TD-06-005
V1.0, 02/06/06

LQXB06-A Test Report

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Quench Training

LQXB06 was cold tested a second time after repair of a broken heater [1]. The magnets had been quench-trained in the first test. To test the heaters and verify the magnets had not been damaged during repair, the magnet was ramped to 12208A (220 T/m) at 1.9K and tripped manually with a dump delay of 1 s. Following this successful test, the magnet was ramped to 220 T/m during strength measurements without quenching.

Summary: The requirements for acceptance are satisfied.

Magnetic Field Quality Measurements

Field quality measurements were made with a rotating coil. The object of the measurements made during the second test was to investigate the absence of hysteretic b_6 seen in the first test in MQXB07 [1]. Complete longitudinal scans were made with a probe of length 0.82 m. The program consisted of the following measurement type.

- A DC loop with a longitudinal scan at each stopping point. This allows body-end field separation. These scans may be integrated to provide a characterization of the entire magnet.

A list of the measurements made is given in Appendix A. Data is posted at the following URL.

http://wwwtsmtf.fnal.gov/~dimarco/usrAnalysisLQX/web_summaries/LQXB06/magneticMeasurements/LQXB06_mag_meas.html

Table 1 summarizes the field quality measurements at injection taken during the two tests with respect to the harmonics acceptance criteria[1] for the magnet. The only significant change is in the normal dodecapole.

Summary: Field quality is good. Most harmonics are within one sigma of the target. The hysteretic value of b_6 at injection measured in the 2^{nd} test is typical of the ensemble of MQXB magnets. A discussion of the dodecapole measurements is given in Appendix F.

[1] Acceptance criteria for harmonics are from v7 of the acceptance document. Acceptance bands are from v3.2 of the reference harmonics table. The method for calculation of integral harmonics is given in Appendix D.

Table 1: Integral Field Harmonics for MQXB07 at injection field measured during the 1st (left) and 2nd tests (right).

	MQXB07		
	669 A (12.3 T/m)	669 A (12.3 T/m)	Unit
TF	n.a.	n.a.	T/A
ML	n.a.	n.a.	m
FD	0	0	mrad
b03	-0.28	-0.21	units
b04	0.35	0.39	units
b05	-0.03	-0.05	units
b06	0.26	-0.93	units
b07	-0.01	-0.02	units
b08	-0.02	-0.02	units
b09	0.00	0.00	units
b10	0.04	0.04	units
a03	0.87	1.04	units
a04	0.08	-0.02	units
a05	0.13	0.19	units
a06	-0.01	0.00	units
a07	0.01	0.00	units
a08	0.04	0.03	units
a09	0.02	0.01	units
a10	0.00	-0.01	units

Magnetic Field Strength Measurements

Due to a suspected problem with the tension gauge of the SSW system during the first set of strength measurements, the integral strength of the magnets was measured again. SSW measured integral field strength with magnets powered in series is given in Table 2. The first 4 entries are taken on the up ramp and the last on the down ramp. Transfer function is plotted versus current in Fig. 1. Note the different slopes. We thus conclude that there was a problem with the data from the 1st test.

Table 2: Field strength vs. current.

	integral gradient transfer function (T/kA)	integral field strength(T)
Current (A)	Q2a+Q2b	Q2a+Q2b
668	202.48	135.3
5460	200.95	1097.2
11346	198.31	2249.9
11923	198.04	2361.3
5460	200.97	1097.3

Summary: The strength at 11345 A is within the acceptance band of 2254.8±5.7. (This corresponds to the band of 1127±4 T for a single cold mass.) Data from the 1st test of the magnet was compromised by a malfunctioning tension gauge. We will report strength from the 2nd test.

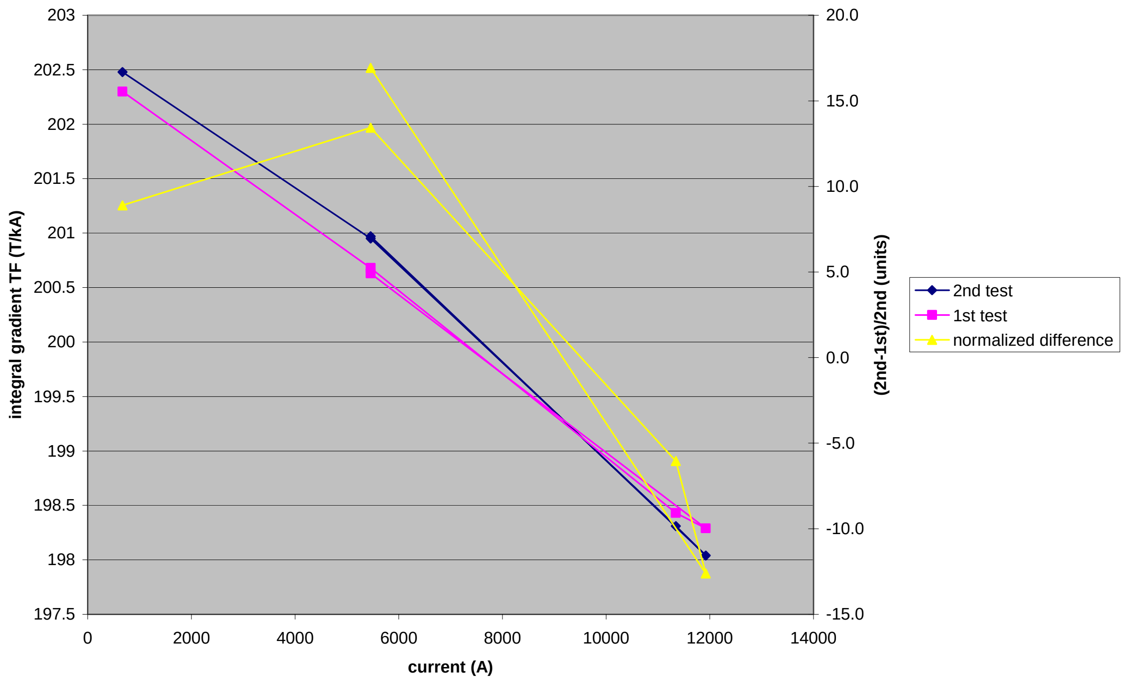

Figure 1: Transfer function measurements of LQXB06.

