

LCLS-II HXU Measurement Results

Serial number from manufacturers label:	HXU-009
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Measurement Procedure:

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

General Hall Probe Scan Evaluation Parameters

Undulator Temperature (should be 20.0)	20.0 ± 0.3	°C
First core pole #	8	
Last core pole #	253	
Tuning Gap	9.000	mm

Evaluation of Hall Probe Scans at Commissioning Gap

Commissioning Gap Temperature (should be 20.0)	20.0 ± 0.1	°C
$rms(B_{pk} /\langle B_{pk} \rangle - 1)$	0.0024	
K_{eff} at Commissioning Gap (should be 2.3400)	2.3401	
Commissioning Gap	7.949	mm
$I1X$ (over 4.012667 m) (should be within ± 40)	7	μTm
$I2X$ (over 4.012667 m) (should be within ± 150)	3	μTm^2
$I1Y$ (over 4.012667 m) (should be within ± 40)	-3	μTm
$I2Y$ (over 4.012667 m) (should be within ± 150)	4	μTm^2
Phase Shake (rms phase fluctuations over core poles (< 4.0))	1.9	degXray
Cell Phase Advance (over 4.012667 m)	48599.8 ($135 \times 360 - 0.2$)	degXray
Undulator Entrance Phase ¹	2249.1 ($25 \times 90 - 0.9$)	degXray
Undulator Exit Phase ²	2250.1 ($25 \times 90 + 0.1$)	degXray

¹Phase advance from cell start (undulator center -2.006334 m) to center of physical pole 8.

²Phase advance from physical pole 253 to cell end (undulator center $+2.006334$ m).



Undulator Encoder Settings

USGapEncoderOffset	41.9866
DSGapEncoderOffset	42.2771
USWLinearEncoder.AOFF	91.6808
DSWLinearEncoder.AOFF	91.9597
USALinearEncoder.AOFF	92.7773
DSALinearEncoder.AOFF	91.5600

Undulator Load Cell Readings at Tuning Gap (Gap Opening)

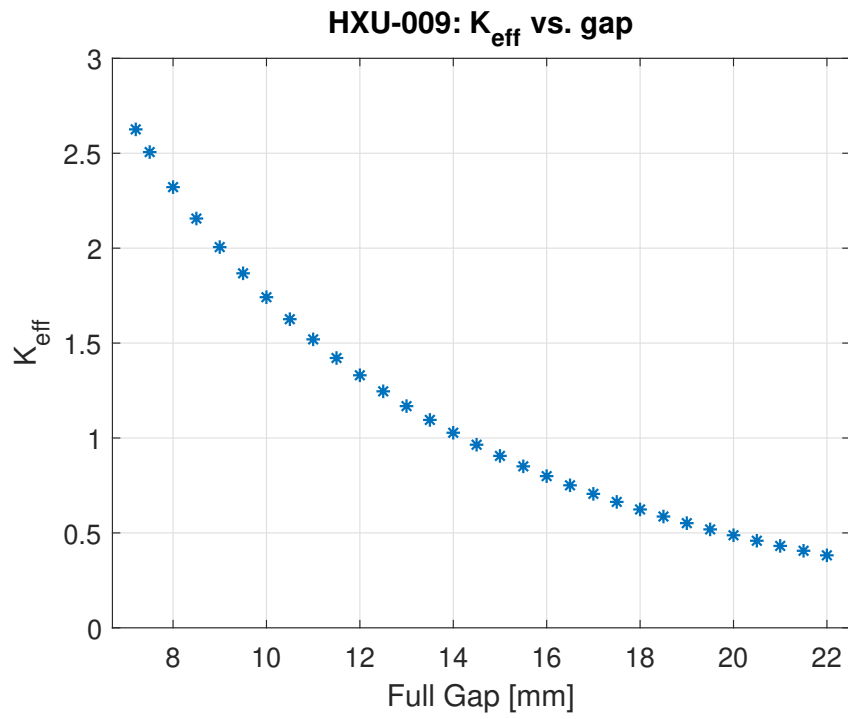
LC.DAL_FORCE	-138.7
LC.DAU_FORCE	-127.9
LC.DWL_FORCE	-231.9
LC.DWU_FORCE	-58.6
LC.UAL_FORCE	-170.2
LC.UAU_FORCE	-111.8
LC.UWL_FORCE	-80.6
LC.UWU_FORCE	-227.8

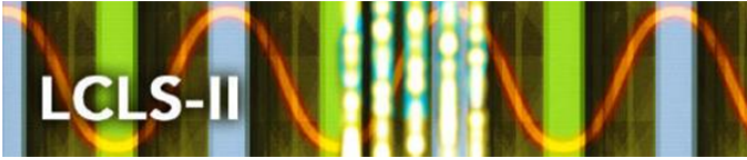
Undulator Load Cell Readings at 100 mm Gap (Gap Opening)

LC.DAL_FORCE	1.0
LC.DAU_FORCE	0.7
LC.DWL_FORCE	1.2
LC.DWU_FORCE	-0.7
LC.UAL_FORCE	3.7
LC.UAU_FORCE	2.9
LC.UWL_FORCE	6.6
LC.UWU_FORCE	3.4

