Los Alamos NATIONAL LABORATORY

Beam Coupling Impedances of Ferrite-Loaded Cavities: Calculations and Measurements

Sergey Kurennoy and Rodney McCrady,
LANL

May 24, 2021

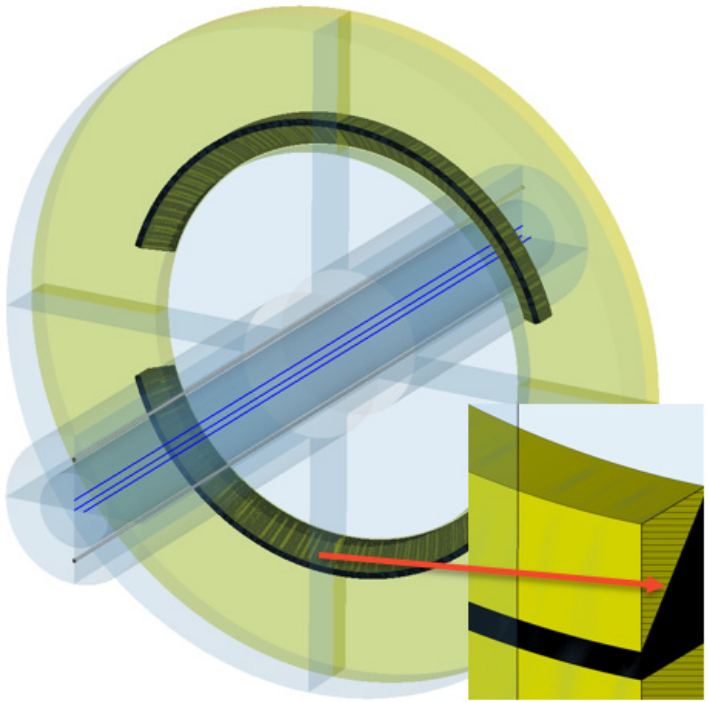
IPAC21

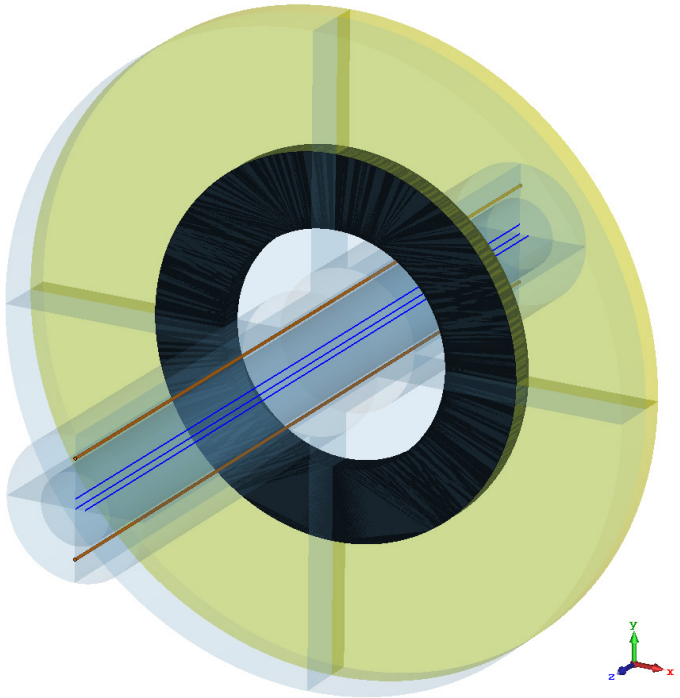
Abstract

We have developed an efficient method of calculating impedances in cavities with dispersive ferrite dampers. The ferrite dispersive properties in the frequency range of interest are fitted in CST, which allows using both wake-field and lossy eigenmode solvers. A simple test cavity with or without ferrite inserts is explored both numerically and experimentally.

The resonance frequencies and beam coupling impedances at cavity resonances are calculated with CST to understand the mode structure. The cavity transverse coupling impedances are also measured on a test stand using a two-wire method. We compare results of impedance calculations and measurements for a few different configurations, with and without ferrites, to ensure a complete understanding of the cavity resonances and their damping with ferrite. These results are important to provide an adequate damping of undesired transverse modes in induction-linac cells.

