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## memorandum

LANSCE-1 Magnet Mapping

To: Distribution  
From: David Barlow  
Symbol: LANSCE-1:01-057 (TN)  
Date: Nov. 15 2001

### IPF Steering Magnets

#### Introduction

A set of dual axis steering magnets have been designed, fabricated, tested and mapped prior to their installation in the 100 MeV proton beam line of the Isotope Production Facility (IPF). The steerers are of conventional design consisting of many turns of solid conductor wound on a rectangular iron yoke, Fig. 1. The set consists one 3" ID steerer (LANL drawing 154Y-653728) and three 4" ID steerers (LANL drawing 154Y-653729). The 3" steerer has been labeled S/N-001 and the 4" steerers have been labeled S/N-001, S/N-002, and S/N-003. The results of the magnetic measurements are described below.

#### Procedure

The integral fields produced by the horizontal and vertical steering windings of each steerer were measured using rotating coils. The 3" ID steerer was measured with a 2.5" OD coil (Coil 130), while the 4" ID steerers were measured with a 4.0" OD coil (Coil 131). The axis of rotation of the coil was aligned within  $\pm 0.5\text{mm}$  of the mechanical axis of the steerers. Prior to measuring the integral fields, both axes of the steerers were conditioned at 12 A. The integral fields were then measured for one steering axis at a time at currents of 10 A on down to 0 A in 1 A steps. The integral field measurements have a systematic uncertainty of about 3% with a random error of 0.5%. The error in the current measurement is 2 mA.

#### Results

The results of the measurements are listed in Tables I-IV. Note that for 100 MeV protons an integral field of 1480 G-cm will steer the beam 1 mr. At 10 A the voltage drop for each axis was measured to be 6 V for the 3" steerer and 8 V for the 4" steerers.

#### Temperature vs. Current

The temperature of the magnet as a function of the current was measured for one of the 4" steerers. Thermocouples were inserted in the small gaps between the inside of the windings and the iron yoke. Both axes were connected in series and the magnet was energized to a fixed current setting. The temperatures of the coils and the ambient air were recorded in 2 minute intervals along with the voltage drop and current until the magnet reached thermal equilibrium. The temperature rise vs. power is plotted in Fig. 2. For the 4" steerers the maximum power is about 60 W which is just under 6 A per axis. The same maximum current setting should apply for the 3" steerer.

Table Ia  
3" Steerer S/N-001 Horizontal Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 3.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.047	4595.3	1.66	5.39	0.14	0.98	0.03	0.07
9.056	4160.6	1.66	5.34	0.14	0.97	0.03	0.07
8.010	3690.3	1.67	5.31	0.14	0.97	0.03	0.07
6.997	3234.8	1.67	5.28	0.14	0.97	0.03	0.07
6.024	2790.9	1.67	5.25	0.14	0.97	0.03	0.06
5.015	2337.5	1.68	5.19	0.14	0.96	0.03	0.06
4.024	1884.5	1.68	5.14	0.13	0.96	0.03	0.06
3.001	1418.5	1.70	5.04	0.13	0.95	0.03	0.06
2.000	963.7	1.73	4.85	0.11	0.94	0.03	0.06
0.994	504.5	1.82	4.37	0.09	0.90	0.03	0.06
0	58.7	-	-	-	-	-	-

Table Ib  
3" Steerer S/N-001 Vertical Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 3.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.079	4619.0	0.41	5.38	0.02	0.98	0.01	0.07
9.011	4144.1	0.42	5.35	0.02	0.98	0.01	0.07
7.993	3687.1	0.42	5.32	0.02	0.98	0.01	0.07
7.009	3244.6	0.42	5.29	0.02	0.97	0.01	0.07
5.990	2781.8	0.42	5.26	0.02	0.97	0.01	0.07
5.057	2358.0	0.43	5.22	0.02	0.97	0.01	0.07
3.989	1876.5	0.44	5.13	0.01	0.96	0.01	0.07
3.013	1430.2	0.46	5.04	0.01	0.95	0.01	0.07
2.011	975.39	0.48	4.84	0.00	0.94	0.01	0.07
0.988	508.72	0.55	4.32	0.02	0.90	0.01	0.06
0	62.42	-	-	-	-	-	-

