

LCLS-II Undulator Segment Measurement Results

HXU-033

## LCLS-II HXU Measurement Results

Serial number from manufacturers label:	HXU-033
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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)	$20.0 \pm 0.1$	°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)	$20.0 \pm 0.1$	°C
$rms( B_{pk} /\langle B_{pk} \rangle - 1)$	0.0021	
$K_{eff}$ at Commissioning Gap (should be 2.3400)	2.3401	
Commissioning Gap	7.955	mm
$I1X$ (over 4.012667 m) (should be within $\pm 40$ )	10	$\mu Tm$
$I2X$ (over 4.012667 m) (should be within $\pm 150$ )	16	$\mu Tm^2$
$I1Y$ (over 4.012667 m) (should be within $\pm 40$ )	1	$\mu Tm$
$I2Y$ (over 4.012667 m) (should be within $\pm 150$ )	9	$\mu Tm^2$
Phase Shake (rms phase fluctuations over core poles ( $< 4.0$ ))	1.6	degXray
Cell Phase Advance (over 4.012667 m)	48599.3 ( $135 \times 360 - 0.7$ )	degXray
Undulator Entrance Phase <sup>1</sup>	2249.2 ( $25 \times 90 - 0.8$ )	degXray
Undulator Exit Phase <sup>2</sup>	2249.8 ( $25 \times 90 - 0.2$ )	degXray

<sup>1</sup>Phase advance from cell start (undulator center  $-2.006334$  m) to center of physical pole 8.

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



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### Undulator Encoder Settings

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USGapEncoderOffset	40.0634
DSGapEncoderOffset	40.4404
USWLinearEncoder.AOFF	90.7975
DSWLinearEncoder.AOFF	93.4077
USALinearEncoder.AOFF	90.6280
DSALinearEncoder.AOFF	91.6666

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

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LC.DAL_FORCE	-170.9
LC.DAU_FORCE	-339.1
LC.DWL_FORCE	-258.2
LC.DWU_FORCE	-246.3
LC.UAL_FORCE	-266.4
LC.UAU_FORCE	-248.5
LC.UWL_FORCE	-178.0
LC.UWU_FORCE	-342.3

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

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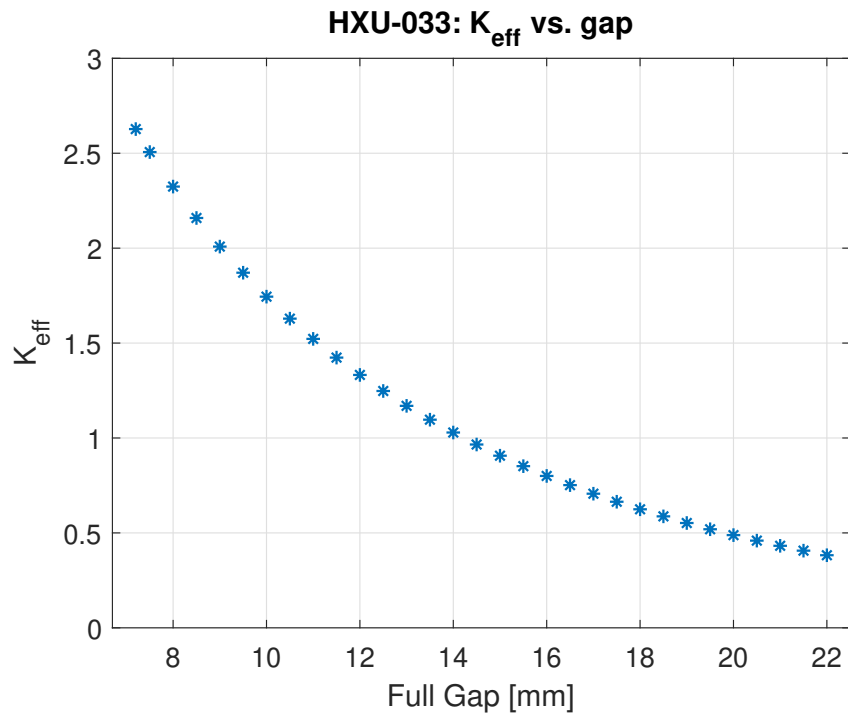
LC.DAL_FORCE	1.7
LC.DAU_FORCE	-4.2
LC.DWL_FORCE	4.9
LC.DWU_FORCE	-0.7
LC.UAL_FORCE	7.6
LC.UAU_FORCE	-1.0
LC.UWL_FORCE	3.4
LC.UWU_FORCE	-6.3



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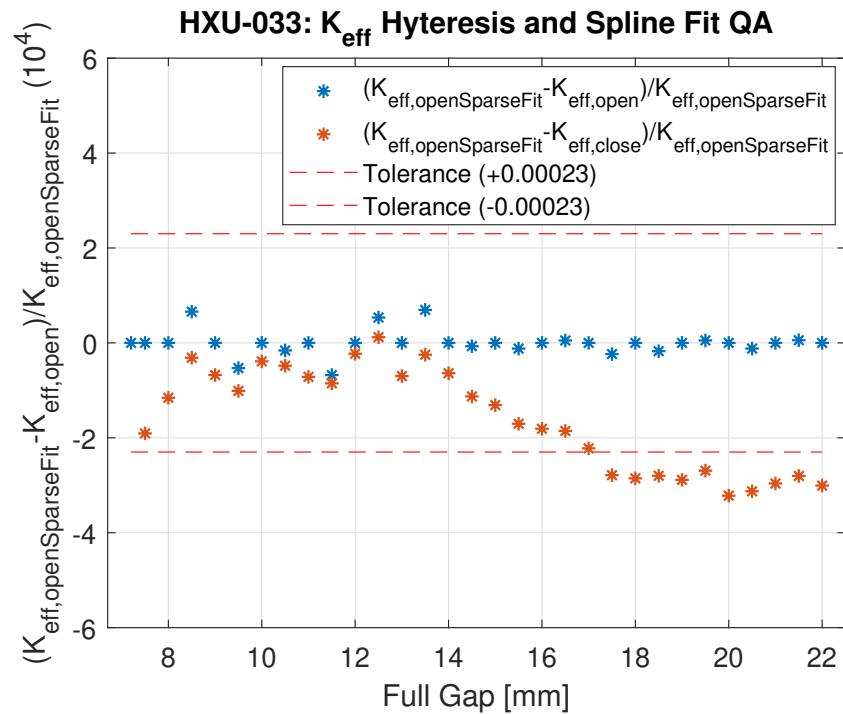
**Evaluation of Hall Probe Scans:  $K_{\text{eff}}$  vs. gap**

