

Transfer Cryostat's NdFeB Magnetic Field Mapping

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June 7th, 2010

Abstract

The magnetic fields of the NdFeB magnet in the transfer cryostat were mapped out and listed in this report.

1 Introduction

A transverse field Halbach dipole NdFeB magnet is one of three magnets used to insure that the HD target does not depolarize when transferred to the IBC. The target cell must always be under a magnetic field of 100 Gauss or larger. The field strength can be measured using a Hall probe and the distance by calipers. Previously, the magnet was known to have a homogeneous field strength region along its center. The region was between 3.5cm and 11.5cm and had field strength of approximately 1.1 kilogauss.

2 Frame of reference

In the report below, the z-axis refers to the transfer axis. The starting position, 0cm, refers to the end of the magnetic cylinder with the label 'top' inscribed on it. The end position refers to the opposite end, which is approximately 16.5cm away (See Fig. 1). Measurements were taken along the z-direction at four different angular positions on the top of the cylinder; these positions were 0°, 90°, 180°, and 270°. The center position refers to the origin of the circle when looking topside down at the magnet (See Fig. 2). The 1cm and 1.9cm radii measurements are from the center position.

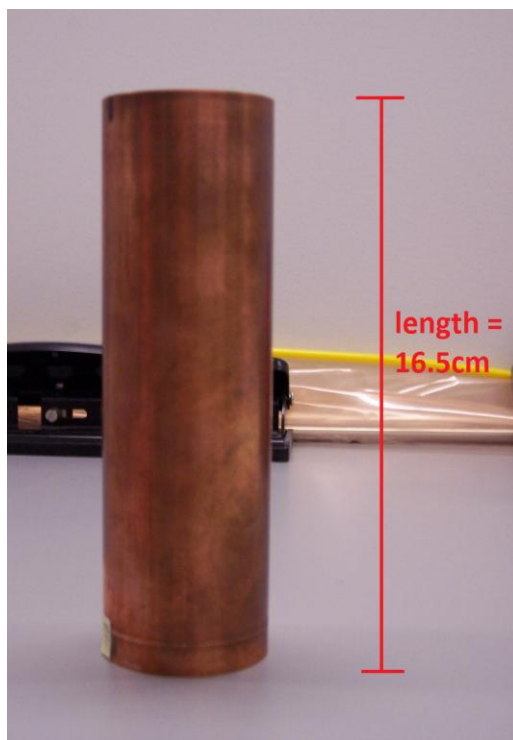


Figure 1:
Side view of NbFeB magnet showing the length.

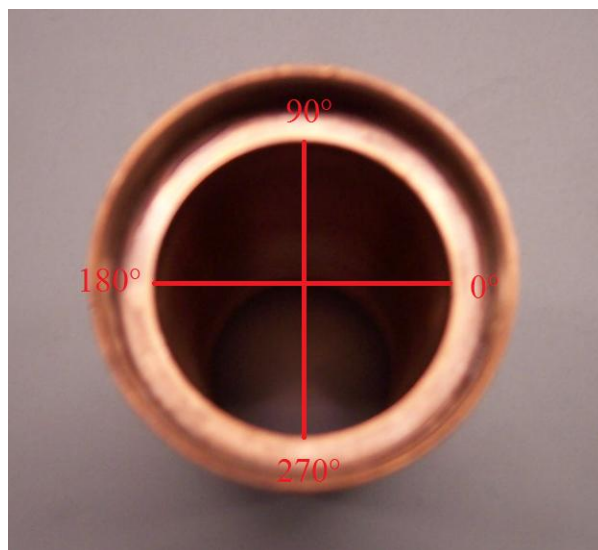


Figure 2:
Top view of NbFeB magnet showing angular positions in which measurements were taken.

3 NdFeB Magnet

The field in the Halbach dipole is transverse and should be homogeneous. This homogeneity can be observed by the center and 1cm radius field maps produced by Thomas O'Connell. Figures 3 through 7 show that the magnetic field remains uniform for over the range $3.5\text{cm} < z < 12.5\text{cm}$. For the center position, the field strength within the steady region is approximately 1.1 kilogauss. At 0° and 180° the steady region field strength slightly larger than 1.2 kilogauss. At 90° and 270° the field strength for this region is smaller around 1.0 kilogauss.

