Characterization measurements with a transverse electron target at a crossed-beams setup

S. Geyer* [1], **S. Lamprecht***, **Th. Conrad***, **H. Podlech***, **and O. Kester**† [2]

* Institute of Applied Physics, Goethe University Frankfurt, 60438 Frankfurt, Germany
† TRIUMF, Vancouver, BC V6T 2A3, Canada

Synopsis A transverse electron target was developed and designed for the experimental investigation of electron-ion interaction processes in a crossed-beam setup. Its performance was characterized in measurements and is presented in comparison to numerical studies.

The investigation of electron-ion collisions is one of the most fundamental topics in the research field of atomic physics and comprises a large variety of elastic and inelastic processes. Experimental studies of these interactions provide access to the structures and dynamics of atomic and ionic systems but also reveals effects of the nucleus on their properties. According data find applications in various related fields (e.g. astrophysics, plasma physics, beam physics). A target of free electrons in crossed beams geometry installed in an ion storage ring would provide a new type of electron-ion collision experiments with special interest on the study of highly charged heavy ions.

In the transverse electron target a sheet beam of free electrons is produced. It is transported and focused into an interaction region by electrostatic fields, where it crosses with the intercepting ion beam. Its open geometry provides access for spectroscopic investigations. The target is designed for an electron beam energy of a few keV, with particle densities of up to 10^9 electrons/cm^3 in the interaction region. Applying the animated-beam technique [1] allows the determination of the overlap region and therewith the measurement of absolute interaction cross sections.

To characterize its performance for atomic physical studies, numerical [2] and experimental investigations have been conducted. These include the emission of the free electrons from the installed rectangular dispenser cathode as well as the beam formation and transport through the electrode assembly with emphasis on the electron beam properties in the target interaction region.

To evaluate the ion optical influence of the target operation on the ion beam transport, a simple model was derived. It describes the target in linear beam dynamics as ion-optical element including the electron beam space charge as well as the contributions from the neighboring electrode potentials depending on the target operation scenario. It demonstrated a good agreement with according particle tracking simulations.

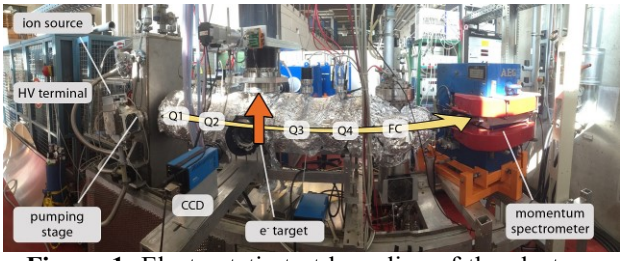

Figure 1. Electrostatic test beamline of the electron target in transverse geometry.

The electron target is installed at an electrostatic test beamline equipped with a volume ion source and a momentum spectrometer for A/q-measurements (see Figure 1). An upgrade of the diagnostics is currently under construction for further collision studies. Measurements with the setup including an EBIS source for highly charged ions are envisaged. Subsequently, the developed target will serve as in-ring target prototype for CRYRING at ESR operation [3] in future ring-experiments with cooled, stored ions.

References

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[1] E-mail: geyer@iap.uni-frankfurt.de

[2] E-mail: okester@triumf.ca