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-029

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)	19.87± 0.02	°C
First core pole # (count includes zero potential pole)	8	
Last core pole # (count includes zero potential pole)	253	
Tuning Gap	9.000	mm

Evaluation of Hall Probe Scans at <u>Commissioning Gap</u>

Commissioning Gap Temperature (should be 20.0)	19.85± 0.06	°C
$rms(|B_{pk}|/<|B_{pk}|> - 1)$	0.00198	
K_{eff} at Commissioning Gap (should be 2.3400)	2.3399	
Commissioning Gap	7.9122	mm
I1X (over 4.012667 m) (should be within ±40)	-6	µTm
I2X (over 4.012667 m) (should be within ±150)	6	µTm^2
I1Y (over 4.012667 m) (should be within ±40)	9	µTm
I2Y (over 4.012667 m) (should be within ±150)	59	µTm^2
Phase Shake (rms phase fluctuations over core poles) (<4.0)	1.03	degXray
Cell Phase Advance (over 4.012667 m)	48,601.6 (135×360+1.59)	degXray
Undulator Entrance Phase[1]	2,250.7 (25×90+0.73)	degXray
Undulator Exit Phase[2]	2,250.9 (25×90+0.86)	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

USGapEncoderOffset	NA
DSGapEncoderOffset	NA
USWLinearEncoder.AOFF	90.0339
DSWLinearEncoder.AOFF	93.1631
USALinearEncoder.AOFF	88.2251
DSALinearEncoder.AOFF	90.3242

## Undulator Load Cell Readings at Tuning Gap (Gap Opening)

LC_DAL_FORCE	-276.9
LC_DAU_FORCE	-309.1
LC_DWL_FORCE	-202.7
LC_DWU_FORCE	-383.6
LC_UAL_FORCE	-248.3
LC_UAU_FORCE	-343.8
LC_UWL_FORCE	-294.8
LC_UWU_FORCE	-289.9

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

LC_DAL_FORCE	1.0
LC_DAU_FORCE	0.0
LC_DWL_FORCE	-1.0
LC_DWU_FORCE	0.9
LC_UAL_FORCE	0.0
LC_UAU_FORCE	0.0
LC_UWL_FORCE	0.0
LC_UWU_FORCE	0.0

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

HXU-029: K_{eff} vs. gap
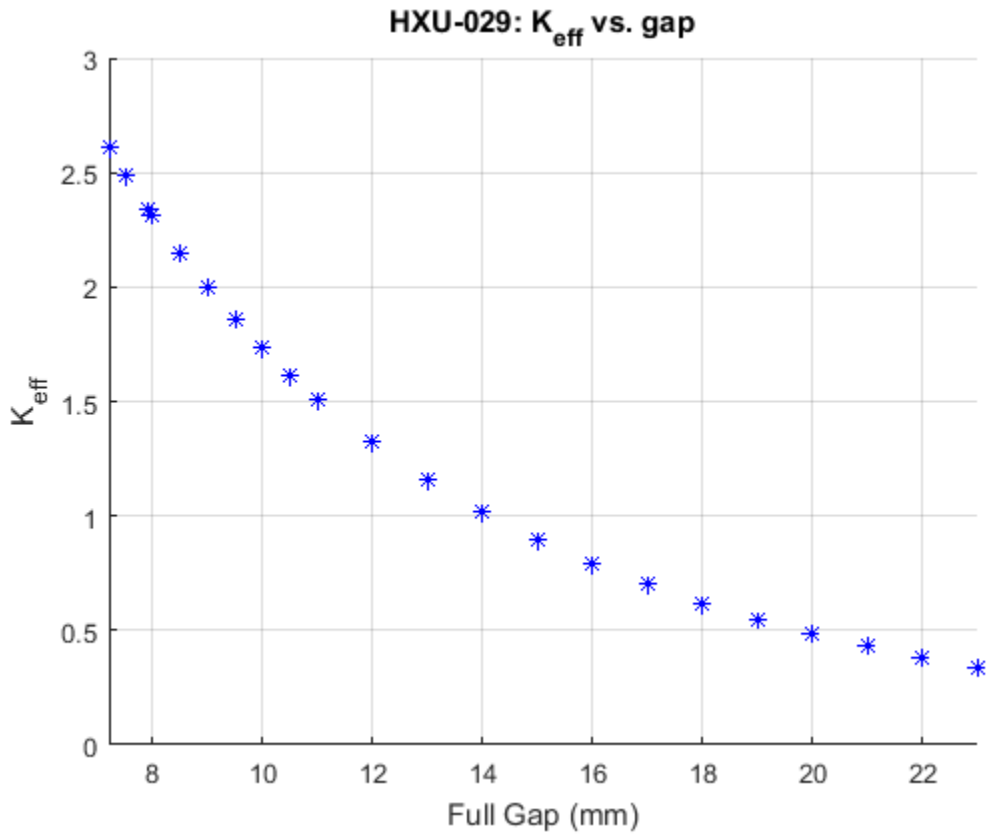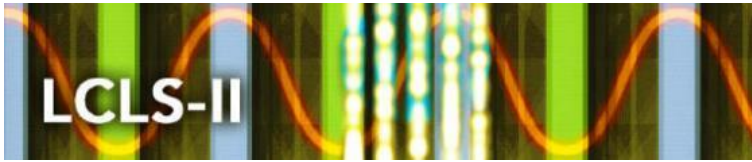
Evaluation of Hall Probe Scans: K_{eff} Hysteresis using Half Gap Encoders
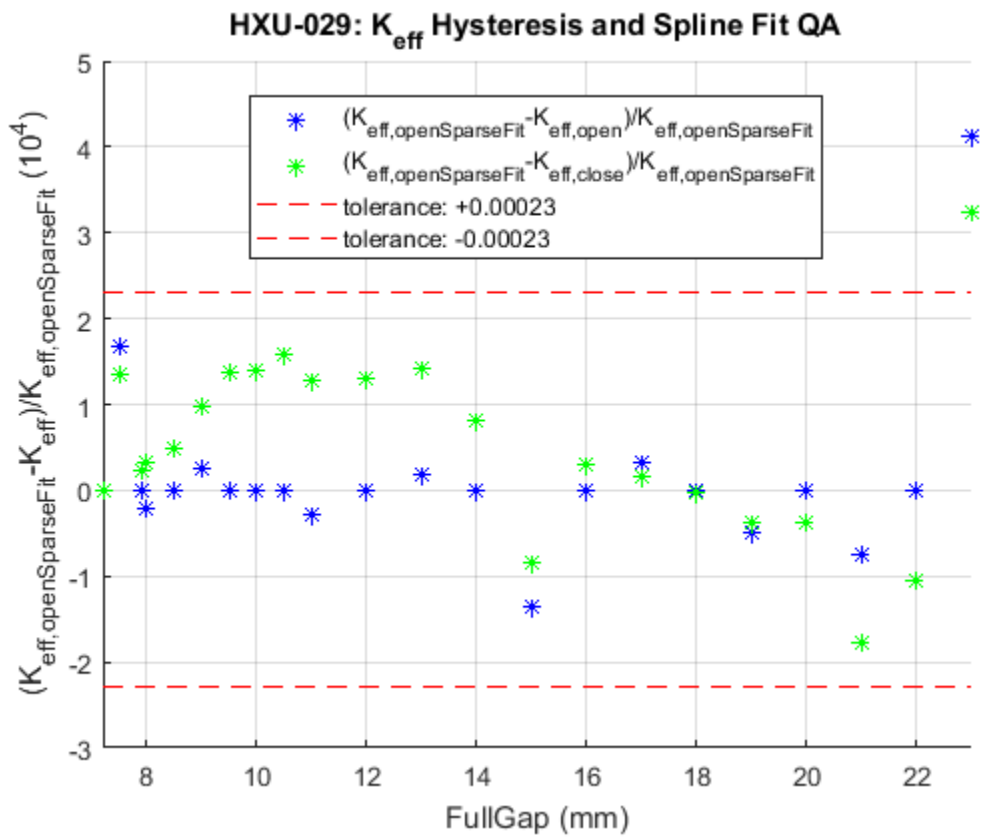
Plotted functions have been calculated from measured values openKeff (opengap) and closeKeff (closegap) using the following Matlab calculations:

