RF POWER TESTS AND RESULTS OF THE FIRST REBUNCHER FOR THE SPIRAL 2 DRIVER

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INTRODUCTION

The SPIRAL 2 project [1] uses normal conducting rebunchers to accelerate high intensity beams of protons, deuterons and heavier ions. All cavities work at 88 MHZ, the beta is 0.04 and the 3 rebunchers are located in the MEBT line, accelerating ions with a ratio A/q up to 6.

DESCRIPTION

The paper describes the tests of the rebuncher prototype with the geometricians' measurements, the vacuum tests, the measurement of the quality factor and the first RF power tests.

Rebuncher Requirements

- operation: **R1: 120 kV, R2: 60 kV, R3: 120 kV,**
- injector commissioning: emittance measurements after RFQ R1: **190 kV, pulsed**
- short distance on the line

RF DESIGN

The choice was made to have RF structure composed of three gaps with two quarter wave stems in opposition. Additionnally, it will be equipped with 2 capacitive tuners and an inductive coupler [2].

The Micro Wave Studio (MWS) software was used to obtain the mechanical dimensions of and the radio frequency parameters of the cavity. Tables 1 and 2 gather the RF design and the mechanical dimensions of the cavities taking into account.

The resonance frequency of the cavity is reached with two movables panels. The first one is used to obtain a good resonance range, the second to adjust the working frequency with the accelerating electric field .

The output radio frequency amplifier available is 5kW for 60kV and 10kW for 120kV.

Table 1: RF Design Parameters

Electrode voltage At 120kV (V beam)	80kV
TTF	0.38
Q	7800
Rs (kVeff^2/ loss)	3680
Power loss (@120 kV)	4kW
Max E field (pulsed)	11MV/m
Max trimmer sensitivity	140kHz/mm

MECHANICAL STRUCTURE

The tank will be a copper-plated stainless steel.

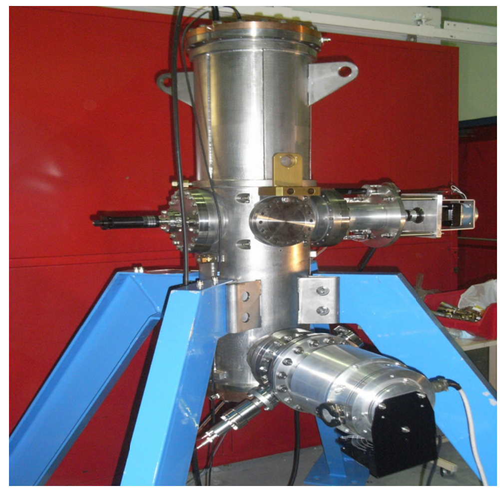

Figure 1: The RF cavity prototype on its test bench for characterisation before reception.

MECHANICAL TESTS OF THE CAVITY

At first, we controlled the position of the stems. Indeed the electrode spacing and the mass is very important because that conditions the behavior in tension of the cavity(Fig.2).The table 2shows the points of measurements.

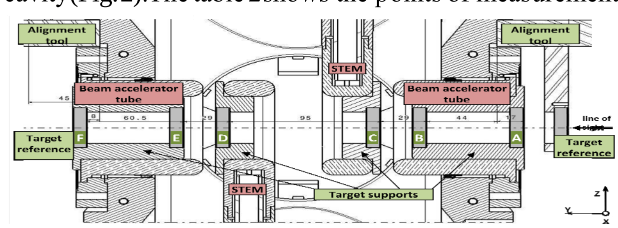

Figure 2: Geometrical measurements.

Table 2 gives us the measured positions; they are in conformity with waiting, the measured variation not having to exceed ±0.5mm.

