

THE NEW CW RFQ PROTOTYPE*

U. Bartz[#], J. Maus, N. Mueller, A. Schempp

Institut für Angewandte Physik (IAP), Goethe Universität, 60438 Frankfurt a.M., Germany

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. HF-Simulations with CST Microwave Studio and measurements were done. Conditioning of the facility with 20 kW/m in cw-operation and simulations of thermal effects with ALGOR are on focus now. 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 adiabatically, keeps it focused and accelerates the bunches to be accepted at the following DTL-structures.

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

To be compatible with 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 |
| Length | 520 mm |
| Distance stem to stem | 146 mm |
| Distance bottom to beam axis | 182 mm |
| Aperture | 7 mm |
| Tuningplate varriability | 20-110 mm |
| Vacuum tank dimension | 550x262x254 mm ³ |

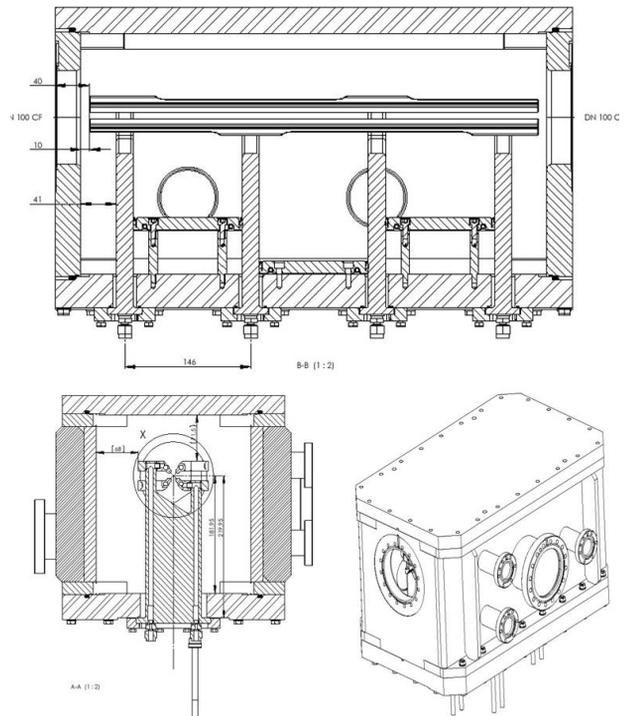


Figure 1: Drawing of the new RFQ- prototype

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 AND MEASUREMENTS

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].

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 and measured results.

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[#]u.bartz@uni-frankfurt.de

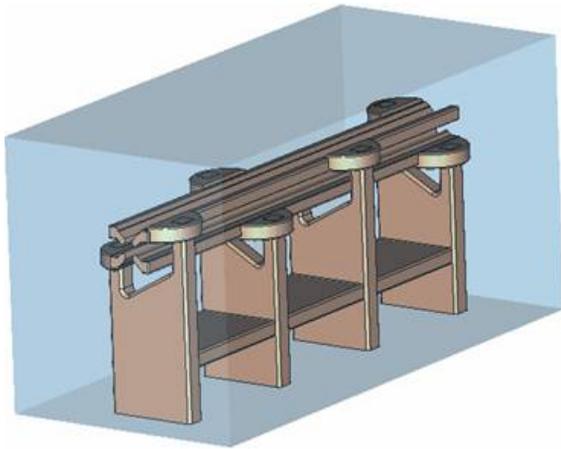


Figure 2: The new prototype in CST

Table 2: Overview of the Resonator Parameters

| Resonator parameter | Simulated value | Measured Value |
|---------------------|------------------------|----------------|
| Qualityfactor | Q=4700 | Q=3200 |
| Shunt impedance | Rp=127 kOhm | 139 kOhm ± 20% |
| Frequency range | 105-154 MHz (Figure 3) | |

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

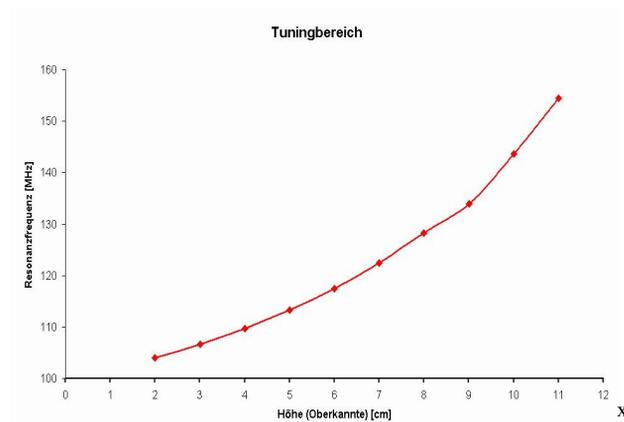


Figure 3: Frequency range (x-axis: Tuningplate height)

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. The measurement shows a variation of ca. 1.5%. This is a typical distribution for a symmetric RFQ structure with unmodulated electrodes.

Measured and simulated values for the frequency range are nearly equal. Both flatness curves are similar. The measurement of Quality factors is not trivial. CST uses a one piece massive model made out of perfect conducting copper. But the real prototype is an assembly made out of separate parts. A discrepancy of 20 – 30 % is typical.

