Progress of the on-line coupling of TRIGA-SPEC

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Introduction: All interactions inside a nucleus are reflected by ground state-properties like mass, magnetic moment, spin and charge radius. Thus, high-precision measurements of these properties are of fundamental importance for nucleosynthesis and nuclear structure studies. The TRIGA-SPEC experiment, which is located at the research reactor TRIGA Mainz, aims for high-precision investigations on neutron-rich radionuclides to obtain the ground-state properties model-independently by means of Penning trap mass spectrometry and collinear laser spectroscopy [1].

The radionuclides are produced by thermal neutron-induced fission of an actinoide target like ^{235}U or ^{249}Cf mounted in a target chamber near the reactor core. The fission products are thermalized in an argon atmosphere at a pressure of about 1.4 bars pressure. After thermalization the non-volatile fission products attach to carbon aerosol particles seeded in the argon gas. The aerosol is subsequently flushed out through a capillary to the experimental setup, where carrier gas and aerosol particles are separated by a skimmer. The fission products break off from the aerosol particles in an electron plasma inside an ECR or in a high-temperature surface ion source on a high-voltage platform. After ionization the fission products are mass-separated in a dipole magnet, cooled and bunched in a radiofrequency quadrupole, and finally transferred either towards the collinear laser spectroscopy beam line or the Penning trap mass spectrometer setup.

Experimental setup and results: The experimental setup of the ECR ion source with the skimmer chamber mounted on an high-voltage platform is shown in Fig. 1. When the gas leaves the capillary, it expands in a Mach cone. The hole of the skimmer is placed inside the cone, the so-called zone of silence, where the supersonic expansion takes place without turbulences.

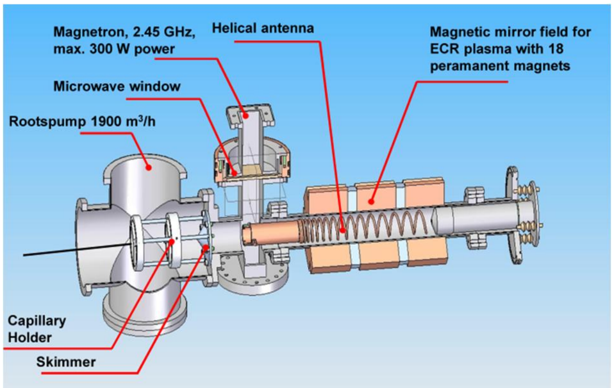

Fig. 1: Sketch of the ECR ion source with the skimmer region. The gas-jet enters the skimmer region through the capillary on the left, passes the skimmer, and is ionized in the plasma.

While most of the light carrier gas is pumped away by a roots pump, the heavy aerosol particles in the center of the Mach cone pass the skimmer and enter the ECR ion source. Inside the ion source the electrons are heated by a 2.45-GHz microwave on a closed surface of constant magnetic field strength, where the excitation frequency matches the cyclotron frequency of the electrons. Thereby, a hot electron plasma is created and confined due to the magnetic mirror effect.

Pure argon was used as carrier gas for the first tests of the ECR ion source and mass separator. The ion source was operated at a high-voltage of 20 kV and after ionization argon and residual ions were extracted from the plasma to ground. The beam was then mass-separated in the dipole magnet and detected on a Faraday cup. Figure 2 shows the beam current as a function of the magnetic field. In the data evaluation the mass-to-charge ratio was assigned to the detected ions and a present mass resolving power of about 100 was achieved.

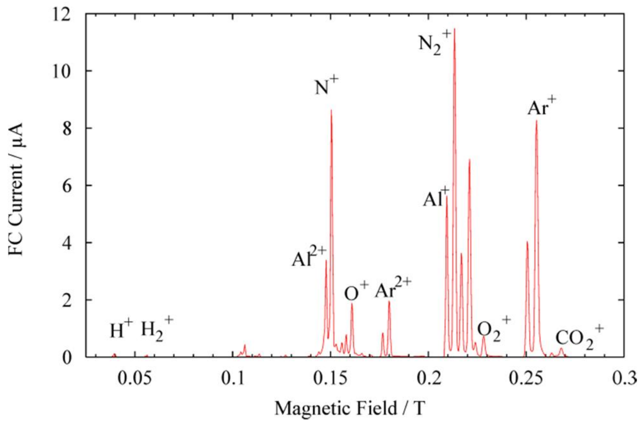

Fig. 2: Mass spectrum of the ions produced in the ECR ion source in off-line operation.

Conclusions and outlook: The ECR ion source as well as the mass separator are being commissioned. Next, the ionization of different elements and the separation of fission products and aerosol particles will be investigated. In addition, a radiofrequency quadrupole cooler buncher will be set up and the resolution of the magnet will be increased by implementing a slit system.

References

[1] J. Ketelaer et al., Nucl. Instrum. Meth. **594** (2008) 162-177.

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