THE NEW CW RFQ PROTOTYPE*

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Abstract

A short RFQ prototype was built for tests of high power RFQ structures. We will study thermal effects and determine critical points of the design. Simulations with CST Microwave Studio and first measurements were done. First results and the status of the project will be presented.

INTRODUCION

As a first section behind the ion source the RFQ bunches the low energy DC-beam adiabaticly, keeps it focused and accelerates the bunches to be accepted at the following DTL-structures.

The 4-rod design has been developed at the IAP as a flexible, stable, efficient and economic RFQ-version [1].

For high power LINAC structures for projects like FRANZ (IAP), FAIR (GSI) and FRIB (MSU) a new RFQ prototype to study primarily thermal effects was built.

SPECIFICATION

Figure 1 shows a drawing of the new RFQ model with its general layout parameters in table 1 based on the experience with the SARAF RFQ [2].

An extended frequency tuning range is provided by water-cooled tuning plates. Stems and electrodes are cooled separately. The connecting parts between electrodes and stems are more massively designed to give better thermal properties there. The traditional circular tank cross section was changed to a rectangular shape.

Table 1: General Layout of the New Prototype

Specification	Technical data
Realisation	4-stems model assembled copper parts, the electrodes have no modulation
Lengh	520 mm
Distance stem to stem	146 mm
Distance bottom to beam axis	182 mm
Aperture	7 mm
Tuningplate varribility	20-110 mm
Standard height	65 mm
Vacuum tank dimension	550x262x254 mm^3

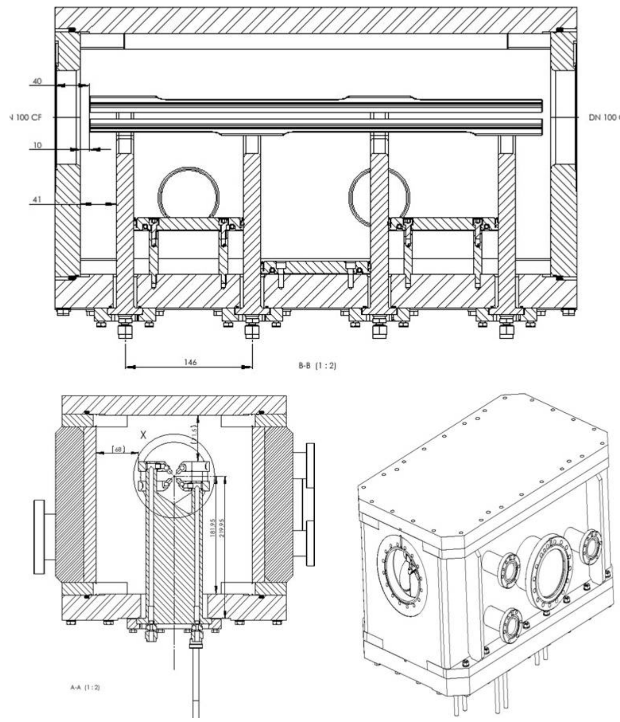

Figure 1: Drawing of the new RFQ- prototype.

Using a rectangular tank geometry has the advantages: It can be produced easier and even more economic. The RFQ structure is mounted directly on the tank bottom without the massive ground plate, which is needed inside a cylindric tank. It gives a good access for adjustment, tuning and maintenance

SIMULATIONS

CST Microwave Studio is a program to simulate HF-resonator structures. After a virtually construction in a 3d-graphic, it solves the Maxwell equations by using a dual grid with a defined number of mesh cells. A matrix algorithm gives exact results for every infinite cube [3]. But the number of cells is limited. So the simulation is even a 3d-rastered picture of reality.

The following simulations were made with 1 million mesh cells. Figure 2 shows a diagonal view of the computer model inside the tank. Table 2 gives an overview of the simulated resonator results.

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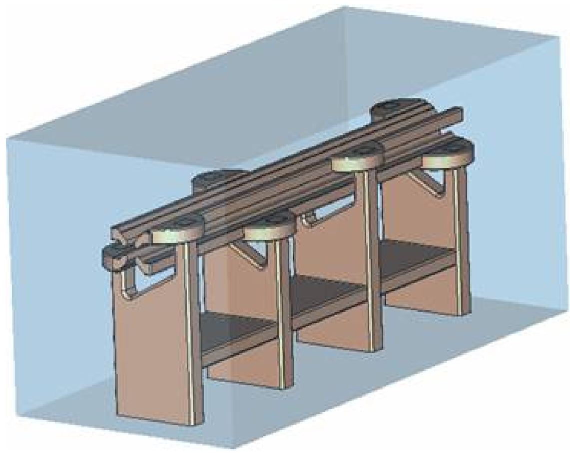

Figure 2: The new prototype in CST.

Table 2: Overview of the Resonator Parameters

Resonator parameter	Simulated value
Frequency at standard height	120 MHz
Qualityfactor	Q=4700
Shunt impedance	Rp=127 kOhm
Frequency range	105-154 MHz (Figure 3)

Figure 3 shows the wide frequency range between minimum height and maximum height of the tuningplates.

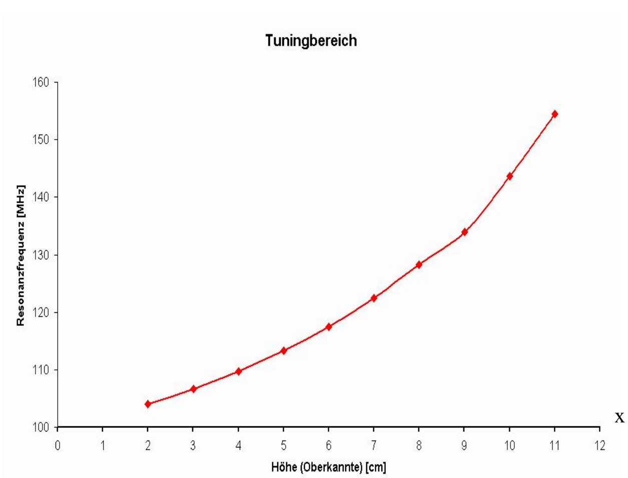

Figure 3: Frequency range (x-axis: Tuning plate height).

