B-field monitoring system

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1 Proposal

We present a proposal for the magnetic field monitoring system using an array of SQUIDs placed outside of the measurement cells. The system consists of 6 pairs of SQUIDs. Eight SQUIDs are placed in the $y = 0$ plane working as gradiometers monitoring the gradient of the x component of the magnetic field at $z = \pm 20$ cm (see Fig. 1).The idea behind this system is to take advantage of the antisymmetry of the magnetic field inside the measurement volume. The gradients of B_x should be:

1. Of the same magnitude and opposite sign at $z = \pm c$ cm where c is a value between zero and 20 cm for for a fixed value of x.
2. The same value for fixed z for left and right cells.

This arrangement monitors the "chirality" of B_x *i.e.* $\partial B_x/\partial x$ needs to change sign as it crosses the $z = 0$ plane.

The other four SQUIDs are also placed in the $y = 0$ plane but at $z = \pm 10$ cm or $z = \pm 15$ cm to monitor the gradient of the z component of the magnetic field. The value of the gradient of the z component of the magnetic field outside of the volume gives a good estimate of the value inside the cell volume.

2 Experimental data

We have tested this idea using the half scale B_0 coil. Figs. 2, 3, 4, 5, and 6 show the experimental results. The plots show that it is possible to keep track of the gradient of B_x by taking measurements outside the measurement cells. Table 1 shows the values of the gradients for left and right cells as a function of position. The lack of symmetry of the experimental data shown is due to technical reasons that are easily overcome with a multi-SQUID setup instead of the current "moving fluxgate" setup.

From Fig. 4 we can see that at $z = 0$ the data is harder to interpret since the field is flatter in that region. It is also important to point out that the magnetic field measured outside the cells at $z = \pm 10$ cm is larger than at the cells. This relaxes the requirements imposed on the SQUIDS for the monitoring system.

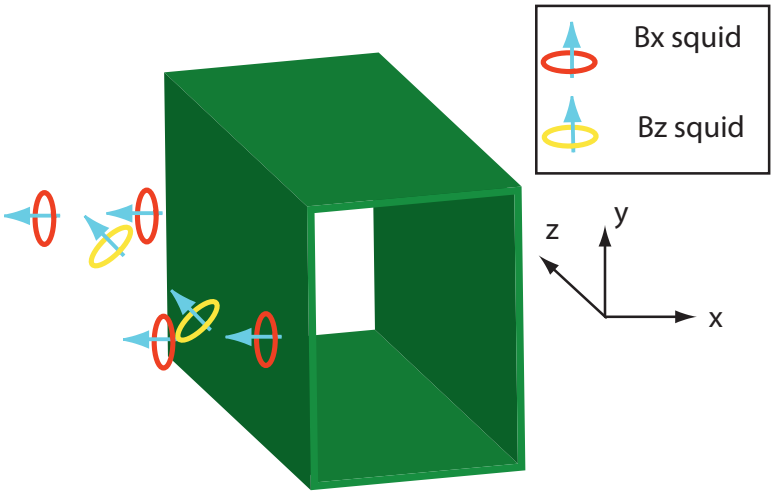

Figure 1: SQUID configuration for the magnetic field monitoring system. Left cell measurement setup shown only.

z position [cm]	$\partial B_x/\partial x$ left cell [%/cm]	$\partial B_x/\partial x$ right cell [%/cm]
-10	2.4×10^{-3}	3.6×10^{-3}
-5	1.5×10^{-3}	1.7×10^{-3}
5	$-.4 \times 10^{-4}$	-1.4×10^{-3}
10	-1.4×10^{-3}	-3.6×10^{-3}

Table 1: Gradients outside of left and right cells.

Figures 7, 8, 9, and 10 show the behavior of B_z for planes inside and out side the measurement cells ($x = \pm 4.5$ is inside the cells). Just like for B_x we can monitor that component by placing SQUID's outside of the cells. Table 2 shows the value of the gradients for inside and outside the cell.

More squids, specially in the x direction, would compliment the information already required and would also be important as a "backup" plan in case the other SQUIDs died for some reason.

