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Precise timing of charged particles with the PICOSEC Micromegas detector: status and prospects

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Fast-timing particle detection in the sub-nanosecond region is a challenge in high energy physics, space science and nuclear physics, as well as in bio-medical imaging instrumentation. The use of fast timing detectors (˜10 ps resolution) is crucial for the successful exploitation of the full potential of the future LHC operation at the high luminosity, and will facilitate the search for physics beyond the standard model. Besides the timing properties, these detectors owe to be robust enough to withstand the high particle fluxes in such environments.

In order to achieve such a performance, we have developed in the frame of the RD51 Collaboration the PICOSEC concept: a Micromegas detector is coupled with a Cerenkov radiator (MgF2 crystal), equipped with a CsI photocathode. The conversion (drift) region between photocathode and micro-mesh is reduced to 200 μm to suppress direct gas ionization, while enabling pre-amplification. Using small, unsegmented prototypes, we have observed a time resolution of 24ps for 150 GeV muons at CERN SPS, and 75 ps for single photoelectrons, produced by 100 fs pulses from a UV laser.
The timing characteristics of the detector have been fully understood in terms of detailed simulations and phenomenological models.

In order to evolve to a large-scale detector, we are currently concentrating our efforts on two directions: the development of larger detectors with resistive and segmented anodes, and the investigation of alternative, robust photocathodes, pure metallic or based on carbon (DLC, diamond). The current status, recent results and the prospects of the project will be presented here.

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