Alignment

LQXB06 had alignment measurements at each stage of testing at MTF. A partial list of the measurements performed is given in Table 3 with a full list in Appendix B.

Table 3: Major alignment data sets

Warm before TC1	05Oct05
Cold TC1	19Oct05
Warm after TC1	31Oct05
Warm after TC1 Lug Adjustments	07Dec05

Data will be posted at the following URL.

http://wwwtsmtf.fnal.gov/~dimarco/usrAnalysisLQX/LQXB06/SSW/LQXB06_align.html

There were also measurements and lug adjustment during mounting of the magnet prior to 05Oct05 to optimize warm alignment before cold test.

The magnet positions experienced some change during first cool down as is common for these magnets. In particular, the yaw of Q2b showed change of about 1 mm over its length. This change remained roughly constant upon warm up. The Q2a yaw showed about a 0.5 mm change at one end, again remaining fairly constant after cold test. The pitch angles showed that the interconnect region moved more than either of the ends. The Q2b vertical change at magnet center was about 0.7 mm for Q2b and about 0.3 mm for Q2a. On warm up, the Q2b end near the interconnect came up about half the original change, while at its other end it continued to move downward another 0.3 mm. Effectively the pitch of Q2b changed sign from cold back to warm and was about the same magnitude. The average positions of the magnets changed by about 0.25 mm in *x* for both Q2a/b, and changed by about 0.25 mm for Q2a and 0.5 mm for Q2b in the vertical direction; which is a fairly typical *y* drop. The change in the roll angle was about 0.6 mrad during initial cool down, of which about 0.3 mrad reversed upon warm up. The cold mass transverse positions otherwise remained generally closer to their cold values on warm up.

Strength measurements on the combined Q2a+Q2b were performed at 1.9K.

Adjustments of the lugs were performed after cold testing on the test stand at MTF. The changes from before and after lug adjustment were applied to the MTF cold and warmAft data to generate the final cold and warm RST values.

Relative alignment of the magnet assemblies compared to AP requirements is given in Table 4.

Table 4: Relative alignment of magnet assemblies (cold).

			x	y
Q2a/Q2b transverse alignment	500	μm	1280	528
Q2a/Q2b relative roll	1	mrad (rms)	0.00	
Q2a/Q2b relative pitch	0.1	mrad	-0.16	
Q2a/Q2b relative yaw	0.1	mrad	-0.35	
relative alignment of MCBX to Q2				
corrector displace-ment	500	μm	n.a.	
corrector roll	5	mrad		
B1 (hor.)			-1.48	
A1 (vertical)			1.1	

A summary plot showing the changes in cold mass positions at various points in testing is shown in Fig. 2. The positions are given relative to the Cold TC1 measurements being on the average axis.

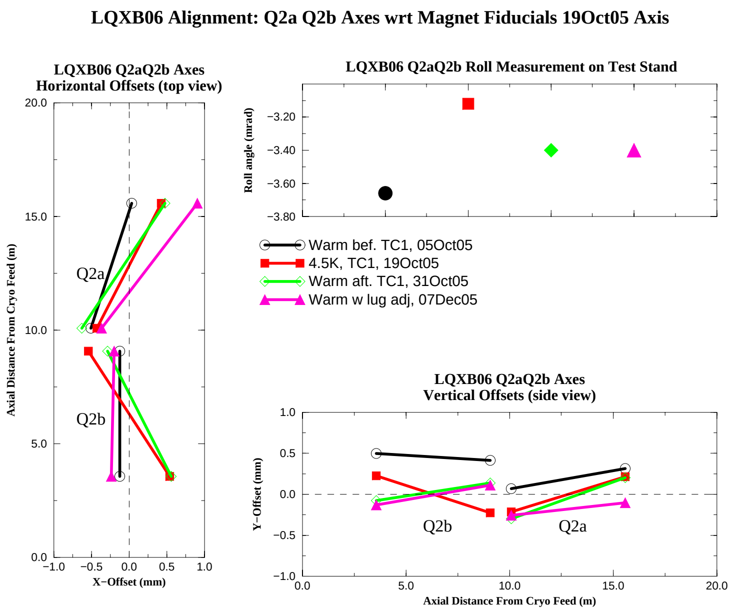

Figure 2: Alignment summary plot.

Summary: Changes of typical magnitude were seen horizontally and vertically in the cold masses during cool down and the cold masses did not fully return to their initial positions after the first TC. Lug adjustment was performed afterwards to maintain the best cold alignment. There was a change in roll during cool down of about 0.6 mrad; this partially reversed after cold test so that warm-warm the change was about 0.3 mrad.

Other tests performed

Other items of interest

References

[1] J. DiMarco, P. Schlabach and G. Velev, “LQXB06 Test Report”, TD-04-056.

Appendix A: List of field quality measurements

This lists measurements made during the 2nd test of LQXB06.

