emission detectors

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To my *Alma Mater Studiorum*
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Foreword

This book was written by a researcher who has been working actively in a field of detector technology originally introduced almost 40 years ago by a group of Russian physicists investigating electron emission from liquid argon. They were able to formulate the unique properties of a new detector technology that could be developed employing this effect. They called these detectors *emission detectors*, meaning detectors of ionizing radiation, in which ionization electrons could be extracted from a condensed matter detection medium into a rarefied gas phase in which the electron signal could be amplified. Such detectors are sometimes called *two-phase* or *dual-phase detectors*, but that does not truly reflect the basic principle of their operation, therefore probably the name *two-phase emission detectors* would be more accurate.

Researchers working in emission detector technology are concerned with effects associated with quasi-free electron transmission through bulk dielectrics and charge carrier penetration through the inter-phase boundary, purification technologies that provide long electron lifetimes, methods of amplification of electron signals in pure dielectrics, analogue and digital visualisation of ionization particle tracks with extremely low ionization yield in condensed matter.

First considered for accelerator experiments hunting for rare processes, such as short-ranged particles, neutral channels of antiproton-nucleon annihilations in heavy nuclei and abnormal low-ionizing particles as well as medical imaging, emission detectors seem to have found their niche in low-background experiments searching for cold dark matter and low-energy neutrino interactions. The further development of this interesting class of radiation detectors may enhance the arsenal

of modern experimental methods in other exciting fields like the neutrinoless double-beta decay search, solar neutrino physics and possibly in many new areas that cannot be satisfactorily served with existing detector technologies. In this sense, this monograph may be useful in providing readers with a solid foundation for development of the new instrumentation.

Boris A. Dolgoshein

Moscow

9 May 2009

Preface

This book is the first attempt to provide a comprehensive presentation of the physics and engineering concepts behind emission detector technology. Over the course of 35-year career in experimental physics, I have been involved in a variety of R&D projects that spans the study of effects associated with quasi-free electron emission, from small, gram-scale quantities of non-polar dielectrics for the purpose of exploring all possible working media for emission detectors, to the recent development of huge, ton-scale, astroparticle emission detectors used in the search for cold dark matter in the Milky Way. Consideration of this research itself can serve as a good example of the evolution of a new technology from basic concept to practical application.

In this book, special attention has been paid to the properties of non-polar dielectrics, since such media can be used for effective detection of penetrating radiation in many important practical applications, ranging from medical imaging to nuclear reactor diagnostics. Applications of emission detector technology are discussed in the concluding chapter of the book. More than two hundred references have been cited in this book and can serve as sources of more detailed information on particular subjects. For additional reading on relevant detector technologies, one can recommend *Liquid Ionization Detectors* (Atomizdat, 1983) by Barabash and Bolozdynya, *Noble Gas Detectors* (Wiley, 2006) by Aprile, Bolotnikov, Bolozdynya and Doke, and, of course, *Radiation Detection and Measurements* (3rd edition, Wiley, 2000) by Knoll, whose comments on the technology of noble gas detectors inspired me to work on this monograph.

I thank my colleagues from LUX collaboration, XENON-10 collaboration, CDMS collaboration, Moscow Engineering Physics

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Alexander Bolozdynya

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