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MEASUREMENTS OF THE MYRRHA-RFQ AT THE IAP FRANKFURT*

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Abstract

The MYRRHA (Multi-purpose hYbrid Research Reactor for Hich-tech Applications) Project is a planned accelerator driven system (ADS) which aims to demonstrate the feasibility of large scale transmutation [1]. The first RF structure of the 600 MeV MYRRHA Linac will be a 176.1 MHz 4-Rod RFQ [2] that will accelerate up to 4 mA protons in cw operation from 30 keV up to 1.5 MeV [3]. The voltage along the approximately 4 m long electrodes has been chosen to 44 kV which limits the RF losses to about 26 kW/m. During the design of the structure a new method of dipole compensation has been applied. This paper describes the status of the RFQ and shows the results of the measurements done at IAP Frankfurt such as dipole and flatness measurements and power tests up to 11 kW.

FLATNESS MEASUREMENT

The frequency and voltage tuning of the RFQ has been performed in several steps. At first tuning plates have been adjusted to a unified height to set the resonance frequency of the structure to the design frequency of 176.1 MHz. After this frequency tuning several iterations of flatness tunings followed, each consisting of flatness measurement and adjusting the heights of individual tuning plates. After finishing a flatness of approximately ±3% could be achieved (see Fig.1).

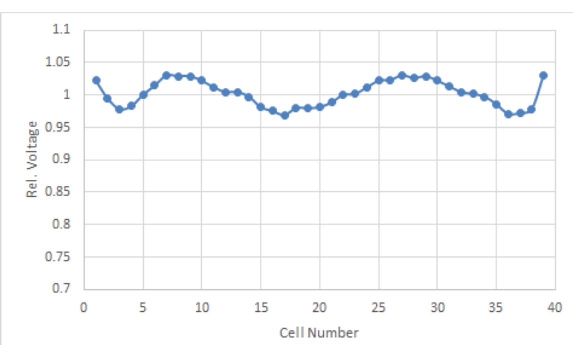

Figure 1: Final voltage distribution after tuning.

DIPOLE MEASUREMENT

The dipole component is the result of the difference in the voltage between the upper electrodes and the voltage between the lower electrodes. This causes an asymmetrical quadrupole field inside the RFQ that would shift the field free region inside the quadrupole and therefore the position of the ideal beam axis. The voltage between the electrodes of a 4-Rod-RFQ can be changed by varying the length of the current paths. For this purpose the stems of the MYRRHA RFQ have been widened alternately perpendicular to the beam direction.

The dipole has been determined on several positions along the electrodes. Therefore a perturbation capacitor has been put between the upper/lower electrodes and the frequency shift has been measured. The dipole component can be calculated by comparing the square roots of the frequency shifts. This measurement has been performed on the MYRRHA and the FRANZ RFQ and compared with the respective simulation results (see Table 1).

Table 1: Comparison of the simulation and the measurement results of the dipole component of the FRANZ and the MYRRHA RFQ.

Cavity	Simulated Dipole Component	Measured Dipole Component
FRANZ RFQ	22.6%	23.1%
MYRRHA RFQ	-0.4%	-4%

As shown in Table 1 the results of the FRANZ RFQ measurement fit the simulations quiet well, whereas the simulation and measurement results for the MYRRHA RFQ differ more. To explain this, it has to be considered, that the simulations for the dipole component of the FRANZ RFQ have been made after it was built. The final heights of the tuning plates had been implemented in these simulations, whereas the simulation for the MYRRHA RFQ have been made before it was built and therefore without knowledge of the final position of the tuning plates.

COOLING SYSTEM

To provide a sufficient cooling of the RFQ the layout of the cooling channels inside the RF structure has been significantly improved [4]. 6 custom made water distributors from stainless steel that provide the water flow to the 118 cooling channels of the RFQ including the cooling channels inside the dynamic tuner and the coupling loop have been installed and tested with an water pressure up to 6 bar. Fig. 3 shows the positions of the water connectors on the lower surface of the RFQ, were the water hoses have been connected.

