VEPP-2000 SINGLE-MODE CAVITY

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Abstract

VEPP-2000 electron–positron collider designed in Novosibirsk Budker INP is a new storage ring with 1 GeV energy and 200 mA current threshold per beam. For a bunch phase motion stability and suppression of a beam coherent interactions with higher order modes (HOM) a single-mode 172 MHz accelerating cavity is developed. The cavity has a low coupling impedance of 200÷300 Ohm at HOM. The cavity design and used HOM loads are described in the paper.

1 INTRODUCTION

e^+-e^- annihilation into hadrons in the energy range from 1400 to 2000 MeV is not studied well enough yet. In Novosibirsk Budker INP for experiments in this energy range it was decided to upgrade the VEPP-2M collider, which operates at the world lowest energy of 2x700 MeV with beam currents of 2x20 mA, to a new collider with larger energy of 2x1000 MeV. The project of the new collider requires the storage of larger beam currents of 2x100 mA [5].

At relatively low energy it causes some problem of providing a stable phase motion of the bunches. To suppress the coherent interaction of the beam with HOM, a single-mode accelerating cavity was developed.

The cavity has a low (200÷300 Ohm) coupling impedance of the HOM. According to the calculations, these values of coupling impedance of the cavity HOM provide a stable phase motion of the bunches even at a two times higher beam current. Fig.1 shows a schematic drawing of the cavity.

2 CAVITY DESIGN

The HOM damping is done by two absorbing cylindrical loads (SiC Absorbers): the coaxial and waveguide loads. The loads are assembled from separate elements (cups) made from conducting SiC-ceramics. Each cup is fixed at the bottom to the heat removing wall of the cylinder. The coaxial load is well matched to the TEM-waves in the range of 36÷3500 MHz (VSWR<1.5) and provides HOM damping over the entire operation range of frequencies (up to 3500 MHz).

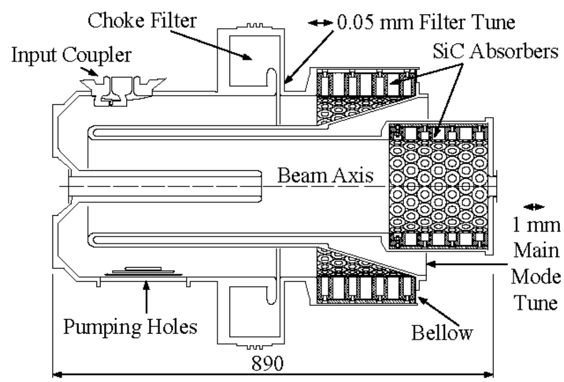

Fig.1. Schematic drawing of the single-mode cavity.

A Choke-Filter tuned to the accelerating mode frequency is placed in the coaxial line before the load. It reflects back the TEM-wave at the accelerating mode frequency. The HOM driven TEM-waves are not affected by the Choke-Filter and are absorbed in the load.
The waveguide load is located in the vacuum chamber of 187 mm in diameter. The load (in addition to the coaxial load) suppresses those HOM with frequencies above the waveguide cut-off frequency (1235 MHz).

The fundamental mode frequency is well below the waveguide cut-off frequency and can not propagate in the waveguide.

The cylindrical detail (see fig.1) being shifted along an axis direction within ±0.5 mm tunes a main mode in a range of ±16 kHz. Tuning of the choke is performed through changing the value of its gap of 6.51÷6.56 мм. The 120 kW RF power input and two sampling loops are situated at 120° on the cylindrical part of the cavity body. One of the loops is used in the system of control and measurement of the accelerating field. The other is intended for measurement of the voltage of the HOM in the cavity.

3 HOM LOADS

Design of the loads of absorbing elements consisting are shown in figure 1. Drawings of the design of the absorbing elements are shown in figure 2a and figure 2b.
The ceramics used in the absorbing elements is of KT-30 type.

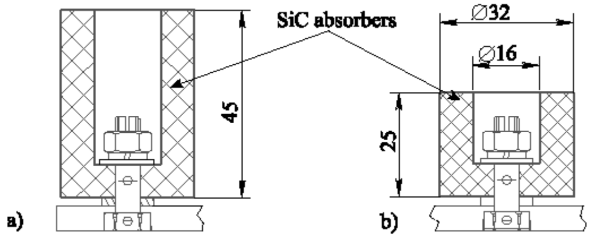

Fig.2. Absorbing element a) of the coaxial HOM load, b) of the waveguard HOM load.

Although the loads are of the form of large number of absorbing elements structure, we had to approximate the loads by the axially symmetric one with the dielectric constant and conductivity reduced by the volume ratio.

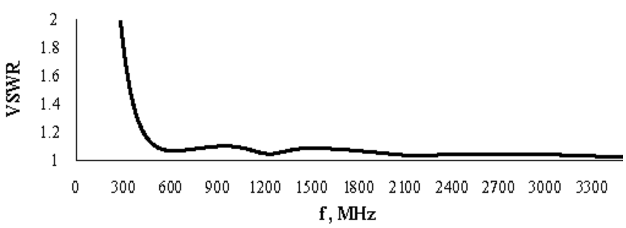

Fig.3. VSWR of coaxial load calculated by SUPERFISH.

