PROJECT OF 181 MHz CAVITY WITH HIGHER ORDER MODES DAMPING

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The project of 181 MHz RF cavity with damped higher-order modes is presented. The cavity shape is a pill-box like. Higher-order modes damping is carried out using 6 waveguide loads, which are connected to one flat cavity wall by 6 rectangular waveguides. For accelerating mode they are cutoff waveguides. For effective coupling with higher-order modes waveguides are united in pairs. Three waveguide pairs are located azimuthally by 120 degrees. The results of the cavity numerical calculations and of the RF measurements for a scaled model are given.

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1. INTRODUCTION

Higher order modes (HOM) damped accelerating RF cavities are widely used for multibunch instabilities damping in colliders. For VEPP-4 collider a possibility of substitution of usual "multi modes" RF cavities by their "single mode" analogues have been considered. One version of such "single mode" RF cavity is described in this paper. The cavity frequency is equal to 181 MHz and cavity longitudinal size is about usual cavity. This allows to minimize necessary changes in colliders elements design.

Commonly used way of HOM damping is to guarantee HOM RF loss in a load, which is joined to cavity by a waveguide, which cutoff frequency is above cavity fundamental mode frequency [1]. In proposed cavity design an original HOM coupling elements are used. This simplifies choice of waveguide-to-cavity joining place and allows designing "single mode" RF cavity, which satisfies laid requirements and is based on design of BINP usual bimetal RF cavity [3].

2. RF CAVITY DESIGN

2.1. BASIC ELEMENTS OF RF CAVITY DESIGN

The cavity design is shown on Fig.1. Cavity base is a bimetal RF cavity body, which is a copy of Race-Track Microtron-Recuperator RF cavity [2,3]. One cavity wall has conical shape. This provides a little wall deformation under atmospheric pressure (Fig.1.pos.1). Another cavity wall has flat shape and is protected from atmospheric pressure by additional pumped shielding volume. Three waveguide pairs, throughout which HOM RF power passes to loads (Fig.1.pos.6), are joined to this wall and allocated azimuthally by 120 degrees (Fig.1.pos.4). Waveguide loads have a poorly conducting ceramic (KT-30, [6]) elements as RF power absorber. In BINP there is a reliable experience of using similar waveguide loads at building of HOM damped cavities [4,5]. The waveguides are cutoff for cavity fundamental mode and have sufficient length; therefore fundamental mode RF fields can not reach waveguide loads. All others cavity parts are fully like Race-Track Microtron-Recuperator cavity ones. There are:

- Cavity main coupler, which has a coaxial design and cylindrical alumina ceramic RF window (Fig.1.pos.3).
- Coaxial feeding line, which has a wave impedance of 75 Ohm. The diameters of its outer and inner conductors are 160 mm and 45 mm respectively (Fig.1.pos.3).
- Two main tuners, which are used for tuning cavity fundamental mode (Fig.1.pos.2).
- Cavity pick-up loop, which provides an electrical signals used by RF control system to operate cavity fundamental mode frequency and accelerating voltage.

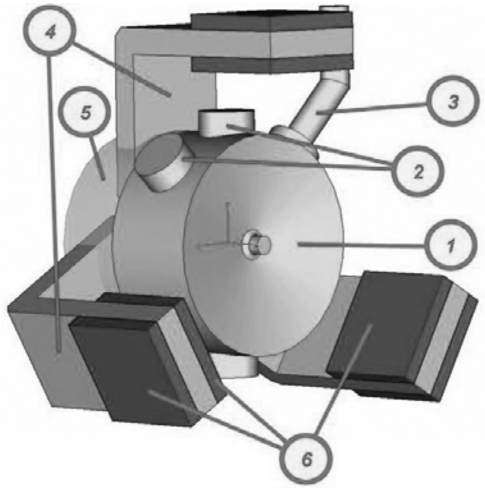

Fig.1. Design of HOM damped cavity: 1 - body of bimetal (copper clad stainless steel) RF cavity, 2 - main cavity tuners, 3 - cavity main coupler and a part of feeder, 4 - waveguide section for HOM damping, 5 - pumped shielding cavity, 6 - waveguide HOM loads

2.2. HOM COUPLING

An arrangement of HOM coupling and tuning elements on the flat cavity wall is shown in Fg.2. A peculiarity of this cavity design is that, every waveguide section consists of two waveguides with rectangular cross-section, which have a common wide wall (Fig.2.pos.2). These common wide walls have parts, which continue into RF cavity and are antennae (Fig.2.pos.3). This waveguide sections design provide effective coupling with HOM at various patterns of HOM RF field (Fig.3). This simplifies choice of coupling hole place on RF cavity shape.