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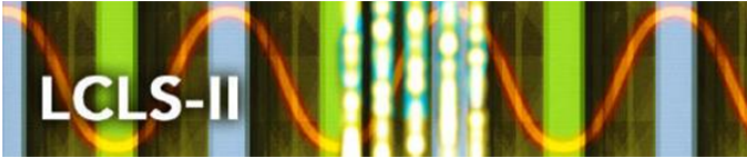


Evaluation of Hall Probe Scans:  $K_{\text{eff}}$  Hysteresis using Half Gap Encoders

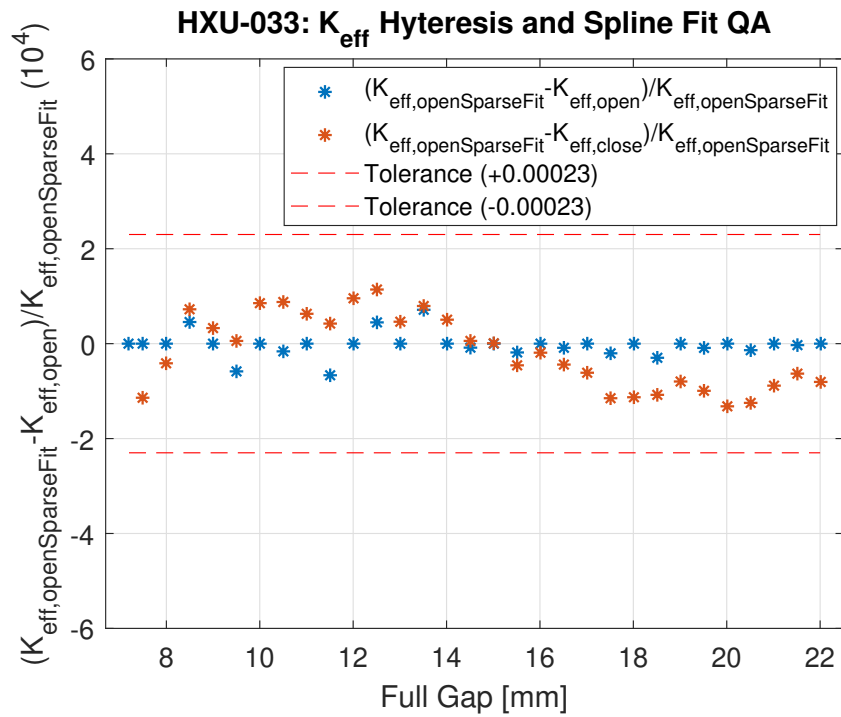


Plotted functions have been calculated from measured values openKeff (opengap) and closeKeff (closegap) using the following Matlab calculations:

- 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:  $K_{\text{eff}}$  Hysteresis using Full Gap Encoders

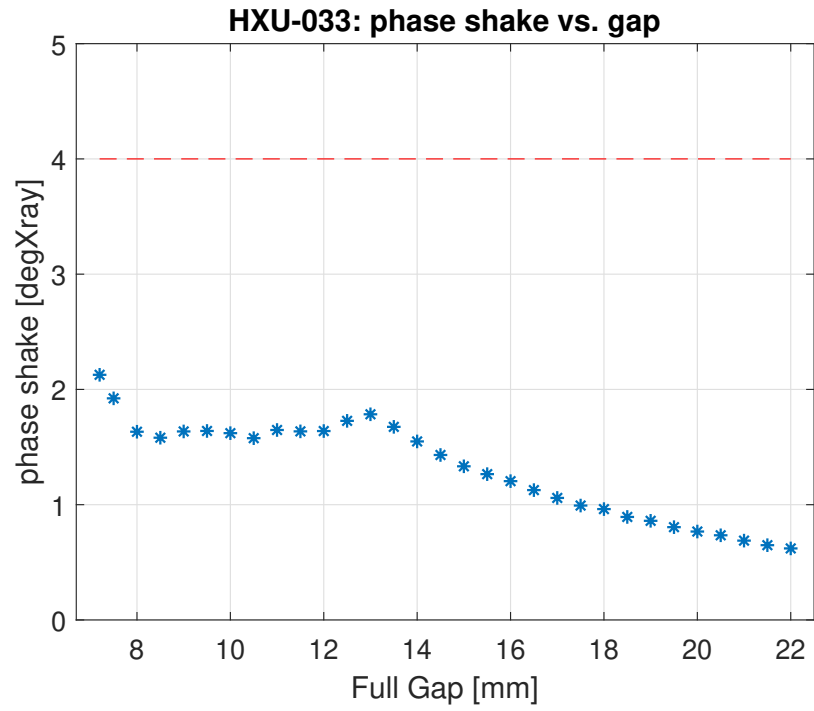


Plotted functions have been calculated from measured values openKeff (opengap) and closeKeff (closegap) using the following Matlab calculations:

- 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

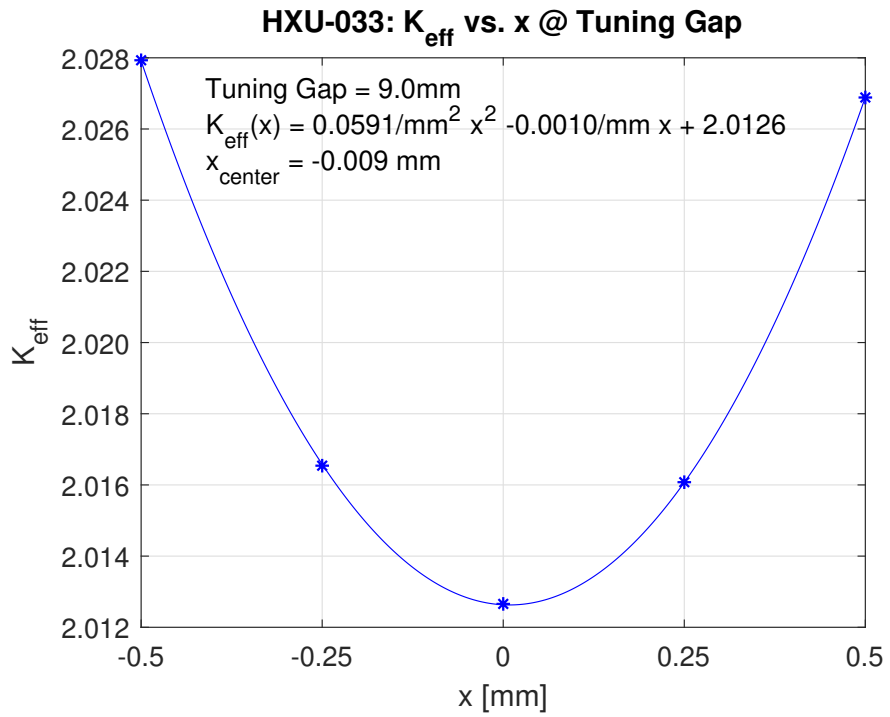




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**Evaluation of Hall Probe Scans:  $K_{\text{eff}}$  vs  $x$  at Tuning Gap**

