LCLS-II HXU Measurement Results

This report is intended to document the results of HXU segment tuning at LBNL and ANL. It should be sent to SLAC for approval before the HXU segment gets shipped.

Serial number from manufacturer's label:	HXU-024

Measurement Procedure:

The measurements have been carried out after the undulator segment had been fully tuned according to "LCLS-II Undulator Test Plan" (LCLS-TN-17-1).

General Hall Probe Scan Evaluation Parameters

Undulator Temperature (should be 20.0)	20.37± 0.34	°C
First core pole # (count includes zero potential pole)	8	
Last core pole # (count includes zero potential pole)	253	
Tuning Gap	8.9999	mm

Evaluation of Hall Probe Scans at Commissioning Gap

Commissioning Gap Temperature (should be 20.0)	20.30± 0.29	°C
rms($|B_{pk}|/<|B_{pk}|> - 1$)	0.00198	
K_{eff} at Commissioning Gap (should be 2.3400)	2.3403	
Commissioning Gap	7.8753	mm
I1X (over 4.012667 m) (should be within ±40)	-12.9	µTm
I2X (over 4.012667 m) (should be within ±150)	69	µTm^2
I1Y (over 4.012667 m) (should be within ±40)	24.6	µTm
I2Y (over 4.012667 m) (should be within ±150)	76	µTm^2
Phase Shake (rms phase fluctuations over core poles) (<4.0)	2.241	degXray
Cell Phase Advance (over 4.012667 m)	486,601.5 (135×360+1.53)	degXray
Undulator Entrance Phase[1]	2,250.9 (25×90+0.94)	degXray
Undulator Exit Phase[2]	2,250.6 (25×90+0.59)	degXray

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[1] Phase advance from cell start (undulator center – 2.006334 m) to center of physical pole 8.
[2] Phase advance from physical pole 253 to cell end (undulator center + 2.006334 m).

Undulator Encoder Settings

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USGapEncoderOffset	-1109.3057
DSGapEncoderOffset	-823.0245
USWLinearEncoder.AOFF	90.311
DSWLinearEncoder.AOFF	92.0093
USALinearEncoder.AOFF	92.8321
DSALinearEncoder.AOFF	92.0029

Undulator Load Cell Readings at Tuning Gap (Gap Opening)

LC_DAL_FORCE	-186.062
LC_DAU_FORCE	-321.9326
LC_DWL_FORCE	-239.5027
LC_DWU_FORCE	-239.1183
LC_UAL_FORCE	-223.0613
LC_UAU_FORCE	-278.1382
LC_UWL_FORCE	-211.039
LC_UWU_FORCE	-306.6484

Undulator Load Cell Readings at 100 mm Gap (Gap Opening)

LC_DAL_FORCE	3.92
LC_DAU_FORCE	4.13
LC_DWL_FORCE	5.79
LC_DWU_FORCE	3.03
LC_UAL_FORCE	2.87
LC_UAU_FORCE	1.12
LC_UWL_FORCE	2.88
LC_UWU_FORCE	1.99

Evaluation of Hall Probe Scans: K_{eff} vs gap

HXU-024: K_{eff} vs. gap
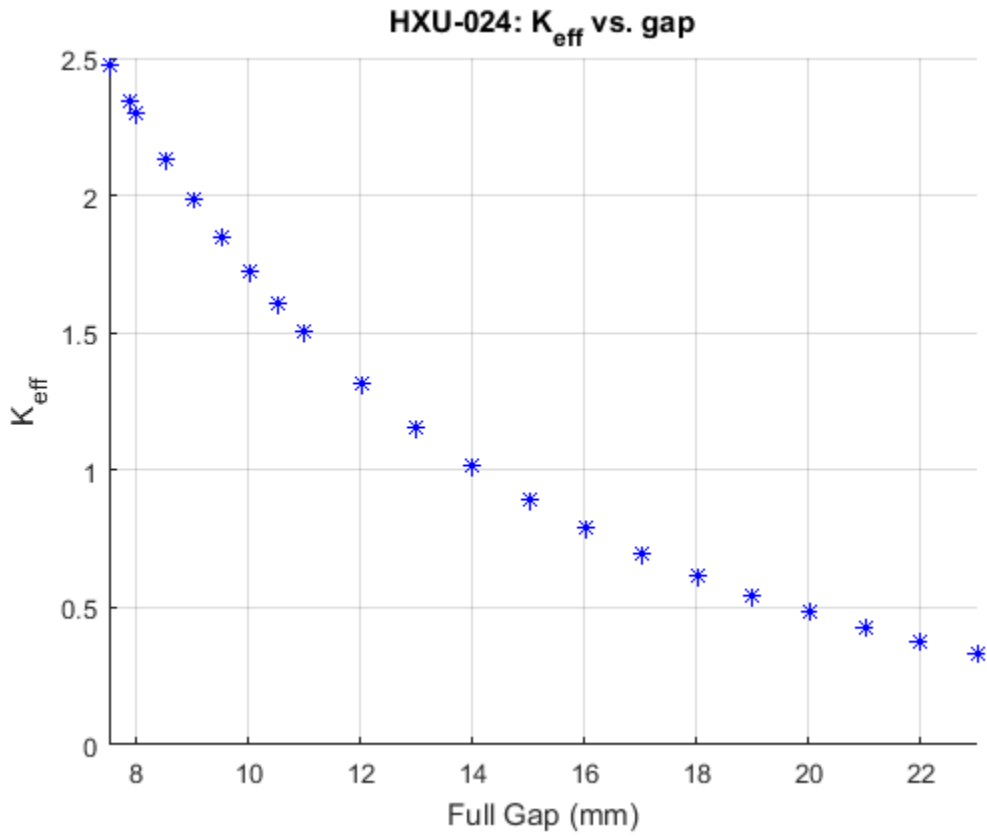
Evaluation of Hall Probe Scans: K_{eff} Hysteresis using Half Gap Encoders
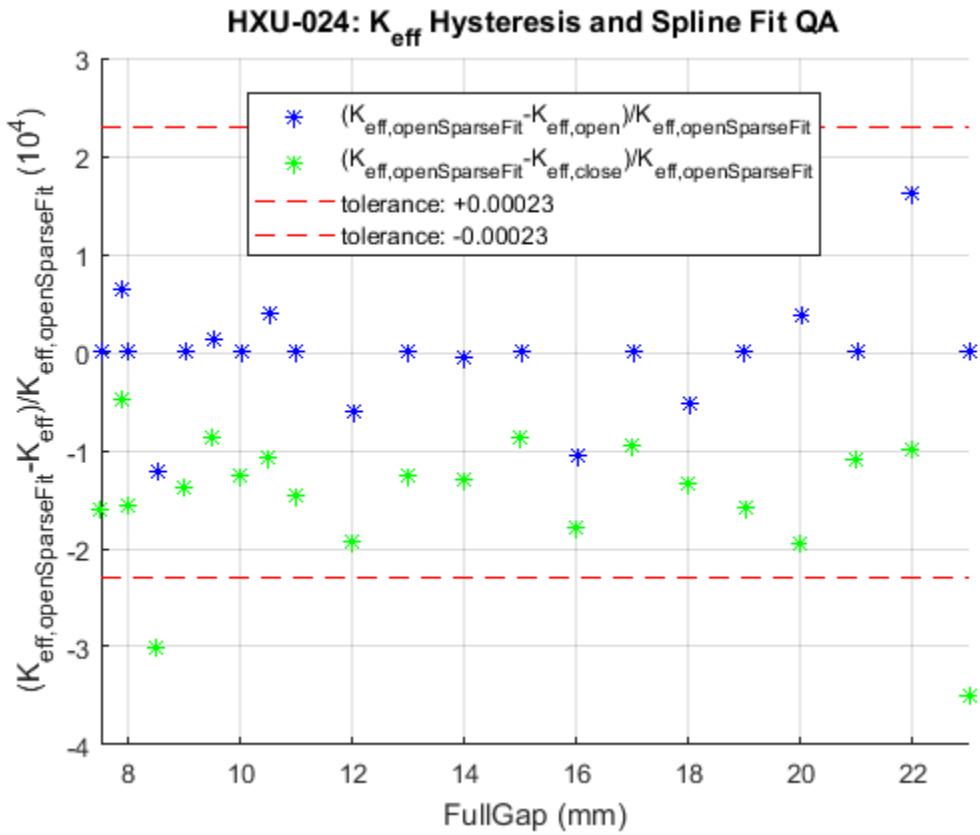
Plotted functions have been calculated from measured values openKeff (opengap) and closeKeff (closegap) using the following Matlab calculations:

