



# **CONTENTS**

---

<i>Preface</i>	vii
<b>1 Physics foundations</b>	<b>1</b>
1.1 Range of application for radiation detectors	1
1.1.1 Natural sources of radiation	1
1.1.2 Units	2
1.1.3 Artificial radioactivity	4
1.1.4 Particle accelerators	5
1.2 Interactions of particles and $\gamma$ -radiation with matter	8
1.2.1 Detection of charged particles	8
1.2.2 Detection of $\gamma$ -rays	17
1.2.3 Bremsstrahlung of electrons	20
1.3 Electrons and ions in gases	22
1.3.1 Mobility of ions	22
1.3.2 Diffusion of ions in a field-free gas	23
1.3.3 Recombination and electron capture	25
1.3.4 Drift of electrons in electric fields	26
1.3.5 Drift of electrons in electric and magnetic fields	29
1.3.6 Diffusion of electrons in presence of electric and magnetic fields	33
1.4 Quantities characterizing detectors	36
<b>2 Measurement of ionization</b>	<b>43</b>
2.1 Ionization chambers	43
2.2 Proportional counters	47
2.3 Geiger–Mueller counters	52
2.4 Measurement of ionization in liquids	54
2.5 Semiconductor detectors	58
<b>3 Measurement of position</b>	<b>65</b>
3.1 Multiwire proportional chamber	65
3.2 Planar drift chambers	70
3.3 Cylindrical drift chambers	73
3.4 The Jet drift chamber	76
3.5 Time projection chamber (TPC)	79

3.6	Simulation of particle tracks by ultraviolet lasers	84
3.7	Bubble chambers	86
3.8	Streamer chambers	90
3.9	Flash chambers	93
3.10	Spark chambers	94
3.11	Nuclear emulsions	96
3.12	Silicon strip detectors	97
3.13	Comparison of position detectors	100
<b>4</b>	<b>Measurement of time</b>	<b>101</b>
4.1	Photomultiplier tubes	101
4.2	Scintillators	107
4.3	Collection of scintillation light	112
4.4	Planar spark counters	117
<b>5</b>	<b>Particle identification</b>	<b>120</b>
5.1	Neutron counters	120
5.2	Time-of-flight measurement	125
5.3	Cherenkov counters	126
5.4	Transition radiation detectors	136
5.5	Multiple ionization measurement	140
5.6	Comparison of identification methods for charged particles	149
<b>6</b>	<b>Measurement of energy</b>	<b>150</b>
6.1	Electron–photon shower counters	150
6.2	Hadron calorimeters	157
6.3	Calibration and monitoring of calorimeters	165
<b>7</b>	<b>Measurement of momentum</b>	<b>169</b>
7.1	Magnet shapes for fixed target experiments	169
7.2	Magnet shapes for storage ring experiments	173
7.3	Central tracking detectors for storage ring experiments	175
<b>8</b>	<b>Applications of detector systems</b>	<b>178</b>
8.1	Medical applications	179
8.2	Geophysical applications	181
8.3	Applications in space sciences	183
8.4	A detector for ion–atom collisions	186
8.5	A detector for heavy ion reactions	188
8.6	Detector systems for high-energy experiments	191
8.6.1	A detector for hadronic reactions	191
8.6.2	A detector for high-energy neutrinos	191
8.6.3	A detector for electron–positron collisions	192
8.6.4	A detector for proton–antiproton collisions at high energy	194
8.7	Proton decay detectors	196
<i>References</i>		199
<i>Index</i>		205