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Position Measurement in single-gap RPCs using Timing-Difference from Two Ends of Pickup Strips in Differential Configuration

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This work explores a technique for extracting the position of particle along the direction of a pickup strip, in a large area single-gap Resistive Plate Chamber (RPC), by measuring the timing-difference from the two ends of the strip. Using precise time-difference measurement, the position can be obtained more precisely than the conventional x-y strip readout with the same number of electronics channels. This technique was reported in the case of multigap RPCs (MRPCs) in [1] with timing difference resolution of 18 ps corresponding to position resolution of 1.7 mm, with sensitivity of 104ps/cm. The sensitivity is defined as the ratio of the change in mean of timing-difference to the change in position where the particle crosses the gas gap. Sensitivity is just twice the inverse of propagation speed in the transmission line formed by the pickup strips. In [1], the readout strips on either side of the MRPC are kept in parallel, and the signals from both ends of the strip are read differentially to minimise noise. It is expected that this method would work on single-gap RPCs also as the signal will be induced to both sides of a strip simultaneously. The intrinsic fluctuations of timing of the device is common to both ends of the strip and gets cancelled out when the timing-difference is taken (pulse height effect may bias the time measurements). However, MRPCs which are operated at higher electric fields produce a sharper rising signal than the single-gap RPCs, so the position resolution may not be as good for single-gap RPCs as in the case of MRPCs. A similar method has been tested on single-gap RPCs in [2] achieving a position resolution of 10.69 mm (timing difference resolution of 150 ps), but this was done using single-ended signals with pickup strips mounted only on one side of the RPC. Single-ended readout will limit the timing-difference resolution as compared to differential readout. A similar method has been tested in the development of the Improved RPCs (iRPCs) in CMS [3] with a resolution of 16mm (160 ps timing-difference resolution), and in [4] with a resolution of 5mm. This work will present the development of readout electronics for differential readout of RPCs and the measurement of the timing-difference resolution and sensitivity of the RPC using a cosmic muon telescope.

[1] MRPC-PET: A new technique for high precision time and position measurements K.Doroud et al, Nuclear Instruments and Methods in Physics Research A (2011) https://doi.org/10.1016/j.nima.2011.09.008

[2] Studies on fast triggering and high precision tracking with Resistive Plate Chambers G. Aielli et al, Nuclear Instruments and Methods in Physics Research A (2013) https://doi.org/10.1016/j.nima.2013.02.044

[3] Improved-RPC for the CMS muon system upgrade for the HL-LHC
Priyanka Kumari et al. https://arxiv.org/abs/2005.11396

[4] Double-end Readout Method Applied in RPC
Q. Li et al 2021 JINST 16 P10036 https://iopscience.iop.org/article/10.1088/1748-0221/16/10/P10036

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