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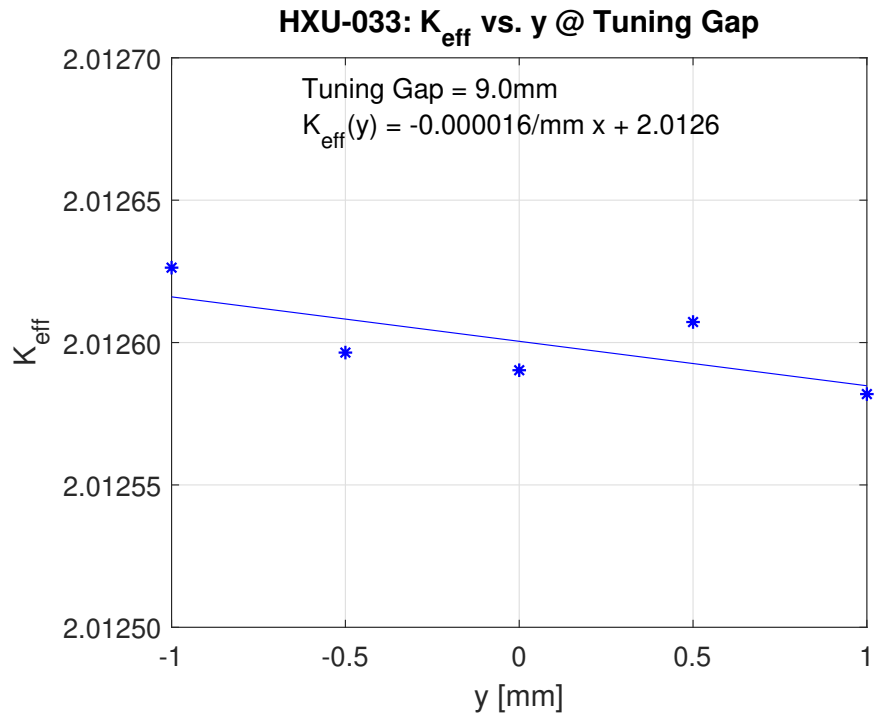




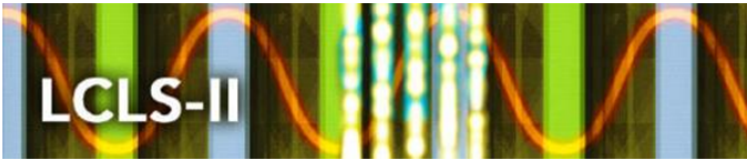
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Evaluation of Hall Probe Scans:  $K_{\text{eff}}$  vs  $Y$  at Tuning Gap

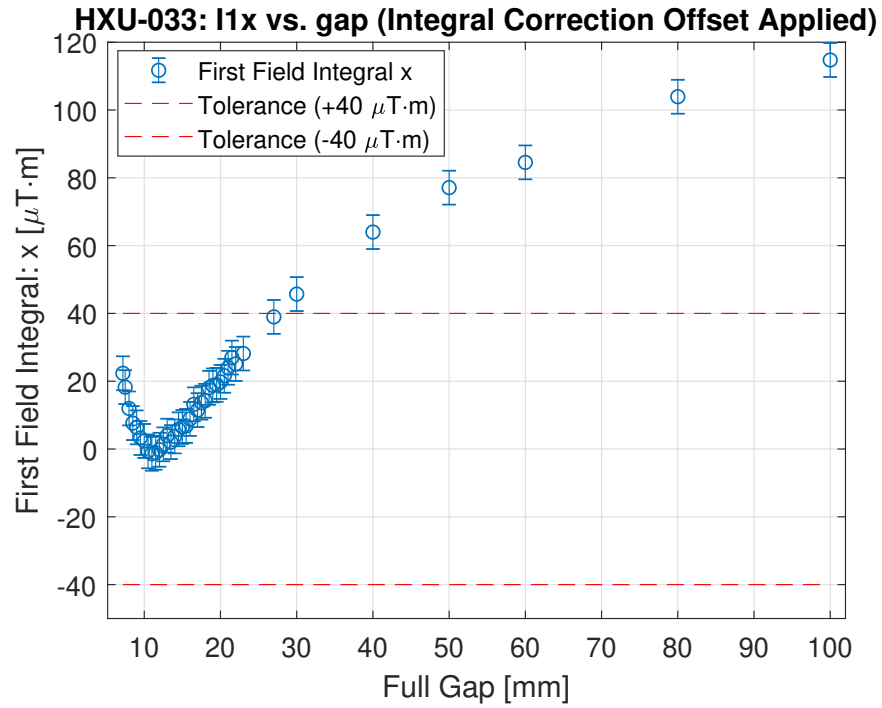
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## Long Coil Measurement of the On-Axis First Horizontal Field Integrals with $+100 \mu\text{T}\cdot\text{m}$ Integral Offset