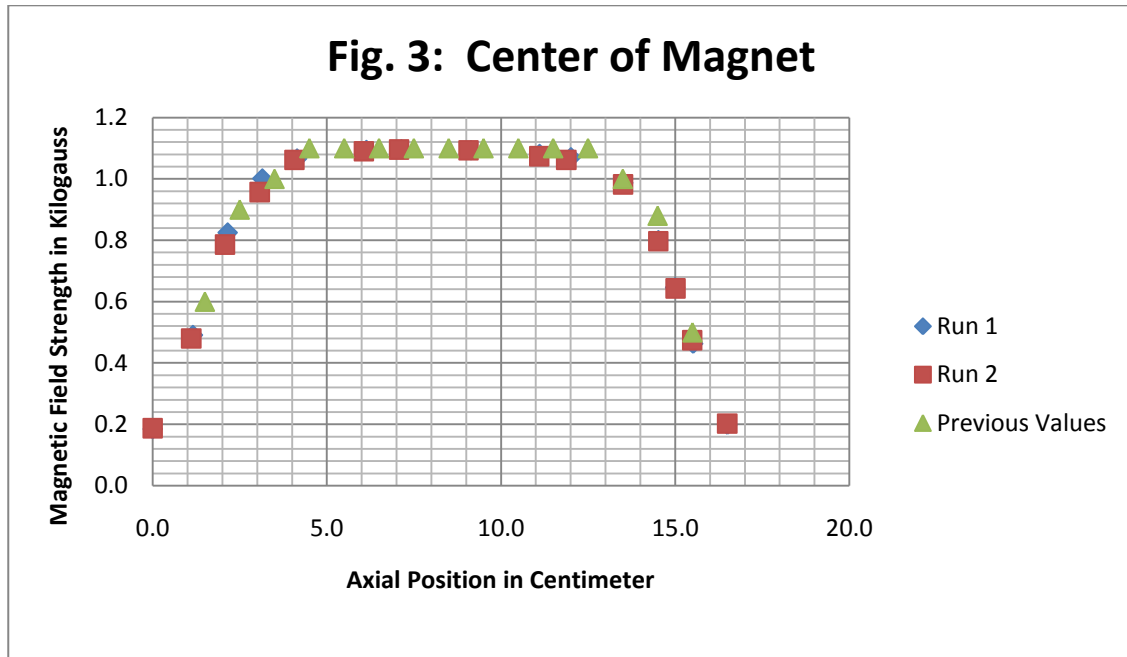


Figure 3: Magnetic field $B_x(z)$ map of the Halbach dipole. The new measurements are denoted by Run 1 and Run 2. The previous values taken from a field map of the dipole provided by Xiangdong Wei are plotted and denoted as Previous Values.