TC2	1.9K									
-rw-r--r--	1	velev	cdf	8909760	Oct	12	19:24	q2a	cold_tc1_beta_2	q2a_11345up.odb
-rw-r--r--	1	velev	cdf	9008576	Oct	12	20:19	q2a	cold_tc1_beta_2	q2a_5459do.odb
-rw-r--r--	1	velev	cdf	8909760	Oct	12	18:56	q2a	cold_tc1_beta_2	q2a_5459up.odb
-rw-r--r--	1	velev	cdf	8909768	Oct	12	18:31	q2a	cold_tc1_beta_2	q2a_669up.odb
TC2	4.5K									
-rw-r--r--	1	velev	cdf	5338560	Oct	17	14:48	q2a	cold_tc1_beta_3_4.5	q2a_5459up.odb
-rw-r--r--	1	velev	cdf	4440160	Oct	17	16:52	q2a	cold_tc1_beta_3_4.5	q2a_669do.odb
-rw-r--r--	1	velev	cdf	8846720	Oct	17	15:22	q2a	cold_tc1_beta_3_4.5	q2a_669up.odb

Appendix B: List of alignment measurements

LQXB06 SSW Measurements Log for both tests of LQXB06.

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(Column 1 is status: R   indicates used directly for results; "a" indicates ancillary)

