Mole Centering Correction for
50 mm Aperture SSC Dipoles

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The program currently used on the vax to analyze warm mole data taken with the Brookhaven ~~22"~~ 24" B2 mole is called MULTI_PROCESS.FOR. It makes use of a parameter file called PROCESS_TABLE.DAT, which specifies various options for how the raw mole data are handled. Among other things, the user chooses how the mole centering correction (offset in x and y from the "natural" origin of the magnetic field) is to be made.

The centering correction is made using "feed-down" from either the 22-pole or the 18-pole. The design 16-pole and 20-pole harmonics for the SSC dipole are very small. (These are both non-allowed harmonics of the dipole fundamental.) Therefore, whatever 16-pole is present in the raw mole data is mainly due to "feed-down" from the 18-pole, measured slightly off axis. Similarly, whatever 20-pole is present is mainly due to feed-down from the 22-pole.

For the 40 mm aperture SSC dipole design (Fermilab DS0 and DC0 series), processing done so far has used feed-down from the 22-pole to calculate the position offset. The corrected higher (16-pole and up) normal and skew coefficients in units at 1 cm for yoked DS0 magnets moled so far are shown in Table 1. The numbers shown are from warm mole data taken following cold testing in Lab 2. In all cases, the measured 22-pole is five to ten times larger than the measured 18-pole, so that a centering correction based on the 22-pole is justified for this type of coil cross section.

Table 1. Higher Multi-poles for 40 mm Aperture
1.5 meter SSC Dipoles (DS0300 series)*

Magnet	b7 (16-pole)	b8 (18-pole)	b9 (20-pole)	b10 (22-pole)
DS0308	.0142	-.0229	.0000	.1234
DS0309	-.0009	.0243	-.0013	.0950
DS0310	.0015	.0117	-.0024	.0943
DS0311	.0001	-.0074	.0000	.0945
DS0313	.0035	-.0036	.0060	.0949

*** (Harmonics averaged over the longitudinal range -.25 m to .25 m with magnetic center at 0 m.)**

Table 2 shows the higher harmonics for two 17-meter collared coil assemblies with the same coil cross section as the DS0 series, DC0302 and DC0303. Again, the measured 22-pole is always much greater than the measured 18-pole, so that it is most natural to use the 22-pole feed-down for a centering correction.

Table 2. Higher Multi-poles for 40 mm Aperture 17 meter SSC Collared Coils (DC0300 series)*

Magnet	b7 (16-pole)	b8 (18-pole)	b9 (20-pole)	b10 (22-pole)
DC0302	.0006	.0223	-.0001	.1240
DC0303	-.0042	-.0140	-.0001	.1264

*** (Harmonics averaged over the longitudinal range -5.0 m to 5.0 m, with magnetic center at 0 m.)**

In the case of the 50 mm aperture SSC dipole coil cross section (DSA and DCA series), the design 18-pole is about three times as large as the 22-pole. We therefore expect that the most natural centering correction should be made using the 18-pole to 16-pole feed-down instead of the 22-pole to 20-pole. The calculated values of the higher harmonics for the 50 mm aperture SSC dipole cross section are given in the first row of Table 3.

The only experimental data we have so far on higher order harmonics for the 50 mm cross section comes from a warm mole measurement of the collared coil DSA320[1]. The DSA320 data are shown in the second and third rows of Table 3 for comparison with the calculated values.

The 22-pole and 18-pole have been used to make a centering correction in two separate runs over the raw data. In both cases, the 18-pole is three to five times larger than the 22-pole, so that it would seem most natural to use the 18-pole feed-down for a centering correction in future mole measurements of 50 mm aperture SSC dipole. Furthermore, the 16-pole and 20- pole should be nearly zero. This is true if the 18-pole is used for the centering correction. If the 22-pole is used, these harmonics are ten times bigger than if the 18-pole is used.

