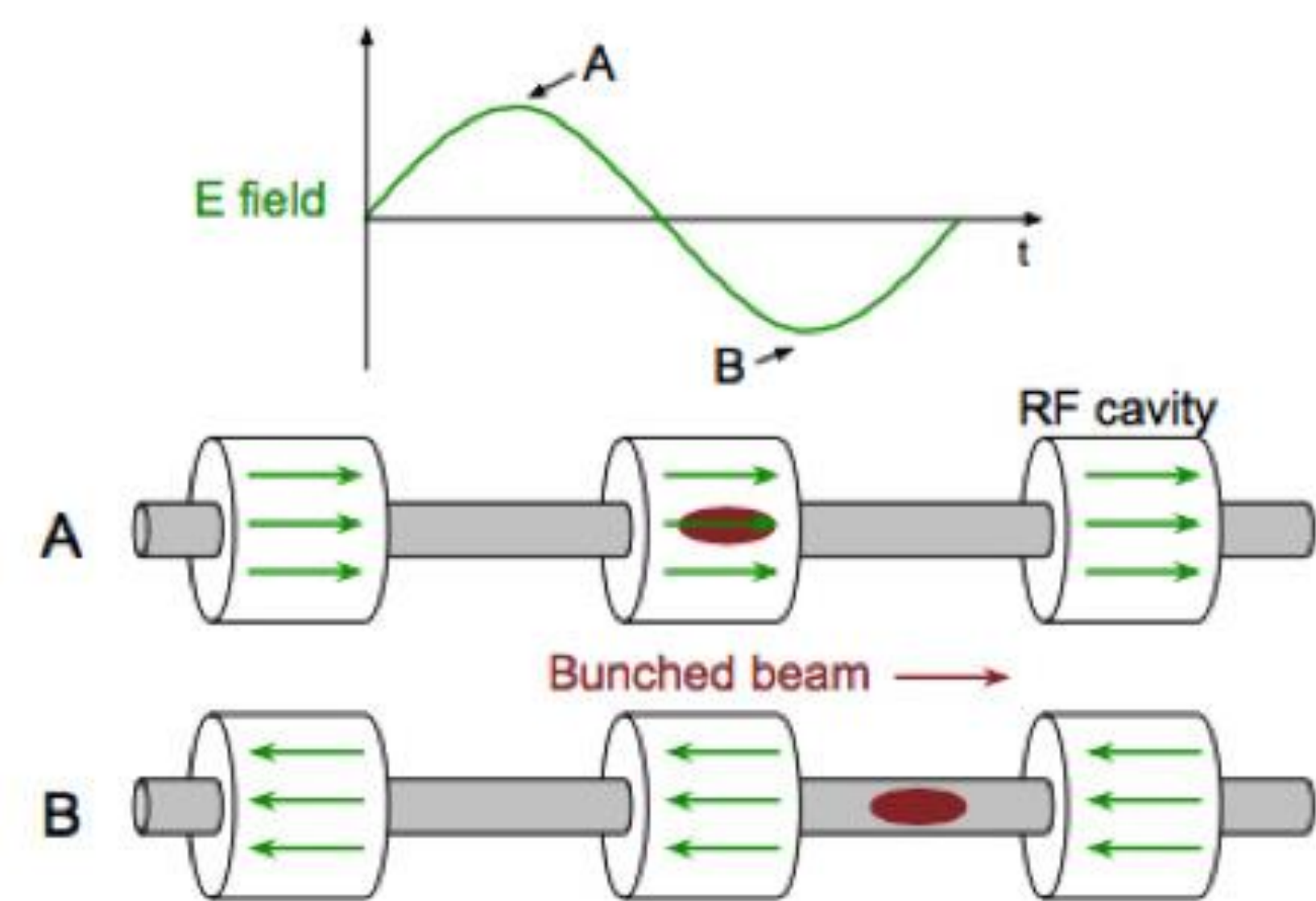


Booster Cavity Tuner Optimization

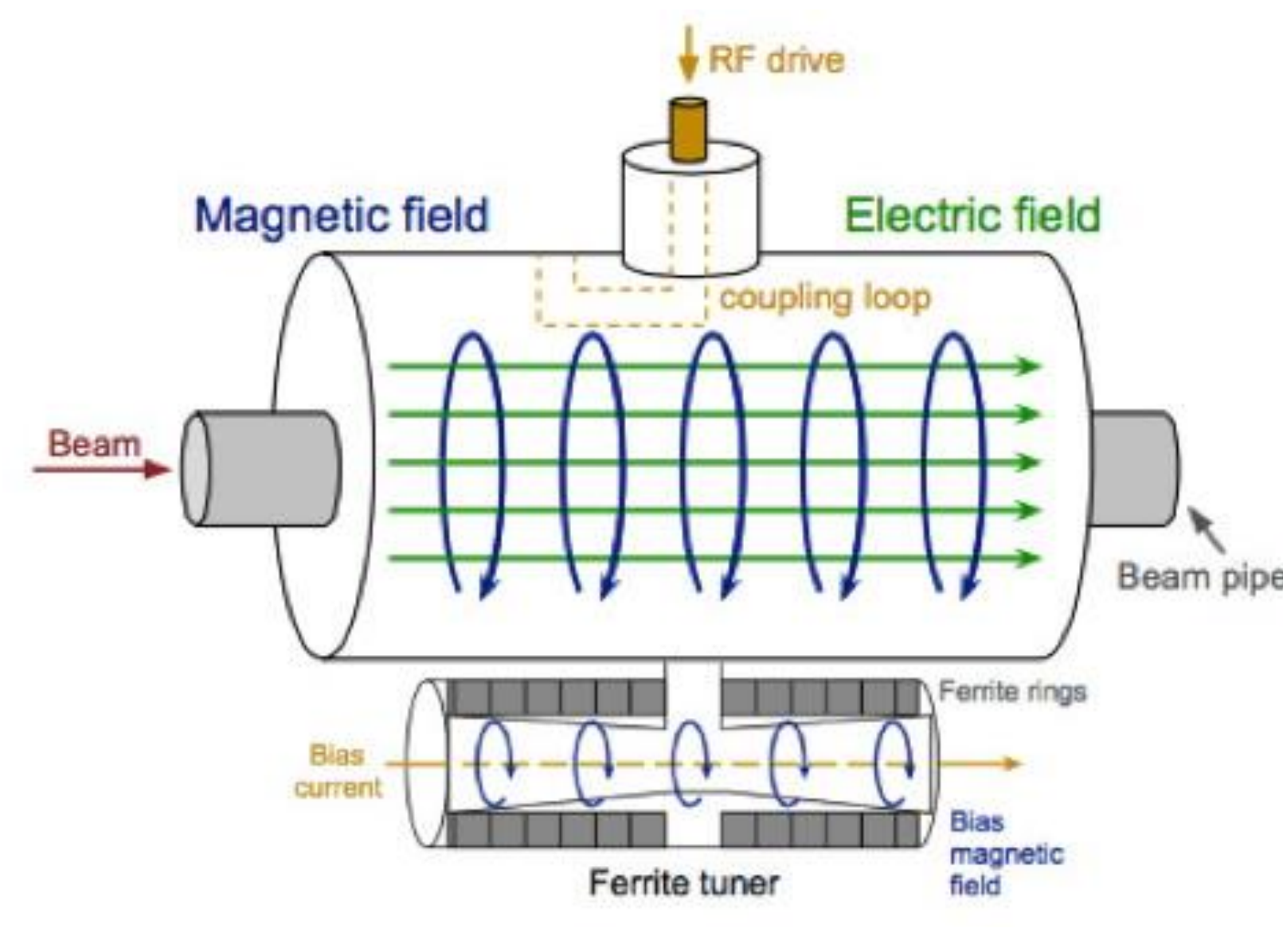
Edward Hazelton, University of Alaska Anchorage – SIST Intern | Brian J. Vaughn | Accelerator Division

Background

The PIP-II linear accelerator will inject energy into the booster at a much higher level than previously. The current booster tuning would require a higher RMS ferrite bias current to keep up. Since the bias current offsets the intrinsic damping of the tuners, it is an unnecessary cost.