Table 2: Measured Positions

Position	Horizontal variation in mm	Vertical variation in mm
A	0.16	-0.03
B	0.17	0.06
C	0.06	-0.49
D	-0.18	0.51
E	0.09	0.08
F	0.04	0.06

VACCUM TESTS

The system of pumping for the vacuum is installed at the bottom of the cavity as shown in the Figure 1.The pumping group is equipped with a primary pump associated a molecular turbo pump. One probe of measurement of the vacuum is installed on one of the ports beam. The measurement of the level is 5.10^{-9} mbar.l.s^{-1}.This value shows us that there is no important leak of the cavity. On the other hand the measurement of the flow of degasification one indicate a level 38 times higher than the calculations. However the level of vacuum is sufficient to begin tests RF, it is established with 1.10^{-8} mbar.

MEASUREMENT OF THE QUALITY FACTOR

The quality factor is an essential element for the operation of a cavity. It is initially calculated. The measurement made on the cavity, must be as near as possible to calculation. This quality factor depends on the shape of the cavity, of material employed for its construction, its cleanliness surface, the quality of the vacuum enclosure.

Definition

If the cavity walls are lossless, then the boundary conditions for a given mode can only be satisfied at a single frequency.

If the cavity walls have some loss, the boundary conditions can be satisfied over a range of frequencies.

The quality factor is a convenient way the power lost in a cavity.

$$Q = \frac{Energy\ stored\ in\ the\ cavity}{Energy\ lost\ /cycle}$$

To measure this quality factor we must initially know the equivalent diagram of the cavity. The Figure 3 represents the equivalent diagram of a cavity with its loop of coupling.

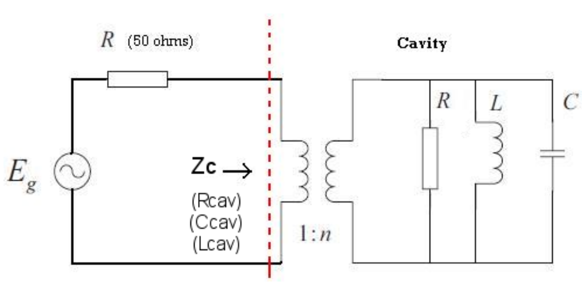

Figure 3: Cavity impedance.

The Zc is the impedance to the entrance of the coupling loop value. It is equivalent to a low pass filter.

Test bench with the cavity and the Network Analyser connection is given Figure 4.

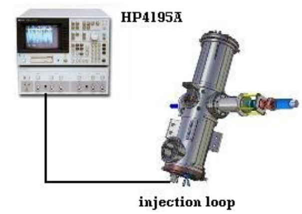

Figure 4: Test bench.

Using Network analyzer, we will vary the frequency around the frequency of resonance of the cavity. In those conditions we get the Figure 5. It is a measure of the impedance and the frequency resonance at the injection loop.

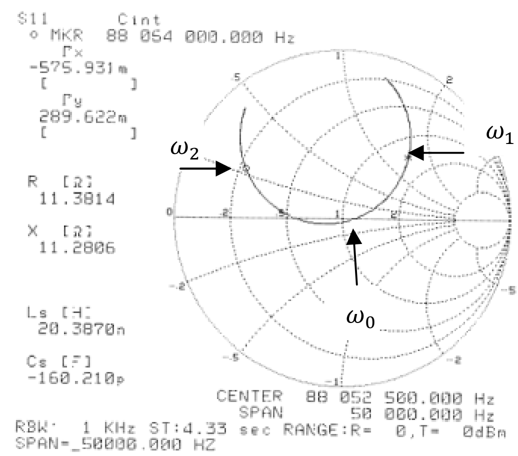

Figure 5: Result of the Network analyzer.

The Q of the cavity can be measured using transmitted bandwidth.

$$Q = \frac{\omega_0}{\omega_2 - \omega_1}$$

From Figure 5

- $\omega_0 = 88{,}0525\ MHz$
- $\omega_2 - \omega_1 = 13.45kHz$
- $Q \sim 6546$

The theoretical calculate made with Micro Wave Studio gave a value of the factor of quality of 7800, to compare with the measured value of 6546. This difference of 20% is explained by the fact that the calculations made with MWS are made for a pure copper and not a copper of industrial origin like that deposited in the cavity. It is a very correct value.