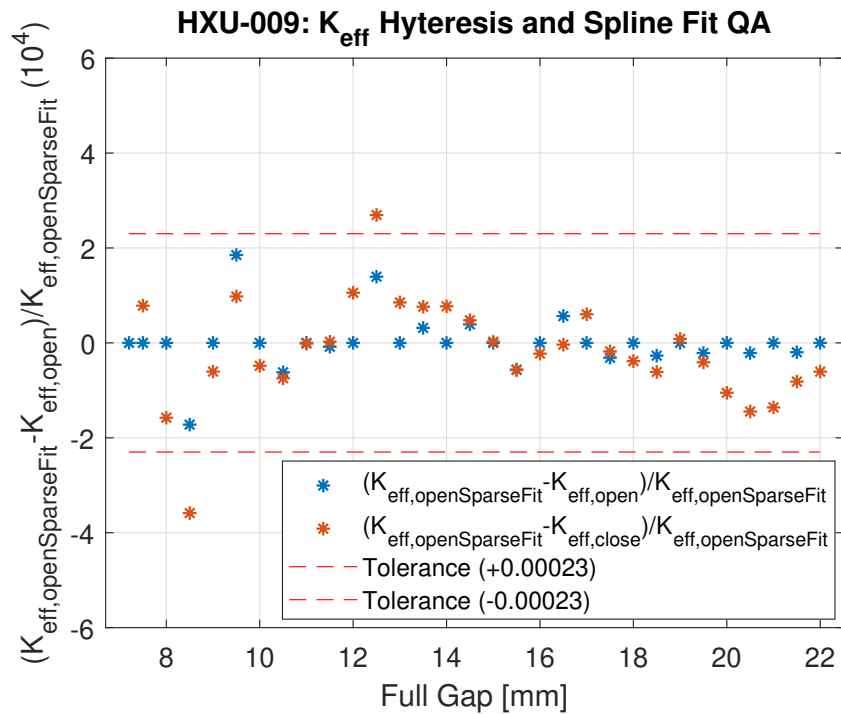


Evaluation of Hall Probe Scans: K_{eff} vs. gap





Evaluation of Hall Probe Scans: K_{eff} Hysteresis using Half Gap Encoders

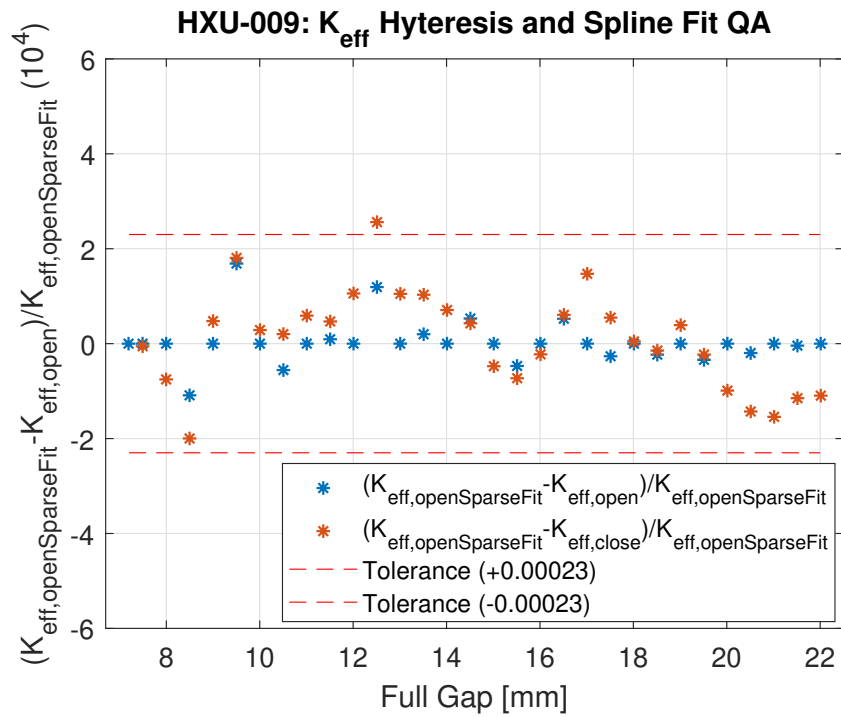


Plotted functions have been calculated from measured values openKeff (opengap) and closeKeff (closegap) using the following Matlab calculations:

Blue Stars: `1-openKeff ./ spline(opengap([1,2,[3:2:end]]),openKeff([1,2,[3:2:end]]),opengap)`
 Green Stars: `1-closeKeff ./ spline(opengap([1,2,[3:2:end]]),openKeff([1,2,[3:2:end]]),closegap)`



Evaluation of Hall Probe Scans: K_{eff} Hysteresis using Full Gap Encoders



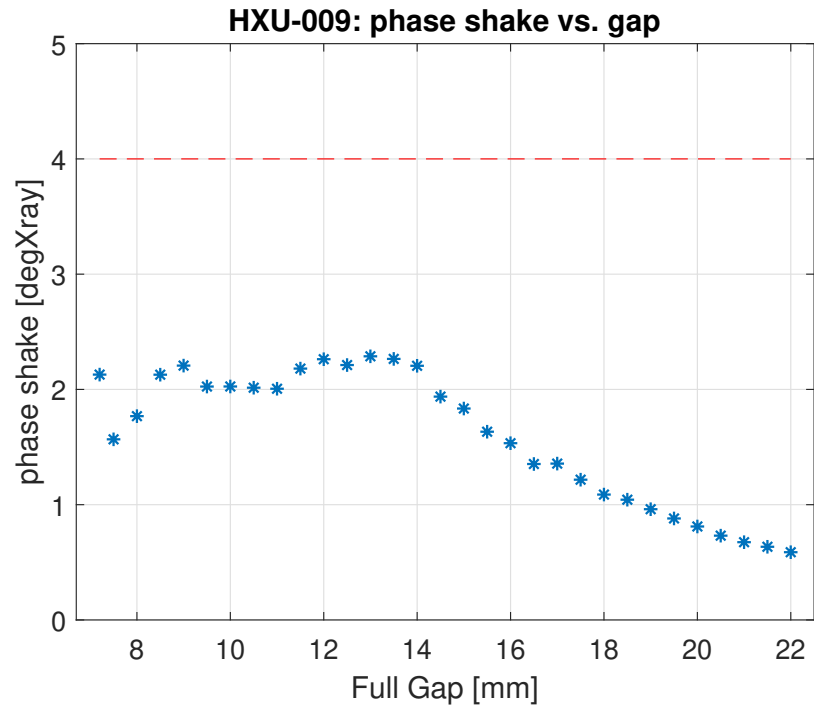
Plotted functions have been calculated from measured values openKeff (opengap) and closeKeff (closegap) using the following Matlab calculations:

Blue Stars: `1-openKeff ./ spline(opengap([1,2,[3:2:end]]),openKeff([1,2,[3:2:end]]),opengap)`

Green Stars: `1-closeKeff ./ spline(opengap([1,2,[3:2:end]]),openKeff([1,2,[3:2:end]]),closegap)`

