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# Automated Magnetic Field Scanning System

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**Sponsor:** Jefferson Laboratory

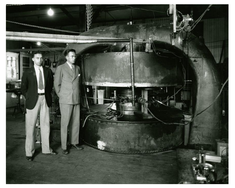
**Sponsor Advisor:** Kirk Davis

ELECTRICAL AND COMPUTER

# Automated Magnetic Field Scanning System

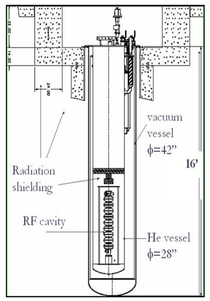
CAPSTONE DESIGN EXPO 2015

## Background



The building that now holds the vertical testing area at Jefferson Laboratory was once occupied by the Space Radiation Effects Laboratory in the 1960's. This laboratory had a cyclotron, which is a type of particle accelerator. As a result of this, the rebar within this particular building is now slightly magnetized.

Jefferson Laboratory tests Superconducting Radiofrequency (SRF) devices within dewar cavities in the vertical testing area. These devices perform poorly under the influence of any magnetic field. Because of this, scientists must find a way to cancel the negative effect caused by the building's magnetic rebar.




To achieve this, a set of coils are wrapped around the testing cavities. When current is driven through the coils, a magnetic field is created that opposes the magnetic field from the building, thus neutralizing it. To optimize this method, an accurate reading of the uncompensated magnetic field must be taken. This data is used to create a field that will exactly negate the building's magnetic field.

An SRF cavity within a liquid helium dewar is shown in the image at the left.

## Objective

Our team developed an automated system which accurately measures and records magnetic field data from within the dewars at Jefferson Laboratory. This device serves the purpose of optimizing an existing system of current carrying coils which are used for cancellation of residual magnetic fields. This process will ensure that the initial conditions for testing of the Superconducting Radiofrequency devices are free of unwanted magnetic fields that could cause unreliable testing data.

## Overall Structure

**Concentric Rings**

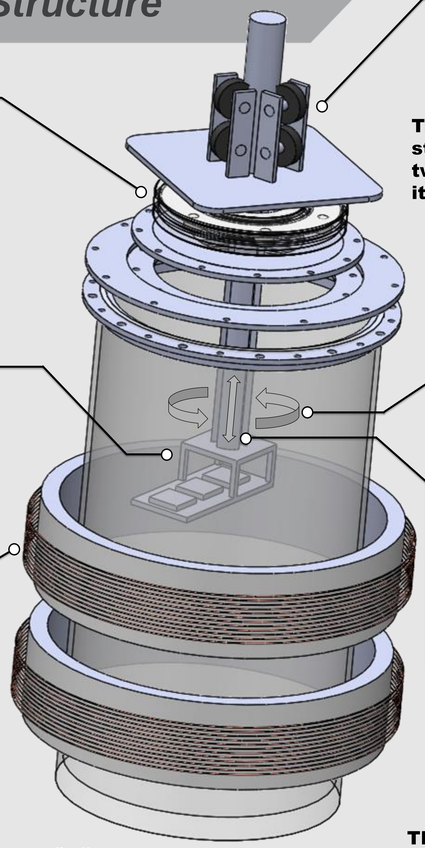
Because Jefferson Lab has different sizes of dewars, the device must be modular. The system includes concentric rings which can be used to adjust the diameter of the mounting apparatus.

**Sensor Housing**

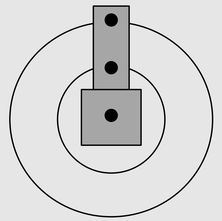
A housing is attached to the bottom of the pole to protect the centerline sensor. An arm extending from the housing holds additional sensors for off-centerline readings.

**Roller Guides**

The linear motion of the pole is stabilized by rollers positioned at two heights, which helps to prevent it from leaning off centerline.

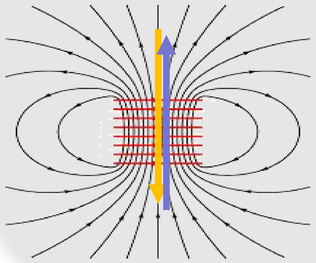


**Rotational Movement**



In order to gather readings that are off-centerline, a ball bearing ring attached to the top platform allows the entire pole, including the extension arm, to rotate 360°.

**Current Carrying Coils**



**Vertical Movement**

The primary function of the system is to read measurements on the centerline. A rack and pinion paired with a stepper motor moves the pole linearly in and out.

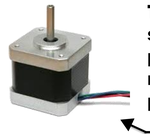
$$I = 2\mu_0 r^2 \sum_{i=1}^{K} \sum_{m=1}^{N} \frac{B_{avg}}{\sqrt{r^2 + \left(z_i - \frac{l_i}{2} + [m * step - step]\right)^2}}^2$$

$K = \#\ of\ coils$

$N = \#\ of\ turns$

Magnetic Field Lines | Current Flow | Compensated Magnetic Field | Residual Magnetic Field

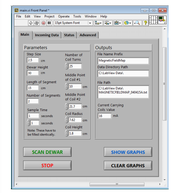
## Control System



The stepper motor moves the pole, waits for samples of magnetic field, then repeats this process until it reaches a point where it must change direction or a new section of pole needs to be added.

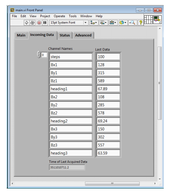
**Magnetic Field Sensors**

The microcontroller interfaces LabVIEW to sensors and motor.

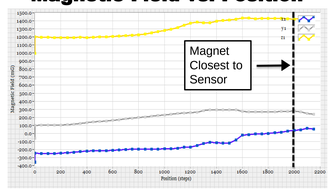


**LabVIEW Graphical User Interace**

- Monitoring of incoming data
- Controls
- Setup Parameters



**Magnetic Field vs. Position**




**Outputs:**

- Real-time Graph
- Log File of the Samples
- Compensating Current Value

## Acknowledgements

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