Mole Measurement of DCA311 Collar-Keyed Assembly

TS-SSC 91-150
S. Delchamps
August 7, 1991

Introduction: The DCA311 collar-keyed assembly, with end clamps installed at both ends, was first moled on July 17th. The files from this first pass were lost in a disc failure on the mole HP computer, and so the mole scan was done a second time on July 30th. This memo presents preliminary results on the harmonics, transfer function, and mole systematics from this measurement. After a summary of data files, measured harmonics are presented and compared to limiting values for the SSC. Figures showing the longitudinal dependence of several harmonics and of the mole horizontal and vertical position in the bore tube are shown.

Data Files: Normally there would be two HP files, one containing data from a centering scan and the other containing the ±10 A data[1]. In the case of DCA311,both the centering data file DCA311_000 and the original ±10 A and 0 A data file DCA311_001 were lost in the disc failure. Since the center position of the magnet had already been determined by data recorded in the log book before DCA311_000 was lost, it was not necessary to redo the centering. For this reason there is only one existing file for DCA311 on the HP. Its corresponding file on the VAX cluster resides in the directory MDTF01::SSC$ROOT:[SSC].

HP File Name	VAX File Name	Data Contained; Record no.'s
DCA311_002	DCA311_002.READMOLE	1-52 (±10A)

Table 1. Hewlett-Packard and VAX File Names

Note that only ±10 A data were recorded for this magnet. The main reason for taking 0 A data in the past has been to measure remnant fields present in already cold-tested magnets. Since there is no iron present in the case of a collar-keyed assembly, only the earth's field and the field due to the coils are of interest. In principle, the ±10 A and 0 A data give two independent evaluations of the earth's magnetic field, and therefore teach us something about systematic errors in the harmonics reported by the mole; however it is not necessary to take such data on the majority of collar-keyed magnets.

The VAX file shown in Table 1 has been copied to the project area subdirectory TS_SSSC_PRJ$HROOT:[HARMONICS.MOLE.DCA311]. Here it has been renamed COLLAR.DAT. The file COLLAR.DAT contains the 52 records of ±10A data.

---

[1]For collared coil DCA310, 0 A data were taken at each position. The motivation for this was a check on mole systematic errors. From DCA311 on, we do not plan to take 0 A data at all positions for collared coil assemblies.

Results:

Harmonics. The program MULTI_PROCESS was run on the file COLLAR.DAT to obtain the skew and normal harmonics shown in Table 2.

For each harmonic, the average and R.M.S. over ±7 m from magnet center are given in Table 2. The average value over the entire lattice of any harmonic must be less than the SSC Systematic value given in the table, and no magnet may fall further than three times the SSC Sigma value from the average value.

Pole	Average Value	R.M.S.	SSC Systematic	SSC Sigma
b2	-2.76 (cold ~ 2.14)	0.11	<0.80	1.15
b4	0.45 (cold ~0.21)	0.03	<0.08	0.22
b6	-0.06	0.01	<0.013	0.018
b8	0.06	0.01	<0.01	0.0075
b10	0.02	0.00		
b1	-0.06	0.25	<0.04	0.50
b3	-0.00	0.04	<0.026	0.16
b5	-0.00	0.02	<0.005	0.017
b7	0.00	0.00	<0.005	0.01
b9	0.00	0.01		
b11	0.00	0.00		
a1	0.64	0.26	<0.04	1.25
a2	0.27	0.26	<0.32	0.35
a3	-0.07	0.09	<0.26	0.32
a4	0.04	0.03	<0.01	0.05
a5	-.01	0.02	<0.005	0.05
a6	0.00	0.01	<0.005	0.008
a7	0.00	0.00	<0.005	0.01
a8	0.01	0 00	<0.005	0.0075
a9	0.00	0.01		
a10	0.00	0.00		
a11	0.00	0.00		

Table 2. Average and R.M.S. Harmonics for DCA311 Compared with SSC Systematic and R.M.S. Multipoles (prime units at 1cm)

Strictly speaking, only the harmonic b8 (normal 18-pole) lies outside the tolerance band. (This is the built-in harmonic which is used to infer the radial position of the mole at each longitudinal position in the magnet by its "feed-down" to the unallowed 16-pole, b7.) However, ike DCA310 [1] this magnet has large b2 and b4. Our studies of 50 mm model magnets can give some information about the change in b2 and b4 with yoking and cooldown, as shown in Figure 1. The expected changes in b2 and b4 on yoking and cooldown are 4.9 units and -.24 units respectively, and the expected cold values of b2 and b4 are shown in Table 2.

Figures 2a and 2b show the average and R.M.S. values of the skew (an) and normal (bn) harmonics over ±7 meters from magnet center.

Figures 3a, 3b, and 3c show the normal sextupole, normal decapole, and skew quadrupole as a function of mole center position (the mole has ~24" active length) with respect to magnet center.

Figures 4a and 4b show the mole position offset from aperture center in mils calculated using the feed-down from the normal 18-pole to the normal 16-pole. (That is, it is assumed that any 16-pole that is present is from such feed-down, and the multi-poles are corrected accordingly.)