Fig. 4: 0 Degrees - 1 cm Radius

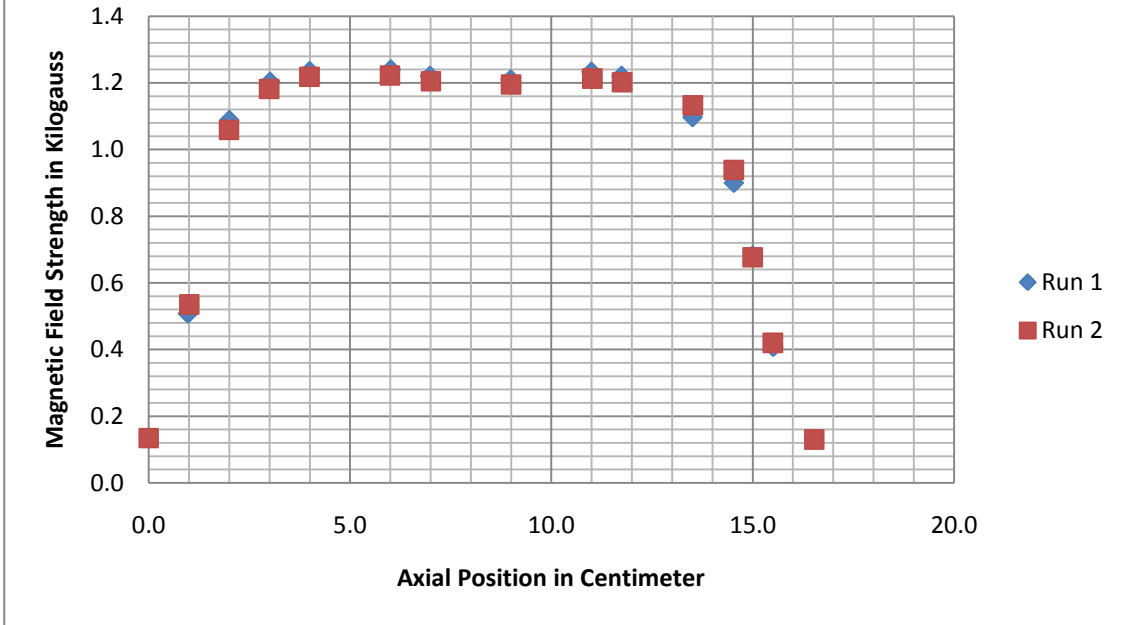


Fig. 5: 90 Degrees - 1 cm Radius

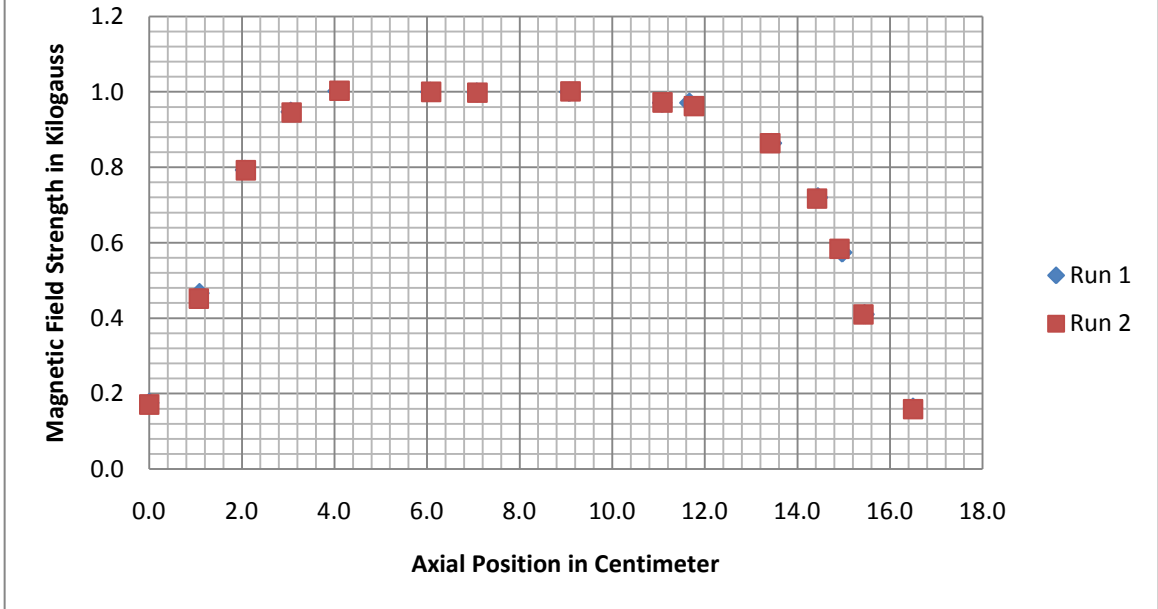


Fig. 6: 180 Degrees - 1 cm Radius

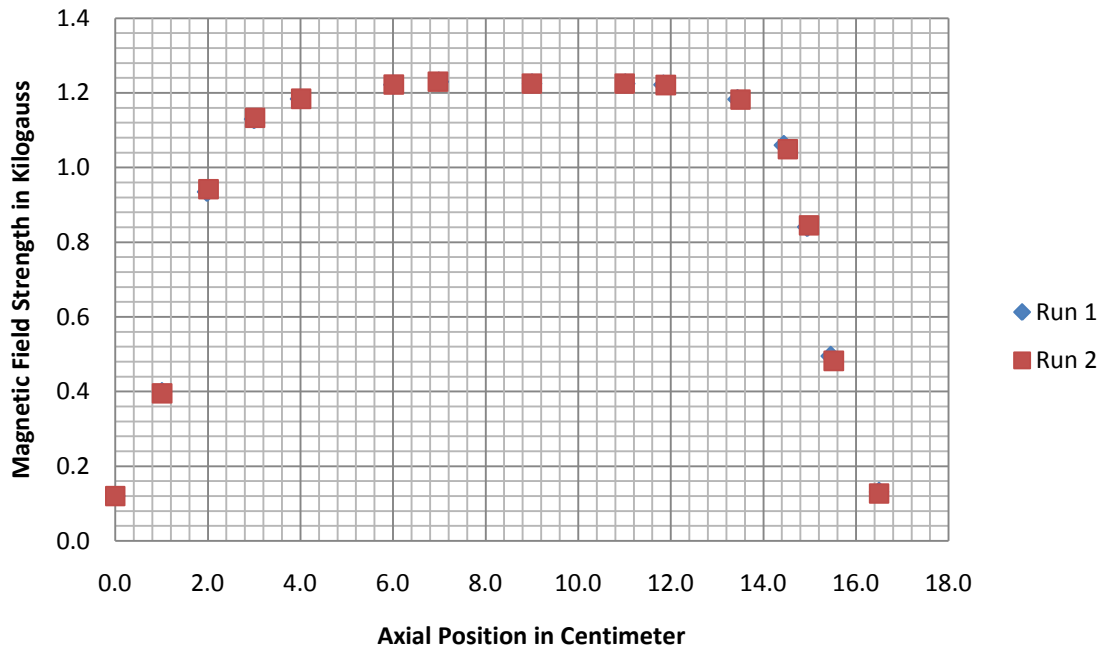
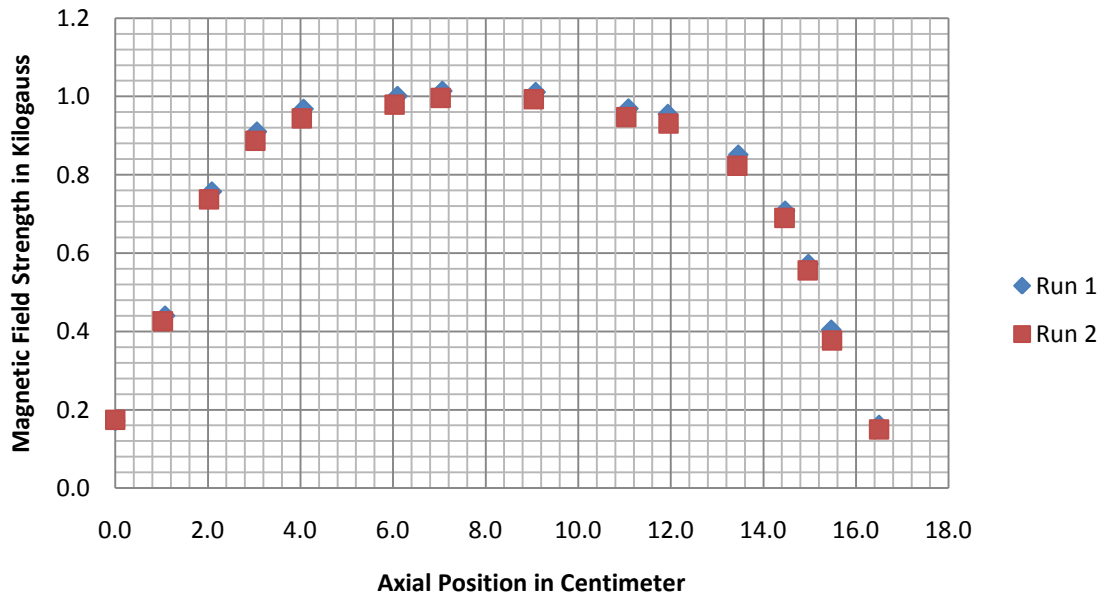


Fig. 7: 270 Degrees - 1 cm Radius



Measurements taken at the edge inside the magnet prove to be less homogeneous. The 0° and 180° measurements in Figures 8 and 10, the magnetic field builds up quickly at 3.5cm and remains steady until 8.5cm. At 8.5cm an approximate 0.2 kilogauss drop occurs in the steady field, but returns shortly after 8.5cm. A similar situation occurs for the 90° and 270° edge measurements seen in Figures 9 and 11. The differences now being the 0.2 kilogauss drops take place around 4.0cm and once the field drops, it doesn't return. The field instead becomes steady until 12.0cm.

