The RFQ-Accelerator of REX-ISOLDE

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The linear accelerator of the Radioactive Beam Experiment (REX) at ISOLDE/CERN [1] consists of three different kinds of rf-structures. These structures are a 3m Radio Frequency Quadrupole (RFQ) accelerator, an interdigital H-type structure (IH-structure) and a special kind of split ring resonator called the 7-gap resonators, which were developed in Heidelberg for the Heidelberg high current injector. All resonators will operate at 101.28 Mhz with a duty factor of 10%. The REX-RFQ will accelerate radioactive ions with a charge-to-mass ratio of 1/4.5 from 5 keV/u to 300 keV/u exit energy.

The REX-RFQ is a 4-rod-RFQ similar to the Heidelberg RFQ of the high current injector [2] and to the GSI HLI-RFQ [3]. This special kind of RFQ is a well tested structure [4] which accelerates low energy ions very efficiently, because the quadrupole field provides strong transverse focusing, while a modulation of the quadrupole rods performs smooth bunching and acceleration of an injected dc-beam. This strong spatial homogenous AG-focusing is the main property for the transport of low energy ion beams even in case of high currents. All RFQ-resonators are heavily loaded by the quadrupole electrode capacity. Thus the cavity is in first order an inductance. The 4-rod structure developed at the J.W. Goethe-Universität Frankfurt consists of a linear arrangement of coupled $\lambda/2$ oscillators. Especially at low frequencies the 4-rod design is more compact than a comparable 4-vane RFQ. In the 4-rod-design the strong separation of rod sections in shaper, buncher and accelerator the Los Alamos method has been revoked to achieve short structures [5].

The design of an RFQ includes three main parts, namely the particle dynamics, the rf and the technical realization. The RFQ design means the choice of minimum aperture, modulation and the cell length along the accelerator as well. The first part of the design, namely the particle dynamics has been already performed with the program PARMTEQ (Phase and Radial Motion in Transverse Electric Quadrupoles) [6]. PARMTEQ generates an RFQ and an input particle distribution and performs beam dynamic calculations using a particle in cell code. The design parameters of the REX-RFQ have been optimized for the dedicated charge-to-mass ratio, a normalized transverse acceptance of 0.6 π mm mrad. Thus the required rod voltage will be 42 kV with an expected peak-power consumption of 53 kW. Fig.1 shows the aceptances and the real beam from the REX-EBIS. The beam calculations show an emittance growth of only 11%. The expected injection emittances are more than 50 times smaller than the design emittances. The design emittances are taken from typical emittances of Electron Cyclotron Resonance (ECR) ion sources. In longitudinal direction the phase spread and the energy spread are in case of 98% transmission $\Delta\varphi = \pm 14^0$ and $\Delta W/W = \pm 1.5\%$. Thus the longitudinal emittance is $\epsilon_{long} = 1.89$ keV/u*ns.

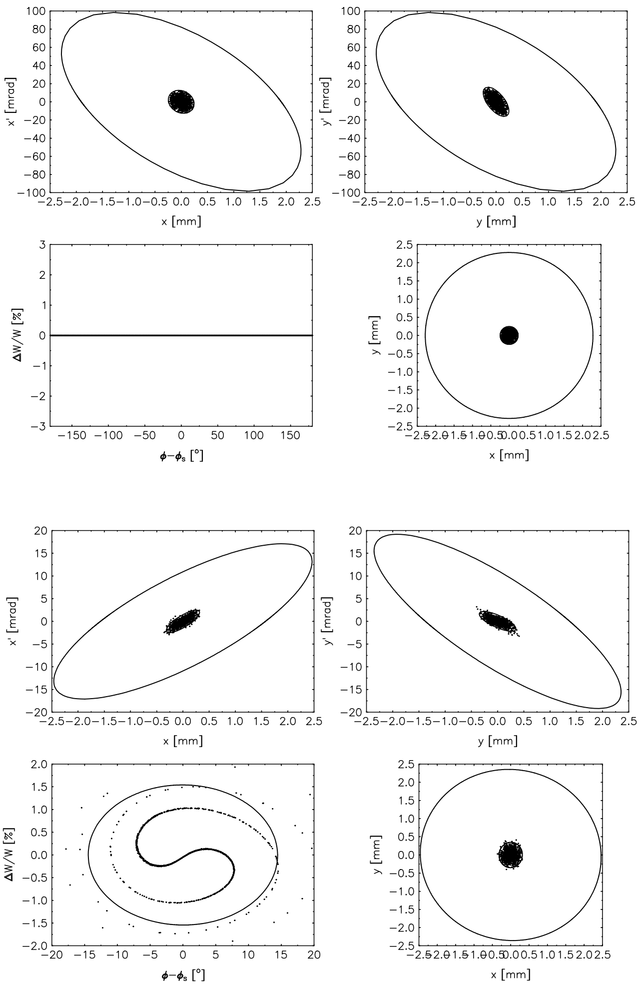

Fig. 1: Entrance acceptances and exit emittances of the REX-RFQ calculated with PARMTEQ

In order to examine the rf-parameters of the cavity, calculations with MAFIA [7] have been performed with a single cell of the resonant structure. Thus the dependence of the resonant frequency on the height of the tuning bottom plates has been calculated with the mean rod aperture as parameter. Calculations of the rod capacity along the axis with the static solver of MAFIA are under way to examine the flatness of the electric field along the axis of the rods. The hardware production will start in the beginning of the next year.

References

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