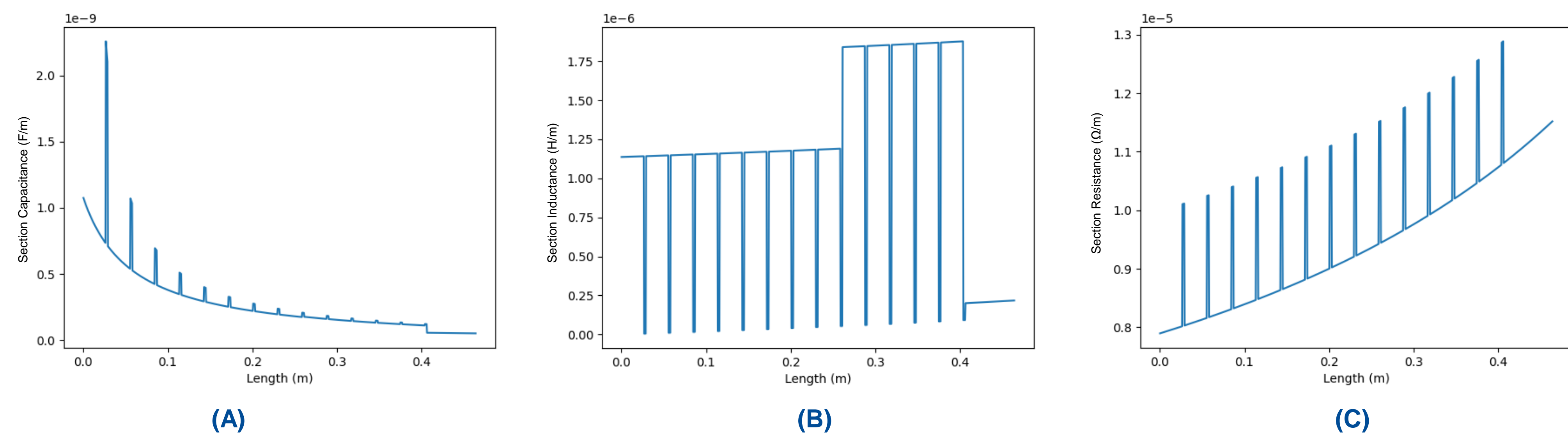


Proton Beam Accelerating through Multiple RF Cavities



An RF Cavity Diagram with One Tuner Shown

How



(A) Capacitance (B) Inductance (C) Resistance vs Length