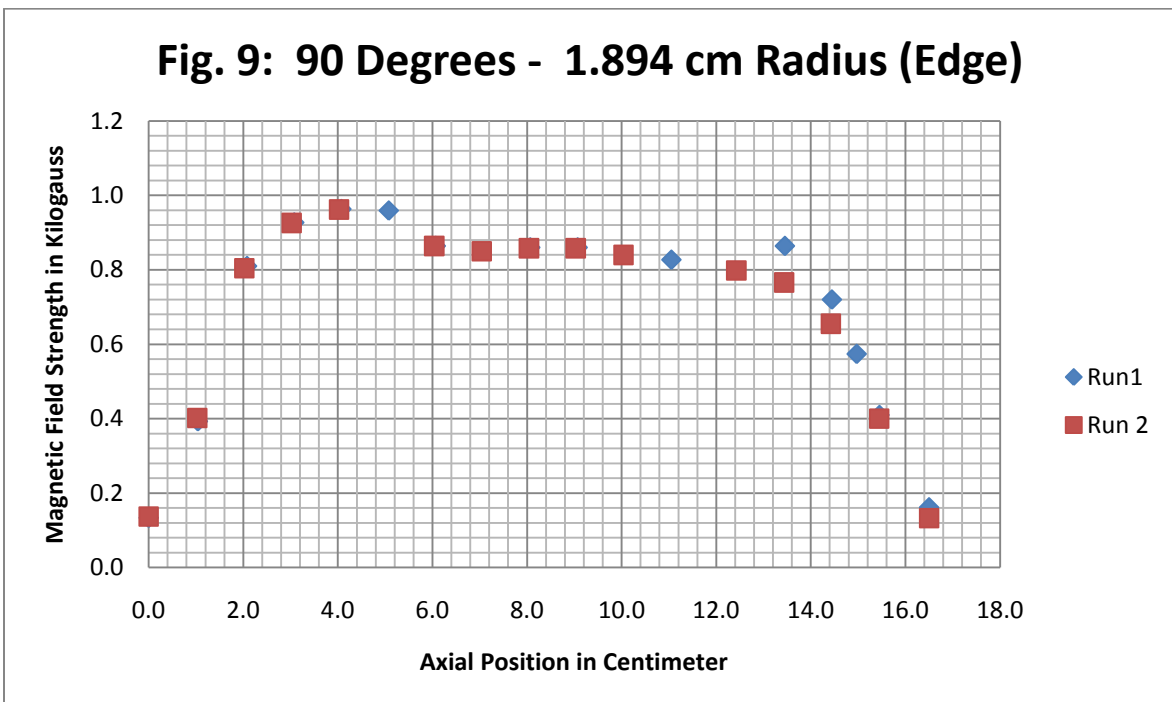
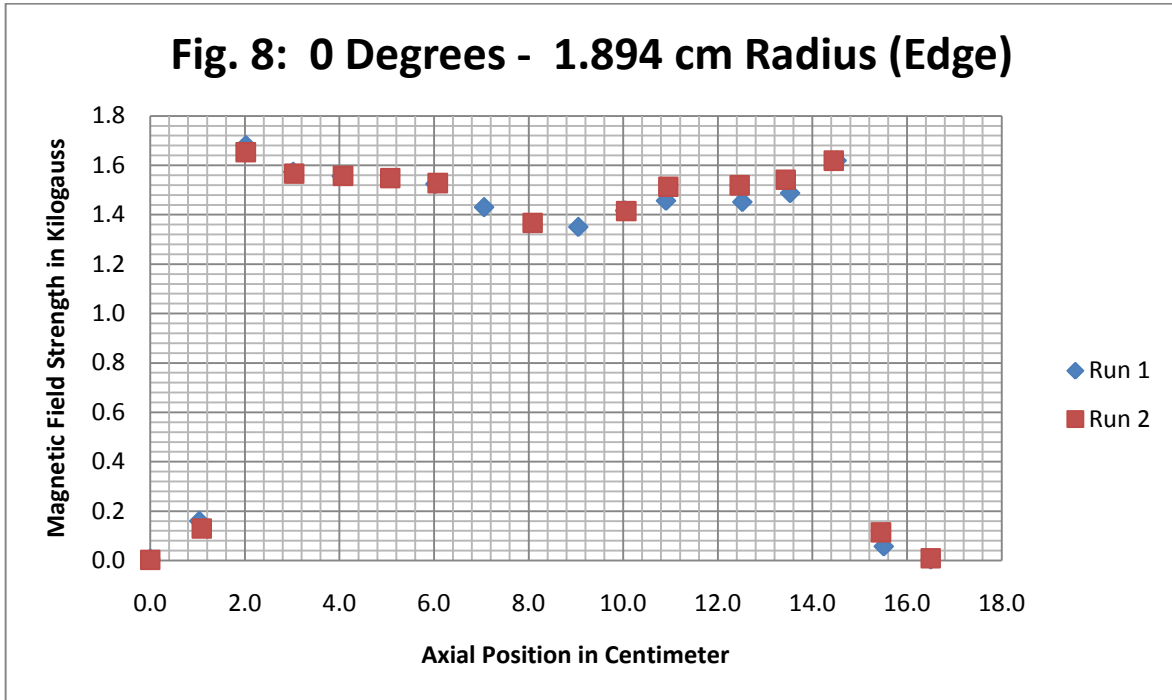


