Detectors for particle radiation

This textbook provides a clear, concise and comprehensive review of the physical principles behind the devices used to detect charged particles and gamma rays and the construction and performance of these many different types of detector. This second edition has been thoroughly revised and updated to include all the latest developments in detector technology.

Detectors for high-energy particles and radiation are used in many areas of science, especially particle physics and nuclear physics experiments, nuclear medicine, cosmic ray measurements, space sciences and geological exploration. This edition includes several new sections, covering microstrip gas chambers, silicon strip detectors and CCDs, scintillating fibres, shower detectors that use liquid noble gases, and compensating calorimeters for hadronic showers.

This lucid text is well illustrated throughout with examples from the many areas in science in which these detectors are used. It provides both a coursebook for students in physics and a useful introduction for researchers in other fields.

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PREFACE

Progress in a branch of experimental physics is always closely linked with improved methods of measurement in this field. In searching for the elementary constituents of matter and for the forces between them, physicists use particle accelerators and detectors as tools to obtain the reaction products produced in collisions between elementary particles. These reaction products are either massive particles or the quanta of electromagnetic radiation.

Accelerators correspond to the microscope of the scientist, except that the probe used is not visible light but a charged particle such as the electron, the proton or a heavy ion. Because of the duality between particles and waves, light and charged particles can both be used as probes. With increasing energy of the particles, their wavelength decreases, and so does the size of objects which can be resolved by particle microscopes. In this way, the search for ever smaller objects has required the construction of larger and larger accelerators. In addition, technological progress in accelerator construction has been made, including the invention of the stochastic cooling of antiproton beams and the development of superconducting pulsed dipole magnets.

Similarly, the methods for detecting particles or radiation have developed rapidly in all fields of application: detectors are needed in particle physics experiments, nuclear physics experiments, nuclear medicine, cosmic-ray measurements and geological exploration. While a rich literature exists on accelerator principles and design, the same is not true for the subject of particle detectors. In particular, an introductory description of the more recent developments is missing.

The content of this book is based on courses of lectures given at Dortmund University since 1974. In addition, I had the opportunity to work on the subject during two summer schools in 1980: one at Zakopane organized by A. Bialas, the other at St. Croix (USVI) at the invitation of T. Ferbel. I thank the organizers for their contribution to the genesis of this book, my colleagues D. Wegener (Dortmund), A. Wagner (Heidelberg), W. Blum (München) and J. May (Geneva) for discussions and useful hints, Mrs. E. Lorenz for typing the manuscript, and Mrs. H. Bussmann and Mr. J. Huhn for drawing and reproducing the diagrams.

Dortmund K. Kleinknecht

Preface to the second edition

This new edition contains several new sections, including the ones on microstrip gas chambers (3.7), scintillating fibres (3.14), new detectors at the electron–positron storage ring LEP, the electron–proton storage ring HERA, and the future large hadron collider at CERN (8.6). A section on solar neutrino detectors (8.8) concludes the text. Figures, tables and the index have been revised.

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