Blue Stars: 1-openKeff ./ spline(opengap(1:2:end),openKeff(1:2:end),opengap)
Green Stars: 1-closeKeff ./ spline(opengap(1:2:end),openKeff(1:2:end),closegap)

Evaluation of Hall Probe: Phase Shake vs. gap
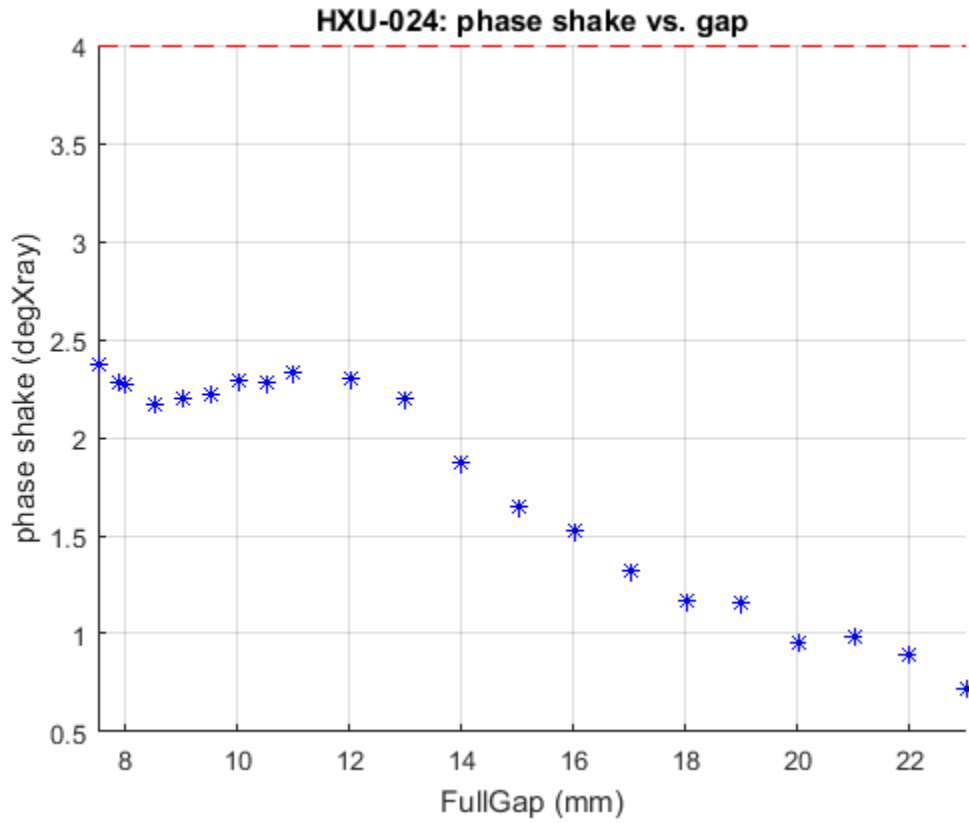
Evaluation of Hall Probe: K_{eff} vs x at Tuning Gap

HXU-024: Keff vs. x @ Tuning Gap
Tuning Gap = 9.0 mm

$$K_{eff}(x) = +0.0585/mm^2 \, x^2 + 0.0005/mm \, x + 1.9835$$

$$x_{center} \approx -0.004 \text{ mm}$$
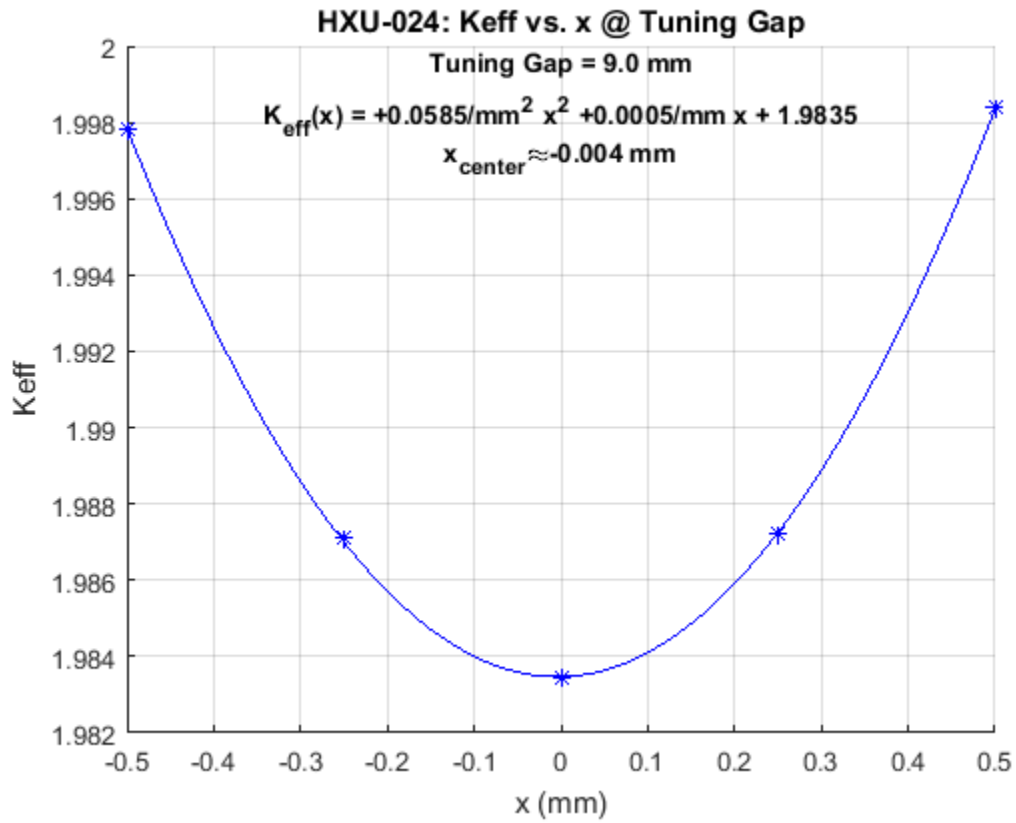
Evaluation of Hall Probe: K_{eff} vs y at Tuning Gap

