Superconducting Magnet Division

Magnet Note

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Title: Measurement of CQS Cold Mass Displacement Due to Cooldown

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MEASUREMENT OF CQS COLD MASS DISPLACEMENT DUE TO COOLDOWN

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Summary

Two novel methods were developed for determining the magnetic centers of RHIC quadrupoles and correctors: the survey antenna and the colloidal cell. The two methods give consistent results. The displacement of two CQS magnets due to cooldown was measured with these methods. The average vertical displacement, due to the thermal contraction of the support posts, was 1.825 mm ± 0.052 mm. The average horizontal displacement was practically zero.

A colloidal cell was developed to measure the centers of RHIC quadrupoles and sextupoles (1,2). The cell, a glass cylinder, contained iron filings suspended in a colloidal solution. The colloidal cell was illuminated with polarized light from one end of the bore tube in a CQS assembly. A second polarizer, rotated 90° from the first, was placed at the opposite end. The collimated light is transmitted past the two polarizers only if the colloidal cell is in a magnetic field. The iron filings are aligned by the magnetic field, producing, after the second polarizer, a pattern of light and dark which shows the field center. Digital analysis of the image gives the field center within ± 50 μm.

The survey antenna (3) was developed so that room temperature measurements of magnet centers could be made more easily. A survey antenna is based on the tangential rotating coils that contain several precisely located windings and are used for the measurement of harmonics. Survey antennas do not rotate. They are precisely located with respect to fiducial notches in the magnet yoke. The magnets are excited by a sinusoidal current. Analysis of the voltage waveforms from two sets of windings yields the transfer function and also the feeddown term. With this information, the location of the center with respect to the fiducials is determined. Reference (2) gives the details of this analysis. It also summarizes warm magnet center data measurements made on many magnets with both the colloidal cell and the survey antenna. For these measurements, the difference between the colloidal and survey antenna measurements had an rms variation of 75 μm. The average differences were 50 μm for the horizontal measurement and 25 μm for the vertical measurement. Given the value of the rms, the differences are consistent with zero.

After a series of development runs, satisfactory warm and cold data were taken on CQS206 in the summer and fall of 1996. The results are given in the first two figures. The center of the sextupole was measured in two positions. The center of the quad was measured in three to five positions. The colloidal measurements were: warm on a level granite surface plate on Oct 20, 1995 (ColW1), cold right after cooldown on Aug. 7,