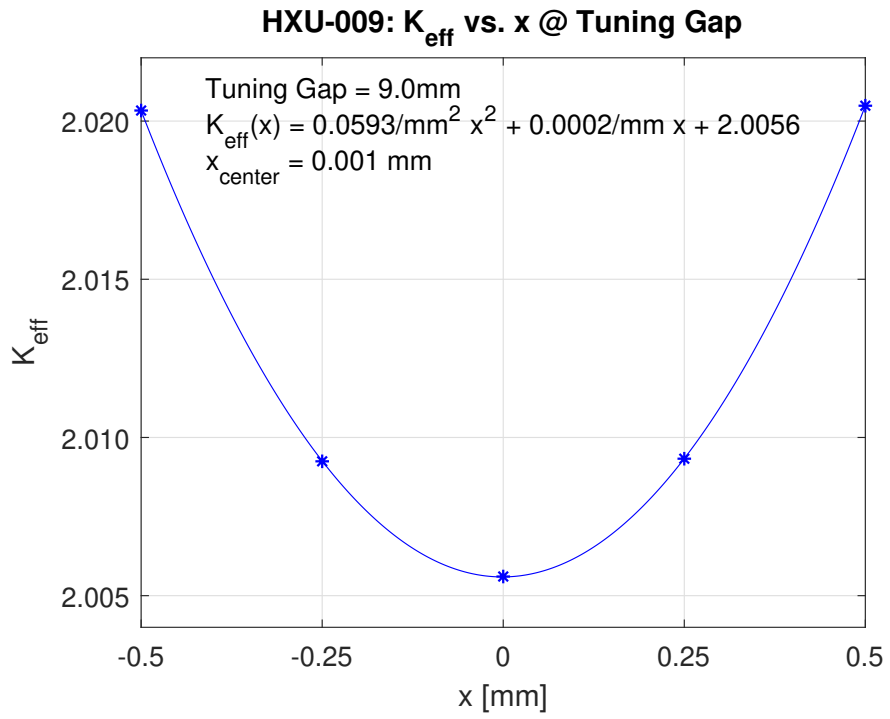


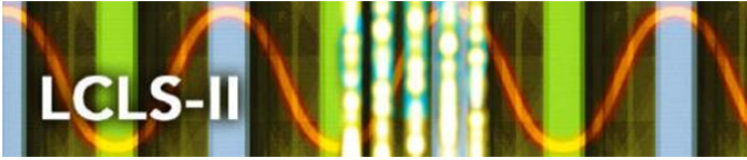
Evaluation of Hall Probe Scans: Phase Shake vs gap



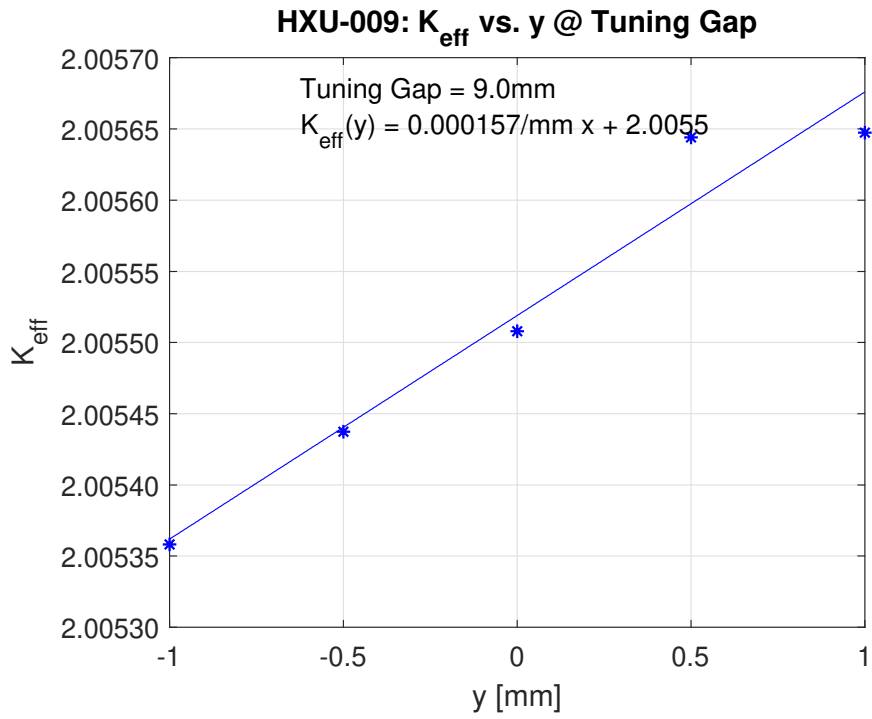


Evaluation of Hall Probe Scans: K_{eff} vs x at Tuning Gap



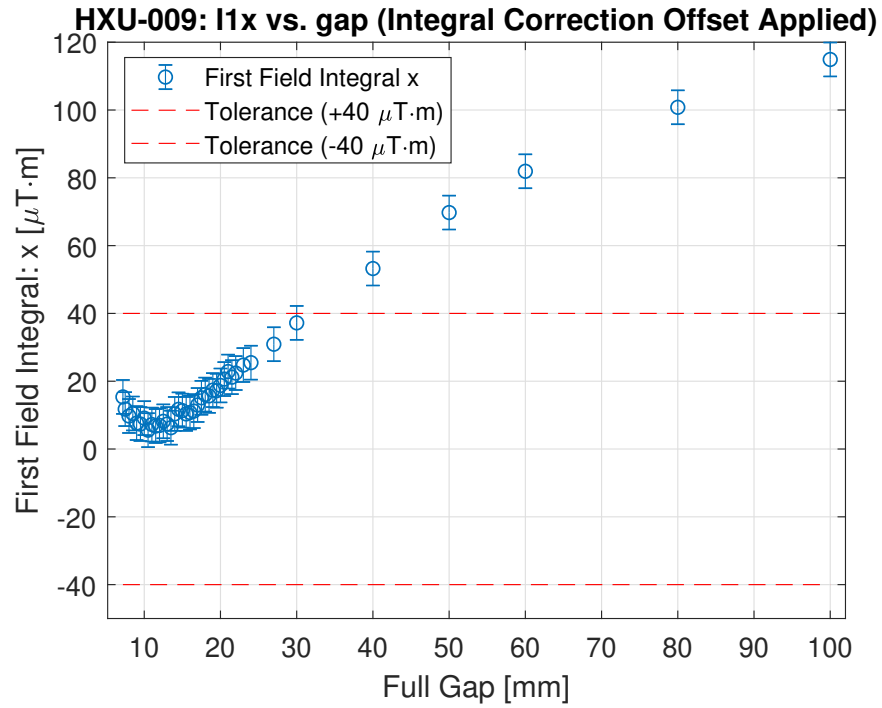


Evaluation of Hall Probe Scans: K_{eff} vs Y at Tuning Gap



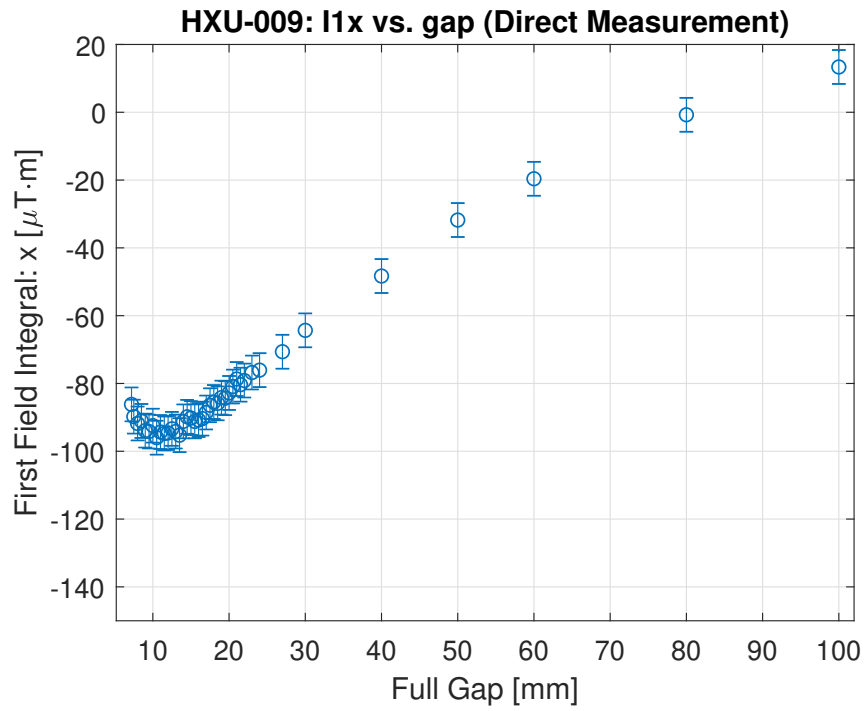


Long Coil Measurement of the On-Axis First Horizontal Field Integrals with +100 $\mu\text{T}\cdot\text{m}$ Integral Offset