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
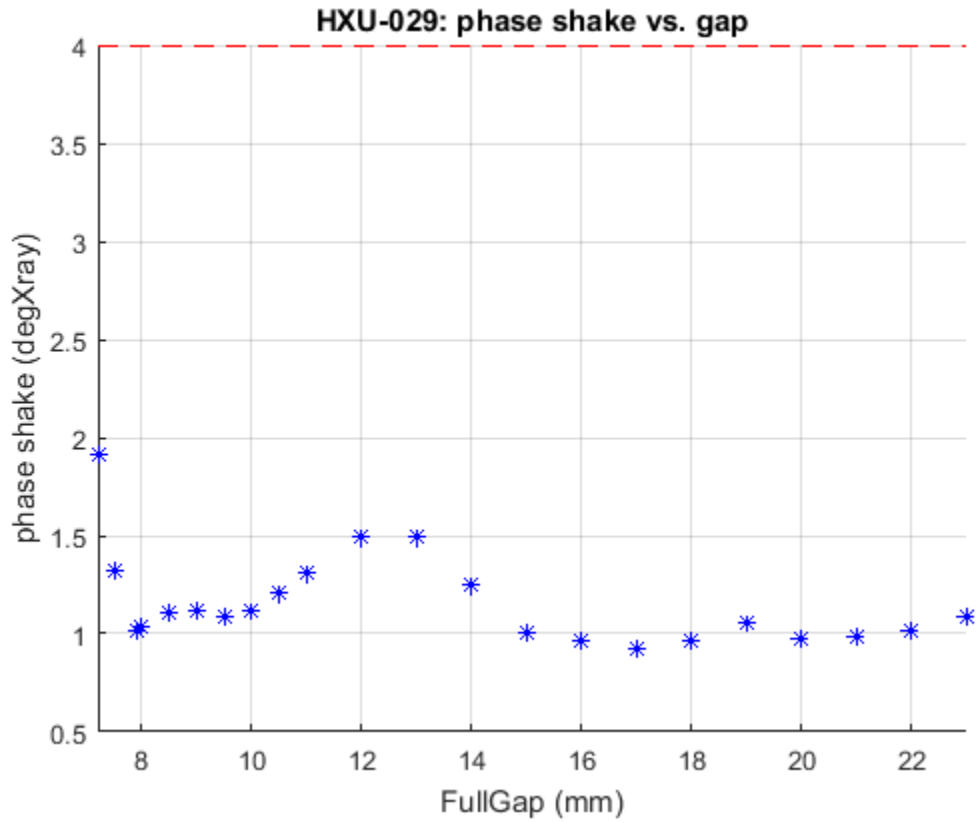
Evaluation of Hall Probe: K_{eff} vs x at Tuning Gap

