RPC prototype test with cosmic irradiation*

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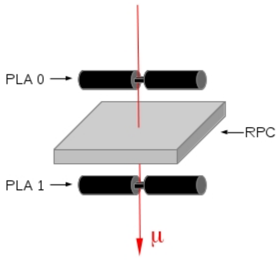
Following the proposal to construct the outer ToF wall based on fully differential multi-strip MRPCs [1] the response of a new prototype RPC designed in Heidelberg to cosmic irradiation was measured throughout the year 2013. In particular, a focus was put on compatibility with the read-out electronics, i.e. PADI-6 preamplifier cards [2] and VFTX FPGA-TDC modules [3], and on refinement of the existing calibration and correction algorithms [4].

The RPC prototype implements an 8-gap single-stack configuration with a gap width of $220\,\mu\mathrm{m}$. It features 56 read-out electrodes of length $53\,\mathrm{cm}$ and pitch $9.4\,\mathrm{mm}$ that add up to an active area of about $2800\,\mathrm{cm}^2$. As RPCs in the outer wall region do not have to stand incident particle fluxes larger than $1\,\mathrm{kHz}$, the prototype is equipped with float glass of resistivity $10^{12}\,\Omega\mathrm{cm}$. The working voltage of the counter amounts to $\pm 11\,\mathrm{kV}$. The preamplifier cards are placed inside the gas volume (cf. Fig. 1, right) and connected directly to the read-out electrodes.



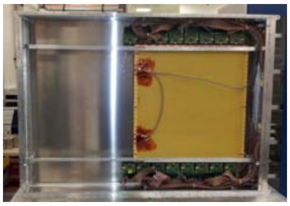


Figure 1: Sketched arrangement (left) of two plastic scintillators with respect to the RPC prototype (right) to measure its response to cosmic irradiation.

The test setup in the lab comprises—besides the RPC prototype—two plastic scintillators (PLA) of dimensions $8 \times 2 \times 1$ and $11 \times 4 \times 2\ \mathrm{cm}^3$ which are each read out on two sides by photomultipliers. One PLA counter is placed above, the other one below the RPC (cf. Fig. 1, left). From the coincidence of signals in both scintillators a trigger is built that is used to read out the RPC.

To evaluate the characteristic RPC parameters time resolution and detection efficiency of the prototype a calibration algorithm needs to process the TDC raw data. In this way, fixed time offsets due to different runtimes of the signals inside the TDCs and the cables connecting the RPC and the PLA counters with the TDCs can be accounted for. Also, systematic effects varying from event to event are corrected for, like charge walk, the velocity spectrum of the incident cosmic muons, and their angular distribution in the test arrangement. After applying all corrections to the raw data the algorithm proceeds with clustering RPC signals on neighboring read-out electrodes that show correlations in time and space. Here, the idea is that an avalanche triggered by a single charged particle traversing the RPC prototype can induce mirror charges on more than one read-out electrode. A typical cluster size for the prototype is 1.3 strips.

In the cosmic muon setup, i.e. for the section of the counter surface affected by the PLA coincidence (cf. Fig. 2, right), a detection efficiency of $98.5\,\%$ and a system time resolution of $67\,\mathrm{ps}$ were found. The term system time resolution refers to the Gaussian standard deviation σ of the time difference spectrum between the RPC and the PLA counters (cf. Fig. 2, left). With a resolution of $55\,\mathrm{ps}$ for the plastic reference system, this allows for an estimate of the counter time resolution—still including the electronics resolution—of about $40\,\mathrm{ps}$. An in-beam test of the prototype in April 2014 at GSI/SIS-18 will demonstrate if these very promising results also hold under heavy-ion load.

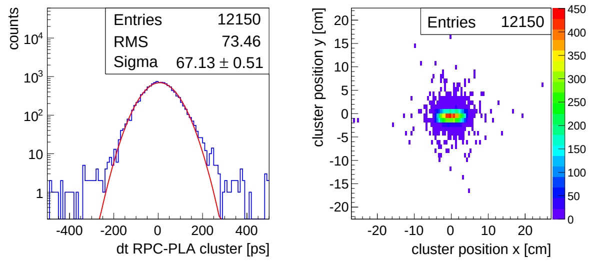


Figure 2: Time resolution of the PLA-RPC system (left) obtained in the trigger spot on the counter surface (right) requiring coincidence of the plastic scintillators.

References

[1] I. Deppner *et al.*, CBM Progress Report 2012, Darmstadt 2013, p. 64

[2] M. Ciobanu *et al.*, CBM Progress Report 2012, Darmstadt 2013, p. 72

[3] J. Frühauf *et al.*, CBM Progress Report 2012, Darmstadt 2013, p. 71

[4] C. Simon *et al.*, CBM Progress Report 2012, Darmstadt 2013, p. 65

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