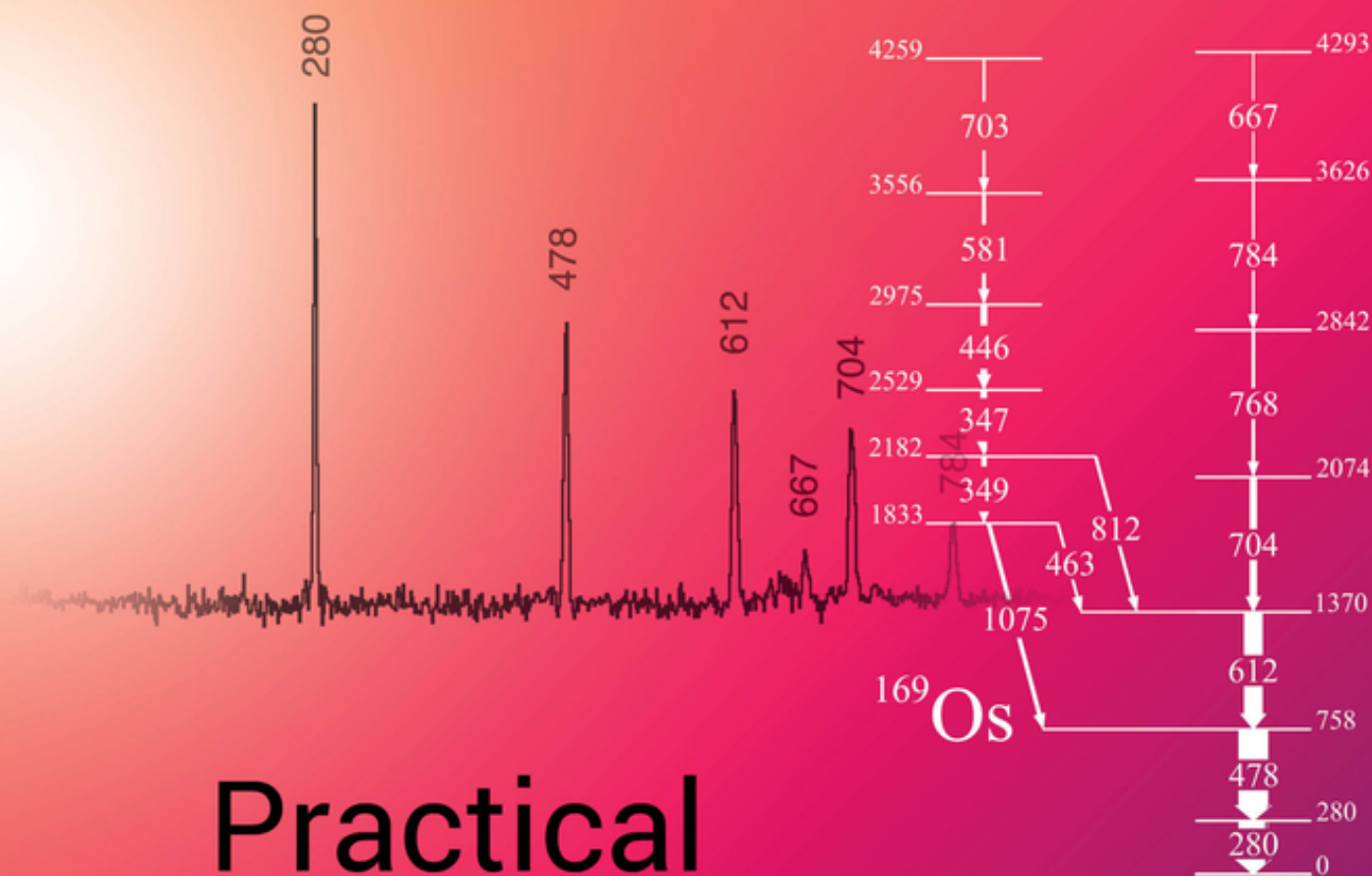


Third Edition



Practical Gamma-ray Spectrometry

Gordon Gilmore • David Joss

WILEY

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Third Edition

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This third edition first published 2024.
© 2024 John Wiley & Sons Ltd

Edition History:
John Wiley & Sons Ltd (1e, 1995 and 2e, 2008)

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Library of Congress Cataloging-in-Publication Data:

Names: Gilmore, Gordon, author. | Joss, David, author. | John Wiley & Sons, publisher.
Title: Practical gamma-ray spectrometry / Gordon Gilmore, David Joss.
Description: Third edition. | Hoboken, NJ : Wiley, 2024. | Includes index.
Identifiers: LCCN 2024011669 (print) | LCCN 2024011670 (ebook) | ISBN 9781119896081 (hardback) | ISBN 9781119896098 (adobe pdf) | ISBN 9781119896104 (epub)
Subjects: LCSH: Gamma ray spectrometry.
Classification: LCC QC793.5.G327 G55 2024 (print) | LCC QC793.5.G327 (ebook) | DDC 537.5/352-dc23/eng/20240507
LC record available at <https://lccn.loc.gov/2024011669>
LC ebook record available at <https://lccn.loc.gov/2024011670>

