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Gaseous Electron Multiplier (GEM) Detectors

KONDO GNANVO, University of Virginia

Gaseous detectors have played a pivotal role as tracking devices in the field of particle physics experiments for the last fifty years. Recent advances in photolithography and micro processing techniques have enabled the transition from Multi Wire Proportional Chambers (MWPCs) and Drift Chambers to a new family of gaseous detectors refer to as Micro Pattern Gaseous Detectors (MPGDs). MPGDs combine the basic gas amplification principle with micro-structure printed circuits to provide detectors with excellent spatial and time resolution, high rate capability, low material budget and high radiation tolerance. Gas Electron Multiplier (GEMs) is a well-established MPGD technology invented by F. Sauli at CERN in 1997 and deployed various high energy physics (HEP) and nuclear NP experiment for tracking systems of current and future NP experiments. GEM detector combines an exceptional high rate capability (1 MHz / mm^2) and robustness against harsh radiation environment with excellent position and timing resolution performances. Recent breakthroughs over the past decade have allowed the possibility for large area GEMs, making them cost effective and high-performance detector candidates to play pivotal role in current and future particle physics experiments. After a brief introduction of the basic principle of GEM technology, I will give a brief overview of the GEM detectors used in particle physics experiments over the past decades and especially in the NP community at Thomas Jefferson National Laboratory (JLab) and Brookhaven National Laboratory (BNL). I will follow by a review of state of the art of the new GEM development for the next generation of colliders such as Electron Ion Collider (EIC) or High Luminosity LHC and future Nuclear Physics experiments. I will conclude with a presentation of the CERN-based RD51 collaboration established in 2008 and its major achievements regarding technological developments and applications of MPGDs.