A Position-Sensitive Xe Gas Detector for Hard X Rays

M. Czanta[1], S. Toleikis[1], C. Strietzel[2], G. Menzel[1], D. Liesen[1], H.F. Beyer[1],
H.J. Besch[2], N. Pavel[2], B. Manil[4], J. Tschischgale[3], A.H. Walenta[2]
[1] *GSI Darmstadt,* [2] *Universität Siegen,* [3] *FSU zu Jena,* [4] *Université de Paris, France*

Quantumelectrodynamical contributions to electronic binding energies in atoms can be investigated by accurate x-ray spectroscopy of highly charged ions. Parallel to the latest advances in theory [1], new experimental approaches have been developed based on the determination of Lyman-alpha energies of very heavy hydrogenlike ions [2,3].

To approach the energy accuracy of theoretical calculations of about 1 eV for $2p_{3/2}-1s$ transition photons at nearly 100 keV, some of these experiments require two-dimensional position-sensitive detectors with efficiencies close to 100 % for hard x-rays and a high spatial resolution of at least 200 µm in one dimension and about 1–2 mm in the perpendicular direction.

For this purpose a gas filled detector has been developed in a collaboration between the University of Siegen and GSI. It is based on the principle of the Time Projection Chamber (TPC) [4] with a sensitive front area of 20×100 mm^2 size. The 200 µm position information is achieved by measuring the drift time of the induced charge cloud and the second dimension is obtained from conducting cathode stripes near the anode wires.

In order to reach a very high absorption efficiency, the detector is filled with Xe gas at pressures of about 20 bar. A quenching gas was added to optimize the spatial resolution by absorbing UV-photons. Varying the amount of the quenching component CH_4, the energy resolution could be improved from 48 % FWHM for a 90:10 to 37 % FWHM for a 83:17 mixture.

Observing the dark rate in dependence on the total amount of Xe in the detector, it appeared that the gas contains a remarkable amount of radioactive isotopes adding up to about 1 Hz per liter Xe-gas. This is most likely due to very small amounts of ^{85}Kr still remaining in the Xe on a level well below any commercially obtainable purities.

Further investigations were carried out to examine the position resolution along the 20 mm long drift direction. Here, a lead slit of 200 µm was moved to different positions in front of the detector. The necessary timing information for photoelectron creation by the observed 81 keV photons of a ^{133}Ba source was achieved by means of a Ge detector triggering on a correlated photon out of a γ–γ cascade. Fig. 1 shows intensity profiles for four different positions as seen by the gas detector after separation of the spatially broad distribution of Xe fluorescence photons.

Focusing on the small movement of only 208 µm as pictured in Fig. 2, it could be shown that a resolution of about 200 µm can easily be reached. In addition, as seen in Fig. 3, the position information correlates perfectly linear with the actual position of the slit.

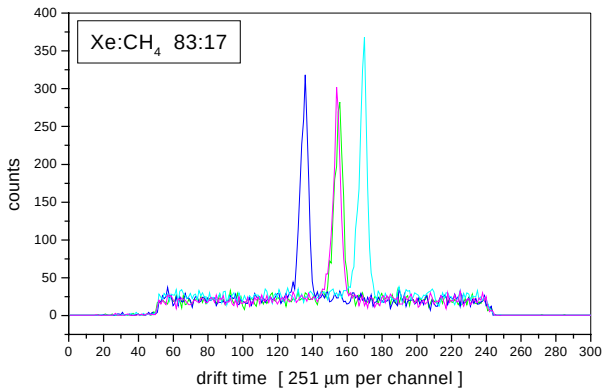

Figure 1: Intensity profiles for four different positions of a moveable lead slit. The widths of the peaks correspond to about 1 mm due to the divergence of the x-rays. The outer steps are a consequence of electronic conditions.

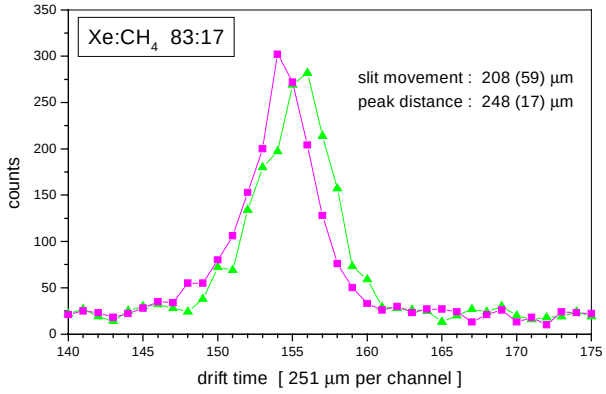

Figure 2: Intensity profiles for two slit positions with a spacing of ~ 200 µm.

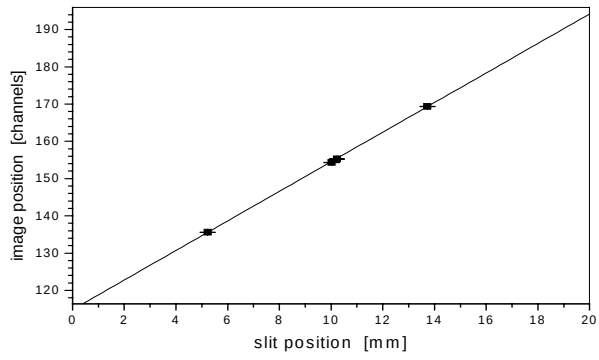

Figure 3: Image positions as seen by the gas detector as a function of the slit position.

References

[1] I. Goidenko et. al., Phys. Rev. Lett. 83, 2312 (1999)
[2] H.F. Beyer, Nucl. Instr. Meth. A400, 137 (1997)
[3] C. Strietzel et. al., this Annual Report
[4] E. Badura et. al., GSI Scient. Rep. 1997, p.181