Cover Design: Wiley
Cover Images: Courtesy of Gordon Gilmore

Set in 9.5/12.5pt STIXTwoText by Straive, Chennai, India

Contents

Preface to the Third Edition *xix*

Preface to the Second Edition *xxi*

Preface to the First Edition *xxiii*

Internet Resources Within the Book *xxv*

About the Website *xxvii*

1	Radioactive Decay and the Origin of Gamma and X-Radiation	1
1.1	Introduction	1
1.2	Beta Decay	2
1.2.1	β^- or Negatron Decay	3
1.2.2	β^+ or Positron Decay	7
1.2.3	Electron Capture (EC)	8
1.2.4	Multiple Stable Isotopes	8
1.3	Alpha Decay	10
1.4	Spontaneous Fission (SF)	11
1.5	Exotic Decay Modes	11
1.6	Gamma Emission	11
1.6.1	The Electromagnetic Spectrum	11
1.6.2	Some Properties of Nuclear Transitions	13
1.6.3	Lifetimes of Nuclear Energy Levels	13
1.6.4	Width of Nuclear Energy Levels	14
1.6.5	Internal Conversion	14
1.6.6	Abundance, Yield and Emission Probability	15
1.6.7	Ambiguity in Assignment of Nuclide Identity	15
1.7	Other Sources of Photons	17
1.7.1	Annihilation Radiation	17
1.7.2	Bremsstrahlung	17
1.7.3	Prompt Gamma-Rays	17
1.7.4	X-rays	18
1.7.4.1	X-ray Nomenclature	18
1.7.4.2	X-ray Energies	18
1.7.4.3	X-rays and Identification	19
1.7.4.4	The Energy Widths of X-rays	19
1.8	The Mathematics of Decay and Growth of Radioactivity	20
1.8.1	The Decay Equation	21
1.8.2	Growth of Activity in Reactors	21
1.8.3	Growth of Activity from Decay of a Parent	23

1.8.3.1	Transient Equilibrium – $t_{1/2}$ Parent > $t_{1/2}$ Daughter	23
1.8.3.2	Secular Equilibrium – $t_{1/2}$ Parent \gg $t_{1/2}$ Daughter	25
1.8.3.3	No Equilibrium – $t_{1/2}$ Parent < $t_{1/2}$ Daughter	25
1.8.3.4	Multiple Parent–Daughter Relationships	25
1.9	The Chart of the Nuclides	26
1.9.1	A Source of Nuclear Data	26
1.9.2	A Source of Generic Information	27
1.9.2.1	Thermal Neutron Capture (n, γ)	27
1.9.2.2	Fast Neutron Reactions, (n, p), etc.	28
1.9.2.3	Fission Reactions (n, f)	28
	Practical Points	31
	Further Reading	31
2	Interactions of Gamma Radiation with Matter	33
2.1	Introduction	33
2.2	Mechanisms of Interaction	33
2.2.1	Photoelectric Absorption	35
2.2.2	Compton Scattering	37
2.2.3	Pair Production	38
2.3	Total Attenuation Coefficients	39
2.4	Interactions Within the Detector	40
2.4.1	The Very Large Detector	40
2.4.2	The Very Small Detector	41
2.4.3	The ‘Real’ Detector	42
2.4.4	Summary	43
2.5	Interactions Within the Shielding	45
2.5.1	Photoelectric Interactions	45
2.5.2	Compton Scattering	46
2.5.3	Pair Production	46
2.6	Bremsstrahlung	47
2.7	Attenuation of Gamma Radiation	48
2.8	The Design of Detector Shielding	49
	Practical Points	50
	Further Reading	51
3	Semiconductor Detectors for Gamma-Ray Spectrometry	52
3.1	Introduction	52
3.2	Semiconductors and Gamma-Ray Detection	53
3.2.1	The Band Structure of Solids	53
3.2.2	Mobility of Holes	54
3.2.3	Creation of Charge Carriers by Gamma Radiation	54
3.2.4	Suitable Semiconductors for Gamma-Ray Detectors	55
3.2.5	Newer Semiconductor Materials	56
3.3	The Nature of Semiconductors	57
3.4	The Manufacture of Germanium Detectors	59
3.4.1	Introduction	59
3.4.2	The Manufacturing Process	60
3.4.3	Lithium-Drifted Detectors	61

3.4.4	Detector Configurations	62
3.4.5	Absorption in Detector Caps and Dead Layers	62
3.4.6	Detectors for Low-Energy Measurements	64
3.4.7	Well Detectors	64
3.5	Detector Capacitance	65
3.5.1	Microphonic Noise	65
3.6	Charge Collection in Detectors	66
3.6.1	Charge Collection Time	66
3.6.2	Shape of the Detector Pulse	67
3.6.3	Timing Signals from Germanium Detectors	68
3.6.4	Electric Field Variations Across the Detector	69
3.6.5	Removing Weak Field Regions from Detectors	69
3.6.6	Trapping of Charge Carriers	70
3.6.7	Radiation Damage	71
3.7	Packaging of Detectors	72
3.7.1	Construction of the Detector Mounting	73
3.7.2	Loss of Coolant	75
3.7.3	Demountable Detectors	75
3.7.4	Electrical Cooling of Detectors	75
3.8	Position-Sensitive Detectors	76
3.8.1	Segmentation	76
3.8.2	Gamma-Ray Tracking	77
	Practical Points	78
	Further Reading	78
4	Electronics for Gamma-Ray Spectrometry	79
4.1	The General Electronic System	79
4.1.1	Introduction	79
4.1.2	Electronic Noise and Its Implications for Spectrum Resolution	80
4.1.3	Pulse Shapes in Gamma Spectrometry Systems	81
4.1.4	Impedance – Inputs and Outputs	81
4.1.5	The Impedance of Cabling	83
4.1.6	Impedance Matching	84
4.2	Detector Bias Supplies	84
4.3	Preamplifiers	85
4.3.1	Resistive Feedback Preamplifiers	85
4.3.2	Reset Preamplifiers	88
4.3.3	The Noise Contribution of Preamplifiers	89
4.3.4	The Rise Time of Preamplifiers	90
4.3.5	Intelligent Preamplifiers and High-Voltage Supplies	90
4.4	Amplifiers and Pulse Processors	90
4.4.1	The Functions of the Amplifier	90
4.4.2	Pulse Shaping	91
4.4.3	The Optimum Pulse Shape	92
4.4.4	The Optimum Pulse Shaping Time Constant	93
4.4.5	The Gated Integrator Amplifier	94
4.4.6	Pole-zero Cancellation	95
4.4.7	Baseline Shift	97