Evolutionary Strategy

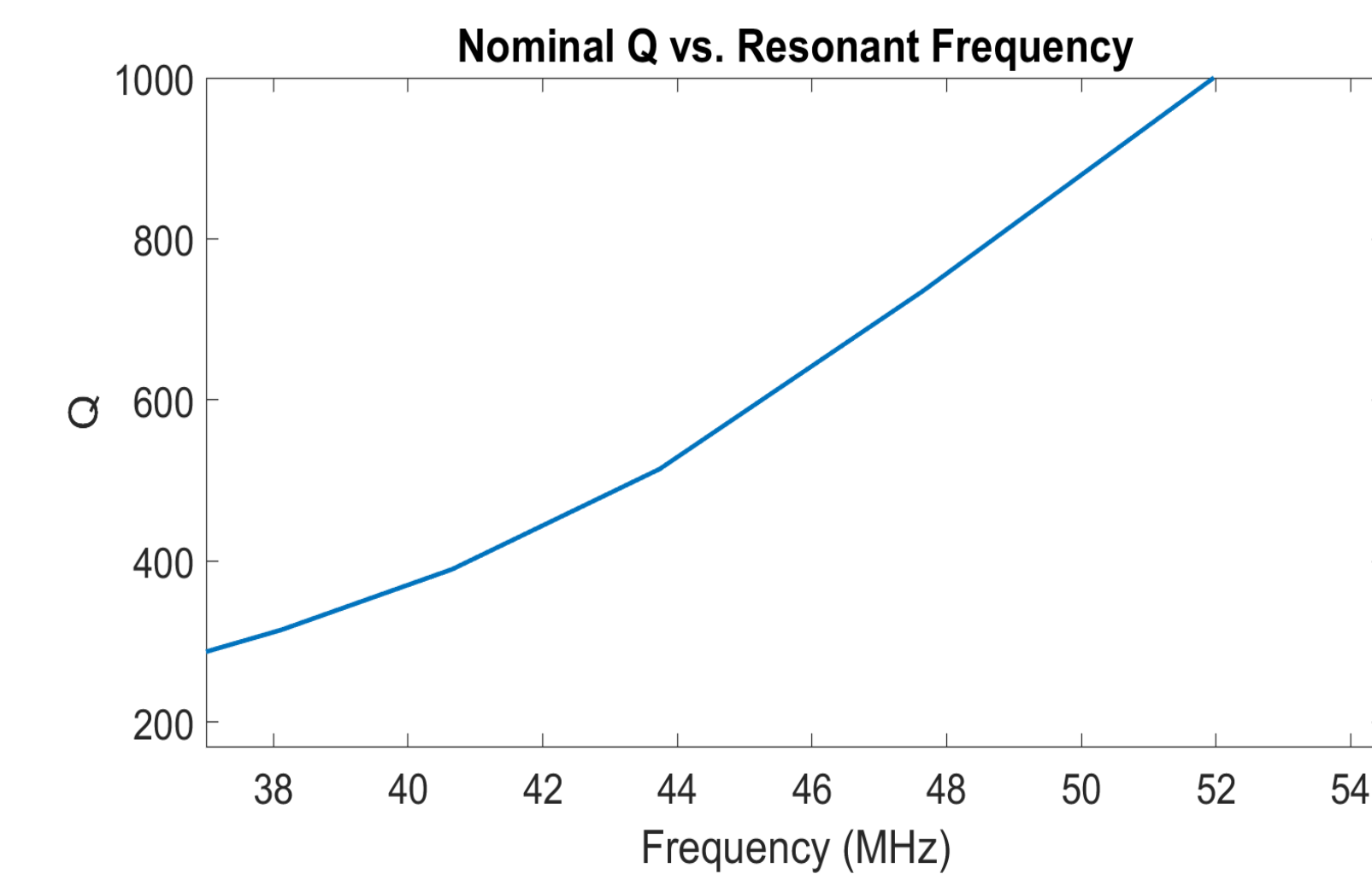
- Modeled on natural selection
- Ideal for continuous, real-valued problems
- Can iterate as long as necessary until a satisfactory solution is found

