

### Error Estimate on AC Loss Measurement Parameters

In several notes Joe Ozelis has presented AC loss measurements on several short[1,2] and long[3,4] dipoles. He has fit the data to a linear function in ramp rate for each magnet, with the zero intercept  $E_0$  giving the hysteresis loss and the slope  $dE/dI$  giving the eddy current loss. He has not, however, quoted any error bars on the results. There is a large difference between the apparent hysteresis losses (as well as eddy current slopes) between the two long magnets measured so far, DCA311 and DCA312. It is useful to know the statistical errors on the two measurements to be able to evaluate the significance of this difference.

The linear least squares fitting routine in Microsoft Excel returns the standard estimate of error for each of the fit coefficients. I have used Excel to refit the data and find the errors. The data are reproduced in Table I for DSA324, DCA311 and DCA312. For the long magnets the "corrected" data from [4] are used, and for the short magnet uncorrected data from [3] has been used. (It is believed that no correction is required for the short magnet data. For the long magnets the corrections range from 6-8% at the lowest ramp rates to <1% at the highest ramp rates measured.) Below the data for each magnet are the fit slopes and intercepts and below them the error estimates. Shown also, labeled "sig( $E_{corr}$ )," are the standard error estimates for the energy loss measurements. The latter is the rms deviation of the measured from the fit values, where the summed squared deviation is divided by the number of data points minus 2. Figure 1 plots the data for the three magnets along with the fits. To facilitate the comparison between the short and long magnets, the short magnet data is plotted against the right axis, whose scale differs by a factor of 11.7, roughly the ratio of magnetic lengths, from the left scale. The heavy solid bars along the left axis show the  $\pm 1$  standard deviation bands for the fit values of  $E_0$  for the two long magnets, and the two heavy tic marks show the same for the short magnet.

It is clear that the errors on the long magnet data are considerably larger in proportion to the magnet length than those on the short magnet data. The hysteresis losses measured in DCA312 and DSA324 are compatible, but DCA311 is significantly lower. The difference in  $E_0$  between DCA312 and DCA311 is  $630 \pm 255$  J. The result from DSA324, scaled by 11.7, predicts a long magnet  $E_0$  of  $1265 \pm 55$  J. The difference between this and the DCA311 result is  $730 \pm 140$  Joules. This difference is more than 5 standard deviations and is therefore statistically significant. Of course, examination of Figure 1 makes it clear that the data from DCA311 and DSA324 are significantly different.

## REFERENCES

- [1] J. Ozelis, AC Loss Measurements in Model Magnets at Fermilab, presented at the MSIM, 5/14/91, TS-SSC 91-190.
- [2] J. Ozelis, Status of AC Loss Measurements of 1.5 m SSC Model Dipole Magnets at Fermilab, TS-SSC 91-205, 10/23/91.
- [3] J. Ozelis, Measurements of AC Losses in Long 50 mm SSC Collider Dipole Magnets at Fermilab, TS-SSC 91-249, 12/18/91.
- [4] J. Ozelis, Corrections to AC Loss Measurements in Long SSC Collider Dipoles Due to Observed DC Energy Dissipation, TS-SSC 92-001, 1/3/92.

## Distribution:

### FNAL

S. Delchamps  
J. Dimarco  
R. Hanft  
W. Koska  
J. Kuzminski  
T. Jaffery  
M.J. Lamm  
P.O. Mazur  
D. Orris  
J. Ozelis  
E.G. Pewitt  
M. Wake

### SSCL

R. Coombes  
A. Devred  
V. Kovachev  
G. Snitchler  
J. Tompkins

### LBL

R. Schermer

### BNL

P. Wanderer

Table I

DSA324			DCA311			DCA312		
ldot	Ecorr	Efit	ldot	Ecorr	Efit	ldot	Ecorr	Efit
0		108	0		534	0		1164
30	121	129	30	1418	1019	30	3486	2885
30	130	129	30	1024	1019	30	2958	2885
50	151	144	50	1285	1343	40	3111	3458
50	156	144	50	1213	1343	40	3390	3458
100	164	179	75	1661	1748	50	3895	4032
100	184	179	75	1416	1748	50	3891	4032
150	218	214	100	2160	2152	60	4382	4605
150	208	214	100	2158	2152	60	4527	4605
200	239	250	125	2604	2557	75	5506	5465
200	254	250	150	3054	2962	75	5451	5465
200	245	250	150	3013	2962	90	6584	6325
250	300	285	200		3771	90	6359	6325
250	282	285				200		12633
300	328	321						
300	313	321						
dE/dldot	Eo sig(Ecorr)		dE/dldot	Eo sig(Ecorr)		dE/dldot	Eo sig(Ecorr)	
0.71	108.1	9.1	16.2	534	186	57.3	1164	256
0.03	4.7		1.3	127		3.6	222	

