A New Optical Detector for the TRIGA-LASER Experiment

J. Krämer[1], M. Hammen[1], K. Eberhardt[1], Ch. Geppert[1,2], N. Frömmgen[1], A. Krieger[1], W. Nörtershäuser[1,2], R. Sánchez[1,2], B. Sieber[1] and the TRIGA-SPEC collaboration

[1]Institut für Kernchemie, Johannes Gutenberg-Universität, D-55128 Mainz, Germany; GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Introduction: The TRIGA-LASER experiment within the TRIGASPEC collaboration aims for the study of neutron-rich fission products from the TRIGA Mainz research reactor [1]. Owing to its simplicity and versatility a purely optical detection setup will be used for fluorescence detection. To really be able to explore new ground on the nuclear chart with respect to spin, radii and nuclear moment determination, a high detection efficiency combined with strong background suppression is required. Therefore, we designed a new optical detection setup using a dedicated optical ray-tracing program.

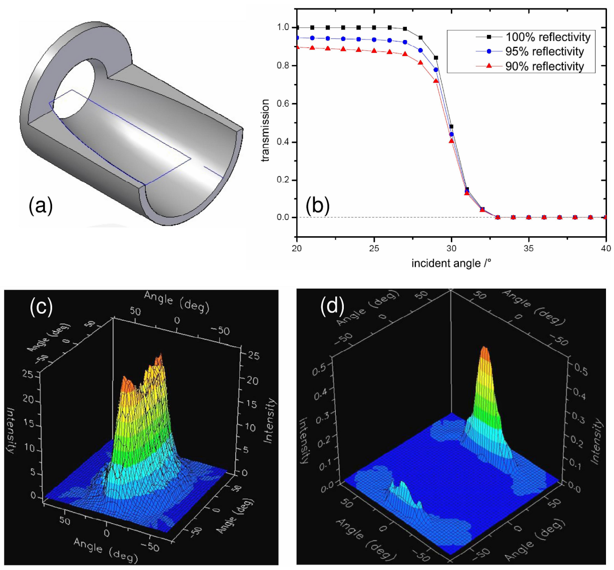

Figure 1: (a) Compound parabolic concentrator (CPC) for the phase space selection. (b) Simulated angular dependence of the concentrator transmission. (c) Simulated angular distribution of the fluorescence light and the straylight (d).

Experimental: The optical detection setup [2] is based on an elliptical light collecting mirror with symmetry plane along the beam axis combined with a compound parabolic concentrator (CPC). The optical elements were simulated and optimized using the optical raytracing software FRED. In Fig. 1 (b) the dependence of the CPC transmission on the angle of the incident light ray is shown as extracted from the simulation. As the fluorescence photons have a different distribution (Fig. 1 (d)) than the stray light photons (Fig. 1 (c)), the CPC can discriminate stray light while cutting only a small part of the fluorescence light. The light collection mirror is mounted in a custom-made vacuum chamber. The optical detection device was tested by laser spectroscopy with Ca^+ ions. The 4s $^2S_{1/2} \rightarrow$ 4p $^2P_{3/2}$ transition at 393.37 nm was excited with a diode laser after second-harmonic generation.

Results: The detection efficiency averaged over several measurements is 1 detected fluorescence photon from 260 ions passing the detector, a very good value considering also the rather low straylight background of 2.5×10^4 s^{-1} per mW of laser power. This is a clear improvement compared to the old setup for Rb atoms with a level of > 2×10^5 s^{-1} per mW. Fig. 2 shows a comparison of two resonances taken under similar conditions. The difference in the background level is well pronounced and means a significant increase in signal-to-noise ratio. However, the

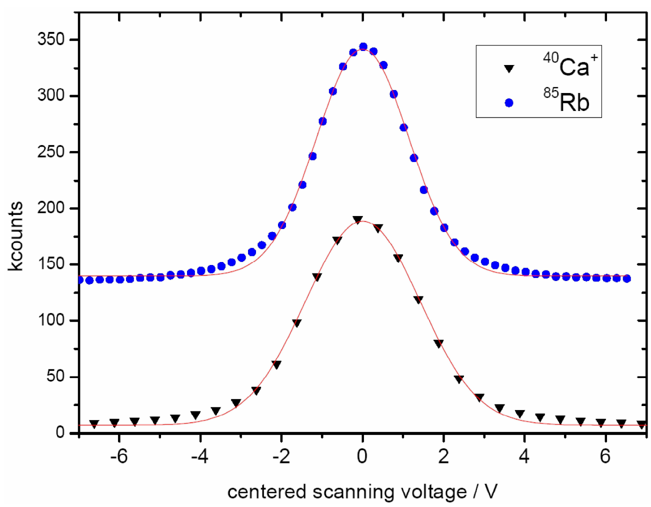

Figure 2: Comparison of resonances taken with the old detector (Rb^{85}) and the newly designed detector (Ca^{40}).

performance of the detector is still lower than expected from the simulations, which is ascribed to a long lived dark state in the Ca^+ atomic system. Further tests with simpler atomic systems will be performed to clarify this. Additionally, a better mirror coating with higher reflectivity and applicable to a wider spectral region will be investigated.

References

[1] J. Ketelaer, J. Krämer, et al., Nucl. Instrum. Methods Phys. Res., Sect. **A 594** (2008) 162-177.

[2] M. Hammen, Diplomarbeit, Johannes Gutenberg-Universit¨at Mainz, 2010.

Acknowledgement

Work supported by HGF under contract VH-NG-148 and 'Stiftung Rheinland-Pfalz f¨ur Innovation' under contract 961-386261/854.