BNL-104840-2014-TECH

AGS/AD/Tech Note No. 424;BNL-104840-2014-IR

THE DIPOLE FIELDS OF THE AGS MAIN MAGNETS

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January 1996

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U.S. Department of Energy

USDOE Office of Science (SC)

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Accelerator Division
Technical Note

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January 26, 1996

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SUMMARY

This note records and parameterizes the strength of the dipole fields in the AGS main magnets.

THE AGS MAIN MAGNETS

The AGS main magnets are combined function C-magnets which have two lengths. The "long" magnets are 90 inches long and are designated "A" or "C" magnets. The "short" magnets are 75 inches long and are designated "B" magnets. If the wide side of the magnet gap is to the outside of the magnet, away from the backleg, the magnet is called an open magnet. If the narrow side of the gap is to the outside of the magnet, the magnet is called a closed magnet. There are three kinds of magnets: long, open or closed, and short, open. Their designations are:

A	long , open
B	short, open
C	long, closed.

Depending on their installation orientation in the ring, each of these magnets may be focussing or defocussing. Therefore there are six designations for magnets installed in the ring: AD, AF, BD, BF, CD, and CF.

THE MEASUREMENT DATA

Some years ago one of us (R.T.) made point to point field maps for an open magnet and a closed magnet over a number of current settings. The data were analyzed and used to generate the excitation functions and harmonic contents for the AGS main magnets. The results of this analysis have been incorporated into a number of operating systems, however the results have never been documented. Since magnetic storage may be long-lasting but the retrieval hardware and software seem to disappear in less than a decade, this note is being prepared to provide a permanent record of the data. It deals only with the analyzed results of dipole component of the main AGS magnets.

THE RESULTS

Tables 1A, 1B, and 1C give the central dipole field strength for magnets A, B, and C for a number of different currents. The integration is performed along two different paths in each magnet: F for integration along the curved central orbit when the magnet is focussing, and D for integration along the curved central orbit when the magnet is defocussing. These paths are defined in Tech. Notes 215 and 217. Table 2 records the integrated field all the way around the AGS by summing over all 240 magnets. Table 2 was transmitted to the AGS power supply group and has been incorporated into the Main Magnet control program.

ACCURACY

The point to point accuracy of the measurements is about one part in 5000. Integrating over the fields probably gives relative accuracies better than this. However the overall calibration of the apparatus is probably about 0.5%. This is the number of interest when Table 2 is compared against data that may be taken on the AGS with the Gauss clock. In this note we carry a lot of decimal places for two reasons: we can avoid round-off problems in the parameterizations and many decimal places will enable us to identify the source of the data in the future.

PARAMETERIZATION

Figure 1 shows the data from Table 2 plotted as B×L/I versus I. We have parameterized this data by fitting the low field data to powers of 1/I, forcing the curve to be flat in the I range around 1000 Amperes, and fitting the remainder to a power series in I. The fitted curve is also shown in Figure 1 and the parameters are given in Table 3.

$$\frac{B\times L}{I} = \frac{a_{-4}}{I^4} + \frac{a_{-3}}{I^3} + \frac{a_{-2}}{I^2} +$$
$$+ a_0 + a_1 I + a_2 I^2 + a_3 I^3 + a_4 I^4 + a_5 I^5 + a_6 I^6$$

The inverse of these results, I/(B×L) versus (B×L), is given in Figure 2 and Table 4. Since the momentum, P, is directly proportional to B×L, the parameterization for P is also given.

BENDING RADIUS

The bending radius of the AGS depends to some degree on how it is calculated. To get a somewhat general answer, we take each magnet, its effective length, and its bend angle from Tech Note 215 to find the arc length of the orbit in the magnet. Summing over the 240 magnets and dividing by 2 pi gives the bending radius:

BENDING RADIUS = 85.380 840 meters

This value should be consistent with other calculations to about 0.5 millimeters.

TABLE 1A

	MAGNET AD		MAGNET AF	
I	B0	B0*L	B0	B0*L
Amperes	Gauss	Gauss*m	Gauss	Gauss*m
0	16.52	44.72	16.80	44.62
30	80.29	198.44	81.82	198.45
32	84.36	208.32	85.96	208.33
34	88.64	218.64	90.33	218.66
38	97.29	239.54	99.15	239.57
60	145.04	354.72	147.84	354.84
100	232.25	565.42	236.75	565.69
108	249.78	607.66	254.63	607.97
116	267.16	649.46	272.34	649.79
360	807.11	1955.38	822.84	1956.58
1000	2234.93	5413.36	2278.57	5416.81
2650	5922.02	14337.76	6037.72	14347.22
3550	7926.60	19176.77	8081.42	19190.55
4450	9907.63	23916.61	10100.98	23937.56
4800	10654.38	25681.18	10862.15	25706.30
5150	11352.72	27317.92	11573.57	27347.74
5500	11948.71	28706.41	12179.98	28740.30
5850	12493.08	29963.29	12733.20	30000.93

