Booster Cavity Tuner Optimization

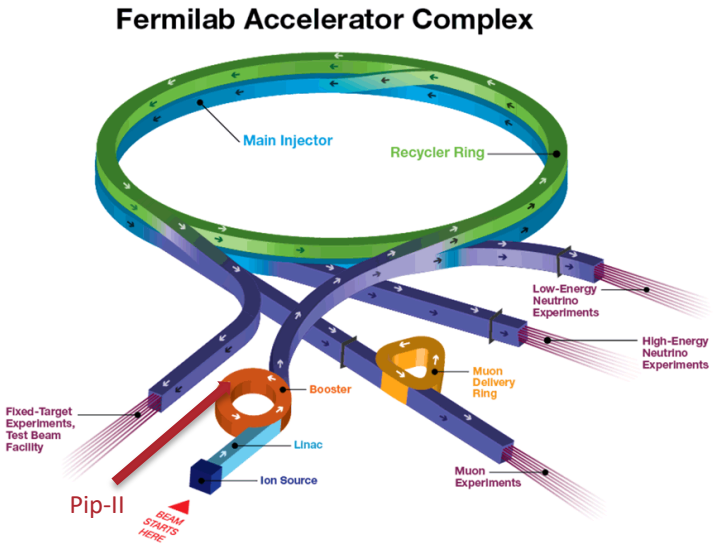
Edward Hazelton
Supervisor: Brian Vaughn