4.4.8	Pile-up Rejection	98
4.4.9	Amplifier Gain and Overview	100
4.5	Resolution Enhancement	102
4.5.1	New Semiconductor Materials	102
4.6	Multichannel Analysers and Their Analogue-to-Digital Converters	103
4.6.1	Introduction	103
4.6.2	Pulse Range Selection	105
4.6.3	The ADC Input Gate	106
4.6.4	The ADC	107
4.6.4.1	The Wilkinson ADC	107
4.6.4.2	The Successive Approximation ADC	108
4.6.5	MCA Conversion Time and Dead Time	109
4.6.6	Choosing an ADC	110
4.6.7	Linearity in MCAs	111
4.6.8	Optimum Spectrum Size	113
4.6.9	MCA Terms and Definitions	113
4.6.10	A Short History of MCA Systems	115
4.6.11	Simple MCA Analysis Functions	115
4.7	Live Time Correction and Loss-Free Counting	116
4.7.1	Live Time Clock Correction	116
4.7.2	The Gedcke–Hale Method	116
4.7.3	Use of a Pulser	117
4.7.4	Loss-Free Counting (LFC)	118
4.7.5	MCA Throughput	119
4.8	Spectrum Stabilization	119
4.8.1	Analogue Stabilization	120
4.8.2	Digital Stabilization	120
4.9	Coincidence and Anticoincidence Gating	121
4.10	Multiplexing and Multiscaling	121
4.11	Digital Pulse Processing Systems	122
	Practical Points	126
	Further Reading	127
5	Statistics of Counting	128
5.1	Introduction	128
5.1.1	Statistical Statements	129
5.2	Counting Distributions	130
5.2.1	The Binomial Distribution	130
5.2.2	The Poisson and Gaussian Distributions	132
5.3	Sampling Statistics	133
5.3.1	Confidence Limits	134
5.3.2	Combining the Results from Different Measurements	135
5.3.3	Propagation of Uncertainty	137
5.4	Peak Area Measurement	138
5.4.1	Simple Peak Integration	139
5.4.2	Peaked-Background Correction	141
5.5	Counting Decision Limits	142
5.5.1	Critical Limit (L_C): ‘Is the Net Count Significant?’	142

5.5.2	Upper Limit (L_U): ‘Given That This Count Is Not Statistically Significant, What Is the Maximum Statistically Reasonable Count?’	145
5.5.3	Confidence Limits	146
5.5.4	Detection Limit (L_D): ‘What Is the Minimum Number of Counts that I Can Be Confident of Detecting?’	146
5.5.5	Determination Limit (L_Q): ‘How Many Counts Would I Have to Have to Achieve a Particular Statistical Uncertainty?’	148
5.5.6	Other Calculation Options	148
5.5.7	Minimum Detectable Activity (MDA): ‘What Is the Least Amount of Activity I Can Be Confident of Measuring?’	148
5.5.8	Uncertainty of the L_U and MDA	149
5.5.9	An Example by Way of Summary	150
5.6	Special Counting Situations	151
5.6.1	Non-Poisson Counting	151
5.6.2	Low Numbers of Counts	152
5.6.3	Non-Poisson Statistics Due to Pile-up Rejection and Loss-Free Counting	153
5.7	Optimizing Counting Conditions	154
5.7.1	Optimum Background Width	154
5.7.2	Optimum Peak Width	155
5.7.3	Optimum Spectrum Size	156
5.7.4	Optimum Counting Time	157
5.8	Uncertainty Budgets	158
5.8.1	Introduction	158
5.8.2	Accuracy and Precision	160
5.8.3	Types of Uncertainty	160
5.8.4	Types of Distribution	160
5.8.5	Uncertainty on Sample Preparation	161
5.8.6	Counting Uncertainties	162
5.8.7	Calibration Uncertainties	162
	5.8.7.1 Nuclear Data Uncertainty	162
	5.8.7.2 Uncertainty on Efficiency Calibration Standards	162
5.8.8	An Example of an Uncertainty Budget	163
	Practical Points	165
	Further Reading	166

6 Resolution: Origins and Control 167

6.1	Introduction	167
6.2	Charge Production – ω_p	169
6.2.1	Germanium Versus Silicon	170
6.2.2	Germanium Versus Sodium Iodide	171
6.2.3	Temperature Dependence of Resolution	171
6.3	Charge Collection – ω_c	172
6.3.1	Mathematical Form of ω_c	172
6.4	Electronic Noise – ω_E	173
6.4.1	Parallel Noise	174
6.4.2	Series Noise	175
6.4.3	Flicker Noise	176
6.4.4	Total Electronic Noise and Shaping Time	176

6.5	Resolving the Peak Width Calibration	177
	Practical Points	180
	Further Reading	181
7	Spectrometer Calibration	182
7.1	Introduction	182
7.2	Reference Data for Calibration	183
7.3	Sources for Calibration	183
7.4	Energy Calibration	184
7.4.1	Errors in Peak Energy Determination	186
7.5	Peak Width Calibration	187
7.5.1	Factors Affecting Peak Width	187
7.5.2	Algorithms for Peak Width Estimation	188
7.5.3	Estimation of the Peak Height	189
7.5.4	Anomalous Peak Widths	190
7.6	Efficiency Calibration	191
7.6.1	Which Efficiency?	191
7.6.2	Full-energy Peak Efficiency	192
7.6.3	Is an Efficiency Calibration Curve Necessary?	194
7.6.4	The Effect of Source-to-Detector Distance	194
7.6.5	Calibration Errors Due to Difference in Sample Geometry	196
7.6.6	An Empirical Correction for Sample Height	197
7.6.7	Effect of Source Density on Efficiency	199
	7.6.7.1 Corrections Based on Estimated Mass Attenuation Coefficients	199
	7.6.7.2 Empirical Correction for Self-absorption	200
7.6.8	Efficiency Loss Due to Random Summing (Pile-up)	201
7.6.9	True Coincidence Summing	204
7.6.10	Corrections for Radioactive Decay	204
7.6.11	Electronic Timing Problems	205
7.7	Absolute Total Efficiency	205
7.8	Mathematical Efficiency Calibration	207
7.8.1	Empirical Mathematics	207
7.8.2	Gamma Spectrometry Goes to Monte Carlo	207
7.8.3	Do Monte Carlo-Based Programs Work?	208
7.8.4	Efficiency Calibration Software	209
7.8.5	Using Monte Carlo to Assist Other Methods	209
	7.8.5.1 Efficiency Transfer	210
	7.8.5.2 The Representative Point (RP) Method	210
7.8.6	The Virtual Gamma Spectrometry Laboratory	211
	Practical Points	211
	Further Reading	211
8	True Coincidence Summing	214
8.1	Introduction	214
8.2	The Origin of Summing	214
8.3	Summing and Solid Angle	216
8.4	Spectral Evidence of Summing	217
8.5	Validity of Close Geometry Calibrations	219

