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Higher Order Modes Damping in CESR-B Cavity*

V. Veshcherevich†, K. Akai††, P. Barnes, W. Fox†††, J. Kirchgessner, D. Metzger, D. Moffat, H. Muller, H. Padamsee, J. Sears, and M. Tigner

Floyd R. Newman Laboratory of Nuclear Studies
Cornell University, Ithaca, NY 14853

ABSTRACT

Higher order modes of the CESR-B superconducting RF cavities must have low R/Q and low Q values to avoid single and multibunch instabilities. Large beam pipes with internal ferrite absorbers have been proposed for this purpose. Numerical estimates showed $Q < 100$ for many longitudinal modes and less than several hundred for many dipole modes. These estimates were confirmed by measurement on a full scale copper prototype of the cavity with real ferrite absorbers and other beam line components.

1. INTRODUCTION

Higher order modes (HOMs) of superconducting accelerating RF cavities designing for the Cornell B-Factory, CESR-B, must have low R/Q and low Q values to avoid single and multibunch instabilities of the high intensity electron and positron beams in this machine. Large beam pipes with internal ferrite absorbers have been proposed earlier for this purpose as an effective method for superconducting cavities [1]. Numerical estimates showed $Q < 100$ for many longitudinal modes and less than several hundred for many dipole modes [2]. It was important to confirm these estimates by measurement with real ferrite absorbers in place. Small cavity models (of 1/6 and 1/3 scale) that have been built and tested [2,3] did not actually model the HOM damping in full measure due to frequency dependence of ferrite loss properties. Therefore a full scale copper prototype of the cavity with ferrite absorbers and other beam line components has been built # and measured.

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† Visitor from Institute of Nuclear Physics, 630090, Novosibirsk, Russia.

†† Visitor from KEK Laboratory, Tsukuba, 305 Japan.

††† Visitor from Los Alamos National Laboratory, Los Alamos, NM 87545.

Full scale copper prototype has been fabricated by Dornier (Germany).

2. CAVITY DESIGN

The design of a superconducting cavity for the CESR-B was described elsewhere [2]. Figure 1 shows a full scale cavity model assembled with ferrite HOM absorbers and taper transitions to regular beam tube cross section.

Resonance frequencies as well as Q and R/Q values of higher order modes of the cavity were calculated using URMEL program. But those calculations did not take into account flutes in one of the beam tubes and the input rectangular waveguide connected to the cavity. Therefore the calculated values were not quite correct and did not give the complete picture (the number of modes in a real cavity is greater than in a computational model) though they were very useful and allowed to choose the optimized cavity shape and to find clues to solving different cavity problems.

Measurements on the cavity model were carried on with an HP 8753C network analyzer. Antenna or loop type probes in beam pipes were used for exciting higher order modes in the cavity. Field perturbation technique was applied to determine azimuthal field patterns of HOMs. For this purpose a number of holes was made in beam pipes near the ferrite absorbers, at different azimuthal positions. Intruding a metal rod in a hole one can see a shift of mode frequency which is proportional to square of electrical or magnetic field in the vicinity of the rod. If the field is too weak to produce a distinguishable frequency shift, one can compare signal magnitudes from probes placed in different holes instead of rods.

