A CW RFQ ACCELERATOR FOR DEUTERONS*

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Abstract

A four-rod RFQ accelerator is being built to accelerate deuterons from 20 keV to 3 MeV. At an operating frequency of 176 MHz the length is 3.8 m and the power consumption 250 kW, the beam current 5 mA. A special feature is the CW-mode operation. The status of the project and properties of the RFQ will be discussed.

STATUS OF THE SET-UP

To assemble the RFQ and to put it into operation, mechanical alignment of the electrodes and RF tuning has to be done. First is the mechanical set-up consisting of an exact adjustment of the structure. Mechanical adjusting passes into adjusting of electrical properties.

Finally, vacuum, power HF and beam tests will be handled.

The actual state of this CW RFQ is the completion of the mechanical adjustment on the one, and some simulations for electrical properties on the other hand.

MECHANICAL ADJUSTMENT

The set-up of a structure of 4 m length requires very accurate measurements in a conditioned environment. Already small changes i.e. in temperature can cause big errors. At all, the mechanical adjustment can be classified in three steps:

The inner resonant structure

The RF structure, made up of copper, is composed of the base plate, on which the stems are mounted. On the stems, the electrodes are mounted. The electrodes are divided in three parts of about 1.3 m length.

Injection/output energy	**20 / 1500 keV/u**
Isotope	**deuterium**
Frequency	**176 MHz**
electrode voltage	**65 kV**
RFQ length	**3.8 m**
inner diameter	**280 mm**
min. aperture	**2.7 mm**
max. modulation	**2.7**
power consumption	**250 kW**
input emittance $\varepsilon_{x,y}$	**160 π mm mrad**
a / b	**0.85 / 0.28 mm mrad^{-1}**
number of cells	**199**
number of stems	**40**
long.outputemittance e-l	**75 π deg. keV/u**
transmission 0 / 5mA	**98 / 96 %**

Table 1: RFQ property values

Alignment to the cavity

The location of the beam, especially at input and output, should be oriented to the outer geometry of the cavity. Therefore, the inner structure, once installed in the cavity, needs to be aligned with respect to the cavity. This was done by the use of an align fixture which was attached to the cavity's head. The align fixture contains an arbour which is centred in the cylindric cavity and can be used as a reference for the beam position. Parts of the inner structure will be aligned to this reference.

Exact adjustment

As an other reference, the top flange of the cavity was used. This works very well, because the whole cavity has only one single lid all over the full length. This gives a very planar and exact reference for measurements in every position along the structure, as shown in figure 1.
Adjustment of the electrodes is done in two steps: the vertical and the horizontal setting. For the horizontal, the tolerance of screws is used. The vertical step is more complex. Therefore, so called *shims* are made, which are

Figure 1: Mechanical adjustment and reference face.

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placed between the stem heads and the electrodes. Each of them has its individual thickness. Thus, errors of the set-up, i.e. from brazing, can be cleared. Again, the arbour of the align fixture gives a reference value, so that the electrode's geometry centre coincides with the cavity's centre.

To get a better conducting between stems and electrodes, the shims are silver plated.

TUNING

The vocable *tuning* of a structure stands for mechanical adjustment that changes electrical properties of the structure, in particular the flatness. The longer an RFQ, the more sensitive is the field distribution to local changes of the capacity. To handle this and to get a proper working RFQ, so called *tuning plates* (see figure 4) of different heights are to be built between the stems. The effect is that each cell has its own inductivity and its own eigenfrequency that differs a little from the operating frequency, and the more it differs, the less gets the local voltage on the electrodes.

To handle this phenomenon, simulations of the structure were done, which show the voltage spreading along the structure. Figure 2 shows the results for a simple 40 stem RFQ structure with constant capacity.

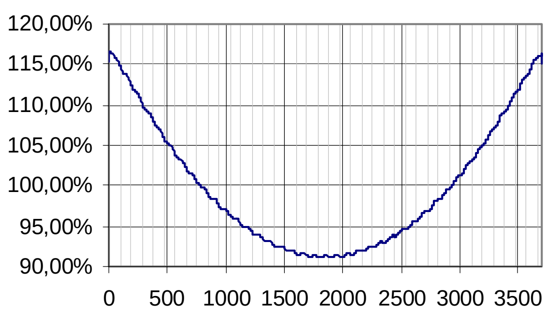

Figure 2: Simulation result of the flatness calculation in a simple 40 stem RFQ design.

Electrode voltage ranges in this case from about 92% in the middle to 117% at the ends of the structure. The values are in relation to the mean value, which is set to 100%.

A bigger changing of the flatness is caused by the differing aperture along the structure. A bigger aperture means that the local capacity is smaller and the eigenfrequency differs from the operating frequency. For the case of this RFQ design, simulations including varying aperture and modulation on the electrodes were done. The results show, how much effect the changing aperture takes comparing to the effect of the open ends, see figure 2. Now voltage differs from 10% to 310% of the reference value given by the mean. The results are shown in figure 3.

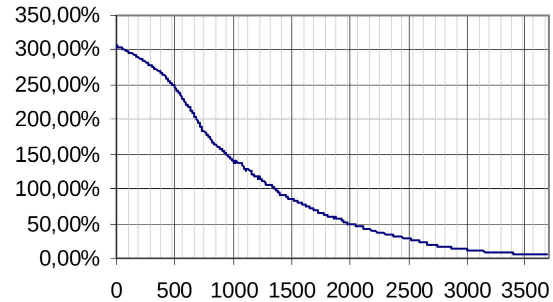

Figure 3: Simulation result of the flatness calculation in a 40 stem RFQ design with varying aperture and electrode modulation.

To balance the voltage, simulations for different tuning plate's widths were done. With these simulations, a combination of different tuning plate's widths can be found to get a flat voltage all over the whole RFQ length.

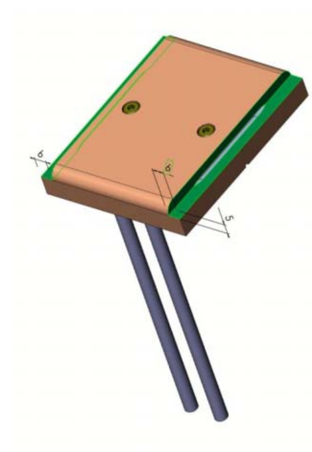

Figure 4: A tuning plate with cooling pipes.

CONCLUSIONS

After finishing the mechanical adjustment, tuning plates will be built in and flatness measurements can be done. According to these measurement results, simulation theory and calculated tuning plate's width values can be proven. Then the mechanical task is finished, and low power HF measurements can be done.

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