LCLS-II HXU Measurement Results

Serial number from manufacturers label:	HXU-011

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 ± 0.1	°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
$rms\,(\lvert B_{pk}\rvert/\langle\lvert B_{pk}\rvert\rangle - 1)$	0.0020	
K_{eff} at Commissioning Gap (should be 2.3400)	2.3402	
Comissioning Gap	7.934	mm
$I1X$ (over 4.012667 m) (should be within ±40)	-6	μTm
$I2X$ (over 4.012667 m) (should be within ±150)	0	μTm^2
$I1Y$ (over 4.012667 m) (should be within ±40)	-5	μTm
$I2Y$ (over 4.012667 m) (should be within ±150)	7	μTm^2
Phase Shake (rms phase fluctuations over core poles (<4.0)	1.3	degXray
Cell Phase Advance (over 4.012667 m)	48598.6 ($135\times360-1.4$)	degXray
Undulator Entrance Phase[1]	2249.0 ($25\times90-1.0$)	degXray
Undulator Exit Phase[2]	2248.0 ($25\times90-2.0$)	degXray

[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	40.3898
DSGapEncoderOffset	40.0815
USWLinearEncoder.AOFF	92.0303
DSWLinearEncoder.AOFF	94.0350
USALinearEncoder.AOFF	92.8664
DSALinearEncoder.AOFF	92.2437

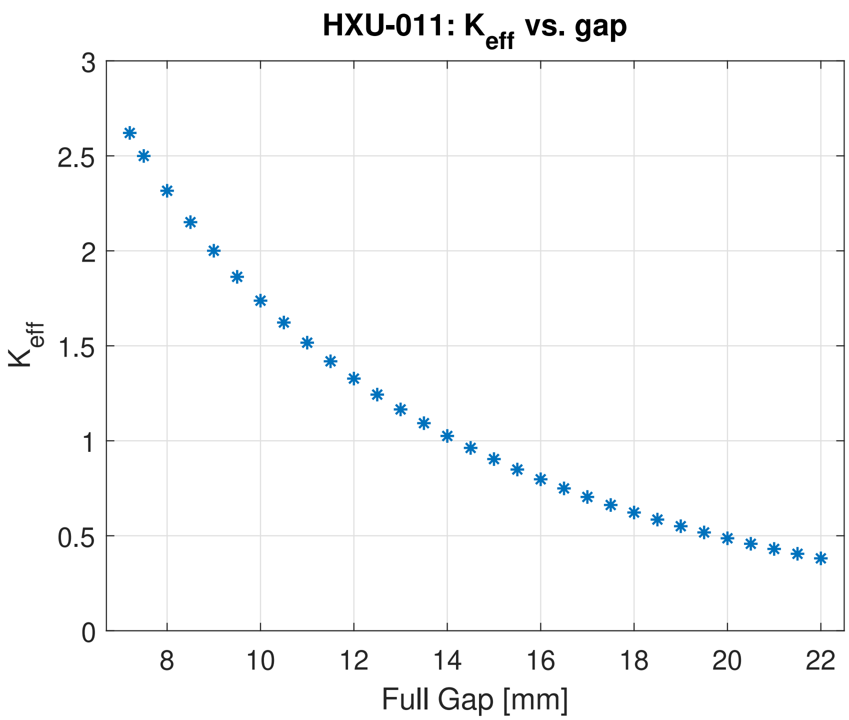
Undulator Load Cell Readings at Tuning Gap (Gap Opening)

LC_DAL_FORCE	-252.0
LC_DAU_FORCE	-194.8
LC_DWL_FORCE	-185.5
LC_DWU_FORCE	-190.9
LC_UAL_FORCE	-232.2
LC_UAU_FORCE	-170.7
LC_UWL_FORCE	-225.1
LC_UWU_FORCE	-196.5

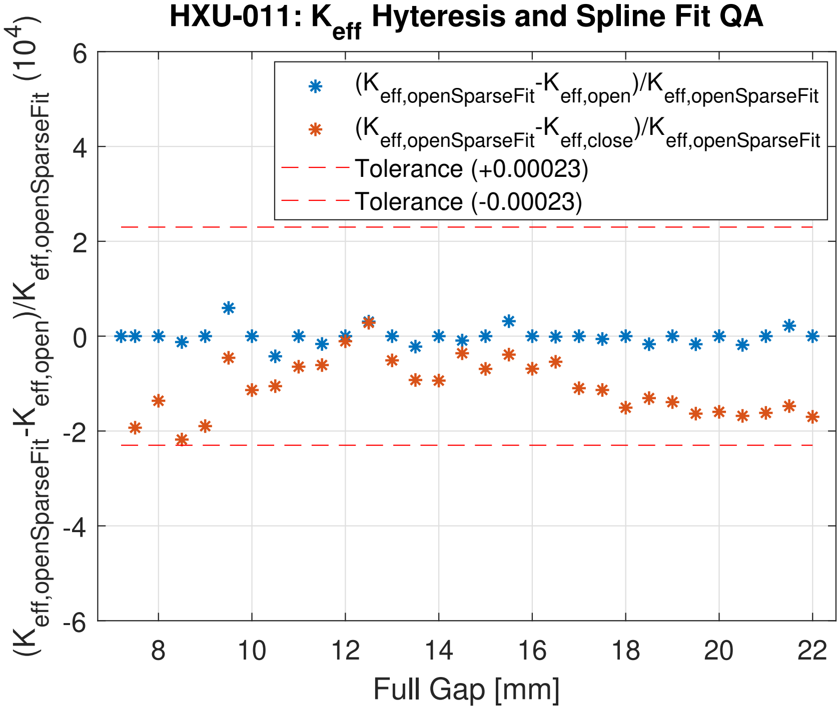
Undulator Load Cell Readings at 100 mm Gap (Gap Opening)

LC_DAL_FORCE	0.7
LC_DAU_FORCE	3.2
LC_DWL_FORCE	7.1
LC_DWU_FORCE	4.4
LC_UAL_FORCE	5.6
LC_UAL_FORCE	3.4
LC_UWL_FORCE	4.2
LC_UWU_FORCE	-0.2