FIRST RF POWER TESTS

The cavity being now vacuum and the sufficient measured factor of quality we carried out the tests in power. Measuring the RF voltage in the cavity can be made several manners. We have probes RF, some cavities are also equipped with divider capacitive. Nevertheless all these measurements call upon more or less debatable because of theoretical calculations. The least contestable method is to measure the energy of the ' X' ray emitted by the cavity. This has been done with the test bench Figure 6.

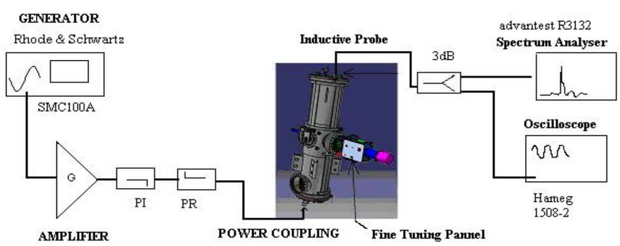

Figure 6: Power test bench.

The calculations [3] carried out by MWS gave us the following results, table 3.

Table 3: MWS Calculations

Vc beam (Kv)	60	94	120	140	165	190
Power amplifier (KW)	0,94	2,30	3,70	5,10	7,10	2,70
V electrode (KV)	40	61	79	92	108	124

The detector for the measurement of the energy of "X" produced by the cavity was provided by the service of protection against radiation of the GANIL. We calibrated this equipment with two 'X' sources of 80 keV and of 120 keV .

Then we injected RF power in the cavity. The table 4 give us the results.

Table 4: RF Power Tests

Power injected in cavity (W)	VRF calculated (kV)	VRF 'X' ray (kV)	Vacuum Pressure (mbars)
1000	71		5.10^{-8}
1500	83		5.10^{-8}
2000	101		5.10^{-8}
2500	113	100	5.10^{-8}
3000	124	110	5.10^{-8}
3500	134	120	5.10^{-7}
4000	143	145	5.10^{-7}
4500	150	160	5.10^{-6}
5000	160		5.10^{-5}
5500	167		5.10^{-4}

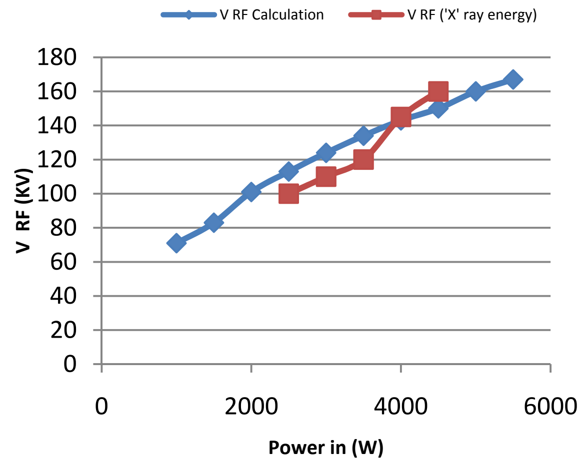

Figure 7: High voltage measurements.

The Figure 7 gives us a comparison between calculation and high voltage we obtain in the cavity.

First tests show a quite good correlation between Microwave Studio and the measurements. The tuning of the cavity works well. The cavity accepts the maximal RF power. Nevertheless, there are some multipactor problems under 1kW which are under observation and have to be resolved. We also observed a fast deterioration of the vacuum in the cavity for a power RF higher than 3.5kW. We think that comes from the problem of rate of desorption of the cavity.

CONCLUSION

The cavity now will be dismounted then cleaned. Tests RF without the fixed and mobile panels will be made in order to check that the encountered problems of multipactor are not related to the shape of the cavity. The panels will have then gone up for new tests RF.

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