Collared Coil Harmonics for DCA321

TS-SSC 92-047
S. Delchamps
April 3, 1992

The collared coil harmonics for DCA321, the first magnet to be successfully keyed with the all-kapton insulation scheme at FNAL, were measured on April 2, 1992. This memo presents preliminary results. The measured harmonics are compared with those of model magnet DSA330 [1], which has the same insulation scheme as DCA321, and with the average values over DCA311 - DCA319, which had glass tape plus kapton insulation.

Note that the odd bn and even an values for DCA311 - 319 have had their signs reversed to compensate for the sign convention used in Reference [2].

Table 1 gives the harmonics averaged over the straight section of the collared coil. The first column gives the averaged harmonics. The second column gives the r.m.s. of each harmonic about its average value. The third column is the standard deviation of five measurements taken at a single position, divided by the square root of 24, the number of straight section positions measured. This value is an estimate of the uncertainty in the average harmonic. For this purpose, the standard deviation is defined as

$$\mathrm{SQRT}\left(\left[\langle x^2 \rangle - n \langle x \rangle \right] / \left[n - 1 \right] \right)$$

All harmonics are given in prime units at 1 cm. The harmonics were adjusted for mis-centering of the mole in the aperture using an iterative technique involving the 18-pole feed-down to the 16 pole (thus the absence of 16-pole harmonics in the table, since these are forced to zero by the technique), and including effects of the 20-pole as well.

DISCUSSION:

I. Allowed Harmonics

For DCA321, b2 is nearly 2 units more positive than for DSA330. (DSA330 and DCA321 had 5 mils of pole shim on the outer coils, and no shim on the inner coils.) Both magnets have b2 considerably more positive than the DCA311-319 series, so that we can expect ~ +5 units of b2 when DCA321 is cold-tested. Figure 1 shows b2 for DCA321. Over one half of the magnet, b2 is predominantly negative, and has smaller variations than over the other half, where it is predominantly positive. (The uncertainty in each measurement of b2 is about 0.04 units, or a little less than one half of a tick mark. Figure 2 shows b2 fro DSA330.

DCA321 has b4 similar to DSA330. Both magnets have b4 about 0.4 units more positive than the DCA311-319 series, whose b4 has never been adequately modeled.

As in the case of DSA330, the b6 is now slightly positive, as opposed to the value of -.06 value for the DCA311 - 319 series. The harmonics b8 and b10 are also similar for DCA321 and DSA330. The

eighteen pole b8 is larger for the new insulation scheme magnets than for the DCA311 - 319 series.

Akbar Mokhtarani has provided model calculations of the harmonics for the DCA311 - 319 series and DCA320 - 321 collared coils. The shifts in b2, b4, b6, and b8 from the earlier to the latter series are shown in Table 2, along with the measured shifts, calculated by subtracting the average values from DCA311 - 319 from the DCA320 values. The measured shifts are in good agreement with prediction.

II. Unallowed Normal Harmonics

Nothing looks very large here. There doesn't seem to be any correlation between the DSA330 and DCA321 values, so that we will have to wait for DCA320 to see whether anything systematic comes up.

III. Skew Harmonics

DSA330 had a fairly large a1, and DCA321 has a1 of nearly -1 unit, but with large variations over length. DCA321 shows the usual skew eighteen pole, a8, known to be an instrumental effect. (The measured a8 does not change sign when the mole is inserted from the opposite end of the magnet.)

REFERENCES

1. S. Delchamps, "Collared Coil Harmonics for DSA330", TS-SSC 92-037, March 13, 1992. (The harmonics for this magnet given in the table were taken with the mole probe centered 12" toward the return end from magnet center.)

2. S. Delchamps, "Magnetic Field Measurements of Fermilab/ General Dynamics Built Full Scale SSC Collider Dipole Magnets", IISSC 1992 Paper.

