Ion Beam Cooling and Trapping at TRIGA-SPEC

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The TRIGA-SPEC setup is the prototype for mass spectrometry and laser spectroscopy at the low-energy branch at FAIR (MATS and LASPEC [1]). At the TRIGA Mainz research reactor this setup serves for the determination of nuclear ground state properties of neutron-rich fission products. Studies in the medium-mass region will yield information to benchmark mass models, nuclear structure calculations and investigate so far unexplored regions towards the r-process path of nuclear synthesis [2].

The TRIGA reactor provides a continuous neutron flux of 10^{11} n/(s·cm^2) to induce nuclear fission in a 300 µg ^{235}U target. The target chamber is flushed with a nitrogen buffer gas and aerosol particles of potassium chloride. The fission products, adsorbed to the aerosol particles, are transported into a surface ion source that is held on high-voltage potential. Temperatures of about 2000°C lead to a release and ionization of the fission products. The ions are extracted against ground potential at 28 keV and are subsequently mass separated in a dipole magnet. A radio-frequency quadrupole RFQ cooler-buncher accumulates the ions in an axial potential well where they are cooled by collisions with the buffer gas (helium) and released as bunches to either the mass spectrometry TRIGATRAP or laser spectroscopy branch TRIGA-LASER.

In 2012, an ion beam was transported through all components of the TRIGA-TRAP and the TRIGA-LASER beam lines for the first time. For the mass spectrometry branch, a 50 pA $^{85}Rb^+$ ion beam was produced in the ion source, cooled and bunched in the RFQ. The transmission efficiency was estimated in the continuous-mode to about 25%. A pulsed drift tube decelerated the bunches to prepare them for injection into the double Penning trap mass spectrometer. The $^{85}Rb^+$ ions were purified in the preparation trap and then injected into the precision trap. A (time-of-flight) cyclotron resonance spectrum was recorded as depicted in Fig. 1.

For TRIGA-LASER, a $^{40}Ca^+$ ion beam was cooled. The RFQ was operated in the continuous-mode at a buffer gas pressure of about 10^{-4} mbar. The transport efficiency was measured using a Faraday cup at the end of the beam line to be about 15%. The very first observation of a

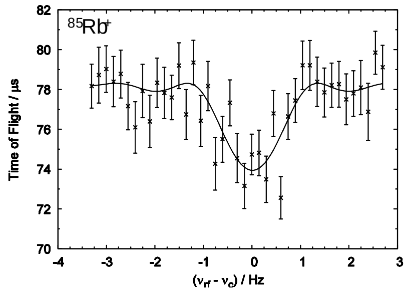

Figure 1: Time-of-flight ion cyclotron resonance spectrum of $^{85}Rb^+$ as a function of the irradiated radio frequency ν_{rf}.

resonance fluorescence spectrum as shown in Fig. 2 was made by collinearly superimposing the Ca beam with laser light of 397 nm. The Doppler-shifted laser frequency was tuned into resonance with the D1 transition applying an additional acceleration voltage to the optical detection region. Further investigations are now ongoing.

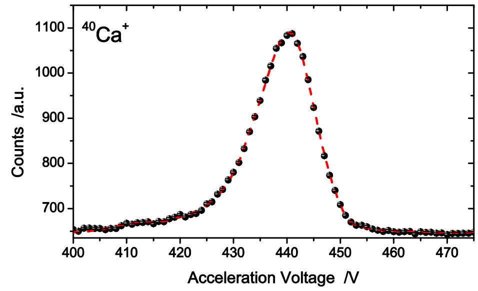

Figure 2: Resonance spectrum of the $2s_{1/2} \rightarrow 2p_{1/2}$ transition in $^{40}Ca^+$. The dashed line shows a multiple Voigt fit to take the asymmetry into account.

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