================================================================================
Measurements in MTF
================================================================================
/usr/analysis/LQX/LQXB06/SSW
================================================================================
R   040504_16:02   ICB/initial_meas_04May04/QA/040504_16:02.sag
a   040505_10:01   ICB/initial_meas_04May04/QA/040505_10:01.checkXY
R   040504_17:20   ICB/initial_meas_04May04/QA/040504_17:20.roll_repeat
R   040506_09:20   ICB/initial_meas_04May04/QA/040506_09:20.checkXYRoll_aftAdj
a   040504_12:01   ICB/initial_meas_04May04/QB/040504_12:01.sag
a   040504_13:40   ICB/initial_meas_04May04/QB/040504_13:40.sag
a   040504_14:57   ICB/initial_meas_04May04/QB/040504_14:57.sag
R   040505_08:22   ICB/initial_meas_04May04/QB/040505_08:22.centerXY
R   040504_19:52   ICB/initial_meas_04May04/QB/040504_19:52.roll_repeat
R   040506_10:16   ICB/initial_meas_04May04/QB/040506_10:16.checkXYRoll_aftAdj
R   040506_15:33   ICB/initial_meas_04May04/QB/040506_15:33.checkXY_aftAdj2
R   040506_15:56   ICB/initial_meas_04May04/QB/040506_15:56.checkRoll_aftAdj2
R   040525_14:48   ICB/afterWeldInterconnect_25May04/QA/040525_14:48.sag
a   040526_09:51   ICB/afterWeldInterconnect_25May04/QA/040526_09:51.sag
R   040526_11:03   ICB/afterWeldInterconnect_25May04/QA/040526_11:03.checkXY
a   040527_07:42   ICB/afterWeldInterconnect_25May04/QA/040527_07:42.checkXY_aftWeldAdj
R   040527_08:14   ICB/afterWeldInterconnect_25May04/QA/040527_08:14.checkXY_aftWeldAdj
R   040527_13:13   ICB/afterWeldInterconnect_25May04/QA/040527_13:13.checkXY_aftWeldAdj2
R   040607_13:38   ICB/afterWeldInterconnect_25May04/QA/040607_13:38.checkXY_flangeAlign
a   040525_13:37   ICB/afterWeldInterconnect_25May04/QB/040525_13:37.sag
a   040525_17:32   ICB/afterWeldInterconnect_25May04/QB/040525_17:32.sagLT_roll
R   040526_08:18   ICB/afterWeldInterconnect_25May04/QB/040526_08:18.centerX
R   040526_08:31   ICB/afterWeldInterconnect_25May04/QB/040526_08:31.checkX
R   040526_08:42   ICB/afterWeldInterconnect_25May04/QB/040526_08:42.sag
R   040526_12:15   ICB/afterWeldInterconnect_25May04/QB/040526_12:15.checkXY
R   040526_16:10   ICB/afterWeldInterconnect_25May04/QB/040526_16:10.checkXY_aftWeldAdj1_repeat
R   040527_13:36   ICB/afterWeldInterconnect_25May04/QB/040527_13:36.checkXY_aftWeldAdj2
R   040607_11:34   ICB/afterWeldInterconnect_25May04/QB/040607_11:34.adjXY_flangeAign
R   050707_13:57   ICB/initial_align_rebuild_07Jul05/QA/050707_13:57.checkXY_roll
R   050707_17:37   ICB/initial_align_rebuild_07Jul05/QA/050707_17:37.checkXY_roll_after1adj
R   050708_08:04   ICB/initial_align_rebuild_07Jul05/QA/050708_08:04.checkXY_roll_after2adj
R   050708_10:16   ICB/initial_align_rebuild_07Jul05/QA/050708_10:16.checkXY_roll_after2adj5mm
R   050708_15:42   ICB/initial_align_rebuild_07Jul05/QA/050708_15:42.checkXY_15mm_noKap
R   050711_10:24   ICB/initial_align_rebuild_07Jul05/QA/050711_10:24.checkXY_roll_after3adj
R   050707_11:49   ICB/initial_align_rebuild_07Jul05/QB/050707_11:49.checkXY_roll
R   050707_16:40   ICB/initial_align_rebuild_07Jul05/QB/050707_16:40.checkXY_roll_after1adj
R   050708_12:14   ICB/initial_align_rebuild_07Jul05/QB/050708_12:14.checkXY_roll_after2adj5mm
R   050708_09:01   ICB/initial_align_rebuild_07Jul05/QB/050708_09:01.checkXY_roll_after2adj
R   050708_15:11   ICB/initial_align_rebuild_07Jul05/QB/050708_15:11.checkXY_15mm_noKap
R   050711_09:37   ICB/initial_align_rebuild_07Jul05/QB/050711_09:37.checkXY_roll_after3adj
R   050719_11:26   ICB/initial_align_rebuild_07Jul05/QB/050719_11:26.checkXY_roll_before_correctors
R   050719_14:00   ICB/initial_align_rebuild_07Jul05/QB/050719_14:00.checkXY_roll_before_correctors2
R   050719_15:16   ICB/initial_align_rebuild_07Jul05/CORRECTORS/050719_15:16.h_roll
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R   050719_15:28   ICB/initial_align_rebuild_07Jul05/CORRECTORS/050719_15:28.v_roll
R   050801_15:29   ICB/afterWeldInterconnect_rebuild_01Aug05/QA/050801_15:29.checkXY
R   050810_11:45   ICB/afterWeldInterconnect_rebuild_01Aug05/QA/050810_11:45.checkXY_flangeAlign
R   050801_15:03   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050801_15:03.checkXY
R   050810_10:50   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050810_10:50.checkXY_flangeAlign
R   050810_08:37   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050810_08:37.centerXY_flangeAlign
