Assembly and Test of the REX-ISOLDE RFQ

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For the REX-ISOLDE-LINAC at CERN [1] a 4-Rod-RFQ is built up and tested. This special RFQ-type, which was developed at the University of Frankfurt [2], consists basically of a linear arrangement of stems which are mounted on a ground-plate and alternately carry the four modulated quadrupole-electrodes (rods). The rf-properties of the RFQ depend on its given capacities and inductances, which are in case of the 4-Rod-RFQ defined by the geometry of the quadrupole-electrodes and the stems. The cavity (vacuum tank) has only slight influence on the rf-behaviour of the resonator ◇.

The most important feature of RFQ-accelerators is that electric fields are used simultaneouslyly for strong transverse AG-focusing and for acceleration. RFQ's are a combination of a quadrupole transport channel and an rf-accelerating structure, whereby the acceleration as well as the matching and bunching of the beam is performed by mechanical modulation of the quadrupole-electrodes. The RFQ is very suitable to operate directly behind ion-sources, where it bunches and accelerates the dc-beam from the source with a very high transmission.

The REX-RFQ has a total length of 3 m and is similar to the GSI HLI-RFQ [3] and the Heidelberg High-Current-Injector-RFQ [4]. It will accelerate the radioactive ions from the REX-ISOLDE mass-separator [5] with an A/q of 3 - 4.5 from 5 keV/u to 300 keV/u and operates at a resonant frequency of 101.28 MHz (duty cycle: 10%). The transmission has been calculated with PARMTEQ to 98% at a design electrode-voltage of (max.) 42 kV. Regarding the particle-dynamics, the electrode-design of the REX-RFQ includes a so called 'matching-out section', which means, that the focusing strength at the exit of the accelerator is reduced by increasing the aperture. This leads to a decreased beam divergence at the RFQ-exit and thus reduces the required field-gradients of the following magnetic quadrupole-lenses. Fig.1 shows the resulting output emittances without (above) and with (below) 'matching-out section'.

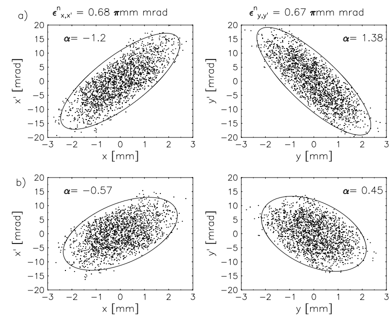

Fig. 1: Output-emittances of the REX-RFQ calculated with PARMTEQ. The parameter α is a measure for the slope of the ellipse (positive α: convergent beam).

Generally an electrode-design is made under the assumption of an ideal (flat) voltage distribution along the whole structure. In reality, the voltage between the electrodes changes with the electrode-capacity, which is not constant due to changes in modulation and aperture. This effect can be compensated by adequate manipulation of the inductances, which is done by mounting of tuning-plates (variation of the stem length). The basic principle of the flatness measurement is that a small capacity is added (stepwise along the whole structure) to the capacity of the rods. This additional capacity changes the energy stored in the resonator and therewith its resonant-frequency. Thus the voltage distribution along the z-axis can be determined by simple frequency measurements.

The first measurements of the characteristic parameters of the resonator resulted in a resonant-frequency of 101.17 MHz, a quality factor of 3600 and an R_p-value of about 120 $k\Omega m$. The relative voltage deviation could be reduced from ±20% to ±3%. Fig.2 shows the measured voltage distribution of the REX-RFQ without tuning-plates (dotted line) and with plates of 5 mm and 10 mm thickness (solid line). After further tuning (using also 2.5 mm plates), electrode alignment and final assembly of the resonator (with piston-tuners etc.), we expect to reach the specified values of f = 101.28 MHz, Q = 4000 and R_p = 130 kΩm. The "unflatness" should then be smaller than ± 1 %.

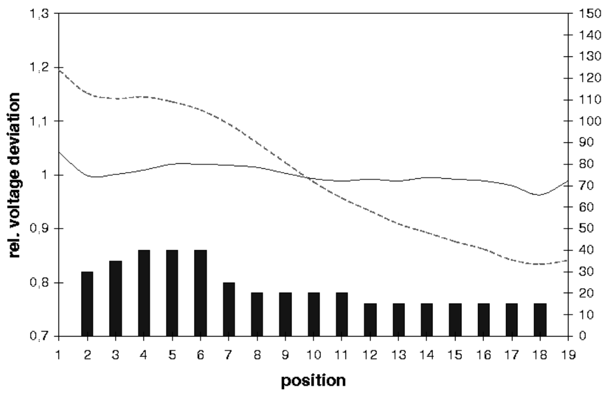

Fig. 2: Voltage distribution of the REX-RFQ before and after tuning.

References

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◇This important difference between the 4-Rod-RFQ and comparable 4-vane- and IH-RFQ-structures enables compact accelerators at low frequencies.