

TEST OF A HIGH POWER ROOM TEMPERATURE CH DTL CAVITY

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Abstract

The Frankfurt Neutron Source at the Stern-Gerlach-Zentrum (FRANZ) is planned to deliver ultra-short neutron pulses at high intensities and repetition rates. As part of FRANZ a 175 MHz room temperature 5-gap CH DTL cavity was designed and built. Its main task will be focusing the particle bunch longitudinally at 2 MeV particle energy. Furthermore the CH-cavity can also be used to increase the energy as well as decrease it by 0.2 MeV. The rebuncher and its cooling system is optimized to work with a 5 kW amplifier. The amplification system is intended to provide continuous power (cw mode). Due to its operating parameters being nearly identical to the requirements of the MYRRHA (Multi-purpose hYbrid Research Reactor for High-tech Applications) Project, experience for future cavity designs was gained. This includes considerations concerning cooling with use of a 12 kW amplifier. The recent results of conditioning and high power tests will be presented.

INTRODUCTION

Within the scope of FRANZ [1] a rebunching cavity is required. For this task a 5-gap cross-bar H-type (CH) DTL cavity was developed, which is shown in Fig. 1. In general CH-cavities are characterized by a high shunt impedance and mechanical robustness. The most important design parameters are summarized in Table 1.

Table 1: Cavity Design Parameters [2]

Design parameters	Value
Resonance frequency	175 MHz
Q-value	12600
Accel. gradient	1.15 MV/m
Total rf input power	5 kW
Shunt impedance	80 MΩ/m

COOLING SYSTEM

To handle the power loss of 5 kW a sophisticated cooling system has been designed. The simulated heat distribution with an input power of 5 kW is shown in Fig. 2. It consists of the following components:

- cooling circuit for each stem
- 16 cooling channels inside the tank shell
- coaxial tuner cooling
- maze-shaped cooling channel for cavity lid

Besides some artifacts the hottest spots inside the cavity are at the weld seam of the stems. These spots are heated by approx. 15 °C.

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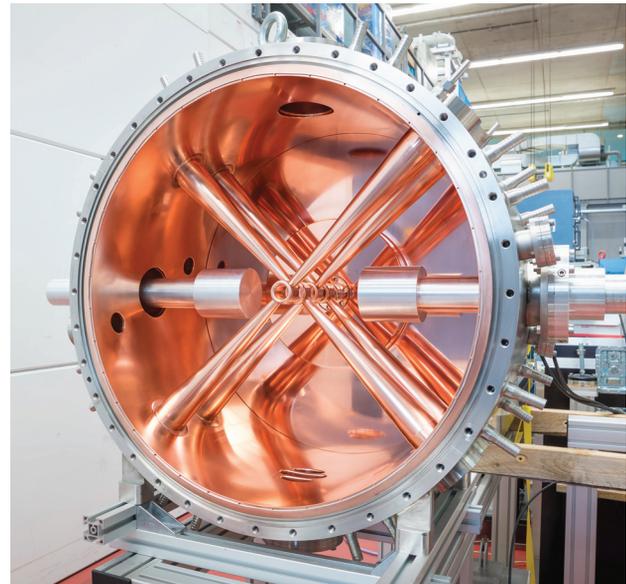


Figure 1: Layout of the CH cavity. The coupling loop is missing in this picture. Also both tuners are dummy tuner. The final tuners are coated with copper, as the rest of the inner geometry.



Figure 2: Simulated heat distribution at 5 kW input power [2]. The hottest spots, which are artifacts, heat up by 17 °C.

EXPERIMENTAL SETUP

Because of changes in the layout of the rf-power cabling of FRANZ the position of the coupling loop and the static tuner was swapped. Due to the symmetrical layout of the CH-cavity the electrical field distribution was not affected

of this change. The cooling system was divided into twelve circuits:

- one for each stem
- four for the cooling channels in the tank
- one for each tuner
- one for both cavity lids
- one for the coupling loop

At the end of each circuit the water temperature was measured with a Pt100 temperature sensor. In addition three Pt100 temperature sensors were connected to the outer skin of the cavity with thermoconductive paste. One was placed on a cavity lid and two were placed on the tank near the hottest spots. Three rf-power signals were measured. One signal was evaluated at a pick-up inside the cavity and the other two at a bidirectional coupler. Last but not least the pressure inside the cavity was logged. MNDACS was used for the data acquisition [3]. Although the usage of a 3-gate circulator was planned the circulator has not been operational in the beginning of the experiment.