CST model of test cavity

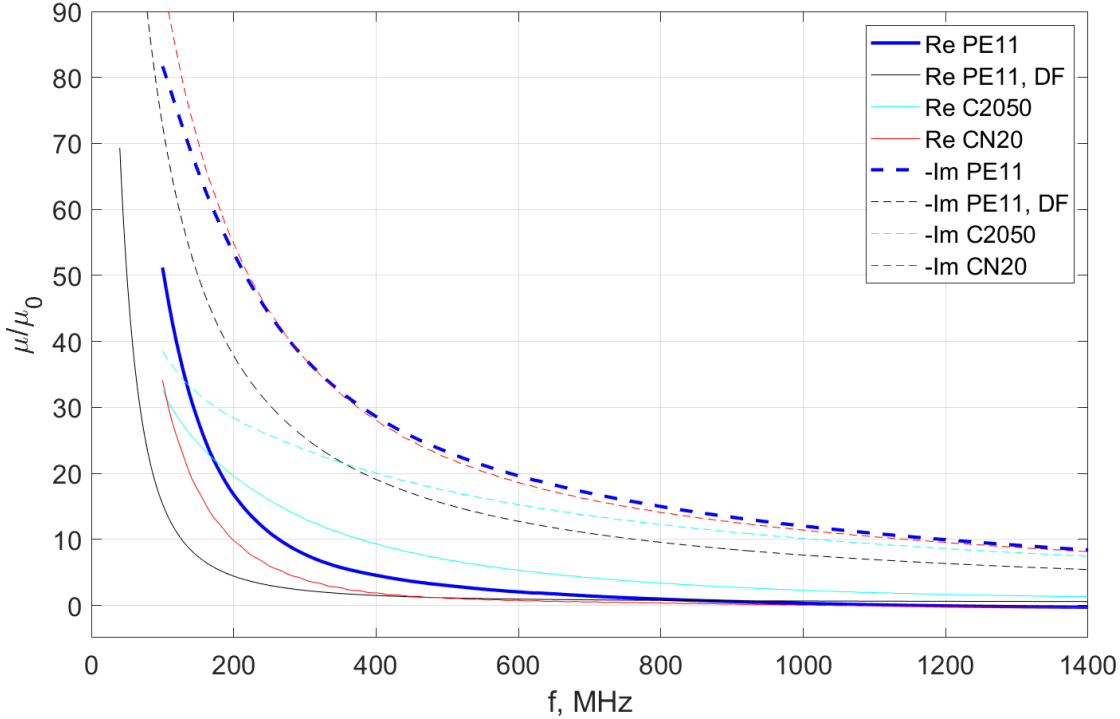




Ferrite configurations in the test cavity: two arcs (left) and ring (right) are shown in black. Aluminum walls are hidden; two wires are in vertical plane; dielectric foam is yellow.

Ferrite dispersive properties

$$\mu = \mu' - i\mu''$$



RF losses depend on μ''

Magnetic permeability μ' & μ'' vs frequency for different ferrites.
CST fits these data with functions allowing simple Fourier transform.