Calculations

- Iterative Impedance
- Lookup Table
- Q-Factor
- Bias Current

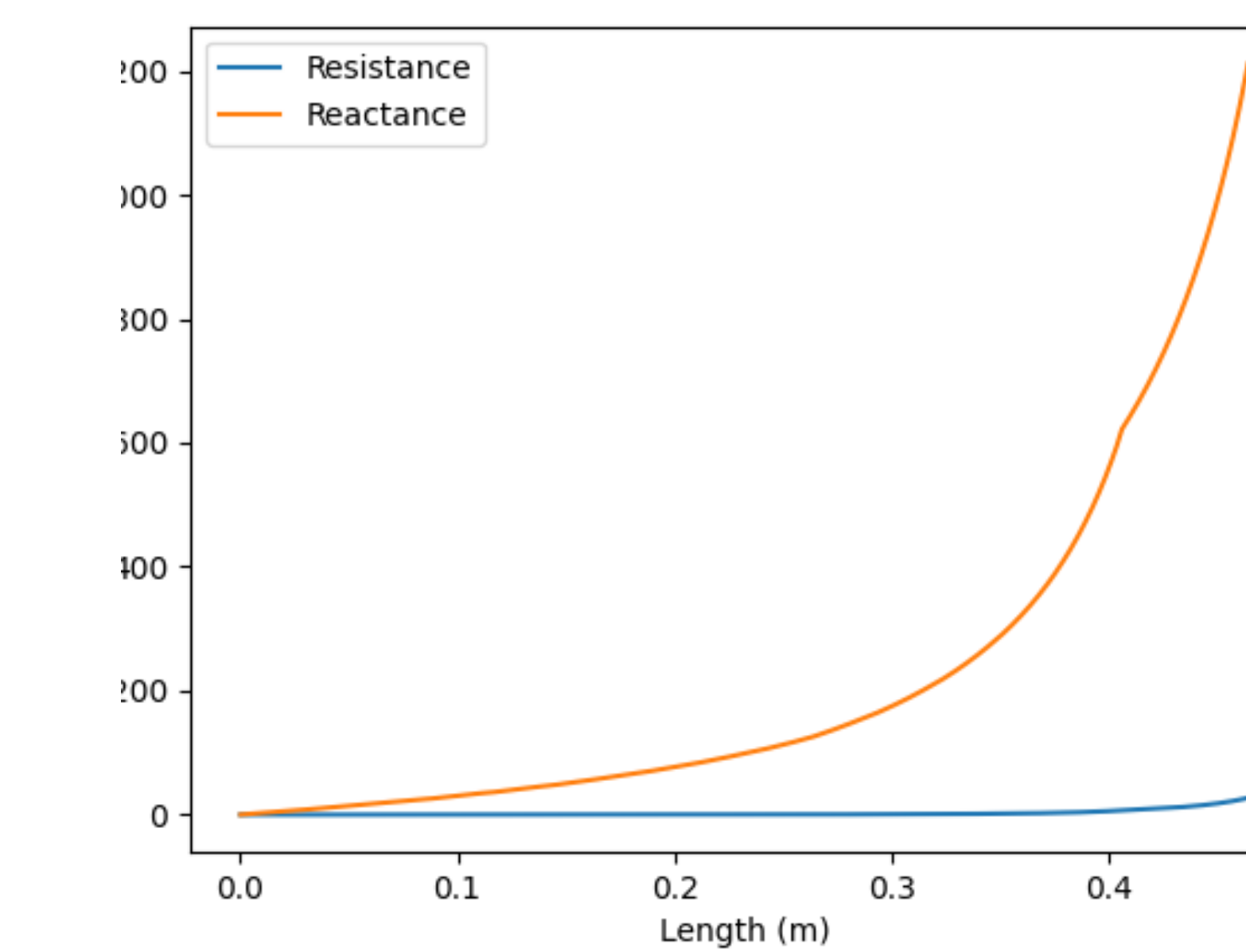
This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics. FERMILAB-POSTER-22-118-AD-STUDENT