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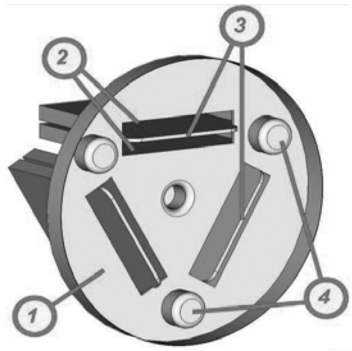

Fig.2. Flat cavity wall with HOM coupling and tuning elements:
1 - RF cavity flat wall, 2 - HOM coupling holes of one waveguide section, 3 - HOM coupling antenna of wave-guide sections, 4 - cavity HOM tuners

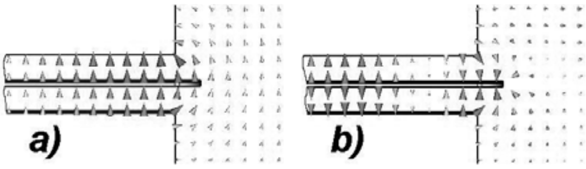

Fig.3. Waveguide section excitement by HOM fields: a) sin-phase excitement, b) anti-phase excitement

2.3. HOM TUNING ELEMENTS

Fixed HOM tuning elements (Fig.2.pos.4) allow to increase a coupling with dampers and to decrease a longitudinal impedances of two HOM, which frequencies equal 423 MHz and 485 MHz, and which have a complex fields patterns (cylindrical cavity TM020 & TM310 hybrids, Fig.4, Microwave Studio [7] simulation).

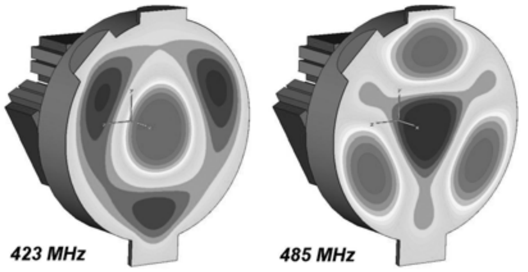

Fig.4. Longitudinal electric field multiplier patterns of HOM with longitudinal impedance ~ 1 kOhm

3. NUMERICAL SIMULATION

3-D numerical simulation was made with Microwave Studio [7]. A calculated spectrum up to 900 MHz consists of about 150 modes. Some cavity simulation results are given in Table.

HOM damped cavity parameters	
Cavity size: length x height x width	1400 x 2400 x 2700 mm
Necessary length of beam tube	1000 mm
Fundamental mode parameters	
Frequency	181 MHz
Tuning range of frequency	300 kHz
Quality factor (Q)	34000…36000
Transit time factor (τ)	0.86
Effective impedance ($\rho\cdot\tau^2$)	112 Ohm
Shunt impedance ($\rho\cdot\tau^2\cdot Q$)	3.8…4.0 MOhm
Wall loss at U_{accel} = 850 kV	90…95 kW
HOM (up to 900 MHz) parameters	
Max ‖ ($\rho\cdot\tau^2$)	≤ 20 Ohm
Max ‖ ($\rho\cdot\tau^2\cdot Q$)	≤ 1 kOhm
Max ⊥ ($\rho\cdot\tau^2$)	≤ 800 Ohm/m
Max ⊥ ($\rho\cdot\tau^2\cdot Q$)	≤ 30 kOhm/m

4. SCALE-MODEL MEASUREMENT RESULTS

For investigating cavity HOM spectra simplified cavity scale-model (scale is 1:5) was made (Fig.5 down). Transmission coefficient S_{12} between two capacitance probes placed on model axis was measured by vector analyzer. Measured frequency span is 500…8500 MHz.

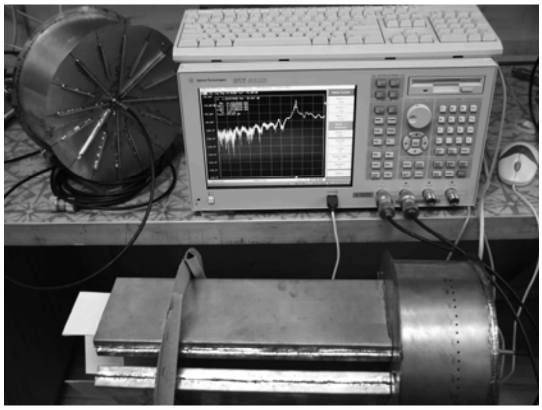

Fig.5. HOM spectra measurement of bimetal RF cavity (up) and HOM damped RF cavity (down) scale-models

Measurement results are shown on Fig.6. According to this data we can consider that real cavity HOM will been damped effectively up to frequency about 1300 MHz. Measurement results of bimetal cavity scale-model (Fig.5 up) are given on Fig.7 to compare.

