Experimental Study of the Inductance of a Toroidal Ferrite Core at High frequencies

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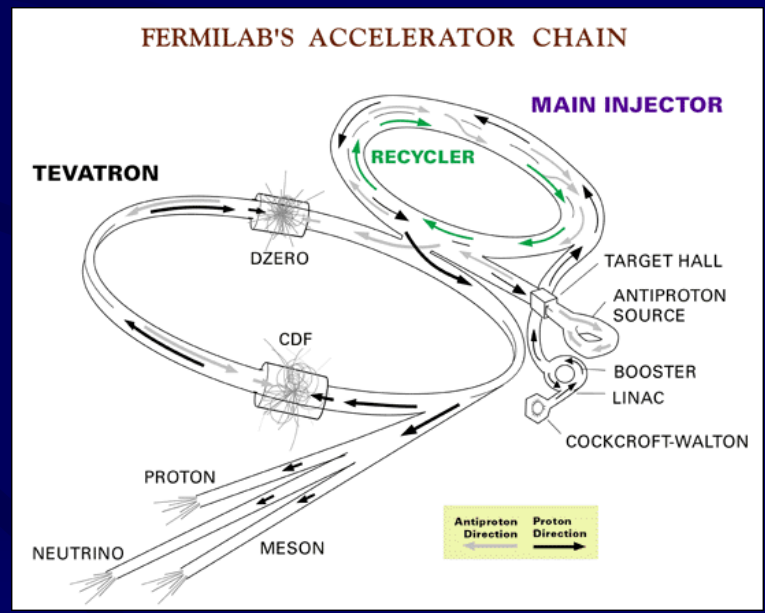
Overview

- FNAL Booster
  - 468 meters in circumfrence
  - Takes protons injected from the LINAC at 400 MeV and accelerates them to 8 GeV



Inside the Booster at FNAL

Beam Instability

- Causes
  - Space Charge
  - Wall Impedance
- Give rise to longitudinal forces that internally effect the beam
  - Bunch length changes
  - Incoherent phase oscillation frequency changes
  - Size of the RF- bucket changes

Inductive Insert

- Uses its own self inductance to produce a voltage on the protons to balance out the voltage due to space charge forces and restore smaller more concentrated bunches