Transfer Function. Table 3 shows the DCA310 collared coil assembly transfer function measured at ±10 A. The first column of the table gives the position relative to magnet center in meters. The transfer function values here were obtained by dividing the dipole field as measured by one of the mole's bucking coils by the average current during the mole measurement. The earth's magnetic field has been eliminated by an appropriate linear combination of +10 A and -10 A measurement. The expected value of the transfer function for the collared coil assembly is 7.95 Gauss per Amp[2].

TABLE 3.

z (meters)	Transfer Function (Gauss/Amp)	Transfer Function Angle (degrees)
7.620	2.044	1.2
7.010	7.937	1.2
6.400	7.914	1.1
5.791	7.913	0.9
5.181	7.915	0.8
4.572	7.912	0.6
3.962	7.913	0.4
3.352	7.913	0.3
2.743	7.913	0.2
2.133	7.910	0.2
1.524	7.910	0.1
0.914	7.912	0.0
0.304	7.911	-0.2
-0.305	7.914	-0.3
-0.305	7.913	-0.3
-0.305	7.912	-0.3
-0.305	7.912	-0.3
-0.305	7.912	-0.3
-0.915	7.914	-0.3
-1.524	7.912	-0.5
-2.134	7.910	-0.7
-2.744	7.911	-0.9
-3.353	7.913	-1.1
-3.963	7.912	-1.2
-4.572	7.912	-1.4
-5.182	7.912	-1.6
-5.792	7.911	-1.6
-6.401	7.915	-1.8
-7.011	7.930	-1.9
-7.620	2.236	-2.7

[2]Ramesh Gupta, private communication.

Mole Precision. Starting with this magnet, five independent measurements of the harmonics[3] were made at a position one foot toward the lead end from magnet center. The purpose of this was to evaluate random errors in the mole-measured harmonics[4]. Table 4 shows the average and rms of each allowed harmonic and the first two skew harmonics for this set of measurements.

Harmonic	Mean and RMS units @ 1 cm
b2	-2.84±.05
b4	0.45±.03
b6	− 0.066±.006
b8	0.064±.004
a1	0.85±.17
a2	0.12±.06

Table 4. Allowed and First two Skew Harmonics near Magnet Center (Mean and RMS values)

It is seen that b2 is known to less than 2% precision, while a1 and a2 are only measured to 20% and 50% precision.

For additional information on these measurements, please contact Steve Delchamps at (708) 840-2416 or send E-mail to FNAL::DELCHTS.

[3]Each measurement is already an average over three spins of the mole.

[4]We know very little about systematic errors in the mole measurement due for example to construction errors. BNL sources claim such errors are "small."

References

1. S. Delchamps, "Mole Measurement of DCA310 Collar-Keyed Assembly", TS-SSC 91-132, June 28, 1991.

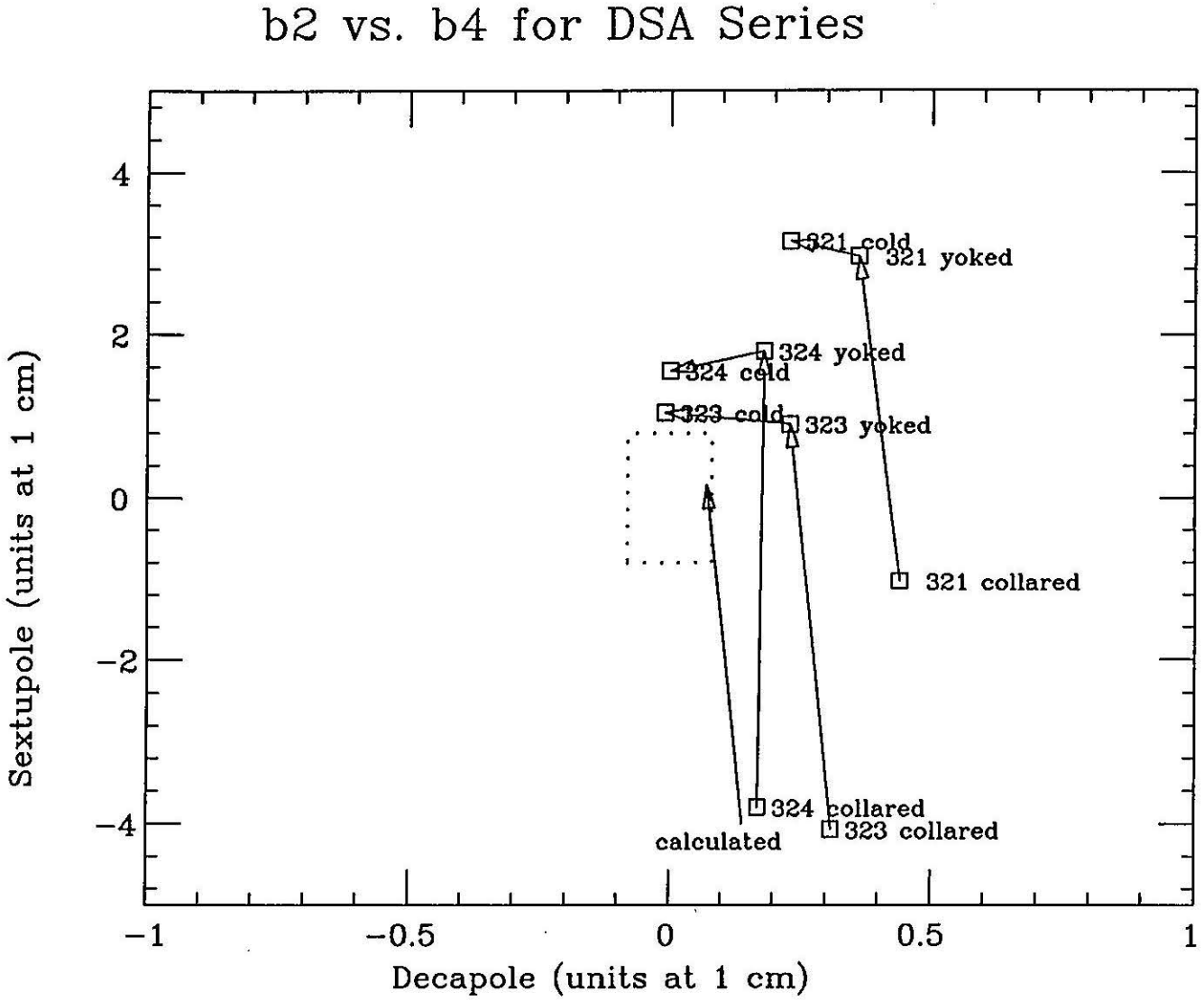
b2 vs. b4 for DSA Series
Sextupole (units at 1 cm)
Decapole (units at 1 cm)
4
2
0
−2
−4
−1
−0.5
0
0.5
1
321 cold
321 yoked
324 yoked
324 cold
323 cold
323 yoked
321 collared
324 collared
323 collared
calculated