a   050812_18:17   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050812_18:17.sagNew
a   050812_18:59   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050812_18:59.centerXY
a   050812_19:31   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050812_19:31.centerXY
a   050815_06:18   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050815_06:18.centerXY
a   050815_10:04   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050815_10:04.centerXY
a   050815_10:40   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050815_10:40.sag2
R   050816_12:36   ICB/afterWeldInterconnect_rebuild_01Aug05/QB/050816_12:36.sag3_centerXY
R   040730_07:29   MTF/warmBefTC1_29Jul04/QA/040730_07:29.checkXY
R   040730_08:11   MTF/warmBefTC1_29Jul04/QA/040730_08:11.checkXY_onAveAxis
R   040730_08:39   MTF/warmBefTC1_29Jul04/QA/040730_08:39.checkY
a   040730_08:48   MTF/warmBefTC1_29Jul04/QA/040730_08:48.checkY_5mmStep
a   040730_09:00   MTF/warmBefTC1_29Jul04/QA/040730_09:00.checkY_4mmStep_aveOnly
a   040730_09:29   MTF/warmBefTC1_29Jul04/QA/040730_09:29.checkY_3mmStep_aveOnly
a   040730_09:43   MTF/warmBefTC1_29Jul04/QA/040730_09:43.checkY_4mmStep_adj1
R   040730_15:05   MTF/warmBefTC1_29Jul04/QA/040730_15:05.checkXY_aftSurv
R   040803_12:02   MTF/warmBefTC1_29Jul04/QA/040803_12:02.checkY_aveOnly
a   040730_16:16   MTF/warmBefTC1_29Jul04/QA/040730_16:16.checkXY_roll_sag_wireBack_repeat
R   040803_15:52   MTF/warmBefTC1_29Jul04/QA/040803_15:52.checkXY_aveOnly
R   040803_16:13   MTF/warmBefTC1_29Jul04/QA/040803_16:13.checkXY_aveOnly_adj1R
R   040803_17:06   MTF/warmBefTC1_29Jul04/QA/040803_17:06.checkXY_onAveAxis
R   040806_10:07   MTF/warmBefTC1_29Jul04/QA/040806_10:07.checkXY_onAveAxis_aftPwrRestore_aveOnly
R   040729_13:12   MTF/warmBefTC1_29Jul04/QB/040729_13:12.checkXY
R   040730_06:57   MTF/warmBefTC1_29Jul04/QB/040730_06:57.checkY
R   040729_13:36   MTF/warmBefTC1_29Jul04/QB/040729_13:36.sag_XY_roll_repeat
R   040730_07:13   MTF/warmBefTC1_29Jul04/QB/040730_07:13.checkY
R   040730_15:36   MTF/warmBefTC1_29Jul04/QB/040730_15:36.checkXY_afterSurvey
R   040803_15:36   MTF/warmBefTC1_29Jul04/QB/040803_15:36.checkXY_aveOnly
R   040803_16:26   MTF/warmBefTC1_29Jul04/QB/040803_16:26.checkXY_aveOnly_adj1
R   040803_16:38   MTF/warmBefTC1_29Jul04/QB/040803_16:38.checkXY_onAveAxis
a   040806_10:19   MTF/warmBefTC1_29Jul04/QB/040806_10:19.checkXY_onAveAxis_aftPwrRestore_aveOnly
a   040823_16:50   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_16:50.str_669A_up
R   040823_17:09   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_17:09.str_669A_up
a   040823_17:26   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_17:26.roll_669A
R   040823_17:45   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_17:45.roll_669A
R   040823_18:00   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_18:00.str_5460A_up
R   040823_18:25   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_18:25.str_11345A_up
a   040823_18:40   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_18:40.str_11923A_up
R   040823_18:57   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_18:57.str_11923A_up
R   040823_19:19   MTF/coldTC1_1.9K_23Aug04/QAQB/040823_19:19.str_5460A_dn
R   040824_11:21   MTF/coldTC1_4.5K_24Aug04/QA/040824_11:21.checkXY_aveOnly
R   040824_11:35   MTF/coldTC1_4.5K_24Aug04/QA/040824_11:35.checkXY_onAveAxis
R   040824_10:58   MTF/coldTC1_4.5K_24Aug04/QB/040824_10:58.checkXY_aveOnly
R   040824_12:11   MTF/coldTC1_4.5K_24Aug04/QB/040824_12:11.checkXY_onAveAxis
R   040824_15:39   MTF/coldTC1_4.5K_24Aug04/QB/040824_15:39.checkXY_onAveAxis_aftSurv
R   040907_12:27   MTF/warmAftTC1_07Sep04/QA/040907_12:27.checkXY_aveOnly
R   040907_12:42   MTF/warmAftTC1_07Sep04/QA/040907_12:42.checkXY_onAveAxis
R   040908_08:49   MTF/warmAftTC1_07Sep04/QA/040908_08:49.roll
R   040909_07:34   MTF/warmAftTC1_07Sep04/QA/040909_07:34.afterLugAdj1
R   040909_07:54   MTF/warmAftTC1_07Sep04/QA/040909_07:54.roll_noVac
R   040909_13:05   MTF/warmAftTC1_07Sep04/QA/040909_13:05.checkXY_onAveAxis_afterAdj
R   040907_12:02   MTF/warmAftTC1_07Sep04/QB/040907_12:02.checkXY_aveOnly
R   040907_12:16   MTF/warmAftTC1_07Sep04/QB/040907_12:16.checkXY_aveOnly
R   040907_12:59   MTF/warmAftTC1_07Sep04/QB/040907_12:59.checkXY_onAveAxis
R   040907_17:04   MTF/warmAftTC1_07Sep04/QB/040907_17:04.checkXY_aveOnly_aftSurv
R   040908_10:02   MTF/warmAftTC1_07Sep04/QB/040908_10:02.zmeas_onQBaxis