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



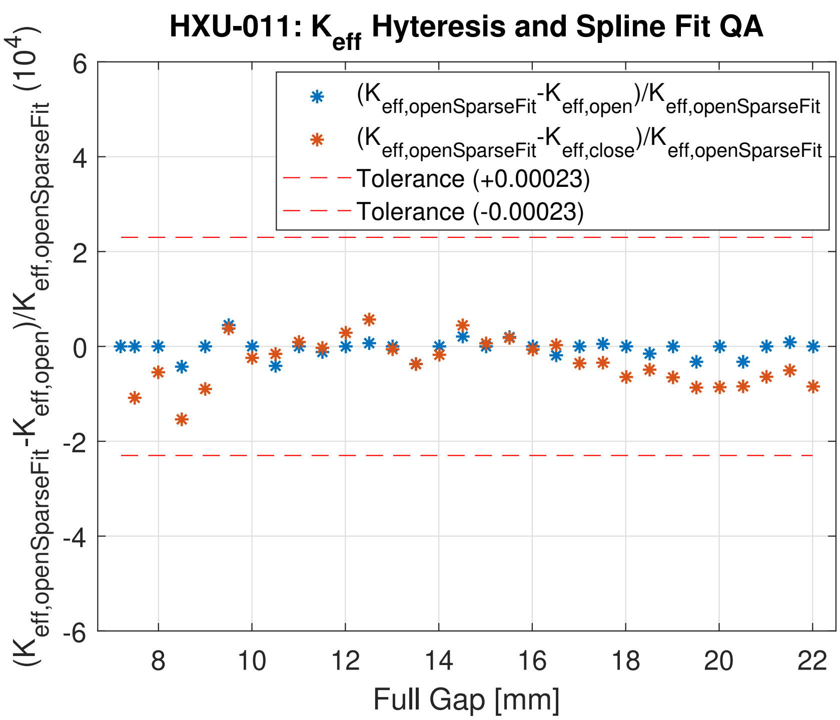
Evaluation of Hall Probe Scans: K_{eff} Hysteresis using Half Gap Encoders



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)

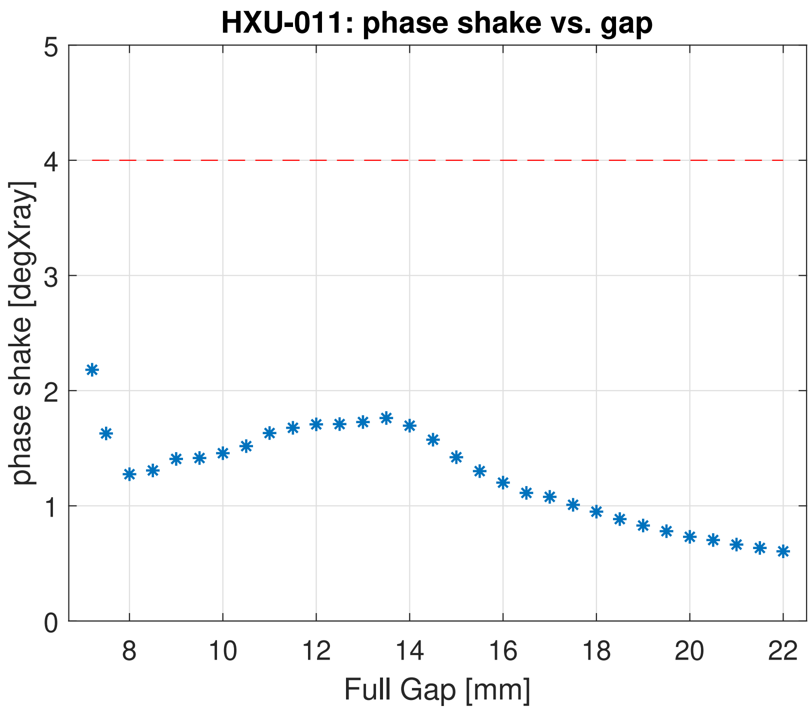
Evaluation of Hall Probe Scans: K_{eff} Hysteresis using Full Gap Encoders



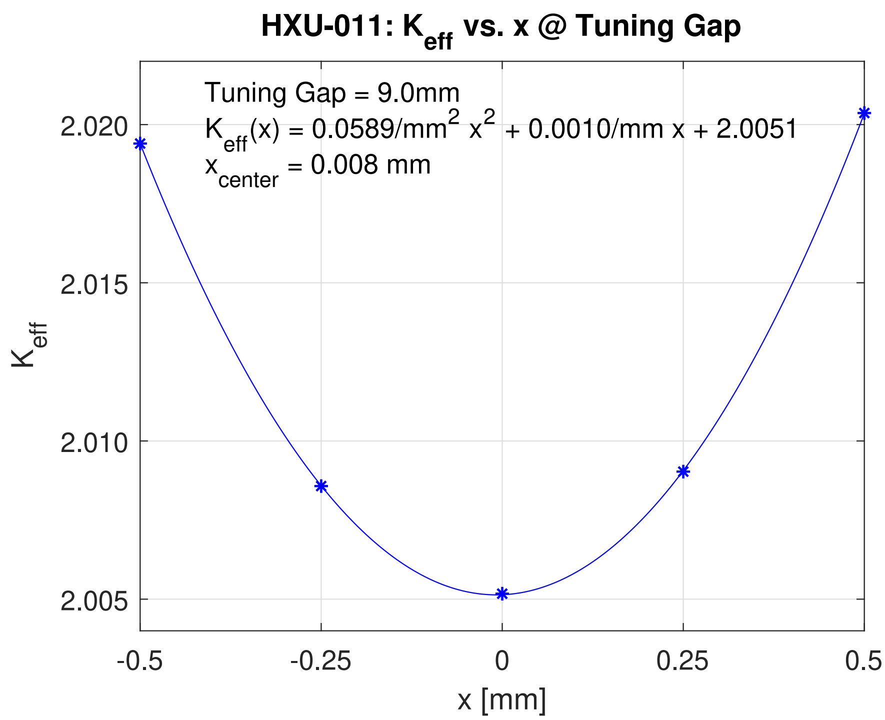
Plotted functions have been calculated from measured values openKeff (opengap) and closeKeff (closegap) using the following Matlab calculations:

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)

