at./cm}^2$ $^{56}\text{Fe}$ -implanted $\text{SrTiO}_3$ following 900°C annealing (a)-(e). The best fits of the channeling patterns for each direction are also shown (f)-(j). The angular resolution has been optimized fitting each pattern. ....	154

Fig. 5.18: <i>Smoothing</i> distribution width taken to obtain the simulated $\beta$ angular distributions giving the best fits for the $^{56}\text{Fe}$ -implanted $\text{SrTiO}_3$ sample following $^{56}\text{Fe}$ implantation and annealing up to $900^\circ\text{C}$ to each axis .....	154
Fig. 5.19: Fraction of $^{59}\text{Fe}$ on Ti- sites (a) as a function of annealing temperature and corresponding <i>rms</i> displacements (b-c) as determined by fits considering smoothed simulated patterns with optimum sigma, i.e. including mosaicity (curves with open symbols) according to fig. 5.18 and fixed sigma to $0.1^\circ$ , i.e. perfect crystal (curves with solid symbols). .....	156
Fig. 5.20: Experimental $\mu(T)$ curves of $\text{SrTiO}_3$ samples acquired to a magnetic field of 5.5 T. An oxygen contamination (condensation) in the sample was identified (1). .....	158
Fig. 5.21: Experimental $\mu(T)$ curve of the virgin sample for the low temperature and contamination free range and fit curves for different values of $S$ . Inset plot shows the normalized deviation $(c/c_{\min}^2)$ giving $S=5/2$ as best fit. Applied magnetic field was 5.5 T. ....	160
Fig. 5.22: Experimental $m(H)$ curves acquired at 10K (blue line) and 100K (red line) from virgin (a) and low fluence Fe-implanted (b) samples. The 100K decreasing field curve of the virgin sample is not included in the analysis because of the strangely different slope in the positive region (1). .....	163
Fig. 5.23: Comparison between the resulting hysteresis from the virgin and low fluence Fe-implanted samples (the former normalized to the last). .....	164
Fig. 5.24: (a) Completely corrected (DM + PM + contaminant FM) $m(H)$ curves of high fluence Fe-implanted $\text{SrTiO}_3$ sample at 10K (blue line) and 100K (red line). <i>Inset</i> : Plot of the entire measured field range. At left, figure is a zoom of the referred curves in the field region of $-2000 < H < 2000$ Oe. ....	165
Fig. 5.25: Experimental substitutional fractions of $\text{Fe}^{3+}$ -, $\text{Sn}^{4+}$ -, $\text{Cd}^{2+}$ - and $\text{Ag}^+$ - ions at Sr ( $S_{\text{Sr}}$ ) and Ti ( $S_{\text{Ti}}$ ) sites as a function of ionic radius following $900^\circ\text{C}$ annealing. The red and blue dashed curves are the linear fits performed to $S_{\text{Sr}}$ and $S_{\text{Ti}}$ data sets including all the referred ions. The data points marked with a cross correspond to $\text{Cu}^{2+}$ , which experimental $S_{\text{Sr}}$ and $S_{\text{Ti}}$ fractions were only available for $\text{SrTiO}_3$ annealed at $600^\circ\text{C}$ . .....	168
<b>CHAPTER 6</b>	
Fig. 6.1: Simplified block diagram of the detector and its VME data acquisition system ....	180
Fig. 6.2: (a) Front-end electronics schematic of a single readout channel of a VATAGP3 ASIC. (b) Screenshot from the oscilloscope showing three signals measured on the chip: trigger due to the charge generated by the detector exposed to the gamma rays of a $^{241}\text{Am}$ source into the preamplifier input (line1 in the fig.); after $\sim 4 \mu\text{s}$ delay, the HOLD signal (line 4 in the fig.) is activated to sample and hold the analog outputs from all channels (line 2 in fig. shows the signal from a single channel). .....	181
Fig. 6.3: A photo of the EC module (pad side), containing the silicon pad sensor bonded to four	183

VATAGP3 chips on a PCB hybrid. ....	
Fig. 6.4: Mapping of the detector indicating the channel indexation number. It is clearly seen that the “adjacent” numbered channels, for the readout, are not necessarily physically adjacent. The lines indicate the edge of each (1 to 4) chip channels. Note that despite of the readout logic being binary, only 484 channels are connected into detector. Each chip has 7 channels not bonded. ....	186
Fig. 6.5: VMEDAQ main window screenshot. ....	189
Fig. 6.6: VMEDAQ monitor screenshot of the LINUX based readout software for on-line EC experiments with the new fast Si pad detector system in sparse mode. The data visible in the center of the screen was obtained from a SrTiO <sub>3</sub> single crystal implanted at ISOLDE with <sup>111</sup> In for test purposes. It shows the energy spectrum of the conversion electrons from <sup>111</sup> In and the corresponding EC pattern of the SrTiO <sub>3</sub> <100> direction, as displayed during the measurement. ....	190
Fig. 6.7: Pedestals and noise distribution measured for all 512 channels in serial readout mode without source. ....	196
Fig. 6.8: Measurements taken with four VATAGP3 chips connected to the 484 pad Si pad detector, which were operating in the serial readout mode: (top) hit map, (middle) <sup>241</sup> Am source pulse height spectrum acquired at channel #100 and (bottom) the Gaussian fit performed for the 59.5 keV $\gamma$ -line of the <sup>241</sup> Am energy spectrum. ....	197
Fig. 6.9: Hit multiplicity plots taken in serial (a) and sparse (b) readout modes. ....	200
Fig. 6.10: <sup>241</sup> Am spectrum of hits in a particular pad. The solid line represents a Gaussian fit to the 59.9 keV line obtained at channel #48. ....	201
Fig. 6.11: Gain variations over the 512 channels for the four chips of the detector. ....	202
Fig. 6.12: (a) Distributions of pedestal and (b) noise (variance values) over all the detector channels. (c) Average electronic noise. Projection of noise distribution for all detector channels. (d) Lego plot of noise values measured for all channels. The vertical scale is calibrated in electrons using the 59.9 keV <sup>241</sup> Am peak as reference. ....	203
Fig. 6.13: Gain corrected <sup>241</sup> Am spectrum. All pads are added. The fit is Gaussian and it is performed to determine the FWHM of the peak. ....	204
Fig. 6.14: <sup>54</sup> Co, Tb, Ba, Ag, Mo and Rb spectra acquired in serial readout mode. ....	205
Fig. 6.15: Energy calibration (a) and energy resolution (b) curves determined with gamma sources. ....	206
Fig. 6.16: S-curves obtained in serial (a) and (b) sparse modes with the Ag X-ray source. The 50% point is obtained from the fit. ....	208