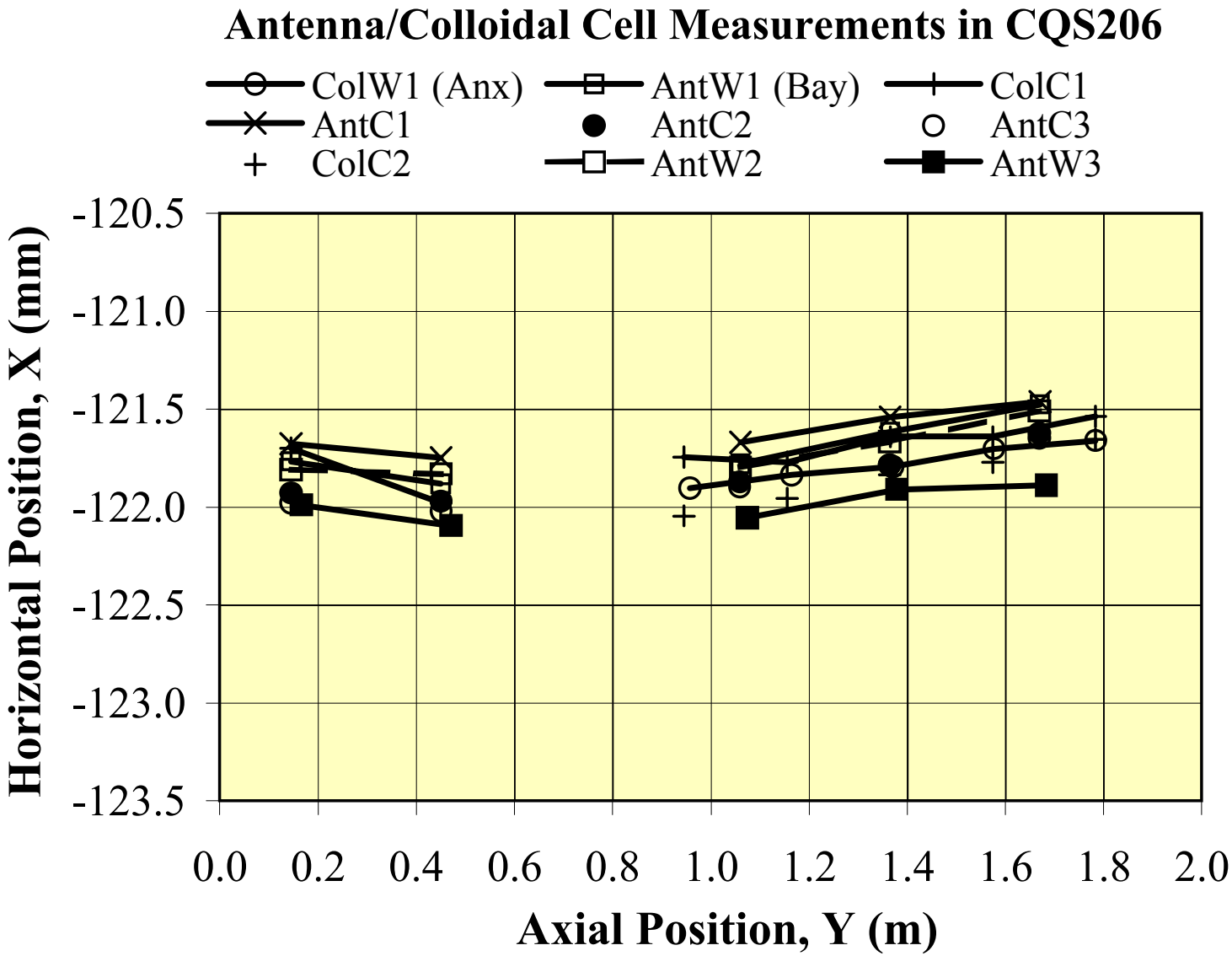
1996 (ColC1), cold on Aug 12, 1996 after holding the magnet near 4.6 K for several days (ColC2). The survey antenna measurements were: warm just before cooldown on Aug 5, 1996 (AntW1), cold on Aug 7, 1996 (AntC1), twice on Aug 12, 1996 (AntC2 and AntC3), warm on the test stand on Sept 24, 1996, and warm on the surface plate on Nov 19, 1996. The average vertical and horizontal displacements based on all warm and all cold data (antenna, colloidal cell, sextupole, quadrupole, short cool down, long cool down, surface plate, test stand) are given in the Table. Each of the measurements has a rms variation of about 150 μm. (Cold and warm measurements on the test stand are more difficult than the warm measurements for several reasons, so the rms variation of these measurements is larger than for the many warm measurements on the surface plate noted above.)

