Position Sensitive TOF-ERD Analysis

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1. TOF-Elastic-Recoil-Detection

Time-of-flight (TOF)-spectrometry as a technique for elastic recoil detection analysis with heavy ions has been established at the Q3D-ERD-setup to quantify the results of high resolution measurements obtained with the Q3D-magnetic-spectrograph. This time of flight setup was enhanced in order to achieve better timing resolutions.
Therefore an existing system of a position-sensitive MCP-detector for secondary electrones has been optimized and adopted to give a start and stop signal. Thus a reliably working TOF-spectrometer was established, whose intrinsic timing resolution could be determined to be 120 ps. This is an improvement of one order of magnitude compared to the setup before and allows now the separation of light elements without any background.
Using a 40 MeV ^{179}Au beam, a scattering angle of 40° at an incident angle of 4° a depth resolution of about 3 nm is achieved in the surface near region.

The data given by a TOF-ERD analysis led to the depth profile of seven elements forming a TiN/Al_2O_3/TiN-multilayer, which thickness was about 70 nm (Fig.1). As in depths more than about 20 nm no nanometer resolution can be achieved in principle [1], this rather simple technique can be used measuring such thick layers instead of the very time-consuming method of using different settings of the Q3D magnetic spectrograph for every element to get the data for the calculation of depth profiles.

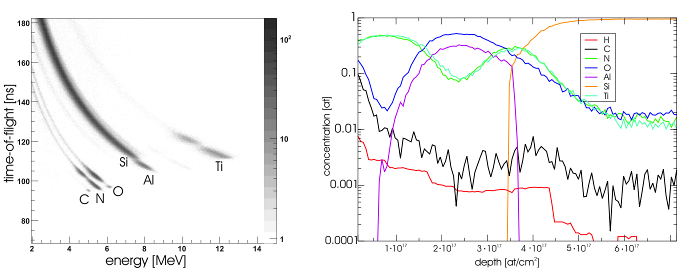

Fig. 1: TOF-E-histogramm and calculated depth profile of a TiN/Al_2O_3/TiN-multilayer

2. Position-Sensitive-Time-of-Flight-Spectrometry

Using this conventional TOF-ERD technique, such high timing resolutions are achieved by admitting only a very small solid angle. Considering the described TOF spectrometer, which solid angle is already limited to about 0.1 msr, timing resolution downgrades to a level not better than 280 ps. This effect is dominated by a kinematical time shift due to the angular acceptance of the detector system. Thus deterioration of sensitive layers due to necessarily high beam currents before getting enough data is a serious problem.
To correct for the kinematical effects and apply detectors with a larger solid angle, it is necessary to measure the actual scattering angle (Fig.2).

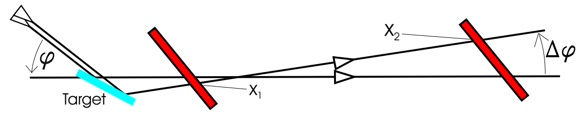

Fig. 2: Reconstruction of flight path by two position measurements

The developement of a special imaging electrostatic lense (Fig.3) along with a backgammon anode made it possible to measure the position of ions passing the detector with an accuracy better than 0.5 mm (Fig.4).

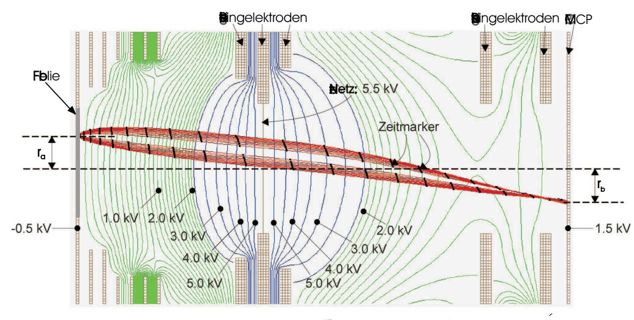

Fig. 3: Simulation of the electrostatic lense.

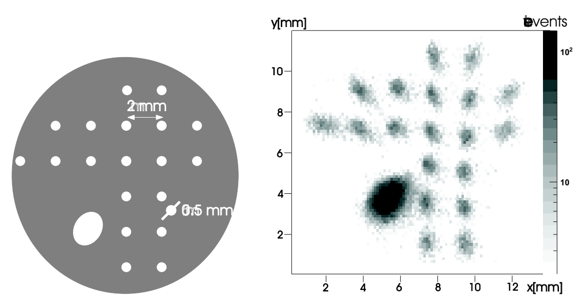

Fig. 4: Mask used in a test of the position measurement and the resulting image

Energy- as well as angle-scattering in the foils of the detectors are reduced to a minimum with recently adopted diamond-like-carbon foils [2], which are as thin as 0.6 μg/cm^2. In combination with the measurement of the scattering angle, this will make timing resolutions better than 200 ps possible.
Channelplates with 75 mm in diameter for the stop counter and a suited highly resolving energy detector will provide a solid angle of up to 3.3 msr for a unique ERD setup.

References

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[2] V.K. Liechtenstein, *et al.*, Nucl.Instr.Meth. **A 521** (2004) 197-202