Development of Micro-Pattern Gas Detector Technologies and the RD51 Collaboration

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Improvements in detector technology often come from capitalizing on industrial progress. Over the past two decades, advances in photo-lithography, microelectronics and printed circuits have opened the way for the production of micro-structured gas-amplification devices. In particular, ease of manufacturing, operational stability and superior performances for charged-particle tracking, muon detection and triggering have given rise to two main designs: the gas electron-multiplier (GEM) and micro-mesh gaseous structure (Micromegas). By using a pitch size of a few hundred micrometres both devices exhibit intrinsic high-rate capability (>1 MHz/mm2), excellent spatial and multi-track resolution (around 30 µm and 500 µm, respectively), and time resolution for single photoelectrons in the sub-nanosecond range.

Coupling the microelectronics industry and advanced PCB technology has been important for the development of gas detectors with increasingly smaller pitch size. An elegant example is the use of a CMOS pixel ASIC, assembled directly below the GEM or Micromegas amplification structure. Using this approach, MPGD-based detectors can reach the level of integration, compactness and resolving power typical of solid-state pixel devices. For applications requiring imaging detectors with large-area coverage and moderate spatial resolution (e.g. ring-imaging Cherenkov (RICH) counters), coarser macro-patterned structures offer an interesting economic solution with relatively low mass and easy construction thanks to the intrinsic robustness of the PCB electrodes. Such detectors are the thick-GEM (THGEM), large electron multiplier (LEM), patterned resistive thick GEM (RETGEM) and the resistive-plate WELL (RPWELL).

MPGDs have also found numerous applications in other fields of fundamental research. They are being used or considered, for example, for X-ray and neutron imaging, neutrino nucleus scattering experiments, dark- matter and astrophysics experiments, plasma diagnostics, material sciences, radioactive-waste monitoring and security applications, medical physics and hadron therapy.

By 2008, interest in the development and use of the novel micro-pattern gaseous detector (MPGD) technologies led to the establishment at the CERN of the RD51 collaboration. Originally created for a five-year term, RD51 was later prolonged for another five years beyond 2013. While many of the MPGD technologies were introduced before RD51 was founded, with more techniques becoming available or affordable, new detection concepts are still being introduced and existing ones are substantially improved.

This talk will highlight recent achievements in the field of micro-pattern gas detectors and review project activities in the framework of the RD51 collaboration.