SLAC Traveler for LCLS Gun Spectrometer Quadrupole Magnets

This traveler is intended to cover magnetic measurements for the three 'waterpipe' quadrupole magnets that are used in conjunction with the BXG gun spectrometer dipole magnet.

This technical note describes the details of the magnetic measurements needed to characterize the QG type quadrupole magnets (small green quadrupole magnets located in the gun and gun-spectrometer region) and to characterize the embedded dipole correctors. The 3 magnets (QG01, QG02 and QG03) of this family are to be used only while running beam into the gun spectrometer beamline. For characterizing the beam energy spread for the nominal 1nC standard tuning only QG02 and QG03 are used. For measuring in more details the longitudinal properties of the beam, the three magnets are to be run. The standardization and calibration of these magnets will be done following a procedure similar to that of the ET magnets. However, steering coils are embedded in those magnets, so the calibration should be repeated while the correctors are on. Finally, since QG01 is on the main beamline, the remnant field in QG01 after switching it off and while beam is run in operation mode should not exceed 5Gauss in integrated gradient value.
A magnet of this family (borrowed from the GTF, before the poles were reshaped) had already been studied for determining the degaussing procedure. Results have been reported in
http://www-ssrl.slac.stanford.edu/lcls/technotes/lcls-tn-06-3.pdf
The dipole field will also be characterized. As the beam is ±3mm large (1.24 mm rms) for the nominal tuning, a good field region of ±6mm has been defined for the dipole field. A requirement of $|\Delta B/B| < 10^{-3}$ at $r = 6$ mm for the dipole field is acceptable.

Receiving:

The following information is to be noted upon receipt of the magnets by the SLAC MFD group:

Received by:		← name
Date received:		← mm/dd/yy
SLAC drawing number:	SA-380-313-01	
Vendor serial number from magnet label:	1	
SLAC approved electrical safety covers?		Y/N

Place barcode sticker on magnet and duplicate the barcode sticker here →	SLAC LCLS 001030

Preparation:

The beam direction should be clearly labeled on the quadrupole and the field polarity should be arranged as shown in Fig. 1, with power supply generating positive current ('normal' polarity).

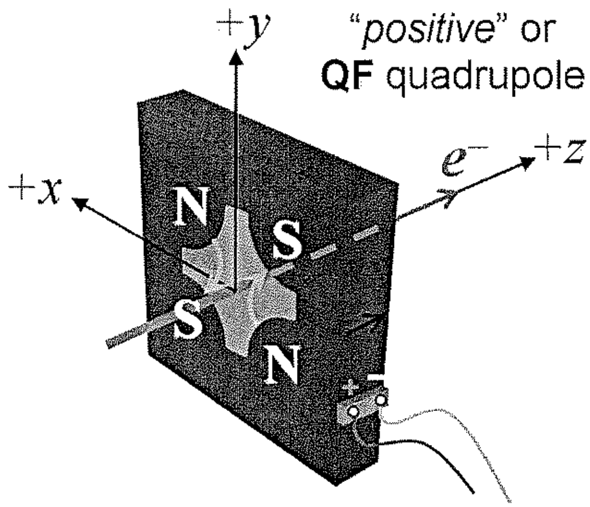


Figure 1. Polarity of quadrupole field with positive power supply output current ('normal' polarity).

Beam direction arrow applied	[illegible]	← installer initials

Fiducialization:

Fiducialization has already been performed by the CMM group; attach their traveler to this traveler.

Magnetic Measurements:

Upon receipt of the magnet, the following information should be recorded:

Date of arrival to Magnetic Measurements group:	4/8/2006	← mm/dd/yy
Responsible measurement operator name:	ADF	← name

URL of Magnetic Measurements Data File:

http://www-group.slac.stanford.edu/MET/MagMeas/MagData/LCLS/quad/ ~~001030~~ QG01

1) Verify that the magnets are complete and undamaged, including wiring connections.

Incoming inspection OK	ADF	← technician initials

Please measure the length-integrated field, $\int Gdl$ over several current settings and the field harmonics as described below.

2) Connect the magnet to a bipolar 12-A power supply, preferably an MCOR12. Use care in turning these supplies on and off to limit current spikes that may occur. Run the magnet up to 8 A for ~30 minutes to warm it up (record temperature).

Ambient temperature	24.51	degrees C
Final magnet temperature	46.41	degrees C

3) Standardize the magnet, starting from 0 to +12 A, then through 3 full cycles from +12 A to −12 A and back up to +12 A, finally ending at −12 A (the MCOR12 ramp rate is not controllable, but a flat-top pause time of 5 seconds is desired at each maximum and minimum current).

Magnet standardized	ADF	technician name

4) Maintaining the history cycle, measure the length integrated gradient, $\int Gdl$, from −12 A to +12 A in 1-A steps, including zero (25 'up' measurements).

Data filename:	strdat.ru1

5) Still maintaining the history cycle, measure $\int Gdl$ back down from +12 A to −12 A in 1-A steps, including zero (25 'down' measurements).

Data filename:	~~hardat.ru2~~ strdat.ru1

6) Measure field harmonics at quadrupole coil settings of: −12, −6, +1, +6, and +12 A using about a 1-inch diameter probe.