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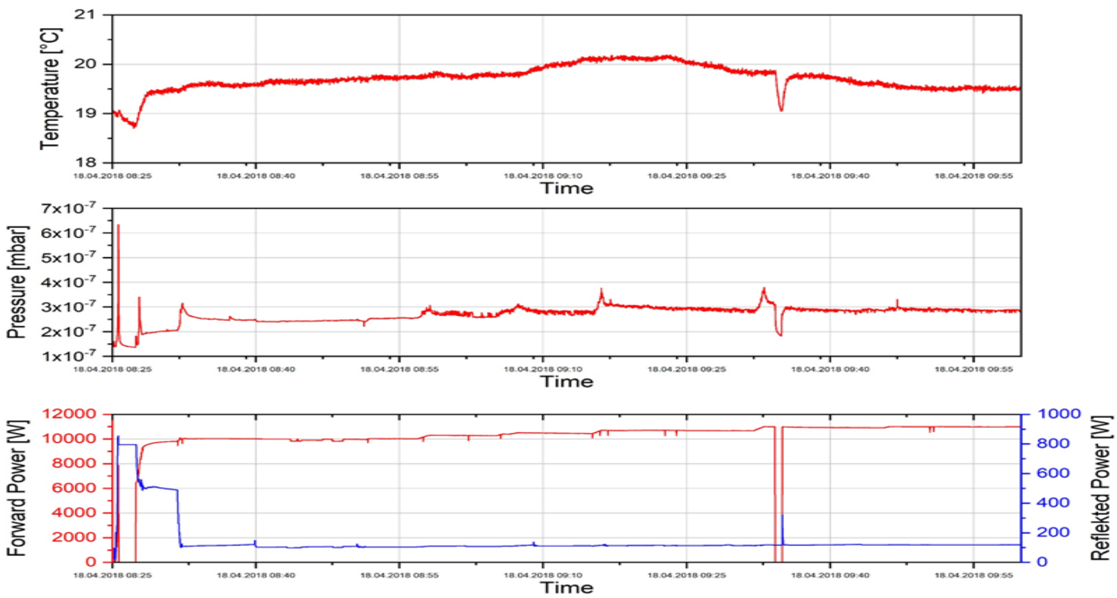

Figure 2: Measured temperature (top), pressure (middle) and forward and reflected power (bottom) at the end of the conditioning.

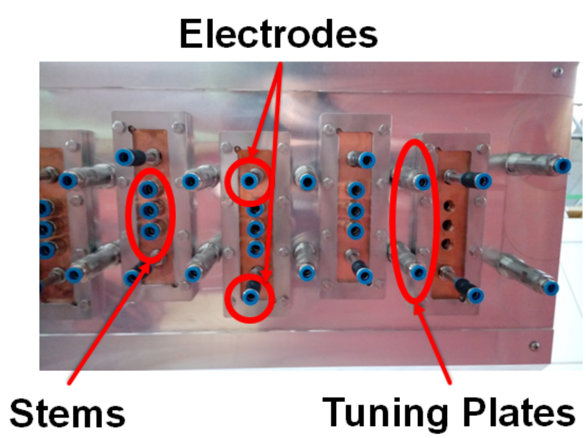

Figure 3: Water connectors of the MYRRHA-RFQ.

EXPERIMENTAL SETUP

During the conditioning, several different types of data were logged: Forward power, reflected power, pressure inside the RFQ as well as temperature at each of the outlets of the cooling water. The forward power and the reflected power where coupled out from the bidirectional coupler in the powerline right before the RFQ. They were logged by the software MNDACS [5] along with the pressure. To control the temperature of the cooling water flowing out of the cooling system, each of the return pipes that lead from the RFQ cooling channels to the water distributor was cut in half and equipped with a T-piece, into which a PT100 temperature sensor was plugged in. Each Sensor was then connected to control-busses, which were read out by MNDACS as well. Additionally, a mass spectrometer was mounted to the RFQ Tank to provide an overview of the substances gassing out during the process of conditioning.

CONDITIONING

The Conditioning at the IAP was performed up to 11kW. The power was increased stepwise, after each increase the pressure and the spectrum of the mass analyser were monitored, with the stability of the pressure in a range of 10^{-7} mbar and the spectrum showing no more outgassing being the premises to take the next step. Fig. 2 (bottom) shows the increase of the forward power up to 11 kW and the corresponding reflected power. This measurement was performed at the end of the conditioning process at IAP, therefore the forward power could be increased from 0 to just under 10kW within seconds. The Tuner position remained constant, while the resonance frequency was adjusted via the signal generator used to control the amplifier. Thus, adjustments of the frequency can be seen in short decreases of the forward power. Fig. 2 (middle) shows the pressure recorded during this measurement, wich remains almost constant at about 3.5 x 10^{-7} mbar. The Peak at the beginning at low Powers is caused by multipackting barriers which occurred up to 30 W. The temperature sensors showed a heating of the cooling water between 0.5 °C and 2 °C. As an example, Fig. 2 (top) shows the temperature of the cooling water from an electrode.

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CONCLUSION

The MYRRHA RFQ has been installed at the experimental hall at IAP Frankfurt. After the voltage tuning a flatness of ±3% could be measured. The dipole component could also be measured with -4% which differs from the simulated -0.4% due to differences in the constellation of the tuning plates between the simulated and the real RFQ.

Custom made water distributers were connected and tested up to 6 bar, before the RFQ was successfully conditioned up to 11 kW.

ACKNOWLEDGMENT

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