R   040907_17:16   MTF/warmAftTC1_07Sep04/QB/040907_17:16.roll_repeat
R   040908_10:12   MTF/warmAftTC1_07Sep04/QB/040908_10:12.zmeas_onQBaxis_15mm
R   040908_10:24   MTF/warmAftTC1_07Sep04/QB/040908_10:24.zmeas_onQBaxis_15mm
R   040908_17:46   MTF/warmAftTC1_07Sep04/QB/040908_17:46.afterAdj1
R   040908_10:34   MTF/warmAftTC1_07Sep04/QB/040908_10:34.zmeas_onQBaxis_15mm_repeat
R   040908_10:49   MTF/warmAftTC1_07Sep04/QB/040908_10:49.zmeas_onQBaxis_15mm_repeat
R   040909_10:14   MTF/warmAftTC1_07Sep04/QB/040909_10:14.afterAdj1_onAveAxis
R   040909_11:37   MTF/warmAftTC1_07Sep04/QB/040909_11:37.roll_aftAdj_repeat
R   040908_12:44   MTF/warmAftTC1_07Sep04/CORRECTORS/040908_12:44.cor12
R   040908_13:02   MTF/warmAftTC1_07Sep04/CORRECTORS/040908_13:02.cor12_10mm
R   040908_17:33   MTF/warmAftTC1_07Sep04/CORRECTORS/040908_17:33.ystr
R   040908_17:39   MTF/warmAftTC1_07Sep04/CORRECTORS/040908_17:39.ystr
R   040909_08:23   MTF/warmAftTC1_07Sep04/CORRECTORS/040909_08:23.xstr12
R   040909_08:39   MTF/warmAftTC1_07Sep04/CORRECTORS/040909_08:39.xstr34
R   040909_08:43   MTF/warmAftTC1_07Sep04/CORRECTORS/040909_08:43.xstr34_repeat
R   040909_09:05   MTF/warmAftTC1_07Sep04/CORRECTORS/040909_09:05.ystr34_repeat
R   040908_17:13   MTF/warmAftTC1_07Sep04/CORRECTORS/040908_17:13.ystr
R   040908_17:18   MTF/warmAftTC1_07Sep04/CORRECTORS/040908_17:18.ystr
R   040908_17:23   MTF/warmAftTC1_07Sep04/CORRECTORS/040908_17:23.ystr
R   040714_14:32   MTF/mounting_14Jul04/QB/040714_14:32.checkXY_aveOnly
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R   040714_15:36   MTF/mounting_14Jul04/QB/040714_15:36.checkY_aveOnly
R   040714_15:40   MTF/mounting_14Jul04/QB/040714_15:40.checkY_aveOnly
R   040714_16:15   MTF/mounting_14Jul04/QB/040714_16:15.checkXY_onAveAxis
R   040715_10:01   MTF/mounting_14Jul04/QB/040715_10:01.checkXY_aftAdj1
R   040715_14:00   MTF/mounting_14Jul04/QB/040715_14:00.checkXY_aftAdj2
R   040715_16:02   MTF/mounting_14Jul04/QB/040715_16:02.checkXY_aftAdj2_onAvgAxis
R   040714_15:52   MTF/mounting_14Jul04/QA/040714_15:52.checkXY_aveOnly
R   040714_16:01   MTF/mounting_14Jul04/QA/040714_16:01.checkXY_onAveAxis
R   040714_16:33   MTF/mounting_14Jul04/QA/040714_16:33.checkY_onAveAxis
R   040715_09:43   MTF/mounting_14Jul04/QA/040715_09:43.checkXY_aftAdj1
R   040715_14:14   MTF/mounting_14Jul04/QA/040715_14:14.checkXY_aftAdj2
R   040715_15:48   MTF/mounting_14Jul04/QA/040715_15:48.checkXY_onAvgAxis
R   051013_15:32   MTF_rebuild/coldTC1_1.9K_13Oct05/QAQB/051013_15:32.roll_669A
R   051013_17:24   MTF_rebuild/coldTC1_1.9K_13Oct05/QAQB/051013_17:24.str_669A_up
R   051013_17:49   MTF_rebuild/coldTC1_1.9K_13Oct05/QAQB/051013_17:49.str_5460A_up
R   051013_18:21   MTF_rebuild/coldTC1_1.9K_13Oct05/QAQB/051013_18:21.str_11345A_up
R   051013_18:43   MTF_rebuild/coldTC1_1.9K_13Oct05/QAQB/051013_18:43.str_11923A_up
R   051013_19:06   MTF_rebuild/coldTC1_1.9K_13Oct05/QAQB/051013_19:06.str_11923A_up
R   051013_19:35   MTF_rebuild/coldTC1_1.9K_13Oct05/QAQB/051013_19:35.str_5460A_dn
R   051003_16:15   MTF_rebuild/warmBefTC1_03Oct05/QA/051003_16:15.checkXY_aveOnly_roll_repeat
R   051004_08:44   MTF_rebuild/warmBefTC1_03Oct05/QA/051004_08:44.checkXY_aveAxis
R   051003_13:20   MTF_rebuild/warmBefTC1_03Oct05/QB/051003_13:20.checkXY_aveOnly
R   051004_10:27   MTF_rebuild/warmBefTC1_03Oct05/QB/051004_10:27.checkXY_onAveAxis
R   051003_13:43   MTF_rebuild/warmBefTC1_03Oct05/QB/051003_13:43.roll_repeat
R   051005_15:02   MTF_rebuild/warmBefTC1_03Oct05/QB/051005_15:02.zpos_aftSurvey_repeat
R   051019_12:48   MTF_rebuild/coldTC1_4.5K_19Oct05/QA/051019_12:48.checkXY_aveOnly
R   051019_13:02   MTF_rebuild/coldTC1_4.5K_19Oct05/QA/051019_13:02.checkXY_aveAxis
R   051019_17:28   MTF_rebuild/coldTC1_4.5K_19Oct05/QA/051019_17:28.checkXY_aveAxis_aftSurv
R   051019_17:41   MTF_rebuild/coldTC1_4.5K_19Oct05/QA/051019_17:41.checkY_aveOnly_aftSurv
R   051020_08:04   MTF_rebuild/coldTC1_4.5K_19Oct05/QA/051020_08:04.checkXY_aftSurv
R   051020_09:07   MTF_rebuild/coldTC1_4.5K_19Oct05/QA/051020_09:07.checkXY_aftSurv
R   051019_17:00   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_17:00.checkY_aftSurvey
R   051019_12:39   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_12:39.checkXY_aveOnly
R   051019_13:27   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_13:27.checkXY_onAveAxis
R   051019_15:47   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_15:47.checkXY_onAveAxis_aftSurvey