Distribution:
J. Dimarco
M. Lamm
G. Pewitt
J. Strait
M. Wake

Table 1. Collared Coil Harmonics of DCA321
Compared with DSA330 and DCA311-319

Harmonic	DCA321 Average Value	RMS About Average	Calculated Uncertainty in Average	DSA330 (-12" from center)	DCA311-319 (average)
b2	-0.007	0.199	0.009	-1.986	-3.11
b4	0.722	0.039	0.008	0.865	0.42
b6	0.024	0.013	0.004	0.040	-0.06
b8	0.098	0.006	0.002	0.092	0.06
b10	0.023	0.003	<0.001	0.022	0.02
b1	-0.137	0.441	0.064	0.204	0.09
b3	0.012	0.081	0.010	-0.015	-0.01
b5	<0.001	0.020	0.002	-0.040	<0.01
b9	-0.001	0.005	0.001	0.001	<0.01
a1	-0.972	0.779	0.027	1.694	0.06
a2	-0.068	0.231	0.013	0.655	0.17
a3	-0.004	0.084	0.011	-0.050	0.01
a4	0.049	0.047	0.005	-0.006	0.05
a5	-0.011	0.015	0.003	0.010	<0.01
a6	<0.001	0.009	0.002	-0.004	<0.01
a8	0.011	0.006	0.002	0.019	0.01
a9	-0.001	0.005	0.001	-0.004	<0.01
a10	0.004	0.003	0.001	0.003	<0.01

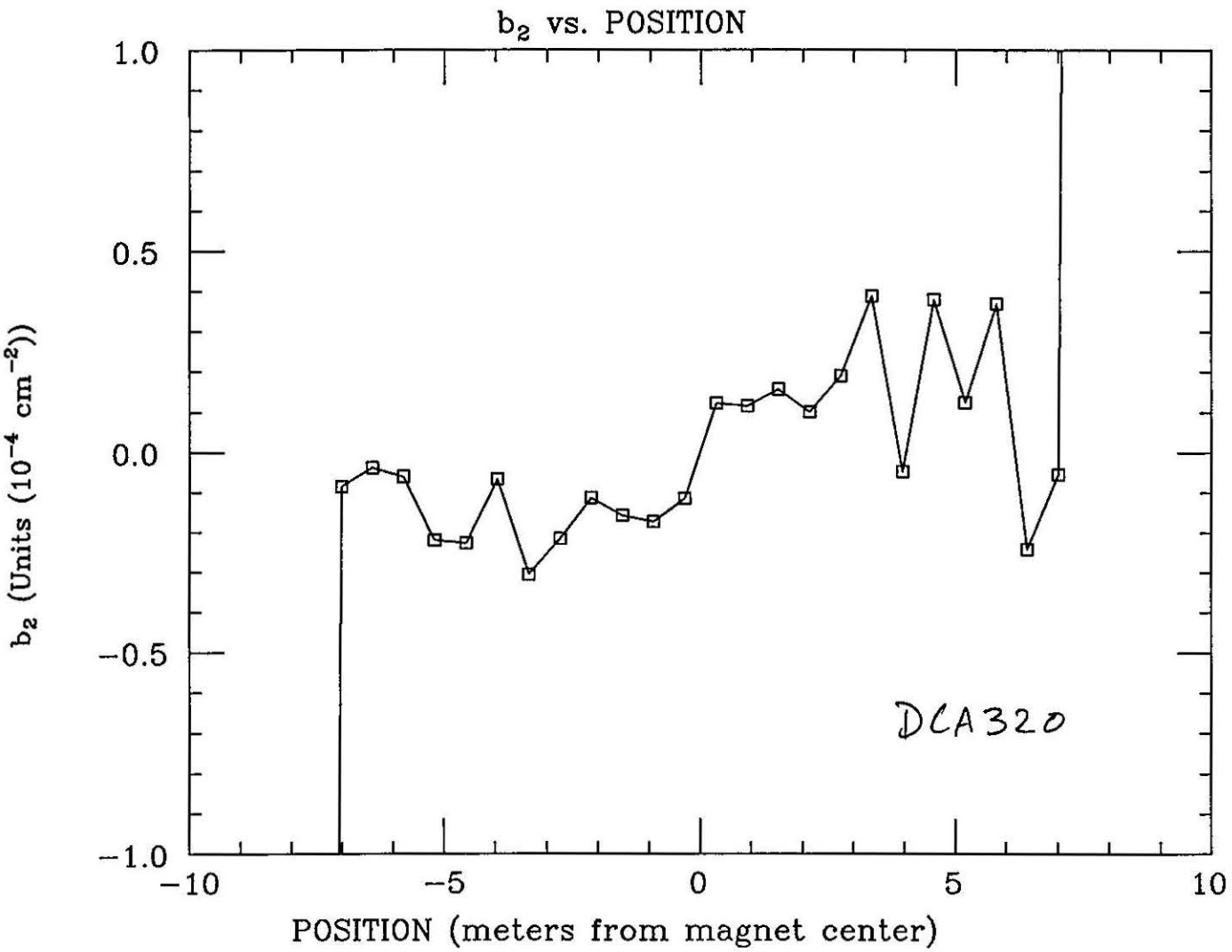
Table 2. Measured and Predicted Harmonic Shifts
Between DCA311-319 and DCA320-321

