THE 7-GAP-RESONATOR-LINAC FOR THE REX-ISOLDE-PROJECT AT CERN

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Abstract

The REX-ISOLDE-Experiment which is presently under construction at CERN is intended to investigate exotic, very neutron rich, radioactive nuclei. A linear accelerator will deliver radioactive beams which are produced by the isotope separator ISOLDE, with energies between 0.85 and 2.2 MeV/u. The Linac will consist of an RFQ-accelerator, an interdigital H-Structure (IH) and three 7-gap-resonators for variable final energy. The 7-gap-resonators are being operated at a frequency of f=101.28 MHz with a pulsed power of P=90 kW (duty cycle 1:10). After the fabrication of the power type resonators high power tests were performed in order to prof the design voltage of 1.74 MV at 90 kW rf power. These tests were carried out with a ^{32}S beam and showed that the 7-gap-resonators exeed their design voltage and voltages between 1.77 and 1.88 MV could be reached. After the successful tests all resonators were shielded with lead due to the radiation safety in the ISOLDE hall. They are already delivered to CERN and aligned on beam axis. The infrastructure work, e.g. water, electricity and vacuum is in progress. In this paper the status of the 7-gap-resonator-accelerator and the results of the high power test are reported.

1 INTRODUCTION

The high energy section of the REX-ISOLDE Linac consists of three 7-gap resonators similar to those built for the new high current injector at Heidelberg [2]. Each resonator has a single resonance structure which is shown in fig.1. It consists of a copper half shell to which three copper arms are attached on each side. Each arm consists of two hollow profiles, surrounding the drift tubes and carrying the cooling water. Copper segments on both sides of the half shell allow to tune the resonator to the radio frequency of 101.28 MHz. A tuning plate corrects the detuning effects due to the temperature changes of the tank or half shell during operation. The rf power is coupled into the resonator near one of the three legs, where the magnetic flux is maximum. Assuming a realistic resonator voltage for each resonator of approximately 1.74 MV for 90 kW rf-power (duty cycle 1:10), the design velocities were chosen to 5.4%, 6.0% and 6.6% of the velocity of light [3][4]. The number of 7 gaps for this resonator is a compromise between maximum reachable accelerating voltage and maximum flexibility in the transit time factor.

2 MAFIA SIMULATIONS

The development of the resonators was accompanied by extensive MAFIA simulations [5] [6]. To investigate the

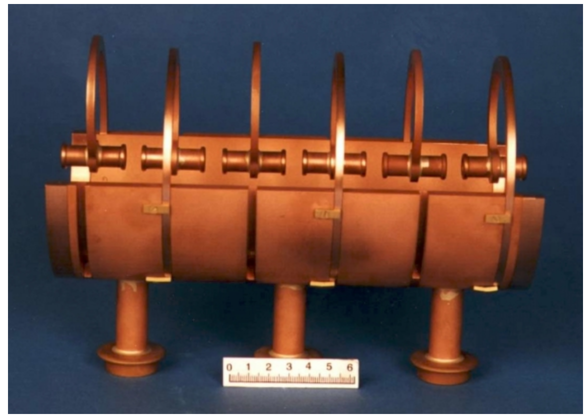

Figure 1: The 6.0% model (1:2.5)

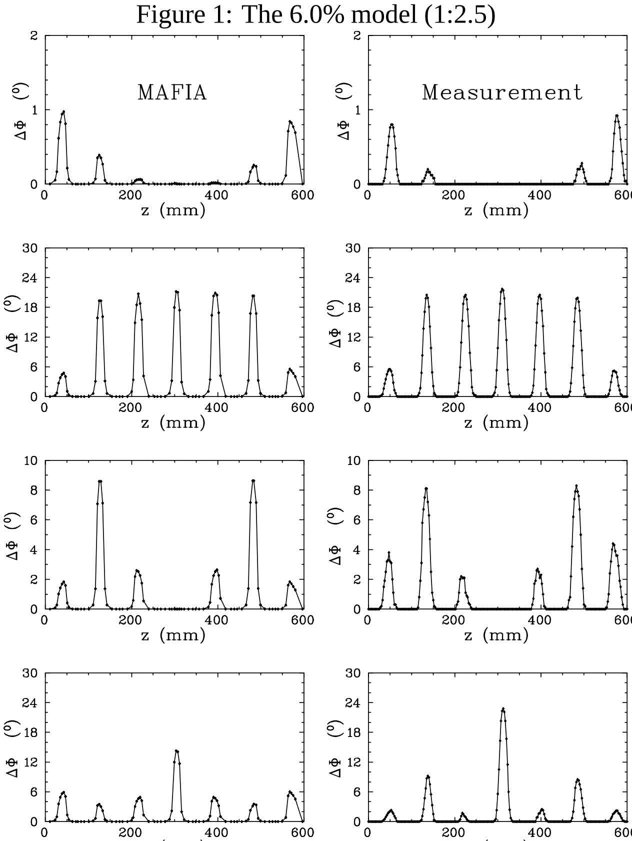

Figure 2: Comparison between the simulated and measured field distribution of the first four eigenmodes.

eigenfrequency and voltage distribution in the gaps MAFIA is a very powerful tool. The eigenfrequency of the push pull mode could be calculated with an accuracy better than 0.5% in comparison to the measurements. Fig. 2 shows the distribution of the electric field of the first four eigenmodes, left is shown the MAFIA simulation and right the

Figure 3: The 5.4% power type resonator.

measured distribution. The calculated quality factor Q and shunt impedance Z are always a factor two too high [3][5]. The power loss inside a 7-gap-resonator was also calculated in order to check the cooling water requirements. These investigations have shown that about 75% of the rf power is dissipated at the resonance structure. Half of this is lost at the arms, which therefore have to be cooled very effectively.