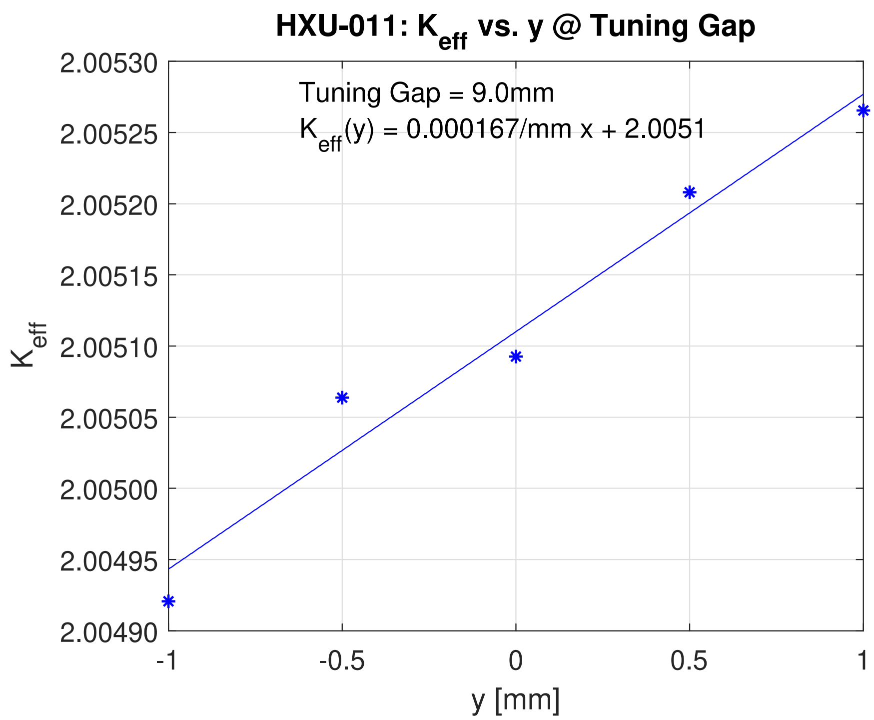
Evaluation of Hall Probe Scans: Phase Shake vs gap



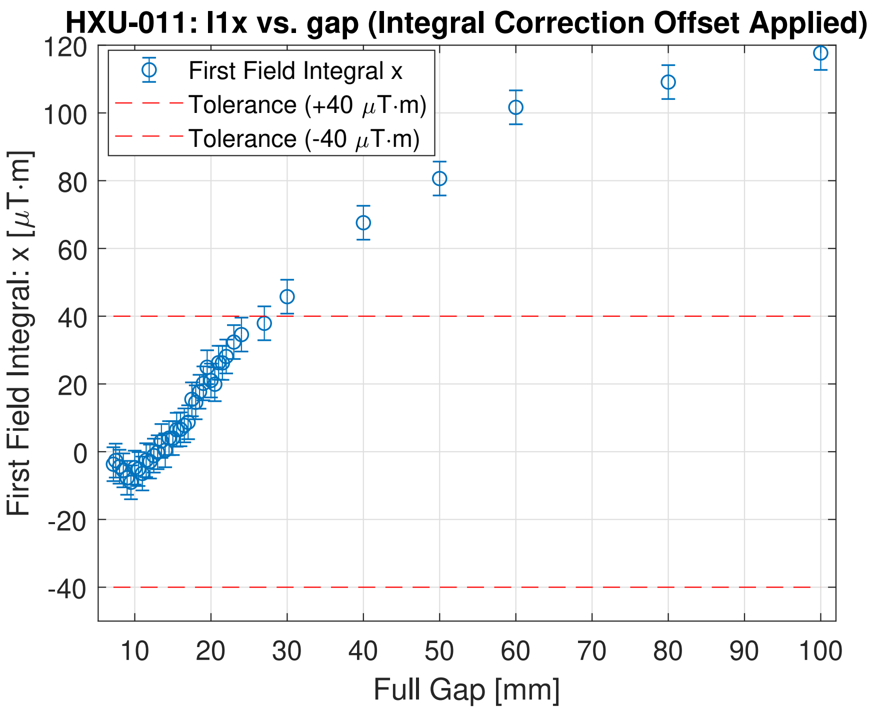
Evaluation of Hall Probe Scans: K_{eff} vs x at Tuning Gap



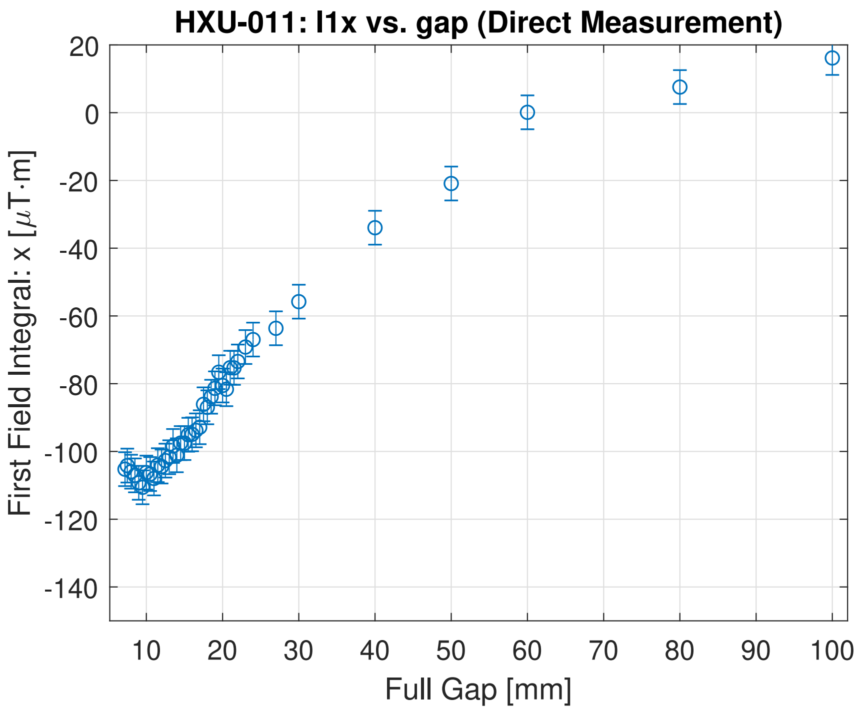
Evaluation of Hall Probe Scans: K_{eff} vs Y at Tuning Gap