HXU-024: Keff vs. y @ Tuning Gap
Tuning Gap = 9.0 mm
$K_{eff}(y) = -0.000083/mm\ y + 1.9834$
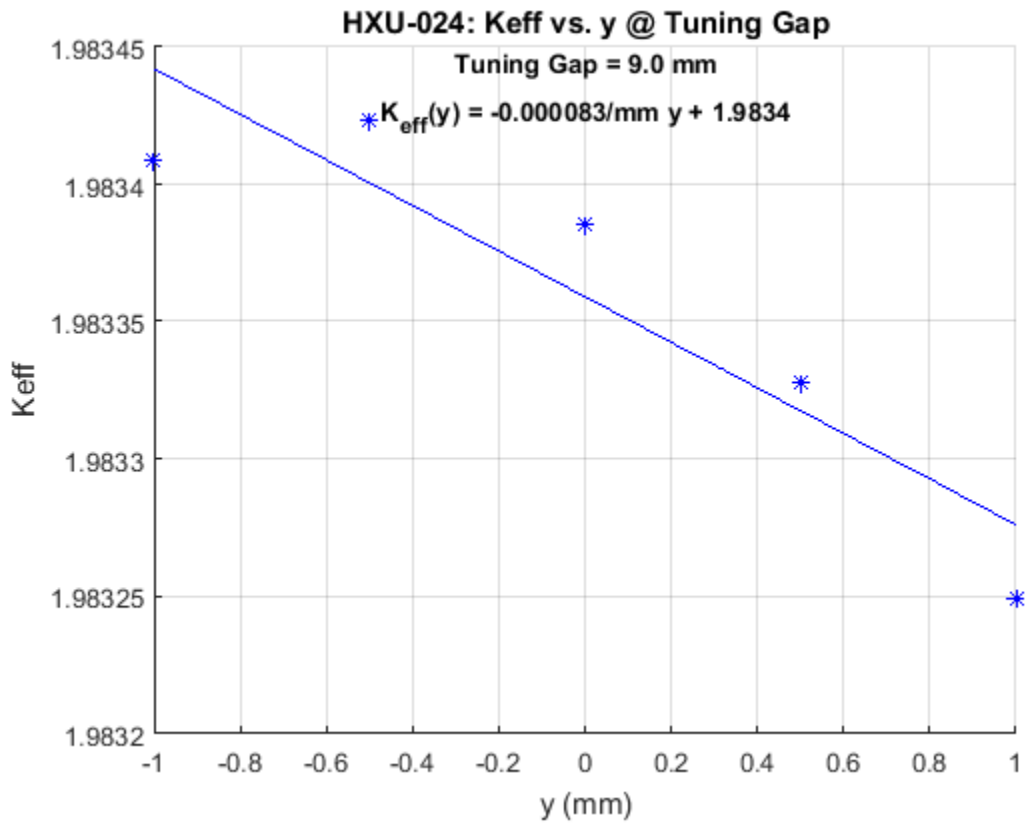
Long Coil Measurement of the On-Axis First Horizontal Field Integrals with +30 µT·m Integral Offset
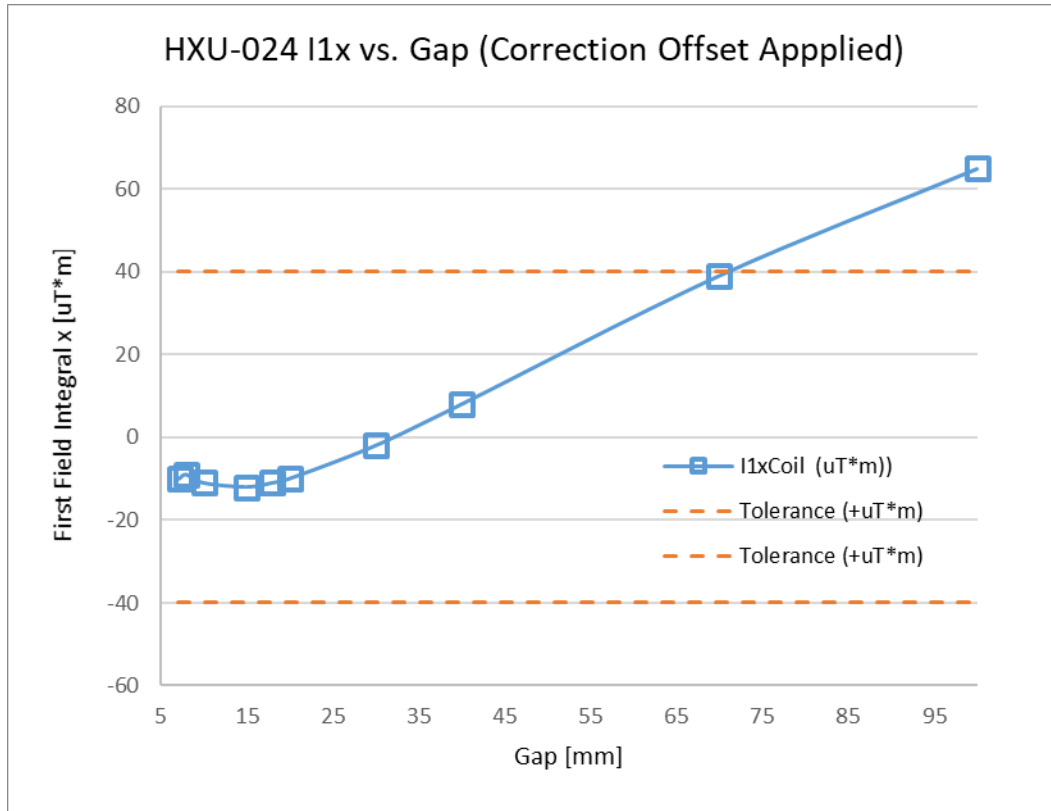
Long Coil Measurement of the On-Axis Second Horizontal Field Integrals with +30 µT·m x 0.5 x 4.012667 m Second Integral Offset

