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QM02 Strength Measurement *

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In late April, Paul Emma reported that his orbit fitting program could find a reasonably good fit only if the strength of QM02 was changed from design value of -5.83 kG to -6.25 kG — a strength change of 7.3%. In late May, we made a focal length measurement of QM02 by turning off all focussing optics between YC07 and BPMS1 (in the spectrometer line) except for QM02 and adjusted the strength of QM02 so that vertical kicks by YC07 did not produce any displacements at BPMS1 (see Figure 1). The result was quoted in the LCLS elog was that QM02 appeared to 6% too weak, and approximately agreed with Paul's observation.

The analysis used for the entry in the log book was based on the thin lens approximation and used the following numbers:

Distance YC07 to QM02	5.128	m
Distance QM02 to BPMS1	1.778	m
Energy	135	MeV

These distances were computed from the X,Z coordinates given the on the large plot of the Injector on the wall of the control room. On review of the MAD output file coordinates, it seems that the distance used for QM02 to BPMS1 is not 1.778 m. The correct value is

Distance, center of QM02 to BPMS1	1.845	m

There may be a typo on the wall chart values for the coordinates of BPMS1, or perhaps there was a misinterpretation of edge versus center of QM02. In any case, the effect of this change is that the thin lens estimate changes from 6% too weak to 9% too weak.

At John Galayda's suggestion, we looked into the thin lens versus thick lens approximation. A Mathematica program was written to solve for the K value of the QM02, in the thick lens approximation, that provides point to point focusing from YC07 to BPMS1, and to compare this number with the value obtained using the thin lens approximation. The length of QM02 used in the thick

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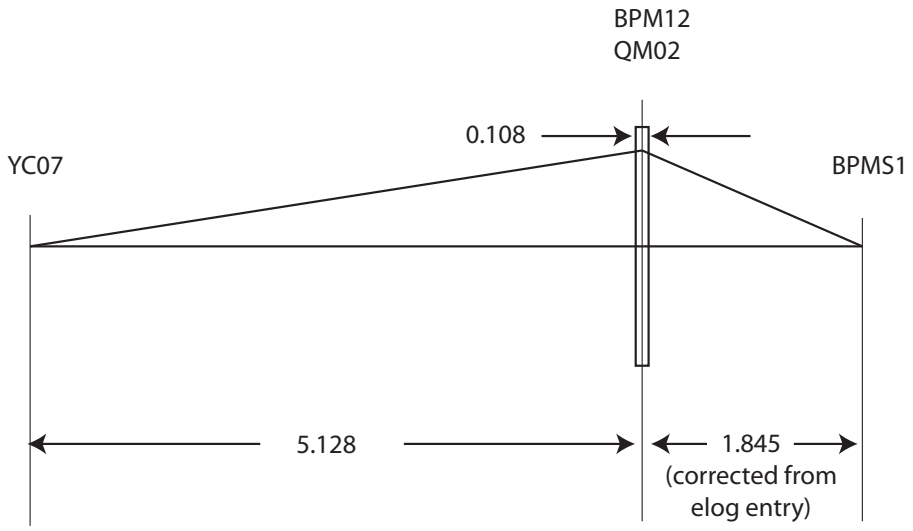

Figure 1: Schematic of measurement. Horizontal scale is in proportion to real distances. Distances in meters.

lens calculation is the effective length determined by magnetic measurements of 0.108 m. The result of the Mathematica calculation is that the thin lens approximation predicts less magnet strength is required to produce the same focussing by about 1.3%.

When both the distance correction and the thick lens approximation are taken into account, the result is:

$$\frac{K_{thick} - K_{mm}}{K_{thick}} = -7.6\%$$

where K_{mm} is the value obtained from magnetic measurements and K_{thick} is the value of K obtained from the focal length measurement in the thick lens approximation. That is, QM02 acts weaker than it was measured by magnetic measurements by 7.6%. This is remarkably close to Paul's original estimate.

The unexpected weakness could in principle be due to several things: shorted turns, a current calibration error, magnetic measurement error; it could even be due to the presence of an gradient from QM01, which is of opposite sign and right next to QM02, despite it being set to zero current (although it was not DAC-zeroed). Plans have been implemented to remove and replace QM02 at the earliest ROD.