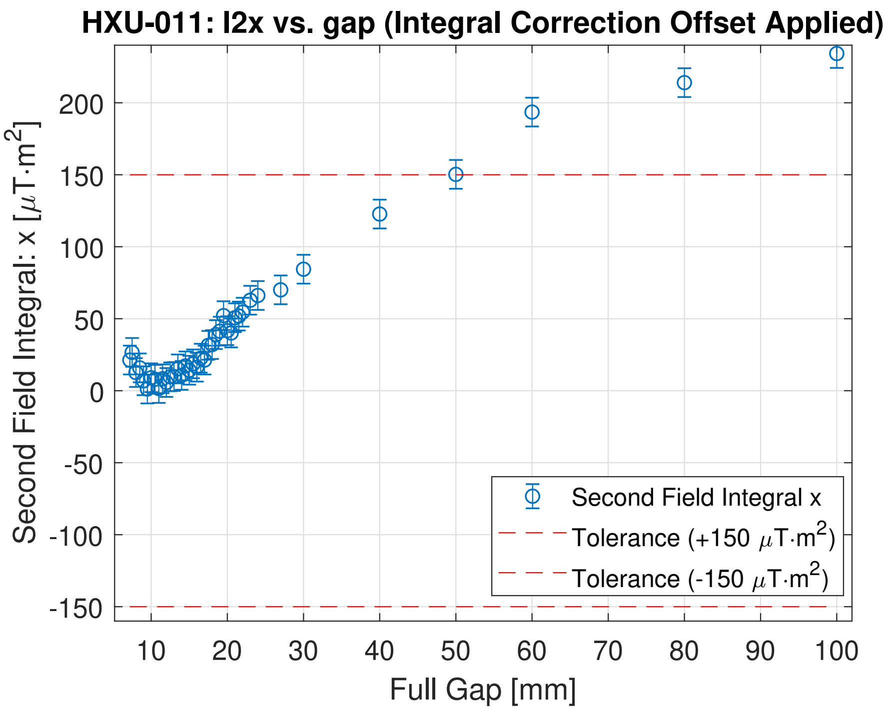
Long Coil Measurement of the On-Axis First Horizontal Field Integrals with +100 μT·m Integral Offset



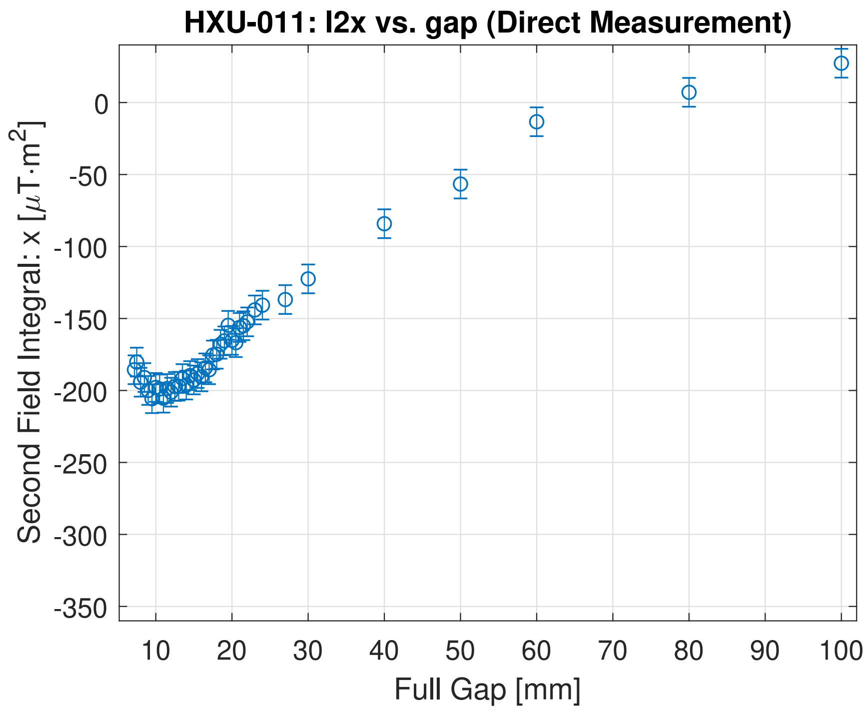
Long Coil Measurement of the On-Axis First Horizontal Field Integrals



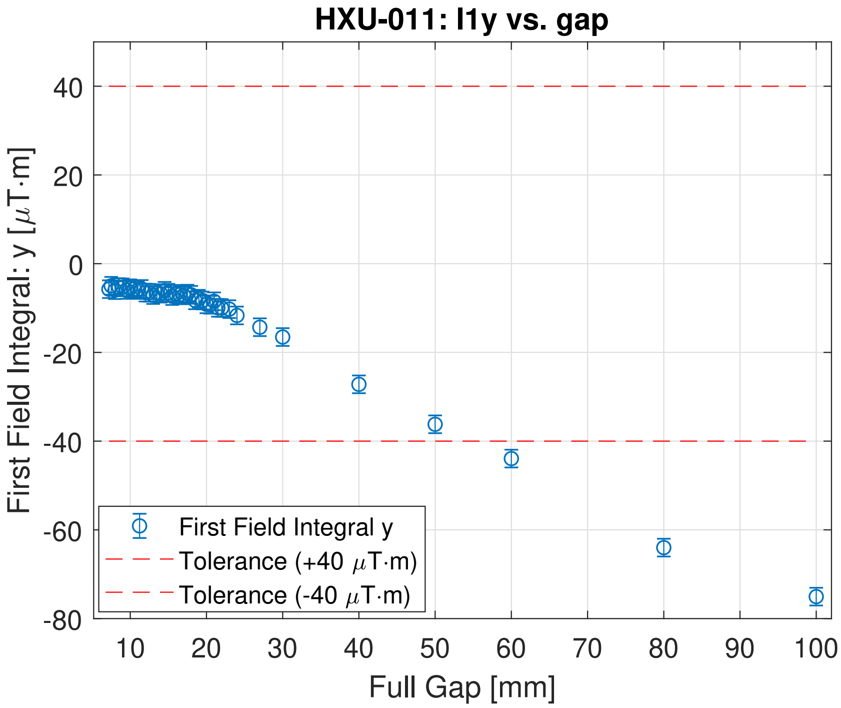
Long Coil Measurement of the On-Axis Second Horizontal Field Integrals with +100 μT·m $\times$ 0.5 $\times$ 4.012667 m Second Integral Offset