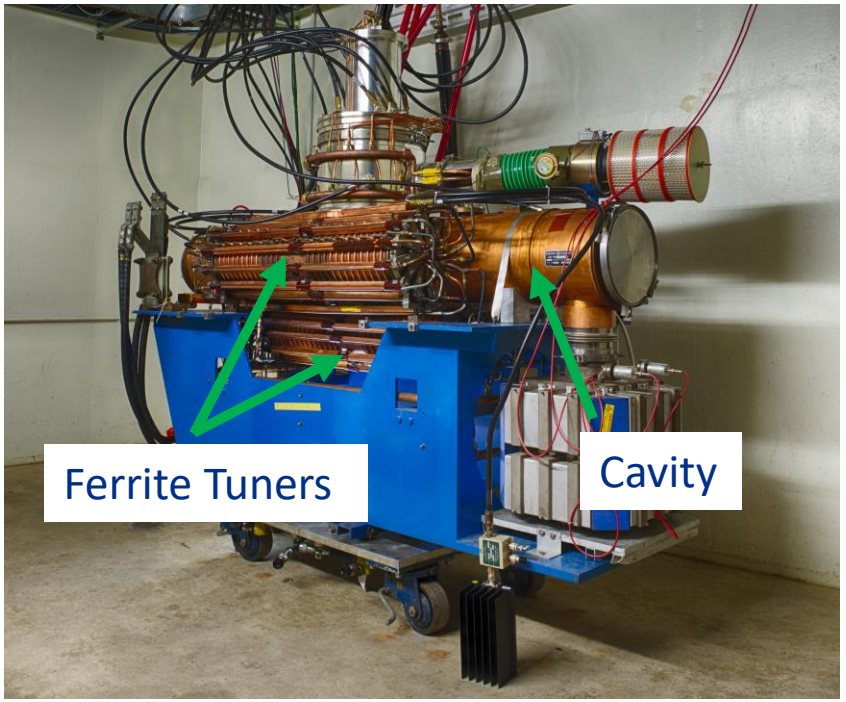
5 Minutes 5 Slides

15 June 2022

Background

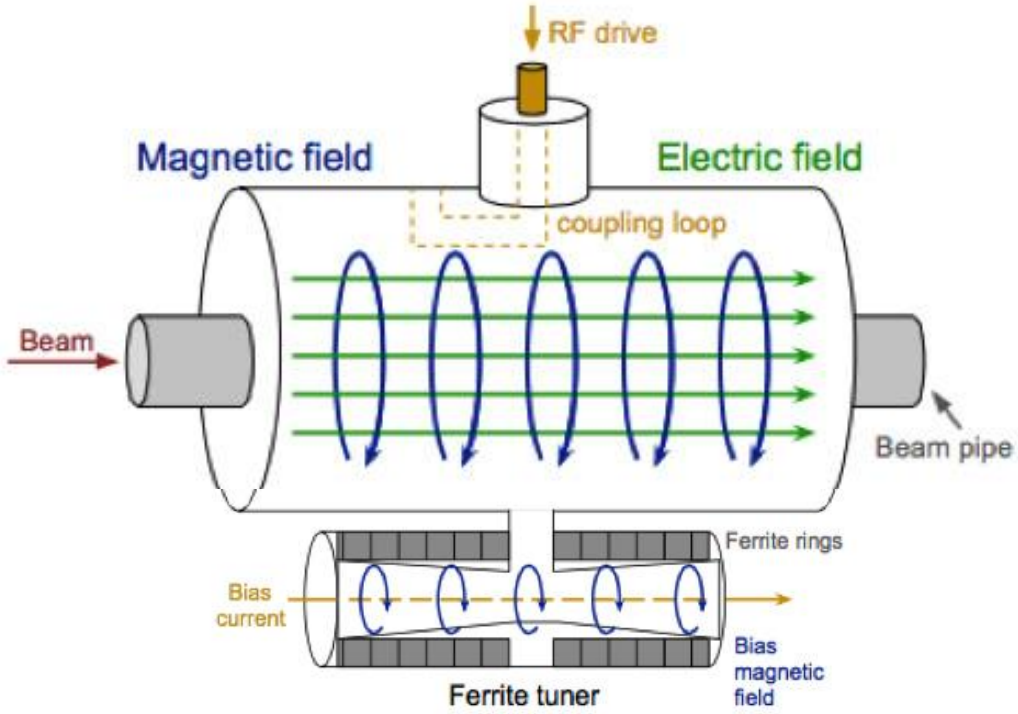
- The PIP-II linear accelerator will inject energy into the booster at a much higher level than previously.
- The current booster tuning would require a higher RMS ferrite bias current to keep up.
  - Since the bias current offsets the intrinsic damping of the tuners, it is an unnecessary cost.





RF Cavity

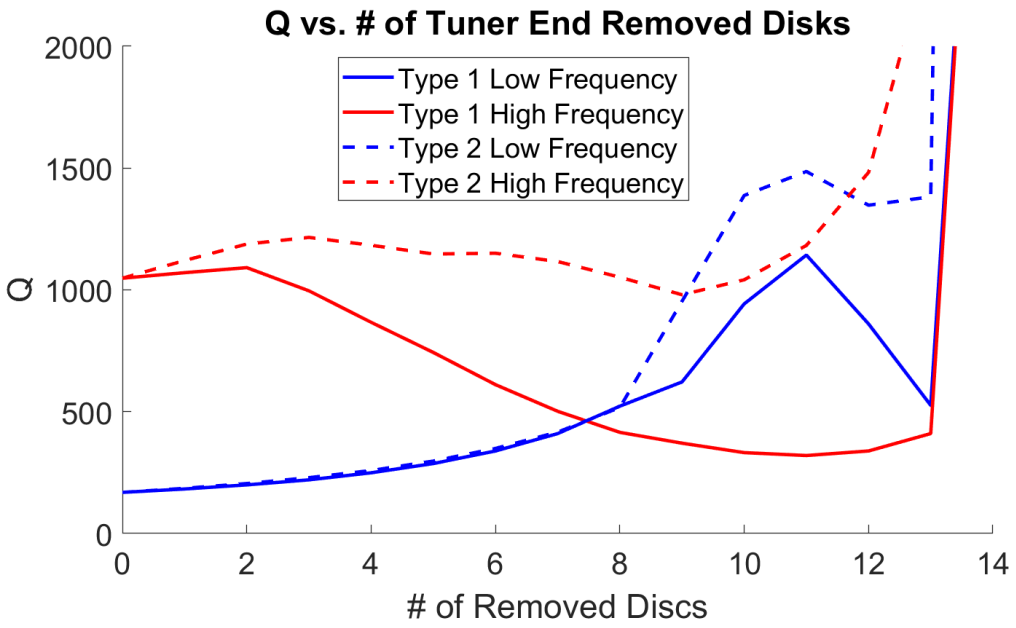
- Oscillates the electric field to minimize power loss
- Tunable resonate frequency using a bias current in ferrite tuners
- Primary Configurable Tuner Properties:
  - Tuner Length
  - Ferrite disk quantity
  - Ferrite disk type and order (Toshiba vs Stackpole)