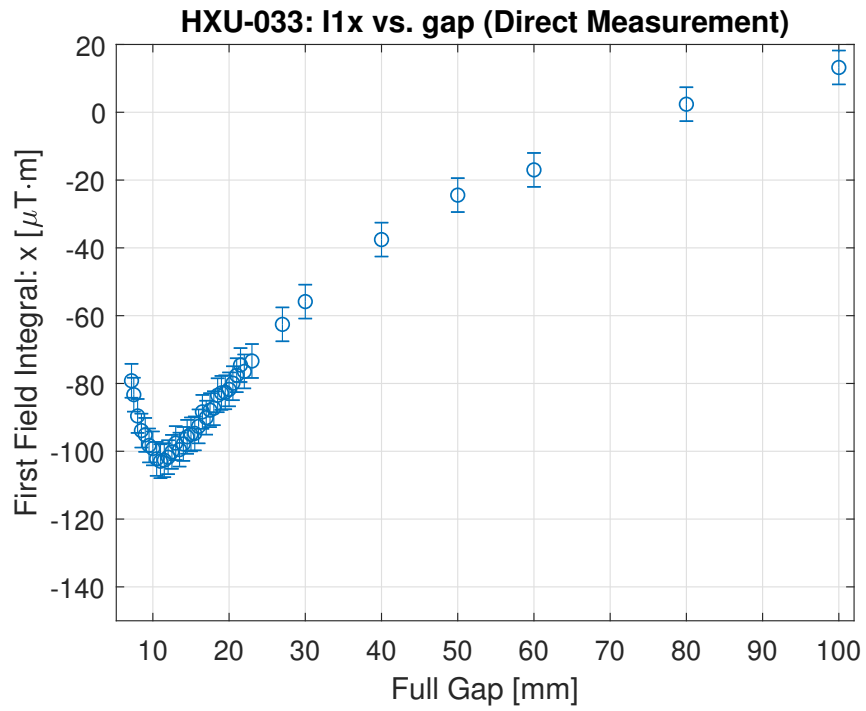




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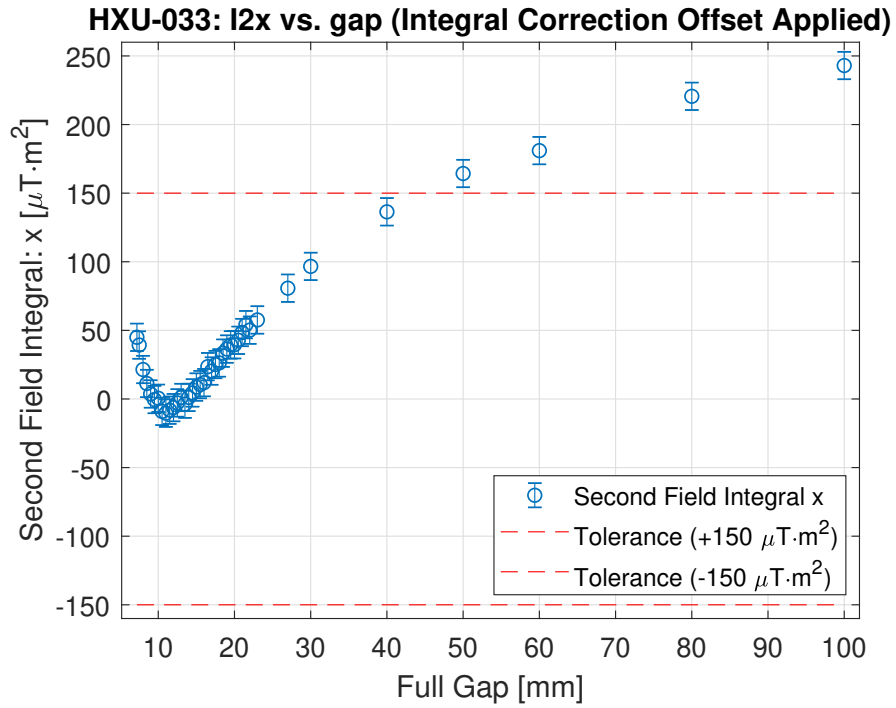
**Long Coil Measurement of the On-Axis First Horizontal Field Integrals**

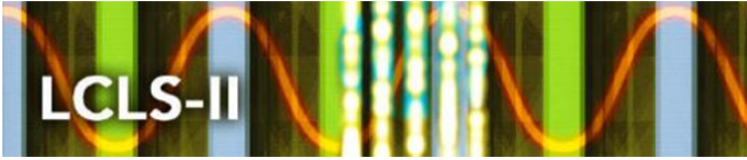
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Long Coil Measurement of the On-Axis Second Horizontal Field Integrals with  $+100 \mu\text{T}\cdot\text{m} \times 0.5 \times 4.012667 \text{ m}$  Second Integral Offset

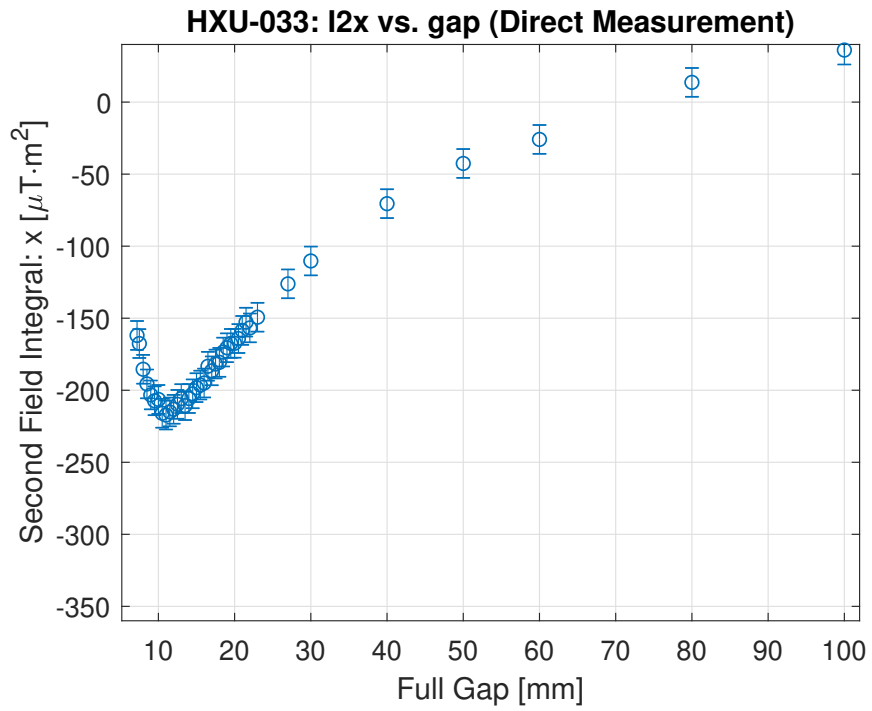




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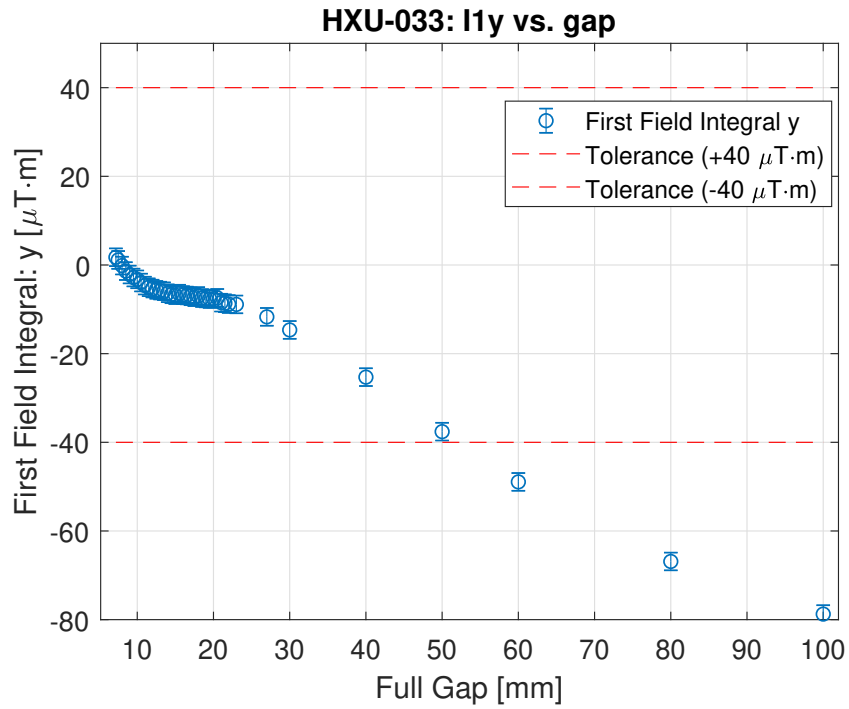
**Long Coil Measurement of the On-Axis Second Horizontal Field Integrals**