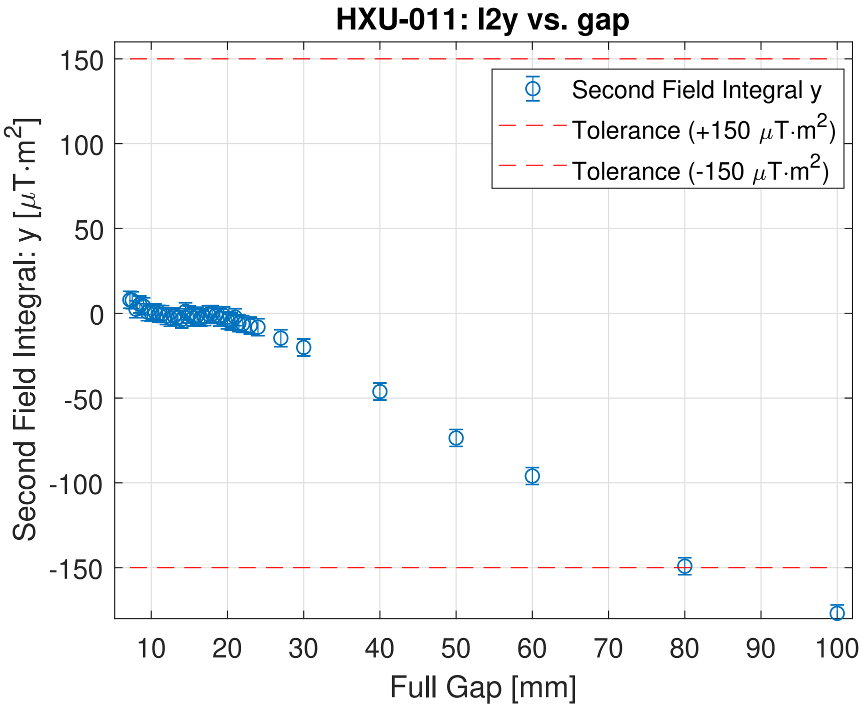
Long Coil Measurement of the On-Axis Second Horizontal Field Integrals



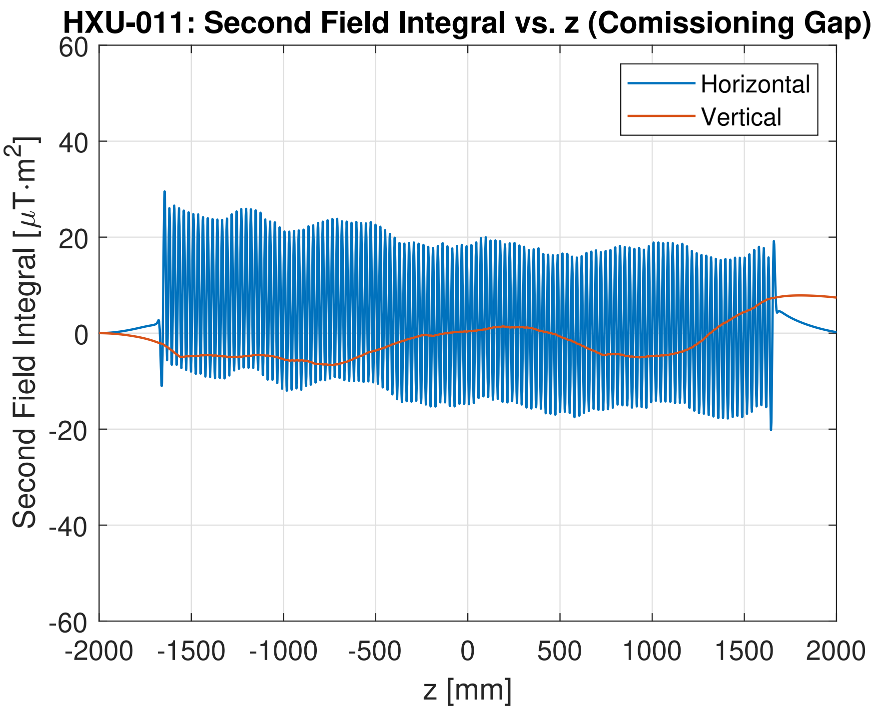
Long Coil Measurement of the On-Axis First Vertical Field Integrals



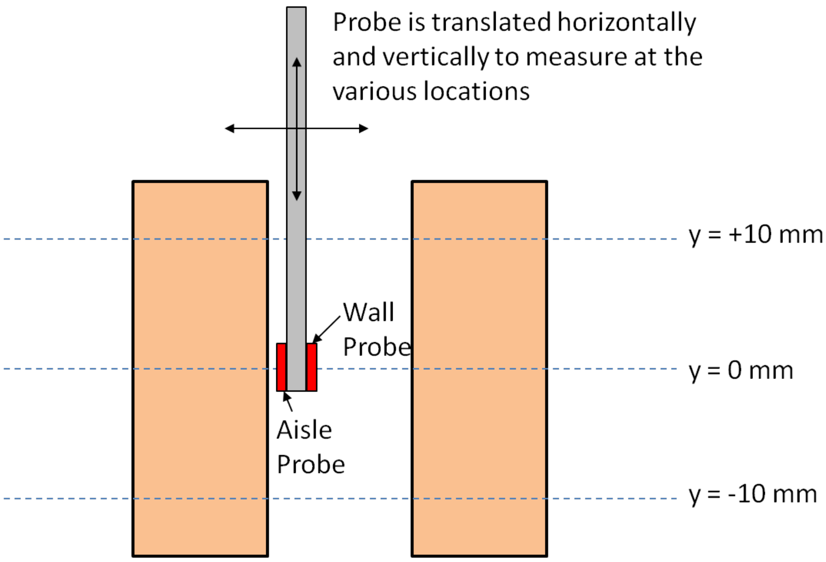
Long Coil Measurement of the On-Axis Second Vertical Field Integrals