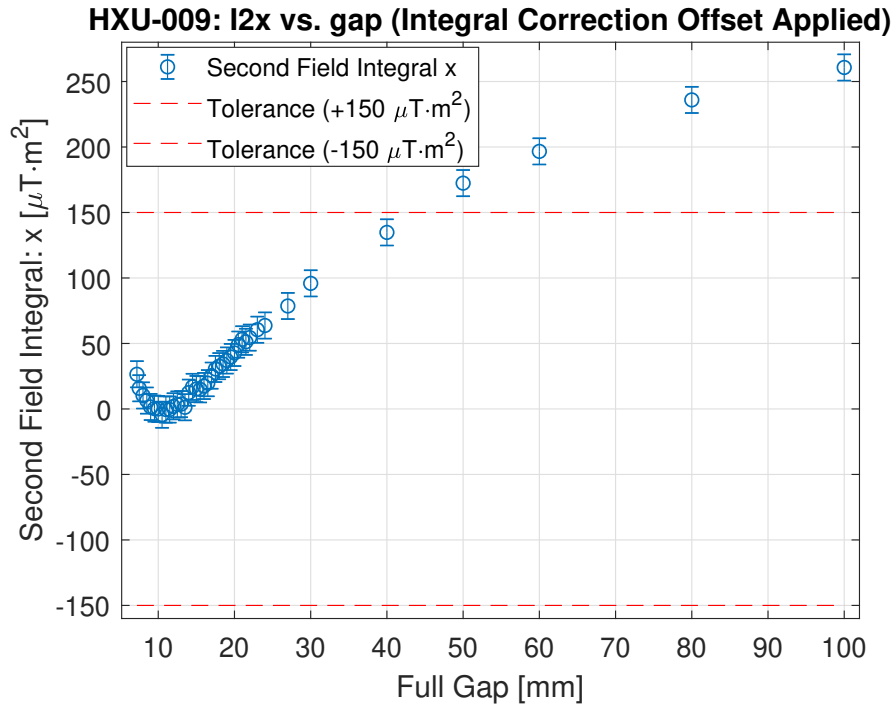


Long Coil Measurement of the On-Axis First Horizontal Field Integrals



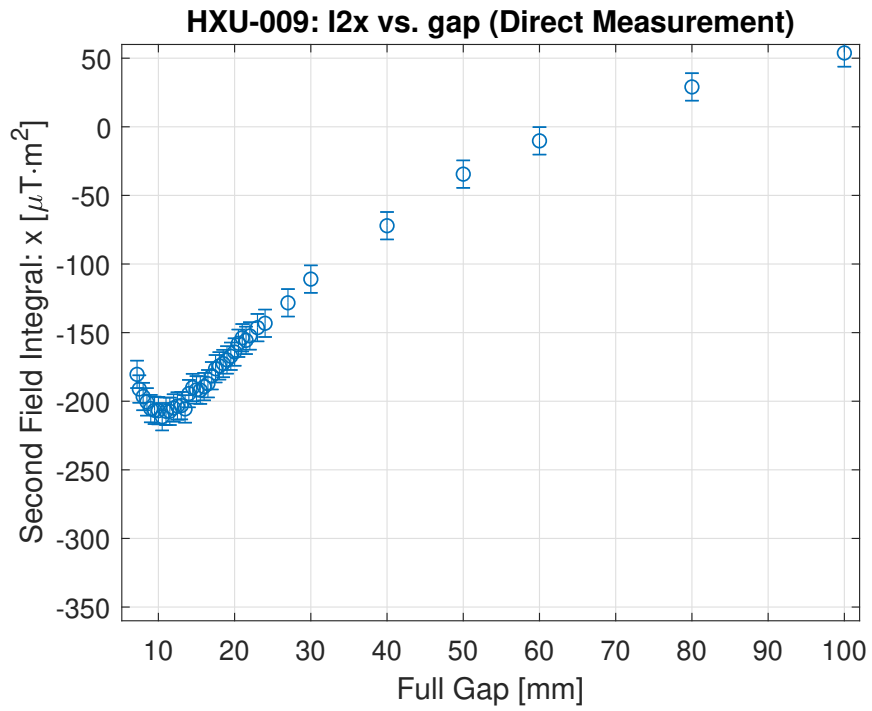


Long Coil Measurement of the On-Axis Second Horizontal Field Integrals with $+100 \mu\text{T}\cdot\text{m} \times 0.5 \times 4.012667 \text{ m}$ Second Integral Offset