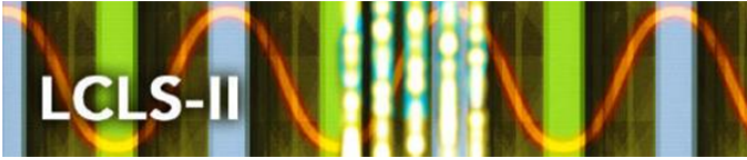
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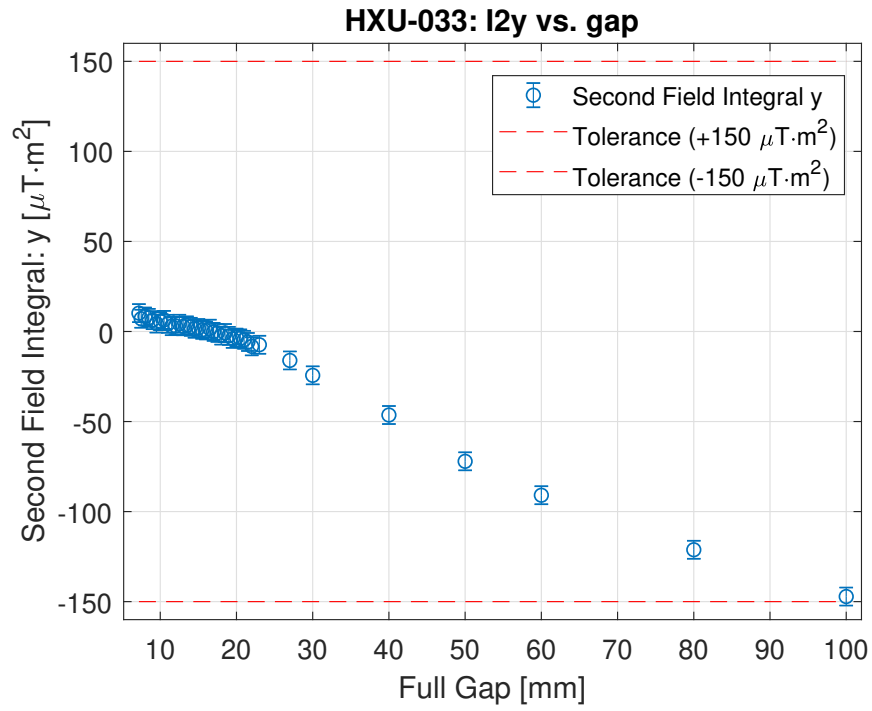


### Long Coil Measurement of the On-Axis First Vertical Field Integrals





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

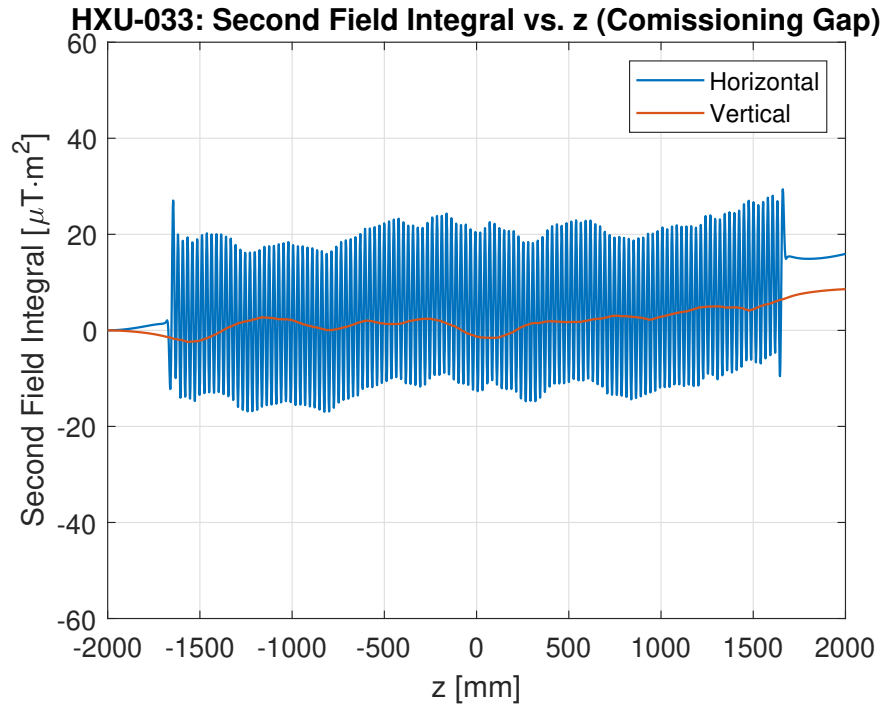




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## Second Horizontal and Vertical Field Integrals Along Undulator Length at Commissioning Gap

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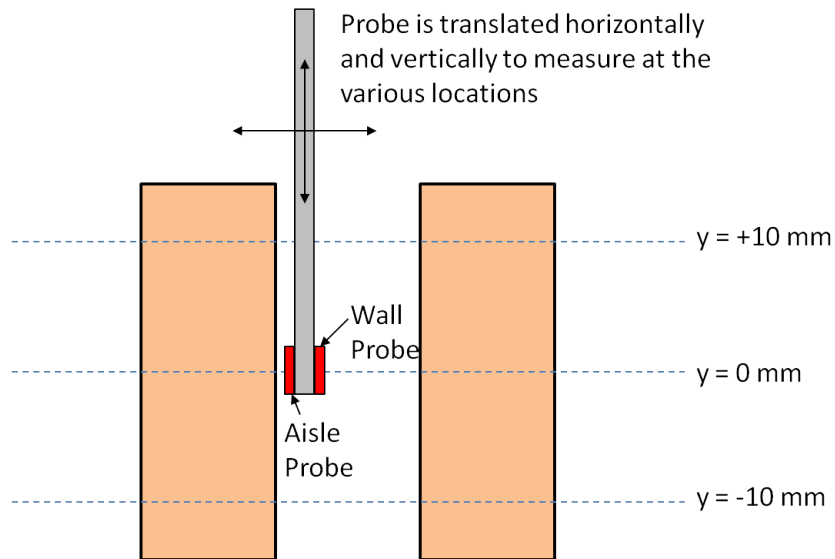