Rotating coil name	DC2-54	name
Rotating coil radius	0.012313	meters
Data filename:	hardat.ru2	

Traveler __Addendum__ for the LCLS 'QG01' Gun Quadrupole Magnets

(August 15, 2006)

This traveler is intended to cover *new* magnetic measurements required for the three 'waterpipe' quadrupole magnets (QG01, QG02, and QG03) that are used in the gun and gun-spectrometer region. The new measurements are required since the dipole coils have been replaced with 7 turns as opposed to the original 60 turns. The quadrupole coils are unchanged and the magnets have not been disassembled, so only the dipole coil measurements are required for this addendum. **This entire addendum procedure only needs to be done for the QG01 magnet.**

Receiving:

The following information is to be noted upon receipt of the magnets by the magnetic measurements group:

Received by (initials):	ADF
Date received (mmm-dd-yyyy):	8/15/06
SLAC drawing number:	SA-380-313-01
Vendor serial number from magnet label:	1
SLAC bar-code number on magnet:	001030

Preparation:

The beam direction should already be clearly labeled on the quadrupole and the 45-degree rotated dipole fields should have polarities shown in Figure 1, with positive power supply output current ('normal' polarity).

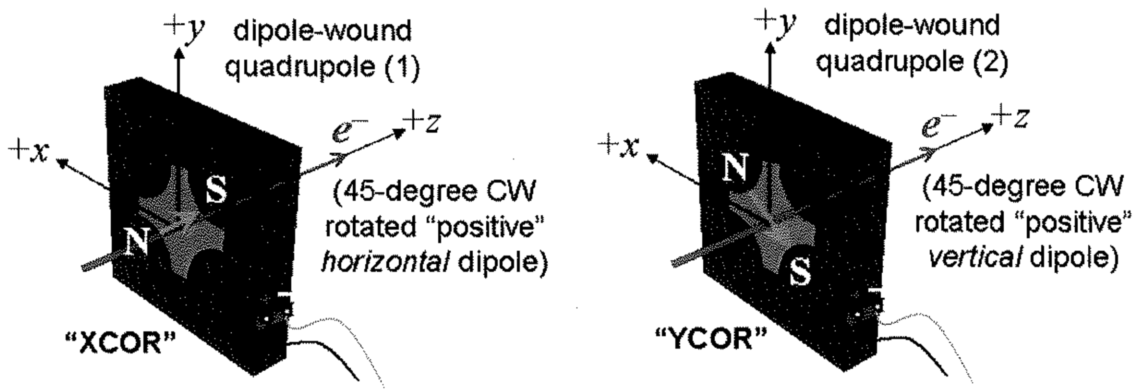


Figure 1. Quadrupole magnets additionally wound with dipole steering coils rotated by 45 degrees. The case at left is defined as the "XCOR" and that at right is the "YCOR".

Fiducialization:

Fiducialization has already been performed by the CMM group.

Magnetic Measurements: ~~PE~~

~~URL of on-line CMM fiducialization data (please modify or correct if necessary):~~

~~\\web002\www-group\met\Quality\FIDUCIAL REPORTS\~~

1) Connect the quadrupole coil to a bipolar 12-A power supply, preferably an MCOR12.

2) Standardize the quadrupole magnet, starting from 0 to +12 A, then through 3 full cycles from +12 A to −12 A and back up to +12 A, ending at −12 A and then finally setting the current to zero (the MCOR12 ramp rate is not controllable, but a flat-top pause time of 5 seconds is desired at each maximum and minimum current).

Magnet standardized (initials):	ADF

3) Degauss the quadrupole field using the procedure below ("Degaussing Procedure").
$|\int G\,dl| = 1.7\,G$ (PE)

4) Disconnect the quadrupole coils from the power supply and re-connect it to one of the two dipole coils.

5) Measure the length integrated dipole field, $\int Bdl$, from −6 A to +6 A in 0.5-A steps, including zero (25 'up' measurements) and then continue down from +6 A to −6 A in 0.5-A steps, including zero (25 'down' measurements).

Data filename & run number:	strdat.ru4

6) Repeat the measurements for the other dipole coil.

Data filename & run number:	strdat.ru5

7) Call P. Emma at 2458 to discuss the results before removing the magnet from the bench.

Degaussing Procedure

The quadrupole current will be ramped up to I_n and then back to $-I_{n-1}$ on each cycle at a rate of 10A/s with 2 s after each ramp, with…

$I_0 = I_{max}$,
$I_1 = -f\,I_{max}$,
...
$I_n = (-1)^n\, f^n\, I_{max}$,
using $f = 0.90$ and for n up to 51, and then finally set the current to zero.