8.5.1	The Effect of TCS on Efficiency Calibration	219
8.6	Summary	222
8.7	Summing in Environmental Measurements	222
8.8	Achieving Valid Close Geometry Efficiency Calibrations	224
8.9	TCS, Geometry and Composition	226
8.10	Achieving 'Summing-Free' Measurements	227
8.10.1	Using the 'Interpolative Fit' to Correct for TCS	227
8.10.2	Comparative Activity Measurements	227
8.10.3	Using Correction Factors Derived from Efficiency Calibration Curves	228
8.10.4	Correction of Results Using 'Bodged' Nuclear Data	228
8.11	Mathematical Summing Corrections	229
8.12	Software for Correction of TCS	231
8.12.1	GESPECOR	232
8.12.2	Calibrations Using Summing Nuclides	232
8.12.3	TCS Correction in Spectrum Analysis Programs	233
8.13	Using Coincidences for Measurement	233
	Practical Points	234
	Further Reading	234
9	Computer Analysis of Gamma-Ray Spectra	236
9.1	Introduction	236
9.1.1	Can You Trust the 'black box'?	237
9.2	Methods of Locating Peaks in the Spectrum	238
9.2.1	Using Regions of Interest	238
9.2.2	Locating Peaks Using Channel Differences	238
9.2.3	Derivative Peak Searches	239
9.2.4	Peak Searches Using Correlation Methods	240
9.2.5	Checking the Acceptability of Peaks	241
9.3	Library-Directed Peak Searches	241
9.4	Energy Calibration	241
9.5	Estimation of the Peak Centroid	243
9.6	Peak Width Calibration	243
9.7	Determination of the Peak Limits	246
9.7.1	Using the Width Calibration	246
9.7.2	Individual Peak Width Estimation	247
9.7.3	Limits Determined by a Moving Average Minimum	247
9.8	Measurements of Peak Area	249
9.9	Full-Energy-Peak Efficiency Calibration	249
9.10	Multiplet Peak Resolution by Deconvolution	252
9.11	Peak Stripping as a Means of Avoiding Deconvolution	253
9.12	Spectrum Smoothing	254
9.13	The Analysis of the Sample Spectrum	255
9.13.1	Peak Location and Measurement	256
9.13.2	Corrections to the Peak Area for Peaked-Background	256
9.13.3	Upper Limits and Minimum Detectable Activity	257
9.13.4	Activity Estimations Using Efficiency Curves	257
9.13.5	Comparative Activity Estimations	258
9.13.6	Corrections Made by the Spectrum Analysis Program	258

9.13.6.1	Random Summing Correction	258
9.13.6.2	Other Corrections	259
9.14	Nuclide Identification	259
9.14.1	Simple Use of Lookup Tables	260
9.14.2	Taking into Account Other Peaks	260
9.15	The Final Report	260
9.16	Setting up Nuclide and Gamma-Ray Libraries	261
9.17	Buying Spectrum Analysis Software	261
9.18	Reading the Manual	262
9.19	The Spectrum Analysis Programs Referred to in the Text	262
	Practical Points	263
	Further Reading	263
10	Scintillation Spectrometry	265
10.1	Introduction	265
10.2	The Scintillation Process	265
10.3	Scintillation Activators	266
10.4	Lifetime of Excited States	267
10.5	Temperature Variation of the Scintillator Response	268
10.6	Scintillator Detector Materials	268
10.6.1	Sodium Iodide – NaI(Tl)	270
10.6.2	Bismuth Germanate – BGO	271
10.6.3	Caesium Iodide – CsI(Tl) and CsI(Na)	271
10.6.4	Undoped Caesium Iodide – CsI	272
10.6.5	Barium Fluoride – BaF ₂	272
10.6.6	Caesium Fluoride – CsF	272
10.6.7	Rare-Earth Halides – LaCl ₃ (Ce), LaBr ₃ (Ce) and CeBr ₃	272
10.6.8	Other Scintillators	274
10.7	Photomultiplier Tubes	274
10.8	The Photocathode	275
10.9	The Dynode Electron Multiplier Chain	275
10.10	Photodiode Scintillation Detectors	276
10.11	Silicon Photomultipliers	276
10.12	Construction of the Complete Detector	277
10.12.1	Detector Shapes	278
10.12.2	Optical Coupling of the Scintillator to the Photomultiplier	278
10.13	The Resolution of Scintillation Systems	279
10.13.1	Statistical Uncertainties in the Detection Process	280
10.13.2	Factors Associated with the Scintillator Crystal	281
10.13.3	The Variation of Resolution with Gamma-Ray Energy	282
10.14	Electronics for Scintillation Systems	282
10.14.1	High-Voltage Supply	282
10.14.2	Preamplifiers	283
10.14.3	Amplifiers	283
10.14.4	Multi-channel Analysers and Spectrum Analysis	284
10.15	Comparison of Sodium Iodide and Germanium Detectors	284
	Practical Points	285
	Further Reading	285