R   051019_16:10   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_16:10.checkXY_onAveAxis_aftSurvey_repeat
R   051019_16:52   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_16:52.checkY_aftSurvey
R   051019_17:11   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_17:11.checkX_zpos
R   051019_17:17   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051019_17:17.checkX_zpos
R   051020_08:27   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051020_08:27.checkXY_aftSurv
R   051020_08:41   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051020_08:41.checkXY_aftSurv
R   051020_08:57   MTF_rebuild/coldTC1_4.5K_19Oct05/QB/051020_08:57.checkY_aftSurv
R   050920_08:07   MTF_rebuild/mountingAfterRebuild_19Sep05/QA/050920_08:07.checkXY
R   050920_09:22   MTF_rebuild/mountingAfterRebuild_19Sep05/QA/050920_09:22.checkY
R   050920_16:27   MTF_rebuild/mountingAfterRebuild_19Sep05/QA/050920_16:27.checkXY_adj1
R   050921_13:43   MTF_rebuild/mountingAfterRebuild_19Sep05/QA/050921_13:43.checkXY_adj2
R   050922_14:15   MTF_rebuild/mountingAfterRebuild_19Sep05/QA/050922_14:15.checkXY_adj3
R   050919_17:06   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050919_17:06.checkXY
R   050920_07:29   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050920_07:29.checkXY
R   050920_07:46   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050920_07:46.checkXY
R   050920_10:45   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050920_10:45.checkY
R   050920_15:46   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050920_15:46.checkXY_adj1
R   050921_14:05   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050921_14:05.checkXY_adj2
R   050921_15:38   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050921_15:38.checkXY_adj2
R   050922_13:39   MTF_rebuild/mountingAfterRebuild_19Sep05/QB/050922_13:39.checkXY_adj3
R   051028_13:10   MTF_rebuild/warmAfterTC1_28Oct05/QA/051028_13:10.checkXY_aveOnly
R   051028_14:54   MTF_rebuild/warmAfterTC1_28Oct05/QA/051028_14:54.checkXY_onAveAxis
R   051028_15:39   MTF_rebuild/warmAfterTC1_28Oct05/QA/051028_15:39.roll
R   051101_09:49   MTF_rebuild/warmAfterTC1_28Oct05/QA/051101_09:49.checkXY_aftSurvey
R   051206_10:19   MTF_rebuild/warmAfterTC1_28Oct05/QA/051206_10:19.checkXY_aftLugAdj
R   051206_14:36   MTF_rebuild/warmAfterTC1_28Oct05/QA/051206_14:36.checkXY_onAveAxis
R   051028_13:39   MTF_rebuild/warmAfterTC1_28Oct05/QB/051028_13:39.checkXY_aveOnly
R   051028_14:07   MTF_rebuild/warmAfterTC1_28Oct05/QB/051028_14:07.checkXY_onAveAxis
R   051101_10:35   MTF_rebuild/warmAfterTC1_28Oct05/QB/051101_10:35.checkXY_aftSurvey
R   051101_10:48   MTF_rebuild/warmAfterTC1_28Oct05/QB/051101_10:48.roll
R   051101_11:05   MTF_rebuild/warmAfterTC1_28Oct05/QB/051101_11:05.zpos
R   051101_11:11   MTF_rebuild/warmAfterTC1_28Oct05/QB/051101_11:11.zpos_repeat
R   051206_14:51   MTF_rebuild/warmAfterTC1_28Oct05/QB/051206_14:51.checkXY_onAveAxis
R   051206_09:49   MTF_rebuild/warmAfterTC1_28Oct05/QB/051206_09:49.checkXY_aftLugAdj
R   051102_11:02   MTF_rebuild/warmAfterTC1_28Oct05/CORRECTORS/051102_11:02.COR12
R   051102_11:11   MTF_rebuild/warmAfterTC1_28Oct05/CORRECTORS/051102_11:11.COR12
R   051102_11:19   MTF_rebuild/warmAfterTC1_28Oct05/CORRECTORS/051102_11:19.COR34_repeat
```

Appendix C: Q2A/Q2B->MQXB07/MQXB09

Inside LQXB06, Q2A, closest to the MTF return can, the CDF side of the building, is MQXB07. Q2B, closest to the MTF feed can, away from CDF, is MQXB09.

Appendix D: Calculation of integral field harmonics

Integral field harmonics are computed from the data taken during the longitudinal scan of the magnets as described in earlier reports.

Appendix E: Calculation of magnetic length

Magnetic lengths were calculated from rotating coil data only instead of from SSW measurements of the strength and rotating coil measurements of the body field.

Appendix F: Discussion of the hysteretic b_6

We have previously remarked on the anomalous normal dodecapole (b_6) measured in MQXB07 during the injection current z scan in the first test of LQXB06 [1]. The measurement at injection current shows the same value as higher current measurements as if there was no hysteretic component from the magnetization field. Following repair of its broken heater, LQXB06 was tested again at 1.9K; and Z scans of MQXB07 at selected currents were made to investigate the anomaly.