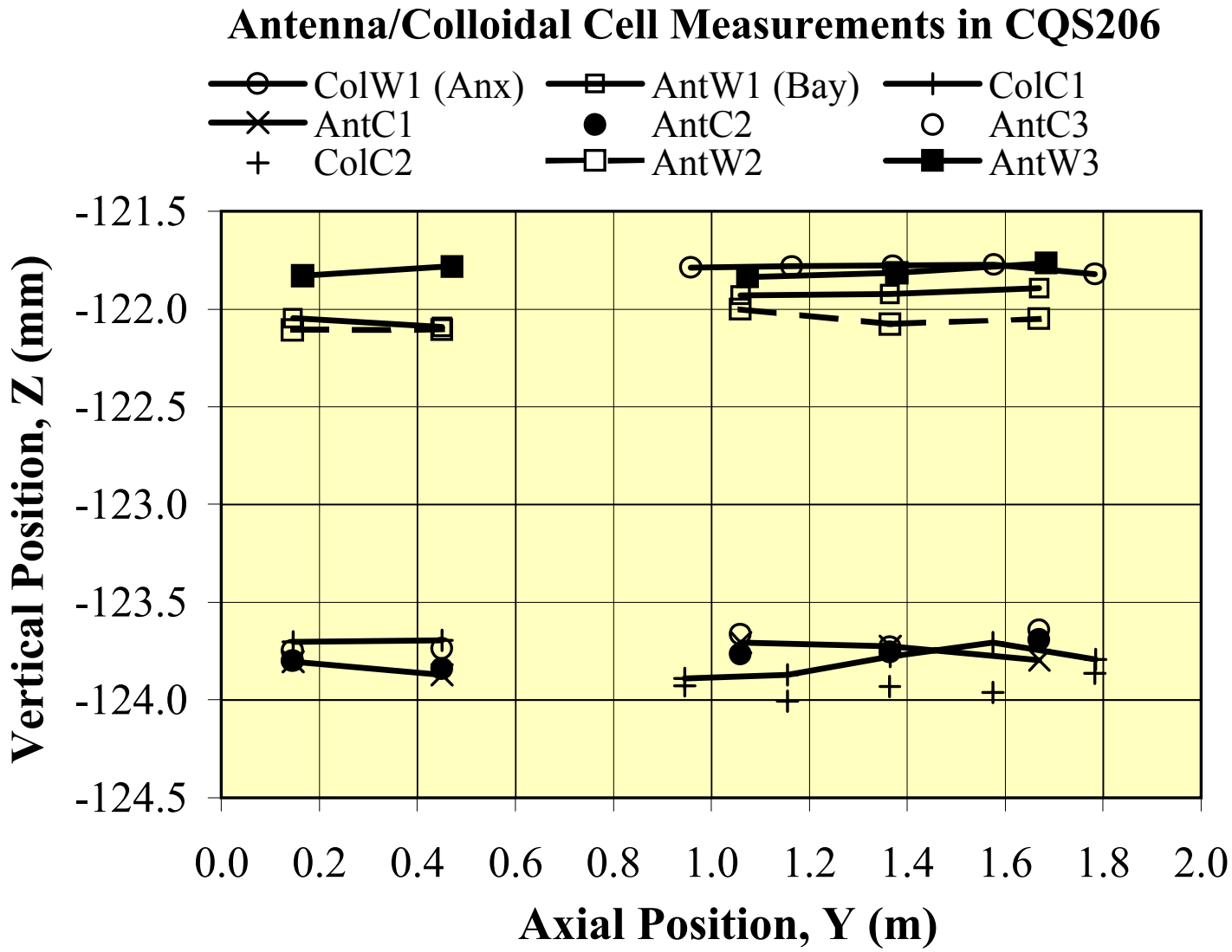
CQS103 was measured early in 1997 in order to check whether the assembly had the same shape warm and cold. (During production, weld stripes were used to straighten the assembly.) The warm measurements were made with the survey antenna. The results are shown in the last two figures and in the second table.

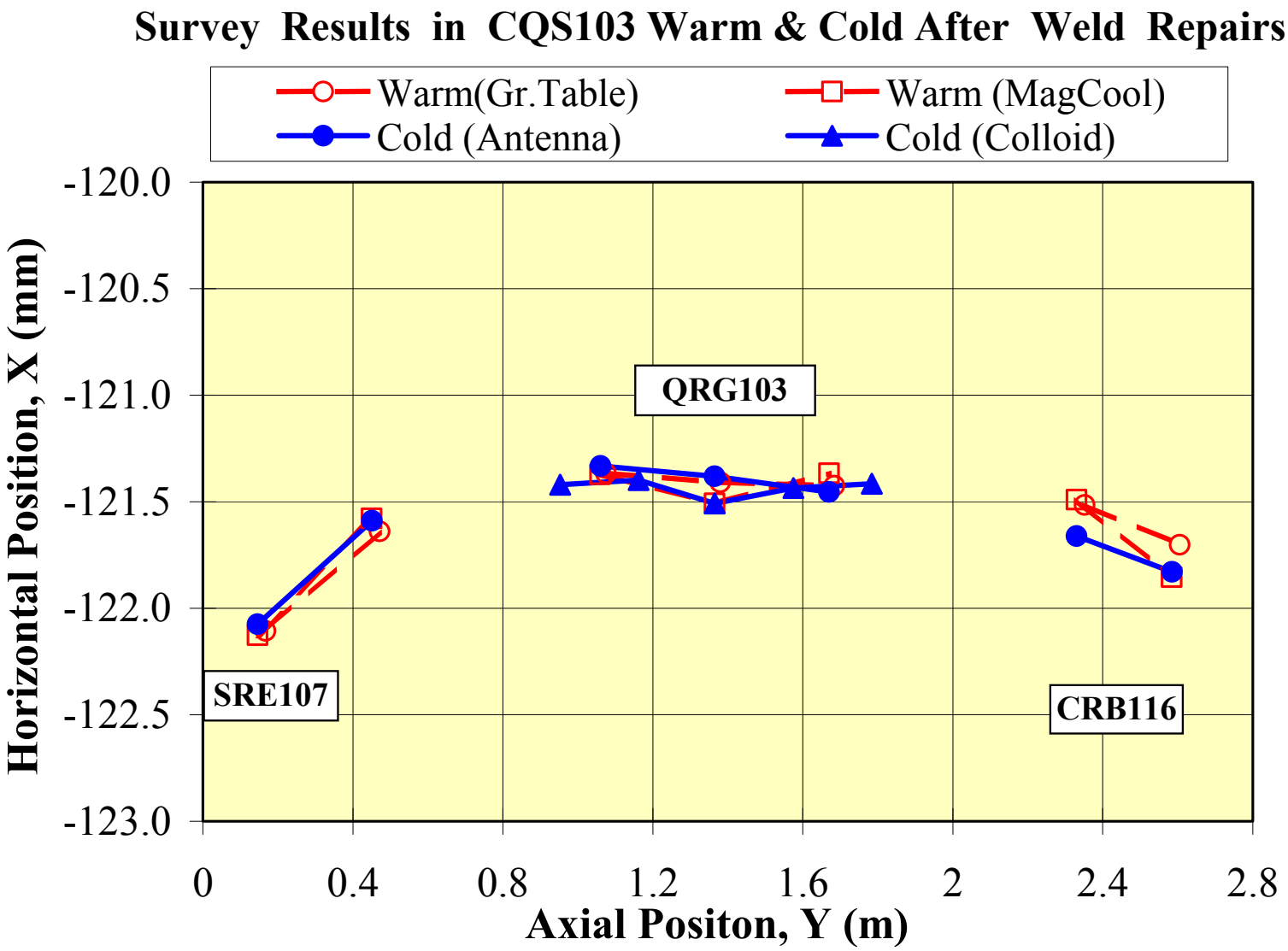
Measurements of both CQS units are combined in the third table.