11 Low Count-Rate Systems 286

- 11.1 Introduction 286
- 11.2 Counting with High Efficiency 288
 - 11.2.1 MDA: Efficiency and Resolution 288
 - 11.2.2 MDA: Efficiency, Background and Counting Period 289
 - 11.2.2.1 Variation of B_S , the Compton Continuum Due to the Sample, with Detector Size 289
 - 11.2.2.2 Variation of B_E , the Environmental Background, with Detector Size 291
 - 11.2.2.3 The Effect of Resolution on Relative MDA and Count Period 292
 - 11.2.2.4 Is Bigger MUCH Better? 294
- 11.3 The Effect of Detector Shape 294
 - 11.3.1 Low-Energy Measurements 294
 - 11.3.2 Well Detectors 295
 - 11.3.3 Sample Quantity and Geometry 297
- 11.4 Low Background Systems 301
 - 11.4.1 The Background Spectrum 302
 - 11.4.2 Low Background Detectors 302
 - 11.4.3 Detector Shielding 304
 - 11.4.4 The Graded Shield 305
 - 11.4.5 Airborne Activity 306
 - 11.4.6 The Effect of Cosmic Radiation 306
 - 11.4.6.1 Direct Interaction of Secondary Cosmic Radiation 307
 - 11.4.6.2 Cosmic Neutron-Induced Activity 307
 - 11.4.7 Underground Measurements 309
- 11.5 Active Background Reduction 311
 - 11.5.1 Compton Suppression Systems 311
 - 11.5.1.1 Design Considerations – Spectrometry (HPGe) Detector 312
 - 11.5.1.2 Design Considerations – Guard Detector 312
 - 11.5.1.3 Disadvantages of Compton Suppression 313
 - 11.5.2 Veto Guard Detectors 314
- 11.6 Limiting Electronic Noise 315
- 11.7 Ultra-low-Level Systems 316
 - Practical Points 318
 - Further Reading 319

12 High Count-Rate Systems 321

- 12.1 Introduction 321
- 12.2 Detector Throughput 322
- 12.3 Preamplifiers for High Count Rate 324
 - 12.3.1 Energy Rate Saturation 324
 - 12.3.2 Energy Resolution 325
 - 12.3.3 Dead Time 325
- 12.4 Amplifiers 326
 - 12.4.1 Time Constants and Pile-up 327
 - 12.4.2 The Gated Integrator 328
 - 12.4.3 Pole-Zero Correction 328
 - 12.4.4 Amplifier Stability – Peak Shift 329
 - 12.4.5 Amplifier Stability – Resolution 329

12.4.6	Overload Recovery	330
12.5	Digital Pulse Processing	330
12.6	The ADC and MCA	333
12.7	Dead Times and Throughput	333
12.7.1	Extendable and Non-extendable Dead Time	333
12.7.2	Gated Integrators	335
12.7.3	DSP Systems	336
12.7.4	Theory Versus Practice	336
12.7.4.1	Semi-Gaussian Analogue Versus Digital Processor	336
12.7.4.2	Gated Integrator Analogue Versus Digital Processor	337
12.7.5	Modern DSPEC and LYNX Digital Systems	337
12.8	System Checks	338
	Practical Points	339
	Further Reading	339
13	Ensuring Quality in Gamma-Ray Spectrometry	341
13.1	Introduction	341
13.2	Nuclear Data	342
13.3	Radionuclide Standards	343
13.4	Maintaining Confidence in the Equipment	344
13.4.1	Setting Up and Maintenance Procedures	344
13.4.2	Control Charts	345
13.4.3	Setting Up a Control Chart	347
13.5	Gaining Confidence in the Spectrum Analysis	348
13.5.1	Test Spectra with Known Peaks	349
13.5.1.1	The IAEA G1 Test Spectra	350
13.5.1.2	The Sanderson Test Spectra	352
13.5.1.3	Programs for Mathematically Creating Test Spectra	352
13.5.2	Test Spectra Created by Counting	352
13.5.2.1	The 1995 IAEA Test Spectra	352
13.5.2.2	The 1997 NPL Test Spectra	353
13.5.2.3	The 2002 IAEA Test Spectra	353
13.5.2.4	The CTBTO Spectrum	354
13.5.2.5	Finding Test Spectra	354
13.5.3	Measuring Test Samples – Intercomparison Exercises	354
13.5.3.1	NPL Environmental Radioactivity Proficiency Test Exercises	355
13.5.3.2	The IAEA Proficiency Exercises	356
13.5.4	Assessing Spectrum Analysis Performance	356
13.5.5	Assessment of Intercomparison Exercises	357
13.6	Maintaining Records	359
13.7	Accreditation	360
	Practical Points	361
	Further Reading	361
14	Gamma Spectrometry of Naturally Occurring Radioactive Materials (NORM)	364
14.1	Introduction	364
14.2	The NORM Decay-Series	364
14.2.1	The Uranium Series – ^{238}U	366

- 14.2.2 The Actinium Series – ^{235}U 367
- 14.2.3 The Thorium Series – ^{232}Th 368
- 14.2.4 Radon Loss 368
- 14.2.5 Natural Disturbance of the Decay-Series 368
- 14.3 Gamma Spectrometry of the NORM Nuclides 368
 - 14.3.1 Measurement of ^7Be 370
 - 14.3.2 Measurement of ^{40}K 370
 - 14.3.3 Gamma Spectrometry of the Uranium/Thorium Series Nuclides 370
 - 14.3.4 Allowance for Natural Background 371
 - 14.3.5 Resolution of the 186 keV Peak 373
 - 14.3.6 Other Spectral Interferences and Summing 373
- 14.4 Nuclear Data of the NORM Nuclides 374
- 14.5 Measurement of Chemically Modified NORM 375
 - 14.5.1 Measurement of Separated Uranium 375
 - 14.5.2 Measurement of Separated Thorium 376
 - 14.5.3 ‘Non-natural’ Thorium 377
 - 14.5.4 Measurement of Gypsum – A Cautionary Tale 378
- Practical Points 380
- Further Reading 381