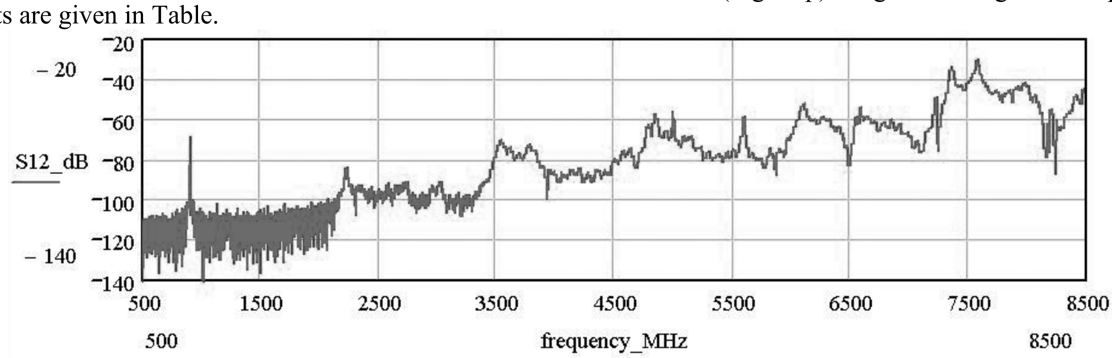

Fig.6. HOM damped RF cavity scale-model spectrum

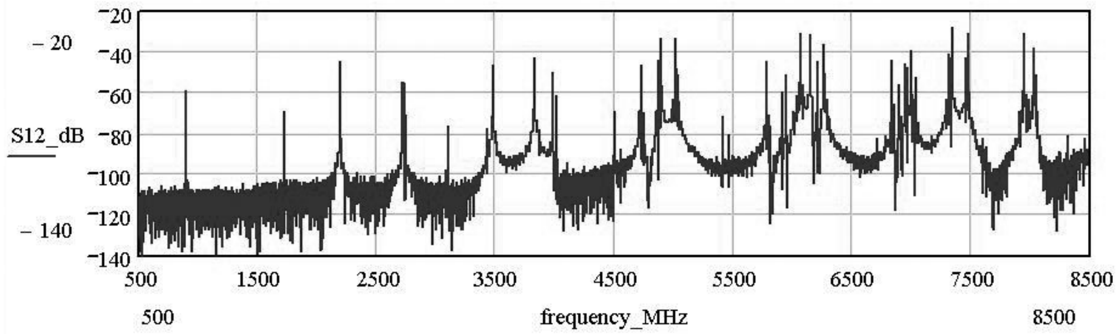

Fig.7. Bimetal RF cavity scale-model spectrum

CONCLUSION

Some estimates of beam longitudinal oscillation increments, which are caused by interaction between a beam and HOM of 6 accelerating cavities, were made for VEPP-4 collider (method is given in [8]). These estimates shown that substitution of existing "multi modes" RF cavities by described "single mode" ones can increase maximum increments by:

• about 3000 times, at collider operating energy of 1.56 GeV, accelerating voltage of 400 kV and beam current of 4*3 mA (2e,2p).

• about 30 times, at collider operating energy of 5 GeV, accelerating voltage of 5100 kV and beam current of 4*40 mA (2e,2p).

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ПРОЕКТ РЕЗОНАТОРА С ПОДАВЛЕНИЕМ ВЫСШИХ МОД НА ЧАСТОТУ 181 МГц

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Представлен проект резонатора с подавлением высших мод на частоту 181 МГц. Резонатор имеет форму, близкую к цилиндрической. Демпфирование высших мод осуществляется 6-ю волноводными нагрузками, присоединенными к одной из плоских стенок резонатора с помощью 6-ти волноводов прямоугольного сечения. Для рабочей моды резонатора волноводы являются запредельными. Для эффективной связи с высшими модами, волноводы объединены попарно. Пары волноводов расположены равномерно по азимуту через 120^0. Приводятся результаты численного моделирования резонатора. Описаны результаты ВЧ-измерений на масштабном макете.

ПРОЕКТ РЕЗОНАТОРА ІЗ ПОДАВЛЮВАННЯМ ВИЩИХ МОД НА ЧАСТОТУ 181 МГц

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Представлено проект резонатора із подавлюванням вищих мод на частоту 181 МГц. Резонатор має форму, близьку до циліндричної. Демпфірування вищих мод здійснюється 6 хвилеводними навантажуваннями, приєднаними до однієї із плоских стінок резонатора за допомогою 6 хвилеводів прямокутного перетину. Для робочої моди резонатора хвилеводи є позамежовими. Для ефективного зв'язку з вищими модами, хвилеводи об'єднані попарно. Пари хвилеводів розташовані рівномірно по азимуту через 120^0. Приводяться результати чисельного моделювання резонатора. Описано результати ВЧ-вимірів на масштабному макеті.