Table IIa  
4" Steerer S/N-001 Horizontal Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 4.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.017	5374.6	0.49	8.10	0.02	1.55	0.02	0.08
9.034	4868.9	0.50	8.03	0.02	1.54	0.02	0.08
8.050	4345.5	0.50	7.98	0.02	1.54	0.02	0.08
7.004	3794.2	0.50	7.90	0.02	1.54	0.02	0.08
6.046	3280.5	0.50	7.86	0.02	1.54	0.02	0.08
5.008	2729.1	0.50	7.76	0.02	1.53	0.02	0.08
4.030	2199.4	0.50	7.69	0.02	1.54	0.02	0.08
2.997	1650.4	0.50	7.48	0.02	1.53	0.02	0.08
1.996	1109.8	0.49	7.21	0.02	1.53	0.02	0.08
0.995	572.0	0.52	6.38	0.03	1.52	0.02	0.07
0	47.8	-	-	-	-	-	-

Table IIb  
4" Steerer S/N-001 Vertical Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 4.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.049	5398.6	0.18	7.81	0.07	1.60	0.03	0.04
9.062	4897.4	0.19	7.75	0.07	1.60	0.03	0.04
8.018	4355.0	0.18	7.69	0.07	1.59	0.03	0.04
7.004	3822.0	0.18	7.63	0.06	1.59	0.03	0.04
5.994	3287.9	0.19	7.56	0.06	1.59	0.03	0.04
5.042	2781.7	0.18	7.47	0.06	1.58	0.03	0.04
4.014	2229.9	0.19	7.37	0.06	1.57	0.03	0.04
3.009	1692.9	0.20	7.18	0.06	1.56	0.03	0.04
1.991	1144.6	0.21	6.85	0.05	1.54	0.03	0.04
1.027	621.1	0.26	6.15	0.04	1.49	0.02	0.04
0	70.7	-	-	-	-	-	-

Table IIIa  
4" Steerer S/N-002 Horizontal Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 4.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.063	5405.5	0.40	8.04	0.05	1.53	0.01	0.08
9.020	4862.1	0.39	7.97	0.06	1.53	0.01	0.08
8.021	4332.7	0.39	7.92	0.05	1.53	0.01	0.08
7.038	3809.2	0.38	7.87	0.05	1.52	0.01	0.08
6.002	3260.6	0.37	7.79	0.05	1.52	0.01	0.08
4.998	2719.9	0.38	7.73	0.05	1.52	0.01	0.08
4.021	2195.1	0.37	7.65	0.05	1.52	0.01	0.08
2.995	1644.7	0.36	7.49	0.05	1.52	0.01	0.08
1.996	1112.6	0.34	7.15	0.05	1.51	0.01	0.08
0.977	560.9	0.31	6.37	0.05	1.51	0.01	0.08
0	46.9	-	-	-	-	-	-

Table IIIb  
4" Steerer S/N-002 Vertical Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 4.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.016	5428.6	0.58	7.78	0.21	1.48	0.02	0.08
9.021	4919.4	0.57	7.73	0.21	1.47	0.02	0.08
8.016	4381.4	0.56	7.69	0.21	1.47	0.02	0.08
6.988	3839.5	0.55	7.62	0.2	1.47	0.02	0.08
5.991	3307.6	0.54	7.56	0.2	1.46	0.02	0.08
5.009	2780.1	0.53	7.49	0.2	1.46	0.02	0.08
4.011	2244.9	0.52	7.36	0.2	1.45	0.02	0.08
2.980	1686.6	0.51	7.19	0.19	1.44	0.02	0.08
2.005	1158.7	0.49	6.89	0.18	1.42	0.02	0.08
1.040	635.0	0.44	6.14	0.16	1.37	0.02	0.07
0	70.8	-	-	-	-	-	-

Table IVa  
4" Steerer S/N-003 Horizontal Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 4.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.017	5433.0	0.08	7.95	0.12	1.50	0.01	0.09
9.012	4904.8	0.09	7.89	0.13	1.50	0.01	0.08
8.035	4386.2	0.10	7.84	0.13	1.50	0.01	0.08
7.047	3858.9	0.10	7.78	0.13	1.49	0.01	0.08
5.998	3294.4	0.10	7.72	0.13	1.49	0.01	0.08
5.014	2768.1	0.11	7.62	0.13	1.49	0.01	0.08
4.035	2239.7	0.11	7.52	0.13	1.48	0.01	0.08
2.997	1678.7	0.10	7.34	0.13	1.48	0.01	0.08
2.040	1160.6	0.09	7.05	0.13	1.46	0.01	0.08
1.027	611.0	0.08	6.25	0.14	1.43	0.01	0.08
0	64.5	-	-	-	-	-	-

