A transverse electron target for the FAIR storage rings

S. Geyer[1], *O. Meusel*[1] *and O. Kester*[1,2]

[1]Goethe-Universität Frankfurt, Germany; [2]GSI, Darmstadt, Germany

Electron-ion interaction processes are of fundamental interest for several research fields like for atomic and astrophysics as well as for plasma physics. To address this topic, a transverse electron target, dedicated to the FAIR storage rings, is under development.

Target Design

The transverse electron target uses a sheet beam of free electrons in crossed-beam geometry. This allows the realization of a small and flexible design with access to the interaction region for spectroscopy (fig.1, left). The electron beam is produced by an indirectly heated BaO cathode. The cathode has a length of 100 mm in ion beam direction and a height of 12 mm. To focus the sheet beam only electrostatic fields are used. For beam formation the cathode is surrounded by a Wehnelt electrode on negative potential relative to the cathode. The anode is the first of three electrodes placed in front of the interaction region. Another three electrodes with mirrored potential configuration are installed behind it. This design gives independency of the electron current from the electron beam energy and assures a symmetric potential distribution in the interaction region. The adjustable electron energy in the interaction region ranges between several 10 eV and a few keV. To gain a large solid angle for spectroscopy the electrodes next to the interaction region are shaped accordingly. Behind the second lens the electron beam is defocused, decelerated and dumped in a collector. For critical electrodes - such as the Wehnelt, the anode and the collector - water-cooling has been implemented. The other electrodes are cooled indirectly by their isolating aluminium oxide ceramics.

For absolute cross section measurements, the overlap between the electron and the stored ion beam has to be determined. Therefore a manipulator system with a stepper motor will be integrated in the setup (fig. 1, right). The target is vertically mounted on a CF160 flange upside down. A bellow allows the stepper motor to mechanically scan the electron beam through the ion beam.

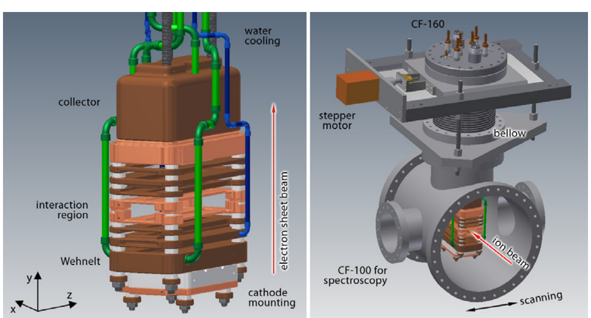

Fig. 1: The design of the transversal electron target (left). The mounted target with its manipulator system (right).

A control and interlock system monitors the water-cooling system, the vacuum system and the beam losses on the different electrodes to protect the target parts from heating by beam losses.

Simulation and beam parameter

To optimize the beam optics in the interaction region, simulations with the Amaze© code have been performed. They give a perveance for the electron target of 5.1 $\mu A/V^{3/2}$. In the interaction region the beam has a height of ~ 5 mm and a density of up to 10^9 electrons /cm^3 (fig. 2), both depending on the voltage setting. The example in figure 3 depicts the emittance of the beam for the direction of the crossing ion beam angle in direction toward the ion beam. Also investigations concerning the energy resolution and the line width in collisions experiments have been performed.

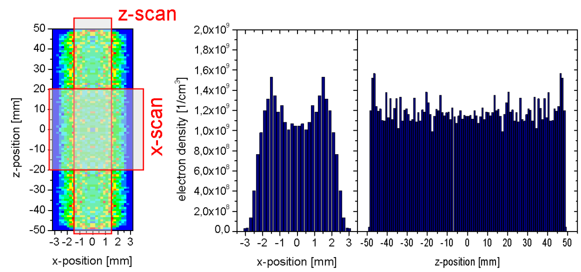

Fig. 2: Simulated cross section (left) and electron density profiles for the marked regions (right).

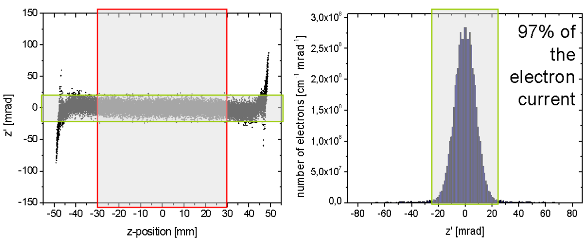

Fig. 3: Simulated emittance in direction of the ion beam (left) and the corresponding density distribution (right).

Summary and Outlook

All parts of the target are currently built at the IAP (Institut für Angewandte Physik) workshop. A test beam line for first characterization measurements of the target is already prepared. Experiments with molecule and ion beams from a volume source and an XEBIS are envisaged. Also the influence of the space charge of the electron beam on the ion optics in storage rings is part of further studies by simulations as well as subsequent measurements.