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

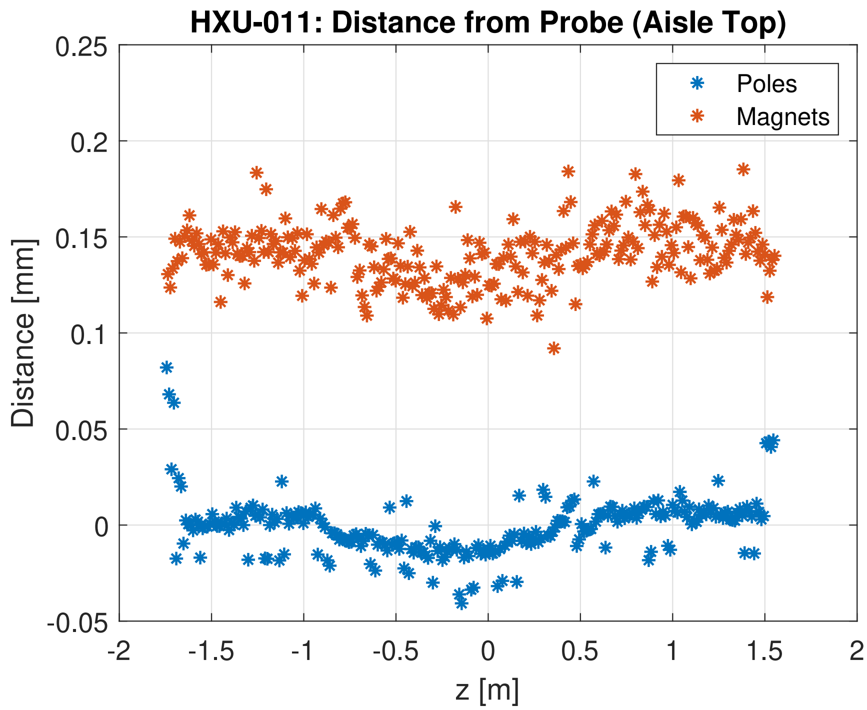


Capacitive Sensor Arrangement

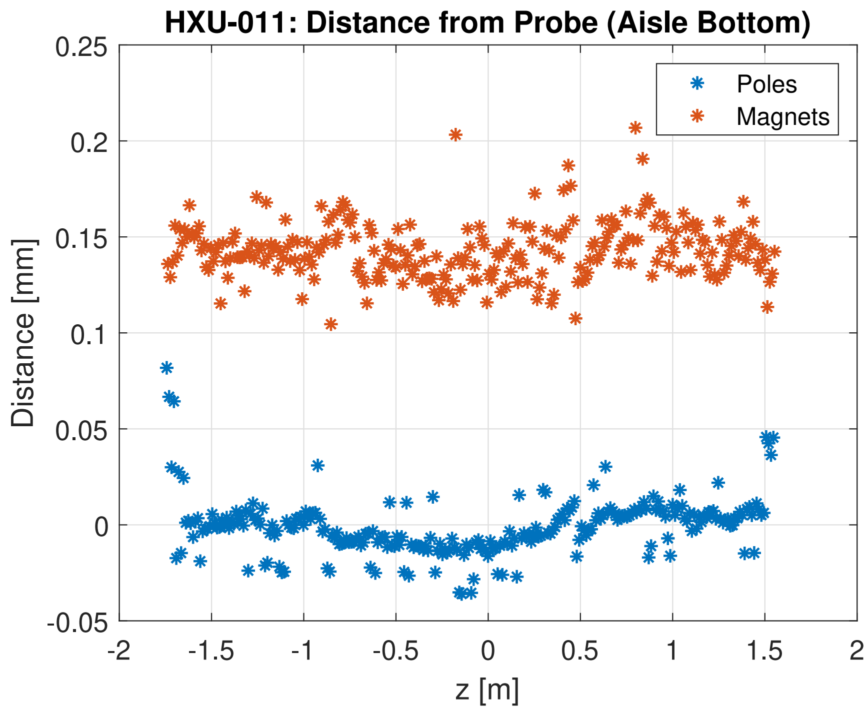


The following plots show the pole and magnet position measurements. The LBNL system has two back-to-back capacitive probes on one probe holder. The x and y stages on the Kugler bench are positioned so that the probe is in the proper location for each of the 9 scan locations. For the data analysis, the 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.