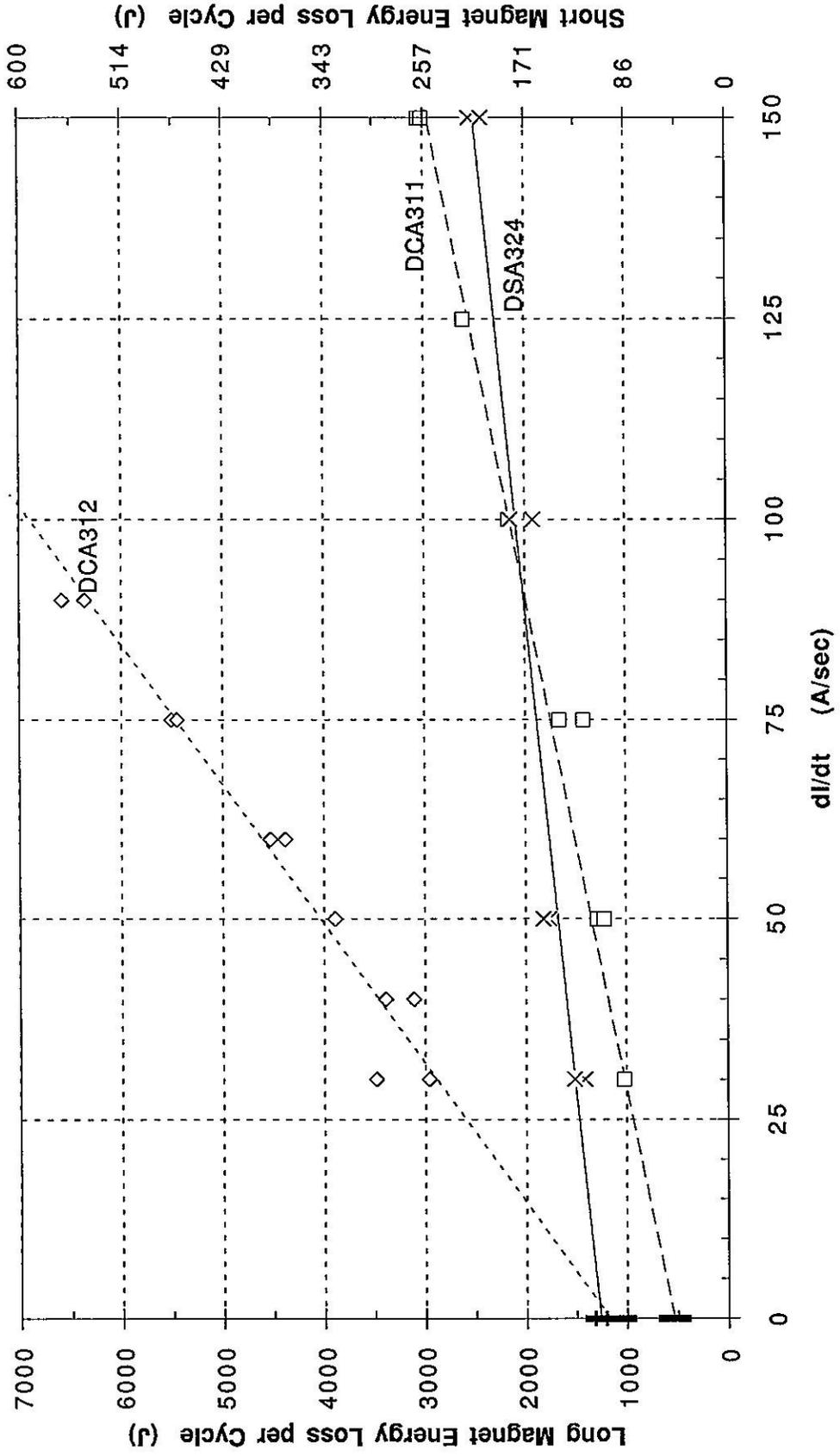


Figure 1