Magnetic Measurements of a QM Quadrupole

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Background:

Two QM (affectionately named Jackie and Patsy) and two QO (Felicia and Tessa) quadrupole magnets were received at Jefferson Lab from the University of Kentucky back in the mid-1990s. One of the QM (Patsy) and both QOs were installed in Hall-A and referred to as the Moeller Quads. One QM (Jackie) remained in Physics Division storage.

Questions were raised regarding the field maps for the installed magnets. Rather than removing these magnets for measurement it was decided to map out the spare QM (Jackie.) This magnet was transported from the Physics Storage Building to MagTest. The magnet had been wired as a dipole so jumpers were swapped to create a quadrupole. The magnet was visibly abused with potting on several coils broken off. Numerous water leaks had to be fixed on the coil cooling circuit. The magnet lacked lifting holes so a special fixture had to be built for rigging. The coils were hi-potted to ground at 1000 volts and a leakage current of 60 μA was measured.

Measurement Requirements:

Requirements for magnetic measurements were outlined by J. Benesch and M. Tiefenback (and negotiated by J. Karn) as follows:

- power supply ramp rate set to 10 Amps/sec
- generate two uni-polar field maps: one for positive and one for negative hysteresis currents
- take measurements at 30 amp increments over the $0 \rightarrow \pm 300 \rightarrow 0$ Amps loop

Magnetic Measurements:

For magnetic measurement databasing the magnet was named QM001. One of the magnet's power input leads was arbitrarily defined and labeled as the "positive" post. The magnet was connected to MagTest Danfysik #2 Power Supply (460 Amp/50 Volt.) This power supply has a reversing switch capable of changing the output DC polarity. The power supply ramp rate was adjusted (in hardware) to achieve the 10 Amp/sec requirement. A software dwell time of 5 seconds was used at the max and min currents.

For each new measurement data set the magnet was standardized using the following sequence:

1. reversing switch set to desired polarity
2. set to 300 Amps for 5 minutes and back to zero amps
3. run through 5 hysteresis cycles 0 → 300 → 0 Amps

Measurements at various currents were taken using the "Operations" hysteresis protocol. Specifically, the magnet would be set to the desired current, cycled through two hysteresis loops, and then return back to the set current (egs For a 120 A set point: 120 → 300 → 0 → 300 → 0→ 120.)

Magnetic measurements were made using the 2" diameter rotating probe (P2B) on the Multipole Measurement Stand. This probe provides the integrated field of the quadrupole component at the radius of the probe. The magnet's mechanical center was used to center the magnet on the probe. Five rotations of the probe were made and averaged at each current setpoint. Data was collected in 30 Amps steps from 0 → 300 → 0 Amps.

A total of six individual field map measurements were made at alternating polarities. The three data sets at a given polarity were checked for repeatability and averaged together to generate the final maps. The final maps are given in Table 1.

Current (amps)	B'L (G)	
	Positive	Negative
0.0	244.3	209.5
30.0	5216.1	5212.8
60.0	10317.2	10318.1
90.0	15463.8	15470.7
120.0	20635.9	20634.0
150.0	25778.9	25785.5
180.0	30893.3	30919.1
210.0	35975.0	35972.2
240.0	40991.0	41015.3
270.0	45879.2	45911.3
300.0	50598.9	50645.0
270.0	45881.0	45922.7
240.0	40987.7	41026.3
210.0	35983.7	36001.2
180.0	30898.2	30904.7
150.0	25772.8	25777.5
120.0	20637.1	20631.8
90.0	15479.4	15476.9
60.0	10317.6	10319.8
30.0	5216.4	5215.0
0.0	246.2	237.1