In numerical simulations of the HOM loads in broad frequency range (40-3000 MHz, see fig.3) a complex dielectric constant was introduced.

Sizes of loads the following: the axis length of the loads is 256 mm, the radial thickness 45 mm and 25 mm, the inner diameter 500 and 190 mm for coaxial and waveguard loads respectively. Volume ratio of the absorbing material is 0.5. The HOM power to be handled in both loads will be on the order of ~350 W. Each load has a cooling water pipe soldered outside.

4 CAVITY COMPUTATIONS

4.1 Monopoly Modes

For calculations of eigen monopoly HOM the program CLANS [1] was used. These calculations have been made in search of the optimal geometry of the cavity. But for the check of beam phase motion stability the coupling HOM impedance are computed by the use of a improved program CLANSX [2]. In particular, this program solves the task of excitation of HOM with low factor of Q by a beam and calculates coupling impedance of HOM. Fig.4 shows the frequency dependence of the real part of coupling impedance of the cavity HOM computed by CLANSX.

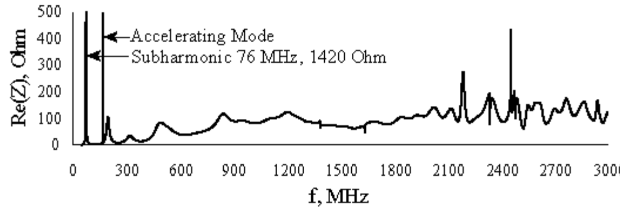

Fig.4. Real part of coupling impedance of HOM of cavity

The beam phase motion stability was checked by the program MBI [4]. For this purpose the coupling HOM impedance on around of frequency harmonics fn = n·12.292 MHz (n = 1÷280) were computed twice. It is accepted that in frequency bands of df = ±fs concentrated around fn (fs = 31 KHz - synchrotron frequency without of coherent shift) a frequent dependence of the coupling impedance be a linear. Because the df is less than any of HOM peak width (it's width not lower then 3 MHz).

4.2.Dipole Modes

The dipole HOM characteristics was computed by the program CLANS2 [3]. On the figure 5 the dipole HOM spectrum introduced as the superposition of separate dipole HOM is presented. The beam transverse motion stability was checked by the program MBI [4] as well.

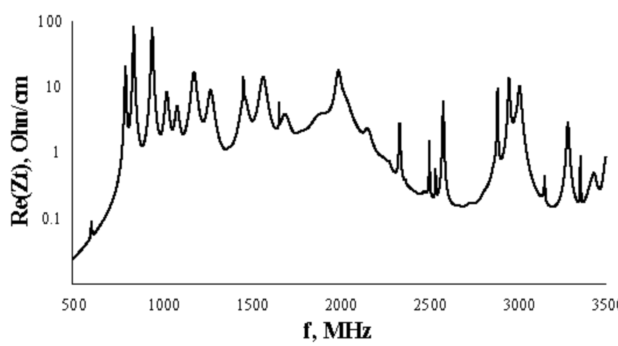

Fig.5. Dipole mode spectrum of the single mode cavity.

4.3. Accelerating Mode

The accelerating mode have been calculated by program CLANS [2]. On the figure 6 the field pattern and field distributions in the cavity gap is presented. In the table 1 the accelerating mode characteristics is presented.

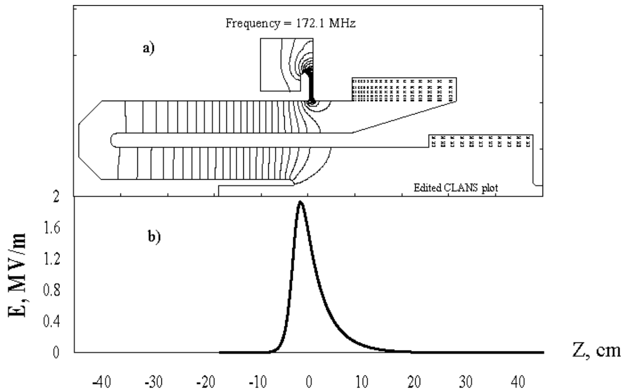

Fig.6. a) Close view of the field pattern of the accelerating mode. After the choke filter TEM mode transforms to E_{01} mode and do not propagate to the load, as the critical frequency of E01 mode in the coaxial waveguide is more higher then accelerating frequency.
b) Axis rf accelerating field of the cavity.

Table1. Accelerating mode characteristics

Frequency	172.099 MHz
Quality factor	8800
Transit time factor	0.9898
Effective impedance	28.07 Ohm
Shunt impedance	246.99 kOhm
Acceleration	120.0 kV
Total power loses	29.15 kWt
Cavity temperature	≤60°

5 SUMMARY

The coupling impedance of the single mode cavity calculated by CLANSX program in frequency band of 3000 MHz has shown a sufficient performance for proves a stable operation of VEPP-2000 collyder. The beam current threshold of the coupled bunch instability in two times higher then the designed beam current of the collider.

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