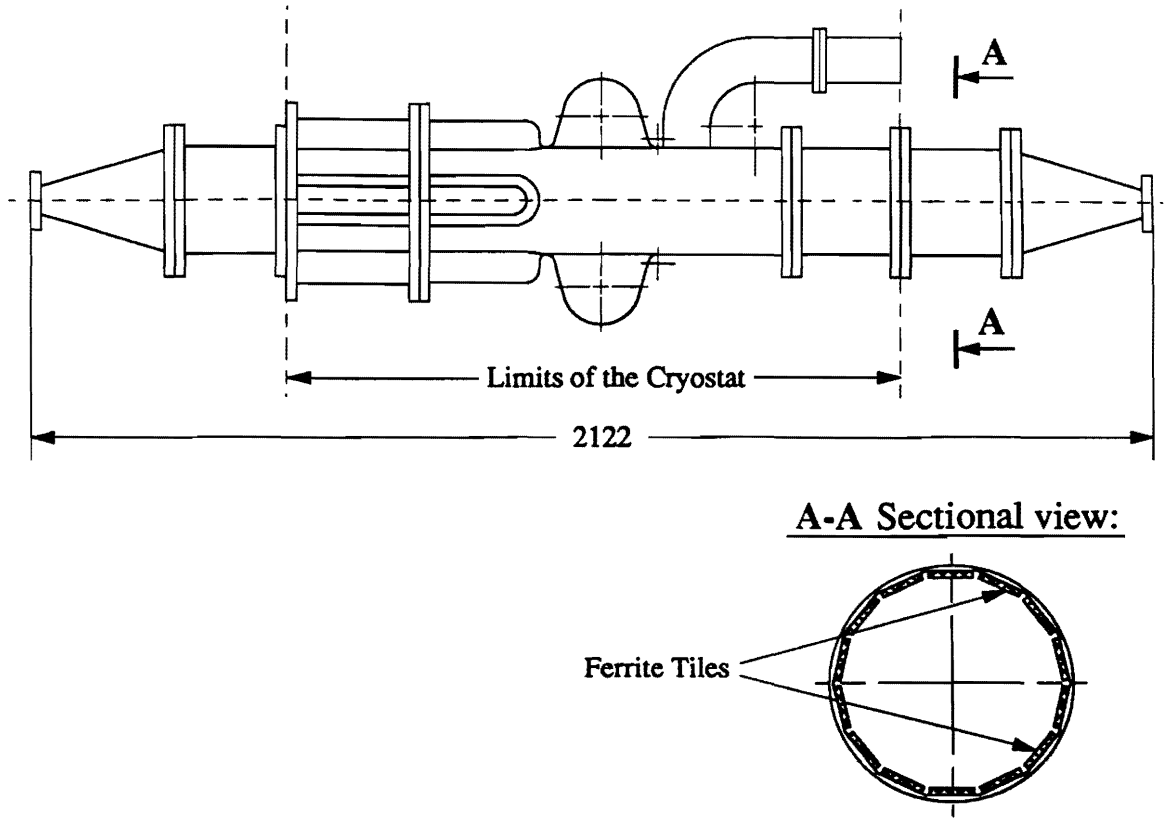

Fig. 1. Scetch of the copper prototype of CESR-B cavity

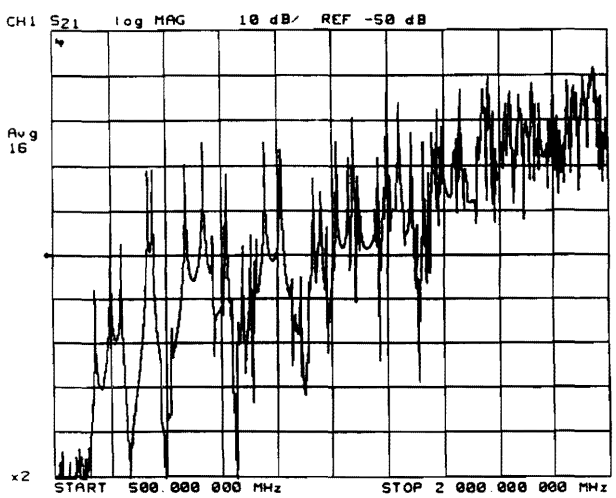

Fig. 2. HOM spectrum of the copper prototype without ferrite absorbers.

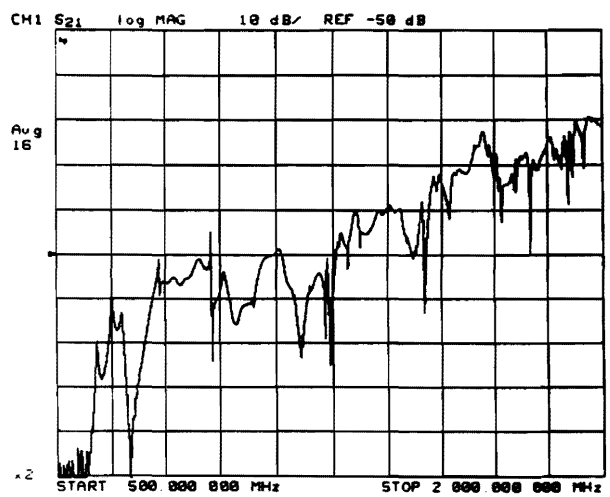

Fig. 3. HOM spectrum of the copper prototype with Ferrite-50 absorbers.