HXU-029: Keff vs. x @ Tuning Gap
Tuning Gap = 9.0 mm
$K_{eff}(x) = +0.0580/mm^2 \; x^2 - 0.0005/mm \; x + 1.9945$
$x_{center} \approx 0.004$ mm
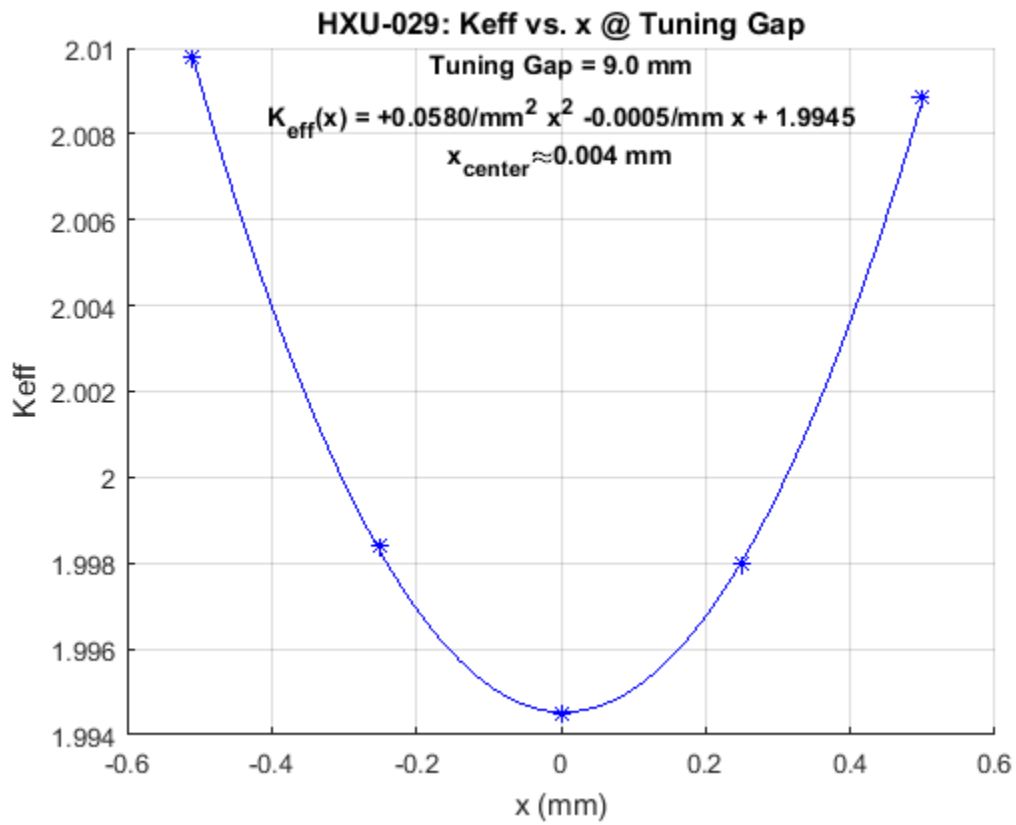
Evaluation of Hall Probe: K_{eff} vs y at Tuning Gap

HXU-029: Keff vs. y @ Tuning Gap
Tuning Gap = 9.0 mm
$K_{eff}(y) = -0.000062/mm\ y + 1.9945$
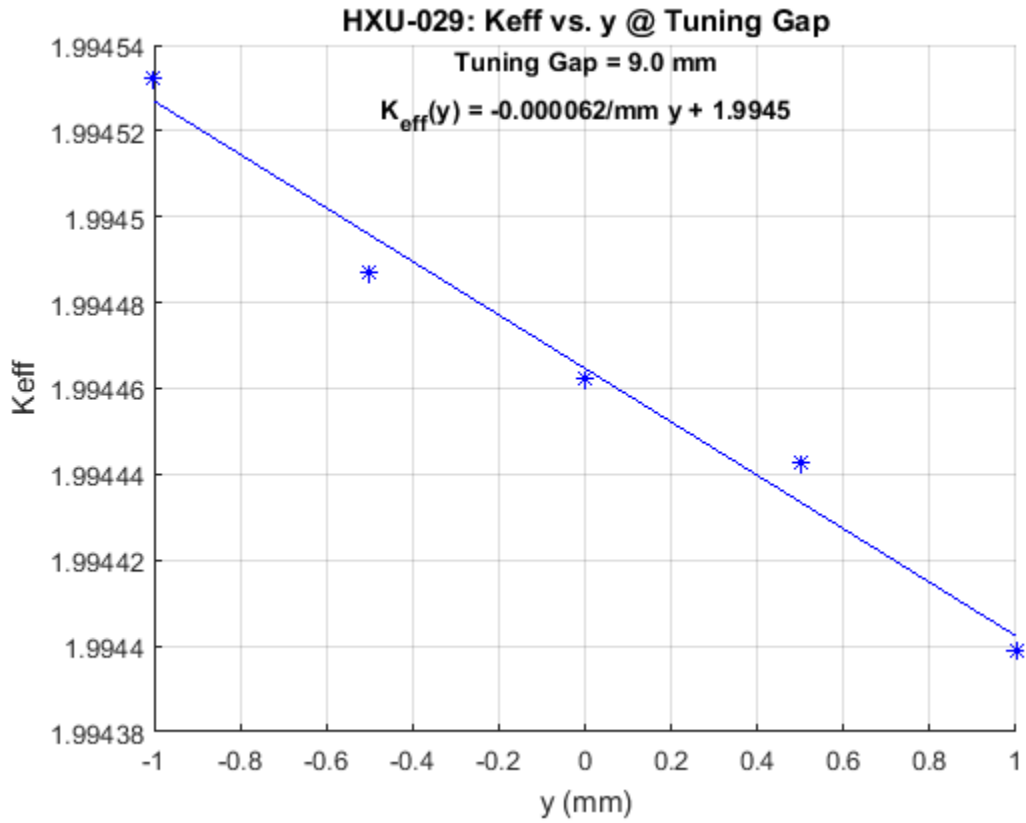
Long Coil Measurement of the On-Axis First Horizontal Field Integrals with +30 μT·m Integral Offset
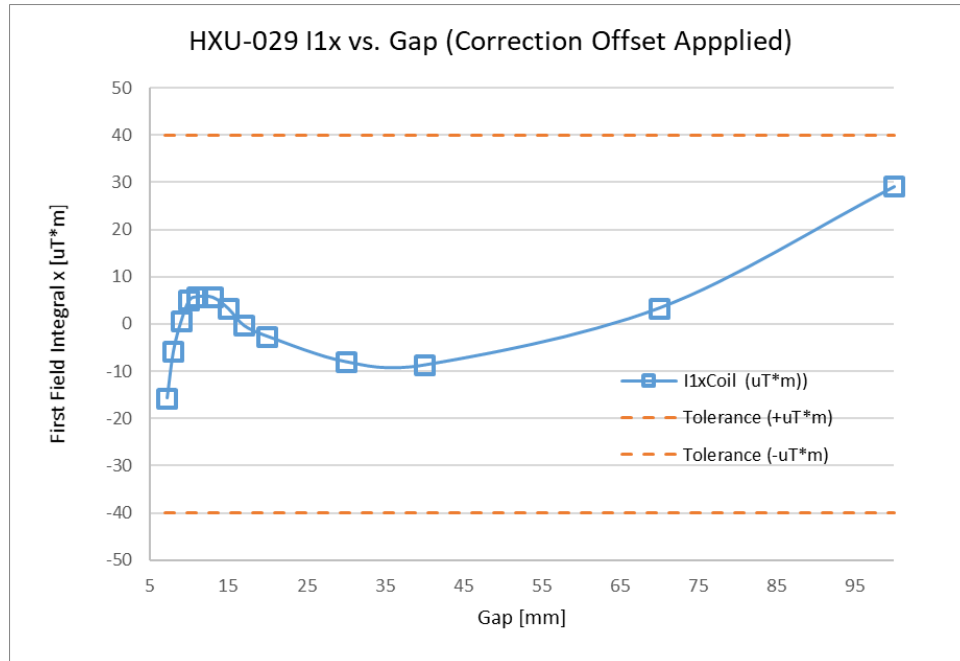
Long Coil Measurement of the On-Axis Second Horizontal Field Integrals with +30 µT·m x 0.5 x 4.012667 m Second Integral Offset
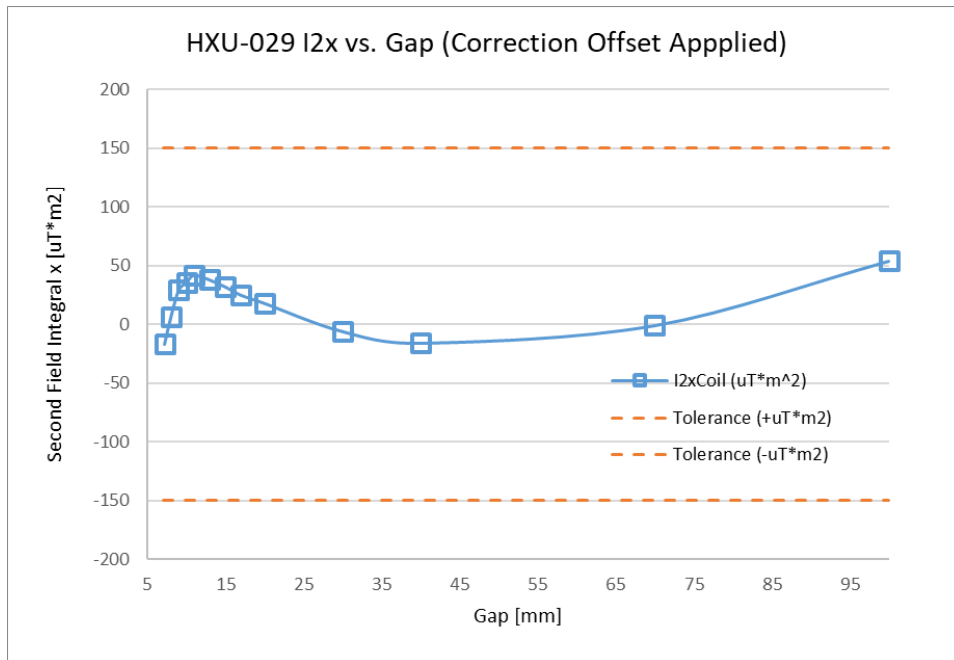
Long Coil Measurement of the On-Axis First Vertical Field Integrals