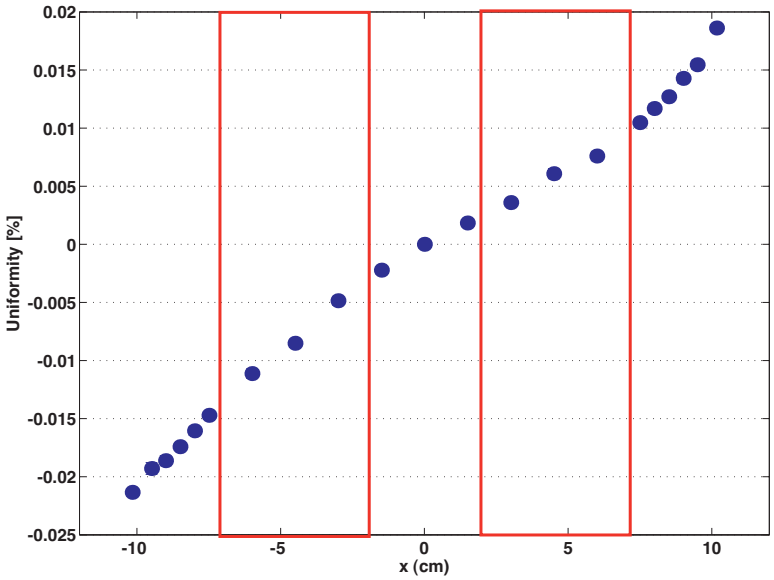

Figure 2: Experimental values of the uniformity of B_x as a function of x position for z=-10 cm for the half scale coil. The red rectangles mark the position of the measurement cells.

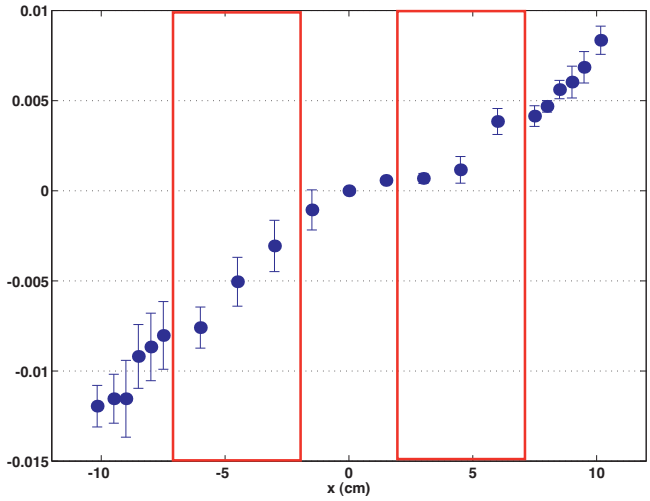

Figure 3: Experimental values of the uniformity of B_x as a function of x position for z=-5 cm for the half scale coil. The red rectangles mark the position of the measurement cells.

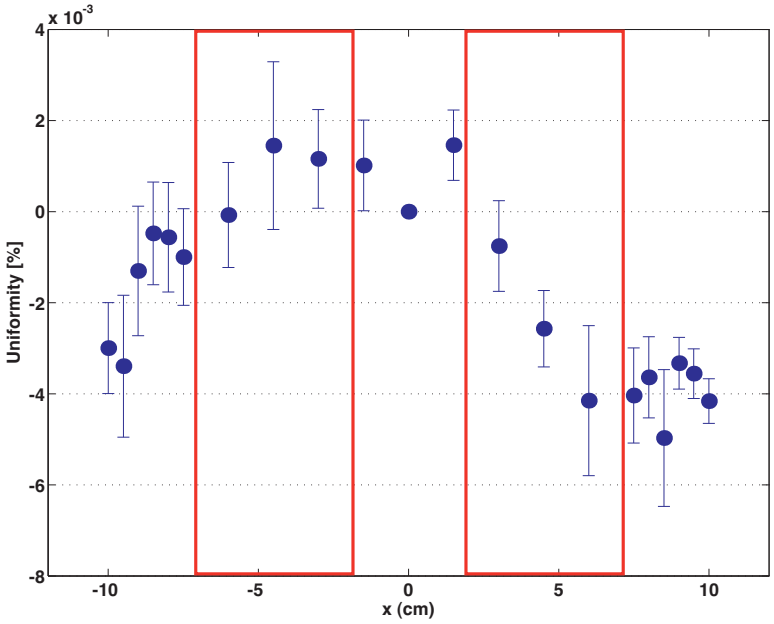

Figure 4: Experimental values of the uniformity of B_x as a function of x position for z=0 cm for the half scale coil. The red rectangles mark the position of the measurement cells.

x position [cm]	$\partial B_z/\partial z$ [%/cm]
-9	-9.2×10^{-3}
-4.5	-8.9×10^{-3}
4.5	-6.7×10^{-3}
9	-6.3×10^{-3}

Table 2: Gradients outside of left and right cells.