FIGURE 1

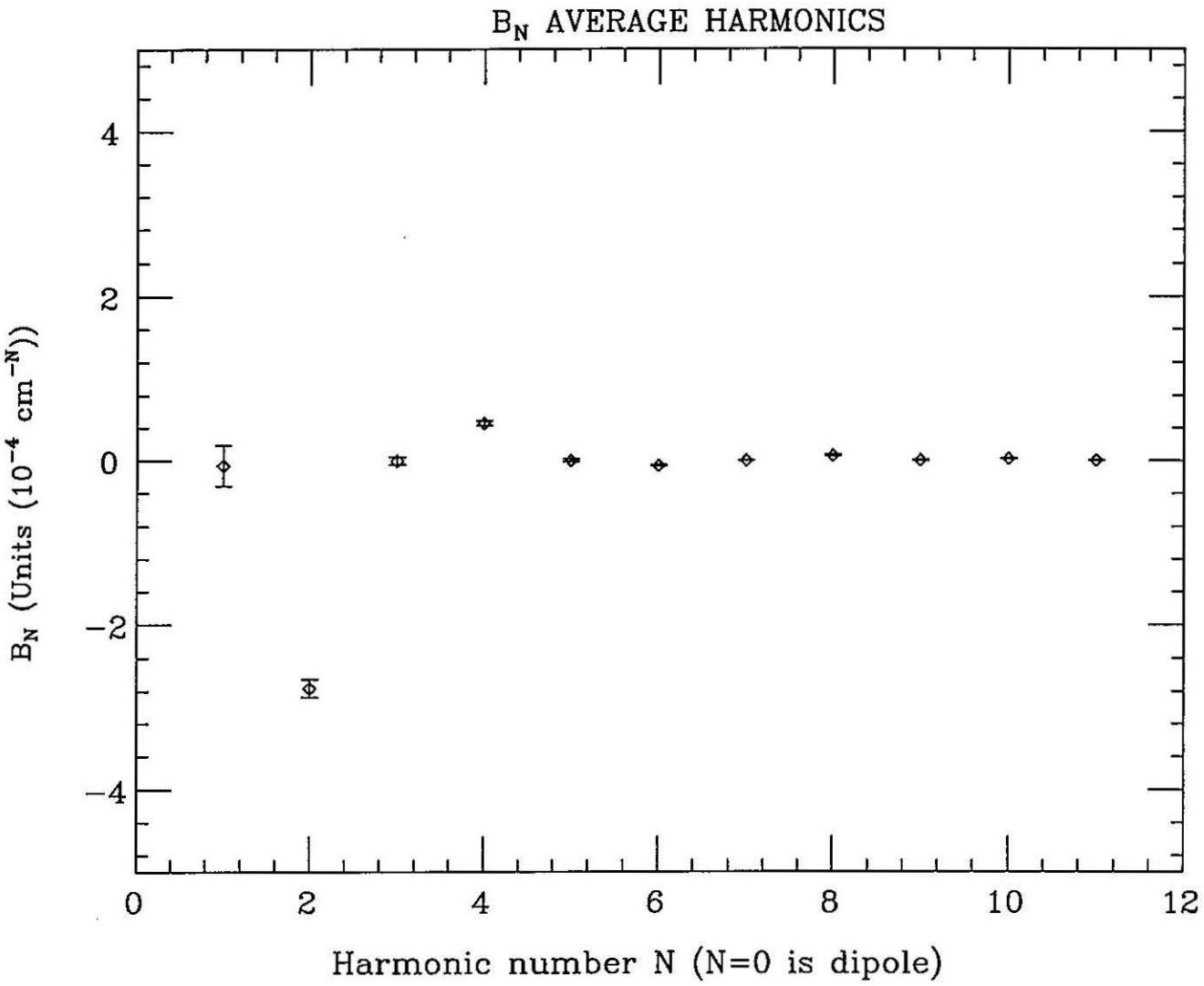

FIGURE 2a.

◇ DCA311 2 30 Jul 1991 warm data 10. Amps DCA311 Collared coil assembly

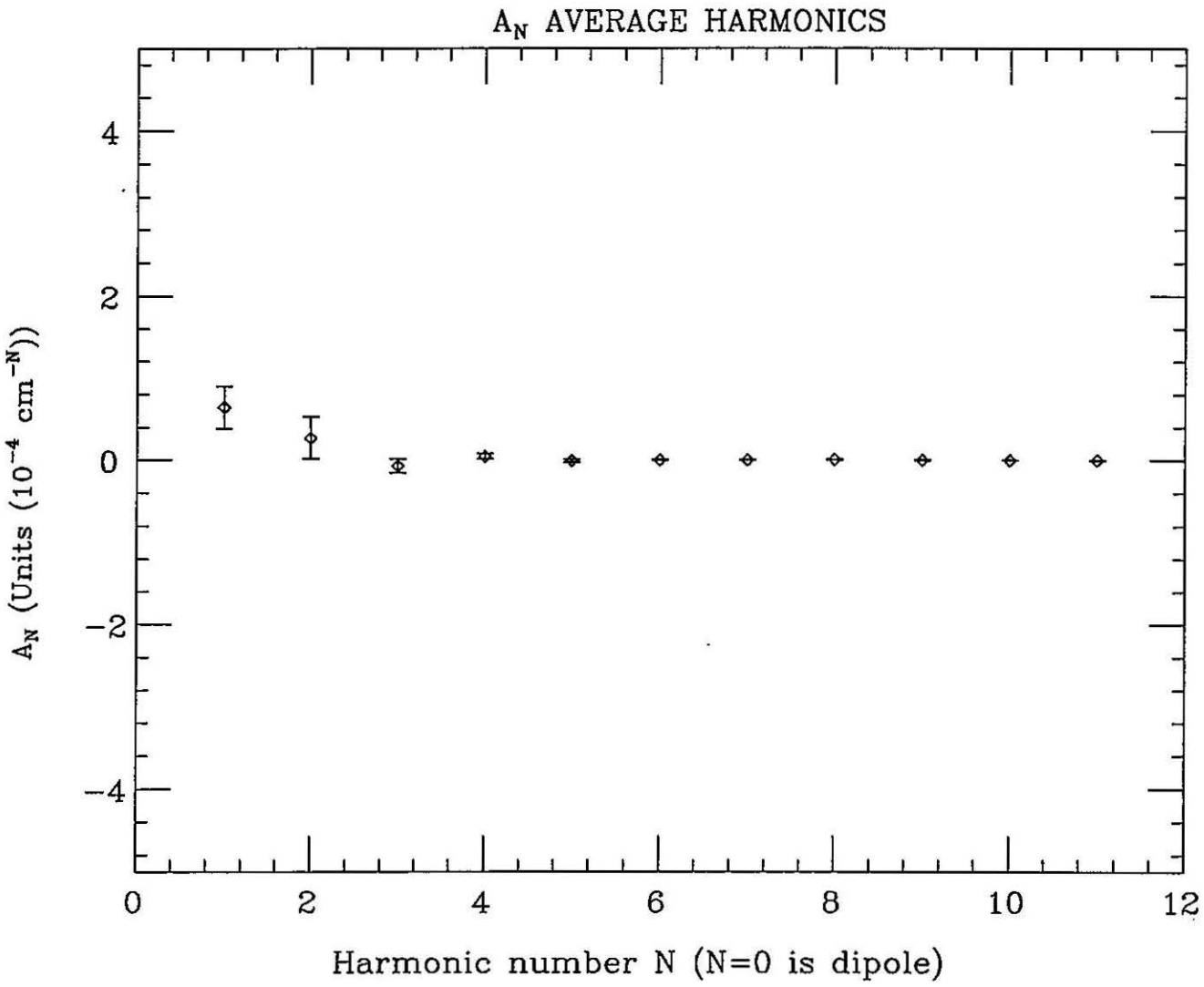

FIGURE 26.