HXU-029 l1y vs. Gap
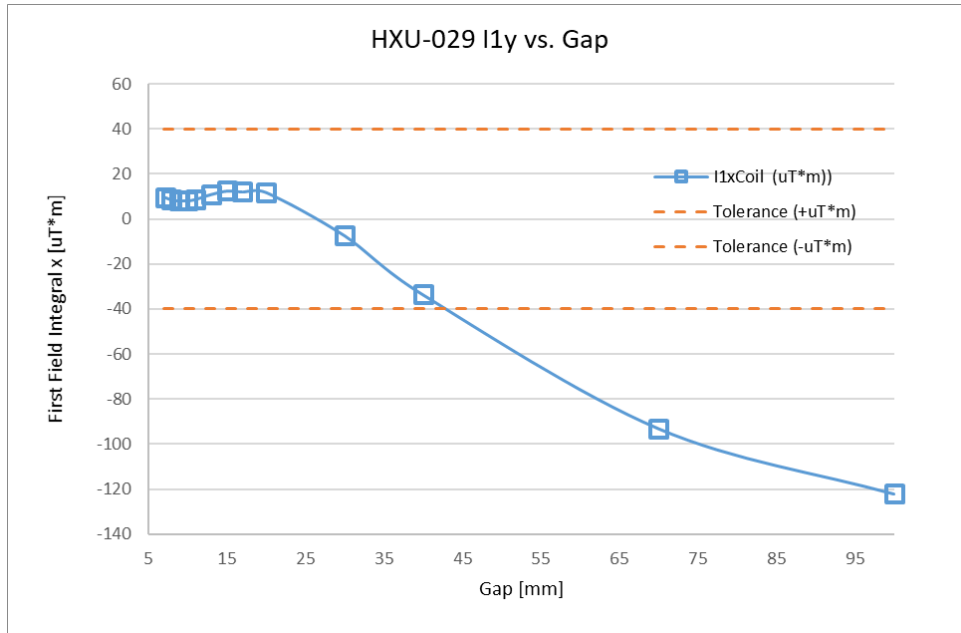
Long Coil Measurement of the On-Axis Second Vertical Field Integrals
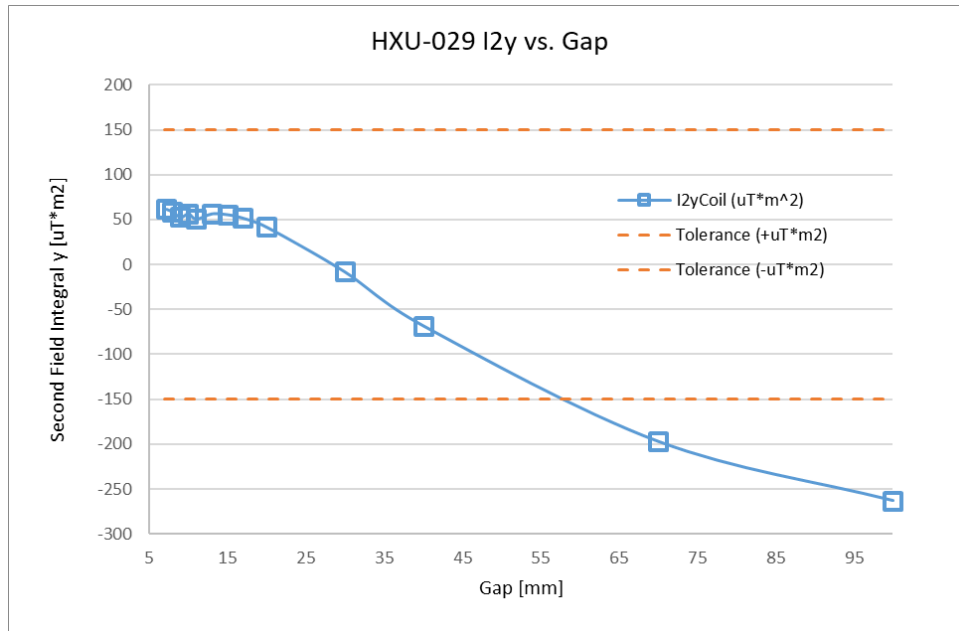
Second Horizontal and Vertical Field Integrals along Undulator Length at Commissioning Gap