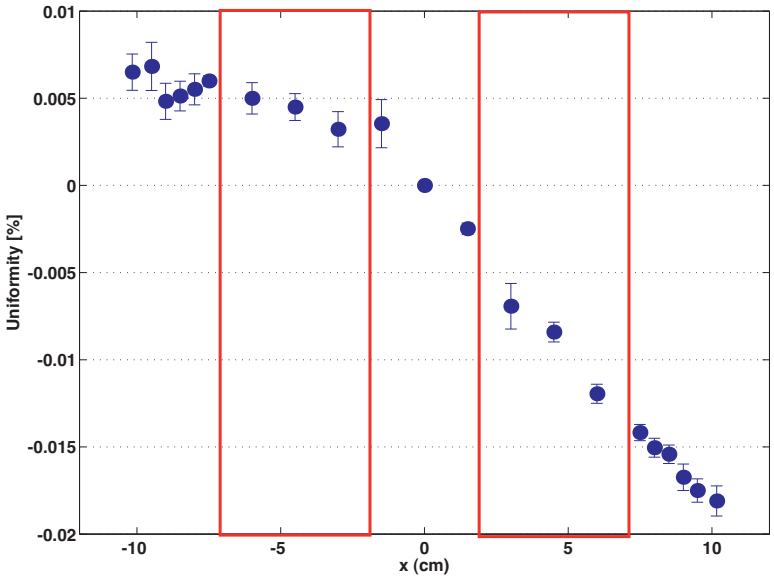

Figure 5: Experimental values of the uniformity of B_x as a function of x position for z=5 cm for the half scale coil. The red rectangles mark the position of the measurement cells.

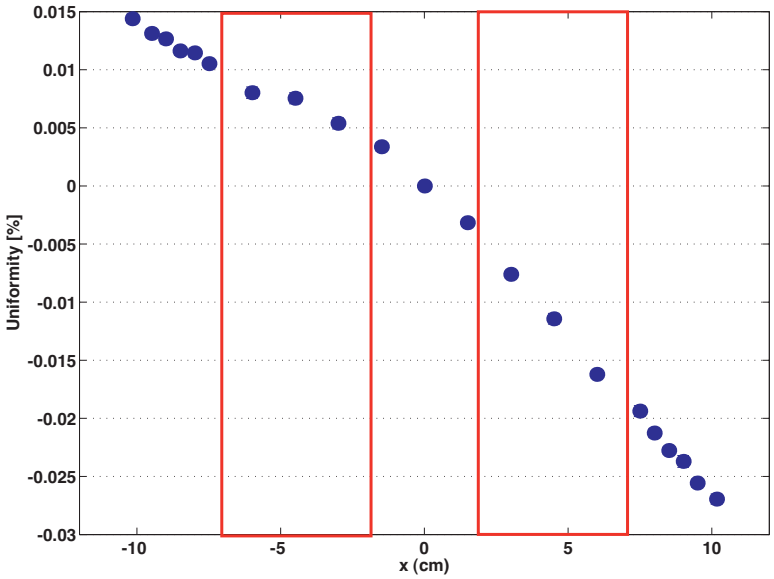

Figure 6: Experimental values of the uniformity of B_x as a function of x position for z=10 cm for the half scale coil. The red rectangles mark the position of the measurement cells.

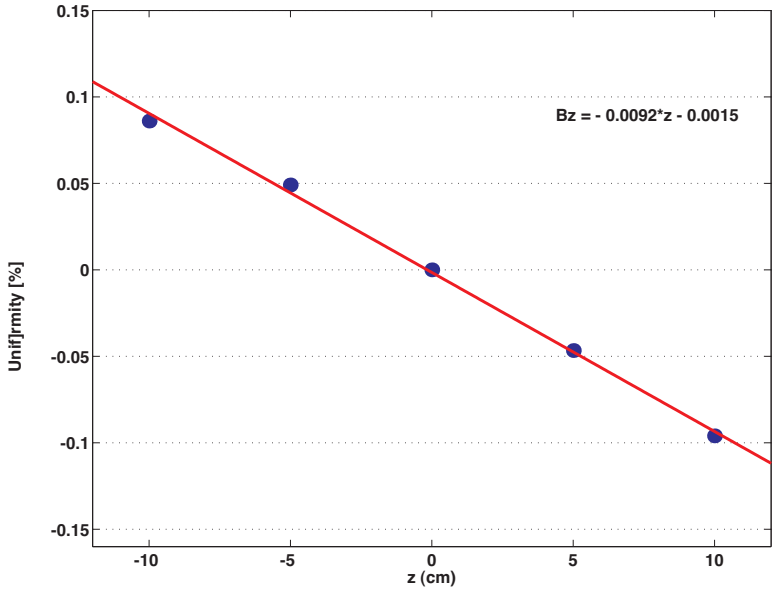

Figure 7: Experimental values of the uniformity of B_z as a function of z position for x=-9 cm for the half scale coil.

