Preface to the first edition

The basic motive which drives the scientist to new discoveries and understanding of nature is curiosity. Progress is achieved by carefully directed questions to nature, by experiments. To be able to analyse these experiments, results must be recorded. The most simple instruments are the human senses, but for modern questions, these natural detection devices are not sufficiently sensitive or they have a range which is too limited. This becomes obvious if one considers the human eye. To have a visual impression of light, the eye requires approximately 20 photons. A photomultiplier, however, is able to 'see' single photons. The dynamical range of the human eye comprises half a frequency decade (wavelengths from 400 nm to 800 nm), while the spectrum of electromagnetic waves from domestic current over radio waves, microwaves, infrared radiation, visible light, ultraviolet light, X-rays and gamma rays covers 23 frequency decades!

Therefore, for many questions to nature, precise measurement devices or detectors had to be developed to deliver objective results over a large dynamical range. In this way, the human being has sharpened his 'senses' and has developed new ones. For many experiments, new and special detectors are required and these involve in most cases not only just one sort of measurement. However, a multifunctional detector which allows one to determine all parameters at the same time does not exist yet.

To peer into the world of the microcosm, one needs microscopes. Structures can only be resolved to the size of the wavelength used to observe them; for visible light this is about 0.5 µm. The microscopes of elementary particle physicists are the present day accelerators with their detectors. Because of the inverse proportionality between wavelengths and momentum (de Broglie relation), particles with high momentum allow small structures to be investigated. At the moment, resolutions of the order

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of 10^{-17} cm can be reached, which is an improvement compared to the optical microscope of a factor of 10^{13}.

To investigate the macrocosm, the structure of the universe, energies in the ranges between some one hundred micro-electron-volts (μeV, cosmic microwave background radiation) up to 10^{20} eV (high energy cosmic rays) must be recorded. To master all these problems, particle detectors are required which can measure parameters like time, energy, momentum, velocity and the spatial coordinates of particles and radiation. Furthermore, the nature of particles must be identified. This can be achieved by a combination of a number of different techniques.

In this book, particle detectors are described which are in use in elementary particle physics, in cosmic ray studies, in high energy astrophysics, nuclear physics, and in the fields of radiation protection, biology and medicine. Apart from the description of the working principles and characteristic properties of particle detectors, fields of application of these devices are also given.

This book originated from lectures which I have given over the past 20 years. In most cases these lectures were titled 'Particle Detectors'. However, also in other lectures like 'Introduction to Radiation Protection', 'Elementary Particle Processes in Cosmic Rays', 'Gamma Ray Astronomy' and 'Neutrino Astronomy', special aspects of particle detectors were described. This book is an attempt to present the different aspects of radiation and particle detection in a comprehensive manner. The application of particle detectors for experiments in elementary particle physics and cosmic rays is, however, one of the main aspects.

I would like to mention that excellent books on particle detectors do already exist. In particular, I want to emphasise the four editions of the book of Kleinknecht [1] and the slightly out-of-date book of Allkofer [2]. But also other presentations of the subject deserve attention [3–25].

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