◇ DCA311 2 30 Jul 1991 warm data 10. Amps DCA311 Collared coil assembly

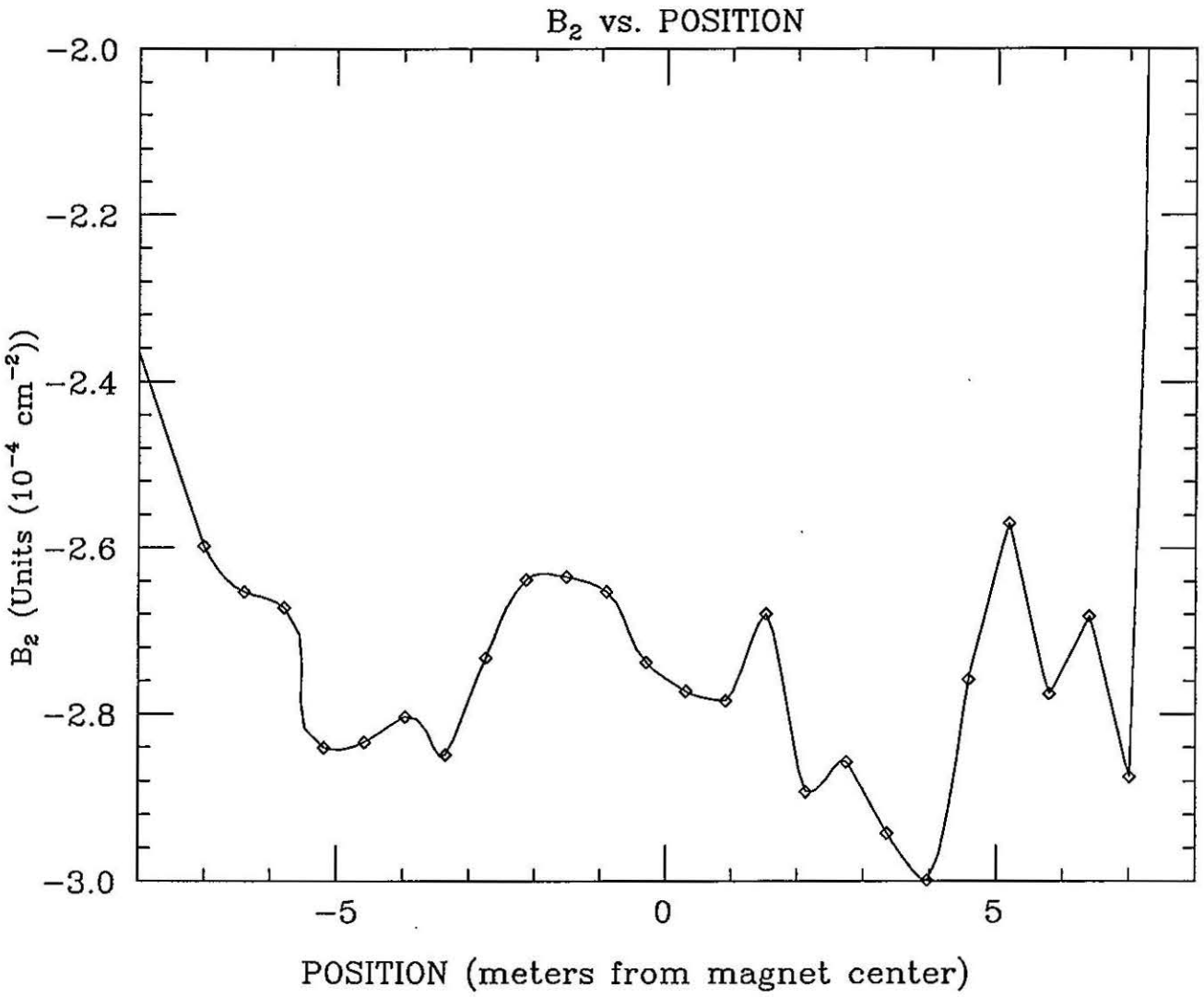

FIGURE 3a.

