Chapter 12
Applications

ABSTRACT

In this chapter, some applications of micropattern detectors are described. Their main application is tracking of charged particles in high-energy physics. However, currently there are a lot of research and developments going on, which may open new exciting fields of applications, for example in dark matter search, medical applications, homeland security, etc. The authors start with the traditional applications, which are in high-energy physics and astrophysics. Later, the focus shifts to promising developments oriented towards new applications. These innovative applications include: imaging of charged particles and energetic photons with unprecedented high 2-D spatial resolution (e.g. in mammography), time projection chambers capable operating in a high flux of particles (e.g. ALICE upgraded TPC), and visualization of ultraviolet and visible photons. Finally, a short description of the international collaboration RD51 established at CERN is given in order to promote the development of micropattern detectors and their applications.

1. INTRODUCTION

The main practical importance of any new detector of charged particles and photons is how large you can make it. This was one of the key factors leading the tremendous success of the MWPC. After its invention by Georges Charpak they were almost immediately adopted in many large-scale high energy physics experiments and later in astrophysical experiments, as well as in some biological and medical instruments (Nappi, 2013). Using the same criteria one can evaluate the significance of any micropattern detector.

The first impressive implementation of a large area micropattern detector, an MSGC, was in the D20 neutron spectrometer at ILL Grenoble (Clergeau, 2001). It consisted of an array of 48 sealed MSGCs with an active area of 8x15cm$^2$ each, see Figure 1. Despite many technical challenges (one of them was exploiting sealed mode instead of traditional gas flow mode), the MSGCs operated successfully for about one year.

Other applications of micropattern detectors (MSGC, GEM and MICROMEGAS) are as tracking devices in several high energy physics experiments and in x-ray detectors in some astro-
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physical experiments. These are traditional fields of application of gaseous detectors.

2. TRADITIONAL APPLICATIONS IN HIGH ENERGY PHYSICS AND ASTROPHYSICS EXPERIMENTS

2.1 Applications in High Energy Physics

One of the first applications of MSGC combined with a GEM as a pre-amplification structure in a high energy physics experiment is in the Hera-B inner tracking system. A schematic drawing of this detector is presented in Figure 17 (Chapter 5). The Hera-B inner tracker consists of 184 detectors with an active area of up to 25x25 cm² each, covering a 100 m² surface.

After this successful experience, micropattern detectors like GEM and MICROMEGAS have been used successfully in several experiments, for example in COMPASS, NA48, LHC-B, TOTEM, CAST, N-TOF, PHENIX etc.

In COMPASS (Common Muon and Proton Apparatus for Structure and Spectroscopy) triple GEMs and MICROMEGAS were used in the charged particles tracking system in this fixed target experiment, together with other conventional gaseous detectors (see Figure 2).

A photograph of a 31x31 cm² GEM detector developed for the COMPASS experiment is shown in Figure 3. To ensure the spark protection each GEM consists of 12 isolated sectors. One of the design features is a so-called “beam killer,” i.e. a voltage controlled central disc which can be seen in Figure 3. This central beam area can be remotely activated for calibrations and aliment and disabled during high intensity runs. In total, COMPASS use 22 triple GEMs mounted in pairs on 11 stations.

12 MICROMEGAS detectors, each 40x40 cm², are installed just after the fixed target to detect particles scattered at small angles with a blind disc in the path of the beam. To minimize the discharge rate a Ne-based gas mixture is used instead of traditional Ar-based mixture. For the efficient spark protection 100 pF capacitances decouple each readout strip on the anode plate.
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