



## Toward a high granularity and high counting rate, differential readout timing MRPC

M. Petriş<sup>a,\*</sup>, M. Petrovici<sup>a</sup>, V. Simion<sup>a</sup>, D. Bartoş<sup>a</sup>, G. Caragheorgheopol<sup>a</sup>, I. Deppner<sup>b</sup>, K. Doroud<sup>c</sup>, N. Herrmann<sup>b</sup>, M. Kiss<sup>b</sup>, P. Loizeau<sup>b</sup>, Y. Zhang<sup>b</sup>, M.C.S. Williams<sup>d</sup>

<sup>a</sup> Horia Hulubei National Institute for Physics and Nuclear Engineering, Bucharest, Romania

<sup>b</sup> Physikalisches Institut der Universität Heidelberg, Germany

<sup>c</sup> World Laboratory, Geneva, Switzerland

<sup>d</sup> INFN, Bologna, Italy

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### ABSTRACT

A new differential architecture of a resistive plate counter based on high granularity strip structure readout electrodes, symmetric relative to the central anode, is proposed. Details of its design and construction are introduced. Results of the  $^{60}\text{Co}$  source tests and of the in-beam investigations using minimum ionizing particles are discussed. A time resolution of 50–60 ps and a cluster size of  $\sim 1.4$  strips were obtained. These results together with previous ones based on low resistivity glass electrodes [1] open the perspective to built large area time-of-flight (TOF) detectors with a very good time resolution and high granularity for high intensity fixed target experiments.

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## 1. Introduction

The MRPC has very good efficiency and time resolution [2–4]. Progress made in the last ten years in developing multigap resistive plate chambers (MRPC) [2–4] has materialized in large area time-of-flight detectors already in operation [5–8], or construction phase [9,10].

A new variant of MRPC developed in our group [4] is based on a strip structure central readout electrode; its advantages and performance have been confirmed in real experiments [6]. The successful commissioning of the FOPI-TOF barrel, with an average time resolution of 60 ps, very good position resolution along and across the strips [5] demonstrated that large area detectors based on such an architecture are achievable. The FOPI-TOF MRPC in combination with the Central Drift Chamber (CDC) reaches kaon identification up to 1 GeV/c momentum.

One should mention that this detector is operated in a single ended mode. The mentioned performance was obtained by a very good minimization of the reflections inside the counter, an appropriate impedance matching and a good screening and grounding of the counter in order to reduce the pick-up of external noise.

Next generation experiments such as CBM [11] at FAIR will be confronted with the selection of rare probes in a high multiplicity environment at collision rates up to  $10^7$  events/s. Hadron identification in such a limiting environment is a real challenge and

requires intensive R&D activity for developing high resolution and high granularity timing detectors at an affordable cost.

The low polar-angle region of CBM-TOF detector will be exposed to high counting rates (up to about 20 kHz/cm<sup>2</sup>) and high multiplicities (up to 1000 tracks/event) at 25 A GeV Au+Au collisions. Therefore, a high counting rate and high granularity detector is required for this particular region of the TOF wall. Here a new differential variant of a multigap resistive plate counter (MRPC) based on a high granularity strip structure readout electrodes is proposed to meet this challenge.

## 2. Detector description

The counter has two identical stacks of plates, symmetrically disposed relative to the central strip structure anode, as can be seen in Fig. 1. On each side of the anode there are stacked six resistive electrodes made of commercial float glass of 0.5 mm thickness with a resistivity of the order of  $10^{12} \Omega \text{ cm}$ , forming a structure with  $2 \times 5$  gas gaps. The gas gap size was given by the 0.14 mm diameter of the fishing line placed between the glass plates. The high voltage electrodes made from a pcb plate have on the inner side the same strip structure as the readout electrodes; these strips are in contact with the last glass plate. An extra layer of mylar of 100  $\mu\text{m}$  is used between the high voltage and cathode read-out layers in order to prevent leakage currents due to imperfections in the printed circuit material which look-up to the cathode strips. The readout electrodes (the cathodes and central double-sided anode) have a strip structure of 2.54 mm pitch and 1.1 mm strip width with a strip

\* Corresponding author.

E-mail address: [mpetris@nipne.ro](mailto:mpetris@nipne.ro) (M. Petriş).

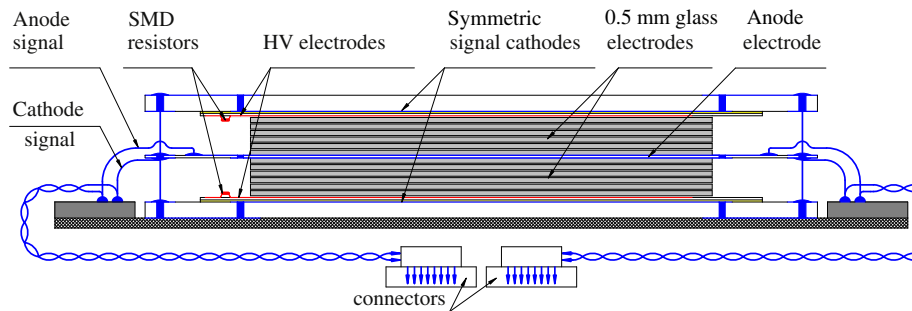


Fig. 1. Schematic structure of the two times five gap differential strip lines read-out MRPC.

length of 46 mm. The cathodes are made from a printed circuit board (pcb) of 1.5 mm thickness while the anode and the high voltage electrodes are from a pcb of 0.6 mm thickness. The active area of the prototype, defined by those 72 readout strips, is  $46 \times 180 \text{ mm}^2$ . The corresponding strips on the two sides of the central anode and of the outer cathodes, respectively, are connected together, (as is shown in Fig. 1). The signals induced on the central and outer corresponding strips on each side of the counter are transported via twisted cables to differential amplifiers. The whole structure is housed in a gas tight rectangular aluminum box. The signals are fed through the connectors mounted on the bottom of the box. The high voltage and the gas connections are on the same side of the box as the connectors.