15 Applications 382

- 15.1 Monitoring Radon in Water 382
 - 15.1.1 The Principle of the Method 383
 - 15.1.2 Detector Background 383
 - 15.1.3 Taking Water Samples 384
 - 15.1.4 Background Measurement 384
 - 15.1.5 Standardization 384
 - 15.1.6 Spectrum Acquisition 385
 - 15.1.7 Analysis of the Spectra 385
- 15.2 Whole Body Counting 385
 - 15.2.1 The Background Problem 386
 - 15.2.2 Whole Body Counting Is Different 386
 - 15.2.3 Is There a Standard Body? 386
- 15.3 Gamma Spectrometry and the CTBT 387
 - 15.3.1 Background 387
 - 15.3.2 The Global Verification Regime 387
 - 15.3.3 Nuclides Released in a Nuclear Explosion 388
 - 15.3.4 Measuring the Radionuclides 389
 - 15.3.4.1 Radioactive Particulate Monitoring 390
 - 15.3.4.2 Noble Gas Monitoring 390
 - 15.3.5 Current Status 390
- 15.4 Gamma Spectrometry of Nuclear Industry Wastes 391
 - 15.4.1 Measurement of Isotopically Modified Uranium 392
 - 15.4.2 Measurement of Transuranic Nuclides 392
 - 15.4.3 Waste Drum Scanning 393
- 15.5 Safeguards 394
 - 15.5.1 Enrichment Meters 396
 - 15.5.2 Plutonium Spectra 396

15.5.3	Fresh and Aged Samples	397
15.5.4	Absorption of Gamma-Rays	398
15.5.5	Hand-held Monitors	398
15.6	PINS – Portable Isotopic Neutron Spectrometry	399
15.7	Gamma-Ray Imaging	400
15.8	Investigating the Structure of the Atomic Nucleus Using Gamma-Ray Spectroscopy	402
	Further Reading	408
16	Choosing and Setting Up a Detector, and Checking Its Specifications	410
16.1	Introduction	410
16.2	Setting Up a Germanium Detector System	411
16.2.1	Installation – The Detector Environment	412
16.2.1.1	The Counting Room	412
16.2.1.2	The Electrical Supply	412
16.2.1.3	Placement of the Detector	412
16.2.2	Liquid Nitrogen Supply	412
16.2.3	Shielding	413
16.2.4	Cabling	414
16.2.5	Installing the Detector	414
16.2.6	Preparation for Powering-up	415
16.2.7	Powering-up and Initial Checks	416
16.2.7.1	Resistive Feedback Preamplifier Systems	416
16.2.7.2	Transistor Reset (TRP) Preamplifier Systems	418
16.2.8	Switching Off the System	418
16.3	Optimizing the Electronic System	418
16.3.1	General Considerations	418
16.3.2	DC Level Adjustment and Baseline Noise	420
16.3.3	Setting the Conversion Gain and Energy Range	420
16.3.4	Pole-zero (PZ) Cancellation	421
16.3.4.1	Oscilloscope and Source	421
16.3.4.2	Oscilloscope and Square Wave	422
16.3.4.3	Automatic Correction	422
16.3.5	Incorporating a Pulse Generator	422
16.3.5.1	With a Resistive Feedback Preamplifier	422
16.3.5.2	With a Transistor Reset Preamplifier	423
16.3.6	Baseline Restoration (BLR)	423
16.3.7	Optimum Time Constant	423
16.4	Checking the Manufacturer's Specification	424
16.4.1	The Manufacturer's Specification Sheet	424
16.4.2	Detector Resolution and Peak Shape	425
16.4.3	Detector Efficiency <i>Coaxial Detectors</i>	429
16.4.3.1	Well Detectors	430
16.4.4	Peak-to-Compton (P/C) Ratio	430
16.4.5	Window Thickness Index	431
16.4.6	Physical Parameters	432
	Practical Points	432
	Further Reading	432

17 Troubleshooting	434
17.1	Fault-finding 434
17.1.1	Equipment Required 434
17.1.2	Fault-finding Guide 435
17.2	Preamplifier Test Point and Leakage Current 439
17.2.1	Resistive Feedback (RF) Preamplifiers 439
17.2.2	Transistor Reset and Pulsed Optical Reset Preamplifiers 440
17.3	Thermal Cycling of the Detector 441
17.3.1	The Origin of the Problem 441
17.3.2	The Thermal Cycling Procedure 442
17.3.3	Frosted Detector Enclosure 443
17.4	Ground Loops, Pick-up and Microphonics 443
17.4.1	Ground Loops 443
17.4.2	Electromagnetic Pick-up 444
17.4.2.1	Common Mode Rejection 445
17.4.2.2	Mains Supply Problems 445
17.4.3	Microphonics 446
17.4.3.1	Mechanisms and Checks 446
17.4.3.2	Solutions 447
	Practical Points 448
Appendix A Sources of Information	449
A.1	Introduction 449
A.2	Nuclear Data 449
A.2.1	Sources of Nuclear Data 450
A.2.2	Online Sources of Gamma-Ray Emission Data 450
A.2.2.1	DDEP 450
A.2.2.2	Lara 451
A.2.2.3	ENSDF 451
A.2.2.4	NuDat 3.0 451
A.2.2.5	IAEA 451
A.2.3	Nuclear Databases Offline and in Print 452
A.3	Internet Sources of Other Nuclear Data 452
A.4	Chemical Information 453
A.5	Further Research 453
A.6	Practical Gamma-Ray Spectrometry Website 453
Appendix B Gamma- and X-Ray Standards for Detector Calibration	455
Appendix C X-Rays Routinely Found in Gamma Spectra	465
Appendix D Gamma-Ray Energies in the Detector Background and the Environment	467
Appendix E Chemical Names, Symbols and Relative Atomic Masses of the Elements	471
Glossary	479
Index	497

Preface to the Third Edition

Some years after the publication of the Second Edition of this book, I received an invitation to meet for lunch from Jenny Cossham, my contact within Wiley at the time. She assured me that she wouldn't be asking me to prepare another edition so I could enjoy lunch – which I did. Since then, I have retired from all gamma spectrometry activities and spent much of my time on a delightful Greek island in the Aegean Sea. It was, therefore, not an unalloyed pleasure to receive an email in the summer of 2021 from Jenny suggesting that I might like to update 'The Book' for a third edition.