TABLE 1B

	MAGNET BD		MAGNET BF	
I	B0	B0*L	B0	B0*L
Amperes	Gauss	Gauss*m	Gauss	Gauss*m
0	16.75	38.49	16.97	38.42
30	80.66	167.69	81.85	167.70
32	84.73	176.00	85.98	176.01
34	89.02	184.68	90.34	184.70
38	97.70	202.25	99.14	202.28
60	145.55	299.07	147.72	299.16
100	232.94	476.24	236.44	476.42
108	250.52	511.75	254.28	511.96
116	267.91	546.85	271.94	547.08
360	808.95	1645.12	821.16	1645.94
1000	2239.78	4554.08	2273.65	4556.45
2650	5934.98	12061.00	6024.77	12067.49
3550	7944.10	16129.61	8064.25	16139.08
4450	9929.28	20108.45	10079.33	20122.79
4800	10677.76	21586.54	10839.00	21603.69
5150	11377.74	22955.64	11549.14	22975.93
5500	11974.52	24115.55	12153.99	24138.53
5850	12520.35	25164.31	12706.70	25189.79

TABLE 1C

	MAGNET CD		MAGNET CF	
I	B0	B0*L	B0	B0*L
Amperes	Gauss	Gauss*m	Gauss	Gauss*m
0	15.95	42.71	16.34	42.62
30	79.48	196.24	81.11	196.29
32	83.74	206.51	85.45	206.57
34	88.74	217.69	90.55	217.76
38	96.79	238.02	98.75	238.10
60	145.64	355.95	148.55	356.15
100	231.72	563.36	236.31	563.76
108	249.13	605.31	254.07	605.75
116	266.99	648.36	272.27	648.84
360	805.84	1950.77	821.62	1952.43
1000	2229.32	5395.74	2272.90	5400.36
2650	5909.51	14291.15	6025.01	14304.24
3550	7909.71	19110.15	8064.35	19129.03
4450	9884.75	23829.66	10077.97	23857.10
4800	10633.90	25595.50	10841.61	25627.80
5150	11333.09	27233.20	11553.89	27269.90
5500	11953.07	28671.57	12184.60	28712.92
5850	12489.53	29904.21	12729.72	29950.46

TABLE 2

I	B*L	B*L/I	P
AMPERES	TESLA*METERS	T*M/A	GeV/c
0	0.9932		0.0474
30	4.4465	0.148218	0.2122
32	4.6724	0.146011	0.2229
34	4.9127	0.144492	0.2344
38	5.3770	0.141500	0.2566
60	7.9925	0.133208	0.3814
100	12.6976	0.126976	0.6058
108	13.6444	0.126337	0.6510
116	14.5956	0.125824	0.6964
360	43.9212	0.122003	2.0956
1000	121.5442	0.121544	5.7993
2650	321.9186	0.121479	15.3598
3550	430.5194	0.121273	20.5416
4450	536.8564	0.120642	25.6153
4800	576.5149	0.120107	27.5075
5150	613.2840	0.119084	29.2619
5500	644.9372	0.117261	30.7722
5850	672.9162	0.115028	32.1072

TABLE 3

FORMULA	TERM	B*L/I T*M/A COEFFICIENT	P/I GeV/c//A COEFFICIENT
a_{-4}	1/I^4	3.833395E+04	1.829045E+03
a_{-3}	1/I^3	-3.003303E+03	-1.432980E+02
a_{-2}	1/I^2	8.165383E+01	3.895986E+00
a_{-1}	1/I	-1.384148E-03	-6.604247E-05
a_0	CONSTANT	1.214860E-01	5.796515E-03
a_1	I	-4.545545E-07	-2.168837E-08
a_2	I^2	9.586722E-10	4.574156E-11
a_3	I^3	-6.700589E-13	-3.197083E-14
a_4	I^4	2.027363E-16	9.673249E-18
a_5	I^5	-2.658005E-20	-1.268226E-21
a_6	I^6	1.052191E-24	5.020365E-26