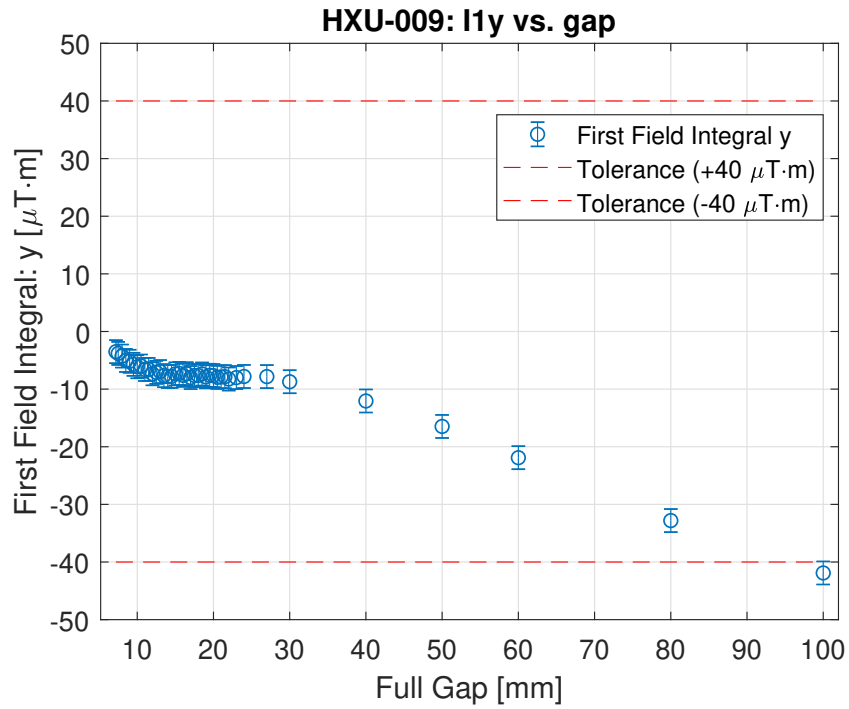


Long Coil Measurement of the On-Axis Second Horizontal Field Integrals



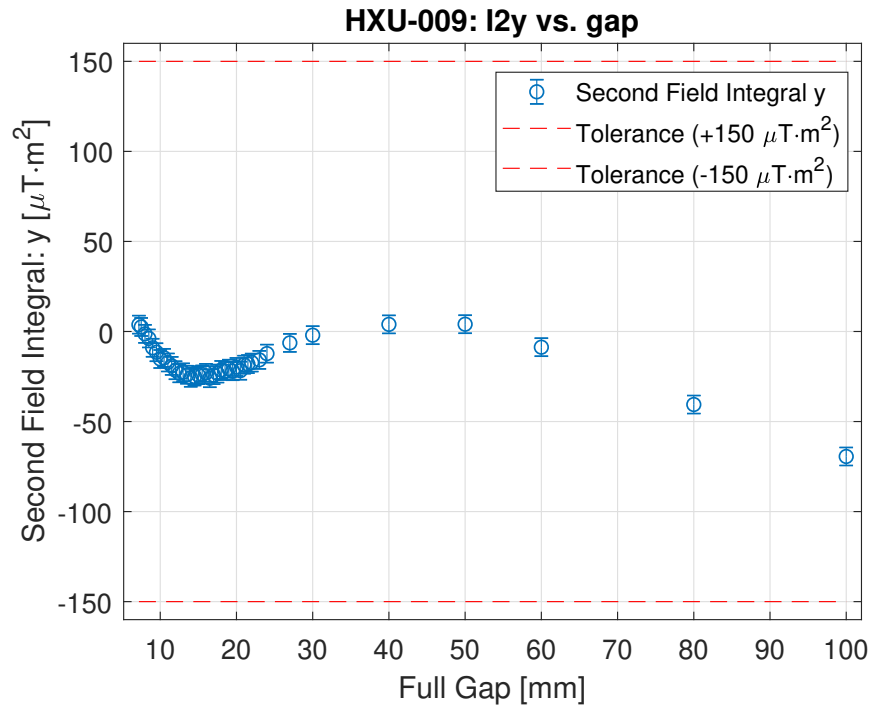


Long Coil Measurement of the On-Axis First Vertical Field Integrals



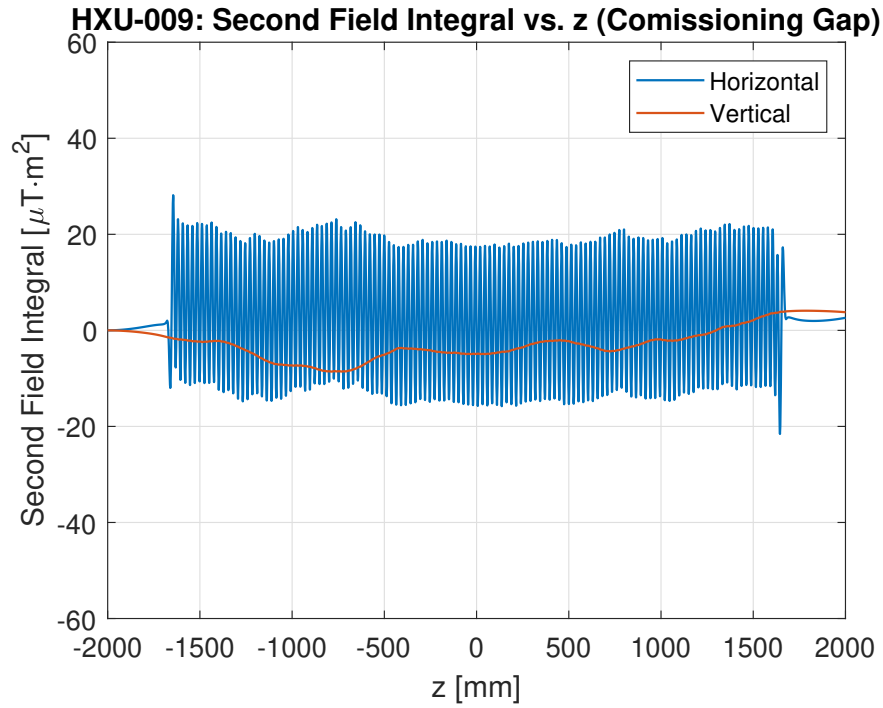


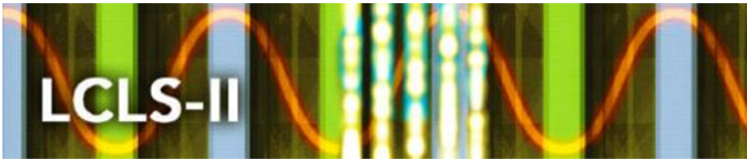
Long Coil Measurement of the On-Axis Second Vertical Field Integrals



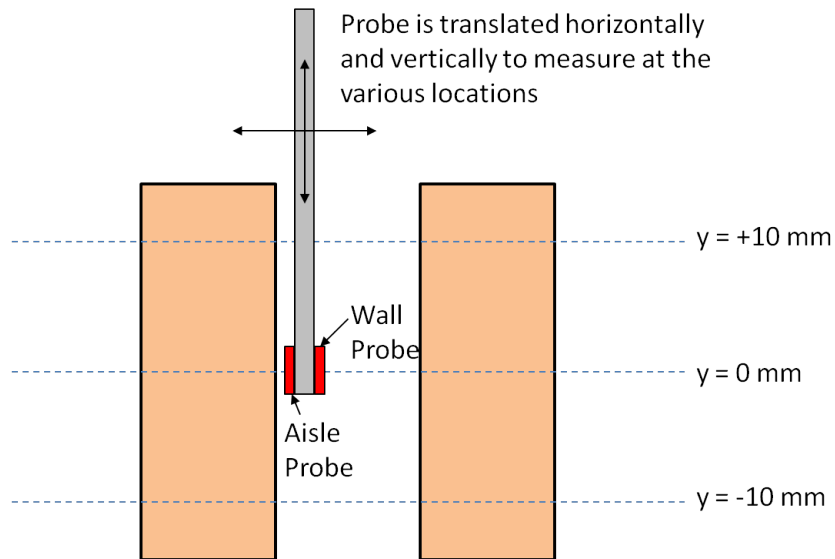


Second Horizontal and Vertical Field Integrals Along Undulator Length at Commissioning Gap