3. EXPERIMENTAL RESULTS

Fig. 2 and 3 show HOM spectra of the full scale cavity model without HOM absorbers and with absorbers made of Ferrite-50 tiles. Many modes, exciting in the cavity without absorbers, disappeared after placing ferrite in the beam tube: their Q values became too low to be measured. In order to have some hints on Q values of HOMs for damped cavity additional measurements with fewer numbers of ferrite tiles have been made as well. Azimuthal symmetry of ferrite tiles spacing was always kept at that measurements.

Different types of ferrites are considered for application in HOM absorbers. Therefore two types of absorbers were made and measured. In one of them, as it has been mentioned, the Ferrite-50 was used. In another one the TT2-111 ferrite was tried. Since the number of TT2-111 tiles available was not sufficient for filling two absorbers completely, only measurements with partially filled absorbers have been made.

Comparison of the Q values of HOMs with different azimuthal symmetry for the cavity with absorbers using ferrite tiles of two types is presented in Fig. 4-6. In both cases Q values for totally filled absorbers are given but these values are calculated from values, measured for half-filled absorbers. It is clear that damping of HOMs is effective with both types of ferrite.

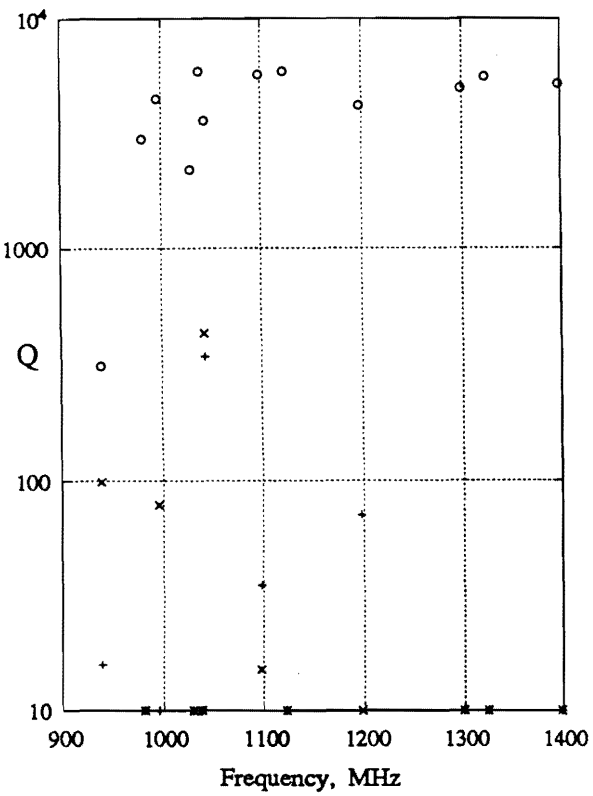

Fig. 4. Q values of monopole higher order modes: o - without ferrites, + - with absorbers of Ferrite-50, x - with absorbers of ferrite TT2-111.