$$V = -L\frac{dI}{dt} \qquad (1)$$

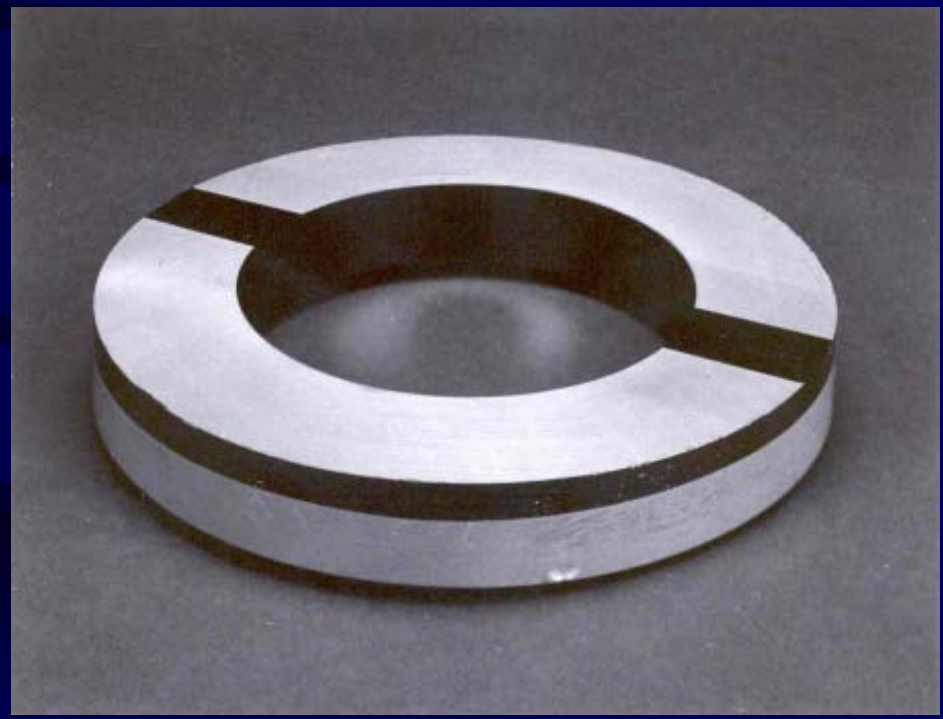
  - Keeps the protons bunched together

- Net voltage per turn resulting from inductive wall impedance and space charge effects can be expressed as:

$$V_s = 2I_{dc}\frac{d}{dt}\sum_{m=1}^{\infty}F_n(m\omega_{rf})\cos(m\omega_{rf}t)\times\left[\frac{g_0 Z_0}{2\beta\gamma^2\omega_0} - L(\omega)\right] \qquad (2)$$

- Contains 30 ferrite cores (Ni-Zn Toshiba M4C21A) with Resistive Paste
  - –Each core is 8 in. outer diameter, 5 in. inner diameter, 1 in. thick

Ni-Zn ferrite core with Resistive Paste



Project Goals

- Develop a method for calculating the inductance of the ferrite core at high frequencies
- Make measurements on the inductance of the core at high frequencies

Method of Finding L of the Ferrite Core

At Resonance

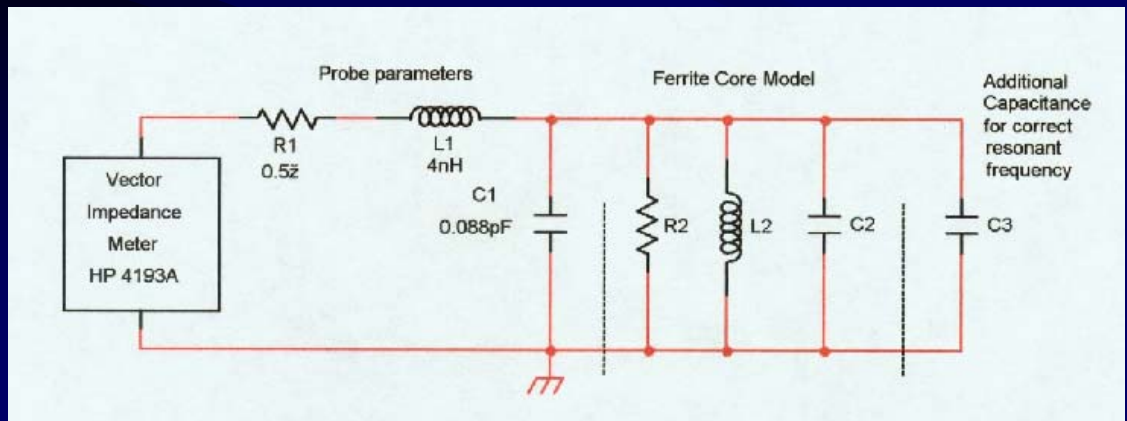
$$F = \frac{}{2\pi\sqrt{LC}} \qquad (3)$$

Assuming L is constant over a small frequency difference and capacitance difference :

$$\frac{\partial F}{\partial C} \quad \frac{\Delta F}{\Delta C} \qquad (4)$$

Procedure

- Ferrite core was coated with resistive paste
- A new test fixture in the shape of a loop was used
- The resonance frequency and |Z| was measured using the vector impedance meter
- Additional capacitance was added to tune the circuit at frequencies ranging from 5 MHz to 100 MHz
- L of the core was calculated subtracting the inductance from the probe and the inductance of the test fixture



Results

- Ferrite core without resistive paste does not show much change in inductance
- L plotted using (3) and (4) are similar at low frequencies
- At higher frequencies the two plots for L separate
  - L calculated by the first two plots assume the capacitance in the core is zero
  - L calculated in the second two plots account for the capacitance in the core but the value of it does not need to be known