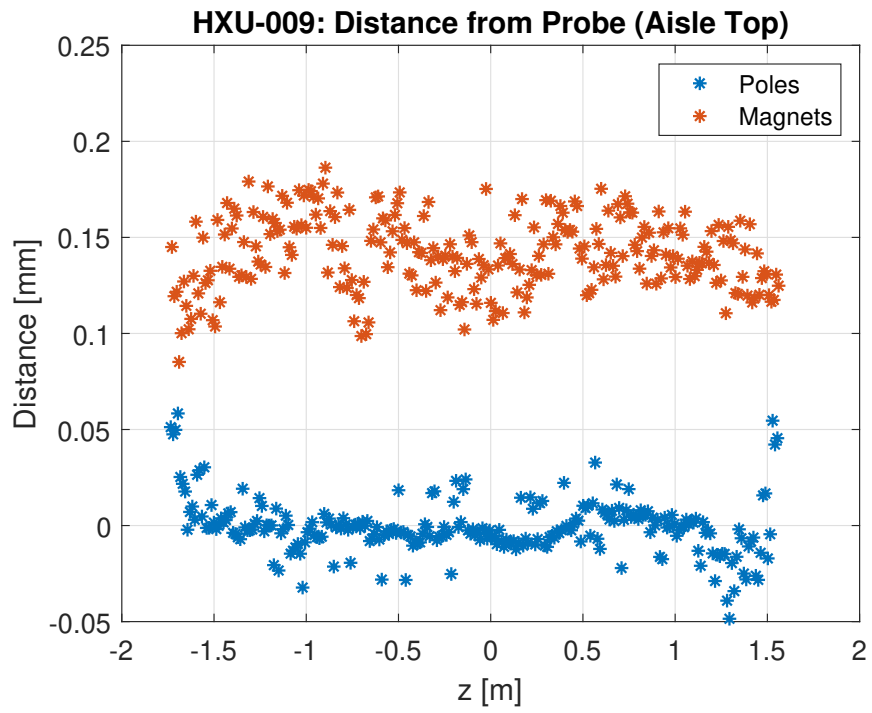
Capacitive Sensor Arrangement



The following plots show the pole and magnet position measurements. The LBNL system has two back-to-back capacitive probes on one probe holder. The x and y stages on the Kugler 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.