HXU-024 I2x vs. Gap (Correction Offset Appplied)
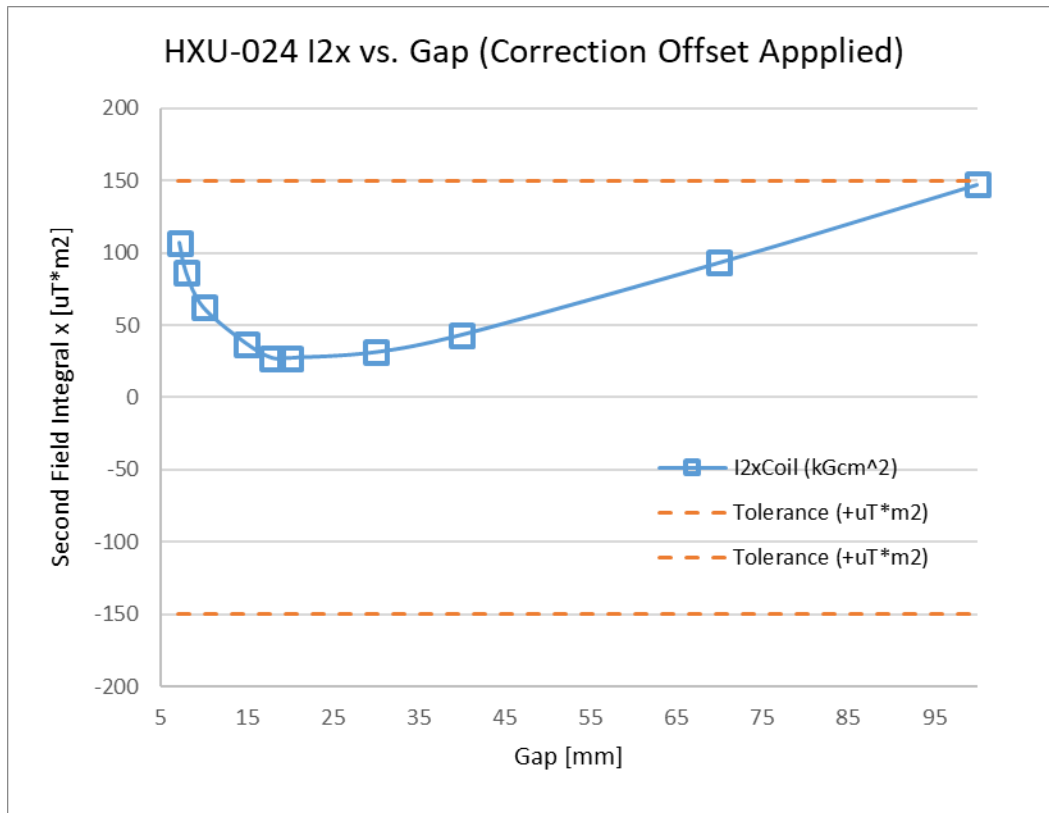
Long Coil Measurement of the On-Axis First Vertical Field Integrals
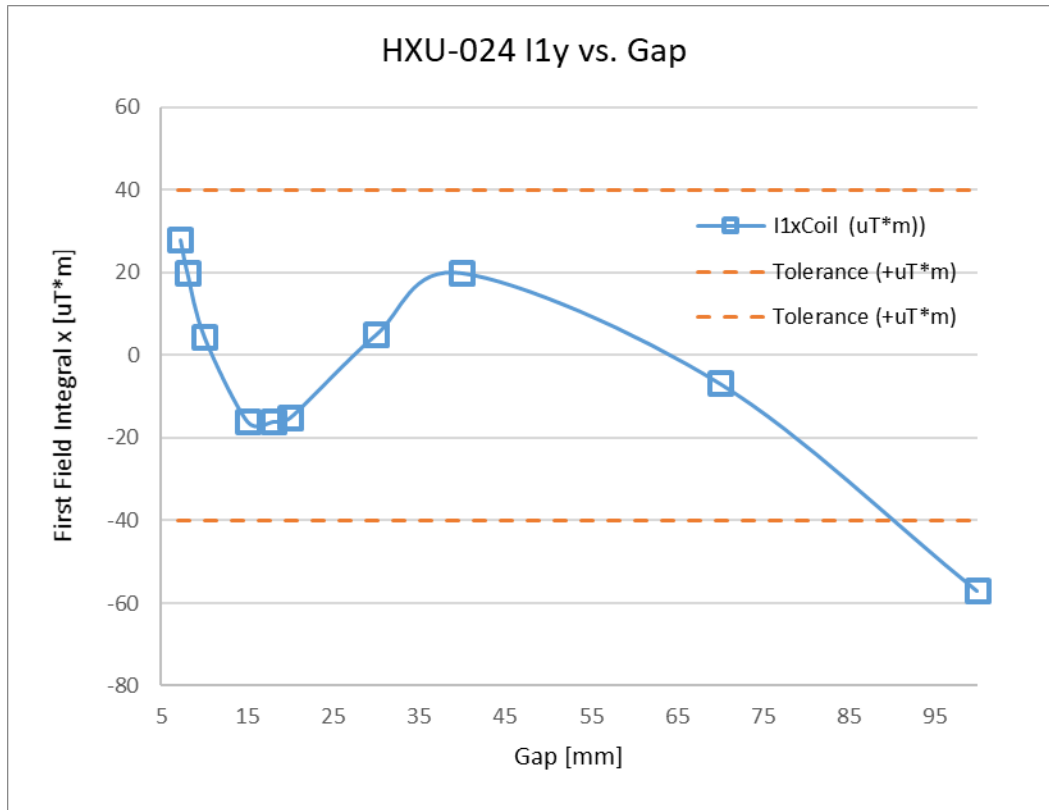
Long Coil Measurement of the On-Axis Second Vertical Field Integrals
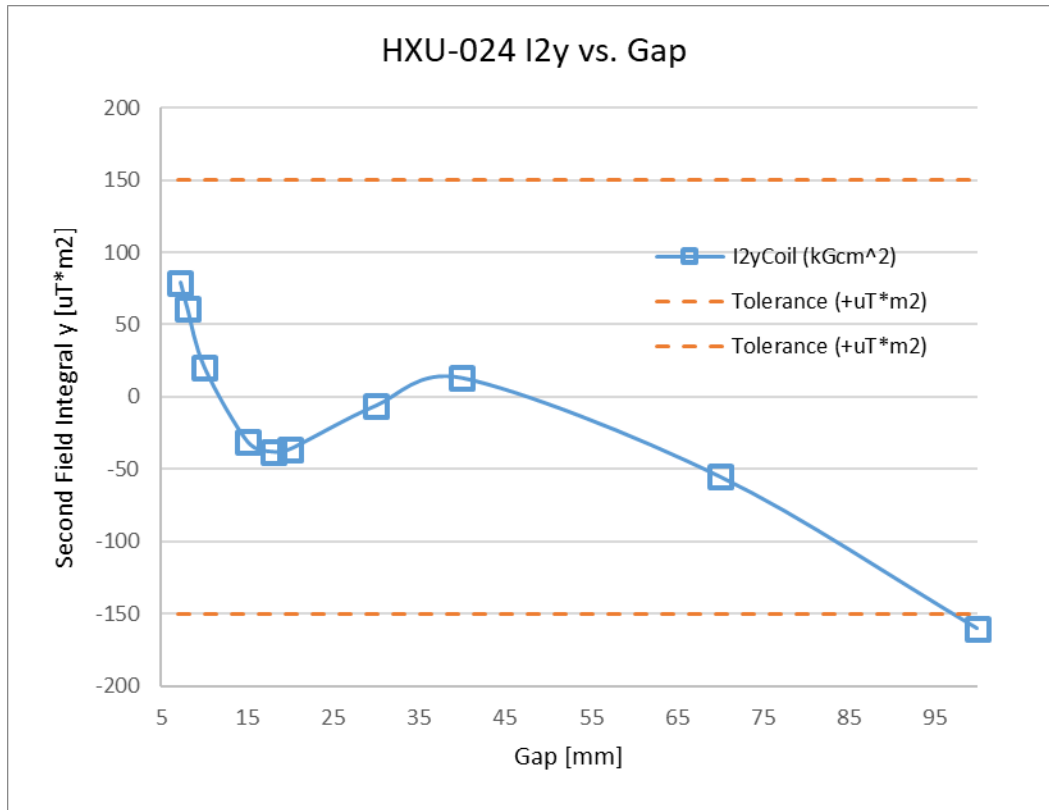
Second Horizontal and Vertical Field Integrals along Undulator Length at Commissioning Gap
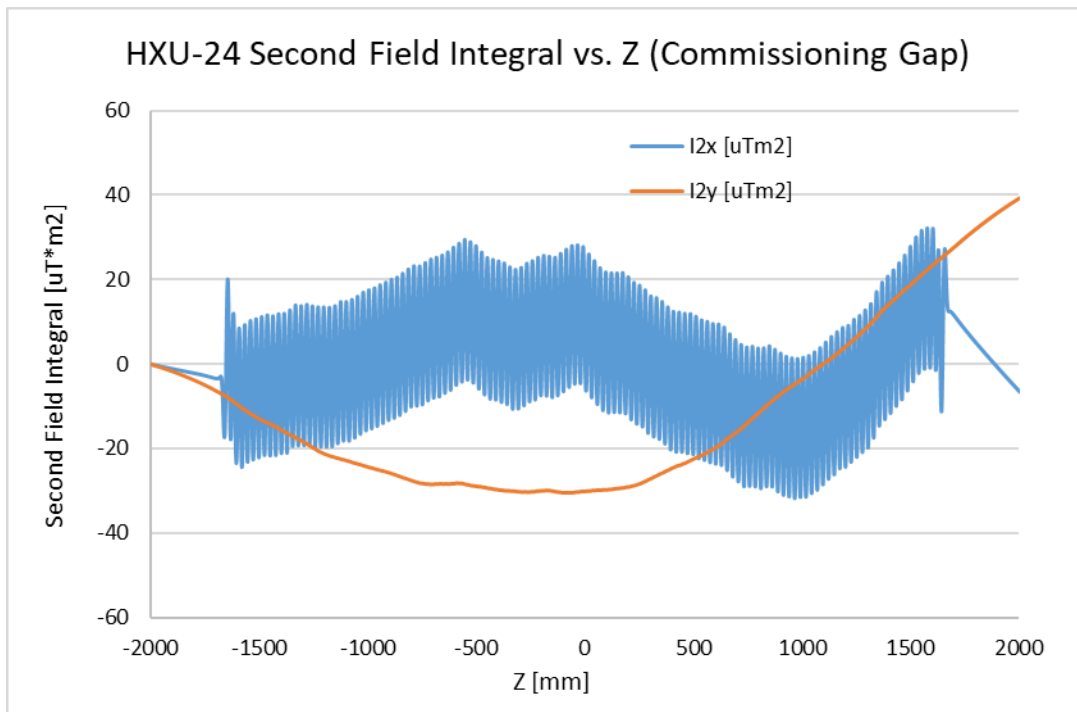
Capacitive Sensor Arrangement

Probe is translated
horizontally and
vertically to measure
at the various
locations

y = +10mm

Wall
Probe

y = 0

Aisle
Probe

y = -10mm
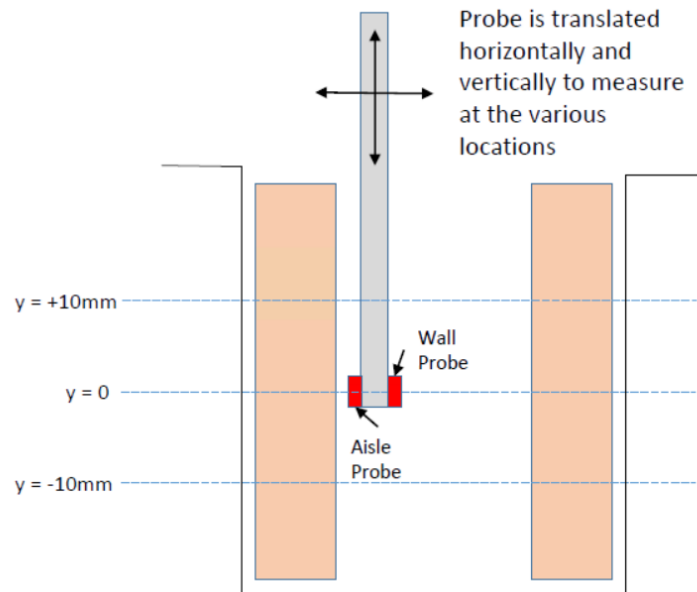
The following plots show the pole and magnet position measurements. The ANL system has two back-to-back capacitive probes on one probe holder. The x and y stages on the 6-meter bench are positioned so that the probe is in the proper location for each of the 9 scan locations. For the data analysis, the average pole position in each scan is used as reference for the plotted pole and magnet positions. Note that for all plots, the first three and last three poles of the device are omitted since the measurement is not accurate due to end efects in the capacitance probe measurement..