Table 3. Higher Multi-poles for 50 mm Aperture SSC Dipole Magnets (Calculated Compared with DSA320 Collared Coil Mole Measurement)*

	b7 (16-pole)	b8 (18-pole)	b9 (20-pole)	b10 (22-pole)
Calculated	---------	.047	---------	.015
DSA320 (using 18-pole feed-down)	.0005	.0646	-.0001	.0193
DSA320 (using 22-pole feed-down)	.0047	.0673	.0010	.0151

*** (Experimental values are averaged over the range -0.5 m to 0.5 m, with magnetic center at 0 m.)**

[1]DSA321, currently under test at Lab 2, was never warm moled as a collared coil or as a yoked magnet. (It will be moled following once the Lab 2 tests are completed.)

Table 4 shows how much the harmonics below the 16-pole change depending upon which harmonic is used to make the centering correction. Except for the 12-pole, none of the multi-poles changes by more than 5.3% when the choice of feed-down correction is made.

Table4. Multi-poles for DSA320 Collared Coil
(Calculated with Alternative Centering Corrections)

	b1	b2	b3	b4	b5	b6
DSA320 (using 18-pole feed-down)	.1918	-2.363	-.1072	.5680	-.0127	-.0891
DSA320 (using 22-pole feed-down)	.2019	-2.328	-.1047	.5706	-.0075	-.0878
% difference	5.3	1.5	2.4	4.6	69	1.5

Figures 1a and 1b show the x and y corrections in mils for DSA320 for the five longitudinal positions measured, using the 22-pole and 18-pole. The correction appears to be quite sensitive to how the centering correction is calculated. Figure 2 shows the radial correction in mils of the mole position.

We conclude that for the time being, it is best to use the ~~22~~ 18 -pole feed-down to locate the mole position relative to the natural coil coordinate system center for 50 mm aperture magnets built at Fermilab. For 40 mm aperture magnet s, the 22-pole feed-down should be used as it has in the past.

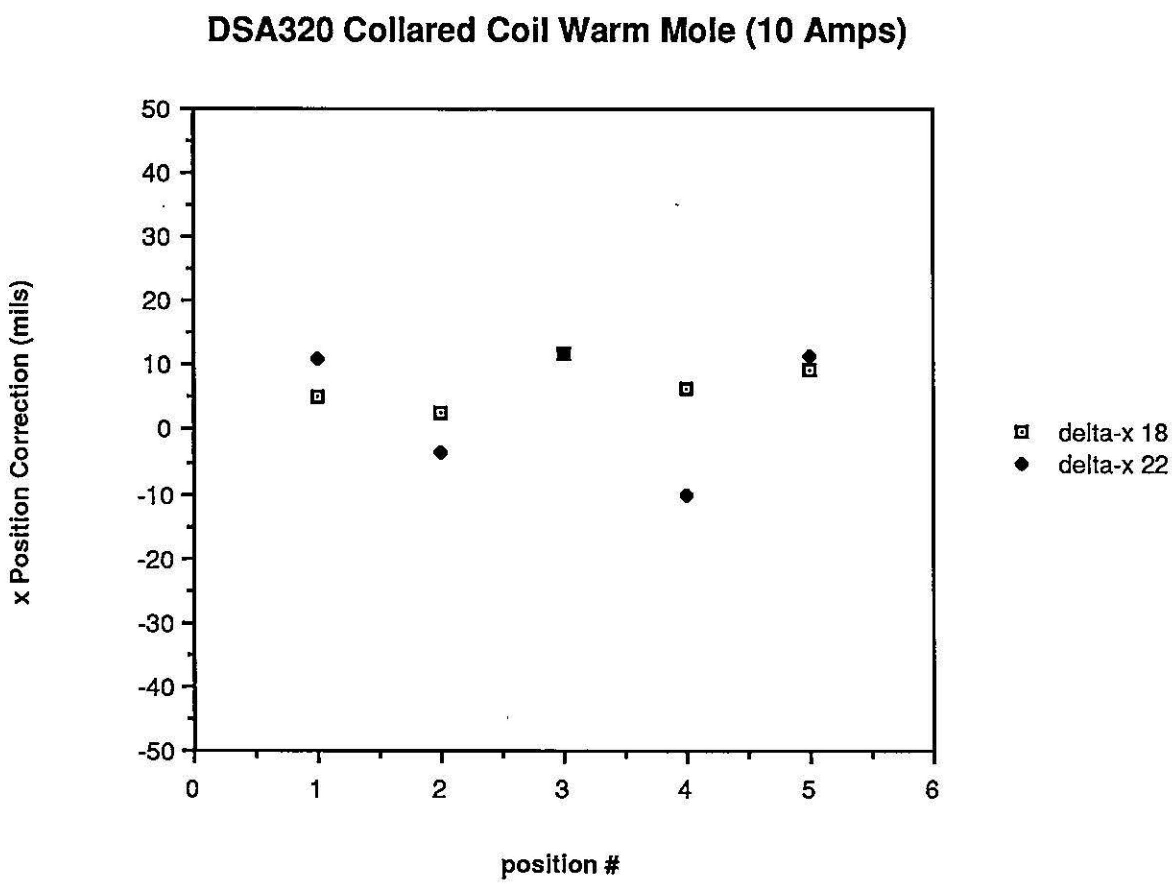
DSA320 Collared Coil Warm Mole (10 Amps)
x Position Correction (mils)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
position #
delta-x 18
delta-x 22