HXU-29 Second Field Integral vs. Z (Commissioning Gap)
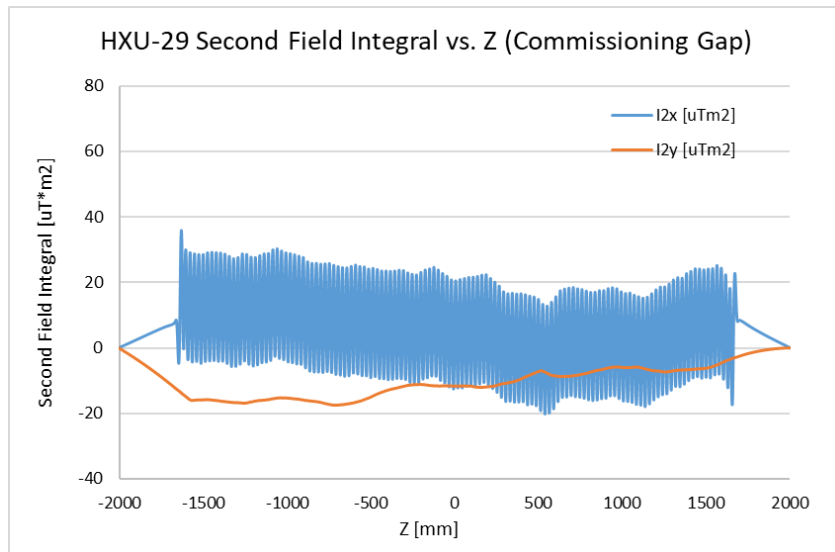
Horizontal Peak Field along Undulator Length at Commissioning Gap
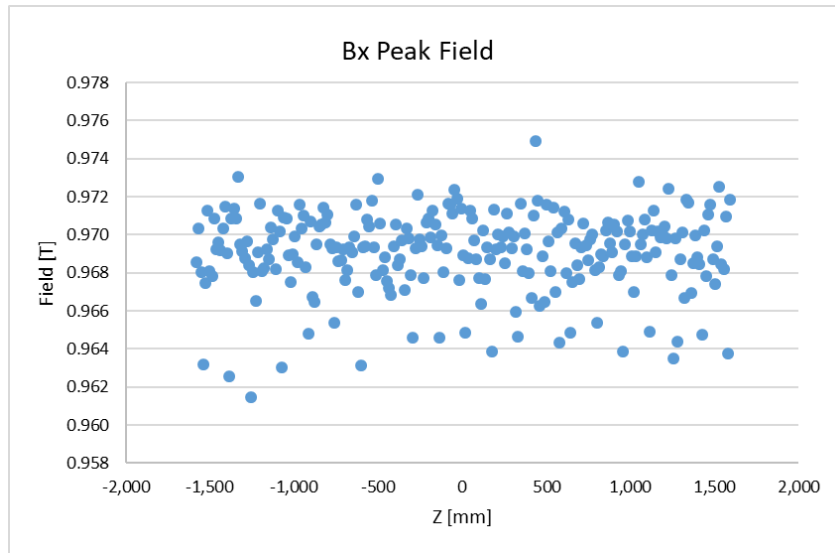
Capacitive Sensor Arrangement
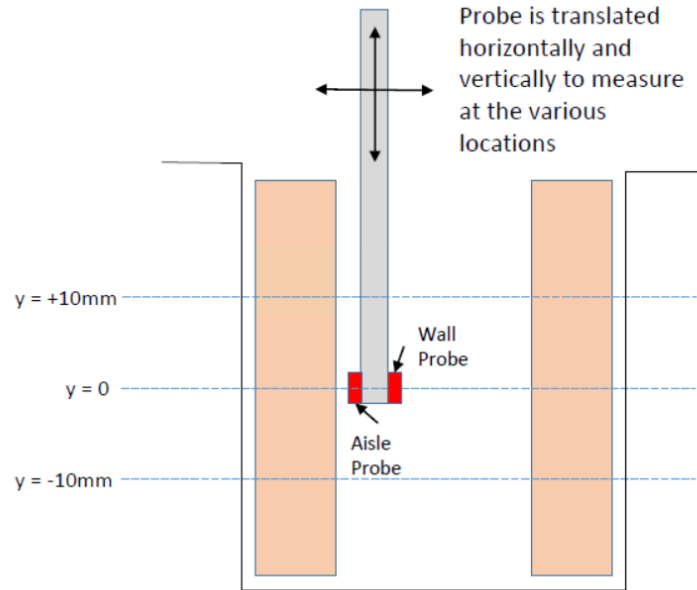
The following plots show the pole and magnet position measurements. The ANL system has two back-to-back capacitive probes on one probe holder. The x and y stages on the 6-meter bench are positioned so that the probe is in the proper location for each of the 9 scan locations. For the data analysis, the 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 effects in the capacitance probe measurement.
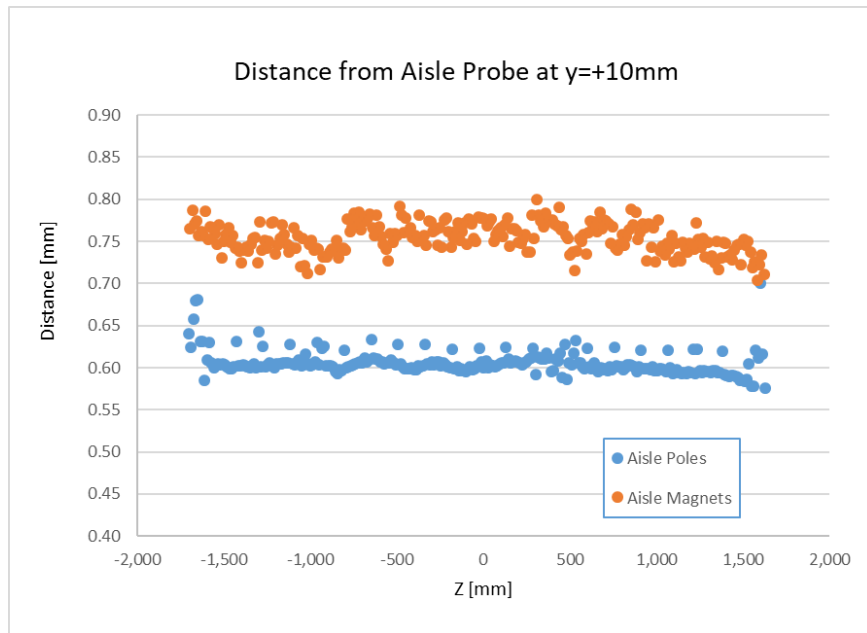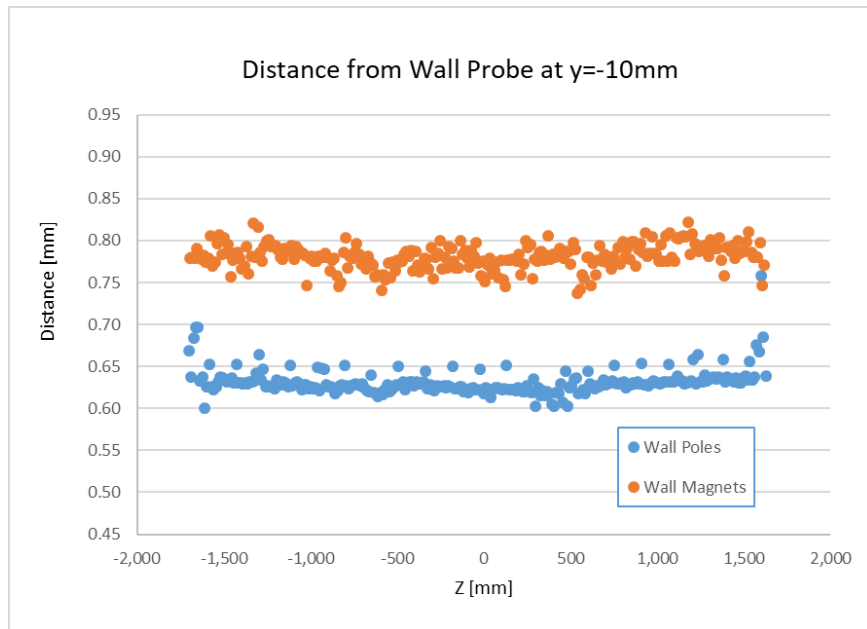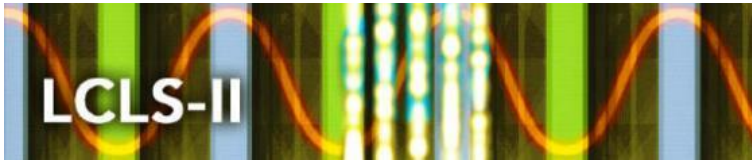
Aisle Capacitive Sensor Readings y = +10mm