Probe 1 Capacitive Sensor Readings y = +10mm
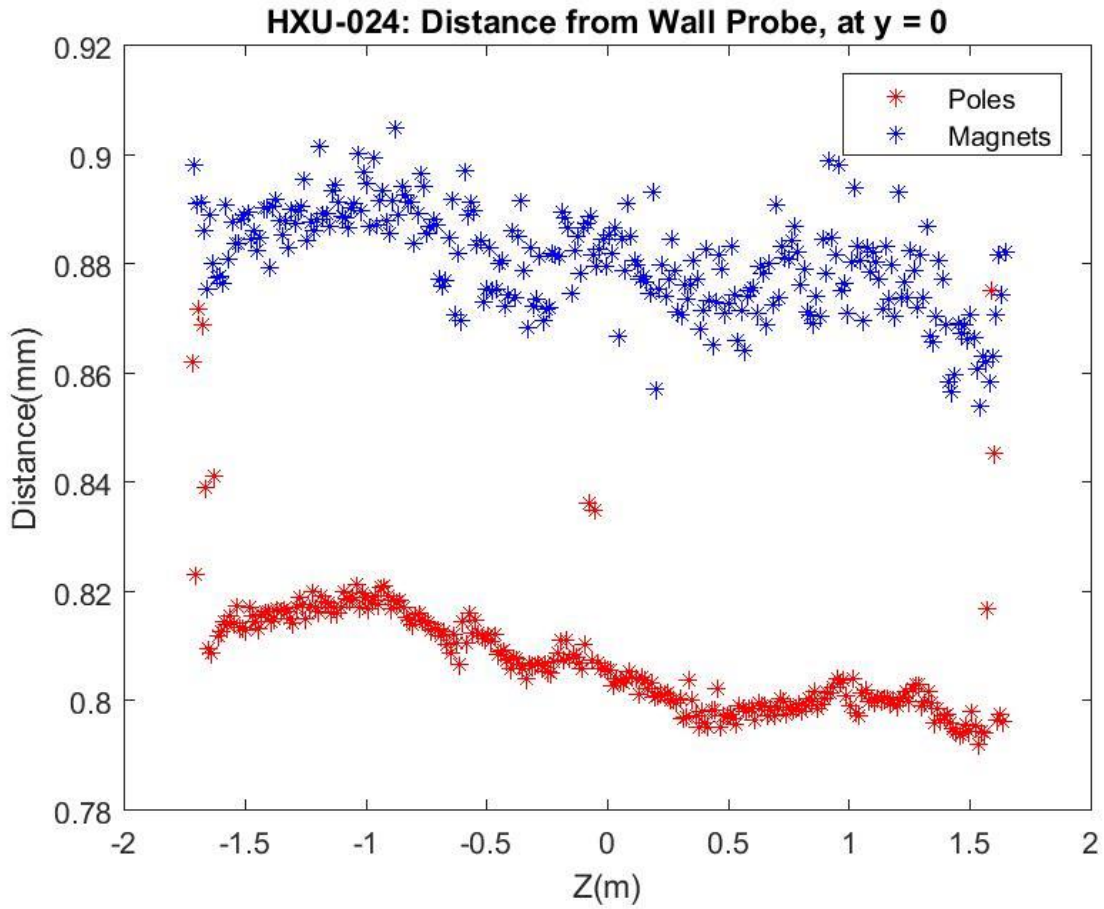
Probe2 Capacitive Sensor Readings y = +10mm