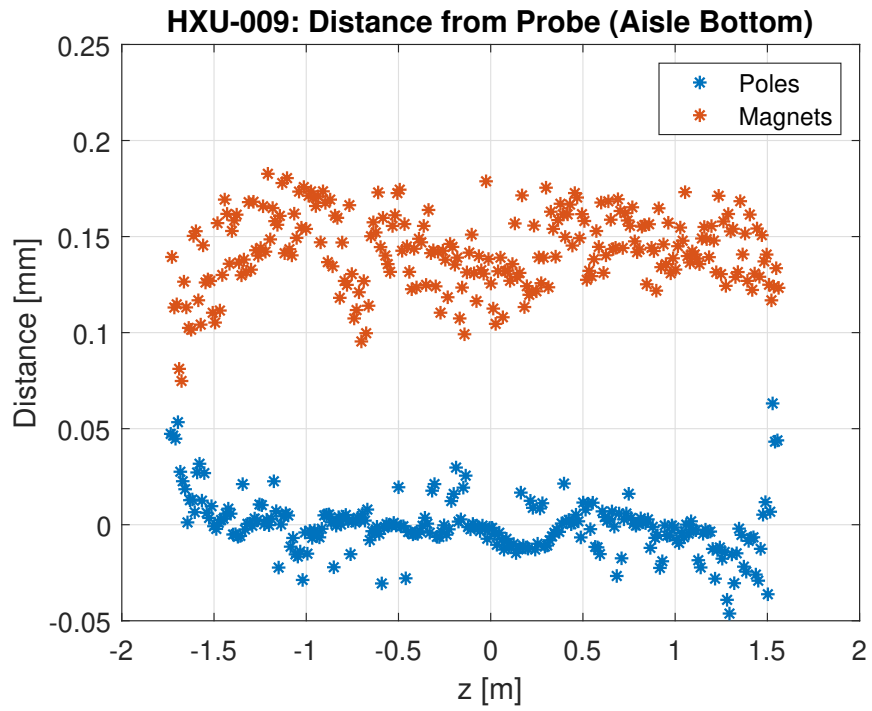


G1 Capacitive Sensor Readings



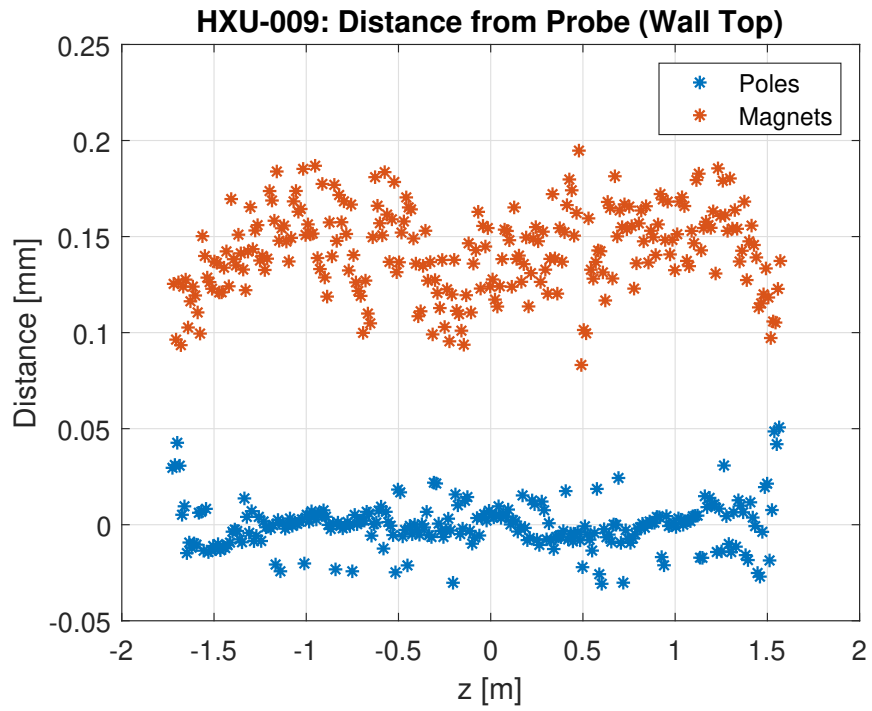


G2 Capacitive Sensor Readings



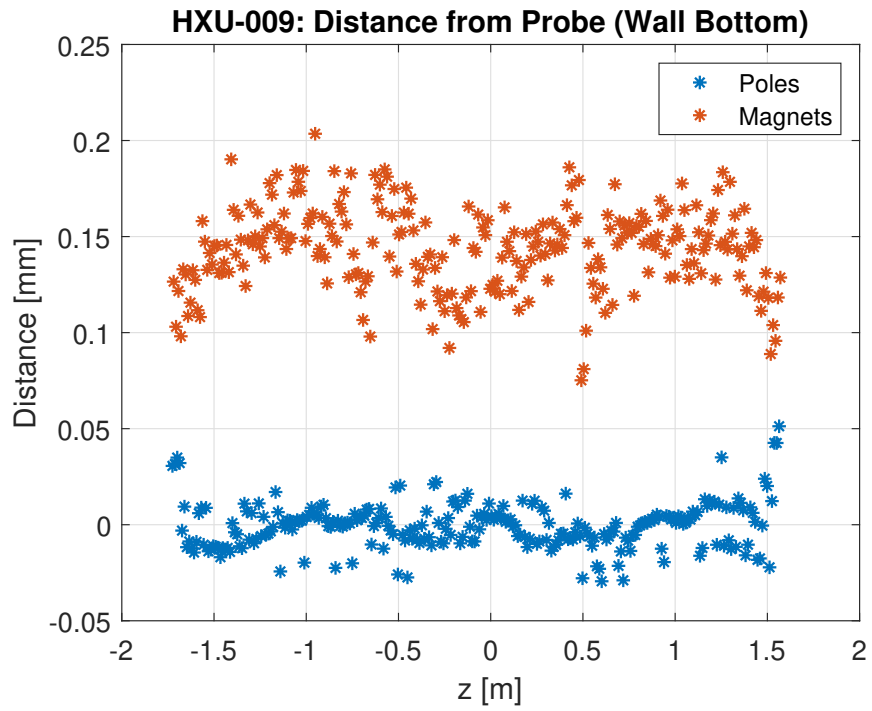


G3 Capacitive Sensor Readings



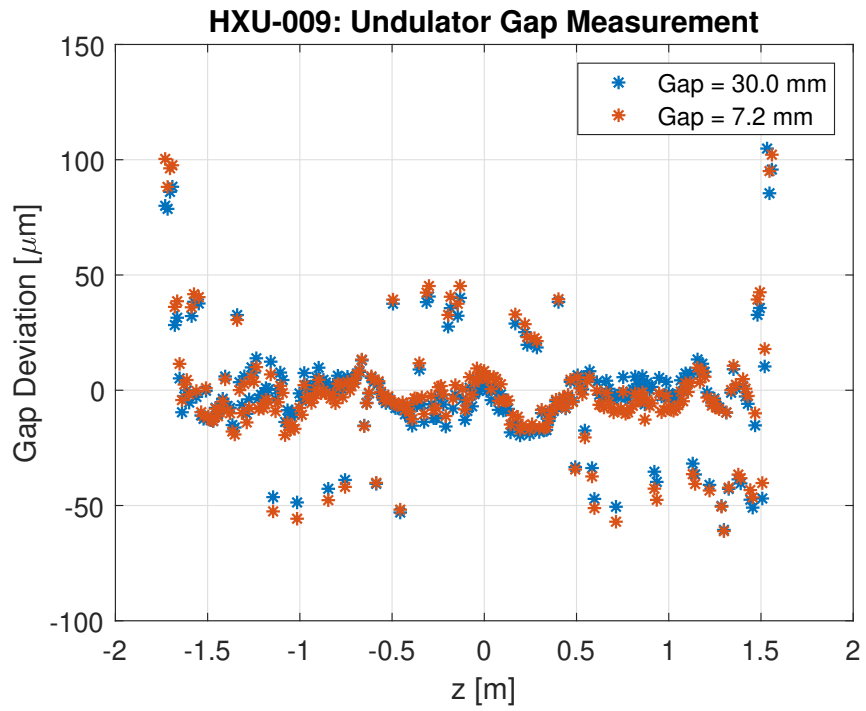


G4 Capacitive Sensor Readings



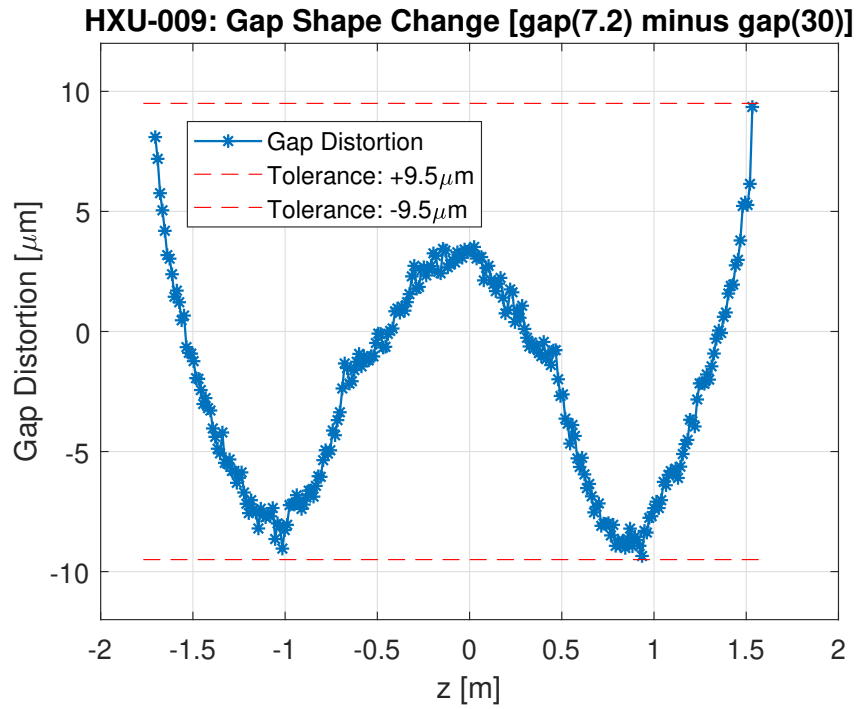


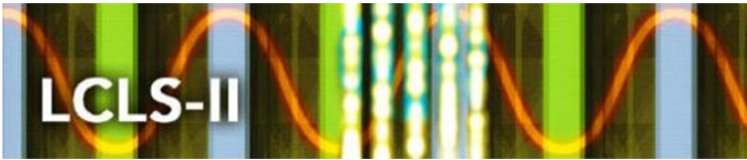
Undulator Gap Measurement