Distance from Wall Probe at y=+10mm

Wall Capacitive Sensor Readings y = +10mm
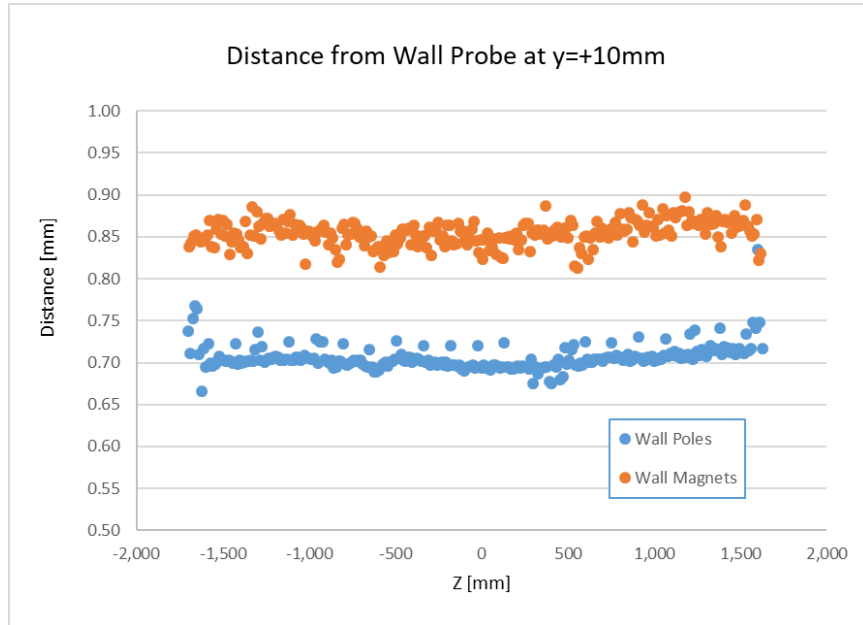
Distance from Aisle Probe at y=+10mm