HXU-024: Distance from Wall Probe, at y = +10
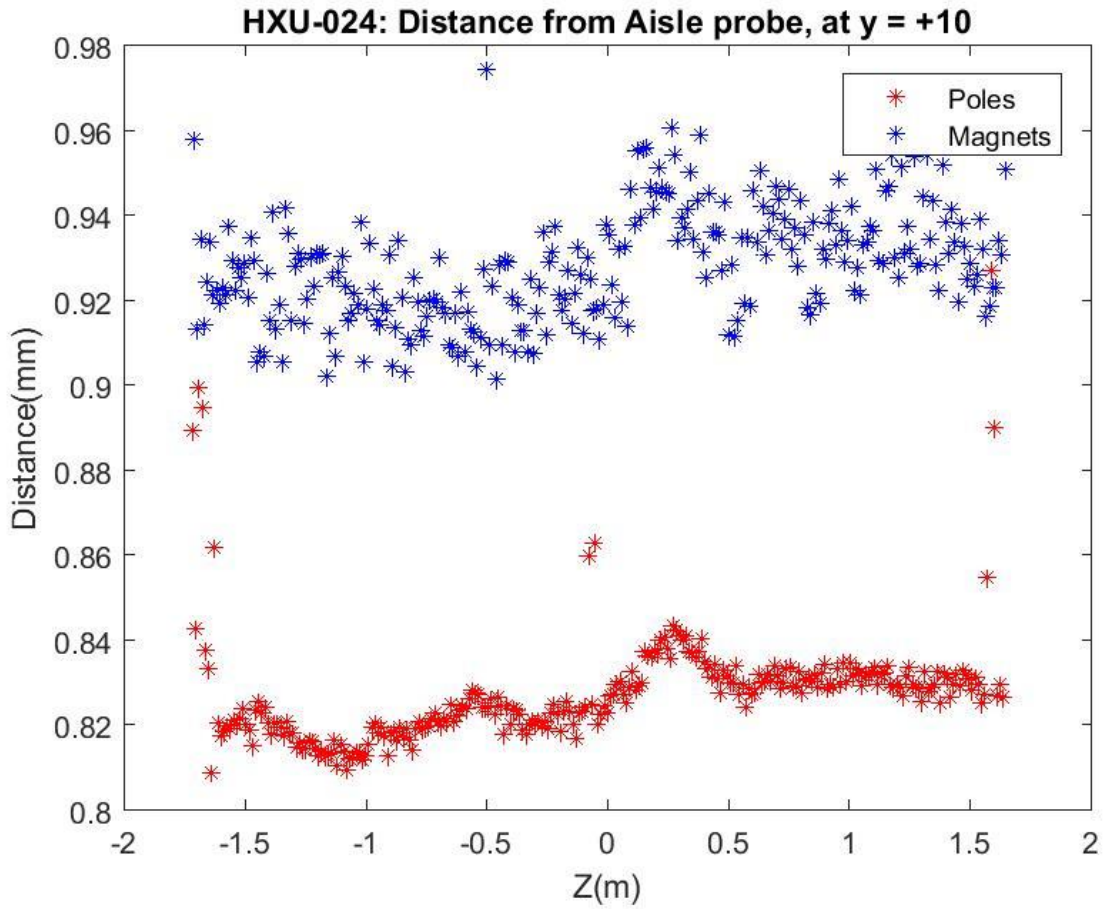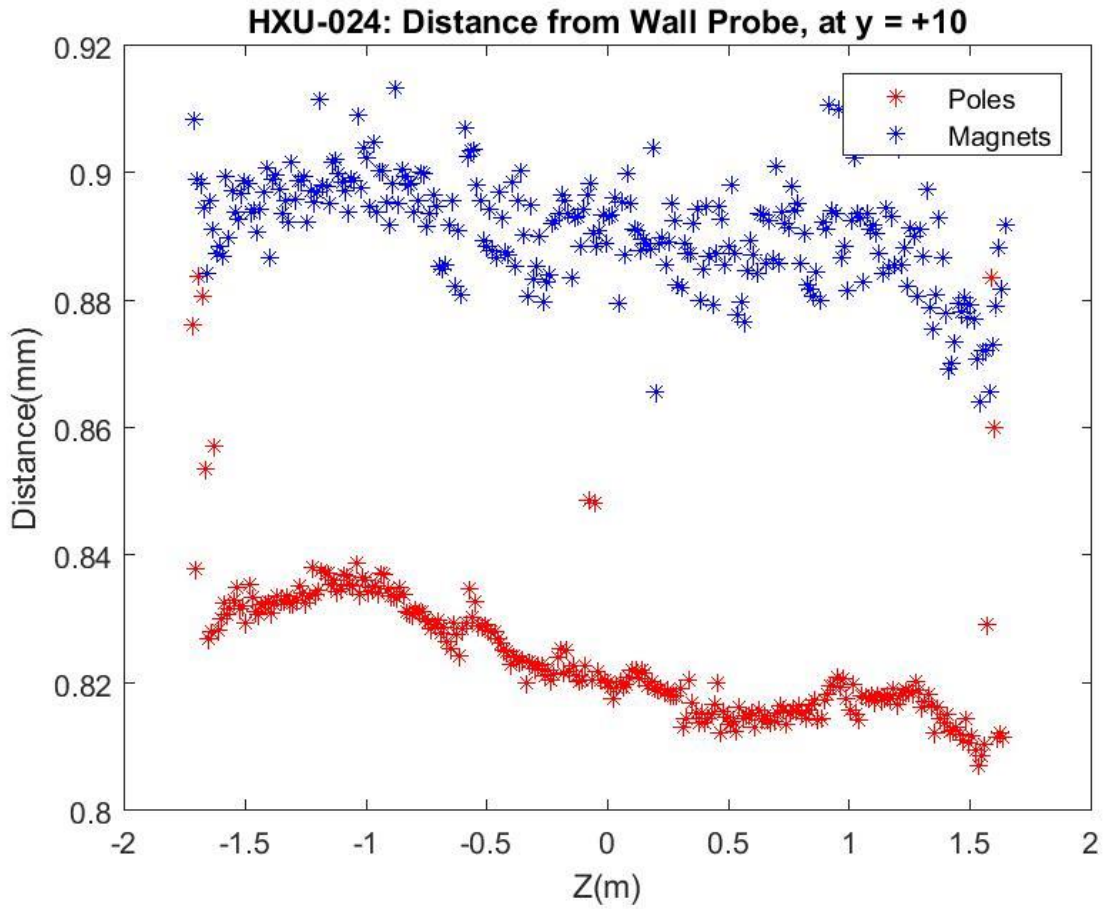
Probe1 Capacitive Sensor Readings y = 0mm
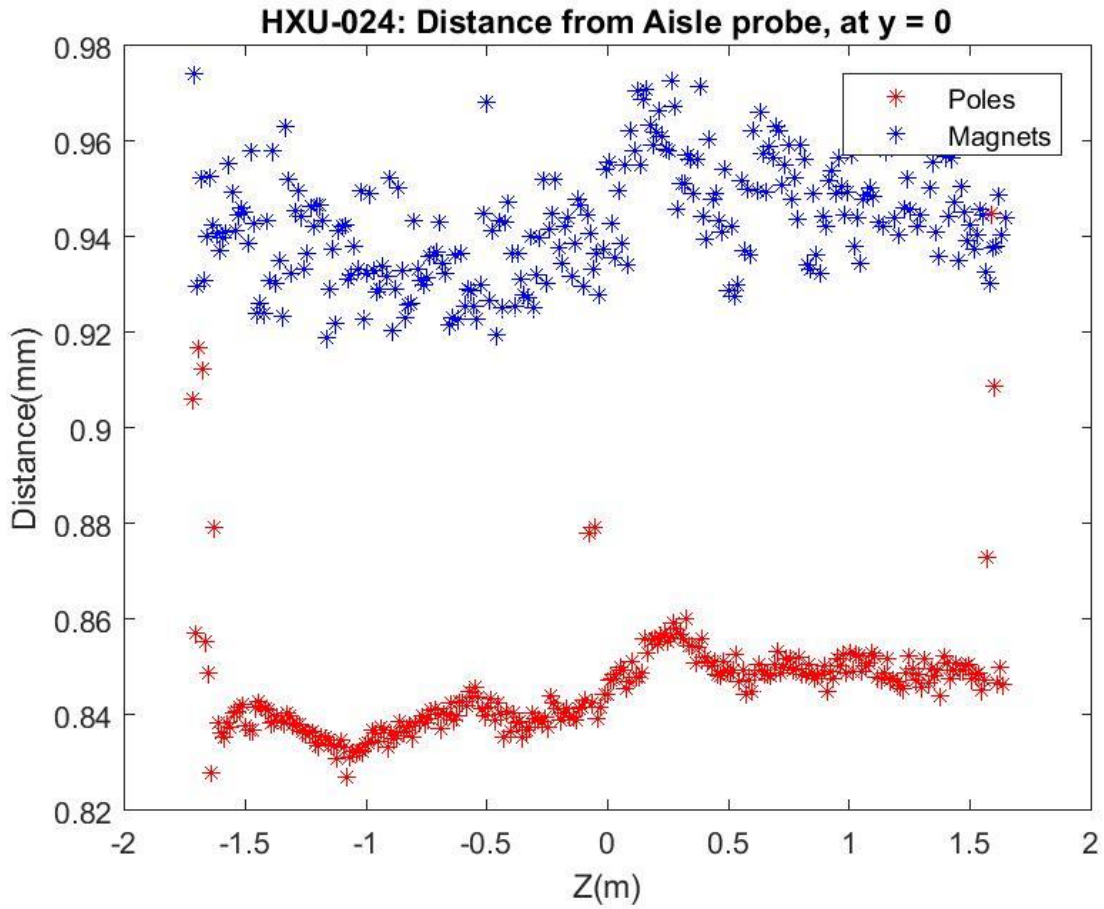
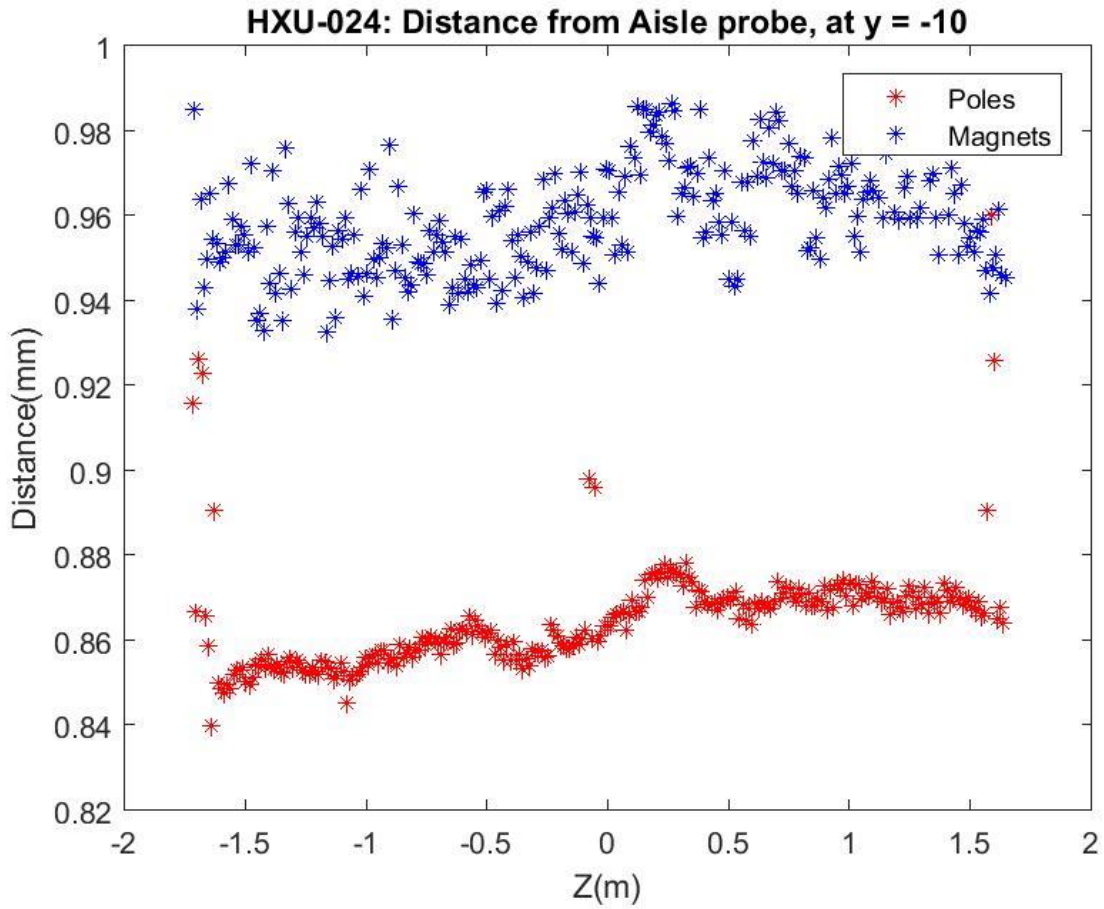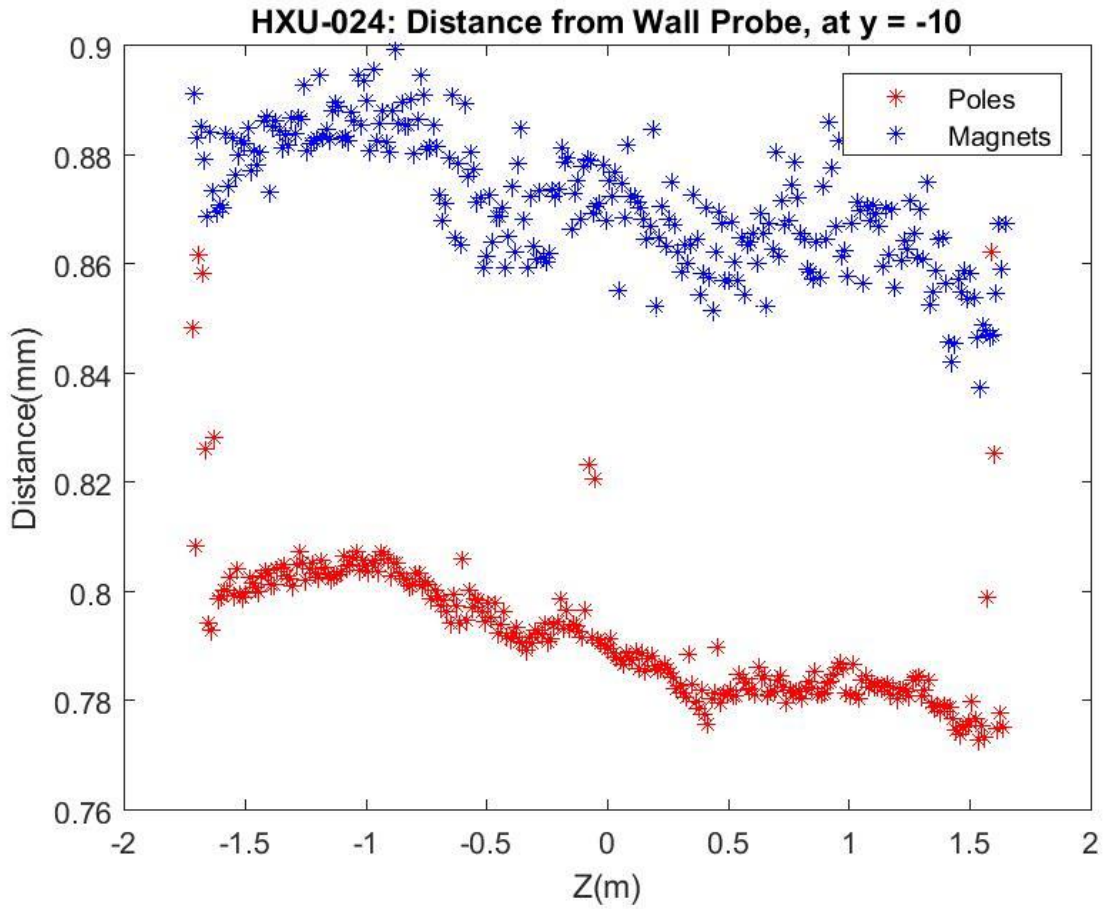## Probe2 Capacitive Sensor Readings y = 0mm
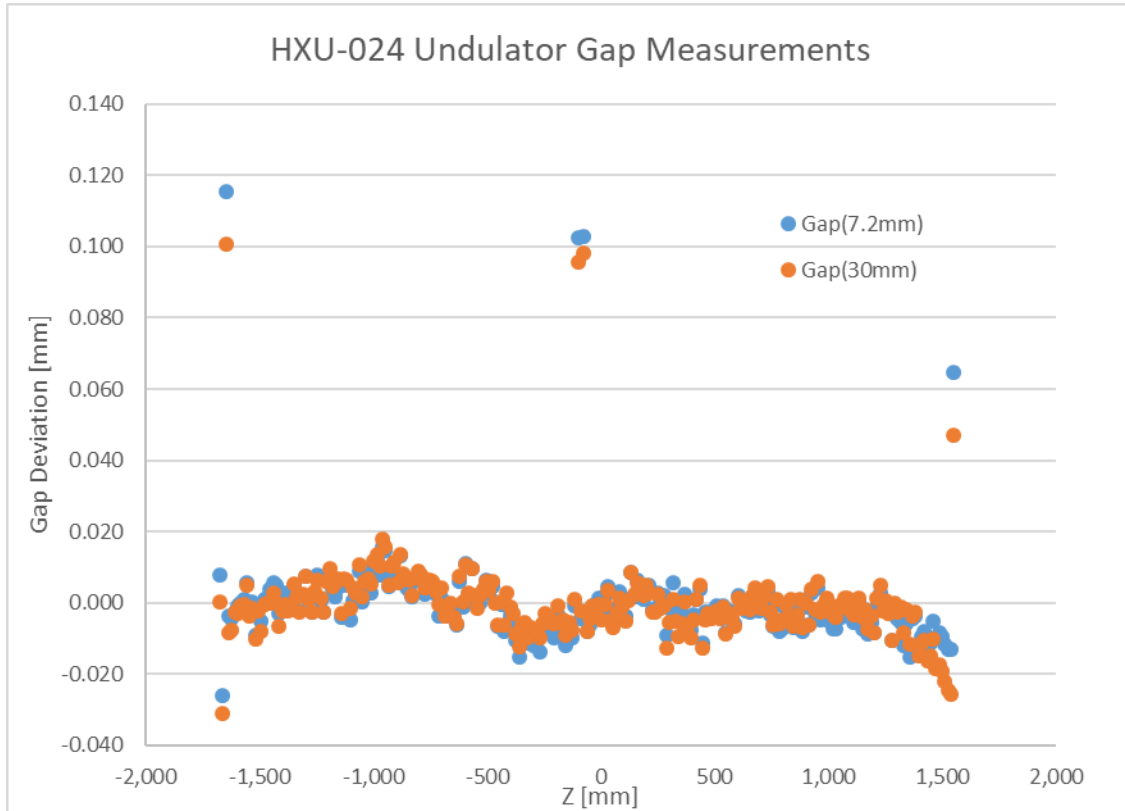
Probe1 Capacitive Sensor Readings y = -10mm