◇ DCA311 2 30 Jul 1991 warm data 10. Amps DCA311 Collared coil assembly

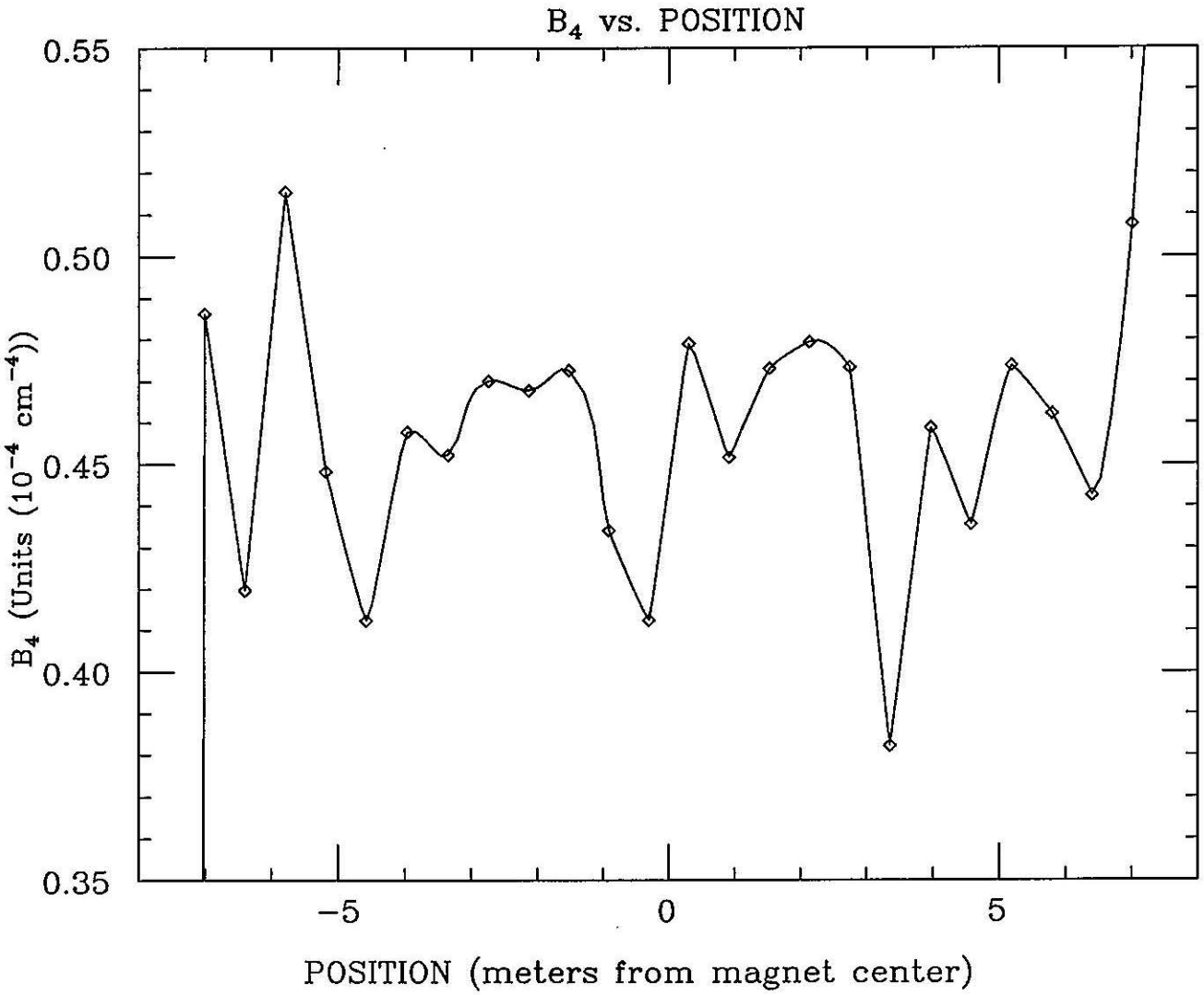

FIGURE 36