Table IVb  
4" Steerer S/N-003 Vertical Steering

I (A)	B.dl (G-cm)	Harmonics in % of n=1 at R = 4.0 cm					
		n=2	n=3	n=4	n=5	n=6	n=7
10.000	5387.9	0.44	7.89	0.13	1.5	0.02	0.08
9.017	4882.7	0.44	7.85	0.13	1.49	0.02	0.08
7.990	4349.9	0.44	7.78	0.12	1.49	0.02	0.08
7.028	3844.1	0.43	7.72	0.12	1.48	0.02	0.08
6.015	3306.5	0.43	7.66	0.12	1.48	0.02	0.08
5.005	2767.9	0.43	7.57	0.12	1.48	0.02	0.08
3.998	2228.1	0.42	7.45	0.11	1.47	0.02	0.08
2.992	1687.9	0.42	7.28	0.11	1.46	0.02	0.08
2.003	1150.1	0.42	7.02	0.10	1.44	0.02	0.08
0.988	607.3	0.42	6.10	0.08	1.38	0.01	0.07
0	74.6	-	-	-	-	-	-

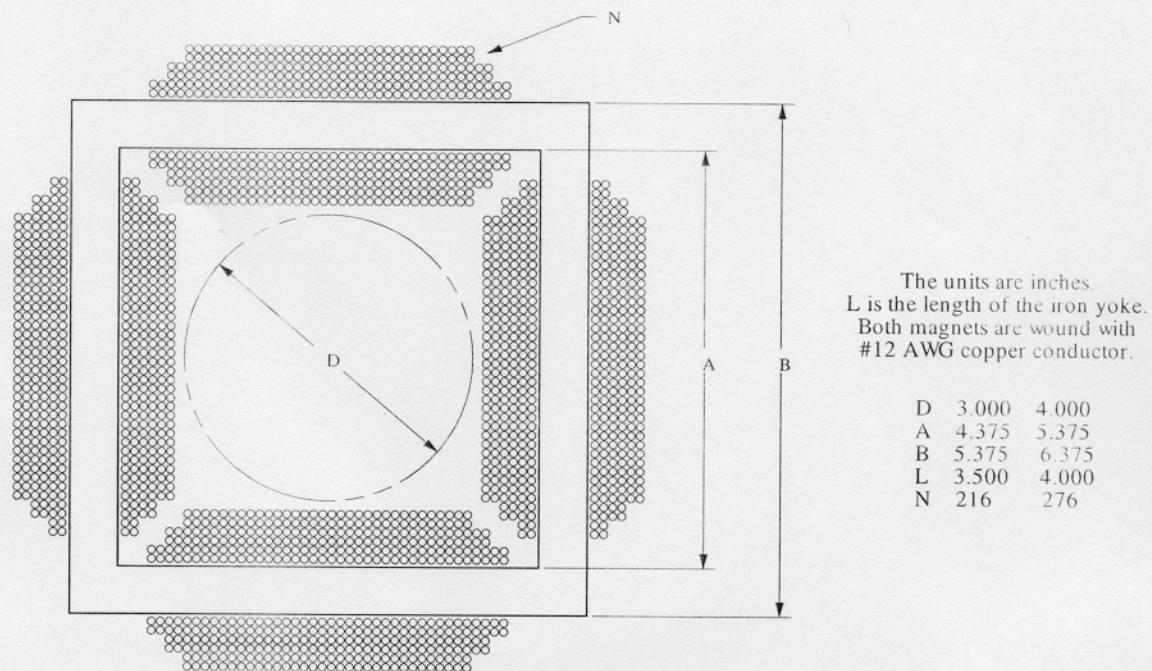


Fig. 1 Cross section of the steering magnets.