Probe2 Capacitive Sensor Readings y = -10mm
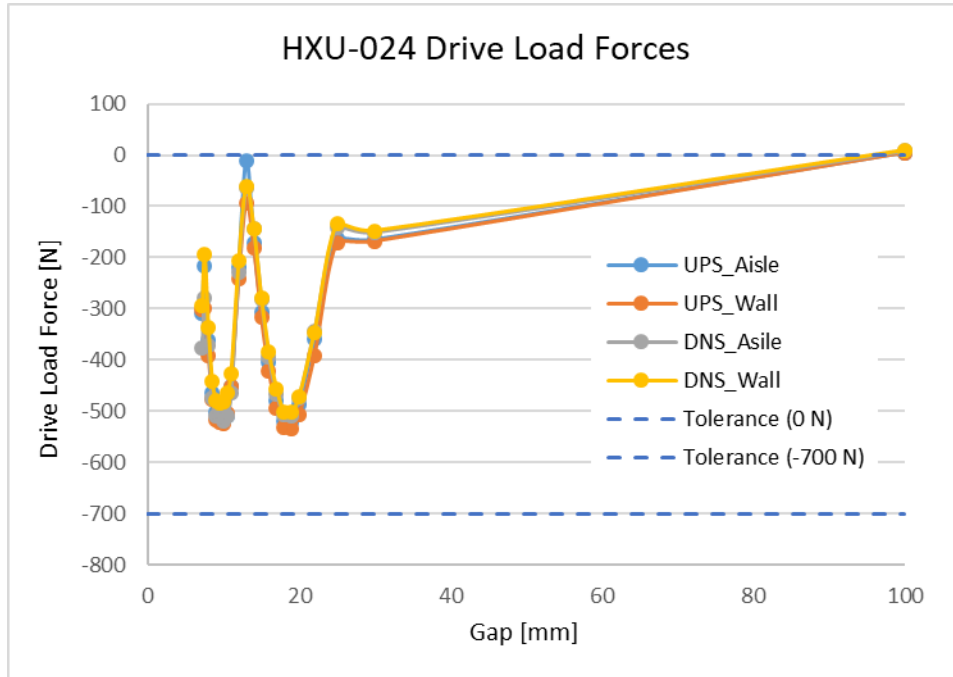
Undulator Gap Measurements
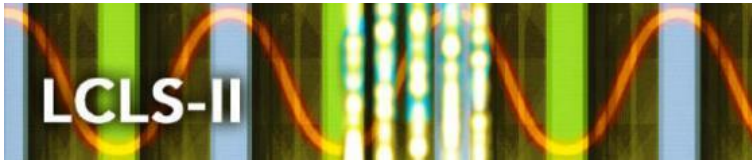
Undulator Gap Difference
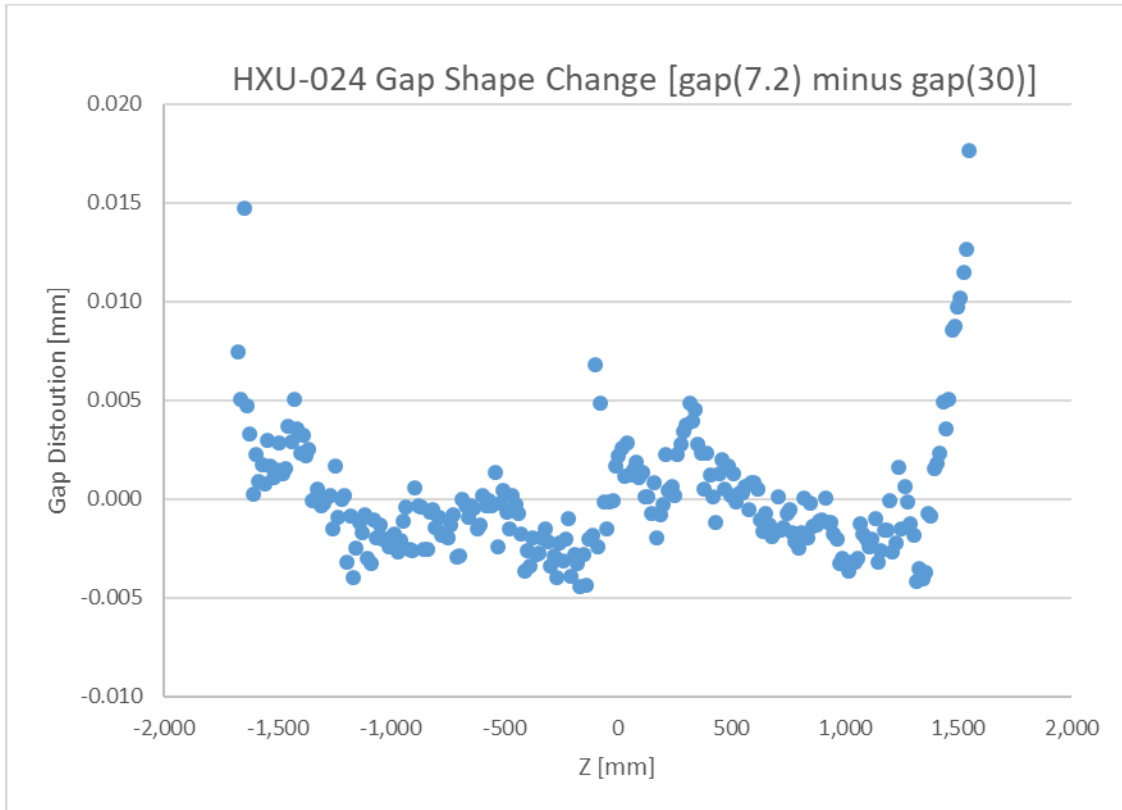
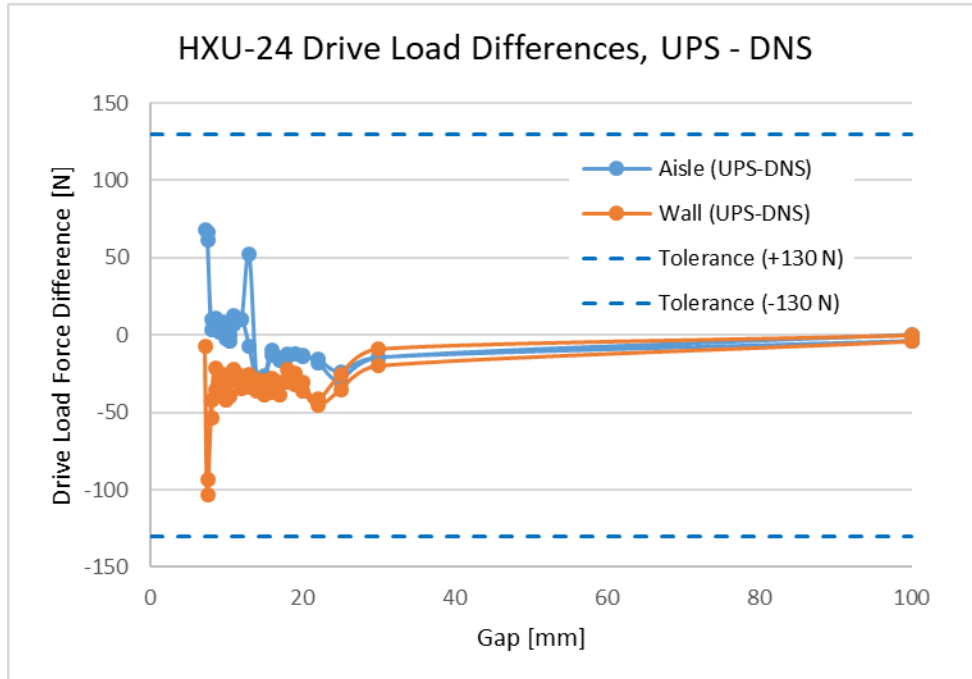## Drive Loads (Gap Opening)

