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PICOSEC Micromegas precise-timing gaseous detectors and studies on robust photocathodes

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The PICOSEC Micromegas (MM) detector is a precise-timing gaseous detector based on a Cherenkov radiator coupled with a semi-transparent photocathode and a MM amplifying structure, targeting a time resolution of tens of picoseconds for minimum ionising particles. Initial single-pad prototypes have demonstrated a time resolution below σ = 25 ps, prompting ongoing developments to adapt the concept for physics applications. The objective is to build robust multi-channel detector modules suitable for large-area detection systems requiring exceptional timing precision.

Extensive R&D activities within PICOSEC have covered all areas from simulations, design, production, and assembly to measurements in laboratory conditions, as well as with 150 GeV/c muon beams. One significant advancement was the improvement of time resolution to σ = 13 ps for a single-pad detector through design optimization. Regarding stability, a resistive PICOSEC MM of 20 MΩ/□ was introduced, obtaining comparable results. In the pursuit of a robust alternative to Cesium Iodide, comprehensive measurements of carbon-based photocathode samples, including Diamond Like Carbon (DLC) and Boron Carbide (B4C) are ongoing. Preliminary results from detectors equipped with DLC and B4C photocathodes exhibited a time resolution below σ = 30 ps. Scaling up the prototype to a 100-channel detector with a 10x10 cm2 active area yielded a time resolution below σ = 18 ps for individual pads, validating that the excellent timing performance of the single-pad proof of concept can be transferred to the 100-channel prototype. Furthermore, successful measurements of the complete read-out chain utilizing RF pulse preamplifiers and a SAMPIC digitiser confirmed the system' s suitability for studying multi-channel detector response.

Efforts dedicated to improving detector stability and robustness, enlarging its coverage, and integrating scalable electronics enhance the feasibility of the PICOSEC MM concept for large experiments requiring sustained performance while maintaining exceptional timing precision.

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