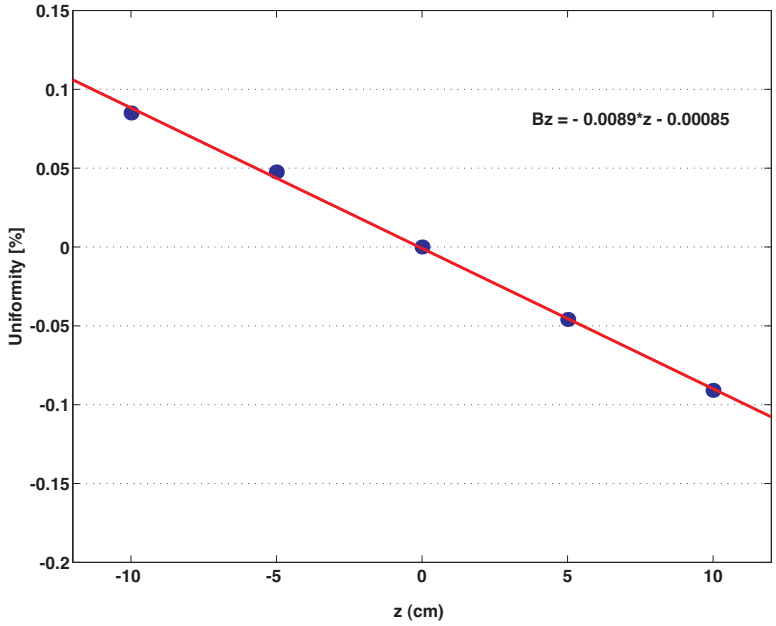

Figure 8: Experimental values of the uniformity of B_z as a function of z position for x=-4.5 cm for the half scale coil.

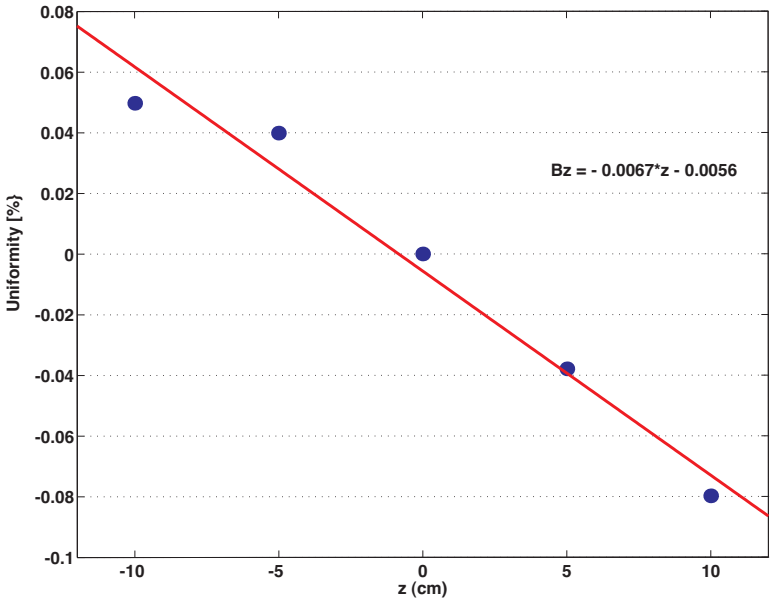

Figure 9: Experimental values of the uniformity of B_z as a function of z position for x=4.5 cm for the half scale coil.

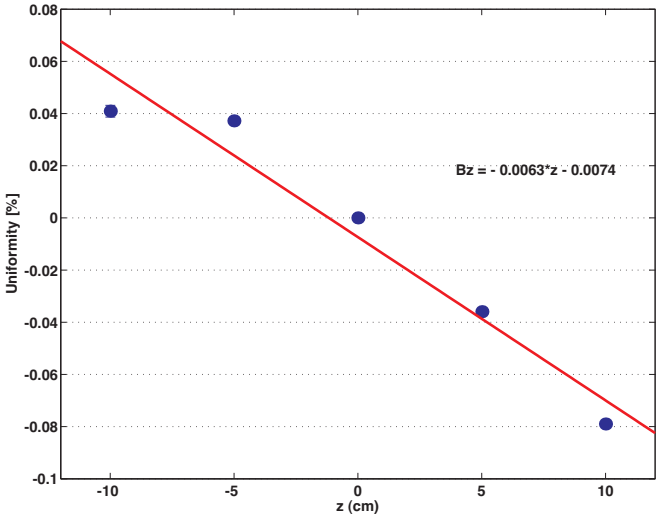

Figure 10: Experimental values of the uniformity of B_z as a function of z position for x=9 cm for the half scale coil.