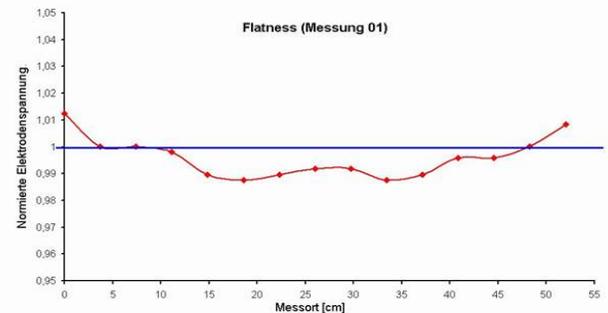
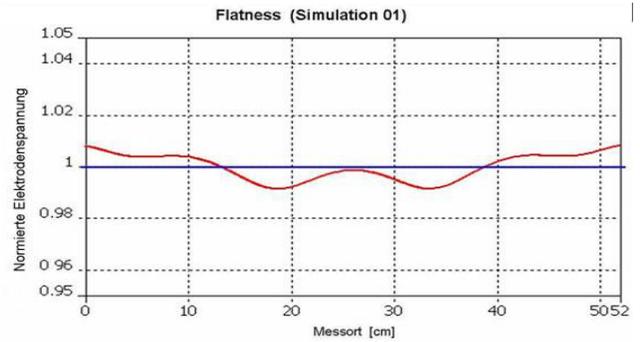


Figure 4: The flatness curve

CONSTRUCTION

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.

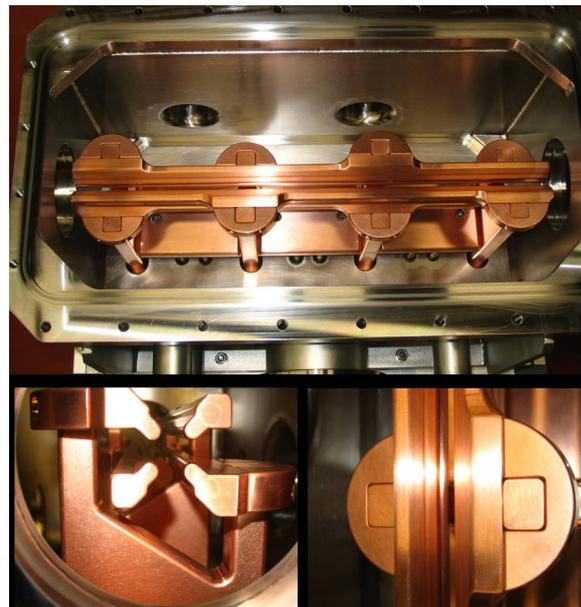


Figure 5: The new cw RFQ prototype

RF -TESTS

RF-tests are relevant to check the temperature distribution and the capability of the structure at cw-operation. Figure 6 shows the experimental setup.

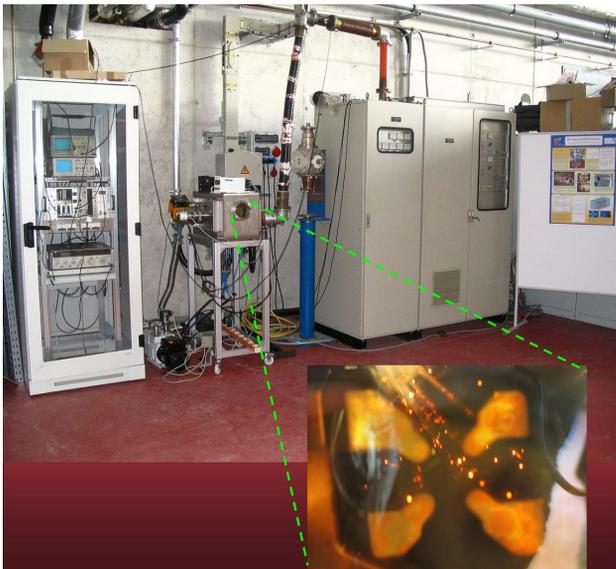


Figure 6: Experimental setup for RF-tests with a detail

On the left is the circuit controlling unit followed by the prototype, which is connected with the HF-Power Amplifier on the right. The detail picture shows some lightning points on the surface of the tank window with an x-ray output of 50 μ Sv/h at 5 kW cw power. It was changed into a steel cover plate. An analogy between simulated currents on the tank surface and measured temperature is shown in figure 7.

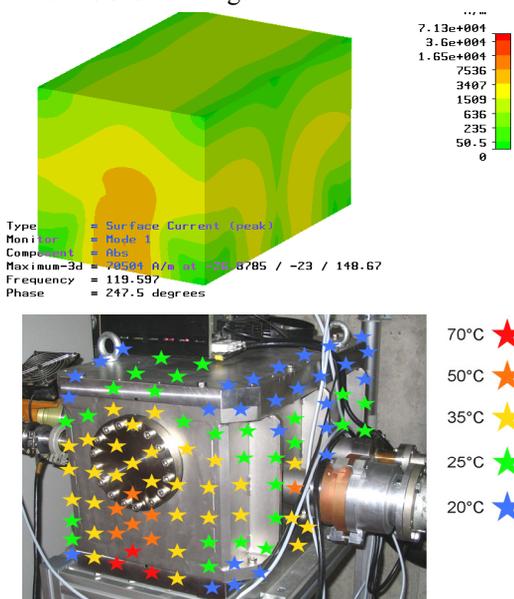


Figure 7: Analogy: Surface currents and temperature

Using a stainless steel tank makes it possible to achieve a thermal distribution on the tank surface while stationary operation, because the electrical and thermal conductivity are in each case seven times more less than using copper.

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 were a reasonable basis for the RF-tests with a continues power of 20 kW/m. The tests were done successfully after getting over the multipacting barriers.

Next steps will be Simulations with *ALGOR* to optimize cooling and stability of the resonator.

REFERENCES

- [1] A. Schempp, „Beiträge zur Entwicklung des Radiofrequenz-Quadrupol“ (RFQ)-Beschleuniger, Habilitationsschrift, IAP, Frankfurt am Main, 1990.
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- [3] Manual of CST Microwave Studio