OPERATION AT DESIGN ENERGY

After some days of rf-power conditioning the cavity could be operated at 5 kW input power, which is shown in Fig. 3. Instead of an absolute temperature a difference in temperature is plotted. The baseline of the temperature was recorded for 44 hours and then an average over those values was taken for the deviation. Additionally a moving average filter was applied to reduce the noise. There are two axes for the rf power. The left axis applies to the forward and injected power and the right axis applies to the reflected power. The pressure is displayed logarithmically. The whole CH-cavity warms

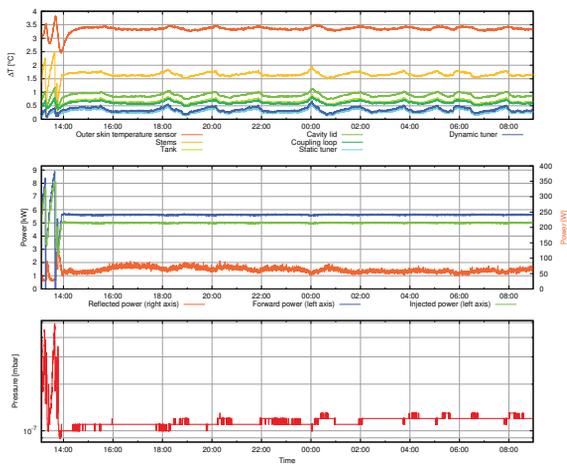


Figure 3: Operation at 5 kW input power. In the first hour conditioning at a higher power than 5 kW was performed. At around 2 pm the operation at 5 kW input power began.

up by 3.5 °C, implying a thermal equilibrium is given. The measured water temperatures are as supposed lower than the outer skin temperature. During the conditioning a pressure of 1.1×10^{-7} mbar at 5 kW input power is achieved. The reflexion is 1.4% of the input power. Due to the missing

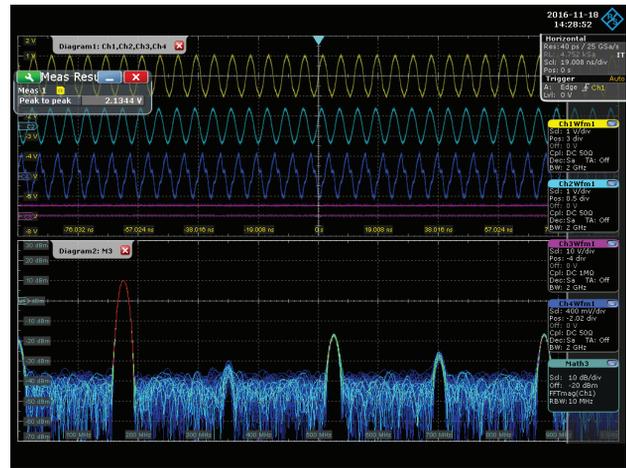


Figure 4: Onboard FFT of the oscilloscope of the forward power signal. The remaining three are power signals, yellow is the forward power, cyan is the injected power and blue the reflected power. Modes which are an even multiple of the fundamental mode are more damped than the odd multiple modes.

circulator higher harmonics propagated in the power cable. Figure 4 shows a FFT of the forward power signal in which the higher harmonics can be seen. After the operation at 12 kW a pressure of 8.5×10^{-8} mbar is achieved.

OPERATION AT 12 kW

Until this point of the experiment the 3-gate circulator was out of order. After the recalibration of the circulator it was connected to the power cable the higher harmonics vanished. Figure 5 shows a 120 h test of the cavity at 12 kW input power. The tuning system didn't find a stable operating point the first three hours, which is the reason for the high reflected power. After some adjustments a stable operating point was located. The whole cavity warms up by 7 °C with a pressure of 1.2×10^{-7} mbar.

CONCLUSION

After the high power conditioning and testing Table 1 can be updated, which results in Table 2.

