Emittance Measurements at the REX-ISOLDE Test Beamline

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Emittance measurements are a very helpful tool to check the beam quality behind ion-sources, and in general, to study the properties of particle optic devices like e.g. focusing elements, slits, bunchers, choppers and particle accelerators as well. The measurement of the transverse phase space with the so called slit-grid method gives - besides the spatial and angular extension of the beam - direct information about nonlinear effects of lenses, beam current, the fractions of different ion species (and charge states) in the beam and about the distribution of the ions inside the beam. For the measurements in the x- respectively y-plane, a horizontal (resp. vertical) slit with a parallel wire-array passes through the beam, driven by a stepping motor. At each slit position, the wires, which are each connected to a high sensitive current amplifier, detect the corresponding angular distribution. The spatial resolution of the device is given by the width of the slit (0.2mm). The angular resolution is in the first order the distance between slit and grid over the cross section of the wires (0.1 mm) [1].

For the accelerator development for REX-ISOLDE and MAFF we bought a new variant of slit-grid emittance scanner, which moves slit and grid in an angle of 45^o towards x- and y axis through the beam. The advantage of this device is on the one hand, that only two vacuum feedthroughs are required for slit and grid instead of four, and on the other hand, that the beam emittance in the x- and y-plane is measured at the same z-position. Furthermore, the system can be adapted to different beam energies by varying the length of the beam tube between the chambers which house the slit and the grid. With a slit/grid distance of 650 mm, our emittance scanner reaches a resolution of 0.2 mm in space and 0.5 mrad in angle. The detection limit is - due to the small beam intensities at Radioactive Ion Beam-facilities - very low. With in Heidelberg specially developed current amplifiers we can measure 5 pA per wire [2]. Figure 2. shows the experimental setup at the emittance measurements behind the injection system of the REX-RFQ [3].

Fig. 1: Setup for the emittance measurements at the RFQ injection beam line.

For the matching of the He^{1+} beam to the acceptance of the RFQ, emittance measurements were done directly behind the duoplasmatron to get an impression of the beam size and quality the source delivers. Here we measured an emittance of 30 π mm mrad and could identify two separate plasma burning areas besides the source filament (split of the beam in x-direction). By using very small aperture slits we could do measurements down to 180 nA. The following measurements behind the injection system were done to check the simulation calculations with the COSY [4] code for beam injection. Fig. 3. shows the measurement results compared to the calculations. The beam was fitted to the acceptance of the RFQ at the later RFQ entrance position and was then calculated to the axial position where the slit of the emittance scanner was located. For the matching, electrode voltages in the quadrupole lens of ± 2 kV were required. The horizontal beam in the emittance figure is a neutral He-beam due to recombination.

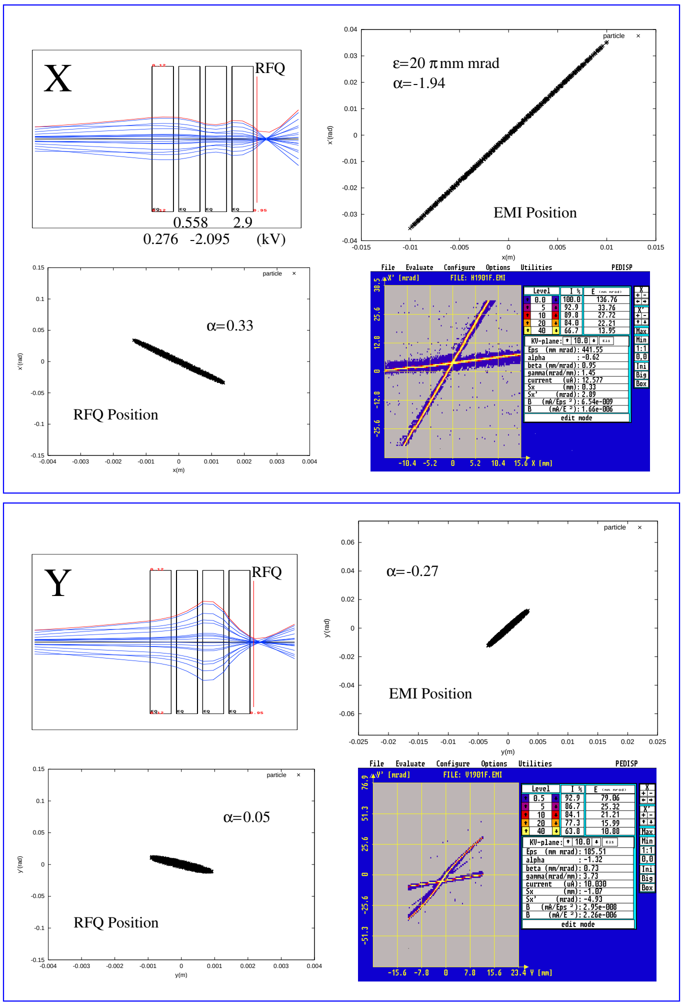

Fig. 2: Comparison between measured and calculated emittances for beam injection into the RFQ.

References

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