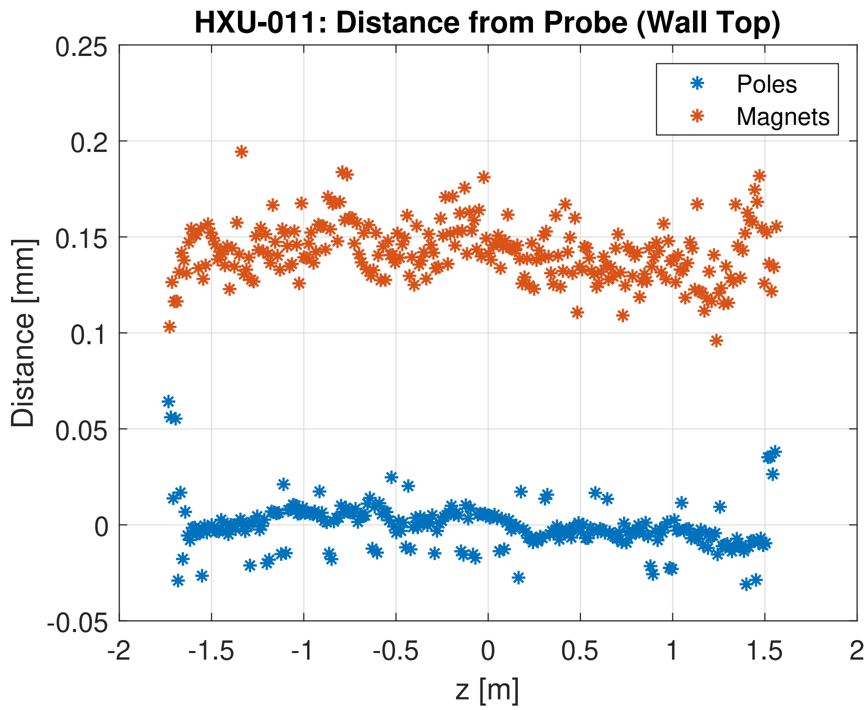
G1 Capacitive Sensor Readings



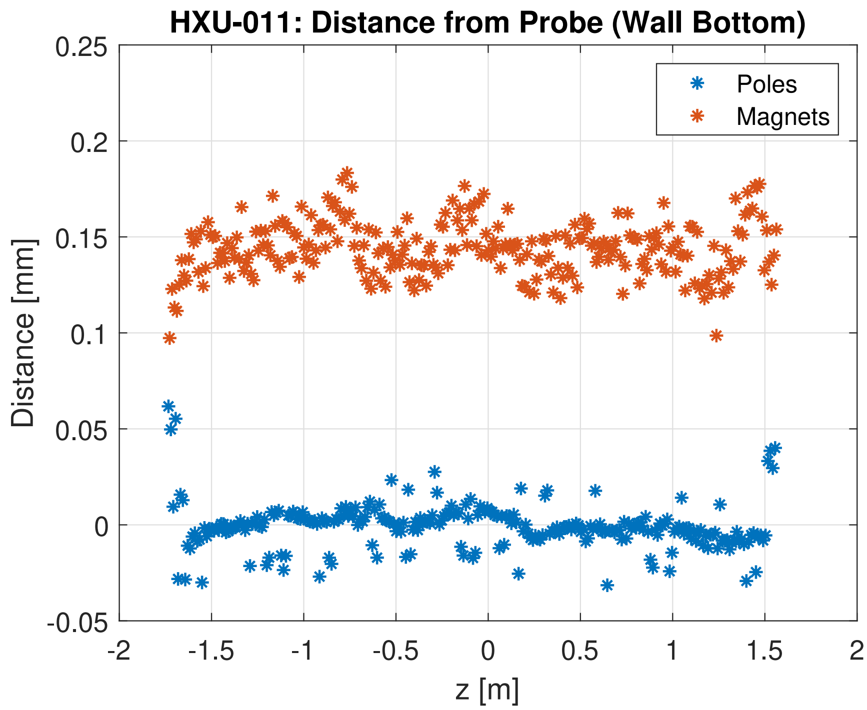
G2 Capacitive Sensor Readings



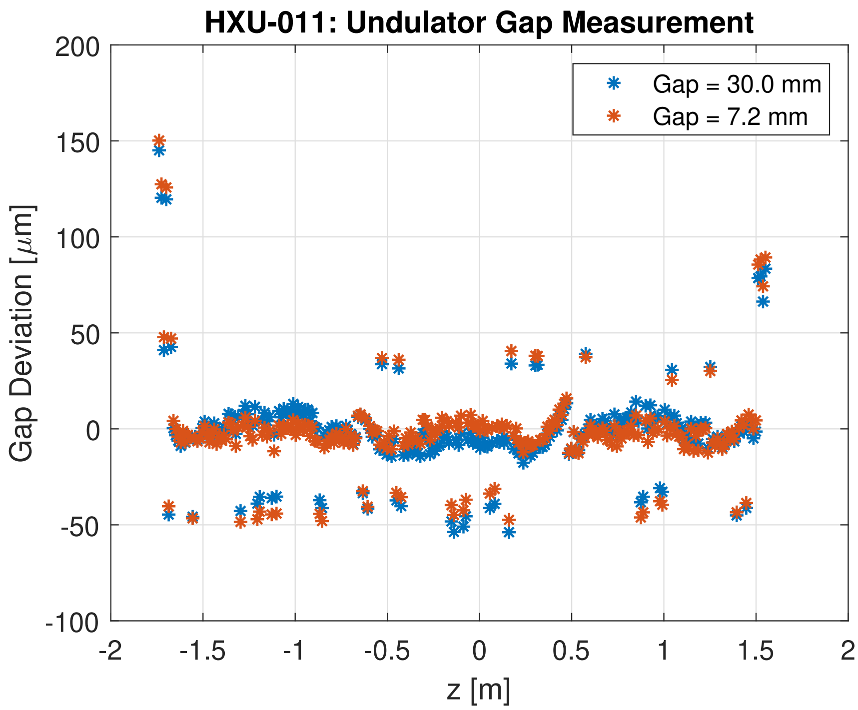
G3 Capacitive Sensor Readings



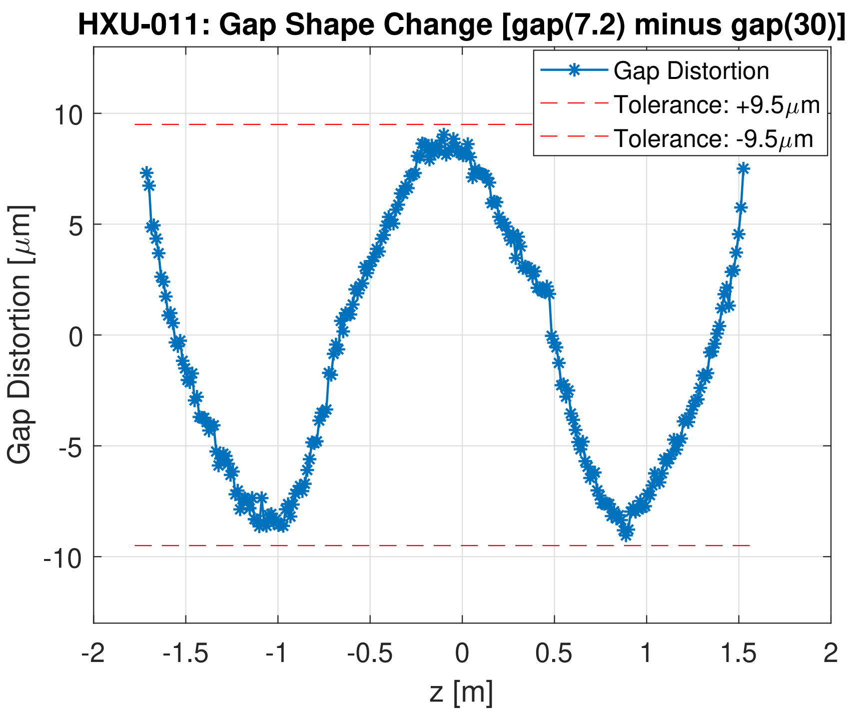
G4 Capacitive Sensor Readings



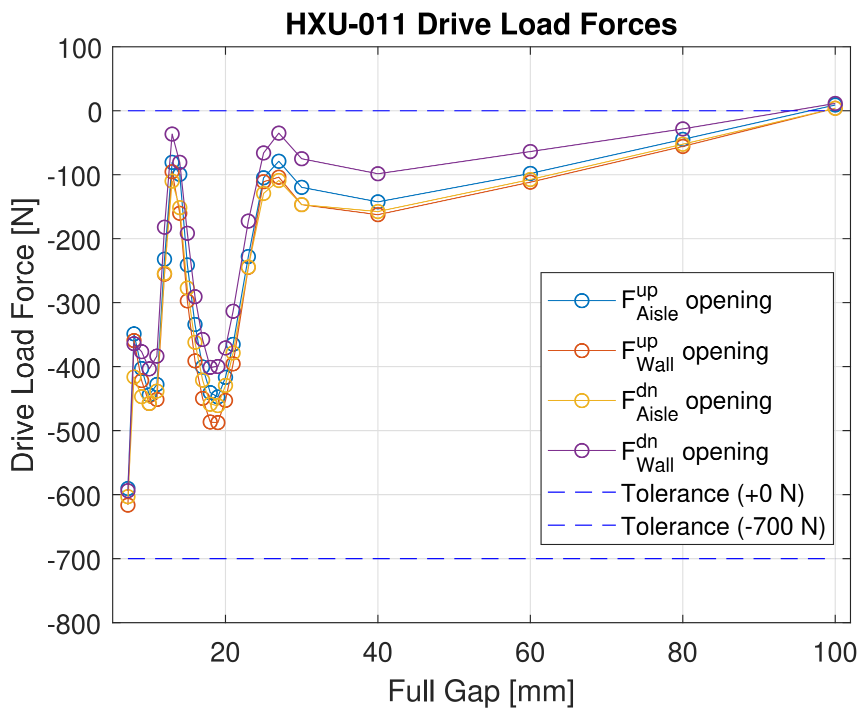