Harmonic	Predicted Shift	Measured Shift
b2	+ 2.527	+ 3.10
b4	+ 0.484	+ 0.30
b6	+ 0.084	+ 0.08
b8	+ 0.037	+ 0.04

FIGURE 1

DCA321 Collared coil

3-APR-92 10:53:19



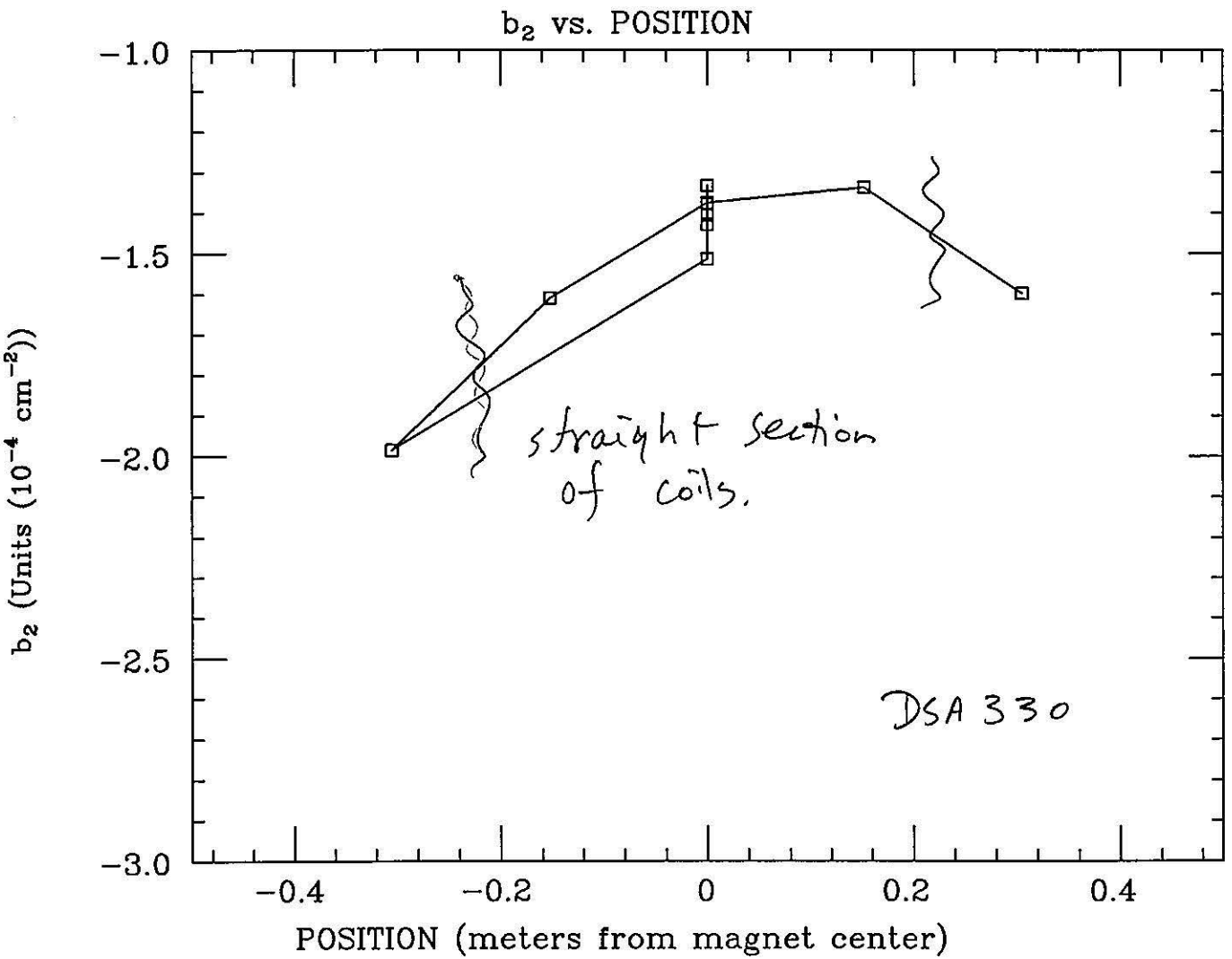
□ DCA321 1 2 Apr 1992 warm data 10. A

DCA321 Collared coil assembly

FIGURE 2

DSA330 Collared Coil Harmonics

9-MAR-92 15:36:28



□ DSA330 1 3 Mar 1992 warm data 10. Amps DSA330 Collared Coil w centering