Results



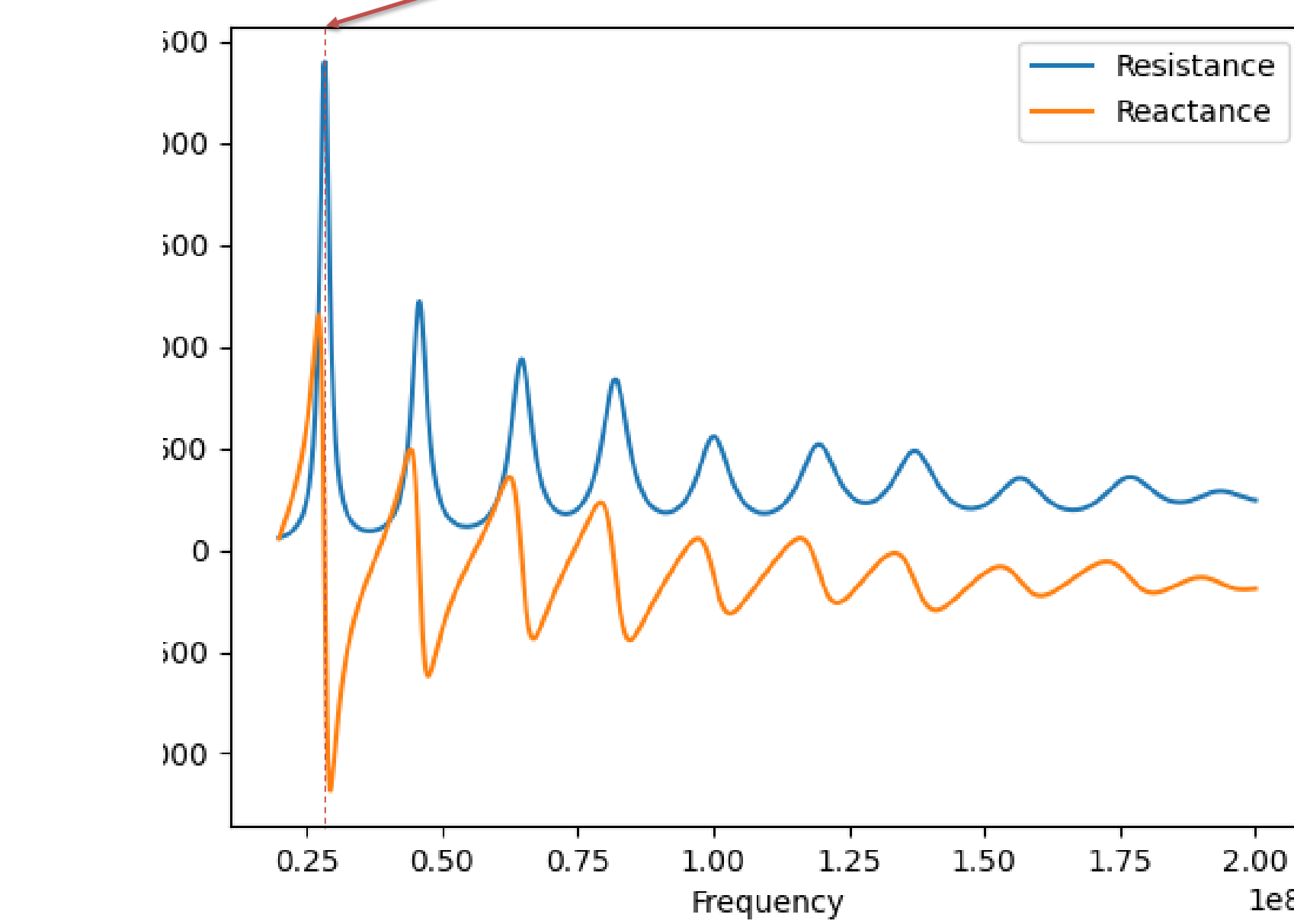
Q-Factor decreases with more discs. Easy-to-adapt script for optimizing tuner modifications as further model information is obtained. The peak in resistance vs frequency communicates the resonant frequency of the cavity at the specified bias current.