Run the magnet current in the sequence of values listed below (sequence is from left to right, and then top to bottom - all units are in amperes):

12.00	–10.80	9.72	–8.75	7.87	–7.09	6.38	–5.74
5.17	–4.65	4.18	–3.77	3.39	–3.05	2.75	–2.47
2.22	–2.00	1.80	–1.62	1.46	–1.31	1.18	–1.06
0.96	–0.86	0.78	–0.70	0.63	–0.57	0.51	–0.46
0.41	–0.37	0.33	–0.30	0.27	–0.24	0.22	0.197
0.177	–0.160	0.144	–0.129	0.116	–0.105	0.094	–0.085
0.076	–0.069	0.062	–0.056	0			

Thermal Testing

The quadrupole coil of just one of the three magnets shall be run at constant current for successive intervals, as indicated, and the temperature at the surface of a coil shall be recorded:

current	**interval**	**temperature (°C)**
0 amps (ambient)	start (ambient)	18.5
6 amps	2 hours	34.0
8 amps	2 hours	50.38
10 amps	2 hours	69.85
12 amps	2 hours	85+

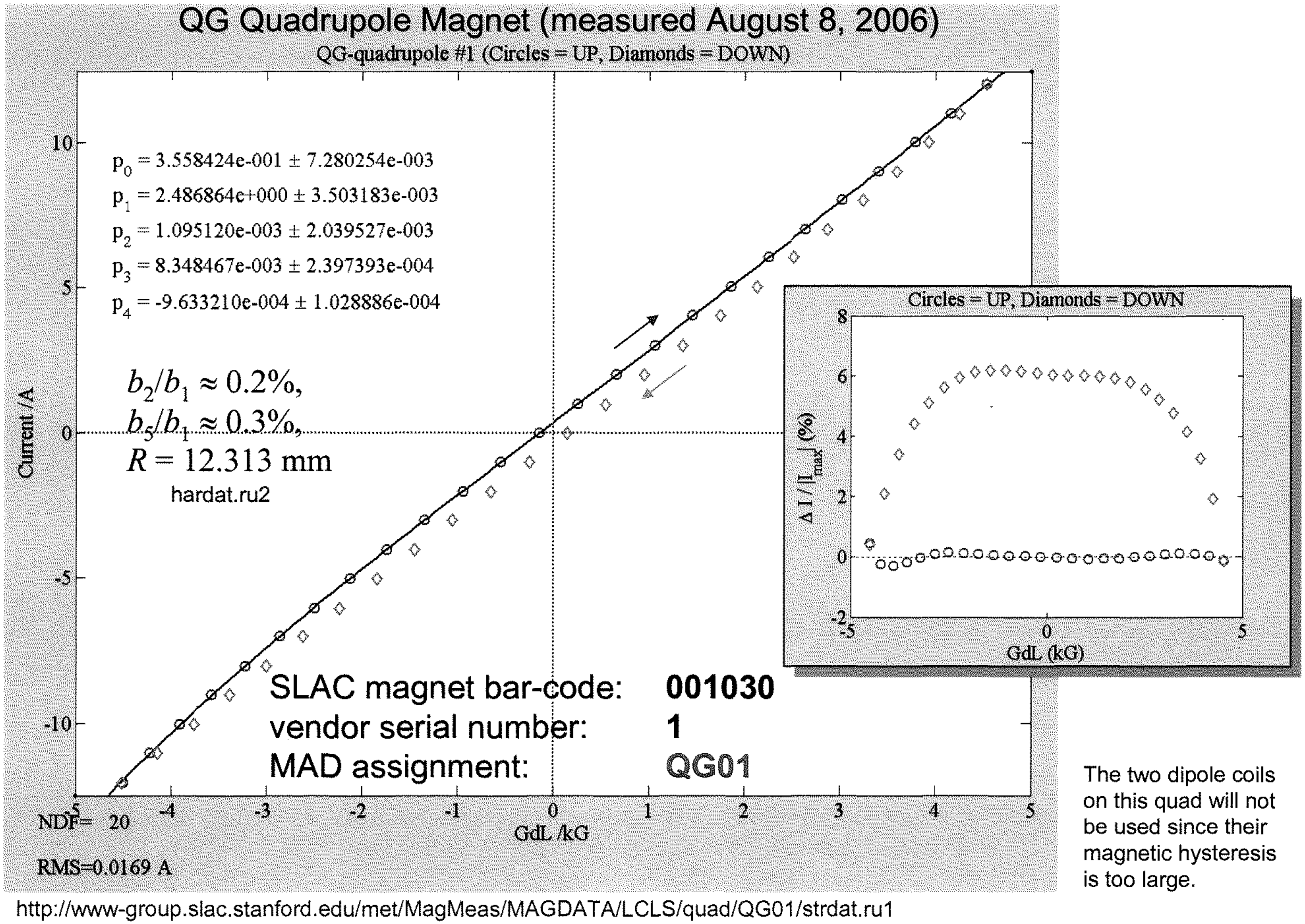
→ Magnet should not be run over 10 A. (–PE, 8/25/06)

This section is to be completed by P. Emma.

Magnet accepted (signed):	NOT TO [redacted] BE USED –PE *
Assigned beamline location (MAD-deck name):	——

Upon full completion, send this ***traveler-addendum*** to Kathleen Ratcliffe at mailstop 18.

* QG01 will ~~not be~~ be removed from the LCLS beamline design and replaced with an air-core corrector pair. –PE; 8/21/06



The two dipole coils on this quad will not be used since their magnetic hysteresis is too large.