Aisle Capacitive Sensor Readings y = -10mm

Wall Capacitive Sensor Readings y = -10mm

Distance from Aisle Probe at y=-10mm
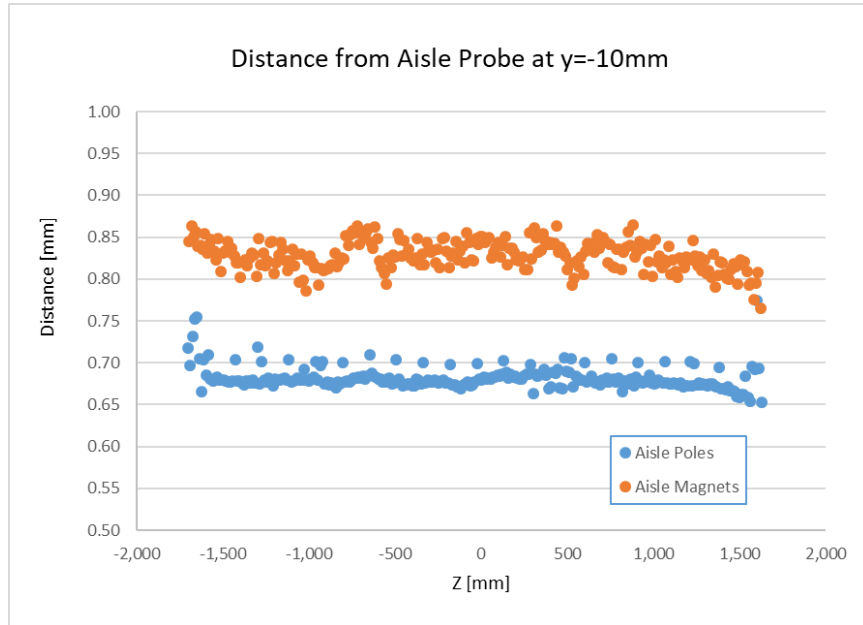
Undulator Gap Measurements
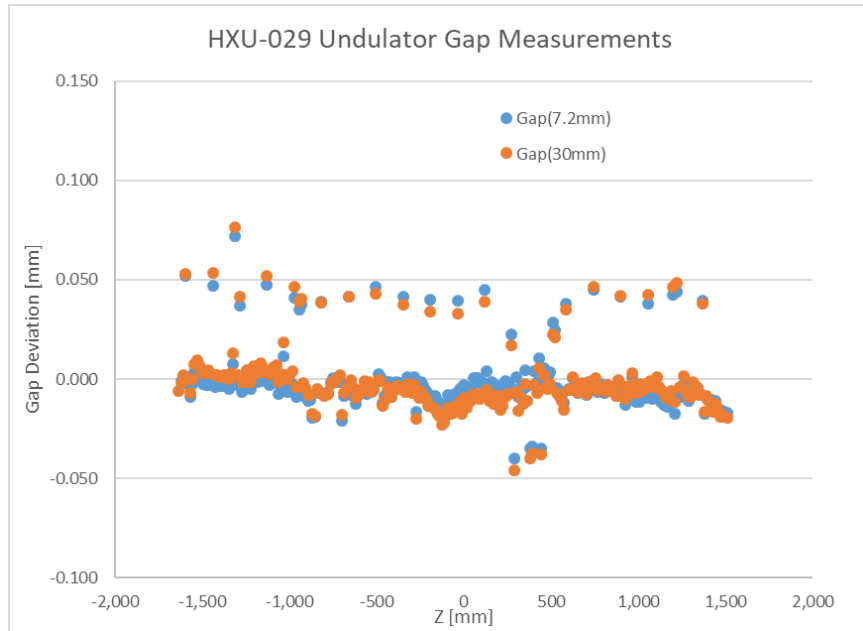
Undulator Gap Difference

HXU-029 Gap Shape Change [gap(7.2) minus gap(30)]
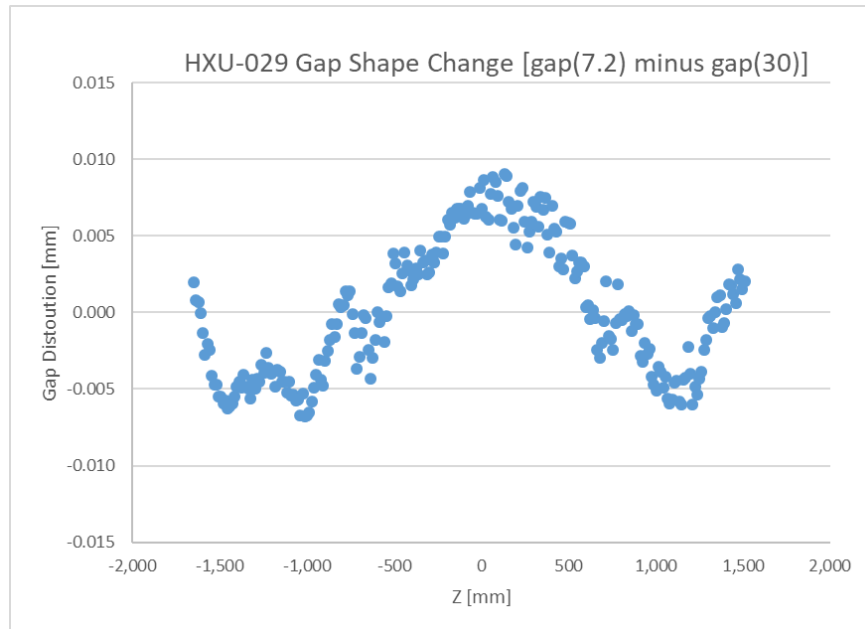
Drive Loads (Gap Opening)
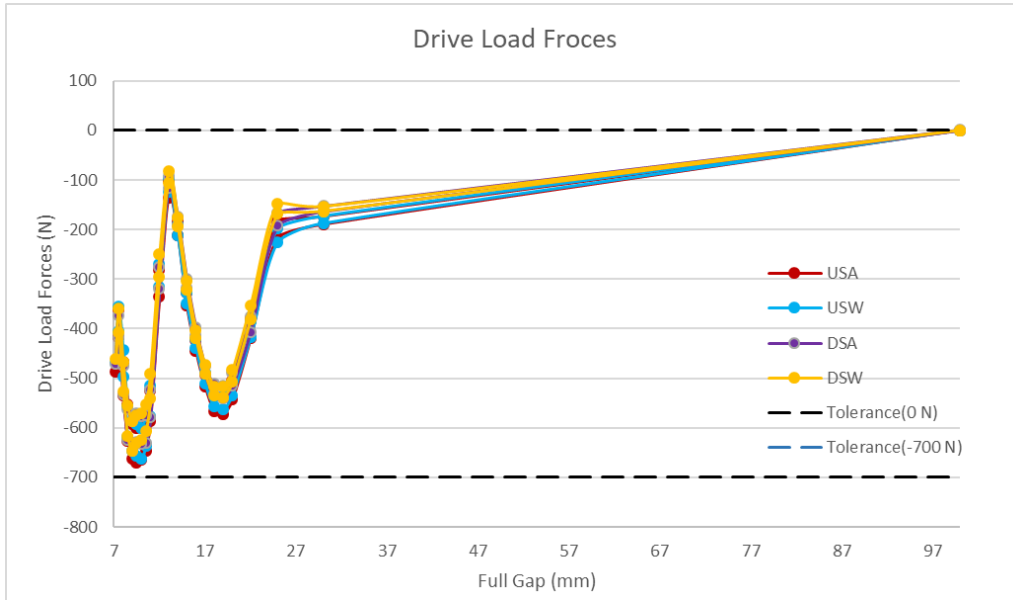
Drive Load Differences (Gap Opening - Closing)