Fig. 10: 180 Degrees - 1.894 cm Radius (Edge)

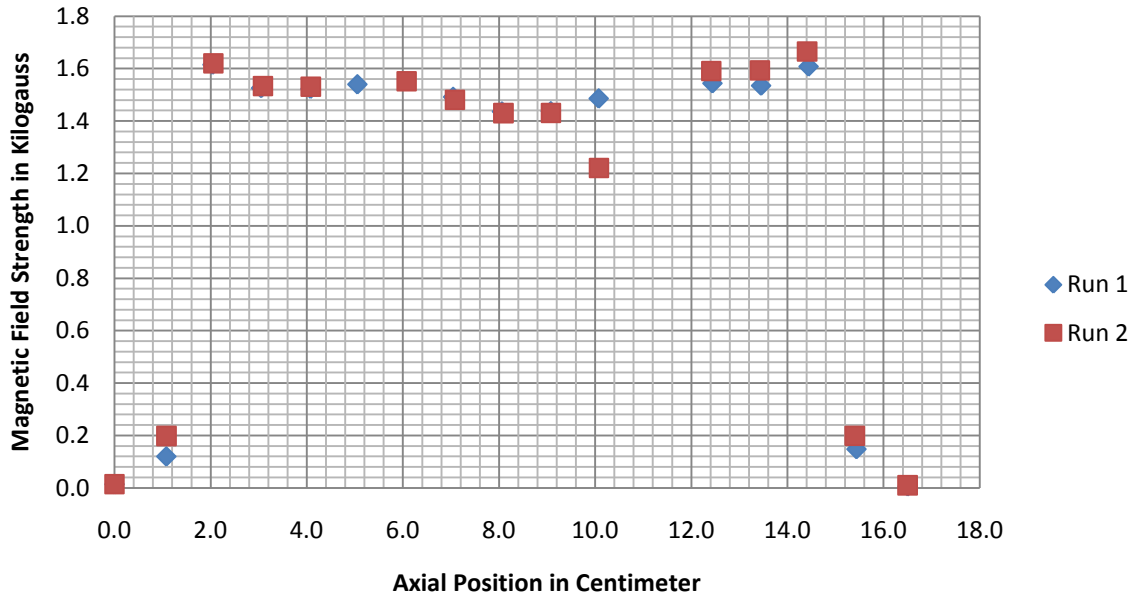
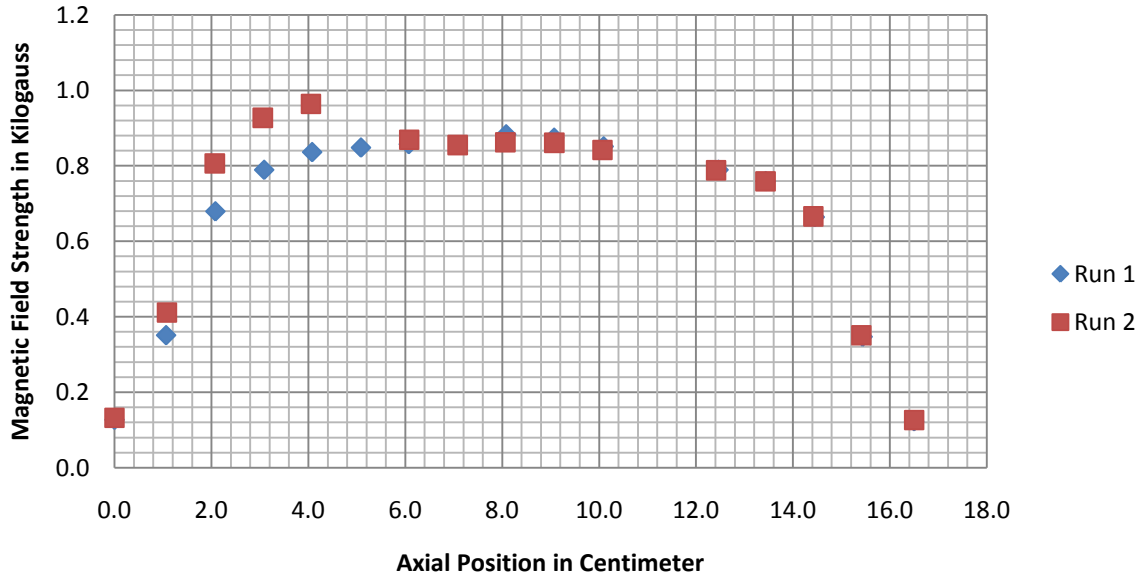


