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Progress on the PICOSEC-Micromegas Detector Development: towards a precise timing, radiation hard, large-scale particle detector with segmented readout

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Detectors with a time resolution of a few 10ps and robustness in high particle fluxes are necessary for precise 4D track reconstruction in future, high luminosity HEP experiments. In the context of the RD51 collaboration, the PICOSEC detector concept has been developed, which is a two-stage Micromegas detector with a photocathode coupled to a Cherenkov radiator. Single channel PICOSEC prototypes equipped with a CsI photocathode have demonstrated an excellent resolution, of 24 ps, for timing the arrival of MIPs. The PICOSEC timing characteristics have been extensively studied with laser beams and have been understood in terms of detailed simulations and phenomenological models.

Due to the fact that ion back-flow in the drift region damages the CsI photocathode, alternative photocathode materials (e.g., pure metallic and Diamond-Like Carbon) have been investigated. Comparison of the charge distribution of the PICOSEC response signal to UV light and muons, allows to consistently estimate the photoelectron yield of the photocathode, a parameter which affects critically the PICOSEC performance. Different resistive anode layers have also been tested for stable operation in a high intensity pion beam.

Towards developing PICOSEC detectors for practical applications, multi-channel PICOSEC prototypes with CsI photocathodes and anodes segmented in hexagonal pads (5 mm side) have been tested in UV light and muon beams. After correcting for systematic errors due to imperfections on the anode planarity, a uniform timing resolution of 25 ps for each pad is achieved. Furthermore, a similar timing resolution has been measured for signals shared across multiple pads.

This conference contribution will present the progress and developments towards a well understood, robust, large-area, PICOSEC detector offering precise timing in the HL-LHC era and beyond.

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