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## Capacitive Sensor Arrangement

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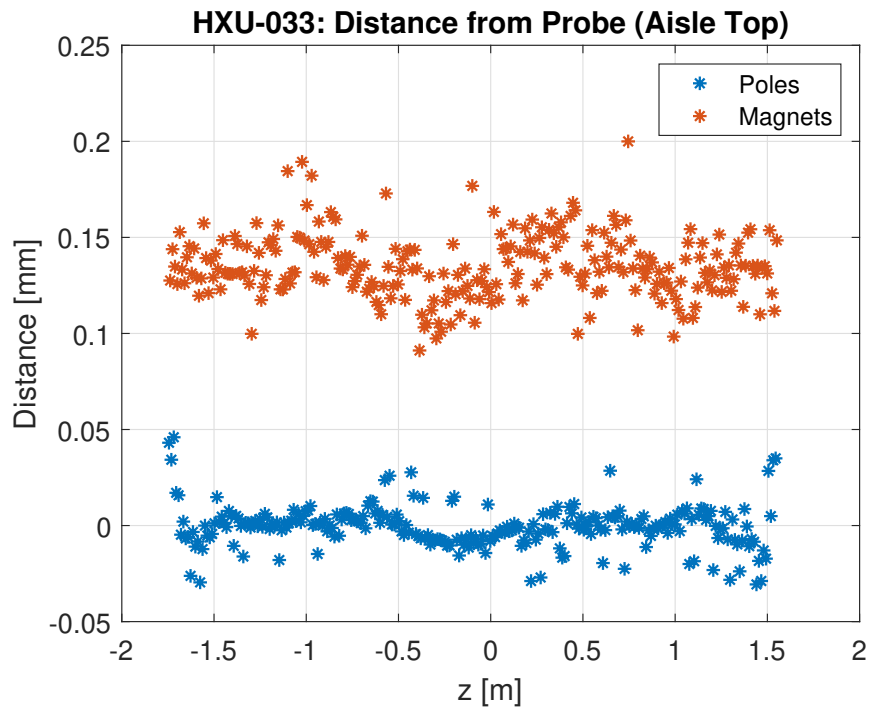


The following plots show the pole and magnet position measurements. The LBNL system has two back-to-back capacitive probes on one probe holder. The x and y stages on the Kugler bench are positioned so that the probe is in the proper location for each of the 9 scan locations. For the data analysis, the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



