DSA324 Transfer Function
Spatial Distortion I

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The Effect: The transfer functions for magnets DSA321 and DSA323, the first two model 50 mm aperture SSC dipole magnets tested at Fermilab, are shown in Figures 1a and 1b. The horizontal axis gives the position of the center of the "Morgan" coil Probe 11 in inches. This probe is nominally 18" long. The Lab 2 magnetometer was used to read out the probe in both cases. The outermost two points in each graph have part of the active area of Probe 11 out of the yoked portion of the magnet. Both transfer functions are measured near 5 kA transport current, at 4.2 K. A slight "bowing" downward toward the ends is apparent in both DSA321 and DSA323.

Figure 2a shows the DSA324 transfer function measured with the dipole bucking coils of BNL B2 mole, a tangential probe with nominal 24" active length. These data were taken at room temperature with 10 A transport current. (Because of the mole probe's length, only the points out to ±10 inches on each side have the entire active length of the probe in the yoked portion of the magnet. The horizontal axis is kept to the same scale as Figures 1a, 1b, and 2b to facilitate comparison.)

Figure 2b shows the transfer function for DSA324 measured with Probe 11 read out by the magnetometer. Figure 2c shows the result when the HAL2 system is used to read out Probe 11. Both tests are done at 4.2 K near 5 kA transport current. In both cases a clear distortion is visible relative to the pattern of DSA321 and DSA323.

Figure 2d shows the result for the Rawson-Lush probe, nominally 1/4" in length. These data were taken near 5 kA at 4.2 K[1]. A distortion of the transfer function is seen at the return end of the magnet. The distortion seems to be concentrated in the region of the return end monolithic yoke pack. The transfer function drops off rapidly outside the yoke at the lead end, but for some reason remains at a high value toward the return end.

[1]The horizontal axis values have been rescaled to make the rapid fall-off of transfer function at the lead end coincide with the nominal end of the yoke packs. A more accurate transformation of the LVDT data used must be made to be rigorous, and the absense of a rapid fall at the return end must be explained.

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Discussion: The main purpose of this first memo is to circulate plots showing the effect seen in the data, so I will keep the theorizing to a minimum.

The appearance of a distortion only in 4.2 K data suggests an effect of the iron yoke. Could the yoke pack near the return end be saturating at a lower field than the rest of the yoke? Since the iron contributes about 30% of the field at this current, the effect would be 1% / 30% ~ 3%. In other words, something has to be amiss with the yoke at the few percent level to account for the distortion. The change in transfer function across the return end monolithic pack indicates that the pack's properties change over its length.

Another possibility is the new 50 mm warm bore. Magnet DSA324 was the first magnet to be tested with this warm bore. If the bore tube were simply tilted relative to the magnet axis at an angle theta, the measured transfer function would be cos(theta) times its true value. To get 99% of the true value would require a tilt angle of 8 degrees, which would mean the bore tube was about 6 inches out of alignment from one end of the yoked portion to the other, which is much greater than the inaccuracy in the real bore tube. Besides, an overall tilt could not alone account for the distortion, since it would give a uniform decrease in transfer function. It may be that the bore tube contains some magnetic material, but it seems that this should lead to an increase in the transfer function.

Finally, since the effect doesn't show up in the warm data, something could have happened to the magnet before or during setup at Lab 2.

Recommendations:

1) Now that magnet DSA324 is warmed up, we will perform ESR measurments at 10 A current to determine whether the spatial distortion of the transfer function remains at room temperature.

2) DSA326 will be tested cold, and if the effect is still there, the new warm bore will be strongly suspect.

3) If the effect does not show up in DSA326 and is also not present in the low current data for DSA324, then something must be happening to DSA324 itself at low temperature.