TABLE 4

	I/(B*L) A/(T*M)		I/P A/(GeV/c)
TERM	COEFFICIENT	TERM	COEFFICIENT
1/(B*L)^4	-1.070694E+03	1/P^4	-1.163023E-01
1/(B*L)^3	5.836957E+02	1/P^3	1.328827E+00
1/(B*L)^2	-1.119693E+02	1/P^2	-5.342444E+00
1/(B*L)	1.282979E+00	1/P	1.282979E+00
CONSTANT	8.224488E+00	CONSTANT	1.723725E+02
B*L	-3.408321E-04	P	-1.497127E-01
(B*L)^2	7.313631E-06	P^2	6.733027E-02
(B*L)^3	-5.642907E-08	P^3	-1.088778E-02
(B*L)^4	1.966953E-10	P^4	7.954074E-04
(B*L)^5	-3.143464E-13	P^5	-2.664177E-05
(B*L)^6	1.897916E-16	P^6	3.371247E-07

Figure 1: B*L/I vs I

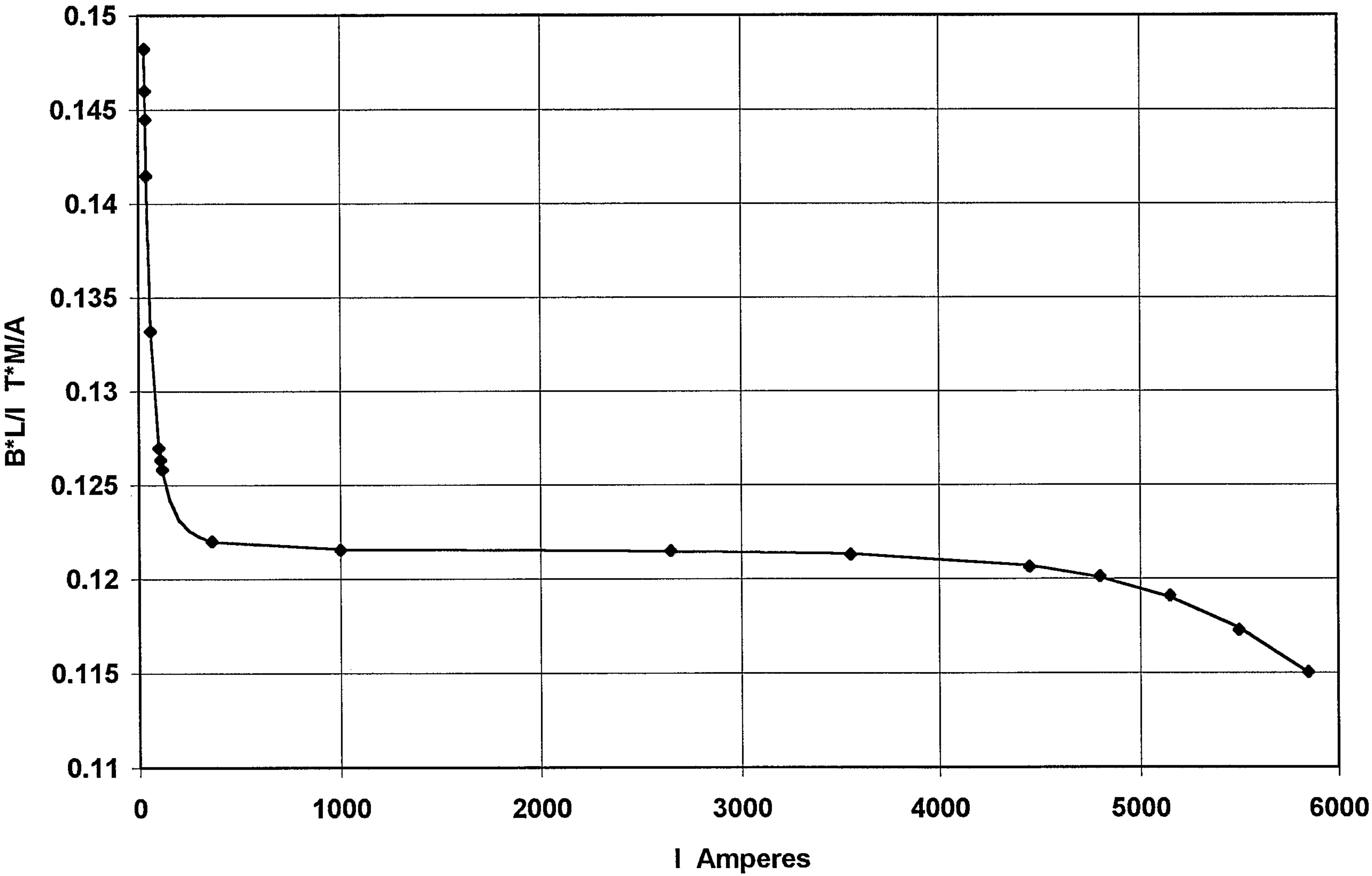

Figure 2: I/(B*L) vs B*L