Fermilab

TS-SSC 92-007
1/14/92
J. Strait

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 Eo giving the hysteresis loss and the slope dE/dIdot 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(Ecorr)," 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 lenghts, from the left scale. The heavy solid bars along the left axis show the +/-1 standard deviation bands for the fit values of Eo 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 Eo between DCA312 and DCA311 is 630+/-255 J. The result from DSA324, scaled by 11.7, predicts a long magnet Eo of 1265+/-55 J. The difference between this and the DCA311 result is 730+/-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

Idot	Ecorr	Efit
0		108
30	121	129
30	130	129
50	151	144
50	156	144
100	164	179
100	184	179
150	218	214
150	208	214
200	239	250
200	254	250
200	245	250
250	300	285
250	282	285
300	328	321
300	313	321

dE/dIdot	Eo	sig(Ecorr)
0.71	108.1	9.1
0.03	4.7	

DCA311

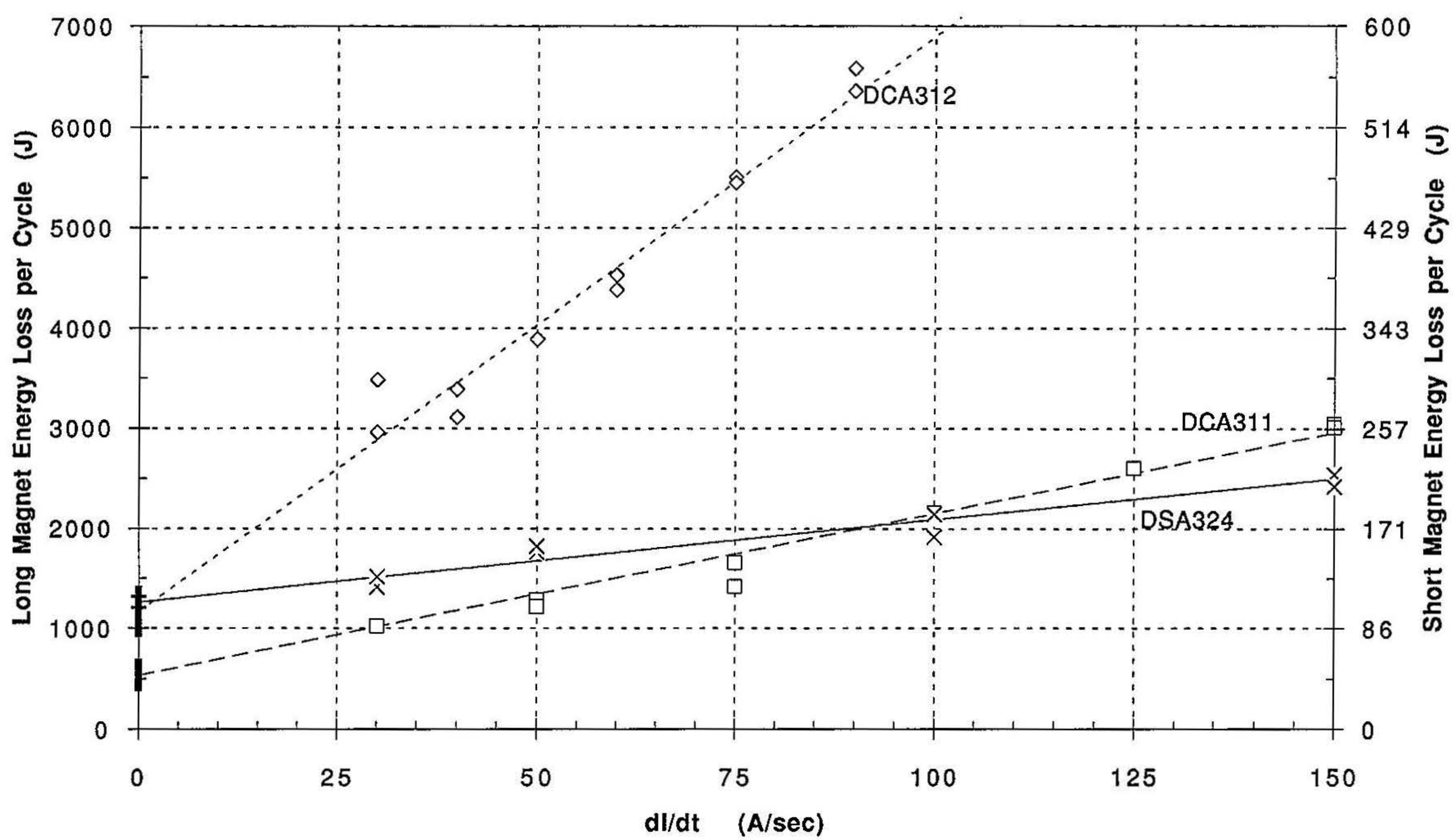
Idot	Ecorr	Efit
0		534
30	1418	1019
30	1024	1019
50	1285	1343
50	1213	1343
75	1661	1748
75	1416	1748
100	2160	2152
100	2158	2152
125	2604	2557
150	3054	2962
150	3013	2962
200		3771

dE/dIdot	Eo	sig(Ecorr)
16.2	534	186
1.3	127	

DCA312

Idot	Ecorr	Efit
0		1164
30	3486	2885
30	2958	2885
40	3111	3458
40	3390	3458
50	3895	4032
50	3891	4032
60	4382	4605
60	4527	4605
75	5506	5465
75	5451	5465
90	6584	6325
90	6359	6325
200		12633

dE/dIdot	Eo	sig(Ecorr)
57.3	1164	256
3.6	222	



7000
6000
5000
4000
3000
2000
1000
0
Long Magnet Energy Loss per Cycle (J)
600
514
429
343
257
171
86
0
Short Magnet Energy Loss per Cycle (J)
0
25
50
75
100
125
150
dI/dt (A/sec)
DCA312
DCA311
DSA324

Figure 1