Table 1

Karn Iso B(I) = 169.545I + 2
Neg 169.535I - 238
Node 1 175.683I + 248.62
2 175.927I + 49.1

ratio .96464

Peter Jacobs (U Kentucky) = 1.000
multiply Soichi's values
by .9653

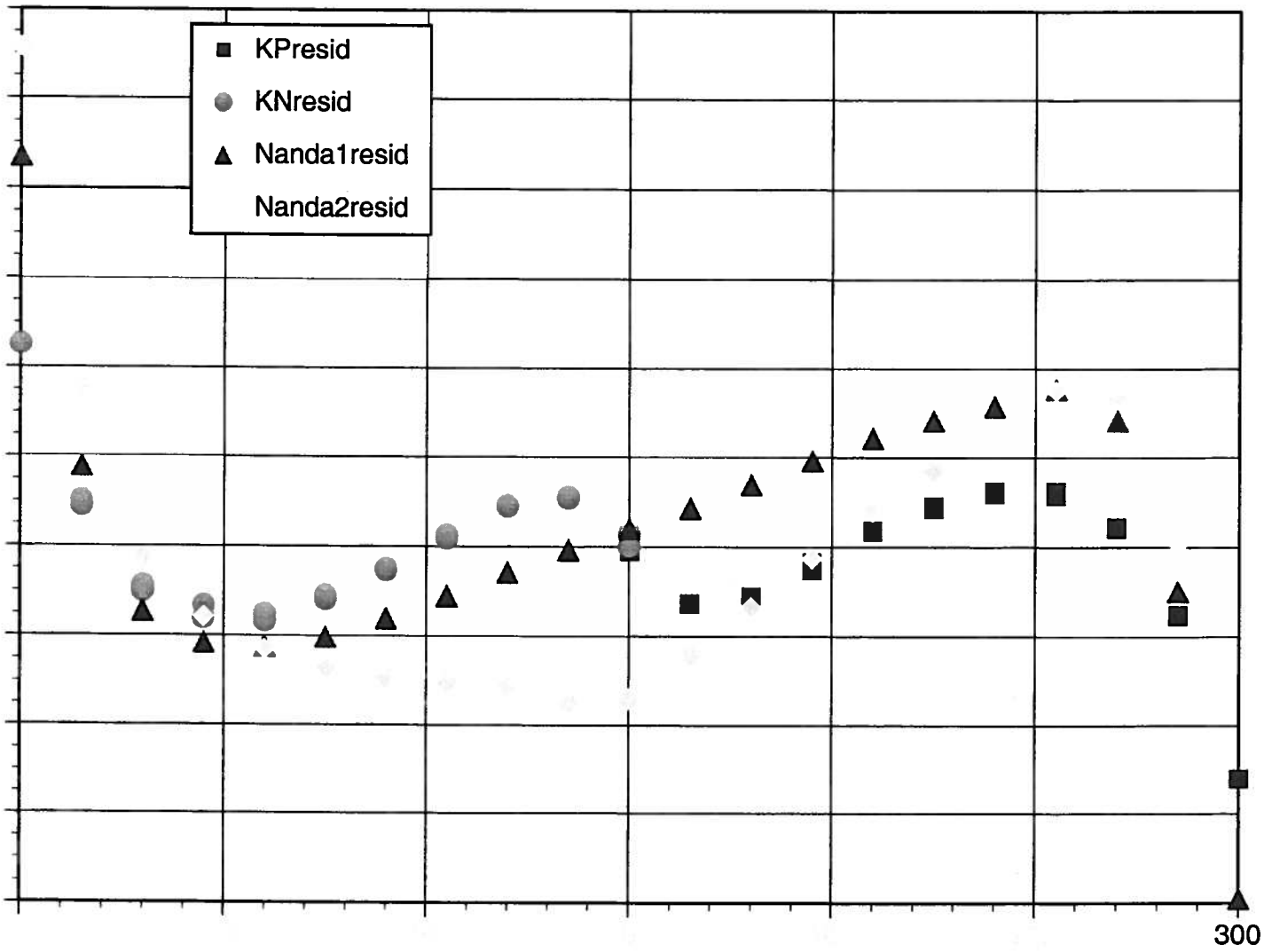
It should be noted that the probe used for the measurements (P2B) required recalibration. Prior to these measurements the litz wire coil in the probe lost 5 turns (from 90 to 85 turns) and had to have these missing turns bypassed. The calibration constant of the probe should thus require scaling:

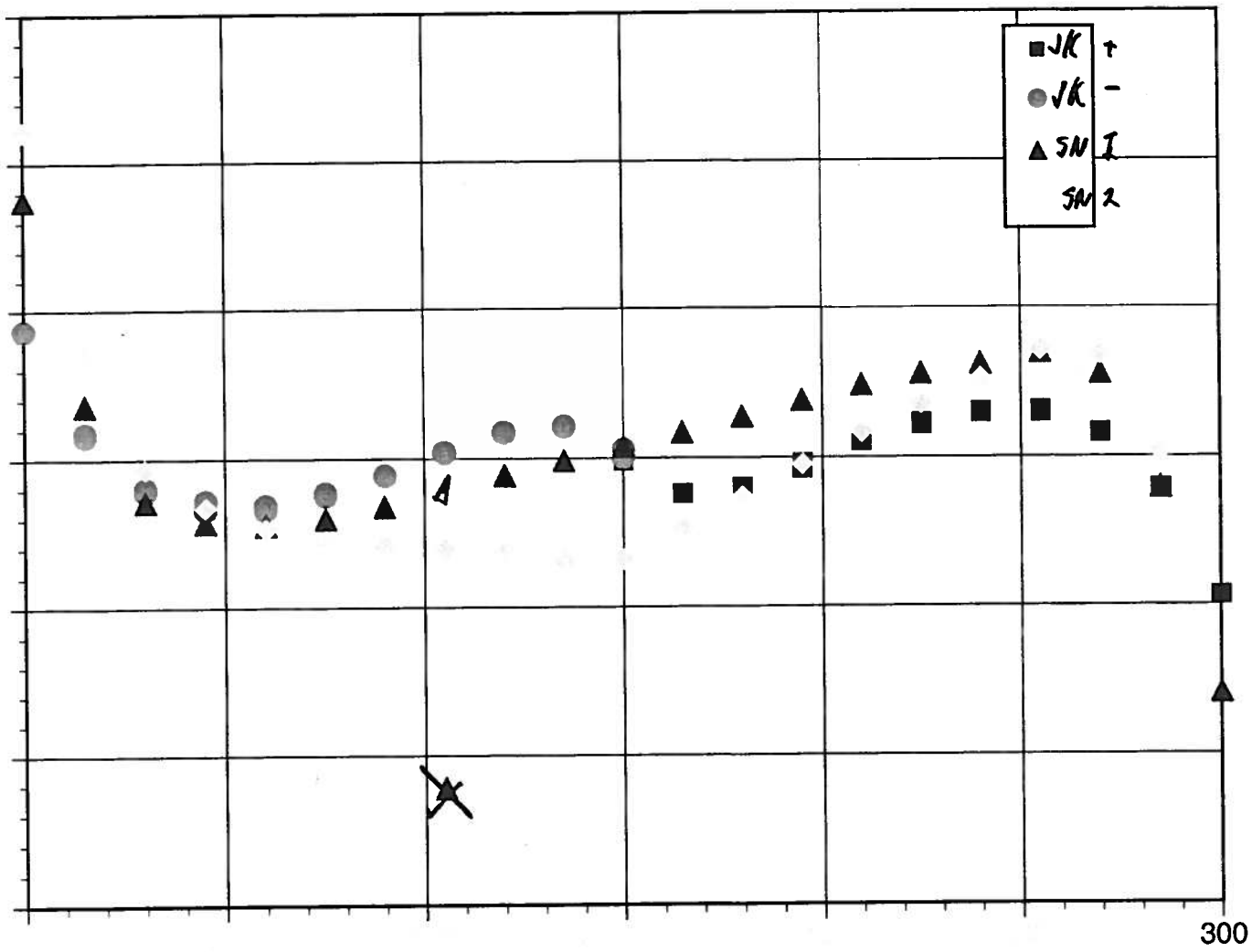
$$C_{new} = C_{old}\left(\frac{N_{old}}{N_{new}}\right) = (0.4569\frac{G-cm}{\mu V-\sec})\left(\frac{90turns}{85turns}\right) = 0.4838\frac{G-cm}{\mu V-\sec}$$