Drive Load Differences (Gap Opening - Closing)

Strongback Forces (Gap Opening and Closing)

HXU-24 Strongback Froces
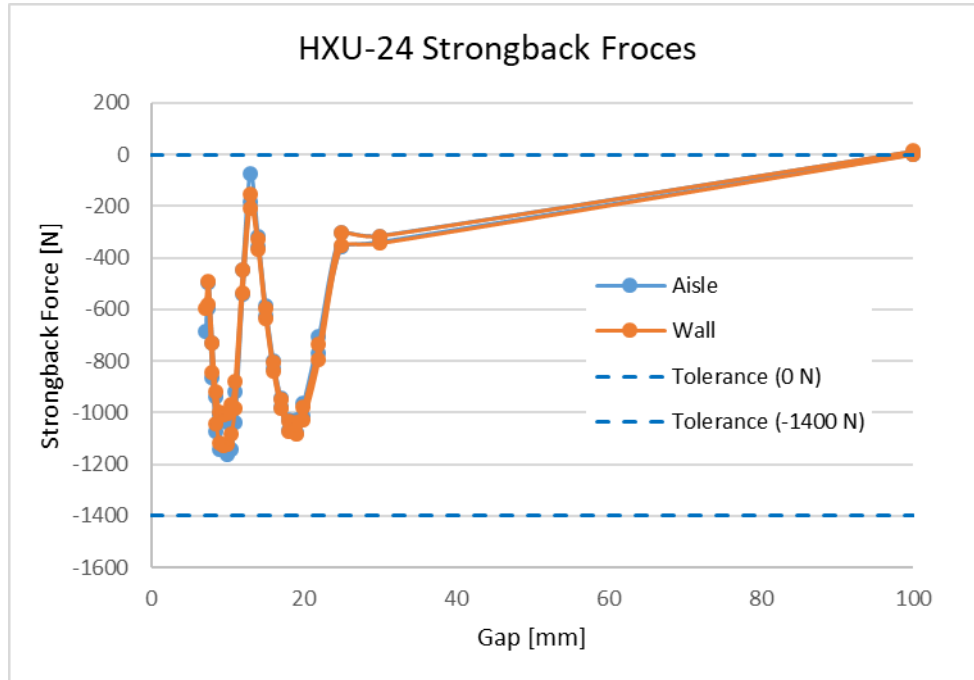
Strongback Force Differences (Gap Closing - Opening)

HXU-24 Strongback Froce Difference Aisle - Wall