Undulator Gap Measurement



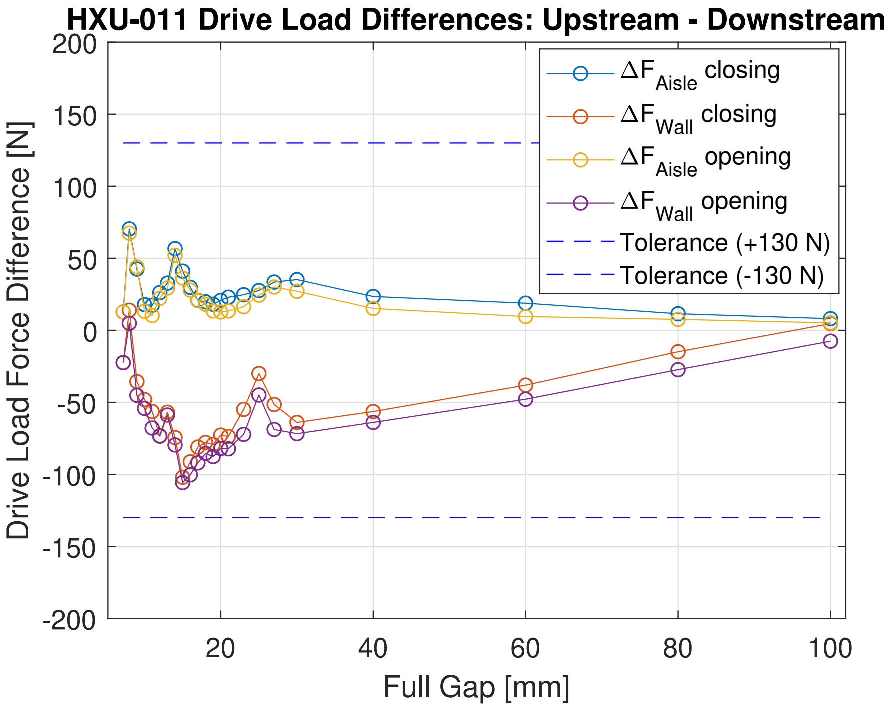
Undulator Gap Difference



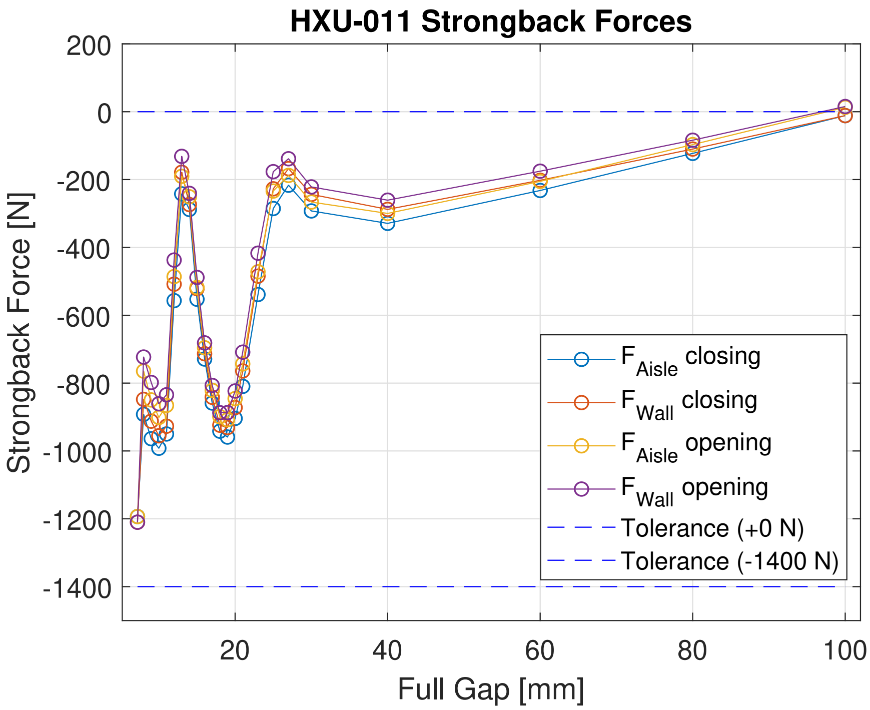
Drive Loads (Gap Opening)



Drive Load Differences (Gap Opening and Closing)



Strongback Forces (Gap Opening and Closing)



Strongback Force Differences (Gap Opening and Closing)