DSA324 Transfer Function (300 K, ±10 A)

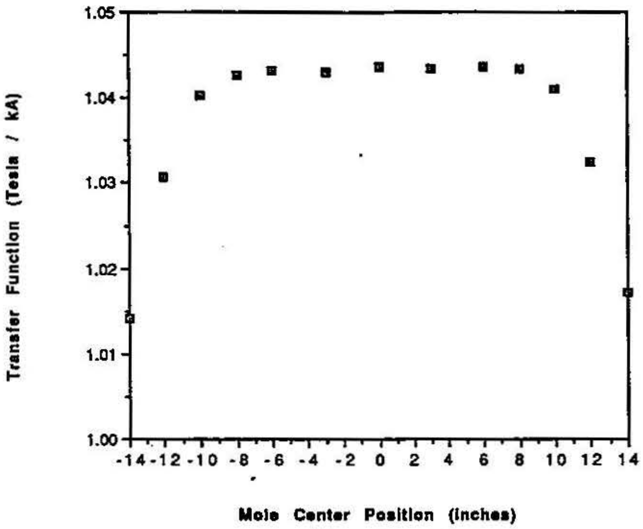

FIGURE 2a.

DSA324 Transfer Function, 4.2 K, 5080 A and 5057 A (from EA002 and EA009)

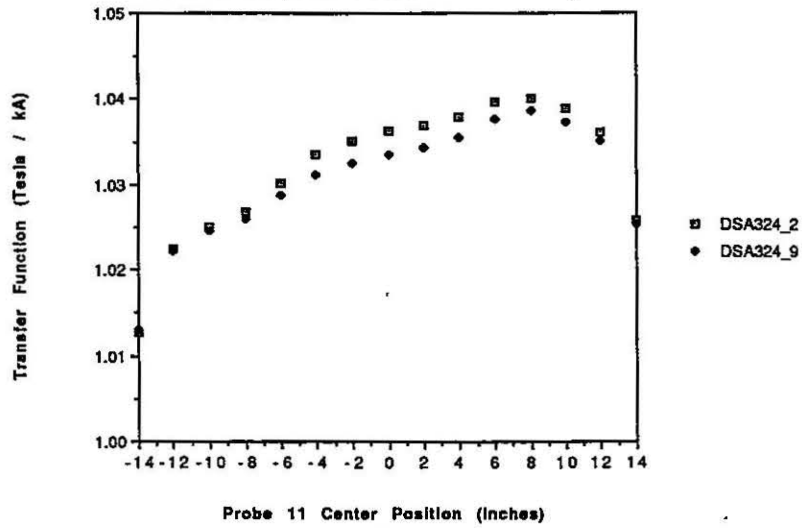

FIGURE 2b.

DSA324 Transfer Function, 4.2 K, 5000 A
Hal 2, Probe 11

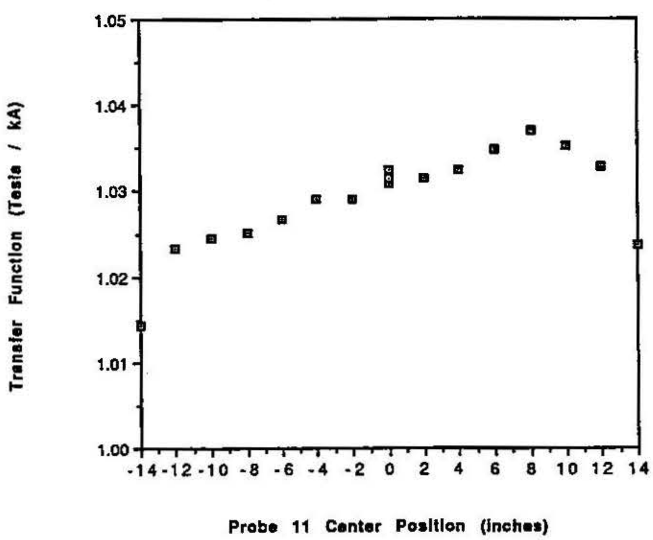

FIGURE 2c.