Fig. 11: 270 Degrees - 1.894 cm Radius (Edge)



4 Results and conclusion

Based on the measured field strength values along the center and 1cm radius being close to the last known measured values, the magnet has not deteriorated significantly enough to warrant a replacement. The edge measurements raise some concern, and should be checked in the future. The full list of measurements is available below for future comparisons.

Magnetic Field Mapping June 6, 2010
Probe Position: Along Center of the Magnet

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.185	0.000	0.187
2.000	1.155	0.491	1.106	0.480
3.000	2.152	0.825	2.074	0.786
4.000	3.148	1.001	3.072	0.957
5.000	4.146	1.066	4.070	1.062
6.000	6.136	1.094	6.062	1.090
7.000	7.140	1.096	7.072	1.096
8.000	9.140	1.093	9.068	1.093
9.000	11.108	1.081	11.096	1.074
10.000	12.010	1.070	11.874	1.062
11.000	13.510	0.987	13.506	0.982
12.000	14.520	0.800	14.512	0.797
13.000	15.000	0.646	15.008	0.643
14.000	15.518	0.463	15.490	0.474
15.000	16.500	0.199	16.494	0.202

Probe Position: 0 Degrees - 1 cm Radius

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.134	0.000	0.134
2.000	0.974	0.508	1.006	0.535
3.000	2.002	1.088	1.994	1.059
4.000	3.014	1.203	2.990	1.182
5.000	3.996	1.235	3.992	1.218
6.000	6.012	1.240	5.990	1.222
7.000	6.988	1.221	7.010	1.205
8.000	8.992	1.210	9.000	1.195
9.000	10.996	1.233	11.018	1.213
10.000	11.744	1.221	11.756	1.202
11.000	13.508	1.097	13.512	1.133
12.000	14.534	0.900	14.530	0.939
13.000	15.002	0.682	15.010	0.677
14.000	15.512	0.408	15.500	0.420
15.000	16.522	0.131	16.530	0.130

Probe Position: 90 Degrees - 1 cm Radius

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.175	0.000	0.171
2.000	1.084	0.466	1.068	0.452
3.000	2.068	0.793	2.084	0.792
4.000	3.056	0.947	3.076	0.945
5.000	4.066	1.002	4.108	1.003
6.000	6.070	1.000	6.090	1.000
7.000	7.076	0.998	7.088	0.998
8.000	9.074	1.000	9.098	1.001
9.000	11.080	0.971	11.088	0.972
10.000	11.668	0.971	11.766	0.962
11.000	13.452	0.864	13.412	0.864
12.000	14.446	0.720	14.424	0.717
13.000	14.970	0.574	14.910	0.584
14.000	15.452	0.410	15.428	0.410
15.000	16.500	0.162	16.500	0.159

Probe Position: 180 Degrees - 1 cm Radius

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.120	0.000	0.120
2.000	1.008	0.398	1.012	0.395
3.000	1.982	0.935	2.014	0.942
4.000	2.998	1.130	3.018	1.133
5.000	3.990	1.184	4.016	1.184
6.000	6.008	1.222	6.016	1.222
7.000	6.990	1.230	6.970	1.230
8.000	9.004	1.225	8.998	1.225
9.000	11.018	1.225	11.002	1.225
10.000	11.842	1.222	11.892	1.221
11.000	13.442	1.183	13.506	1.182
12.000	14.444	1.060	14.530	1.049
13.000	14.948	0.841	14.986	0.845
14.000	15.456	0.495	15.520	0.482
15.000	16.500	0.131	16.500	0.127