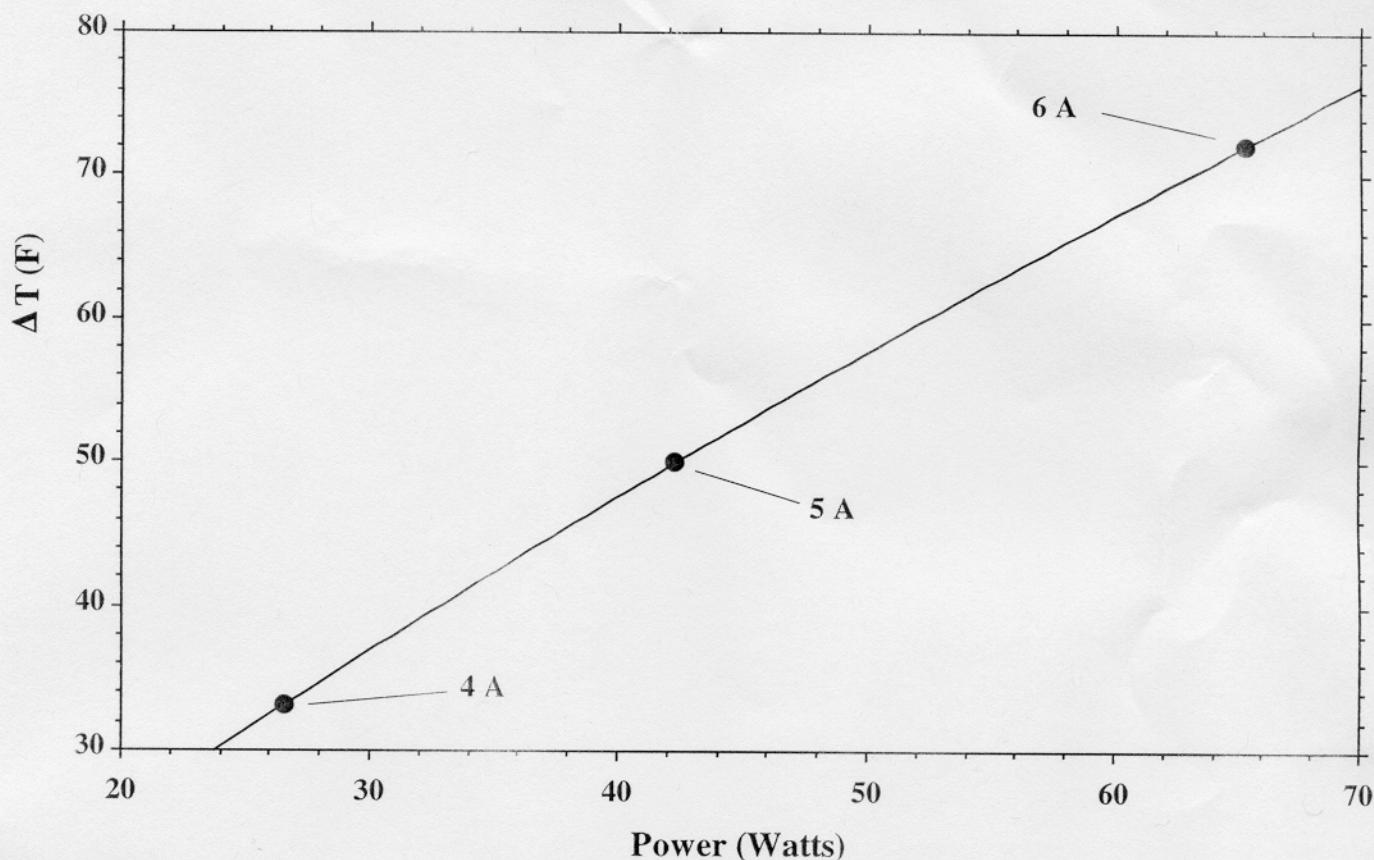


Fig. 2  $\Delta T$  vs. power for a 4" steerer, where  $\Delta T$  is the difference between the coil and air temperatures. Both axes are connected in series. The data have been fit with a second order polynomial.

Distribution:

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M. Perez	LANSC-E-2	H838
K. Johnson	LANSC-E-1	H817
A. Jason	LANSC-E-1	H817
LANSC-E-1 File	LANSC-E-1	H817
LANSC-DO File	LANSC-DO	H850