DSA324 Transfer Function
Rawson - Lush Probe, 5.1 kA, 4.2 K

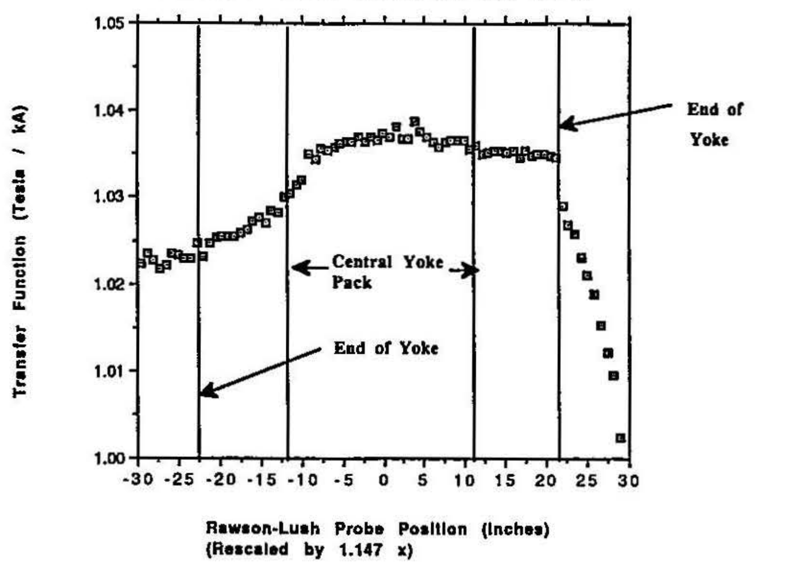

FIGURE 2d

DSA321 Transfer Function, 4.2K, 5000 A
(From [.EA001])

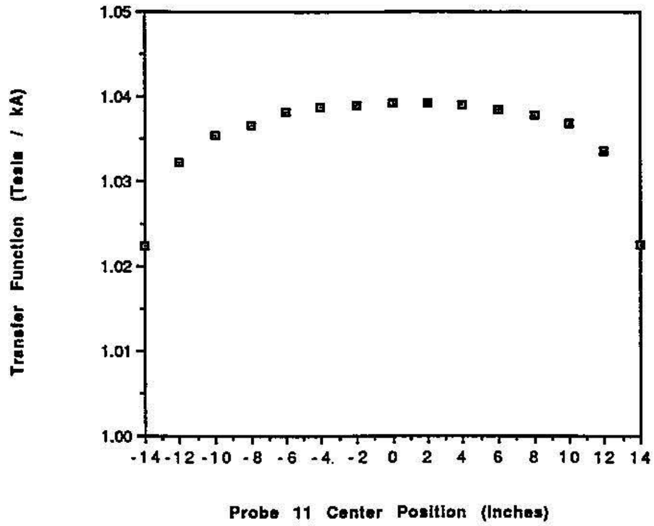

FIGURE 1a.

DSA323 Transfer Function, 4.2 K, 5040 A
(From [.EA012])

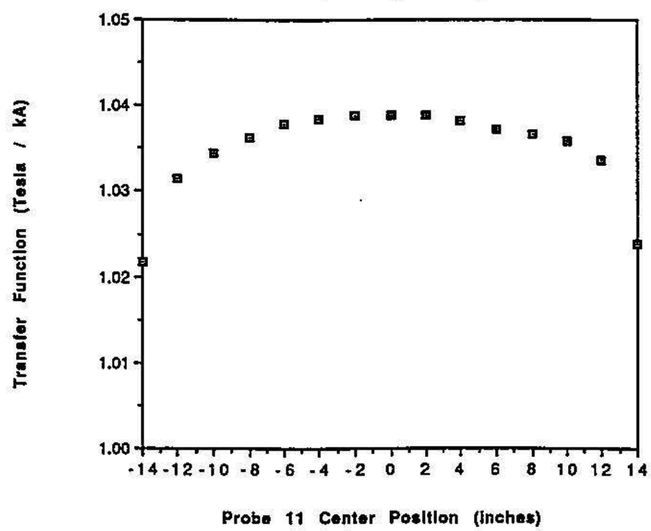

FIGURE 1b.