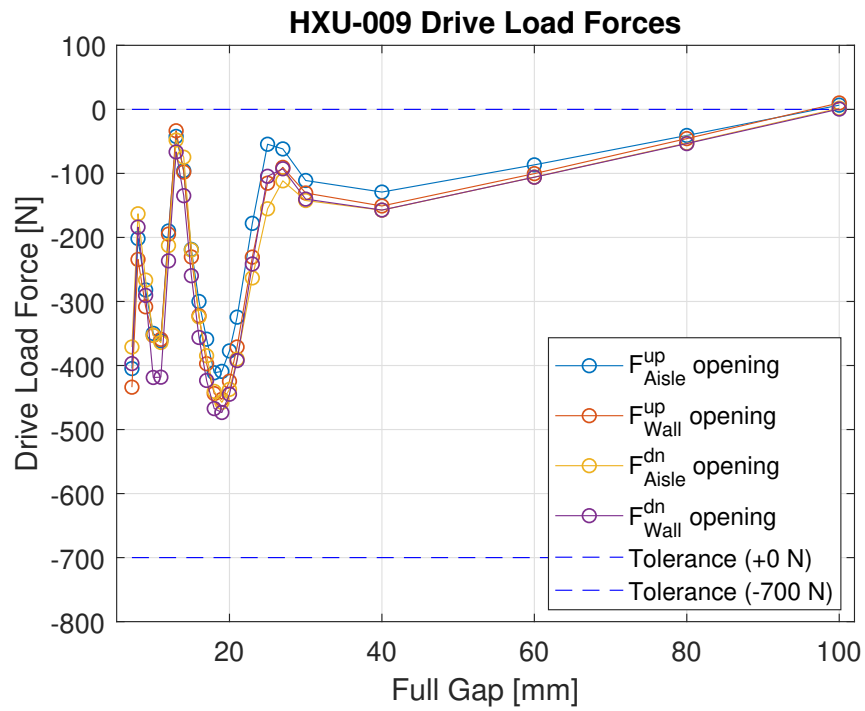


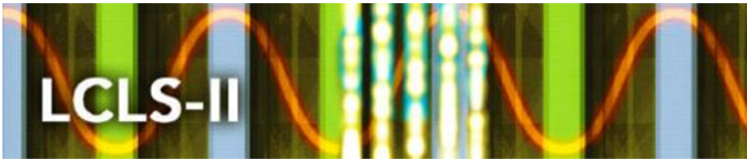
Undulator Gap Difference



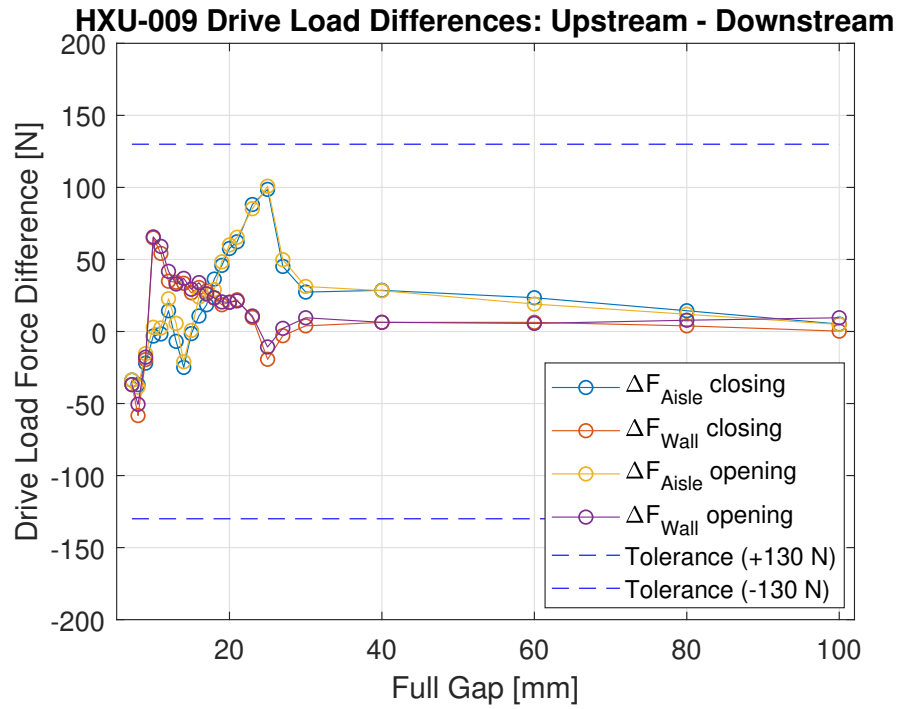


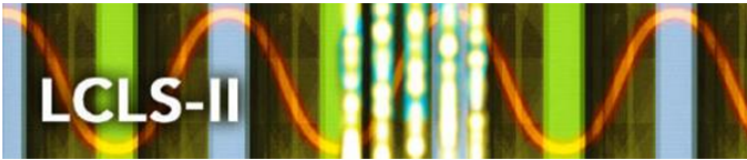
Drive Loads (Gap Opening)



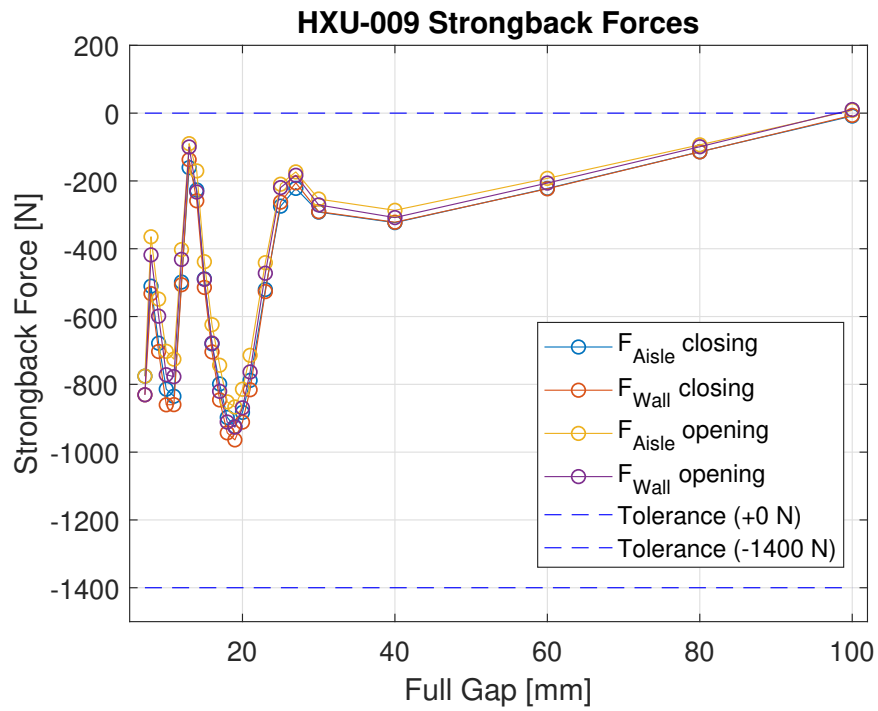


Drive Load Differences (Gap Opening and Closing)





Strongback Forces (Gap Opening and Closing)





Strongback Force Differences (Gap Opening and Closing)