◇ DCA311 2 30 Jul 1991 warm data 10. Amps DCA311 Collared coil assembly

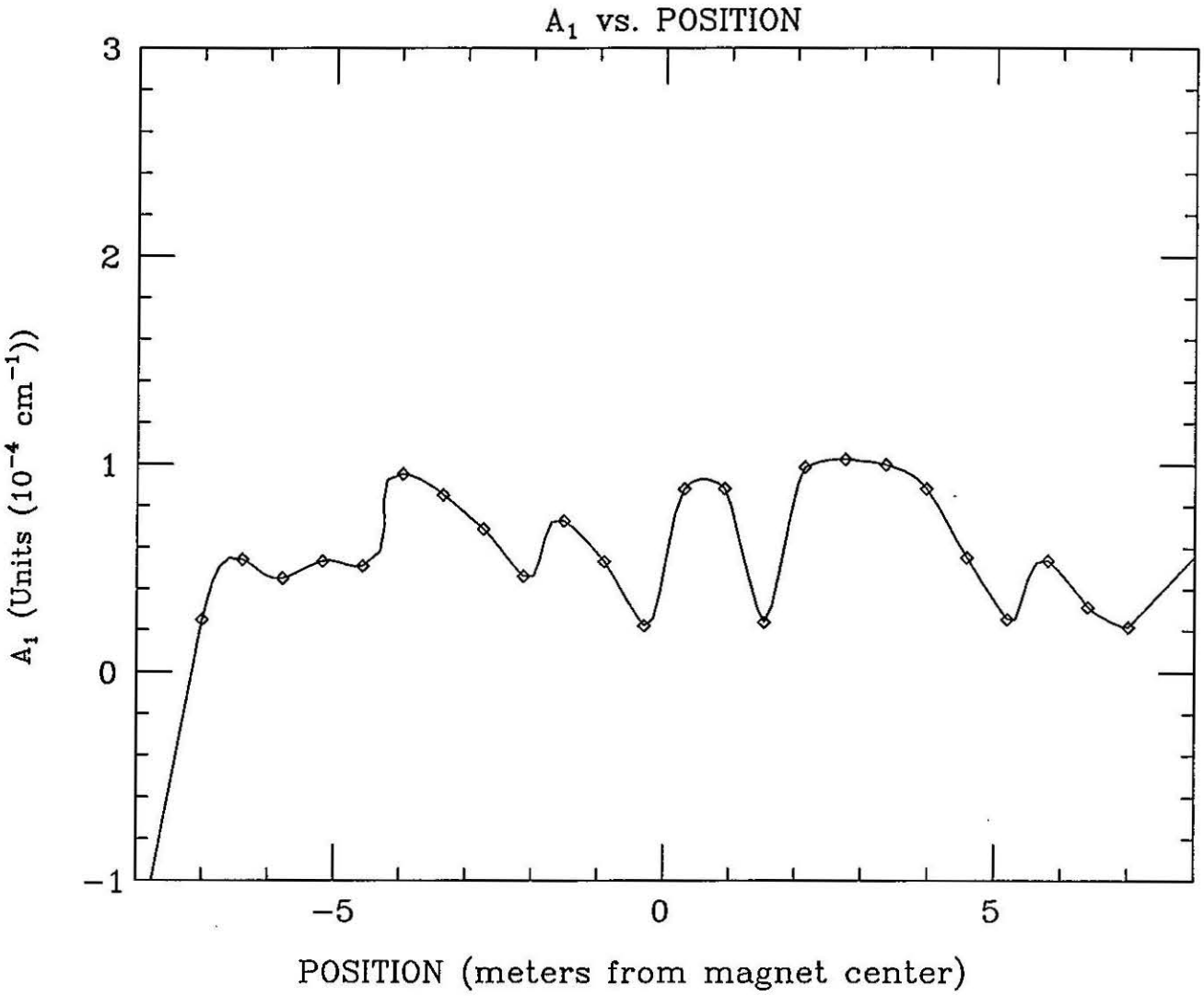

FIGURE 3c.

