9th SYMPOSIUM ON LARGE TPCs FOR LOW-ENERGY RARE EVENT DETECTION

Contribution ID: **28** Type: **not specified**

Optical readout of GEM-based TPCs: ultra-fast optical readout and transparent readout anodes

The high signal amplification factors achievable by multi-layer amplification stages of Gaseous Electron Multipliers (GEMs) and the possibility to record scintillation light emitted during avalanche multiplication with high-granularity imaging sensors makes optical readout of GEM-based detectors an attractive technology for Time Projection Chambers (TPCs). Optically read out GEM-based TPCs have been shown to allow three dimensional (3D) track reconstruction of alpha particles and are used in nuclear physics studies as well as rare-event applications.
Previously, this readout concept relied on auxiliary photon detectors such as PhotoMultiplier Tubes (PMTs) to provide timing information needed to augment 2D particle track images with depth information to achieve full 3D track reconstruction. Thus, this reconstruction approach was limited to straight trajectories such as alpha particle tracks. To overcome this limitation, we have studied two novel readout approaches allowing 3D track reconstruction: combined optical and electronic readout as well as ultra-fast optical readout.
Combining optical and electronic readout by using a segmented, optically transparent anode below a triple-GEM stack at the endcap of a TPC, 3D reconstruction of intricate particle tracks was achieved without the need for a PMT as auxiliary photon detector. An ITO-based strip anode plane was manufacture by direct laser lithography and etching techniques. Electronic signals were read out from this anode with an APV25 ASIC. The arrival time of electronic signals provided depth of interaction information. Detailed integrated 2D images corresponding to the XY-projections of particle tracks were recorded optically by a camera located below the triple-GEM stack. The visible scintillation light emitted in an Ar/CF₄ gas mixture during electron avalanche multiplication was passing through the ITO-based anode before being recorded by the camera. By combining the 2D information provided by the recorded images with Z-coordinate information extracted from signal arrival times obtained with electronic readout, complex trajectories could be reconstructed in 3D.
While the low frame rate of imaging sensors has previously been a limiting factor for optical readout, modern ultra-high-speed CMOS cameras permit imaging at up to one million frames per second at reduced resolution. Corresponding to microsecond-scale inter-frame time intervals, this permits recording a sequence of images for a single event in a TPC with a low drift velocity. Track segments at different depths are recorded in different frames and together with a known charge carrier drift velocity, the inter-frame interval can be used to determine relative depth information of particle track segments. We have demonstrated that ultra-fast CMOS cameras can be used for 3D track reconstruction of alpha particle tracks. This provides an unprecedented readout modality for TPCs and may allow the reconstruction of intricate events without the need for auxiliary timing detectors or complex reconstruction algorithms. In addition, this readout approach may be especially attractive for negative ion TPCs due to the lower drift velocities.

Primary author: Dr BRUNBAUER, Florian Maximilian (CERN, Vienna University of Technology (AT))

Co-authors: PFEIFFER, Dorothea (CERN); OLIVERI, Eraldo (CERN); GARCIA FUENTES, Francisco Ignacio (Helsinki Institute of Physics (FI)); ROPELEWSKI, Leszek (CERN); LUPBERGER, Michael (CERN); VAN STENIS, Miranda (CERN); THUINER, Patrik (CERN)

Presenter: Dr BRUNBAUER, Florian Maximilian (CERN, Vienna University of Technology (AT))