Fig. 3 is a summary plot of b_6 measurements at injection in the cold masses cold tested so far. One can clearly see that the measured b_6 of MQXB07 in the second test cycle is quite different from that of the first test cycle and is similar to that of other cold masses.

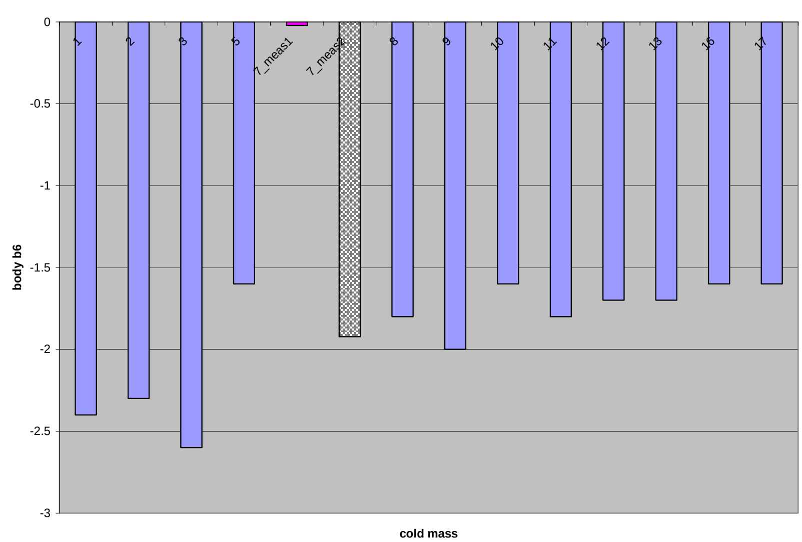

Figure 3: Measured normal dodecapole in the magnet body at injection field (669A). Measurements of MQXB07 were made in two different test cycles, before and after repair of a heater on one of the two cold masses in LQXB06.

For comparison, similar summary plots of the body b_{10} and body transfer function (B_2/I) are given in Fig. 4. These are the low order field components in which one expects a hysteretic component. We see reasonable agreement between the measured values in MQXB07 in the first and second tests and in both cases values similar to the other cold masses.

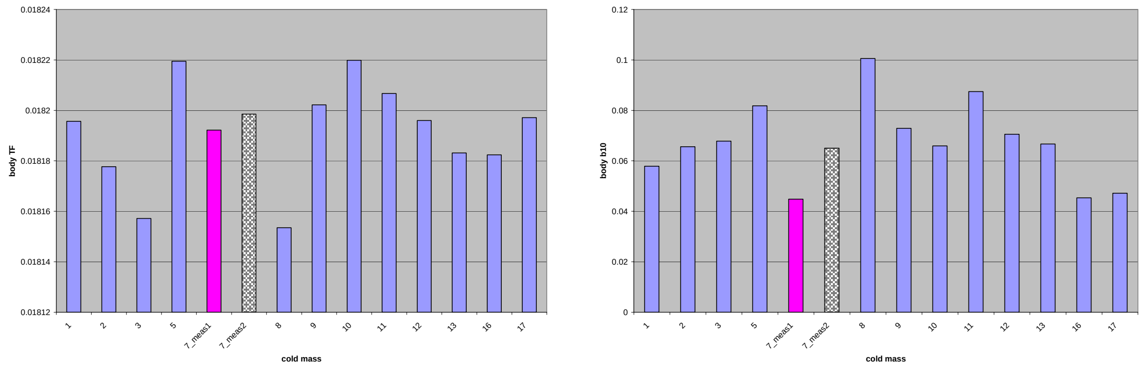

Figure 4: Measured b_{10} and transfer function (TF) in the magnet body at injection field.

We consider the following possibilities for the anomalous b_6 measurement at injection in the discussion that follows.

1) The measurement was made at the wrong current.
2) The measurement was made at 669A but on the down ramp.
3) The measurement was made at 669A without a cleansing quench (i.e. in a dirty magnet).
4) The measurement was at 669A after a long delay during which the b_6 decays.

We discuss these point by point.

1) The recorded current measurement is 669A. The transfer function as measured is at the correct value which, given the usual saturation of B_2 with current, must have been taken at injection. This pretty much means the measurement was taken at 669A. A piece of secondary evidence is that the 20 pole (b_{10}) also shows hysteresis.
2) The b_6 in the original measurement at 669A is at the same value as the higher current measurements (e.g. at the geometric value). If it were taken on the down ramp, it should be on the upper branch of the hysteresis, say at positive 1-2 units. It would not be at the geometric.
3) A somewhat similar argument applies here, the dirty magnet might have a smaller hysteretic value (smaller in absolute value), but not no hysteretic at all. For example, in model magnet HGQ002, we see a b_6 of -3 units in the first ramp of the virgin magnet and -2 units on subsequent ramps. The b_6 isn't at the geometric of -1.5 units on the subsequent ramps.
4) While the b_6 decays toward the geometric, it doesn’t reach it on any conceivable time scale and the rate of decay slows as decay takes place. In this magnet, after 12 minutes, the b_6 has decayed to -1.4 units from -1.9 with a decay rate 0.01 units/min.

If one considers the ensemble of allowed harmonics measurements summarized in Fig. 5 and Fig. 6, the only oddball harmonic is the b_6 measured during the z scan in the first test. Included in the plotted data are measurements made with the same probe in the magnet body during an accelerator loop in the first test. These are in line with the TF and b_{10} measurements in the first test and the TF, b_6 and b_{10} measurements in the second.

We also considered the possibility of a bad measurement or a bad analysis (i.e. bug in the analysis code). With respect to the former, there are 5 measurements in the magnet body all giving the same anomalous value. As to the latter, we go back to the raw flux signals and see that the FFT amplitudes for the dodecapole are quite small for a measurement in the first test z scan and large for a measurement in the second test scan.

We conclude that the likely value of b_6 at injection is -2 units. We are left with two possible explanations for the measurement in the first test. The first is a corruption of all the z scan measurements at 669A that somehow corrupted only one harmonic (e.g. a wholesale insertion of b_6 measurements made at a higher current in the raw data file for the 669A measurements). The other is that the field truly was anomalous. Both are implausible. It is impossible to reject the latter much as one would like to.

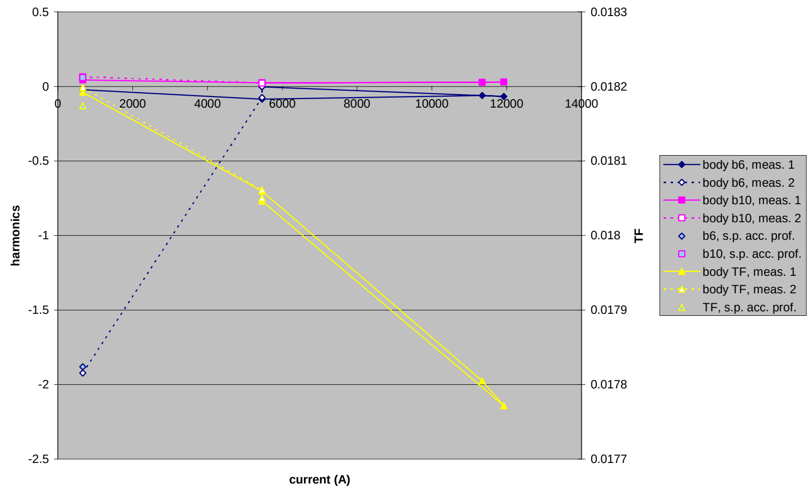

Figure 5: Measurements of the 3 lowest order allowed components of the magnetic field as a function of current in the magnet body of MQXB07.

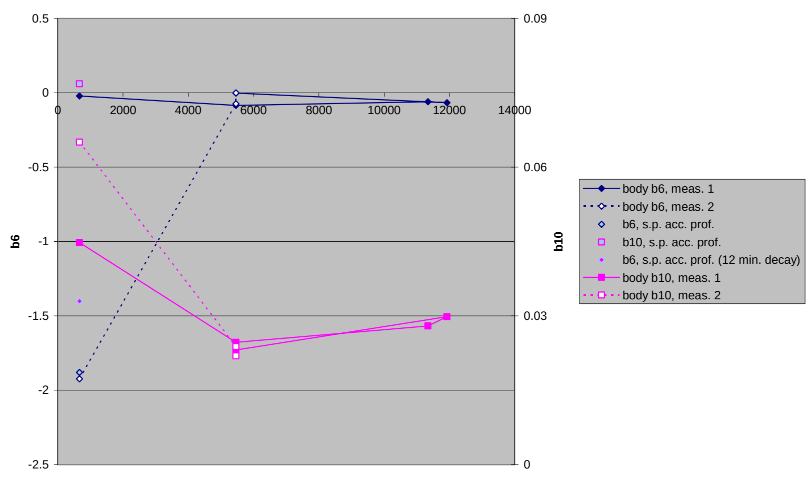

Figure 6: Measurements of the lowest order allowed harmonics as a function of current in the magnet body of MQXB07. Only the harmonics are shown here for easier viewing. An additional point has been added from the short probe accelerator profile.