Nominal Q Factor vs Resonant Frequency of Current RF Cavity



(A)

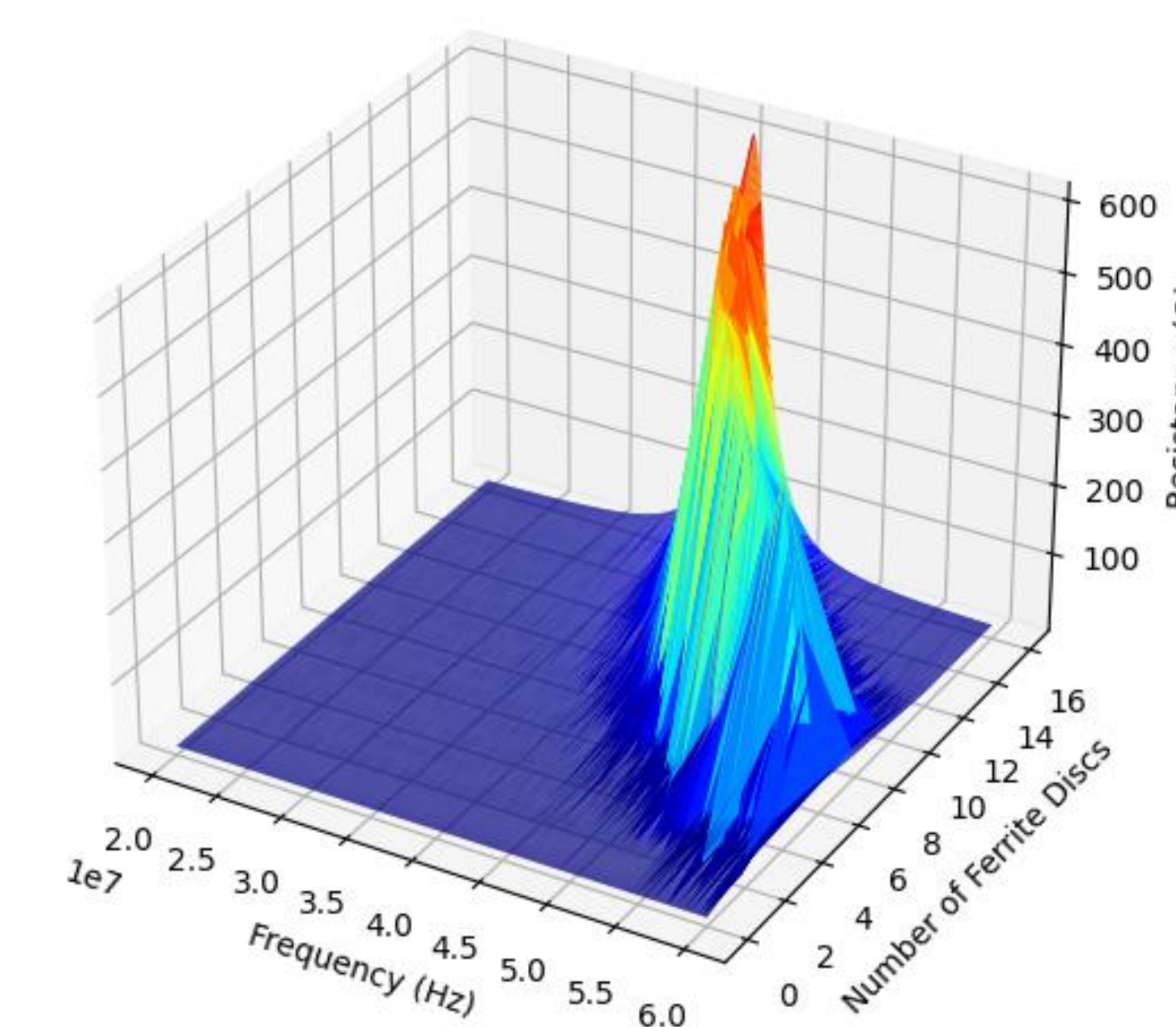
Resonant Frequency



(B)