Transverse dipole modes of test cavity

Empty cavity w/o wires

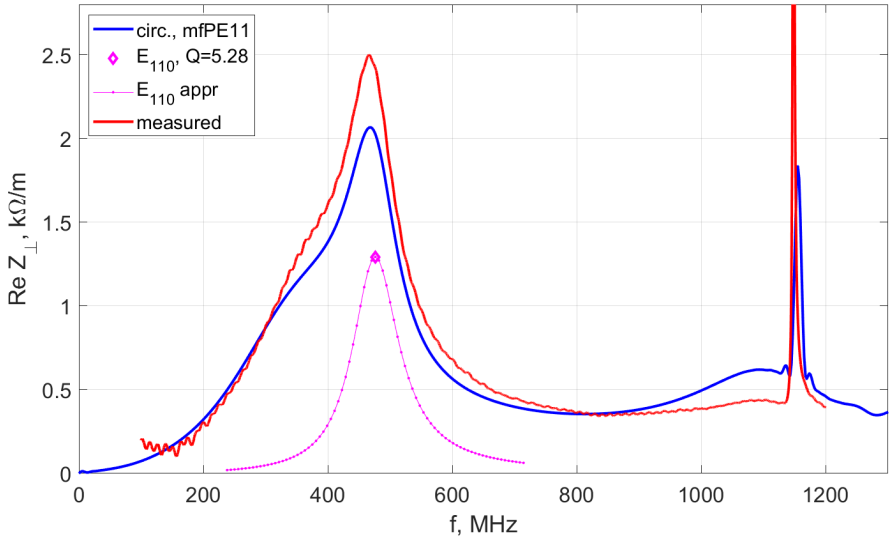
Mode	*f*, MHz	*Q*	Z_{tr}, Ω/m
E_{110}	521.7	16,700	$2.45 \cdot 10^6$
E_{120}	952.7	21,814	$2.64 \cdot 10^6$

Cavity with arc ferrites (asymmetry *x*, *y*)

Mode	f, MHz	Q	Z_{tr}, Ω/m
E_{110x}	504.0	6.94	1685
E_{110y}	522.9	5.37	988
E_{120x}	950.5	18.9	4951
E_{120y}	958.7	15.2	4292

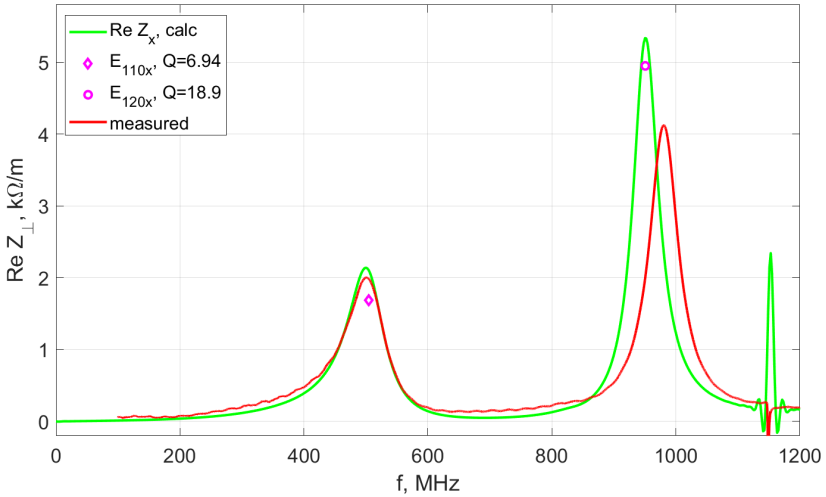
Cavity with ring ferrite

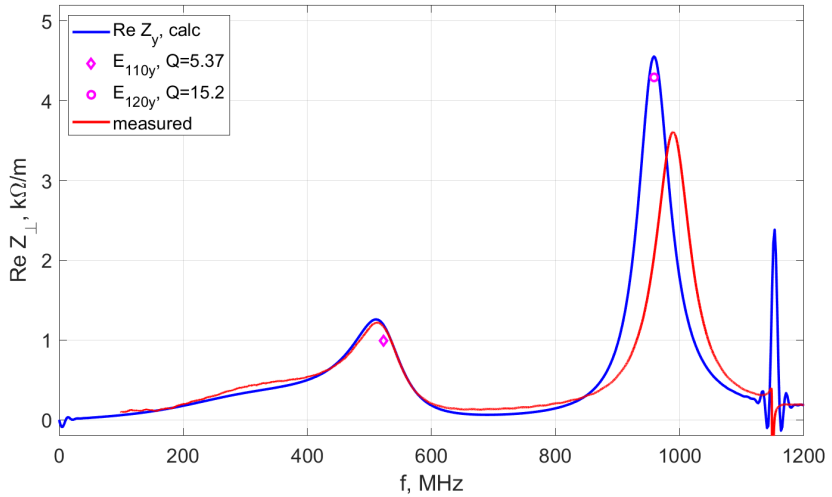
Mode	f, MHz	Q	Z_{tr}, Ω/m
E_{110}	476.2	5.28	1293
E_{120}	-	-	-



Transverse dipole impedance vs. frequency for cavity with ring ferrite: calculated from wakes (blue), eigenmode contribution fit (magenta), and measured (red).