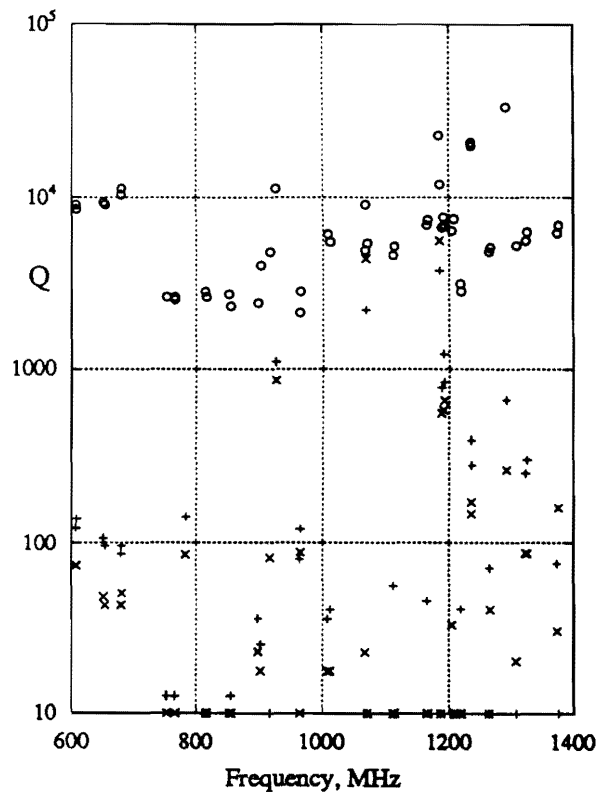

Fig. 5. Q values of dipole higher order modes: o - without ferrites, + - with absorbers of Ferrite-50, x - with absorbers of ferrite TT2-111.

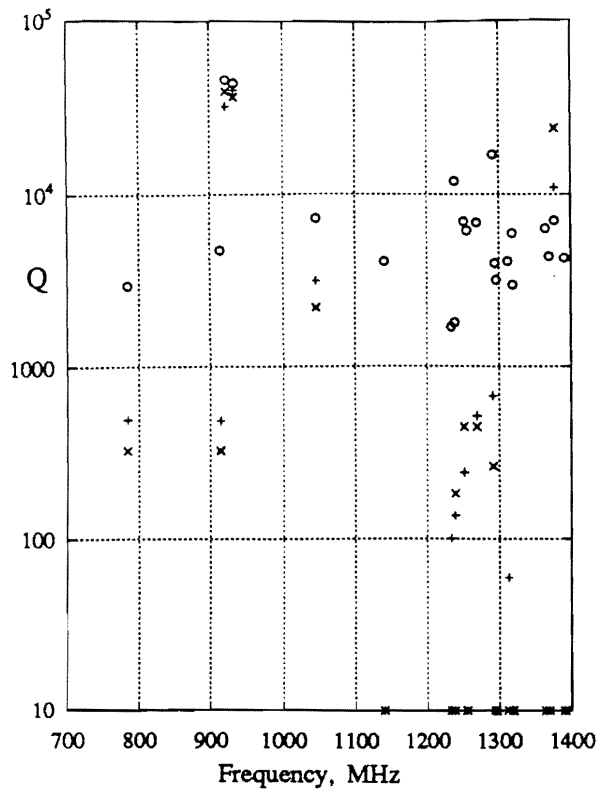

Fig. 6. Q values of quadrupole higher order modes: o - without ferrites, + - with absorbers of Ferrite-50, x - with absorbers of ferrite TT2-111.

4. SUMMARY

Measurements, carried out on the full scale copper prototype of the superconducting cavity for the Cornell B-Factory, confirmed the effectiveness of the HOM ferrite absorbers placed in the beam tube. The Q values of most higher order modes were less than 100. Some modes were found however that have Q of several hundreds but they had low R/Q values. The trapped multipole modes nevertheless had a small coupling to the absorbers and had Q of the order of 10^4. This is important for a superconducting cavity since it means that a possibility of appearance of very high fields, induced by the beam, is excluded.

Numerical estimates using Q values, been measured on the copper prototype, showed [4] that accelerating cavity should not cause longitudinal multibunch instabilities. The rise time of transverse oscillations was found to be 20 ms, as compared to 27 ms for the radiation damping time. That means a minimal transverse feedback system is required.

Two types of ferrites were tested and both of them were good for HOM damping. So other characteristics of ferrites should be taken into account for making the choice of material, such as mechanical, thermal, high vacuum properties as well as the value of broadband loss factor of ferrite absorber unit.

REFERENCES:

[1]. H. Padamsee et al. Accelerating Cavity Development for the Cornell B-Factory, CESR-B. Proc. of the 1991 IEEE Part. Accel. Conf., San Francisco, May 1991, p. 786.

[2]. H. Padamsee et al. Design Challenges for High Current Storage Rings. Proc. of the 5th Workshop on RF Superconductivity, Hamburg, August 1991, to be published.

[3]. D. Moffat et al. Use of Ferrite-50 to Strongly Damp Higher Order Modes. Proc. of the 1991 IEEE Part. Accel. Conf., San Francisco, May 1991, p. 664.

[4]. M. Tigner. CESR-B Accelerating System, Concept and R&D Program. Report at this Conference.

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