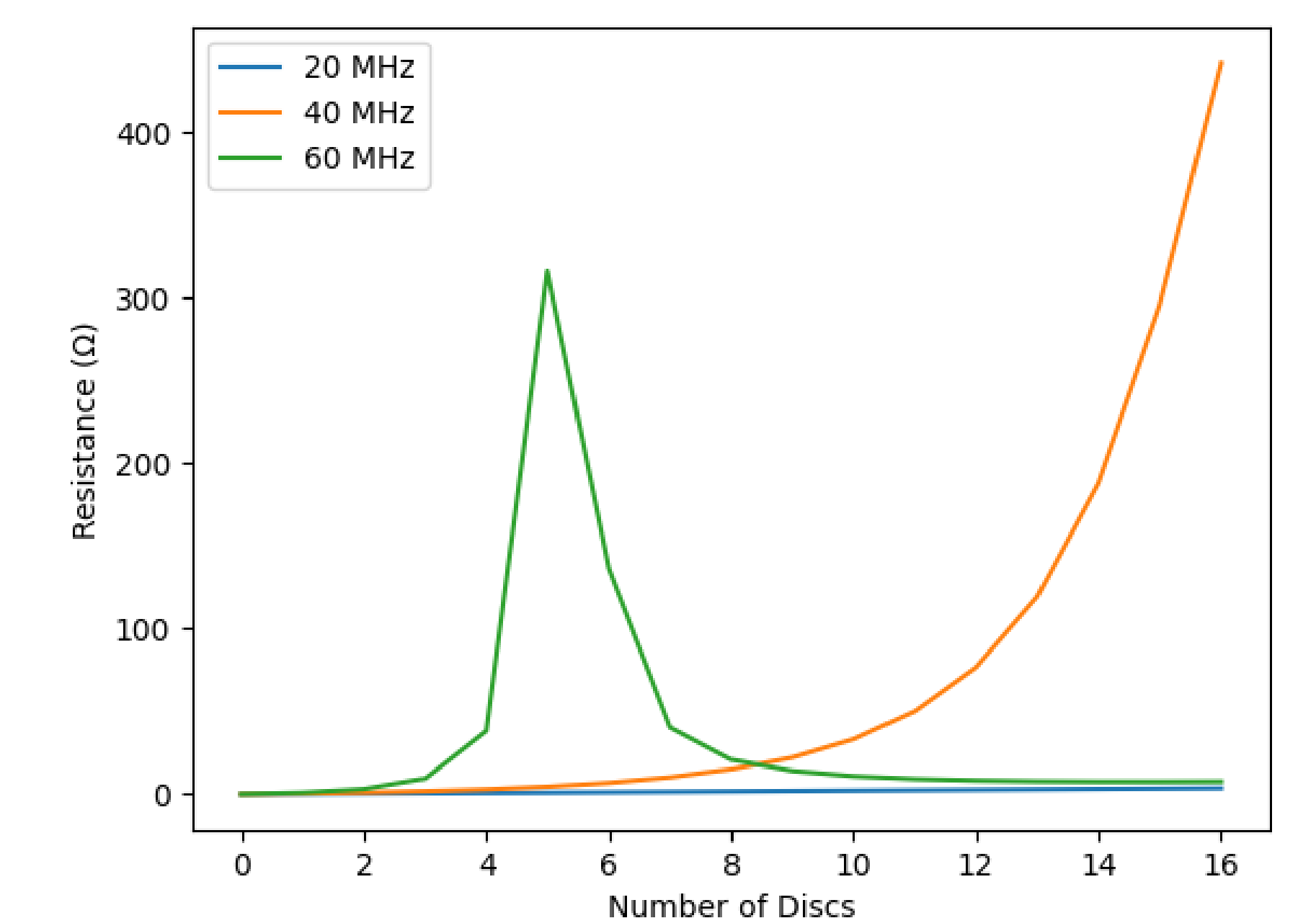
(A) Iterated Impedance over the length of a tuner half at 20 MHz

(B) Calculated Impedance vs Frequency



Resistance vs Frequency and Number of Discs (left)

Resistance vs Number of Disc at Specific Frequencies (right)



Next Steps

The next big goal is to implement pareto optimization, or multi-objective optimization. This would allow us to find optimal solutions that balance all our constraints. Additionally, we want to find a good method to quantify tuner sensitivity. And as always, there is further work to be done on approximations for real systems.