◇ DCA311 2 30 Jul 1991 warm data 10. Amps DCA311 Collared coil assembly

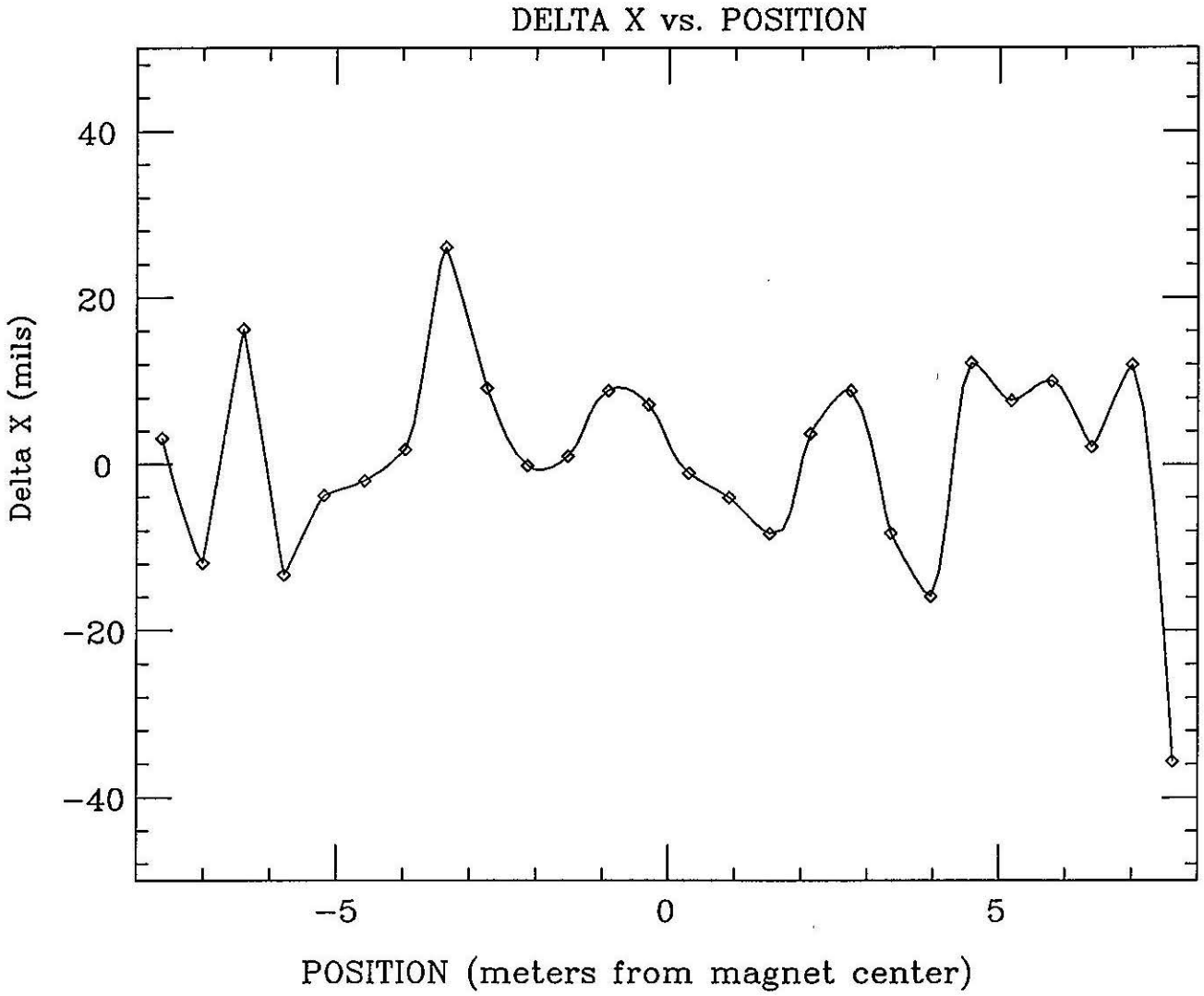

FIGURE 4a.

◇ DCA311 2 30 Jul 1991 warm data 