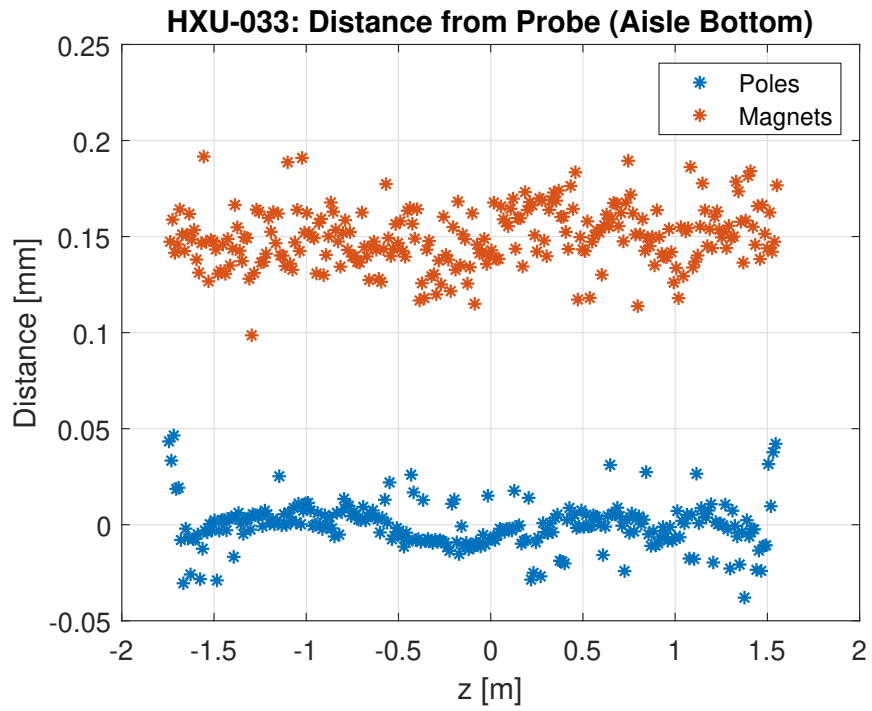


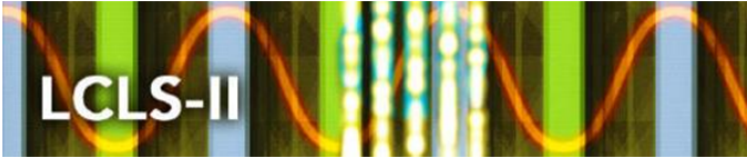
## G1 Capacitive Sensor Readings



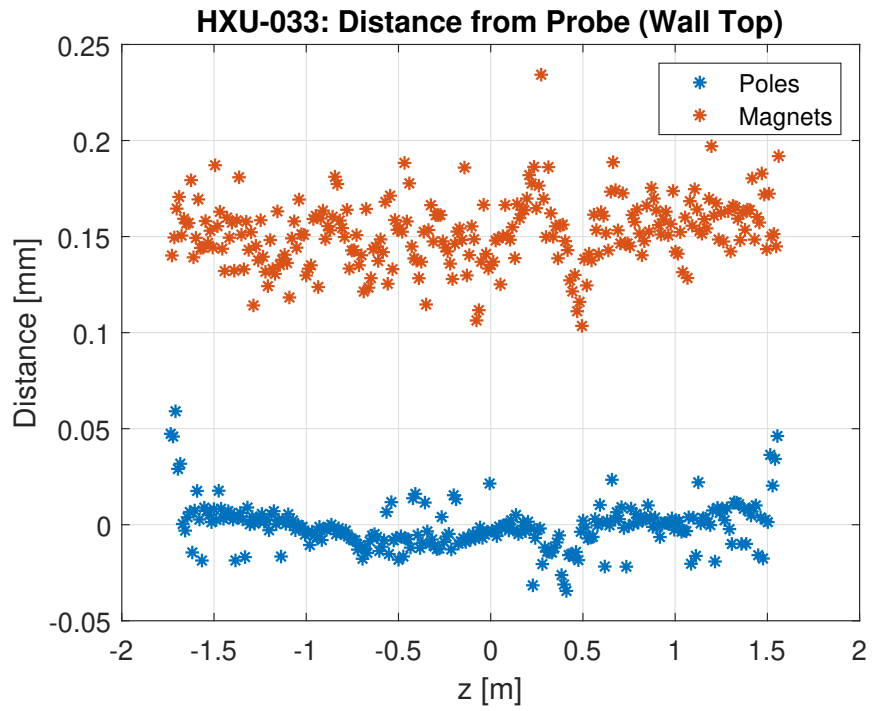


## G2 Capacitive Sensor Readings



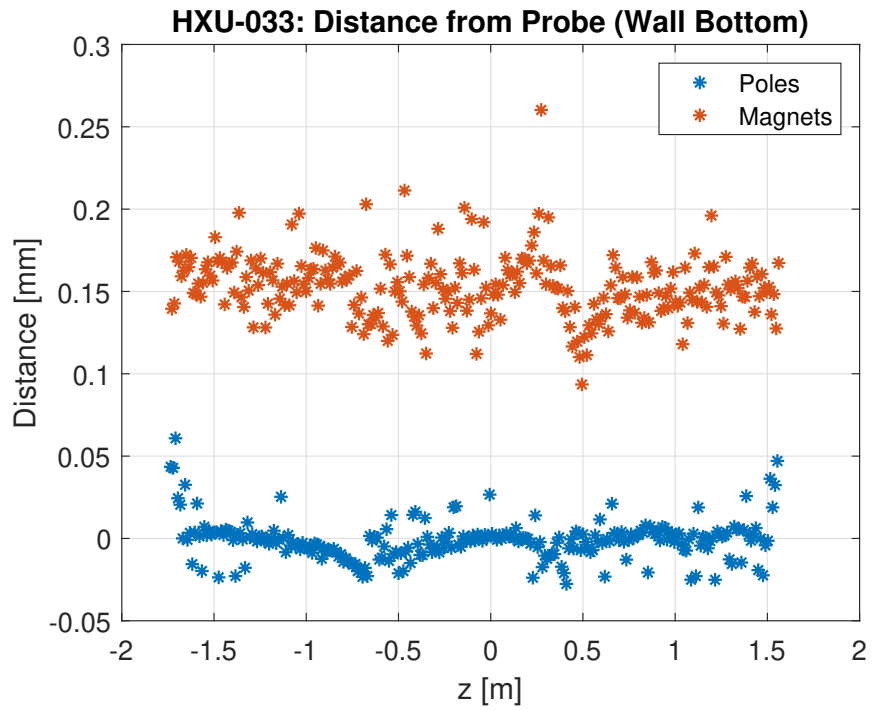


### G3 Capacitive Sensor Readings



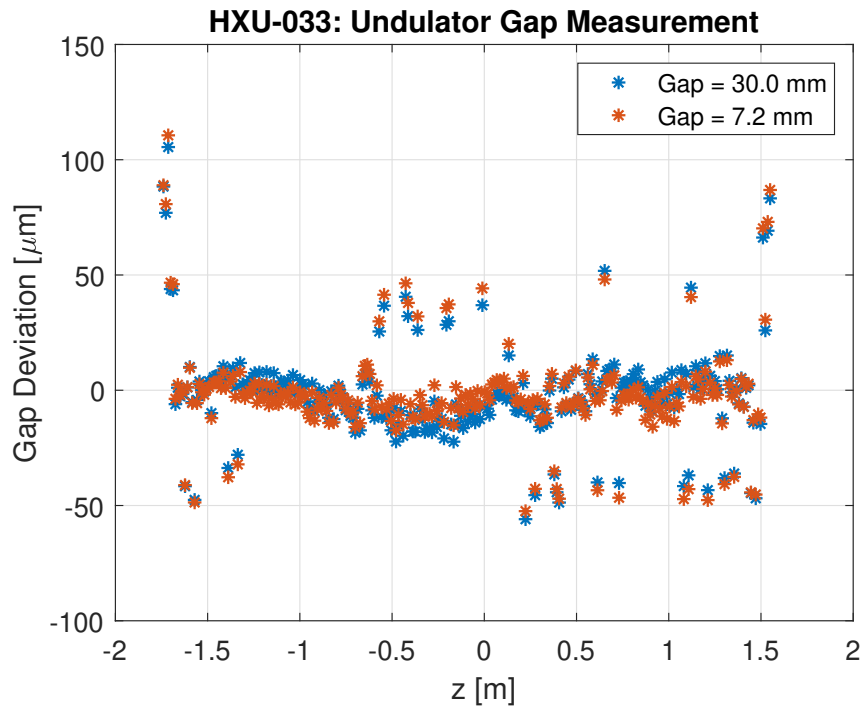


## G4 Capacitive Sensor Readings



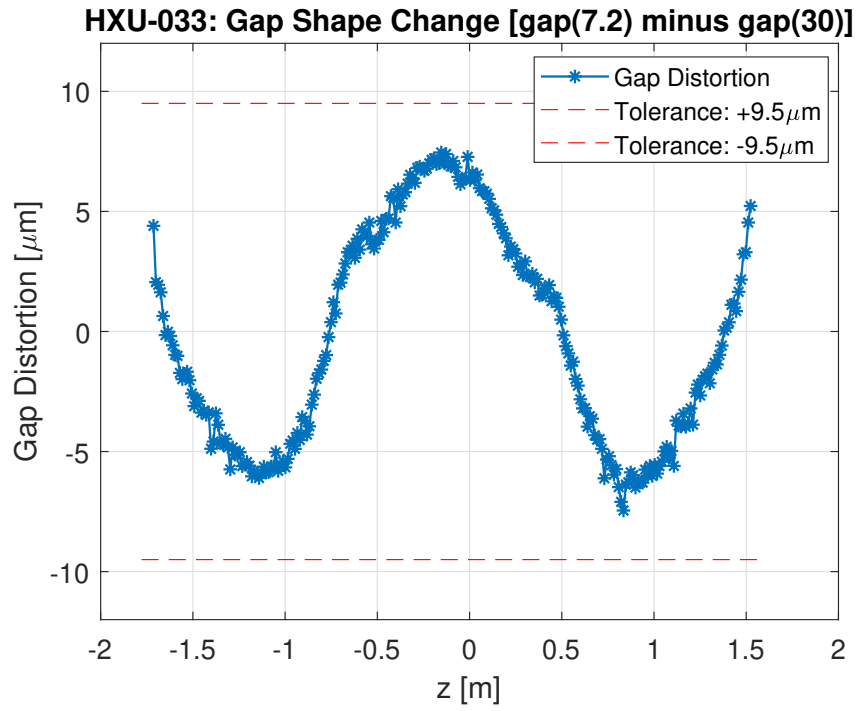