3 POWER TYPE RESONATORS

All three power type resonators are successfully completed. Fig. 3 shows the 5.4% power type resonator with the resonance structure and tuning plate prepared for low level rf measurements. After tuning the eigenfrequency of the push-pull-mode to the operation frequency of the amplifiers (101.28 MHz) the quality factors were determined to 5560 (5.4%), 5280 (6.0%) and 5030 (6.6%). The shunt impedances are 71 MΩ/m (5.4%), 68 MΩ/m (6.0%) and 67 MΩ/m (6.6%).

Fig. 4 shows the resonator doublet consisting of the 6.0% and 6.6% resonator prepared for high power and beam tests. To perform these tests the resonators were placed and aligned into the beam line of the Heidelberg postaccelerator. Fig. 5 shows an rf-amplifier which provides an rf power of 100 kW at a duty cycle of 10%.

4 HIGH POWER AND BEAM TESTS

After a short conditioning period an rf power of up to 105 kW could be coupled into the resonators. No problems were occured due to mechanical resonances or multipactoring effects.

Beam tests have been performed in order to determine the resonator voltages. Fig. 6 shows a schematic overview of the setup for the beam tests. For the tests a $^{32}S^{7+}$ dc beam with an energy between 43.5 and 64.9 MeV adapted to the

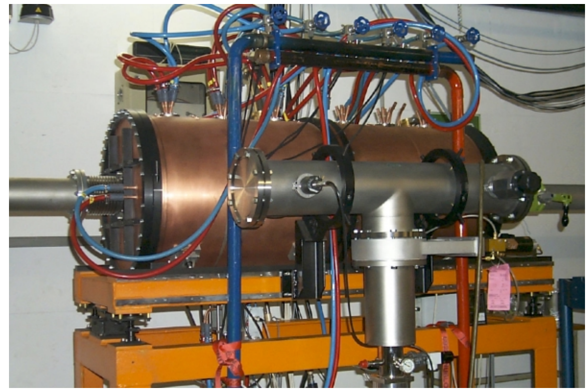

Figure 4: Resonator doublet prepared for high power tests.

design velocities was used.

Due to the dc beam the ions are affected by all possible

Figure 5: 100 kW amplifier

phases in relation to the radio frequency . Therefore ions can be accelerated or decelerated with the maximum resonator voltage. The result is an energy modulation which corresponds to a momentum modulation of the beam. The momentum spectrum is determined by measuring the cup current as function of the dipol field.

The resonator voltages and shunt impedances were calculated with the energy gain of the ions. Tab. 1 summarizes the measured parameters of the three resonators. The resonator voltages determined by beam tests are between 1.77 and 1.88 MV. This is slightly lower than the values which were expected with low level measurements. This can be explained by heating effects during operation which results in a reduced electrical conductivity. In spite of it all three resonators exceed their design voltage of 1.74 MV.

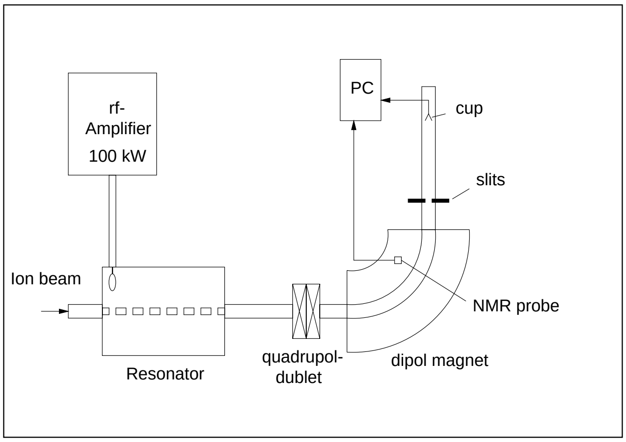

Figure 6: Principle of the beam tests

resonator	parameter	low level tests	beam tests
5.4%	U [MV]	1.88 ± 0.08	1.77 ± 0.05
	Z [MΩ/m]	71 ± 6	62.5 ± 4.0
6.0%	U [MV]	1.94 ± 0.04	1.81 ± 0.05
	Z [MΩ/m]	68.5 ± 2.7	59.7 ± 3.6
6.6%	U [MV]	2.00 ± 0.04	1.88 ± 0.05
	Z [MΩ/m]	66.9 ± 2.7	59.5 ± 3.5

Table 1: Voltage and shunt impedance determined by measurements

5 STATUS AND OUTLOOK

After the successful tests all resonators were shielded with lead to reduce the X-ray radiation below 5 μSv/h in a distance of 1 m. In June 2000 the resonators were delivered to REX-ISOLDE (CERN) and could be already aligned on beam axis (see fig.7). The resonators and lenses delivered are equipped with all necessary water manifolds so that the connection to the CERN cooling water system has already started. The next steps are the electrical connections and to mount the vacuum equipment, e.g. valves, bellows and pumps. The rf amplifiers passed all acceptance tests and are also delivered. They are now placed in the amplifier room. After the connection to water and eletricity the installation of flexible and rigid rf lines can be started. A first accelerated beam is still expected in this year.

Figure 7: The 7-gap-resonator Linac mounted in the ISOLDE hall

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