Princeton Magnet Coils: Test Results

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At Princeton there are available eighty individual magnet coils (built about 1950) that could be configured to produce sufficient magnetic field for the wire-tension measurement during the BABAR drift-chamber stringing operation. In this note we present the geometry of the coil and results of various tests and calculations.

1 Geometry of the Coil

The coil is made of $0.4\times 0.4''$ square copper tubing. The tubing is hollow for possible water cooling. Each coil has two layers (double-pancake form), and each layer consists of 26 turns of the copper tubing. A sketch of the coil is shown in Fig. 1.

The thickness of the coil is $0.8''$. The surface of the coil is flat, so several coils can be stacked together to provide a stronger field if space permits. The coil leads are slightly thicker than the coil itself, so a stack of coils must have the leads of different coils at different azimuths.

2 Resistance of the Coil

Four coils were connected together in series and the voltage vs. current was measured with results as shown in Fig. 2. From the slope the resistance of the four coils in series is 0.0731Ω, or 0.018Ω per coil.

If the current is set at, say, 86 A, the power consumption will be 540 W.

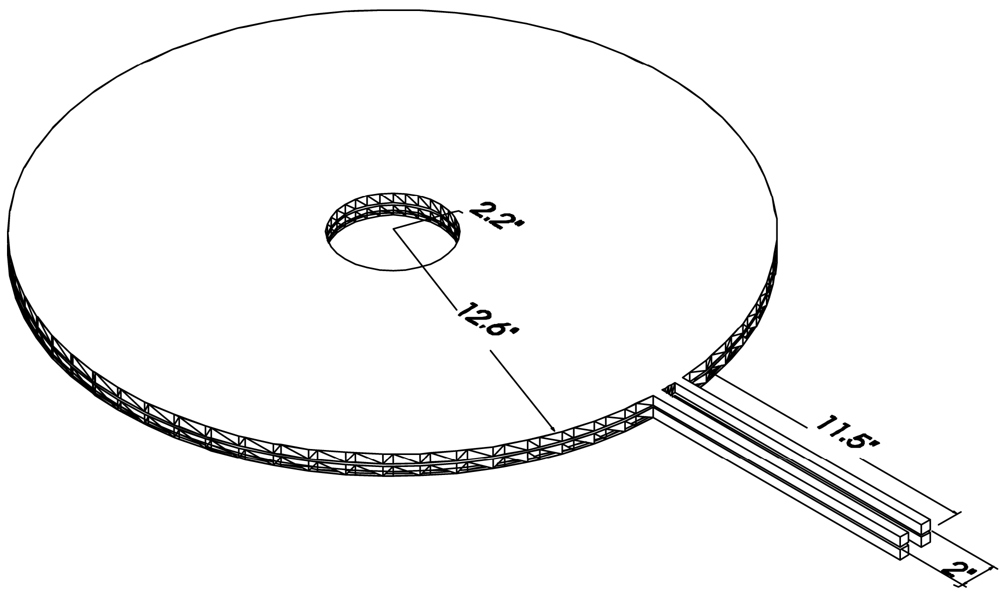

Figure 1: Magnet coil geometry.

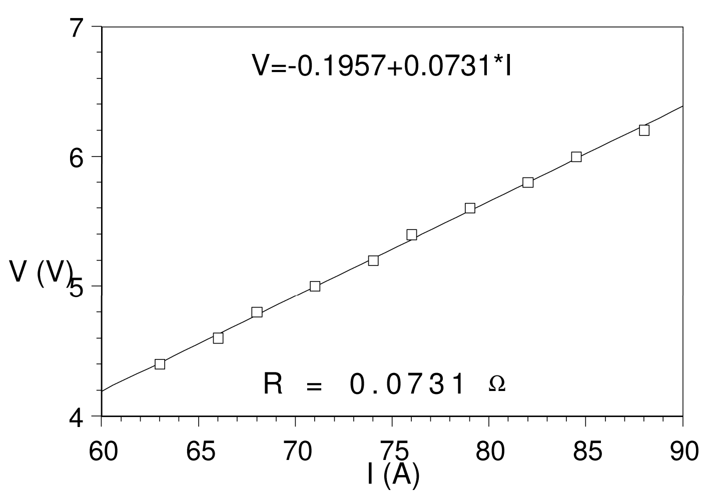

Figure 2: Measured voltage *vs.* current for four coils in series.

After two hour's activation the temperature of the top coil's surface reached 38^oC starting from 16^oC.

3 Magnetic Field Measurements

The measured magnetic field B_z along the axis of a set of four coils energized by 86 A is summarized in Fig. 3. The magnetic-field integral Gauss-meters is shown in Fig. 4. At the largest tested distance above the top coil, 56 cm, the magnetic field integral was 11 Gauss-meter.

