The RoentDek Delay-Line Detector
Applications and Experiences

Harald Bräuning

Institut für Kernphysik, Justus-Liebig Universität, D-35392 Giessen, Germany

The Giessen ion-ion crossed-beams experiment offers a great opportunity to study specially tailored collision systems like e.g. pure one-electron systems (see [1] for an overview). Two ECR sources produce the ion beams which are crossed under an angle of 17.5^o degrees. The reaction products are detected with a channeltron detector and a position sensitive Micro-Channel-Plate (MCP) detector. The position readout is achieved by a resistive anode.
Recently we have extended our studies towards the break-up of molecular ions, especially H_2^+ [2]. For complete experiments with molecules the position sensitive detection of the product ions from both beams is necessary. We have thus exchanged the channeltron detector with a RoentDek [3] delay-line detector to detect the molecular fragments. This detector fulfills our following requirements (in decreasing order of importance):

- UHV compatible and bakable (up to 150^oC)
- single particle detection
- time resolution $\leq$ 1 ns
- high count rate capability (100 kHz – 1 MHz)
- large active area ($\geq$ 40 mm diameter)
- position resolution $\leq$ 0.5 mm
- double hit capable

A detector with discrete pixel readout has never been considered by us due to the large amount of electronics needed. In addition with a delay-line readout the detector image can be directly displayed on an oscilloscope in x-y mode, which greatly simplifies the beam tuning. Another advantage of the delay-line readout over methods using charge distributions — besides the multihit capability — is the fact that both dimensions are completely decoupled. Thus while the image might by squeezed horizontally or vertically, it will never be distorted in a way as it happens with a Wedge&Strip Anode for example, when the amplifiers are not calibrated well.
The detector installed consists of 2 MCPs in chevron configuration. The MCPs are made by Photonics with 44 mm active diameter and 1 mm thickness. The length-to-diameter ratio of the channels is 80:1. The MCPs are matched in resistance with 161 MΩ and 162 MΩ, respectively. These plates require a rather high operating voltage. To achieve pulse heights in the order of 100–200 mV we apply 2.8–3.0 kV across both MCPs. The delay line anode is of the conventional two-layer design. Thus the double hit detection capability is intrinsically limited by the pulse pair

resolution of the subsequent electronics. Very good constant-fraction discriminators (CFD) like the Ortec 934 quad CFD have pulse pair resolution in the order of 5 ns. The VME based CAEN V767A multihit TDC used by us for the readout has a pulse pair resolution of 10 ns.
Figure 1 shows the high voltage connections to the detector with the typical operating voltages. The parts inside the frames are part of the DLA-TR6 module which

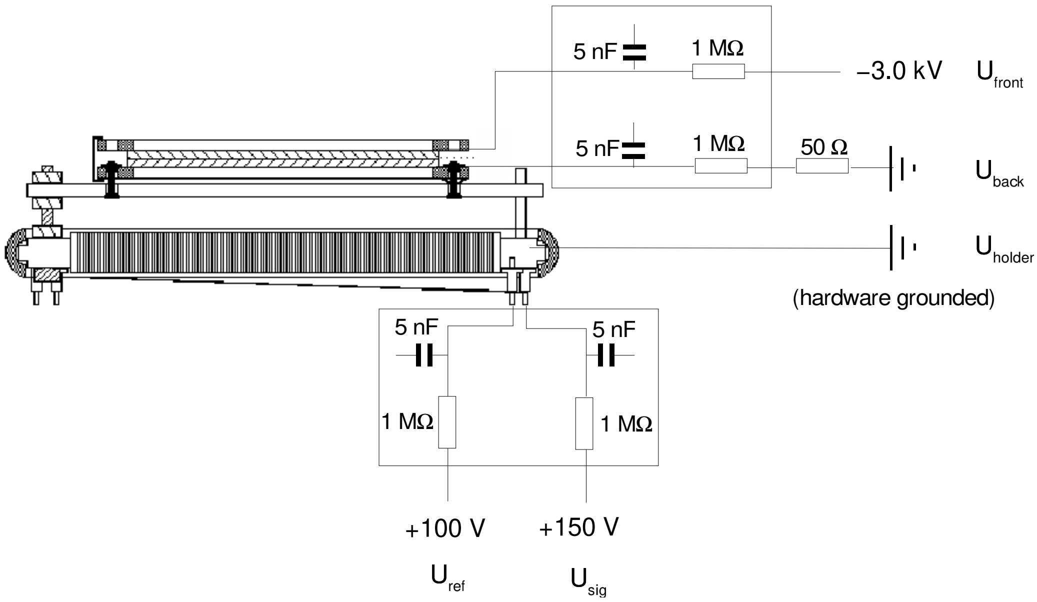

Figure 1: High voltage connection to the detector and typical operating voltages.

also houses the differential amplifier and the CFDs. The DLA-TR6 not only contains practically all of the needed electronics in one single module but also provides easy and reliable connections to the detector via a special cable and 12-pin UHV feedthrough and to the power supplies. It is furthermore available with NIM or ECL outputs, with the latter version used by us. However, the high packaging density has several severe disadvantages. Most important is the fact, that there is only one discriminator level for all 4 delay-line channels. Thus different pulse heights on the different channels cannot be compensated for by different discriminator levels. This results in a significant amount of events where one or more delay-line signals are missing and where the position cannot be obtained. Furthermore, this is usually position dependent, resulting in dark areas on the image. There are two ways to avoid this. First, the amplification of the amplifiers can be adjusted. This however requires opening of the module, which is not advisable when the detector is in operation as the high voltage terminals might be touched. We currently obtain very good results by using the analog output of the DLA-TR6 with a separate CFD, where all thresholds can be adjusted separatly.
Figure 2 shows the typical pulses obtained from the front side of the MCP and one end of the delay-line. All pulses are clearly separated from the noise. The total count rate was in the order of 50–100 kHz. While the overall count rate of the RoentDek delay-line detectors exceeds 1 MHz, great care has to be taken, when the distribution