Being in my 80th year and not having had my hands on a gamma spectrometer for a considerable time and having no understanding of the latest developments in software and equipment, my first instinct was to refuse. However, after Jenny suggested the idea of making a joint venture to update the book with someone who was actively engaged in gamma spectrometry, I decided to consider the invitation. So, after meeting with David Joss, Professor at Liverpool University, and coming to an understanding about how much, or little, I was able to contribute, taking into account my long absence from active spectrometry, I decided to accept the commission and start work.

From the beginning, when John Hemingway and I wrote the first edition, the intention was to write a 'plain man's' guide to gamma spectrometry, free of academic starch. A book that gave the impression that its content was the result of long practical experience in the laboratory. I think we achieved that, and, in this third edition, David and I have tried to stay true to that. Of course, most of the book deals with unchanging principles, so, necessarily, much of the second edition is unchanged. David has had the task of removing unnecessary out-of-date information and introducing our readers to more recent exciting developments. I am extremely grateful to David for doing that, as I am no longer in a position to do it myself.

In the second edition, I expressed a passion for quality issues in gamma spectrometry and tried to demonstrate that one cannot blindly trust the software we buy to analyse our spectra. While preparing this new edition, I was looking forward to finding out that the glaring problems within some of the software had been addressed. The reader will be able to judge if that was the case.

Within the book, I have frequently used FitzPeaks as a positive example of a spectrum analysis program. It was, therefore, with great sadness that I received news at the end of January 2023 that Jim Fitzgerald, the creator of FitzPeaks, had passed away.

Gordon Gilmore

The first edition of *Practical Gamma-Ray Spectrometry* by Gordon Gilmore and John Hemingway was published shortly after I started my doctoral research degree in nuclear physics. The book proved to be invaluable in providing a wealth of accessible practical knowledge for a fledgling gamma-ray spectroscopist. The second edition was released shortly after I became a lecturer, and it immediately became an essential reference text that I would recommend to my students. Indeed, I have bought many copies of the book over the years to replace those that found themselves on 'long-term loan' to students and colleagues. *Practical Gamma-Ray Spectrometry* has been a

constant companion throughout my working life. When I was invited to work with Gordon Gilmore on the third edition, I was delighted to accept it without hesitation. It has been a pleasure to work with Gordon on this project. I am grateful to Jenny Cossham at Wiley for introducing me to Gordon and inviting me to contribute.

The underlying concepts and challenges in gamma-ray spectrometry that were discussed in earlier editions remain just as relevant today. It has been our aim to complement the discussion of those ideas with some of the recent developments in the field. The manufacturers of gamma-ray spectrometry systems have been very active since the publication of the second edition and have brought new technological innovations to the marketplace. These include small contact HPGe detectors that achieve excellent energy resolution and good efficiency over a broad energy range, new scintillator materials for gamma-ray detection and high-performance digital pulse processing systems. This is an exciting time for gamma-ray spectrometry and its applications.

I would like to acknowledge my colleagues at the University of Liverpool who have engaged in fruitful discussions about gamma-ray spectrometry, collaborated in measurements, or shared research data. In particular, I am indebted to Andy Boston, Helen Boston, Fraser Holloway, Dan Judson, Robert Page, Ellis Rintoul and Conor Sullivan.

David Joss

Preface to the Second Edition

During 2005, while this second edition was being prepared, I was totally unprepared to receive a telephone call that my co-author on the first edition, John Hemingway, was seriously ill after suffering a brain haemorrhage. Only a few days later, on 5th September, he passed away. My original, and obvious, intent was to update the sections allocated to John and myself and publish this second edition as 'Gilmore and Hemingway'. That intent was frustrated by contractual difficulties with John's estate. It became necessary for me to rewrite those sections completely and remove John's name from the second edition. I deeply regret that that was necessary. It has deprived us all of John's often elegant prose and has meant that some topics that John had particular interest in introducing to the new edition have had to be omitted.

Earlier in that year, another reminder of the inexorable passage of time came with the death of someone whose name had been familiar to me throughout my career in gamma spectrometry. On 16th January, Richard Helmer passed away at the age of 70 years. His co-authored work, the justly famous *Gamma and X-Ray Spectrometry with Semiconductor Detectors*, was one of the books that introduced John and myself to the complexities of gamma spectrometry and one which we consistently recommended to others. His influence as an author and in many other roles, such as an evaluator of nuclear data, has left all of us in his debt, whether we all realize it or not.

On a lighter note, during the year 2005 the very title of this book was called into question. The radiochemical mailing list, RADCH-L, agonized, in general terms, over which is the correct term – 'spectrometry' or 'spectroscopy'. Of course, the suffix '-metry' means to measure and '-scopy' means to visualize – and so the discussion went on, to and fro. Eventually, the 1997 IUPAC 'Golden Book', *Compendium of Chemical Terminology*, was quoted: 'SPECTROMETRY is the measurement of such [electromagnetic] radiations as a means of obtaining information about the system and their components'.

That seemed to be the 'clincher'. The prime objective of our activities is to measure gamma radiation, not just to create a spectrum, and so spectrometry' it is, performed by 'gamma spectrometrists'!

Before a second edition is approved, the publishers canvass the opinion of people in the field as to whether a new edition is justified and ask them for suggestions for inclusion. I have taken all of the suggestions offered seriously but, in the event, have had to disappoint some of the reviewers. For example, X-ray spectrometry is such a wide field with a different emphasis than gamma spectrometry and the space available within this new edition is so limited that merely exposing a little more of the 'iceberg' seemed pointless. In other cases, my ignorance of certain specific matters was sufficient to preclude inclusion. I can only offer my apologies to those who may feel let down.

Since the first edition (1995), there have been a number of significant advances in gamma spectrometry. Indeed, some of those advances were taking place while I was writing, meaning re-writes even to the update! In particular, I have included digital pulse processing and I have explained the changes in the way that nuclear data are being kept up to date. On statistics, I have introduced the matter of uncertainty budgets as being of increasing importance now that more laboratories seek accreditation. I have had to re-assess the ideas I espoused in the first edition on peak width and now have a much more comfortable mathematical justification for fitting peak-width calibrations.