Quality Factor

Ratio of energy stored to power dissipation

$$Q = \frac{\omega Re(Z_{cavity}(\omega))}{2} \frac{d(Im(1/Z_{cavity}(\omega)))}{d\omega}$$

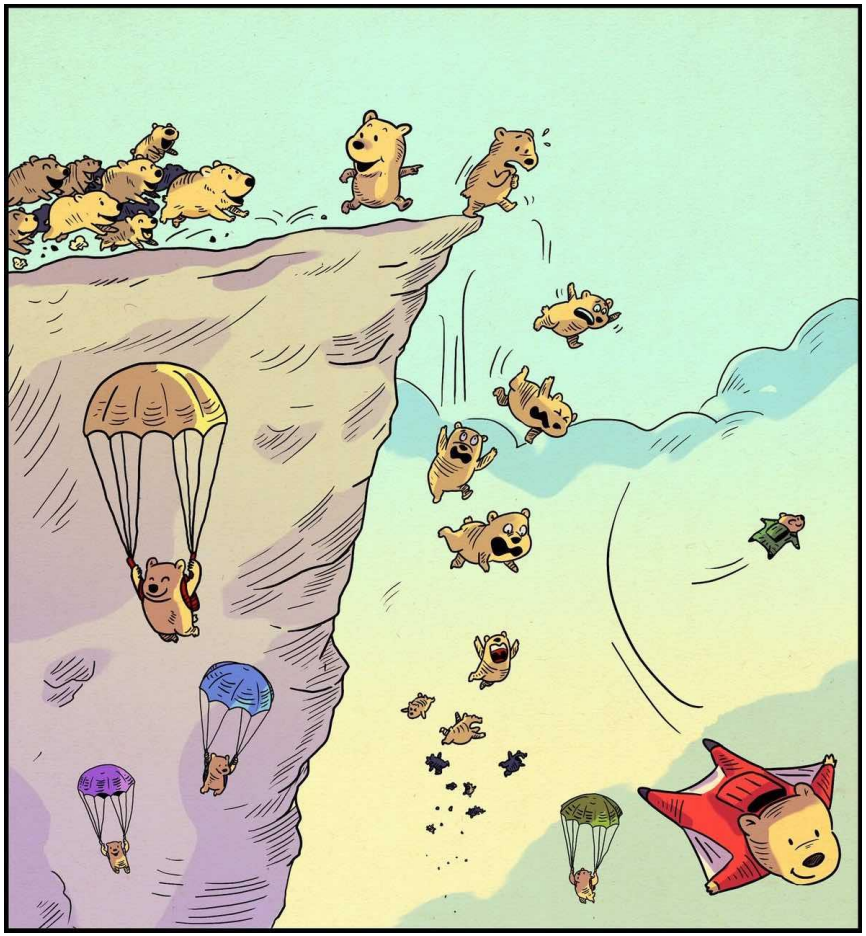


Type 1: Remove end disks and short the tuner

Type 2: Remove end disks and fill the space with a dielectric

Fermilab

Evolution Strategy



https://blog.otoro.net/2017/10/29/visual-evolution-strategies/

- Modeled on natural selection
- Ideal for real-valued problems
- Can iterate continuously until a satisfactory solution is found

- Key Limitation:
  - No guaranteed optimal solution
  - Well known, with many ways to combat

Thank You!