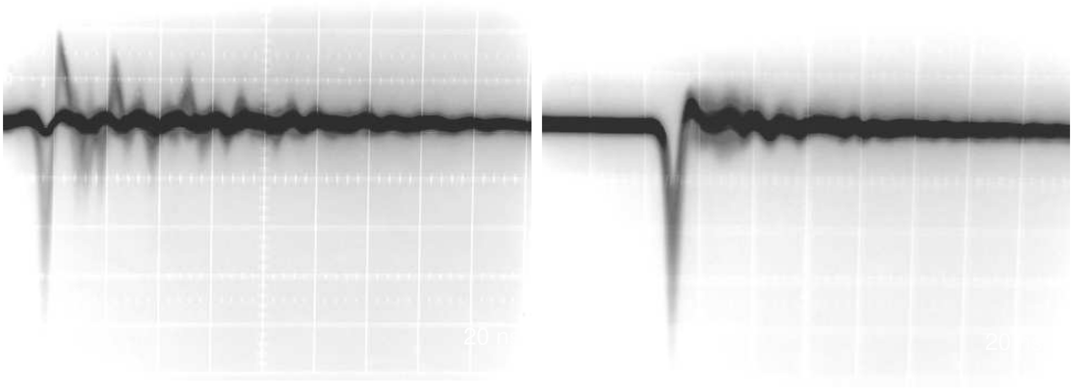

Figure 2: Typical pulses from the MCP front (left) and delay-line (right). The pulse width is significantly less than 10 ns. The pulse heights are in the order of 100–200 mV.

is not uniform. We have used another RoentDek detector in an experiment at GSI, Darmstadt, studying electron capture from thin carbon foils into 46 MeV/u U^{91+} ions. The detector was used to detect the various charge states which are well localized. Here a dependence on the ratio U^{90+} / U^{91+} on the count rate has been observed. This is the result of a local breakdown of the MCP voltage due to the high rate. The pulse height decreases for these events which results in a locally reduced detection efficiency. From these experiments we estimate a maximum count rate in the order of 230 Hz mm^{-2}.

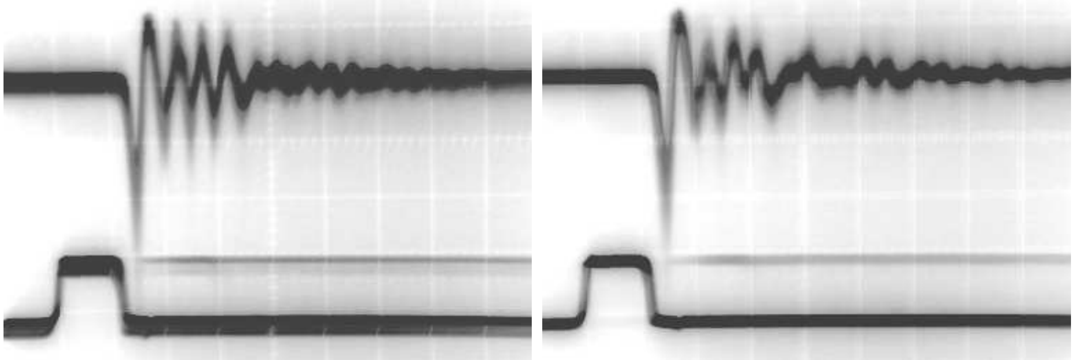

Figure 3: Signalshape from MCP front depending on the termination of the unused signal line for MCP back.

While double hit detection is currently not needed in our experiment, it is a future option. As already mentioned the double hit capability is intrinsically limited by the electronics. However, ringing on the signals also influences the double hit performance by possible false triggers. As can be seen from figure 2 the delay-line signals are very clean but the signals from the MCP have a significant amount of ringing. It should be noted that in our setup the cables between detector and amplifier are by necessity very long, unshielded and the connectors are not soldered but pressed to the wires. Still the ringing can be positively influenced by terminating unused signal lines after decoupling from the high voltage with a variable resistor. The DLA-TR6 module provides this possibility. The effect can be seen in figure 3, where the pulse height of the ringing could be significantly reduced.

To summarize, while the RoentDek delay-line detectors are not plug and play yet, they perform well and are reliable. In good vacuum conditions we have found them so far to be quite forgiving concerning the occasional spark or very high rates.

References

[1] F. Melchert and E. Salzborn. In Y. Itikawa, editor, *The Physics of Electronic and Atomic Collisions*, pages 478–494, Sendai, 1999. American Institute of Physics.

[2] H. Bräuning, I. Reiser, A. Diehl, A. Theiß, E. Sidky, C.L. Cocke, and E. Salzborn. *J. Phys. B: At. Mol. Opt. Phys.*, 34:L321, 2001.

[3] RoentDek Handels GmbH. www.roentdek.com.