The simulation of the flatness curve is shown in figure 4 with a variation of ca. 1,2 % of the normalized voltage along the beam axis. This is a typical distribution for a symmetric RFQ structure with unmodulated electrodes.

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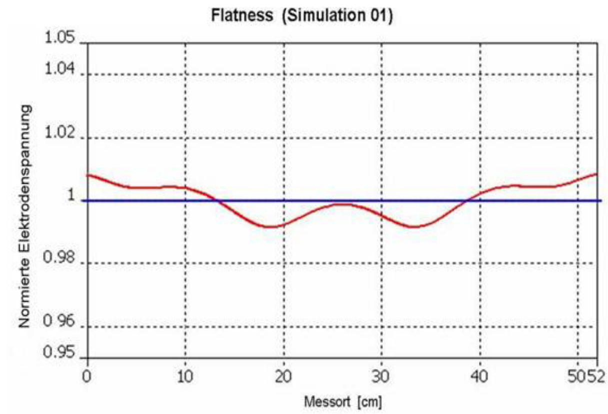

Figure 4: Flatness (simulation).

MEASUREMENTS

The prototype was built similar to the engineering drawing. Figure 5 shows the real construction of the new model. It articulates explicit the compactness of the assembled copper parts for an effective thermal conduction.

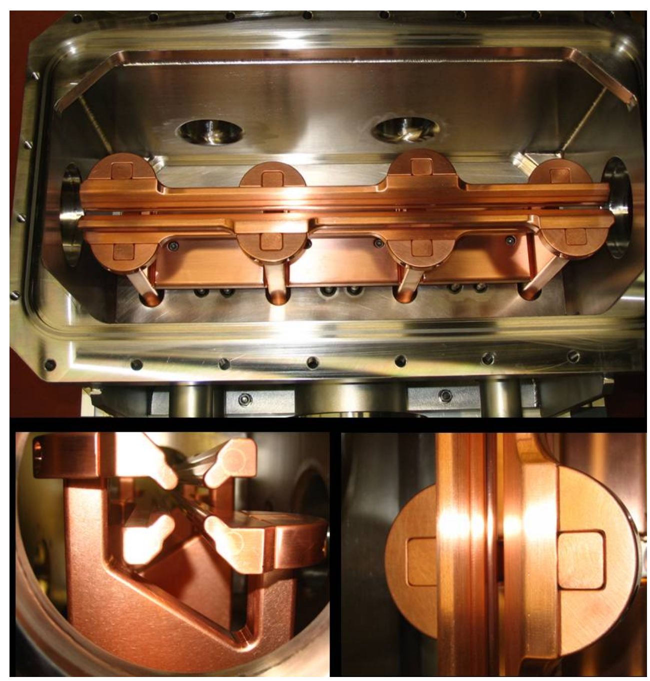

Figure 5: The new cw RFQ prototype.

The results of the measured resonator parameters are listed in table 3.

Table 3: Overview of the Resonator Parameters

Resonator parameter	Measured value
Frequency at standard height	121,3 MHz
Qualityfactor	Q=3200
Shunt impedance	Rp=140 kOhm
Frequency range	104-150 MHz

The measured flatness curve is shown in Figure 6 with a variation of ca. 1,5 % of the normalized voltage along the beam axis.

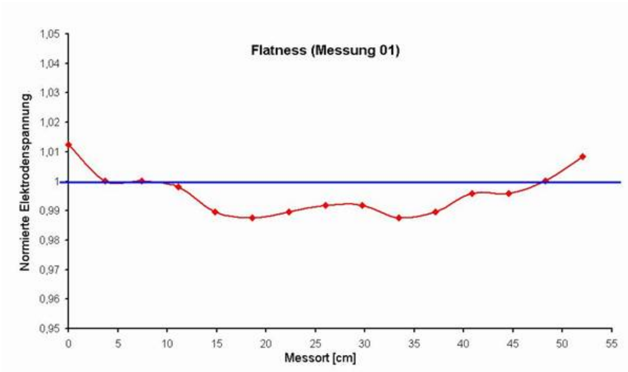

Figure 6: Flatness (measurement).

DISCUSSION

There is often a discrepancy between experiment and simulation. Measured and simulated values for the frequency at the standard height of the tuning plates (65 mm) are nearly equal. Both flatness curves are similar. The measurement of Quality factors is not trivial because of coupling phenomena. The simulation uses a one piece massive model made out of perfect conducting copper. But the real prototype is an assembly made out of separate parts. Hence the discrepancy factor of 20 – 30 % is typical. The difference between the Rp values is due to a different processing of determination at measurement and simulation.

CONCLUSION AND OUTLOOK

The new RFQ prototype is a 4-rod RFQ LINAC structure especially for high duty cycle and cw operation. The simulations and measurements made until now are a reasonable basis for further tests.

Next steps will be RF-tests to check the temperature distribution and the capability of the structure. Simulations with *ALGOR* will be done to optimize cooling and stability of the resonator.

REFERENCES

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[2] P. Fischer, “*Ein Hochleistungs-RFQ-Beschleuniger für Deuteronen*“, Dissertation , IAP, Frankfurt am Main, 2007
[3] Manual of CST Microwave Studio