Towards new Front-End Electronics for the HADES Drift Chamber System

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Abstract

Operating HADES at the future FAIR SIS-100 accelerator challenges the rate capability of DAQ and electronics. A new, more robust version of front-end electronics needs to be built for the HADES drift chamber system. Due to the unavailability of the previously used ASD-8 analog read-out ASIC, PASTTREC (PANDA straw tube read-out ASIC) was tested as an ASD-8 replacement in different scenarios including a beam test. PASTTREC falls 20\% short of the ASD-8 time precision but performs better w.r.t. signal charge measurements and overall operation stability. The measured time precision as a function of distance to the sense wire was modeled within a 3D GARFIELD simulation of the HADES drift cell.

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1. Introduction

In the HADES set-up 24 Mini (cell) Drift Chambers (MDC) allow for track reconstruction and determination of charged particle momenta via deflection in a magnetic field. In addition, MDC supplements particle identification by measuring the specific energy loss. Each of the 27000 sensing wires are equipped with a preamplifier, analog pulse shaper and discriminator, which are combined in the ASD-8 \cite{1} ASIC. Due to limitations of the current on-board TDCs, especially regarding higher reaction rates, the electronics need to be replaced by new boards featuring multi-hit TDCs. Whereas ASD-8 chips cannot be procured anymore, a promising replacement candidate is the PASTTREC \cite{2} ASIC, developed by JU Krakow. We tested the ASIC as read-out option for MDC in a variety of set-ups in direct comparison to ASD-8.

Figure 1: Sketch of the COSY beam test set-up to assess timing precision of the joint system comprising a drift chamber and different read-out electronics.

![Figure 1](image1.png)

Figure 2: Arrival time and time precision of an MDC drift cell read out with ASD-8 and PASTTREC as a function of track distance to sense wire. The arrival time measurement has a systematic offset due to unknown propagation delay in cables and electronics. The lower plot shows the standard deviation of an asymmetric gaussian fit of the arrival time distribution.

2. Beam test

The timing precision was assessed during a beam test at COSY/Jülich using a minimum ionizing proton beam. As shown in figure\textsuperscript{1} a diamond detector\textsuperscript{3} provides reference time and triggers on particles in a narrow beam slice (<100\,\mu m), aligned with the orientation of the sensing wire, i.e. at near constant distance to it. The resulting arrival time and arrival time precision is depicted in figure\textsuperscript{2}. After applying a walk correction based on the time-above-threshold information, the PASTTREC falls short of the performance of the ASD-8 by only 20\%. The difference can be attributed to the longer peaking time of PASTTREC (15\,ns) in contrast to ASD-8 (7\,ns).
3. Laboratory tests

Apart from testing and preparing the DAQ system for a beam test, the drift-chamber set-up at the GSI detector lab allowed for complementary measurements. The two adjacent sense-wire layers were shifted relative to each other by half the cell width to enable intrinsic drift time precision measurements by correlating (summing) the drift times of overlapping cells while tracking cosmic muons. The measured precisions are in agreement with the beam test data.

To study energy loss measurement precision, a drift chamber was irradiated with a $^{55}$Fe X-ray source while varying the high voltage. The pulse charge spectrum (figure 3) is derived from the time-over-threshold information via a calibration function. PASTTREC was able to separate the $^{55}$Mn K-alpha peak from the Ar escape peak while varying the gain by a factor of 15. In the ASD-8 data no clear separation could be observed.

4. GARFIELD simulation

The beam test was simulated using 3D GARFIELD [4] and the measured drift time as function of track position was reproduced. To model the characteristic “W” shape of the measured precision, two additional effects had to be taken into account in the simulation: First a gaussian error added as proxy for the noise at the input of the preamplifier. Second, the effect of the discriminator threshold was imitated by waiting for the n-th fastest electron to arrive at the sensing wire. As seen in figure 4 the gaussian noise defines the best precision achieved while the integration over more than one electron deteriorates the resolution in the vicinity of the sensing and potential wires. According to this model, ASD-8 is sensitive to the third arriving electron, while PASTTREC reacts to the fourth to fifth arriving electron, as expected due to the different peaking times.

5. Conclusion

The PASTTREC ASIC was tested for its suitability to replace ASD-8 for the read-out of the HADES drift chambers. While a better time precision is observed when the detector is read out with ASD-8, a PASTTREC-based read-out seems to benefit the measurement of the deposited energy. We interpret these findings as an indication that particle identification in HADES will significantly improve when employing PASTTREC. This benefit might outweigh the loss in spatial precision, especially because PASTTREC proved to be far less susceptible to pickup noise and self-oscillation than the ASD-8-based FEE, both in the beam test and the lab test environment.

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References

[1] F.M. Newcomer, A Fast Low Power, Amplifier-Shaper-Discriminator for High Rate Straw Tracking Systems, IEEE Transactions on Nuclear Science, 40(4):630, August 1993
[2] G. Korcyl et al., "Readout electronics and data acquisition for gaseous tracking detectors," in IEEE Transactions on Nuclear Science, vol. PP, no. 99, pp. 1-1. doi: 10.1109/TNS.2017.2786464
[3] J. Pietraszek et al., doi:10.15120/GIR-2015-1-MU-NQM-HADES-28
[4] GARFIELD 9, Simulation of gaseous detectors, http://cern.ch/garfield