### 3. $^{60}\text{Co}$ source measurements

#### 3.1. Experimental setup

The results reported here have been obtained using a high voltage of 1.98 kV/gap and a gas mixture (85%  $\text{C}_2\text{F}_4\text{H}_2$ , 10%  $\text{SF}_6$  and 5%  $\text{i-C}_4\text{H}_{10}$ ) flushed at normal pressure.

A photo of the experimental setup used in the  $^{60}\text{Co}$  source tests is shown in Fig. 2. The signals delivered by the detector have been fed into a differential front-end electronics based on the NINO chip, developed within the ALICE Collaboration [12], providing both the time and time-over-threshold information (used for slewing correction). The discriminated signals were fed into a home made LVDS–NIM converter and sent to LeCroy 2228A TDCs. Time spectra have been obtained from  $^{60}\text{Co}$  source  $\gamma$ – $\gamma$  coincidences between a measured strip and a plastic scintillator (NE102) of cylindrical geometry ( $\Phi = 25 \text{ mm}$  and  $h = 20 \text{ mm}$ ) coupled to a R9800 Hamamatsu photomultiplier.

#### 3.2. Co source test results

The time distribution was obtained as the mean of the time information of the two strip ends,  $t_{\text{mean}} = (t_{\text{left}} + t_{\text{right}})/2$  relative to the start signal delivered by the plastic scintillator. The position of the avalanche along the strip is derived from the difference of the time information measured at the ends of a strip:  $t_{\text{diff}} = (t_{\text{left}} - t_{\text{right}})$ .

The data corrected for time slewing were used to calculate the MRPC time performance. With a narrow condition of 3 cm in position along the strip centered on the maximum yield in the position distribution spectra, a cut of the small amplitudes in the plastic scintillator and selecting large signals in MRPC (large time over threshold) the  $t_{\text{mean}}$  distribution presented in Fig. 3, left panel was obtained. A Gaussian fit of this spectrum gives  $\sigma = 4.12$  channels (one TDC8222A channel corresponds to 42 ps). If we subtract quadratically the contribution of the plastic scintillator, see Fig. 3, right panel (144 ps—measured in separate runs

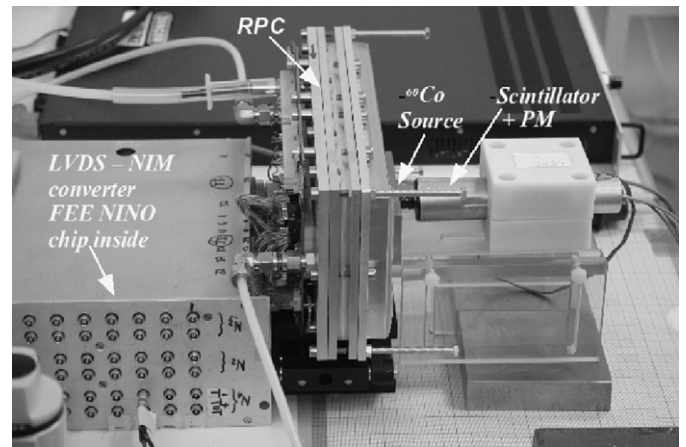


Fig. 2. Experimental set-up used in  $^{60}\text{Co}$  source tests.

using 2 identical scintillators and phototubes), a time resolution of  $\sigma = 96 \text{ ps}$  is obtained.

### 4. In-beam tests

#### 4.1. Experimental setup

The experiment has been performed at the SIS accelerator of GSI—Darmstadt with secondary hadrons produced by a proton beam of 3.1 GeV/c on a Pb target. The experiment geometry can be seen in Fig. 4.

We will present the results obtained with two identical MRPC counters marked as: MRPC1—horizontal position, and MRPC2—rotated by  $90^\circ$  relative to MRPC1.

The experimental setup was installed on a movable platform and lowered under the horizontal beam direction in order to avoid the exposure of the counter to very high particle fluxes. Two plastic scintillators (P11 and P12) of  $1 \times 2 \text{ cm}^2$  section and 100 mm length, readout by R9800 Hamamatsu photomultipliers, positioned each one in front of the corresponding counter, were used as beam trigger. They were mounted on horizontal position and opposite directions, overlapping on a 3 cm length, defining a beam spot size of  $2 \times 3 \text{ cm}^2$  area on the center of the 15 strips operated on each MRPC. For signal amplification we used the same amplifier/discriminator cards based on NINO chip as for the source measurement. The digitization was made with 32-channel CAEN TDC V1290A. The signals from 15 strips readout at both ends were recorded for each counter. Two channels of each TDC were used for recording the information from each plastic scintillator in the same TDC as the corresponding MRPC in order to have the right reference time.

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