Characterization of the GET4 v1.0 TDC ASIC with detector signals *

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A free-streaming readout chain is planned for the CBM Time-of-Flight (TOF) wall. The first element in this readout chain with a difference to usual triggered systems is the Time to Digital Converter (TDC). The GET4 ASIC is a free-streaming TDC developed for the CBM TOF wall. After tests with a first version called GET4 *Proto*, the GET4 v1.0 became available at the end of 2012 [1]. It was tested with pulser first alone [3] and then in conjunction with the PADI-6 pre-amplifier and discriminator ASIC [2].

Another interesting option for the TDC in the CBM TOF readout chain is the development of FPGA-TDCs. A first prototype for those is the VFTX board. A cosmic irradiation test campaign was performed throughout 2013 in Heidelberg using our last MRPC prototype, PADI-6 cards and VFTX boards to validate the detector design and this TDC option. Two plastics scintillators readout on both ends by photo-multipliers provide the efficiency and time reference. Results of the VFTX readout chain are presented in [5]. In the current VFTX readout chain, splitter boards are used between the PADI output and the VFTX input to ensure proper LVDS levels of the signals. As pictured in Fig. 1, the GET4 readout chain was connected in parallel for some of the data taking periods using the second output of the splitters. The GET4 readout chain is composed of 8 GET4 v1.0 chips, a Syscore v2 Readout Controller and an ABB PCI-E board for the optical readout. The analysis chain in software is the same as in the VFTX case.

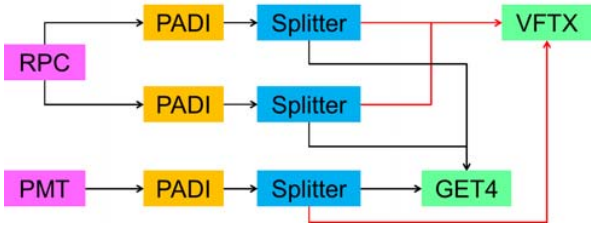

Figure 1: Connection scheme of the setup used for the cosmic rays test of GET4 v1.0.

A measurement was done with the systems running in parallel at an RPC High Voltage of 11.5 kV. At this high voltage, the RPC efficiency relative to coincidences of the plastic scintillators reaches 97.5 % in the GET4 system. The system time resolution obtained after all calibrations is 82 ps. This can, however, be separated into two classes of events: those with multiple TDC hits on at least one RPC channel, for which the resolution is 90 ps, and those with only single TDC hits, for which the resolution is 76 ps. This stresses the importance of a proper matching between the components in a free-streaming TOF system to reduce fake data from reflexions, noise and cross-talk. When taking only single hit events, a time resolution of 49 ps can be extracted for the RPC and its electronics, by subtracting the contribution of the reference system. Similar results were obtained both when using a synchronization signal from the triggered system and in free-streaming mode.

In parallel to the trigger on coincidences of the two plastics, triggers on the OR of the PMTs and on the OR of the RPC strips were used to prevent buffer overflows in the VFTX system. This provides the opportunity to extract the time resolution of the GET4 system in real conditions with quite good statistics. As the time resolution of the VFTX systems and of the splitter boards are known, this can be done by comparing the time measured in the VFTX system to the one measured in the GET4 system. As the time frames of the two systems are independent, one actually needs to compare the value of time differences measured in both the VFTX and GET4 systems (Eq. 1).

$$\Delta t = (t_A - t_B)_{GET4} - (t_A - t_B)_{VFTX} \qquad (1)$$

Assuming the jitters of the VFTX, GET4 and splitter are independent and Gaussian, the GET4 resolution can be extracted for each pair (A,B) of signals (Eq. 2). This procedure was done for the left-right time differences of both plastics and of the equipped RPC strips. The counts for each left-right pairs are used to obtain a mean time resolution. The values of time resolution for the other elements are $\sigma_{VFTX} = 12$ ps [4] and $\sigma_{Splitter} = 10$ ps. The mean time resolution for GET4 v1.0 channels on different daughter boards and with RPC signals is then $\sigma_{GET4} = 24$ ps.

$$\sigma_{GET4\ channel} = \sqrt{\frac{1}{2}\sigma^2_{\Delta t} - \sigma^2_{VFTX} - \sigma^2_{Splitter}} \qquad (2)$$

These value are within the CBM TOF specifications, but need to be tested with higher particle fluxes.

References

[1] H. Flemming et al., CBM Progress Report 2012, Darmstadt 2013, p. 70

[2] P.-A. Loizeau et al., CBM Progress Report 2012, Darmstadt 2013, p. 66

[3] J. Frühauf et al., CBM Progress Report 2012, Darmstadt 2013, p. 67

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

[5] C. Simon et al., “RPC prototype test with cosmic irradiation”, this report

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