BROOKHAVEN NATIONAL LABORATORY

MAGNET DIVISION NOTES

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Date: October 6, 1994

No: 545-16 (RHIC-MD-246)

Task Force: RHIC

Title: Analysis of QRJ105 Magnet with a Broken Shim

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List revised 8/05/94

Analysis of QRJ105 Magnet with a Broken Shim

Ramesh Gupta

This note describes a careful analysis of the measured field quality in magnet QRJ105 and the process by which a mechanical errors in construction was detected. This highlights the power of *analysis and follow up procedure* of the field quality (warm measurements) during the production not only from the acceptability in machine point of view but also as a tool for detecting a possible mishap during the construction of a magnet.

The magnet QRJ105 was found to have (a) some unusually large deviations from the expected values of field harmonics and (b) large differences in the body harmonics between the lead-end and return-end halves of the magnet. These large deviations/variations in harmonics could not be explained from the specified tolerances in parts. A mechanical inspection of the parts which went inside this magnet was undertaken. These parts include (i) RX630 spacers (ii) two wedges (iii) coil sizes of all four coils and (iv) pole and midplane shims. None of them showed a deviation large enough to explain the measured harmonics.

Based on this, a measurement of field harmonics in small steps was requested to localize the problem. As shown in figure 1, a large change in harmonics is seen in an $18''$ section near the center of the magnet which is towards the lead-end side. b_5 suggests a possible $0.012''$ to $0.016''$ error in overall dimension. A large value of a_2 ($\sim$-11 unit) suggests that a top-bottom symmetry is broken and that the dimensional errors mentioned above are not uniformly distributed (azimuthally) in the cross-section of that local area. Moreover, a large drop in b_3 suggests that the horizontal and vertical symmetry is also significantly broken. A visual inspection of the suspected area in the magnet revealed that a $0.014''$ shim between the two coils at 90 degree has broken off in about $18''$ long section.

In table 2, we list the computed and measured harmonics due to this missing shim at 90 degree azimuthal location. In the computer model, it is assumed that the coils in first and second quadrant are shifted by $0.007''$ towards the Y-axis. The poles at 45 degree and 135 degree move by half of this amount ($0.0035''$). The deflection of the coil in an actual magnet would be more complex than this simple model, however, the model should be good enough for estimating the errors in the field harmonics. Similarly, due

to a large variation in measured harmonics in the steps requested, an estimate has to be made regarding what the actual change is and therefore, the values listed in table are subjected to some uncertainties. Nevertheless, the agreement between the calculation and measurements is rather good. In table 1, we have listed only those harmonics which are generated by this geometric error. Because of the left-right symmetry, no change in even-b_n and odd-a_n is expected.

The results of this successful investigation clearly supports the importance of continued monitoring of field quality and the need to follow up when some thing strange is seen. The magnet QRJ105, tested as is, would have given a poor quench performance.

Table 1: A comparison between the measured and computed harmonics due to a missing $0.014''$ shim at 90 degree in the 130 mm aperture RHIC insertion quadrupole.

	Computed	Measured
δa_2	-11.3	-11
δb_3	-5.8	-4.5
δa_4	2.5	3.0
δb_5	1.2	1.3
δa_6	-0.6	-0.5
δb_7	-0.4	-0.35

Axial Variation of Harmonics in QRJ105
Harmonics Normalized to Central C(2)

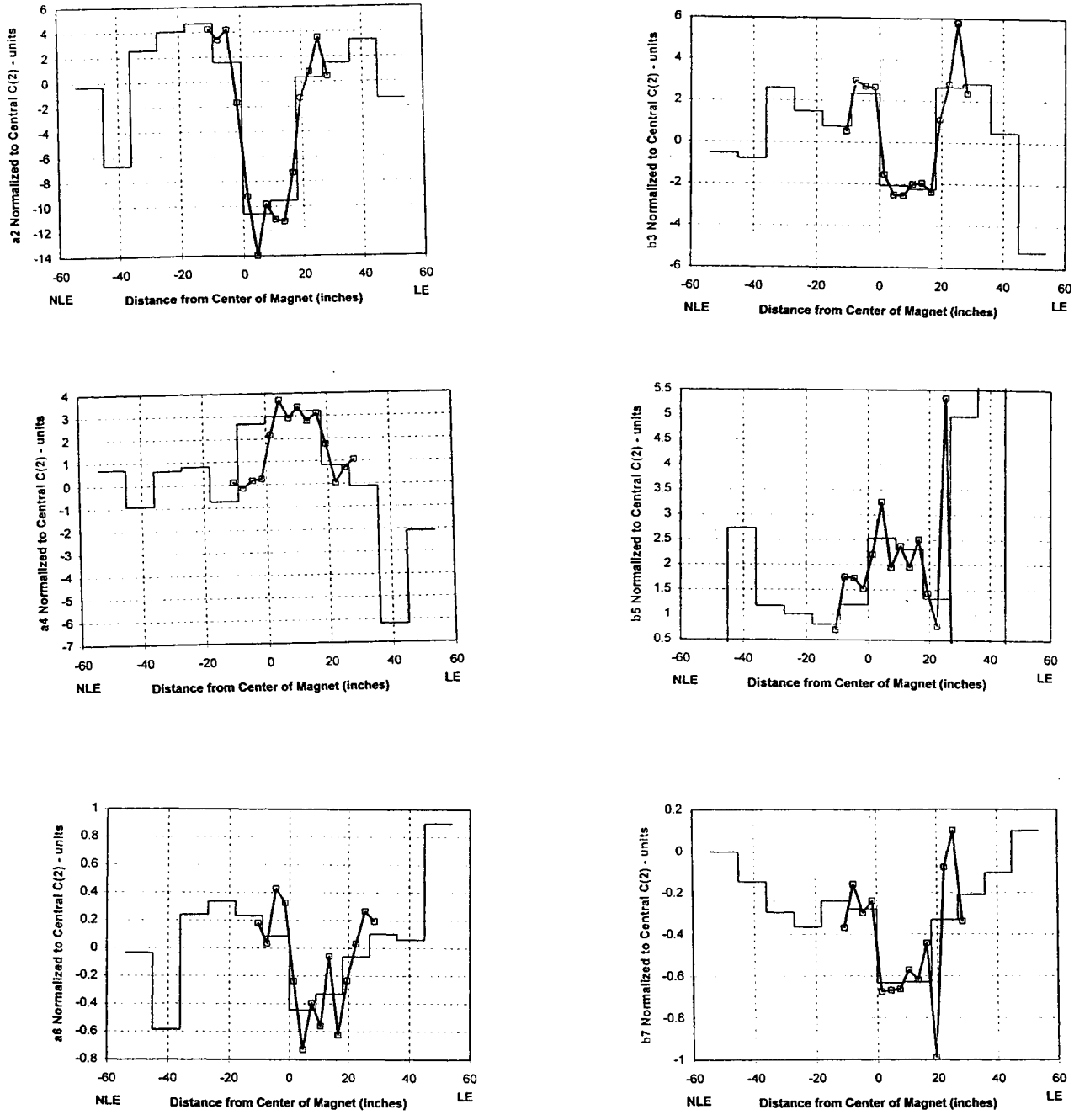

Figure 1: Measured axial-variation in field harmonics in 3″ and 9″ steps (courtesy A. Jain).