# Optimizing the PaDiWa-AMPS TDC and QDC front-end electronics for the HADES pion beam Hodoscope*

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The HADES pion beam experiment has started to take data in summer 2014. A dedicated tracking system CER-BEROS [1] and a Start detector have been used to measure the momentum, the position and precise time of the pions in front of the spectrometer. A Hodoscope was located behind the spectrometer and was used as an additional beam position monitor detector. The Hodoscope [2] is built from 16 plastic scintillator rods with the dimensions of $10x5x100\,$mm, aligned horizontally. The scintillation signal of the rods is read out on each side by Hamamatsu R3478 photo-multiplier tubes (PMTs) providing to get horizontal position information.

Fast TDC and QDC with online monitoring in real-time were needed to control the direction of the pion beam in the spectrometer. The PaDiWa-AMPS front-end board for the TRBv3 [3] was used to measure the time and the charge information of the PMT signals. The TDC is implemented in an FPGA by the tapped delay method. A high precision charge measurement is achieved by implementing a modified Wilkinson-ADC method, so that actively discharging of the integrated signal results in a fast crossing of the threshold. The width of the pulses, which are proportional to the charge, are measured by the well-established TRBv3 platform. Because it is realized based on the KISS (Keep it Small and Simple) principle, it is possible to modify the front-end electronics with little effort and adapt it to different PMT signal shapes. The first version of the PaDiWa-AMPS front-end electronics was optimized for HADES ECAL PMTs and was already successfully tested under beam conditions [4].

In Fig. 1 (left) a Hodoscope PMT signal is shown. In comparison, HADES ECAL PMT pulse-shapes have an amplitude of about 1 V and a pulse-width of about 50 ns. An adaption to the smaller and shorter Hodoscope signals was needed. By modifying the input attenuation of the PaDiWa-AMPS front-end board and by reducing the integration time by an FPGA design update, a significant improvement in the signal-to-noise ratio and in the rate capability has been achieved. In Fig. 1 (right) the charge measurement of the Hodoscope version is shown.

By subtracting the measured time information of the Start detector $t_0$ from the Hodoscope $t_1$ and with the assumption $\sigma^2 \cong \sigma_{\mathrm{Hodo}}^2 + \sigma_{\mathrm{Start}}^2$ a time measurement precision of the Hodoscope and the Start detector could be estimated. After time-walk corrections and for events with the pion beam aligned in the central part of both detectors a

time resolution of $\sigma_{\mathrm{Hodo}} \cong \sigma_{\mathrm{Start}} \cong \frac{\sigma_{\mathrm{Fit}}}{\sqrt{2}} = 196\,$ps could be achieved (see Fig. 2).
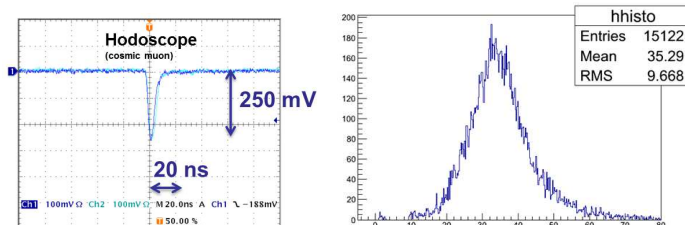


Figure 1: PMT pulse-shape of the Hodoscope (left). The measured charge encoded in the width of the integrated and linearly discharged signal (right).
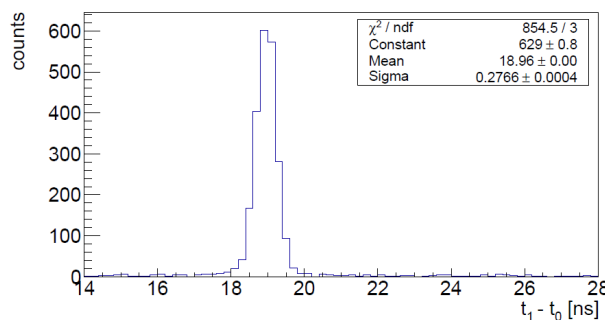


Figure 2: Time difference between Hodoscope and Start detector after time-walk corrections and for events with pion beam aligned in the central part of both detectors.

## References

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