Throughout, I have tried to keep to the principles John and I declared in the Preface to the first edition – an emphasis on the practical application of gamma spectrometry at the expense of, if possible, the mathematics. That being the case, I have reproduced most of the preface to the first edition below. The first edition was very well received. I can only hope that I have done enough to ensure that popular opinion is as supportive of this second edition.

Gordon R. Gilmore

Preface to the First Edition

This book was conceived during one of the gamma spectrometry courses then being run at the Universities' Research Reactor at Risley. At that time, we had been 'peddling' our home-spun wisdom for seven or eight years, and transforming the lecture notes into something more substantial for the benefit of course participants seemed an obvious development.

Our intention is to provide more of a workshop manual than an academic treatise. In this spirit, each chapter ends with a 'Practical Points' section. This is not a summary as such but a reminder of the more important practical features discussed within the chapter. We have attempted, not always successfully, it must be admitted, to keep the mathematics to a minimum. In most cases, equations are presented as *faites accomplis* and are not derived.

One practical process that can have a major influence on the reliability of the results obtained by users of gamma-spectrometric equipment is that of *sampling*. It was after much discussion and with some regret that we decided to omit this topic. This is because it is peripheral to our main concern of describing the best use of instrumentation, because we suspect that another book would be necessary to do justice to the subject and because we do not know much about it. What is clear is that an analyst must be aware that uncertainties introduced by taking disparate samples from an inhomogeneous mass can far outweigh uncertainties in the individual measurements themselves. This is a particular problem when sampling such a diverse and complex mass as the natural environment.

No previous knowledge of nuclear matters or instrumentation is assumed, and we hope the text can be used by complete beginners. There is even a list of names and symbols of the elements; while chemists may smile at this, in our experience not every otherwise scientifically literate person can name Sb and Sn or distinguish Tb and Yb.

In a practical book, we think it useful to mention particular items of commercial equipment to illustrate particular points. We must make the usual disclaimer that these are not necessarily the best, nor the worst, and in most cases are certainly not the only items available. In general, the manufacturers do a fine job, and choosing one product rather than another is often an invidious task. We can only recommend that the user (1) decides at an early stage what capabilities are required, (2) reads and compares specifications (this text should explain these), (3) is not seduced by the latest 'whizz-bang device', yet (4) bears in mind that more recent products are better than older ones, not just in 'bald' specification but also in manufacturing technology, and should consequently show greater reliability.

Readers may notice the absence of certain terms in common use. The exclusion of some such terms is a deliberate choice. For example, instead of 'photopeak' we prefer 'full-energy peak'; we have avoided the statisticians' use of 'error' to mean uncertainty and reserve that word to indicate bias or error in the sense of 'mistake'. 'Branching ratio' we avoid altogether. This is often used ambiguously and without definition. In other texts, it may mean the relative proportions of different decay modes, the proportions of different beta-particle transitions, or the ratio of 'de-excitation' routes from a nuclear-energy level. Furthermore, it sometimes appears as a synonym for 'gamma-ray emission probability', where it is not always clear whether or not internal conversion has been taken into account.

We hope sensitive readers are not upset by our use of the word 'program'. This 'Americanized' version is well on its way to being accepted as meaning specifically 'computer program', and enables a nice distinction to be made with the more general (and more elegant-looking) 'programme'.

We have raided unashamedly the manufacturers' literature for information, and our thanks are due particularly to Canberra and Ortec (in alphabetical order) for their cooperation and support in this. The book is not a survey of the latest research nor a historical study, and there are very few specific references in the text. Such that do exist are put at the end of each chapter, where there will also be found a more general short-list of 'Further Reading'.

We also acknowledge our continuing debt to two books: *Radiation Detection and Measurement*, by G.F. Knoll, John Wiley & Sons, Ltd (1979, 1989) and *Gamma- and X-Ray Spectrometry with Semiconductor Detectors*, by K. Debertin and R.G. Helmer, North-Holland (1988).

These can be thoroughly recommended.

So why write another book? Fine as these works are, we felt that there was a place for a 'plain-man's' guide to gamma spectrometry, a book that would concentrate on day-to-day operations. In short, the sort of book that we wish had been available when we began work with this splendid technique.

Gordon R. Gilmore and John D. Hemingway

Internet Resources Within the Book

Throughout this book, we list sources of information of value to gamma spectrometrists. The reality of modern life is that, for very many people, the Internet is the first ‘port-of-call’ for information. Because of this, we have leaned heavily on Internet sources and quoted links to them as standard URLs – Uniform Resource Locators, i.e. Internet addresses. URLs are usually not ‘case-sensitive’. However, that may depend on the type of server used to host the website. It is better to type the URL as given here, preserving upper/lowercase characters.

A word of caution is necessary. The Internet can be a source of the most up-to-date information and can be far more convenient than waiting for books and articles to be delivered or making a trip to a distant library. However, we feel duty bound to remind readers that, as well as holding up-to-date information, the Internet is also a vast repository of ancient, irrelevant, inaccurate and out-of-date information. It is up to the user to check the pedigree, and date, of all downloaded material. We believe the links that we have quoted to be reliable.

It is also said that once something gets on the Internet, it is there forever, that is not necessarily true, as we found out while checking the URLs in the Third edition of this book. Companies can cease to trade or be taken over and their domain name can be abandoned. Sometimes a website can be reorganized by a zealous new manager and information may still be on the website – but in a different place. So, the Internet is essentially an ephemeral entity.

The Practical Gamma-Ray Spectrometry Companion Website, written for the Second Edition by Gordon Gilmore, has been updated for the Third Edition. It carries links to most of the websites referred to in the book, test spectra (or links to them), and some of the spreadsheets used to create the diagrams and data in the book. It also carries a Corrections Page, where readers who find typographical or factual errors can report them to the Publisher and the authors.

The address of the Companion Website is: www.wiley.com/go/Gilmore/PracticalGammaRaySpectrometry3e.

About the Website

www.wiley.com/go/Gilmore/PracticalGammaRaySpectrometry