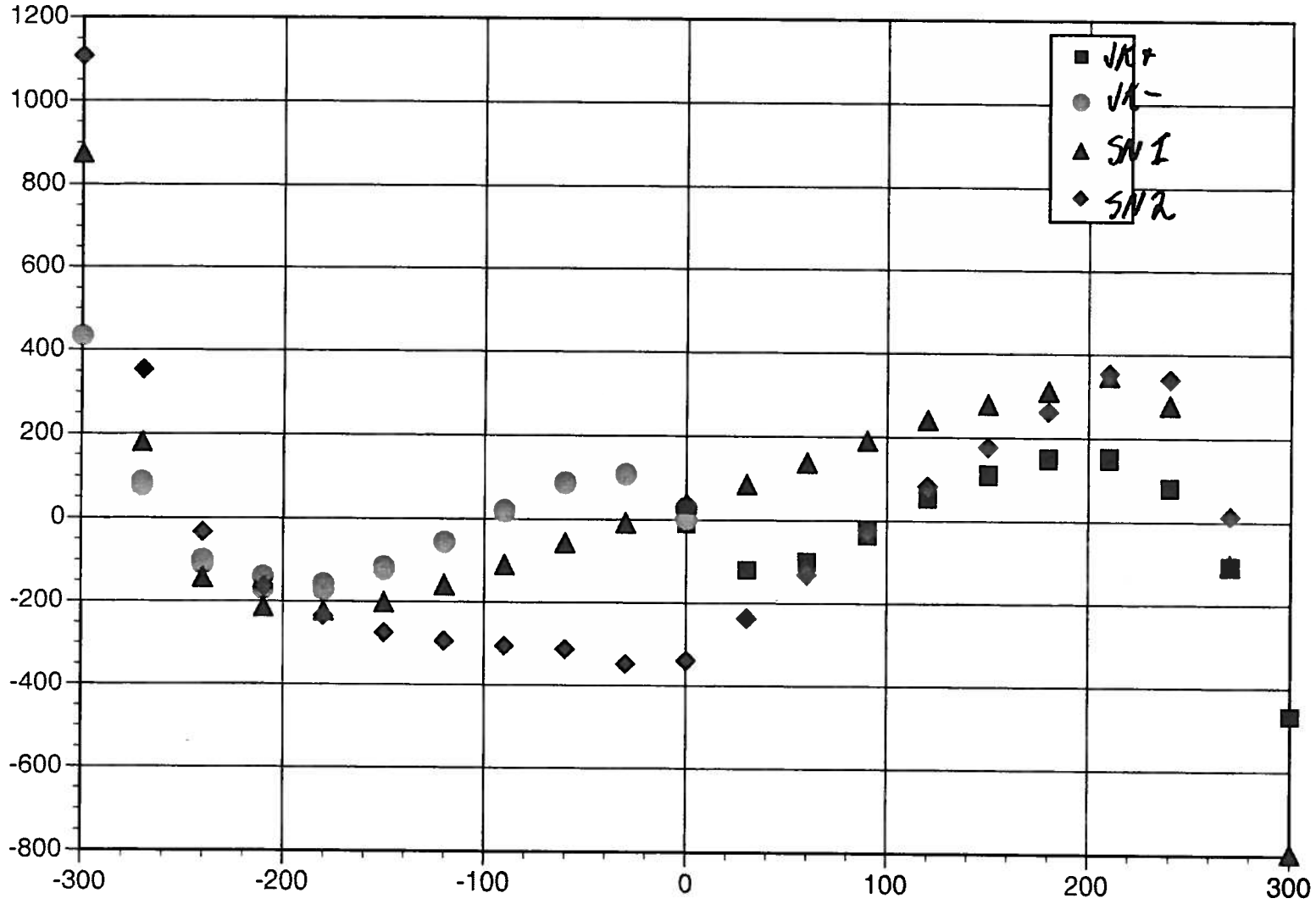
The calibration correction was then verified using the "Standard QG" magnet. This magnet was used for the last calibration of the probe in April of 1997. Three data sets were taken, averaged, and showed agreement to the 1997 calibration to ±0.5%.

Reference Documents:

- M:\MagTest\DataBase\QM\Analysis\QM001 Analysis.xls
- M:\MagTest\DataBase\Qg\Analysis\ QG-STD Calibration on P2B, Rev. B.xls


KPresid
KNresid
Nanda1resid
Nanda2resid
300


JK +
JK -
SN I
SN 2
300


1200
1000
800
600
400
200
0
-200
-400
-600
-800
-300
-200
-100
0
100
200
300
JK+
JK−
SN1
SN2