## Undulator Gap Measurement



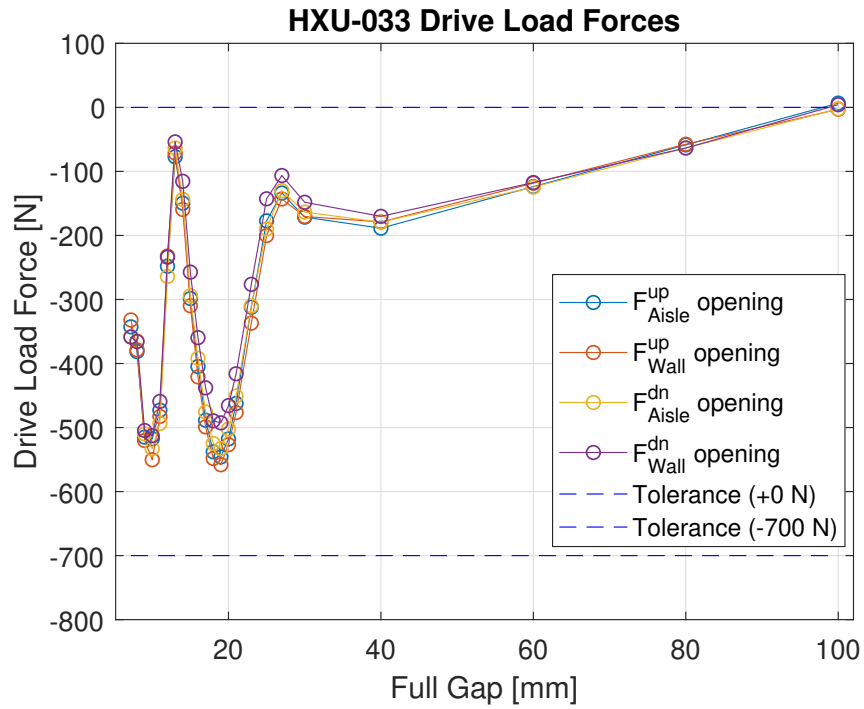


## Undulator Gap Difference



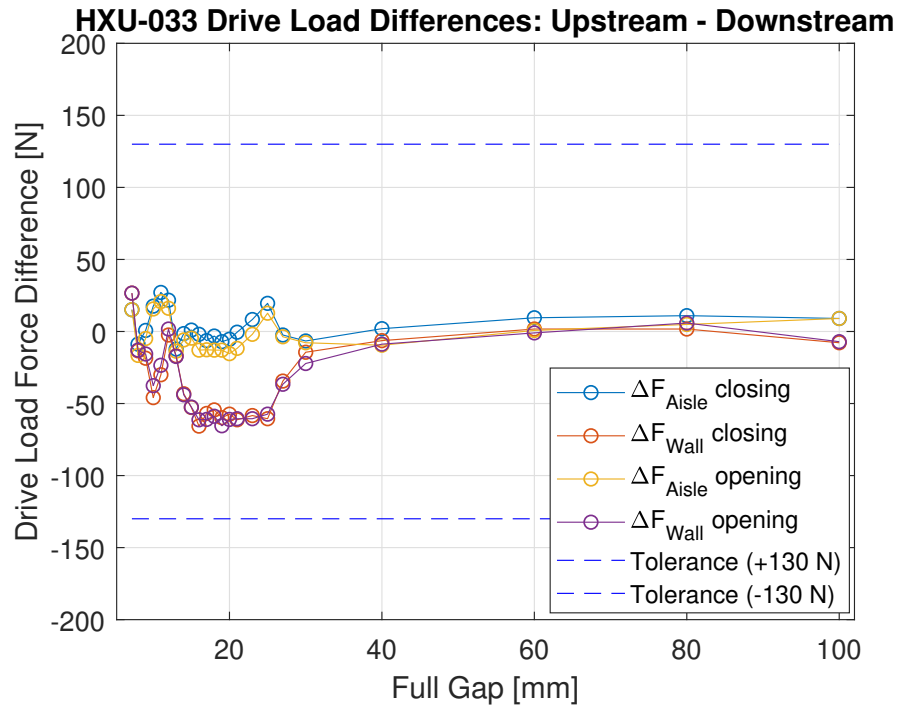


### Drive Loads (Gap Opening)

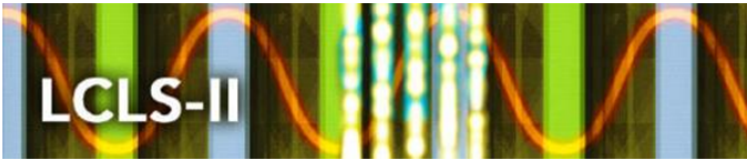




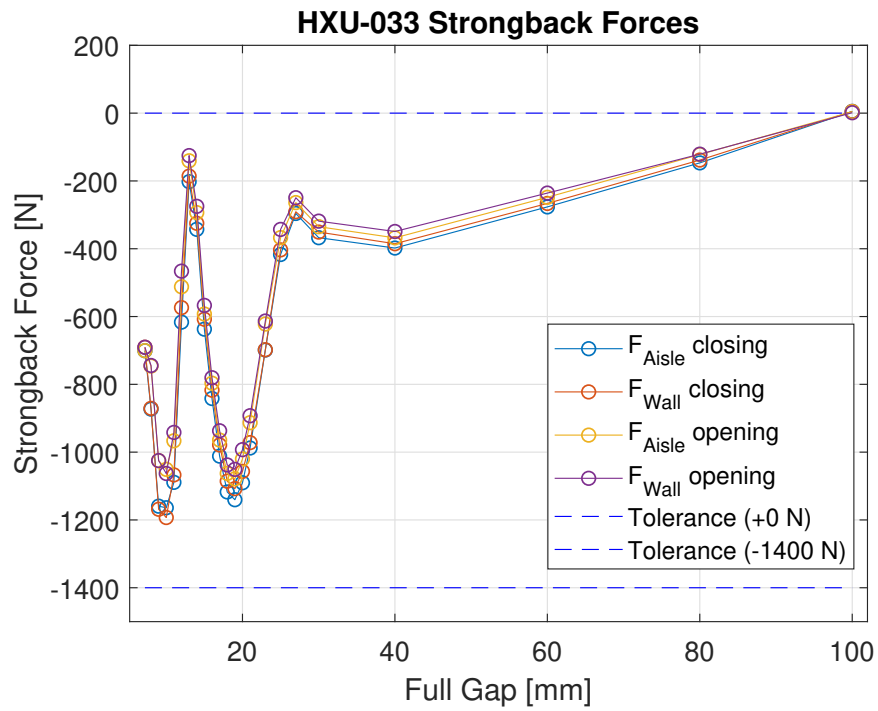
### Drive Load Differences (Gap Opening and Closing)







### Strongback Forces (Gap Opening and Closing)





### Strongback Force Differences (Gap Opening and Closing)