Probe Position: 270 Degrees - 1 cm Radius

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.171	0.000	0.174
2.000	1.076	0.440	1.026	0.426
3.000	2.086	0.757	2.022	0.737
4.000	3.060	0.910	3.028	0.887
5.000	4.068	0.968	4.030	0.944
6.000	6.096	1.001	6.034	0.979
7.000	7.066	1.014	7.028	0.996
8.000	9.082	1.011	9.040	0.993
9.000	11.086	0.969	11.036	0.947
10.000	11.938	0.955	11.950	0.931
11.000	13.460	0.851	13.438	0.823
12.000	14.472	0.708	14.456	0.690
13.000	14.974	0.572	14.956	0.556
14.000	15.468	0.404	15.480	0.377
15.000	16.500	0.161	16.500	0.150

Probe Position: 0 Degrees - 1.894 cm Radius (The Edge)

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.007	0.000	0.003
2.000	1.036	0.160	1.088	0.130
3.000	2.022	1.682	2.018	1.653
4.000	3.022	1.574	3.044	1.566
5.000	4.048	1.557	4.076	1.557
6.000	6.028	1.525	5.072	1.548
7.000	7.058	1.431	6.078	1.528
8.000	9.050	1.351	8.082	1.367
9.000	10.040	1.417	10.064	1.415
10.000	10.904	1.457	10.952	1.513
11.000	12.518	1.452	12.462	1.519
12.000	13.528	1.488	13.438	1.542
13.000	14.512	1.620	14.450	1.619
14.000	15.508	0.057	15.448	0.114
15.000	16.500	0.004	16.500	0.009

Probe Position: 90 Degrees - 1.894 cm Radius (The Edge)

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.134	0.000	0.137
2.000	1.040	0.393	1.026	0.402
3.000	2.080	0.810	2.022	0.804
4.000	3.078	0.927	3.024	0.926
5.000	4.074	0.963	4.026	0.962
6.000	5.076	0.959	6.038	0.864
7.000	6.070	0.864	7.044	0.850
8.000	8.068	0.860	8.040	0.858
9.000	9.070	0.860	9.028	0.858
10.000	11.052	0.827	10.038	0.840
11.000	13.452	0.864	12.424	0.798
12.000	14.446	0.720	13.436	0.766
13.000	14.970	0.574	14.422	0.655
14.000	15.452	0.410	15.446	0.400
15.000	16.500	0.162	16.500	0.133

Probe Position: 180 Degrees - 1.894 cm Radius (The Edge)

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.014	0.000	0.014
2.000	1.078	0.120	1.080	0.198
3.000	2.038	1.615	2.054	1.620
4.000	3.050	1.526	3.086	1.533
5.000	4.078	1.523	4.082	1.531
6.000	5.052	1.540	6.078	1.552
7.000	7.044	1.492	7.082	1.481
8.000	8.060	1.436	8.092	1.430
9.000	9.076	1.437	9.080	1.431
10.000	10.072	1.486	10.076	1.221
11.000	12.438	1.544	12.414	1.591
12.000	13.450	1.535	13.426	1.593
13.000	14.438	1.608	14.410	1.665
14.000	15.434	0.148	15.402	0.199
15.000	16.500	0.006	16.500	0.010

Probe Position: 270 Degrees - 1.894 cm Radius (The Edge)

Measurement #	Run 1		Run 2	
	Starting Position centimeter	Field Strength kilogauss	Starting Position centimeter	Field Strength kilogauss
1.000	0.000	0.127	0.000	0.132
2.000	1.064	0.351	1.080	0.411
3.000	2.082	0.679	2.068	0.806
4.000	3.088	0.789	3.060	0.927
5.000	4.078	0.836	4.052	0.964
6.000	5.086	0.848	6.082	0.869
7.000	6.072	0.857	7.082	0.855
8.000	8.082	0.883	8.064	0.862
9.000	9.072	0.874	9.076	0.861
10.000	10.094	0.851	10.068	0.842
11.000	12.464	0.789	12.412	0.788
12.000	13.438	0.759	13.434	0.759
13.000	14.450	0.664	14.420	0.666
14.000	15.438	0.347	15.410	0.351
15.000	16.500	0.123	16.500	0.126