Figure 1a.

DSA320 Collared Coil Warm Mole (10 Amps)

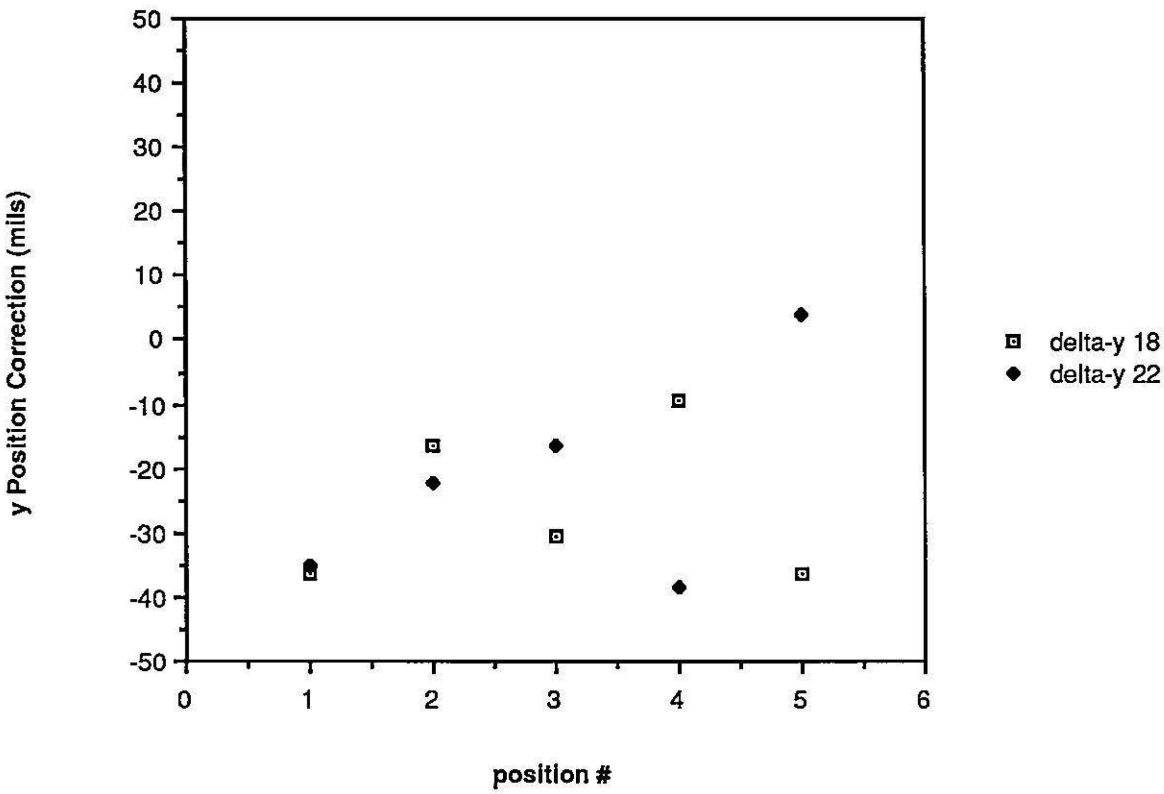

Figure 1b

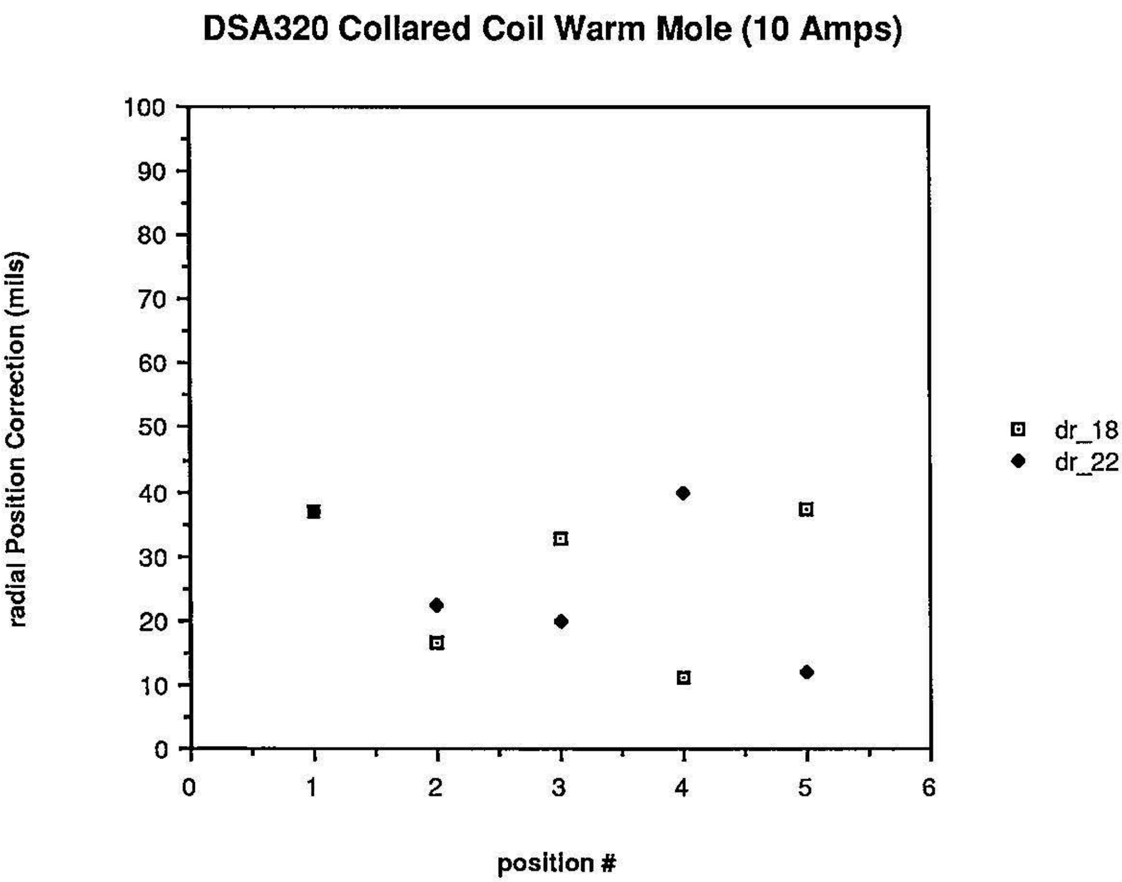
DSA320 Collared Coil Warm Mole (10 Amps)
radial Position Correction (mils)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
position #
dr_18
dr_22

Figure 1c.

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