Study of the timing resolution of a PANDA Barrel DIRC prototype

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A prototype of the PANDA Barrel DIRC [1] detector was tested with hadronic beams at the CERN PS in the summer of 2012. The outcome of this test was analysed during the last year and converted into design improvements. A synthetic fused silica bar ($17 \times 35 \times 1225$ mm^3) with a focusing lens attached to one end and a mirror to the other end was placed into a light-tight container. A large synthetic fused silica prism with a depth of 30 cm, located about 2 mm from the lens, served as expansion volume. The hit location and the photon propagation time of photons were measured with an array of nine Micro-Channel Plate Photomultiplier Tubes (MCP-PMTs) coupled with optical grease to the back surface of the prism. The data acquisition for 896 channels was performed using the TRB (version 2) boards [2] in combination with TOF addOns [3], customized for MCP-PMT readout. The primary goal were the determination of the single photon Cherenkov angle resolution and the photon yield for several design options, including different focusing systems and radiator sizes.

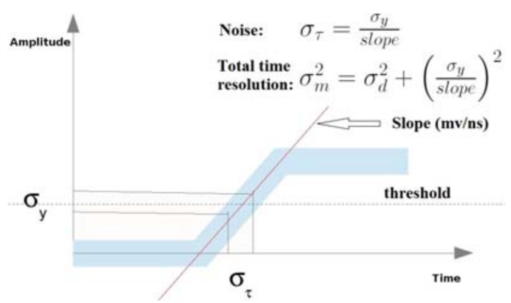

Figure 1: Schematic of signal amplitude vs. time, illustrating the influence of noise on the timing resolution.

The observed timing resolution of $\sigma \approx 150 - 200$ ps was significantly worse than the goal of $\sigma < 100$ ps. Since test bench measurements had previously demonstrated that the intrinsic resolution of the Photonis Planacon MCP-PMT is less than 50 ps [4], the readout system was studied in detail at GSI after the beam time. For this study we used a Tektronix pulse generator (AFG3252) to vary amplitude and rise time of the signal. Any noise on the pure single photon signal, picked up by the MCP-PMT or the cable connecting the sensor to the discriminator, contributes to the measured timing jitter σ_m via the slope of the signal, as shown in Fig. 1, taking the timing jitter of the discriminator σ_d into account. The results of a measurement for one of the addOn boards used during the beam time are shown in Fig. 2 for a range of signal amplitudes. The slopes of the signals were adjusted by changing the rise times for the corresponding signal heights. The timing resolution drops as as a function of the signal slope, independent of the signal amplitude and converges asymptotically to the timing jitter value of the discriminator. The slope of the rise time of a Planacon MCP-PMT is about 5 mV/ns, which corresponds to a contribution of 60 ps from the readout to the single photon timing resolution.

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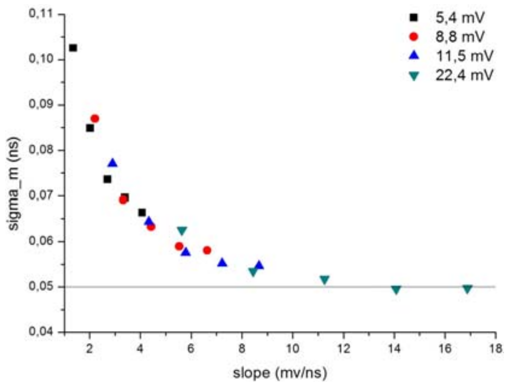

Figure 2: Timing resolution sigma_m vs. slope of the signal for a NINO threshold of 1.65 mV. The symbols represent different signal amplitudes.

The time resolution observed during the CERN test beam experiment would be consistent with a rather high noise level of $\sigma_{noise} = 1.2$ mV. This noise may have been pick-up from the 2 m-long cables between the MCP-PMT array and the addOn boards with the long cables acting as antennas in the busy T9 beam line area.
The next PANDA Barrel DIRC prototype, with an improved readout system based on the TRB version 3 [5] in combination with a new discriminator board (PADIWA), will be tested with particle beams at GSI in the summer of 2014.

References

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