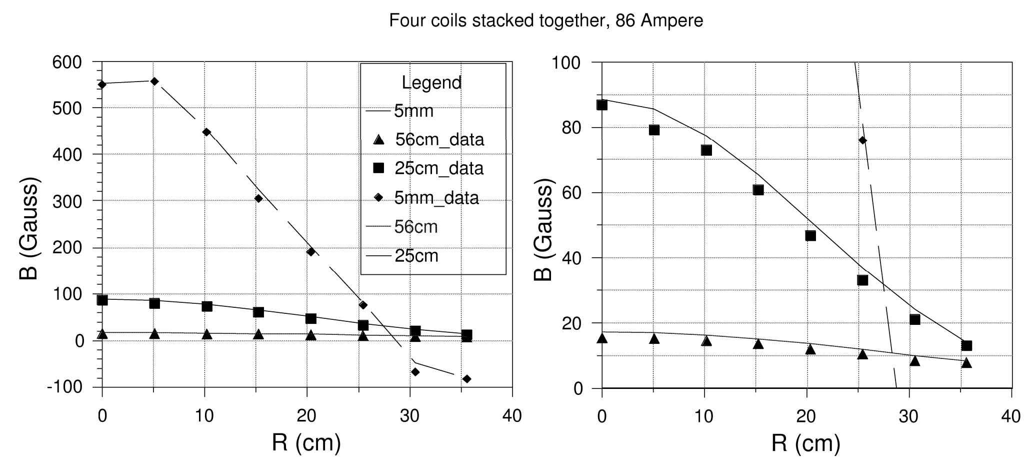

Figure 3: The measured and calculated magnetic field *vs.* height above a set of four coils operated at 86 A.

We also calculated the magnetic field using the Biot-Savart law:

$$\overrightarrow{B} = \frac{\mu_0}{4\pi} I \oint \frac{d\overrightarrow{l} \times \overrightarrow{r}}{r^2}.$$

The coordinate system used in the calculation is shown in Fig. 5. The calculations are in good agreement with the data in Figs. 3 and 4.

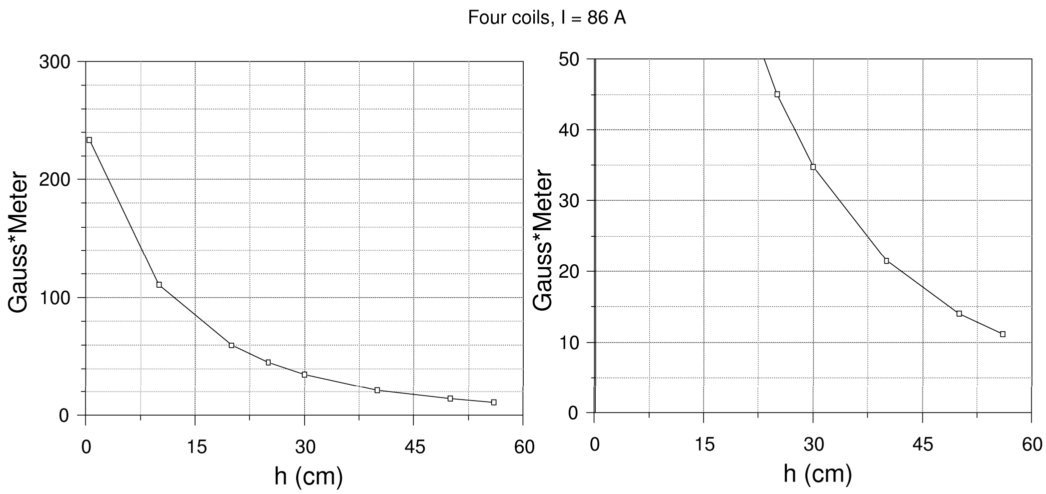

Figure 4: The magnetic field integral *vs.* height above a set of four coils at 86 A.

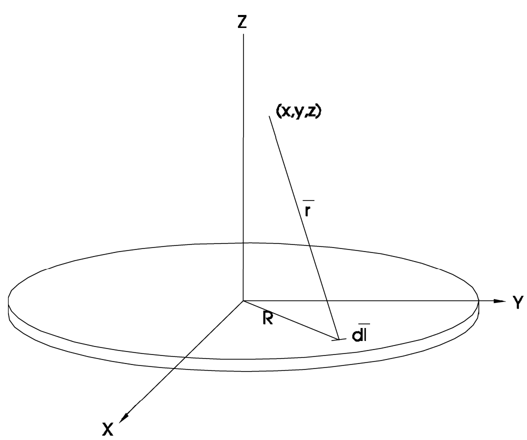

Figure 5: The coordinate system used in the calculation.

4 Inductance of the Coils

The inductance L of a coil was measured to be 400 μH. The time constantτ of a coil is therefore 0.02 s. When a coil is run at 100 A its stored energy is 2 Joules. When a coil is quickly turned off from 100 A the back EMF is about $LI/\tau \approx 2$ V per coil.