Preface

Major scientific advances are the result of interplay between ground breaking theoretical intuitions and experimental observations, validating or contradicting the predictions. In elementary particle physics, the commissioning of high-energy accelerators and colliders demanded the development of innovative detectors capable of recording increasingly complex events; in astrophysics, where the scope is to detect radiation from remote sources, or ubiquitously present in the Universe but with little if any interaction with ordinary matter, the focus is rather on the realization of large volume, low noise devices capable of revealing rare events obscured by diffuse backgrounds. In both cases, dedicated gas-filled detectors have demonstrated their flexibility of conception and excellent performances.

Starting with Ernest Rutherford's original development of the single-wire proportional counter in the early 1900s, through the multi-wire and drift chambers introduced by Georges Charpak in the late sixties, to the powerful new tracking devices collectively named micro-pattern gas chambers, the development of gaseous detectors has been a continuous story of success and, sometimes, disappointments.

While many textbooks exist on gaseous detectors (see the Further Reading section), most of the information on recent progress in the field is scattered in thousands of articles, conference records, doctoral theses and other documents. This book aims to collate selected information in an organized way, reproducing relevant data on the various developments, providing extended references to published material as well as links to useful web-based tools and databases. The content is largely based on the many courses given by the author at CERN and various universities and research laboratories worldwide, and greatly profits from constructive interactions with the students. Whenever possible, simplified, back-of-the-envelope calculation examples are provided as a complement to more rigorous algorithms.

After a recall of the major processes of interaction between charged particles, photons and neutrons with the medium, releasing detectable messages in matter,

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the first part of the book follows the fate of the ionisation yields, released in a counter's gas, under the effect of externally applied electric and magnetic fields, from simple collection to charge multiplication and breakdown. Depending on the counter geometry and field strength, a detector can be made then to operate in simple charge collection, in a regime of avalanche charge multiplication with the detected charge proportional to the primary ionisation, or in gain-saturated regimes providing conveniently large signals, almost independent from the original charge. Primary or field-enhanced photon emission can also be exploited for detection. Each mode has its own advantages and disadvantages, discussed in the subsequent chapters, which have to be thoroughly analysed to best cope with the experimental needs.

Associated for many years with Georges Charpak's research group at CERN, I was easily fascinated by his enthusiasm in searching new directions for the development and applications of detectors, mostly based on the use of a gas as sensitive medium; a short personal recollection of my participation to these research efforts is illustrated in the first chapter of the book. Over the years, the activity of the group attracted many young scholars, who contributed to the various developments before returning to their home institution, often subsequently creating their own research team while keeping friendly and constructive contacts with our group; this book is dedicated to them and their works, with apologies for any mistake or omission.

I am particularly grateful to Ugo Amaldi, who hosted me in the TERA Foundation premises at CERN during the final drafting of the book; a warm word of appreciation goes to many colleagues who provided scientific help and support in obtaining original documents and reprint permissions: Marcello Abbrescia, Ugo Amaldi, Elena Aprile, Tullio Basaglia, Malte Hildebrandt, John Kadyk, Salete Leite, Eugenio Nappi, Anna Peisert-Elliott, Archana Sharma, Emile Schins, Graham Smith, Jerry Va'vra, and many others.

Last but not least, warm thanks to my daughter Raffaella who undertook the strenuous task of improving the language on a subject rather extraneous to her field of expertise.

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