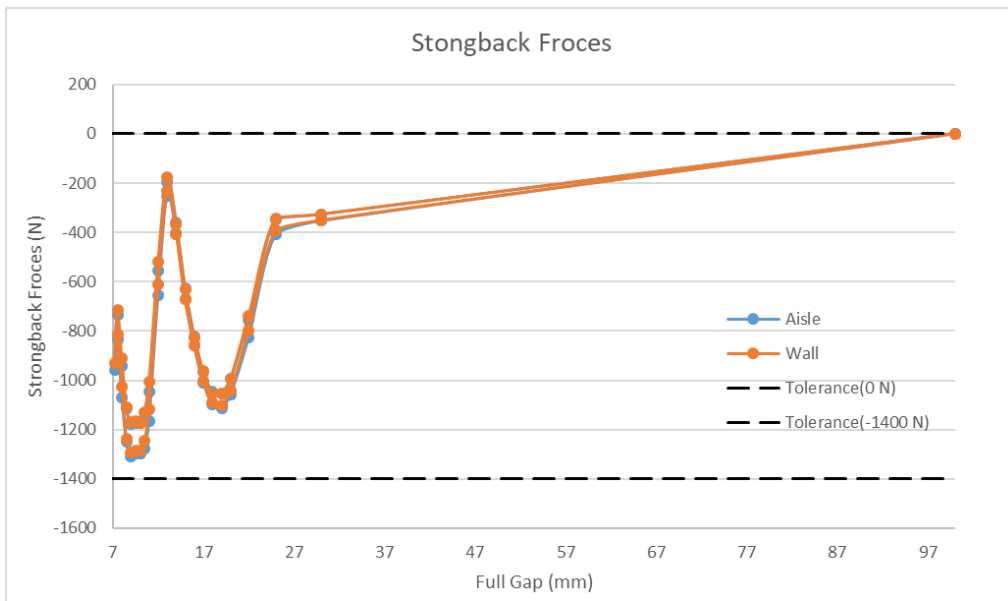

Drive Load Froces Differences: UPS-DNS
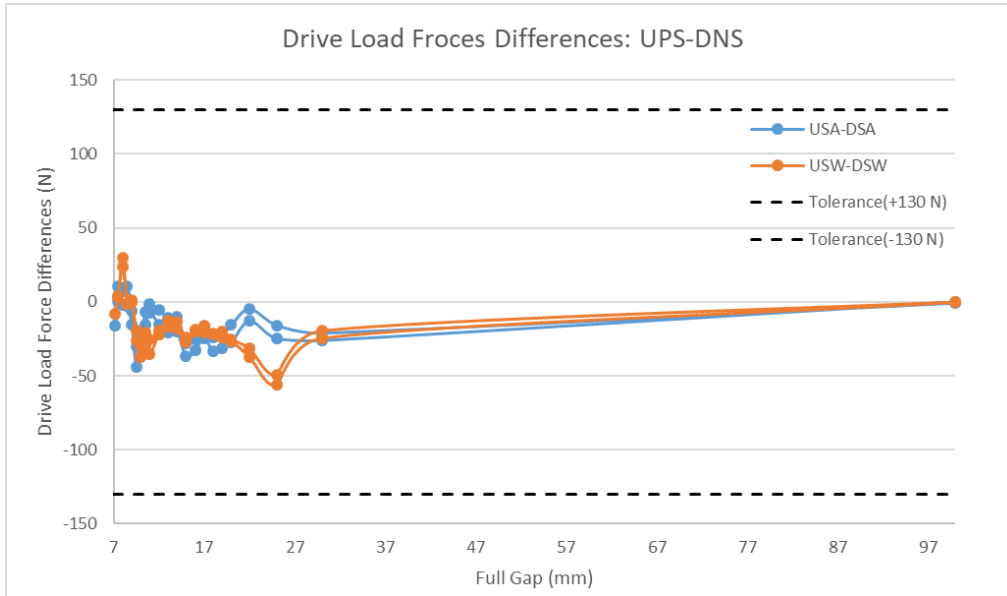
Strongback Forces (Gap Opening and Closing)

Strongback Force Differences (Gap Closing - Opening)

Strongback Force Differences: Aisle-Wall