

Drift Time Measurements on Lanthanide Elements \diamond

M. Laatiaoui, L. Trepl, M. Sewtz, D. Habs, W. Lauth^a, and H. Backe^a

^a Institut für Kernphysik der Universität Mainz, 55099 Mainz

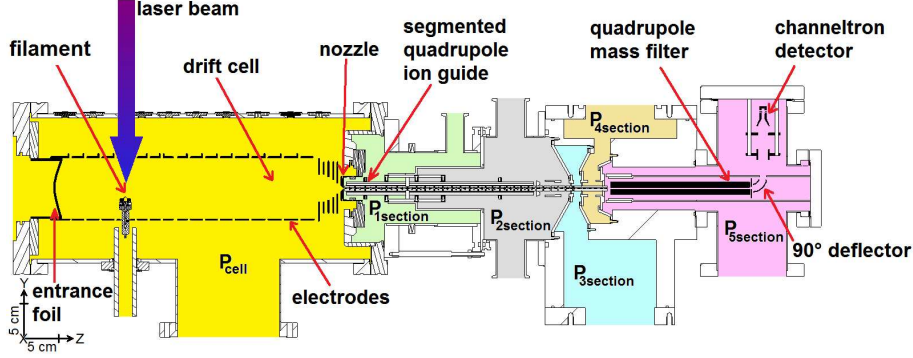


Fig. 1: Schematic view of the developed drift time spectrometer.

A drift time spectrometer for heavy element research (Fig.1) has been developed and extensively tested. It consists of a drift cell and a differential pumping section containing a segmented quadrupole ion guide (QPIG), a mass filter and a channeltron detector. The drift cell is decoupled from the differential pumping section by an extraction nozzle of 0.5 mm throat diameter. The apparatus is designed for drift time measurements at a ratio $E/N < 10^{-16}$ Vcm². E denotes the static electric field strength and N is the number density of buffer gas atoms in the drift region. First systematic drift time measurements were performed using an erbium and holmium filament in off-line experiments. The filament is placed inside the drift cell at 32 cm distance from the extraction nozzle. After evaporation from the filament Er and Ho atoms are resonantly ionized in a two-step excitation scheme via two suitable laser wavelengths. In a homogeneous electric field and at an argon pressure of 40 mbar the ions drift towards the nozzle and get extracted out of the drift cell. After extraction the ions are trapped inside the QPIG and transferred to the high vacuum section, where mass selective detection occurs. In the differential pumping section the background pressure decreases from $4 \cdot 10^{-2}$ mbar near the nozzle up to 10^{-6} mbar in the last pumping section.

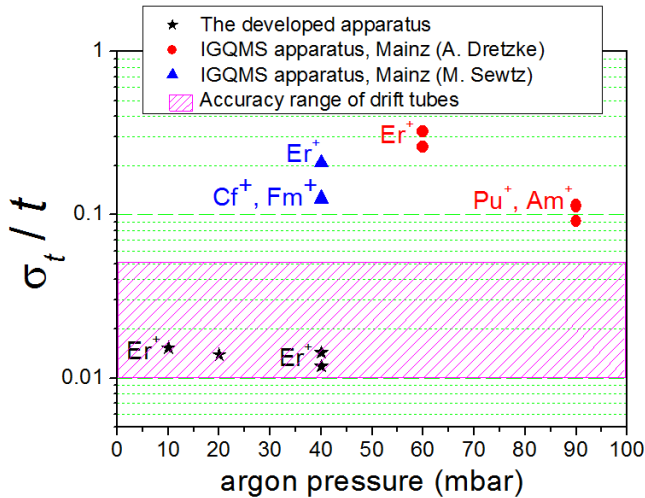


Fig. 2: Relative drift time uncertainty of the developed spectrometer compared with antecessor drift cells [1,2].

The arrival time distribution (ATD) of a certain ion is usually a gaussian with its uncertainty σ_t , which is predefined by the longitudinal and transversal diffusion of the ions during their drift. Hence the lower limit of the relative uncertainty for usual drift time spectrometers can be given by 1%. The developed spectrometer comes close to this lower limit as seen in Fig. 2 and thus provides a good tool for testing the dependence of the drift time of lanthanides and actinides on their ionic radii [3,4].

In Fig. 3 the ATDs of Er⁺ and Ho⁺ imply a tiny drift time difference of ca. 80 μ s at an ATD mean of 35 ms of the neighboring elements, which remains unresolved even for sophisticated future spectrometers. The fact that Er⁺ drifts faster than Ho⁺ may be traced back to the relatively stronger relativistic contraction of the valence-electrons at the heavier erbium ion. The contraction of the molecular bound length [5] at their oxides would underline this conclusion. Future experiments will focus on systematic drift time measurements at lanthanides and by exploiting the electrodeposition techniques [6] at the actinides as well.

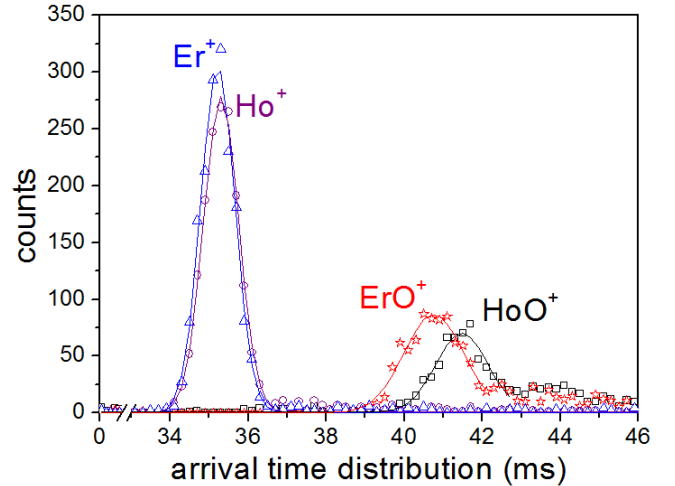


Fig. 3: Arrival time distribution of Er⁺, Ho⁺ and their oxides at an $E/N = 3.1$ Td and an argon pressure of 40.5 mbar.

References

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