Contribution ID: **145** Type: **poster**

Timing techniques with picosecond-order accuracy for novel gaseous detectors

Thursday, 16 September 2021 08:02 (1 minute)

To meet the needs arising from the high-rate environments in current and future accelerators, detectors with high precision timing capabilities are of utmost importance. Dedicated R&D effort is carried out, resulting in novel detector technologies with excellent timing capabilities. Gaseous detectors instrumentation contributes to this effort and an example is the PICOSEC-Micromegas, which has demonstrated the ability to time 150GeV muons with 25ps timing resolution and photons beams (~70p.e.) with 6.8ps.
However, during R&D phase, the full waveform is usually used for the extraction of the timing information from the signal, increasing the data amount and requiring expensive, energy-consuming and bulky fast oscilloscopes. Towards forward applications and large-scale detectors, front-end electronics are of paramount importance to undertake the data acquisition. For each detection technology data acquisition should retain the signal timing characteristics and consequently the timing resolution on the particle's arrival time.
This work investigates the potential of timing techniques, alternative to the Constant Fraction Discrimination applied on the full digitised waveform, used in the data analysis of prototype detectors (i.e. for the PICOSEC Micromegas). More specifically, we investigate the adequacy of Time-over-Threshold timing technique using multiple constant thresholds, on experimental data. This method introduces a "time walk"that impinges on the timing resolution. We mitigate the effect of time walk using two different methods. In the first, the required correction is applied using the Time-over-Threshold value, while in the second approach the fraction of the area of the pulse that lies above the appropriately selected constant threshold value is used to parameterize the time walk correction. The results of this study prove the feasibility of the Time-over-Threshold timing technique using multiple thresholds for data acquisition and achieving resolution 10ths of picoseconds. We also demonstrate that similar results can be achieved using machine learning approaches.

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Session Classification: Poster Session 4 (Position Sensitive Fast Timing Detectors)

Track Classification: Position Sensitive Fast Timing Detectors