Fig. 6.17: Threshold vs. energy calibration lines taken in serial and sparse readout modes with an X-ray variable gamma source. ....	209
Fig. 6.18: (a) distributions of pedestal, (b) noise (variance values) and (c) gain over all the detector channels for three serial readout mode runs taken with $^{181}\text{Hf}$ , $^{141}\text{Ce}$ and $^{111}\text{In}$ . ....	211
Fig. 6.19: Energy spectra of $^{181}\text{Hf}$ (a), $^{141}\text{Ce}$ (b) and $^{111}\text{In}$ (c) recorded with the 1 mm thick detector, showing conversion electron lines with energies ranging from 65 keV to 242 keV. The square evidences peaks and energies used for calibration. ....	214
Fig. 6.20: Energy calibration lines determined from $^{141}\text{Ce}$ , $^{181}\text{Hf}$ and $^{111}\text{In}$ electron spectra acquired in serial readout mode. ....	216
Fig. 6.21: Measured electron energy resolution as function of energy from the $^{181}\text{Hf}$ , $^{141}\text{Ce}$ and $^{111}\text{In}$ collected data in serial readout mode. ....	217
Fig. 6.22: $^{169}\text{Yb}$ integral gain corrected energy spectra acquired with a 1 mm thick Si pad detector readout by (a) VATAGP3 and (b) readout chips. ....	219
Fig. 6.23: Energy calibration (a) and energy resolution (b) curves determined from the electron energy peaks of $^{169}\text{Yb}$ spectrum acquired in serial readout mode. ....	220
Fig. 6.24: (a) Distribution of pedestal, (b) noise (variance values) and (c) gain variations over all the detector channels measured from $^{169}\text{Yb}$ electron source. ....	221
Fig. 6.25: (a) Distribution of pedestal, (b) noise (variance values), (c) gain variations over all the detector channels and (d) average electron noise measured from $^{181}\text{Hf}$ electron source. The single (e) pad and integral gain corrected energy spectra (f) were acquired in sparse with 20 channels mode. ....	222
Fig. 6.26: Distribution of pedestal, (b) noise (variance values), (c) gain variations over all the detector channels and (d) average electron noise measured from $^{141}\text{Ce}$ electron source. The integral gain corrected energy spectrum (e) was acquired in sparse with 10 channels mode. ....	223
Fig. 6.27: Pedestal and gain corrected $^{111}\text{In}$ spectrum acquired in sparse readout mode. The square evidences peaks and energies used for calibration. ....	225
Fig. 6.28: Electron empirical resolution curves for each VATAGP3 readout mode. The black dashed line corresponds to the measured gamma resolution curve given in figure 6.15. ...	225
Fig. 6.29: Top view layout drawing of the new on-line EC set-up showing: in blue and grey the diaphragm-collimator chamber with lead shield, in green the implantation chamber with the sample location in the center and in brown the detector box assembly. ....	227
Fig. 6.30: Detail side layouts of the diaphragm-collimator_1 chamber (a) and (b) on-line implantation chamber with the second collimator (colimmator_2), and the faraday cup. ...	228

- Fig. 6.31: Schematic drawing of the new EC set-up built to host the new fast silicon pad detector and to mount online in case of short lived probe are used. The heavy orientation stand is also shown in the picture (labelled). ..... 229
- Figure 6.32: (a) Sketch of the detector box showing the two movable flanges. (b) Lateral flange of the detector box holding the module. It is visible the backside of the detector surrounded by the cooling system. (c) Front view of the lateral flange of the detector box detailing the plug for electrical connections and the copper tubes for water pipes connection. 230
- Fig. 6.33: Energy spectra recorded during the  $\beta^-$  decay of implanted  $^{61}\text{Mn}$  isotope, in ZnO, to its daughter isotopes,  $^{61}\text{Fe}$  and  $^{61}\text{Co}$ . The energy peaks emerging from the  $\beta^-$  spectra, acquired in sparse readout mode with 10 adjacent channels, are from the K and L conversion electrons emitted in the 67.4 keV  $^{61}\text{Co} \rightarrow ^{61}\text{Ni}$  transition. .... 231
- Fig. 6.34: Electron energy spectrum from the  $\beta^-$  decay of  $^{56}\text{Mn}$  implanted in GaN. .... 232
- Fig. 6.35: Experimental EC patterns of (a)  $^{61}\text{Co}$ - and (b)  $^{56}\text{Mn}$ - implanted impurities in ZnO and GaN, after annealing at 800°C and 900°C, respectively. .... 233