Table 2: Measured Cavity Parameters

Measured parameters	Value
Resonance frequency	175 MHz
Q-value	12600
Accel. gradient	1.7 MV/m
Total rf input power	12 kW
Shunt impedance	80 MΩ/m

With an input power of 12 kW a voltage of 480 kV is generated inside the cavity. This results in an acceleration

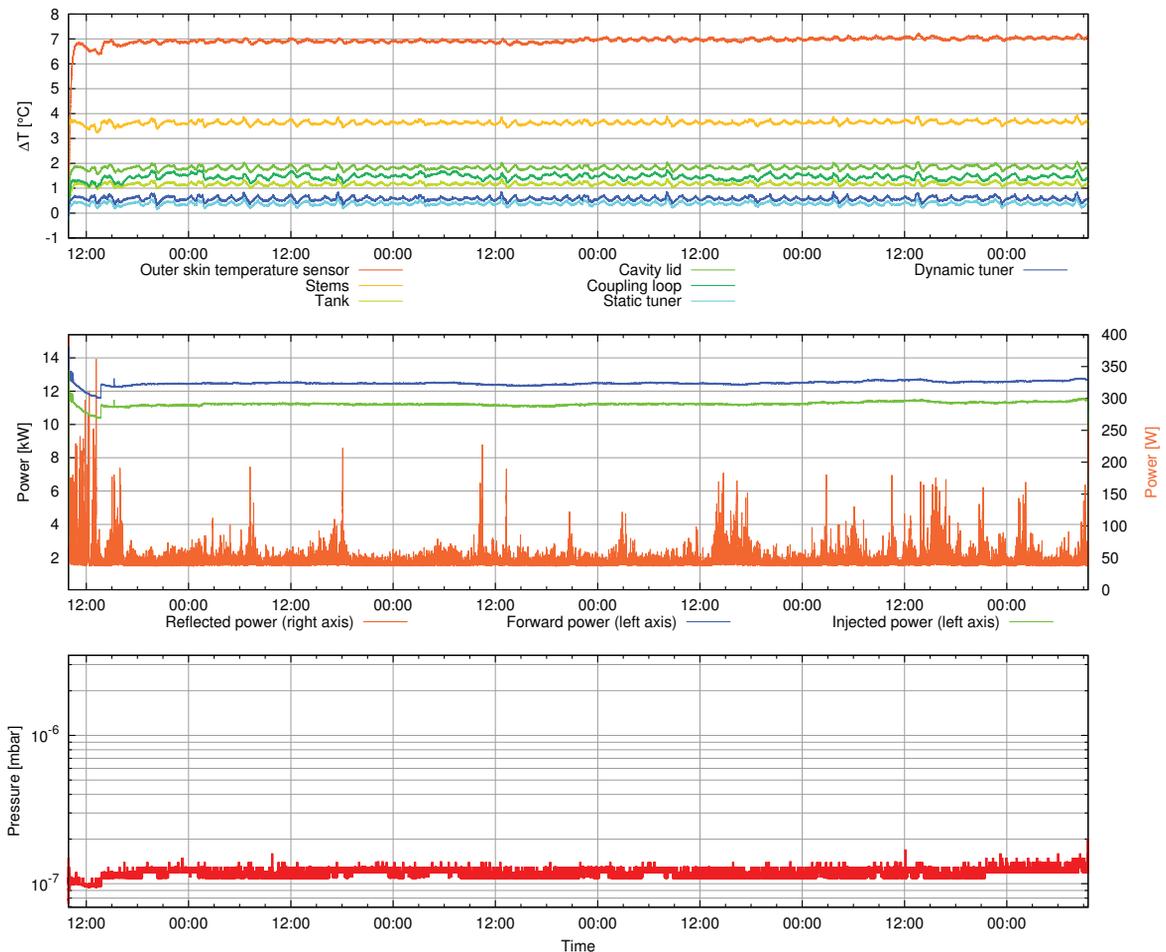


Figure 5: 120-hours high power test. The fluctuations in the measured temperatures are based on natural temperature fluctuations in the cooling water.

gradient of 1.7 MV/m, which was maintained for 120 consecutive hours. MYRRHA requires an acceleration gradient of 1.3 MV/m [4]. The current cooling system is sufficient enough to meet those requirements. Nevertheless an enhanced version of this cooling system was developed [5].

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