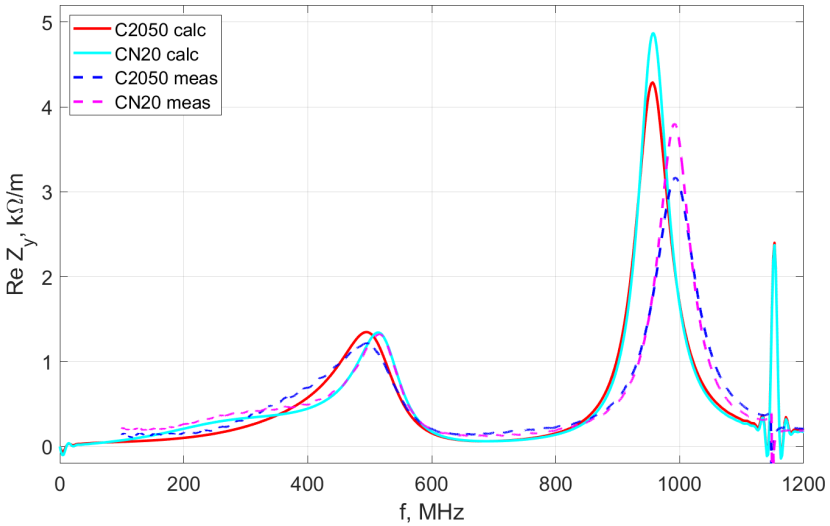
Transverse dipole impedance of cavity with arc ferrites



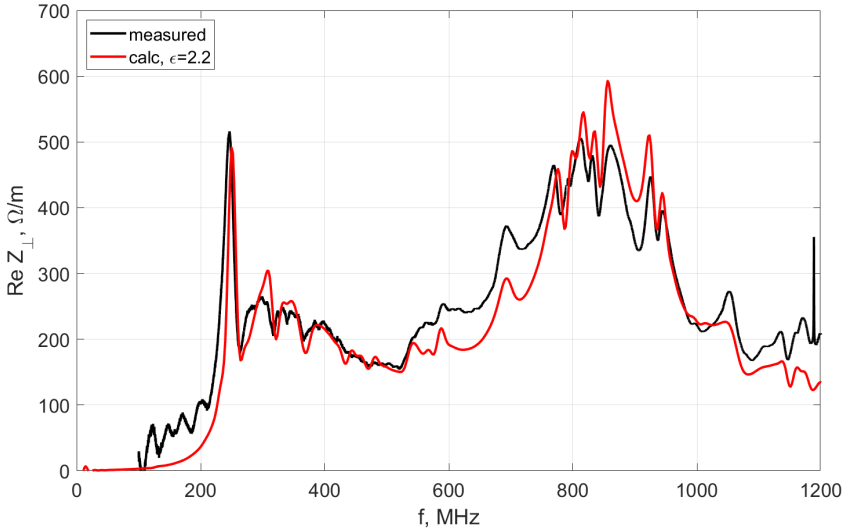


Transverse dipole impedance vs. frequency for cavity with arc ferrites: calculated from wakes (green, blue), eigenmode contributions (magenta marks), and measured (red).

Transverse dipole impedance – calculated & measured



Vertical impedance of cavity with arcs made of different ferrites: calculated and measured.



More complicated case: Transverse impedance of Scorpius prototype cavity with 8 induction cells and ferrite absorbers.

Summary

- We have developed an efficient method of calculating impedances in cavities with dispersive ferrites. A simple test cavity with or without ferrite inserts was studied as an example. The cavity transverse coupling impedances are also measured on a test stand using a two-wire method.
- The results of impedance calculations and measurements are in agreement, even for complicated cavities.
- This method gives us a convenient tool to evaluate various design options and guide the design process for cavities of linear induction accelerators.