Preface to the Second Edition

The second edition of this book takes its origin from the positive comments of readers received by the authors following the publication of the first edition. It includes additional material covering the fundamental mechanisms of energy deposition and particle interactions resulting in a) permanent damage (like the displacement damage) in silicon semiconductor devices and b) single event effects due to individual events caused by the interactions of particles inside the active volume of silicon devices. This treatment also includes a description of radiation environments, in which these mechanisms are expected to operate. The extensive coverage of the displacement damage is discussed in the framework of the electromagnetic and nuclear interactions treated in the book. Furthermore, the electromagnetic interaction resulting in energy-loss processes is extended to cover low energy Coulomb scatterings with atomic electrons and nuclei of the medium, thus introducing processes depending on the sign of the incoming particle charge and the nuclear energy-losses. The applications of silicon devices in particle physics experiments, reactor physics, nuclear medicine and space possibly occur in adverse (or, even, very adverse) radiation environments that may affect the operation of the devices. These environments, which are described in this edition of the book, are generated by i) the operation of the high-luminosity machines for particles physics experiments , ii) the cosmic rays and trapped particles of various origins in the interplanetary space and/or the Earth magnetosphere and iii) the operation of nuclear reactors.

In addition to people and Institutions acknowledged in the first edition of the book, we wish to thank the library staff of the Department of Physics of the University of Milano-Bicocca for the help and assistance received. We are also grateful to Profs. Nathan Croitoru (Tel-Aviv University) for his suggestions and Stanislav Pospisil (Czech Technical University in Prague) for discussions about interpretation of results of spectrometry methods applied to the study of semiconductor detectors and neutron detection. Marie-Hélène Genest and Céline Lebel of the University of Montreal have provided help for many figures presented in several chapters of the book. The help of Andrea Gutiérrez of the University of Montreal for the sections on neutron detection with silicon detectors is gratefully acknowledged. We are indebted to Drs. Cristina Consolandi and Davide Grandi for the their help and Dr.

Monica Rattaggi for her careful reading of the text regarding the radiation effects in silicon devices. We wish to thank those Editors who permitted us to reproduce or adapt figures from their articles or books for the text added in this edition. We acknowledge and wish to thank again the Institute of Physics (IoP) for the permission in reproducing and adapting text material, figures and tables from the Author's review article published in *Rep. Prog. in Phys.* **70** (2007) 403 for this revised version, in addition to that already permitted, published in *Rep. Prog. in Phys.* **63** (2000) 505, for the previous Edition. American Geophysical Union (AGU), Annual Reviews Inc., Elsevier and IEEE organization are acknowledged for their permissions to reproduce and adapt figures from their articles or books. The permissions are indicated in the figure captions according to indications from Editors.

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15 August 2008

Preface to the First Edition

This book originates from lectures given to undergraduate and graduate students over several academic years. Students questions and interests have driven the need to make systematic and comprehensive (we hope) the presentation of the basic principles of a field which is under continuous development. The physics principles of radiation interaction with matter are introduced as a general knowledge background needed to understand how radiation can be detected. Technical developments are making available detectors and detecting media of increasing complexity. Historically, the first nuclear particle detectors (like those based on X-rays films) were very simple. In the course of time, the detectors have become more and more sophisticated. In addition, complex systems of detectors generally targeting a wide range of physics goals led to large experimental apparata often constituted by several sub-detectors. These large detector assemblies require dedicated methods of reconstruction and analysis of data to decrease the experimental errors. Therefore, both detectors and detection methods are fields of developments and investigations. To be detected, radiation and particles have to interact during their passage through a medium. Therefore, the first chapters are dealing with collision and radiation energy losses by charged particles, photon absorption and nuclear collision in matter. A particular attention has been given to the discussion of both the energy loss and the energy straggling, and the absorption of photons and hadrons in media. The second part of the book covers the particle energy determination, solid state, wire chambers and droplet detectors, and applications in the field of nuclear medicine. Detailed examples are presented which illustrate the operation of the various types of detectors, and help the understanding of the optimization factors.

We are grateful for the help received from individuals and groups of students in writing this book. The chapters on electromagnetic and hadron interactions in matter have taken advantage of discussions with undergraduate and graduate students of the University of Milan and Montreal. Their questions have helped the shaping of the content of these chapters. Help for the drawing of some of the figures and assistance have been provided by Pasquale D'Angelo from the National Institute of Nuclear Physics (Milan) and Dr. Simonetta Pensotti from the University of Milano-Bicocca. The chapters on solid state and nuclear medicine benefitted from the input of Céline Lebel PhD student at the University of Montreal and Dr. Patrick Roy former PhD student at the Montreal University. We have to acknowledge our collaborators of the SICAPO collaboration for the scientific achievements in the field of high energy electromagnetic and hadronic shower propagation in matter presented in the chapter on particle energy determination. Sections of the chapter on droplet detectors present results obtained in the framework of the PICASSO experiment in Montreal. They are the result of collaboration with Profs. Louis Lessard and Viktor Zacek of Montreal University. Input on this chapter has also been provided by Marie-Hélène Genest. The part of the chapter on wire chambers dealing with ionization chambers and their application in the measurement of liquid argon purity borrows material developed with our Dubna colleagues, in particular Drs. Alexander Tcheplakov and Victor Kukhtin.

We wish to thank many Authors and Editors who permitted us to reproduce adapt figures from their articles or books. For their permission in reproducing materials and figures, we acknowledge the Annual Review of Nuclear Science, the American Physical Society (APS), Cambridge University Press, European Organization for Nuclear Research (CERN), Elsevier, the International Atomic Energy Agency (IAEA), the Institute of Physics (IoP), the National Academic Press (NAS), Zeitschrift für Naturforschung, the Oxford University Press, Physica Scripta, the Italian Physical Society (IPS), and Springer-Verlag. We wish to thank for their collaboration Profs. A. Bohr, A. Fassò, R. Fernow, B. Mottelson, B. Povh, J.O. Rasmussen, K. Rith, G.B. Yodh, F. Zetsche, the Particle Data Group at Lawrence Berkeley National Laboratory, and the American Institute of Physics responsible for the succession of E. Segrè. The permissions are indicated in figure captions according to the indications from Editors.

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19 March 2004