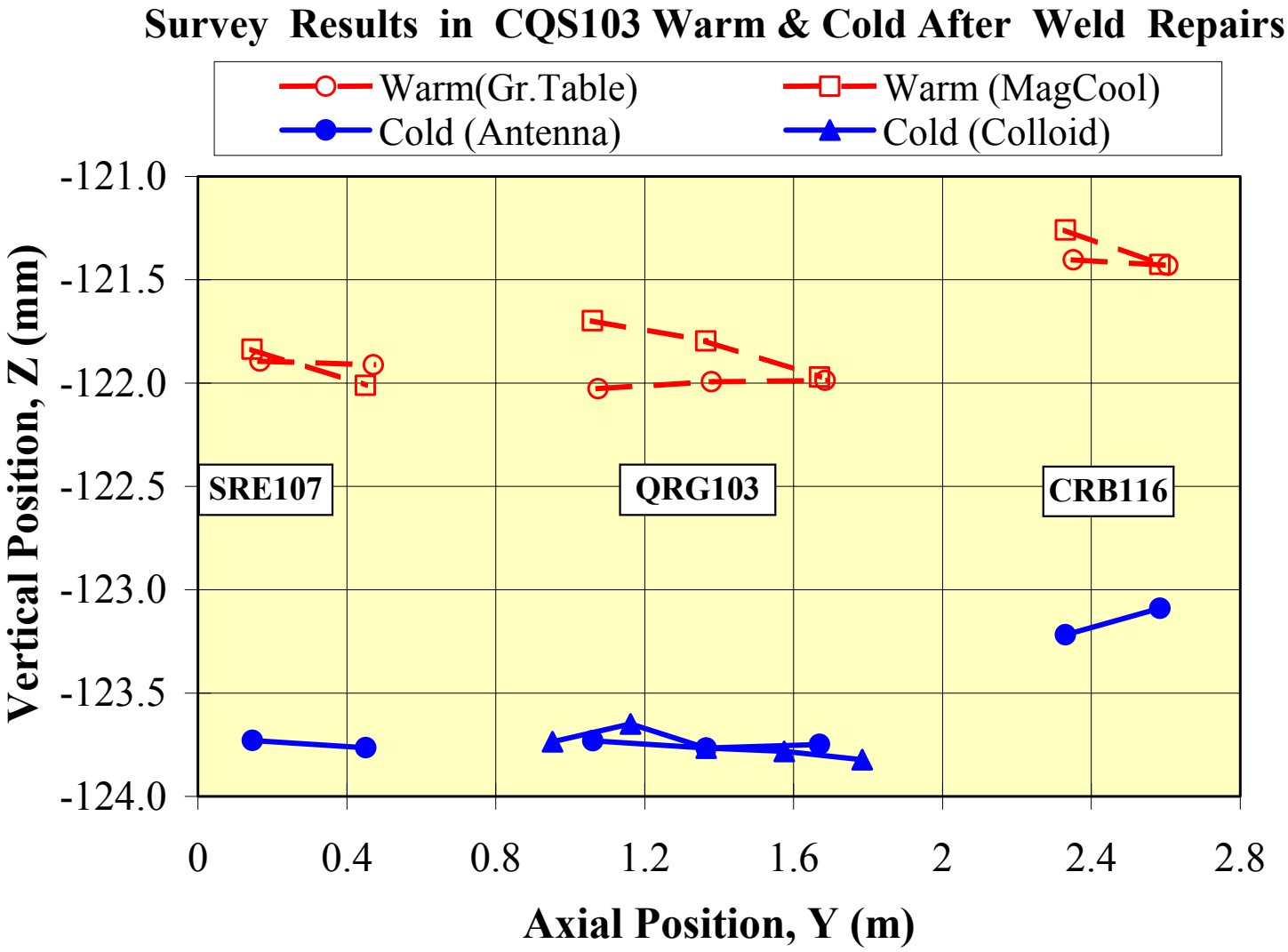
References:

(1) M. A. Goldman, R. E. Sikora, T. J. Shea, "Preliminary Studies on a Magneto-Optical Procedure for Aligning RHIC Magnets," Proc. 1993 Particle Accelerator Conference, Washington DC, p. 2916.
(2) D. Trbojevic et al, "Alignment and Survey of the Elements in RHIC," Proc. 1995 Particle Accelerator Conference, Dallas, TX, p. 2099.
(3) A. Jain et al, "A 'Survey Antenna' for Determining Magnetic Centers," Magnet Division Note #624-11 (AM-MD-324), January 2003 (talk from IMMW X, Fermilab, 1997)


Antenna/Colloidal Cell Measurements in CQS206
ColW1 (Anx)
AntW1 (Bay)
ColC1
AntC1
AntC2
AntC3
ColC2
AntW2
AntW3
Horizontal Position, X (mm)
-120.5
-121.0
-121.5
-122.0
-122.5
-123.0
-123.5
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Axial Position, Y (m)


Antenna/Colloidal Cell Measurements in CQS206
ColW1 (Anx)
AntW1 (Bay)
ColC1
AntC1
AntC2
AntC3
ColC2
AntW2
AntW3
-121.5
-122.0
-122.5
-123.0
-123.5
-124.0
-124.5
Vertical Position, Z (mm)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Axial Position, Y (m)


Survey Results in CQS103 Warm & Cold After Weld Repairs
Warm(Gr.Table)
Warm (MagCool)
Cold (Antenna)
Cold (Colloid)
-120.0
-120.5
-121.0
-121.5
-122.0
-122.5
-123.0
Horizontal Position, X (mm)
QRG103
SRE107
CRB116
0
0.4
0.8
1.2
1.6
2
2.4
2.8
Axial Positon, Y (m)


Survey Results in CQS103 Warm & Cold After Weld Repairs
Warm(Gr.Table)
Warm (MagCool)
Cold (Antenna)
Cold (Colloid)
-121.0
-121.5
-122.0
-122.5
-123.0
-123.5
-124.0
Vertical Position, Z (mm)
SRE107
QRG103
CRB116
0
0.4
0.8
1.2
1.6
2
2.4
2.8
Axial Position, Y (m)

Warm to Cold Changes in CQS206

Element	Delta-X (mm)	Delta-Z (mm)
Sextupole	0.019	-1.780
Quadrupole	0.035	-1.902
Average=	0.027	-1.841
Std.Dev=	0.011	0.086

Warm to Cold Changes in CQS103

Element	Delta-X (mm)	Delta-Z (mm)
Sextupole	0.031	-1.833
Quadrupole	-0.011	-1.838
Corrector	-0.105	-1.774
Average=	-0.028	-1.815
Std.Dev=	0.069	0.035

CQS Cold Mass Shift on Cool Down

Magnet	Element	ΔX (mm)	ΔZ (mm)
CQS103	Sextupole	0.031	-1.833
	Quadrupole	-0.011	-1.838
	Corrector	-0.105	-1.774
CQS206	Sextupole	0.019	-1.780
	Quadrupole	0.035	-1.902
	Average=	-0.006	-1.825
	Std. Dev.=	0.058	0.052