10. Amps DCA311 Collared coil assembly

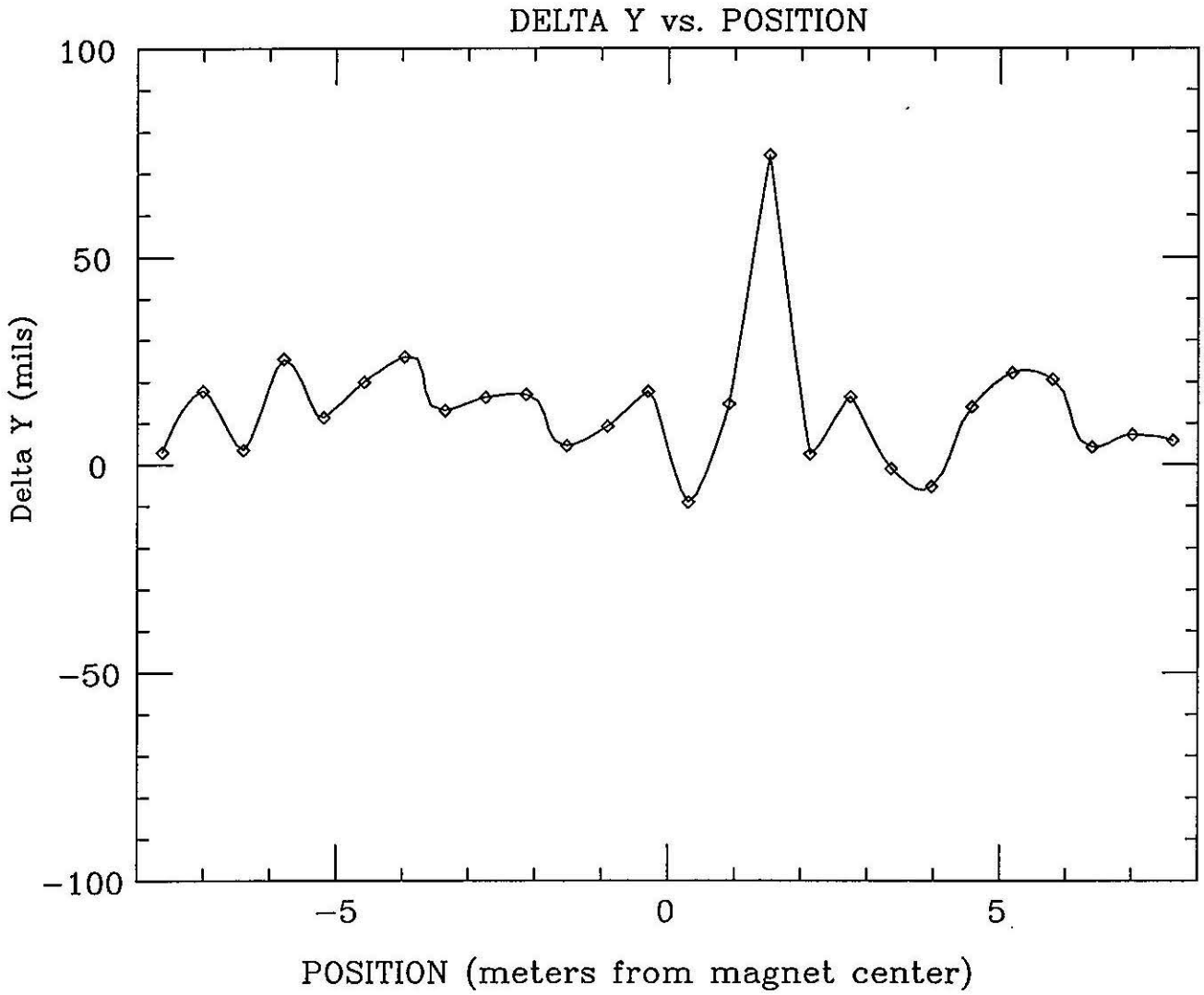

FIGURE 46.

◇ DCA311 2 30 Jul 1991 warm data 10. Amps DCA311 Collared coil assembly